Next-Generation Liquefaction (NGL) Project Update

PEER Researchers Workshop

19 September 2022

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http://nextgenerationliquefaction.org

NGL Introduction

Project innovations

- Relational **database**
  - Interactive tools
  - New classes of case histories
- **Supporting studies**: constrain critical effects that cannot be captured through case histories alone
- **Model** formulation

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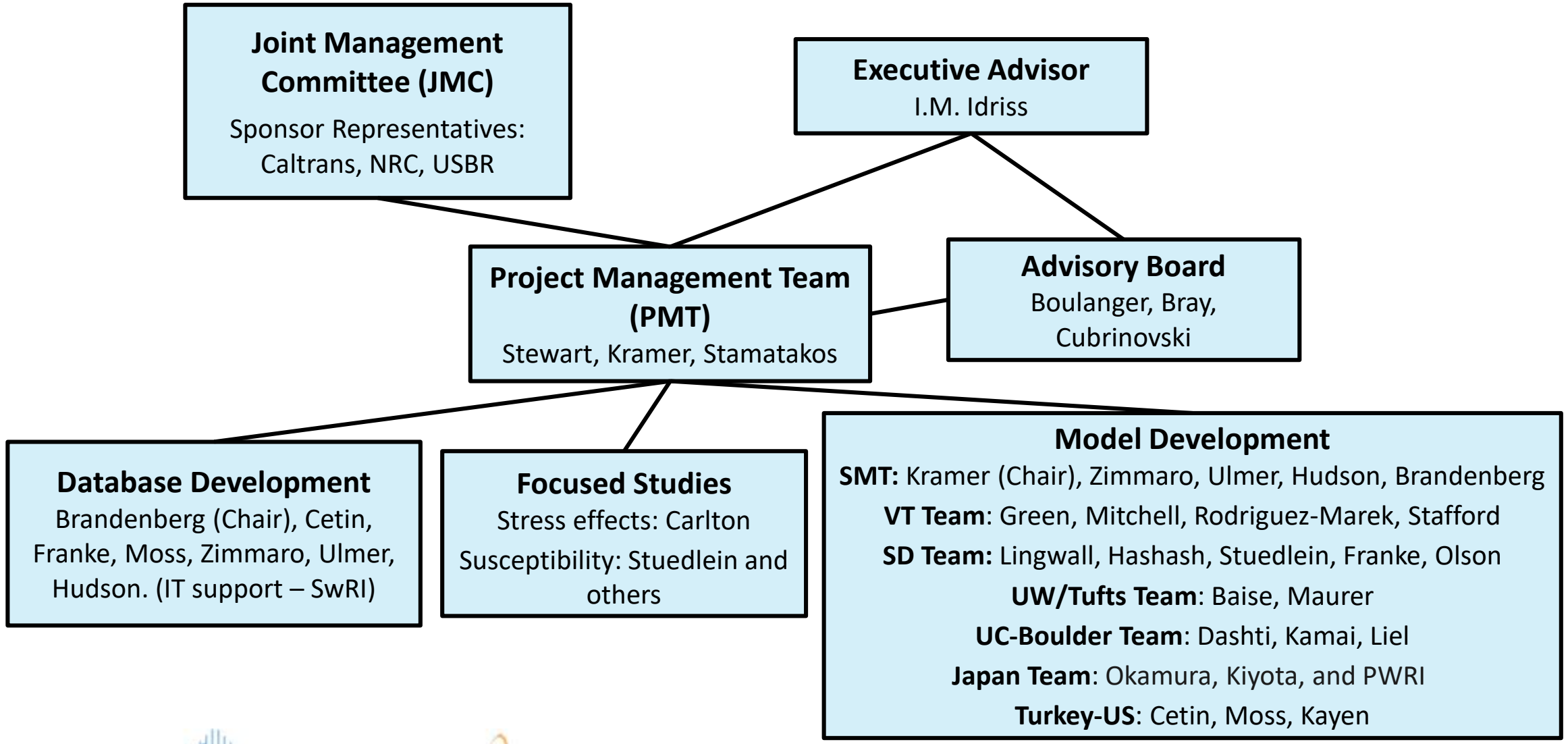
NGL Project Structure

