Appendix N
Retardant Composition and Use

Fire-control chemicals are an important tool to manage and suppress wildland fire. The Alaska Fire Service uses Fire-Trol LCG-R as its primary fire retardant. Fire-Trol LCG-R is a proprietary mixture of ammonium polyphosphate, attapulgite clay thickener, corrosion inhibitor, and iron oxide as a coloring agent to mark aerial drop sites (Chemonics, Inc., Phoenix, AZ). It is manufactured from fertilizer, which is highly corrosive without an inhibiting agent in the formulation. The Fire-Trol product line of retardant uses sodium ferrocyanide (also known as yellow prussiate of soda or YPS) as a corrosion inhibitor. Recent laboratory studies indicate a significant photo-enhanced toxicity of products containing YPS. Toxicity data determined in laboratory studies may not accurately reflect toxicity in natural habitat because a variety of environmental variables can influence persistence as well as toxicity. Without information on toxicity in natural settings, it is difficult to determine the ecological hazards and probability of injury resulting from exposure following field application of fire-retardant chemicals. (Little and Calfee 2003).

BLM fisheries biologists are concerned about the effects on fish and other aquatic life that result from being exposed to the toxic chemicals making up fire retardant. The sodium ferrocyanide in Fire-Trol LCG-R is a stable metal cyanide complex that is subject to photochemical dissociation into free cyanide upon exposure to UV radiation. Cyanide in its free form is highly toxic to aquatic life and only a minute amount can be toxic to aquatic life. During the time that fire retardant would most likely be used on BLM-managed lands in Alaska (May-July), fish of a variety of species will be in their early developmental life stages when they are most susceptible to the toxic effects of fire retardant. In addition, fish in their early developmental stages are not very mobile and may be incapable of avoiding waters contaminated by retardant. Often, fish in the early phases of their development seek out smaller tributaries or microhabitats within larger streams because they commonly have warmer water temperatures and/or provide refuge from areas having higher water velocities that can displace them downstream. Because many young-of-the year fish seek out low volume or low water velocity habitats they may be exposed to higher concentrations of fire retardant for greater periods of time. (BLM Northern Field Office comments May 2004).

Early literature suggests that YPS causes significant toxicity to fish (Burdick and Lipschuetz 1950). In 2002, the Forest Service requested an investigation to determine the potential for Ultraviolet(UV)-enhanced toxicity and environmental persistence of fire-retardant chemicals (Little and Calfee 2002). According to this study, the presence of YPS consistently increased the toxicity of fire retardants in the presence of UV. Mortality of the juvenile rainbow trout and southern leopard frog tadpoles (the two aquatic organisms being tested) commonly occurred within a few hours of exposure. The toxicity should be immediate and may be severe, but is generally non-persistent in the water. The potential for continued toxicity does exist when chemicals end up on stream banks and may enter the water through runoff. The study noted that retardants remained toxic in soils over 21 days, and that the persistence of toxicity was dependent on soil quality. The toxicity of fire retardants may persist in rainwater runoff from treated areas, particularly from sandy or rocky surfaces; however, toxicity was often eliminated on soils with high organic content. It also showed that fish are capable of avoiding fire retardant chemicals in streams, with the salinity of the solution being the sensory cue. If fish have some avenue of escape, they can limit hazardous exposure by avoiding areas where fire chemicals are persistent. However, exposure may result in high mortality in fish if they are unable to escape exposure.

One study that included testing an Alaska site was completed by Dynamac Corporation in 2003; it assessed cyanide levels in soil after retardant drops. Samples were taken at the Clear Fire southwest of Anderson, Alaska on September 26, 2000 (65 days after drop) and June 26, 2001 (340 days after drop). Drop zone was outside the burn area and not subject to intense heat that may alter the chemical properties of retardant. Samples were analyzed for free and total cyanide. Total cyanide was detected in a majority of the samples collected during both sampling events, while free cyanide was detected only once during the course of the assessment. Data showed that total cyanide is prevalent across the assessment area and, based on the second sampling, is persistent. The assessment concluded that:

- soil cyanide concentrations are extremely variable across a drop zone and do not exhibit a discernable footprint or pattern;
- total cyanide remains is persistent in the soil over a period of almost one year after the initial drop;
- some percentage of retardant will infiltrate into the soil; and
- higher coverage levels result in greater soil concentrations of cyanide.

