



Is your local fireworks display environmentally friendly?

It seems only fitting as we approach the Fourth of July holiday to turn our attention to the environmental impacts and regulation of fireworks. As it turns out, our age-old patriotic tradition of exploding packages of toxic chemicals in the air is not without its environmental drawbacks. Although much is still unknown about the environmental consequences of fireworks displays, it is clear that fireworks can adversely impact water quality, air quality, biological resources, and possibly even human health through debris, noise, and toxic contaminant pollution. Fortunately, there are many ways regulators and citizens can mitigate the adverse impacts of fireworks.

In order to understand the environmental impacts of aerial fireworks displays you first have to appreciate the basic mechanics. The heart of a colorful firework is the “**color shell**,” which contains a bunch of chemical pellets arranged to emit a particular color and design. Commonly used chemicals include: potassium chlorate, potassium perchlorate, potassium nitrate, sodium benzoate, sodium oxalate, ammonium perchlorate, strontium nitrate, strontium carbonate, sulfur, charcoal, copper oxide, polyvinyl chloride, iron, titanium, shellac, dextrine, phenolic resin, and aluminum.



PHOTO: DANIEL STAINER

### Firework Shell

The pellets are packed in a paper or plastic casing, and stuffed inside the shell along with a “**burst charge**,” usually made of black powder. The shell is then packed in a metal or plastic tube called a “**mortar**.” Upon lighting the black powder charge, the shell is launched from the mortar up to 200-1000 feet in the air, where it explodes. In addition to color shells, a fireworks display may include “**salute shells**,” which produce the loud percussive noise we associate with fireworks shows. Salute shells are packed and launched similarly to color shells, and also explode at high altitude.

The short-term environmental impacts of fireworks include **debris, smoke, noise, and light**. Most of the components of a firework device will burn up in the atmosphere, but some portions of the casing and residue typically are carried by the winds and fall back to earth. Debris also can result from duds or misfires. Debris from fireworks launched off an ocean, river, or lake coast can impact water quality or litter sensitive habitat areas if not properly cleaned up following the show.



Firework smoke can produce dangerous **fine particulate matter**

**(PM 2.5) pollution** that significantly impacts air quality. The metals and chemicals in fireworks make firework smoke more toxic than other kinds of smoke. Firework smoke can contribute to lung inflammation, heart attacks, stroke, asthma attacks, and reduced lung function. [Spikes in particulate matter have been documented](#) during and immediately following fireworks shows. Such spikes [can cause localities to exceed state or federal air quality standards for PM 2.5](#). [In some cases, particulate concentrations after a fireworks display nearly double the federal maximum](#). [Research shows](#) that in urban areas, firework pollution clouds can drift over cities, resulting in elevated levels of PM 2.5 for multiple days following a fireworks display. Fireworks displays in urban areas may be particularly harmful because the urban atmosphere is already polluted. In May 2013, EPA issued [interim guidance](#) to help air quality agencies manage “exceptional air quality events” such as large fireworks displays in order to maintain National Ambient Air Quality Standards (NAAQS) under the Clean Air Act.

The **noise and light pollution** accompanying fireworks shows can negatively impact wildlife, as illustrated by the 2006-2010 controversy over the fireworks display in the Town of Gualala in Mendocino County, CA. On Independence Day weekend 2006, following a fifteen-minute fireworks display near the Gualala River estuary and Gualala Point Island, which is part of the California Coastal National Monument, the CA Coastal Commission received complaints that the explosions had disturbed nesting shorebirds and harbor seal haul-out sites. This prompted the U.S. Bureau of Land Management and Fish & Wildlife Service to study the 2007 Gualala fireworks. The federal agencies published [a report](#) documenting a high rate of Cormorant nest abandonments during the period surrounding the display, citing that the abandonments “likely resulted from fireworks disturbance.” Any eggs or juvenile chicks left in the abandoned nests were consumed or killed by predators. In addition, the CA Department of Fish and Game noted that

Brown Pelicans, an endangered species, use [Gualala Point Island] as a roost at night. Marbled Murrelets, another endangered species, are also observed in the ocean near Gualala at dawn and dusk every year at this time. Both of these endangered species, and the nesting birds, could potentially be impacted by the fireworks display. . . .

(Ultimately, upon learning that Gualala was planning a 2008 fireworks display without seeking a permit, the Commission proposed a [cease-and-desist order](#). Gualala sued to prohibit the Commission from issuing the order. The trial court ruled for the Commission, finding that fireworks constitute “development” subject to the permitting requirements of

the CA Coastal Act. The Court of Appeal affirmed in *Gualala Festivals Comm. v. Cal. Coastal Comm'n*, 183 Cal. App. 4<sup>th</sup> 60 (2010), and the CA Supreme Court subsequently declined review.)

Fireworks also have the **potential to cause fires**. [According to the National Fire Protection Association \(NFPA\)](#), in 2011, fireworks were the cause of an estimated 17,800 fires resulting in 8 deaths, 40 injuries, and \$32 million in property damage. The NFPA further reports that more US fires are reported on Independence Day than any other day of the year, accounting for 2/5 of all fires on that day. In dry areas, firework-related fires have the potential to develop into wildfires. As a result, in 2012, Colorado Governor Hickenlooper issued an [executive order banning private fireworks displays](#), and [more than 40 Colorado cities canceled Fourth of July fireworks displays](#).

