APPENDIX D

HAZARDS ANALYSIS

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QUEST
CONSULTANTS INC.®

October 23, 2012

Ms. Debra Bright Stevens
Environmental Audit, Inc.
1000-A Ortega Way
Placentia, CA 92670-7125

Re: Ultramar Inc. Cogen Unit Project
Risk of Upset Calculations
QCI Project 6841

Dear Ms. Stevens:

Ultramar Inc., a Valero Energy Company, is proposing to install a 35 megawatt Cogeneration Unit including a natural gas-fired turbine electric generator, a heat recovery steam generator equipped with a refinery fuel gas-fired duct burner for supplemental steam production, a selective catalytic reduction (SCR) unit and catalyst for emissions control of nitrogen oxides (NOx) and carbon monoxide (CO), the necessary piping to connect to an existing aqueous ammonia tank to supply ammonia to the SCR unit, and a new control room. As part of the installation of the Cogeneration Unit, three new, short-length, flammable gas pipelines are required in its refinery located at 2402 East Anaheim Street, Wilmington, California. The three new pipelines will be located in an area of the refinery where two flammable fuel pipelines are currently located. The existing and proposed pipelines are summarized in Table 1. The location of the proposed pipelines are shown on Figure 1

Table 1
Existing and Proposed Pipeline Parameters

Pipeline Status	Pipeline	Pipeline Diameter	Pipeline Operating Pressure	Pipeline Operating Temperature	Pipeline Length	Pipeline Normal Flow Rate	
		(inches)	(psig)	(°F)	(ft)	(lb/s)	(mmscfd)
Existing	Natural Gas	8	125	70	10,560	0.52	1
Existing	Fuel Gas	12	125	70	10,560	0.21	0.4
Proposed	Natural Gas	8	400	70	100	4.2	8
Proposed	Natural Gas	3	540	70	150	4.2	8
Proposed	Refinery Gas	6	60	70	600	2.3	4.4

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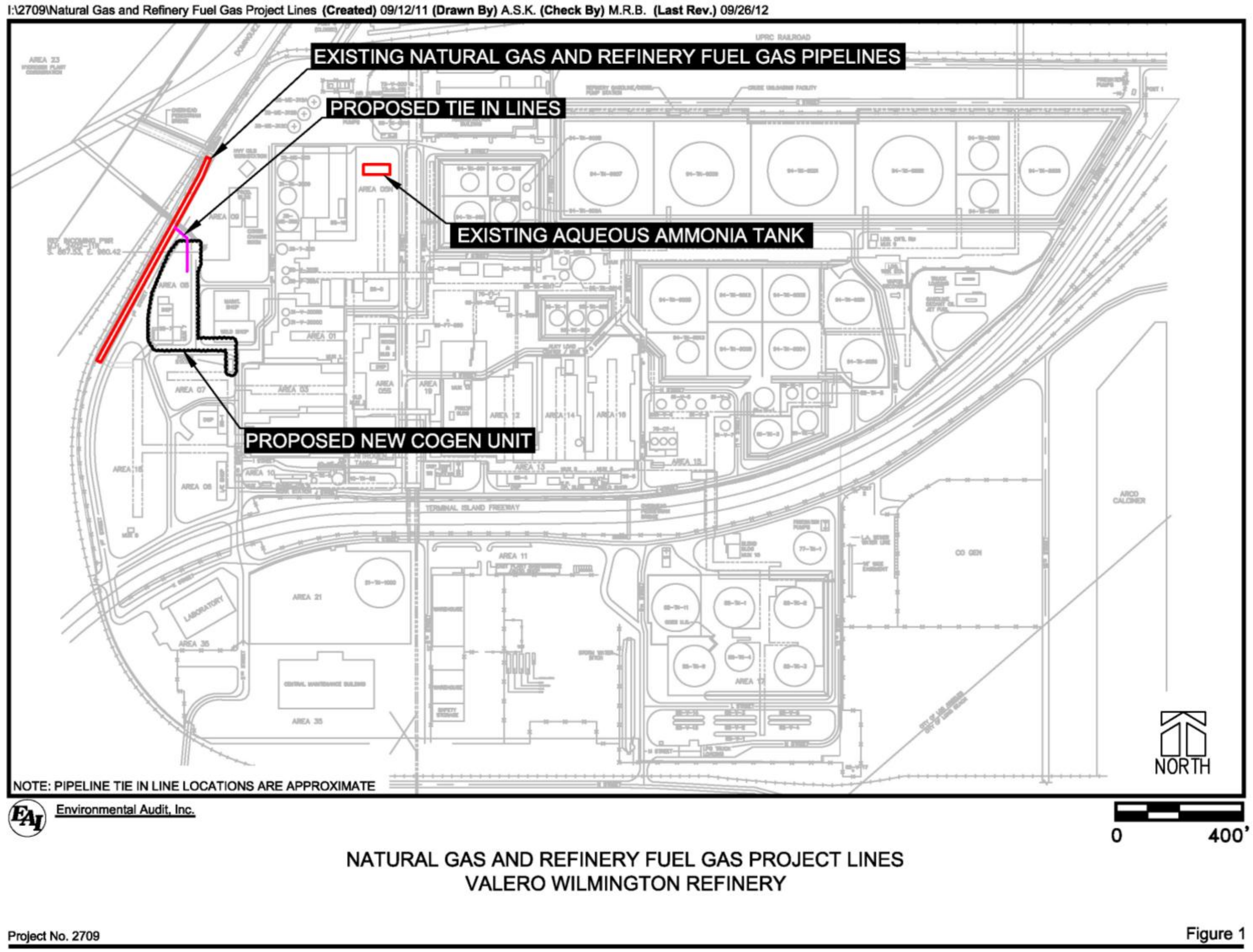

