DEMONSTRATING GIS SPATIAL ANALYSIS TECHNIQUES IN A PREHISTORIC MORTUARY ANALYSIS:

A CASE STUDY IN THE NAPA VALLEY, CALIFORNIA

by

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Abstract

This thesis uses a geographic information system (GIS) to demonstrate spatial analysis techniques in order to examine changes to a prehistoric society of Native American Wappo dating from 2450 to 1950 years before present (BP) from the Upper Archaic Period in the Napa Valley of California. This cemetery was excavated by Pacific Legacy Inc., a private cultural resources management firm, in compliance with the National Historic Preservation Act (NHPA) and the California Environmental Quality Act (CEQA) for a flood control project. While Pacific Legacy Inc. analyzed the burials on an individual basis, they did not conduct a spatial analysis. They incorporated their data into a simple spreadsheet to look for patterns. This thesis serves as a complimentary spatial examination of the burials based on spatial data.

The dataset is incomplete as it was not collected using a consistent, systematic methodology. Additional burials related to the dataset had also been removed from the site before excavation by erosion and other archaeological excavations. This paper demonstrates select spatial analysis techniques using this dataset as an example.

This thesis examines the distribution of the burials within the cemetery to identify spatial patterns based on burial attributes and artifact distribution. Spatial autocorrelation, cluster analysis, and grouping analysis focus on identifying burial clusters and individual burial outliers.

A form of interpolation known as kriging was used to estimate the dates for the burials that were not subjected to Accelerator Mass Spectrometry (AMS) Radiocarbon dating. The burials were then grouped into corresponding date ranges covering one hundred year time spans. This experimental study allows for identification of changes to society by analyzing the change in burial attributes and artifact types over the course of the Upper Archaic Period.

Due to the incomplete nature of the dataset, only two conclusions could be reached with the remaining findings considered suggestive. There is clustering based on bone preservation and the spatial analysis results tend to vary depending on different excavation techniques. Possible clustering of depth, wealth diversity index, directly associated shell beads, and directly associated pendants may reflect certain aspects of ancient society. The possible clustering of artifact association, total tools, tool diversity index, indirectly associated bifaces, indirectly associated edge-modified flakes, indirectly associated unifaces, and indirectly associated pestles can likely be explained due to differing excavation techniques. Possible clustering of natural obsidian needles may be explained as naturally occurring in the soil. Dental caries were found to be possibly dispersed, which is likely just a random occurrence. The experimental radiocarbon date interpolation allowed for an examination of changes to CA-NAP-399 over a five hundred year period. Thus results from the analyses in this report should not be seen as definitive nor should they be used as foundations for further archaeological analysis. The main purpose here is to demonstrate how spatial analysis may be used with data of this type.

Disclaimer

Archaeological and other heritage resources can be damaged or destroyed through uncontrolled public disclosure of information regarding their location. This document contains sensitive information regarding the nature and location of archaeological sites which should not be disclosed to unauthorized persons. The exact locations of these cultural resources are kept vague in an attempt to avoid future relocation by those individuals who do not need to know this information.

Information regarding the location, character, or ownership of a historic resource is exempt from the Freedom of Information Act pursuant to 16 U.S.C 470w-3 (National Historic Preservation Act) and 16 U.S.C. § 470hh (Archaeological Resources Protection Act) and California State Government Code, Section 5254.10.

Chapter 1 - Introduction

In 1986 and 1995 the Napa River flooded, causing millions of dollars worth of damage. In order to alleviate future flooding events, a massive new floodwall and holding basin was proposed along with altering the channel of the Napa River. In accordance with the NHPA and CEQA, Pacific Legacy Inc. was contracted to research, study, survey, excavate, and monitor cultural resources related to the construction of the flood control project. Several cultural resources were located within the project's area of potential effects (APE). One cultural resource in particular, CA-NAP-399, proved to be an exceptionally rich and complex site that required extensive investigation and monitoring. During the course of excavation and monitoring for the flood control project, 162 prehistoric Native American Wappo burials were recovered.

The purpose of this research is to demonstrate how spatial analysis might be used with this kind of archaeological data. This large collection of individuals allows a unique examination of a prehistoric society in one location over a period of 500 years. The findings of this research will hopefully demonstrate to other archaeologists the potential usefulness of spatial analysis techniques available in GIS. It may also help expand our understanding of prehistory in the area.

Spatial autocorrelation, cluster analysis, and grouping analysis allow for the analysis of clusters or groups of burials based on certain attributes (such as age, sex, orientation, etc.), artifact types (projectile points, bifaces, shell beads, etc.), and certain pathologies and health anomalies (anemia, osteomyelitis, dental caries, etc.). Burials reflect a deceased individual's place in society (Binford 1971). The experimental use of GIS to gain a rough date of internment for each individual allows for the comparison of different burial attributes and artifacts types over time to see how they changed. This change is reflected in prehistoric society, and will greatly enhance our understanding of prehistory in the area. It will also allow for greater inter-site comparisons in the region.

1.1 Motivation

Several archaeologists have conducted spatial analysis of prehistoric burial populations that spanned thousands of years, such as Bellifemine (1997), Byrd and Monahan (1995), Hudson (1977), Huggett (1997), and Savage (1997) among others. They often looked for patterns or clustering based on age, sex, and status. These studies will be addressed further in Chapter 3. While this is acceptable if examining the entire burial population, it often ignores analysis of burials by time periods or components. This thesis attempts a much finer examination of the burials examining changes over centuries, not millennia.

By identifying the date the individuals were interred on the site, we can gain insight into how site use and prehistoric society changed over time. We can also gain insight into the increasing complexity of prehistoric society. Changes in artifact types over time can give insight into procurement strategies and activities occurring onsite. This will contribute to our understanding of the prehistory of the region.

The actual dating of Native American remains is incredibly rare. This is a rare instance where the Wappo tribe granted permission to study and better understand their past. This is an opportunity that few archaeologists have ever had. It would be folly to let an opportunity like this pass, especially if some greater understanding could be reached.

As discussed later in Chapter 3, using GIS to try to determine the dates of the burials is something that has not been examined in depth. Often GIS is used to produce maps of burials located on sites. Using GIS to conduct spatial analysis is becoming increasingly popular;

however using GIS to conduct prehistoric mortuary analysis seems to have lagged behind other advancements in archaeology. Most mortuary studies still tend to focus on cluster analysis, looking for burials patterns based on age, sex, status, and/or grave goods. There are few examples of studies that use GIS to conduct an intrasite mortuary analysis. This may be from the lack of sites providing a large enough sample of burials to conduct a statistical analysis.

It is hoped this study will lead to a broader examination of burials within California using GIS. This examination and paper is not meant to create an application for burial analysis, but rather create a foundation upon which additional knowledge and insight regarding burial analysis may be built. It should show archaeologists that GIS is a capable tool to compliment burial and mortuary analyses. It is important for archaeologists to recognize incomplete datasets, and to use complete datasets whenever possible. This can be difficult in archaeology given that entire sites are no longer totally excavated. Sites are typically sampled, leaving portions of the site untouched for future archaeologists to excavate and compare with past excavation using newer and more advanced excavation techniques. This can present problems regarding datasets that only sampling can solve.

1.2 Organization of the Thesis

The project and scope of the thesis are presented in the introduction. This report is organized into nine chapters.

Chapter 2 gives information regarding the project background. There are six subsections. The first two give a brief introduction and overview of the study area location and environmental setting. Various cultural chronologies from the San Francisco Bay Area are then presented to give a sense of where the site lies within regional prehistory. A very brief accounting of Wappo ethnography is then given. This is followed by an account of the project history. This chapter is then finished by a brief account of three Native American cultural resource laws and regulations that concern the project.

Chapter 3 provides relevant information concerning archaeology and GIS. There are three subsections. The first deals with mortuary studies in archaeology. The second details several examples of GIS mortuary analysis. The third section gives background on several GIS analysis techniques relevant to this study.

Chapter 4 details information regarding the data and methods used to analyze them. This chapter is divided into three subsections. The first details the collection and digitization of survey data into GIS shapefiles and details its limitations. This is followed by a section that details the burial attribute data. The final section gives a brief overview of the data as a whole, examining the spatial distribution of attributes, artifacts, and pathologies and anomalies.

Chapter 5 details the spatial autocorrelation study based on burial attributes, artifacts, and pathologies and anomalies. The results and implications on prehistoric society are then discussed.

Chapter 6 details the cluster analysis study based on burial attributes and select artifacts. The results and implications on prehistoric society are then discussed.

Chapter 7 details the grouping analysis based on burial attributes. There are two sections within this chapter. The first details the results and implications on prehistoric society followed by the second section where the technique itself is then discussed.

Chapter 8 deals with an experimental study into the interpolation of radiocarbon dates to date the remaining burials. This chapter is divided into three subsections. The first deals with interpolation using cokriging on 21 radiocarbon dates coupled with depth data. The second then compares the burials across five arbitrary one hundred year date ranges to see changes over time for attributes, artifacts, and pathologies and anomalies. The third summarizes the changes seen over time and their possible implications on prehistoric society.

Chapter 9 details the conclusion of this thesis and is comprised of two sections. The first offers suggestions for future analytical work dealing with GIS and mortuary analysis. The second summarizes the findings from CA-NAP-399.

Terms used for archaeology and GIS are found in the glossary. This is followed by a reference section and the appendices. The first appendix presents a table of the burial shapefile attributes. Appendix B discusses several methods of cokriging. It also contains a table that details the prediction errors and accuracy of several possible cokriging methods for the date interpolation model from Chapter 8.

Chapter 2 - Project Background

This chapter presents a general location of the study site, an environmental description of the area, the history of the project, relevant background information concerning the prehistory of the area, and a brief ethnography of the Native American Wappo.

2.1 Project Location

As shown in Figure 1, the project area is located in the Napa Valley in Northern California, some thirty miles north of San Francisco Bay Area and thirty miles east of the Pacific Ocean. The San Francisco Bay Area is a densely populated region surrounding the San Francisco and San Pablo estuaries.

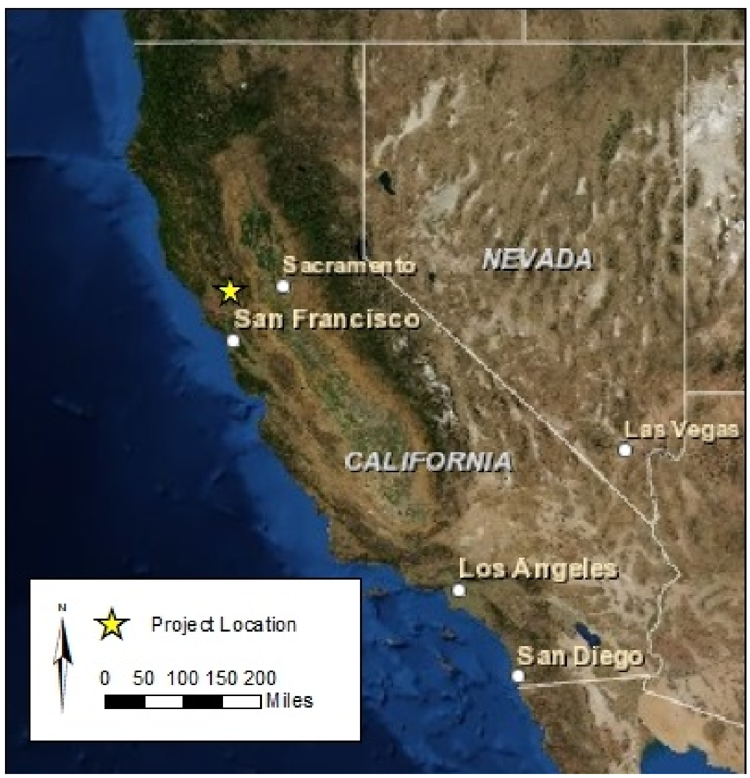

Figure 1: Study Area.

The study site, CA-NAP-399, was originally recorded by Beard in 1976 when it was noticed that human remains were eroding out of the side of the Napa river channel (Beard 1976). The original site record does not mention the size of the site. Shortly after that, the site was leveled for a mobile home park and the site was assumed to have been destroyed. Large boulders were brought in to slow erosion into the riverbank which eliminated visibility. In the 1990's, work to install a storm drain immediately to the west of the cinder block floodwall (which demarcated the western boundary of CA-NAP-399) uncovered human remains. These remains were excavated by Origer (1994) who designated a new site number for the site, still thinking CA-NAP-399 had been destroyed.

The Flood Protection Project focused on a section of the Napa River directly adjacent to a mobile home park (Figure 2). The Flood Protection Project involved creating large holding ponds and a floodwall as well as reengineering the drainage of the river to better accommodate future flood events. The floodwall will protect a larger area from flooding in the future. It will also allow for future development behind the safety of the floodwall. The Flood Protection project was contentious, with many residents viewing it as a waste of money. Residents of the mobile home park were not pleased as several mobile homes were removed and their scenic walking path along the edge of the river was eliminated.

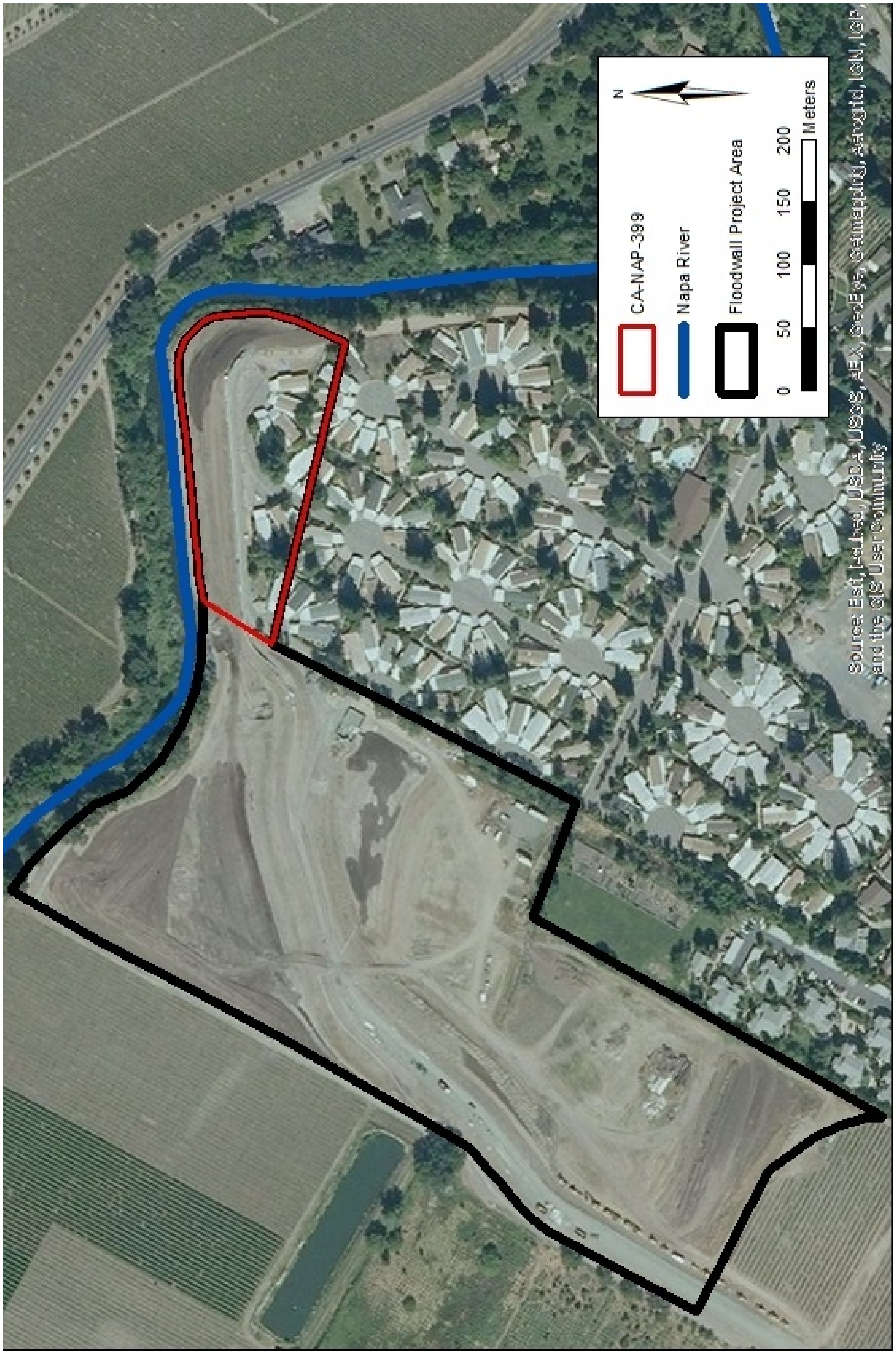

Figure 2: Project Overview.

2.2 Environmental Setting

Napa County is located in the North Coast Range, which is part of the California Coast Ranges. This mountain range is characterized by relatively low mountains. There are several volcanic intrusions in this mountain range. One of the most important is Napa Glass Mountain, part of the Sonoma Volcanic formation, located two miles north of the project area. This was one of the main sources of obsidian for creating stone tools for Native Americans in Northern California.

The Napa River is the dominant drainage for the county. It flows from near Calistoga, several miles north of the project area, south approximately 35 miles to where it forms a delta and enters San Pablo Bay.

There are six distinct vegetation communities in the area consisting of Valley and Foothill Grassland, Oak Woodland, Northern Mixed Chaparral, Coast Range Mixed Coniferous Forest, Alluvial Redwood Forest, and Riparian Forest (Holson et al. 2013). These communities support a wide variety of fish, shellfish, waterfowl, birds, amphibians, and large and small mammals. These were important foodstuffs to the Native Wappo, as were acorns from Oak trees and grass seeds.

2.3 Cultural Chronologies of the Bay Area

The cultural and temporal chronology for the Bay Area and the North Coast Ranges has varied considerably over the years. There are at least three different systems for organizing the archaeology of the Bay Area into coherent units of observation and comparison (Milliken et al. 2007). Which system an archaeologist uses often depends on their academic background. Milliken et al. (2007) gives an overview of the history of the Bay Area. Bennyhoff (1977) provides an examination of archaeological excavations in the Napa Valley up until the date of publishing.

The Early-Middle-Late period nomenclature was created by Beardsley in 1948, and was dubbed the Central California Taxonomic System by Gerow (1968). This is typically used by South Bay archaeologists and some central Bay archaeologists (Milliken et al. 2007).

The Archaic Emergent temporal framework was put forth by Fredrickson (1973) based on earlier work with Bennyhoff (Bennyhoff and Fredrickson 1967). This system relies on specific cultural configurations identified by economic patterns, stylistic aspects, and temporally constricted regional phases (Milliken et al. 2007). According to Milliken et al, this system is used by North Bay archaeologists and some Central Bay archaeologists.

A hybrid system that marks large blocks of time with the Early-Middle-Late Period structure coupled with Fredrickson's system is used by some Central Bay archaeologists including Milliken et al. (2007) who suggest that this has the advantage of allowing the identification of regional aspects within larger cultural patterns.

Table 1 is taken from the Pacific Legacy Inc. templates for the Bay Area, and shows a breakdown of the cultural chronologies of the area. In order to properly understand it, a variety of terms must be defined and are presented in the Glossary. The project area falls into the Napa Valley Cultural Pattern, seen in Table 1. Only aspects and patterns that occur in the project study area are described here in detail.

Table 1: Cultural Chronologies of the Area.

<table>
<tr><th>Temporal Periods (Fredrickson 1973, 1974)</th><th>Temporal Periods (Milliken et al. 2007)</th><th>San Francisco Bay Cultural Pattern</th><th colspan="2">North Coast Cultural Pattern</th><th colspan="2">Napa Valley Cultural Pattern</th></tr>
<tr><td rowspan="2">Upper Emergent (AD 1500-1800)</td><td>Terminal Late Period (AD 1550-1800)</td><td rowspan="5">Augustine Pattern Emeryville Aspect</td><td colspan="2" rowspan="5">Augustine Pattern Clear Lake Aspect</td><td colspan="2" rowspan="5">Augustine Pattern St. Helena Aspect</td></tr>
<tr><td rowspan="2">Initial Late Period (AD 1050-1550)</td></tr>
<tr><td rowspan="3">Lower Emergent or Late Horizon (AD 900-1500)</td></tr>
<tr><td>Middle/Late Period Transition (AD 1000-1050)</td></tr>
<tr><td rowspan="3">Upper Middle Period (500 BC-1050 AD)</td></tr>
<tr><td rowspan="2">Upper Archaic or Middle Horizon (500 BC–AD 900)</td><td>Upper Berkeley Pattern Ellis Landing Aspect</td><td rowspan="3">Houx Aspect</td><td rowspan="3">Mendocino Aspect</td><td rowspan="3">Houx Aspect</td><td rowspan="3">Hultman Aspect</td></tr>
<tr><td rowspan="2">Lower Berkeley Pattern Stege Aspect</td></tr>
<tr><td>Middle Archaic or Early Horizon (3000-500 BC)</td><td rowspan="2">Early Period (3500-500 BC)</td></tr>
<tr><td rowspan="3">Lower Archaic (6000-3000 BC)</td><td rowspan="5">No Defined Pattern</td><td colspan="2" rowspan="3">Borax Lake Pattern Borax Lake Aspect</td><td colspan="2" rowspan="2">Borax Lake Pattern</td></tr>
<tr><td rowspan="3">Early Holocene (8000-3500 BC)</td></tr>
<tr><td colspan="2" rowspan="3">No Defined Pattern</td></tr>
<tr><td rowspan="2">Paleo-Indian (10000-6000 BC)</td><td colspan="2" rowspan="2">Post Pattern</td></tr>
<tr><td>No Defined Pattern</td></tr>
</table>

Paleo-Indian Period

The Paleo-Indian period dates from 12,000 to 8,000 years BP. This period is poorly understood with only one known site being discovered (Meighan and Haynes, 1968). This is likely due to geological processes burying the sites. Isolated artifacts dating to this time period have been discovered and consist of large fluted projectile points called Clovis points, crescent shaped bifaces, and large shouldered projectile points. Fredrickson (1992) hypothesized that the period was characterized by lacustrine sites with a probable emphasis on hunting. There is no evidence of milling technology. Trade and exchange was probably on an individual basis. The primary social unit was likely the extended family. Resources were likely acquired through mobility rather than trade.

Lower Archaic Period

The Lower Archaic dates from 8,000 to 5,000 years BP. Very few sites dating to this pattern have been discovered (again, likely due to geological processes). During this period, the ancient lakes, which had been the subsistence base during the Paleo-Indian Period, began to dry up as a result of climate change. An increased emphasis on plant foods can be inferred by the abundant appearance of milling slabs and handstone/manos (Fredrickson, 1973). Projectile points are typified by concave-base and stemless projectile points. Wide-stemmed points occur in smaller numbers. Fredrickson (1992) stated that the family unit continued to be the main primary social unit.

Borax Lake Pattern

The Borax Lake Pattern is difficult to categorize given the low number of sites excavated. The material culture appears to be identical to the Lower Archaic Period description given above. It is assumed this pattern occurs in the Napa Valley, only it is buried under more recent geological deposits.

Middle Archaic Period

The Middle Archaic Period dates from 5,000 to 2,500 years BP. This time period is much more widely known than the previous two time periods (Milliken et al. 2007). The mortar and pestle appear during this pattern. Population growth increases. Projectile points are typified by large leaf shaped dart points, shouldered projectile points, and bipoints. Deer ulna bone awls and flakers are also common. Obsidian quarries create an industry for biface trade to neighboring areas across the state. The Berkeley Pattern represents the expansion of Miwokian speakers into the North Bay at approximately 500 BC (Bennyhoff 1968).

Houx Aspect

The Houx Aspect is believed to be indigenous to the Clear Lake area, while the Mendocino Pattern was intrusive to the region (White and Fredrickson 1992; White 2002). Mortars and pestles appear replacing the milling slab assemblage. This indicates a dependence on acorns. Ulna awls and flakers appear, indicating possible basketry. Atlatl dart projectile points consist of leaf shaped projectile points. Shouldered bifaces and bipoints are also present.

Hultman Aspect

The type site for the Hultman aspect is located one mile upstream from the project area. This aspect is characterized by milling slabs and mullers with no beads. This southern aspect of the Mendocino Pattern utilized obsidian for atlatl dart points that were leaf shaped. This differs from the more northern portions of the pattern which relied more heavily on chert material and corner-notched projectile points.

Upper Archaic Period

The Upper Archaic Period dates from 2,500 to 1,100 years BP. The expansion of settlements coupled with population growth continued. Fredrickson (1974:48) suggested that the Upper Archaic Period "seems to have been marked by ever increasing socio-political complexity, a growth of status distinctions based on wealth, the emergence of group-oriented religious activities, and greater complexity of the exchange systems." Stone tools continue to be dominated by large leaf shaped projectile points and shouldered projectile points. Deer ulna bone awls, mortars, and pestles continue to be plentiful. There is also an increase in *Olivella* beads, abalone ornaments, and incised bone. The large obsidian biface manufacturing industry collapses throughout California around 1,800 years ago.

Emergent Period

The Emergent Period dates from 1,100 to 200 years ago. Prehistoric cultures throughout California "reached levels of sociocultural complexity usually considered correlates of agricultural societies" (Fredrickson 1973:38). The emergence of the bow and arrow technology some 1,500 years ago meant a shift away from larger dart points to smaller arrowheads. Early arrowheads called Stockton Serrated had numerous square barbs running up each margin. These were replaced around 900 years ago by small, triangular, corner-notched projectile points. Well shaped mortars and pestles are prevalent.

Augustine Pattern

The Augustine Pattern arose through stimulation from Patwin speakers newly arrived in the lower Sacramento Valley from Oregon (Milliken et al. 2007). It is believed that they brought with them the bow and arrow, the flanged pipe, preinternment grave-pit burning, and other new cultural traits (Bennyhoff 1982). It is difficult for linguists to explain how so many varying tribes in the Bay Area speaking different languages were able to share such a similar material culture. Milliken et al. (2007) hypothesized that the Augustine Pattern, with its shared religious and ceremonial organization, was developed as a means of overcoming insularity in an area where many neighboring language groups were in contact.

St. Helena Aspect

The St. Helena Aspect is characterized by small serrated arrow points called Stockton Serrated projectile points. These are replaced by small corner-notched points with few to no serrations towards historic times. Well shaped mortars and pestles are present. Bone awls likely indicate basketry, as does the presence of hopper mortars. Tubular tobacco pipes are common. There in an increase in the number of ornamental objects and beads created from shell, stone, and bone.

2.4 Wappo Ethnography

It is important to use ethnographic data as the starting point for any analysis (Larsen 1997). The project area lies in the ethnographic territory of the Native American Wappo. Wappo is a name likely derived from the Spanish term *guapo*, which means "brave or good looking" (Kroeber 1925:217). This name was most likely given to the Wappo during the Mission Period (the late 18th and early 19th centuries) since the group was well known for their strong resistance to Spanish and Mexican incursions within their territory (Driver 1936; Kroeber 1925). The Wappo call themselves *ona-cáttis,* "the people who speak plainly and truthfully, the outspoken ones" (Sawyer 1978:263)

The ethnographic Wappo are composed of five linguistic subdivisions (the Southern Wappo, Central Wappo, Northern Wappo, Western (or, Russian River) Wappo, and Clear Lake Wappo) that are part of the Yukian language family (Kroeber 1925). Wappo linguistic subdivisions are further subdivided by a mosaic of hunter-gatherer tribelets. A tribelet is the largest autonomous or self-governing political unit for California hunter-gatherers and consists of a single permanent village which serves as a sociopolitical center (Kroeber 1955). This sociopolitical center is composed of several coalesced lineages, and was surrounded by a network of smaller satellite villages (Kroeber 1955).

As recorded by early ethnographers such as Barrett (1908), Driver (1936), and Kroeber (1925), the territory of the Wappo was unusual in that it was discontinuous and included portions of several drainages (see Figure 3). The primary area of settlement was the Napa Valley. Their territory stretched from near present-day Geyserville on the Russian River in the northwest to the delta of the Napa River at San Pablo Bay in the southeast (Kroeber 1925).

Subsistence was based mainly on plant resources and was supplemented by animal resources. Acorn was the primary plant resources. It was stored for use throughout the year, and prepared as either a mush or bread. Several other plant resources supplemented the acorn staple such as buckeye, various plant roots, and berries. Small game such as rabbits was the most plentiful animal resource in the area, and was supplemented by larger game such as deer whenever possible. Fish was an occasional resource as well, but did not reach the level of fishing industries seen in the Pacific Northwest tribes with their Salmon fishing.

The Wappo settlement system was semi-sedentary with large permanent or semi-permanent villages that were situated near fresh water sources and in environments with diverse and abundant resources (Kroeber 1955). In the areas surrounding these villages, task specific seasonal camps were distributed near specific resources. According to Driver (1936:183), primary village sites were "occupied continually throughout the year and other sites were visited in order to procure particular resources that were especially abundant or available only during certain seasons."

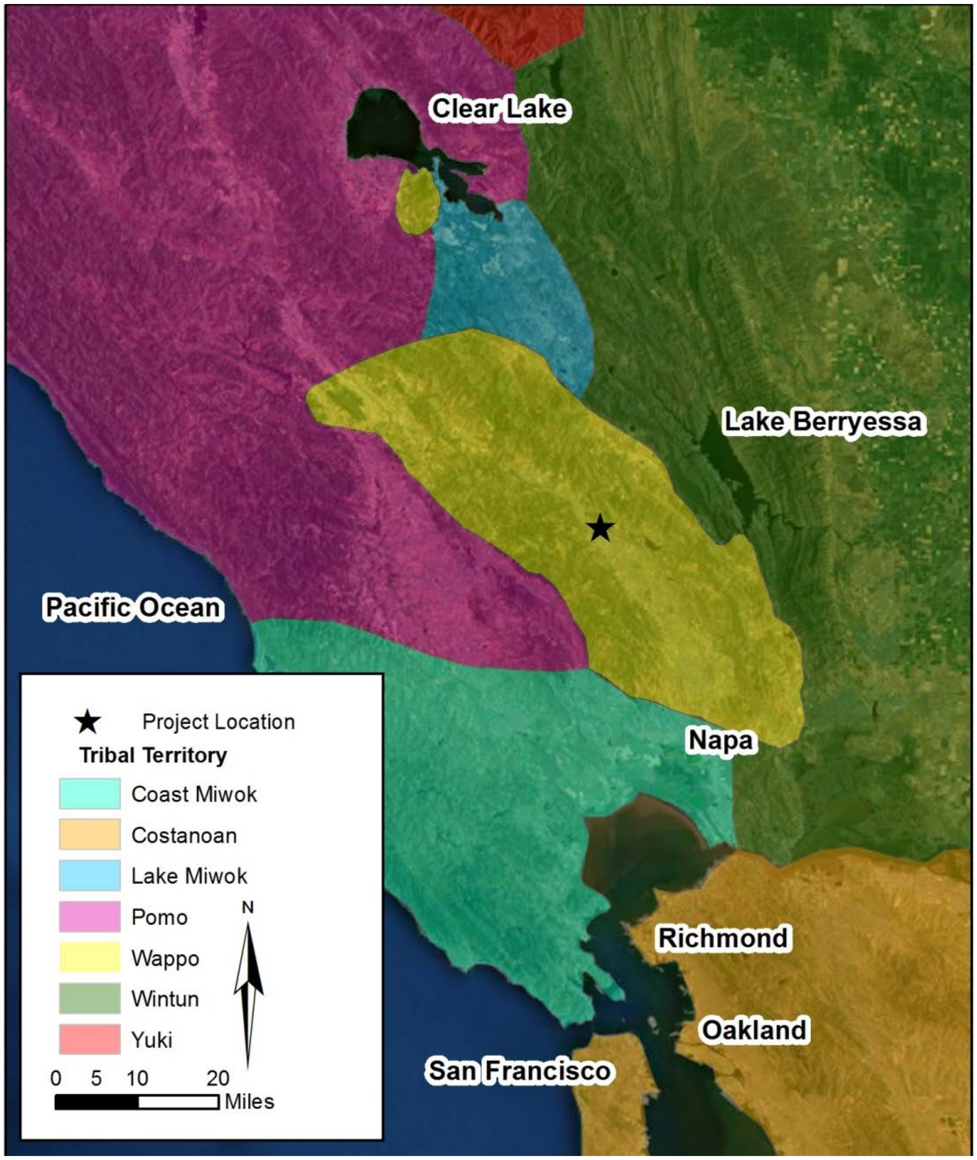

Figure 3: Tribal Territory.

The sweathouse seems to have been the primary factor in the organization of the village. The sweathouse was located centrally within the village and its entrance always faced south (Driver 1936). Dwellings were placed around the sweathouse but were not laid out in a geometric form. Both the sweathouse and dwellings were semi-subterranean. The sweathouse structure was constructed more substantially out of planks and posts, while the dwellings were constructed of grass thatch and poles (Driver 1936). Summer houses were more temporary, built on the ground surface with poles, thatch, and open ceilings.

The basic unit of Wappo social structure was the immediate bilateral kin group (Driver 1936). The largest unit of effective organization was the village community. Villages were led by a chief who fulfilled "four offices or functions: 1) war chief; 2) home chief; 3) dance or ceremonial chief; and 4) news-man or town crier" (Driver 1936:212). A different person could fill each of these functions, but often a single chief fulfilled all four. The position was almost always filled by a man even though there were women who also filled similar roles (Driver 1936). The Wappo had little specialization in terms of occupation and even chiefs were expected to hunt and fish to feed their families. However, that little specialization included occupations such as doctors, specialized ceremonial positions, and specialized craft artisans that may have been learned through apprenticeships (Driver 1936).

The territory occupied by the Wappo was rich in desirable resources, particularly in raw materials for stone tool manufacture such as obsidian. Obsidian sourced to the Napa Valley has been found at archaeological sites throughout Central and Northern California. The Wappo were obviously an important part of a regional trade network, however the exact nature and operation of this network is not completely known. Trade was conducted through contact with neighboring tribes or travel through their territory.

Kroeber (1925) stated there are no specific descriptions of Wappo habits regarding burials, though he suggested they resemble those of the Pomo who practiced cremation of the deceased. Driver (1936) elaborated, stating that there was no tribal mourning ceremony or public tribute. He goes on to briefly recount what happened to the body after a death. The individual was carried on three sticks by six men one to two miles outside of the village, and then cremated with their possessions in a pit dug approximately two feet deep (Driver 1936). The ethnohistoric account of cremations does not necessarily indicate that the same practice was used in earlier prehistoric times. Burial practices can shift over time.

2.5 Project History

Pacific Legacy (2013) detailed the history of the project. An abbreviated account is presented below.

Floods in 1986 and 1995 overtopped existing flood control structures along the Napa River, resulting in over $50 million in damages. A collaborative effort by the City of St. Helena with the Napa County Board of Supervisors and the Napa County Flood Control District performed a joint study of the Napa River to better understand the hydraulics of flood flows. The study's conclusions resulted in the enlargement of the 100 year flood plain indicating a more serious flood hazard than previously established by the Federal Emergency Management Agency (FEMA).

FEMA awarded a grant to the city of St. Helena to study potential ways to reduce damage from future flooding. A number of possible projects from this study were evaluated over the next three years. A final project design and environmental impact report was finalized in February 2004. Pacific Legacy Inc. was then hired by the City of St. Helena to assist in managing any cultural resources within the project area. An addendum was adopted in November 2005 addressing several design changes. In April 2006, a shortage of funds was identified, necessitating further revisions to reduce costs.

A Historic Properties Treatment Plan (HPTP) was created by Pacific Legacy Inc. outlining a program of archaeological excavation and analysis that fulfilled the research potential of cultural resources within the Area of Potential Effects (APE). A Memorandum of Agreement (MOA) between the State Historic Preservation Officer (SHPO), United States Army Corps of Engineers (USACE), and State Water Resources Control Board (SWRCB) was signed in March of 2007. The City of St. Helena and the Mishewal-Wappo Tribe of Alexander Valley were concurring parties to the MOA.

The entire APE was subjected to an extended archaeological survey (Bartoy and Holson 2005). As a result of the survey, eight archaeological resources were identified within the APE. These eight resources were formally evaluated by Bartoy et al. (2005). Three resources (including CA-NAP-399) were determined eligible for listing on the California Register of Historical Resources (CRHR) and the National Register of Historic Places (NRHP). A fourth was determined to not have enough information by the State Historic Preservation Officer (SHPO) and further excavation was recommended.

The SWRCB and USACE applied the criteria of effect found within the Federal Register at Title 36 of the Code of Federal Regulation (CFR), Chapter VIII, Part 800 (the protection of historic properties) Section 5 (a) (1) and determined that the flood protection project would result in significant adverse effects to the three eligible cultural resources. Requirements for these environmental laws are found in Section 2.6. The SHPO agreed with the findings of adverse effects, and recommended continued consultation regarding the fourth site. Under the implementing regulations for Section 106 at 36 CFR § 800.6, the SWRCB and USACE consulted on ways to avoid, minimize, or mitigate the potential adverse effects to the cultural resources. This lead to the signing of the MOA with SHPO.

The SWRCB and USACE elected to conduct Phase III archaeological data recovery excavations at the resources prior to their disturbance. Phase III data recovery excavation is the controlled excavation of a sample of the site designed to recover a representative sample of artifacts to allow for detailed analysis. The justification for implementing and funding archaeological treatment measures at the cultural resources within the APE is founded on SWRCB's and USACE's commitment to comply with Section 106 of the NHPA of 1996 (amended 2006). The HPTP was prepared to provide a cost effective and time-efficient approach for completing archaeological data recovery excavations for the cultural resources within the APE. The HPTP was based on a sampling strategy in which site areas with the greatest data potential within the APE are targeted for archaeological data recovery. Less archaeological investigations were expended on site areas that were already compromised by previous disturbances and/or those that demonstrated a low archaeological data potential. However, the City of St. Helena was committed to archaeological monitoring during all grading and data recovery if new and relevant data was exposed during ground disturbing activities.

The Mishewal-Wappo Tribe provided a Native American monitor for the Phase III data recovery effort, as well as all monitoring activities. Additionally, the Mishewal Wappo Tribe of Alexander Valley and the client developed a burial agreement for the treatment of human remains found as a result of construction or construction related activities associated with the project.

Phase III data recovery excavations began in the summer of 2007 and proceeded for three months. A Native American monitor was present at all times. The data recovery excavation produced over 190,000 artifacts from roughly 60 cubic meters of soil. Three of the excavation units from the Phase III data recovery in 2007 encountered human remains. In accordance with protocol, the County coroner was called for the first incident. He accepted that the burials were Native American as they were within a prehistoric context, and ceded control over to Pacific Legacy Inc. The Native American Heritage Commission was contacted, who appointed a most likely descendent from the Mishewal-Wappo to oversee how the burials were handled.

Fieldwork for the archaeology monitoring operations began in September 2007 and ended in December 2007. The site then sat idle for over a year as budget issues and public protest prevented any further activity. Work resumed in June 2009 and continued intermittently through November 2010.

Heavy machinery such as backhoes and excavators worked in small, irregular sections of the site. These sections were called surface scrapes, and were typically irregularly shaped polygons measuring several meters by several meters. The heavy machinery would systematically remove soil in a controlled manner until sterile soils beneath the cultural deposit were reached. One archaeologist and a Native American monitor closely monitored inside the surface scrape watching the excavation activities, while another archaeologist raked through the back dirt looking for human remains. A representative sample of artifacts located onsite were collected in a controlled manner during Phase III data recovery. Monitoring operations focused on the recovery of human remains.

This method of excavation resulted in the discovery of some burial pits, but also destroyed the stratigraphic relationships that might have existed across the site. Because they were not excavated in a controlled manner (in which the particular stratigraphic layer into which they had been cut originally, if preserved, would have been carefully documented) recovery of any extant archaeological data that might have informed archaeologists about the relative dating of the burials was lost. Further, any artifacts directly over the burials would have been removed as well and their association lost.

When a burial or feature was encountered, it was numbered and the machinery would move to another surface scrape to continue working. Excavation of the feature might take place a few days after discovery depending on the backlog of features to excavate and record. Archaeologists would record the location and depth of the finds using a transit (theodolite) and stadia rod. Data was recorded relative to the main site datum located in the eastern portion of the site directly on top of the proposed floodwall. Several sub datums were also used across the site to gain better visibility for shots.

A reading was taken on top of the skull (as this was generally the highest point for the burial) and the bottom of the grave using the stadia rod viewed through the theodolite. A trained osteologist would work to excavate and expose the burial and record as much information as they needed in situ. This included the age, sex, burial flexure, orientation, and any associated artifacts. The burial would be drawn and photographed, then carefully lifted and taken to the laboratory at the Berkeley location of Pacific Legacy Inc. where a more thorough examination would take place.

There were a total of 163 numbered burials. Burial 162 ended up not being human and the number was discarded. This left 162 individuals that were recovered from the site. Burials were labeled in order of discovery. Unfortunately five individuals were entirely removed and deposited in the back dirt and sadly have only a rough provenience associated with them. A rough placement in the stratigraphic profile was noted. All five fell within the range of the other burials and were not considered outliers by depth.

These five were not considered for the analysis but they were located within the burial area with the other burials. Figure 4 shows the locations of the burials within CA-NAP-399. The burials are confined to the northwest corner of the site in an area roughly 120 meters east/west by 30 meters north/south.

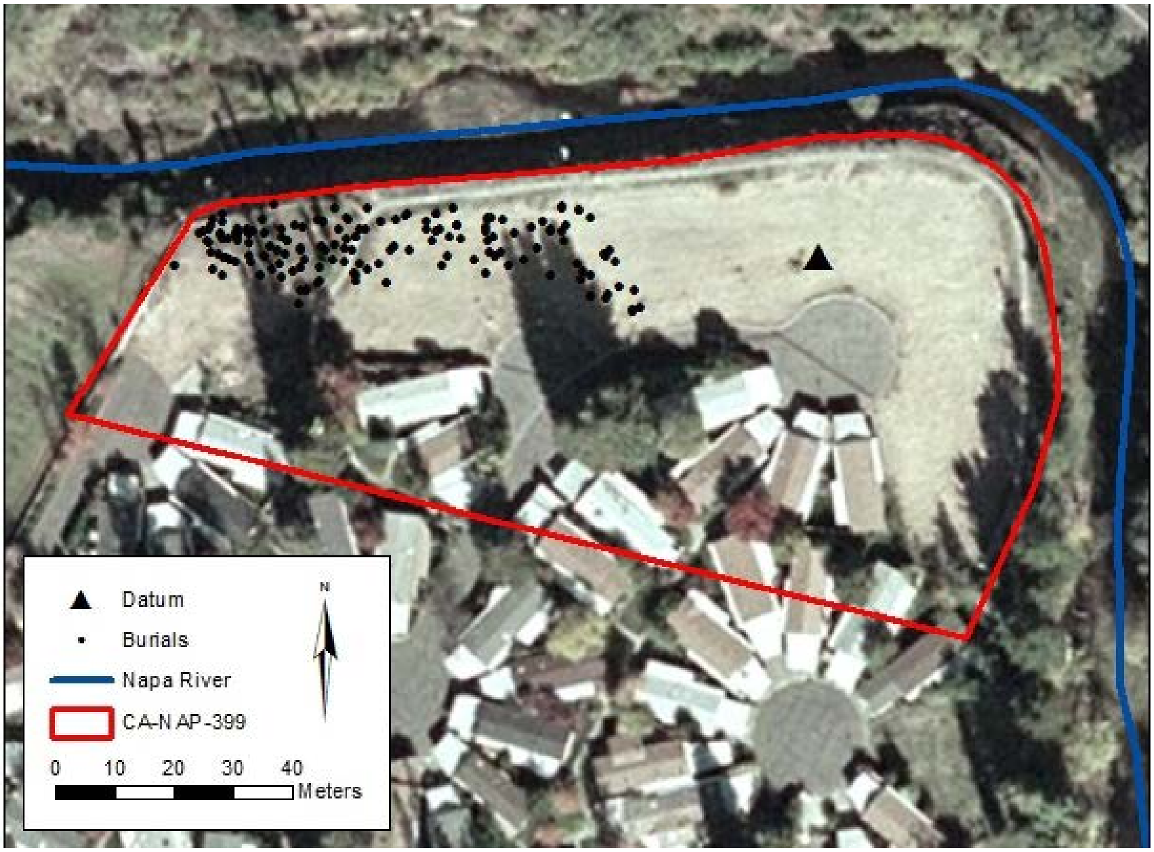

Figure 4: CA-NAP-399 Overview.