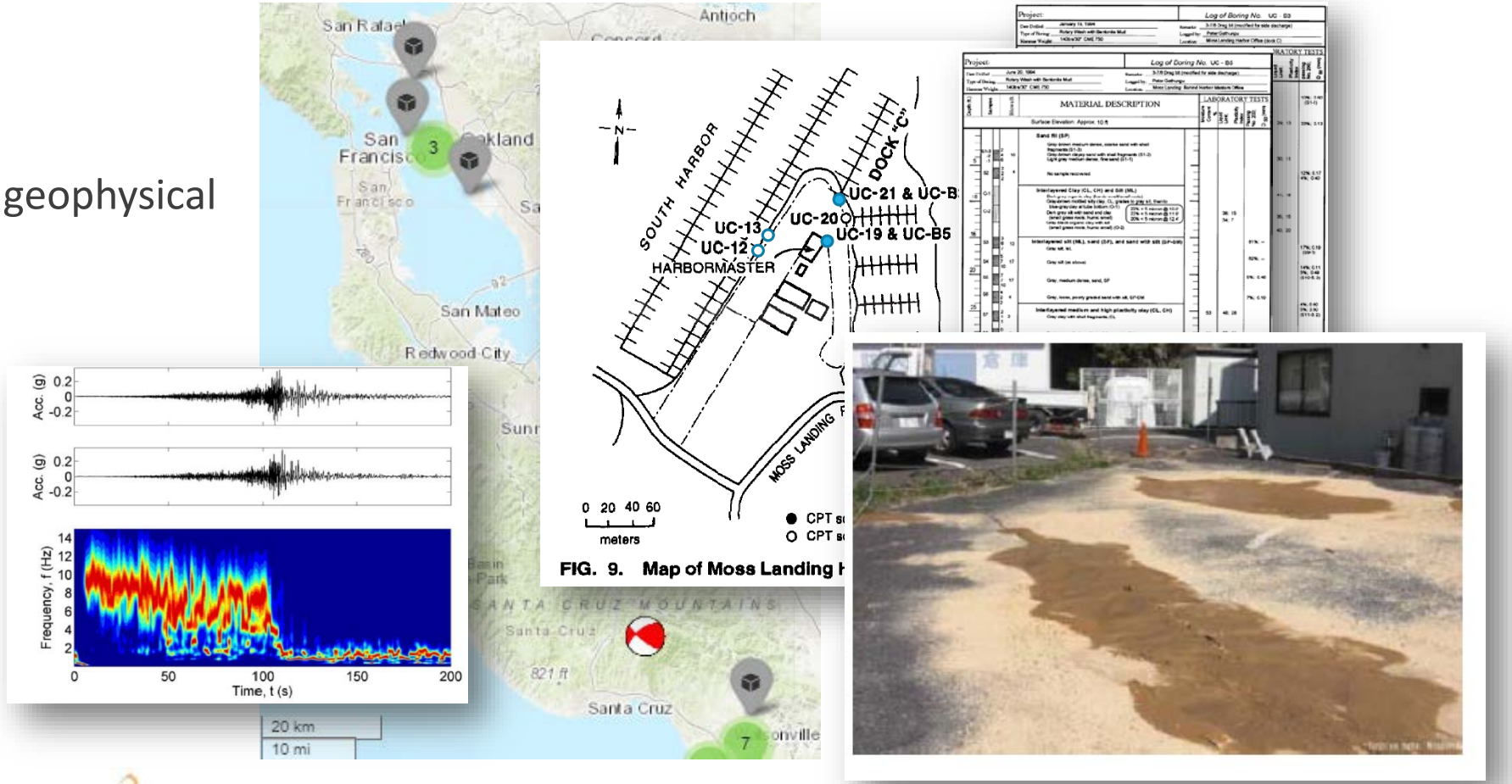


NGL NEXT GENERATION LIQUEFACTION


NGL
NEXT GENERATION LIQUEFACTION
View Data
Interact With Data
About
Sign In
Sites
Field Performance
Field Investigation
Earthquake
Type event name
Magnitude:
min
max
(choose one or type
Submit
Reset
Statistics
https://www.nextgenerationliquefaction.org/
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
Other
NORTH AMERICA
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTRALIA
Atlantic Ocean
Pacific Ocean
Indian Ocean
3000 km
2000 mi

Database Contents

- **Events**
- **Sites**
- **In-situ Tests** (SPT, CPT, geophysical tests)
- **Observations**
- **Laboratory Tests**



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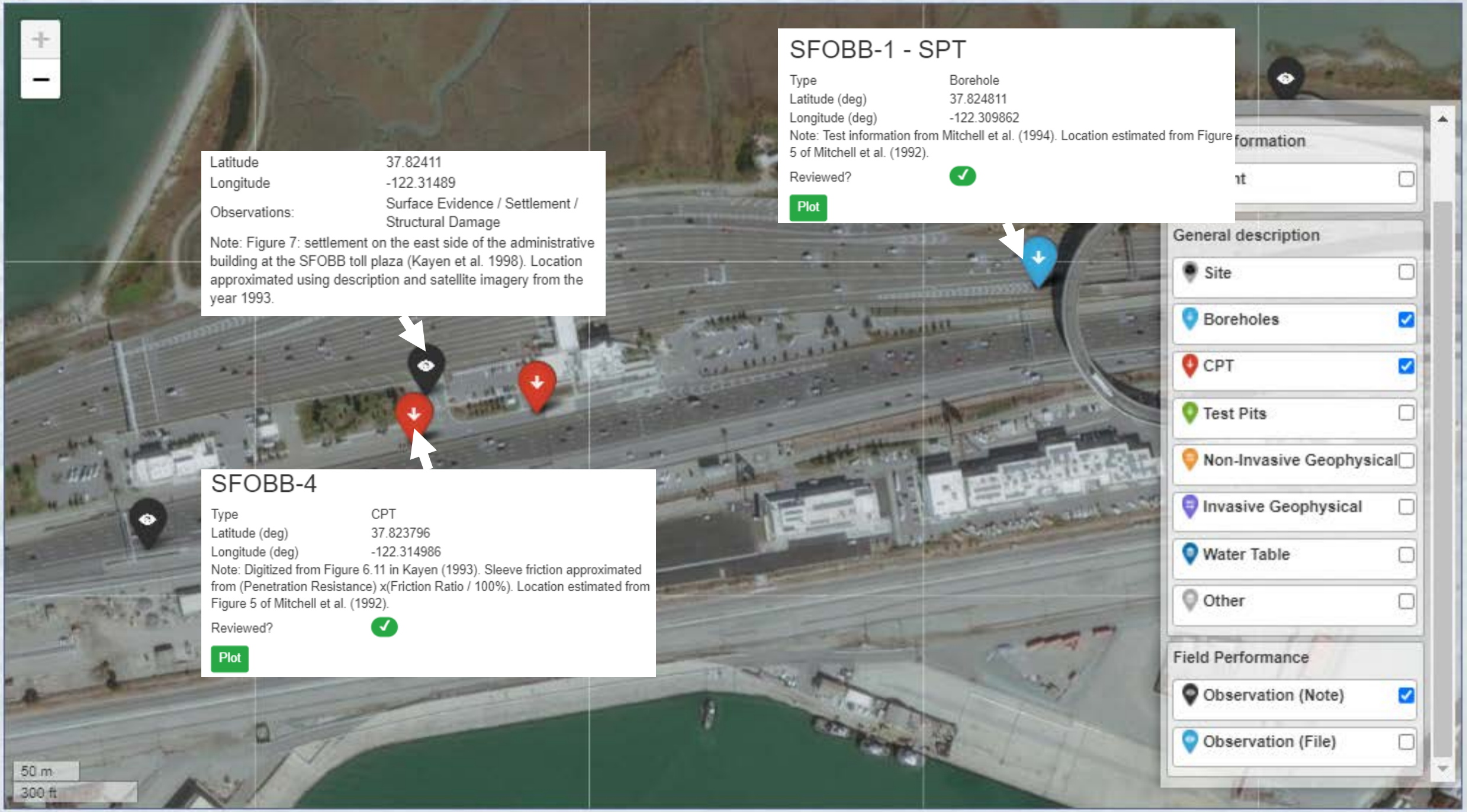
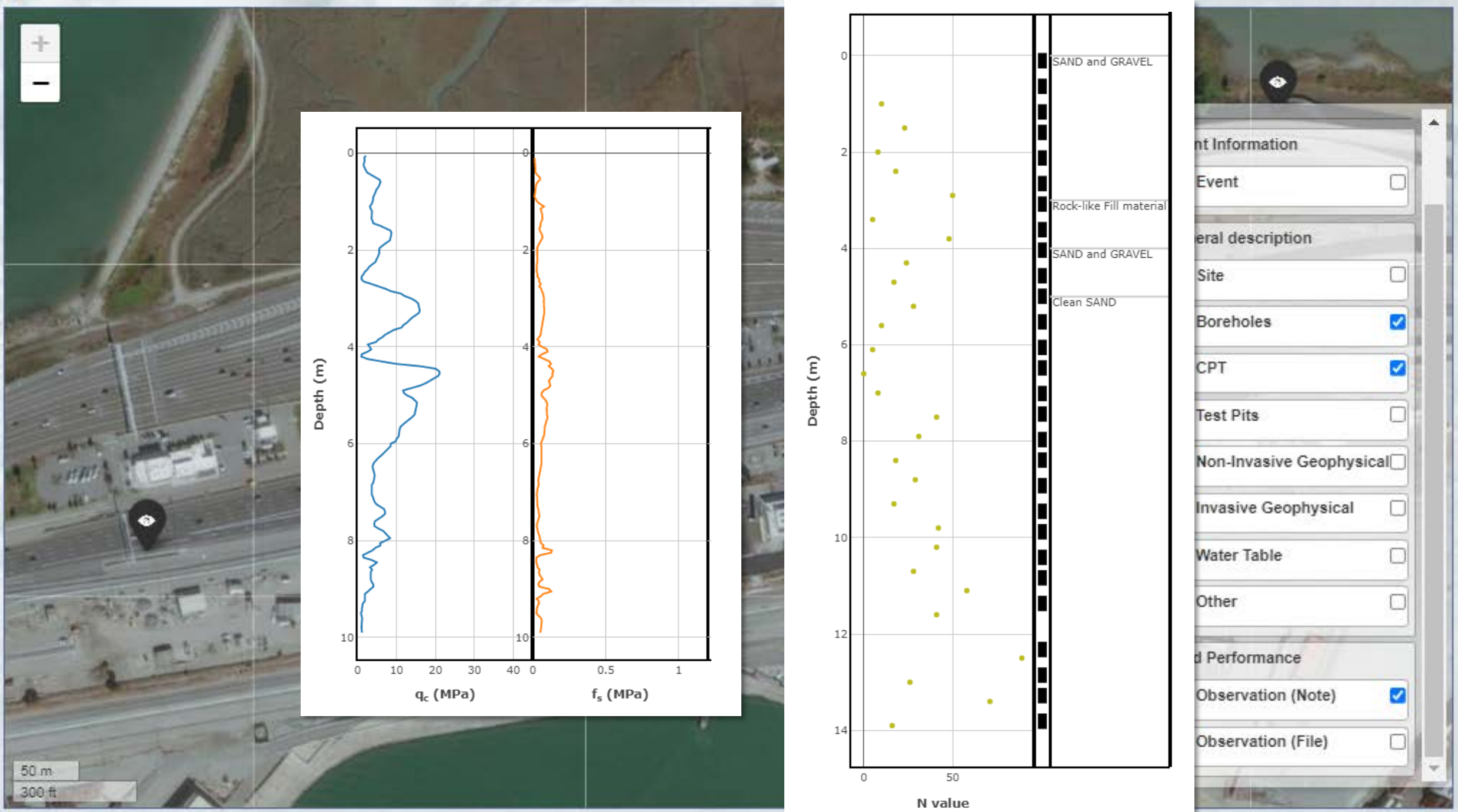

