Baker

Department of Transportation
Research and Special Programs Administration
Office of Pipeline Safety

TTO Number 1

Integrity Management Program
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Consequences of HVL Releases

FINAL REPORT

This report is intended to serve as a technical resource for OPS and State pipeline safety inspectors evaluating operators' integrity management (IM) programs. Inspectors consider information from a number of sources in determining the adequacy of each IM program. Development of this report was funded via a Congressional appropriation specifically designated for implementation of IM oversight. This and other similar reports are separate and distinct from the work products associated with and funded via OPS's R&D Program.

Submitted by:
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Introduction

This report has been developed in accordance with the Statement of Work and proposal submitted in response to RFP for Technical Task Order (TTO) Number 1 entitled "Consequences of HVL Releases." 49 CFR 195.452 requires operators of hazardous liquid pipelines to identify all pipeline segments that could affect High Consequence Areas (HCAs) in the event of an accidental release. The focus of TTO 1 is on those pipelines transporting hazardous liquids that qualify as highly volatile liquids (HVL) per the criteria in 49 CFR 195.2. OPS requested, in this scope, "an approach and criteria for determining when releases from HVL segments could affect ecological and drinking water HCAs. OPS inspectors would use this approach when determining operator compliance under Protocol #1.06, Segment Identification, Direct Intersection Exceptions. HVLs, as defined in 49 CFR 195 are *"Highly volatile liquids….a hazardous liquid which will form a vapor cloud when released to the atmosphere and which has a vapor pressure exceeding 276 kPa (40 psia) at 37.8 degrees C (100 degrees F)."*

This scope included three subtasks that required surveys and/or literature searches. The results of each subtask are summarized below. Subtask 04 included the development of an approach for OPS operators to use for determining operator compliance. The approach presented in Subtask 04 is a checklist that can be used for evaluating "could affect" determinations for pipeline segments within HCAs, as well as for evaluating whether an operators' assessment adequately addressed all potentially relevant HCAs. Following the checklist in the Subtask 04 section of this report is a summary of additional data needs that were identified during this effort. The suggestions for additional information are provided for those areas that may provide another level of support for inspectors during reviews of operators' plans.

Based on information in the public domain and on discussions with several OPS inspectors regarding the primary HVL products transported, the HVLs addressed in this report include: propane, butane, liquefied petroleum gases (LPG), ethylene, propylene, and anhydrous ammonia.

Results of Subtask 01: HVL Pipeline Accident Research

Subtask 01 - Scope of Services

Conduct a survey of consequences resulting from accidents involving HVL pipelines. The survey should be based on information available in the public domain (including, but not limited to, OPS accident reports available at http://ops.dot.gov/IA98.htm, and published NTSB findings). To the extent possible, note contributing factors or other conditions (such as weather, geography) that aggravate or mitigate accident consequences.

Sources and Information Discovered

Baker conducted research of available public domain data relating to the consequences resulting from accidents involving HVL pipelines. The sections below summarize specific sources and a brief discussion of the information found. Most research was conducted using Internet search engines, with follow-ups by e-mail, phone call, or fax transmissions to key contact persons. Key words such as "highly volatile liquids" and "HVL" were not productive. More information was found when using specific product names (e.g. butane, propane, LPG) in association with other keywords (pipeline, release, spill, regulation). Based on this search and on discussions with OPS inspectors, the primary products investigated in this task order include: Butane, Propane, Liquefied petroleum gas (LPG), and anhydrous ammonia. In addition, ethylene, propylene, and 1,3-butadiene were also investigated. NIOSH summaries of properties for each, along with DOT "hazmat" guides, are provided in Attachment A.

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Accident reports (http://ops.dot.gov/IA98.htm) – two databases of reports were searched and summarized: 1986 to 2002 and Jan – Oct 2002. The more recent reports contain fields for recording impacts to ecological resources. The older reports do not contain this information. Other locations within the OPS website were searched. Yearly accident reports by commodity were found at http://ops.dot.gov/stats.htm. A summary table of this data is shown below:

Average (1990 to 2001)							
Commodity	No. of accidents	% Total of Accidents	Barrels Lost	Property Damage	% Total Damages	Fatalities	Injuries
Anhydrous Ammonia	4.8	7.8	1491.6	$300,700	1.1	0.1	0.9
Butane	4.3	2.6	2363.1	$1,482,327	2.0	0.3	0
L.P.G.	11	5.7	11769.2	$867,712	2.3	0.7	4.7
Propane	4.8	3.2	8035.8	$497,153	0.9	0	0.8
Total Average	6.2	4.8	5914.9	$786,973	1.6	0.3	1.6

Note: the average percent total number of accidents from Anhydrous Ammonia, Butane, L.P.G., and Propane is 4.8% and Total Damages 1.6%.

A map showing the OPS regions and regional offices is located at http://ops.dot.gov/rinfo.htm. On the OPS online Library site http://ops.dot.gov/libindex.htm, a General Accounting Office report and some congressional reports were found covering general pipeline safety.

