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An Exploratory Study of Burial Identification Using Historic Human Remains Detection Dog Alerts and Inorganic Soil Analyses

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AN EXPLORATORY STUDY OF BURIAL IDENTIFICATION USING HISTORIC HUMAN REMAINS DETECTION DOG ALERTS AND INORGANIC SOIL ANALYSES

By

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Abstract Content:
One point at which forensic science and historical archaeology intersect, and the focus of this thesis, is using the decidedly forensic avenues of trained dogs, probing, and chemical analyses of soils, informed by archaeological survey, to locate burials. Human remains detection dogs have proven to be a nonintrusive and effective method for identifying or confirming historic unmarked burial locations. Inorganic soil analyses have been demonstrated in prior research to show variations in grave soil. For this research, the hypothesis that is explored is that a corpse will chemically alter the soil in or on which it is placed to a degree that is detectable using inorganic chemical analyses, after many decades or even centuries, and that the inorganic chemical profile associated with grave soil will correspond with canine alerts. If certain elements do co-occur with dog alerts, then testing for their presence in soil may be a reliable and less costly method on its own or potentially could be employed as a second source of evidence for burials identified by dog alerts or other methods of detection. In an effort to gauge the reliability and agreement of these methods, Historic Human Remains Detection (HHRD) dog alerts were recorded and corresponding soil samples were attempted in five case studies at geographically distinct sites of potential burials, 100 to 1,100 years old. Soil samples were tested using inductively coupled plasma optical emission spectrometry (ICP-OES) elemental analysis to determine their inorganic composition. Three of these sites were previously reported as inconclusive and were reanalyzed here. Results showed that there appeared to be some correspondence between HHRD dog alerts and inorganic soil profiles consistent with that reported in other studies. Although further and more robust research on inorganic soil analysis is required to confirm its validity and reliability, this thesis concludes that appropriate surface soil analyses appear to have potential as a minimally invasive tool to help identify historic human burials, particularly those burials that have been located with the use of HHRD dog investigations.

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Chapter 1

Introduction

Context and Goals

This thesis sought to determine the potential for associating Historic Human Remains Detection (HHRD) dog scent alerts from both known and unknown burials with inorganic chemical analyses of associated soil samples in anticipation that these two methods may be complementary and might provide a successful alternative, when used in tandem, to other more invasive or costly archaeological methods. Though much of this study is informed by forensic research, the focus will be within an anthropological paradigm rather than a medico-legal and/or human rights context to better serve the archaeologist who may be dealing with historic burials and/or crime scenes outside of statutory limits (Blau and Ubelaker 2009:21).

In the literature pertaining to the search for remains, the delineation between forensic and archaeological timescales and inquiry is oftentimes stark. Procedures that can narrow the interval between death and the discovery of a corpse, as well as determining whether and how a crime was committed, are of paramount concern for law enforcement agencies and archaeologists working with those agencies. Archaeologists in this forensic sphere do perform work in settings that are older, yet are still crime scenes, often in concert with human rights organizations or tribunals. For example, in the aftermath of the 1990s Bosnian genocide in the former Yugoslavia, hundreds of burials, both single and mass, spanned several regions; interdisciplinary recovery teams aimed to uncover and document evidence to be used in criminal proceedings being held contemporaneously, with an ultimate goal of repatriating the remains (Sterenberg 2009:416-424). In contrast, an anthropological archaeologist's interest lies at or beyond the last stage of decomposition and generally approaches the search for potential burials as a means to gain a

range of knowledge in material culture, lifeways, and at times, cause of death. As Connor and Scott (2001) state succinctly in their essay comparing the two distinct areas where an archaeologist can work, "The methods can be the same in both anthropological and forensic archaeology, but the goals are different" (Connor and Scott 2001:3).

Forensic science and historical archaeology intersect in the use of trained dogs, probing, and chemical analyses of grave soils, informed by archaeological use of survey and testing to locate burials. These potential burials are of interest for a variety of reasons, from evaluating an entrenched tale of one well-known, ill-fated group of travelers journeying to the newly accessible American West to curiosity about a lone burial marker on private land in Montana. However, for this research, interest is on the *methods* of locating burials rather than the research questions generated by archaeologists that make the search relevant. The aim is to provide access to another set of tools that might benefit those who address these questions. In a field that has paradigmatically shifted away from more destructive practices due to changing attitudes toward disturbing human remains, one must rely more heavily on less invasive methods that can help archaeologists find ways of avoiding excavation, but still "ground truth" cemeteries when working to protect burial areas from the impacts from any number of undertakings threatening cultural sites in the modern world. It is the goal presently to test the efficacy of using HHRD dogs and/or soil chemistry analyses and to help to substantiate these methods as useful, further adding to the literature and enhance methods available to archaeologists trying to navigate the complex requirements of today's cultural heritage management and stewardship.

Literature Review

Forensic exploration into the use of cadaver dogs or soil analysis for locating burials or remains is extensive (Rebmann et al 2000; Killam 2004; Vass 1991, 2010, 2012; Vass et al.

2004; Vass et al. 2008; Komar 2009; Cablk and Sagebiel 2011; Larson et al. 2011). Early in his research (1991), using cadavers in a controlled environment, forensic anthropologist Arpad Vass attempted to generate a method to determine time since death. Of interest here, he identified the peak and subsequent baseline of certain cations and anions within a two-year period that were the result of dissolution of bone. He further found biomarkers such as amino acids to be strong indicators of time since death if certain variables could be controlled. In later studies, Vass and colleagues went on to isolate, identify, and catalog hundreds of volatile organic compounds (VOCs), gases that emanate from both human and animal decomposing remains, including cremations, in his Decompositional Odor Analysis Database (Vass, Eckenrode et al. 2004; Vass et al. 2008; Vass 2012). Vass et al. (2012) measured these gases using headspace analysis whereby a collected sample is placed in a vial with a lid and the vapors rising from the sample into the "headspace" above it are collected by syringe and put into a gas chromatograph and then a mass spectrometer for separation and identification (Vass 2012:235). Of these VOCs identified, 50 were human specific (Vass 2012:234). This "odor of death" is believed to be what alerts detection dogs and thus can be used in their training. Cablk et al. (2011), using Vass et al.'s (2008) data with their own headspace analysis of a pig, cow, and chicken, found that the latter had the most VOCs in common with the human and would make the better training aid over the often used pig proxy. Dovetailing Vass' research into human and animal VOCs is the question of whether dogs can be trained to differentiate between the two – and it appears that they could as Baxter and Hargrave's (2015) study indicates; this study tested HHRD dogs by burying both animal and human bones in controlled sites in a blind study with a dog handler team (Baxter and Hargrave 2015:94).

In archaeology, inorganic soil analyses have been used as a means to determine what

remains were preserved in certain environments. Thus, soils can be expected to help reveal information that might provide proxy data for requirements such as identifying graves (Keeley et al. 1977; Gordon and Buikstra 1981; Henderson 1987; Bethell and Smith 1989; Janaway 1996); ascertaining a singularly human chemical indication of a burial having been in soil (Bethell and Carver 1987; Beard et al. 2000); and commonly, reconstructing past diets and health focusing on diagenesis and its effect on chemical traces in the soil and on bone (Vlasak 1983; Lambert et al. 1985; Waldron 1987). Bethell (1989) and Smith and Beard et al. (2000) performed chemical analyses on "soil silhouettes," a situation where the body is no longer visible except for a stained outline or three-dimensional settling of soil, both in hope of finding a chemical signature of the former body as well as the best method to measure it. Lambert et al. (1985) and Vlasak (1983), in interrelated research, conducted testing on modern and centuries-old human bone to determine the range of flux of inorganic elements from death to discovery to determine how this can skew dietary information.

Conversely, the use of HHRD dogs for grave detection is found infrequently in the literature and there is no cohesive line of inquiry, as the use of these dogs is still fledgling (Grebenkemper et al. 2012; Baxter and Hargrave 2015; Grebenkemper and Johnson 2015). At the forefront of this inquiry, Grebenkemper et al. (2012; see also Grebenkemper and Johnson 2015) used HHRD dogs in researching the Donner-Reed party, a group consisting of several families and individuals who in 1846 left Missouri by wagon train to relocate in California. The party was stopped in the Sierra Nevada mountain range by snowstorms and were rumored to have practiced cannibalism after a long period of starvation. The team traveled to two Donner-Reed sites, one along the Emigrant Trail and one at a Donner starvation camp, aided with historic documentation and HHRD dogs to help locate burials.

In another example, Baxter and Hargrave (2015), in a blind study, attempted to gauge the limits of HHRD dog abilities to find the source of an old burial by setting up multiple staged internments of both human and animal bones. Although subject to multiple variables, this study provided researchers approximate distances from the source of the smell (bones) to where the dogs most often alerted, ranging from one to three meters concentrically. Likewise, the use of soil analysis as a means to identify historic graves is not widely reported and is used more often to confirm a known burial (Beard et al. 2000). Beard et al., using maps, documents, witness statements, and heavy equipment, were able to locate the outline of grave cuts and then proceeded to excavate to body level where soil samples were then taken. The use of HHRD dogs for detecting much older burials in conjunction with inorganic soil analyses has not been previously published.

A Review of Other Methods Used in Surveying and Testing

This project experimented with using a particular type of survey method infrequently used, HHRD dogs, along with probing and soil testing to potentially corroborate the dog alerts. Direct evidence of historic human remains was not sought, for a variety of practical, ethical, and legal reasons. In archaeology, excavation, although an incomparable method to gain knowledge, is inherently destructive. Further, federal, state, and tribal laws rarely grant permission to excavate human burials unless they are threatened (LaRoche and Blakey 1997:84; Connolly 2010:28). Even then, the threat – usually infrastructure projects – must be thoroughly studied and given approval by a governing agency, working within the National Environmental Policy Act (NEPA) realm, which assesses environmental and cultural impacts (King 2008:4). More importantly, excavation of graves was a practice that was commonly done in the past, often of Native Americans, with little consideration or adequate consultation with the community. As a

result, the practice is now carefully regulated, though the rules continue to evolve (Leone et. al 2005:587-589; King 2008:261).

Archaeologists have a range of alternative methods, both invasive and non-invasive, to locate graves, and the starting point used is to look, or survey, for physical anomalies on the surface and then move underground or test from there if found. However, each method has its drawbacks and more than one method is often needed to potentially substantiate any findings. In this section, a range of approaches used in survey and testing, short of excavation, to aid in locating burials, remains, and other types of cemetery investigations will be examined. This will not be an exhaustive treatment of all methods. Non-invasive survey and testing methods include aircraft-based remote sensing such as LIDAR, as well as geophysical methods such as ground penetrating radar (GPR), electrical conductivity, and magnetic survey. Minimally invasive methods for testing include probing, coring, electrical resistivity, and soil analysis. For the following select methods, advantages and limitations will be considered.

LIDAR (Light Detection and Ranging) is a type of remote sensing performed using pulsating lasers, an accompanying receiver mounted on aircraft, and Global Positioning System (GPS) to create a 3D digital terrain model of the landscape below (AOC Archaeology Group 2015:3). Depending on the amount and speed of the lasers, which can generate upwards of 600,000 pulses per second if needed, LIDAR can generate massive amounts of data, creating an extremely detailed map of the landscape (Gugliotta 2017). LIDAR would be used generally for a large survey area or a particularly canopied one, such as found with forests and jungles (Crutchley 2010:160). The lasers are directed to the surface below from the low and slow-flying aircraft, and every pulse is recorded one to multiple times, the final recording being the ground. The rate at which the pulses are received indicates how close to the surface they have reached,

which can then be calculated for distance (Fernandez-Diaz et al. 2014:9955).

Using software to decipher the recordings, a researcher can diminish short transmissions called first return data, from tops of trees for example, which enhances areas where the laser had particularly long transmissions, called bare earth data, potentially uncovering an anticipated pattern on the landscape (AOC 2015:3). Once a researcher has the digital terrain model and using Global Imaging System (GIS) software, the light cast upon it can be altered to maximize the relief of the landscape. This manipulation of the light source on the ground is called hillshades and is one way of visualizing LIDAR information. Other ways include color gradations to see slope, and minimizing large aspects of the terrain to highlight smaller and possibly archaeological anomalies (Crutchley 2010:163; AOC 2015:3-7). These could include mounds and other features associated with graves or mass burials. Mass burials, such as with the Bosnian genocide, are situations where some researchers predict LIDAR as being useful when other identifiers have failed (Hoag 2015).

The limits of LIDAR are found in analyzing the data being received and knowing what is noise, what is modern, and what can be interpretation issues with the LIDAR itself (Crutchley 2010:162; AOC 2015:9). Also, its use in locating graves is specific to identifying surface anomalies. Therefore, other complementary forms of data, such as photographs and maps, may be needed, and ground-truthing would typically be employed next. As mentioned above, LIDAR works best in areas of heavy cover where traditional aerial photography would be useless or where a foot survey is not feasible. Further, LIDAR, depending on the size of the area being surveyed and how much data one wants, can be very expensive, from $200 – $450 per mi^2 (Portland State University [2012]). However, the price of implementing alternative methods, such as pedestrian survey, must be considered in light of the quickness and accuracy of LIDAR

(Gugliotta 2015).

Geophysical survey identifies anomalies or disturbances in an otherwise homogeneous medium. This is performed using one of two types of methods: actively where signals are transmitted from a device into the ground; or passively, measuring signals that are naturally occurring (Killiam 2004:73). The disturbance can be an object or a change in soil, both of which will appear in contrast to the host environment (Killam 2004:72). Those experienced with such geophysical surveys can determine whether an inclusion is native or anthropogenic, but whether it is a burial requires other methods and would ultimately need to be verified by excavation. The type of geophysical method selected ultimately depends on the project location and needs. An example of a passive method is magnetic surveying that uses magnetometers to measure variances such as the stronger magnetic sensitivity of disturbed soil. Examples of active methods include resistivity, electromagnetic surveying, and GPR. Soil type, ground moisture, ground cover, and surface structures can significantly challenge available options. The cost and speed of equipment is also a consideration.

GPR is an active method that uses radar waves emanating from a transmitter antenna to penetrate the ground. When the waves encounter a disturbance, the time it takes them to return to receiving antenna is converted to distance, thus giving the depth of the anomaly (Conyers 2004:65; Killam 2004:132). These waves appear in profile view as a vertical line of parabolas, emanating from the source of the disturbance. Mapping the amplitude of the waves at each depth creates a plan view map where the location of the anomalies can be seen spatially, the higher the amplitude, thus contrast, appearing as darker the spot. GPR can provide excellent resolution as a result of its ability to change the frequencies of the waves depending on the medium of the subsoil (Killam 2004:137). In archaeological situations, resolution is sought at depths of one to

two meters. Disadvantages arise with GPR when there is ground cover, sloping terrain, or a rocky subsurface. Further, since GPR requires a skilled operator, the cost of use can be high, as with other geophysical methods.

Probing, as the name suggests, is a moderately invasive testing method used to find the disturbed dirt and boundaries of a possible burial (Killam 1990:43; Owsley 1995:737). It is not to be used to locate the body or coffin, as that could result in damage and thus a loss of information, but rather to locate the burial shaft. The burial shaft will be less compact than surrounding dirt and, if using a probe with a core, the soil will be visibly mixed in comparison. At this point, other testing methods would be enlisted for further verification that this is a burial. A caveat is that disturbed dirt can become compact again with age (Owsley 1995:737). A tile probe is a T-shaped metal rod that is sharpened at one end and then plunged gingerly into the ground, and importantly, in a patterned fashion in a predetermined grid. Killam (1990) advises that the probe only be used when surveying has yielded nothing at which point one would then proceed to probe the area of interest. Owsley (1995), however, suggests using a probe once visual markers indicate a burial. The execution of the probe is simple and it is an inexpensive tool. Where skill is needed is knowing when soil compaction has changed enough to indicate a burial. A simple way to do this is to do control probes adjacent to the survey area, although experience also helps.

This project is exploring minimally invasive methods used to locate burials, focusing on chemical signatures of human decomposition in soil that can be measured and signaled to by a trained dog. The other methods discussed in this chapter do not identify human remains, but rather indications of them in the form of surface and subsurface disturbances. Subsurface disturbances can be measured and plotted to show their dimensions using GPR. LIDAR, which also employs wavelength data, can account for surface interference, especially vegetation, to

reveal surface anomalies. Probing is an inexpensive method for locating loosened soil that may indicate a burial. Without the benefit of excavation, these minimally invasive methods necessitate additional sources of evidence, such as informants, historic documents, and surface features, to support that a burial is present.

Project Hypothesis

For this research, the hypothesis is that a corpse will chemically alter the soil in or on which it is placed to a degree that is detectable using inorganic chemical analyses, after many decades or even centuries, and that the inorganic chemical profile associated with this grave soil will correspond with canine alerts. When detecting the locations of burials, HHRD dogs are not alerting to these inorganic minerals; rather they are detecting decomposing organic matter from the body that has leached into or from bone (Vass 2012; Baxter and Hargrave 2015; Grebenkemper and Johnson 2015). The decision to test for the inorganic components of soil over the vaporous scent molecules was to continue an existing line of inquiry using inorganic analysis that began in 2005. Other benefits of exploring inorganic soil testing, as opposed to VOCS, are that it is less costly and sample collection is easier and less prone to error.

Due to the age of these burials, it can be assumed that the bone has begun some deterioration and that some of its inorganic components will have entered the surrounding soil along with organic compounds. Conversely, the bone can also uptake elements from the soil. It follows that the elemental flux between bone and soil would be measurable in each case as an increase or decrease. Any inorganic elements that have migrated from bone into the soil will presumptively be found in a higher abundance than in the neighboring host soil. The general trend reported in prior studies of changes in inorganic soil composition of burial soils has focused on deposits as the more common effect and the direction that is observed for more

elements. For that reason, this research will test increases in abundance in soil samples from possible grave sites that have been alerted to by HHRD dogs.

Previously, an unpublished chemical analysis of inorganic elements was conducted on soil samples associated with dog alerts (Hill 2005). The analysis of these samples from Lolo, Montana, a Donner Party starvation camp in California, and two burials in and near Prague, Czechoslovakia was reported as inconclusive. The present project reanalyzes these data to examine whether changes in the soil might be identified and associated with dog alerts. The sites in Prague where HHRD dogs alerted were excavated and proven to be burials. Soil samples collected in a field investigation in Virginia City, Montana will be compared with the soil analysis results from the Hill (2005) data to complete this project.

To establish a backdrop for this inquiry, Chapter 2 begins with an overview of the variety of terms used to define working dogs and a brief introduction to the trainers who worked on this project. Next, a synopsis of how dogs operate both internally and in the field will be presented; this section includes an overview of a dog's smelling ability, an examination of canine olfaction, and a summary of how trainers harness the abilities of dogs. Chapter 3 addresses the effects of human decomposition on soil and the effects of soil on human remains, both being governed, at a minimum, by weather, geology, taphonomy, and hydrology. Chapters 4, 5, and 6 present the settings and data collection for this project's case studies, all of which entailed attempts to use ICF dogs and soil samples to identify human burials. Other methods supplementing both the dog alerts and soil sampling will be discussed. Chapter 7 will discuss the results of the soil analyses from dog-alerted locations and the feasibility of the two methods, going forward, as complimentary techniques.

Chapter 2

How Working Dogs Work - Inside and Out

Historic Human Remains Detection Dogs

Historic Human Remains Detection dogs are a more recent development in the traditional use of canines to detect humans - living or dead - and are a subset of Human Remains Detection (HRD) dogs. HRD dogs are never trained on live human scent and are used for new and old forensic cases. The added "historic" in HHRD fundamentally differentiates these dogs from HRD by their training to detect the scent of human burials and remains hundreds of years old, well after soft tissue has deteriorated, and by their slower pace for detailed searches of minute scents.

There are differing opinions on whether HRD and HHRD dogs would fall under the rubric of "cadaver dogs." As broadly defined by Rebmann et al. (2000:1), both would, since they are "canines…which are specially trained to find human decomposition scent and alert to their handlers to its location." Conversely, the Institute of Canine Forensics (ICF) (2013b) finds "cadaver dog" to be "A narrow term, used in search and rescue context, to indicate a canine primarily trained as a trailing or area search dog that has also received cross training in the location of dead human bodies." The ICF defines HRD and HRDD separately from cadaver dogs, though elsewhere the terms are often used interchangeably. An opinion by live, cadaver and HRD dog handler Heather Roche (2005) is that "Cadaver is cadaver. No difference b/n (sic) scent as they claim – no need for their 'historical source trained' K9s," contrasts perfectly with Rebmann's statement (2000:13) that "cadaver scent is not a single scent, but a range of scents produced at different stages" and epitomizes the debate on terminology and ultimately, scent training. For this paper, ICF definitions of the above-mentioned terms will be used.

Institute of Canine Forensics

The ICF, which was a partner in portions of this research, is a nonprofit organization founded in 1998 that provides clients with teams of HRD, HHRD, or Forensic Evidence dogs and their handlers (ICF 2013b) (Figure 2.1). The founder of ICF, Adela Morris, shifted her focus from cadaver dog training to historic remains detection and clients now span law enforcement agencies, tribal agencies, archaeologists, cultural resource management firms, state and national parks, military bases, and historic cemetery associations (Grebenkemper et al. 2012:100; ICF 2013b; Baxter and Hargrave 2015:8). ICF teams also volunteer their time and dogs, as will be addressed later, to researchers and carry out published research themselves (Grebenkemper et al. 2012; Grebenkemper and Johnson 2015). Further, ICF oversees training and certification of HRD and HRDD canines and, at the time of this writing, is the only organization to train and certify HHRD dogs. Dogs are trained 40 hours per month, compared to the industry standard of

Figure 2.1: *Trainer/handlers with the Institute of Canine Forensics from L to R: John Grebenkemper, Lynn Angeloro, and Adela Morris. Photo by author.*

16 hours set by the National Association for Search & Rescue, United States Police Canine Association, and the North American Police Work Dog Association (ICF 2013a; Martin 2009). To be certified, the dog must be able to alert to no less than a century old human bone (Grebenkemper et al. 2012:100; ICF 2013a). They view HHRD dogs as providing a means of

non-invasive detection, not unlike ground penetrating radar or aerial photography. They promote heavily the importance of a well-mannered and compliant dog that uses passive alerts, such as sitting or lying down, and handlers that are sensitive to a variety of situations, landscapes, and beliefs that may be present (ICF 2013b).

Canine Olfaction

Understanding the morphology of dogs' noses and olfactory system is central to a discussion of dogs and their sense of smell as a tool for detection. To begin, the snout is comprised of three parts (Craven et al. 2007:1326; Stoddart 2015:16): the divided rhinarium in front, typically black, or what is commonly labeled the nose, where air enters and leaves and where scent molecules often stick (Settles 2005:199; Horowitz 73:2009); the extended and bisected nasal cavity attached to it where incoming air is either prepared to go the lungs or olfactory region; and the olfactory ethmoturbinates beyond that. Turbinates are coiled bone, which by design makes for a large surface area, covered with epithelium tissue (Craven et al. 2007:1326) (Figure 2.2). The ethmoturbinates, most germane to this research, are strictly for olfaction. Epithelium is a membrane of cells found within the nasal cavity and various epithelium work as either filters or sensory receptors (Stejskal 2013:3). The surface area of the ethmoturbinates are twice that of the respiratory turbinates, due in part to olfactory receptor cells being found in distinct areas, and not throughout the epithelium (Craven et al. 2007:1334). The extent of canine nasal turbinates is apparent when comparing surface area to that of a human's: 66.04 cm^2 to 4.04 cm^2 (Stejskal 2013:8).

Starting at the exterior, with the nose, when a dog breathes, inhaled air is separated at the nostril into either an olfactory or a respiratory pathway (Stoddart 2015:63). Depending on how the dog is breathing, the inhaled air flows through the respiratory turbinates located along either

side of the snout and down into the lungs or, alternatively, and much more quickly, some air circumvents these turbinates and heads directly to the olfactory ethmoturbinates (Craven et al. 2009:6-7). It is in the respiratory turbinates and epithelium that air is made temperate and particles are filtered (Craven et al. 2007:1326). When respiration is bypassed, it is via a channel found at the roof of the cavity called the *dorsal meatus* (Craven et al. 2007:1331). The air and odor molecules flowing through the *dorsal meatus* to the olfactory region will either be exhaled or alternatively sit inactive in the ethmoturbinates being analyzed, absorbed, and separated (Craven et al. 2009:7). This ability of the dog olfaction region to capture odors for further scrutiny, their escape into respiratory pathways made impossible by a bone plate called a *lamina traversa*, is a hallmark of canine olfaction (Craven et al. 2009:1). Eventually some odor molecules reaching the olfactory epithelium, and their receptors located in the ethmoturbinates, will bind (Craven et al. 2009:7). Scent molecules will bind to only certain of these olfactory receptors if the component shape of the molecule fits (Rebmann et al. 2000:10; Stejskal 2013:6). If receptor and scent molecule match, nerve pathways reach the olfactory bulb where the odor is then, if trained on, recognized (Rebmann et al. 2000:10; Stejskal 2013:6).

