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GLYPHOSATE
Frequently Asked Questions

What is glyphosate?

Glyphosate is N-phosphonomethyl glycine. Glyphosate agricultural products are broad-spectrum, non-selective herbicides used on most species of green plants. You may know the product name, or have purchased the product for your own home use by one of its common names i.e., Roundup, WeatherMax or Roundup Ultramax. Glyphosate has been used for more than 35 years and is probably the world's most widely used herbicide. It is registered in more than 130 countries and is approved for weed control in more than 100 crops. The glyphosate formulation that will be used by the Alaska Railroad Corporation (hereafter referred to as "ARRC") is called Aquamaster Herbicide and contains 53.8% glyphosate (isopropylamine salt). In addition to glyphosate, the formulation typically includes water and a surfactant system. The surfactant system enables the product to adhere to the plant surfaces. A few days after treatment, the plant wilts and yellows. In addition to being approved for use on land, Aquamaster is approved for weed control in aquatic environments, including ponds and reservoirs, waterfowl sanctuaries, and recreational waterways. Only a few herbicides have the favorable toxicological and environmental characteristics that allow them to be directly applied to aquatic vegetation. Most recently, AquaMaster was selected by the State of Florida to rid the Everglades of invasive weeds. The University of Florida in their publication on glyphosate, discuss why land managers should continue to use glyphosate containing products to protect managed habitats from weeds without concern for unreasonable adverse environmental impacts.

Glyphosate is water soluble and binds tightly to soil. The product works by disrupting a plant enzyme essential for plant growth. The enzyme is called EPSP synthetase and is not present in humans or animals. Therefore, the biochemical pathway affected is specific to plant species (not humans, mammals, or fish) contributing to the low risk to human and animal health from use of glyphosate according to the label directions used by ARRC.

In addition to agricultural use, glyphosate is used to control weeds in utility right-of-ways, on roadsides, along railways or in places around the home such as sidewalks and gardens. Glyphosate is also used by Wildlife organizations to protect and restore wildlife habitats threatened by invasive, non-native vegetation. Conservation groups have chosen glyphosate formulations because of their effectiveness against most weeds and because they have very low toxicity to wildlife.

How does glyphosate compare in toxicity to other commonly used chemicals?

Glyphosate has been the subject of hundreds of health, safety, and environmental studies. To get a clear picture of the environmental and toxicological characteristics of glyphosate it is important to consider the total weight of evidence from scientific studies provided by regulatory agencies,

industry, universities, governmental agencies, and scientists from around the World. The U.S Environmental Protection Agency (EPA), Health Canada, European Commission, U.S. Department of Agriculture Forest Service, World Health Organization and other scientists have reviewed this data. Those reviews applied internationally accepted methods, principles and procedures in toxicology and have determined that there are no grounds to suggest concern for human health. Their overwhelming consensus is that glyphosate when used according to label directions, poses no unreasonable risk to people, wildlife, or the environment. Researchers from New York Medical College similarly conclude that glyphosate does not have the potential to produce adverse effects in humans. Short-term exposure to glyphosate and its breakdown products is estimated to be 7,350 to 1,730,000 times lower than their corresponding median lethal dose (LD50) values, thus demonstrating that potential short-term exposure is not a health concern. Several toxicology text books have developed a relative ranking system for chemicals by their LD50 values to help people answer the question "how toxic is this stuff"? The ranking system listed below puts glyphosate in the category of slightly toxic and is less toxic than table salt.

Table 1.
General Toxicity Ranking Categories

Toxicity ranking	Dose (mg/kg)	For Average Adult
Practically nontoxic	>15,000	> 1 quart
Slightly Toxic	5,000-15,000	1 pint to 1 quart
Moderately toxic	50 – 5,000	1 ounce to 1 pint
Very toxic	50 – 500	1 teaspoon to 1 ounce
Extremely toxic	5 – 50	7 drops to 1 teaspoon
Supertoxic	< 5	< 7 drops

Table 2
Relative Toxicity Ranking of Glyphosate Compared to Other Compounds

Actual Ranking #	LD_{50} (mg/kg)	Chemical
14	10,000	Alcohol (ethanol)
13	**>5,000**	**Glyphosate**
12	4,000	Sodium Chloride (table salt)
11	2,400-3,480	biphenyl
10	1,500	Ferrous Sulfate (iron supplement)
9	1,375	Malathion (pesticide)
8	900	Morphine (opiate analgesic)
7	150	Phenobarbital (sedative)
6	142	Tylenol (acetaminophen)
5	2	Strychnine (rat poison)
4	1	Nicotine (stimulant found in cigarettes)
3	0.5	Curare (arrow poison)
2	0.001	2,3,7,8-TCDD (dioxin)
1	0.00001	Botulinum toxin (food poison)

Can glyphosate cause genetic damage?

