HUMAN HEALTH RISK ASSESSMENT OF WILDLAND FIRE-FIGHTING CHEMICALS: LONG-TERM FIRE RETARDANTS

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Acronyms and Abbreviations

EPA	Environmental Protection Agency
kg	kilogram
LD_{50}	median lethal dose
LOAEL	lowest observed adverse effect level
m^3	cubic meter
mg	milligram
mg/kg	milligrams per kilogram
mg/m^3	milligrams per cubic meter
NOAEL	no observed adverse effect level
QPL	Qualified Products List
RfD	reference dose

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1.0 INTRODUCTION

The U.S. Forest Service uses a variety of chemicals to aid in the suppression of fire in wildlands, including long-term fire retardants, Class A foams, and water enhancers. The potential human health impacts of the products were first assessed in a programmatic risk assessment prepared in 1994. The risk assessment has been periodically updated to include new products and assessment approaches. This report provides a structure for maintaining the product-specific risk assessments for efficient reference, access, and organization of the most current information for each product.

This risk assessment analyzes the human health risks of using long-term fire retardants in wildland fire-fighting. A companion report evaluates the ecological risks from retardant use. Separate risk assessments address human health and ecological risks from Class A foams and water enhancers.

This risk assessment evaluates the toxicological effects associated with chemical exposure, that is, the direct effects of chemical toxicity, using methodologies established by the U.S. Environmental Protection Agency (EPA). A risk assessment is different from and is only one component of a comprehensive impact assessment of an action's possible effects on health and the human environment, including aircraft noise, cumulative impacts, physical injury, and other direct or indirect effects. Environmental assessments or environmental impact statements[1] pursuant to the *National Environmental Policy Act* consider chemical toxicity as well as other potential effects to make management decisions.

This report is organized into five major sections and three attachments. Section 1.0 provides an introduction, background information, and an overview of the analysis approach. Section 2.0 presents the hazard assessment methodology. Section 3.0 provides the exposure assessment methodology. Section 4.0 presents the risk characterization methodology. Section 5.0 lists the references cited throughout this report. Attachments A, B, and C present a summary of the current risk conclusions, the Qualified Products List (QPL) of long-term retardant formulations evaluated in this risk assessment, and product-specific risk estimates, respectively.

1.1 Background: Fire-Fighting Chemicals

The information in the following paragraphs was derived from the Forest Service's Wildland Fire Chemicals Systems information web site (https://www.fs.usda.gov/rm/fire/wfcs/):

[1] In 2011, the Forest Service authorized continued use of aerially applied fire retardants as the decision following an environmental impact statement and associated public participation for three alternative approaches to aerial retardant use.

- *Long-term fire retardants*, commonly referred to as retardants, are applied from aerial or ground equipment. The red liquids dropped from aircraft, often viewed in media coverage of wildland fire-fighting activities, are retardants. These products, many of which are primarily the same salts found in agricultural fertilizers, are supplied as either wet or dry concentrates. They are mixed with water in a prescribed ratio and applied to a target area just ahead of a fire (during wildland firefighting) or prior to a fire (during prescribed fire operations). While the water contained in the mixed product aids in firefighting, its primary purpose is to aid in accurately delivering the product to the fire. They continue to be effective after the water in the mixture has evaporated, as the retardant residue slows the spread and reduces the intensity of fire.

- *Class A Foam fire suppressants*, commonly referred to as foams, are supplied as wet concentrates similar to liquid dishwashing products that are mixed with water and then aerated to produce foam. They are applied from aerial or ground equipment directly to the fire area to slow or stop combustion. Foam bubbles and their components (water and the concentrated product in it) interact with fuel surfaces in several ways. The fuels may absorb the moisture as it drains out of the foam mixture, which makes them less susceptible to combustion, and may be protected from wind, heat, and flame by foam coating the fuel's surface. Depending on the desired outcome, a wide range of foam characteristics can be prepared from the same concentrate by changing the mix ratio and adjusting the foam generation and application method used. Higher amounts of concentrate and aeration in the foam solution produce drier, slow draining foam for vertical surface protection. Moderate amounts produce wetting, fast draining foam for vegetation (horizontal surface) application. Low amounts can be used to make "wet water" that has enhanced penetration for mop up.

- *Water enhancers,* commonly referred to as gels, are supplied as wet or dry concentrates that contain thickeners and other ingredients that, when mixed with water, improve aerial application, minimize drift, and aid in adherence to fuels. Water enhancers may be applied from ground or aerial application equipment. These products may be used in structure protection within the wildland interface or on wildland fuels. The effectiveness of water enhancers depends on the water content of the gels and, once they dry out, they are no longer effective.

Foams and water enhancers all increase the inherent ability of water to suppress fire, while retardants leave a dried residue after the water evaporates that helps to protect the fuel from burning.

Fire-fighting chemicals may be dropped from fixed-wing airplanes ("airtankers") or helicopters, or applied by ground crews from fire engines or using portable equipment; the application methods approved for each product are listed on the current QPL, which can be found online at https://www.fs.usda.gov/rm/fire/wfcs/.

1.2 Overview of Analysis

The purpose of this assessment is to estimate the risks to the health of workers and the public as a result of the use of retardants in wildland fire-fighting. This human health risk assessment looks only at the biological risks of the retardants, should they be used. It does not evaluate alternatives to their use, nor does it discuss factors affecting management decisions on whether chemicals should be used in a particular situation.

This human health risk assessment employs the three principal analytical elements that the National Research Council (1983) described and EPA (1989, 2000, 2021) affirmed as necessary for characterizing the potential adverse health effects of human exposures to existing or introduced hazards in the environment: hazard assessment, exposure assessment, and risk characterization.

1.2.1 Hazard Assessment

Hazard assessment requires gathering information to determine the toxic properties of each chemical and its dose-response relationship. Sometimes this element of the health risk assessment process is divided into two separate steps: hazard identification and dose-response assessment:

1. Hazard identification determines whether exposure to a stressor can cause an increase in the incidence of specific adverse health effects and whether the adverse health effect is likely to occur in humans. That is, it answers the question “What health problems does the chemical cause?”
2. Dose-response assessment describes how the likelihood and severity of adverse health effects are related to the amount of exposure to a chemical (the “dose”). It answers the question “What are the health effects at different levels of exposure?”

Human hazard levels are derived primarily from the results of laboratory studies on animals. The goal of this hazard assessment is to identify acceptable doses for noncarcinogens and identify the cancer potency (a factor that relates dose to cancer risk) of potential carcinogens.

In this risk assessment, the toxicity of each product formulation as a whole was assessed, as well as the toxicity of some individual ingredients in the product formulations, according to criteria described in Section 2.3.2.

1.2.2 Exposure Assessment

Exposure assessment involves estimating doses to persons potentially exposed to the retardants. It answers the question “How much of the chemical are people exposed to?” In this exposure assessment of the retardants, dose estimates were made for typical, maximum, and accidental exposures for firefighting personnel and members of the public. These exposures are defined as follows:

- *Typical:* Typical exposure reflects the average dose an individual may receive if all exposure conditions are met. Typical exposure assumptions include the average amount of a chemical to which an individual may be exposed in a day, the average number of days worked throughout their fire-fighting career, the amount of residue that a homeowner may encounter while cleaning it off of their house, the average length of time elapsed until showering or changing clothes, and other similar assumptions.

- *Maximum:* Maximum exposure defines the upper bound of credible doses that an individual may receive if all exposure conditions are met. Maximum exposure assumptions include the estimated upper bounds on the amount of a chemical to which an individual may be exposed in a day, the number of days worked throughout their fire-fighting career, the amount of residue that a homeowner may encounter while cleaning it off of their house, the length of time elapsed until showering or changing clothes, and other similar assumptions.

- *Accidental:* The possibility of error exists with all human activities. Therefore, it is possible that an individual fire-fighter, other worker, or member of the public could be in the path of an aerial drop during fire-fighting activities, resulting in an accidental drench. This accident scenario was evaluated for potential health effects to firefighting personnel and members of the public.

Exposure scenarios are described in detail in Section 3.0. These scenarios estimate risks from clearly defined types of exposure. If all the assumptions in an exposure scenario are not met, the dose will differ from that estimated in this analysis or may not occur at all.

1.2.3 Risk Characterization

Risk characterization presents the results of the risk assessment in terms of the nature, and presence or absence, of risks. Risk characterization answers the question “What is the risk of health effects in the exposed population?” This step compares the hazard information with the dose estimates to predict the potential for health effects to individuals under the conditions of exposure. The risk characterization also identifies uncertainties (such as data gaps where scientific studies are unavailable) that may affect the magnitude of the estimated risks.

2.0 HAZARD ASSESSMENT

This section presents the approach for conducting the hazard assessment of the fire retardants—a review of available toxicological information on the potential human health hazards associated with the chemical formulations and individual ingredients used by the Forest Service. Section 2.1 provides background information to familiarize the reader with the terminology and technical information in this hazard assessment. Section 2.2 describes the hazard assessment methodology. Section 2.3 summarizes the approach for identification and development of the toxicity values used in this risk assessment. Section 2.4 describes the hazard assessment data gaps that affect the ability to quantify risks from these products and their ingredients.