Figure 5 shows the burial numbers, labeled in order of discovery. 153 out of the remaining 157 burials have depth data. Two of the last burials were recorded quickly and the depths were not properly recorded. Depth data for Burial 97 was illegible. Depth data for Burial 42 was inconsistent, and had to be ignored.

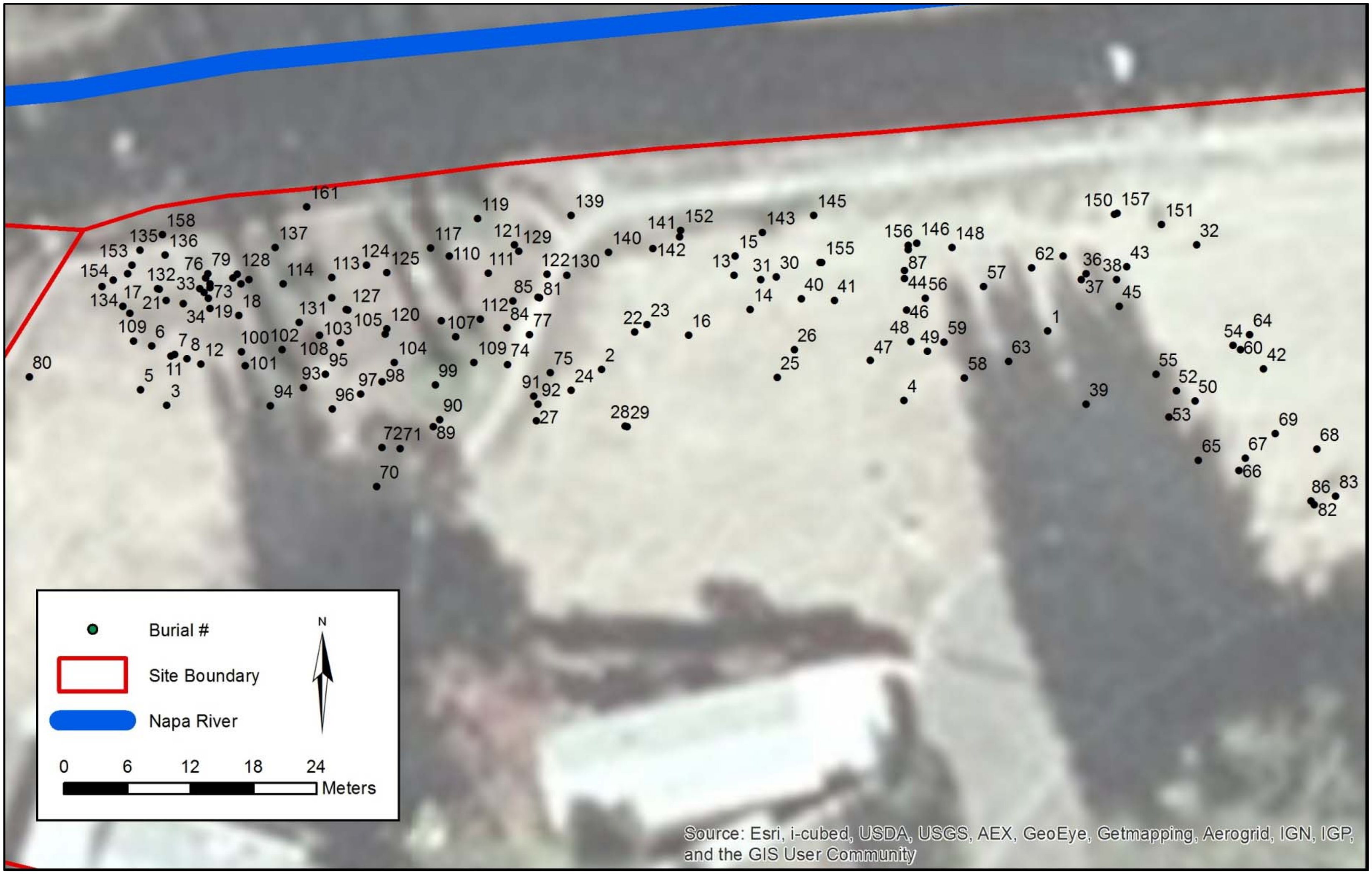

Figure 5: Labeled Burials

The 157 individuals studied in this analysis are part of a larger population. The burials that were recovered from the site immediately to the west during the mid 1990's by Origer are likely cotemporaneous with the majority of those from CA-NAP-399. An untold of number of individuals could also have been eroded out of the site by the Napa River. Other individuals could have completely decomposed. There could also be more burials underneath the mobile home park to the south. This means the dataset used for the spatial analysis later in the paper is incomplete.

It is unlikely we will ever know the total number of individuals who were interred on this site. When conducting a spatial analysis it is important that all the points be used. Unfortunately, this is not possible due to a number of circumstances. This paper analyzes the 157 individuals who have solid spatial information associated with them. Please keep in mind that if the other burials were also a part of this analysis, some of the spatial statistics results may have been different.

Analysis of the burials and the related artifacts occurred in 2011 and 2012. The laboratory examination provided a more in-depth and thorough analysis of burials (Holson et al. 2013). The age and sex of the individuals were verified. Any health pathologies and abnormalities were examined. An extensive look into the life of the individual occurred. Their past health issues could be determined as could some of their activities in life. Most of the musculature attachments to the bone were very large indicating very strong muscles, likely from having to continually hike over the North Coast Range. Many individuals also showed signs of anemia.

Artifacts recovered from the burials were catalogued and examined. Those artifacts found directly associated with the individuals were called *directly associated artifacts*. Due to the richness of the site, other artifacts were also recovered from the soil matrix (midden) surrounding the burial. These artifacts may or may not be related to the burials, and are termed *indirectly associated artifacts*.

All the Native American remains and artifacts recovered from burial contexts were repatriated and reburied near CA-NAP-399 in spring of 2012. This was done in accordance with the Native American Graves and Repatriation Act. A small ceremony was held with members of the Wappo tribe overseeing the reburial. The burial was on public land which allows the modern Native Wappo access to their ancestors.

2.6 Native American Laws and Regulations

The North American Graves and Repatriation Act (NAGPRA) is a federal law that was passed in 1990 (National Park Service, 2013). This provides a process for museums and federal agencies to return certain Native American cultural items (human remains, funerary objects, sacred objects, or objects of cultural patrimony) to lineal descendants and culturally affiliated Indian tribes and Native Hawaiian organizations. NAGPRA laws and regulations are available online at http://www.nps.gov/nagpra.

The National Historic Preservation Act (NHPA) was passed in 1966 and created the National Register of Historic Places (NRHP), the list of National Historic Landmarks (NHL), and the State Historic Preservation Offices (Advisory Council on Historic Preservation, 2013). NHPA requires federal agencies to consider the effects of proposed federal projects on historic properties. Federal agencies must initiate consultation with the State Historic Preservation Officer (SHPO) as part of the Section 106 review process. CFR 800 is available online at www.achp.gov/regs-rev04.pdf.

The California Environmental Quality Act (CEQA) was passed in 1970 (California Natural Resources Agency, 2013). Part of CEQA requires state and local government agencies to consider the environmental consequences of projects over which they retain discretionary authority even after and environmental impact report have been certified. Cultural resources management falls under the purview of the environmental impact reporting. Statutes and guidelines concerning CEQA are located online at www.ceres.ca.gov/ceqa/docs/CEQA_Handbook_2012_wo_covers.pdf.

Chapter 3 - Literature Review

In order to understand the analysis of the burials presented in this thesis, one must have an understanding of the context in which this research exists. Relevant information regarding archaeology and GIS are presented below, as are applicable studies incorporating the two fields of study.

3.1 Mortuary Studies in Archaeology

Archaeology is the study of human culture through the physical remains it leaves behind. While not an exact science, it often relies on subjective observations based on ethnographic data to interpret the past. A variety of terms are used in this thesis that, while familiar to archaeologists, may be unknown to other individuals reading this paper. Archaeological terms and their definitions are presented in the Glossary section at the end this paper.

The analysis of deceased individuals and their burials has been one of the most widely studied aspects of archaeology. A burial is defined as the result of a series of ritualized practices performed in relation to death (Fahlander and Oestigaard 2008).

The views regarding mortuary analysis have changed with the different paradigms of archaeology over the last century. The cultural-historical paradigm championed by Kroeber in the 1920s saw burials as “unstable, varying independently of biological social behaviors, and that the level of similar or multiple practices among independent sociocultural units was the result of cultural mixing, hybridization, or of generic or affiliational cultural relationships” (Bellifemine 1997:10-11 summarizing Kroeber 1925). Binford (1971) refuted this view based on his comparative ethnographic study of 40 societies where he found that burials reflected patterns found in society.

A traditional perspective that remains in use today still regarding mortuary analysis is based on the premise that disposal of the dead by ancient societies reflected patterns inherent in society which reflected the social position of the individual (Binford 1971, Saxe 1970, Brown 1971, Chapman et al. 1981, Fahlander and Oestigaard 2008). This is highlighted in the Binford-Saxe Model, named for two researchers whose work has guided mortuary analysis for the past fifty years.

In the last decade, a new way of conducting mortuary analysis has gained popularity called bioarchaeology. Bioarchaeology focuses more on the individual as it creates a narrative of an individual's life, and interprets their place in society. It has also been termed osteobiography. For a more comprehensive overview of mortuary analysis refer to Brown (1971), Chapman and Randsborg (1981), Chapman et al (1981), Goldstein (1981), and O'Shea (1984).

The Binford-Saxe Model

Saxe (1970) formulated a theoretical framework that argued mortuary practices could be analyzed in the context of social systems. Saxe created three terms that form the foundation of his study: social identity, identity relationship, and social persona. Social identity is "a category of persons or what has been called a social position or status" (Saxe 1970:4). Identity relationship is "when two or more social identities are engaged in a social relationship" (Saxe 1970:4). Social personae are "a composite of several social identities selected as appropriate to a given interaction" (Saxe 1970:7). Saxe proposed that different types of social organizations with different sets of social relationships would evidence different sets of disposal treatments. Saxe created his theoretical framework in the form of eight hypotheses.

Hypothesis 1 states "that the components of a given disposal domain cooperate in a partitioning of the universe, the resultant combinations representing different social personae" (Saxe 1970:65). Components are any unidimensionally scaled value of a variable in mortuary practices that reflect social personae differently (Saxe 1970). This means that social personae are symbolized by differences in mortuary practices (Bellifemine 1997).

Hypothesis 2 states "in a given domain, the principles organizing the set of social personae (produced by cooperative partitioning of the universe of disposal components) are congruent with those organizing social relations in the society at large" (Saxe 1970:66). For egalitarian societies, differences are based on age, sex, and/or personal achievements while in non-egalitarian societies differences are based on ascription (Bellifemine 1997).

Hypothesis 3 states "within a given domain personae of lesser social significance tend to manifest fewer positive components in their significance relative to others, and conversely" (Saxe 1970:69). This means the higher the social status, the higher the number of burial components (i.e. grave goods).

Hypothesis 4 states "the greater the social significance of the deceased the greater will be the tendency for the social personae represented at death to contain social identities congruent with that higher position at the expense of other (and less socially significant identities) the deceased may have had in life, and conversely" (Saxe 1970:71). This hypothesis focuses on the content of the social personae rather than the number of components (Saxe 1970). Positions of greater social significance will involve more groups and exhibit greater privilege according to Saxe. Aspects of being a kin group member or great hunter for example, might be suppressed as compared to attributes relevant to being chief of the tribe.

Hypothesis 5 states "the more paradigmatic the attributes evidenced in the key structure of the domain, the less complex and more egalitarian the social organization. Conversely, the more tree-like the attributes, the more complex and the less egalitarian the social organization" (Saxe 1970:75). Bellifemine (1997) summarized this by stating the greater the independence of the burial attributes, the more egalitarian the society; while the greater the number of correlations found among burial attributes, the more hierarchal the social organization.

Hypothesis 6 states "the simpler a sociocultural system the greater will be the tendency for there to be a linear relationship between number of components in *significata*, number of contrast sets necessary to define them and the social significance of the *significata*; and conversely" (Saxe 1970:112). In egalitarian societies there are opportunities for many to attain high status, while in a highly stratified society the individual with the highest rank may be unique (Bellifemine 1997).

Hypothesis 7 states "the simpler the sociocultural system the less divergence will be evident in the treatment of different kinds of deviant social personae, and conversely" (Saxe 1970:118). This states the relationship between the complexity of a society and the degree of differentiation in the treatment of different kinds of individuals such as the disabled, deviants, and the sickly (Bellifemine 1997).

Hypothesis 8 states "to the degree that corporate group rights to use and/or control crucial but restricted resources are attained and/or legitimized by means of lineal descent from the dead (i.e. lineal ties to ancestors). Such groups will maintain formal disposal areas for the exclusive disposal of their dead" (Saxe 1970:119). This hypothesis moved into causality in describing economic and/or ecological reasoning for burial areas (Bellifemine 1997).

Goldstein (1981) examined the negative connotations behind Hypothesis 8 through empirical testing, and demonstrated that the hypothesis does not work in both directions. She found that not all corporate groups that control crucial and restricted resources through lineal descent will maintain formal and bounded disposal areas for their deceased. Goldstein restated Hypothesis 8 in three separate but related sub-hypotheses. The first is that if a corporate group controls or uses a restricted resource through lineal descent from the dead, they will regularly reaffirm the lineal corporate group by the popular religion and its ritualization. The second is if a permanent or specialized bounded area for the exclusive disposal of the groups dead exists, then it is likely that this represents a corporate group that has rights over restricted resources by means of lineal descent linking the corporate group to the dead. The third is that the more structured and formal the disposal area, the fewer the alternative explanations of social organization that may apply, and conversely.

Binford (1971) conducted an ethnographic study of 40 societies regarding their burial practices and refuted the cultural-historical paradigm. He suggested that two components should be evaluated. The first is social persona (a composite of the social identities maintained in life and recognized as appropriate for considerations at death) and the second is the composition and size of the social unit recognizing status responsibilities to the deceased.

Binford (1971) set forth three characteristics for the funerary treatment of the individual. The first characteristic is body treatment, which involves the preparation of the body, form of disposal, and disposition of the body. The second is grave preparation, which includes the form, orientation, and location of the grave. The third is grave furniture, which consists of the furniture (different types of grave goods), the quantity, or a combination of both.

Binford (1971) put forth three propositions regarding burials, as follows:

Proposition 1 states that “there should be a high degree of isomorphism between (a) the complexity or the status structure in a sociocultural system and (b) the complexity of mortuary ceremonialism as regards differential treatment of persons occupying different status positions” (Binford 1971:18). This states that the more complex a society, the more complex the mortuary treatments.

Proposition 2 states that “there should be a strong correspondence between the nature of the dimensional characteristics serving as the basis for differential mortuary treatment and the expected criteria employed for status differentiation among societies arranged on a scale from simple to complex” (Binford 1971:19). This proposition states that simpler societies should have mortuary treatments based on physical characteristics such as age, sex, and personal achievement while more complex societies base their mortuary treatments on more abstract thoughts (Bellifemine 1997).

Proposition 3 states that “the locus of mortuary ritual and the degree that the actual performance of the ritual will interfere with the normal activities of the community should vary directly with the number of duty status relationships obtaining between the deceased and other members of the community (scale of identity)” (Binford 1971:21). This proposition states that older adults who have a high number of intra community relationships will be buried in a more central location than those with less relationships (such as children and infants).

Binford (1971:25) concluded that “variation among cultural units in frequencies of various forms of mortuary treatment vary in response to (a) the frequency of the character symbolized by the mortuary form in the relevant population and (b) the number and distribution of different characteristics symbolized in mortuary treatment as a function of the complexity and degree of differentiation characteristic of the relevant society."

The unified Binford-Saxe research approach has become the framework in modern mortuary analysis. It has also created a basic foundation for the construction of larger arguments concerning mortuary analysis (see O'Shea 1984, Brown 1995).

Bioarchaeology

Bioarchaeology shifts away from the Binford-Saxe Model by focusing on an individual and their place in society. This is because the Binford-Saxe Model seldom focuses on individuals. Populations are comprised of individuals, and those individuals provide a rich source for developing an informed understanding of the lives, lifeways, and lifestyles of ancestors (Stodder and Palkovich 2012). Bioarchaeology looks at diet and nutrition, health and disease, demography, physical behavior, and lifestyles in the past (Larsen 1997). This essentially writes a narrative of an individual.

Skeletal remains represent the majority of burials recovered across the globe. The skeleton can provide a wealth of knowledge to the eye of a trained osteologist. Chemical analysis of tooth enamel can reveal where an individual was born and where they moved to. Repetitive motions can build muscle mass, increasing the size of the musculature attachment to the skeleton. Previous injuries can give an insight into levels of interpersonal violence in society. Those individuals who suffered from severe bone infections and even amputations can be shown to have relied on the compassion of their family and community to stay alive as long as they did.

This author is not a trained osteologist so there will be no bioarchaeology analysis in this study. It is mentioned here for the sake of completeness. Larsen (1997) offers a comprehensive overview regarding bioarchaeology. Stodder and Palkovich (2012) collect a series of osteobiographies telling the narratives of deceased individuals from across the globe. Goldstein (2008) provides an overview of modern trends in bioarchaeology.

Other Studies

While the Binford-Saxe model forms the foundation of modern mortuary analysis, and bioarchaeology is increasing in popularity, there are many other approaches that give specific insights into mortuary analysis. A brief discussion of a few such relevant works follows.

Brown (1981) focused on the issue of rank in prehistoric burials which is one of the most widely studied aspects of mortuary analysis. He distinguished between social rank, power, and authority as they seem to operate independently in small scale societies. These are related to the material world using the Binford-Saxe Model. Brown stated that three arguments can be employed to translate the archaeological record into forceful statements about the organization of prehistoric groups. The Effort-Expenditure argument is that the greater the social rank of the deceased, the greater the expenditure of energy (and wealth) in the internment. The Symbol of Authority argument is that the disposition of symbols of authority among the deceased will indicate the composition of the group within which authority is normally vested. The Age/Sex Distribution argument is that normal populations should exhibit an equal ratio between sexes; any deviation from this ratio can be seen as an indication of differential internment.

Brown also laid out three pitfalls that may await an archaeologist conducting a mortuary analysis. The apical social order may be missed if there are not enough levels in society to form distinctions between levels. Symbols of authority may not be identified by the archaeologist, their meaning lost to time. Complex burial processing may also create false impressions of disposal programs. Implications for this study from Brown's three pitfalls involve there not being a great deal of understanding about the levels of social order during the Upper Archaic. Only broad generalizations regarding increasing complexity are mentioned with no obvious examples given. Symbols of authority may only be recognized as utilitarian artifacts or wealth goods, their meanings as symbols of authority lost over time. Most of the burials at the site were buried very similarly, so there really was no false impression of disposal systems.

O'Shea's (1984) seminal work covers a large portion of burial analysis, but it is his insights into variations among burials that are relevant to this paper. Variation in the organization and content of a society's funerary treatment program can be summarized in terms of two basic types of change: the manner in which a particular distinction is expressed through the funerary ritual or the social positions that are marked or emphasized in the ritual. Variation is the symbolic expression of social distinctions which may arise as a result of three basic forms: the markers may change as a result of a conscious design by the living; they may vary due to alteration in the overall inventory of material culture; or the markers may effectively change as a result of variation in the consistency with which the proscriptive and prescriptive conventions of funerary treatment are applied by the living.

Larsen (1997) reiterated that mortuary behavior is highly variable. She also emphasized the use of ethnological and historical data in the analysis of mortuary behavior as especially important in that the evidence gives solid grounding for phenomena that are simply not available based on archaeological data alone.

Chapman (2000) argued that burial analyses are generally heavily under-theorized, especially concerning agency structure relations. He also argued for conducting a detailed analysis of smaller groups of graves within a cemetery rather than analyzing cemeteries as closed entities.

Milliken et al. (2007) succinctly described the mortuary patterns and symbolic expressions in the San Francisco Bay Area. The authors discussed various grave goods in terms of energy expenditures. Shaped stone mortars are the costliest, and appear after 1200 AD. Shell beads are also very costly to manufacture, as thousands of beads went into the ground each year as mortuary offerings. The authors described the four main modes of mortuary locations and organization in the Bay Area: the first is the most common and consists of the non-cemetery pattern where people were buried in a dispersed informal way in and around villages; the second is cemeteries in rich midden adjacent to villages; the third is cemeteries located away from villages in sterile soils; and lastly possibly dedicated cemetery mounds with formal burials and some dietary residue from feasting.

Fahlander and Oestigaard (2008) stated that objects follow the dead as either personal objects or gifts that may relate to different social relations, various persons and groups the deceased had with the living. They also reiterated that perishable materials may not be recoverable. It is also not clear whether the deceased's profession or status was most important.

To summarize, burials reflect the society which interred them (Saxe 1970, Binford 1971). Differences in mortuary practices can reflect status, social ties, and the rank of the individual, as well as the structure of society (Saxe 1970). The more complex a society, the more complex the mortuary treatments should be (Binford 1971). A simpler society should have mortuary treatments based on physical characteristics while a more complex society would be based on more abstract principles (Binford 1971). The locations of discrete disposal areas can also indicate control over resources (Saxe 1970, Goldstein 1981). It is important to consider the ethnographic data concerning mortuary practices when conducting a mortuary analysis on a prehistoric population. It is also important to realize that preservation may mean that certain burial goods are underrepresented, and that a true representation of burial goods may not be possible. Finally, the deceased individual did not bury themselves. They were interred by members of their own society, who cared enough about them to bury them in the first place.

3.2 Using GIS in Burial Analysis

The use of GIS in burial analysis has increased recently, but it is still mostly used to merely display spatial distribution of the burials. This ignores an important aspect regarding GIS, the ability to analyze the spatial relationships between attributes of the burials.

3.2.1 World Studies

There have been several studies that have merged GIS with mortuary analysis from across the globe. While few intra-site studies have been completed (most focus on landscape analysis) there are a few intra-site mortuary studies that are relevant to this paper.

Goldstein (1981) produced a very influential article on spatial analysis of burials. She reiterated that mortuary practices are reflections of interpersonal, intergroup, and intra-group relationships as well as society itself. Examining the spatial component of burials can yield information on at least two levels. The first is the degree of structure, spatial separation, and ordering of the disposal area which may reflect organizational principles of society as a whole. The second is the spatial relationship between individuals within a disposal area can represent status differentiation, family groups, descent groups, or spatial classes. She observed that archaeologists analyze mortuary sites almost exclusively in terms of substance languages, but they should also use space-time language as well.

Goldstein closed her article with five conclusions: mortuary systems are a multidimensional system which includes a spatial component; the spatial component is also multidimensional, and may reflect different levels of relationships and interactions; simple visual techniques are the best way to begin a spatial analysis; when the spatial component is used as the framework for examining the results of substance language approaches it can yield an understanding of the meaning of the groups or statuses represented; it is the interplay between the substance and spatial components which provides the maximum information about the cultural elements represented in a mortuary site.

Aldenderfer (1982) analyzed methods of cluster validation for archaeology. He stated that archaeologists who use cluster analysis often fail to validate it. Aldenderfer (1982:70) defined validation methods as "methods which assess the compatibility of a clustering solution with a particular theoretical perspective on what constitutes good classification." He recognized three families of cluster validation, but stops short of saying which one is the best. Aldenderfer noted it is up to the archaeologists themselves to determine which validation to use and that choice reflects their own biases of which they should be aware.

Voorrips and O'Shea (1984) created a method for the analysis of spatial patterning based on aspects of spatial autocorrelation. By using a computer simulation they show that the join count statistic has a wider validity than was originally presumed. The join count statistic is the simplest measure of spatial autocorrelation used for binary variables (in this case, present or absent). They apply this analysis to a late Mesolithic cemetery in Russia by studying three pendant types in graves created from elk, bear, and beaver teeth. Voorrips and O'Shea (1984) notice several interesting patterns such as all three pendant types exhibiting significant clustering at a relatively small number of neighbors, but only elk and bear are still clustered at 10 to 13 neighbors. At 30 neighbors however, beaver pendants are clustered, bear pendants are uniformly distributed, and elk are randomly distributed. The authors interpret these as wealth tokens accumulated and gifted through close kin relations which form small corporate units, probably extended families, which were buried in close proximity to one another.

Voorrips and O'Shea (1984) stated that the absolute Euclidean distance between neighbors plays no part in their analysis, only the rank order distance expressed in the neighbor order matrix matters. Euclidean distance is the shortest distance between two points. They maintain that their analysis methods add a valuable dimension to spatial analysis in archaeology.

Savage (1997) used GIS to conduct a cluster analysis of an Egyptian Predynastic cemetery in order to determine clusters of burials. He found that there were six clusters of burials. He went on to examine the distribution of grave goods, architectural elements, animal offerings, and the temporal date range for burials within the clusters. Savage found that descent based on kinship, power, and competition appear as powerful organizing principles. He suggested that the clusters seem to be descent groups likely representing clan-type organizations or different factions that made up the socio-spatial structure of Predynastic society. Savage found that economic power is not shared equally among the different groups, and evidence of competition occurs as intensification in plundering, elaboration of grave architecture and mortuary ritual, and an increase in the number of grave goods occur through time. He believed these findings imply why Upper Egypt began to expand.

Smith and Lee (2008) analyze two burial areas from a sedentary Neolithic village in Jiahu, China, dating back to 9,000 BP. There were several discrete burial areas uncovered during excavations, but they chose to focus on two where the boundaries had been completely defined. Graves were partitioned into discrete formal disposal areas with graves being more densely distributed towards the center of the disposal areas. They used spatial analysis techniques to come to a number of conclusions regarding the burial area. There were smaller partitions within the graveyards, with some graves sharing unique mortuary features. Sometimes the graves cut into other graves. The authors argue this dense distribution projects a collective group identity. The authors also found that there was differential treatment of the single and collective burials during the second phase of the site.

3.2.2 Regional Studies

There have been relatively few GIS studies in the Bay Area and California that focus on mortuary analysis. Only four could be located for this paper. This may be due to the relative low number of sites producing a large number of burials. It could also be that private cultural resource management firms excavate the sites to fulfill the environmental laws, but do not publish scholarly papers on their findings. These companies may also not have access to GIS technology.

Cartier et al. (1993) developed a statistical model to quantify social inequality based on the range of wealth within a given mortuary component. This methodology scored the value of each type of item found with the burials. Those items that were uncommon, exotic, and took a large amount of production time were given higher scores. The authors then totaled the value and gave each grave a grave association score. By using the score distributions, they found a distinction along a cline from the poorest mortuary located at CA-SCL-128 to the richest mortuary at CA-SCL-690. Wealth was more evenly distributed at CA-SCL-690, a predominately middle to late period transition site. The inequality was highest at the poorest site, CA-SCL-128, which was a mixture of middle and late period components.

Bellifemine (1997) examined the burials from the Yukisma Site (CA-SCL-38) in Santa Clara County. She examined 244 individuals (and their burial goods) that span a period of 2,000 years. Bellifemine utilized a multivariate analysis to demonstrate a high degree of spatial organization at the site. Multivariate analysis involves observation and analysis of more than one statistical outcome variable at a time. She found the site is a highly structured cemetery where individuals were allocated to specific areas based on their age and gender. She also found a solid dependency between the age of the individuals and the spatial cluster in which the grave was located. A similar correlation is found between sex and the spatial cluster. Artifact diversity shows differences among the spatial clusters, suggesting wealth inequality existed in prehistoric society. Bellifemine hypothesized that some spatial clusters could represent lineal groups or moieties based on sex. She also found a high correlation between spatial cluster distribution and the mode of internment of its individuals. The results indicate that the age, and to a lesser degree the gender, of the individual are strong determinants of the location of burials in the cemetery.

Luby (2004) examined the mortuary behavior of hunter gatherers associated with a San Francisco Bay Area shell mound. He used cluster analysis to examine the burials from CA-ALA-328 where approximately 571 burials were recovered during various excavations from the 1930s-1960s. He focused on the concept of inequality and its link to surplus. Luby summarized Price and Feinman (1995) noting that inequality possesses political, economic, and ideological dimensions, is present in all societies, and varies by degree along a continuum. He found that the degree of inequality lessened as the site transitioned from a cemetery to a shell mound. Luby also suggested that the concept of corporate group membership implied by the submound cemetery was later transferred to the shell mound itself.

Luby reached several conclusions regarding mortuary analysis in the San Francisco Bay Area. The first is this case illustrated the limitations of relying solely upon rank as a way to understand mortuary behavior in hunter-gatherers. Second, it is important to expand the frame of reference for mortuary analysis, both on theoretical and analytical grounds. Third, the continued presence of some form of corporate group structure suggests that once a cemetery is established, its function may be transferred to another site structure if significant mortuary functions are retained. Fourth, although inequality has been observed in the mortuary practices of CA-ALA-328 in this study, the cause remains unknown. Fifth, analysis of the mortuary behavior of coastal central California hunter-gather-collectors can contribute to a wider understanding of issues concerning inequality, exchange, and settlement patterns. Finally, introducing concepts from more recent mortuary analyses into studies of coastal central California populations can contribute to mortuary theory itself.

Wiberg (2005) excavated a late prehistoric site on Cache Creek in Yolo County, California, approximately 30 miles west of Sacramento. A total of 122 formal burials were recovered from an area measuring 75 meters north/south by 55 meters east/west. There were 88 inhumations and 34 cremations. Also discovered were 94 loci of bone which may have represented burials. Wiberg does not expressly state that he is conducting a GIS analysis, but it is evident that GIS was used in the production of the maps.

Wiberg (2005) discovered that most of the site features such as earthen ovens and hearths were located outside the burial area. There were not a lot of post deposit disturbances to the burials for additional internments. He found that there were three distinct clusters of burials, distinguished by differences in the frequency of particular mortuary variables and grave goods. They also discovered that most of the sub-adults were located along the perimeter of the burial area.

3.3 GIS and Spatial Analysis for Burial Studies

GIS is a technology that is used to visualize, analyze, interpret, and understand spatial data by analyzing trends, relationships, and patterns (Esri 2012). A variety of terms are used in this paper that while familiar to GIS professionals, may not be understood by other readers. GIS terms and definitions are presented in the Glossary section. The key concepts that are relevant to this study are summarized below.

3.3.1 Spatial Autocorrelation

Spatial autocorrelation is the similarity between observations as a function of the distance between them. This means that objects that are closer in space tend to be more similar than objects further away. ArcGIS 10 Desktop help center (Esri 2012) gives the Global Moran's I statistic for Spatial Autocorrelation as:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2}$$

where z_i is the deviation of an attribute for feature j from its mean (x_i-$\bar{X}$). $w_{i,j}$ is the spatial weight between features i and j. n is equal to the total number of features. S_0 is the aggregate of all the spatial weights, and is represented by the following equation:

$$S_0 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j}$$

This evaluates whether the data points are dispersed, random, or clustered.

3.2.2 Cluster Analysis

Cluster analysis identifies the locations of statistically significant hot spots, cool spots, and spatial outliers by subjecting a set of weighted features to the Anselin Local Moran's I Statistic (Anselin 1995). Cool spots are a statistically significant cluster of low values, and a hot spot is a statistically significant cluster of high values. In addition to Local Moran's I statistic, the tool also calculates the z-score and p-value of the feature (Mitchell 2005). The z-score is the standard deviations from the expected result. A number greater or more negative than two standard deviations (z) would indicate that the feature is outside the normal distribution and likely did not occur naturally. A positive z-score indicates the feature has neighbors with similar high or low attribute values making it part of a cluster. A negative value indicates dissimilar neighbor values making them outliers. The p-value measures the probability that the spatial pattern was created by a random process. A very low p-value score (< 0.05) indicates that the observed process is very unlikely to be the result of a random process. The Anselin Local Moran's I Statistic is given as

$$I_i = \frac{x_{i-\bar{X}}}{S_i^2} \sum_{j=1, j\neq 1}^{n} w_{i,j}\,(xj - \bar{X})$$

where x_i is an attribute for feature i, $\bar{X}$ is the mean of the attribute, and $w_{i,j}$ is the spatial weight between features i and j.

$$S_i^2 = \frac{\sum_{j=1, j\neq 1}^{n} (xj - \bar{X})^2}{n-1} - \bar{X}^2$$

where *n* is the total number of features.

3.2.3 Grouping Analysis

Grouping analysis performs a classification procedure that tries to find natural clusters within the data (Esri 2012). Given a number of groups to create, this analysis will look for a solution where all the features within each group are as similar as possible, and all the groups are as dissimilar as possible. It is unrealistic to try to identify a grouping algorithm that will perform best for all the possible data scenarios. Groups can have different shapes, sizes, and densities while their attribute data can reflect a wide variety of values and measurements. It is best to think of the Grouping Analysis as an exploratory tool that can help the user learn more about the underlying structure of their data (Esri 2012).

In order to better gauge the optimal number of groups to create for the analysis, the Calinski-Harbasz pseudo F-Statistic is used. The Calinski-Harbasz psuedo F-Statistic is a ratio reflecting within group similarity and between group differences and is given as:

$$\frac{\frac{R^2}{(n_c - 1)}}{\frac{1 - R^2}{n - n_c}}$$

where:

$$R^2 = \frac{SST - SSE}{SST}$$

SST is the reflection of between group differences and is given as:

$$SST = \sum_{i=1}^{n_c} \sum_{j=1}^{n_i} \sum_{k=1}^{n_v} \left(V_{ij}^k - \overline{V^k}\right)^2$$

SSE is the reflection within group similarity and is given as:

$$SSE = \sum_{i=1}^{n_c} \sum_{j=1}^{n_i} \sum_{k=1}^{n_v} \left(V_{ij}^k - \overline{V_t^k} \right)^2$$

where n is the number of features; n_i is the number of features in group i; n_c is the number of classes; n_v is the number of variables used to group features; V_{ij}^k is the value of the k^{th} variable of the j^{th} feature in the i^{th} group; $\overline{V^k}$ is the mean value of the k^{th} variable; and $\overline{V_t^k}$ is the mean value of the k^{th} variable in group i.

The largest F-Statistic indicates how many groups will be most effective at distinguishing the features and variables specified. The Esri ArcGIS model only provides F-Statistics for the first 15 groups. There may be a higher number of groups past this number that are optimal.

3.2.4 Interpolation using Cokriging Analysis

Interpolation is an analysis method which uses spatially distributed data points to produce a continuous field of values between all the known points. This continuous field is generally represented as a raster, with individual values stored in each pixel.

There are two different general methods of interpolation, deterministic and geostatistical. The deterministic approach assigns values based on the surrounding measured values and uses non-statistical mathematical formulas to determine the resulting surface (Esri 2012). Inverse distance weighting interpolation (IDW) is one example of a deterministic method in which the influence of a single data point on nearby interpolated values diminishes with distance.

Geostatistical methods are based on statistical models that use measures of spatial autocorrelation to predict the interpolated surface as well as to produce a spatial estimate of the accuracy of the prediction. Kriging, one form of geostatistical analysis, is divided into two distinct tasks: quantifying the spatial structure (variography) and producing a prediction. The semivariogram measures the strength of spatial correlation as a function of distance. It is used to estimate a curve that best describes the spatial structure of the data. This in turn can be used to produce the predicted surface as well as the estimation of accuracy of the prediction.

There are several different types of kriging. Each of these methods may also produce a specific output display. These are discussed more in detail in Appendix B. Cokriging, the method used in this paper, uses the main variable of interest, its spatial autocorrelation, and cross correlations between the variable of interest and other variables to make better predictions.

The actual statistical models which underpin these methods are beyond the scope of this paper. Tools for kriging, such as those provided by ArcGIS, use multistep wizards to assist the well-informed novice to make the right choices and to produce valid results. The use of this tool and choices made in this study are described in Chapter 8.

Chapter 4 - Data and Data Management Methods

This chapter describes the data used in the study and explains the processes used to transform field survey data into GIS data. An overview of the data as a whole, including a visual examination of the spatial distribution of attributes, artifacts, and pathologies and anomalies is then discussed.

4.1 Digitizing Field Data for use in GIS

The burials, features, units from data recovery excavations, and modern infrastructure located onsite were recorded using a theodolite and stadia rod. The theodolite was set to true north on the datum or subdatum, and then the object was shot in. The theodolite had a digital display that provided the degrees, minutes, and seconds. The distance and elevation were calculated using the stadia rod. This data was transferred to a log.

The surveyed locations of the burials, features, excavation units, and other modern day objects such as the existing floodwall, street, sidewalk, and trees were plotted manually on blank paper using a compass and ruler from the readings from the theodolite. A scanned image of the resulting map was georeferenced in ArcGIS using the WGS 84 datum as the geographic coordinate system. A GPS point was taken on the datum and floodwall corner in the field using a hand held Garmin GPS unit and used as the initial georeference points. Using aerial imagery already georeferenced from Esri, the other modern day features were georeferenced as well. Points representing the location of each burial were then manually digitized onscreen to create the Burials GIS shapefile. Additional attributes (described in the next section) were then added to the Burials attribute table. While it is possible to join a large spreadsheet to a shapefile, that did not occur for this project. The attributes were continually expanded as examination techniques evolved requiring additional attribute entries. This created a much more time consuming approach to data entry. Table A-1 in Appendix A lists all of the attributes added to each burial record.

It is important to recognize that a small amount of positional error may have entered at any step in this process. A stadia rod may not have been perfectly upright which may have shifted the depth or distance by a fraction of a centimeter. North may have been off slightly when it was initially sighted using a compass and the theodolite. When the hand drawn map was scanned it might have been slightly distorted and the georeferencing process may also have a small positional error in the adjustment.

Fortunately, while there are many potential sources of positional error, the total errors should be negligible. Given the small size of the site, these errors should be no more than a few centimeters. Relative positions are preserved and the precision of point locations at the scale of analysis is sufficient. We also must remember that the points represent only the crania of the individuals and at the scale of any map in this report each dot is actually larger than the real life crania of the individuals.

Several additional shapefiles and data layers were used during the course of the analysis. All of the shapefiles were created by the author. All subsequent shapefiles and raster datasets from analysis were derived from these shapefiles. The satellite imagery comes courtesy of ArcGIS Online from Esri. The names and type of layer are presented in Table 2, along with the source.

This dataset is limited in several ways, however, it still serves its purpose in demonstrating the spatial analysis techniques discussed in the upcoming chapters. The first thing to note is that this dataset does not encompass all the burials from CA-NAP-399. Two more individuals were excavated by Origer (1994) in the early 1990's immediately west of CA-NAP-399; those were likely related to that site. These should have been included, but there was no way to positively ascertain their correct position in space from the site drawings. During the original recording of the site in the late 1970's, Beard (1976) mentions that several burials have eroded out of the banks during floods, but does not give a concrete number or position of those burials. It should be pointed out that this was secondhand knowledge from local inhabitants. These burials too should have been included in the dataset. It is also possible that a burial was missed during monitoring activities. The excavator and backhoe did remove soil in small increments; however there is always the chance something got missed. A more methodical method of excavation would have allowed for more controlled manner of monitoring, however this would have increased costs for the floodwall project exponentially, and delayed its construction for years. Several burials also lost data between field excavation and the office due to illegible writing or mistakes. These issues narrow down the usefulness of the dataset because some of the spatial analytical techniques require all the points to have a value. An unknown value for a burial can affect the analysis and skew results. As well, these issues of data loss indicate that the dataset is incomplete in its spatial extent. Thus results from the analyses in this report should not be seen as definitive nor should they be used for as foundations for further archaeological analysis. As stated earlier, the main purpose here is to demonstrate how spatial analysis may be used with data of this type.

Table 2: Shapefiles and Data Layers.

Name	Type	Creator/Credit
Burials	Point	Lucian N Schrader III
Floodwall Project Area	Polygon	Lucian N Schrader III
CA-NAP-399 Site Datum	Point	Lucian N Schrader III
Napa River	Line	Lucian N Schrader III
Site Boundary	Polygon	Lucian N Schrader III
Tribal Territory (Based on Kroeber 1925)	Polygon	Lucian N Schrader III
Political Boundaries of the United States of America	Raster	Esri
World Imagery	Raster	Esri

4.2 Burial Attribute and Artifact Data

Trained osteologists at Pacific legacy Inc., Dr. Lori Hager and Samantha Schnell, analyzed the burials and coded the information using their own internal system. This coding was carried over to the burial attributes in the Burials shapefile. Information about artifacts discovered with each burial was also entered into the attribute table.

Age

Table 3 shows the codes used for the age of the individuals. Age is determined from the maturation of the human bone. As the individual grows older, different bones fuse together in known age ranges. By identifying which bones have and have not fused allows for the estimation of the individual's age. Due to preservation issues or missing skeletal elements, the age may not have been able to be determined.

Table 3: Age Codes.

Code	Age
9	Fetus (pre-term)
0	Neonate (at birth)
1	Infant (0-3 years)
2	Child (3-12 years)
3	Adolescent (12-20 years)
4	Young Adult (20-30 years)
5	Middle Adult (30-49 years)
6	Old Adult (50+ years)
7	Adult (20+ years)
8	Unable to determine

Sex

Table 4 refers to the sex of the individuals. Note that the sex is not the same thing as gender, which is assigned by cultural mores and individual decisions. Until individuals undergo puberty, it is very difficult to determine their sex. The shape of the pelvis is the main determining factor in determining the sex.

Table 4: Sex Codes.

Code	Sex
0	Too Young to Determine
1	Female
2	Possible Female
3	Unable to Determine
4	Possible Male
5	Male

Flexure

Figure 6 refers to the flexure of the burial, and provides four examples from Pacific Legacy (2012). Flexure refers to how tightly the burial is flexed during its internment. This can change slightly over time as decomposition occurs. This category could also be considered burial position or burial type. Given that almost all the burials were flexed, it was decided to focus more on the flexure.

The burial flexure is defined as the range of flexing incurred by the burial. Tightly flexed individuals have their knees drawn up to nearly touch their heads, where the leg bones run parallel to the spine. Semi-flexed is the flexure where the legs are brought up to around 20 degrees from parallel with the spine. Flexed is where the legs are at a 45 degree angle from the spine. Loosely flexed is where the legs are around 70 to 90 degrees with the spine. Examples of each type of flexure are shown in Figure 6. These are examples from CA-NAP-399.

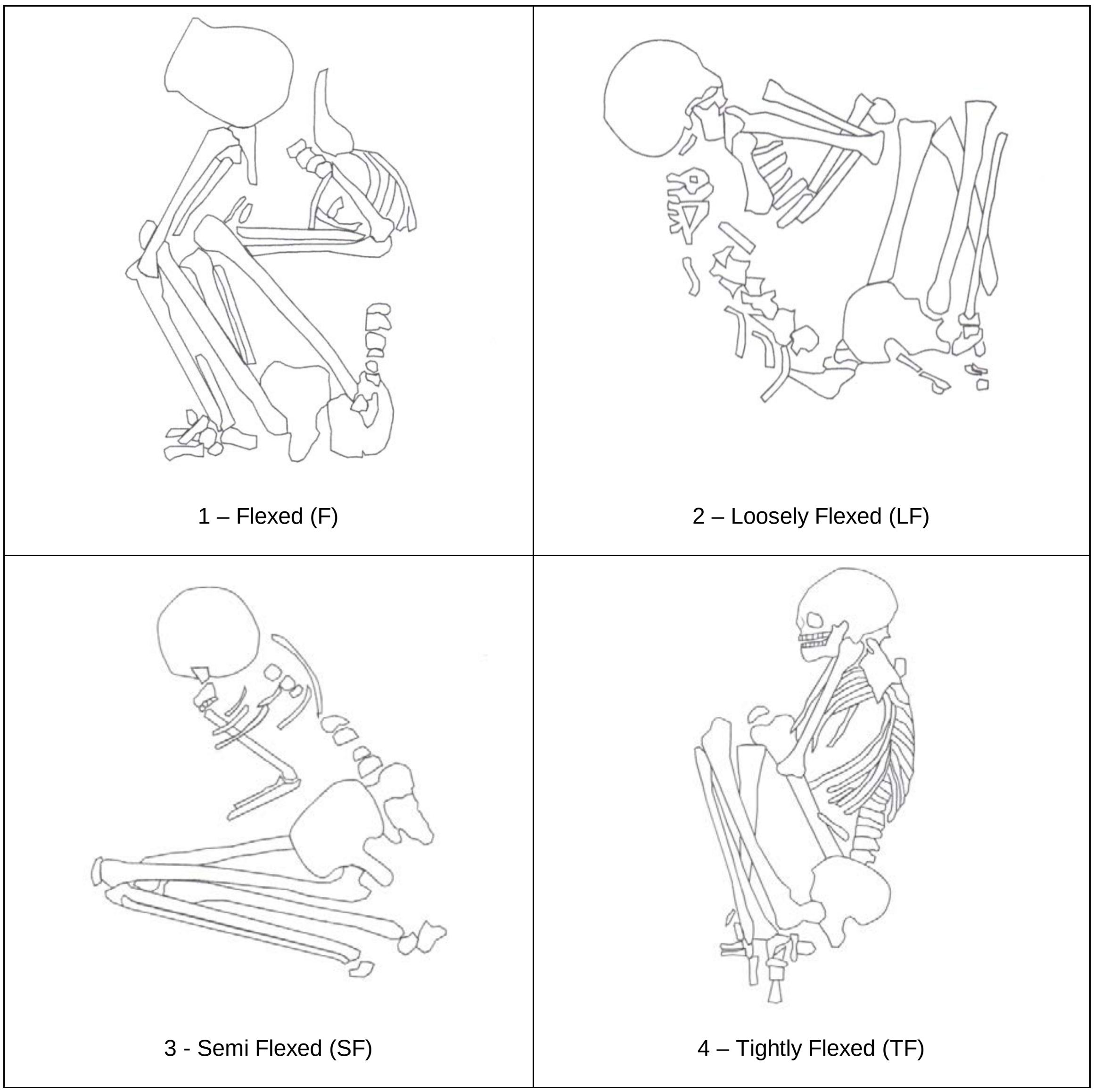

Figure 6: Burial Flexure Examples and Codes

Orientation

Orientation refers to what cardinal direction the burial is facing. These were recorded in degrees in the field. It is believed that whatever direction the burials were facing when buried represents something sacred. That direction could be towards a sacred mountain or the setting sun in the west.

