



**Human Health and Ecological Risk Assessment
for the Use of Wildlife Damage Management Methods
by USDA-APHIS-Wildlife Services**

Chapter IX

**The Use of Aluminum Phosphide in
Wildlife Damage Management**

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THE USE OF ALUMINUM PHOSPHIDE IN WILDLIFE DAMAGE MANAGEMENT

EXECUTIVE SUMMARY

Aluminum phosphide is a fumigant used by USDA-APHIS-Wildlife Services (WS) to control various burrowing rodents and moles. Formulations for burrow treatments are in 3-g tablets or 600-mg pellets containing about 56% active ingredient. WS applicators place the tablets or pellets into the target species' burrow and seal the burrow entrance with soil. Aluminum phosphide reacts with moisture in burrows to release phosphine gas, which is the toxin in the fumigant. WS applicators used aluminum phosphide to take 19 species of rodents and moles between FY11 and FY15 and treated an annual average of including prairie dogs, ground squirrels, pocket gophers, voles, and moles. WS annually averaged the known take of 54,095 target rodents and an estimated 2,333 vertebrate nontarget species with aluminum phosphide in 9 states. An average of 58,329 burrows was treated with the primary target species being black-tailed and Gunnison's prairie dogs.

APHIS evaluated the human health and ecological risk of aluminum phosphide under the WS use pattern for rodent and mole control. Although phosphine gas is toxic to humans, the risk to human health is low because inhalation exposure is slight for the underground applications. WS applicators wear proper personal protective equipment according to the pesticide label requirements, which reduces their exposure to aluminum phosphide and phosphine gas, and lowers the risk to their health. Label restrictions protect the public from exposure to the fumigant when used accordingly.

Label restrictions, use patterns, environmental fate, and aquatic toxicity data for aluminum phosphide suggest low risk to aquatic species and their habitats, and terrestrial plants. Aluminum phosphide risks to terrestrial vertebrates and invertebrates in burrows and exposed to phosphine gas during treatment is high. WS applicators reduce the exposure and risk to nontarget species by checking burrows and confirming the presence of target animals before applying aluminum phosphide. There is no secondary risk to nontarget species because the gas rapidly dissipates, and aluminum phosphide and phosphine do not accumulate in target animals. Restrictions are present on labels to lower the chance of exposure and risks to nontarget terrestrial species.

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1 INTRODUCTION

This human health and ecological risk assessment is a qualitative evaluation of the risks and hazards to human health and nontarget species from the use of aluminum phosphide (AIP) by the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS) Program. The methods used to assess human health effects conform to the guidance of other Federal agencies, such as the U.S. Environmental Protection Agency (USEPA) Office of Pesticide Programs and the National Research Council (NRC), and follow regulatory methods (NRC 1983, USEPA 2016) that these agencies have outlined. The methods used to assess the ecological risk to nontarget species generally follow USEPA (2016) ecological risk assessment methods.

This assessment starts with the problem formulation (identifying the hazard) and then evaluates toxicity (the dose-response assessment) and exposure (identifying exposed populations and determining exposure pathways for these populations). Lastly, the integration of the toxicity and exposure analysis provides a characterization of risks (a determination whether adverse human health or ecological risks are present and the significance). Uncertainties and cumulative effects are part of this assessment.

1.1 Use Pattern

WS fumigated an annual average of 58,329 burrows of semi-fossorial rodents, including prairie dogs, ground squirrels, pocket gophers, yellow-bellied marmots, voles, and moles¹ from FY11 and FY15 with AIP (Table 1). WS did not dig up dens to determine actual take of target and nontarget species, but numbers were estimated from the expected number of target animals per treated burrow (Tables 1).

Table 1. The annual average number of target burrowing rodents killed with aluminum phosphide by WS in WDM activities for FY11 to FY15 throughout the United States. No known nontarget take occurred in this time.

ANNUAL AVERAGE SPECIES KILLED WITH ALUMINUM PHOSPHIDE					
Species	Target ¹	Burrows	AIP Tablets ² Used	Est. #/burrow	% of Take
Black-tailed Prairie Dog	28,479	28,479	104,543	1	52.6%
Gunnison's Prairie Dog	16,161	24,121	95,242	0.67	29.9%
White-tailed Prairie Dog	1,772	2,644	8,688	0.67	3.3%
California Ground Squirrel	385	128	410	3	0.7%
Rock Squirrel	90	30	60	3	0.2%
Paiute Ground Squirrel	720	240	464	3	1.3%
Uinta Ground Squirrel	44	15	59	3	0.1%
Belding's Ground Squirrel	60	29	117	2 ³	0.1%
Columbian Ground Squirrel	1,244	415	1,669	3	2.3%
Thirteen-Lined Ground Squirrel	828	276	552	3	1.5%
Mexican Ground Squirrel	1,216	405	1,620	3	2.2%
Yellow-Faced Pocket Gopher	2,594	1,297	5,191	2	4.8%
Botta's Pocket Gopher	452	226	904	2	0.8%
Camas Pocket Gopher	18	9	28	2	0.03%
Other Rodent (4T – 4 spp.)*	15	5	21	2-4	0.03%
Townsend's Mole	17	9	26	2	0.03%
Ave. Ann. No. Animals (19T – 19 spp.)	54,095	58,329	219,594		

*Includes yellow-bellied marmot and plains pocket gopher (2/burrow), and meadow vole and sagebrush vole (4/burrow)

¹ - The burrows taken were multiplied by the estimated number of rodents in each burrow unless an estimate of take was provided. Depending on time of year, you could have 0 (often burrowing rodents use more than one burrow system so some have none, especially the prairie dogs) to 9 for ground squirrels (several species have the potential for 1 adult and 8 young until July when they disperse). Males are often in their own burrows.

² - If pellets were used, they were converted to an equivalent number of tablets (1 tablet equals 5 pellets)

¹ Scientific names are given in the Risk Assessment Introduction Chapter

³ – Specialist estimated the number of ground squirrels taken, so burrows were estimated.

WS personnel record take or the number of burrows treated in the MIS². Burrows treated were converted to take using estimated burrow occupant values noted in Table 1. To make an estimate of the number of animals in a burrow or den, assumptions were made. The factors needed to make an estimate of take include the average litter size, litters per year, the length of time young are with parent(s), the number of burrow systems used by an individual or family group (Gunnison’s and white-tailed prairie dogs often use several burrows, which makes some burrows empty when treated), and timing when AIP was used.

For FY11-FY15, WS killed an estimated annual average of 54,095 target rodents representing 19 species with AIP (Table 1) in nine states (Table 2). Of the targeted animals, black-tailed and Gunnison’s prairie dogs were the species taken most (83%) and had the most AIP used (91%). Colorado and New Mexico were the states that used most AIP (91% of use). Potential nontarget take is discussed in Sections 4.2.2 and 5.2.2.

Table 2. The annual average burrowing rodent take targeted with aluminum phosphide by WS in WDM throughout the United States for FY11-FY15.

ANNUAL AVERAGE ALUMINUM PHOSPHIDE USE BY WS FOR FY11 TO FY15			
STATE	Target Take ¹	AIP Tablets Used ²	% of AIP Use
Colorado	30,640	119,674	54.5%
Idaho	720	465	0.2%
Nebraska	2,359	4,813	2.2%
New Mexico	13,435	80,509	36.7%
Oklahoma	120	600	0.3%
Oregon	484	584	0.3%
Texas	4,395	9,139	4.2%
Utah	698	2,141	1.0%
Washington	1,244	1,669	0.8%
Total (9 States)	54,095	219,594	

1 – Numbers of animals were estimated for the burrows taken.

