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NGL: An Open Source Global Database for Next-Generation of Liquefaction Assessment

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UCLA undergraduate and graduate students

Outline

- ***Liquefaction assessment: Needs and current situation***
- ***The Next-Generation Liquefaction Project (NGL) Vision***
- ***Flatfiles vs Relational Databases***
- ***The NGL Database***
- ***Final Remarks***

Liquefaction assessment: Needs and current situation

Steps in liquefaction risk assessment (three-step approach):

- 1. Susceptibility***
- 2. Triggering (Factor of safety and/or probability of liquefaction)***
- 3. Effects (consequences)***

Each is empirical or semi-empirical, and hence is reliant on available data.

Liquefaction Assessment: Current Needs

Small data sets

A few sites are especially consequential

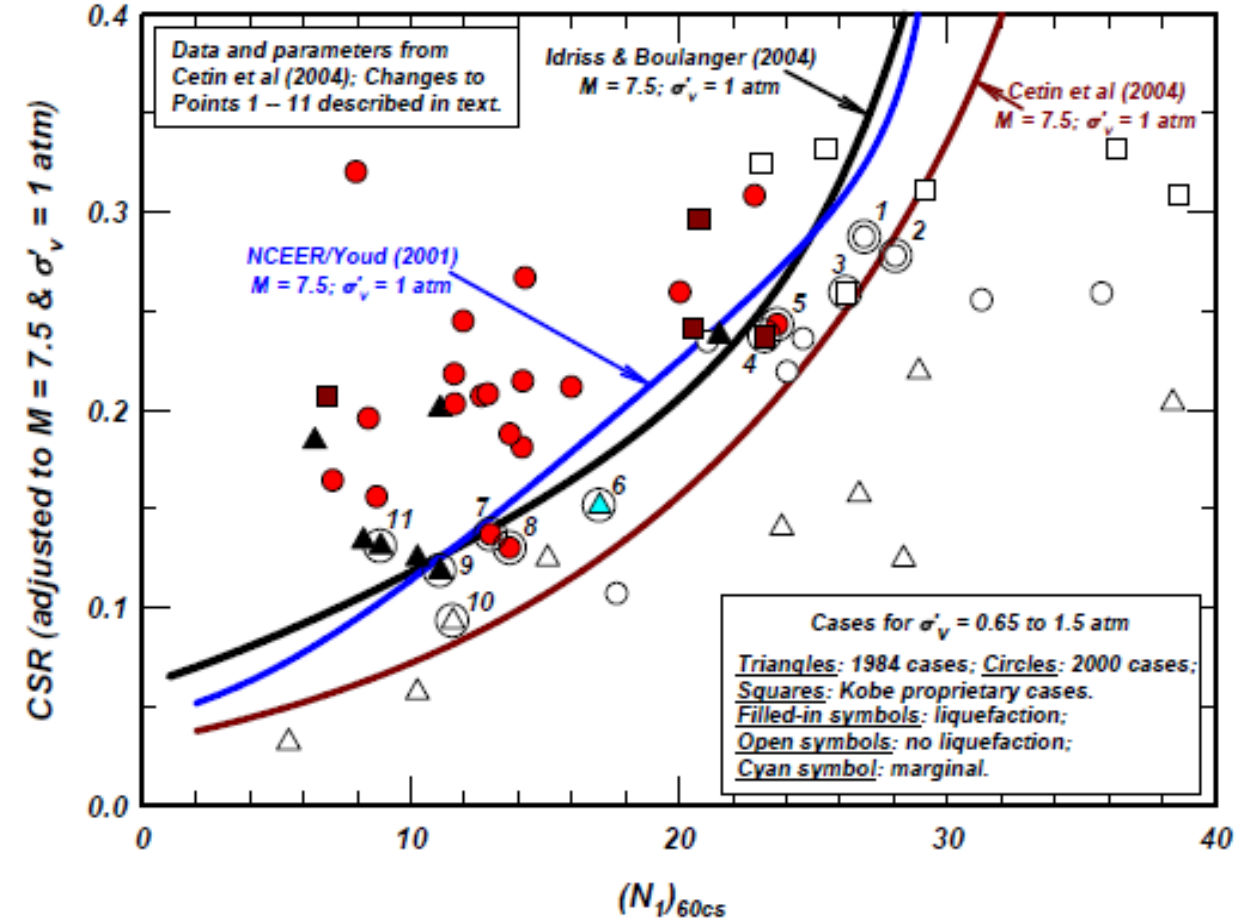
Existing data sets are necessarily incomplete, especially:

Depth > 10 m

$M > 7.5$ and $M < 6.0$

$FC > 30\%$

$CSR > 0.4$



From Idriss and Boulanger (2010)

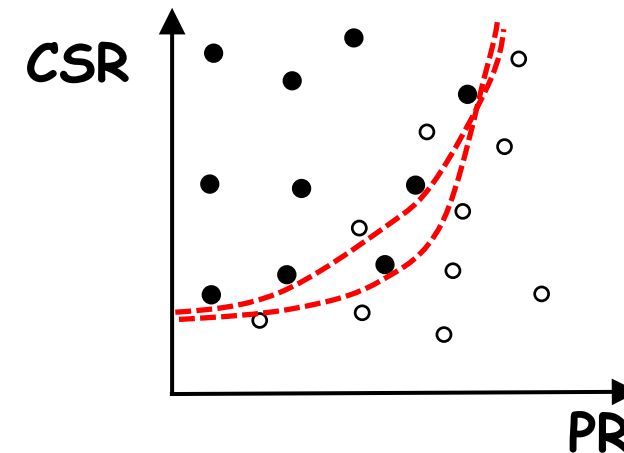
Liquefaction Assessment: Present Situation

Alternate liquefaction models provide different outcomes.

Why?

1. Inconsistent data sets
2. Different methods for data interpretation
3. Different models for extrapolation beyond data range
4. Potential errors in data analysis
5. Minimal between-developer interaction

- Liquefaction
- No Ground Failure



Graphic: S. Kramer

The NGL Project Vision

- Community field **case-history *relational* database**
- **Supporting studies** of critical effects poorly constrained by data
- **Model development:** team meetings, common resources, required parameter space

The NGL Project Vision

- Community field **case-history *relational* database**
- Supporting studies of critical effects poorly constrained by data
- Model development: team meetings, common resources, required parameter space

Flatfiles vs Relational Databases

From *spreadsheet (flatfiles)*
(Traditional data analysis)



To **relational database**
(big-data analytics)

Event Name	Magnitude	Epicentral Latitude	Epicentral Longitude	Station Name	V ₅₃₀ (m/s)	R _{jb} (km)	PGA (g)
Westwood Hills	6.3	34.0689	118.4452	Factor Building	380	2	0.84
Westwood Hills	6.3	34.0689	118.4452	Santa Monica Courthouse	215	14	0.28
Hollywood Valley	7.2	34.1027	118.3404	Factor Building	380	20	0.61
Hollywood Valley	7.2	34.1027	118.3404	Santa Monica Courthouse	215	30	0.32

Primary Key
Foreign Key

Event table

Event_id	Event Name	Magnitude	Epicentral Latitude	Epicentral Longitude
1	Westwood Hills	6.3	34.0689	118.4452
2	Hollywood Valley	7.2	34.1027	118.3404

Station table

Station_id	Station Name	V ₅₃₀ (m/s)
1	Factor Building	380
2	Santa Monica Courthouse	215

Ground Motion table

Motion_id	Event_id	Station_id	R _{jb} (km)	PGA (g)
1	1	1	2	0.84
2	1	2	14	0.28
3	2	1	20	0.61
4	2	2	30	0.32

Relationships set through shared fields (keys)

Primary key: unique identifier for each record

Foreign key: field in one table that identifies a record in another table

Benefits of relational databases:

Smart database (query, advanced tools)

Minimize duplicated fields

Avoid null fields

From Brandenburg et al. (2018)

Benefits of a Relational Databases

```

In [7]: 1 import pymysql
        2 import csv
        3 import numpy
        4 import xlrd
        5 conn = pymysql.connect(host='127.0.0.1', port=3306, user='root', passwd='root', db='ngawest2')
        6 cursor = conn.cursor()
        7
        8 MySQLCommand1 = "SELECT event_name FROM event WHERE event_id=1"
        9 cursor.execute(MySQLCommand1)
       10 event_name = cursor.fetchone()[0]
       11 print("Event Name =| " + event_name)
       12
       13 MySQLCommand2 = "SELECT pga FROM motion INNER JOIN event ON motion.event_id = event.event_id WHERE event.event_
       14 cursor.execute(MySQLCommand2)
       15 pga = cursor.fetchone()[0]
       16 print("PGA = " + str(pga))
       17
       18 conn.commit()
       19 conn.close()
       20
       21
Event Name: Helena, Montana-01
PGA = 0.15702
    
```

Advanced tools (work on the cloud)

ation Liquefaction Project | Map | Upload | Help | Admin | Review | Log Out

Users
Teams

Site Name	Latitude	Longitude	Geology	Remarks	Reviewed?	Actions
Urayasu Sea	35.638	139.934	Fill		No	
Test Site With File	80	80			No	

Files

Location Name	Latitude	Longitude	Elevation	Remarks
Within spreading	35.637925	139.93356		

