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August 3, 2016

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Technical Memorandum: NW Citizen Science Initiative DEIS Comments

Introduction

NW Innovation Works, Inc. (NWIW) is proposing to construct a methanol plant to be located at an existing industrial park owned by the Port of Kalama, in Washington State. The final Environmental Impact Statement (EIS) is currently being prepared for the site under Washington's SEPA process, and a Draft EIS (DEIS) was released for public review March 3, 2016.

Included in the DEIS as Appendix G1 is a Quantitative Risk Assessment Final Report (February 2016) ("QRA") for the proposed methanol plant. The QRA was conducted by AcuTech to review the potential hazards and risks the proposed plant could pose to onsite employees and the offsite community from an accidental release from the methanol production, storage and vessel loading operations. Accidental release scenarios defined for the QRA were developed through an initial HAZard IDentification (HAZID) workshop facilitated by AcuTech Group, Inc. (the QRA contractor) included representatives from the NWIW project team, Johnson Matthey Davy Technologies, Worley Parsons, Williams Northwest Pipeline, Endeavour EHS LLC and Port of Kalama. All onsite hazards (e.g., fire, explosion, and toxic) with the potential to impact onsite personnel and potential for offsite exposure were included in the QRA, and included the full range of releases sizes (from leaks to ruptures).

The results of the QRA illustrated that the proposed NWIW site does not present a significant risk of serious or permanent injury outside of the plant, and all identified fire, vapor cloud explosion, and toxic hazards do not extend beyond the plant boundary.

On April 18, 2016 revised comments were submitted by Alastair Roxburgh, NW Citizen Science Initiative (NWCSI). The comments are in the form of a preliminary analysis of the hazards of methanol storage, and consequence modeling conducted using the ALOHA® (Areal Locations of Hazardous Atmospheres) model, developed by the Environmental Protection Agency (EPA), Office of Emergency Management (OEM) and the National Oceanic and Atmospheric Administration (NOAA), Emergency Response Division.

Since the NWCSI analysis present results that are contradictory to the QRA, NWIW requested AcuTech to review the NWCSI comments and analysis, and to provide a technical response. As detailed above, AcuTech conducted the QRA for the proposed methanol plant. AcuTech is a specialty-consulting firm with a deep background in process safety, risk assessment, security, and emergency management. AcuTech has served both industry and government clients since 1994 and is a leader in industrial safety.

This letter supplements the QRA, but does not change any of the analysis, consequence modeling or conclusions in the QRA (Appendix G1 of the DEIS).

AcuTech's review of the NWCSI analysis identified:

- Incorrect project design information
- Exaggerated scenarios leading to scientifically unrealistic large-scale methanol releases
- Use of an emergency response planning tool designed to err in favor of overestimation of the hazards[1] of a chemical release
- Improper model assumptions and inputs

AcuTech's response to NWCSI includes a comparative analysis of the methanol plant hazards, and is based on selection of credible large-scale methanol release scenarios. Our analysis utilizes the same ALOHA model, and even with the designed conservatism in estimating chemical hazards, our results illustrate that NWCSI overstated the potential level of hazard and risk posed to the surrounding community by the proposed methanol plant. Our analysis shows that a large-scale methanol release will be contained within the plant boundary, and does not pose a significant risk outside of the plant boundary. This conclusion is consistent with the conclusions in the QRA.

The formal review of the NWCSI comments and analysis is provided in the following sections.

AcuTech Comments to NWCSI Analysis

The NWCSI Analysis speculated about four (4) events and outcomes if a loss of containment of methanol from storage were to occur:

- Case 1: Pool Fire and BLEVE Domino Effect Scenario
- Case 2: Pure Pool Fire Scenario
- Case 3: Vapor Cloud Explosion (Detonated) Scenario
- Case 4: Toxic Vapor Cloud Scenario

AcuTech comments for each case are presented in detail below. General comments on NWCSI analysis include:

1. **Model Selection**: The ALOHA® model is designed for use during accidental chemical spills to help spill response professionals assess the risk to human populations associated with toxic air hazards, thermal radiation from fires, and blast effects. It is designed to provide an upper bound to the threat distances associated with chemical spills.