2.1 Background Information

Because of the limitations on testing in humans, effects in non-human systems, primarily animals, provide the basis for an informed judgment as to whether an adverse impact is correlated with a particular exposure. Animal toxicity test results may be supplemented by information on a chemical's effects on humans, such as the results of dermatologic or exposure testing in humans, and occasional studies of low-level dosing of human volunteers by oral or other routes.

Toxicity tests in laboratory animals are designed to identify specific toxic endpoints (effects of concern), such as lethality or cancer, and the doses associated with such effects. Studies vary according to the test species used, the endpoint, test duration, route of administration, and dose levels. The dosing schedule, number of test groups, and number of animals per group also vary from one test to another, but the tests are generally designed to demonstrate whether a causal relationship exists between administered doses and any observed effects.

2.1.1 Duration of Tests

The duration of toxicity tests ranges from a single dose or a few doses in a short time period (acute) or multiple doses over a few weeks (subacute) tests, through longer subchronic studies, to chronic studies that may last up to the lifetime of an animal. Acute toxicity studies involve administering a chemical to each member of a test group, either in a single dose or in a series of doses over a period of a few days to two weeks. Subacute, subchronic, and chronic studies are used to determine the effects of multiple doses. Subacute toxicity studies involve repeated exposure to a chemical for one month or less. Subchronic toxicity studies generally last from one to three months, and chronic studies last for more than three months.

Acute studies are used primarily to determine doses that are immediately lethal, which results in limited utility in an assessment of long-term or repeated low-level human exposures. Acute and subacute toxicity studies include dermal irritation tests, dermal sensitization tests, eye irritation tests, and inhalation exposure or daily oral dosing of laboratory animals for up to one month to further define effects from limited exposures.

Longer term studies are designed to characterize the dose-response relationship resulting from repeated exposure to a compound. All other things being equal, the greater the duration of the

study, the more reliable will be the resulting value for estimating the effects of subchronic or chronic exposures in humans. Adverse effects in laboratory tests may include overt clinical signs of toxicity, reduced food consumption, abnormal body weight change, abnormal clinical hematology or chemistry, or visible or microscopic abnormalities in the tissue of the test organism. Chronic studies in rats or mice that continue for longer periods of time, usually about two years, may also be used to assess the carcinogenic potential of a chemical.

2.1.2 Routes of Exposure

For assessing hazards from the retardants, the routes of administration in laboratory tests that reflect the likely types of exposures to humans include dermal (applied to the skin), inhalation (through exposure to vapors or aerosol particles), and oral by dietary (in food or water) or gavage (forced into the stomach through tubing). Selection of the route of administration of a particular test material is based on the probable route of human exposure.

2.1.3 Units

A dose is expressed as milligrams of a chemical per kilogram of body weight (mg/kg) of the test animal, in parts per million in the animal's diet, in milligrams per liter in the water that it drinks, or milligrams per cubic meter (mg/m^3) in the air that the animal breathes. In chronic studies, the test substance is generally administered in the diet at specified amounts in parts per million (mg of chemical per kg of food). The known weight of the animal over the test period and its food intake rate are used to convert parts per million in the diet to milligrams of a chemical per kilogram of body weight per day (mg/kg/day) for extrapolation to humans. In most chronic toxicity studies, at least two dosing levels are used, in addition to a zero-dose, or control group. In general, the control group receives only the vehicle (for example, water or saline) used in administering the test material. In a dietary study, the animal’s feed would serve as the vehicle.

2.1.4 Toxicity Endpoints

In acute toxicity studies, the endpoint of interest is often the median lethal dose (LD_{50}), which is the single dose that is calculated to be lethal to 50 percent of the test animals.

For examination of non-lethal, noncarcinogenic endpoints, toxicity testing can be used to estimate threshold exposure levels. The threshold level is the dose level at which a significant proportion of the test animals first exhibit the toxic effect. The threshold dose will vary among tested species and among individuals within species. Examples of toxic effects include pathologic injury to body tissue; a body dysfunction, such as respiratory failure; or another toxic endpoint, such as developmental defects in an embryo. It is not possible to determine threshold dose levels precisely; however, the no-observed-adverse-effect level (NOAEL) indicates the dose at which there is no statistically or biologically significant increase in the frequency or severity of an adverse effect in individuals in an exposed group, when compared with individuals in an appropriate control group. The next higher dose level in the study is the lowest-observed-adverse-effect level (LOAEL), at which adverse effects are observed. The true threshold dose level for the particular animal species in a study lies between the NOAEL and the LOAEL. If a chemical produces effects at the lowest dose tested in a study, the NOAEL must be at some

lower dose. If the chemical produces no effects, even at the highest dose tested, the NOAEL is equal to or greater than the highest dose.

Carcinogenicity studies are used to determine the potential for a compound to cause malignant (cancerous) or benign (noncancerous) tumors when administered over an animal's lifetime. Several dose levels are used, with the highest set at the maximum tolerated dose, as established from preliminary studies. A control group is administered the vehicle (the liquid or food with which the test chemical is given) alone. Because tumors may arise in test animals for reasons unrelated to administration of the test compound, statistical analyses are applied to the tumor incidence results to determine the significance of observed results. Amdur et al. (1991) listed four types of responses that have generally been accepted as evidence of compound-induced tumors:

- The presence of types of tumors not seen in controls.
- An increase in the incidence (compared to controls) of the tumor types that also occur in controls.
- The development of tumors earlier than in controls.
- An increased multiplicity of tumors.

Some chemicals that elicit one or more of these responses may not be primary carcinogens (that is, tumor-inducers on their own), but may be enhancers or promoters. However, a carcinogenicity evaluation remains appropriate, because they may contribute to an increase in cancer incidence. EPA's guidelines for carcinogen risk assessment (EPA 2005) list the following considerations for judging whether scientific studies indicate that a substance may cause a cancerous response: (1) consistency of the observed association, (2) strength of the observed association, (3) specificity for the observed association, (4) temporal relationship of the observed association, (5) exposure-response relationship, (6) biological plausibility, (7) coherence among lines of evidence, (8) experimental evidence from human populations, and (9) insights from structurally similar chemicals and modes of action (analogy).

For chemicals that are characterized as known or likely to be carcinogenic to humans, the dose-specific tumor incidence data are used to calculate a cancer slope factor, which represents the probability that a 1-mg/kg/day chronic dose of the agent will result in formation of a tumor, and is expressed as a probability, in units of "per mg/kg/day" or $(mg/kg/day)^{-1}$. The approach to applying a slope factor may vary on a chemical-by-chemical basis, depending on the factors described above and also the level of exposure under consideration.

2.2 Hazard Assessment Methodology

The goal of the hazard analysis is to determine toxicity levels with which to quantify risk. There are two types of toxicity endpoints: noncarcinogenic effects and carcinogenic effects.

For noncarcinogenic effects, it is generally assumed that there is a threshold level, and that doses lower than this threshold can be tolerated with little potential for adverse health effects. The U.S.

EPA has determined threshold doses for many chemicals and refers to these as reference doses (RfDs). The RfD is an estimate of the highest possible daily dose of a chemical that will pose no appreciable risk of deleterious effects to a human during his or her lifetime. The uncertainty of the estimate usually spans about one order of magnitude (EPA 2020). The RfD is calculated using the lowest NOAEL from the species and study most relevant to humans, or the most sensitive species (the species that exhibited the lowest NOAEL overall). This NOAEL is divided by an uncertainty factor (usually 100) consisting of a factor of 10 to allow for the variation of response within the human population and a factor of 10 to allow for extrapolation to humans. Additional uncertainty factors may be applied to account for extrapolation from a shorter term study, overall inadequacy of data, or failure to determine a no-effect level. RfDs are expressed in units of mg/kg/day. EPA lists RfDs in its Integrated Risk Information System, a chemical risk database (EPA 2020). RfDs can also be calculated using the steps outlined in EPA's methodology, if none has been developed by EPA. RfDs are analogous to the acceptable daily intake levels identified by groups such as the World Health Organization.

For compounds that are known or likely human carcinogens, cancer slope factors that have been calculated by EPA or other appropriate sources are identified for use in this risk assessment.

2.3 Toxicity Data and Estimation of Reference Doses

2.3.1 Formulations

For many chemicals, including the majority of those found in the fire-fighting products and the formulations themselves, long-term study data for estimating chronic RfDs are not available. Layton et al. (1987) developed a methodology for deriving acceptable daily intake levels for noncarcinogenic compounds for which chronic toxicity data are unavailable. This methodology uses acute toxicity data, specifically, LD_{50}s. Acute and chronic toxicity values for many chemicals were correlated to identify a factor that allowed a reasonable estimate of a chronic NOAEL based on an LD_{50}. The LD_{50} is multiplied by this factor, which ranges from 0.00005 to 0.001, to obtain an estimate of the chronic NOAEL. This is the methodology on which the hazard assessment for the fire-fighting product formulations is based, because only acute toxicity data are available for these mixtures. In addition, Layton et al. (1987) summarized research that identified a factor of 5 that distinguished NOAELs in subchronic studies from NOAELs in chronic studies. Because the exposures evaluated in this risk assessment are predicted to occur at most 120 days per year (airtanker base personnel), this additional factor was also used in estimating the RfDs. The estimated NOAEL was then divided by an uncertainty factor of 100, to account for the uncertainty associated with interspecies extrapolation from laboratory animals to humans, and interindividual variation in sensitivity among humans. The estimated RfD was determined as follows:

$$RfD\ (mg/kg/day) = \frac{LD_{50}\ (mg/kg) \times 0.001 \times 5}{100}$$

This calculation was applied to the acute toxicity data for each of the products assessed, to provide an estimate of an acceptable exposure level. The estimated RfDs are summarized in the product-specific attachments.

