Review of the Transportation Corridor Risks of Hazardous Material Spills in the Proposed Stibnite Gold Project Draft Environmental Impact Statement

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Photo credit: Chris English, “Ultra Cool Salmon”, August 19, 2007 in Cascade, Idaho
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Executive Summary

The Stibnite Gold Project (SGP) will require large quantities of hazardous materials. The supplies would be brought to the mine site in thousands of heavy truckloads each year. Transporting hazardous materials in trucks is a common occurrence in the United States, and there are several governmental agencies that track what is shipped, how far hazardous materials move, and the safety associated with those shipments.

Environmental impact statements for other mines and resource extraction projects have included spill risk calculations for numbers of hazardous materials spills and the probability of at least one spill. The presentations vary by project but show several ways to quantify spill risk. No such project-specific risk was found in the SGP Draft Environmental Impact Statement (DEIS).

The transportation corridor for the SGP, as defined in the DEIS, includes two main possible routes from the proposed Stibnite Gold Logistics Facility to the mine site. The amount of supplies needed and associated number of truck trips varies by Alternative and project stage. The presence of on-site lime production and a water treatment plant in Alternative 2 change mine reagent needs from Alternatives 1, 3, and 4. The SGP DEIS quantified the risks from spills by measuring road lengths, number of trips, and distances to streams but did not include calculations of cumulative trips per year, total truck-miles traveled per year, or spill probabilities. The descriptions of the differences between Alternative 2 and the other Alternatives were inconsistent, with shifting values for the reduction in trips needed to bring lime to the mine site if on-site lime generation were approved and varying payloads of propane described. These inconsistencies make it difficult to calculate the true number of truck-miles associated with each Alternative. Assessments of fish habitat impacts are based on measuring the amount of stream that is a 91 m distance from the roadway centerline, which is less than half the published distance for a 200 m impact zone around rural roadways. Therefore, the effects on fish habitats are underestimated. Other environmental effects to consider are greenhouse gas emissions and dust generation, which, like spill risks, will also be dependent on the amount of traffic, and application of chemicals to the roadway. Safety is also a concern. The SGP DEIS shows that the largest number of accidents occurs on Warm Lake Road but then contrarily posits that it would have the lowest spill probability.

More than 30 different hazardous materials will be brought to and from the mine site if the SGP is approved. Those hazardous materials include fuels, explosives, acids, and toxic materials, but the dangers posed by the reagents are not discussed. Under Alternatives 1, 3, and 4, more than 7.7 million gallons of bulk liquid hazardous materials in at least 1,100 truckloads, as well as more than 143,000 tons of bulk solid hazardous materials in at least 5,300 truckloads, will be transported along the roadways every year. Under Alternative 2, more than 9.2 million gallons of bulk liquid hazardous materials in at least 1,300 truckloads and more than 95,000 tons of bulk solid hazardous materials in at least 3,300 truckloads will be moved along the transportation corridor annually. Although the SGP DEIS promises that there will be a pilot vehicle to accompany bulk liquid transport, only 522 pilot cars per year are shown in traffic impact studies. Spills from SPCC facilities may be twice as likely as spills from vehicles, but the SGP DEIS did not discuss the possibility of spills from storage facilities.

Quantitative risk assessment for determining optimal hazardous materials routes is an area with decades of study in the field of operations research. Most models of risk include a measure of spill probability by road segment or length and the associated consequences along each segment. Models of consequences vary by what impact or impacts the interested parties want to optimize.

I was able to find potential distributor locations nearest to Cascade, Idaho for 21 supplies that would be used at SGP. Only five supplies (propane, gasoline, nitric acid, sulfuric acid, and hydrogen peroxide) were available within 100 miles of Cascade, Idaho. Diesel fuel was available inside a 250-mile radius. The remaining reagents I was able to find distributors for were only available from cities that were up 500 or 1,000 miles away. Supplies would travel on SH-55 both north and south of Cascade. The percentage of heavy vehicles carrying hazardous materials on SH-55 north or south of Cascade depends on which Alternative is considered, the source cities for lime and propane, and how accurate the assignment of Boise, Idaho is as the source/destination city to estimate the travel direction for all the materials that I was unable to find distribution points for.

Instead of only considering the transportation corridor from SH-55 at Cascade to the mine site, the true measure of the communities and environment at risk will extend to the distribution points of the reagents brought to the mine and the destinations of the ore concentrate and wastes taken from it. The overall exposure will depend on the distances the reagents, products, and wastes need to travel and the number of trips that are necessary for the respective quantities of the hazardous materials. The total estimated miles per year uses an average value for the road miles for the four action Alternatives from Cascade to the mine site and an educated approximation of the minimum distances for sourcing the reagents. This set of origin and destination cities is only an example and likely underestimates the total truck-mile exposure per year because both the number of trips and the number of miles to travel used may be lower than the actual values.

The SGP DEIS used Federal Motor Carrier Safety Administration data to estimate hazardous material spill rates of 1.4×10^{-9} spills per truck-mile in 2013 and 1.9×10^{-9} spills per truck-mile in 2016. These estimates are two orders of magnitude lower than rates cited in other DEISs, including for Pogo Mine, which used an estimate of 1.9×10^{-7} spills per truck-mile, and Pebble Mine, which used an estimate of 2.0×10^{-7} spills per truck-mile for diesel spills >3,000 gallons and 7.8×10^{-7} spills per truck-mile for ore concentrate. I was able to recreate the math performed in the SGP DEIS and correct it, arriving at an average spill rate of 1.62×10^{-7} spills per truck-mile for the period of 2009-2017 based on data from the Federal Motor Carrier Safety Administration. This rate is closer to rates cited in other EISs but lower than rates from the Pipeline and Hazardous Materials Safety Administration, which estimated that there were an average 3.2×10^{-7} spills of hazardous material per truck-mile, depending on the class of hazardous material. Due to underreporting, it is likely that all these estimated rates are too low, perhaps by as much as a factor of ten.

Estimates of spill risk per truck-mile based on data collected nationwide are generalized and miss factors that may be relevant to individual hazardous material transportation scenarios. Some risks are dependent on the route chosen (road grade, number of lanes, weather, etc.) and some are route independent (driver experience level, material type, truck configuration, etc.) SGP would have some significant risks (road grade and quality, avalanche/landslide/rockfall, fires, etc.) that would be expected to increase the spill rate if a detailed model were used. While road improvement and speed limits might help abate some of the risks inherent in the analysis area, it is clear that developing a project-specific spill risk per truck-mile for one or more segments of the transportation corridor would be complicated, even if enough data were available, and would likely result in an estimated rate that is higher than the national average spill rate per truck-mile.

Using the total number of heavy vehicles trips, with and without hazardous materials, I found the expected number of spills and crashes along the SH-55 to mine site portion of the transportation corridor and the full distribution point to mine site distance and the probabilities of spills and crashes. Spill probabilities fall into the possible range even for the SH-55 to the mine segment under Alternative 2, which had fewer truck trips, using the smallest version of the spill rate per truck-mile. Overall, spills and crashes involving heavy vehicles are near certain to occur for all Alternatives. The calculations shown here serve as an example of the general process for estimating spill and crash numbers and likely underestimate the risks. Still, these numbers indicate that the impacts that spills and accidents may have on the environment and human safety along the transportation corridor should be seriously and thoroughly considered.

Minimum values of spills and crashes expected in the analysis area in 12 years of mine operations.

In 12 years from SH-55 to mine site (70 miles one-way)	Alternatives 1, 3, and 4	Alternative 2
Expected number of hazardous materials spills from heavy vehicles	0.88	0.63
Probability of at least one hazardous material spill from a heavy vehicle	58%	46%
Expected number of crashes involving a heavy vehicle loaded with hazardous materials	6.89	4.92
Probability of at least one crash involving a heavy vehicle loaded with hazardous materials	100%	100%
Expected number of crashes involving a heavy vehicle	19.14	15.20
Probability of at least one crash involving a heavy vehicle	100%	100%

The SGP DEIS's rudimentary attempt at quantitatively estimating the risk of hazardous materials spills was constrained to a limited analysis area and a single source (trucks) of potential spills. This narrow consideration of the possible impacts of the transportation corridor and hazardous materials misses other effects. Transportation impacts extend beyond the risk of spills. Mine-related spills of hazardous materials can come from many processes besides transportation. The conclusions in the DEIS that spills along the roadway will have limited if any impacts on fish and the aquatic environment are not justified. Neither are conclusions that spills from chemical storage will be rare or small. The DEIS did not examine the probability or potential sizes of spills of either tailings or contact water from pipelines. Even if the modeling had been better done, it is likely that the number of spills that would occur would be much higher than the predictions. The Pogo Mine, which is roughly 12% as large as the proposed SGP and has a shorter transportation corridor, has had more than 1,400 spills across a wide range of hazardous materials, spill volumes, and spill sources, with spills from vehicles representing less than 5% of that number.

Overall, the analysis of the potential impacts from hazardous materials in the SGP DEIS is inadequate to make an informed decision. EISs for other mines include expected spill numbers and probabilities, and the SGP DEIS did not. The SGP DEIS had inconsistent descriptions of the reagents to be used and the number of trips of hazardous materials trucks would require and multiple arithmetic errors. The transportation corridor analysis area did not consider any risks beyond Cascade, Idaho. EISs for other mines include spill risk rates that are on the order of 2.0×10^{-7} spills per truck-mile, but the SGP DEIS estimated a spill rate ranging from $1.4\text{-}1.9 \times 10^{-9}$ spills per truck-mile, which is two orders of magnitude lower than rates published in multiple sources. Using a spill risk rate of 1.6×10^{-7} spills per truck-mile, I found that probabilities of spills and accidents range from possible to probable (if not certain) for all Action Alternatives for the analysis area considered in the SGP DEIS and the full length of the transportation corridor. The spill rate I used is likely too small as it is an average based on national spill data that may suffer from substantial underreporting and the road characteristics near the proposed SGP would increase spill risks. Without an accurate characterization of the true exposure along the transportation corridor and the spill rate per truck-mile, it is impossible to then make informed statements about spill likelihood and the potential consequences to the environment and to public safety. Data from the Pogo Mine illustrate that hazardous materials spills are frequent, can be sizable, and that transportation spills are only a small fraction of mine-related spills.

Note to the reader

This report draws heavily on the three volumes of the SGP DEIS, among other documents. I make no assumptions that the reader has access to those references. Therefore, I have made liberal use of extracted blocks of texts, each preceded by the name of the source, to aid comparisons and provide ample context.

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1. Introduction

USFS (2020), p. 2-11

> Midas Gold proposes to develop a mining operation that produces gold and silver doré, and antimony concentrates from ore deposits associated with their mining claims in the SGP area. The current estimated recoverable mineral resource consists of:
>
> - 4 to 5 million ounces of gold
> - 6 to 7 million ounces of silver
> - 100 to 200 million pounds of antimony
>
> Development of the mineral resources would include construction of access and haul roads within the mine site; construction of supporting infrastructure for the mine site; open pit mining; ore processing; placement of tailings in a [tailings storage facility] TSF; and placement of development rock. New access to the mine site would be provided by the proposed Burntlog Route, which would be a combination of widening the existing Burnt Log Road (FR 447) and Meadow Creek Lookout Road (FR 51290) and constructing new connecting road segments of 15 miles.

Mining 75,000-100,000 tons of development rock per day as well as mining and processing 20,000-25,000 tons of ore per day (Midas Gold Idaho, Inc. 2016) would require millions of gallons of bulk liquid reagents and tens of thousands of tons of bulk solid reagents listed as hazardous materials, which would be brought to the mine site using the transportation corridor. Kravitz and Blair (2019) examined the risks to fish posed by the roadway ton the proposed Pebble Mine and found that

> [f]our sources of potentially toxic chemicals are related to the transportation corridor: traffic residues, road construction, chemical cargos, and road treatment. During runoff events, traffic residues (metals, oil, grease) can wash into streams and accumulate in sediments or disperse into groundwater (Van Bohemen and Van de Laak 2003). Road construction involves the crushing of minerals for the road fill and bed and the exposure of rock surfaces at road cuts, which leads to leaching of minerals and increased dissolved solids. Chemical reagents used to process ore would be transported by road to the mine site. Truck accidents along the transportation route could spill reagents into wetlands and streams. Roads are treated with salts and other materials to reduce dust and improve winter traction.

This report focuses on the probability of hazardous materials spills along the transportation corridor but will touch on other aspects associated with hazardous materials and roadways. First, it is important to define terms and put the proposed Stibnite Gold Project (SGP) into the larger context of what is already known about transporting hazardous materials in the United States.

Definition of hazardous materials

Erkut et al. (2007), p. 539.

> According to the US Department of Transportation (US DOT), a hazardous material is defined as any substance or material capable of causing harm to people, property, and the environment. … There are thousands of different hazardous materials in use today (US DOT, 2004b). The United Nations sorts hazardous materials into nine classes according to their physical, chemical, and nuclear properties: explosives and pyrotechnics; gasses; flammable and combustible liquids; flammable, combustible, and dangerous-when-wet solids; oxidizers and organic peroxides; poisonous and infectious materials; radioactive materials; corrosive materials (acidic or basic); and miscellaneous dangerous goods, such as hazardous wastes (UN, 2001).

Craft (2004)

> Types of hazardous materials range from relatively innocuous products, such as hair spray and perfumes, to bulk shipments of gasoline by highway cargo tanks, to transportation of poisonous, explosive, and radioactive materials.

Transportation Research Board (2005)

> Hazardous materials regulation has long been focused on acute hazards, such as flammability, which pose a risk to the public when hazardous materials are accidentally released. This focus, however, has diminished over time as concern over other nonacute risks to human health and the environment has grown. During the 1970s, Congress called on the U.S. Environmental Protection Agency (EPA) to require the reporting of releases of certain environmental contaminants in specific quantities. DOT was subsequently required to regulate the transportation of these hazardous substances when they are shipped in quantities equal to or exceeding their reportable quantities…. Understanding and managing the full array of public safety, environmental, and security risks associated with the transportation of hazardous materials have become more explicit goals of both government and industry.

Transportation Research Board (2005)

> EPA designates certain materials as hazardous substances that are potentially harmful to human health and the environment if they are released in specific quantities. These designated substances are regulated by DOT in transportation. EPA also requires

> generators of hazardous wastes to keep track of shipments of these wastes by maintaining detailed manifests of their movements from origin to disposal.

Barilla et al. (2009)

> The transport of HazMat is an important, complex, socially and environmentally sensitive problem; involving a plethora of parameters: economic, social and environmental… Generally HazMats have to be transported from a point of origin to one or more destination points. The origin points are fixed facilities where the HazMats are produced, or stored. The HazMats are then transported from a production facility to storage, distribution, or another facility where the HazMat is required. Typically, the transporter will wish to use the minimum cost route. It is also being required that the route(s) taken are to be chosen so as to minimize exposure to hazard in the event of an accident.

Gerard (2005)

> There are over 800,000 daily shipments of hazardous materials moving by plane, train, truck, or vessel in quantities varying from several ounces to many thousands of gallons. These shipments move through densely populated or sensitive areas where the consequences of an incident could be loss of life or serious environmental damage.

Transport of hazardous materials in the United States

The amount of shipping of hazardous materials is large and growing (Table 1). The number of truck trips carrying hazardous materials has increased from 800,000 to more than 1,000,000 per day, moving billions of tons.

Table 1. Estimates of quantities and distances hazardous materials are shipped in daily and annually in the United States. Unless otherwise specified, shipments may be transported by train, pipeline, truck, and/or airplane.

Source • Summary statistic	Internal reference (if any)
Erkut and Verter 1998 • 250,000-500,000 shipments per day • 1.5-4 billion tons per year	
Battelle 2001 • 74,410 million ton-miles in 1993	1993 Commodity Flow Survey
• 74,939 million ton-miles in 1997 • 7,763,282,762 vehicle miles in 1997 • 1.4 billion tons/year	1997 Commodity Flow Survey

• 5% of all commodity shipment miles	
• In 1996, 7.2 percent of all trucks surveyed carried HM.	Star Mountain Inc., 1997
• 769,000 hazardous truck shipments per day	US DOT, 1998
• 314,000 petroleum product shipments per day by truck	
• 445,000 chemicals and allied products shipped per day by truck	
• 1.4 billion tons in hazardous shipments by truck per year	
• 1.04 billion tons petroleum per year by truck	
• 43% of all HazMat tonnage is transported by truck	
Craft 2004	
• >800,000 truck shipments/day	
• 7.2% of trucks carry enough HazMat to warrant displaying a warning placard	Office of Motor Carriers 1996 fleet survey
Gerard 2005	
• >800,000 shipments per day	
• >3 billion tons per year	
Transportation Research Board 2005	
• 817,000 shipments per day	1997 Census Bureau
• almost 3 million shipments per year	
• 5.4 million tons per day	
• 2 billion tons per year	
• 768,907 truck shipments per day	
• 205 million tons-miles per day by truck	
• average shipment weight by truck = 4.82 tons	
• 94% of daily shipments are by truck	
• 69% of tonnage shipped is by truck	
• 34% of ton-miles are by truck	
• 41% of truck shipments are petroleum products; 59% are mostly chemical and allied products	
Erkut et al. 2007	
• 800,000 shipments/day	US DOT, 2000
• 9 million tons/day	
Inanloo et al. 2015	
• >15,000 incidents reported to the Pipeline and Hazardous Materials Safety Administration (PHMSA)	
• > 1,000,000 daily shipments of hazardous materials by truck	PHMSA, 2010

Definition of an incident

Erkut and Verter (1998)

> Although accident probabilities are quite low for any given trip, the sheer volume of hazmat shipments almost guarantees that there will be some accidents over a sufficiently long period of time.

Erkut et al. (2007)

> An accident resulting in a release of the hazmat is called an incident.

Battelle (2001)

> In this report, an incident is defined as an event involving the transportation of hazardous material that results in an unanticipated cost to the shipper, carrier or any other party. An accident is an incident that occurs when the vehicle transporting the goods is involved in a collision. The study included HM accidents with a release, HM accidents with no release, loading/unloading with release, and enroute leaks not caused by a vehicular accident.

Transportation Research Board (2005)

> Since passage of [Hazardous Materials Transportation Act] HMTA in 1974, federal law has defined a hazardous materials transportation incident as an unintentional release of a hazardous material from its package during transportation, which includes periods of loading and unloading and storage incidental to transportation. [Research and Special Programs Administration] RSPA's Hazardous Materials Information System (HMIS) is DOT's main source of safety data related to hazardous materials transportation.

PHMSA (2010), p. 20

> The definition of "serious" incidents used by PHMSA's Office of Hazardous Materials Safety (OHMS) for hazardous materials releases from road and railway transportation includes additional criteria. Since 2002, PHMSA/OHMS has defined "serious incidents" as incidents that involve either:
>
> - a fatality or major injury caused by the release of a hazardous material,
> - the evacuation of 25 or more persons as a result of release of a hazardous material or exposure to fire,
> - a release or exposure to fire which results in the closure of a major transportation artery,
> - the alteration of an aircraft flight plan or operation,
> - the release of radioactive materials from Type B packaging,
> - the release of over 11.9 gallons or 88.2 pounds of a severe marine pollutant, or

- the release of a bulk quantity (over 119 gallons or 882 pounds) of a hazardous material.

The number of "serious" incidents presented in the tables of this section for road and railway includes only incidents meeting the first of these criteria (incidents with fatality or injury caused by the release of a hazardous material), and no other incidents meeting the other criteria. For transmission pipelines, all serious incidents are included.

PHMSA 2010, p. 10

PHMSA defines significant incidents as those incidents reported by pipeline operators when any of the following conditions are met:

1. fatality or injury requiring in-patient hospitalization
2. $50,000 or more in total costs, measured in 1984 dollars
3. highly volatile liquid releases of 5 barrels or more or other liquid releases of 50 barrels or more
4. liquid releases resulting in an unintentional fire or explosion

PHMSA defines a serious pipeline incident as an event involving a fatality or injury requiring in-patient hospitalization. Note that serious incidents are a subset of significant incidents, including only incidents with consequences to human health and safety (fatalities and injuries only).

PHMSA 2010, p. 21

Questions were raised in 2009 Congressional hearings about the completeness of reporting of (non-pipeline) hazardous materials incidents. One estimate quoted was that 60-90% of all such incidents were unreported. If these estimates apply equally to serious incidents, then the number of serious road and railway hazardous material incidents presented in this section could be too low by a factor of 10 (some cases were cited of non-pipeline incidents involving fatalities or injuries that went unreported).

Overview of this report

Section 2. The SGP is not the first proposed project that would require the use and transportation of hazardous materials or have risks of spills. In this section I review how the potential risks and impacts of spills are characterized in previous environmental impact statements (EISs) released by the Bureau of Land Management (BLM), the Environmental Protection Agency (EPA), and the US Army Corps of Engineers (USACE).

Section 3. This is a summary of the description of the transportation corridor, amount of traffic that would be due to the mine, and how environmental and other risks associated with mine traffic and hazardous materials are addressed over the various stages of the project for different Alternatives. The SGP draft EIS (DEIS) has inconsistent presentations of the hazardous materials to transport depending on the Alternative considered, and the measures assessing environmental impacts were incomplete.

Section 4. The SGP DEIS lists more than 30 hazardous materials that would be transported to and from the proposed project. The hazards from the various chemical reagents are not disclosed. The description of the number of trips for transporting hazardous materials is not consistent between DEIS chapters. Not enough pilot cars are planned to accompany individual loads of bulk liquids, much less all trucks carrying hazardous materials.

Section 5. This section provides an overview of quantitative risk assessments as a well-established field of study in operations research. Risk models in the peer-reviewed literature vary in how they incorporate consequences into the math, depending on the priorities of the specific application. Ignoring that, an estimate of spill probability is an essential first step.

Section 6. The transportation corridor needs clearly defined endpoints. The analysis area for the SGP DEIS artificially truncates the transportation corridor to only consider the road from SH-55 to the mine site. The length of the corridor will vary by the substance/supply required by the mine. Example distribution points of many mine reagents are shown.

Section 7. The annual probability of a spill of a specific hazardous material will be based on the total transportation corridor length from the distribution point to the mine site and the number of truck trips required per year. The cumulative spill probability is based on the total distance reagents are transported to the mine from their respective distribution locations over the life of the mining project. The individual and combined exposure variables for hazardous materials transportation are calculated in this section.

Section 8. The SGP DEIS cited Federal Motor Carrier Safety Administration (FMCSA) data to calculate a constant spill probability that is two orders of magnitude smaller than rates used in peer-reviewed studies and other EISs. I went to the original data cited in the FMSCA reports for several years to both recreate the rates cited in the SGP DEIS and show how to correct those calculations. I then compare the rates I computed with previously cited rates.

Section 9. Models for spill probability range from very simple to very specialized and detailed. The simplest model of spill probability uses a single, constant spill rate for all types of roadway. A more detailed model could incorporate location-specific factors that increase and decrease the estimated rate for segments of the transportation corridor. This section reviews other factors that could affect calculations of spill probabilities per mile of exposure in general and for the SGP specifically.

Section 10. Using the total number of truck-miles from Section 7 with the spill rate per truck-mile I estimated in Section 8, I calculated expected numbers of spills and probability of at least one spill of hazardous materials along the portion of the transportation corridor from SH-55/Warm Lake Road and along my best estimate of the entire transportation corridor from the individual regent distribution locations. Not all accidents result in spill incidents. Very similar math can also be used to find the expected number of accidents of loaded and unloaded heavy vehicles along the transportation corridor for just the vehicles transporting hazardous materials and for all heavy vehicles using the roadway.

Section 11. This critique only scratches the surface of potential impacts related to hazardous materials and transportation. Mine-related spills of hazardous materials can come from many processes besides transportation. Transportation impacts extend beyond the risk of spills. Finally, to compare theoretical calculations to observed incidents, I collected data about spills from Pogo Mine and found the probability of spills estimated in the EIS was vastly lower than the actual number of incidents.

Section 12. This section offers my conclusions about the adequacy of the presentation of the potential risks posed by hazardous materials along the transportation corridor in the SGP DEIS.

2. Quantitative spill risks and probability assessments from other EISs

The probabilities and potential impacts of spills have been treated as important considerations in other EISs, albeit often with mathematical flaws in the estimations and presented in ways that downplay the cumulative risk exposure (Lubetkin 2020). Here are several (semi-)quantitative treatments of spill risks as presented in EISs written over the last two decades. These examples show that 1. there are probability ranges defining when potential impacts need to be thoroughly addressed in an EIS and 2. that it is often possible to estimate the number of spills and the probability of spill occurrence based on spill rates from existing data and the exposure specific to a proposed project. The five examples here are from EISs with the EPA, the BLM, and the USACE as the lead agencies and are presented in chronological order.

EPA (2003): Pogo Mine spill rates and probabilities for fuel and reagents

Pogo Mine is a gold mine approximately 38 miles northeast of Delta Junction in the interior of Alaska, predicted in its EIS to process 2,500 to 3,500 tons of ore per day (tpd). It will serve as a point of comparison for the SGP throughout this report. In this section I highlight how the transportation corridor spill risks were characterized. In Section 4 I will show the comparison of the reagents needed at Pogo with the ones slated for used at the SGP. Pogo Mine has been in operation long enough to compare the estimates of spill probabilities and numbers predicted in the EIS with the observed spill records available through the Alaska Department of Environmental Conservation online database (ADEC 2020). I will contrast the observed spills with the predictions in Section 11.

EPA (2003), p. 4-20

> The following metrics have been applied [for accidental or unplanned releases of fuel or chemicals]:
>
> - *No or low impact*: No planned release or low likelihood of occurrence; if an accidental release or spill occurred, the potential for impacts to environment or public interests would be negligible.

- *Moderate impact*: There is a risk of accidental release, or a release has a low likelihood of occurrence but the impacts could be high.
- *High impact*: A high potential for accidental release exists, and the severity of the release would be high.

Table 2. The Pogo Mine EIS included estimates of the probability of diesel spills under different alternatives using a "probability of truck accidents and release was reported as 1.9 x10^{-7} spills per mile of travel for rural two-lane roads (Harwood and Russell, 1990)", an 11-year project life, and a 49-mile transportation corridor (EPA 2003).

Scenario	Amount (in gallons)	Truck loads	Probability of ≥1 spill
without on-site power generation	786,000 gallons per year	100 tanker trucks (8,000 gallons each) each year	1%
with on-site power generation	an additional 4.2 million gallons of diesel fuel per year	an additional 525 tanker trucks (8,000 gallons each), for a total of 625 fuel trucks each year	~6%

The number of tanker loads of diesel per year and miles to travel were used to calculate diesel spill probabilities, which depended on the specifics of the project options and were estimated to be 1 or 6% (Table 2). Spill risk probabilities for individual reagents or the cumulative number of reagent truck-miles were not calculated, but it was noted that fuel spills near a wetland could have an impact, that a major diesel spill near a creek could result in a high impact in a large area of the watershed, and that a substantial release of cyanide into surface water would have a high impact (EPA 2003).

USACE (2012): Point Thomson Project spill probability impact categories

The Point Thomson Project is also in Alaska and would produce hydrocarbon liquids. The USACE has developed a semi-quantitative description of spill likelihood for consideration in EISs (USACE 2012). In the Point Thomson Project Final EIS, Table 5.24-4 lists the impact criteria for spills (USACE 2012, p. 5-692, 693). Within that table, the potential for impacts to occur are defined as

- Probable: highly likely to occur (likelihood would approach 1.0)
- Possible: moderately likely to occur (likelihood in the range of 0.4)
- Unlikely: not likely to occur (likelihood less than 0.1)

- Highly unlikely: very unlikely to occur (likelihood would be essentially zero).

Because USACE (2012) did not specify exact numeric ranges for the potential for impacts to occur, I assigned values to each category (Table 3). I will use these ranges and intensity types to characterize later spill and accident probability estimates for the SGP.

Table 3. Suggested numerical ranges for the spill probability categories listed and described in USACE (2012).

Intensity type	Quantitative description from USACE (2012)	Assigned numeric range	Reasoning
Probable	likelihood would approach 1.0	0.7 to 1.0	Extends from the upper bound for "possible" spills to 100%
Possible	likelihood in the range of 0.4	0.1 to 0.69	Bottom of range extends to the upper bound for "unlikely" spills; symmetric around 0.4
Unlikely	likelihood less than 0.1	0.01 to 0.09	
Highly unlikely	likelihood would be essentially zero	<0.01	

USACE (2018): Donlin Mine qualitative relative rates by spill size class

Donlin Mine is an open pit gold mine in Alaska. Although the Donlin Mine EIS was released 15 years later than the Pogo Mine EIS, it has a less quantitative approach to spill risk assessment, largely borrowed from EISs related to proposed fossil fuel development. The language used by the USACE for spill risks for the Donlin Mine (USACE 2018, p. 3.24-11, emphasis added):

> This section describes, by alternative, the expected relative rate of occurrence and estimated volumes of spills from the proposed project. *The likelihood of a spill is a qualitative assessment based on the rate or frequency of occurrence*. The rate of occurrence is a function of several factors, including operating procedures, personnel training and awareness, maintenance, and human error. *The relative rates listed below are based on the experience of several personnel with spill background, peer-reviewed and "gray" literature, and reports as referenced. The assessment is a subjective evaluation and the categories are relative to each other in the context of area operations*.

is very similar to language used by the BLM (2004, p. 379) to describe spill risks related to oil and gas extraction in the Alpine Satellite Development Plan (emphasis added):

> *The qualitative assessment of potential rate of occurrence is provided …. The relative ranks are based on: the experience of several personnel with extensive oil spill background with spills, peer-reviewed and "gray" literature, USCG spill reports; the reports incorporated by reference earlier*, and other spill reports for North Slope incidents. *The assessment is a subjective evaluation and the categories are relative to each other* in the context of North Slope oil field operations.

The Donlin Mine EIS (USACE 2018, p. 3.24-12) also borrowed the spill size classes and relative risk rate terminology from BLM (2004) (reproduced in Table 4). Unfortunately, "relative", "subjective", and "qualitative" rankings of spill risk are not very informative. While recognizing that larger spills are both less frequent and more damaging is important, this description is insufficient for making decisions, especially if cumulative effects from frequent small spills from many different hazardous materials are to be evaluated.

*Table 4. **Reproduction of Table 3.24-1: Expected Relative Rate of Occurrence for Diesel Fuel Spills from Main Project Sources for Donlin Mine. "Note: Probability of Spill: Very high has a probability approaching one, very low has a probability approaching zero" (USACE 2018).***

Source	Spill Size (US gallons)				
	Very Small	Small	Medium	Large	Very Large
	<10	10–99.9	100-999.9	1,000–100,000	>100,000
Storage tanks/Tank farms	High	Medium	Low	Very Low	Very Low
Vessels (Barges)	High	Medium	Low	Very Low	Very Low
Tanker trucks	Very High	Medium	Very Low	Very Low	Would not occur
Pipeline	Very High	High	Low	Very Low	Very Low

The Donlin Mine EIS specifically addresses risks of spills of diesel and cyanide from vehicles along the roadway and acknowledges previous spills of those substances in Alaska and internationally (USACE 2018). The discussion of diesel spill risks includes the number and size of the truckloads that would be required for the project but did not show any measure of road length or total truck-miles or a spill rate per truck-mile. According to the EIS, most diesel spills are expected to be less than 100 gallons but could be as large as the entire volume transported.

USACE (2018), p. 3.24-14

> A fleet of ten 13,500-gallon capacity B-train tanker trucks (with two tanks of approximately 6,750 gallons each) would be used to transport diesel from Angyaruaq (Jungjuk) Port to the Mine Site. There would be an average of 2,424 round trips per year during the shipping season of the Operations Phase, (approximately 22 per day). Research has been conducted into the probability of accidents on a number of different types of roads, but no research has been identified that examines accident rates on controlled access, private industrial roads such as the proposed mine access road (ARCADIS 2013a). Most potential spills would likely be small or very small. It is possible for a medium to large spill (up to 13,500 gallons) to occur in the unlikely event of a rollover or collision that results in a cargo tank being breached and the contents released to the surrounding environment. The risk of a release would be reduced to some degree with provisions made for driver safety through the continued use of [best management practices] BMPs such as travelling at safe speeds. There would be no transport of fuel during winter and trucking would be curtailed during extreme weather events, such as high wind, during the shipping season. The tanker trucks would be equipped with spill response kits, and the drivers would be trained to minimize and contain low-volume spills.

The discussion of potential sodium cyanide spills emphasizes safety, the low probability of a spill, and the expectation that spills can be cleaned up properly (USACE 2018, p. 3.24-24):

> The sodium cyanide containers would be offloaded at the port terminal and trucked to the mine throughout the barging season. NICNAS (2010) found that incidences of spilled cyanide internationally from 1984 to 2010 were rare, relative to the amount of sodium cyanide that is annually transported. The spill risk during truck transportation is very low to non-existent due to the safeguards at the Donlin Gold access road (design for industrial traffic, dedicated use and low speed limits), and the appropriate containment to prevent a spill if an accident occurred. The sodium cyanide would be transported as dry solid briquettes that would be stored in watertight tank-tainers. Potential spills could occur in the unlikely event of an accident or wildlife collision that results in the tank-tainer rupturing. This event could result in either the dry sodium briquettes being spilled on dry ground or the contents could be spilled on wet ground or surface waters. If solid sodium cyanide is spilled on dry ground, it does not present a danger to people or the environment as long as the sodium cyanide remains dry and is swept up and properly contained for disposal. Spill residues would be properly disposed. Sodium cyanide that comes in contact with water poses immediate toxic and acute health dangers.

Overall, the Donlin Mine EIS is an example of a poorly executed spill risk analysis.

BLM (2020): National Petroleum Reserve - Alaska expected numbers of spills by substance and size category

An example of estimating the number of spills comes from the National Petroleum Reserve – Alaska (NPR-A) Final EIS (FEIS). The expected number of spills can be calculated based on a spill rate from historical spill occurrences. In this case the exposure variable was not based on distances traveled and number of trips but instead on the total volume of oil to be produced (spills per billion barrels of oil (BBO)). This FEIS found spill rates for crude oil, refined oil, produced water, and other hazardous materials. The historical spill data were grouped into specific substance and size classes to estimate the rate of occurrence for each category. That is, how frequent is a spill of <2,100 gallons of refined oil? Of 2,101 to 36,036 gallons of hazardous materials? These frequencies vary by substance and size. For example, the spill rates for three size categories and four substance classes were found on the North Slope for the NPR-A using Alaska Department of Environmental Conservation data from 2000-2018 (BLM 2020, Table I-1 reproduced here as Table 5).

Table 5. North Slope spill rates by substance and size per billion barrels of oil (BBO) produced (2000-2018). (BLM 2020, Appendix I, Table I-1.)

Substance	Spill size range (in gallons)			Total
	0-2,100	2,101-36,036	>36,036	
Crude oil	129.53	2.63	0.20	132.36
Refined oil	563.37	1.41	0.00	564.79
Seawater and produced water	94.57	8.08	1.41	104.07
Other hazardous materials	386.16	3.23	0.20	389.59
Total	1,173.62	15.36	1.82	1,190.80

The estimated spill frequency rates can then be used with Alternative-specific exposure variables to estimate the number of spills. For example, BLM (2020) then used a variety of oil production values from several Alternatives to compute specific number of spills that would be expected if 1.35, 1.48, 1.98, or 2.64 billion barrels of oil were produced (BLM 2020, Appendix I, Tables I-3 to I-7), one of which is reproduced here (Table 6).

Table 6. *Projected spills count for Alternative E of the NPR-A (expected production of 2.64 billion barrels of oil) (BLM 2020, Appendix I, Table I-6.) BLM (2020) did not include the bottom total row.*

Substance	Spill size range (in gallons)			Total
	0-2,100	2,101-36,036	>36,036	
Crude oil	341.95	6.94	0.53	349.42
Refined oil	1,487.30	3.73	0.00	1,491.04
Seawater and produced water	249.66	21.34	3.73	274.73
Other hazardous materials	1,019.45	8.54	0.53	1,028.52
Total	3,098.36	40.55	4.79	3,143.71

While this was not shown in the NPR-A FEIS, the expected number of spills can be used to calculate the probabilities that at least one such spill in each specified category would occur over the lifetime of the proposed project. Thus, the spill rates from Table 5 can be used to calculate expected numbers of spills (Table 6), which can in turn be used to calculate spill probabilities (Table 7). In this example, using the terminology from USACE (2012) (Table 3), we can see that several substances and size classes that are expected to have a 100% probability of occurrence in the NPR-A, falling into the "probable" range of potential impacts. Only spills larger than 36,036 gallons of crude oil and of other hazardous materials fall in the *unlikely* category, and only refined oil spills larger than 36,036 gallons are in *the highly unlikely* category. The impacts will vary depending on their size and their frequency, which could run into the thousands for small spills (Table 6). The NPR-A FEIS has an explicit statement of the total number of spills for each class of hazardous materials for each Alternative. One important aspect of the relationship between estimated numbers of spills and spill probabilities becomes clear in examining Tables 6 and 7: Spill probability cannot exceed 100% and does not given a direct indication of the expected number of spills. Both the expected number of spills and the probability should be considered. Often small spills are dismissed in EISs as having little to no impact as individual events. However, if hundreds or thousands of such spills were to occur, particularly in a limited area, it is harder to downplay their potential harmful effects when they are considered cumulatively.

Table 7. Probability of having at least one spill in each substance and size class based on the spill rates calculated per billion barrels of oil (BBO) produced and predicted production volume of 2.64 BBO at the NPR-A and assuming spills follow a Poisson distribution. Probability of at least 1 spill = 1 – exp(-N) where N is the expected number of spills for that category from Table 6.

Substance	Probability of at least one spills in a size range (in gallons)			All sizes
	0-2,100	2,101-36,036	>36,036	
Crude oil	100%	99.9%	41.1%	100%
Refined oil	100%	97.6%	0%	100%
Seawater and produced water	100%	100%	97.6%	100%
Other hazardous materials	100%	100%	41.1%	100%
Total	100%	100%	99.2%	100%

USACE (2020): Pebble Mine Project spill risk rates along a mine transportation corridor

The proposed Pebble Mine would extract copper, gold, and molybdenum upstream from Bristol Bay, Alaska. The transportation corridor for the Pebble Mine varies by Alternative and may include marine barges, trucks, a lake ferry, pipelines, and lightering barges, as well as storage facilities along the route and transfers between transport types. The Pebble Mine EIS only developed quantitative spill risk estimates for five transportation corridor spill scenarios: 1. Spills of >300,000 gallons of diesel from marine barges, 2. Spills of >300,000 diesel from the lake ferry, 3. Spills of >3,000 gallons of diesel from tanker trucks, 4. Spills of 80,000 pounds of ore concentrate from trucks, and 5. Spills of 54,000 pounds of ore concentrate slurry from a pipeline. USACE (2020, p. 4.27-1) notes that "The substances analyzed do not include all of the hazardous materials that would be used for the project" and "Substances analyzed in this section were selected based on their spill potential (probability) and potential impacts (consequences)." The diesel and ore concentrate spill scenarios from trucks are most relevant to the SGP DEIS and discussed further below.