NTSB findings

A small number of Accident Summary Reports were available regarding HVLs. None of the accidents occurred in areas that would meet the definition of ecological High Consequence Areas (HCAs). Two accident reports, Lively, TX and Puerto Rico, were found on the NTSB website that involved highly volatile liquids. Summaries were also available. These reports focus on fatalities, injuries, property damages, causes, and recommendations and do not address environmental effects from these explosive ruptures.

Reports from trade organizations

The following are results from a general Internet search:

- One report of an HVL spill was found from the Butane Propane News - An LPG pipeline ruptured, followed by an explosion, had little impact on propane supply, according to owner ChevronTexaco Corp. The incident occurred in an isolated part of North Central Texas. No environmental damage was reported.
- One meeting announcement in the Federal Register for a meeting held in January 1996 concerning pipeline safety was found on the EPA website. (EPA 1996)
- Two abstracts from the Society for Risk Assessment (SRA) were found concerning HVL release experiments. The first paper presented a methodology of the prediction of hazardous zones resulting from the accidental release of liquefied gases. The second presented the mathematical modeling and computations of LPG pipeline rupture. The SRA does not have copies of the entire papers. (SRA)

State sources

Research of CA, FL, IL, NY, and TX state agencies revealed no available documentation regarding the consequences of release of HVLs on HCAs. Most contact within these agencies was made through telephone calls. Most agencies reported that they do not track or study environmental consequences from HVLs specifically. Written Freedom of Information Act (FOIA) requests to these agencies could result in narrative reports or investigations in response to the accidents recorded by OPS. Baker did not submit FOIA requests because of the time constraints of this task order.

International sources

Little information was readily available from international sources. The World Bank, during international development actions such as building pipelines, requires owner-operators to comply with their general Operational Directives and Operational Procedures in order to qualify for development loans. These directives do not contain specific measures regarding environmental protections; they are reviewed on a case-by-case basis for general compliance. No information was found from these sources regarding HVLs. Other international sources may retain reports on HVLs, but many required membership in oil and gas associations or fees to even enter their websites or request information.

Local municipalities

Baker was able to contact several local municipalities during in-depth studies for the Case Studies presented below. The agencies reported a response to the incidents, but did not document environmental damage.

Summary of Consequences

Baker found that most sources focused on the human safety aspect of vapor clouds, odors, fires and explosions, while little information was available to document specific ecological and environmental consequences. Common regulatory health standards and public safety precautions exist concerning the acute and long-term exposure effects from HVLs such as propane, n-butane, or other common liquefied petroleum gases (LPGs) (NIOSH, 2002 and ERG, 2002). Examples from the NIOSH handbook and ERG are presented in Attachment A. Baker found no standards that guide or regulate exposure from HVLs to ecosystems, flora, or fauna.

Data were compiled from the Office of Pipeline Safety accident reports for the periods 1986-2001 and 2002. These reporting periods differ in the available data; the more recent reports contained more details than older reports. The reports from these two periods were filtered to only contain incidents involving HVLs and relevant data were summarized. These summaries are presented in Attachment B. Only one HVL release in 2002 reported an "Impact," but detailed information regarding the release amount was not available.

The environmental consequences to HCAs from an HVL release would greatly depend on local site conditions, the product released, and the species present at the time of the release. There is no general rule that can be followed regarding impacts from HVLs; however, knowledge of the product's behavior under varying conditions will provide an inspector with a basic understanding of likely direct environmental impacts. Since these products are heavier than the air, they will tend to collect in low-lying areas, displacing the oxygen in those areas. Non-motile animals or plant species in the HCA may be detrimentally affected by a released vapor cloud, while larger species may be able to flee the cloud. In the event of the ignition of the vapor cloud and subsequent fire or explosion, damage would likely be restricted to the immediate area. The incidental take or death of a species of concern may only be likely in those areas of high species density, such as nesting, roosting or migration sites. It is anticipated that the actions associated with the response and repair would present the greatest risk of harming an HCA. For example, the immediate mobilization of heavy equipment to extinguish a fire or repair a pipeline would be necessary. The timing of this emergency repair may coincide with species migration, nesting, or mating, thereby creating an unavoidable harassment or incidental take of a species or unavoidable harm to sensitive ecosystems.

Case Studies

Baker performed in-depth research of several incidents involving the release of HVLs. None of these are believed to have occurred in HCAs, but demonstrate typical consequences of an HVL release.

<u>Case Study No. 1 – Koch Pipeline Rupture, Liquid Butane Release, and Fire. 8/24/96. Lively, Texas.</u>

This event resulted in a localized fire in the right-of-way and adjacent woodlands. Nearby trees and underbrush burned, but there is no information documenting other ecological consequences. The rupture of a steel pipeline under a roadway sent a butane vapor cloud into a nearby residential area. The butane vapor ignited as two residents in a pickup truck drove into the cloud. The occupants of the truck died from thermal injuries and about 25 families were evacuated. Property losses of $217,000 were sustained. The fire damaged the pickup truck, a mobile home, several outbuildings, and the adjacent woodlands.

Case Study No. 2 – MAPCO Pipeline Rupture. Propane Release. 1/29/02. Warren County, IL.