2.3.2 Components

In addition to evaluating the risks to workers and members of the public from the wildland fire-fighting product formulations, several individual ingredients in the formulations were targeted for quantification of the risk that they may present. These ingredients meet one or more of the following criteria:

- It is one of the fertilizer salt components of a retardant product.
- It is a suspected or known carcinogen by a relevant route of exposure, and a cancer slope factor is available for that exposure route.
- The oral LD_{50} in laboratory animals is less than 500 mg/kg.
- The chemical is a toxic chemical reportable under SARA Section 313.

2.4 Data Gaps

The hazard assessment of the products and their ingredients may include one or more of the following data gaps:

- No long-term toxicity tests were available for the products as a whole. RfDs were estimated based on acute toxicity data and the methodology described by Layton et al. (1987).

- Dermal penetration rates were unavailable for most of the chemicals. In the absence of dermal absorption data, a rate of 1 percent per 8 hours was used for inorganic chemicals, and a rate of 10 percent per 8 hours was used for organic chemicals.

- If toxicity data are not available for a specific ingredient, risks from that ingredient were not evaluated.

- If a cancer slope factor is unavailable for a chemical that is identified as a potential carcinogen, a cancer risk estimate for the chemical could not be quantified.

3.0 EXPOSURE ASSESSMENT

3.1 Introduction

This section describes the human populations potentially exposed to wildland fire retardants and the scenarios for which doses were estimated. There are two populations potentially at risk: (1) wildland fire-fighters and (2) members of the public. Fire-fighters include airtanker base personnel, helitack crews, smokejumpers, hotshot crews, type 2 firefighters, engine crews, and overhead workers. The public includes individuals who may be near the scene of an application of a retardant, or who live or work at a house or other structure to which a retardant was applied.

3.2 Exposure and Dose

Two primary conditions are necessary for a human to receive a chemical dose that may result in a toxic effect. First, the chemical must be present in the person's immediate environment—in the air, on a surface such as vegetation that may contact the skin, or in food or water—so that it is available for intake. The amount of the chemical present in the person's immediate environment is the exposure level. Second, the chemical must enter the person's body by some route. Chemicals on vegetation, on clothing that is in contact with the skin, or on the skin itself, may penetrate the skin. Chemicals in food or water may be ingested. The amount of a chemical that moves into the body by any of those routes constitutes the dose. While two people may be subjected to the same level of exposure (for example, two workers walking through vegetation treated with retardant), one may get a much lower dose than the other by wearing protective clothing or washing as soon as possible. Exposure, then, is the amount of a chemical available for intake into the body; dose is the amount of the substance that actually enters the body.

3.3 Potential Exposures

This subsection describes the populations that may be exposed to retardants and lists the representative human health exposure scenarios analyzed in this risk assessment.

3.3.1 Affected Populations and Exposure Scenarios

The human population that could be exposed to retardants falls into two groups. The first group is the workers directly involved in their use, including airtanker base personnel, firefighters, and workers who enter areas where the chemicals have been applied. The second group is the public who may be subject to non-occupational exposure.

Airtanker base personnel, helitack crews, smokejumpers, hotshot crews, type 2 firefighters, engine crews, and overhead workers include both male and female workers. Therefore, risks to each were assessed separately, using gender-specific body weight and skin surface area data. This risk assessment used mean body weights of 84.0 and 70.2 kg (185 and 155 pounds) for male and female fire-fighters, respectively, between 30 and 40 years old (EPA 2011).

Members of the public may be exposed as a result of cleaning a structure, and may include both adults and children. For members of the public, it was assumed that an adult (male or female)

weighs an average of 80 kg (176 lb), and a 6- to 11-year-old child weighs 31.8 kg (70 lb) (EPA 2011).

The accidental drench of an individual in the path of an aerial drop of retardant was also evaluated. Although a fire-fighter would be more likely to be exposed in an accidental drench scenario, this exposure was also estimated for members of the public.

3.3.2 Levels of Exposure

To allow for some of the uncertainty inherent in any quantitative risk assessment, two levels of human exposure were evaluated.

Typical Exposures. Typical exposure assumptions attempt to target the average dose an individual may receive if all exposure conditions are met. These assumptions include the average duration of exposure, typical number of days worked per year, and other similar assumptions.

Maximum Exposures. Maximum exposure assumptions attempt to define the upper bound of credible doses that an individual may receive if all exposure conditions are met. These assumptions include an estimate of the maximum duration of exposure, the maximum number of days worked per year, and other similar assumptions.

3.4 Potential Exposures to Workers

The doses to workers were estimated for each type of worker, using the assumptions described below about their activities and exposures.

3.4.1 Airtanker Base Personnel

Airtanker base personnel include both mixmasters and loaders. Frequently, a single individual carries out both functions. They unload retardant concentrate when received from suppliers, prepare mixed retardant by blending dry or wet concentrate with water, pump mixed retardant into airtankers, and wash down spills from ramps and storage areas. Protective clothing includes a dust mask, eye and ear protection, cotton overalls, and leather or fabric shoes. A hard hat may also be used, especially near the airtankers.

Exposures to mixers were assumed to result from both dermal and inhalation exposure to dry retardant concentrate. For dermal exposure, the mean daily solids adherence factors for skin recommended in EPA (2011) were used: 0.0982, 0.1859, 0.2763, and 0.0660 mg/cm^2 of surface area for the face, arms, hands, and legs, respectively, all based on measured solids adherence for construction workers. For inhalation exposure, the retardant concentration of 4.43 mg/m^3 that was measured in a monitoring study at airtanker bases (USFS 1979) was assumed to be present in the air at the mixing station. The mixers were assumed to be exposed to this concentration for either a typical mixing shift of two hours or a maximum shift of 10 hours, at an inhalation rate of 1.62 m^3/hour (moderate intensity physical activity for adult in their 30s) (EPA 2011) at 10 percent absorption efficiency of the chemicals by the lungs. The concentration of retardant in inhaled air is estimated to be reduced by 90 percent when the mixers use a dust mask.

The loaders were assumed to be exposed to mixed retardant as a result of spills over the hands and forearms. This was assumed to create a layer on the skin that would be absorbed, with the amount on the skin varying based on whether the liquid was partially wiped off (typical) or not wiped off (maximum), using the exposure factors in EPA (2011). There are four (typical) or 55 (maximum) loading events per day.

Both mixers and loaders are assumed to have a 12-year career, working 37 days per year in the typical case and 120 days per year in the maximum case. It is assumed that two (typical) or 10 (maximum) hours elapse until the chemical is completely washed off by showering and changing clothes.

3.4.2 Helitack Crews

Helitack crews arrive at a fire by helicopter and stay on site for the duration of the fire. Protective clothing includes a helmet (hard hat when on the ground), eye and ear protection, Nomex® fire shirt and pants, leather boots, leather fire gloves, and a fire shelter.

Helitack crew members were assumed to be exposed to retardant residues by walking through an area where vegetation has been treated. This scenario assumes that 75 percent of the legs' surface area contacts treated vegetation, with a 90% reduction in exposure due to protective clothing. These individuals are assumed to have a seven-year career, with 25 days per year (typical) or 100 days per year (maximum) when they encounter treated vegetation. Two (typical) or four (maximum) hours elapse until the chemical is washed off thoroughly by showering and changing clothes.

3.4.3 Smokejumpers

Smokejumpers parachute into the area of a fire and stay on site for the duration of the fire or until they are replaced with other firefighters. Protective clothing includes a helmet (hard hat when on the ground), eye and ear protection, Nomex® fire shirt and pants, leather boots, leather fire gloves, and a fire shelter.

Smokejumpers were assumed to be exposed to fire retardant residues by walking through an area where vegetation has been treated. The risk assessment assumes that 75 percent of the legs' surface area contacts treated vegetation, with a 90% reduction in exposure due to protective clothing. Smokejumpers were assumed to have a 10-year career, with seven days per year (typical) or 20 days per year (maximum) when they encounter treated vegetation, and 2 (typical) or 7 (maximum) hours elapse until the chemical is washed off thoroughly by showering and changing clothes.

3.4.4 Hotshot Crews

Hotshot crews are specialized fire-fighters, the first reinforcements after initial attack. They are used in suppression of large fires, and build and reinforce fire lines. Protective clothing includes

a hard hat, eye and ear protection, Nomex® fire shirt and pants, leather boots, leather fire gloves, and a fire shelter.

Hotshot crew members were assumed to receive exposure to retardant residues by walking through an area where vegetation has been treated. The scenario assumes that 75 percent of the legs' surface area contacts treated vegetation, with a 90% reduction in exposure due to protective clothing. These individuals are associated with a 7-year career, with 20 days per year (typical) or 40 days per year (maximum) when they encounter treated vegetation, and 3 (typical) or 7 (maximum) hours elapsing until the chemical is washed off thoroughly by showering and changing clothes.