Field Tests

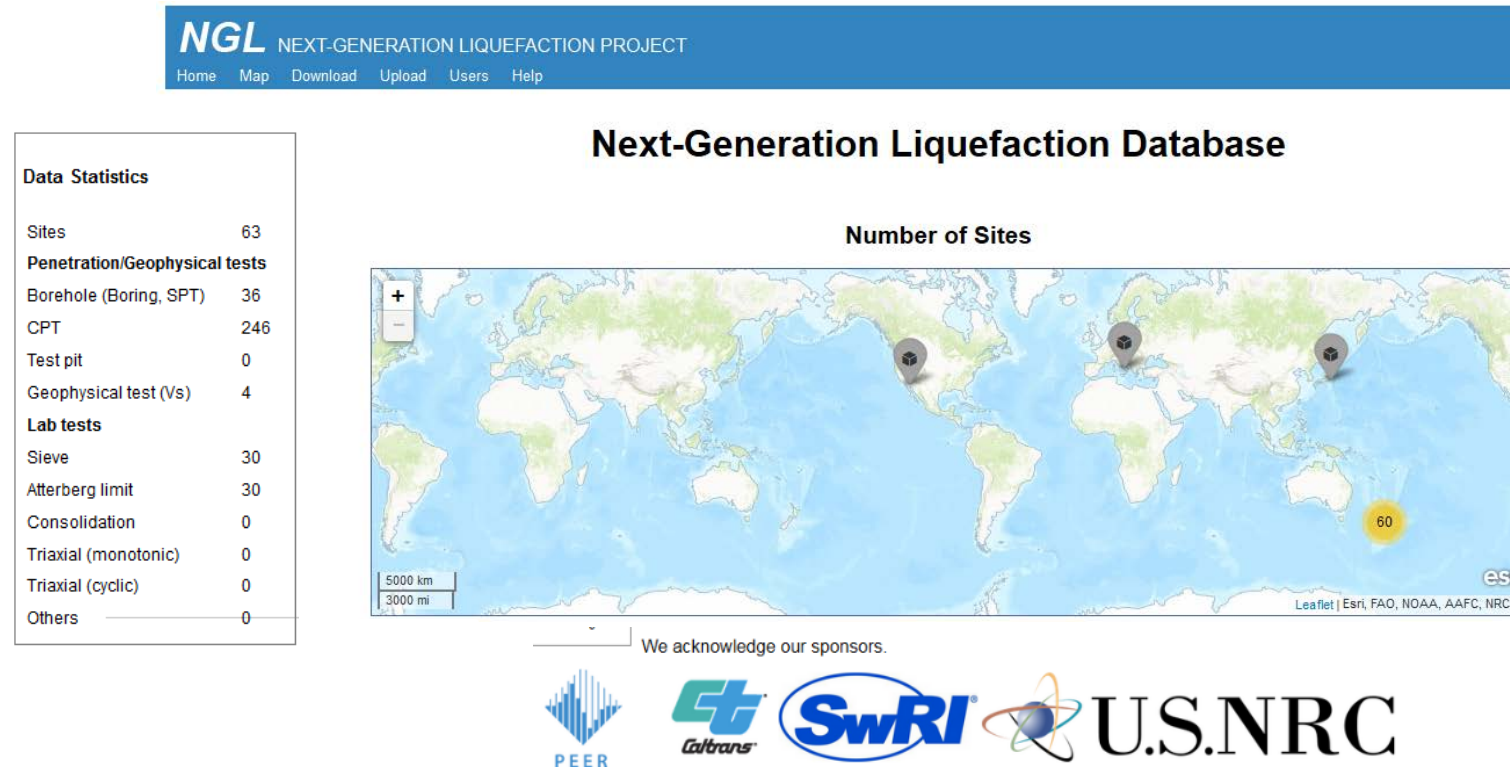
Submit

ju/ngl/admin/teams" in a new tab

"Smart" database

The NGL Database

KPHP platform, GIS-based mapping tool, To be hosted at DesignSafe (UT NHERI site)



On-line beta version

<http://uclageo.com/NGL/database/index.php>

The NGL Database

Graphical interface – User Experience Design



The NGL Database

What constitutes a case history?

- Site information

Minimum requirements:

- Soil stratigraphy
- Ground water depth
- Details pertaining to soil type
- Penetration resistance or V_S

NGL NEXT-GENERATION LIQUEFACTION PROJECT
Home Map Download Upload Users Help NGL Sign Out

SITE INFORMATION EVENT INFORMATION GROUND PERFORMANCE

5000 km
3000 mi

Leaflet | Esri, FAO, NOAA, AAFC, NRCAN

On-line beta version

<http://uclageo.com/NGL/database/index.php>

The NGL Database

What constitutes a case history?

- Site information
- Event information

- From NGA!

NGL NEXT-GENERATION LIQUEFACTION PROJECT

Home Map Download Upload Users Help NGL Sign Out

SITE INFORMATION **EVENT INFORMATION** GROUND PERFORMANCE

5000 km
3000 mi

Leaflet | Esri, FAO, NOAA, AAFC, NRCAN

On-line beta version

<http://uclageo.com/NGL/database/index.php>

The NGL Database

What constitutes a case history?

- Site information
- Event information
- Ground performance

Minimum requirements:

- Written, mapped, or imaged observations
- Date/time of reconnaissance
- Location (lat/long)

NGL NEXT-GENERATION LIQUEFACTION PROJECT
Home Map Download Upload Users Help NGL Sign Out

SITE INFORMATION EVENT INFORMATION **GROUND PERFORMANCE**

5000 km
3000 mi

esri
Leaflet | Esri, FAO, NOAA, AAFC, NRCAN

On-line beta version

<http://uclageo.com/NGL/database/index.php>

The NGL Database

Site Information

NGL Next-Generation Liquefaction Project | Map | Upload | Help | Admin | Review | Log Out

Sites

Field Performance
Field Investigation
Earthquake

Type event name

Magnitude
mir | ma

Reset | Submit

Urayasu Sea Front

Latitude (deg) 35.638
Longitude (deg) 139.934
Elevation
Surface Geology Fill
Reviewed? No

Downloads
Data [Download](#)

