Liquefaction Potential Determination And Hazard Mapping Based On Passive Surface Wave Geophysical Test In The Long Beach And Tuzla Region Of Cyprus

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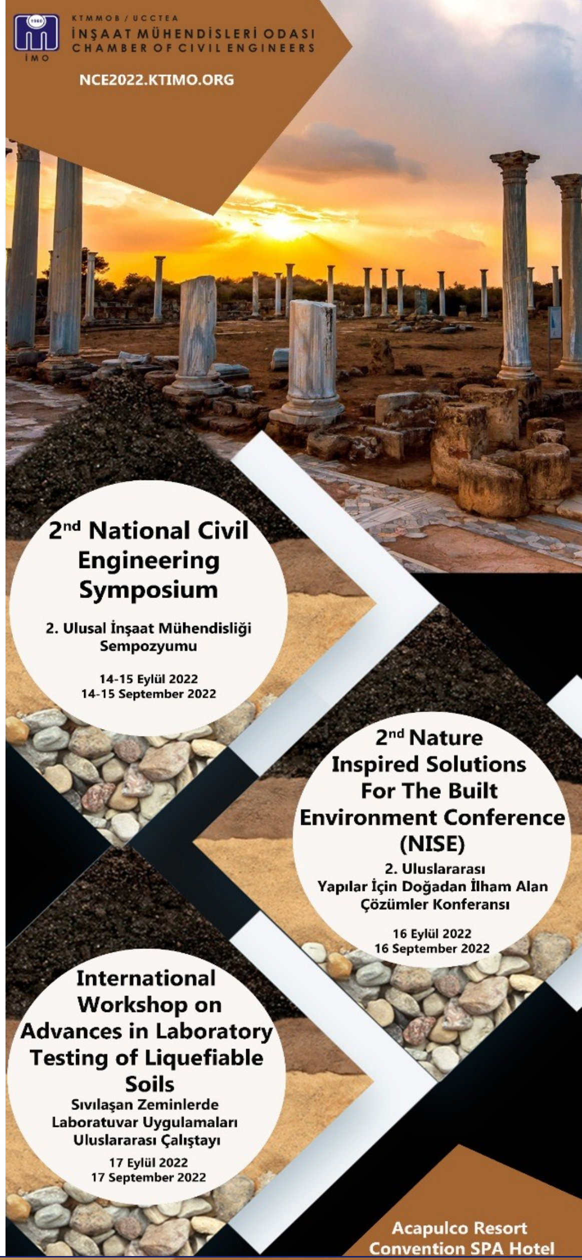


Outline

Literature Review

Methodology

Results

Conclusion and Future Plans

Geotechnical Soil Problems Faced in Cyprus

There are two geotechnical soil related problem that can be observed in Cyprus island.

- Expansive clays (swelling clays of Cyprus)

Expansive clays are known as problematic soils especially for low weight structures. They cause economical problems instead of failure of the structures like cracks. Constantinou, G, Petrides, G, Kyrou, K, Chrysostomou, C (2001).

