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HYDROGEN SULFIDE MONITORING NEAR OIL AND GAS PRODUCTION FACILITIES IN SOUTHEASTERN NEW MEXICO AND POTENTIAL EFFECTS OF HYDROGEN SULFIDE TO MIGRATORY BIRDS AND OTHER WILDLIFE

by

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ABSTRACT

Hydrogen sulfide (H_2S) is a colorless, flammable and highly toxic gas with a characteristic odor of rotten eggs. It is produced naturally and as a result of human activity. Nationally, the largest source of hydrogen sulfide is from petroleum production. We monitored hydrogen sulfide near oil and gas production facilities near the cities of Roswell, Artesia, Hobbs, and Carlsbad in southeastern New Mexico and evaluated its potential effects on migratory birds and other species of wildlife. We deployed hydrogen sulfide monitors in different wildlife habitats near oil and gas production facilities starting November 6, 2002 and concluding August 6, 2003. Concentrations of hydrogen sulfide as high as 33 parts per million (ppm) were measured near the town of Loco Hills, New Mexico, approximately 25 miles (mi) (40 kilometers [km]) east of Artesia, New Mexico.

Point count surveys of migratory birds were also conducted to determine differences in habitat use of areas impacted by oil and gas production activities. Point count survey results of migratory birds from undisturbed sites (areas without oil and gas activities within 250 meters) were compared with disturbed sites (areas affected by oil and gas activities). Point count surveys began on November 21, 2002 and concluded on August 6, 2003. We found statistically significant differences in the average number of avian individuals per point count, the average number of avian species per point count, the species diversity, and the average concentration of hydrogen sulfide per point count at disturbed and undisturbed sites. Avian diversity and number of species as determined by point count surveys were significantly lower at disturbed sites than at undisturbed sites.

There is little information on the effect of hydrogen sulfide on migratory birds or other wildlife species even though they often occupy habitats that contain elevated hydrogen sulfide in the ambient air. In order to evaluate the toxicity of hydrogen sulfide to a variety of species, we modeled the dose and potential response of the sand dune lizard, as well as several migratory birds and mammal species to hydrogen sulfide. We determined that concentrations as low as 1 ppm may affect highly active migratory birds and mammals. Adoption of ambient hydrogen sulfide air quality standards as low as 1 ppm may be appropriate to protect wildlife.

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INTRODUCTION

Petroleum is a thick, flammable mixture of gaseous, liquid, and solid hydrocarbons that occurs naturally beneath the earth's surface. During extraction, petroleum is brought to the surface and transported to refineries where it is separated into liquid and gas fractions including natural gas, gasoline, kerosene, lubricating oils, paraffin wax, and asphalt (U.S. Environmental Protection Agency [USEPA] 1999). Hydrogen sulfide is found naturally in underground petroleum reserves. Hydrogen sulfide may be emitted or released during exploration, development, extraction, treatment and storage, transportation and refining of petroleum products (USEPA 1993).

In New Mexico, Dubyk *et al*. (2002), monitored ambient hydrogen sulfide levels and reported the highest concentrations (0 to 15 ppm) around oil and gas facilities near the Black River northeast of Whites City, New Mexico. In this region, Sias and Snell (1998) also had reported moribund wildlife species (e.g., owls and other raptors) as well as carapace remains of turtles near oil and gas wells that were known to emit hydrogen sulfide and other gases. Sias and Snell (1998) suggested that since some reptiles were strongly associated with the bottoms of dune valleys in the area, then these reptiles may be more susceptible to gas poisoning since hydrogen sulfide is heavier than air. The U.S. Fish and Wildlife Service (Service) was requested to review the available information to determine the risks posed to wildlife from local hydrogen sulfide emissions.

There are no Federal or State rules that identify protective air quality standards specifically to protect wildlife. There is little information on the effect of hydrogen sulfide on migratory birds or other wildlife species even though they often occupy habitats that contain elevated hydrogen sulfide in the ambient air. The Service therefore initiated this investigation (in conjunction with the New Mexico Department of Game and Fish and the U.S. Bureau of Land Management [BLM]) in order to determine: 1) the ambient concentrations in areas associated with oil and gas activities as well as in areas without that activity; 2) determine and associate the density, diversity or composition of the avian community in these two types of areas; 3) empirically test hydrogen sulfide toxicity to animals in a laboratory setting; and 4) identify whether measured hydrogen sulfide concentrations pose a risk to wildlife and which guilds of animals may be sensitive to hydrogen sulfide exposures in southeastern New Mexico. Note that Objective 3; the laboratory toxicity testing was not conducted due to lack of funding.

Hydrogen Sulfide Characteristics

Hydrogen sulfide (Chemical Abstract Service Registration Number 7783-06-4) is a colorless, flammable and highly toxic gas with a characteristic odor of rotten eggs. It is produced naturally and as a result of human activity (USEPA 1993). Natural sources include anaerobic bacterial reduction of sulfates and sulfur-containing organic compounds. Organic matter almost always contains sulfur and wherever it undergoes putrefaction (such as at the bottom of a lake, deep underground, in piles of manure, during decomposition, etc.), some of that sulfur is converted to hydrogen sulfide. Hydrogen sulfide is also found in crude petroleum,

natural gas, volcanic gases, stagnant, thermal or polluted waters, livestock manure, coal pits and in springs (USEPA 1993).

Hydrogen sulfide is soluble in both water and oil and as a result can move great distances before conditions favor its emergence as a vapor. Hydrogen sulfide may evaporate from surface water, depending on temperature and pH. Because hydrogen sulfide vapor is heavier than air, it may also creep along the ground for a distance before being neutralized by chemical reactions, ignited, and it may pool in low-lying areas in the environment (USEPA 1993).

During petroleum extraction activities, impurities like hydrogen sulfide, water, sand, silt, or additives used to enhance extraction, are removed or allowed to volatilize into the air. In addition to hydrogen sulfide emission during petroleum production and refining, accidental air releases of hydrogen sulfide can occur through leaking tubing, valves, tanks, pipeline ruptures or open pits (USEPA 1993). During spills or leaks, hydrogen sulfide gas can volatilize to the atmosphere before clean up. Releases to the environment are primarily by emissions into ambient air, where the hydrogen sulfide is likely to remain for less than 1 day, but may persist for as long as 42 days in cold climates (Agency for Toxic Substances and Disease Registry [ATSDR] 2004). The concentrations of hydrogen sulfide in air in unpolluted areas are low (ATSDR 2004), with areas that have natural sources ranging between 0.1 and 0.3 parts per billion (ppb). Hydrogen sulfide is unlikely to bioconcentrate or biomagnify in the food chain, and has not been found to cause cancer (ATSDR 2004).

Hydrogen sulfide is corrosive; therefore, it is desirable to remove hydrogen sulfide during the petroleum conditioning process and during wastewater treatment (USEPA 1991). Hydrogen sulfide emission can occur during petroleum production and refining, through pipeline ruptures or leaking tubing, valves, flanges, tanks, and open pits (USEPA 1993). When natural gas is produced from the well that is not sold or used on-site, it can be flared or vented, thereby releasing carbon monoxide, nitrogen oxides, hydrogen sulfide, or sulfur dioxide to the atmosphere.

Rules and Regulations Governing Hydrogen Sulfide Emissions in New Mexico

The Clean Air Act requires the USEPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. Toxic air pollutants are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. The USEPA regulates emissions of toxic air pollutants from industrial sources referred to as “source categories." Hydrogen sulfide was originally listed as a toxic air pollutant for which the USEPA was to assess the hazards to public health and the environment resulting from the emission of hydrogen sulfide associated with the extraction of oil and natural gas (USEPA 1993). However, it was later noted that a clerical error led to the inadvertent inclusion of hydrogen sulfide on the list of toxic air pollutants and it was removed (USEPA 1993). There are no national standards regulating hydrogen sulfide.

The New Mexico Environment Department (NMED) Air Quality Bureau has adopted 0.010 ppm as the ambient air quality standard for hydrogen sulfide (NMED 2002). However, Part 20.2.3.110.B(2) of the New Mexico Annotated Code (NMAC) identifies a regional air quality standard for hydrogen sulfide in the Pecos-Permian Basin (30-minute [min] average) as 0.100 ppm. The Pecos-Permian Basin Intrastate Air Quality Control Region is composed of Quay, Curry, De Baca, Roosevelt, Chaves, Lea, and Eddy Counties in New Mexico. Also, the ambient air quality standard for hydrogen sulfide is 0.03 ppm (30-min average) within corporate limits of municipalities in the Pecos-Permian Basin Intrastate Air Quality Control Region or within 5 mi (8 km) of the corporate limits of municipalities having a population of greater than twenty thousand. However, there are no requirements for monitoring hydrogen sulfide emissions from any new source or from the net increase of hydrogen sulfide emissions where these emissions could cause ambient concentrations to exceed the air quality standards in New Mexico unless those emissions exceed 10 tons of sulfur per year from a stationary source (20.2.74.502 NMAC).

The New Mexico Oil Conservation Division of the Energy, Minerals, and Natural Resources Department (EMNRD) has promulgated rules regarding the emission of hydrogen sulfide from any well or gas-producing facility in New Mexico (EMNRD 2001). These rules provide for the protection of the public's safety in areas where hydrogen sulfide concentrations are greater than 100 ppm. Generally, any gas-processing facility where hydrogen sulfide is present at concentrations of 100 ppm or more must take reasonable measures to forewarn and safeguard people that have occasion to be on or near the area. Wells drilled where there is substantial probability of people encountering hydrogen sulfide gas in concentrations of 500 ppm or more must have warning "poison gas" signs. Facilities (except gas-processing plants) having storage tanks with hydrogen sulfide gas in concentrations of 1,000 ppm or more must have identifying signs indicating the specific protective measures that may be necessary to protect public safety. Any well, lease, or processing plant handling gas with a hydrogen sulfide concentration and volume that equates to 10,000 cubic feet (ft^3) (283 cubic meters [m^3]) per day or more, which is located within 0.25 mi (0.4 km) of a dwelling, public place, or highway, must install safety devices and maintain them in operable conditions or establish safety procedures designed to prevent the undetected escape of hydrogen sulfide as well as prepare a contingency plan for people's safe evacuation.

The BLM has applied rules and regulations for well leases and facilities on all BLM lands in New Mexico (43 Code of Federal Regulations [CFR] 3160; see BLM 1991). The BLM has identified areas or zones they manage for oil and gas production (along with other resource uses and goals), where postings must occur and human entry must be accompanied by monitoring devices to reduce the risk of hydrogen sulfide exposure (BLM 1997). The BLM has also identified, mapped, and posted signs in areas where elevated hydrogen sulfide releases from oil and gas wells are known to occur that may pose risks to human health and safety in New Mexico (BLM 1997).

Most gas emissions are minimized through prevention (i.e., preventive maintenance and occasional monitoring, inspections, leak detection and notification systems, installation of catalytic converters, filters, sponges, routine replacement of gaskets, seals, valves, tightening

connections, and welding, as well as educating and informing the workforce)(USEPA 1993). Flaring or burning off gases may sometimes be used to reduce air emissions that are unavoidable. Nearly all oil and gas production wells are equipped with a vent or flare to release unusual pressure, and some wells that produce only a small amount of natural gas will vent or flare it when there is no on-site use for the gas (e.g., to power engines), no pipeline nearby to transport the gas to market, and no regulations regarding its disposal (USEPA 1993). Since natural gas has economic value, flaring is usually considered a last resort. When a gas is flared, it passes through the vent away from the well, and is burned in the presence of a pilot light. Although it is preferable to prevent the emission in the first place, flaring has benefits over simple venting of unburned material. However, the practice of flaring also produces sulfur dioxide, which is a regulated air pollutant (USEPA 1993).

Toxicity of Hydrogen Sulfide to Wildlife

There are no Federal or State rules that identify protective air quality standards for wildlife. Few studies address the risks posed to wildlife from hydrogen sulfide emissions. One investigation by Siegel *et al.* (1986) examined the ambient levels of hydrogen sulfide at Sulphur Bay Wildlife Area in New Zealand where shorebirds were exposed to hydrogen sulfide of geothermal origin at concentrations of 0.13 to 3.9 ppm. They found fewer species of birds used this habitat compared to similar wetlands without detectable levels of hydrogen sulfide. However, no parameters of exposure were measured at either the population level or the individual level. The Canadian Wildlife Service also conducted a study of the effects of a gas well blowout in Alberta, Canada on wildlife (New Norway Scientific Committee 1974). Concentrations between 5 and 10 ppm were documented and birds and small animals were absent from the study area after the blowout. The New Norway Scientific Committee (1974) suggested that low concentrations of hydrogen sulfide, as low as 5 to 10 ppm, negatively affect habitat usage by avian species.

Data on the effects of hydrogen sulfide are only well documented for common test animals and humans (ATDSR 2004). The following information on human toxicity was included because the mechanism of hydrogen sulfide toxicity is considered to be common among all vertebrates that utilize aerobic pathways of metabolism (USEPA 2003; U.S. National Library of Medicine [USNLM] 2003). The characteristics of acute hydrogen sulfide toxicity are dependent on the concentration and duration of exposure. Exposure is usually by inhalation. At high concentrations (250-500 ppm), hydrogen sulfide acts as a respiratory irritant, which can lead to a pulmonary edema (USEPA 2003; USNLM 2003). At higher concentrations (500-1,000 ppm), hydrogen sulfide acts as a systemic poison, causing unconsciousness and death by respiratory paralysis in minutes (USNLM 2003). Long-term damage and death in small mammals occurs when hydrogen sulfide gas levels exceed 50-100 parts per million (ppm) (Dahme *et al.* 1983). A single 4-hour exposure to hydrogen sulfide concentrations of 15-100 ppm may cause eye irritation and conjunctivitis ("gas eye"), convulsions and pulmonary edema in rodents (Lopez *et al.* 1989). At concentrations ranging from 10 to 25 ppm people report flu-like symptoms including headaches, dizziness, nausea, vomiting, irritation of the eyes, nose and throat, fatigue, insomnia, and digestive disturbances (National Institute for Occupational Safety and Health [NIOSH] 1977). The health effects of chronic,

low-level exposure to hydrogen sulfide to wildlife or humans, however, are not well defined (USEPA 2003; ATSDR 2004).

After inhalation, hydrogen sulfide enters the circulation directly across the alveolar-capillary membrane where it dissociates into a sulfide ion (USNLM 2003). The sulfide ion is then selectively taken up by the brainstem where it interferes with neurotransmitter levels and also reversibly interacts with a number of enzymes, proteins, including hemoglobin and myoglobin. Sulfide ions will bind to cytochrome-oxidase within mitochondria, thereby blocking electron transport leading to metabolic acidosis to cytotoxic anoxia, and finally, cell death (Smith 1991). As a cellular poison, the effects of hydrogen sulfide are seen across all organ systems and would be expected to behave similarly in all vertebrate species that utilize aerobic metabolism such as in migratory birds, mammals, certain reptiles and amphibians (Dombkowski *et al.* 2005).

Hydrogen sulfide has been recently identified as vasoactive (*i.e.*, affecting the blood vessels) in all vertebrate classes of mammals, birds, reptiles and fish (Dombkowski *et al.* 2005). When isolated blood vessels were exposed to hydrogen sulfide vasoactivity was observed including constriction, dilation, and multiphasic responses that were both species- and vessel-specific (Dombkowski *et al.* 2005). The ability of hydrogen sulfide to serve as either (or both) a vasoconstrictor or vasodilator is an evolutionary feature for regulation of vasoactivity that seems to have been exploited by nearly all vertebrates (Dombkowski *et al.* 2005). As a result, hydrogen sulfide may trigger a "startle" response in exposed wildlife by constricting blood vessels, increasing heart rate and blood pressure with a consequent increase in respiration and glucocorticoid release (Gabrielsen and Smith 1995, Maren 1999).

Olfactory Toxicity

The olfactory toxicity of hydrogen sulfide exposure deserves special emphasis for wildlife because their chemical senses such as odor detection are well-developed to detect food, danger, or potential mates (Geist 2000; Rehorek *et al.* 2000; Getchell and Getchell 2005; Lledo *et al.* 2005). In most terrestrial vertebrates, the vomeronasal organ is a dome-shaped, cartilage-encased nasal chemosensory structure found on the rostral floor in the nasal cavity (Rehorek *et al.* 2000). The vomeronasal organ is an important interface between the environment and the central nervous system (Rehorek *et al.* 2000). Sensory perception is a process by which information from the external world is subsequently reformatted into an internal state, so this organ is responsible for correctly coding sensory information from thousands of odorous chemicals and other stimuli to the brain (Lledo *et al.* 2005). Snakes are thought to possess the most complex vomeronasal organs. Odorous compounds, even when present at concentrations that cannot be consciously detected by people, often produce a distinct response in a variety of animals (Roth and Goodwin 2002).

For land animals, the initial step in olfactory response involves the interaction of an odor, usually a volatile organic molecule, with specific receptors located on the surface of the olfactory sensory neurons that penetrate the skull and terminate in the olfactory bulb at the base of the brain (Roth and Goodwin 2002). After entering, odorants dissolve in the mucous lining, bind to specific receptors on the neuron's cilia, which opens various ion channels and

depolarizing the membranes of sensory neurons sending various signals throughout the brain (Mombaerts 1999). There are substantial animal toxicology data demonstrating damage to the olfactory senses by airborne chemicals (Cowart *et al.* 1997), and particularly due to hydrogen sulfide exposure (USEPA 2003; ATSDR 2004).

In the derivation of the reference concentration (RfC) used for the Integrated Risk Information System, the USEPA (2003) used the results of a study by Brenneman *et al.* (2000) that exposed 10-week old male rats to 0, 10, 30, or 80 ppm hydrogen sulfide for 6 hours per day for 10 weeks. At the end of the exposure period, the noses of the animals were dissected, sectioned and histological evaluations were made of the respiratory and olfactory epithelium. Lesions were observed in the olfactory mucosa in the animals exposed to 30 or 80 ppm hydrogen sulfide (Brenneman *et al.* 2000). The critical effects in the Brenneman *et al.* (2000) study were nasal lesions of the olfactory mucosa; with 30 ppm identified as the Lowest-Observable-Adverse-Effect Level (LOAEL), 10 ppm identified as the No-Observable-Adverse-Effects-Level (NOAEL), 100 ppm identified as the Frank-Effects Level (FEL) by the USEPA (2003) in their derivation of the RfC. Lopez *et al.* (1987) and Moulin *et al.* (2002) identified that the olfactory epithelium was more sensitive to the toxic effects of hydrogen sulfide than the respiratory epithelium. Credence for the hypothesis that hydrogen sulfide specifically impacts the olfactory senses is supported by the correlation between hydrogen sulfide flux and the human nasal response to hydrogen sulfide odor (USEPA 2003).

In humans, the odor threshold begins at 0.003-0.3 ppm, is easily perceptible at 1 ppm, and is reminiscent of rotten eggs at 3-30 ppm (ATSDR 2004). A sickeningly sweet odor is described from 30-100 ppm above which rapid olfactory fatigue and paralysis ends perception (ATSDR 2004). Prolonged exposure to low concentrations may also result in olfactory paralysis or nasal membrane necrosis (USNLM 2003). Compared with animals, humans have a relatively small area of olfactory epithelium (USEPA 2003).

Reptiles, birds and mammals posses one or more pairs of cartilaginous, epithelially covered projections within the nasal cavity know as turbinates (Geist 2000). In reptiles, these turbinates are relatively simple structures associated with olfaction, however, with birds and mammals, these turbinates are relatively elaborate convoluted structures lined with moist mucociliated epithelium (Geist 2000). Respiratory turbinates are situated directly in the path of respiratory airflow. As inspired air passes through the nasal cavities and over the moist surfaces of the respiratory turbinates, heat and water are exchanged – as is hydrogen sulfide (Geist 2000).

After passing through the nasal passages, inspired air passes down the trachea and through to the main respiratory organ of mammals, birds and reptiles. The trachea consists of repeatedly branching longitudinal and transverse tubes and ducts that terminate in numerous blind-ending sacs or alveoli in the lungs of terrestrial animals. The respiratory organs of mammals, birds, and reptiles are very different from each other (Bennett 1973; Brown *et al.* 1997). However, these structural differences and the differences in ventilation rates for these different classes of animals (mammals, birds and reptiles) can be used to account for the relative inhalation dose of hydrogen sulfide and therefore, the derivation of an inhalation reference concentration for animals (USEPA 1994).

STUDY AREA

The study area includes portions of Chaves, Eddy, and Lea Counties in southeastern New Mexico (Figure 1). Generally, the study area includes the areas known as the Southern High Plains, the lower Pecos River drainage basin, the Caprock, and the Mescalero Sands (also known as the Shinnery Sands Ecoregion). The Mescalero Sands are an extensive deep-sand dune area west of the Caprock, south of State Highway 70, north of State Highway 31, and east of the Pecos River (Griffith *et al.* 2006). Portions of the Mescalero Sands have been designated as a National Natural Landmark, an Outstanding Natural Area, and a Research Natural Area (BLM 1997). Hawley (1986) identified this area as part of the Great Plains Province, while Dick-Peddie (1993) further identified this area as Plains-Mesa Sand Scrub due to the presence of shin oak (*Quercus havardii*). This region also contains extensive petroleum resources of the Permian Basin that annually produce over 65 million barrels (7.5 million m^3) of crude oil and over 550 trillion ft^3 (15.6 trillion m^3) of natural gas (EMNRD 2000). Irrigated farming occurs along the Pecos River in lower Chaves and Eddy Counties.