3.4.5 Type 2 Firefighters

Type 2 firefighters act as reinforcements on large fires. They do mop-up and patrol the control lines. Protective clothing includes a hard hat, eye and ear protection, Nomex® fire shirt and pants, leather boots, leather fire gloves, and a fire shelter.

Type 2 firefighters were assumed to be exposed to retardant residues by walking through an area where vegetation has been treated, and by mixing and applying retardants to structures. The vegetation contact exposure assumes that 75 percent of the legs' surface area contacts treated vegetation, with a 90% reduction in exposure due to protective clothing. For retardant mixing and application activities, it was assumed that mixture spills over hands and forearms each time a load is mixed and applied. This was assumed to create a layer on the skin that that would be absorbed, with the amount on the skin varying based on whether the liquid was partially wiped off (typical) or not wiped off (maximum), using the exposure factors in EPA (2011). There are four (typical) or 55 (maximum) loading events per day. They are assumed to have an eight-year career, with two days per year (typical) or six days per year (maximum) when they encounter treated vegetation or mix/apply retardants. It was assumed that two (typical) or six (maximum) hours elapse until the chemical is washed off thoroughly by showering and changing clothes.

3.4.6 Engine Crews

Engine crews may mix retardant concentrates with water, and apply them in support of fire-fighting activities. Protective clothing includes a hard hat, eye and ear protection, Nomex® fire shirt and pants, leather boots, leather fire gloves, and a fire shelter.

Ground-based application by engine crews has not been a common method of retardant application, and the worker exposure parameters could range widely. This exposure scenario is evaluated qualitatively in this risk assessment. In general, members of engine crews could be exposed to ground-applied retardants when walking through an area where vegetation has been treated, and by mixing and applying retardant products that are approved for engine (ground-based) application. In either case, their exposure would be expected to be no more than that of hotshot crews from walking through treated vegetation, nor any greater than mixers or loaders at airtanker bases.

3.4.7 Overhead Workers

Overhead workers oversee an assigned portion of the fire operations. They inspect and supervise from the fire line. Protective clothing includes a hard hat, eye and ear protection, Nomex® fire shirt and pants, leather boots, leather fire gloves, and a fire shelter.

Overhead workers were assumed to be exposed to the retardant residues when walking through an area where vegetation has been treated. The risk assessment assumes that 75 percent of the front half of the legs' surface area contacts treated vegetation, with a 90% reduction in exposure due to protective clothing. Overhead workers are assumed to have a 15-year career, with 2 days per year (typical) and 6 days per year (maximum) when they encounter treated vegetation. It is further assumed that two (typical) or six (maximum) hours elapse until the chemical is washed off thoroughly by showering and changing clothes.

3.4.8 Rehabilitation Teams

Members of rehabilitation teams could encounter dried chemical residues as they assess fire damage and plan/implement measures to minimize secondary damage to the environment (such as mud slides). Protective clothing includes a hard hat, eye and ear protection, Nomex® fire shirt and pants, leather boots, and leather fire gloves. These workers have an average 10-year career in this job function, with 2 (typical) or 6 (maximum) days per year of exposure at 2 (typical) or 6 (maximum) hours of exposure per day. Risks to rehabilitation team members were addressed qualitatively.

3.4.9 Lifetime Doses to Workers

The lifetime doses for workers handling potential carcinogens were estimated assuming that 95 percent of the time the worker is exposed to the typical dose for the typical number of days per year, and 5 percent of the time the worker is exposed to the maximum dose for the maximum number of days per year. Annual doses were multiplied by the estimated career length to indicate cumulative exposure, which was then averaged over the typical 75-year (males) or 80-year (females) lifetime, based on EPA (2011).

3.5 Potential Exposures to Members of the Public

The doses to members of the public from exposure to wildland fire retardants were estimated for one exposure scenario: cleaning a structure. In this analysis, doses from the dermal route of exposure were estimated. The following section describes the parameters used in calculating these doses. Several additional types of potential exposure to members of the public were evaluated qualitatively.

3.5.1 Quantitative Analysis: Cleaning a Structure

This scenario assumes that, while an adult male or female is cleaning a structure to which a retardant was applied, aqueous rinsate (in a dilution the same as the mixture strength) is dispersed over hands and forearms during pressure washing or observation of cleaning activities.

This was assumed to create a layer on the skin that would be absorbed, with the amount on the skin varying based on whether the liquid was partially wiped off (typical) or not wiped off (maximum), using the exposure factors in EPA (2011). The same level of exposure was assumed to occur for a child observing this activity as his or her own home is cleaned. The exposure duration is one hour.

3.5.2 Qualitative Analyses

Potential public exposures that were addressed qualitatively in the risk discussion include the following:

- Individuals re-entering areas to which retardant had been applied; this may include individuals such as hikers, researchers, hunters, biologists, or children playing in the area.
- Individuals harvesting mushrooms or berries from wildlands after vegetative regrowth has occurred.
- Individuals consuming vegetables from home gardens.
- Individuals handling pets that re-entered areas to which retardant had been applied.
- Individuals conducting salvage logging of burned areas, with contact for up to four hours per day twice per year for two years.

3.5.3 Lifetime Doses to Members of the Public

Lifetime doses to members of the public were calculated for the potential carcinogens evaluated in this risk assessment. The lifetime dose was estimated by assuming that an individual participates in cleaning a structure once in his or her lifetime. The estimated dose from this activity was averaged over a 78-year lifetime (EPA 2011).

3.6 Potential Exposure from Accidental Drench

In the event of an accidental drench, workers or members of the public may be exposed to greater amounts of a retardant than under the previously described routine exposure circumstances.

3.6.1 Workers

The accident scenario in which a worker is drenched by an aerial drop of retardant was assessed by assuming that the application rate of the chemical is received on 50 percent of the body surface area, with a 90% reduction in exposure due to protective clothing and 2 hours elapses until the individual is able to shower and change clothes. The potential frequency of this accident is assumed to be as follows:

- helitack crews: two per year
- smokejumpers: two per year
- hotshot crews: three per year
- type 2 firefighters: one per year

3.6.2 Members of the Public

The accident scenario in which an adult or child is drenched by an aerial drop of retardant was also assessed. In this scenario, the application rate of the chemical is received on 50 percent of the body surface area. This event is assumed to occur no more than once in an individual's lifetime.

4.0 RISK CHARACTERIZATION

4.1 Introduction

This section describes the approach for characterizing the estimated risks to the health of workers and members of the public that may result from any of the retardants on the Forest Service's QPL. In the risk characterization step, the human doses estimated in the exposure assessment (Section 3.0) are compared with the toxicity characteristics described in the hazard assessment (Section 2.0), to arrive at estimates of risk.

Section 4.2 describes the methods used to evaluate human health risks, including both noncarcinogenic and carcinogenic risks. Section 4.3 discusses several additional exposure scenarios that were addressed qualitatively, and Section 4.4 discusses the uncertainties in this risk assessment.

4.2 Methodology for Assessing Risks

All of the products on the QPL are mixtures of several ingredients. Risks from these mixtures were evaluated following the recommendations of EPA (2000): *Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures*. Specifically, the following approaches were applied:

- EPA states that "whenever possible, the preferred approach to the health risk evaluation of chemical mixtures is to perform the assessment using health effects and exposure data on the whole mixture." To accomplish this, risks were calculated for the formulated products as a whole, using the RfDs that were estimated for each product as described in Section 2.3.1.

- EPA also stated that "even if a risk assessment can be made using whole-mixture data, it may be desirable to also conduct a risk assessment based on toxicity data on the components in the mixture . . . When a mixture contains component chemicals whose critical effects are of major concern, e.g., cancer or developmental toxicity, an approach based on the mixture data alone may not be sufficiently protective in all cases." This additional analysis was deemed particularly important in the case of the retardants because only acute toxicity data were available on the products as a mixture. Therefore, each formulation was reviewed for components that meet the criteria presented in Section 2.3.2.

The assessment of risks for the products and for the targeted ingredients was conducted following the standard risk assessment methodology described in NRC (1983) and EPA (1989). Please refer to Attachment A for a summary of the risk conclusions, and to Attachment C for product-specific risk estimates.

4.2.1 Noncarcinogenic Risk Estimation

In this risk assessment, the potential risks were evaluated by comparing the representative doses (estimated in the exposure assessment) with the RfDs (identified in the hazard assessment). All the RfDs used in this risk analysis take into account the possibility of multiple exposures and

represent acceptable dose levels. The comparison of dose to RfD consists of a simple ratio, called the Hazard Quotient:

$$Hazard\ Quotient = \frac{Estimated\ Dose\ (mg/kg/day)}{RfD\ (mg/kg/day)}$$

If the estimated dose does not exceed the RfD, the hazard quotient will be one or less, indicating a negligible risk of noncarcinogenic human health effects. Two characteristics of the hazard quotient to note: (1) the greater the value of the hazard above one, the greater the level of concern; but (2) the level of concern does not increase linearly as the hazard quotient increases, because RfDs do not have equal accuracy or precision and are not all based on the same severity of toxic effects. Thus, the interpretation of the potential toxic response associated with a particular hazard quotient can range widely among chemicals (EPA 1989).