2 - If pellets were used, they were converted to an equivalent number of tablets (1 tablet equals 5 pellets)

2 PROBLEM FORMULATION

The first registration for AIP as a pesticide in the United States was in 1958 (USEPA 1998b). AIP reacts with moisture in the atmosphere and soil to form phosphine gas, a toxin (USEPA 1998a). As an indoor fumigant, AIP controls insect pests in raw and processed food commodities, and non-food commodities in sealed containers or structures. As a burrow fumigant, AIP controls rodents and moles in non-residential and agricultural areas (USEPA 1998b). WS uses AIP to reduce rodent damage from prairie dogs, voles, rats, mice, ground squirrels, gophers, woodchucks, and chipmunks, but Table 1 represents the typical array of species taken. WS conducted an annual average of 448 work tasks³ per year during FY11-FY15 with AIP, about 130 burrows per work tasks treated.

² MIS - Computer-based Management Information System used for tracking WDM activities. Throughout the text, data for a year (i.e. FY11 to FY15) will be given and is from the MIS. MIS reports will not be referenced in the text or Literature Cited Section because MIS reports are not kept on file. A database is kept that allows queries to be made to retrieve the information needed.

³ A Work Task is defined as a visit to a property, or a portion of it, where a WS employee conducts fieldwork. However, duration is not taken into account and, thus, a Work Task could be 10 minutes to 10 hours in duration.

2.1 Chemical Description and Product Use

Aluminum phosphide (CAS # 20859-73-8) is an inorganic compound with a molecular weight of 57.96 and a molecular structure shown in Figure 1 (USEPA 1998a). AIP is available in tablets, pellets, impregnated materials and dusts (USEPA 1998a). AIP is a fumigant used to control insects and rodents (USEPA 1998a). AIP reacts with moisture to produce hydrogen phosphide, or phosphine gas (CAS# 7803-51-2), which is the toxin in the pesticide (USEPA 1998a).

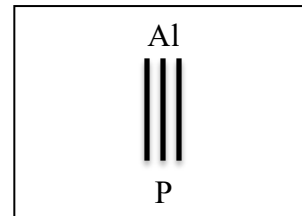


Figure 1. Chemical structure of AIP.

WS uses AIP as a burrow fumigant for rodents such as prairie dogs, except the threatened Utah prairie dog (*Cynomys parvidens*), ground squirrels, pocket gophers, voles, marmots, and moles per label directions. AIP comes in 3-g tablets or 600-mg pellets containing between 55% to 60% active ingredient (a.i.) (Witmer and Fagerstone 2003). WS applicators place one to four 3-g tablets or five to twenty 600-mg pellets in burrows and immediately seal the burrow entrances with soil (Snider 1983, USEPA 1998b). Applicators may plug the entrance to the burrow with crumpled newspaper or another material to prevent soil from covering the tablets or pellets (Virchow et al. 2002). Applicators may drop AIP tablets or pellets through a four to five foot plastic pipe with a 1.5 to 1.75 inch diameter inserted deep into the burrow entrance (Virchow et al. 2002). AIP reacts with moisture in burrows to release phosphine gas. Phosphine reaches peak concentrations in 48 – 60 hours (Virchow et al. 2002). Several product labels specify a maximum application of 12 grams of AIP (about 4 grams of phosphine) per burrow, which produces around 1,000 ppm phosphine near the pellets or tablets (Snider 1983). Burrow residents inhale phosphine which then enters the bloodstream and interferes with cell physiology and alters hemoglobin (Witmer and Fagerstone 2003).

Only certified pesticide applicators or persons under their direct supervision may use AIP (USEPA 1998b, Witmer and Fagerstone 2003). WS uses several AIP products, including DEGESCH Phostoxin® (USEPA Reg. No. 72959-4), Fumitoxin® (USEPA Reg. No. 72959-1), Weevil-Cide® (USEPA Reg. No. 70506-13), Gastoxin® (USEPA Reg. No. 70506-14), and DREX-PH₃™ (USEPA Reg. No. 19713-571) AIP tablets (Table 3).

Table 3. Aluminum phosphide formulations used by WS to control burrowing rodents. Manufacturer websites provide labels and material safety data sheets for these formulations.

Product	Registration date	USEPA registration number	Active/Inert ingredients	Animals labelled to be treated
Fumitoxin® Mfg: D&D Holdings	10/10/1958 Last update: 9/30/2013	Tablet: 72959-1 Pellet: 72959-2	ai: AIP 55% Inert: 45%	Burrowing Rodents: prairie dogs except Utah prairie dog, woodchucks, yellow-bellied marmots, ground squirrels, pocket gophers, chipmunks, brown rats, black rats, mice, voles, and moles
DetiaPhos® Mfg: D&D Holdings	4/13/1978 Last update: 9/30/2013	Tablet: 72959-4 Pellet: 72959-5	ai: AIP 55% Inert: 45%	
Gastoxin® Mfg: Bernardo Chemicals, Inc.	8/14/1980 Last update: 7/8/2010	Tablet: 43743-1 Pellet: 43743-2	ai: AIP 57% Inert: 43%	
DREX-PH ₃ ™ Mfg: Douglas Products & Packaging	3/10/1981 Last update: 1/8/2013	Tablet: 19713-571 Pellet: 19713-569	ai AIP 60% Inert: 40%	
Weevil-Cide® Mfg: United Phosphorous, Inc.	12/13/2005 Last update: 3/20/2016	Tablet: 70506-13 Pellet: 70506-14	ai: AIP 60% Inert: 40%	

AIP label instructions require applicators to verify that burrows are active with the target species to increase efficacy and reduce impacts to nontarget animals (Ramey and Schafer 1996); this can be difficult because several species of rodents can have more than one active den, and, thus, empty dens may be treated. It also specifies the time of year treatment can occur in certain areas to protect animals that use burrows created by target animals, such as the burrowing owl.

2.2 Physical and Chemical Properties

AIP is a grayish green or black to yellow granular or powdered solid with a sulfurous/garlic odor. It has a melting point above 1000°C, vapor pressure of 40 mm Hg at 129.4°C, and a Henry's Law Constant of 0.1 atm m³/mol (USEPA 1998b). AIP is stable when dry, but readily reacts with water, including moisture in the air, to release phosphine gas (USEPA 1998b). Phosphine is a colorless gas with a vapor density (air = 1) of 1.17 and melting and boiling points of -133.5°C and -87.4°C, respectively (World Health Organization (WHO) 1988).

2.3 Environmental Fate

The environmental fate describes how AIP moves and transforms in the environment. This includes its: 1) mobility, persistence, and degradation in soil, 2) movement to air, and 3) migration potential to ground and surface water. AIP is non-persistent under most environmental conditions. It reacts with moisture to form phosphine gas. Phosphine is non-persistent and non-mobile in the soil environment and is unlikely to be found in groundwater and surface waters (USEPA 1998b).