   From the ALOHA Technical Documentation (NOAA Technical Memorandum NOS OR&R 43, November 2013), Section 1.2 Design Criteria and Limitations:

[1] ALOHA Technical Documentation (NOAA Technical Memorandum NOS OR&R 43, November 2013), Section 1.2 Design Criteria and Limitations.

- "Wherever uncertainty is unavoidable, ALOHA will err in favor of overestimating rather than underestimating threat distances."
- "In some cases, ALOHA will significantly overestimate threat zones".

AcuTech Comment: ALOHA is a planning and response tool designed to calculate potential impact boundaries quickly enough to be of use to responders during a real emergency. Since ALOHA's calculations represent a compromise between accuracy and simplicity or speed, ALOHA is not an appropriate model for conducting consequence modeling for a quantitative risk assessment for the purpose of siting an industrial plant. NWCSI's modeling results are further exacerbated by the use of exaggerated, unrealistic and impossible proposed methanol release scenarios and model inputs.

The QRA for NWIW was conducted by AcuTech using the commercially available Process Hazards Analysis Software Tool (Phast) and Software for the Assessment of Fire, Explosion and Toxic Impacts (Safeti). The software package is available from Det Norske Veritas (DNV), with Phast used to complete the hazard/ consequence modeling and Safeti used to develop the risk results. The Phast software provides more robust modeling capacities, as compared to ALOHA, and has been well validated and is widely used in the oil and gas and chemical industries for quantitative studies.

2. **Model Meteorological Conditions**: NWCSI assumed values for local ambient conditions.

   AcuTech Comment: From the current analysis provided by NWCSI there are no comments on the meteorological conditions selected.

3. **Model Endpoints**: NWCSI assumed endpoints for thermal radiation, toxic dispersion and explosion overpressure.

   AcuTech Comment: From the current analysis provided by NWCSI there are no comments on the modeling endpoints selected.

4. **Methanol Storage Tanks**: NWCSI assumed tank dimensions of 105' tall and 145' diameter (9,400,000 gallons)

   AcuTech Comment:
   - The tank design for the NWIW facility uses smaller methanol storage tanks that are 82' tall; 142' 9" diameter (8,200,000 gallons).
   - The methanol product storage tanks are atmospheric storage tanks designed for 0.7 pounds per square inch gauge (psig) internal pressure.
   - From NFPA 30 Flammable and Combustible Liquids Code; Section 3.3.51.2, an atmospheric tank is defined as "A storage tank that has been designed to operate at pressures from atmospheric through a gauge pressure of 1.0 psi (6.9 kPa) (i.e., 760 mm Hg through 812 mm Hg) measured at the top of the tank."

Case 1: Pool Fire and BLEVE Domino Effect Scenario

NWCSI assumed that all but one methanol tank would fail and that the entire contents of those tanks would be ignited. NWCSI then assumed that the resulting fire would heat a single remaining methanol storage tank within the containment area. NWCSI then assumed that a pressure relief valve would fail on the one remaining tank and that pressure would build to tank failure, resulting in a Boiling Liquid Flammable Vapor Explosion (BLEVE).

AcuTech Comment: As discussed in the QRA, no fireball/ BLEVE scenarios were developed as the methanol storage tanks are all designed for atmospheric conditions (i.e., methanol will not be stored in pressurized tanks). A BLEVE scenario is not possible because such tanks cannot provide the pressurization necessary to suppress boiling as would be necessary to produce a BLEVE. If catastrophic tank failure were to occur, the resulting hazard would be a large pool fire, not a fireball or BLEVE.

Additionally, the following is from the American Institute of Chemical Engineers (AIChE), Center for Chemical Process Safety (CCPS) "Guidelines for Vapor Cloud Explosion, Pressure Vessel Burst, BLEVE and Flash Fire Hazards", 2nd Edition, 2010.