Genetic toxicity tests are performed to provide information on the production of heritable changes (mutations) that could lead to further adverse biological consequences. In other words, will the chemical cause DNA damage? Glyphosate has been studied extensively in a wide battery of genetic toxicity tests. Such extensive data sets are sometime difficult to interpret but for glyphosate this is not the case. The overwhelming evidence indicates that glyphosate does not damage DNA. No genotoxic activity is observed in standard assays conducted according to international guidelines. A number of regulatory agencies, scientists, and researchers conclude that glyphosate is neither mutagenic nor clastogenic (causing chromosome breaks). Thus, glyphosate does not pose a risk of heritable (passed from parent to child) or somatic (body cell) mutations in humans.

Can glyphosate cause cancer?

The long-term toxicity and cancer potential of glyphosate has been evaluated in studies with mice and rats. Glyphosate was not carcinogenic to either species. These studies and results have been evaluated by a number of regulatory agencies and scientific organizations. Each group has concluded that glyphosate is not carcinogenic. The EPA uses a summary ranking system for human and animal cancer studies. These rankings place the overall evidence in classification Groups A through D. Group A rankings are chemicals that are known human carcinogens, whereas Group D chemicals are not classifiable as to human carcinogenicity. Accordingly, EPA has classified glyphosate as Group D, "Not classifiable as to human carcinogenicity" because there is inadequate evidence that glyphosate causes cancer in animals and no evidence that it causes cancer in humans.

Have other studies indicated health issues with Glyphosate?

A basic principle of toxicology was first stated by the 16th century physician Paracelsus, who said *"all substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."* In other words, all chemicals are toxic at some dose, and conversely, there is some dose at which no toxicity is apparent. For all chemicals, the toxicity resulting from exposure is determined by the dose of chemical absorbed by the organism. As the dose of a chemical increases, its effects increase in magnitude and severity; conversely, as the dose of a chemical decreases, so does the magnitude and severity of its effects. This concept is termed "dose-response," and forms one of the basic foundations of toxicology. For all chemicals there is a dose (termed the "threshold dose") below which no effect is elicited. This is true for both the beneficial (pharmacological) and harmful (toxicological) effect of chemicals. Some studies show toxicity of glyphosate at very high concentrations. Given the fact that there are literally hundreds of toxicology studies on glyphosate, the question should not be "have other studies indicated health issues with glyphosate?", but rather "would health effects be expected from AKRR's use of glyphosate along railroad right-of-ways?"

The answer to this question is that glyphosate poses no substantial concern for systemic toxic effects in workers or the general public at the recommended application rate. Adult applicators and children have been identified as the most sensitive subpopulations because they have the highest potential exposures to glyphosate. Estimates of exposure to these two subpopulations are typically evaluated using a "Margin of Exposure" or MOE analysis where toxicologists compare the lowest No Observable Adverse Effect Levels (NOAELs) determined from animal and human studies to worst-case levels of human exposure. MOEs of greater than 100 are considered by authoritative bodies to indicate confidence that no adverse health effects would occur. The MOEs for worst-case chronic exposure to glyphosate ranged from 3,370 to 5,420. Based on these values, it can be concluded that glyphosate does not have the potential to produce adverse effects in humans. The only real risk from glyphosate exposure is possible skin or eye irritation from direct contact with the

liquid by those individuals preparing the spray for weed control. Irritant effects are considered to be transient and reversible.

What is the environmental fate of glyphosate?

As with the human health risks described above, there is very little indication that glyphosate will cause adverse effects in the environment at the anticipated levels of exposure from use of this product on railroad right-of-ways. Glyphosate binds readily with soil particles, which limits its movement in the environment; therefore it does not have herbicidal activity once it contacts soil. Glyphosate is also not absorbed from the soil by plant roots. Glyphosate has a low Koc (measure of soil adsorption) which is an indication that glyphosate will not move readily through soil and is unlikely to leach into non-target areas. When applied to foliage, glyphosate is readily absorbed and translocated to various parts of plants via the phloem. Glyphosate is readily degraded by soil microbes with an average half-life of two months in soil and two to 10 weeks in water. The major degradation product is aminomethylphosphonic acid (AMPA). AMPA is further degraded in the environment to carbon dioxide and phosphate. In plants, glyphosate is slowly metabolized. The potential for glyphosate to leach into groundwater has been evaluated in a number of studies which reveal that glyphosate is unlikely to cause groundwater contamination. Most studies show no adverse effect on soil microorganisms.

How rapidly does glyphosate break down in the Alaska environment?

The University of Alaska with assistance from the Alaska Railroad and the US Department of Agriculture is conducting a study on the environmental fate and soil dissipation of glyphosate in the Alaskan environment. The first phase of the study near Seward included two separate rail bed sites; one site in the Seward Yard and the other near the Upper Trail Lake area. Monitoring wells were installed and samples of glyphosate were taken over time from surface soils, root zone soils, below root zone soils, and groundwater. Results agree with the discussion above in that glyphosate is degraded relatively rapidly in Alaskan soil and does not migrate to a significant degree in the soil environment. In addition, the results indicate that the levels of glyphosate detected in soil and groundwater after treatment would not be toxic to humans or animals including fish. The second phase of the study is being concluded near Fairbanks.