This event resulted in a localized release and evacuations. There is no information documenting ecological consequences. OPS Report No. 20020045 – 7500 barrels of propane released due to excavation damage. Mid-America Pipeline Co (MAPCO). Baker contacted the Warren County, IL sheriff's office. They indicated that they responded to a report of a pipeline rupture. The pipeline was punctured by a farmer who was laying drainage tiles. The sheriff's office evacuated residents from the area. This incident occurred in an agricultural area; no environmental effects were noted.

Case Study No. 3 – Koch Pipeline Accident. Anhydrous Ammonia Release. 12/17/01. Algona, Iowa. A maintenance crew broke a valve off an underground anhydrous ammonia pipeline causing a plume of vapors and a chemical spill to a nearby creek. The 8-inch line was ruptured at 3 pm and the leak was stopped by 11 pm that night. By the following day, contamination from the spill had killed virtually all fish and several other animals including snapping turtles, frogs, and muskrat along at least 31 miles of Lotts Creek. Ammonia laden water was also flowing into the Des Moines River. The contaminated water was expected to take six days to reach Des Moines, where the river is used as a source of drinking water. The contamination was not expected to cause problems with the city's water source because the city could easily draw water from the Raccoon River. The spill killed nearly 1.3 million fish along a 48- mile stretch of Lotts Creek and the Des Moines River. The Iowa DNR estimated that 310,000 pounds of anhydrous ammonia, or 58,000 gallons spilled.

Results of Subtask 02: Literature Search of Effects on Drinking Water HCAs and Ecological HCAs

Subtask 02 - Scope of Services

Conduct a survey/literature search to document the effects on drinking water HCAs and ecological HCAs resulting from the presence of HVLs or HVL by-products from any source.

Sources and Information Discovered

As discussed in Subtask 01, for the most part, summaries of accidents involving HVLs do not include evaluations of environmental affects. Likewise, the literature did not include much information addressing the secondary effects from HVL releases (e.g., by-products formed from combustion of product, physical emergency response effects such as use of heavy equipment on wetlands, or from the effects of a fire and explosion on drinking water or ecological HCAs). That is especially true for propane, butane, LPG, ethylene, and propylene. Butadiene soot (from incomplete combustion) has aromatic hydrocarbons with high molecular mass, which could be a concern in water, soil, and sediments because of the potential for toxicity. There is a significant amount of information in the literature on the environmental effects of anhydrous ammonia in the environment. Anhydrous ammonia is added to agricultural sites to enhance vegetative growth and production; however, if applied in amounts greater than the suggested application rates, vegetative growth can be inhibited or death can occur. Anhydrous ammonia is highly toxic in the aquatic environment, even at relatively low concentrations. It is soluble and can be dispersed great distances at toxic concentrations in surface and ground water. Criteria depend on pH and temperature, as well as the type of organism. Increases in temperature often show LC50s at higher values in fish, whereas temperature decreases generally result in lower LC50 values for macroinvertebrates. EPA indicates that the acute criterion for fish is dependent on pH and the chronic criterion is dependent on pH and temperature. At lower temperatures, the dependency of chronic criterion is also dependent on the presence or absence of early life stages of fish.

In lieu of the paucity of fate and effects information from HVL releases, another way to evaluate the potential effects of a release of HVLs would be by using toxicity data. The U.S. Environmental Protection Agency's ECOTOX database was screened for ecotoxicological data. The database was queried using the CAS number for the HVLs identified for analysis in Subtask 01. Information was available from the aquatic resources database. Table 1 provides a summary of findings for aquatic biota. As can be seen by the data provided in Table 1, ethylene and ammonia are toxic to aquatic organisms at much lower concentrations than butane, propane, and LPG.

To evaluate the potential threat posed to wildlife from HVL vapor clouds, inhalation toxicity data was searched to determine hazardous concentrations in air. Table 2 provides representative data from laboratory tests performed on mammals. Asphyxiation is the primary cause of death for mammals exposed to HVL product vapor clouds. No toxicity-related data was identified for birds, reptiles, amphibians, or insects. The results of the tests on mammals are used by human health risk assessors for determining OSHA time weighted average concentrations and for determining Immediately Dangerous to Life or Health Concentrations (IDLH).

Table 1. Reported Toxicity Data for Aquatic Receptors from ECOTOX Database for HVL Products.