Associated with the Mescalero Sands is a community of plants and animals called a "sand shinnery" (Peterson and Boyd 1998). Shin oaks co-dominate the sand shinnery vegetative community along with sand sagebrush (*Artemisia filifolia*), tall grasses and forbs. These shin oaks comprise the largest stand of oaks in the United States and occupy nearly six million acres in northern Texas, western Oklahoma, and southeast New Mexico. This shin oak forest is only 1 to 4 ft (0.3 to 1.2 m) tall and is composed of ancient plants, most of them hundreds to thousands of years old (Peterson and Boyd 1998). Two wildlife species characteristic of the sand shinnery include the lesser prairie-chicken (T*ympanuchus pallidicinctus)*, known for its courtship rituals, and the sand dune lizard (*Sceloporus arenicolus*). Both of these species are candidates for listing under the Endangered Species Act as their population declines have been attributed to habitat loss and degradation (Taylor 1980; Service 1998; Painter *et al*. 1999). Common avian species in the study area such as mourning dove, scaled quail, red-tailed hawk, and common roadrunner were described by Peterson and Boyd (1998). Table 1 lists these wildlife species and others found in the area along with their scientific names.

METHODS

Monitoring Site Selection and Characterization

Areas that were selected for monitoring or for bird surveys were characterized as "disturbed" if they were within ~80 to 100 ft (25 to 30 meters [m]) of any visible well pads, drilling rigs, oil storage tanks, pipelines or oil pumps. Often there was a distinct change in the vegetative community near the well pads, tanks, pipelines or pumps as the vegetation was cleared, or was distinctly different from the surrounding area. Areas were characterized as "undisturbed" if they were at least 800 to 1000 ft (~250 to 300 m) from any visible well pads, storage tanks, pipelines or processing facilities and the vegetation community appeared homogenous in all directions (except for roads – see below).

We employed a survey technique recommended by Ralph (1993) that included the systematic placement bird survey point counts at designated distances along roads or trails rather than random sampling design. Site selection for surveys and handheld hydrogen sulfide monitoring was conducted by access along tertiary roads (*i.e.*, often unpaved County roads). A systematic grid of points along tertiary roads was implemented. A randomization program was used to choose those tertiary roads among those available. Thereafter the distance between survey locations was set at approximately every 0.6 mi (~1,000 m) as gauged by an odometer or as measured using a global positioning system (GPS; Garmin, Model GPS V, Olathe, Kansas. The GPS was Wide Area Augmentation System-enabled, set to degrees, minutes and seconds using the 1983 North American Datum). This GPS was also used to mark the location of all observations. The process of driving along roads and stopping approximately every 0.6 mi (1,000 m) was repeated until at least eight bird surveys with eight hydrogen sulfide measurements with a handheld hydrogen sulfide gas detector were conducted each from disturbed and undisturbed sites.

Avian Survey Methods

Few studies have measured natural or accidental exposure of wildlife to hydrogen sulfide. Additionally, few studies have been conducted on bird communities in areas associated with the extensive oil and gas activities in southeast New Mexico. In this study, we quantified the concentrations of hydrogen sulfide in the environment using long-term stationary and hand-held monitors in conjunction with point count surveys of the avian community. A point count is a total of all the birds detected visually and aurally by an observer from a fixed station during a fixed period of time (Ralph *et al.* 1993, 1995; Hamel *et al.* 1996; Huff *et al.* 2000). We used point counts to determine the presence or absence of bird species and their number along with our characterization of the landscape as either "disturbed" or "undisturbed" by oil and gas activities. Note that we did not quantify the area's vegetation within the observational point count area (*i.e.,* vegetation species, number, or spatial extent).

Point count bird surveys were conducted along tertiary roads as described above. Point count surveys began on November 21, 2002 and concluded on August 6, 2003. Counts lasted 3 to 5 min and survey sites consisted of a circle with a radius of approximately 164 ft (50 m). Initial tests of the statistical differences in the point count results from either 3- or 5-min

point count surveys of similar habitats showed no detectable difference (t-test, $P = 0.69$). Once the survey started, all birds that were seen or heard by a trained observer within the point count circle were recorded. The total number of birds, number of species, and number of individuals of each species were recorded. Using a handheld hydrogen sulfide monitor (Industrial Scientific, Model HS560, Oakdale, Pennsylvania), the average concentration of hydrogen sulfide was also recorded from measurements before, during and after the bird survey. Bird surveys were conducted during winter, spring and summer (but not in autumn), as migratory bird community composition changes with season, however, surveys were not repeated in the same areas during each season (winter, spring and summer).

To test for differences between hydrogen sulfide data and bird habitat use we conducted point count surveys of birds in areas that we classified as disturbed or undisturbed by oil and gas activities and season. For each season and for each habitat classification, the number of birds, the number of species, and the number of individuals of each species were summed. Then the average number of birds per point count, the average number of species per point count, the average number of individuals of each species per point count, and the average concentration of hydrogen sulfide gas per point count location were calculated. For each season, the differences in the average number of birds per point count, the average number of species per point count, and the average concentration of hydrogen sulfide gas at the disturbed sites and the undisturbed sites were determined with the use of t-tests (Schefler 1969). For each season and the study overall, differences between the average numbers of individuals of each species per point count for each habitat type were determined with the use of an rXc contingency table (Schefler 1969). The statistical threshold of acceptability that was used was $P \leq 0.05$ (Schefler 1969).

Long-term Hydrogen Sulfide Monitoring Methods

Site selection for hand-held hydrogen sulfide monitoring was as described above. However, three sites were preselected for long-term monitoring based on site characteristics. Long-term monitoring occurred northwest of Carlsbad, New Mexico, due to concerns reported by the community for hydrogen sulfide odors; west of Tatum, New Mexico, as the reference condition; and near Maljamar, New Mexico. For the long-term monitoring of hydrogen sulfide, an Odalog H_2S Gas Logger (App-Tek International Proprietary Limited, Munich, Germany) was attached to a nearby shrub at approximately 3 ft (~1 m) in height using a chain and lock. The monitors were placed as close as possible (less than 50 ft [15 m]) to oil and gas equipment within disturbed sites and over 1,000 ft (300 m) away from any such equipment at the undisturbed site. The hydrogen sulfide monitors contained a data logger that recorded the hydrogen sulfide concentration to within 1 ppm once every minute. The monitors were cleaned and inspected every 2 to 4 weeks, data were downloaded onto a laptop computer and batteries changed prior to placement at a new site. Monitors were calibrated according to manufacturer's specifications and data were later downloaded and then imported into a spreadsheet for graphic representation. Data collection of long-term hydrogen sulfide monitoring began on November 6, 2002 and concluded on August 6, 2003.

Derivation of Wildlife Toxicity Benchmarks

One of the challenges of evaluating the potential effects on wildlife by ambient hydrogen sulfide concentrations is that there is little or no direct exposure data on which to base the thresholds of concern. The USEPA (1994) developed a methodology for estimation of the RfC as benchmark estimates of the quantitative dose response assessment of chronic toxicity for individual inhaled chemicals such as hydrogen sulfide. The USEPA (1994) RfC methodology accounts for the dynamics of the respiratory system to account for species-specific relationships of exposure concentrations to delivered doses. The RfC methodology, which is a set of procedures to estimate a dose-response assessment, has inherent uncertainty and imprecision because it requires judgment, the use of assumptions, and data extrapolations (USEPA 2003).

The RfC derivation begins with the identification of a NOAEL and a LOAEL, which are determined for a specified adverse effect from the exposure levels of a given individual study. The USEPA (2003) validated and used the results of the Benneman *et al.* (2000) study to derive the RfC for humans, and therefore we shall use the results of the Benneman *et al.* (2000) study to derive a wildlife specific RfC for evaluation in this report. The NOAEL and LOAEL may need to be converted to standard units (milligrams per cubic meter [mg/m^3]), normalized to an exposure time (24 hours [h]), and adjusted to a wildlife species equivalent dose by accounting for species-specific dosimetric differences in the surface area of the trachea region and the ventilation rate. The dosimetric adjustment factors wildlife species were calculated as:

$$NOAEL_{wildlife}\ (mg/m^3) = NOAEL_{rat}\ (mg/m^3) \times DAF_r \qquad \text{(Equation 1)}$$

where:

$NOAEL_{wildlife}$ is the NOAEL (or analogous effect level) for a particular wildlife species obtained using USEPA (1994).

$NOAEL_{rat}$ is the NOAEL (or analogous effect level) from the Benneman *et al.* (2000) study.

DAF_r is a dosimetric adjustment factor for the surface area of the trachea and either the resting respiration rate or the active respiration rate for each species.

Therefore, the DAF_r for any wildlife species compared to the laboratory rat would be:

$$DAF_r = \left(\frac{\left(\dfrac{\textit{Rat ventilation rate} \quad (ml/\min)}{\textit{surface area of trachea} \quad (cm^2)} \right)}{\left(\dfrac{\textit{Wildlife ventilation rate} \quad (ml/\min)}{\textit{surface area of trachea} \quad (cm^2)} \right)} \right) \qquad \text{(Equation 2)}$$

The ventilation rates and surface area of the laboratory rat were reported by the USEPA (1994). However, ventilation rates and trachea dimensions area in wildlife species are a function of body mass (Calder 1968; Hinds and Calder 1971; Bennett 1973; Brown *et al.* 1997; Frappell *et al.* 2001). We used the avian body masses reported by Dunning (1993) and Sell (1977) as well as the mammalian body masses reported and Silva and Downing (1995) to calculate the ventilation rates and trachea surface area while active or at rest (Table 2). However, while respiration rates for various reptile species was reported by Bennett (1973), and body mass was reported by Degenhardt *et al.* (1996), information on trachea surface area was not available. Therefore, we made an assumption that sand dune lizard trachea dimensions were equivalent to that of a bird of equal mass (0.005 kilograms [kg]). Then we used geometry to determine the surface area of the trachea. We assumed the trachea radius was one half the trachea width and the surface area was equal to that of a cylinder with a circumference of 2 times the trachea radius times pi ($2\pi r$) times the height that is equal to that of the trachea length (Table 2). Note that if hydrogen sulfide toxicity is not related to exposure by ventilation, but rather by species-specific differences in gas exchange surfaces, then this dose scaling may not be appropriate.

Calculation of a protective air quality standard for wildlife would require the development of an RfC using uncertainty factors to account for species differences, laboratory-to-field study modifiers, and duration of exposure. We compared the ambient concentrations of hydrogen sulfide to the NOAEL to indicate potential risks to wildlife. The lowest NOAEL concentration was rounded to an integer and that value was recommended as an interim ambient air quality recommendation to protect wildlife until an RfC could be further developed. These interim ambient air quality recommendations are therefore "action levels" as they do not consider a number of uncertainty factors normally used to derive ambient air quality criteria (USEPA 1994, 2003)

Determination of Potential Sources of Monitored Hydrogen Sulfide Concentrations

For those two events when hydrogen sulfide concentrations exceeded 5 ppm during our long-term monitoring, we evaluated the nearby wind speed and direction for the hour at which the elevated hydrogen sulfide concentration was measured to determine potential source(s). Wind data at the monitoring device was unavailable; therefore we obtained hourly wind speed and direction from a nearby weather station in Roswell, New Mexico (NOAA 2003) and assumed they were representative. For example, when wind speeds and direction were reported at 17 mi/h (~27 km/h) from the north, we assumed that the measured hydrogen sulfide concentrations came from sources in an upwind cone up to 17 mi (24 km) in length were the most likely sources of the hydrogen sulfide concentrations measured.

RESULTS

Long term hydrogen sulfide monitors were placed near seven oil well pumping jacks and eight oil tanks for periods averaging 2 to 4 weeks at a time. For most sites, the peak concentrations of hydrogen sulfide measured were often less than 6 ppm (Figures 2 through 17). The highest concentration (33 ppm) was measured near an oil tank (North 32 º 49' 54" by West 104 º 02' 41") for a period lasting about an hour. A concentration of 27 ppm was also measured at an oil tank (North 32º 36' 48" by West 103 º 18' 44") for a period of 2 h. (Figure 13). At these sites, during periods when hydrogen sulfide was elevated, the 1-hour average was also found to exceed the New Mexico air quality standard. The hydrogen sulfide monitors that were placed in reference habitats that were far removed from oil and gas production facilities had peak hydrogen sulfide concentrations less than 1 ppm.

During the winter survey season, a total of 52 point count surveys of birds were conducted on undisturbed sites and 50 point count surveys were conducted on disturbed sites. A total of 198 birds representing 34 species were counted on undisturbed sites and 40 birds representing 19 species were counted on disturbed sites (Table 3, Figure 18). The average number of individuals counted per point count survey at the undisturbed sites was 3.8 (Standard Deviation [S.D.] = 4.4). The average number of individuals counted per point count survey at the disturbed sites was 0.8 (S.D. = 1.3). The observed difference in the average number of individuals at the undisturbed and disturbed sites was statistically significant (t-test, $P < 0.01$). The average number of species counted per point count survey at the undisturbed sites was 1.3 (S.D. = 1.2) and 0.5 (S.D. = 0.7) at the disturbed sites. Also the difference in the average number of species counted per point count at the undisturbed and disturbed sites was statistically significant (t-test, $P < 0.01$). The observed differences in species composition at the undisturbed and disturbed sites were statistically significant (rXc contingency table, $P < 0.01$). The average concentration of hydrogen sulfide present at the undisturbed sites was 0.1 ppm (S.D. = 0.3) and at the disturbed sites was 1.5 (S.D. = 0.7). The observed difference was statistically significant (t-test, $P < 0.01$).

During the spring survey season a total of 42 point count surveys of birds were conducted on undisturbed sites and 33 point count surveys were conducted on disturbed sites. A total of 62 birds representing 15 species were counted on undisturbed sites and six birds representing four species were counted on disturbed sites (Table 4, Figure 19). The average number of individuals counted per point count survey at the undisturbed sites was 1.5 (S.D. = 1.4) and 0.2 (S.D. = 0.5) at the disturbed sites. The observed difference in the average number of individuals was statistically significant (t-test, $P < 0.01$). The average number of species counted per point count survey at the undisturbed sites was 0.9 (S.D. = 0.1) and 0.2 (S.D. = 0.1) at the disturbed sites. The observed difference was statistically significant (t-test, $P < 0.01$). The observed differences in species composition at the undisturbed and disturbed sites were statistically significant (rXc contingency table, $P < 0.01$). The average concentration of hydrogen sulfide at the undisturbed sites was 0.2 ppm (S.D. = 0.5) and 1.2 ppm (S.D. = 0.6) at the disturbed sites. The observed difference was statistically significant (t-test, $P < 0.01$).

During the summer survey season a total of 26 point count surveys of birds were conducted on undisturbed sites and 33 point count surveys were conducted on disturbed sites. A total of

54 birds representing 15 species were counted on undisturbed sites and 15 birds representing five species were counted on disturbed sites (Table 5, Figure 20). The average number of individuals counted per point count survey at the undisturbed sites was 2.1 (S.D. = 2.3) and 0.5 (S.D. = 0.8) at the disturbed sites. The observed difference in the average number of individuals was statistically significant (t-test, $P < 0.01$). The average number of species counted per point count survey at the undisturbed sites was 0.9 (S.D. = 0.1) and 0.3 (S.D. = 0.5) at the disturbed sites. The observed difference was statistically significant (t-test, $P < 0.01$). The observed differences in species composition at the undisturbed and disturbed sites were statistically significant (rXc contingency table, $P < 0.01$). The average concentration of hydrogen sulfide at the undisturbed sites was 0.3 ppm (S.D. = 0.5) and 2.0 ppm (S.D. = 1.6) at the disturbed sites. The observed difference was statistically significant (t-test, $P < 0.01$).

Overall, a total of 120 point count surveys of birds were conducted on undisturbed sites and 116 point count surveys were conducted on disturbed sites. A total of 314 birds representing 40 species were counted on undisturbed sites and 58 birds representing 25 species were counted on disturbed sites (Table 6, Figure 21). Lesser prairie-chickens were not observed at any of the study sites. The average number of individuals counted per point count survey at the undisturbed sites was 2.6 (S.D. = 3.3) and 0.5 (S.D. = 0.9) at the disturbed sites. The observed difference was statistically significant (t-test, $P < 0.01$). The average number of species counted per point count survey at the undisturbed sites was 1.1 (S.D. = 0.9) and 0.4 (S.D. = 0.6) at the disturbed sites. The observed difference was statistically significant (t-test, $P < 0.01$). The observed differences in species composition at the undisturbed and disturbed sites were statistically significant (rXc contingency table, $P = 0.04$). The average concentration of hydrogen sulfide at the undisturbed sites was 0.2 ppm (S.D. = 0.4) and 1.6 ppm (S.D. = 1.1) at the disturbed sites. The difference was statistically significant (t-test, $P < 0.01$).

DISCUSSION

Dubyk *et al.* (2002), monitored ambient hydrogen sulfide levels in areas of New Mexico near these facilities: 1) a sewage treatment plant; 2) four dairy operations; 3) a poultry operation; 4) a liquid septage disposal facility; 5) a sewage sludge disposal facility; and, 6) nine oil and gas facilities. All of the facilities they inspected indicated a high likelihood that they could exceed the New Mexico air quality standards for hydrogen sulfide. At oil and gas facilities, hydrogen sulfide concentrations ranged from 0 to 15 ppm; the highest concentrations were reported near the Black River northeast of Whites City, New Mexico. Dubyk *et al*. (2002) reported that all other facilities were measured with ambient concentrations less than 0.11 ppm. Dubyk *et al.* (2002) also reported that background ambient air concentrations of hydrogen sulfide in New Mexico range from 0 to 0.010 ppm and averaged 0.0057 ppm.

We measured concentrations of hydrogen sulfide as high as 33 ppm near an oil tank in the vicinity of Loco Hills, New Mexico, approximately 25 mi (40 km) east of Artesia, New Mexico. Using wind speed and direction, oil production wells and injection wells were identified upwind of the elevated hydrogen sulfide concentrations detected by the long-term monitors (Figure 22). However, it is uncertain if any of these particular production or injection wells were the source of the measured hydrogen sulfide peak concentrations in the ambient air.

Based on our dosimetric calculations, mammals appeared to be more sensitive to hydrogen sulfide toxicity than either birds or reptiles. Reptile ventilation rates are slower and therefore reduce the amount of hydrogen sulfide exposure to their tissues. Hydrogen sulfide concentrations less than 2 ppm appear not to pose a risk to mammal species at rest, while concentrations greater than 5 ppm pose a risk to wildlife and are likely to affect their olfactory senses, irritate their eyes and mucus membranes, or dilate their blood vessels and cause a startle or stress reaction (Table 2). Mammals exposed to greater than 11 ppm would be more likely to flee an area or succumb to hydrogen sulfide toxicity (Table 2).

Avian species are more at risk when they are active or flying as they inhale deeper. Hydrogen sulfide concentrations less than 1 ppm would appear not to pose a risk to birds when they are active or flying (Table 2). Hydrogen sulfide concentrations less than 8 ppm appear not to pose a risk to avian species at rest, while concentrations greater than 25 ppm pose a risk to avian species and may affect their olfactory senses, irritate their eyes and mucus membranes, or dilate their blood vessels and cause a startle or stress reaction (Table 2). Based on these analyses, ambient air hydrogen sulfide concentrations should be less than 1 ppm to protect flying birds and less than 2 ppm to protect resting mammals from hydrogen sulfide toxicity in their habitat. These recommendations would be considered “action levels” as they do not consider a number of uncertainty factors normally used in the derivation of ambient air quality criteria (USEPA 1994, 2003).

Sias and Snell (1998) hypothesized that since sand dune lizards are strongly associated with the bottoms of dune valleys, these lizards may be more susceptible to gas poisoning (than other lizard species) associated with these wells since hydrogen sulfide is heavier than air. Sias and Snell (1996, 1998) provided data and evidence to conclude that the presence of oil

and gas wells is strongly correlated with a reduction in sand dune lizard abundance. Their plots within 263 ft (80 m) of an oil or gas well pad (the area of disturbance around a well) had a 39 percent reduction in the population of sand dune lizards compared with plots more than 623 ft (190 m) from an oil or gas well pad. Sias and Snell (1998) also identified impacts to other wildlife including observations of moribund owls and other raptors as well as they found the carapace remains of turtle carcasses (*e.g.* turtle shells) in areas around oil and gas wells that were reported to emit hydrogen sulfide and other gases (identified by signage).

We found that sand dune lizards that are active should begin to demonstrate adverse effects at concentrations in their environment greater than 14 ppm. On February 2, 2003, we measured hydrogen sulfide concentrations as high as 26 ppm for 1 h in the early evening (Figure 22) with little or no wind measured nearby. On March 25, 2003, we measured hydrogen sulfide concentrations as high as 33 ppm for 32 min in the early morning with winds measured nearby approaching 17 mi/h (~27 km/h) from the north (Figure 22). These ambient concentrations during these periods were at levels that would be expected to have adverse effects on active sand dune lizards and perhaps other wildlife species as well (Table 2). Sand dune lizards that are resting should be protected from adverse effects of hydrogen sulfide if concentrations in their environment remain below 50 ppm. No ambient hydrogen sulfide concentrations above 50 ppm were measured during this study.

Other studies have found that habitat disrupted by oil and gas activities negatively impacts populations of birds. Migration routes of waterfowl are often changed and the breeding success of waterfowl decreases as a result of oil and gas activities (Monda *et al.* 1994; Johnson 1998). Populations of birds of prey dramatically decrease when oil wells are placed within habitat they occupy (Squires *et al.* 1993; Van Horn 1993). Many species of passerines have also been impacted negatively by the building of oil well sites (Baker 1987).

In this study, there was a statistical difference in the average number of individuals counted per point count, the average number of species counted per point count survey, the species composition, and the average concentration of hydrogen sulfide at the undisturbed and the disturbed sites. This suggests that habitat quality may be affected by oil and gas activities and may alter the composition of local avian communities. Habitat disrupted by oil and gas activities favored avian species adapted to feeding in disturbed habitat such as doves, quail, and sparrows. Habitat disturbed by oil and gas activities contained fewer species and reduced usage by species such as wrens, vireos, flycatchers and phoebes.