Under normal environmental conditions, phosphine exists as a gas. Phosphine reacts with photochemically-produced hydroxyl radicals in the atmosphere, degrading in 5 hours (half-life) (WHO 1988, USEPA 1998b). The reaction products are non-volatile oxyacids of phosphorous and inorganic phosphate, both of which contribute nutrients to soil and surface water (WHO 1988, USEPA 1998b). Without light, the half-life can be as long as 28 hours (Gurusinghe 2014). Phosphine has a high vapor pressure and high Henry's Law Constant, thus at the soil surface it undergoes rapid dissipation into the atmosphere (Gurusinghe 2014). Studies suggest phosphine below the soil surface is quickly adsorbed and degraded (Berck and Gunther 1970, Hilton and Robison 1972a, Eismann et al. 1997a, USEPA 1999). Phosphine (at 1,000 ppm of phosphorus) reaches undetectable levels quicker in dry soils than saturated soils. In air-dried soils, phosphine disappeared within 18 days, whereas in saturated soils it disappeared in 40 days (Hilton and Robison 1972b, Gurusinghe 2014). The USEPA does not require environmental fate studies for AIP due to its physical properties and use patterns (USEPA 1998b).

2.4 Hazard Identification

AIP can be a hazard to human health and lethal at high doses due to its acute inhalation toxicity. This section summarizes human incidents and acute and chronic toxicity data for mammals.

2.4.1 Human Incidents

Human toxicity occurs from the ingestion of AIP or from the inhalation of phosphine (Gurjar et al. 2011). Ingested AIP reacts with water and stomach acids to produce phosphine gas which passes into the bloodstream (Gurjar et al. 2011). Inhaled phosphine passes through the lung epithelium (Gurjar et al. 2011). This can lead to systemic effects involving the heart, lung, kidney, and liver with symptoms of irregular heartbeat (cardiac arrhythmia), acidosis, and excess fluid in the lungs (pulmonary edema) (Gurjar et al. 2011). The reaction of phosphine with hemoglobin causes a denaturation of oxyhemoglobin and interferes with several enzymes important for metabolism and respiration, and may also affect the integrity of cell membranes (WHO 1988). Excretion of phosphine is through urine in the form of hypophosphite, and exhalation from the lungs (Gurjar et al. 2011). Symptoms of mild to moderate acute AIP toxicity include nausea, abdominal pain, tightness in chest, restlessness, agitation and chills (Degesch America Inc. 1988, USEPA 1998b). Symptoms of more severe toxicity include diarrhea, cyanosis, difficulty breathing, pulmonary

edema, respiratory failure, tachycardia (rapid pulse) hypotension (low blood pressure), and dizziness (Gurjar et al. 2011). Toxicity can cause death (Gurjar et al. 2011).

USEPA (2013) reviewed human incidents for AIP and phosphine. The fatality of two children after an applicator (not WS) applied Fumitoxin[®] pellets within 7 feet of a residence as opposed to the minimum of 15 feet triggered a revision of the label to prevent accidental poisonings. The revision increases the buffer distance from 15 to 100 feet for applications around buildings occupied by a human or animal and prohibits use in residential areas.

2.4.2 Acute Toxicity

AIP has a high acute inhalation toxicity ($LC_{50} > 0.014$ mg/L) placing it in Toxicity Category I (USEPA 1998b). The Phostoxin[®], Fumitoxin[®], Gastoxin[®], DetiaPhos[™] and DREX-PH₃[™] formulations of AIP have an acute median oral toxicity of 11.5 mg/kg of body weight as discussed on material safety data sheets for the various formulations. The Phostoxin[®] and Fumitoxin[®] material safety datasheets give a dermal toxicity LD₅₀ greater than 5,000 mg/kg for a 1-hour exposure to AIP, which is very low.

2.4.3 Subchronic Toxicity

Researchers exposed male and female rats to phosphine in three inhalation exposure tests (USEPA 1998b). In test 1, they exposed rats to 0, 0.3, 1.0 or 3.0 ppm phosphine for 6 hours a day, five days per week for 13 weeks. In test 2, they exposed rats to 0 or 10 ppm of phosphine on day 48 of the study. Test 2 stopped after 3 days of exposure because four of the 10 females died. In test 3, they exposed rats to 0 or 5 ppm of phosphine for 15 days, starting on day 75 of the study. This subchronic toxicity study set a no observable effect level (NOEL) of 3 ppm (USEPA 1998b). In the 13-week exposure to 3 ppm or less of phosphine (test 1), rats decreased their food consumption which caused their weight to drop but no rats died (USEPA 1998b). In rats exposed to 10 ppm for 3 days (test 2), several of the females died while no males died. The kidneys in both sexes had coagulative necrosis in the tubules. In the 5 ppm for 15-day exposure (test 3), male rats had an increase in alkaline phosphatase activity and blood urea nitrogen but these increases were not significant. At this exposure level, there were no effects on survival, food consumption, body weight, or eye and blood parameters in either sex (USEPA 1998b).

2.4.4 Chronic Toxicity

Male and female rats fed phosphine-treated food for two years did not show any changes in normal food consumption, growth, hematology, survival and morbidity, or show signs of carcinogenicity (USEPA 1998b). Just prior to feeding, phosphine concentrations in the food ranged from 0.2 to 7.5 ppm. The precise amount of phosphine ingested by the rats is unknown because some of the gas dissipates from the food prior to consumption.

In another study, rats kept in enclosed chambers did not show any abnormal change in body weight, food consumption, blood and urinary analysis, and other pathology and histopathology tests after a one-year inhalation exposure of up to 3 ppm phosphine gas (USEPA 1998b).

2.4.5 Reproductive or Developmental Effects

The maternal NOEL is 5 ppm for phosphine and the maternal lowest observable effect level (LOEL) is 7.5 ppm for phosphine, based on a developmental study on mated female rats (USEPA 1998b). In this study, inhalation exposure of rats to 7.5 ppm phosphine gas six hours a day for 15 gestation

days caused an increase in resorption of litters. The resorption occurred by day 10, at which point the study stopped due to the high rat mortality. Rats exposed to concentrations of phosphine below 7.5 ppm had body weight, food consumption, corpora lutea, fetus survival, resorptions, external malformations and visceral and skeletal defects of pups similar to the untreated rats (USEPA 1998b).

The USEPA (1998b) waived reproductive toxicity studies because residues of phosphine in food or drinking water are not expected. The available evidence for developmental and reproductive effects in animals suggests that such effects are not likely in humans.

2.4.6 Carcinogenicity and Mutagenicity

There is no evidence that phosphine gas causes carcinogenicity in rats (USEPA 1998b). Several studies suggest phosphine is not likely to cause mutations or increase the mutation rate in bacteria but may cause breakage of the chromosome *in vitro* (USEPA 1998b).

Exposure of human lymphocyte cells in culture to phosphine caused chromosomal aberrations (Garry et al. 1989). People exposed to phosphine in their job had a higher occurrence of chromosomal aberrations (e.g., deletions, gaps, breaks), in comparison to people exposed less or not at all, indicating a dose-related increase in aberrations (Garry et al. 1989).

2.4.7 Neurotoxicity Effects

Inhalation exposure of male and female rats to 20, 30, and 40 ppm phosphine for four hours caused a decrease in body temperature and motor activity compared to the control (USEPA 1998b). Other neurotoxicity observations in the study were suspect as a result of study design, lack of positive control data, and deficiency in reporting the study's findings (USEPA 1998b).

