

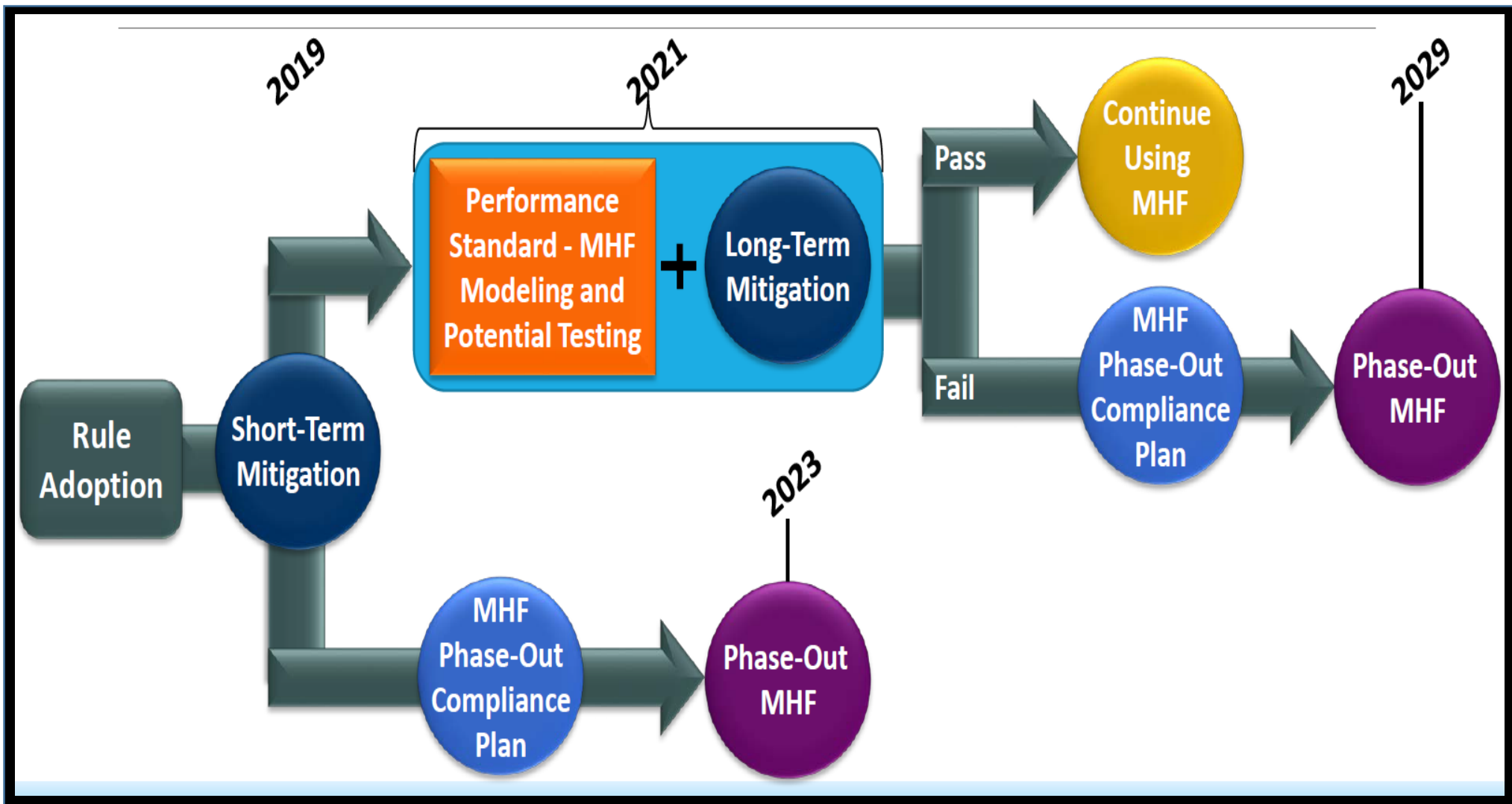
**A Community And Refinery Environmental Safety  
(CARES)  
Alternative**

to SCAQMD Proposed Rule 1410  
**General Approach**

Respectfully submitted by:  
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1 February 2019

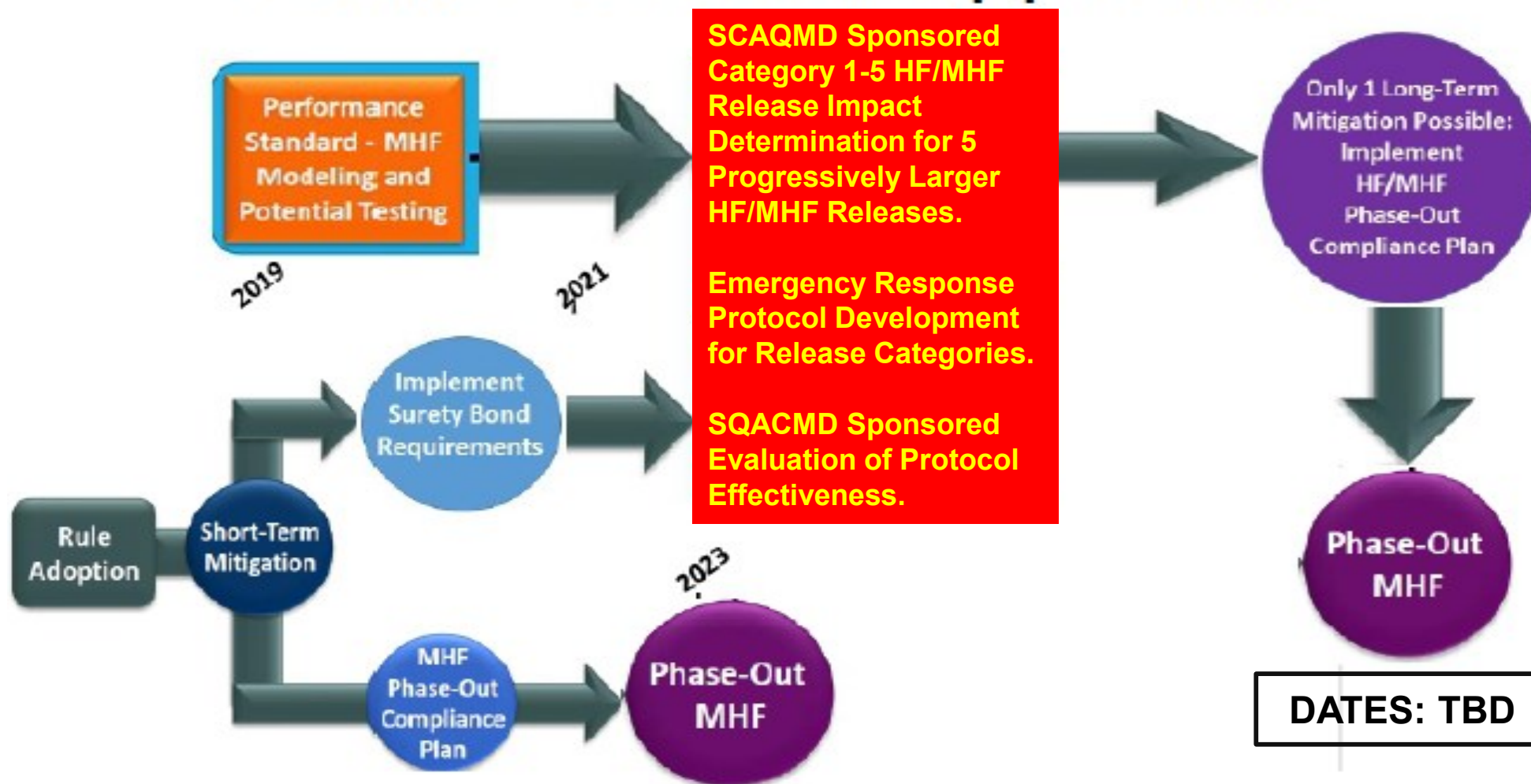
# Original SCAQMD Proposed “General Approach”