Unfortunately when conducting the spatial analysis, it was realized that there was a difference of 359 degrees between a bearing of 359 degrees and 0 degrees north when there should have only been a one degree difference. This necessitated the bearings to be grouped into eight categories of orientation covering 45 degrees each. These categories include: North (337.5° to 22.5°), Northeast (22.5° to 67.5°), East (67.5° to 112.5°), Southeast (112.5° to 157.5°), South (157.5° to 202.5°), Southwest (202.5° to 247.5°), West (247.5° to 292.5°) and Northwest (292.5° to 337.5°). Each category was then coded 1-8, starting with north coded at 1 and proceeding clockwise through northwest with a code of 8. This did not solve the problems as Bellifemine (1997) noted similar problems and no solution. The implications for this included biased and incorrect results within this study.

Side

Table 5 refers to what side the body was interred on. This has not been widely studied, and the implications are unknown. Portions of the body may have also shifted post deposition, affecting identification. The upper torsos of some burials were interred on the ventral (back) or dorsal (front) side, but the legs were to the left or right. These are identified first with the position of the torso, a backslash symbol, then the position of the legs. A cremation does not technically have a side to be interred on, and are listed here for the sake of completeness.

Table 5: Side Codes.

Code	Sides
1	dorsal
2	dorsal/left
3	dorsal/right
4	ventral
5	ventral/left
6	ventral/right
7	left
8	right
9	sitting
10	cremation

Preservation

Table 6 refers to the preservation of the bone. The age and overall health of the individual can influence this. Preservation is mainly influenced by the type of soil. Some soils are very good for preservation while others are very poor.

Table 6: Bone Preservation Codes.

Code	Bone Preservation	Description
1	Poor	Little to no integrity, sometimes the consistency of oatmeal
2	Poor/Fair	In-between poor and fair preservation
3	Fair	Some preservation issues but most of the bone is intact
4	Fair/Good	In-between fair and good preservation
5	Good	Solid, well preserved

Depth

The depth was compiled in two ways for this study. The first depth attribute, depth, was originally intended to represent the depth to the bottom of the burial and was recorded in centimeters below the site datum. It was not until several days later that it was realized that ArcGIS interpreted these numbers in meters. So instead of the range of depth for the burials being between 60 and 250 centimeters, the program thought it was 60 and 250 meters.

Depth in meters was created to remedy this mistake. This was entered in as a negative numbers with two decimal places. The range for the depth was now -0.60 to -2.20 meters.

Artifact Association

Artifact association refers to burial goods that are associated with the burials. In any given archaeological context there can be displacement of artifacts over time. These possibly displaced artifacts are discovered near the burial, but cannot be positively linked to the burial, and are termed here *indirectly* associated artifacts. Artifacts that are positively linked to the burial are termed here *directly* associated artifact. Burials with no artifacts were coded with a zero, burials with indirectly associated artifacts were coded with a one, and burials with directly associated artifacts were coded with a two.

Artifacts

Most of the remaining attributes refer to the artifacts discovered with the individual. The artifact type is given with either a "DIR" or "IND" before its name. "DIR" stands for direct association, which means that these artifacts were found directly associated with the burial. "IND" stands for indirect association, which means that the artifacts may or may not be related to the individual.

These artifacts were examined in a variety of ways. A spatial autocorrelation analysis was conducted for each type of artifact, examining both directly and indirectly artifacts associated with the burials in an attempt to discern areas of possible professions or guild burials.

Total tools refer to the total number of direct and indirectly associated tools found with each burial. Total artifacts refer to the total number of all artifacts found with each burial. Total artifacts minus debitage and faunal remains are an attempt to eliminate background noise from the midden by eliminating those artifacts commonly found in midden soils.

The tool diversity index is a way of measuring tool diversity from the burials. Each type of tool was given a value of one. If that tool was present with the burial, it received a value of one; otherwise the value would be zero. These values were added together, then divided by the total number of tool categories, in this case 13 (bifaces, bone awls, bone pins, bowl mortars, cores, core tools, drills, edge-modified flakes, handstones/manos, millingslabs/metates, pestles, projectile points, and unifaces). A burial with a tool diversity index value of one can be said to contain all the manner of tools available onsite, while a burial with zero has no tools.

The wealth diversity index was created in a similar way to the tool diversity index. It is important to point out here that the word wealth brings with it certain connotations of status. It is also possible that some tools could be considered wealth items. For the purpose of this paper, wealth items are considered non-utilitarian items that are not required to live life day to day. These items can also be considered personal adornment items and include bird bone beads, charmstones, obsidian needles, pendants, quartz crystals, shell beads, stone beads, and whistles. A burial with a wealth diversity index of one can be said to contain all the manner of wealth items available onsite, while a burial with zero has no wealth items. Inferences regarding status and hierarchy may be made from this value.

Health Issues

Several issues regarding the health of the individuals were analyzed as well. These values were often represented as a presence (value of one) or absent (value of zero). These pathologies and anomalies were not initially entered to see if there was any spatial clustering, but rather to see their change through time.

Anemia is a condition characterized by low levels of iron in the blood, and presents itself on the bones of the individual, usually in the form of small pin holes, although recent research has shown there are other possible causes (Walker et al. 2009). Auditory exostoses is also known as swimmers ear, and is characterized by the heavy ossification of the inner bones of the ear in response to repeated exposure to very cold water. Dental caries are essentially cavities. Healed fractures can give an indication into interpersonal violence or heavy workload. It should be noted that there were only two burials with evidence of interpersonal violence (Holson et al. 2013). Osteomyelitis is a bone infection, and presents itself in the bones as accretions with holes to drain pus. Femurs with anterior to posterior flattening are indications of heavy workload and travel. The Inca bone is an extra plate in the skull, and is considered a non metric trait that may be indicative of familial or genetic traits, and can give evidence into whether certain parts of the cemetery were used by families.

4.3 Exploring the Data

The distribution of a variety of burial attributes and heath pathologies and anomalies are shown in the following pages. This will allow for a preliminary visual analysis to determine if there are any identifiable patterns to the naked eye. This can be considered one of the first steps in spatially exploring a dataset.

A preliminary analysis of the data provides several insights and relevant details. The first thing to notice from the distribution of burial points is they trend along an east/west axis. This can be seen in Figure 8, or any of the other figures showing all the burial points. The Napa

River also flows in this same direction immediately north of the site. Any burials to the north of the burial points likely would have been eroded out of the banks, as evidenced by Beard's original site recording in 1976. It also appears as if the burials are curving to the south along the eastern edge of the burial deposit.

The burials are found in an area measuring approximately 125 meters east/west by 30 meters north south. This calculates to a burial area that has a burials density of roughly one burial for every 23 square meters. There is roughly 7,500 cubic meters of soil in this area for the two meters of site deposit with the burials. There is on average one burial per approximately 46 cubic meters.

It is also worth noting the spacing between the burials. Only two burials showed signs of disturbance from post depositional burial activities. Given the relatively small area, and the number of burials present, this would seem to imply two possibilities. The first is that there were burial markers of some kind to keep track of where burials were located. There were no obvious indicators above the burials that were observed during data recovery excavations or monitoring. This could be the result of post depositional cultural activities on the site erasing the markers. It could also be that the grave pits were visible in the landscape until they naturally filled in over a course of years. The second is that cultural memory of burial events lived on within the society. Each generation would inform the next of the location of the burials so they would not be disturbed.

The burials selected for radiocarbon dating were chosen by Pacific Legacy for a variety of reasons. The first was to try to obtain a more accurate obsidian hydration rind correlation, so those burials with obsidian artifacts directly associated with them were given preference. In addition, a sample of burials from across the site near the top and bottom of the deposit was selected to provide a cross section and range of dates. Finally, those burials that were particularly interesting were selected as well to answer select questions regarding the individual. The results of the 22 radiocarbon dated burials are presented in Table 7.

Table 7: Radiocarbon Dated Burials (Holson et al. 2013).

Burial	Age	Sex	Depth (mbd)	Conventional Age (BP)	Conventional Age Range (BP)
10	5	2	0.76	2130±30	2160-2100
15	4	3	1.85	2380±30	2410-2350
28	2	0	1.45	2090±30	2120-2060
29	2	0	1.45	2090±30	2120-2060
32	5	1	0.66	150±30	180-120
55	6	3	1.29	2030±30	2060-2000
56	4	5	1.52	2290±30	2320-2260
67	6	2	1.56	2450±30	2480-2420
70	5	1	1.57	1990±30	2020-1960
73	4	5	1.21	2200±30	2230-2170
79	1	0	1.29	2200±30	2230-2170
86	5	4	1.54	2430±30	2460-2400
94	5	5	1.42	2230±30	2260-2200
115	3	5	1.00	2200±30	2230-2170
116	5	1	0.68	2200±30	2230-2170
117	6	1	1.29	2240±30	2270-2210
125	7	3	1.24	2380±30	2410-2350
130	5	5	1.12	2150±30	2180-2120
139	6	5	1.34	2030±30	2060-2000
148	1	0	1.04	2140±30	2170-2110
149	5	5	1.34	2200±30	2230-2170
156	6	1	1.23	2380±30	2410-2350

Examination of the range of radiocarbon dates is shown in Figure 7. This shows the burial dates are tightly clustered in time with one outlier. Radiocarbon dates have a low level of uncertainty. This is usually plus or minus thirty years, a relatively small window for archaeologists. Upon the initial examination of the artifacts from the data recovery excavation units at CA-NAP-399, particularly the projectile point types, it was initially thought that the burials would represent individuals from over the course of several thousand years. Instead, all save one appear to date to a tight 500 year time span centering on 2200 BP.

Four distinct projectile point types were recognized in the assemblage form the excavation units at CA-NAP-399. The types and relative date ranges come from Justice (2002). A small, triangular, corner-notched arrowhead termed the Rattlesnake series dates from approximately 800 BP to contact times. The Stockton series are arrowheads with distinctive square denticulated edges in a variety of shapes dating from approximately 1,500 BP up to 500 BP. The Excelsior series are larger leaf shaped dart points that date from approximately 5,000 BP up to 1,300 BP. Mendocino Concave Base projectile points a dart points with a concave base that date from approximately 5,000 BP to 3,000 BP. Most of the burials found from CA-NAP-399 are contemporaneous with the Excelsior series, while Burial 32, the protohistoric outlier, was contemporaneous with the Rattlesnake series.

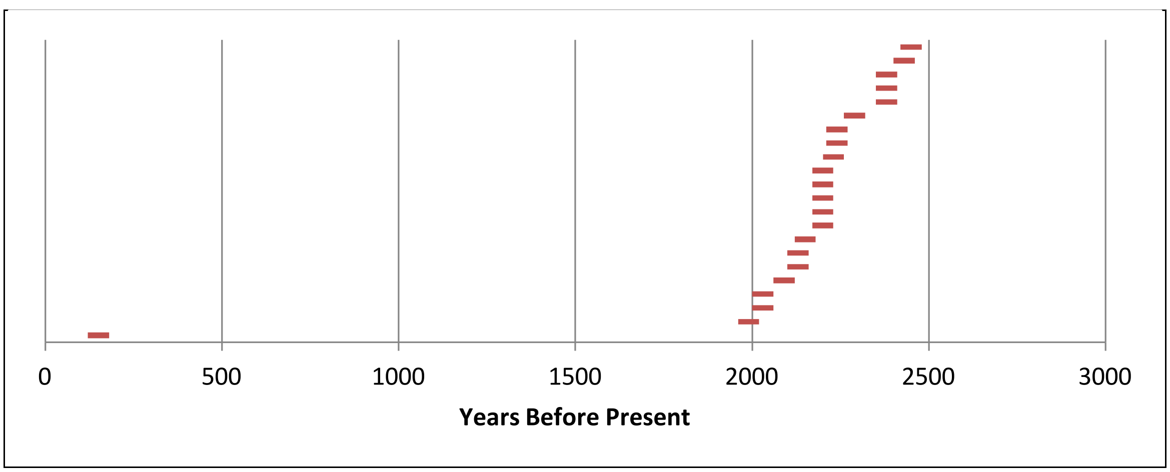

Figure 7: AMS Radiocarbon Dates from Burials (Holson et al. 2013).

Figure 8 shows the distribution of the radiocarbon dates across the site. There does appear to be patterning based merely on visual inspection. The western portion of the site seems to contain more individuals from approximately 2200 BP, while the older burials seem to be located in the eastern half of the burial area, particularly towards the southeast. This could imply that as the site was utilized, the burials were buried further and further to the west.

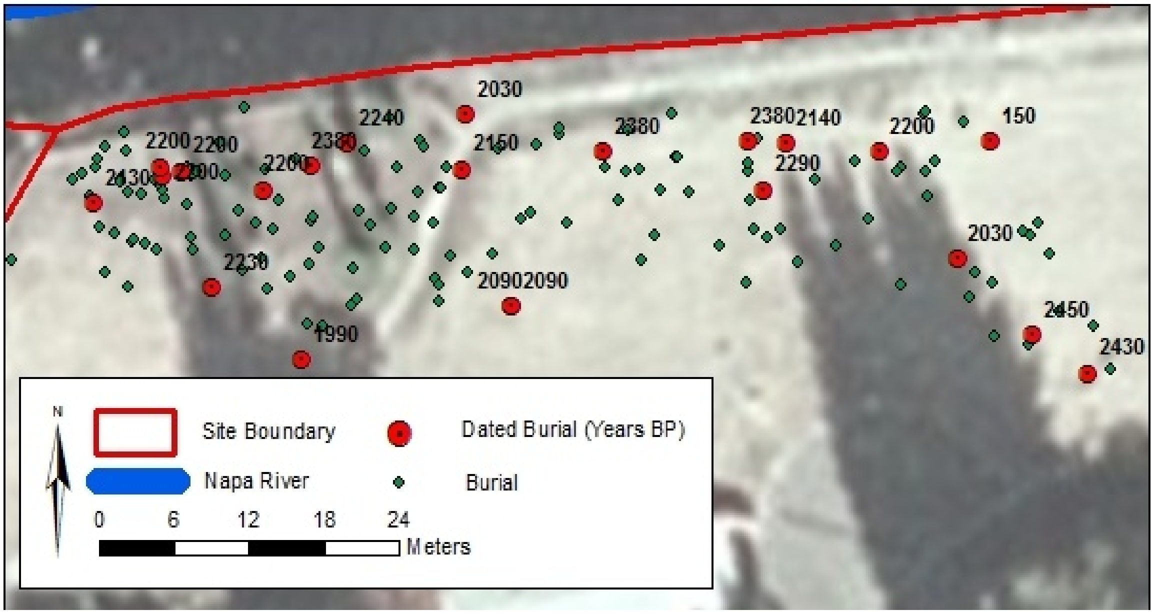

Figure 8: Radiocarbon Dated Burials with Dates.

Table 8 compares the radiocarbon dated burials by date across five one hundred year date ranges. This format is created to better understand changes over time. While the sample size is small, it does offer potential insights into how society changed over time.

The second and third date ranges from 2350-2150 BP seem to be high points for wealth items and tools. There also seems to be more variability in flexure during these date ranges as well. The orientation later in time seems to be more variable as well. There appears to be fewer artifacts from the first date range from 2450-2350 BP.

Table 8: Radiocarbon Date Range Comparisons.

Burial Attribute		**Date Range (BP)**				
		2450-2350	**2350-2250**	**2250-2150**	**2150-2050**	**2050-1950**
n=		5	1	7	5	3
Sex	Male	1	1	4	1	1
	Female	2	0	2	1	1
	Unknown	2	0	1	3	1
Age	0-3	0	0	1	1	0
	3-12	0	0	0	2	0
	12-20	0	0	1	0	0
	20-30	1	1	1	0	0
	30-50	1	0	3	2	1
	50+	2	0	1	0	2
	Unknown	1	0	0	0	0
Flexure	Loose	0	0	1	0	0
	Flexed	0	0	1	0	0
	Semi	0	1	2	0	0
	Tight	3	0	3	1	3
Cremation		1	0	0	0	0
Orientation	North	0	0	0	0	0
	Northeast	0	0	0	0	0
	East	0	0	0	0	1
	Southeast	0	0	0	0	0
	South	0	0	0	0	1
	Southwest	1	0	0	0	1
	West	2	1	5	1	0
	Northwest	0	0	2	1	0
Artifact Association	None	1	0	0	0	0
	Indirect	3	0	1	1	1
	Direct	1	1	6	5	2
Total Tools		7	9	63	48	12
Average Tools		1.4	9	0	9.6	3
Highest Tool Index		0.15	0.23	0.23	0.31	0.23
Median Tool Index		0.08	0.23	0.15	0.15	0.15
Mean Tool Index		0.08	0.23	0.153	0.154	0.15
Total Wealth		0	115	249	12	2
Average Wealth		0	115	35.571	2.4	0.67
Highest Wealth Index		0	0.25	0.75	0.125	0.125
Median Wealth Index		0	0.25	0.375	0.125	0.125
Mean Wealth Index		0	0.25	0.286	0.1	0.083

Age

The distribution of age for the burials is unusual (see Figure 9). There were two neonates, 11 individuals from 0-3 years, 11 from 3-12 years, six individuals from 12-20 years, 23 individuals from 20-30 years, 61 individuals from 30-49 years, 28 over 50 years of age, and 15 adults 20 years or older. There does not appear to be any clustering visible to the naked eye. The distribution appears to be fairly random. There are slightly more individuals coded 7 along the eastern edge, however this may be a reflection of preservation affecting the accurate aging of the individuals.

There are very few children represented in the burial population. There are also a high number of adults present. This would appear to form a normal bell shaped distribution related to age, however that rarely happens in nature. In nature, there should be a more bimodal distribution with children and elderly dying. This population appears to show that mostly adults passing away. Possible implications and causes are examined further in Chapter 8.

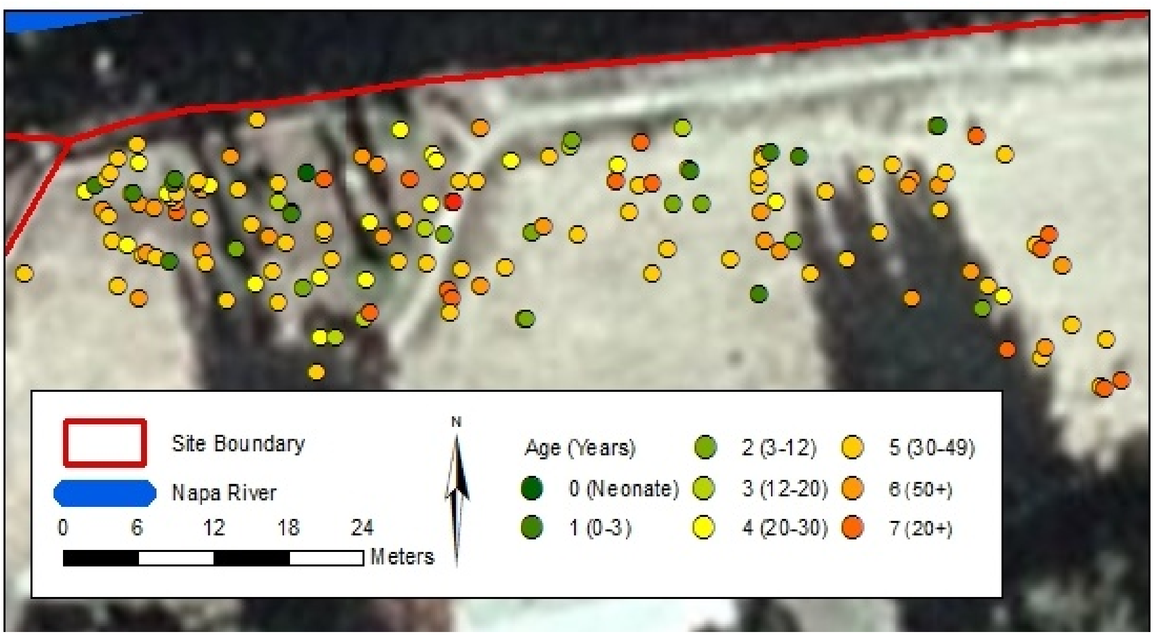

Figure 9: Map of Age Attribute Distribution by Burial.

Sex

The distribution of sex is shown in Figure 10. There are 28 individuals that are too young to determine sex, 47 females, 19 possible females, 19 that were unable to determine, five possible males, and 39 males.

This attribute appears to be randomly distributed spatially around the burial area. There are more individuals along the eastern edge of the site that are unable to have their sex determined due to preservation issues. It is odd that there are more females present. In a normal population the ratio between sexes should be closer to 50:50 while here it is closer to 60:40. Brown (1981) might consider this evidence of differential interment based on sex, however there are a few possible explanations. The first is that there is a normal distribution between the sexes but that evidence did not preserve. Some males may have suffered from poorer preservation where their sex could not be positively determined. Some males may have also died away from the village, and were unable to be transported back for burial.

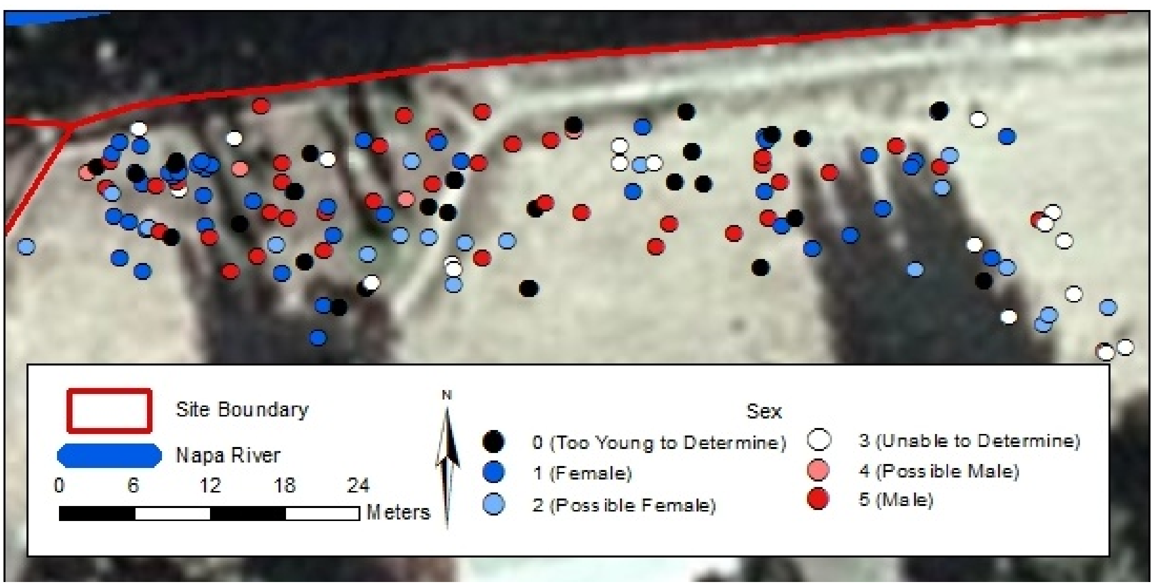

Figure 10: Map of Sex Attribute Distribution by Burial.

Flexure

The flexure of the burials is shown in Figure 11. There were 29 individuals where the flexure could not be determined, four that were flexed, eight that were loosely flexed, ten that were slightly flexed, and 106 that were tightly flexed.

Again, there does not appear to be any spatial patterning present to the naked eye. The majority of the burials appear to be tightly flexed. There does appear to be a few more loosely flexed burials in the western half of the burial area. The overwhelming type of internment could be a reflection of religious beliefs or cultural preferences. The Windmiller culture, located in Central California in the California Delta region, dates to approximately 3500 BP. Their preferred flexure was fully extended. Another possible explanation could be found in energy expenditure theory. This could mean that the grave was excavated to a point where the body would just fit inside. Excavating a grave larger than was needed would require additional effort or energy expenditure.

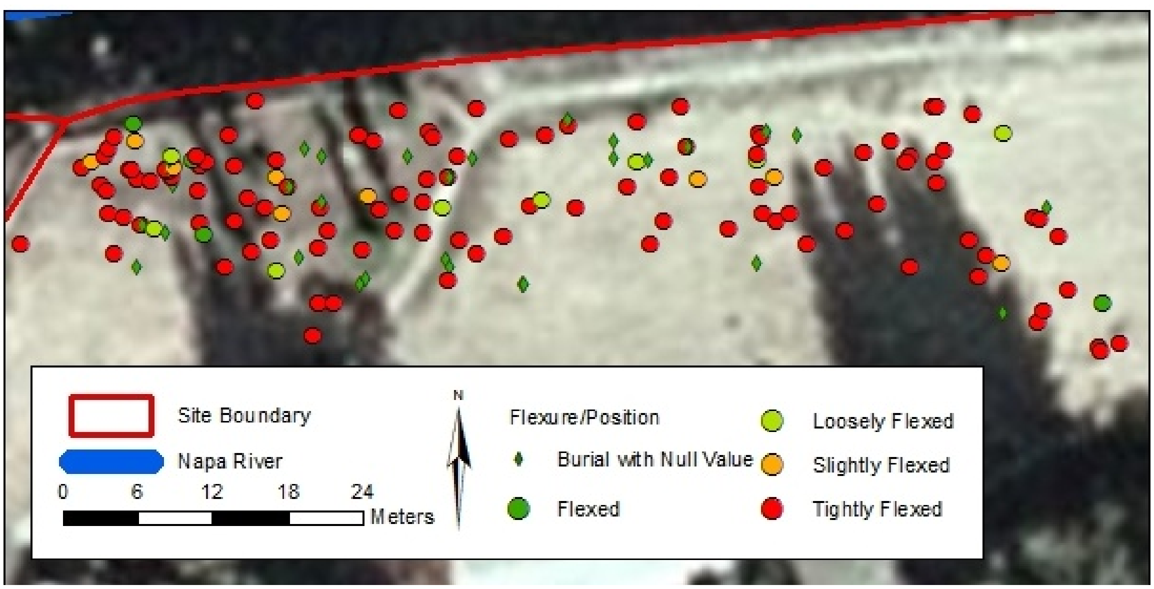

Figure 11: Map of Flexure/Position Attribute Distribution by Burial.

Orientation

The orientation of the burials is shown in Figure 12. There were 28 individuals where the orientation could not be determined, eight individuals oriented to the north, six to the northeast, six to the east, two to the southeast, four to the south, 15 to the southwest, eight to the west, and 20 to the northwest. Of the 28 individuals where no orientation could be determined, four were cremations while the remainder had poor preservation that prevented positive identification of their orientation.

There is no discernible pattern or clustering observed by the naked eye. The majority of burials appear to favor orientation to the west. Most of the burials that are oriented more towards the north appear to be located in the western half of the burial area.

The majority of burials are oriented to the west which is a common orientation in prehistoric societies where the individual is orientated facing the setting sun. A cluster of burials that deviates from the normal could indicate a difference in belief systems.

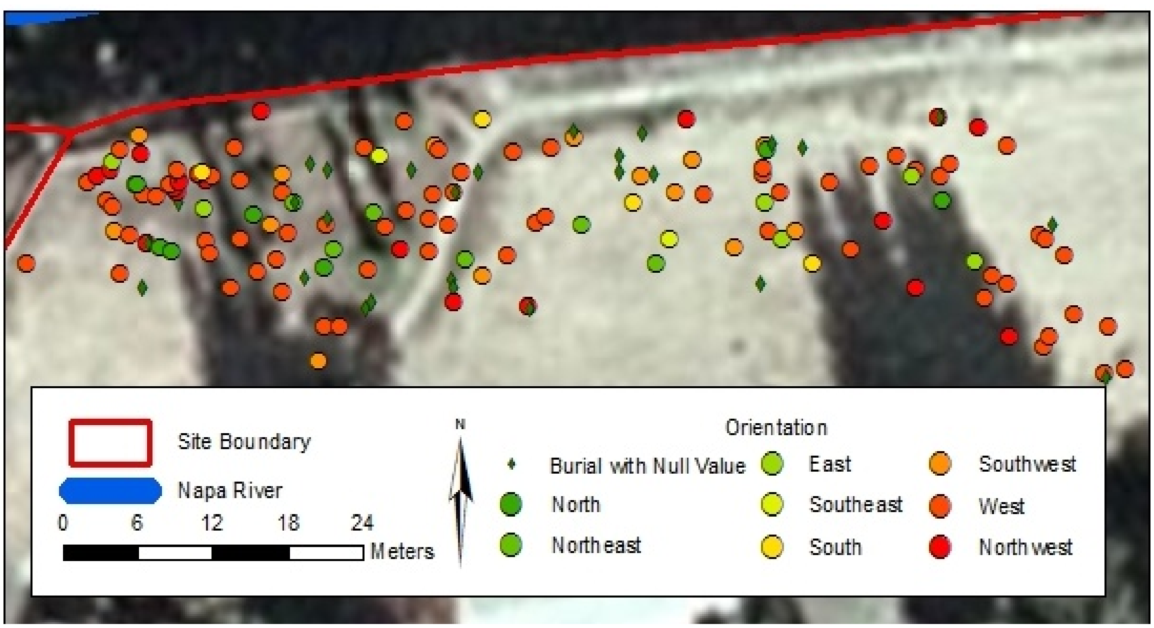

Figure 12: Map of Orientation Attribute Distribution by Burial.

Side

The side the burials were interred on is shown in Figure 13. There were 25 burials where the side of internment could not be determined, 13 individuals were interred on the dorsal side, six on the dorsal/left side, three on the dorsal/right side, 46 on the left side, 40 on the right side, one sitting, 12 on the ventral side, four on the ventral/left side, three on the ventral/right side, and four cremations.

This shows that there was a wide variety of sides for the individuals at CA-NAP-399 to be buried on. There appears to be possible clustering based on the naked eye. The cremations appear to be clustered near the southern portion of the burial area towards the center. There are also slightly more individuals interred on the dorsal side in the western half of the burial area. There also appears to be slightly more individuals interred on the ventral side in the eastern half of the burial area. Burials interred on the left or right sides are the most common. The individual interred in a sitting position is located near the northern edge of the burial area.

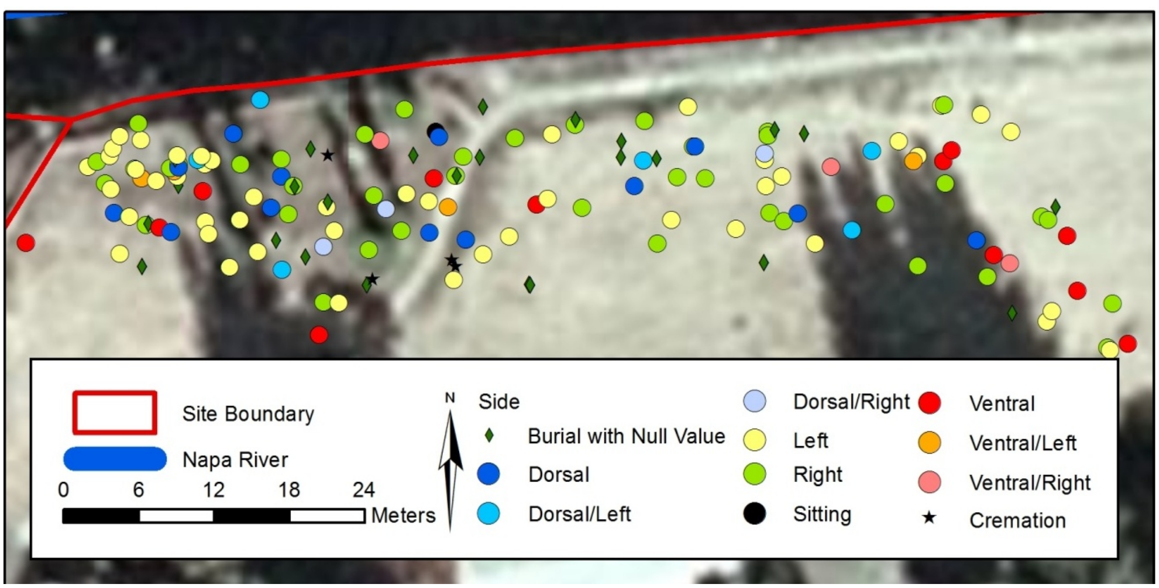

Figure 13: Map of Side Attribute Distribution by Burial.

Preservation

The preservation of the burials is shown in Figure 14. Thirty burials had poor preservation, 25 had poor to fair preservation, 41 had fair preservation, 21 had fair to good preservation, and 40 had good preservation. Actually, the distribution of preservation is fairly even along a spectrum of preservation, with the number of poor and poor to fair burials almost equal to that of fair to good and good.

There does appear to be a cluster of poorly preserved burials along the eastern edge of the burial area. All the burials along the eastern edge of the burial area have poor preservation. The remainder of the site shows a fairly random distribution of preservation. There are a few isolated instances of individuals demonstrating poor preservation in the western half of the burial area. This could represent poorer preservation along the northern edge of the burial area adjacent to the Napa River. The age and health of the individual may also influence the bone preservation.

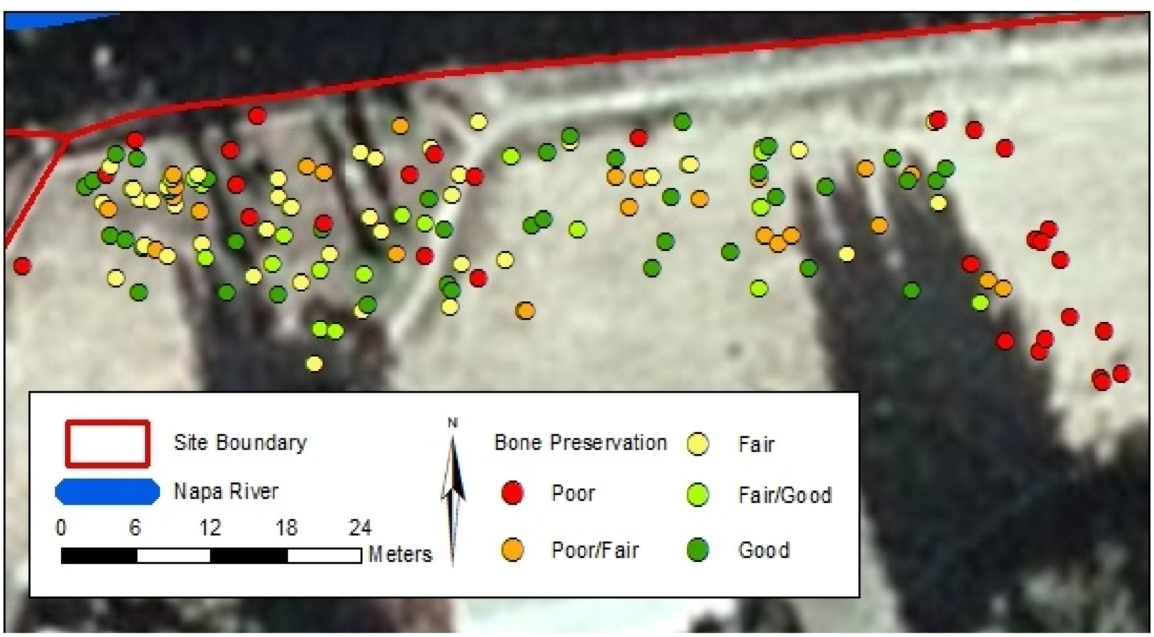

Figure 14: Map of Bone Preservation Attribute Distribution by Burial.

Depth

The west/east profile of burial depth across the site is shown in Figure 15 below. Burial 80 is the burial furthest to the west. Burial 83 is the burial furthest to the east. There appears to be one outlier. Burial 32 is the protohistoric outlier to the upper right at 62 centimeters below the site datum.

There is a general trend of the burials being located higher in the soil column further to the west. The burials are typically deeper along the eastern edge of the burial area. This corresponds with the radiocarbon dates shown in Figure 8 above, where the older radiocarbon dates are towards the east, and the more recent towards the west. This would seem to indicate that the older burials are located deeper. This is further examined in Figure 51, from Chapter 7, where grouping by depth (coupled with radiocarbon dates) is examined. This allows for a more detailed analysis of depth and radiocarbon dates.

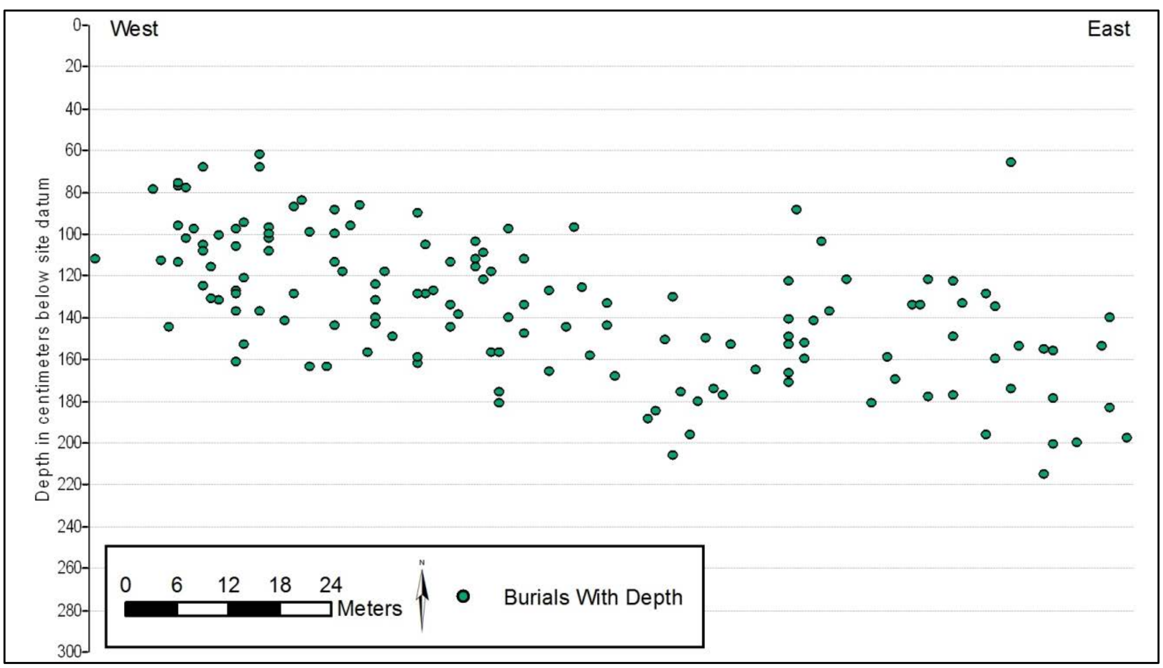

Figure 15: Stratigraphic Profile of Burials from West to East.

Artifact Association

The association of artifacts is shown in Figure 16. Twenty-one burials had no artifacts whatsoever, 100 burials had only indirectly associated artifacts, and 36 had directly associated artifacts. This is a normal bell shaped distribution curve. This would seem to indicate a roughly egalitarian society. If there was high number of individuals with no individuals, and a few individuals with a high number of artifacts, it would be indicative of a hierarchal society.

There are some possible patterns or clustering discernible to the naked eye. It appears that most of the burials in the western half of the burial area contain artifacts, while those in the southeastern corner of the burial area have mostly indirectly associated artifacts. There is no cluster of burials without artifacts which could indicate an area designated for "poor" individuals. There appears to be small possible cluster of individuals with directly associated artifacts. It is located roughly 30 meters west of the eastern edge of the burial area where six individuals with directly associated burials are located within a five meter radius.

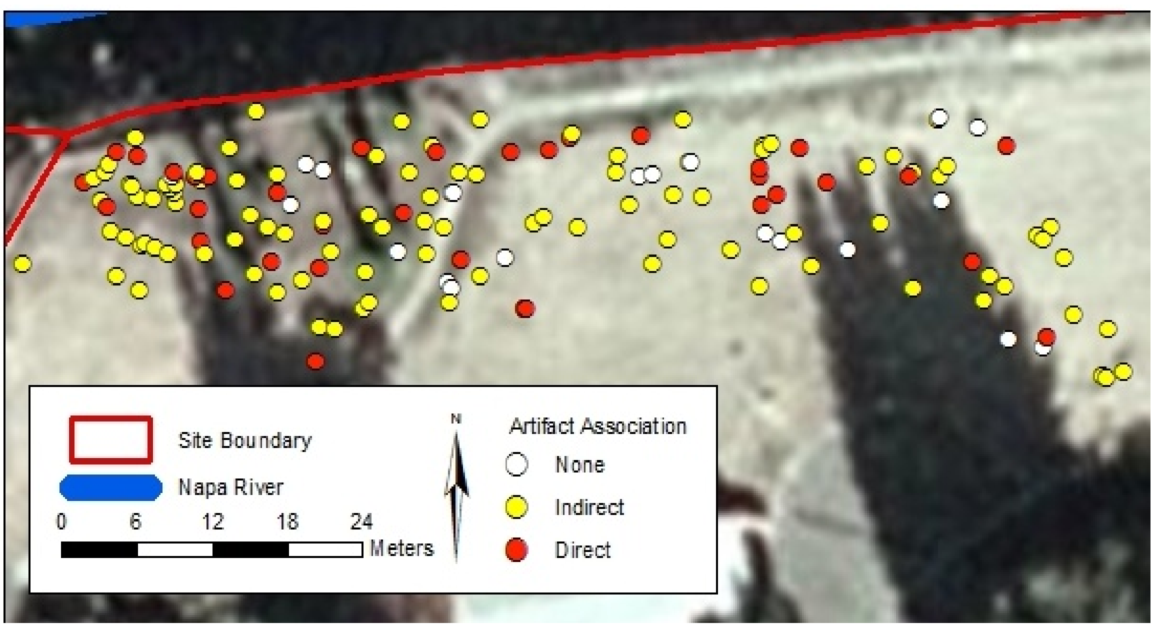

Figure 16: Map of Artifact Association Attribute Distribution by Burial.

Wealth Items

The distribution of the total number of wealth items is shown in Figure 17. The number of individuals by the range of wealth items per burial is shown in Table 9. Table 10 summarized the wealth items from the Burials from CA-NAP-399 by direct and indirect association.

Table 9: Number of Burials by Range of Wealth Items per Burial.

Total Wealth Items Per Burial	Number of Individuals
0	100
1-3	47
4-11	2
12-23	1
24-35	2
36-41	1
42-116	3
117-251	1

Table 10: Summary of Wealth Items from Burials at CA-NAP-399.

Wealth Item	Directly Associated	Indirectly Associated	Total
Bird Bone Beads	0	30	30
Charmstones	5	13	18
Glass Beads	233	0	233
Obsidian Needles	29	23	52
Pendants	4	3	7
Quartz Crystals	173	20	193
Shell Beads	182	13	195
Stone Beads	29	11	40
Whistles	0	3	3
Total	655	116	771

The shell beads were all manufactured from olivella *shell*. There were multiple *olivella* bead types recovered from the burials (Holson et al. 2013). Types A, C, and G were recovered, which typically date to the Middle Archaic period (Milliken and Schwitalla 2009). The stone beads were manufactured from steatite. The quartz crystals could be Lake County diamonds, a small quartz crystal found near Clear Lake. The pendants were manufactured from *haliotis* shell.