It is possible that oil and gas activities may negatively affect avian diversity and their numbers through changes in vegetation that were not quantified during this study. However, we found that changes in habitat conditions as described as “disturbed” by oil and gas activities, were significantly related to reduced numbers of birds observed during point counts, decreased avian species diversity observed during point counts, and increased hydrogen sulfide concentrations. Nonetheless, the causes of the decline of bird density, diversity and elevated hydrogen sulfide were not determined during this study. Further long-term studies of the effects of oil and gas activities on migratory birds and their habitat are needed. Restoration of habitat affected by activities of oil and gas is needed to preserve migratory bird populations and avian species diversity.

RECOMMENDATIONS

The authors recommend that Federal, State and Tribal agencies implement the following actions to protect wildlife:

1. Adopt an interim air quality standard of 1 ppm hydrogen sulfide to protect wildlife.

2. Require monitoring of hydrogen sulfide to identify sources in areas where ambient concentrations routinely exceed 1 ppm and find ways to reduce those sources. Routine monitoring should include appropriate meteorological monitoring, particularly local wind conditions and direction, so as to identify any seasonal or geographic trends. Hydrogen sulfide monitoring programs should be adequate to characterize a geographic area and its ambient conditions over time, as well as be able to identify any local sources for management actions.

3. Report incidences of migratory bird deaths to the Service, as may occur when birds are affected by oil and gas activities, hydrogen sulfide emissions or release of other hazardous fluids. Federal, State and Tribal agencies should identify any means and measures necessary to avoid or minimize the potential for take of migratory birds.

4. Fund studies that confirm the toxicity and mechanisms of action of hydrogen sulfide using mammal, avian and reptile species in order to refine this risk assessment in this study as well as identify any adverse effects to their olfactory tissues and functions.

5. Routinely monitor avian communities in habitats that are affected by oil and gas activities in order to determine any long-term deleterious trends and develop management strategies to address those trends to conserve migratory bird habitats.

6. Evaluate the changes to the vegetative community by oil and gas activities and any associated surface waters for effects to migratory birds, and other wildlife.

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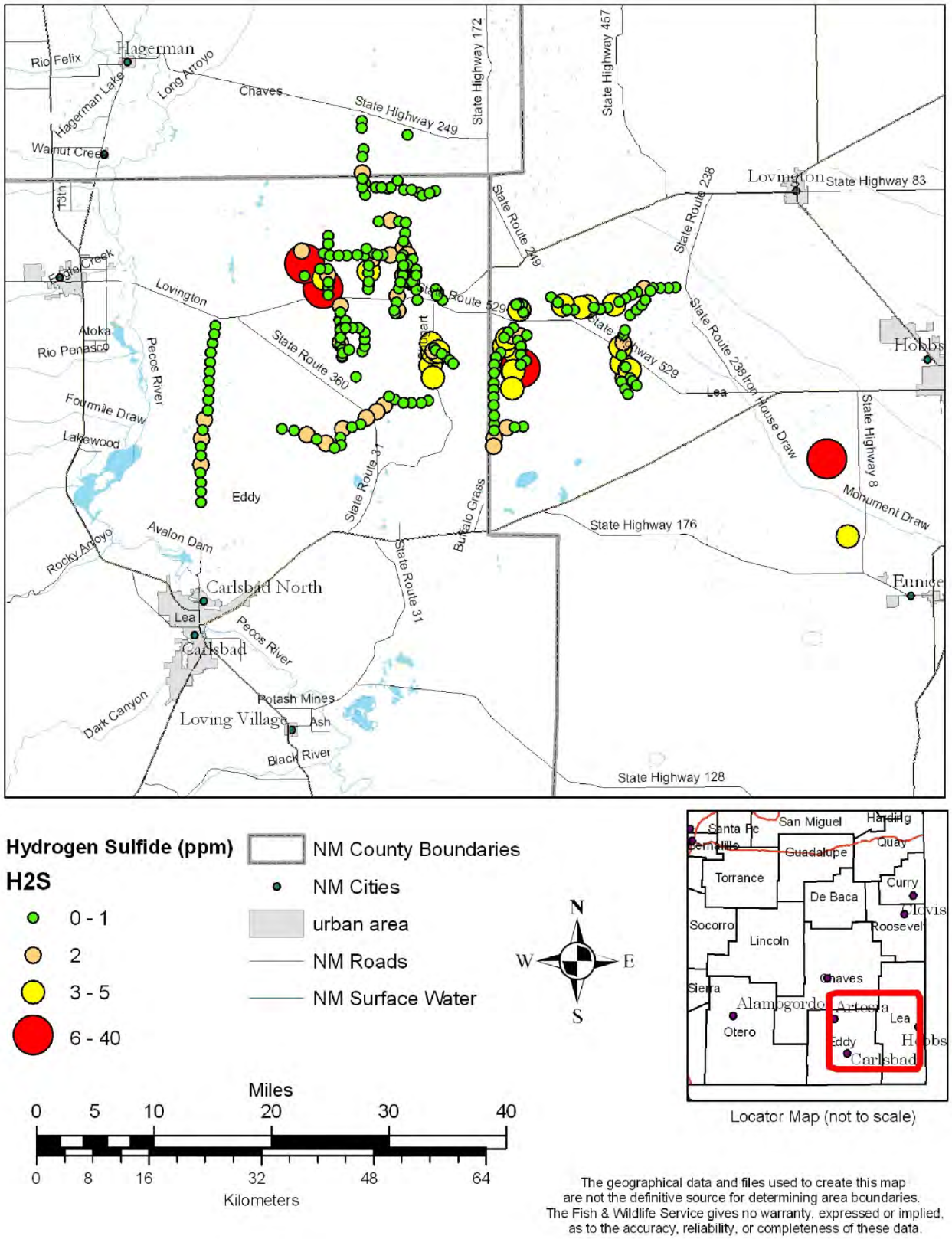

Figure 1. Map of the Study Area and Hydrogen Sulfide Monitoring Results

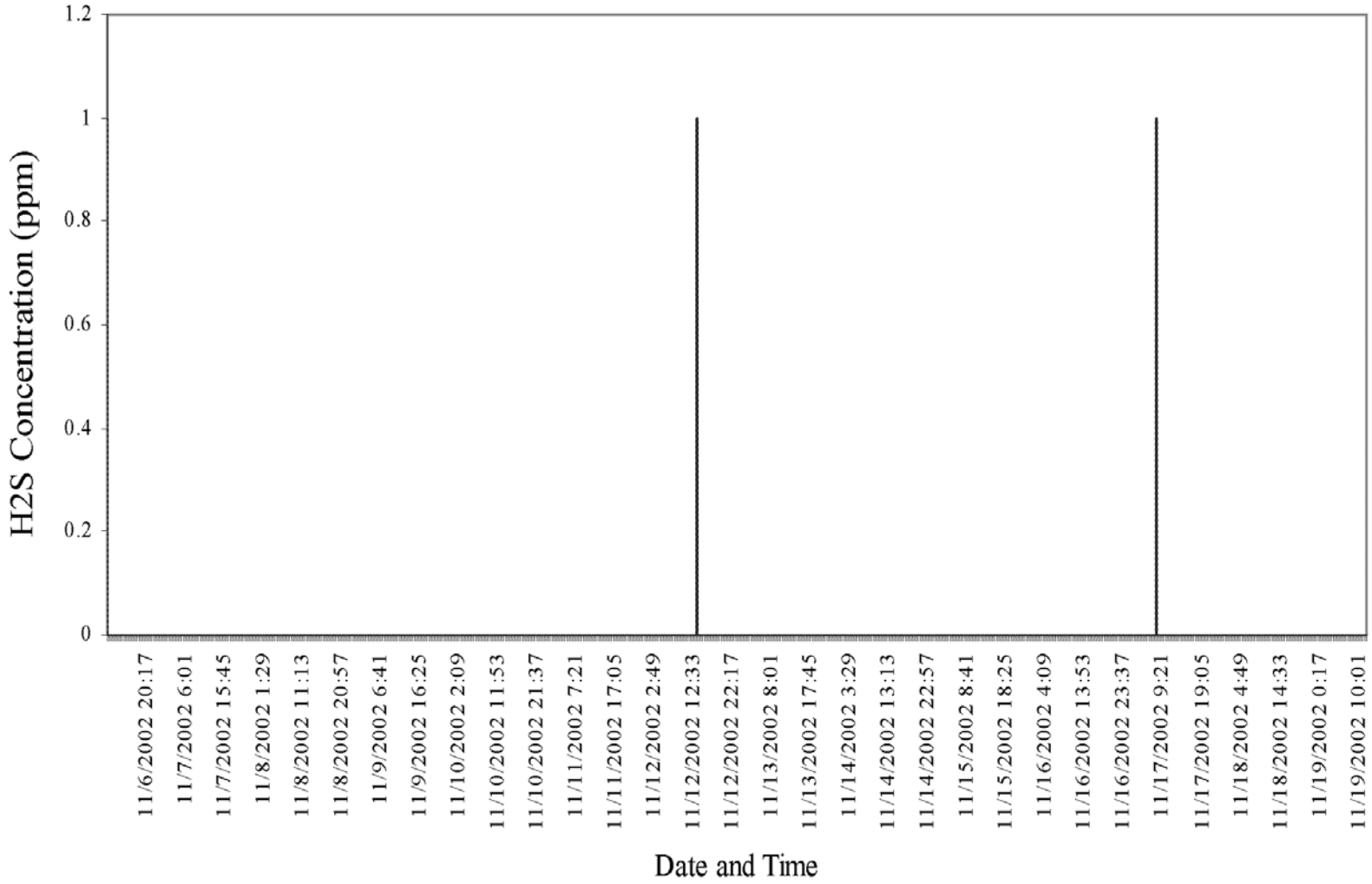

Figure 2. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 º 50' 10" by West 103 º 58' 39") for November 6, 2002- November 19, 2002.

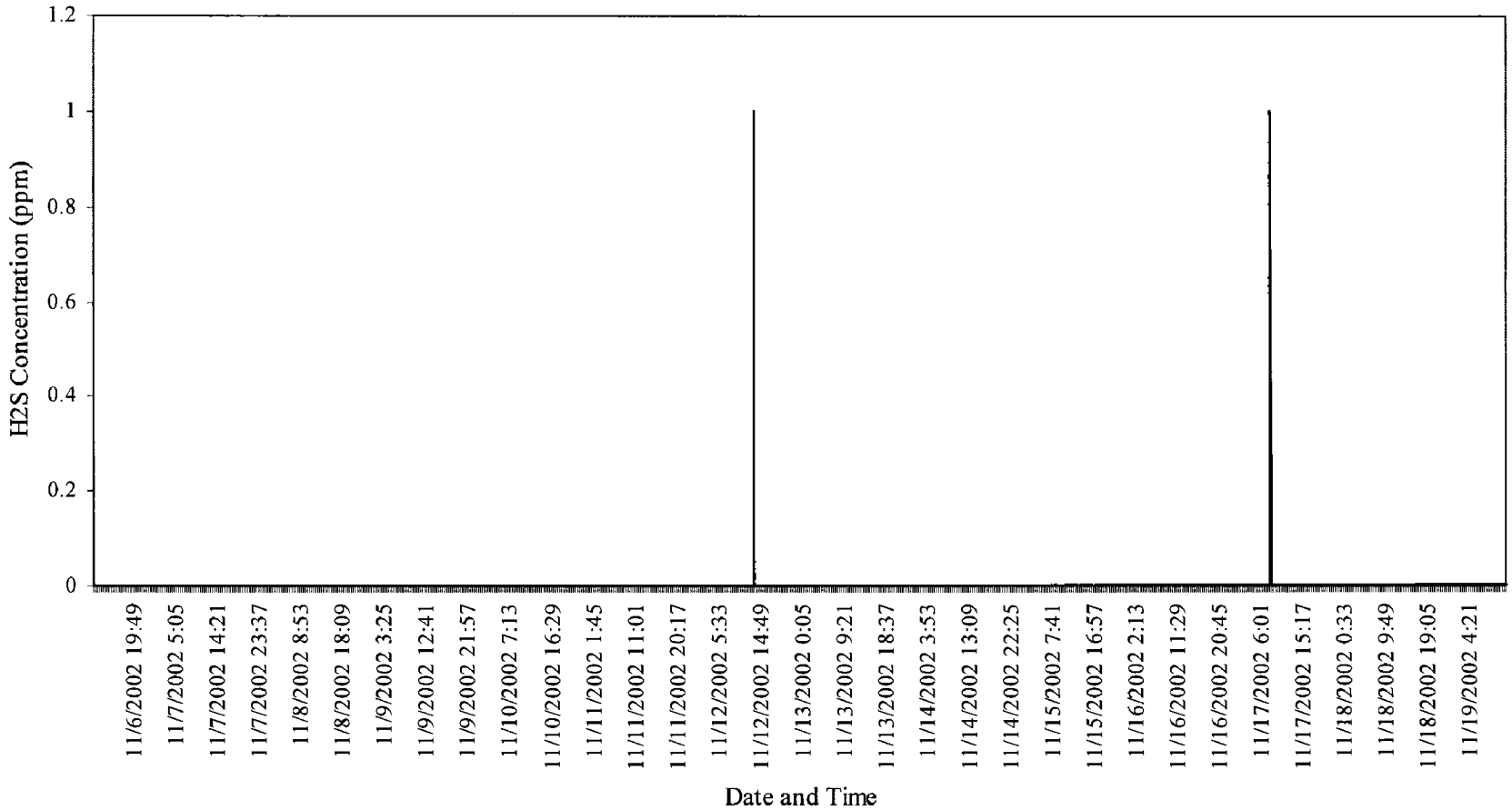

Figure 3. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 27' 05" by West 104 ° 31' 29") for November 6, 2002- November 19, 2002.

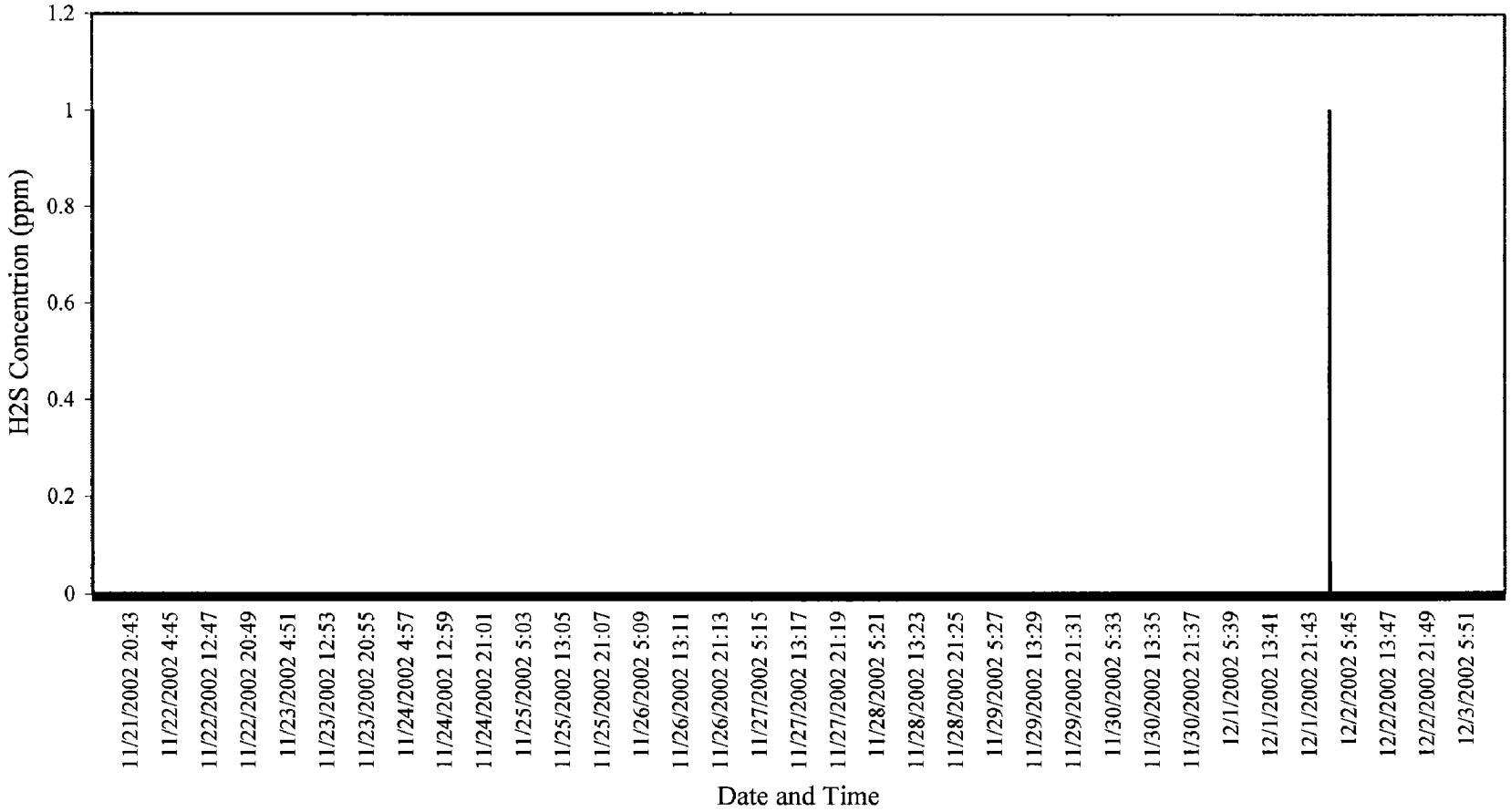

Figure 4. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 ° 60' 17" by West 104 ° 36' 34") for November 21, 2002- December 3, 2002.

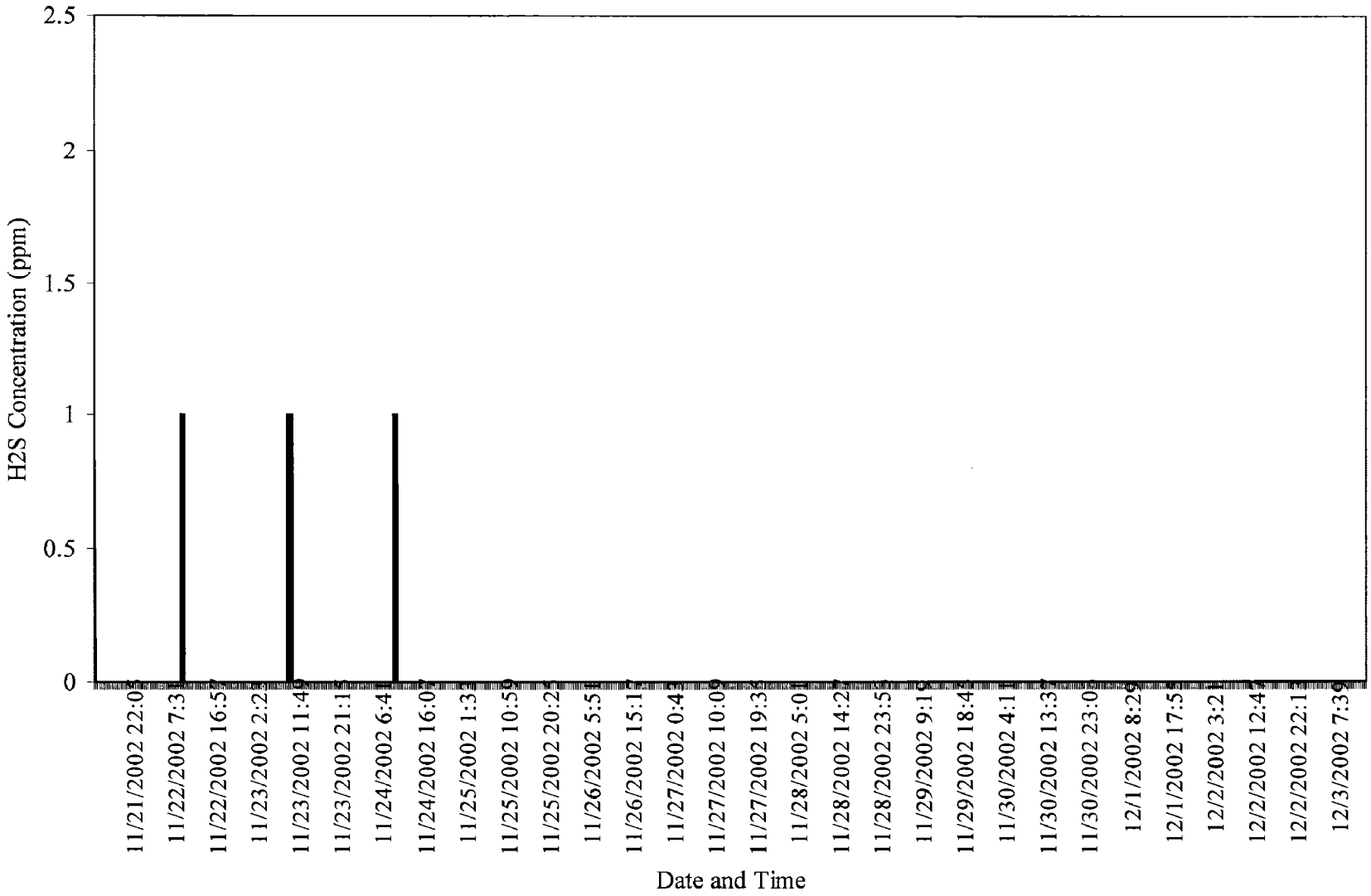

Figure 5. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 33 ° 59' 04" by West 104 ° 36' 34") for November 21, 2002- December 3, 2002.