SCAQMD “PR 1410 Working Group Meeting #9”, Nov. 16, 2018, p. 10 of 38

# Graphical Summary of the CARES Alternative

## Community Needs this Revised AQMD General Approach



**Community Concerns addressed by CARES and Overall CARES Approach Summarized Next**

# Why the CARES Alternative is Needed:

## Background

- The Massive Feb. 18, 2015 Torrance Refinery Explosion spread reactive Catalyst Dust for miles across Torrance and nearby densely populated South Bay cities.
- The U.S. Chemical Safety Board said the event was a “near-miss” to a massive catastrophic release of Hydrogen Fluoride (HF) and Modified Hydrogen Fluoride (MHF).
- Prior to 2015, ExxonMobil personnel stated that a catastrophic HF/MHF release could not happen in millions to billions of years.
- Even with 100 “near-misses” occurring before a catastrophe, this “near miss” should not have happened in ~10,000 years (time since the *Dawn of Civilization*), yet it occurred within 60 years.
- It shows that numerical estimates can easily underestimate Risk by factors of Hundreds to Millions.
- As a result of this “near miss”, any indefinitely continuing massive HF/MHF use in our densely populated South Bay is inconsistent with the SCAQMD protecting the Public Health and Safety.

# Why the CARES Alternative is Needed:

**Koopman 1986 Nevada Desert ~8000 lb HF Release shows how Deadly HF is**

Picture shows initial aerosol HF Cloud Formation, which then traveled downwind for miles.



**Goldfish Series Anhydrous Hydrogen Fluoride release**

Koopman Test Showed Massive HF Releases form Dense Ground-Hugging Clouds, that can spread Toxic levels of HF over Miles.

# SCAQMD Adopted *MHF Supplier* Honeywell's Recommendations for Treatment of HF Inhalation Exposure

## SUPPLY OF CALCIUM GLUCONATE (ANTIDOTE TO TREAT HF BURNS)

- For significant inhalation exposure – nebulizer every 4 hours for 48 hours\*\*

\*\* Recommended medical treatment of hydrofluoric acid, Honeywell, Version 7.0, 2018



From SCAQMD “Status Update on PR 1410 – Hydrogen Fluoride Storage and Use at Petroleum Refineries”, Sep. 22, 2018, p. 12 of 23

*Honeywell treatment protocol fails to mention the need for “intensive care” for HF Inhalation exposures, except for one extreme HF exposure case:*

[From the Honeywell Document p. 13 of 23]. Continuous Renal Replacement Therapy (CRRT) has been utilized in a patient with systemic toxicity due to a significant (60%) total body surface area burn from HF and concomitant inhalation injury. CRRT is a mode of renal replacement therapy for hemodynamically unstable, fluid overloaded patients and patients with sepsis and septic shock in management of acute renal failure, especially in the intensive care unit setting. (58)

# *Air Products and Chemicals Inc.*

## **Recommends Treatment in an Intensive Care Unit for many HF Inhalation Exposures**

Safetygram 29



### **Treatment protocol for hydrofluoric acid burns \***

Absorption of HF may cause hypocalcemia due to HF's fixation of blood calcium. Hyperkalemia may occur if severe hypocalcemia appears. A person who has HF burns greater than four (4) square inches should be admitted immediately to an intensive care unit and carefully monitored for 24 to 48 hours. Anyone who has been exposed to gaseous HF and experiences respiratory irritation should also be admitted to and monitored in an intensive care unit. Blood sampling should be taken to monitor fluoride, potassium, and calcium levels. In some cases, hemodialysis is necessary for fluoride removal and for correction of hyperkalemia.

\* [https://sms.asu.edu/sites/default/files/safetygram-29\\_hf\\_burns.pdf](https://sms.asu.edu/sites/default/files/safetygram-29_hf_burns.pdf)

***Air Products and Chemicals, Inc.* manufactures cylinders of compressed HF(gas) for industrial use.**

# Why the CARES Alternative is Needed:

*SCAQMD Mitigation: “Have sufficient supplies of calcium gluconate [at hospitals].”*

- Calcium gluconate can mitigate HF skin burns and swallowed HF.
- Calcium Gluconate Nebulizer Mitigation is NOT Effective for Large Dose HF Inhalation Exposures.

## MEDICAL TREATMENT OF HF

- Potential exposure can be to dermal (skin), eyes, or inhalation
- Local hospitals can treat HF exposure
- Patients with significant HF exposure will need to be transported to a burn unit
- One hospital with a burn unit within a 10 mile radius
  - ❑ Torrance Memorial Medical Center (8 beds)
- Three hospitals with burn units within a 10 to 30 mile radius
  - ❑ LAC+USC Medical Center (21 beds)
  - ❑ University of California, Irvine Medical Center (16 beds)
  - ❑ Grossman Burn Center/Santa Ana (5 beds)

**Only 50  
Hospital  
Treatment  
Beds in  
30 mile  
Radius**

SCAQMD “Status Update on PR 1410 – Hydrogen Fluoride Storage and Use at Petroleum Refineries”, Sep. 22, 2018, p. 11 of 23

- Hospitals cannot handle an influx of 100's-1000's of HF ICU cases.
- What if *Little Company* (~2 mi.), *Harbor-UCLA* (~3.5 mi.), or *Torrance Memorial* (~4 mi.) Hospitals “Shelter-In-Place” to protect personnel, and can't open their doors to the outside Community with an HF-Cloud?