In a subchronic inhalation neurotoxicity study, no rats died after exposure to 3 ppm or less of phosphine for six hours per day, five days per week over a 90-day period. A tentative NOEL for subchronic systemic/neurobehavioral finding was 3 ppm for male and female rats because by week 13, male rats had effects in sleep patterns, body temperature, and motor activities (USEPA 1998b). A LOEL was not determined in this study (USEPA 1998b).

Several labels specify a maximum application of 12 grams of AIP (about 4 grams of phosphine) per burrow, which produces around 1,000 ppm phosphine near the pellets or tablets (Snider 1983). Phosphine gas diffuses from the source to lesser concentrations (Snider 1983).

3 DOSE-RESPONSE ASSESSMENT

3.1 Human Health and Safety

A dose-response assessment evaluates the dose levels (toxicity criteria) for potential human health effects. The chronic reference dose (RfD) is "the amount of pesticide that could be consumed daily without causing adverse effects" (USEPA 1998a). The chronic RfD for AIP is 0.0113 mg/kg/day. This value is based on the NOEL of 1.13 mg/kg/day from the 90-day inhalation study in rats described in the Subchronic Toxicity section (USEPA 1998a, b).

The acute reference dose of 0.018 mg/kg/day for AIP is based on no detectable effects after 15 days of exposure in the 90-day inhalation study in rats described above (USEPA 1998a, b). The

dietary risk for AIP is based on residues in food since phosphine residues are not likely to occur in drinking water (USEPA 1998a).

The Food Quality Protection Act of 1996 requires a 10-fold safety factor for the establishment of tolerances to protect infants and children; however, change to this requirement may occur if data demonstrate it is appropriate to reduce or remove the safety factor (USEPA 1998b). In the prenatal developmental inhalation toxicity study in rats described in the Reproductive and Developmental Effects section, the data “provides no indication of increased susceptibility of rats to *in utero* or postnatal exposure” to AIP (USEPA 1998a). Additionally, the restrictions for residential use and the expected lack of phosphine residue in drinking water indicated a lack of exposure to infants and children (USEPA 1998a). Given these factors, the USEPA (1998a) determined that the additional 10-fold safety factor is not necessary.

AIP labels require personal protection equipment (PPE) be worn to use AIP. This includes cotton gloves and a respirator on hand. Outdoor use does not require the use of a respirator, but applicators should monitor AIP levels in the air. A respirator for AIP includes a full-face gas mask, phosphine canister combination, self-contained breathing apparatus (SCBA), or an equivalent must be available to the applicator. Air levels can be monitored with a gas monitor such as the ToxiRAE Pro PID, primarily one specific to AIP gas.

3.2 Ecological Effects Analysis

This section of the risk assessment discusses available ecological effects data for terrestrial and aquatic species. Because of the physical properties and use patterns of AIP, USEPA (1998a) determined that no environmental fate studies were required (USEPA 1998b).

AIP is non-persistent under most environmental conditions and degrades rapidly in the presence of water to aluminum hydroxide and phosphine. The instability of AIP at atmospheric moisture contents indicates it is non-mobile in soil. Phosphine degrades in days. Phosphine near the soil surface diffuses into the atmosphere where it degrades through reaction with hydroxyl radicals. Phosphine binds to soil, inhibiting movement, and oxidizes to phosphates (USEPA 1998b). As a result of these attributes, AIP and phosphine are at low risk for contaminating surface waters (USEPA 1998b) and causing harm to aquatic species.

Phosphine gas is highly toxic and all animals in a fumigated burrow will die (USEPA 1998b). WS uses AIP as a burrow fumigant for the control of rodents, potentially exposing nontarget animals including sensitive species that may be present in fumigated burrows. The United States Fish and Wildlife Service (USFWS) determined that AIP used as a burrow fumigant may jeopardize the following federally-listed endangered species: the black-footed ferret (*Mustela nigripes*), the Utah prairie dog, the San Joaquin kit fox (*Vulpes macrotis mutica*), the desert tortoise (*Gopherus agassizii*), the blunt-nosed leopard lizard (*Gambelia sila*), and the eastern indigo snake (*Drymarchon couperi*) (USEPA 1998b). AIP labels contain use restrictions designed to prevent the take of endangered species. For example, the labels specify where in the states and counties AIP may be applied as well as requirements for conducting surveys for the presence of species of concern.

3.2.1 Aquatic Effects Analysis

AIP is highly toxic to fish, with a reported 96-hour LC₅₀ of 4.1 µg/L in rainbow trout (Gurusinghe 2014) and 0.178 mg/m³ for bluegill (WHO 1988, Gurusinghe 2014). The 96-hr LC₅₀ for phosphine toxicity in rainbow trout was 0.0097 mg/L. The 24-hr EC₅₀ value for *Daphnia magna* was 0.2 mg/L.

In frogs, the LC50 for 30-minute phosphine exposure was 0.56 mg/L and for a 15-minute phosphine exposure was 0.84 mg/L (WHO 1988). No data was available regarding the specific toxicity of AIP or phosphine to additional fish or aquatic species, but due to the mechanism of action, it is likely that it will be very highly toxic to other aquatic species. However, such exposure is unlikely as AIP will rapidly react to form phosphine gas, which is somewhat soluble in water, but volatilizes into the atmosphere based on the high Henry's Law Constant (USEPA 1998b).

3.2.2 Terrestrial Effects Analysis

Mammals

AIP and phosphine is used as a mammal toxicant with labeled uses to control target animals inside burrows. The effect of AIP to wild and domestic mammals is similar to the types of impacts discussed in the hazard identification section of this risk assessment (Section 2.4). Toxicity studies on the effects of AIP on nontarget mammals are limited. The lethal inhalation concentration values for the mouse and the cat are 380 mg/m³/2hr and 70 mg/m³/2hr, respectively (Witmer and Fagerstone 2003).

An assumption is that phosphine will kill all animals residing in treated burrows (Odenkirchen 2010), including nontarget animals that use burrows such as rodents, rabbits, raccoons, foxes, weasels, skunks, burrowing owls, reptiles, and amphibians (Witmer and Fagerstone 2003). WHO (1998) summarized secondary poisoning studies where animals killed by phosphine (poisoned with zinc phosphide, not AIP, but ultimately died from phosphine gas) were fed to fox, rats, cats, and mice with no toxic effects observed. In one of the studies, kit foxes were fed one kangaroo rat per day for three days that was dosed with 480 mg of zinc phosphide (a dose that is around three times the LD₅₀ for kit fox) showed no ill effects other than regurgitation and one fox refused to eat the rat for two days (Schitoskey 1975). Studies indicate bio-accumulation does not occur (WHO 1988, Witmer and Fagerstone 2003).

Birds

Information on the oral and inhalation median lethal doses for AIP and phosphine in birds is lacking. Exposure of three tom turkeys and six hens to 211 mg/m³ for 74 minutes and 224 mg/m³ for 59 minutes, respectively, caused labored breathing, apathy, and restlessness. The birds died in less than 2 hours (Gurusinghe 2014, Klimmer 1969 *cited in* WHO 1998). Exposure of other bird species to similar levels of phosphine is likely to cause similar results given the mode of action. However, exposure to these concentrations and durations is unlikely, as phosphine dissipates quickly in open air and birds would not be expected to nest or forage in burrows (Gurusinghe 2014); burrowing owls would be a species at primary risk along with other nesting birds that occupy burrows.

