Dr. Diana Felton
State of Hawaii Department of Health
Hazard Evaluation and Emergency Response Office
2385 Waimano Home Road
Pearl City, Hawaii 96720-4623

Arcadis U.S., Inc.
500 Ala Moana Boulevard
Suite 7400
Honolulu
Hawaii 96813
Phone: 808 522 0321
Fax: 808 522 0366
www.arcadis.com

Date: June 24, 2022
Subject: Arcadis Public Comment on HDOH HEER *Risks of Sea Level Rise and Increased Flooding on Known Chemical Contamination in Hawaii (updated June 2021)*

Dear Dr. Diana Felton,

Arcadis U.S., Inc. (Arcadis) prepared this letter to provide public comment and ask questions following review of the Hawaii Department of Health (HDOH), Hazard Evaluation & Emergency Response Office (HEER Office) memorandum *Risks of Sea Level Rise and Increased Flooding on Known Chemical Contamination in Hawaii (updated June 2021)*, herein referred to as "the memo".

Introduction

The memo encompasses many aspects that combine to create future sea level rise concerns, including the understanding of flooding, groundwater inundation, disruption of contaminated lands due to climate change (e.g., storm surge, extreme precipitation/system capacity, compound flooding) to both human health and built environment and translate findings to workable policies.

Each aspect requires detailed analyses by itself and a systematic analysis to understand interrelations and be able to quantify impacts to exposed communities and assets (health and built environment). An integrated study would need to be scenario based, discuss climate uncertainty, and relate to monitoring data of plumes and contamination.

It is stated that, "It is anticipated that additional guidance, policies and regulations will be necessary to adequately prepare for and address impending impacts to human health and the environment from climate change." The policy objective is not explained. What exactly is HDOH wanting to achieve and discuss with stakeholders to achieve these goals?

Background

Approximately 1,000 sites are being addressed by the 3.2 foot sea level rise projection screening. Which portion of the sites are located within a current flood zone and/or future flood zone? What portion of the sites are currently exposed to high groundwater table and/or future high groundwater table? What does the monitoring program look like? Are the right aspects being monitored that allows HDOH to be able to answer the goals presented in the Introduction section of the memo?

How do Geographic Information System (GIS) come into play, what are the most prominent sites and how have they been addressed? Is there 1 site that has been resolved and can function as a best practice from a remediation perspective (with or without accounting for climate change/SLR)?

Abandoning (waterfront) sites will likely lead to further spreading, exposure, and contamination of surface water and aquatic ecology and increased exposure to bordering assets and communities. What criteria does HDOH currently have and how do these need to be revised? The Background section of the memo states that changing conditions require new strategies.

There is a limit to what can be regulated and managed with regard to current and future land-use. Active area management will be needed to inform landowners, and this generally requires an area (with contaminants) masterplan.

A Climate Sensitive Development Plan with environmental constraints was shaped for the Iwilei Kapalama industrial area. But before that Plan can be adapted to future HDOH strategy, HDOH in collaboration with the city and other stakeholders need accurate data and data projections with regard to future conditions.

The background introduction is asking some of the questions but is by far not comprehensive and needs but is not touching much more on the interrelation between data and broader area/land-use processes, legal land ownership practicalities that will obstruct policy, and solution implementation.

Planning for Sea Level Rise

The 2017 *Sea Level Rise Vulnerability and Adaptation Report*[1] from the Hawaii Climate Change Mitigation and Adaptation Commission is 5 years old and may not be an accurate reflection on SLR projections. Arcadis recommends an evaluation against comparable studies(e.g., Gulf Coast U.S. studies). Beside comparison on SLR data, Arcadis recommends comparison on methodology / framework and mitigation recommendations.

SLR assumptions would benefit from a curve showing likelihood / time scenarios. Doing nothing (mitigation in place) under changing circumstances was mentioned before as an issue. Also, the scope outlined is here being limited to pollution, the effects of SLR to broader and built environment are not mentioned nor explained (100RC workshop did explore the interplay – as it relates to SLR protection strategies, development potential, land-use, zoning/up-zoning: see page 47 https://resilientoahu.org/resilience-strategy)

The National Oceanic and Atmospheric Administration (NOAA) managed sea level datum station (1612340 Honolulu, Hawaii) indicates at relative sea level trend of 1.55 millimeters/year over the period of 1905 to 2021, which is the equivalent to a change of 0.51 feet in 100 years[2]. Arcadis acknowledges that the magnitude of sea level rise is projected to increase over the future decades and century, and that HDOH HEER Office is using the 3.2 feet of sea level rise as a primary planning benchmark for chronic sea-level rise related impacts.