# SCAQMD Evaluation of Water Mitigation for HF/MHF Releases

## How Much of Water Is Needed?

- Example of an HF Release:
  - 470 gallons/minute from acid settler and storage (*based on Goldfish Test 1*)
  - 200 gallons/minute from others

HF Release Rate Assumed (GPM)	Water to HF Ratio Needed	Water Release Rate Calculated (GPM)	Mitigation Duration (Minutes)	Total Water Needed (Gallons)
470	60 to 1	28,200	10	282,000
200	60 to 1	12,000	10	120,000

- Need water storage, delivery system, and backup power for pumps

30

# Why the CARES Alternative is Needed:

## Water Needed for even a USEPA OCA HF Release Is Not Available

- “How much water is needed [to mitigate an HF release]?”
  - USEPA OCA has a 50,000 lb Settler Tank HF release occurring in 10 minutes. At ~104.F this is ~634.38 GPM (gals/min), not 470 GPM used by AQMD.

HF Release Rate Assumed (GPM)	Water to HF Ratio Needed	Water Release Rate Calculated (GPM)	Mitigation Duration (Minutes)	Total Water Needed (Gallons)
470	60 to 1	28,200	10	282,000
200	60 to 1	12,000	10	120,000
<b>634.38</b>	<b>60 to 1</b>	<b>38,060</b>	<b>10</b>	<b>380,600</b>

**100' x 100' x 5' LAKE !**



**gallons = 50,880 cu.ft.**

- Need water storage, delivery system, and backup power for pumps
- Torrance cannot source water fast enough even for the OCA.
  - A fire hydrant at 50 psig can source ~1200 GPM
  - All of Torrance uses only about ~10,000 GPM for the whole City

### August monthly water use by the City Of Torrance

August 2016

415 million gallons

August 2017

431 million gallons

**44640 minutes is 1 Month**

# **Why the CARES Alternative is Needed:**

## **Performance Standards are Insufficient**

- Any “Performance Standards” requirements by SCAQMD for Permitted Facilities can only cover anticipated scenarios.
- Protocols developed using anticipated “accident scenarios” may work for small events in which enough time is available:
  - To provide a well-coordinated response between various personnel and agencies, and
  - To implement an orderly “by the book” response.
- Even allowing any individual to activate emergency systems can still result in resource conflicts and misapplications, such as misdirected Water Cannons or misapplied Water Curtains.
- By definition, “Accidents” represent Facility Operations that are outside the bounds of normal, Permitted, and expected events.
- No “Performance Standard” can be developed that provides 100% Fail-Safe protection against all possible major accidents.

# Why the CARES Alternative is Needed:

## MOUs are Insufficient

- The Rule-Making process represents a “good-faith” negotiation between the SCAQMD, Refineries, and the affected Public.
- An MOU process cuts out the Public, and reserves SCAQMD “good-faith” negotiations only for the Refineries.
  - MOUs, *prima facie*, are counter to the Public Health and Safety.
- Refineries are unlikely to agree to any MOU conditions they do not have a reasonable expectation of meeting.
  - Once the SCAQMD agrees to an MOU, any MOU changes to further enhance and protect Public Health and Safety are unlikely.
  - In contrast, the Refineries can always ask for follow-on MOU changes, if an MOU condition turns out to be not to their liking.
- The City of Torrance Consent Decree allowed alkylation using MHF to be deemed “safer” than using Sulfuric Acid, which is non-volatile.
  - Original MHF had a minimum of 50 wt% MHF modifier. It was then reduced to 30%, then down to 10%, then 8%, and now is at 6%.
  - SCAQMD agrees 6% MHF is basically no safer than anhydrous HF.
  - Similar dilutions to Public Health and Safety can occur with an MOU.

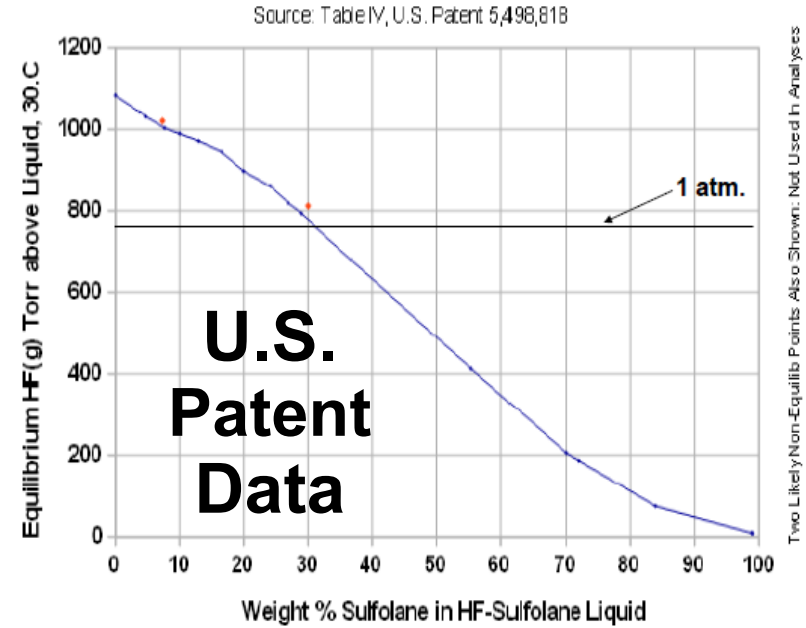
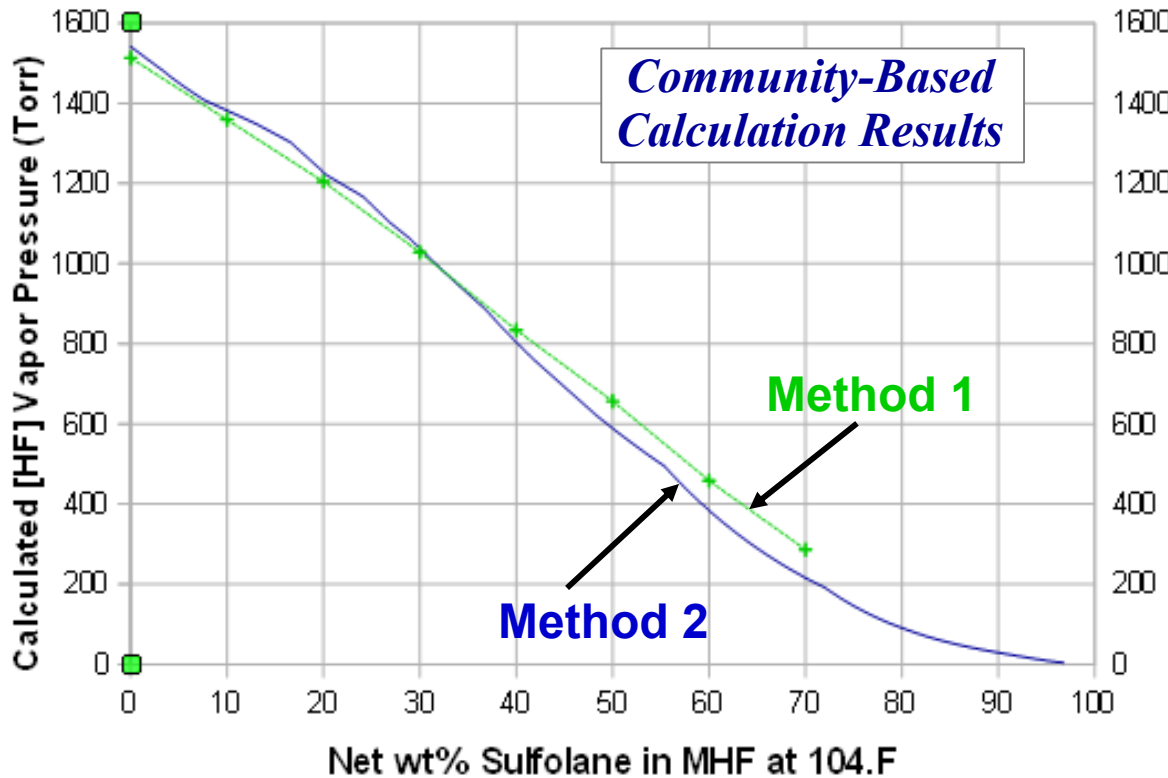
# Why the CARES Alternative is Needed:

**New Modeling of HF/MHF shows that a 40 sq.cm Hole in a Settler Tank Can Release 50,000-lbs of HF in 3-4 Minutes: Minute-by-Minute Emergency Response Planning is Needed**

- New community-based HF/MHF Modeling efforts have developed 2 independent estimates for MHF vapor pressure vs wt% Sulfolane.
  - *Dr. G. Harpole* (Method 1) used *Clausius-Clapeyron Equation* approximation
  - *Dr. G. Eng* (Method 2) used *Spline-Fitting and Conformal Mapping* of the [HF]-Sulfolane system to known [HF]-Water temperature Data
  - Both methods agree to better than 1.65% for 0 wt% - 30 wt% Sulfolane
- Allows HF/MHF Tank Release rate predictions for Nominal Settler Tank 104.F temperature, augmenting the 86.F (30.C) Patent Data.
  - Release Rate Results can be compared to SCAQMD Maximum Planned Water Deluge Rate WDR=28,200 gallons per minute (gpm)
  - WDR value provided by SCAQMD in Working Group #8 presentation
- Calculations show that the Refinery Settler Tank can Release 50,000 lbs of HF from a 40 sq.cm. (~3" diam.) Hole in 3-4 Minutes.

**Why The CARES Alternative Is Needed:  
U.S. Patent shows MHF is Sulfolane plus Anhydrous HF:**

**Calculated [HF]-Sulfolane Vapor Pressures  
(at Normal Settler Tank Temperature of 104.F)**

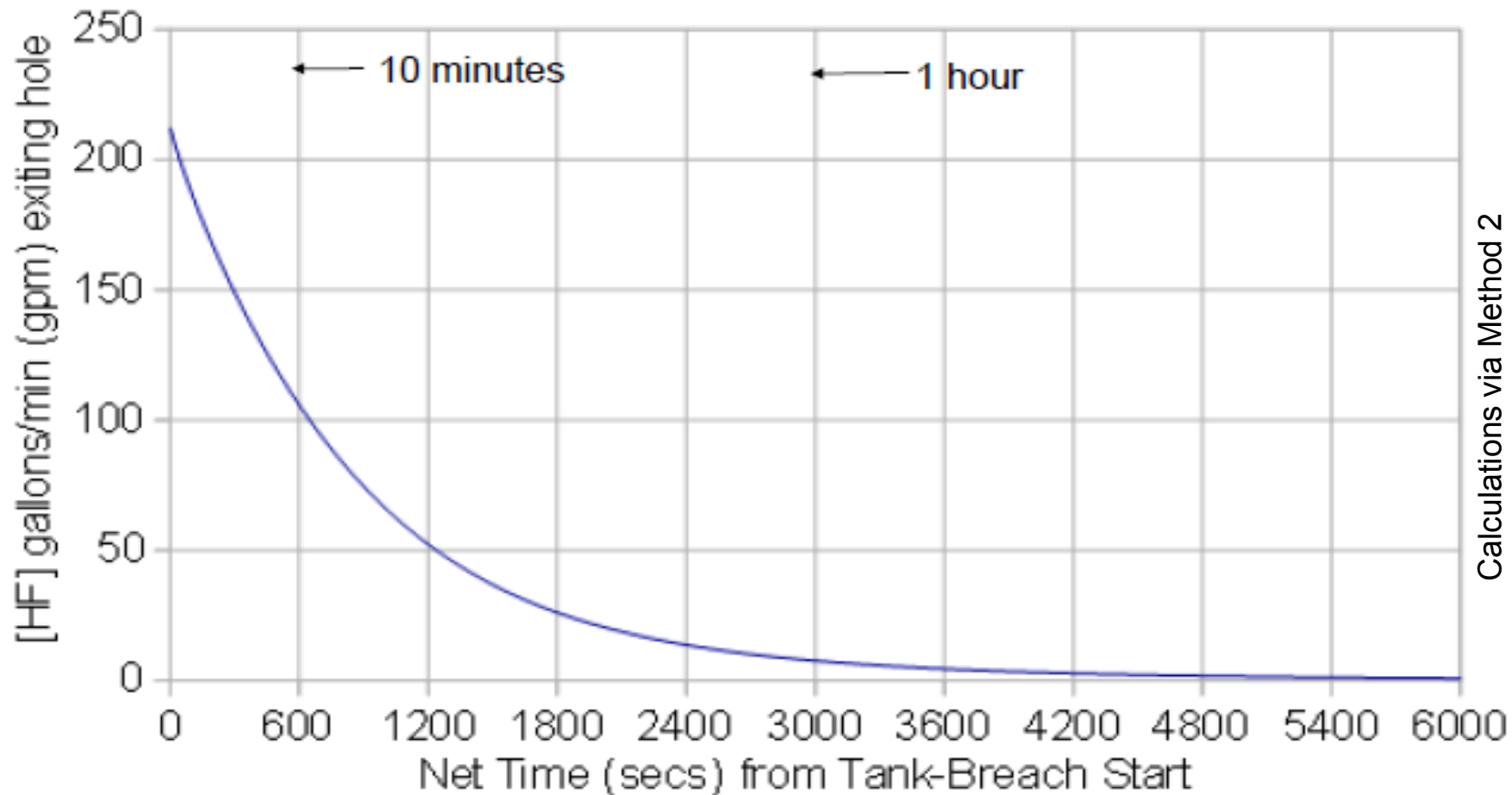


Both Calculation Methods agree to better than 1.65% for 0 wt% - 30 wt% Sulfolane.