Latitude 37.82411
Longitude -122.31489
Observations: Surface Evidence / Settlement / Structural Damage
Note: Figure 7: settlement on the east side of the administrative building at the SFOBB toll plaza (Kayen et al. 1998). Location approximated using description and satellite imagery from the year 1993.
SFOBB-1 - SPT
Type Borehole
Latitude (deg) 37.824811
Longitude (deg) -122.309862
Note: Test information from Mitchell et al. (1994). Location estimated from Figure 5 of Mitchell et al. (1992).
Reviewed?
Plot
SFOBB-4
Type CPT
Latitude (deg) 37.823796
Longitude (deg) -122.314986
Note: Digitized from Figure 6.11 in Kayen (1993). Sleeve friction approximated from (Penetration Resistance) x(Friction Ratio / 100%). Location estimated from Figure 5 of Mitchell et al. (1992).
Reviewed?
Plot
General description
Site
Boreholes
CPT
Test Pits
Non-Invasive Geophysical
Invasive Geophysical
Water Table
Other
Field Performance
Observation (Note)
Observation (File)
50 m
300 ft


50 m
300 ft
Depth (m)
0
2
4
6
8
10
0
10
20
30
40
q_c (MPa)
0
0.5
1
f_s (MPa)
SAND and GRAVEL
Rock-like Fill material
SAND and GRAVEL
Clean SAND
0
50
N value
nt Information
Event
eral description
Site
Boreholes
CPT
Test Pits
Non-Invasive Geophysical
Invasive Geophysical
Water Table
Other
d Performance
Observation (Note)
Observation (File)

Tools and Resources

- Graphical User Interface (GUI) https://nextgenerationliquefaction.org/
- Connect to the NGL database through Jupyter Notebooks on DesignSafe https://www.designsafe-ci.org/
- Schema website https://nextgenerationliquefaction.org/schema/index.html
- NGL Tools Documentation
  - Use case documentation on DesignSafe (https://www.designsafe-ci.org/rw/use-cases/)
  - https://ngl-tools.readthedocs.io/en/latest/
- NGL YouTube Channel
  - Webinars on case histories and related topics
  - October DesignSafe Workshop: creating Jupyter Notebooks

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DS Use Case Products

Search docs

Use Cases Products
Taggit - Image Tagging
ML and AI
NGL Database
Background
Understanding the Database Schema
Querying Data via Jupyter Notebooks
Installing Database Connection Script
Example Queries

« Previous Next »

NEXT GENERATION LIQUEFACTION (NGL) DATABASE JUPYTER NOTEBOOKS

Brandenberg, S.J. - UCLA
Ulmer, K.J. - Southwest Research Institute
Zimmaro, P. - University of Calabria

The example makes use of the following DesignSafe resources:

Jupyter notebooks on DS Juypterhub
NGL Database

Background

In [ ]:
```
!pip install --user git+https://github.com/sjbrandenberg/designsafe_db
```

1. Query contents of SITE table

The lines of code below first imports the ngl_db Python package, then creates a query to read all data from the `SITE` table, then creates a Pandas dataframe by executing the read_sql command that is part of the designsafe_db.ngl_db package.

