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Review of the Hazard Analysis For The Macpherson Oil Company Hermosa Beach Project

FINAL REPORT

Prepared for
California Coastal Commission
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1.0 Introduction

This report has been prepared for the California Coastal Commission (CCC) to provide an independent, qualified third-party review of certain hazard analysis aspects of a proposed exploration and production project submitted by Macpherson Oil Company (MACPHERSON) to the CCC as part of Application E-96-28 for a coastal development permit (CDP).

MACPHERSON has been selected by the City of Hermosa Beach to conduct exploratory drilling and production of hydrocarbons from the City Maintenance Yard. MACPHERSON proposes to drill three exploratory wells from the City Maintenance Yard. If the exploratory drilling and associated temporary production testing prove successful, MACPHERSON proposes to drill up to 30 wells from the City Maintenance Yard. Permanent tanks and production facilities would also be installed at the City Maintenance Yard site.

The original CDP application submitted by MACPHERSON indicated that crude oil would be shipped to the Chevron El Segundo Refinery, while produced gas would be dehydrated and delivered to the Southern California Gas Company. During the exploratory phase of the project, gas would be flared, and the oil would be trucked from the site to the Chevron El Segundo Refinery. If the exploration phase of the project proves successful, then the gas would be delivered to Southern California Gas Company via pipeline and the oil and natural gas liquids (NGLs) would be commingled and shipped via pipeline to the Chevron El Segundo Refinery.

Subsequent to the preparation of a draft of this report, MACPHERSON amended their CDP application to address some of the concerns that were raised in the draft report, as well as clarified some potential inconsistencies between their CDP application and their project as permitted by the City of Hermosa Beach. These changes, as well as the potential implications, and summarized as follows:

- ***Crude Oil Transportation*** - MACPHERSON is no longer proposing to utilize a decommissioned Chevron crude oil pipeline to transport crude oil to the Chevron El Segundo Refinery. Instead, MACPHERSON has decided to connect their proposed crude oil pipeline into the Edison Pipeline and Terminal Company (EPTC) transportation system at the Southern California Edison Redondo Beach Terminal and Generating Station. This change will allow MACPHERSON to deliver their crude oil to any of the refineries in the Los Angeles Basin.

- ***Produced Gas Transportation*** - The MACPHERSON Hermosa Beach Project, as permitted by the City of Hermosa Beach, did not include any gas sweetening equipment that would allow for the removal of hydrogen sulfide, nor did the Environmental Impact Report (EIR) for the project include any analysis of potential environmental or safety impacts associated with hydrogen sulfide. Based on available data on potential hydrogen sulfide concentrations in the produced gas, it is likely that the produced gas would not meet the Southern California Gas Company hydrogen sulfide limit of 4 ppm during the entire lifetime of the project without the installation of gas sweetening equipment and further environmental review. As a result, MACPHERSON has amended their CDP to transport produced gas to the Southern California Edison Redondo Beach Terminal and Generating Station which can accept natural gas with concentrations of up to 40 ppm hydrogen sulfide.

Several hazard impact analysis reports have been prepared for the MACPHERSON Hermosa Beach Project by Reese-Chambers Systems Consultants (Reese-Chambers) over the past year. The original draft report of this third-party review was based on Reese-Chambers' reports dated May 9, 1995 and March 3, 1997. Subsequent to our draft third-party review, two additional reports have been prepared by Reese-Chambers dated October 2, 1997 and October 29, 1997. These reports are included as Attachments 1 through 4, respectively.

The original hazard impact analyses (May 9, 1995 and March 3, 1997) conducted by Reese-Chambers for this project have generally identified the range and magnitude of potential hazards associated with the proposed MACPHERSON Hermosa Beach Project. However, there was still some uncertainty associated with the magnitude of potential risk associated with the proposed project, hazards associated with equipment that is ancillary to the project, as well as characteristics of the Torrance Oil Field and proposed project. Based on this initial review, the following sections were prepared to present a discussion of a wide variety of safety issues associated with the proposed project, including:

- Potential hydrogen sulfide hazards,
- Additional hazard scenarios,
- Project risk profiles,
- Transportation risk,
- Pipeline safety, and
- Concerns related to the abandoned Chevron pipeline.

Each of these issues has been evaluated as part of this review in terms of the adequacy of the analyses conducted to date, proposed safety features and the potential need for additional mitigation. Generally, the project is well designed and provides a wide variety of safety and mitigation measures that would serve to minimize potential hazards associated with the proposed project. However, in cases where some potential hazards had not been identified, or safety issues had not been fully evaluated or resolved, additional analyses were required.

Many of these safety issues have been resolved through further analysis, clarification by the applicant or additional mitigation measures. However, for each of the issues identified above, the original discussion from the draft report, as well as how each issue was resolved, is included in this final third-party review.

2.0 Potential Hydrogen Sulfide Hazards

2.1 Previous Hydrogen Sulfide Hazard Issue

While reservoir sulfur content is not an absolute indicator of produced gas hydrogen sulfide (H_2S) concentrations, reservoir fluid (crude oil and gas mixture) data indicated that onshore sulfur levels average approximately 1.4 percent while offshore levels average approximately 2.4 percent. While much of this sulfur would remain with the crude oil as elemental sulfur, the presence of sulfur in the reservoir fluids would tend to indicate the potential for elevated H_2S levels in the produced gas. In addition, other nearby wells in the same reservoir have shown elevated hydrogen sulfide concentrations, some greater than 5,000 ppm (MACPHERSON May 30, 1997 responses to CCC, page 8).

MACPHERSON has stated they do not expect to observe elevated H_2S concentrations in the produced gas stream, and that proper management of the reservoir would prevent the formation of H_2S, but the reservoir is not a virgin field that has never been produced. Even if no H_2S is observed during the initial production stages, it is likely that sour gas will migrate from other nearby parts of the reservoir that have shown relatively high levels of H_2S (i.e., levels well in excess of 1,000 ppm). MACPHERSON has acknowledged the potential for reservoir fluid migration in their responses to the CCC (July 2, 1997 responses, page 9).

To address the uncertainty associated with current and future levels of hydrogen sulfide in the produced gas, MACPHERSON originally committed to monitoring the produced gas for hydrogen sulfide gas. Under that proposal, if hydrogen sulfide concentration were found to exceed 1,000 ppm, MACPHERSON would have treated the produced gas downhole (i.e., in the well casing) to maintain a hydrogen sulfide level of less than 1,000 ppm. In the event that hydrogen sulfide concentrations could not be reduced to a level of less than 1,000 ppm, the well would have been permanently shut in.

MACPHERSON originally proposed to monitor produced gas H_2S concentrations at a single location in the well header collection system. Under that proposal, the produced gas from each well would be commingled in the well header system. As a result, it is quite likely that wells could have operated with H_2S concentrations well in excess of 1,000 ppm because these levels would be masked by dilution from other unaffected wells (the applicant proposes to drill 30 wells). MACPHERSON has subsequently committed to monitoring the wells individually for elevated H_2S.

Possible Mitigation Measures

2-1 Monitoring for Hydrogen Sulfide
Continuous monitoring for H_2S should occur at each wellhead casing, as well as in the well header, gas processing train, or any other process location where high H_2S levels are possible. Gas streams found to exceed the 1,000 ppm limit for H_2S should be immediately shut down until excess levels of H_2S can be abated. Widespread, continuous monitoring for H_2S, associated with

the ability to isolate gas streams with high H_2S levels, would effectively abate potentially high levels of H_2S. Should continuous H_2S monitoring not be feasible at each well casing, the H_2S levels that would trigger an evaluation of each well should be based on the ratio of 1,000 ppm H_2S divided by the number of wells entering the gas stream, as well as weighted for the flow rate of each well.

2.2 Resolution of the Hydrogen Sulfide Hazard Issue

The MACPHERSON project, as currently proposed, would not be permitted to produce or process gas with H_2S levels of more than 40 ppm. Therefore, any potential risk to the public from exposure to H_2S would be negligible under the currently proposed project (see Section 3.1.1). The Reese-Chambers report dated October 2, 1997 evaluated potential H_2S hazards associated with a range of potential accidental release scenarios and H_2S concentrations. The Reese-Chambers report dated October 29, 1997 removed all analysis of potential H_2S hazards, since the project, as currently proposed in the CDP permit application to the Commission, would not allow for any H_2S in the produced gas at concentrations greater than 40 ppm. Section 3.1 of this report summarizes the potential H_2S hazards that were identified in the Reese-Chambers report dated October 29, 1997.

The H_2S monitoring requirements outlined in the previous section would also be applied to the revised MACPHERSON project. Produced gas at each well would be monitored on a regular basis (i.e., monthly), and the gas from the combined wells would be monitored on a continuous basis. Any well found to contain H_2S in excess of 40 ppm would be shut in, or recompleted in a reservoir zone with less than 40 ppm H_2S.

It should also be noted that the applicant has proposed to install and operate hydrogen sulfide monitoring equipment through the facility and around the perimeter of the project site. This monitoring system would be capable of detecting low concentrations of hydrogen sulfide and would warn the facility operators of potential equipment malfunctions and accidental releases of hydrogen sulfide. Also, at these low hydrogen sulfide levels, and with the proposed monitoring equipment in place, the facility should not create objectionable hydrogen sulfide odors in areas surrounding the facility under normal operating conditions.

3.0 Additional Hazard Scenarios

Overall, the hazard impact analyses prepared by Reese-Chambers have generally identified the range and magnitude of potential hazards associated with the proposed Hermosa Beach Project. However, two additional scenarios need to be evaluated and included in the project risk profile. These include potential hydrogen sulfide releases and produced gas treatment releases. Both of these are summarized below.

3.1 Hydrogen Sulfide Risk

3.1.1 Previous Hydrogen Sulfide Risk Issue

As noted in the previous section, the potential for H_2S in the produced gas remained a concern if elevated H_2S levels were found in the produced gas. Figures 1 and 2 provide information on the potential health effects associated with exposure to hydrogen sulfide. Additional information is also included on odor thresholds and perception. Note that these potential health effects are derived from occupational exposure and extrapolated to include children, the elderly and people with respiratory ailments. As a result, there is some uncertainty when applying these potential health effects to the general population, since some segments of the population may experience potentially adverse health effects at lower concentrations.

While MACPHERSON had proposed an H_2S contingency to mitigate potential production of sour gas, this mitigation did not completely abate the risk associated with sour gas. Subsurface casing gas treatment did not address the following issues:

- Reliability of the H_2S treatment system under normal conditions.
- Effectiveness of the H_2S treatment system.
- Reliability of the H_2S treatment system under upset conditions.
- Potential for high levels of sour gas upstream of H_2S monitoring.
- Potential failures of shut in wells.

The proposed H_2S monitoring system would not prevent the potential for sour gas to occur or to be released, but only reduced the amount of sour gas handling that could occur, thus reducing the potential for an accidental sour gas release. Even with effective monitoring and control for elevated H_2S levels, there was still a potential for an H_2S release with a concentration greater than 1,000 ppm. The combined reliability of the proposed H_2S treatment system, the effectiveness of monitoring equipment, and the reliability of the well head complex needed to be fully evaluated. This is especially important since the proposed facility location is in such close proximity to a populated area.

In addition, the risk profile developed by Reese-Chambers did not include any hydrogen sulfide release scenarios. Potential hydrogen sulfide release scenarios should be developed and included in the risk profile for the project. The scenarios should include normal operation as well as possible upset conditions, such as a well head release with failure of the H_2S treatment system. While this type of scenario would have a low likelihood of occurrence, it could have high consequences given the close proximity to a populated area.

Possible Mitigation Measures

3-1 Reliability of Hydrogen Sulfide Monitoring and Treatment Systems
A thorough evaluation of all components associated with the detection and treatment of sour gas should be thoroughly evaluated and included in the project's risk profile. Additional safety

Figure 1 - Hydrogen Sulfide Fatality Dose-Response Data

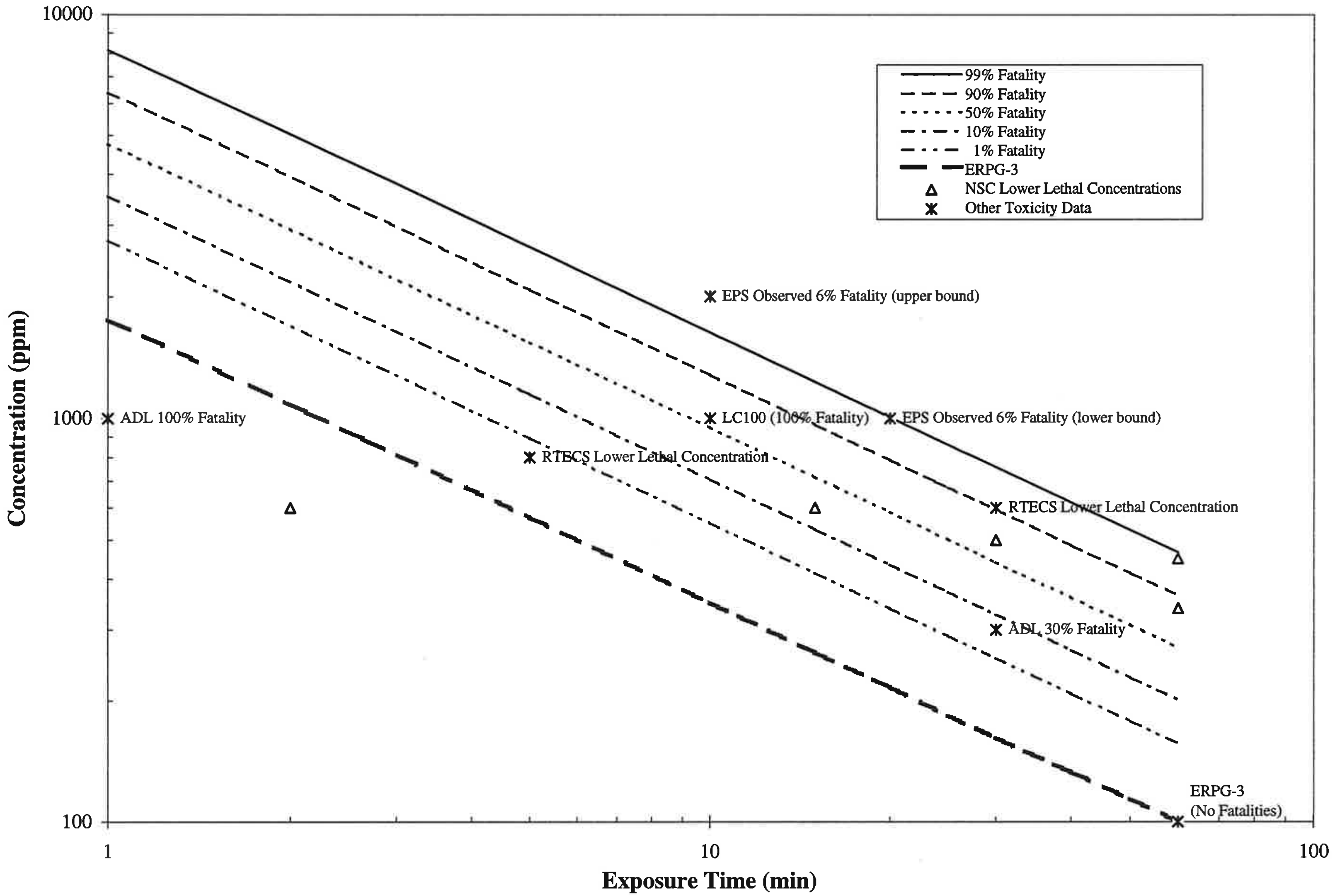

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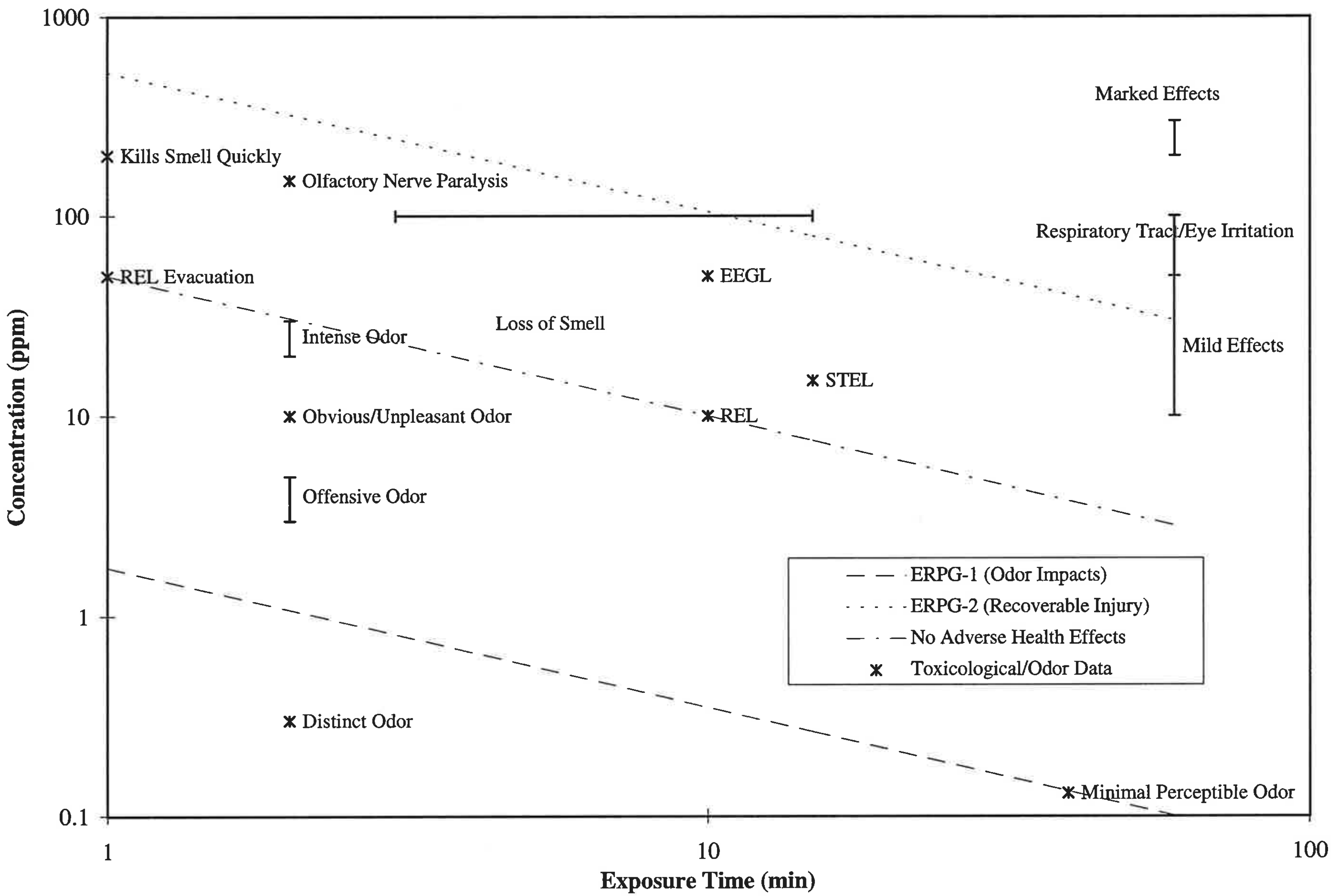
Figure 2 - Hydrogen Sulfide Injury Dos-Response Data



features or permit limitations should be added to effectively abate H_2S hazards if the results of risk assessment warrant additional mitigation. (Note: this mitigation measure would not be necessary as long as the hydrogen sulfide levels in the produced (untreated) gas remain below the applicant's proposed limit of 40 ppm.)

3.1.2 Resolution of the Hydrogen Sulfide Risk Issue

The Reese-Chambers report dated October 2, 1997 evaluated potential hazards associated with an accidental release of produced gas with elevated H_2S concentrations. The analysis evaluated H_2S concentrations ranging from 1,000 to 5,000 ppm. The results of this analysis indicated that an accidental release of produced gas containing 2,000 ppm H_2S would not result in potentially fatal concentrations of H_2S over the nearby residential areas under worst-case meteorological conditions, but potentially fatal H_2S concentrations could occur at the adjacent businesses that surround the site (see Figure 3). However, the worst-case meteorological conditions would occur at night when most of the businesses would be closed. Therefore, the potential for fatalities was considered unlikely. Based on the results of this analysis, MACPHERSON identified 2,000 ppm as a potential H_2S limit for the produced gas.

Produced (i.e., untreated) gas containing 2,000 ppm H_2S would have the potential to result in potential injuries at nearby residential and commercial/industrial areas, potentially affecting areas within 630 feet of the proposed facility (see Figure 3). While the hazards analysis showed that there would be a low probability for a fatality at 2,000 ppm H_2S in the produced gas, the likelihood that there would be injuries would be higher and extend further offsite. Based on the Reese-Chambers report dated October 2, 1997, a produced gas H_2S limit of approximately 300 ppm per well would be required to prevent potential injuries to the population surrounding the proposed MACPHERSON facility in the event of an accidental produced gas release.

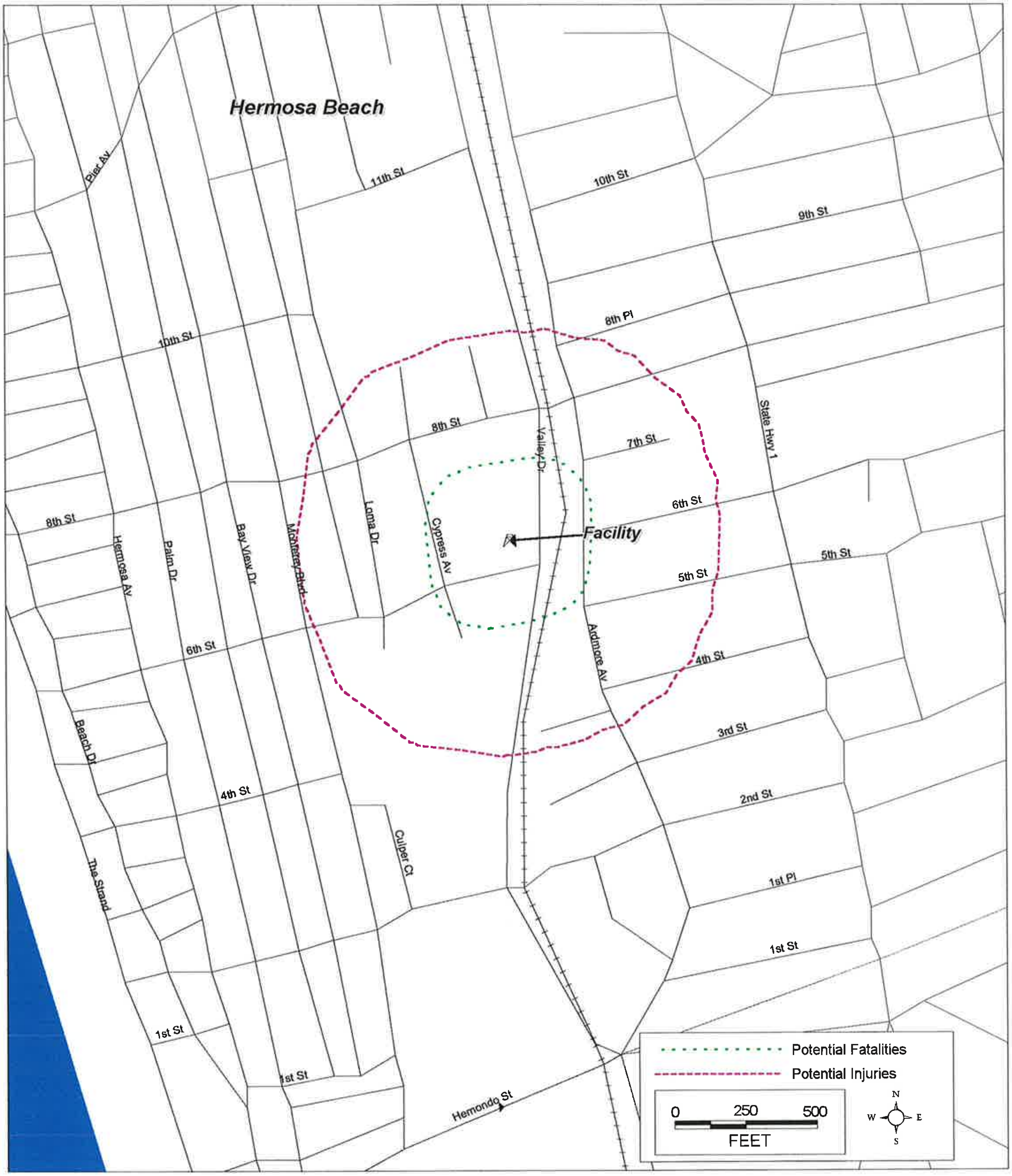
As stated previously, the MACPHERSON project, as currently proposed, would not be permitted to produce or process gas with H_2S levels of more than 40 ppm. Therefore, any potential risk to the public from exposure to H_2S would be negligible under the currently proposed project. The project, as currently proposed in the CDP permit application to the CCC, would not allow for any H_2S in the produced gas at concentrations greater than 40 ppm. Potential toxic hazards to the population surrounding the proposed facility associated with a produced gas H_2S concentration of 40 ppm would be considered negligible.

3.2 Produced Gas Treatment and Natural Gas Liquids

3.2.1 Previous Produced Gas Treatment and Natural Gas Liquids Issue

The Piping and Instrumentation Diagrams (P&IDs) showed that a refrigeration system would be included in the design of the project's production phase. A refrigeration system is necessary to treat the produced gas which has fractions of heavier hydrocarbons (e.g., propane, butane, etc.) that are above the Southern California Gas Company's pipeline specifications. Refrigeration

Figure 3 Hazard Zones for Produced Gas with a Hydrogen Sulfide Concentration of 2,000 ppm



skids generally use propane as a refrigerant in a closed loop system, much like a refrigerator uses freon. The refrigeration system is used to remove the heavier hydrocarbons from the gas and produce what are called natural gas liquids (NGLs).

NGLs are relatively volatile and extremely flammable. Under the current project Phase II design that was used in the initial hazards analysis report, NGLs extracted from the produced gas stream would be commingled with the crude oil and transported to the Chevron El Segundo Refinery via pipeline (the project has since been revised to utilize the Edison pipeline system). Since the hazard analysis prepared for the proposed project treated the crude oil as a flammable liquid, potential hazards associated with the combined crude oil/NGL stream have been adequately evaluated.

Potential hazards associated with the refrigeration system would include the potential for a NGL spill and resulting fire or explosion. In addition, if propane is used as a refrigerant, there is a potential for a release, fire and/or explosion.

Based upon previous studies we have conducted on similar refrigeration systems, there is the potential for release to affect the surrounding population. Hazards associated with a propane refrigeration can be easily abated.

3.2.2 Resolution of the Produced Gas Treatment and Natural Gas Liquids Issue

The revised Reese-Chambers reports dated October 2, 1997 and October 29, 1997 evaluated potential hazards associated with the proposed propane refrigeration and NGL systems. The results of the Reese-Chambers hazard analyses indicated that many of the potential accidental release scenarios associated with proposed propane refrigeration and NGL systems would be negligible. A potential catastrophic failure of the NGL surge vessel could result in adverse offsite impacts, but the probability of this scenario is extremely low. However, the potential risks associated with the proposed propane refrigeration and NGL systems were evaluated further in the Reese-Chambers risk profiles as discussed in the following section. While potential hazards associated with the proposed propane refrigeration and NGL systems were not evaluated in the draft Reese-Chambers report, the evaluations presented in the revised Reese-Chambers reports adequately identify and address potential hazards associated with these systems.

4.0 Project Risk Profiles

4.1 Previous Risk Profile Issue

The risk profile prepared for the proposed project was incorrectly presented in the report entitled *"Hazard Footprint Analysis Hermosa Beach Project"* prepared by Reese-Chambers dated March 3, 1997. While this was most likely an inadvertent graphical error (the numerical data supplied by Reese-Chambers was correct), the incorrect risk profile gave the indication that the potential risk posed by the project would be in the *"De Minimis"*, or insignificant region of the risk matrix. Based on a review of the data that was used to generate the risk profile, it became apparent that the risk profile was plotted one order of magnitude too low, and that the risk profile actually traverses the *"Grey Region"* of the risk matrix which is indicative of a significant risk that requires mitigation. The corrected risk profile is shown in Figure 4.

The risk profile was constructed based on the risk to local residents and traffic. The risk profiles did not include estimates for potential fatalities in nearby commercial and industrial locations. Therefore, this risk would likely be slightly higher if the commercial/industrial population, excluding those workers at the MACPHERSON project site, were included in the risk estimate.

The risk profile was also based on a limited number of accidental release scenarios (i.e., one scenario), and did not include risk estimates for facilities such as the offsite oil and gas pipelines, and most of the onsite treatment facilities. The risk profile did not include any hydrogen sulfide releases. While many of these release scenarios would not likely result in offsite fatalities, there are some scenarios that should have been included in the risk estimate.

Risk profiles are commonly used to identify the cumulative frequency of potential fatalities that could occur from a wide range of accidental release scenarios. The analysis of the MACPHERSON Oil Company Hermosa Beach Project followed the methodology and presentation style outlined by Santa Barbara County's Environmental Thresholds for Public Safety. These thresholds, which were recently revised, specify levels of acceptable risk based on the likelihood for different numbers of potential fatalities. Santa Barbara County's safety thresholds are based on, and are consistent with, many national and international risk analysis thresholds, including the United States Nuclear Regulatory Commission, United Kingdom Health and Safety Executive, UK Atomic Energy Authority, the Netherlands, and the European Union. In addition, several companies and organizations, such as British Petroleum, Shell Oil, and the American Institute of Chemical Engineers, have adopted similar risk criteria. Using these generally accepted risk criteria, three general zones, or levels of risk, have been identified as follows:

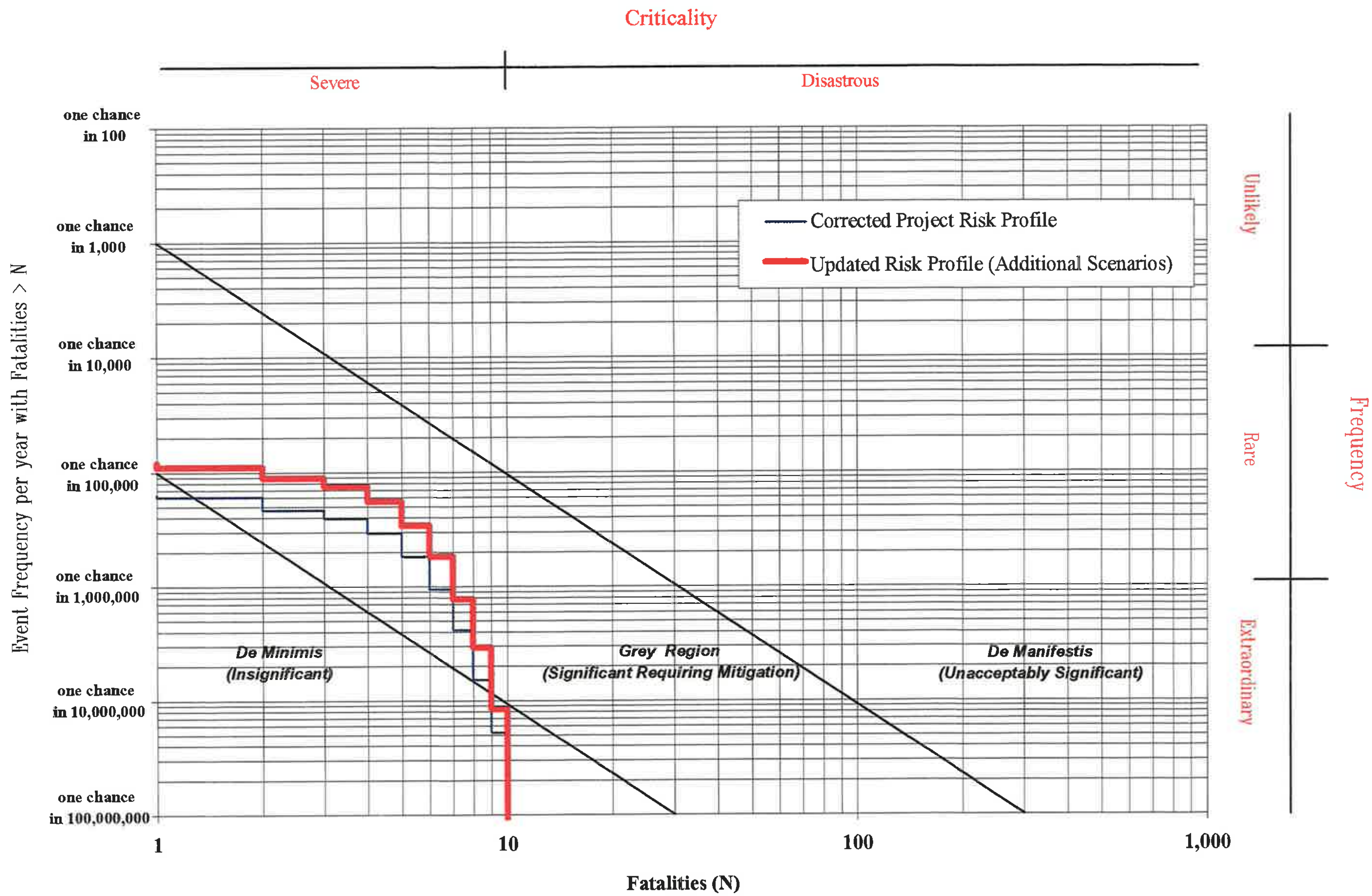
De Manifestis **-** This classification is considered unacceptable, and the proposed development or activity should not proceed unless mitigation can be instituted that successfully reduces the risk to below this level.

Grey Region **-** This classification is considered significant but acceptable if mitigated to the maximum extent feasible, preferably to a level of insignificance.

De Minimis **-** Risk levels within this classification are considered tolerable; however, feasible mitigation is still recommended for possible catastrophic events at commensurate costs to keep their probability of occurrence sufficiently low to qualify as insignificant.

Based on the risk profile prepared by Reese-Chambers for the MACPHERSON Oil Company Hermosa Beach Project, public safety impacts would be considered significant and should

Figure 4 - Macpherson Oil Company Hermosa Beach Project Fixed Facility Risk Profiles



require further evaluation and possibly additional mitigation in an effort to reduce the overall risk associated with the proposed project.

Possible Mitigation Measures

4-1 Hazard and Operability Study
A Hazard and Operability Study (HAZOP) for the proposed facility and ancillary equipment should be prepared by MACHPERSON prior to both Phase I and II operations. The HAZOP should identify potential accidental release scenarios and mitigation measures that would prevent or reduce the likelihood of the release scenarios that are identified. The HAZOP should also be reviewed and approved by the State Lands Commission prior to initiation of facility operations.

4.2 Resolution of the Risk Profile Issue

Reese-Chambers completely reevaluated their risk profile for the MACPHERSON project based on the comments in the draft version of this report. The Reese-Chambers report dated October 2, 1997 evaluated all of the additional accidental release scenarios that were identified, including potential hydrogen sulfide hazards. The Reese-Chambers report dated October 29, 1997 includes an evaluation of the risk associated with the project, as currently proposed for CDP approval. The risk profile for the currently proposed project is also shown on Figure 4. This risk profile illustrates the cumulative risk for all the hazard scenarios that were identified in the Reese-Chambers analysis.

As summarized above, the risk associated with the proposed project falls mainly in the "Grey Region" which is classified as a significant impact "...but acceptable if mitigated to the maximum extent feasible, preferably to a level of insignificance." A review of the safety features that are included in the project's design, as well as additional commitments made by the applicant for additional safety features, would indicate that the proposed project incorporates safety mitigation measures to the maximum extent feasible. However, potential fire and explosion hazards associated with the proposed project, especially given the location in close proximity to residential areas, would still be classified as a significant impact based on the generally accepted risk criteria used by the applicant. As a result, the detailed hazard and operability study recommended above may be able to identify additional design and operational hazards that could lead to the need for additional safety features or design/operational modifications.

5.0 Transportation Risk

5.1 Previous Transportation Risk Issue

Under the original proposal, crude oil would be transported via tanker truck during Phase I, while crude oil and natural gas would be transported via pipeline during Phase II of the proposed project. Two issues were identified related to product transportation including quantification of transportation risk and emergency response capabilities.

Hazard zones were identified for crude oil spills (truck and pipeline transportation) and gas pipeline failures. These hazard zones appear to represent a reasonable worst-case. However, the risk associated with these accidental releases had not been quantified, and potential hazard zones had not been displayed on a map. As a result, the potential risk associated with crude oil and natural gas transportation had not been fully evaluated.

MACPHERSON has developed an emergency response plan covering a potential release from their proposed natural gas pipeline, and would be responsible for responding to any accident/incident. Crude oil will be metered at the site, thus relieving MACPHERSON of most emergency response requirements. A crude oil spill would continue to flow after a spill, potentially to the ocean, as well as pose a fire hazard to the surrounding population. Since the potential for an oil spill is directly related to the proposed development project, MACPHERSON should consider cooperating with the crude oil shippers on oil spill planning and response, as well as maintain oil spill response equipment onsite.

Possible Mitigation Measures

5-1 Transportation Risk Analysis
The risk associated with crude oil and natural gas transportation should be fully evaluated and include a quantification of the risk associated with product transportation (risk profile or risk matrix identifying the probability of an accident and the potential number of fatalities/injuries), and a map that clearly shows the pipeline/truck routes and associated hazard zones. This information should be prepared for truck transportation, as well as the crude oil and natural gas pipelines (including the Chevron pipeline).

5-2 Oil Spill Response
MACPHERSON should maintain onsite oil spill response equipment, plans and procedures to respond to an offsite truck or pipeline spill. The Oil Spill Contingency and Emergency Response Plan for crude oil transportation, as well as the onsite equipment necessary to respond to a spill, should be approved by the California Department of Fish and Game, Office of Oil Spill Prevention prior to operation of the proposed project.

5.2 Resolution of the Transportation Risk Issue

The revised hazard analysis prepared by Reese-Chambers clearly outlines potential transportation hazards and risk. Results of the Reese-Chambers risk analysis indicate that potential hazards associated with crude oil and natural gas transportation would be less than significant for the project as currently proposed. While the hazard zones related to crude oil and natural gas transportation clearly overlap developed residential areas, the probabilities of these hazards occurring are sufficiently low to warrant a less than significant finding.

Subsequent to the preparation of the draft version of this report, an oil spill response plan was received from MACPHERSON outlining their proposed oil spill response planning. This planning, while quite comprehensive, does not meet the above proposed mitigation measure (#5-2), especially since MACPHERSON will be responsible for any crude oil spill between their facility and the Edison pipeline terminus at the Redondo Beach Terminal and Generating Station. Therefore, additional oil spill response equipment and/or agreements may be necessary.

6.0 Pipeline Safety - New Pipelines

6.1 Previous New Pipeline Safety Issue

The proposed new pipelines directly associated with the proposed project are generally well designed per the requirements of the California State Fire Marshall (CSFM). A wide variety of safety measures are incorporated in the oil and gas pipeline designs, and pipeline installation includes several mitigation measures to reduce the potential for third-party pipeline damage. These measures include a cement/sand slurry around the pipeline to prevent settling and alert third parties that a pipeline is present, and brightly colored tape placed above the pipeline to again alert third parties that a pipeline is present. The pipeline is also designed to meet the current code requirements for material specifications.

The crude oil pipeline would be operated using a Supervisory Control and Data Acquisition (SCADA) system which allows the operator, in this case Chevron, to remotely monitor and control the pipeline. It is unclear what type of valves are proposed for the new pipeline, as well as what valves are included on the Chevron pipeline.

The natural gas pipeline is also designed per the requirements of the CSFM, and is equipped with check and control valves. The natural gas pipeline will be equipped with a pressure monitoring system with an automatic shutdown system.

Mitigation Measures

6-1 Crude Oil Pipeline Valves
All valves on the MACPHERSON oil pipeline should be designed to be operated by Chevron using their SCADA system and should be designed to fail in a closed position. Valves on the Chevron pipeline should also be upgraded to fail in a closed position. A fail-closed block valve should be installed at the intersection of the MACPHERSON and Chevron pipelines. Block/check valve combinations should be installed at any channel or fault crossing (if any).

6.2 Resolution of the New Pipeline Safety Issue

The proposed new crude oil and natural gas pipelines would meet or exceed current regulatory safety requirements. In addition, MACPHERSON has proposed to add additional safety valves on the crude oil pipeline to reduce the volume of oil that would be spilled in the event of a pipeline failure. Continuous pressure readings taken at these valves would be communicated to the SCADA system and would contribute to the rapid detection of a pipeline leak or rupture. Results of the Reese-Chambers risk analysis also indicate that potential hazards associated with crude oil and natural gas pipeline transportation would be less than significant for the project as currently proposed. This is a reasonable finding given the relatively short length of these pipelines and the more rigorous design and operational provisions now required by the California State Fire Marshall. However, given the close proximity of these pipelines to the population in a densely developed urban area (i.e., the pipelines would be constructed under the street), there would still be a potential for the public to be exposed to potential fire and explosion hazards in the event of a pipeline failure. In addition, a failure of the crude oil pipeline could cause oil to flow into the ocean through existing storm drains resulting in localized coastal environmental damage, although adequate onsite oil spill containment equipment and planning could prevent or reduce the likelihood of oil reaching the ocean in the event of a spill.

7.0 Concerns Related to the Abandoned Chevron Pipeline

7.1 Previous Chevron Pipeline Safety Issue

The main concern related to the proposed project and pipeline product transportation was the reactivation of a very old, and partially abandoned, crude oil pipeline owned by Chevron. While the crude oil would not be the responsibility of MACPHERSON once it leaves their site and is transferred to Chevron ownership, reactivation of this pipeline is clearly a result of MACPHERSON's Hermosa Beach project.