What effect does Glyphosate have on birds, insects, and mammals?

Glyphosate has been tested on a variety of wildlife birds and mammals in both laboratory and wild land environments. Furthermore, there are several available field studies that examine the effects of glyphosate application comparable to those that will be used by AKRR. The toxicity studies on terrestrial animals are generally consistent with those on experimental mammals. The available field studies clearly show that at plausible levels of ambient exposure, direct toxic effects are unlikely. In fact, if any effects are seen in terrestrial mammals after the application of glyphosate, they are most likely to be associated with changes in habitat rather than direct toxic effects. The changes would be no different than from mechanical clearing of vegetation. Data for single

exposures classify glyphosate as practically non-toxic to tested insects and birds. Glyphosate is no more than slightly toxic to mammals. EPA does not expect that most endangered terrestrial organisms will be affected by the registered uses of glyphosate. The small mammal is a conservative target species for characterizing risks because small organisms, compared with large organisms generally receive higher doses at fixed levels of exposure in environmental media (e.g., contaminated food, water). Also, available toxicity data does not suggest systematic differences in sensitivity to glyphosate among species. The primary route of exposure for a terrestrial animal is from contaminated vegetation. For this source, levels of exposure remain below those of concern even at the highest allowed application rates of glyphosate. At application rates that ARRC would use, levels of exposure are substantially below those of concern. This analysis is consistent with field studies on glyphosate that indicate that it would be unlikely for glyphosate to have direct toxic effects on wildlife. Based on current data, EPA has determined that the effects of glyphosate on birds and mammals are minimal. The available data indicate that glyphosate does not bioaccumulate in terrestrial species including carnivores, herbivores, and omnivores.

What effect does Glyphosate have on aquatic species including fish?

There is not much evidence that aquatic animals or plants will be adversely affected by normal applications of glyphosate. Although glyphosate is registered for use as an aquatic herbicide, it is only effective on plants with vegetation growing above the water level. Most species of algae and macrophytes do not appear to be more sensitive than fish or aquatic invertebrates to glyphosate. For most aquatic species, glyphosate levels of 1 mg/L are not likely to cause adverse effects. Field studies indicate that maximum initial concentrations of glyphosate in water after aerial or ground applications is considerably less than 1 mg/L.

A review of the published toxicity studies on fish indicate that glyphosate is relatively non-toxic to fish with 24-96 hours LC50 values ranging from approximately 10 mg/L to >200 mg/L. EPA and USDA examined the toxicity of glyphosate to a variety of fish species including rainbow trout, various salmonid species including chinook, coho, sockeye, as well as fingerlings, fry, and early life stages. EPA and USDA determined that glyphosate effects on fish would not be expected based on registered application rates. Glyphosate does not bioaccumulate in fish.

What happens if I eat berries from along the tracks?

Glyphosate application along right-of-ways creates the potential for accidental overspray of wild foods such as berries that could be later collected for consumption. Consideration of actual glyphosate use patterns, the percentage of forests or roadsides that actually receive treatment, and the resulting phytotoxic effects on the sprayed plants, suggests that inadvertent exposure will be extremely unlikely. Residual levels of glyphosate arising from mock overspray of berries have been measured and the potential dietary exposure quantified. Peak glyphosate residue levels were 19.5 ug/g and it was estimated that maximal berry consumption for an individual might be 150 g for an adult and 30 g for a 1-6 year old child. These parameters predict an exposure of 45 ug/kg body wt

for both subgroups and rely on the assumption that the surface residues were not reduced by washing before consumption. This dose is considerably below the NOAEL for chronic toxicity and more than two times below the EPA reference dose for glyphosate, indicating that occasional eating of berries containing a glyphosate residue would not result in adverse human health effects.

What can you tell me about the toxicity of the "inert ingredients" i.e., the surfactant Agri-Dex?

Agrid-Dex is a trade name of a product and is approved for use in aquatic applications. Agri-Dex is a surfactant used with glyphosate. The surfactant system enables the products to adhere to the surface of leaves so the active ingredient (glyphosate) can penetrate. AGRI-DEX is designed to be compatible with a wide range of pesticides and form stable emulsions in their tanks mixes. Agri-Dex is classified as practically non-toxic to both fish and vertebrates.

What is the overall Risk of Herbicide Program Proposed by ARRC?

To address the overall risk and potential toxicity impact of glyphosate uses specific to the state of Alaska ARRC contracted a study with the University of Alaska Fairbanks to address the transport and degradation of glyphosate under real-world conditions that mimic use by the ARRC. As previously mentioned the preliminary results of this study indicate that glyphosate has low mobility on the environment and is being degraded in the soil. Concentrations of glyphosate measured in soil and water were well below those that would harm humans or animals, including fish. The results of this study build on the large knowledge base of the environmental impacts of glyphosate which indicate that the herbicide program proposed by ARRC would not have an adverse impact on the health of humans or the environment.

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