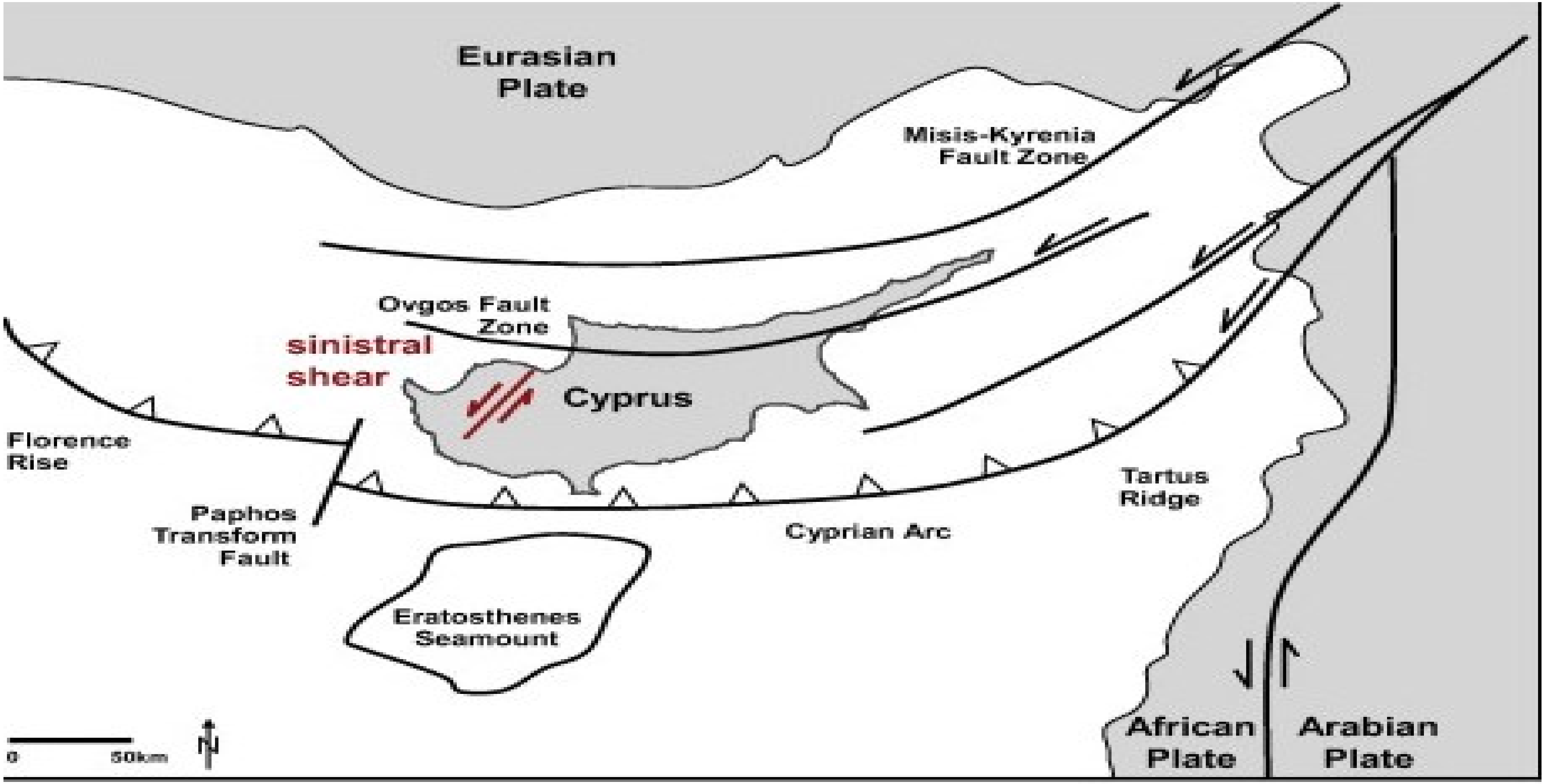
- Liquefaction

It is a soil failure caused by effect of an earthquake.

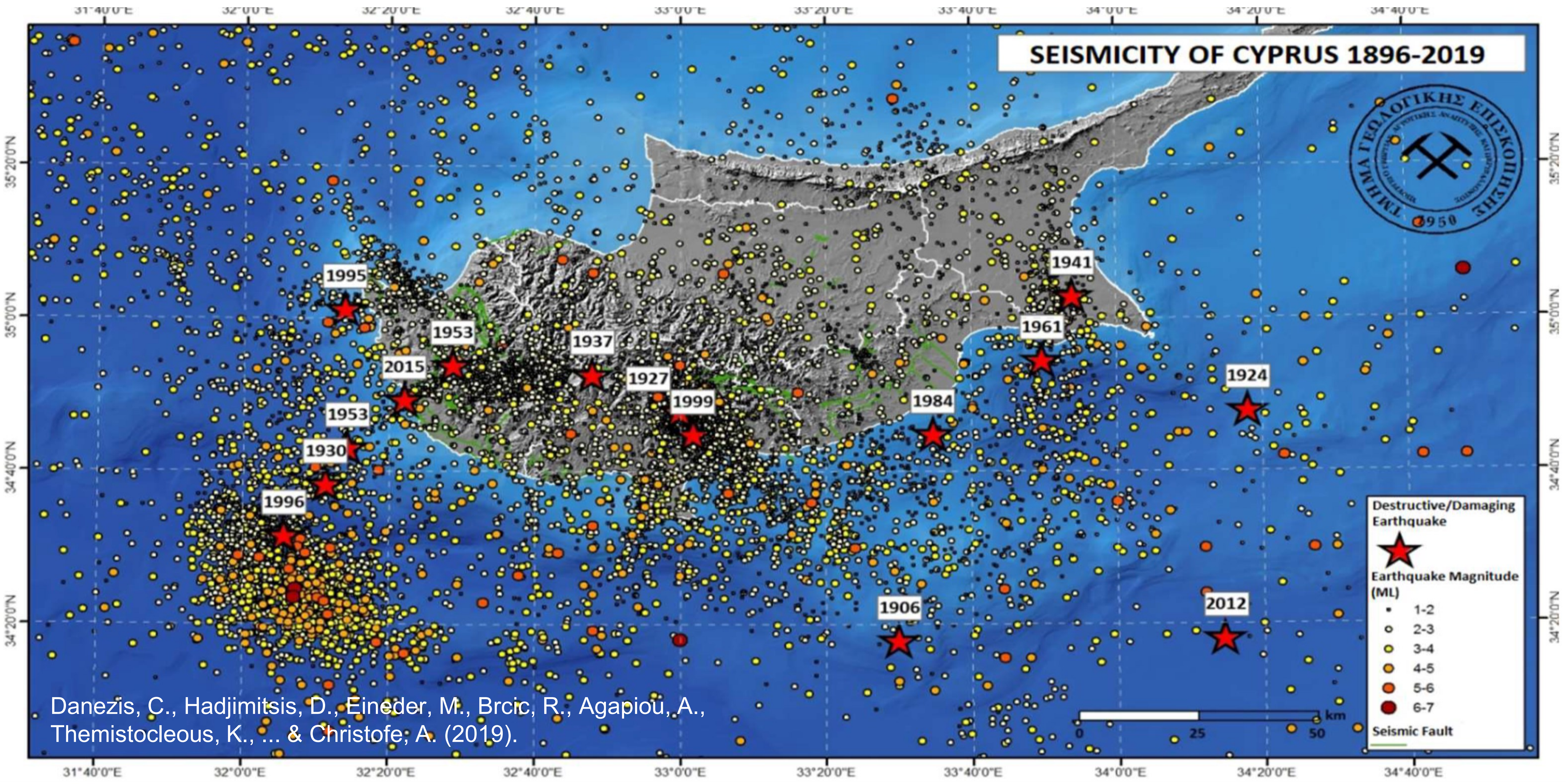
Seed, H. B., & Idriss, I. M. (1971).


("Cracking in walls," 2017)


("What is soil liquefaction Causes and importance of soil liquefaction," 2018)



Ren, L., Cohen, D. R., Rutherford, N. F., Zissimos, A. M., & Morisseau, E. G. (2015).



Danezis, C., Hadjimitsis, D., Eineder, M., Brcic, R., Agapiou, A., Themistocleous, K., ... & Christofe, A. (2019).

("Famagusta & Salamis - Civitatis.com," n.d.)