The Chevron pipeline was originally constructed in 1925, although several segments have been replaced as recently as 1984. Pipelines during this period generally utilized lap welded pipe which has a failure rate of approximately 18 times greater than electric resistance welded pipe which is commonly used today (CSFM, 1993). Pre-1940 pipelines have also been found to have failure rates approximately 20 times greater than those constructed in the 1980s (CSFM, 1993). Some portions of this pipeline are approximately 72 years old and will likely be more than 100 years old near the end of the project's life. It is doubtful that this pipeline was designed for this long of a service life.

There was also a considerable amount of uncertainty related to the overall condition of this pipeline, how the pipeline was abandoned, how, or if, the pipeline was sealed when segments were removed, and whether or not cathodic protection was continued after the pipeline was abandoned.

It should be noted that the CSFM refused to allow Arco to resume crude oil shipments in their Line 1 between the San Joaquin Valley and Carson Refinery until significant improvements were made to the line. Since Arco declined to replace all of the segments that were lap welded, they abandoned the pipeline. This pipeline was also constructed in the 1920s and failed in several locations during the Northridge earthquake. It is also possible that Chevron may decline to commit the resources necessary to reactivate this pipeline, given the resources that may be required. Without this pipeline, it is unlikely that the proposed project could move forward without a reasonable method of crude oil transportation.

Possible Mitigation Measures

7-1 Chevron Crude Oil Pipeline Testing
The Chevron pipeline should be upgraded to allow for the use of an instrumented tool (i.e., smart pig) to allow for a thorough evaluation of the pipeline's condition. Once modified, the pipeline should be evaluated, and repaired as necessary, prior to crude oil shipments proceed. All pipeline sections that show a degradation of wall thickness of more than 25 percent should be replaced.

7-2 Chevron Crude Oil Pipeline Upgrades
All lap welded section of the Chevron pipeline should be replaced with seamless steel pipe. Block and check valves should be installed, as appropriate, as listed in Mitigation Measure 6-1.

7-3 Transportation Risk Analysis
The risk associated with crude oil transportation should be fully evaluated and include a quantification of the risk associated with product transportation (risk profile or risk matrix identifying the probability of an accident and the potential number of fatalities/injuries), and a map that clearly shows the pipeline route and associated hazard zones.

7-4 Alternate Crude Oil Transportation
Crude oil transportation for the final phase of the project should be limited to pipeline transportation. Assuming the peak production of 6,000 barrels per day, approximately 40 truck trips per day would be required if a pipeline were not available. Given the accident high probabilities associated with truck transportation, this would represent an unacceptable risk.

7.2 Resolution of the Chevron Pipeline Safety Issue

MACPHERSON is no longer proposing to utilize the decommissioned Chevron crude oil pipeline to transport crude oil to the Chevron El Segundo Refinery. Instead, MACPHERSON has decided to connect their proposed crude oil pipeline into the Edison Pipeline and Terminal Company (EPTC) transportation system at the Southern California Edison Redondo Beach Terminal and Generating Station.

EPTC owns and operates a pipeline system and petroleum storage facility that is used to move and store various types of petroleum products. The EPTC system has a total storage capacity of approximately 16.6 million barrels, and consists of one tank farm, storage facilities at eight generating stations, eleven heating and pumping stations (five of which are individual facilities and six of which are located at generating stations), and an underground oil pipeline system located in the greater Los Angeles area.

9.0 Summary of Project-Related Hazards

The hazard analyses that have been prepared for the proposed MACPHERSON Hermosa Beach Project have evaluated a wide variety of potential hazards that could adversely affect the surrounding community as shown in Figure 5. A majority of the hazards are associated with fire and explosion hazards associated with crude oil and natural gas production, processing and transportation. Since MACPHERSON has committed to monitor their wells for hydrogen sulfide, and would shut down wells containing more than 40 ppm hydrogen sulfide, potential acute toxic hazards associated with the proposed project would be considered minimal.

As summarized in the previous section, the risk associated with the proposed project falls mainly in the "Grey Region" which is classified as a significant impact "...but acceptable if mitigated to the maximum extent feasible, preferably to a level of insignificance (Santa Barbara County Risk Guidelines)." A review of the safety features that are included in the project's design, as well as additional commitments made by the applicant for additional safety features, would indicate that the proposed project incorporates safety mitigation measures to the maximum extent feasible. However, potential fire and explosion hazards associated with the proposed project, especially given the location in close proximity to residential areas, would still be classified as a significant impact based on the generally accepted risk criteria used by the applicant. As a result, the detailed hazard and operability study recommended in this report may be able to identify additional design and operational hazards that could lead to the need for additional safety features or design/operational modifications.

The quantitative risk estimates for the proposed project can be compared to the individual chances of fatality due to other causes, as shown in Table 1 (all of these figures should be compared on an order of magnitude basis, but not in terms of their exact numerical value). As can be seen from this figure, the risks from the proposed MACPHERSON Hermosa Beach Project are low relative to those associated with various diseases and accidental causes.

Figure 5 Macpherson Hermosa Beach Project Hazard Zones

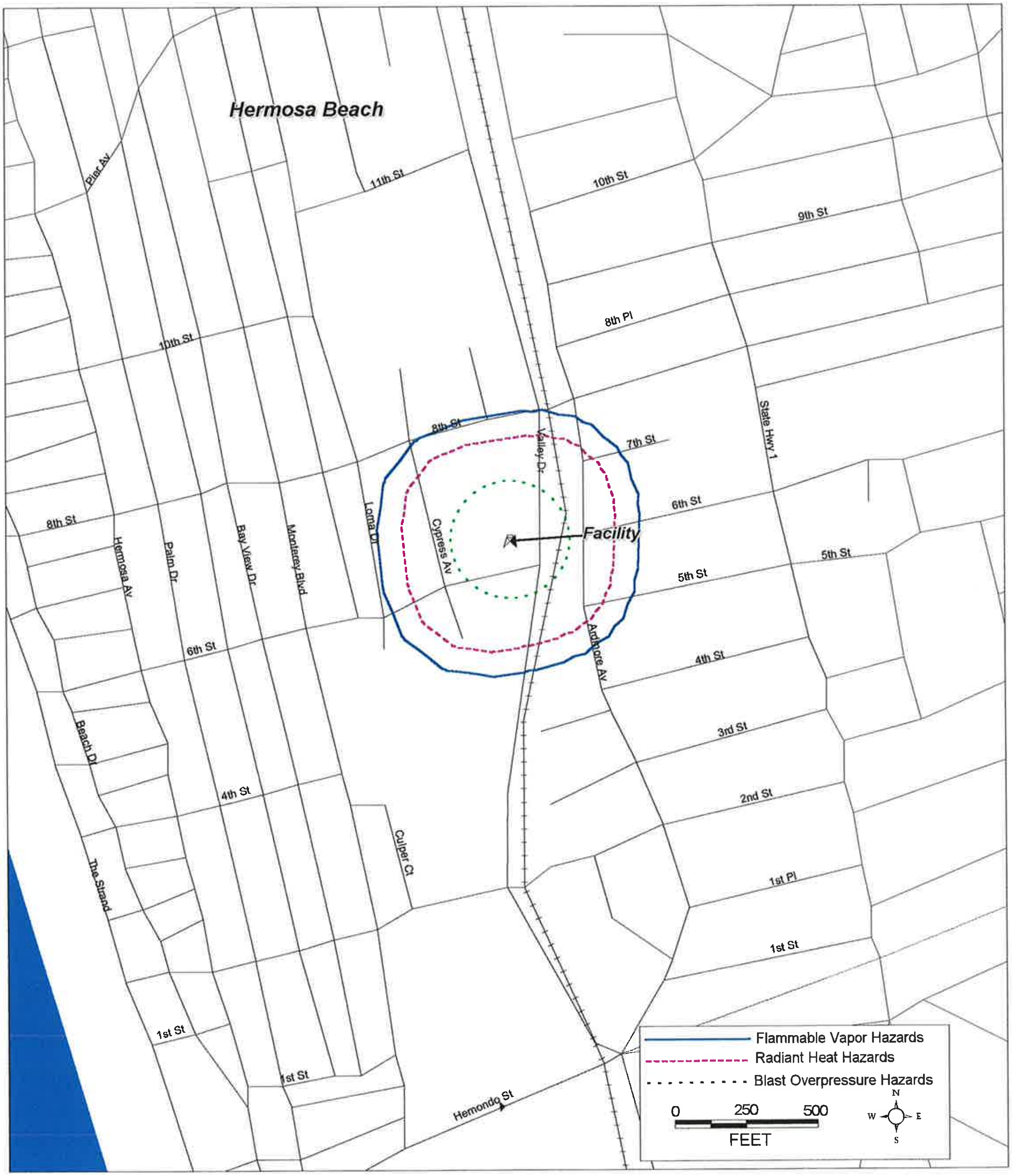


Table 1 Individual Risk Comparisons for the Proposed MACPHERSON Hermosa Beach Project

Cause of Death	Annual Mortality Rate	
	Per Single Person at Risk	Per 1,000 Persons at Risk
MACPHERSON Hermosa Beach Project	0.000012	0.012
All causes:	0.009	9
Heart Disease	0.003	3
Cancer	0.002	2
Accidents:	0.0004	0.4
- Motor Vehicles	0.0002	0.2
- Fires	0.00002	0.02
- Falls	0.00005	0.05
- Drowning	0.00002	0.02
- Excessive Heat	0.000002	0.002
- Lightning	0.0000003	0.0003

Source: Accident Facts, 1991 Edition. National Safety Council.

Attachment 1

Macpherson Oil Company City of Hermosa Beach Project
Hazard Footprint Analysis - May 9, 1995

MACPHERSON OIL COMPANY

CITY OF HERMOSA BEACH PROJECT

HAZARD FOOTPRINT ANALYSIS

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1.0 INTRODUCTION

The purpose of this analysis is to determine the potential risk to the surrounding community from the proposed Macpherson Oil Company City of Hermosa Beach Project. The analysis addresses the potential impact from fires, explosions, and releases at the proposed production site and from potential accidents involving the transportation of oil and gas from the site. The analysis makes use of the hazard footprint methodology described in the Port of Los Angeles "Final Risk Management Plan, An Amendment to the Port Master Plan" (Port of Los Angeles, 1983) and the Port of Long Beach "Risk Management Plan, An Amendment to the Certified Port Master Plan, Final" (Port of Long Beach, 1981). The methodology was developed in concert with the City of Long Beach and City of Los Angeles Fire Departments, the U.S. Coast Guard, and the California Coastal Commission.

The Risk Management Plans are in use at the Ports and govern the development of new projects and the modification of existing projects handling hazardous materials. Proposed new or modified projects are analyzed using the methodology in the Risk Management Plans, and projects not meeting the criteria in the plan are not approved. These procedures have been in place in the Ports for over 10 years.

In addition, the analysis estimates the probability of accidents occurring involving the proposed project. These estimates are based on historical data for similar projects.

Appendix A presents information on Reese-Chambers Systems Consultants, Inc. experience in conducting risk analysis. Appendix B contains the resumé of Tim Chambers, the individual who conducted the analysis.

2.0 METHODOLOGY

This analysis looked at the proposed project and then postulated the types of accidents that could occur. The types of accidents postulated were based on historical data with similar type projects and on the types of accidents required to be analyzed by the Ports' Risk Management Plans. These accidents, referred to as Design Basis Accidents (DBAs), are listed below.

(1) A release in the well area without a fire
(2) A release in the well area with a fire
(3) A fire in an atmospheric storage tank
(4) The rupture of a storage tank into the surrounding secondary containment system without an ensuing fire
(5) The rupture of a storage tank into the surrounding secondary containment system with an ensuing fire
(6) An explosion in a storage tank
(7) A gas release from a process vessel
(8) A liquid release from a process vessel into the surrounding secondary containment system without an ensuing fire
(9) A liquid release from a process vessel into the surrounding secondary containment system with an ensuing fire
(10) An accident involving the trucking of crude oil during Phase I
(11) An accident involving the crude oil pipeline during Phase II
(12) An accident involving the gas pipeline during Phase II

For each of the DBAs, the extent of the potential impact is then estimated using "hazard footprints." A hazard footprint is a diagram indicating the extent of the area within which a specified level of adverse effect is exceeded against a specified vulnerable resource. The following hazard footprints were calculated for the above DBAs as appropriate.

- *Radiant Heat from a Fire.* A fire will produce radiant heat. The distances to the 5 kW/m^2 (1,600 Btu/sq.ft./hr) heat level from those accidents involving fires have been calculated. This is the level that can begin causing second-degree burns to human skin exposed for 30 seconds. People inside homes or shielded by objects such as buildings or walls could stand a higher heat level before being impacted.

- *Flammable Gas Cloud from a Release.* When a flammable material is released, it begins producing flammable vapors which can drift with the wind, producing a gas cloud which may be ignited. The distances the cloud may travel before dispersing to a concentration below its lower flammability limit (LFL) have been calculated for releases of flammable materials. The flammable gas cloud hazard footprint has been calculated for two atmospheric conditions: stability condition F with 2.2 mph wind, and stability condition D with 5 mph wind. Stability Condition F consists of a low inversion layer, which tends to trap gas releases and prevent them from dispersing in the atmosphere. This condition occurs at night with low wind speeds. This condition usually results in the largest gas cloud hazard footprints. The largest of hazard footprints for the two atmospheric conditions has been presented in this analysis.

- *Toxic Gas Cloud from a Release.* When a potentially toxic material is released, it begins producing toxic vapors which can drift with the wind. The distances the cloud may travel before dispersing to a concentration below which it is no longer toxic has been calculated for releases of toxic materials. The toxic gas cloud hazard footprint has been calculated for the two atmospheric conditions described above. The largest of hazard footprints for the two atmospheric conditions has been presented in this analysis.

- *Blast Overpressure and Flying Debris from an Explosion.* Both vessels and unconfined vapor clouds have the potential to explode. The blast overpressure, as a function of distance from such an explosion, has been calculated, along with an estimate of the distance that debris may be hurled by an explosion, as appropriate. A blast overpressure of 2.5 psig, which represents the pressure that can begin causing eardrum rupture, has been used as the blast overpressure hazard footprint threshold.

The crude oil and gas to be produced by the proposed project are not expected to contain constituents that can generate toxic vapors if released. In particular, the gas is not expected to contain any hydrogen sulfide (H_2S). However, toxic gas cloud hazard footprints for gas containing various levels of H_2S have been calculated to assist in establishing maximum H_2S levels allowed for the proposed project.

Hazard footprints have been determined using HFCP, the computer model used by the Ports of Los Angeles and Long Beach. The details of the methodology used by HFCP are documented in the Users' Manual (Reese-Chambers Systems Consultants, Inc., 1991). Gas release rates were modeled using Chems-Plus, developed by Arthur D. Little.

3.0 ANALYSIS AND RESULTS

The proposed project will consist of two phases. Phase I will include the drilling of one to three exploratory and producing wells to prove the commercial value of the development. The emulsion (an oil and water mixture) and associated gas will be processed on site using portable equipment and the oil will be trucked offsite to a refinery. The water will be reinjected into a reservoir. The gas will be scrubbed and incinerated. Phase II will produce emulsion and associated gas from 30 wells; separate the gas, oil, and water using gravity and heat; clean the separated water and reinject it using four wells; and store the oil on site until shipped by a newly constructed pipeline. The gas will also be shipped by a newly constructed pipeline.

The exact characteristics of the crude oil to be produced is not known at this time, however, the API gravity is expected to be between 17 and 21. While the characteristics of the oil have little effect on the size of the radiant heat, blast overpressure, and flying debris hazard footprints, they can have a significant impact on the flammable vapor cloud hazard footprint. Thus, to be conservative, we have assumed that the crude is fairly light with a flash point below 100°F, making it a flammable liquid. This assumption will tend to overestimate the size of the flammable vapor cloud hazard footprint.

The produced gas is expected to be sweet, that is, it is not expected to contain hydrogen sulfide (H_2S) in concentrations high enough to be considered hazardous. The potential effects of H_2S on humans is a function of two parameters, the exposure concentration and the exposure time. The higher the exposure concentration, the less time it takes to cause adverse health effects. This analysis has addressed two concentration exposure times, 300 parts per million(ppm) for 30 minutes and 1000 ppm for 30 seconds. The 300 ppm concentration is the immediately dangerous to life or health (IDLH) concentration for H_2S. IDLH represents a maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects. The 1000 ppm concentration could cause death after a few breaths.

3.1 Risk From Wells

The best known and potentially the most significant accident associated with well drilling is a blowout. A blowout is defined as the uncontrolled flow of formation fluids from a wellbore. They occur when formation fluids flow uncontrolled into a low-pressure subsurface zone (an underground blowout) or to the surface (a surface blowout). Most commonly, a blowout happens when there is insufficient pressure in a wellbore to control subsurface pressures. If wellbore hydrostatic pressure is allowed to drop below the subsurface formation pressure, then a "kick" will occur as the formation fluids flow into the well. Typically, a kick is circulated out of a well in a controlled manner, with formation fluids flowing into a production flowline or emergency flare line. When a kick is detected during drilling operations, the blowout prevention equipment (BOPE) is closed, sealing the wellbore and preventing any additional formation fluid from entering the wellbore. Additional kick-control procedures are implemented such as circulating higher density drilling fluid into the wellbore until the kick is circulated out of the well and normal operations can be resumed. A surface blowout occurs when formation fluids flow to the surface in an uncontrolled manner. A kick can lead to a blowout in rare instances (e.g., in a gas well that experiences a failure in the mechanical integrity of the equipment/system). Redundancy of equipment is a primary feature of blowout prevention equipment design.

A source of information on blowouts in California is a document titled "A History of Oil- and Gas-Well Blowouts in California, 1950 - 1990", published by the California Department of Conservation Division of Oil, Gas and Geothermal Resources (CDOG). This database includes both onshore and offshore wells.

The CDOG data shows an overall drilling incident rate of one blowout per 1,953 wells drilled during the time period 1950 - 1990. The incident rate for blowouts resulting in a release of oil is 1:20,315. The blowout incident rate from 1970 (after the Unocal blowout offshore Santa Barbara) through 1990 was 1:3,046 (a probability of 3.3×10^{-4} per well drilled).

A detailed analysis of the CDOG data for the time period 1980 - 1990 conducted by Mobil for their Clearview Project application determined that after blowouts caused by steam injection and in abnormally high pressurized reservoirs were removed from the database, the blowout incident rate is 1:10,969 (a probability of 9.1×10^{-5} per well drilled). None of the remaining blowouts in the database flowed oil.

One factor that would tend to further reduce this low probability of a blowout is the fact that the Hermosa Beach project will be drilling into a reservoir whose characteristics are well known. The reservoir is not highly pressurized and will require pumping to bring the oil to the surface.

Based on the above statistics (blowout incident rate of 1:10,969), the probability of a blowout for the two phases of the proposed project are presented below.

PHASE	NUMBER OF WELLS	PROBABILITY OF BLOWOUT
I	6	5.5×10^{-4}
II	24	2.2×10^{-3}
BOTH	30	2.7×10^{-3}

The probability of a blowout during drilling was deemed to be not significant by the previous Final Environmental Impact Report (Ultrasystems, 1994). This conclusion was based on the fact that the wells will be equipped with redundant safety devices, including blowout protectors. Thus, the worst case accident involving the wells has been postulated to be a leak in the well area flooding the well cellar. The leak would involve an emulsion containing approximately half oil and half water.

The well cellar covers an area of approximately 2,060 feet. HFCP was utilized to calculate the flammable vapor cloud and radiant heat hazard footprints for a release that would cover the entire cellar area. The size of the hazard footprints is measured from the edge of the cellar area. The results are presented below.

- Radiant heat - 152 feet
- Flammable gas cloud - 17 feet

It is noted here that the vaporization rate from this pool would not produce enough vapor to become involved in an unconfined vapor cloud explosion.

Regulations and technology have made wells extremely safe and the probability of a release of any size from a well is unlikely. Previous EIRs (County of Santa Barbara, 1985) have estimated that the probability of a major spill from a wellhead is 1.8 x 10^{-8} per year. This would equate to an annual probability of a major release of 5.4 x 10^{-7} (once in 1.8 million years) for all 30 proposed wells. The probability that the oil would become ignited would be 1.0 x 10^{-2} or one in a hundred (Country of Santa Barbara, 1985). Thus, the annual probability of a release with fire would be 5.4 x 10^{-9}.

Although the probability of a gas blowout is extremely low, a discussion of such an event follows. First, if a large pressure surge is encountered, the blowout prevention systems should prevent gas from escaping by closing off the annulus. In the highly improbable event that the annulus does not close, the gas will be diverted to the processing equipment or the on-site vent if the processing equipment is unable to handle the flow. The vent allows the gas, which is lighter than air, to escape upward away from potential ignition sources. Modeling shows that the gas being vented from a vertical flare will not reach flammable concentrations (approximately 5 percent for methane) at ground level and therefore should not be subject to ignition.

As stated previously, the gas is expected to be sweet and should therefore not present a toxic hazard. An H_2S concentration of 6000 ppm means that the gas contains 0.6 percent (0.006) H_2S. If released, the gas would immediately begin to mix with air thereby diluting the overall concentration of H_2S. When the gas has been diluted with air such that the mixture is 95 % air and 5% gas, the H_2S concentration would be 300 ppm (6000 ppm X .05). Five percent has been utilized here since modeling for the flammable vapor cloud has shown that a 5 % concentration would not reach ground level. Thus, produced gas containing 6,000 ppm H_2S would not result in a 300 ppm ground level concentration of H_2S.

3.2 Risk from Storage Tanks

Oil and process water will be stored in five storage tanks located in a common secondary containment system (i.e. diked area). All of the tanks will have cone roofs with weak seams. In the unlikely event of an explosion, the roof is designed to lift up to vent the energy, thereby preventing the tank from rupturing and possibly resulting in flying debris. The roof is expected to travel no more than several tank diameters from the tank. It is also noted here that the tanks will be blanketed with gas to prevent oxygen from being present. As long as oxygen is not present, an explosion is impossible.

The potential DBAs from the tanks addressed in this analysis include a fire in a tank, an explosion in a tank, and a rupture of a tank flooding the diked area, either with or without a fire. The following hazard footprint distances were calculated using HFCP. The largest tank, with a 3,333 bbl capacity, was used in the calculations. All of the hazard footprints are measured from the edge of the tank or diked area.

- Radiant heat from a fire in a tank - 156 feet
- Blast overpressure from an explosion in a tank - 141 feet
- Flying debris from an explosion in a tank - 77 feet
- Radiant heat from a fire in the diked area - 271 feet
- Flammable gas cloud from a release into the dike area - 33 feet

The rupture of an atmospheric storage tank due to all causes, including seismic events, is estimated to be 1.6 x 10^{-4}/year or once in 6,300 years (Country of Santa Barbara, 1985). The probability that the oil is ignited is 1.0 x 10^{-2}, or one in a hundred. Thus, the probability of a release with a fire is estimated to be 1.6 x 10^{-6} per tank, or once in 625,000 years. Since there will be three storage tanks that may store crude oil, the probability of a spill with fire, per year, would be 4.8 x 10^{-6}, or once in 208,000 years.

The probability of an explosion in an oil storage tank has been estimated to be 1 x 10^{-4} per year (County of Santa Barbara, 1988). This is for all types of storage tanks. The tanks for the proposed project will be gas blanketed, which will virtually eliminate the possibility of a tank explosion.

3.3 Risk from Process Area

The first step in processing the emulsion will be the separation of the gas, oil, and water by means of gravity using free water knockout (FWKO) vessels. The gas that will be separated out will be primarily methane which is the predominant gas in natural gas piped to most homes. The emulsion enters the FWKO whereby the water, which is heavier than the oil, falls to the bottom of the tank while the oil floats on the oil. The gas which escapes from the emulsion goes to the top of the tank. The water is drawn off the bottom of the tank and sent to the wastewater treatment system. The gas is drawn off and directed to the gas compression and treatment system. The oil is sent to heater treaters where it is further processed. The FWKOs are ASME certified pressure vessels. The potential for an explosion in one of these vessels is extremely unlikely, and thus no hazard footprints have been calculated for a vessel rupture. Instead, the DBA from a FWKO has been assumed to be a release from a 2-inch diameter hole, which represents a release from a pipe connection or other small release. The flammable gas hazard footprint from a 2-inch diameter hole in the tank would produce a flammable vapor cloud hazard footprint that would extend up to 327 feet from the point of release under worst case atmospheric conditions (stability F, 2.2 mph wind). The rate of release from the vessel was calculated using the Chems-Plus model developed by Arthur D. Little. This rate of release was then input to both Chems-Plus and HFCP to calculate the flammable gas cloud hazard footprint. The models also determined that the amount of gas (methane) in the cloud would not be enough to become involved in an unconfined vapor cloud explosion.

The release has also been modeled assuming the gas contains various levels of H_2S. First, if the gas contains 6,000 ppm H_2S, then the 300 ppm hazard footprint would extend 327 feet from the point of release (the 300 ppm hazard footprint would be the same size as the 5 % flammable vapor cloud hazard footprint since 5 % dilution of a gas containing 6,000 ppm H_2S would contain 300 ppm H_2S). However, it is unlikely that a release would last for 30 minutes and thus this hazard footprint is conservative. Chems-Plus and HFCP were utilized to calculate the toxic gas cloud hazard footprint to 1000 ppm H_2S. The size of this hazard footprint was calculated to be 173 feet.

The oil is sent to heater treaters where it is heated to further separate out water and gas from the oil. In this case the majority of the emulsion entering the vessels is oil. The heater treaters are also ASME certified pressure vessels. Since the heater treaters will operate at approximately the same pressure as the FWKO, the release rate of gas from a 2-inch diameter hole will be approximately the same as that from the FWKO (it will actually be slightly less since the gas will expand because it is heated) and thus, the flammable vapor cloud hazard footprint will be approximately the same size. Again, there should not be a toxic gas hazard footprint because the gas is expected to be sweet. The discussion in the previous paragraph applies if the gas contains H_2S.

A release of oil from the FWKOs or heater treaters could spread and cover the secondary containment area around the vessels. The surface area of the secondary containment area is approximately 7780 sq.ft. The flammable gas cloud (if the spill doesn't ignite) and radiant heat hazard footprints were calculated by HFCP to be:

- Flammable gas cloud - 41 ft
- Radiant heat - 266 ft

County of Santa Barbara, 1985, has estimated that the probability of a major release from a pressure vessel is 2×10^{-5} per year, or once in 50,000 years. For the four vessels proposed for the facility, the combined annual probability of a major release would be 8.0×10^{-5} (once 12,500 years).

The probability that the released oil would become ignited is 1.0×10^{-2}. Thus, the annual probability of a major spill with fire is 8.0×10^{-7} (once in 1.25 million years).

3.4 Risk from Trucking

During Phase I, the oil will be stored on site in portable tanks and then loaded into tanker trucks for transportation to a refinery. It is estimated that four tanker truck trips per day, each carrying 150 bbls of oil, will be required to handle the 600 bbl per day production. The tanker trucks will be loaded inside the facility in an area equipped with a drain and sump to contain any spillage, although none is expected. The Phase I site sump/containment system will be adequate to fully contain a 150 bbl spill. Trucks will exit the facility and follow designated routing from the facility. Trucks will not deviate from the designated routing through residential neighborhoods.

Trucking of petroleum products is quite common throughout the country. Gasoline and other petroleum products are routinely transported by tanker trucks to gas stations and industrial facilities. Tanker trucks can become involved in traffic accidents but these do not usually result in a loss of cargo. A worst case accident would result in the loss of the entire contents of the truck (150 bbls). The released oil would then spread on the ground and could ignite if it encounters an ignition source. The area covered by the spill would be a function of the elevation profile of the surrounding area. It is also possible that the spilled oil could enter a storm sewer.

For the purpose of calculating the potential hazard footprints, it has been assumed that the oil is spilled on a flat surface and spreads to a uniform depth of one inch. The spill would cover an area of approximately 10,000 sq. ft. with a radius of approximately 57 ft. The radiant heat and flammable gas cloud hazard footprints were calculated by HFCP to be:

- Flammable gas cloud - 47 ft
- Radiant heat - 297 ft

It is noted here that oil burns at a rate of approximately 4 mm (0.16 in.) per minute and hence, a one-inch deep pool would burn for approximately 6.4 minutes. The pool would burn for a longer time if it were deeper, however, then the area would be smaller and the radiant heat footprint smaller.

The Handbook of Chemical Hazard Analysis Procedures (FEMA, undated) recommends using a truck accident rate of 2×10^{-6} accidents per mile with 20% of the accidents resulting in a release of cargo. The Handbook goes on to recommend that the following spill distribution be utilized:

- 10% cargo loss (15 bbl) - 60% of the time
- 30% cargo loss (45 bbl) - 20% of the time
- 100% cargo loss (150 bbl) - 20% of the time

Assuming that a loaded truck travels 10 miles results in the following annual probabilities of accidents and releases. It is assumed that the trucking lasts for one full year.

Event	Annual Probability
Accident	2.9×10^{-2}
Spill of any size	5.8×10^{-3}
Spill less than 30 bbls	3.5×10^{-3}
Spill between 30 bbls and 100 bbls	1.2×10^{-3}
Spill greater than 100 bbls	1.2×10^{-3}

3.5 Risk from Crude Oil Pipeline

A new produced crude oil shipping line will be constructed to transport produced crude oil from the oil production facility to the existing Wilmington to Torrance Pipeline. The Wilmington to Torrance Pipeline, operated by Chevron, will transport the crude oil to the Chevron refinery in El Segundo. The new pipeline will have an outside diameter of 6 inches and be approximately 0.5 miles (2500 ft) long. The pipeline is designed for a maximum crude flow of 8,000 bbl per day with a maximum operating pressure of 350 psig.

The amount of oil that can be released from a pipeline is made up of the amount that can be released until pumping is stopped plus the amount that can drain from the line due to gravity. Because the pipeline will be equipped with a supervisory control and data acquisition (SCADA) system that will monitor the pipeline at all times, it is conservatively estimated that a pipeline rupture would be detected and the pumping shut down within 10 minutes. Hence, a maximum of 56 bbls [8,000 bbls per hour / (24 hr X 60 min per hr) X 10 min] could be lost due to pumping. The capacity of the pipeline is 85 bbls. That is the maximum amount of oil that could drain from the pipeline if all the oil were to escape. Thus, the worst case release from the pipeline would be 141 bbls (56 bbls + 85 bbls).

As with a trucking accident, the area impacted by a pipeline spill would be a function of the elevation profile of the surrounding area. Assuming again that the spill occurs on a flat surface and spreads to a depth of one inch, this results in a 9500 sq. ft. area being covered.

The radiant heat and flammable gas cloud hazard footprints were calculated by HFCP to be:

- Flammable gas cloud - 46 ft
- Radiant heat - 289 ft

The probabilities of a leak and rupture for modern, crude oil pipelines are generally estimated to be around 5.4×10^{-4} spills per pipeline-mile per year, and 2.7×10^{-4} ruptures per pipeline-mile per year, respectively (Aspen, 1995). This equates to the following annual probabilities for the 0.5 mile pipeline.

- Probability of leak - 2.7×10^{-4}
- Probability of rupture - 1.3×10^{-4}

3.6 Risk from Gas Pipeline

A new gas pipeline will be constructed to transport utility-grade gas from the facility to an existing utility gas pipeline. The new pipeline will have an outside diameter of 4 inches and will be approximately 0.5 miles long. Gas will be sent through the line on a continuous basis at approximately 120 psig, using the compressor located at the Macpherson production facility. Any H_sS that might be in the gas will be removed at the Macpherson production facility and hence, the gas will not be toxic.

The rate of release of gas from the pipeline would be a function of the size of the hole. The larger the hole, the greater the release rate. A complete rupture of the line would shut down the compressor almost immediately. In addition, the line will be equipped with a check valve at the point where it connects to the utility line that would prevent gas from flowing into the line from the utility line.

Chems-Plus has been utilized to calculate the release rate and flammable vapor cloud hazard footprint from a pipeline rupture and from a small leak (e.g. ¼-inch diameter hole). The results are presented below.

Accident	Downwind Distance to LFL
• Pipeline rupture	474 feet
• ¼-inch hole	54 feet

It is noted here that the downwind distance to the LFL calculated for the rupture is an overprediction because Chems-Plus treats the release as a point source and ignores the initial mixing with air caused by the jet release of the gas. The pipeline would be emptied of gas within about 4 seconds in the rupture case. It is also noted that this line is essentially the same as the numerous utility owned and operated gas lines throughout the area.

If the gas release were to ignite, it would burn as a jet release until the gas flow ceased. This would last about 4 seconds. The flame length could be up to 211 feet long. If the gas cloud were to ignite, the fire would burn back to the source and then burn as a jet flame. Thus, the radiant heat hazard footprint has been assumed to be equal to the flammable gas cloud hazard footprint.

3.7 Summary of Results

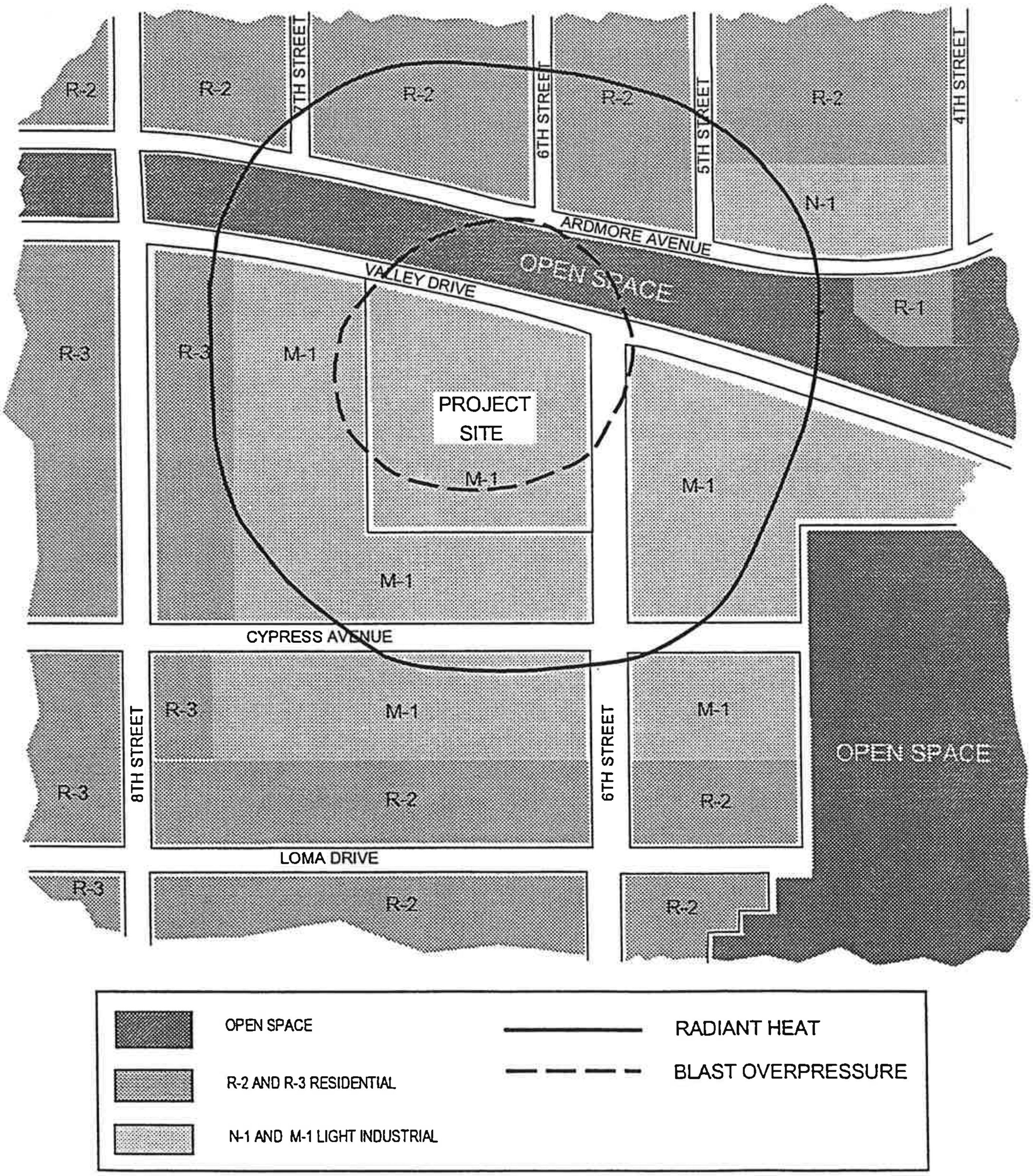
The results of hazard footprint analysis are summarized below. The hazard footprints are displayed on Figure 3-1. Since sour gas is not expected, toxic hazard footprints are not included in the table.

COMPONENTS	RADIANT HEAT HAZARD FOOTPRINT (ft)	FLAMMABLE GAS CLOUD HAZARDOUS FOOTPRINT (ft)	BLAST OVERPRESSURE HAZARD FOOTPRINT (ft)	FLYING DEBRIS HAZARD FOOTPRINT (ft)
Wells	152	17	N/A	N/A
Storage Tanks	271	33	141	77
Process Equipment	266	41	N/A	N/A
Trucks	297	47	N/A	N/A
Oil Pipeline	289	46	N/A	N/A
Gas Pipeline	474	474	N/A	N/A

As can be seen from the table, the largest hazard footprint from the facility would be 271 feet from a release by a storage tank into the surrounding secondary containment system, followed by a fire. The radiant heat hazard footprint could extend into the residential neighborhood to the north and just touch the R-3 neighborhood to the west. It is noted here that this footprint would not impact people inside or behind structures. In addition, people outdoors, exposed to the heat from a fire, would have time to find shelter before they would sustain burns. A fire at the facility should not impact homes or other structures in the area. The other facility hazard footprints should not impact residential areas.

The truck, oil pipeline, and gas pipeline accidents would occur offsite and their potential impact would be a function of where the accident occurred relative to vulnerable resources.

FIGURE 3-1 HAZARD FOOTPRINT



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APPENDIX A
EXPERIENCE SUMMARY

REESE-CHAMBERS SYSTEMS CONSULTANTS, INC.

Reese-Chambers Systems Consultants, Inc. (RCSC) is a small company located in Southern California near the City of Camarillo. RCSC has been providing professional consulting services to industry and agencies since 1979. One of RCSC's specialty areas is risk analysis of industrial projects. RCSC has conducted risk analysis in conjunction with Environmental Impact Reports and Statements (EIRs and EISs), Risk Management and Prevention Programs (RMPP), Hazard and Operability Studies (HAZOPs), Environmental Quality Assurance Programs (EQAP), and other agency-required special studies. RCSC has utilized various models in the conduct of risk studies including *ARCHIE, CHEMS-PLUS, WHAZAN, SLAB, AFTOX,* and *ISC*. RCSC has specific experience with a broad range of industrial applications including numerous oil industry facilities such as pipelines, pump stations, tank farms, and marine terminals:

- Preparation of the system safety/public safety section of the EIR for the State Lands Commission lease renewal of the Unocal Rodeo Marine Terminal.
- Conduct of 25 separate risk and hazard analyses to fullfill California Office of Oil Spill Prevention and Response (OSPR) requirements for oil spill contingency plans. Analyses included marine terminals, pipelines, oil platforms, onshore producing facilities, and onshore processing facilities.
- Consultant to Texaco Trading and Transportation, Inc. (TTTI) for the permitting of the Gaviota Marine Terminal. Also developed various risk analysis studies and papers in support of permit negotiation and compliance. Developed many of the Terminal contingency plans including the Emergency Response Plan and Oil Spill Contingency Plan.
- Developed the Risk Management Plans for the Ports of Los Angeles and Long Beach. The plans have been certified by the California Coastal Commission as annexes to the Ports' Master Plans, dealing with risk management for hazardous cargoes and petroleum products.
- Developed the risk analysis section of an environmental study addressing a proposed oil and gas development project on Sakhalin Island, Russia. The analysis addressed all aspects of the proposed project including oil and LNG export terminals.
- Developed terminal operations manuals for the Gaviota Marine Terminal and Unocal Avila Terminal to meet U.S. Coast Guard and California State Lands Commission requirements.
- Developed EQAP for Unocal Sisquoc Pipeline and Santa Maria Pump Station.

- Conducted overall spill risk and prevention analysis for Pacific Pipeline System, Santa Barbara to Los Angeles refineries.

- Conduct of RMPP and HAZOP studies for four electrical generation plants, a steam generating facility, a refrigeration plant, and numerous oil industry facilities including pipelines, tank farms, processing plants, and pump stations.

- Preparation of Process Safety Manuals for Unocal Rincon oil processing facility.

- Developed oil spill response plans for numerous facilities including the Gaviota Marine Terminal, Unocal Avila Wharf Terminal, Bush Oil Rincon Operations, and several pipelines in response to OPA 90 requirements.

- Developed numerous emergency response plans and fire protection plans for oil and gas projects including marine terminals, processing plants, pump stations, and pipelines.