**Results show that HF/MHF Tank Breaches can be effectively modeled without expensive large-scale new MHF release experiments.**

# Tank Breach with the MHF that the Community Was Originally Promised

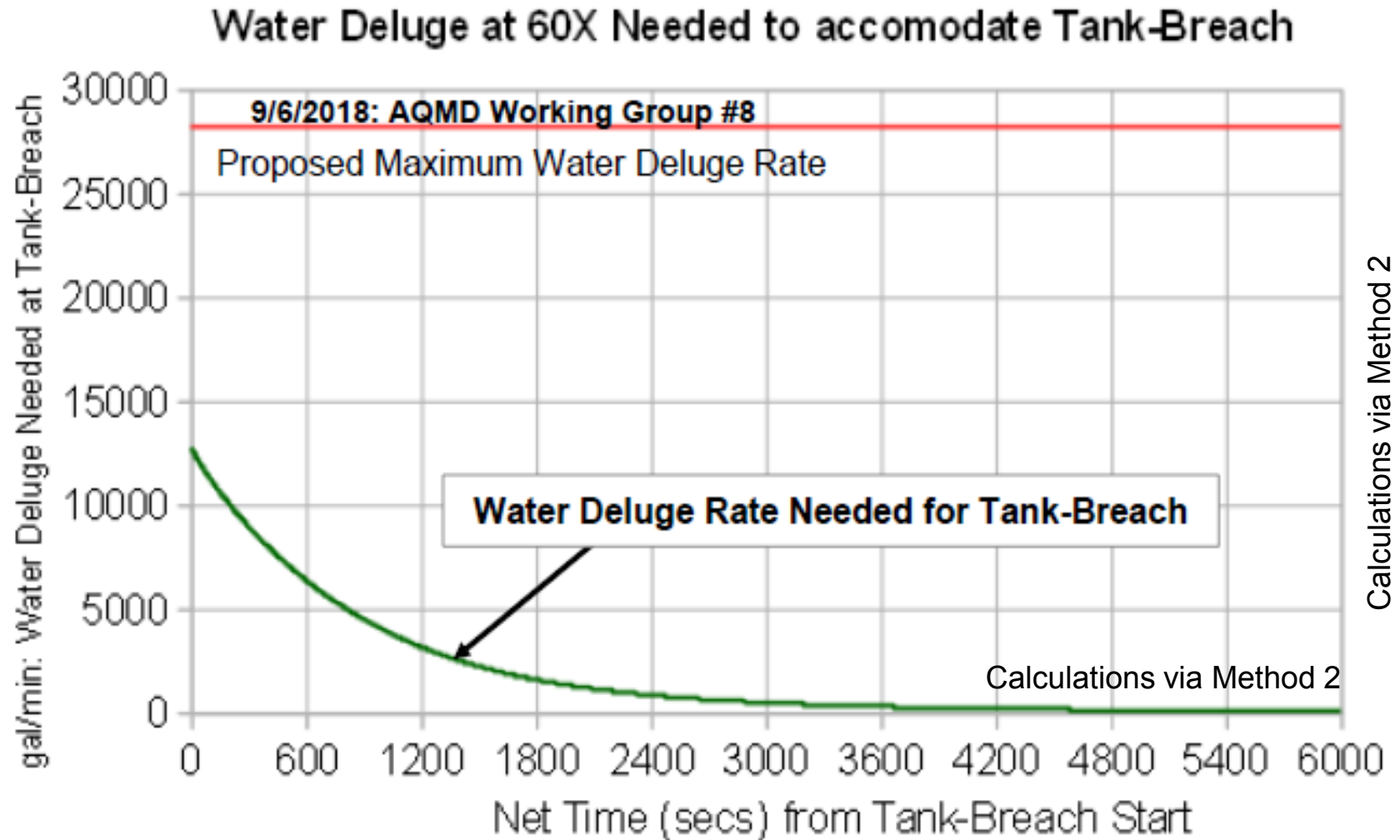
Calculated HF-Cloud from 40 cm<sup>2</sup> Tank Breach at Bottom  
Tank 96% full with the MHF that we were Initially Promised at 104°F:  
**MHF= Anhydrous [HF] with 50 wt% Sulfolane**



- Time to empty 50,000 lb [HF] Tank using Initially Promised MHF composition from a 2.8" Diameter Hole (= 40cm<sup>2</sup>).

# SCAQMD Proposed Water Deluge might handle this Tank Breach

HF-Cloud from 40 cm<sup>2</sup> Tank Breach at Bottom (96% full with MHF)  
**104°F Tank Breach: Anhydrous [HF] with 50 wt% Sulfolane**