In [2]:
```
import designsafe_db.ngl_db as ngl
sql = 'SELECT * FROM SITE'
df = ngl.read_sql(sql)
df
```

Out[2]:

	SITE_ID	SITE_NAME	SITE_LAT	SITE_LON	SITE_GEOL	SITE_REM	SITE_STAT	SITE_REVW
0	147	Amagasaki	34.715560	135.400750	Qal	Industrial site near Yomoga River. Coordinate...	1	2
1	148	Bonds Corner	32.693100	-115.338200	Qal, deep, Imperial Valley		1	2
2	149	Hachirogata	39.850000	140.017000	Af (Fill)	Gingery indicates the geology near the strong ...	1	2
3	150	Higashi-Kobe Bridge	34.710214	135.293345	Af (Fill)	A geologic map of the area (Geological Survey ...	1	2
4	151	Hanshin Expressway	34.724834	135.301489		Hanshin Expressway (Mylonakis et al. 2006)	1	2
...	...	...	...	...	...	...	...	...
301	711	Martella (MAR)	36.699000	-121.713000		Site information from Bennett and Tinsley (199...	1	2
302	712	Salinas River Bridge (SRB)	36.629500	-121.677500		Site information from Bennett and Tinsley (199...	1	2

Database Content vs. Analysis Objective

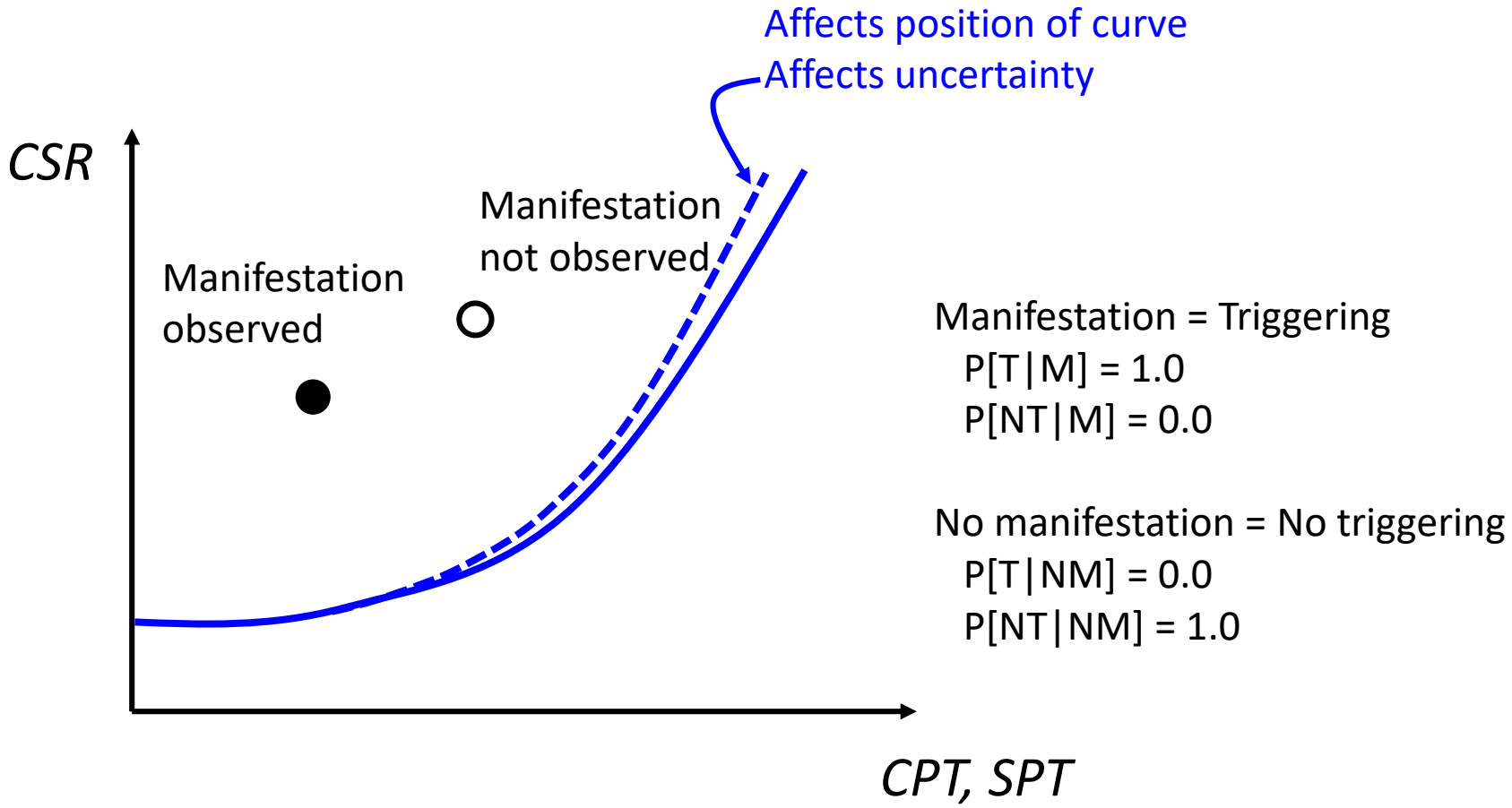
Database: field observations are of surface manifestation or lack thereof

Analysts may want:

- Triggering model (stability problems): P(T)
- Manifestation model: P(M)

Traditional approach…

Common Historical Interpretation



Manifestation = Triggering
P[T|M] = 1.0
P[NT|M] = 0.0

No manifestation = No triggering
P[T|NM] = 0.0
P[NT|NM] = 1.0

Bayes' Theorem: P(A | B) P(B) = P(B |A) P(A)

$$P[T \mid M] = \frac{P[M \mid T]P[T]}{P[M]} = \frac{P[M \mid T]P[T]}{P[M \mid T]P[T] + P[M \mid NT]P[NT]}$$