- Conducted numerous risk studies as listed below:

  - GATX Port of Los Angeles Chemical Terminal
  - Proposed California Ammonia Company Ammonia Terminal in the Port of Los Angeles
  - Chevron Carpinteria Oil and Gas Processing Facility
  - Chevron Elk Hills Gas Plant Risk of Explosion Study
  - McMillen Long Beach Refinery Potential Risk to Nearby School Site
  - Oil and Gas Development Project on Sakhalin Island, Russia
  - Relocation of Defense Logistic Agency Fuel Pier and Pipeline in the Port of Los Angeles
  - Mutual Liquid Gas Propane Storage and Truck Loading Facility in Wilmington, California
  - Liquefied Gas and Chemical Terminal on the Firth of Forth, Scotland
  - Southern Pacific Pipeline Tank Farm Expansion in Carson, California
  - Unocal Product Pipeline through the City of Carson
  - Gaviota Interim Marine Terminal
  - Matlack Hazardous Material Trucking Terminal and Truck Cleaning Facility in Carson
  - Proposed Oil and Gas Development on Vandenberg Air Force Base
  - Proposed Natural Gas Pipeline Projects into the San Joaquin Valley

- Tesoro Fuel Depot and Southern California Edison Storage Tanks in the Port of Hueneme
- OSCO Solvent Recycling Facility in City of Azusa, California
- Unocal Gas and Oil Processing Facility in Lisbon, Utah

Timothy J. Chambers
Senior System Safety Analyst

SUMMARY OF EXPERIENCE

Over 24 years of experience as a systems analyst, with major emphasis on safety and risk management analysis; oil and gas activities; hazardous material handling, storage, and transportation analysis; and contingency planning. Experience during the past 15 years has included extensive environmental work including that involving facilities handling hazardous materials. Other environmental analysis has involved risk management of maritime transportation, marine terminals, oil and gas activities, pipelines, truck and train transportation, and processing facilities. Experience includes work with industry and governmental agencies.

MAJOR PROJECT EXPERIENCE

- Conduct of 25 separate risk and hazard analyses to fulfill OSPR requirements for oil spill contingency plans. Marine facilities addressed included marine terminals, pipelines, platforms, onshore producing facilities, and onshore processing facilities, and customers included Unocal, Shell, Vintage, Torch, Global, Macpherson, and Mobil.

- Consultant to Unocal for the development of OPA 90 and OSPR oil spill contingency plans for the Avila Marine Terminal, Coast Area pipelines, Valley Area pipelines, and Point Pedernales pipeline.

- Consultant to Macpherson Oil Company for development of Oil Spill and Emergency Response Plans for their proposed Hermosa Beach oil development project. Plans were prepared for the drilling and production site, crude oil pipeline, and gas pipeline.

- Project Manager for the development of operating procedures for Unocal's Rincon Facility (ROSF)

- Development of public safety and vessel traffic analysis sections of an EIR on the renewal of Unocal's Rodeo Marine Terminal lease with the California State Lands Commission.

- Conduct of an analysis addressing the potential impacts on marine operations (nearby terminals and vessel traffic) caused by the construction of four alternative bridge configurations parallel to the existing Benicia-Martinez Bridge.

- Consultant to the Gaviota Terminal Company for the permitting of an oil transport marine terminal at Gaviota, California. Work included conduct of various studies and analyses to support system safety aspects of the marine terminal, its operations, and the transport of oil by tankers; negotiation of permit conditions; and the development of contingency plans including the Oil Spill Contingency Plan, Shoreline Cleanup Plan, Shoreline Access Plan, Terminal Operations Manual, Emergency Response Plan, and Fire Protection Contingency Plan.

- Development of the Navigational Hazard Analysis section of the various oil spill cooperative Regional Resource Manuals.

- Development of the vessel traffic analysis section of the Wickland Oil Terminal Expansion EIR.

- Consultant to Unocal Oil and Gas for the development of emergency response plans for their Santa Maria Basin oil and gas development project. Specifically developed separate emergency response plans for the Lompoc HS&P, the Battles Gas Plant, oil and gas pipeline segment from shore to the Lompoc HS&P, and the oil pipeline segment from the HS&P to the Orcutt Pump Station.

- Consultant to Unocal for the permitting of the Sisquoc Pipeline System. Conducted various analyses and developed various plans in support of this effort, including Fire Protection Plan, Emergency Response Plan, Oil Spill Contingency Plan, Environmental Quality Assurance Plan, Risk Analysis, and HAZOP.

- Responsible for risk analysis and mitigation development for a proposed offshore oil and gas development project in Russia. Risk analysis addressed all aspects of the project including offshore drilling and production, offshore and onshore oil and gas pipelines, oil and gas processing facilities, oil export terminal, LNG plant and export terminal, and refinery.

- Consultant for development of risk management programs and addressal of citizen concerns for various petroleum pipeline, tank farm, processing plant, refinery, and gas pipeline projects. Clients included City of Carson, City of Torrance, Long Beach Unified School District.

- Manager of system safety portions of EIR and EIS documents for various projects, including transportation, transfer, handling, and storage of chemicals for a proposed GATX chemical tank farm in Carson, California; natural gas pipeline development in San Joaquin Valley; oil and gas drilling, storage, transportation, and processing for Vandenberg Air Force Base; hazardous material transport, transfer, cleaning, and storage for the City of Carson; and hazardous waste material storage, transfer, processing, transport, and recycling for a facility located in Azusa, CA.

- Conducted risk analysis of potential for release, fire, and explosion at one of the gas plants at the Elk Hills Naval Petroleum Reserve.

- Risk analysis and mitigation design, contingency planning, and design and operation of risk management programs for various clients including County of Santa Barbara, Ports of Los Angeles and Long Beach, Cities of Beaumont and Carpinteria, Holchem, California Ammonia Company, Mutual Liquid Gas and Equipment Company, and others.

- Development of Risk Management and Prevention Programs (RMPPs) as required by California law for several industrial facilities including Colmac Energy, Bonneville Pacific, and Tracy Operators power plants; Sharyn Steam steam generation plant; and United Foods food processing plant. RMPPs address acutely hazardous materials such as ammonia, chlorine, and sulfuric acid.

- Conduct of Hazard and Operability (HAZOP) studies in support of the RMPPs listed above and for several oil pipeline and pump station projects.

- Development of risk management and maritime factors portions of EAs/EIRs/EISs for various oil and natural gas recovery projects covering gas and oil pipeline safety, shipping and other maritime impacts, drilling safety, etc. Projects included ARCO, Cities Service, Chevron, Phillips Petroleum, Shell Oil Company, Texaco.

- Responsible for public and system safety analysis section of EIR on a proposed household and small business hazardous waste collection facility in Santa Barbara, California.

- Responsible for all public and system safety aspects of the EIR/EIS for the Port of Los Angeles/Port of Long Beach 2020 Plan, a proposed landfill and expansion project. Work covered potential system safety impacts from landfill construction; impact on recreational, fishing, and commercial vessels; impact from trucking, pipeline, and train transportation of hazardous materials; impact on anchorages; and impact from oil spills.

- Responsible for analysis of potential impacts between tanker traffic to a proposed Exxon offshore marine terminal and potential oil and gas development in the vicinity of the marine terminal. Work conducted in the form of a supplemental EIR for the California State Lands Commission.

- Developed risk analysis and emergency procedures section of an environmental and risk assessment of coastal communities from LNG tanker traffic offshore Alaska.

- Responsible for risk analysis section of oil spill response plan developed for Alyeska Valdez Marine Terminal.

- Prime consultant to PBQ&D and US Navy for risk and reliability analysis for relocation of Navy fuel pier to Port of Long Beach. Work included extensive pipeline, tank farm, and marine terminal risk management analysis.

- Consultant to GATX for permitting risk analysis of a proposed expansion of a multi-petroleum product and chemical marine terminal and storage facility in the Port of Los Angeles.

- Project manager and consultant for port and vessel traffic risk management analysis for a multi-liquefied-gas terminal on the Firth of Forth, Scotland. Client was the Forth Ports Authority.

- Prime contractor and consultant to the Ports of Los Angeles and Long Beach, California in the development of the Ports' risk management plan for the handling, transportation, and storage of hazardous cargos at and through the ports. Also developed a generalized computerized model to calculate potential areas at risk from existing and proposed facilities.

EDUCATION

Bachelor of Science, Mathematics, Northeast Missouri University, Kirksville, MO (1966)

Bachelor of Science, Education (Mathematics and Physics), Northeast Missouri University, Kirksville, MO (1966)

Master of Science, Mathematics, University of Toledo, Toledo, OH (1968)

EMPLOYMENT EXPERIENCE

1979-Present	Reese-Chambers Systems Consultants, Inc. Principal of small consulting firm.
1968-1979	Naval Ship Systems Engineering Station, Port Hueneme, CA Branch Head for the Systems Analysis Branch.

ORGANIZATIONS

Society for Risk Analysis

Attachment 2

Macpherson Oil Company City of Hermosa Beach Project
Hazard Footprint Analysis - March 3, 1997

HAZARD FOOTPRINT ANALYSIS
HERMOSA BEACH PROJECT

Revised

Prepared by:
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FIGURES

1.0 INTRODUCTION

The purpose of this analysis is to determine the potential risk to the surrounding community from the proposed Macpherson Oil Company City of Hermosa Beach Project. The analysis addresses the potential impact from fires, explosions, and releases at the proposed production site. The analysis makes use of the hazard footprint methodology described in the Port of Los Angeles "Final Risk Management Plan, An Amendment to the Port Master Plan" (Port of Los Angeles, 1983); the Port of Long Beach "Risk Management Plan, An Amendment to the Certified Port Master Plan, Final" (Port of Long Beach, 1981); and the Molino Gas Project EIR (Arthur D. Little, 1995). The methodology in the Port Risk Management Plans was developed in concert with the City of Long Beach and City of Los Angeles Fire Departments, the U.S. Coast Guard, and the California Coastal Commission. The methodology in the Molino Gas Project EIR was developed in accordance with County of Santa Barbara criteria.

The Port Risk Management Plans are in use at the Ports and govern the development of new projects and the modification of existing projects handling hazardous materials. Proposed new or modified projects are analyzed using the methodology in the Risk Management Plans, and projects not meeting the criteria in the plan are not approved. These procedures have been in place in the Ports for over 10 years. The County of Santa Barbara safety impact thresholds utilized for projects within the County are presented in their Environmental Thresholds and Guidelines Manual (County of Santa Barbara, 1995).

The analysis also estimates the probability of accidents occurring involving the proposed project. These estimates are based on historical data for similar projects. These probabilities, the hazard footprints, and the nearby population density are then combined to construct risk profiles similar to those presented in the Molino Gas Project EIR. The risk profiles present estimated annual frequency of number of fatalities from the proposed project.

Appendix A presents information on Reese-Chambers Systems Consultants, Inc. experience in conducting risk analysis. Appendix B contains the résumé of Tim Chambers, the individual who conducted the analysis.

This analysis looked at the proposed project and then postulated the types of accidents that could occur. The types of accidents postulated were based on historical data with similar type projects and on the types of accidents required to be analyzed by the Ports' Risk Management Plans. These accidents, referred to as Design Basis Accidents (DBAs), are listed below.

(1) A release in the well area without a fire

(2) A release in the well area with a fire

(3) A fire in an atmospheric storage tank

(4) The rupture of a storage tank into the surrounding secondary containment system without an ensuing fire

(5) The rupture of a storage tank into the surrounding secondary containment system with an ensuing fire

(6) An explosion in a storage tank

(7) A gas release from a process vessel

(8) A liquid release from a process vessel into the surrounding secondary containment system without an ensuing fire

(9) A liquid release from a process vessel into the surrounding secondary containment system with an ensuing fire

(10) An accident involving the trucking of crude oil during Phase I

(11) An accident involving the crude oil pipeline during Phase II

(12) An accident involving the gas pipeline during Phase II

For each of the DBAs, the extent of the potential impact is then estimated using "hazard footprints." A hazard footprint is a diagram indicating the extent of the area within which a specified level of adverse effect is exceeded against a specified vulnerable resource. The following hazard footprints were calculated for the above DBAs as appropriate.

- *Radiant Heat from a Fire.* A fire will produce radiant heat. The distances to the 5 kW/m^2 (1,600 Btu/sq.ft./hr) heat level from those accidents involving fires have been calculated. This is the level that can begin causing second-degree burns to human skin exposed for 30 seconds. People inside homes or shielded by objects such as homes or walls could stand a higher heat level before being impacted.

- *Flammable Gas Cloud from a Release.* When a flammable material is released, it begins producing flammable vapors which can drift with the wind, producing a gas cloud which may be ignited. The distances the cloud may travel before dispersing to a concentration below its lower flammability limit (LFL) have been calculated for releases of flammable materials. The flammable gas cloud hazard footprint has been calculated for two atmospheric conditions: stability condition F with 2.2 mph wind, and stability condition D with 5 mph wind. Stability Condition F consists of a low inversion layer, which tends to trap gas releases and prevent them from dispersing in the atmosphere. This condition occurs at night with low wind speeds. This condition usually results in the largest gas cloud hazard footprints.

- *Toxic Gas Cloud from a Release.* When a potentially toxic material is released, it begins producing toxic vapors which can drift with the wind. The distances the cloud may travel before dispersing to a concentration below which it is no longer toxic has been calculated where required for releases of toxic materials. The toxic gas cloud hazard footprint has been calculated for the two atmospheric conditions described above.

- *Blast Overpressure and Flying Debris from an Explosion.* Both vessels and unconfined vapor clouds have the potential to explode. The blast overpressure, as a function of distance from such an explosion, has been calculated, along with an estimate of the distance that debris may be hurled by an explosion, as appropriate. A blast overpressure of 2.5 psig, which represents the pressure that can begin causing eardrum rupture, has been used as the blast overpressure hazard footprint threshold.

The only potential toxic material to be handle by the proposed project would be hydrogen sulfide (H_2S). It is possible that small amounts of H_2S will be present in the oil and gas produced by the proposed project, however, no more than 5 parts per million (ppm) of H_2S is expected. Thus, only "sweet" gas is expected. However, to provide for unforeseen circumstances, this risk analysis assumes that up to 100 ppm H_2S could be present.

Hazard footprints have been determined using HFCP, the computer model used by the Ports of Los Angeles and Long Beach, and Chems-Plus, a commercially available program developed by and available from Arthur D. Little. The details of the methodology used by HFCP are documented in the Users' Manual (Reese-Chambers Systems Consultants, Inc., 1991). Details of Chems-Plus are contained in the Chems-Plus User Guide (Arthur D. Little, 1988). Gas release rates were modeled using Chems-Plus.

The proposed project will consist of two phases. Phase I will include the drilling of one to three exploratory and producing wells to prove the commercial value of the development. The emulsion (an oil and water mixture) and associated gas will be processed on site using portable equipment and the oil will be trucked offsite to a refinery. The water will be reinjected into a reservoir. The gas will be scrubbed and incinerated. Phase II will produce emulsion and associated gas from 30 wells; separate the gas, oil, and water using gravity and heat; clean the separated water and reinject it using four wells; and store the oil on site until shipped by a newly constructed pipeline. The gas will also be shipped by a newly constructed pipeline.

The exact characteristics of the crude oil to be produced is not known at this time, however, the API gravity is expected to be between 17 and 21. While the characteristics of the oil have little effect on the size of the radiant heat, blast overpressure, and flying debris hazard footprints, they can have a significant impact on the flammable vapor cloud hazard footprint. Thus, to be conservative, we have assumed that the crude is fairly light with a flash point below 100°F, making it a flammable liquid. This assumption will tend to overestimate the size of the flammable vapor cloud hazard footprint.

The produced gas is expected to be sweet, that is, it is not expected to contain hydrogen sulfide in concentrations high enough to be considered hazardous. As stated in the previous section, the risk analysis assumes a maximum H_2S concentration of 100 ppm while the expected H_2S concentration is less than 5 ppm. The potential effects of H_2S on humans is a function of two parameters, the exposed concentration level and the exposure time. The higher the exposure concentration, the less time it takes to cause adverse health effects. Previous analyses done for projects in Santa Barbara County (e.g., Sandpiper Golf Course and Residential Development Draft EIR [County of Santa Barbara, 1994] and Chevron Point Arguello Field and Gaviota Processing Facility SEIR [Arthur D. Little, 1988]) have generally used one or both of the following two H_2S concentrations in their risk analysis; 1000 ppm and/or 300 ppm. The 1000 ppm concentration was utilized as the H_2S concentration which could cause death after a few breaths. The 300 ppm concentration is the immediately dangerous to life or health (IDLH) concentration for H_2S. The IDLH concentration is defined as the maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects (U.S. Department of Transportation, 1992).

Recently, some analysts have been examining the Emergency Response Planning Guidelines (ERPGs) for use in risk analyses. These levels have been issued by the

American Hygiene Association for use in emergency response planning and are not meant to be exposure thresholds. The ERPGs are substantially more conservative than IDLHs. The ERPG-3 concentration for H_2S is 100 ppm. ERPG-3 is defined as the maximum airborne concentration below which it is believed that nearly all individuals could be exposed up to one hour without experiencing or developing life-threatening health effects. Note that the maximum H_2S concentration considered in this analysis is equal to the ERPG-3 value and one third that of the IDLH.

3.1 Risk From Wells

The best known and potentially the most significant accident associated with well drilling is a blowout. A blowout is defined as the uncontrolled flow of formation fluids from a wellbore. They occur when formation fluids flow uncontrolled into a low-pressure subsurface zone (an underground blowout) or to the surface (a surface blowout). Most commonly, a blowout happens when there is insufficient pressure in a wellbore to control subsurface pressures. If wellbore hydrostatic pressure is allowed to drop below the subsurface formation pressure, then a "kick" will occur as the formation fluids flow into the well. Typically, a kick is circulated out of a well in a controlled manner, with formation fluids flowing into a production flowline or emergency flare line. When a kick is detected during drilling operations, the blowout prevention equipment (BPOE) is closed, sealing the wellbore and preventing any additional formation fluid from entering the wellbore. Additional kick-control procedures are implemented such as circulating higher density drilling fluid into the wellbore until the kick is circulated out of the well and normal operations can be resumed. A surface blowout occurs when formation fluids flow to the surface in an uncontrolled manner. A kick can lead to a blowout in rare instances (e.g., in a gas well that experiences a failure in the mechanical integrity of the equipment/system). Redundancy of equipment is a primary feature of blowout prevention equipment design.

A source of information on blowouts in California is a document titled "A History of Oil- and Gas-Well Blowouts in California, 1950 - 1990", published by the California Department of Conservation Division of Oil, Gas and Geothermal Resources (CDOG). This database includes both onshore and offshore wells.

The CDOG data shows an overall drilling incident rate of one blowout per 1,963 wells drilled during the time period 1950 - 1990. The incident rate for blowouts resulting in a release of oil is 1:20,315. The blowout incident rate from 1970 (after the 1969 Unocal blowout offshore Santa Barbara) through 1990 was 1:3,046 (a probability of 3.3×10^{-4} per well drilled).

A detailed analysis of the CDOG data for the time period 1980 - 1990 determined that after blowouts caused by steam injection and in abnormally high pressurized reservoirs were removed from the database, the blowout incident rate is 1:10,969 (a probability of 9.1×10^{-5} per well drilled). None of the remaining blowouts in the database flowed oil.

One factor that would tend to further reduce this low probability of a blowout is the fact that the Hermosa Beach project will be drilling into a reservoir whose characteristics are well known. The reservoir is not highly pressurized and will require pumping to bring the oil to the surface.

Based on the above statistics (blowout incident rate of 1:10,969), the probability of a blowout for the two phases of the proposed project are presented below.

PHASE	NUMBER OF WELLS	PROBABILITY OF BLOWOUT
1	6	5.5×10^{-4}
II	24	2.2×10^{-3}
BOTH	30	2.7×10^{-3}

Although the probability of a gas blowout is extremely low, a discussion of such an event follows. First, if a large pressure surge is encountered, the blowout prevention systems should prevent gas from escaping by closing off the annulus. In the highly improbably event that the annulus does not close, the gas will be diverted to the processing equipment or the on-site vent if the processing equipment is unable to handle the flow. The vent allows the gas, which is lighter than air, to escape upward away from potential ignition sources. Modeling shows that the gas being vented from a vertical flare will not reach flammable concentrations (approximately 5 percent for methane) at ground level and therefore should not be subject to ignition.

The Molino Gas Project EIR combined the analysis of a blowout with that of the gas production pipelines. The annual probability of such an occurrence was estimated to be 1.1×10^{-4}. The document states that a blowout has a lower probability of occurring than a production pipeline failure. The Molino estimate of a blowout is consistent with the blowout probabilities in the table above when considering that the Molino estimates include the pipelines. The extent of the potential flammable gas cloud hazard footprint from a blowout was assumed to be the same as that of a pipeline rupture. The flammable gas cloud hazard footprint was calculated to be 381 feet for stability condition F. This same approach was taken in this analysis and the flammable gas cloud hazard footprint was calculated using Chems-Plus to extend 327 feet for stability condition F, 2.2 mph wind.

As stated previously, the gas is expected to be sweet and should therefore not present a toxic hazard. An H_2S concentration of 100 ppm means that the gas contains 0.01 percent (0.0001) H_2S. If released, the gas would immediately begin to mix with air thereby diluting the overall concentration of H_2S to a concentration of less than 100 ppm, the ERPG-3 value. The H_2S concentration that would be in the air from a release of gas would be well below the 300 ppm IDLH level and below the 100 ppm ERPG-3 level and, therefore, would not present a health risk to the surrounding area. Thus, no modeling of an H_2S gas cloud was done or required.

The probability of a blowout during drilling was deemed to be not significant by the Final Environmental Impact Report (Ultrasystems, 1994). This conclusion was based on the fact that the wells will be equipped with redundant safety devices, including blowout protectors. Thus, the worst case accident involving the wells has been postulated to be a leak in the well area flooding the well cellar. The leak would involve an emulsion containing approximately half oil and half water.

The well cellar covers an area of approximately 2,060 feet. HFCP was utilized to calculate the flammable vapor cloud and radiant heat hazard footprints for a release that would cover the entire cellar area. The size of the hazard footprints is measured from the edge of the cellar area. The results are presented below.

- Radiant heat - 152 feet
- Flammable gas cloud - 17 feet

It is noted here that the vaporization rate from this pool would not produce enough vapor to become involved in an unconfined vapor cloud explosion.

Regulations and technology have made wells extremely safe and the probability of a release of any size from a well is unlikely. Previous EIRs (Arthur D. Little, 1995) have estimated that the probability of a major spill from a wellhead complex is 1.1×10^{-4} per year. The probability that the oil would become ignited would be 1.0×10^{-2} or one in a hundred (Country of Santa Barbara, 1985). Thus, the annual probability of a release with fire would be 1.1×10^{-6}.

3.2 Risk from Storage Tanks

Oil and process water will be stored in five storage tanks located in a common secondary containment system (i.e. diked area). All of the tanks will have cone roofs with weak seams. In the unlikely event of an explosion, the roof is designed to lift up to vent the energy, thereby preventing the tank from rupturing and possibly resulting in flying debris. The roof is expected to travel no more than several tank diameters from the tank. It is also noted here that the tanks will be blanketed with gas to prevent oxygen from being present. As long as oxygen is not present, an explosion is impossible.

The potential DBAs from the tanks addressed in this analysis include a fire in a tank, an explosion in a tank, and a rupture of a tank flooding the diked area, either with or without a fire. The following hazard footprint distances were calculated using HFCP. The largest tank, with a 3,333 bbl capacity, was used in the calculations. All of the hazard footprints are measured from the edge of the tank or diked area.

- Radiant heat from a fire in a tank - 156 feet
- Blast overpressure from an explosion in a tank - 141 feet
- Flying debris from an explosion in a tank - 77 feet
- Radiant heat from a fire in the diked area - 271 feet
- Flammable gas cloud from a release into the dike area - 33 feet

The annual probability of a tank fire has been estimated to be 7.0 x 10 (Envicom, 1992). This equates to an annual probability of 2.1×10^{-4} for the three tanks. The rupture of an atmospheric storage tank due to all causes, including seismic events, is estimated to be 1.6×10^{-4}/year or once in 6,300 years (County of Santa Barbara, 1985). The probability that the oil is ignited is 1.0×10^{-2}, or one in a hundred. Thus, the probability of a release with a fire is estimated to be 1.6×10^{-6} per tank, or once in 625,000 years. Since there will be three storage tanks that may store crude oil, the probability of a spill with fire, per year, would be 4.8×10^{-6}, or once in 208,000 years.

The probability of an explosion in an oil storage tank has been estimated to be 1×10^{-4} per year (County of Santa Barbara, 1988). This is for all types of storage tanks. The tanks for the proposed project will be gas blanketed, which will virtually eliminate the possibility of a tank explosion.

3.3 Risk from Process Area

The first step in processing the emulsion will be the separation of the gas, oil, and water by means of gravity using free water knockout (FWKO) vessels. The gas that will be separated out will be primarily methane which is the predominant gas in natural gas piped to most homes. The emulsion enters the FWKO whereby the water, which is heavier than the oil, falls to the bottom of the tank while the oil floats on the water. The gas which escapes from the emulsion goes to the top of the tank. The water is drawn off the bottom of the tank and sent to the wastewater treatment system. The gas is drawn off and directed to the gas compression and treatment system. The oil is sent to heater treaters where it is further processed. The FWKOs are ASME certified pressure vessels. The potential for an explosion in one of these vessels is extremely unlikely, and thus no hazard footprints have been calculated for a vessel rupture. Instead, the DBA from a FWKO has been assumed to be a release from a 2-inch diameter hole, which represents a release from a pipe connection or other small release. The flammable gas hazard footprint from a 2-inch diameter hole in the tank would produce a flammable vapor cloud hazard footprint that would extend up to 327 feet from the point of release under worst case atmospheric conditions (stability F, 2.2 mph wind). The rate of release from the vessel was calculated using the Chems-Plus model developed by Arthur D. Little. This rate of release was then input to both Chems-Plus and HFCP to calculate the flammable gas cloud hazard footprint. The models also determined that the amount of gas (methane) in the cloud would not be enough to become involved in an unconfined vapor cloud explosion.

Again, no toxic (H_2S) gas cloud hazard foot print was calculated because the gas would have no more than 100 ppm H_2S and , thus, not present a health hazard from a release.

The oil is sent to heater treaters where it is heated to further separate out water and gas from the oil. In this case the majority of the emulsion entering the vessels is oil. The heater treaters are also ASME certified pressure vessels. Since the heater treaters will operate at approximately the same pressure as the FWKO, the release rate of gas from a 2-inch diameter hole will be approximately the same as that from the FWKO (it will actually be slightly less since the gas will expand because it is heated) and thus, the flammable vapor cloud hazard footprint will be approximately the same size. Again, there will not be a toxic gas hazard footprint because the gas is expected to be sweet (less than 5 ppm H_2S) and in no case will it contain more than 100 ppm H_2S.

A release of oil from the FWKOs or heater treaters could spread and cover the secondary containment area around the vessels. The surface area of the secondary containment area is approximately 7,780 sq.ft. The flammable gas cloud (if the spill doesn't ignite) and radiant heat hazard footprints were calculated by HFCP to be:

- flammable gas cloud - 41 ft
- radiant heat - 266 ft

Arthur D. Little, 1995, has estimated that the probability of a major release from a pressure vessel is 8.0×10^{-7} per year, or once in 1,250,000 years. For the four vessels proposed for the facility, the combined annual probability of a major release would be 3.2×10^{-5} (once every 312,500 years). The probability that the released oil would become ignited is 1.0×10^{-2}. Thus, the annual probability of a major spill with fire is 3.2×10^{-7} (once in 3 million years).

3.4 Risk from Trucking

During Phase 1, the oil will be stored on-site in portable tanks and then loaded into tanker trucks for transportation to a refinery. It is estimated that three to four tanker truck trips per day, each carrying 175 bbls of oil, will be required to handle the 600 bbl per day production. The tanker trucks will be loaded inside the facility in an area equipped with a drain and sump to contain any spillage, although none is expected. The Phase I site sump/containment system will be adequate to fully contain a 175 bbl spill. Trucks will exit the facility and follow designated routing from the facility. Trucks will not deviate from the designated routing through residential neighborhoods.

Trucking of petroleum products is quite common throughout the country. Gasoline and other petroleum products are routinely transported by tanker trucks to gas stations and industrial facilities. Tanker trucks can become involved in traffic accidents but these do not usually result in a loss of cargo. A worst case accident would result in the loss of the entire contents of the trucks (175 bbls). The released oil would then spread on the ground and could ignite if it encounters an ignition source. The area covered by the spill would be a function of the elevation profile of the surrounding area.

For the purpose of calculating the potential hazard footprints, it has been assumed that the oil is spilled on a flat surface and spreads to a uniform depth of one inch. The spill would cover an area of approximately 11,800 sq. ft. with a radius of approximately 57 ft. The radiant heat and flammable gas cloud hazard footprints were calculated by HFCP to be:

- Flammable gas cloud - 52 ft
- Radiant heat - 320 ft

It is noted here that oil burns at a rate of approximately 4 mm (0.16 in.) per minute and hence, a one-inch deep pool would burn for approximately 6.4 minutes. The pool would burn for a longer time if it were deeper, however, then the area would be smaller and the radiant heat footprint smaller.

The Handbook of Chemical Hazard Analysis Procedures (FEMA, undated) recommends using a truck accident rate of 2×10^{-6} accidents per mile with 20% of the accidents resulting in a release of cargo. The Handbook goes on to recommend that the following spill distribution be utilized:

- 10% cargo loss (17.5 bbl) - 60% of the time
- 30% cargo loss (52.5 bbl) - 20% of the time
- 100% cargo loss (175 bbl) - 20% of the time

Assuming that a loaded truck travels 10 miles results in the following annual probabilities of accidents and releases. It is assumed that the trucking lasts for one full year.

Event	Annual Probability
Accidents	2.5×10^{-2}
Spill of any size	5.0×10^{-3}
Spill of 17.5 bbls or less	3.0×10^{-3}
Spill between 17.5 bbls and 52.5 bbls	1.0×10^{-3}
Spill greater than 52.5 bbls	1.0×10^{-3}

3.5 Risk from Crude Oil Pipeline

A new produced crude oil shipping line will be constructed to transport produced crude oil from the oil production facility to the existing Wilmington to Torrance pipeline. The Wilmington to Torrance Pipeline, operated by Chevron, will transport the crude oil to the Chevron refinery in El Segundo. The new pipeline will have an outside diameter of 6 inches and be approximately 0.5 miles (2,500 ft.) long. The pipeline is designed for a maximum operating pressure of 350 psig.

The amount of oil than can be released from a pipeline is made up of the amount that can be released until pumping is stopped plus the amount than can drain from the line due to gravity. Because the pipeline will be equipped with a supervisory control and data acquisition (SCADA) system that will monitor the pipeline at all times, it is conservatively estimated that a pipeline rupture would be detected and the pumping shut down within 10 minutes. Hence, a maximum of 56 bbls [8,000 bbls per hour / (24 hr x 60 min per hour) x 10 min] could be lost due to pumping. The capacity of the pipeline is 85 bbls which is the maximum amount of oil that could drain from the pipeline if all the oil were to escape. Thus, the worst case release from the pipeline would be 141 bbls (56 bbls + 85 bbls).

As with a trucking accident, the area impacted by a pipeline spill would be a function of the elevation profile of the surrounding area. Assuming again that the spill occurs on a flat surface and spreads to a depth of one inch, this results in a 9,500 sq. ft. area being covered.

The radiant heat and flammable gas cloud hazard footprints were calculated by HFCP to be:

- Flammable gas cloud - 46 ft
- Radiant heat - 289 ft

The probabilities of a leak and rupture for modern crude oil pipelines are generally estimated to be around 5.4×10^{-4} spills per pipeline-mile per year, and 2.7×10^{-4} ruptures per pipeline-mile per year, respectively (Aspen, 1995). This equates to the following annual probabilities for the 0.5 mile pipeline.

- Probability of leak - 2.7×10^{-4}
- Probability of rupture - 1.3×10^{-4}

3.6 Risk from Gas Pipeline

The new gas pipeline will be constructed to transport utility-grade gas from the facility to an existing utility gas pipeline. The new pipeline will have an outside diameter of 4 inches and will be approximately 0.5 miles long. Gas will be sent through the line on a continuous basis at approximately 120 psig, using the compressor located at the Macpherson production facility. Any small amounts of H_2S that might be in the gas will be removed at the Macpherson production facility and hence, the gas will not be toxic.

The rate of release of gas from the pipeline would be a function of the size of the hole. The larger the hole, the greater the release rate. A complete rupture of the line would shut down the compressor almost immediately. In addition, the line will be equipped with a check valve at the point where it connects to the utility line that would prevent gas from flowing into the line from the utility line.

Chems-Plus has been utilized to calculated the release rate and flammable vapor cloud hazard footprint from a pipeline rupture and from a small leak (e.g. ¼-inch diameter hole). The results are presented below.

Accident	Downwind Distance to LFL
• Pipeline rupture	467 feet
• ¼-inch hole	<10 feet

It is noted here that the downwind distance to the LFL calculated for the rupture is an overprediction because Chems-Plus treats the release as a point source and ignores the initial mixing with air caused by the jet release of the gas. The pipeline would be emptied of gas in about 4 seconds in the rupture case. It is also noted that this line is essentially the same as the numerous utility-owned and -operated gas lines throughout the area.

If the gas release were to ignite, it would burn as a jet release until the gas flow ceased. This would last about 4 seconds. The flame length could be up to 211 feet long. If the gas cloud were to ignite, the fire would burn back to the source and burn as a jet flame. Thus, the radiant heat hazard footprint has been assumed to be equal to the flammable gas cloud hazard footprint.

The probability of a leak for a modern gas line is estimate to be 1.5×10^{-3} per pipeline-mile per year (Arthur D. Little, 1995). Thirty one percent of the leaks are estimated to be major leaks or ruptures. This equates to the following annual probabilities for the 0.5 mile gas pipeline.

- Probability of leak - 5.2×10^{-4}
- Probability of rupture - 2.3×10^{-4}

Table 3-1 Summary of Accident Probabilities and Hazard Footprints

SCENARIO	ANNUAL PROB OF ACCIDENT	STABILITY F / 2.2 MPH WIND			STABILITY D / 5 MPH WIND		
		DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)	DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)
(1) Release in well area (blowout or pipe rupture) without fire - flammable gas hazard	1.1×10^{-4}	327	131	33,600	101	41	3,250
(2) Release in well area with fire - radiant heat hazard	1.1×10^{-6}	152	Circle	18,150	152	Circle	18,150
(3) Fire in atmospheric storage tank - radiant heat hazard	2.1×10^{-6}	156	Circle	19,100	156	Circle	19,100
(4) Release into containment system from storage tank without fire - flammable gas hazard	4.8×10^{-4}	33	15	390	11	5	43
(5) Release into containment system from storage tank with fire - radiant heat hazard	4.8×10^{-6}	271	Circle	53,000	271	Circle	53,000
(6) Explosion in storage tank - blast overpressure and flying debris hazards	0 - tanks will be gas blanketed						
(7) Release from a process vessel - flammable gas hazard	3.2×10^{-5}	327	131	33,600	101	41	3,250
(8) Process vessel leak into containment system without fire - flammable gas hazard	3.2×10^{-6}	41	20	640	14	6	115
(9) Process vessel leak into containment system with fire - radiant heat hazard	3.2×10^{-7}	266	Circle	55,600	266	Circle	55,600
(10) Truck release of crude oil without fire - flammable gas hazard	5.0×10^{-3}	52	25	1,020	16	8	100
(11) Truck release of crude oil with fire - radiant heat hazard	5.0×10^{-3}	320	Circle	80,400	320	Circle	80,400
(12) Pipeline release of crude oil without fire - flammable gas hazard	1.3×10^{-4}	46	22	800	15	7	80
(13) Pipeline release of crude oil with fire - radiant heat hazard	1.3×10^{-5}	289	Circle	65,000	289	Circle	65,000
(14) Gas pipeline release - flammable gas hazard	2.3×10^{-4}	467	187	68,600	214	86	14,450

3.7 Summary of Accident Probabilities and Hazard Footprints

The results of hazard footprint analysis are summarized in Table 3-1. The table includes the probability of the accident, the extent of the hazard footprints (downwind and crosswind for flammable gas hazard footprints) for the two environmental conditions (stability F and stability D), and the area covered by the hazard footprint. The hazard footprints are displayed on Figure 3-1.

As can be seen from the table, the largest hazard footprint would be 327 feet from a wellhead, blowout, or gas processing release. This hazard footprint would extend into the residential neighborhood to the north and the R-3 neighborhood to the west. The actual hazard footprint at the time of a release would only extend downwind, and would not cover the entire circular area shown. Also, it is noted here that the footprint would only be 327 feet during worst case environmental conditions, e.g. stability F with low wind speeds. As can be seen from the table, the hazard footprint would only extend 101 feet during typical environmental conditions, The flammable gas hazard footprint would only be a hazard if it were to be ignited. The radiant heat hazard footprint would extend 271 feet and would form a circle as shown because the radiant heat would be given off in all directions. The radiant heat hazard footprint extends into the residential neighborhood to the north and just touches the R-3 neighborhood to the west. It is noted here that this footprint would not impact people inside or behind structures. In addition, people outdoors exposed to the heat from a fire, would have time to find shelter before they would sustain burns. A fire at the facility should not impact homes or other structures in the area.

The truck, oil pipeline, and gas pipeline accidents would occur offsite and their potential impact would be a function of where the accident occurred relative to vulnerable resources.

3.8 Consequence Analysis

The results of the failure rate and consequence analysis have been combined to develop plots of frequency versus fatalities similar to that shown in the Molino Gas Project EIR. These curves are commonly called risk profiles. Figure 3-2 presents the guidelines used in the Molino Gas Project EIR for the determination of offsite risk and significance. Points above the upper line, labeled "De Manifestis", are considered to be an unacceptable risk, while those below the line, labeled "De Minimis", are considered acceptable. Points between the two lines, labeled "grey region", are acceptable but mitigation may be required. The following factors were utilized in developing the risk profiles.

- extent of hazard footprint for each environmental condition
- estimated frequency rate for each accident
- estimated frequency of occurrence for each atmospheric condition
- estimated frequency of occurrence of wind direction
- population density

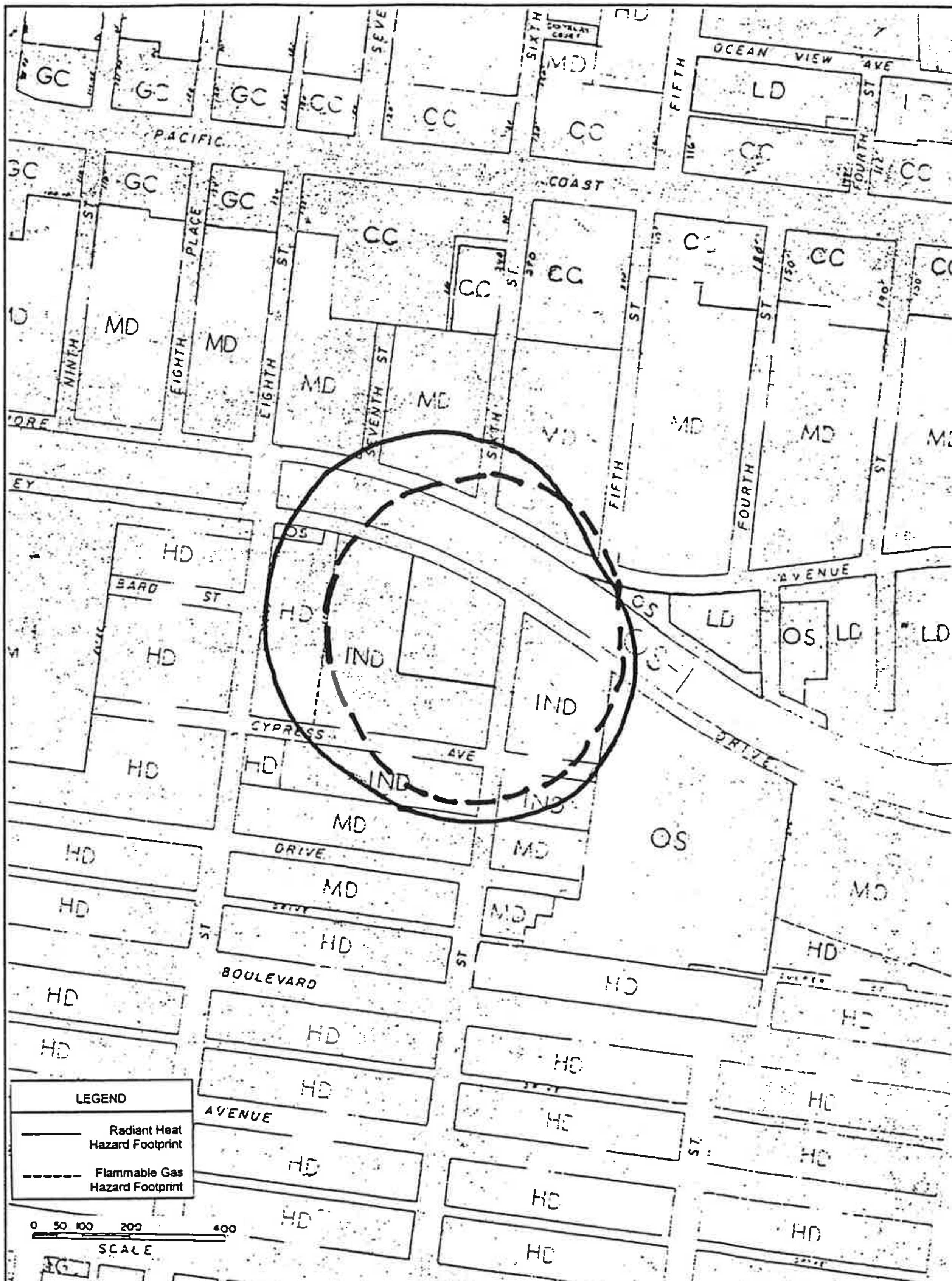
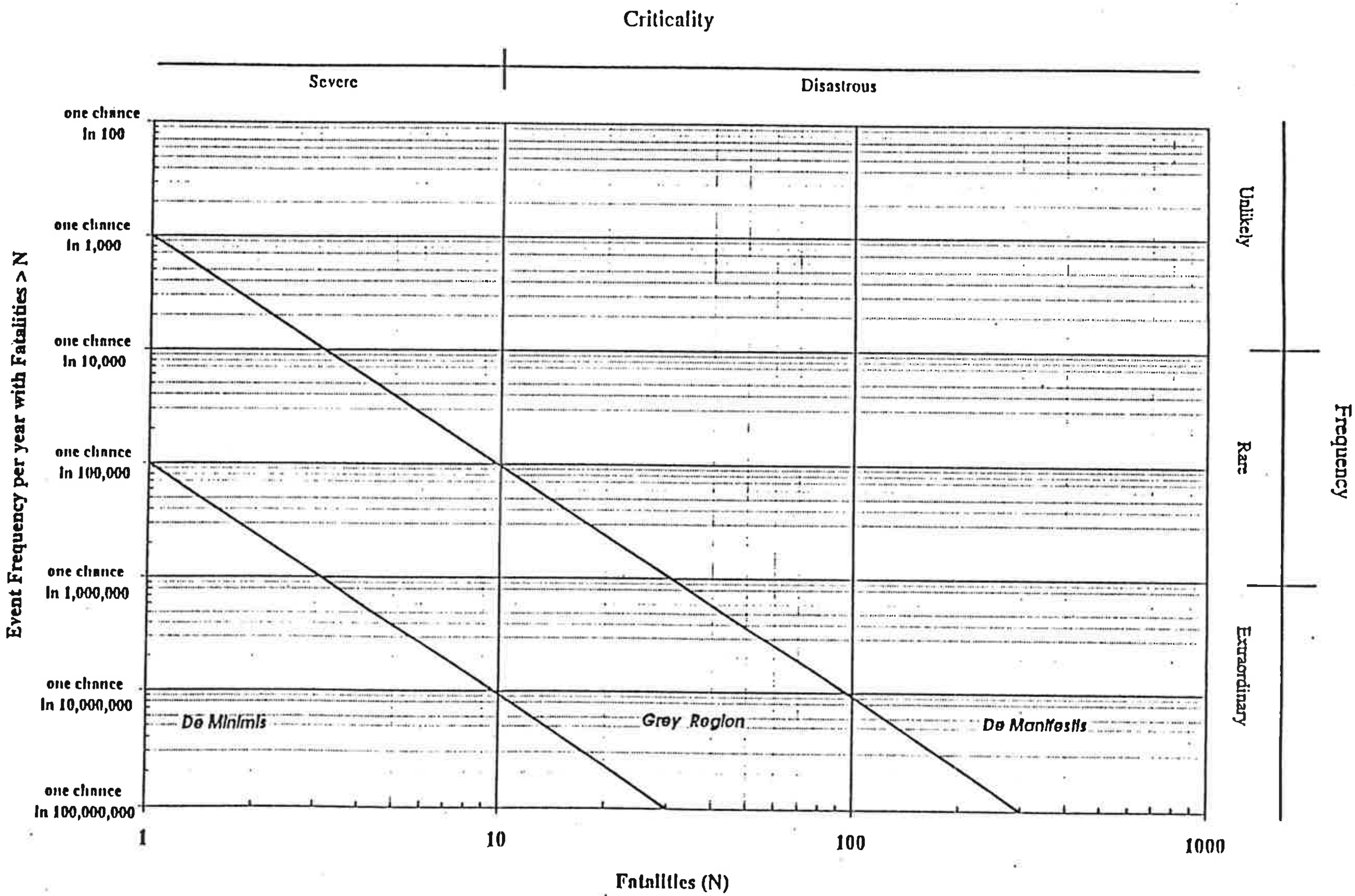


Figure 3-1
Results of Hazard Footprint Analysis

Figure 3-2
Offsite Risk and Significance Guidelines



- presence of ignition sources
- probability of ignition from each ignition source

Meteorological Data - Meteorological data for the project site were obtained from California Air Resources Board, 1984 and California Department of Water Resources, 1978. Data for two sites, Los Angeles International Airport and Redondo-King Harbor were utilized.