Reptiles

Data on AIP toxicity for reptiles is lacking. However, studies on the use of AIP as a fumigant for brown tree snake control in Guam suggest that it may be effective for the control of snakes in cargo and other unwanted areas, but did not include specific dosages (Savarie and Bruggers 1999, Witmer and Fagerstone 2003). The USFWS determined that use of AIP as a burrow fumigant may jeopardize the blunt-nosed leopard lizard, the eastern indigo snake, the desert tortoise, and other threatened and endangered reptile species (USEPA 1998b, Odenkirchen 2010). WS does not use AIP where threatened or endangered species are present.

Terrestrial Invertebrates and Microorganisms

Insects are a principal target of AIP. Susceptibility varies at different life stages, with larvae in diapause exhibiting tolerance, and some species are resistant (WHO 1988). The common fruit fly (*Drosophila melanogaster*) exhibits adverse effects to 1.4 mg/m³ (1 ppm) of phosphine (Noack and Reichmuth 1981 *cited in* WHO 1988), a threshold similar to the acute inhalation effects in mammals (WHO 1988). Mites appear to be less sensitive than insects (WHO 1988). As with insects, microorganisms vary in their sensitivity to phosphine with many species surviving levels that are fatal to arthropods (WHO 1988). The Mediterranean white snail (*Ceratomyxa virgata*) and the small conical snail (*C. acuta*) exhibit tolerance to phosphine, with an LD₁₀₀ of 4.4 g/m³ and 5.4 g/m³, respectively, for 10 days (Cassells et al. 1994).

Terrestrial Plants

Data on the effect of phosphine on terrestrial plants is limited. Phosphine levels between 3 mg/m³ and 8 mg/m³ in the air had harmful effects on growing lettuce (*Lactuca sativa capitata*) (Noack and Reichmuth 1982 *cited in* WHO 1988). WHO (1988) summarized several studies that indicated exposure of a variety of seed to phosphine had minimal or no effect on seed germination. For example, exposure of watercress seeds to air concentrations of phosphine between 20 and 1400 mg/m³ for three days did not affect germination (Noack and Reichmuth 1982 *cited in* WHO 1988).

4 EXPOSURE ASSESSMENT

4.1 Human Health and Safety

This qualitative exposure assessment estimates the potential exposure of humans to AIP and phosphine. It begins with the use and application method of AIP. An identified exposure pathway for AIP includes (1) a release from a source, (2) an exposure point where contact can occur, and (3) an exposure route such as ingestion or inhalation by which contact can occur (USEPA 2013). Each AIP pellet weighs 0.6 g and releases 0.2 g of phosphine. Each AIP tablet weighs 3 g and releases 1 g of phosphine. For outdoor fumigation of rodent burrows (agricultural and non-crop land areas), USEPA (1998b) recommends dosages of 5 to 20 pellets/burrow and 1 to 4 tablets/burrow.

The most at risk group for exposure to AIP or phosphine is WS applicators. AIP comes in prepared pellets or tablets, which require no mixing by applicators and, therefore, reduces potential dermal exposure to AIP. Dermal contact with AIP pellets or tablets is unlikely because the label requires applicators to wear dry cotton gloves, which prevents hands from contacting the formulation and prevents hand moisture from reacting with AIP.

Acute inhalation exposure is the primary concern for applicators. USEPA (1998b) used an 8-hour time-weighted-average (TWA) level of 0.3 ppm as the short-term exposure standard for applicators. This includes the time it takes to open the first container, apply the appropriate first dosage of fumigant, and close the burrow opening. The Occupational Safety and Health Administration developed a permissible exposure limit (PEL) of 0.3 ppm (0.0004 mg/l) for phosphine. The maximum concentration after application must not exceed 0.3 ppm for applicator exposure (USEPA 1998b). The current labels for AIP (Table 3) restrict exposure to phosphine to not exceed the 8-hour TWA of 0.3 ppm (0.0004 mg/l) or the 15 minute short-term exposure limit (STEL) of 1.0 ppm phosphine for applicators during application (USEPA 1998b).

The current Phostoxin[®] label states the tablets and pellets release phosphine gas slowly when encountering moisture from the air, depending upon the temperature and humidity. In general, this release is slow enough to permit applicators to deposit the fumigant in the desired areas and then leave the premises without significant human exposure to the gas. The label requires monitoring to determine the fumigator's exposure and to ensure their safety. The current labels also require a written fumigation management plan prepared for all fumigants prior to actual treatment to ensure a safe, legal, and effective fumigation. This fumigation management plan must describe the steps used to comply with requirements of pesticide product labels, such as (1) characterizations of the area, (2) personnel qualifications, (3) appropriate monitoring and notification requirements, (4) sealing procedures, (5) application procedures and fumigation period, and (6) post-application operations.

Exposure of WS applicators to high levels of phosphine gas during or after applications to burrows is unlikely. Labels for AIP require PPE be worn, which includes cotton gloves, so moisture from hands does not react the AIP, and a respirator on hand should AIP be detected. Respirator protections may include an approved full-face gas mask-phosphine canister combination, an SCBA, or an equivalent, when concentration of phosphine in the air. A facemask may be worn when the concentration in the air is unknown or exceeds 0.3 ppm from monitoring to minimize unexpected exposures. Units are available to measure AIP in the air and include ToxiRAE PID. WS applicators that have monitored the air while applying AIP have not detected measurable levels of AIP except when the bottle containing AIP tablets or pellets is opened (WS personnel typically open bottles away from the body and upwind to ensure they are not exposed). Applications occur outdoors where phosphine gas that escapes from the burrow dissipates into the atmosphere quickly.

An industrial hygiene study looked at phosphine gas levels during applications of AIP to rodent burrows through hand and mechanical applications. The hand application method resulted in detectable phosphine gas levels below the 8-hour TWA (time-weighted average) of 0.3 ppm according to air monitoring results in the applicator-breathing zone (USEPA 1998b, Baker 1992). The mechanical application method did not expose applicators to detectable levels of phosphine gas (Baker 1992). In another study, however, applicators who used AIP tablets (Phostoxin[®], Degesch America, 3-g tablet released 1 g hydrogen phosphide gas) to control Richardson's ground squirrels in grasslands experienced discomfort and nausea after hand-applying tablets despite using the safety measures recommended at the time of the study, 2007-2009 (Proulx et al. 2011). The study did not specify the safety measures used or environmental conditions. Following label directions during the burrow applications minimizes exposure for WS personnel to AIP.

Once the pellets/tablets are placed in the burrow, the applicator plugs the entrance to the burrow with crumpled newspaper or another material to prevent soil from covering the tablets or pellets (Virchow et al. 2002) and immediately seals the burrow entrances with soil (Snider 1983, USEPA 1998b); some rodents have multiple burrow openings and all entrances are sealed after one or all entrances are treated. The sealing of the burrow entrance traps the phosphine gas within the burrow reducing the potential for exposure to the applicator. After placement, applicators move away from the treated burrows, reducing exposure to phosphine gas that may escape from the burrow entrance. Lethal exposure is unlikely during proper use; however, an accidental event could expose applicators to phosphine. In the event of an accidental spill or leak, instructions on the product label explain the clean-up steps including the use of proper personal protective equipment (PPE) to protect those cleaning up the spill or leak. It is important not to use water at any time to clean up a spill as noted on labels and material safety data sheets for the labels in Table 3.