Figure 1
Location of Flammable Fuel Lines Associated With the Proposed Cogeneration Project

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The objective of this study was to compute the potential decrease and/or increase in hazard to the public due to the proposed pipeline additions.

This report details the calculations made to identify the maximum fire radiation and explosion overpressure hazard zones associated with a release flammable gas (natural gas, fuel gas, or refinery gas) from the existing or proposed pipelines. The scenarios selected represent the largest, credible releases (i.e., ruptures) of the pipelines followed by immediate ignition (torch fire hazard zone) or delayed ignition (flash fire and vapor cloud explosion hazard zones).

The following atmospheric conditions were employed in the modeling.

Wind speed = 1.5 m/s
Atmospheric Stability = F (extremely stable)
Relative humidity = 70%
Air temperature = 70°F
Surface temperature = 70°F

The study was divided into three tasks.

Task 1. Determine the maximum credible potential releases, and their consequences, for the existing pipelines.

Task 2. Determine the maximum credible potential releases and their consequences for the new pipelines to be added.

Task 3. Determine whether the consequences associated with the proposed pipeline additions generate a potential hazard that is larger than the potential hazard from the current pipelines.

Potential hazards from the existing and new pipelines are associated with accidental releases of flammable gas. Hazardous events associated with gas releases include flash fires, torch fires, and vapor cloud explosions.

The hazard of interest for flash fires is direct exposure to the flames. Flash fire hazard zones are determined by calculating the maximum size of the flammable gas cloud prior to ignition. These hazard zones are defined by the lower flammable limit (LFL) of the released hydrocarbon mixture. For vapor cloud explosions, the hazard of interest is the overpressure created by the blast wave. The hazard of interest for torch fires is fire radiation.

For each type of hazard identified (radiant, overpressure), maximum distances to potentially injurious levels are determined. The hazard levels have been approved by the Southern California Air Quality Management District (SCAQMD).