Chemical	**Organism**	**Endpoint**	**Effect**	**Media/Exposure**	**Concentration (ug/L)**	**Reference**
Butanone	*Daphnia magna*	EC_{50} LC_{50}	Behavior Mortality	FW/24 hr FW/24 hr	2,600 – 7,060 >520,000	Bringmann and Kuhn, 1982 LeBlanc, 1980
Butanone	*Leuciscusidus melanotus*	LC_{50}	Mortality	FW/48 hr	4,600 – 4,800	Juhnke and Luedemann, 1978
Butanone	*Cyprinodon variegatus*	LC_{50} NOEC	Mortality	SW/24 hr SW/48 hr SW/96 hr SW/96 hr	>400,000 >400,000 >400,000 400,000	Heitmuller, Hollister, and Parrish, 1981
Butanone	*Americamysis bahia*	LC_{50}	Mortality	SW/96 hr	>402,000	U.S. EPA, 1978
Ethylene oxide	*Artemia sp.*	LC_{50}	Mortality	SW/24 hr SW/48 hr	350,000 - >500,000	Conway, Waggy, Spiegel, and Berglund, 1983
Ethylene oxide	*Carassius auratus*	LC_{50}	Mortality	FW/24 hr	90,000	Birdie, Wolff, and Winter, 1979
Ethylene oxide	*Daphnia magna*	LC_{50} LC_{50}	Mortality Mortality	FW/24 hr FW/48 hr	260,000 - >300,000 83,000 – 300,000	Conway, Waggy, Spiegel, and Berglund, 1983
Ethylene oxide	*Pimephales promelas*	LC_{50}	Mortality	FW/24 hr FW/48 hr FW/96 hr	63,000 – 500,000 63,000 – 125,000 73,000 – 96,000	Conway, Waggy, Spiegel, and Berglund, 1983
Propylene oxide	*Carassius auratus*	LC_{50}	Mortality	FW/24 hr	170,000	Birdie, Wolff, and Winter, 1979
Propylene oxide	*Gambusia affinis*	LC_{50}	Mortality	FW/96 hr	141	Crews, 1974
Propylene oxide	*Lepomis macrochirus*	LC_{50}	Mortality	FW/96 hr	215	Crews, 1974
Propylene oxide	*Mugil cephalus*	LC_{50}	Mortality	SW/96 hr	89	Crews, 1974
Ammonia	*Daphnia magna*	EC_{20}	Mortality	Not provided	7,370	U.S. EPA, 1999
Ammonia	*Hyalella azteca*	EC_{20}	Mortality	Not provided	1,580	U.S. EPA, 1999
Ammonia	*Catostomus commersoni*	EC_{20}	Mortality	Not provided	2,900	U.S. EPA, 1999
Ammonia	*Lepomis macrochirus*	EC_{20}	Mortality	Not provided	1,850	U.S. EPA, 1999
Ammonia	*Ictalurs punctatus*	EC_{20}	Mortality	Not provided	11,500	U.S. EPA, 1999
Ammonia	*Pimephales promelas*	EC_{20}	Mortality	Not provided	1,970	U.S. EPA, 1999
Ammonia	*Micropterus dolomieu*	EC_{20}	Mortality	Not provided	1,540	U.S. EPA, 1999
Ammonia	*Musculium transversum*	EC_{20}	Mortality	Not provided	1,230	U.S. EPA, 1999

Table 2. Inhalation and Ingestion Toxicity Data for Representative Mammal Species.

Product	Test Species	Measurement (ppm)	Exposure Time	Adjusted 0.5-hr LC/LD	Reference	Human IDLH (ppm)
Ammonia	Rat	40,300 LC_{50}	10 min	23,374	Alarie 1981	
Ammonia	Rat	28,595 LC_{50}	20 min	23,448	Alarie 1981	
Ammonia	Rat	20,300 LC_{50}	40 min	23,345	Alarie 1981	
Ammonia	Rat	11,590 LC_{50}	1 hr	16,342	Alarie 1981	
Ammonia	Rat	7,338 LC_{50}	1 hr	10,347	Back et al. 1972	
Ammonia	Mouse	4,837 LC_{50}	1 hr	6,820	Back et al. 1972	
Ammonia	Rabbit	9,859 LC_{50}	1 hr	13,901	Boyd et al. 1944	
Ammonia	Rat	2,000 LC_{50}	4 hr	5,660	Deichmann and Gerarde 1969	
Ammonia	Mouse	4,230 LC_{50}	1 hr	5,964	Kapeghian et al. 1982	
Ammonia						300
Ethylene oxide	Mouse	836 LC_{50}	4 hr	1,672	Back et al. 1972	
Ethylene oxide	Rat	4,000 LC_{50}	4 hr	8,000	Carpenter et al. 1949	
Ethylene oxide	Rat	800 LC_{50}	4 hr	1,600	Deichmann and Gerarde 1969	
Ethylene oxide	Guinea pig	819 LC_{50}	4 hr	1,638	Izmerov et al. 1982	
Ethylene oxide	Rat	1,460 LC_{50}	4 hr	2,920	Jacobson et al. 1956	
Ethylene oxide	Mouse	835 LC_{50}	4 hr	1,670	Jacobson et al. 1956	
Ethylene oxide	Dog	960 LC_{50}	4 hr	1,920	Jacobson et al. 1956	
Ethylene oxide						800
Propylene oxide	Mouse	1,740 LC_{50}	4 hr	3,480	Jacobson et al. 1956	
Propylene oxide	Dog	2,005 LC_{Lo}	4 hr	4,010	Jacobson et al. 1956	
Propylene oxide	Rat	4,000 LC_{50}	4 hr	8,000	Jacobson et al. 1956	
Propylene oxide	Guinea pig	4,000 LC_{Lo}	4 hr	8,000	Rowe et al. 1956	
Propylene oxide	Rat	4,000 LC_{67}	4 hr	8,000	Smyth et al. 1969	
Propylene oxide	Rat	380 LD_{50}	Ingestion	1,099 LD	Pugaeva et al. 1970	
Propylene oxide	Rat	1,140 LD_{50}	Ingestion	3,298 LD	Smyth et al. 1941	
Propylene oxide	Mouse	440 LD_{50}	Ingestion	1,273 LD	Pugaeva et al. 1970	
Propylene oxide	Guinea pig	690 LD_{50}	Ingestion	4,830 LD	Smyth et al. 1941	
Propylene oxide						400
1,3-Butadiene	Rabbit	250,000 LC_{Lo}	30 min	250,000	Carpenter et al. 1944	
1,3-Butadiene	Mouse	115,111 LC_{50}	Not provided	Not provided	Dow 1941	
1,3-Butadiene	Rat	200,000 LC_{50}	30 min	200,000	Dow 1941	
1,3-Butadiene	Mouse	122,000 LC_{50}	2 hr	195,200	Dow 1941	
1,3-Butadiene	Rat	126,667 LC_{50}	4 hr	253,334	Shugaev 1968	
1,3-Butadiene	Rat	130,000 LC_{50}	4 hr	260,000	Von Oettingen 1940	
1,3-Butadiene						2,000*
LPG						2,000*
Propane						2,100*
(*)=based on LEL						