There appears to be more burials with wealth items in the western half of the burial area. The eastern half has few wealth goods. This could perhaps be related to the poor bone preservation. If the bone was poorly preserved in this area, then perhaps shell, which serves as the material type for beads and pendants, decomposed completely. There is a small cluster of individuals with more than 30 wealth items approximately 12 meters east of the western edge of the burials ground, in a dense cluster of burials. The few burials with between 12 and 35 wealth items appear to occur in the middle of the burial area. The rest of the wealth items appear to be randomly distributed across the burial area. The outlier in the northeast corner of the burial area is Burial 32.

There are very few burials with a high number of wealth items. There are only five individuals with more than 35 items. This suggests a certain degree of wealth inequality was present at the site.

Figure 17: Map of Total Wealth Item Distribution by Burial.

Total Tools

The distribution of the total number of tools is shown in Figure 18. A total of 639 tools were recovered from the burial excavations. A total of 54 were directly associated with burials while the remaining 585 were indirectly associated. Table 11 shows the number of burials by range of total tools per burial. Table 12 summarized the tools by direct and indirect association from the burials at CA-NAP-399.

Table 11: Number of Burials by Range of Total Tools.

Total Tools Per Burial	Number of Individuals
0	35
1-3	63
4-6	28
7-10	16
11-13	6
14-17	4
18-22	4
23-29	1

Table 12: Summary of Tools from Burials at CA-NAP-399.

Tool	Directly Associated	Indirectly Associated	Total
Bifaces	40	501	541
Bone Awls	5	8	13
Bone Pins	1	3	4
Bowl Mortars	0	6	6
Cores	0	2	2
Core Tools	0	3	3
Drills	0	1	1
Edge-Modified Flakes	2	41	43
Handstones	2	5	7
Millingslabs	0	1	1
Pestles	2	6	8
Projectile Points	2	5	7
Unifaces	0	3	3
Total	54	585	639

There does not appear to be any spatial patterning present based on the total number of tools. Most of the burials have a few tools while very few have none. These seem to be interspersed across the site.

Those burials with the highest number of tools are found towards the western half of the burial area. This could be explained by a higher artifact density present in the midden soils. This area also had the higher number of burials with directly associated tools. The burial with the highest number of tools recovered was one of the first excavated, suggesting differing excavation techniques may be at work. The other initial burials also had higher number of burials. These differing excavation techniques are discussed later in Section 5.2.

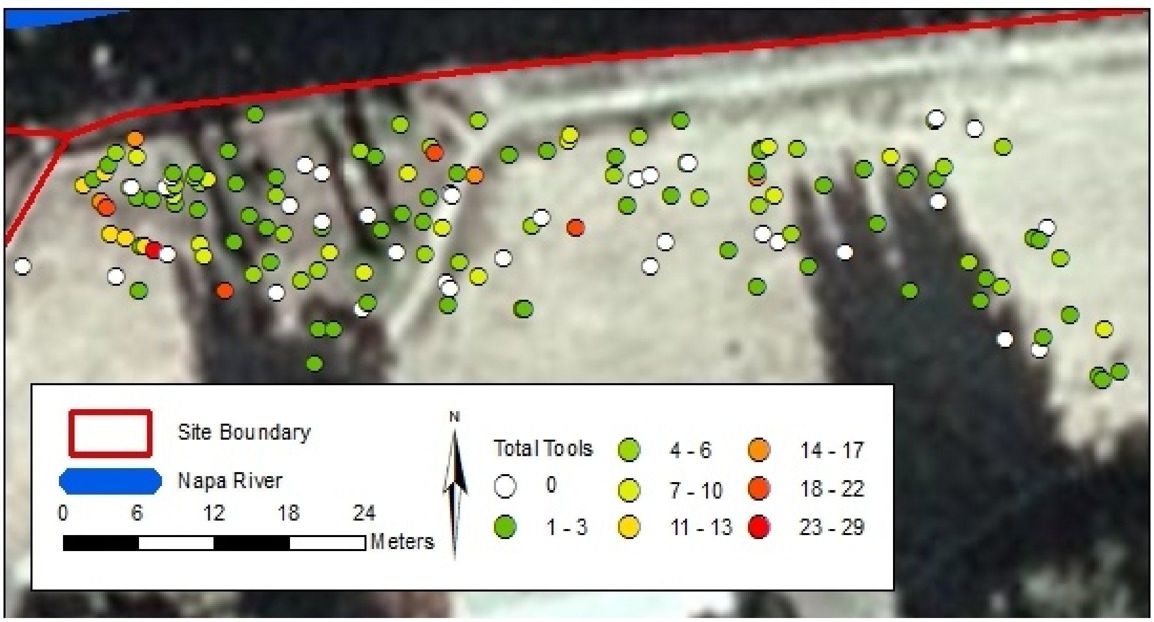

Figure 18: Map of Total Tool Distribution by Burial.

Total Artifacts

The distribution of the total number of artifacts is shown in Figure 19. Table 13 shows the number of burials by the range of total artifacts recovered per burial.

Table 13: Number of Burials by Range of Total Artifacts.

Total Artifacts Per Burial	Number of Individuals
0	24
1-11	87
12-21	18
22-32	10
33-45	10
46-63	4
64-174	5
175-625	3

Seven burials (24, 32, 56, 73, 79, 80, and 141) had over 100 artifacts. The burials with over 175 artifacts seem to be located along the periphery of the burial area. The center of the burial area shows burials with few artifacts. There is no discernible spatial patterning visible.

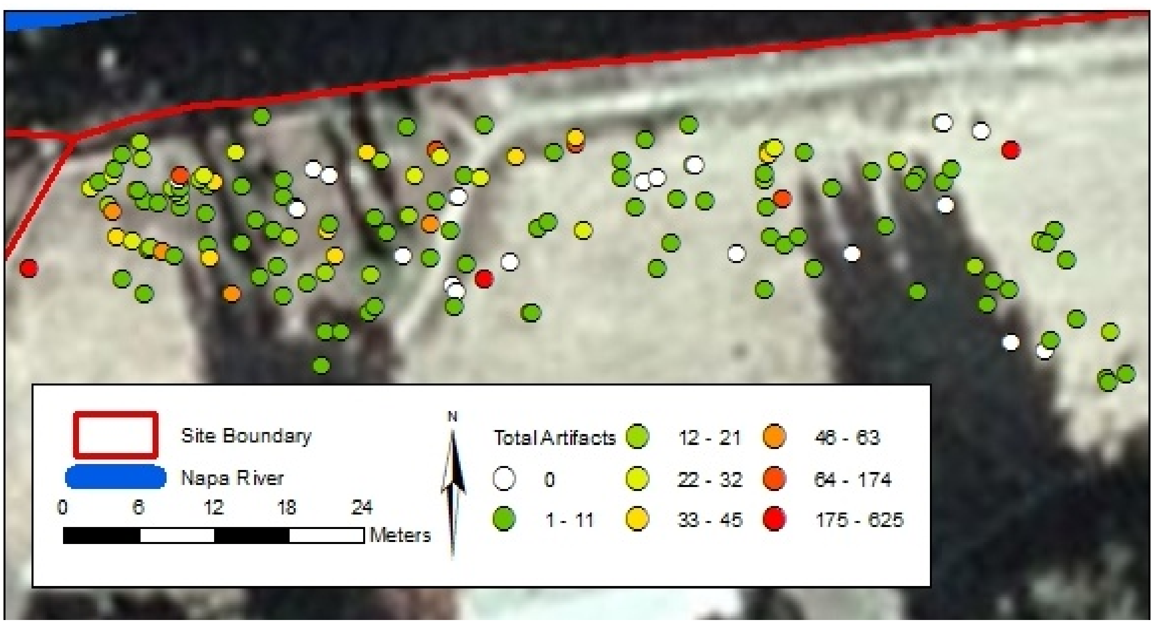

Figure 19: Map of Total Artifact Distribution by Burial.

Total Artifacts minus Debitage and Faunal Remains

The distribution of the total number of artifacts without debitage or faunal remains is presented in Figure 20. Table 14 shows the number of burials by range of total artifacts minus debitage and faunal remains.

Table 14: Number of Burials by Range of Total Artifacts Minus Debitage and Faunal Remains.

Total Artifacts Minus Debitage and Faunal Remains Per Burial	Number of Individuals
0	24
1-5	74
6-10	26
11-15	11
16-20	7
21-30	5
31-55	6
56-140	2
141-261	2

There is a small cluster of individuals with more than 30 artifacts near the western edge of the burials ground, in a dense cluster of burials, however the remainder are low in number.

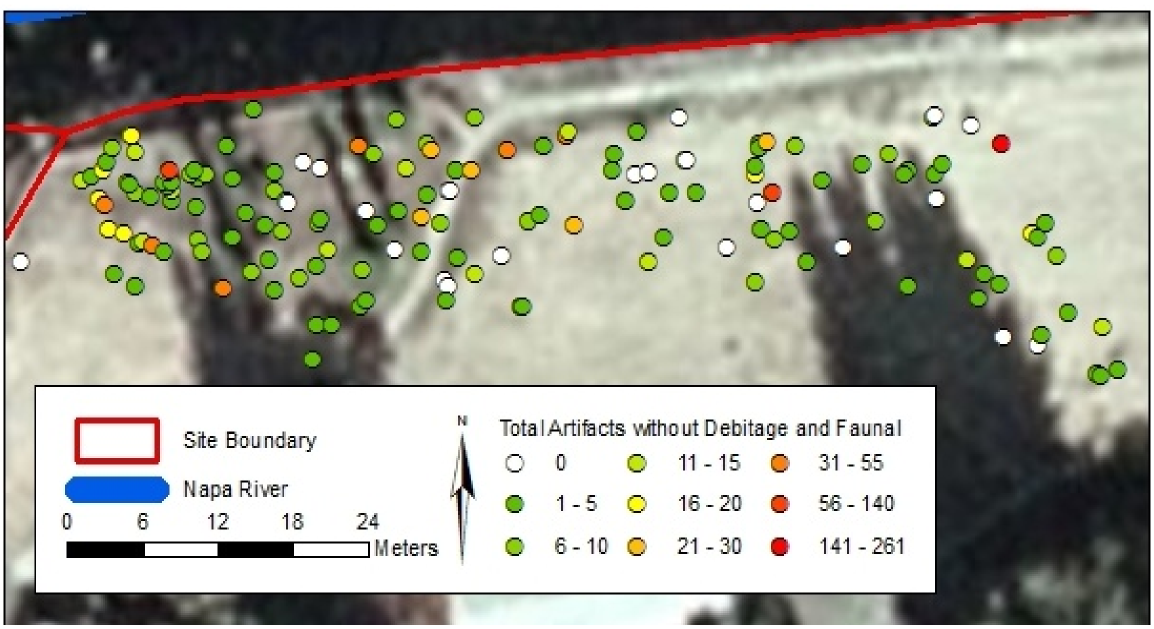

Figure 20: Map of Total Artifact without Debitage and Faunal Distribution by Burial.

Tool Diversity Index

The distribution of the tool diversity index values for the burials is shown in Figure 21. Thirty five individuals had a tool diversity index score of zero, 79 had a score of 0.08, 32 had a score of 0.15, 15 had a score of 0.23, two had a score of 0.31, and one individuals had a score of 0.38.

There are very few burials with no tools. Most burials have one type of tool. The overall distribution appears fairly random to the naked eye. There is a small cluster of individuals with a score greater than 0.08 approximately 12 meters east of the western edge of the burials ground, in a dense cluster of burials. Not surprisingly this distribution and map mimic that seen under the Total Artifacts and Total Artifacts minus Debitage and Faunal Remains previously described. Most of the burials with a higher tool diversity index are seen in the western half of the burial area which may be a reflection of the early excavation techniques used. Cultural implications of spatially clustered tool diversity index values could indicate areas designated for craftspeople.

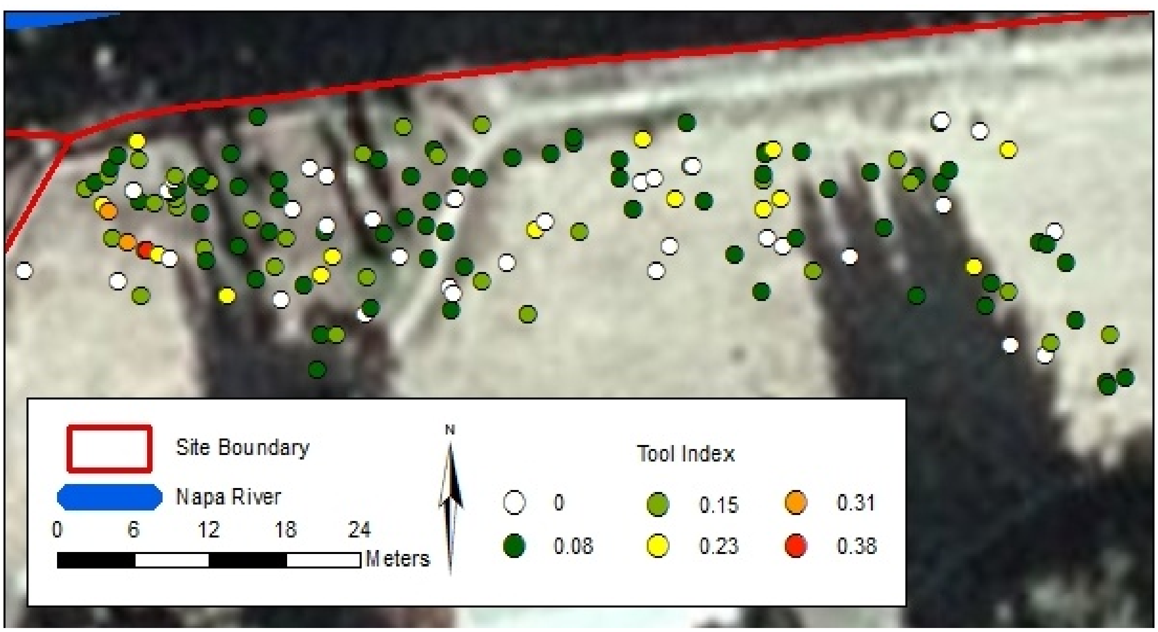

Figure 21: Map of Tool Diversity Index Distribution by Burial.

Wealth Diversity Index

The distribution of the wealth diversity index values for the burials is shown in Figure 22. One hundred individuals had zero wealth items, 39 had a wealth diversity score of 0.125, 12 had a score of 0.25, five had a score of 0.375, and one had a score of 0.75. The 0.75 is located in a dense cluster of burials approximately 12 meters east of the western edge of the burial area.

Most of the burials show a very low diversity of wealth items. Most of the burials with wealth items appear to be located in the western half of the burial area. The amount of individuals with no wealth items is striking in this view. This could indicate that there is perhaps some wealth inequality at work on the site. The very low diversity of wealth items among the burials could also be evidence of this.

Cultural implications of clustered wealth diversity index can be applied to rank and status studies, and also help denote specific areas for rank and status.

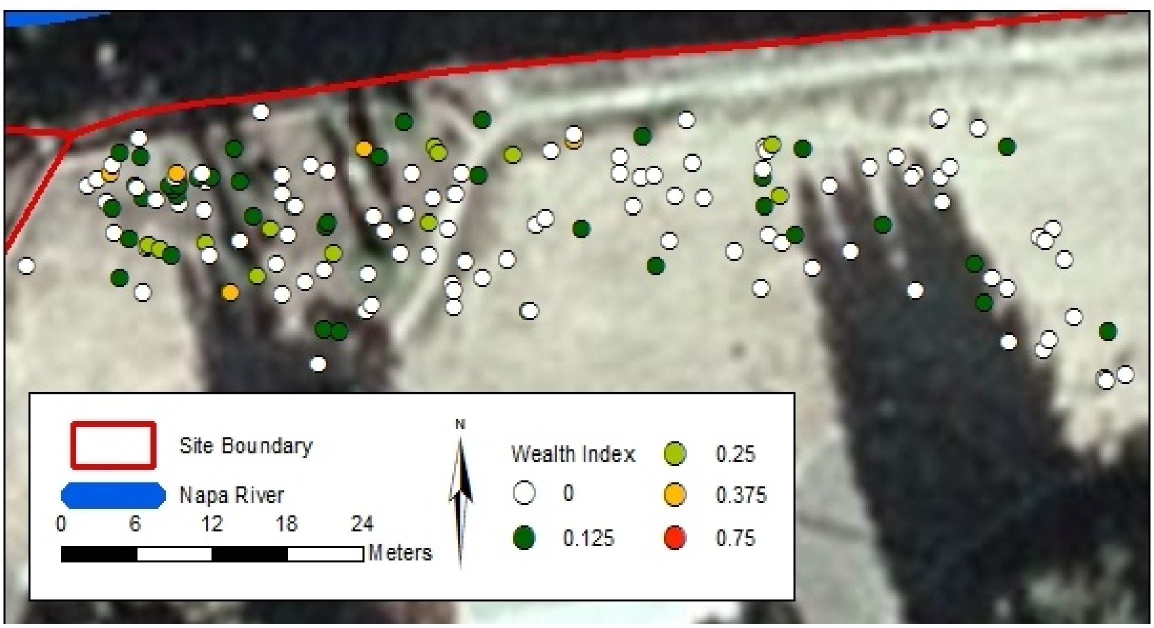

Figure 22: Map of Wealth Diversity Index Distribution by Burial.

Anemia

The distribution of burials with anemia is shown in Figure 23. A total of 112 out of 162 burials demonstrated anemia. This is a very high number and percentage in a population. This could indicate a variety of issues were at work on the site including malnourishment, a genetic abnormality causing this, improperly leeched tannins from acorns, or another disease like scurvy that presents itself in a similar manner to anemia on the bones. There is no clustering discernible to the naked eye.

Recent work by Walker et al. (2009) has shown that anemia is not necessarily tied with iron deficiency. They concluded that iron anemia does not provide a reasonable physiological explanation for the lesions. The authors argue the small lesions are the result of megaloblastic anemia acquired by nursing as an infant from depleted maternal vitamin B12 reserves and unsanitary living conditions. A lack of vitamin C (scurvy) and a vitamin B12 deficient diet can also cause the small pin hole sized lesions.

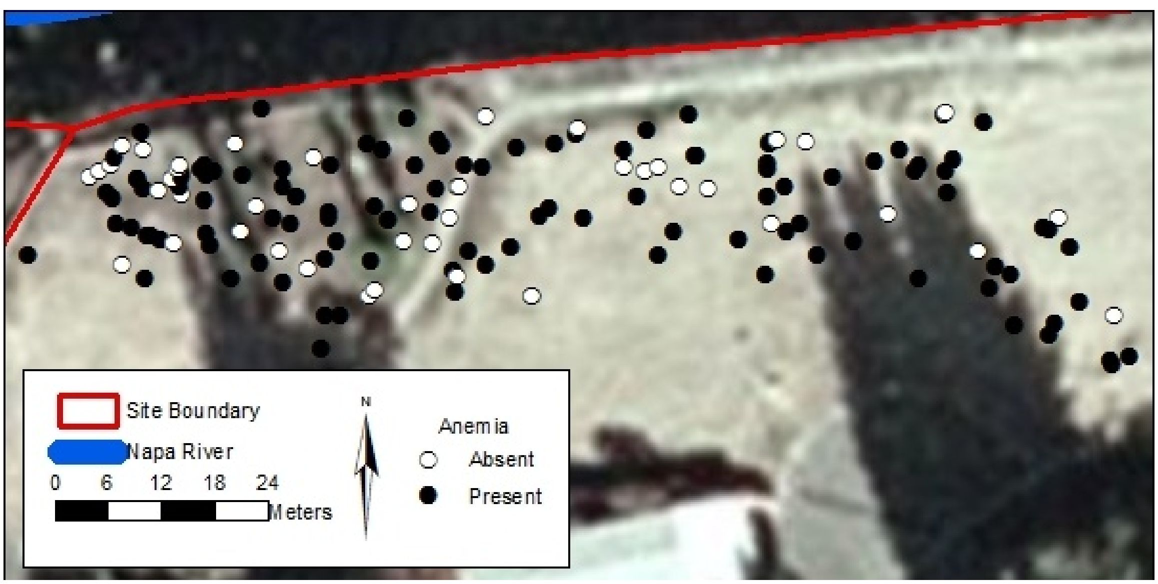

Figure 23: Map of Burials with Anemia.

Auditory Exostoses

The distribution of burials with auditory exostoses is shown in Figure 24. A total of 15 burials were found with this condition. The burials exhibiting this condition appear to be randomly dispersed across the burial area. There are none near the southeastern corner of the burial area however. The preservation in this area was poor, so perhaps the evidence of auditory exostoses did not survive.

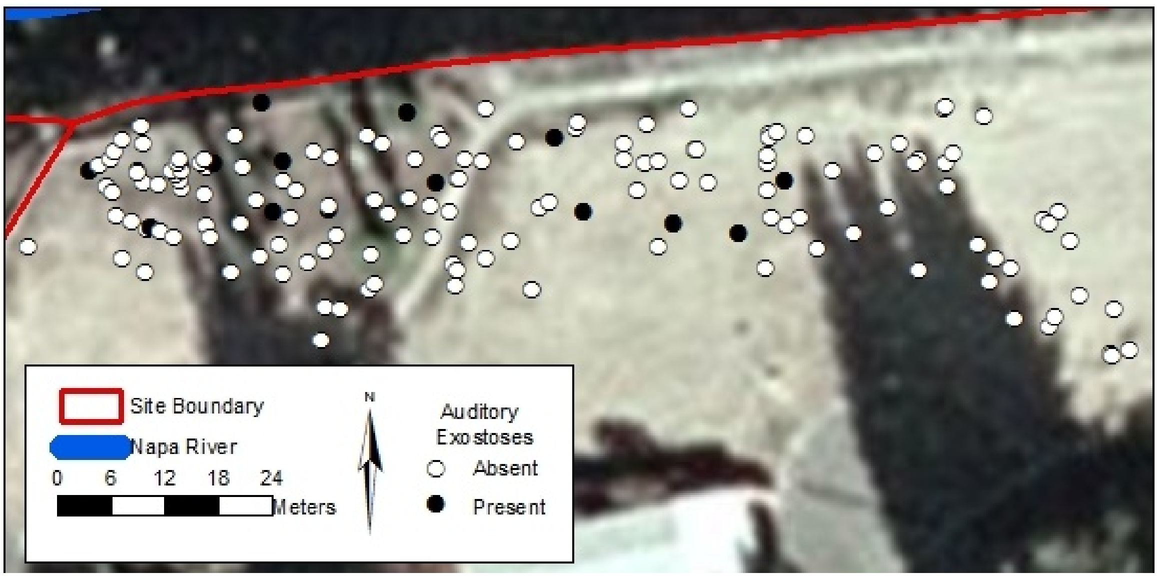

Figure 24: Map of Burials with Auditory Exostoses.

Dental Caries

The distribution of burials with dental caries is shown in Figure 25. Forty-one out of 162 burials had dental caries. There does not appear to be any clustering discernible to the naked eye for this condition.

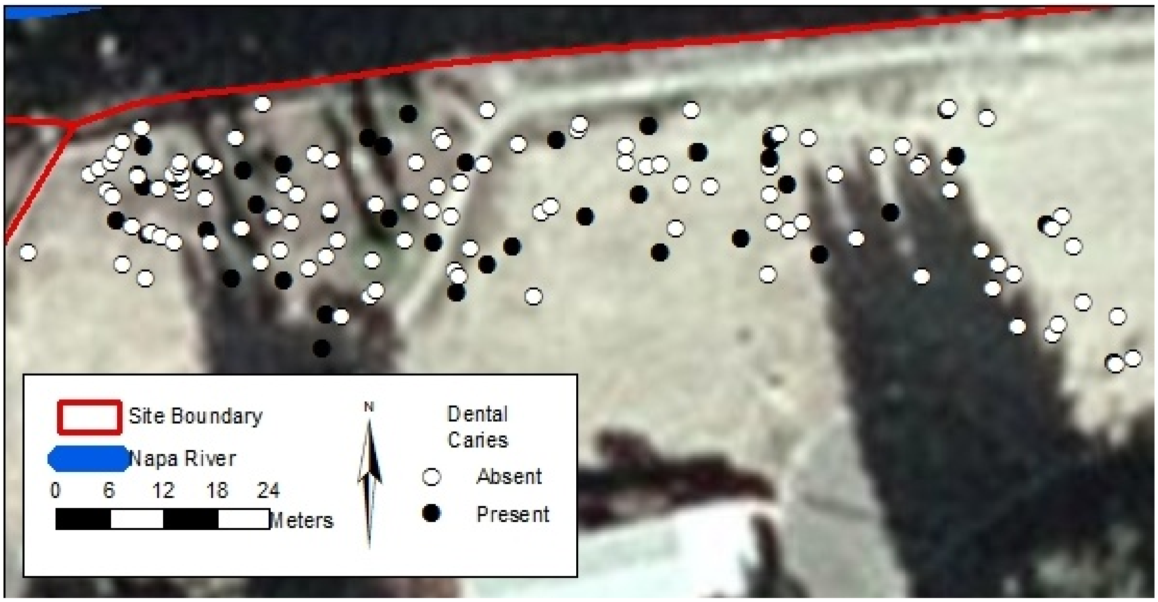

Figure 25: Map of Burials with Dental Caries.

Healed Fractures

The distribution of burials demonstrating healed fractures is shown in Figure 26. A total of 33 burials demonstrated healed fractures. There appears to be possible clusters based on this condition.

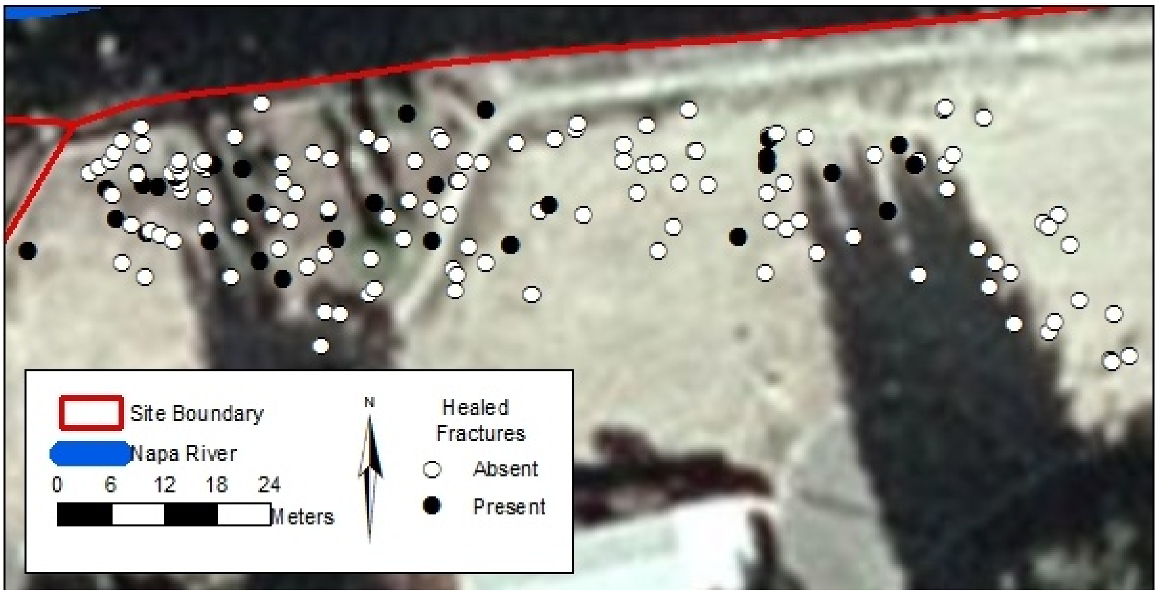

Figure 26: Map of Burials with Healed Fractures.

Osteomyelitis

The distribution of burials with osteomyelitis is shown in Figure 27. Only ten burials show evidence of suffering from osteomyelitis. There does not appear to be any clustering to the naked eye based on this condition. There are no cases towards the center of the burial area.

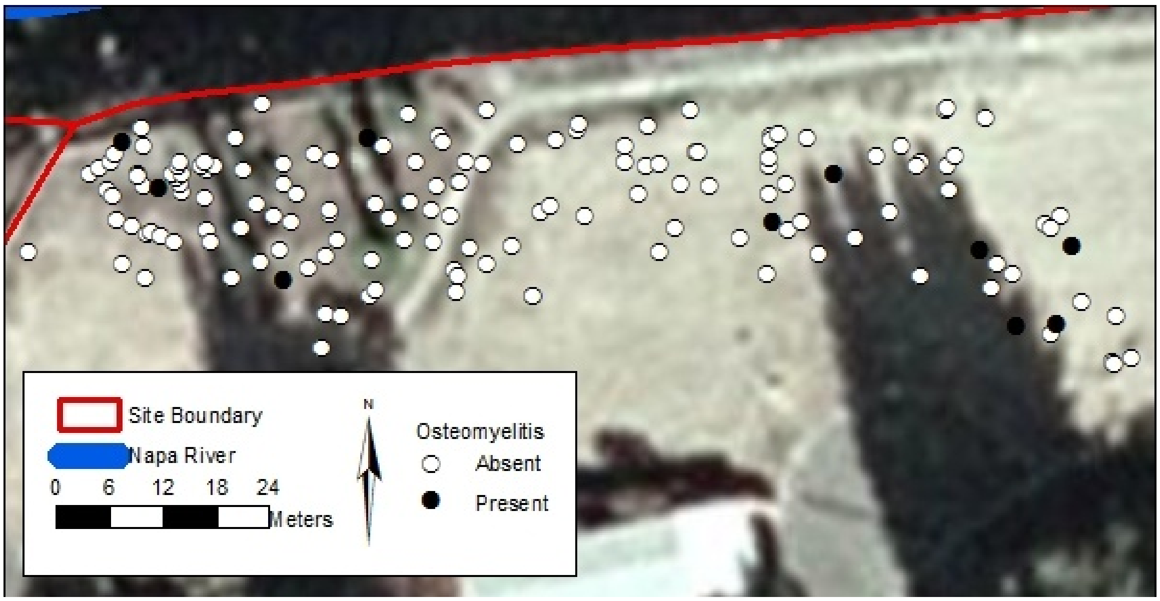

Figure 27: Map of Burials with Osteomyelitis.

Femurs with Anterior to Posterior Flattening

The distribution of burials demonstrating femurs with anterior to posterior flattening is shown in Figure 28. A total of 82 out of 162 burials suffered from this condition. There does not appear to be any discernible clustering to the naked eye.

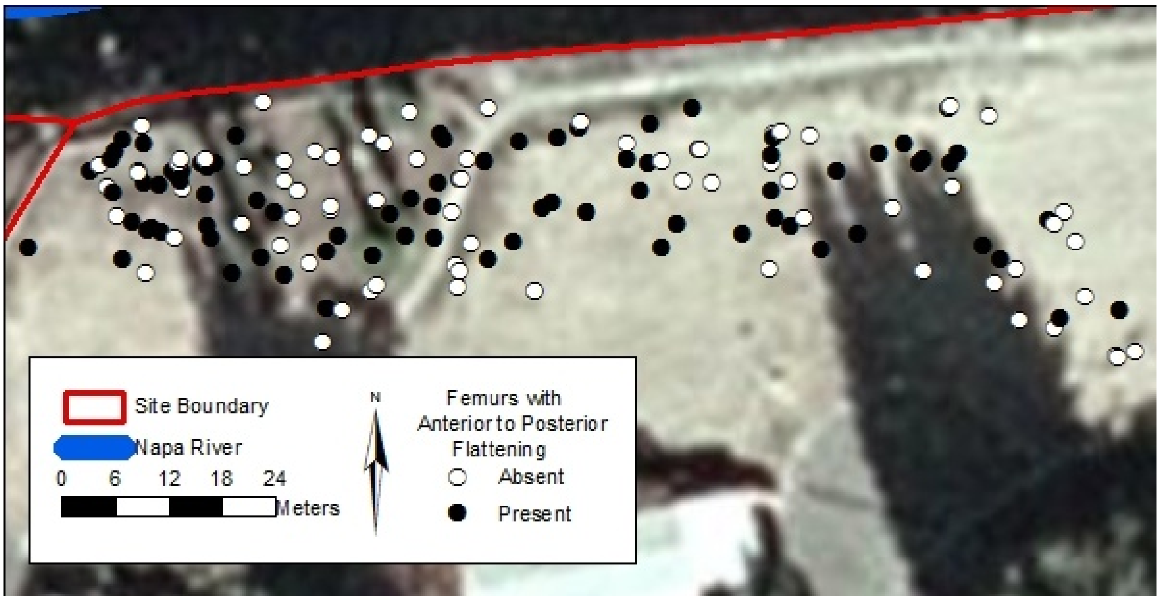

Figure 28: Map of Burials Demonstrating Femurs with Anterior to Posterior Flattening.

Inca Bone

The distribution of Burials with the non metric Inca Bone trait is shown in Figure 29. Only four individuals exhibited this non metric trait. It does appear that there could be possible clustering based on visual observations.

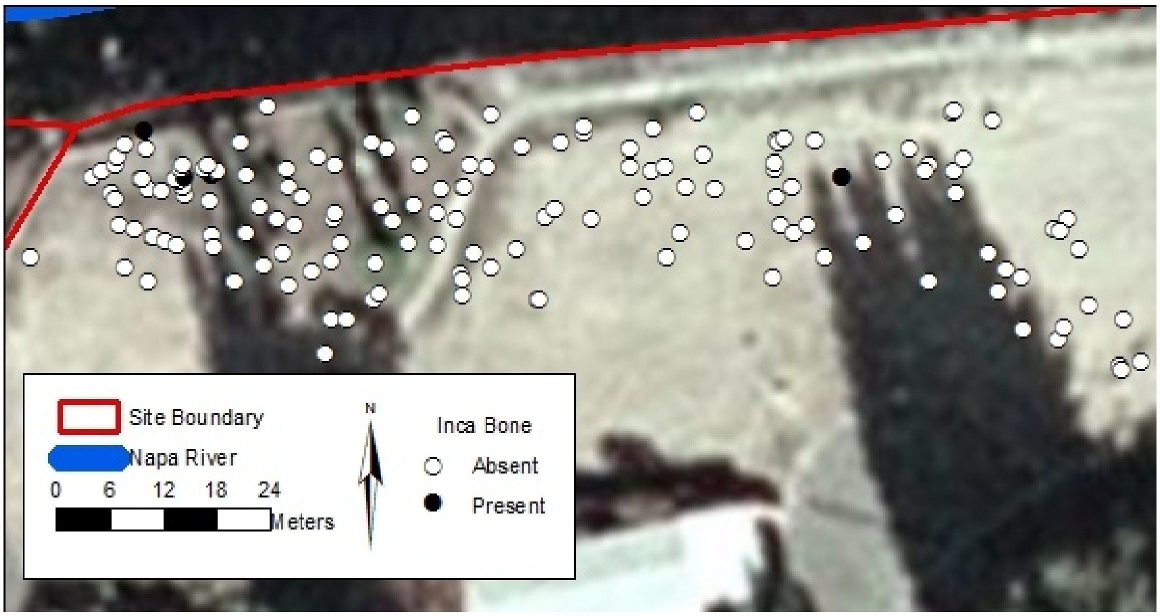

Figure 29: Map of Inca Bone Distribution.

Chapter 5 – Spatial Autocorrelation Analysis

This chapter examines the spatial autocorrelation of the burial points. The results are presented in the first section. This is followed by a brief discussion regarding select attributes, artifacts, and pathologies and anomalies. Numerous tables in this chapter refer to burial attributes that are abbreviated; please refer to Table A-1 in Appendix A for their meanings.

5.1 Spatial Autocorrelation Analysis Results

The distribution of burial points was tested for spatial autocorrelation. The spatial autocorrelation tool from ArcGIS 10 uses the Global Moran's I statistic to determine feature similarity based on both feature location and attribute value simultaneously. In this project the tool was run using the following specifications: inverse distance was chosen so there is less of a steep drop off in influence; Euclidian distance was chosen as it represents the closest distance between any two points; and ROW was chosen for standardization as some point data may be potentially biased due to sampling design or aggregation. The results of the demographic attributes of the burials are summarized in Table 15 below. The Z-Score refers to the number of standard deviations. The P-Score is the probability value, the closer to zero, the more likely that the object is not randomly placed in space.

Table 15: Burial Attributes Spatial Autocorrelation Summary.

Attribute	Moran's Index	Z-Score	P-Value	Distribution
Age	0.061	1.304	0.192	Random
Sex	0.026	0.627	0.531	Random
Flexure	-0.046	-0.660	0.510	Random
Orientation	0.068	1.308	0.191	Random
Side	-0.064	-0.965	0.334	Random
Bone Preservation	0.204	4.040	0.000	Clustered, <1% chance random
Depth	0.400	7.688	0.000	Clustered, <1% chance random
Depth in Meters	0.422	13.549	0.000	Clustered, <1% chance random
Direct Association	0.104	2.121	0.034	Clustered, <5% chance random
Total Wealth Items	0.015	0.521	0.602	Random
Total Tools	0.152	3.131	0.002	Clustered, <1% chance random
Total Artifacts	-0.004	0.059	0.9523	Random
Total Artifacts minus Debitage and Faunal Remains	0.010	0.385	0.700	Random
Tool Diversity Index	0.102	3.529	0.000	Clustered, <1% chance random
Wealth Diversity Index	0.128	4.486	0.000	Clustered, <1% chance random

Clustering was found for bone preservation, depth, depth in meters, direct association, total tools, tool diversity index, and wealth diversity index. The remainders of the burial attributes were randomly distributed.

Spatial autocorrelation was examined for the tools. Clustering of these items could denote possible profession, clan, or moiety areas within the cemetery area. The summary of spatial autocorrelation scores for tools is presented in Table 16. Those items with only a zero listed did not have any items recovered.

Table 16: Tool Spatial Autocorrelation Summary.

Attribute	Moran's Index	Z-Score	P-Value	Distribution
Direct Projectile Points	0.021	1.200	0.230	Random
Indirect Projectile Points	-0.015	-0.316	0.752	Random
Direct Bifaces	0.015	0.826	0.409	Random
Indirect Bifaces	0.075	2.712	0.007	Clustered, <1% chance random
Direct Edge-Modified Flakes	-0.013	-0.868	0.385	Random
Indirect Edge-Modified Flakes	0.130	4.687	0.000	Clustered, <1% chance random
Direct Drills	0	0	0	0
Indirect Drills	-0.001	0.741	0.459	Random
Direct Cores	0	0	0	0
Indirect Cores	-0.008	-0.047	0.963	Random
Direct Core Tools	0	0	0	0
Indirect Core Tools	0.015	0.843	0.399	Random
Direct Unifaces	0	0	0	0
Indirect Unifaces	0.133	7.420	0.000	Clustered, <1% chance random
Direct Millingslabs	0	0	0	0
Indirect Millingslabs	-0.005	0.207	0.836	Random
Direct Handstones	-0.013	-0.306	0.760	Random
Indirect Handstones	-0.018	-0.436	0.663	Random
Direct Bowl Mortars	0	0	0	0
Indirect Bowl Mortars	-0.020	-0.460	0.645	Random
Direct Pestles	-0.012	-0.259	0.795	Random
Indirect Pestles	0.068	2.821	0.005	Clustered, <1% chance random
Direct Bone Awls	-0.032	-1.350	0.177	Random
Indirect Bone Awls	-0.012	-0.186	0.853	Random
Direct Bone Pins	-0.007	-0.045	0.964	Random
Indirect Bone Pins	-0.022	-0.851	0.395	Random

Spatial autocorrelation was then examined for the wealth items. Clustering of these items could denote possible high status, high rank, or privileged areas within the cemetery area. The summary of spatial autocorrelation scores for the wealth items is presented in Table 17. Those items with only a zero listed did not have any items recovered.

Table 17: Wealth Items Spatial Autocorrelation Summary.

Attribute	Moran's Index	Z-Score	P-Value	Distribution
Direct Bird Bone Beads	0	0	0	0
Indirect Bird Bone Beads	-0.012	-0.614	0.539	Random
Direct Shell Beads	0.100	5.242	0.000	Clustered, <1% chance random
Indirect Shell Beads	0.007	0.445	0.656	Random
Direct Steatite Beads	-0.001	0.577	0.564	Random
Indirect Steatite Beads	0.003	1.192	0.233	Random
Direct Quartz Crystals	-0.017	-0.608	0.543	Random
Indirect Quartz Crystals	-0.009	-0.128	0.898	Random
Direct Natural Obsidian Needles	-0.001	0.721	0.471	Random
Indirect Natural Obsidian Needles	0.081	2.910	0.004	Clustered, <1% chance random
Direct Pendants	0.113	5.225	0.000	Clustered, <1% chance random
Indirect Pendants	-0.037	-1.638	0.101	Random
Direct Charmstones	-0.034	-0.993	0.321	Random
Indirect Charmstones	-0.036	1.552	0.121	Random
Direct Whistles	0	0	0	0
Indirect histles	-0.037	-1.641	0.101	Random

Indirect bifaces, indirect edge-modified flakes, indirect unifaces, and indirect pestles were found to be clustered for tools. Direct shell beads, indirect natural obsidian needles, and direct pendants were found to be clustered for wealth items. The remainders of the artifacts were randomly distributed or had no artifacts recovered.

Several pathologies and anomalies regarding the burials were examined for evidence of spatial autocorrelation. These are summarized in Table 18. This could give insight into whether particular parts of the cemetery were utilized as an area for the diseased or sickly. Auditory exostoses and the femurs with anterior posterior flattening can possibly mark occupation or profession areas in the burial area. The Inca bones are non-metric traits that can be inherited, and could give an indication into whether familial plots existed within the cemetery. Inca bone may also indicate occasional marrying in or capture of outsiders.

Table 18: Pathologies and Anomalies Spatial Autocorrelation Summary.

Attribute	Moran's Index	Z-Score	P-Value	Distribution
Anemia	0.003	0.290	0.771	Random
Auditory Exostoses	-0.035	-0.955	0.340	Random
Dental Caries	-0.071	-2.0875	0.037	Dispersed, <5% chance random
Healed Fractures	-0.003	0.125	0.900	Random
Osteomyelitis	0.000	0.225	0.822	Random
Femurs with Anterior-Posterior Flattening	0.002	0.259	0.796	Random
Inca Bone	0.013	0.722	0.471	Random

None of the pathologies and anomalies studied for spatial autocorrelation displayed clustering. Dental Caries were found to be dispersed. Dispersed is the opposite of clustering, and can be better visualized as a checkerboard pattern.

5.2 Spatial Autocorrelation Analysis Discussion

Only six of the burial attributes showed evidence of clustering while the remainders are randomly distributed. It was expected that there would be clustering based on depth given that all the burials were within a tight range. The bone preservation, directly associated artifacts, and total tools were unexpected.

Age

There is no spatial clustering based on age, as the spatial distribution is random. If there was to be preferential burial treatment based on age, it should reflect the age of the individual as they had a longer life in which to establish social ties that would be reflected in the mortuary treatment.

Brown (1981) argues that those individuals with greater social ties should be present near the center of the village or cemetery, while those individuals with less social ties (the younger individuals who did not have the time to develop many social ties) would be buried on the periphery of the burial area. We see no evidence for this occurring at CA-NAP-399, indicating that preferential treatment based on age did not occur. If there was clustering based on age, it would be an indication that greater social interactions were at work.

Sex

There is no spatial clustering based on sex, as the spatial distribution is random. Brown (1981) argues that there should be an equal distribution between the sexes, and that any deviation from this ratio can be seen as an indication of differential internment. The ratio between men and women is not equal, as there are more women present. There are several explanations for this, the most likely of which is that the men from the site simply died further away, and could not be transported back and buried. This suggests that women, children, and the elderly stayed in more central locations while the adult males ventured out further from the village for either hunting or trading expeditions. Other reasons include one man with multiple females or with females who live longer or with more than one female over life of male (if they die earlier in childbearing for example).

Flexure

There is no spatial clustering based on the burial flexure as the spatial distribution is random. This could be because the vast majority of the burials were tightly flexed, meaning all the tightly flexed burials could be considered “normal”. Any deviations from this could be considered outliers.

In terms of energy expenditures, the tightly flexed method is one of the easiest methods of burials since it is placed in the smallest grave that requires the least amount of energy expenditure to dig depending on the depth. This could merely be a reflection of an expedient burial method.