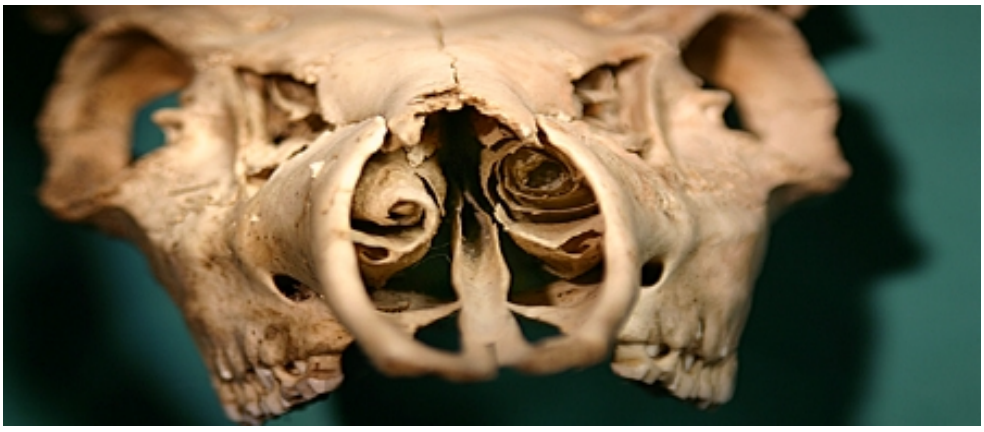

Figure 2.2: *Spiraled Canine Ethmoturbinates.*

Though it is not known how some inhaled air is destined for the ethmoturbinates instead of lungs, Craven et al. (2009) hypothesized that the act of sniffing moves more odor molecules to

the olfactory system than normal breathing. These researchers measured the speed and repetition of dog sniffs and found that in addition to dogs being microsmatic— having an olfactory system that is recessed and essentially separate from the respiratory one—it also has a phenomenal amount of receptor neurons, upwards of 300 million to a human's six million. For this system focused on scent, the act of sniffing created "optimal" pathways to this region (Craven et. al. 2009:1,9; Horowitz 2009:71). When a dog is breathing in a relaxed manner, it is receiving some olfactory triggers, but much less than when there is a switch to sniffing (Stejskal 2013:4). Referred to as "a disruption of normal breathing," this fast, focused smelling changes the dog's external morphology - the shape of their nostrils – and the dog inhales more air very quickly; more air than they exhale (Craven et al. 2009:5; Stejskal 2013:4). A study found that one dog trained in a type of air scenting could inhale for 40 seconds without pause (Settles 2005:199).

Dog nostrils have a thin, moveable membrane of skin just inside the nostrils called an alar fold (Figure 2.3). When a dog inhales through the nostrils, the alar fold dilates. When exhaling, the alar fold closes thus routing the air backward out the slits of the nostril where it then hits the ground in an area just behind the nose (Stoddart 2013:67) (Figure 2.4). Air being exhaled in this manner is essentially out of the way while simultaneously creating a dust up of fresh scents that circulates back into the nostrils and nasal cavity (Settles 2005:199; Stoddart 2015:69). This stream of new smells prevents the dog from getting accustomed, thus no longer smelling a smell (Horowitz 2009:70). This circular inhale/exhale pattern of air is found to create a smelling "reach" that acts as an extension of the dog nose and measures the distance a dog's nose is from the ground when smelling (Settles 2005:198; Craven et al 2009:5), though a dog does not need to be this close to the odor source to smell something. Finally, due to the divided architecture of the snout, each nostril is capable of independent smelling which is thought to help in odor sourcing

(Craven et al. 2009:6; Stoddart 2013:68).

Figure 2.3: *A dog's alar fold is located just inside nostril and directs inhaled and exhaled air. Photo by author.*

Figure 2.4: *When exhaling, the alar fold closes thus routing the air backward out the slits of the nostril where it then hits the ground in an area just behind the nose. Photo by author.*

It should be noted that there is an opinion that the research done on a dog's smelling ability, as well as problem solving, is overwhelmingly done on non-working dogs and that it is training over morphology that makes dogs, and even humans, capable of very refined smelling (Warren 2013:31-37). The following section will discuss this training.

Training of Dogs

Though there is a range in the size of dog snouts and amount of olfactory receptor cells across and within breeds, it is generally accepted that they all have an exceptional ability to smell (Warren 2013:37). But more importantly, unlike other keen-scented animals like cats or grizzly bears, often dogs demonstrate an eagerness to work and please humans thus making them trainable (Settles 2005:199; Warren 2013:30,34,59). This section looks at how this scent ability is harnessed. John Grebenkemper, an HHRD handler with the ICF who has published about his experience investigating historic burials with his dog Kayle, warned that the topic of dog training was problematic, stating that this is due in part because there is more anecdote being reported than replicable results—he is thus a proponent for more rigorous studies (2016 elec. Comm.). This need for standardized training and testing amongst handlers and their dogs is a common theme found in the discourse about detection dogs (Komar 1999; Page 2008; Cablk and Sagebeil 2011; Vass 2012). Grebenkemper did not consult training books for his own detection dog training, though not opposed to them, calling it "an art more than science." He instead worked closely with seasoned handlers, such as Morris, and combined this knowledge with his own evolving observations of what worked for him as well as his dog.

Acknowledging that training a scent dog will involve variations individual to the handler, those at the ICF are required to train their own dogs. There are also some accepted general principles used as part of training any animal. Andrew Rebmann (2000), considered a pioneer in

cadaver dog training and for introducing scents into the process, published a manual that is cited often in literature pertaining to use of and reliability of cadaver dogs (Killam 2004; Connor 2007; Stejskal 2013; Riezzo et. al 2014; Warren 2013). The following paragraphs outlining training are synthesized from this manual. Positive reinforcement as opposed to punishment is the foundation of Rebmann's method as it lets the dog know it will be rewarded for correct action. Repetition and prompt rewards are fundamental to training in this fashion and speed (although at times deemphasized with HHRD) and accuracy are the desired result (Rebmann 2000:43). To train a dog on live human or decomposition smell is seen as another form of hunting, where the reward is not in killing the prey but a reward from the handler (Rebmann et al. 2000:35).

To begin, a type of conditioning reinforcer (sic), such as a whistle or clicker, is used to shape a desired behavior. When the dog hears the sound it knows it has performed correctly and will get a reward. The handler starts with one desired action at a time and eventually delays the clicking (reinforcer) to add more actions to the regime. By not clicking, the handler is shaping the behavior by confusing the dog into trying more movements. It is imperative that the handler be vigilant of catching and then clicking instantly when the dog does what is wanted. Further, the reward must be exceptional to the dog whether it is a snack, toy, or play. Generally, the clicker is used only for training and to add to existing routines (Rebmann et al. 2000:26-34).

What is being instilled in the dog, beginning with the clicker training, is for it to eventually recognize, commit, and alert to scents fluently (Rebmann et al. 2000:36). To begin to be able to do these three actions, a physical and verbal cue is added to begin scent training. Unique gear like a work vest, the physical cue, tells the dog to get ready to work and a verbal cue such as "find the bones" sends the dog to a scent line. A scent line is a row of containers or

blocks, one or more of which is a “hot block” holding, for example, the scent of decomposing human body. When the dog shows a recognition of the scent, either by sticking the nose in the block or even close to it, the trainer will click and reward. After many cycles of this, the dog will be rewarded when given a cue to show its commitment to the scent, a cue such as “show me,” and the dog puts its nose in the scent block getting a click and reward. The trainer will next want the dog to give an alert, such as a passive one of sitting down at the scent. After being told “show me” and the dog does so, the trainer says “sit.” This alert will be what is seen in the field (Rebmann et al. 2000:35-44). Again, all these steps in training will be performed repeatedly, with a variety of scents and many different settings and distractions. Moreover, because of the nature of training, it will have to be adjusted for setbacks, but hopefully in time, certain cues will disappear and the process will become fluid.

Figure 2.5: *ICF dog Kayle alerting at the Hebrew Cemetery, Virginia City, Montana. Photo by John Grebenkemper.*

Scent Cones

An important aspect of detection dogs is knowing the variables that can be present in the

field and thus being able to interpret the alerts. The following is a synopsis of Rebmann et al.'s (2000) scent cone model. When a dead body is deposited, its subsequent decomposition will leave a saturated area called a scent pool. This scent remains, if only to dogs, even if the body has been moved (Oesterhelweg 2008). This scent pool emanates above and around the body, the scent stronger at the source and weakening with distance, and will remain there in absence of wind. Heat will turn a scent pool into scent cone as it pulls the molecules vertically. The introduction of wind will create a horizontal scent cone as it pushes the scent direction away from the remains. This wind-directed scent cone, if it comes upon an obstacle such as a tree or a hill, will go around the feature but also leave some scent behind called a secondary scent pool or cone. Further, varying wind speeds and directions can create stronger or weaker, many or few additional scent pools (Rebmann et al. 2000).

This scent of decay is made up of VOCs with differential solubility and water, either above and belowground, can carry scent away from the body in the same manner as wind thus creating secondary scent pools downhill or downstream (Rebmann et al. 2000; Vass 2012). Similarly, depending on soil and chemical type, subsurface inclusions from vegetation or anthropogenic features can create channels for scent molecules to travel. Vass (2012) in his research into VOC migration from remains found them surfacing up to 800 m away from the source (Vass 2012:240). Baxter and Hargrove (2015), in measuring the distance of dog alerts from buried human bone, advise calculating in a four- to five-meter ring in which a burial may lie (Baxter and Hargrove 2015:95). Handlers from the ICF were wary of committing to a set minimum distance for the investigator to start from, as every burial is site-specific.

Chapter 3

Everything Put Together Falls Apart: Death, Taphonomy, and Soil

This project hypothesizes that the soil chemistry surrounding a deceased human body will be measurably altered by decomposition processes, even well beyond a century after death and burial. Inherent in this supposition is that soils are geologically heterogeneous and that the response to the addition of a body will be dependent upon a host of taphonomic variables, such as the texture of the soil, weather, or even the condition of the body at time of death. Though changes in soil chemistry may vary as a function of factors such as pre-burial soil composition, there is a presumption that measurable changes will still occur and it is of interest to identify a method to test them that might be used widely regardless of site-specific variables. Of specific interest in this study is the remains' stage of decomposition, when inorganic elements are beginning to leach into the soil. Thus, due to the probability that these bodies are skeletonized, it is important to understand how bone and soil interact so that the matrix, when analyzed, could provide evidence of a burial.

This chapter aims to address the variability at play with soil and the potential effects on its makeup as a result of an introduced cadaver that is at the final stage of decomposition wherein what remains is likely the organic and inorganic phases of the bone material. Though not technically living, soil chemistry is dynamic and its support of many organisms is dependent upon things dying. In this way, soil and corpse function symbiotically and, as in most biosphere processes, transformations by both are constrained by the limits of water and air. Knowing the variability within soils, how introduced material can react in or on soil, and how efficiently soil can decompose a body help to predict what a researcher might expect in a given search area. Forensic archaeologist R.C. Janaway states that though "…it may be possible to predict general

trends within a specific soil type… it is unlikely that valid predictions can be made between widely different geographical regions or differing burial situation" (Janaway 1995:64). Janaway proceeds to address variability in soil environments and make recommendations on how to account for these.

A very general summary of taphonomy, which encompasses soil and death and their transformations, soil science, and human decomposition focusing on the last stage, remains, will be presented here. These subjects will be referred to in the coming chapters concerning the individual sites involved in this project.

Taphonomy

A concept originating in paleontology and subsequently becoming the study of the mechanisms that change organisms after death, taphonomy was defined in 1940 by I.A. Efremov as "the study of the transition (in all its details) of animal remains from the biosphere into the lithosphere" (Lyman 2010:1). Plants were subsequently added to Efremov's definition. The formation of the archaeological record differs from taphonomy in that it includes non-living materials and cultural modifications also occur (Lyman 2010:12). Taphonomy, specifically as it has been adapted for forensic science, is relevant to this research as it encompasses all the processes that go into decomposing a body and subsequent transition into mobile molecules that will be analyzed here. A general overview of taphonomy and its subfield in forensics, where locating burials is often central, will follow in this section.

Taphonomy, Micozzi (1991) explains, branches into biostratinomic and diagenetic processes. Biostratinomic processes include all changes from the time of death to discovery and diagenetic is the transformation of remains in soil into fossils. Taphonomy examines three types of assemblages: living organisms, that comprise a biocoenose; the thanatocoenose, comprised of

organisms that have died; and the taphocoenose, which is made up of the biocoenose and the thanatocoenose and comprises the fossil and archaeological record. What will be found in the record will depend on environmental and individual factors of the area and person, such as cause and circumstances of death, health, numbers, and size in life, whether the remains are in or ex situ, and whether the remains had been unburied, all of which influence the taphocoenose (Micozzi 1991:3-5; Nawrocki 1995:50).

Taphonomic specialists, archaeologists, and those in other fields use research on modern analogues to gain knowledge about the past. Actualistic research presumes that modern examples of taphonomic factors, like a dog chewing on a scavenged deer leg and what patterns that will create, can be seen as being a phenomenon unchanged throughout time (Lyman 2001:xix). This research includes observing the phenomenon in its natural environment, attempting to replicate what is seen in a controlled environment, and then applying the observations from both to the assemblage, though with the knowledge that it is impossible to account accurately for the full suite of conditions of the fossil or archaeological record (Pobiner and Braun 2005:58-59). To the extent that the process cannot be reconstructed, taphonomy, since inherently destructive to preservation, can be seen as biasing and destroying evidence, thus muddling information about the specimen. A scavenger, being a taphonomic agent, can change an assemblage by gnawing on a bone and erase evidence of butchering. However, it also shows that a particular predator existed at some point. A need to “strip away the taphonomic cover print” ignores that negative evidence can also carry information (Lyman 2001:xx).

The core of this research project involves the decomposition of human remains and the alteration of the soil surrounding them. Although no bodies were uncovered and analyzed, as incorporated in other studies, taphonomic processes can be measured to infer whether a body is

present. Areas where taphonomy and human decomposition are particularly important for archaeological perspectives is in the study of bone chemistry to reconstruct merge archaeologically include ancient diet, migration, and the sequencing of DNA as well as bone preservation studies (Lambert et al. 1985). In these studies, examination of skeletal remains and diagenesis, the flux of minerals to and from soil and bone, is important for accessing whether the molecules from the original bone composition survive, and how they may have been modified or partially replaced. Although the implications for this exchange of elements has for bioarchaeology is not be considered in the analysis of this project's soil samples, aspects are discussed briefly below.

The subfield of forensic taphonomy, as with all things forensic, is interested in human decomposition for determining why, when, and where a person died for legal purposes usually involving a crime. Though the medicolegal aspects of forensics are not of concern for this paper, the ongoing forensic research into methods for locating unknown burials are relevant, specifically, the impact of soil and remains on each other and what that looks like (Dent et al. 2004; Tibbett and Carter 2009); and the products of human decomposition found in soil at every stage (Vass 1991; Vass et al. 1992; Larson et al. 2011). Particularly valuable for the purposes of this paper is Arpad Vass' work with identifying VOCs released in decomposition and cadaver dog training (Vass et al. 2008; Vass 2012) and Alexander et al.'s (2015) research into the length of time a cadaver dog can smell these compounds and the effect of training on this ability (Alexander et al. 2015).

Soil

Soil is comprised of four components, the majority consisting of mineral material and water, followed by air, and most minimally, organic matter. The mineral component is critical

for two reasons: it is the parent material of this mineral that dictates the pH—acidity or alkalinity—of the soil; and it is the size and mix of the mineral particles that create the soil texture (Janaway 1996:59-60). This texture, with particle sizes ranging from boulders to invisible clay particles, affecting how they aggregate, in turn affects water flow and replenishment of oxygen. The pH of the soil can help predict the likelihood of bone and other human tissue remaining in the soil, since acidity is destructive (Janaway 1996:60). The pore size in and between the aggregates, called peds, can cause a waterlogged soil if too small or, alternatively, can make the soil unable to hold water if too large. Additionally, soil with no organic matter cannot form peds, so cannot hold water (Kohnke and Franzheimer 1995:11). This interplay between the amount of water and gasses, along with the pH of the soil, are major factors dictating the rate and results of decomposition because they create the host environment for the organisms breaking down organic matter.

An example of a soil texture from this project and unique to the Virginia City site is Varney clay loam, in which clay is the predominant particle in the clay, silt, and sand mix that constitutes loam. The name Varney denotes an array of information about the soil but at minimum, designates that this soil is found in Madison County, Montana [Natural Resources Conservation Service (NRCS) 2016]. Soil texture and color typically change descending from the surface, with the surface generally being higher in organic matter. These visible effects of soil development, organized in a profile view from the surface to bedrock, are called horizons (Kohnke 1986:44). Horizons are important as they provide approximate depth and characteristics of that section of soil. In a stable environment of soil development these horizons are labeled, at their simplest and from surface to bedrock, as O, A, E, B, C, and R (Kohnke and Franzheimer 1995:76-79). Burials are likely to be found in the B horizon, which in Virginia City starts at

about 13 cm and ends about 152 cm below surface (Killam 2004:52).

Water clings to the surface of soil particles, the grip weakening the larger is the particle. The size of the particle thus determines how much energy it takes for water to be available for plants (Kohnke and Franzmeir 1995:18). Clay being the smallest particle size and having the largest surface area means it holds onto the most water and using the most energy (Kohnke 1986:14). Clay dominated soils can hold on to water so well that it will render the soil impermeable to cultivation, a situation observed in Virginia City (Kohnke and Franzmeier 1995:18-22). When a soil does not drain at least as quickly as precipitation, because it has a high clay content or high water table, it creates a situation where the flow of gases from the microbes that are living in the water film surrounding the soil particles is restricted. This restriction of oxygen due to water saturation, miniscule particle size, or depth of the remains results in an anaerobic environment (Janaway 1996:59-60).

According to Janaway (1996), the soil organisms that play the major role in breaking down organic matter are heterotrophic bacteria and fungi; these are organisms that depend on organic material to provide the nutrition that they need. After food, moisture is the next most important factor in the livelihood of a microorganism. In waterlogged soils, oxygen present in the water is quickly absorbed by microbes, the carbon dioxide they create is trapped, and oxygen from the surface is unable to permeate, thus creating an anaerobic environment. This slows down the destructive capabilities of the organisms. Alternatively, a very dry soil can have the same hindering effect, as can a burial below three feet (Janaway 1995:61-62; Kohnke and Franzheimer 1995:14).

In some cases, if the anaerobic decay condition persists, acid from organic matter builds, creating a low pH level. Fungi and some bacteria do well in low pH and anaerobic environments

but are not as efficient decomposers as aerobic microbes. Thus, an ideal setting for microorganisms to work and break matter down is at a pH level of seven and in well-aerated, damp soil (Janaway 1995:62). This aerobic soil, where the speed of evaporation precludes waterlogging and where oxygen is getting to the microbes, can also be created in an anaerobic environment by animals scavenging burial remains, aiding the flow of oxygen and moisture (Janaway 1996:61). Macrofaunal scavengers are considered to be as necessary to the breakdown of organic matter as microorganisms (Carter and Tibbett 2008:31).

A burial at a depth of about one meter or below is in an environment where microbes have access to minimal amounts of oxygen, which slows their activity (Kohnke and Franzheimer 1995:14). This environment is also colder and less affected by aboveground temperatures, which also slows down the growth of bacteria and fungi, thus slowing down the rate of decomposition (Janaway 1996:69). Closer to ground surface, warm weather increases decomposition by increasing microbe activity, and for surface remains, by increasing insect activity (Carter and Tibbett 2008:38).

Human Bone and Diagenesis

Researchers studying human decomposition and soil, as well as those who focus on locating burials, clandestine or otherwise, consistently warn that the variables mentioned previously—soil texture, pH level, water, and temperature—prevent making anything other than very general predictions on what one should expect to find based on soil type. Further, introduced variables including the corpse itself and the condition of the body at time of death, any items buried with or on it, and whether the body is buried or on the surface broadens the range of possible effects of decomposition. Even if remains are not preserved, though, some elements will remain in the surrounding soil. For this project, a chemical analysis of inorganic

elements was chosen as the possible indicator of a human burial (Hill 2005). The analysis of inorganic elements is found to be widely used in connection with known, centuries-old burials where what remains is the inorganic portion of bone both intact or disintegrated (Keeley et al. 1977; Gordon and Buikstra 1981; Bethell and Smith 1989; Janaway 1996; Beard et al. 2000). Bone and the soil that it is buried in rest in a matrix in which molecules are exchanged. The presence of this bone can potentially be measured by testing only the soil, though a majority of prior research tests both the soil and the actual bone.

Living human bone is made up of three components, or phases, which by approximate percentage weight are 6% matrix water, 24% organic, and 70% inorganic (Waldron 1987:149). The organic phase, a protein collagen, is supported by the inorganic phase, a mineral composite of Ca and P called hydroxyapatite (Crist 1995:199). The matrix water is generally dissipated at the remains stage (Waldron 1987:150). The hydroxyapatite and collagen are held together by a protein-mineral bond that gives bone strength and under ideal circumstances, lends itself to seemingly indefinite preservation that can be found in neutral pH and aerobic soils (Janaway 1996:67; Dent 2003:584). In acidic soils, certain bacteria found in the alkaline range, fungi, plant chemicals, and roots, can break the protein mineral bond. This destruction of the bond can also happen inside the bone regardless of soil (Henderson 1987:44). The decomposition of the collagen begins the process of chemical weathering of the hydroxyapatite, leading to bone destruction (White 1983:316). To be clear, destruction means the eventual and total dissolution of bone into mineral components, a condition found with silhouette burials. Prior to this, bone can go through several stages where visually it appears intact although it is in the process of degrading (Gordon and Buikstra 1981:568). The pH of the soil in particular is seen as a reliable predictor of preservation in-ground; in young remains, the immature state of their bones makes

them especially vulnerable to destruction at a low pH (Gordon and Buikstra 1981:569).

Diagenesis is the postmortem exchange of mineral elements from soil to bone and bone to soil. Diagenesis mimics living bone, which is continuously adjusting elemental levels to achieve equilibrium due to the onslaught of diet and environmental fluctuations (Sanford and Weaver 2013:332). The study of bone elemental composition in anthropology is widely used to reconstruct past diets and migrations with a focus on trace elements often augmenting archival sources and archaeological findings, and as a way to establish burials where the remains have totally decomposed (Bethell and Carver 1987; Whitmer et al. 1989; Crist 1995; Beard et al. 2000; Sanford and Weaver 2013). It is of specific interest to the current research project that this flux of elements can potentially indicate a possible burial by measuring variation between the soil and control soil samples.

How elements move between bone and soil is still under study. Whitmer et al. (1989), in their research into the relationship between trace elements and diagenesis, used diffusion theory, which states that elements will move between soil and bone in a dynamic relationship to areas of low concentrations toward equilibrium. The bone and soil, in moving toward this balance, will show the effects of mineral uptake (soil to bone) and of leaching (bone to soil) that ostensibly is measurable. Diagenesis and its measurement in soil can be affected by multiple variables. The inorganic portion of bone does not disintegrate in a linear fashion and the rates of uptake or leaching of elements can vary over time; uptake and leaching can recur, which can skew attempts to accurately measure change since death. Whitmer et al. contend “universal statements about postmortem behavior of specific elements may not be possible” (1989:244; 259-261).

Yet, studies have accumulated to a degree that several elements do appear consistently in the literature pertaining to inorganic signatures of a burial (Keeley 1977; Bethell and Carver

1987; Bethell and Smith 1989; Beard et al. 2000), as well as found most prominently in diagenetic dietary studies (Vlasak 1983; Lambert et al. 1985; Waldron 1987). Further, to contain costs to be able to gather more samples in Virginia City, it was decided to narrow the chemical analysis for this research. Based on prior research, seven elements were selected: phosphorus (P), potassium (K), calcium (Ca), sodium (Na), zinc (Zn), copper (Cu), magnesium (Mg). Using this limited set of elements, this project then applied Beard et al.'s (2000) soil chemical analyses of silhouette burials at a slave cemetery to develop a foundation for analyzing the elemental abundances in the soil samples.

Elements known to leach from bone should be found in higher concentrations in the soil. The above seven elements, which comprise the main and trace inorganic components of bone, have been historically regarded as indicators of burials (Beard et al. 2000:326). Ca, Na, and P leach from bone. K and Mg have been found to be both adsorbed by bone and to leach into soil (Lambert et al 1985:480; Beard et al. 2000:344). Thus, higher abundances of Ca, Na, and P and possibly K and Mg were expected at dog-alerted locations.

Drawing from Lambert et al.'s (1985) findings to direct their research, Beard et al. (2000) eventually diverged from them by also focusing on Zn and Cu, asserting that a ratio of the two strongly indicated a chemical signature of a burial (Beard et al. 2000:344). Zn and Cu are much less soluble than the other components and tend to precipitate as minerals. Although Zn is much more concentrated in bone than Cu, the two tend to behave similarly as durable enrichments in grave soil, even after other more soluble chemical markers have been diluted by frequent flooding or irrigation or confounded by the addition of P at sites that have been fertilized, for example. A high Zn/Cu ratio is therefore considered an indicator of grave soil. Since these two elements tend to migrate less than others do, they should be observed at greatest abundance at

body level. In the case of Virginia City, where body level was undetermined and soil would be sampled close to ground surface, the abundance of Zn and Cu might or might not be elevated at dog-alerted locations.

The following three chapters describe the settings and data collection methods for the five case studies that attempt to establish a correspondence between the abundance of these inorganic components of human bone with HHRD dog alerts at potential burials.

Chapter 4

Valley of the Moon Ranch, Montana

Possible Grave Marker of an Infant Chi Yo

The Valley of the Moon Ranch (24GN0009 and 24MO0007) is located four kilometers south of the current Interstate 90 corridor and is bisected by Granite and Missoula County lines. The Valley of the Moon comprises 3,500 acres that are divided colloquially into the mountainous "Finlen Place" and the flat "Valley of the Moon Ranch" (Olson 1990:59). Since 1974, the land has been partially owned by the U.S. Forest Service; the remainder is owned by the Bandy family who have lived there since 1959. A possible grave of a child "Chi Yo September 21, 1915 – Aug 15, 1916," sits at 3,600 ft. elevation on a Douglas-fir forested hillside above a road and overlooks the Bandy family residence (Figure 3.1). The marker is located in the SE ¼ of Section 24 (Township 11 and Range 17) in Missoula County. The Bandy family owns this piece of land with the Chi Yo grave. They live only a few hundred meters southeast of it, in Section 19 (Township 11 and Range 16) in Granite County. These Section numbers are important, as they remain consistent through several ownerships of the land. The soil at the site of the marker is Winkler gravelly loam, local to mountainous areas of western Montana where native vegetation is the Douglas fir and ponderosa pine. The slope of the site is 30-60%, and with gravel being the dominant particle size, that classifies the area as being "somewhat excessively drained" of water (NRCS 2016). This information may provide useful when studying the location of the dog alerts for this location. That minerals are being leached somewhat excessively makes this soil slightly acidic with a pH of 6.4 getting more acidic at lower depths.