The City of the Salamis

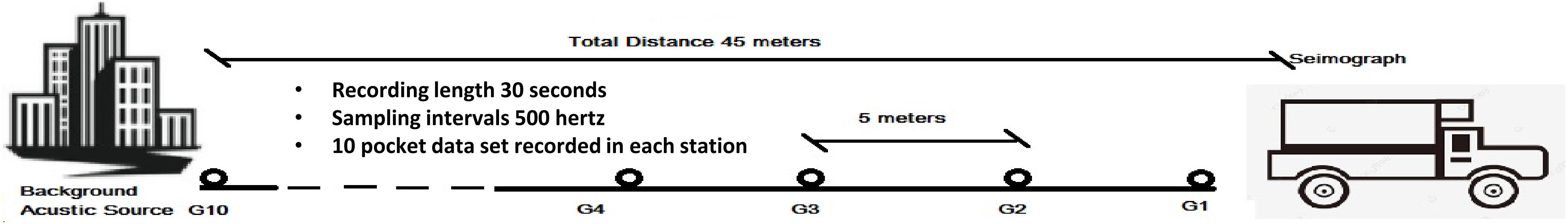
- Antanapoulos (1980) investigated seismic sea-wave analysis. The author reported that part of the ancient city of Salamis collapsed and sunk into the Mediterranean because region was hit by a strong earthquake 342 AD. Therefore, ,it is clear that investigated areas Tuzla and Long beach had been subjected liquefaction.

- Shear wave velocity is one of the recently developed and widely used techniques and applications for evaluating different parameters in building codes, and designing the hazard mapping technique in urbanised regions is evolving to more accurate local hazard prediction with geophysics tests
- Earthquake evaluation will depend on accurate Vs (shear wave velocity) measurements in the depth of upper soil strata layers. As an outcome, it is a quick, less costly and efficient testing way that represents site responses in future hazard maps.

- Nazarian (1984) presented the SASW (spectral analysis of surface waves) approach to the engineering community. Two main ways for non-destructive in situ testing have been developed from SASW, multi-channel analysis of surface waves (MASW) and multi-channel analysis of passive surface waves or refraction microtremor (ReMi)

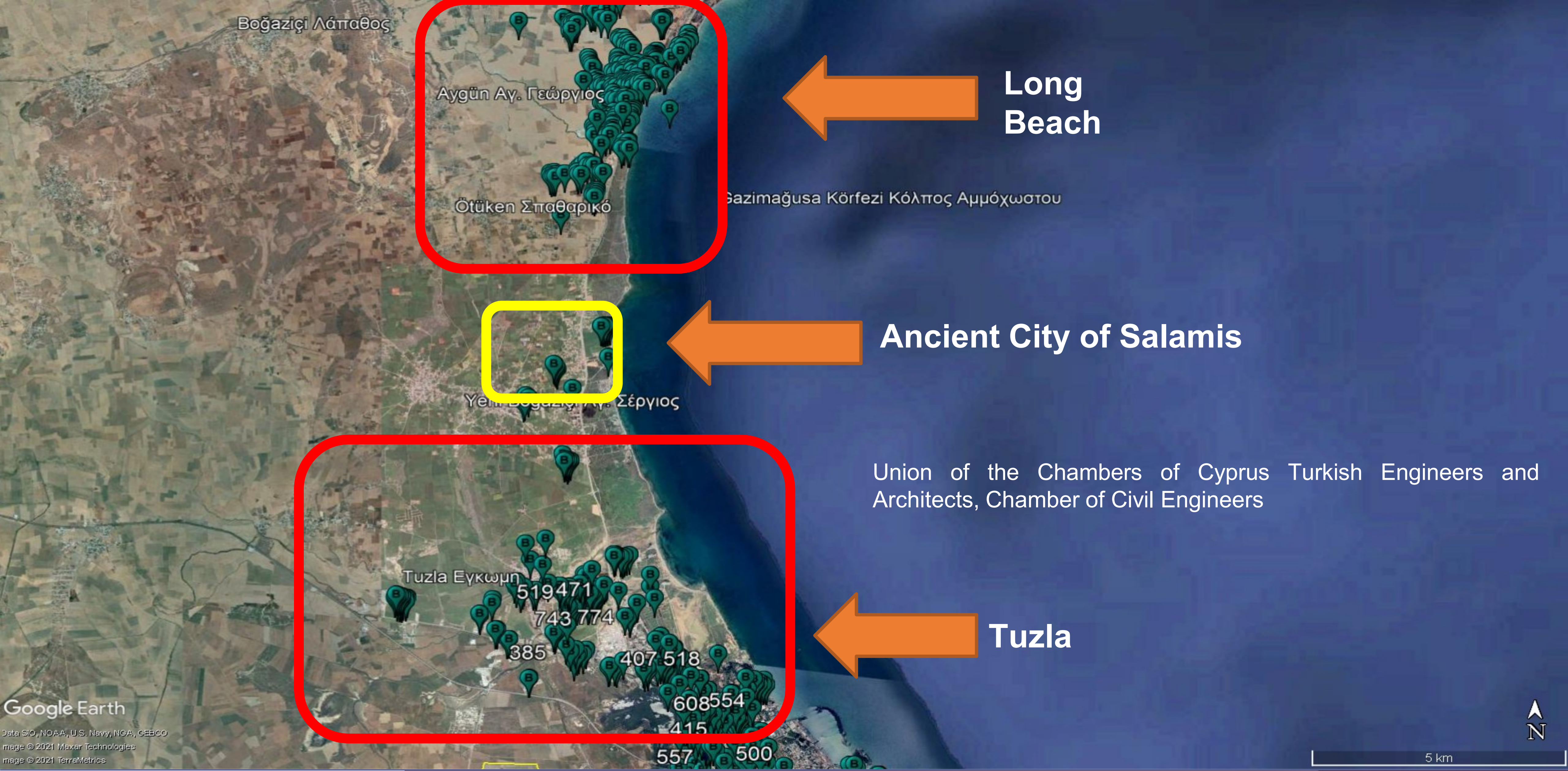
  MASW data allows for the detection and removal of non-source, increased surface waves and other continuous noises Rayleigh waves from the results.

  The refraction microtremor approach is better to be used when external energy sources generate Rayleigh surface wave such as high ways. In order to reach required depth, ReMi method preferred to benefit from current background noises.