To identify other potential sources of information on environmental effects of HVL releases, several federal agencies that have responsibility for natural resource damage assessments (NRDA) were contacted None of the respondents was familiar with any NRDA cases involving HVLs. It was suggested that most available information on these compounds relates to human exposure and/or collateral environmental impacts due to resulting explosion, fire, cryogenic effects, etc. and the natural resource impacts resulting from the response effort to contain and cleanup the affected area. A NOAA respondent indicated that a ship carrying butadiene grounded on a coral reef in Florida; however, there was no release of butadiene, just physical damage from the ship crushing the coral reef. The NOAA respondent also indicated that a release of anhydrous ammonia at a waterway had the potential for large scale, adverse impacts to the waterway because ammonia is soluble and toxic to aquatic resources at low concentrations (personal communication, Doug Helton, NOAA).

Results of Subtask 03: Applicable Regulation Research

Subtask 03 - Scope of Services

Survey applicable regulatory standards or other bases for determining acceptable levels of HVLs or HVL by-products in drinking water and ecological HCAs.

Sources and Information Discovered

Baker conducted research of available public domain data relating to the regulatory standards for determining acceptable levels of HVLs in drinking water and ecological HCAs. The following list summarizes specific sources and a brief discussion of the information found:

Federal sources

Department of Energy – (DOE) - Baker contacted Elizabeth Campbell – (Director of Natural Gas Division) – Ms. Campbell did not have much information on HVLs, but directed Baker to two other entities that could possibly help in the search.

Environmental Protection Agency – (EPA) - Little information was found on the EPA website concerning specific standards for HVLs in water or the environment. (http://www.epa.gov/). The only HVL that had water quality criteria or drinking water standards was ammonia. Task Order 1 did not include a task for modeling HVL concentrations due to releases. Based on the behavior of ammonia when released to waters in high concentrations (i.e., high solubility), the potential exists for widescale dispersion in waterways. Actual behavior is dependent on many variables, including: temperature, pH, velocity, flow, and the presence of carbon. Ammonia and ammonium, as the by-products of normal nitrogen decomposition, are naturally present in surface waters, however, in the event of an accidental release of anhydrous ammonia, a significant release of anhydrous ammonia in a waterway would be expected to result in exceedances. Over time, via nitrogen cycling processes, ammonia, nitrate, and nitrite in surface waters, could potentially result in upsetting a water treatment plant and ultimately drinking water standards for nitrate and nitrite, individually and combined. The upset would be temporary and also be affected by the volume released, dilution capacity of the receiving water, physio-chemical properties of the receiving water, and water treatment plant processes.

The federal drinking water standard is 1 mg/L for nitrite and is 10 mg/L for total nitrate and nitrite combined.

United States Department of Transportation – Office of Pipeline Safety (OPS) - A map showing the OPS regions and regional offices http://ops.dot.gov/rinfo.htm. On the OPS online Library site http://ops.dot.gov/libindex.htm a General Accounting office report and some congressional reports were found covering general pipeline safety.

State sources

Research of CA, FL, IL, NY, and TX state agencies revealed some information. Representatives from TX and CA were reached by phone and were helpful in relaying their knowledge of HVLs. A representative from Illinois was called multiple times but was never reached. Table 3 summarizes ammonia and nitrogen-related standards.

Table 3. Numerical Water Quality Criteria for Ammonia and Nitrogen-Related Standards in Selected States

State Surface Water Criteria	**NO_3 (mg/L)**	**$NO_3 + NO_2$ (mg/L)**	**Total Kjeldahl N (mg/L)**	**Ammonia-N (mg/L)**
Illinois		none	none	15.0
Florida	< 10 (1)			≤ 0.02 (2)
California	2	4		No quantitative criteria
New York	10 (3)	10		2 (4)

(1) Or that concentration that exceeds the nutrient criteria (i.e., the discharge of nutrients shall continue to be limited as needed to prevent violations of other standards. Man-induced nutrient enrichment (total nitrogen and total phosphorus) shall be considered degradation in relation to the provisions of Sections 62-302.300, 62-302.700, and 62-4.242. In no case shall nutrient concentrations in a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna.