WS Directive on Pesticide Use (WS Directive 2.401, 12/08/2009)⁴ ensures that WS personnel are trained regarding proper and safe pesticide use and adherence to all label requirements. For burrowing rodent applications, the label prohibits use within 100 feet of any building occupied by humans, domestic animals, or where they may reside, in single or multi-family residential properties and nursing homes, schools except athletic fields, daycare facilities, and hospitals. WS uses these products outdoors and applies the pellets or tablets directly to underground burrow systems not connected to an occupied building. A recent paper assessed the minimum distance from buildings necessary to fumigate burrows given the length of North American rodent species' burrows; the length, depth and number of burrow openings was described for each species (Eisemann et al. 2017).

The label restrictions and WS use patterns result in a low exposure potential to the public. The public would have limited access to AIP, as it is a restricted use pesticide and the label prohibits its use on residential properties. Applicators post warning signs at all entry points to a treatment area that is accessible to the public, such as athletic fields or parks. The signs, which remain in place for a minimum of two days after treatment, warn of the dangers of AIP, indicate reentry period, and provide emergency contact information as discussed on labels.

The use pattern, label restrictions, and fate of AIP and phosphine in the environment indicate no exposure pathway for dietary consumption. The risk of phosphine contamination of drinking water is negligible, thus the exposure to phosphine through drinking water is not likely (USEPA 1998b). Human consumption of animals treated with AIP during WS program activities is unlikely, especially considering the fact that animals die in their burrows underground. A USEPA (1998b) analysis indicated that phosphine residues are unlikely in food because the gas dissipates into the atmosphere, especially during preparation and cooking of food. WS uses AIP only as a burrow fumigant to control rodents and moles, not for the treatment of food commodities. The USEPA (1998b) concluded that aggregate acute dietary risk is not a concern.

4.2 Environmental

4.2.1 Aquatic Exposure Assessment

Aquatic exposure to AIP is unlikely based on its environmental fate and chemistry characteristics and use pattern. AIP reacts with water, forming phosphine gas, which is volatile and has low solubility in water (Gurusinghe 2014). Phosphine degrades in days to phosphates (WHO 1988) and is at low risk for contaminating ground or surface water (Gurusinghe 2014). It is unlikely that AIP or phosphine will be in surface waters making the likelihood of aquatic exposure low (USEPA 1998b).

4.2.2 Terrestrial Exposure Assessment

The primary exposure pathway to terrestrial species is the inhalation route. The label requires animal burrows to be sealed, and therefore, no expected exposure pathways above ground are expected (Odenkirchen 2010). Phosphine gas is highly toxic and assumed to kill all animals residing in treated burrows including nontarget animals (USEPA 1998b, Odenkirchen 2010). Product labels instruct applicators to verify that burrows are occupied by target animals before treatment with AIP (Witmer and Fagerstone 2003).

⁴ All WS Policy Directives referenced in this document can be found @ <http://www.aphis.usda.gov/wps/portal/aphis/ourfocus/wildlifedamage> under Wildlife Damage – WS Program Directives.

A primary concern of the use of fumigants is nontarget species take. In a study to determine the efficacy of camera probes and retrieval hooks for exploring California ground squirrel burrows following a treatment with toxicants (chlorophacinone and diphacinone) and retrieving their carcasses, Vercauteren et al. (2002) found that this system could be used. The study was most interested in determining whether animals would be found within 2 meters of the burrow entrance, which coincides with the area the researchers believed would have the highest opportunity for secondary poisoning from the toxicants used. Two days after treatment, researchers probed 654 burrows; 104 burrows could only be probed to less than one meter due to obstructions and 550 to greater than or equal to one meter. They found 45 California ground squirrels: 31 dead, 9 dying, and 5 healthy. Of interest though, they also found one dead western harvest mouse (*Reithrodontomys megalotis*), a clutch of burrowing owls, three side-blotched lizards (*Uta stansburiana*), three western diamondback rattlesnakes, and one gopher snake. Of the burrows they surveyed, it was likely that additional ground squirrels and nontarget species were further in the burrow system (Vercauteren et al. 2002). The cameras were much easier than using hand shovels or backhoes to dig up the burrow system, but they had difficulties getting the camera into some burrows and going beyond two meters in any burrows because cameras were difficult to maneuver. However, for a relative frequency of nontarget species in the California ground squirrel burrows, they found one for every five ground squirrels found, or a nontarget vertebrate for 1.4% of the burrows probed.

In another study of black-tailed prairie dog burrows, Witmer et al. (2006) probed 777 burrows, 460 active and 317 inactive, to a depth of three meters using similar cameras in natural grasslands and urban/suburban areas. Black-tailed prairie dog burrows are typically 12 meters in length, two to three meters in depth, 10-15 cm in diameter, and average two openings; many have enlarged nest areas and sometimes plugged areas (Sheets et al. 1971). Witmer et al. (2006) and Sheets et al. (1971) found little vertebrate usage of burrow systems, other than prairie dogs, but that invertebrates were common consisting of mostly beetles and crickets, and to a lesser extent sow bugs, spiders, and fleas. Thus, WS believes that nontarget species are killed by AIP, primarily invertebrates, but numbers should be minimal based on these studies.

Exposure of plant roots growing in and around treated burrows to phosphine is possible; however, this potential damage was not quantifiable (Odenkirchen 2010). Phosphine trapped beneath the soil surface will bind to soil, inhibiting movement, and be oxidized to phosphates (USEPA 1998b). Phosphates occur naturally in the environment and are nutrients to plants and other organisms (WHO 1988). Phosphine disappeared from air-dried soils within 18 days, but it took 40 days for it to disappear completely from 100% saturated soils (Gurusinghe 2014).

5 RISK CHARACTERIZATION

This section discusses the qualitative risks associated with the WS use of AIP. The determination of risks to human health and nontarget species uses the effects data with the exposure assumptions.

5.1 Human Health and Safety

Although phosphine has high acute inhalation toxicity in humans, the WS use pattern, label restrictions, and environmental fate indicate minimal risk to human health from AIP and phosphine. Potential exposure of the public is at most negligible as AIP is a restricted use pesticide. Dietary exposure to the public is expected to be nil since WS does not apply AIP to food commodities. WS personnel do not use AIP where it would contaminate drinking water.

WS applicators are the most likely to be exposed to phosphine through inhalation. Following label instructions including the use of PPE and other requirements will minimize exposure and risk to applicators.

5.2 Environmental

5.2.1 Aquatic

AIP does not pose a significant ecological risk to aquatic resources given its chemical characteristics and WS use pattern (USEPA 1998b). AIP reacts with water, forming phosphine gas which quickly dissipates (Gurusinghe 2014). Phosphine degrades in days to phosphates and is at low risk for contaminating ground or surface water (USEPA 1998a, Gurusinghe 2014). While phosphine has been found to be toxic to some fish species (WHO 1988), it is highly unlikely that AIP or phosphine will be found in surface waters making the probability of risk negligible (USEPA 1998b).