A dose estimate that exceeds the RfD, although not necessarily leading to the conclusion that there will be toxic effects, clearly indicates a potential risk for adverse health effects. Risk is presumed to exist if the hazard quotient is greater than one. However, comparing one-time or once-a-year doses (such as those experienced by the public or in an accident) to RfDs that are designed to represent long-term exposures with repeated daily doses tends to exaggerate the risk from those infrequent events.

For workers and the public, hazard quotients were computed for each product and targeted ingredient for typical, maximum, and accident situations. If the hazard quotient exceeds one, the risk may require mitigation, depending on the circumstances of exposure.

Following the guidance presented in EPA (2000), the additive approach was used to sum the hazard quotients when more than one targeted ingredient was identified in a product. In these cases, a hazard index for the product, representing the sum of the hazard quotients, was calculated. The hazard index is interpreted in the same manner as the hazard quotient; that is, risk is presumed to exist if the product hazard index exceeds one.

4.2.2 Cancer Risk Estimation

The mechanism for cancer dose-response can be complex. In 2005, EPA updated agency guidance (EPA 2005) for deriving cancer slope factors, as described in Section 2.1.4 of this report. Historically, carcinogenic effects were assumed to have no threshold, requiring extrapolation to compare exposures from the much lower doses associated with environmental exposure to chemicals. However, new perspectives on methods to assess risks of cancer are gaining wider acceptance, such as consideration of mode of action, thresholds for carcinogenicity, and incorporating other types of biological data. Estimation of cancer slope factors using updated methods is occurring on a chemical-by-chemical basis, as new laboratory studies are completed and new risk assessments are conducted. For any chemical identified as a known or potential human carcinogen in this risk assessment, the chemical-specific approach developed by EPA for estimating its cancer risk is applied.

When the cancer slope factor approach is recommended by EPA for estimating human cancer risk from a chemical, the cancer risk is expressed as the probability that cancer would occur over the course of a person's lifetime, as a result of the stated exposure. This risk probability is calculated as follows:

$$RISK = DOSE \times CSF \times OCC / LIFE$$

where:

RISK	=	the lifetime probability of cancer as a result of the specified exposure
DOSE	=	estimated dose (mg/kg/day)
CSF	=	cancer slope factor (per mg/kg/day)
OCC	=	number of occurrences of the daily dose during an individual's lifetime
LIFE	=	the number of days in a lifetime of 75 years (male worker), 80 years (female worker), or 78 years (member of the public, average for both genders) (27,375, 29,200, or 28,470 days, respectively)

The resulting cancer probability is compared to a benchmark value of $1x10^{-6}$ (or 1 in 1 million), a value commonly accepted in the scientific community as representing a cancer risk that would result in a negligible addition to the background cancer risk of approximately 39.5% in the United States (NCI 2020). In some occupational health risk assessments, cancer risks as high as $1x10^{-4}$ (1 in 10,000) can be considered acceptable. However, the benchmark of 1 in 1 million is used for both workers and the public in this risk assessment.

4.3 Qualitative Risk Evaluations

4.3.1 Rehabilitation Team Members

Rehabilitation teams may encounter dried retardant residue. The estimated daily exposure is comparable to that of overhead workers, although the residues would be dried by the time the rehabilitation team enters the area, resulting in a much lower rate of dermal transfer and absorption. Risks are expected to generally be negligible, not exceeding those predicted for overhead workers in the typical or maximum scenarios.

4.3.2 Re-Entry to Treated Areas

Individuals such as hikers, researchers, hunters, biologists, or children playing could re-enter areas to which retardant has been applied. These exposures are expected to generally result in a negligible risk, similar to and no greater than those of rehabilitation team members.

4.3.3 Harvesting Wild Vegetation

Individuals may harvest mushrooms and berries from wildlands after vegetative regrowth has occurred, in areas that were treated with retardants. The dermal exposure from harvesting these edibles is expected to generally present negligible risk and would be similar to the exposure of rehabilitation team members, hunters, ecologists, or others who re-enter treated areas.

4.3.4 Ingesting Vegetables or Wild Vegetation

Individuals are advised against consuming vegetables from home gardens to which retardant may have been applied, or from areas in wildlands where residues are apparent. In addition to avoiding consuming food items with visible residues, the ammonium-based fertilizer component of some retardants may lead to temporary increases in the nitrate content of soils in areas of application. Some vegetables are known to concentrate nitrates, particularly cauliflower, beets, spinach, broccoli, collard greens, carrots, turnips, and other root vegetables. Elevated levels of ingested nitrate could pose a risk upon conversion to nitrite, especially to infants who are more susceptible to methemoglobinemia. Methemoglobinemia results in decreased oxygen transport from the lungs to the body's tissues. Infants are more sensitive to nitrite than adults, because the hemoglobin in an infant's blood is more easily changed into methemoglobin, and an infant's digestive system is less acidic, which enhances the conversion of nitrate to nitrite (AAP 1970, ATSDR 2001).

4.3.5 Handling Pets with Exposure to Treated Vegetation

Handling dogs or other domestic animals whose fur contains residues as a result of exposure to vegetation in treated areas is not expected to pose risks to humans any greater than those that would be associated with direct vegetation contact, as described in Section 4.3.2.

4.3.6 Salvage Logging

Salvage logging may take place in burned areas, in which an individual has contact for up to four hours per day twice per year for two years. This daily exposure of four hours exceeds the typical duration of vegetation contact predicted for most fire-fighters in the typical scenarios, but is bounded by higher exposures (up to seven hours) for vegetation contact in some maximum scenarios. In general, negligible risks are predicted for salvage loggers from retardants. Please refer to Attachment A for a current summary of the comparable risks to fire-fighters, particularly those in the maximum exposure scenarios, and to Attachment C for product-specific risk estimates.

4.4 Discussion and Uncertainties

The risks summarized in this assessment are not probabilistic estimates of risk, but are conditional estimates. That is, these risks are likely only if all exposure scenario assumptions that were described are met. The primary areas of uncertainty in this analysis include the predicted RfDs and dermal penetration rates for each formulation and ingredient, and the quantity of a chemical to which an individual may actually be exposed. For individual ingredients with RfDs based on subchronic or chronic studies, more confidence can be placed in the degree to which they represent actual acceptable intake levels. In most cases, no dermal penetration data are available, so reasonable estimates (see details in Section 2.4) were applied in the assessment. Although monitoring studies could identify some levels of exposure more accurately, the highly variable nature of fire-fighting activities would require application of a large margin of error, limiting their utility in providing greater confidence in the risk conclusions.

Exposure durations for workers were estimated by Forest Service personnel with years of experience in the fire-fighting program. If longer durations of exposure occur in the field, with no increase in frequency of washing or showering, then a comparable increase in the estimate dose and risk would be predicted. For any estimated hazard quotients (see Attachment C) that were estimated to be between 0.1 and 1, such a change in exposure duration could increase the hazard quotient to the point where it would exceed the threshold value of one, at which point a potential health risk would be indicated in this type of predictive assessment. In general, this situation may primarily apply to exposures to mixers of dry retardant at airtanker bases; this risk can be mitigated by removing any powder residue from exposed skin by washing with water. Based on products evaluated to date, increases in exposure duration for helitack crews, smokejumpers, hotshot crews, type 2 firefighters, engine crews, and overhead workers would still likely result in estimated risks that remain far below the level of concern.

It is important to note that, during the many years of these chemicals' use in fire-fighting, reports of adverse health effects have been limited to skin and eye irritation, and potential allergic reactions. This use history does not appear to warrant extensive testing, especially given the emergency nature of the use of these products.

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Attachment A: Health Risk Assessment Summary

LONG-TERM FIRE RETARDANTS
March 2026

The U.S. Forest Service uses a variety of fire-fighting chemicals to aid in the suppression of fire in wildlands. These products can be categorized as long-term retardants, Class A foams, and water enhancers. A chemical toxicity risk assessment of the long-term retardants examined their potential impacts on fire-fighters and members of the public. Typical and maximum exposures from planned activities were considered, as well as an accidental drench of an individual in the path of an aerial drop.

This risk assessment evaluated the toxicological effects associated with chemical exposure, that is, the direct effects of chemical toxicity, using methodologies established by the U.S. Environmental Protection Agency. A risk assessment is different from and is only one component of a comprehensive impact assessment of all of an action's possible effects on health and the human environment, including aircraft noise, cumulative impacts, physical injury, and other direct or indirect effects. Environmental assessments or environmental impact statements pursuant to the *National Environmental Policy Act* consider chemical toxicity, as well as other potential effects, to make management decisions.

Each long-term retardant product used in wildland fire-fighting is a mixture of individual chemicals. The product is supplied as a concentrate, in either a wet (liquid) or dry (powder) form, which is then diluted with water to produce the mixture that is applied during fire-fighting operations. The risk assessment process for a product had a two-part approach: (1) toxicity data for the whole product were considered, to account for any effects due to the product being a mixture (synergism or antagonism); and (2) each ingredient in the product formulations was screened, and risk from any ingredient with toxicity exceeding a screening threshold was separately quantified.