- BLEVE is defined as a sudden loss of containment of a pressure-liquefied gas existing above its normal atmospheric boiling point at the moment of its failure, which results in rapidly expanding vapor and flashing liquid.
- A BLEVE requires three key elements:
    - A liquid at a temperature above its normal atmospheric pressure boiling point.
    - Containment that causes the pressure on the liquid to be sufficiently high to suppress boiling.
    - A sudden loss of containment to rapidly drop the pressure on the liquid.
- Liquids normally stored under pressure have atmospheric pressure boiling points well below ambient temperature. Common examples of these types of materials include light hydrocarbons (e.g., propane, ethane, butane), ammonia, and refrigerants. Other liquids whose atmospheric pressure boiling points are above ambient temperature may be heated intentionally or unintentionally during use to above their boiling points and stored at pressure. These include many liquids, but common examples are water (e.g., in steam generation) and heavy hydrocarbons. If any of these commodities are pressurized to suppress boiling and suddenly lose containment, the pressure will drop and the liquids will become superheated and flash to vapor.

Based on the information above, a BLEVE of an atmospheric methanol storage tank is not possible:

- Methanol is a liquid at ambient temperature and pressure and will not be stored as a pressure-liquefied gas.
- Methanol storage tanks are designed to contain methanol at atmospheric pressure and not pressurized design.
- Since the vapor pressure of methanol at its boiling point is greater than 14.7 psig, an atmospheric storage tank (with a design pressure of 0.7 psig) would fail before the material would boil. Therefore, a methanol tank of the design proposed by NWIW cannot provide containment of pressures sufficiently high to suppress boiling.

If a catastrophic tank failure were to occur, the resulting hazard would be a large pool fire, not a fireball or BLEVE.

Case 2: Pure Pool Fire Scenario

NWCSI assumed a methanol spill and fire within the storage tank containment area. The results were that thermal radiation from the case "is not particularly dangerous outside the NWIW site".

AcuTech Comment: This case is discussed in detail in the QRA and this conclusion is consistent with the QRA. We agree that the pool fire scenario does not present a significant offsite hazard.

Case 3: Vapor Cloud Explosion (Detonated) Scenario

NWCSI assumed a coordinated terrorist-type scenario:

1. Initiating event where a commercial aircraft is used to damage all eight (8) methanol storage tanks.
2. The contents of the methanol tanks are not consumed as a localized fire, but somehow the entire volume is instantaneously converted from liquid to vapor.
3. Secondary attack where an explosive is detonated within the flammable cloud, after allowing the cloud to disperse downwind to the lower flammable limit (LFL[2]).

AcuTech Comment:

NWCSI developed a scenario requiring an event triggered by an intentional combination of actions. The scenario begins with an intentional aircraft crash into the methanol storage area, followed by a coordinated and a delayed detonation of a truck bomb to ignite a vapor cloud. This scenario can be evaluated in the context of a security risk analysis. AcuTech was the lead author of the American National Standards Institute (ANSI)/American Petroleum Institute (API) Standard 780[3] Security Risk Assessment (SRA) Methodology. The standard was published in June 2013 as a U.S. standard for SRAs for petroleum, chemical, and petrochemical facilities. The standard evaluates the risk of terrorism as a function of potential consequence, vulnerability, and threat. These factors are considered below in the context of the scenario NWCSI modeled:

- Consequence: As detailed above, the NWCSI scenario assumes a one (1) second release duration of the full storage volume, and complete and instantaneous conversion of methanol liquid to vapor. We have been unable to develop a realistic scenario where such an instantaneous release and conversion of methanol liquid to vapor could actually occur. All potential scenarios involving catastrophic release from methanol storage would result in a liquid release and spill to the impoundment area that would be most-likely ignited by the sparks/ fire of an airplane crash, resulting in a pool fire and consequence similar to NWCSI Case 2. Immediate conversion of methanol from liquid to vapor is not credible.

[2] Lower flammability limit (LFL), usually expressed in volume per cent, is the lower end of the concentration range over which a flammable mixture of gas or vapor in air can be ignited at a given temperature and pressure. The flammability range is delineated by the upper and lower flammability limits. Outside this range of air/vapor mixtures, the mixture cannot be ignited (unless the temperature and pressure are increased).

