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Archaeological Database: A Method for Managing Cultural Resources

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Archaeological Database:
A Method for Managing Cultural Resources

A Major Individual Project submitted in partial satisfaction of the requirements
for the degree of Master of Science in Geographic Information Systems

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Abstract

Archaeological Database: A Method for Managing Cultural Resources

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Geographic Information System (GIS) technology is spreading into all types of disciplines, including archaeology and anthropology. GIS technology is a valuable tool that can be used to manage large databases. CRM TECH recognizes a need for such a system to help it maintain the large amount of data that it has collected for cultural resources in California. This document outlines the procedures for using GIS to provide a solution for CRM TECH in managing its cultural resources. The solution involved producing a database that would be used by CRM TECH for project proposals, record searches, map creation, research before and after fieldwork is completed, field recording, and analysis of data recorded in the field. By creating this database, the researchers at CRM TECH can now look at the spatial data behind the artifacts, sites locations, and project areas that have been recorded to help improve their workflow and research.

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List of Acronyms and Definitions

CRM	Cultural Resource Management
DEM	Digital Elevation Model
ESRI	Environmental Systems Research Institute
GIS	Geographical Information System
GPS	Global Positioning System
GRASP	Graduate Research and Scholarly Project
GUI	Graphic User Interface
IC	Information Centers
RS	Record Search
STP	Shovel Test Pit
USGS	United States Geological Survey
UML	Unified Model Language
WOR	Weighted Overlay Raster

Chapter 1 – Introduction

For many years, archaeologists have recorded cultural resource data the old-fashioned way, with pencil and paper. Many archaeological site maps are sketched on graph paper, using measurements from hand-held compass and tape measures (Garret, 2007). As one can imagine, a paper trail starts to mount up with the discoveries of new cultural resources, along with the management of previously recorded resources that need to be updated. With so much paper information stored in different locations within an office environment, the chances increase for the record to be incomplete or lost. This all started to change with the introduction of Geographical Information Systems (GIS) into the field of archaeology. A database of cultural resources can now be created to assist archaeologists and historians in organizing the large amounts of data that have been collected in the past and in managing new information.

The purpose of this project was to create a GIS system for a small Cultural Resource Management (CRM) company interested in incorporating GIS into its professional activities. In order to create this system, a database needed to be designed to store vital cultural resource information, such as locations of known prehistoric and historic sites, locations of surveys that have been conducted over the years, current and past project locations for CRM TECH, and locations of cultural artifacts. The information stored within the database needed to be able to be checked out to mobile Global Positioning System (GPS) units and checked back in so that the database can be updated with the new information collected in the field. The database was comprised of several feature datasets, database tables, and raster images. By having the information in a database, archaeologists and historians can analyze the data more easily and efficiently than manually searching for all the paper work associated with past cultural resource projects. Reports, site record documents, and artifact catalogs can be added to the database as hyperlinks associated with a cultural resource that has been mapped.

This chapter is comprised of five sections. The first section identifies the project's client and why they are interested in GIS. The second section presents a general problem that the client needed addressed by this project. The third section outlines the solution, including the project goals and objectives, scope, and methodology. The fourth section addresses the primary audience for the project. The fifth section presents a summary of the topics covered in this project report.

1.1 Client

The client for this project is CRM TECH. CRM TECH is a small CRM company that specializes in archaeological, historical, and paleontogical surveys, evaluations, treatment, and mitigation plans. They are located in Colton, California and have been serving clients all over California for 19 years. CRM TECH was trying to incorporate GIS into their daily activities to efficiently manage data and to facilitate business operations. Dr. Michael Hogan, Principal Investigator and part owner of CRM TECH,

was the point of contact for this project and provided the primary data that were used for creating the archaeological database.

1.2 Problem Statement

The problem that CRM TECH had was that its system of collecting and storing data was outdated. To be able to compete in today's market, CRM TECH needed to be able to catch up with their competitors in terms of technology and data management. CRM TECH had been using ArcGIS for the last couple of years, but not to its full capability. A fully functional GIS was needed for efficient data collection and management. A fully functional GIS for CRM TECH included the ability of not only data management and map creation in the office, but also the ability to collect data in the field and be able to bring it back to the office to use a variety of spatial analyst tools on the data.

1.3 Proposed Solution

This section outlines the proposed solution that was pursued for development of an archaeological system. "The database is essentially the foundation from which the system is built and without this there would be no GIS" (Rivett, 1997, p. 15). The solution for CRM TECH's problem was to develop a GIS system that can be used for both research and field work. An archaeological geodatabase of the cultural resource data was needed, along with a user interface that any employee at CRM TECH can easily use. By building up their GIS capabilities, CRM TECH was able to offer more services for their clients and was able to save time and money in the areas of research and fieldwork.

1.3.1 Goals and Objectives

The goal for this project was to help CRM TECH develop their GIS capabilities within the cultural resource management field by creating a database of the cultural resource data that can be used for both research and field work. The objectives for this project were:

- To create the database in a way that the data can be easily used for different types of analyses provided within the ArcGIS Desktop tools.
- To create a user-friendly interface to help non-GIS workers access the database for research objectives.

By achieving these goals and objectives, CRM Tech was able to manage their data in a more structured way and was able to provide GIS data and services to their clients. It gave the company another tool to assist staff in studying past human development and to meet data requirements from potential clients such as large government agencies.

1.3.2 Scope

The scope for this project consisted of three components. The first component was to develop a database that would allow for querying spatial information concerning cultural resources. The second component was to create an interface that will allow a non-GIS user to import, export, update, and delete information from the database. This also included the ability to check out and check in the database from mobile GIS devices. The

third component was to develop a work flow of using the built-in ArcGIS Desktop analysis tools on the database in order to analyze spatial information for specific cultural resources.

For this project, a specific region within southern California was chosen to test the database and the analysis tools. The region selected was a portion of the Coachella Valley, near the cities of La Quinta, Coachella, Thermal, and Indio (Figure 1.1).

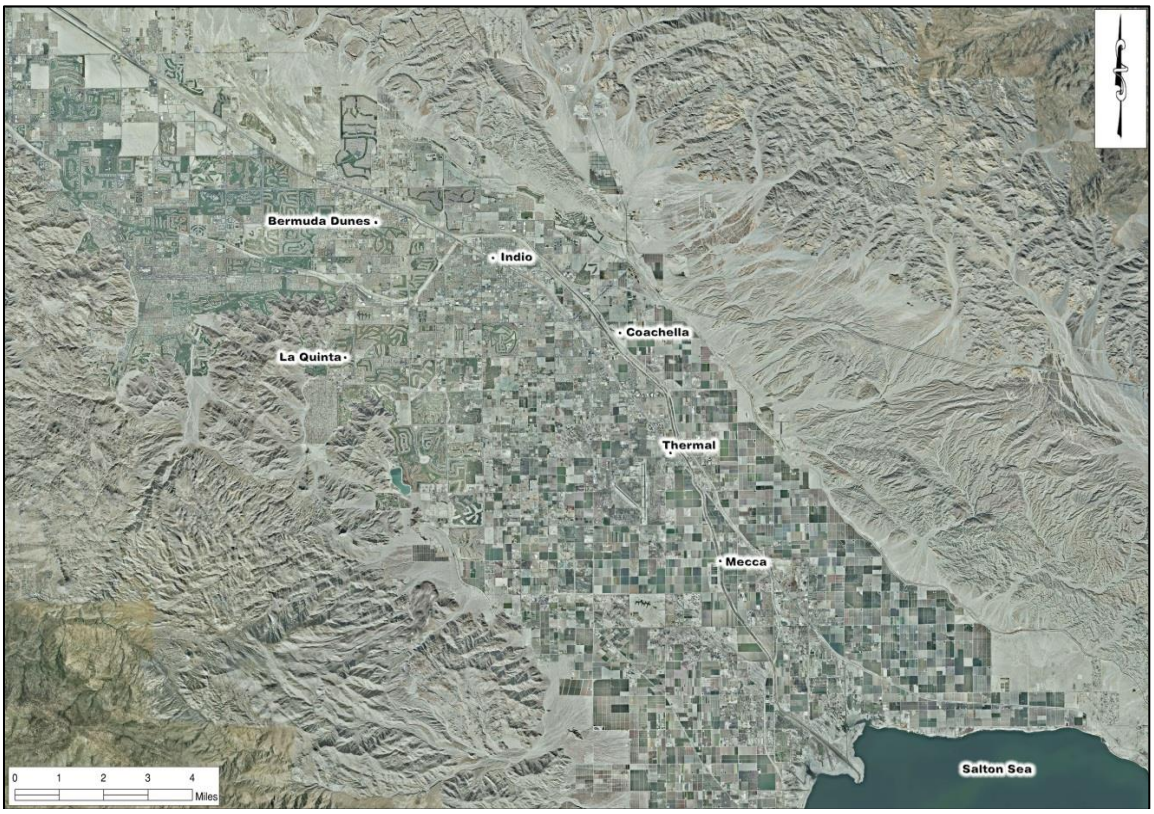

Figure 1-1: Project Study Area at Coachella Valley, California.

This area was chosen because of the wealth of archaeological data that the client had collected over the years. The client believed that this area was the best location to test the functionality of the database. The data that were used for this project were provided by the client, including aerial images, current and historical USGS Quad maps, shapefiles for known cultural resources, site records and report documents, and MS Excel spreadsheets of archaeological data collected for individual sites.

1.3.3 Methods

The main objective of this project was to create a database that would allow the client to prepare for project proposals, record searches, map creation for technical reports, and the analysis of data recorded in the field. This project was developed using the Agile approach to project development; functional segments of the project were submitted to the client for input as soon as they were developed, then reworked if needed (Figure 1.2).

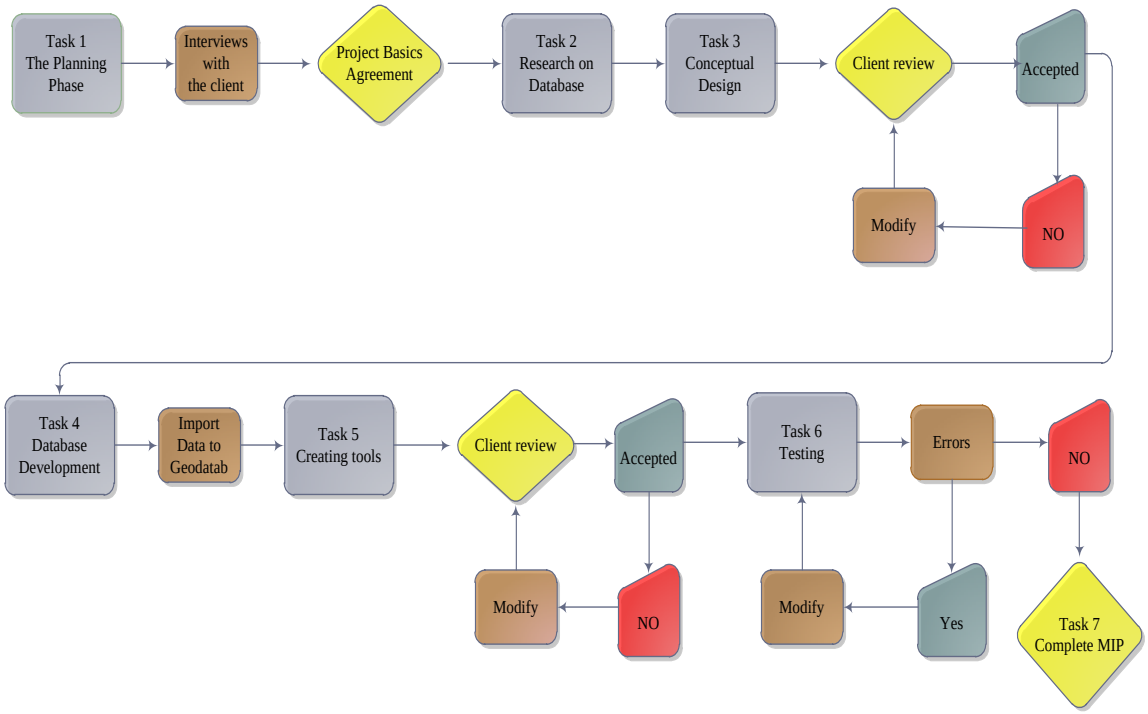

Figure 1-2: Project Method Outline

The first step of the project was to create the database. The problem that CRM TECH had was that their data was stored in different formats and locations within the office. Some of the data had been converted to digital format, while other types of data had not been. The challenge was to convert the data into the format that would be used for the database. Among the types of information that had not been digitized were many of the site locations and records, historic maps, survey locations, and project locations. The solution for this problem was to have CRM TECH digitize them in a timely matter. The database was made up of several different types of feature classes, feature datasets, and data tables. Some examples of the feature datasets were CRM TECH Projects, Cultural Resources, Archaeological Resources, Artifacts, and Ancient Lake Cahuilla.

The second step was to create an interface that helped both the GIS specialist and non-GIS workers to access the database for research and editing. There were several employees at CRM TECH who had limited training in using ArcGIS software. The interface created was used mostly for simplifying the workflow. Toolbars were created to place tools that are required for daily use of the software. The editing toolbar was for basic functions such as adding new cultural sites into the database, updating the cultural sites information, and deleting some attributes associated with a site. A new tool was created to automate some of the daily tasks that were required for producing technical maps, such as the Records Search Map.

The last step entails designing the database so that the data can be easily used for different types of analysis found within ArcGIS Desktop tools. CRM TECH wanted to explore the Analysis Tools, Spatial Analyst Tools, Spatial Statistic Tools, and 3-D Analysis Tools. For this project, CRM TECH wanted to take a closer look at the process called suitability analysis. Suitability analysis uses a tool called Weighted Overlay, a

spatial analysis tool, to rank the suitability of a given location to specific criteria. A new tool was created for this project to explore suitability analysis.

1.4 Audience

This report is intended for two groups of people: The archaeological community and a general audience with an introductory knowledge of GIS.

1.5 Overview of the Rest of this Report

This report is divided into three main categories: the project background, the overall approach of the project, and the outcome of the project. Chapter Two will discuss the key topic areas in academic research and studies that are relevant to the project.

The second part is presented in Chapters Three, Four, and Five, which discuss the overall approach to the project. Chapter Three describes the problem statement, requirement analysis, system design, project plan, and provides a summary of the overall system analysis and design of the project. Chapter Four discusses the structure of the database design that includes a conceptual and logical data model, source of the data used, and methods used for obtaining the data. Chapter Five describes the steps taken to implement the project achieving the stated project goals and objectives. The last part of the paper includes Chapter Six− which discusses the results of the project implementation− and Chapter Seven, which presents the general conclusions of the project and suggestions for future work.

Chapter 2 – Background and Literature Review

The use of GIS in archaeology is not a new idea. Archaeologists have been using some form of GIS in their fieldwork, analysis, and in data management for at least 40 years. The problems that this project faced are how to create and manage a new database so that the client can access the information for their analyses. For this project, research was conducted in Cultural Resource Management, the use of GIS in archaeology, database designs, and suitability analysis.

2.1 Cultural Resource Management

Cultural Resource Management (CRM) is a process by which the protection and management of scarce elements of cultural heritage are given consideration in an ever changing modern world. Often equated with archaeology, CRM in fact should and does include a range of types of properties: "cultural landscapes, archaeological sites, historical records, social institutions, expressive cultures, old buildings, religious beliefs and practices, industrial heritage, folk life, artifacts and spiritual places" (King, 2002, p 1).

As part of federal legislation regulating cultural resources, Section 106 of the National Historic Preservation Act of 1966 (NHPA) requires consideration of impacts on cultural resources. In addition, state laws such as the California Environmental Quality Act (CEQA) and various municipal regulations have been established to protect cultural resources. Due to the details of these federal and state regulations, compliance with these statutes may appear puzzling and overwhelming for those who are not familiar with the detail of the laws guiding cultural resources management. Due to the need to simplify the process of identifying and protecting cultural resources, CRM companies were established to focus on providing cultural resources services for a diverse clientele ranging from federal agencies to individual homeowners. Cultural resource management services offered by many CRM companies consist of all phases of archaeological and historical investigations, including Native American consultation, historical and ethno-historical research, archaeological and historical building surveys, historic building evaluations, test phase excavations to determine significance of archaeological sites, mitigation/data recovery site excavations, and monitoring of earth moving/heavy equipment operations in sensitive areas for sub-surface archaeological sites.

2.2 GIS in Archaeology

Archaeologists have long been aware of the importance of the spatial component of the archaeological record. Highly precise maps and ground-plans date back to the 18th century, and some of the earliest formal excavations are notable for the meticulous way in which the locations of finds were recorded (Wheatley and Gillings 2002). Much of the data archaeologists recovered in the field are spatial by nature, or have an important spatial component. Over the last 40 years, the quality and volume of the spatial data that

archaeologists have collected have increased due to new surveying techniques, new equipment, and regulatory statues requiring historical and archaeological studies. Traditional tools such as plane-tables have been replaced with total stations and high-precision GPS units, which can measure and log thousands of locations in a short time.

Cartographic and spatial analysis software was first used in archaeological analyses during the 1970s and became more common in the 1980s. The most common use of GIS at the time was the potential for predictive modeling. This attracted many archaeologists, especially those who worked in the cultural resource management field. Requirements of cultural resource management often involve large geographic areas under conditions of development or exploitation, often where only small portions may have been previously surveyed. With much area unknown to the archaeologists charged with land management, predictive modeling was seen as an ideal tool (Wheatley and Gillings, 2002).

By the beginning of the 1990s, many archaeologists responsible for regional archaeological records were implementing GIS, such as in the archaeological information centers for various counties, and large cultural resource management organizations like the Arkansas State Archaeological Department, which adopted GIS as the basis for their site inventories. This trend continues today, where it is difficult to conceive a regional survey project that does not involve GIS in one way or another.

The most important aspect of GIS in archaeology lies not in its use as a pure map-making tool, but in its capability to merge and analyze different types of data in order to create new information. The use of GIS in archaeology has changed not only the way archaeologists acquire and visualize data, but also the way in which archaeologists think about space itself. GIS facilitates mapping to analyze depositional patterns as well as catalog and quantify artifacts. It can provide a well-structured descriptive and analytical tool for identifying spatial patterns.

2.3 Archaeological Databases

There is not a great deal of information on how to create databases exclusively for archaeology, but there is enough information to start to tackle this issue. During the research into archaeological databases, most of the literature discussing archaeology and GIS dealt with the analysis portion, not so much with creating and managing the data and the database scheme. One of the best views comes from Conolly and Lake (2006), “It is not our intention to discuss … the appropriate structure of a spatial database for managing the archaeological record, as these decisions are most appropriately made by government bodies and the archaeologists charged with the tasks of recording and managing the archaeological resource” (p.33).

Edward W. Tennant, on the other hand, looked into the database side of archaeology and GIS. According to Tennant (2007), the most important advantage for a database is how the data are structured. If the database structure is set up properly, then it can be used for more in-depth analysis. If the database is designed correctly, it then becomes what he calls “Living Documents” (p.12). The goal of a living document is to remain usable and useful after its initial creation. Tennant has been helping archaeologists interested in database management by creating tutorial videos and a database example on his website. The sample database that he provides is a great place to get ideas on how to design a database from the bottom up.

In his presentation during the 3rd annual GRASP Symposium, Merkel (2007) discussed the innovative benefit of developing an archaeological database for Sedgwick County. That project was the most similar to this project. As Merkel pointed out, "the first benefit realized from the project is the creation of a system for electronic record keeping of sites and surveys for the Wichita City Archaeology Office. Beyond this, the second, and perhaps most important, cutting edge benefit of the project is the foundation of a base for future expansion into the arena of statistical research and the subsequent predictive modeling of archaeological site distribution for effective cultural resource management. Modeling allows university students and professors, city, county, and state planners to study impact on finite cultural resources" (Merkel, 2007, p. 153).

The Mid-Pacific Regional Office of the U.S. Bureau of Reclamation has been in the process of collecting GIS data over the past ten years for its archeological sites. At the 2005 ESRI User Conference, Hansen and Simpson (2005) unveiled a model for the management of archaeological sites that they developed to serve as a management tool for archaeological data. It was not intended to store all the information associated with a site. The project they applied their model to was very similar to this project. Archaeologists and historians at CRM TECH, just like the staff archaeologists at the Bureau, want the archaeological data in a readily accessible format for analysis in addressing impacts that development can have on known and potential cultural resources. Figure 2-1 shows an example of archaeological data that was collected.

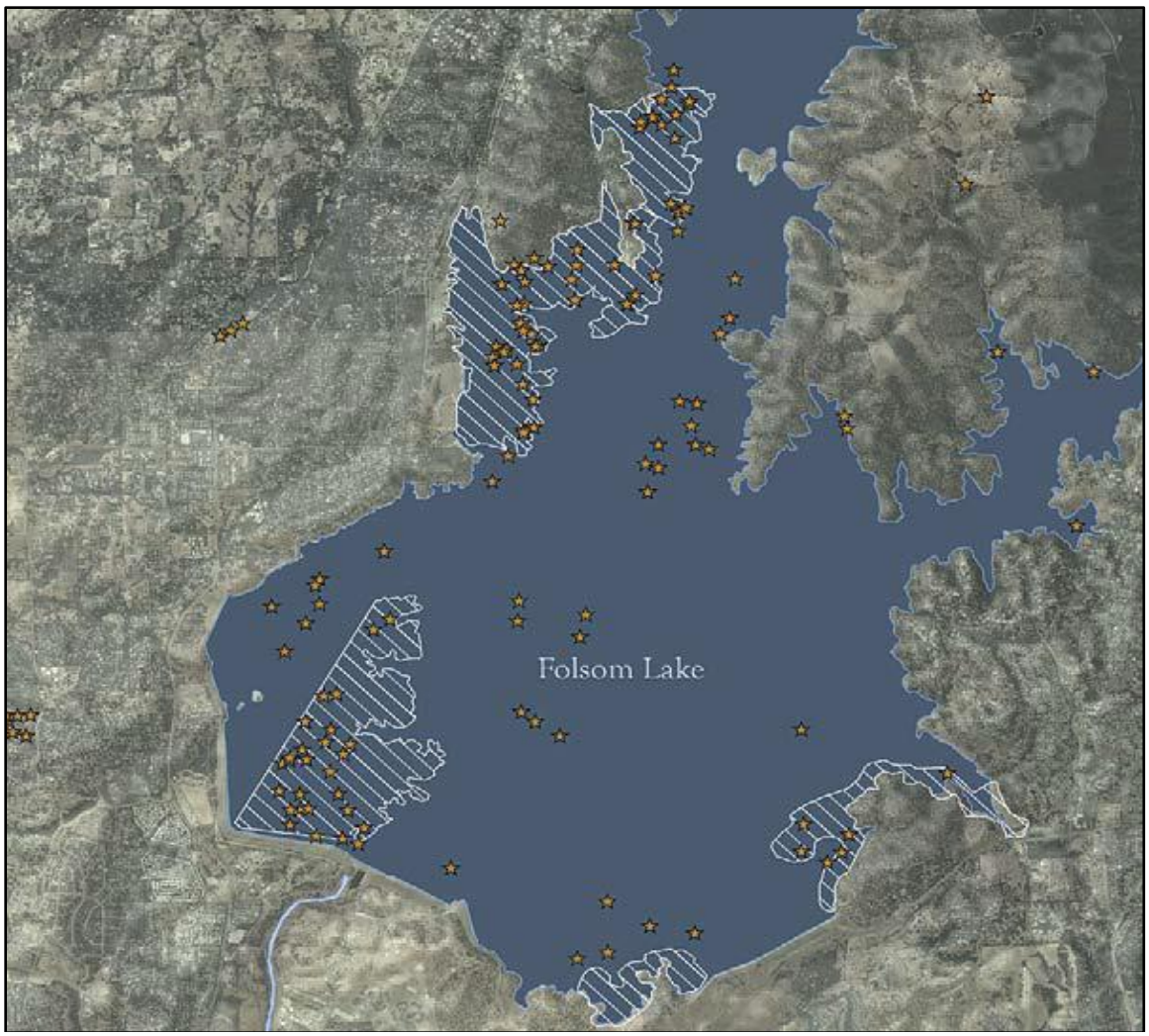

Figure 2-1: Archaeological Surveys (White Hatching) and Archaeology Sites (Orange Stars).