- population density
- presence of ignition sources
- probability of ignition from each ignition source

The basic approach determined the relative likelihood of each of the two stability conditions, D and F, occurring. Condition D was used to represent conditions A through D and condition G to represent conditions E and F. The frequency of wind direction was taken from the two data sources.

Conditional Impact Probabilities - The likelihood is not 100 percent of a fatality resulting from an exposure to a vapor cloud fire. Buildings can provide some protection hazards. The analysis assumes 30 percent fatality within the lower flammability limit.

People inside buildings would not be harmed by a radiant heat hazard footprint. People outside their homes could begin to received second degree burns if exposed for longer than 30 seconds. Because the radiant heat hazard footprint only overlaps a small residential area, it has been assumed that most people exposed would be in their homes or could easily leave the area in a short time. Thus, it has been assumed there would be no fatalities due to radiant heat.

Population Distribution - The population distribution was estimated from the Hermosa Beach General Plan Map. Each residential unit was assumed to house four people.

Ignition Probabilities - Flammable vapor clouds have the potential to ignite anywhere within their flammable limits. Hence, it is necessary to identify potential ignition sources that a cloud may encounter, and to quantify the likelihood of ignition, if the cloud encompasses the sources. In general, when trying to identify ignition sources, the search is primarily for open flames, hot surfaces and electrical sparks, and, to a lesser extent, friction sparks from both continuous and intermittent activities. Some of the potential ignition sources identified in the Molina Gas Project EIR were:

- Vehicles (many specific sources were identified)
- Boilers
- Gas turbines
- Blow torches
- Fired heaters
- Welding
- Faulty wiring
- Pilot flames
- Fireplaces and wood/coal stoves
- Smoking materials
- Doorbells
- Switches
- Furnaces/incinerators
- Machine tools
- Flares

Ignition probabilities used in the Molino Gas Project EIR include:

- ***Cars*** - 0.2 per car; although many potential ignition sources within a car like faulty wiring or backfires are due to fuel rich mixtures in intake air, they are not always present nor guaranteed to cause ignition.

- ***Houses*** - 0.01 per house; while there are many ignition sources within a home, such as switches, doorbells, faulty wiring, pilot lights, smoking materials, fireplaces and wood- or coal-burning stoves, the flammable vapors must first penetrate the house before these ignition sources pose a hazard. Typical residence times of clouds are often brief enough that this is relatively unlikely.

- ***Immediate Ignition*** - There are various ignition sources at the project facility such as electrostatic ignition or friction sparks that would ignite the vapor cloud on the project site. In keeping with the Molino Gas Project EIR, a figure of 0.2 has been assumed for the probability of immediate ignition.

<u>*Construction of Risk Profiles*</u> - The risk profile displays the frequency with which fatalities could occur. They indicate accident size and display how the potential number of fatalities varies as a function of frequency. The risk profile has been plotted on a log-log scale because the profiles span multiple orders of magnitude.

The general approach involved in constructing a risk profile involves determining the frequency and number of fatalities associated with each release scenario. A release scenario is defined by the following:

- Release location
- Release frequency
- Meteorological stability condition and its likelihood
- Wind direction and its likelihood
- Whether and where ignition occurs
- Area of the hazard zone
- Number of individuals exposed within each hazard zone
- Assumed fatality rate for that type of hazard

Some of these factors affect frequency, some determine impacts, and some influence both. Once all possible combinations have been analyzed, the results are combined to give the overall risk profile.

If a flammable release does not ignite immediately, the material will disperse, forming a vapor cloud which will travel downwind. Should the cloud encounter an ignition source (such as cars, pilot lights, open flames, furnaces or other equipment), the cloud will ignite and burn through the flammable area until all flammable material is consumed. For each release scenario, it is necessary to identify the ignition sources that would be encountered. Assuming that a particular area or travel path contains a number of potential ignition sources, the probability can be calculated for the cloud not igniting after covering that area. Hence, it is possible to calculate the probability for the cloud to ignite at various stages in its development, for a given release location and wind direction.

For each release scenario (consisting of a release quantity, release location, a specific stability class and wind speed, and a wind direction), the ignition sources encountered by the cloud are listed. Letting P_i represent the ignition probability of the i^{th} ignition source to be encountered, and assuming that area A contains the first k sources, the probability that the cloud has not yet ignited after covering the area A is given by:

$$\prod_{i=1}^{k}(1-P_i)=(1-P_1)(1-P_2)\ldots(1-P_k)$$

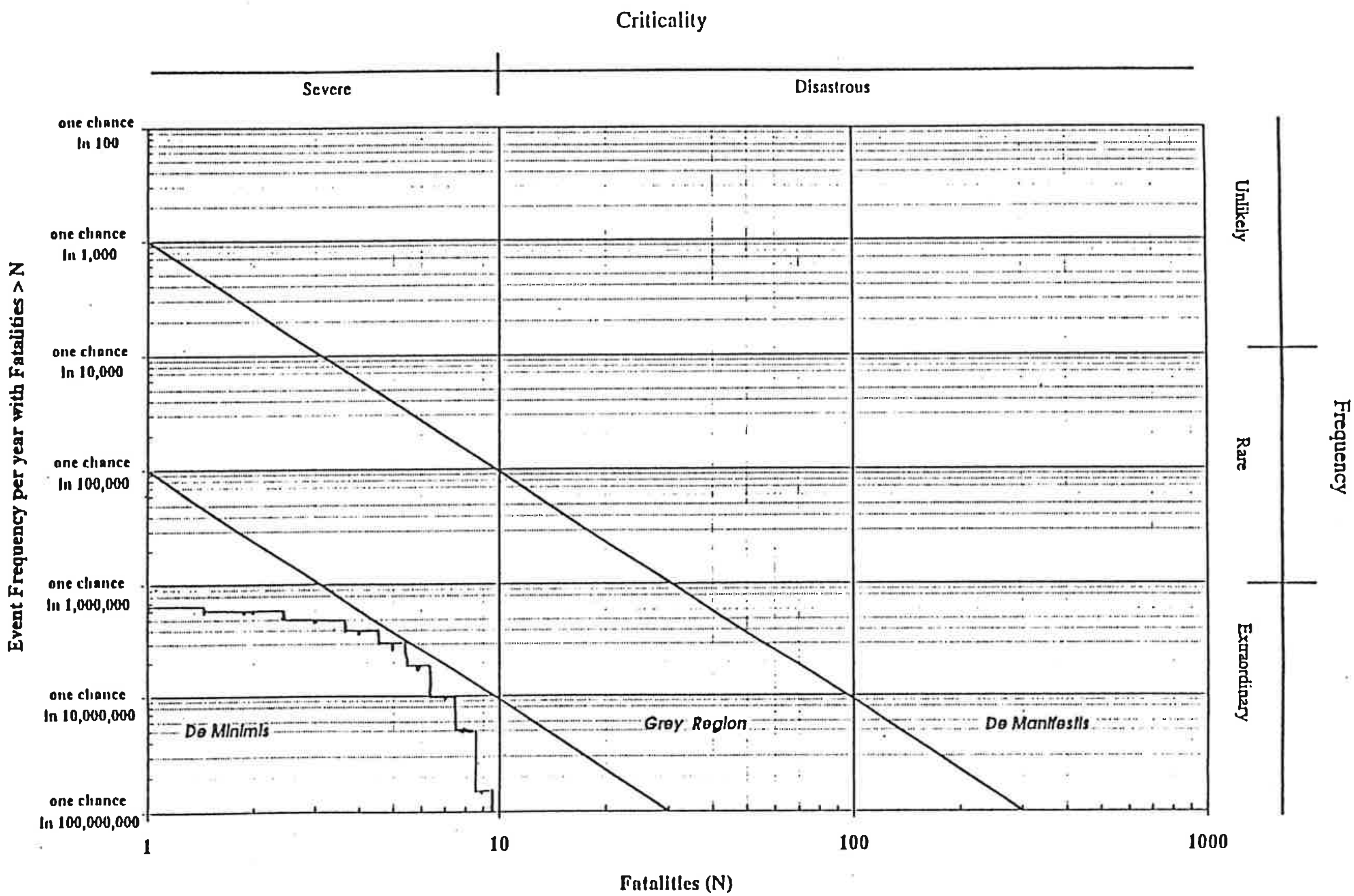
Uncertainties Associated with the Risk Profiles - There are many sources of uncertainty which can affect the accuracy of the risk profiles. These uncertainties deal with:

- Release frequency
- Release size
- Population impacts, including distribution and likelihood of fatality
- Behavior of the release (jet mixing versus passive dispersion)
- Accuracy of the hazard models
- Ignition sources and probabilities

The release frequencies and sizes are the most important contributors to overall uncertainty. The values chosen are conservative, i.e., they overstate rather than understate the risk. Changes in failure rates will directly influence the risk profile. A doubling of the event frequencies would double the probability of fatalities. Changes in the relative size of leaks and ruptures will influence the risk profile, but to a lesser extent. The assumptions on population distribution and ignition probability also influence the risk profiles, but are not as significant as the other sources of uncertainty.

Results of Analysis - The results of the consequence analysis are displayed on Figure 3-3. As can be seen by the figure, the risk profile for the proposed project lies in the "De Minimus" range and hence, is considered to present an acceptable risk.

Figure 3-3
Project Risk Profile



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APPENDIX A
EXPERIENCE SUMMARY

REESE-CHAMBERS SYSTEMS CONSULTANTS, INC.

Reese-Chambers Systems Consultants, Inc. (RCSC) is a small company located in Southern California near the City of Camarillo. RCSC has been providing professional consulting services to industry and agencies since 1979. One of RCSC's specialty areas is risk analysis of industrial projects. RCSC has conducted risk analysis in conjunction with Environmental Impact Reports and Statements (EIRs and EISs), Risk Management and Prevention Programs (RMPP), Hazard and Operability Studies (HAZOPs), Environmental Quality Assurance Programs (EQAP), and other agency-required special studies. RCSC has utilized various models in the conduct of risk studies including *ARCHIE, CHEMS-PLUS, WHAZAN, SLAB, AFTOX,* and *ISC.* RCSC has specific experience with a broad range of industrial applications including numerous oil industry facilities such as pipelines, pump stations, tank farms, and marine terminals:

- Preparation of the system safety/public safety section of the EIR for the State Lands Commission lease renewal of the Unocal Rodeo Marine Terminal.

- Conduct of 25 separate risk and hazard analyses to fullfill California Office of Oil Spill Prevention and Response (OSPR) requirements for oil spill contingency plans. Analyses included marine terminals, pipelines, oil platforms, onshore producing facilities, and onshore processing facilities.

- Consultant to Texaco Trading and Transportation, Inc. (TTTI) for the permitting of the Gaviota Marine Terminal. Also developed various risk analysis studies and papers in support of permit negotiation and compliance. Developed many of the Terminal contingency plans including the Emergency Response Plan and Oil Spill Contingency Plan.

- Developed the Risk Management Plans for the Ports of Los Angeles and Long Beach. The plans have been certified by the California Coastal Commission as annexes to the Ports' Master Plans, dealing with risk management for hazardous cargoes and petroleum products.

- Developed the risk analysis section of an environmental study addressing a proposed oil and gas development project on Sakhalin Island, Russia. The analysis addressed all aspects of the proposed project including oil and LNG export terminals.

- Developed terminal operations manuals for the Gaviota Marine Terminal and Unocal Avila Terminal to meet U.S. Coast Guard and California State Lands Commission requirements.

- Developed EQAP for Unocal Sisquoc Pipeline and Santa Maria Pump Station.

- Conducted overall spill risk and prevention analysis for Pacific Pipeline System, Santa Barbara to Los Angeles refineries.

- Conduct of RMPP and HAZOP studies for four electrical generation plants, a steam generating facility, a refrigeration plant, and numerous oil industry facilities including pipelines, tank farms, processing plants, and pump stations.

- Preparation of Process Safety Manuals for Unocal Rincon oil processing facility.

- Developed oil spill response plans for numerous facilities including the Gaviota Marine Terminal, Unocal Avila Wharf Terminal, Bush Oil Rincon Operations, and several pipelines in response to OPA 90 requirements.

- Developed numerous emergency response plans and fire protection plans for oil and gas projects including marine terminals, processing plants, pump stations, and pipelines.

- Conducted numerous risk studies as listed below:

    - GATX Port of Los Angeles Chemical Terminal
    - Proposed California Ammonia Company Ammonia Terminal in the Port of Los Angeles
    - Chevron Carpinteria Oil and Gas Processing Facility
    - Chevron Elk Hills Gas Plant Risk of Explosion Study
    - McMillen Long Beach Refinery Potential Risk to Nearby School Site
    - Oil and Gas Development Project on Sakhalin Island, Russia
    - Relocation of Defense Logistic Agency Fuel Pier and Pipeline in the Port of Los Angeles
    - Mutual Liquid Gas Propane Storage and Truck Loading Facility in Wilmington, California
    - Liquefied Gas and Chemical Terminal on the Firth of Forth, Scotland
    - Southern Pacific Pipeline Tank Farm Expansion in Carson, California
    - Unocal Product Pipeline through the City of Carson
    - Gaviota Interim Marine Terminal
    - Matlack Hazardous Material Trucking Terminal and Truck Cleaning Facility in Carson
    - Proposed Oil and Gas Development on Vandenberg Air Force Base
    - Proposed Natural Gas Pipeline Projects into the San Joaquin Valley

- Tesoro Fuel Depot and Southern California Edison Storage Tanks in the Port of Hueneme
- OSCO Solvent Recycling Facility in City of Azusa, California
- Unocal Gas and Oil Processing Facility in Lisbon, Utah

Timothy J. Chambers
Senior System Safety Analyst

SUMMARY OF EXPERIENCE

Over 24 years of experience as a systems analyst, with major emphasis on safety and risk management analysis; oil and gas activities; hazardous material handling, storage, and transportation analysis; and contingency planning. Experience during the past 15 years has included extensive environmental work including that involving facilities handling hazardous materials. Other environmental analysis has involved risk management of maritime transportation, marine terminals, oil and gas activities, pipelines, truck and train transportation, and processing facilities. Experience includes work with industry and governmental agencies.

MAJOR PROJECT EXPERIENCE

- Conduct of 25 separate risk and hazard analyses to fulfill OSPR requirements for oil spill contingency plans. Marine facilities addressed included marine terminals, pipelines, platforms, onshore producing facilities, and onshore processing facilities, and customers included Unocal, Shell, Vintage, Torch, Global, Macpherson, and Mobil.

- Consultant to Unocal for the development of OPA 90 and OSPR oil spill contingency plans for the Avila Marine Terminal, Coast Area pipelines, Valley Area pipelines, and Point Pedernales pipeline.

- Consultant to Macpherson Oil Company for development of Oil Spill and Emergency Response Plans for their proposed Hermosa Beach oil development project. Plans were prepared for the drilling and production site, crude oil pipeline, and gas pipeline.

- Project Manager for the development of operating procedures for Unocal's Rincon Facility (ROSF)

- Development of public safety and vessel traffic analysis sections of an EIR on the renewal of Unocal's Rodeo Marine Terminal lease with the California State Lands Commission.

- Conduct of an analysis addressing the potential impacts on marine operations (nearby terminals and vessel traffic) caused by the construction of four alternative bridge configurations parallel to the existing Benicia-Martinez Bridge.

- Consultant to the Gaviota Terminal Company for the permitting of an oil transport marine terminal at Gaviota, California. Work included conduct of various studies and analyses to support system safety aspects of the marine terminal, its operations, and the transport of oil by tankers; negotiation of permit conditions; and the development of contingency plans including the Oil Spill Contingency Plan, Shoreline Cleanup Plan, Shoreline Access Plan, Terminal Operations Manual, Emergency Response Plan, and Fire Protection Contingency Plan.

- Development of the Navigational Hazard Analysis section of the various oil spill cooperative Regional Resource Manuals.

- Development of the vessel traffic analysis section of the Wickland Oil Terminal Expansion EIR.

- Consultant to Unocal Oil and Gas for the development of emergency response plans for their Santa Maria Basin oil and gas development project. Specifically developed separate emergency response plans for the Lompoc HS&P, the Battles Gas Plant, oil and gas pipeline segment from shore to the Lompoc HS&P, and the oil pipeline segment from the HS&P to the Orcutt Pump Station.

- Consultant to Unocal for the permitting of the Sisquoc Pipeline System. Conducted various analyses and developed various plans in support of this effort, including Fire Protection Plan, Emergency Response Plan, Oil Spill Contingency Plan, Environmental Quality Assurance Plan, Risk Analysis, and HAZOP.

- Responsible for risk analysis and mitigation development for a proposed offshore oil and gas development project in Russia. Risk analysis addressed all aspects of the project including offshore drilling and production, offshore and onshore oil and gas pipelines, oil and gas processing facilities, oil export terminal, LNG plant and export terminal, and refinery.

- Consultant for development of risk management programs and addressal of citizen concerns for various petroleum pipeline, tank farm, processing plant, refinery, and gas pipeline projects. Clients included City of Carson, City of Torrance, Long Beach Unified School District.

- Manager of system safety portions of EIR and EIS documents for various projects, including transportation, transfer, handling, and storage of chemicals for a proposed GATX chemical tank farm in Carson, California; natural gas pipeline development in San Joaquin Valley; oil and gas drilling, storage, transportation, and processing for Vandenberg Air Force Base; hazardous material transport, transfer, cleaning, and storage for the City of Carson; and hazardous waste material storage, transfer, processing, transport, and recycling for a facility located in Azusa, CA.

- Conducted risk analysis of potential for release, fire, and explosion at one of the gas plants at the Elk Hills Naval Petroleum Reserve.

- Risk analysis and mitigation design, contingency planning, and design and operation of risk management programs for various clients including County of Santa Barbara, Ports of Los Angeles and Long Beach, Cities of Beaumont and Carpinteria, Holchem, California Ammonia Company, Mutual Liquid Gas and Equipment Company, and others.

- Development of Risk Management and Prevention Programs (RMPPs) as required by California law for several industrial facilities including Colmac Energy, Bonneville Pacific, and Tracy Operators power plants; Sharyn Steam steam generation plant; and United Foods food processing plant. RMPPs address acutely hazardous materials such as ammonia, chlorine, and sulfuric acid.

- Conduct of Hazard and Operability (HAZOP) studies in support of the RMPPs listed above and for several oil pipeline and pump station projects.

- Development of risk management and maritime factors portions of EAs/EIRs/EISs for various oil and natural gas recovery projects covering gas and oil pipeline safety, shipping and other maritime impacts, drilling safety, etc. Projects included ARCO, Cities Service, Chevron, Phillips Petroleum, Shell Oil Company, Texaco.

- Responsible for public and system safety analysis section of EIR on a proposed household and small business hazardous waste collection facility in Santa Barbara, California.

- Responsible for all public and system safety aspects of the EIR/EIS for the Port of Los Angeles/Port of Long Beach 2020 Plan, a proposed landfill and expansion project. Work covered potential system safety impacts from landfill construction; impact on recreational, fishing, and commercial vessels; impact from trucking, pipeline, and train transportation of hazardous materials; impact on anchorages; and impact from oil spills.

- Responsible for analysis of potential impacts between tanker traffic to a proposed Exxon offshore marine terminal and potential oil and gas development in the vicinity of the marine terminal. Work conducted in the form of a supplemental EIR for the California State Lands Commission.

- Developed risk analysis and emergency procedures section of an environmental and risk assessment of coastal communities from LNG tanker traffic offshore Alaska.

- Responsible for risk analysis section of oil spill response plan developed for Alyeska Valdez Marine Terminal.

- Prime consultant to PBQ&D and US Navy for risk and reliability analysis for relocation of Navy fuel pier to Port of Long Beach. Work included extensive pipeline, tank farm, and marine terminal risk management analysis.

- Consultant to GATX for permitting risk analysis of a proposed expansion of a multi-petroleum product and chemical marine terminal and storage facility in the Port of Los Angeles.

- Project manager and consultant for port and vessel traffic risk management analysis for a multi-liquefied-gas terminal on the Firth of Forth, Scotland. Client was the Forth Ports Authority.

- Prime contractor and consultant to the Ports of Los Angeles and Long Beach, California in the development of the Ports' risk management plan for the handling, transportation, and storage of hazardous cargos at and through the ports. Also developed a generalized computerized model to calculate potential areas at risk from existing and proposed facilities.

EDUCATION

Bachelor of Science, Mathematics, Northeast Missouri University, Kirksville, MO (1966)

Bachelor of Science, Education (Mathematics and Physics), Northeast Missouri University, Kirksville, MO (1966)

Master of Science, Mathematics, University of Toledo, Toledo, OH (1968)

EMPLOYMENT EXPERIENCE

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ORGANIZATIONS

Society for Risk Analysis

Attachment 3

Macpherson Oil Company City of Hermosa Beach Project
Hazard Footprint Analysis - October 2, 1997

MACPHERSON OIL COMPANY

CITY OF HERMOSA BEACH PROJECT

HAZARD FOOTPRINT ANALYSIS

October 1997

MACPHERSON OIL COMPANY

CITY OF HERMOSA BEACH PROJECT

HAZARD FOOTPRINT ANALYSIS

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1.0 INTRODUCTION

The purpose of this analysis is to determine the potential risk to the surrounding community from the proposed Macpherson Oil Company City of Hermosa Beach Project. The analysis addresses the potential impact from fires, explosions, and releases at the proposed production site. The analysis makes use of the hazard footprint methodology described in the Port of Los Angeles "Final Risk Management Plan, An Amendment to the Port Master Plan" (Port of Los Angeles, 1983); the Port of Long Beach "Risk Management Plan, An Amendment to the Certified Port Master Plan, Final" (Port of Long Beach, 1981); and the Molino Gas Project EIR (Arthur D. Little, 1995). The methodology in the Port Risk Management Plans was developed in concert with the City of Long Beach and City of Los Angeles Fire Departments, the U.S. Coast Guard, and the California Coastal Commission. The methodology in the Molino Gas Project EIR was developed in accordance with County of Santa Barbara criteria.

The Port Risk Management Plans are in use at the Ports and govern the development of new projects and the modification of existing projects handling hazardous materials. Proposed new or modified projects are analyzed using the methodology in the Risk Management Plans, and projects not meeting the criteria in the plan are not approved. These procedures have been in place in the Ports for over 10 years. The County of Santa Barbara safety impact thresholds utilized for projects within the County are presented in their Environmental Thresholds and Guidelines Manual (County of Santa Barbara, 1995).

The analysis also estimates the probability of accidents occurring involving the proposed project. These estimates are based on historical data for similar projects. These probabilities, the hazard footprints, and the nearby population density are then combined to construct risk profiles similar to those presented in the Molino Gas Project EIR. The risk profiles present estimated annual frequency of number of fatalities from the proposed project.

Appendix A presents information on Reese-Chambers Systems Consultants, Inc. experience in conducting risk analysis. Appendix B contains the résumé of Tim Chambers, the individual who conducted the analysis.

2.0 METHODOLOGY

This analysis looked at the proposed project and then postulated the types of accidents that could occur. The types of accidents postulated were based on historical data with similar type projects, on the types of accidents required to be analyzed by the Ports' Risk Management Plans, and on discussion with the Coastal Commission and Arthur D. Little. These accidents, referred to as Design Basis Accidents (DBAs), are listed below.

(1) A release in the well area without a fire

(2) A wellhead release containing hydrogen sulfide (H_2S)

(3) A release in the well area with a fire

(4) A fire in an atmospheric storage tank

(5) The rupture of a storage tank into the surrounding secondary containment system without an ensuing fire

(6) The rupture of a storage tank into the surrounding secondary containment system with an ensuing fire

(7) An explosion in a storage tank

(8) A gas release from a process vessel

(9) A liquid release from a process vessel into the surrounding secondary containment system without an ensuing fire

(10) A liquid release from a process vessel into the surrounding secondary containment system with an ensuing fire

(11) An NGL system accident

(12) An accident involving the trucking of crude oil during Phase I

(13) An accident involving the crude oil pipeline during Phase II

(14) An accident involving the gas pipeline during Phase II

For each of the DBAs, the extent of the potential impact is then estimated using "hazard footprints." A hazard footprint is a diagram indicating the extent of the area within which a specified level of adverse effect is exceeded against a specified vulnerable resource. The following hazard footprints were calculated for the above DBAs as appropriate.

- *Radiant Heat from a Fire.* A fire will produce radiant heat. The distances to the 5 kW/m^2 (1,600 Btu/sq.ft./hr) and 10 kW/m^2 (3,200 Btu/sq.ft./hr) heat levels from those accidents involving fires have been calculated. 5 kW/m^2 is the level that can begin causing pain and second-degree burns to human skin exposed for

30 seconds, and is considered the minor injury level while 10 kW/m^2 can begin causing pain after 8 seconds and is considered the major injury threshold. People inside homes or shielded by objects such as homes or walls could stand a higher heat level before being impacted.

- *Flammable Gas Cloud from a Release.* When a flammable material is released, it begins producing flammable vapors which can drift with the wind, producing a gas cloud which may be ignited. The distances the cloud may travel before dispersing to a concentration below its lower flammability limit (LFL) have been calculated for releases of flammable materials. The flammable gas cloud hazard footprint has been calculated for two atmospheric conditions: stability condition F with 2.2 mph wind, and stability condition D with 5 mph wind. Stability Condition F consists of a low inversion layer, which tends to trap gas releases and prevent them from dispersing in the atmosphere. This condition occurs at night with low wind speeds. This condition usually results in the largest gas cloud hazard footprints.

- *Toxic Gas Cloud from a Release.* When a potentially toxic material is released, it begins producing toxic vapors which can drift with the wind. The distances the cloud may travel before dispersing to a concentration below which it is no longer toxic has been calculated where required for releases of toxic materials. The toxic gas cloud hazard footprint has been calculated for the two atmospheric conditions described above.

- *Blast Overpressure and Flying Debris from an Explosion.* Both vessels and unconfined vapor clouds have the potential to explode. The blast overpressure, as a function of distance from such an explosion, has been calculated, along with an estimate of the distance that debris may be hurled by an explosion, as appropriate. A blast overpressure of 2.5 psig, which represents the pressure that can begin causing eardrum rupture, has been used as the blast overpressure hazard footprint threshold.

The only potential toxic material to be handle by the proposed project would be hydrogen sulfide (H_2S). It is possible that small amounts of H_2S will be present in the oil and gas produced by the proposed project, however, no more than 10 parts per million (ppm) of H_2S is initially expected. Thus, only "sweet" gas is expected. However, to provide for unforeseen circumstances and to determine thresholds, this risk analysis has analyzed H_2S concentration of up to 5,000 ppm in the produced gas.

Hazard footprints have been determined using HFCP, the computer model used by the Ports of Los Angeles and Long Beach, and Chems-Plus, a commercially available program developed by and available from Arthur D. Little. The details of the methodology used by HFCP are documented in the Users' Manual (Reese-Chambers Systems Consultants, Inc., 1991). Details of Chems-Plus are contained in the Chems-Plus User Guide (Arthur D. Little, 1988). Gas release rates were modeled using Chems-Plus.

3.0 ANALYSIS AND RESULTS

The proposed project will consist of two phases. Phase I will include the drilling of one to three exploratory and producing wells to prove the commercial value of the development. The emulsion (an oil and water mixture) and associated gas will be processed on site using portable equipment and the oil will be trucked offsite to a refinery. The water will be reinjected into a reservoir. The gas will be scrubbed and incinerated. Phase II will produce emulsion and associated gas from 30 wells; separate the gas, oil, and water using gravity and heat; clean the separated water and reinject it using four wells; and store the oil on site until shipped by a newly constructed pipeline. The gas will also be shipped by a newly constructed pipeline.

The exact characteristics of the crude oil to be produced is not known at this time, however, the API gravity is expected to be between 17 and 21. While the characteristics of the oil have little effect on the size of the radiant heat, blast overpressure, and flying debris hazard footprints, they can have a significant impact on the flammable vapor cloud hazard footprint. Thus, to be conservative, we have assumed that the crude is fairly light with a flash point below 100°F, making it a flammable liquid. This assumption will tend to overestimate the size of the flammable vapor cloud hazard footprint.

The produced gas is expected to be sweet, that is, it is not expected to contain hydrogen sulfide in concentrations high enough to be considered hazardous. As stated in the previous section, the risk analysis analyzes H_2S concentrations up to 5,000 ppm while the expected H_2S concentration is less than 10 ppm. The potential effects of H_2S on humans is a function of two parameters, the exposed concentration level and the exposure time. The higher the exposure concentration, the less time it takes to cause adverse health effects. Previous analyses done for projects in Santa Barbara County (e.g., Sandpiper Golf Course and Residential Development Draft EIR [County of Santa Barbara, 1994] and Chevron Point Arguello Field and Gaviota Processing Facility SEIR [Arthur D. Little, 1988]) have generally used one or both of the following two H_2S concentrations in their risk analysis; 1000 ppm and/or 300 ppm. The 1000 ppm concentration was utilized as the H_2S concentration which could cause death after a few breaths. The 300 ppm concentration is the immediately dangerous to life or health (IDLH) concentration for H_2S. The IDLH concentration is defined as the maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects (U.S. Department of Transportation, 1992).

Recently, some analysts have been examining the Emergency Response Planning Guidelines (ERPGs) for use in risk analyses. These levels have been issued by the American Hygiene Association for use in emergency response planning and are not meant to be exposure thresholds. The ERPGs are substantially more conservative than IDLHs. The ERPG-3 concentration for H_2S is 100 ppm. ERPG-3 is defined as the maximum airborne concentration below which, it is believed, that nearly all individuals could be exposed up to one hour without experiencing or developing life-threatening health effects. The ERPG-2 concentration for H_2S is 30 ppm. ERPG-2 is defined as the maximum airborne concentration below which, it is believed, nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that would impair an individual's ability to take protective action.

3.1 Risk From Wells

Blowouts - The best known and potentially the most significant accident associated with well drilling is a blowout. A blowout is defined as the uncontrolled flow of formation fluids from a wellbore. They occur when formation fluids flow uncontrolled into a low-pressure subsurface zone (an underground blowout) or to the surface (a surface blowout). Most commonly, a blowout happens when there is insufficient pressure in a wellbore to control subsurface pressures. If wellbore hydrostatic pressure is allowed to drop below the subsurface formation pressure, then a "kick" will occur as the formation fluids flow into the well. Typically, a kick is circulated out of a well in a controlled manner, with formation fluids flowing into a production flowline or emergency flare line. When a kick is detected during drilling operations, the blowout prevention equipment (BPOE) is closed, sealing the wellbore and preventing any additional formation fluid from entering the wellbore. Additional kick-control procedures are implemented such as circulating higher density drilling fluid into the wellbore until the kick is circulated out of the well and normal operations can be resumed. A surface blowout occurs when formation fluids flow to the surface in an uncontrolled manner. A kick can lead to a blowout in rare instances (e.g., in a gas well that experiences a failure in the mechanical integrity of the equipment/system). Redundancy of equipment is a primary feature of blowout prevention equipment design.

A source of information on blowouts in California is a document titled "A History of Oil- and Gas-Well Blowouts in California, 1950 - 1990", published by the California Department of Conservation Division of Oil, Gas and Geothermal Resources (CDOG). This database includes both onshore and offshore wells.

The CDOG data shows an overall drilling incident rate of one blowout per 1,963 wells drilled during the time period 1950 - 1990. The incident rate for blowouts resulting in a release of oil is 1:20,315. The blowout incident rate from 1970 (after the 1969 Unocal blowout offshore Santa Barbara) through 1990 was 1:3,046 (a probability of 3.3×10^{-4} per well drilled).

A detailed analysis of the CDOG data for the time period 1980 - 1990 determined that after blowouts caused by steam injection and in abnormally high pressurized reservoirs were removed from the database, the blowout incident rate is 1:10,969 (a probability of 9.1×10^{-5} per well drilled). None of the remaining blowouts in the database flowed oil.

One factor that would tend to further reduce this low probability of a blowout is the fact that the Hermosa Beach project will be drilling into a reservoir whose characteristics are well known. The reservoir is not highly pressurized and will require pumping to bring the oil to the surface.

Based on the above statistics (blowout incident rate of 1:10,969), the probability of a blowout for the two phases of the proposed project are presented below.

PHASE	NUMBER OF WELLS	PROBABILITY OF BLOWOUT
1	6	5.5×10^{-4}
II	24	2.2×10^{-3}
BOTH	30	2.7×10^{-3}

Although the probability of a gas blowout is extremely low, a discussion of such an event follows. First, if a large pressure surge is encountered, the blowout prevention systems should prevent gas from escaping by closing off the annulus. In the highly improbably event that the annulus does not close, the gas will be diverted to the processing equipment or the on-site vent if the processing equipment is unable to handle the flow. The vent allows the gas, which is lighter than air, to escape upward away from potential ignition sources. Modeling shows that the gas being vented from a vertical flare will not reach flammable concentrations (approximately 5 percent for methane) at ground level and therefore should not be subject to ignition.

The Molino Gas Project EIR combined the analysis of a blowout with that of the gas production pipelines. The annual probability of such an occurrence was estimated to be 1.1×10^{-4}. The document states that a blowout has a lower probability of occurring than a production pipeline failure. The Molino estimate of a blowout is consistent with the blowout probabilities in the table above when considering that the Molino estimates include the pipelines. The extent of the potential flammable gas cloud hazard footprint from a blowout was assumed to be the same as that of a pipeline rupture. The flammable gas cloud hazard footprint was calculated to be 381 feet for stability condition F. This same approach was taken in this analysis and the flammable gas cloud hazard footprint was calculated using Chems-Plus to extend 327 feet for stability condition F, 2.2 mph wind.

The probability of a blowout during drilling was deemed to be not significant by the Final Environmental Impact Report (Ultrasystems, 1994). This conclusion was based on the fact that the wells will be equipped with redundant safety devices, including blowout protectors. Thus, the worst case accident involving the wells has been postulated to be a leak in the well area flooding the well cellar. The leak would involve an emulsion containing approximately half oil and half water.

Wellhead Releases - Initially, very little H_2S is expected in the produced gas. Over time, it is possible that the amount of H_2S in the produced gas will increase. If an increase does occur, it would be gradual over an extended time period. Macpherson will monitor the H_2S concentration in the commingled gas stream of all the wells on a continuous real time basis. In addition, the H_2S concentration of each individual well will be measured on a monthly basis. Based on the H_2S concentration of the individual wells and the combined gas stream, a real time H_2S concentration increase threshold will be established for the combined gas stream that will cause all the wells to be shut in and then analyzed individually to determine if any have increased above the shutdown threshold.

If the H_2S concentration of any well gets above a predetermined threshold, then downhole treatment will begin. The gas comes to the surface through the casing. The gas must travel through water which is put in the casing. When treatment is begun, a chemical is pumped into the water. As the gas travels through the water containing the chemical, the chemical reacts with the H_2S, pulling it out of the H_2S. Extra chemical is put in the water at the beginning and maintained at all times. Thus, it for some reason the pump that injects the chemical is shut down or fails, the H_2S scrubbing system will still be effective for several days. In fact, another way of treating the gas downhole is to have the supplier inject the chemical on a periodic bases.

Chems-Plus was utilized to calculate the downwind distances to four concentrations, 1,000 ppm, 300 ppm, 100 ppm, and 30 ppm for the two meteorological conditions. Five potential H_2S concentrations (1,000 ppm, 2,000 ppm, 3,000 ppm, 4,000 ppm, and 5,000 ppm) in the gas were analyzed. The results are summarized in Table 3-1.

TABLE 3-1

H_2S HAZARD AREAS FROM WELL RELEASE

H_2S CONCENTRATION IN GAS (ppm)	DOWNWIND HAZARD ZONE TO LISTED CONCENTRATION (FEET)							
	1000 ppm		IDLH 300 ppm		ERPG-3 100 ppm		ERPG-2 30 ppm	
	F/2.2	D/5	F/2.2	D/5	F/2.2	D/5	F/2.2	D/5
1,000	0	0	128	41	226	71	431	132
2,000	99	32	183	58	327	101	634	189
3,000	122	39	226	71	407	125	798	235
4,000	141	45	263	82	512	155	942	274
5,000	158	50	298	92	540	163	1072	309

The probability of a well release containing H_2S concentrations above 1,000 ppm have been estimated as follows. First, a release would have to take place. Arthur D. Little supplied a fault tree which established the failure rate to be 1.05 x 10^{-4}/yr. This is consistent with previous EIRs (Arthur D. Little, 1995). Next, the H_2S concentration in the gas would have to be above 1,000 ppm. In order for this to occur, the downhole concentration would have to be above 1,000 ppm, and the H_2S treatment system would have to fail. Macpherson has agreed to shut-in any well that has an H_2S concentration greater than 2,000 ppm. Additional analysis and permitting would be required before such a well could be restarted.

Of the wells proposed to be drilled, less than one third will be to the south into the Redondo Beach area. This area has been previously developed and thus has some potential for higher levels of H_2S. Records show that of the 60 wells produced in that area, 5 were being treated for H_2S levels above 1,000 ppm. Thus, not every well drilled to that area would be expected to have elevated levels of H_2S. The wells being drilled into the new zones (over two thirds) would be carefully managed and would have even a less likely probability of ever having elevated levels of H_2S.

The next thing that would have to happen is that the downhole treatment system would have to fail. Because of the way the system works, this is highly unlikely. First, as stated previously, excess chemical is maintained in the water column in the casing. Thus, even if the injection pump were to fail, the treatment system would continue to be effective for several days. Second, Macpherson will alarm the injection pumps to notify the operator in the event of a failure. Spare pumps will be maintained at the facility so the pump could be quickly replaced. Third, if an adequate amount of chemical is not maintained in the water column, the H_2S content in the combined stream would significantly increase, resulting in all the wells being shut down.