(2) Applies to public water supply waters and to waters for recreation and propagation and maintenance of a healthy and well-balanced population of fish and wildlife.

(3) Standard is 100 ug/L for warm water fishery waters and 20 ug/L for cold water fishery waters.

(4) Includes both ionized ammonia and ionized ammonium. Unionized values for each are based on pH and temperature and water classifications (Table 1 at 6NYCRR, Chapter X, Section 703.5).

Currently, the State of Texas has no numerical criteria for nutrients in the Texas Surface Water Quality Standards. Nutrient controls do exist in the form of narrative criteria, watershed rules, and antidegradation considerations. Criteria are based on uses (e.g., recreation, aquatic life, drinking water supply). Likewise, the regulations indicate that waters should not be toxic to aquatic or terrestrial life.

Conclusion

Baker's research of available public domain data relating to the regulatory standards for determining acceptable levels of HVLs in drinking water and ecological HCA's were inconclusive. There are no standards for the specific hydrocarbon substances. Releases of anhydrous ammonia can result in significant adverse effects because ammonia is toxic to aquatic life at relatively low concentrations. Because ammonia is soluble, a release from a pipeline where all or some of the anhydrous ammonia is in liquid form can disperse at toxic concentrations. A vapor cloud over water would also add ammonia to a waterway as vapor droplets form and drop to the surface.

By-products from the combustion of the hydrocarbon HVL substances may result in some concentration of total organic carbon (TOC), a regulated parameter in water and soil. In the event of an n-butane, ethylene, or propylene release of gaseous nature, it is possible that the heavy ends (longer carbon chain molecules) from the transportation, cracking, and distillation would be released into water or soil, causing hydrocarbon contamination.

Results of Subtask 04: Develop Approach for Evaluating Operator's "Could Affect" Determinations

Subtask 04 - Scope of Services

Based on these surveys, develop an approach for validating or refuting operators' assertions that HVL pipeline segments located within drinking water or ecological HCAs should not be identified as "could affect." The approach should consider all relevant parameters, including the commodity released, the possible release scenarios and consequences, and the effects of potential by-products due to a fire or explosion. The "could affect" determination should be consistent with applicable public health and environmental laws and standards.

Sources and Information Discovered

The general intent of this checklist is to provide OPS inspectors with a range of questions/considerations that should be factored into their review of operator's plans. This is not meant to be a quantitative analysis; that is, should the response to more than 2 or 3 or 4 questions be "no" then the inspector would automatically reject an operator's plan. Rather, the questions can be used by inspectors to increase their "comfort level" that operators have satisfactorily addressed a full range of "could affect" scenarios. The inspectors should use the responses to these questions to request additional information from operators for those areas where concerns are raised regarding "could affect" determinations. Use of this checklist applies to not only pipelines that are *within* HCAs, but also will help trigger whether or not the operator's analysis included HCAs downwind/downgradient/downstream from pipeline segments the could potentially be affected.

Checklist for Evaluating "Could Affect" Determinations in Operator Integrity Management Plans

QUESTIONS	YES	NO	COMMENTS
1.0 Has the operator used other data, in addition to that developed by OPS (and provided from HCAs on NPMS data), regarding the types and locations of HCAs along their HVL pipeline corridor?			
1.A If yes, to Item 1.0, has the operator clearly characterized each HCA (e.g., water intake for a Community Water System (CWS), Western Hemisphere Shorebird Reserve Network (WHSRN), area with a critically imperiled species, etc) as well as describing the pathway to the HCA?			
1.B If not based only on OPS-provided HCA information, has the operator clearly described the process they used to determine that no additional HCA's were proximate to or downstream from the pipeline?			
2.0 Has the operator satisfactorily characterized the rate of release and the total potential HVL release at segments potentially affecting HCA's (i.e., from a low volume release and accounting for the worst case release).			Note to OPS reviewers: In addition to the local setting and meteorological conditions, the product type, pipeline size, pipeline pressure, rate of release, potential total volume released, and type of accident scenario addressed all influence the potential distance of product dispersal. As such, has the operator demonstrated that these variables were used? Did the operator calculate the rate of release and volume of release using the same factors for the entire pipeline segment or did they account for changes along the pipeline segments?
3.0 The direction a release will migrate (as a vapor cloud, pool liquid, or solubilized liquid (i.e., for anhydrous ammonia) is highly dependent, among other variables, on the adjacent landscape. Has the operator selected locations along the segment that represent worst-case locations (e.g., not only along a farm field, but at locations with drainage swales, drainage tiles, streams, rivers, surface roughness, steep topography, from piping along a bridge, a clear cut through forested land, etc) for predicting the pathways a release might follow?			