Study Area


Long Beach
Tuzla
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
N
60 km



Union of the Chambers of Cyprus Turkish Engineers and Architects, Chamber of Civil Engineers

Methodology

$$CSR = \frac{\tau_{av}}{\sigma'_v} = 0.65 \left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_v}{\sigma'_v}\right) r_d$$

(Seed and Idriss 1971)

$$V_{S1} = V_S C_V = V_S \left(\frac{P_a}{\sigma'_v}\right)^{0.25}$$

$$V^*_{S1} = 215 \text{ m/s}, \quad \text{for sands with } FC \leq 5\% \qquad (11a)$$

$$V^*_{S1} = 215 - 0.5(FC - 5) \text{ m/s}, \quad \text{for sands with } 5\% < FC < 35\% \qquad (11b)$$

$$V^*_{S1} = 200 \text{ m/s}, \quad \text{for sands and silts with } FC \geq 35\% \qquad (11c)$$

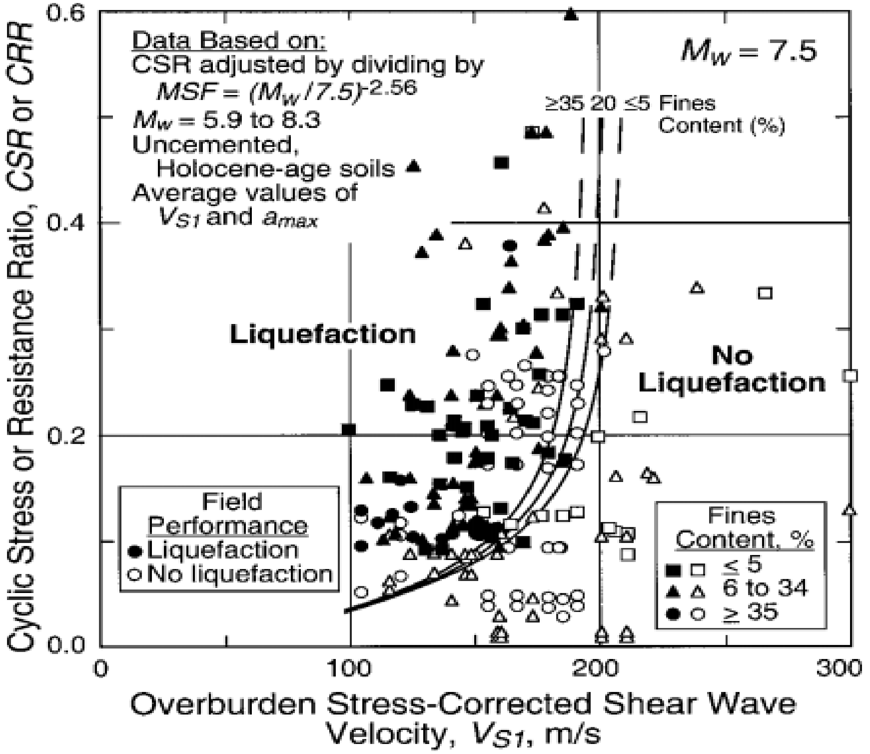
(Andrus, Stokoe. et.al.2004)

$$CRR = \left\{ a \left(\frac{K_c V_{S1}}{100}\right)^2 + b \left(\frac{1}{V^*_{S1} - K_c V_{S1}} - \frac{1}{V^*_{S1}}\right)\right\} MSF$$

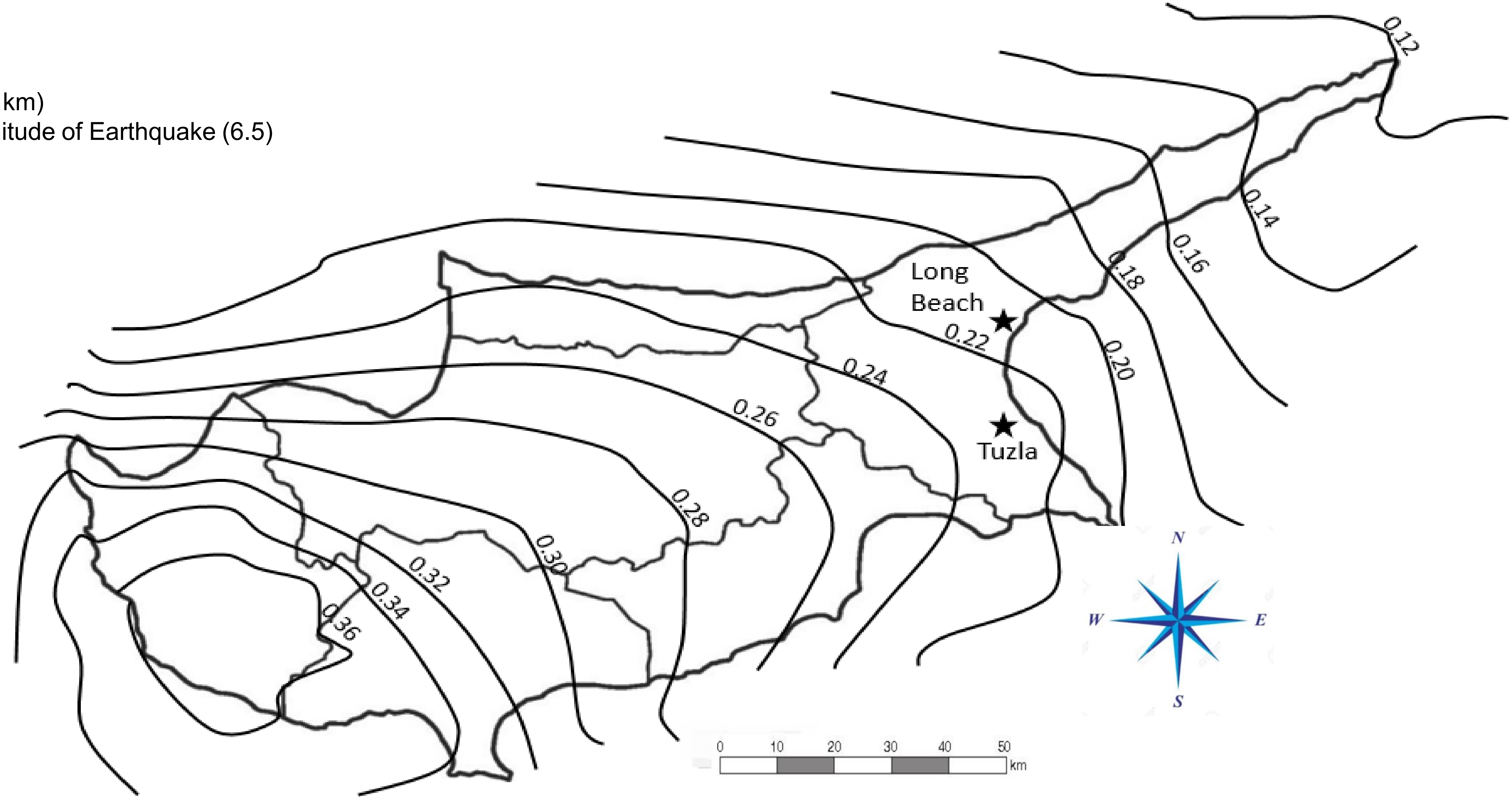
(Andrus, Stokoe. et.al.2004)