Pebble Mine may require 16,000,000 gallons of diesel every year. Depending on the Alternative, the road length would vary from 53 to 82 miles, with trucks hauling triple trailers with a combined payload of 19,050 gallons making 840 trips per year. Pebble Mine expects to produce 876,000 wet tons of copper-gold ore concentrate per year, which would require 7,684 trips per year with each truck hauling 114 tons of ore concentrate. Different spill rates per truck-mile were used for diesel and ore concentrate based on two different roads in Alaska. For diesel, the spill risk per mile was

> [b]ased on interpretation of the available Dalton Highway data, [and] the potential annual spill rate for a 3,000-gallon spill was calculated to be 2.0×10^{-7} spills per truck-mile traveled, or 0.011 spill per year over 66 miles of road transport (55,433 truck-miles traveled per year). (Note that miles of road transport varies by alternative from 53 to 82 …. The original calculation used for the Alternative 1 road corridor was 66 miles.) This equates to a probability of a 3,000-gallon spill of 1 percent in any given year; 20 percent in 20 years; 55 percent in 78 years; or an average of one 3,000-gallon spill every 90 years (AECOM 2019a). Although these estimates are based on limited historical data, the calculated spill rate of 2.0×10^{-7} per truck-mile is essentially identical to the 1.9×10^{-7} rate identified in a separate analysis by the EPA Watershed Assessment (EPA 2014). (USACE 2020, p. 4.27-18, 19)

For ore concentrate, USACE (2020) based the spill rates on observed spill from another Alaska Mine (USACE 2020, p. 4.27-59, 60),

> The Red Dog zinc and lead mine in northwestern Alaska is an appropriate data analog for the Pebble mine, based on similar transport of ore concentrate from the mine site by truck/trailer to a port. Red Dog concentrate spills data are therefore used in determining spill probabilities for the project. … As of 2005, haul trucks at Red Dog mine hauled 85 tons of concentrate in two side-dump trailers (AECOM 2019a).

USACE (2020), p. 4.27-64, 65

> No studies have been identified that analyze trucking-related spill rates on private, controlled-access industrial roads, such as the project access roads (ARCADIS 2013). The probability of this scenario is therefore based on available historic spill data from transport of ore concentrate along the 52-mile haul road used by Red Dog Mine (as discussed above), the most relevant concentrate transport analog in Alaska. Based on the [Alaska Department of Environmental Conservation] ADEC record of spills at Red Dog Mine, the estimated spill rate per mile for a trucking-related concentrate spill in the project was calculated to be 0.78×10^{-6}, which equates to an average of 0.4 trucking-related concentrate spills per year for 66 miles of road transport. Note that miles of road transport vary by alternative from 53 to 82 miles (Table 4.27-1). Sixty-six miles was used in the original calculation for the Alternative 1 road corridor. This equates to a 33 percent probability of such a spill in any given year, and a 100 percent probability in 10 years or more (i.e., 100 percent probability during the proposed 20-year project); or an average of one spill every 2.5 years (AECOM 2019a). (Note that in the expanded mine scenario, concentrate would be transported by pipeline, not by truck.)

Note that the location-specific spill rates per mile vary by substance, with the risks of diesel spills >3,000 gallon being 2.0×10^{-7} spills per truck-mile and an ore concentrate spills rate of 7.8×10^{-7} spill per truck-mile, and that the estimates were compared to the 1.9×10^{-7} spills per truck-mile rate that the EPA (2014) cited for context.

Table 8. Reported expected spill numbers and probabilities for diesel and ore concentrate from trucks based on the 66-mile road corridor Alternative for Pebble Mine and different project lifetimes. Numbers in bold were not explicitly included in the EIS. The percent probability for diesel spills for the 78-year project life does not match the text because the one cited in USACE (2020) mistakenly used a 72-year Project life for that calculation.

	Expected number of spills			Percent probability of ≥1 spill		
Number of years	1	20	78	1	20	78
Spill of ≥3,000 gallons of diesel; road length = 66 miles; 840 trips per year						
spill rate = 2.0×10^{-7} per truck-mile	0.011	**0.22**	**0.86**	1.09%	19.7%	57.9%
Spill of 80,000 pounds of ore concentrate; road length = 66 miles; 7,684 trips per year						
spill rate = 0.78×10^{-6} per truck-mile	0.396	**7.91**	**30.85**	32.7%	**100%**	**100%**

If we apply the spill probability ranges from USACE (2012) (Table 3) to the Pebble Mine truck spill risks (Table 8), we find that in any given year, diesel spills of ≥3,000 gallons are "unlikely" and spills of ore concentrate are "possible", and that for the 20- and 78- year timespans, diesel spills ≥3,000 gallons are "possible" and ore concentrate spills are "probable".

Summary

Environmental impact statements for other mines and resource extraction projects have included spill risk calculations for numbers of hazardous materials spilled and the probability of at least one spill. The presentations vary by project but show several ways to quantify spill risk. No such project specific risk was found in the SGP DEIS.

3. Summary of transportation, risks, and potential impacts as presented in the SGP DEIS

The transportation corridor for the SGP will rely mostly on truck transport (USFS 2020). The road system, traffic, materials, and hazards are described throughout the DEIS. I have consolidated and summarized the descriptions of the transportation corridor from Chapter 2: Alternatives Including the Proposed Action, Chapter 3: Affected Environment, and Chapter 4: Environmental Consequences. Within Chapters 3 and 4, I focused mostly but not exclusively on the portions relating to Hazardous Materials (chapter sections 3.7 and 4.7), Access and Transportation (chapter sections 3.16 and 4.16), and Public Health and Safety (chapter sections 3.18 and 4.18). I also reviewed DEIS Appendix E: Geologic Resources and Geotechnical Hazards, which included figures showing where various geohazards are mapped along the one of the proposed routes (Appendix E-1) and the results of a desktop study of geohazards along the two proposed routes (Appendix E-2).

USFS (2020), p. 3-7.1

> Hazardous materials are substances which may pose a risk to human health, wildlife, or the environment. Hazardous materials that would be used and/or transported for the proposed mining activities include diesel fuel, gasoline, lubricants, antifreeze, chemical reagents and reactants (including sodium cyanide and sulfuric acid), antimony concentrate, mercury containing residuals, lime, explosives, and other substances.
>
> When not properly managed, hazardous materials can represent potential risks to human health, the environment, and wildlife. Spills or accidental releases of hazardous materials can impact air, surface water, groundwater, soil, vegetation, wildlife, fish and other aquatic resources and public health and safety; they can occur during transportation to and from a site, during storage and use activities, or through improper disposal of waste materials.

Although the DEIS acknowledges that spills may occur during activities other than transporting hazardous materials, the only attempt at calculating a spill rate was for spills from heavy trucks.

The SGP DEIS defines the area for assessing hazardous materials impacts risks as

USFS (2020), p. 3-7.1

> • The proposed mine site (including all operational areas and haul roads);
>
> • Proposed off-site facilities: Stibnite Gold Logistics Facility and the Maintenance Facility locations. The proposed Stibnite Gold Logistics Facility would be used as a central depot for consolidating loads and deliveries;
>
> • Access roads: Warm Lake Road (County Road [CR] 10-579), from Cascade past the Stibnite Gold Logistics Facility, continuing to Landmark and northeast to the mine site via the proposed Burntlog Route; and the Yellow Pine Route: Johnson Creek Road (CR 10-413) and the Stibnite Road portion of the McCall-Stibnite Road (Stibnite Road; CR 50-412), from the village of Yellow Pine to the mine site; and
>
> • Watershed tributaries of the East Fork South Fork Salmon River (Sugar Creek, Meadow Creek, Johnson Creek, Riordan Creek, Burntlog Creek, and Trout Creek); and tributary streams to the South Fork of the Salmon River (Cabin Creek and Warm Lake Creek).

That specification did not extend beyond the access roads, even though "national highways would be used to transport materials to the SGP area as far as Cascade, Idaho" (USFS 2020, p. 4.7-4).

The SGP DEIS only quantifies the miles of roadway and numbers of trips for various reagents, but did not include calculations of total numbers of truck trips or truck-miles with hazardous materials, expected numbers of spills, or the probability of spills for the transportation corridor or other potential spill sites.

USFS (2020), p. 4.7-1, 2

> The following analysis of effects associated with hazardous materials is considered in the overall context of direct impacts caused by accidental releases or spills to localized areas, as well as potential impacts to outlying areas associated with releases to groundwater or nearby drainages/streams/surface waters. Elements of this context include:
>
> • Amount, type, and location of storage, use, or disposal of hazardous materials and the potential for release to the environment;
>
> • Transportation of hazardous materials to or from the mine site, and the potential for accidental release to the environment; and
>
> • Fate and transport (i.e., where the hazardous material may go in the environment) of hazardous materials that have entered the environment.
>
> Impacts associated with the storage, use, and disposal of hazardous materials are measured quantitatively by the amount, type, and location of use. Impacts to the

> environment in the event of an accidental release are assessed qualitatively, based on the type and amount of hazardous material, handling techniques, location of use and contingency plans, risk of accidental release, and exposure pathway to potential sensitive receptors.

No formal definition of spill size classes was given, but we can infer that 25 gallons may be the threshold between small and large spills:

USFS (2020), p. 4.7-1, 2

> A release event could range from a minor spill of up to a few gallons (for which on-site cleanup would be readily available) to a large, reportable spill (e.g., over 25 gallons of fuel). Some hazardous chemicals could have immediate adverse impact on soils and vegetation, and potentially degrade aquatic resources and water quality if they enter surface water. Spills of hazardous materials also could potentially seep into the ground and contaminate the groundwater system over the long term. The risk and potential transport to the environment exists for all hazardous materials.

The SGP DEIS includes five Alternatives. Alternatives 1-4 share many common elements (mine pit locations, pit dewatering, Yellow Pine development rock storage facility (DRSF) dimensions, DRSF construction methods, ore processing, TSF construction methods, water supply needs and uses, surface and underground exploration, and the construction of a Stibnite Gold Logistics Facility (SGLF)) (USFS 2020, p. 2-4). Alternative 5 is the No Action Alternative. "Alternative 2 is, in practical effect, the proposed project for which Midas Gold is seeking approval," but "Midas Gold has not submitted a revised plan of operations premised upon this alternative" (USGS 2020, p. 2-3).

All mine traffic would be routed through the SGLF, which has a proposed location of approximately seven miles east of SH-55 on Warm Lake Road (USGS 2020, p. 2-57). "Midas Gold would require supply truck drivers to check in at the SGLF and direct them to either proceed to the mine site or unload at the warehouse for temporary storage and consolidation of their load" (USGS 2020, p. 2-58).

There are two general routes that could be used for reaching the mine site from the SGLF: the existing Yellow Pine Route and the proposed Burntlog Route and variations. (See Figure 1 in Section 7.) The Yellow Pine Route would have improvements to the road corridor (USFS 2020, p. 2-5). The Burntlog Route would require constructing 15 miles of new road to connect the terminus of the existing Burntlog Road to Meadow Creek Lookout Road (USFS 2020, p. 2-21). Alternatives 1, 2, and 3 have slight variations around the Burntlog Route specifics (USFS 2020, Table 2.2-1, p. 2-5) and would use the Yellow Pine Route during the anticipated two years required to construct the Burntlog Route (USFS 2020, p. 2-20). Alternative 4 would not involve constructing the Burntlog Route and instead upgrade the existing Yellow Pine Route (USFS 2020, Table 2.2-1, p. 2-5). Alternative 2 includes on-site lime generation (USFS 2020, p. 2-6) and a water treatment plant (USFS 2020, p. 2-8) that are not part of the other Alternatives. Alternatives 1, 3, and 4 refer to a "conceptual water treatment system" (USFS 2020, p. 2-8).

Expected traffic to the mine varies by project phase (construction, operations, and closure and reclamation) and Alternative (Table 9). Annual traffic estimates for Alternative 2 differ from Alternatives 1, 3, and 4 in that on-site lime production would require less lime to be transported for ore processing (although additional propane and other reagents would be required) and the water treatment plant, which would run in perpetuity, requiring deliveries of supplies during operations and, to a lesser extent, post-closure.

The number of trips by heavy vehicles and total vehicle trips per year in Table 9 are underestimates of the actual traffic during mining and operations because not all mine transportation needs are listed. Table 9 shows the export of 365 truckloads of ore concentrate from the mine, as well as removal of trash and recyclables, demolished and dismantled items, and tailings storage facility residuals. The totals shown do not account for the range of 365-730 annual truck trips hauling antimony concentrate, the 148,000 gallons of waste oil (50% of the lubricants brought to the mine site), or an unspecified number of trips for wastes containing mercury from ore processing leaving the mine site (USFS 2020, Table 4.7-1). Based on the predicted mine traffic, heavy vehicles will account for 70.2% of mine traffic during construction, 65.6-73.2% during mine operations, 48.3-48.7% during closure and reclamation, and 100% in perpetuity post-closure (Alternative 2 only).

Table 9. Expected round trips by operations phase and Alternative. Operations phase durations from USFS (2020), p. 2-13. Data sources for vehicle traffic: Tables 2.3-2, 2.3-7, 2.3-8, 2.4-3, p. 4.7-14, and p. 2-116 in USFS (2020). Alternative 2 values that differ from Alternatives 1, 3, and 4 are in shaded cells. Hazardous material truck tips are in ***bold****.*

	Number of round trips per year					
Mine Phase	Construction	Ore Mining and Processing Operations		Closure and Reclamation		Post-Closure and Reclamation
Number of years	2-3	12-15		5		perpetual
Alternative(s)	1, 2, 3, 4	1, 3, 4	2	1, 3, 4	2	2
Light vehicles						
Crew personal vehicles	965	651	651	261	261	
Salaried employees	261	417	417	520	520	
Pilot vehicle (fuel and hazardous materials)	522	522	522	261	261	
Equipment and supply representatives	522	522	522	522	522	
Miscellaneous traffic	1,044	1,044	1,044	365	365	
Total annual light vehicles	3,314	3,156	3,156	1,929	1,929	0
Heavy vehicles						
Crew bus/van transport to site	730	287	287	104	104	
Salaried employees bus/van transport to site	52	104	104			
Steel and cement	456					
Fuel (includes propane in Alternative 2) and miscellaneous supplies	**522**	**522**	**655**	**261**	**261**	
Reclamation supplies				304	304	
Machine parts and consumables	1,044	730	730			
Ore processing supplies		**5,220**	**2,436**			
Water treatment material and supplies			**40**		**30**	**20**
Food delivery	522	522	522	261	261	
Trash and recyclables	156	156	156	52	52	
Construction supply	2,871					
Ore concentrate haulage		**365**	**365**			
Demolished and dismantled items				456	456	
Tailings storage facility residuals						**14**
Road maintenance	1,460	730	730	365	365	
Total annual heavy vehicles	7,813	8,636	6,025	1,803	1,833	34
Total annual vehicles	11,127	11,792	9,181	3,732	3,762	34

The SGP DEIS acknowledges that the mine would increase traffic on an existing road system that is already hazardous, particularly in winter.

USFS (2020), p. 3.18-15

> Vehicle travel on National Forest System roads and CRs in the analysis area presents health and safety risks ranging from hazardous road conditions to transportation of hazardous materials through the analysis area. Many National Forest System roads, including those in the analysis area, are open to the public and used by federal, county, state, Midas Gold, and private vehicles. The analysis area is dominated by unpaved roads, one state highway, and county roads … The analysis area experiences harsh weather conditions that pose potential travel hazards, especially during winter, when roads become snow-covered or icy. During winter, Valley County maintains only one route from Cascade to the analysis area, which follows Warm Lake Road (CR 10-579) to the intersection with South Fork Salmon River Road (National Forest System Road 474), then to the East Fork Stibnite Road portion of the McCall-Stibnite Road (CR 50-412) to the village of Yellow Pine. Midas Gold maintains Stibnite Road (CR 50-412) for access from the village of Yellow Pine to the mine site. All other routes to the mine site are not maintained (plowed or sanded) when snow-covered roads become impassable to vehicles.

USFS (2020), p. 4.16-3

> Vehicle accidents occurring on the existing roadway network are caused by driver error, vehicle mechanical issues, and environmental factors such as poor road conditions due to weather and wildlife crossings. Warm Lake Road experiences the highest incidents of accidents within the forest transportation system due to the higher traffic volumes and higher speeds observed (DJ&A, PC 2017).

Logistics facility description

USFS (2020) p. 2-57

> **STIBNITE GOLD LOGISTICS FACILITY**
>
> The SGLF would be located along Warm Lake Road on private land (approximately 7 miles northeast of Cascade), with access to State Highway 55 (**Figure 2.3-1**). The SGLF would require approximately 25 acres of disturbance to accommodate employee parking, an assay laboratory building, a core sampling logging storage facility, warehouses, laydown yards, equipment inspection areas, a truck scale, and an administration building for Midas Gold personnel. The parking and assembly area would accommodate approximately 250 light vehicles for employees using bus or van pooling to the mine site. Midas Gold would mandate the use of busing and vans for employee and contractor transportation to the mine site.

> Midas Gold would require supply truck drivers to check in at the SGLF and direct them to either proceed to the mine site or unload at the warehouse for temporary storage and consolidation of their load. A truck scale would be located at the SGLF to verify loads going into or out of the warehouse area. The check-in process would include general safety and road readiness inspection of incoming trucks and equipment being transported to mine site. Heavy equipment transport vehicles would be inspected for items such as presence of weeds, excessive dirt on earth moving equipment, safety equipment, installed and maintained engine brake muffling systems, and general safety checks of equipment.

The major differences between Alternative 2 and Alternatives 1, 3, and 4 are the additions of a lime kiln and a water treatment plant, both of which change the reagents needed and quantity of hazardous materials to be transported. In addition, all four action Alternatives have variations on the mine access routes and mine site haul roads, which will lead to differing road lengths, grades, and risks. Sections 7 and 9 of this report address the mine access routes and potential hazards along them.

On-site lime generation

The reagent requiring the most trips to the mine site is lime (70,000 tons per year in 2,917 shipments for Alternatives 1, 3, and 4). This could be reduced by mining limestone from a limestone/marble pit in the area and generating lime on site.

USFS (2020), p. 2-103

> **ON-SITE LIME GENERATION**
>
> Under Alternative 2, lime and crushed limestone would be produced on-site from mining a limestone/marble formation in the West End pit. Over the life of the mine, approximately 130,000 to 318,000 tons of limestone/marble would be mined annually, averaging approximately 240,000 tons per year. Approximately 25 to 30 percent of the limestone mined annually would be run through the lime kiln with the remainder crushed and stockpiled for direct use as limestone. Both ore and limestone would be temporarily stored at the run-of-mine stockpile.
>
> The on-site lime generation would require additional equipment, which would be placed within the ore processing area. This equipment would include: limestone crusher and conveyor; propane-fired kiln with the capacity to generate up to approximately 200 tons per day; kiln combustion air system including preheat heat exchanger; 30,000-gallon propane storage tank plus vaporizer; air compressor, receivers, and dryers for plant air and instrument air at kiln area; roll crusher for kiln product discharge; six conveyors for

> moving feed and product materials; off-gas fume filter for kiln discharge; dust collector kiln feed bin; 500-ton storage bin for kiln feed material; and 1,000- to 11,000-ton storage bin for lime products.
>
> The limestone crusher, screens, conveyors, and feed bins would not be enclosed. Dust would be controlled in a similar manner to the ore crushing and conveying process through the use of water sprays and/or bag house dust collectors.

There are inconsistencies throughout the DEIS about how generating lime on site would change the reagents required and the number of associated heavy vehicle trips. While "[t]he production of lime on-site would reduce lime deliveries to the site by 2,032 trips per year and would require an average of 133 additional propane deliveries per year (Midas Gold 2018b)" (USFS 2020, p. 2-112), the values in Tables 2.3-7 and 2.4-3 (USFS 2020) cannot be reconciled based on the differences in the numbers of trips bringing lime and propane to the mine site (Table 10). The category "fuel and miscellaneous supplies" differs by 133 between Table 2.3-7 for Alternative 1 and Table 2.4-3 for Alternative 2, making the fuel truck needs listed in the tables are consistent with the text. However, in Table 2.3-7, ore processing supplies would require 5,220 annual trips under Alternative 1. In Table 2.4-3 for Alternative 2, ore processing supplies would require 2,436 trips, a difference of 2,784 trips, not 2,032 trips. Unless producing lime on site also reduces other ore processing reagent needs by more than 750 trips per year in an unspecified way, there is at least one error in the DEIS describing the difference in reagent needs and transportation that would occur under Alternative 2. Elsewhere in the DEIS, it is stated that

USFS (2020), p 4.4-17:

> The on-site generation of lime would reduce the number of lime delivery truck trips annually to the mine site by more than 2,900, but would require an average of 133 additional propane deliveries per year (Midas Gold 2016).

If that were true, transportation of lime to the mine site would be nearly eliminated.

Table 10. The DEIS description of reagents needed with and without the on-site lime production are not internally consistent. The trips per year for fuel and miscellaneous supplies and ore processing supplies for Alternative 1 and 2 are from Tables 2.3-7 and 2.4-3. The trips per year for propane and the expected difference in number of trips bringing lime are from Table 2.3-6 and the text on p. 2-112 (USFS 2020).

Supply	Trips per year		
	Alternative 1	Alternative 2	Difference = Alternative 1 – Alternative 2
Fuel and miscellaneous supplies	522	655	-133
Propane	93	226	-133
Ore processing supplies	5,220	2,436	2,784
Lime	2,917	885	2,032

Alternative 2 has payloads for additional propane that are almost double in size of those described for Alternatives 1, 3, and 4. The text in the DEIS (USFS 2020) states:

> p. 4.3-51: "Alternative 2 modeling including the emissions from an average of 133 additional propane deliveries per year (Midas Gold 2016) in on-road delivery trucks with an 11,000-gallon capacity";
>
> p. 4.7-18: "Alternative 2, which would include an on-site limestone crushing plant and associated lime generation equipment. This would require an additional 1,463,000 gallons of propane annually to fuel the lime kiln, and would require additional propane storage";

and 133 truckloads/year x 11,000 gallons/truckload = 1,463,000 gallons per year. However, Table 2.3-6 (USFS 2020, p. 2-60) shows propane being delivered in typical vehicle payloads of 6,000 gallons. If that were the case, Alternative 2 would require 244 additional trips per year for propane for the lime kiln instead of 133. This difference in propane payloads and number of trips would affect the calculation of greenhouse gas effects, potential spill sizes, and number of truck-miles associated with the Project.

USFS (2020), p. 4.7-13, 14

> Under Alternative 2, an on-site limestone crushing plant and associated lime generation equipment is proposed and would require additional hazardous materials present at the mine site (i.e., diesel for associated trucking and propane to fuel the lime kiln). Producing lime from an on-site source of limestone as opposed to hauling lime from off-site sources would result in an estimated average 13 daily round trips to transport ore processing supplies, fuel, concentrate, and other materials during operation for Alternative 2.

(Note: 13 trips/day x 365 days/year = 4,745 trips/year, which is not far off from the total number of 4,653 hazardous material trips shown for Alternative 2 in Table 13 in Section 4 of this report.)

Water treatment plant

Alternative 2 is the only action alternative to include a centralized water treatment plant, although Alternatives 1, 3, and 4 could have what is referred to as a "conceptual water treatment system" (USFS 2020, p. 2-8).

USFS (2020), p. 2-110

> The Water Quality Management Plan provides details on additional components that would be implemented under Alternative 2. The following describes the components of the water management program that differ from Alternative 1.
>
> …
>
> - A Centralized WTP would be constructed to handle peak monthly flows exceeding 1,000 gpm, expected in year 7 and beyond. The Centralized WTP would treat up to 4,000 gpm using iron coprecipitation to remove arsenic, antimony, and mercury. If needed, an additional step to precipitate mercury using organic sulfide precipitant would be employed.
>
> The Centralized WTP would be a permanent facility. The facility is currently proposed to be located on NFS land. Midas Gold would investiage (*sic*) moving the system to private land before construction in order to avoid a permanent feature on NFS land. The Centralized WTP would treat contact water, including pit dewatering water, and also could be used to treat process water, if needed. A separate facility would be maintained at the worker housing facility for treatment of domestic wastewater.

The water treatment plant would require several chemicals and reagents annually during mine operations, during restoration efforts, and in perpetuity post-closure. The DEIS is inconsistent in the reagents listed and their quantities needed during operations and post-closure in Chapter 2 (USFS 2020, p. 2-111 and Table 2.4-4 on p. 2-115) and Chapter 4 (USFS 2020, p. 4.7-14) (Table 11).

Table 11. A comparison of the reagents listed for water treatment under Alternative 2 in various parts of the DEIS.

DEIS location	p. 2-111	Table 2.4-4, p. 2-115		Table 4.7-2, p. 4.7-14		Units
Project Phase	Oper-ations	Oper-ations	Post-closure	Oper-ations	Post-closure	
Sodium hypochlorite	15,000	5,000	2,600	5,500	2,600	gallons
Ferric sulfate	125,000	65,000	44,800	65,000	44,800	gallons
Hydrated lime	250	130	90	Not listed		tons
Organic flocculant (polymer)	1,900	1,300	670	Not listed		gallons
Sulfuric acid	2,400	1,700	870	1,700	870	gallons
Sodium bisulfite	2,000	1,400	690	Not listed		gallons
Organic sulfide precipitant (if needed)	TBD	TBD	TBD	Not listed		not specified

It is estimated that "[t]ransport of these chemicals and reagents would add approximately 40 round trips for delivery to the operational [annual average daily traffic] AADT presented in Table 2.4-3" (USFS 2020, p. 2-111). Presumably, that is an additional 40 trips annually and not daily, as USFS (2020) p. 4.7-13 states

> Alternative 2 also would require water treatment chemicals at the Centralized water treatment plant. Water treatment during operations would require hazardous chemicals as listed in Table 4.7-2 in addition to those listed [for ore processing]. Water treatment chemical transport would require approximately 40 trips annually. Water treatment could result in sludges which would be transported to the tailings storage facility for disposal with tailings during operations.
>
> Water treatment at the water treatment plant would continue post closure and would require ongoing transport of chemicals to the site. The expected amount of chemicals needed post closure are listed on Table 4.7-2. In addition, an unknown number of trips would be required to transport any residual treatment sludges and wastes from the site, since these wastes would no longer be able to be disposed of in the TSF.
>
> The in-perpetuity treatment would result in approximately 20 truck trips annually to delivery water treatment chemicals and an unknown number of trips to haul sludges and wastes from the treatment plant off-site for disposal. Transport would occur during the spring through fall with chemicals stockpiled in the fall to avoid winter transport.

USFS (2020), p 4.4-17:

> Alternative 2 also would include the addition of a Centralized Water Treatment Plant (WTP) near the Ore Processing Facility as part of a Water Quality Management Plan. The Centralized WTP would require approximately 40 additional annual truck trips during operations for water treatment-related chemical deliveries. Post-closure, the Centralized WTP would continue to operate in perpetuity (with approximately 34 annual truck trips for chemical deliveries and removal of residuals). Operation of the Centralized WTP in perpetuity also would require continued operation of the new transmission line.

Road corridor differences by Alternative

USFS (2020), p. 4.18-23

> **Roads**
> Once Burntlog Route is completed, the substantial increase in traffic volume would shift to exclusively Warm Lake and Burnt Log (National Forest System Road [FR] 447) roads as they are parts of the Burntlog Route.
>
> As discussed in Section 3.16.3, Existing Conditions, existing traffic volumes on Warm Lake Road are at least 15 times greater than the other access roads.

USFS (2020), p. 4.16-17

> **4.16.2.3 Alternative 3**
> Under Alternative 3, project features associated with access and transportation would be the same as Alternative 1 except for:
>
> - An approximately 3.2-mile segment of Burntlog Route would be routed through Blowout Creek valley, resulting in 19.6 miles of new construction for the Burntlog Route. The mine security gate would be located along this segment and would restrict public access through the mine site.

USFS (2020), p. 4.12-22

> Both Routes would use the Warm Lake Road (CR 10-579) from its intersection with State Highway 55 to its intersection with Johnson Creek Road (CR 10-413). The risk of spills would be lower on Warm Lake Road because it is a paved and generally wider with lower grades (except near Warm Lake area). …The transport of fuel and other materials (e.g., antimony concentrate) along both these routes put fish in these adjacent streams at risk from impacts of a spill.

Road corridor impacts addressed in the DEIS: spills

Hazardous materials spills, changes in drainage, traffic residues, and application of road treatment chemicals are four ways in which roadways may be damaging to nearby aquatic environments (Kravitz and Blair 2019). The SGP DEIS included measures of increased traffic from mine vehicles, the amount of fish habitat and number of streams potentially impacted by their proximity to roadways used for mine-related transportation (Table 12) and acknowledged the transportation corridor can potentially affect water quality by spills of fuels and other hazardous materials, and fugitive dust from vehicles driving on the haul roads and SGP access roads (USFS 202, p. 4.9-1).

USFS (2020), p. 4.7-1, 2

> Spills of hazardous materials could adversely affect soils, vegetation, water quality, wildlife and fish, including lower trophic level aquatic organisms (e.g., bacteria and algae). Impacts could include degraded soil and water quality, fish and wildlife habitat contamination, and toxicity, injury or mortality to fish and other aquatic organisms, depending on the type and volume of material released, location, proximity to streams, timing, spill response, etc.
>
> Impacts could occur at the mine site, off-site facilities, along access routes, or in downstream watersheds. The geographic extent of any impacts would depend on the location and size of the spill and the effectiveness of the response. For most spills the extent would likely be limited to the immediate vicinity of the spill due to the response and cleanup measures that would be in place, but if a spill were to occur into a stream, impacts could extend downstream.
>
> The potential for impacts would perist (*sic*) for the life of the mine.

USFS (2020), p. 4.12-19, 20

> ***Spill Risk***
> Hazardous material spills at the mine site could injure or kill individual fish through direct contact with contaminants. …
>
> Spills of hazardous materials could negatively affect fish and fish habitat. Strict regulatory controls and SGP emergency response procedures would be expected to limit the extent of any incidents. However, the duration of spill risk, and the potential to negatively impact fish and fish habitat, would be long-term because it would exist throughout the life of the SGP. The effect would generally be localized, though spills to

flowing water could spread contaminants downstream of the spill site quickly if containment of the spill is delayed or the spill cannot be contained because of the fast-moving nature of the stream/river. Some materials that are highly toxic (e.g., diesel fuel) could result in greater impacts to a localized area. The type of impact could range from habitat loss through displacement from contaminated habitat to direct mortality from a spill. Spills occurring in the winter may be easier to contain because spilled material may not penetrate frozen ground as readily as unfrozen ground, and snow would absorb some spilled material; however, winter conditions also may slow the rate of the response.

Table 12. Summary of indicators used to assess how the SGP may affect fish species by degrading water quality in waterways adjacent to access roads and through hazardous material spills at the mine site or along access roads and how the SGP may affect public safety on the roads used by mine vehicles during construction, operations, and closure and reclamation activities. Sources: Table 2.9-1, Table 4.7-3, Table 4.9-13, 4.9-20, and Table 4.9-25 in USFS (2020).

Indicator	Alternative			
	1	2	3	4
Mine road miles used				
Yellow Pine Route	70	70	70	70
Burntlog Route	73	71	75	-
Change in AADT over baseline (all mine traffic; heavy vehicle traffic)				
Construction	65; 45	65; 45	65; 45	65; 45
Operations	68; 49	50; 33	68; 49	68; 49
Reclamation	25; 13	25; 13	25; 13	25; 13
Post-closure	6; 0	6+; 0	6; 0	6; 0
Mine-related vehicles per hour (Yellow Pine Route; Burntlog Route)				
Construction	5, -	5, -	5, -	5, -
Operations	-, 5	-, 4	-, 5	5, -
Reclamation	-, 2	-, 2	-, 2	2, -
Kilometers of Chinook intrinsic potential (IP) habitat within 91 m (100 yards) of roadway centerline				
Yellow Pine Route	36	36	36	36
Burntlog Route	7.3	5.91	4.83	0
Warm Lake Road	9.2	9.2	9.2	9.2
Kilometers of IP habitat within 91 m (100 yards) of roadway centerline (steelhead; bull trout)				
Yellow Pine Route	32.3, 33.7	32.3, 33.7	32.3, 33.7	32.3, 33.7
Burntlog Route	1.62, 8.87	1.23, 7.67	1.23, 5.74	0, 0
Warm Lake Road	4.06, 9.05	4.06, 9.05	4.06, 9.05	4.06, 9.05
Miles of route within 0.5 miles of streams				
Yellow Pine Route	27	27	27	27
Burntlog Route	9	9	9	-
Access road stream crossings				
Warm Lake Road	16	16	16	16
Johnson Creek Road	16	-	16	16
McCall-Stibnite Road	11	11	11	11
Burnt Log Road	21	19	21	-
Cabin Creek Groomed OSV Route	7	7	7	7

While the SGP DEIS uses a 91 m (100 yard) distance from the centerline of the roadway (Table 12) to measure the lengths of streams potentially affected by road effects, especially spills, Kravitz and Blair (2019) recommend a 200 m distance to define the stream areas inside the effect zone of rural roadways.

USFS (2020), p. 4.12-21

> To evaluate the risk of spills during the transportation and handling of hazardous materials, several factors were assessed, including: past fuel hauling accidents…, length of roads traveled within 91 meters (300 feet) from road centerline of important fish habitat, number and timing of hazardous material trips, and mitigation measures. …
>
> Most of the streams that occur within 91 meters (i.e., the area in which potential impacts to fish habitat from a spill may reasonably occur) of the Yellow Pine and Burntlog routes support Chinook salmon, steelhead trout, bull trout, and cutthroat trout. **…** the location of the spill risk would transition from the Yellow Pine Route to the Burntlog Route as the SGP progresses, which has less critical habitat for bull trout, steelhead, and intrinsic potential habit for Chinook salmon. Johnson Creek and the portion of the EFSFSR between Landmark and the mine site would be at risk during the first 1 to 2 years of the SGP when the Yellow Pine Route would be used as the access route. For the remainder of the SGP, until mine site closure and reclamation activities are complete and the Burntlog Route is reclaimed, the waterbodies adjacent to the Burntlog Route would be at greater risk.

The comparison of intrinsic potential habitat for Chinook, steelhead, and bull trout involved summing the lengths for the three species:

USFS (2020), p. 4.12-22

> **[**T**]**he amount of important fish habitat that would be at risk along the Yellow Pine Route is higher (102 km) compared to the Burntlog Route (17.8 km). The Yellow Pine Route includes approximately 24.8 km more bull trout critical habitat, 30.7 km more steelhead trout critical habitat, and 28.7 km more Chinook salmon IP habitat than the Burntlog Route. A spill on the Yellow Pine Route could affect a much higher number of fish compared to a spill along the Burntlog Route.

but that may not be a valid measure if they have overlapping ranges in the streams. Furthermore, the assertion that the Yellow Pine Route could affect a higher number of fish should be tied to the fish populations in each stream, as well as to the likelihood that a spill would reach a stream from that route. (See Section 5 of this report for consequence modeling.)

USFS (2020), p. 4.12-23

> As an example, schools of adult Chinook salmon (20 to 100 individuals) have been seen in the EFSFSR and Johnson Creek. Thus, a large spill could potentially kill a substantial number of adult salmon depending on various factors (NMFS 1995). A spill in the fall could kill all the 1-year old juveniles and zero age eggs/alevins, thus eliminating 2 years of Chinook salmon progeny. Diesel from a spill could mix with spawning gravels and sand and be retained in the stream substrate for a year or more, and thereby negatively affect salmon eggs, alevins, and juveniles for several years (Korn and Rice 1981; Moles et al. 1981).

Chemical contaminants are expected to change the baseline watershed condition indicators [WCI] and functional index [FI] because "[a]n increase in traffic and activity increases the potential for spills of deleterious substances. Accidental spills in the soil or directly into waterbodies are likely to decrease the FI, from large-scale spills or an accumulation from small, incidental spills. Furthermore, reaches downstream of the mine site could be exposed to contaminant inputs from the mine site itself. A decline in FI is anticipated." The baseline functional index for Johnson Creek, Upper EFSFSR and Upper South Fork Salmon River are all FR (Functioning at Risk)" (USFS 2020, p. 4.12-57).

Other road corridor environmental impacts: Greenhouse gas emissions, dust, and road surface treatments

USFS (2020), p 4.4-17:

> Alternative 2 includes a limestone kiln, which would increase GHG emissions through propane fuel combustion and release of CO_2 by reactions during the limestone calcining process (i.e., heating to a high temperature). The added GHG emissions for the limestone kiln operation are quantified for Alternative 2 below.

USFS (2020), p 4.4-17:

> Although the Centralized WTP would require additional truck trips, there would be an overall net reduction of operational truck activity under Alternative 2 due to the on-site generation of lime. However, the reduced GHG emissions for the net reduction in delivery truck activity would largely be offset by off-highway mining haul truck traffic bringing limestone to the lime generation process, at approximately two trucks per day. These trucks are much larger, and while they travel a short distance, they carry much

larger volumes of materiel (400 tons per load) and burn 100 gallons of fuel per hour of operation. Assuming each truck operates one hour per day, five days per week, that is 200 gallons of diesel per day. At 19.4 pounds/gallon CO_2 emissions, over 260 days per year, that is approximately 500 tons of CO_2 per year from limestone hauling.

Kravitz and Blair (2019)

> To estimate the amount of dust generated from the transportation corridor we used an Iowa Highway Research Board project (Hoover et al. 1973) that quantified dust sources and emissions created by traffic on unpaved roads. According to that study, one vehicle, traveling 1 mile of unpaved road once a day every day for 1 year, would result in the deposition of 1 ton of dust within a 1000-foot corridor centered on the road (i.e., traffic would annually deposit 1 ton of dust per mile per vehicle).

Kravitz and Blair (2019)

> Roads are treated with salts and other materials to reduce dust and improve winter traction. In Alaska, calcium chloride is commonly used for dust control and is mixed with sand for winter application. Compounds used to control ice and dust (Hoover 1981) have been shown to cause toxic effects when they run off and enter surface waters.

Road corridor safety

USFS (2020), p. 3.18-9:

> Increased mine related trucking traffic on roads could increase potential for spills of hazardous substances, as well as increase the potential for traffic accidents, which could have injury impacts as well as well-being and psychosocial impacts.

USFS (2020), p. 4.12-22

> The risk of spills would be lower on Warm Lake Road because it is a paved and generally wider with lower grades (except near Warm Lake area).

USFS (2020), p. 3.16-14

> **Vehicle Accidents**
> Vehicle accident data for full-size vehicles and OHVs from 2000 through 2016 was obtained from Valley County Sheriff Department records for the six roads associated with the three existing primary access routes to the mine site. Warm Lake Road (CR 10-579) experienced an average of eight accidents per year from 2000 through 2016, followed by South Fork Salmon River Road (FR 50674/FR 474) with an average of three accidents per year, Lick Creek Road (CR 50-412) with two accidents per year, Johnson Creek Road (CR 10-413) with two accidents per year, and Stibnite Road (CR 50-412) with one accident per year (DJ&A, PC 2017).

> According to the Valley County sheriff's traffic incident records from 2000 through 2016, the causes of most accidents on the existing roadways fall under the general categories of driver error, vehicle mechanical issues, and environmental factors (DJ&A, PC 2017). Examples of driver error include speeding, following another vehicle too closely, inattentiveness, fatigue, gear shift issues, failure to share road, inexperience as a driver, and impairment. Examples of mechanical issues include brake and engine failure and tire-related problems including the misuse or lack of use of chains during ice or snow conditions. Environmental factors that affected traffic incidents include weather-related (e.g., snow, ice, flooding, and other conditions that contributed to poor visibility), poor road conditions (e.g., soft shoulders), and wildlife crossings.
>
> It is likely that Warm Lake Road (CR 10-579) experiences the most accidents due to the higher traffic volumes and higher speeds observed. No OHV or motorcycle-related crashes were noted in the Valley County Sheriff's Department records; however, it is likely that not all crashes are reported (DJ&A, PC 2017).

USFS (2020), p. 4.7-4

> Statistics for haul truck accidents on county roads and/or in mountainous terrain are very limited. Transportation on local access roads would be at lower speeds and with less traffic than highways, and would likely be safer than highway travel.