[3] ANSI/API Standard 780 Security Risk Assessment Methodology for the Petroleum and Petrochemical Industry", Washington, DC: American Petroleum Institute (2013)

- Vulnerability: The majority of private assets do not have security countermeasures for the attack scenario developed from NWCSI. Therefore, NWIW would not be expected to have systems that would prevent an attack from a commercial aircraft piloted by a terrorist. NWIW would rely on national and state security measures to prevent such a scenario.
- Threat: Based on the following:
  - Nature/history of the threat – No similar events for chemical facilities or other infrastructure where a coordinated attack with a commercial aircraft and secondary detonation have been attempted.
  - Capability – The probability that an adversary has the capability and resources for this attack scenario is low. The scenario involving secondary detonation following the initial attack requires 1) allowing the flammable cloud to disperse downwind to the LFL, 2) the device is correctly located downwind and 3) detonation of the device is precisely timed. Orchestrating such a secondary detonation together with crashing a commercial aircraft into the methanol tanks would require highly complex logistics, specialized technical expertise and ideal meteorological conditions.
  - Attractiveness – The attractiveness of this type of attack against the NWIW facility is low since it would require extensive resources and coordination, and given the plant location, an attack would not meet typical terrorist goals for mass casualties, extensive property damage, damage to national assets/landmarks, damage to critical infrastructure, or severe economic impacts. Far more attractive targets are available with less effort and higher potential of achieving terrorist goals.

Evaluating the scenario using the security risk assessment techniques illustrates that the NWCSI Case 3 is not credible, and is not a sound basis for decision making for the facility design.

<u>Case 4: Toxic Vapor Cloud Scenario</u>
NWCSI's scenario is the same as Case 3 with a terrorist piloting a commercial aircraft to crash it into the methanol storage tanks at the NWIW facility, except the flammable cloud is not detonated, and the cloud disperses downwind to three toxic concentration levels. Using the same analysis provided above, this case is not considered credible:

1. Consequence: As explained above, instantaneous conversion of methanol liquid to vapor is not credible. All potential scenarios involving catastrophic release from methanol storage would result in a liquid spill to the impoundment area. Most likely the spill would be ignited by sparks or fire from such an aircraft crash as described in Case 3. If the spill were not ignited in the event (as proposed by NWCSI), the worst case is an evaporating pool of methanol, not an instantaneous conversion of liquid to vapor.
2. Vulnerability: As stated above, the NWIW plant could be vulnerable to an attack from a commercial aircraft piloted by a terrorist. NWIW would rely on national and state security measures to prevent such a scenario.
3. Threat: Based on the following:
   - Nature/history of the threat – No similar events for chemical facilities or other infrastructure where a terrorist attempted to cause a release of potentially toxic gases.

  - Capability – Historic events have shown that terrorists can successfully commandeer a commercial aircraft and use it as a weapon. National and state security measures, however, have reduced the potential for such an attack.
  - Attractiveness – The attractiveness of this type of attack against the NWIW facility is low since it would require extensive resources and coordination, and given the plant location, an attack would not meet typical terrorist goals for mass casualties, extensive property damage, damage to national assets/landmarks, damage to critical infrastructure, or severe economic impacts. Methanol's toxicity is relatively low compared to many other chemicals stored in bulk at facilities closer to large population centers. Far more attractive targets are available with less effort and higher potential of achieving terrorist goals.

Accordingly, the NWCSI Case 4 is not credible, and is not a sound basis for decision making for the facility design.

In the next section, AcuTech presents more plausible worst case scenarios for a large release from methanol storage.

Credible Worst-Case Methanol Storage Hazard

The following is an analysis conducted by AcuTech. This analysis is provided to replace NWCSI's Case 3 and Case 4, and to represent a credible worst-case release from methanol storage at the NWIW site, as modeled with ALOHA. Although ALOHA is not an appropriate consequence model for a quantitative risk assessment due to the potential over conservatism of the reported hazard distances, we have used ALOHA in our analysis for consistency with NWCSI's approach and to illustrate a comparison of the potential impact boundaries.