Probability of manifestation given triggering

Probability of manifestation without triggering

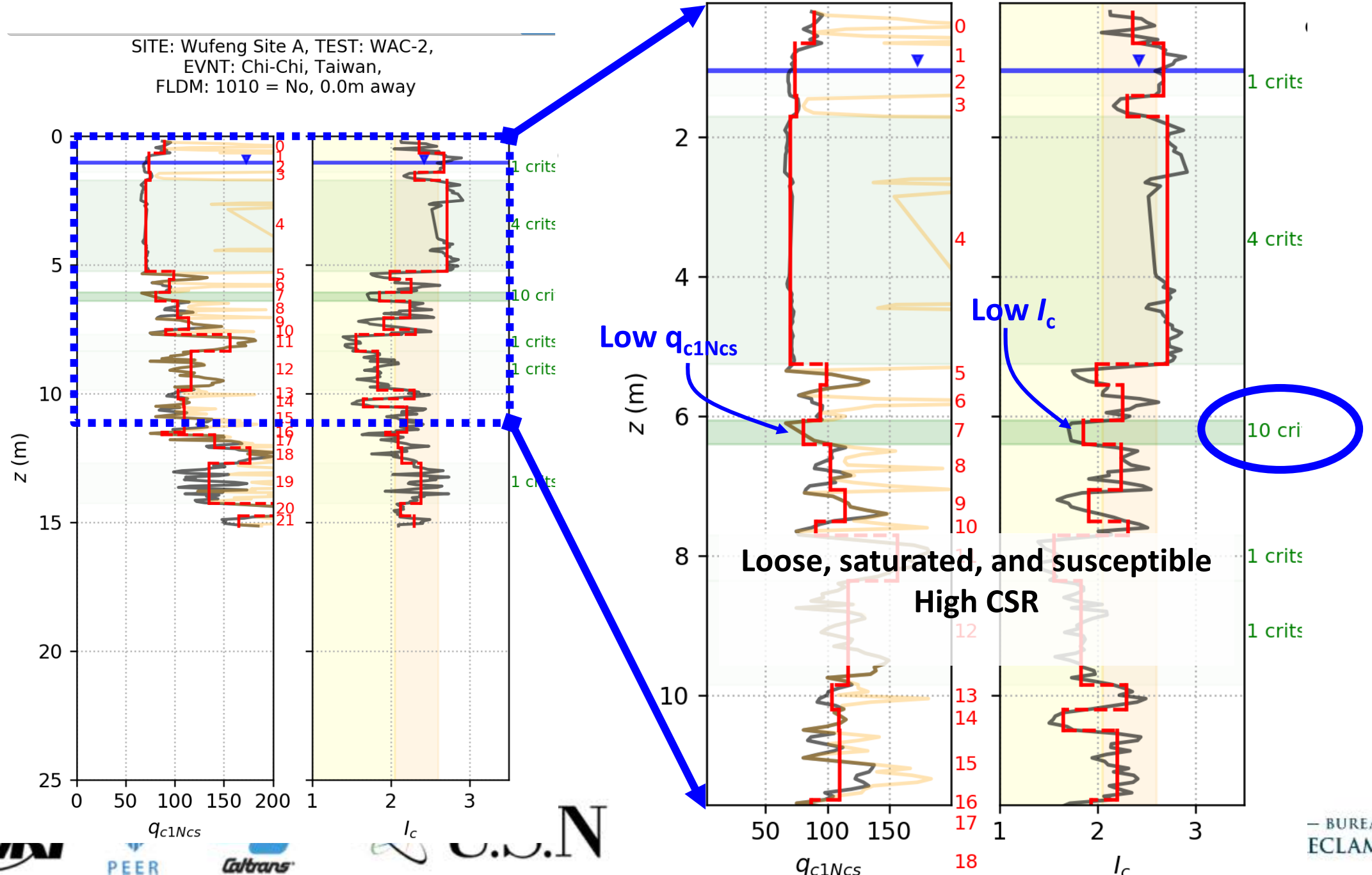
(e.g., sand boils with $r_{u,max}$ = 0.8 in thick, shallow layer)

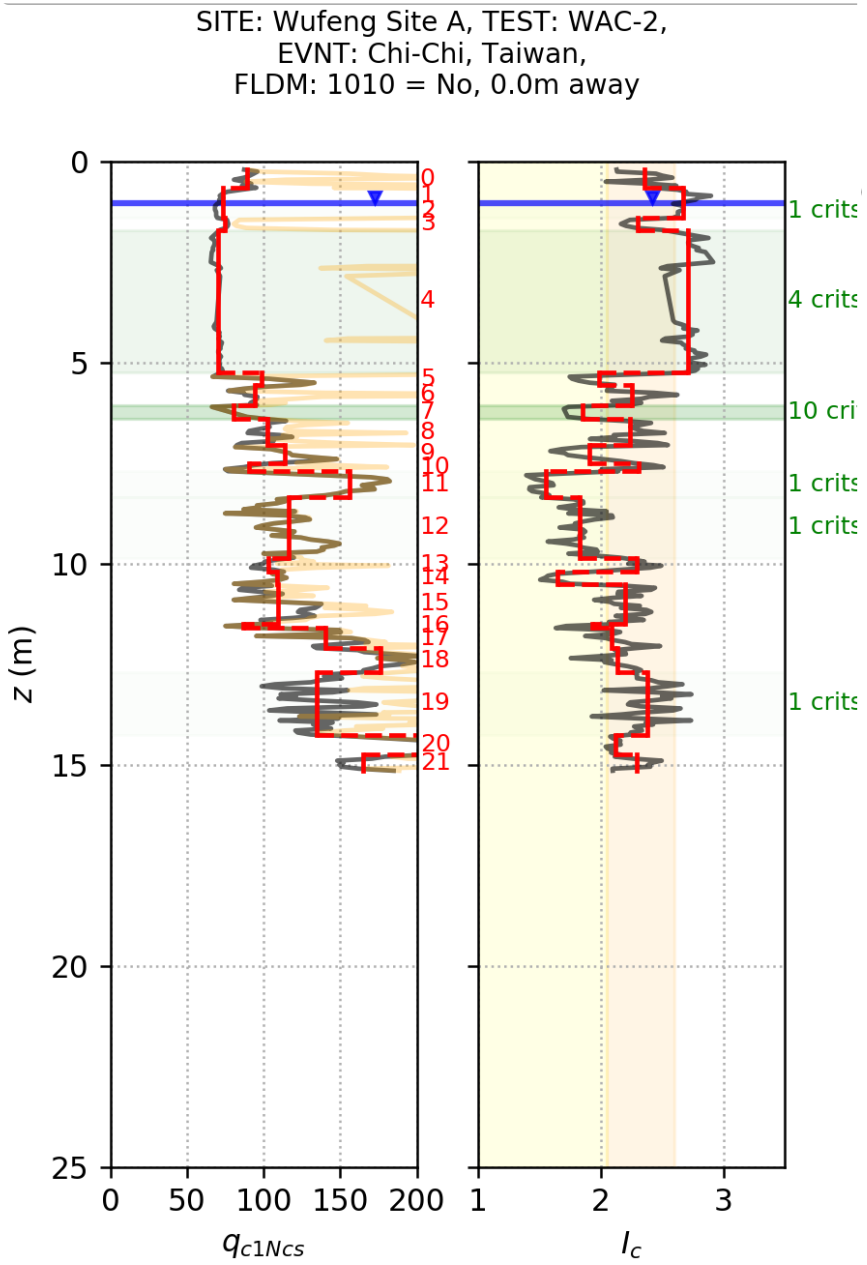
Bayes' Theorem : P(A | B) P(B) = P(B |A) P(A)

$$P[T \mid M] = \frac{P[M \mid T]P[T]}{P[M]} = \frac{P[M \mid T]P[T]}{P[M \mid T]P[T] + P[M \mid NT]\left(1 - P[T]\right)}$$