An advantage of using archaeological databases is that the data compiled can be analyzed from different points of view by changing retrieval conditions (Hochin et al., 2007). For example, by changing the retrieval conditions, the user can look at specific locations of artifacts within a site or examine artifacts located within a certain depths across the entire site.

There have been many projects in China where universities have tried to tackle the problems with an archaeological database. Some data models have been created to help archaeologists arrange data information into these new models. Based on their research and designs of data models and the needs of archaeology, Hong-dan and Qin-xia (2010), suggested an object-oriented data model to organize the spatial data.

2.4 Suitability Analysis

Suitability analysis is a GIS-based process for determining the fitness of a given area for a particular use. The basic premise of a GIS suitability analysis is to examine each aspect

of the landscape for characteristics that are in some degree either suitable or unsuitable for the activities being planned. Suitability is determined through systematic, multi-factor analysis of the different aspects of the terrain. Model inputs include a variety of physical, cultural, and economic factors (LaGro 2002). The suitability model answers the question, "where is the best location". For instance, a commercial developer building a new retail store may take into consideration distance to major highways and any competitors' stores, then combine the results with land use, population density, and consumer spending data to decide on the best location for that store (Kaiser, Godschalk, and Chapin, 1995).

Site suitability modeling in archaeology is useful for determining the environmental parameters for site placement, thereby exceeding chance or random factors. If one is able to predict which factors dictate a site's placement, then the salient questions are "Why did Prehistoric people choose a certain location? Which terrestrial qualities were considered most useful for placing a circle of stones necessary for holding a tipi in place?" (Cunningham 2008). The Cunningham paper examined patterns of site locations of Native American groups in North Dakota. Many sites were found on the valley floors close to water, gently sloping open terraces, and bluff tops. By looking for these variables, areas with high probability of finding new sites can be identified. Figure 2-2 is a map displaying site potential in an area in North Dakota.

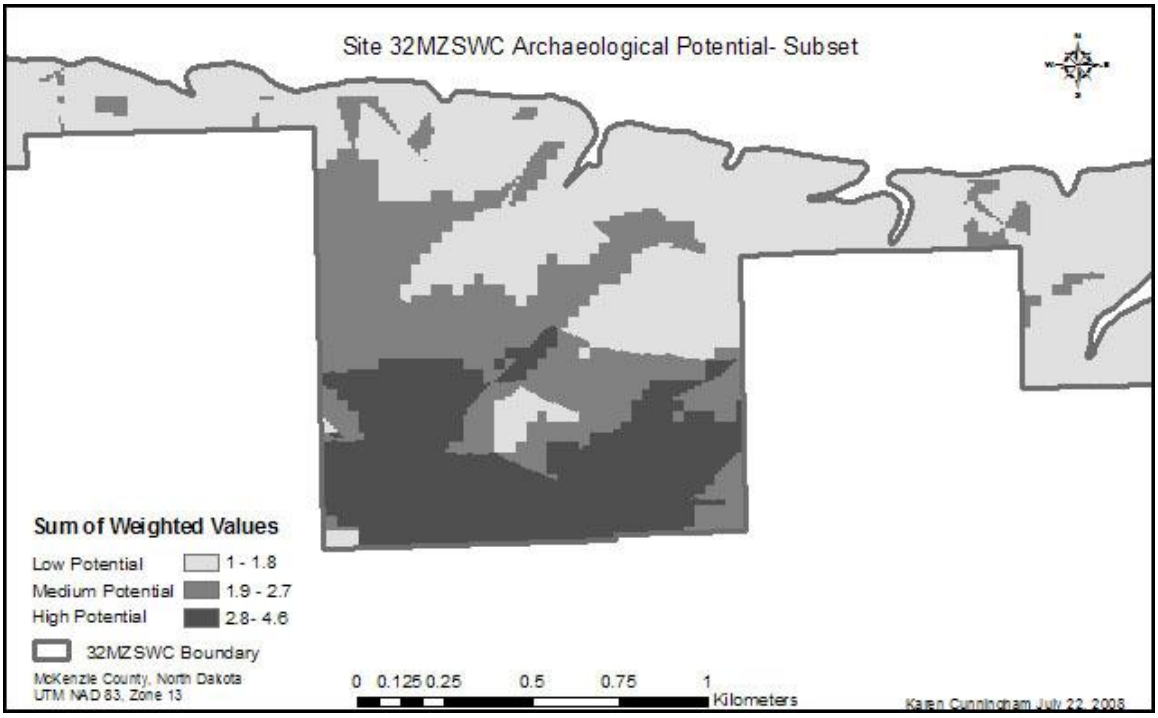

Figure 2-2: Zones of Site Potential for Sites.

In a second study performed by the University of North Carolina, Greensboro, and the University of Wyoming, with the help from the Armenia National Academy of Sciences, they were able to successfully use a site suitability model to identify 25 new Paleolithic sites in the Debed River Valley in Armenia. The variables that were used to help identify new sites came from the locations of previously located Paleolithic sites. "The variables most closely associated with site location were slope, aspect, elevation,

land cover, and proximity to river…. In general, the highest suitability scores were associated with areas located near rivers, with low slope and relatively open vegetation" (Nicholson, Egeland, and Gasparian, 2011, p. 34).

2.5 Summary

Overall, this chapter examines research in Cultural Resource Management, use of GIS in archaeology, archaeological databases, and using suitability analysis. The first section provided the reader with some basic background in CRM and uses of GIS in archaeology. The next section provided background on archaeological databases and reviews different projects that have been carried out in this area. The last section discussed the method of suitability analysis in order to find possible prehistoric sites using different variables.

Chapter 3 – Systems Analysis and Design

The success of a GIS project involves the understanding of the client's needs and the scope of a given project in order to implement an appropriate plan. A good project plan starts with a system design that meets the client's needs. Chapter 3 revisits the problem that this project is addressing. Next, it discusses three major components: the requirement analysis, system overview, and the development of the project plan. The requirement analysis describes the functional and non-functional requirements for the proposed GIS solution. The overview of the system design discusses the hardware and software needed for this project. Finally, the project plan captures the process to manage the tasks for this project.

3.1 Problem Statement

CRM TECH's system of collecting and storing data was in need of major upgrading. A GIS system had to be designed so that they could organize and access their data collection in a more efficient way. The data collection consisted of cultural resource information that had been gathered over the past 19 years.

3.2 Requirements Analysis

The requirements that must be addressed for the requirements analysis include functional and non-functional requirements. The functional requirements discuss what the primary function of the solution is−in this case, to create different types of visual maps for technical reports. These maps were created by using the database that had been generated using gathered cultural resources information. The non-functional requirements consist of the operational, technical, and transitional needs. The technical requirements included what types of hardware and software were needed for the solution to work properly. The project was designed to keep costs low for the client. The operational requirement relates what the system needed to keep it running properly. The final requirement deals with the transition of the solution to the client. This consisted of testing the database and training personnel who would use the system.

3.2.1 Functional Requirements

The users of this database− selected personnel from CRM TECH−were able to produce different types of maps for technical reports and proposals. They used data that had been imported into the database from record searches and data collected from the field with GPS units. The database was accessed through a single designated desktop computer due to the client having a single license. An enterprise system would be ideal to allow more than one user to access the database and be able to edit, but due to financial restrictions a single desktop was used. The maps completed included record search maps, site location maps, site maps, historical maps, analysis maps, and geologic maps. The user was able to complete these maps in the office using the developed system.

The project design took into consideration that most employees at CRM TECH did not have any previous GIS experience. Therefore, the workflow for the creation of

maps was simplified as much as possible. Custom tools were produced to help the user with limited experience to be able to add the required datasets to a map, create the buffering and clipping layers, and produce the final maps for the reports and site records. The functional requirements for the database are:

- The database must be able to store any type of cultural resource information that has been collected in the field or digitized in the office.
- The database must store the data consistently in order to allow data updates and edits.
- The database must be able to overlay multiple layers of data into a single, readable map in a semi-automated fashion.
- The database must allow efficient querying for information the user requires.
- The database must able to work with various mobile GPS devices.
- The database is limited to a desktop computer due to a single user license.

3.2.2 Technical Requirements

The technical requirements for this solution were relatively simple in comparison to what would be ideal. Since CRM TECH is a small company, their resources for hardware acquisition are somewhat limited due to the current economic climate. The hardware needed for this solution were a desktop computer, Trimble GeoExplorer XH or XT, and a color printer. The software needed were ArcGIS, Microsoft Office Suite, XTool pro software, and Adobe Photoshop.

While the desktop computer that was used for the solution surpassed the required specifications for the ArcGIS software, a computer with a large amount of RAM memory and speed would be helpful for quicker analysis. The computer hard drive has to be large enough to store large amounts of data. An external drive of at least a terabyte was ideal for storage. A large computer display was required so that a larger area can be seen when creating maps. The printers that were used for this solution were a HP color printer with a maximum size of 11 x 17 inches and a Sharp copier.

The main software used for this solution was ArcGIS 10 desktop; Microsoft Word and Excel were used for report creation and tables. Adobe Photoshop was used for editing the maps created in ArcGIS. The database is accessed through ArcMap or ArcCatalog, depending on what activity will be done. The map creation was done through the ArcMap interface. The interface was customized with only the necessary toolbars open for users to help simplify the process.

3.2.3 Operational Requirements

As time goes on, the database created for this project will need to be maintained, updated, and revised. This database was used for the organization of all spatial information that came into the office from record searches to field collection. Due to the lack of user experience–technical support will be needed to maintain the database. Either an experienced GIS technician or a user who has been trained can do the support. Help documents can be set up for users in case problems arise. The entire system should be set up with backup software and hard drives. Inexperienced users should not be allowed to troubleshoot the system.

3.2.4 Transitional Requirements

When this solution was completed and delivered to the client, it was tested thoroughly. The database was updated with new datasets, feature classes, and tables. Support documents were created to help the client with the transition. This solution is being maintained by an experienced GIS specialist for the time being. The specialist will be able to help with the transition by training the users in basic skills and map making, with training concentrated on how to create the basic maps needed for the technical reports. The non-functional requirements for the database are:

- Technical
  - The desktop computer must meet or surpass the required performance levels for the ArcIGIS software.
  - The hard drive must be large enough to store large amounts of data. An external drive of at least a terabyte would be ideal for storage and backup copy of database.
  - A large computer display will be required so that a larger area can be seen when creating maps; at least 22 inches would be ideal.
  - The system should have Windows 7 operating system environment.
  - A Trimble GeoExplorer XH or XT handheld GPS unit will be needed for collection of data in the field. The GPS unit must be able to check-out and check-in data collected in the field to the database.
  - The client's printers that will be used are HP Color Laser Jet 2550 and a Sharp MX-2601N copier.
  - The client's system should have the ArcGIS Desktop 10, Microsoft Office Suite, and Adobe Photoshop.
  - The user must be familiar with the software and hardware that will be used.
- Operational
  - The system will work with the data that is available from clients.
  - The system will work within the client's new organization standards.
  - The GIS Specialist will have the ability to edit and maintain the database.
  - The GIS Specialist should allow archiving the database daily or weekly.
  - Map templates will be created for the solution.
- Transitional
  - The database should be tested before delivery.
  - This solution should be maintained by an experienced GIS specialist
  - Training will be provided for the user in basic skills for using ArcGIS and map making.

3.3 System Design

The system was designed with simplicity in mind, so the database was created in a way that a user was able to access the information with ease. A number of datasets were created with information that was vital for the user when making different types of technical maps. After analysis of the client's requirements, it was decided that the raster images used for the maps would be kept on an external hard drive located outside of the

database. These images consist of both current and historic USGS maps and aerials images. Figure 3-1 shows the overall system diagram.

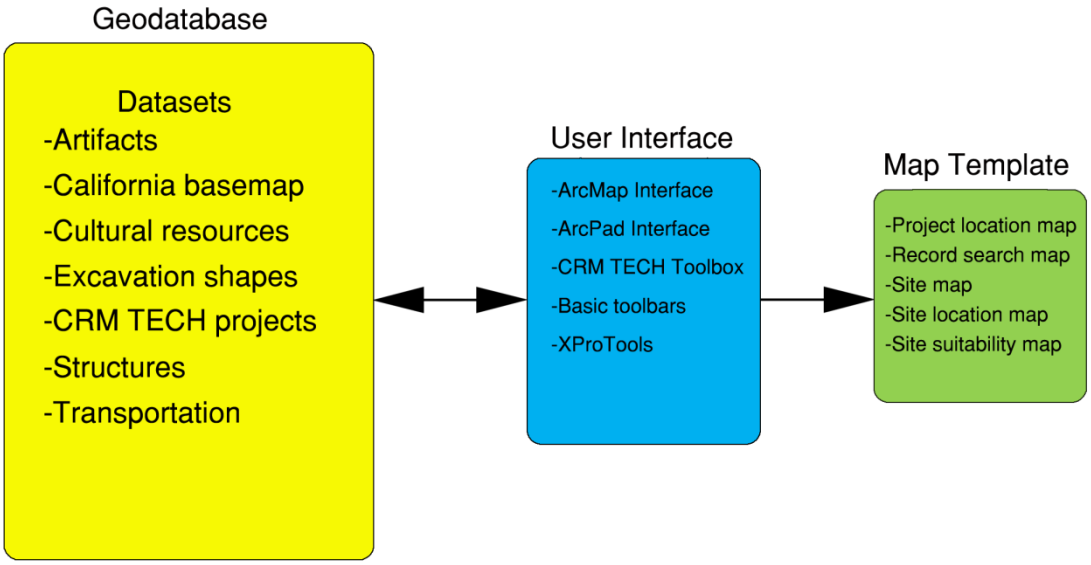

Figure 3-1: System Diagram

All tools required for a user to interact with the database were included in the user interface (UI) and within ArcToolbox. The UI portion of the system includes the basic ArcMap software interface, with the essential toolbars attached to the top of the screen. These toolbars will include, but not be limited to, Editor, Effects, Labeling, Layout, Standard, and Tools. The two geoprocessing tools that were created for this project will be located in the ArcToolbox under CRMTECH_Tools. Both tools were created using ModelBuilder. A map template and preset symbology were created for users in the final production of maps.

3.4 Project Plan

This section outlines a plan for accomplishing the goals and objectives of the project. Tasks are described chronologically, and estimated periods for completing these tasks are indicated. Note that many tasks occur concurrently. Figure 3-2 gives a graphic view of the proposed workflow as delineated in this work plan.

- Task 1: Planning (2 months)
  The planning phase for this project was to determine the needs of the client. The client's objectives were discussed in a series of interviews conducted at the client's office. From these meetings, an agreement was made about the client's specific needs.
- Task 2: Research (1 Month)
  As part of the proposal for this project, a literature review was completed. As the project moved forward, a more in-depth review was conducted. The types of

information that were looked into were sources dealing with building databases, geodesigns, and GIS used for archaeology. A review of different types of schemas that can be used for this database was conducted.

- Task 3: Design (1 Month)
  After the research was completed, the next task was to start the conceptual design of the database. A database diagram was created using the Microsoft Visio program. The diagram showed feature datasets, tables, feature classes, etc. Once the diagram was completed, the client reviewed the design for approval.
- Task 4: Database Development (2 Months)
  ArcCatalog software was used to create the file database for the project. During this entire process, the methodology was carefully documented. Data that the client has provided were imported into the database at the end of this task.
- Task 5: Creating tools (2 Months)
  With the database completed, user-friendly tools were created for non-GIS users. These tools were built using the model builder.
- Task 6: Testing(1 month)
  The functionality of the database was tested. The tools were found to be error free.
- Task 7: Completion of Project (2 Months)
  A finished database and tools were delivered to the client. A project paper was written up to explain the entire process for the project.

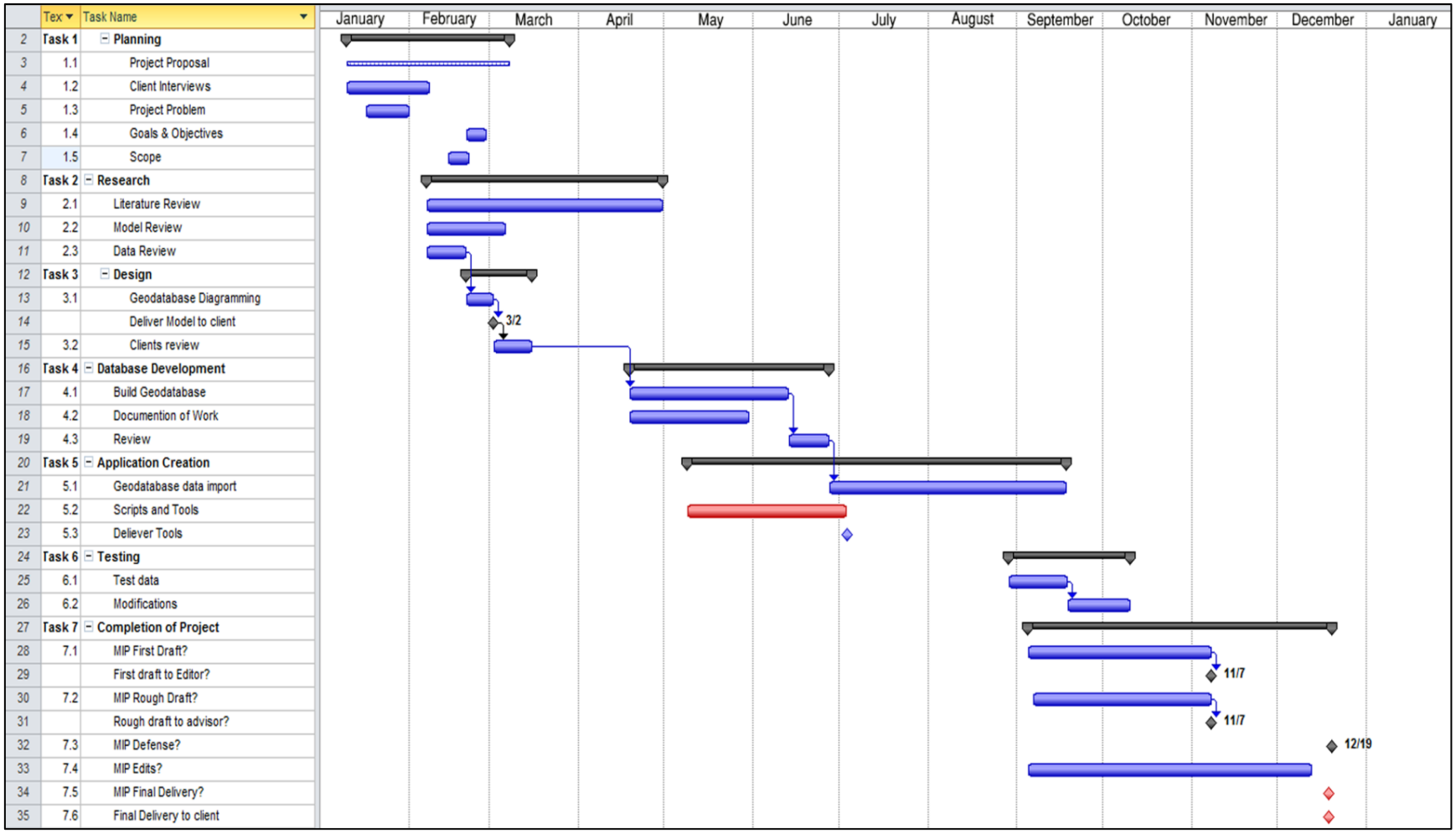

Figure 3-2: Project Schedule Gantt Chart (Original).

The project schedule unfortunately had to be revised in late September and early October of 2011 due to an unforeseen accident, which delayed the project several months. Task 7, completion of the project, was the portion of the schedule that was affected. The revised Gantt chart (Figure 3-3) shows that Task 7 was extended from late 2011 to July of 2013.