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

General description

Site

Field Investigation

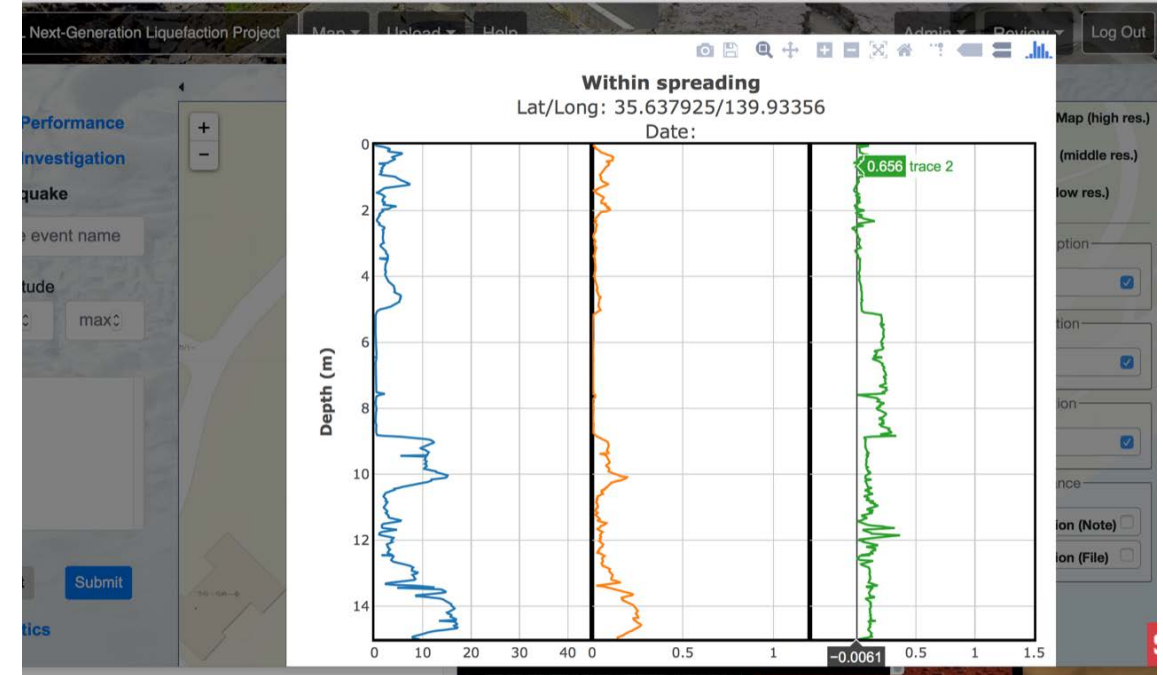
Location

Event Information

Event

Field Performance

Observation (Note)
 Observation (File)



The NGL Database

Event Information: Integration with NGA (Next-Generation Attenuation) products

NGA data

	A	B	C	D	E	F
Record Sequence Number	EQID	Earthquake Name	YEAR	MODY	HRMN	
1	0001	Helena, Montana-01	1935	1031	1838	
2	0002	Helena, Montana-02	1935	1031	1918	
3	0003	Humbolt Bay	1937	0207	0442	
4	0004	Imperial Valley-01	1938	0606	0242	
5	0005	Northwest Calif-01	1938	0912	0610	
6	0006	Imperial Valley-02	1940	0519	0437	
7	0007	Northwest Calif-02	1941	0209	0945	
8	0008	Northern Calif-01	1941	1003	1614	
9	0009	Borrego	1942	1021	1622	
10	0010	Imperial Valley-03	1951	0124	0717	
11	0011	Northwest Calif-03	1951	1008	0411	
12	0012	Kern County	1952	0721	1153	
13	0012	Kern County	1952	0721	1153	
14	0012	Kern County	1952	0721	1153	
15	0012	Kern County	1952	0721	1153	
16	0012	Kern County	1952	0721	1153	