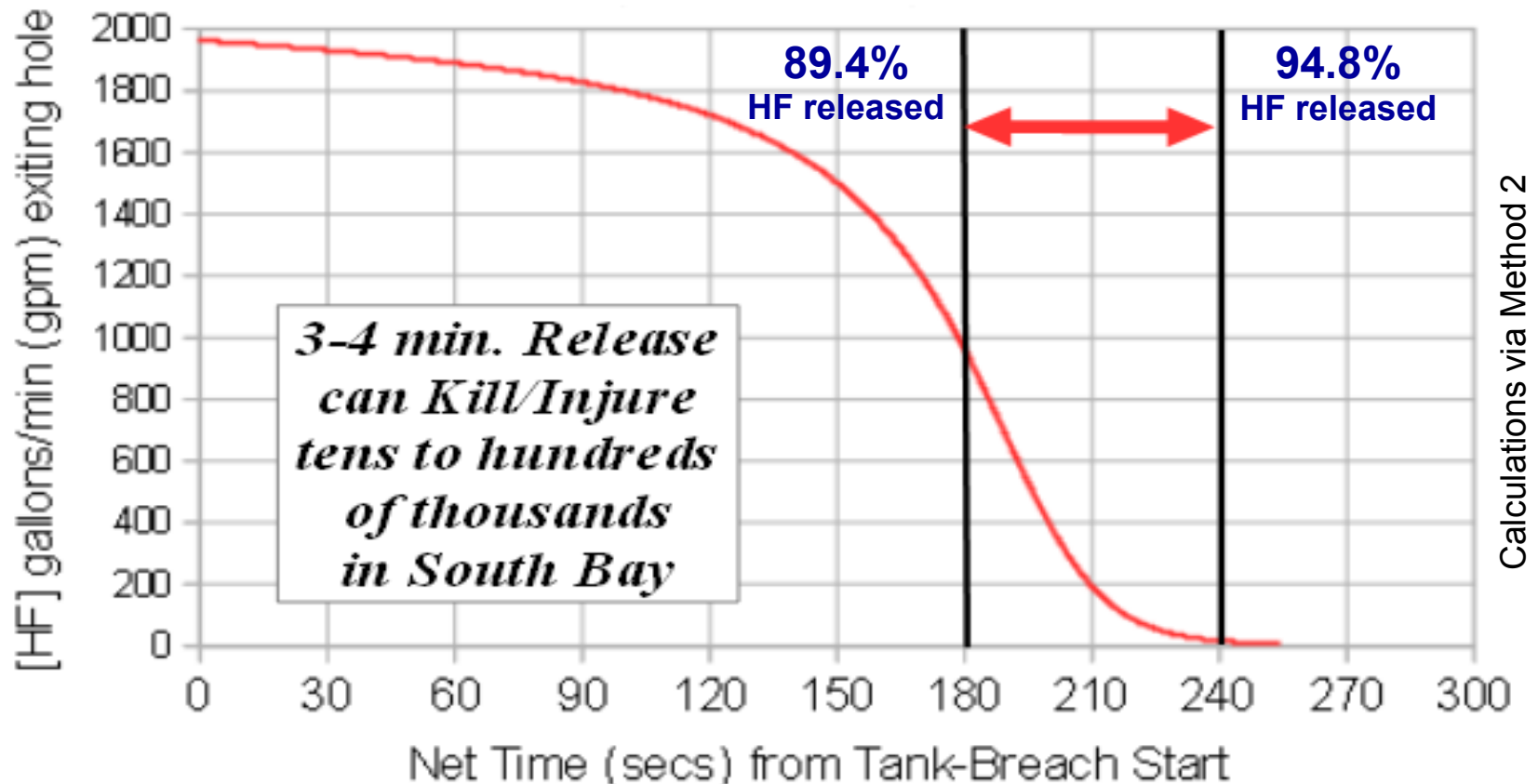


- AQMD Proposed Water Deluge with a Best-Possible Response could accommodate this size Tank-Breach



# Calculated HF/MHF Tank-Breach Results for Settler Tank Conditions that the Community Likely Has

HF-Cloud from 40 cm<sup>2</sup> Tank Breach at Bottom (96% full with MHF)  
104°F Tank Breach: Anhydrous [HF] with 6 wt% Sulfolane  
plus 3 wt% Liquid Hydrocarbon overlayer of Isobutane



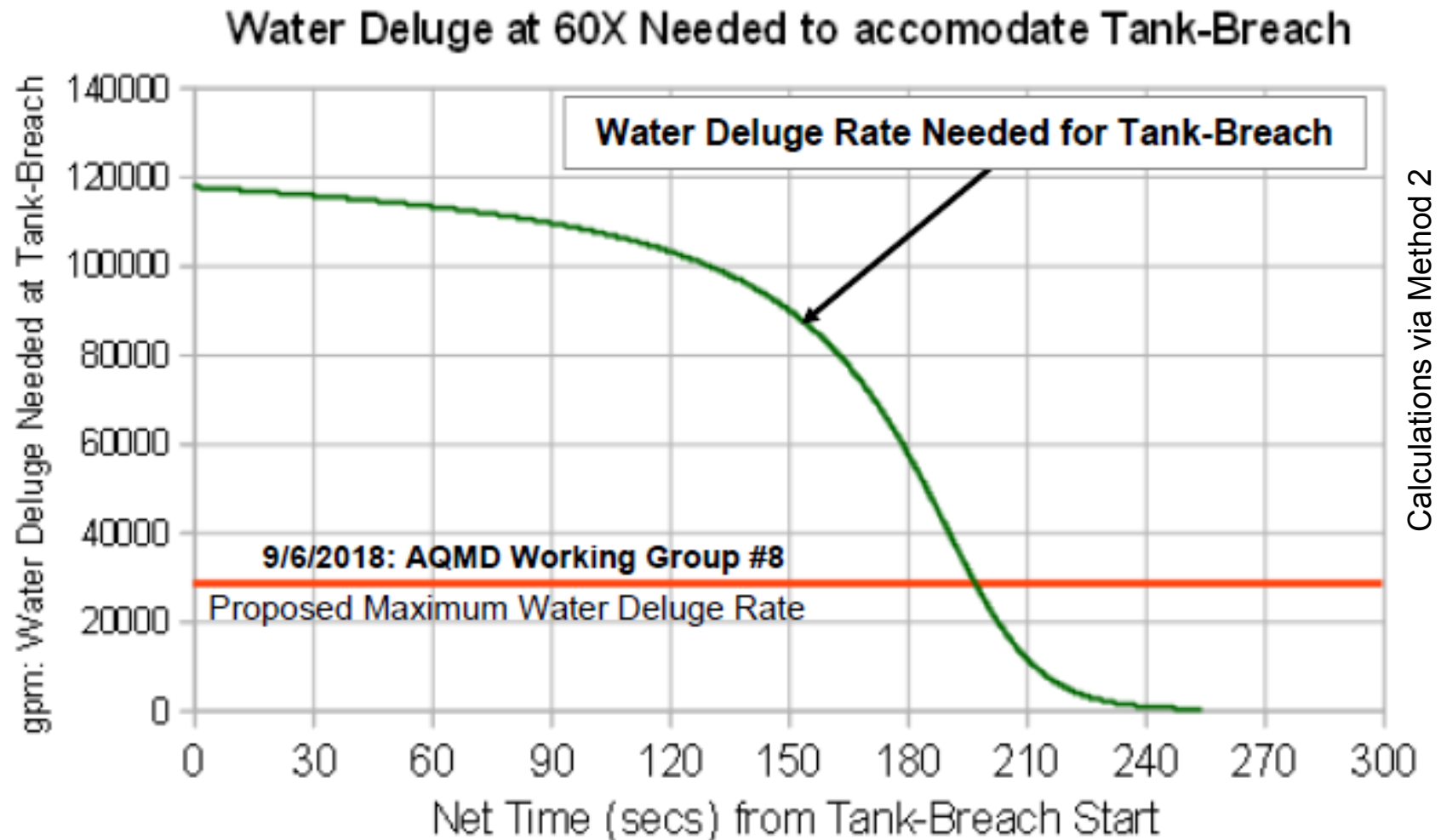
With 50,000 lb [HF] Tank, 2.8" Diameter Hole (= 40 cm<sup>2</sup>), and present In-Tank Materials.

**Minute-by-Minute Emergency Response Planning  
Would be Needed to Handle this Release Scenario**

# Water Deluge Is Woefully Inadequate In This Case

HF-Cloud from 40 cm<sup>2</sup> Tank Breach at Bottom (96% full with MHF)

**104°F Tank Breach: Anhydrous [HF] with 6 wt% Sulfolane  
plus 3 wt% Liquid Hydrocarbon overlayer of Isobutane**



- Water Deluge Systems cannot accommodate this Tank-Breach.

## Net Total Pounds of HF Released vs Time

<b>Time from Tank-Breach Start</b>	<b>50% Sulfolane MHF</b>	<b>6% Sulfolane + 3% Isobutane</b>	<b>“Goldfish Test” Koopman Avg.</b>
10 secs	305	2573	616
20 secs	578	5127	1233
31.318 secs	882	<b>8000</b>	1930
60 secs	1635	15186	3698
90 secs	2395	22505	5547
125 secs	3248	30626	7704
2 min. 10 sec.	3367	31728	<b>8000</b>
3 min.	4520	40919	8000
4 min.	5820	43361	8000
5 min. 51 sec	<b>8004</b>	43374	8000
10 min.	12010	43374	8000
20 min.	18007	43374	8000
1 hour	23766	43374	8000

Different Settler Tank contents can change the Emergency Response Time from <6 min. to <30 secs. for preventing an **~8000 lb** release as in the Koopman Test. The ~50,000 lb HF/MHF release time changes from ~1 hr. to ~4 min.