Arcadis agrees that global climate change is likely to continue to occur and climate-driven sea level rise is likely to occur. However, the sea level rise projections do not consider the impact resilience engineering will have to offset the impacts of sea level rise. Resilience engineering includes engineering mitigation measures such as repairing and rebuilding infrastructure. Significant federal funding has been set aside for the State of Hawaii for resilience engineering including at least $1.2 billion to repair and rebuild roads with a focus on climate change mitigation, resilience, and safety for all road users. Additionally, the State of Hawaii has access to $7 billion in nationwide funding to support flood control projects that protect vulnerable communities from sea level rise and extreme weather[3]. Arcadis concludes that the screening of HEER managed sites using the 3.2 feet of sea level rise

---

[1] Hawaiʻi Climate Change Mitigation and Adaptation Commission. 2017. Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report. Prepared by Tetra Tech, Inc. and the State of Hawaiʻi Department of Land and Natural Resources, Office of Conservation and Coastal Lands, under the State of Hawaiʻi Department of Land and Natural Resources Contract No: 64064.https://climate.hawaii.gov/wpcontent/uploads/2019/02/SLR-Report_Dec2017-with-updated-disclaimer.pdf pg 241-245
[2] Accessible via: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=1612340
[3] Accessible via: https://www.schatz.senate.gov/news/press-releases/president-signs-infrastructure-bill-into-law-at-least-28-billion-in-new-federal-funding-heading-to-hawaii-even-more-expected

projection (Appendix A, Figures 1 and 2 of the memo) does not currently account for any offsetting impacts from resilience engineering.

Case Examples

The broader context needs to be discussed with range of stakeholders. Also, this example speaks to “resolving remediation” as part of an opportunity, not just a historic liability. The memo could identify “delaying/complicating” but also “enhancing” factors.

The Case Study overview could benefit from a range of different circumstances that speak to the overarching goals in the Introduction. Various sites and conditions that, as a whole, give better insight on the comprehensive need, feasibility, interrelations etc. or in other words, how big is the problem.

On the Petroleum example, what is the impact to current buildings; exposure of below ground spaces or slab on grade construction? How is SLR being addressed in building codes (Base and Design Flood Elevations) for new development. What ambition has the city/county in addressing existing assets? Will HDOH provide detailed approaches for understanding flood risk to properties?

SLR Petroleum Contamination and Byproducts (Methane and Hydrogen Sulfide)

Methane present in the subsurface can potentially lead to explosive conditions. Methane in the subsurface can be generated from biologic decomposition of organic matter, derived from high pressure and temperature that produce fossil fuels, or produced by the biodegradation of petroleum hydrocarbons in the subsurface. Specific conditions including a sufficient concentration of methane, a sufficient concentration of oxygen, and an ignition source need to be met to create a potentially explosive environment.

The lower flammability limit (or LEL) for methane is 5%volume (%v) and the upper flammability limit (or UEL) is 15%v. At concentrations between 5% to 15%v methane, and with the appropriate concentration of oxygen, explosive or flammable conditions are possible in the presence of a flame. At concentrations higher than 15%v, methane can dilute with air to yield a concentration within the flammable/explosive range.

Methane is not flammable in the subsurface soil matrix; the primary hazard is flammability of methane in air, specifically in an enclosed space. Methane in the subslab soil vapor is of concern if it migrates into enclosed spaces and mixes with air (including an appropriate concentration of oxygen) to form a mixture with the flammable range of 5% to 15%v methane. Methane in the subsurface is not typically under significant pressure and usually migrates by diffusion rather than advection. Diffusion into subsurface utility corridors could pose localized flash explosion or fire concerns if methane mixes with oxygenated air and is encountered during subsurface construction or utility work. Accumulation of methane in poorly ventilated rooms of buildings with cracked floors, gaps around utility penetrations in the floor, or other vapor entry routes could also pose potential hazards.

Arcadis agrees that it is possible that sea level rise may generate a more anerobic environment in the subsurface. A more anerobic environment could lead to higher subsurface methane concentrations where petroleum-impacted media is present as methane is produced via anaerobic biodegradation instead of aerobic biodegradation. However, it is unknown to what degree this will increase (if at all) methane generation in the subsurface. Figure 4 of Appendix A of the memo suggests this relationship.

However, it should be noted that Figure 4 of Appendix A presents a limited range of groundwater data (12-25 discrete sampling points) collected from four groundwater monitoring wells at one project site located near the shoreline near Honolulu Harbor. Additionally, the figure only presents two variables (dissolved methane concentration and monthly mean sea level) over time and does not include other variables that may impact dissolved methane concentration. Thus, conclusions from this dataset are not representative of site conditions at the over 300 chemically contaminated sites statewide that are included within the area impacted by the 3.2 feet of sea level rise projection.

Dissolved methane concentrations in groundwater are presented in Figures 3 and 4 of Appendix A and a relationship between rising mean sea level and increased dissolved methane concentrations in groundwater is concluded. In the worst-case scenario (MW-35), there is a potential correlation between an approximately 0.5 foot rise in mean sea level and an increase of 1-3 milligrams per liter (mg/L) of methane in groundwater.