<u>Introduction to Physiological Effects of Fires and Explosions</u>

The analysis performed on the Ultramar pipeline additions involved the evaluation of several potential hazardous material releases. The potential releases may result in one or more of the following hazards:

- Exposure to flame radiation
  Torch fire (rupture of line followed by ignition)
  Flash fires (ignition of slow-moving flammable vapors)

- Exposure to explosion overpressure
  Vapor cloud explosion (release, dispersion, and explosion of a flammable vapor cloud)

In order to compare the hazards associated with each type of hazard listed above, a common measure of consequence or damage must be defined. In consequence and risk analysis studies, a common measure for such hazards is their impact on humans. For each fire and explosion hazard listed, there are data available that define the effect of the hazard on humans.

When comparing a flammable to an explosive hazard, the magnitude of the hazard's impact on humans must be identically defined. For instance, it would not be meaningful to compare human exposure to nonlethal overpressures (low overpressures which break windows) to human exposure to lethal fire radiation (34,500 Btu/(hr • ft^2) for five seconds). Thus, in order to compare the hazards of fires and explosions on humans, equivalent levels of hazard must be defined.

The endpoint hazard criterion defined in this study corresponds to a hazard level which might cause an injury. With this definition, the injury level must be defined for each type of hazard (radiant heat, or overpressure exposure). Fortunately, data exist which define an equivalent injury level for each of the hazards listed. Table 2 presents the endpoint hazard criteria used by federal agencies and national associations for this type of analysis.

Consequence Analysis

When performing site-specific consequence analysis studies, the ability to accurately model the release, dilution, and dispersion of gases and aerosols is important if an accurate assessment of potential exposure is to be attained. For this reason, Quest uses a modeling package, CANARY by Quest®, that contains a set of complex models that calculate release conditions, initial dilution of the vapor (dependent upon the release characteristics), and the subsequent dispersion of the vapor introduced into the atmosphere. The models contain algorithms that account for thermodynamics, mixture behavior, transient release rates, gas cloud density relative to air, initial velocity of the released gas, and heat transfer effects from the surrounding atmosphere and the substrate. The release and dispersion models contained in the QuestFOCUS package (the predecessor to CANARY by Quest) were reviewed in a United States Environmental Protection Agency (EPA) sponsored study[1] and an American Petroleum Institute (API) study[2]. In both studies, the QuestFOCUS software was evaluated on technical merit (appropriateness of models for specific applications) and on model predictions for specific releases. One conclusion drawn by both studies was that the dispersion software tended to overpredict the extent of the gas cloud travel, thus resulting in too large a cloud when compared to the test data (i.e., a conservative approach).

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[1] *Evaluation of Dense Gas Dispersion Models*. Prepared for the U.S. Environmental Protection Agency by TRC Environmental Consultants Inc., East Hartford, Connecticut, 06108, EPA Contract No. 68-02-4399, May, 1991.

[2] *Hazard Response Modeling Uncertainty (A Quantitative Method)*; *Volume II, Evaluation of Commonly-Used Hazardous Gas Dispersion Models*, S. R. Hanna, D. G. Strimaitis, and J. C. Chang, Study cosponsored by the Air Force Engineering and Services Center, Tyndall Air Force Base, Florida, and the American Petroleum Institute, and performed by Sigma Research Corporation, Westford, Massachusetts, September 1991.

Table 2
Consequence Analysis Hazard Levels
(Endpoint Criteria for Consequence Analysis)

Hazard Type	Injury Threshold		
	Exposure Duration	Hazard Level	Reference
Radiant heat exposure	40 sec	1,600 Btu/(hr•ft^2) *	40 CFR 68 [EPA, 1996]
Explosion overpressure	Instantaneous	1.0 psig †	40 CFR 68 [EPA, 1996]
Flash fires (flammable vapor clouds)	Instantaneous	Lower Flammable Limit (LFL)	40 CFR 68 [EPA, 1996]

40 CFR 68. United States Environmental Protection Agency RMP endpoints.
* Corresponds to second-degree skin burns.
† An overpressure of 1 psi may cause partial demolition of houses, which can result in serious injuries to people, and shattering of glass windows, which may cause skin laceration from flying glass.