The results of the risk assessment depend on a number of factors, including the availability of relevant scientific information, standard risk assessment practices, exposure assumptions, and toxicity dose-response assumptions. Whenever possible, the risk assessment integrated chemical-specific scientific information on toxicity endpoints. The approaches used to address these factors introduce minor to significant amounts of uncertainty into the risk assessment's conclusions; the risk assessment identified the types of uncertainty affecting the analysis and estimated the degree to which they may affect the conclusions reached. Overall, when assumptions were required, a conservative approach was taken, to provide risk results that are protective of human health.

Summary of Estimated Risks to Human Health from Long-Term Retardants

The estimated risks to human health are summarized below for the retardants listed on the February 5, 2026, Qualified Products List at https://www.fs.usda.gov/rm/fire/wfcs/, including conditionally or interim qualified products. Any time the QPL is updated, the current applicability of this risk summary will change. The risk assessment will be updated as federal agency resources and priorities allow.

- For typical and maximum exposures, all products as a whole and individual ingredients were predicted to pose negligible risk to fire-fighting personnel from the retardant products.
- No risks were predicted for adult and child members of the public cleaning a structure that had been treated with a retardant.
- In the accidental drench scenario, no risks were predicted for workers or members of the public.
- Risks are expected to generally be negligible for
  - rehabilitation team members
  - individuals who could re-enter areas to which retardant has been applied, such as hikers, researchers, hunters, biologists, or children playing
  - dermal exposure from harvesting mushrooms or berries from wildlands after vegetative regrowth has occurred, in areas that were treated with retardants
  - handling dogs or other domestic animals whose fur contains residues as a result of exposure to vegetation in treated areas
- Individuals are advised against consuming vegetables from home gardens to which retardant may have been applied, or from areas in wildlands where residues are apparent.

Attachment B: Qualified Products List

US Forest Service | Washington Office | Fire & Aviation Management

February 5th, 2026

Long-Term Retardant for Wildland Fire Management – Aerial Applications

Qualified by US Forest Service in Accordance with Forest Service Specification 5100-304d

These products are evaluated, qualified, and approved for use only at the specified mix ratio with the indicated application equipment.

Consult individual agencies for specific policies relating to long-term retardant use.

Definition: Retardants contain salts that decrease fire intensity and slow advance of the fire, even after the water they contain evaporates.

Aerial Qualified Chemical	Mix Ratio	Qualified Applications[1]			
		Fixed-Wing		Helicopter	
	(Pounds concentrate per gallon water)	Multi Engine	SEATS	Fixed-Tank	Bucket
Dry Concentrate - Gum-thickened; Permanent or Temporary Base					
Phos-Chek MVP-Fx	0.96 lb/gal	●	●	-	●
Phos-Chek MVP-F	0.95 lb/gal	●	●	-	●
Dry Concentrate - Gum-thickened; Temporary Base					
Phos-Chek 259-Fx	1.01 lb/gal	●	●	●	●
Wet Concentrate - Gum-thickened; Permanent or Temporary Base					
Phos-Chek LC-95A-R	5.5:1	●	●	-	●
Phos-Chek LC-95A-Fx	5.5:1	●	●	-	●
Phos-Chek LC-95A-F	5.5:1	●	●	-	●
Phos-Chek LCE20-Fx	5.2:1	●	●	-	●
Wet Concentrate - Gum-thickened; Temporary Base					
Phos-Chek LC-95-W *Also sold as* Phos-Chek GS 23 RR	5.5:1	●	●	-	●

1 – Qualification Notes

- ● Fully Qualified – Product complies with all requirements of a formal specification.
- o Conditionally Qualified – Product complies with all requirements in the specification for laboratory evaluation; an operational field evaluation is required for full qualification.

Note: Notwithstanding the requirements of Forest Service Specification 5100-304d, the Government reserves the right to suspend or remove product qualification status if operational, safety, quality, airworthiness, or other issues are identified.

US Forest Service Washington Office Fire & Aviation Management

February 5th, 2026

Long-Term Retardant for Wildland Fire Management – Pretreatment/Ground Applications

Qualified by US Forest Service in Accordance with Forest Service Specification 5100-304d

These products are evaluated, qualified, and approved for use only at the specified mix ratio with the indicated application equipment.

Consult individual agencies for specific policies relating to long-term retardant use.

Definition: Retardants contain salts that decrease fire intensity and slow advance of the fire, even after the water they contain evaporates.

Ground Applied Chemicals	Mix Ratio (Gallons of water per gallon Concentrate)	Qualified Applications[1] -Ground Applied
Pretreatment, Non Storable[2]		
Phos-Chek LC-95-W	5.5:1	●
Phos-Chek LC-95A-Fx	5.5:1	●
Phos-Chek Fortify	3	●
Phos-Chek LCE20W	3	●
Komodo	3	●
Flame Security International FIRECOAT DEFEND	1.04 lb/gal	●
Kaiterra 100-FC-F	5.5:1	●

1 – Qualification Notes
- ● Fully Qualified – Product complies with all requirements of a formal specification.

2 – Pretreatment category has not been evaluated for durability and weathering.
3 – These products are designed to be delivered pre-mixed and ready-to-use as pretreatment chemicals. No mixing shall take place after purchase.

Note: Notwithstanding the requirements of Forest Service Specification 5100-304d, the Government reserves the right to suspend or remove product qualification status if operational, safety, quality, or other issues are identified.

Attachment C: Health Risk Assessments for Retardants on Qualified Products List

March 2026

Product	Formulation ID Number(s) Evaluated in Risk Assessment
Phos-Chek MVP-Fx	0439-014A 0439-014B 0532-047A 0532-048A 0532-049A
Phos-Chek MVP-F	0403-014A 0403-014B
Phos-Chek 259-Fx	0439-091B 0532-056E 0532-056F
Phos-Chek LC-95A-R	1051695-C 1051695-A
Phos-Chek LC-95A-Fx	0439-076B
Phos-Chek LC-95A-F	0381-045C 0381-045D
Phos-Chek LCE20-Fx	0502-050A
Phos-Chek LC-95-W Also sold as Phos-Chek GS 23 RR	0381-090B
Phos-Chek Fortify	0518-022A
Phos-Chek LCE20W	0518-022C
Komodo	K500CC
Flame Security International FIRECOAT DEFEND	FSI-FC-Defend-P001
Kaiterra 100-FC-F	2024-KFC-1

Scientific notation: Some of the risk tables in this section use scientific notation, since many of the values are very small. For example, the notation 3.63E-001 represents 3.63×10^{-1}, or 0.363. Similarly, 4.65E-009 represents 4.65×10^{-9}, or 0.00000000465.

Boldface type is used in these tables to indicate the risks for which the hazard quotient, hazard index, or cancer risk exceeds the acceptable value, indicating risk in that scenario; that is, the risk value is in boldface type if the hazard index or hazard quotient is greater than 1, or if the cancer risk is greater than 1 in 1 million.

Phos-Chek MVP-Fx (0439-014A)

Product Data

Concentrate form:	Dry	
Mix ratio:	0.96	lb/gal
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.32E-02	1.44E-02	3.12E-01	3.10E-01
Airtanker base personnel - loading	2.02E-03	1.90E-03	1.23E-01	1.12E-01
Helitack crews	3.78E-05	3.97E-05	7.56E-05	7.93E-05
Smokejumpers	3.78E-05	3.97E-05	1.32E-04	1.39E-04
Hotshot crews	5.67E-05	5.95E-05	1.32E-04	1.39E-04
Type 2 firefighters	3.78E-05	3.97E-05	1.13E-04	1.19E-04
Overhead workers	3.78E-05	3.97E-05	1.13E-04	1.19E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.62E-04	1.95E-04	2.07E-04	2.49E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.48E-02	3.67E-02	1.72E-01	2.36E-01

Phos-Chek MVP-Fx (0439-014B)

Product Data

Concentrate form:	Dry	
Mix ratio:	0.96	lb/gal
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.32E-02	1.44E-02	3.12E-01	3.10E-01
Airtanker base personnel - loading	2.02E-03	1.90E-03	1.23E-01	1.12E-01
Helitack crews	3.78E-05	3.97E-05	7.56E-05	7.93E-05
Smokejumpers	3.78E-05	3.97E-05	1.32E-04	1.39E-04
Hotshot crews	5.67E-05	5.95E-05	1.32E-04	1.39E-04
Type 2 firefighters	3.78E-05	3.97E-05	1.13E-04	1.19E-04
Overhead workers	3.78E-05	3.97E-05	1.13E-04	1.19E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.62E-04	1.95E-04	2.07E-04	2.49E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.48E-02	3.67E-02	1.72E-01	2.36E-01

Phos-Chek MVP-Fx (0532-047A)

Product Data

Concentrate form:	Dry	
Mix ratio:	0.96	lb/gal
Formulation Oral LD_{50}:	>5,000	mg/kg
Formulation RfD:	0.25	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.34E-02	1.46E-02	3.15E-01	3.13E-01
Airtanker base personnel - loading	2.04E-03	1.92E-03	1.24E-01	1.17E-01
Helitack crews	3.82E-05	4.01E-05	7.64E-05	8.01E-05
Smokejumpers	3.82E-05	4.01E-05	1.34E-04	1.40E-04
Hotshot crews	5.73E-05	6.01E-05	1.34E-04	1.40E-04
Type 2 firefighters	3.82E-05	4.01E-05	1.15E-04	1.20E-04
Overhead workers	3.82E-05	4.01E-05	1.15E-04	1.20E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.63E-04	1.97E-04	2.09E-04	2.52E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.52E-02	3.71E-02	1.85E-01	2.39E-01