The depth of the burials can vary, and this can present various problems analyzing data. This is especially evident from the western cluster of burials according to depth. There were five radiocarbon dated burials dating to 2200 BP from this cluster. The center third of the cluster showed a half meter difference between three of the radiocarbon dated burials (see Figure 53). There are a variety of reasons this may have occurred.

There could have been more soil accumulation along this cluster, or an uneven topography to begin with. Given that there were a high number of graves dating to the same time period from this area, it could be that the surface level rose from all the burials taking place. The depth of the burial could also have something to do with the individual themselves.

A person could be buried deeper based on their wealth, whether they were seen as good or evil, or even based on the smell of the body. It is a highly variable attribute that can be very difficult to discern if the grave outlines are not noticed during controlled excavation. Those proponents of the greater energy expenditure that allowed for wealthier individuals to be buried deeper fail to answer why being buried deeper would be preferred. One could suppose it would allow for a smaller chance of the burial being robbed, but that rarely occurred in prehistoric society. One could also propose that the deceased wished to be closer to their ancestors, but this supposes earlier burials being present onsite.

Orientation

There is no spatial clustering based on burial orientation as the spatial distribution is random. It was originally thought that most of the burials would be facing Napa Glass

Mountain, an assumed place of sacredness. Most of the burials were facing west however, possibly facing the setting sun or possibly even the ocean. Whether this means the inhabitants did not consider the obsidian source sacred cannot be discerned from the evidence at hand.

Side

There is no spatial clustering based on the side the individual was buried on as the spatial distribution is random. It was hoped that some sort of pattern would emerge from this attribute, but it is simply too variable. The body may shift post internment which can also complicate matters.

It is likely that the real meaning to which side the individual was buried on, if any, has been lost to time. It could simply be an unintentional side effect of how the individual was laid to rest in the excavated grave.

Preservation

There was spatial clustering based on bone preservation. This is unlikely the result of cultural actions however. Bone preservation likely has more to do with where the burials were placed in site, coupled with the age of the burials and the overall health of the individual at the time of death. Different soils types and stratigraphic layers onsite may have affected preservation, while those individuals who are older at the time of their death generally have less robust bones.

In the case of CA-NAP-399, most of the poorly preserved burials are all located along the eastern edge of the site. This area also appears to have been slightly lower in prehistoric times judging by the differing burial depths and the radiocarbon dated burials across the site. Geomorphological studies of the site reveals that this area suffered repeated breaches by the

Napa River as it encounter Sulpher Creek slightly to the southeast (Holson et al. 2013). This periodic inundation over the years likely accounts for the overall poor preservation of the burials along the eastern edge of the site.

Depth

There is clustering based on depth. It is interesting to note that even with the large discrepancy in the depth between the attributes "depth" and "depth in meters", there was still spatial clustering. This makes sense as the burials date within a five hundred year period and suggests an almost continuous use of the site for burials over that time. There is very little variation in the depth across the site, as all the burials were discovered within a 1.75 meter thick swath.

Direct Association

There is spatial clustering based on direct association. The outliers are more likely to produce more information when depth is factored in and their place in the site chronology is established.

The direct association of artifacts could be skewed by a few individuals in an area who were deliberately buried with grave goods. There does not appear to be a single area where individuals without grave goods were buried, nor does there seem to be an area where those with grave goods were buried. A likely explanation for this clustering can be found below in the artifacts subsection.

Artifacts

There is clustering based on a variety of attributes related to tools. Spatial clustering was discovered for Total Tools, Tool Diversity Index, Wealth Diversity Index, indirect bifaces, indirect edge-modified flakes, indirect unifaces, indirect pestles, direct shell beads, indirect natural obsidian needles, and direct pendants.

Total tools could be the result of excavation techniques as there were many tools present in the soil matrix that may or may not have been associated with the individual. Some of the burials with the highest amount of tools recovered were some of the very first ones excavated. Differing excavation techniques could account for this. The first 12 burials were excavated with a "moat" around the burial. This moat was generally a few inches wide and encircled the burial. Excavation of the burial proceeded inward from this moat as dirt was pulled into the moat for removal. Excavation of this moat likely accounted for a higher number of these tools. Later burials were dug stratigraphically, in which the visible outlines of the graves were followed and the soil inside the excavated grave was screened. It is important to keep in mind that varying excavation techniques can produce differing data, and must be addressed.

Given that the tool diversity index is dependent on the total tools attribute, it is not surprising that there is clustering for this attribute. Again, the differing excavation techniques likely account for this clustering, as artifact density was very high in this area.

The wealth diversity index does have the potential to identify areas where individuals with a greater potential amount of wealth were located. This could suggest that these areas were designated areas devoted to individuals containing a higher number of variable burials goods, possibly indicating rank or high status areas.

A disadvantage to this attribute is that it does not quantify the amount of wealth, or even what sort of wealth is more important. Is an individual who only has five different wealth items wealthier or considered higher status than one individual with over a hundred of the same item? These are questions that archaeologists may never know. As a measure of diversity it can be helpful, but it does have its shortcomings.

Indirect bifaces were found to be clustered. Again, this is likely the result of the excavation techniques. The same can be said for edge-modified flakes and pestles.

Indirect unifaces were found to be clustered as well. This is very odd as there were only three unifaces recovered with the burials, and very few encountered during the data recovery excavation. Analysis of the clustering revealed that all three unifaces were located with two burials in close proximity to one another. This too can likely be explained as differing excavation techniques for the earlier burials.

Another explanation regarding the clustering of indirect tools is that they could also possibly represent activity areas onsite. Certain areas of the site, in prehistoric times, could have been devoted to different activities such as habitation, tool production, food preparation, cooking, basket production, tanning of hides, etc. Tools specifically related to project specific tasks could be located within the soil matrix within specific areas of the site, and were exposed during excavation of the burials in these areas.

Spatial clustering based on wealth items holds a great potential into the examination of status and rank within the site. Both shell beads and pendants could be seen as an indication of rank or even social clans, and being buried in a cluster could denote a specified area reserved for high ranking members of society. Examination of both attributes found that they were clustered based on two individuals with a large number and assortment of burial goods in close proximity to one another. Both burials date to 2200 BP. However, there are a large number of contemporaneous burials nearby. It is also worth noting that these two individuals seem to be at the center of the westernmost cluster based on depth. This suggests that these two individuals were of higher rank than those burials surrounding them.

Indirectly associated natural obsidian needles were also found to be clustered. A possible explanation for this is that naturally occurring needles are found in the soil matrix. The site is located on a floodplain located downriver from Napa Glass Mountain. Erosion of obsidian deposits could have resulted in deposition of these objects into the soil, which was then revealed during excavation of the burials. This could happen to any of the burials with one or two of the natural obsidian needles.

Pathologies and Anomalies

There was no clustering with any of the pathologies and anomalies entered into the attribute data. The dental caries were found to be evenly dispersed across the site, with less than 5% chance of this being random. This result is still likely random, as it seems highly unlikely for the prehistoric inhabitants to space out all the burials based on dental caries.

Chapter 6 – Cluster Analysis

This chapter presents the results of the cluster analysis. It also discusses the results and the implications on prehistoric society.

6.1 Cluster Analysis Results

The Anselin Local Moran's I clustering was run in ArcGIS using inverse distance squared, with the Euclidian distance, and a ROW for standardization. The results of running the Anselin Local Moran's I clustering statistic for the demographic attributes are presented in Table 19. This identifies burials that are part of a cluster of higher values (HH), or lower values (HL). It also indicates which burials were outliers. Burials could be considered outliers with either high values surrounded by low values (LH) or low values surrounded by high values (LL).

The use of nominal values to represent specific data presents a few problems for the cluster analysis. These data sets are not applicable to this type of study as they represent discrete values and are not numeric values. For this reason, those attributes that consisted of nominal data were removed from this particular analysis.

It is also worth noting that this particular analysis technique does not identify clusters of middle range values. The clusters reported within this chapter are different than those from the previous chapter. The clusters within this chapter focus on high and low values for the data. A more comprehensive grouping analysis that incorporates all values is used in the next chapter.

Table 19: Individual Burial Cluster Analysis Summary.

Cluster Analysis	HH Burials	HL Burials	LH Burials	LL Burials
Depth in meters	13, 14, 15, 25, 26, 30, 31, 39, 60, 64, 66, 69, 83, 144, 145, 155	131	32	5, 6, 9, 18, 21, 100, 101, 102, 113, 114, 115, 116, 124, 126, 127, 132, 133, 134, 135, 138, 154,
Total Wealth Items	73, 79	32, 56	None	None
Total Tools	6, 7, 8, 9, 10, 17, 94, 136, 158	16	5,12	None
Total Artifacts	None	24,32	None	None
Total Artifacts Minus Debitage and Faunal Remains	73, 79	32, 56	151	None
Tool Diversity Index	3, 6, 7, 8, 9, 10, 11, 17, 158	22, 32, 40, 143	5, 12, 23, 33, 73, 138	91, 124
Wealth Diversity Index	7, 8, 20, 33, 51, 73, 79, 94, 100, 121, 129	84, 141	18, 76, 101	None

For the sake of brevity, only the seven artifact types that had evidence for clustering in the autocorrelation analysis were subjected to cluster analysis. These are presented in Table 20.

Table 20: Cluster Analysis of Artifacts Summary.

Cluster Analysis	HH Burials	HL Burials	LH Burials	LL Burials
Indirect Bifaces	6, 7, 8, 9, 10, 17, 94, 133, 158	16	5, 11, 12	None
Indirect Edge-Modified Flakes	3, 6, 7, 8, 9, 10, 17, 19, 35	16, 32, 68	None	None
Indirect Unifaces	7, 8	None	None	None
Indirect Pestles	10, 17, 158	104	None	None
Direct Shell Beads	73, 79	None	None	None
Indirect Natural Obsidian Needles	5, 7, 8, 12, 33, 73, 79, 100	1, 68, 105	None	None
Direct Pendants	73, 79	143	None	None

6.2 Cluster Analysis Discussion

The results of the cluster and outlier analysis based on certain attributes allowed for the advancement of studies in other areas regarding the burials. Determining which individuals were parts of clusters, and which were outliers, allows for archaeologists to ask more pertinent questions regarding these burials.

It is also worth noting that even though the spatial autocorrelation results showed that there was no clustering in some cases, running the cluster and outlier analysis can result in clustered burials. This is because that while a few burials may show signs of clustering; there are not enough clustered burials to be considered statistically significant. Further, there could be a cluster consisting of one burial as the surrounding burials had higher values, but not enough to be considered statistically significant.

Another aspect to consider is that while there is clustering in two dimensions, the clustering seen may not be present among cotemporaneous burials in the same date range. This could be accounted for by random happenstance, or it could be an indication that an oral narrative detailing the burials was maintained by the inhabitants of the site which dictated the placement of certain individuals with certain attributes.

Depth in meters

The cluster and outlier analysis based on depth in meters is presented in Figure 30. It showed that there were 16 burials (13, 14, 15, 25, 26, 30, 31, 39, 60, 64, 66, 69, 83, 144, 145, 155) that had high scores surrounded by high scores, one burial (131) that had a high value surrounded by burials with small values, one burial (32) that had a low value surrounded by high values, and 21 burials (5, 6, 9, 18, 21, 100, 101, 102, 113, 114, 115, 116, 124, 126, 127, 132, 133, 134, 135, 138, 154) that had low values surrounded by low values.

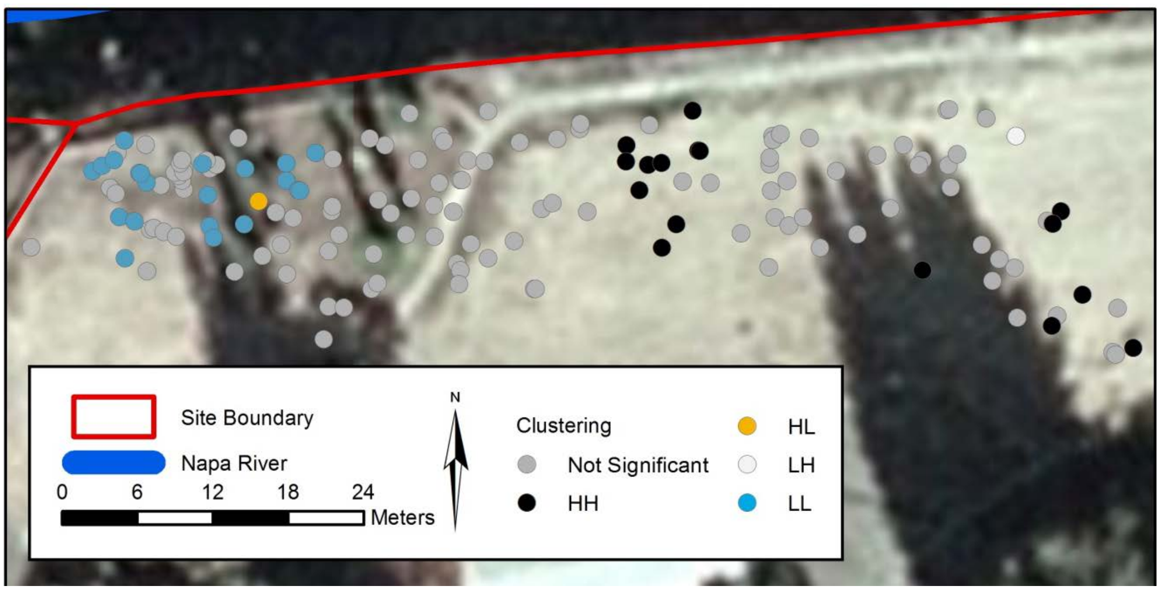

Figure 30: Map of Cluster Analysis of the Burials Based on Depth in Meters.

Depth is one of the more useful attributes to study for clustering. Clustering most likely indicates areas that had numerous individuals interred at the depth. In this case, high values surrounded by high values indicate burials with a deeper depth. Low values surrounded by low values indicate burials with a higher depth and later internment date. It is possible that burials that cluster at the same depth may be from the same date range. This is examined further in Chapter 7 where the burials are examined in groups by depth.

Outliers based on depth could indicate burials that are from different date ranges or time periods onsite. A high value surrounded by low values indicates a deeper burial with numerous other burials above it, suggesting greater antiquity. A low value surrounded by high values indicates a burial higher in the soil profile than the deeper burials beneath it.

At CA-NAP-399 there are three discrete, discernible to the naked eye, clusters of burials based on depth. Burials 39, 50, 60, 64, 66, 67, and 69 appear to be a cluster of burials at the eastern edge of the burial area from around 2450 BP based on the radiocarbon date from Burial 67. Burials 13, 15, 25, 26, 30, 31, 144, 145, and 155 appear to be a cluster of burials near the center of the burial area from around 2380 BP based on the radiocarbon date from Burial 15. Burials 3, 5, 6, 7, 8, 9, 10, 18, 19, 20, 21, 33, 93, 100, 101, 102, 113, 114, 115, 116, 118, 123, 124, 126, 127, 132, 133, 134, 135, 138, 153, 154 appear to be a cluster of burials from the western edge of the burial area dating from between 2200 BP and 2130 BP. This is based on the four radiocarbon dates of 2200 BP from Burials 73, 79, 115, and 116 along with the date of 2130 BP from Burial 10.

For further discussion regarding depth, please refer to Chapter 7 where another analysis technique similar to clustering, grouping, is used. This technique avoids the high/low clustering seen within this chapter. This chapter also gives a greater insight into the vertical distribution of the burials across the site, coupled with the radiocarbon dates.

Total Wealth Items

The cluster and outlier analysis based on the total number of wealth items is presented in Figure 31. It showed that there were two burials (73, 79) with high values surrounded by high values and two burials (32, 56) with high values surrounded by low values.

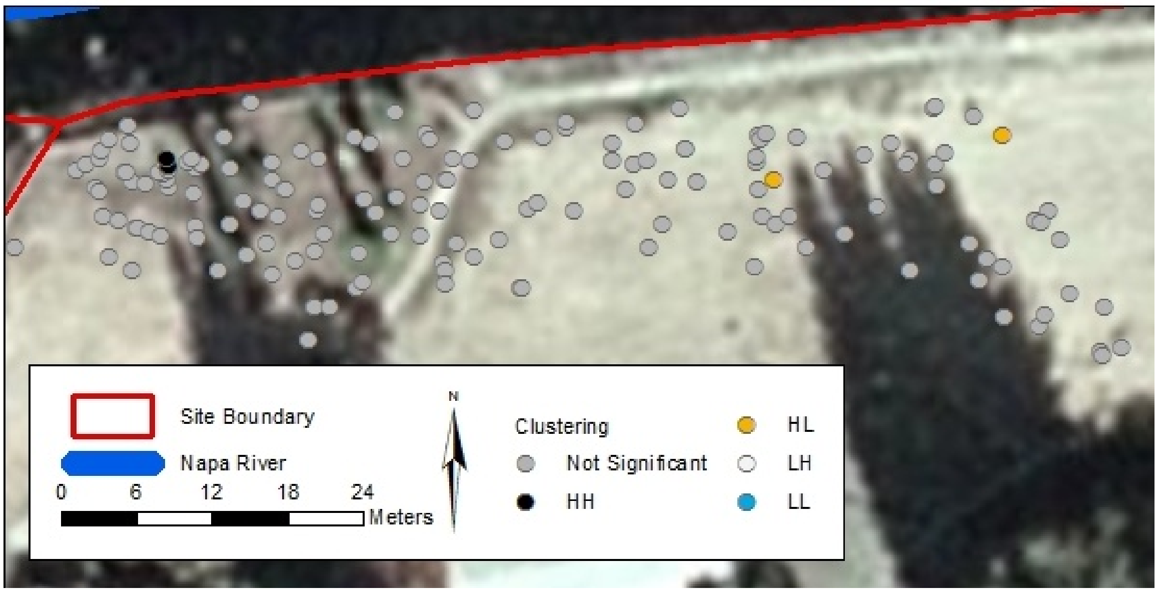

Figure 31: Map of Cluster Analysis of the Burials Based on Total Wealth Items.

A cluster of high values surrounded by high values would indicate an area where the individuals were buried with a large number of wealth items. This could indicate an area dedicated to higher status individuals. A high value surrounded by low values indicates an individual with a large number of wealth items surrounded by individuals with less. A low value surrounded by high values would indicate a person with few wealth items being buried near individuals with large numbers of wealth items. A cluster of low values surrounded by low values would indicate an area where individuals had very few wealth items. This could indicate an area where people of a lower status or rank were buried. Results would suggest a high status area; however one of these burials was a sub-adult who did not have a chance to achieve status.

Total Tools

The cluster and outlier analysis based on the total number of tools is presented in Figure 32. It showed that there were nine burials (6, 7, 8, 9, 10, 17, 94, 136, 158) with high values surrounded by high values, one burial (16) with a high value surrounded by low values, and two burials (5, 12) with low values surrounded by high values.

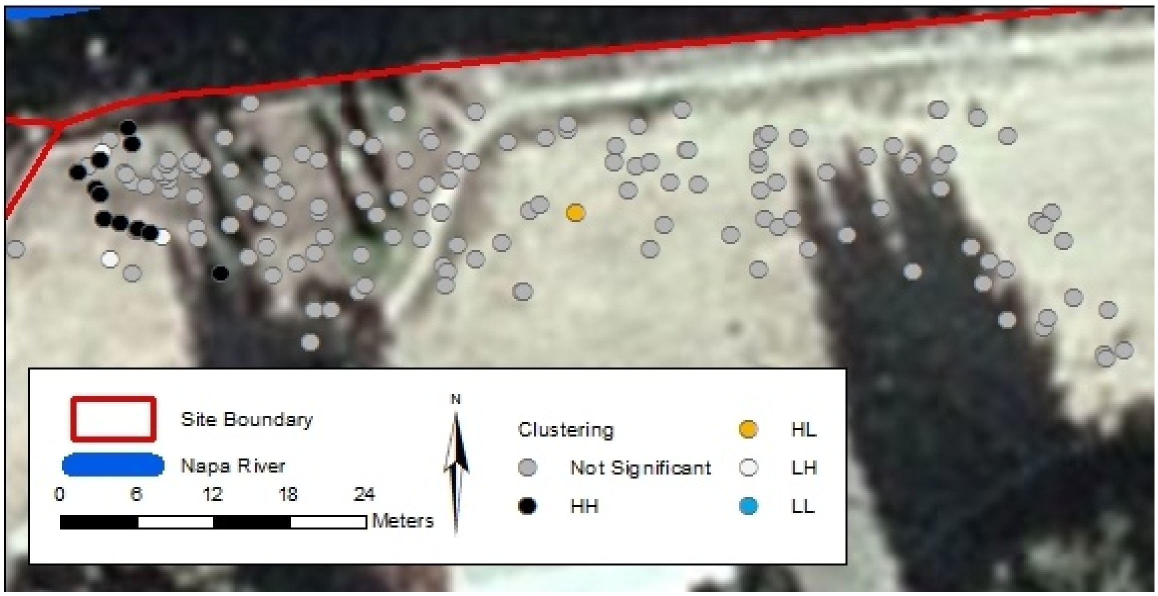

Figure 32: Map of Cluster Analysis of the Burials Based on Total Tools.

A cluster of high values surrounded by high values could indicate an area where individuals were interred with large number of tools. It could also indicate a possible activity area onsite where a large number of tools were left behind, then mixed into the burial matrix during the burial.

It is likely the clustering seen here is the result of excavation techniques, where excess midden soils containing a high number of tools were excavated around a number of the initial burials.

Total Artifacts

The cluster and outlier analysis based on total artifacts is presented in Figure 33. It showed two burials (32, 56) where there were high values surrounded by low values.

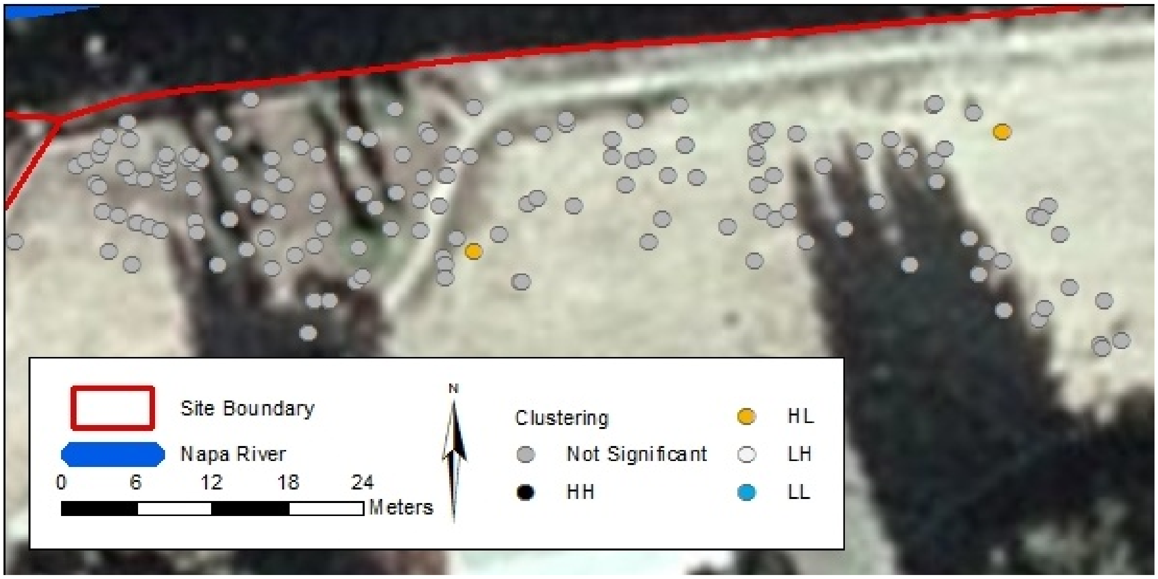

Figure 33: Map of Cluster Analysis of the Burials Based on Total Artifacts.

Clustering based on similar artifact totals would indicate that there was a controlled effort to bury the individuals with similar numbers of artifacts. The high values surrounded by low values show there are outlier burials with a high number of artifacts surrounded by individuals with fewer total artifacts.

Excavation techniques may also explain the higher artifact totals. Burial 32 in the northeast corner of the burial area required excavation through 1/16" wire mesh in order to recover the small glass trade beads. This likely recovered a number of smaller flakes as well from the burial matrix that may not have necessarily been directly associated.

Total Artifacts minus Debitage and Faunal Remains

The cluster and outlier analysis based on total artifacts minus debitage and faunal remains is presented in Figure 34. It showed two burials (73, 79) that had high values surrounded by high values, two burials (32, 56) with high values surrounded by low values, and one burial (151) with a low value surrounded by high values.

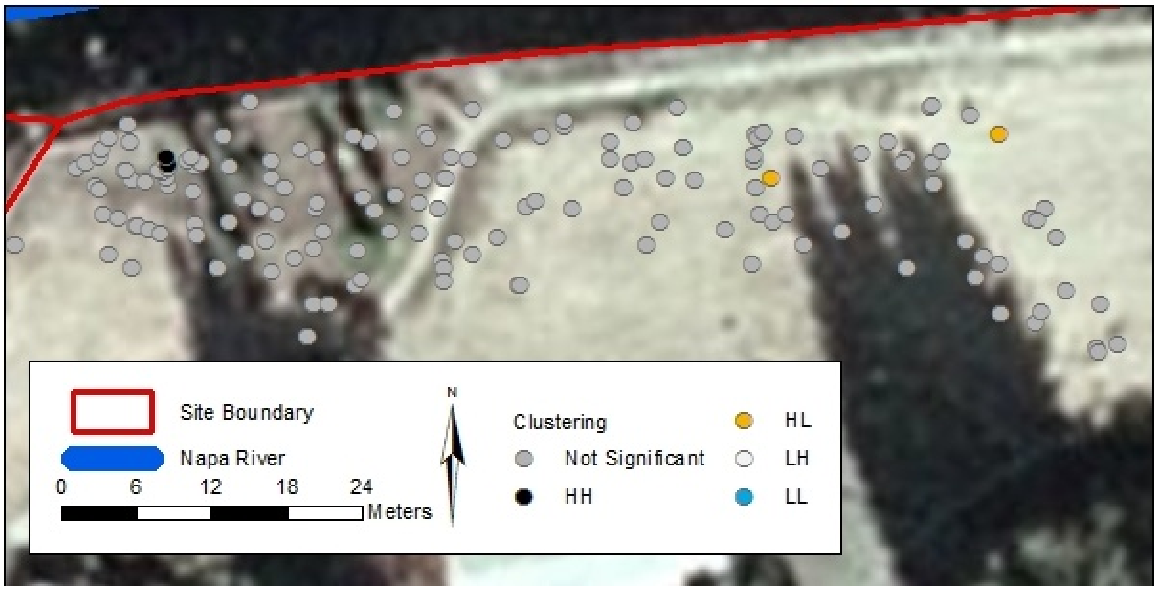

Figure 34: Map of Cluster Analysis of the Burials Based on Total Artifacts Minus Debitage and Faunal.

Clustering based on similar artifact totals would indicate that there was a controlled effort to bury the individuals with similar numbers of artifacts. It would be difficult for this to occur naturally. This attribute singled out four out of the six burials with the highest amount of wealth items. This attribute strongly mimics the total wealth items attribute.

By eliminating the debitage and faunal remains, the total number of artifacts is greatly reduced. This results in eliminating some of the background noise from the midden, and allows for a more even examination of artifacts that might have more significance.

Tool Diversity Index

The cluster and outlier analysis based on tool diversity index is presented in Figure 35. It showed nine burials (3, 6, 7, 8, 9,10, 11, 17, 158) that had high values surrounded by high values, four burials (22, 32, 40, 143) with high values surrounded by low values, six burials (5, 12, 23, 33, 73, 138) with low values surrounded by high values, and two burials (91, 124) with low values surrounded by low values.

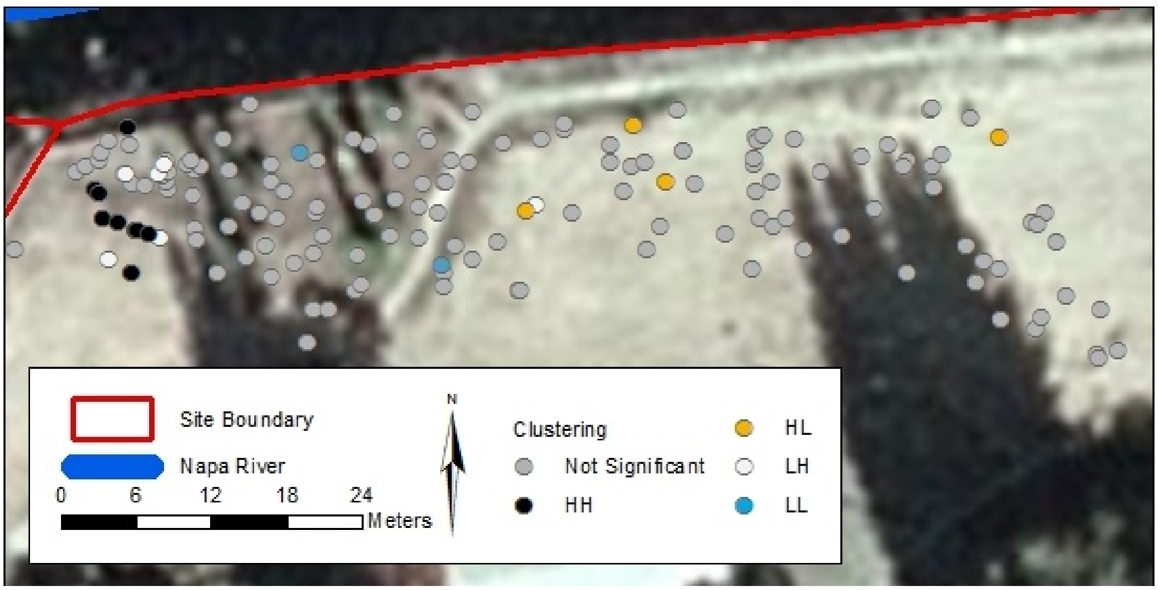

Figure 35: Map of Cluster Analysis of the Burials Based on Tool Diversity Index.

Clustering based on the tool diversity index mimics the total tools attribute. This is not surprising as the tool diversity is based on that attribute to a certain extent. Clustering can likely explained by excavation techniques. Another possible explanation is the presence of artifact specific activity areas onsite that may have mixed a different number of tools into the soil matrix which was then incorporated into the burial fill unintentionally.

Wealth Diversity Index

The cluster and outlier analysis based on wealth diversity index is presented in Figure 36. It showed 11 burials (7, 8, 20, 33, 51, 73, 79, 94, 100, 121, 129) with high values surrounded by high values, two burials (84, 141) with high values surrounded by low values, and three burials (18, 76, 101) with low values surrounded by high values. This would seem to suggest that there are possibly two areas where individuals with a diverse array of wealth items that may reflect rank were interred.

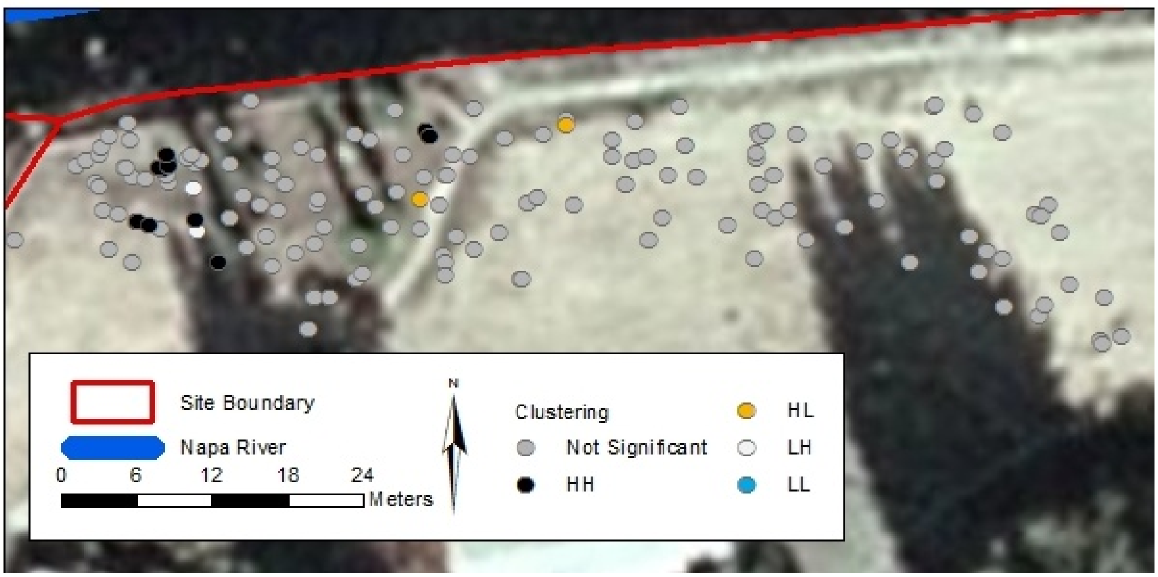

Figure 36: Map of Cluster Analysis of the Burials Based on Wealth Diversity Index.

Clustering based on the wealth diversity index shows individuals with similarly diverse wealth assemblages were clustered together. Burials 73 and 79 had two of the highest wealth diversity index readings, and are located near to one another. This suggests the possibility that portions of the burial area were reserved for individuals with a more diverse assemblage of wealth items.

Indirect Bifaces

The cluster and outlier analysis based on indirectly associated bifaces is presented in Figure 37. It showed nine burials (6, 7, 8, 9, 10, 17, 94, 133, 158) with high values surrounded by high values, one burial (16) with a high value surrounded by low values, and three burials (5, 11, 12) with low values surrounded by high values.

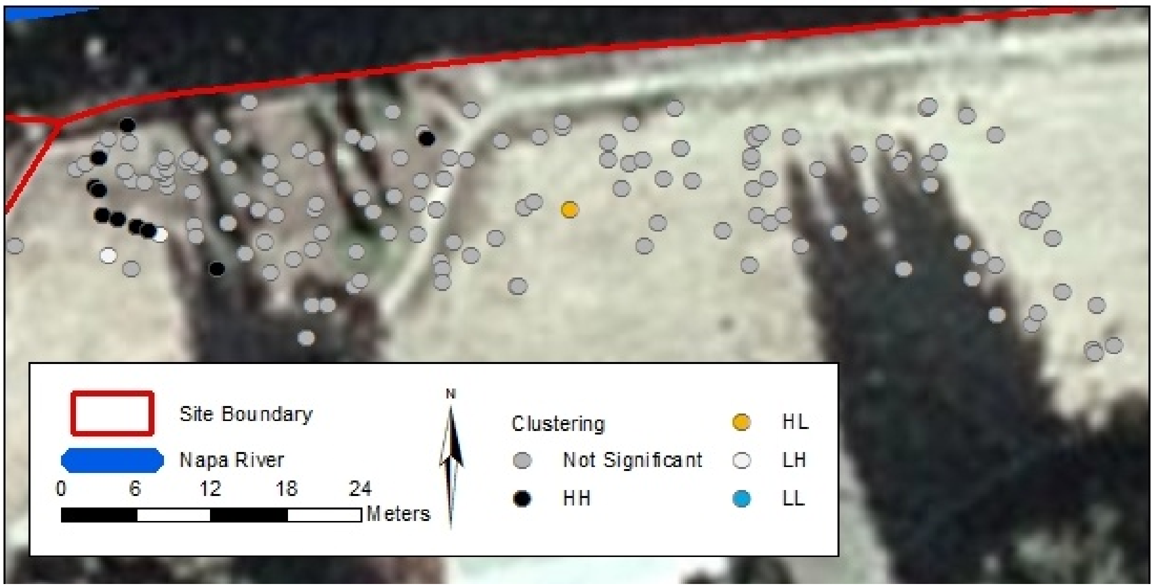

Figure 37: Map of Cluster Analysis of the Burials Based on Indirectly Associated Bifaces.

Clustering based on indirect bifaces can be explained in a variety of ways. Given the massive biface production that was occurring onsite for trade, it seems likely that bifaces from the midden became intermixed with burial fill. Another possible explanation is the differing excavation techniques, however this would not account for four of the burials from the high values surrounded by high values cluster.

Indirect Edge-Modified Flakes

The cluster and outlier analysis based on indirectly associated edge-modified flakes is presented in Figure 38. It showed nine burials (3, 6, 7, 8, 9, 10, 17, 19, 35) with high values surrounded by high values and three burials (16, 32, 68) with high values surrounded by low values.

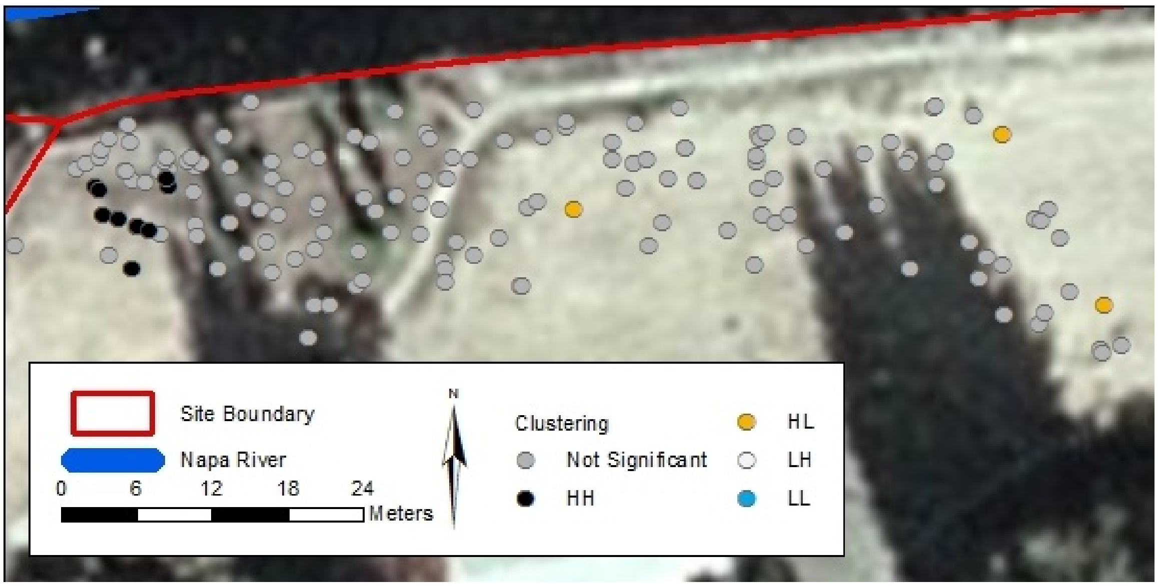

Figure 38: Map of Cluster Analysis of the Burials Based on Indirectly Associated Edge-Modified Flakes.

Much like indirectly associated bifaces, the indirectly associated edge-modified flakes can likely be explained by excavation techniques. It is also possible that given the large amount of debitage onsite, that flakes demonstrating trampling could have been interpreted as intentionally edge-modified. Another possibility is that the cluster of high values could have been in an activity area where edge-modified flakes were in use, which then became intermixed with the burial matrix.

Indirect Unifaces

The cluster and outlier analysis based on indirectly associated unifaces is presented in Figure 39. It showed two burials (7, 8) with high values surrounded by high values.

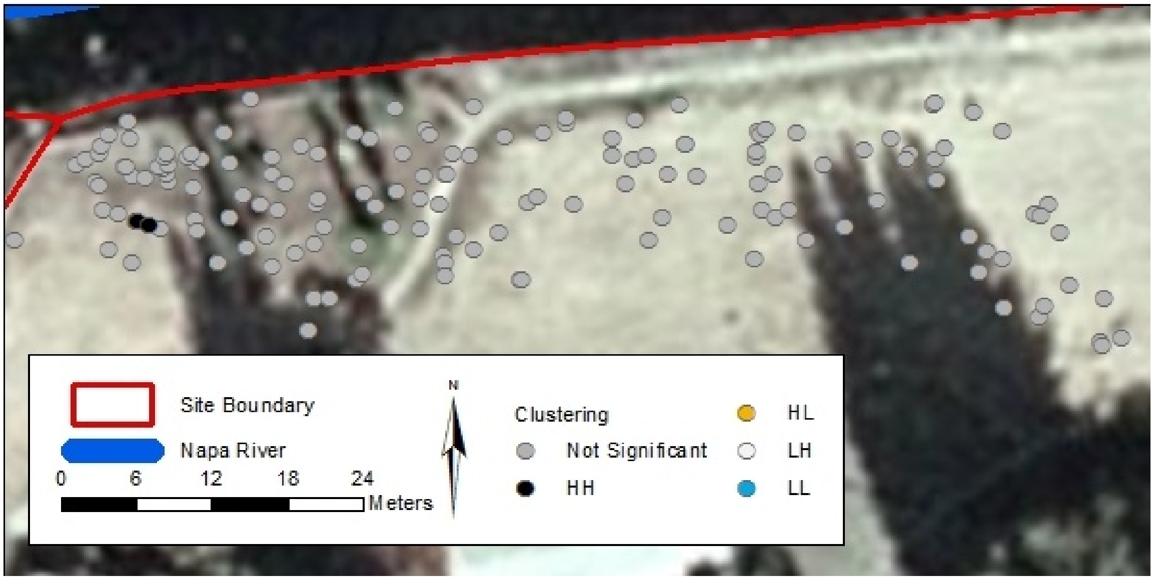

Figure 39: Map of Cluster Analysis of the Burials Based on Indirectly Associated Unifaces.

This clustering is likely the result of excavation techniques and the very low number of unifaces being recovered. There were a low number of unifaces recovered from the excavation units. It seems that two or three unifaces popping up in the burial matrix would be random in this case, and again, a direct result of the differing excavation techniques for the burials employed early on in the excavation. An activity area that utilized unifaces may be another explanation.

Indirect Pestles

The cluster and outlier analysis based on indirectly associated pestles is presented in Figure 40. It showed three burials (10, 17, 158) with high values surrounded by high values and one burial (104) with a high value surrounded by low values.

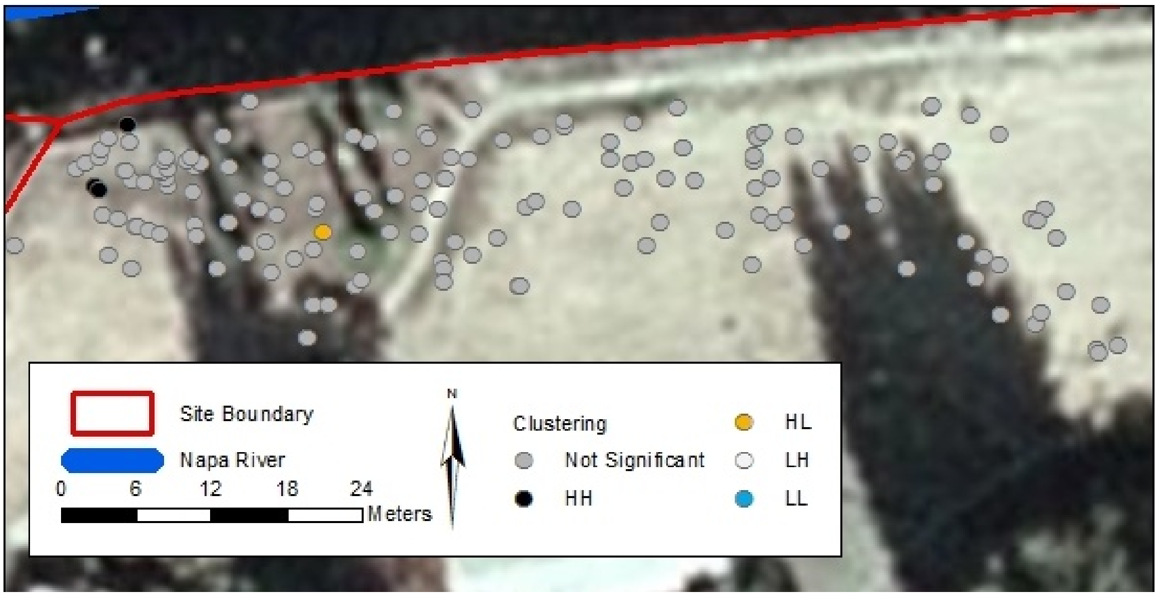

Figure 40: Map of Cluster Analysis of the Burials Based on Indirectly Associated Pestles.