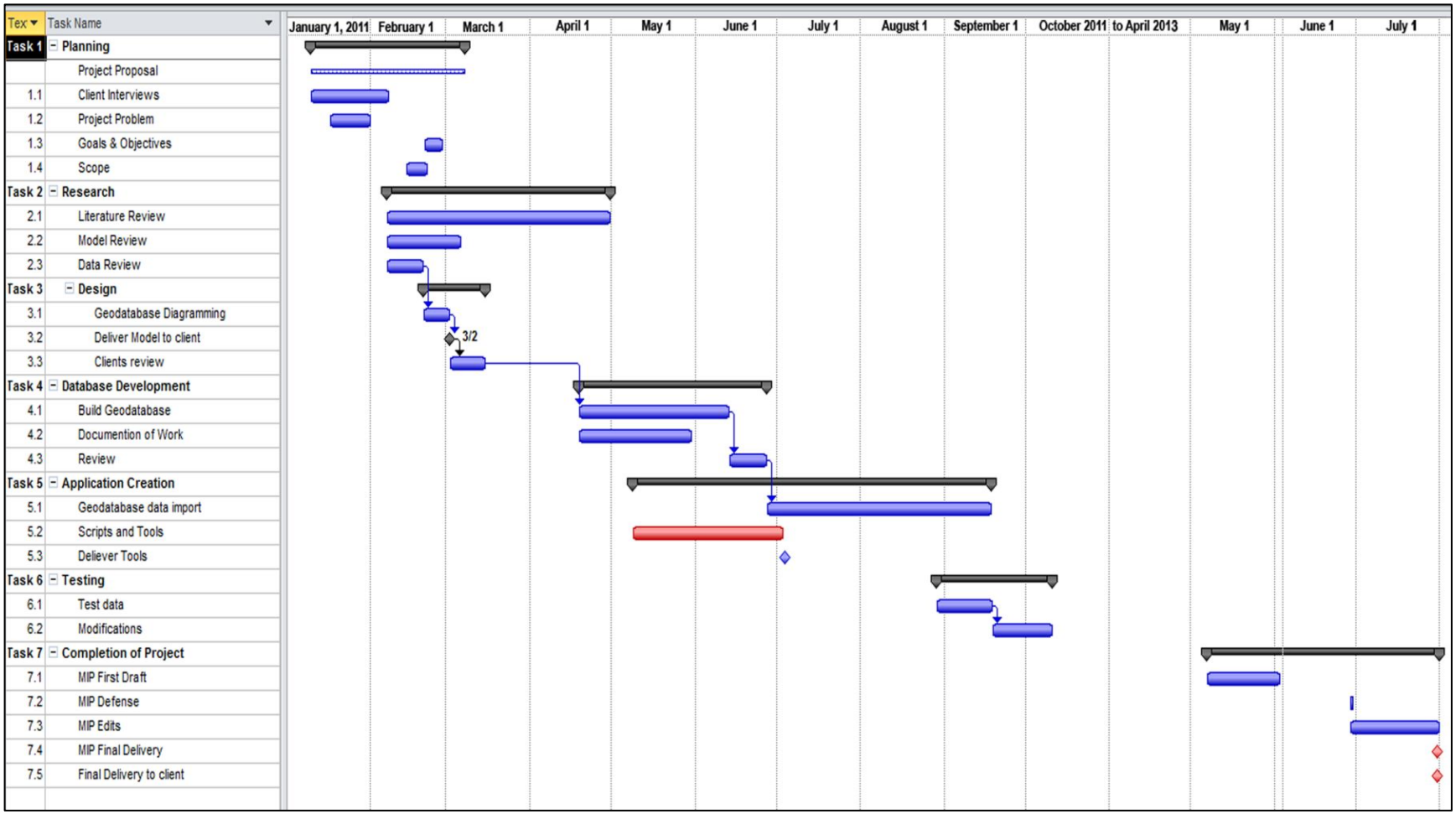

Figure 3-3: Project Schedule Gantt Chart (Revised).

3.5 Summary

The system analysis, design, and project plan were discussed in this chapter. The requirements analysis addressed the goals and objectives that this portion of the project was intended to accomplish. The analysis discussed both the functional and non-functional requirements, which entailed technical, operational, and transitional components. The overview of the system design discussed the hardware and software requirements to complete this project. The project plan showed the seven tasks needed for completing this project on time. An original project plan illustrated required tasks with their proposed milestones. The next chapter outlines the database design for the project.

Chapter 4 – Database Design

This chapter discusses the process of creating the conceptual and logical data models for the archaeological database. The database design is crucial because it helps to identify the data necessary for a project, explores the data relationships, and organizes the data as part of a workflow. During the design process of the database, several conceptual models were presented to the client for approval. Once the conceptual models were approved, a logical model was created. Data collecting, importing, and scrubbing, which is the prepping of data sets before loading into a database, took place after the logical model was designed.

4.1 Conceptual Data Model

A conceptual data model consists of the entities that address a particular project and their relationships. This conceptual model provides a layout of the components of the project, which includes data organization and a system workflow. In order to create the conceptual model, a few tasks were identified. These tasks included: identifying the data objects or entities, researching attributes associated with the object, and identifying the data relationships.

Creating an Archaeological Database was the main purpose of this project. The overall design of the database was fairly simple. The most basic elements of the database are the feature classes, which consist of point, line, and polygon features. The feature classes that share common similarities are then grouped together to form feature datasets. During the design for this database, seven datasets were identified: artifacts, cultural resources, features located in California, excavation methods, project areas, and types of structure and transportation features. There were two ways that the database could be accessed. The first is through the ArcMap interface and the second is through ArcCatalog interface. The different types of raster images that CRM TECH uses included aerial images and USGS Topographic maps. These maps were stored outside of the database in an external hard drive due to their storage size. CRM TECH does use several online basemaps that are accessed through the Environmental Systems Research Institute (ESRI) web page. The end products of the database are the maps that produced for the technical reports and for research purposes.

The Record Search Map (Figure 4-1) was one of the primary tasks for which the database was designed. A Record Search (RS) is conducted on all new projects that CRM TECH is awarded. A RS consists of searching all previous cultural studies that had been conducted in the vicinity of the project area, usually within a one-mile buffer. The cultural studies consist of survey reports, prehistoric and historic site records, and any other type of studies that have been conducted. A RS begins with preparation in the office, then a trip is made to the local Information Center (IC) for more up-to-date information. For the in-house portion of the RS, the user creates a new map showing the previous survey areas and the previously recorded prehistoric and historic sites that had been collected by CRM TECH. A geoprocessing tool, RS_Clippping_Tool, was created to automate this process. Once this map was completed, the next step was to conduct a RS at the appropriate IC to gather any new information. New information gathered at the IC was imported into the database, usually by digitizing the survey and site locations, and

adding the information into the feature class attribute table. Finally, the record search map was updated and inserted into the project report.

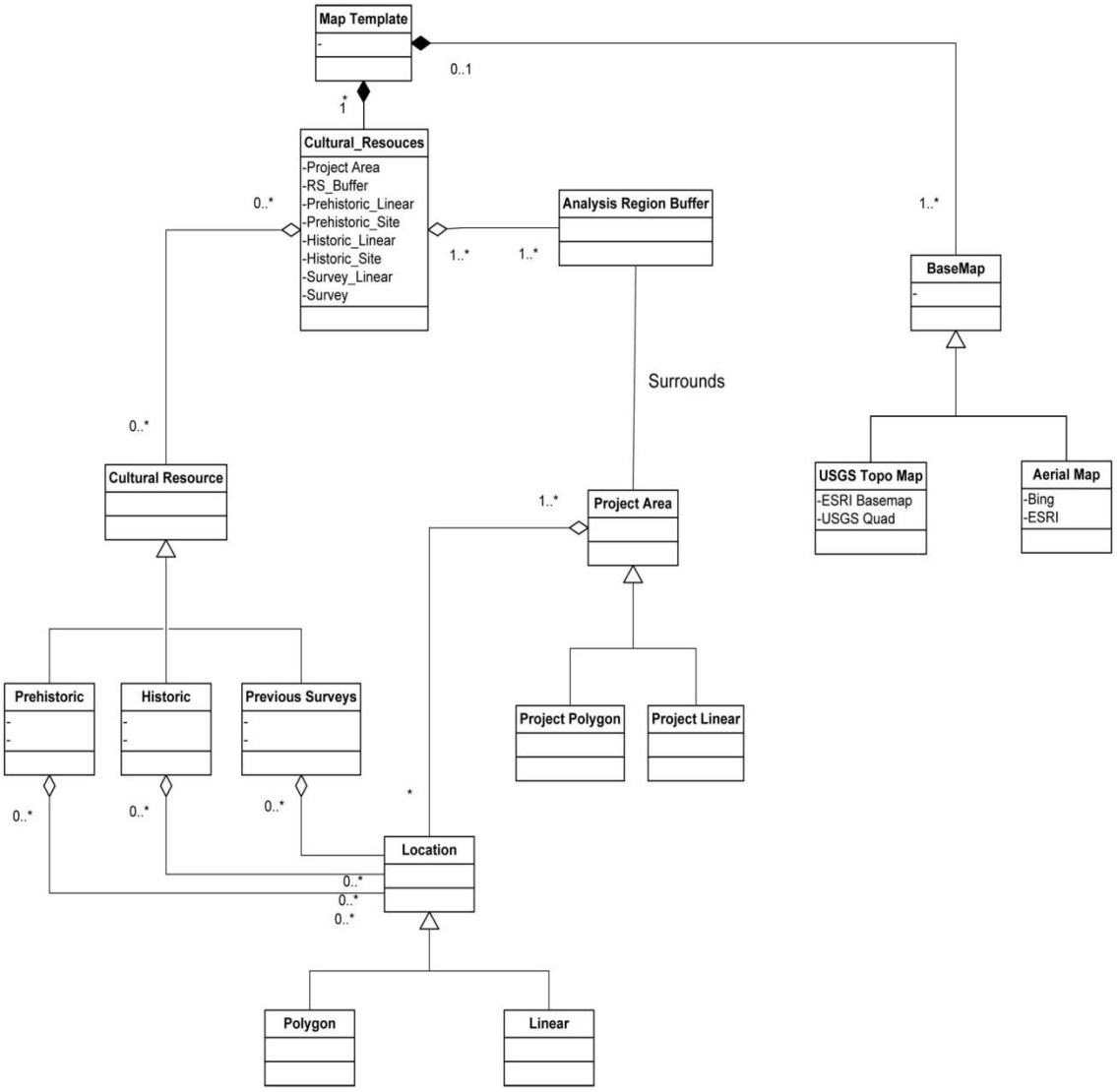

Figure 4-1: Record Search Map Conceptual Model.

Suitability analysis is a process of determining the fitness of a given area for a particular use. In archaeology, it is useful for determining the environmental parameters for site locations. A Site Suitability Map conceptual model is illustrated in Figure 4-2. The model uses three variables, distance to water, slope, and vegetation, to create the Weighted Overlay Image (WOI). Using the outcome of the WOI, along with the locations of known archaeological sites and project locations layers, a map was produced to show the possibility that a new prehistoric site might be found in or around the project area.

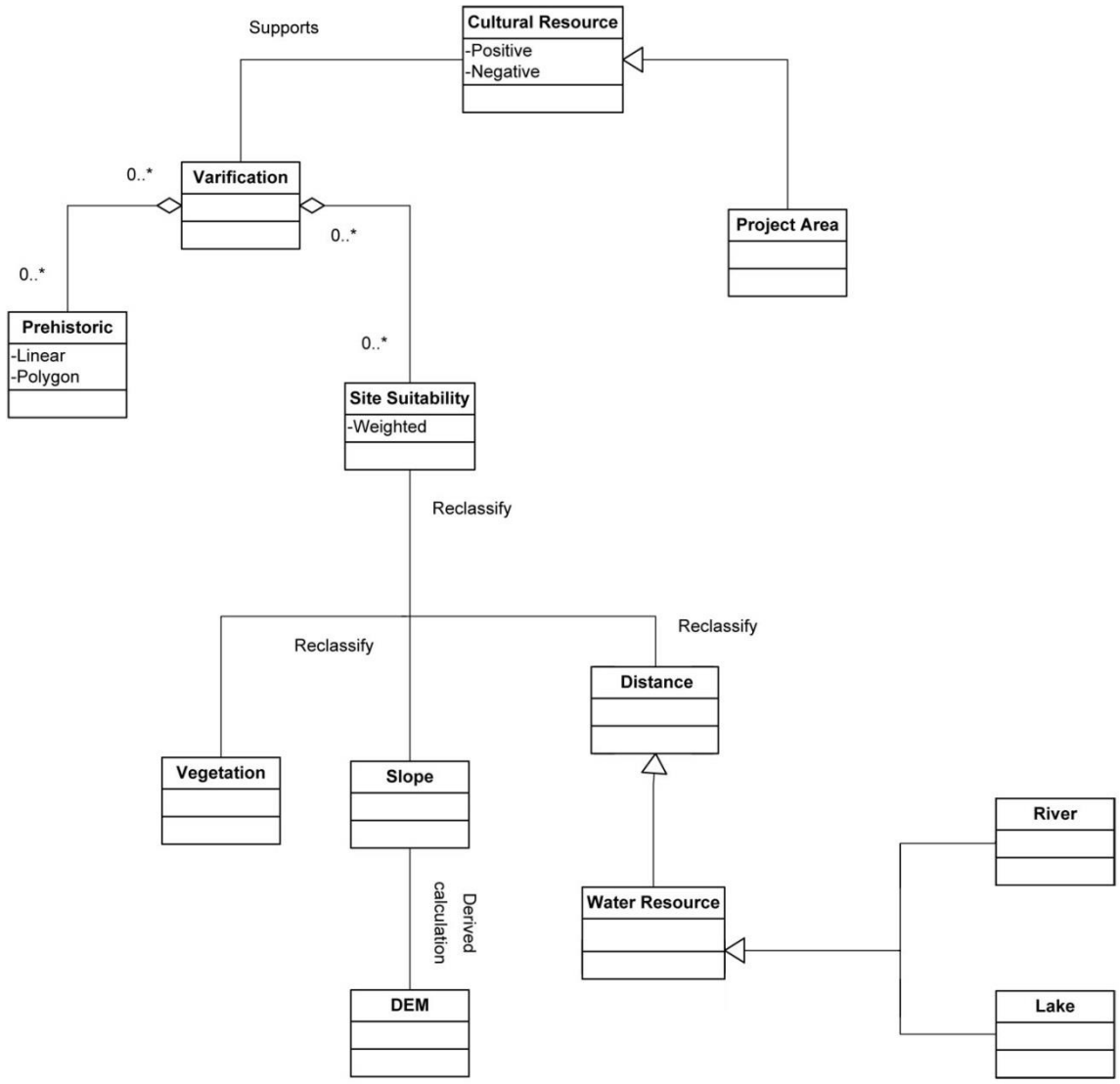

Figure 4-2: Suitability Map Conceptual Model.

4.2 Logical Data Model

A logical data model takes the concepts from the conceptual models and describes the features in a physical database. The logical data model was built in ArcGIS Desktop using ArcCatalog. The main objective of the model was the creation of a database to store cultural resource data. Because of the large amount of disk space that was required, a file database was chosen, rather than a personal database. A personal database can only contain two gigabytes of information, while the file database doesn't have a size limitation.

A database often contains multiple feature classes. The feature classes that have similar characteristics are grouped together in what are called feature datasets. At the end of this project, a total of 13 datasets were created, along with 39 domains for the archaeological database that was created. Within these 13 datasets, a total of 122 feature classes were used or created. Two database table files−Prehistoric_Sites_Table and Report_Table−were used to create a relationship with two feature classes located in the Cultural_Resources dataset. A single ArcToolbox called CRMTECH_Tools is located within the database. This toolbox holds the RS-Clipping_Tool and Site_Suitability_Tool created for this project. A more detailed picture of the Archaeological database is located in Appendix A. Figure 4-3 shows the entire database that was created for this project.

Contents | Preview | Description

Name	Type
Administration_Boundaries	File Geodatabase Feature Dataset
Ancient_Lake_Cahuilla	File Geodatabase Feature Dataset
Artifacts	File Geodatabase Feature Dataset
California_Basemap	File Geodatabase Feature Dataset
CRM_TECH_Projects	File Geodatabase Feature Dataset
Cultural_Resources	File Geodatabase Feature Dataset
Excavation_Shapes	File Geodatabase Feature Dataset
Hydro_Ca	File Geodatabase Feature Dataset
Parcel_Boundaries_Counties	File Geodatabase Feature Dataset
Rocks_and_Minerals	File Geodatabase Feature Dataset
Structures	File Geodatabase Feature Dataset
Transportation	File Geodatabase Feature Dataset
Vegetation	File Geodatabase Feature Dataset
CRMTECH_Tools	Toolbox
Prehistoric_Site_Relate	File Geodatabase Relationship Class
Prehistoric_Site_Table	File Geodatabase Table
Report_Table	File Geodatabase Table
Survey_Relate_TAble	File Geodatabase Relationship Class

Figure 4-3: The Archaeological Database.

The archaeological database was designed to be used in both the office environment for research and in the field for data collection. Of the 13 datasets that were created, four−Artifacts, Excavation_Shapes, Structures, and Transportation−were created for use in the field with mobile GPS units. Table 4-1 shows the four datasets and the feature classes associated with them. These datasets can be checked out and checked back into the database when field work is completed. Each of the feature classes in these datasets has attribute domains associated with it, so that the data can be easily collected in the field with reduced chance of error. A domain is a mechanism located within a database that enforces data integrity. Attribute domains define what values are allowed in a field within a feature class or nonspatial attribute table.

Table 4-1 Datasets Created for Use with Mobile GPS Units

Dataset	Feature Class	Description
Artifacts	Artifact_Line	To be used to record any type of linear feature.
	Artifact_Point	To be used to record any type of artifacts. (generic point)
	Artifact_Polygon	To be used to record any type of concentration and feature boundaries.
	Bead_Point	To be used to record any type of bead artifacts (stone or shell).
	Bedrock_Milling _Point	To be used to record bedrock milling features.
	Ceramic_Point	To be used to record ceramic artifacts.
	Datum_Point	To be used to record a site datum.
	FAR_Point	To be used to record any type of FAR artifacts.
	Groundstone_ Point	To be used to record any type of groundstone artifacts.
	Lithic_Core_ Point	To be used to record any type of lithic core artifacts.
	Lithic_Point	To be used to record any type of lithic artifacts.
	Projectile_Point _Point	To be used to record any type of projectile point artifacts.
	Site_Boundary_ Polygon	To be used to record the extent of the site boundary.
	Tool_Point	To be used to record any type of tool artifacts, not including points.
Excavation_ Shapes	Excavation_ Boring	To be used to record Borings excavated in the field.
	Excavation_STP	To be used to record STP's excavated in the field.
	Excavation_Tren ch	To be used to record Trenches excavated in the field.
	Excavation_Unit	To be used to record Units excavated in the field.
Structures	Strucrture_ Linear	To be used to record Linear structure features.
	Strucrture_Point	To be used to record Structure features.
	Strucrture_ Polygon	To be used to record Structure Features.
Transportation	Transportation_ Linear	To be used to record Linear transportation features.
	Transportation_ Point	To be used to record Transportation features.

The Artifact Dataset consists of 17 feature classes of different types of prehistoric artifacts and features that can be found in the field. An artifact topology rule was created within this dataset to make sure that certain polygons do not over-lap each other during field recording. For example, new site boundaries should never overlap each other. Figure 4-4 shows a portion of the attribute table for the Groundstone feature class, located within the artifact dataset. In the portion of the attribute table shown below, nine domains were created for this artifact feature class. Each type of artifact created within this dataset has several domains associated with them. The Excavation_Shape dataset was created for use when field excavations are being conducted. The dataset consists of four feature classes of different types of excavation methods. These methods include borings, Shovel Test Pits (STPs), Trenches, and Units. The last two datasets−Structures and Transportation−each consist of three feature classes that have similar attributes. These features classes are made up of a point feature, a line feature, and a polygon feature. These two datasets would be used for the recording of certain types of historical artifacts and features that deal with structures or transportation, such as roads, railroads, building foundations, buildings, and refuse (trash) scatters.

Site_ID	CRM_ID	Artifact_ID	Type	GS_Type	GS_Material	Art_Count	GS_Condition	GS_Surface	Collec_Methods
19-004288	2593-1	GS-1	Groundstone artifacts	Metate	Schist	1	Fragment	Polished	Trimble GeoExplorer XH (2005)
19-004288	2595-1	GS-2	Groundstone artifacts	metate frag	Schist	1	Fragment	Polished	Trimble GeoExplorer XH (2005)
19-004288	2593-1	GS-3	Groundstone artifacts	metate	Schist	1	Fragment	Polished	Trimble GeoExplorer XH (2005)
19-004288	2595-1	GS-4	Groundstone artifacts	Mano	Schist	Single	Complete	Polished	Trimble GeoExplorer XH (2005)
19-004288	2593-1	GS-5	Groundstone artifacts	metate	Schist	2	Fragment	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-1	Groundstone artifacts	Mano	Granitic	Single	Fragment	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-2	Groundstone artifacts	Metate	Granitic	Single	Fragment	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-3	Groundstone artifacts	Metate	Granitic	Single	Fragment	Exfiolated	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-8	Groundstone artifacts	Metate	Granitic	Single	Fragment	Exfiolated	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-7	Groundstone artifacts	Mano	Granitic	Single	Fragment	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-5	Groundstone artifacts	Metate	Granitic	Single	Fragment	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-4	Groundstone artifacts	Mano	Quartz	Single	Complete	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-6	Groundstone artifacts	Mano	Granitic	Single	Complete	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-28	Groundstone artifacts	Metate	Granitic	Single	Fragment	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-10	Groundstone artifacts	Mano	Granitic	Single	Complete	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-11	Groundstone artifacts	Metate	Granitic	Single	Fragment	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-32	Groundstone artifacts	Metate	Granitic	Single	Fragment	Polished	Trimble GeoExplorer XH (2005)
33-020292	2630	GS-12	Groundstone artifacts	Mano	Granitic	Single	Complete	Polished	Trimble GeoExplorer XH (2005)

Figure 4-4: A Portion of the Groundstone Attribute Table.

In the office, the most important datasets to be used are CRM_TECH_Projects and Cultural_Resources. The CRM_TECH_Projects datasets contain four feature classes that deal with both job proposals and current or past project locations. The two types of feature classes that were created for the CRM_TECH_Proposals and CRM_TECH_Projects are linear and polygon shapes. The linear feature classes are used when the project consists of a linear feature, for example pipelines, underground utilities, roads, and power line alignments. The polygon feature class is used for project locations that cover areas. The CRM_TECH Project attribute table shown below in Figure 4-5, details the type of information that is important for CRM TECH employees to know about current or old jobs. Two domains were created for the Project_Type and the Fieldwork_Type fields within these feature classes.

