



REMTECH EXPO

GEOSSIMICA

20 Settembre 2018

LIQUEFAZIONE E INSTABILITA' DINAMICA DEI TERRENI



ANALISI DEL RISCHIO DA LIQUEFAZIONE A SCALA URBANA: IL COMUNE DI TERRE DEL RENO

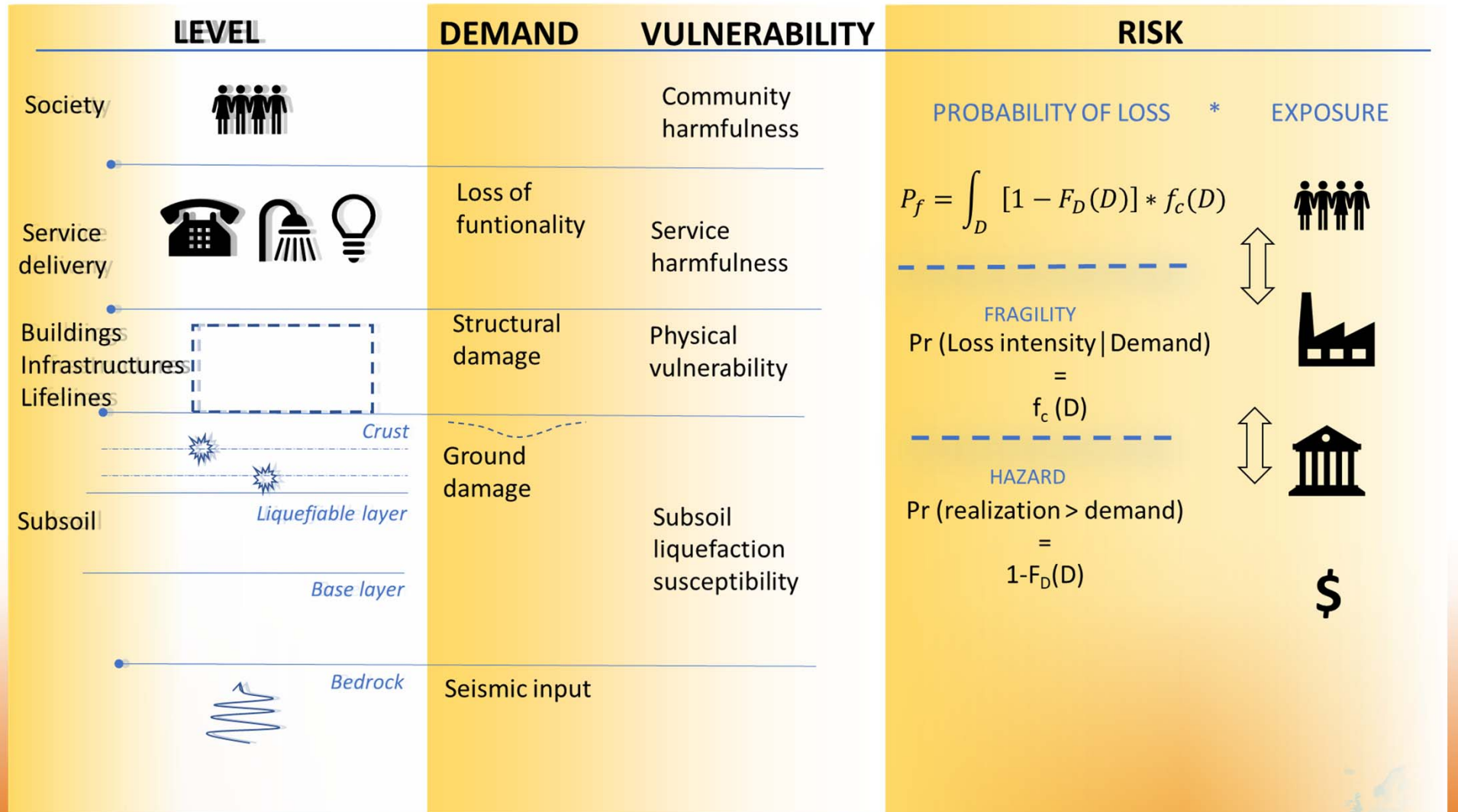
Giuseppe Modoni – Rose Line Spacagna – Luca Paoella – Erminio Salvatore



RemTech Expo 2018 (19, 20, 21 Settembre) FerraraFiere

www.remtechexpo.com

Risk = Probability of loss * Amount of loss



Sites prone to Liquefaction

- River meanders/point deposits
- Lake shore delta
- Estuarine
- Beach ridge backwater
- Abandoned river channels
- Former ponds, marshes, swamps
- Reclamation fills
- Tailing dams

New Zealand Geotechnical Society (2016)

Christchurch
New Zealand (2010-2011)



Mw 6.2
60 000 damaged buildings
1/3 of city infrastructures
out of service

Emilia Romagna
Italy (2012)



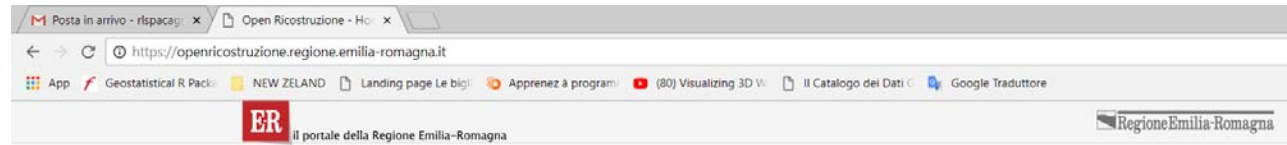
Mw 5.9
12 000 damaged buildings

Urayasu (Tokyo)
Japan (2011)