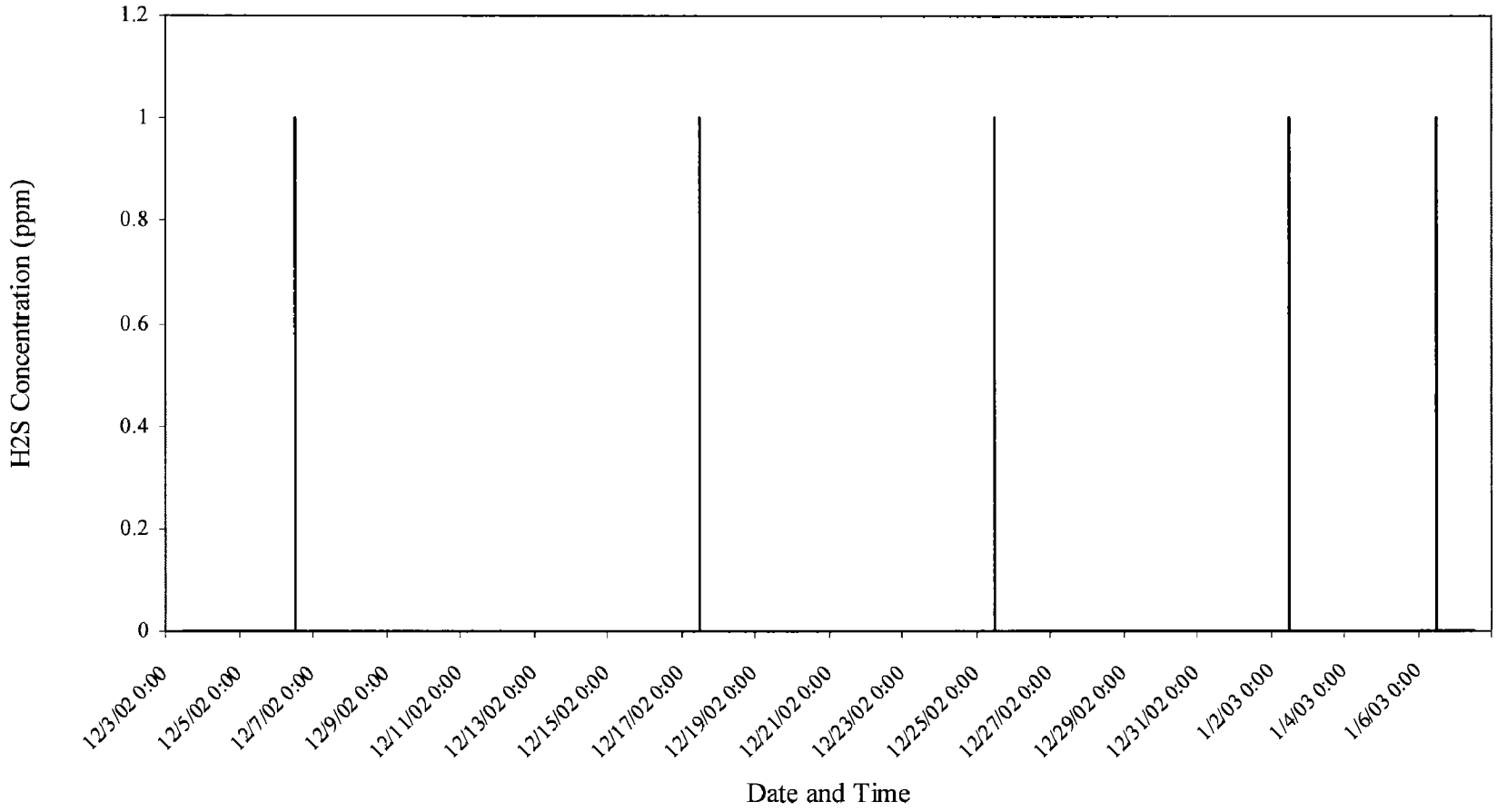

Figure 6. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 33 ° 50' 45" by West 104° 05' 56") for December 6, 2002- January 7, 2003.

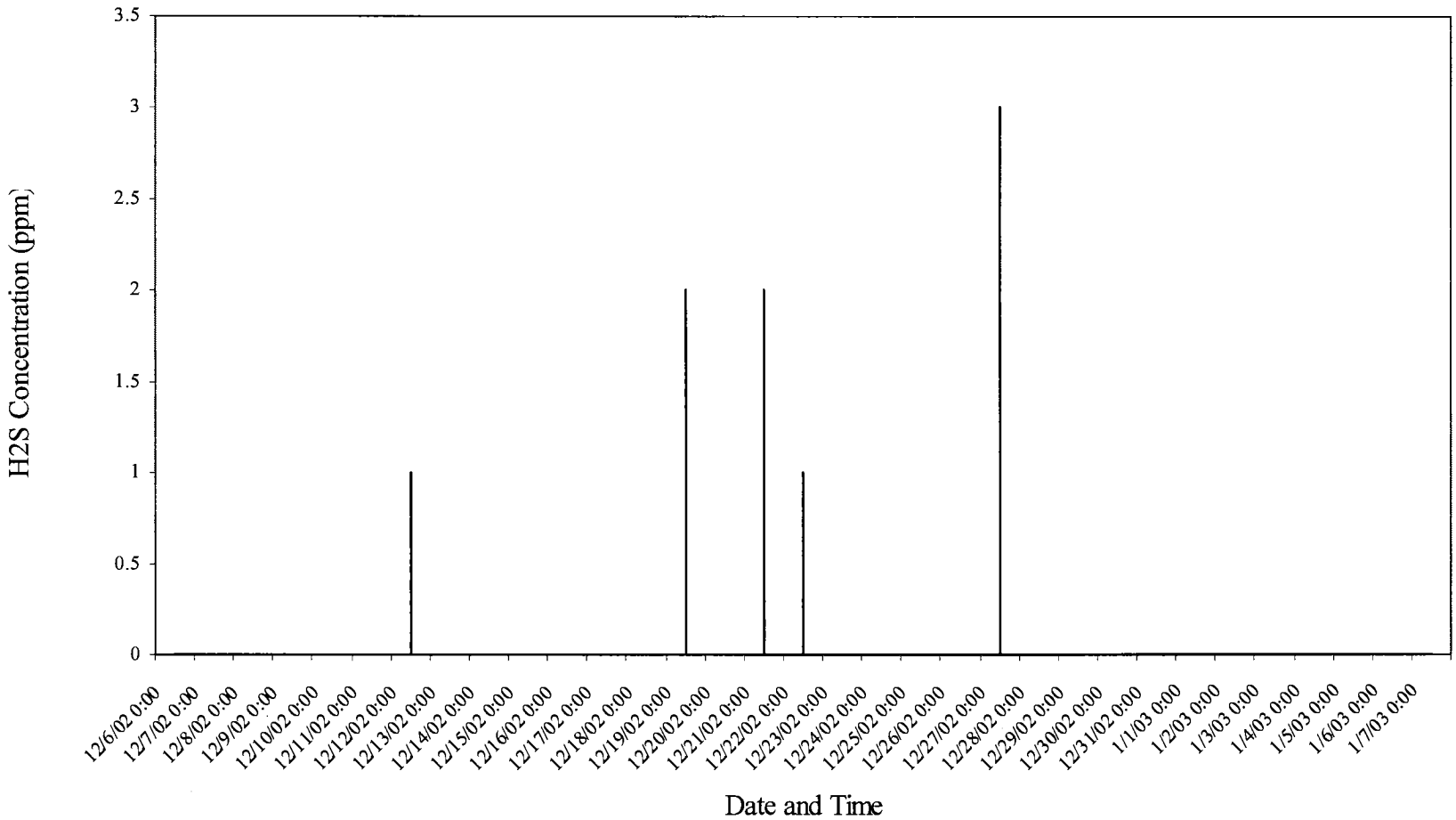

Figure 7. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 51' 10" by West 103 ° 58' 39") for December 6, 2002- January 7, 2003.

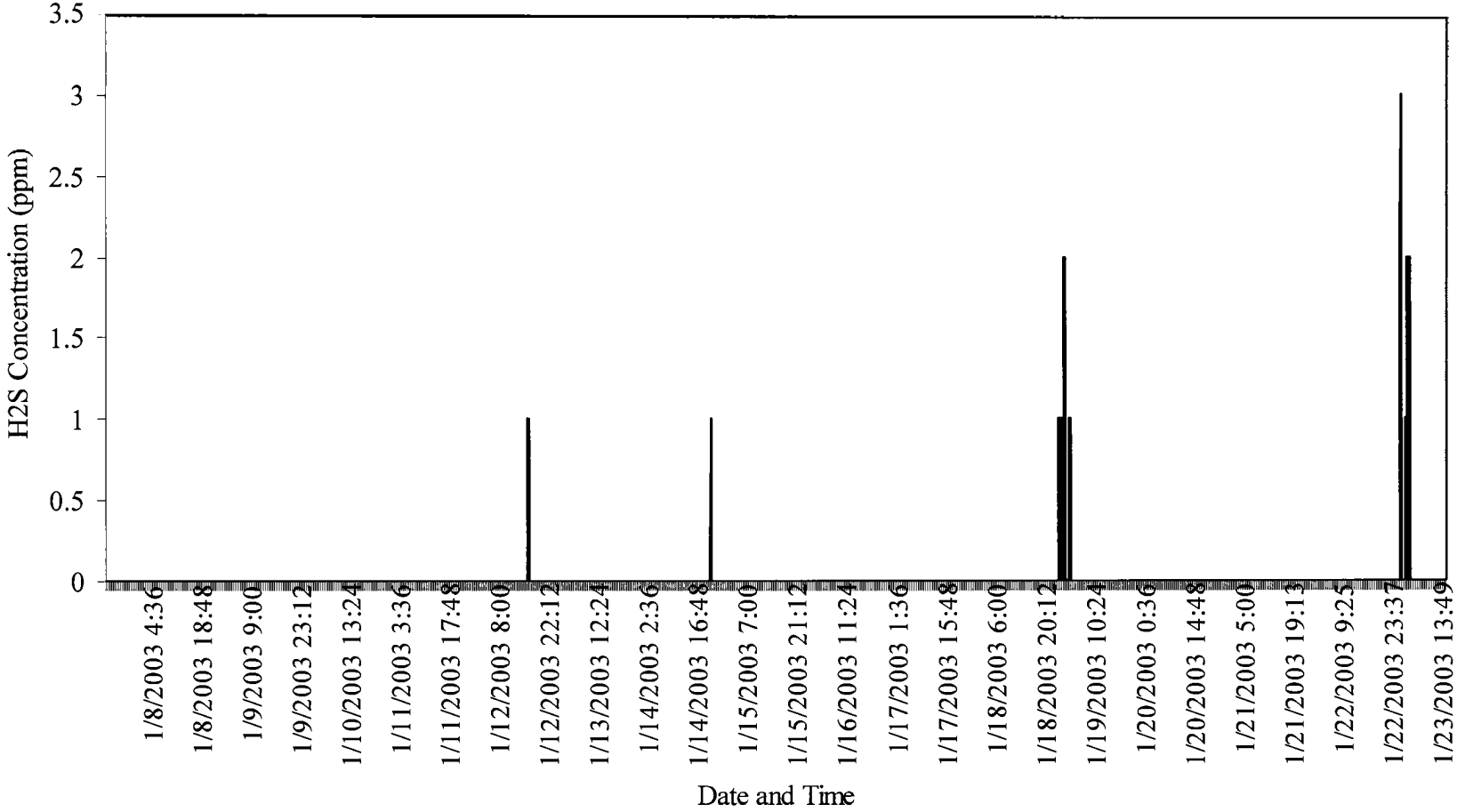

Figure 8. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 ° 50' 37" by West 104 ° 02' 37") for January 7, 2003- January 23, 2003.

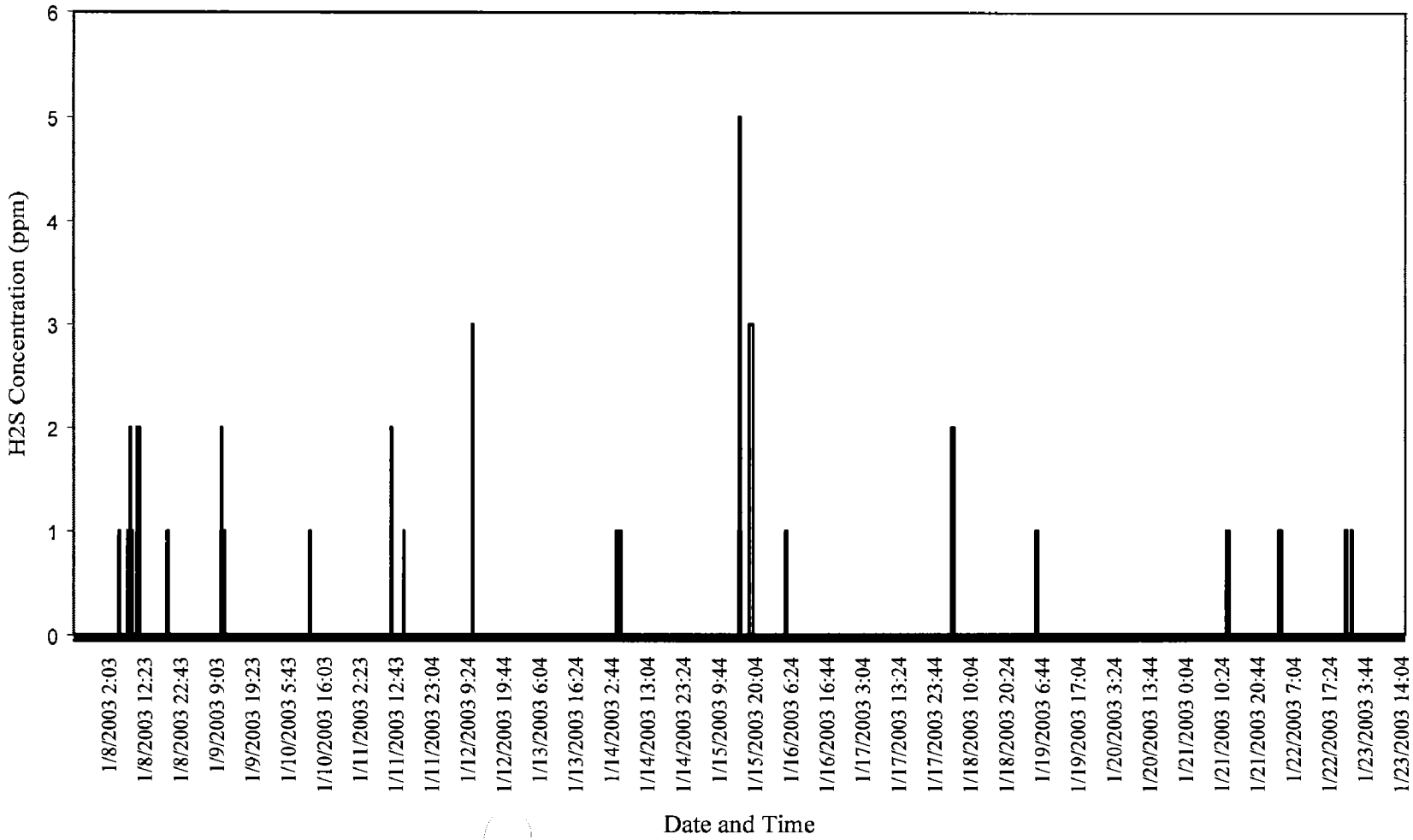

Figure 9. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 31' 01" by West 103 ° 16' 59") for January 7, 2003- January 23, 2003.

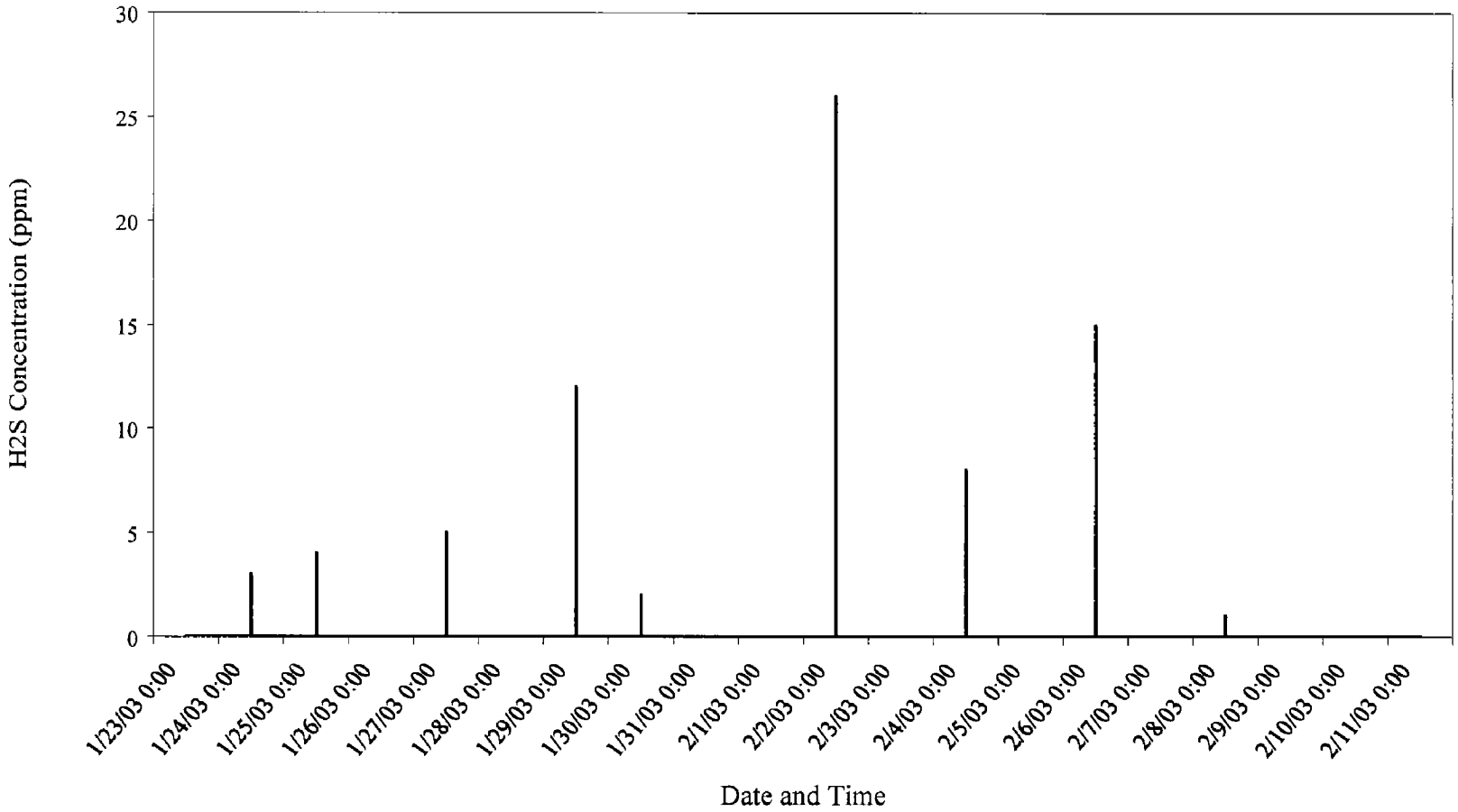

Figure 10. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 ° 36' 48" by West 103 ° 18' 44") for January 23, 2003- February 11, 2003.

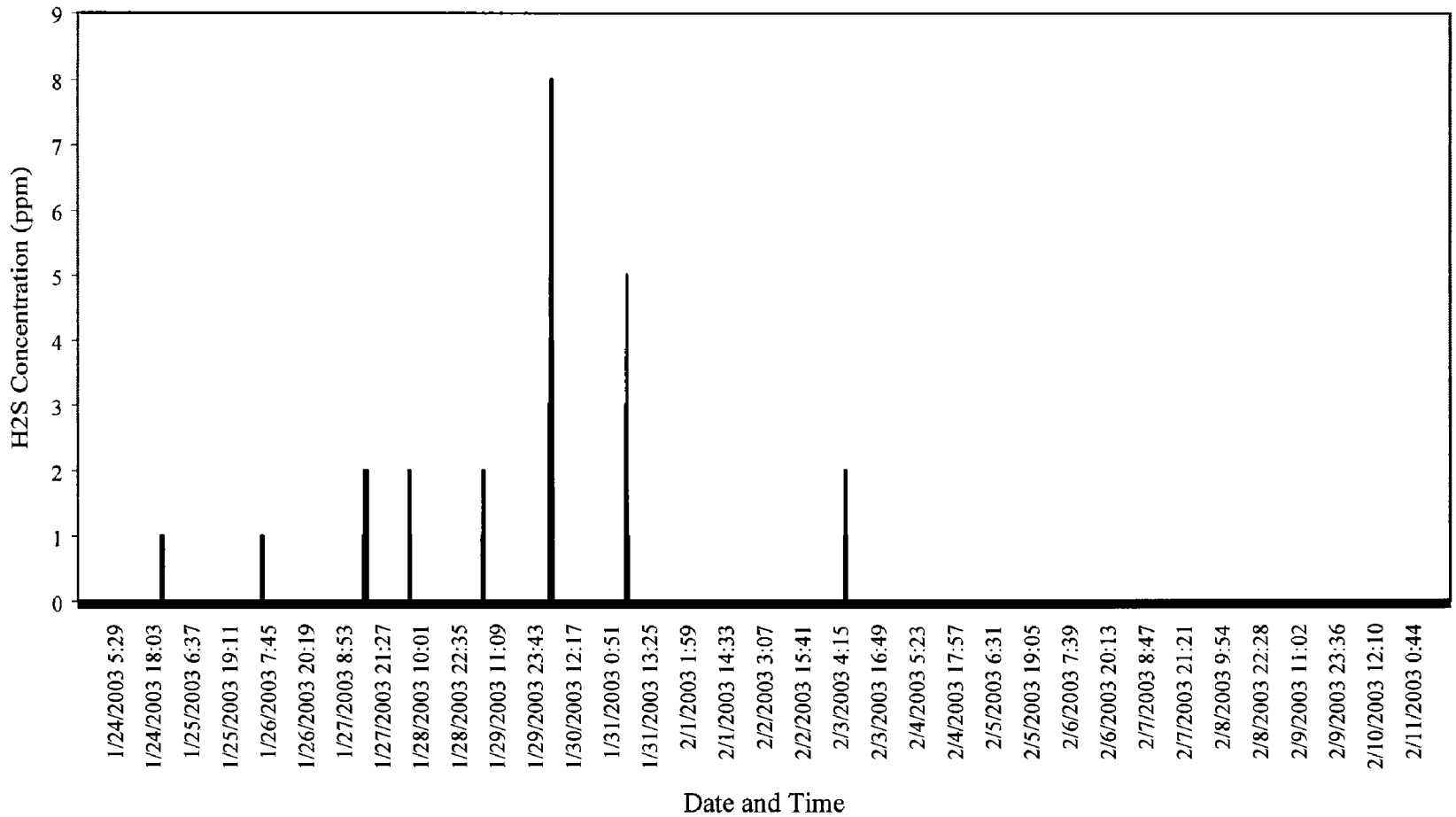

Figure 11. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 51' 46" by West 104 ° 04' 16") for January 23, 2003- February 11, 2003.