However, the study stated that drawing definitive conclusions about persistence of cyanide in the environment from this assessment data would be difficult due to the limited sampling frequency, lack of field replicates, and the very considerable variations inherent in this type of field work. Caffee and Little (2003)[1] also concluded that environmental impacts resulting from the use of fire-retardant chemicals will be specific to the event and the site. Toxicity data on fire retardant are not predictive of the environmental effects in the absence of information on the environmental persistence of these chemicals, their binding affinity with solids and surface substrates, the amount applied, and dilution ratios of the watershed to which they are applied.

Fire-Trol LCG-R is applied by aerial tanker. It is supplied by the manufacturer as a liquid concentrate, and is prepared for field use by mixing 1 gallon of concentrate per 4.5 gallons of water to produce 5.39 gallons of slurry, which is equivalent to 1457.25 gram/liter. Retardant use ranges from 0.41 liter/square meter (1 gallon/100 square feet) for fires in annual and perennial grasses or tundra to >2.44 liter/square meter (>6 gallon/100 square feet) for fires in mixed chaparral or heavy slash. The effects of retardants will change depending on the volume of the retardant that actually enters the water, the size of the body of water, and the volume of flow in the stream or river. For example, if an 800-gallon drop is made into a fast flowing river, it is likely that the lethal effects will be short-lived as dilution below the toxic level is quickly achieved. In contrast, if a 3,000-gallon drop is made into a stagnant pond, toxic levels will be likely to persist for some time. If the retardant hasn't been directly sprayed over lakes and streams, whether there will be an adverse impact on the surface waters through runoff will depend largely on the amount of rainfall that occurs, the steepness of the terrain, and the size of the receiving stream or lake.

The following example, provided by the BLM Northern Field Office, examines the effects of a retardant drop bisecting on a small 20 foot wide stream with a flow of 5cfs. The calculations assume that the retardant line crosses the stream at right angles, there is no runoff outside of the wetted width of the stream, and the width of the retardant line is 100 feet. It would take 1.6 hrs to dilute the retardant to the LC-50 concentration. (The MSDS for Fire-Trol LCG-R states that the 96-hour LC-50 for rainbow trout which is the concentration required to kill 50% of the test population after 96-hours of exposure is 790 mg/L.) A small stream would likely have water velocities ranging from 0.5 to 1.0 foot per second. At these velocities the retardant could be transported 0.5 to 1.1 miles downstream or into larger receiving waters located 300-500 feet downstream in 5 to 17 minutes at a concentration that could be lethal to aquatic life.

Fish kills due to retardant have been documented in the Lower 48; there is no documentation nor anecdotal evidence of fish kills in Alaska.[2]

Fire retardants are primarily fertilizers, and as such stimulate growth. The fertilizer contained in long-term retardants consists of ammonia and phosphate or sulfate ions. Excessive fertilizer may cause a temporary "burn" on exposed vegetation and in some cases even kill the plants. In May 1993, field studies were initiated to evaluate the response of the aquatic, terrestrial and vegetative communities associated with a prairie wetland habitat to several firefighting chemicals. The vegetative and terrestrial components were

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[1] http://www.cerc.cr.usgs.gov/pubs/briefs/uv_fire_chemicals.pdf.
Other publication of interest: http://www.cerc.cr.usgs.gov/query/query.asp

[2] Based on personal conversations with Fire Management Officers, firefighters, and pilots.

exposed to a foam suppressant and a non-foam suppressant. Results suggested that fire chemical application may cause changes in growth, including biomass accumulation and changes in species diversity (Larson, 1994). Although the fertilization effect produced a pronounced increase in herbaceous biomass, species diversity was depressed since the fertilization process caused an exotic grass to out-compete other species. The application of these chemicals will give an edge to more competitive non-native plant species. Therefore, in areas with endangered plant species, this could be a concern.

Many studies show that foam retardants are more toxic than chemical retardants to aquatic life. Foam retardants are more toxic than chemical retardants to algae, aquatic invertebrates, scuds and all stages of fish life (Buhl and Hamilton 1997, Hamilton 1994, Johnson and Sanders, 1977). Both studies show that the egg life stage of fish is the least sensitive to retardants and the swim-up stage the most sensitive. Least toxic of the five fire retardants tested on the rainbow trout and Chinook salmon, including two foams and three non-foam chemical retardants on the rainbow trout, Chinook salmon and fathead minnow was Fire-Trol LCG-R (Buhl and Hamilton 1997, Hamilton 1994). However, this does not mean that Fire-Trol LCG-R is not toxic. The 96-h LC50 of Fire Trol LCG-R on five life stages of rainbow trout range from 872->10,000 mg/L. Results suggest that this is the least toxic formulation tested but accidental entry of fire-fighting chemicals into aquatic environments could adversely affect fish populations.