Mw 9.0
27.000 damaged
buildings
2 000 collapsed levees
Several destroyed
bridges





OPEN RICOSTRUZIONE

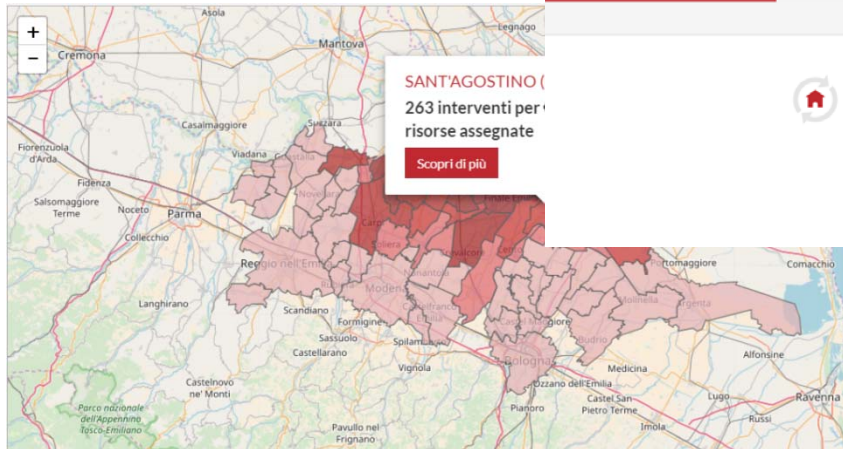
Monitora gli interventi per la ricostruzione in Emilia-Romagna

 Cerca

Inserisci il nome di un beneficiario, di una stazione appaltante, di un tecnico o di un'impresa, l'indirizzo di un intervento o il nome di un'opera pubblica.

HOME RICOSTRUZIONE PUBBLICA RICOSTRUZIONE DELLE ABITAZIONI RICOSTRUZIONE ATTIVITÀ PRODUTTIVE ALTRI INTERVENTI DOVE SI INTERVIENE

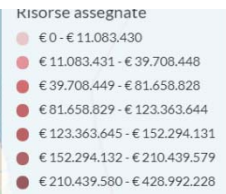
Ultimo aggiornamento: 30 giugno 2018



Segui tutti gli interventi e le donazioni per la ricostruzione in Emilia-Romagna: qui trovi i dati relativi alla ricostruzione pubblica, delle abitazioni, delle imprese e agli interventi provvisori. Puoi conoscere il numero degli interventi, i finanziamenti, lo stato di avanzamento lavori, chi sono i responsabili e quali imprese stanno lavorando.

Opere pubbliche: **€ 646.033.915,62** di risorse assegnate a 2.381 interventi

Interventi privati: **€ 4.472.287.140,76** di risorse assegnate a 13.250 interventi



Terre del Reno (2012)

	Sant'Agostino	Mirabello
Public	9.481.162	53.569
Private	81.658.828	39.708.448
Productive	123.608.822	34.872.851



Triggering conditions for liquefaction

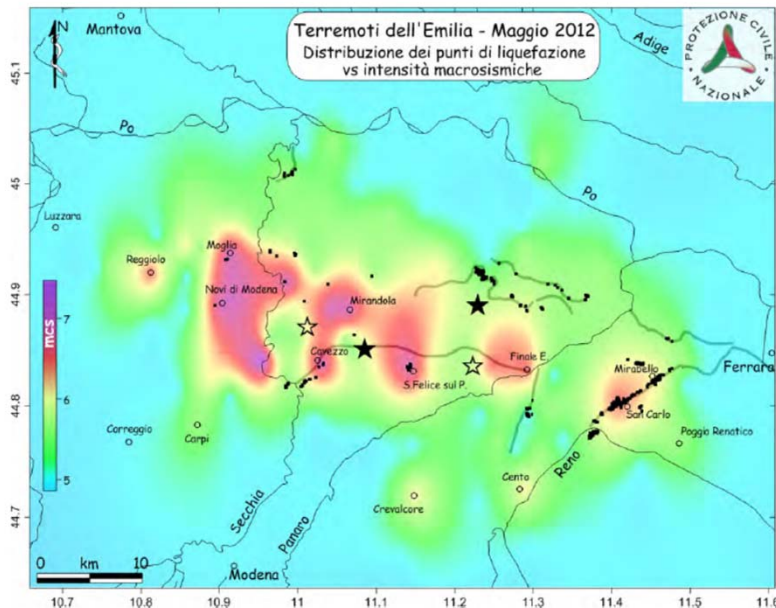
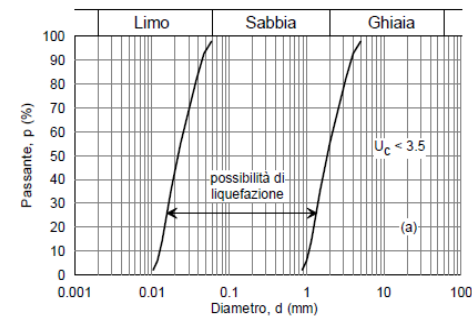


Fig. 16 – Distribuzione dei fenomeni di liquefazione osservati a seguito dei due mainshocks della sequenza del 2012 in confronto alla distribuzione dell'intensità macrosismica (stelle nere e vuote, epicentri strumentali e macrosismici, rispettivamente). E' evidente una scarsa correlazione tra i massimi di intensità e le liquefazioni che sembrano più che altro guidate dalla presenza di depositi altamente suscettibili di liquefazione relativi ai paleo alvei (linee grigie, da Castaldini e Raimondi, 1985), come nel caso di quello del Reno, verso Mirabello, e della Secchia, verso Cavezzo e San Felice sul Panaro o degli alvei abbandonati del Po nei casi più a nord.

7.11.3.4.2 Esclusione della verifica a liquefazione

La verifica a liquefazione può essere omessa quando si manifesti almeno una delle seguenti circostanze:

1. eventi sismici attesi di magnitudo M inferiore a 5;
2. accelerazioni massime attese al piano campagna in assenza di manufatti (condizioni di campo libero) minori di 0,1g;
3. profondità media stagionale della falda superiore a 15 m dal piano campagna, per piano campagna sub-orizzontale e strutture con fondazioni superficiali;
4. depositi costituiti da sabbie pulite con resistenza penetrometrica normalizzata $(N_1)_{60} > 30$ oppure $q_{c1N} > 180$ dove $(N_1)_{60}$ è il valore della resistenza determinata in prove penetrometriche dinamiche (Standard Penetration Test) normalizzata ad una tensione efficace verticale di 100 kPa e q_{c1N} è il valore della resistenza determinata in prove penetrometriche statiche (Cone Penetration Test) normalizzata ad una tensione efficace verticale di 100 kPa;
5. distribuzione granulometrica esterna alle zone indicate nella Figura 7.11.1(a) nel caso di terreni con coefficiente di uniformità $U_c < 3,5$ ed in Figura 7.11.1(b) nel caso di terreni con coefficiente di uniformità $U_c > 3,5$.