Data collection stored in a series of flatfiles

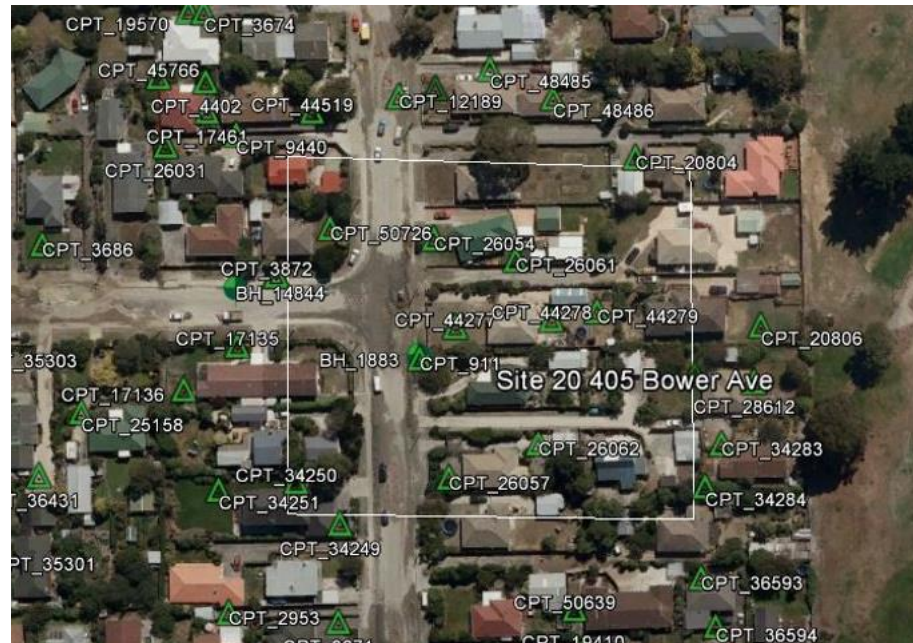
Integration with NGL

	HZ	IA
1	T7.500S	T8.000S
8151	0.000247	0.000231
8152	0.003331	0.003473
8153	0.000661	0.000639
8154	0.000486	0.000700
8155	0.001060	0.001011
8156	0.001217	0.001057
8157	0.000836	0.000772
8158	0.008571	0.007123
8159	0.011123	0.009935
8160	0.002338	0.001956
8161	0.134076	0.112643
8162	0.298595	0.233477
8163	0.002516	0.002555
8164	0.004065	0.005418
8165		

- NGA Data implemented as part of the NGL Relational Database
- Only fields relevant to NGL are included:
 - Recording stations
 - Event information
 - Fault-segments information (more than one for multi-fault ruptures)
 - 5% damped response spectra only

The NGL Database

Ground Performance: High-Resolution Satellite Images



SITE INFORMATION
EVENT INFORMATION
GROUND PERFORMANCE

Server Message

Site Name: Site 20 405 Bower Ave
Event Name: Christchurch, New Zealand

Field Observation

Fill data from file [CHOOSE A FILE](#)

Observation Tag	Observation Type	Latitude (deg)	Longitude (deg)	Description	File Add
2 SELECTED	Photo	-43.4851	172.712	Aerial photograph taken 2 day after earthqu	CHOOSE A FILE aerial 20110224.JPG
1 SELECTED	LIDAR Image	-43.4851	172.712	Measured settlement	CHOOSE A FILE lidar 20110222.JPG

[ADD](#) [DELETE](#)

Ground Motion Intensity Measures

Fill data from file [CHOOSE A FILE](#)