Phos-Chek MVP-Fx (0532-048A)

Product Data

Concentrate form:	Dry	
Mix ratio:	0.96	lb/gal
Formulation Oral LD_{50}:	>5,000	mg/kg
Formulation RfD:	0.25	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.34E-02	1.46E-02	3.15E-01	3.13E-01
Airtanker base personnel - loading	2.04E-03	1.92E-03	1.24E-01	1.17E-01
Helitack crews	3.82E-05	4.01E-05	7.64E-05	8.01E-05
Smokejumpers	3.82E-05	4.01E-05	1.34E-04	1.40E-04
Hotshot crews	5.73E-05	6.01E-05	1.34E-04	1.40E-04
Type 2 firefighters	3.82E-05	4.01E-05	1.15E-04	1.20E-04
Overhead workers	3.82E-05	4.01E-05	1.15E-04	1.20E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.63E-04	1.97E-04	2.09E-04	2.52E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.52E-02	3.71E-02	1.85E-01	2.39E-01

Phos-Chek MVP-Fx (0532-049A)

Product Data

Concentrate form:	Dry	
Mix ratio:	0.96	lb/gal
Formulation Oral LD_{50}:	>5,000	mg/kg
Formulation RfD:	0.25	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.34E-02	1.46E-02	3.15E-01	3.13E-01
Airtanker base personnel - loading	2.04E-03	1.92E-03	1.24E-01	1.17E-01
Helitack crews	3.82E-05	4.01E-05	7.64E-05	8.01E-05
Smokejumpers	3.82E-05	4.01E-05	1.34E-04	1.40E-04
Hotshot crews	5.73E-05	6.01E-05	1.34E-04	1.40E-04
Type 2 firefighters	3.82E-05	4.01E-05	1.15E-04	1.20E-04
Overhead workers	3.82E-05	4.01E-05	1.15E-04	1.20E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.63E-04	1.97E-04	2.09E-04	2.52E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.52E-02	3.71E-02	1.85E-01	2.39E-01

Phos-Chek MVP-F (0403-014A)

Product Data

Concentrate form:	Dry	
Mix ratio:	0.95	lb/gal
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.32E-02	1.44E-02	3.12E-01	3.10E-01
Airtanker base personnel - loading	2.00E-03	1.88E-03	1.21E-01	1.11E-01
Helitack crews	3.74E-05	3.92E-05	7.48E-05	7.85E-05
Smokejumpers	3.74E-05	3.92E-05	1.31E-04	1.37E-04
Hotshot crews	5.61E-05	5.89E-05	1.31E-04	1.37E-04
Type 2 firefighters	3.74E-05	3.92E-05	1.12E-04	1.18E-04
Overhead workers	3.74E-05	3.92E-05	1.12E-04	1.18E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.60E-04	1.93E-04	2.05E-04	2.47E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.44E-02	3.63E-02	1.70E-01	2.34E-01

Phos-Chek MVP-F (0403-014B)

Product Data

Concentrate form:	Dry	
Mix ratio:	0.95	lb/gal
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel – mixing	1.32E-02	1.44E-02	3.12E-01	3.10E-01
Airtanker base personnel - loading	2.00E-03	1.88E-03	1.21E-01	1.11E-01
Helitack crews	3.74E-05	3.92E-05	7.48E-05	7.85E-05
Smokejumpers	3.74E-05	3.92E-05	1.31E-04	1.37E-04
Hotshot crews	5.61E-05	5.89E-05	1.31E-04	1.37E-04
Type 2 firefighters	3.74E-05	3.92E-05	1.12E-04	1.18E-04
Overhead workers	3.74E-05	3.92E-05	1.12E-04	1.18E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.60E-04	1.93E-04	2.05E-04	2.47E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.44E-02	3.63E-02	1.70E-01	2.34E-01

Phos-Chek 259-Fx (0439-091B)

Product Data

Concentrate form:	Dry	
Mix ratio:	1.01	lb/gal
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.32E-02	1.44E-02	3.12E-01	3.10E-01
Airtanker base personnel - loading	2.13E-03	2.00E-03	1.29E-01	1.18E-01
Helitack crews	3.98E-05	4.17E-05	7.95E-05	8.34E-05
Smokejumpers	3.98E-05	4.17E-05	1.39E-04	1.46E-04
Hotshot crews	5.97E-05	6.26E-05	1.39E-04	1.46E-04
Type 2 firefighters	3.98E-05	4.17E-05	1.19E-04	1.25E-04
Overhead workers	3.98E-05	4.17E-05	1.19E-04	1.25E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.70E-04	2.05E-04	2.18E-04	2.62E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.66E-02	3.86E-02	1.81E-01	2.49E-01

Phos-Chek 259-Fx (0532-056E)

Product Data

Concentrate form:	Dry	
Mix ratio:	1.01	lb/gal
Formulation Oral LD_{50}:	>5,000	mg/kg
Formulation RfD:	0.25	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.34E-02	1.46E-02	3.15E-01	3.13E-01
Airtanker base personnel - loading	2.15E-03	2.02E-03	1.30E-01	1.23E-01
Helitack crews	4.02E-05	4.21E-05	8.03E-05	8.43E-05
Smokejumpers	4.02E-05	4.21E-05	1.41E-04	1.47E-04
Hotshot crews	6.02E-05	6.32E-05	1.41E-04	1.47E-04
Type 2 firefighters	4.02E-05	4.21E-05	1.20E-04	1.26E-04
Overhead workers	4.02E-05	4.21E-05	1.20E-04	1.26E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.72E-04	2.07E-04	2.20E-04	2.65E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.70E-02	3.90E-02	1.94E-01	2.51E-01

Phos-Chek 259-Fx (0532-056F)

Product Data

Concentrate form:	Dry	
Mix ratio:	1.01	lb/gal
Formulation Oral LD_{50}:	>5,000	mg/kg
Formulation RfD:	0.25	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.34E-02	1.46E-02	3.15E-01	3.13E-01
Airtanker base personnel - loading	2.15E-03	2.02E-03	1.30E-01	1.23E-01
Helitack crews	4.02E-05	4.21E-05	8.03E-05	8.43E-05
Smokejumpers	4.02E-05	4.21E-05	1.41E-04	1.47E-04
Hotshot crews	6.02E-05	6.32E-05	1.41E-04	1.47E-04
Type 2 firefighters	4.02E-05	4.21E-05	1.20E-04	1.26E-04
Overhead workers	4.02E-05	4.21E-05	1.20E-04	1.26E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.72E-04	2.07E-04	2.20E-04	2.65E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.70E-02	3.90E-02	1.94E-01	2.51E-01

Phos-Chek LC-95A-R (1051695-C)

Product Data

Concentrate form:	Wet	
Mix ratio:	0.182	gal LC/gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel – mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel – loading	3.92E-03	3.69E-03	2.38E-01	2.17E-01
Helitack crews	7.33E-05	7.69E-05	1.47E-04	1.54E-04
Smokejumpers	7.33E-05	7.69E-05	2.57E-04	2.69E-04
Hotshot crews	1.10E-04	1.15E-04	2.57E-04	2.69E-04
Type 2 firefighters	7.33E-05	7.69E-05	2.20E-04	2.31E-04
Overhead workers	7.33E-05	7.69E-05	2.20E-04	2.31E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	3.14E-04	3.78E-04	4.01E-04	4.83E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	6.75E-02	7.11E-02	3.33E-01	4.58E-01

Phos-Chek LC-95A-R (1051695-A)

Product Data

Concentrate form:	Wet	
Mix ratio:	0.182	gal LC/gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	3.92E-03	3.69E-03	2.38E-01	2.17E-01
Helitack crews	7.33E-05	7.69E-05	1.47E-04	1.54E-04
Smokejumpers	7.33E-05	7.69E-05	2.57E-04	2.69E-04
Hotshot crews	1.10E-04	1.15E-04	2.57E-04	2.69E-04
Type 2 firefighters	7.33E-05	7.69E-05	2.20E-04	2.31E-04
Overhead workers	7.33E-05	7.69E-05	2.20E-04	2.31E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	3.14E-04	3.78E-04	4.01E-04	4.83E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	6.75E-02	7.11E-02	3.33E-01	4.58E-01

Phos-Chek LC-95A-Fx (0439-076B)

Product Data

Concentrate form:	Wet	
Mix ratio:	0.182	gal LC/gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	3.92E-03	3.69E-03	2.38E-01	2.17E-01
Helitack crews	7.33E-05	7.69E-05	1.47E-04	1.54E-04
Smokejumpers	7.33E-05	7.69E-05	2.57E-04	2.69E-04
Hotshot crews	1.10E-04	1.15E-04	2.57E-04	2.69E-04
Type 2 firefighters	7.33E-05	7.69E-05	2.20E-04	2.31E-04
Overhead workers	7.33E-05	7.69E-05	2.20E-04	2.31E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	3.14E-04	3.78E-04	4.01E-04	4.83E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	6.75E-02	7.11E-02	3.33E-01	4.58E-01

