



2020 PEER Annual Meeting

The Future of Performance-Based Natural Hazards Engineering

**UCLA**

**Samueli**  
School of Engineering

# Next Generation Liquefaction: A Community Discussion

**Paolo Zimmaro, Ph.D.**

*Project Scientist and Lecturer*

Co-Authors: Scott J. Brandenberg, Jonathan P. Stewart, Kenneth Hudson  
University of California, Los Angeles

January 17, 2020



**Engineer Change.**

# Outline

---

Introduction and current needs

The Next-Generation Liquefaction (NGL) database

Laboratory component of the database

Cloud-based community access

Discussion points

# NGL Database Contributors

---

- **NGL leadership:** Jonathan Stewart, Steven Kramer, Yousef Bozorgnia
- **Database working group:** Scott Brandenberg (chair), Robb E.S. Moss (Cal Poly), K. Onder Cetin (METU), Kevin Franke (BYU), Paolo Zimmaro (UCLA), and Dong Youp Kwak (Hanyang University)
- **Southwest Research Institute:** John Stamatakos, Miriam Juckett, Bis Dasgupta, Joey Mukherjee, Zackary Murphy, Steven Ybarra
- **Nuclear Regulatory Commission:** Thomas Weaver
- **Caltrans:** Tom Shantz



# NGL Database Contributors

---

- ***U. of Utah:*** Steve Bartlett, Masoud Hosseinali
- ***Virginia Tech:*** Russell Green, Kristin Ulmer
- ***UC Berkeley:*** Jonathan Bray, Christine Beyzaei
- ***Tonkin & Taylor:*** Sjoerd Van Ballegooey, Mike Liu
- ***BYU:*** Heidi Dacayanan, Lila Lasson
- ***METU:*** Gizem Can, Makbule Ilgac
- ***UCLA:*** Omar Issa, Chris Nicas, Trini Inouye, Arielle Sanghvi, Tristan Buckreis, Naoto Inagaki, Wyatt Iwanaga, Michael Winders, Bryan Ong, Siddhant Jain, Allison Lee, Honor Fisher
- ***Others:*** Mike Greenfield, Teruo Nakai, Hideo Sekiguchi, ...



U.S.NRC



# Liquefaction effects on the built environment and the community

**Liquefaction manifestation (Ridgecrest, 2019)**



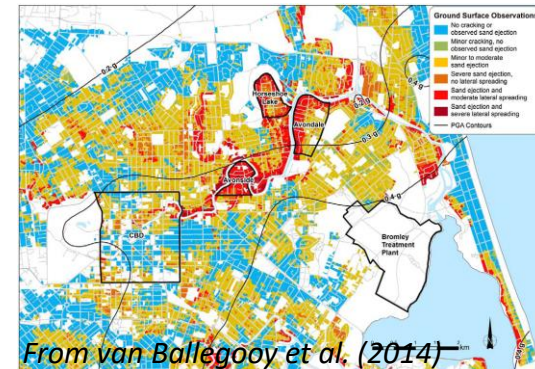
**and its effects (Kocaeli, 1999)**



**Effects on infrastructure and lifelines (Northridge, 1994)**



**Regional scale impact (Christchurch, 2010-2011)**

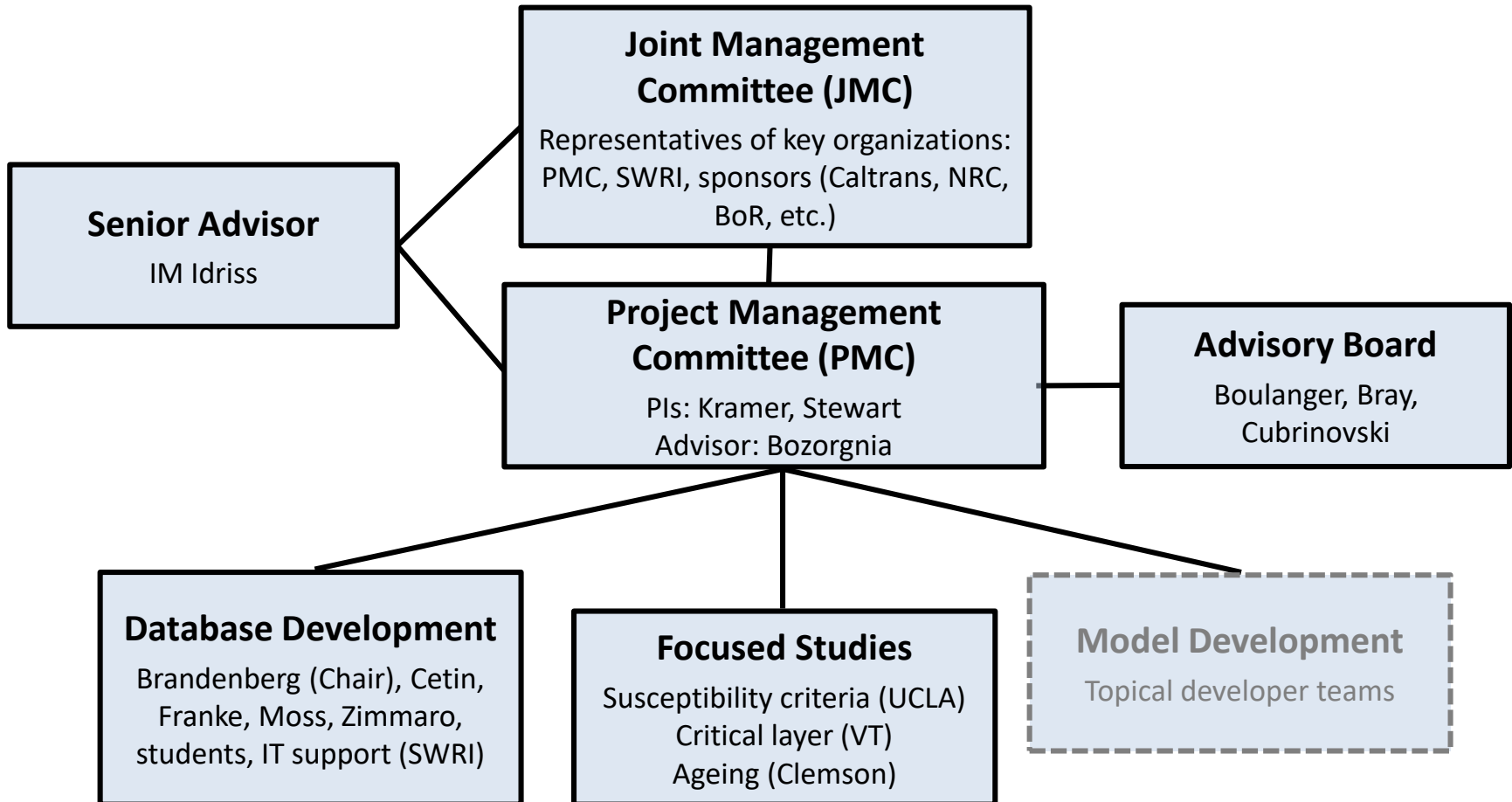


# NGL Project Components

---

- Community **liquefaction and non-ground failure database**
- **Fully-vetted relational database**
- **Supporting studies** of critical effects poorly constrained by data
- **Model development:** team meetings, common resources, required parameter space