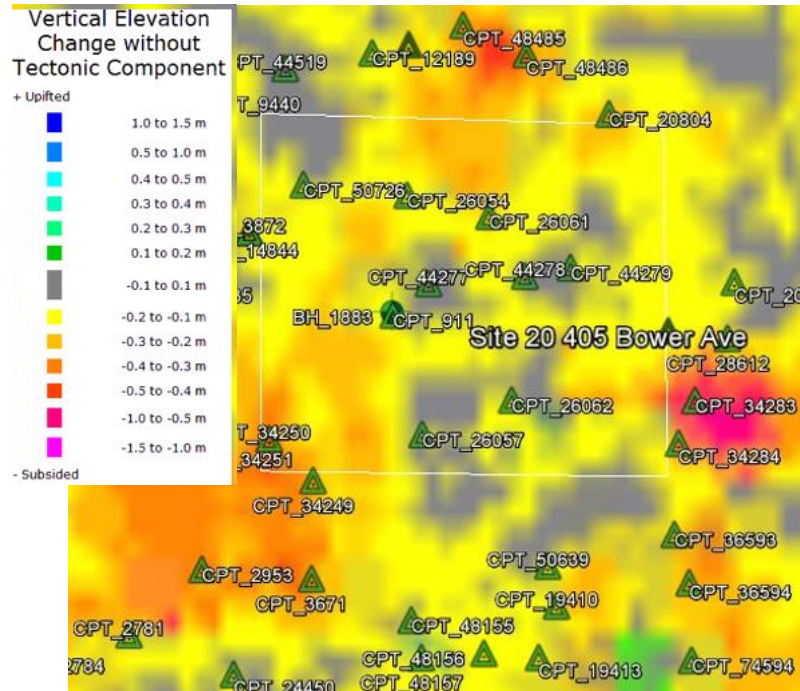
IM Value	IM Type	Method	Standard Deviation	Remark
0.42	PGA (g)	Interpolated from nearby sta	0.325 to 0.35	

[GMM RUN](#)

Bower Avenue Site after the 2011 Christchurch Earthquake (New Zealand)

The NGL Database

Ground Performance: LiDAR Maps



SITE INFORMATION EVENT INFORMATION GROUND PERFORMANCE

Server Message

Site Name: Site 20 405 Bower Ave
Event Name: Christchurch, New Zealand

Field Observation

Fill data from file: CHOOSE A FILE

Observation Tag	Observation Type	Latitude (deg)	Longitude (deg)	Description	File Add
2 SELECTED	Photo	-43.4851	172.712	Aerial photograph taken 2 day after earthqu	CHOOSE A FILE
1 SELECTED	LiDAR Image	-43.4851	172.712	Measured settlement	CHOOSE A FILE

ADD DELETE

Ground Motion Intensity Measures

Fill data from file: CHOOSE A FILE

IM Value	IM Type	Method	Standard Deviation	Remark
0.42	PGA (g)	Interpolated from nearby sta	0.325 to 0.35	