Thus, for H_2S treatment not to be effective, the injection pump would have to fail and the operator would have to not replace the pump within two days, or the pump would have to fail and the water column would not have to have sufficient chemical to continue to be effective. Assuming extremely conservative estimates of 10 percent failure rates (extremely high) for each of the events results in a one percent probability that the treatment system could fail at the same time there is a release. Thus, the overall estimated frequency of a well release containing elevated levels of H_2S would be 0.01 x 1.05 x 10^{-4}/yr = 1.05 x 10^{-6}/yr. This would equate to 3.1 x 10^{-5}/yr if all 30 wells had 2,000 ppm H_2S.

<u>*Releases into the Well Cellar*</u> - The well cellar covers an area of approximately 2,060 feet. HFCP was utilized to calculate the flammable vapor cloud and radiant heat hazard footprints for a release that would cover the entire cellar area. The size of the hazard footprints is measured from the edge of the cellar area. The results are presented below.

- Radiant heat (5 kW/m^2) - 152 feet
- Radiant heat (10 kW/m^2) - 75 feet
- Flammable gas cloud - 17 feet

It is noted here that the vaporization rate from this pool would not produce enough vapor to become involved in an unconfined vapor cloud explosion.

Regulations and technology have made wells extremely safe and the probability of a release of any size from a well is unlikely. As estimated previously, the probability of a major spill from a wellhead complex is 1.05×10^{-4} per year. The probability that the oil would become ignited would be 1.0×10^{-2} or one in a hundred (County of Santa Barbara, 1985). Thus, the annual probability of a release with fire would be 1.05×10^{-6}.

3.2 Risk from Storage Tanks

Oil and process water will be stored in five storage tanks located in a common secondary containment system (i.e. diked area). All of the tanks will have cone roofs with weak seams. In the unlikely event of an explosion, the roof is designed to lift up to vent the energy, thereby preventing the tank from rupturing and possibly resulting in flying debris. The roof is expected to travel no more than several tank diameters from the tank. It is also noted here that the tanks will be blanketed with gas to prevent oxygen from being present. As long as oxygen is not present, an explosion is impossible.

The potential DBAs from the tanks addressed in this analysis include a fire in a tank, an explosion in a tank, and a rupture of a tank flooding the diked area, either with or without a fire. The following hazard footprint distances were calculated using HFCP. The largest tank, with a 3,333 bbl capacity, was used in the calculations. All of the hazard footprints are measured from the edge of the tank or diked area.

- Radiant heat from a fire in a tank - 156 feet ($5kW/m^2$); 76 feet ($10kW/m^2$)
- Blast overpressure from an explosion in a tank - 141 feet
- Flying debris from an explosion in a tank - 77 feet ($5kW/m^2$); 131 feet ($10kW/m^2$)
- Radiant heat from a fire in the diked area - 271 feet
- Flammable gas cloud from a release into the dike area - 33 feet

The annual probability of a tank fire has been estimated to be 7.0×10^{-5} (Envicom, 1992). This equates to an annual probability of 2.1×10^{-4} for the three tanks. The rupture of an atmospheric storage tank due to all causes, including seismic events, is estimated to be 1.6×10^{-4}/year or once in 6,300 years (County of Santa Barbara, 1985). The probability that the oil is ignited is 1.0×10^{-2}, or one in a hundred. Thus, the probability of a release with a fire is estimated to be 1.6×10^{-6} per tank, or once in 625,000 years. Since there will be three storage tanks that may store crude oil, the probability of a spill with fire, per year, would be 4.8×10^{-6}, or once in 208,000 years.

The probability of an explosion in an oil storage tank has been estimated to be 1×10^{-4} per year (County of Santa Barbara, 1988). This is for all types of storage tanks. The tanks for the proposed project will be gas blanketed, which will virtually eliminate the possibility of a tank explosion.

3.3 Risk from Process Area

Free Water Knockouts - The first step in processing the emulsion will be the separation of the gas, oil, and water by means of gravity using free water knockout (FWKO) vessels. The gas that will be separated out will be primarily methane which is the predominant gas in natural gas piped to most homes. The emulsion enters the FWKO whereby the water, which is heavier than the oil, falls to the bottom of the tank while the oil floats on the water. The gas which escapes from the emulsion goes to the top of the tank. The water is drawn off the bottom of the tank and sent to the wastewater treatment system. The gas is drawn off and directed to the gas compression and treatment system. The oil is sent to heater treaters where it is further processed. The FWKOs are ASME certified pressure vessels. The potential for an explosion in one of these vessels is extremely unlikely, and thus no hazard footprints have been calculated for a vessel rupture. Instead, the DBA from a FWKO has been assumed to be a release from a 2-inch diameter hole, which represents a release from a pipe connection or other small release. The flammable gas hazard footprint from a 2-inch diameter hole in the tank would produce a flammable vapor cloud hazard footprint that would extend up to 327 feet from the point of release under worst case atmospheric conditions (stability F, 2.2 mph wind). The rate of release from the vessel was calculated using the Chems-Plus model developed by Arthur D. Little. This rate of release was then input to both Chems-Plus and HFCP to calculate the flammable gas cloud hazard footprint. The models also determined that the amount of gas (methane) in the cloud would not be enough to become involved in an unconfined vapor cloud explosion. A release from a FWKO or gas line would result in a rapid release which would last for a very short time, less than several minutes. The gas can have a maximum H_2S concentration of 1,000 ppm. Since the hazard would only be present for several minutes, the 1,000 ppm concentration is the only one that would present a hazard, and since the gas only has a maximum H_2S concentration of 1,000 ppm, there would be no H_2S hazard footprint.

Heater Treaters - The oil is sent to heater treaters where it is heated to further separate out water and gas from the oil. In this case the majority of the emulsion entering the vessels is oil. The heater treaters are also ASME certified pressure vessels. Since the heater treaters will operate at approximately the same pressure as the FWKO, the release rate of gas from a 2-inch diameter hole will be approximately the same as that from the FWKO (it will actually be slightly less since the gas will expand because it is heated) and thus, the flammable vapor cloud hazard footprint will be approximately the same size. Again, there will not be a toxic gas hazard footprint because the gas will not contain more than 1,000 ppm H_2S.

A release of oil from the FWKOs or heater treaters could spread and cover the secondary containment area around the vessels. The surface area of the secondary containment area is approximately 7,780 sq.ft. The flammable gas cloud (if the spill doesn't ignite) and radiant heat hazard footprints were calculated by HFCP to be:

- flammable gas cloud - 41 ft
- radiant heat (5 kW/m^2) - 266 ft

- radiant heat (10 kW/m^2) - 130 ft

Arthur D. Little, 1995, has estimated that the probability of a major release from a pressure vessel is 8.0×10^{-7} per year, or once in 1,250,000 years. For the four vessels proposed for the facility, the combined annual probability of a major release would be 3.2×10^{-5} (once every 312,500 years). The probability that the released oil would become ignited is 1.0×10^{-2}. Thus, the annual probability of a major spill with fire is 3.2×10^{-7} (once in 3 million years).

NGL Treatment - The gas stream will be run through a refrigeration system to condense out the natural gas liquids (NGLs). It is most likely that a freon-based system will be used. However, depending on the composition of the gas, it is possible that a propane-base system will be required. The project engineer has calculated that if a propane system is required, only 5 to 10 gallons of propane will be required. This is equivalent to a backyard barbecue system and presents no hazard to the surrounding area.

The gas will be run through a 2 ft. diameter by 16 ft. tall cylindrical vessel (tower) for processing. There will be about a 5 ft. liquid level in the tower. The estimated maximum production rate of NGLs from the tower is 1 gal/min which will be blended with the crude oil. The worst case accident involving the tower is a boiling liquid expanding vapor explosion (BLEVE). For this scenario to occur, four events need to occur simultaneously, including significant external fire, failure of the pressure relief valve, vessel blockage, and no external fire fighting efforts. It is noted here that the tower is located in a containment pit with the other processing equipment, and that the floor is contoured such that all spills would drain to a sump system away from the equipment. Arthur D. Little, 1995 has estimated that the failure rate of this event is 8.0×10^{-7} per year which is classified as extraordinary.

The consequences of such an event include a fireball and a blast wave. Chems-Plus was utilized to calculate the following hazard footprints.

- Blast overpressure (0.5 psi) - 700 ft
- Blast overpressure (2.5 psi) - 194 ft
- Fireball thermal radiation - 183 ft (minor injury); 84 ft (major injury)

Two other types of releases could occur with the NGL system, a gas release and a liquid release. The consequence of a gas release would be the same as addressed previously for the other processing equipment except that the H_2S would be removed prior to going to NGL processing. The liquid from a release would drain toward the sump. It would begin evaporating immediately upon release. The maximum amount of NGLs that could be released would be $\pi \times 1^2$ (radius) x 5 (liquid height) = 15.7 ft^3 = 118 gal. Such a release would product a flammable vapor cloud of 353 ft. for F stability with 2.2 mph wind and 144 for D stability with 5 mph wind. The probability of such an event occurring has been estimated to be the same as that of a process vessel (3.2×10^{-5}).

3.4 Risk from Trucking

During Phase 1, the oil will be stored on-site in portable tanks and then loaded into tanker trucks for transportation to a refinery. It is estimated that three to four tanker truck trips per day, each carrying 175 bbls of oil, will be required to handle the 600 bbl per day production. The tanker trucks will be loaded inside the facility in an area equipped with a drain and sump to contain any spillage, although none is expected. The Phase I site sump/containment system will be adequate to fully contain a 175 bbl spill. Trucks will exit the facility and follow designated routing from the facility. Trucks will not deviate from the designated routing through residential neighborhoods.

Trucking of petroleum products is quite common throughout the country. Gasoline and other petroleum products are routinely transported by tanker trucks to gas stations and industrial facilities. Tanker trucks can become involved in traffic accidents but these do not usually result in a loss of cargo. A worst case accident would result in the loss of the entire contents of the trucks (175 bbls). The released oil would then spread on the ground and could ignite if it encounters an ignition source. The area covered by the spill would be a function of the elevation profile of the surrounding area.

For the purpose of calculating the potential hazard footprints, it has been assumed that the oil is spilled on a flat surface and spreads to a uniform depth of one inch. The spill would cover an area of approximately 11,800 sq. ft. with a radius of approximately 57 ft. The radiant heat and flammable gas cloud hazard footprints were calculated by HFCP to be:

- Flammable gas cloud - 52 ft
- Radiant heat (5 kW/m^2) - 320 ft
- Radiant heat (10 kW/m^2) - 182 ft

It is noted here that oil burns at a rate of approximately 4 mm (0.16 in.) per minute and hence, a one-inch deep pool would burn for approximately 6.4 minutes. The pool would burn for a longer time if it were deeper, however, then the area would be smaller and the radiant heat footprint smaller.

The Handbook of Chemical Hazard Analysis Procedures (FEMA, undated) recommends using a truck accident rate of 2×10^{-6} accidents per mile with 20% of the accidents resulting in a release of cargo. The Handbook goes on to recommend that the following spill distribution be utilized:

- 10% cargo loss (17.5 bbl) - 60% of the time
- 30% cargo loss (52.5 bbl) - 20% of the time
- 100% cargo loss (175 bbl) - 20% of the time

Assuming that a loaded truck travels 10 miles results in the following annual probabilities of accidents and releases. It is assumed that the trucking lasts for one full year.

Event	Annual Probability
Accidents	2.5×10^{-2}
Spill of any size	5.0×10^{-3}
Spill of 17.5 bbls or less	3.0×10^{-3}
Spill between 17.5 bbls and 52.5 bbls	1.0×10^{-3}
Spill greater than 52.5 bbls	1.0×10^{-3}

3.5 Risk from Crude Oil Pipeline

A new produced crude oil shipping line will be constructed to transport produced crude oil from the oil production facility to the Southern California Edison (SCE) Redondo Beach storage facility and pipeline system. The Chevron pipeline previously being considered has been dropped. The new pipeline will be connected to the SCE manifold at the Redondo Beach storage facility and the oil directed to one of the storage tanks. The oil would then later be batched to one of the local refineries through the existing SCE pipeline system. The new pipeline would have an outside diameter of 6 inches and be approximately 0.5 miles (2,500 ft.) long. The pipeline is designed for a maximum operating pressure of 350 psig.

The amount of oil than can be released from a pipeline is made up of the amount that can be released until pumping is stopped plus the amount than can drain from the line due to gravity. Because the pipeline will be equipped with a supervisory control and data acquisition (SCADA) system that will monitor the pipeline at all times, it is conservatively estimated that a pipeline rupture would be detected and the pumping shut down within 5 minutes. The SCADA system monitoring the pipeline system would automatically shut down the pumps and close the appropriate block valves in the event an abnormal condition is detected. Hence, a maximum of 28 bbls [8,000 bbls per day / (24 hr x 60 min per hour) x 5 min] could be lost due to pumping. The capacity of the entire pipeline is 85 bbls, however block valves would be located at both ends of the line, with an additional one located approximately in the middle and hence, the maximum amount of oil that could drain from the pipeline if all the oil between block valves were to escape would be 43 bbls. Thus, the worst case release from the pipeline would be 71 bbls (28 bbls + 43 bbls).

As with a trucking accident, the area impacted by a pipeline spill would be a function of the elevation profile of the surrounding area. Assuming again that the spill occurs on a flat surface and spreads to a depth of one inch results in a 4,800 sq. ft. area being covered.

The radiant heat and flammable gas cloud hazard footprints were calculated by HFCP to be:

- Flammable gas cloud - 30 ft
- Radiant heat (5 kW/m^2) - 216 ft
- Radiant heat (10 kW/m^2) - 106 ft

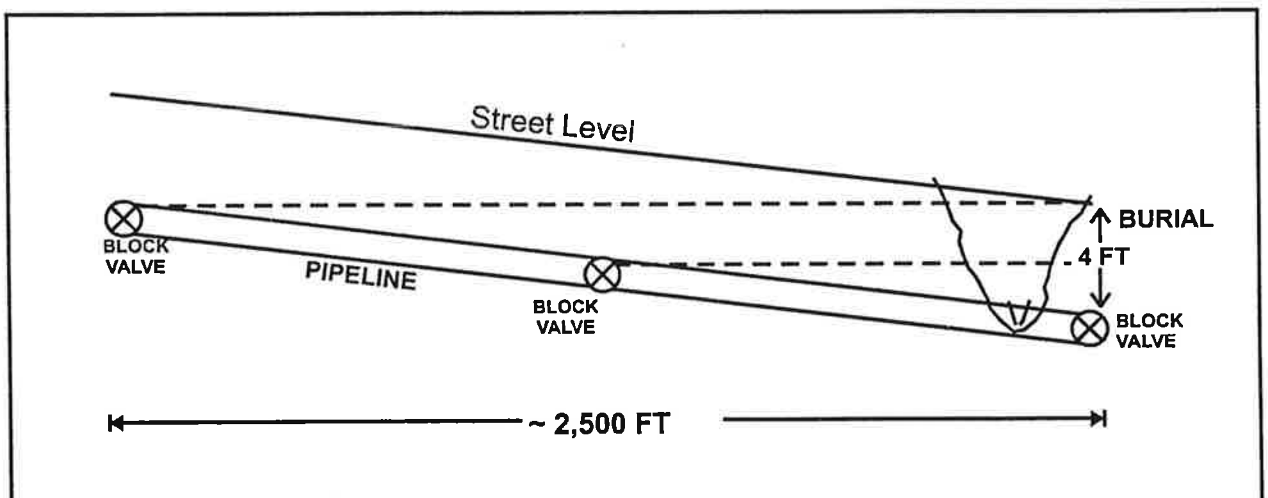
The probabilities of a leak and rupture for modern crude oil pipelines are generally estimated to be around 5.4×10^{-4} spills per pipeline-mile per year, and 2.7×10^{-4} ruptures per pipeline-mile per year, respectively (Aspen, 1995). This equates to the following annual probabilities for the 0.5 mile pipeline.

- Probability of leak - 2.7×10^{-4}
- Probability of rupture - 1.3×10^{-4}

The potential for oil getting in the ocean from a pipeline release was also examined. First, it would be virtually impossible for 43 bbls of oil to drain from the pipeline after pumping has ceased and the block valves are shut. The pipeline follows a relatively flat terrain dropping only about four feet in elevation between the proposed facility and the SCE Redondo Beach facility. The pipeline will be buried four feet below grade.

If the pipeline were to rupture near the end at its lowest point, up to 28 bbls could be pumped out. The pipeline trench will be backfilled with sand during construction. Much of the released oil would soak into the sand. Once the pumping has stopped, oil would begin draining out due to gravity. As shown in Figure 3-1, the top of the grade (i.e. street level) would be about even with the top of the pipeline at the facility. The top of the grade would be about two feet above the top of the pipe at the center of the block valve. Thus, it would not be possible for oil to drain out of the pipe into the street due to gravity.

FIGURE 3-1
PIPELINE PROFILE



Hence, it has been assumed that 28 bbls could be pumped out. It has further been assumed that one fourth of the oil (7 bbls) would be absorbed by the sand in the trench, leaving 21 bbls that could escape. This oil would flow in the street and most likely eventually find its way to a storm drain opening. If it were raining, it is likely that most of the 21 bbls would reach the storm drain and get carried to the ocean. If it were dry, the oil would form smaller pools due to the unevenness of the street. Some of the oil would stick to the street as it flowed. Thus, somewhat less than 21 bbls would enter the drain and flow to the ocean though it is difficult to estimate the amount.

3.6 Risk from Gas Pipeline

The new gas pipeline will be constructed to transport utility-grade gas from the facility to an existing utility gas pipeline. The new pipeline will have an outside diameter of 4 inches and will be approximately 0.5 miles long. Gas will be sent through the line on a continuous basis at approximately 120 psig, using the compressor located at the Macpherson production facility. Any small amounts of H_2S that might be in the gas will be removed at the Macpherson production facility and hence, the gas will not be toxic.

The rate of release of gas from the pipeline would be a function of the size of the hole. The larger the hole, the greater the release rate. A complete rupture of the line would shut down the compressor almost immediately. In addition, the line will be equipped with a check valve at the point where it connects to the utility line that would prevent gas from flowing into the line from the utility line.

Chems-Plus has been utilized to calculated the release rate and flammable vapor cloud hazard footprint from a pipeline rupture and from a small leak (e.g. ¼-inch diameter hole). The results are presented below.

Accident	Downwind Distance to LFL
• Pipeline rupture	467 feet
• ¼-inch hole	<10 feet

It is noted here that the downwind distance to the LFL calculated for the rupture is an overprediction because Chems-Plus treats the release as a point source and ignores the initial mixing with air caused by the jet release of the gas. The pipeline would be emptied of gas in about 4 seconds in the rupture case. It is also noted that this line is essentially the same as the numerous utility-owned and -operated gas lines throughout the area.

If the gas release were to ignite, it would burn as a jet release until the gas flow ceased. This would last about 4 seconds. The flame length could be up to 211 feet long. If the gas cloud were to ignite, the fire would burn back to the source and burn as a jet flame. Thus, the radiant heat hazard footprint has been assumed to be equal to the flammable gas cloud hazard footprint.

The probability of a leak for a modern gas line is estimate to be 1.5×10^{-3} per pipeline-mile per year (Arthur D. Little, 1995). Thirty one percent of the leaks are estimated to be major leaks or ruptures. This equates to the following annual probabilities for the 0.5 mile gas pipeline.

- Probability of leak - 5.2×10^{-4}
- Probability of rupture - 2.3×10^{-4}

3.7 Summary of Accident Probabilities and Hazard Footprints

The results of hazard footprint analysis are summarized in Table 3-2. The table includes the probability of the accident, the extent of the hazard footprints (downwind and crosswind for flammable gas hazard footprints) for the two environmental conditions (stability F and stability D), and the area covered by the hazard footprint. The hazard footprints are displayed on Figure 3-2.

As can be seen by the table, the largest hazard footprint would be 700 feet from an NGL tower BLEVE. This hazard footprint would consist of a 0.5 psi blast wave that is capable of breaking windows. The probability of a BLEVE is classified as extraordinary (8.0×10^{-7}/yr). The next largest hazard footprint is that of an NGL liquids release. Such a release would produce a 353 foot flammable gas cloud hazard footprint. This hazard footprint would extend into the residential neighborhood to the north and the R-3 neighborhood to the west. The actual hazard footprint at the time of a release would only extend downwind, and would not cover the entire circular area shown. Also, it is noted here that the footprint would only be 353 feet during worst case environmental conditions, e.g. stability F with low wind speeds. As can be seen from the table, the hazard footprint would only extend 144 feet during typical environmental conditions. The flammable gas hazard footprint would only be a hazard if it were to be ignited. The largest injury radiant heat hazard footprint would extend 271 feet and would form a circle as shown because the radiant heat would be given off in all directions. The injury radiant heat hazard footprint extends into the residential neighborhood to the north and just touches the R-3 neighborhood to the west. It is noted here that this footprint would not impact people inside or behind structures. In addition, people outdoors exposed to the heat from a fire, would have time to find shelter before they would sustain burns. The largest major injury radiant heat hazard footprint would extend 131 feet. A fire at the facility should not impact homes or other structures in the area.

The largest toxic gas cloud hazard footprint for gas containing 2,000 ppm H_2S extends 99 feet to 1,000 ppm and 183 feet to 300 ppm for worst case meteorological conditions. Neither of these footprints extend into residential areas. For D stability and 5 mph winds, the cloud extends 32 feet to 1,000 ppm and 58 feet to 300 ppm. The 58-foot hazard footprint extends slightly into the industrial area west of the facility.

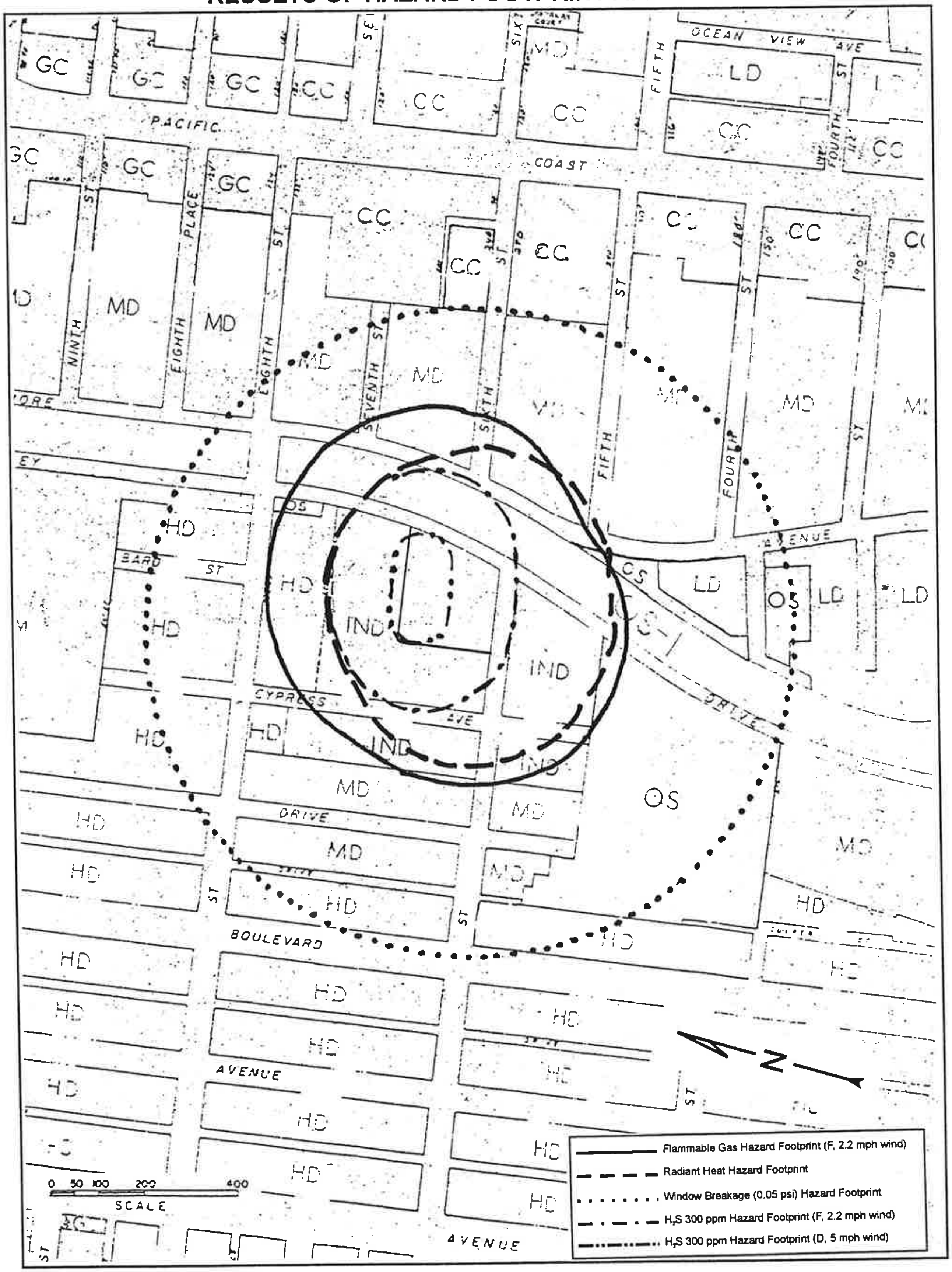
The truck, oil pipeline, and gas pipeline accidents would occur offsite and their potential impact would be a function of where the accident occurred relative to vulnerable resources. Figure 3-3 shows the proposed truck route and Figure 3-4 shows the proposed oil and gas pipeline route. Figure 3-5 plots the truck hazard footprints while Figure 3-6 plots the pipeline hazard footprints.

TABLE 3-2
SUMMARY OF ACCIDENT PROBABILITIES AND HAZARD FOOTPRINTS

SCENARIO	ANNUAL PROB OF ACCIDENT	STABILITY F / 2.2 MPH WIND			STABILITY D / 5 MPH WIND		
		DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)	DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)
(1) Release in well area (blowout or pipe rupture) without fire - flammable gas hazard	1.1×10^{-4}	327	131	33,600	101	41	3,250
(2) Wellhead release containing 2,000 ppm H_2S - toxic gas hazard footprint	3.1×10^{-5}	99 ft to 1,000 ppm 183 ft to 300 ppm	40 74	2,800 10,400	32 ft to 1,000 ppm 58 ft to 300 ppm	13 24	330 1,100
(3) Release in well area with fire - radiant heat hazard	1.1×10^{-6}	152 ft minor injury 75 ft major injury	Circle	18,150 4,400	152 ft minor injury 75 ft major injury	Circle	18,150 4,400
(4) Fire in atmospheric storage tank - radiant heat hazard	2.1×10^{-6}	156 ft minor injury 76 ft major injury	Circle	19,100 4,500	156 ft minor injury 76 ft major injury	Circle	19,100 5,400
(5) Release into containment system from storage tank without fire - flammable gas hazard	4.8×10^{-4}	33	15	390	11	5	43
(6) Release into containment system from storage tank with fire - radiant heat hazard	4.8×10^{-6}	271 ft minor injury 131 ft major injury	Circle	53,000 13,500	271 ft minor injury 131 ft major injury	Circle	53,000 13,500
(7) Explosion in storage tank - blast overpressure and flying debris hazards	0 - tanks will be gas blanketed						
(8) Release from a process vessel - flammable gas hazard	3.2×10^{-5}	327	131	33,600	101	41	3,250
(9) Process vessel liquids leak into containment system without fire - flammable gas hazard	3.2×10^{-5}	41	20	640	14	6	115
(10) Process vessel leak into containment system with fire - radiant heat hazard	3.2×10^{-7}	266 ft minor injury 130 ft major injury	Circle	55,600 13,300	266 ft minor injury 130 ft major injury	Circle	55,600 13,300

SCENARIO	ANNUAL PROB OF ACCIDENT	STABILITY F / 2.2 MPH WIND			STABILITY D / 5 MPH WIND		
		DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)	DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)
(11a) NGL tower BLEVE Blast overpressure	8.0×10^{-7}	700 ft to 0.05 psi 194 ft to 2.5 psi	Circle	385,000 29,600	700 ft to 0.5 psi 194 ft to 2.5 psi	Circle	385,000 29,600
(11b) NGL tower BLEVE Fireball thermal radiation	8.0×10^{-7}	183 ft minor injury 84 ft major injury	Circle	26,600 5,500	183 ft minor injury 84 ft major injury	Circle	26,600 5,500
(11c) NGL tower gas release - flammable gas hazard	3.2×10^{-5}	327	131	33,600	101	41	3,250
(11d) NGL tower liquid release - flammable gas hazard	3.2×10^{-5}	353	142	39,500	144	58	6,600
(12a) Truck release of crude oil without fire - flammable gas hazard	5.0×10^{-3}	52	25	1,020	16	8	100
(12b) Truck release of crude oil with fire - radiant heat hazard	5.0×10^{-4}	320 ft minor injury 182 ft major injury	Circle	80,400 26,000	320 ft minor injury 182 ft major injury	Circle	80,400 26,000
(13a) Pipeline release of crude oil without fire - flammable gas hazard	1.3×10^{-4}	30	14	330	10	5	40
13b) Pipeline release of crude oil with fire - radiant heat hazard	1.3×10^{-5}	216 ft minor injury 106 ft major injury	Circle	36,600 8,800	216 ft minor injury 106 ft major injury	Circle	36,600 8,800
(14) Gas pipeline release - flammable gas hazard	2.3×10^{-4}	467	187	68,600	214	86	14,450

FIGURE 3-2
RESULTS OF HAZARD FOOTPRINT ANALYSIS



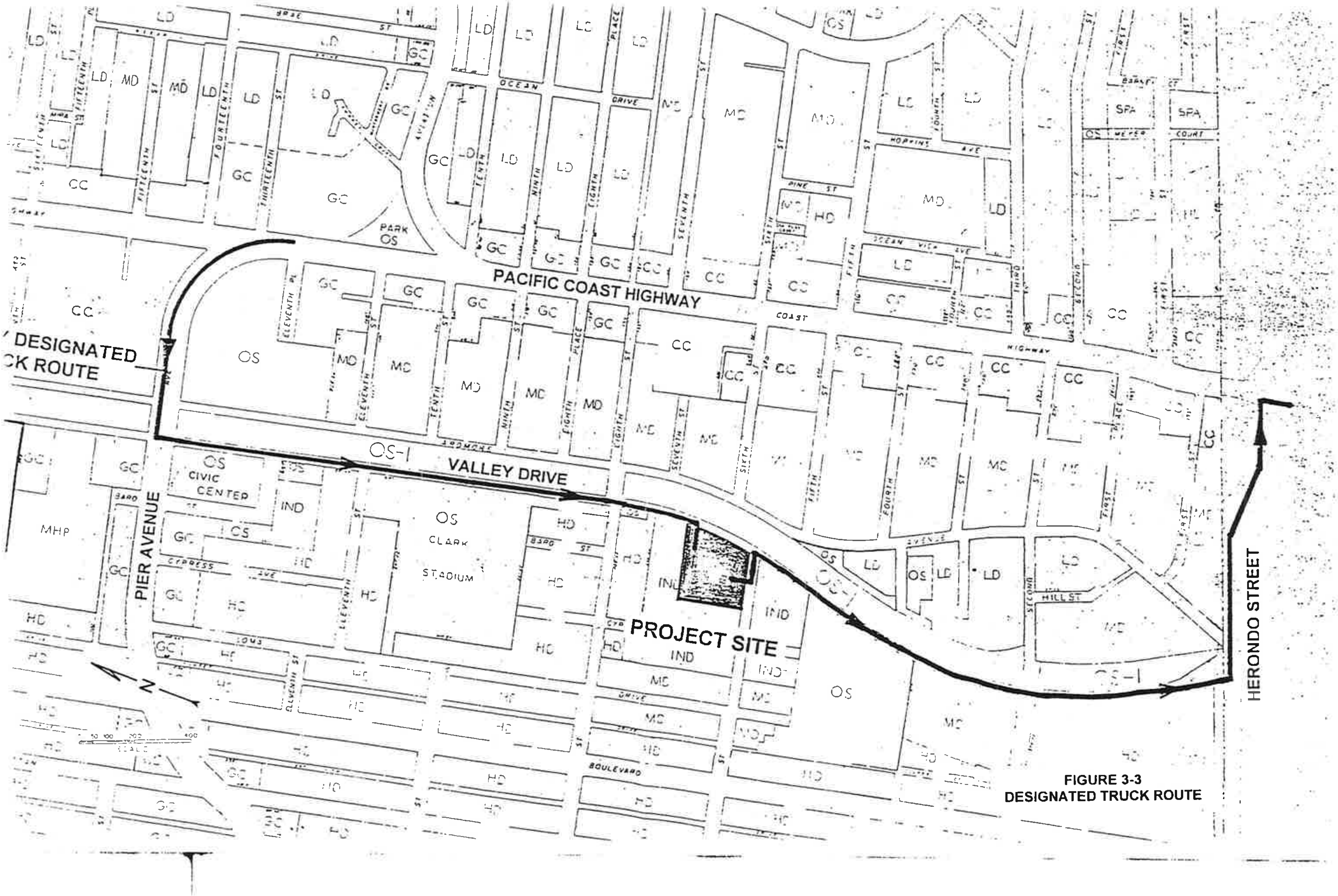
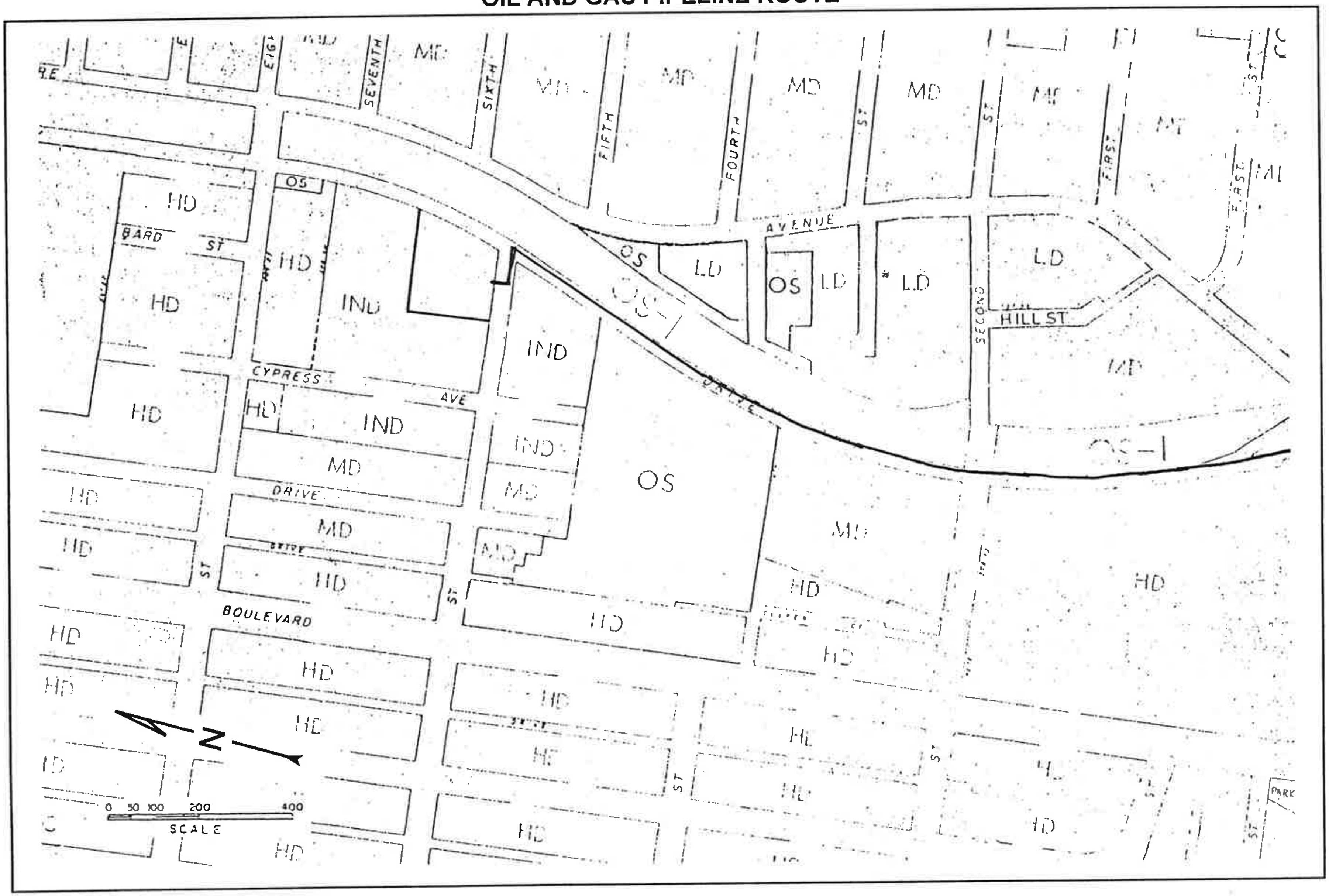


FIGURE 3-3
DESIGNATED TRUCK ROUTE

FIGURE 3-4
OIL AND GAS PIPELINE ROUTE



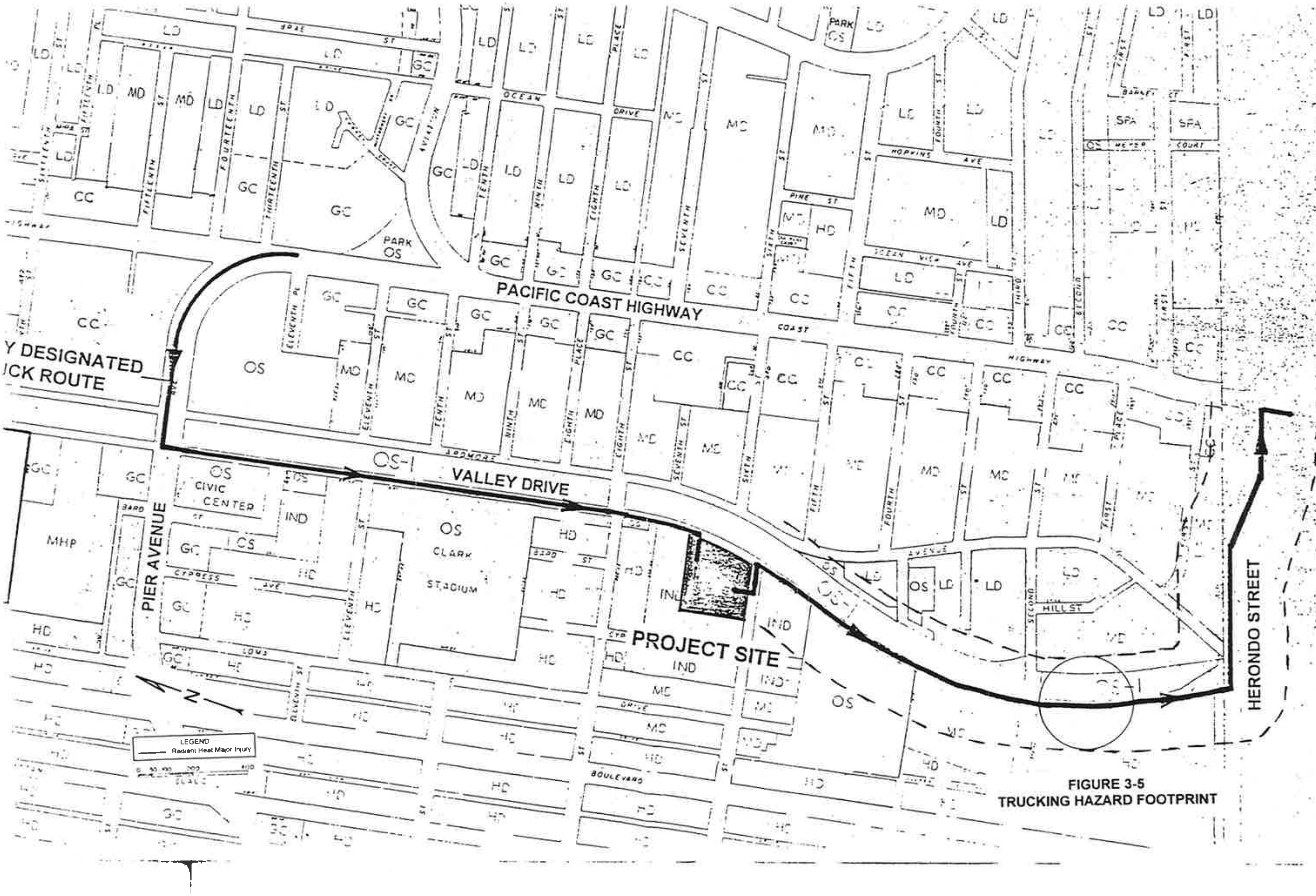
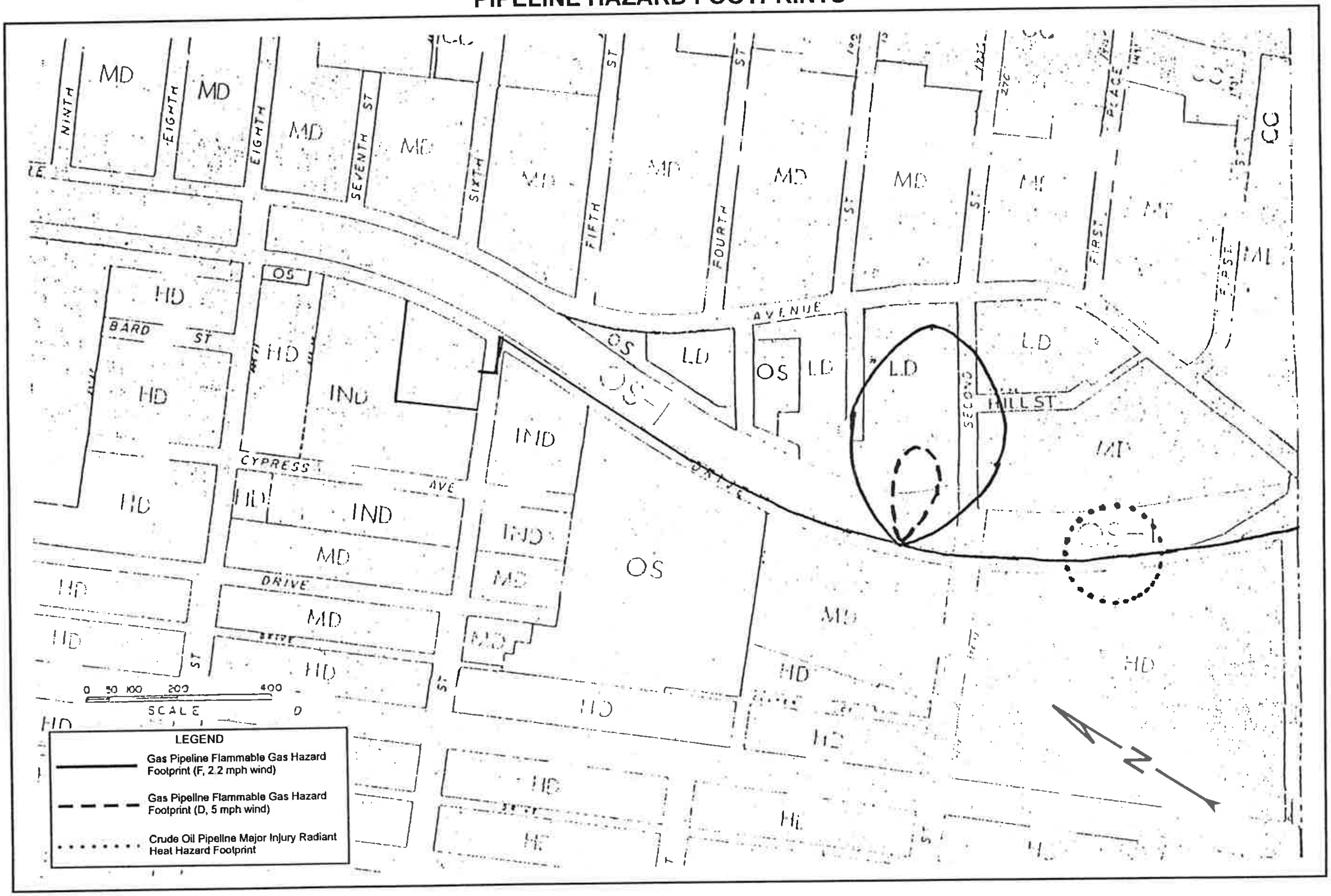


FIGURE 3-5
TRUCKING HAZARD FOOTPRINT

FIGURE 3-6
PIPELINE HAZARD FOOTPRINTS



3.8 Consequence Analysis

The results of the failure rate and consequence analysis have been combined to develop plots of frequency versus fatalities similar to that shown in the Molino Gas Project EIR. These curves are commonly called risk profiles. Figure 3-7 presents the guidelines used in the Molino Gas Project EIR for the determination of offsite risk and significance. Points above the upper line, labeled "De Manifestis", are considered to be an unacceptable risk, while those below the line, labeled "De Minimis", are considered acceptable. Points between the two lines, labeled "grey region", are acceptable but mitigation may be required. The following factors were utilized in developing the risk profiles.