# NGL Project Organization



# The Next-Generation Liquefaction Database

[www.nextgenerationliquefaction.org](http://www.nextgenerationliquefaction.org)

DOI: 10.21222/C2J040

The screenshot displays the web application interface for the Next-Generation Liquefaction Database. At the top, there is a navigation bar with the NGL logo and menu items: "View Data", "Interact With Data", and "Actions". On the right side of the navigation bar, it shows "Current Mode: User" and a "Log Out" button. Below the navigation bar, the main content area is divided into several sections:

- Sites**: A dropdown menu.
- Field Performance**: A dropdown menu.
- Field Investigation**: A dropdown menu.
- Earthquake**: A search box for "Type event name" and a "Magnitude" filter with "min" and "max" dropdowns. Below this is a list of earthquake events: M6.9 Kobe, Japan; M6.5 Imperial Valley-06; M7.2 El Mayor-Cucapah; M7.7 Nihonkai-Chubu - near the; M6.2 Hokkaido; M8.3 Tokachi; M6.9 Obihiro - Hokkaido. There are "Reset" and "Submit" buttons below the list.
- Statistics**: A dropdown menu.
- Map**: A world map showing various sites marked with red and white circular icons. A scale bar at the bottom left indicates 3000 km and 2000 mi.
- Map Controls**: On the right side of the map, there are three radio buttons for map styles: "Topographic Map (high res.)", "Imagery Map (middle res.)", and "Terrain Map (low res.)".
- Event Information**: A panel on the right side of the map with several checkboxes:
  - Event:
  - Site:
  - Boreholes:
  - CPT:
  - Test Pits:
  - Non-Invasive Geophysical:
  - Invasive Geophysical:
  - Water Table:
  - Stratigraphic Units:



U.S. NRC





# The NGL Database: Definition of a Site

---

- **Site:** *high level entity into which NGL users organize their data.*
- **Single point on map** for plotting purposes. *It should not be interpreted as a single location in space.*
- *Geotechnical conditions and observations of liquefaction effects **may vary spatially** within a site.*
- *Users exercise **judgment** in assigning a point to a site. Add remarks on how the choice was made.*

# The NGL Database: Definition of a Site

- *CBD-21, Green et al. (2014) (Canterbury earthquake sequence)*
- *Observed liquefaction manifestation*



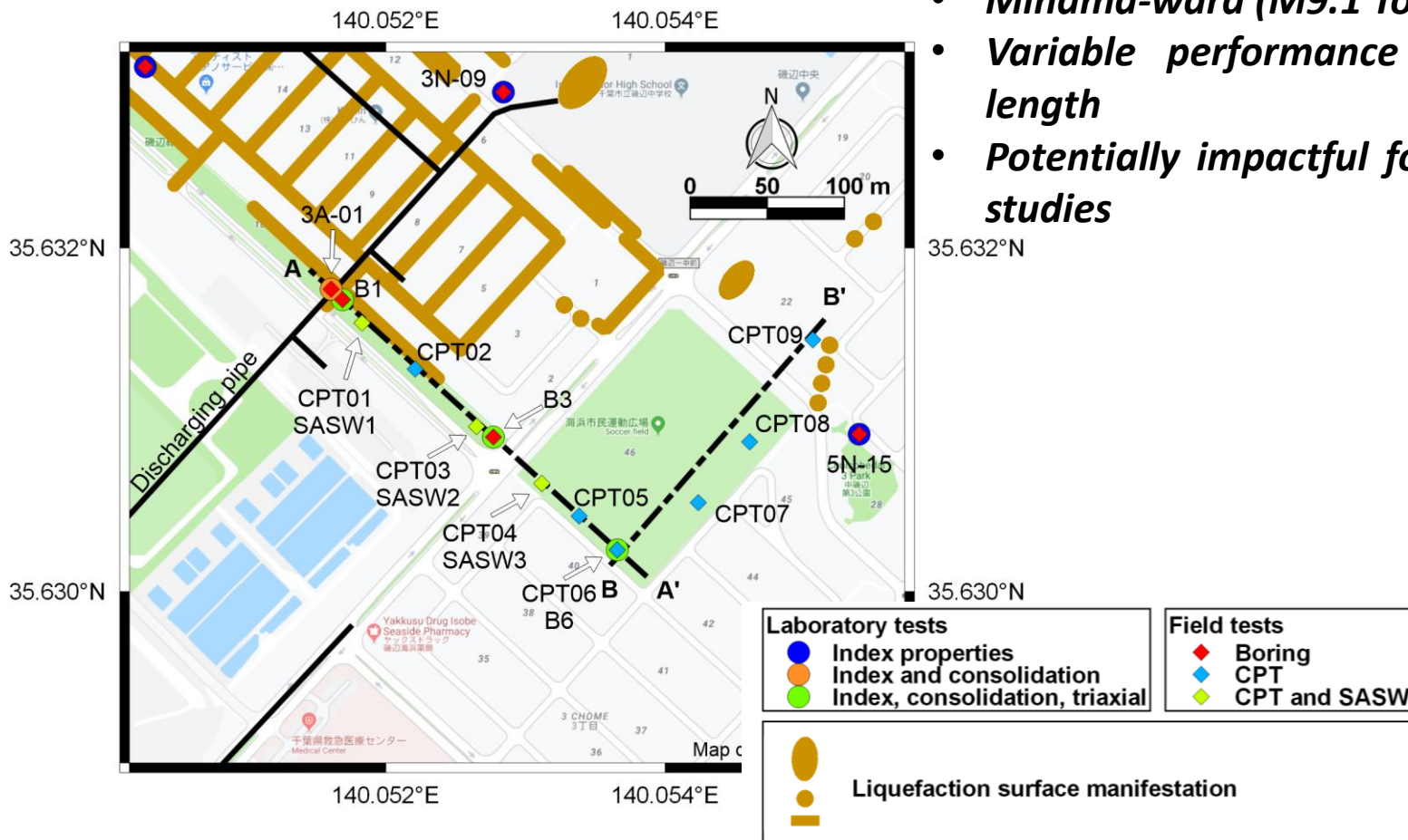
# The NGL Database: Definition of a Site