Summary

The SGP DEIS quantified the risks from spills by measuring road lengths, number of trips, and distances to streams but did not include calculations of spill probabilities. The descriptions of the differences between Alternative 2 and the other Alternatives were inconsistent, with shifting values for the reduction in trips needed to bring lime to the mine site if on-site lime generation were approved and varying payloads of propane described. These inconsistencies make it difficult to calculate the true number of truck-miles associated with each Alternative. Assessments of fish habitat impacts are based on measuring the amount of stream that is a 91 m distance from the roadway centerline, which is less than half the published distance for a 200 m road-effect zone around rural roadways. Therefore, the effects on fish habitats are underestimated. Other environmental effects to consider are greenhouse gas emissions and dust generation, which, like spill risks, will also be proportional to the amount of traffic, and application of chemicals to the roadway. Safety is also a concern. The SGP DEIS shows that the largest number of accidents occurs on Warm Lake Road but then contrarily posits that it would have the lowest spill probability.

4. Hazardous material list: substances, quantities used annually by Alternative, properties

Hazardous materials would be transported to and from the mine site in millions of gallons of bulk liquids and tens of thousands of tons of bulk solids (Table 13).

Transportation Research Board (2005)

> Carriers specializing in the transportation of hazardous materials often move what are defined by DOT as "bulk packaged" shipments, which are single packagings exceeding 119 gallons for liquids, 882 pounds for solids, and 1,000 pounds for gases. Tank trucks, railroad tank cars, barge tankers, and intermodal tanks are forms of bulk packaging. Tank trucks typically hold between 2,000 and 10,000 gallons… Intermodal tank containers, which are transported on flatbed trucks and flat rail cars, can hold as much as 6,500 gallons. Bulk packaged shipments may also be shipped by truck in van-type trailers, on railroad flatcars, on flat barges, and in other nontank vehicles and containers. Many portable tanks, bins, and drums for transporting hazardous liquids and solids exceed 119 gallons or 1,000 pounds and are thus defined in the regulations as bulk shipments.

Table 2.3-6 (USFS 2020) shows the materials, quantities, delivery form, onsite storage capacity, and other data for 33 supplies. Table 4.7-1 (USFS 2020) lists 27 hazardous materials, 25 of which appear in Table 2.3-6. (Table 4.7-1 includes antimony concentrate and wastes containing mercury from ore processing, which did not appear in Table 2.3-6.) Eight substances in Table 2.3-6 do not appear in Table 4.7-1: tires, batteries, light ballasts, pesticides/insecticides, herbicides, fertilizer, sulfuric acid, and sodium hypochlorite. The list of reagents and supplies varies by Alternative, with Alternative 2 having a significant change due to production of some of the lime at the mine site (USFS 2020, p. 4.7-18) and a water treatment facility (USFS 2020, p. 4.7-14).

USFS (2020), p. 2-112:

> **2.4.5.10 Traffic**
> The production of lime on-site would reduce lime deliveries to the site by 2,032 trips per year and would require an average of 133 additional propane deliveries per year (Midas Gold 2018b).

USFS (2020), p. 4.7-18

> "Use, volumes, and storage of fuels, lubricants, and chemicals at the mine site and off-site facilities (SGLF and the off-site maintenance facility) would be the same or similar across all action alternatives, with the exception of Alternative 2, which would include an on-site limestone crushing plant and associated lime generation equipment. This would require an additional 1,463,000 gallons of propane annually to fuel the lime kiln, and would require additional propane storage. Alternative 2 would have a somewhat elevated spill risk of these materials over other alternatives during storage and use at the mine site.

USFS (2020), p. 4.7-18

> **4.7.7.2 Transport of Hazardous Materials**
>
> Transport of hazardous materials would occur for all alternatives. The volume and frequency of hazardous material transport by truck would be the same or similar for Alternatives 1, 3, and 4, but the volume and frequency would change under Alternative 2, with on-site lime generation. Under Alternative 2, fewer truck trips would occur during an operational year. The reduced truck trips would be related to reduction of 2,032 truck trips each year for shipment of lime for use at the site and an increase of 133 propane delivery trucks each year for an overall net decrease of 1,889 truck trips each year of operations (an average annual daily traffic reduction from 49 trips per day to 33 trips per day. The overall risk of a spill would be reduced with reduced truck trips."

The math described in the paragraph above that posits a net reduction of 16 trips per day for Alternative 2 relative to the other Alternatives does not work. It is true that a reduction of 2,032 lime deliveries and an increase in 133 propane deliveries per year leads to a net reduction of 1,889 truck trips per year for Alternatives 1, 3, and 4 compared to Alternative 2. However, 1,889 fewer trips per year/365 days per year = 5.2 fewer trips per day. (If there are only 261 delivery days per year for lime and propane as shown in Table 2.3-7, the reduction is 7.2 trips per delivery day.)

USFS (2020), p. 4.4-17

> The Centralized WTP would require approximately 40 additional annual truck trips during operations for water treatment-related chemical deliveries. Post-closure, the Centralized WTP would continue to operate in perpetuity (with approximately 34 annual truck trips for chemical deliveries and removal of residuals). Operation of the Centralized WTP in perpetuity also would require continued operation of the new transmission line.

*Table 13. Hazardous materials transported to and from the proposed SGP Project during operations. Compiled from Tables 2.3-6, 4.7-1, 4.7-2 (USFS 2020). The changes in supplies needed for Alternative 2 are in the shaded rows. Materials in **bold** did not appear in the list of hazardous materials in Table 4.7-1. "Water treatment chemical transport would require approximately 40 trips annually [for Alternative 2 during operations]" (USFS 2020, p. 4.7-14), which is included in the total.*

Common name	Annual use	Typical vehicle payload	Estimated number of deliveries each year
Bulk liquids			
Diesel fuel	5,800,000 gallons	10,000 gallons	580
Propane (additional for Alternative 2 on-site lime production)	1,463,000 gallons	11,000 gallons	133
Propane	560,000 gallons	6,000 gallons	93
Gasoline	500,000 gallons	5,000 gallons	100
Lubricants	296,000 gallons	3,000 gallons	99
Waste oil (50% of lubricant quantity)	148,000 gallons	3,000 gallons?	49
Magnesium chloride	250,000 gallons	4,500 gallons	56
Nitric acid	115,000 gallons	3,000 gallons	38
Ferric sulfate (Alternative 2 water treatment chemical)	65,000-125,000 gallons		
Sulfuric acid	**60,000 gallons**	**3,000 gallons**	**20**
Methyl isobutyl carbonyl	55,000 gallons	3,000 gallons	18
Antifreeze	40,000 gallons	3,000 gallons	13
Hydrogen peroxide	30,000 gallons	4,000 gallons	8
Aerophine 3418A	10,000 gallons	200 gallons	50
Sodium hypochlorite (additional for Alternative 2 water treatment chemical)	5,000-15,000 gallons		
Scale control reagents	5,000 gallons (lbs?)	500 gallons (lbs?)	10
Sulfuric acid (additional for Alternative 2 water treatment chemical)	1,700-2,400 gallons		
Solvents	1,000 gallons	200 gallons	5
Alternatives 1, 3, and 4 bulk liquid totals	7,722,000 gallons		1,139
Alternative 2 bulk liquid totals	9,256,700 gallons		1,312
Bulk solids and containers			
Antimony concentrate	Up to 29,200 tons	Up to 40 tons	365-730
Lime (Alternatives 1, 3, and 4)	70,000 tons	24 tons	2,917
Lime (Alternative 2)	21,240 tons	24 tons	885
Sodium metabisulfite	14,000 tons	24 tons	583
Grinding metals (steel balls for mill)	10,000 tons	24 tons	417
Ammonium nitrate	7,300 tons	24 tons	304
Sodium cyanide	3,900 tons	24 tons	163
Crusher and grinding liners	3,200 tons	24 tons	133
Copper sulfate	2,500 tons	15 tons	167
Potassium amyl xanthate	1,700 tons	15 tons	113

Table 13, continued.

Common name	Annual use	Typical vehicle payload	Estimated number of deliveries each year
Lead nitrate	700 tons	10 tons	70
Flocculant	600 tons	15 tons	40
Activated carbon	470 tons	10 tons	47
Sodium hydroxide	300 tons	10 tons	30
Explosives	100 tons	5 tons	20
Fertilizer	**~2,500 pounds**		**1**
Herbicides	**~1,000 pounds**		**1**
Sodium hypochlorite	**1,000 pounds**	**1,000 pounds**	**1**
Pesticides/insecticides	**~250 pounds**		**1**
Wastes containing mercury from ore processing (carbon canisters, filter packs, gas condensers)	Not quantified		
Alternatives 1, 3, and 4 solids totals	143,972 tons		>5,373
Alternative 2 solids totals	95,212 tons		>3,341
Alternatives 1, 3, and 4 bulk liquid and solid total trips/year			>6,512
Alternative 2 bulk liquid and solid total trips/year			>4,653

The total annual number of hazardous materials trips is 6,512 trips for Alternatives 1, 3, and 4 (an average of 17.8 trips per day if deliveries are received 365 days per year; an average of 23.6 trips per day for 6,147 loads of hazardous materials on 261 days per year, which excludes 365 daily trips hauling ore concentrate (USFS 2020, p. 2-64)) and 4,653 trips for Alternative 2 (12.7 trips per day on average if deliveries are received 365 days per year; an average of 16.4 trips per day for 4,288 loads of hazardous materials on 261 days per year, which excludes 365 daily trips hauling ore concentrate) (Table 13).

The total number of hazardous materials trips based on the number of loads for each reagent do not match the expected number of heavy vehicle round trips per year from Chapter 2 of the DEIS (USFS 2020) (Table 13). Chapter 2 of the DEIS shows that under Alternatives 1, 3, and 4, a total of 6,107 truck trips would be needed to bring fuel and miscellaneous supplies (522 trips) and ore processing supplies (5,220) to the mine site and haul away 365 loads of ore concentrate (USFS 2020, Table 2.3-7) (Table 9). Again in Chapter 2, under Alternative 2 with the changes for on-site lime production and water treatment plant chemicals, that value is 655 + 2,436 + 40 + 365 = 3,496 trips each year (USFS 2020, Table 2.4-3) (Table 9). Those values are lower than the totals shown Table 13 by 405 hazardous materials trips per year for Alternatives 1, 3, and 4 and by 1,157 trips per year for Alternative 2. For the remainder of this report I will base my calculations concerning hazardous spills along the transportation corridor on the number of truck trips from Table 13, which has a more detailed description of each reagent quantity and associated number of trips than is given in Table 9.

Bulk liquids

Transportation Research Board (2005)

> A fairly small number of commodities constitute the vast majority of hazardous materials moved in bulk in terms of weight. Gasoline, diesel, and home heating fuel are the most common hazardous cargoes moved in tank trucks. About 125 commodities account for 90 percent of shipments moved by railroad tank car, but 6 of these—liquefied petroleum gas, caustic soda, sulfuric acid, anhydrous ammonia, chlorine, and fuel oil—account for more than half of tank car shipments (AAR 2002).

For Alternatives 1, 3 and 4, a combined 6.86 million gallons of diesel, propane and gasoline would be required at the mine site. For Alternative 2, that increases to 8.323 million gallons each year. According to the Transportation Research Board (2005), "[a]bout 41% of the truck shipments of hazardous materials are petroleum products, and most of the remaining 59% are chemical and allied products." For the proposed SGP, the combined number of trips for diesel, propane, gasoline, lubricants, and waste oil represents 14.1% of the trips for Alternatives 1, 3, and 4, and 22.7% of the number of trips for Alternative 2.

USFS (2020), p. 2-59

> **DIESEL FUEL, GASOLINE, AND PROPANE**
> Aboveground storage tanks at the mine site would be used for fuels and other fluids, including gasoline, diesel fuel, lubricants, coolants, hydraulic fluids, and propane. Approximately 200,000 gallons of diesel fuel, 10,000 gallons of gasoline, and 30,000 gallons of propane would be stored at the mine site … The storage tank facility for gasoline, diesel fuel, and propane would be located near the maintenance workshop with additional propane storage at the ore processing facility area, the underground portal area, and the worker housing facility.

The quantities listed above for diesel, gasoline and propane (under Alternative 1) for storage at the mine site represent 3.4%, 2%, and 5.4% of the annual ore processing needs, respectively. With relatively little storage capacity at the mine site, either deliveries of these petroleum products will have to continue year-round, regardless of weather and road conditions, or other storage facilities will be needed. From 1980-2003, 27.88% of the oil spills of at least 50 gallons that reached US navigable waters within EPA Region 10, which includes Alaska, Idaho, Oregon and Washington, were from vehicles, and 57.09% were from spill prevention, control, and countermeasure (SPCC) facilities (Table 9 in Etkin 2006), rather than other sources such as pipelines, vessels, railways, etc., so truck transport and storage accounted for nearly 85% of the spill that reached streams.

The descriptions of how a release of hazardous materials, both for small releases <25 gallons and larger ones up to 10,000 gallons, would be handled are full of imprecise language, such as "could likely be contained" and "[s]pill response and recovery measures… may help to limit impacts."

USFS (2020), p. 4.7-10, 11

> The most probable release scenario associated with truck transport would be relatively small (for example, less than 25 gallons of fuel) and attributed to mechanical failure or human error. Under this scenario, immediate cleanup actions would typically include deployment of containment and spill recovery materials, and removal of impacted roadbed material. Material spilled to soils/roadbed could likely be contained and recovered, while material which enters waterways may be difficult or impossible to fully recover. Response actions would include notification to the appropriate regulatory agencies.
>
> Most small volume release scenarios would be temporary due to prompt response and cleanup actions; however, higher volume/lower probability spill scenarios could result in longer-term remedial actions and impacts. The risk of spills would last throughout the life of the SGP (long-term). Effects would generally be local and in close proximity to the release source in most scenarios; however, if surface or groundwater were to be impacted with fuels or other hazardous materials, the potential for migration beyond the local area could occur.
>
> A low probability fuel release of up to 10,000 gallons or large spill of concentrate could potentially occur assuming the complete failure of a bulk tanker truck or truck rollover or accident. Under this scenario, spilled material would be released to the immediate roadbed area, and potentially to nearby surface water depending on the topography and location. Spill response and recovery measures such as containment, deployment of absorbent materials, removal of impacted roadbed material and vegetation, and deployment of water-based spill recovery equipment (as needed) may help to limit

> impacts. Impacts to physical resources and ecological receptors (e.g., vegetation or wildlife) could be greater depending on the location of the spill.

While Tables 2.3-2 and 2.3-7 (USFS 2020) show 522 pilot vehicles to accompany 522 fuel and miscellaneous supplies trips during construction and operations (Alternative 1), the number of pilot vehicles is less than the number of trips required to bring bulk liquids to the mine site each year during operations. USFS (2020, p. 2-62) states under "Miscellaneous consumables", which include sulfuric acid and nitric acid, that

> [l]iquids would be shipped to the mine site in tank trucks designed for spill prevention and escorted to the mine site by pilot cars manned and equipped to handle spills. All reagents would be transported and stored in suitable containers in designated reagent storage areas.

If 5,800,000 gallons of diesel are used annually, that alone will require 580 trips (Table 13). The bulk liquids transported in the largest quantities and requiring the most trips are diesel, propane, gasoline, lubricants, and magnesium chloride. Overall, these five supplies total to 7,406,000 to 8,869,000 gallons to be transported annually, depending on the Alternative, and 928-1,061 trips of heavy vehicles transporting 3,000 to 10,000 gallons hazardous liquids each. From 1980-2003, 7,334,426 gallons of refined oil products spilled into inland from waterways from vehicles, an average of 305,601 gallons per year (Etkin 2006), indicating that vehicle spills of petroleum products are a risk that requires serious consideration.

USFS (2020), p. 2-62

> **MISCELLANEOUS OILS, SOLVENTS, AND LUBRICANTS**
> Various oils including motor oils, lubricants, antifreeze, and solvents would be shipped to the mine site on trucks. These would be stored in approved containers located within, or directly adjacent to, the maintenance shop and contained within secondary containments to prevent spills into the environment. All used petroleum products, waste antifreeze, and used solvents would be collected in approved containers, transported off site, and disposed or recycled.

Bulk solids

There are six reagents transported as bulk solids that would be brought to the mine in quantities requiring at least 100 truck deliveries per year (excluding grinding metals and crusher and grinding liners). They are lime, sodium metabisulfite, ammonium nitrate, sodium cyanide, copper sulfate, and potassium amyl xanthate. Overall, these six supplies total to 50,640 to 99,400 tons to be transported annually, depending on the Alternative, and 2,215-4,247 trips of heavy vehicles transporting 15 to 40 tons of hazardous solids each. When all the bulk solid hazardous materials to be transported are counted, there would be at least 5,373 trips per year for Alternatives 1, 3, and 4 and 3,341 trips per year for Alternative 2 (Table 13).

USFS (2020), p. 2-62 under "Miscellaneous consumables"

> Lime would be shipped in dry form in sealed trucks and would be stored in silos at the ore processing facility. Silos would be equipped with air emission controls.

USFS (2020), p. 2-62

> **EXPLOSIVES STORAGE**
> Ammonium nitrate would be received in bulk in tanker trucks and transferred into storage silos. Other blasting supplies used for mine blasting operations would include blasting emulsion products, detonating cord, cast primers, and blasting caps. These products would be delivered in boxes or other approved containers on trucks. Components of bulk explosive material would be stored in separate and isolated containers, sized and designed to meet Bureau of Alcohol, Tobacco, Firearms and Explosives and Mine Safety and Health Administration requirements. Explosive magazines for detonating cord, cast primers, and blasting caps also would be in a separate, fenced, and gated site away from the diesel fuel oil storage tanks and the ammonium nitrate silos, and other mine surface facilities.

USFS (2020), p. 2-62

> **MISCELLANEOUS CONSUMABLES**
> Sodium cyanide would be transported as dry cyanide briquettes to the mine site. Nitric and sulfuric acid would be transported in tanks designed to prevent spills even in the event of rollovers. Nitric and sulfuric acids would be stored in specialized non-corrosive, polyethylene-lined tanks located within the ore processing facility and would have secondary containment.

Safety data about some of the most transported reagents and antimony concentrate

I compiled information from the safety data sheets for the reagents from two commercial suppliers (IXOM Safety Data Sheets (https://www.ixom.com/sds-search) and EChemi Safety Data Sheets (http://www.echemi.com)), as well as a few other commercial sources (Appendix A). Reagents and other materials are listed in the same order in Appendix A as they are in Table 13, first by those transported in liquid forms and then those as bulk solids, in order of decreasing quantities to be used annually. Information about each reagent may include chemical classification, hazard and precautionary statements, chemical and physical properties, including stability and reactivity, and information about toxicity to humans and ecological effects, if known. A few details are given for seven reagents and for antimony concentrate below, but this is far from a complete description of the dangers these reagents may pose if there are accidental releases individually or in combination.

Diesel

USFS (2020), p. 4.12-22

> Past accident records indicate that of all the substances to be transported, diesel fuel may pose the highest risk to fish and fish habitat. This is because large quantities of diesel fuel are transported in each load, numerous trips are made each year, and the substance is a liquid that rapidly flows down gradient toward nearby streams.
>
> The intensity of the impact of a hazardous materials spill on fish and fish habitat could be high; as a large diesel spill could kill 100 percent of the Chinook salmon juveniles, adults, alevins, and eggs for a considerable distance (several miles) downstream of the accident (National Marine Fisheries Service [NMFS] 1995). In terms of toxicity to water-column organisms, diesel is one of the most acutely toxic oil types. Fish, invertebrates, and aquatic vegetation that come in direct contact with a diesel spill may be killed (U.S. Environmental Protection Agency [EPA] 2019). The severity of the impact would depend on the timing, size, and location of the spill. Small spills in deep open waters are expected to rapidly dilute; however, fish kills have been reported for small spills in confined, shallow water (EPA 2019).

Diesel is a flammable liquid, may be fatal if swallowed, and is acutely and chronically toxic to aquatic life. (See Appendix A.)

Propane

Propane is an extremely flammable gas and an asphyxiant. It can react violently with chlorine and with nitric acid, is incompatible with oxidizing agents, and produces carbon dioxide when it decomposes. (See Appendix A.)

Gasoline

Gasoline is also extremely flammable and harmful or fatal if swallowed. It contains benzene, which is a known human carcinogen. Gasoline is incompatible with strong oxidizers and will form nitrocresols if it comes in contact with nitric or sulfuric acids. (See Appendix A.)

Ammonium nitrate

One of the supplies needed in substantial quantities every year is ammonium nitrate, which would be used in combination with diesel fuel oil for blasting. The annual usage of ammonium nitrate proposed for SGP is 7,300 tons, with 200 tons stored at the mine site at a time (USFS 2020, Table 2.3-6 on p. 2-60). Following the correct storage protocols for ammonium nitrate is critical for safety. On August 4, 2020, 2,750 tons of ammonium nitrate that had been stored at a port in Beirut, Lebanon since November 2013 exploded and a two-mile radius around the blast was flattened (*New York Times*). Domestic explosions of ammonium nitrate have also occurred. The *New York Times* described the explosion of 540,000 pounds (270 short tons) ammonium nitrate at a fertilizer storage plant in West, Texas on April 17, 2013, which registered as a 2.1 earthquake on the Richter scale. In that case the ammonium nitrate was stored on site with 110,000 pounds (55 short tons) of anhydrous ammonia. (See also Appendix A.)

Sodium cyanide

Sodium cyanide is corrosive to metals and acutely toxic to humans and to aquatic organisms. It can have long term effects on aquatic life. Contact with water or acids liberates toxic gas. (See Appendix A.)

Copper sulfate

Copper sulfate is very toxic to aquatic life with long lasting effects. (See Appendix A.)

Potassium amyl xanthate

Potassium amyl xanthate is toxic, self-heating in large quantities, and can potentially spontaneously combust. It reacts exothermically with water, is incompatible with oxidizing agents, acids, and water, and can have hazardous decomposition products. (See Appendix A.)

Antimony concentrate

USFS (2020), p. 2-31

> **ANTIMONY CONCENTRATE TRANSPORT**
> The antimony concentrate would contain approximately 55 to 60 percent antimony by weight. The remaining balance, 40 to 45 percent by weight, of the concentrate includes common rock forming minerals with trace amounts of gold, silver, and mercury. The concentrate would be in 1 to 2 ton super sacks and transported on flatbed trailers from the mine site for off-site smelting and refining. An estimated one to two truckloads of antimony concentrate, containing up to 20 supersacks per truckload, would be hauled off site each day. The antimony concentrate would be transported via Burntlog Route to State Highway 55, and then to a commercial barge or truck loading facility depending upon the refinery location. It is assumed that the concentrate, when sold, would be shipped to facilities outside of the U.S. for smelting and refining because there are currently no smelters in the U.S. with capacity for refining the antimony concentrate.

USFS (2020), p. 4.12-40

> Numerous studies have shown how exposure to toxic contaminants in surface waters can impact fish olfaction which is used in mating, locating prey, and avoiding predators (Tierney et al. 2010).

USFS (2020), p. 4.12-43

> Antimony does not have a specified NMFS or USFWS standard and is based on EPA's human health chronic criterion for consumption of water and organisms is 0.0056 mg/L.

Questions that remain about the reagent quantities, truckloads, and storage

How does the storage capacity at mine compare to the usage needs in the event driving may be hazardous/delayed over winter months; how does that compare to storage capacity at SGLF?

Will HazMats get consolidated on trucks if they arrive to the SGLF in small enough quantities?

What are the chances of HazMat spills of multiple substances either due to consolidation of multiple reagents in a single truck or due to multiple vehicle accidents if there are caravans of bulk liquid trucks following pilot vehicles?

Total mine related traffic

Using the more detailed list of annual trips needed for each reagent gave a more complete picture of the number of heavy vehicles that would travel to the mine site. Table 14 is an updated version of Table 9 in which hazardous materials are a combined total of fuel and miscellaneous supplies, ore processing supplies, water treatment chemicals, and ore concentrate haulage. Based on Table 14, 25.9-30.5% of mine traffic would be light vehicles and 69.5-74.1 % would be heavy vehicles, depending on the Alternative. For Alternatives 1, 3, and 4, 72% of heavy vehicles would be carrying hazardous materials to or from the mine site. For Alternative 2, 64.8% of heavy vehicles would be carrying hazardous materials to or from the mine site. (Such vehicles would likely only be carrying hazardous materials on one leg of a round trip.)

Table 14. Heavy vehicles vs. light vehicles during mine operations using HazMat trips from Table 2.3-6 and other traffic from Tables 2.3-7 and 2.4-3.

	Alternative 1	Alternative 2
Light vehicles		
Crew personal vehicles	651	651
Salaried employees	417	417
Pilot vehicle (fuel and hazardous materials)	522	522
Equipment and supply representatives	522	522
Miscellaneous traffic	1,044	1,044
Total annual light vehicles (% of total)	3,156 (25.9%)	3,156 (30.5%)
Heavy vehicles		
Hazardous materials, incl. ore concentrate	6,512	4,653
Crew bus/van transport to site	287	287
Salaried employees bus/van transport to site	104	104
Machine parts and consumables	730	730
Food delivery	522	522
Trash and recyclables	156	156
Road maintenance	730	730
Total annual heavy vehicles (% of total)	9,041 (74.1%)	7,182 (69.5%)
Total annual vehicles	12,197	10,338

Comparison to Pogo Mine reagent list, HazMat transport, and mine traffic

To compare reagent use and transport for Pogo Mine and SGP, I estimated the number of truckloads per year for reagents and supplies for two different daily processing rates at Pogo. I used a default capacity of 20 tons per truckload for everything but cement and (diesel) fuel. The list of hazardous materials used as reagents at Pogo Mine has a substantial overlap with the list of reagents proposed for use at SGP. The SGP would use more tons of lime, sodium cyanide, sodium metabisulfite, flocculant, and sodium hydroxide in each year than Pogo. Assuming that mine "consumables" for Pogo are not hazardous materials, 545 truckloads of hazardous materials were slated to be brought to Pogo Mine annually under the 2,500 tpd scenario, a figure that increases to 878 truckloads per year in the 3,500 tpd scenario. Under the 3,500 tpd scenario, the Pogo Mine EIS description requires 13-19% of the number of annual hazardous material truck trips that would be needed at the SGP for processing 20,000-25,000 tons of ore per day (Midas Gold 2016). (Note that 3,500 tpd/25,000 tpd = 14%, so the scale of reagents used to ore processed is similar for the two mines. The values for Pogo Mine do not include the possibility of on-site power generation, which would require another 525 truckloads of diesel each year.) At Pogo Mine, trucks with hazardous materials account for 42.2 to 43.8% of the vehicles listed in Table 15, depending on the amount of ore processed per day. (Again, such vehicles would likely only be carrying hazardous materials on one leg of a round trip.)

Table 15. *Pogo Mine supplies and hazardous material quantities and annual truck trips (EPA 2003, p. 2-34, Table 2.3-3 and Table 4.3-15). Values in bold are from EPA (2003). Shaded rows represent hazardous materials.*

Commodity	2,500 tpd scenario			3,500 tpd scenario		
Mine	tons/yr	tons/truck	trucks/yr	tons/yr	tons/truck	trucks/yr
Cement	**14,000**	**27**	**520**	**21,000**	**27**	780
Propane	**2,000**	20	100	**4,000**	20	200
Consumables	**4,000**	20	200	**6,000**	20	300
Explosives	**1,000**	20	50	**1,500**	20	75
Subtotal	**21,000**		870	**32,500**		1,355
Mill						
Grinding Media and Liners	2,000	20	100	3,000	20	150
Mill Reagents	tons/yr	tons/truck	trucks/yr	tons/yr	tons/truck	trucks/yr
Lime	**1,000**	**20**	**50**	**1,500**	**20**	75
Sodium cyanide	**1,000**	**20**	**50**	**1,500**	**20**	75
Sodium metabisulfite	**1,000**	**20**	**50**	**1,500**	**20**	75
Sulfuric acid	**500**	**20**	**25**	**750**	**20**	38
Aero Promoter 208	**68**	20	4	**96**	20	5
MIBC	**64**	20	4	**89**	20	5
Flocculant	**55**	20	3	**77**	20	4
Copper sulfate	**50**	20	3	**75**	20	4
Potassium amyl xanthate	**41**	20	2	**57**	20	3
Sodium hydroxide	**30**	20	2	**45**	20	3
Nitric acid	**20**	20	1	**30**	20	2
Activated carbon	**5**	20	1	**10**	20	1
Subtotal	**3,833**		195	**5,729**		290
Fuel	gal/yr	gal/truck	trucks/yr	gal/yr	gal/truck	trucks/yr
Diesel	**786,000**	**8,000**	**100**	**1,300,000**	**8,000**	163
	tons/yr	tons/truck	trucks/yr	tons/yr	tons/truck	trucks/yr
Spare Parts	**250**	20	13	**400**	20	20
Food & Camp Supplies	**290**	20	15	**500**	20	25
Total HazMat trucks/yr (%)			545 (42.2%)			878 (43.8%)
Total	**30,173**		1,293	**46,749**		2,003

Summary

More than 30 different hazardous materials will be brought to and from the mine site if the SGP is approved. Those hazardous materials include fuels, explosives, acids, and toxic materials, but the dangers posed by the reagents are not discussed. Under Alternatives 1, 3, and 4, more than 7.7 million gallons of bulk liquid hazardous materials in at least 1,100 truckloads and more than 143,000 tons of bulk solid hazardous materials in at least 5,300 truckloads will be transported along the transportation corridor every year. Under Alternative 2, more than 9.2 million gallons of bulk liquid hazardous materials in at least 1,300 truckloads and more than 95,000 tons of bulk solid hazardous materials in more at least 3,300 truckloads will be moved along the transportation corridor annually. Although the SGP DEIS promises that there will be a pilot vehicle to accompany bulk liquid transport, only 522 pilot cars are shown in traffic impact studies. Spills from SPCC facilities may be twice as likely as spills from vehicles, but the SGP DEIS did not discuss the possibility of spills from storage facilities.

5. Hazardous materials risk modeling peer-reviewed literature and models

There are decades of research and peer-reviewed models for quantifying the risks of transporting hazardous materials and finding optimal routes.

Erkut and Verter (1998)

> The routing of hazardous materials is an important decision problem that is of interest to hazmat producers and consumers, hazmat carriers, local governments, insurance companies, and the people exposed to the risks from the shipments.

Erkut and Verter (1998)

> The modeling of transport problems is a popular application area in OR. In most transport planning models, the objective is to move products from origins to destinations at minimal cost. However, for hazmat shipments, a cost-minimizing objective is usually not suitable. The risk associated with hazmats makes these problems more complicated (and more interesting) than many other transport problems.

Definition of risk

Risk models in the peer-reviewed literature are nearly always a function that represents both the probability of an incident, like a spill, occurring and the consequences of such an event. The idea that risk is a product of two elements is found in the public health rating matrix shown in Section 4.19 (USFS 2020, p. 4.19-3), reproduced as Table 16. No quantitative ranges were cited for what constitutes unlikely, sometimes likely, and often likely occurrences, but it would be possible to assign such ranges, which may be context-dependent, in a fashion similar to Tables 2 and 3.

Table 16. Public health rating matrix (USFS 2020).

Magnitude of Health Impact	Low possibility of health impact occurrence (unlikely to occur)	Medium possibility of health impact occurrence (likely to occur sometimes)	High possibility of health impact occurrence (likely to occur often)
None	negligible	negligible	negligible
Low	negligible	minor	moderate
Medium	minor	moderate	major
High	moderate	major	major

Etkin (2006), emphasis in the original

> Risk assessment incorporates an evaluation of both the *probability* and *consequences* of particular events. Wtih (*sic*) oil spills, risk assessment requires looking at the *frequency* of spill incidents from historical spill rates, as well as measuring the *consequences* or *potential impacts* (costs and damages) of spill incidents. Impacts vary with oil type, spill magnitude, and a variety of location-related factors (*e.g*., sensitive natural and socioeconomic resources, waterway type).

Erkut and Verter (1998), emphasis added

> [T]here is no agreement among researchers on the proper representation of the associated transport risks… Although risk is a popular term in the media, and a popular topic with many authors, there is no universally accepted definition of risk. Most people would agree that risk has to do with the probability and the consequence of an undesirable event. Although some authors define risk as only one of these terms (i.e., probability or consequence), *it is more common to define risk as the product of both the probability of and the consequence of the undesirable event (Covello and Merkhofer 1993). Note that this is an "expected consequence" definition, and it is the definition that we refer to as "traditional risk" in this paper (primarily for the reason that it is the definition used in the U.S. Department of Transportation 1989 guidelines for transporting hazmats, which have influenced many researchers in this area).* We emphasize that, depending on the circumstances, it might make sense to use other definitions of risk.

Kazantzi et al. (2011)

> The problem of identifying potential risks and their consequences in Hazardous Material (HazMat) transportation has been a great concern and largely acknowledged by many researchers, government bodies, regulatory authorities and the public in general as one of the main issues in the broader field of transportation security (List et al., 1991).

Barilla et al. (2009)

> In the planning of routes, in order to justify the route of minimal risk between [the origin] O and [the destination] D, it is necessary to identify the "risk factors" (hazard, vulnerability, and exposure) which must be considered to achieve the objective. Risk can be defined as the expected consequences associated with a given activity.

Qiao et al. (2009)

> Risk is a combination of two parameters: frequency and the magnitude of the consequence.

Goals of quantitative risk analysis

Erkut and Verter (1998)

> Although most researchers agree on the need to include risks in route selection for hazmat transport, they do not agree on how transport risk should be modeled. We discussed five different models: traditional risk, population exposure, incident probability, perceived risk, and conditional risk…. we searched for answers to the following two questions: "How similar are the paths found by different objectives for a given origin-destination pair?" and "How does the optimal solution for one objective perform under the other objectives?" Our analysis was performed using a professional decision-support system for hazmat route selection. … We found that the optimal paths with respect to the three fundamental risk models— namely, minimizing the traditional definition of risk, minimizing total incident probability, and minimizing total population exposed—do not exhibit strong similarities…. Based on our analysis, we conclude that considerable attention should be paid to the modeling of risk for hazmat transport since the different objectives that are suggested in the literature cannot be used interchangeably. Different models result in different paths, and the models do not tolerate one another very well.

Erkut and Verter (1998)

> One can argue that lower incident probabilities should be preferred to higher ones, and lower population exposures should be preferred to higher ones. Thus, we can view the risk minimization problem as a bicriterion optimization problem: one of minimizing incident probability and population exposure.

Erkut et al. (2007)

> *Quantitative risk assessment* (QRA) involves the following key steps:
>
> (1) hazard and exposed receptor identification;
> (2) frequency analysis; and
> (3) consequence modeling and risk calculation.

Kazantzi et al. (2011)

> A generic framework for risk evaluation can be formulated in three stages (Barnhart and Laporte, 2007):
>
> - evaluation of the probability of an undesirable event (for example, an incident with a release of a harmful material)

> • determination of potential exposure level of the population and the environment, given the nature of the event
> • estimation of the magnitude of the consequences (e.g. deaths, injured people, damages) given the exposure level.

Erkut et al. (2007)

> The language of QRA is one of *frequencies* and *consequences*, and unlike in qualitative risk analysis, QRA results in a numerical assessment of risks involved, for example, an expected number of individuals impacted per year. In the next two sections we discuss frequency analysis and consequence modeling along with risk calculation.

Impacts and consequences to consider and model

Erkut and Verter (1998)

> [I]n route evaluation and selection models… are network optimization models, where roads are represented as edges of the network. In the context of hazmat routing it is desirable for an edge to be relatively uniform in its two important attributes: incident probability and population density around the roads.

Erkut and Verter (1998)

> Risk modeling objectives can include minimizing one or more of the following:
>
> 1. Shortest travel distance,
> 2. Minimum population exposure,
> 3. Minimum societal risk,
> 4. Minimum DoT risk,
> 5. Minimum accident probability, and
> 6. Minimum incident probability.

Barilla et al. (2009) demonstrated how to consider several risk measures to minimize (travel time, travel distance, risk for the population, risk for the urban environment, and risk related to a natural hazard) coupled with a matrix describing the relative weight each of those metrics. Barilla et al. (2009) note that "The objectives are not fixed; they reflect the interests of stakeholders in the decision-making process."

Erkut and Verter (1998)

> Although there can be many undesirable consequences of an incident (such as damage to wildlife, economic losses, and injuries), almost all the literature in this area is concerned

> with fatalities. Hence, it is common to assume that the undesirable consequence is proportional to the size of the population in the neighborhood of the incident, where the size of the neighborhood depends on the substance carried.

Inanloo et al. (2015)

> Impacts of hazardous material releases during transport depend on the characteristics of the cargo, incident location and time, weather conditions (i.e., wind direction and speed), and land use.

Erkut et al. (2007)

> Risk is the primary ingredient that separates hazmat transportation problems from other transportation problems. … In the context of hazmat transport, risk is a measure of the probability and severity of harm to an exposed receptor due to potential undesired events involving a hazmat (Alp, 1995). The exposed receptor can be a person, the environment, or properties in the vicinity. The undesired event in this context is the release of a hazmat due to a transport accident. The consequence of a hazmat release can be a health effect (death, injury, or long-term effects due to exposure), property loss, an environmental effect (such as soil contamination or health impacts on flora and fauna), an evacuation of nearby population in anticipation of imminent danger, or stoppage of traffic along the impacted route. Risk assessment can be qualitative or quantitative. Qualitative risk assessment deals with the identification of possible accident scenarios and attempts to estimate the undesirable consequences.

Frequency analysis

Deriving an estimate of spill probability (or frequency) is an essential first step. Models for spill probability range from very simple to very specialized and detailed.

Erkut et al. (2007)

> The frequency analysis involves (a) determining the probability of an undesirable event; (b) determining the level of potential receptor exposure, given the nature of the event; and (c) estimating the degree of severity, given the level of exposure (Ang and Briscoe, 1989). Each stage of this assessment requires the calculation of a probability distribution, with stage (b) and (c) involving conditional distributions.

Qiao et al. (2009)

> [A]ccident frequency estimation is essential for risk analysis.

Qiao et al. (2009)

> Currently, the most popular data cited for accident frequency takes only a few factors into consideration. This paper presents a methodology to estimate the accident frequency for different types of roads by incorporating the effects of a larger number of parameters, including the nature of truck configurations, operating conditions, environmental factors, and road conditions.

Qiao et al. (2009)

> Accident frequency can be defined as the number of accidents per unit of road (mile, kilometer, etc.). The frequency can be computed by dividing the number of accidents by the number of vehicle miles, which is the corresponding exposure measure of opportunities for an accident to occur. There are three basic options to assess accident frequency with reasonable accuracy. The first is to obtain at least one database and analyze both accident data and travel data for the specific conditions under investigation (assuming that the dataset is structured to support distinctions between the desired variables). The second option is to access state databases for specific routes. Frequently, states have accident data and travel data for major state highways. A third option is to use an existing limited analysis of databases and apply the results to a specific route of interest. All three options are harnessed in this work.

Kazantzi et al. (2011)

> There is a double-centered arena of HazMat transportation problems; one considered with optimal transportation routing and the other with risk probabilities evaluation of HazMat transportation.

Models of risk

Models vary in how they incorporate consequences into the math, depending on the priorities of the specific application. Erkut and Verter (1998) identified five models for quantifying risk along different potential routes that hazardous materials might travel: traditional risk, population exposure, incident probability, perceived risk, and conditional risk. Erkut et al. (2007) expanded the list to nine models by adding maximum population exposure, expected disutility, mean-variance, and demand satisfaction models. Only one of these formulations, the population exposure model, did not include some form of *p*, the probability of an incident along a route segment (Table 17).