In April 2000, the federal agencies developed "Guidelines for Aerial Application of Fire Retardant and Foams in Aquatic Environments." Those guidelines are updated and published yearly in the U.S. Department of the Interior and Department of Agriculture. Interagency Standards for Fire and Aviation Operations.[3] Pursuant to the Guidelines, the aerial application of retardant beyond 300 feet of a waterway is presumed to avoid adverse effects to aquatic systems. The Guidelines have multiple exceptions, however, allowing discharges over waterways when alternative tactics are not available due to terrain constraints, congested areas, life or property concerns, lack of ground personnel, or when potential damage to natural resources outweighs possible loss of aquatic life. Caution and good judgment must be exercised when a retardant drop is made.

As noted above, whether or not retardant drops are lethal to fish depends on several factors. The amount of the load, the size of the stream and the volume of the flow will affect concentration and dilution levels. Most wildland fires occur during hot summer months, when the potential for chemicals to dilute rapidly is diminished due to low stream flows. While the 300 yard buffer zone does exist, retardant chemicals can also enter the waterways post-fire through run-off. The amount of time the chemicals remain toxic following a fire depends on soil conditions, weather and aquatic dilution. (Buhl and Hamilton, 1997)(Dodge1970).

Human health risk assessments reveal that cyanide exposure from the use of fire retardants is of limited toxicity to humans or other terrestrial organisms (Labat-Anderson 1994). Terrestrial field studies support this, indicating no measurable effects on small mammal populations (Vyas and Hill, 1994). In tests with terrestrial organisms, there is no indication that problems of toxicity may result from dietary exposure, such as hay or grasses eaten in an area where chemical retardants were dropped. Both dietary and dermal exposure studies have been explored in bears, as well as exposure in ground nesting birds, and in predatory birds (kestrel).

The current National Contract for Long-Term Aerial Fire Retardants has been extended until February 2005. Since 1994, the USFS has told Fire-Trol that YPS in aerial fire retardants poses a problem because, under optimum conditions, it can cause fish mortality. A few years ago, the USFS issued a “stop work order,“ meaning Fire-Trol products with YPS would no longer be used. However, the order was lifted shortly thereafter because of a court challenge, and because nothing in the bid specification said that retardant could not contain YPS. Concerns over the presence of YPS in retardant continue, and a phase-out

[3] Available at http://www.fire.blm.gov/Standards/redbook.htm. 2004 Guidelines are on page N-4.

of YPS which would start in 2005 and continue until 2007 has been suggested (internal communication). A recent law suit over the use of sodium ferrocyanide in fire retardant has raised the general awareness concerning the potential environmental impacts associated with the use of fire retardant. In October 2003, the Forest Service Employees for Environmental Ethics filed a lawsuit against the USFS challenging compliance with the National Environmental Policy Act (NEPA) in association with the alleged failure to prepare an environmental assessment or impact statement on the use of fire retardant in fighting wildland fires on National Forest System lands. Also included in the allegation is the USFS failed to consult with Fish and Wildlife and National Marine Fisheries as required by the Endangered Species Act. Documents are being compiled by the USFS for the Department of Justice to meet the request for discovery deadline in June 2004. A litigation report is being built.

For a graphic presentation of the retardant use in Alaska from 1998-2003, see Map 9. The following table was compiled from Alaska Fire Service billing records and State of Alaska Air Attack yearly reports. The AFS records contain actual gallons loaded into the air tankers; the State records list the gallons dropped based on the capacity of the air tanker. For example for fire A128 in 1998, the AFS recorded 2,041 gallons and the State recorded 2,200.

Year	1998	1999	2000	2001	2002	2003
Gallons	232,408	283,517	140,486	239,298	480,625	500,559

2004 National Guidelines
(From Interagency Standards for Fire and Aviation 2004, Chapter 12[4])

Environmental Guidelines for Delivery of Retardant or Foam Near Waterways

1. Definition

Waterway - Any body of water including lakes, rivers, seeps, intermittent streams and ponds whether or not they contain aquatic life.