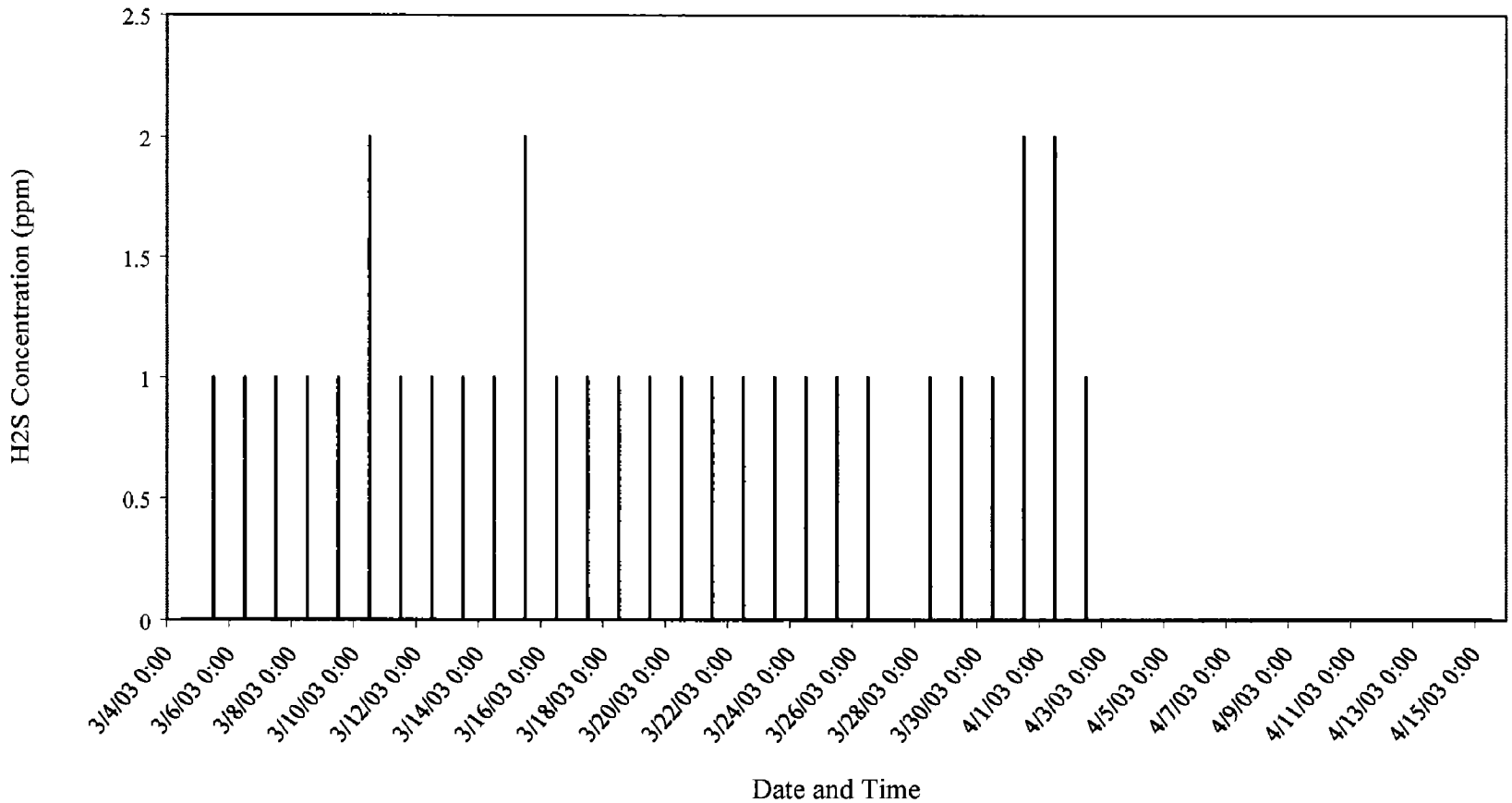

Figure 12. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 ° 52' 43" by West 104 ° 04' 32") for March 4, 2003- April 16, 2003.

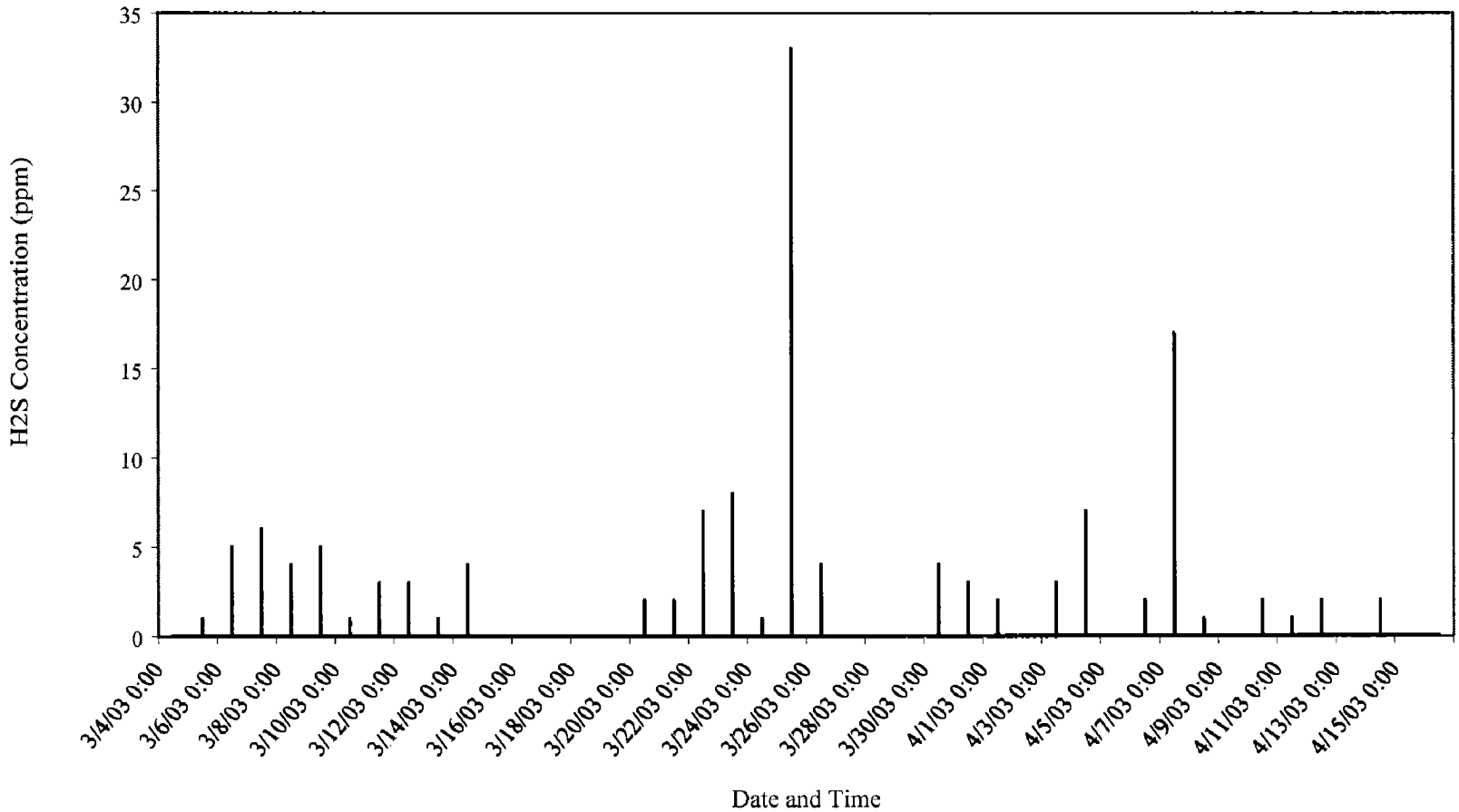

Figure 13. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 49' 54" by West 104 ° 02' 41") for March 4, 2003- April 16, 2003.

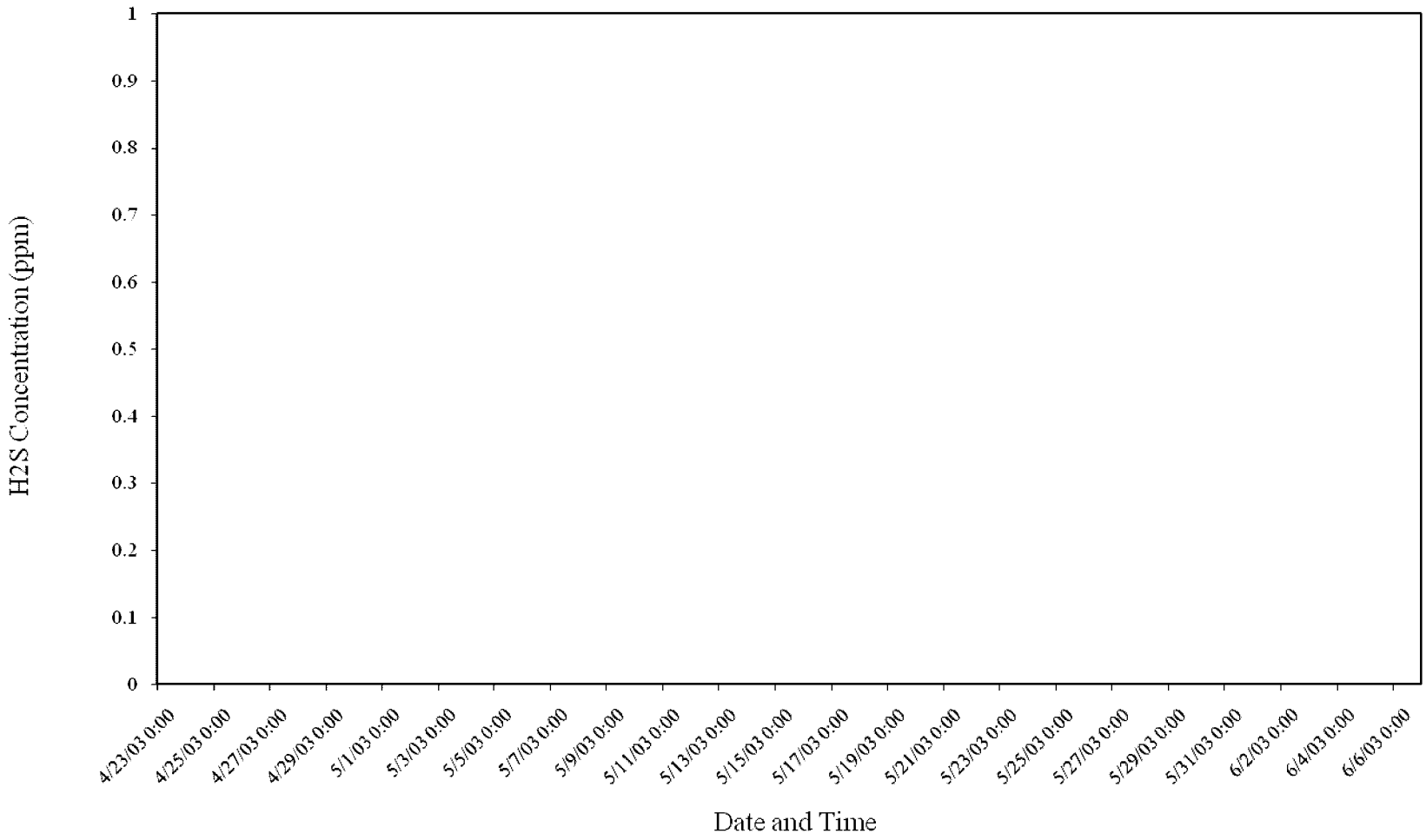

Figure 14. Graph of Hydrogen Sulfide Concentrations near Mathers Natural Area (North 32° 48' 14" by West 103° 56' 27") for April 23, 2003- June 28, 2003. [Note: concentration of hydrogen sulfide measured in ambient air for 65 days at this site was zero.]

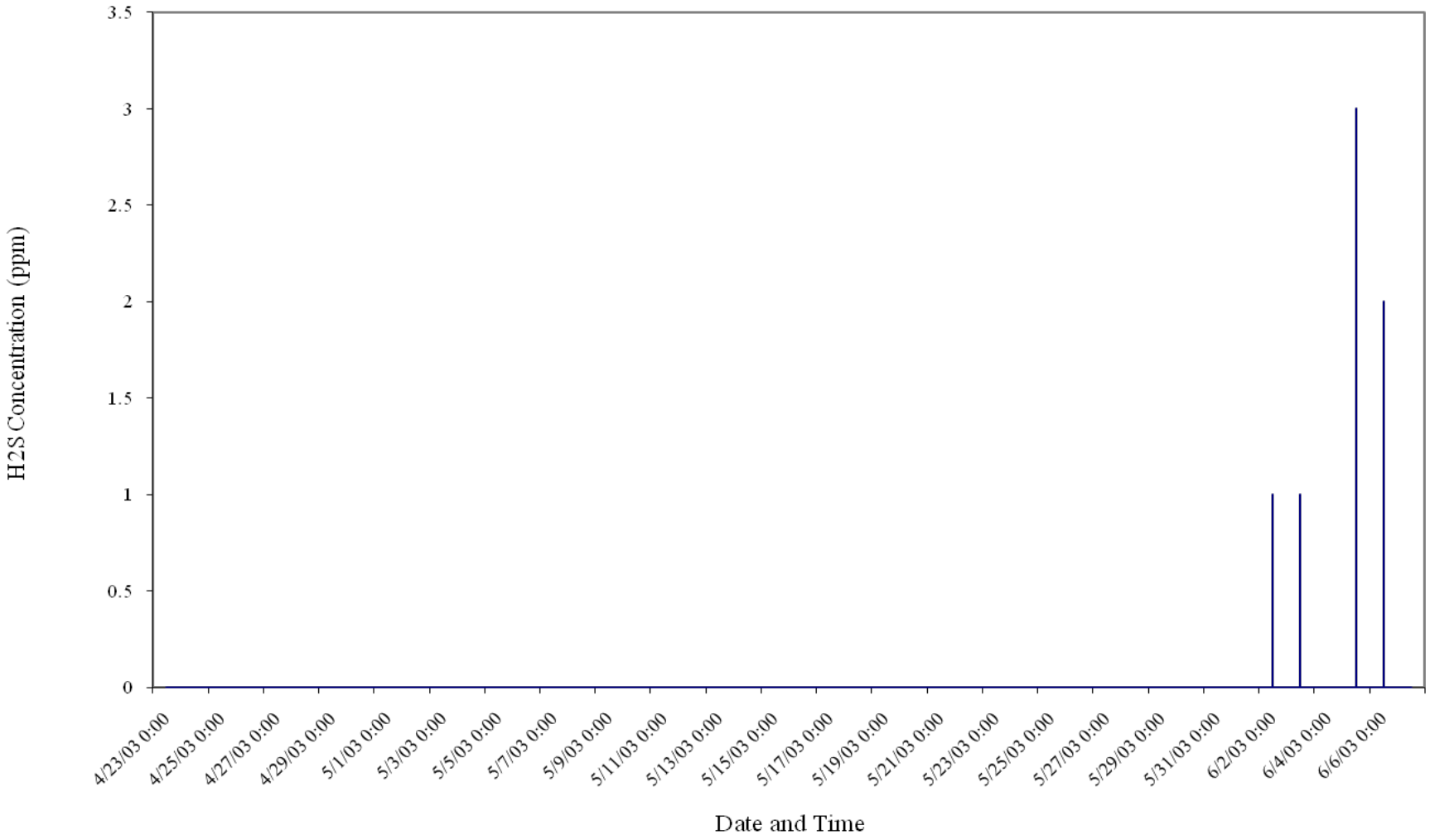

Figure 15. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32° 42' 21" by West 103° 46' 12") for April 23, 2003- June 28, 2003.

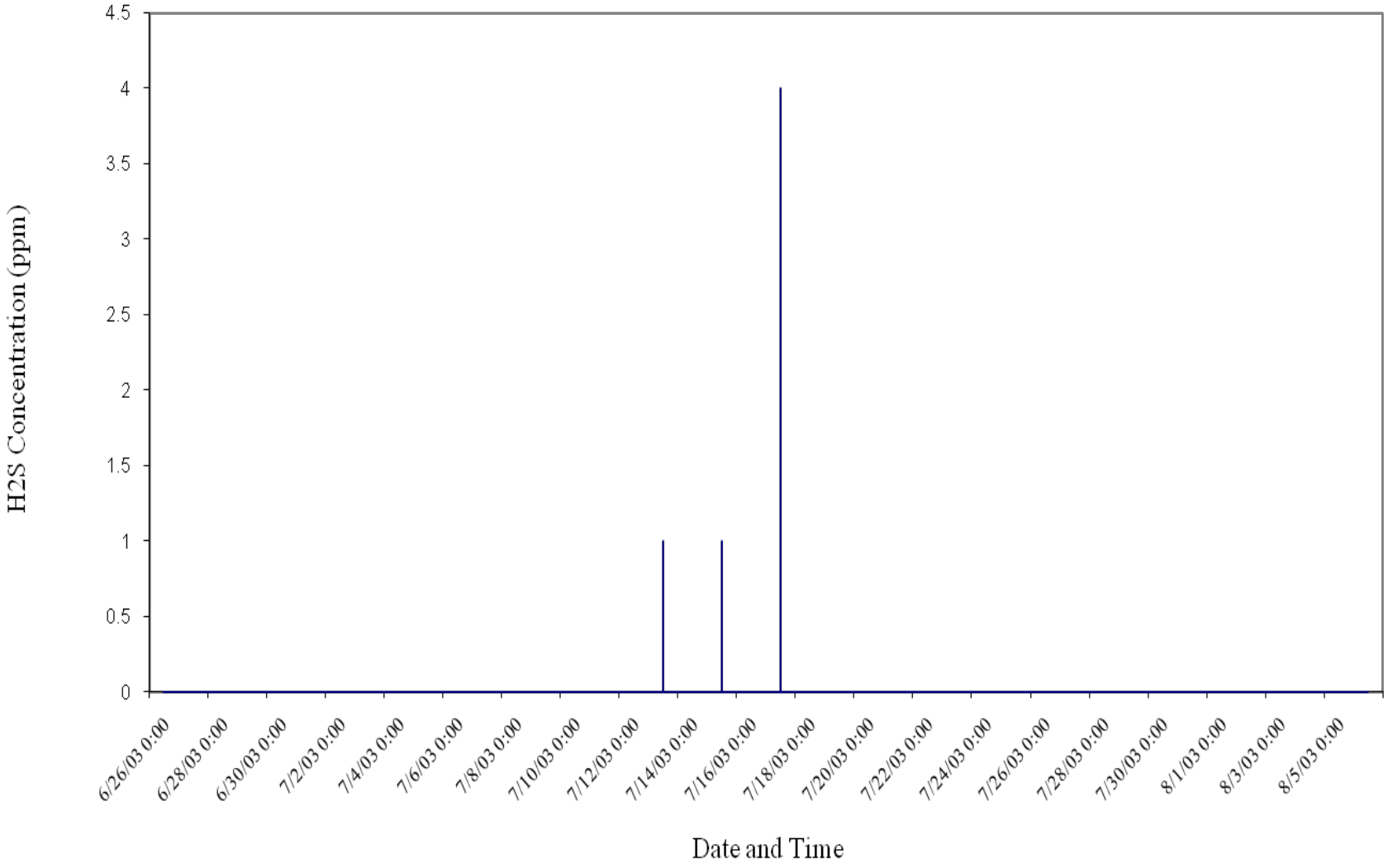

Figure 16. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32° 48' 10" by West 103° 45' 31") for June 28, 2003- August 6, 2003.