Requires three components:

- Probability of manifestation given triggering, $P[M|T]$
- Probability of manifestation without triggering, $P[M|NT]$
- Probability of triggering before seeing this data, $P[T]$ - prior probability


SITE: Wufeng Site A, TEST: WAC-2,
EVNT: Chi-Chi, Taiwan,
FLDM: 1010 = No, 0.0m away
z (m)
q_{c1Ncs}
I_c
Low q_{c1Ncs}
Low I_c
Loose, saturated, and susceptible
High CSR
1 crits
4 crits
10 cri
1 crits
1 crits
1 crits
4 crits
10 cri
1 crits
1 crits



Suppose:

P(T) = 0.9

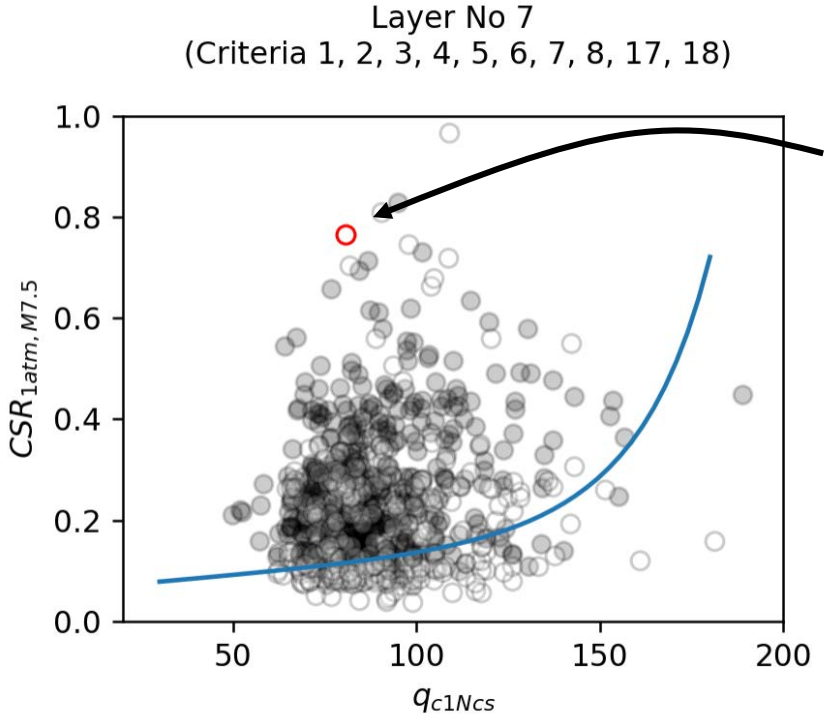
P(M|T) = 0.15

P(M|NT) = 0.005

Then:

P(T | NM) = **0.885**

P(NT | NM) = **0.115**



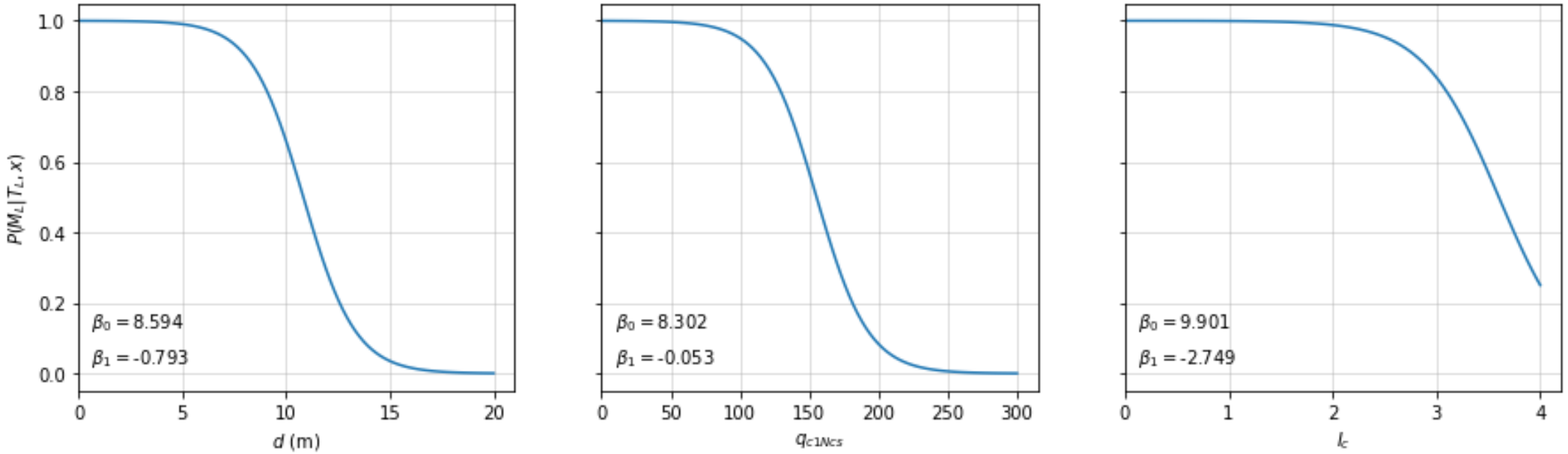
Two co-located circles for this case history

Closed circle with weighting factor of 0.885

Open circle with weighting factor of 0.115

Profile-Based Method

$$P\left[M_L \mid T_L\right]_{jk} = 1 - \prod_i \left(1 - P\left[M_L \mid T_L, x_{ijk}\right]\right)^{t_{jk}/t_c} = 1 - \prod_i \left(1 - \frac{1}{1 + e^{-(\beta_{0,i} + \beta_{1,i} x_{ijk})}}\right)^{t_{jk}/t_c}$$



