APPENDIX C

HAZARDS ANALYSIS
July 3, 2013

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

Re: Phillips 66 Tank Fire Calculations

Dear Ms. Stevens:

Phillips 66 is proposing to install one new 615,000 barrel crude storage tank at the Phillips 66 Carson Plant located at 1520 East Sepulveda Boulevard, Carson, California. Phillips 66 is also proposing to increase the throughput of two existing 320,000 barrel nominal capacity storage tanks so the proposed project includes the construction of geodesic domes on existing crude Tanks 510 and 511. The proposed project also includes the construction of a 14,000 barrel water draw surge tank. The new 615,000 barrel tank will be located in an area that already has existing crude storage tanks. The existing and proposed storage tanks are summarized in Table 1. The location of the existing and proposed storage tanks are shown on Figure 1 with the proposed tanks marked with diagonal lines.

Table 1  
Storage Tank Parameters

<table>
<thead>
<tr>
<th>Tank Status</th>
<th>Tank Number(s)</th>
<th>Contents</th>
<th>Tank Diameter (ft)</th>
<th>Tank Wall Height (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed</td>
<td>2640</td>
<td>Crude oil with Reid Vapor Pressure up to 11 psi</td>
<td>260</td>
<td>65</td>
</tr>
<tr>
<td>Proposed</td>
<td>2643</td>
<td>Crude oil and water</td>
<td>44</td>
<td>52</td>
</tr>
<tr>
<td>Existing</td>
<td>510, 511, 512, 513</td>
<td>Crude oil</td>
<td>218</td>
<td>50</td>
</tr>
</tbody>
</table>

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

This report details the calculations made to identify the maximum fire radiation hazard zones associated with a tank top fire (pool fire) from any one of the proposed storage tanks. The scenario selected represents the largest, credible releases (i.e., storage tank dome failure) followed by ignition (pool fire) resulting in a large fire.
The following atmospheric conditions were employed in the modeling.

- **Wind speed**: 20 miles/hour (worst case for fires as flame is bent downwind)
- **Relative humidity**: 70%
- **Air temperature**: 70°F
- **Surface temperature**: 70°F

The hazard of interest for pool fires is direct exposure to the flames. Pool fire hazard zones are determined by first calculating the maximum size of the flame column created by the pool fire and then determining how far specific radiant impacts extend from the fire column. For fire radiation hazards, the maximum distance to potentially injurious levels are determined.

The fire radiation hazard endpoint criterion defined in this study corresponds to a hazard level which might cause an injury. Data exist which define an injury level following exposure to fire radiation. Table 2 presents the endpoint hazard criteria used by federal agencies and national associations for this type of analysis.

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**Figure 1**

**Existing and Proposed Tank Locations**

The following atmospheric conditions were employed in the modeling.
Table 2
Consequence Analysis Hazard Levels
(Endpoint Criteria for Consequence Analysis)

<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>Exposure Duration</th>
<th>Injury Threshold</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiant heat exposure</td>
<td>40 sec</td>
<td>1,600 Btu/(hr*ft^2)</td>
<td>40 CFR 68 [EPA, 1996]</td>
</tr>
</tbody>
</table>

40 CFR 68. United States Environmental Protection Agency RMP endpoints.

* Corresponds to second-degree skin burns.

Consequence Analysis

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

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

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

**Conclusions**

CANARY by Quest® was used to model the potential tank top fire following the failure of the tank dome. Table 3 presents the maximum downwind distances for the pool fire hazard associated with two proposed and four existing storage tanks in the same area of the Phillips 66 refinery. As can be seen from the table, the impact distances can extend up to about 510 feet from the center of the proposed 615,000 barrel tank. This maximum impact distance is larger than the potential hazard zones associated with the nearby existing tanks but the impact distance to 1,600 Btu/(hr•ft²) does not extend off the refinery property. Thus, the addition of the two proposed storage tanks to this section of the Phillips 66 refinery does not pose any new hazards to areas outside of the existing Refinery.

The results listed in Table 3 are presented in Figure 2. The maximum impact zone distances are shown in Figure 2 for each proposed and existing tank evaluated. The dashed lines around the existing tanks show the area currently potentially exposed to a 1,600 Btu/(hr•ft²) radiant impact. The dashed lines around the proposed tanks show the area that could be exposed to a 1,600 Btu/(hr•ft²) radiant impact. As can be seen in Figure 2, neither of the two proposed tanks can produce this impact level outside the refinery property line. The potential radiant impact zones all shown for the four existing tanks (510, 511, 512, and 513) in order to demonstrate the existence of the current potential hazard relative to the potential new hazard associated with tank 2640.

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

Sincerely,

John B. Cornwell.
Principal Engineer
Table 3
Consequence Modeling Radiation Results

<table>
<thead>
<tr>
<th>Tank Status</th>
<th>Tank Number(s)</th>
<th>Contents</th>
<th>Tank Diameter (ft)</th>
<th>Tank Wall Height (ft)</th>
<th>Distance (ft) to 1,600 Btu/(hr•ft²) [measured from center of tank]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed</td>
<td>2640</td>
<td>Hydrocarbon mix with Reid Vapor Pressure up to 11 psi</td>
<td>260</td>
<td>65</td>
<td>510</td>
</tr>
<tr>
<td>Proposed</td>
<td>2643</td>
<td>Crude oil and water</td>
<td>44</td>
<td>52</td>
<td>130</td>
</tr>
<tr>
<td>Existing</td>
<td>510, 511, 512, 513</td>
<td>Crude oil</td>
<td>218</td>
<td>50</td>
<td>450</td>
</tr>
</tbody>
</table>

Figure 2
Potential 1,600 Btu/(hr•ft²) Impact Zones for Existing and Proposed Storage Tanks