Clustering based on indirectly associated pestles may also be based on excavation techniques. However, most of these burials were found after the change to stratigraphic excavation so this seems unlikely. Pestles were relatively rare from the excavation units. This could denote a possible activity area onsite, with the pestles becoming intermixed with the burial matrix. Yet the pestles are fairly large so this too seems unlikely. It could also mean that these indirectly associated pestles were directly associated with these burials, and their proximity shifted post deposition.

Direct Shell Beads

The cluster and outlier analysis based on directly associated shell beads is presented in Figure 41. It showed two burials (73, 79) with high values surrounded by high values.

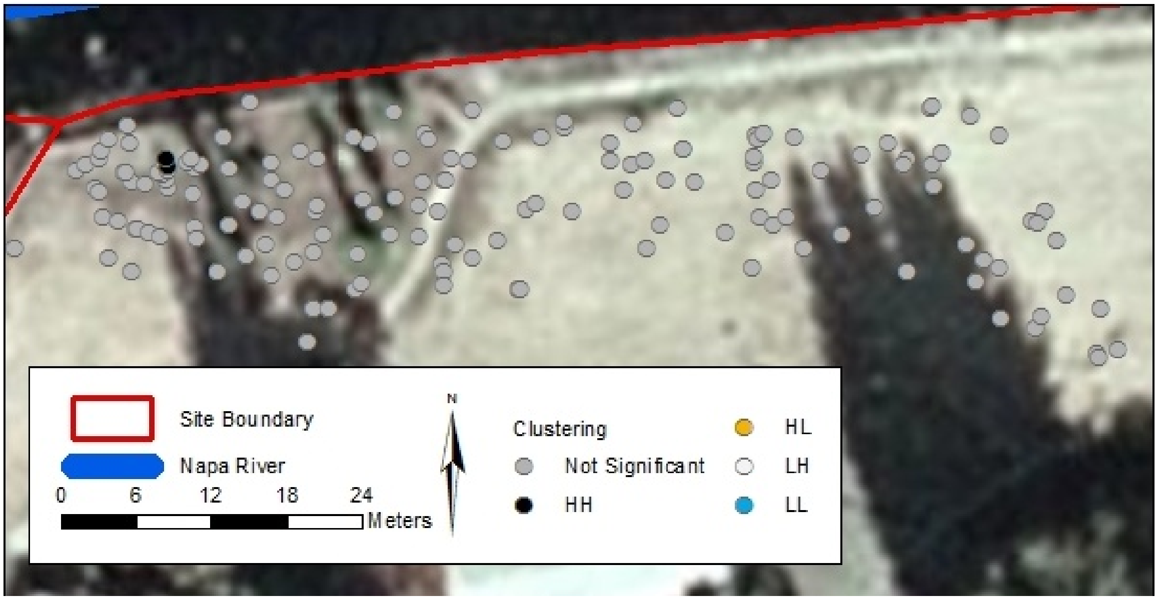

Figure 41: Map of Cluster Analysis of the Burials Based on Directly Associated Shell Beads.

Clustering based on directly associated shell beads can be a good indicator of areas devoted to wealth or possibly status. This suggests the presence of a small wealth area. This same area appears in the wealth diversity index analysis from earlier. It is odd how the other burials in the area which only had one or two beads did not seem to form a cluster of low values.

Indirect Natural Obsidian Needles

The cluster and outlier analysis based on indirectly associated natural obsidian needles is presented in Figure 42. It showed eight burials (5, 7, 8, 12, 33, 73, 79, 100) with high values surrounded by high values and three burials (1, 68, 105) with high values surrounded by low values.

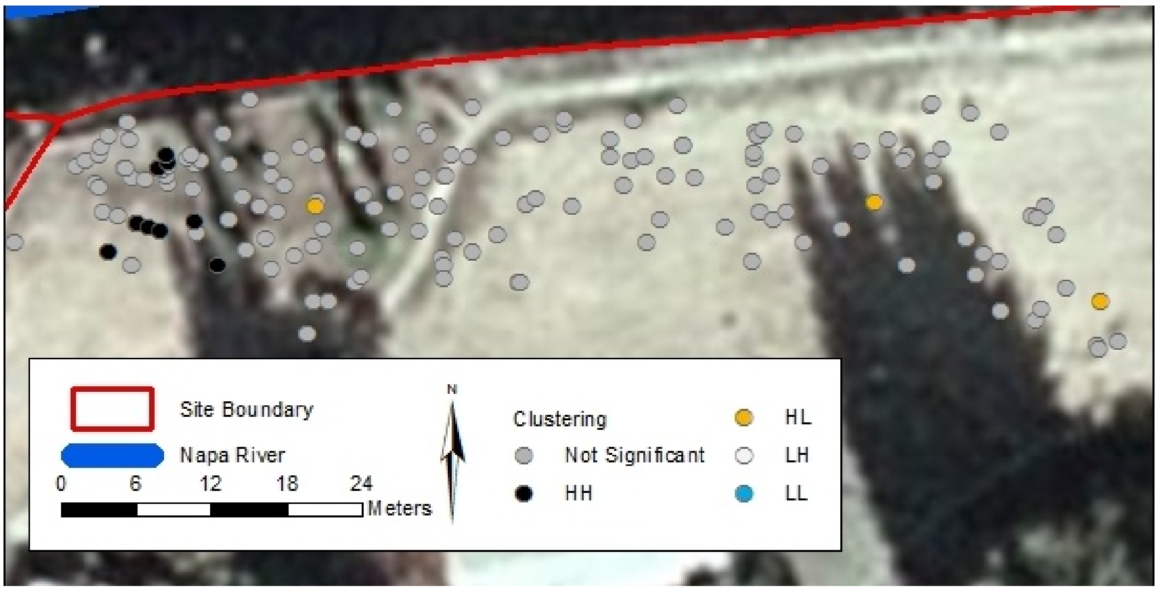

Figure 42: Map of Cluster Analysis of the Burials Based on Indirectly Associated Natural Obsidian Needles.

Clustering based on indirectly associated natural obsidian needles can likely be explained as a natural phenomena occurring in the soil. If there was clustering of obsidian needles, it may denote a specific area indicative of ceremonial dance regalia. Only one burial had a large number of needles. The remaining burials likely obtained their needles as a result of the natural obsidian needles that occurred naturally in the soil matrix next to the Napa River. It could also be partially explained by excavation techniques as well.

Direct Pendants

The cluster and outlier analysis based on directly associated pendants is presented in Figure 43. It showed two burials (73, 79) with high values surrounded by high values with one burial (143) with a high value surrounded by low values.

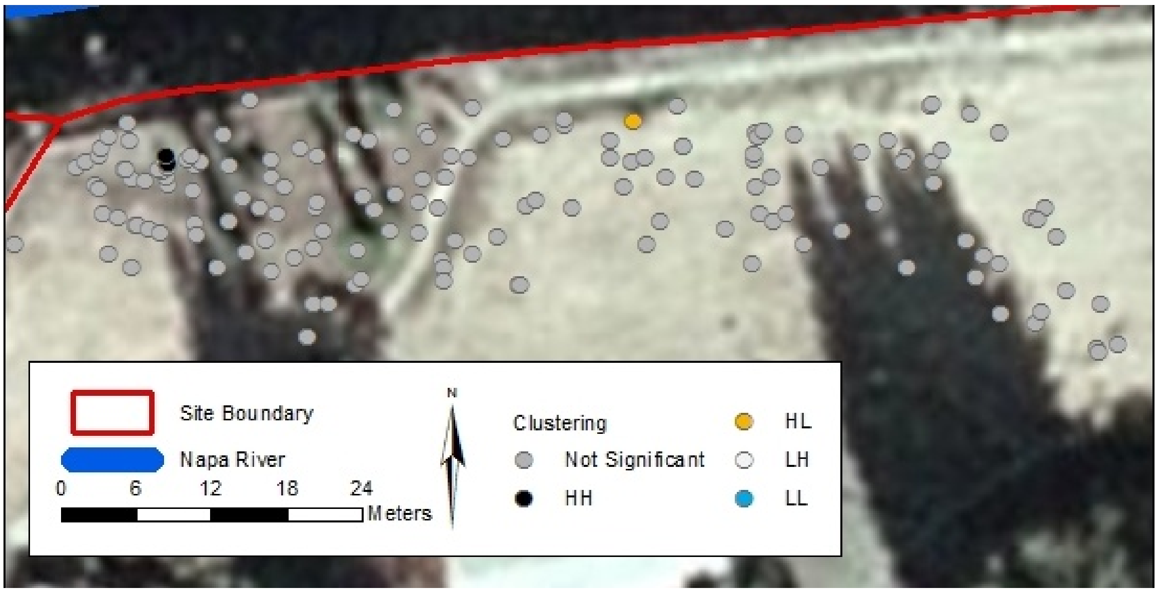

Figure 43: Map of Cluster Analysis of the Burials Based on Directly Associated Pendants.

Clustering based on directly associated pendants can be an indication of areas devoted to the internment of individuals based on wealth, status, or even clan moieties. In this case, it is the same two burials that keep appearing for many other various wealth variables. The pendants are not shaped like some other examples from the San Jose area which are attributed to certain religious movements later in time.

Chapter 7 - Grouping Analysis

This chapter uses a spatial analysis technique similar to that used by Bellifemine (1997). For a brief description as to how grouping analysis works, please refer to Section 3.2.3. Depth was singled out for a more in depth examination in the analysis. This is to examine the possible dates of the undated burials and determine how the burial area was formed.

The grouping analysis was run using the K nearest neighbors with a value of eight for determining spatial constraint. A preliminary analysis, using 15 groups that generated a report was run on all the attributes in order to determine the best number of groups to use. The analysis report also gives the value for r^2 (the coefficient of determination) where the closer to the value of one, the more explanatory the variable. Ideally, the number of groups would be lower. Burials with attributes that were unknown were eliminated from that particular analysis, as the burials with unknown or null values was found to be disruptive for the grouping analysis.

The tables in this section summarize the results by listed grouping class number (GC) and:

- the number of data points within the group;
- the mean value for the group;
- the standard deviation within the group;
- the minimum value for the group;
- the maximum value of the group
- the share value (the ratio of the group and global range);

The radiocarbon dates of any burials within the group are included to see if there is temporal clustering.

Maps showing the distribution of burials in each group analysis (provided substantial clustering was observed) are provided. This technique examines groups with similar values in spatial proximity. The grouping analysis also allows for using multiple attributes to determine if there are distinct groups based on combinations of these attributes. A preliminary examination of common combinations involving age, sex, orientation, and flexure produced no distinct groups. Therefore, this chapter focuses on groups within each possible attribute.

The results of the grouping analysis are summarized below in Table 21. Depth was run twice, once to see the optimum number of groups, and the second to determine if smaller groupings of burials represented a tight, cohesive date range.

Table 21: Burial Attributes Grouping Analysis Summary.

Attribute	Number of Groups	F-Statistic	r^2	Grouping?
Age	15	34.279	0.772	No
Sex	7	124.769	0.871	No
Flexure	15	113.663	0.932	No
Orientation	15	115.801	0.935	Possible
Side	7	110.063	0.841	No
Preservation	15	76.182	0.883	Yes
Depth in Meters	2	98.895	0.396	No
Depth in Meters	15	64.099	0.867	Yes
Artifact Association	15	73.236	0.878	Yes
Total Wealth Items	15	38454.602	0.999	No
Total Tools	3	67.989	0.476	No
Total Artifacts	15	1484.89	0.993	No
Total Artifacts minus Debitage and Faunal	15	502.074	0.980	No
Tool Diversity Index	2	46.629	0.227	No
Wealth Diversity Index	15	129.377	0.927	Yes

7.1 Grouping Analysis Results

Age

When evaluating the age attribute, it was found that the best choice for number of groups was 15 which had the highest F-Statistic score at 34.279. The coefficient of determination was 0.772. It was found that too there were too many groups, with no discernible grouping.

Sex

When evaluating the sex attribute, it was found that the best choice for number of groups was 7 which had the highest F-Statistic score at 124.769. The coefficient of determination was 0.871. It was found, that after eliminating the burials with an unknown sex, the distribution of burials was not acceptable as there was numerous gaps in coverage for the burials. The grouping analysis was conducted for the sake of completeness, but there was no discernible grouping.

Flexure

When evaluating the flexure attribute, it was found that the best choice for number of groups was 15 which had the highest F-Statistic score at 113.663. The coefficient of determination was 0.932. Similar to sex, when the burials with an unknown flexure were removed, the burial distribution was skewed and the whole population was not represented. The grouping analysis was conducted for the sake of completeness, but did not observe any grouping.

Orientation

When evaluating the orientation attribute, it was found that the best choice for number of groups was 15 which had the highest F-Statistic score at 115.801. The coefficient of determination was 0.935.

Examining the groups in Figure 44 we see one large group that runs across the entire burial area (westerly orientation). There are a few small clusters of non-westerly oriented individuals; however few are tight and discrete. Group 5 is a small clustering of three easterly oriented individuals. Group 3 is slightly discrete, and consists of three easterly oriented individuals. Group 11 would seem to be a group of three southerly oriented individuals; however it is not very discrete. If the orientation of the burials with null values was known, it could mean some slightly larger groups. It is possible there is grouping for orientation as there were few non western oriented individuals buried on site, and a small number of them seem to be in close proximity suggesting intentional internment, however it could also be random.

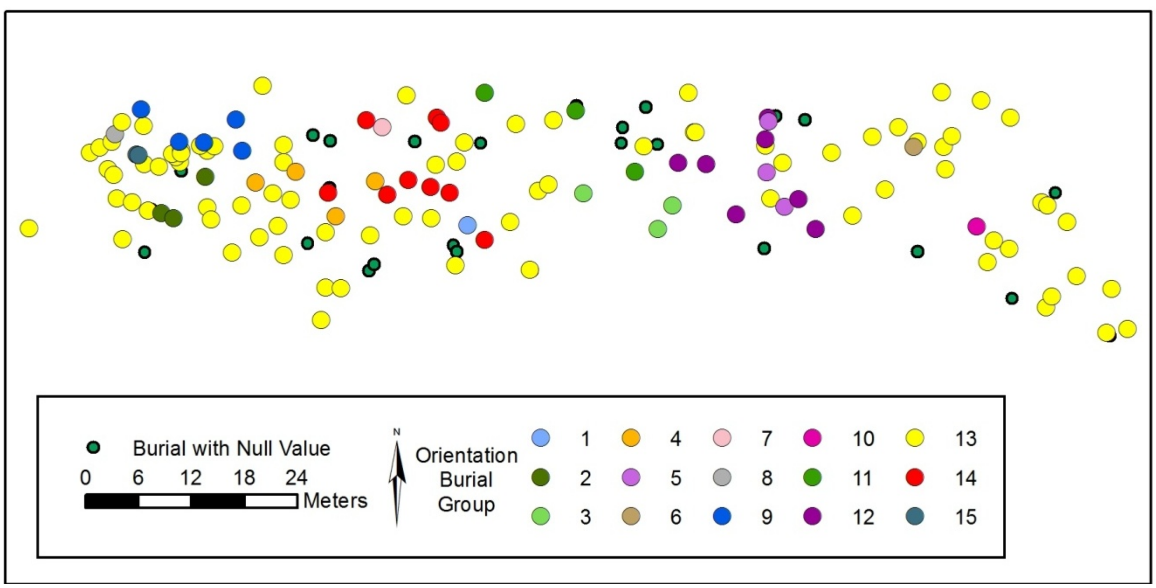

Figure 44: Map of Orientation Burial Group.

Side

When evaluating the side attribute, it was found that the best choice for number of groups was 7 which had the highest F-Statistic score at 110.063. The coefficient of determination was 0.841. As with sex and flexure, there were a number of burials with null values that had to be removed from the study, skewing the results and decreasing the validity of the results. The grouping analysis was run for the sake of completeness, and did not discover discreet grouping.

Preservation

When evaluating the preservation attribute, it was found that the best choice for number of groups was 15 which had the highest F-Statistic score at 76.182. The coefficient of determination was 0.883.

Examining the groups in Figure 45 we see several larger groups. Group 1 along the eastern edge of the burial area appears to be a large group of poorly preserved individuals. This is contrasted with Group 10, a small discrete cluster of well preserved burials immediately adjacent Group 1 to the west. The standard deviation is also on the lower side, with none of the groups having a very large range of values. This could be a reflection of the coded values representing a spectrum of preservation. There are several smaller groups of better preserved individuals that are not discrete. These are broken up by several smaller groups of lesser preserved individuals that are also not discrete. There does appear to be grouping based on preservation. As stated before this is likely not a reflection of cultural actions, but rather of natural environmental ones.

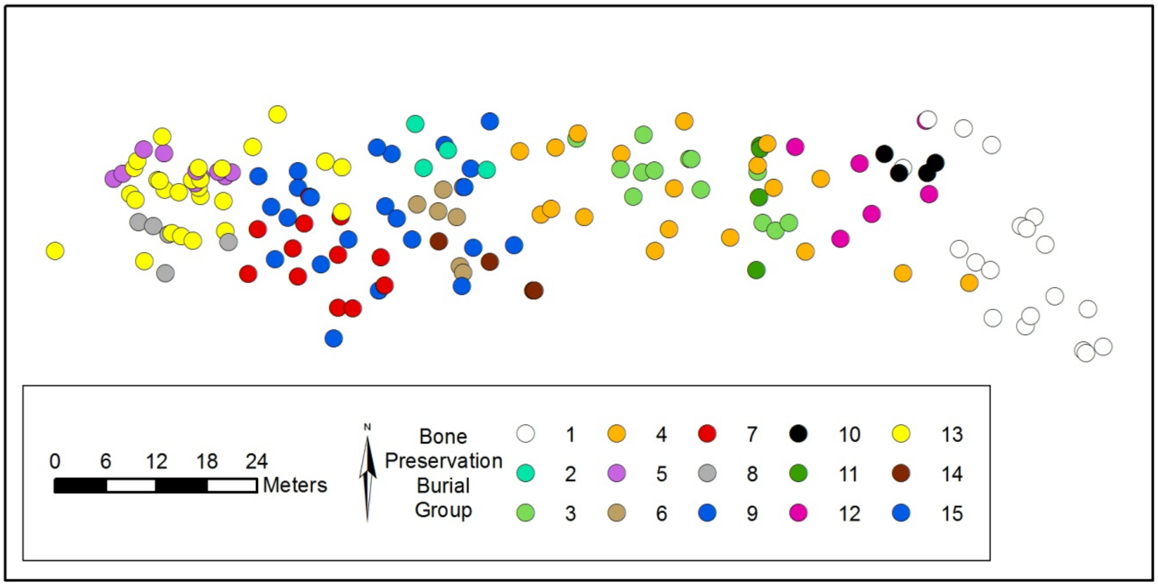

Figure 45: Map of Preservation Burial Groups.

Depth

The four burials without depth were eliminated from this particular analysis. When evaluating the depth in meters attribute, it was found that the best choice for number of groups was 2 which had the highest F-Statistic score at 98.895. The coefficient of determination was low at 0.396. The grouping analysis divided the burials into an upper and lower half of burials at around 140 cmbd. This was not considered grouping.

In order to determine if smaller groups of burials represent discrete internment events with a tight date range, a grouping of 15 was chosen. It allowed for more differentiation across the site, and also had the next highest and acceptable F-Statistic value at 64.099. The coefficient of determination was 0.867. The results are summarized in Table 22 below. The values in this case refer to centimeters below the site datum.

Table 22: Results of Grouping Analysis Examining Depth in Centimeters.

GC#	n=	mean	St. Dev.	Min	Max	Share	Burials	Radiocarbon Dates (BP)
1	6	74.3	4.57	68	79	0.063	10, 132, 133, 134, 135, 138	2130
2	8	111.4	11.5	97	134	0.211	22, 110, 119, 121, 122, 129, 130, 139	2030, 2150
3	5	198.6	11.5	179	215	0.206	60, 64, 66, 69, 82	None
4	6	116.3	15.5	89	137	0.247	4, 57, 58, 146, 148, 156	2140, 2380
5	1	66.0	0.0	66	66	0.000	32	150
6	9	159.p	14.0	142	192	0.286	70, 71, 89, 90, 94, 96, 99, 108, 131	1990, 2230
7	1	235.0	0.0	235	235	0.000	85	None
8	3	183.3	9.0	177	196	0.109	150, 151, 157	None
9	12	132.3	12.8	108	158	0.286	11, 12, 34, 35, 51, 73, 76, 79, 123, 128, 136, 137	2200, 2200
10	9	86.6	13.3	60	100	0.229	18, 113, 114, 115, 116, 118, 124, 126, 127	2200, 2200
11	25	107.6	11.9	87	145	0.331	3, 5,6, 7, 8, 9, 17, 19, 20, 21, 33, 74, 77, 80, 84, 93, 95, 100, 101, 102, 103, 104, 107, 153, 154	None
12	5	129.2	5.5	122	134	0.069	36, 37, 38, 43, 149	2200
13	14	179.6	11.7	158	206	0.274	13, 15, 16, 25, 26, 30, 31, 78, 81, 140, 142, 144, 145, 155	2380
14	22	139.8	12.1	124	176	0.297	2, 23, 24, 27, 28, 29, 72, 75, 91, 92, 98, 105, 106, 109, 111, 112, 117, 120, 125, 141, 143, 152	2090, 2090, 2240, 2380
15	27	153.9	14.9	112	181	0.394	1, 14, 39, 40, 41, 44, 45, 46, 47, 48, 49, 50, 52, 53, 54, 55, 56, 59, 62, 63, 65, 67, 68, 83, 86, 87, 147	2030, 2290, 2430, 2450

Examining the groups in Figure 46 we see several discrete groups. The burial area was also divided into six roughly identical sized areas to better examine the grouping in the soil profile along a north/south axis.

Group 12 is a very tight and discrete group with a very low standard deviation, suggesting internment around the same time. Examining Table 16 however, we see that there is a good deal of variation in the radiocarbon dates by group, suggesting mixing and uneven vertical distribution of burials throughout time. A few groups (9 and 10) did have a tighter date range it seems. To determine if this is indeed the case, a three dimensional view of the burials through the soil profile is examined further in Figures 47-53.

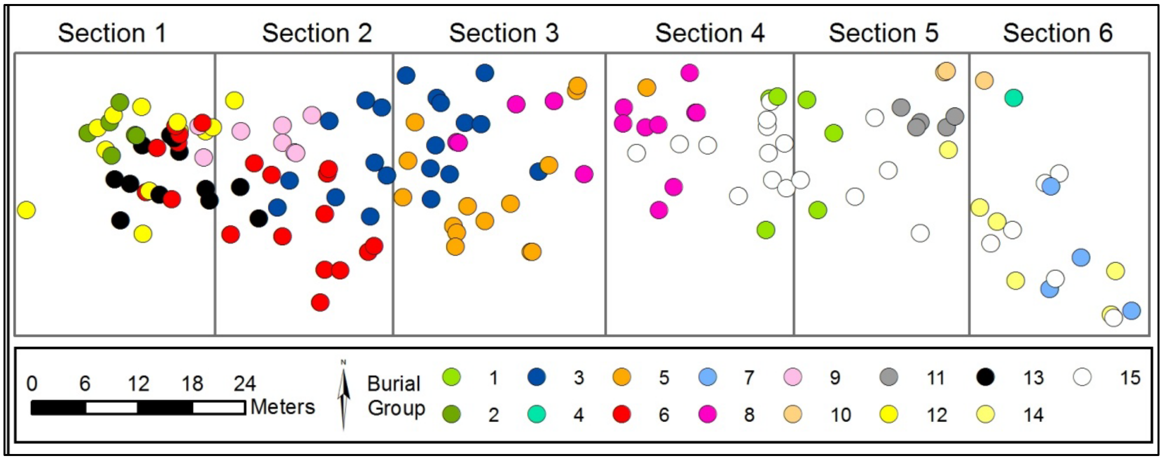

Figure 46: Depth Grouping Analysis.

Figure 47 below shows the depth grouping and radiocarbon dates from stratigraphic profile along a west/east axis. This shows that some groups that are dispersed in plan view are slightly more discrete when viewed in profile. Another thing to note is that the radiocarbon dates appear to become younger towards the upper right (west), though there is still mixing.

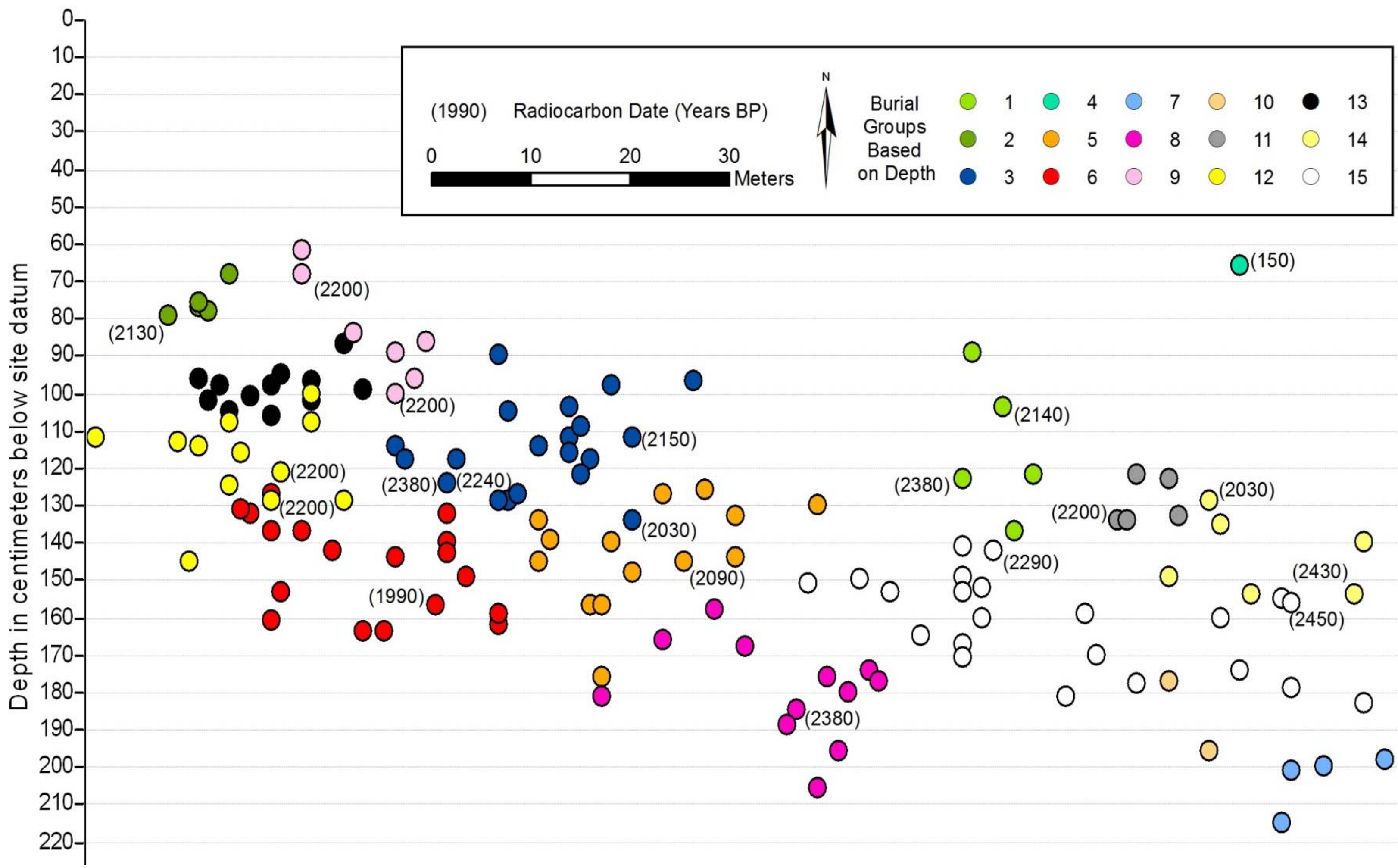

Figure 1: Depth Grouping and Radiocarbon Dates from Stratigraphic Profile from West (at left) to East (at right).

Figure 48 shows the depth grouping and radiocarbon dates for Section 1 from the stratigraphic profile along a north/south axis. The grouping does not appear to be that bad. One burial from Group 12 does appear to be mixed in with Group 6. Some of Group 12 appears as if they could also be part of Group 13 near 100 centimeters below site datum. Judging by the radiocarbon dates, it would appear that most of these burials would be from later in the site formation process. Another thing to note is that the uppermost burials of Group 11 seem to form a gentle hill surface, suggesting that this was the original site surface at the time of interment. The gap in the center of the burials is also odd, perhaps suggesting something present onsite prevented internment in this area. This could have been a tree, an activity area, or even a structure of some sort. It is only a few meters wide, which is the size of some dwellings. It could also be completely random.

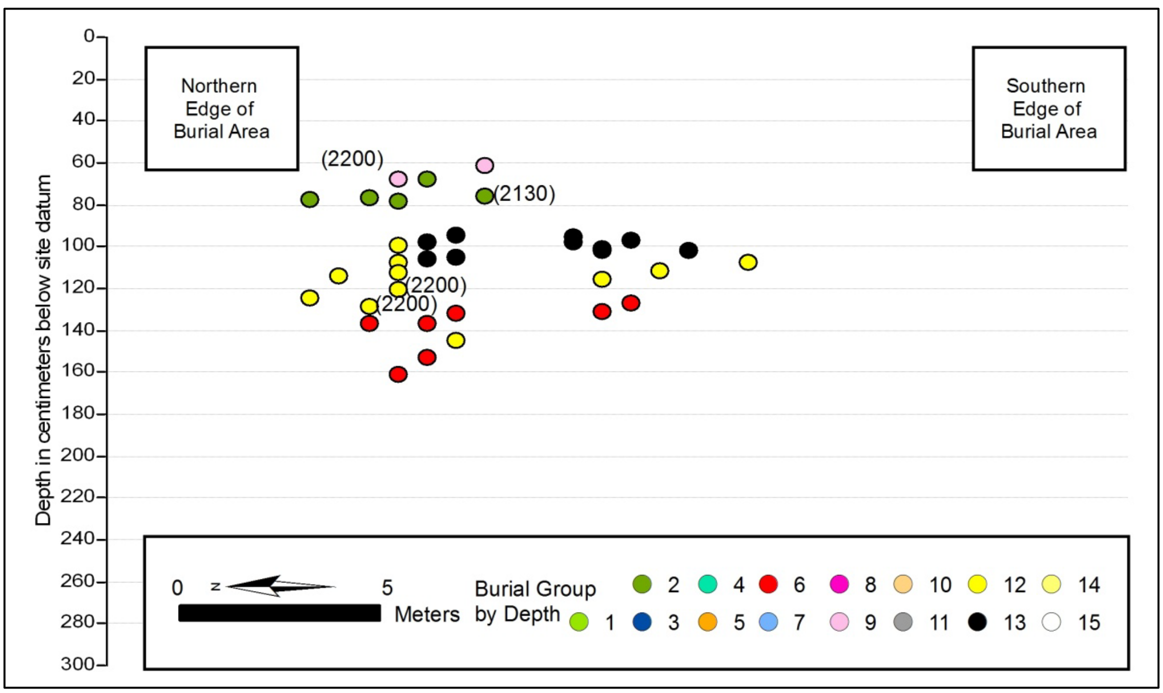

Figure 48: Section 1 of Depth Grouping Analysis.

Figure 49 shows the depth grouping and radiocarbon dates for Section 2 from the stratigraphic profile along a north/south axis. The grouping is better than that seen in Section 1. One burial from Group 12 is also included in this group, and should not be considered an outlier as the grouping by sections was random. Group 9 looks acceptable but there is a larger range in Groups 3 and 6.

Another thing to note is with the radiocarbon dates. The date of 2380 BP from Group 3 seems to be rather high in the profile. Also the latest date is the deepest in this section. It is along the southern edge of the burial area however. This again gives credence to the possibility that the original site was on a gently sloping hill or natural levee adjacent to the Napa River. If it was on a floodplain, then the ancient inhabitants went out of their way to bury this particular individual very deep for some reason.

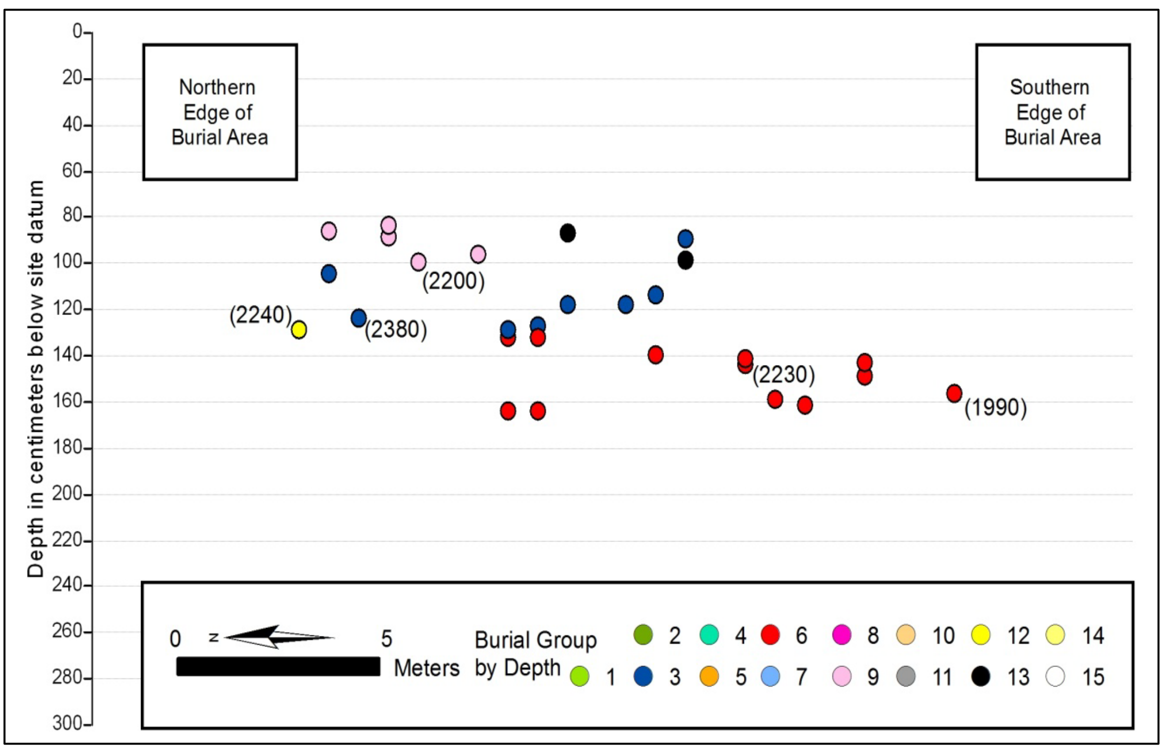

Figure 49: Section 2 of Depth Grouping Analysis.

Figure 50 shows the depth grouping and radiocarbon dates for Section 3 from the stratigraphic profile along a north/south axis. The grouping is not bad. The overall distribution of the burials again resembles a small hill or levee, as the older date is higher towards the center with the more recent dates towards the perimeter.

Examining the distribution of radiocarbon dates we again see that there is an older date above the younger dates. This is located in almost the same position as the other older burial from Section 2, suggesting a higher, linear site surface running west to east across the two, perhaps the top of the levee. The younger radiocarbon dates along the perimeter of the burial area would again suggest that there was a natural slope or else those individuals buried along the periphery of the burial area were interred progressively deeper. It appears that Groups 3 and 5 would date to later in the site formation process, while Group 8 would be earlier.

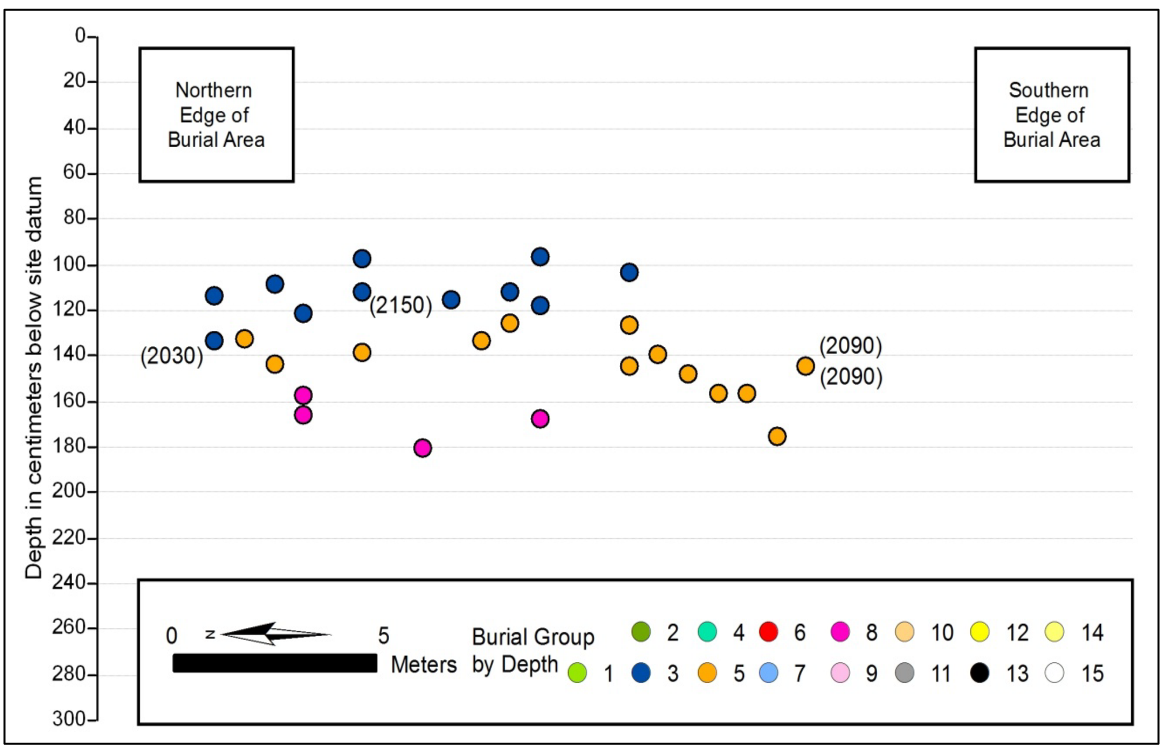

Figure 50: Section 3 of Depth Grouping Analysis.

Figure 51 shows the depth grouping and radiocarbon dates for Section 4 from the stratigraphic profile along a north/south axis. The grouping does not appear to be that good upon initial inspection. Group 2 would appear to be very widespread and unconnected, however that is merely the result of the arbitrary placement of the sections as the group continues further to the east where they all connect. The same is true of Group 8, only it continues further west.

Examining the radiocarbon dates we see a later date sandwiched between two older dates. This would seem to confirm that groups do not exactly correspond to dates. The upper radiocarbon date of 2380 BP from Group 4 is again in line with the older dates from Sections 2 and 3 that are higher in the stratigraphic profile. The lower radiocarbon date of 2380 BP from Group 9 occurs between them suggesting a possible break or dip in the original site surface.

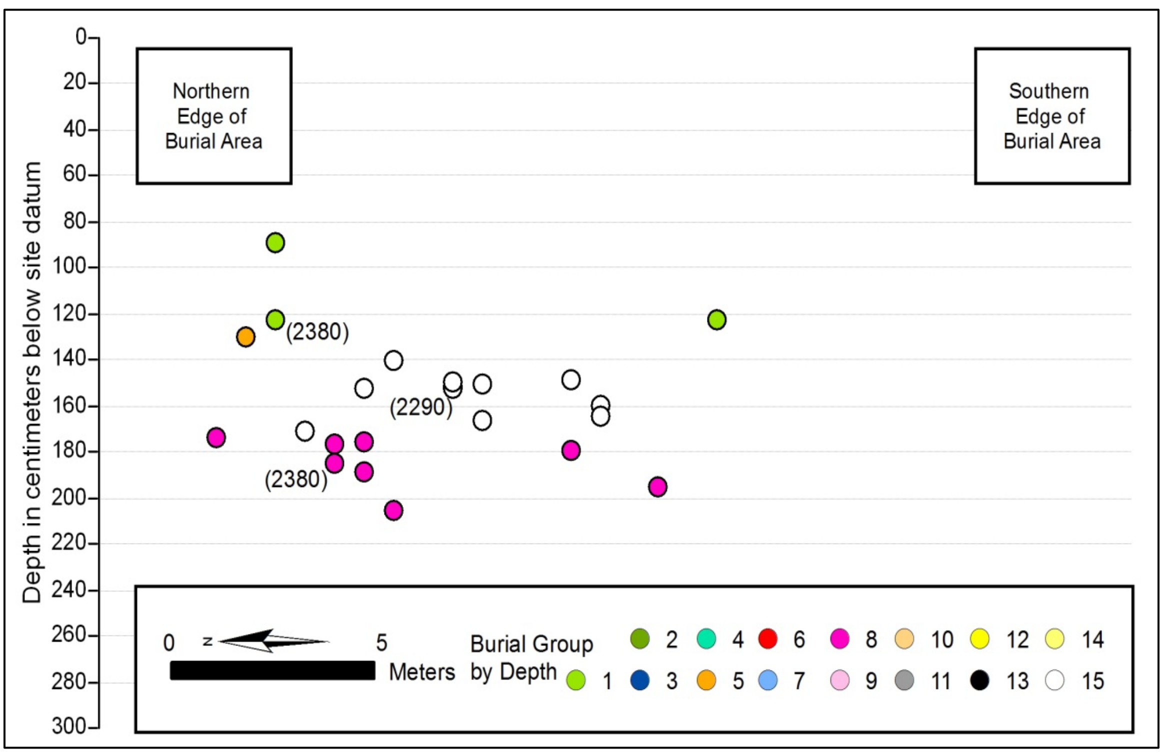

Figure 51: Section 4 of Depth Grouping Analysis.

Figure 52 shows the depth grouping and radiocarbon dates for Section 5 from the stratigraphic profile along a north/south axis. The grouping appears to be very good except for Group 15. Group 11 is very tightly grouped in both profiles and plan views, suggesting cotemporaneous internment with one another. This would appear to be around 2200 BP given the lone radiocarbon date from the group. Another possible explanation is the intentional internment of familial relations in a small area, with descendants being buried next to their ancestors. This assumes the location and depth that the ancestor was buried was known.

Examining the radiocarbon dates we see that the younger date is near the top and the older date near the bottom which is what an archaeologist would hope for. It would appear the Group 11 is likely from slightly before the other burials given its placement in the stratigraphic profile. Group 10 might possibly predate Group 11.

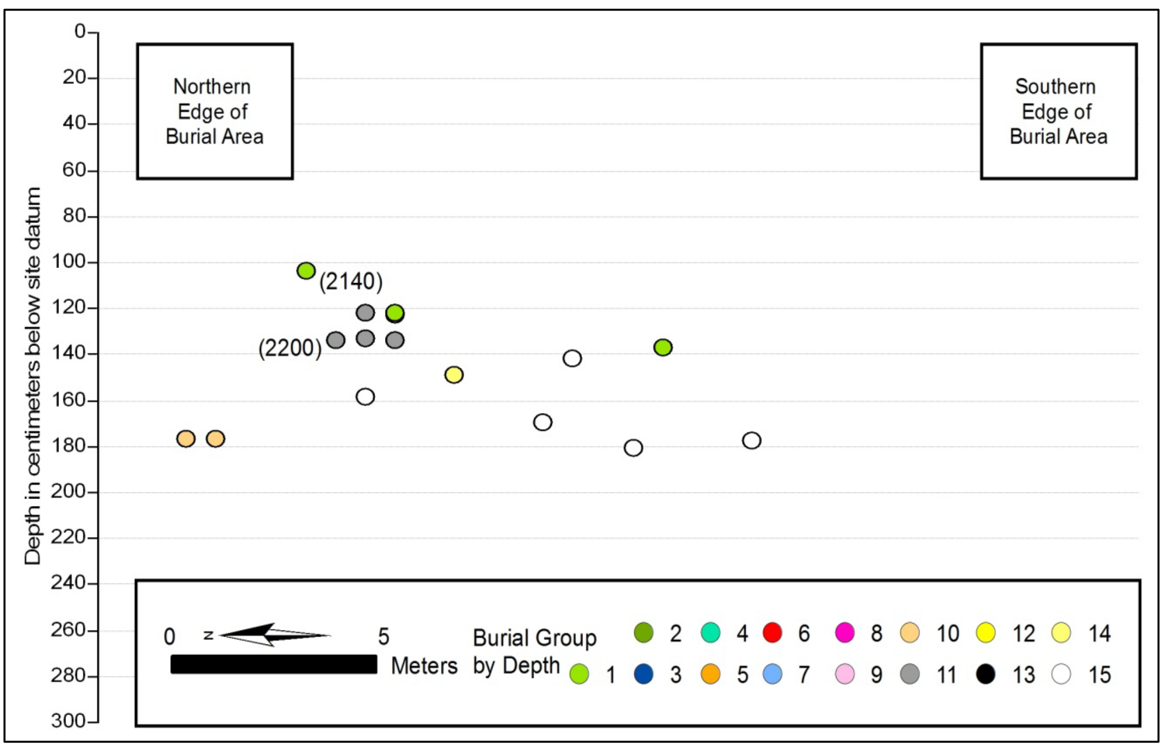

Figure 52: Section 5 of Depth Grouping Analysis.