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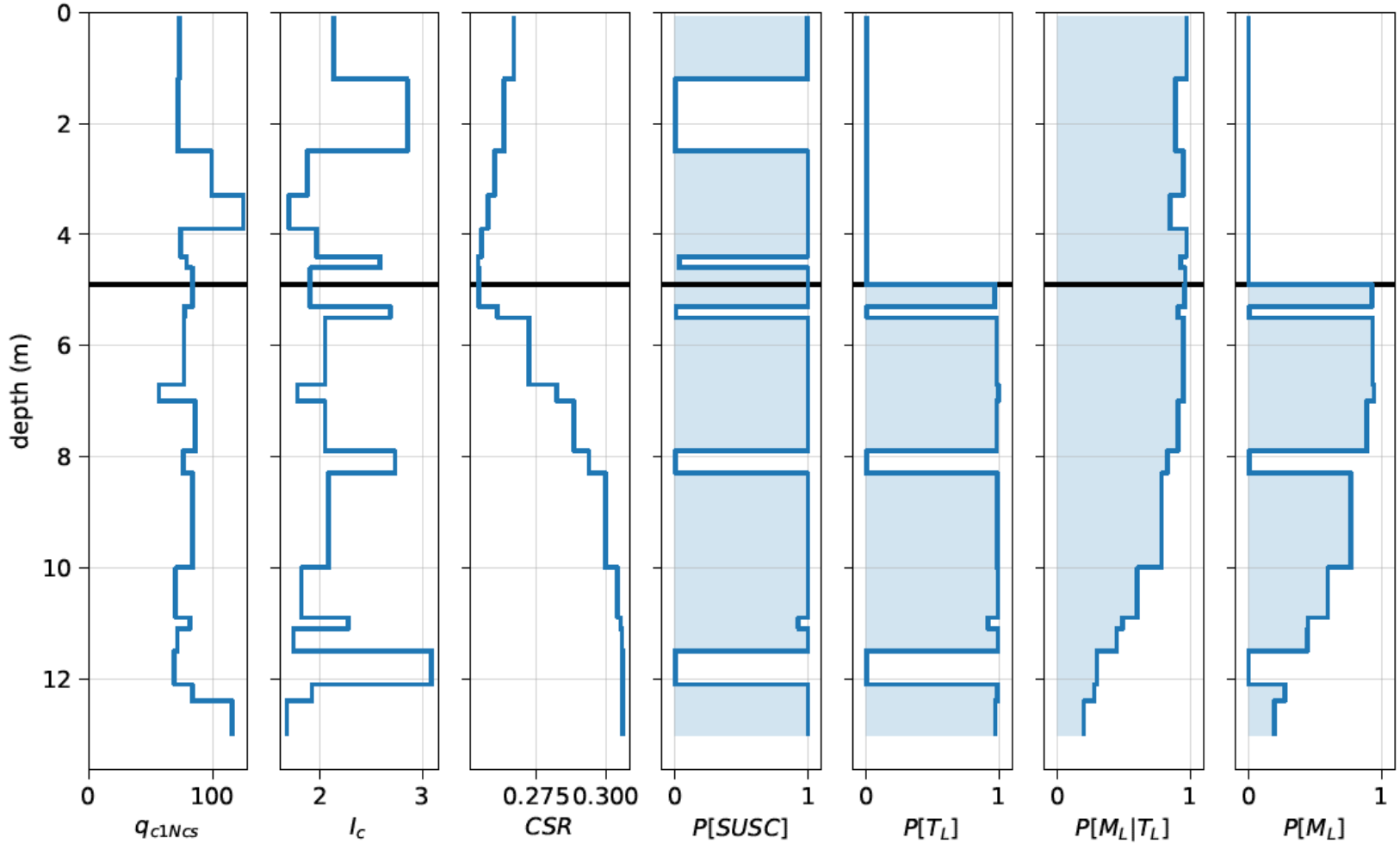
P[MP]: 0.907
FLDM_SFEV: Yes
FLDM_SNBL: Unknown
Site Name: Miller Farm (CMF)
Event Name: Loma Prieta
Test Name: CMF009
FLDM_DESC: CMF-9: Liquefaction manifestation (Bennett and Tinsley 1995, Toprak and Holzer 2003)



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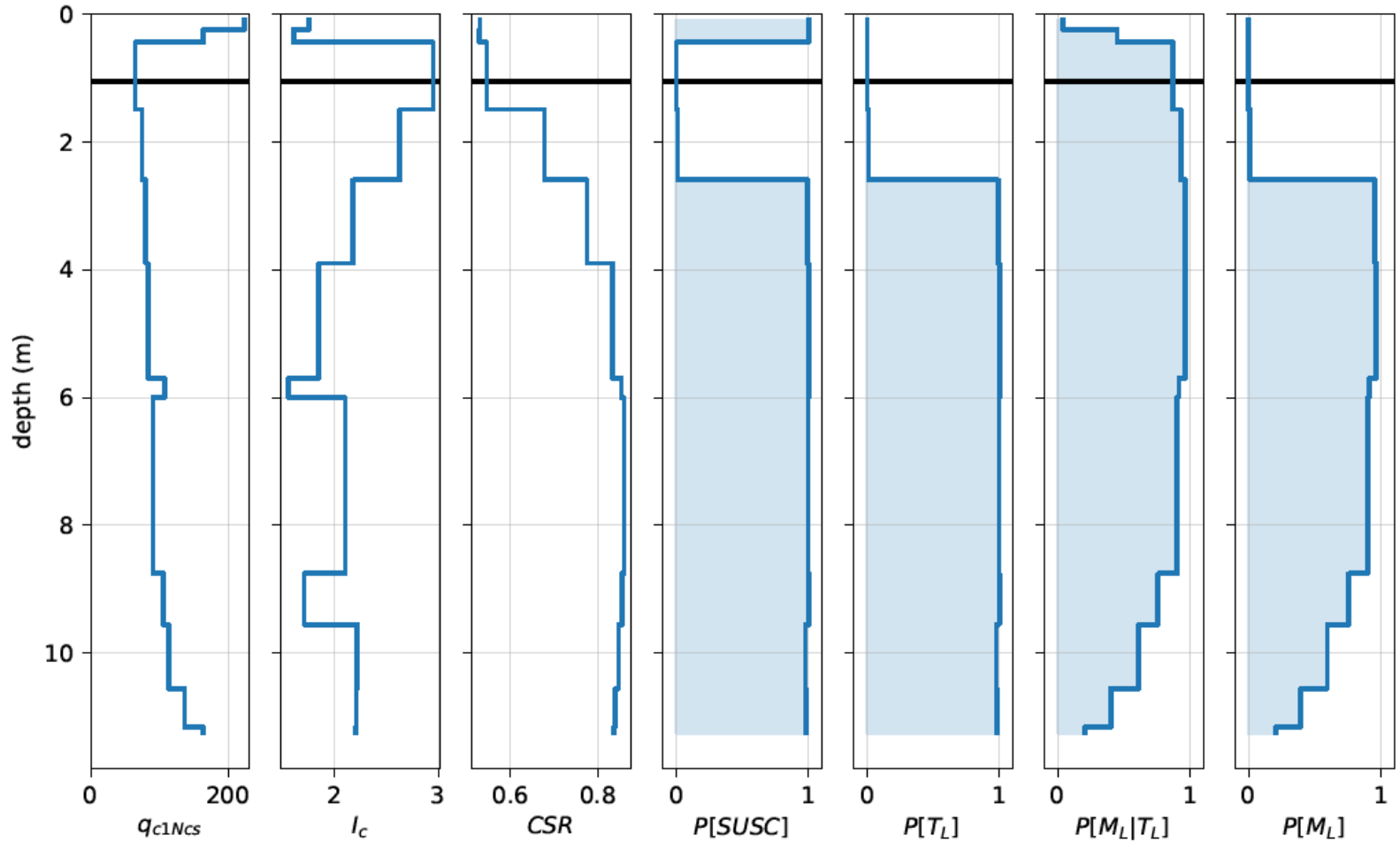
P[MP]: 0.984
FLDM_SFEV: No
FLDM_SNBL: No
Site Name: Wufeng Site A
Event Name: Chi-Chi, Taiwan
Test Name: WAC-3
FLDM_DESC: WAC-3: No Ground Failure Observed. More information can be obtained directly from PEER's Taiwan Ground Failure Database:
https://apps.peer.berkeley.edu/lifelines/research_projects/3A02/wufeng-site-a.html