Additionally, there may be **long-term water quality and human health impacts** associated with the toxic components like lead, barium, ammonium perchlorate, and sulfur dioxide in the firework shell, although the long-term effects of these chemicals is not well understood. Fireworks are often launched near waterbodies like lakes or along ocean coasts, allowing combustion residue to fall into surface waters. Chemical pollutants in the residue can adversely impact water and sediment quality. Water quality monitoring reports following fireworks displays have [documented elevated levels of water pollutants such as arsenic, copper, and phosphorous](#). Consequently, in 2007, a California Regional Water Quality Control Board issued San Diego's Sea World the nation's [first National Pollution Discharge Elimination System \(NPDES\) permit regulating the discharge of fireworks](#) under the Clean Water Act. SeaWorld launches fireworks every night during the summer months. The NPDES permit limits Sea World to a maximum of 150 fireworks shows per year, and specifies mitigation and monitoring requirements to deal with dangerous chemical residue that may fall into Mission Bay. Specifically, permit mandates three monitoring periods per year during Sea World's largest displays, at which time Sea World must monitor water quality, sediment quality, and bottom-dwelling organisms for 41 pollutants.

The firework-related pollutant **perchlorate** ( $\text{NH}_4\text{ClO}_4$ ) is of particular concern to Eastern lake states. Perchlorate is both naturally occurring and man-made. In fireworks, perchlorate acts as a propellant. Scientists do not fully understand the health and environmental impacts associated with perchlorate water pollution, but [perchlorate has been demonstrated to interfere with thyroid function in humans, affecting metabolism and growth](#). It is clear that fireworks displays can result in perchlorate accumulation in surface and ground waters, resulting in perchlorate concentration spikes of 24 to 1028 times the mean baseline value following a fireworks display. These perchlorate spikes potentially can

be a problem for drinking water sources. In 2006, [the Massachusetts Department of Environmental Protection determined historic fireworks displays were the likely cause of perchlorate contamination](#) in two of its nine water supply systems showing high perchlorate levels. Currently, only California and Massachusetts have state perchlorate standards. [EPA currently is working to develop Safe Drinking Water Act standards for perchlorate](#) in primary drinking water supplies. They are expected to be released sometime this year.



Eutrophication

Although **phosphorus** typically is only included in modern-day fireworks in trace amounts, [phosphorus residue can accelerate eutrophication of lakes](#). In states like New Hampshire, where lakes are already nitrogen-loaded from sources like fertilizers, [even small amounts of additional phosphorus can be a cause for concern](#). Eutrophication is linked to algal and cyanobacteria blooms that can negatively impact drinking water quality, fisheries, wildlife, and human health.

There are many ways **regulators can mitigate the adverse impacts of fireworks**. The first, most important step is to require permits or registration of all public and private firework displays so that environmental regulators can keep track of the number of shows, where they occur, and what types of fireworks are used.

Where **firework permits** are required, regulators can use permit conditions to mitigate potential adverse impacts to the environment and human health. Regulators should require that displays be located away from environmentally sensitive areas like marine sanctuaries, habitats for endangered species, migratory bird pathways, and nesting areas. Similarly, localities or entities sponsoring large public displays should be required to implement measures to ensure public viewers keep away from environmentally sensitive areas. Fireworks also should be timed to avoid common spawning, nesting, and roosting seasons.



Proper monitoring procedures before and after the display are key to alerting officials of any environmental threats. Permits can provide for **third-party monitoring** (e.g., by the Audubon Society or state agency officials). The monitoring report should identify a baseline for wildlife abundance and behavior in the event vicinity several hours prior to the fireworks display and identify any adverse impacts to wildlife during and for several hours after the display. Follow-up monitoring should occur at regular intervals for several weeks following the event. Based on the monitoring, officials can recommend modifications to the event for future years to mitigate any negative impacts to wildlife.

A fireworks permit also should require **clean-up and restoration** following the display to remove any fallen debris. Debris can be further controlled by subjecting fireworks displays to **limitations** on the total number of aerial shells detonated, requirements that all plastic labels and wrappings be removed from devices prior to launch, and prohibitions on devices that include more than a specified percentage of non-biodegradable components.

To better protect water quality, regulators should prohibit private firework explosions on sidewalks or roadways, where contaminants and debris can end up in storm drains. In addition, for large fireworks displays, regulators should require sponsors to **contain runoff** in cases where water is used to control misfires or duds.

To address the air quality impacts of fireworks, officials can monitor air pollutant concentrations before and after fireworks displays and warn the public of any dangerous conditions. To reduce smoke and perchlorate pollution, regulators can **require that all fireworks be perchlorate-free**. For instance, in 2004, Disney Corporation began using [compressed air](#) to launch all fireworks at Disneyland, resulting in a reduction in particulate air pollution and perchlorate water concentrations. Researchers also have working to develop [alternative propellants](#) that use nitrogen-based materials instead of perchlorates.



And of course, in place of fireworks, Fourth of July revelers can opt for **laser light shows** or other alternative displays of patriotism.

Happy Fourth of July!