The modeling assumptions include:

- Use of ALOHA model (same model as NWCSI comments/analysis)
- Use of NWCSI meteorological data
- Use of NWCSI endpoints for thermal radiation, flammable vapor dispersion, vapor cloud explosion overpressure, and toxic concentration

The case evaluated is a physical impact to a methanol storage tank (e.g., earthquake, small/light aircraft impact) that results in a release to the containment area surrounding the tanks. Following a release of methanol, the following hazards were evaluated:

- Pool fire within the impoundment.
- Evaporating pool within impoundment – dispersion to LFL and potential for vapor cloud explosion.
- Evaporating pool within impoundment – dispersion to toxic concentration endpoints.

The ALOHA modeling files are provided as an attachment. The methanol pool scenarios were evaluated in ALOHA assuming:

- Source: Puddle model
  - Evaporating pool

- Pool area: 915 feet x 460 feet methanol storage impoundment
  - Area = 420,900 square feet
  - ALOHA Limit[4] = 338,000 square feet
- Pool volume
  - 8,200,000 gallons
  - ALOHA Limit = 2,640,000 gallons

- ALOHA dispersion using buoyant dispersion. ALOHA allows options for using a heavy gas model or a buoyant dispersion model. From the ALOHA Technical Documentation (NOAA Technical Memorandum NOS OR&R 43, November 2013), Section 4.4.1 Criteria for Use of the Heavy Gas Model:
  - Designed to account for the gravitational effects on pollutant clouds with densities significantly different than air.
  - Gravitational effects can be insignificant for dense pollutants if the dispersion is dominated by the wind or thermal convection in the atmosphere, or the evaporative flux from a pool is small. The Heavy Gas model can still be used with these clouds, but the Gaussian (buoyant gas) Model is preferred.

  Since the vapor density of methanol is similar to air and the dispersion of an evaporating pool will be dominated by the wind. AcuTech used the Gaussian Model for both flammable vapor and toxic dispersion.

Pool Fire within Impoundment

No additional analysis, see NWCSI Case 2.

Evaporating Pool within Impoundment (flammable dispersion and potential VCE)

The distances to LFL and ½ LFL were evaluated. The ½ LFL concentration was also considered to be conservative. The results using the ALOHA model predict the following:

- Distance to the LFL and ½ LFL concentration does not extend beyond the impoundment area.
- As no part of the flammable cloud is above the LFL or ½ LFL there is no potential for a vapor cloud explosion. This result is shown in the ALOHA results.

Evaporating Pool within Impoundment (toxic dispersion)

Toxic modeling was conducted using the same Acute Exposure Level Guidelines (AEGLs) endpoints as assumed by NWCSI in its modeling:

- **AEGL-3** is the airborne concentration, expressed as parts per million (ppm) or milligrams per cubic meter (mg/m3), of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.
- **AEGL-2** is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

[4] ALOHA Technical Documentation (NOAA Technical Memorandum NOS OR&R 43, November 2013), Section 6.5 Pool Fires. "A 200-meter diameter limit applies in all cases."

- **AEGL-1** is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

The distances to the toxic concentration endpoints as predicted by ALOHA are detailed below (measured from the center of the methanol storage impoundment):

- 109 yards to AEGL-3 (7,200 ppm [60 min])
- 166 yards to AEGL-2 (2,100 ppm [60 min])
- 545 yards to AEGL-1 (530 ppm [60 min])

The AEGL-3 and AEGL-2 levels would not extend beyond the impoundment area and are maintained within the NWIW plant boundary. Therefore, the risk of serious or permanent injury from the toxic effects of a worst-case methanol release would be limited to within the plant boundary.

Using the ALOHA model the AEGL-1 level may extend beyond the NWIW plant boundary, north of the methanol storage tanks. As detailed above the AEGL-1 concentration level is not disabling, with no long-term effects. Additionally, the offsite area north of the methanol storage tanks is forest/wetlands with no residences or other occupied structures.