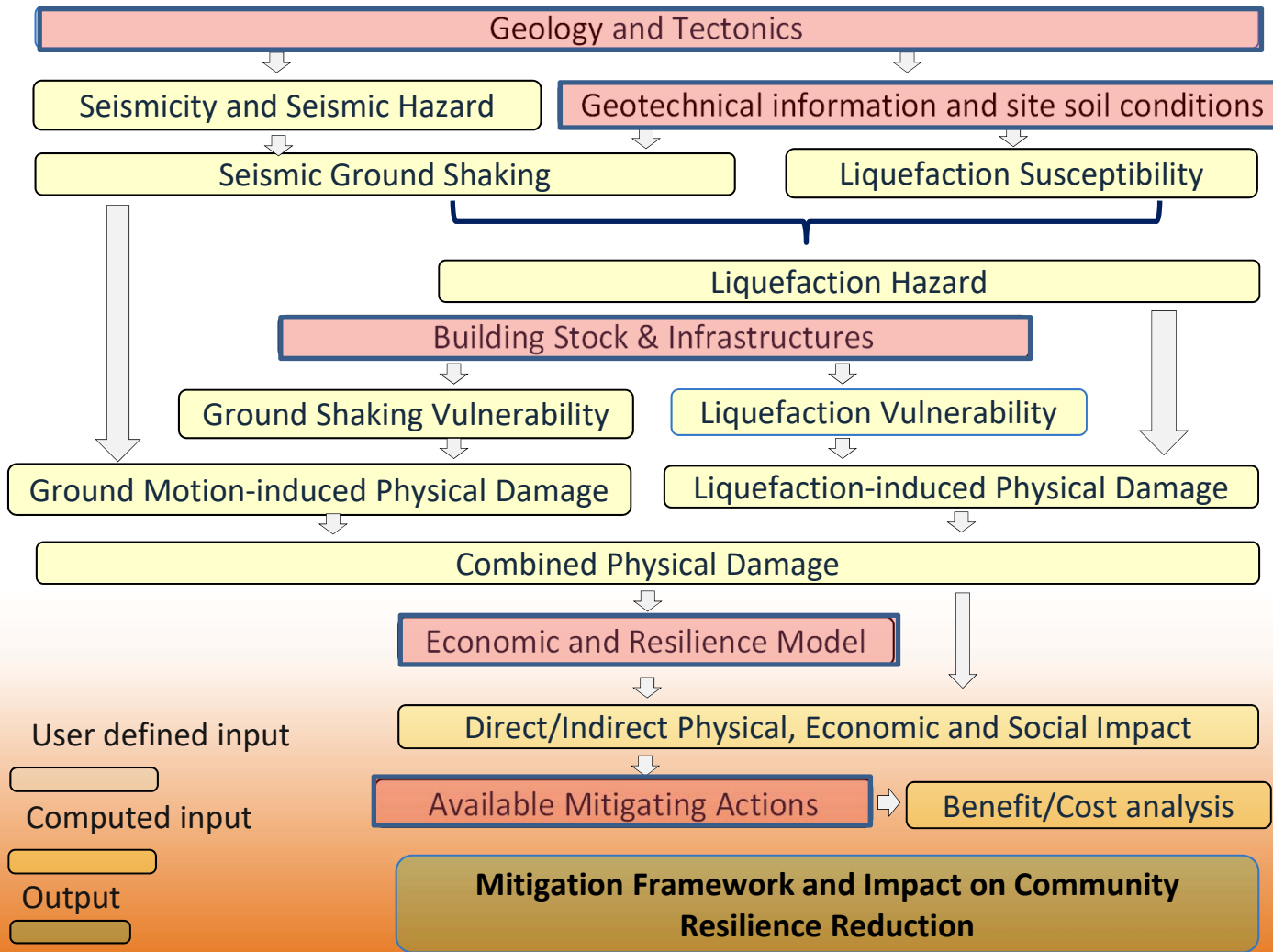
Galli and Peronace (2012)

(NTC 2008)

- High seismicity ($M_w > 5 - a_g > 0.1g$)
- Soil characteristics
- Water bearing strata ($H_w < 15$ m)