Phos-Chek LC-95A-F (0381-045C)

Product Data

Concentrate form:	Wet	
Mix ratio:	0.182	gal LC/gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	3.92E-03	3.69E-03	2.38E-01	2.17E-01
Helitack crews	7.33E-05	7.69E-05	1.47E-04	1.54E-04
Smokejumpers	7.33E-05	7.69E-05	2.57E-04	2.69E-04
Hotshot crews	1.10E-04	1.15E-04	2.57E-04	2.69E-04
Type 2 firefighters	7.33E-05	7.69E-05	2.20E-04	2.31E-04
Overhead workers	7.33E-05	7.69E-05	2.20E-04	2.31E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	3.14E-04	3.78E-04	4.01E-04	4.83E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	6.75E-02	7.11E-02	3.33E-01	4.58E-01

Phos-Chek LC-95A-F (0381-045D)

Product Data

Concentrate form:	Wet	
Mix ratio:	0.182	gal LC/gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	3.92E-03	3.69E-03	2.38E-01	2.17E-01
Helitack crews	7.33E-05	7.69E-05	1.47E-04	1.54E-04
Smokejumpers	7.33E-05	7.69E-05	2.57E-04	2.69E-04
Hotshot crews	1.10E-04	1.15E-04	2.57E-04	2.69E-04
Type 2 firefighters	7.33E-05	7.69E-05	2.20E-04	2.31E-04
Overhead workers	7.33E-05	7.69E-05	2.20E-04	2.31E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	3.14E-04	3.78E-04	4.01E-04	4.83E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	6.75E-02	7.11E-02	3.33E-01	4.58E-01

Phos-Chek LCE20-Fx (0502-050A)

Product Data

Concentrate form:	Wet	
Mix ratio:	0.192	gal LC/gal water
Formulation Oral LD_{50}:	5,000	mg/kg
Formulation RfD:	0.2500	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	3.81E-03	3.59E-03	2.31E-01	2.18E-01
Helitack crews	7.13E-05	7.48E-05	1.43E-04	1.50E-04
Smokejumpers	7.13E-05	7.48E-05	2.50E-04	2.62E-04
Hotshot crews	1.07E-04	1.12E-04	2.50E-04	2.62E-04
Type 2 firefighters	7.13E-05	7.48E-05	2.14E-04	2.24E-04
Overhead workers	7.13E-05	7.48E-05	2.14E-04	2.24E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	3.05E-04	3.68E-04	3.90E-04	4.70E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	6.56E-02	6.92E-02	3.45E-01	4.46E-01

Phos-Chek LC-95-W (0381-090B)
(also sold as Phos-Chek GS 23 RR)

Product Data

Concentrate form:	Wet	
Mix ratio:	0.182	gal LC/gal water
Formulation Oral LD_{50}:	5,050	mg/kg
Formulation RfD:	0.2525	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	3.92E-03	3.69E-03	2.38E-01	2.17E-01
Helitack crews	7.33E-05	7.69E-05	1.47E-04	1.54E-04
Smokejumpers	7.33E-05	7.69E-05	2.57E-04	2.69E-04
Hotshot crews	1.10E-04	1.15E-04	2.57E-04	2.69E-04
Type 2 firefighters	7.33E-05	7.69E-05	2.20E-04	2.31E-04
Overhead workers	7.33E-05	7.69E-05	2.20E-04	2.31E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	3.14E-04	3.78E-04	4.01E-04	4.83E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	6.75E-02	7.11E-02	3.33E-01	4.58E-01

Phos-Chek Fortify (0518-022A)

This product is currently qualified and approved for application using ground equipment; estimated risks from aerial application scenarios are provided for information only.

Product Data

Concentrate form:	Wet	
Mix ratio:	0.167	gal LC/gal water
Formulation Oral LD_{50}:	>5,000	mg/kg
Formulation RfD:	0.2500	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	3.97E-03	3.74E-03	2.41E-01	2.27E-01
Helitack crews	7.42E-05	7.79E-05	1.48E-04	1.56E-04
Smokejumpers	7.42E-05	7.79E-05	2.60E-04	2.73E-04
Hotshot crews	1.11E-04	1.17E-04	2.60E-04	2.73E-04
Type 2 firefighters	7.42E-05	7.79E-05	2.23E-04	2.34E-04
Overhead workers	7.42E-05	7.79E-05	2.23E-04	2.34E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	3.18E-04	3.83E-04	4.06E-04	4.90E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	6.84E-02	7.21E-02	3.59E-01	4.64E-01

Phos-Chek LCE20W (0518-022C)

This product is currently qualified and approved for application using ground equipment; estimated risks from aerial application scenarios are provided for information only.

Product Data

Concentrate form:	Wet	
Mix ratio:	0.15625	gal LC/gal water
Formulation Oral LD_{50}:	>5,000	mg/kg
Formulation RfD:	0.2500	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	3.72E-03	3.51E-03	2.26E-01	2.13E-01
Helitack crews	6.96E-05	7.30E-05	1.39E-04	1.46E-04
Smokejumpers	6.96E-05	7.30E-05	2.44E-04	2.56E-04
Hotshot crews	1.04E-04	1.10E-04	2.44E-04	2.56E-04
Type 2 firefighters	6.96E-05	7.30E-05	2.09E-04	2.19E-04
Overhead workers	6.96E-05	7.30E-05	2.09E-04	2.19E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	2.98E-04	3.59E-04	3.81E-04	4.59E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	6.41E-02	6.76E-02	3.37E-01	4.35E-01

Komodo (K500CC)

This product is currently qualified and approved for application using ground equipment; estimated risks from aerial application scenarios are provided for information only.

Product Data

Concentrate form:	Wet	
Mix ratio:	0.2224	gal LC/gal water
Formulation Oral LD_{50}:	>5,000	mg/kg
Formulation RfD:	0.2500	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	5.13E-03	4.83E-03	3.11E-01	2.93E-01
Helitack crews	9.59E-05	1.01E-04	1.92E-04	2.01E-04
Smokejumpers	9.59E-05	1.01E-04	3.36E-04	3.52E-04
Hotshot crews	1.44E-04	1.51E-04	3.36E-04	3.52E-04
Type 2 firefighters	9.59E-05	1.01E-04	2.88E-04	3.02E-04
Overhead workers	9.59E-05	1.01E-04	2.88E-04	3.02E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	4.11E-04	4.95E-04	5.25E-04	6.33E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	8.83E-02	9.31E-02	4.64E-01	6.00E-01

Flame Security International FIRECOAT DEFEND (FSI-FC-Defend-P001)

This product is currently qualified and approved for application using ground equipment; estimated risks from aerial application scenarios are provided for information only.

Product Data

Concentrate form:	Dry	
Mix ratio:	1.04	lb/gal
Formulation Oral LD_{50}:	5,000	mg/kg
Formulation RfD:	0.25	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	1.34E-02	1.46E-02	2.88E-01	2.81E-01
Airtanker base personnel - loading	2.21E-03	2.08E-03	1.34E-01	1.26E-01
Helitack crews	4.14E-05	4.34E-05	8.27E-05	8.68E-05
Smokejumpers	4.14E-05	4.34E-05	1.45E-04	1.52E-04
Hotshot crews	6.20E-05	6.51E-05	1.45E-04	1.52E-04
Type 2 firefighters	4.14E-05	4.34E-05	1.24E-04	1.30E-04
Overhead workers	4.14E-05	4.34E-05	1.24E-04	1.30E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	1.77E-04	2.13E-04	2.26E-04	2.73E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	3.81E-02	4.01E-02	2.00E-01	2.59E-01

Kaiterra 100-FC-F (2024-KFC-1)

This product is currently qualified and approved for application using ground equipment; estimated risks from aerial application scenarios are provided for information only.

Product Data

Concentrate form:	Wet	
Mix ratio:	0.167	gal LC/gal water
Formulation Oral LD_{50}:	>5,000	mg/kg
Formulation RfD:	0.2500	mg/kg/day
Mixture application rate:	0.06	gal/ft^2

Estimated Risks from Formulation

	Hazard Quotient			
	Typical Scenario		Maximum Scenario	
	Male	Female	Male	Female
Airtanker base personnel - mixing	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Airtanker base personnel - loading	4.33E-03	4.08E-03	2.63E-01	2.48E-01
Helitack crews	8.10E-05	8.50E-05	1.62E-04	1.70E-04
Smokejumpers	8.10E-05	8.50E-05	2.84E-04	2.98E-04
Hotshot crews	1.22E-04	1.28E-04	2.84E-04	2.98E-04
Type 2 firefighters	8.10E-05	8.50E-05	2.43E-04	2.55E-04
Overhead workers	8.10E-05	8.50E-05	2.43E-04	2.55E-04
	Adult	Child	Adult	Child
Public: cleaning a structure	3.47E-04	4.18E-04	4.43E-04	5.34E-04
	Worker (male)	Worker (female)	Public (adult)	Public (child)
Drench (accident)	7.46E-02	7.86E-02	3.92E-01	5.07E-01