$$MSF = \left(\frac{M_w}{7.5}\right)^n$$

$$FS = \frac{CRR}{CSR}$$



R= km (20 km)
MS =Magnitude of Earthquake (6.5)



(Adapted from Algermissen T., Rogers A., 2004)

Liquefaction Potential Index

$$L_I = \int_0^{20} F(z)W(z)dz$$

(Iwasaki et. al., 1982)

$$W(z) = 0 \text{ for } z > 20\text{m} F(z) = 0 \text{ for } F_L \geq 1.2 \quad (3a)$$

$$W(z) = 0 \text{ for } z > 20\text{m} F(z) = 0 \text{ for } F_L \geq 1.2 F(z) = 2 \times 10^6 e^{-18.427 F_L} \text{ for } 1.2 > F_L > 0.95 \quad (3b)$$

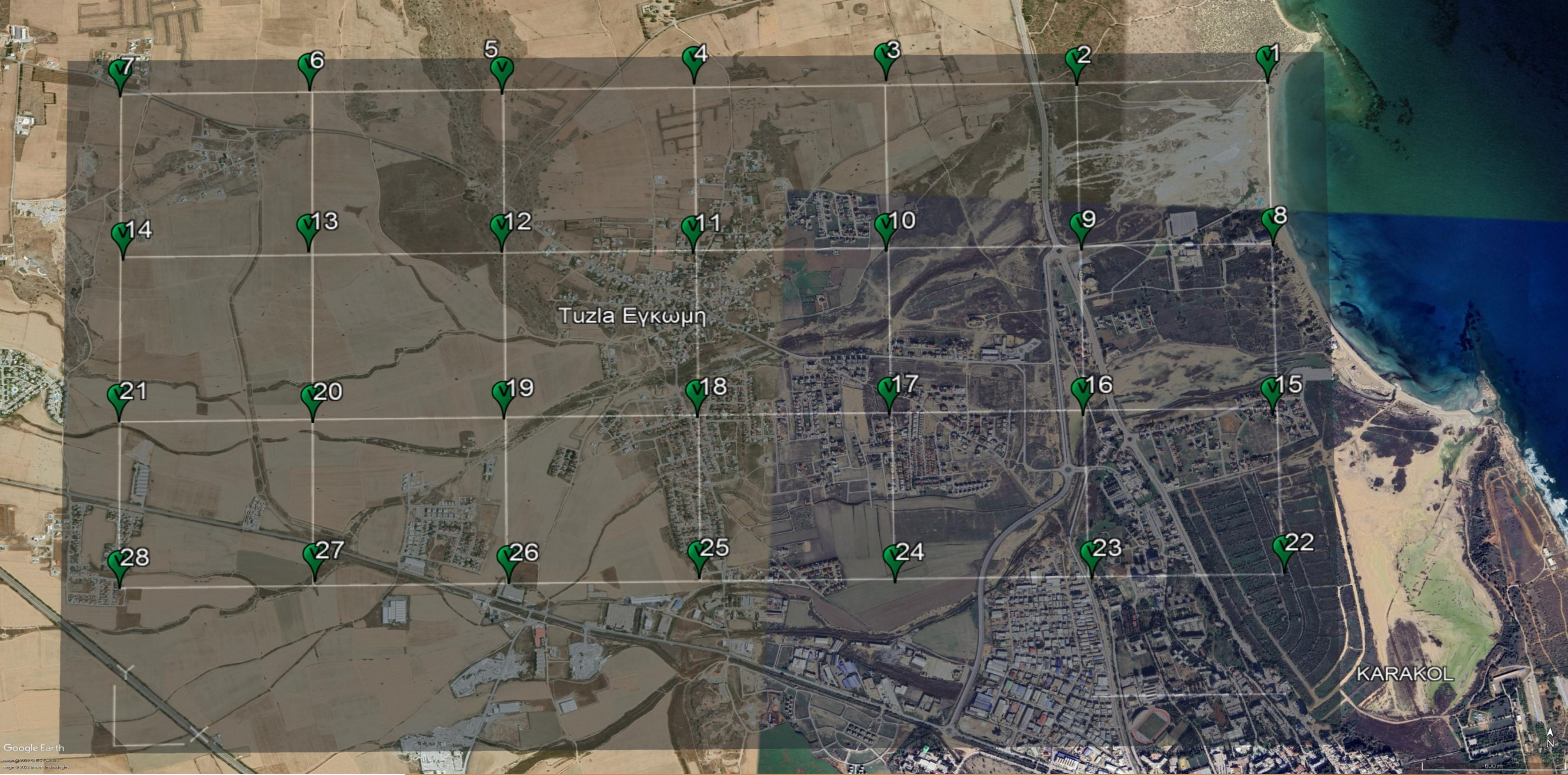
$$F(z) = 1 - F_L \text{ for } F_L < 0.95 \quad (3c)$$