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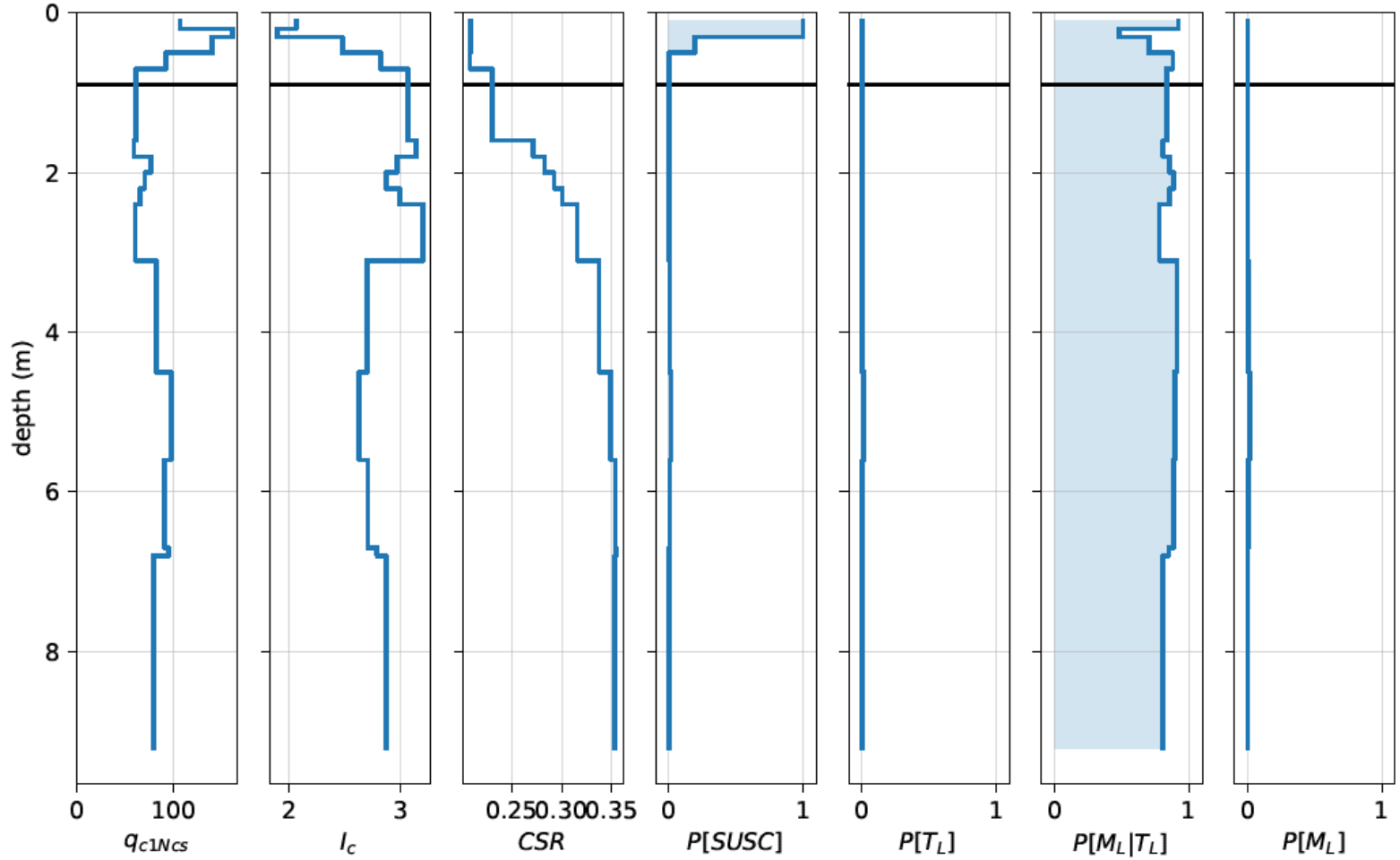
P[MP]: 0.005
FLDM_SFEV: Yes
FLDM_SNBL: Unknown
Site Name: Kett (KET)
Event Name: Loma Prieta
Test Name: KET075
FLDM_DESC: Lateral spread observed in the site area (Toprak et al. 1999). Precise location/extents of lateral spread not given.



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Conclusions

- NGL Database:
  - Field case histories and laboratory data
  - Connect to the database through the GUI or Jupyter notebooks in DesignSafe
- Supporting Studies
- Model Development
  - Unpacking of triggering from manifestation
  - Multiple modeling approaches being considered

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