# The CARES Alternative

## Overall Mission and Goals:

- Since Large-Scale HF and MHF releases will form catastrophic deadly vapor clouds, permitting ongoing Large-Scale HF and MHF use in high-density urban areas is inconsistent with the SCAQMD mission of protecting the Public Health and Safety.
- The Primary SCAQMD Mitigation for this nearly unbounded risk needs to be either: (i) an immediate phase-out of HF and MHF use, or (ii) an eventual phase-out of HF and MHF use.
- Eventual phase-out of HF and MHF still presents an ongoing and continuing risk to the Public Health and Safety during the phase-out period.
- During this potentially many-year phase-out period, the SCAQMD needs to develop and require additional HF/MHF mitigation measures to protect the Public Health and Safety.

# Elements of the CARES Alternative

- SCAQMD Rule 1410 needs to be completed with no MOU elements.
- To properly protect the Public Health and Safety, all Rule 1410 pathways must either immediately eliminate or phase-out HF/MHF.
- Prior to final HF/MHF phase-out completion, additional HF/MHF Performance-Standards and Mitigation Requirements are still needed.
- To properly protect the Public Health and Safety, the SCAQMD should require all HF/MHF Refineries to post a Surety Bond to fund a Victims' Compensation Fund for covering Public Health Impacts of large-scale HF/MHF releases.
- The SCQMD should develop minute-by-minute Detailed Emergency Response Plans in coordination with FEMA, Police, Fire, Hospitals, Schools and the Public, covering the different possible impacts for several categories of successively larger HF/MHF releases.
- The SCAQMD should develop Economic and Socio-economic Impact Reports, with total \$ Dollar impacts for each category of successively larger HF/MHF releases.

# Details of the CARES Alternative

- Require HF/MHF Refineries to post a Surety Bond of at least \$1 Billion Dollars from an independent insurer to cover acute and chronic health impacts to the Public resulting from any HF/MHF releases.
  - Surety Bond Amount should increase for Refinery HF/MHF releases.
- Develop SCAQMD-sponsored evaluation of the economic impacts of HF/MHF releases for each of the following 5 categories:
  - **Category 5:** 50,000 lbs or more HF/MHF release, with or without a concurrent FEMA response disaster, such as a large earthquake or terrorist attack.
  - **Category 4:** 10,000 lbs – 50,000 lbs HF/MHF release, with and without a concurrent FEMA response disaster.
  - **Category 3:** 1,000 – 10,000 lbs HF/MHF release, with and without a concurrent FEMA response disaster.
  - **Category 2:** 100 lbs – 1,000 lbs HF/MHF release.
  - **Category 1:** Less than 100 lbs HF/MHF release.
- Develop SCAQMD-sponsored Emergency-Response protocols for what Police, Firefighters, Hospitals, Schools, and the Public, should do during each of the above Category releases.
- Perform SCAQMD-sponsored evaluation of likely effectiveness of the Emergency Response protocols for each of the above Category releases
  - Evaluation should include independent estimates for the likely number of long-term Public injuries and deaths.

# SUMMARY

- To properly Protect the Public Health and Safety:
  - Rule 1410 needs to be implemented without Refinery MOUs.
  - All Rule 1410 paths need to end in HF/MHF elimination or phase-out.
    - Phase-out Schedule and Dates: [TBD]
- Prior to full HF/MHF elimination or phase-out:
  - Refinery Surety Bond is needed to cover Public Health Impacts from accidental HF/MHF releases.
  - SCAQMD needs to develop **minute-by-minute** emergency response scenarios for all HF/MHF releases, from Small to Catastrophic.
  - An SCAQMD Economic and Socio-economic Analysis needs to be done to identify impacts of Large to Catastrophic HF/MHF releases.
- Community efforts to date show that:
  - Numerical estimates for Event Probabilities can underestimate Risk by factors of Hundreds to Millions.
  - A Settler Tank can have an ~50,000 lb HF/MHF release time of ~4 min.
  - “Performance Standards” cannot guarantee 100% Fail-Safe protection against all possible accidents.
  - Water Deluge cannot effectively mitigate large HF/MHF releases.
  - *Calcium Gluconate* Nebulizers insufficient for large HF Inhalations.

**Video Capture Details from the  
Gumi, South Korea  
Massive  
16,000 lb. HF Release  
of Sept. 27, 2012**



# HF Cloud from the Massive Sept. 27 2012 HF Release in South Korea



- Prevailing wind carried the HF cloud *away from the city*. Our refinery is surrounded by city.
- 16,000 lb. released, 5 killed, 18 severely injured, 12,243 treated, thousands evacuated for weeks.
- The area around the plant was declared a 'special disaster zone.'
- 80 other firms in the area were affected, with millions in business losses

Above Photo and Text Compiled by: Dr. Sally Hayati, TRAA  
Follow-on material compiled herein, with notes by Dr. G. Eng.

(1:11 min) VIDEO FROM THE ORIGINAL SOUTH KOREA ACCIDENT SITE  
[https://www.youtube.com/watch?v=6EpE3JHHoal&has\\_verified=1](https://www.youtube.com/watch?v=6EpE3JHHoal&has_verified=1)

HF  
Tank  
Top  
Cover



Hydrogen Fluoride Release Kills 5 (CCTV)

147,558 views

103 33 SHARE SAVE ...

- Innocuous start: Workers bring hose-line to HF Tank Top Cover. They were not expecting any problems, and had **no** HF protective gear on.

[https://www.youtube.com/watch?v=6EpE3JHHoal&has\\_verified=1](https://www.youtube.com/watch?v=6EpE3JHHoal&has_verified=1)

Time 0:48 secs out of 1:11 minutes Total

The image shows a YouTube video player interface. The video content is a CCTV recording of an industrial facility. In the top left corner of the video, there is a watermark that reads "HOSTED ON LiveLeak ID=002". The video shows several large, cylindrical tanks and a network of pipes. A yellow arrow points from the left side of the frame to a red circle that highlights a white, misty cloud beginning to form on a platform or walkway. Below the video player, the title "Hydrogen Fluoride Release Kills 5 (CCTV)" is displayed, along with "147,558 views". At the bottom right of the video player, there are icons for likes (103), comments (33), share, and save. The video progress bar at the bottom indicates the video is at 0:48 / 1:11.

HF  
Cloud  
Start

- Something obviously goes wrong, and an escaping HF cloud starts to form.