(Sonmez, 2003)

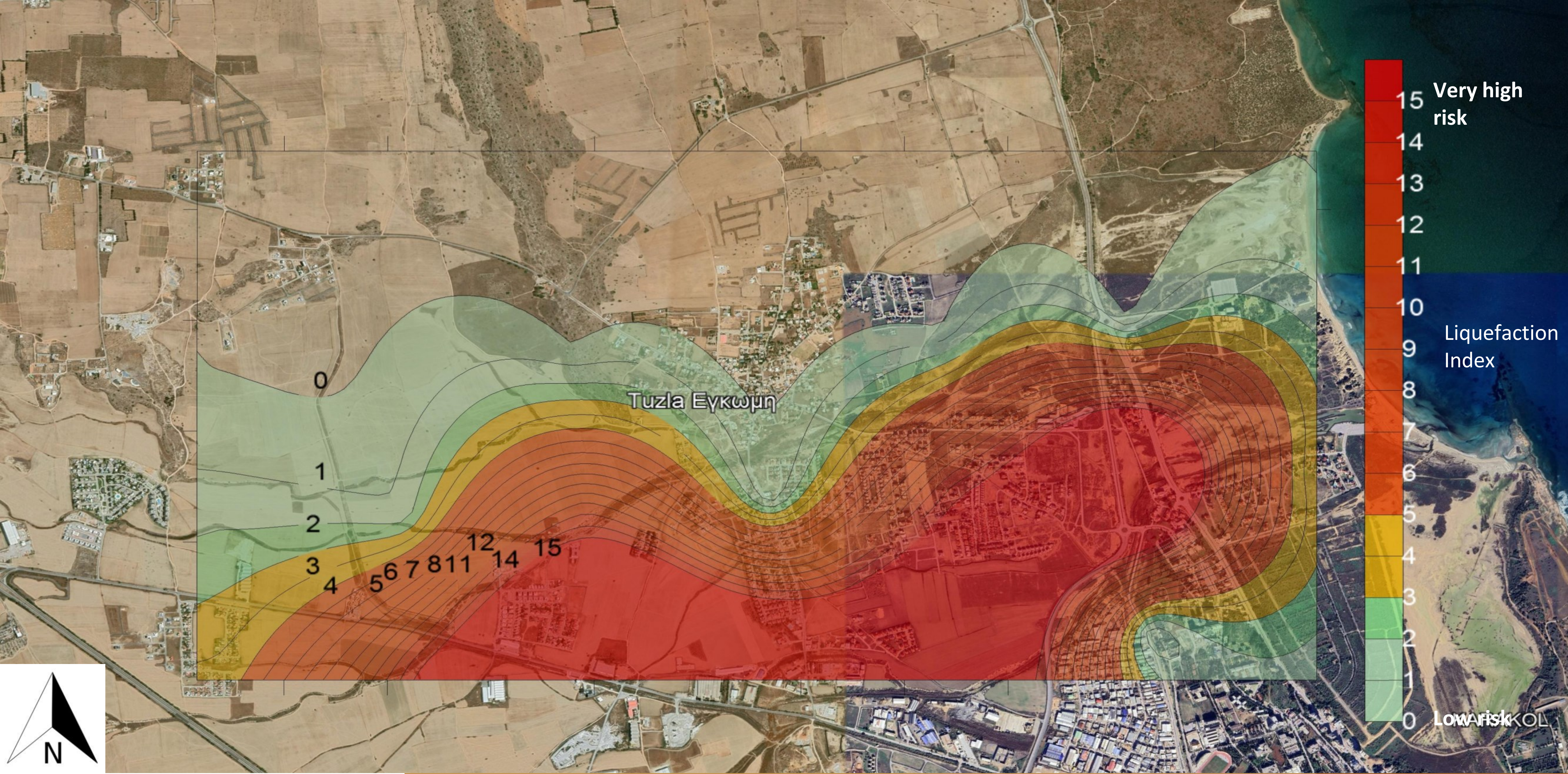
Liquefaction potential classification modified from the categories proposed by Iwasaki and others (1982)

Liquefaction index (L_I)	Liquefaction potential
0	Non-liquefied (based on $F_L \geq 1.2$)
$0 < L_I \leq 2$	Low
$2 < L_I \leq 5$	Moderate
$5 < L_I \leq 15$	High
$15 > L_I$	Very high