CRM_ID	CRM_Name	Project_Type	Project_Name
2499	Wintec NPS	Archaeology	Wintec Energy Projects
2503	DHS Line F	Archaeology	DHS Master Drainage Lines ...
2512	Baristo Museum	Archaeology	RFP #05-11; Agua Caliente Cultural Museum Road and Drainage Improvements
2524	Indio Bus Oasis	Bldg	College of the Desert Indio Education Center Project; APNs 611-211-002,
2381	Fire Station Ave 52nd	Mon	La Quinta Fire Station Project
2536	Harrison & 76	Archaeology	The Oasis Fire Station Project
2571	Palm Royale LQ	Archaeology	La Quinta Survey
2572	Coachella Crossing	Record Search	Indio Water Authority Canal Crossing
2575	Sinatra & 111 Intersection Improvement	Archaeology	Frank Sinatra and Highway 111 Intersection Improvement
2582	Desert Land Sands	Archaeology	Wind Sands I, Desert Land Ventures III
2581	Element Sands PS Intensive	Archaeology	Element Power US, LLC Wild Sands I Project
2484	Madison Conchita	Arch-Paleo	Tentative Tract Map 36403
2586	Coachella Montana	Archaeology	Vista Montana Apartments
2596	Sunlight Sites	Archaeology	Horn 4097 19.2 acres
2606	Cat City VW	Archaeology	Cathedral City Volkswagen Dealership
2607	Sunlight Test - Horn	Archaeology	Site CA-LAN-4288 Testing Horn Property
2614	Madison 50 to 52	Archaeology	Madison Street Improvement
2615	Thermal Club	Archaeology	Thermal Club
2470	St. Francis de Assi Church Mon	Arch Mon	St. Francis of Assi Parking Lot and Expansion
2624	Cat City Annex	Archaeology	Messenger SP/EIR (Messenger & Lazar and Marvin Family)
2597	Ramon Road Widen	CEQA and section 106	Ramon Road Widening Project
2647	DHS Mission Springs	CEQA	Mission Springs Water District Sewer Project AD-12 Area F Sewer
2658	76th Pierce Med	CEQA	Borrego Medical Expansion Project; Oasis; APN 755-162-010
2319	Airport Near Van Buren Archaeo	CEQA	84-155 56th Avenue; Thermal Kingdom Hall; Tentative Tract Map 33971
2330	COD WVC Arch	CEQA and section 106	The Planned Site of the College of the Desert West Valley campus
2388	Whitewater River and Garnet Addendum	NEPA	Mountain View IV Windfarm Access
2352	Arvin Multi Res	NEPA	Arvin 60-Unit Multi-Family Residential Project
2353	Harrison Polk Archaeo / Paleo Mon	Arch-Paleo	Mt. View Estates Farm Labor Housing Park; APNs 751-280-016 and -017
2369	Polk Filmore 66 Archaeo	CEQA and section 106	The Agua Azul Project; APN 749-320-002
2377	Pierce Community Paleo Mon	CEQA	San Jose Community & Bea Main Learning Center; 69-455 Pierce St
2395	Frederick & Mitchell Archaeo	CEQA and section 106	Rancho Las Flores Reservoir, Booster, and Pipeline

Client	Fieldwork_Type	Area	Date	GlobalID *
Wintec Energy, Ltd.	Field Survey	446.2583	12/17/2010	{9E3A3AA6-9E42-4A9
AMEC Earth and Environmental	Field Survey	25.51277	1/14/2011	{E74AE35F-DA8A-471
PMC	Field Survey	7.091552	11/29/2011	{E8571A56-589E-496E
Terra Nova Planning and Research, Inc.	Building	4.273701		{9325CC75-4ACD-416
City of La Quinta	Monitoring	4.918003	5/18/2011	{F9BAD318-106F-467
Krieger and Stewart	Field Survey	3.346498	6/16/2011	{DC16AE92-D753-429
Terra Nova (Nicole Criste)	Field Survey	7.465034	10/11/2011	{DAD3592C-9E1E-4AE
MSA for Bureau of Reclamation (BoR)	Field Survey	0.8135779	10/17/2011	{5A4E2D22-804F-470
Terra Nova Planning	Field Survey	26.54223	11/9/2011	{A28292C2-FB8A-496
Nici Boon, Desert Sands Venture	Field Survey	143.5066	12/13/2011	{D4C85785-79F4-46F
Element Power US	Field Survey	87.21124	12/13/2011	{29C70DF5-BE05-43B
Albert A. Webb Associates	Field Survey	8.43631	12/20/2011	{EC9D279E-088E-404
Chelsea Investment Corp	Field Survey	10.1753	1/3/2012	{9190ED27-4675-4EF1
Sunlight Partners	Field Survey	19.16935	2/21/2012	{04546568-0A57-4DA
Terra Nova (Nicole)	Field Survey	6.291374	4/11/2012	{0049F14F-07A9-4EF7
Sunlight Partners	Excavations	19.07272	2/21/2012	{394DEABE-769D-452
Albert Webb Associates	Field Survey	23.57574	5/14/2012	{0048F1B8-9F1F-4E43
	Monitoring	597.5317	5/14/2012	{520A9D4B-79DA-433
Orr Builders	Monitoring	7.378495		{512D5414-6860-4BA
MSA Consulting (Michelle W.)	Field Survey	669.4702	6/20/2012	{55D5A003-3B8B-4D9
John Criste (Terra Nova)	Field Survey with Building(s)	135.2335	8/13/2012	{59EB9349-8586-4FC
Tom Dodson & Associates	Archaeological Monitoring		9/10/2012	{91F2A544-198C-480
Borrego Community Health Foundation (Lenny Pepper)	Archaeo Field Survey	4.930553	10/24/2012	{83D9663E-CC15-4A1
Stoker Construction, Inc.	Archaeo-Paleo Survey			{C14E53C6-996E-4F42
Terra Nova Planning and Research, Inc.	Archaeo-Paleo Survey			{870FCE10-3F27-4CD
Mountain View Power Partner IV, LLC (AES Wind Generation, Inc.)	Archaeo Field Survey			{52A2B10A-FE24-45B

Figure 4-5: A Portion of the CRM_TECH Project Attribute Table.

The Cultural_Resources dataset shown in Table 4-2 contains the locations and data regarding cultural resources that CRM TECH has collected over the years through either field work or from record searches that they have conducted. The Cultural_Resources dataset consists of six feature classes made up of both linear and polygon shapes. These feature classes hold important information concerning sites, such as primary number assigned by a local IC, resource attribute, locational information, the hyperlink location for the site record document, date when the site was last recorded, and a short description. A single domain was created for the resource attribute codes for the Historic and Prehistoric feature classes. The Historic_Sites and Sites_Linear consist of resources that are historic in age, i.e. any sites older than 50 years of age and arrival of Euro-American groups. The Prehistoric_Sites and Sites_Linear consist of resources that are associated with Native American activities usually before contact. The Surveys_Previous and Surveys_Previous_Linear are feature classes that contain information on past cultural

resource studies that have been conducted on properties throughout Southern California. Some of these surveys are past jobs completed by CRM TECH.

Table 4-2 Cultural_Resources Dataset

Dataset	Feature Class	Description
Cultural_Resources Dataset	Historic_Sites	Consists of resources that are historic in age, i.e. older than 50 years of age.
	Historic_Sites_ Linear	Consists of resources that are historic in age, i.e. older than 50 years of age.
	Prehistoric_Sites	Consists of resources that are associated with Native American activities.
	Prehistoric_Sites_ Linear	Consists of resources that are associated with Native American activities.
	Suverys_Previous	Consists of information on past cultural resource studies.
	Suverys_Previous _Linear	Consists of information on past cultural resource studies, linear in nature.

The rest of the datasets within the database shown in Figure 4-6 are to be used for reference and research purposes. The Administration datasets contain feature classes of the California state boundary, country boundaries, land grant boundaries, Native American territories, and US Land Survey System boundaries. The Parcel_Boundaries_Counties dataset is made up of four feature classes dealing with parcels located in San Bernardino and Riverside County. The Lake Cahuilla datasets contains feature classes of the locations of geothermal activities, hot springs, inflows, river inflows, and the last high lake stand of ancient Lake Cahuilla. The Hydro_Ca datasets contain feature classes with the location information of major rivers, lakes, streams, and drainages in California. The rock and mineral dataset contains two feature classes with the types of minerals found throughout the state. The vegetation feature dataset contains two feature classes of vegetation found in the Salton Sea area and in Southern California. The California_Basemap dataset is made up of 63 feature classes of different features found throughout California. The base_map layer was created by ESRI and was modified to be used for the basemap for CRM TECH when producing technical maps for reports. New feature classes had been added and the original features classes have been clipped so only the data for California are used. Two image layers had been

Contents | Preview | Description

Name	Type
Administration_Boundaries	File Geodatabase Feature Dataset
Ancient_Lake_Cahuilla	File Geodatabase Feature Dataset
California_Basemap	File Geodatabase Feature Dataset
Hydro_Ca	File Geodatabase Feature Dataset
Parcel_Boundaries_Counties	File Geodatabase Feature Dataset
Rocks_and_Minerals	File Geodatabase Feature Dataset
Vegetation	File Geodatabase Feature Dataset

Figure 4-6: Datasets used for Reference and Research Purposes.

added to the Califonia_Basemap layer, so the user can either use aerial images or the USGS topographic maps.

4.3 Data Sources

The client, CRM TECH, provided a large amount of data for this project, including MS Excel files, aerial images, topographic maps, PDF files, and shapefiles. The shapefiles consisted of locations of cultural resources, project locations, and survey locations. Other data that were used for this project came from online sources from ESRI, USGS, San Bernardino County, Riverside County, and from the State of California.

The shapefiles that were provided for the project were created at CRM TECH within the last year. The shapefiles were created by digitizing the locations of sites, surveys, and project locations as recorded on USGS maps. This process involved georeferencing USGS maps in ArcMap. Once a USGS Quad map was georeferenced into the project coordinate system, the CRM TECH employee manually digitized the locations of the cultural resources into the correct feature classes. This process was supervised by the GIS specialist at CRM TECH.

4.4 Data Collection Methods

In order to complete one of the objectives for this project, data collection was needed in the field to test the flexibility of the database. The archaeological database, as stated before, is designed to be used in both the office and in the field. During a few projects conducted by CRM TECH, portions of the archaeological database were checked out to mobile GPS devices for testing. The two devices that were used during the testing phase are a Trimble GeoExplorer XH 2005 Series and a GeoExplorer 2008 XT Series handheld GPS device. The testing was conducted on three projects located within the Coachella Valley. The three projects that were chosen for the testing phase represent the different types of field work that are normally done by CRM TECH. The first project was a field survey, the second project was an excavation, and third project was a monitoring job that consisted of earth-moving activities.

4.5 Data Scrubbing and Loading

A small portion of the project consisted of the preparation of data for loading into the database. The main reasons for data scrubbing and loading of the data were to organize the data in the database, to make sure they were in the correct coordinate system, and to delete repeated data from some of the shape files. A few of the feature classes were newly created and have no data. They were later populated by data gathered from the field. The data provided by CRM TECH required little editing prior to be loaded into the database. The reason for this was that the cultural resources shapefiles were created with the attributes and fields that were the same as the existing project. The coordinate system for these shapefiles was the same as the one used in the database (NAD_1983_UTM_Zone_11N). Some digitizing was needed for some of the prehistoric and historic sites and for some of the previous survey locations. This was done by loading a USGS quad map with site locations into ArcMap, georeferencing the quad map to its correct location, and then digitizing the site boundary shapes off the map into the correct feature class.

Some of the feature classes that were used for this database were collected from different online sources. Some of these feature classes were converted to the correct coordinate system and some of the fields in their attribute tables were deleted because the information was repeated or obsolete for CRM TECH's purposes.

4.6 Summary

In this chapter, the database's conceptual and logical models were discussed, along with the data sources, collection methods, scrubbing, and loading. A conceptual model was represented with UML diagrams that express the entities used in this project and their interaction. The logical model represents the data structures that were used in the database. The chapter concluded with the description of data sources, data collection, and loading into the database.

Chapter 5 – Implementation

Chapter Five discusses the implementation of the archaeological database and the tools that were created for it. By implementing the GIS archaeological database, CRM TECH can start to incorporate GIS into their daily activities. They would be able to use it for project proposals, record searches, creating maps for reports, research done before and after fieldwork is carried out, and analyses of data recorded in the field.

5.1 Archaeological Database

The archaeological database was produced using ArcCatalog software. This process involves creating the database, creating the individual feature classes and feature datasets, defining domains, and assigning domain values to attribute fields within each feature class. Importing other data such as shapefiles and excel files took place after the database was created. The type of database that was chosen for this project was the file database.

Once the file database was created and named, the next step was to create feature classes and import them into the database. The feature classes for this project were created as shapefiles. After several discussions with the client about what type of information would be most useful in the attribute tables, work began on creating the cultural resource feature classes. The prehistoric and historic feature classes were created using the same fields within their attribute tables. The reason for this is that both prehistoric and historic sites use the same primary site record document−Form DPR 523−for recording and submission to the appropriate Information Centers shown in Figure 5-1.

State of California--The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # _____
HRI # _____
Trinomial _____
NRHP Status Code _____
Other Listings _____
Review Code Reviewer Date

Page 1 of 6 *Resource Name or # (Assigned by recorder) CRM TECH 2161-1

P1. Other Identifier: _____
*P2. Location: √ Not for Publication ____ Unrestricted *a. County Riverside County
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
*b. USGS 7.5' Quad Riverside East, Calif. Date 1967/1980
T3S; R 4W; NW 1/4 of NW 1/4 of SE 1/4 of NW 1/4 of Sec 4 ; S.B. B.M.
Elevation: Approximately 1601 feet above mean sea level
c. Address N/A City _____ Zip _____
d. UTM: (Give more than one for large and/or linear resources) Zone 11S; 471,761 mE/ 3,755,559 mN
UTM Derivation: ___ USGS Quad √ GPS (NAD 27)
e. Other Locational Data: (e.g., parcel #, directions to resource, etc., as appropriate) This site is located about 2224 feet west of Sycamore Canyon Boulevard and about 3795 feet north of Eastridge.

*P3a. Description: (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries) The site consists of two granite boulder with two bedrock milling slicks located on the surface of each of the boulders. The boulder for Feature 1 measures about 3.4 x 2.6 m in size. Slick 1 measures 25 x 23 cm in size with no depth. The second slick measures about 17 x 15 cm in size and is has its high points polished. Feature 2 is a single bedrock boulder with two milling slicks. The boulder measures 5.3 x 3.1 m in size. Slick 1 measures 20 x 18 cm in size and Slick 2 measures 26 x 18 cm in size.

*P3b. Resource Attributes: (List attributes and codes) AP4: Bedrock milling feature
*P4. Resources Present: ____ Building ____ Structure ____ Object √ Site ____ District ____ Element of District
Isolate Other
P5a. Photograph or Drawing (Photograph required for buildings, structures, and objects.)
P5b. Description of Photo: (view, date, accession #) _____
*P6. Date Constructed/Age and Sources: ___ Historic √ Prehistoric ____ Both _____
*P7. Owner and Address: Unknown
*P8. Recorded by: (Name, affiliation, and address) Daniel Ballester, CRM TECH, 1016 E. Cooley Drive, Suite A/B, Colton, CA 92324
*P9. Date Recorded: November 9, 2007
*P10. Survey Type: (Describe) Intensive-level survey for CEQA-compliance purpose
*P11. Report Citation: (Cite survey report and other sources, or enter "none") Forthcoming

*Attachments: __ None √ Location Map √ Sketch Map __ Continuation Sheet __ Building, Structure, and Object Record
√ Archaeological Record __ District Record ___ Linear Resource Record __ Milling Station Record ___ Rock Art Record
__ Artifact Record __ Photograph Record __ Other (List):

DPR 523A (1/95) *Required information

Figure 5-1: A Primary Record Form used for Recording Cultural Sites.

The fields within the attribute tables of the historic and prehistoric feature classes have some of the basic information found on page one of the DPR form. Table 5-1 shows the fields that were created within the attribute table. Four feature classes were made for

the prehistoric and historic sites, two line feature classes, and two polygon feature classes.

Table 5-1 Attribute Table for Prehistoric and Historic Feature Classes

Attribute field	Description of Each Field
CRM_ID	Project number assigned by CRM TECH.
Primary_Number	Site number assigned by the Information Center.
Trinomial	The secondary number assigned by the Information Center
Resource	Resource attribute for the record cultural site
USGS_Quad	The name of the USGS Quad map where the site is located.
Section	The section number where the site is located.
Township	The Township number where the site is located.
Range	The Range number where the site is located.
APN	The parcel number for the property containing the site.
Hyperlink	The location where the PDF document is stored at on the computer.
Date	The date when the site was recorded or the last time the site was updated.
Description	A short summary of the site components.

These fields are to be filled out when adding a new prehistoric or historic site into the feature class. The fields required for these feature classes are the primary number and the trinomial. After these four feature classes were created, data were imported by digitizing the location of the site using ArcMap. Once the shape of an individual site was created, the rest of the site information was completed by entering the information from the site record documents. Figure 5-2 shows an example of feature records for Prehistoric sites.

CRM_ID *	Primary_Number *	Trinomial	Resource	USGS_Quad	Section
686	33-011114	CA-RIV-6880	AP2: Lithic scatter	La Quinta	33
686	33-011115	CA-RIV-6681	AP2: Lithic scatter	La Quinta	33
686	33-011116	CA-RIV-6682	AP3: Ceramic scatter	La Quinta	33
686	33-011117	CA-RIv-6683	AP3: Ceramic scatter	La Quinta	33
686	33-011118	CA-RIV-6684	AP2: Lithic scatter	La Quinta	33

Township	Range	APN	Hyperlink	Date	Description
5S	7E		Riverside_County\33-11114 RIV-6680.pdf	9/20/2001	AP3, AP16: clay, bone
5S	7E		Riverside_County\33-11115 RIV-6681.pdf	9/20/2001	AP3, AP16: clay, bone
5S	7E		Riverside_County\33-11116 RIV-6682.pdf	9/20/2001	AP16: clay, bone
5S	7E		Riverside_County\33-11117 RIV-6683.pdf	9/20/2001	AP16: Clay
5S	7E		Riverside_County\33-11118 RIV-6684.pdf	9/20/2001	AP3, AP16: clay

Figure 5-2: A Portion of the Attribute Table for Prehistoric_Sites.

A single domain was created for the Resource Attribute field in ArcCatalog. The domain that was created for this field was called Res-att_cds (Resource attribute codes). A code was created along with its description as shown in Figure 5-3. Once the domain was created, it could be connected to the correct field within the feature class.

Coded value domain
Res-att_cds

Description	Resource Attrribute
Field type	Codes
Split policy	String
Merge policy	Default value

Code	Description
HP1	Unknown
HP2	Single family property
HP3	Multiple family property
HP4	Ancillary building
HP5	Hotel/Motel
HP6	1-3 story commerical building
HP7	3+ story commerical building
HP8	Industrial building
HP9	Public utility building
HP10	Theater
HP11	Engineering structure
HP12	Civic auditorium
HP13	Community center
HP14	Govermenr building
HP15	Education building
HP16	Religious building
HP17	Railroad depot
HP18	Train
HP19	Bridge
HP20	Canal/aqueduct
HP21	Dam
HP22	Lake/river/reservoir
HP23	Ship
HP24	Lighthouse
HP25	Amusement park
HP26	Monument/mural/gravestone
HP27	Folk art
HP28	Street furniture
HP29	Landscape architecture
HP30	Trees/vegetation
HP31	Urban open space
HP32	Rural open space
HP33	Farm/ranch
HP34	Military property
HP35	CCC/WPA property
HP36	Ethnic minority property (list group)
HP37	Highway/trail
HP38	Women's property
HP39	Other
HP40	Cemetery
HP41	Hospital
HP42	Stadium/ sports arena
HP43	Mine structure/ building
HP44	Adobe building/ structure
HP45	Unreinforced masonry building
HP46	Walls/ gate/ fences
AH1	Unknown
AH2	Foundations/ structure pads
AH3	Landscaping/ orchard
AH4	Privies/ dump/ trash scatter
AH5	Wells/ cinterns
AH6	Water conveyance system
AH7	Roads/ trails/ railroad grades
AH8	Dams
AH9	Mines/ quarries/ tailings
AH10	Machinery
AH11	Walls/ fence
AH12	Graves/ cemetery
AH13	Wharfs
AH14	Ships/ barge
AH15	Standing structures
AH16	Other
AP1	Unknown
AP2	Lithic scatter
AP3	Ceramic scatter
AP4	Bedrock-milling feature
AP5	Petroglyphs
AP6	Pictographs
AP7	Architectual feature
AP8	Cairns/ rock feature
AP9	Burials
AP10	Caches
AP11	Hearth/ pits
AP12	Quarry
AP13	Trails/ linear earthworks
AP14	Rock shelter
AP15	Habitation debris
AP16	Other

Figure 5-3: Coded Value and Description for Res-att_cds Domain.

Two feature classes were created to represent surveys conducted in the past Previous_Surveys_Linear and Previous_Surveys. The attribute tables for these two feature classes are the same. Two features were created because they need to be symbolized on a map differently. The Previous_Surveys_Linear feature class records linear surveys, such as roads, pipelines, transmission lines, or utility lines, while the Previous_Surveys feature class records field surveys that are non-linear and cover larger areas. The fields for the attribute tables are shown in Table 5-2.

Table 5-2 Attribute Table for Previous_Surveys and Previous_Surveys_Linear Feature Classes

Attribute field	Description of each field
CRM_ID	Project number assigned by CRM TECH, if the survey was a past project.
NADB	National Archaeological Database ID number.
RI_IC	Riverside County Information report number.
Report_Num	Report number assigned by company conducting the survey.
Title	The name of the report.
Preparer	The name of the report writers.
Company	The name of the company that conducted the survey.
City	The city where the survey was conducted.
Hyperlink	The location where the PDF document is stored on the computer.
Date	The date when the site was recorded or the last time the site was updated.

When a new survey is added to the feature class, these are the ten fields that will be used to record information. Unfortunately, some of these fields do not always get filled due to missing information. The most important fields that have to be recorded are the NADB and the RI_IC fields (Riverside County). After the two feature classes were created, data were imported by digitizing the location of the previous surveys known by CRM TECH using ArcMap. Once the geometry of an individual survey was created, the rest of the table was completed by recording the information from the survey report documents. Figure 5-4 shows a portion of the attribute table for Previous-Surveys.

CRM_ID	CRM_Name	Project_Type	Project_Name
2499	Wintec NPS	Archaeology	Wintec Energy Projects
2503	DHS Line F	Archaeology	DHS Master Drainage Lines ...
2512	Baristo Museum	Archaeology	RFP #05-11; Agua Caliente Cultural Museum Road and Drainage Improve
2524	Indio Bus Oasis	Bldg	College of the Desert Indio Education Center Project; APNs 611-211-002,
2381	Fire Station Ave 52nd	Mon	La Quinta Fire Station Project
2536	Harrison & 76	Archaeology	The Oasis Fire Station Project
2571	Palm Royale LQ	Archaeology	La Quinta Survey
2572	Coachella Crossing	Record Search	Indio Water Authority Canal Crossing
2575	Sinatra & 111 Intersection Improvement	Archaeology	Frank Sinatra and Highway 111 Intersection Improvement
2582	Desert Land Sands	Archaeology	Wind Sands I, Desert Land Ventures III
2581	Element Sands PS Intensive	Archaeology	Element Power US, LLC Wild Sands I Project
2484	Madison Conchita	Arch-Paleo	Tentative Tract Map 36403
2586	Coachella Montana	Archaeology	Vista Montana Apartments
2596	Sunlight Sites	Archaeology	Horn 4097 19.2 acres
2606	Cat City VW	Archaeology	Cathedral City Volkswagen Dealership
2607	Sunlight Test - Horn	Archaeology	Site CA-LAN-4288 Testing Horn Property
2614	Madison 50 to 52	Archaeology	Madison Street Improvement
2615	Thermal Club	Archaeology	Thermal Club
2470	St. Francis de Assi Church Mon	Arch Mon	St. Francis of Assi Parking Lot and Expansion
2624	Cat City Annex	Archaeology	Messenger SP/EIR (Messenger & Lazar and Marvin Family)
2597	Ramon Road Widen	CEQA and section 106	Ramon Road Widening Project

Client	Fieldwork_Type	Area	Date	SHAPE *
Wintec Energy, Ltd.	Field Survey	446.2583	12/17/2010	Polygon
AMEC Earth and Environmental	Field Survey	25.51277	1/14/2011	Polygon
PMC	Field Survey	7.091552	11/29/2011	Polygon
Terra Nova Planning and Research, Inc.	Building	4.273701		Polygon
City of La Quinta	Monitoring	4.918003	5/18/2011	Polygon
Krieger and Stewart	Field Survey	3.346498	6/16/2011	Polygon
Terra Nova (Nicole Criste)	Field Survey	7.465034	10/11/2011	Polygon
MSA for Bureau of Reclamation (BoR)	Field Survey	0.8135779	10/17/2011	Polygon
Terra Nova Planning	Field Survey	26.54223	11/9/2011	Polygon
Nici Boon, Desert Sands Venture	Field Survey	143.5066	12/13/2011	Polygon
Element Power US	Field Survey	87.21124	12/13/2011	Polygon
Albert A. Webb Associates	Field Survey	8.43631	12/20/2011	Polygon
Chelsea Investment Corp	Field Survey	10.1753	1/3/2012	Polygon
Sunlight Partners	Field Survey	19.16935	2/21/2012	Polygon
Terra Nova (Nicole)	Field Survey	6.291374	4/11/2012	Polygon
Sunlight Partners	Excavations	19.07272	2/21/2012	Polygon

Figure 5-4: A Portion of the Attribute Table for the Feature Previous_Surveys.