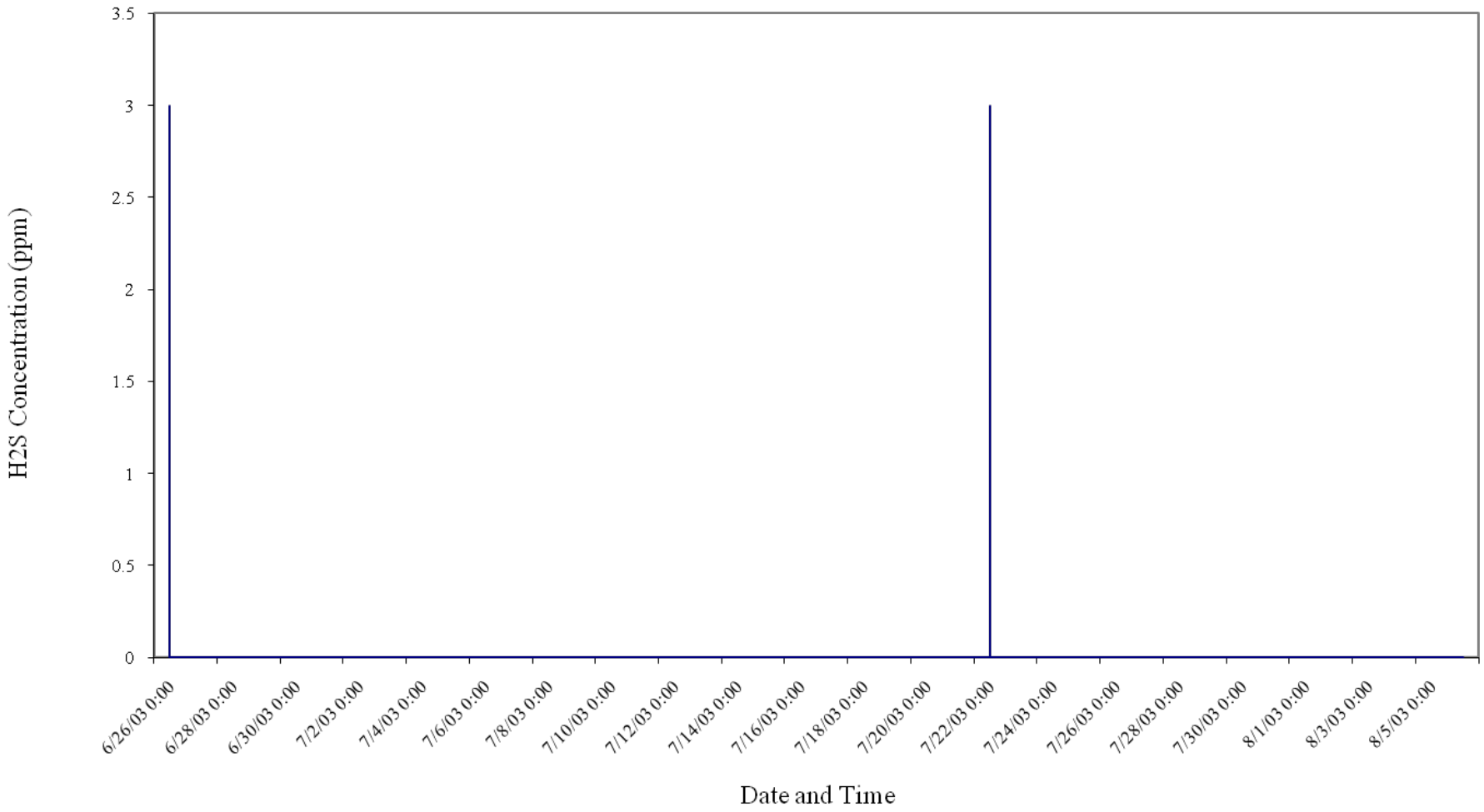

Figure 17. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32° 45' 16" by West 103° 36' 39") for June 28, 2003- August 6, 2003.

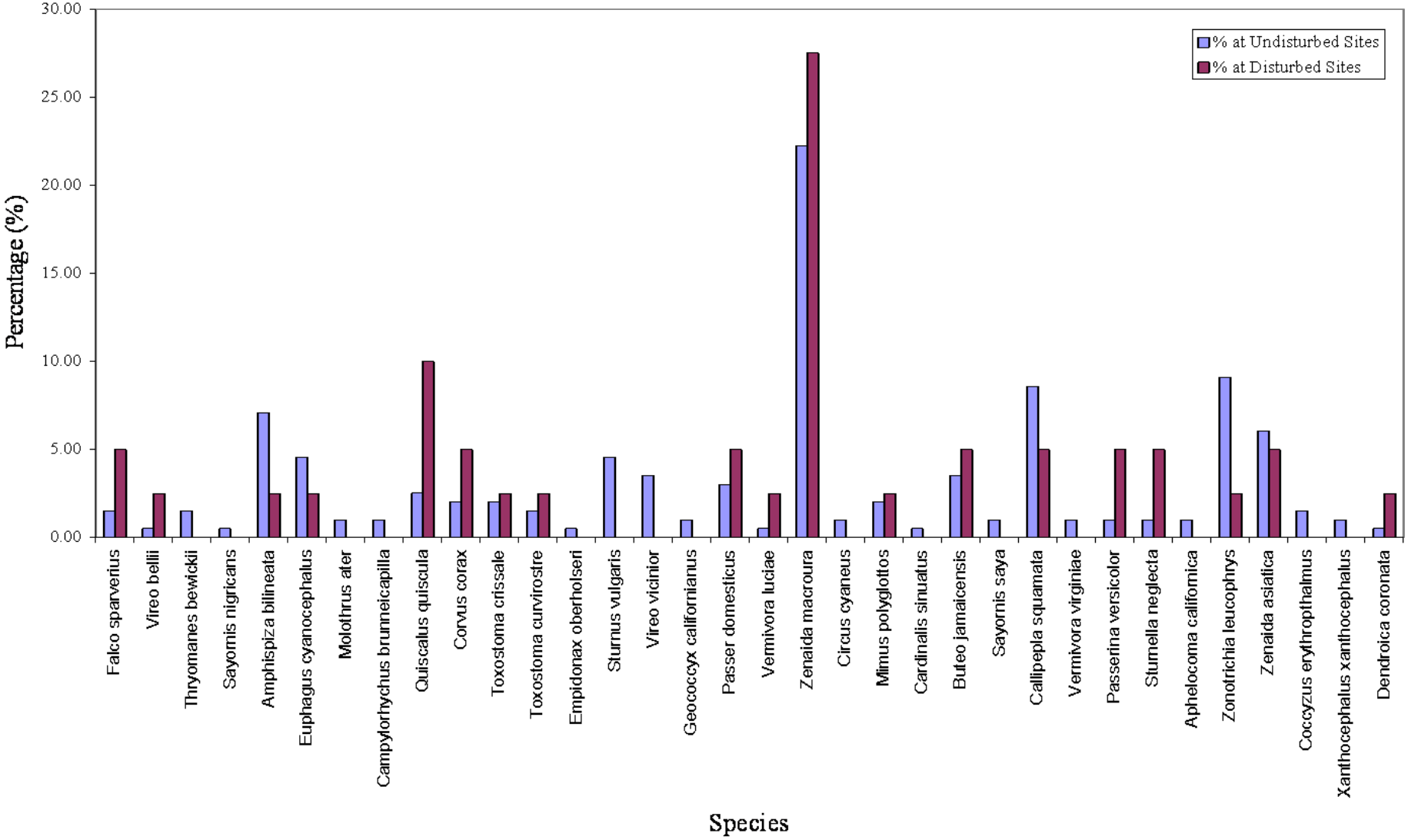

Figure 18. Graph of Species Composition Present at Undisturbed and Disturbed Sites for the Winter Survey Season.

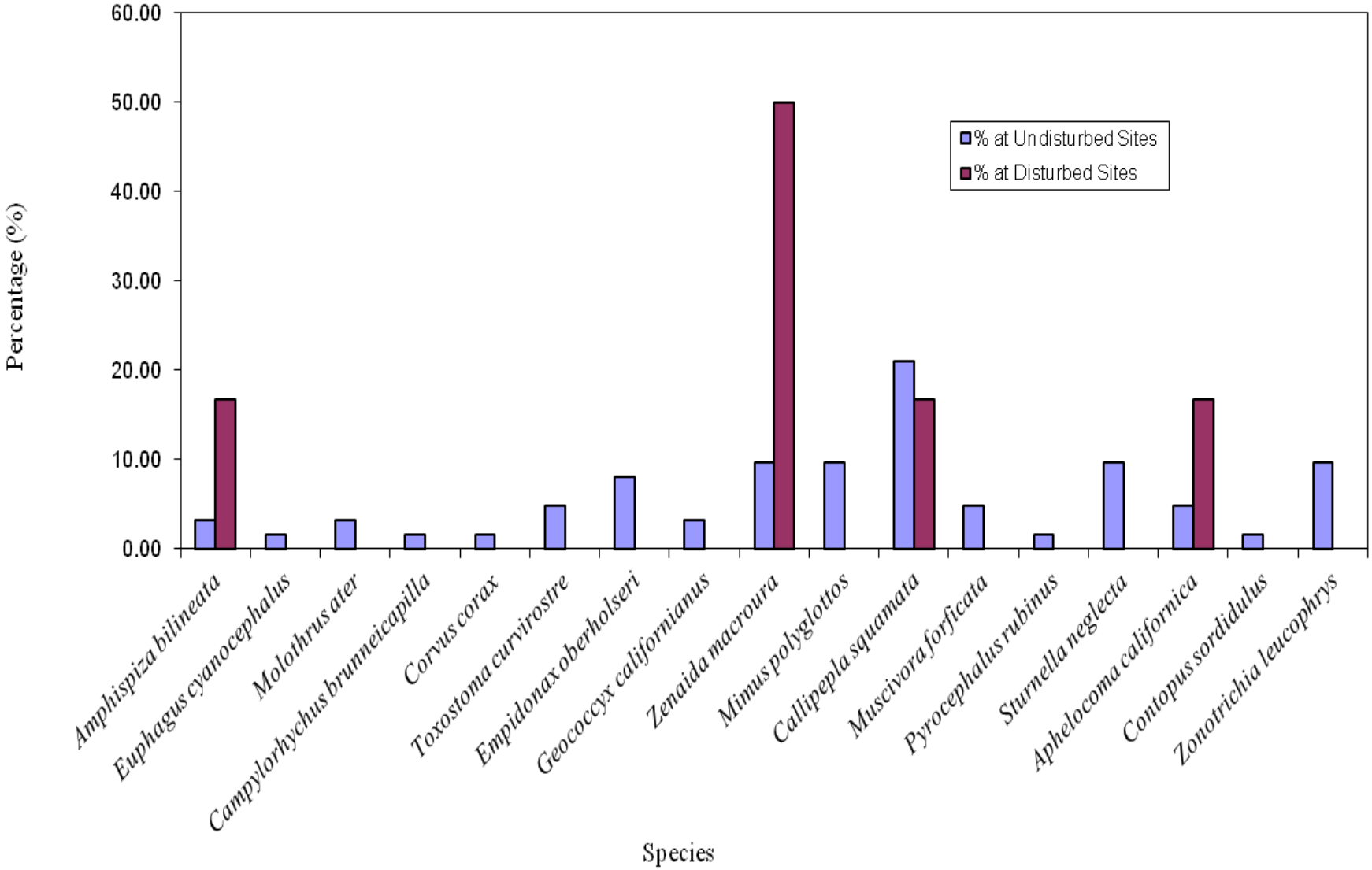

Figure 19. Graph of Species Composition Present at Undisturbed and Disturbed Sites for the Spring Survey Season.

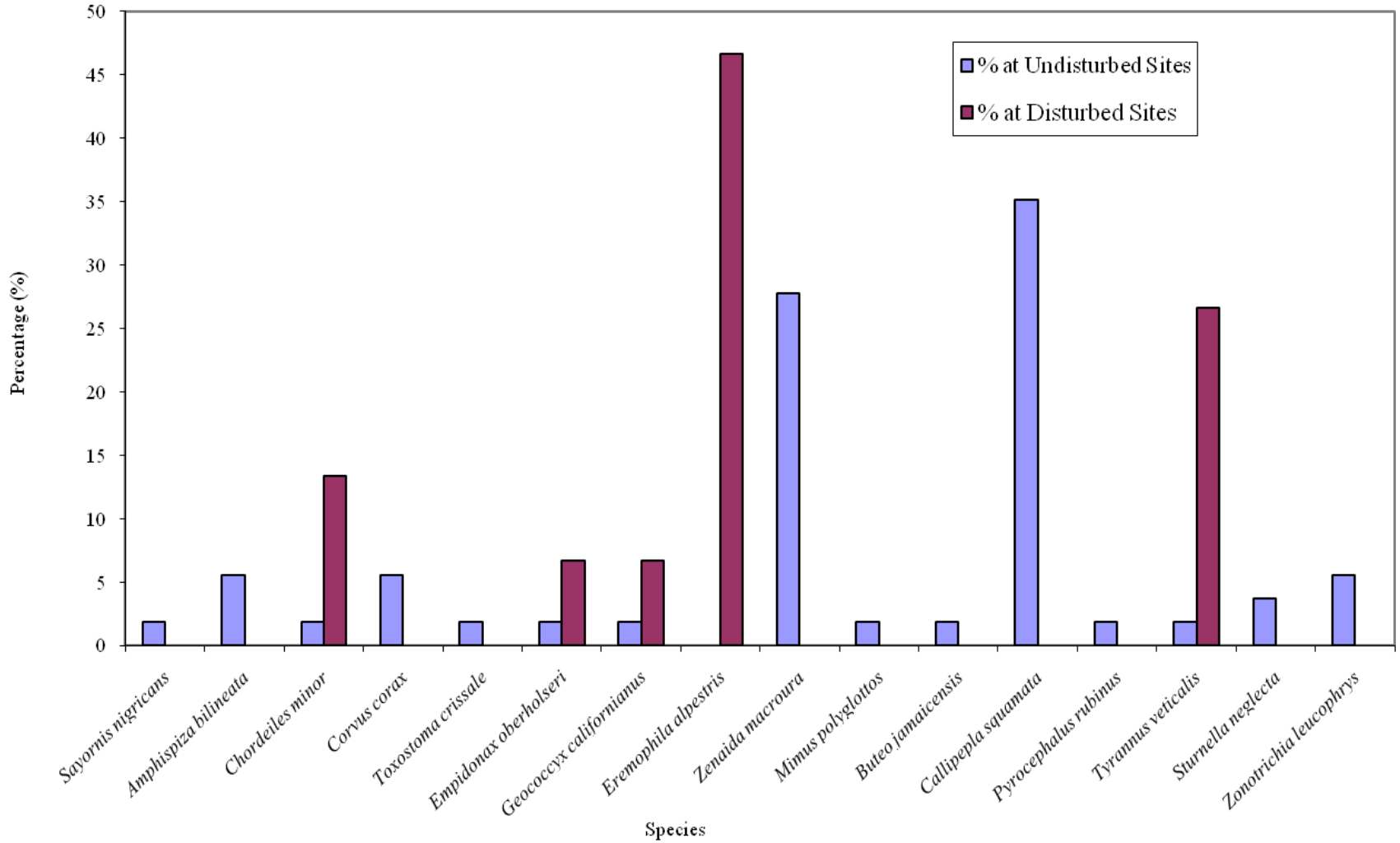

Figure 20. Graph of Species Composition Present at Undisturbed and Disturbed Sites for the Summer Survey Season.

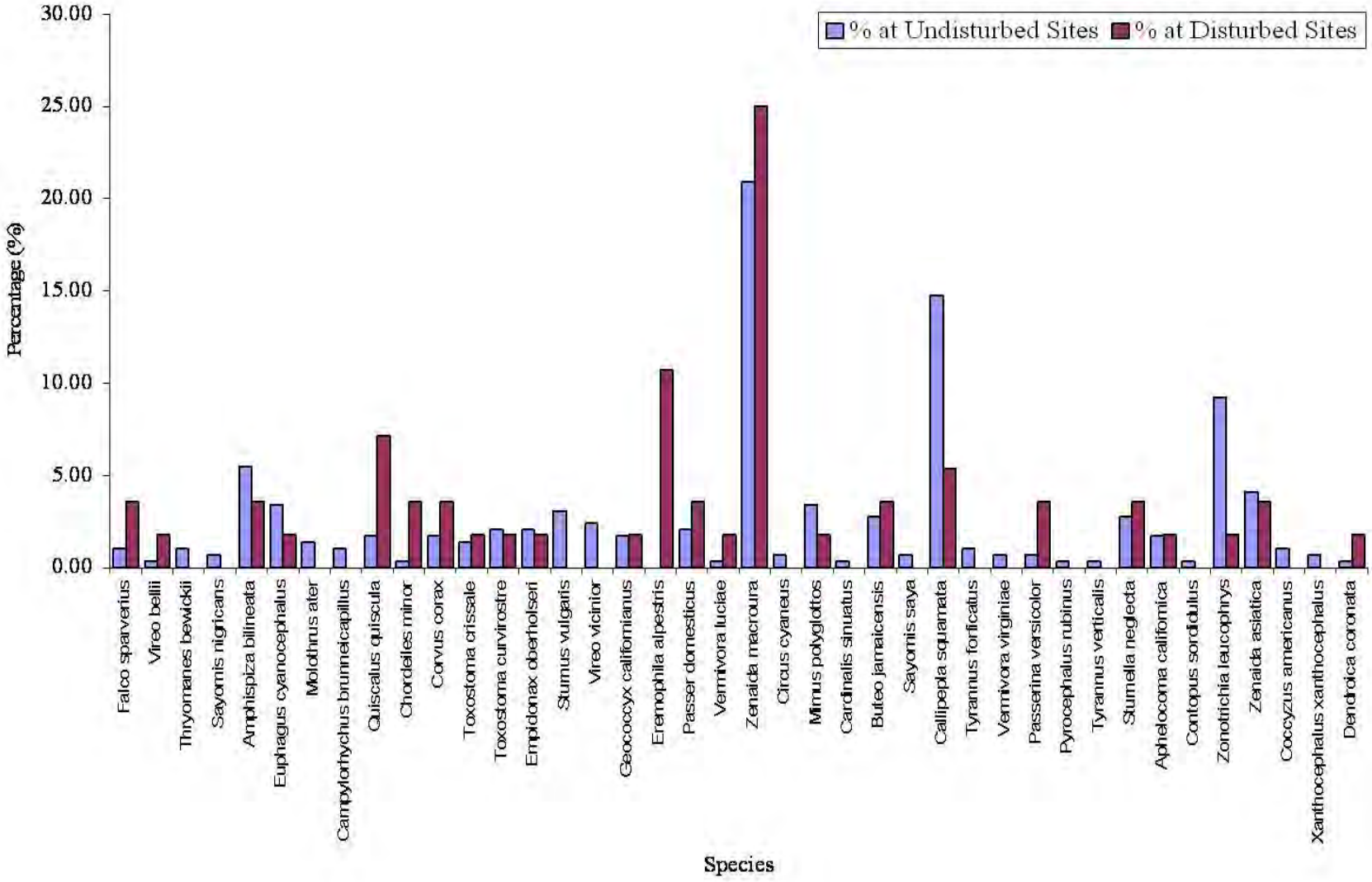

Figure 21. Graph of Species Composition Present at Undisturbed and Disturbed Sites for the Entire Survey Season.

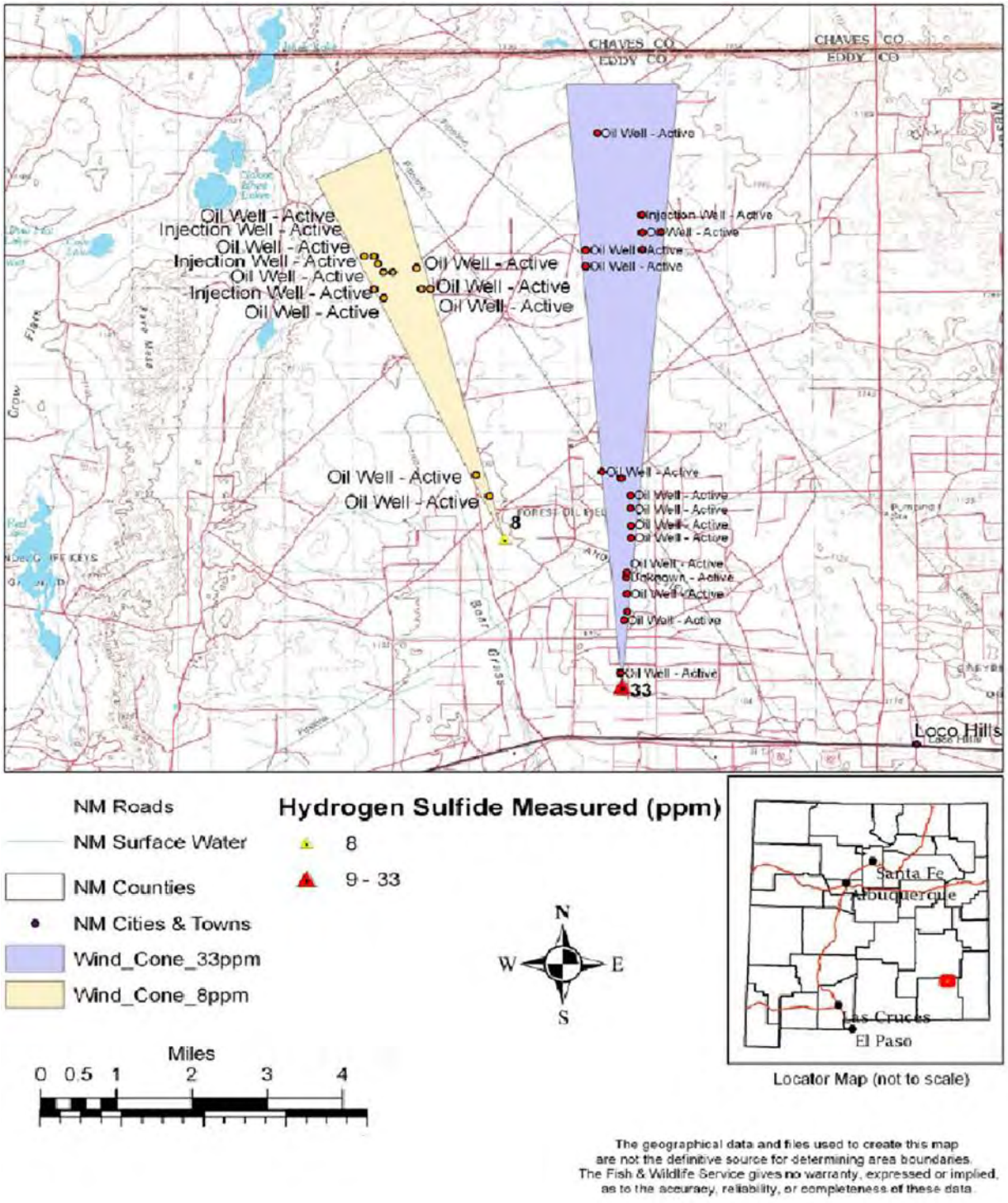

Figure 22. Potential Sources of Hydrogen Sulfide in a "Wind Cone" based on nearby Wind Speed and Direction towards the Measured Hydrogen Sulfide Concentration. Any One or a Combination of Marked Active Wells could be the Source of the Hydrogen Sulfide.