5.2.2 Terrestrial

Exposure and risk to nontarget animals is greatest for those animals in a burrow that WS treats. Because of the high degree of toxicity of phosphine gas, all animals in a treated burrow will likely be killed (USEPA 1998b). The method of application and environmental fate of AIP keeps impacts localized to any sensitive terrestrial vertebrates and invertebrates inside treated burrows. WS applicators minimize the potential for exposure and risk by monitoring burrows and verifying occupation by target animals before applying AIP. Risk of secondary exposure to animals that consume animal carcasses killed by fumigation is unlikely since the phosphine gas quickly dissipates from the body, which eliminates secondary toxicity concerns (Snider 1983, Witmer and Fagerstone 2003, Baldwin 2012).

WS recorded no nontarget animals taken between FY11 and FY15, but some likely occurred. In one study, the treatment of 97 woodchuck burrows with gas cartridges (carbon monoxide fumigation) took 4 nontarget animals - one juvenile eastern cottontail rabbit in a burrow and three deermice in two other burrows (Dolbeer et al. 1991). Without excavating the burrows, WS would not likely know the nontarget species taken. Following the Dolbeer et al. (1991) study, it would be expected that if four nontarget vertebrates were taken for every hundred burrows treated, WS could have potentially taken about 2,333 nontarget vertebrate animals annually in the average 58,329 rodent burrows treated from FY11 to FY15. Other studies suggest less nontargets, especially in prairie dog burrows, than this study. Considering the species found in the woodchuck burrows, this would be minimal. The take of invertebrates would be higher as Witmer et al. (2006) found that they were common, but take would not be anticipated to affect any species populations. It should be noted that WS personnel inspect burrow entrances for potential nontargets and do not treat them if present; WS personnel also does not treat in areas where threatened or endangered species could be exposed. Thus, this level of nontarget take would be minimal.

AIP and phosphine “degrade to mineral constituents in the soil, so no biologically significant effects are expected for terrestrial plants above ground” (Odenkirchen 2010). In addition, the use pattern for AIP prevents exposure of above ground parts of terrestrial plants. However, exposure of roots inside the burrows is possible. AIP will have a negligible effect to roots since it rapidly reacts with water to produce phosphine gas (Odenkirchen 2010). Data on the effects of phosphine gas on plant roots is limited. As summarized in section 3.2.2.5, observations of harmful effects on growing lettuce occurred at phosphine gas concentrations between 3 and 8 mg/m³. Phosphine concentrations inside burrows can reach 1,000 ppm near the pellets or tablets (Snider 1983),

indicating phosphine gas may reach levels that are damaging to roots (Odenkirchen 2010). Any effects that could occur to plants would be localized areas adjacent, or in treated burrows.

6 UNCERTAINTIES AND CUMULATIVE IMPACTS

The predominant uncertainty associated with this assessment is the lack of definitive toxicity estimates in terrestrial organisms. The assumption that all vertebrates and invertebrates in a treated burrow would die may overestimate acute lethal risk within burrows. Recommended dosage often generates over 1,000 ppm phosphine near the pellets or tablets, but the gas concentration decreases as the gas diffuses out from the source (Snider 1983). Phosphine gas concentrations in burrows may be lower than expected to achieve complete mortality of the inhabitants.

Areas where cumulative impacts could occur are: 1) repeated worker and environmental exposures to AIP from program activities and other sources, 2) co-exposures to other chemicals with a similar mode of action, and 3) exposures to other chemicals affecting the toxicity of AIP. WS applicators wear PPE that reduce the risk to negligible for repeated exposures to AIP and phosphine. A failure in the function of PPE or misuse of the product could expose applicators to AIP, but this exposure is still unlikely to cause substantial risk or accumulation in the body (See Section 4.1).

The use of phosphine gas to control pests in and around stored food can cause phosphine residue in food. WHO (1988) summarized several studies on phosphine residue concentration in treated food items (a variety of grain and bean commodities treated at several phosphine concentrations) as well as the toxicity of residues in food to rodents. Residue levels in food dropped to negligible levels within several days and residues did not have significant toxicological effects on rodents. The phosphine residue in food is unlikely to contribute cumulatively in applicators who apply burrow fumigants because the gas quickly dissipates in the air, particularly during food preparation and cooking and worker exposure to phosphine during burrow fumigation is negligible.

WS use of AIP may occur in areas where other pesticide applications may occur. Other chemicals with a similar mode of action include the fumigants magnesium and zinc phosphide. Similar to AIP they degrade to phosphine. WS uses zinc phosphide in its program to control burrowing rodents so there is the potential for exposure to both aluminum and zinc phosphide. WS does not use multiple fumigant types in the same burrow at the same time. The proper use of required PPE for both products reduces exposure and the aggregate risks would be minimal for applicators. Zinc and magnesium phosphide are also restricted use chemicals with buffer restrictions in residential and public areas where public exposure could occur.

Cumulative impacts to ecological resources from the use of phosphide compounds (aluminum and zinc) in the WS program are also unlikely because AIP degrades rapidly in the environment, phosphine has a low risk for contaminating ground or surface waters, and it is not persistent or mobile under most environmental conditions.

Phosphine in the environment comes from other sources such as aerobic degradation in soil, sediments, decomposing plant matter and sludge, but is somewhat rare (Glindemann et al. 1996, Eismann et al. 1997b). The contribution of phosphine from WS applications would be negligible, particularly in comparison to its use in non-vertebrate applications and other sources of phosphine in the environment. For example, in California, vertebrate pest control accounted for 6% of the AIP chemical used in agricultural and structural applications (California Department of Pesticide

Regulation 2017). This percentage would be much less if restricted to just vertebrate applications by the WS program (AIP was not used by WS-California during this time).

7 SUMMARY

Aluminum phosphide is a fumigant used by WS to control various burrowing rodents and moles. WS personnel place the tablets or pellets into the target species' burrow and seal the burrow entrance with soil. AIP reacts with moisture in burrows to release phosphine gas, which is the toxin in the fumigant. Formulations for burrow treatment are in 3-g tablets or 600-mg pellets containing about 56% active ingredient. WS personnel have not had any known exposures or exposed the public or pets to AIP. Thus, it is assumed that risk to human health from AIP used by WS in WDM has been at the most minimal. WS applicators placed 219,594 tablets and took an estimated 54,096 burrowing rodents and moles annually from FY11 to FY15. Black-tailed and Gunnison's prairie dogs were the species targeted the most. WS applicators attempt to minimize nontarget take by inspecting burrows for signs such as tracks and scat of the target species. WS did not record any nontarget species take, but could have taken an estimated 1,921 nontarget vertebrate species, theorized to be mostly other rodents, rabbits, lizards, and snakes.

This risk assessment evaluated the human health and ecological risk of AIP under the WS use pattern for rodent control. Although phosphine gas is toxic to humans, the risk to human health is low because inhalation exposure is slight for the underground applications. WS applicators wear proper personal protective equipment (PPE) according to the pesticide label requirements, which reduces their exposure to AIP and phosphine gas, lowering the risk to their health. Label restrictions protect the public from exposure to the fumigant when used accordingly.