Figure 53 shows the depth grouping and radiocarbon dates for Section 6 from the stratigraphic profile along a north/south axis. It is also worthwhile to note the dramatic shift to the south of the burials in this area. This mimics the nearby bend in the Napa River, giving additional evidence that the original site was situated on a small levee. It also demonstrates just how much of an outlier Burial 32 was. Group 10 is small, but they cluster together well. The arbitrary placement of the sections makes it seem as if they are outliers.

Examining the radiocarbon dates one sees a very large discrepancy in Group 12. There is a span of almost 400 years in 20 cm. This would seem to indicate that there was either not much soil accumulation along this edge of the burial area or that the individual from 2030 was buried very deep.

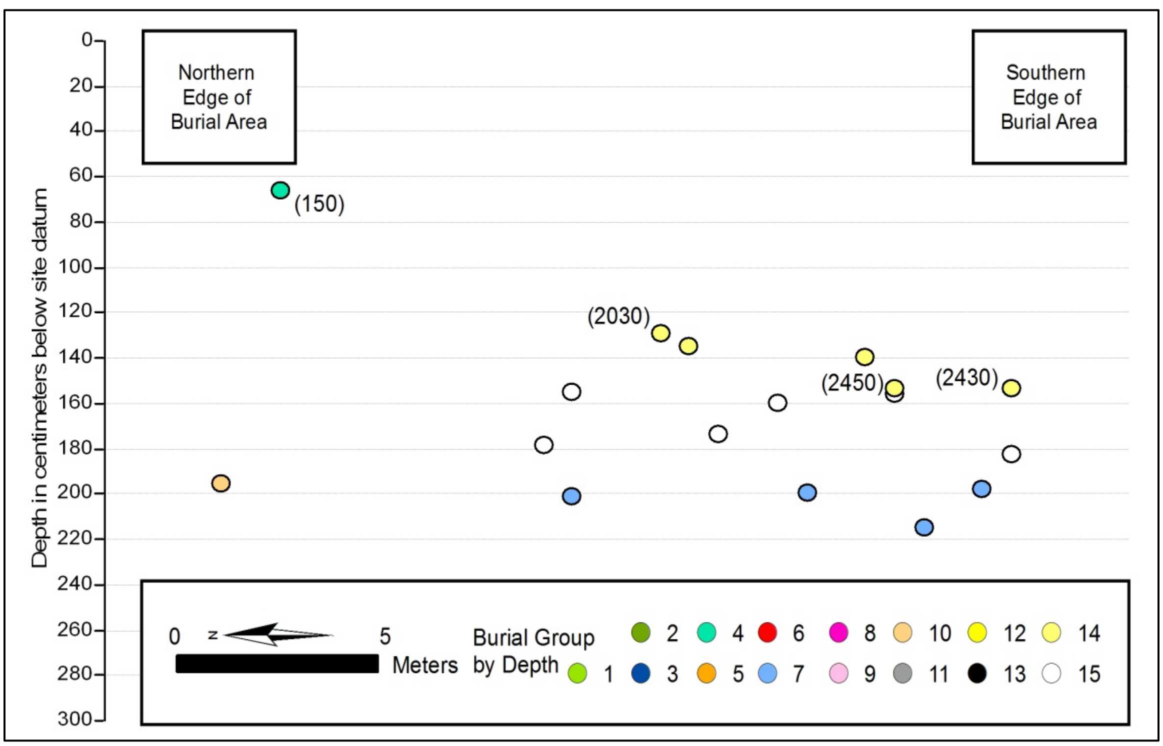

Figure 53: Section 6 of Depth Grouping Analysis.

Artifact Association

When evaluating the artifact association attribute, it was found that the best choice for number of groups was 15 which had the highest F-Statistic score at 73.236. The coefficient of determination was 0.878. The results are summarized in Table 23. Refer back to Section 4.2 for an explanation regarding the artifact association. A value of 0 denoted no artifacts, a value of 1 denoted indirectly associated artifacts, and a value of 2 denoted directly associated artifacts.

Table 23: Results of Grouping Analysis Examining Artifact Association.

GC#	n=	mean	St. Dev.	Min	Max	Share	Radiocarbon Dates (BP)
1	4	0.0	0.0	0.0	0.0	0.0	None
2	3	0.0	0.0	0.0	0.0	0.0	None
3	11	2.0	0.0	2.0	2.0	0.0	1990, 2200, 2200, 2200, 2230
4	3	0.0	0.0	0.0	0.0	0.0	None
5	3	0.0	0.0	0.0	0.0	0.0	None
6	3	0.0	0.0	0.0	0.0	0.0	2380
7	4	2.0	0.0	2.0	2.0	0.0	None
8	3	1.0	0.0	1.0	1.0	0.0	2380
9	2	0.0	0.0	0.0	0.0	0.0	None
10	2	2.0	0.0	2.0	2.0	0.0	None
11	6	2.0	0.0	2.0	2.0	0.0	2140, 2290
12	4	2.0	0.0	2.0	2.0	0.0	None
13	3	2.0	0.0	2.0	2.0	0.0	2090, 2090
14	2	0.0	0.0	0.0	0.0	0.0	None
15	104	1.048	0.255	0.0	2.0	1.0	150, 2030, 2030, 2150, 2200, 2200, 2380, 2430, 2450

Examining the groups in Figure 54 we see that there are a few small discrete groups. It is interesting to note the Group 3 has five radiocarbon dates from the 11 members of the group, all within a 50 year period. Group 11 also has a cluster of individuals with directly associated burial goods; however there is a 150 year range in the radiocarbon dates. Group 15 is the largest and consists mostly of individuals with indirectly associated artifacts and can be considered background. There are several small groups (2, 6, 14) of individuals with no artifacts.

It is unlikely that this is meaningful or that they represent discrete areas for “poor” individuals given their small size. Organic grave goods may have also decomposed, influencing this attribute. There is grouping based on artifact association.

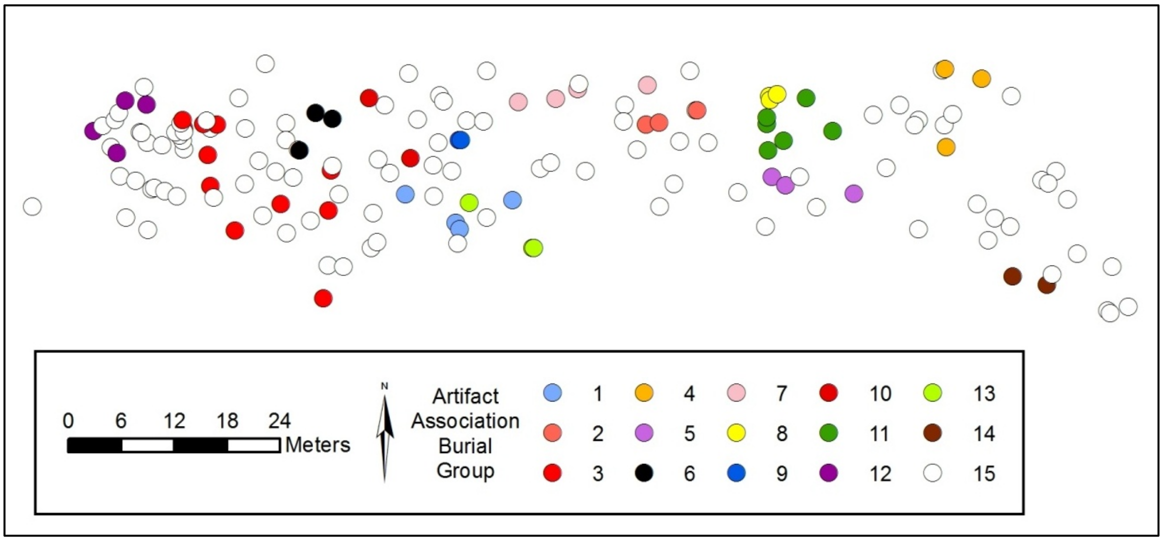

Figure 54: Map of Artifact Association Burial Groups.

Total Wealth Items

When evaluating the total wealth items attribute, it was found that the best choice for number of groups was 15 which had the highest F-Statistic score at 38454.602. The coefficient of determination was 0.9997. Total wealth items refer to both indirectly and directly associated items. Given the very high F-Statistic score and coefficient of determination value, grouping was expected. However, when the results are analyzed, it points out the wealth outliers, and combines most of the individuals into one group with little to no wealth items. There is no discernible grouping observed for total wealth items.

Total Tools

When evaluating the total tools attribute, it was found that the best choice for number of groups was 3 which had the highest F-Statistic score at 74.513. The coefficient of determination was 0.476. Total tools includes both indirectly and directly associated tools found with the burials. One discrete group of burials was observed, but it was the same one that has appeared continually throughout this analysis as the difference in excavation techniques recovered more tools from the midden. There was no discernible grouping for total tools.

Total Artifacts

When evaluating the total artifacts attribute, it was found that the best choice for number of groups was 15 which had the highest F-Statistic score at 1484.89. The coefficient of determination was 0.993. Total artifacts refer to both indirectly and directly associated items. There was no discernible grouping for total artifacts.

Total Artifacts minus Debitage and Faunal

When evaluating the total artifacts minus debitage and faunal attribute, it was found that the best choice for number of groups was 15 which had the highest F-Statistic score at 502.074. The coefficient of determination was 0.980. Similar to Total Artifacts there was no discernible grouping observed.

Tool Diversity Index

When evaluating the tool diversity attribute, it was found that the best choice for number of groups was 2 which had the highest F-Statistic score at 46.629. The coefficient of determination was 0.227. There was no grouping based on the tool diversity index.

Wealth Diversity Index

When evaluating the wealth diversity index attribute, it was found that the best choice for number of groups was 15 which had the highest F-Statistic score at 129.377. The coefficient of determination was 0.927. The results are summarized in Table 24. The tool diversity index is a measurement of the number of different tools interred with a burial.

Table 24: Results of Grouping Analysis Examining Wealth Diversity Index.

GC#	n=	mean	St. Dev.	Min	Max	Share	Radiocarbon Dates (BP)
1	1	0.75	0.0	0.75	0.75	0.0	2200
2	1	0.375	0.0	0.375	0.375	0.0	2240
3	4	0.125	0.0	0.125	0.125	0.0	2140
4	6	0.271	0.047	0.25	0.375	0.167	2230
5	1	0.25	0.0	0.25	0.25	0.0	None
6	1	0.375	0.0	0.375	0.375	0.0	None
7	2	0.125	0.0	0.125	0.125	0.0	2030
8	1	0.375	0.0	0.375	0.375	0.0	2200
9	21	0.131	0.027	0.125	0.25	0.167	2130, 2200
10	2	0.125	0.0	0.125	0.125	0.0	None
11	2	0.125	0.0	0.125	0.125	0.0	None
12	106	0.007	0.029	0.0	0.125	0.167	150, 1990, 2090, 2090, 2200, 2200, 2380, 2380, 2380, 2430, 2450
13	1	0.375	0.0	0.375	0.375	0.0	None
14	6	0.188	0.063	0.125	0.25	0.167	2030, 2150
15	2	0.25	0.0	0.25	0.25	0.0	2290

Examining the groups in Figure 55 we see that there are a few discrete groups. Group 12 is the largest group that covers almost the entire burial area. It consists almost entirely of individuals with little to no wealth items and can be considered background noise. Groups 3 and 14 appear to be fairly discrete. Both have individuals with only one or two types of wealth items. Group 4 is more widespread but it has a higher standard deviation and a higher mean value. There does appear to be grouping present based on the wealth diversity index.

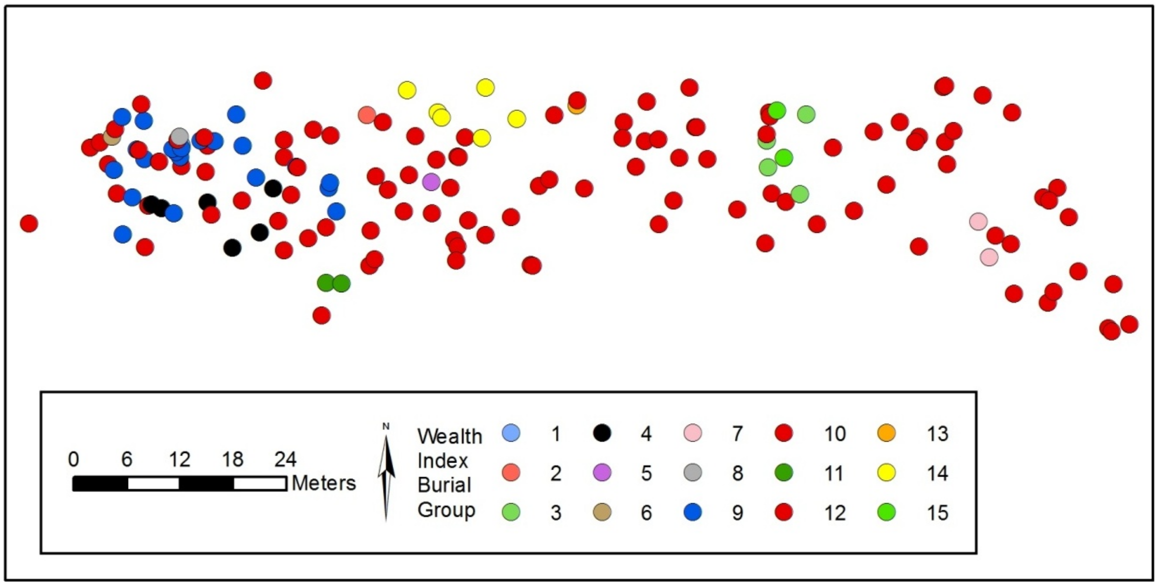

Figure 55: Map of Wealth Diversity Index Burial Group.

7.2 Grouping Analysis Discussion

This analysis found that grouping may not be useful in populations that have a few outliers. This analysis was useful as a tool for spatial exploration of the data. It was observed that with the more groups selected for the grouping analysis, there tended to be more individual outliers. However if there were fewer groups in number, there tended to be a larger standard deviation seen in the group as the outliers were consolidated into larger and larger groups. The identification of outliers as individual groups was not expected.

Just because the analysis says there was a group, does not necessarily mean that one existed. Often there is a standard deviation which means that the group is not uniform. The mixing of nominal values should not occur in a discrete, uniform group. Further, many of the groups do not have a tight date range which would be expected if the group represented a single, discrete, burial period in time and space.

Another thing to consider is at what point could a group be considered legitimate? Certainly there is a bit of subjective reasoning involved. Are there a minimum number of individuals in a group? Would two individuals be too little? Does one individual constitute a group? Where is the cut-off point at which there is a group and not just a random collection of individuals? Also, do the groups have to be tight and discrete, or can they be a little more widespread? These are valid questions that could not be addressed by this incomplete dataset whose excavation process means that there are unknown relationships between the direct and indirectly associated artifacts in and around the burial itself. It is up to other archaeologists and the GIS user to decide these things as they explore their own dataset.

In summary, grouping was observed for preservation, depth, artifact association, and wealth diversity. Possible grouping was observed for orientation.

Chapter 8 – Radiocarbon Date Interpolation

Of the 162 burials recovered from CA-NAP-399, 157 have data regarding their exact location. These 157 form the bases of the spatial autocorrelation and cluster and outlier analysis. One burial, 32, was a protohistoric outlier that was removed from the radiocarbon date interpolation study as it skewed the data too much. That leaves 156 burials for this particular study.

This chapter examines the changes to society, the burials, and their artifacts over time by interpolating the dates of the burials from the known radiocarbon dates and depths of 21 samples. This will allow the grouping of burials into five 100 year date ranges. What is being predicted is a surface representing the age of the burials based on the 21 radiocarbon samples. When the radiocarbon date surface values are assigned to each burial point, this assumes that all burials in a specific location have the same date, that there is no superposition occurring. This is a large assumption to make, however this chapter is more of an experimental analysis to see if any insight can be gained by exploring an interpolated date surface. A discussion of different kriging types can be found in Appendix B, as well as the summarized results of this particular study run through several different types of kriging.

8.1 Burial Radiocarbon Date Interpolation

A simple cokriging with prediction model was used with the 21 radiocarbon dates as the primary data coupled with depth in meters as the secondary data. The model was auto-optimized for increased accuracy. Depth was chosen as the secondary dataset because the lower in the stratigraphic deposit the burial was, the older it should be. There is a correlation between the depth of the burial and the radiocarbon age, as seen in Figure 56. Burial 32 was omitted from this study as it greatly skewed the results. A possible explanation for this correlation not being greater is that the original surface of the site at the time of internment had irregular topography or was sloped. Some cotemporaneous burials may have been buried deeper than others of the same time period which could also affect the results as well. This may sound like a great deal of uncertainty; however the point of this experiment is a test of method rather than an assertion that the data for this particular case study is relevant for cultural comparative purposes.

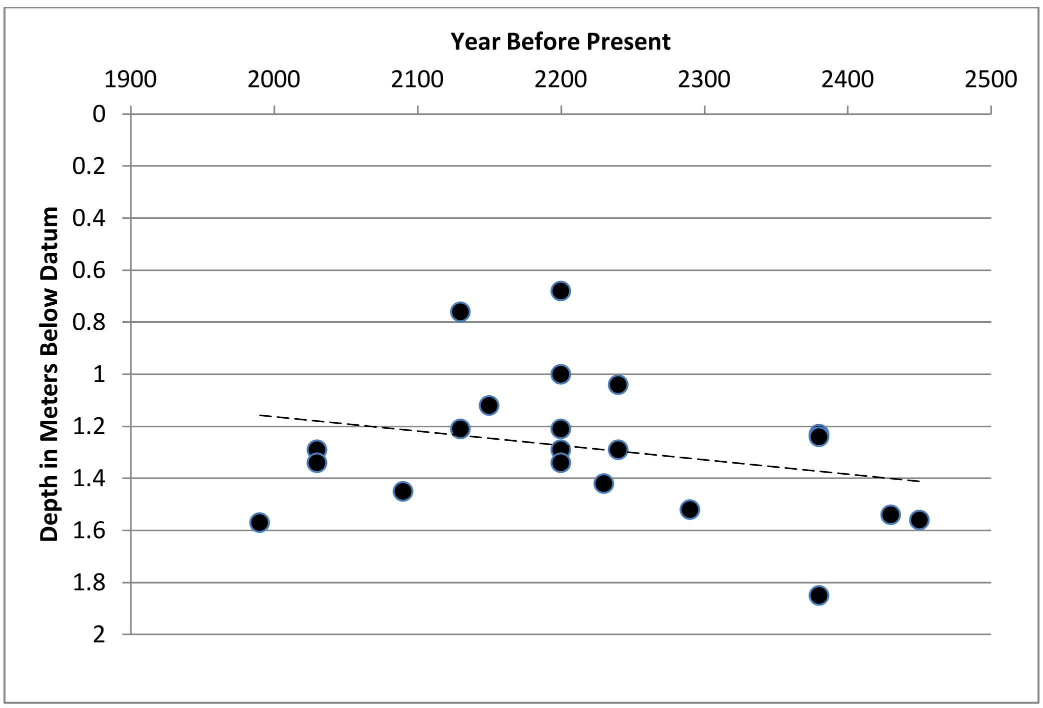

Figure 56: Correlation of Radiocarbon Dates and Depth.

The geostatistical wizard from ArcGIS provides a series of prediction errors for cokriging models. These vary slightly based on which particular type of cokriging is used (see Appendix B). These prediction errors allow the user to judge how valid the interpolation model was. The root mean square error indicates how closely the model predicts the measured values.

The results of only running the 21 radiocarbon dates coupled with depth follow. The root mean squared error was 121.522. A full range of values from the kriging exercise can be found in Table B-1 in Appendix B. With this level of error, there is essentially a 250 year window in which each burial falls. The prediction error values for the model suggest an acceptable model; however there is still a wide range of error. It does mark an improvement over stating the burials occur in a 500 year window. With a better dataset one could remove a single radiocarbon date to see if the methods predicted it. It is also worth exploring the variability of radiocarbon dates and depth in specific areas of the site to see if perhaps certain areas work better than others.

Figure 57 shows the interpolated surface from the cokriging model using radiocarbon dates with depth in meters. The older dates seem to be located in the eastern half of the burial area, with most confined to the southeastern corner. The interpolated surface appears to be younger towards the western half of the burial area, with a few older outliers underneath. This would suggest that the burials were interred progressively further to the west over time, with periodic revisits to older burial areas. These revisits could possibly represent familial internment areas, clan areas, or moiety areas.

Figure 58 shows the prediction error surface. Given the sparse distribution of dated locations, it is important to acknowledge that the error surface shows a distinctive pattern of low error values around each sample point. This does point to the limited reliability of the analysis, but it was felt that the potential opportunity for further insight based on the date surface made it worth proceeding with this analysis.

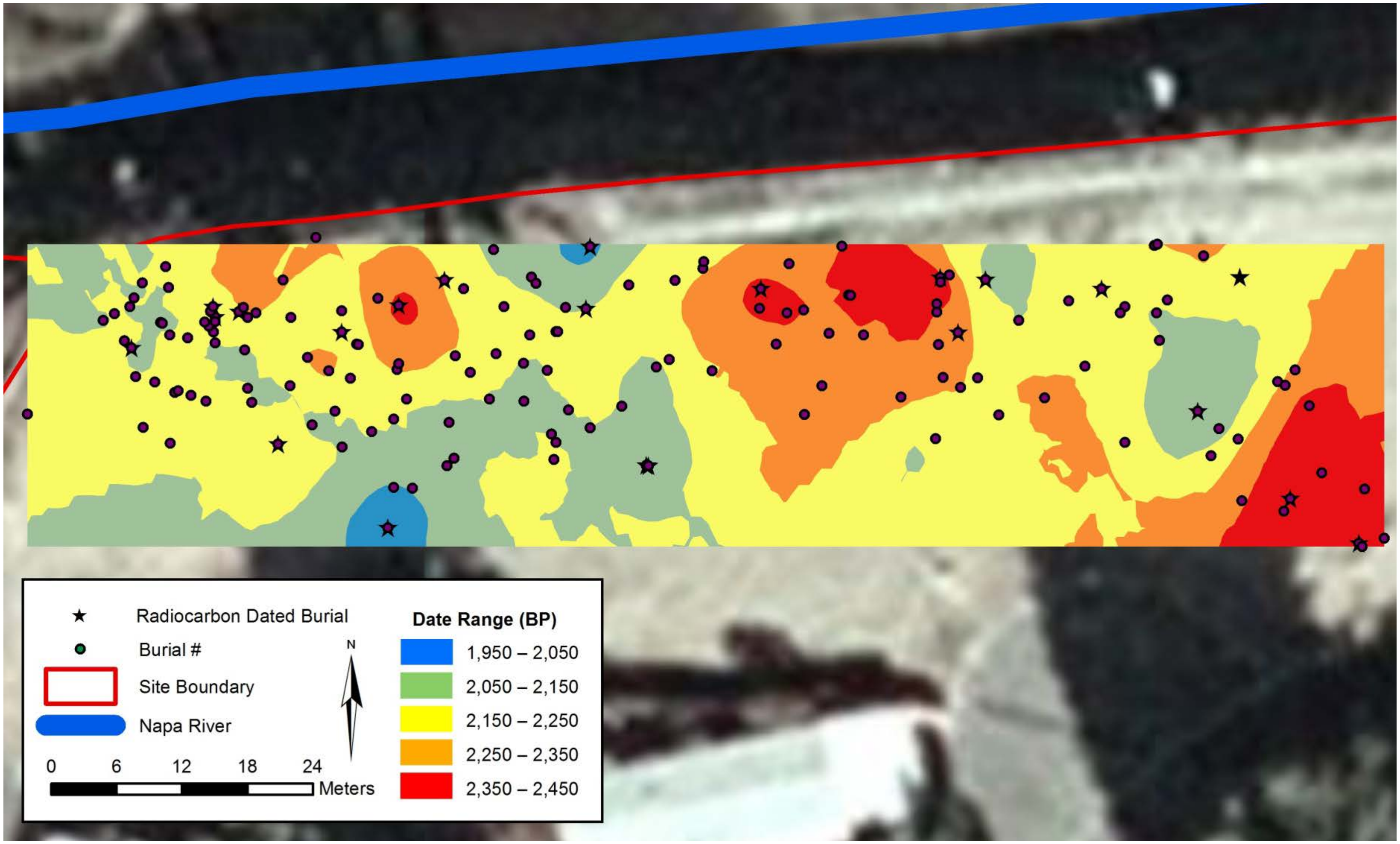

Figure 57: Interpolated Dates from Radiocarbon Dates Only.

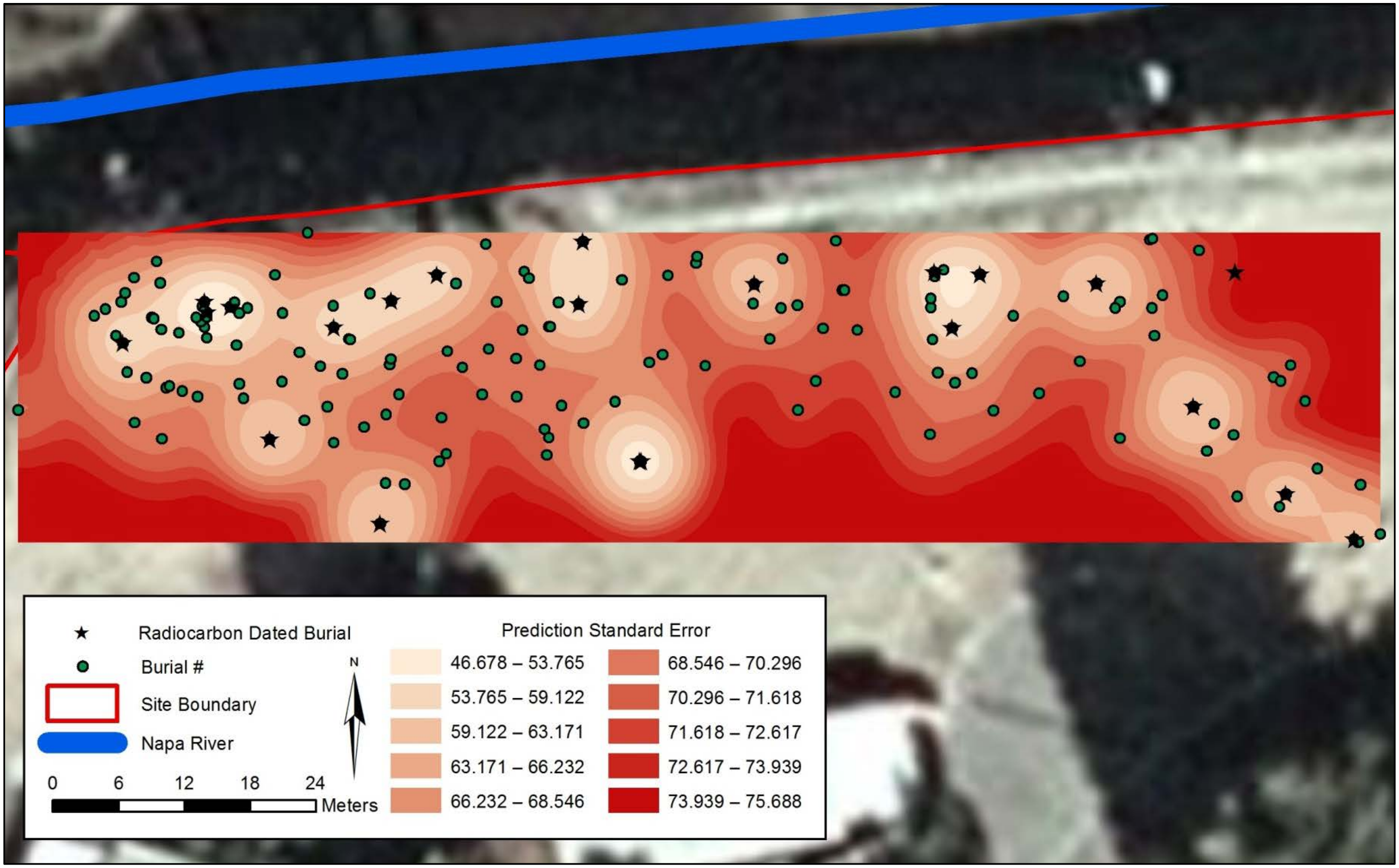

Figure 58: Prediction Standard Error Map for Interpolated Burial Date Surface.

To assign dates from the interpolated surface to individual burials the interpolation result was converted to a raster file with a default cell output size of 0.113 meters. Next, the raster value to point feature tool in ArcGIS was used to extract the interpolated date from the raster for each burial point. This created a new attribute with the value from the raster, which was named Int_Dates. This attribute allowed for the sorting of the burials into five date ranges of one hundred years each. These values are presented in years before present (BP). This allows for the examination of change over time presented and discussed in Section 8.3.

The results of the 156 burials that were suitable for the dating interpolation based on radiocarbon dates and depth are listed in Table 25. There were 18 burials in the first date range from 2450-2350 BP, 33 in the second date range from 2350-2250 BP, 70 in the third date range from 2250-2150 BP, 31 in the fourth date range from 2150-2050 BP, and four in the fifth date range from 2050-1950 BP.

Table 25: Burials by Interpolated Date Range.

Date Range (BP)	Burials	Total
2450-2350	13, 15, 31, 42, 66, 67, 68, 69, 82, 83, 86, 87, 125, 144, 145, 147, 155, 156	18
2350-2250	14, 16, 25, 26, 30, 40, 41, 44, 46, 47, 48, 49, 56, 60, 63, 64, 65, 78, 81, 105, 108, 120, 123, 124, 128, 131, 137, 143, 146, 150, 151, 157, 161	33
2250-2150	1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 17, 19, 20, 21, 23, 27, 33, 34, 35, 36, 37, 39, 43, 45, 50, 51, 53, 54, 58, 59, 62, 73, 76, 77, 79, 80, 85, 91, 92, 94, 95, 9798, 100, 103, 104, 106, 107, 109, 110,111, 112, 113, 114, 115, 116, 117, 118, 126, 127, 135, 136, 140, 141, 142, 149, 152, 153, 154, 158	70
2150-2050	2, 10, 18, 22, 24, 28, 29, 38, 52, 57, 71, 74, 75, 84, 89, 90, 93, 96, 99, 101, 102, 119, 121, 122, 129, 130, 132, 133, 134, 138, 148	31
2050-1950	55, 70, 72, 139	4

8.2 Comparison by Date Range from Radiocarbon Date Interpolation

Table 26 compares several attributes over the five one hundred year date ranges. The number of burials peaks during the third date range from 2250-2150 BP with 70 individuals. There are very few individuals buried later in time onsite from 2050-1950 BP.

The ratio between the sexes remains fairly constant throughout all five date ranges with there being slightly more females than males. In normal populations, the ratio should be closer to 50:50. This is true for the second, fourth, and fifth date ranges. The first and third date ranges show a greater discrepancy in this ratio. Brown (1981) might consider this evidence of differential internment based on sex that varied through time onsite. A few possible explanations for this discrepancy is that the ratio is actually closer to 50:50, only a disproportionate percentage of males had poorer preservation which meant their sex could not be positively identified, so they were classified as unknown. Another explanation is that the some of the males died away from the village, and were unable to be transported back for burial.

The ratio between ages also remains fairly constant across the date ranges. There are a higher number of older individuals throughout all five date ranges. There are very few young individuals being buried onsite. There is more variation in the middle date range, but that is likely the result of the greater number of individuals present within the date range. This goes against normal populations seen in nature, where the very young and elderly are more at risk. At CA-NAP-399, it is possible that the very young did not die that often, and most adults survived into middle adulthood before succumbing to death. Another possible explanation is that the very young individuals from the site did not preserve well, or were missed entirely during monitoring operations.

The flexure of the burials is predominantly tightly flexed through all five date ranges. There is more variation in the middle date range from 2250-2150 BP which is again likely the result of the greater number of individuals. The tight flexure may be related to the energy expenditure theory, in that there would be additional effort or energy expenditure in excavating a grave larger than was needed. The tightly flexed burials fit into the smallest graves that require the smallest amount of soil removal.

The cremations are not clustered in any particular date range which could have indicated a shift in burial practices. It seems more likely that these cremations are isolated events that are person specific and are not reflections of society as a whole.

Orientation is predominantly westerly oriented throughout the five date ranges with more variation in the second and third date ranges. This is again likely due to the larger number of individuals.

The artifact distributions show a normal statistical distribution throughout the date ranges. The majority of individuals have indirectly associated burial goods. Very few individuals had no artifacts associated with them. There appears to be a slightly higher percentage of individuals with no burial associated artifacts earlier in time. The percentage of individuals with directly associated artifacts increases through time.

The side of internment is fairly consistent throughout time, with internment on the left and right side being the most numerous. There is again more variation in the middle date range, likely due to the large numbers of individuals.

Table 26: Comparison of Selected Attributes by Interpolated Date Range.

Burial Attribute		**Date Range (BP)**				
		2450-2350	**2350-2250**	**2250-2150**	**2150-2050**	**2050-1950**
Number of Burials		18	33	70	31	4
Sex	Male	2 (11%)	10 (30%)	21 (30%)	10 (32%)	1 (25%)
	Female	7 (39%)	11 (33%)	34 (49%)	11 (36%)	2 (50%)
	Unknown	9 (50%)	12 (37%)	15 (21%)	10 (32%)	1 (25%)
Age	0-3	1 (6%)	4 (12%)	6 (9%)	2 (6%)	0
	3-12	0	2 (6%)	5 (7%)	4 (13%)	0
	12-20	1 (6%)	0	2 (3%)	3 (10%)	0
	20-30	2 (11%)	3 (9%)	10 (14%)	7 (23%)	1 (25%)
	30-50	7 (39%)	12 (37%)	28 (40%)	12 (39%)	1 (25%)
	50+	3 (16%)	6 (18%)	15 (21%)	2 (6%)	2 (50%)
	Unknown	4 (22%)	6 (18%)	4 (6%)	1 (3%)	0
Flexure	Loose	1 (6%)	1 (3%)	4 (6%)	1 (3%)	0
	Flexed	1 (6%)	0	1 (1%)	2 (6%)	0
	Semi	0	2 (6%)	8 (11%)	0	0
	Tight	12 (67%)	23 (70%)	44 (63%)	23 (74%)	4 (100%)
Cremation		1 (6%)	0	2 (3%)	1 (3%)	0
Orientation	North	1 (6%)	1 (3%)	4 (6%)	2 (6%)	0
	Northeast	0	2 (6%)	3 (4%)	1 (3%)	0
	East	0	2 (6%)	2 (3%)	1 (3%)	1 (25%)
	Southeast	0	1 (3%)	1 (1%)	0	0
	South	0	2 (6%)	1 (1%)	0	1 (25%)
	Southwest	4 (22%)	3 (9%)	5 (7%)	2 (6%)	1 (25%)
	West	8 (44%)	9 (27%)	30 (43%)	17 (55%)	1 (25%)
	Northwest	1 (6%)	5 (15%)	12 (17%)	2 (6%)	0
Artifact Association	None	4 (22%)	10 (30%)	6 (9%)	1 (3%)	0
	Indirect	12 (67%)	18 (55%)	46 (66%)	21 (68%)	2 (50%)
	Direct	2 (11%)	5 (15%)	17 (25%)	9 (29%)	2 (50%)
Side	Dorsal	1 (6%)	3 (9%)	5 (7%)	3 (10%)	1 (25%)
	Dorsal/Left	1 (6%)	2 (6%)	2 (3%)	1 (3%)	0
	Dorsal/Right	1 (6%)	0	2 (3%)	0	0
	Ventral	3 (16%)	0	4 (6%)	4 (13%)	1 (25%)
	Ventral/Left	0	0	4 (6%)	0	0
	Ventral/Right	0	0	2 (3%)	1 (3%)	0
	Left	4 (22%)	11 (33%)	19 (27%)	11 (36%)	0
	Right	5 (28%)	10 (30%)	20 (29%)	4 (13%)	1 (25%)
	Sitting	0	0	0	1 (3%)	0

(%) denotes the percentage of the population during the date range with that attribute.

Table 27 summarizes the results of the pathologies and anomalies found in the burials by component from the interpolated burial component. There are a total of 112 cases of anemia, 15 auditory exostoses, 41 dental caries, 33 individuals with healed fractures, 10 osteomyelitis, 82 cases of femurs demonstrating anterior-posterior flattening, and four Inca Bone. Anemia, dental caries, osteomyelitis, healed fractures, and femurs demonstrating anterior to posterior flattening are found in all five date ranges. Auditory exostoses and Inca Bone are found in the middle three date ranges.

Table 27: Comparison of Pathologies and Anomalies by Interpolated Date Range.

Pathology or Anomaly	Date Range (BP)					Total
	2450-2350	2350-2250	2250-2150	2150-2050	2050-1950	
Anemia	14 (78%)	21 (64%)	52 (74%)	23 (74%)	2 (50%)	112
Auditory exostoses	0	7 (21%)	6 (9%)	2 (6%)	0	15
Dental Caries	4 (22%)	9 (27%)	19 (27%)	7 (21%)	2 (50%)	41
Healed Fractures	2 (11%)	5 (15%)	17 (24%)	8 (24%)	1 (25%)	33
Osteomyelitis	2 (11%)	2 (13%)	3 (4%)	2 (6%)	1 (25%)	10
Femurs A-P flattening	8 (44%)	16 (48%)	37 (53%)	19 (58%)	2 (50%)	82
Inca Bone	0	1 (3%)	2 (3%)	1 (3%)	0	4

(%) denotes the percentage of the population during the date range with that attribute.

Table 28 shows there are a total of 54 tools directly associated with the burials according to the interpolated date range. A total of 27 individuals had directly associated tools. The first date range from 2450-2350 BP had one individual, the second date range from 2350-2250 BP had two, the third date range from 2250-2150 BP had 15 individuals, the fourth date range from 2150-2050BP had seven, and the fifth date range from 2050-1950 BP had one individual. Bifaces appear in all the date ranges, and account for 80% of all directly associated tools. There were no directly associated bowl mortars, cores, core tools, drills, millingslabs/metates, or unifaces.

Table 28: Comparison of Directly Associated Tools by Interpolated Date Range.

Tool	Date Range (BP)					Total
	2450-2350	2350-2250	2250-2150	2150-2050	2050-1950	
Bifaces	1	1	15	19	4	40
Bone Awls	0	0	4	1	0	5
Bone Pins	0	0	1	0	0	1
Bowl Mortars	0	0	0	0	0	0
Cores	0	0	0	0	0	0
Core Tools	0	0	0	0	0	0
Drills	0	0	0	0	0	0
Edge-Modified Flakes	0	0	2	0	0	2
Handstones/Manos	0	1	1	0	0	2
Millingslabs/Metates	0	0	0	0	0	0
Pestles	0	0	1	1	0	2
Projectile Points	0	0	2	0	0	2
Unifaces	0	0	0	0	0	0
Total	1	2	26	21	4	54

Table 29 shows the total number of tools, including both direct and indirect association, by interpolated burial component. A measure of the tools diversity is also included. A total of 121 individuals had tools. The first date range from 2450-2350 BP had 14 individuals with tools, the second date range from 2350-2250 BP had 19 individuals, the third date range from 2250-2150 BP had 7 individuals, the fourth date range from 2150-2050 BP had 27 individuals, and the fifth date range from 2050-1950 BP had four individuals buried with tools. A total of 636 tools were recovered from the burials. The number of total tools by date range consists of 39 for the first, 90 in the second, 327 in the third, 168 in the fourth, and 11 in the fifth. The tool diversity index shows a normal distribution for the maximum value across the five date ranges, peaking in the third date range with a value of 0.38. The average number of tools increases from the first date range over time, peaking in the fourth date range which had an average of 5.39 tools per burial, slightly higher than the third date range at 4.614.

Table 29: Comparison of Total Tools by Interpolated Date Range.

Tool	Date Range (BP)					Total
	2450-2350	2350-2250	2250-2150	2150-2050	2050-1950	
Bifaces	33	75	270	152	10	540
Bone Awls	0	2	10	2	0	14
Bone Pins	0	0	4	0	0	4
Bowl Mortars	0	1	4	0	1	6
Cores	0	1	0	1	0	2
Core Tools	0	3	0	0	0	3
Drills	0	0	1	0	0	1
Edge-Modified Flakes	6	5	23	7	0	41
Handstones / Manos	0	1	2	3	0	6
Millingslabs / Metates	0	1	0	0	0	1
Pestles	0	0	6	2	0	8
Projectile Points	0	1	5	1	0	7
Unifaces	0	0	3	0	0	3
Total	39	90	327	168	11	636
Average Tools	2.17	2.72	4.64	5.39	2.75	
Highest Tool Index	0.15	0.23	0.38	0.31	0.23	
Median Tool Index	0.08	0.08	0.08	0.08	0.08	
Mean Tool Index	0.07	0.075	0.103	0.103	0.135	

Table 30 summarizes the directly associated wealth items by interpolated burial component. Only a total of 12 individuals were buried with directly associated wealth items. There were four individuals in the second date range from 2350-2250 BP, seven individuals in the third date range from 2250-2150 BP, and one individual in the fourth date range from 2150-2050 BP. One individual from the second date range was buried with 112 quartz crystals, accounting for the vast majority of directly associated wealth items for that component. Five other individuals, all from the third date range, had 30 or more items while the remainder of all other burials had less than two wealth items total. There were a total of 422 directly associated wealth items directly associated with the burials. There were no directly associated bird bone beads or whistles. Shell beads (n=182) and quartz crystals (n=173) were the most abundant directly associated wealth items.

Table 30: Comparison of Directly Associated Wealth Items by Interpolated Date Range.

Wealth Item	Date Range (BP)					Total
	2450-2350	2350-2250	2250-2150	2150-2050	2050-1950	
Bird Bone Beads	0	0	0	0	0	0
Charmstones	0	1	3	1	0	5
Obsidian Needles	0	0	29	0	0	29
Pendants	0	1	3	0	0	4
Quartz Crystals	0	113	59	1	0	173
Shell Beads	0	0	182	0	0	182
Stone Beads	0	0	29	0	0	29
Whistles	0	0	0	0	0	0
Total	0	115	305	2	0	422

Table 31 summarizes the total number of wealth items by interpolated burial component. A measure of wealth item diversity is included. A total of 54 individuals had wealth items. There was one individual from the first date range from 2450-2350 BP, 11 in the second date range from 2350-2250 BP, 28 in the third date range from 2250-2150 BP, 12 in the fourth date range from 2150-2050 BP, and two in the fifth date range from 2050-1950 BP. A total of 538 wealth items were recovered with the burials. The first date range only had two wealth items, two obsidian needles. The second date range had 134 wealth items while the third date range had 348. The fourth date range had a total of 47 wealth items while the fifth date range had two. The most abundant wealth items consist of shell beads (n=195), quartz crystals (n=193), and obsidian needles (n=52). The average number of wealth items peaks in the second date range with 5.52 wealth items per burial. The wealth diversity index shows a normal distribution with the highest value of 0.75 found in the third date range.

Table 31: Comparison of Total Wealth Items by Interpolated Date Range.

Wealth Item	Date Range (BP)					Total
	2450-2350	2350-2250	2250-2150	2150-2050	2050-1950	
Bird Bone Beads	0	3	2	25	0	30
Charmstones	0	3	13	2	0	18
Obsidian Needles	2	2	44	3	1	52
Pendants	0	1	5	0	1	7
Quartz Crystals	0	113	62	13	0	193
Shell Beads	0	1	190	4	0	195
Stone Beads	0	11	29	0	0	40
Whistles	0	0	3	0	0	3
Total	2	134	348	47	2	538
Average Wealth	0.118	4.06	5.12	1.52	0.5	
Highest Wealth Diversity Index	0.125	0.25	0.75	0.375	0.125	
Median Wealth Diversity Index	0.0	0.0	0.0	0.0	0.0	
Mean Wealth Diversity Index	0.007	0.059	0.085	0.073	0.063	

8.3 Changes in Attributes over Time

This section provides a tentative view of changes over time for various attributes through time. It would be interesting to see if these changes apply only to the site or can perhaps be applied to other nearby sites on a regional analysis.