Table 17. Various models of path risk shown in Erkut et al. (2007). In these models p_i *is the probability of an incident along segment* i*, and* c_i *is a measure of the consequence (e.g., population size that would be affected) along segment* i *for path segments 1 to* n*.*

Model	Approximation formula	Notes
Traditional risk	$\sum_{i=1}^{n} p_i c_i$	Used by the Department of Transportation
Population exposure	$\sum_{i=1}^{n} c_i$	Measures the total consequence along the entire route
Incident probability	$\sum_{i=1}^{n} p_i$	Measures the total probability along the entire route
Perceived risk	$\sum_{i=1}^{n} p_i {c_i}^{\alpha}$	$\alpha > 0$; allows the modeler to increase the importance of the consequence as it gets larger
Conditional risk	$\frac{\sum_{i=1}^{n} p_i c_i}{\sum_{i=1}^{n} p_i}$	Addresses the size of the consequence if it known that an event will occur
Maximum population exposure	$\max e_i \in pc_i$	Finds the largest consequence along the route
Expected disutility	$\sum_{i=1}^{n} p_i \left(\exp\left(\alpha c_i\right) - 1\right)$	$\alpha > 0$; “incorporates the risk aversion of the society toward hazmat incidents, especially incidents with very large consequences”
Mean-variance	$\sum_{i=1}^{n} (p_i c_i + \beta p_i {c_i}^2)^4$	$\beta > 0$; “identifies the least expected length path subject to the constraint that the variance of the path length is within a pre-specified threshold”
Demand satisfaction	$\sum_{i=1}^{n} (1 - \exp(-p_i)) c_i \prod_{j=1}^{n} \exp(p_i)$	Considers that additional shipments will be necessary following an incident to fill the demand that went unmet due to the event

Erkut et al. (2007)

> Given the large number of papers in this area, we believe a simple classification can be useful in providing some structure to the rest of the chapter. The articles in this area deal with different aspects of the problem. One possible classification is the following (in no particular order):
>
> (1) risk assessment,
> (2) routing,
> (3) combined facility location and routing,
> (4) network design.
>
> Although we have offered this simple classification, it is fair to say that numerous papers deal with problems that lie at the intersection of the above areas and such problems are receiving increasingly more attention in the literature.

See Table 2a (Erkut et al. 2007) for a list of peer-reviewed papers on the topic of risk assessment for hazardous materials transportation by road published from 1973-2004.

Inanloo et al (2015)

> The health risks were calculated for the two chemicals and under different atmosphere stability scenarios. Two approaches were taken into account in order to estimate the risk, which are based on the size of the impact area and the population under risk. The size of the area impacted after a chemical release depends on the characteristics of the chemical along with the meteorological and atmospheric conditions. However, the magnitude of the population exposed depends on the population density in the surrounding area. In this regard, a similar an accidental release in two different locations would affect similar square miles but different number of people depending of the populations density (i.e., rural, urban).

Inanloo et al (2015)

> The analyses showed that the impact zones can be significantly different for different types of hazardous cargo. …. The overlay of the toxic threat zone plots over the GIS map of the accident location provided an effective tool to visualize the geographical domain affected by the release (number of people exposed, age distribution of the exposed population, potential secondary exposure routes such as water and soil). …. The health risks estimated based on the area and population at risk showed the significance of the consequences of the accidental releases. The analyses showed that the risk which is quantified for a specific consequence can be different from the risk quantified based upon another type of consequence (e.g., impacted area vs. population). … Therefore, a great consideration should be focused on the selecting of the consequences of accidents. The results vary depending on the released chemical, atmospheric condition, location, traffic

> volume, and crash rate data. … Considering uncertainties and lack of data, risk assessments similar to the proposed approach can help to decrease the accidental release risks of hazardous chemicals during transport by avoiding densely populated areas or segments with high crash rates, as well as selecting specific paths or road segments based on their level of accident risks. The multilevel analysis of impacts after hazardous material releases during transport (i.e., type of material, geographical data, dispersion profile, meteorological information, population density, and traffic data) can be used for planning and implementing appropriate response and mitigation measures for hazardous cargo releases to atmosphere. The insights provided by this research can aid decision makers for routing and scheduling of hazardous material cargos and developing strategies which avoid high-risk and vulnerable regions for transporting hazardous materials.

Summary

Kazantzi et al. (2011)

> [HazMat] can be extremely harmful to the environment and to human health, and although this situation corresponds to a low probability - but high consequence - transportation risk event, the attendant risk level needs to be assessed and characterized even in the absence of sufficient data for the quantification of all parameters involved.

Kazantzi et al. (2011)

> The estimated value of risk may be considered either in an absolute sense, or as a quantitative comparative representation between different alternatives for risk screening and classification risk purposes or finally as a means to compare different solutions assuming in an analyzed road network various routes linking two set points and assessing the value of risk for each.

Barilla et al. (2009)

> [The] estimated value of risk *R* may be considered in an absolute sense or to represent a term of comparison between different alternatives and to evaluate if the risk is more or less tolerable or to compare different solutions, assuming in analyzed road network various routes linking the two set points and assessing the value of risk for each.

Not only can risk modeling be used to compare the four action Alternatives in the SGP DEIS, but also to measure the risks as compared to the No Action Alternative. Although formulations for risk vary and can incorporate a range of consequences (safety, environmental harm, etc.), having a measure of the spill frequency is an essential component of the analysis.

6. Potential transportation corridor endpoints

Cascade, Idaho is not currently a hub for the manufacturing, storage, or distribution of many industrial reagents used in mining. Therefore, although the analysis area for hazardous materials only includes the mine site and haul roads on it, the SGLF, access roads from Cascade to the mine site, and associated streams that might be impacted, the USFS (2020, p. 4.7-4) notes that "national highways would be used to transport materials to the SGP area as far as Cascade, Idaho." There was no attempt in the DEIS to characterize points of origin for the reagents that will be needed or destinations for the mine products, either those for sale or waste materials.

The goal of this section is to find the nearest distribution point for each of the reagents and supplies listed in Section 4 to determine minimum exposures for the number of truck-miles that hazardous materials will be transported for the SGP. In a simple analysis of spill probability that does not assign different spill likelihoods to different route segments, shorter route distances lead to lower spill frequencies. Estimates of spill risk based on the sources and destinations closest to Cascade, Idaho will underestimate the actual risk to the extent that the distances used in the model underestimate the actual distance hazardous materials are transported.

Transportation Research Board (2005)

> According to the U.S. Department of Commerce's Commodity Flow Survey, more than 14,000 establishments in the country are engaged in the manufacture of hazardous materials (Census Bureau 2003; RSPA 2003). DOT estimates that about 45,000 firms regularly ship significant quantities of hazardous materials and that another 30,000 are occasional shippers (RSPA 2003). These estimates do not take into account the multiple business locations of many shippers, which can result in many more shipping points. Shippers of large quantities of hazardous materials include oil refiners chemical manufacturers, and gasoline distributors. … Between the time a hazardous materials shipment leaves its place of origin and arrives at its final destination, it may pass through several modes of transportation and transfer point.

Erkut et al. (2007)

> Hazmat transport incidents can occur at the origin or destination (when loading and unloading) or *en-route*. Incidents involving hazmat cargo can lead to severe consequences characterized by fatalities, injuries, evacuation, property damage, environmental degradation, and traffic disruption. In 2003, there were 488 serious incidents (among a total of 15,178 incidents) resulting in 15 deaths, 17 major and 18

> minor injuries, and a total property damage of $37.75 million (US DOT, 2004c). About 90% of hazmat incidents occur on highways. As far as causes go, human error seems to be the single greatest factor (see Figure 2) in all hazardous materials incidents (minor and serious incidents).

I searched for the chemical reagents listed in Table 13 on

https://www.thomasnet.com/products/mining-chemicals-13860325-1.html#register

to find the suppliers within specified radii of Cascade, Idaho (ZIP code 83611). The radius distance choices I checked were <100 miles, <250 miles, <500 miles, and <1,000 miles. The distance categories were inclusive, so the number of distributors inside the 100-mile radius was part of the total number of suppliers in each of the larger radii (Table 18). I used Google maps to find the distance between a distributor in the shortest radius category and Cascade, Idaho. These are example distances; the actual supply chain sourcing used by the Applicant may vary from this (and over time) if the permit is approved.

Table 18 does not include mine reagents and supplies that were listed generically (solvents, lubricants, flocculent, fertilizers, explosives, herbicides, and pesticides/herbicides), grinding and crushing materials, hazardous materials being transported from the mine during operations (antimony concentrate, wastes containing mercury), or Aerophine 3418A. Later modeling will use Boise, Idaho as the assumed distribution point for these substances as a reasonable general minimum distance from Cascade, Idaho for computing the total miles hazardous materials travel. (See Sections 7 and 10.)

Based on the example distributor locations in Table 18, I looked at the expected proportions of hazardous materials that would travel north or south on SH-55 to Cascade, Idaho (Table 19). The assumption in the DEIS is that "[a]pproximately two-thirds of all mine-related traffic would originate south of Warm Lake Road and would use State Highway 55 through Cascade and other communities along State Highway 55 south of Cascade including Banks and Horseshoe Bend. Approximately one-third of all mine-related traffic originating north of Warm Lake Road would use State Highway 55 through the communities of Donnelly, Lake Fork, and McCall" (USFS 2020, p. 2-63). It was not possible to determine exactly how many hazardous materials trips would be using SH-55 north or south of Cascade because the distribution points shown are example origins or destinations, some distribution points west of Cascade could travel north or south on SH-55 depending on the route chosen (US-95 through Weiser, Idaho and I-84 though Ontario, Idaho have similar distances and travel times), and I was unable to determine sources for several reagents and supplies. Under Alternative 1, if lime is sourced from a distributor in Greenacres, Washington at least 55.9% of hazardous materials traffic will travel on SH-55 north of Cascade, Idaho (Table 19). The reduction of lime transportation in Alternative 2 drops that to 37.7%, even if propane's distribution point is north of Cascade. Under Alternative 1, a minimum of 15.4% to a maximum of 45.1% of hazardous materials would travel on SH-55 south of Cascade, well less than the approximately two-thirds stated for mine traffic overall. Under Alternative 2, a minimum of 21.9% to a maximum of 62.3% of hazardous materials would travel on SH-55 south of Cascade; the maximum value nears the approximately two-thirds fraction stated in the DEIS for all mine traffic.

Table 18. Hazardous materials to be transported to the proposed SGP Project during operations. Compiled from Tables 2.3-6, 4.7-1, 4.7-2 (USFS 2020). Supplier list, distance ranges, and locations from Thomasnet.com, accessed September 21, 2020. Distance from location listed to Cascade, Idaho 83611 from Google maps. Lubricants, Aerophine 3418A, solvents, grinding metals, crusher and grinding liners, flocculant, explosives, fertilizer, herbicides, pesticides/insecticides would also be brought to the mine site. Antimony concentrate, wastes containing mercury, and water treatment plant sludges and wastes (under alternative 2) would be transported away from the mine site.

Common name	Number of commercial suppliers listed within *x* miles of 83611 (Cascade, Idaho)				Potential nearest distributor location	Distance to nearest distributor from 83611 (miles)
	100	250	500	1,000		
Bulk liquids						
Diesel fuel	0	4	43	115	Baker City, OR	176
Propane	3	12	58	128	McCall, ID	31
Gasoline	2	18	111	279	Caldwell, ID	90
Magnesium chloride	0	0	7	15	Richland, WA	326
Nitric acid	1	2	5	14	Boise, ID	79
Ferric sulfate	0	0	1	3	Renton, WA	499
Sulfuric acid	1	1	6	15	Boise, ID	79
Methyl isobutyl carbonyl (MIBK)	0	0	1	2	Seattle, WA	500
Antifreeze	0	0	5	11	Salt Lake City, UT	420
Hydrogen peroxide	1	2	14	44	Boise, ID	79
Sodium hypochlorite	0	0	5	12	Portland, OR	479
Scale control reagents	0	0	0	4	Fortuna, CA	724
Bulk solids and containers						
Lime	0	0	7	10	Greenacres, WA	298
Sodium metabisulfite	0	0	2	7	Seattle, WA	500
Ammonium nitrate	0	0	0	6	Suisin City, CA	665
Sodium cyanide	0	0	2	5	Winnemucca, NV	326
Copper sulfate	0	0	5	13	Salt Lake City, UT	420
Potassium amyl xanthate	0	0	0	2	Gardena, CA	923
Lead nitrate	0	0	0	1	Gardena, CA	923
Activated carbon	0	0	29	70	Yakima, WA	401
Sodium hydroxide	0	0	6	17	Renton, WA	499

Table 19. Percentage breakdown of hazardous material travel on SH-55 north and south of Cascade, Idaho using potential nearest distributor locations from Table 18. Shaded cells show where Alternative 2 differs from Alternative 1.

Origin/destination city	Substance	Number of annual trips	
		Alternative 1	Alternative 2
Origin/destination cities with trucks traveling north to/south from Cascade, Idaho			
Boise, Idaho	hydrogen peroxide	8	8
Boise, Idaho	sulfuric acid	20	33
Boise, Idaho	nitric acid	38	38
Caldwell, Idaho	gasoline	100	100
Fortuna, California	scale control reagents	10	10
Gardena, California	lead nitrate	70	70
Gardena, California	potassium amyl xanthate	113	113
Salt Lake City, Utah	antifreeze	13	13
Salt Lake City, Utah	copper sulfate	167	167
Suisin, California	ammonium nitrate	304	304
Winnemucca, NV	sodium cyanide	163	163
Total trips (% of all HazMat truck trips)		1,006 (15.4%)	1,019 (21.9%)
Origin/destination cities with trucks traveling south to/north from Cascade, Idaho			
Greenacres, Washington	lime	2,917	885
McCall, Idaho	propane	93	226
Renton, Washington	ferric sulfate	0	13
Renton, Washington	sodium hydroxide	30	30
Seattle, Washington	Methyl isobutyl carbonyl (MIBK)	18	18
Seattle, Washington	sodium metabisulfite	583	583
Total trips (% of all HazMat truck trips)		3,641 (55.9%)	1,755 (37.7%)
Origin/destination cities with trucks traveling either north or south to/from Cascade, Idaho			
Baker City, Oregon	diesel	580	580
Portland, Oregon	sodium hypochlorite	1	14
Richland, Washington	magnesium chloride	56	56
Yakima, Washington	activated carbon	47	47
Total trips (% of all HazMat truck trips)		684 (10.5%)	697 (15.0%)

Origin/destination city assumed to be Boise, Idaho for exposure miles modeling			
	fertilizer	1	1
	herbicide	1	1
	pesticide/insecticide	1	1
	solvents	5	5
	explosives	20	20
	flocculent	40	40
	waste oil	49	49
	Aerophine 3418A	50	50
	lubricants	99	99
	crusher and grinding liners	133	133
	antimony concentrate	365	365
	grinding metals	417	417
Total trips (% of all HazMat truck trips)		1,181 (18.1%)	1,181 (25.4%)
Total trips (% of all HazMat truck trips)		6,512	4,652

Summary

I was able to find potential distributor locations nearest to Cascade, Idaho for 21 supplies that would be used at SGP. Only five supplies (propane, gasoline, nitric acid, sulfuric acid, and hydrogen peroxide) were available within 100 miles of Cascade, Idaho. Diesel fuel was available inside a 250-mile radius. The remaining reagents I was able to find distributors for were only available from cities that were up to 500 or 1,000 miles away. Supplies would travel on SH-55 both north and south of Cascade. The percentage of heavy vehicles carrying hazardous materials on SH-55 north or south of Cascade depends on which Alternative is considered, the source cities for lime and propane, and how accurate the assignment of Boise, Idaho is as the source/destination city to estimate the travel direction for all the materials that I was unable to find distribution points for.

7. Transportation corridor lengths and exposure

In this section I calculate exposure variables (e.g. number of truck-miles per year and for the project lifetime) based on supply endpoints and quantities to be moved. First, I compared the lengths of routes from Cascade, Idaho to the proposed mine site. The distances shown are from Table 3.16-1: Existing Primary Roads in the Analysis Area. Roads in *italics* are categorized in the Forest Service Handbook as maintenance level 3 or lower. (Higher ratings indicate roads designed more for passenger vehicles use and comfort.)

Yellow Pine Route

To State Highway 55, just north of Cascade, Idaho – varies; see Table 18

Warm Lake Road (county road 10-579)	34 miles
Johnson Creek Road (county road 10-413) to Yellow Pine	25 miles
McCall-Stibnite Road (county road 50-412) to the mine site	14 miles
Total distance	distance to Cascade + 73 miles

Burntlog Route (Alternative 1)

To State Highway 55, just north of Cascade, Idaho – varies; see Table 18

Warm Lake Road (county road 10-579)	34 miles
Burntlog Road (existing)	*20 miles*
Burntlog Road (proposed new construction)	15 miles
Total distance	distance to Cascade + 69 miles

Burntlog Route (Alternative 2 – Riordan Creek segment reroute)

To State Highway 55, just north of Cascade, Idaho – varies; see Table 18

Warm Lake Road (county road 10-579)	34 miles
Burntlog Road (existing)	*20 miles*
Burntlog Road (proposed new construction, joining to Thunder Mountain Road)	12? miles
Total distance	distance to Cascade + 66? Miles

Burntlog Route (Alternative 3 – access through Blowout Creek)

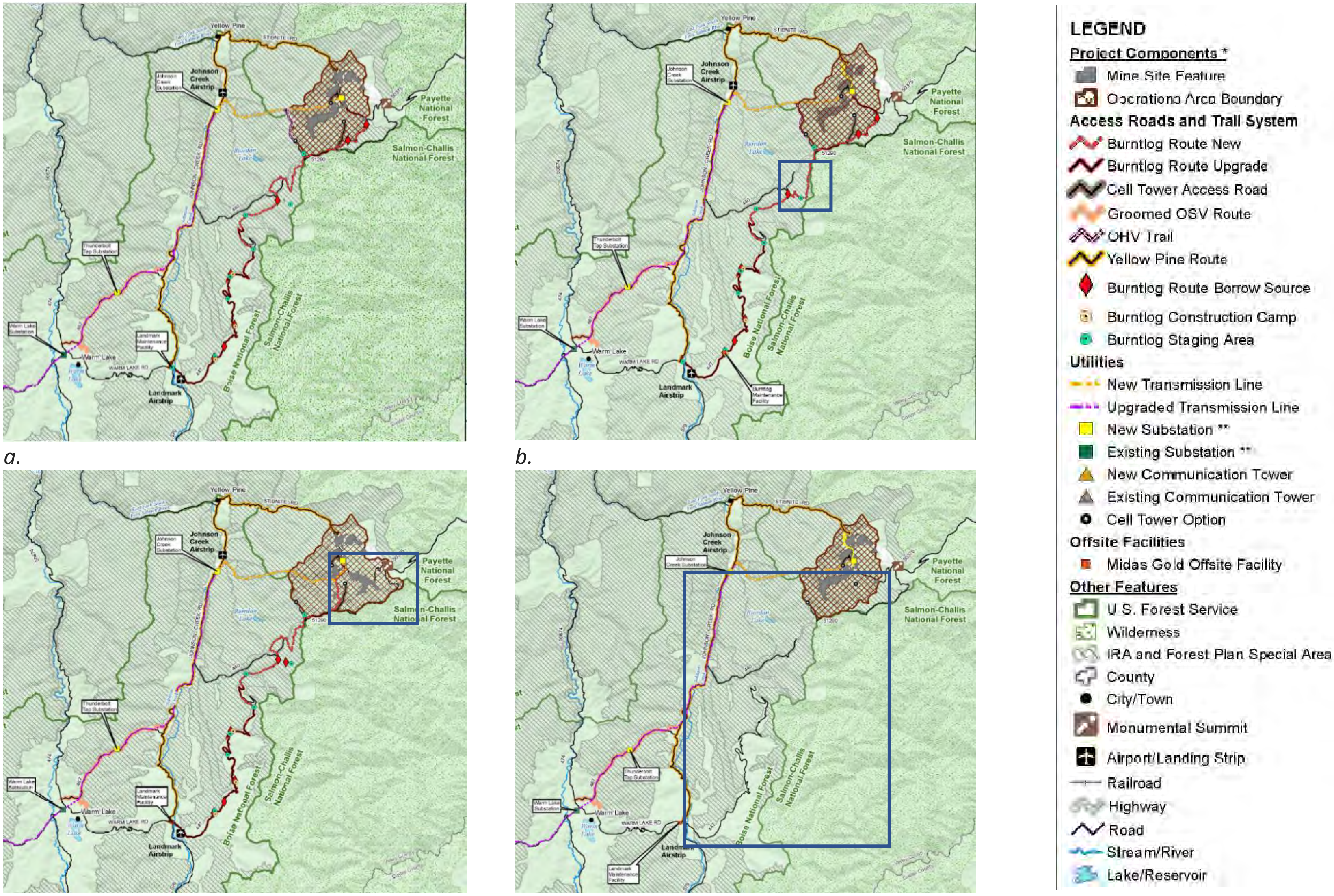
To State Highway 55, just north of Cascade, Idaho – varies; see Table 18

Warm Lake Road (county road 10-579)	34 miles
Burntlog Road (existing)	*20 miles*
Burntlog Road (proposed new construction)	15? miles
Total distance	distance to Cascade + 69? miles

These length are similar to the length to those reported in USFS (2020), p. ES-34:

Alternative 1: Yellow Pine Route = 70 miles; Burntlog Route = 73 miles.
Alternative 2: Yellow Pine Route = 70 miles; Burntlog Route = 71 miles.
Alternative 3: Yellow Pine Route = 70 miles; Burntlog Route = 75 miles.
Alternative 4: Yellow Pine Route = 70 miles.

For simplicity, I used 70 miles as the approximate length of the road corridor from SH 55 in Cascade to the mine site for all Alternatives. I combined that 70 mile segment with the distances in Table 18 from the distribution point locations to Cascade and the number of expected truck trips per year for each substance to calculate the minimum number of truck-miles for vehicles carrying hazardous materials for the SH-55 to mine site and for the example full transportation corridor (Table 20).



c. d. e.

Figure 1. Comparison of access roads by Alternative. a. Alternative 1; b. Alternative 2; c. Alternative 3; d. Alternative 4 with differences in the transportation corridor from Alternative 1 in boxes; and e. map legend. Reproduced from USFS (2020) figures 2.3-1, 2.4-1, 2.5-1, and 2.6-1. Legend from USFS (2020) Figure 2.3-1.

*Table 20. Total annual truck-mile exposures for mine supplies and antimony concentrate based on nearest sourcing points and number of annual trips required for each Alternative. *A total of 40 annual truck trips for water treatment reagents during mine operations for Alternative 2 were spread evenly across ferric sulfide, additional sodium hypochlorite, and additional sulfuric acid.*

Material	Distance to Cascade, Idaho	Total distance to mine site	Number of annual trips	One-way (loaded) miles per year by truck, SH-55 to mine site only		One-way (loaded) miles per year by truck, full transportation corridor length	
				Alts 1, 3, and 4	Alt 2	Alts 1, 3, and 4	Alt 2
Bulk liquids							
Diesel	176	246	580	40,600	40,600	142,680	142,680
Propane	31	101	93	6,510	6,510	9,393	9,393
Propane (Alt. 2, additional)	31	101	133	-	9,310	-	13,433
Gasoline	90	160	100	7,000	7,000	16,000	16,000
Magnesium chloride	326	396	56	3,920	3,920	22,176	22,176
Nitric acid	79	149	38	2,660	2,660	5,662	5,662
Ferric sulfate (Alt. 2)*	499	569	13	-	910	-	7,397
Sulfuric acid	79	149	20	1,400	1,400	2,980	2,980
Methyl isobutyl carbonyl	500	570	18	1,260	1,260	10,260	10,260
Antifreeze	420	490	13	910	910	6,370	6,370
Hydrogen peroxide	79	149	8	560	560	1,192	1,192
Sodium hypochlorite	479	549	1	70	70	549	549
Scale control reagents	724	794	10	700	700	7,940	7,940
Sulfuric acid (Alt. 2, add'al)*	79	149	13	-	910	-	1,937
Sodium hypochlorite (Alt. 2, add'al)*	479	549	13	-	910	-	7,137
Bulk solids							
Lime (Alt's 1, 3, and 4)	298	368	2,917	204,190	-	1,073,456	-
Lime (Alt. 2)	298	368	885	-	61,950	-	325,680
Sodium metabisulfite	500	570	583	40,810	40,810	332,310	332,310
Ammonium nitrate	665	735	304	21,280	21,280	223,440	223,440
Sodium cyanide	326	396	163	11,410	11,410	64,548	64,548
Copper sulfate	420	490	167	11,690	11,690	81,830	81,830
Potassium amyl xanthate	923	993	113	7,910	7,910	112,209	112,209
Lead nitrate	923	993	70	4,900	4,900	69,510	69,510
Activated carbon	401	471	47	3,290	3,290	22,137	22,137
Sodium hydroxide	499	569	30	2,100	2,100	17,070	17,070

Table 20, continued.

Material	Distance to Cascade, Idaho	Total distance to mine site	Number of annual trips	One-way (loaded) miles per year by truck, SH55 to mine site only		One-way (loaded) miles per year by truck, full transportation corridor length	
				Alts 1, 3, and 4	Alt 2	Alts 1, 3, and 4	Alt 2
Other materials transported to and from the mine site – assume Boise, Idaho as source/destination							
Lubricants	79	149	99	6,930	6,930	14,751	14,751
Waste oil (50% of lubricants)	79	149	49	3,430	3,430	7,301	7,301
Aerophine 3418A	79	149	50	3,500	3,500	7,450	7,450
Solvents	79	149	5	350	350	745	745
Grinding metals	79	149	417	29,190	29,190	62,133	62,133
Crusher and grinding liners	79	149	133	9,310	9,310	19,817	19,817
Flocculent	79	149	40	2,800	2,800	5,960	5,960
Explosives	79	149	20	1,400	1,400	2,980	2,980
Fertilizer	79	149	1	70	70	149	149
Herbicides	79	149	1	70	70	149	149
Pesticides/insecticides	79	149	1	70	70	149	149
Antimony concentrate	79	149	365	25,550	25,550	54,385	54,385
Total of estimated annual truck-miles with haz. mat.				455,840	325,640	2,397,681	1,679,809

Summary

Instead of only considering the transportation corridor from SH-55 at Cascade to the mine site, the true measure of the communities and environment at risk will extend to the distribution points of the reagents brought to the mine and the destinations of the ore concentrate and wastes taken from it. The overall exposure will depend on the distances the reagents, products, and wastes need to travel and the number of trips that are necessary for the respective quantities of the hazardous materials. The total estimated miles per year in Table 20 uses an average value for the length of roadway for the four action Alternatives from Cascade to the mine site and an educated approximation of the minimum distances for sourcing the reagents. This set of origin and destination cities is only an example and likely underestimates the total truck-mile exposure per year because both the number of trips and the number of miles to travel used may be lower than the actual values.

8. Risk per truck-mile from the Federal Motor Carrier Safety Administration

Spill frequency may be estimated using local, regional or national data, depending on which is most appropriate, reliable, and/or available.

Kazantzi et al. (2011)

> [T]here is a number of papers that have pointed out the uncertainties and pitfalls in assessing accident and release rates as well as characterizing consequential risk incidents because of the significant gap in available data. Harwood et al (1993) described a general procedure in estimating truck accident rates as a function of road and area type (urban/rural) from state data on highway geometrics, traffic volume, and accidents. Release probabilities in accidents were also derived by using combined federal and state truck accident data. However, the study also underlined some issues in combining data from different states, where estimates relate to different local factors that may need to be used as parameters in this kind of models.

Calculating the probability of a hazardous material spill requires knowing the number of trips, the trip lengths to find the exposure a specific project or route entails, and the risk of a spill over a given road length based on previously collected data. The first two of these are described in Sections 4, 6, and 7 of this report. The SGP DEIS (USFS 2020) characterized the third, the rate of hazardous materials spills per truck-mile, as very low. First, USFS (2020) made the point that there are no recent local data about spill risks on the mine access roads:

USFS (2020), p. 4.7-10, 11

> **Spills on Access Roads**
> There is no past incidence of spills (since 2016) while transporting fuel and consumables to the mine site (Midas Gold 2016).

but this statement lacks important context because it does not specify how long a time frame was considered or how many truck trips were made during that time. Second, USFS (2020) used national spill data about heavy vehicles transporting hazardous materials to estimate a risk rate per truck-mile.

USFS (2020), p. 4.7-3 (emphasis added):

> **4.7.2.1 Spill Risk from Truck Transport**
> **4.7.2.1.1 HIGHWAYS**
> *Trucks would be used to transport hazardous materials to the mine site and off-site facilities*. Based on the proposed hazardous materials, supplies, reagents, and wastes being transported to and from the mine site, the greatest concern would be a release of any hazardous material from a transportation accident resulting in a high potential impact to the environment. *Data from the Federal Motor Carrier Safety Administration (Federal Motor Carrier Safety Administration 2018) show very low rates of large truck accidents resulting in spills of hazardous material*, as addressed below. Strict regulatory controls and SGP emergency response procedures would be expected to limit the extent of any such incidents. *The duration of spill risk would be long-term because it would exist throughout the life of the SGP*. The impacted area would include the site of the spill and potentially downstream areas as far as the point of dilution. The East Fork South Fork Salmon River (EFSFSR) and associated tributaries, including streams within 0.5 mile of access routes, are the major surface waterbodies that could be impacted by accidental releases.
>
> To evaluate the potential impact of the transport of hazardous materials to and from the mine site, the risk of a transportation accident resulting in the release of hazardous materials was estimated. *Accident and incident rates were derived from national statistics for truck accidents that involve hazardous materials as published by the Federal Motor Carrier Safety Administration (2018).* Records show that the number of large trucks (gross vehicle weight of more than 10,000 pounds) on national highways from 2013 to 2016 ranged from over 10.59 million to 11.49 million; with large trucks traveling between 275.01 billion miles to 287.89 billion miles annually. Over that same time frame, large truck crashes involving hazardous materials cargo (with no release) ranged from 2,420 to 2,475, while large truck accidents with release of hazardous materials cargo ranged from 385 to 552. *The statistical rate of large-truck accidents involving hazardous cargo for miles traveled ranged from approximately 1 accident for every 714 million miles traveled in 2013 to approximately 1 accident for every 522 million miles traveled in 2016.* Therefore, statistically, the rate of accidents on the nation's highways involving crashes or spills of hazardous material cargo by large trucks is very low (Federal Motor Carrier Safety Administration 2018).

The risk rates cited in the DEIS (1 spill in 714 million truck-miles in 2013 and 1 spill in 522 million truck-miles in 2016, based on national statistics) are off by two orders of magnitude. In the remainder of this section, I will show that I can recreate the rates cited in the SGP DEIS from the Federal Motor Carrier Safety Administration (FMCSA) data, why those calculations are incorrect, what the actual spill rates are based on the data, and how those rates compare with other estimates of hazardous spill risk rates.

The *Pocket Guide to Large Truck and Bus Statistics* is published annually by the FMCSA. The data presented in each guide cited here (FMCSA 2014, 2015, 2018, and 2020) cover a four-year time frame, with the most recent twenty-two months in each guide considered preliminary data. I concatenated data from the guides to assess the number of large trucks registered in the United States (Table 1-1 from FMCSA 2014, 2015, 2018, and 2020), the number of vehicle miles traveled by large trucks in the United States (Table 1-2 from FMCSA 2014, 2015, 2018, and 2020), the total number of crashes by vehicle type (Table 4-1 from FMCSA 2014, 2015, 2018, and 2020), fatal crashes by vehicle type (Table 4-2 from FMCSA 2014, 2015, 2018, and 2020), injury crashes (Table 4-3 from FMCSA 2014, 2015, 2018, and 2020), and crashes involving trucks with hazardous material placards, both with and without known releases (Table 4-15 from FMCSA 2014, 2015, 2018, and 2020). Collectively, the data span from 2009-2018, but the data from 2017 and 2018 were considered provisional when the most recent guide (FMCSA 2020) was published. I used the most recently published for each year in Table 21, which may supersede a value from a previous Pocket Guide. For example, FMCSA (2018) lists 522 large truck crashes with known releases in 2016, which is the number cited in USFS (2020). The most recent guide (FMCSA 2020) had updated that to 551 large truck crashes with releases of hazardous materials in 2016, which is the value shown in Table 21.

Table 21. Data extracted from Pocket Guides to Large Truck and Bus Statistics (FMSCA 2014, 2015, 2018, 2020) for large trucks from 2009-2017. Data cited in USFS (2020) are in the shaded rows. Column letters are used in Table 22 to show how the rate calculations were performed.

Year	Large trucks registered	Millions of vehicle miles traveled (VMT)	Crashes	Fatal crashes	Hazardous materials crashes	Hazardous materials crashes with known release	Hazardous materials crashes with known release or possible release
	A	B	C	D	E	F	G
2009	10,973,610	288,306	286,000	2,983	2,462	270	772
2010	10,770,054	286,527	266,000	3,271	2,579	281	763
2011	10,270,693	267,594	273,000	3,365	2,892	311	881
2012	10,659,380	269,207	317,000	3,486	2,775	371	812
2013	10,597,356	275,018	327,000	3,554	3,244	385	824
2014	10,905,956	279,131	411,000	3,429	3,619	434	1,161
2015	11,203,184	279,843	415,000	3,622	3,712	483	1,062
2016	11,498,561	287,895	434,000	3,896	3,557	551	1,071
2017	12,229,216	297,592	450,000	4,237	3,881	606	1,096
2009-2017		2,531,113	3,179,000	31,843	28,721	3,692	8,442

Based on the data, I was able to recreate how the DEIS (USFS 2020) arrived at the estimated rate of hazardous materials crashes (Table 22). USFS (2020) assumed that the hazardous materials crash rate could be computed by dividing the number of large truck crashes that released hazardous materials by the total large truck vehicle miles traveled in a given year:

$$Hazardous\ material\ crash\ rate\ (crashes\ with\ spills\ per\ truck\ mile\ traveled) = \frac{Large\ truck\ crashes\ involving\ hazardous\ material\ releases}{Large\ truck\ miles\ traveled}$$

which was reported in its inverse form in USFS (2020) as

$$Hazardous\ material\ crash\ rate\ (truck\ miles\ traveled\ per\ crash\ with\ a\ spill) = \frac{Large\ truck\ miles\ traveled}{Large\ truck\ crashes\ involving\ hazardous\ materials\ releases}$$

USFS (2020) calculated that hazardous material spills occurred once every 714 million miles in 2013 and once every 522 million miles in 2016. Inverting those values yields estimated spill rates of 1.4×10^{-9} spills per vehicle mile traveled (VMT) in 2013 and 1.91×10^{-9} spills per VMT in 2016 (Table 22, shaded columns). The rates cited in USFS (2020), shown in the shaded columns in Table 22, are incorrect because not all large trucks carry hazardous materials. (The percent of all large truck crashes involving trucks with hazardous materials placards has ranged from 0.82 to 1.06% of all large truck crashes from 2009-2017 (Table 21, columns C and E).)

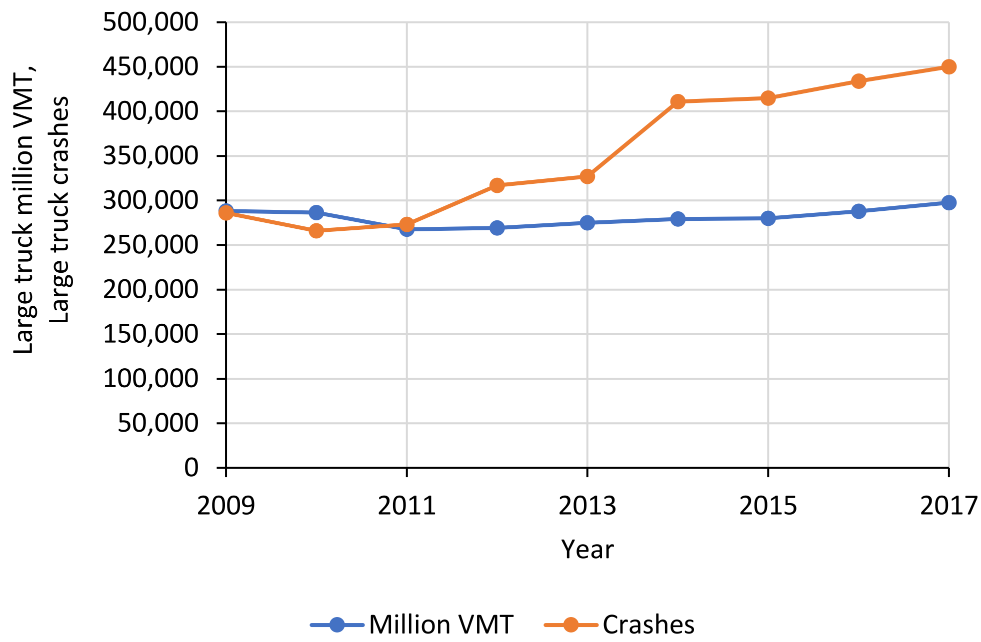
Ideally, the rate of hazardous materials releases would be calculated based on the number of vehicle miles that large trucks transported hazardous materials, but those data are unavailable. Instead, I will assume that the rate of crashes per million VMT for large trucks carrying hazardous materials is the same as a crash rate per million VMT for all large trucks (Figure 2).

The annual number of truck-miles amassed by heavy vehicles remained relatively constant from 2009-2017, but the number of heavy vehicle crashes generally increased over that period (Figure 2a), leading to an increase in the estimated number of crashes per truck-mile traveled by heavy vehicles (Figure 2b). Not all crashes involving large trucks with hazardous materials placards result in spills. The rate of spills per million VMT is found by taking the large truck crash rate per million VMT and multiplying it by the proportion of crashes that results in spills. The number of known spills has generally been less than half the number of possible spills (Figure 3a). From 2009-2017, the rate of potential spills from heavy vehicles has remained near 30% of crashes and the number of known spills has been between 10-16% of crashes annually and showing a slight upward trend (Figure 3b). (With only 9 years of data, I did not check if this trend was statistically significant.) The percent of crashes involving large trucks potentially carrying hazardous materials that may have had releases ranged from 25.4-32.1% from 2009-2017 (Figure 3b). The percent of potential releases is consistent with other estimates. For trucks that were involved in fatal crashes from 1991-2000, Craft (2004) found that and average of 31.2% of those carrying hazardous materials had releases, compared to 20.9% of the trucks carrying non-hazardous materials.

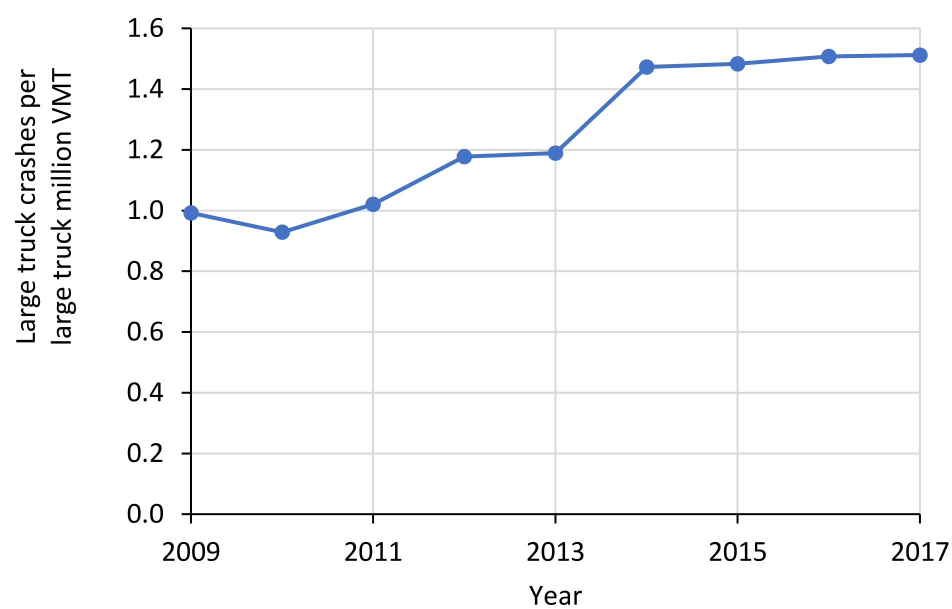
Table 22. Rates of crashes and hazardous materials releases from large trucks per year from 2009-2017 based on FMCSA (2014, 2015, 2018, and 2020). The rate calculation method used in USFS (2020) is in the shaded columns. The minimum spill rate of hazardous materials per million VMT is in the boxed column. See appropriate columns in Table 21 for data used to calculate each rate.