- *CBD-21, Green et al. (2014) (Canterbury earthquake sequence)*
- *Observed liquefaction manifestation*
- *One Cone Penetration Test*



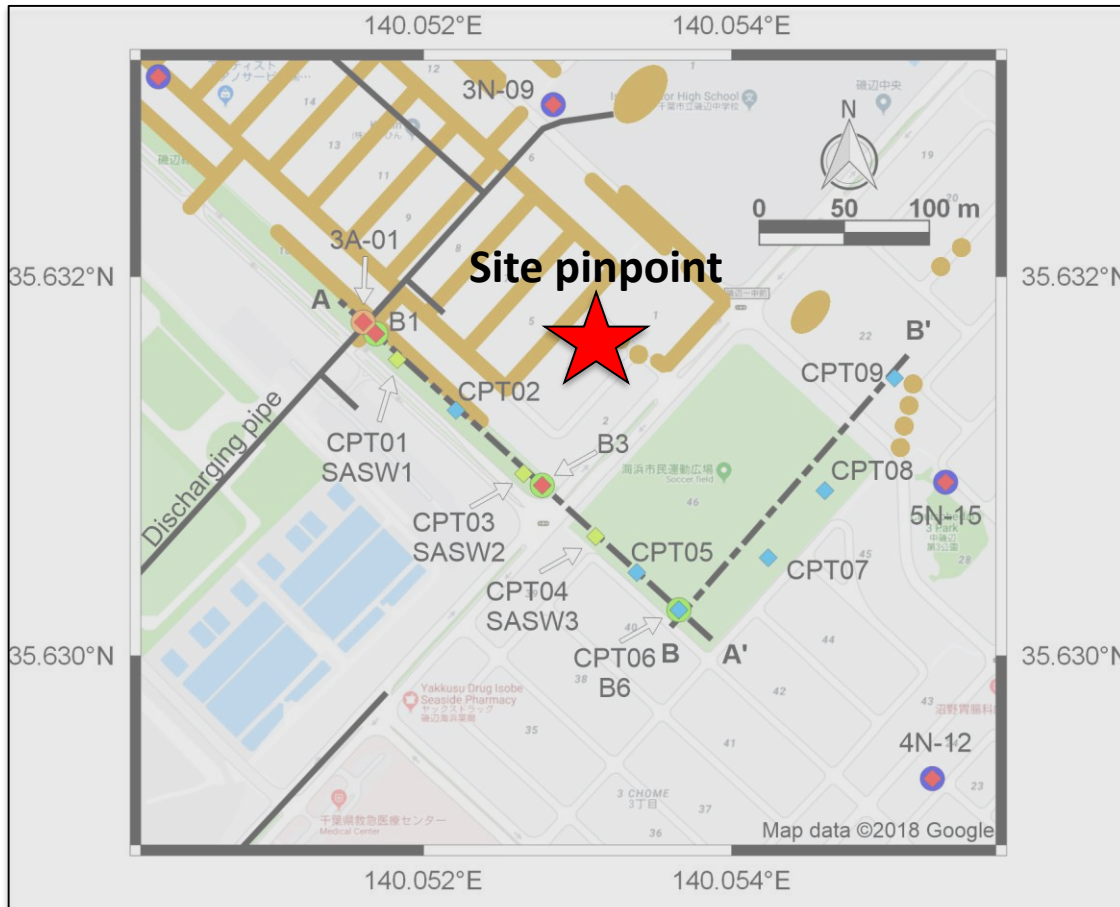
# The NGL Database: Definition of a Site

- *Mihama-ward (M9.1 Tohoku event)*
- *Variable performance over a short length*
- *Potentially impactful for susceptibility studies*

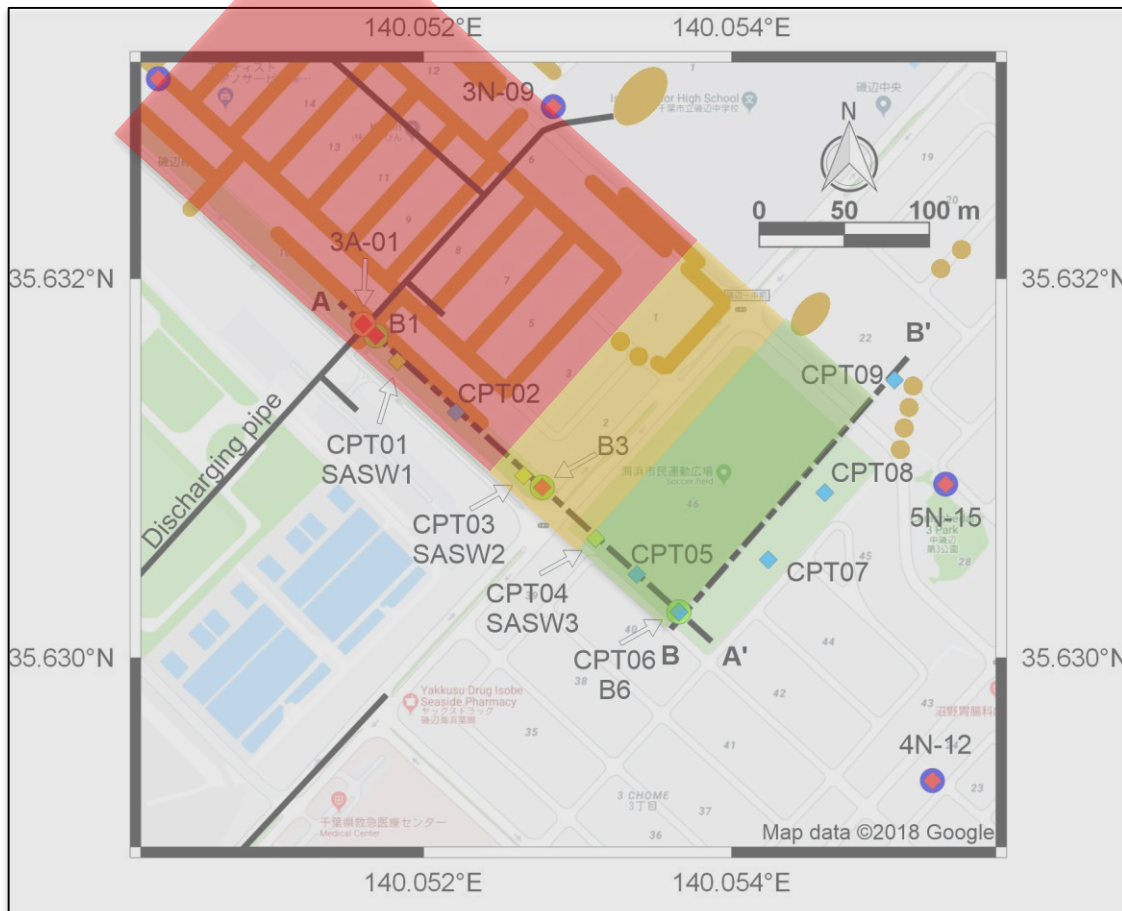


# The NGL Database: Definition of a Site

- *Site and its characteristics in NGL DB*
- *1 site location (but sites can encompass a wide area)*