Liquefaction Reference Guide



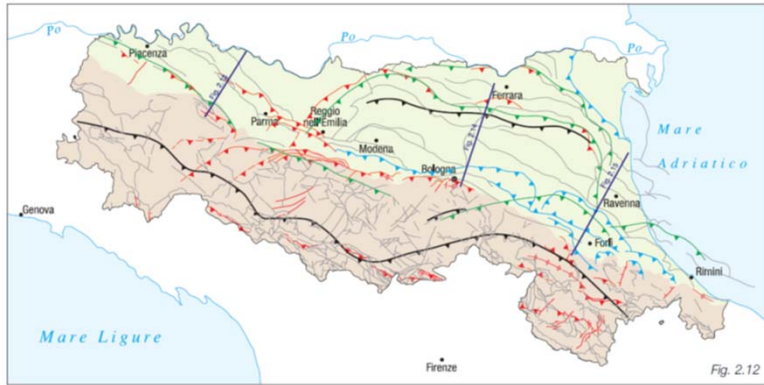
HAZARD ASSESSMENT

RISK ASSESSMENT

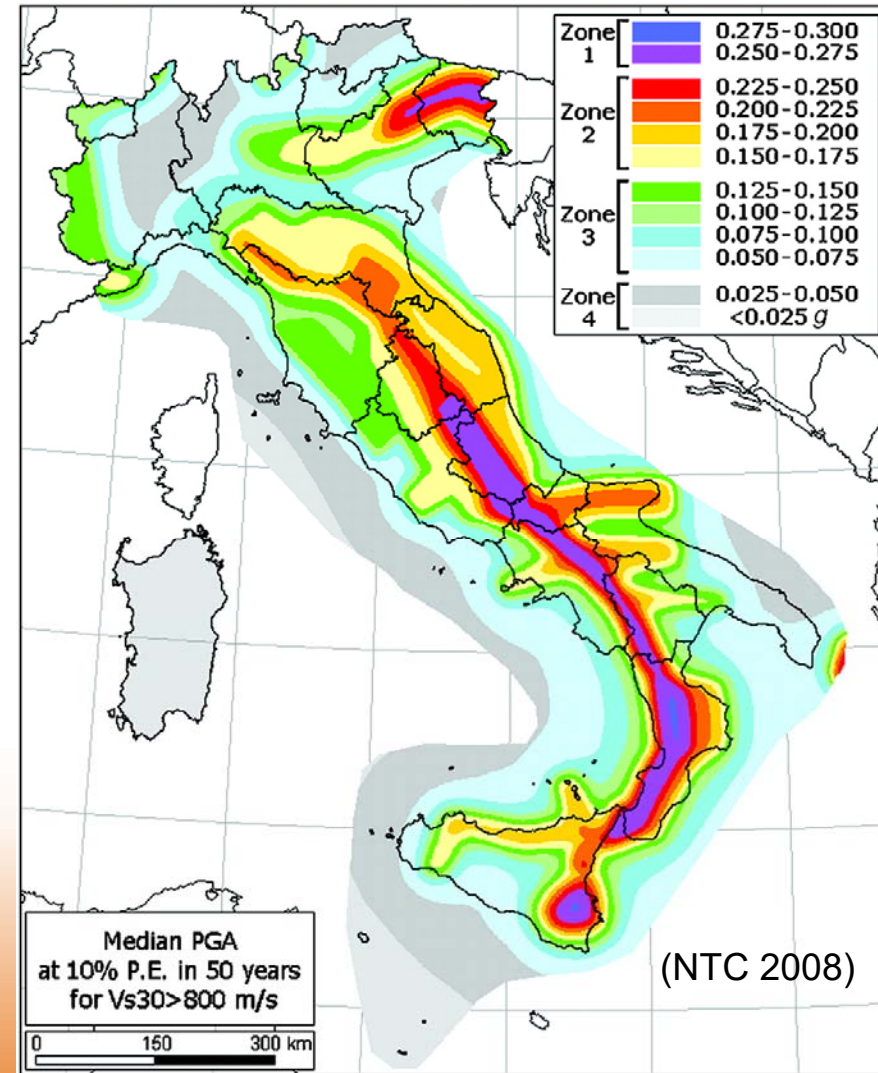
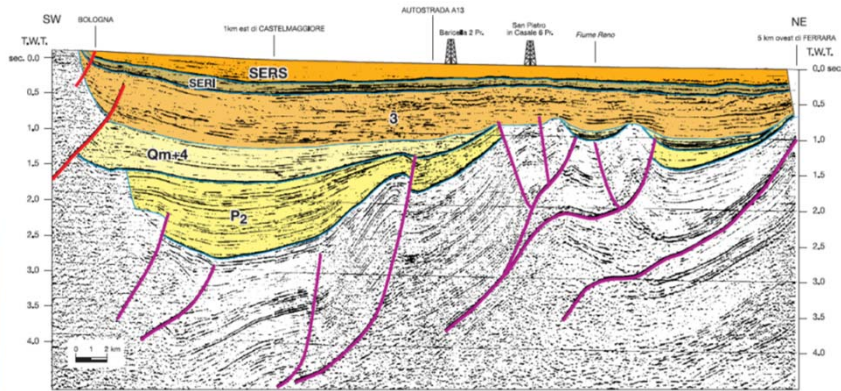
RISK ASSESSMENT AND MITIGATION FRAMEWORK

- User defined input
- Computed input
- Output

Terre del Reno: geology and tectonics



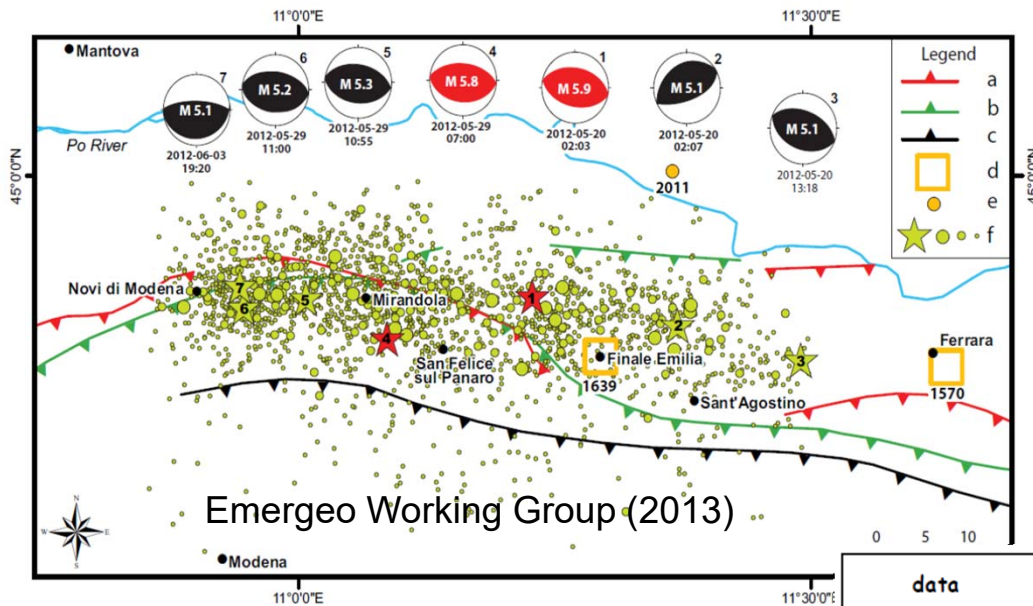
Sovrascandimenti attivi superficiali
 Faglie attive con cinematica indeterminate
 Sovrascandimenti attivi nel basamento
 Faglie estensionali superficiali attive
 Antidive attive
 Sovrascandimenti del Pliocene-Quaternario, riattivati
 Faglie trascorrenti attive
 Sovrascandimenti attivi nella successione carbonatica
 Principali strutture neogeniche senza evidenze di attività recente