The grave was recorded as a Chinese site by a 1974 UM field school and in subsequent updates by archaeologists from the Lolo National Forest who visit it regularly since the site has a

special status. The grave is generally considered Chinese, based on information from the property owner, who has been there since 1959, as well as from other locals. Alternative attributions have been offered. The name “Chi Yo” on the grave has been assumed to be a Chinese name and most likely for a human though one local stated it was a pet (Keyser et al.

Figure 4.1: *Chi Yo headstone, looking east, Valley of the Moon Ranch. Photo by Kelly Dixon.*

1974). There is further speculation that Chi Yo could be of Japanese ancestry do to the influx of Japanese immigrants replacing Chinese workers after the Chinese Exclusion Act of 1882 (Damon Murdo 2015, pers. comm.). The owner of the property believes the grave has been disturbed prior to 2004, when she moved back and found that it had sunken. The grave marker is

about two feet tall and one foot wide and made of concrete with the name and dates in block print. Three other possible graves were recorded in 1974 but subsequent inquiries into locating them, the last being in 2015 with the ICF, did not confirm them visually or by dog alerts.

Historical Context: Valley of the Moon Ranch and the Rock Creek Valley, Montana

The town of Quigley (1894-1896) was situated at the intersection of Rock Creek and Brewster Creek on Rock Creek Road, fourteen kilometers south of the Northern Pacific Railroad (NPRR), which is located on the current Interstate 90 corridor. In 1894, gold assayed at $20 per ton of ore was discovered at the Golden Scepter mine located eight kilometers east on Brewster Creek in the Alps Mining District and the following year, Quigley was founded (Halden 2007:7; Department of Environmental Quality 2009). In 1896, with a population numbering 2,000, it was discovered that the ore was "pinched out," and Quigley was abandoned, its main street plowed under and turned into a potato crop (Davis 1962:194). This short-lived boomtown is possibly relevant in connection to the grave of Chi Yo because of the Chinese railroad workers rumored to have been in the Rock Creek Valley. The NPRR contracted to have Montana's first electric railway spur line built, which would run from the Golden Scepter Mine at the head of Brewster Creek to a 100-stamp mill at Quigley and then on to Bonita on the main line for a total of nineteen kilometers (Halden 2007:75). Chinese laborers, as reported to Floyd Sharrock's 1974 field school by local informants, were said to have been hired for this project (Keyser et al. 1974:20).

Though the Chinese were inexorably linked to the construction of the NPRR up to its completion in 1883, anti-Chinese sentiment coalesced nationally and, despite protests by railroad owners, the Chinese Exclusion Act of 1882 was instituted (White 2011:303). The act foremost made Chinese immigration illegal and other provisions placed demands on Chinese already

residing in the U.S. It was not repealed until 1943 (Voss and Allen 2008:7). The confluence of many Chinese workers leaving to work on the Canadian Pacific after the completion of the NPRR, the Exclusion Act, and later a series of boycotts and protests by labor unions and unemployed workers, resulted in contracted Japanese unskilled laborers becoming the sought after immigrants (White 1985:273). Numbering over 27,000 entering the U.S. between 1891 and 1900, the railroad industry was second only to agriculture in hiring these immigrants (White 1985:273; Ichioka 1980:325-326). In 1890, there were six Japanese and over 2,500 Chinese people recorded living in Montana. By the turn of the century, the numbers had changed to over 2,000 Japanese and approximately 1,750 Chinese living in the state. Merritt (2010) suggests these changes are the result of the Exclusion Act and the bringing over of Japanese immigrant labor for the Great Northern and NPRR (Merritt 2010:329-330).

There are numerous possible explanations for the grave marked Chi Yo. It is of interest however to explore whether a relationship can be established between the workers on the brief railroad construction period at Quigley and the apparent settlement of Chinese or Japanese persons at the Valley of the Moon Ranch, post-construction, who then would have appeared to have started a family and had a child die 20 years later. If Chinese labor was no longer easily accessible due to the Chinese Exclusion Act and if Japanese contract laborers were beginning to immigrate to the United States to work on railroads, then Japanese workers were most likely working at Quigley and possibly remained in the valley after the Quigley railroad construction ceased.

Methods

Historical

An aim of this research is to establish who or what Chi Yo is by using GPR, HHRD dogs, books, and historic documents. Soil sampling was not permitted at this site. Prior investigation thus far on the Quigley railroad found only Keyser et al.'s 1974 report and subsequent addendum citing Chinese labor as having been used in the building of the railroad. Yet a different source, Olson's (1990) history of the Rock Creek Valley, alternatively asserts that only one Chinese person resided in Quigley, and though it provides a very detailed look at the town during the period, it lacks references. What little information on Quigley that exists seems to be regurgitated repeatedly, with Keyser et al. (1974) taking information from Davis (1962), and Halden (2007) and the Department of Environmental Quality (2009) both referencing heavily from Keyser et al. (1974). At the moment, the possible grave at Valley of the Moon Ranch is only mentioned in the 1974 report and repeated in the updated site reports.

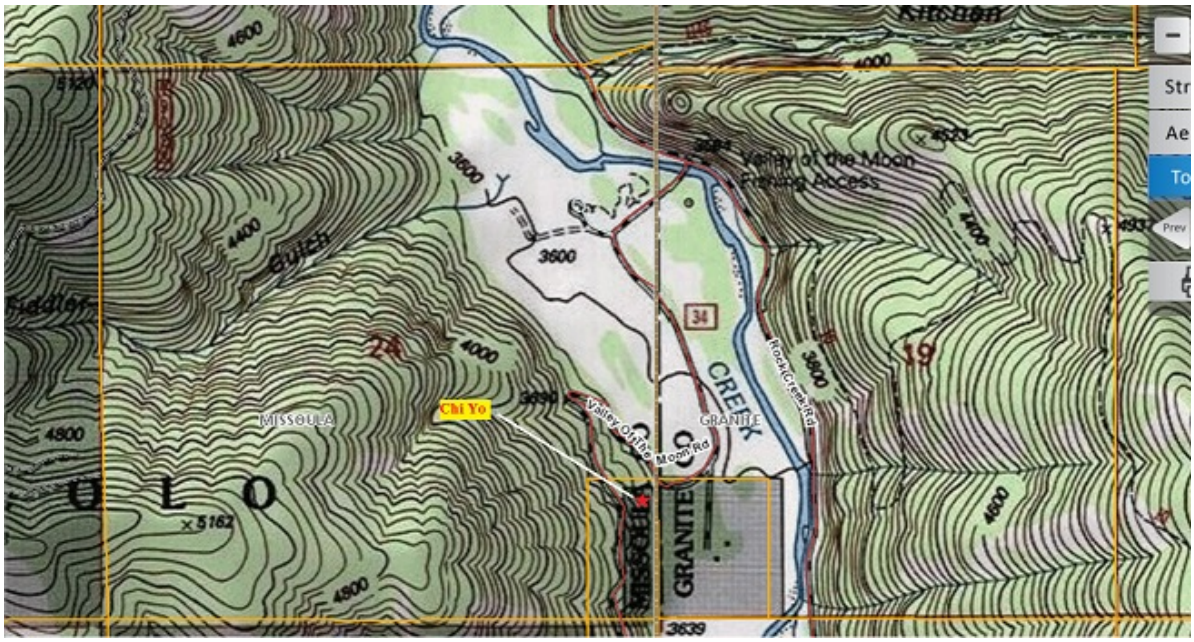

Figure 4.2: *Chi Yo and Sections 24 and 19.*

To begin, it is necessary to establish who was present on the land during Chi Yo's lifetime from 1915 through 1916. The Valley of the Moon Ranch grew in pieces over two counties, which presents some difficulty in navigating change in ownership. For this research, the section containing the possible grave, 24, and the neighboring section, 19, containing the dwellings, are of interest going forward and the following section will be an attempt to untangle the two Sections' ownership (Figure 4.2). A record search was performed at the Missoula County Record of Deeds office for land deeds for Section 24, some of which had some Granite County Section 19 information on them.

In March 1911, 145 acres of Section 24 was given to Edward J. O'Farrell by way of the Homestead Act of 1862. Though unclear as to how, back in November 1910, O'Farrell had sold this same parcel to Alvin Sidler. Sidler was the owner until May 1915 when he sold to William Wallace McDowell, then Montana's lieutenant governor. He was given 175 more acres in this section in trade for an unknown parcel by the United States Forest Service in 1925. This land in Section 24 remained in McDowell's family through the 1940s. James Finlen, Jr. bought the ranch from McDowell's stepson in 1947. The Valley of the Moon Ranch was purchased from Finlen by the current owners in 1959.

In 1913, neighboring Section 19 was granted to the NPRR. After 1913, James Finlen Sr. purchased the land from the railroad and then sold it in 1921 to William McDowell. In July 1915, the NPRR had a contract with McDowell to sell him 104 acres in Section 19, which was subsequently deeded to McDowell in 1920. It is unclear when McDowell took possession of this acreage, either in 1915 under contract or when it was deeded to him in 1920. In 1927, McDowell's Valley of the Moon Ranch had grown to encompass Sections 13, 23, 24, and 25 in Missoula County and Sections 19 and 30 in Granite County for a total of 2,300 acres.

The owner of the land where the grave sits prior to 1915 was Sidler, starting in 1911 until he sold to McDowell in 1915. The land a few hundred yards east in a different county was owned by the NPRR in 1913, sold to Finlen sometime after that, after which he sold to McDowell in 1921. The grave was placed on the land McDowell owned in the fall of 1916. Yet the close proximity of Section 19 begs examination, since it adds two more possible owners that could be a link to Chi Yo - either the NPRR who owned it in 1913 or Finlen who bought the land sometime after 1913. Adding to this is the 1915 McDowell contract with NPRR to buy a parcel in this Section in 1915, but not receiving the deed until 1920.

A search of the Quigley, Granite County, censuses in 1900, 1910, and 1920 list no Chinese or Japanese families in the area. McDowell and James Finlen Sr. were at all times located officially in Butte, their names never entered on the Quigley census. In Butte, no people of Asian ancestry lived in their households. The Sidler family, who owned the land where the grave rests from 1911-1915, were listed on the 1910 census but that is all. A search of neighbors' households nearby the Valley of the Moon Ranch and who lived down the main Rock Creek road yielded no persons with Chi or Yo in their names, confirming the census. The closest Asian people living in either Missoula or Granite counties lived in Missoula or Philipsburg. It is possible that Chi Yo and family existed in between the 1910 and 1920 census and so were not recorded in either one. A search of Montana birth and death records yielded no Chi Yo events, though it is possible that Chi Yo was neither born nor died in Montana. Finally, the Chi Yo marker may not be a grave at all.

Ground Penetrating Radar

Even though the records search had proven unfruitful, it was still possible that a determination of whether this was a human burial by GPR by using HHRD dogs. As detailed in

Chapter 1, GPR can give the user an image of subsurface anomalies detected by electromagnetic waves being aimed at the ground, at which point specific breaks in the soil transmit back to the antenna receiving results (Jones 2008:26). These anomalies can be due to grave goods or caskets being present within a grave shaft. The air present in a skull can also read as a disturbance (Jones 2008:27). Further, disturbed soil from the grave shaft is distinct from surrounding soil profiles (Conyers 2006). Dr. Steve Sheriff of the University of Montana's Department of Geosciences kindly volunteered to visit the Chi Yo site to see whether GPR might be an option in determining if this was a burial. As stated above, the Winkler gravelly loam found in this area of Montana means that the soil starting at 10 inches below surface to 60 inches increases in rock fragments from 15-65% to 60-85%. Dr. Sheriff found the sloped and rocky terrain to not be conducive to GPR, because the rocks will disperse the signal, rendering a profile difficult to see. Moreover, when an area is on a slope, like at the Chi Yo site, the horizons of the soil in comparison to grave shaft backfill do not stand out as they would if the terrain was flat.

Dog Alerts

In summer 2015, three handlers and their dogs from the ICF visited the Valley of the Moon Ranch at the request of Lolo National Forest Archaeologist Erika Karuzas. In addition to the Chi Yo marker, there was a report of three other possible burials. These rock-outlined burials, thought to simply be rocks piled from the clearing of a field, were supposed to be located

Figure 4.3: *View of people standing at locations of dog alerts from the Chi Yo marker looking east. Photo by John Grebenkemper.*

downslope and north of the Chi Yo site. One was to be alongside and just off the road below Chi

Yo and the other two east of this same road. The outlines were neither located, nor did the dogs alert in the vicinity. The three dogs also did not alert at the Chi Yo marker.

Results

After some time up on the hill, one of the dogs, independent from the other two who were down below on the road, alerted at a spot six meters NW of the Chi Yo marker. Together, after a

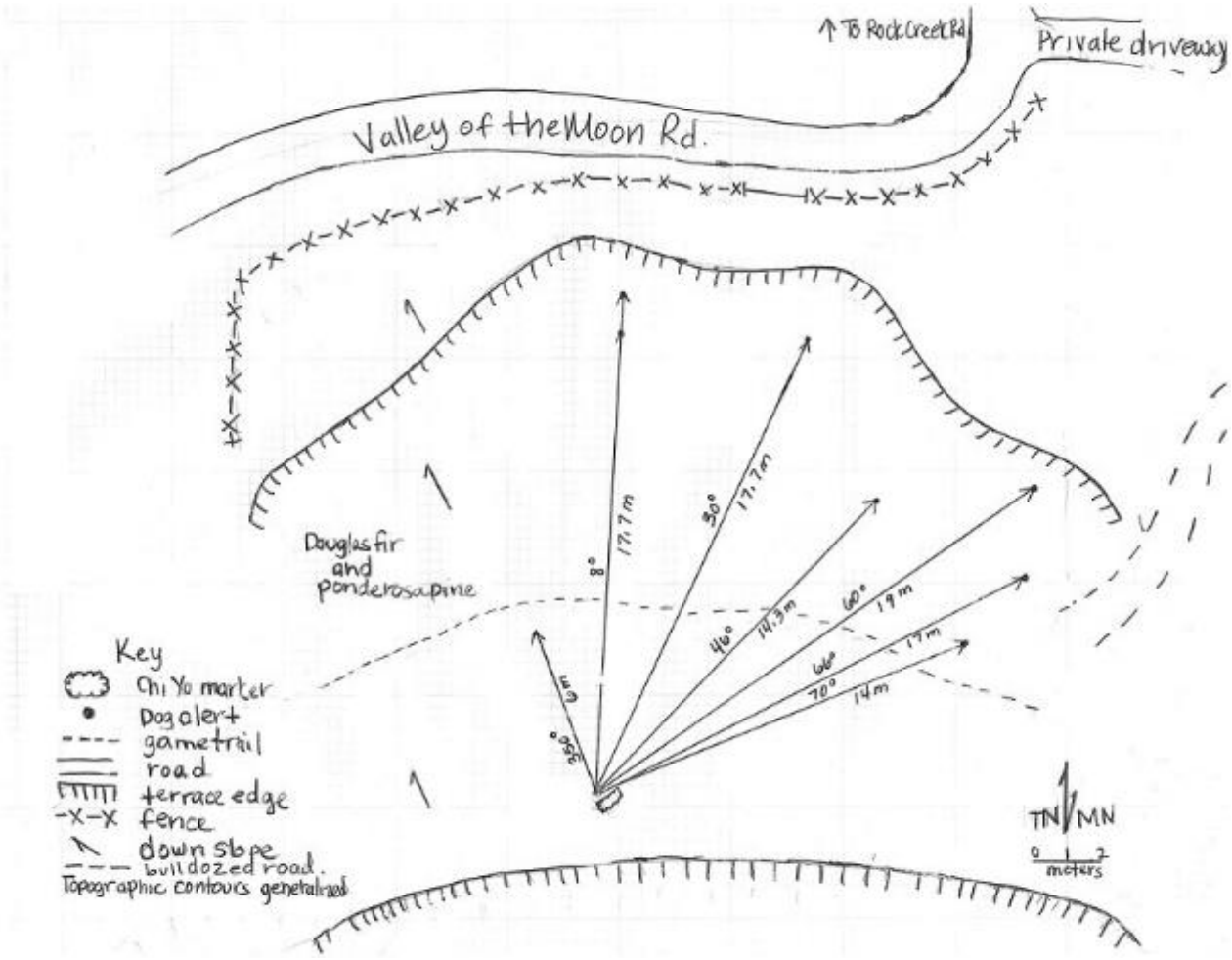

Figure 4.4: *Chi Yo Sketch Map.*

time, the remaining ICF dogs proceeded to alert at seven more spots. From the Chi Yo marker and looking north, the seven further alerts fanned out downslope from the grave in a NW to NE direction that followed the contour of the hillside (Figures 4.3 and 4.4). The average distance from the marker was 16 m. The distance between the furthest west alert to the furthest east alert

measured 8° NE to 70° NE. These results are discussed in comparison with others in Chapter 7.

Chapter 5

Hill Data

Introduction to the Hill Dataset

The Hill dataset consists of soil samples that were collected from locations where ICF HHRD dogs had alerted and that were subjected to inorganic chemical analyses. The alerted to and sampled locations in the Hill dataset came from four sites: two confirmed graves in two villages near Prague, Czechoslovakia; a starvation camp likely to have been inhabited by some of the Donner Party in California; and a possible burial in Lolo, Montana. The usefulness of this approach was retested in a new study at the Hebrew Cemetery in Virginia City, MT, described in Chapter 6.

The Hill dataset was originally reported by Heidi Hill in 2005 as not demonstrating any strong conclusive link between the dog alerts and variations in inorganic soil composition. In the present study, this dataset was re-examined. As discussed in Chapter 3, the focus was narrowed for the Hill and the Hebrew Cemetery data to seven elements: Ca, Cu, Mg, P, K, Na, and Zn. However, in the interest of potential future research, the full set of data are presented in Appendix A,

It should be emphasized that the research data from the Prague sites examined here differs from that collected at the other sites in that there was access to soil at the body level from the Prague sites (Lambert et al. 1985; Beard et al. 2000). Variations in inorganic elements in the soil samples from Prague were identified and used to predict results from the later field work and inorganic chemical analyses of soil samples collected at the Hebrew Cemetery in Virginia City, Montana.

As this dataset was collected by other researchers and certain of its specifics are not

known, discretion was exercised as to what information might be highlighted. This approach, as well as results from prior research, resulted in the culling of elements to be analyzed down from 29 to 7 (discussed in Chapter 3). Background on the other sites will be briefer than the overview of the Chi Yo grave site; this is because the Donner-Reed tragedy has been written about extensively, and conversely, because only limited information is available for Lolo.

Prague Burials

Eva Cecil (2008), a handler with the ICF, traveled to Czech Republic over a four-year span to work her dog Nessie at several sites to further train the dog and to put her to work on projects. In 2008, Cecil wrote up a summary of her experiences with Nessie for the ICF, which is the source of the following information. Most of the projects were the result of major construction that happened to unearth burials, which was when an archaeologist was called. The oldest of the burials that Nessie alerted on during this time were a series of Neolithic graves dated to 5000 BC in Divoka Sarka–Liboc, a section of Prague. The locations of the burials were known to the lead archaeologist, who agreed to let Nessie train there and then confirmed the locations to the handler afterward. Nessie alerted for the presence of historic human remains at excavated burials (no bones present), excavated burial soil piles, and tarp-covered bones.

In 2007, Nessie was invited to work at a site in Zlican, Prague where apartment buildings were going in and, as Cecil says in her report, “as is the usual scenario in Central Europe, human skeletal remains were found,” dated to AD 400-450. At an unexcavated section where topsoil had been removed, Nessie alerted to suspected burials, which had been marked with red plastic tubes in the ground and were then verified by excavation. At a subsequent visit to the site after those excavations, Nessie alerted to an unmarked spot that was then excavated and found to contain a burial at a depth of about 1 m. Cecil called this a “pure dog find.”

Another site in Klecany, a village about 20 km north of Prague, had a burial dated by head archaeologist Dr. Nada Profantova as late AD 800 to early AD 900 and was discovered in June 2005 during the excavation of a 457-meter-long ditch, one to two meters deep, to lay new underground power lines. This is one of the locations where soil samples and controls were taken from body level, so the samples served as a control for comparison with all other soil samples in this project. The specifics about the burial where the soil sample was pulled in Klecany are not known—just that it was "pelvis soil." Cecil states that the multiple skeletal remains were situated one meter below the surface. Subsequent to removal of bones, Nessie alerted blindly at the location where the bones *had been* as well as other locations where bones remained *in situ*.

The second site of grave soil samples and controls was in Cakovice, a district of Prague. Grave soil samples were collected from the human remains at chest level. These were at a site associated with the Uneticka Culture, 2300-1600 BC, though the manager of the site dated the remains that were sampled as an intrusive burial from the ninth century. Cecil commented that when visiting the site again, three months after some remains were removed, Nessie took a long time to alert on the excavated pits as opposed to at other sites when remains had been removed the day before (Cecil 2008). The soil in this part of Czechoslovakia is acidic, reaching a maximum pH of 5.5. Although the bones in the photos are visibly intact, the physical condition of the bones is unclear. Many are stained to a dark orange, which is common in an acidic environment where bones remain (Mays 2010:25).

Donner Camps

In October 1846, multiple families and individuals travelling west to California became snowbound in the Sierra Nevada for the winter, their rescue not occurring until late February of the following year. Known commonly as the Donner Party, because the brother patriarchs

George and Jacob who were at the helm of this migration west with their families, the group started the journey with the Reed family. The Donner-Reed Party grew along the route to comprise more families and individuals. At the location in the Sierras where this large group was forced to winter, two camps emerged approximately eight miles apart, at the Lake camp where approximately 60 people took up residence in existing cabins or built shelter in the vicinity of current day Donner Lake and at the Alder Creek camp where a smaller group of about 20 camped (Johnson 2011:37). The Alder Creek camp was where the two Donner families and some individuals settled because this meadow, by survivor accounts, had less snow (Johnson 2011:37). George and Jacob's camps were about 275 meters apart, both paralleling a creek (Johnson 2011:39). It has been speculated that a third more ephemeral camp, comprised of four men associated with different families from the migration, was in the meadow (Johnson 2011:40; Grebenkemper and Johnson 2015:67-68). At the end of their time in both camps, around the time when relief parties arrived in February 1847, it was rumored that those still alive had resorted to cannibalism (Grebenkemper and Johnson 2011:69).

This purported cannibalism is central to the tale of the Donner Party and one could surmise that this story would be much less well known were it not for this part of survivor and rescuers' accounts. Yet, from this claim has followed research into all aspects of the conditions that would have led to such acts.

Archaeology has been conducted at the Lake site at its three cabins, both in 1984 and 1990, and at the possible Alder Creek camps location from 1989-1993 and in 2003 and 2004. The 1984 and 1990 excavations were undertaken by Donald Hardesty of the University of Nevada, Reno in conjunction with California Parks and Recreation and the Tahoe National Forest. During the 1990 season, Hardesty and crew uncovered a layer of ash, bone, and artifacts

in the subsequently named Meadow location. The 2003 and 2004 excavations expanded on the Meadow location and were led by Julie Schablitsky and the University of Montana's Kelly Dixon. The majority of the archaeological remains at both camps were animal bones in the form of highly processed fragments (Dixon 2011:114; Hardesty 2011:93). This reduction of bone, performed so exhaustively by boiling and butchering to extract any and all nutrition, signals a starvation diet (Dixon 2011:114). No human bone was identified, but due to the condition of the bone remnants, much of it was of unknown origins (Hardesty 2011:95; Schug and Gray 2011:178).

One could take the findings of no human bone as proving the cannibalism rumor to be false, but interestingly, it sheds light on the probability that it did happen. To back up in time from the allegations of cannibalism happening at around the time of the first relief party, is the information that dear family pets had been consumed by the camps. From the book *An Archaeology of Desperation: Exploring the Donner Party's Alder Creek Camp* (2011), a treatise on the archaeology done at Alder Creek: "They demonstrate a struggle to survive that transgressed social and cultural boundaries, such as those that separate horses and dogs from other animals commonly used for food" (Schug and Gray 2011:179). And due to the lateness of the supposed cannibalism in the timescale of the Donner Party's plight, most likely only the flesh would have been eaten, the bones left untouched and unprocessed (Schug and Gray 2011:178).

A primary goal of Hardesty and Dixon was to find a hearth in the Alder Creek meadow, an area that historically was thought to be the location of the George and Jacob Donner family camps. In the 2003, Professor Dixon, Julie Schablitsky, and crew, while expanding on Hardesty's 1990 grid in the Meadow locale, uncovered a layer of ash and bone. The following season, this meandering ash residue was traced to a hearth where processed bone and artifacts

were found in large quantities (Dixon 2011:109). Both at the residue and the hearth, soil samples were taken, the results of analyses of which are presented here. After the hearth discovery, ICF dogs were brought in and subsequently alerted near the hearth at an area outside of the grid (Dixon 2011:110). This alerted-to area was excavated as a 1 x 1 m unit outside the grid, where the field crew collected nine more samples, ranging in depths from 30 to 100 cm.

Later investigations using HHRD dogs in the Alder Creek meadow, outside of the Hardesty and Dixon locales, were conducted between the years 2007 and 2013. Grebenkemper and Johnson's (2015) report of these investigations that totaled 40 dog working days and 80 alerts cited the observation of intriguing clusters of alerts east and northwest of the Meadow locality. These clusters suggested to the authors that these, more than the Meadow locality, might be the site of the Donner brothers' camps—or at least the site of where the Donner families may have places their dead. The weak scent at the hearth, they surmised, is more likely to be the elusive third camp inhabited briefly by four men associated with the Donner Party, despite the sheer amount of artifacts (Grebenkemper and Johnson 2015:87).

Lolo, Montana

In the 1850s, Lawrence Rence was a fur trapper who lived with his Nez Perce wife on Graves creek, approximately 27 km west of the current-day town of Lolo. He was nicknamed "Lolo" because the r in his name could not pronounced by the native speakers in the area. Lolo was killed by a grizzly bear and was buried somewhere along Graves creek. There was a headstone marking the spot as late as 1939, but that has since disappeared, likely as a result of later timber harvests. In 2005, the Traveler's Rest Chapter of the Lewis and Clark Heritage Foundation asked the ICF to join the search for the grave of Lolo, a man whose name is now memorialized throughout western Montana. Two ICF dogs, independent from each other, alerted

at a copse of pine trees from where four samples were taken (ICF 2005).