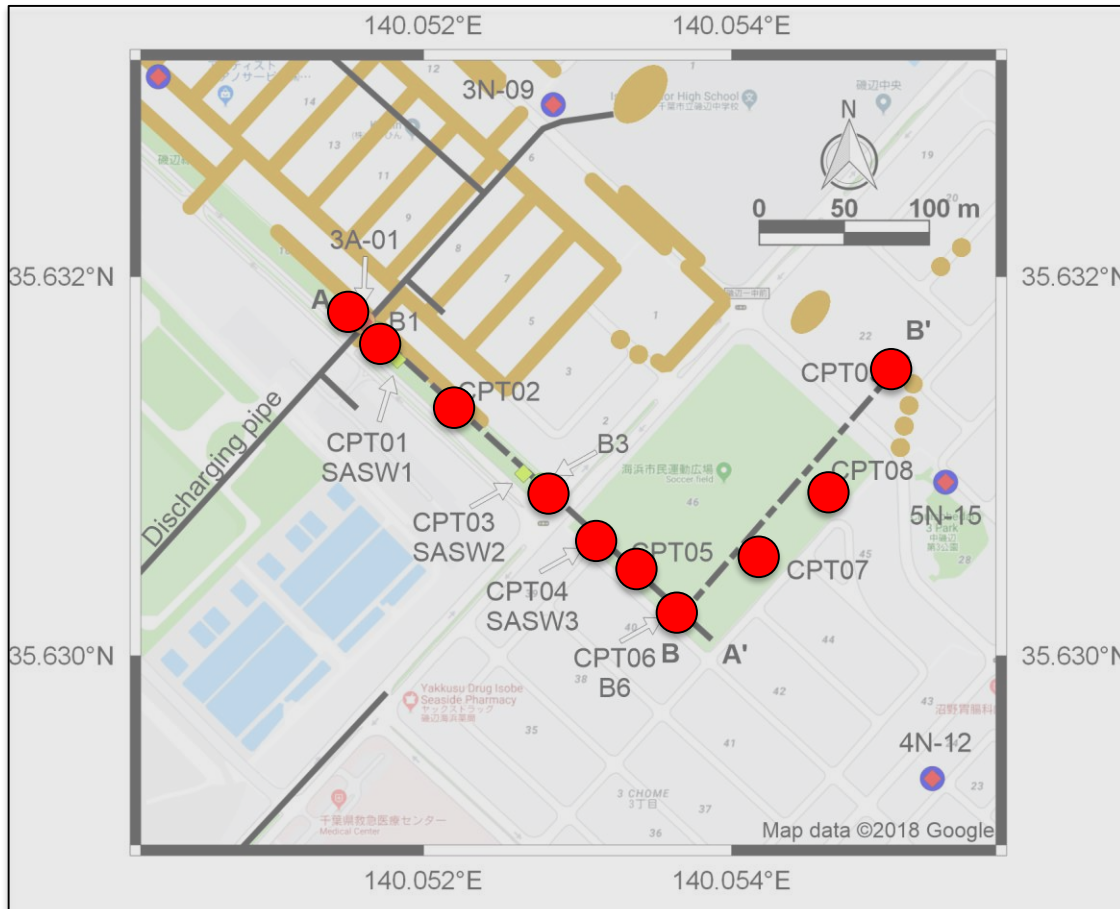


# The NGL Database: Definition of a Site



- *Site and its characteristics in NGL DB*
- *1 site location (but site encompass a wide area)*
- *Multiple observations across site*

# The NGL Database: Definition of a Site



- *Site and its characteristics in NGL DB*
- *1 site location (but site encompass a wide area)*
- *Multiple observations across site*
- *Multiple field/lab tests*
- *NGL database has flexibility to host both:*

*single-point sites*  
*geospatially distributed datasets*

# The NGL Database: Current Status

---

[www.nextgenerationliquefaction.org](http://www.nextgenerationliquefaction.org)

	Total Number
CPT Soundings	336
Boreholes	177
Surface Wave Measurements	12
Invasive Vs Profiles	34
Liquefaction Observations	215
Non-Liquefaction Observations	288

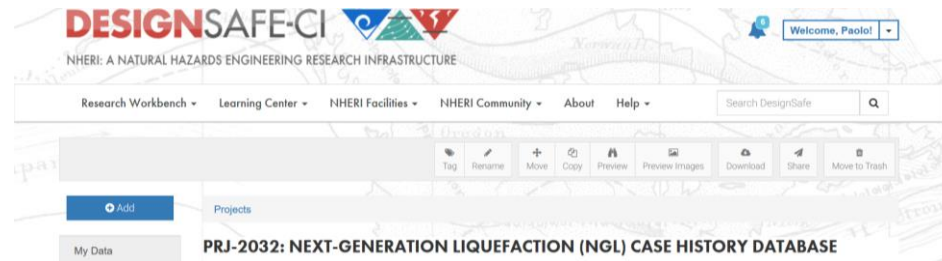
- Quality control via formal **review process**
- Each piece of information needs to be reviewed by two reviewers
- Most sites currently under review
- More than 20% already reviewed