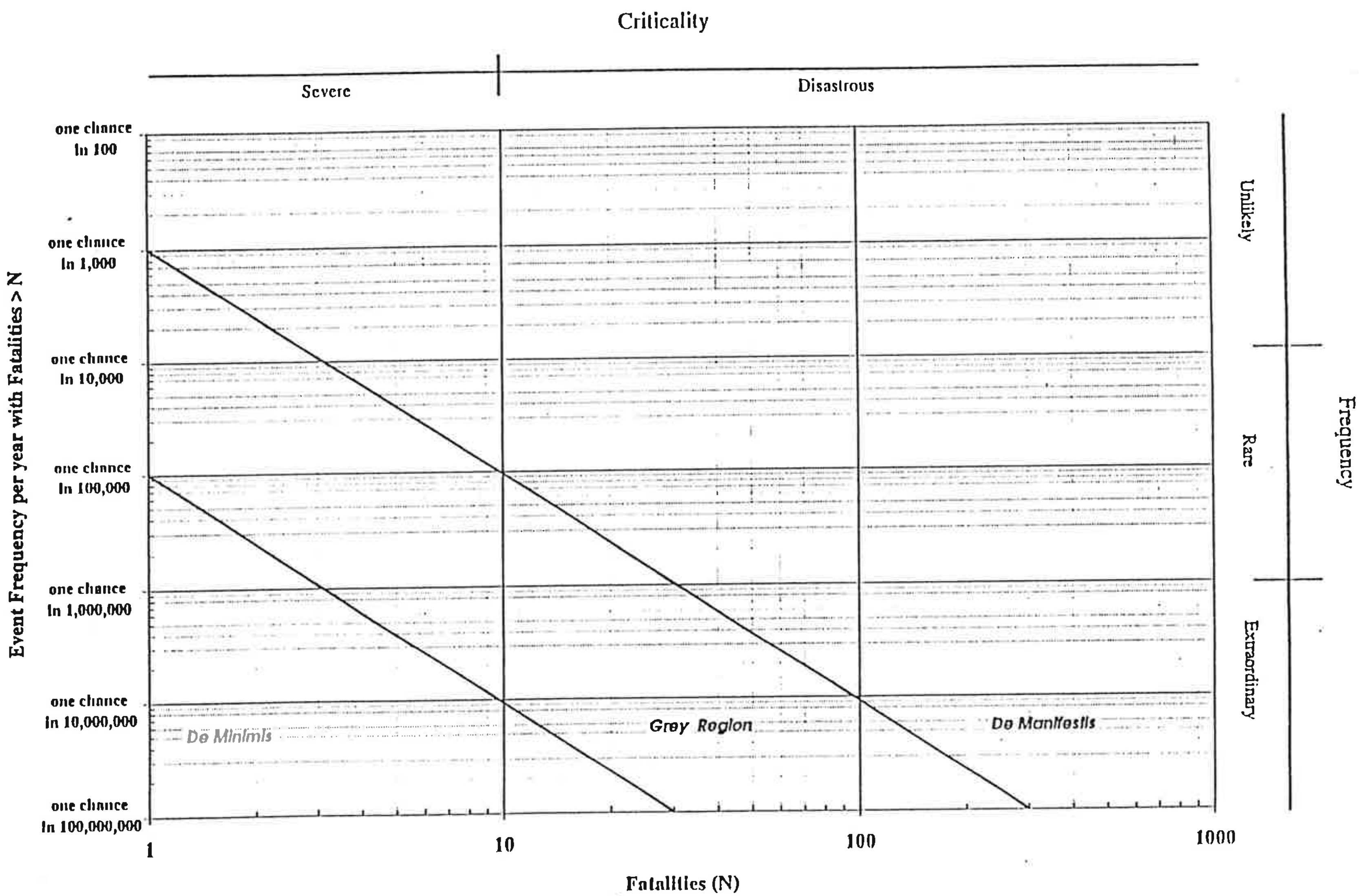
- extent of hazard footprint for each environmental condition
- estimated frequency rate for each accident
- estimated frequency of occurrence for each atmospheric condition
- estimated frequency of occurrence of wind direction
- population density
- presence of ignition sources
- probability of ignition from each ignition source

Meteorological Data - Meteorological data for the project site were obtained from California Air Resources Board, 1984 and California Department of Water Resources, 1978. Data for two sites, Los Angeles International Airport and Redondo-King Harbor were utilized.

The basic approach determined the relative likelihood of each of the two stability conditions, D and F, occurring. Condition D was used to represent conditions A through D and condition f to represent conditions E and F. The frequency of wind direction was taken from the two data sources.

Conditional Impact Probabilities - The likelihood is not 100 percent of a fatality resulting from an exposure to a vapor cloud fire. Buildings can provide some protection hazards. The analysis assumes 30 percent fatality within the lower flammability limit. Likewise, the likelihood of fatality resulting from an exposure to H_2S is not 100 percent. The following assumptions have been taken from Arthur D. Little, 1988. A 30 percent fatality rate has been assumed for an exposure to 300 ppm for 30 minutes for people both indoors or outdoors. A 50 percent fatality rate has been assumed for an exposure to 1,000 ppm because the cloud may pass very quickly and those indoors may be protected.

FIGURE 3-7
OFFSITE RISK AND SIFNIFICANCE GUIDELINES



People inside buildings would not be harmed by a radiant heat hazard footprint. People outside their homes could begin to received second degree burns if exposed for longer than 30 seconds. Because the radiant heat hazard footprint only overlaps a small residential area, it has been assumed that most people exposed would be in their homes or could easily leave the area in a short time. Thus, it has been assumed there would be no fatalities due to radiant heat.

Population Distribution - The population distribution was estimated from the Hermosa Beach General Plan Map. Each residential unit was assumed to house four people.

Ignition Probabilities - Flammable vapor clouds have the potential to ignite anywhere within their flammable limits. Hence, it is necessary to identify potential ignition sources that a cloud may encounter, and to quantify the likelihood of ignition, if the cloud encompasses the sources. In general, when trying to identify ignition sources, the search is primarily for open flames, hot surfaces and electrical sparks, and, to a lesser extent, friction sparks from both continuous and intermittent activities. Some of the potential ignition sources identified in the Molina Gas Project EIR were:

- Vehicles (many specific sources were identified)
- Boilers
- Gas turbines
- Blow torches
- Fired heaters
- Welding
- Faulty wiring
- Pilot flames
- Fireplaces and wood/coal stoves
- Smoking materials
- Doorbells
- Switches
- Furnaces/incinerators
- Machine tools
- Flares

Ignition probabilities used in the Molino Gas Project EIR include:

- ***Cars*** - 0.2 per car; although many potential ignition sources within a car like faulty wiring or backfires are due to fuel rich mixtures in intake air, they are not always present nor guaranteed to cause ignition.

- ***Houses*** - 0.01 per house; while there are many ignition sources within a home, such as switches, doorbells, faulty wiring, pilot lights, smoking materials, fireplaces and wood- or coal-burning stoves, the flammable vapors must first penetrate the house before these ignition sources pose a hazard. Typical residence times of clouds are often brief enough that this is relatively unlikely.

- ***Immediate Ignition*** - There are various ignition sources at the project facility such as electrostatic ignition or friction sparks that would ignite the vapor cloud on the project site. In keeping with the Molino Gas Project EIR, a figure of 0.2 has been assumed for the probability of immediate ignition.

Construction of Risk Profiles - The risk profile displays the frequency with which fatalities could occur. They indicate accident size and display how the potential number of fatalities varies as a function of frequency. The risk profile has been plotted on a log-log scale because the profiles span multiple orders of magnitude.

The general approach involved in constructing a risk profile involves determining the frequency and number of fatalities associated with each release scenario. A release scenario is defined by the following:

- Release location
- Release frequency
- Meteorological stability condition and its likelihood
- Wind direction and its likelihood
- Whether and where ignition occurs
- Area of the hazard zone
- Number of individuals exposed within each hazard zone
- Assumed fatality rate for that type of hazard

Some of these factors affect frequency, some determine impacts, and some influence both. Once all possible combinations have been analyzed, the results are combined to give the overall risk profile.

If a flammable release does not ignite immediately, the material will disperse, forming a vapor cloud which will travel downwind. Should the cloud encounter an ignition source (such as cars, pilot lights, open flames, furnaces or other equipment), the cloud will ignite and burn through the flammable area until all flammable material is consumed. For each release scenario, it is necessary to identify the ignition sources that would be encountered. Assuming that a particular area or travel path contains a number of potential ignition sources, the probability can be calculated for the cloud not igniting after covering that area. Hence, it is possible to calculate the probability for the cloud to ignite at various stages in its development, for a given release location and wind direction.

For each release scenario (consisting of a release quantity, release location, a specific stability class and wind speed, and a wind direction), the ignition sources encountered by the cloud are listed. Letting P_i represent the ignition probability of the i^{th} ignition source to be encountered, and assuming that area A contains the first k sources, the probability that the cloud has not yet ignited after covering the area A is given by:

$$\prod_{i=1}^{k}(1-P_i)=(1-P_1)(1-P_2)...(1-P_k)$$

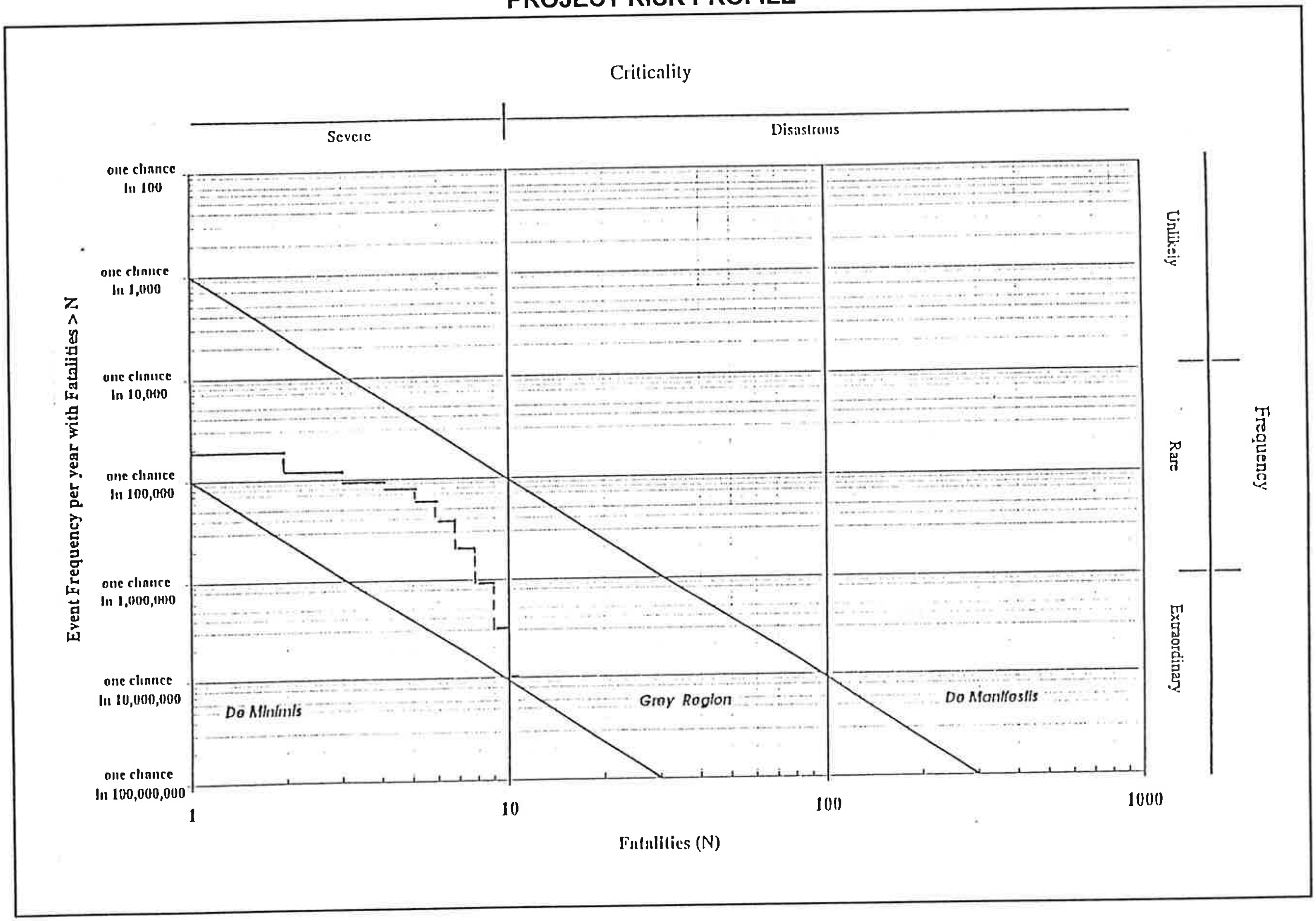
Uncertainties Associated with the Risk Profiles - There are many sources of uncertainty which can affect the accuracy of the risk profiles. These uncertainties deal with:

- Release frequency
- Release size
- Population impacts, including distribution and likelihood of fatality
- Behavior of the release (jet mixing versus passive dispersion)
- Accuracy of the hazard models
- Ignition sources and probabilities

The release frequencies and sizes are the most important contributors to overall uncertainty. The values chosen are conservative, i.e., they overstate rather than understate the risk. Changes in failure rates will directly influence the risk profile. A doubling of the event frequencies would double the probability of fatalities. Changes in the relative size of leaks and ruptures will influence the risk profile, but to a lesser extent. The assumptions on population distribution and ignition probability also influence the risk profiles, but are not as significant as the other sources of uncertainty.

Results of Analysis - The results of the consequence analysis are displayed on Figure 3-8. As can be seen by the figure, the risk profile for the proposed project lies in the grey region which is acceptable since the proposed project is equipped with extensive mitigation measures.

FIGURE 3-8
PROJECT RISK PROFILE



3.9 Transportation Risk Matrix

The potential risk of transportation of crude oil by truck and pipeline and natural gas by pipeline have been summarized using the criticality and frequency classification matrix defined in County of Santa Barbara Environmental Thresholds and Guidelines Manual and used in numerous EIRs in Santa Barbara County, including the Molino Gas Project EIR. The criticality and frequency classifications are presented in Table 3-3, while Figure 3-9 presents them in matrix format with shading added to show those boxes of the matrix classified as significant. The transportation-related accidents have been added to the appropriate boxes in the matrix and displayed as Figure 3-10. The following describes how the proper box was chosen for each mode of transportation.

Risk from Trucking

Section 3.4 presented information on the potential risk of transportation of crude oil by truck for one year during Phase 1 of the proposed project. Each tank truck will carry a maximum of 175 bbls of oil. Thus, according Figure 3-9, a tank truck release would be classified as "minor" according to spill size. The estimate frequency of tank truck release is 5.0×10^{-3} per year or once every 200 years (see Scenario 12a in Table 3-2). This would put the accident in the "unlikely" category which, when coupled with the minor consequence, would make the accident not significant. For a tank truck accident to present a public safety impact, the released oil would have to become ignited. The estimated frequency of occurrence of a spill with a fire has been calculated to be 5.0×10^{-4} per year or once every 2,000 years (see Scenario 12b in Table 3-2). This would place the accident in the "unlikely" category. If only the less than one mile section near the facility in Hermosa Beach is considered instead of the 10 mile trip, the estimated frequency of a spill with fire would be 5.0×10^{-5} per year or once every 20,000 years. This would put it in the "rare" category. A spill with fire would create a radiant hear footprint which could cause burns to the skin of exposed personnel. The radiant heat footprint would be limited to the area around the spill. People inside nearby homes or buildings would be protected from the radiant heat. People near the fire would instinctively move away from the heat. Thus, at most, such an accident could result in few minor injuries, putting it in the "minor" category. Thus, this accident would not be classified as significant. It is also pointed out here that this risk would only be present for one year.

Risk from Crude Oil Pipeline

The potential risk from the crude pipeline would be less than that of trucking because the estimated frequency of occurrence would be less and the maximum volume released would be less. The maximum volume that could be released would be 71 bbls, putting it in the "minor" category. The estimated frequency of a release is 1.3×10^{-4} per year, or once in

7,700 years (see Scenario 13a in Table 3-2), putting it in the "unlikely" category. Thus, the accident would not be classified as significant.

The estimated frequency of a release with fire is 1.3×10^{-5} per year or once in 77,000 years, putting it in the "rare" category. As with a truck release with fire, such an accident could cause, at most, a few minor injuries, putting it in the "minor" category. Such an accident would not be classified as significant.

Risk for Natural Gas Pipeline

It is possible for the 0.5-mile gas pipeline to become ruptured thereby releasing natural gas. The estimated expected frequency of such an event occurring is 2.3×10^{-4} or once every 4,300 years. The extent of the flammable gas hazard footprint and the potential consequences of the cloud would be a function of the size of the release, the location of the release relative to land use, the wind direction and speed, and stability condition. When all these variables are factored in, the probability of injuries from a gas pipeline release is less than 1.0×10^{-4} or once every 10,000 years, putting it in the "rare" category. Such an accident would result in some severe injuries due to burns, putting the accident in the "major" severity of consequence classification. Such an accident would not be classified as significant.

In summary, as can be seen by Figure 3-10, none of the transportation-related accidents would be classified as significant.

TABLE 3-3
CRITICALITY AND FREQUENCY CLASSIFICATIONS

CLASSIFICATION	DESCRIPTION OF PUBLIC SAFETY HAZARD
Negligible	No significant risk to the public, with no minor injuries
Minor	Small level or public risk with, at most, a few minor injuries
Major	Major level of public risk with up to 10 severe injuries
Severe	Severe public risk with up to 100 severe injuries or up to 10 fatalities
Disastrous	Disastrous public risk involving more than 100 severe injuries or more than 10 fatalities

TYPE	FREQUENCY	DESCRIPTION
Extraordinary	Less than once in one million years	An event whose occurrence is extremely unlikely
Rare	Between once in ten thousand years and once in one million years	An event which almost certainly would not occur during the project lifetime
Unlikely	Between once in a hundred and once in ten thousand years	An event which is not expected to occur during the project lifetime
Likely	Between once a year and once in one hundred years	An event which probably would occur during the project lifetime
Frequent	Greater than once a year	An event which would occur more than once a year on average

FIGURE 3-9
SEVERITY AND FREQUENCY MATRIX OF SIGNIFICANCE

		SEVERITY OF CONSEQUENCE				
		Negligible: No significant risk to the public, with no minor injuries; less than 10 bbls spilled	Minor: Small level of public risk, with at most a few minor injuries	Major: Major level of public risk with up to 10 severe injuries; 238-2,380 bbls spilled	Severe: Severe public risk with up to 100 severe injuries or up to 10 fatalities; 2,380 to 357,142 bbls spilled	Disastrous: Disastrous public risk involving more than 100 severe injuries or more than 10 fatalities; greater than 357,142 bbls spilled
FREQUENCY OF OCCURRENCE	Frequent: Greater than once a year					
	Likely: Between once a year and once in one hundred years					
	Unlikely: Between once in a hundred and once in ten thousand years					
	Rare: Between once in ten thousand years and once in a million years					
	Extraordinary: Less than once in a million years					

County defined as significant impacts

Source: County of Santa Barbara Department of Resource Management, Environmental Thresholds & Guidelines Manual, Amended 1990; Shell Hercules Platform EIR, 1983.

FIGURE 3-10
TRANSPORTATION RISK MATRIX

		SEVERITY OF CONSEQUENCE				
		Negligible: No significant risk to the public, with no minor injuries; less than 10 bbls spilled	Minor: Small level of public risk, with at most a few minor injuries	Major: Major level of public risk with up to 10 severe injuries; 238-2,380 bbls spilled	Severe: Severe public risk with up to 100 severe injuries or up to 10 fatalities; 2,380 to 357,142 bbls spilled	Disastrous: Disastrous public risk involving more than 100 severe injuries or more than 10 fatalities; greater than 357,142 bbls spilled
FREQUENCY OF OCCURRENCE	Frequent: Greater than once a year					
	Likely: Between once a year and once in one hundred years					
	Unlikely: Between once in a hundred and once in ten thousand years		Trucking accident with release and/or fire Crude oil pipeline release			
	Rare: Between once in ten thousand years and once in a million years		Crude oil pipeline release with fire	Gas pipeline accident		
	Extraordinary: Less than once in a million years					

County defined as significant impacts

Source: County of Santa Barbara Department of Resource Management, Environmental Thresholds & Guidelines Manual, Amended 1990; Shell Hercules Platform EIR, 1983.

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REESE-CHAMBERS SYSTEMS CONSULTANTS, INC.

Reese-Chambers Systems Consultants, Inc. (RCSC) is a small company located in Southern California near the City of Camarillo. RCSC has been providing professional consulting services to industry and agencies since 1979. One of RCSC's specialty areas is risk analysis of industrial projects. RCSC has conducted risk analysis in conjunction with Environmental Impact Reports and Statements (EIRs and EISs), Risk Management and Prevention Programs (RMPP), Hazard and Operability Studies (HAZOPs), Environmental Quality Assurance Programs (EQAP), and other agency-required special studies. RCSC has utilized various models in the conduct of risk studies including *ARCHIE, CHEMS-PLUS, WHAZAN, SLAB, AFTOX,* and *ISC.* RCSC has specific experience with a broad range of industrial applications including numerous oil industry facilities such as pipelines, pump stations, tank farms, and marine terminals:

- Preparation of the system safety/public safety section of the EIR for the State Lands Commission lease renewal of the Unocal Rodeo Marine Terminal.

- Conduct of 25 separate risk and hazard analyses to fullfill California Office of Oil Spill Prevention and Response (OSPR) requirements for oil spill contingency plans. Analyses included marine terminals, pipelines, oil platforms, onshore producing facilities, and onshore processing facilities.

- Consultant to Texaco Trading and Transportation, Inc. (TTTI) for the permitting of the Gaviota Marine Terminal. Also developed various risk analysis studies and papers in support of permit negotiation and compliance. Developed many of the Terminal contingency plans including the Emergency Response Plan and Oil Spill Contingency Plan.

- Developed the Risk Management Plans for the Ports of Los Angeles and Long Beach. The plans have been certified by the California Coastal Commission as annexes to the Ports' Master Plans, dealing with risk management for hazardous cargoes and petroleum products.

- Developed the risk analysis section of an environmental study addressing a proposed oil and gas development project on Sakhalin Island, Russia. The analysis addressed all aspects of the proposed project including oil and LNG export terminals.

- Developed terminal operations manuals for the Gaviota Marine Terminal and Unocal Avila Terminal to meet U.S. Coast Guard and California State Lands Commission requirements.

- Developed EQAP for Unocal Sisquoc Pipeline and Santa Maria Pump Station.

- Conducted overall spill risk and prevention analysis for Pacific Pipeline System, Santa Barbara to Los Angeles refineries.

- Conduct of RMPP and HAZOP studies for four electrical generation plants, a steam generating facility, a refrigeration plant, and numerous oil industry facilities including pipelines, tank farms, processing plants, and pump stations.

- Preparation of Process Safety Manuals for Unocal Rincon oil processing facility.

- Developed oil spill response plans for numerous facilities including the Gaviota Marine Terminal, Unocal Avila Wharf Terminal, Bush Oil Rincon Operations, and several pipelines in response to OPA 90 requirements.

- Developed numerous emergency response plans and fire protection plans for oil and gas projects including marine terminals, processing plants, pump stations, and pipelines.

- Conducted numerous risk studies as listed below:

  - GATX Port of Los Angeles Chemical Terminal
  - Proposed California Ammonia Company Ammonia Terminal in the Port of Los Angeles
  - Chevron Carpinteria Oil and Gas Processing Facility
  - Chevron Elk Hills Gas Plant Risk of Explosion Study
  - McMillen Long Beach Refinery Potential Risk to Nearby School Site
  - Oil and Gas Development Project on Sakhalin Island, Russia
  - Relocation of Defense Logistic Agency Fuel Pier and Pipeline in the Port of Los Angeles
  - Mutual Liquid Gas Propane Storage and Truck Loading Facility in Wilmington, California
  - Liquefied Gas and Chemical Terminal on the Firth of Forth, Scotland
  - Southern Pacific Pipeline Tank Farm Expansion in Carson, California
  - Unocal Product Pipeline through the City of Carson
  - Gaviota Interim Marine Terminal
  - Matlack Hazardous Material Trucking Terminal and Truck Cleaning Facility in Carson
  - Proposed Oil and Gas Development on Vandenberg Air Force Base
  - Proposed Natural Gas Pipeline Projects into the San Joaquin Valley
  - Tesoro Fuel Depot and Southern California Edison Storage Tanks in the Port of Hueneme
  - OSCO Solvent Recycling Facility in City of Azusa, California
  - Unocal Gas and Oil Processing Facility in Lisbon, Utah

Timothy J. Chambers
Senior System Safety Analyst

SUMMARY OF EXPERIENCE

Over 24 years of experience as a systems analyst, with major emphasis on safety and risk management analysis; oil and gas activities; hazardous material handling, storage, and transportation analysis; and contingency planning. Experience during the past 15 years has included extensive environmental work including that involving facilities handling hazardous materials. Other environmental analysis has involved risk management of maritime transportation, marine terminals, oil and gas activities, pipelines, truck and train transportation, and processing facilities. Experience includes work with industry and governmental agencies.

MAJOR PROJECT EXPERIENCE

- Conduct of 25 separate risk and hazard analyses to fulfill OSPR requirements for oil spill contingency plans. Marine facilities addressed included marine terminals, pipelines, platforms, onshore producing facilities, and onshore processing facilities, and customers included Unocal, Shell, Vintage, Torch, Global, Macpherson, and Mobil.

- Consultant to Unocal for the development of OPA 90 and OSPR oil spill contingency plans for the Avila Marine Terminal, Coast Area pipelines, Valley Area pipelines, and Point Pedernales pipeline.

- Consultant to Macpherson Oil Company for development of Oil Spill and Emergency Response Plans for their proposed Hermosa Beach oil development project. Plans were prepared for the drilling and production site, crude oil pipeline, and gas pipeline.

- Project Manager for the development of operating procedures for Unocal's Rincon Facility (ROSF)

- Development of public safety and vessel traffic analysis sections of an EIR on the renewal of Unocal's Rodeo Marine Terminal lease with the California State Lands Commission.

- Conduct of an analysis addressing the potential impacts on marine operations (nearby terminals and vessel traffic) caused by the construction of four alternative bridge configurations parallel to the existing Benicia-Martinez Bridge.

- Consultant to the Gaviota Terminal Company for the permitting of an oil transport marine terminal at Gaviota, California. Work included conduct of various studies and analyses to support system safety aspects of the marine terminal, its operations, and the transport of oil by tankers; negotiation of permit conditions; and the development of contingency plans including the Oil Spill Contingency Plan, Shoreline Cleanup Plan, Shoreline Access Plan, Terminal Operations Manual, Emergency Response Plan, and Fire Protection Contingency Plan.

- Development of the Navigational Hazard Analysis section of the various oil spill cooperative Regional Resource Manuals.

- Development of the vessel traffic analysis section of the Wickland Oil Terminal Expansion EIR.

- Consultant to Unocal Oil and Gas for the development of emergency response plans for their Santa Maria Basin oil and gas development project. Specifically developed separate emergency response plans for the Lompoc HS&P, the Battles Gas Plant, oil and gas pipeline segment from shore to the Lompoc HS&P, and the oil pipeline segment from the HS&P to the Orcutt Pump Station.

- Consultant to Unocal for the permitting of the Sisquoc Pipeline System. Conducted various analyses and developed various plans in support of this effort, including Fire Protection Plan, Emergency Response Plan, Oil Spill Contingency Plan, Environmental Quality Assurance Plan, Risk Analysis, and HAZOP.

- Responsible for risk analysis and mitigation development for a proposed offshore oil and gas development project in Russia. Risk analysis addressed all aspects of the project including offshore drilling and production, offshore and onshore oil and gas pipelines, oil and gas processing facilities, oil export terminal, LNG plant and export terminal, and refinery.

- Consultant for development of risk management programs and addressal of citizen concerns for various petroleum pipeline, tank farm, processing plant, refinery, and gas pipeline projects. Clients included City of Carson, City of Torrance, Long Beach Unified School District.

- Manager of system safety portions of EIR and EIS documents for various projects, including transportation, transfer, handling, and storage of chemicals for a proposed GATX chemical tank farm in Carson, California; natural gas pipeline development in San Joaquin Valley; oil and gas drilling, storage, transportation, and processing for Vandenberg Air Force Base; hazardous material transport, transfer, cleaning, and storage for the City of Carson; and hazardous waste material storage, transfer, processing, transport, and recycling for a facility located in Azusa, CA.

- Conducted risk analysis of potential for release, fire, and explosion at one of the gas plants at the Elk Hills Naval Petroleum Reserve.

- Risk analysis and mitigation design, contingency planning, and design and operation of risk management programs for various clients including County of Santa Barbara, Ports of Los Angeles and Long Beach, Cities of Beaumont and Carpinteria, Holchem, California Ammonia Company, Mutual Liquid Gas and Equipment Company, and others.

- Development of Risk Management and Prevention Programs (RMPPs) as required by California law for several industrial facilities including Colmac Energy, Bonneville Pacific, and Tracy Operators power plants; Sharyn Steam steam generation plant; and United Foods food processing plant. RMPPs address acutely hazardous materials such as ammonia, chlorine, and sulfuric acid.

- Conduct of Hazard and Operability (HAZOP) studies in support of the RMPPs listed above and for several oil pipeline and pump station projects.

- Development of risk management and maritime factors portions of EAs/EIRs/EISs for various oil and natural gas recovery projects covering gas and oil pipeline safety, shipping and other maritime impacts, drilling safety, etc. Projects included ARCO, Cities Service, Chevron, Phillips Petroleum, Shell Oil Company, Texaco.

- Responsible for public and system safety analysis section of EIR on a proposed household and small business hazardous waste collection facility in Santa Barbara, California.

- Responsible for all public and system safety aspects of the EIR/EIS for the Port of Los Angeles/Port of Long Beach 2020 Plan, a proposed landfill and expansion project. Work covered potential system safety impacts from landfill construction; impact on recreational, fishing, and commercial vessels; impact from trucking, pipeline, and train transportation of hazardous materials; impact on anchorages; and impact from oil spills.

- Responsible for analysis of potential impacts between tanker traffic to a proposed Exxon offshore marine terminal and potential oil and gas development in the vicinity of the marine terminal. Work conducted in the form of a supplemental EIR for the California State Lands Commission.

- Developed risk analysis and emergency procedures section of an environmental and risk assessment of coastal communities from LNG tanker traffic offshore Alaska.

- Responsible for risk analysis section of oil spill response plan developed for Alyeska Valdez Marine Terminal.

- Prime consultant to PBQ&D and US Navy for risk and reliability analysis for relocation of Navy fuel pier to Port of Long Beach. Work included extensive pipeline, tank farm, and marine terminal risk management analysis.

- Consultant to GATX for permitting risk analysis of a proposed expansion of a multi-petroleum product and chemical marine terminal and storage facility in the Port of Los Angeles.

- Project manager and consultant for port and vessel traffic risk management analysis for a multi-liquefied-gas terminal on the Firth of Forth, Scotland. Client was the Forth Ports Authority.

- Consultant to US NAVY for the development of the risk management portions of an encroachment analysis for the Seal Beach Naval Weapons Station. Risk management portions included vessel safety relative to explosive ordnance handling in Anaheim Bay, and potential hazards to the surrounding populace from ammunition storage and handling.

- Prime contractor and consultant to the Ports of Los Angeles and Long Beach, California in the development of the Ports' risk management plan for the handling, transportation, and storage of hazardous cargos at and through the ports. Also developed a generalized computerized model to calculate potential areas at risk from existing and proposed facilities.

EDUCATION

Bachelor of Science, Mathematics, Northeast Missouri University, Kirksville, MO (1966)

Bachelor of Science, Education (Mathematics and Physics), Northeast Missouri University, Kirksville, MO (1966)

Master of Science, Mathematics, University of Toledo, Toledo, OH (1968)

EMPLOYMENT EXPERIENCE

1979-Present	Reese-Chambers Systems Consultants, Inc. Principal of small consulting firm.
1968-1979	Naval Ship Systems Engineering Station, Port Hueneme, CA Branch Head for the Systems Analysis Branch.

ORGANIZATIONS

Society for Risk Analysis

Attachment 4

Macpherson Oil Company City of Hermosa Beach Project
Hazard Footprint Analysis - October 29, 1997

MACPHERSON OIL COMPANY

CITY OF HERMOSA BEACH PROJECT

HAZARD FOOTPRINT ANALYSIS

October 29, 1997

MACPHERSON OIL COMPANY

CITY OF HERMOSA BEACH PROJECT

HAZARD FOOTPRINT ANALYSIS

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FIGURES

The purpose of this analysis is to determine the potential risk to the surrounding community from the proposed Macpherson Oil Company City of Hermosa Beach Project. The analysis addresses the potential impact from fires, explosions, and releases at the proposed production site. It is emphasized here that the gas produced by the proposed project will contain levels of hydrogen sulfide (H_2S) well below levels considered to be a hazard to the surrounding community. The analysis makes use of the hazard footprint methodology described in the Port of Los Angeles "Final Risk Management Plan, An Amendment to the Port Master Plan" (Port of Los Angeles, 1983); the Port of Long Beach "Risk Management Plan, An Amendment to the Certified Port Master Plan, Final" (Port of Long Beach, 1981); and the Molino Gas Project EIR (Arthur D. Little, 1995). The methodology in the Port Risk Management Plans was developed in concert with the City of Long Beach and City of Los Angeles Fire Departments, the U.S. Coast Guard, and the California Coastal Commission. The methodology in the Molino Gas Project EIR was developed in accordance with County of Santa Barbara criteria.

The Port Risk Management Plans are in use at the Ports and govern the development of new projects and the modification of existing projects handling hazardous materials. Proposed new or modified projects are analyzed using the methodology in the Risk Management Plans, and projects not meeting the criteria in the plan are not approved. These procedures have been in place in the Ports for more than 10 years. The County of Santa Barbara safety impact thresholds utilized for projects within the County are presented in their Environmental Thresholds and Guidelines Manual (County of Santa Barbara, 1995).

The analysis also estimates the probability of accidents occurring involving the proposed project. These estimates are based on historical data for similar projects. These probabilities, the hazard footprints, and the nearby population density are then combined to construct a risk profile similar to those presented in the Molino Gas Project EIR. The risk profile presents an overall estimate of the total risk of the proposed project site to the surrounding community.

The results of the analysis show that the potential for accidents involving the facility is quite low and that the potential for these accidents causing fatalities is even lower. Some of the major results of the analysis are presented below.

- The expected annual frequency of a gas release that could result in an offsite flammable gas cloud is 8.2×10^{-5} (once in 12,100 years)

- The expected annual frequency of an oil release with fire is 5.1×10^{-6} (once in 195,000 years)

- The expected annual frequency of a vessel explosion is 8.0×10^{-7} (once in 1.25 million years)

- The expected annual frequency of a facility-caused offsite fatality is 1.2×10^{-5} (once in 83,000 years)

The expected annual frequency of a fatality to a nearby resident or other member of the public (e.g. passerby or worker) due to fires and/or burns from all causes is approximately 100 times greater than that due to an accident at the proposed facility. The expected annual frequency of a fatality due to electrocution is about five times greater than that due to the facility. The risk of fatality from distribution of natural gas to homes is approximately the same as the risk from the proposed facility.

It is also noted here that the proposed project site is currently being used by the City of Hermosa Beach as a maintenance operations facility and that these operations include the storage and handling of hazardous materials. As such, the site presently presents a potential hazard to the surrounding area similar to that of the proposed project. This potential hazard is discussed in the last section of this report.

This analysis looked at the proposed project and then postulated the types of accidents that could occur. The types of accidents postulated were based on historical data with similar type projects, on the types of accidents required to be analyzed by the Ports' Risk Management Plans, and on discussion with the Coastal Commission and Arthur D. Little, Inc. These accidents, referred to as Design Basis Accidents (DBAs), are listed below.

(1) A release of gas or oil in the well area without an immediate fire
(2) A release of oil in the well area with a fire
(3) A fire in an atmospheric oil storage tank
(4) The rupture of an oil storage tank into the surrounding secondary containment system without an ensuing fire
(5) The rupture of an oil storage tank into the surrounding secondary containment system with an ensuing fire
(6) An explosion in an oil storage tank
(7) A gas release from a process vessel
(8) An oil release from a process vessel into the surrounding secondary containment system without an ensuing fire
(9) An oil release from a process vessel into the surrounding secondary containment system with an ensuing fire
(10) A natural gas liquids (NGL) system accident including a liquids and gas release
(11) An accident involving the trucking of crude oil during Phase I
(12) An accident involving the crude oil pipeline during Phase II
(13) An accident involving the natural gas pipeline during Phase II

For each of the DBAs, the extent of the potential impact is then estimated using "hazard footprints." A hazard footprint is a diagram indicating the extent of the area within which a specified level of adverse effect is exceeded against a specified vulnerable resource. The following hazard footprints were calculated for the above DBAs as appropriate.

- *Radiant Heat from a Fire.* A fire will produce radiant heat. The distances to the 5 kW/m^2 (1,600 Btu/sq.ft./hr) and 10 kW/m^2 (3,200 Btu/sq.ft./hr) heat levels from those accidents involving fires have been calculated. 5 kW/m^2 is the level that can begin causing pain and second-degree burns to human skin exposed for 30 seconds, and is considered the minor injury level while 10 kW/m^2 can begin causing pain after 8 seconds and is considered the major injury threshold. People inside homes or shielded by objects such as homes or walls could stand a higher heat level before being impacted.

- *Flammable Gas Cloud from a Release.* When a flammable material is released, it begins producing flammable vapors which can drift with the wind, producing a gas cloud which may be ignited. The distances the cloud may travel before dispersing to a concentration below its lower flammability limit (LFL) have been calculated for releases of flammable materials. The flammable gas cloud hazard footprint has been calculated for two atmospheric conditions: stability condition F with 2.2 mph wind, and stability condition D with 5 mph wind. Stability Condition F consists of a low inversion layer, which tends to trap gas releases and prevent them from dispersing in the atmosphere. This condition occurs at night with low wind speeds. This condition usually results in the largest gas cloud hazard footprints.

- *Blast Overpressure and Flying Debris from an Explosion.* Both vessels and unconfined vapor clouds have the potential to explode. The blast overpressure, as a function of distance from such an explosion, has been calculated, along with an estimate of the distance that debris may be hurled by an explosion, as appropriate. A blast overpressure of 2.5 psig, which represents the pressure that can begin causing eardrum rupture, has been used as the blast overpressure hazard footprint threshold.