Carta sismotettonica della Pianura Padana (modified from RER & ENI - Agip, 1998)



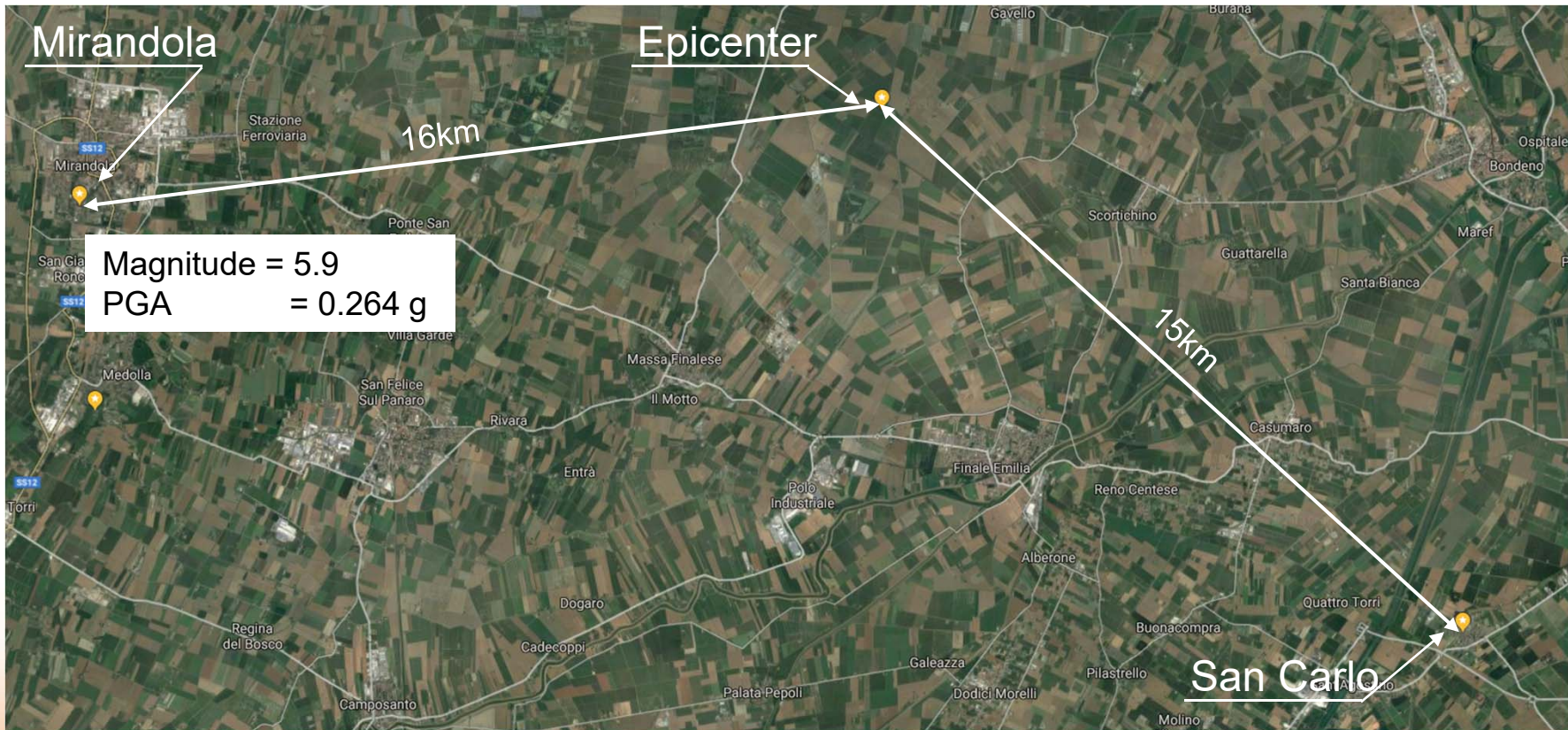
Terre del Reno: seismicity and ground shaking



data	ora GMT	Latitudine	Longitudine	Profondità	MI CNT	Mw RCMT	Io
20/05/2012	02.03.52.0	44.889	11.228	6.3	5.9	6.11	VII
20/05/2012	02.06.30.0	44.886	11.189	7.7	4.8	-	-
20/05/2012	02.07.31.0	44.863	11.37	5	5.1	-	-
20/05/2012	03.02.50.0	44.86	11.095	10	4.9	5.05	-
20/05/2012	13:18:02.0	44.831	11.49	4.7	5.1	5.18	-
20/05/2012	17:37:14.0	44.876	11.382	3.2	4.5	4.52	-
29/05/2012	07.00.03.0	44.851	11.086	10.2	5.8	5.96	VII
29/05/2012	08:25:51.0	44.901	10.943	3.2	4.5	4.69	-
29/05/2012	08:27:23.0	44.854	11.106	10	4.7	-	-
29/05/2012	10:55:57.0	44.888	11.008	6.8	5.3	5.53	-
29/05/2012	11:00:02.0	44.873	10.95	11	4.9	-	-
29/05/2012	11:00:25.0	44.879	10.947	5.4	5.2	-	-
03/06/2012	19:20:43.0	44.899	10.943	9.2	5.1	4.89	-

Terre del Reno: seismicity and ground shaking

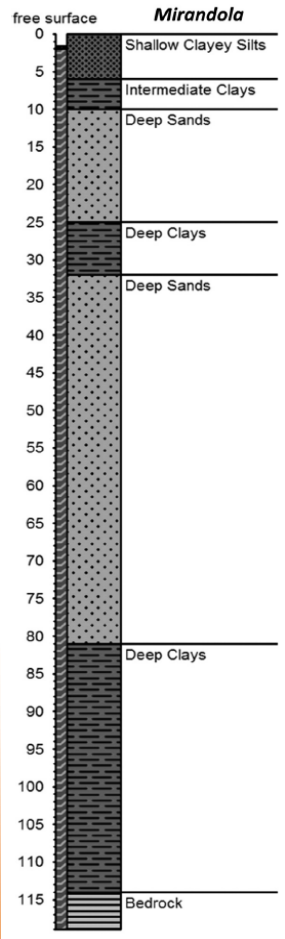
20th of May 2012 Earthquake



Satellite image of the area of interest (Google Earth)

Terre del Reno: seismicity and ground shaking

Soil profile and Materials' properties in Mirandola (Sinatra and Foti, 2015)



L. Sinatra, S. Foti / Soil Dynamics and Earthquake Engineering 75 (2015) 234–245

Table 1
Model parameters for Mirandola site.