***Population and review process overseen by NGL Database Working Group  
(Chair S.J. Brandenberg)***



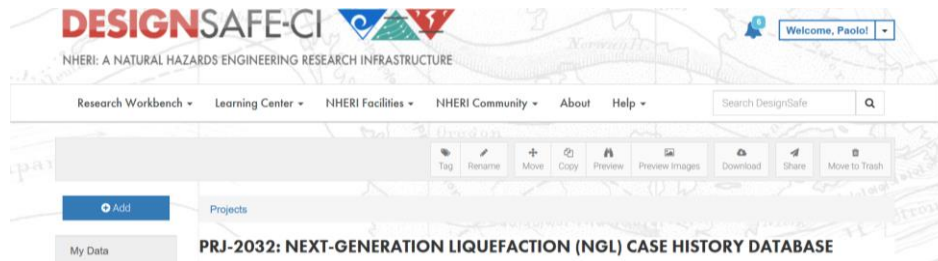
# Cloud-Based Community Access

- *Database replicated daily onto DesignSafe servers*
- *Cloud-based tools*

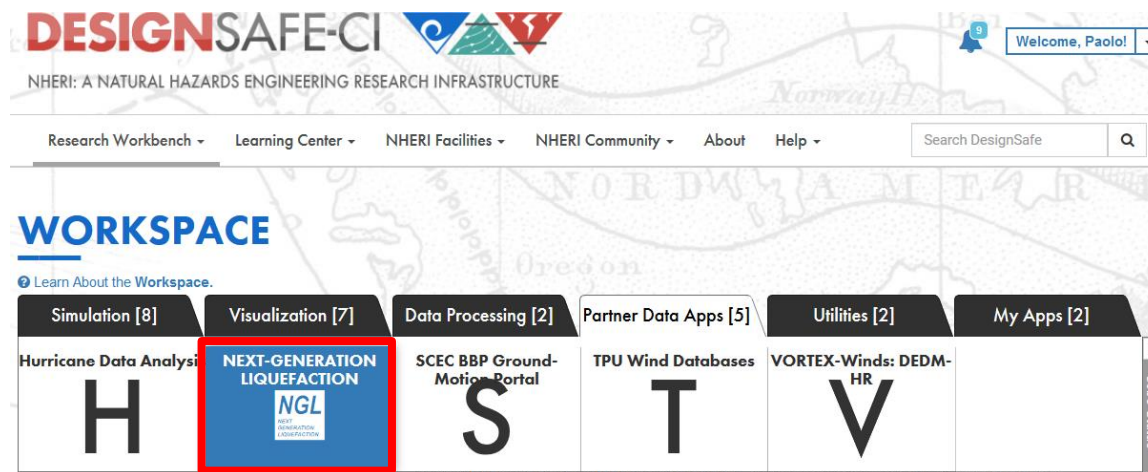


# Cloud-Based Community Access

- Database replicated daily onto DesignSafe servers
- Cloud-based tools



## NGL Partner Data App



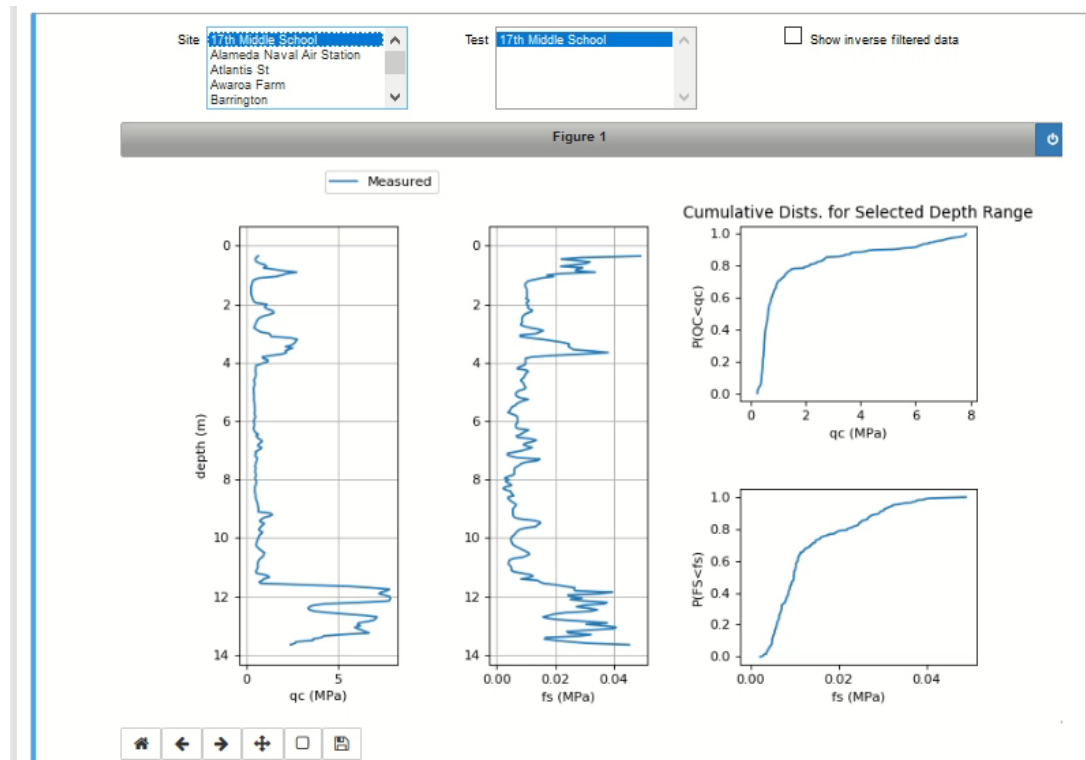
# Cloud-Based Community Access

**NGL Jupyter notebooks are all available in DesignSafe Community Data**  
**<https://jupyter.designsafe-ci.org>**

<input type="checkbox"/>	0	CommunityData / NGL	Name ↓	Last Modified
<input type="checkbox"/>		..		seconds ago
<input type="checkbox"/>		InverseFilteredCPT		5 hours ago
<input type="checkbox"/>		Connection.ipynb		a month ago
<input type="checkbox"/>		CPT_viewer.ipynb		5 hours ago
<input type="checkbox"/>		ExampleQueries.ipynb		5 hours ago
<input type="checkbox"/>		SPT_Viewer.ipynb		21 hours ago
<input type="checkbox"/>		VS_Invasive_Plots_and_Widgets.ipynb		seconds ago
<input type="checkbox"/>		VS_Invasive_viewer.ipynb		a month ago
<input type="checkbox"/>		VS_non_Invasive_viewer.ipynb		21 hours ago
<input type="checkbox"/>		CPT_thin_layer.py		15 days ago
<input type="checkbox"/>		footer.png		a month ago
<input type="checkbox"/>		NGLlogo-italic.png		a month ago