The only potential toxic material to be handled by the proposed project would be hydrogen sulfide (H_2S). It is possible that small amounts of H_2S will be present in the oil and gas produced by the proposed project, however, no more than 40 parts per million (ppm) of H_2S is expected, which is substantially below concentrations that would pose a health risk. The H_2S concentration of the produced gas will be monitored on a regular basis, i.e. each well will be tested monthly and the combined gas from all the wells will be monitored continuously. Any well found to contain H_2S in excess of 40 ppm will be shut in, or recompleted in a zone with less than 40 ppm.

It is noted here that the gas will be sold to Southern California Edison, which will accept up to 40 ppm H_2S in the gas. The proposed project also has a permit from the South Coast Air Quality Management District (SCAQMD) allowing gas with up to 40 ppm to be burned in the thermal oxidizer.

Hazard footprints have been determined using HFCP, the computer model used by the Ports of Los Angeles and Long Beach, and Chems-Plus, a commercially available program developed by and available from Arthur D. Little. The details of the methodology used by HFCP are documented in the Users' Manual (Reese-Chambers Systems Consultants, Inc., 1991). Details of Chems-Plus are contained in the Chems-Plus User Guide (Arthur D. Little, 1988). Gas release rates were modeled using Chems-Plus.

The proposed project will consist of two phases. Phase I will include the drilling of one to three exploratory and producing wells to prove the commercial value of the development. The emulsion (an oil and water mixture) and associated gas will be processed on site using portable equipment and the oil will be trucked offsite to a refinery. The water will be reinjected into the oil-producing reservoir. The gas will be scrubbed and incinerated. Phase II will produce emulsion and associated gas from 30 wells; separate the gas, oil, and water using gravity and heat; clean the separated water and reinject it using four wells; and store the oil on site until shipped by a newly constructed pipeline. The gas will also be shipped by a newly constructed pipeline.

The exact characteristics of the crude oil to be produced is not known at this time, however, the API gravity is expected to be between 17 and 21. While the characteristics of the oil have little effect on the size of the radiant heat, blast overpressure, and flying debris hazard footprints, they can have a significant impact on the flammable vapor cloud hazard footprint. Thus, to be conservative, we have assumed that the crude is fairly light with a flash point below 100°F, making it a flammable liquid. This assumption will tend to overestimate the size of the flammable vapor cloud hazard footprint.

The produced gas is expected to contain less than 40 ppm of hydrogen sulfide (H_2S). Hence, it is not expected to contain H_2S in concentrations high enough to be considered hazardous. Previous analyses done for projects in Santa Barbara County (e.g., Sandpiper Golf Course and Residential Development Draft EIR County of Santa Barbara, 1994] and Chevron Point Arguello Field and Gaviota Processing Facility SEIR [Arthur D. Little, 1988]) have generally used one or both of the following two H_2S concentrations in their risk analysis; 1000 ppm and/or 300 ppm. The 1000 ppm concentration was utilized as the H_2S concentration which could cause death after a few breaths. The 300 ppm concentration is the immediately dangerous to life or health (IDLH) concentration for H_2S. The IDLH concentration is defined as the maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects (U.S. Department of Transportation, 1992).

Recently, some analysts have been examining the Emergency Response Planning Guidelines (ERPGs) for use in risk analyses. These levels have been issued by the American Hygiene Association for use in emergency response planning and are not meant to be exposure thresholds. The ERPGs are substantially more conservative than IDLHs. The ERPG-3 concentration for H_2S is 100 ppm. ERPG-3 is defined as the maximum airborne concentration below which, it is believed, that nearly all individuals could be exposed up to one hour without experiencing or developing life-threatening health effects. As can be seen by the discussion above, the maximum expected H_2S concentration 40 ppm in the proposed project produced gas is well below the concentrations considered to be hazardous. In addition, it is noted that any gas released would immediately begin mixing with the surrounding air and that the H_2S concentration in the air would be well below 40 ppm.

3.1 Risk From Wells

Blowouts - A blowout is defined as the uncontrolled flow of formation fluids from a wellbore. They occur when formation fluids flow uncontrolled into a low-pressure subsurface zone (an underground blowout) or to the surface (a surface blowout). Most commonly, a blowout happens when there is insufficient pressure in a wellbore to control subsurface pressures. If wellbore hydrostatic pressure is allowed to drop below the subsurface formation pressure, then a "kick" will occur as the formation fluids flow into the well. Typically, a kick is circulated out of a well in a controlled manner, with formation fluids flowing into a production flowline or emergency flare line. When a kick is detected during drilling operations, the blowout prevention equipment (BPOE) is closed, sealing the wellbore and preventing any additional formation fluid from entering the wellbore. Additional kick-control procedures are implemented such as circulating higher density drilling fluid into the wellbore until the kick is circulated out of the well and normal operations can be resumed. A surface blowout occurs when formation fluids flow to the surface in an uncontrolled manner. A kick can lead to a blowout in rare instances (e.g., in a gas well that experiences a failure in the mechanical integrity of the equipment/system). Redundancy of equipment is a primary feature of blowout prevention equipment design.

A source of information on blowouts in California is a document titled "A History of Oil- and Gas-Well Blowouts in California, 1950 - 1990", published by the California Department of Conservation Division of Oil, Gas and Geothermal Resources (CDOG). This database includes both onshore and offshore wells.

The CDOG data shows an overall drilling incident rate of one blowout per 1,963 wells drilled during the time period 1950 - 1990. The incident rate for blowouts resulting in a release of oil is 1:20,315. The blowout incident rate from 1970 (after new regulations were implemented) through 1990 was 1:3,046 (a probability of 3.3×10^{-4} per well drilled).

Since the proposed project will not be into abnormally high pressurized reservoirs, and since steam injection will not be utilized, these types blowouts were excluded from the blowout incident rate calculations, resulting in a blowout incident rate of 1:10,969, a probability of 9.1×10^{-5} per well drilled. None of the remaining blowouts in the database flowed oil.

One factor that would tend to further reduce this low probability of a blowout is the fact that the Hermosa Beach project will be drilling into a reservoir whose characteristics are well known. The reservoir is not highly pressurized and will require pumping to bring the oil to the surface.

Based on the above statistics (blowout incident rate of 1:10,969), the probability of a blowout for the two phases of the proposed project are presented below. It is noted here that there is also one existing well on the site which will be converted to a water injection well.

PHASE	NUMBER OF WELLS	PROBABILITY OF BLOWOUT
1	3	2.7×10^{-4}
II	31	2.8×10^{-3}
BOTH	34	3.1×10^{-3}

Although the probability of a gas blowout is extremely low, a discussion of such an event follows. First, if a large pressure surge is encountered, the blowout prevention systems located on each well should prevent gas from escaping by closing off the annulus. In the highly improbably event that the annulus does not close, the gas will be diverted to the processing equipment or the on-site vent if the processing equipment is unable to handle the flow. The vent allows the gas, which is lighter than air, to escape upward away from potential ignition sources. Modeling shows that the gas being vented from a vertical flare will not reach flammable concentrations (approximately 5 percent for methane) at ground level and therefore should not be subject to ignition.

The Molino Gas Project EIR combined the analysis of a blowout with that of the gas production pipelines. The annual probability of such an occurrence was estimated to be 1.05×10^{-4}, or once every 9,500 years. The document states that a blowout has a lower probability of occurring than a production pipeline failure. The Molino estimate of a blowout is below that presented in the above table. The extent of the potential flammable gas cloud hazard footprint from a blowout was assumed to be the same as that of a pipeline rupture. The flammable gas cloud hazard footprint was calculated to be 381 feet for stability condition F. This same approach was taken in this analysis and the flammable gas cloud hazard footprint was calculated using Chems-Plus to extend 327 feet for stability condition F, 2.2 mph wind.

The probability of a blowout during drilling was deemed to be not significant by the Final Environmental Impact Report (Ultrasystems, 1994). This conclusion was based on the fact that the wells will be equipped with redundant safety devices, including blowout protectors. Thus, the worst case accident involving the wells has been postulated to be a leak in the well area flooding the well cellar. The leak would involve an emulsion containing approximately half oil and half water. The well cellar would be expected to contain any spilled liquid keeping it from spreading out.

Releases into the Well Cellar - The well cellar covers an area of approximately 2,060 feet. HFCP was utilized to calculate the flammable vapor cloud and radiant heat hazard footprints for a release that would cover the entire cellar area. The size of the hazard footprints is measured from the edge of the cellar area. The results are presented below.

- Radiant heat (5 kW/m^2) - 152 feet
- Radiant heat (10 kW/m^2) - 75 feet
- Flammable gas cloud - 17 feet

It is noted here that the vaporization rate from this pool would not produce enough vapor to become involved in an unconfined vapor cloud explosion. It is also noted here that the well cellar is below grade and that there is a 12 foot high block wall around the whole facility. This wall would somewhat reduce the extent of the radiant heat and flammable gas hazard footprints.

Regulations and technology have made wells extremely safe and the probability of a release of any size from a well is unlikely. As estimated previously, the probability of a major spill from a wellhead complex is 1.05×10^{-4} per year. The probability that the oil would become ignited would be 1.0×10^{-2} or one in a hundred (County of Santa Barbara, 1985). Thus, the annual probability of a release with fire would be 1.05×10^{-6}, or once every 950,000 years.

3.2 Risk from Storage Tanks

Oil and process water will be stored in five storage tanks located in a common secondary containment system (i.e. diked area that is eight feet below grade). The space above the liquid in the tanks will be filled (i.e. blanketed) with gas to prevent oxygen from being present. As long as oxygen is not present, an explosion is impossible. Hence, for an explosion to occur in a tank, the gas blanketing system would have to fail, a gas vapor/oxygen mixture in the flammable range would have to be present in the tank, and a source would have to ignite the vapor. The chances of this happening are extremely low. Nevertheless, the tanks will be constructed with weak seam cone roofs which are designed to lift to vent energy from an explosion, thereby preventing the tank from rupturing or blowing apart. If a roof does lift up from an explosion, it is expected to travel no more than several tank diameters from the tank. Although the proposed tank mitigation measures will virtually eliminate the possibility of an explosion, we have been requested to include such an accident in this analysis.

To mitigate the potential for a fire, each crude oil tank will be equipped with an external water deluge system that can flood the exterior of the tank with water for cooling purposes. Each tank will be fitted with a fire protection system that can blanket the internal head space of each tank with fire retardant foam, eliminating any possibility of fire. The water deluge system and foam system can be operated independently of each other or together as the case may require. These systems can be used to protect the tanks from other fire sources (e.g. a building fire on a nearby property).

The potential DBAs from the tanks addressed in this analysis include a fire in a tank, an explosion in a tank, and a rupture of a tank flooding the diked area, either with or without a fire. The following hazard footprint distances were calculated using HFCP. The largest tank, with a 2,600 bbl capacity, was used in the calculations. All of the hazard footprints are measured from the edge of the tank or diked area.

- Radiant heat from a fire in a tank - 156 feet (5kW/m^2); 76 feet (10kW/m^2)
- Blast overpressure from an explosion in a tank - 141 feet
- Flying debris from an explosion in a tank - 77 feet (5kW/m^2); 131 feet (10kW/m^2)
- Radiant heat from a fire in the diked area - 271 feet
- Flammable gas cloud from a release into the dike area - 33 feet

Again, it is noted that the 12 foot high block wall and the below-grade containment area would somewhat reduce the extent of all the hazard footprints.

The annual probability of a tank fire has been estimated to be 7.0 x 10^{-5} (Envicom, 1992). This equates to an annual probability of 2.1 x 10^{-4} for the three tanks, or once in 4,700 years. The rupture of an atmospheric storage tank due to all causes, including seismic events, is estimated to be 1.6 x 10^{-4}/year or once in 6,300 years (County of Santa Barbara, 1985). The probability that the oil is ignited is 1.0 x 10^{-2}, or one in a hundred. Thus, the probability of a release with a fire is estimated to be 1.6 x 10^{-6} per tank, or once in 625,000 years. Since there will be three storage tanks that may store crude oil, the probability of a spill with fire, per year, would be 4.8 x 10^{-6}, or once in 208,000 years.

The probability of an explosion in an oil storage tank has been estimated to be 1 x 10^{-4} per year (County of Santa Barbara, 1988). This is for all types of storage tanks. The tanks for the proposed project will be gas blanketed, which will virtually eliminate the possibility of a tank explosion.

3.3 Risk from Process Area

Free Water Knockouts - The first step in processing the emulsion will be the separation of the gas, oil, and water by means of gravity using free water knockout (FWKO) vessels. The gas that will be separated out will be primarily methane which is the predominant gas in natural gas piped to most homes. The emulsion enters the FWKO whereby the water, which is heavier than the oil, falls to the bottom of the tank while the oil floats on the water. The gas which escapes from the emulsion goes to the top of the tank. The water is drawn off the bottom of the tank and sent to the wastewater treatment system. The gas is drawn off and directed to the gas compression and treatment system. The oil is sent to heater treaters where it is further processed. The FWKOs are ASME certified pressure vessels. The potential for an explosion in one of these vessels is extremely unlikely, and thus no hazard footprints have been calculated for a vessel rupture. Instead, the DBA from a FWKO has been assumed to be a release from a 2-inch diameter hole, which represents a release from a pipe connection or other small release. The flammable gas hazard footprint from a 2-inch diameter hole in the tank would produce a flammable vapor cloud hazard footprint that would extend up to 327 feet from the point of release under worst case atmospheric conditions (stability F, 2.2 mph wind). The rate of release from the vessel was calculated using the Chems-Plus model developed by Arthur D. Little. This rate of release was then input to both Chems-Plus and HFCP to calculate the flammable gas cloud hazard footprint. The models also determined that the amount of gas (methane) in the cloud would not be enough to become involved in an unconfined vapor cloud explosion. A release from a FWKO or gas line would result in a rapid release which would last for a very short time, less than several seconds.

Heater Treaters - The oil is sent to heater treaters where it is heated to further separate out water and gas from the oil. In this case the majority of the emulsion entering the vessels is oil. The heater treaters are also ASME certified pressure vessels. Since the heater treaters will operate at approximately the same pressure as the FWKO, the release rate of gas from a 2-inch diameter hole will be approximately the same as that from the FWKO (it will actually be slightly less since the gas will expand because it is heated) and thus, the flammable vapor cloud hazard footprint will be approximately the same size.

A release of oil from the FWKOs or heater treaters could spread and cover the secondary containment area around the vessels. The surface area of the secondary containment area is approximately 7,780 sq.ft. The flammable gas cloud (if the spill doesn't ignite) and radiant heat hazard footprints were calculated by HFCP to be:

- flammable gas cloud - 41 ft
- radiant heat (5 kW/m^2) - 266 ft
- radiant heat (10 kW/m^2) - 130 ft

Arthur D. Little, 1995, has estimated that the probability of a major release from a pressure vessel is 8.0×10^{-7} per year, or once in 1,250,000 years. For the four vessels proposed for the facility, the combined annual probability of a major release would be 3.2×10^{-5} (once every 31,250 years). The probability that the released oil would become ignited is 1.0×10^{-2}. Thus, the annual probability of a major spill with fire is 3.2×10^{-7} (once in 3 million years).

Gas Dehydration - The gas from the FWKOs and heater treaters will be commingled with the casing gas and then compressed to 200 psig for further processing to remove any remaining water and the natural gas liquids (NGLs). The gas is then shipped out of the facility via a pipeline to be constructed.

A release from the 200 psig portion of the gas processing system would result in a rapid release and depressurization of the piping, glycol tower, and NGL tower. It has been conservatively estimated that there is less than 27 lbs. of produced gas in this portion of the system. This gas would be released in a few seconds. Low pressure sensors should shutdown production, preventing any additional gas from being released. If the system were to fail, gas would then be released from the 50 psig system until it was depressurized and then at the gas production rate. The 50 psig system was addressed above.

The release from the 200 psig system was modeled as a puff release. The flammable gas cloud for the two meteorological conditions is presented below. It is also noted that the gas cloud would dissipate rather rapidly. Also presented below is the maximum length of time that the lower flammability limit would be exceeded at any given location within the cloud.

- Stability F, 2.2 mph wind - 249 ft (7 seconds)
- Stability D, 5 mph wind - 118 ft (3 seconds)

NGL Treatment - The gas stream will be run through a refrigeration system to condense out the natural gas liquids (NGLs). It is most likely that a freon-based system will be used. However, depending on the composition of the gas, it is possible that a propane-base system will be required. The project engineer has calculated that if a propane system is required, only 5 to 10 gallons of propane will be required. This is equivalent to a backyard barbecue system and presents no hazard to the surrounding area.

The gas will be run through a 2 ft. diameter by 16 ft. tall cylindrical vessel (tower) for processing. This NGL tower will be an ASME-certified, heavy-walled pressure vessel equipped with safety relief valves to prevent the tank from being overpressurized. The vessel is designed in excess of a 4 to 1 safety factor. There will be about a 5 ft. liquid level in the tower. The estimated maximum production rate of NGLs from the tower is 1 gal/min which will be blended with the crude oil. The worst case accident involving the tower is a boiling liquid expanding vapor explosion (BLEVE). For this scenario to occur, four events need to occur simultaneously, including significant external fire, failure of the pressure relief valve, vessel blockage, and no external fire fighting efforts. It is noted here that the tower is located in a containment pit with the other processing equipment, and that the floor is contoured such that all spills would drain to a sump system away from the equipment. Arthur D. Little, 1995 has estimated that the failure rate of this event is 8.0×10^{-7} per year (once in 1.25 million years), which is classified as extraordinary.

The consequences of such an event include a fireball and a blast wave. Chems-Plus was utilized to calculate the following hazard footprints.

- Blast overpressure (2.5 psi) - 194 ft
- Fireball thermal radiation - 183 ft (minor injury); 84 ft (major injury)

Two other types of releases could occur with the NGL system, a gas release and a liquid release. The gas release was addressed above under gas dehydration. The liquid from a release would drain toward the sump. It would begin evaporating immediately upon release. The maximum amount of NGLs that could be released would be $\pi \times 1^2$ (radius) x 5 (liquid height) = 15.7 ft^3 = 118 gal. Such a release would produce a flammable vapor cloud of 353 ft. for F stability with 2.2 mph wind and 144 for D stability with 5 mph wind. The probability of such an event occurring has been estimated to be the same as that of a process vessel (3.2×10^{-5} or once in 31,250 years).

3.4 Risk from Trucking

During Phase 1, the oil will be stored on-site in portable tanks and then loaded into tanker trucks for transportation to a refinery. It is estimated that three to four tanker truck trips per day, each carrying 175 bbls of oil, will be required to handle the 600 bbl per day production. The tanker trucks will be loaded inside the facility in an area equipped with a drain and sump to contain any spillage, although none is expected. The Phase I site sump/containment system will be adequate to fully contain a 175 bbl spill. Trucks will exit the facility and follow designated routing from the facility. Trucks will not deviate from the city-designated route.

Trucking of petroleum products is quite common throughout the country. Gasoline and other petroleum products are routinely transported by tanker trucks to gas stations and industrial facilities. Tanker trucks can become involved in traffic accidents but these do not usually result in a loss of cargo. A worst case accident would result in the loss of the entire contents of the trucks (175 bbls). The released oil would then spread on the ground and could ignite if it encounters an ignition source. The area covered by the spill would be a function of the elevation profile of the surrounding area.

For the purpose of calculating the potential hazard footprints, it has been assumed that the oil is spilled on a flat surface and spreads to a uniform depth of one inch. The spill would cover an area of approximately 11,800 sq. ft. with a radius of approximately 57 ft. The radiant heat and flammable gas cloud hazard footprints were calculated by HFCP to be:

- Flammable gas cloud - 52 ft
- Radiant heat (5 kW/m^2) - 320 ft
- Radiant heat (10 kW/m^2) - 182 ft

It is noted here that oil burns at a rate of approximately 4 mm (0.16 in.) per minute and hence, a one-inch deep pool would burn for approximately 6.4 minutes. The pool would burn for a longer time if it were deeper, however, then the area would be smaller and the radiant heat footprint smaller.

The Handbook of Chemical Hazard Analysis Procedures (FEMA, undated) recommends using a truck accident rate of 2 x 10^{-6} accidents per mile with 20% of the accidents resulting in a release of cargo. The Handbook goes on to recommend that the following spill distribution be utilized:

- 10% cargo loss (17.5 bbl) - 60% of the time
- 30% cargo loss (52.5 bbl) - 20% of the time
- 100% cargo loss (175 bbl) - 20% of the time

Assuming that a loaded truck travels 10 miles results in the following annual probabilities of accidents and releases. It is assumed that the trucking lasts for one full year.

Event	Annual Probability
Accidents	2.5 x 10^{-2}
Spill of any size	5.0 x 10^{-3}
Spill of 17.5 bbls or less	3.0 x 10^{-3}
Spill between 17.5 bbls and 52.5 bbls	1.0 x 10^{-3}
Spill greater than 52.5 bbls	1.0 x 10^{-3}

3.5 Risk from Crude Oil Pipeline

A new produced crude oil shipping line will be constructed to transport produced crude oil from the oil production facility to the Southern California Edison (SCE) Redondo Beach storage facility and pipeline system. The Chevron pipeline previously being considered has been dropped. The new pipeline will be connected to the SCE manifold at the Redondo Beach storage facility and the oil directed to one of the storage tanks. The oil would then later be batched to one of the local refineries through the existing SCE pipeline system. The new pipeline would have an outside diameter of 6 inches and be approximately 0.5 miles (2,500 ft.) long. The pipeline is designed for a maximum operating pressure of 350 psig.

The amount of oil than can be released from a pipeline is made up of the amount that can be released until pumping is stopped plus the amount than can drain from the line due to gravity. The pipeline will be equipped with two systems that will continuously monitor the pipeline operation and shut it down automatically if abnormal conditions are detected. The supervisory control and data acquisition (SCADA) system will monitor crude oil flow rates at both ends of the pipeline and the volume of crude oil sent at the one end and the amount received on the other end. If the flow rates or volume at the two ends of the pipeline do not match within preset limits, the pipeline will be shut in, i.e. the pump shut down and the block valves closed. The second system will measure the pressure in the pipeline. The pipeline will be shut in if

The second system will measure the pressure in the pipeline. The pipeline will be shut in if either the pressure exceeds a preset limit or drops below a preset limit. A pipeline rupture would result in a nearly instantaneous pressure drop that would automatically shut in the pipeline. It is conservatively estimated that this would be done within 2 minutes. Hence, a maximum of 11 bbls [8,000 bbls per day / (24 hr x 60 min per hour) x 2 min] could be lost due to pumping. The capacity of the entire pipeline is 85 bbls, however block valves would be located at both ends of the line, with an additional one located approximately in the middle and hence, the maximum amount of oil that could drain from the pipeline if all the oil between block valves were to escape would be 43 bbls. Thus, the worst case release from the pipeline would be 54 bbls (11 bbls + 43 bbls).

As with a trucking accident, the area impacted by a pipeline spill would be a function of the elevation profile of the surrounding area. Assuming again that the spill occurs on a flat surface and spreads to a depth of one inch, this results in a 3,600 sq. ft. area being covered.

The radiant heat and flammable gas cloud hazard footprints were calculated by HFCP to be:

- Flammable gas cloud - 30 ft
- Radiant heat (5 kW/m^2) - 193 ft
- Radiant heat (10 kW/m^2) - 95 ft

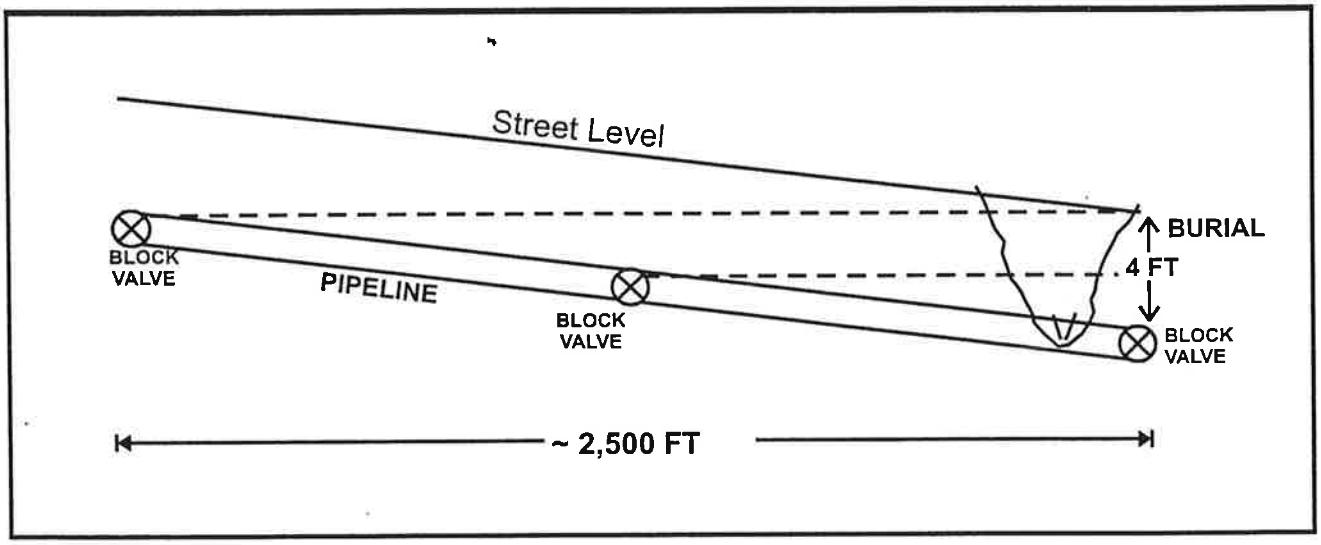
The probabilities of a leak and rupture for modern crude oil pipelines are generally estimated to be around 5.4 x 10^{-4} spills per pipeline-mile per year, and 2.7 x 10^{-4} ruptures per pipeline-mile per year, respectively (Aspen, 1995). This equates to the following annual probabilities for the 0.5 mile pipeline.

- Probability of leak - 2.7 x 10^{-4} (once in 3,700 years)
- Probability of rupture - 1.3 x 10^{-4} (once in 7,700 years)

The potential for oil getting in the ocean from a pipeline release was also examined. First, it would be virtually impossible for 43 bbls of oil to drain from the pipeline after pumping has ceased and the block valves are shut. The pipeline follows a relatively flat terrain dropping only about four feet in elevation between the proposed facility and the SCE Redondo Beach facility. The pipeline will be buried four feet below grade.

If the pipeline were to rupture near the end at its lowest point, up to 11 bbls could be pumped out. The pipeline trench will be backfilled with sand during construction. Much of the released oil would soak into the sand. Once the pumping has stopped, oil would begin draining out due to gravity. As shown in Figure 3-1, the top of the grade (i.e. street level) would be about even with the top of the pipeline at the facility. The top of the grade would be about two feet above the top of the pipe at the center of the block valve. Thus, it would not be possible for oil to drain out of the pipe into the street due to gravity.

FIGURE 3-1
PIPELINE PROFILE



Hence, it has been assumed that 11 bbls could be pumped out. It has further been assumed that approximately one fourth of the oil (3 bbls) would be absorbed by the trench, leaving 8 bbls that could escape. This oil would flow in the street and most likely eventually find its way to a storm drain opening. If it were raining, it is likely that most of the 8 bbls would reach the storm drain and get carried to the ocean. If it were dry, the oil would form smaller pools due to the unevenness of the street. Some of the oil would stick to the street as it flowed. Thus, somewhat less than 8 bbls would enter the drain and flow to the ocean though it is difficult to estimate the amount. It is also noted here that response actions would be taken to prevent the oil from entering storm drain openings. Sandbags and other measures would be used to block the drain openings and direct oil away from the drains to an area where the oil could be recovered. Cleanup contractors also have the necessary equipment and experience to contain the oil in the storm drains if it is not raining too hard. Macpherson has prepared a preliminary oil spill response plan which must be finalized and approved by the California Office of Oil Spill Prevention and Response (OSPR) prior to startup of the project. This plan addresses measures to be taken in the event of a pipeline release.

3.6 Risk from Gas Pipeline

The new gas pipeline will be constructed to transport gas from the facility to Southern California Edison. The new pipeline will have an outside diameter of 4 inches and will be approximately 0.5 miles long. Gas will be sent through the line on a continuous basis at approximately 120 psig, using the compressor located at the Macpherson production facility. Edison is permitted by SCAQMD to burn gas containing up to 40 ppm of H_2S. As stated previously, this concentration of H_2S is not hazardous. In addition, it is noted that any released gas would immediately mix with the air at the release point resulting in much lower concentrations of H_2S in the air than 40 ppm.

The rate of release of gas from the pipeline would be a function of the size of the hole. The larger the hole, the greater the release rate. A complete rupture of the line would shut down the compressor almost immediately. In addition, the line will be equipped with a check valve at the point where it connects to the utility line that would prevent gas from flowing into the line from the utility line.

Chems-Plus has been utilized to calculated the release rate and flammable vapor cloud hazard footprint from a pipeline rupture and from a small leak (e.g. ¼-inch diameter hole). The results are presented below.

Accident	Downwind Distance to LFL
• Pipeline rupture	467 feet
• ¼-inch hole	<10 feet

It is noted here that the downwind distance to the LFL calculated for the rupture is an overprediction because Chems-Plus treats the release as a point source and ignores the initial mixing with air caused by the jet release of the gas. The pipeline would be emptied of gas in about 4 seconds in the rupture case. It is also noted that this line is essentially the same as the numerous utility-owned and -operated gas lines throughout the area.

If the gas release were to immediately ignite, it would burn as a jet release until the gas flow ceased. This would last about 4 seconds. The flame length could be up to 211 feet long. If the gas cloud were to ignite, the fire would burn back to the source and burn as a jet flame. Thus, the radiant heat hazard footprint has been assumed to be equal to the flammable gas cloud hazard footprint.

The probability of a leak for a modern gas line is estimate to be 1.5×10^{-3} per pipeline-mile per year (Arthur D. Little, 1995). Thirty one percent of the leaks are estimated to be major leaks or ruptures. This equates to the following annual probabilities for the 0.5 mile gas pipeline.

- Probability of leak - 5.2×10^{-4} (once in 1,900 years)
- Probability of rupture - 2.3×10^{-4} (once in 4,300 years)

3.7 Summary of Accident Probabilities and Hazard Footprints

The results of hazard footprint analysis are summarized in Table 3-2. The table includes the probability of the accident, the extent of the hazard footprints (downwind and crosswind for flammable gas hazard footprints) for the two environmental conditions (stability F and stability D), and the area covered by the hazard footprint. The hazard footprints are displayed on Figure 3-2. Also included on the figure is the expected frequency of the accidents causing the hazard footprints. The expected frequencies presented are the sum of all the events that could cause that hazard footprint to occur.

As can be seen by the table, the largest hazard footprint from the facility would be an NGL liquids release. Such a release would produce a 353 foot flammable gas cloud hazard footprint. This hazard footprint would extend into the residential neighborhood to the north and the R-3 neighborhood to the west. The actual hazard footprint at the time of a release would only extend downwind, and would not cover the entire circular area shown. The actual hazard footprint for a west wind condition is also shown on the figure to illustrate this point. Also, it is noted here that the footprint would only be 353 feet during worst case environmental conditions, e.g. stability F with low wind speeds. As can be seen from the table, the hazard footprint would only extend 144 feet during typical environmental conditions. The flammable gas hazard footprint would only be a hazard if it were to be ignited. The largest injury radiant heat hazard footprint would extend 271 feet and would form a circle as shown because the radiant heat would be given off in all directions. The injury radiant heat hazard footprint extends into the residential neighborhood to the north and just touches the R-3 neighborhood to the west. It is noted here that this footprint would not impact people inside or behind structures. In addition, people outdoors exposed to the heat from a fire, would have time to find shelter before they would sustain burns. The largest major injury radiant heat hazard footprint would extend 131 feet. A fire at the facility should not impact homes or other structures in the area.

The truck, oil pipeline, and gas pipeline accidents would occur offsite and their potential impact would be a function of where the accident occurred relative to vulnerable resources. Figure 3-3 shows the proposed truck route and Figure 3-4 shows the proposed oil and gas pipeline route. Figure 3-5 plots the truck hazard footprints while Figure 3-6 plots the pipeline hazard footprints.

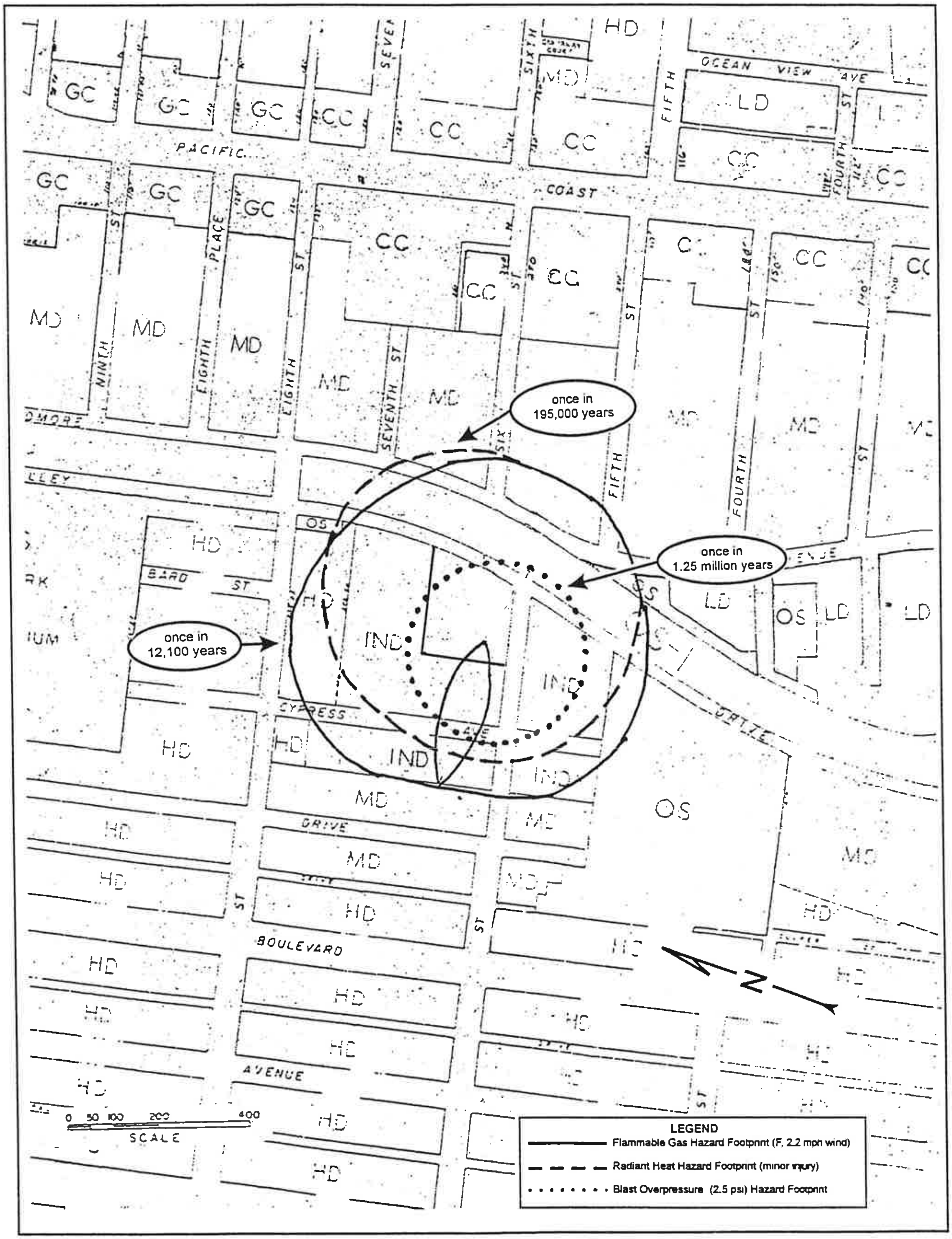
TABLE 3-2
SUMMARY OF ACCIDENT PROBABILITIES AND HAZARD FOOTPRINTS

SCENARIO	ANNUAL PROB OF ACCIDENT	STABILITY F / 2.2 MPH WIND			STABILITY D / 5 MPH WIND		
		DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)	DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)
(1) Release in well area (blowout or pipe rupture) without fire - flammable gas hazard	1.1×10^{-4}	327	131	33,600	101	41	3,250
(2) Release in well area with fire - radiant heat hazard	1.1×10^{-6}	152 ft minor injury 75 ft major injury	Circle	18,150 4,400	152 ft minor injury 75 ft major injury	Circle	18,150 4,400
(3) Fire in atmospheric storage tank - radiant heat hazard	2.1×10^{-8}	156 ft minor injury 76 ft major injury	Circle	19,100 4,500	156 ft minor injury 76 ft major injury	Circle	19,100 5,400
(4) Release into containment system from storage tank without fire - flammable gas hazard	4.8×10^{-4}	33	15	390	11	5	43
(5) Release into containment system from storage tank with fire - radiant heat hazard	4.8×10^{-6}	271 ft minor injury 131 ft major injury	Circle	53,000 13,500	271 ft minor injury 131 ft major injury	Circle	53,000 13,500
(6) Explosion in storage tank - blast overpressure and flying debris hazards	0 - tanks will be gas blanketed						
(7a) Release from a 50 psig process vessel - flammable gas hazard	3.2×10^{-5}	327	131	33,600	101	41	3,250
(7b) Release from the 200 psig process system	3.2×10^{-5}	249	21	5,200	118	17	2,000
(8) Process vessel liquids leak into containment system without fire - flammable gas hazard	3.2×10^{-5}	41	20	640	14	6	115
(9) Process vessel leak into containment system with fire - radiant heat hazard	3.2×10^{-7}	266 ft minor injury 130 ft major injury	Circle	55,600 13,300	266 ft minor injury 130 ft major injury	Circle	55,600 13,300

TABLE 3-2
SUMMARY OF ACCIDENT PROBABILITIES AND HAZARD FOOTPRINTS (continued)

SCENARIO	ANNUAL PROB OF ACCIDENT	STABILITY F / 2.2 MPH WIND			STABILITY D / 5 MPH WIND		
		DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)	DOWNWIND DISTANCE (FT)	CROSSWIND DISTANCE (FT)	AREA (SQ. FT.)
(10a) NGL tower BLEVE Blast overpressure	8.0×10^{-7}	194 ft to 2.5 psi	Circle	29,600	194 ft to 2.5 psi	Circle	29,600
(10b) NGL tower BLEVE Fireball thermal radiation	8.0×10^{-7}	183 ft minor injury 84 ft major injury	Circle	26,600 5,500	183 ft minor injury 84 ft major injury	Circle	26,600 5,500
(10c) NGL tower liquid release - flammable gas hazard	3.2×10^{-5}	353	142	39,500	144	58	6,600
(11a) Truck release of crude oil without fire - flammable gas hazard	5.0×10^{-3}	52	25	1,020	16	8	100
(11b) Truck release of crude oil with fire - radiant heat hazard	5.0×10^{-4}	320 ft minor injury 182 ft major injury	Circle	80,400 26,000	320 ft minor injury 182 ft major injury	Circle	80,400 26,000
(12a) Pipeline release of crude oil without fire - flammable gas hazard	1.3×10^{-4}	30	14	330	10	5	40
12b) Pipeline release of crude oil with fire - radiant heat hazard	1.3×10^{-5}	193 ft minor injury 95 ft major injury	Circle	36,600 8,800	193 ft minor injury 95 ft major injury	Circle	36,600 8,800
(13) Gas pipeline release - flammable gas hazard	2.3×10^{-4}	467	187	68,600	214	86	14,450