However, there is no discussion whether the increased dissolved methane concentrations in groundwater pose a hazard at the more elevated concentrations (maximum concentration ~9 mg/L at MW-35 in 2015). The United States Geological Survey (USGS) recommends that groundwater methane concentrations greater than 10 mg/L are an indication that methane concentrations may become a hazard (USGS 2006)[4]. The solubility limit for methane in water is pressure and temperature dependent but is generally within the 20-22 mg/L range for warm, shallow groundwater typical to coastal areas in Hawaii[5]. Concentrations greater than 10 mg/L indicate that dissolved methane concentrations may be near the solubility limit. If the solubility limit is reached, then any excess methane generated in the subsurface cannot solubilize in groundwater and could indicate that methane is being produced at rates that could lead to advective flow into areas where methane could create a hazard. When methane concentrations exceed the 10 mg/L screening criteria, USGS recommends collecting soil vapor data in the direction of receptors and in any preferential pathways that may act as corridors for soil-gas transport. Soil vapor data can better evaluate whether further monitoring and/or mitigation is necessary.

Arcadis agrees that there may potentially be a relationship between rising mean sea level and increased dissolved methane concentrations in groundwater. Arcadis recommends that in addition to analyzing the trend that the concentration of the dissolved methane be compared to a hazard-specific screening level and suggests using the 10 mg/L screening criteria recommended by USGS.

Generally, the sites that are included within the 3.2 feet sea level rise projection scenario are located within areas where the groundwater table is already very shallow (0-4 feet below ground surface). At these sites, there is limited unsaturated vadose zone and there would be less unsaturated vadose zone as the groundwater table rises. The limited unsaturated vadose zone does not allow for significant air pore space available for volatilization and accumulation. In the more extreme case where no unsaturated vadose zone is present, the methane would need to off-gas into cracks/openings in the building slab (if a building is present) and would "trickle in". In this scenario, there would not be sufficient mass loading to create a potentially flammable environment.

Methane dissipates very quickly within air and attenuates readily in the presence of oxygen. Therefore, to create a potentially flammable environment, a scenario like a leak from a pressurized gas line would be required, where there is high pressure, unlimited (or a very high) volume of methane, and a high concentration of methane. All three criteria would be required to create a potentially flammable environment.

Additionally, the project sites identified within the 3.2 feet sea level rise projection scenario are associated with historic (decades old) subsurface petroleum releases. Older releases have typically undergone significant biodegradation where most of the biodegradable fractions (the fractions that would be responsible for the highest methane degradation rates) have already been removed. Moreover, as sulphate present in sea water becomes more available, a transition to sulphate reducing conditions is expected, which would inhibit methane production.

[4] USGS; (2006); Methane in West Virginia Ground Water; USGS Fact Sheet 2006-3011; available online at: http://pubs.usgs.gov/fs/2006/3011/pdf/Factsheet2006_3011.pdf
[5] ASTM E2993-16 standard

In terms of hydrogen sulfide production, it is expected that sulfur would become bound and precipitate. Finally, it is assumed that light non-aqueous phase liquid (LNAPL) would be expected to become occluded as the water tables rises; thus, potentially reducing potential LNAPL mobility.

Recommendations

Many good suggestions are being made but as stated before there are quite a few more that should be incorporated. Foremost, gathering reliable data that speaks to interplay of groundwater hydrology, SLR, surface water, contaminants in groundwater, drinking water implications, and changes over time.

- A Peer 2 Peer review, comparison on approaches would be helpful, based on a selection of sites that are representative for 1,000 sites total or highest risk / waterfront sites.
- Understand current / future land use and identify the opportunity areas, where to start “piloting”?

The “potential examples” reads comprehensive. What is missing is the interrelation with built environment and buildings and a vision on the way the currently exposed and contaminated sites (or waterfront sites in general) may be protected from SLR in the future, that will limit or inform feasible approaches e.g., is retreat to higher ground considered, protection through walls and berms, hybrid or more natural solutions to let the water in and raise land at other development places?

From a zoning perspective a widely accepted statement is that “what can be managed will be protected and what can’t be managed… will be “repurposed”.

Arcadis appreciates the opportunity to provide comment on HDOH’s memorandum. If any comments or questions require further discussion or clarification, please do not hesitate to contact us.

Sincerely,
Arcadis U.S., Inc.

Nick Wood
Senior Environmental Engineer
nick.wood@arcadis.com
808.522.0342

Copies:
Michael Mailloux (Chevron)
Natasha Sihota (Chevron)
Edgar Westerhof (Arcadis)
Amy Goldberg-Day (Arcadis)
Megan Hamilton (Arcadis)