The rest of the datasets within the database were created in a similar fashion. The client had input as to what type of information would be needed in each of the tables for the feature classes. The artifact dataset required the creation of a total of 14 feature classes, as shown in Figure 5-5. An artifact topology was also created in this feature dataset in order to avoid certain feature classes overlapping each other.. A total of 28 domains were created for the different types of artifacts in the dataset. These domains dealt with the different characteristics of specific types of artifacts.

Name	Type
Artifact_Line	File Geodatabase Feature Class
Artifact_Point	File Geodatabase Feature Class
Artifact_Polygon	File Geodatabase Feature Class
Artifacts_Topology	File Geodatabase Topology
Bead_Point	File Geodatabase Feature Class
Bedrock_Milling_Point	File Geodatabase Feature Class
Ceramic_Point	File Geodatabase Feature Class
Datun_Point	File Geodatabase Feature Class
FAR_Point	File Geodatabase Feature Class
Groundstone_Point	File Geodatabase Feature Class
Lithic_Core_Point	File Geodatabase Feature Class
Lithic_Point	File Geodatabase Feature Class
Projectile_Point_Point	File Geodatabase Feature Class
Site_Boundaries_Polygon	File Geodatabase Feature Class
Tool_Point	File Geodatabase Feature Class

Figure 5-5: Feature Classes Within the Artifact Dataset.

5.2 Customized Tools Using ModelBuilder

ModelBuilder is an application found in ArcGIS that can be used to create, edit, and manage models. Models are workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another tool as input. Both tools created for the archaeological database−the RS_Clipping_Tool and Site Suitability_Tool−were created using ModelBuilder (Figure5-6). ModelBuilder also provides a user-friendly interface which enables a user to sidestep code-writing. To create the tools in ModelBuilder, simply drag the geoprocessing tool that needs to be done into the ModelBuilder window along with its input and outputs.

Name	Type
RS_Clipping_Tool	Toolbox Tool
Site_Suitiablity	Toolbox Tool

Figure 5-6: Tools Created in ModelBuilder.

5.2.1 RS_Clipping_Tool

The first tool created for the users of the Archaeological database was the RS_Clipping_Tool., which strings together two geoprocessing tools−the buffer and the clipping tool−to create seven new shapefiles. This tool was created to help automate the process for creating a Record Search Map. Figure 5-7 illustrates the data and process that were used to build the tool.

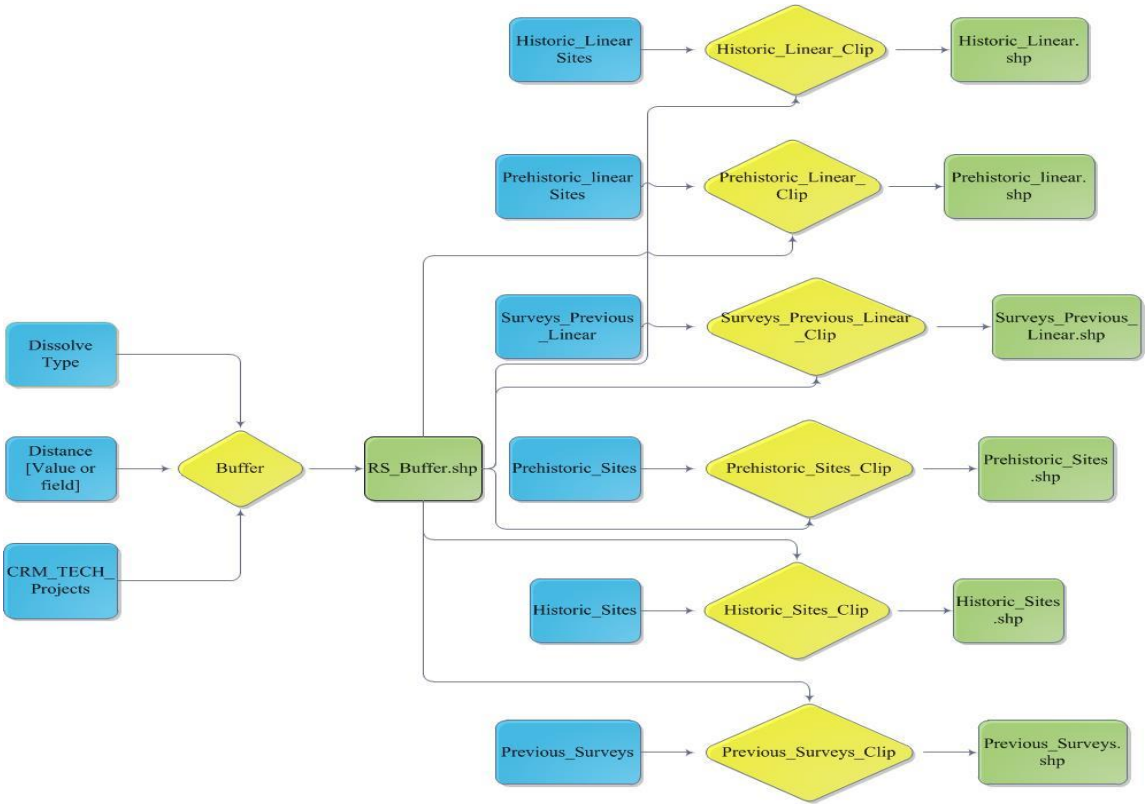

Figure 5-7: RS_Clipping_Tool created in ModelBuilder.

The RS_Clipping_tool creates a buffer around a given project area, giving the user the ability to establish the distance around the project area. For a Record Search Map, the distance for the buffer is usually one mile. The next option a user has is to dissolve the buffers together. This is useful when the project area consists of separate properties that are close to each other. The user can name and save the new shapefiles in the project folder for the on-going job. These project folders are located in a place that contains all projects that CRM TECH has created using GIS, labeled by the job number. The new shapefiles are not to be placed within the database because these data are specific to each project. This tool works off the Cultural_Resource dataset, so the new shapefiles created are copies of the Cultural_Resource dataset, but clipped to the buffer zone.

5.2.2 Site_Suitability Tool

The Site-Suitability model uses three variables, namely distance to water, slope, and vegetation, to create the Weighted Overlay Raster (WOR). The Site Suitability tool strings together two geoprocessing tools to produce one outcome. The geoprocessing

tools used are the Reclassify and the Weighted Overlay. The reclassify geoprocessing tools are used on three raster layers; slope, distance, and vegetation (Figure 5-8).

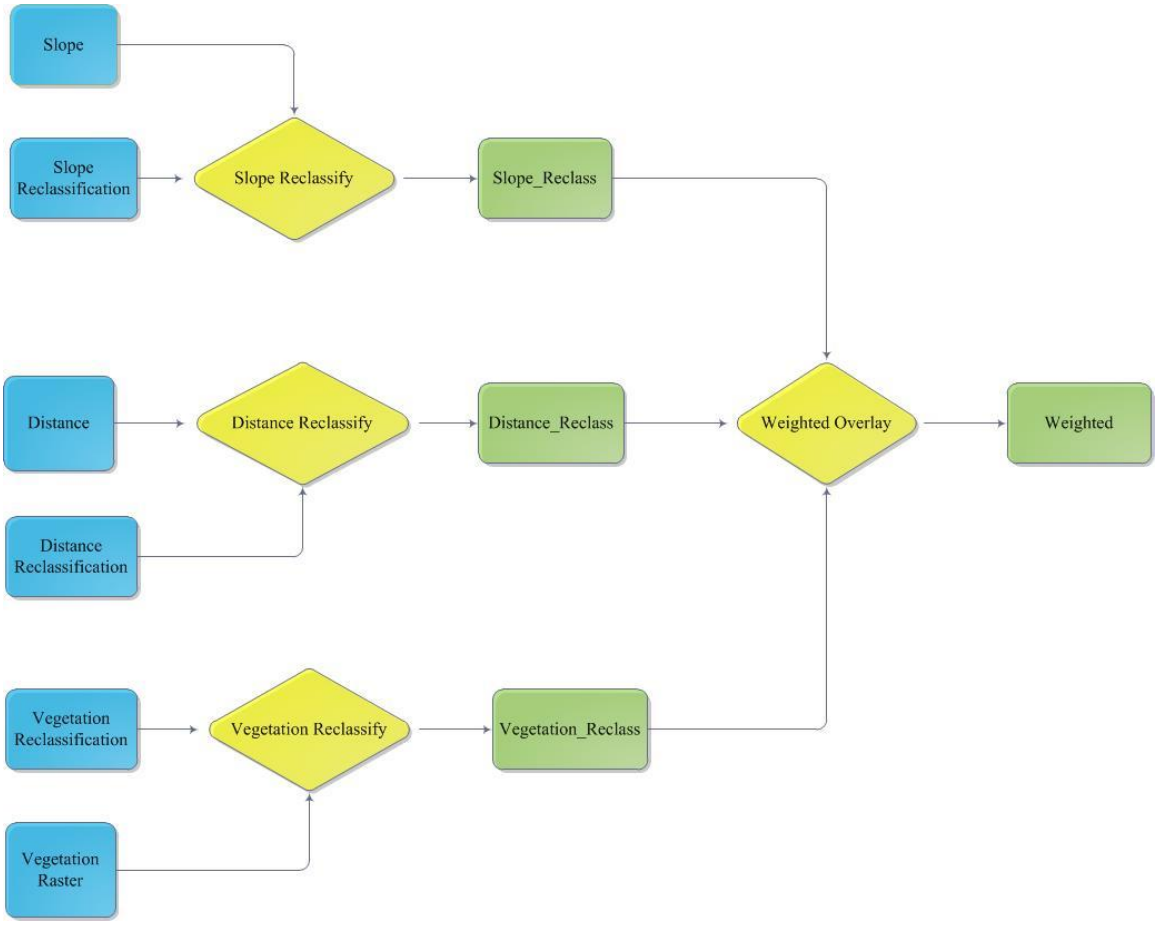

Figure 5-8: Site Suitability Tool Created in ModelBuilder.

In order for the tool to work properly, users need to create a distance raster, a slope raster, and import the vegetation raster. Given a DEM, a user can calculate a slope raster using the slope geoprocessing tool in ArcGIS. The user will also need to create a raster for the distance from the water source. Using the Euclidean Distance geoprocessing tool, the users can calculate the distance to the nearest water source for each cell. After the distance raster is created, the users can use the suit suitability tool. Once the tool is open, the users will use the tool interface to reclassify the three input raster images, the slope, vegetation, and distance.

5.3 Graphic User Interface

All tools required for the user to interact with the database are provided with graphic user interface (GUI) within ArcToolbox. The GUI portion of the system is the basic ArcMap software interface, with the essential toolbars attached to the top of the

screen. These toolbars include, but are not be limited to, the Standard Toolbar, Editor, Effects, Labeling, Layout, and a third party software known as XTools Pro (Figure 5-9). The two geoprocessing tools that were created for this project are located in the ArcToolbox under CRMTECH_Tools.

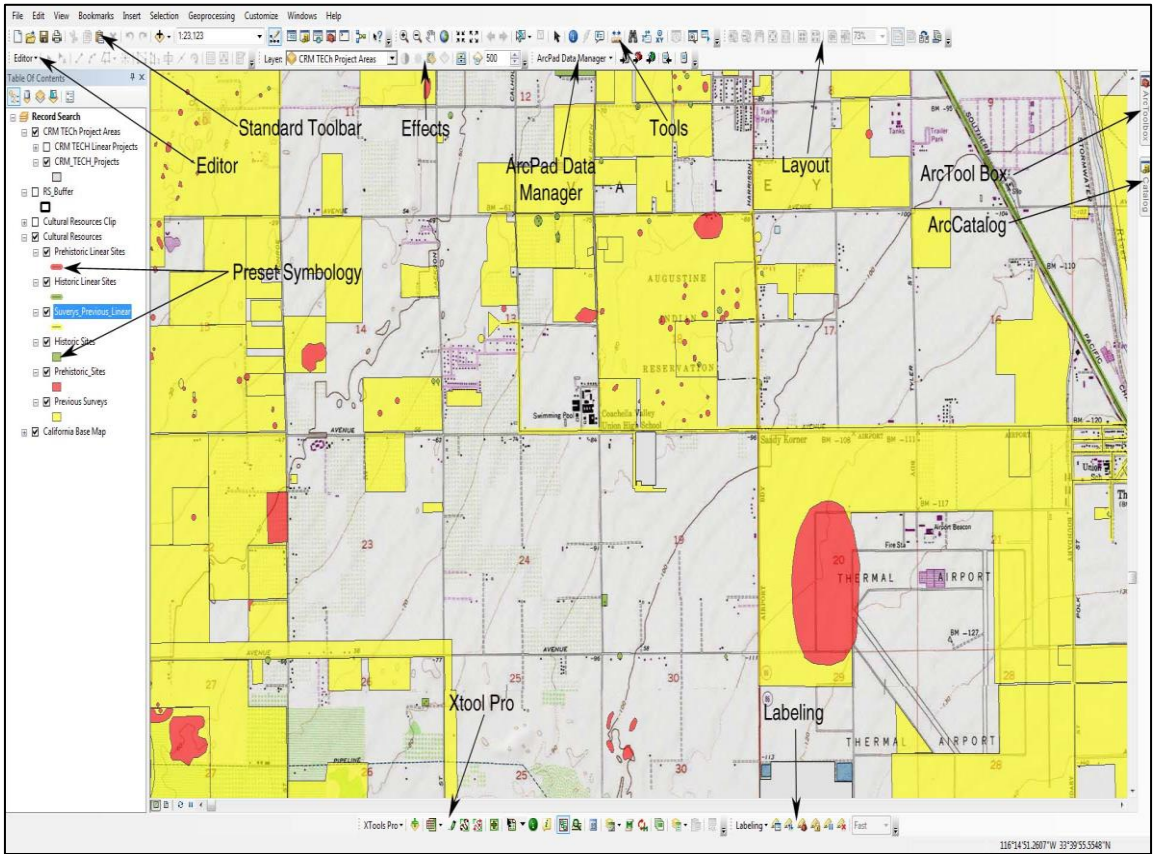

Figure 5-9: Graphic User Interface

The XTools Pro Toolbar is third party software that comes as an extension for ArcGIS Desktop. This toolbar is quite useful for daily operations of the client's GIS system. The toolbar comes with many geoprocessing tools that are not found in the ArcToolbox. These new geoprocessing tools help speed up the production of maps and table operations.

A map template and preset symbology was created for the users once they had completed a map. This preset symbology is used for all maps that are produced for technical reports for each project. The Record Search Map template (Figure 5-10) displays some important information about the map that was produced. Near the bottom of the template the project number and name are given along, with projection and datum information.

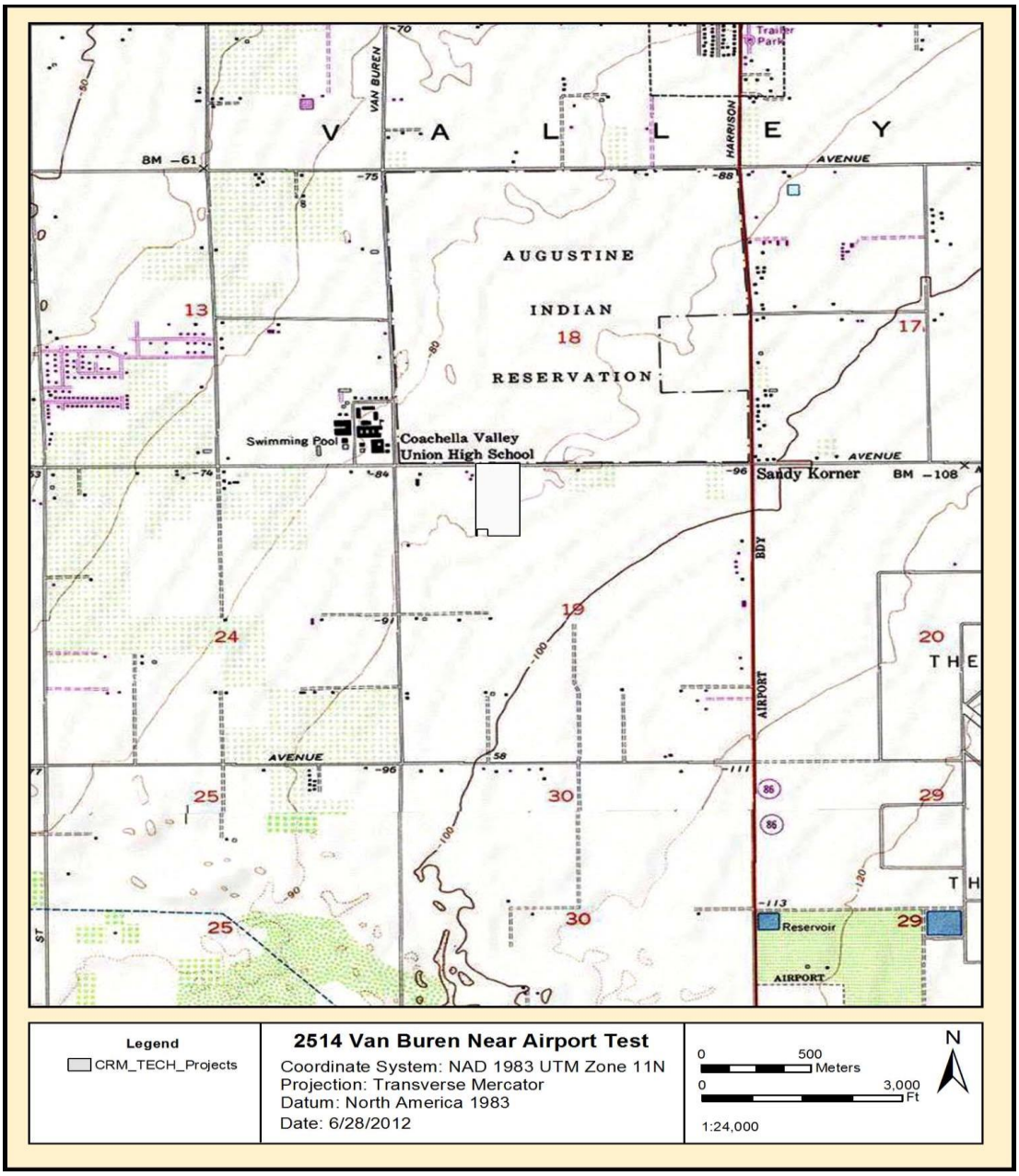

Figure 5-10: Record Search Map Template.

5.4 Summary

Chapter Five discussed the implementation of the archaeological database and the tools that were created for it. Several steps were outlined on how portions of the database−feature classes, feature datasets, and domains−were developed. The two geoprocessing tools that were developed for this project were explained. The last part of the chapter discussed the user interface and the map template for the RS map.

Chapter 6 – Results and Analysis

The results and analyses for the project were based on three components: to create a flexible archaeological database optimized for use with various tasks; to create a user-friendly interface and tools; and to create the database in a way that the data can be easily used for different types of analysis found within the ArcGIS Desktop tools. This chapter discusses the results and analysis for each component.

6.1 The Archaeological Database

At the end of this project, an archaeological database was successfully created to meet the clients specifications. Not only does the database hold data on the cultural resources located within the scope of the project (Figure 6-1) and throughout Southern California, but it also holds data on projects that CRM TECH has conducted throughout the years. As a result, the database has been slowly growing since being put into action. Locations of new and old cultural sites and previous surveys are being digitized on a daily basis and added to feature classes. Over 250 projects have been added to the CRM_TECH Project feature class since the middle of 2011. A total of 976 historic sites, 1446 prehistoric sites, and 2526 previous surveys have been added to the database. In addition, hyperlinks have been created for most of the historic and prehistoric sites within each of the feature class so attached documents can be easily accessed.

The ArcGIS built-in query tools have been working well with the database. The users have had no problem searching for certain sites or artifacts. The mobile portion of the database has performed excellently when checking out the database to the mobile GPS units and when checking in the database. Depending on the size of a project and how many feature classes a user is checking out, however, the speed on the mobile devices can be affected. The solution to this was only to check out the feature classes that are essential for the project.

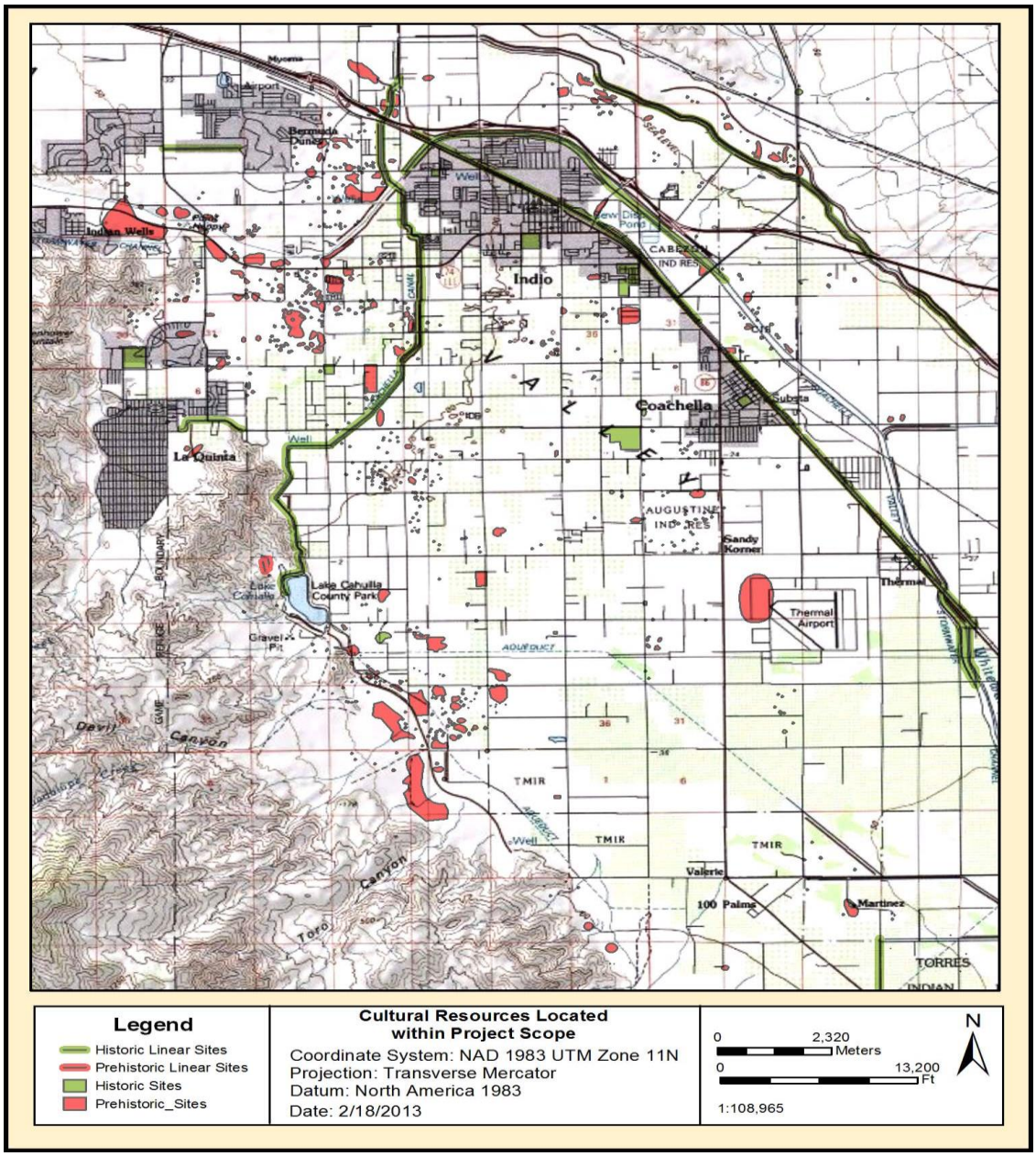

Figure 6-1: Cultural Resources Located within the Scope of the Project Area.