Methods

Inorganic Chemical Soil Analyses

Soil samples were collected at select locations at these sites based on dog alerts. Soil samples were also collected at control locations at a distance from dog alerts. Details at some of the locations, such as depths where the soil was collected, are not available. The inorganic chemical analyses of soil samples from the Prague, Donner, and Lolo sites were conducted in 2005 using inductively coupled plasma optical emission spectrometry (ICP-OES) at the Environmental Biogeochemistry Laboratory at the University of Montana. These results comprise the Hill dataset. Dr. Jesse Hyslop (2016), an analytical chemist at the University of Montana, describes ICP-OES as a method of measuring the wavelengths produced by specific atoms, or elements in a sample. The soil sample is nebulized into a mist that is pumped into an inductively coupled plasma, a neutral medium in an ionized equilibrium generated by igniting argon gas. Individual molecules are then broken apart and, along with high temperature, are reduced to atoms. The high temperature breaks the sample molecules into charged ions which lose electrons. When the atoms relax they emit photons. The energy of the photons is the same as the energy difference between the excited and relaxed state of the electron. These energies are matched to specific elements which gives off one or more unique wavelengths (Hyslop 2016, pers. comm.).

The ICP-OES testing included a number of Quality Assurance/Quality Control (QAQC) measures of laboratory methods and instruments at a level of 20-30% for every 10 samples: laboratory/analytical and method blanks; continued calibration verification; standardized reference samples of known concentrations from the National Institute of Standards and

Technology (NIST) and internal performance check (IPC) samples from a second manufacturer; analytical (laboratory) and method duplicates; and spike recovery using laboratory fortified blanks, analytical/laboratory spikes, and method spikes. QAQC followed EPA Method 6010 protocols. Samples showed varying quality across elements. Error rates for testing as measured by method duplicates showed a range of ± 2.9% to ± 8% for Ca, Mg, Na, P and Zn, as high as ± 14.5% for Cu, and as high as ± 28.8% for K. The complete QAQC report for ICP testing of these soil samples is reported in Appendix B.

New Interpretation of the Hill Data

The Hill dataset was reexamined for the present study. A reassessment of these data might reveal trends previously overlooked when initially reported by Hill. Results of inorganic chemical analyses were charted, with each site being treated independently. Special attention was given to the data from the soil samples collected at the two sites in Czechoslovakia, Klecany and Cakovice, since these were from two known burials. It was predicted that these should show some variation in the inorganic soil chemistry as a result of human burials.

Since prior research has demonstrated that human remains do have certain effects on the inorganic chemistry of surrounding soils, due to the commonality of human bone, though subject to variation as a result of environmental factors and diagenetic processes, it was predicted that enrichment of at least some inorganic elements in the Prague soil samples would be consistent with those reported in other studies. Additionally, any such chemical variations might be useful as a guide for examination of the soil chemistry at the other two sites in the Hill dataset, as well as in Virginia City, and predictive of whether soil chemistry at dog alerted locations are consistent with that of known burials. Conversely, results of the analyses of soil samples from the Donner and Lolo sites might or might not be consistent with those previously associated with

human burials, since these had not been confirmed as such. Since the Donner and Lolo soil samples did each include dog alerted locations, differences in the inorganic soil composition might be observed.

However, at Donner, the supposition was that these might not have been full body burials or that the bodies may well have been deposited at ground level beneath a layer of snow and thus may have been later exposed and subject to movement by weather and scavengers or, as in some reports, moved by people for burial elsewhere. The effect might be a lingering smell detectable by dogs, but not measurable in soil samples. At the Lolo site, dogs might have been detecting odor at a location that had traveled via subsurface scent plumes from a nearby location and so soil testing would not show a result at the alerted to location.

Results

The results of ICP analyses of soil samples at control and dog alerted locations in the data from the Prague sites, Klecany and Cakovice, are shown in Table 1. These are presented as abundance in parts per million (ppm) for the seven elements of interest. The ratio of zinc to copper is also reported, since enriched levels of this ratio can be indicative of the presence of a burial when the effect of other more soluble elements are not observed (Beard et al. 2000; Morse 1997:94). Included are results for testing conducted for Hill of two ionic variants of each of Cu, K, and Zn. Though the differences between the ions for each of these three elements are not

Table 1. Chemical Abundance in ppm and Ratios from ICP Analyses of Prague Soil Samples

EBL ID #	Sample Label Information	Date Collected	Ca	Cu	Cu	K	K	Mg	Na	P	Zn	Zn	Zn/Cu
HH25	Control Soil Klecany Prague	2005	17540	9.68	11.28	2974	2817	3003	103.3	590.2	38.18	38.39	3.40
HH28	Pelvis Soil Klecany Prague Late 800-900 AD	JUL 2005	24830	9.79	11.85	3468	3414	4053	110.5	1005	51.68	51.95	4.38
HH26	Control Soil Cakovice Prague	2005	34910	8.4	10.14	2866	2653	5118	136.7	392	39.79	40.51	4.00
HH27	Chest Soil Cakovice Prague	7/18/2005	52010	9.22	10.67	3089	2864	5795	109.9	954.7	42.65	44.03	4.13

dramatic, and are observed in the same directions, they are included as demonstrative of how such levels might vary as a function of ionic differences.

It is instructional to compare percent differences in abundance of individual chemicals in soil samples from dog alerted locations over those taken at control locations. By using percentages, results from these two sites can be readily recognized as enriched or depleted and overall trends are more apparent. Such percent difference results for Klecany and Cakovice are reported in Table 2. It should be noted that for the data from these two sites, percentages are more easily represented than those for other sites since the data set for each is comprised of a single burial and non-burial sample. This does, though, present an obvious problem of validity, since, with all testing in the present study, a very limited set of data points are used.

Table 2. Percent Differences in Chemical Abundance in Dog Alerted vs. Control Soil Samples at Prague Sites

Site	Ca	Cu	Cu	K	K	Mg	Na	P	Zn	Zn	Zn/Cu
Klecany	42%	1%	5%	17%	21%	35%	7%	70%	35%	35%	29%
Cakovice	49%	10%	5%	8%	8%	13%	-20%	144%	7%	9%	3%

All the elements, with the exception of sodium, were slightly to dramatically enriched at dog alerted locations as compared to controls at Klecany and Cakovice. The high enrichment of Ca and P at both sites has been cited elsewhere as being indicative of burials (Beard et al. 2000). Magnesium is also clearly enriched at both burial locations. Less dramatically, copper demonstrates a trend toward enrichment and though less consistently across sites, and potassium also shows elevated levels. It is notable that at Klecany, the levels of K, Mg, and Zn are all more elevated than at Cakovice. Additionally, Zn/Cu ratios differ between the two sites, again clearly elevated at the Klecany site, but only slightly elevated at the Cakovice site. This is as a result of the higher level of zinc at the Klecany burial location as compared to Cakovice. Overall, the soil from the two sites with the confirmed burials, with the exception of depleted Na in Cakovice, follows the findings suggested by the literature regarding burial soil.

The results of ICP-OES analyses of soil samples at two control and three dog alerted locations at Donner are likewise represented as abundance in ppm in Table 3. A control, HH1, was removed from the table as its elemental levels fluctuated wildly and contamination was suspected; inclusion of this control had the potential of causing misleading results (see Appendix A for the HH1 results). As with the Prague samples, the results of Cu, K, and Zn ions are reported. In this dataset, the results for the K ions differed so profoundly that contamination is suspected and will not be further analyzed.

Table 3. Chemical Abundance in ppm from ICP Analysis of Donner Soil Samples

EBL ID #	Sample Label Information	Date Collected	Quad	Sample Depth (cm)	Ca	Cu	Cu	K	K	Mg	Na	P	Zn	Zn	Zn/Cu
HH2	Donner Party Alder Cr Control	unknown		unknown	5132	15.8	16.4	565	822	3053	354	133	39.2	39.1	2.39
HH3	Donner Party Alder Cr Control	unknown		unknown	4491	18.0	19.6	703	550	2937	297	151	34.2	34.5	1.76
HH4	Donner Family Camp Unit G	unknown	NW	30-40	2018	23.1	24.3	716	516	2147	154	467	79.9	82.2	3.38
HH5	Donner Family Camp Unit George	7/11/2004	NW	30-40	2120	19.7	21.3	816	460	2252	180	513	83.5	85.8	4.03
HH6	Donner Family Camp Unit George	7/11/2004	SW	40-50	2307	22.3	22.3	546	670	2958	204	395	68.8	70.0	3.14
HH7	Donner Family Camp Unit George	7/11/2004	NE	50-60	2705	18.6	20.4	452	708	3827	245	176	51.1	51.3	2.52
HH8	Donner Family Camp Unit George	7/11/2004	SE	50-60	2630	20.7	22.1	675	455	3141	241	371	63.3	65.0	2.95
HH9	Donner Family Camp Unit George	7/11/2004	SW	60-70	2645	18.8	21.1	547	453	3720	248	220	52.4	53.2	2.52
HH10	Donner Family Camp Unit George	7/11/2004	NW	70-80	2897	20.0	20.8	508	515	3890	261	207	55.8	56.6	2.72
HH11	Donner Family Camp Unit George	7/11/2004	NE	80-90	3296	19.3	20.8	385	589	4087	312	182	52.2	52.4	2.52
HH12	Donner Family Camp Unit George	7/11/2004	SE	90-100	2854	17.1	17.1	432	599	3522	290	232	51.5	51.5	3.02
HH15	Donner Family Camp Feature 1: Hearth Residue bag 1 of 2 units D,E,F Unit George	8/8/2003		unknown	7386	23.6	23.5	462	959	1931	270	3754	101	103	4.39
HH16	Donner Family Camp Feature 2: Hearth. bag 1 of 3 Unit George	2004		unknown	#####	36.3	37.8	636	661	2106	273	6377	118	122	3.22

Again, for ease of interpretation, percent differences in dog alerted vs. control soil samples from Donner are shown in Table 4. Since depths and locations of the control samples relative to those from dog alerted samples is unknown, the control levels were averaged. Hypothetically, the soil at the control locations should be comparable, and averaging should account for any spurious variability. Because the dog alerted locations at Donner have not been

confirmed as burials, the present question is whether the results of soil analyses here are consistent with what would be expected at a burial site, based on prior studies, including the Prague sites.

Table 4. Percent Differences in Chemical Abundance in Dog Alerted vs. Averaged Control Soil Samples at Donner Locations

Location	Sample Depth (cm)	Ca	Cu	Cu	K	K	Mg	Na	P	Zn	Zn	Zn/Cu
Donner Family Camp Unit George	30-40	-58%	37%	35%	13%	-25%	-28%	-53%	230%	118%	123%	65%
Donner Family Camp Unit George	30-40	-56%	17%	18%	29%	-33%	-25%	-45%	262%	128%	133%	97%
Donner Family Camp Unit George	40-50	-52%	32%	24%	-14%	-2%	-1%	-37%	179%	88%	90%	53%
Donner Family Camp Unit George	50-60	-44%	10%	13%	-29%	3%	28%	-25%	24%	39%	39%	23%
Donner Family Camp Unit George	50-60	-45%	23%	23%	6%	-34%	5%	-26%	162%	73%	77%	44%
Donner Family Camp Unit George	60-70	-45%	11%	18%	-14%	-34%	24%	-24%	55%	43%	44%	23%
Donner Family Camp Unit George	70-80	-40%	18%	16%	-20%	-25%	30%	-20%	46%	52%	54%	33%
Donner Family Camp Unit George	80-90	-31%	15%	15%	-39%	-14%	36%	-4%	29%	42%	42%	23%
Donner Family Camp Unit George	90-100	-41%	2%	-5%	-32%	-13%	18%	-11%	64%	41%	40%	48%
Donner Family Camp Feature 1: Hearth Residue. bag 1 of 2 units D, E, F Unit George	unknown	54%	40%	31%	-27%	40%	-36%	-17%	2550%	177%	181%	115%
Donner Family Camp Feature 2: Hearth. bag 1 of 3 Unit George	unknown	177%	115%	110%	0%	-4%	-30%	-16%	4402%	223%	231%	57%

Certain elements at the Donner site varied in proportion between the areas outside the grid where the dogs alerted, the Donner Hearth residue, and the Donner Hearth. Outside the grid at the Donner site, the nine soil samples were taken from a depth of 30 to 100 cm, in 10 cm increments, and from all four quadrants of a 1x1 m unit. Together, the Hearth and Hearth residue showed elevated levels in Ca, Cu, Zn, and P, with depleted levels of Mg and Na, in comparison to the controls. Overall, the Hearth, in its enrichment of elements, was almost twice that of the already enriched Hearth residue locale. The nine samples from outside the grid had elevated levels of Cu, P, and Zn at the 30 cm level, but decreasing at lower depths. Ca and Na were depleted in comparison to controls, but became less depleted at lower depths. Mg was depleted at 30 cm, but rose to an elevated level starting at 50 cm.

The results of ICP analyses of soil samples at control and four dog alerted locations at the

Lolo site are likewise represented as abundance in ppm in Table 5. As in the case of Donner, the site at Lolo has not been confirmed as a burial, so these results are treated here as a test, to be compared with the standards set in previous studies, including the Prague sites.

Table 5. Chemical Abundance in ppm from ICP Analysis of Lolo Soil Samples

EBL ID #	Sample Label Information	Ca	Cu	Cu	K	K	Mg	Na	P	Zn	Zn	Zn/Cu
HH17	Lolo Grave Control 1	3567	13.0	13.7	6240	5947	12230	82.2	433	57.6	56.5	4.13
HH18	Lolo Grave Control 2	11960	9.3	10.4	5018	4925	12140	b.d	412	51.3	50.9	4.91
HH19	Lolo Grave Dog Alert 1	2594	9.9	9.4	6001	5672	12390	b.d	335	53.4	52.3	5.57
HH20	Lolo Grave Dog Alert 2	3059	9.2	10.9	4528	4472	11890	b.d	335	52.2	51.2	4.68
HH21	Lolo Grave Dog Alert 3	2881	10.6	11.0	6470	6260	12040	b.d	391	54.2	53.1	4.85
HH22	Lolo Grave Dog Alert 4	2993	11.5	12.7	5582	5586	13290	b.d	519	61.5	60.0	4.71

Percent differences in dog alerted vs. control soil samples from Lolo are shown in Table 6. The soil samples from all Lolo dog alerted locations show a depletion in Ca in comparison to the two controls. Ca is the only element that showed a consistent directional change in comparison to the two control samples. This would indicate uptake from bones, if they were present, which is not consistent with expectations of decomposition. Cu does show as depleted in comparison with Control 1, but vacillates with Control 2. Zn is elevated against Control 2 but

Table 6. Percent Differences in Chemical Abundance in Dog Alerted vs. Control Soil Samples at Lolo Site

Location	Ca	Cu	Cu	K	K	Mg	Na	P	Zn	Zn	Zn/Cu
Lolo Dog Alert 1 vs. Control 1	-27%	-23%	-31%	-4%	-5%	1%	b.d	-23%	-7%	-7%	35%
Lolo Dog Alert 2 vs. Control 1	-14%	-29%	-20%	-27%	-25%	-3%	b.d	-23%	-9%	-9%	13%
Lolo Dog Alert 3 vs. Control 1	-19%	-18%	-20%	4%	5%	-2%	b.d	-10%	-6%	-6%	17%
Lolo Dog Alert 4 vs. Control 1	-16%	-12%	-7%	-11%	-6%	9%	b.d	20%	7%	6%	14%
Lolo Dog Alert 1 vs. Control 2	-78%	7%	-9%	20%	15%	2%	b.d	-19%	4%	3%	13%
Lolo Dog Alert 2 vs. Control 2	-74%	-2%	6%	-10%	-9%	-2%	b.d	-19%	2%	1%	-5%
Lolo Dog Alert 3 vs. Control 2	-76%	14%	6%	29%	27%	-1%	b.d	-5%	6%	4%	-1%
Lolo Dog Alert 4 vs. Control 2	-75%	23%	23%	11%	13%	9%	b.d	26%	20%	18%	-4%

varies in Control 1. Na is below detection against both controls. The remaining, K, Mg, and P elements fluctuate and deplete against the controls and without knowing depths, a pattern is

impossible to hazard. The Zn/Cu ratio of Lolo Dog Alert 1 against both controls might be indicative of a burial, except that is skewed positive by virtue of a ratio of depleted (negative) levels of Zn and Cu as compared with control samples. Overall, the results from Lolo vary dramatically and do not appear to support the presence of a burial at the location tested.

Chapter 6

Virginia City, Montana

The Hebrew Cemetery

The project area sits at an elevation of 5,800 feet and is classified as rangeland. This type of land is used for grazing and consists predominantly of native vegetation which for this location is silvertip and mountain big sagebrush, rabbitbrush, Rocky Mountain juniper, and Douglas fir (Department of Natural Resources and Conservation 2013:7-8) (Figure 6.1). The neighbor who owns the driveway east of the cemetery informed me that cattle drives occur on this land annually, which likely have caused untold surface changes to possible grave markers and related artifacts. This square parcel's southern side slopes down towards Madison Street, a slope that may be more pronounced due to the construction of Madison street that likely cut into the hillside.

Figure 6.1: *View looking west atop the Hebrew Cemetery, Virginia City, Montana. Photo courtesy of Kelli Casias.*

In a letter to American Jewish Historical Society member Norman Winestine (April 9, 1967) from Jeanne Jasmann of the Virginia City Zoning Commission, there is a discussion of the newly discovered plot of land that held the Hebrew cemetery, noted on the 1868 plat map (Figure 6.2). Jasmann had it surveyed to find its exact place off of Madison Street due to concerns of the impending construction and desires to protect it in perpetuity; Jasmann succeeded. She reported to Winestine that up to seven graves had been discovered, six being definite burials in her opinion, probably from the years 1864 to 1875. The graves she said,

consisted of "…merely native lava rock, such as abounds in this country, placed over the tops of graves, more like a cairn than anything else, with, in some cases, one larger lava rock placed as a headstone might be." Further evidence of these graves included "weathered scraps of wood and a few old square nails" (Jasmann Letter 1967). Jasmann's letter indicates she took photographs and was planning to visit Helena to inquire whether Winestine had any more knowledge of the cemetery, as she had found nothing in her research.

Figure 6.2: *An overlay of the 1868 plat map of the City of Virginia, Montana atop current view of Virginia City, Montana with the Hebrew Cemetery marked. Photo courtesy of Google Earth. Plat map created by J. L. Corbett, courtesy of the Montana Memory Project.*

In 2014, a pedestrian survey was completed at the three cemeteries in Virginia city. This included flagging artifacts and features and subsequently mapping them. This survey was

completed for the Virginia City State Historic Preservation Officer (SHPO) as part of the process of developing National Register of Historic Places (NRHP) nomination for these cemeteries (Ciani 2014). The Hebrew cemetery was viewed as being "the least understood, one of the earliest, the most threatened, and perhaps the most unique" (Ciani 2014:1). During the survey of the cemetery, artifacts that could be construed as remains of fencing, coffin, or markers were found, including square nails, cut wood, and metal debris. Stones placed in the outline of a burial and larger stones in a headstone position were interpreted as grave features. It was near these features that nails and wood were found strewn about and it was the opinion of the SHPO personnel, similar to Jasmann's in 1967, that four of the features were created purposefully (Ciani 2014:3-4).

The soil here, as noted earlier, is Varney clay loam, the clay being the most abundant sediment, and the location sits on a slope of 8-15% which means that top-soil runoff, and elements leached from remains due to rain, would be at a minimum. The structure of this clay loam soil and ability to hold water classifies it, among other geological qualities, as having "somewhat limited" ease of completing shallow excavations up to six feet, and some preparation would be needed (NRCS). The mayor of Virginia City stated to me that it took him 45 minutes to dig a shoe box-sized hole for his deceased cat, at which point he used a pick-axe to make it larger. This anecdote could lead one to suspect that when the Hebrew cemetery was active, means beyond shovels were likely necessary to create a grave shaft. This "diggability" of the soil, how easily it is moved, leads one to further speculate that burials might potentially be relatively shallow (Harrison and Donnelly 2009:208). The pH level for this soil is a slightly acidic pH of 6.6 just below the surface to rising to pH 8.4 with depth making it is alkaline. This increases the likelihood of remains still being in place.

Historical Context

The Hebrew cemetery was established by the Jewish Benevolent Society in 1867 in Virginia City and located, in the year before statehood, in the Montana territory. A small population of Jewish merchants came to the area soon after gold was discovered and helped build Virginia City. Virginia City was founded in 1863, after gold was discovered in Alder Gulch, stretching 14 miles along the Ruby River. Bannack, a mining site east of Alder Gulch, was no longer booming thus came a migration of miners to the area (Grant 1998:7-8). By 1868, the population of the officially recognized town of Virginian City stood at 2,500. A gold strike north of Virginia City in what became Helena depleted the population of Virginia City to 900 by 1880 (Grant 1998:14-23).

In researching written documents about the founding Jewish members of Virginia City, I went on to trace several of these individuals and their family members, starting with the 1870 census through to when they were no longer listed on any subsequent census. The census does not list religious affiliation, but death notices and cemetery records often do and I was able to track some Jewish residents from their time in Virginia City to their place of burial. Many founding members listed in the 1870 census were, in 1880 and beyond, listed in Butte and Helena and buried in those cities' Hebrew cemeteries. The remaining Jewish population that I was able to track as living in Virginia City through the decades were buried in the Virginia City cemetery, ¼ mile east of the Hebrew cemetery. This exodus of the population shortly after the formation of the Hebrew cemetery and the use of the Virginia City cemetery by the remaining Jewish population, along with no mention of the Hebrew cemetery in death notices, Montana cemetery listings, or grave location websites, lends evidence to the possibility that this cemetery may not have been used.

Currently, the cemetery resides in Madison County on just under two acres, about four blocks north of downtown Virginia City on Madison Street, bordered by Van Buren Street on the west and a private driveway to the east. This private driveway is ostensibly the northern terminus of Broadway Street (Figure 6.4). Madison Street, which appears as X Street on the 1868 plat map, was improved in the early 1980s according to a resident.

Jewish Burial Traditions

Jewish burial customs impart that at death everyone is rendered equal and that the deceased should be returned to the earth as soon as possible. This is facilitated by having the deceased dressed in a white linen shroud and placed in an unadorned kosher coffin with no metal hardware. The shroud and plain coffin precludes ostentation and also hastens a return to earth. Since there was a community of Jewish citizens in Virginia City as well as a Hebrew Benevolent Society, there was likely a chevra kadish, a person who deals specifically with the preparation of the dead for burial. This would include cleaning and dressing the body. Burial is to take place within a day and it is because of this quickness of pace that flowers, often used to mask odors of decay, are not a part of Jewish burial practices. Jewish law states that a body cannot be embalmed or cremated and must be in a closed casket. However, at times these customs are modified, becoming a more syncretic affair. A 1904 *Anaconda Standard* article says of Julias Silverman's January 15th funeral, four days after his death, that "The body reposed in the front parlor. There were no flowers, in accordance with the wishes of the departed."

Embalming, while hindering decomposition, and an open casket is seen as prolonging the living's need to accept the finality of death. This is why it is also frowned upon to visit the grave too often. When visiting the grave though, a small stone is left to remember the dead "physically, visibly, and publically" (Lever 2009:468). A grave marker is not put at the grave from one month

up to eleven months after death where it is then presented at a specially prayer ceremony. There is no doctrine stating how the marker should appear, following the belief in the leveling effect that aesthetically death brings to all, and can range from a boulder to a typical grave stone. Typically, the name, relationship, and birth and death names are on the marker in Hebrew and local language. Disinterment is prohibited under Talmudic law as it is seen as embarrassment or confusing to the deceased. It can be performed for specific purposes with permission from a Rabbi (Geller 1996:414).

Methods

Dog Alerts

On September 13, 2016 the ICF and their dogs began a five-day investigation of three locations in Virginia City: Tendoy Park, the Hebrew cemetery, and the Boot Hill cemetery. For this research, patterned probing and soil samples were planned for areas where two or more dogs alerted within the Hebrew cemetery. Before commencing the search with the ICF dogs, weather, temperature, wind, and barometric pressure was noted, as were any areas of foxtail grass. These needed to be avoided as they can lodge in a dog's nose. The ICF reports that the accessible terrain for the Hebrew cemetery, after avoiding foxtail, was 40 to 60%, the remainder being untested. Each handler worked a section of the cemetery alone where they would then rotate until they had all covered the entire project area. This was done in part not to have the dogs distract each other and to give them a wide berth to follow scents. When a dog did catch a scent, it would put its nose almost to the ground and slow down. These dogs were trained to alert by either sitting or lying down, head up. GPS waypoints, coordinates, were taken by each handler at the location of an alert and a color-coded flag was placed in the soil. The area each handler surveyed was tracked and recorded using a Garmin 60CSx GPS (Figure 6.3). At the cemetery, one dog

was kept on a long lead, the other two were unleashed.