Year	Crash rate per million VMT	Fatal crash rate per million VMT	Hazardous material crashes per million VMT	Hazardous material crashes with releases per million VMT (USFS 2020)	Miles per hazardous material crashes with release (USFS 2020)	Percent of hazardous materials crashes with known releases	Hazardous materials crashes with known releases per million VMT	Percent of hazardous materials with potential releases per million VMT	Hazardous material crashes with potential releases per million VMT
	C/B	D/B	E/B	F/B	(B/F) x 10^6	F/E	(C/B) x (F/E)	G/E	(C/B) x (G/E)
2009	0.992	0.0103	0.0085	0.00094	1,067,800,000	11.0%	0.1088	31.4%	0.3111
2010	0.928	0.0114	0.0090	0.00098	1,019,669,039	10.9%	0.1012	29.6%	0.2747
2011	1.020	0.0126	0.0108	0.00116	860,430,868	10.8%	0.1097	30.5%	0.3108
2012	1.178	0.0129	0.0103	0.00138	725,625,337	13.4%	0.1574	29.3%	0.3446
2013	1.189	0.0129	0.0118	0.00140	714,332,468	11.9%	0.1411	25.4%	0.3020
2014	1.472	0.0123	0.0130	0.00155	643,158,986	12.0%	0.1766	32.1%	0.4724
2015	1.483	0.0129	0.0133	0.00173	579,385,093	13.0%	0.1930	28.6%	0.4243
2016	1.507	0.0135	0.0124	0.00191	522,495,463	15.5%	0.2335	30.1%	0.4539
2017	1.512	0.0142	0.0130	0.00204	491,075,908	15.6%	0.2361	28.2%	0.4270
2009-2017	1.256	0.0126	0.0113	0.00146	685,566,901	12.9%	0.1615	29.4%	0.3692

Based on the crash rate per million VMT and proportion of crashes that resulted in known spills of hazardous materials, the rate of hazardous materials spills per VMT by large trucks ranged from 1.01 x 10^{-7} spills per mile traveled in 2010 to 2.36 x 10^{-7} spills per mile traveled in 2017 (Table 22, boxed column and Figure 4). The known spill rate per number of miles traveled by heavy vehicles increased from 2009-2017, with all rates based on data from an individual year falling between 0.10-0.25 spills per million VMT, and had an average value of 1.615 x 10^{-7} per vehicle mile, which is approximately two orders of magnitude higher than the rates cited in the SGP DEIS (USFS 2020) (Figure 4 and Table 22, first shaded column).

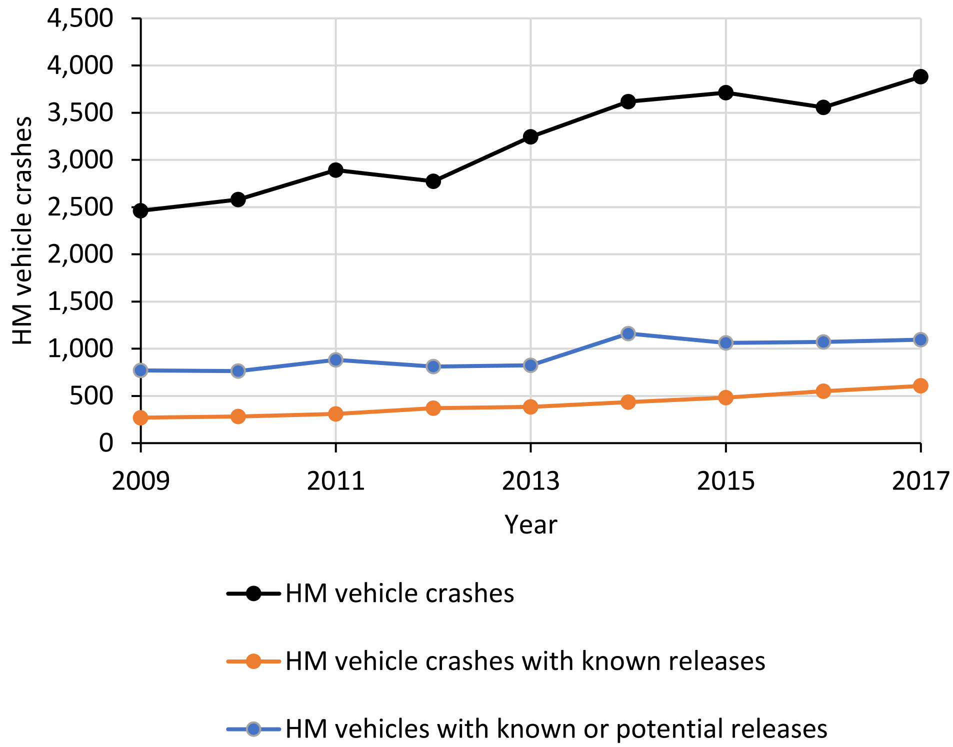


a.

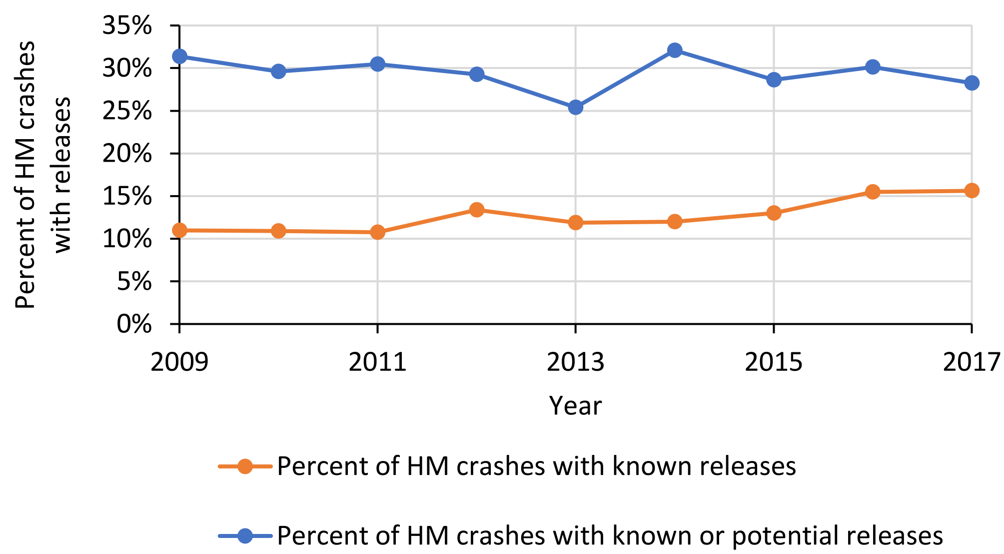


b.

Figure 2. a. Millions of vehicle miles traveled by large trucks (blue line) and number of large truck crashes (orange line) from 2009-2017; b. Number of large truck crashes per million vehicle miles traveled from 2009-2017. Data from FMCSA (2014, 2015, 2018, 2020).



a.



b.

Figure 3. a. Crashes involving large trucks with hazardous materials placards (black line) and the number of known releases of hazardous materials in those crashes (orange line) and known and potential releases of hazardous materials (blue line) from 2009-2017; b. Percent of crashes from large trucks with hazardous materials with known releases (orange line) and percent of crashes from large trucks with hazardous materials with known or potential releases (blue line) from 2009-2017. Data from FMCSA (2014, 2015, 2018, 2020).

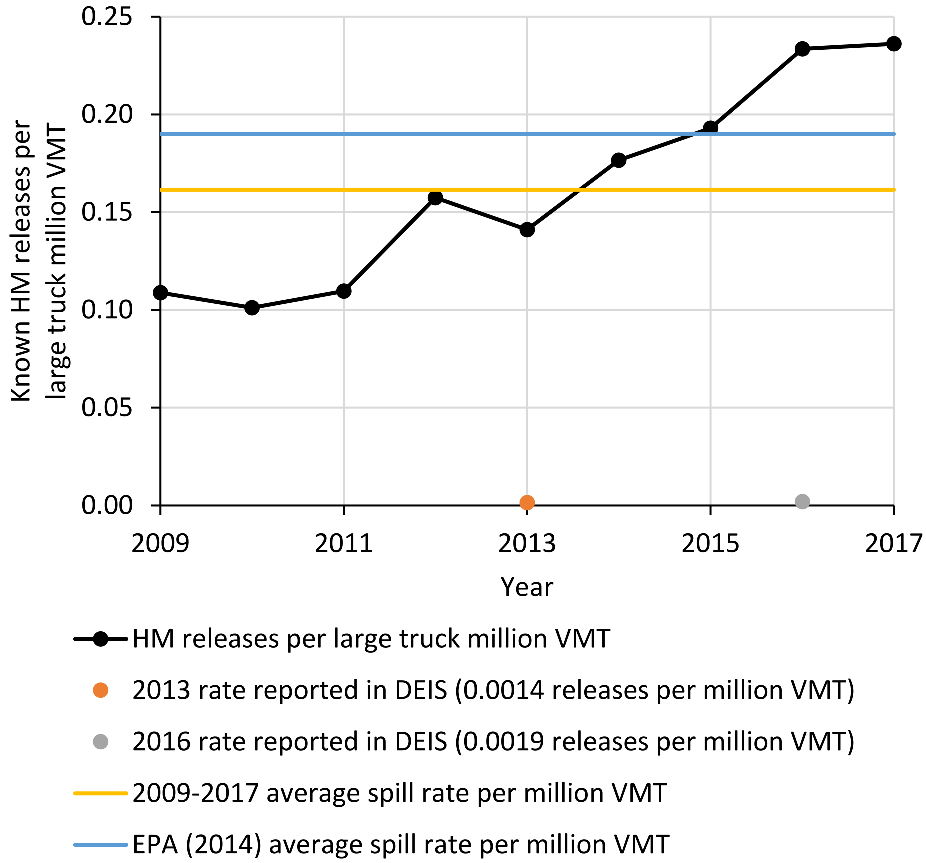


Figure 4. Estimated rate of known hazardous materials releases per million vehicles miles traveled by large trucks with hazardous materials placards from 2009-2017. Data from FMCSA (2014, 2015, 2018, 2020). The rates reported in the DEIS (USFS 2020) from data from 2013 and 2016 are shown for comparison.

For comparison, recall that when estimating the risks of spills of hazardous materials from trucks for the Pogo and Pebble Mines, EPA (2003, 2014) used a risk rate per mile of 1.9 x 10^{-7} spills per truck-mile, citing statistics from Harwood and Russell (1990). Harwood and Russell (1990) used data from California, Michigan, and Illinois that are now at least 30 years old to estimate hazardous material spill rates per vehicle mile. USACE (2020) used data specific to other roads in Alaska to estimate spills risks for Pebble Mine and estimated spill frequencies of 2.0 x 10^{-7} spills of >3,000 gallon diesel per truck-mile and 7.8 x 10^{-7} spill per truck-mile for spills or ore concentrate. (See Section 2 of this report.)

Battelle (2001) found that the average hazardous material accident rate of 3.2 x 10^{-7} spill per vehicle mile, based on estimated mileage figures from the 1997 Commodity Flow Survey. The rate varies by hazardous material class:

Battelle (2001), p. 4.13

> Risk of an accident per mile ranges from 1.3E-07 for Division 2.2 [non-flammable gases] to 7.2E-07 for Class 9 [miscellaneous dangerous goods]. The average accident rate for HM is 3.2E-07. If enroute incidents are included, as shown in Table 25, the risk increases to an average risk of 5.0E-07. Thus, without including enroute incidents, the accident/incident rate for accidents on the road declines by about 37 percent.

Combining leaks and accidents with releases yields the total spills per mile for the various hazardous materials classes. Non-flammable gases have the lowest spill rate of 0.32 x 10^{-7} per mile, while toxic materials and miscellaneous dangerous goods have spill rates of 6.4 x 10^{-7} and 6.2 x 10^{-7} per truck-mile, respectively. (Sodium cyanide was listed as a miscellaneous consumable in the SGP DEIS, but that may not match its classification in Table 23.) This still does not describe all vehicle spills because "[t]he accidental releases of hazardous materials occur not only during transport, but also at fixed locations during loading and unloading activities (US DOT 2010)" (Inanloo et al 2015).

Table 23. Spill probabilities (given an accident) may vary by substance type. See Battelle (2001), Table 6 (p. 3-9), and Tables 24 and 25 (p. 4.13).

Hazardous material classes and divisions, with descriptions	HazMat Miles	Total HazMat Accidents	Leaks *en route*	Accidents per mile	Leaks per mile	Fraction of accidents with releases	Accidents with releases per mile	Leaks and accidents with releases per mile
1.1, 1.2, and 1.3: Explosives with the potential for mass detonation	23,000,000	14.2	1	6.2×10^{-7}	0.43×10^{-7}	0.155	0.96×10^{-7}	1.4×10^{-7}
1.4, 1.5, and 1.6: Explosives with characteristics making mass detonation extremely unlikely	46,000,000	32.101	3	7.0×10^{-7}	0.65×10^{-7}	0.284	2.0×10^{-7}	2.6×10^{-7}
2.1: Flammable gases	805,000,000	276	15	3.4×10^{-7}	0.19×10^{-7}	0.170	0.58×10^{-7}	0.77×10^{-7}
2.2: Non-flammable gases	1,400,000,000	178	19	1.3×10^{-7}	0.14×10^{-7}	0.146	0.19×10^{-7}	0.32×10^{-7}
2.3: Poisonous gases	50,000,000	12.02	5	2.4×10^{-7}	1.0×10^{-7}	-	-	$\geq 1.0 \times 10^{-7}$
3: Flammable liquids and combustible liquids	2,800,000,000	1,379.021	587	4.9×10^{-7}	2.1×10^{-7}	0.355	1.7×10^{-7}	3.8×10^{-7}
4.1, 4.2, and 4.3: Flammable solids; spontaneously combustible materials and dangerous when wet materials	48,000,000	33	13	6.9×10^{-7}	2.7×10^{-7}	0.242	1.7×10^{-7}	4.4×10^{-7}
5.1, 5.2: Oxidizers and organic peroxides	201,000,000	61	50	3.0×10^{-7}	2.5×10^{-7}	0.475	1.4×10^{-7}	3.9×10^{-7}
6.1, 6.2: Toxic (poison) materials and infectious substances	218,000,000	50	125	2.3×10^{-7}	5.7×10^{-7}	0.300	0.69×10^{-7}	6.4×10^{-7}
7: Radioactive materials	30,000,000	12.001	4	4.0×10^{-7}	1.3×10^{-7}	-	-	$\geq 1.3 \times 10^{-7}$
8: Corrosive materials	1,900,000,000	257	539	1.4×10^{-7}	2.8×10^{-7}	0.284	0.38×10^{-7}	3.2×10^{-7}
9: Miscellaneous dangerous goods	250,000,000	179.3	94	7.2×10^{-7}	3.8×10^{-7}	0.336	2.4×10^{-7}	6.2×10^{-7}

These risk calculations likely underestimate the actual risk due to underreporting of spills. Not only does the national database of hazardous materials spills, Hazardous Material Information System, not record accidents occurring on intrastate roads and accidents not resulting in a spill (Qiao et al. 2009), but one estimate prepared for a Congressional hearing on PHMSA's effectiveness suggested that spill estimates based on national data could be up to an order of magnitude too small.

PHMSA 2010, p. 21

> Questions were raised in 2009 Congressional hearings about the completeness of reporting of (non-pipeline) hazardous materials incidents. One estimate quoted was that 60-90% of all such incidents were unreported. If these estimates apply equally to serious incidents, then the number of serious road and railway hazardous material incidents presented in this section could be too low by a factor of 10 (some cases were cited of non-pipeline incidents involving fatalities or injuries that went unreported).

Summary

The SGP DEIS used FMCSA data to estimate hazardous material spill rates of 1.4 x 10^{-9} spills per truck-mile in 2013 and 1.9 x 10^{-9} spills per truck-mile in 2016. These estimates are two orders of magnitude lower than rates cited in other EISs, including for Pogo Mine, which used an estimate of 1.9 x 10^{-7} spills per truck-mile, and Pebble Mine, which used an estimate of 2.0 x 10^{-7} spills per truck-mile for diesel spills >3,000 gallons and 7.8 x 10^{-7} spills per truck-mile for ore concentrate. I was able to recreate the math performed in the SGP DEIS and correct it, arriving at an average spill rate of 1.62 x 10^{-7} spills per truck-mile for the period of 2009-2017. This rate is closer to the rates cited in other DEISs but lower than rates from PHMSA, which estimated that there were an average 3.2 x 10^{-7} spills of hazardous material per truck-mile and found the rate varied by class of hazardous material. Due to underreporting, it is likely that all these estimated rates are too low, perhaps by as much as a factor of ten.

9. Location specific road hazards

With the exceptions of the rates estimated specifically for the proposed Pebble Mine, the hazardous spill risk rates in Section 7 are based on national data. The average the rates given do not reflect the variability and localization of spill probabilities, a fact which is acknowledged by both EPA and PHMSA.

EPA (2003)

> The probability of truck accidents and release was reported as 1.9 x10^{-7} spills per mile of travel for rural two-lane roads (Harwood and Russell, 1990). … This frequency provides an order-of-magnitude estimate because the conditions on the Pogo mine road would be different from those for which the statistics were developed (more difficult driving and road conditions).

PHMSA (2010), p. 24

> The rate of serious incidents per mile in a specific location in any specific community may vary considerably, based on the specific characteristics of the transportation infrastructure at the location (pipeline, roadway, and railway) and characteristics of the surrounding community. The expected rate of incidents involving different hazardous material transportation modes in a specific community will depend on the degree of exposure to each mode, namely, the number of miles of road, railway, and pipeline. The higher the pipeline, road, and railway mileage in a community, the higher is the community's level of exposure to potential incidents. However, the characteristics of the area (e.g., rural versus urban; density, pattern, and type of structures; topography) could decrease or increase the risk to the area surrounding the transportation infrastructure.

While in an ideal world (from a statistical standpoint) there would sufficient data to characterize each region specifically, with up-to-date, accurate, and detailed records of accidents, spills, and truck-miles, the reality is that hazardous spill rates are low and data are often collected in different formats by different agencies around the country, incomplete, or inaccurate.

Kazantzi et al. (2011)

> There are two main difficulties in assessing the risk; one can observe that probabilities of incident occurrences in HazMat transportation are very low and reported incident data are very scarce (Erkut and Gzara, 2008). This lack of consistent and sufficient data and the difficulty of obtaining accurate parameter values lead to high degrees of uncertainties

> associated with incident rates and consequence measurements for dangerous goods transportation. There are many critical variables that need to be taken into account in assessing the actual risk in Hazmat transportations (material type, mode of transportation, container type, meteorological and weather conditions, geographical location, season, time of the day, road conditions), as well as variables that depend on the human component and management of the transportation process (such as age, training and condition of the driver, management system, operations performed, equipment used etc). Based on a huge number of possible HazMat transportation alternative combinations, one can conclude that this is a very case-dependent problem...

Erkut et al. (2007)

> QRA relies heavily on empirical accident/incident probabilities. However past data [are] not very reliable. …. What makes matters worse is that there is no agreement on general truck accident probabilities and conflicting numbers are reported by different researchers. Furthermore, applying national data uniformly on all road segments of similar type is quite problematic since it ignores hot spots such as road intersections, highway ramps, and bridges. Researchers need to have access to high quality accident probability data and empirical or theoretical research that leads to improvements in the quality of such data would be welcome.

Erkut and Verter (1998)

> Furthermore, the probability of an incident occurring depends on the substance carried and the road type. Clearly, the risk associated with transporting a hazardous material depends not only on the substance being transported but also on the road network characteristics, such as road type and population, along the chosen route.

Factors that may affect hazardous material spill rates per truck-mile

Detailed models of spill probability per mile can incorporate area-specific risks that more generalized ones do not. The general procedure is to first find the base (average) accident frequency by dividing the number of accidents by the number of miles traveled, as in Section 7, and then modifying it based on factors that make a significant change to the rate for the specified scenario (Qiao 2009). Potential factors that can affect the accident rate have been studied in mathematical modeling contexts (Qiao et al 2009, Kazantzi et al., 2011), in governmental guidelines (AASHTO 2018), and suggested by examination of specific road corridors (USGS

2020) (Table 24). Factors may be important singly or have compounding effects (Kazantzi et al. 2011).

Erkut et al. (2007)

> [T]he occurrence of an accident may be influenced by intrinsic factors such as tunnels, rail bridges, road geometry, weather conditions, and human factors, as well as other factors correlated to traffic conditions, such as traffic volume and frequency of hazmat shipment. Consequently, some locations are more vulnerable to accidents than others. Therefore, a careful analysis should be done prior to the use of historical data. The rarity of hazmat accidents may result in insufficient information to determine whether historical figures are relevant to the circumstances of concern, particularly regarding rare catastrophic accidents.

Kazantzi et al. (2011)

> There is a considerable variance in estimating these [release] probabilities as reported by various researchers (Pet-Armacost et al.1999, Button and Reilly, 2000, Erkut and Verter, 1998, Saccomanno and Haastrup, 2002), because data are scarce and values depend on methodology and data sources used, as well as assumptions made.

Kravitz and Blair (2019)

> Because conditions on the mine road would be different from those for which the statistics were developed (e.g., more difficult driving and road conditions), this calculation provides an order of magnitude estimate. The reasonableness of these estimates is suggested by an assessment of the Cowal Gold Project in Australia, which estimated that a truck wreck would occur every 1 to 2 years, resulting in a spill every 3 to 6 years (NICNAS 2000).

Recall that in Section 2, some these same factors were mentioned in discussion of hazardous materials spill rates on the roadways to Pogo and Pebble Mines.

Table 24. Some potential factors that may affect spill probabilities for trucks carrying hazardous materials.

Reference	Factors that may affect spill risk
Qiao et al. 2009	nature of the roads, characteristics of the trucks, environmental factors, and driver conditions
	urban versus rural and divided versus undivided highway
	location specific conditions, such as vehicle speed limit, topographical conditions, excessive grade, obstructions to vision, poorly designed intersections
	weather conditions, such as rain, fog, storms, icing, wind, or tornado conditions
	driver training programs, fleet maintenance, speed monitoring, driver stress level, driver drinking-habits
Kazantzi et al. 2011	material type, mode of transportation, container type, meteorological and weather conditions, geographical location, season, time of the day, road conditions, management of the transportation, age, training and condition of the driver, operations performed, and equipment used
AASHTO 2018	type of terrain (level, rolling, mountainous); straight or winding
	grade, cross slope, width, medians, number of lanes, speed, rural vs. urban, traffic volumes, sight distances, lighting, drainage
USFS 2020	road surface or substrate; landslide, rockfall and avalanche risk; fires; flash floods; earthquakes; road condition and maintenance level; previous disturbances to the area

Incorporation of potential spill risk modifying factors in the SGP DEIS

SGP would have some significant risks (road grade and quality, avalanche/landslide risk, fires, etc.) that would be expected to increase the spill rate if a detailed model were used. It is beyond the scope of this report to model these for different segments of the proposed transportation corridor, for either the ~70 mile section from SH-55 at Cascade to the mine site or the multiple cities that are sources and destinations of hazardous materials. Instead, in the extracted sections of the DEIS shown, I show that there is sufficient reason to believe that the transportation corridor for the proposed SGP would be more prone to accidents and spills than would be predicted using rates based on national data. Factors making driving on the roads near SGP more difficult include the steep, narrow, rocky roads, harsh winters, debris, and geohazards such as landslides, rockfalls, avalanches and slumps (Table 25).

USFS (2020), p. 3.16-6, emphasis added

> **Existing Road Transportation Network**
>
> The Stibnite Mining District has been explored and mined since the early 1900s and included activities such as road construction and exploration. *Many of the forest roads in the area were originally built to access mining claims or other remote sites and tend to be very steep, rocky, and winding* (Forest Service 2019d).
>
> The transportation network in the analysis area includes SH 55, Valley County roads, and NFS roads. Valley County maintains Warm Lake (CR 10-579), Johnson Creek (CR 10-413), and McCall-Stibnite (CR 50-412)1 roads on NFS lands through easements issued under the FRTA. There are approximately 130 miles of state roads, approximately 278 miles of Valley County roads, and approximately 1,557 miles of NFS roads in the analysis area.
>
> …
>
> The road width of SH 55 generally spans from 20 to 24 feet and the average posted speed limit is 55 miles per hour. Valley County road travelway widths range from 14 to 26 feet and general speed limits range from 20 to 50 miles per hour (Valley County 2008b). NFS roads in the SGP area range from 10 to 16 feet wide for travelways. Most NFS roads do not have posted speed limits, but generally have a design speed limit of 5 to 15 miles per hour depending on the level of service and design criteria of the road. *Most roads in the PNF and BNF are single-lane, native surfaced roads with high rock fragment content from the rocky terrain and include pullouts for passing vehicles.* General maintenance during snow-free months consists of grading and re-compacting the road base, intermittent dust control, and periodic cleaning of drainage culverts and ditches.

USFS (2020), p. 3.16-14, emphasis added

> According to the Valley County sheriff's traffic incident records from 2000 through 2016, *the causes of most accidents on the existing roadways fall under the general categories of driver error, vehicle mechanical issues, and environmental factors* (DJ&A, PC 2017). Examples of driver error include speeding, following another vehicle too closely, inattentiveness, fatigue, gear shift issues, failure to share road, inexperience as a driver, and impairment. Examples of mechanical issues include brake and engine failure and tire-related problems including the misuse or lack of use of chains during ice or snow conditions. Environmental factors that affected traffic incidents include weather-related

(e.g., snow, ice, flooding, and other conditions that contributed to poor visibility), poor road conditions (e.g., soft shoulders), and wildlife crossings.

USFS (2020), p. 3.18.-13, emphasis added

EXISTING TERRAIN AND FEATURES

As described in the Public Health and Safety Baseline Study (HDR 2017b), *the rugged, mountainous terrain in the analysis area includes many potential hazards to public health and safety that could result in severe injuries or fatalities to users. Common hazards related to terrain include extremely steep slopes, rock cliffs, uneven terrain, and fallen trees. Avalanches, rock falls and debris flows also present a potential hazard for travelers, recreationists, and Forest Service and Midas Gold employees*. They can cause severe injury or death and can block access to homes, cabins, and recreation sites. As described in the Recreation Baseline Study (HDR 2017c), the analysis area is a popular destination for winter recreation activities, including snowmobiling, snowshoeing, and cross-country skiing. Recreationists participating in these activities are at risk for causing or encountering avalanches in the analysis area.

Also described in the Public Health and Safety Baseline Study (HDR 2017b), *the entire analysis area presents potential flash flood and debris-flow hazards* that also can cause severe injury or death, and can block access to homes, cabins, and recreation sites. In addition, areas that were not traditionally flood-prone are at risk due to changes to the landscape caused by wildfires.

Similar to flash-flooding and debris flows, *portions of the analysis area are susceptible to landslides and avalanches due to factors such as geology, landscape, climate, and soil*, as was experienced in 2014, 2017 and 2019 along the South Fork of the Salmon River Road (National Forest System Road 474/50674) and the Stibnite portion of the McCall-Stibnite Road (County Road [CR] 50-412).

USFS (2020), p. 3.18.-14, emphasis added

Wildfires are another potential hazard in the analysis area that can cause severe injury or death for travelers, recreationists, and Forest Service and Midas Gold employees, as well as damage to homes and property. They can spread unpredictably and rapidly and are highly dependent on changing weather patterns. Past wildfires have presented health and safety risks to the public. Much of the analysis area was burned by major wildfires in 2000, 2006, and 2007, as detailed in the Vegetation Baseline Study (HDR 2017d), as well as more recently in 2019. The danger of wildfires in the analysis area remains. The dense stands of snags and dead material left behind on the forest floor by those fires could be sources of fuel for future fires.

USFS (2020), p. 3.18-15, emphasis added

> *The analysis area is dominated by unpaved roads, one state highway, and county roads* **…** The road segment of highest safety and traffic concern from the access and transportation risk analysis was found to be the Warm Lake Road (CR 10-579), with an average of 8 vehicle accidents per year from 2000 to 2016 ....
>
> …
>
> *The analysis area experiences harsh weather conditions that pose potential travel hazards, especially during winter, when roads become snow-covered or icy. During winter, Valley County maintains only one route from Cascade to the analysis area*, which follows Warm Lake Road (CR 10-579) to the intersection with South Fork Salmon River Road (National Forest System Road 474), then to the East Fork Stibnite Road portion of the McCall-Stibnite Road (CR 50-412) to the village of Yellow Pine. Midas Gold maintains Stibnite Road (CR 50-412) for access from the village of Yellow Pine to the mine site. All other routes to the mine site are not maintained (plowed or sanded) when snow-covered roads become impassable to vehicles.

USFS (2020), p. 4.2-2, emphasis added

> The following analysis of effects associated with geologic resources and geotechnical hazards is considered within the overall context of the local and regional geology. Elements of this context include:
>
> > • *A majority of the analysis area is on National Forest System lands within the Salmon River Mountains, a high-relief mountainous physiographic province of central Idaho with the presence of steep slopes that are subject to landslides and avalanches.*
> >
> > …
> >
> > • *The analysis area is within the seismically active Centennial Tectonic Belt and it is anticipated to be subjected to earthquake ground shaking (URS Corporation 2013).*
> >
> > • *The mine site includes disturbed areas as a result of previous mining activities, resulting in the presence of legacy mine features with associated slope stability and seismic stability considerations*.

USFS (2020), p. 4.7-11, 12, emphasis added

> All access routes could present occasionally adverse road conditions that are common on remote mountain roads, especially due to ice and snow conditions during winter months. *Road conditions on high mountain passes such as Warm Lake, Landmark and and (*sic*)*

*Big Creek Summit may be particularly challenging in the winter. Both the Burntlog and Yellow Pine routes have segments with steep grades (above 6 percent), and no emergency truck ramps are present or planned on the routes. Switchbanks (*sic*) and reduced turning radius also may be a challenge for large trucks operating on these roads*. Any additional transport of hazardous materials under the action alternatives would increase the spill risk compared to the No Action Alternative.

Both the Burntlog and Yellow Pine access routes have segments that are susceptible to geohazards, including avalanches, landslides and rockfalls. See Sections 3.2 and 4.2, Geologic Resources and Geotechnical Hazards, for additional information on geohazards relevant to the SGP. *These geohazards present along the road corridors could increase the potential for truck accidents resulting in spills of hazardous materials*.
No geologic hazard assessment, including field reconnaissance, has been conducted to date for the Yellow Pine Route. Therefore, as part of preparation of the Environmental Impact Statement and to enable a general comparison of identified hazards between the Yellow Pine and Burntlog routes, *a desktop study of both corridors was conducted … the desktop study focused on larger avalanches (Class 3 and above) that could be capable of burying or overturning a vehicle.* Smaller avalanches (Class 1 or 2) could result in temporary road closures, but would be unlikely to increase the risk of a truck accident.

- Along the Burntlog Route, the desktop study identified 6 landslides and 20 rockfalls. No avalanche paths were identified along the Burntlog Route, although the existing Burnt Log Road (National Forest System Road [FR] 447) is known to experience small avalanches. The Burntlog Route is closer to avalanche “starting zones” such that it may have frequent but small avalanches (Class 1 or 2) that would be unlikely to impact vehicles.
- Along the Yellow Pine Route, 26 landslides, 19 rockfalls, and 12 avalanche paths were identified. Stibnite Road in particular is at the base of several large avalanche paths, and the route is known to have significant avalanches that disrupt traffic periodically.

Avalanches also can happen outside of existing avalanche paths, especially along road cuts and in areas that have undergone burning.

The Yellow Pine Route has increased potential for trucking accidents and greater spill risk from these geohazards compared to the Burntlog Route. See Section 3.2.3.7.2, Access Roads for the complete background information on geohazards across the two access routes.

Road conditions for transport routes beyond Landmark also would include occasionally adverse road conditions as noted above, as well as avalanche hazards at Warm Springs (see **Figure 3.2-6**). Occasional “slides” on Big Creek Summit in the last 20 years have caused temporary road closures, and Warm Lake Summit often has avalanche debris areas (Valley County Road Department 2020). These conditions are generally associated with road cuts. *Road hazards past Landmark could increase spill risk for all action alternatives compared to the No Action Alternative*.

Appendix E – Geologic Resources and Geotechnical Hazards (44 pp.)

A desktop study of geohazards was conducted for the Burntlog Route transportation corridor and Yellow Pine Route transportation corridor (which includes Johnson Creek Road [County Road (CR) 10-413] and the Stibnite Road segment of McCall-Stibnite Road [CR 50-412]) to provide a general comparison of identified geohazards along both corridors.

2.0 Methods
Imagery from Google Earth (2020) was examined using the following criteria to identify probable landslides, rockfalls, and avalanche paths along the two transportation corridors…

…

An important difference in types of avalanche hazards between Stibnite Road and Burntlog Route relates to the types of avalanche regimes. *Stibnite Road is at the base of large avalanche paths that may have a 5-year return interval with associated impacts. The Burntlog Route is closer to the avalanche starting zone and may contain more frequent, but smaller-size avalanches as compared to Stibnite Road* (personal communication, T. Leeds, USFS via email May 5, 2020 [Forest Service 2020]).

In addition to the two corridors described above, the U.S. Forest Service notes an avalanche path along Warm Lake Road (CR 10-579) that would be part of the transportation corridor common to both the Burntlog and Yellow Pine routes. This feature was observed in Google Earth during the desktop study…

Table 25. *There are recognized geohazards along all the road segments that would be part of the transportation corridor for hazardous materials. Sources: USFS (2020) Appendix E, Tables 1, 2, 3, 4, 5, 6, and 7.*

Road segment	Geohazard type			
	Rockfall	Landslide	Avalanche Paths	Slumps
Landmark to Burntlog Saddle	3			
Burntlog Saddle to connection with Thunder Mountain Road	15	4		
Thunder Mountain Road to mine site	2	2		
Burntlog Route			1	
Johnson Creek Road	8	11		2
Stibnite Road	11	15	12	

The impact rankings (negligible, minor, moderate, and major) from SGP DEIS Section 4.18 shown below refer to the public health rating matrix shown in Table 16 in Section 5 of this report.

USFS (2020), p. 4.18-34, emphasis added

> Issue: The SGP may affect human health or exposure to hazards.
> Indicator: Increased risk of natural hazards (wildfire, avalanche, landslide).
>
> Baseline conditions and Alternative 5
>
> > *The entire SGP area presents potential flash-flood and debris-flow hazards that also can cause severe injury or death, or block access. Some portions of the mine site also are conducive to landslides and avalanches. Fires can cause severe injury or death* for travelers, recreationists, and Forest Service and Midas Gold employees, as well as damage to property.
>
> Alternative 1 Moderate
>
> > *The SGP would increase the risk of damage, injury, or loss of life by allowing the increase in people traveling through the area to the mine site and construction and/or use of roads would increase the risk of damage, injury, or loss of life from such hazards* by allowing additional people and facilities into avalanche susceptible areas.
>
> Alternative 2
>
> > Same as Alternative 1, however with slight improvements as it reduces overall disturbance of the area.
>
> Alternative 3
>
> > Same as Alternative 1 however with slight improvement by elimination of public access roads.
>
> Alternative 4 Major
>
> > None of the positive impacts associated with improvement and development of the Burntlog Route. Yellow Pine Route has a steeper topography and terrain and there are more areas of landslides and rockfalls along the Yellow Pine Route than there are along the Burntlog Route. *Safety issues also are increased by heavy truck traffic through the Village of Yellow Pine and the general public traveling on the same road as large mining equipment*.

Mitigations suggested in the SGP DEIS

USFS (2020), p. 4.7-18, 19

> In general, the potential for a release of hazardous material from a truck accident can be reduced for both the Burntlog and Yellow Pine Routes with the use of appropriate management practices such as pilot vehicles, speed restrictions and requiring appropriate spill kits in trucks hauling hazardous materials and in pilot vehicles.

USFS (2020), pp. 2-20, 21, emphasis added

> **BURNTLOG ROUTE**
>
> During the first 2 years of construction, Midas Gold would widen and improve the existing Burnt Log Road (FR 447) and construct 15 miles of new road connecting with Meadow Creek Lookout Road (FR 51290). Improvements on the existing Burnt Log Road (FR 447) include:
>
> - Straightening tight corners to allow for improved safety and traffic visibility;
> - Maintaining grades of less than 10 percent in all practicable locations;
> - Placing sub-base material and surfacing with gravel;
> - Widening the existing road surface to a 20-foot-wide travel way (approximately 26 feet including shoulders); and
> - Installing side-ditching, culverts, guardrails, and bridges, where necessary with design features to provide fish passage.

Summary

Estimates of spill risk per truck-mile based on data collected nationwide are generalized and miss factors that may be relevant to individual hazardous material transportation scenarios. Some risks are dependent on the route chosen (road grade, number of lanes, weather, etc.) and some are route independent (driver experience level, material type, truck configuration, etc.) SGP would have some significant risks (road grade and quality, avalanche/landslide/rockfall, fires, etc.) that would be expected to increase the spill rate if a detailed model were used. While road improvement and speed limits might help abate some of the risks inherent in the analysis area, it is clear that developing a project-specific spill risk per truck-mile for one or more segments of the transportation corridor would be complicated, even if enough data were available, and would likely result in an estimated rate that is higher than the national average spill rate per truck-mile.

10. Transportation corridor spill (incident) probability calculations

The SGP DEIS acknowledges that "[i]ncreased mine related trucking traffic on roads could increase potential for spills of hazardous substances, as well as increase the potential for traffic accidents, which could have injury impacts as well as well-being and psychosocial impacts" (USFS 2020, p. 3.18-9). In this section I use the exposure variables (total truck-miles) from Section 7 for the hazardous mine reagents, products, and wastes (Section 4) with estimated spill and crash rates (Section 8) to calculate the expected numbers and probabilities of spills and accidents along the transportation corridor defined in the SGP DEIS and a more complete corridor that begins and ends at substance-specific cities (Section 6). I performed the computations for Alternatives 1, 3, and 4 as a group and for Alternative 2 individually.

The risk rates I used in the examples are:

- 2009-2017 average: 1.6 x 10^{-7} spills per truck-mile (Table 20)
- 2017 rate: 2.3 x 10^{-7} spills per truck-mile (Table 20)
- EPA (2014) rate based on Harwood and Russell (1990): 1.9 x 10^{-7} spills per truck-mile
- 2009-2017 average: 1.26 x 10^{-6} accidents per truck mile (Table 20)

These rates are based on national data cited in the SGP DEIS (USFS 2020) and in other analyses of hazardous materials spill likelihood on mine access roads (EPA 2003, 2014). This is the simplest possible model and likely underestimates the risk rate per truck-mile. (See sections 8 and 9.)