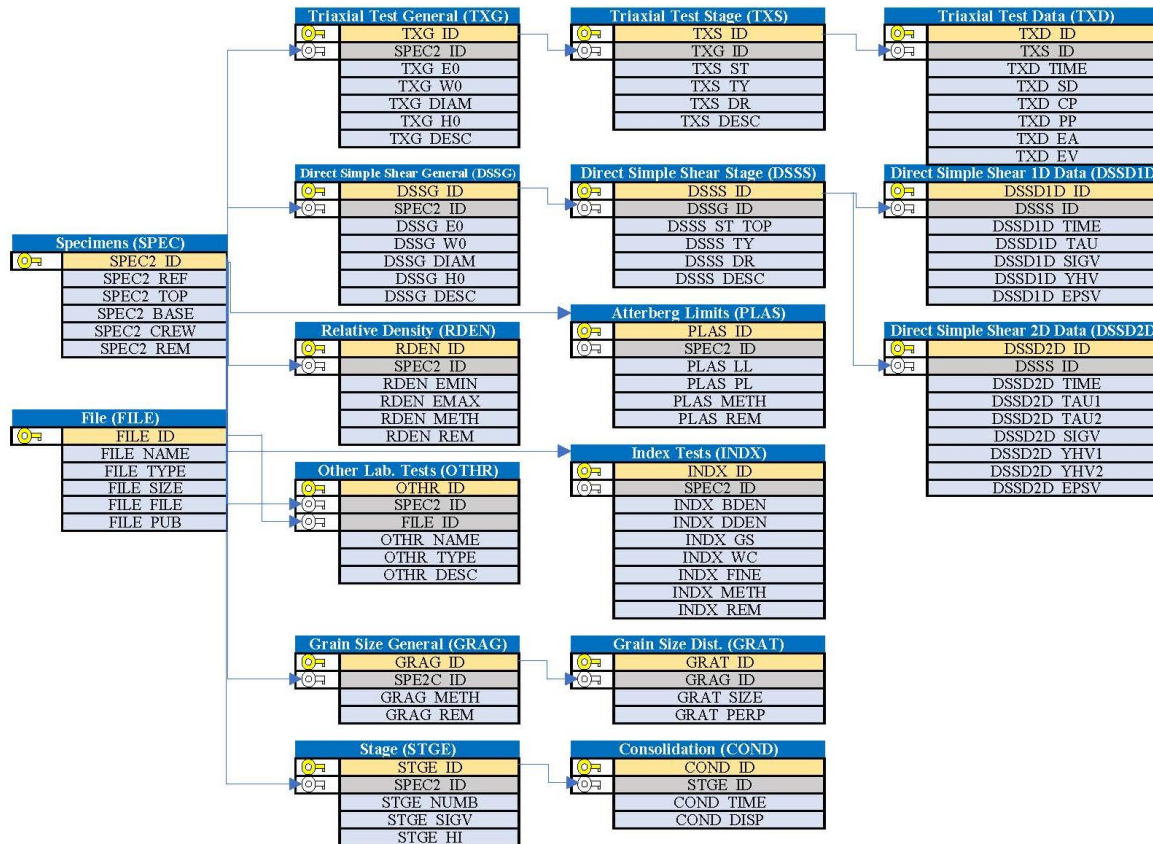
# Cloud-Based Community Access

## Cone Penetration Test (CPT) visualization tool



# Laboratory Component of the Database

- *New database tables to host laboratory test results*



- *Index tests*
- *Grain size distribution*
- *Triaxial*
- *Direct Simple Shear (1D-2D)*
- *Others...*



From Hudson et al. (2020) – PEER Poster

# Laboratory Component of the Database Cloud-Based Community Access

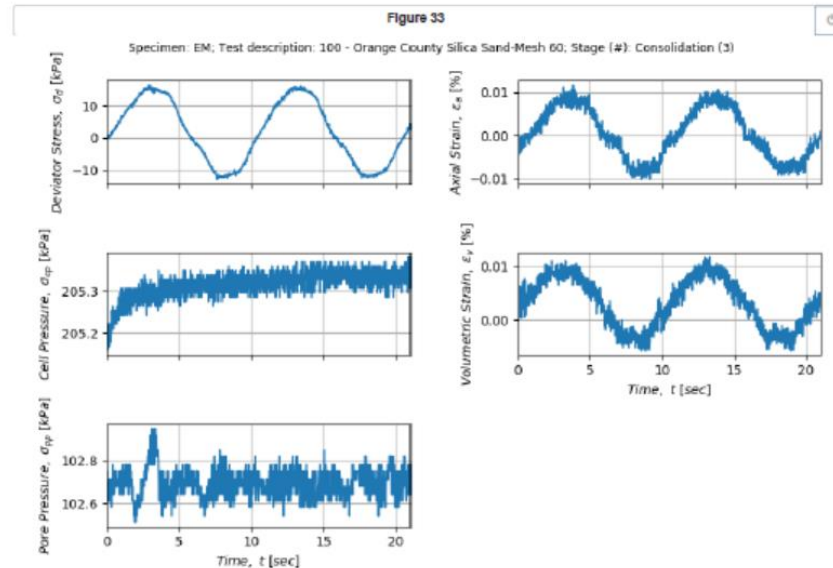
Laboratory Component (New Tools – Available online soon!)

## View Triaxial Tests

To run the notebook, click Cell->Run All.

out[1]: To toggle on/off the raw code, click [here](#).

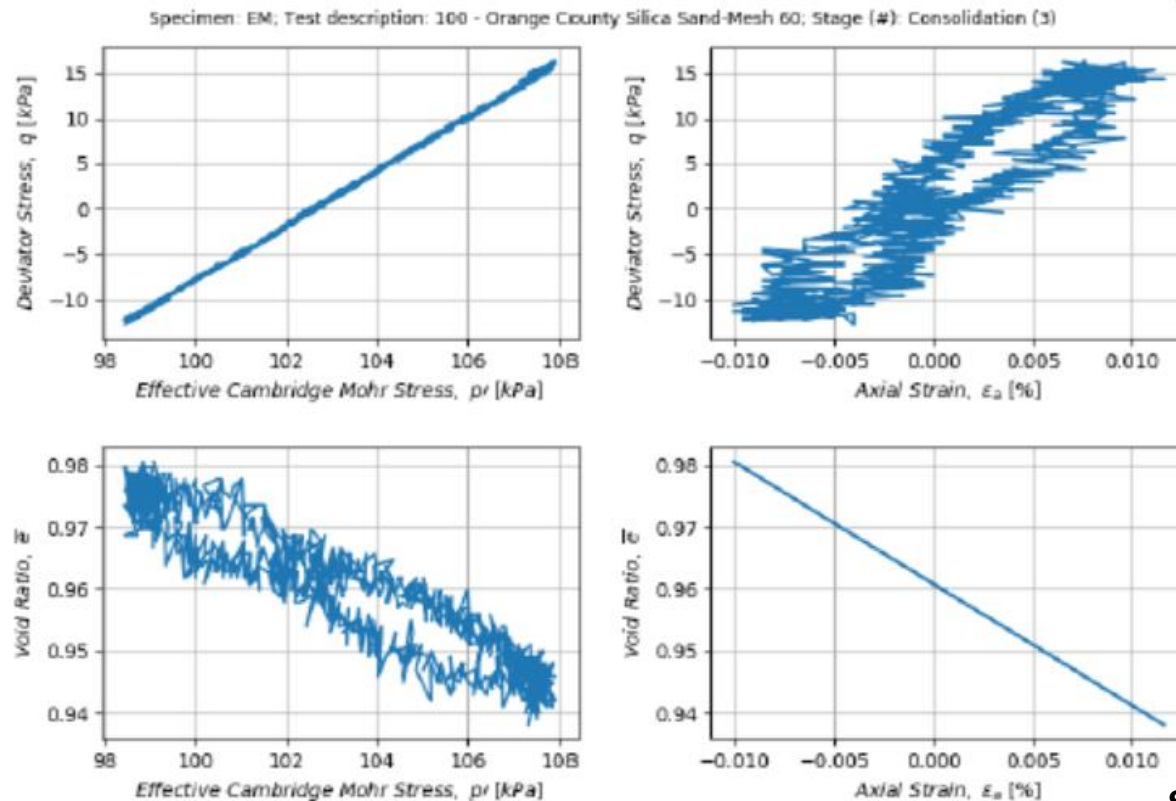
Specimen   
TestID   
StageID   
 PlotLogScale  
 Normalize