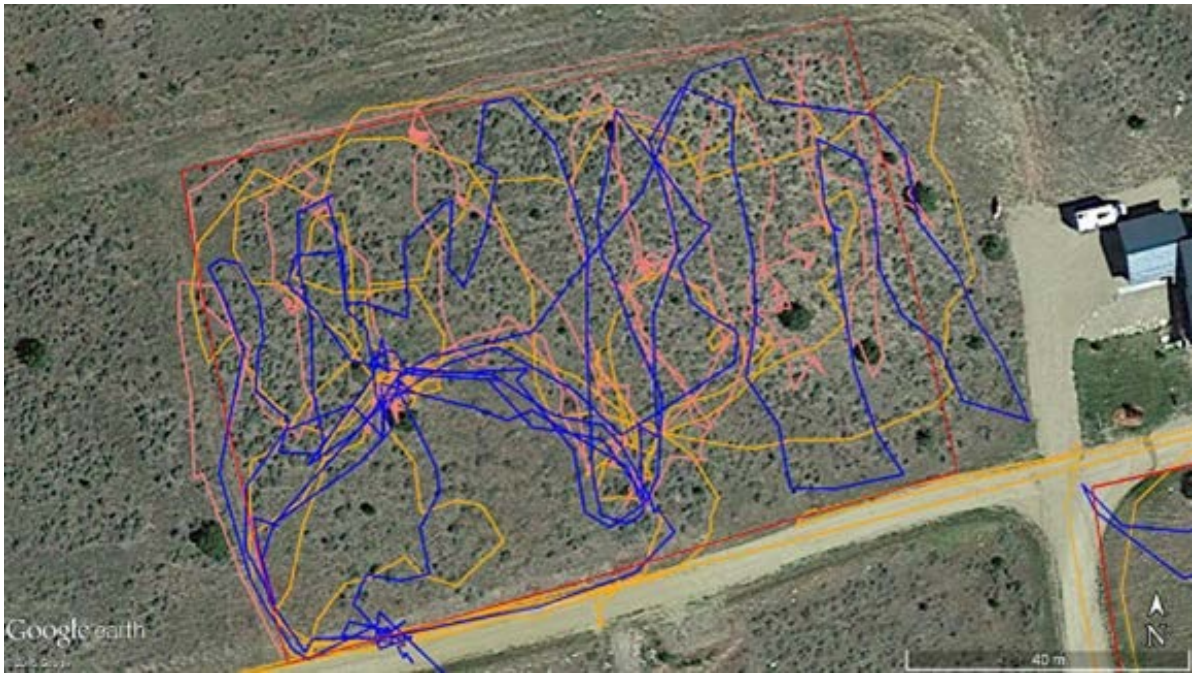

Figure 6.3: *ICF dog tracking in the Hebrew Cemetery. Photo courtesy of Google Earth.*

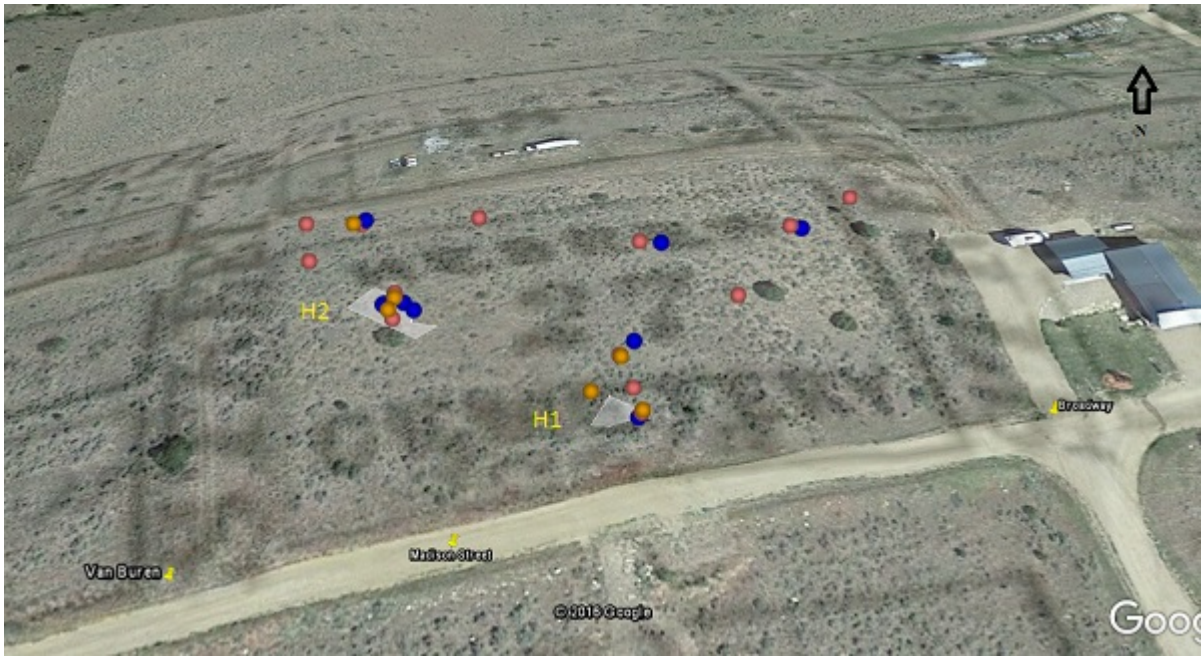

Figure 6.4: *ICF dog alerts in the Hebrew Cemetery. Photo courtesy of Google Earth.*

Observations of the handlers showed them to be relaxed, as if on a walk. There were never any suggestions to the dogs beyond letting them know they were going to walk a different direction or to call them back if they were wandering too far. Some handlers, if finding the dog

too easily distracted, possibly because of boredom, play tug with them briefly. Often, this small reward of play inspires the dog to focus again. The dogs were never forcibly led to a spot nor were they cajoled in any way to alert. Researching scent detection dogs is certainly different from seeing them work: they are definitely still dogs, distracted by animal smells, other dogs and noises, but when they catch a smell from their scent lexicon, they go to work and it is a noticeable switch. They visibly seem to compress as they slow down and put their nose down, circle sometimes, and then alert. This is not done quickly. One can see the dog making the decision to alert or not and, in the end, you have to have trust in the training and handling that led to this moment. Adela Morris's dog Jasper alerted on Madison Street, off site and across the street from the cemetery (Figure 6.5). The previous day, Adela had hidden and then retrieved a tooth used in a demonstration and Jasper was alerting to the spot where the tooth had been.

Figure 6.5: *ICF dog Jasper alerting on a human tooth. Photo courtesy of Kelli Casias.*

At the end of the ICF investigation of the cemetery, and in consultation with the group, two sites were singled out and labeled for further investigation for this project: H1 and H2. H1 is located on a south eastern section of a slope on the southern facing portion of the property in

view of Madison street (Figure 6.4). All three dogs alerted strongly to this trench-like area midway down the slope of the property, specifically at a rock pile and prickly pear cactus. Visually, there was no appearance of a burial, just strong dog alerts according to their handlers that were reconfirmed subsequent times. Nothing was recorded from this trench-like area in the 2014 survey. North of H1, on the plateau of the cemetery land was a second site, H2. Here, three grave-like features, each of which having a large stone at one end and either an outline of smaller stones or a piled rock formation, are found in close proximity. These three stone piles in H2 are likely part of the four features recorded in the 2014 survey.

Figure 6.6: *H1 looking west. Photo by author.*

H2 is located 30.5 meters north-west of H1 and about three meters higher in elevation as the site sits where the land levels out. Unlike H1, three features visually stood out as possible graves and thus designated as grave one, two and three. Each one had what could be interpreted as a headstone from which smaller stones migrated outward into a body length outline. Grave one had piled stones (Figure 6.7). Grave two was visibly sunken in its outline and grave three

Figure 6.7: *H2, Grave 1. Photo courtesy of Kelli Casias.*

had a stone outline (figures 6.8 and 6.9). The three graves line up on a 60 degree north-east (headstone) to south-west diagonal, on an east-west line. The distance from grave one to grave two is 135 cm, and grave two to grave three is 200 cm.

Figure 6.8: *H2, Grave 2. Photo courtesy of Kelli Casias.*

Figure 6.9: *H2, Grave 3. Photo courtesy of Kelli Casias.*

Soil Probing and Sampling

On September 15, 2016 a grid was established at H1 where all three ICF dogs had alerted the previous day. The location of the alerts, a pile of stones and a prickly pear cactus, were established as the center of this grid and as a sub-datum. This sub-datum was triangulated to four more features on the landscape: a large and small juniper, and two intersections. A large juniper functioned as this project's mapping datum; the two sites investigated each used this tree since it visible from both sites. From this sub-datum, measurements extended two meters out in four directions to create a 2 x 2 m grid. This grid size was suggested by ICF handlers at the site, countering my interest in following Baxter and Hargrove's (2015) recommended 4-5 m grid. The ICF handlers surmised that due to the compactness of the soil, any burials would be shallow, thus easier for the dog to alert more closely to the target. While excavation and shovel testing were not permitted at this cemetery, in an effort to contribute to the sparse information regarding the site, Rabbi Chaim Bruk granted permission to probe and collect soil samples with the agreement that the soil would be returned when the project was completed. Using the GIS software Avenza, coordinates were recorded where samples were pulled, along with pin flags to mark locations.

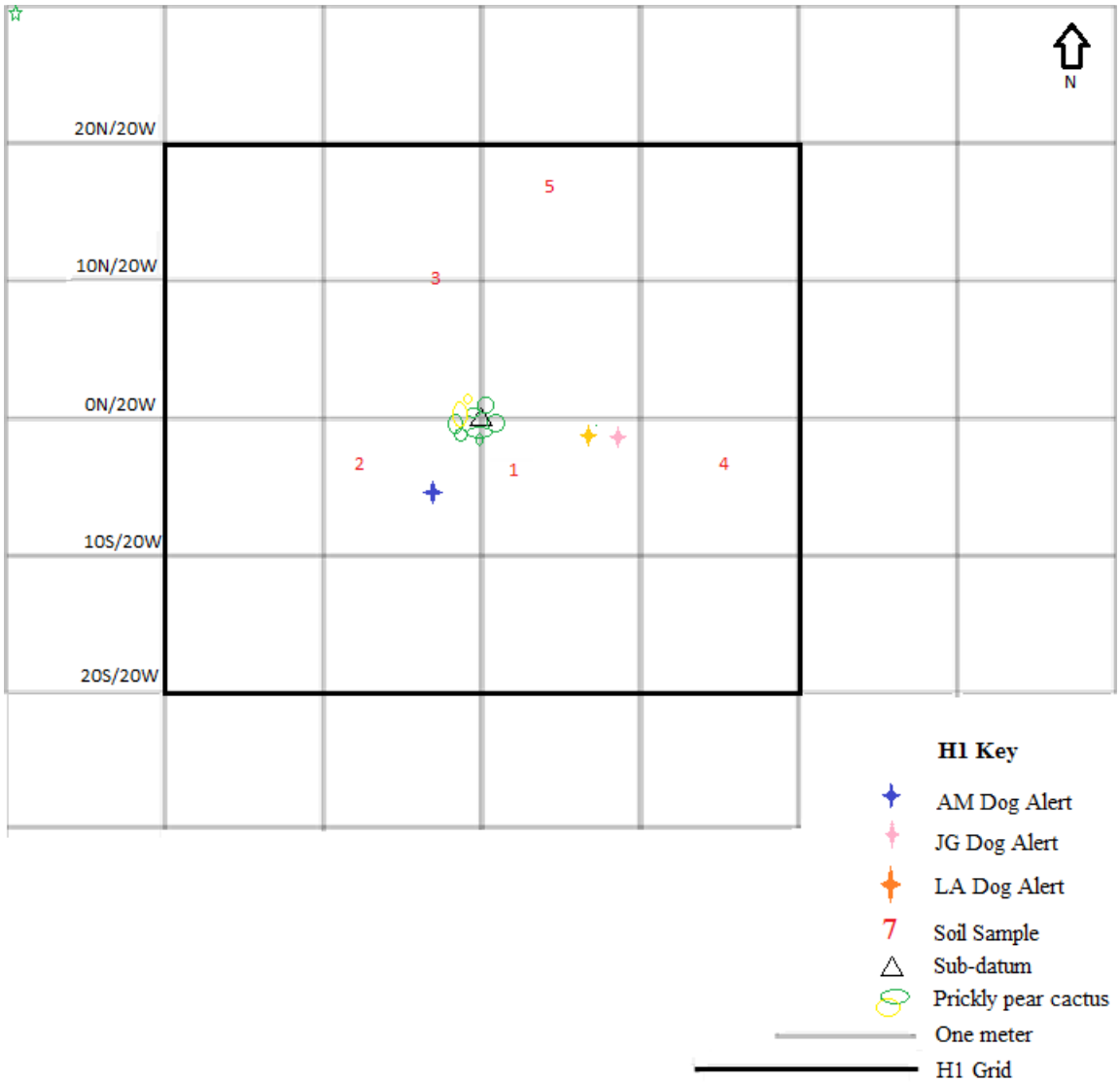

Figure 6.10: *H1 grid.*

Using Killam's (1990) method for using a probe to find disturbed soil, starting at 0 cm, a probe was performed every 75 cm until reaching 400 cm, moving NE to SE. Heading 70 cm W and starting at 0 cm; this systematic pattern was continued again in the same NE to SE direction, for a total of 36 probes. There was no discernable change in the compaction of the dirt which throughout this project's probing remained hard to penetrate, with the deepest probe hole going down 12 cm at H1. Recalling from Chapter 3 the description of the Varney clay loam that is found in this county, that it holds onto water very well, and from testing outside of the cemetery,

the difficulty seemed unvarying except near the base of mature shrubs. Also, the probe used for the inaugural probing at H1 was a metal tube hand-hammered to a point at one end and approximately 1 cm in diameter that was found unsuitable. It was decided for the probing of H2 that an AMS brand steel soil corer would be used as the probe. A total of five samples were collected from H1 ranging from 0 to 42 cm.

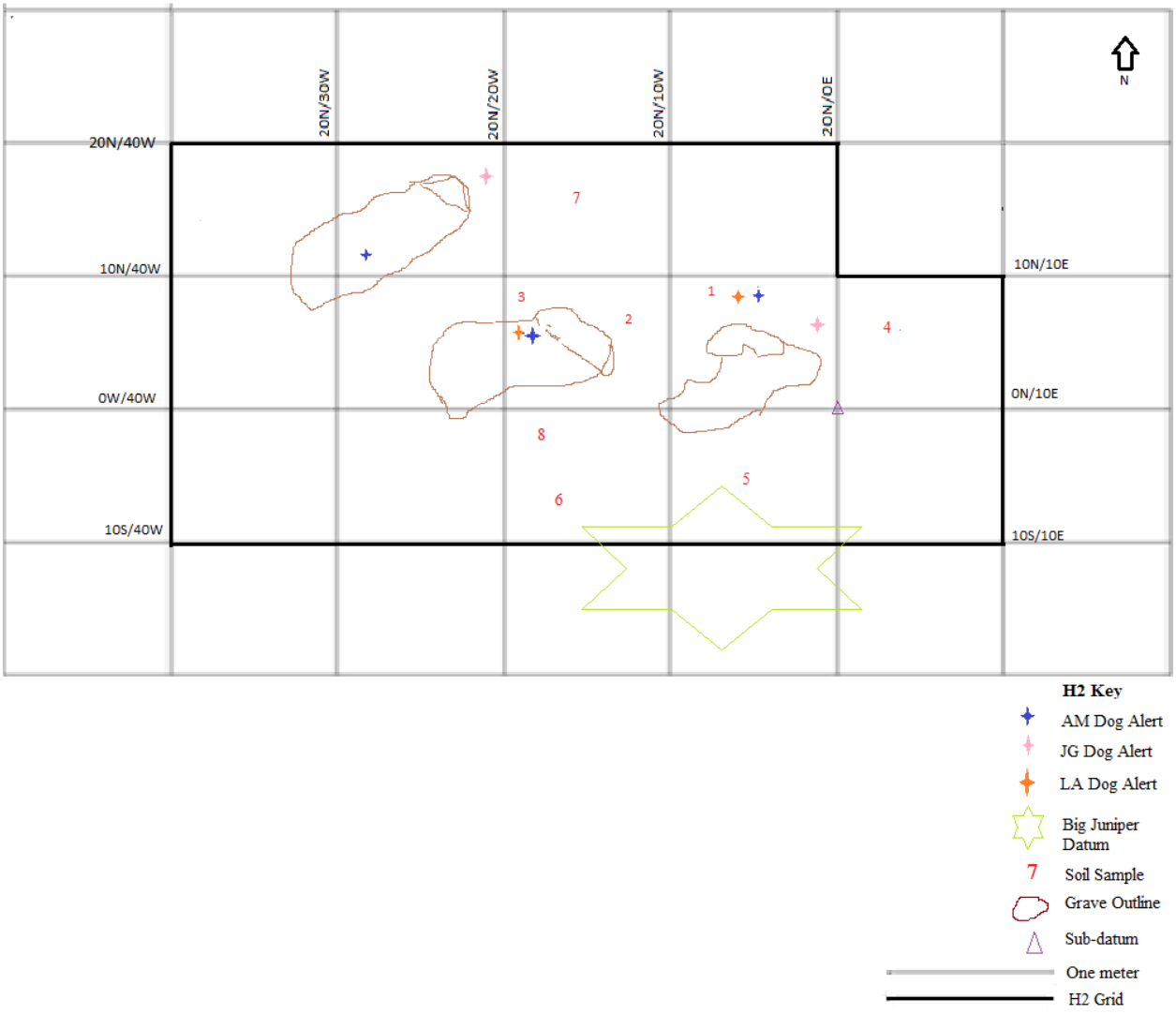

Figure 6.11: *H2 grid.*

At the H2 location, a sub-datum (railroad spike) was established just east of Grave 1. From this datum, the grid expanded in one meter squares to encompass the three graves. In the

end, the grid totaled 14 1x1 m squares. Due to the difficulty of penetrating the soil encountered in H1, and because of the larger sized grid, it was decided to probe every meter going N to S and E to W. In the end, no change in the soil indicated a grave cut, even with the new probe. Unlike at H1, where samples were pulled a distance from the alerts as suggested by Baxter and Hargrove (2015), at H2 it made sense to take samples directly from obvious grave-like features. Unfortunately, attempts to extract soil from the features themselves was not possible with the corer because it could not penetrate the layer of stones covering the graves. The samples were taken from areas in the grid that were penetrable and as close to the features as possible. Eight soil samples were taken at differing depths ranging from 0 to 24 cm.

Inorganic Chemical Soil Analyses

As with the Hill data, a selection of soil samples (18 including 3 controls) were taken from the Hebrew Cemetery and were subject to ICP-OES analysis (see Chapter 5) conducted at the Environmental Biogeochemistry Laboratory at the University of Montana; the methods and standards employed are similar to the Hill study, although the reported error rates indicate overall improved precision (Appendix B). QAQC measures were implemented following EPA Method 200.7. Error rates for testing as measured by method duplicates showed a range of ± 2.1% to ± 3% for Ca, Cu, K, Mg, Na, and Zn and ± 10.5% for P. A full QAQC report for ICP testing of these soil samples is reported in Appendix B.

In an attempt to find altered soil indicative of a grave, a cross-section of samples was analyzed from both H1 and H2. In this way, rather than analyzing all the levels of one sample chosen randomly, or all the levels of all the samples (fiscally prohibitive here), one level was taken from each of the 13 samples and 2 of the controls. For the third control, three out of four levels were analyzed. The controls for the Cemetery are named Control 1, Control 2, and

Control 3.

Results

The results of ICP-OES analyses of soil samples at control and dog alerted locations at the Hebrew Cemetery in Virginia City are shown in Table 7.

Table 7. Chemical Abundance in ppm and Ratios from ICP Analysis of Hebrew Cemetery Soil Samples

EBL ID #	Sample Name	Core Sample Depth (cm)	Ca	Cu	K	Mg	Na	P	Zn	Zn/Cu
1	H2	10-24	10390	45.2	3001	8608	1494	621	59.4	1.31
2	H2	9-25	9807	37.6	3048	7207	1578	738	56.4	1.50
3	H2	0-9	12928	45.3	2594	8412	2064	890	58.0	1.28
4	H2	0-11	8739	38.5	3098	7446	1499	698	62.9	1.64
5	H2	0-16	9416	35.0	3816	8079	1410	797	57.7	1.65
6	H2	0-13	10333	37.3	3339	7542	1629	739	60.8	1.63
7	H2	0-14	8669	34.8	3184	6864	1409	804	56.3	1.62
8	H2	10-18	11005	43.3	2833	8705	1769	629	62.6	1.45
9	Control 1 36 m SE of H1, Outside of HC	0-13	7798	33.4	2770	6713	1363	731	62.2	1.86
10	Control 2 21 m S of H2	10-22	9376	29.9	3182	7484	1199	697	55.7	1.86
11	Control 3a 16 m NE of H1	10-20	10998	37.1	4401	11919	719	521	61.4	1.66
12	Control 3b 16 m NE of H1	20-32	26763	32.8	3582	10046	975	690	53.1	1.62
13	Control 3c 16 m NE of H1	32-42	42793	32.4	3299	11529	886	657	46.3	1.43
14	H1	35-42	11421	32.5	3806	8594	1938	735	64.5	1.99
15	H1	12-22	12978	32.4	3067	8484	1552	785	61.5	1.90
16	H1	28-41	8769	29.8	4607	8789	1217	666	70.2	2.36
17	H1	9-26	9778	29.3	3375	7858	1074	640	59.1	2.01
18	H1	20-30	7843	28.9	3357	7186	1332	755	59.9	2.08

H2

Since depth levels of all soil samples were recorded as part of the field work at the Hebrew Cemetery, results have been divided into two levels at H2: 0-16 cm and 9-24 cm below surface. Percent differences in dog alerted samples at level 0-16 cm from H2 vs. Control 1 (0-13 cm) and dog alerted samples at level 9-25 cm from H2 vs. Control 2 (10-22 cm) are shown in Table 8.

Table 8. Percent Differences in Chemical Abundance in H2 Dog Alerted vs. Control Soil Samples in and near the Hebrew Cemetery

EBL ID #	Location vs. Control	Core Sample Depth (cm)	Ca	Cu	K	Mg	Na	P	Zn
3	H2 vs. Control 1 (0-13 cm)	0-9	66%	36%	-6%	25%	51%	22%	-7%
4	H2 vs. Control 1 (0-13 cm)	0-11	12%	15%	12%	11%	10%	-4%	1%
5	H2 vs. Control 1 (0-13 cm)	0-16	21%	5%	38%	20%	3%	9%	-7%
6	H2 vs. Control 1 (0-13 cm)	0-13	33%	12%	21%	12%	19%	1%	-2%
7	H2 vs. Control 1 (0-13 cm)	0-14	11%	4%	15%	2%	3%	10%	-9%
1	H2 vs. Control 2 (10-22 cm)	10-24	11%	51%	-6%	15%	25%	-11%	7%
2	H2 vs. Control 2 (10-22 cm)	9-25	5%	26%	-4%	-4%	32%	6%	1%
8	H2 vs. Control 2 (10-22 cm)	10-18	17%	45%	-11%	16%	48%	-10%	12%

Levels of all seven elements, with the notable exception of zinc, appear generally enriched in the dog alerted soil samples from the H2 site as compared to Control 1. Sample 3, level 0-9 cm, is the most curious sample because at that level in H2, all elements except K and Zn showing increases over the control. This sample was taken in close proximity to Grave 2. Samples 5 and 6 follow with Ca, K, and Mg showing increases over the control. Cu, Na, and P show some increase. Zn remained depleted compared to the control. These two samples were just north of the Big Juniper datum and south of Graves 1 and 2. Samples 4 and 7, found NE of Grave 1 and north of Graves 2 and 3 respectively, were minimally enriched.

A question here is whether such enrichment might be observed throughout the cemetery, because Control 1 was located outside the cemetery. A comparison of dog alerted samples within the cemetery compared with Control 2, also collected within the cemetery, addresses that question. Percent differences in dog alerted samples at level 9-24 cm vs. Control 2 from the Hebrew Cemetery (H2 vs. Control 2) are shown in Table 9.

At this lower level, H2 demonstrates generally enriched levels of Ca, Cu, Mg, Na, and Zn. Recall, though, that sodium is not considered strongly reliable in this study, based on the results from the Prague sites. Enrichment of Ca, Cu, and Mg at this level is consistent with the higher levels observed in the shallower range represented in Table 8. Samples 1 and 8 are the most enriched in Ca, Mg, and Na. P and K levels are depleted at this lower level. Values for

phosphorous do not appear to demonstrate a trend.

Table 9. Percent Differences in Chemical Abundance in H1 Dog Alerted vs. Control Soil Samples in and near the Hebrew Cemetery

EBL ID #	Location vs. Control	Core Sample Depth (cm)	Ca	Cu	K	Mg	Na	P	Zn
17	H1 vs. Control 1	9-26	25%	-12%	22%	17%	-21%	-12%	-5%
15	H1 vs. Control 1	12-22	66%	-3%	11%	26%	14%	7%	-1%
18	H1 vs. Control 1	20-30	1%	-14%	21%	7%	-2%	3%	-4%
16	H1 vs. Control 1	28-41	12%	-11%	66%	31%	-11%	-9%	13%
14	H1 vs. Control 1	35-42	46%	-3%	37%	28%	42%	1%	4%
17	H1 vs. Control 2	9-26	4%	-2%	6%	5%	-10%	-8%	6%
15	H1 vs. Control 2	12-22	38%	8%	-4%	13%	29%	13%	11%
18	H1 vs. Control 2	20-30	-16%	-4%	5%	-4%	11%	8%	8%
16	H1 vs. Control 2	28-41	-6%	0%	45%	17%	2%	-4%	26%
14	H1 vs. Control 2	35-42	22%	9%	20%	15%	62%	6%	16%

H1

For H1, soil samples started at 9 cm and ended at 42 cm below surface for a total of 5 samples. Percent differences in dog alerted samples at level H1 vs. Control 1 and Control 2 and the level increments are shown in Table 9. At levels 12-22 cm and 35-42 cm, samples 15 and 16 against Control 1 show the strongest indicator of representing remains. Ca, K, Mg, Na, and P are all elevated. Ca, K, and Mg remain increased over Control 1 for samples 16,17, and 18. Cu is decreased across all the samples, and Na, P, and Zn vary between samples. Sample 14, at 35-42 cm, shows an increase of all elements over Control 2.

Control 3

Finally, a percent comparison of abundances of elements in Controls 3a, 3b, and 3c vs. Controls 1 and 2 is merited and presented in Table 10.