Label restrictions, use patterns, environmental fate, and aquatic toxicity data for AIP suggest low risk to aquatic species and their habitats. AIP risks to terrestrial plants is also low, but nontarget terrestrial vertebrates and invertebrates that are in burrows and exposed to phosphine gas during treatment could be killed from exposure. WS personnel reduces the exposure and risk to nontarget species by checking burrows for use by nontarget vertebrate species and confirming the presence of target animals before applying AIP. AIP does not have no secondary risks to nontarget species because the gas rapidly dissipates and AIP and phosphine do not accumulate in target animals. Restrictions are present on all labels to lower the chance of exposure and risks to nontarget terrestrial species.

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Experience: Joined APHIS in 2012, preparing human health risk assessments and providing assistance on environmental compliance. Prior experience before joining APHIS includes 18 years environmental consulting experience specializing in human health risk assessments for environmental contaminants at Superfund, Resource Conservation and Recovery Act (RCRA), and state-regulated contaminated facilities.

Primary Writer: Jim Warren

Position: USDA-APHIS-Policy and Program Development (PPD), Environmental and Risk Analysis Services (ERAS), Environmental Toxicologist, Little Rock, AR

Education: B.S. Forest Ecology and M.S. Entomology – University of Missouri; Ph.D. Environmental Toxicology – Clemson University

Experience: Eight years of experience working for APHIS preparing ecological risk assessments and providing assistance on environmental compliance. Prior experience before joining APHIS includes other government and private sector work regarding ecological risk assessments related to various environmental regulations.

Editors/Contributors for “Use of Aluminum Phosphide in Wildlife Damage Management Risk Assessment”:

Editor/Contributor: Jeanette O’Hare

Position: USDA-APHIS-Wildlife Services (WS), National Wildlife Research Center (NWRC), Registration manager, Fort Collins, CO

Education: B.S. Biology – College of Saint Mary; M.A. Biology – University of Nebraska - Omaha

Experience: 13 years of experience working for WS NWRC providing regulatory compliance support for the development of WDM tools. Prior experience before joining APHIS includes assessing the environmental fate of pesticides and providing the agency guidance on water quality issues at the state

government level, and laboratory experience in the fields of pharmacology and toxicology, and immunology.

Editor/Contributor: Emily Ruell

Position: USDA-APHIS-WS, NWRC, Registration Specialist, Fort Collins, CO

Education: B.S. Zoology and Biological Aspects of Conservation – University of Wisconsin - Madison; M.S. Ecology – Colorado State University (CSU); M.A. Political Science – CSU

Experience: Three years of experience with APHIS WS NWRC preparing and reviewing vertebrate pesticide registration data submissions and other registration materials, and providing pesticide regulatory guidance to WS, WS NWRC, and collaborators. Prior experience before joining APHIS includes seven years of conducting field and laboratory wildlife research at CSU, and environmental policy research for the U.S. Geological Survey.

Editor/Contributor: Ryan Wimberly

Position: USDA-APHIS-WS, Operational Support Staff, Staff Wildlife Biologist, Madison, TN

Education: BS Wildlife Management and Ecology – Northwest Missouri State University

Experience: Special expertise in wildlife biology, ecology, and damage management. Seventeen years of service with APHIS Wildlife Services, including operations and research, conducting a wide variety of programs, including bird damage research and management, livestock protection, invasive species management, wildlife hazard management at airports, property, and natural resource protection. Expert in preparing environmental documents for WS programs to comply with the National Environmental Policy Act and the Endangered Species Act.

Data Contributor: Joey Millison

Position: USDA-APHIS-WS Information and Technology (IT), Junior Applications Developer

Education: Information and Technology coursework from various sources

Experience: Eleven years of experience in APHIS, WS Management Information System (MIS) Group. Retrieves WS field data from the MIS for writers, reviewers, and editors.

9.2 Internal Reviewers

USDA APHIS Wildlife Services

Reviewer: Gary Witmer

Position: USDA/APHIS/WS/NWRC Supervisory Research Wildlife Biologist, Fort Collins CO

Education: B.S. and M.S. General Biology – University of Michigan; M.S. Wildlife Ecology – Purdue University; Ph.D. Wildlife Science with minors in Statistics and Forest Management – Oregon State University

Experience: Twenty-five years as a USDA research wildlife biologist with a focus on rodent population and damage management. Three years on the wildlife faculty of Penn State University. Four years as a terrestrial ecologist with Argonne National Laboratory.

9.3 Peer Review

The Office of Management and Budget requires agencies to have peer review guidelines for scientific documents. The APHIS guidelines were followed to have “The Use of Foothold Traps in Wildlife Damage Management Risk Assessment” peer reviewed. WS asked AFWA to have experts review the documents. AFWA selected reviewers from various state agencies.

9.3.1 Peer Reviewer Agencies Selected by the Association of Fish and Wildlife Agencies

California Department of Fish and Wildlife
Colorado Parks and Wildlife
Nevada Department of Wildlife
Texas Parks and Wildlife Department

9.3.2 Comments

Comments regarding concerns with the risk assessment and a response:

- 1. Comments:** While Wildlife Services may not use aluminum phosphide in areas with threatened or endangered species, potential impacts on other nontarget species such as burrowing owls are possible.

Response: We agree with the possibility that AIP has high acute risks to nontarget species, especially as outlined in Sections 3, 4, and 5, and that checking for signs of nontarget species at burrow entrances reduce nontarget hazards. We believe that nontarget take is relatively low as discussed in Section 4.2.2. We added additional studies that reflect the fact that few nontarget species are found in rodent burrow systems, but these were not directly related to AIP treatments. We believe that WS takes relatively few nontarget species as estimated in Section 5.2.2.
- 2. Comments:** The Risk Characterization of terrestrial nontarget wildlife only uses data from one study, on woodchuck burrows. From this study, the number and species of nontargets is estimated using four per 100 burrows. Given the use of aluminum phosphide for at least nineteen species of burrowing mammals, more research is required before an assessment can be made with any certainty regarding number and species of nontarget losses.

Response: The sheer number of underground dwelling wildlife in the United States would make it difficult to have any meaningful analysis of nontarget wildlife take at a species level (Section 4.2.2). Section 2 was revised to refer to Sections 4.2.2 and 5.2.2 where studies of other burrowing rodents were discussed and nontarget species take by WS was roughly estimated based on the one study available where burrows were excavated to determine nontarget take. Section 4.2.2 was expanded to include more studies that looked at nontarget species in burrow systems. Nontarget species, with the exception of invertebrates such as beetles, crickets, and spiders, were found to be minimal. WS cannot use AIP where threatened and endangered species occur or could be affected without conservation measures in place, so these species would not be impacted. WS believes that nontarget take was minimal and no species' population would be impacted by use of AIP since most species that may be taken are, at least, fairly abundant in areas where AIP is used. In fact, from FY96 to FY15, the only known nontarget take by fumigants was a raccoon in FY09 for a project protecting federally threatened piping plovers (*Charadrius melodus*) from red fox and raccoons, a WS employee found a den that he thought was an active red fox den. After applying a gas cartridge, he dug up the den and found a raccoon occupied it. Even though the raccoon was targeted for the project, it was a nontarget because the method used was not registered for it.

Comments received not requiring a response.

- 1. Comment:** I have reviewed the risk assessment and believe the document is adequate for continued use.
- 2. Comment:** I believe this tool should remain available in the same capacity for USDA WS to use.
- 3. Comment:** I have no comments but say the risk assessment appears complete and the protocols/reviews seem appropriate.
- 4. Comment:** I believe this is a fairly safe toxicant since it is used almost entirely underground.