6.2 The Record Search Map and RS_Clipping_Tool

The Record Search Map is one of the primary tasks for which the database was designed. Once the archaeological database was complete, CRM TECH was able to use the RS_Clipping_Tool to automate part of the process for producing the Record Search Map. A record search has to be completed for all new projects that CRM TECH is awarded. A Record Search Map process usually begins in the office, once the project area has been established and confirmed with CRM TECH's client. The GIS Specialist for CRM TECH can now start the first portion of the record search process. This process begins with

opening the Record Search Map.mxd in ArcMap (Figure 6-2). The Record Search.mxd is a map template that was created for conducting an in-house record search and for updating record searches that have been conducted at the local Information Centers. The RS map template includes the California_Basemap, CRM_TECH_Projects and Projects_Linear, and the Cultural_Resources_Dataset.

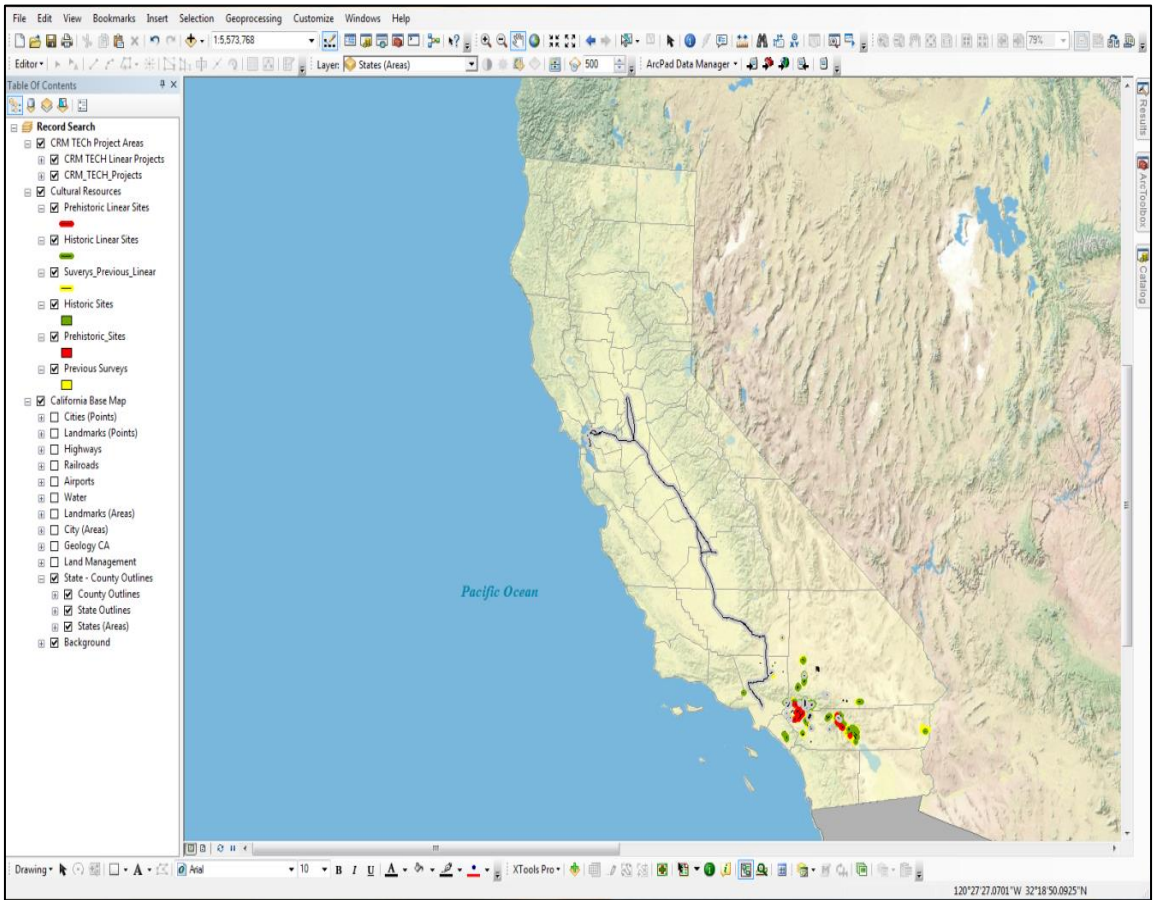

Figure 6-2: Record Search Map.mxd.

The next step in the process of making the record search map is the creation of the project location using either the CRM_TECH_Projects or CRM_TECH_Projects_Linear feature class. Once the project location has been created, the users can open the RS_Clipping_Tool to finish the record search map. The process is as follows. Open the CRMTECH_Toolbox located in the ArcToolbox and open the RS_Clipping_Tool. Once the GUI opens up for the tool, type in the location where the clip shapefiles will be saved. This location will usually be in the Record_Search_Clip_Transfer folder located in the project folder for that specific job. Enter the distance desired for the RS_Buffer; usually a one mile radius is conducted for most record searches. Figure 6-3 shows the GUI of this tool.

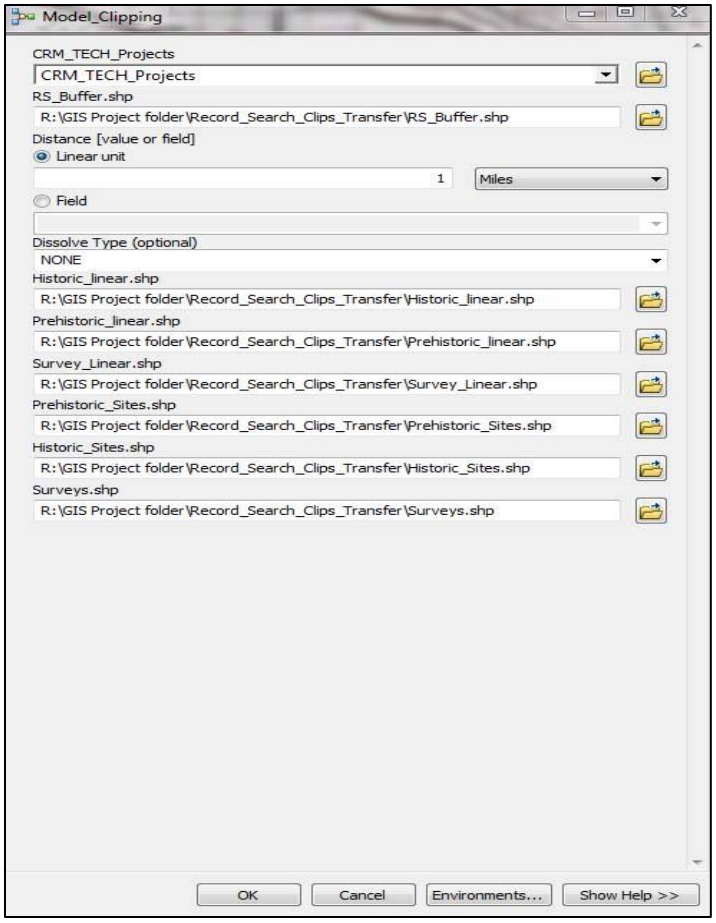

Figure 6-3: RS-Clipping_Tool GUI.

The results are displayed on the map content window of ArcMap. A template is used here to keep all record search maps the same. Figure 6-4 shows the template that was created for the record search map.

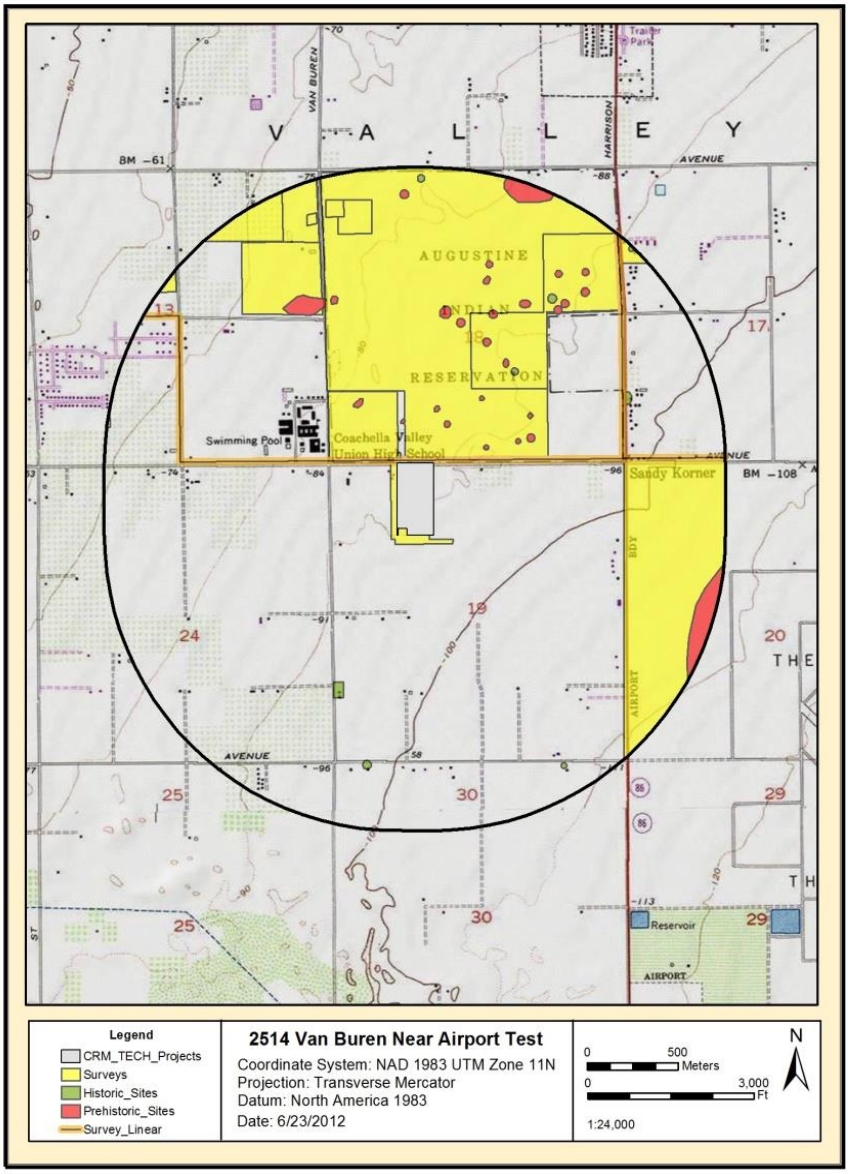

Figure 6-4: Record Search Map for Project 2514 (No labels).

The first part of the Record Search map is now complete. The next step is for a CRM TECH employee to visit the local IC and gather any new cultural information that is located within the buffer area. The last step for completing this research map is to include any new cultural resources found within the buffer zone by digitizing the new location of the cultural resources and complete the attribute tables associated with them. The record search map is complete and can be put into the technical reports. The client is very pleased with the time that has been saved by using this tool and the process for creating this type of map.

6.3 Site Suitability Map and Site_Suitability Tool

Suitability analysis is a GIS-based process of determining the fitness of a given area for a particular use. A Site Suitability Map can be made using the Site_Suitability Tool. The model uses three variables−distance to water, slope, and vegetation−in order to create the Weighted Overlay Raster (WOR). The process begins by opening the Site Suitability.mxd map which shows the location of the scope of the project. It includes layers for Prehistoric_Sites, Ancient Lake Cahuilla, Southern California Vegetation raster, the Digital Elevation Model (DEM) files of the location area, and the Rivers_Detail_CA feature class. The user must make sure that all layers are clipped to the DEM image. Figure 6-5 shows how the map should look before the Site_Suitability tool is used.

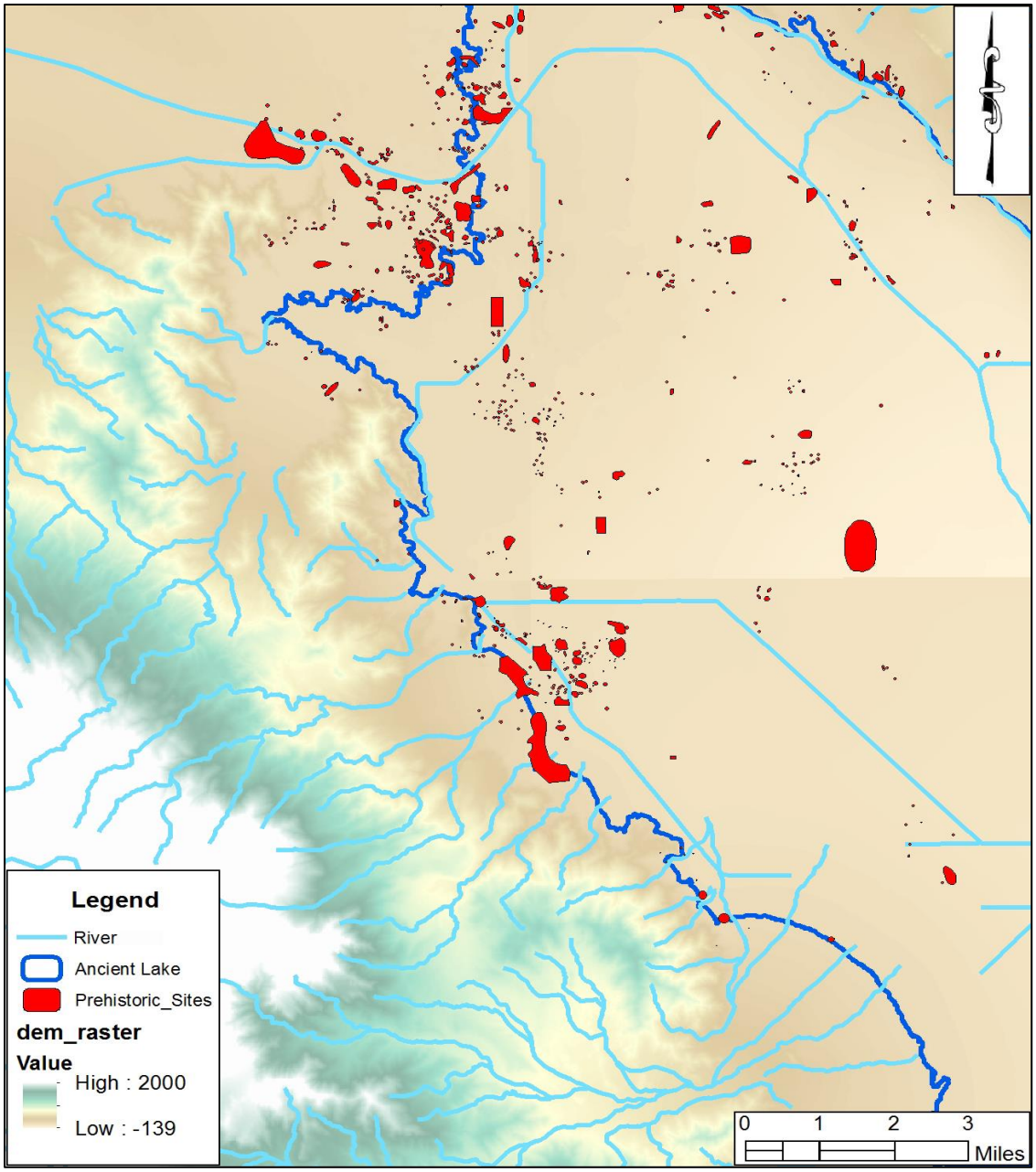

Figure 6-5: A Map of Prehistoric Sites and Water Features.

A slope layer is created first from the DEM data by using the Slope geoprocessing tool located in the Spatial Analyst toolbox. Next is to use the Euclidean distance geoprocessing tool that is also located in the Spatial Analyst toolbox to determine the distance from the river layer. Once the distance raster is created, the last step is to use the Site_Suitability tool located in the CRMTECH_Toolbox and reclassify the new values between 1 to 3, 1 being good and 3 being poor (Figure 6-6). Then the tool can be run to generate the results of the WOR.

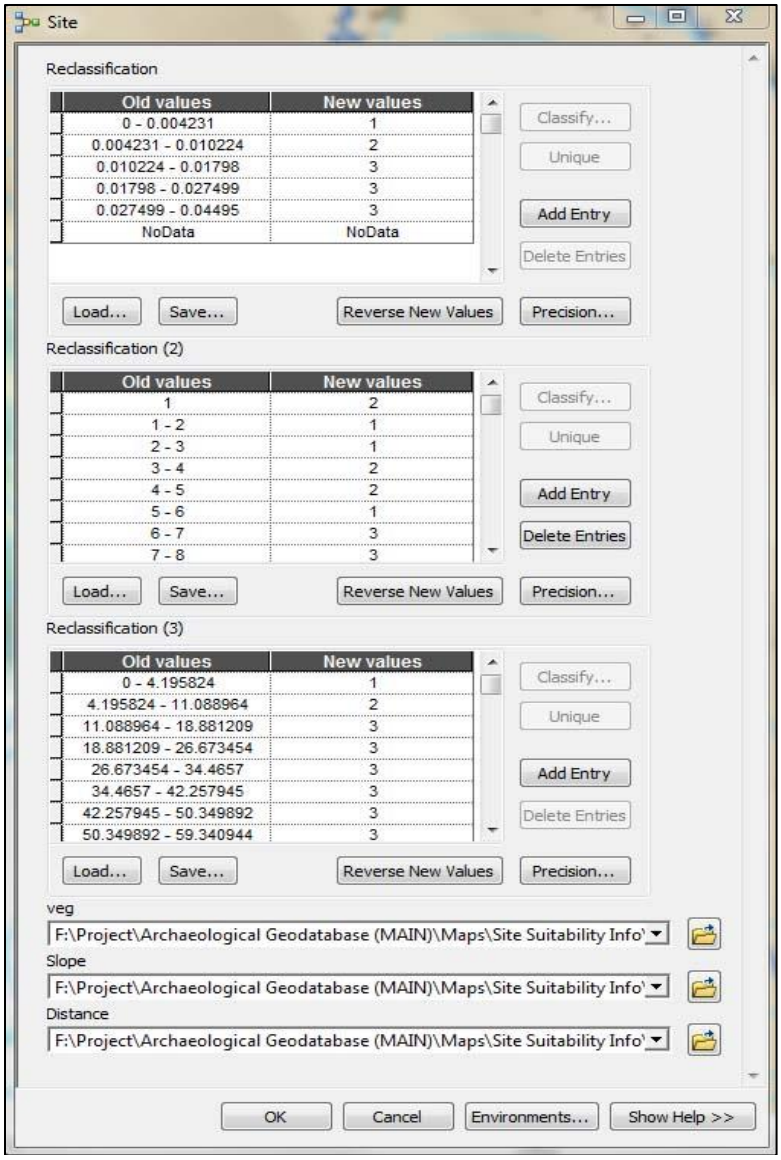

Figure 6-6: Site Suitability Tool.

Once the map is created and displayed, the symbology colors can be changed to one that is easily distinguishable. Figure 6-7 shows the results of the completed Site Suitability map.

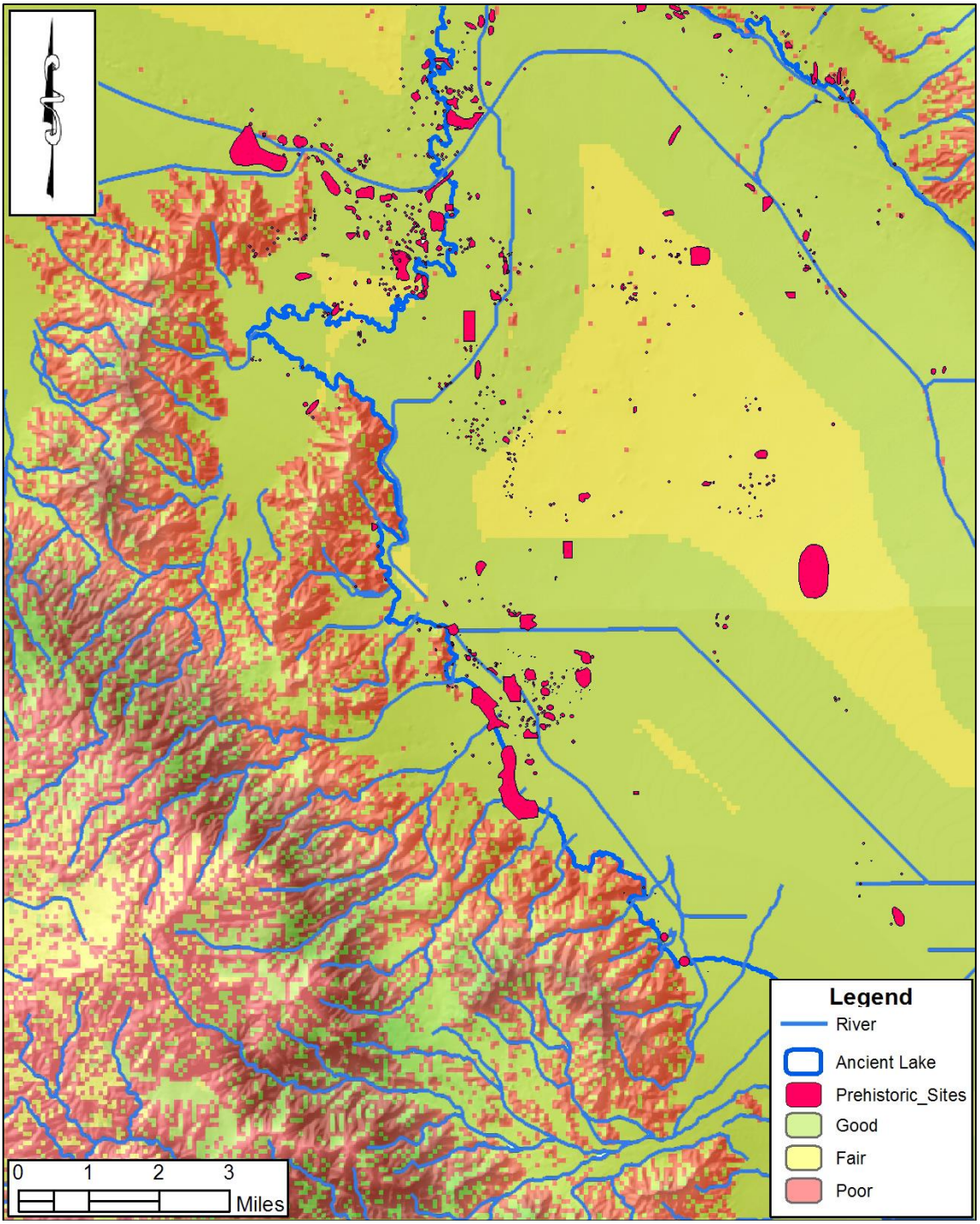

Figure 6-7: Site Suitability Results.