4.0 Has the operator satisfactorily addressed the effects that seasonal weather conditions might have on a release of HVLs relative to the "could affect" determination?			From a transport perspective, a release of some HVLs in very cold winter conditions may result in the product remaining as a liquid for a longer duration and potentially over a greater distance than during warmer weather.
5.0 Has the operator provided MSDS sheets for their products or has their analysis provided a chemical characterization of what other chemical compounds might be released in the event of an accident?			HVL products include mixes (as in the case of liquefied petroleum gases (LPG) and other compounds such as aldehydes, etc) that are potentially more toxic than the primary product. These compounds may have adverse environmental impacts even at low concentrations. If the accidental release scenario indicates the potential for a large volume release, it is possible that a larger amount of these potentially more toxic and persistent (to both human and ecological receptors) compounds may be released and potentially impact an HCA.
6.0 Has the operator relied solely on a pre-determined distance between their pipeline and an HCA to demonstrate that a "could affect" determination was not warranted?			Note to reviewers: The dispersal distance should address vapor clouds as well as releases as a liquid in surface waters. Anhydrous ammonia released directly to a waterway can be dispersed in toxic concentrations over tens of miles (e.g., the literature review indicated an anhydrous ammonia release was toxic to aquatic life over 48 miles downstream from the release site).
6.A If yes, what was the threshold distance based on; air or water transport, or both?			
6.A1 Did the operator's analysis use any modeling to predict the potentially affected distance?			
6.A2 Did the modeling adequately account for worst-case releases based on product, size of pipe, pressure in pipe, ability of system shutdown to cease flow, local topography and physical pathways, and seasonal conditions?			
6.A3 Did the modeling adequately address the potential dispersal distance based on type of product shipped (e.g., anhydrous ammonia releases have demonstrated total mortality in streams over 45 miles downstream (the impact zone can potentially be greater than 45 miles as well depending on the site, product, seasonal conditions, and product			Note to reviewers: Water quality criteria are lacking for the hydrocarbon HVLs. Ammonia and nitrogen standards exist for surface water, as well as for drinking water standards. Ammonia is soluble. Spills of anhydrous ammonia near/into waterways will exceed surface water

released) and releases of ethylene and propylene, based on potential volume that can be released may result in toxic effects several miles downstream from release).			quality standards at most locations, although the actual area impacted would depend on the flow regime of the specific waterway impacted and the volume released and the distance to the drinking water HCA (surface water or groundwater).
6.B If not based solely on distance, continue with following questions.			
7.0 Has the operator relied solely on topography to demonstrate that a "could affect" determination was not warranted?			
7.A If yes, did the operator's analysis rely on detailed, site-specific topographic data?			
7.A1 If yes, was the analysis of potential connectivity from the pipeline to an HCA sufficiently rigorous to account for transport via low profile ditches, drain tiles, storm sewers, etc?			
7.A2 If no, was the analysis of potential connectivity sufficiently rigorous?			Heavier than air releases will be influenced by the type of product, topography, and wind. In addition, the presence of "barriers" (buildings, trees, berms, etc) will also influence dispersal patterns. These dispersal patterns will not be predictable unless the operator accounted for the actual conditions in the field at potential release sites. Does the operator's analysis suggest that the local site-specific conditions were used as the basis for dispersal?
7.B If no, was the determination made on USGS 7.5 minute quadrangle scale mapping?			Use of mapping at this scale is suspect for making a determination solely on topography. Additional justification is warranted.
8.0 Did the operator use air dispersion modeling to determine the potential distance and product concentration in the event of a release?			
8.A If yes, did the operator select an air dispersion model suitable for the site conditions along the pipeline segment?			In support of this question, OPS would benefit from a detailed evaluation of commercial off-the-shelf (COTS) air dispersion models, including a summary of what models are most appropriate for certain products, which function best under different topographic conditions, which work best in wooded areas, as well as a summary of potential

			regional meteorological conditions that should be incorporated relative to wind speed and direction, gradient, temperature (seasonal variations), humidity, precipitation, etc.). Such an evaluation of models was not included in the original scope of work for TTO 1.
8.A1 If yes, did the operator's analysis incorporate variable meteorological conditions relative to differing geographies along their pipeline segments?			
8.A2 If yes, did the model account for the product type and worst case release capacity to predict vapor cloud dispersion and persistence of vapor cloud concentrations representing hazardous conditions (with regard to flammability, explosivity, and specifically for anhydrous ammonia, concentrations potentially toxic to vegetation).			The note regarding the potential toxicity of anhydrous ammonia vapor clouds to vegetation is included as a caution specifically when the potentially affected HCA is any of the unusually sensitive area ecological resources.
8.A3 For wooded/forested areas, has the operator satisfactorily accounted for vapor cloud dispersion through woodlands, including accounting for migration via clear cut areas (e.g., maintained right-of-ways, logging trails, etc)?			
8.B Has the operator satisfactorily justified not using an air dispersion model to predict direction, distance, and concentration of vapor clouds?			The operator should not have to model dispersion along the entire pipeline segment, especially for areas where HCAs do not occur near the pipeline (near is subjective and depends on the type of product, the local setting, and the type of HCA). This question is meant to determine whether an "arbitrary" buffer distance was used in lieu of modeling? If so, has the operator provided a convincing analysis that the buffer selected is appropriate for the product type, release potential, release volume, local setting, and relative distances to nearby HCAs. As an example, an HVL release from a pipeline on the top of a hill/mountain, may disperse a much greater distance (based on slope, barriers, etc) downgradient from the pipeline at a distance greater than an arbitrarily selected buffer.
9.0 Has the operator's analysis included the potential for and range of damages (fire, smoke, firefighting activities) related to a fire affecting an HCA?			Note to reviewers: Most vegetation directly in the area of heat and flames will be destroyed by fire. Less mobile animals may not escape and will die. Those that escape