Site: Mirandola

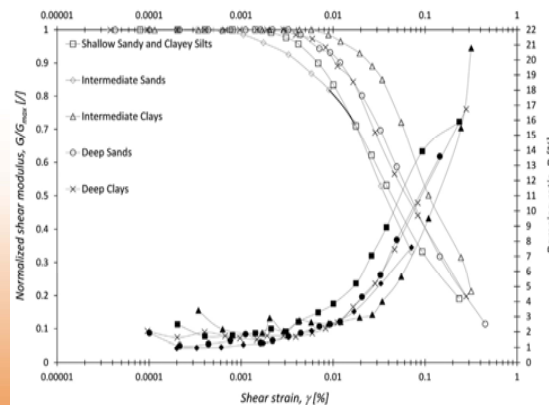
Unit	Depth [m]	γ [kN/m ³]	V_s [m/s]
Shallow clayey silts	0–6	18	175
Intermediate clays	6–10	18.5	200
Deep sands	10–14	19.5	225
Deep sands	14–25	20	250
Deep clays	25–32	20	300
Deep sands	32–36	20	300
Deep clays	36–68	20	350
Deep clays	68–81	20	450
Deep clays	81–114	21	500

Table 2
Model parameters for San Carlo site.

Site: San Carlo

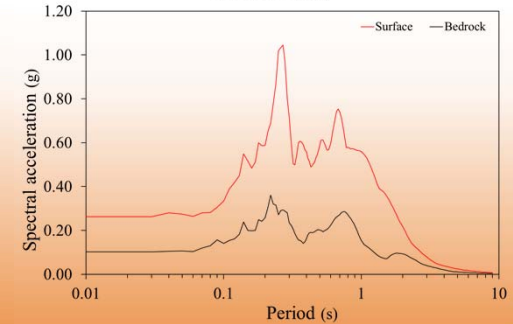
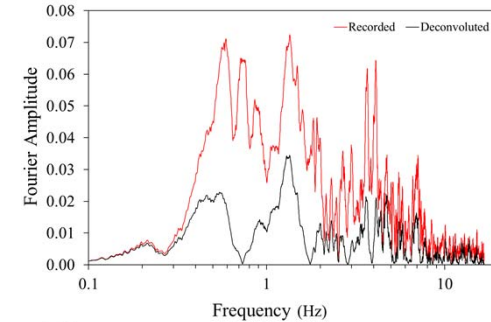
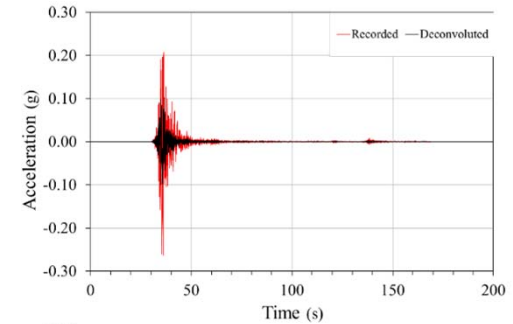
Unit	Depth [m]	γ [kN/m ³]	V_s [m/s]	ν_r	n	K_0	ϕ	S_w	γ_f	ψ	c_1	c_2	d_1	d_2	l_1	l_2	k	NYS
Shallow sandy silts	0–4	16.5	125	19	0.1	0.35	37	–	11.87	–	–	–	–	–	–	–	–	20
Shallow clayey silts	4–8	17	150	–	–	–	33.45	8.903	–	–	–	–	–	–	–	–	–	–
Intermediate sands	8–12	18.5	175	56	–	–	0.41	33	28.79	29	0.5	0.2	0.1	10	0.0125	2E-06	–	–
Intermediate clays	12–17	18	150	–	–	–	0.56	45.55	3.667	–	–	–	–	–	–	–	–	–
Deep sands	17–22	18.5	175	–	–	–	0.56	50.85	6.376	–	–	–	–	–	–	–	–	–
Deep sands	22–25	19	250	119	–	–	0.36	36	2.938	–	–	–	–	–	–	–	–	–
Deep clays	25–32	19.5	250	–	–	–	0.5	100	6.376	–	–	–	–	–	–	–	–	–
Deep sands	32–36	20	300	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Deep clays	36–68	350	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Deep clays	68–81	450	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Deep clays	81–114	21	500	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Parameters not requested in analyses performed for the present work