Conclusions

On April 18, 2016 revised comments were submitted by Alastair Roxburgh, NW Citizen Science Initiative (NWCSI). The comments are in the form of a preliminary analysis of the hazards of methanol storage, and consequence modeling was conducted using the ALOHA model. The NWCSI Analysis speculated four (4) events and outcomes if a loss of containment of methanol from storage were to occur:

- Case 1: Pool Fire and BLEVE Domino Effect Scenario
- Case 2: Pure Pool Fire Scenario
- Case 3: Vapor Cloud Explosion (Detonated) Scenario
- Case 4: Toxic Vapor Cloud Scenario

In addition to identifying NWCSI inconsistencies in NWIW project design information (e.g., storage tank dimension and capacities), the following are the conclusion of AcuTech's review:

- Case 1 – BLEVE of a methanol storage tank is not credible or even possible with the tank design proposed by NWIW.
- Case 2 – Pool Fire Scenario:
  - AcuTech agrees with NWCSI that a methanol spill and fire within the storage tank impoundment area "is not particularly dangerous outside the NWIW site".
- Case 3 and Case 4 – Terrorism initiated events:
  - Following the American National Standards Institute (ANSI)/American Petroleum Institute (API) Standard 780 Security Risk Assessment (SRA) methodology, NWCSI's terrorist attack scenarios are not credible. Threat of this type of attack

scenario is low based on nature/history of threat, capabilities of the adversary, and attractiveness of the NWIW plant to meet the goals of the adversary.
  - Moreover, the consequence of the event was overstated by NWCSI, assuming instantaneous vaporization of the entire contents, which is not possible.

While Case 3 and Case 4 were not considered credible (due to the low threat level and overstated consequences), a more realistic worst case scenario for a large release from methanol storage was provided by AcuTech using the ALOHA model. Although we have illustrated that ALOHA is not an appropriate consequence model for a quantitative risk assessment for the purpose of siting an industrial plant, ALOHA was used for consistency with NWCSI's approach, and to illustrate a comparison of the potential impact boundaries.

The worst-case analysis utilized the same model and modeling inputs as the NWCSI:

- ALOHA model
- Meteorological data
- Endpoints for thermal radiation, flammable vapor dispersion, vapor cloud explosion overpressure, and toxic concentration

The credible worst-case evaluated is a physical impact to a methanol storage tank (e.g., earthquake, small/ light aircraft impact) that results in a catastrophic release to the impoundment area surrounding the tanks, with a potential for:

- Pool fire within the impoundment.
- Evaporating pool within impoundment – dispersion to the lower flammable limit (LFL) and potential for vapor cloud explosion.
- Evaporating pool within impoundment – dispersion to toxic concentration endpoints.

As illustrated from this comparative analysis, the methanol hazards do not pose the level of risk presented in the NWCSI analysis. The NWCSI analysis utilized exaggerated scenarios leading to scientifically unrealistic large-scale methanol releases and their results showing potential hazard zones extending up to 6 miles from the proposed NWIW methanol plant are not possible.

Our comparative analysis presenting more plausible worst case scenarios for a large release from methanol storage illustrates that the proposed plant does not present any potential for serious or permanent injury outside of the plant boundary. This conclusion is consistent with the more detailed analysis and conclusions in the QRA (included as Appendix G1 of the DEIS).

Sincerely,

Brad A. Fuller
Manager, Risk Assessment Services
AcuTech Group, Inc.
1919 Gallows Road, Suite 900
Vienna, VA 22182

ATTACHMENT A

ALOHA MODELING FILES

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 SITE DATA:
   Location: KALAMA, WA, WASHINGTON
   Building Air Exchanges Per Hour: 0.48 (unsheltered single storied)
   Time: June 28, 2016  1406 hours PDT (using computer's clock)

 CHEMICAL DATA:
   Chemical Name: METHANOL
   CAS Number: 67-56-1                    Molecular Weight: 32.04 g/mol
   AEGL-1 (60 min): 530 ppm   AEGL-2 (60 min): 2100 ppm   AEGL-3 (60 min): 7200
ppm
   IDLH: 6000 ppm     LEL: 71800 ppm      UEL: 365000 ppm
   Ambient Boiling Point: 148.5° F
   Vapor Pressure at Ambient Temperature: 0.12 atm
   Ambient Saturation Concentration: 116,181 ppm or 11.6%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 5 miles/hour from NW at 3 meters
   Ground Roughness: open country         Cloud Cover: 5 tenths
   Air Temperature: 65° F
   Stability Class: C (user override)
   No Inversion Height                    Relative Humidity: 50%