Sex

The ratio of the sex between individuals at CA-NAP-399 remains fairly consistent across all five arbitrary date ranges. There are slightly more females in all the date ranges. There are a few possible explanations for this.

The first is that the ratio is actually close to even; only a disproportionate number of males are located in the unknown sex class. The second is that perhaps some males from every generation tended to die away from the village, perhaps due to accidents or infections, where the body could not be returned to the village. The third possibility is that perhaps there were just a higher number of women each generation buried onsite.

Age

The age ratio of the individuals remains fairly constant across the date ranges. There are mostly adults and elderly individual' interred onsite, with few children. In a normal biological model, the distribution of death should be bimodal with peaks among the young and elderly, who tend to be more vulnerable to nature.

The highest number of young and elderly individuals who succumbed to death is found in the third date range from 2250-2150 BP, which had more individuals than the other date ranges. This could represent the apex of the village during this date range. There appears to be a drop-off in the number of individuals after this date range.

This could represent the inhabitants moving to another village nearby, and that those interred onsite afterwards held a connection to the site and/or their ancestors buried there. The number of young children drops off substantially which could also represent families moving to the other village.

Flexure

The ratio of flexure between burials remains fairly consistent across all date ranges. Tightly flexed is the most common method, but there is more variation when there are a higher number of burials during a date range. The most likely explanation is the effort expenditure for digging the graves. It appears as if the graves were excavated to be just big enough, to move the least amount of material, to fit the individual into the grave.

Orientation

The orientation of the burials is primarily to the west throughout all the date ranges. This is likely in relation to the setting sun, a common theme in prehistoric societies thought to symbolize the afterlife. There appears to be more variation during the second date range for some unknown reason. The third date range also had a large amount of variation, but this is likely explained by the larger number of individuals.

Variations in orientation may be due to post depositional shifts in the body or changes in beliefs or references to sacred locations over time. The higher variation seen in the second date range may reflect this.

Artifact Association

The percentage of individuals who had no associated grave goods peaked during the first second range and decreased afterwards. This may indicate poorer conditions occurred earlier at the site.

The percentage of individuals with directly associated grave goods starts low, at around 10% during the first date range from 2450-2350 BP. This increases over time to just under 30% for the fourth date range. The low percentage of directly associated grave goods during the first date range may also reflect poorer conditions onsite at this time.

Side

Given the somewhat random nature of the side of internment, it is difficult to make definitive statements regarding the implications of its change over time. The left and right side seem to be the preferred side of internment. Once again, the highest diversity is seen during the middle date range from 2250-2150 BP, likely the result of a larger population.

Tools

Bifaces are the most common tool found with the burials. They account for 80% of directly associated grave tools and 85% of all tools. The peak in directly associated bifaces is not in the middle date range from 2250-2150 BP which had more individuals, but rather in the fourth date range from 2150-2050 BP. The number of total bifaces peaks during the middle date range. If the site was an important biface production area for trade, it could be expected that certain craftsmen could have bifaces directly associated with them.

Bone awls are found in the middle three date ranges, and peak in the third. Most (80%) of the directly associated bone awls were from burials in the middle date range, and one from the fourth. This could indicate increased basket production since this distribution mimics the number of edge-modified flakes which can also associated with basketry. Looking at the sex of the individuals with bone awls however shows that most were male. Males are typically not associated with basket production. This would seem to indicate the awls are related to some other activity, possibly hide preparation.

Bone pins are found during the third date ranges. These may also give an indication into possible basket production or clothing manufacture. Bone pins could even be considered articles of adornment, and may represent certain hair styles in which pins were used to hold up the hair.

Bowl mortars are used in conjunction with pestles and indicate a reliance on acorns. It is possible that the increasing number of bowl mortars seen in the date ranges, coupled with the decrease in the number of millingslabs and handstones, could give an indication of increased reliance on acorns. It is also hypothesized that this increased reliance on acorns could affect the health of the individuals, leading to higher numbers of dental caries and even anemia if the tannins are not leached correctly or thoroughly enough. This is examined further in the health and pathologies subsection below.

Cores are rare in the burial assemblage. This is likely due to these being little used during the occupation of the site when the burials were interred. Cores are typically found later in time in the area, when the demand for finished tools manufactured from smaller pieces of debitage or flakes was higher. During the Upper Archaic, the production of large bifaces seems to have been from individual cobbles of obsidian and large reduction flakes, not cores (Holson et al. 2013).

Core tools are like cores but they have been used as tools. A more functional term would be choppers or even scrapers. The three tools in this case are likely choppers, and are found in the second date range from 2350-2250 BP. This could represent a specific activity type that occurred onsite earlier, and then discontinued, disappeared, or left no visible trace afterward. Wood working is one possible explanation.

There was only one drill found with the burials in the middle date range from 2250-2150 BP. This artifact was not shaped, and was actually created from an odd nodule of obsidian with a nice thumb hold for a right handed user. It is likely that this represents an exception, or even a personal tool, rather than a stylized and shaped drill. Drills were not very common onsite during this time.

Edge-modified flakes can be considered expedient tools used for cutting or scraping. They are used with a variety of tasks such as food processing, basketry, and clothing manufacture. There is a slight dip during the second date range from 2350-2250 BP, followed by the peak in the third date range. These artifacts from the burials may be related to basketry. However the idea of them as expedient tools seems to be at odds of them as grave goods, if one usually thinks of grave goods as containing the nicest things. This could mean that they were inserted as tools for the deceased to use in the afterlife. However, given that there were only two directly associated edge-modified flakes, a likelier answer would be that they are likely part of the midden.

Handstones are used in conjunction with millingslabs to process grass seeds. Their presence indicates that the inhabitants of the site continued to focus on grass seeds as a food staple. Their temporal placement indicates that seed processing coexisted with acorn processing.

Projectile points are used to hunt game. They are found in the second and third date ranges, peaking during the third date range from 2250-2150 BP. This could indicate an increased focus on hunting, but a more likely explanation is that there was simply the same percentage of hunters in a larger group of people in the community at that time hunting. An odd thing is that five of the projectile points were associated with women.

Unifaces are only found in the middle date range, and may represent task specific activities such as scraping hides. This could also be a reflection of unifaces being present in the midden onsite, or the presence of an activity area where unifaces were utilized.

Wealth Items

Bird bone beads are found in the second, third, and fourth date ranges. These are likely made onsite from the remains of birds brought to the site as food. These could represent a demand for beads, but no way of acquiring other types such as shell or stone, so they made their own. This fits well with the fourth date range where there was a much higher number of bird bone beads, but little shell and no stone beads. They could also have been used as adornment for baskets.

Charmstones are found in the second, third, and fourth date ranges, peaking in middle. Given the unknown nature of the charmstones themselves, it is difficult to make definitive conclusions regarding their changing number over time. It could be as simple as people just liked them, or as complex as being physical representations of religious rights or representations of abstract concepts.

The obsidian needles peak during the middle date range from 2250-2150 BP, but are found in all the date ranges. The peak during the middle date range can be credited to one individual who had approximately 27 needles. The remainder of the needles can likely be attributed to occurring naturally in the soil matrix surrounding the burials, which would account for the clustering of the indirectly associated needles.

The pendants are found in the second, third, and fifth date ranges, peaking in the middle. These are likely indicator of rank, status, and/or wealth given that very few individuals had these, and that they were clustered together.

Quartz crystals are found in the second, third, and fourth date ranges, peaking during the second date range from 2350-2250 BP where one individual was buried with 112 crystals. Another individual from the middle date range was buried with over 50. These are the only two individuals who possessed a large number of these crystals, while the other individuals had only a few. These may be indicators of status, rank, or possibly religious importance. These items are usually found associated with burials assumed to be shamans or other types of important religious figures. While there is no spatial clustering, it is interesting to see the decrease in numbers over time which could indicate increasing scarcity or difficulty in obtaining via trade. It could also indicate a change in religious practices if the crystals are in fact ceremonial in nature. These are possibly Lake County diamonds from the vicinity of Clear Lake.

Shell beads first appear during the second date range, peak in third, and drop of sharply after that. These *olivella* beads were obtained from the ocean either via trade or direct procurement. Either option involves dealing with neighboring tribes. Their sudden appearance, could suggest that trade routes were established during this time period.

Whistles are only found in the middle date range, and could indicate items of rank. Increasing complexity in ceremonies could also be a factor; however their appearance in only one time component suggests a singular event.

Pathologies and Anomalies

Anemia is present during all the components. The number of cases peaks during the middle date range from 2250-2150 BP; however, this actually represents a slight dip in the percentage of the overall population of the date range at 73.5%. The peak is from the second date range which is at 76.0% while other date ranges occur in the 65%-75% range. Due to the low number of individuals from the last date range, the percentage dips to half. This is a very high percentage of the population that is fairly consistent through time. It is unknown if this could be the result of a genetic abnormality or another disease such as scurvy which can present itself in the bones same way. Possibly not leeching the tannic acid in acorns is another possibility.

Auditory exostoses is present during the second, third, and fourth date ranges, peaking in number during the third. However 20% of the population during the second date range had this condition in comparison with just under 10% of the third date range. This could represent repeated forays by select individuals to either the ocean or San Francisco Bay. The increasing number over time could be a reflection of increased trade or direct procurement of ocean or bay goods.

Dental caries are present during every date range. The number peaks in the third date range at 19 cases, which represents 28.9% of the date range population. All the date ranges have between 20% and 30% of individuals demonstrating dental caries, except for the fifth date range which has a lower number of individuals. It was thought that increasing reliance on acorns would lead to an increase in the number of dental caries, however, this does not appear to be the case at CA-NAP-399.

Healed fractures are present in all the date ranges, peaking in the third with 22 cases representing 26.5% of the population in this date range. This is a marked increase from the previous date ranges where only around 12% of the population exhibited evidence of healed fractures. This could perhaps indicate an increase in risky behavior during the third date range. Most of the fracture types appear to be the result of accidents, suggesting this happened fairly regularly to a portion of the population.

Osteomyelitis is found in all five date ranges. It appears to be randomly distributed and is likely dependent on the individual.

Femurs with anterior to posterior flattening peak in number during the third date range. There is a gradual increase in the percentage of the population that demonstrated femurs with anterior to posterior flattening. The first date range had 41.2% of the population afflicted, increasing to 48% during the second date range, and peaking in the third at just under 60%. This then decreases to 44.4% in the fourth date range. This indicates an increased workload or longer walking over difficult terrain. This again gives credence to the theory of establishing trade routes, as more walking over difficult North Coast terrain would produce these results.

The Inca bones only occur in the middle three date ranges. It does not appear that this represents a genetic or familiar marker that would indicate familial cemetery plots. It could indicate the influx of a small group of individuals with this trait into the village over time however. Genetic testing may hold the key for future analysis.

Chapter 9 – Conclusions

This chapter examines considerations for future mortuary analysis using GIS and summarizes the findings using GIS from CA-NAP-399.

9.1 Considerations for Future Burial Analysis

There are a number of improvements to suggest regarding data capture of burials in the future. The first is to recommend that excavation techniques attend to preserving the data that on the basis of its recovery alone make some of these detailed studies possible. The second (and this is more relevant for the study in this thesis) is that a GPS device be used to record the positions of the body. This would reduce the chance for error, and also cut down on person hours converting physical data to digital data. Any device that can gain sub-meter accuracy would be ideal. Given the amount of time it takes to remove the soil around a burial, a GPS device could easily be gently set on the burial to record points for hours on end if need be. It would also potentially help avoid differing data values and locations.

While considering burials as point locations has been used often, there is a loss of information regarding the overall presence of the burial. Instead of seeing articulated burials or the shapes of grave outlines in close association to one another, all one sees is a point. Instead of taking a single solitary point on the burial, a series of lines might be better at distinguishing the position, orientation, and burial type. A line feature can be created with the first point on the head, the second on the hips, the third on the knee, and the fourth on the feet. A second line could start with the position of the hands, then move on to the elbows, and finally end at the shoulders. The point on the head can even be buffered to provide the rough size of the crania. This would create a sort of stick figure which would allow archaeologists to better gauge how the position, orientation, and burial type vary across the site. If we were to represent the burials as polygons one wonders how different the results would be. Future studies on flexure should include a range from fully extended to tightly flexed.

Depending upon the accuracy of the GPS device in use, a total station might be the best option at recording the depth and location of the burials. A difference of even a few centimeters regarding the depth may be enough to skew the data and suggest different temporal placement. Archaeologists should remember to take plenty of readings regarding the surface elevation to allow for better recreation of the original site topography. Multiple points along the outline of the prepared grave if observable could be of use as well.

It would also be worthwhile to begin to incorporate DNA analysis into the spatial data as well. While this is unlikely to occur in the United States due to the politically sensitive nature of Native American burials, it could conceivably gain acceptance in Europe and elsewhere. By integrating DNA analysis, archaeologists would be able to examine genetic relationships between individuals. Intra site analysis would be the most useful aspect at first, but as the database grows over time, it would allow for a greater examination of human migration and relationships over time and space.

The number and type of burial attributes can reach overwhelming levels quickly depending on the level of analysis and questions one wishes to pursue. For example the indirect and directly associated bifaces could be refined further into the five stages of bifaces and possible projectile points, each one with a direct, indirect, and total attribute. Selecting only essential attributes for study can allow for a more generalized study of burials, but some of the smaller pictures may end up getting lost. Projectile points too could be broken down into temporally sensitive types.

Shell beads are another example where the attributes could be split almost indefinitely. *Olivella* shell bead types are useful as chronological indicators. In a site with numerous burials that occupy a wider range of time with a more diverse variety of beads, the beads can be used like the radiocarbon dates in this thesis to extract burials into particular temporal ranges. The only problem is that there are over a dozen types or classes of *olivella* beads, each with numerous subtypes or sub classes. There is at least fifty, which translates into at least 150 attributes for the *olivella* beads alone based on direct and indirect association along with a type or subtype total. A whole separate shapefile devoted to just the bead types could be a possible solution.

Incorporating health information regarding the individuals such as disease, signs of interpersonal violence, and other abnormalities, present a technical challenge. A single attribute column for each disease can be used, with a simple presence or absence value. This was experimented within this paper with mixed results. However, this would greatly increase the number of attributes for the burials, further stretching the GIS. A list of the top ten or twenty most common afflictions may be the answer. An attribute for interpersonal violence as a present or absent attribute would also be useful. Interpersonal violence has been singled out recently as an indicator of inter-societal pressure, and presents a skewed view of the past focusing on instances of violence. A second column to counter this would be recommended called interpersonal compassion. This attribute would be a simple present or absent value. It would be present if the individual showed signs of hardships that would have likely killed them on their own, so the interpersonal compassion could be seen as keeping them alive. Examples include amputation and sever cases of osteomyelitis.

The uses of codes representing nominal classifications have been problematic during this study. The very act of coding itself is almost like weighting the results. One naturally presents the best or most desired attribute at the end. This larger value then tends to overshadow all the other codes in terms of weighted totals and means. This does not mean that the results are wrong; it is merely something to keep in mind for future studies.

GIS can be very useful in distinguishing between prehistoric burial components where temporally diagnostic artifacts are present. Sorting through the burials based on the *Olivella* bead typology or projectile points can allow archaeologists to better characterize components, instead of examining potentially thousands of years worth of burials en masse. Creating attributes for diagnostic projectile points and temporally diagnostic beads can help to differentiate between burial components and allow for a finer grained spatial inspection of those components and how the burials were interred onsite over time.

Perhaps we should be wary of conducting a study with such a fine focus. At which point are the attributes seen the reflection of individual choices or that of society's? What this means is that at a certain point, at a certain level of focus, all the attributes and choices can be considered individual and not societal.

GIS analysis represents a powerful tool for analytical study. However that tool is wielded by the human mind which must understand and comprehend the reasons behind using that tool. A novice user may use that tool to find a faulty assumption or biased results. Proper cognitive reasoning, coupled with GIS, can provide a wealth of information when used properly.

9.2 Site Summary

Given the incomplete nature of the dataset, only two solid conclusions can be reached. The first is that there was clustering of bone preservation. The second is that the results of analysis indicated differences in excavation techniques. The incomplete nature of the data set means that the results are not valid for formal archaeological analysis and should not be relied upon by others who may be seeking comparisons for their own arguments about ancient socio-cultural patterns. The following section reports on results that are implied by the analysis of the given data and are provided as a means of assessing the usefulness of spatial analysis, not as conclusions about this specific set of archaeological data.

Based on the Binford-Saxe model, if the underlying dataset were reliable, then it would appear that CA-NAP-399 during the Upper Archaic could be considered evidence of a stratified, hierarchal, and complex society. Wealth and or status were in the hands of the few indicating a stratified society. If the experimental date interpolation is true, then this society became stratified quickly. One of the six individuals with a large number of wealth items was too young to have achieved status, suggesting that wealth was concentrated in familial groups.

As the largest prehistoric cemetery discovered so far in Napa County, there are not many nearby sites to compare with. The site is unique when compared to the other sites discussed in Section 3.2.2. CA-NAP-399 does match with the wealth inequality at CA-SCL-128, a mixture of middle and late period components, discussed by Cartier et al. (1993). CA-NAP-399 does not demonstrate the same type of determinants, such as age and sex, which determined the location of burials from CA-SCL-38 as discussed by Bellifemine (1997). It is similar to Luby's (2004) examination of CA-ALA-328 where inequality was found earlier in the site structure. Wiberg's (2005) study is the closest site to CA-NAP-399. Wiberg found that the late period site had activity areas outside the burials areas which did not occur at CA-NAP-399 as numerous ash, hearth, and rock features were found within the burial area. Sub adults were also located along the periphery of the burial area, which did not occur at CA-NAP-399.

There were a large number of artifacts found with the burials. Examining the distribution of direct versus indirect artifacts, it was found that wealth items were more likely to be directly associated with burials. The low percentage of directly associated tools suggest that many of the tools were present in the burial fill, likely becoming intermixed into the burial matrix by the excavation of graves into midden soil.

In this study it has been shown that GIS can provide a useful tool for mortuary analysis. It can be used to identify spatial clustering of artifacts or burials traits, as well as to interpolate dates for the burials. Depositional events of the burials show that the cemetery gradually moved to the west, with each subsequent date range focusing on a westward expansion of the cemetery.

Spatial analysis using GIS has demonstrated that there is spatial autocorrelation among burial attributes such as depth, bone preservation, direct artifact association, and total tools, the tool diversity index, and the wealth diversity index. Spatial autocorrelation was also found for indirectly associated bifaces, indirectly associated edge-modified flakes, indirectly associated unifaces, indirectly associated pestles, directly associated shell beads, indirectly associated natural obsidian needles, and directly associated pendants. Dental caries were found to be dispersed. Most of these can likely be attributed to excavation techniques, natural phenomena, or possible activity areas onsite where discarded tools became intermixed in the burial matrix. The directly associated shell beads and pendants are likely indicative of a high status or wealth area onsite.

The spatial cluster and outlier analysis singled out burials that were part of clusters or outliers. This will allow the osteologist to reexamine specific burials to ask questions regarding the connections between certain burials. Three distinct clusters of burials were observed by depth. Each cluster contained at least one radiocarbon date allowing for the relative dating of the other burials within that cluster. A small cluster of burials with a high number of wealth items was observed which correspond to the clustering of shell beads, pendants, and wealth diversity index seen in the spatial autocorrelation study.

The grouping analysis examined the burials to determine if they were part of unique groups. Grouping was observed for preservation, depth, artifact association, total tools, and wealth diversity. Total wealth items and orientation had possible grouping. The other attributes studied did not show signs of grouping. Examining if clusters of burials based on depth date to the same time period provided mixed results.

The experimental burial date interpolation allowed for a more fine grained examination of the burials through time. It has the potential to allow for mortuary studies based on generations, not centuries or millennia. While not exact, it does suggest a few trends that might be examined in depth in the future at other sites in the area. These include the sudden increase of wealth, the co-occurrence of millingslab and mortar technology, the progression of femurs demonstrating anterior to posterior flattening through time, and if other sites in the area show similar distinct spatial clustering based on attributes.

GIS, used most simply as a spatial visualization tool, allows for the visual analysis of the spatial distribution of burial attributes, artifact numbers, and health anomalies and pathologies. By exploring spatial autocorrelation in the data, it can be tested if the data is clustered, dispersed, or random. It will not tell you which points are parts of these spatial patterns however. Cluster and outlier analysis can be used to show spatial clusters of high or low values and outliers, but it does not detect meaning in the spatial distribution of intermediate values. Grouping analysis can be used to explore spatial groups within the dataset, but it is important to recognize that not every resulting group will actually represent a true group of data. One must examine the mean of each group and the coefficient of determination in order to determine the distinctness of each group. An experiment with cokriging using radiocarbon dates and depth to produce a date surface was undertaken in an attempt to assign unknown date values missing from the full set of burials. In this case, the likely complex topography of the original site surface, coupled with the variable depth at which individuals were buried, calls into question the value of the date surface as a valid analytical result. However, despite all of the shortcomings in the interpretative results reported here, this study has demonstrated that with a reliable, methodologically excavated or scientifically sampled dataset; an archaeologist should be able to enhance their interpretation in a particular prehistoric mortuary analysis using these spatial analysis techniques.

Glossary

Term	Definition
ArcGIS	A geographic information system developed by Esri for working with maps and spatial information.
AMS	Stands for accelerated mass spectrometry, used in radiocarbon dating, which measures the actual C14 atoms and not their decay.
Aspect	Aspect is termed by Fredrickson as a sequence of phases within a single area or smaller geographic area.
Average Standard Error	The average of the prediction standard errors.
Biface	A piece of stone that has been flaked on two sides, may be a finished tool or in the process of manufacture
Bird Bone Beads	Small tubular beads fashioned from bird bones, usually ground along the ends.
Burial	The result of a series of ritualized practices performed in relation to death (Fahlander and Oestigaard 2008)
Charmstone	A shaped stone of varying design with no utilitarian purpose.
Cool Spot	Statistically significant cluster of low values.
Core	Any mass of stone that has had flakes removed from it for the purpose of manufacturing those flakes into tools
Core Tool	A core that has been used as a tool
Dart Points	Medium to large projectile points on a small shaft propelled through the air with an atlatl (throwing stick)
Debitage/Flakes	Waste material from the manufacture of stone tools
Drill	A piece of worked stone with a distinctive bit used to drill through objects, may or may not have a handle.
Edge-Modified Flake	A piece of debitage that has been intentionally retouched or inadvertently retouched during use as an expedient tool
Egalitarian	A society where all individuals are considered equal, typically one of the more primitive manifestations of society.
Faunal	Refers to non-human animal or shell remains
Feature	A non-movable, human created, object. Examples include hearths, house floors, and burials.
GIS	Abbreviation for geographic information system or sciences, a technology that is used to visualize, analyze, interpret, and understand spatial data by analyzing trends, relationships, and patterns.
Ground stone	Bowl mortars, pestles, milling slabs, and manos. Implements used in the processing of plant materials.
Handstone/Mano	A groundstone implement held in the hand, that crushes seeds between the handstone and a metate in a back and forth grinding motion.
Hot Spot	Statistically significant cluster of high values.

Term	Definition
Locality	Locality is a geographical location which exhibits complete cultural homogeneity at any given time (Fredrickson 1973). Milliken et al. (2007) divide the Bay Area into 18 localities.
Mean Error	The averaged difference between the measured and predicted values. The lower the number, the better the result.
Midden	Accumulation of manmade soils resulting from decomposing organic material, ash, charcoal, faunal remains, and artifactual debris
Millingslab/Metate	A large stone, usually with a slightly concave surface, that holds seeds as they are ground using a handstone in a back and forth motion.
Natural Obsidian Nodule	Long, skinny natural obsidian needles believed to be used in ceremonies for their tinkling sound as they hit one another
Obsidian Hydration	Obsidian is a naturally occurring volcanic glass. Each source possesses a distinctive chemical signature allowing for sourcing. Obsidian also absorbs water very slowly whenever a fresh surface is exposed. A thin cross section of the obsidian artifact is removed, sanded down, and fitted to a slide. An electron microscope then examines the size of the hydration rind present along the edge. The thicker the rind, the older the artifact.
Obsidian Needle	Naturally occurring masses of obsidian, typically long, tabular, and thin. These were used in ceremonies as “tinklers” or “bangles” for the sound they would make as they banged into one another, usually attached to dress garbs.
Olivella Bead	A bead manufactured from the shell of the sea snail *Olivella biplicata.* The shapes and types of these beads change over time and are used as diagnostic chronological indicators.
Pattern	Patterns are units of culture defined by distinct ceremonial beliefs, economic modes, and technological adaptations common over a wide area.
Pendant	A pierced object fashioned from stone or shell, usually worn around the neck on a string.
Period	A time span determined by archaeologists to be chronologically distinct based on observed cultural patterns seen in the archaeological record.
Phase	Phases are the smallest units of related site components limited to smaller geographic areas.
Projectile Point	Any bifacially modified mass of stone with a distinctive hafting element used in conjunction with spear, dart, and bow and arrow technology.
Pseudo F-Statistic	A ratio reflecting within-group similarity and between-group differences (ArcGIS 2012).
P-Value	A probability score, the closer to zero, the more likely the even it not the result of random distribution.
Raster	A data structure representing a grid of pixels of uniform size, each with a value.

Term	Definition
Root Mean Square	Indicates how closely the model predicts the measured values, the smaller the error, the better the model.
Root Mean Square Standardized Error	This value should be close to one if the prediction standard errors are valid. If the root mean square standardized error is greater than one, the model underestimates the variability in the predictions. If the root mean square standardized error is less than one, the model is overestimating the variability in the predictions.
ROW Standardization	When row standardization is selected, each weight is divided by its row sum (the sum of the weights of all neighboring features). Row standardized weighting is often used with fixed distance neighborhoods and almost always used for neighborhoods based on polygon contiguity. This is to mitigate bias due to features having different numbers of neighbors. Row standardization will scale all weights so they are between 0 and 1, creating a relative, rather than absolute, weighting scheme (ArcGIS 2012).
Shapefile	A geospatial vector data format used with GIS software.
Spatial Autocorrelation	The similarity between observations as a function of the distance between them. This means that objects that are closer in space tend to be more similar than objects further away.
Spatial Outlier	An object that is beyond the expected spatial distribution of nearby objects.
Uniface	A mass of stone that has been flaked along one face.
Z-Score	Measures of standard deviation.

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Appendix A: Burial Shapefile Attributes Table

Table A-1: Burial Shapefile Attributes.

Name	Extended Name	Data Type	NotNull	Unique	Domain/Restrictions/Notes
ObjectID	Object ID	Object ID	NotNull	Unique	Unique identifying number for each object, numbers are sequential with object creation
SHAPE*	Shape	Geometry			Point
BurialNumber	Burial Number	Short Integer	NotNull	Unique	Unique identifying number for each burial, numbers are sequential with discovery.
Age	Age	Short Integer			The age of the individual (see Table 5 for codes).
Sex	Sex	Short Integer			The sex of the individual (see Table 6 for codes).
Depth	Depth	Short Integer			In centimeters below the main site datum.
Depth_in_m	Depth in meters	Short Integer			In meters below the main site datum.
BurialGoods	Burial Goods	Short Integer			Discerns between those burials with directly associated artifacts (2), unassociated (1), or no artifacts (0).
Orientation	Orientation	Text			The direction the individual was laid to rest facing, in cardinal direction terms.
OrientationDegrees	Orientation Degrees	Short Integer			The direction the individual was laid to rest facing, sighted in compass degrees.
Position	Position	Text			The type of flexure for the burial.
Side	Side	Text			Which side the individual was laid to rest on.
Preservation	Preservation	Text			Described integrity of the bone preservation.
BonePreservation	Bone Preservation	Short Integer			Coded values for bone preservation (see Table 9).
DirectArtifacts	Direct Artifacts	Short Integer			The number of directly associated artifacts.
IndirectArtifacts	Indirect Artifacts	Short Integer			The number of indirectly associated artifacts.
TotalArtifacts	Total Artifacts	Short Integer			The number of direct and indirectly associated artifacts.
RadioCarbonDateBP	Radiocarbon Date (Years BP)	Short Integer			AMS dates calibrated in years before present.

Table A-1 Continued: Burial Shapefile Attributes.

Name	Extended Name	Data Type	NotNull	Unique	Domain/Restrictions/Notes
PositionID	Position ID	Short Integer			The position/flexure of the individual (see Table 7 for codes).
SideID	Side ID	Short Integer			The side the individual was laid on (see Table 8 for codes).
DirPPTs	Direct PPTs	Short Integer			Count of directly associated projectile points.
IndPPTs	Indirect PPTs	Short Integer			Count of indirectly associated projectile points.
DirBIFs	Direct BIFs	Short Integer			Count of directly associated bifaces.
IndBIFs	Indirect BIFs	Short Integer			Count of indirectly associated bifaces.
DirEMFs	Direct EMFs	Short Integer			Count of directly associated edge-modified flakes.
IndEMFs	Indirect EMFs	Short Integer			Count of indirectly associated edge-modified flakes.
DirOTHFLSTools	Direct Other Flaked Stone Tools	Short Integer			Count of directly associated cores, core tools, and drills.
IndOTHFLSTools	Indirect Other Flaked Stone Tools	Short Integer			Count of indirectly associated cores, core tools, and drills.
DirDEB	Direct DEB	Short Integer			Count of directly associated debitage.
IndDEB	Indirect DEB	Short Integer			Count of indirectly associated debitage.
DirFAU	Direct FAU	Short Integer			Count of directly associated faunal remains.
IndFAU	Indirect FAU	Short Integer			Count of indirectly associated faunal remains.
DirMOS	Direct MOS	Short Integer			Count of directly associated modified stone.
IndMOS	Indirect MOS	Short Integer			Count of indirectly associated modified stone.
DirMOB	Direct MOB	Short Integer			Count of directly associated modified bone.
IndMOB	Indirect MOB	Short Integer			Count of indirectly associated modified bone.
DirQZC	Direct QZC	Short Integer			Count of directly associated quartz crystals.

Table A-1 Continued: Burial Shapefile Attributes.

Name	Extended Name	Data Type	NotNull	Unique	Domain/Restrictions/Notes
IndQZC	Indirect QZC	Short Integer			Count of indirectly associated Quartz crystals.
DirBEDs	Direct BEDs	Short Integer			Count of directly associated beads.
IndBEDs	Indirect BEDs	Short Integer			Count of indirectly associated beads.
DirNON	Direct NON	Short Integer			Count of directly associated natural obsidian nodules/needles.
IndNON	Indirect NON	Short Integer			Count of indirectly associated natural obsidian nodules/needles.
DirPEN	Direct PEN	Short Integer			Count of directly associated pendants.
IndPEN	Indirect PEN	Short Integer			Count of indirectly associated pendants.
DirGDS	Direct GDS	Short Integer			Count of directly associated ground stone.
IndGDS	Indirect GDS	Short Integer			Count of indirectly associated ground stone.
DirWealth	Direct Wealth	Short Integer			Summed totals from DirMOS, DirQZC, DirBEDs, DirNON, and DirPEN.
IndWealth	Total Wealth	Short Integer			Summed totals from DirMOS, IndMOS, DirQZC, IndQZC, DirBEDs, IndBEDs, DirNON, IndNON, DirPEN and IndPEN.
DirTools	Direct Tools	Short Integer			Summed totals from DirPPTs, DirBIFs, DirEMFs, DirOTHFLSTools, DirMOB, and DirGDS.
IndTools	Total Tools	Short Integer			Summed totals from DirPPTs, IndPPTs, DirBIFs, IndBIFs, DirEMFs, IndEMFs, DirOTHFLSTools, IndOTHFLSTools, DirMOB, IndMOB, DirGDS, and IndGDS.
Total_Artifacts_Minus_DEB_and_FAU	Total Artifacts Minus Debitage and Faunal Remains	Short Integer			Total_Artifacts minus IndDEB an IndFAU.
DirCHA	Direct CHA	Short Integer			Count of directly associated charmstones.
IndCHA	Indirect CHA	Short Integer			Count of indirectly associated charmstones.

Table A-1 Continued: Burial Shapefile Attributes.

Name	Extended Name	Data Type	NotNull	Unique	Domain/Restrictions/Notes
DirSTB	Direct STB	Short Integer			Count of directly associated stone beads.
IndSTB	Indirect STB	Short Integer			Count of indirectly associated stone beads.
DirBBB	Direct BBB	Short Integer			Count of directly associated bird bone beads.
IndBBB	Indirect BBB	Short Integer			Count of indirectly associated bird bone beads.
DirSHB	Direct SHB	Short Integer			Count of directly associated shell beads.
IndSHB	Indirect SHB	Short Integer			Count of indirectly associated shell beads.
DirWHI	Direct WHI	Short Integer			Count of directly associated whistles.
IndWHI	Indirect WHI	Short Integer			Count of indirectly associated whistles.
Wealth_Diversity_Index	Wealth Diversity Index	Short Integer			Measure of the diversity of wealth items with each burial.
DirBLM	Direct BLM	Short Integer			Count of directly associated bowl mortars.
IndBLM	Indirect BLM	Short Integer			Count of indirectly associated bowl mortars.
DirPES	Direct PES	Short Integer			Count of directly associated pestles.
IndPES	Indirect PES	Short Integer			Count of indirectly associated pestles.
DirMSL	Direct MSL	Short Integer			Count of directly associated millingslabs.
IndMSL	Indirect MSL	Short Integer			Count of indirectly associated millingslabs.
DirHST	Direct HST	Short Integer			Count of directly associated handstones.
IndHST	Indirect HST	Short Integer			Count of indirectly associated handstones.
DirCOR	Direct COR	Short Integer			Count of directly associated cores.
IndCOR	Indirect COR	Short Integer			Count of indirectly associated cores.
DirCRT	Direct CRT	Short Integer			Count of directly associated core tools.
IndCRT	Indirect CRT	Short Integer			Count of indirectly associated core tools.
DirDRI	Direct DRI	Short Integer			Count of directly associated drills.
IndDRI	Indirect DRI	Short Integer			Count of indirectly associated drills.
DirUNF	Direct UNF	Short Integer			Count of directly associated unifaces.
IndUNF	Indirect UNF	Short Integer			Count of indirectly associated unifaces.

Table A-1 Continued: Burial Shapefile Attributes.

Name	Extended Name	Data Type	NotNull	Unique	Domain/Restrictions/Notes
DirAWL	Direct Bone Awls	Short Integer			Count of directly associated bone awls.
IndAWL	Indirect Bone Awls	Short Integer			Count of indirectly associated bone awls.
DirPIN	Direct PIN	Short Integer			Count of directly associated pins.
IndPIN	Indirect PIN	Short Integer			Count of indirectly associated pins.
Total_Tools	Total Tools	Short Integer			Count of total tools (all directly and indirectly associated PPTs, BIFs, EMFs, DRIs, CORs, CRTs, UNFs, BLMs, PESs, MSLs, HSTs, AWLs, and PINs.
Anemia	Anemia	Short Integer			Denotes presence (1) or absence (0) of anemia.
Inca_Bone	Inca Bone	Short Integer			Denotes presence (1) or absence (0) of Inca bone.
Auditory_Exostoses	Auditory Exostoses	Short Integer			Denotes presence (1) or absence (0) of auditory exostoses.
Dental_Caries	Dental Caries	Short Integer			Denotes presence (1) or absence (0) of dental caries.
Healed_Fractures	Healed Fractures	Short Integer			Denotes presence (1) or absence (0) of healed fractures.
Osteomyelitis	Osteomyelitis	Short Integer			Denotes presence (1) or absence (0) of osteomyelitis.
Femurs_with_AP_Flattening	Femurs with AP Flattening	Short Integer			Denotes presence (1) or absence (0) of femurs with anterior to posterior flattening.
Int_Dates	Interpolated Dates	Short Integer			Interpolated dates derived from the resulting raster of cokriging RadioCarbonDateBP with depth in meters.

Appendix B: Cokriging Prediction of Error Analysis Table for Interpolated Dates

This appendix will analyze the various interpolation models used in the date reconstruction. The geostatistical wizard from ArcGIS provides a series of prediction errors for cokriging models. These vary slightly based on which particular type of cokriging is used. These prediction errors allow the user to judge how valid the interpolation model was. The mean error is the averaged difference between the measured and predicted values, the lower the value, the better. The root mean square indicates how closely the model predicts the measured values, the smaller the error, the better. The average standard error is the average of the prediction standard errors. The root mean square standardized error should be close to one if the prediction standard errors are valid. If the root mean square standardized error is greater than one, then the model is underestimating the variability in the prediction. If the root mean square standardized error is less than one, then the model is overestimating the variability in the predications.

There are several different types of kriging. Cokriging, the method used in this paper, uses the main variable of interest, its spatial autocorrelation, and cross correlations between the variable of interest and other variables to make better predictions. Each type of kriging or cokriging can produce a specific output. There are five outputs, with some not available to certain kriging and cokriging types. Prediction creates a raster of predicted values. Quantile creates a surface that classifies data into a certain number of categories with an equal number of units in each category. Probability produces a surface that maps the probability the values match one another. The prediction standard error maps the predicted standard errors across the point distribution area. The standard error of indicators maps the standard error across the area. Probability, prediction standard error, and the standard error of indicators were not useful outputs for obtaining the interpolated date data. All models also had the potential to be optimized, in which ArcGIS automatically optimizes the model to produce the lowest amount of error.

Ordinary kriging is used if there is a simple constant that is unknown. The geostatistical wizard allows for the data to be transformed using either Box-Cox, Arcsine, Log, or Normal Score transformations to best fit the data trend. In this model there was no transformation used. For the initial interpolation analysis, the regular method produced a mean value of 5.145, a mean standardized error of 0.015, and a root mean square standardized score of 1.003. The mean is a bit high; however the mean standardized and root mean square standardized scores are at expected values for a valid model. Optimizing the model actually increases the values, but lowers the root mean square and average standard error. The best model is the optimized as it has the lowest average standard error. In the refined model the regular model produced a mean of 1.805, a mean standardized of 0.011, and a root mean square standardized score of 1.788. These numbers are acceptable however the mean and root mean square standardized score are a bit high. Optimizing the model increases the mean and mean standardized score but decreases the root mean square, root mean square standardized, and average standard error values. The best model is the optimized again, as it had the lower average standard error.

Simple kriging is used where the trend is completely known, and is the least general. This method also allows for the user to determine the number of bins for the study. In this case, the default was eight bins. Experimenting with the number of bins did not seem to have a noticeable effect. In this case study the trend was not known, so this method would likely not have been used anyway. It was run for the sake of completeness and curiosity. The original interpolation was run using the regular model which produced a mean of -0.938, a mean standardized of -0.007, and a root mean square standardized score of 0.992. The mean is a bit off; however the other values do not appear to be too bad. Optimizing the model greatly increases the mean and mean standardized, and decreases the other values. In this case the root mean square standardized value moved further away from one indicating it might not be the better model. Using the refined data for the regular analysis the mean value as -12.646, the mean standardized was -0.094, and the root mean square standardized was 0.732. The mean is way off in this model. Optimizing the model however shows significant improvements to all the values.

Universal kriging is used for trends that vary, where the regression coefficients are unknown. This uses indicator functions instead of the process itself. In other words, the model conducts the regression analysis with the spatial coordinates as the explanatory variable. For the original interpolation study using the regular model, the mean was 5.145, the mean standardized was 0.015, and the root mean square standardized was 1.003. The mean is high, but the other values appear acceptable. Optimizing the model actually increases all the values slightly. Using the refined data to run the regular model provides a mean value of 1.805, a mean standardized of 0.011, and a root mean square standardized value of 1.788. The root mean square standardized value is a bit high in this model. Optimizing the model decreases the root mean square and root mean square standardized error but increases the other values.

Indicator kriging measures the probability a value is above a certain threshold. The threshold value of 2200BP was used. This model produces and output of errors and likely would not have been used in the study.

Probability kriging produces a probability or standard error of indicators map. This method also uses a threshold that was set at 2200BP.

Disjunctive kriging is a nonlinear generalization of kriging. It is used to predict the value itself or an indicator. It has a large number of requirements in order to be valid. It requires a bivariate normality assumption and approximates certain functions. The assumptions are difficult to verify and the solutions are mathematically and computationally complicated. It is included here for the sake of completeness and curiosity.

Table B-1 provides the prediction of errors for the initial interpolation of radiocarbon dates using the 21 radiocarbon dated burials coupled with depth.

For future studies it is not necessary to run all the different methods and models of kriging and cokriging in order to obtain data. Knowing which particular methods are best for the user's data set and the possible outputs are essential starting points. After these are known, the user may attempt to create a more valid model through the use of transformations or bins in order to better fit the data.

In the case of this study, the optimized ordinary prediction method of cokriging was the best model as it had the lowest average standard error. While this essentially gives a window of 78 years for each burial, consider the radiocarbon dating windows are also typically 60 years. While this data cannot be considered factual, it is an interesting attempt to determine the ages of the burials, and it is more information than we had before.

Table B-1: Cokriging Prediction of Error Analysis Table for Interpolated Dates.

Cokriging Type	Results	Prediction		Quantile		Probability		Prediction Standard Error		Standard Error of Indicators	
		Regular	Optimized	Regular	Optimized	Regular	Optimized	Regular	Optimized	Regular	Optimized
Ordinary	Mean	5.145	5.670	5.145	5.670	0.173	0.196	5.145	5.670	Not An Option	
	Root Mean Square	120.358	115.206	120.358	115.206	0.490	0.531	120.358	115.206		
	Mean Standardized	0.015	0.021	0.0153	0.021	Not Given		0.015	0.021		
	Root Mean Square Standardized	1.003	1.0158	1.003	1.015			1.003	1.015		
	Average Standard Error	109.508	108.688	109.508	108.688			109.508	108.688		
Simple	Mean	-0.938	2.488	-0.938	2.488	0.145	0.154	-0.938	2.488	Not An Option	
	Root Mean Square	130.784	114.508	130.784	114.508	0.500	0.459	130.784	114.508		
	Mean Standardized	-0.007	0.023	-0.007	0.023	Not Given		-0.007	0.023		
	Root Mean Square Standardized	0.992	0.899	0.992	0.899			0.992	0.899		
	Average Standard Error	131.513	124.179	131.513	124.179			131.513	124.179		
Universal	Mean	5.145	6.614	5.145	9.224	0.173	0.139	5.145	9.224	Not An Option	
	Root Mean Square	120.385	125.144	120.385	119.195	0.490	0.479	120.385	119.195		
	Mean Standardized	0.015	0.027	0.0153	0.037	Not Given		0.015	0.037		
	Root Mean Square Standardized	1.003	1.033	1.003	1.032			1.003	1.032		
	Average Standard Error	109.508	110.097	109.508	110.365			109.508	110.365		

Table B-1 Continued: Cokriging Prediction of Error Analysis Table for Interpolated Dates.

Cokriging Type	Results	Prediction		Quantile		Probability		Prediction Standard Error		Standard Error of Indicators	
		Regular	Optimized	Regular	Optimized	Regular	Optimized	Regular	Optimized	Regular	Optimized
Indicator	Mean	Not An Option		Not An Option		0.008	0.103	Not An Option		-0.229	-0.227
	Root Mean Square					0.458	0.439			0.664	0.699
	Mean Standardized					0.166	0.009			-1.441	-2.998
	Root Mean Square Standardized					0.932	0.877			3.468	7.603
	Average Standard Error					0.455	0.472			0.455	0.472
Probability	Mean	Not An Option		Not An Option		-0.006	-0.111	Not An Option		-0.245	-0.249
	Root Mean Square					0.423	0.410			0.746	0.717
	Mean Standardized					0.010	-0.009			-3.764	-1.859
	Root Mean Square Standardized					0.905	1.008			9.698	4.433
	Average Standard Error					0.444	0.387			0.444	0.387
Disjunctive	Mean	-0.936	2.509	Not An Option		0.145	0.154	-0.936	2.509	-0.928	-0.839
	Root Mean Square	130.783	114.514			0.500	0.459	130.783	114.514	0.502	0.557
	Mean Standardized	-0.007	0.018			0.291	0.328	-0.007	0.0183	-0.186	-0.188
	Root Mean Square Standardized	0.994	0.908			1.004	0.957	0.994	0.908	1.008	1.160
	Average Standard Error	131.555	124.203			0.498	0.481	131.555	124.203	0.498	0.481