Slide K. Hudson (UCLA)

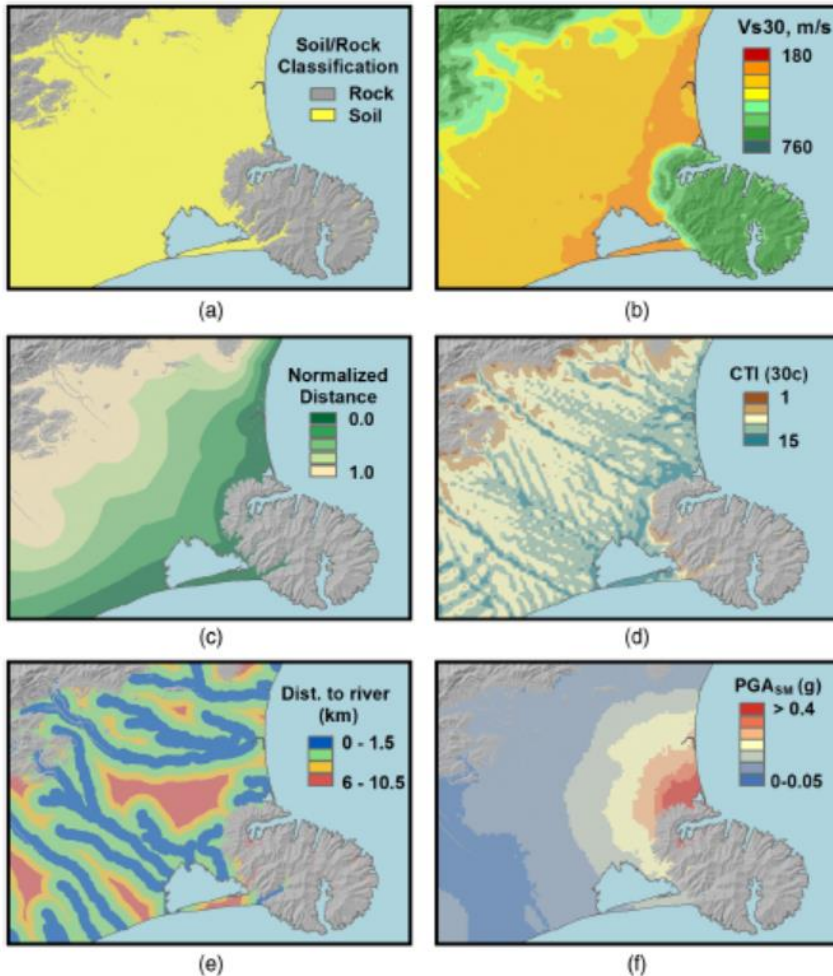
# Laboratory Component of the Database Cloud-Based Community Access

Laboratory Component (New Tools – Available online soon!)



Slide K. Hudson (UCLA)