Table 10. Percent Differences in Chemical Abundance in Control 3 vs. Controls 1 and 2 Soil Samples in and near the Hebrew Cemetery

Location vs. Control	Core Sample Depth (cm)	Ca	Cu	K	Mg	Na	P	Zn
Control 3a vs. Control 1	10-20	41%	11%	59%	78%	-47%	-29%	-1%
Control 3b vs. Control 1	20-32	243%	-2%	29%	50%	-28%	-6%	-15%
Control 3c vs. Control 1	32-42	449%	-3%	19%	72%	-35%	-10%	-26%
Control 3a vs. Control 2	10-20	17%	24%	38%	59%	-40%	-25%	10%
Control 3b vs. Control 2	20-32	185%	10%	13%	34%	-19%	-1%	-5%
Control 3c vs. Control 2	32-42	356%	8%	4%	54%	-26%	-6%	-17%

An effect that is readily observable is the relatively high values of some elements for

Controls 3a, 3b, and 3c relative to Controls 1 and 2 and even to some samples from dog alerted sites H1 and H2. Controls 3a, 3b, and 3c were all collected at increasing depths at one location east of H1 and H2. This sample set location was approximately 16 meters NE and up slope from H1 with a total grade difference of approximately 2 meters, and 36 meters SE with a 2-meter grade downslope from H2. All three dog alerted in the vicinity of the control, two alerts approximately five meters west and one alert three meters NW. At the time of taking the control, the flags were unseen. It should be noted that GPS coordinates have a 3-meter accuracy so though the three alerts appear near Control 3, on the ground that may look different. However, levels of enrichment of calcium, potassium, and magnesium at this Control 3 location could be considered indicative of a burial in the area.

Chapter 7

Discussion and Conclusion

Specialized detection dogs and seven inorganic elements, Ca, Cu, K, Mg, Na, P, and Zn, as well as Zn/Cu ratios, were selected for this project to be potential indicators of possible burials. At the time of a HHRD dog alert, a soil sample would be taken nearby and the elements would be tested. The Klecany and Cakovice sites, with the distinction of having a confirmed dog alert and access to soil at body level, substantially bolstered this project's hypothesis by showing that an alteration of the soil due to the addition of a body would be measurable. This Prague soil data is consistent with literature as indicative of a burial. This would be expected, but is confirmed by the inorganic soil analyses and further evidences the enrichment of six of the elements at burials. This was omitted when the Hill dataset was previously reported (Hill 2005).

At the Chi Yo marker in the Rock Creek Valley, soil samples where not collected at the request of the archaeologists from the Lolo National Forest. GPR was not possible and research into the property ownership and area historically did not yield insight into this marker. Further, the dogs did not alert at the Chi Yo marker. They did proceed to alert to eight other locations of decomposition scent. Three alternative explanations could account for these dog alerts, one being 6 m west, and the other seven below the Chi Yo marker: subsurface scent plumes, unknown burials, and/or scavenged remains. As discussed in Chapter 2, scent from buried remains can be channeled in subsurface plumes, water, or root systems and then surface at an opening in the ground. This is possible since the area of the marker is considerably upslope from seven of the eight alerts, less so to the alert just 6 m west, and the area is described as "excessively drained" by the NRCS. A contrary factor is that the remains of Chi Yo, if any, were toddler sized. Child burials, especially in acidic soil, tend to not last in the archaeological record (Gordon and

Buikstra 1981:569). However, given the demonstrated ability for trained dogs to alert to soil alone that once contained bones, the dogs could have been alerting to subsurface plumes from a burial at the Chi Yo marker.

The second alternative is that this was a burial ground, either pre or post contact, and that the dogs discovered it. Keyser et al. (1974) mentions the smallness of the trees compared to large stumps. In 1916, the hill would have been deforested thus offering a view of the meadow below, probably having been deforested for decades at that point due to mining and railroad building. Finally, if any burial was done on that hill or any remains left on the surface, they could have been unearthed and/or scavenged. The owner of the property mentioned that she thought the grave had been disturbed due to a new depression of the soil. This could be due to a robbery or it could indicate that a casket had collapsed. The Chi Yo site is an example of one where a variety of methods could not be implemented and as such is representative of limitations of current technology and knowledge when attempting to identify burials without excavation.

At Donner, the Hearth and Hearth Residue soil chemistry is indicative of human remains but also, potentially animal remains, for which there were several identified. This report at its basic level was testing for the inorganic residue of bone. Across species there are differences in bone tissue but the composition of it is the same (Von Endt and Ortner 1984:247). At this juncture one sees the limit of inorganic soil analysis and detection dogs when not directly tied to a known source as it was in Prague. Further, the HHRD dogs did not alert upon the hearth but in the vicinity which Grebenkemper and Johnson (2015) theorize could be lingering decomposition scent. In the case of Donner, remains may well have not been deposited in the form of full body burials in soil, but rather as surface deposits in the snow. Remains may have been subsequently moved and buried or scavenged, leaving only a lingering dog-detectable smell. Also, remains

might consist only of minute pieces of bone, and as with the conditions stated above, any effects on inorganic soil chemistry might be nominal and undetectable, or nonexistent. Finally, dogs alert where scent has settled at a moment in time. This is affected by wind, water, soil, and temperature fluctuations that can result in an alert near, and not necessarily above, remains.

As discussed in Chapter 5, it is possible the inorganic analysis of the hearth and residue did contain human bone but it was unidentifiable, yet the intense processing of human bones was not thought to have happened at Donner. Suggested explanations for the inorganic signature in the hearth, if it was human could be the result scavenging and scattering, or it was in fact, cooked human bone all of which could leave a signature. Together, the dog alerts, soil analysis, and historical sources are helping to narrow what may have happened at the Donner camps. The testing for areas of dog alerts outside the main grid at the Donner site was inconclusive.

Lolo site soil chemistry is not consistent with what would be expected for changes in enrichment at a burial. The assertion here is that based on soil chemistry, there is not a burial at the Lolo site nor it is located nearby. Dog alerts may have been confounded by factors such as plumes.

In the Hebrew Cemetery, there appears to be some evidence for burials at H1 and H2 at lower depths, but enrichment levels are not strong. The Control 3 location results may indicate leeching of elements from grave soil nearby, but are not conclusive.

Overall, inorganic chemical analyses of soil appear to correspond with HHRD dog alerts, as evidenced in the data from the two sites in Prague. Burials may be indicated by enrichment of Ca, Cu, K, Mg, P, and Zn. Such effects are notable, but do merit more extensive research.

In this study, reliability of HHRD dog alerts is assumed. Also, prior research on the specific effects of historic human burials on inorganic soil composition is used to support the

general view that soil chemistry provides another means to identify burials. The reanalysis of the Hill dataset is an attempt to find agreement between these two methods and, though a very small dataset, the results from the two sites in Prague appeared to bear out such agreement. The dog alerted sites had soil chemistry that is predicted according to the literature. The validity here relied on confirmation by the very strong third method: excavation. Thus, the Prague results were treated as a test for Donner, Lolo, and Virginia City. However, numerous other variables may be at play – pH levels of soil, soil composition, flooding or irrigating, the introduction of other chemicals such as fertilizer, type of burial, age of burial, depth of burial, and so on. So though there may be differences between control samples and HHRD alerted samples, the fact that the Prague dataset was so small – one control and one burial sample per site – it is problematic for its use in predicting the soil composition at all other burial sites.

The method of soil chemistry is foreseen as primarily playing a role of confirmation when other information suggests the presence of a burial. Large-scale exploratory soil testing is simply not practical, whereas the collection of too few samples could easily miss identifying burial locations. Therefore, inorganic soil analyses could prove useful in cases where a burial is suspected due to the presence of a marker, an apparent grave, and/or historic accounts and most useful at the level of a suspected burial, as in the case of a silhouette, where it could serve as an effective tool for confirmation. The Chi Yo marker is an example of a case where inorganic soil analyses could have been effective had collection been permitted.

Although there does appear to be some predictability of specific elemental changes in the soil chemistry, further and more robust research on the method of inorganic soil analysis is required to confirm its validity and reliability, with datasets adequately large for statistical analysis of the effect on soil of historic burials. Specifically, testing should be conducted at sites

where burials can be confirmed using other methods, on burials at various depths below surface, in a variety of soil types and subjected to a variety of environmental conditions, and on soil samples collected at a progression of depths from surface to body level. Future research should also take into account how elements move in the soil and at what points in time changes can be measured, as this could indicate when to expect enrichment near a body. Further, since it is known that elements do move in both directions in soil and bone, depletion of elements in burial soil could additionally be explored. Finally, research into inorganic elements in burial soil is often performed with remains found in acidic soil. Examination of the effects of neutral and alkaline soils would contribute to a more robust body of research. With further support of being a reliable measure, inorganic soil testing could prove a relatively cost effective and minimally invasive method for identifying the presence of historic human burials.

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Appendix A

The University of Montana - Geology Department
Environmental Biogeochemistry Laboratory

ICP Sample Analysis Results

Heidi Hill's Soil Samples

Analysis Date: 11/9/2005
Units: mg/kg

PQL — Practical Quantitation Limit (lower reporting limit)
b.d. — Concentration < PQL

Run	Sample Label #	Sample Label Info	Date Collected	Quad	Depth (cmbs)	MEBL ID	%Nitrogen	%Carbon	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Cu	Fe	Hg	K	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Ti	Tl	V	Zn	Zn
							PQL		20	2.5	1	0.5	0.05	10	0.4	0.5	1	1	1	10	8	80	80	0.5	40	0.4	0.5	80	1	6	8	10	8	8	5	2	0.5	1.5	10	2	0.4	0.4
18	1	Donner Party Alder Cr Control #5	7/14/2005		0-20	HH1	0.14	2.63	47570	6.6	b.d	202	1.7	2831	b.d	17.4	26.6	19.1	19.7	43500	b.d	648	830	9.9	2192	670	b.d	253	11.9	526	46.8	254	11.8	b.d	706	b.d	55.5	1418	10.1	161	73.7	74.6
19	2	Donner Party Alder Cr Control #6				HH2	0.03	0.54	25130	3.3	b.d	100	0.9	5132	b.d	5.8	8.5	15.8	16.4	20400	b.d	565	822	6.1	3053	49.5	b.d	354	4.9	133	24.8	65.3	b.d	b.d	705	b.d	78.1	289	b.d	49.3	39.2	39.1
20	3	Donner Party Alder Cr Control #7				HH3	0.03	0.61	30690	4.2	3.3	117	0.7	4491	b.d	7.5	9.5	18.0	19.6	18460	b.d	703	550	6.8	2937	67.8	b.d	297	4.9	151	29.2	78.8	b.d	b.d	646	b.d	69.7	418	b.d	56.6	34.2	34.5
21	4	Donner Family Camp Unit G		NW	30-40	HH4	0.06	0.87	54040	6.5	4.1	223	1.5	2018	b.d	16.7	30.7	23.1	24.3	45450	b.d	716	516	11.5	2147	905	b.d	154	12.2	467	51.8	122	11.4	b.d	682	b.d	44.5	1717	b.d	176	79.9	82.2
22	5	Donner Family Camp Unit George	7/11/2004	NW	30-40	HH5	0.05	0.92	55570	6.5	2.9	253	1.6	2120	b.d	21.0	33.6	19.7	21.3	50140	b.d	816	460	12.1	2252	1120	b.d	180	13.7	513	54.6	123	11.5	b.d	695	b.d	47.1	1805	b.d	192	83.5	85.8
23	6	Donner Family Camp Unit George	7/11/2004	SW	40-50	HH6	0.03	0.57	53150	6.8	b.d	217	1.9	2307	b.d	21.3	31.5	22.3	22.3	51990	b.d	546	670	10.6	2958	707	b.d	204	12.5	395	48.9	70.0	13.5	b.d	660	b.d	49.4	1552	b.d	194	68.8	70.0
24	7	Donner Family Camp Unit George	7/11/2004	NE	50-60	HH7	0.01	0.27	47730	6.0	b.d	205	1.5	2705	b.d	15.4	23.3	18.6	20.4	41860	b.d	452	708	7.6	3827	480	b.d	245	10.5	176	41.5	38.9	11.6	b.d	630	b.d	52.7	1176	b.d	131	51.1	51.3
25	8	Donner Family Camp Unit George	7/11/2004	SE	50-60	HH8	0.03	0.68	51820	6.5	b.d	226	1.5	2630	b.d	14.8	31.3	20.7	22.1	46390	b.d	675	455	9.9	3141	568	b.d	241	12.4	371	48.9	92.6	11.5	b.d	737	b.d	53.2	1490	b.d	171	63.3	65.0
32	9	Donner Family Camp Unit George	7/11/2004	SW	60-70	HH9	0.01	0.32	45780	5.7	b.d	186	1.4	2645	b.d	10.2	28.3	18.8	21.1	42630	b.d	547	453	8.1	3720	233	b.d	248	10.2	220	41.2	55.5	10.5	b.d	668	b.d	52.1	1258	b.d	144	52.4	53.2
33	10	Donner Family Camp Unit George	7/11/2004	NW	70-80	HH10	0.00	0.18	45180	6.0	b.d	199	1.4	2897	b.d	12.8	21.2	20.0	20.8	43340	b.d	508	515	8.5	3890	375	b.d	261	10.3	207	40.6	28.9	10.2	b.d	599	b.d	56.4	1168	b.d	129	55.8	56.6
35	11	Donner Family Camp Unit George	7/11/2004	NE	80-90	HH11	0.00	0.14	45410	6.3	b.d	197	1.4	3296	b.d	11.4	21.0	19.3	20.8	41750	b.d	385	589	8.3	4087	242	b.d	312	10.1	182	38.8	21.8	9.7	b.d	678	b.d	61.6	1105	b.d	123	52.2	52.4
36	12	Donner Family Camp Unit George	7/11/2004	SE	90-100	HH12	0.01	0.35	43400	5.4	b.d	182	1.2	2854	b.d	9.2	23.0	17.1	17.1	35260	b.d	432	599	8.0	3522	280	b.d	290	10.3	232	38.3	46.5	9.5	b.d	661	b.d	55.4	1084	b.d	105	51.5	51.5
37	13	Donner Family Camp Control Soils #2 83 Green Clay Deposit bag 2 of 2 Unit George	8/16/1990		mound shovel test	HH13	0.02	0.71	24830	3.6	b.d	107	0.9	5339	b.d	5.6	9.4	12.9	14.0	19560	b.d	701	643	6.5	3268	54.0	b.d	342	5.3	147	25.7	64.9	b.d	b.d	592	b.d	80.5	218	b.d	48.5	40.7	40.6
38	14	Donner Family Camp bag # 82 Ashy Deposit Unit George	8/16/1990		mound shovel test	HH14	0.03	0.62	29970	3.8	b.d	111	0.8	4251	b.d	6.7	9.7	14.9	16.0	18630	b.d	517	776	6.8	2787	59.5	b.d	300	5.4	153	28.5	77.1	b.d	b.d	658	b.d	67.6	389	b.d	54.1	32.5	32.1
39	15	Donner Family Camp Feature 1: Hearth Residue bag 1 of 2 units D,E,F Unit George	8/8/2003			HH15	0.11	2.12	54820	7.5	b.d	243	2.5	7386	b.d	20.4	27.3	23.6	23.5	52680	b.d	462	959	12.0	1931	652	b.d	270	15.2	3754	66.4	191	13.6	b.d	658	2.0	58.6	1492	10.0	176	101	103
40	16	Donner Family Camp Feature 2: Hearth. bag 1 of 3 Unit George	2004			HH16	0.10	3.22	49870	6.6	b.d	373	1.8	13320	b.d	20.3	29.5	36.3	37.8	47670	b.d	636	661	10.8	2106	1318	b.d	273	13.3	6377	81.5	152	11.5	b.d	635	2.2	86.8	1394	b.d	163	118	122
41	17	Lolo Grave Control 1				HH17	0.09	1.96	20870	5.5	b.d	139	1.0	3567	b.d	5.3	9.1	13.0	13.7	19460	b.d	6240	5947	33.1	12230	502	b.d	82.2	13.8	433	26.7	103	b.d	b.d	504	b.d	7.8	655	b.d	16.6	57.6	56.5
42	18	Lolo Grave Control 2				HH18	0.04	1.50	18250	11.9	b.d	104	0.9	11960	b.d	5.1	8.7	9.3	10.4	18540	b.d	5018	4925	31.9	12140	531	b.d	b.d	11.7	412	23.1	62.5	b.d	b.d	720	b.d	8.5	571	b.d	15.2	51.3	50.9
48	19	Lolo Grave Dog Alert 1				HH19	0.07	1.46	20920	5.7	b.d	130	1.0	2594	b.d	7.3	9.5	9.9	9.4	19970	b.d	6001	5672	34.7	12390	506	b.d	b.d	14.4	335	28.3	86.3	b.d	b.d	501	b.d	6.7	678	b.d	16.6	53.4	52.3
49	20	Lolo Grave Dog Alert 2				HH20	0.04	1.41	19660	5.4	b.d	122	0.9	3059	b.d	5.4	8.6	9.2	10.9	19400	b.d	4528	4472	35.2	11890	542	b.d	b.d	14.4	335	30.4	66.1	b.d	b.d	484	b.d	6.7	652	b.d	16.1	52.2	51.2
53	21	Lolo Grave Dog Alert 3		NE		HH21	0.07	1.98	21150	5.7	b.d	140	1.0	2881	b.d	5.0	9.1	10.6	11.0	19610	b.d	6470	6260	34.1	12040	525	b.d	b.d	13.4	391	27.1	85.2	b.d	b.d	629	b.d	7.6	691	b.d	17.2	54.2	53.1
54	22	Lolo Grave Dog Alert 4		NE Stump		HH22	0.08	3.14	19090	5.1	b.d	116	0.9	2993	b.d	4.7	9.8	11.5	12.7	19740	b.d	5582	5586	34.3	13290	442	b.d	b.d	16.9	519	26.3	107	b.d	b.d	490	b.d	6.3	634	b.d	15.9	61.5	60.0
55	23	Pig Burial front legs				HH23	0.07	0.75	3460	3.0	b.d	34.6	0.4	534	b.d	1.3	14.8	1.1	1.8	11000	b.d	1212	1435	2.7	555	58.2	1.7	242	2.7	550	b.d	237	b.d	b.d	427	2.0	6.7	198	b.d	15.7	15.1	14.8
56	24	Pig Skull Sample				HH24	0.03	0.69	4655	3.6	b.d	53.4	0.4	648	b.d	1.6	11.3	57.1	57.1	12500	b.d	1592	1578	3.6	721	84.3	2.0	320	20.2	237	11.7	90.7	b.d	b.d	420	3.2	9.4	267	b.d	18.0	2204	2145
63	25	Control Soil - Klecany Prague	2005			HH25	0.04	1.29	13210	11.7	6.4	87.8	1.1	17540	b.d	7.3	19.5	9.7	11.3	16740	b.d	2974	2817	12.4	3003	501	b.d	103	17.4	590	25.7	968	b.d	b.d	598	b.d	36.4	256	b.d	29.3	38.2	38.4
64	26	Control Soil - Cakovice Prague	2005			HH26	0.04	1.95	16060	9.0	9.2	83.1	1.1	34910	b.d	7.5	22.4	8.4	10.1	19390	b.d	2866	2653	16.7	5118	384	b.d	137	20.3	392	24.2	203	b.d	b.d	503	b.d	71.7	296	b.d	33.8	39.8	40.5
65	27	Chest Soil - Cakovice Prague	7/18/2005			HH27	0.06	2.77	15620	9.4	10.2	84.1	1.1	52010	b.d	7.1	22.9	9.2	10.7	18730	b.d	3089	2864	17.9	5795	370	b.d	110	20.0	955	23.0	265	b.d	b.d	647	b.d	78.2	277	b.d	32.8	42.7	44.0
66	28	Pelvis Soil - Klecany Prague Late 800-900 AD	JUL 2005			HH28	0.04	1.52	17030	10.1	7.6	89.3	1.3	24830	b.d	7.7	24.1	9.8	11.9	19210	b.d	3468	3414	15.2	4053	408	b.d	111	20.1	1005	23.8	133	b.d	b.d	742	b.d	53.5	247	b.d	32.8	51.7	52.0

Original Hill Dataset ICP-OES Soil Analyses, 2005

Appendix B

The University of Montana - Geology Department
Environmental Biogeochemistry Laboratory