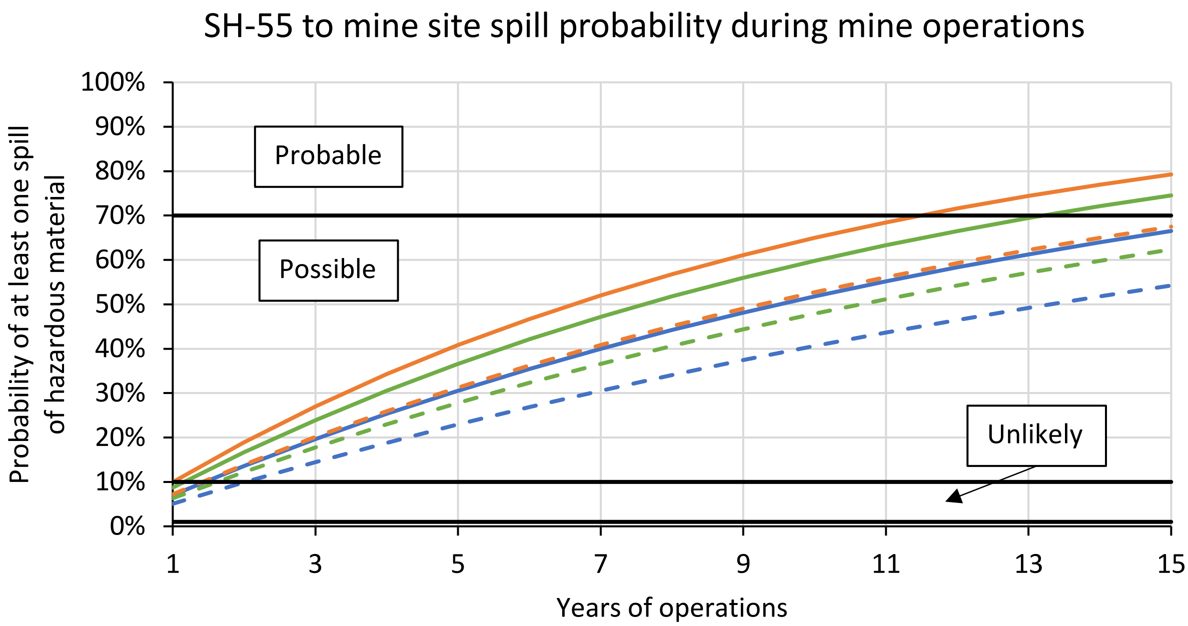
The reagents and products from the mine travel farther than just the distance from the SH-55 turn-off near Cascade to the mine. The combined distance from origin city to Cascade, Idaho, and then from Cascade to the mine site (rounded to 70 miles across all four action Alternatives) was the total exposure length in miles per one-way (loaded) trip. (See Sections 6 and 7.) The total exposure to hazardous materials spills from trucks per year for the SH-55 to the mine site segment and longer, material-specific transportation corridor for all Alternatives can be used with the spill risk rate per truck-mile to find expected numbers of spills (Table 26). To find the probability of at least one spill in each size class or for a spill of any size, I followed the common practice of assuming that the spill rates followed a Poisson distribution. In that case, $P(\geq 1 \text{ spill})$ is the probability of at least one spill, which can be found by subtracting the probability of there being no spills, *P*(0 spills), from the total probability (100% by definition). The probability of zero spills under a Poisson distribution is $e^{-\lambda t}$, where λ is the spill rate per amount of exposure, *t*. Often exposure is given in units of time. In this case, the units of exposure are the total truck-miles over a given number of years.

$$P(\geq 1\, spill) = 1 - P(0\, spills) = 1 - e^{-\lambda t}$$

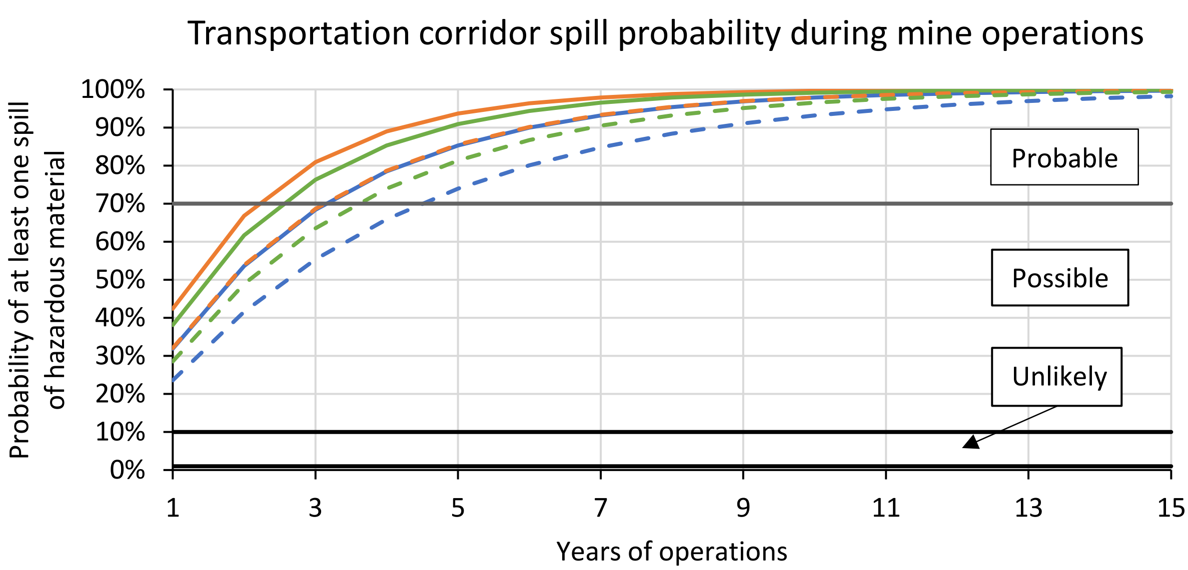
Even using the lowest of the three spill rates, the probability of a spill along the SH-55 to the mine site is above 40% and well into the possible range during the 12-year Project life (Table 26, Figure 5a). The greater distances included with the full transportation corridor mean a greater exposure to environmental and human safety risks, and between three and five spills of hazardous substances are expected in 12 years, depending on the Alternative. In that time frame, there is a 96-99% chance that at least one hazardous material spill occurs at some point along the combined transportation corridor (Table 26, Figure 5b).

Table 26. *Total truck-miles and spill incidents of all sizes for HazMat spills for each Alternative for the SH-55 to mine site and full transportation corridor for 1 year and 12- and 15-year mine operating lifetimes. The rate of 1.6 x 10^{-7} spills per truck-mile is the average from 2009-2017 and is lower than the rate cited in EPA (2014) or the 2017 rate (Figure 4).*

Alternative	SH-55 to mine site		Full transportation corridor	
	1, 3, and 4	2	1, 3, and 4	2
Road miles (one-way)	70	70	Varies by substance	
Number of trips/year	6,512	4,652	6,512	4,653
Truck-miles/year	455,840	325,640	2,397,681	1,679,809
Incident rate per truck-mile	1.6 x 10^{-7}	1.6 x 10^{-7}	1.6 x 10^{-7}	1.6 x 10^{-7}
Project life = 1 year				
Number of truck-miles	455,840	325,640	2,397,681	1,679,809
Number of spill incidents	0.07	0.05	0.38	0.27
Probability of $\geq$ 1 spill	0.07	0.05	0.32	0.24
Project life = 12 years				
Number of truck-miles	5,470,080	3,907,680	28,772,172	20,157,708
Number of spill incidents	0.88	0.63	4.60	3.23
Probability of $\geq$ 1 spill	0.58	0.46	0.99	0.96
Project life = 15 years				
Number of truck-miles	6,837,600	4,884,600	35,965,215	25,197,135
Number of spill incidents	1.09	0.78	5.75	4.03
Probability of $\geq$ 1 spill	0.67	0.54	1.00	0.98



a.



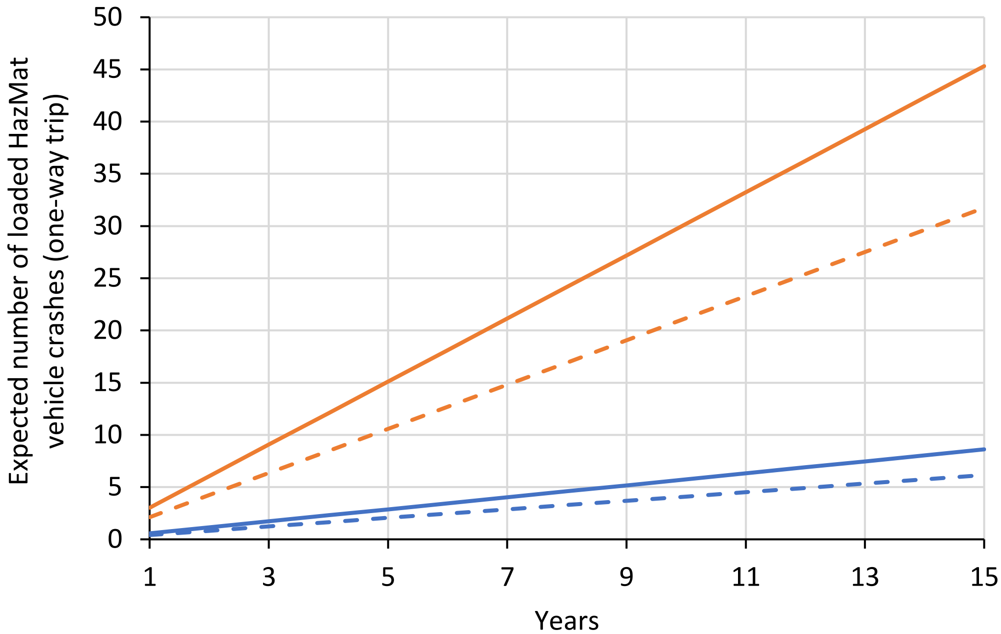
b.

Figure 5. Comparison of probabilities of at least one spill of a hazardous material from trucks from a. the ~70 roadway from SH-55 to the proposed mine site and b. the transportation corridor estimated using the reagent origins from Table 20, including the ~70 miles shown in part a. Solid curves are for Alternatives 1, 3, and 4. Dashed curves are for Alternative 2. The blue curves use the 2009-2017 average spill rate (Table 22), the orange curves use the 2017 spill rate, and the green curves use the spill rate cited in EPA (2014). The black horizontal lines separate the probable, possible, and unlikely probability ranges, based on USACE (2012) (Table 3).

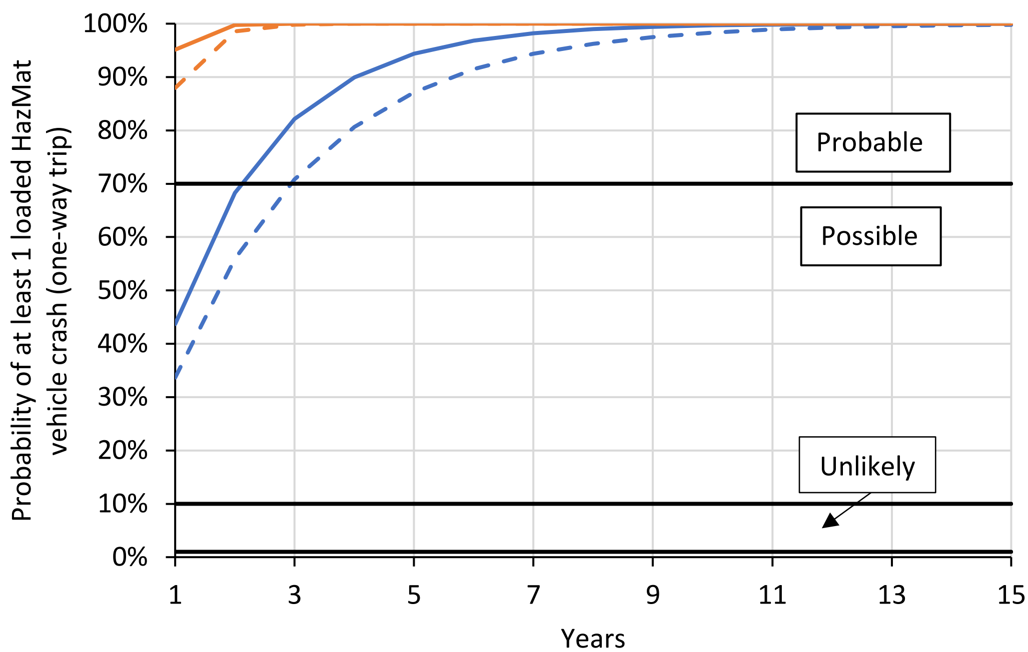
Not all crashes of vehicles carrying hazardous materials result in spill incidents, but they can still have impacts such as traffic delays, injuries, and/or fatalities. In addition to finding the expected numbers of hazardous materials spills, I also calculated the number of accidents expected from vehicles carrying hazardous materials (one-way road miles) (Table 27 and Figure 6) and the number of accidents expected for all heavy trucks moving to and from the mine site (Table 28 and Figure 7). Using the average crash rate from 2009-2017 of 1.26 x 10^{-6} crashes per truck-mile, the probability of a heavy vehicle loaded with hazardous materials crashing along the SH-55 to the mine site is between 34 and 44% and well into the possible range in year 1 (Table 27, Figure 6b), and 4-7 crashes involving loaded hazardous materials heavy vehicles along the mine access roads would be expected. The greater distances included with the full transportation corridor mean a greater exposure to environmental and human safety risks, and between 25 and 37 crashes in 12 years, depending on the Alternative (Table 27, Figure 6a).

Table 27. *Total truck-miles and expected numbers of accidents for loaded HazMat vehicles for each Alternative for the SH-55 to mine site and full transportation corridor for 1 year and 12- and 15-year mine operating lifetimes. The rate of 1.26 x 10^{-6} spills per truck-mile is the average from 2009-2017 and is lower than the 2017 rate (Table 22).*

Alternative	SH-55 to mine site		Full transportation corridor	
	1, 3, and 4	2	1, 3, and 4	2
Road miles (one-way)	70	70	Varies by substance	
Number of trips/year	6,512	4,652	6,512	4,653
Truck-miles/year	455,840	325,640	2,397,681	1,679,809
Accident rate/truck-mile	1.26 x 10^{-6}	1.26 x 10^{-6}	1.26 x 10^{-6}	1.26 x 10^{-6}
Project life = 1 year				
Number of truck-miles	455,840	325,640	2,397,681	1,679,809
Number of accidents	0.57	0.41	3.02	2.12
Probability of $\geq$ 1 accident	0.44	0.34	0.95	0.88
Project life = 12 years				
Number of truck-miles	5,470,080	3,907,680	28,772,172	20,157,708
Number of accidents	6.89	4.92	36.25	25.40
Probability of $\geq$ 1 accident	1.00	0.99	1.00	1.00
Project life = 15 years				
Number of truck-miles	6,837,600	4,884,600	35,965,215	25,197,135
Number of accidents	8.62	6.15	45.32	31.75
Probability of $\geq$ 1 accident	1.00	1.00	1.00	1.00



a.



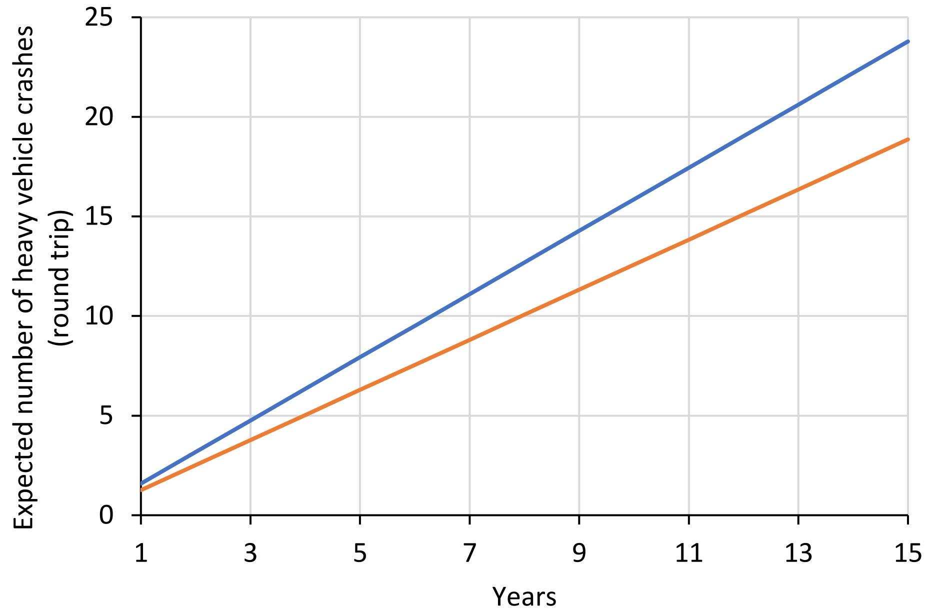
b.

Figure 6. Comparison of a. expected numbers of crashes of loaded hazardous material trucks from the ~70 roadway from SH-55 to the proposed mine site (blue lines) and the full transportation corridor (orange lines) estimated using the reagent origins from Table 20, including the ~70 miles from SH-55 to the mine site and b. probabilities of at least one such crash. Solid lines are for Alternatives 1, 3, and 4. Dashed line are for Alternative 2. The calculations use the 2009-2017 average heavy truck accident rate per truck-mile (Table 22). The black horizontal lines separate the probable, possible, and unlikely probability ranges, based on USACE (2012) (Table 3).

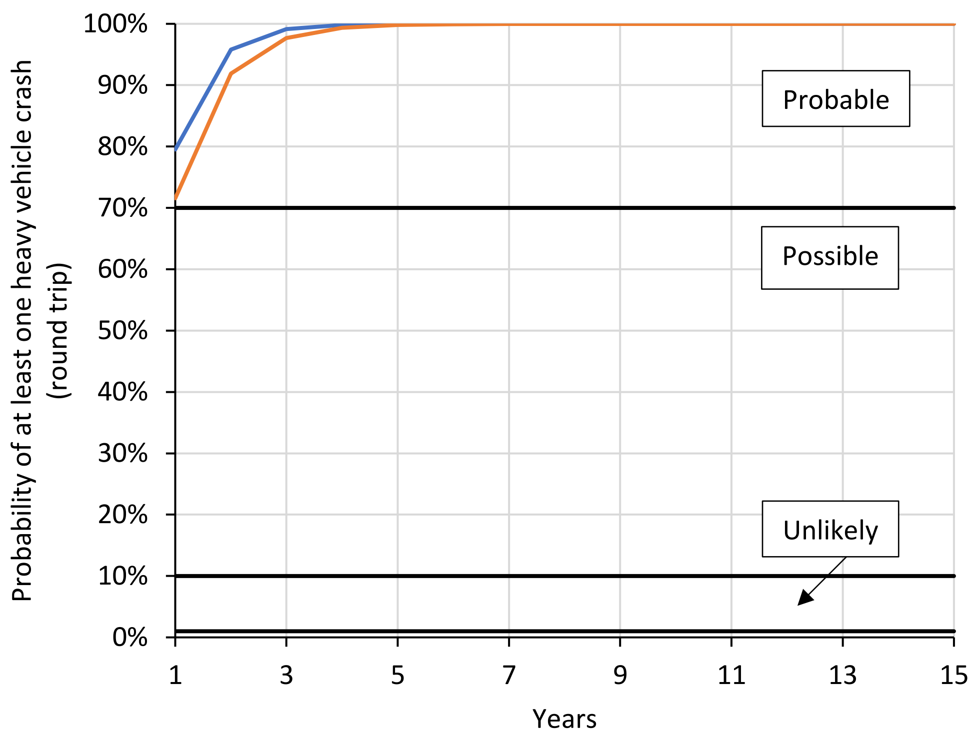
Unless the hazardous materials trucks can arrive at the mine site with a load of reagent and leave with a load of ore concentrate or wastes, the heavy vehicles will have half their miles in the mine site area loaded with hazardous materials and half unloaded. Not all heavy vehicles carry hazardous materials, as some are used to transport crew, food, recyclables, and other supplies to or from the mine. I found the expected number of crashes involving heavy vehicles on the mine access roads, using the same crash rate as before but with all heavy vehicle trips counted and round-trip miles. This analysis was limited to the mine access route from SH-55 to the mine site. Heavy crashes are probable even if the mine operated only one year, and 15-20 crashes involving heavy vehicles would be expected in 12 years of mine operations (Table 28 and Figure 7).

Table 28. *Total truck-miles and expected numbers of accidents for heavy vehicles, with and without hazardous materials, for each Alternative for the SH-55 to mine site for 1 year and 12- and 15-year mine operating lifetimes. The rate of 1.26 x 10^{-6} accidents per truck-mile is the average from 2009-2017 and is lower than the 2017 rate (Table 22).*

Alternative	SH-55 to and from mine site	
	1, 3, and 4	2
Road miles (roundtrip)	140	140
Number of trips/year	9,041	7,182
Truck-miles/year	1,265,740	1,005,480
Accident rate/truck-mile	1.26 x 10^{-6}	1.26 x 10^{-6}
Project life = 1 year		
Number of truck-miles	1,265,740	1,005,480
Number of accidents	1.59	1.27
Probability of $\geq$ 1 accident	0.80	0.72
Project life = 12 years		
Number of truck-miles	15,188,880	12,065,760
Number of accidents	19.14	15.20
Probability of $\geq$ 1 accident	1.00	1.00
Project life = 15 years		
Number of truck-miles	18,986,100	15,082,200
Number of accidents	23.92	19.00
Probability of $\geq$ 1 accident	1.00	1.00



a.



b.

Figure 7. Comparison of a. expected numbers of crashes of heavy vehicles on round trips along the ~70 roadway from SH-55 to the proposed mine site. The blue lines are for Alternatives 1, 3, and 4, and the orange lines are for Alternative 2. The calculations use the 2009-2017 average heavy truck accident rate per truck-mile (Table 22). The black horizontal lines separate the probable, possible, and unlikely probability ranges, based on USACE (2012) (Table 3).

Bias and uncertainty in the calculations

There are biases and uncertainties associated with all the values used to calculate the expected numbers of spills and their probabilities.

- The number of trips to transport hazardous materials to and from the mine site is underestimated because it assumes the minimum number of ore concentrate hauling trips, does not include trips for wastes containing mercury, and likely undercounts the number of trips needed to bring additional propane under Alternative 2.
- The sample origin/destination cities for the reagents and mine products were chosen to minimize the distance hazardous materials would have to travel to and from Cascade, Idaho. To the extent that the selected group of cities is incorrect, the calculations of truck-miles beyond SH-55 at Cascade will also be wrong.
- The risk rate per truck-mile based on FMCSA data from 2009-2017 is lower than estimates used in other DEISs from multiple lead agencies and in peer-reviewed journals and governmental reports.
- Those national rates are also like underestimates due to underreporting of accidents and spills.
- The risks per truck-mile used in Tables 26-28 and Figures 5-7 do not factor in important location-specific variables that could increase the spill rate per truck-mile for the SGP over the national average.

In short, the calculations in this section show the simplest possible method for estimating spill and accidents with rates that are highly uncertain and biased downwards. A more thorough approach should address these concerns explicitly and present not only quantitative estimates of the risks but also the uncertainties around those estimates. Only then can the impacts associated with spills and crashes be assessed to the appropriate degree, and stakeholders and decision-makers be properly informed.

Summary

Using the total number of heavy vehicles trips, with and without hazardous materials, I found the expected number of crashes and spills along the SH-55 to mine site portion of the transportation corridor and the full distribution point to mine site distance and the probabilities of spills and crashes (Table 29). Spill probabilities fall into the possible range even for the SH-55 to the mine segment under Alternative 2, which had fewer truck trips, using the smallest version of the spill rate per truck-mile. Overall, spills and crashes involving heavy vehicles are near certain to occur for all Alternatives. The calculations shown here serve as an example of the general process for estimating spill and crash numbers and likely underestimate the risks. Still, these numbers indicate that the impacts that spills and accidents may have on the environment and human safety along the transportation corridor should be seriously and thoroughly considered.

Table 29. Minimum values of spills and crashes expected in the analysis area in 12 years of mine operations.

In 12 years from SH-55 to mine site (70 miles one-way)	Alternatives 1, 3, and 4	Alternative 2
Expected number of hazardous materials spills from heavy vehicles	0.88	0.63
Probability of at least one hazardous material spill from a heavy vehicle	58%	46%
Expected number of crashes involving a heavy vehicle loaded with hazardous materials	6.89	4.92
Probability of at least one crash involving a heavy vehicle loaded with hazardous materials	100%	100%
Expected number of crashes involving a heavy vehicle	19.14	15.20
Probability of at least one crash involving a heavy vehicle	100%	100%

11. Other concerns related to the transportation corridor or spills

The bulk of this analysis has focused on quantifying the likelihood of hazardous materials spills along the SGP transportation corridor. While spills from trucks are important to model, they comprise only one aspect of several larger questions.

- What might spills impact when they occur?
- What could the impacts to fish and aquatic habitats be?
- What are the public health risks are associated with mine traffic?
- What other effects could roadways have?
- What about spills from other sources, such as the tailings and contact water pipelines or the reagent storage facilities?
- Finally, how good are spill predictions when they are compared to observations, and what might that tell us about how to view the predictions made thus far?

Impacts and consequences of spills

Erkut et al. (2007)

> There are many undesirable consequences of a hazmat transportation accident, such as economic losses, injuries, environmental pollution, damage to wildlife, and fatalities. These consequences are a function of the impact area (or exposure zone) and population, property, and environmental assets within the impact area. The shape and size of an impact area depends not only on the substance being transported but also on other factors, such as topology, weather, and wind speed and direction.

Battelle (2001)

> Selected impact categories that could be compared among the incidents/accidents. The impacts categories selected were:
>
> - Injuries and Deaths
> - Cleanup Costs
> - Property Damage
> - Evacuation
> - Product Loss
> - Traffic Incident Delay
> - Environmental Damage.

Impacts to fish and aquatic habitats

The assessment of hazardous spill risk on fish and aquatic habitats contains several problematic statements, some of which are in italics in the extract shown:

USFS (2020), p. 4.12-23

> *It is expected the risk associated with a spill large enough to negatively affect fish or aquatic habitat would generally be low. This varies depending on the substance that is spilled but considers typical substances that would be transported*. An exception may be when materials are transported during inclement weather conditions, this could increase the risk to moderate. Spills during the winter would be easier to contain because spilled material wouldn't penetrate frozen ground as readily as unfrozen ground, and snow could absorb the spilled material. However, areas that are harder to access (e.g., remote or in a canyon) may increase the time it takes to access and cleanup a spill, creating the potential for fish or fish habitat to be in contact with a hazardous material longer and could impact more fish or fish habitat.
>
> The duration of spill risks would extend throughout the SGP. The geographic extent of impacts would depend on the location and size of the spill and the effectiveness of the response. *The extent of the spill risk was limited to streams within 91 meters of the access roads - and downstream of spill locations*.
>
> While the likelihood of a spill is low to moderate, the magnitude of impacts could be high to individuals exposed to harmful concentrations of hazardous materials. The duration of the risk of impacts would extend throughout the SGP.
>
> ***Stream Crossings Along Access Roads, Utilities, and Off-site Facilities***
> Stream crossings are another potential place where hazardous spills could enter waterways. Access roads, including those necessary for access to the transmission line and off-site facilities, cross streams in the analysis area. Although not all waterbodies crossed via culvert are fish-bearing, spills into any waterway could travel downstream to fish-bearing waters.
>
> *Based on the analysis in the subsections above, and the short length of each crossing, it is expected that the risk of a spill large enough to negatively affect fish or aquatic habitat would be low.* The duration of the risk of impacts would extend throughout the SGP. The geographic extent of impacts would depend on the location and size of a spill and the effectiveness of the response.

I will address the italicized sentences in order.

1. It is expected the risk associated with a spill large enough to negatively affect fish or aquatic habitat would generally be low.

Section 9 of this report shows that there is a 46-58% chance of at least one hazardous material spill during the 12-year operating life of the Project within the analysis area as defined in the SGP DEIS, a probability that grows to 96-99% when the larger extent of the true transportation corridor is considered. This report has not included any information on spill size distribution, so I cannot speculate on how many spills would qualify as serious as defined by PHMSA or meet a biologically significant threshold.

2. This varies depending on the substance that is spilled but considers typical substances that would be transported.

The reagents that would be transported to the mine most often and could be considered "typical substances" include diesel, propane, gasoline, lubricants, waste oil, antimony concentrate, lime, sodium metabisulfite, ammonium nitrate, sodium cyanide, copper sulfate, and potassium amyl xanthate. For details about their specific properties, see Appendix A.

3. The extent of the spill risk was limited to streams within 91 meters of the access roads - and downstream of spill locations.

The reason for the 91 meter boundary for spill risks impacts was not specified and is less than half as wide as the 200 m road effect zone used to assess roadway impacts for Pebble Mine (Kravitz and Blair 2019).

4. Based on the analysis in the subsections above, and the short length of each crossing, it is expected that the risk of a spill large enough to negatively affect fish or aquatic habitat would be low.

See response for point 1.

Public health risks associated with mine traffic

The impact rankings (negligible, minor, moderate, and major) in the section below from SGP DEIS Section 4.18 refer to the public health rating matrix shown in Table 16 in Section 5 of this report.

USFS (2020), p. 4.18-23

> Increase in traffic volume has the potential to increase the vehicle accident incidence rate. Thus, the possibility that an increase in traffic related accidents could affect public health and safety is rated as "medium" and the magnitude of impact shown on **Table 4.18-3** is "high" (because injuries from of an accident could be severe), resulting in an overall public health rating of "major."

Section 10 of this report shows that there is a 99-100% chance of at least one crash involving a heavy vehicle carrying hazardous material during the 12-year operating life of the Project within the analysis area as defined in the SGP DEIS, and that 4.9 to 6.9 such accidents are expected. The high probability I calculated reinforces the designation of heavy vehicles having a major public health impact.

USFS (2020), p. 4.18-34

> Issue: The SGP may affect human health or exposure to hazards.
>
> Indicator: Increased risk of natural hazards (wildfire, avalanche, landslide).
>
> Baseline conditions and Alternative 5
> The entire SGP area presents potential flash-flood and debris-flow hazards that also can cause severe injury or death, or block access. Some portions of the mine site also are conducive to landslides and avalanches. Fires can cause severe injury or death for travelers, recreationists, and Forest Service and Midas Gold employees, as well as damage to property.
>
> Alternative 1 Moderate
> The SGP would increase the risk of damage, injury, or loss of life by allowing the increase in people traveling through the area to the mine site and construction and/or use

> of roads would increase the risk of damage, injury, or loss of life from such hazards by allowing additional people and facilities into avalanche susceptible areas.
>
> Alternative 2 Same as Alternative 1, however with slight improvements as it reduces overall disturbance of the area.
>
> Alternative 3 Same as Alternative 1 however with slight improvement by elimination of public access roads.
>
> Alternative 4 Major
> None of the positive impacts associated with improvement and development of the Burntlog Route. Yellow Pine Route has a steeper topography and terrain and there are more areas of landslides and rockfalls along the Yellow Pine Route than there are along the Burntlog Route. Safety issues also are increased by heavy truck traffic through the Village of Yellow Pine and the general public traveling on the same road as large mining equipment.

Other roadway impacts

Other roadway impacts not related to hazardous material transport include dust, application of chemicals, and changes to the drainage that result from new or modified roadways.

Kravitz and Blair (2019)

> Dust results from traffic operating on unpaved roads in dry weather, grinding and breaking down road materials into fine particles (Reid and Dunne 1984). The amount of dust derived from a road surface is a function of many variables, including composition and moisture state of the surface, amount and type of vehicle traffic, and speed. Dust particles are either transported aerially in the dry season or mobilized by water in the wet season. These fines may also include trace contaminants, including deicing salts, hydrocarbons, and metals. Following initial suspension by vehicle traffic, aerial transport by wind spreads dust over long distances, so that it can reach surface waters that are otherwise buffered from sediment delivery via aqueous overland flow. Dust control agents such as calcium chloride have been shown to reduce the generation of road dust by 50–70% (Bader 1997), but these agents may cause toxic effects when they run off and enter surface waters.

Kravitz and Blair (2019)

> To estimate the amount of dust generated from the transportation corridor we used an Iowa Highway Research Board project (Hoover et al. 1973) that quantified dust sources and emissions created by traffic on unpaved roads. According to that study, one vehicle, traveling 1 mile of unpaved road once a day every day for 1 year, would result in the deposition of 1 ton of dust within a 1000-foot corridor centered on the road (i.e., traffic would annually deposit 1 ton of dust per mile per vehicle).

Kravitz and Blair (2019)

> Roads are treated with salts and other materials to reduce dust and improve winter traction. In Alaska, calcium chloride is commonly used for dust control and is mixed with sand for winter application. Compounds used to control ice and dust (Hoover 1981) have been shown to cause toxic effects when they run off and enter surface waters.

Kravitz and Blair (2019)

> Roads modify natural drainage networks and accelerate erosion processes, which can lead to changes in streamflow regimes, sediment transport and storage, channel bank and bed configurations, substrate composition, and the stability of slopes adjacent to streams (Furniss et al. 1991). These changes may occur long distances from the road, both down- and up-gradient of the road crossing (Richardson et al. 2001). Road construction can increase the frequency of slope failures by orders of magnitude, depending on variables such as soil type, slope steepness, bedrock type and structure, and presence of subsurface water. These slope failures can result in episodic sediment delivery to streams and rivers, potentially for decades after roads are built (Furniss et al. 1991; Trombulak and Frissell 2000). All of these potential changes can have important biological consequences for anadromous and resident fishes by negatively affecting food, refugia, spawning habitat, water quality, and access for upstream and downstream migration (Furniss et al. 1991).

Pipeline spills: tailings and contact water

Midas Gold, Idaho, Inc. (2016), p. 149

> Tailings are what remain after desired recoverable minerals are removed from ore. Tailings at the Stibnite Gold Project will be comprised of the finely ground rock materials remaining after the minerals stibnite (hosting antimony and some silver) and pyrite (hosting the gold and some silver) and free gold, are extracted and concentrated in the ore processing facility…
>
> To ensure long-term operational integrity, the tailings pipeline will be a 24-inch diameter carbon steel pipe (or equivalent), lined with high-density polyethylene (**HDPE**). A geosynthetic-lined trench will provide secondary containment of the pipeline and capture

> any potential release or spillage. The trench will have emergency containment catchment basins at low points along the alignment to collect any leakage, precipitation or runoff collected within the trench. The geosynthetic-lined trench will also house an 18-inch HDPE (or equivalent) reclaim water return pipeline to supply recycled water back to the ore processing facility.

No flow rates or failure likelihoods are given for these pipelines, not are their lengths, making it impossible to assess the expected number or probability of a spill, the duration of a spill, or the potential volume that might be released. Without that analysis, environmental impacts of releases of tailings or contact water cannot be assessed.

Reagent storage spills

The assessment of hazardous spill risk from storage facilities contains problematic statements, some of which are in italics in the extract shown:

USFS (2020), p. 4.7-10

> **Spills at Mine Site and Off-Site Facilities**
> *A large volume release to the environment at the mine site or off-site facilities (SGLF, Landmark Maintenance Facility) is not likely to occur based on the planned infrastructure specifically designed for the storage and management of hazardous materials and use of secondary containment.* There was a reportable spill at the mine site from a plane crash in February of 2012 that resulted in a diesel spill. There have been no reportable spills since then.
>
> *In the event a release was to occur, it would be relatively small in volume based on estimated container volumes* and would be promptly addressed by stopping the source of the spill, using absorbent material or barriers to prevent further migration of the spilled material, and removing, characterizing, and properly disposing of any impacted soil per implementation of the prescribed SPCC Plan and/or Emergency Response Plan recovery efforts. The bulk fuel storage facilities would be constructed with appropriate, redundant, and legally required protection systems in place. The fuel tanks would be aboveground and located within a concrete-lined secondary containment facility that would be capable of holding a minimum of 110 percent of the largest tank volume present within the containment (Midas Gold 2016). *For these reasons, possible spill-related impacts to surface water and other physical resources would be low to negligible.* Any effects would be temporary in duration, assuming proper spill response measures, but the low risk of spills would be throughout the life of the SGP (long-term). Spills would be limited

> to the immediate area of release and would therefore be local in geographic extent. The effects would be localized, though spills to flowing water could spread contaminants downstream. Some materials that are highly toxic (e.g. cyanide) could result in greater impacts to a localized area.

I will address the italicized sentences in order.

1. A large volume release to the environment at the mine site or off-site facilities (SGLF, Landmark Maintenance Facility) is not likely to occur based on the planned infrastructure specifically designed for the storage and management of hazardous materials and use of secondary containment.

Etkin (2006) studied oil spill incident data for the years 1980 – 2003. Her analysis was of nearly 52,000 oil spills of at least 50 gallons that had at least 1 gallon reach a navigable waterway in the US. The spills originated from pipelines, vehicles, vessels, rail, and spill prevention, control, and countermeasure (SPCC) facilities, among others. She found that the largest sources of oil spilled (by volume) into inland waterways are pipelines and SPCC facilities, that the largest number of oil spills came from SPCC facilities, and that spills from SPCC facilities have an average size of almost 6,000 gallons (Etkin 2006).

2. In the event a release was to occur, it would be relatively small in volume based on estimated container volumes.

The SGP DEIS mentions the total amounts of storage available at the mine site for diesel, gasoline, and propane, but not the number and size of the containers. The storage volumes range from 10,000 to 200,000 gallons.

USFS (2020), p. 2-59

> **DIESEL FUEL, GASOLINE, AND PROPANE**
>
> Aboveground storage tanks at the mine site would be used for fuels and other fluids, including gasoline, diesel fuel, lubricants, coolants, hydraulic fluids, and propane. Approximately 200,000 gallons of diesel fuel, 10,000 gallons of gasoline, and 30,000 gallons of propane would be stored at the mine site

3. For these reasons, possible spill-related impacts to surface water and other physical resources would be low to negligible.

See responses to 1 and 2.

Pogo Mine: Predictions and observations

One important question to address is how accurately the potential impacts and effects described in an EIS are predicted. We can get a sense of that for one example of a mining DEIS by circling back to the Pogo Mine estimates of spills and comparing them to actual spill data from ADEC. As a comparison with the SGP project, the Pogo Mine output, transportation corridor road lengths, and reagents required are shown (Table 30). Pogo Mine, as described in its EIS, was about 12% the size of the proposed SGP in terms of its daily ore processing rate and number of annual truck shipments carrying hazardous materials (Table 30). The projected operating times of the two mines are similar, and Pogo has a shorter road corridor. Recall that the prediction for Pogo Mine was that there was a 1% chance of a spill associated with moving 786,000 gallons of diesel annually from a truck along its transportation corridor (EPA 2003).

Table 30. Comparison of scale between Pogo Mine and SGP for ore processing, reagent quantities and transportation corridor length.

Characteristic	Pogo Mine	SGP
Ore processing rate (tons per day)	2,500-3,500	20,000-25,000
Annual hazardous materials truck shipments	545-878	4,653-6,512
Expected years of ore processing	11	12-15
Length of road corridor analyzed	50 miles	~70 miles
Annual diesel used annually	786,000-1,300,000	5,800,000
Annual diesel truck shipments	100-163	580

To find the number of spills associated with Pogo Mine, I searched the ADEC Prevention Preparedness and Response database (ADEC 2020) using Pogo Mine and Delta Junction as the locations (Appendix B). I removed spills not related to mining and duplicate spill listings. There were 1,428 spills associated with Pogo Mine in the database from April 7, 1998 to September 3, 2020, with 1,417 added since February 2004. The bulk of the spills (85.3%) were of non-crude oil, especially hydraulic oil (Table 31). There were 79 spills of diesel, ranging from 0.5-1,500 gallons (Table 32). The spills include hazardous and extremely hazardous substances, non-crude oil, and process water. The largest spill was 135,000 gallons of mill slurry due to a line failure. The cumulative volume of all the spills is over 260,000 gallons.