The result of the Suit Suitability map shows areas for the possible locations of prehistoric site based on the three variables. The map above shows that many of the known prehistoric sites are located within the good areas and some are located in the fair area. The blue outline of Ancient Lake Cahuilla also shows that there is a higher potential

of finding prehistoric sites along the old shore lines. These types of maps are helpful to the archaeologists at CRM TECH because it gives them additional information for conducting field surveys on possible locations of sites in a given area.

6.4 Mobile GIS

The archaeological database was designed for use in both the office and field environment. In order to use the database in the field, CRM TECH will need the proper equipment and software. Currently, CRM TECH has a Trimble GeoExplorer XH 2005 series hand held GPS unit with ArcPad 7.1 installed for use in data recording in the field. If additional GPS units are needed, a Trimble GeoExplorer XT 2008 Series hand held GPS and a Trimble Yuma computer tablet (personal devices of the GIS Specialist) are available. Both of these devices have ArcPad 10 pre-installed. For this project, the GPS unit used for collecting the field data was the Trimble GeoExplorer XT 2008 series handheld. The reason for this choice was that the device had the ArcPad 10 software enabling easy downloading and uploading data into database.

During the first field test of the mobile capabilities of the database, a new prehistoric site consisting of an artifact scatter was recorded in the community of Thermal, California. The Prehistoric site was recorded by using the Trimble GeoExplorer XT with the Artifact Dataset checked out to the device. Each prehistoric artifact that was observed was entered into the GPS unit. Since each of the artifact feature classes was created with domains, a user is able to record each artifact accurately. A drop down menu appears with the options that the user has to choose for each artifact. After the site was recorded, the information was brought back to the office. The artifact dataset was checked back into the database and the new artifacts appeared within the correct feature class of the artifact dataset. Figure 6-8 presents the prehistoric site that was recorded during the first field test.

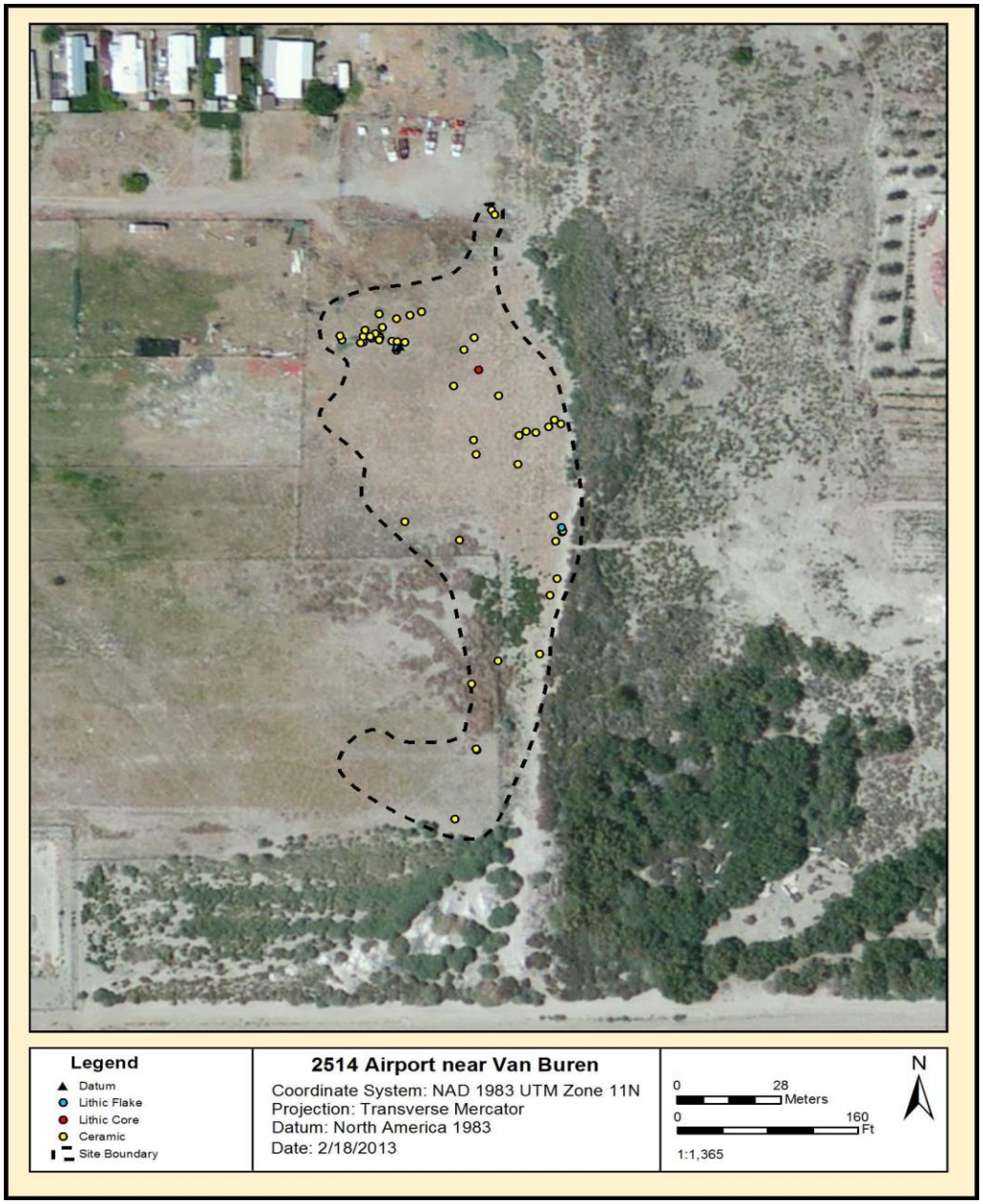

Figure 6-8: Prehistoric Site Recorded During the First Field Test.

The second field test project for the database was an excavation project in the city of Lancaster, California. In this project, only the groundstone feature class was checked out from the artifact dataset along with the Excavation_Shape dataset. These feature classes were checked into the GeoExplorer 2008 XT Series handheld GPS device that was used in the field. During the project, the locations of all the units and trenches, as well as the groundstone pieces, were recorded using the GPS device. Since the feature classes in the Excavation_Shape Dataset were created with domains, they were recorded quickly. Once the field work was completed for the excavation, the new features were

checked back into the archaeological database in the office. A map was then produced for the data recorded in the field (Figure 6-9).

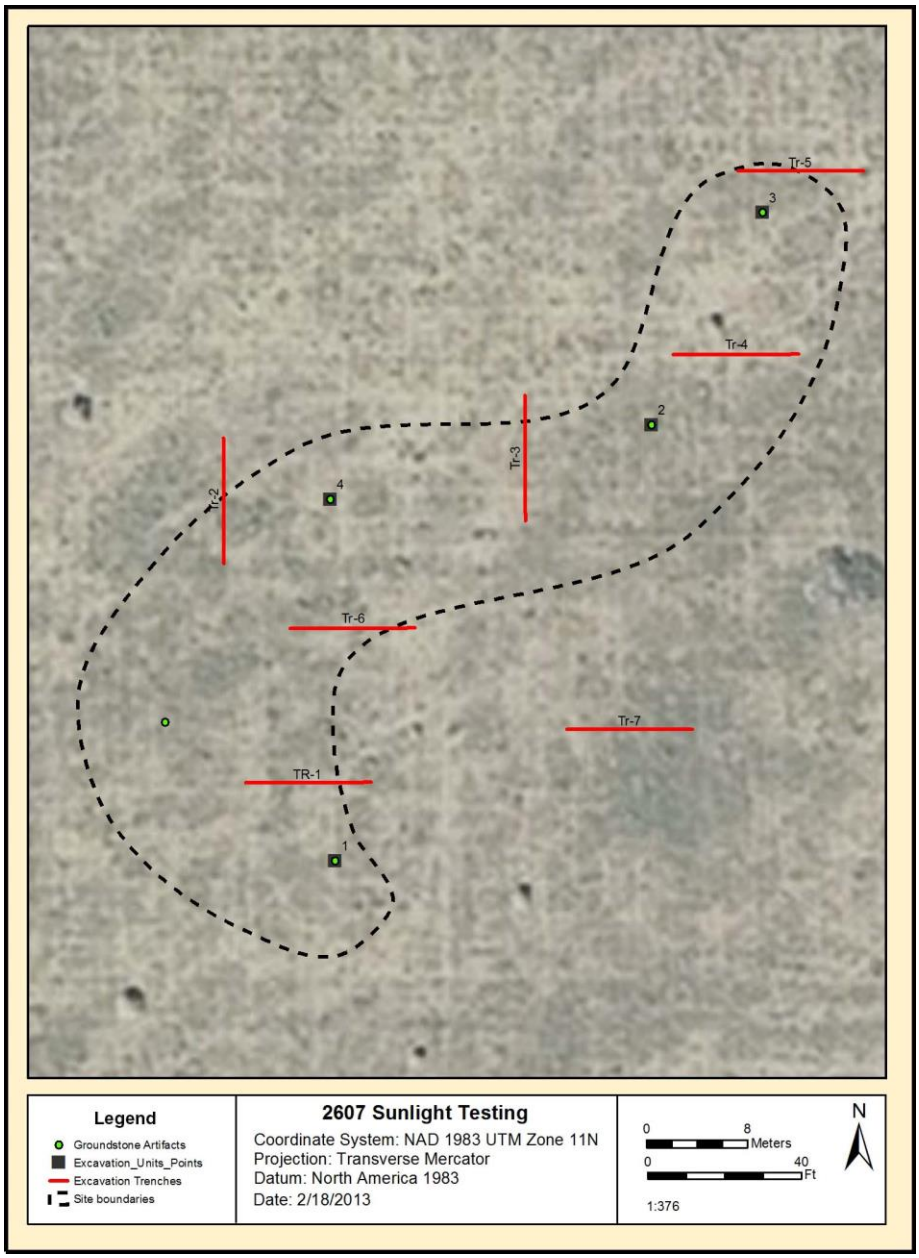

Figure 6-9: Excavation Recorded During the Second Field Test.

The third project used to test the database was located in the City of La Quinta, California. This project was a monitoring job, i.e. a project where a CRM TECH archaeologist watches heavy equipment removing soils. Portions of the database were checked out to the GeoExplorer 2008 XT Series handheld GPS devices during the monitoring of a parking lot. All prehistoric artifacts, features, and sites were recorded using the feature classes from the Artifacts and Excavation_Shape datasets. The artifacts

were recorded as soon as they were discovered. At the end of the project, the database was checked into the main archaeological database in the office. With the data recorded in the field, a map was produced for the technical report and for the site record updates (Figure 6-10).

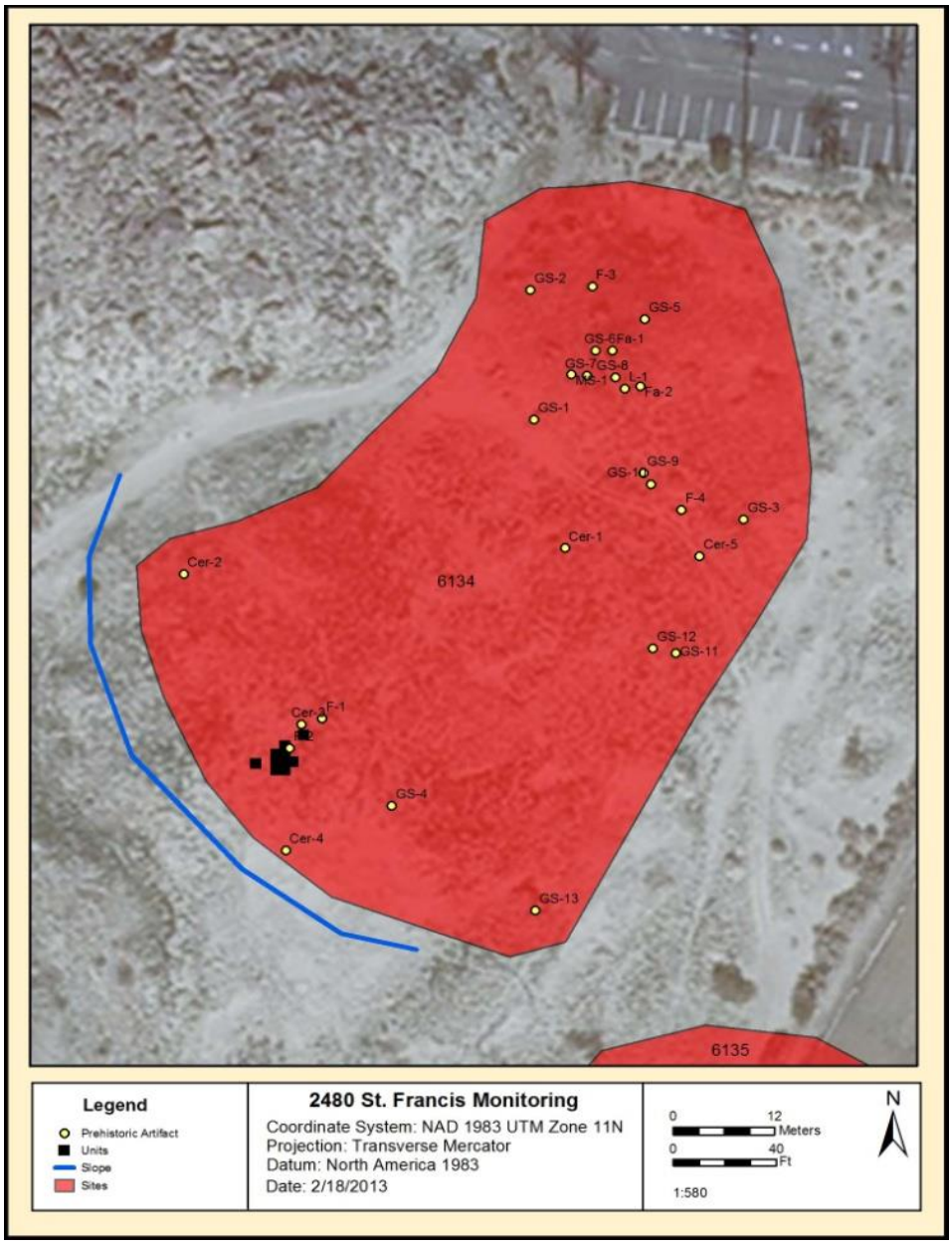

Figure 6-10: Prehistoric Site Recorded During the Third Field Test.

As stated before, depending on the size of the project and how many feature classes the user is checking out, the speed on the mobile devices can be affected. The devices affected by these speed problems are the two Trimble GeoExplorer GPS units. The Trimble Yuma tablet was not affected by this problem due to the fact that the tablet

runs on the Window 7 operating system and has a faster processor than the two handheld GPS units, which run on Windows Mobile 5 and 6.1. The solution to this was only checking out the feature classes that were considered important for the project done using the two handheld GPS units. The original artifact shapefiles that were imported into the database were also copied into the mobile devices. If a user needs to add more data in the field, they can upload the shapefiles onto the GPS unit without affecting the speed of the device.

Chapter 7 – Conclusions and Future Work

This chapter concludes and summarizes the creation of the archaeological database for the client and presents potential ideas for future work. The project fulfilled all six of the functional requirements and satisfied all non-functional requirements established by the client and the archaeological database, along with the two geoprocessing tools that are already in use. The archaeological database has been in use at CRM TECH since August of 2011. As part of the testing phase for this project, the database, along with the tools and map templates, were transferred into the GIS desktop computer at the office of CRM TECH. The client has been very pleased with the success of this project and how well the transition of GIS into the daily workflow has been.

7.1 Summary

This project produced and provided the client with six functional requirements.

- The database must be able to store all the types of cultural resource information that has been collected in the field or digitized in the office. This includes feature datasets, feature classes, rasters (including USGS Maps and aerial images), and tables.
- The database must store the data consistently in order to allow data updates and edits. Domains are to be used to minimize input errors.
- The database must be able to overlay multiple layers of data into a single, readable map in a semi-automated fashion.
- The database must allow efficient querying for information the user requires.
- The database must be able to work with varies mobile GPS devices.
- The database is limited to a desktop computer due to a single user license.

The first requirement was achieved by the creation of the archaeological database that has been in operation since August 2011 at the office of CRM TECH. Since the database went into operation, a number of new feature classes and tables have been added, with minimal constraints to the database. The second requirement has been completed by creating domains to minimize input errors. The majority of the feature classes that are used on a daily basis have domains assigned to them. This has helped keep the data in the database consistent and with few errors. The third requirement was that the database be able to overlay multiple layers has been completed with the creation of the two geoprocessing tools that helped automate the production of two types of maps: the Record Search map and the Site Suitability map. Being able to query the database was the fourth requirement that was completed. Users have been able to query the data located within the database with efficiency. A user can find prehistoric or historic sites with similar resource attributes, or find locations of similar types of artifacts found in different sites. The fifth requirement completed was to work on the User Interface. The User Interface has been simplified for the users of the system. Only a few toolbars have been opened for daily activities and a third party toolbar has been added to the interface. The XTool Pro software places a good deal of geoprocessing tools into one location for the user and also adds the ability to work, import, and export the attribute tables to

Microsoft Excel. The last requirement for the project was to have the proper type of computer and software to be able to use the system. This was done by the client by purchasing a computer with the hardware requirements to run ArcGIS 10 Desktop software correctly. Since the client only has a single license for the software, only one computer was needed.

7.2 Future Work

The completion of this project created some opportunities for future work using this database. One of these potential projects is to improve the Site Suitability Tool. The tool will be more accurate and helpful to researchers if more variables are added. Some of the variables that can be used are soil types, detailed vegetation information, and distance to other types of resources besides water. The tool that was created for this project was built around the available information that CRM TECH had in GIS format, but if more detailed feature classes can be found or created, it will greatly help the research process.

Another potential project could be to create a tool that can automatically populate new feature layers attribute tables. For example, if a new site boundary or project boundary is created, some of the location information can automatically be filled. The USGS quad, township, range, and section could be filled by using a tool designed for that purpose.

Another area that can be worked on is creating a database which catalogs and maintains the location of all items stored in the CRM TECH lab, including artifacts, photographs, maps, samples, and documentation. This could be done within the database created for this project, but it would be better perhaps to create a new database solely for that purpose and be able to integrate it with the existing database.

The last potential project is link the project database to the local Information Center's database. This would be ideal for research purposes and for record searches that have to be conducted for each project. The time and money that can be saved would be significant.

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Appendix A. Archaeological Database

This section will list the table of each of the datasets, feature classes, and domains that were created for this database. It will not show the feature classes that were used from other sources.

Artifact Dataset

Simple feature class
Artifact_Line

Geometry Polyline
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
Art_Count	String	Yes		Artifact Count			50
Condition	String	Yes		Condition			50
Collec_Methods	String	Yes		Collection Methods			50
Short_Desc	String	Yes					50
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
SHAPE_Length	Double	Yes			0	0	
GlobalID		No			0	0	38

Generic Artifact_Line feature class

Simple feature class
Artifact_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
Art_Count	String	Yes		Artifact Count			50
Condition	String	Yes		Condition			50
Collec_Methods	String	Yes		Collection Methods			50
Short_Desc	String	Yes					50
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
GlobalID		No			0	0	38

Generic Artifact_Point feature class

Simple feature class
Artifact_Polygon

Geometry Polygon
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
Art_Count	String	Yes		Artifact Count			50
Condition	String	Yes		Condition			50
Collec_Methods	String	Yes		Collection Methods			50
Short_Desc	String	Yes					50
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	
GlobalID		No			0	0	38

Generic Artifact_Polygon feature class

Simple feature class
Bead_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
Bead_Type	String	Yes		Bead_Type			50
Bead_Material	String	Yes		Bead_Material			50
Art_Count	String	Yes		Artifact Count			50
Condition	String	Yes		Condition			50
Collec_Methods	String	Yes		Collection Method			50
Short_Desc	String	Yes					100
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
GlobalID		No			0	0	38

Bead_point: This feature class is for recording any type of bead artifacts.

Simple feature class
Bedrock_Milling_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
Milling_Type	String	Yes		Milling_Condition			50
Milling_Condition	String	Yes		Milling_Condition			50
Milling_Surface	String	Yes					50
Boulder_Size	String	Yes					50
Art_Count	String	Yes		Artifact Count			50
Condition	String	Yes		Condition			50
Collec_Methods	String	Yes		Collection Methods			50
Short_Desc	String	Yes		Disposition			50
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Updated	String	Yes		File Updated			50
GlobalID		No			0	0	38

Bedrock_Milling_Point: For recording bedrock milling features.

Simple feature class
Ceramic_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
Ceramic_Type	String	Yes		Ceramic Artifacts			50
Ceramic_Feature	String	Yes		Ceramic_feature			50
Art_Count	String	Yes		Artifact Count			50
Condition	String	Yes		Condition			50
Collec_Methods	String	Yes		Collection Methods			50
Short_Desc	String	Yes					50
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Updated	String	Yes		File updated			50
GlobalID		No			0	0	38

Ceramic_Point: For recording ceramic sherds or vessels.

Simple feature class
Datum_Point

Geometry Polygon
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Artifact_ID	String	Yes					50
Res_Att_Cds	String	Yes		Res-att_cds			50
Collec_met	String	Yes		Collection Method			50
Shrt_desc	String	Yes					100
Date_rec	Date	Yes			0	0	8
photos	String	Yes		Photographs			50
file_update	String	Yes		File updated			50
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	
GlobalID		No			0	0	38

Datum_Point: For recording the location of a site datum.