FIGURE 3-2
RESULTS OF HAZARD FOOTPRINT ANALYSIS



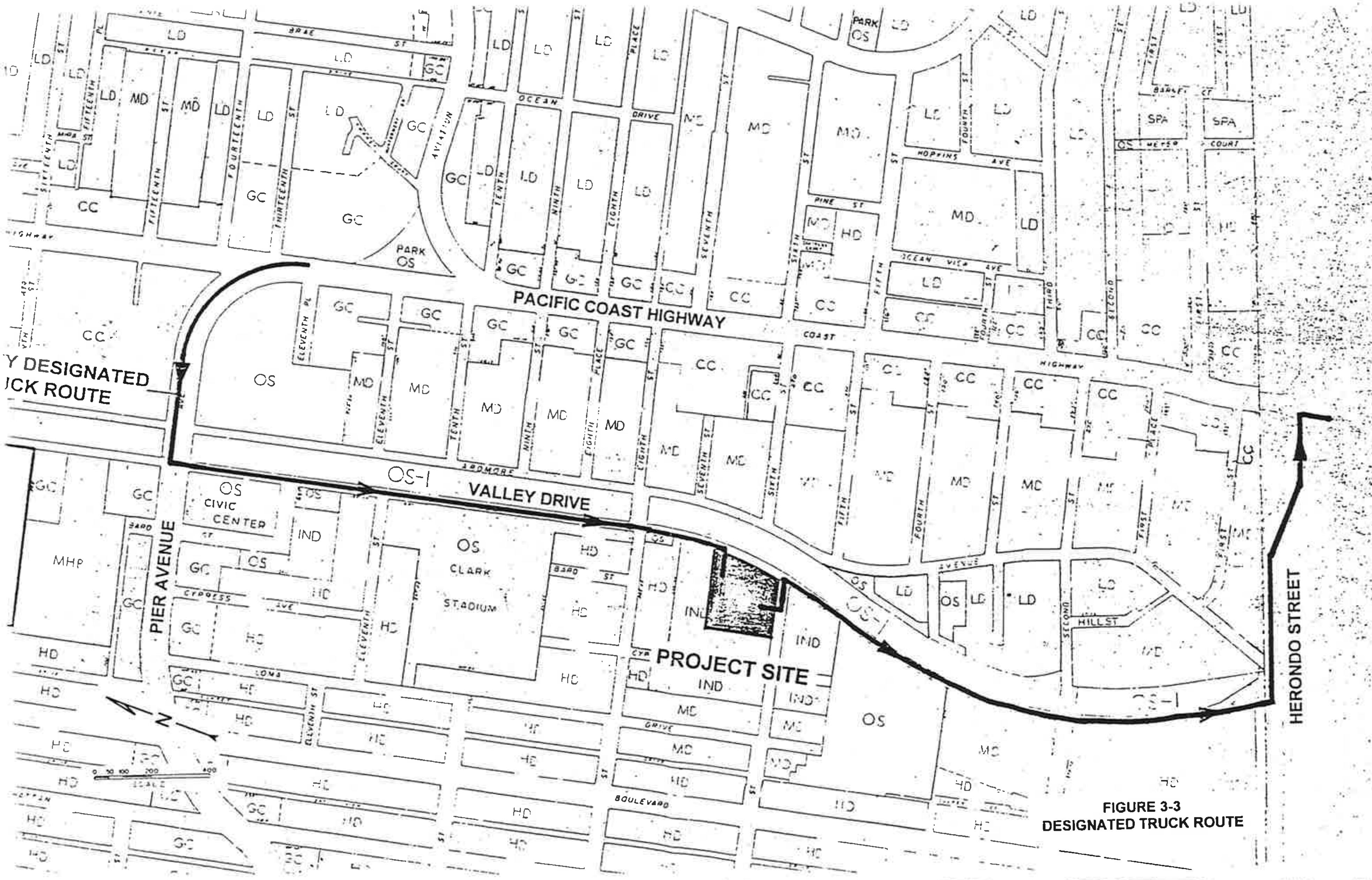
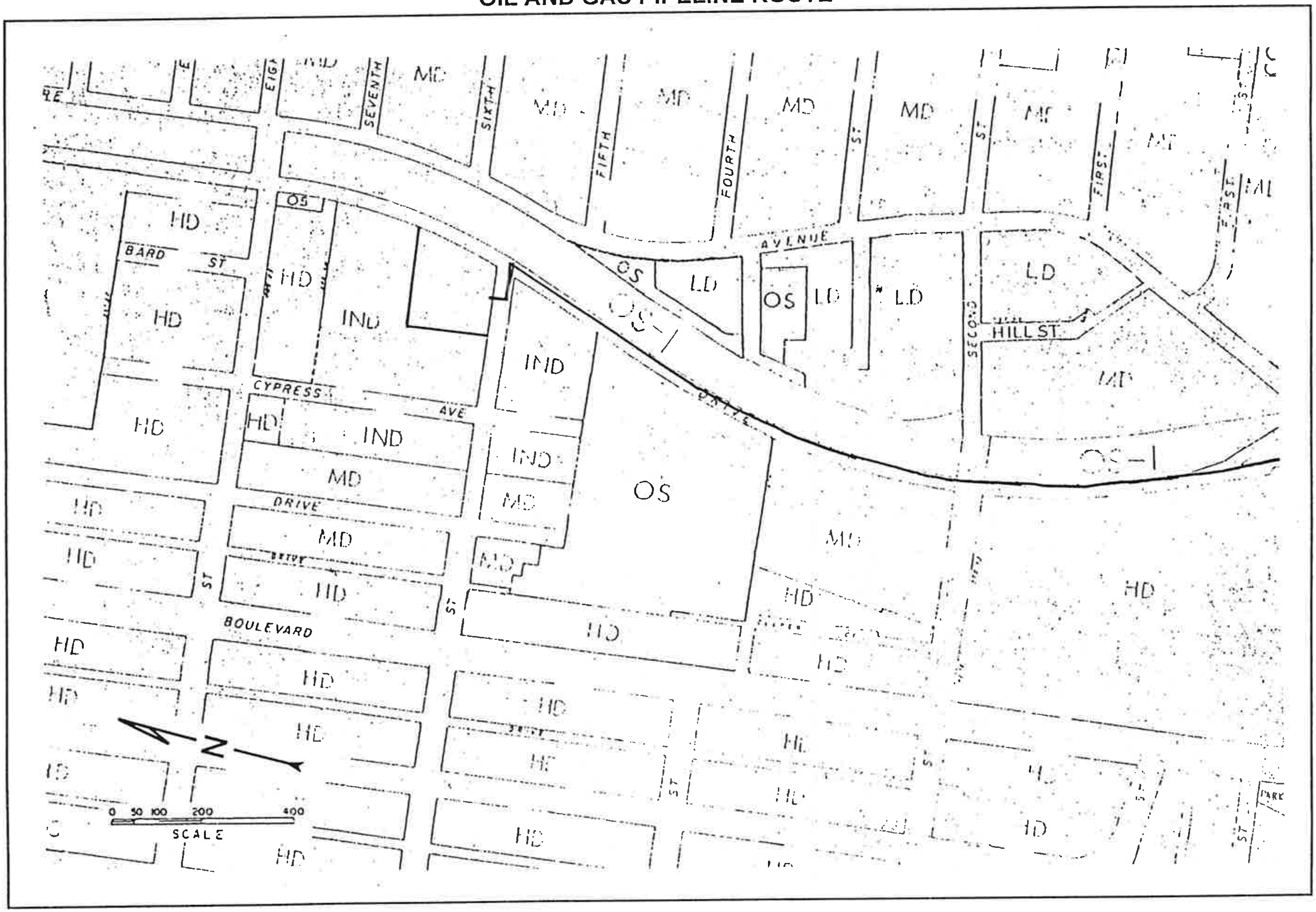


FIGURE 3-3
DESIGNATED TRUCK ROUTE

FIGURE 3-4
OIL AND GAS PIPELINE ROUTE



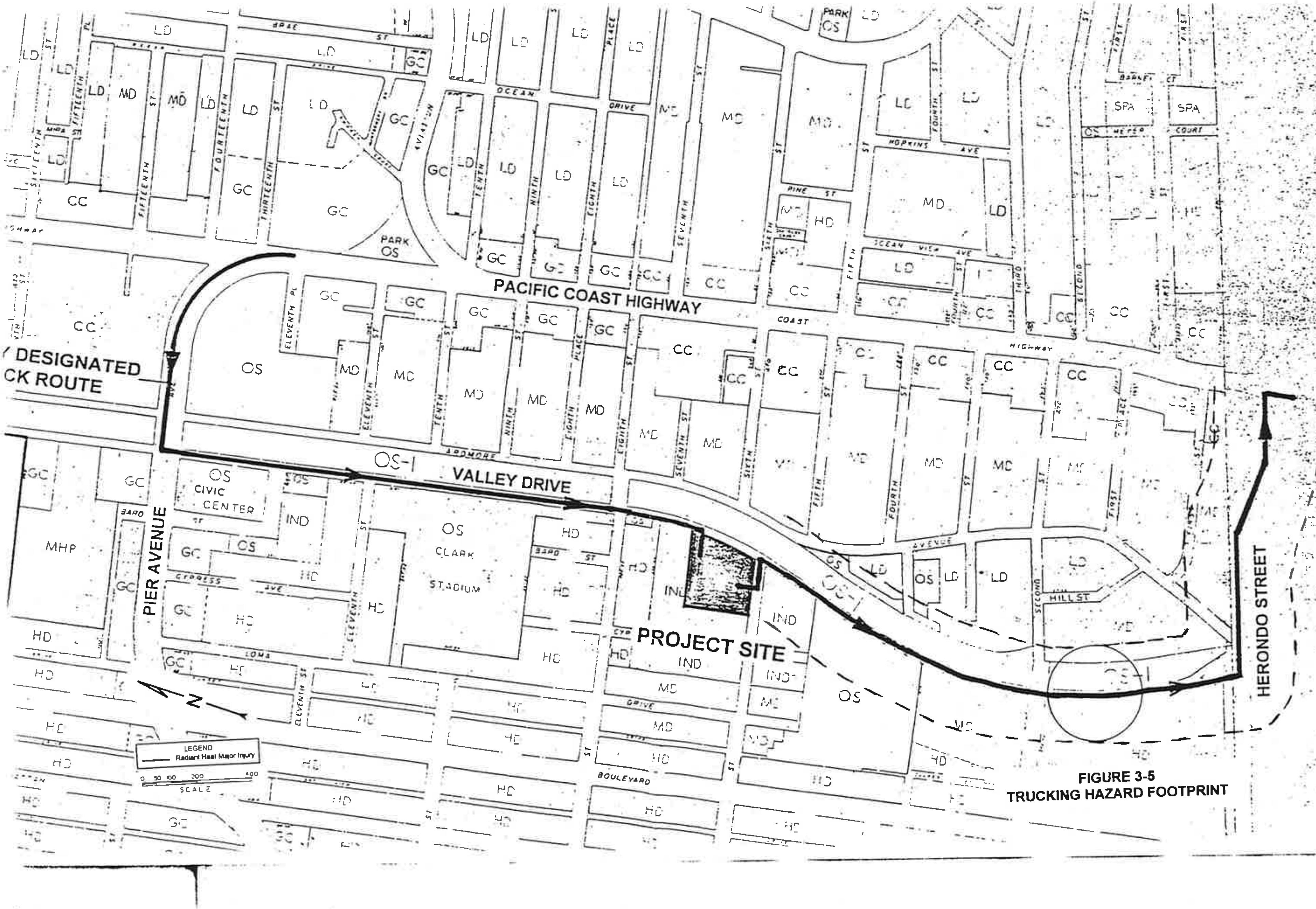
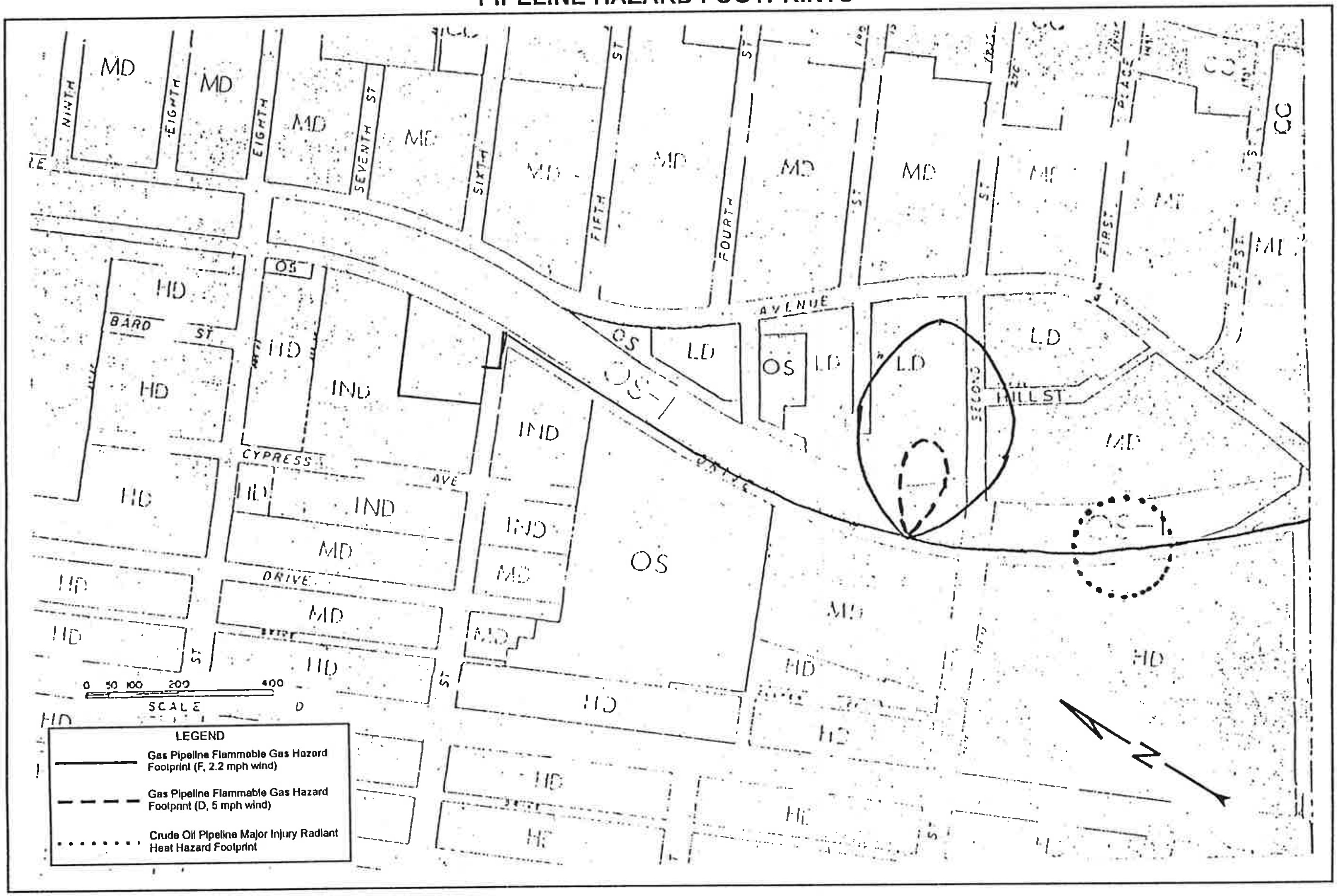


FIGURE 3-5
TRUCKING HAZARD FOOTPRINT

FIGURE 3-6
PIPELINE HAZARD FOOTPRINTS



3.8 Consequence Analysis

The results of the failure rate and consequence analysis have been combined to develop plots of frequency versus fatalities similar to that shown in the Molino Gas Project EIR. These curves are commonly called risk profiles. Figure 3-7 presents the guidelines used in the Molino Gas Project EIR for the determination of offsite risk and significance. Points above the upper line, labeled "De Manifestis", are considered to be an unacceptable risk, while those below the line, labeled "De Minimis", are considered acceptable. Points between the two lines, labeled "grey region", are acceptable but mitigation may be required. The following factors were utilized in developing the risk profiles.

- extent of hazard footprint for each environmental condition
- estimated frequency rate for each accident
- estimated frequency of occurrence for each atmospheric condition
- estimated frequency of occurrence of wind direction
- population density
- presence of ignition sources
- probability of ignition from each ignition source

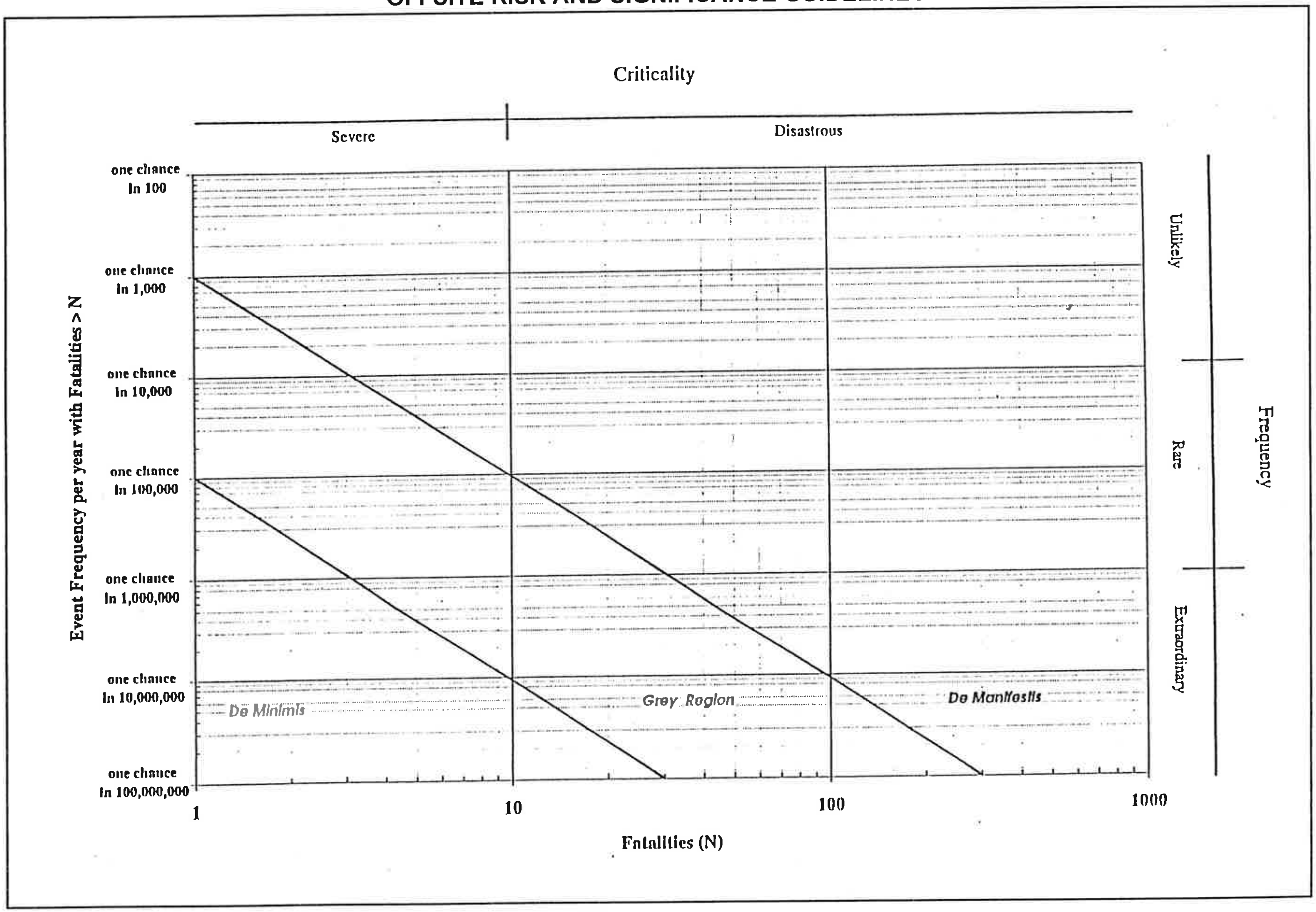
Meteorological Data - Meteorological data for the project site were obtained from California Air Resources Board, 1984 and California Department of Water Resources, 1978. Data for two sites, Los Angeles International Airport and Redondo-King Harbor were utilized.

The basic approach determined the relative likelihood of each of the two stability conditions, D and F, occurring. Condition D was used to represent conditions A through D and condition f to represent conditions E and F. The frequency of wind direction was taken from the two data sources.

Conditional Impact Probabilities - The likelihood is not 100 percent of a fatality resulting from an exposure to a vapor cloud fire. Buildings can provide some protection hazards. The analysis assumes 30 percent fatality within the lower flammability limit.

People inside buildings would not be harmed by a radiant heat hazard footprint. People outside their homes could begin to received second degree burns if exposed for longer than 30 seconds. Because the radiant heat hazard footprint only overlaps a small residential area, it has been assumed that most people exposed would be in their homes or could easily leave the area in a short time. Thus, it has been assumed there would be no fatalities due to radiant heat.

FIGURE 3-7
OFFSITE RISK AND SIGNIFICANCE GUIDELINES



Population Distribution - The population distribution was estimated from the Hermosa Beach General Plan Map. Each residential unit was assumed to house four people.

Ignition Probabilities - Flammable vapor clouds have the potential to ignite anywhere within their flammable limits. Hence, it is necessary to identify potential ignition sources that a cloud may encounter, and to quantify the likelihood of ignition, if the cloud encompasses the sources. In general, when trying to identify ignition sources, the search is primarily for open flames, hot surfaces and electrical sparks, and, to a lesser extent, friction sparks from both continuous and intermittent activities. Some of the potential ignition sources identified in the Molina Gas Project EIR were:

- Vehicles (many specific sources were identified)
- Boilers
- Gas turbines
- Blow torches
- Fired heaters
- Welding
- Faulty wiring
- Pilot flames
- Fireplaces and wood/coal stoves
- Smoking materials
- Doorbells
- Switches
- Furnaces/incinerators
- Machine tools
- Flares

Ignition probabilities used in the Molino Gas Project EIR include:

- ***Cars*** - 0.2 per car; although many potential ignition sources within a car like faulty wiring or backfires are due to fuel rich mixtures in intake air, they are not always present nor guaranteed to cause ignition.

- ***Houses*** - 0.01 per house; while there are many ignition sources within a home, such as switches, doorbells, faulty wiring, pilot lights, smoking materials, fireplaces and wood- or coal-burning stoves, the flammable vapors must first penetrate the house before these ignition sources pose a hazard. Typical residence times of clouds are often brief enough that this is relatively unlikely.

- ***Immediate Ignition*** - There are various ignition sources at the project facility such as electrostatic ignition or friction sparks that would ignite the vapor cloud on the project site. In keeping with the Molino Gas Project EIR, a figure of 0.2 has been assumed for the probability of immediate ignition.

Construction of Risk Profiles - The risk profile displays the frequency with which fatalities could occur. They indicate accident size and display how the potential number of fatalities varies as a function of frequency. The risk profile has been plotted on a log-log scale because the profiles span multiple orders of magnitude.

The general approach involved in constructing a risk profile involves determining the frequency and number of fatalities associated with each release scenario. A release scenario is defined by the following:

- Release location
- Release frequency
- Meteorological stability condition and its likelihood
- Wind direction and its likelihood
- Whether and where ignition occurs
- Area of the hazard zone
- Number of individuals exposed within each hazard zone
- Assumed fatality rate for that type of hazard

Some of these factors affect frequency, some determine impacts, and some influence both. Once all possible combinations have been analyzed, the results are combined to give the overall risk profile.

If a flammable release does not ignite immediately, the material will disperse, forming a vapor cloud which will travel downwind. Should the cloud encounter an ignition source (such as cars, pilot lights, open flames, furnaces or other equipment), the cloud will ignite and burn through the flammable area until all flammable material is consumed. For each release scenario, it is necessary to identify the ignition sources that would be encountered. Assuming that a particular area or travel path contains a number of potential ignition sources, the probability can be calculated for the cloud not igniting after covering that area. Hence, it is possible to calculate the probability for the cloud to ignite at various stages in its development, for a given release location and wind direction.

For each release scenario (consisting of a release quantity, release location, a specific stability class and wind speed, and a wind direction), the ignition sources encountered by the cloud are listed. Letting P_i represent the ignition probability of the i^{th} ignition source to be encountered, and assuming that area A contains the first k sources, the probability that the cloud has not yet ignited after covering the area A is given by:

$$\prod_{i=1}^{k}(1-P_i)=(1-P_1)(1-P_2)\ldots(1-P_k)$$

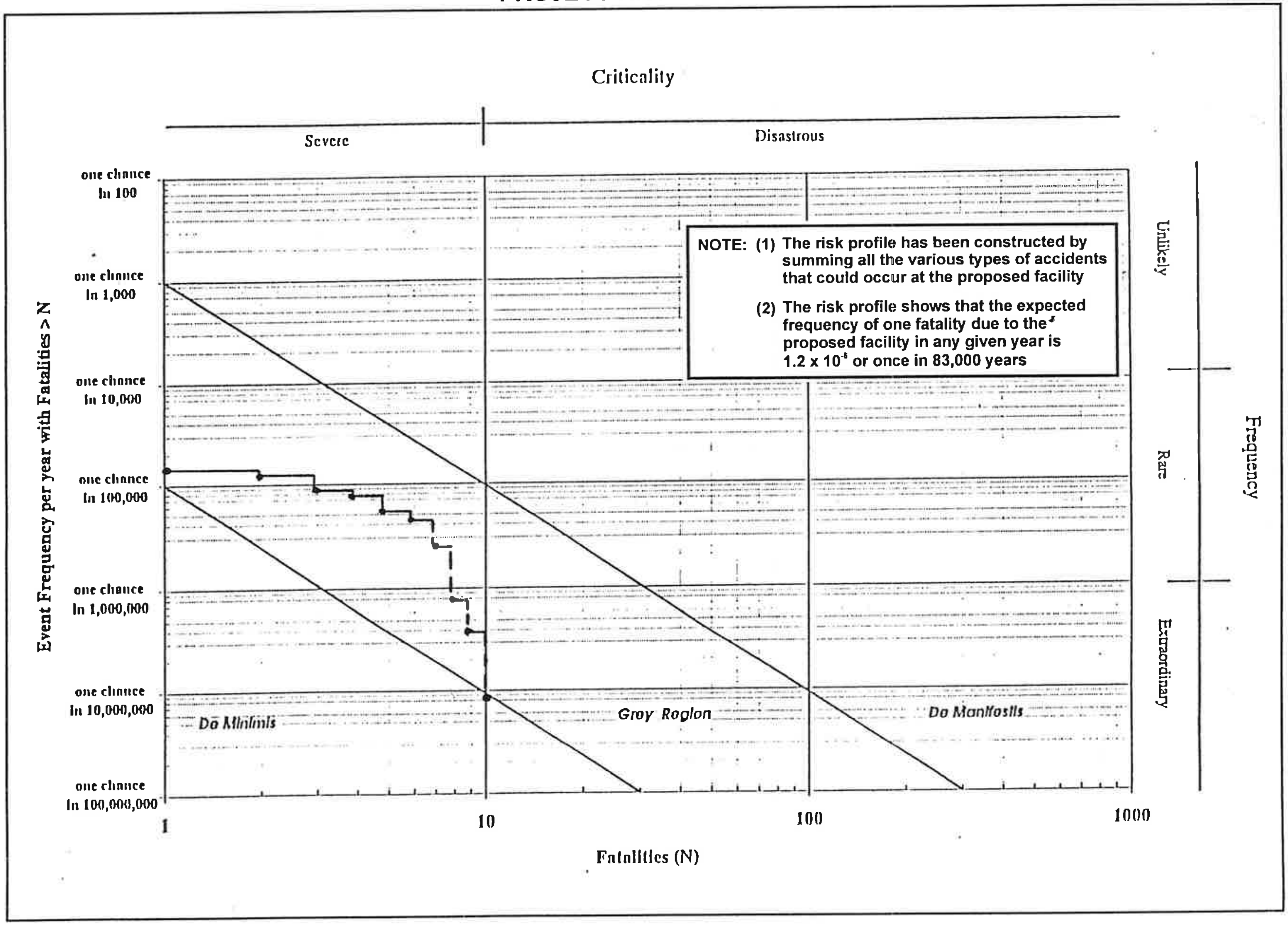
Uncertainties Associated with the Risk Profiles - There are many sources of uncertainty which can affect the accuracy of the risk profiles. These uncertainties deal with:

- Release frequency
- Release size
- Population impacts, including distribution and likelihood of fatality
- Behavior of the release (jet mixing versus passive dispersion)
- Accuracy of the hazard models
- Ignition sources and probabilities

The release frequencies and sizes are the most important contributors to overall uncertainty. The values chosen are conservative, i.e., they overstate rather than understate the risk. Changes in failure rates will directly influence the risk profile. A doubling of the event frequencies would double the probability of fatalities. Changes in the relative size of leaks and ruptures will influence the risk profile, but to a lesser extent. The assumptions on population distribution and ignition probability also influence the risk profiles, but are not as significant as the other sources of uncertainty.

Results of Analysis - The results of the consequence analysis are displayed on Figure 3-8. As can be seen by the figure, the risk profile for the proposed project lies in the grey region which is acceptable since the proposed project is equipped with extensive mitigation measures. It is emphasized here that the risk profile presents the expected frequency of fatalities occurring due to all the types of accidents that could occur at the proposed facility involving all the various pieces of equipment and operations. The risk profile shows that the expected frequency of a single fatality (the left-most point on the risk profile) in any given year is 1.2×10^{-5} (once in 83,000 years), while the expected frequency of ten fatalities (the right-most point) is 8.3×10^{-8} (once in 12 million years).

FIGURE 3-8
PROJECT RISK PROFILE



3.9 Transportation Risk Matrix

The potential risk of transportation of crude oil by truck and pipeline and natural gas by pipeline have been summarized using the criticality and frequency classification matrix defined in County of Santa Barbara Environmental Thresholds and Guidelines Manual and used in numerous EIRs in Santa Barbara County, including the Molino Gas Project EIR. The criticality and frequency classifications are presented in Table 3-3, while Figure 3-9 presents them in matrix format with shading added to show those boxes of the matrix classified as significant. The transportation-related accidents have been added to the appropriate boxes in the matrix and displayed as Figure 3-10. The following describes how the proper box was chosen for each mode of transportation.

Risk from Trucking

Section 3.4 presented information on the potential risk of transportation of crude oil by truck for one year during Phase 1 of the proposed project. Each tank truck will carry a maximum of 175 bbls of oil. Thus, according Figure 3-9, a tank truck release would be classified as "minor" according to spill size. The estimate frequency of tank truck release is 5.0×10^{-3} per year or once every 200 years (see Scenario 11a in Table 3-2). This would put the accident in the "unlikely" category which, when coupled with the minor consequence, would make the accident not significant. For a tank truck accident to present a public safety impact, the released oil would have to become ignited. The estimated frequency of occurrence of a spill with a fire has been calculated to be 5.0×10^{-4} per year or once every 2,000 years (see Scenario 11b in Table 3-2). This would place the accident in the "unlikely" category. If only the less than one mile section near the facility in Hermosa Beach is considered instead of the 10 mile trip, the estimated frequency of a spill with fire would be 5.0×10^{-5} per year or once every 20,000 years. This would put it in the "rare" category. A spill with fire would create a radiant heat footprint which could cause burns to the skin of exposed personnel. The radiant heat footprint would be limited to the area around the spill. People inside nearby homes or buildings would be protected from the radiant heat. People near the fire would instinctively move away from the heat. Thus, at most, such an accident could result in few minor injuries, putting it in the "minor" category. Thus, this accident would not be classified as significant. It is also pointed out here that this risk would only be present for one year.

Risk from Crude Oil Pipeline

The potential risk from the crude pipeline would be less than that of trucking because the estimated frequency of occurrence would be less and the maximum volume released would be less. The maximum volume that could be released would be 71 bbls, putting it in the "minor" category. The estimated frequency of a release is 1.3×10^{-4} per year, or once in 7,700 years (see Scenario 12a in Table 3-2), putting it in the "unlikely" category. Thus, the accident would not be classified as significant.

TABLE 3-3
CRITICALITY AND FREQUENCY CLASSIFICATIONS

CLASSIFICATION	DESCRIPTION OF PUBLIC SAFETY HAZARD
Negligible	No significant risk to the public, with no minor injuries
Minor	Small level or public risk with, at most, a few minor injuries
Major	Major level of public risk with up to 10 severe injuries
Severe	Severe public risk with up to 100 severe injuries or up to 10 fatalities
Disastrous	Disastrous public risk involving more than 100 severe injuries or more than 10 fatalities

TYPE	FREQUENCY	DESCRIPTION
Extraordinary	Less than once in one million years	An event whose occurrence is extremely unlikely
Rare	Between once in ten thousand years and once in one million years	An event which almost certainly would not occur during the project lifetime
Unlikely	Between once in a hundred and once in ten thousand years	An event which is not expected to occur during the project lifetime
Likely	Between once a year and once in one hundred years	An event which probably would occur during the project lifetime
Frequent	Greater than once a year	An event which would occur more than once a year on average

The estimated frequency of a release with fire is 1.3×10^{-5} per year or once in 77,000 years, putting it in the "rare" category. As with a truck release with fire, such an accident could cause, at most, a few minor injuries, putting it in the "minor" category. Such an accident would not be classified as significant.

Risk for Natural Gas Pipeline

It is possible for the 0.5-mile gas pipeline to become ruptured thereby releasing natural gas. The estimated expected frequency of such an event occurring is 2.3×10^{-4} or once every 4,300 years. The extent of the flammable gas hazard footprint and the potential consequences of the cloud would be a function of the size of the release, the location of the release relative to land use, the wind direction and speed, and stability condition. When all these variables are factored in, the probability of injuries from a gas pipeline release is less than 1.0×10^{-4} or once every 10,000 years, putting it in the "rare" category. Such an accident would result in some severe injuries due to burns, putting the accident in the "major" severity of consequence classification. Such an accident would not be classified as significant.

In summary, as can be seen by Figure 3-10, none of the transportation-related accidents would be classified as significant.

FIGURE 3-9
SEVERITY AND FREQUENCY MATRIX OF SIGNIFICANCE

		SEVERITY OF CONSEQUENCE				
		Negligible: No significant risk to the public, with no minor injuries; less than 10 bbls spilled	Minor: Small level of public risk, with at most a few minor injuries	Major: Major level of public risk with up to 10 severe injuries; 238-2,380 bbls spilled	Severe: Severe public risk with up to 100 severe injuries or up to 10 fatalities; 2,380 to 357,142 bbls spilled	Disastrous: Disastrous public risk involving more than 100 severe injuries or more than 10 fatalities; greater than 357,142 bbls spilled
FREQUENCY OF OCCURRENCE	Frequent: Greater than once a year					
	Likely: Between once a year and once in one hundred years					
	Unlikely: Between once in a hundred and once in ten thousand years					
	Rare: Between once in ten thousand years and once in a million years					
	Extraordinary: Less than once in a million years					

County defined as significant impacts

Source: County of Santa Barbara Department of Resource Management, Environmental Thresholds & Guidelines Manual, Amended 1990; Shell Hercules Platform EIR, 1983.

FIGURE 3-10
TRANSPORTATION RISK MATRIX

FREQUENCY OF OCCURRENCE	SEVERITY OF CONSEQUENCE				
	Negligible: No significant risk to the public, with no minor injuries; less than 10 bbls spilled	Minor: Small level of public risk, with at most a few minor injuries	Major: Major level of public risk with up to 10 severe injuries; 238-2,380 bbls spilled	Severe: Severe public risk with up to 100 severe injuries or up to 10 fatalities; 2,380 to 357,142 bbls spilled	Disastrous: Disastrous public risk involving more than 100 severe injuries or more than 10 fatalities; greater than 357,142 bbls spilled
Frequent: Greater than once a year					
Likely: Between once a year and once in one hundred years					
Unlikely: Between once in a hundred and once in ten thousand years		Trucking accident with release and/or fire Crude oil pipeline release			
Rare: Between once in ten thousand years and once in a million years		Crude oil pipeline release with fire	Gas pipeline accident		
Extraordinary: Less than once in a million years					

County defined as significant impacts

Source: County of Santa Barbara Department of Resource Management, Environmental Thresholds & Guidelines Manual, Amended 1990; Shell Hercules Platform EIR, 1983.

The proposed project site is presently being used by the City of Hermosa Beach as a maintenance operations facility. These operations include a variety of activities such as repair and maintenance of vehicles; storage of materials, supplies and equipment; a workplace for city workers who repair and maintain facilities and equipment in the city; and for storage and painting of signs. It is natural that there would be some hazards associated with these activities and the purpose of this section is to describe these hazards and compare them with similar hazards presented by the proposed project.

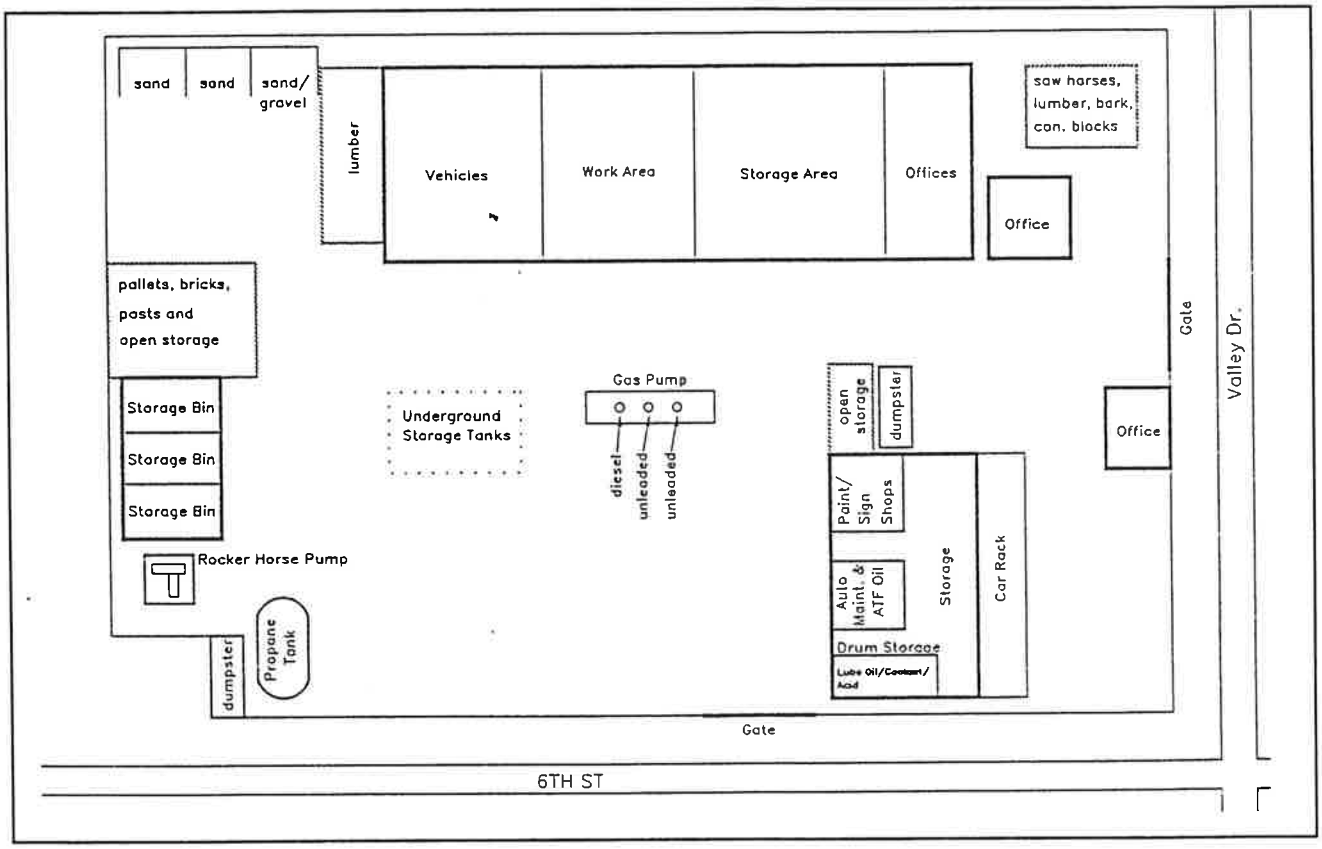
Figure 4-1 is a diagram of the present site usage and graphically depicts the location of materials and equipment throughout the facility. The following list indicates the major items on-site that could present a hazard to the surrounding community.

- 100 gallon propane tank
- 2 - 4000 gallon underground fuel storage tanks (gasoline)
- 1 - 2000 gallon underground fuel storage tank (diesel)
- Storage and use of flammable paints and solvents
- Storage and use of flammable compressed gases (acetylene)
- Storage and use of automotive lubricants (55 gallon drums)
- Flammable structures and other materials on-site

None of the items in the above list is unusual or presents a greater hazard than one would expect from a facility of this type. These types of hazards would probably exist to a greater or lesser degree at many industrial operations where a significant number of vehicles are serviced and maintained. The purpose of the comparison with the project hazards is to show that many of the hazards associated with the project will be similar to those presently existing at the site.

The significant off-site hazards associated with the materials presently on-site are thermal radiation associated with fire and blast overpressure associated with explosion of on-site materials. While there may be toxic materials on-site, the amounts are sufficiently small that a significant off-site hazard does not exist. In addition, it is possible that a fire could release some toxic materials from the stored paints and solvents. Because the volumes are limited, it is not expected that a significant off-site hazard would exist.

FIGURE 4-1
CITY OF HERMOSA BEACH
MAINTENANCE YARD



The potential explosion hazard associated with the proposed project results from a thermal load on an NGL liquids storage tank and resulting BLEVE. The risk analysis has determined this to be a very low probability event and extensive damage would only occur in close proximity to the site. The proposed NGL liquids tank could have a maximum of 118 gals of NGL in storage. There presently exists a propane storage tank on the site with a maximum capacity of 100 gals. The same scenario that would cause the proposed NGL liquids tank to undergo a BLEVE would cause the existing propane tank to BLEVE. The resulting overpressures would essentially be the same. In addition, present maintenance operations utilize compressed flammable gases such as acetylene which have similar potentials for explosion. Thus, the present hazard of an explosion associated with fire is very similar to that which would be expected from the proposed new facility.

Thermal radiation associated with fire is a hazard associated with the present facility as well as the new facility. For the new facility, this hazard is associated with a crude oil fire that could occur at the facility, as described earlier in the report. The probability of this fire is quite low and the facility has been designed to contain any spilled oil and restrict the occurrence of fire. The existing facility contains many flammable materials as well as flammable structures. Because of the number of diverse maintenance operations that occur on-site and the many different flammable materials on-site, there is a greater probability of fire on the present site than would be found at the proposed facility. Several of the present operations such as welding and cutting use active torches that could ignite materials and cause a fire. The changing nature of the materials and equipment on-site make it difficult to provide an exact comparison of the hazard region however, the hazards associated with a fire at the current site are at least as great as those associated with the proposed facility and may be greater.

The final hazard for the present site is associated with the transfer of gasoline to the site from trucks. While the new facility would transport oil from the site in trucks for a period of time, crude oil is not as volatile as the gasoline that is presently being transported to the site. There would be a greater number of vehicular trips containing crude than are presently used to refill the underground gasoline tanks. The present trucking hazard is significantly lower than a commercial gasoline service station because the usage is much smaller. Both the present and proposed usages would have some hazard from trucking of flammable materials.

In summary, the hazards associated with the present facility are similar to those that would result from the new facility. The new facility is not introducing any new hazards to the area. They all presently exist because of the present operations at the site.

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