Table 31. Spills associated with Pogo Mine by cause sub-type and substance category. There were also two spills of unknown substances: a 100-gallon spill caused by equipment failure and a 275-gallon spill due to human error.

Cause subtype	Extremely Hazardous Substances		Hazardous Substances		Non-crude oil		Process Water	
	n	volume range (gal)	*n*	volume range (gal)	*n*	volume range (gal)	*n*	volume range (gal)
Cargo not secured	1	0.25	3	0-25	6	2-55		
Collision/allision			2	15	2	10-120		
Containment overflow	1	20	21	1-175			14	3-6,000
Corrosion					1	1		
Crack					1	5		
Equipment failure	1	1	64	0.004-40,000	971	1-130	8	0.5-6,000
External factors							2	500-2,500
Gauge/site glass failure			2	100-4,500			1	500
Human error	1	5	9	0.1-7,500	25	1-70	19	0.5-600
Leak			9	1-18	46	1-150		
Line failure			14	1-135,000	88	1-200	6	4-6,000
Overfill			9	4-335	13	1-400	4	2-1,000
Puncture			2	1-25	3	5-41		
Rollover/capsize			2	0.75-500	6	0.5-500		
Seal failure			2	1-122	9	1-30	1	4
Tank failure			1	20			1	1,500
Valve failure			1	1,500	4	1-41		
Vehicle leak, all			1	2	28	1-25		
Other			3	0.3-50	2	5	1	3
Unknown			2	1-25	13	1-1,500		
Total	4	0.25-20	147	0-135,000	1,218	1-1,500	57	0.5-6,000

At least 51 spills associated with Pogo Mine can be traced to vehicles (shaded cells in Table 31), but that undercounts them. The shaded cells in Table 31 do not include all spills from vehicles because the spill sources (vehicles, heavy equipment, etc.) and causes (collision/allision, accident, rollover, etc.) do not align perfectly. For example, a total of 11 vehicle spills were listed with collision/allision (1), equipment failure (3), human error (1), leak (1), line failure (2), overfill (1), and rollover/capsize (2) as the cause subtypes. Of those 11 spills, only the three spills from collision/allision and rollover/capsize are counted in the shaded rows in Table 31.

Table 32. Spills associated with Pogo Mine by substance, number of spills, volume range, and total volume. This table does not include 4 spills of "other" hazardous substances with quantities given in pounds (weights ranged from 0.5 to 25 pounds).

Substance	Number of spills	Spill volume range (gallons)	Total volume spilled (gallons)
Extremely hazardous substances			
Hydrogen cyanide	1	5	5
Sodium cyanide	1	20	20
Sulfuric acid	2	0.25-1	1.25
Hazardous substances			
Acid, other	1	0.004	0.004
Drilling muds	1	6,000	6,000
Ethylene glycol	50	0.063-30	241
Propylene glycol	4	0.75-30	41
Glycol, other	12	1-15	70
Mill slurry	21	0.5-135,000	152,297
Zinc slurry	5	1-35	60
Other	48	0.032-40,000	81,422
Non-crude oil			
Diesel	79	0.5-1,500	4,049
Engine lubricant	41	1-40	159
Gasoline	2	1-10	11
Grease	1	1	1
Hydraulic oil	1,052	1-150	3,853
Transmission oil	30	1-20	128
Used oil (all)	10	1-30	51
Other	4	3-25	36
Process water			
Process water	48	0.5-6,000	15,115
Produced water	5	10-500	1,085
Source water	4	1-2,500	2,516
Unknown	2	100-275	375

Tables 30-32 through show that spills are inevitable, and modeling spill risk based on a single chemical reagent or spill source will vastly underestimate the spills that may occur. There were least 59 spills associated with transportation at Pogo Mine (the 51 shown in the shaded rows in Table 31 and the additional 8 vehicle spills attributed to other cause subtypes), which represent only 4% of the spills listed. The observations from Pogo Mine show that the spill risks as analyzed in the DEIS for the proposed SGP, a project approximately eight times larger than Pogo with a longer transportation corridor analysis area, are inadequate to assess potential spill impacts.

Summary

The SGP DEIS's rudimentary attempt at quantitatively estimating the risk of hazardous materials spills was constrained to a limited analysis area and a single source of potential spills (trucks). This narrow consideration of the possible impacts of the transportation corridor and hazardous materials misses other effects related to the SGP. Transportation impacts extend beyond the risk of spills. Mine-related spills of hazardous materials can come from many processes besides transportation. The conclusions in the DEIS that spills along the roadway will have limited if any impacts on fish and the aquatic environment are not justified. Neither are conclusions that spills from chemical storage will be rare or small. The DEIS did not examine the probability or potential sizes of spills of either tailings or contact water from pipelines. Even if the modeling had been better done, it is likely that the number of spills that would occur would be much higher than the predictions. The Pogo Mine, which is roughly 12% as large as the proposed SGP and has a shorter transportation corridor, has had more than 1,400 spills across a wide range of hazardous materials, spill volumes, and spill sources, with spills from vehicles representing less than 5% of that number.

12. Conclusions

Overall, the analysis of the potential impacts from hazardous materials in the SGP DEIS is inadequate to make an informed decision. EISs for other mines include expected spill numbers and probabilities, and the SGP DEIS did not. The SGP DEIS had inconsistent descriptions of the reagents to be used and the number of trips of hazardous materials trucks would be required and multiple arithmetic errors. The transportation corridor analysis area did not consider any risks beyond Cascade, Idaho. EISs for other mines include spill risk rates that are on the order of 2.0×10^{-7} spills per truck-mile, but the SGP DEIS estimated a spill rate ranging from $1.4\text{-}1.9 \times 10^{-9}$ spills per truck-mile, which is two orders of magnitude lower than rates published in multiple sources. Using a spill risk rate of 1.6×10^{-7} spills per truck-mile, I found that probabilities of spills and accidents range from possible to probable (if not certain) for all Action Alternatives for the analysis area considered in the SGP DEIS and the full length of the transportation corridor. The spill rate I used is likely too small as it is an average based on national spill data that may suffer from substantial underreporting and the road characteristics near the proposed SGP would increase spill risks. Without an accurate characterization of the true exposure along the transportation corridor and the spill rate per truck-mile, it is impossible to then make informed statements about spill likelihood and the potential consequences to the environment and to public safety. Data from the Pogo Mine illustrate that hazardous materials spills are frequent, can be sizable, and that transportation spills are only a small fraction of mine-related spills.

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Appendix A. Extracts from material safety data sheets for the materials that would be transported under various Alternatives.

I compiled information from the safety data sheets for the reagents from two commercial suppliers (IXOM Safety Data Sheets (https://www.ixom.com/sds-search) and EChemi Safety Data Sheets (http://www.echemi.com)) and other sources as noted. Reagents and other materials are listed in the same as they are in Table 13, first by those transported in liquid forms and then those as bulk solids, in order of decreasing quantities to be used annually.

Bulk liquids

Diesel fuel **5,800,000 gallons/year in 580 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for fuel oil.

> Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
>
> This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.
>
> *Classification of the chemical:*
> Flammable liquids - Category 4
> Aspiration hazard - Category 1
> Skin Irritation - Category 2
> Acute Inhalation Toxicity - Category 4
> Carcinogenicity - Category 2
> Specific target organ toxicity (repeated exposure) - Category 2
> Acute Aquatic Toxicity - Category 2
> Chronic Aquatic Toxicity - Category 2
>
> SIGNAL WORD: DANGER
>
> *Hazard Statement(s):*
>
> H227 Combustible liquid.
> H304 May be fatal if swallowed and enters airways.
> H315 Causes skin irritation.
> H332 Harmful if inhaled.
> H351 Suspected of causing cancer.

H373 May cause damage to organs through prolonged or repeated exposure.
H411 Toxic to aquatic life with long lasting effects.

Precautionary Statement(s): Prevention:

P201 Obtain special instructions before use.
P202 Do not handle until all safety precautions have been read and understood.
P210 Keep away from heat, sparks, open flames, hot surfaces. No smoking.
P260 Do not breathe mist, vapours, spray.
P264 Wash hands thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P273 Avoid release to the environment.
P280 Wear protective gloves / protective clothing / eye protection / face protection.

Accidental release measures

Emergency procedures/Environmental precautions: Shut off all possible sources of ignition. Clear area of all unprotected personnel. Shut off leak if possible without risk. Work up wind. Use water spray to disperse vapour. Do not allow container or product to get into drains, sewers, streams or ponds. If contamination of sewers or waterways has occurred advise local emergency services.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting and central nervous system depression. If the victim is showing signs of central system depression (like those of drunkeness) there is greater likelihood of the patient breathing in vomit and causing damage to the lungs. Breathing in vomit may lead to aspiration pneumonia (inflammation of the lung).

Eye contact: May be an eye irritant. Overexposure to diesel exhaust fumes may result in eye irritation.

Skin contact: Contact with skin may result in irritation. Will have a degreasing action on the skin. Repeated or prolonged skin contact may lead to irritant contact dermatitis. Repeated exposure may cause skin dryness or cracking.

Inhalation: Breathing in vapour may produce respiratory irritation. Breathing in vapour can result in headaches, dizziness, drowsiness, and possible nausea. Breathing in high concentrations can produce central nervous system depression, which can lead to loss of co-ordination, impaired judgement and if exposure is prolonged, unconsciousness. Overexposure to diesel exhaust fumes may result in headaches, nausea and respiratory irritation.

Ecological information

Ecotoxicity Avoid contaminating waterways.

Aquatic toxicity: Toxic to aquatic organisms. May cause long lasting harmful effects to aquatic life. Material floats on water. Films formed on water may affect oxygen transfer between the water and the atmosphere and cause adverse effects on aquatic organisms. Prevent entry of the material into waterways, sewers, basements or confined areas.

Propane **560,000 gallons/year in 93 deliveries (Alternatives 1, 3, and 4)**
Additional 1,463,000 gallons/year in 133 deliveries (Alternative 2)

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for propane.

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.

This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Flammable Gases - Category 1
Gases under pressure - Liquefied Gas

SIGNAL WORD: DANGER

Hazard Statement(s):

H220 Extremely flammable gas.
H280 Contains gas under pressure; may explode if heated.

Precautionary Statement(s):
Prevention:
P210 Keep away from heat, sparks, open flames, hot surfaces. No smoking.

Response:
P377 Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
P381 Eliminate all ignition sources if safe to do so.

Storage:
P410+P403 Protect from sunlight. Store in a well-ventilated place.
P403 Store in a well-ventilated place.

Accidental release measures

Emergency procedures/Environmental precautions: Shut off all possible sources of ignition. Clear area of all unprotected personnel. Increase ventilation.

Personal precautions/Protective equipment/Methods and materials for containment and cleaning up: If safe to do so, isolate the leak. Small spills are allowed to evaporate provided there is adequate ventilation. Wear protective equipment to prevent skin and eye contact and breathing in vapours. Avoid breathing in vapours. Work up wind or increase ventilation. Contain - prevent run off into drains and waterways.

Use absorbent (soil, sand or other inert material). Collect and seal in properly labelled containers or drums for disposal. Use non-sparking tools.

Exposure controls/personal protection

Propane: Asphyxiant

Asphyxiant - gases which can lead to reduction of oxygen concentration by displacement or dilution. The minimum oxygen content in air should be 18% by volume under normal atmospheric pressure.

Stability and reactivity

Possibility of hazardous reactions: Can react violently with chlorine, pool chlorine, or nitric acid.

Conditions to avoid: Avoid exposure to heat, sources of ignition, and open flame. Avoid exposure to direct sunlight. Avoid exposure to extremes of temperature.

Incompatible materials: Incompatible with strong oxidising agents.

Hazardous decomposition products: Carbon monoxide. Carbon dioxide.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting and central nervous system depression. If the victim is showing signs of central system depression (like those of drunkeness) there is greater likelihood of the patient breathing in vomit and causing damage to the lungs.

Eye contact: Vapour from product may irritate eyes. Liquid splashes or spray may cause freeze burns to the eye.

Skin contact: Contact with skin may result in irritation. Liquid splashes or spray may cause freeze burns.

Inhalation: Vapours may cause drowsiness and dizziness. Intentional misuse by deliberately concentrating and breathing the contents can be harmful or fatal. An asphyxiant; exposure to high concentrations can eventually lead to a lack of oxygen in the blood, which may cause death.

Ecological information

Ecotoxicity: Avoid contaminating waterways.

Gasoline **500,000 gallons per year in 100 deliveries**

Extracts from Hess Corporation 1 Hess Plaza Woodbridge, NJ 07095-0961; Internet Website www.hess.com

EMERGENCY OVERVIEW

DANGER!

EXTREMELY FLAMMABLE
- EYE AND MUCOUS MEMBRANE IRRITANT
- EFFECTS CENTRAL NERVOUS SYSTEM
- HARMFUL OR FATAL IF SWALLOWED
- ASPIRATION HAZARD

High fire hazard. Keep away from heat, spark, open flame, and other ignition sources.

If ingested, do NOT induce vomiting, as this may cause chemical pneumonia (fluid in the lungs). Contact may cause eye, skin and mucous membrane irritation. Harmful if absorbed through the skin. Avoid prolonged breathing of vapors or mists. Inhalation may cause irritation, anesthetic effects (dizziness, nausea, headache, intoxication), and respiratory system effects.

Long-term exposure may cause effects to specific organs, such as to the liver, kidneys, blood, nervous system, and skin. Contains benzene, which can cause blood disease, including anemia and leukemia.

Hazards Identification

EYES Moderate irritant. Contact with liquid or vapor may cause irritation. SKIN Practically non-toxic if absorbed following acute (single) exposure. May cause skin irritation with prolonged or repeated contact. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are exposed repeatedly.

INGESTION The major health threat of ingestion occurs from the danger of aspiration (breathing) of liquid drops into the lungs, particularly from vomiting. Aspiration may result in chemical pneumonia (fluid in the lungs), severe lung damage, respiratory failure and even death. Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur.

INHALATION Excessive exposure may cause irritations to the nose, throat, lungs and respiratory tract. Central nervous system (brain) effects may include headache, dizziness, loss of balance and coordination, unconsciousness, coma, respiratory failure, and death.

WARNING: the burning of any hydrocarbon as a fuel in an area without adequate ventilation may result in hazardous levels of combustion products, including carbon monoxide, and inadequate oxygen levels, which may cause unconsciousness, suffocation, and death.

CHRONIC EFFECTS and CARCINOGENICITY Contains benzene, a regulated human carcinogen. Benzene has the potential to cause anemia and other blood diseases, including leukemia, after repeated and prolonged exposure. Exposure to light hydrocarbons in the same boiling range as this product has been associated in animal studies with systemic toxicity. See also Section 11 - Toxicological Information.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE Irritation from skin exposure may aggravate existing open wounds, skin disorders, and dermatitis (rash). Chronic respiratory disease, liver or kidney dysfunction, or pre-existing central nervous system disorders may be aggravated by exposure.

Fire fighting measures

FIRE AND EXPLOSION HAZARDS Vapors may be ignited rapidly when exposed to heat, spark, open flame or other source of ignition. Flowing product may be ignited by self-generated static electricity. When mixed with air and exposed to an ignition source, flammable vapors can burn in the open or explode in confined spaces. Being heavier than air, vapors may travel long distances to an ignition source and flash back. Runoff to sewer may cause fire or explosion hazard.

Stability and reactivity

CONDITIONS TO AVOID Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources INCOMPATIBLE MATERIALS Keep away from strong oxidizers. HAZARDOUS DECOMPOSITION PRODUCTS Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke). Contact with nitric and sulfuric acids will form nitrocresols that can decompose violently.

Toxicological properties

ACUTE TOXICITY

Acute Dermal LD50 (rabbits): > 5 ml/kg Acute Oral LD50 (rat): 18.75 ml/kg Primary dermal irritation (rabbits): slightly irritating Draize eye irritation (rabbits): non-irritating Guinea pig sensitization: negative

CHRONIC EFFECTS AND CARCINOGENICITY

Carcinogenicity: OSHA: NO IARC: YES - 2B NTP: NO ACGIH: YES (A3) IARC has determined that gasoline and gasoline exhaust are possibly carcinogenic in humans. Inhalation exposure to completely vaporized unleaded gasoline caused kidney cancers in male rats and liver tumors in female mice. The U.S. EPA has determined that the male kidney tumors are species-specific and are irrelevant for human health risk assessment. The significance of the tumors seen in female mice is not known. Exposure to light hydrocarbons in the same boiling range as this product has been associated in animal studies with effects to the central and peripheral nervous systems, liver, and kidneys. The significance of these animal models to predict similar human response to gasoline is uncertain. This product contains benzene. Human health studies indicate that prolonged and/or repeated overexposure to benzene may cause damage to the blood-forming system (particularly bone marrow), and serious blood disorders such as aplastic anemia and leukemia. Benzene is listed as a human carcinogen by the NTP, IARC, OSHA and ACGIH.

This product may contain methyl tertiary butyl ether (MTBE): animal and human health effects studies indicate that MTBE may cause eye, skin, and respiratory tract irritation, central nervous system depression and neurotoxicity. MTBE is classified as an animal carcinogen (A3) by the ACGIH.

Magnesium chloride **250,000 gallons per year in 56 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for magnesium chloride solution

Hazards identification

Not classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for transport by Road and Rail; NON-DANGEROUS GOODS. Based on available information, not classified as hazardous according to Safe Work Australia; NON-HAZARDOUS CHEMICAL.

Stability and reactivity

Incompatible materials: Incompatible with strong acids.
Hazardous decomposition products: Oxides of magnesium.

Ecological information

Ecotoxicity Avoid contaminating waterways.

Nitric acid **115,000 gallons per year in 38 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for nitric acid 30% (Data sheets for 1, 30, 40, 40-50, 45, and 60-64% solutions were available.)

> *Hazards identification*
>
> Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
>
> This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.
>
> *Classification of the chemical:*
> Corrosive to Metals - Category 1
> Skin Corrosion - Sub-category 1A
> Eye Damage - Category 1
>
> SIGNAL WORD: DANGER
>
> *Hazard Statement(s):*
> H290 May be corrosive to metals.
> H314 Causes severe skin burns and eye damage.
>
> *Precautionary Statement(s):*
> *Prevention:*
> P234 Keep only in original container.
> P260 Do not breathe mist, vapours, spray.
> P264 Wash hands thoroughly after handling.
> P280 Wear protective gloves / protective clothing / eye protection / face protection.
>
> *Response:*
> P301+P330+P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
> P303+P361+P353 IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
> P363 Wash contaminated clothing before re-use.
> P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
> P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
> P310 Immediately call a POISON CENTER or doctor/physician.
> P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
> P390 Absorb spillage to prevent material damage.

Stability and reactivity

Reactivity: Reacts with strong alkalis. Corrodes metals.
Chemical stability: Stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.

Possibility of hazardous reactions: Reacts with metals liberating flammable hydrogen gas. May cause fire in contact with organic materials such as wood, cotton or straw, evolving toxic nitrogen oxides gases (brown fumes).

Conditions to avoid: Avoid exposure to light. Avoid contact with foodstuffs.

Incompatible materials: Incompatible with strong alkalis, organic chemicals, reducing agents, carbides, chlorates, metals.

Hazardous decomposition products: Oxides of nitrogen.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.

Eye contact: A severe eye irritant. Corrosive to eyes; contact can cause corneal burns. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin will result in severe irritation. Corrosive to skin - may cause skin burns.

Inhalation: Breathing in mists or aerosols may produce respiratory irritation. Nitric acid may decompose to a toxic brown gas of nitrogen dioxide. Inhalation of the gas may result in chest discomfort, shortness of breath and possible pulmonary oedema, the onset of which may be delayed.

Chronic effects: Chronic overexposure to vapour, fumes or aerosols may produce adverse effects on the lungs and erosion of the teeth.

Ecological information

Ecotoxicity Avoid contaminating waterways.

Ferric sulfate **65,000-125,000 gallons per year (Alternative 2 only)**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for ferric sulphate 70% w/v (40-45% w/w)

Hazards identification

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.

This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Corrosive to Metals - Category 1
Skin Corrosion - Sub-category 1B
Eye Damage - Category 1

SIGNAL WORD: DANGER

Hazard Statement(s):
H290 May be corrosive to metals.
H314 Causes severe skin burns and eye damage.

Precautionary Statement(s):
Prevention:
P234 Keep only in original container.
P260 Do not breathe mist, vapours, spray.
P264 Wash hands thoroughly after handling.
P280 Wear protective gloves / protective clothing / eye protection / face protection.

Response:
P301+P330+P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303+P361+P353 IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P363 Wash contaminated clothing before re-use.
P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P310 Immediately call a POISON CENTER or doctor/physician.
P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P390 Absorb spillage to prevent material damage.

Storage:
P405 Store locked up.
P406 Store in corrosive resistant container with a resistant inner liner.

Physical and chemical properties

Physical state: Liquid
Colour: Dark red-brown-black
Odour: Odourless
Solubility: Miscible with water.
pH: <1

Stability and Reactivity

Reactivity: Reacts with alkalis. Corrodes metals.

Chemical stability: Stable under normal conditions of use.

Possibility of hazardous reactions: Mildly corrosive to metals and concrete. Reacts with alkalis. Hazardous polymerisation will not occur.

Conditions to avoid: Avoid contact with metals. Avoid contact with alkalis.

Incompatible materials: Incompatible with alkalis. Mildly corrosive to metals and concrete.

Hazardous decomposition products: Oxides of sulfur. Oxides of iron.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.

Eye contact: A severe eye irritant. Corrosive to eyes; contact can cause corneal burns. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin will result in severe irritation. Corrosive to skin - may cause skin burns.

Inhalation: Breathing in mists or aerosols may produce respiratory irritation.

Acute toxicity: Oral LD50 (rat): >5000 mg/kg for product (1)
(1) Supplier Safety Data Sheet; 04/ 2001.

Ecological information

Ecotoxicity Avoid contaminating waterways

Disposal considerations

Disposal methods: Refer to Waste Management Authority. Dispose of material through a licensed waste contractor.
Special precautions for landfill or incineration: Decontamination and destruction of containers should be considered.

Sulfuric acid **60,000 gallons per year in 20 deliveries**
Additional 1,700-2,400 gallons per year for Alternative 2

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for sulfuric acid 10-51%. (Data sheets for <5, 5-10, 10-51, and >51% solutions were available.)

> *Hazards identification*
>
> Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
>
> This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.
>
> Classification of the chemical:
> Skin Corrosion - Sub-category 1A
> Eye Damage - Category 1
> Specific target organ toxicity (single exposure) - Category 3
>
> SIGNAL WORD: DANGER
>
> *Hazard Statement(s):*
> H290 May be corrosive to metals.
> H314 Causes severe skin burns and eye damage.
> H335 May cause respiratory irritation.
>
> *Precautionary Statement(s):*
> *Prevention:*
> P234 Keep only in original container.
> P260 Do not breathe mist, vapours, spray.
> P264 Wash hands thoroughly after handling.
> P271 Use only outdoors or in a well-ventilated area.
> P280 Wear protective gloves / protective clothing / eye protection / face protection.
>
> *Response:*
> P301+P330+P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
> P303+P361+P353 IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
> P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
> P363 Wash contaminated clothing before re-use.
> P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
> P312 Call a POISON CENTER or doctor/physician if you feel unwell.
> P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
> P310 Immediately call a POISON CENTER or doctor/physician.
> P390 Absorb spillage to prevent material damage.

Stability and reactivity

Reactivity: Reacts with alkalis.

Chemical stability: Stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.

Possibility of hazardous reactions: Corrosive to most metals. Reacts exothermically with water.

Conditions to avoid: Avoid exposure to moisture.

Incompatible materials: Incompatible with many metals, organic chemicals, alkalis.

Hazardous decomposition products: Sulfur dioxide.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.

Eye contact: A severe eye irritant. Corrosive to eyes; contact can cause corneal burns. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin will result in severe irritation. Corrosive to skin - may cause skin burns.

Inhalation: Breathing in mists or aerosols will produce respiratory irritation.

Acute toxicity: No LD50 data available for the product. For the constituent Sulfuric acid (1):

Oral LD50 (rat): 2140 mg/kg
Inhalation LC50 (rat): 510 mg/m^3/2hours

Respiratory or skin sensitisation: No information available.

Chronic effects: No information available for the product.

For the component Sulfuric acid: Repeated overexposure may lead to chronic conjunctivitus, lung damage and dental erosion. The International Agency for Research on Cancer (IARC) have concluded that occupational exposure to strong inorganic acid mists containing sulfuric acid is carcinogenic to humans, causing cancer of the larynx and to a lesser extent, the lung. No direct link has been established with sulfuric acid, itself, and cancer in humans. Exposure to any mist or aerosol during the use of this product should be avoided and exposure should not exceed the exposure standard. (2)

Ecological information

Ecotoxicity Avoid contaminating waterways.

(1) `Registry of Toxic Effects of Chemical Substances'. Ed. D. Sweet, US Dept. of Health & Human Services: Cincinnati, 2019.

(2) International Agency for Research on Cancer. In: `IARC Monographs on the Evaluation of Carcinogenic Risk to Humans'. World Health Organisation, 1992.

Methyl isobutyl carbinyl **55,000 gallons per year in 18 deliveries**

From USACE 2020, p. 4.27-89:

> [Methyl isobutyl carbinol] is a flammable liquid, with flammable vapor. It is classified as Dangerous Goods by the International Maritime Dangerous Goods Code (IXOM 2017)…
>
> [Methyl isobutyl carbinol] is considered hazardous, can cause eye and respiratory irritation, is a kidney toxin, and a carcinogen (IXOM 2017). The Materials Safety Data Sheet (MSDS) recommends use only outdoors or in a well-ventilated area, and to avoid breathing mist, vapor, or spray (IXOM 2017).

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for **Methyl isobutyl carbinol**

> Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
> This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.
>
> *Classification of the chemical:*
> Flammable liquids - Category 3
> Eye Irritation - Category 2A
> Specific target organ toxicity (single exposure) - Category 3
>
> Signal word Warning
>
> *Hazard statement(s)*
>
> H226 Flammable liquid and vapour.
> H319 Causes serious eye irritation.
> H335 May cause respiratory irritation.
>
> *Precautionary statement(s): Prevention*
>
> P210 Keep away from heat, sparks, open flames, hot surfaces. No smoking.
> P233 Keep container tightly closed.
> P240 Ground or bond container and receiving equipment
> P241 Use explosion-proof electrical, ventilating, lighting equipment.
> P242 Use only non-sparking tools.
> P243 Take precautionary measures against static discharge.
> P261 Avoid breathing mist, vapours, spray.
> P264 Wash hands thoroughly after handling.

P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves / protective clothing / eye protection / face protection.

Accidental Release Measures

Emergency procedures/Environmental precautions: Shut off all possible sources of ignition. Clear area of all unprotected personnel. If contamination of sewers or waterways has occurred advise local emergency services.

Personal precautions/Protective equipment/Methods and materials for containment and cleaning up: Slippery when spilt. Avoid accidents, clean up immediately. Wear protective equipment to prevent skin and eye contact and breathing in vapours. Work up wind or increase ventilation. Contain - prevent run off into drains and waterways. Use absorbent (soil, sand or other inert material). Collect and seal in properly labelled containers or drums for disposal. Use non-sparking tools.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting and central nervous system depression. If the victim is showing signs of central system depression (like those of drunkenness (*sic*)) there is greater likelihood of the patient breathing in vomit and causing damage to the lungs.

Eye contact: An eye irritant.

Skin contact: Contact with skin may result in irritation. Will have a degreasing action on the skin. Repeated or prolonged skin contact may lead to irritant contact dermatitis. Can be absorbed through the skin with resultant adverse effects.

Inhalation: Material is irritant to the mucous membranes of the respiratory tract (airways). Breathing in vapour can result in headaches, dizziness, drowsiness, and possible nausea. Breathing in high concentrations can produce central nervous system depression, which can lead to loss of co-ordination, impaired judgement and if exposure is prolonged, unconsciousness.

Ecological information

Ecotoxicity Avoid contaminating waterways.
Persistence/degradability: The material is readily biodegradable.
48hr EC50 (*Daphnia magna*): 337 mg/L (semi-static test)
96hr LC50 (rainbow trout): 359 mg/L (semi-static test)

Hydrogen peroxide **30,000 gallons per year in 8 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for hydrogen peroxide 20-60% solution

Hazards identification

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Oxidising liquids - Category 2
Skin Corrosion - Sub-category 1B
Eye Damage - Category 1
Acute Oral Toxicity - Category 4
Acute Inhalation Toxicity - Category 4
Specific target organ toxicity (single exposure) - Category 3

SIGNAL WORD: DANGER

Hazard Statement(s):
H272 May intensify fire; oxidizer.
H302+H332 Harmful if swallowed or if inhaled.
H314 Causes severe skin burns and eye damage.
H335 May cause respiratory irritation

Precautionary Statement(s):
Prevention:
P210 Keep away from heat. No smoking.
P220 Keep and store away from clothing, incompatible materials, combustible materials.
P221 Take any precaution to avoid mixing with combustibles / incompatible materials.
P260 Do not breathe mist, vapours, spray.
P264 Wash hands thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves / protective clothing / eye protection / face protection.

Response:
P301+P330+P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P301+P312 IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
P303+P361+P353 IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P312 Call a POISON CENTER or doctor/physician if you feel unwell.

P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310 Immediately call a POISON CENTER or doctor/physician.
P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
P363 Wash contaminated clothing before re-use.
P370+P378 In case of fire: Use extinguishing media as outlined in Section 5 of this Safety Data Sheet to extinguish.

Physical and chemical properties

pH: 1-4

Stability and reactivity

Conditions to avoid: Avoid exposure to heat.

Incompatible materials: Incompatible with acids, reducing agents, alkalis, heavy metals and their salts, dust, enzymes, combustible material, organic chemicals, cyanides, dirt, rust, hexavalent chromium compounds.

Hazardous decomposition products: Oxygen, which will support combustion

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract. Decomposition may occur in the stomach leading to the production of oxygen gas. This may cause distension of the stomach and the possibility of some bleeding. Death may occur if large amounts are ingested.

Eye contact: A severe eye irritant. Corrosive to eyes; contact can cause corneal burns. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin will result in severe irritation. Corrosive to skin - may cause skin burns.

Inhalation: Breathing in vapour will produce respiratory irritation.

Acute toxicity: Oral LD50 (rat): 841 mg/kg (60% solution)

Respiratory or skin sensitisation: No information available.

Chronic effects: Available evidence from animal studies indicate that repeated or prolonged exposure to this material could result in effects on the lungs.

Ecological information

Ecotoxicity Avoid contaminating waterways.

Sodium hypochlorite **1,000 pounds per year in 1 delivery**
additional 5,000-15,000 gallons per year for Alternative 2

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for sodium hypochlorite solution (10-15% solution)

Hazards identification

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Skin Corrosion - Sub-category 1B
Eye Damage - Category 1
Specific target organ toxicity (single exposure) - Category 3
The following health/environmental hazard categories fall outside the scope of the Workplace Health and Safety Regulations:
Acute Aquatic Toxicity - Category 1
Chronic Aquatic Toxicity – Category 1

SIGNAL WORD: DANGER

Hazard Statement(s):
H314 Causes severe skin burns and eye damage.
H335 May cause respiratory irritation.
H410 Very toxic to aquatic life with long lasting effects.

Precautionary Statement(s):
Prevention:
P260 Do not breathe mist, vapours, spray.
P264 Wash hands thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves / protective clothing / eye protection / face protection.
P273 Avoid release to the environment.

Response:
P301+P330+P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303+P361+P353 IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
P363 Wash contaminated clothing before re-use.
P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P312 Call a POISON CENTER or doctor/physician if you feel unwell.
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

P310 Immediately call a POISON CENTER or doctor/physician.

Other Hazards:
AUH031 Contact with acids liberates toxic gas.

Physical and chemical properties

pH: 12.5 (1% w/w)

Stability and reactivity

Possibility of hazardous reactions: Hazardous polymerisation will not occur. Reacts exothermically with acids. Reacts with ammonia, amines, or ammonium salts to produce chloramines. Decomposes on heating to produce chlorine gas.

Conditions to avoid: Avoid contact with foodstuffs. Avoid exposure to heat, sources of ignition, and open flame. Avoid exposure to light. Avoid contact with other chemicals. Avoid contact with acids.

Incompatible materials: Incompatible with acids, metals, metal salts, peroxides, reducing agents, ethylene diamine tetra-acetic acid, methanol, aziridine, urea. Incompatible with ammonia and ammonium compounds such as amines and ammonium salts.

Hazardous decomposition products: Chlorine.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.

Eye contact: A severe eye irritant. Corrosive to eyes; contact can cause corneal burns. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin will result in severe irritation. Corrosive to skin - may cause skin burns.

Inhalation: Breathing in mists or aerosols will produce respiratory irritation. Delayed (up to 48 hours) fluid build up in the lungs may occur.

Acute toxicity: No LD50 data available for the product.

For the constituent SODIUM HYPOCHLORITE:
Oral LD50 (mice): 5800 mg/kg
Serious eye damage/irritation: Moderate irritant (rabbit). Standard Draize test

Ecological information

Ecotoxicity: Avoid contaminating waterways.

Persistence/degradability: This material is biodegradable.

Bioaccumulative potential: Does not bioaccumulate.

Mobility in soil: No information available.

Aquatic toxicity: Very toxic to aquatic life with long lasting effects.
96hr LC50 (fish): 0.065 mg/L (for sodium hypochlorite)

Antifreeze **40,000 gallons per year in 13 deliveries**

The DEIS did not specify the exact formula; the MSDSs for monoethylene glycol, polyethylene glycol, and propylene glycol are shown here.

Monoethylene glycol

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for monoethylene glycol

> Not classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for transport by Road and Rail; NON-DANGEROUS GOODS.
>
> This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.
>
> *Classification of the chemical:*
> Acute Oral Toxicity - Category 4
> Specific target organ toxicity (single exposure) - Category 3
> Specific target organ toxicity (repeated exposure) - Category 2
>
> SIGNAL WORD: WARNING
>
> *Hazard Statement(s):*
> H302 Harmful if swallowed.
> H335 May cause respiratory irritation.
> H373 May cause damage to organs through prolonged or repeated exposure.
>
> *Precautionary Statement(s):*
> *Prevention*:
> P260 Do not breathe mist, vapours, spray.
> P264 Wash hands thoroughly after handling.
> P270 Do not eat, drink or smoke when using this product.
> P271 Use only outdoors or in a well-ventilated area.
>
> *Response:*
> P301+P312 IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
> P330 Rinse mouth.
> P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
> P312 Call a POISON CENTER or doctor/physician if you feel unwell.
> P314 Get medical advice/attention if you feel unwell.
>
> *Toxicological information*

Ingestion: Initial symptoms following a large dose (>100ml) are those of alcohol intoxication progressing to vomiting, headache, stupor, convulsions and unconsciousness. Respiratory system involvement may occur 12 - 24 hours after ingestion. Symptoms may include hyperventilation and rapid shallow breathing. Death may occur from respiratory failure or pulmonary oedema.

Eye contact: A mild eye irritant.

Skin contact: Contact with skin will result in mild irritation. Will have a degreasing action on the skin. Repeated or prolonged skin contact may lead to irritant contact dermatitis. Can be absorbed through the skin. Effects can include those described for 'INGESTION'.

Inhalation: Breathing in vapour will produce respiratory irritation. Breathing in vapour can result in headaches, dizziness, drowsiness, and possible nausea.

Acute toxicity: Oral LD50 (rat): 4700 mg/kg

Skin corrosion/irritation: Mild irritant (rabbit).

Serious eye damage/irritation: Mild irritant (rabbit).

Respiratory or skin sensitisation: No information available.

Chronic effects: Available evidence from animal studies indicate that repeated or prolonged exposure to this material could result in effects on the central nervous system, liver and kidneys.

Aspiration hazard: No information available.

Estimated minimum lethal dose (human) following ingestion of ethylene glycol is thought to be 1.4ml/kg. High doses of ethylene glycol in rats and mice have resulted in reproductive and developmental toxicity following exposure by the oral and inhalation (respirable aerosol) routes. These particular data sets are not considered relevant to normal industrial use but do emphasise the need for care in handling.

Ecological information

Ecotoxicity Avoid contaminating waterways.

96hr LC50 (fish): >10,000 mg/L (marine water); 8050 mg/L (fresh water).

Polyethylene glycol

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for polyethylene glycol

Not classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for transport by Road and Rail; NON-DANGEROUS GOODS.

Based on available information, not classified as hazardous according to Safe Work Australia; NON-HAZARDOUS CHEMICAL.

Stability and reactivity

Conditions to avoid: Avoid exposure to heat, sources of ignition, and open flame. Avoid dust generation.

Incompatible materials: Incompatible with strong acids and oxidising agents.

Hazardous decomposition products: Oxides of carbon.

Ecological information

Ecotoxicity Avoid contaminating waterways.

Propylene glycol

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for propylene glycol

Not classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for transport by Road and Rail; NON-DANGEROUS GOODS.
Based on available information, not classified as hazardous according to Safe Work Australia; NON-HAZARDOUS CHEMICAL.

Stability and reactivity

Conditions to avoid: Avoid exposure to heat, sources of ignition, and open flame. Avoid temperatures above 40°C. Avoid exposure to direct sunlight.

Incompatible materials: Incompatible with strong oxidising agents, strong acids, isocyanates.

Hazardous decomposition products: Oxides of carbon. Aldehydes. Alcohols. Ethers. Organic acids.

Ecological information

Ecotoxicity 96hr LC50 (rainbow trout): 40,613 mg/L

Sodium bisulfite **1,400-2,000 gallons per year for Alternative 2**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for sodium bisulfite solution (15-40%)

Hazards identification

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Acute Oral Toxicity - Category 4
Skin Irritation - Category 2
Eye Irritation - Category 2A

SIGNAL WORD: WARNING

Hazard Statement(s):
H302 Harmful if swallowed.
H315 Causes skin irritation.
H319 Causes serious eye irritation.
Precautionary Statement(s):
Prevention:
P264 Wash hands thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P280 Wear protective gloves / protective clothing / eye protection / face protection.

Response:
P301+P312 IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
P330 Rinse mouth.
P302+P352 IF ON SKIN: Wash with plenty of soap and water.
P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
P332+P313 If skin irritation occurs: Get medical advice/attention.
P362 Take off contaminated clothing and wash before reuse.
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P337+P313 If eye irritation persists: Get medical advice/attention.

Disposal:
P501 Dispose of contents and container in accordance with local, regional, national, international regulations.

Other Hazards:

AUH031 Contact with acids liberates toxic gas.

Physical and chemical properties

Physical state: Liquid
Colour: Pale Yellow
Odour: Pungent , Sulfur – like
Solubility: Soluble in water.
pH: ca. 4-5

Stability and reactivity

Reactivity: Contact with acids liberates toxic gas.

Incompatible materials: Incompatible with acids, strong oxidising agents, and materials that react violently with water.

Hazardous decomposition products: Sulfur dioxide.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, and gastrointestinal irritation.

Eye contact: An eye irritant.

Skin contact: Contact with skin will result in irritation. May cause skin sensitisation in sensitive individuals. Repeated or prolonged skin contact may lead to allergic contact dermatitis.