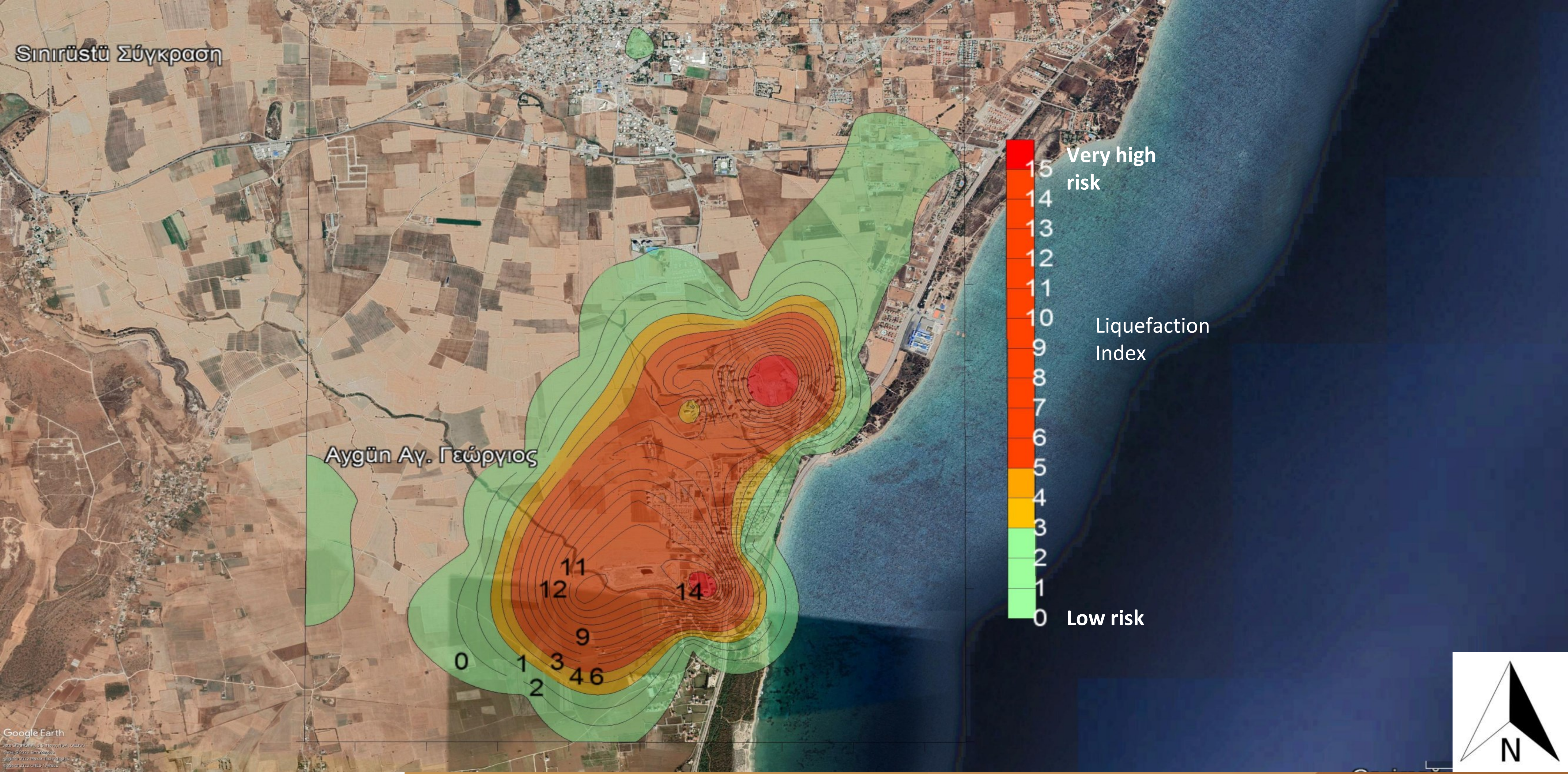
(Sonmez, 2003)



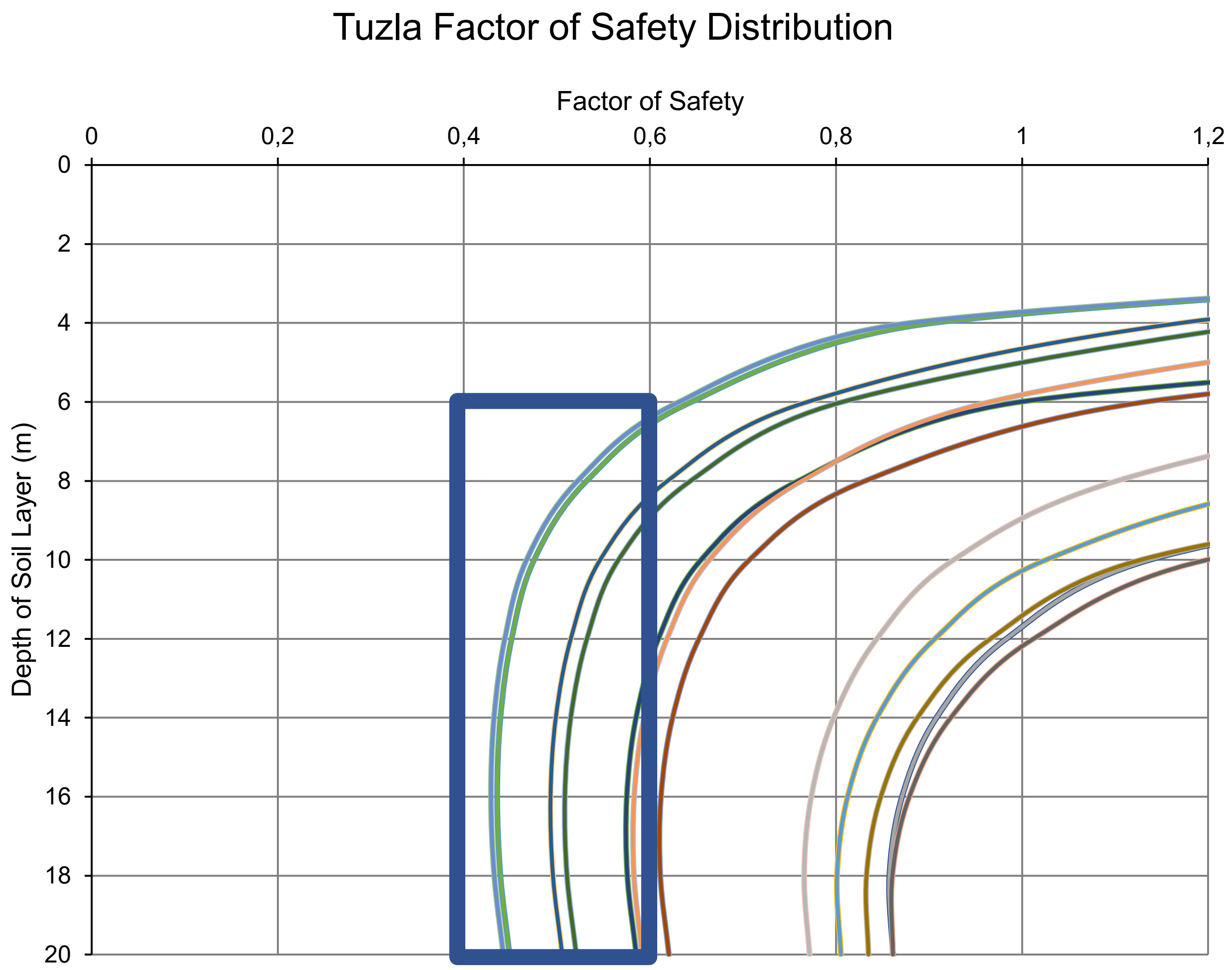
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
Tuzla Εγκωμη
KARAKOL
Google Earth