Table 1. Common and Scientific Names of Selected Wildlife Species found in the Sand Shinnery Community of the Mescalero Sands in Southeast New Mexico.

Amphibians	Scientific Name
Couch's Spadefoot	*Scaphiopus couchii*
Plains Spadefoot	*Spea bombifrons*
New Mexico Spadefoot	*Spea multiplicata*
Reptiles	
Eastern Glossy Snake	*Arizona elegans*
Chihuahuan Spotted Whiptail	*Aspidoscelis exsanguis*
Prairie Racerunner	*Cnemidophorus sexlineata viridis*
Greater Earless Lizard	*Cophosaurus texanus*
Western Diamondback Rattlesnake	*Crotalus atrox*
Prairie Rattlesnake	*Crotalus viridis*
Eastern Collared Lizard	*Crotaphytus collaris*
Ringneck Snake	*Diadophis punctatus*
Longnose Leopard Lizard	*Gambelia wislizenii*
Western Hognose Snake	*Heterodon nasicus*
Lesser Earless Lizard	*Holbrookia maculata*
Chihuahuan Night Snake	*Hypsiglena jani*
Desert Kingsnake	*Lampropeltis getula splendida*
Milk Snake	*Lampropeltis triangulum*
New Mexico Blind Snake	*Leptotyphlops dissectus*
Coachwhip	*Masticophis flagellum*
Texas Horned Lizard	*Phrynosoma cornutum*
Roundtail Horned Lizard	*Phrynosoma modestum*
Gopher Snake	*Pituophis catenifer*
Great Plains Skink	*Plestiodon obsoletus*
Longnose Snake	*Rhinocheilus lecontei*
Sand Dune Lizard	*Sceloporus arenicolus*
Eastern Fence Lizard	*Sceloporus undulatus*
Desert Massasauga	*Sistrurus catenatus edwardsii*
Ground Snake	*Sonora semiannulata*
Plains Blackhead Snake	*Tantilla nigriceps*
Ornate Box Turtle	*Terrapene ornata*
Side-blotched Lizard	*Uta stansburiana*
Birds	
Red-winged Blackbird	*Agelaius phoeniceus*
Cassin's Sparrow	*Aimophila cassinii*
Grasshopper Sparrow	*Ammodramus savannarum*
Burrowing Owl	*Athene cunicularia*
Great horned Owl	*Bubo virginianus*
Red-tailed Hawk	*Buteo jamaicensis*
Ferruginous Hawk	*Buteo regalis*
Swainson's Hawk	*Buteo swainsoni*

Table 1. Common and Scientific Names of Selected Wildlife Species found in the Sand Shinnery Community of the Mescalero Sands in Southeast New Mexico.

Scaled Quail	*Callipepla squamata*
House Finch	*Carpodacus mexicanus*
Turkey Vulture	*Cathartes aura*
Killdeer	*Charadrius vociferus*
Lark Sparrow	*Chondestes grammacus*
Common Nighthawk	*Chordeiles minor*
Northern Bobwhite	*Colinus virginianus*
Chihuahuan Raven	*Corvus cryptoleucus*
Horned Lark	*Eremophila alpestris*
American Kestrel	*Falco sparverius*
Greater Roadrunner	*Geococcyx californianus*
Barn Swallow	*Hirundo rustica*
Bullock's Oriole	*Icterus bullockii*
Dark-eyed Junco	*Junco hyemalis*
Loggerhead Shrike	*Lanius ludovicianus*
Northern Mockingbird	*Mimus polyglottos*
Brown-headed Cowbird	*Molothrus ater*
Ash-throated Flycatcher	*Myiarchus cinerascens*
House Sparrow	*Passer domesticus*
Blue Grosbeak	*Passerina caerulea*
Great-tailed Grackle	*Quiscalus mexicanus*
Common Grackle	*Quiscalus quiscula*
Lesser Goldfinch	*Spinus psaltria*
Eastern Meadowlark	*Sturnella magna*
Western Meadowlark	*Sturnella neglecta*
European Starling	*Sturnus vulgaris*
Curve-billed Thrasher	*Toxostoma curvirostre*
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*
Scissor-tailed Flycatcher	*Tyrannus forficatus*
Western Kingbird	*Tyrannus verticalis*
Barn Owl	*Tyto alba*
Mourning Dove	*Zenaida macroura*
Mammals	
Pallid bat	*Antrozous pallidus*
Coyote	*Canis latrans*
Townsend's big-eared bat	*Corynorhinus townsendii*
Ord's Kangaroo Rat	*Dipodomys ordii*
Big brown bat	*Eptesicus fuscus*
Silver-haired bat	*Lasionycteris noctivagans*
Red bat	*Lasiurus blossevillii*
Hoary bat	*Lasiurus cinereus*
California myotis	*Myotis californicus*

Table 1. Common and Scientific Names of Selected Wildlife Species found in the Sand Shinnery Community of the Mescalero Sands in Southeast New Mexico.

Western small-footed myotis	*Myotis ciliolabrum*
Fringed myotis	*Myotis thysanodes*
Cave myotis	*Myotis velifer*
Long-legged myotis	*Myotis volans*
Yuma Myotis	*Myotis yumanensis*
Pocketed free-tailed bat	*Nyctinomops femorosacca*
Big free-tailed bat	*Nyctinomops macrotis*
Mule Deer	*Odocoileus hemionus*
White-tailed Deer	*Odocoileus virginianus*
Northern Grasshopper Mouse	*Onychomys leucogaster*
Western Pipistrelle	*Pipistrellus hesperus*
Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*
Desert Cottontail	*Sylvilagus audubonii*
Mexican free-tailed bat	*Tadarida brasiliensis mexicana*
American Badger	*Taxidea taxus*
Gray Fox	*Urocyon cinereoargenteus*
Kit Fox	*Vulpes macrotis*
Swift Fox	*Vulpes velox*
References:	
Amphibians and Reptiles	Collins and Taggart (2009)
Birds	AOU (1998)
Mammals	Frey *et al*. (2006)

Table 2. Dosimetric Factors for Avian, Mammal and Reptile Species and Calculation of Hydrogen Sulfide NOAEL, LOAEL and FEL for Wildlife.									
Parameter	Equation	Black-chinned hummingbird[1]	Cassin's Sparrow	Mourning Dove	Scaled Quail	Greater Roadrunner	Chihuahuan Raven	Lesser Prairie-Chicken	Red-tailed Hawk
Mass (kg)		0.005	0.0255	0.115	0.177	0.3056	0.512	0.727	1.127
Resting Avian Respiration Rate (ml/min)	$V_{ER} = 385M^{0.72}$ *	8.5	27.4	81.1	110.7	164.0	237.8	306.0	419.6
Resting Mammal Respiration Rate (ml/min)	$V_{ER} = 518M^{0.74}$ *	---[a]	---	---	---	---	---	---	---
Resting Reptile Respiration Rate (ml/min)	$V_{ER} = 76.9M^{0.76}$ **	---	---	---	---	---	---	---	---
Flying Avian Respiration Rate (ml/min)	$V_{EA} = 5000M^{0.74}$ †	99.1	331.0	1,009.0	1,388.3	2,079.6	3,046.7	3,949.2	5,462.5
Active Mammal Respiration Rate (ml/min)	---	---	---	---	---	---	---	---	---
Active Reptile Respiration Rate (ml/min)	$V_{EA} = 1922.5M^{0.76}$ **	---	---	---	---	---	---	---	---
Trachea Length (cm^2)	$Tl = 16.77M^{0.39}$ ‡	2.1	4.0	7.2	8.5	10.6	12.9	14.8	17.6
Trachea Width (cm^2)	$Td = 0.53M^{0.35}$ ‡	0.08	0.15	0.25	0.29	0.35	0.42	0.47	0.55
Trachea Surface Area (cm^2)	$SA_t = 2prh$	0.55	1.85	5.63	7.75	11.61	17.01	22.05	30.51
NOAEL Resting (mg/m^3)	$= (190/15)/(V_{ER}/SA_t)x14\ mg/m^3$	11.6	12.0	12.3	12.4	12.6	12.7	12. 8	12.9
LOAEL Resting (mg/m^3)	$= (190/15)/(V_{ER}/SA_t)x42\ mg/m^3$	34.7	35.9	37.0	37.3	37.7	38.1	38.3	38.7
FEL Resting (mg/m^3)	$= (190/15)/(V_{ER}/SA_t)x100\ mg/m^3$	82.6	85.4	88.0	88.7	89.7	90.6	91.3	92.1
NOAEL Active (mg/m^3)	$= (190/15)/(V_{EA}/SA_t)x14\ mg/m^3$	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
LOAEL Active (mg/m^3)	$= (190/15)/(V_{EA}/SA_t)x42\ mg/m^3$	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97
FEL Active (mg/m^3)	$= (190/15)/(V_{EA}/SA_t)x100\ mg/m^3$	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07
NOAEL Resting (ppm)	= NOAEL Resting (mg/m^3)/1.39	8.3	8.6	8.9	8.9	9.0	9.1	9.2	9.3
LOAEL Resting (ppm)	= LOAEL Resting (mg/m^3)/1.39	25.0	25.8	26.6	26.8	27.1	27.4	27.6	27.8
FEL Resting (ppm)	= FEL Resting (mg/m^3)/1.39	59.4	61.4	63.3	63.8	64.5	65.2	65.7	66.2
NOAEL Active (ppm)	= NOAEL Active (mg/m^3)/1.39	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
LOAEL Active (ppm)	= LOAEL Active (mg/m^3)/1.39	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
FEL Active (ppm)	= FEL Active (mg/m^3)/1.39	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1

Table 2. Dosimetric Factors for Avian, Mammal and Reptile Species and Calculation of Hydrogen Sulfide NOAEL, LOAEL and FEL for Wildlife.

(~Continued) Parameter	Equation	Cave Myotis	Ord's Kangaroo Rat	Desert Cottontail	Kit Fox	Coyote	White-tailed Deer	Sand Dune Lizard
Mass (kg)		0.014	0.0834	0.756	1.82	10	50	0.0051
Resting Avian Respiration Rate (ml/min)	$V_{ER} = 385M^{0.72}$ *	---	---	---	---	---	---	---
Resting Mammal Respiration Rate (ml/min)	$V_{ER} = 518M^{0.74}$ *	22.0	82.4	421.1	806.8	2,846.6	9,366.3	---
Resting Reptile Respiration Rate (ml/min)	$V_{ER} = 76.9M^{0.76}$ **	---	---	---	---	---	---	1.4
Flying Avian Respiration Rate (ml/min)	$V_{EA} = 5000M^{0.74}$ †	---	---	---	---	---	---	---
Active Mammal Respiration Rate (ml/min)	---	---	---	---	---	---	---	---
Active Reptile Respiration Rate (ml/min)	$V_{EA} = 1922.5M^{0.76}$ **	---	---	---	---	---	---	34.8
Trachea Length (cm^2)	$Tl = 16.77M^{0.39}$ ‡	1.1	2.3	5.5	7.9	15.6	29.6	---[b]
Trachea Width (cm^2)	$Td = 0.53M^{0.35}$ ‡	0.08	0.16	0.37	0.52	1.01	1.89	---[b]
Trachea Surface Area (cm^2)	$SA_t = 2prh$	0.27	1.12	6.40	12.82	49.24	175.59	0.55[b]
NOAEL Resting (mg/m^3)	$= (190/15)/(V_{ER}/SA_t)x14\ mg/m^3$	2.21	2.41	2.70	2.82	3.07	3.32	70.52
LOAEL Resting (mg/m^3)	$= (190/15)/(V_{ER}/SA_t)x42\ mg/m^3$	6.63	7.24	8.09	8.45	9.20	9.97	211.55
FEL Resting (mg/m^3)	$= (190/15)/(V_{ER}/SA_t)x100\ mg/m^3$	15.77	17.25	19.26	20.12	21.91	23.75	503.70
NOAEL Active (mg/m^3)	$= (190/15)/(V_{EA}/SA_t)x14\ mg/m^3$	---	---	---	---	---	---	2.82
LOAEL Active (mg/m^3)	$= (190/15)/(V_{EA}/SA_t)x42\ mg/m^3$	---	---	---	---	---	---	8.46
FEL Active (mg/m^3)	$= (190/15)/(V_{EA}/SA_t)x100\ mg/m^3$	---	---	---	---	---	---	20.15
NOAEL Resting (ppm)	= NOAEL Resting (mg/m^3)/1.39	1.6	1.7	1.9	2.0	2.2	2.4	50.7
LOAEL Resting (ppm)	= LOAEL Resting (mg/m^3)/1.39	4.8	5.2	5.8	6.1	6.6	7.2	152.2
FEL Resting (ppm)	= FEL Resting (mg/m^3)/1.39	11.3	12.4	13.9	14.5	15.8	17.1	362.4
NOAEL Active (ppm)	= NOAEL Active (mg/m^3)/1.39	---	---	---	---	---	---	2.0
LOAEL Active (ppm)	= LOAEL Active (mg/m^3)/1.39	---	---	---	---	---	---	6.1
FEL Active (ppm)	= FEL Active (mg/m^3)/1.39	---	---	---	---	---	---	14.5

* = Frappell *et al.* (2001)
† = Brown *et al.* (1997)
a = "---" = data not available
** = Bennett (1973)
‡ = Hinds and Calder (1971)
b = Assumed avian dimensions
[1] = *Archilochus alexandrii* Example of high activity, small-bodied bird.

Table 3. Species Composition of Birds Present at the Disturbed Sites and Undisturbed Sites During the Winter Survey Season from November 21, 2002 to March 21, 2003.

Common Name	Scientific Name	Total No. Undisturbed Sites	Total No. Disturbed Sites	Percent Undisturbed Sites	Percent Disturbed Sites
American Kestrel	*Falco sparverius*	3	2	1.5	5.0
Bell's Vireo	*Vireo bellii*	1	1	0.5	2.5
Bewick's Wren	*Thryomanes bewickii*	3	0	1.5	0.0
Black Phoebe	*Sayornis nigricans*	1	0	0.5	0.0
Black-throated Sparrow	*Amphispiza bilineata*	14	1	7.1	2.5
Brewer's Blackbird	*Euphagus cyanocephalus*	9	1	4.6	2.5
Brown-headed Cowbird	*Molothrus ater*	2	0	1.0	0.0
Cactus Wren	*Campylorhychus brunneicapillus*	2	0	1.0	0.0
Common Grackle	*Quiscalus quiscula*	5	4	2.5	10.0
Common Raven	*Corvus corax*	4	2	2.0	5.0
Crissal Thrasher	*Toxostoma crissale*	4	1	2.0	2.5
Curve-billed Thrasher	*Toxostoma curvirostre*	3	1	1.5	2.5
Dusky Flycatcher	*Empidonax oberholseri*	1	0	0.5	0.0
European Starling	*Sturnus vulgaris*	9	0	4.6	0.0
Gray Vireo	*Vireo vicinior*	7	0	3.5	0.0
Greater Roadrunner	*Geococcyx californianus*	2	0	1.0	0.0
House Sparrow	*Passer domesticus*	6	2	3.0	5.0
Lucy's Warbler	*Vermivora luciae*	1	1	0.5	2.5
Mourning Dove	*Zenaida macroura*	44	11	22.2	27.5
Northern Harrier	*Circus cyaneus*	2	0	1.0	0.0
Northern Mockingbird	*Mimus polyglottos*	4	1	2.0	2.5
Pyrrhuloxia	*Cardinalis sinuatus*	1	0	0.5	0.0
Red-tailed Hawk	*Buteo jamaicensis*	7	2	3.5	5.0
Say's Phoebe	*Sayornis saya*	2	0	1.0	0.0
Scaled Quail	*Callipepla squamata*	17	2	8.6	5.0
Virginia's Warbler	*Vermivora virginiae*	2	0	1.0	0.0
Varied Bunting	*Passerina versicolor*	2	2	1.0	5.0
Western Meadow Lark	*Sturnella neglecta*	2	2	1.0	5.0
Western Scrub-Jay	*Aphelocoma californica*	2	0	1.0	0.0
White-crowned Sparrow	*Zonotrichia leucophrys*	18	1	9.1	2.5
White-winged Dove	*Zenaida asiatica*	12	2	6.1	5.0
Yellow-billed Cuckoo	*Coccyzus americanus*	3	0	1.5	0.0
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	2	0	1.0	0.0
Yellow-rumped Warbler	*Dendroica coronata*	1	1	0.5	2.5

Table 4. Species Composition of Birds Present at the Disturbed Sites and Undisturbed Sites During the Spring Survey Season from March 21, 2003 to June 21, 2003.

Common Name	**Scientific Name**	**Total No. Undisturbed Sites**	**Total No. Disturbed Sites**	**Percent Undisturbed Sites**	**Percent Disturbed Sites**
Black-throated Sparrow	*Amphispiza bilineata*	2	1	3.2	16.7
Brewer's Blackbird	*Euphagus cyanocephalus*	1	0	1.6	0.0
Brown-headed Cowbird	*Molothrus ater*	2	0	3.2	0.0
Cactus Wren	*Campylorhychus brunneicapillus*	1	0	1.6	0.0
Common Raven	*Corvus corax*	1	0	1.6	0.0
Curve-billed Thrasher	*Toxostoma curvirostre*	3	0	4.8	0.0
Dusky Flycatcher	*Empidonax oberholseri*	5	0	8.1	0.0
Greater Roadrunner	*Geococcyx californianus*	2	0	3.2	0.0
Mourning Dove	*Zenaida macroura*	6	3	9.7	50.0
Northern Mockingbird	*Mimus polyglottos*	6	0	9.7	0.0
Scaled Quail	*Callipepla squamata*	13	1	21.0	16.7
Scissor-tailed Flycatcher	*Tyrannus forficatus*	3	0	4.8	0.0
Vermillion Flycatcher	*Pyrocephalus rubinus*	1	0	1.6	0.0
Western Meadowlark	*Sturnella neglecta*	6	0	9.7	0.0
Western Scrub-Jay	*Aphelocoma californica*	3	1	4.8	16.7
Western Wood-Peewee	*Contopus sordidulus*	1	0	1.6	0.0
White-crowned Sparrow	*Zonotrichia leucophrys*	6	0	9.7	0.0

Table 5. Species Composition of Birds Present at the Disturbed Sites and Undisturbed Sites During the Summer Survey Season from June 21, 2003 to August 6, 2003.

Common Name	***Scientific Name***	**Total No. Undisturbed Sites**	**Total No. Disturbed Sites**	**Percent Undisturbed Sites**	**Percent Disturbed Sites**
Black Phoebe	*Sayornis nigricans*	1	0	1.9	0.0
Black-throated Sparrow	*Amphispiza bilineata*	3	0	5.6	0.0
Common Nighthawk	*Chordeiles minor*	1	2	1.9	13.3
Common Raven	*Corvus corax*	3	0	5.6	0.0
Crissal Thrasher	*Toxostoma crissale*	1	0	1.9	0.0
Dusky Flycatcher	*Empidonax oberholseri*	1	1	1.9	6.7
Greater Roadrunner	*Geococcyx californianus*	1	1	1.9	6.7
Horned Lark	*Eremophila alpestris*	0	7	0.0	46.7
Mourning Dove	*Zenaida macroura*	15	0	27.8	0.0
Northern Mockingbird	*Mimus polyglottos*	1	0	1.9	0.0
Red-tailed Hawk	*Buteo jamaicensis*	1	0	1.9	0.0
Scaled Quail	*Callipepla squamata*	19	0	35.2	0.0
Vermillion Flycatcher	*Pyrocephalus rubinus*	1	0	1.9	0.0
Western Kingbird	*Tyrannus verticalis*	1	4	1.9	26.7
Western Meadowlark	*Sturnella neglecta*	2	0	3.7	0.0
White-crowned Sparrow	*Zonotrichia leucophrys*	3	0	5.6	0.0

Table 6. Species Composition of Birds Present at the Disturbed Sites and Undisturbed Sites During the Overall Study from November 21, 2002 to August 6, 2003.