ICP Quality Assurance/Quality Control Report

Heidi Hill, CFR, Andy Bookter

Analysis Date: 11/9/2005
Units: mg/L
EPA Method: 6010

Run #	Sample Name	Comment	Corr. F.	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Ti	Tl	V	Zn
PQL				0.2	0.025	0.01	0.005	0.0005	0.1	0.004	0.005	0.01	0.01	0.1	0.08	0.8	0.005	0.4	0.004	0.005	0.8	0.01	0.06	0.08	0.1	0.08	0.08	0.05	0.02	0.005	0.015	0.1	0.02	0.004
LDR				1000	100	100	50	5	2000	100	100	100	500	1500	100	100	30	2000	400	100	50	100	250	100	1000	100	100	100	100	25	100	0	100	50
BLANKS																																		
Laboratory/Analytical Blanks ("LBLANK")																																		
	Number of LBLANKs:	8																																
	Instrument Output																																	
15	Blank1		1.000	0.0	0.00	0.00	-0.001	0.000	0.0	0.001	0.000	-0.01	0.00	0.0	0.00	1.8	0.003	0.0	0.00	0.00	0.0	0.00	-0.02	-0.01	0.0	-0.01	0.00	-0.01	0.01	0.00	-0.001	0.0	-0.01	0.001
30	LBLANK		1.000	0.0	0.00	0.00	0.000	0.000	0.1	0.000	0.001	-0.01	0.00	0.0	0.00	1.0	0.001	0.0	0.00	0.00	0.1	0.00	-0.03	-0.01	0.0	0.01	-0.01	0.00	0.00	0.00	-0.001	0.0	0.00	0.001
46	LBLANK		1.000	0.0	0.00	0.00	0.000	0.000	0.0	0.001	0.001	-0.01	0.00	0.0	0.00	1.6	0.000	0.0	0.00	0.00	0.0	0.00	-0.02	-0.01	0.0	0.00	-0.01	-0.01	0.00	0.00	-0.004	0.0	0.00	0.000
61	LBLANK		1.000	0.0	0.00	0.00	-0.001	0.000	0.0	0.000	0.001	-0.01	0.00	0.0	0.00	-0.3	-0.002	0.0	0.00	0.00	-0.2	0.00	-0.03	-0.01	0.0	0.00	-0.01	0.00	0.00	0.00	-0.001	0.0	0.00	0.000
76	LBLANK		1.000	0.0	0.00	0.00	0.000	0.000	0.0	0.001	0.001	-0.02	-0.01	0.0	0.00	3.9	-0.002	0.0	0.00	0.00	0.2	0.00	-0.03	-0.01	0.0	0.00	-0.01	0.00	0.00	0.00	-0.006	0.0	0.00	0.002
92	LBLANK		1.000	0.0	0.00	0.00	0.001	0.000	0.0	0.001	0.000	-0.01	0.00	0.0	0.00	1.9	-0.002	0.0	0.00	0.00	-0.1	0.00	-0.03	-0.01	0.0	0.01	0.00	-0.01	0.00	0.00	-0.004	0.0	0.00	0.002
107	LBLANK		1.000	0.0	0.01	0.00	-0.001	0.000	0.0	0.001	0.001	-0.01	0.00	0.0	0.00	1.2	-0.001	0.0	0.00	0.00	0.0	0.00	-0.03	-0.01	0.0	0.01	-0.01	-0.01	0.00	0.00	-0.002	0.0	0.00	0.000
114	LBLANK		1.000	0.0	0.00	0.00	0.000	0.000	0.0	0.000	0.001	0.00	0.00	0.0	0.00	2.3	-0.001	0.0	0.00	0.00	0.0	0.00	0.01	-0.01	0.0	0.00	0.00	0.00	0.00	0.00	-0.004	0.0	0.00	0.001
	Reported Concentration																																	
15	Blank1			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	1.8	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
30	LBLANK			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	1.0	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
46	LBLANK			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	1.6	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
61	LBLANK			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
76	LBLANK			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	3.9	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
92	LBLANK			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	1.9	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
107	LBLANK			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	1.2	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
114	LBLANK			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	2.3	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
Method Blanks (e.g. Digestion Blanks, "MBLANK")																																		
	Number of MBLANKs:	3																																
	Instrument Output																																	
17	MBlank		1.000	0.0	0.00	0.00	0.000	0.000	0.1	0.000	0.001	-0.01	0.00	0.0	0.00	0.7	-0.002	0.0	0.00	0.00	0.0	0.00	0.18	-0.01	0.0	0.01	0.00	0.01	0.02	0.00	-0.003	0.0	0.00	0.004
52	MBLANK		1.000	0.0	0.00	0.00	0.001	0.000	0.0	0.001	0.000	-0.01	0.00	0.1	0.00	1.5	-0.003	0.0	0.00	0.00	0.1	0.00	0.13	-0.01	0.0	0.00	0.00	0.01	0.02	0.00	-0.002	0.0	0.00	0.006
71	MBLANK		1.000	0.0	0.00	0.00	0.001	0.000	0.0	0.000	0.000	-0.01	-0.01	0.0	0.00	1.6	0.000	0.0	0.01	0.00	0.2	0.00	0.08	0.00	0.0	0.00	0.00	0.02	0.01	0.00	0.001	0.0	0.00	0.008
	Reported Concentration																																	
17	MBlank			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	0.2	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	0.0
52	MBLANK			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	0.1	b.d.	1.5	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	0.1	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	0.0
71	MBLANK			b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	1.6	b.d.	b.d.	0.0	b.d.	b.d.	b.d.	0.1	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	0.0
INTERNAL PERFORMANCE CHECKS																																		
CCV																																		
	No. of CCV analyzed:	9																																
	Nominal Concentration (mg/L)			**33.33**	**3.33**	**0.667**	**0.667**	**0.333**	**33.33**	**0.667**	**1.67**	**1.67**	**3.33**	**33.3**	**0.166667**	**6.66**	**0.333**	**16.67**	**3.33**	**0.667**	**3.33**	**0.667**	**3.33**	**3.33**	**13.33**	**3.33**	**3.33**	**6.667**	**3.33**	**0.333**	**3.33**	**1.667**	**1.667**	**3.33**
	Measured Concentration (mg/L)																																	
10	CCV		1.000	34.3	3.45	0.69	0.678	0.342	34.4	0.692	1.728	1.71	3.40	34.4	0.01	7.8	0.344	17.8	3.56	0.68	4.8	0.69	3.43	3.56	13.9	3.45	3.44	6.86	3.43	0.33	3.423	1.8	1.76	3.534
31	CCV		1.000	35.0	3.53	0.72	0.694	0.353	34.6	0.724	1.782	1.78	3.49	35.4	0.01	5.7	0.352	18.2	3.67	0.70	3.1	0.71	3.58	3.68	15.0	3.54	3.68	7.21	3.56	0.34	3.663	1.8	1.80	3.695
44	CCV		1.000	32.6	3.29	0.66	0.641	0.326	31.8	0.675	1.651	1.64	3.20	32.9	0.01	7.1	0.327	17.0	3.38	0.65	3.2	0.65	3.34	3.47	13.8	3.28	3.39	6.65	3.31	0.31	3.390	1.6	1.66	3.450
59	CCV		1.000	31.2	3.25	0.66	0.634	0.323	30.4	0.669	1.634	1.56	3.06	32.4	0.01	7.6	0.309	16.2	3.35	0.64	3.2	0.64	3.33	3.44	13.7	3.24	3.39	6.60	3.29	0.30	3.214	1.6	1.58	3.420
74	CCV		1.000	31.4	3.25	0.64	0.617	0.322	29.9	0.671	1.637	1.56	3.04	32.3	0.01	8.3	0.315	16.1	3.29	0.63	3.3	0.64	3.32	3.42	13.4	3.20	3.31	6.54	3.23	0.30	3.204	1.6	1.57	3.395
90	CCV		1.000	31.8	3.25	0.66	0.636	0.321	31.4	0.666	1.626	1.58	3.11	32.4	0.01	7.4	0.315	16.6	3.35	0.64	3.2	0.65	3.34	3.42	13.8	3.25	3.39	6.57	3.30	0.30	3.280	1.6	1.60	3.428
105	CCV		1.000	32.3	3.26	0.65	0.627	0.320	31.3	0.668	1.628	1.60	3.13	32.2	0.01	8.7	0.318	16.5	3.31	0.63	3.2	0.64	3.34	3.41	13.6	3.23	3.37	6.55	3.26	0.31	3.256	1.6	1.62	3.402
127	CCV		1.000	32.7	3.27	0.67	0.664	0.323	32.7	0.643	1.612	1.67	3.33	32.4	0.02	5.0	0.317	17.4	3.46	0.65	3.1	0.66	3.31	3.33	13.9	3.30	3.49	6.58	3.38	0.32	3.405	1.7	1.69	3.396
130	CCV		1.000	32.9	3.32	0.66	0.650	0.329	31.9	0.661	1.658	1.63	3.27	33.0	0.02	7.8	0.326	17.0	3.44	0.65	3.2	0.66	3.36	3.39	13.7	3.30	3.43	6.65	3.33	0.32	3.300	1.7	1.67	3.410
	Measured/Nominal Concentration (%)																																	
10	CCV			103	104	103	102	103	103	104	103	103	102	103	8	117	103	107	107	107	102	144	103	103	107	105	104	103	103	100	103	105	105	106
31	CCV			105	106	109	104	106	104	109	107	106	105	106	8	85	106	109	110	105	92	106	108	111	112	106	111	108	107	103	110	107	108	111
44	CCV			98	99	99	96	98	95	101	99	98	96	99	7	106	98	102	102	97	96	98	100	104	104	98	102	100	100	94	102	98	99	104
59	CCV			94	98	98	95	97	91	100	98	94	92	97	8	115	93	97	100	96	96	97	100	103	103	97	102	99	99	90	97	97	95	103
74	CCV			94	97	96	92	97	90	101	98	93	91	97	8	124	95	97	99	94	99	96	100	103	100	96	99	98	97	90	96	96	94	102
90	CCV			95	98	98	95	97	94	100	97	95	93	97	8	111	95	100	101	96	98	97	100	103	103	97	102	99	99	91	98	97	96	103
105	CCV			97	98	97	94	96	94	100	97	96	94	97	8	131	96	99	99	95	97	96	100	102	102	97	101	98	98	93	98	97	97	102
127	CCV			98	98	100	100	97	98	96	97	100	100	97	13	75	95	104	104	98	94	98	100	100	104	99	105	99	101	96	102	101	101	102
130	CCV			99	100	99	98	99	96	99	99	98	98	99	13	117	98	102	103	97	95	99	101	102	102	99	103	100	100	96	99	100	100	102
IPC4																																		
	No. of IPC4 analyzed:	8																																
	Nominal Concentration (mg/L)			**10**	**1**	**0.2**	**0.2**	**0.1**	**10**	**0.2**	**0.5**	**0.5**	**1**	**10**	**0.5**	**20**	**0.1**	**5**	**1**	**0.2**	**10**	**0.2**	**1**	**1**	**0.5**	**1**	**1**	**2**	**1**	**0.1**	**1**	**0.5**	**0.5**	**1**
	Measured Concentration (mg/L)																																	
11	IPC4		1.000	9.9	0.95	0.22	0.217	0.094	10.1	0.202	0.502	0.50	1.01	10.1	0.06	19.3	0.099	5.1	1.08	0.19	10.1	0.20	0.92	1.04	0.5	1.00	1.01	2.37	1.00	0.10	1.044	0.5	0.53	1.017
28	IPC4		1.000	9.7	0.93	0.21	0.209	0.092	9.9	0.198	0.493	0.48	0.98	9.9	0.06	19.6	0.093	5.0	1.05	0.18	9.9	0.20	0.96	1.02	0.5	0.97	0.96	2.29	0.97	0.10	1.023	0.5	0.51	0.996
45	IPC4		1.000	9.5	0.93	0.21	0.200	0.092	9.4	0.201	0.497	0.46	0.94	9.9	0.06	21.6	0.093	4.8	1.02	0.18	9.8	0.19	0.96	1.02	0.5	0.96	0.93	2.29	0.94	0.10	0.957	0.5	0.50	0.984
60	IPC4		1.000	9.6	0.93	0.22	0.209	0.092	9.8	0.197	0.488	0.48	0.97	9.8	0.06	19.0	0.091	5.0	1.05	0.18	9.8	0.20	0.96	1.01	0.5	0.96	0.96	2.30	0.97	0.10	1.000	0.5	0.51	0.991
75	IPC4		1.000	9.9	0.96	0.22	0.212	0.097	9.9	0.209	0.520	0.48	0.99	10.4	0.06	21.1	0.096	5.0	1.08	0.19	10.1	0.20	1.01	1.06	0.5	1.01	1.00	2.42	1.00	0.10	1.014	0.5	0.52	1.033
91	IPC4		1.000	9.9	0.94	0.22	0.207	0.094	9.9	0.203	0.503	0.48	0.98	10.0	0.06	21.2	0.098	5.0	1.05	0.19	10.1	0.20	0.99	1.03	0.5	0.98	0.96	2.33	0.97	0.10	1.005	0.5	0.52	1.006
106	IPC4		1.000	9.5	0.93	0.22	0.208	0.091	9.7	0.196	0.486	0.47	0.96	9.8	0.06	19.1	0.092	4.9	1.04	0.18	9.9	0.19	0.97	1.01	0.5	0.96	0.97	2.29	0.97	0.10	0.995	0.5	0.51	0.988
128	IPC4		1.000	9.6	0.91	0.21	0.213	0.091	9.9	0.187	0.478	0.50	1.00	9.7	0.09	17.7	0.092	5.1	1.06	0.19	9.9	0.20	0.97	0.98	0.5	0.96	0.97	2.25	0.98	0.10	1.007	0.5	0.52	0.972
	Measured/Nominal Concentration (%)																																	
11	IPC4			99	95	111	108	94	101	101	100	101	101	101	12	97	99	103	108	96	101	102	92	104	100	100	101	119	100	101	104	101	106	102
28	IPC4			97	93	107	105	92	99	99	99	97	98	99	12	98	93	101	105	92	99	98	96	102	101	97	96	115	97	98	102	100	103	100
45	IPC4			95	93	105	100	92	94	100	99	92	94	99	12	108	93	95	102	90	98	97	96	102	94	96	93	115	94	96	96	100	100	98
60	IPC4			96	93	108	104	92	98	98	98	96	97	98	12	95	91	99	105	92	98	98	96	101	99	96	96	115	97	97	100	102	101	99
75	IPC4			99	96	112	106	97	99	105	104	97	99	104	12	105	96	100	108	95	101	101	101	106	101	101	100	121	100	100	101	107	104	103
91	IPC4			99	94	108	103	94	99	101	101	96	98	100	12	106	98	100	105	93	101	99	99	103	100	98	96	117	97	100	101	103	104	101
106	IPC4			95	93	108	104	91	97	98	97	95	96	98	12	95	92	99	104	92	99	97	97	101	102	96	97	114	97	97	100	101	102	99
128	IPC4			96	91	107	107	91	99	94	96	99	100	97	17	88	92	102	106	93	99	99	97	98	102	96	97	113	98	98	101	101	103	97

ICP Quality Assurance/Quality Control Report

Heidi Hill, CFR, Andy Bookter

Analysis Date: 11/9/2005
Units: mg/L
EPA Method: 6010

Run #	Sample Name	Comment	Corr. F.	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Ti	Tl	V	Zn
STANDARD REFERENCE MATERIALS																																		
	Number of SRMs:	6																																
NIST8704																																		
	Measured Concentrations (mg/L)																																	
16	NIST8704		1.000	122.8	0.16	-0.01	0.751	0.013	219.3	0.017	0.104	0.67	0.80	313.4	0.00	19.0	0.261	82.3	4.35	0.02	1.1	0.36	8.39	1.46	35.4	0.06	-0.01	5.41	0.06	0.30	0.784	0.0	0.23	3.643
	Measured Recovery (%)																																	
16	NIST8704			20	68	n.a.	18	n.a.	84	50	75	50	81	76	n.a.	10	55	69	78	n.a.	2	82	84	90	89	n.a.	n.a.	0	60	23	2	n.a.	24	83
	Additional Standard Reference Material Information:																																	
	Measured Concentrations (mg/kg)																																	
16	NIST8704		100	12280	16	b.d.	75	1	21930	2	10	67	80	31340	b.d.	1900	26	8233	435	2	109	36	839	146	3542	b.d.	b.d.	541	6	30	78	b.d.	23	364
	Nominal Conc. (mg/kg)			61100	23.4	not reported	414	not reported	26000	3.45	14	135	98.6	41100	1.47	20000	47.5	12000	555	not reported	5470	44.1	998	161	3970	3.79	1.12	290800	9.5	130	4570	1.06	95	438
	Range (mg/kg)			1600	0.8		12		300	0.22	0.6	5	5	1000	0.07	400	4.1	200	19		140	3	28	17	40	0.15	0.05	1300			180	0.07	4	12
NIST8704																																		
	Measured Concentrations (mg/L)																																	
51	NIST8704		1.000	120.3	0.15	0.01	0.741	0.012	216.4	0.017	0.100	0.65	0.77	301.6	0.00	18.1	0.256	81.8	4.23	0.02	1.1	0.35	8.30	1.44	34.3	0.06	-0.01	5.20	0.05	0.30	0.782	0.0	0.23	3.516
	Measured Recovery (%)																																	
51	NIST8704			20	65	n.a.	18	n.a.	83	50	71	48	78	73	n.a.	9	54	68	76	n.a.	2	79	83	90	86	n.a.	n.a.	0	56	23	2	n.a.	24	80
	Additional Standard Reference Material Information:																																	
	Measured Concentrations (mg/kg)																																	
51	NIST8704		100	12030	15	1	74	1	21640	2	10	65	77	30160	b.d.	1812	26	8178	423	2	115	35	830	144	3430	b.d.	b.d.	520	5	30	78	b.d.	23	352
	Nominal Conc. (mg/kg)			61100	23.4	not reported	414	not reported	26000	3.45	14	135	98.6	41100	1.47	20000	47.5	12000	555	not reported	5470	44.1	998	161	3970	3.79	1.12	290800	9.5	130	4570	1.06	95	438
	Range (mg/kg)			1600	0.8		12		300	0.22	0.6	5	5	1000	0.07	400	4.1	200	19		140	3	28	17	40	0.15	0.05	1300			180	0.07	4	12
NIST2710																																		
	Measured Concentrations (mg/L)																																	
70	NIST2710		1.000	172.8	5.44	-0.04	2.985	0.014	37.4	0.182	0.068	0.15	26.03	259.1	0.05	46.6	0.244	49.8	65.15	0.15	5.0	0.10	8.33	51.19	20.7	0.13	0.01	6.46	0.02	0.94	8.802	-0.3	0.47	54.360
	Measured Recovery (%)																																	
70	NIST2710			27	87	n.a.	42	n.a.	30	84	n.a.	n.a.	88	77	n.a.	22	n.a.	58	65	n.a.	4	70	79	93	86	n.a.	n.a.	0	n.a.	n.a.	31	n.a.	61	78
	Additional Standard Reference Material Information:																																	
	Measured Concentrations (mg/kg)																																	
70	NIST2710		100	17280	544	b.d.	299	1	3743	18	7	15	2603	25910	b.d.	4655	24	4981	6515	15	501	10	833	5119	2069	13	b.d.	646	b.d.	94	880	b.d.	47	5436
	Nominal Conc. (mg/kg)			64400	626	not reported	707	not reported	12500	21.8	not reported	not reported	2950	33800	32.6	21100	not reported	8530	10100	not reported	11400	14.3	1060	5532	2400	not reported	not reported	289700	not reported	not reported	2830	not reported	76.6	6952
	Range (mg/kg)			800	38		51		300	0.2			130	1000	1.8	1100		420	400		600	1	150	80	60			1800			100		2.3	91
NIST8704																																		
	Measured Concentrations (mg/L)																																	
115	NIST8704		1.000	106.0	0.14	0.02	0.697	0.011	211.9	0.014	0.094	0.63	0.76	286.1	0.00	14.1	0.225	79.2	4.21	0.02	1.1	0.33	7.75	1.28	32.9	0.05	0.01	5.05	0.05	0.28	0.590	0.0	0.20	3.377
	Measured Recovery (%)																																	
115	NIST8704			17	60	n.a.	17	n.a.	82	41	67	47	77	70	n.a.	7	47	66	76	n.a.	2	75	78	80	83	n.a.	n.a.	0	55	21	1	n.a.	21	77
	Additional Standard Reference Material Information:																																	
	Measured Concentrations (mg/kg)																																	
115	NIST8704		100	10600	14	2	70	1	21190	1	9	63	76	28610	b.d.	1406	22	7924	421	2	105	33	775	128	3286	b.d.	b.d.	505	5	28	59	b.d.	20	338
	Nominal Conc. (mg/kg)			61100	23.4	not reported	414	not reported	26000	3.45	14	135	98.6	41100	1.47	20000	47.5	12000	555	not reported	5470	44.1	998	161	3970	3.79	1.12	290800	9.5	130	4570	1.06	95	438
	Range (mg/kg)			1600	0.8		12		300	0.22	0.6	5	5	1000	0.07	400	4.1	200	19		140	3	28	17	40	0.15	0.05	1300			180	0.07	4	12
NIST8704																																		
	Measured Concentrations (mg/L)																																	
116	NIST8704		1.000	107.0	0.14	0.07	0.734	0.010	216.2	0.014	0.094	0.64	0.78	284.8	0.00	12.0	0.229	81.5	4.29	0.03	1.0	0.34	7.75	1.34	33.7	0.05	0.01	3.51	0.05	0.28	0.573	0.0	0.20	3.330
	Measured Recovery (%)																																	
116	NIST8704			18	61	n.a.	18	n.a.	83	41	67	48	79	69	n.a.	6	48	68	77	n.a.	2	77	78	83	85	n.a.	n.a.	0	53	22	1	n.a.	21	76
	Additional Standard Reference Material Information:																																	
	Measured Concentrations (mg/kg)																																	
116	NIST8704		100	10700	14	7	73	1	21620	1	9	64	78	28480	b.d.	1204	23	8146	429	3	96	34	775	134	3369	b.d.	b.d.	351	5	28	57	b.d.	20	333
	Nominal Conc. (mg/kg)			61100	23.4	not reported	414	not reported	26000	3.45	14	135	98.6	41100	1.47	20000	47.5	12000	555	not reported	5470	44.1	998	161	3970	3.79	1.12	290800	9.5	130	4570	1.06	95	438
	Range (mg/kg)			1600	0.8		12		300	0.22	0.6	5	5	1000	0.07	400	4.1	200	19		140	3	28	17	40	0.15	0.05	1300			180	0.07	4	12
NIST8704																																		
	Measured Concentrations (mg/L)																																	
117	NIST8704		1.000	109.9	0.14	0.04	0.771	0.010	220.4	0.015	0.095	0.66	0.80	291.9	0.00	12.7	0.236	84.1	4.35	0.02	1.0	0.34	7.92	1.39	34.8	0.04	0.00	3.90	0.05	0.29	0.631	0.0	0.21	3.480
	Measured Recovery (%)																																	
117	NIST8704			18	62	n.a.	19	n.a.	85	43	68	49	81	71	n.a.	6	50	70	78	n.a.	2	78	79	87	88	n.a.	n.a.	0	49	22	1	n.a.	22	79
	Additional Standard Reference Material Information:																																	
	Measured Concentrations (mg/kg)																																	
117	NIST8704		100	10990	14	4	77	1	22040	1	9	66	80	29190	b.d.	1273	24	8413	435	2	100	34	792	139	3476	b.d.	b.d.	390	5	29	63	b.d.	21	348
	Nominal Conc. (mg/kg)			61100	23.4	not reported	414	not reported	26000	3.45	14	135	98.6	41100	1.47	20000	47.5	12000	555	not reported	5470	44.1	998	161	3970	3.79	1.12	290800	9.5	130	4570	1.06	95	438
	Range (mg/kg)			1600	0.8		12		300	0.22	0.6	5	5	1000	0.07	400	4.1	200	19		140	3	28	17	40	0.15	0.05	1300			180	0.07	4	12

ICP Quality Assurance/Quality Control Report, Hill Dataset, cont'd

ICP Quality Assurance/Quality Control Report

Heidi Hill, CFR, Andy Bookter

Analysis Date: 11/9/2005
Units: mg/L
EPA Method: 6010

Run #	Sample Name	Comment	Corr. F.	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Ti	Tl	V	Zn
SPIKES																																	
Laboratory Fortified Blank (i.e., spiked blank, "LFB")																																	
	Number of LFBs:	2																															
114	LBLANK		1.000	0.0	0.00	0.00	0.000	0.000	0.0	0.000	0.001	0.00	0.00	0.0	0.00	2.3	-0.001	0.0	0.00	0.00	0.0	0.00	0.01	-0.01	0.0	0.00	0.00	0.00	0.00	0.00	-0.004	0.0	0.00	0.001
126	LFB		1.000	98.3	1.00	0.45	0.352	0.092	144.2	0.180	0.188	0.47	9.77	142.8	0.00	40.3	0.471	71.3	23.18	0.19	4.9	0.48	9.89	4.42	38.6	0.53	0.98	0.52	0.18	0.46	6.622	0.4	0.41	12.340
	Spike Recovery (%)			98	100	90	7	92	96	90	94	94	98	95	#DIV/0!	85	94	95	93	96	99	96	99	89	97	107	98	10	89	92	95	81	103	93
	Additional Spike Information:																																
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V sample only (mL)			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	V final (mL)			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			-0.012	0.00	0.0008	0.0001	0.00	-0.004	0.000	0.001	0.001	0.001	0.0	0.0000	2.1	-0.0013	-0.001	0.0	0.000	-0.04	0.00	0.01	-0.01	-0.002	-0.003	0.00	0.00	-0.001	0.000	-0.003	-0.002	0.000	0.001
30	LBLANK		1.000	0.0	0.00	0.00	0.000	0.000	0.1	0.000	0.001	-0.01	0.00	0.0	0.00	1.0	0.001	0.0	0.00	0.00	0.1	0.00	-0.03	-0.01	0.0	0.01	-0.01	0.00	0.00	0.00	-0.001	0.0	0.00	0.001
29	LFB		1.000	106.2	1.05	0.47	0.361	0.098	152.9	0.197	0.202	0.50	10.37	152.1	0.00	45.2	0.533	75.6	24.05	0.20	5.0	0.51	10.50	4.79	41.1	0.56	1.02	0.55	0.19	0.50	7.310	0.4	0.45	13.120
	Spike Recovery (%)			106	105	94	7	98	102	99	101	103	104	101	#DIV/0!	98	107	101	96	100	98	102	105	96	103	111	102	11	92	100	104	83	112	99
	Additional Spike Information:																																
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V sample only (mL)			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	V final (mL)			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			0.044	0.00	0.0005	-0.0002	0.00	0.051	0.000	0.001	-0.013	0.002	0.0	0.0000	0.9	0.0005	0.022	0.0	0.000	0.06	0.00	-0.02	-0.01	-0.001	0.006	-0.01	0.00	0.001	0.000	0.000	0.017	-0.001	0.001
Analytical/Laboratory Spikes ("LSPIKE")																																	
	Number of LSPIKEs:	7																															
19	HH2		1.000	251.3	0.03	-0.01	1.002	0.009	51.3	-0.005	0.058	0.09	0.16	204.0	0.00	8.2	0.061	30.5	0.49	-0.01	3.5	0.05	1.33	0.25	0.7	0.07	0.00	7.05	0.00	0.78	2.885	0.0	0.49	0.392
27	HH2LSPIKE		1.000	328.1	0.98	0.47	1.228	0.100	186.3	0.171	0.231	0.55	9.65	312.0	0.00	44.6	0.523	95.7	22.15	0.18	8.0	0.51	10.84	4.57	39.3	0.56	0.96	6.82	0.17	1.16	9.429	0.4	0.84	12.330
	Spike Recovery (%)			102	95	95	7	92	93	88	89	94	95	86	#DIV/0!	83	94	91	87	94	96	92	96	87	97	100	96	9	87	91	98	79	98	90
	Additional Spike Information:																																
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V sample only (mL)			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	V final (mL)			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			226.170	0.03	-0.0061	0.9018	0.01	46.188	-0.004	0.052	0.077	0.142	183.6	-0.0018	7.4	0.0547	27.477	0.4	-0.006	3.19	0.04	1.19	0.22	0.588	0.061	0.00	6.35	-0.004	0.703	2.597	0.028	0.443	0.353
33	HH10		1.000	451.8	0.06	-0.04	1.985	0.014	29.0	-0.012	0.128	0.21	0.20	433.4	0.00	5.2	0.085	38.9	3.75	-0.01	2.6	0.10	2.07	0.41	0.3	0.10	-0.01	5.99	-0.02	0.56	11.680	0.1	1.29	0.558
43	HH10LSPIKE		1.000	498.3	1.01	0.37	2.100	0.105	165.2	0.166	0.296	0.65	9.61	512.5	0.00	44.9	0.558	100.6	24.08	0.18	7.2	0.55	11.51	4.73	38.4	0.61	0.94	5.88	0.15	0.95	16.990	0.5	1.54	12.410
	Spike Recovery (%)			92	96	81	6	92	93	88	90	92	94	82	#DIV/0!	89	96	87	83	94	96	92	97	87	95	103	95	10	82	88	93	75	94	90
	Additional Spike Information:																																
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V sample only (mL)			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	V final (mL)			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			406.620	0.05	-0.0380	1.7865	0.01	26.073	-0.011	0.115	0.191	0.180	390.1	-0.0037	4.6	0.0762	35.010	3.4	-0.010	2.35	0.09	1.86	0.37	0.260	0.092	0.00	5.39	-0.019	0.508	10.512	0.080	1.159	0.502
48	HH19		1.000	209.2	0.06	-0.01	1.304	0.010	25.9	-0.005	0.073	0.10	0.10	199.7	0.00	56.7	0.347	123.9	5.06	0.00	0.7	0.14	3.35	0.28	0.9	0.05	-0.01	5.01	0.01	0.07	6.776	0.0	0.17	0.534
58	HH19LSPIKE		1.000	293.5	1.03	0.42	1.454	0.103	164.9	0.176	0.247	0.56	9.65	310.6	0.00	91.5	0.819	166.0	25.68	0.18	5.2	0.59	12.82	4.67	39.3	0.57	0.96	4.96	0.18	0.52	13.110	0.4	0.55	12.500
	Spike Recovery (%)			105	98	84	6	94	94	90	91	94	96	87	#DIV/0!	90	101	73	84	93	93	92	98	88	96	104	97	9	86	92	100	76	100	90
	Additional Spike Information:																																
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V sample only (mL)			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	V final (mL)			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			188.280	0.05	-0.0053	1.1736	0.01	23.346	-0.005	0.066	0.086	0.089	179.7	0.0004	51.0	0.3126	111.510	4.6	-0.003	0.59	0.13	3.02	0.25	0.776	0.047	-0.01	4.51	0.005	0.060	6.098	0.041	0.150	0.481