A study prepared for the Minerals Management Service[3] reviewed models for use in modeling routine and accidental releases of flammable and toxic gases. CANARY by Quest received the highest possible ranking in the science and credibility areas. In addition, the report recommends CANARY by Quest for use when evaluating toxic and flammable gas releases. The specific models contained in the CANARY by Quest software package have also been extensively reviewed.

CANARY by Quest also contains models for pool fire and torch (jet) fire radiation. These models account for material composition, target height relative to the flame, target distance from the flame, atmospheric attenuation (includes humidity), wind speed, and atmospheric temperature. The fire models are based on information in the public domain (published literature) and have been validated with experimental data.

For vapor cloud overpressure calculations, CANARY employs the Baker-Strehlow method. It accounts for the reactivity of the fuel in the vapor cloud, the size of the flammable vapor cloud, and the degree to which the vapor cloud is obstructed or confined. The model is based on experimental and historical observations of vapor cloud explosions and deflagrations, with relation to the amount of confinement and obstruction present in the volume occupied by the vapor cloud.

Conclusions

CANARY by Quest was used to model the potential pipeline ruptures of both the existing and proposed flammable gas pipelines. Table 3 presents the maximum downwind distances for the torch fire, flash fire, and vapor cloud explosion hazards associated with two existing and three proposed flammable gas pipelines in the Valero refinery. As can be seen from the table, the impact distances can extend up to about 160 feet from one of the existing pipelines. This maximum impact distance is larger than any of the

[3] *A Critical Review of Four Types of Air Quality Models Pertinent to MMS Regulatory and Environmental Assessment Missions*, Joseph C. Chang, Mark E. Fernau, Joseph S. Scire, and David G. Strimaitis. Mineral Management Service, Gulf of Mexico OCS Region, U.S. Department of the Interior, New Orleans, November, 1998.

potential hazard zones associated with the three proposed pipelines. Thus, the addition of the three proposed flammable gas pipelines to this section of the Valero refinery does not pose any new hazards to areas not currently potentially exposed to the same hazard from the existing pipelines.

In addition to the evaluation of the proposed flammable gas pipelines, the existing aqueous ammonia tank was evaluated for the potential toxic hazard associated with a release of aqueous ammonia into the impoundment basin. A release, vaporization, and dispersion model set of calculations were made to identify the downwind travel distance to ammonia's Emergency Response Planning Guideline level 2 (ERPG-2) concentration of 150 ppm.

The data required for the calculation are:

Aqueous ammonia concentration = 30 % by weight
Impoundment area = 37 feet by 37 feet square

Wind speed = 1.5 m/s
Atmospheric Stability = F (extremely stable)
Relative humidity = 70%
Air temperature = 70°F
Surface temperature = 70°F

The results of the analysis are presented in Table 4.

The maximum travel distance of 215 ft to the ERPG-2 concentration level for ammonia does not extend past the Valero refinery property line.

I believe this covers the analysis requested. If you have any questions, please give us a call.

Sincerely,

John B. Cornwell.
Principal Engineer

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Table 3
Consequence Modeling Radiation Results

Pipeline Status	Pipeline	Pipeline Diameter	Pipeline Operating Pressure	Pipeline Operating Temperature	Pipeline Length	Pipeline Normal Flow Rate		Maximum Distance (ft) to		
		(inches)	(psig)	(°F)	(ft)	(lb/s)	(mmscfd)	LFL	1 psig	1,600 Btu/(hr•ft^2)
Existing	Natural Gas	8	125	70	10,560	0.52	1	75	0	100
Existing	Fuel Gas	12	125	70	10,560	0.21	0.4	115	0	160
Proposed	Natural Gas	8	400	70	100	4.2	8	70	0	70
Proposed	Natural Gas	3	540	70	150	4.2	8	40	0	70
Proposed	Refinery Gas	6	60	70	600	2.3	4.4	50	0	50

Table 4
Dispersion Distances for Worst-Case Aqueous Ammonia Release

Release	Wind Speed (m/s)	Atmospheric Stability	Distance (ft) to ERPG-2 (150 ppm)
Release of aqueous ammonia which covers the tank impoundment floor area	1.5 m/s	F	215 ft