Common Name	***Scientific Name***	**Total No. Undisturbed Sites**	**Total No. Disturbed Sites**	**Percent Undisturbed Sites**	**Percent Disturbed Sites**
American Kestrel	*Falco sparverius*	3	2	1.0	3.5
Bell's Vireo	*Vireo bellii*	1	1	0.3	1.7
Bewick's Wren	*Thryomanes bewickii*	4	0	1.3	0.0
Black Phoebe	*Sayornis nigricans*	2	0	0.6	0.0
Black-throated Sparrow	*Amphispiza bilineata*	19	2	6.1	3.5
Brewer's Blackbird	*Euphagus cyanocephalus*	10	1	3.2	1.7
Brown-headed Cowbird	*Molothrus ater*	4	0	1.3	0.0
Cactus Wren	*Campylorhychus brunneicapillus*	3	0	1.0	0.0
Common Grackle	*Quiscalus quiscula*	5	4	1.6	6.9
Common Nighthawk	*Chordeiles minor*	1	2	0.3	3.5
Common Raven	*Corvus corax*	8	2	2.6	3.5
Crissal Thrasher	*Toxostoma crissale*	5	1	1.6	1.7
Curve-billed Thrasher	*Toxostoma curvirostre*	6	1	1.9	1.7
Dusky Flycatcher	*Empidonax oberholseri*	7	1	2.2	1.7
European Starling	*Sturnus vulgaris*	9	0	2.9	0.0
Gray Vireo	*Vireo vicinior*	7	0	2.2	0.0
Greater Roadrunner	*Geococcyx californianus*	5	1	1.6	1.7
Horned Lark	*Eremophila alpestris*	0	6	0.0	10.3
House Sparrow	*Passer domesticus*	6	2	1.9	3.5
Lucy's Warbler	*Vermivora luciae*	1	1	0.3	1.7
Mourning Dove	*Zenaida macroura*	65	14	20.7	24.1
Northern Harrier	*Circus cyaneus*	2	0	0.6	0.0
Northern Mockingbird	*Mimus polyglottos*	11	1	3.5	1.7
Pyrrhuloxia	*Cardinalis sinuatus*	1	0	0.3	0.0
Red-tailed Hawk	*Buteo jamaicensis*	8	2	2.6	3.5
Say's Phoebe	*Sayornis saya*	2	0	0.6	0.0
Scaled Quail	*Callipepla squamata*	48	3	15.3	5.2
Scissor-tailed Flycatcher	*Tyrannus forficatus*	3	0	1.0	0.0
Virginia's Warbler	*Vermivora virginiae*	2	0	0.6	0.0
Varied Bunting	*Passerina versicolor*	2	2	0.6	3.5
Vermillion Flycatcher	*Pyrocephalus rubinus*	2	0	0.6	0.0
Western Kingbird	*Tyrannus verticalis*	1	2	0.3	3.5
Western Meadowlark	*Sturnella neglecta*	10	2	3.2	3.5
Western Scrub-Jay	*Aphelocoma californica*	5	1	1.6	1.7
Western Wood-Peewee	*Contopus sordidulus*	1	0	0.3	0.0
White-crowned Sparrow	*Zonotrichia leucophrys*	27	1	8.6	1.7
White-winged Dove	*Zenaida asiatica*	12	2	3.8	3.5
Yellow-billed Cuckoo	*Coccyzus americanus*	3	0	1.0	0.0
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	2	0	0.6	0.0
Yellow-rumped Warbler	*Dendroica coronata*	1	1	0.3	1.7

Appendix A-1. Data Set for **Undisturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
1	11/21/2002	32.786633	-104.202917	11	4	0
2	11/21/2002	32.776650	-104.204367	6	2	0
3	11/21/2002	32.730000	-104.211350	2	1	0
4	11/21/2002	32.718733	-104.212217	1	1	0
5	11/21/2002	32.706300	-104.212883	0	0	0
6	11/21/2002	32.657883	-104.222150	5	2	0
7	11/21/2002	32.636983	-104.224633	3	1	1
8	11/21/2002	32.626567	-104.224900	0	0	0
9	11/21/2002	32.581250	-104.225600	7	3	1
10	11/21/2002	32.568450	-104.225833	0	0	0
11	12/3/2002	32.691767	-103.892217	11	3	0
12	12/3/2002	32.689083	-103.902900	8	3	0
13	12/3/2002	32.688883	-103.916817	4	2	0
14	12/3/2002	32.688983	-103.929200	0	0	0
15	12/3/2002	32.663650	-103.991867	8	3	0
16	12/3/2002	32.660183	-104.003967	1	1	0
17	12/3/2002	32.637833	-104.021017	0	0	0
18	12/3/2002	32.634167	-104.029983	3	1	0
19	12/3/2002	32.656133	-104.088433	15	3	0
20	12/3/2002	32.658550	-104.106550	3	1	1
21	1/7/2003	32.780367	-103.766800	1	1	0
22	1/7/2003	32.774683	-103.774583	0	0	0
23	1/7/2003	32.768683	-103.780483	5	2	0
24	1/7/2003	32.712483	-103.796767	6	2	0
25	1/7/2003	32.704483	-103.796767	3	1	0
26	1/7/2003	32.695167	-103.796767	15	3	0
27	1/7/2003	32.684967	-103.796767	1	1	0
28	1/7/2003	32.672183	-103.796767	5	2	0
29	1/7/2003	32.657600	-103.766800	12	3	0
30	1/7/2003	32.658367	-103.753933	7	2	1
31	1/23/2003	32.827833	-103.529417	11	4	0
32	1/23/2003	32.827833	-103.539967	3	1	0
33	1/23/2003	32.827833	-103.551867	15	3	0
34	1/23/2003	32.827833	-103.562183	4	2	0
35	1/23/2003	32.804067	-103.628617	3	1	0
36	1/23/2003	32.802083	-103.639867	2	1	0

Appendix A-1 *Continued*. Data Set for **Undisturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H2S Concentration (ppm)
37	1/23/2003	32.804450	-103.649067	8	2	0
38	1/23/2003	32.801550	-103.677700	3	1	0
39	1/23/2003	32.802117	-103.687767	2	1	0
40	1/23/2003	32.811700	-103.701667	0	0	0
41	2/11/2003	32.782400	-104.019633	0	0	0
42	2/11/2003	32.773817	-104.019600	0	0	0
43	2/11/2003	32.756000	-104.017717	0	0	0
44	2/11/2003	32.747750	-104.017967	0	0	0
45	2/11/2003	32.830567	-103.978967	0	0	0
46	2/11/2003	32.839867	-103.977467	0	0	0
47	2/11/2003	32.859983	-103.977433	1	1	0
48	2/11/2003	32.872450	-103.964517	1	1	0
49	3/4/2003	32.896367	-104.036683	1	1	0
50	3/4/2003	32.886950	-104.036667	0	0	0
51	3/4/2003	32.839600	-104.037033	1	1	1
52	3/4/2003	32.847250	-104.071733	0	0	1
53	4/3/2003	32.856100	-104.037383	1	1	1
54	4/3/2003	32.856150	-104.048950	0	0	0
55	4/3/2003	32.872283	-104.021233	1	1	0
56	4/3/2003	32.872417	-104.994433	0	0	0
57	4/3/2003	32.880700	-104.981017	4	1	0
58	4/3/2003	32.914017	-103.962900	0	0	0
59	4/3/2003	32.913983	-103.932733	0	0	0
60	4/3/2003	32.911867	-103.922917	2	1	0
61	4/3/2003	32.899533	-103.924067	1	1	0
62	4/9/2003	32.889567	-103.926200	0	0	0
63	4/9/2003	32.838600	-103.930933	3	2	0
64	4/9/2003	32.800183	-103.939517	1	1	0
65	4/9/2003	32.859133	-103.926717	0	0	0
66	4/9/2003	32.854267	-103.908583	6	1	0
67	4/9/2003	32.846850	-103.908267	1	1	0
68	4/16/2003	32.801867	-104.019650	3	2	0
69	4/16/2003	32.780200	-104.019617	4	2	0
70	4/16/2003	32.770700	-104.019667	1	1	0
71	4/16/2003	32.751767	-104.017233	2	2	0
72	4/16/2003	32.755667	-104.007667	1	1	0

Appendix A-1 *Continued*. Data Set for **Undisturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
73	4/16/2003	32.721983	-103.997967	1	1	0
74	4/16/2003	32.753467	-103.988167	0	0	0
75	4/16/2003	32.759850	-103.984483	0	0	0
76	4/16/2003	32.768533	-103.984400	1	1	0
77	4/16/2003	32.776867	-103.984267	2	2	0
78	4/16/2003	32.782650	-103.992433	0	0	0
79	4/16/2003	32.782950	-104.001933	3	1	0
80	4/16/2003	32.783017	-104.011900	3	2	0
81	4/24/2003	33.038650	-103.985467	2	1	0
82	4/24/2003	33.030150	-103.985350	3	1	0
83	4/24/2003	33.020867	-103.918883	0	0	0
84	4/24/2003	32.993967	-103.985550	2	1	0
85	4/24/2003	32.967017	-103.985450	2	1	0
86	4/24/2003	32.974333	-103.985467	3	2	2
87	4/24/2003	32.965367	-103.985450	0	0	1
88	4/24/2003	32.956050	-103.985400	1	1	1
89	4/24/2003	32.954217	-103.948700	2	1	1
90	4/24/2003	32.955817	-103.943967	1	1	1
91	4/24/2003	32.964100	-103.934083	2	1	1
92	4/24/2003	32.952967	-103.925067	1	1	0
93	4/24/2003	32.952900	-103.913533	1	1	0
94	4/24/2003	32.948600	-103.887267	1	1	0
95	6/28/2003	32.756450	-103.883250	3	1	0
96	6/28/2003	32.754083	-103.880983	4	2	0
97	6/28/2003	32.749767	-103.871883	1	1	0
98	6/28/2003	32.745833	-103.866100	1	1	1
99	6/28/2003	32.741583	-103.860633	2	1	0
100	6/28/2003	32.737000	-103.855850	2	1	0
101	6/28/2003	32.757617	-103.756450	2	1	0
102	6/28/2003	32.746933	-103.756450	3	1	0
103	6/28/2003	32.739867	-103.749300	0	0	0
104	6/28/2003	32.734917	-103.756250	1	1	0
105	7/17/2003	32.809150	-103.758733	2	1	1
106	7/17/2003	32.838833	-103.924750	11	1	1
107	7/17/2003	32.861783	-103.924750	0	0	1
108	7/17/2003	32.868283	-103.930250	0	0	1

Appendix A-1 *Continued*. Data Set for **Undisturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
109	8/6/2003	32.769733	-103.606817	4	1	0
110	8/6/2003	32.775933	-103.604083	2	1	0
111	8/6/2003	32.794450	-103.595967	5	1	0
112	8/6/2003	32.800617	-103.586667	0	0	0
113	8/6/2003	32.806783	-103.579250	3	1	0
114	8/6/2003	32.813017	-103.573883	1	1	0
115	8/6/2003	32.824550	-103.566233	0	0	0
116	8/6/2003	32.730467	-103.603933	2	1	0
117	8/6/2003	32.712817	-103.594167	2	2	1
118	8/6/2003	32.707167	-103.588467	1	1	0
119	8/6/2003	32.703033	-103.605350	2	1	1
120	8/6/2003	32.696750	-103.600883	0	0	0

Appendix A-2. Data Set for **Disturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
1	11/21/2002	32.764950	-104.207317	2	1	1
2	11/21/2002	32.753683	-104.209450	0	0	1
3	11/21/2002	32.741717	-104.210450	0	0	1
4	11/21/2002	32.695083	-104.213800	0	0	1
5	11/21/2002	32.682267	-104.214250	3	2	1
6	11/21/2002	32.670817	-104.219483	1	1	2
7	11/21/2002	32.646967	-104.223650	1	1	2
8	11/21/2002	32.615283	-104.225183	4	2	2
9	11/21/2002	32.605017	-104.225917	0	0	1
10	11/21/2002	32.592950	-104.225383	0	0	1
11	12/3/2002	32.693867	-103.941650	0	0	1
12	12/3/2002	32.697467	-103.949500	2	1	1
13	12/3/2002	32.686917	-103.956583	1	1	2
14	12/3/2002	32.678967	-103.967950	1	1	2
15	12/3/2002	32.671317	-103.982783	1	1	2
16	12/3/2002	32.657633	-104.017700	0	0	2
17	12/3/2002	32.647167	-104.021617	0	0	1
18	12/3/2002	32.640000	-104.042883	2	2	2
19	12/3/2002	32.645200	-104.055767	0	0	1
20	12/3/2002	32.650883	-104.069900	0	0	2
21	1/7/2003	32.758133	-103.780633	0	0	3
22	1/7/2003	32.750250	-103.786133	2	1	1
23	1/7/2003	32.744567	-103.792800	0	0	1
24	1/7/2003	32.735500	-103.795700	2	1	1
25	1/7/2003	32.725517	-10.795517	4	2	1
26	1/7/2003	32.661983	-103.796633	0	0	1
27	1/7/2003	32.653433	-103.796417	2	1	1
28	1/7/2003	32.644850	-103.796417	3	3	2
29	1/7/2003	32.634467	-103.798033	0	0	2
30	1/7/2003	32.656950	-103.777617	0	0	2
31	1/23/2003	32.827050	-103.575317	0	0	2
32	1/23/2003	32.822850	-103.585217	2	1	1
33	1/23/2003	32.819467	-103.593400	0	0	1
34	1/23/2003	32.815533	-103.602667	0	0	1
35	1/23/2003	32.811417	-103.611967	1	1	1
36	1/23/2003	32.807950	-103.619833	2	1	3

Appendix A-2 *Continued*. Data Set for **Disturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
37	1/23/2003	32.806183	-103.658583	0	0	3
38	1/23/2003	32.804483	-103.667683	0	0	3
39	1/23/2003	32.807917	-103.693767	0	0	3
40	1/23/2003	32.818217	-103.711617	0	0	1
41	2/11/2003	32.810133	-104.019617	0	0	2
42	2/11/2003	32.800667	-104.019600	1	1	1
43	2/11/2003	32.792883	-104.021250	0	0	1
44	2/11/2003	32.764050	-104.019683	0	0	2
45	2/11/2003	32.850583	-103.978550	0	0	1
46	2/11/2003	32.867450	-103.972183	0	0	2
47	3/4/2003	32.875383	-104.043667	0	0	1
48	3/4/2003	32.848500	-104.037350	0	0	2
49	3/4/2003	32.832933	-104.037400	0	0	1
50	3/4/2003	32.823550	-104.037033	0	0	1
51	4/3/2003	32.872450	-104.034383	1	1	1
52	4/3/2003	32.872467	-104.009517	0	0	1
53	4/3/2003	32.872533	-103.983300	0	0	1
54	4/3/2003	32.873650	-103.969367	0	0	1
55	4/3/2003	32.872533	-103.957483	0	0	1
56	4/3/2003	32.872667	-103.946267	0	0	2
57	4/3/2003	32.914833	-103.945083	0	0	2
58	4/9/2003	32.881733	-103.926417	0	0	2
59	4/9/2003	32.872383	-103.927750	0	0	1
60	4/9/2003	32.865400	-103.927617	0	0	1
61	4/9/2003	32.854517	-103.927517	0	0	1
62	4/9/2003	32.847100	-103.927483	0	0	2
63	4/9/2003	32.830867	-103.933950	0	0	1
64	4/9/2003	32.821333	-103.936317	0	0	2
65	4/9/2003	32.813483	-103.937267	0	0	1
66	4/9/2003	32.803817	-103.936150	0	0	2
67	4/9/2003	32.828783	-103.908117	0	0	1
68	4/9/2003	32.838783	-103.914733	1	1	2
69	4/9/2003	32.838167	-103.920983	0	0	1
70	4/9/2003	32.872467	-103.921067	0	0	2
71	4/9/2003	32.867317	-103.913350	0	0	1
72	4/16/2003	32.791767	-104.020750	0	0	1

Appendix A-2 *Continued*. Data Set for **Disturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
73	4/16/2003	32.761717	-104.019683	0	0	1
74	4/16/2003	32.746650	-104.017767	0	0	1
75	4/16/2003	32.791450	-104.012367	0	0	1
76	4/24/2003	33.003033	-103.983583	0	0	0
77	4/24/2003	32.947183	-103.981417	0	0	1
78	4/24/2003	32.961517	-103.981417	0	0	1
79	4/24/2003	32.956083	-103.966533	0	0	0
80	4/24/2003	32.955900	-103.958017	0	0	0
81	4/24/2003	32.949067	-103.902983	2	1	1
82	4/24/2003	32.945433	-103.898150	1	1	1
83	4/24/2003	32.951300	-103.879083	1	1	1
84	6/28/2003	32.751867	-103.885683	0	0	3
85	6/28/2003	32.762617	-103.887550	0	0	3
86	6/28/2003	32.752667	-103.877017	3	1	3
87	6/28/2003	32.752867	-103.885150	1	1	2
88	6/28/2003	32.742833	-103.886117	0	0	4
89	6/28/2003	32.735317	-103.888650	0	0	4
90	6/28/2003	32.720233	-103.885083	2	1	4
91	6/28/2003	32.767233	-103.776883	1	1	3
92	6/28/2003	32.770883	-103.769367	0	0	2
93	6/28/2003	32.770767	-103.756600	0	0	2
94	6/28/2003	32.770867	-103.747717	0	0	1
95	6/28/2003	32.764733	-103.760850	0	0	1
96	6/28/2003	32.750450	-103.765450	0	0	4
97	6/28/2003	32.730467	-103.757867	0	0	7
98	6/28/2003	32.727433	-103.768150	2	1	3
99	7/17/2003	32.809150	-103.762467	2	2	0
100	7/17/2003	32.809200	-103.754283	0	0	1
101	7/17/2003	32.800150	-103.752267	0	0	1
102	7/17/2003	32.816133	-103.870250	0	0	1
103	7/17/2003	32.826000	-103.876250	0	0	1
104	7/17/2003	32.829283	-103.879983	1	1	1
105	7/17/2003	32.821733	-103.878100	1	1	1
106	7/17/2003	32.815967	-103.906583	0	0	0
107	7/17/2003	32.838883	-103.914350	0	0	0
108	7/17/2003	32.847267	-103.927400	0	0	0

Appendix A-2 *Continued*. Data Set for **Disturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
109	7/17/2003	32.859867	-103.921233	0	0	0
110	8/6/2003	32.760433	-103.606817	1	1	2
111	8/6/2003	32.744950	-103.609067	0	0	1
112	8/6/2003	32.734833	-103.609983	0	0	3
113	8/6/2003	32.727033	-103.597567	0	0	3
114	8/6/2003	32.716683	-103.597383	1	1	1
115	8/6/2003	32.716833	-103.602033	0	0	4
116	8/6/2003	32.712867	-103.609950	0	0	1

Appendix B. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
1								
2	1							
3								2
4				1				
5								
6					1			
7						3		
8								
9					3			
10								
11					5			
12								
13								
14								
15						2		
16								
17								
18								
19								
20								
21			3					
22								
23								
24								
25								
26								
27	1							
28		1						
29					5			
30								
31	1							
32								
33						4	2	
34								
35								
36								
37								
38								
39								
40			1					
41								
42								
43								
44								

Appendix B. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
45								
46								
47								
48								
49								
50								
51								
52								
53								1
54								
55								
56								
57								
58								
59								
60							2	
61								
62								
63								
64								
65								
66								
67								
68						1		
69								
70								
71								
72								
73								
74								
75								
76								
77								
78								
79								
80								
81								
82								
83								
84								
85					2			
86								
87								
88								

Appendix B. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
89								
90								
91								
92								
93								
94								
95								
96				1				
97								
98								
99								
100								
101								
102								
103								
104								
105								
106								
107								
108								
109								
110								
111								
112								
113					3			
114								
115								
116								
117								
118								
119								
120								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12						1		
13								
14								
15	5							
16								
17								
18								
19								
20								
21								
22			4					
23								
24								
25					3			
26								
27								
28								
29								
30				4				
31								
32								
33							9	
34								7
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
45								
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61					1			
62								
63								
64								
65								
66								
67								
68								
69						1		
70								
71								
72								
73								
74								
75								
76								
77					1			
78								
79								
80								
81						2		
82								
83								
84								
85								
86			1			2		
87								
88								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
89								
90					1			
91								
92								
93								
94								
95								
96								
97		1						
98								
99								
100								
101								
102								
103								
104								
105								
106						1		
107								
108								
109			2					
110								
111								
112								
113								
114			1					
115								
116								
117				1				
118								
119								
120								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
1	1				6			
2					5			
3								
4								
5								
6								
7								
8								
9							1	
10								
11							2	
12					6	1		
13								
14								
15			1					
16								1
17								
18								
19								
20					3			
21								
22								
23								
24								
25								
26					13		1	
27								
28								
29			5					
30								
31				1	7			
32					3			
33								
34								
35	1							
36								
37						1		
38								
39								
40								
41								
42								
43								
44								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
45								
46								
47					1			
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64	1							
65								
66								
67					1			
68								
69								
70								
71					1			
72							1	
73								
74								
75								
76								
77								
78								
79								
80					2			
81								
82								
83								
84					2			
85								
86								
87								
88							2	

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
89							1	
90								
91							2	
92								
93								
94	1							
95					3			
96					3			
97								
98								
99					2			
100					1			
101								
102								
103								
104	1							
105					2			
106								
107								
108								
109								
110							1	
111								
112								
113								
114								
115								
116					2			
117					1			
118					1			
119								
120								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
1	1		3					
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19	1							
20			1					
21		2						
22								
23								
24								
25								
26								
27								
28			4					
29					2			
30	3							
31						2		
32								
33								
34								
35								
36	2							
37			7					
38								
39								
40								
41								
42								
43								
44								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
45								
46								
47								
48			1					
49								
50								
51			1					
52								
53								
54								
55							1	
56								
57			4					
58								
59								
60								
61								
62								
63								
64								
65								
66			6					
67								
68			2					
69								
70								
71								
72								
73			1					
74								
75								
76								
77								
78								
79								
80								
81								
82				3				
83								
84								
85								
86								
87								
88								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
89								
90								
91								
92								
93								
94								
95								
96								
97								
98	1							
99								
100								
101			2					
102								
103								
104								
105								1
106			11					
107								
108								
109								
110								
111			5					
112							1	
113								
114								
115								
116								
117								
118								
119								
120								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Dove	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
1								
2								
3								
4								
5								
6						1		
7								
8								
9				3				
10								
11				4				
12								
13							2	1
14								
15								
16								
17								
18				3				
19	2				12			
20								
21								
22		2						
23								
24								
25								
26				1				
27								
28								
29								
30								
31								
32								
33								
34				3				
35								
36								
37								
38				3				
39						2		
40								
41								
42								
43								
44								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Dove	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
45								
46								
47								
48								
49				1				
50								
51								
52								
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Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Dove	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
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92		1						
93	1							
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119	2							
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Appendix C. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
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Appendix C. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
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Appendix C. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Doved	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Doved	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Doved	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
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