Inhalation: Breathing in mists or aerosols may produce respiratory irritation. May cause respiratory sensitisation in sensitive individuals, producing asthma-like symptoms.

Acute toxicity: No LD50 data available for the product.

For the constituent SODIUM BISULFITE:
Oral LD50 (rat): 2000 mg/kg
Skin corrosion/irritation: Irritant.
Serious eye damage/irritation: Irritant.
Respiratory or skin sensitisation: No information available.
Chronic effects: Not a listed carcinogen.
Aspiration hazard: No information available.
Estimated fatal dose in humans is 10 g.

The sodium bisulfite constituent in this product can sensitise the skin and/or respiratory tract of some susceptible individuals.

Ecological information

Ecotoxicity Avoid contaminating waterways.

Bulk solids

Lime **70,000 tons per year in 2,917 deliveries in Alternatives 1, 3, and 4**
(quick lime, calcium oxide) **21,240 tons per year in 885 deliveries in Alternative 2**

Extracts from echemi.com Safety Data Sheet (http://www.echemi.com/sds/calcium-oxide-pd180727113170.html):

Classification of the substance or mixture
Flammable liquids, Category 3
Aspiration hazard, Category 1
Hazardous to the aquatic environment, long-term (Chronic) - Category Chronic 2

Signal word Danger

Hazard statement(s)

H226 Flammable liquid and vapour
H304 May be fatal if swallowed and enters airways
H411 Toxic to aquatic life with long lasting effects

Precautionary statement(s): Prevention

P210 Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P233 Keep container tightly closed.
P240 Ground and bond container and receiving equipment.
P241 Use explosion-proof [electrical/ventilating/lighting/...] equipment.
P242 Use non-sparking tools.
P243 Take action to prevent static discharges.
P280 Wear protective gloves/protective clothing/eye protection/face protection/hearing protection/...
P273 Avoid release to the environment.

Accidental release measures

Personal precautions, protective equipment and emergency procedures: Avoid dust formation. Avoid breathing mist, gas or vapours. Avoid contacting with skin and eye. Use personal protective equipment. Wear chemical impermeable gloves. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Keep people away from and upwind of spill/leak.

Environmental precautions: Prevent further spillage or leakage if it is safe to do so. Do not let the chemical enter drains. Discharge into the environment must be avoided.

Ecological information

Toxicity:

Toxicity to fish: LL50 - *Cyprinus carpio* - 6.8 mg/L - 96 h.

Toxicity to daphnia and other aquatic invertebrates: EL50 - *Daphnia magna* - 5.3 mg/L - 48 h.

Toxicity to algae: EL50 - *Pseudokirchneriella subcapitata* (previous names*: Raphidocelis subcapitata*, *Selenastrum capricornutum*) - 15 mg/L - 72 h.

Toxicity to microorganisms: NOEC - 10 mg/L - 28 d.

Slaked lime (hydrated lime, milk of lime, calcium hydroxide)

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for calcium hydroxide

Not classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for transport by Road and Rail; NON-DANGEROUS GOODS.
This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Skin Irritation - Category 2
Eye Damage - Category 1
Specific target organ toxicity (single exposure) - Category 3

SIGNAL WORD: DANGER

Hazard Statement(s):
H315 Causes skin irritation.
H318 Causes serious eye damage.
H335 May cause respiratory irritation.

Precautionary Statement(s):
Prevention:
P261 Avoid breathing dust / fume / gas / mist / vapours / spray.
P264 Wash hands thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves / protective clothing / eye protection / face protection.

Response:
P302+P352 IF ON SKIN: Wash with plenty of soap and water.
P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
P332+P313 If skin irritation occurs: Get medical advice/attention.

P362 Take off contaminated clothing and wash before reuse.
P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P312 Call a POISON CENTER or doctor/physician if you feel unwell.
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310 Immediately call a POISON CENTER or doctor/physician.

Stability and reactivity

Reactivity: Reacts with acids.

Chemical stability: Stable under normal ambient and anticipated storage and handling conditions of temperature and pressure. Absorbs carbon dioxide from air. Attacks aluminium, lead and brass in the presence of moisture. Decomposes with loss of water at approximately 580°C to form calcium oxide (quicklime).

Possibility of hazardous reactions: None known.

Conditions to avoid: Avoid exposure to moisture. Avoid exposure to air.

Incompatible materials: Incompatible with acids, nitromethane, nitroethane, nitroparaffins, nitropropane, maleic anhydride.

Hazardous decomposition products: Calcium oxide.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.

Eye contact: A severe eye irritant. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin will result in irritation.

Inhalation: Breathing in dust will result in respiratory irritation.

Acute toxicity: Oral LD50 (rat): 7340 mg/kg.

Skin corrosion/irritation: Irritant (rabbit).

Serious eye damage/irritation: Severe irritant (rabbit).

Respiratory or skin sensitisation: No information available.

Chronic effects:

Mutagenicity: No information available.

Carcinogenicity: Not listed as carcinogenic according to the International Agency for Research on Cancer (IARC).

Reproductive toxicity: No information available.

Specific Target Organ Toxicity (STOT) - single exposure: May cause respiratory irritation.

Aspiration hazard: No information available.

Ecological information

Ecotoxicity Avoid contaminating waterways.

Persistence/degradability: Biodegradation is not an applicable endpoint since the product is an inorganic chemical.

Bioaccumulative potential: Does not bioaccumulate.

Mobility in soil: No information available.

48hr EC50 (*Daphnia magna*): 49.1 mg/L
96hr LC50 (fish): 33.9 mg/kg (*Clarias gariepinus*)

Ammonium nitrate **7,300 tons per year in 304 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for ammonium nitrate

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Oxidising solids - Category 3
Eye Irritation - Category 2A

SIGNAL WORD: WARNING

Hazard Statement(s):
H272 May intensify fire; oxidizer.
H319 Causes serious eye irritation.

Precautionary Statement(s): Prevention:
P210 Keep away from heat, sparks, open flames, hot surfaces. No smoking.
P220 Keep and store away from clothing, incompatible materials, combustible materials.
P221 Take any precaution to avoid mixing with combustibles / incompatible materials.
P264 Wash hands thoroughly after handling.
P280 Wear protective gloves / protective clothing / eye protection / face protection

Accidental release measures

Emergency procedures/Environmental precautions: Shut off all possible sources of ignition. Clear area of all unprotected personnel. Do not allow the product to mix with combustible/organic materials. Do not allow container or product to get into drains, sewers, streams or ponds. If contamination of sewers or waterways has occurred advise local emergency services.

Personal precautions/Protective equipment/Methods and materials for containment and cleaning up: Clean up spillages immediately. Contain - prevent run off into drains and waterways. Wear protective equipment to prevent skin and eye contact and breathing in dust. Sweep up, but avoid generating dust. Collect in properly labelled containers, with loose fitting lids, for disposal. (Loose fitting lids). DO NOT return spilled material to original container for re-use. Ensure that contaminated material (clothing, pallets) is thoroughly washed.

Physical and chemical properties

Physical state: Granular Solid / Prills
Colour: White to Off-white
Odour: Negligible
Molecular Formula: NH_4NO_3
Solubility: Soluble in water
pH: 4.5 - 5.2 (10% solution @20°C)

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, and abdominal pain. Swallowing large amounts may result in headaches, dizziness and a reduction in blood pressure (hypotension).

Eye contact: An eye irritant.

Skin contact: Repeated or prolonged skin contact may lead to irritation. Can be absorbed through cut, broken, or burnt skin with resultant adverse effects. Contact with molten material may cause skin burns. See effects as noted under 'Inhalation'.

Inhalation: Breathing in dust may result in respiratory irritation. Blasting may produce a toxic brown gas of nitrogen dioxide. Inhalation of the gas may result in chest discomfort, shortness of breath and possible pulmonary oedema, the onset of which may be delayed.

Absorption of ammonium nitrate by inhalation, ingestion or through burnt or broken skin may cause dilation of blood vessels by direct smooth muscle relaxation and may also cause methaemoglobinaemia. May cause dizziness, drowsiness, nausea and headache due to central nervous system effects.

Ecological information

Ecotoxicity Avoid contaminating waterways. Ammonium nitrate is a plant nutrient. Large scale contamination may kill vegetation and cause poisoning in livestock and poultry.

Low toxicity to aquatic life. TL_m 96: 10-100 ppm
Ammonia: 48hr LC50 (*Cyprinus carpio*): 1.15-1.72mg un-ionised NH_3/L; 95-102 mg total NH_3/L
Nitrates: 96hr LC50 (Chinook salmon, rainbow trout, bluegill): 420-1360 mg NO_3^-/L

Mobility in soil: The material is water soluble and may disperse in soil.

Aquatic toxicity: Ammonium nitrate was evaluated at 5, 10, 25 and 50 mg (NH_4^+)/L. The fertility of *Daphnia magna* was decreased at 50 mg/L. Post embryonic growth of crustacea was impaired at 10, 25 and 50 mg/L.

Sodium cyanide **3,900 tons per year in 163 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search)

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.

This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Corrosive to Metals - Category 1
Acute Dermal Toxicity - Category 1
Acute Inhalation Toxicity - Category 2
Acute Oral Toxicity - Category 2
Skin Irritation - Category 2
Eye Damage - Category 1
Specific target organ toxicity (repeated exposure) - Category 1 Acute Aquatic Toxicity - Category 1
Chronic Aquatic Toxicity - Category 1

SIGNAL WORD: DANGER

Hazard Statement(s):
H290 May be corrosive to metals.
H300+H310+H330 Fatal if swallowed, in contact with skin or if inhaled.
H315 Causes skin irritation.
H318 Causes serious eye damage.
H372 Causes damage to organs through prolonged or repeated exposure.
H410 Very toxic to aquatic life with long lasting effects.

Prevention:
P234 Keep only in original container.
P260 Do not breathe mist, vapours, spray.
P262 Do not get in eyes, on skin, or on clothing.
P264 Wash hands thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P271 Use only outdoors or in a well-ventilated area.
P273 Avoid release to the environment.
P280 Wear protective gloves / protective clothing / eye protection / face protection.
P284 Wear respiratory protection.

Other Hazards:
AUH029 Contact with water liberates toxic gas.
AUH032 Contact with acids liberates very toxic gas.
AUH070 Toxic by eye contact.

Poisons Schedule (SUSMP): S7 Dangerous Poison

Accidental release measures

Emergency procedures/Environmental precautions: Clear area of all unprotected personnel. Isolate spill or leak area immediately. Shut off all possible sources of ignition. Work up wind or increase ventilation. Do not allow container or product to get into drains, sewers, streams or ponds. If contamination of sewers or waterways has occurred advise local emergency services. For large spills notify the Emergency Services.

Personal precautions/Protective equipment/Methods and materials for containment and cleaning up: Avoid breathing in dust. Work up wind or increase ventilation. Wear protective equipment to prevent skin and eye contact and breathing in vapours/dust. DO NOT allow material to get wet. Contain - prevent run off into drains and waterways. Spillage area and contaminated solids can be detoxified by treatment with an excess of dilute sodium hypochlorite, calcium hypochlorite, or ferrous sulfate after the addition of soda ash or lime to raise the pH to greater than 10.5. Allow 1 hour for complete decomposition before washing spillage area down with large quantities of water to ensure maximum dilution. Collect and seal in properly labelled containers or drums for disposal.

Toxicological information

Ingestion: Highly toxic. Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain, convulsions and loss of consciousness. May cause cyanosis (blueness of the skin) due to lack of oxygen in the blood. May cause a weak or irregular heart beat, drop in blood pressure or cardiac arrest. Collapse and possible death may occur.

Eye contact: Causes serious eye damage. A severe eye irritant. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin will result in irritation. Toxic in contact with skin. Can be absorbed through the skin. Effects can include those described for 'INGESTION'.

Inhalation: Breathing in high concentrations may result in the same symptoms described for 'INGESTION'. High inhaled concentrations may lead to a feeling of suffocation and cause difficulty in breathing, headaches, dizziness and loss of consciousness. Can cause suffocation. Material is toxic - inhalation may be fatal.

Chronic effects: Repeated or prolonged skin contact may lead to irritant contact dermatitis - 'cyanide rash' - characterised by itching and skin eruptions. Chronic and subchronic exposure to cyanide is known to induce thyroid effects due to the cyanide metabolite, thiocyanate. Thiocyanate adversely affects the thyroid gland via competitive inhibition of iodide uptake and perturbation of the homeostatic feedback mechanisms that regulate the synthesis and secretion of essential thyroid hormones. Other chronic effects reported include headache, eye irritation, fatigue, shortness of breath and nose bleeds.

Ecological information

Ecotoxicity: Avoid contaminating waterways. Avoid release to the environment.

Bioaccumulative potential: Not expected to bioconcentrate or bioaccumulate.

Mobility in soil: Toxic to the soil environment.

Aquatic toxicity: Very toxic to aquatic organisms. May cause long lasting harmful effects to aquatic life.

Copper sulfate **2,500 tons per year in 167 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search)

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
Environmentally Hazardous Substances meeting the descriptions of UN 3077 or UN 3082 are not subject to the provisions of the Australian Code for the Transport of Dangerous Goods by Road and Rail when transported by road or rail in: packagings that do not incorporate a receptacle exceeding 500 kg(L); or IBCs.

This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Acute Oral Toxicity - Category 4
Skin Irritation - Category 2
Eye Irritation - Category 2A
Acute Aquatic Toxicity - Category 1
Chronic Aquatic Toxicity - Category 1

SIGNAL WORD: WARNING

Hazard Statement(s):
H302 Harmful if swallowed.
H315 Causes skin irritation.
H319 Causes serious eye irritation.
H410 Very toxic to aquatic life with long lasting effects.

Precautionary Statement(s):
Prevention:
P264 Wash hands thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P273 Avoid release to the environment.
P280 Wear protective gloves / protective clothing / eye protection / face protection.

Response:
P301+P312 IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
P330 Rinse mouth.
P302+P352 IF ON SKIN: Wash with plenty of soap and water.
P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
P332+P313 If skin irritation occurs: Get medical advice/attention.
P362 Take off contaminated clothing and wash before reuse.
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

P337+P313 If eye irritation persists: Get medical advice/attention.
P391 Collect spillage.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, and gastrointestinal irritation.

Eye contact: An eye irritant.

Skin contact: Contact with skin will result in irritation. May cause skin sensitisation in sensitive individuals. Repeated or prolonged skin contact may lead to allergic contact dermatitis.

Inhalation: Breathing in dust may result in respiratory irritation. Breathing in fumes from heating may produce symptoms of 'metal fume fever'. This condition is characterised by influenza type symptoms occurring a few hours after exposure and lasting up to 48 hours. Symptoms may include chills, fever, headache, tightness of the chest, coughing, weakness, dryness of nose and mouth, muscular pain, nausea, and vomiting.

Acute toxicity:
Oral LD50 (rat): 482 mg/kg (anhydrous)
Dermal LD50 (rat): >2000 mg/kg (anhydrous)

Ecological information

Ecotoxicity: Avoid contaminating waterways.
Aquatic toxicity: Very toxic to aquatic organisms. May cause long lasting harmful effects to aquatic life.
48hr EC50 (*Daphnia magna*): 0.024 mg/L

Potassium amyl xanthate **1,700 tons per year in 113 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search)

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Self-heating substances and mixtures - Category 2
Acute Oral Toxicity - Category 4
Acute Dermal Toxicity - Category 4
Skin Irritation - Category 2
Eye Irritation - Category 2A
Specific target organ toxicity (single exposure) - Category 3
Toxic to Reproduction - Category 2
Specific target organ toxicity (repeated exposure) - Category 2

SIGNAL WORD: WARNING

Hazard Statement(s):
H252 Self-heating in large quantities; may catch fire.
H302+H312 Harmful if swallowed or in contact with skin.
H315 Causes skin irritation.
H319 Causes serious eye irritation.
H335 May cause respiratory irritation.
H361 Suspected of damaging fertility or the unborn child.
H373 May cause damage to organs through prolonged or repeated exposure.

Precautionary Statement(s):
Prevention:
P201 Obtain special instructions before use.
P202 Do not handle until all safety precautions have been read and understood.
P235+P410 Keep cool. Protect from sunlight.
P260 Do not breathe dust.
P264 Wash hands thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves / protective clothing / eye protection / face protection.
P281 Use personal protective equipment as required.

Response:
P301+P312 IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
P330 Rinse mouth.

P302+P352 IF ON SKIN: Wash with plenty of soap and water.
P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
P322 Specific measures (see First Aid Measures on Safety Data Sheet).
P362 Take off contaminated clothing and wash before reuse.
P363 Wash contaminated clothing before re-use.
P332+P313 If skin irritation occurs: Get medical advice/attention.
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P337+P313 If eye irritation persists: Get medical advice/attention.
P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P312 Call a POISON CENTER or doctor/physician if you feel unwell.
P308+P313 IF exposed or concerned: Get medical advice/attention.
P314 Get medical advice/attention if you feel unwell.

Fire fighting measures

Specific hazards arising from the chemical:

Substance liable to spontaneous combustion.
Avoid all ignition sources.
In common with many organic chemicals, may form flammable dust clouds in air. For precautions necessary refer to Safety Data Sheet "Dust Explosion Hazards".

Special protective equipment and precautions for fire-fighters:

Heating can cause expansion or decomposition of the material, which can lead to the containers exploding. If safe to do so, remove containers from the path of fire. Decomposes on heating emitting toxic fumes, including those of carbon disulphide.
Fire fighters to wear self-contained breathing apparatus and suitable protective clothing if risk of exposure to products of decomposition.

Stability and reactivity

Reactivity: Reacts exothermically on dilution with water. Contact with acids liberates toxic gas.

Chemical stability: Stable under normal conditions of use. Hygroscopic: absorbs moisture or water from surrounding air.

Possibility of hazardous reactions: Hazardous polymerisation will not occur. Can react with water producing carbon disulfide.

Conditions to avoid: Avoid dust generation. Avoid exposure to heat, sources of ignition, and open flame. Avoid exposure to moisture. Avoid exposure to direct sunlight. Avoid electrostatic discharge.

Incompatible materials: Incompatible with oxidising agents, combustible materials, acids, water, phosgene, sulfur chlorides, copper, copper alloy.

Hazardous decomposition products: Carbon disulfide. Hydrogen sulfide. Oxides of sulfur. Oxides of carbon.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain, convulsions and loss of consciousness. Death may occur if large amounts are ingested.

Eye contact: An eye irritant.

Skin contact: Contact with skin will result in irritation. Will liberate carbon disulfide upon contact with moist skin. Carbon disulfide can be absorbed through the skin with resultant adverse effects.

Inhalation: Breathing in dust will result in respiratory irritation. Breathing in high concentrations can produce central nervous system depression, which can lead to loss of co-ordination, impaired judgement and if exposure is prolonged, unconsciousness. Breathing in high concentrations may result in an irregular heart beat and prove suddenly fatal.

Acute toxicity: Oral LD50 (rat): 500-2000 mg/kg

Chronic effects:

Mutagenicity: No information available.

Carcinogenicity: Not listed as carcinogenic according to the International Agency for Research on Cancer (IARC).

Reproductive toxicity: Suspected of damaging fertility or the unborn child.

Specific Target Organ Toxicity (STOT) - single exposure: May cause respiratory irritation.

Specific Target Organ Toxicity (STOT) - repeated exposure: May cause damage to organs through prolonged or repeated exposure.

Ecological information

Ecotoxicity Avoid contaminating waterways

Lead nitrate **700 tons per year in 70 deliveries**

From ixom.com Safety Data Sheet (https://www.ixom.com/sds-search)

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.
This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Oxidising solids - Category 2
Acute Oral Toxicity - Category 4
Acute Inhalation Toxicity - Category 4
Toxic to Reproduction - Category 1A
Mutagenicity - Category 2
Carcinogenicity - Category 2
Specific target organ toxicity (repeated exposure) - Category 2
Acute Aquatic Toxicity - Category 1
Chronic Aquatic Toxicity - Category 1

SIGNAL WORD: DANGER

Hazard Statement(s):
H272 May intensify fire; oxidizer.
H302+H332 Harmful if swallowed or if inhaled.
H318 Causes serious eye damage.
H341 Suspected of causing genetic defects.
H351 Suspected of causing cancer.
H360 May damage fertility or the unborn child.
H373 May cause damage to organs through prolonged or repeated exposure.
H410 Very toxic to aquatic life with long lasting effects.

Precautionary Statement(s):
Prevention:
P201 Obtain special instructions before use.
P202 Do not handle until all safety precautions have been read and understood.
P210 Keep away from heat, sparks, open flames, hot surfaces. No smoking.
P220 Keep and store away from clothing, incompatible materials, combustible materials.
P221 Take any precaution to avoid mixing with combustibles / incompatible materials.
P260 Do not breathe mist, vapours, spray.
P264 Wash hands thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P271 Use only outdoors or in a well-ventilated area.
P273 Avoid release to the environment.
P280 Wear protective gloves / protective clothing / eye protection / face protection.
P281 Use personal protective equipment as required.

Response:
P301+P312 IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
P312 Call a POISON CENTER or doctor/physician if you feel unwell.
P330 Rinse mouth.
P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310 Immediately call a POISON CENTER or doctor/physician.
P308+P313 IF exposed or concerned: Get medical advice/attention.
P314 Get medical advice/attention if you feel unwell.
P370+P378 In case of fire: Use extinguishing media as outlined in Section 5 of this Safety Data Sheet to extinguish.
P391 Collect spillage.

Physical state and chemical properties

pH: 3.0-4.0 (20% aq. solution)

Stability and reactivity

Conditions to avoid: Avoid dust generation. Avoid exposure to heat, sources of ignition, and open flame.

Incompatible materials: Incompatible with ammonium thiocyanate, powdered carbon, hydrogen peroxide, lead hypophosphite, combustible materials, organic materials, strong reducingagents, powdered metals.

Hazardous decomposition products: Lead fume. Oxides of nitrogen. Oxides of lead.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, and abdominal pain. Swallowing large amounts may result in lethargy, motor weakness, muscle tenderness and inco-ordination. Death may occur if large amounts are ingested.

Eye contact: A severe eye irritant. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin may result in irritation.

Inhalation: Breathing in dust may result in respiratory irritation.

Acute toxicity: No oral LD50 data available for the product.

Chronic effects: Absorption of lead over a prolonged period of time (by any route) can produce adverse effects on the blood, central and peripheral nervous systems and reproductive systems, and renal injury. Long term exposure to low concentrations of lead (by any route) may result in blood effects, anaemia, central and peripheral nervous system damage, gastrointestinal disturbances, renal injury, foetotoxicity, developmental deficiencies in neonates and children, and testicular damage including decreased sperm count.

Lead compounds, inorganic: Have been classified by the International Agency for Research on Cancer (IARC) as a Group 2A carcinogen. Group 2A - The agent is probably carcinogenic to humans.

Mutagenicity: Suspected of causing genetic defects.

Carcinogenicity: Suspected of causing cancer.

Reproductive toxicity: May damage fertility or the unborn child.

Specific Target Organ Toxicity (STOT) - single exposure: No information available.

Specific Target Organ Toxicity (STOT) - repeated exposure: May cause damage to organs through prolonged or repeated exposure.

Ecological information

Ecotoxicity: Avoid contaminating waterways.

Persistence/degradability: No information available.

Bioaccumulative potential: No information available.

Mobility in soil: No information available.

Aquatic toxicity: Very toxic to aquatic organisms. May cause long lasting harmful effects to aquatic life.

48hr EC50 (*Daphnia magna*): 0.5-2.0 mg/L
96hr LC50 (fish): 0.4-1.3 mg/L (Carp)

Activated carbon **470 tons per year in 47 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for activated carbon (not spontaneously combustible)

Not classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for transport by Road and Rail; NON-DANGEROUS GOODS.
This product has been tested according to "United Nations Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria Part III - 33.3.1.3" and is not classified as a Class 4.2 dangerous good.
This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:
Eye Irritation - Category 2A
Specific target organ toxicity (single exposure) - Category 3

SIGNAL WORD: WARNING

Hazard Statement(s):
H319 Causes serious eye irritation.
H335 May cause respiratory irritation.

Precautionary Statement(s):
Prevention:
P261 Avoid breathing dust / fume / gas / mist / vapours / spray.
P264 Wash hands thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves / protective clothing / eye protection / face protection.

Response:
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P337+P313 If eye irritation persists: Get medical advice/attention.
P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P312 Call a POISON CENTER or doctor/physician if you feel unwell.

Stability and reactivity

Possibility of hazardous reactions: Dust explosion hazard. Hazardous polymerisation will not occur.

Conditions to avoid: Avoid dust generation. Avoid exposure to moisture.

Incompatible materials: Incompatible with strong oxidising agents. Incompatible with hydrocarbons.

Hazardous decomposition products: Oxides of carbon.

Toxicological information

Ingestion: No adverse effects expected, however, large amounts may cause nausea and vomiting.

Eye contact: An eye irritant.

Skin contact: Contact with skin may result in irritation.

Inhalation: Breathing in dust will result in respiratory irritation.

Ecological information

Ecotoxicity Avoid contaminating waterways.

Sodium hydroxide **300 tons per year in 30 deliveries**

Extracts from ixom.com Safety Data Sheet (https://www.ixom.com/sds-search) for caustic soda – liquid (46-50%) (Data sheet for 5-45% also available.)

Classified as a Dangerous Good according to NZS 5433:2012 Transport of Dangerous Goods on Land.
Classified as hazardous according to criteria in the Hazardous Substances (Minimum Degrees of Hazard) Notice 2017 and the Hazardous Substances (Classification) Notice 2017.

SIGNAL WORD: DANGER

Subclasses:
Subclass 6.1 Category D - Substances which are acutely toxic.
Subclass 8.1 Category A - Substances that are corrosive to metals.
Subclass 8.2 Category B - Substances that are corrosive to dermal tissue.
Subclass 8.3 Category A - Substances that are corrosive to ocular tissue.
Subclass 9.1 Category D - Substances that are slightly harmful to the aquatic environment or are otherwise designed for biocidal action.

Hazard Statement(s):
H290 May be corrosive to metals.
H302 Harmful if swallowed.
H313 May be harmful in contact with skin.
H314 Causes severe skin burns and eye damage.
H402 Harmful to aquatic life.

Precautionary Statement(s):
Prevention:
P102 Keep out of reach of children.
P103 Read label before use.
P234 Keep only in original container.
P260 Do not breathe mist/vapours/spray.
P264 Wash hands thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P273 Avoid release to the environment.
P280 Wear protective gloves/protective clothing/eye protection/face protection.

Response:
P301+P330+P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303+P361+P353 IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304+P340 IF INHALED: Remove to fresh air and keep at rest in a position comfortable for breathing.
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

P310 Immediately call a POISON CENTER or doctor/physician.
P321 Specific treatment (see First Aid Measures on the Safety Data Sheet).
P363 Wash contaminated clothing before re-use.
P390 Absorb spillage to prevent material damage.

Physical and chemical properties

Physical state: Liquid
Colour: Colourless
Odour: Odourless
Solubility: Miscible with water.
Specific Gravity: 1.48-1.52 @20°C
Relative Vapour Density (air=1): Not available
Vapour Pressure (20 °C): 1.34 mm Hg (calculated)
Flash Point (°C): Not applicable
Flammability Limits (%): Not applicable
Autoignition Temperature (°C): Not applicable
Boiling Point/Range (°C): ca. 145 (literature)
pH: 14 (literature)
Freezing Point/Range (°C): ca. 12 (calculated)

Stability and reactivity

Reactivity: Reacts violently with acids. Reacts exothermically on dilution with water.
Chemical stability: Stable under normal ambient and anticipated storage and handling conditions of temperature and pressure. Absorbs carbon dioxide from the air.

Possibility of hazardous reactions: Reacts with ammonium salts, evolving ammonia gas. Reacts readily with various reducing sugars (i.e. fructose, galactose, maltose, dry whey solids) to produce carbon monoxide. Take precautions including monitoring the tank atmosphere for carbon monoxide to ensure safety of personnel before vessel entry.

Conditions to avoid: Avoid exposure to moisture. Avoid exposure to direct sunlight.

Incompatible materials: Incompatible with acids, ammonium salts, aluminium, tin, zinc, brass.

Toxicological information

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain andchemical burns to the gastrointestinal tract.

Eye contact: A severe eye irritant. Corrosive to eyes; contact can cause corneal burns.

Contamination of eyes can result in permanent injury. May cause blindness.

Skin contact: Contact with skin will result in severe irritation. Corrosive to skin - may cause skin burns.

Inhalation: Breathing in mists or aerosols may produce respiratory irritation.

Acute toxicity: No LD50 data available for the product.

For the constituent Sodium hydroxide: Skin corrosion/irritation: Severe irritant (rabbit).

Specific Target Organ Toxicity (STOT) - single exposure: May cause respiratory irritation. Serious eye damage/irritation: Severe irritant (rabbit).

Ecological information

Ecotoxicity Avoid contaminating waterways.

Bulk liquids I was unable to find MSDSs for

Lubricants	296,000 gallons per year in 99 deliveries
Aerophine 3418A	10,000 gallons per year in 50 deliveries
Scale control reagents	5,000 gallons (or pounds?) per year in 10 deliveries
Solvents	1,000 gallons per year in 5 deliveries

Bulk solids I was unable to find MSDSs for

Antimony concentrate	Up to 29,200 tons per year in 365-730 deliveries
Sodium metabisulfite	14,000 tons per year in 583 deliveries
Grinding metals (Steel balls for mill)	10,000 tons per year in 417 deliveries
Crusher and grinding liners	3,200 tons per year in 133 deliveries
Flocculent	600 tons per year in 40 deliveries
Explosives	100 tons per year in 20 deliveries

Fertilizer	2,500 pounds per year in 1 delivery
Sodium hypochlorite (solid)	1,000 pounds per year in 1 delivery
Herbicide	1,000 pounds per year in 1 delivery
Pesticides/insecticides	250 pounds per year in 1 delivery

Appendix C. Susan Lubetkin statement of qualifications

SUMMARY

Environmental statistician interested in the intersections of science and policy, with specific focus and experience in analysis of regulatory science used in decision-making

Areas of expertise include:

- Experimental design, linear and nonlinear regression, bootstrap methods, mixed effects models, longitudinal models, non-parametric multiplicative regression, fault trees, risk analysis
- Statistical software, especially R Studio
- Communication of research results to both specialists and non-specialists, either in small groups or large audiences

RECENT EXPERIENCE

Independent analyst June 2015-present

- Research the data sets, assumptions, and statistical models contracted by and used within environmental impact statements for on- and offshore fossil fuel development in the Arctic (spill risk models), Sea Port Oil Terminal Project Offshore Brazoria County, Texas (spill risk models), and Pebble Mine (transportation corridor spill risks, tailings storage facility failure models, fish habitat models), Gulf of Mexico Oil and Gas (spill risk models)
- Client list (paid and *pro bono*) includes Alaska Wilderness League, Cook Inletkeeper, Defenders of Wildlife, Earth Justice, Trustees for Alaska, and Wild Salmon Center

Executive Director: Terra Nostra*, a multi-media symphony about climate change* July 2013-April 2020

- Commissioned a symphony about climate change from Christophe Chagnard, which was performed by the Lake Union Civic Orchestra in June of 2015 at Meany Hall, University of Washington
- Laid the groundwork for starting *Terra Nostra* as a non-profit, showing the effectiveness of using music and images to illustrate the contemporary and local effects of climate change
- Led a successful $55,000 fundraising effort to professionally record the revised version of the score in January 2019 and create the film version
- Oversaw getting the film version of *Terra Nostra* produced and submitted to film festivals around the country. Honors include *Best Original Score* (Top Shorts, October 2019), *Honorable Mention - Experimental Film* (Independent Shorts, November 2019), *Award of Merit - Nature/Environment/Wildlife* (Best Shorts Competition, December 2019), *Award of Merit - Documentary Short* (Impact DOCS, January 2020), inclusion in the American Documentary and Animation Film Festival (Palm Springs, California, March 2020; rescheduled to September 2020), finalist (Deep Focus Film Festival, April 2020), *Award of Merit Special Mention: Nature/Environment/Wildlife* (Accolade Global Film Festival, August 2020), Official Selection (Nature Without Borders International Film Festival, August 2020)

Instructor, University of Washington January-December 2014

- Nomination for a Distinguished Teaching Award, December 2014, University of Washington
- Quantitative Science (QSci) 482: Statistical Inference in Applied Research I: Hypothesis Testing and Estimation for Ecologists and Resource Managers (Fall 2014, Summers 1999, 2000)
- Quantitative Ecology and Resource Management (QERM) 514: Analysis of Ecological and Environmental Data (Spring 2014)
- QSci 486: Analysis of Designed Experiments (Winter 2014)

RESEARCH POSITIONS

September 2011- February 2013
University of Washington Seattle, Washington

Post-doctoral research assistantship with Evelyn Lessard (School of Oceanography) using nonparametric multiplicative regression to characterize the environmental variables best for predicting harmful algal blooms of *Pseudo-nitzschia* spp. and the production of domoic acid in the Pacific northwest.

September 2008 – May 2010
University of Washington Seattle, Washington

Post-doctoral research assistantship with Judith Zeh (Department of Statistics) modeling bowhead whale baleen length and body length at age with several canonical growth models. This involved fitting nonlinear models to multivariate data and using bootstrapping procedures to then estimate the ages of whales with known baleen and/or body lengths.

September 1997- June 1998
National Oceanographic and Atmospheric Administration Seattle, Washington

Research assistantship with Sarah Hinckley modeling nutrient-phytoplankton-zooplankton dynamics along the coastal Gulf of Alaska

EDUCATION

2008 University of Washington Seattle, Washington

Ph.D., Quantitative Ecology and Resource Management (QERM): Using annual cycles of stable carbon isotope ratios with baleen and body length data from bowhead whales (*Balaena mysticetus*) to estimate whale age and explore anomalous years

My dissertation was focused on modeling the growth of bowhead whales, using stable isotope patterns in non-linear mixed effects (NLME) models and nonlinear regression techniques.

1997 University of Washington Seattle, Washington

M.S., QERM: Multi-source mixing models: food web determination using stable isotope tracers

I developed a model to use stable isotopes to estimate primary production and other nutrient flows through estuarine food webs.

1994 Harvey Mudd College Claremont, California

B.S., Biology

PUBLICATIONS

Peer reviewed articles and book chapters

George, J.C., S. C. Lubetkin, H. Thewissen, J. E. Zeh, and G. Givens. In press. Age estimation in bowhead whales. Forthcoming chapter in the second edition of *The Bowhead Whale*.

Lubetkin, S.C. 2020. The tip of the iceberg: three case studies of spill risk assessments used in environmental impact statements. *Marine Pollution Bulletin.* Available online January 31, 2020. https://doi.org/10.1016/j.marpolbul.2019.110613

Lubetkin, S. C., Zeh, J. E., and George, J. C. 2012. Statistical modeling of baleen and body length at age in bowhead whales (*Balaena mysticetus*). *Canadian Journal of Zoology*. 90: 915-931.

Lubetkin, S. C., Zeh, J. E., Rosa, C., and George, J. C. 2008. Age estimation for young bowhead whales (*Balaena mysticetus*) using annual baleen growth increments. *Canadian Journal of Zoology*. 86: 525-538.

Lubetkin, S. C. and Simenstad, C. A. 2004. Two multi-source mixing models using conservative tracers to estimate food web sources and pathways. *Journal of Applied Ecology 41*: 996-1008.

Schindler, D. E. and Lubetkin, S. C. 2004. Using stable isotopes to quantify material transport through food webs. Pp. 25-42 in Gary A. Polis, Mary E. Power, and Gary R. Huxel, eds., *Food Webs at the Landscape Level*. University of Chicago Press.

Schindler, D.E., Chang, G. C., Lubetkin, S. C., Abella, S. E. B., and Edmondson, W. T. 2002. Rarity and functional importance in a phytoplankton community. Pp. 206-220 in Peter Kareiva and Simon A. Levin, eds., *The Importance of Species*. Princeton University Press.

In preparation

Lubetkin, S. C., Zeh, J. E., Rosa, C., and George, J. C. Evidence of a decadal scale shift in the carbon sources for the Beaufort and Bering Seas from stable isotopic records in bowhead whale (*Balaena mysticetus*) baleen.

Lubetkin, S. C., Zeh, J. E., Rosa, C., and George, J. C. Bowhead whale (*Balaena mysticetus*) migration pattern changes in response to changing ice dynamics in the Arctic.

Lubetkin, S. C., Zeh, J. E., Rosa, C., and George, J. C. Stable isotopic evidence of bowhead whales (*Balaena mysticetus*) not migrating from the Bering Sea to the Beaufort Sea: frequency, characteristics, and ecological implications.

MEETING PRESENTATIONS, WORKSHOPS

Lubetkin, S.C. 2020. The tip of the iceberg: three case studies of spill risk assessments used in environmental impact statements. Poster at the Alaska Marine Sciences Symposium, January 27-30, 2020.

September 22-23, 2016, Washington, DC. Science and Tools for Developing Arctic Marine Protected Area Networks: Understanding Connectivity and Identifying Management Tools. Invited participant to the Arctic Council, Protection of the Arctic Marine Environment (PAME) scientific working group.

Lubetkin, S. C., and Lessard, E. J. 2013. Habitat modeling of *Pseudo-nitzschia* distribution and toxicity in the coastal waters of the northwest Pacific using non-parametric multiplicative regression. Poster at the 7th Annual Harmful Algal Bloom Symposium, Sarasota, Florida, October 2013.

Lubetkin, S. C., and Lessard, E. J. 2013. Habitat modeling of *Pseudo-nitzschia* distribution and toxicity in the coastal waters of the northwest Pacific using non-parametric multiplicative regression. Oral presentation at the Association for the Sciences of Limnology and Oceanography meeting, New Orleans, Louisiana, February 2013.

Lubetkin, S. C., and Zeh, J. E. 2006. Deriving age-length relationships for bowhead whales (*Balaena mysticetus*) using a synthesis of age estimation techniques. Paper SC/58/BRG14 presented to the International Whaling Commission Scientific Committee, June 2006.

Lubetkin, S. C., Zeh, J. E., Rosa, C., and George, J. C. 2004. Deriving von Bertalanffy age-length relationships for bowhead whales (*Balaena mysticetus*) using a synthesis of age estimation techniques. Paper SC/56/BRG3 presented to the IWC SC, June 2004.

Lubetkin, S. C. 2000. Bowhead whale age determination: extending estimates from baleen stable isotope signatures. Oral presentation at the 4th Meeting of the Society of Marine Mammalogy Northwest Student Chapter. University of Washington, Seattle, Washington, April 29, 2000.

Lubetkin, S. C. and Simenstad, C. A. 1997. Food web determination using a multiple stable isotope mixing model. Poster at the 14th Biennial Estuarine Research Federation International Conference: The State of Our Estuaries. Providence, Rhode Island, October 12-16, 1997.

November 7-9, 1996, Savannah, Georgia. Land Margin Ecosystems Research Program Workshop. (Participant with Charles Simenstad.)

February 3-6, 1996, Woods Hole, Massachusetts. Land Margin Ecosystems Research Program Workshop. (Participant with Charles Simenstad.)

COMMUNITY INVOVLEMENT AND SERVICE

Alaska Wilderness League Leadership Council (charter member, January 2019-present)

Social Venture Partners (partner from 2005-present)

- Inaugural cohort of the Conservation Philanthropy Fellowship Program in Autumn 2013
- Service on the Environment Collective Action Team (EnviroCAT) (October 2015-June 2019, co-chair June 2017-June 2019)

Lake Union Civic Orchestra (cello, 1995-present)

Sustainable Seattle Board of Directors (October 2015-October 2017)