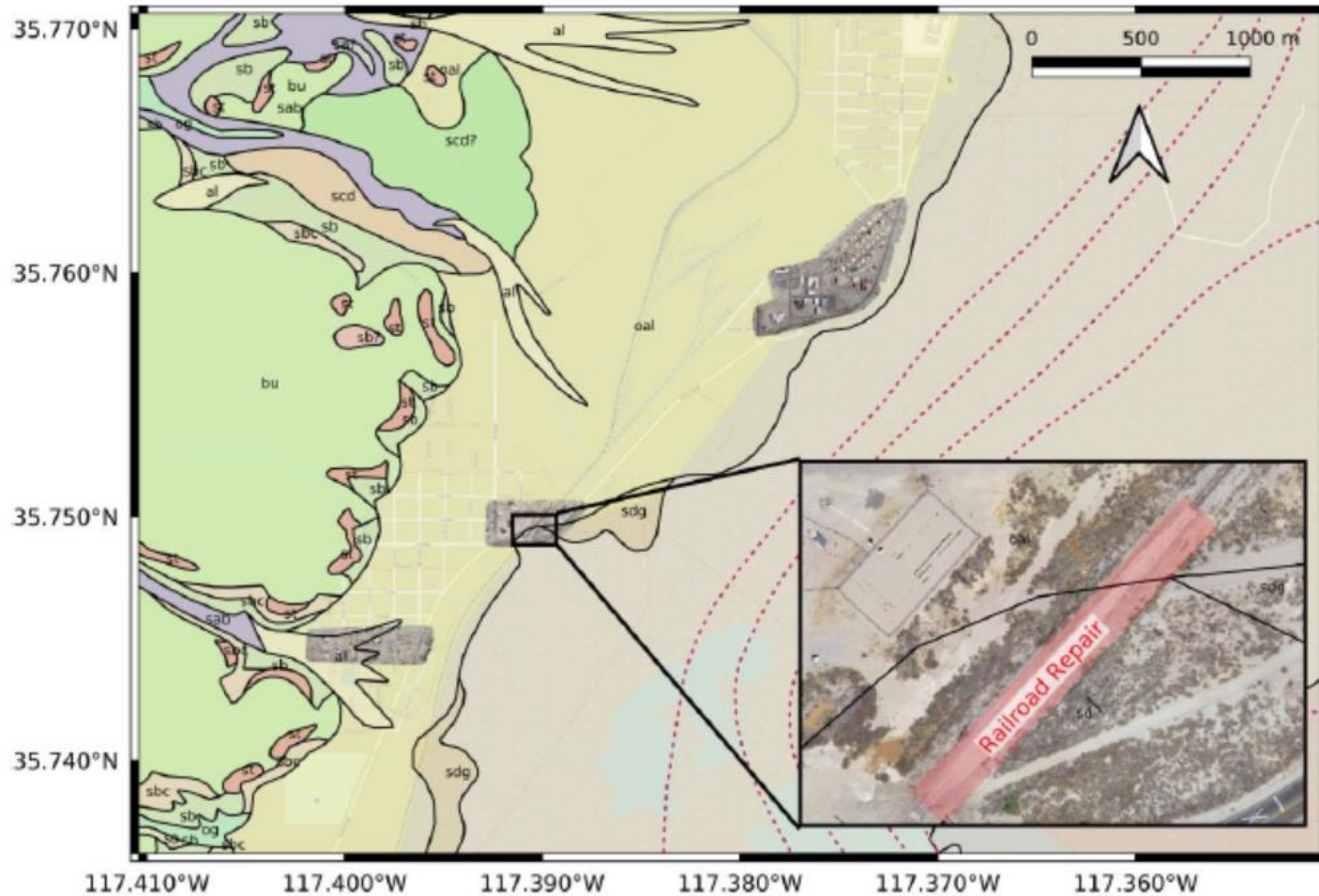
# Recent Geospatial Datasets



- *Geospatial models (e.g. Zhu et al., 2017) require additional layers (e.g. geology maps, ground water table maps, etc.)*
- *Can be added to NGL via supplemental files or DOI (if data resides elsewhere – e.g. DesignSafe)*



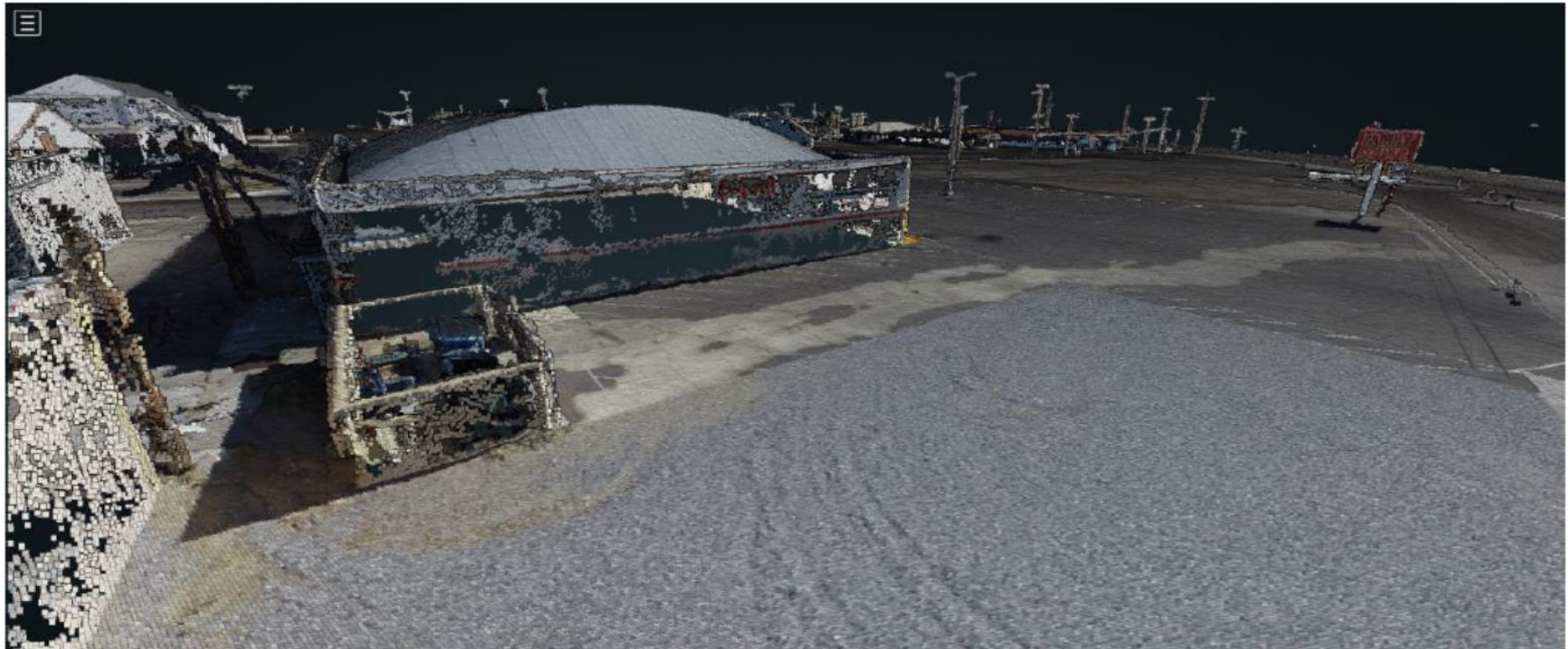
# Geospatial Visualization Tools



From Brandenburg et al. (2020)

# Geospatial Visualization Tools

---



*From Brandenburg et al. (2020)*

# Recent Geospatial Datasets: NGL Vision

- *How to visualize additional layers in NGL? Coming soon*



Admin Current Mode: Admin Log Out

Additional layers  
(or datasets)  
all unchecked  
by default

Topographic Map (high res.)  
Imagery Map (middle res.)  
Terrain Map (low res.)

Event information

Event

General description

Site

Boreholes

CPT

Test Pits

Non-Invasive Geophysical

Invasive Geophysical

Water Table

Stratigraphic Units

U.S. NRC MPC LTDOT

UCLA Samueli

# Discussion points

---

- **Geospatial models**

  - what layers do we need to add?

  - layer format (geojson, shapefile, etc.)?

- **Laboratory component:**

  - Additional test types?

  - Available lab test datasets?

- **Upcoming model development phase:**

  - New tools (e.g. Artificial Intelligence)?

  - Community needs/gaps?

# Thank you!

## Open Discussion

### Relevant References

Brandenberg S.J., Zimmaro P., Stewart J.P., Kwak D.Y., Franke K.W., Moss R.E.S., Cetin K.O., Can G., Ilgac M., Stamatakos J., Weaver T., Kramer S.L. (2020). Next Generation Liquefaction Database. Earthquake Spectra. In Press.

Zimmaro P., Brandenberg S.J., Stewart J.P., Kwak D.Y., Franke K.W., Moss R.E.S., Cetin K.O., Can G., Ilgac M., Stamatakos J., Juckett M., Mukherjee J., Murphy Z., Ybarra S., Weaver T., Bozorgnia Y., Kramer S.L. (2019). Next-Generation Liquefaction Database. Next-Generation Liquefaction Consortium. DOI: 10.21222/C2J040.

The logo for the Next Generation Liquefaction (NGL) project, featuring the letters 'NGL' in a large, bold, white font on a blue square background.

NEXT  
GENERATION  
LIQUEFACTION

**Project homepage:**

<https://uclageo.com/NGL/>

**Database:**

**DOI: 10.21222/C2J040**

<http://nextgenerationliquefaction.org>

Engineer Change.