20th of May 2012 Earthquake

Equivalent-linear Earthquake site Response Analy

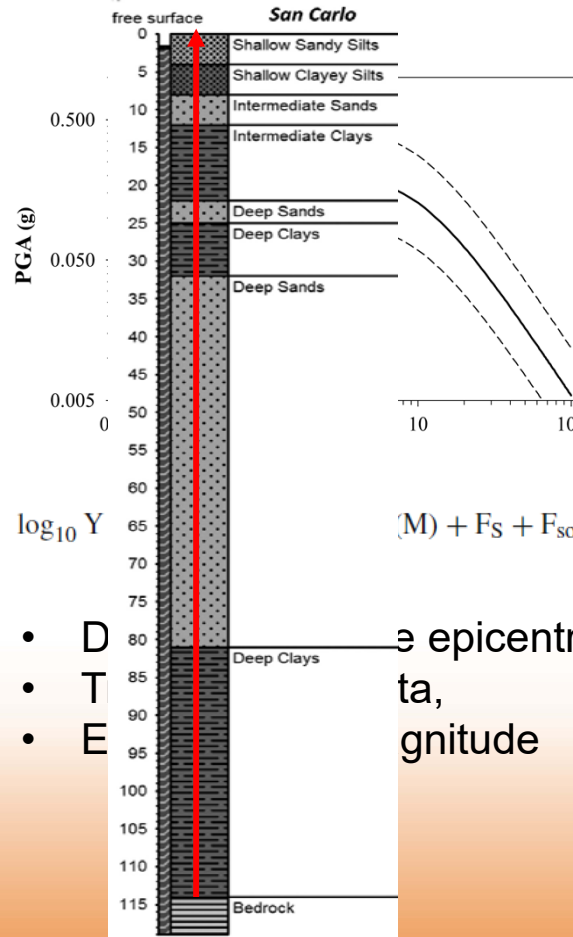


Terre del Reno: seismicity and ground shaking

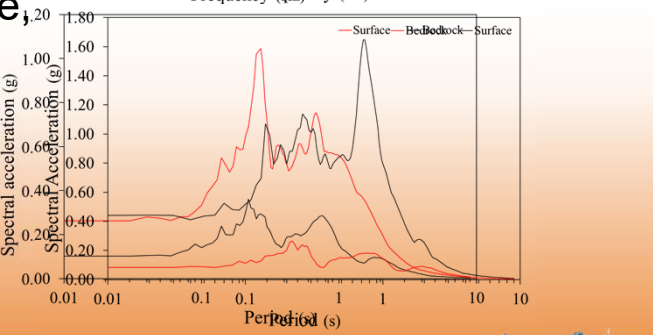
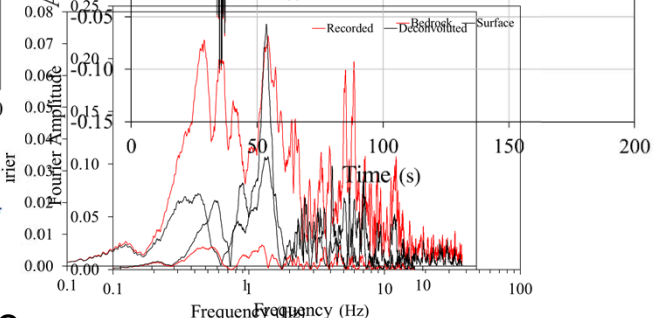
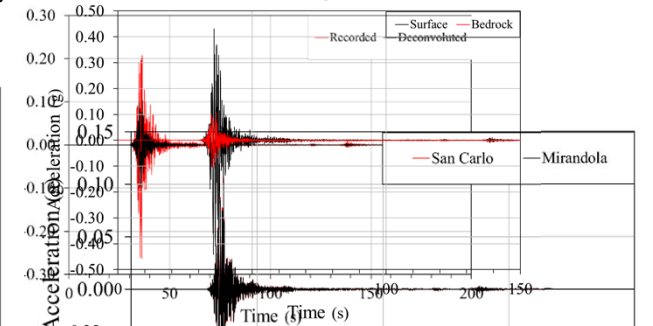
Mirandola – deconvoluted to bedrock

Attenuation law (Bindi et al., 2011) Equivalent-line San Carlo site Response Analysis