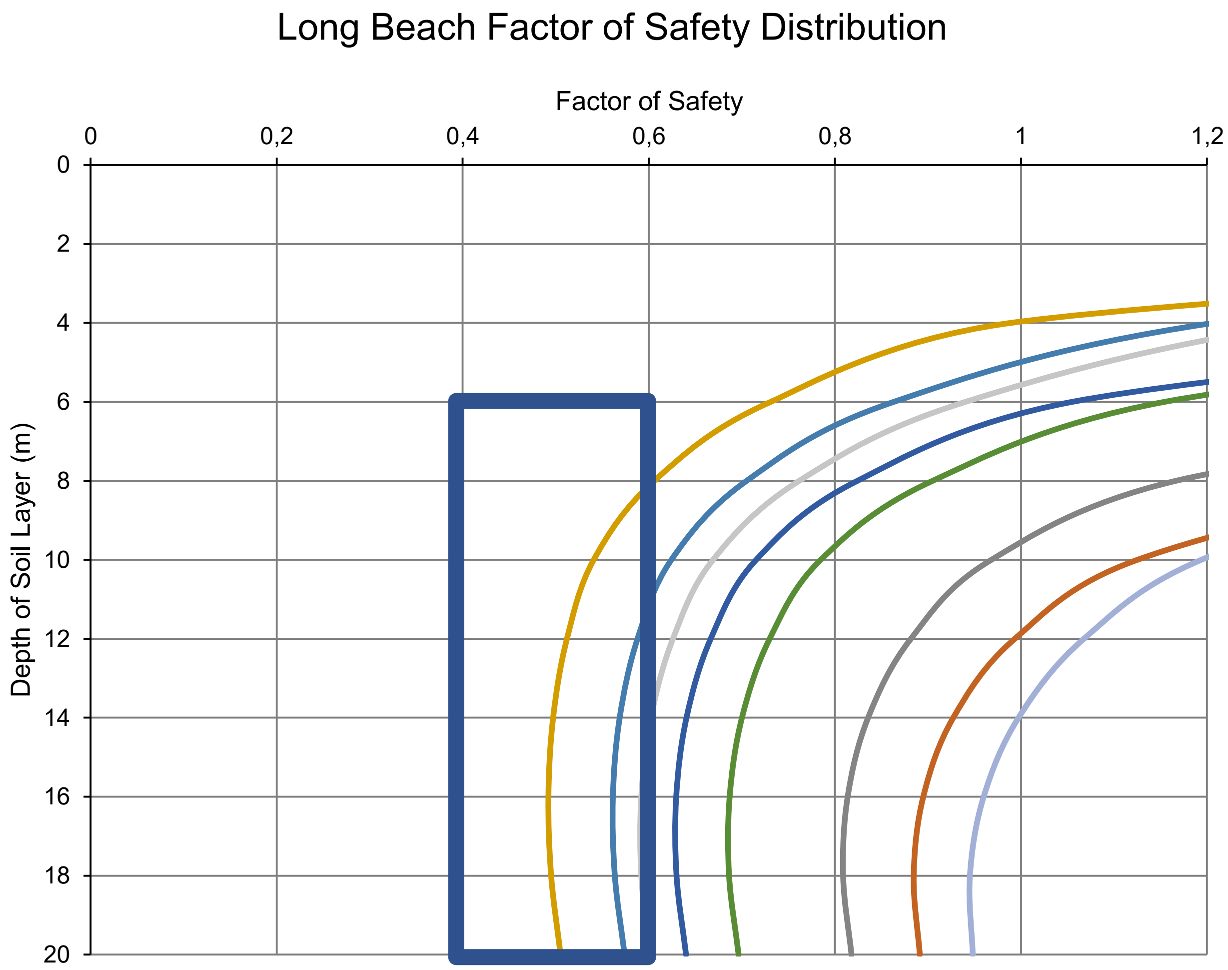

Very high risk
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Low risk
Liquefaction Index
Tuzla Εγκωμη
0
1
2
3
4
5
6
7
8
11
12
14
15
N


ü Σύγκραση
26
21
27
28
22
23
17
18
24
13
19
20
14
9
15
10
16
5
Aygün Αγ. Γεώργιος
11
12
6
7
1
2
8
3
4
Google Earth
900 m
N



Sınırüstü Σύγκραση
Aygün Αγ. Γεώργιος
11
12
14
9
0
1
3
2
4 6
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Very high risk
Liquefaction Index
Low risk
Google Earth
N


Tuzla Factor of Safety Distribution
Factor of Safety
0
0,2
0,4
0,6
0,8
1
1,2
Depth of Soil Layer (m)
0
2
4
6
8
10
12
14
16
18
20


Long Beach Factor of Safety Distribution
Factor of Safety
0
0,2
0,4
0,6
0,8
1
1,2
Depth of Soil Layer (m)
0
2
4
6
8
10
12
14
16
18
20

Conclusion

- It is clear that both Tuzla and Long Beach areas are susceptible to liquefaction.
- With respect to the Tuzla area, the results align well with earlier studies.
- The Remi testing method proposes a fast, cheap and, most importantly, non-destructive alternative to current well-established testing methods.
- Both regions' liquefaction potential is related to the catchment area that caries the deposit to both sites.

Future Plans

- Soil samples were collected from depth of half meter for all locations.
- These samples are going to be subjected laboratory experiments in METU NCC.
- Correlations between field results and laboratory results is going to be examined.

Thanks for their contributions

Civil Engineering Chamber of Northern Cyprus

Dr. Hilmi Dindar

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