ICP Quality Assurance/Quality Control Report, Hill Dataset, cont'd

ICP Quality Assurance/Quality Control Report

Heidi Hill, CFR, Andy Bookter

Analysis Date: 11/9/2005
Units: mg/L
EPA Method: 6010

Run #	Sample Name	Comment	Corr. F.	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Ti	Tl	V	Zn
63	HH25		1.000	132.1	0.12	0.06	0.878	0.011	175.4	-0.004	0.073	0.20	0.10	167.4	0.00	28.2	0.124	30.0	5.01	0.00	1.0	0.17	5.90	0.26	9.7	0.05	-0.01	5.98	0.01	0.36	2.557	0.0	0.29	0.382
73	HH25LSPIKE		1.000	218.6	1.07	0.43	1.101	0.104	281.9	0.176	0.247	0.63	9.34	280.9	0.00	67.0	0.598	91.2	25.17	0.18	5.7	0.60	14.95	4.57	46.1	0.54	0.92	7.49	0.17	0.77	8.752	0.4	0.65	12.160
	Spike Recovery (%)			100	96	75	6	95	83	90	91	90	93	87	#DIV/0!	92	97	86	83	91	96	89	96	87	94	101	93	42	83	89	92	76	97	89
	Additional Spike Information:																																	
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V sample only (mL)			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	V final (mL)			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			118.890	0.11	0.0572	0.7905	0.01	157.860	-0.004	0.066	0.176	0.087	150.7	0.0002	25.4	0.1116	27.027	4.5	0.000	0.93	0.16	5.31	0.23	8.708	0.041	-0.01	5.38	0.009	0.328	2.301	0.015	0.264	0.344
79	09.17.05 DLY		1.000	195.6	1.27	-0.02	3.028	0.017	174.7	0.028	0.079	0.22	10.03	289.2	0.00	34.1	0.179	62.3	12.96	0.01	2.2	0.14	13.64	1.92	21.2	0.08	-0.02	5.55	0.02	0.68	5.227	0.0	0.51	9.777
89	09.17.05 DLYLSPIKE		1.000	267.2	2.06	0.39	2.937	0.107	282.9	0.198	0.247	0.64	17.84	382.7	0.00	69.1	0.632	115.3	31.08	0.18	6.7	0.56	21.61	5.90	56.4	0.58	0.93	5.51	0.18	1.04	11.230	0.4	0.83	19.700
	Spike Recovery (%)			91	91	80	4	91	84	86	88	88	88	82	#DIV/0!	85	94	79	78	89	95	88	93	84	93	100	94	10	81	86	93	74	92	82
	Additional Spike Information:																																	
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V sample only (mL)			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	V final (mL)			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			176.040	1.14	-0.0158	2.7252	0.02	157.230	0.025	0.071	0.199	9.027	260.3	0.0016	30.7	0.1613	56.025	11.7	0.006	1.96	0.12	12.28	1.72	19.107	0.076	-0.02	5.00	0.015	0.608	4.704	-0.002	0.461	8.799
94	08.28.05 DLY		1.000	136.1	0.92	0.02	3.456	0.012	306.0	0.033	0.085	0.17	9.26	223.2	0.01	26.1	0.134	50.8	30.54	0.01	2.3	0.12	14.08	1.56	25.9	0.07	0.00	4.51	0.02	0.79	4.032	-0.1	0.42	9.806
104	08.28.05 DLYLSPIKE		1.000	218.3	1.74	0.42	3.264	0.103	389.4	0.199	0.249	0.60	17.08	323.0	0.01	63.2	0.585	105.0	45.02	0.18	6.9	0.54	21.81	5.52	60.3	0.56	0.93	4.60	0.18	1.14	9.769	0.3	0.75	19.520
	Spike Recovery (%)			96	91	79	3	92	76	85	86	88	88	81	#DIV/0!	88	93	79	70	90	95	86	91	82	92	100	94	11	80	84	88	77	92	80
	Additional Spike Information:																																	
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V sample only (mL)			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	V final (mL)			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			122.490	0.83	0.0219	3.1104	0.01	275.400	0.030	0.076	0.154	8.330	200.9	0.0059	23.5	0.1210	45.738	27.5	0.005	2.10	0.11	12.67	1.40	23.337	0.062	0.00	4.06	0.015	0.715	3.629	-0.092	0.382	8.825
116	NIST8704		1.000	107.0	0.14	0.07	0.734	0.010	216.2	0.014	0.094	0.64	0.78	284.8	0.00	12.0	0.229	81.5	4.29	0.03	1.0	0.34	7.75	1.34	33.7	0.05	0.01	3.51	0.05	0.28	0.573	0.0	0.20	3.330
125	NIST8704_2LSPIKE		1.000	200.0	1.08	0.36	0.975	0.103	314.3	0.181	0.264	1.01	10.05	388.6	0.00	52.1	0.693	129.3	24.33	0.20	5.7	0.75	16.40	5.32	65.9	0.54	0.92	4.07	0.20	0.70	6.768	0.4	0.58	14.190
	Spike Recovery (%)			104	95	60	6	94	80	84	90	86	93	88	#DIV/0!	92	97	75	82	88	97	88	94	82	89	100	92	18	78	90	89	74	98	84
	Additional Spike Information:																																	
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V sample only (mL)			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	V final (mL)			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			96.300	0.13	0.0631	0.6610	0.01	194.580	0.013	0.085	0.580	0.702	256.3	0.0018	10.8	0.2064	73.314	3.9	0.023	0.86	0.31	6.98	1.20	30.321	0.041	0.01	3.16	0.046	0.254	0.516	-0.012	0.183	2.997
Method Spikes (e.g. digestion spikes, "MSPIKE")																																		
	Number of MSPIKEs:	3																																
35	HH11		1.000	454.1	0.06	-0.09	1.968	0.014	33.0	-0.012	0.114	0.21	0.19	417.5	0.00	5.9	0.083	40.9	2.42	-0.01	3.1	0.10	1.82	0.39	0.2	0.10	-0.01	6.78	-0.03	0.62	11.050	0.1	1.23	0.522
50	HH11MSPIKE		1.000	716.2	0.98	0.29	2.363	0.108	169.9	0.161	0.289	0.68	9.46	562.8	0.00	45.7	0.585	106.0	22.37	0.15	9.2	0.57	11.19	4.76	37.1	0.38	0.90	5.94	0.12	1.10	17.460	0.5	1.70	12.140
	Spike Recovery (%)			262	92	77	8	93	91	86	88	94	93	97	#DIV/0!	88	100	87	80	80	122	94	94	87	92	58	91	-17	76	96	92	77	118	87
	Additional Spike Information:																																	
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1	5	5	5	5	5	5	5	5	5
	V sample only (mL)			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	V final (mL)			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			454.100	0.06	-0.0942	1.9680	0.01	32.960	-0.012	0.114	0.210	0.193	417.5	-0.0046	5.9	0.0832	40.870	2.4	-0.011	3.12	0.10	1.82	0.39	0.218	0.087	-0.01	6.78	-0.028	0.616	11.050	0.090	1.225	0.522
63	HH25		1.000	132.1	0.12	0.06	0.878	0.011	175.4	-0.004	0.073	0.20	0.10	167.4	0.00	28.2	0.124	30.0	5.01	0.00	1.0	0.17	5.90	0.26	9.7	0.05	-0.01	5.98	0.01	0.36	2.557	0.0	0.29	0.382
67	HH25MSPIKE		1.000	151.4	1.03	0.37	0.664	0.098	145.8	0.183	0.205	0.61	9.45	263.7	0.00	55.9	0.525	75.7	22.62	0.20	7.5	0.50	15.45	4.64	40.9	0.48	0.93	4.70	0.19	0.53	8.633	0.4	0.58	12.530
	Spike Recovery (%)			19	91	62	-4	88	-20	94	66	82	94	64	#DIV/0!	62	80	61	70	102	129	66	95	88	78	89	95	-26	91	34	87	80	73	91
	Additional Spike Information:																																	
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1	5	5	5	5	5	5	5	5	5
	V sample only (mL)			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	V final (mL)			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	10	50	50	50	50	50	50	50	50	50
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			132.100	0.12	0.0636	0.8783	0.01	175.400	-0.004	0.073	0.195	0.097	167.4	0.0002	28.2	0.1240	30.030	5.0	0.000	1.03	0.17	5.90	0.26	9.675	0.041	-0.01	5.98	0.011	0.364	2.557	0.017	0.293	0.382
93	08.28.05 DLX		1.000	162.2	0.97	-0.01	2.461	0.014	203.2	0.030	0.075	0.20	8.62	251.6	0.00	29.6	0.154	57.1	9.66	0.00	2.0	0.13	12.84	1.61	28.5	0.08	0.00	4.83	0.02	0.65	4.152	0.0	0.44	9.505
102	08.28.05 DLXMSPIKE		1.000	318.9	1.88	0.34	2.767	0.108	323.6	0.203	0.253	0.66	17.48	393.4	0.00	72.7	0.678	118.3	28.70	0.17	7.1	0.57	21.95	5.83	65.5	0.37	0.90	5.65	0.17	1.11	12.220	0.4	0.87	20.110
	Spike Recovery (%)			157	91	71	6	94	80	87	89	92	89	95	#DIV/0!	96	105	82	76	85	103	89	91	84	93	59	91	16	76	93	115	79	106	80
	Additional Spike Information:																																	
	[Sed Spike] (mg/L)			1000	10	5	50	1	1500	2	2	5	100	1500	0	450	5	750	250	2	50	5	100	50	400	5	10	50	2	5	70	5	4	133
	V spike addition (mL)			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1	5	5	5	5	5	5	5	5	5
	V sample only (mL)			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	V final (mL)			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	10	50	50	50	50	50	50	50	50	50
	[Spike contribution] (mg/L)			100.000	1.00	0.5000	5.0000	0.10	150.000	0.200	0.200	0.500	10.000	150.0	0.0000	45.0	0.5000	75.000	25.0	0.200	5.00	0.50	10.00	5.00	40.000	0.500	1.00	5.00	0.200	0.500	7.000	0.500	0.400	13.300
	[Sample contribution] (mg/L)			162.200	0.97	-0.0091	2.4610	0.01	203.200	0.030	0.075	0.198	8.617	251.6	0.0011	29.6	0.1542	57.120	9.7	0.005	1.96	0.13	12.84	1.61	28.530	0.069	0.00	4.83	0.017	0.646	4.152	0.002	0.443	9.505

ICP Quality Assurance/Quality Control Report, Hill Dataset, cont'd

The University of Montana - Geosciences Department Environmental Biogeochemistry Laboratory																
ICP Quality Assurance/Quality Control	255/75 17															
Britt Schlosshardt / Kelly Dixon Soil																
Analysis Date:	2/13/2017															
Units:	mg/L															
EPA Method:	200.7 Sed all 140127															
Sample ID	**Remarks**	**Run**	**Corr. Factor**	**As mg/L**	**Ba mg/L**	**Ca mg/L**	**Cu mg/L**	**K mg/L**	**Mg mg/L**	**Na mg/L**	**Ni mg/L**	**P mg/L**	**Pb mg/L**	**Tl mg/L**	**V mg/L**	**Zn mg/L**
MDL				0.0015	0.005	0.003	0.0008	0.1	0.002	0.01	0.003	0.005	0.002	0.002	0.0003	0
PQL				0.015	0.01	0.1	0.005	0.5	0.1	0.5	0.01	0.06	0.05	0.1	0.01	0.1
LDR				5	100	500	30	50	250	100	100	100	25	100	100	100
BLANKS																
Laboratory/Analytical Blanks ("LBLANK")																
	Number of LBLANKs:	4														
	Instrument Output															
LBLANK		7	1.000	0.007	0.001	0.0	0.001	0.0	0.1	0.1	0.00	0.00	0.00	0.0	0.00	0.00
LBLANK		22	1.000	0.004	0.003	0.1	0.000	0.1	0.1	0.1	0.00	0.01	0.00	0.0	0.00	0.00
LBLANK		36	1.000	0.002	0.003	0.2	-0.001	0.2	0.1	0.1	0.00	0.00	0.00	0.0	0.00	0.00
LBLANK		44	1.000	0.005	0.002	0.1	0.001	0.1	0.1	0.0	0.00	0.01	0.00	0.0	0.00	0.00
	Reported Concentration															
LBLANK		7		b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
LBLANK		22		b.d.	b.d.	0.1	b.d.	b.d.	0.1	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
LBLANK		36		b.d.	b.d.	0.2	b.d.	b.d.	0.1	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
LBLANK		44		b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.	b.d.
Method Blanks (e.g. Digestion Blanks, "MBLANK")																
INTERNAL PERFORMANCE CHECKS																
CCV																
	No. of CCV analyzed:	2														
	Nominal Concentration (mg/L)			**3.33**	**0.333**	**16.66**	**3.33**	**6.667**	**16.67**	**3.33**	**0.667**	**3.33**	**3.33**	**1.667**	**1.667**	**3.33**
	Measured Concentration (mg/L)															
CCV		5	1.000	3.530	0.345	16.2	3.458	6.4	16.4	3.3	0.70	3.27	0.32	1.7	1.73	3.37
CCV		42	1.000	3.574	0.350	16.7	3.482	6.9	16.8	3.5	0.71	3.92	0.33	1.8	1.75	3.35
	Measured/Nominal Concentration (%)															
CCV		5		106	104	97	104	95	99	99	106	98	10	104	104	101
CCV		42		107	105	100	105	103	101	106	106	118	10	105	105	100
IPC6																
	No. of IPC6 analyzed:	4														
	Nominal Concentration (mg/L)			**0.5**	**0.5**	**10**	**0.5**	**10**	**10**	**10**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
	Measured Concentration (mg/L)															
IPC6		6	1.000	0.554	0.517	10.1	0.513	10.5	9.9	9.8	0.55	0.52	0.48	0.5	0.52	0.51
IPC6		21	1.000	0.552	0.532	9.3	0.521	10.0	10.0	10.0	0.56	0.60	0.49	0.5	0.53	0.52
IPC6		35	1.000	0.559	0.513	10.1	0.503	10.5	10.2	10.1	0.54	0.61	0.47	0.5	0.52	0.49
IPC6		43	1.000	0.570	0.498	9.4	0.495	10.2	9.7	9.8	0.53	0.60	0.46	0.5	0.51	0.49
	Measured/Nominal Concentration (%)															
IPC6		6		111	103	101	103	105	99	98	109	104	96	106	104	103
IPC6		21		110	106	93	104	100	100	100	112	121	98	107	107	103
IPC6		35		112	103	101	101	105	102	101	108	121	95	107	103	99
IPC6		43		114	100	94	99	102	97	98	106	120	93	109	101	98
200.7 STD 1																
	No. of 200.7 STD 1 analyzed:	1														
	Nominal Concentration (mg/L)			**10**	**1**		**10**	**20**	**50**	**10**	**2**	**10**		**5**	**5**	
	Measured Concentration (mg/L)															
200.7 STD 1		45	1.000	10.480	1.053	0.0	10.390	20.1	46.4	10.1	2.13	10.58	0.00	4.9	5.23	0.00
	Measured/Nominal Concentration (%)															
200.7 STD 1		45		105	105	n.a.	104	100	93	101	107	106	n.a.	98	105	n.a.

ICP Quality Assurance/Quality Control Report, Virginia City Dataset

ICP Quality Assurance/Quality Control	255/75 17															
Britt Schlosshardt / Kelly Dixon Soil																
Analysis Date:	2/13/2017															
Units:	mg/L															
EPA Method:	200.7 Sed all 140127															
Sample ID	**Remarks**	**Run**	**Corr. Factor**	**As mg/L**	**Ba mg/L**	**Ca mg/L**	**Cu mg/L**	**K mg/L**	**Mg mg/L**	**Na mg/L**	**Ni mg/L**	**P mg/L**	**Pb mg/L**	**Tl mg/L**	**V mg/L**	**Zn mg/L**
MDL				0.0015	0.005	0.003	0.0008	0.1	0.002	0.01	0.003	0.005	0.002	0.002	0.0003	0
PQL				0.015	0.01	0.1	0.005	0.5	0.1	0.5	0.01	0.06	0.05	0.1	0.01	0.1
LDR				5	100	500	30	50	250	100	100	100	25	100	100	100
STANDARD REFERENCE MATERIALS																
	Number of SRMs:	1														
NIST2710a																
	Measured Concentrations (mg/L)															
NIST2710a	0	11	1.000	3.311	1.133	4.0	7.498	9.9	7.3	1.3	0.02	2.00	10.69	0.0	0.10	8.17
	Measured Recovery (%)															
NIST2710a	NIST2710a			103	106	104	105	115	100	100	104	92	93	466	121	94
	Additional Standard Reference Material Information:															
	Measured Concentrations (mg/kg)															
NIST2710a	NIST2710a		480.3073967	1590	544	1906	3601	4741	3517	628	8	961	5134	15	48	3925
	Nominal Conc. (mg/kg)			1540	792	9640	3420	21700	7340	8940	8	1050	5520	1.52	82	4180
	Range (mg/kg)			100	36	450	50	1300	380	190	1	40	30	0.02	9	150
	Leachable Factor			100	65	19	100	19	48	7	100	100	100	213	48	100
DUPLICATES																
Analytical (Laboratory) Duplicates ("LDUP")																
	Number of LDUPs:	3														
3		16	1.000	0.161	4.980	129.0	0.453	25.9	83.9	20.6	0.88	8.88	0.19	0.2	0.90	0.58
3 LDUP		17	1.000	0.167	4.935	131.4	0.448	24.7	84.9	20.9	0.87	9.33	0.19	0.2	0.89	0.57
	2*(a-b)/(a+b)*100			3.3	0.9	1.8	1.0	4.6	1.1	1.7	1.3	5.0	1.7	2.3	1.3	1.3
6		23	1.000	0.148	3.515	103.1	0.372	33.3	75.3	16.3	0.69	7.38	0.13	0.2	0.77	0.61
6 LDUP		24	1.000	0.159	3.495	93.7	0.371	30.5	67.9	15.6	0.69	7.52	0.13	0.1	0.76	0.60
	2*(a-b)/(a+b)*100			7.2	0.6	9.6	0.4	8.9	10.3	4.2	0.7	1.9	1.8	40.8	0.6	1.0
16		37	1.000	0.105	2.216	87.7	0.298	46.1	87.9	12.2	0.55	6.66	0.08	0.1	0.74	0.70
16 LDUP		38	1.000	0.113	2.175	81.0	0.295	42.2	82.8	11.1	0.54	6.82	0.08	0.1	0.73	0.69
	2*(a-b)/(a+b)*100			7.3	1.9	8.0	0.8	8.8	6.1	9.5	1.6	2.2	0.9	b.d.	1.6	1.5
Method Duplicates (e.g. Digestion Duplicates, "MDUP")																
	Number of MDUPs:	1														
1		12	1.000	0.123	4.389	103.9	0.452	30.0	86.1	14.9	0.90	6.21	0.09	0.2	0.84	0.59
1 MDUP		13	1.000	0.125	4.374	100.9	0.439	29.2	84.3	14.5	0.90	6.90	0.09	0.2	0.84	0.58
	2*(a-b)/(a+b)*100			2.0	0.3	2.9	3.0	2.7	2.1	2.9	0.2	10.5	3.2	16.5	0.5	2.5

ICP Quality Assurance/Quality Control Report, Virginia City Dataset, cont'd

ICP Quality Assurance/Quality Control	255/75 17															
Britt Schlosshardt / Kelly Dixon Soil																
Analysis Date:	2/13/2017															
Units:	mg/L															
EPA Method:	200.7 Sed all 140127															
Sample ID	**Remarks**	**Run**	**Corr. Factor**	**As mg/L**	**Ba mg/L**	**Ca mg/L**	**Cu mg/L**	**K mg/L**	**Mg mg/L**	**Na mg/L**	**Ni mg/L**	**P mg/L**	**Pb mg/L**	**Tl mg/L**	**V mg/L**	**Zn mg/L**
MDL				0.0015	0.005	0.003	0.0008	0.1	0.002	0.01	0.003	0.005	0.002	0.002	0.0003	0
PQL				0.015	0.01	0.1	0.005	0.5	0.1	0.5	0.01	0.06	0.05	0.1	0.01	0.1
LDR				5	100	500	30	50	250	100	100	100	25	100	100	100
SPIKES																
Laboratory Fortified Blank (i.e., spiked blank, "LFB")																
	Number of LFBs:	1														
LBLANK		7	1.000	0.007	0.001	0.0	0.001	0.0	0.1	0.1	0.00	0.00	0.00	0.0	0.00	0.00
LFB		8	1.000	0.561	0.526	9.8	0.517	10.4	9.8	9.9	0.56	0.53	0.50	0.5	0.52	0.52
	Spike Recovery (%)			111	105	98	103	104	97	98	112	106	99	108	103	104
	Additional Spike Information:															
	[Water Spike] (mg/L)			10	10	200	10	200	200	200	10	10	10	10	10	10
	V spike addition (mL)			0.35	0.35	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	V sample only (mL)			6.3	6.3	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	V final (mL)			7	7	5	5	5	5	5	5	5	5	5	5	5
	[Spike contribution] (mg/L)			0.500	0.500	10.0	0.500	10.0	10.0	10.0	0.500	0.500	0.500	0.500	0.500	0.500
	[Sample contribution] (mg/L)			0.006	0.001	0.042	0.001	0.036	0.046	0.050	0.001	0.002	-0.002	0.003	0.001	0.000
Analytical/Laboratory Spikes ("LSPIKE")																
	Number of LSPIKEs:	3														
3		16	1.000	0.161	4.980	129.0	0.453	25.9	83.9	20.6	0.88	8.88	0.19	0.2	0.90	0.58
3 LSPIKE		18	1.000	0.655	4.904	130.5	0.909	30.2	87.4	28.4	1.27	8.95	0.61	0.6	1.29	0.96
	Spike Recovery (%)			102	84	144	100	69	118	99	96	192	88	89	95	88
	Additional Spike Information:															
	[Water Spike] (mg/L)			10	10	200	10	200	200	200	10	10	10	10	10	10
	V spike addition (mL)			0.35	0.35	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	V sample only (mL)			6.3	6.3	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	V final (mL)			7	7	5	5	5	5	5	5	5	5	5	5	5
	[Spike contribution] (mg/L)			0.500	0.500	10.0	0.500	10.0	10.0	10.0	0.500	0.500	0.500	0.500	0.500	0.500
	[Sample contribution] (mg/L)			0.145	4.48	116.1	0.407	23.3	75.5	18.5	0.789	7.99	0.169	0.163	0.809	0.521
7		25	1.000	0.134	3.274	86.6	0.348	31.8	68.6	14.1	0.58	8.04	0.14	0.1	0.73	0.56
7 LSPIKE		26	1.000	0.581	3.423	87.1	0.804	39.3	71.3	21.3	1.00	7.48	0.52	0.5	1.13	0.94
	Spike Recovery (%)			92	95	91	98	106	95	86	94	49	80	84	94	86
	Additional Spike Information:															
	[Water Spike] (mg/L)			10	10	200	10	200	200	200	10	10	10	10	10	10
	V spike addition (mL)			0.35	0.35	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	V sample only (mL)			6.3	6.3	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	V final (mL)			7	7	5	5	5	5	5	5	5	5	5	5	5
	[Spike contribution] (mg/L)			0.500	0.500	10.0	0.500	10.0	10.0	10.0	0.500	0.500	0.500	0.500	0.500	0.500
	[Sample contribution] (mg/L)			0.121	2.95	78.0	0.313	28.6	61.7	12.7	0.524	7.23	0.123	0.094	0.661	0.507
17		39	1.000	0.095	2.308	98.0	0.294	33.8	78.8	10.8	0.46	6.41	0.06	0.1	0.69	0.59
17 LSPIKE		40	1.000	0.584	2.502	98.7	0.757	39.8	81.2	18.8	0.88	6.83	0.49	0.5	1.09	0.96
	Spike Recovery (%)			100	85	105	98	94	103	91	93	211	87	85	93	85
	Additional Spike Information:															
	[Water Spike] (mg/L)			10	10	200	10	200	200	200	10	10	10	10	10	10
	V spike addition (mL)			0.35	0.35	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	V sample only (mL)			6.3	6.3	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	V final (mL)			7	7	5	5	5	5	5	5	5	5	5	5	5
	[Spike contribution] (mg/L)			0.500	0.500	10.0	0.500	10.0	10.0	10.0	0.500	0.500	0.500	0.500	0.500	0.500
	[Sample contribution] (mg/L)			0.086	2.08	88.2	0.265	30.5	70.9	9.69	0.418	5.77	0.052	0.066	0.625	0.533
Method Spikes (e.g. digestion spikes, "MSPIKE")																
	Number of MSPIKEs:	2														
MBLANK	0	9	1.000	0.009	0.002	0.2	0.047	0.1	0.1	0.1	0.00	0.03	0.01	0.0	0.00	0.05
MFB	0	10	1.000	0.003	0.000	9.4	1.053	9.8	9.5	9.8	0.00	0.03	0.00	0.0	0.00	0.95
	Spike Recovery (%)					93	101	97	94	97						89
	Additional Spike Information:															
	[Dixon Soil Spike] (mg/L)					10000	1000	10000	10000	10000						1000
	V spike addition (mL)			5	5	0.05	0.05	0.05	0.05	0.05	5	0.05	5	5	5	0.05
	V sample only (mL)			50	50	50	50	50	50	50	50	9	50	50	50	50
	V final (mL)			50	50	50	50	50	50	50	50	10	50	50	50	50
	[Spike contribution] (mg/L)			0.000	0.000	10.0	1.00	10.0	10.0	10.0	0.000	0.000	0.000	0.000	0.000	1.00
	[Sample contribution] (mg/L)			0.009	0.002	0.174	0.047	0.079	0.108	0.146	0.005	0.023	0.010	0.005	0.004	0.054
2		14	1.000	0.147	3.195	97.8	0.375	30.4	71.9	15.7	0.65	7.36	0.08	0.1	0.75	0.56
2 MSPIKE		15	1.000	0.163	3.411	109.4	1.419	39.5	83.1	25.3	0.69	8.17	0.08	0.1	0.81	1.46
	Spike Recovery (%)					116	104	91	112	96						90
	Additional Spike Information:															
	[Dixon Soil Spike] (mg/L)					10000	1000	10000	10000	10000						1000
	V spike addition (mL)			5	5	0.05	0.05	0.05	0.05	0.05	5	0.05	5	5	5	0.05
	V sample only (mL)			50	50	50	50	50	50	50	50	9	50	50	50	50
	V final (mL)			50	50	50	50	50	50	50	50	10	50	50	50	50
	[Spike contribution] (mg/L)			0.000	0.000	10.0	1.00	10.0	10.0	10.0	0.000	0.000	0.000	0.000	0.000	1.00
	[Sample contribution] (mg/L)			0.147	3.20	97.8	0.375	30.4	71.9	15.7	0.645	6.62	0.083	0.126	0.755	0.563

ICP Quality Assurance/Quality Control Report, Virginia City Dataset, cont'd