 SOURCE STRENGTH:
   Evaporating Puddle (Note: chemical is flammable)
   Puddle Area: 338000 square feet        Puddle Volume: 2640000 gallons
   Ground Type: Default soil              Ground Temperature: 65° F
   Initial Puddle Temperature: Ground temperature
   Release Duration: ALOHA limited the duration to 1 hour
   Max Average Sustained Release Rate: 2,540 pounds/min
      (averaged over a minute or more)
   Total Amount Released: 151,558 pounds

 THREAT ZONE: (GAUSSIAN SELECTED)
   Threat Modeled: Flammable Area of Vapor Cloud
   Model Run: Gaussian
   Red   : 109 yards --- (71800 ppm = LEL)
   Note: Threat zone was not drawn because dispersion predictions are
      unreliable for lengths less than the maximum diameter of the puddle.
      Maximum diameter of the puddle: 219 yards
   Orange: 109 yards --- (35900 ppm)
   Note: Threat zone was not drawn because dispersion predictions are
      unreliable for lengths less than the maximum diameter of the puddle.
      Maximum diameter of the puddle: 219 yards
```

Overpressure (Blast Force) Threat Zone

ALOHA® 5.4.6

Time: June 28, 2016 1406 hours PDT (using computer's clock)

Chemical Name: METHANOL

Wind: 5 miles/hour from NW at 3 meters

THREAT ZONE: (GAUSSIAN SELECTED)

- Threat Modeled: Overpressure (blast force) from vapor cloud explosion
- Type of Ignition: ignited by spark or flame
- Level of Congestion: uncongested
- Model Run: Gaussian
- No explosion: no part of the cloud is above the LEL at any time

Threat Modeled: Overpressure (blast force) from vapor cloud
Type of Ignition: ignited by spark or flame
Level of Congestion: uncongested
Model Run: Gaussian
No explosion: no part of the cloud is above the LEL at any

```
 SITE DATA:
   Location: KALAMA, WA, WASHINGTON
   Building Air Exchanges Per Hour: 0.48 (unsheltered single storied)
   Time: June 28, 2016  1406 hours PDT (using computer's clock)

 CHEMICAL DATA:
   Chemical Name: METHANOL
   CAS Number: 67-56-1                   Molecular Weight: 32.04 g/mol
   AEGL-1 (60 min): 530 ppm   AEGL-2 (60 min): 2100 ppm   AEGL-3 (60 min): 7200
ppm
   IDLH: 6000 ppm     LEL: 71800 ppm      UEL: 365000 ppm
   Ambient Boiling Point: 148.5° F
   Vapor Pressure at Ambient Temperature: 0.12 atm
   Ambient Saturation Concentration: 116,181 ppm or 11.6%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 5 miles/hour from NW at 3 meters
   Ground Roughness: open country         Cloud Cover: 5 tenths
   Air Temperature: 65° F
   Stability Class: C (user override)
   No Inversion Height                    Relative Humidity: 50%

 SOURCE STRENGTH:
   Evaporating Puddle (Note: chemical is flammable)
   Puddle Area: 338000 square feet        Puddle Volume: 2640000 gallons
   Ground Type: Default soil              Ground Temperature: 65° F
   Initial Puddle Temperature: Ground temperature
   Release Duration: ALOHA limited the duration to 1 hour
   Max Average Sustained Release Rate: 2,540 pounds/min
      (averaged over a minute or more)
   Total Amount Released: 151,558 pounds

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red   : 109 yards --- (7200 ppm = AEGL-3 [60 min])
   Note: Threat zone was not drawn because dispersion predictions are
      unreliable for lengths less than the maximum diameter of the puddle.
      Maximum diameter of the puddle: 219 yards
   Orange: 166 yards --- (2100 ppm = AEGL-2 [60 min])
   Note: Threat zone was not drawn because dispersion predictions are
      unreliable for lengths less than the maximum diameter of the puddle.
      Maximum diameter of the puddle: 219 yards
   Yellow: 545 yards --- (530 ppm = AEGL-1 [60 min])
```