Simple feature class
FAR_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
FAR_Type	String	Yes					50
FAR_Material	String	Yes		Rock_Material			50
Art_Count	String	Yes		Artifact Count			50
FAR_Condition	String	Yes		FAR_Condition			50
Collec_Methods	String	Yes		Collection Methods			50
Short_Desc	String	Yes		Disposition			50
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Updated	String	Yes		File Updated			50
GlobalID		No			0	0	38

FAR_Point: For recording of fire affected rocks (FAR) observed in the field.

Simple feature class
Groundstone_Point

Geometry Point
Contains M values No
Contains Z values No

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
GS_Type	String	Yes		GS_Type			50
GS_Material	String	Yes					50
Art_Count	String	Yes		Artifact Count			50
GS_Condition	String	Yes		GS_Condition			50
GS_Surface	String	Yes		GS_Surface			50
Collec_Methods	String	Yes		Collection Methods			50
Short_Desc	String	Yes					100
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
GlobalID		No			0	0	38

Groundstone_Point: For recording Groundstone artifacts.

Simple feature class
Lithic_Core_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes		Artifact Type			50
Type	String	Yes		Artifact Type			50
Core_Type	String	Yes		Core_Type			50
Core_Color	String	Yes		Core_Color			50
Core_Material	String	Yes		Core_Material			50
Lithic_FL_Type	String	Yes		Lithic_Fl_Type			50
Art_Count	String	Yes		Artifact Count			50
Condition	String	Yes		Condition			50
Collec_Methods	String	Yes		Collection Method			50
Short_Desc	String	Yes					100
Disposition	String	Yes		Disposition			50
Date_recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
GlobalID		No			0	0	38

Lithic_Core_Point: Foe recording lithic cores observed in the field.

Simple feature class
Lithic_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
Lithic_Type	String	Yes		Lithic_Type			50
Lithic_Color	String	Yes		Lithic_Color			50
Lithic_Material	String	Yes		Lithic_Material			50
Lithic_FL_Type	String	Yes		Lithic_Fl_Type			50
Art_Count	String	Yes		Artifact Count			50
Condition	String	Yes		Condition			50
Collec_Methods	String	Yes		Collection Method			50
Short_Desc	String	Yes					100
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Updated	String	Yes		File Updated			50
GlobalID		No			0	0	38

Lithic_Point: To record debitage observed in the field.

Simple feature class
Projectile_Point_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
Point_Type	String	Yes		Point_Type			50
Point_Material	String	Yes		Lithic_Material			50
Art_Count	String	Yes		Artifact Count			50
Point_Condition	String	Yes		Point_condition			50
Collec_Method	String	Yes		Collection Method			50
Short_Desc	String	Yes					100
Disposition	String	Yes		Disposition			50
Date_Recorded	String	Yes		Date Recorded_1			50
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
GlobalID		No			0	0	38

Project_Point_Point: Feature classes to record arrowhead or dart points.

Simple feature class
Site_Boundaries_Polygon

Geometry Polygon
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Res_att_cds	String	Yes		Res-att_cds			50
Site_Type	String	Yes		Site_Type			50
Collec_Method	String	Yes		Collection Method			50
Short_Desc	String	Yes					100
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	
GlobalID		No			0	0	38

Site_Boundary_Polygon: Feature class for recording site boundaries in the field.

Simple feature class
Tool_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Artifact Type			50
Tool_Type	String	Yes		Tool_Type			50
Tool_Material	String	Yes		Tool_Material			50
Art_Count	String	Yes		Artifact Count			50
Condition	String	Yes		Condition			50
Collec_Method	String	Yes		Collection Method			50
Short_Desc	String	Yes					100
Disposition	String	Yes		Disposition			50
Date_Recorded	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
GlobalID		No			0	0	38

Tool_Point: For recording different types of prehistoric tools.

CRM_TECH_Projects Dataset

Simple feature class
CRM_TECH_Linear_Projects

Geometry Polyline
Contains M values No
Contains Z values No

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
CRM_ID	String	Yes					50
CRM_Name	String	Yes					100
Project_Type	String	Yes		CRM_Job_Type			100
Project_Name	String	Yes					100
Client	String	Yes					100
Fieldwork_Type	String	Yes		CRM_Fieldwork-Type			50
Area	Float	Yes			0	0	
Date	Date	Yes			0	0	8
SHAPE_Length	Double	Yes			0	0	
GlobalID		No			0	0	38

CRM-TECH Linear_Projects: Feature class for new and old CRM TECH linear projects.

Simple feature class
CRM_TECH_Projects

Geometry Polygon
Contains M values No
Contains Z values No

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
Shape	Geometry	Yes					
CRM_ID	String	Yes					50
CRM_Name	String	Yes					100
Project_Type	String	Yes		CRM_Job_Type			100
Project_Name	String	Yes					100
Client	String	Yes					100
Fieldwork_Type	String	Yes		CRM_Fieldwork-Type			50
Area	Float	Yes			0	0	
Date	Date	Yes			0	0	8
Shape_Length	Double	Yes			0	0	
Shape_Area	Double	Yes			0	0	
GlobalID		No			0	0	38

CRM-TECH_Projects: Feature class for new and old CRM TECH projects.

Simple feature class
CRM_TECH_Linear_Proposals

Geometry Polyline
Contains M values No
Contains Z values No

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
CRM_ID	String	Yes					50
CRM_Name	String	Yes					100
Project_Type	String	Yes		CRM_Job_Type			100
Project_Name	String	Yes					100
Client	String	Yes					100
Fieldwork_Type	String	Yes		CRM_Fieldwork-Type			50
Area	Float	Yes			0	0	
Date	Date	Yes			0	0	8
SHAPE_Length	Double	Yes			0	0	
GlobalID		No			0	0	38

CRM-TECH_ Linear_Proposals: Feature class for new linear project proposals.

Simple feature class
CRM_TECH_Proposals

Geometry Polygon
Contains M values No
Contains Z values No

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
CRM_ID	String	Yes					50
CRM_Name	String	Yes					100
Project_Type	String	Yes		CRM_Job_Type			100
Project_Name	String	Yes					100
Client	String	Yes					100
Fieldwork_Type	String	Yes		CRM_Fieldwork-Type			50
Area	Float	Yes			0	0	
Date	Date	Yes			0	0	8
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	
GlobalID		No			0	0	38

CRM-TECH_ Linear_Proposals: Feature class for new linear project proposals.

Cultural_Resources Dataset

Simple feature class
Prehistoric_Sites

Geometry Polygon
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
CRM_ID	String	Yes					50
Primary_Number	String	Yes					50
Trinomial	String	Yes					50
Resource	String	Yes		Res-att_cds			100
USGS_Quad	String	Yes					50
Section	String	Yes					50
Township	String	Yes					50
Range	String	Yes					50
APN	String	Yes					50
Hyperlink	String	Yes					200
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	
Date	String	Yes					50
Description	String	Yes					200
GlobalID		No			0	0	38

Prehistoric_Sites: Feature class for recording data on prehistoric sites in California.

Simple feature class
Prehistoric_Sites_Linear

Geometry Polyline
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
CRM_ID	String	Yes					50
Primary_Number	String	Yes					50
Trinomial	String	Yes					50
Resource	String	Yes		Res-att_cds			100
USGS_Quad	String	Yes					50
Section	String	Yes					50
Township	String	Yes					50
Range	String	Yes					50
APN	String	Yes					50
Hyperlink	String	Yes					200
SHAPE_Length	Double	Yes			0	0	
Date	String	Yes					50
Description	String	Yes					100
GlobalID		No			0	0	38

Prehistoric_Sites_Linear: Feature class for recording data on prehistoric sites that are linear in shape.

Simple feature class
Historic_Sites

Geometry Polygon
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
CRM_ID	String	Yes					50
Primary_Number	String	Yes					50
Trinomial	String	Yes					50
Resource	String	Yes		Res-att_cds			100
USGS_Quad	String	Yes					50
Section	String	Yes					50
Township	String	Yes					50
Range	String	Yes					50
APN	String	Yes					50
Hyperlink	String	Yes					200
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	
Date	String	Yes					50
Desription	String	Yes					200
GlobalID		No			0	0	38

Historic_Sites: Feature class for recording data on historic sites in California.

Simple feature class
Historic_Sites_Linear

Geometry Polyline
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
CRM_ID	String	Yes					50
Primary_Number	String	Yes					50
Trinomial	String	Yes					50
Resource	String	Yes		Res-att_cds			100
USGS_Quad	String	Yes					50
Section	String	Yes					50
Township	String	Yes					50
Range	String	Yes					50
APN	String	Yes					50
Hyperlink	String	Yes					200
SHAPE_Length	Double	Yes			0	0	
Date	String	Yes					50
Description	String	Yes					200
GlobalID		No			0	0	38

Historic_Sites_Linear: Feature class for recording data on historic sites that are linear in shape.

Simple feature class
Surveys_Previous

Geometry Polygon
Contains M values No
Contains Z values No

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
CRM_ID	String	Yes					50
NADB	String	Yes					50
RI_IC	String	Yes					50
Report_Number	String	Yes					50
Title	String	Yes					100
Preparer	String	Yes					200
Company	String	Yes					100
City	String	Yes					50
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	
Hyperlink	String	Yes					50
Date	String	Yes					50
GlobalID		No			0	0	38

Surveys_Previous: Feature class for recording data on previous surveys in California.

Simple feature class
Suverys_Previous_Linear

Geometry Polyline
Contains M values No
Contains Z values No

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
Shape	Geometry	Yes					
CRM_ID	String	Yes					50
NADB	String	Yes					50
RI_IC	String	Yes					50
Report_Number	String	Yes					50
Title	String	Yes					100
Preparer	String	Yes					200
Company	String	Yes					100
City	String	Yes					50
Hyperlink	String	Yes					100
Shape_Length	Double	Yes			0	0	
Date	String	Yes					50
GlobalID		No			0	0	38

Surveys_Previous_Linear: Feature class for recording data on previous surveys that are linear in shape.

Simple feature class
Buffer_Shape

Geometry Polygon
Contains M values No
Contains Z values No

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
CRM_ID	String	Yes					50
CRM_Name	String	Yes					100
Project_Type	String	Yes		CRM_Job_Type			100
Project_Name	String	Yes					100
Client	String	Yes					100
Fieldwork_Type	String	Yes		CRM_Fieldwork-Type			50
Area	Float	Yes			0	0	
Date	Date	Yes			0	0	8
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	
GlobalID		No			0	0	38

Buffer_Shape: Feature class for record search buffers for each of CRM TECH projects.

Structure Dataset

Simple feature class
Structure_Point

Geometry Point
Contains M values Yes
Contains Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Structure_Type			50
Use	String	Yes		Original Use			50
In_use	String	Yes		In_Use			50
Condition	String	Yes		Condition			50
Material	String	Yes		Structure Material			50
Art_present	String	Yes		Art_Present			50
Collec_Met	String	Yes		Collection Method			50
Disposition	String	Yes		Disposition			50
Prev_excav	String	Yes		Prev_Excavation			50
Shrt_Desc	String	Yes					100
Date_rec	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File updated			50
GlobalID		No			0	0	38

Structure_Point, Linear, and Polygon: For recording structure features observed in the field. All three feature classes have the same attribute tables and domains.

Transportation Dataset

Simple feature class
Transportation_Point

Geometry	Point
Contains M values	Yes
Contains Z values	Yes

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Site_ID	String	Yes					50
CRM_ID	String	Yes					50
Feature_ID	String	Yes					50
Artifact_ID	String	Yes					50
Type	String	Yes		Transportation Type			50
Use	String	Yes		Original Use			50
In_use	String	Yes		In_Use			50
Condition	String	Yes		Condition			50
Art_present	String	Yes		Art_Present			50
Collec_Met	String	Yes		Collection Method			50
Disposition	String	Yes		Disposition			50
Shrt_desc	String	Yes					100
Date_Rec	Date	Yes			0	0	8
Photos	String	Yes		Photographs			50
File_Update	String	Yes		File Updated			50
GlobalID		No			0	0	38

Transportation_Point, Linear, and Polygon: For recording transportation features observed in the field. All three feature classes have the same attribute tables and domains.

Domains

Domains assist in standardizing information associated with the sites.

Coded value domain
Artifact Amount

Description	Artifact Amount
Field type	String
Split policy	Default value
Merge policy	Default value

Code	Description
Single	Single
Multiple	Multiple artifacts (2-5)
Scatter	Many artifacts (>5)

Coded value domain
Artifact Count

Description	Number of Artifacts
Field type	String
Split policy	Default value
Merge policy	Default value

Code	Description
Single	Single
Multiple	Multiple artifacts (2-5)
Scatter	Many Artifacts (>5)

Coded value domain
Artifact Type

Description	Type of artifact
Field type	String
Split policy	Default value
Merge policy	Default value

Code	Description
Ceramic	Ceramic artifacts
Bead	Bead artifacts (shell, glass, or stone)
lithic	Lithic flakes, cores
Groundstone	Groundstone artifacts
Shell	Freshwater or marine shells
FAR	Fire affected rocks
Tool	Tool artifacts
Bedrock_feature	Bedrock milling features
Metal	Metal objects
Wood	Wooden objects
Other	Other
Unknown	Unknown object

Coded value domain
Artifacts Present

Description	Were artifacts
Field type	present?
Split policy	String
Merge policy	Default value

Code	Description
Yes	Yes
No	No

Coded value domain
Bead_Type

Description: Type of bead
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Clothing	Clothing
Jewery	Jewery

Coded value domain
Bead_Material

Description: Material of bead
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Bone	Bone bead
Freshwater	Freshwater shell
Marine	Marine shell
Stone	Stone material

Coded value domain
Ceramic_feature

Description: Ceramic feature
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Painted	Painted sherd
Sherd	Sherd
Rim sherd	Rim Sherd
Pot drop	Pot drop
Bowl	Bowl
Figure	Clay figure

Coded value domain
Collection Methods

Description: Method used to record
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
GeoXH	Trimble GeoExplorer XH (2005)
GPS	Commerical GPS unit
Photo	Digitized from aerial photos
USGS	Digitized from USGS Quad 7.5
Historic	Digitized from historic map

Coded value domain
Condition

Description: Condition of artifact,
Field type: feature, or structure
Split policy: String
Merge policy: Default value

Code	Description
Good	Good condition
Fair	Fair condition
Poor	Poor condition
Ruined	Very bad condition
Standing	Standing structure
Restored	Restored from poor condition
Unknown	Unknown
N/A	N/A
Complete	Complete
Fragment	Fragment

Coded value domain
CRM_Job_Type

Description: Job Type
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Arch	Archaeology
Arch-Paleo	Both
Paleo	Paleo
Rpt	Report
RS	Record Search

Coded value domain
Core_Type

Description: Type of core
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Bifacial	Bificaial core
MDFC	Multi-DF Core
Unknown	Unknown

Coded value domain
Collection Method

Description: Methods used to
Field type: generate data
Split policy: String
Merge policy: Default value

Code	Description
Total Station	Total Station
Survey Grade GPS	Survey Grade GPS (accuracy <1m or greater)
Digitized from 7.5 min. guad map	Digitized from 7.5 min. guad map
Digitized from historic map	Digitized from historic map
Located from PLSS location	Located from PLSS location
Digitized from aerial photograph	Digitized from aerial photograph
Commerical Grade GPS	Commercial Grade GPS (accuracy 1-5m or less)

Coded value domain
Ceramic Artifacts

Description: Type of ceramics
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
BR	Brownware
BF	Buffware
RW	Redware
UK	Unknown

Coded value domain
Disposition

Description Disposition
Field type String
Split policy Default value
Merge policy Default value

Code	Description
Observed	Observed in the field
Observed 2nd	Observed second handed
Digitized	Digitized from record form

Coded value domain
FAR_Condition

Description Condition of rock
Field type String
Split policy Default value
Merge policy Default value

Code	Description
SB	Slightly burned
HB	Highly burned
DC	Decomposing

Coded value domain
GS_Type

Description Type of groundstone
Field type artifact
Split policy String
Merge policy Default value

Code	Description
BL	Bowl
MA	Mano
ME	Metate
MO	Mortar
PL	Pestle
DI	Disc-ceremonial

Coded value domain
GS_Condition

Description Complete or fragment
Field type String
Split policy Default value
Merge policy Default value

Code	Description
CM	Complete
FR	Fragment

Coded value domain
Lithic_Color

Description Material color
Field type String
Split policy Default value
Merge policy Default value

Code	Description
Black	Black
Brown	Brown
Clear	Clear
Dark Brown	Dark Brown
Green	Green
Grey	Grey
Light Brown	Light Brown
Maroon	Maroon
Red	Red
Smokey	Smokey
Tan	Tan
Yellow	Yellow
White	White
Other	Other

Coded value domain
GS_Surface

Description Surface condition
Field type String
Split policy Default value
Merge policy Default value

Code	Description
EX	Exfiolated
PO	Polished

Coded value domain
Lithic_Material

Description Type of material
Field type String
Split policy Default value
Merge policy Default value

Code	Description
Basalt	Basalt material
Chalcedony	Chalcedony
Jasper	Jasper
Obsidian	Obsidian
Milky Quartz	Quartz vein
Clear Quartz	Quartz crystal
Wonderstone	Wonderstone
Sandstone	Sandstone
Metavolcanic	Meatvolcanic
Quartzite	Quarzite

Coded value domain
Lithic_Type

Description Type of lithic artifacts
Field type String
Split policy Default value
Merge policy Default value

Code	Description
Flake	Flake
Biface	Biface flake
Core	Core
Modified	Modified flake
Uniface	Uniface

Coded value domain
Lithic_Fl_Type

Description: Type of flake
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Percussion	Percussion Flaking
Pressure	Pressure flaking
Primary	Primary flaking
Unknown	Unknown

Coded value domain
Milling_Condition

Description: Condition of elements
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Highly polished	Highly polished
Lightly polished	Lightly polished
Polished	Polished
Eroded	Eroded
Exfiolating	Exfiolating

Coded value domain
Milling_Type

Description: Type of milling feature
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Mortar	Mortar
Slick	Slick
Yoni	Yoni
Cuples	Cuples
Mortar & Slicks	Both
Unknown	Unknown

Coded value domain
Point_Type

Description: Type of point
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Clovis	Clovis point
Cottonwood	Cottonwood point
DSN	Derest side-notch
Elko	Elko dart point
Pinto	Pinto point
Unknown	Unknown

Coded value domain
Photographs

Description: Photos taken
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Yes	Yes it was
No	No it wasn't
N/A	N/A
Unknown	Don't know

Coded value domain
Point_condition

Description: Condition of point
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
Base	Base of point
Complete	A complete point
Fragment	Point fragment
Mid-section	Mid-section of point
Tip	Tip of point
Unknown	unknown portion

Coded value domain
Rock_Material

Description: Type of rock
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
GR	Granitic
SC	Schist
SS	Sandstone
LS	Limestone
BA	Basalt

Coded value domain
Site_Type

Description: Time period of site
Field type: String
Split policy: Default value
Merge policy: Default value

Code	Description
PH	Prehistoric
HI	Historic
MO	Modern

Coded value domain
SS_Veg_Code

Description Vegetation codes for
Field type Salton Sea area
Split policy String
Merge policy Default value

Code	Description
AGR	Agriculture
CBS	Sonoran Creosote Bush Scrub
DDWW	Desert Dry Wash Woodland
MCF	Mixed Conifer Forest
MCSC	Mixed Chapparral Scrub Communities
MMWS	Mojave Mixed Woody Scrub
PJW	Pinyon Juniper Woodland
RW	Riparian Woodland
TF	Transition Forest
UNK	Unknown
URB	Urban

Coded value domain
Structure Material

Description Material used for
Field type structure
Split policy String
Merge policy Default value

Code	Description
Brick	Brick
Adobe	Adobe
Wood	Wood
Cement Block	Cement Blocks
Cement Poured	Poured cement
Stone	Stone

Coded value domain
Tool_Material

Description Material of the tool
Field type String
Split policy Default value
Merge policy Default value

Code	Description
Stone	stone tool
Bone	made of faunal material
Wood	made of wood
Metal	Metal tool
Glass	Glass material
Unknown	Unknown

Coded value domain
Tool_Type

Description Type of tool
Field type String
Split policy Default value
Merge policy Default value

Code	Description
Arrow St	Arrow straighter
Awl	Awl
Blade	Blade
Drill	Drill
Hammerstone	Hammerstone
Scraper	Scraper
Chopper	Chopper
Unknown	Unknown

Coded value domain
Res-att_cds

Description Resource Attrribute
Field type Codes
Split policy String
Merge policy Default value

Code	Description
HP1	Unknown
HP2	Single family property
HP3	Multiple family property
HP4	Ancillary building
HP5	Hotel/Motel
HP6	1-3 story commerical building
HP7	3+ story commerical building
HP8	Industrial building
HP9	Public utility building
HP10	Theater
HP11	Engineering structure
HP12	Civic auditorium
HP13	Community center
HP14	Govermenr building
HP15	Education building
HP16	Religious building
HP17	Railroad depot
HP18	Train
HP19	Bridge
HP20	Canal/aqueduct
HP21	Dam
HP22	Lake/river/reservoir
HP23	Ship
HP24	Lighthouse
HP25	Amusement park
HP26	Monument/mural/gravestone
HP27	Folk art
HP28	Street furniture
HP29	Landscape architecture
HP30	Trees/vegetation
HP31	Urban open space
HP32	Rural open space
HP33	Farm/ranch
HP34	Military property
HP35	CCC/WPA property
HP36	Ethnic minority property (list group)
HP37	Highway/trail
HP38	Women's property
HP39	Other
HP40	Cemetery
HP41	Hospital
HP42	Stadium/ sports arena
HP43	Mine structure/ building
HP44	Adobe building/ structure
HP45	Unreinforced masonry building
HP46	Walls/ gate/ fences
AH1	Unknown
AH2	Foundations/ structure pads
AH3	Landscaping/ orchard
AH4	Privies/ dump/ trash scatter
AH5	Wells/ cinterns
AH6	Water conveyance system
AH7	Roads/ trails/ railroad grades
AH8	Dams
AH9	Mines/ quarries/ tailings
AH10	Machinery
AH11	Walls/ fence
AH12	Graves/ cemetery
AH13	Wharfs
AH14	Ships/ barge
AH15	Standing structures
AH16	Other
AP1	Unknown
AP2	Lithic scatter
AP3	Ceramic scatter
AP4	Bedrock-milling feature
AP5	Petroglyphs
AP6	Pictographs
AP7	Architectual feature
AP8	Cairns/ rock feature
AP9	Burials
AP10	Caches
AP11	Hearth/ pits
AP12	Quarry
AP13	Trails/ linear earthworks
AP14	Rock shelter
AP15	Habitation debris
AP16	Other

Coded value domain
Veg_Code

Description Vegetation Code
Field type Short integer
Split policy Default value
Merge policy Default value

Code	Description
1	Shrub
2	Agriculture
3	Herbaceous
4	Desert Shrub
5	Hardwood
6	Barren/Other
7	Hardwood Woodland
8	Conifer Forest
9	Desert Woodland
10	Water
11	Wetland
12	Conifer Woodland
13	Urban