[https://www.youtube.com/watch?v=6EpE3JHHoal&has\\_verified=1](https://www.youtube.com/watch?v=6EpE3JHHoal&has_verified=1)

Time 0:48.3 secs out of 1:11 minutes Total



HOSTED ON  
LiveLeak  
ID=002

▶ ⏪ 🔊 0:48 / 1:11 ⚙️ 📺 🗑️

Hydrogen Fluoride Release Kills 5 (CCTV)

147,558 views

👍 103 💬 33 ➦ SHARE ⋮ SAVE ...

- **Within a fraction of a second, the escaping HF cloud envelops both workers.**

[https://www.youtube.com/watch?v=6EpE3JHHoal&has\\_verified=1](https://www.youtube.com/watch?v=6EpE3JHHoal&has_verified=1)

Time 0:49 secs out of 1:11 minutes Total



The video player shows a CCTV recording of an industrial facility. A large white cylindrical tank is the central focus. A person is seen being propelled backwards by a large release of gas. The video player interface includes a progress bar at 0:49 / 1:11, a volume icon, and standard YouTube controls (play, pause, settings, full screen, etc.).

Hydrogen Fluoride Release Kills 5 (CCTV)

147,558 views

103 33 SHARE SAVE ...

- **Within 1 second, full force of the escaping HF gas propels man backwards.**

[https://www.youtube.com/watch?v=6EpE3JHHoal&has\\_verified=1](https://www.youtube.com/watch?v=6EpE3JHHoal&has_verified=1)

Time 0:53 secs out of 1:11 minutes Total



Hydrogen Fluoride Release Kills 5 (CCTV)

147,558 views

103 33 SHARE SAVE ...

- Within 5 seconds, a dense ground-hugging HF cloud forms and begins spreading out.

[https://www.youtube.com/watch?v=6EpE3JHHoal&has\\_verified=1](https://www.youtube.com/watch?v=6EpE3JHHoal&has_verified=1)

Time 1:02 min out of 1:11 minutes Total



Hydrogen Fluoride Release Kills 5 (CCTV)

147,558 views

103 33 SHARE SAVE ...

- By 14 seconds, the initial ground-hugging cloud falls down and around the HF tank sides, temporarily clearing the camera view.

[https://www.youtube.com/watch?v=6EpE3JHHoal&has\\_verified=1](https://www.youtube.com/watch?v=6EpE3JHHoal&has_verified=1)

Time 1:08 min out of 1:11 minutes Total

HF  
Jet



The image shows a YouTube video player interface. The video content is a CCTV recording of an industrial facility. In the upper left corner of the video frame, there is a 'LiveLeak' watermark with '(tel)' above it and 'ID=002' below it. A yellow arrow points from the text 'HF Jet' on the left to a white, plume-like jet of gas being released from a structure in the middle ground. The video player controls at the bottom show a progress bar at 1:08 / 1:11, along with play, volume, settings, and full screen icons. Below the video, the title 'Hydrogen Fluoride Release Kills 5 (CCTV)' is displayed, followed by '147,558 views' and engagement icons for likes (103), comments (33), share, save, and a menu icon.

- By 20 seconds, prevailing winds push the ongoing HF cloud formation away from the camera, allowing the HF release jet to be visible.



[https://www.youtube.com/watch?v=6EpE3JHHoal&has\\_verified=1](https://www.youtube.com/watch?v=6EpE3JHHoal&has_verified=1)

Time 1:09 min out of 1:11 minutes Total



Hydrogen Fluoride Release Kills 5 (CCTV)

147,558 views

103 33 SHARE SAVE ...


- From this HF Jet, eventually 16,000 lbs. of HF would be released, becoming the worst chemical accident in Korean history.

[https://www.youtube.com/watch?v=6EpE3JHHoal&has\\_verified=1](https://www.youtube.com/watch?v=6EpE3JHHoal&has_verified=1)

*South Korea 2012 News Article:*  
**Massive ~16,000 lb. HF Release Kills 5**

Hydrogen Fluoride Release Kills 5 (CCTV)

147,558 views

 103  33  SHARE  SAVE ...



LiveLeak

Published on Oct 17, 2012

SUBSCRIBE 298

Damages from toxic gas leak worsen in southern S. Korea

GUMI, South Korea, Oct. 7 (Yonhap) – More than 3,000 people have received emergency care for nausea and other symptoms, officials said Sunday, following a disastrous gas leak that also caused widespread damages to crops, livestock and factories in southern South Korea. A total of

3,178 people have been treated for nausea, rashes and other symptoms since the Sept. 27 explosion of a chemical plant that leaked some eight tons of hydrofluoric acid, an acute poison that can damage lungs and bones and affect the nervous system.

Five workers were killed and 18 others were injured in the blast at chemical maker Hube Global at the Gumi National Industrial Complex in the industrial city, about 200 kilometers southeast of Seoul.

The gas leak has cost factories in the industrial complex about 17.7 billion won (US\$15.9 million) in lost production, officials said. Hundreds of angry villagers in Gumi who suffered after the massive gas leak moved to a safer region with some residents reporting blood in their saliva. About 110 elderly people in Bongsan-ri village evacuated to a facility about 10 kilometers away. "We decided to move because the government overlooked us and did not come up with countermeasures," Park Myeong-seok, the head of Bongsang-ri, told reporters.

About 190 people in nearby Imcheon-ri left their village and moved to a training center for teenage students. An acrid smell still hangs in the air in the two villages, home to some 1,200 people. Villagers accused the government of failing to give proper and timely information about the gas leak, and expressed disbelief over the announcement hydrofluoric acid was not detected in their towns. Crops and fruit on more than 212 hectares of farmlands and orchards have withered, and some 3,200 livestock animals have been drooling heavily or showing symptoms similar to a cold, according to local officials and villagers. The central government, under mounting criticism for poorly handling the disaster at the initial stage of the explosion, is considering designating the affected area as a special disaster zone, a move that would bring extra financial support for the victims.

On Monday, the government will announce the results of its in-depth inquiry into the gas leak, officials said.

Two workers at top of tank lorry for transfer and two worker at ground level for pump repair and one officer at office building close to tank lorry died. See this tragic event unfold with this CCTV footage of the workers on top of the ISO tank connecting air lines to effect the transfer of HF - moments later the HF is released.

Anhydrous HF leaked from the liquid valve as two workers were on top preparing to connect a Anhydrous Hydroflouric ISO Tank for offloading. They accidentally fully opened the quarter turn valve. An estimated 8 tons of HF was released. 5 people including the 2 workers perished, 18 responders, workers, reporter wound-up in the hospital, almost 3000 villagers from 2 villages downwind of the facility were treated for irritation, exposure.

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Some pre-report key issues to consider are:

1. Both workers had no chemical protective clothing or SCBA
2. No fall protection
3. Emergency response equipment/systems to mitigate the leak

This has been reported to be the worst chemical accident in Korean history.