2. Aerial Application Guidelines

Avoid aerial or ground application of retardant or foam within 300 feet of waterways. These guidelines do not require the pilot-in-command to fly in such a way as to endanger his or her aircraft, other aircraft, structures, or compromise ground personnel safety. Guidance to pilots can be found in Aviation Chapter 175.

3. Exceptions

When alternative line construction tactics are not available due to terrain constraints, congested area, life and property concerns, or lack of ground personnel, it is acceptable to anchor the foam or retardant application to the waterway. When anchoring a retardant or foam line to a waterway, use the most accurate method of delivery in order to minimize placement of retardant or foam in the waterway. Deviations from these guidelines are acceptable when life or property is threatened and the use of retardant or foam can be

[4] http://www.fire.blm.gov/Standards/redbook.htm

[5] Aviation Chapter 17: Guidance for Pilots: To meet the 300-foot buffer zone guideline, implement the following: a. Medium/Heavy Airtankers: When approaching a waterway visible to the pilot, the pilot shall terminate the application of retardant approximately 300 feet before reaching the waterway. Pilots shall make adjustments for airspeed and ambient conditions such as wind to avoid the application of retardant within the 300-foot buffer zone.

reasonably expected to alleviate the threat. When potential damage to natural resources outweighs possible loss of aquatic life, the agency administrator may approve a deviation from these guidelines.

Environmental Procedures for Application of Fire Chemicals

1. Threatened and Endangered (T&E) Species

The following provisions are guidance for complying with the emergency Section 7 consultation procedures of the Endangered Species Act (ESA) with respect to aquatic species. These provisions do not alter or diminish an agency's responsibilities under ESA. Where aquatic T&E species or their habitats are potentially affected by aerial application of retardant or foam, the following additional procedures apply: a. As soon as practical after the aerial application of retardant or foam near waterways, determine whether the aerial application has caused any adverse effect on T&E species or their habitat using the following criteria:

1) Aerial application of retardant or foam outside 300 feet of a waterway is presumed to avoid adverse effects to aquatic species and no further consultation for aquatic species is necessary.
2) Aerial application of retardant or foam within 300 feet of a waterway requires that the unit administrator determine whether there have been any adverse effects to T&E species within the waterway.
3) If the action agency determines that there were adverse effects on T&E species or their habitats, then the agency must consult with Fish and Wildlife Service (FWS) or National Marine Fisheries Service (NMFS) as required by 50 CFR 402.05 (Emergencies). Procedures for emergency consultation are described in the Interagency Consultation Handbook, Chapter 8 (March 1998). In the case of a long duration incident, emergency consultation should be initiated as soon as practical during the event. Otherwise, post-event consultation is appropriate. The initiation of the consultation is the responsibility of the unit administrator. These procedures shall be documented in a Biological Assessment (BA). All occurrences of adverse effects will be immediately reported to Wildland Fire Chemicals Systems in Missoula, Montana at phone 406-329-3900 or to individuals listed in website referenced above.
4) Each agency is responsible for ensuring that their appropriate agency specific guides and training manuals reflect these standards.

In addition to the above, the Alaska Land Use Plan Amendment has the following mitigation included:

Use of aerial fire retardant near lakes, wetlands, streams, rivers, sources of human water consumption, and areas adjacent to water sources should be avoided to protect fish habitat and water quality. If feasible in these areas, the use of water rather than retardant is preferred. When the use of retardant is necessary, avoid aerial or ground application of retardant or foam within 300 feet of a waterway; application beyond 500 feet is preferred. Examples of when use of retardant is authorized are for the protection of :

- Human life.
- Permanent year-around residences.
- National Historic land marks.
- Structures on or eligible for the National Register of Historic Places.
- Government Facilities.
- Sites or structures designated by Field Office resource specialists to be protected.
- High value resources on BLM-managed lands and those of adjacent land owners.
- Threatened, endangered and sensitive species habitats as identified by resource specialist.

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Buhl, K.J., and S.J. Hamilton. 1999. Acute toxicity of fire-control chemicals, nitrogenous chemicals, and surfactants to rainbow trout. Transactions of the American Fisheries Society 129:408-418. (Contains acute toxicity information on Fire-Trol LCA-F, Fire-Trol LCM-R, Phos-Chek 259F, Fire Quench, Fire-Trol FireFoam 103B, Fire-Trol FireFoam 104, ForExpan S, Pyrocap B-136, ammonia, nitrate, nitrite, LAS [linear alkylbenzene sulfonate], and SDS [sodium dodecyl sulfate] to one life stage of rainbow trout.)

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