			will have to find undisturbed habitat. Wildlife will also be affected by smoke and will seek to avoid areas with smoke. So the impact area for wildlife would include not only the direct area affected by fire, but the areas downwind that are affected by smoke.
9.A If yes, is the geographic extent of fire impact limited to the same geography as the vapor cloud dispersal?			
9.A1 Has the operator satisfactorily justified why the footprint of fire impact is limited to the same area as the vapor cloud?			The potential exists for a fire to start within the "buffer," but due to a lack of firebreaks or remoteness of a site, the fire is likely to spread to a much greater area (e.g., forest fires in the western U.S. that affect hundreds of thousands of acres).
9.A2 Has the operator estimated the potential spread of fire, especially if the fire could impact wooded/forested areas? Does the analysis include the spread of fire into ecological HCAs?			
9.B Does the operator's analysis satisfactorily justify why damage by fire is not included in their "could affect" determination, especially if the nearest HCA(s) is an ecological resource?			Has the operator addressed the existence of sufficient emergency response and firefighting resources so that catastrophic damage by fire (e.g., fire spreading into tens of thousands of acres in areas containing ecological HCAs) is not likely to occur?

Potential Additional Data Needs to Support OPS Inspector Activities

Detailed evaluation of COTS air dispersion models to determine potential flaws and limitations of each so that inspectors have justification that the appropriate model(s) was used for a specific product along pipeline segments with varying terrain and meteorological conditions. Potential models to evaluate include: ARCHIE, ALOHA, PHAST, WHAZAN II, DEGATEC, LNGFIRE, AIRTOX, CANADA, HFSYSTEM, HGSYSTEM, CHARM, and CANARY.

Evaluate the availability of models for use, especially for anhydrous ammonia releases with ready access to waterways, **to determine contaminant concentrations downstream**. The literature notes occurrences where adverse impacts (mortality of aquatic biota) were reported nearly 50 miles downstream from an anhydrous ammonia release. Un-ionized ammonia is toxic to aquatic biota at concentrations of only 1 ppm.

It would be beneficial to provide inspectors with some level of understanding as to how far from a release and how large of an area might be impacted by fire to assist with the "could affect" determination for ecological resource HCAs. This task would **develop several "rules of thumb" on "typical" fire pathway migration and dispersion** using typical firefighting response times and response resources based on typical habitat (forested/shrub/grassland) so that operators satisfactorily address the impact footprint from a release and fire.

The literature/reports/publicly available documentation screened for Task 1 demonstrated that trace amounts or "impurities" exist in the basic HVL products (e.g., aldehydes in LPGs). The scope, however, did not permit a detailed investigation of the concentrations, chemical/physical behavior, and toxicity of these compounds. Some gas mixes might be 50% propane and 50% propylene. Propane is not soluble, but propylene is somewhat soluble and propylene has greater toxicity to biota than propane. In another examples, aldehydes may exist in trace amounts. Some aldehydes are carcinogens. To better validate the operators' "could affect" determinations, especially those potentially affecting drinking water (surface water and groundwater) and ecological resource HCAs, **it is recommended that consideration be given to developing a detailed characterization (type, range of concentration in product, etc) of the secondary/tertiary components of HVL products to better predict their potential impacts on HCAs**.

A readily available template work plan for performing post-HVL release environmental monitoring would be useful for OPS to help develop a state of knowledge of environmental effects, especially as they may related to ecological HCAs. This work plan should include a Sampling and Analysis Plan as a template for investigating environmental impacts on soil, sediment, surface water, groundwater, vegetation, and wildlife. The plan could be executed by OPS or OPS could provide it to the responsible owner of an accidental release for execution. OPS should consult with the operators and advise them that the analysis was only being performed to gain additional knowledge related to HVL releases and that the results would not be used to initiate a natural resource damage assessment. Elements of the plan could address both the direct effects from a release as well as indirect effects (e.g., a release results in a fire that damages vegetation leaving soils exposed and increases erosion and sedimentation that in turn may have adverse effects on aquatic biota; or a release of anhydrous ammonia into soils at concentrations that prohibit revegetation; what mitigation methods might be necessary to reestablish the vegetative habitats upon which several key terrestrial species rely on for food, shelter, and nesting habitat; or a release results in an explosion in scrub/shrub or forested habitats and a post-accident survey would be performed to determine whether there are any dead animals within or beyond the overpressure zone that could be related to the explosion).

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