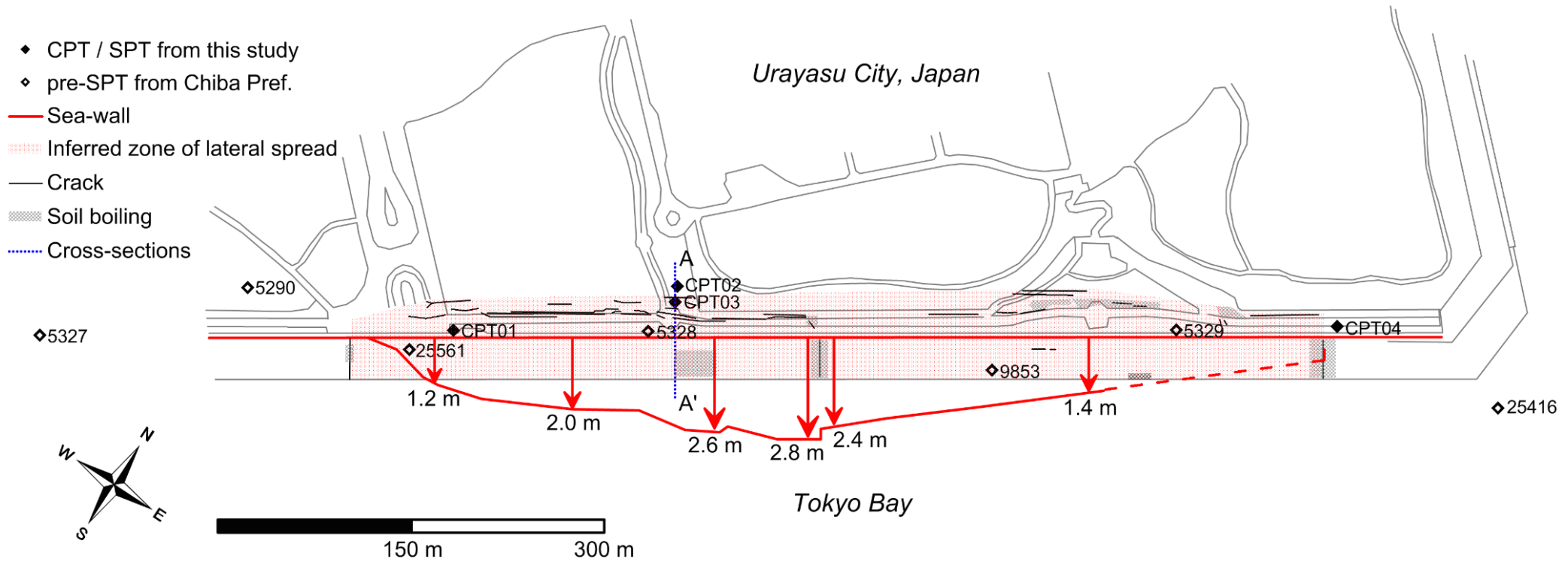
Interpolated from nearby stations
Measured from adjacent station
Interpolated from nearby stations
Inferred from GMM

GMM RUN

Bower Avenue Site after the 2011 Christchurch Earthquake (New Zealand)

The NGL Database

Ground Performance: Site Maps



Urayasu City Site after the 2011 Tohoku Earthquake (Japan)

The NGL Database

Current Tasks: Database Population and Data Vetting

The screenshot shows the NGL Next-Generation Liquefaction Project website. The top navigation bar includes 'NGL Next-Generation Liquefaction Project', 'Map', 'Upload', 'Help', 'Admin', 'Review', and 'Log Out'. The main content area features a 'Review Sites' table with the following data:

Site Name	Latitude	Longitude	Actions
Test Site With File	80	80	Review

Below the table, logos for PEER, Caltrans, SwRI, and U.S. NRC are displayed.

Review/Vetting: NGL Database Working Group (Brandenberg (chair), Moss, Franke, Cetin)

Final Remarks

- ***Urgent need for high-quality, transparent, case-history database***
- ***The NGL relational database (being populated): open-source relational database***
- ***Relational databases are more powerful than flatfiles (transformational shift from past practices!)***
- ***The NGL database will include NGA data***
- ***Future task: Completion of database population, supporting studies, model development***



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Thank You!

Relevant References:

- Brandenberg S.J., Kwak D.Y., Zimmaro P., Bozorgnia Y., Kramer S.L., Stewart J.P. (2018). Next-Generation Liquefaction (NGL) Case History Database Structure. Fifth decennial Geotechnical Earthquake Engineering and Soil Dynamics Conference, Earthquake Engineering and Soil Dynamics Committee of the Geo-Institute. Austin, TX (USA), June 10-13.
- Stewart J.P., Kramer S.L., Kwak D.Y., Greenfield M.W., Kayen R.E., Tokimatsu K., Bray J.D., Beyzaei C.Z., Cubrinovski M., Sekiguchi T., Nakai S., Bozorgnia Y. (2016). PEER-NGL project: Open source global database and model development for the next-generation of liquefaction assessment procedures. *Soil Dyn. Earthquake Eng.*, 91, 317–328.



Project homepage:

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

Database (beta):

<http://uclageo.com/NGL/database/index.php>