20th of May 2012 Earthquake

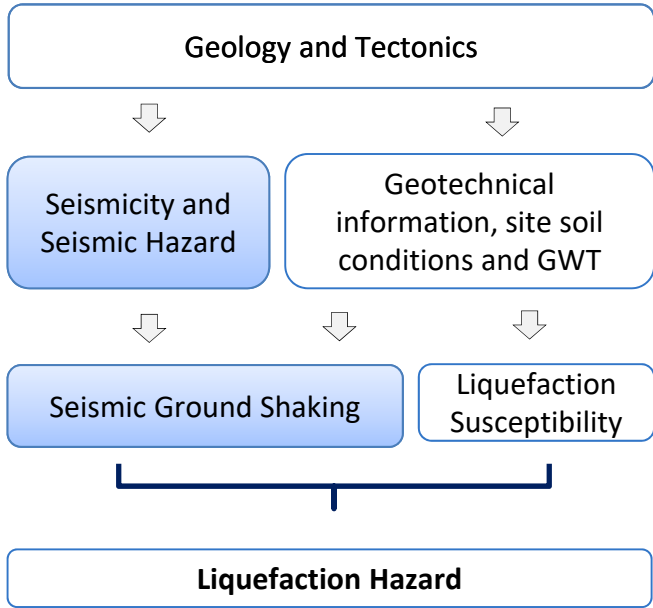


- D
 - T
 - E
- epicentre, ta, gnitude



Terre del Reno: seismicity and ground shaking

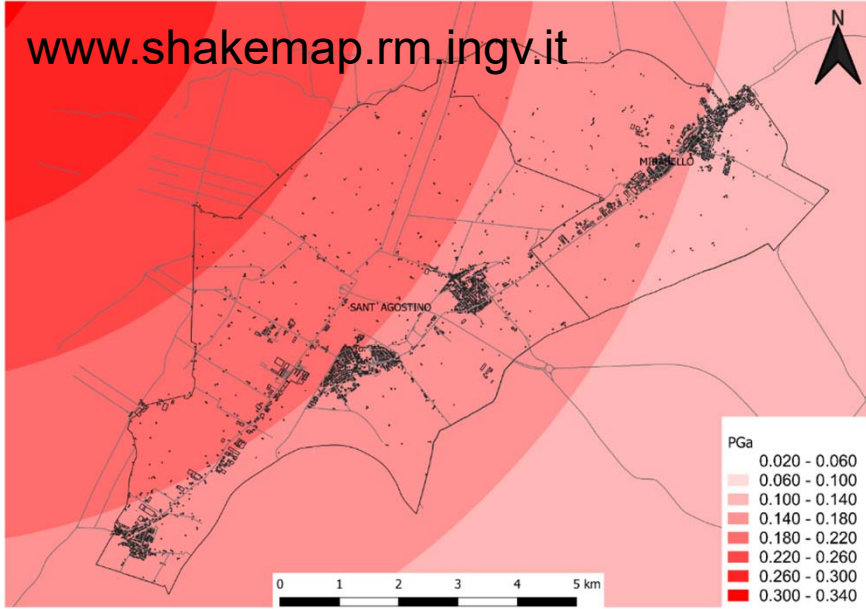
Selena-LRG Flow Chart



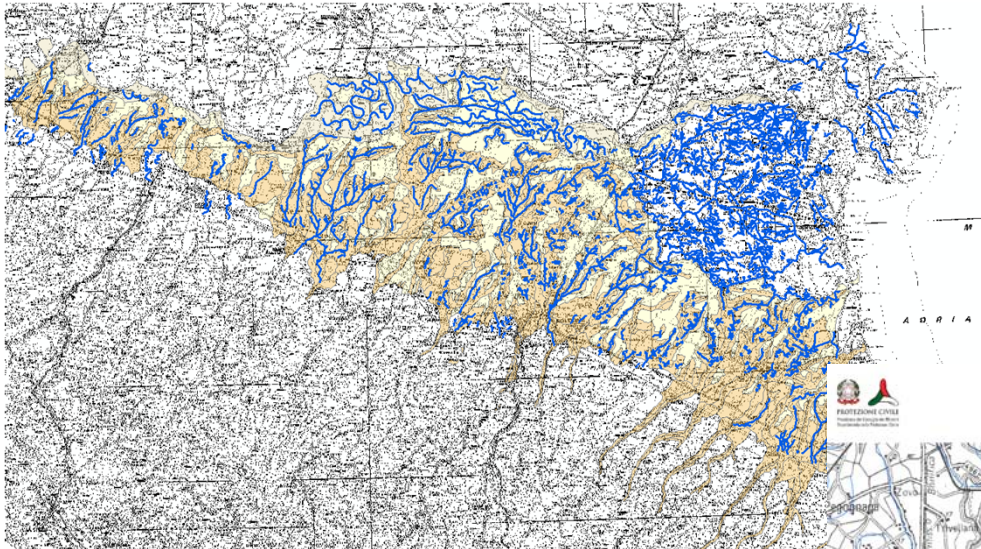
Fattori di amplificazione

- FA_{PGA} = 1.5; FH_{0.1-0.35} = 1.8; FH_{0.3-1.05} = 2.5 (abachi DAL 112/2007)
- FA_{PGA} = 1.7; FH_{0.1-0.35} = 1.9; FH_{0.3-1.05} = 2.6 (abachi DAL 112/2007)

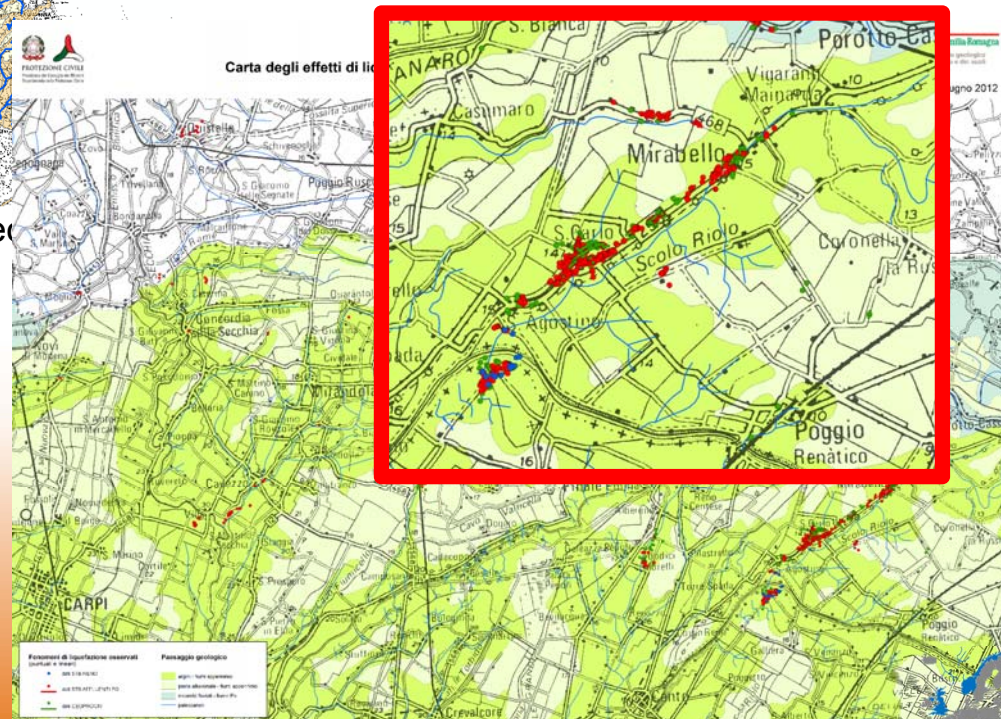
0.18 < PGa < 0.36



Terre del Reno: geology

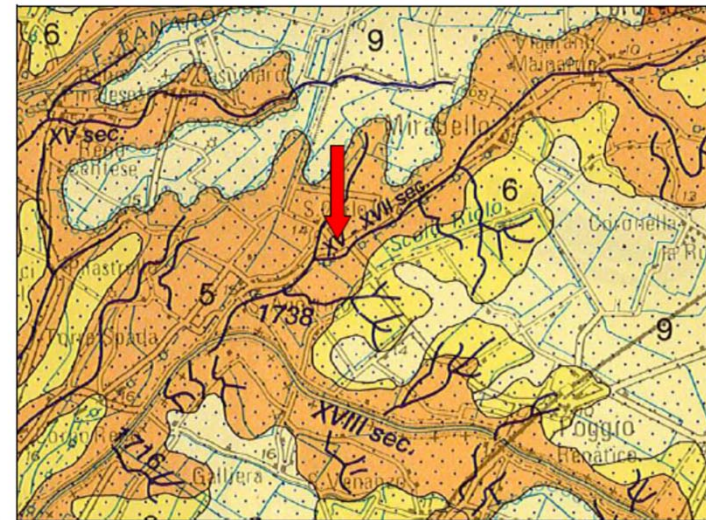
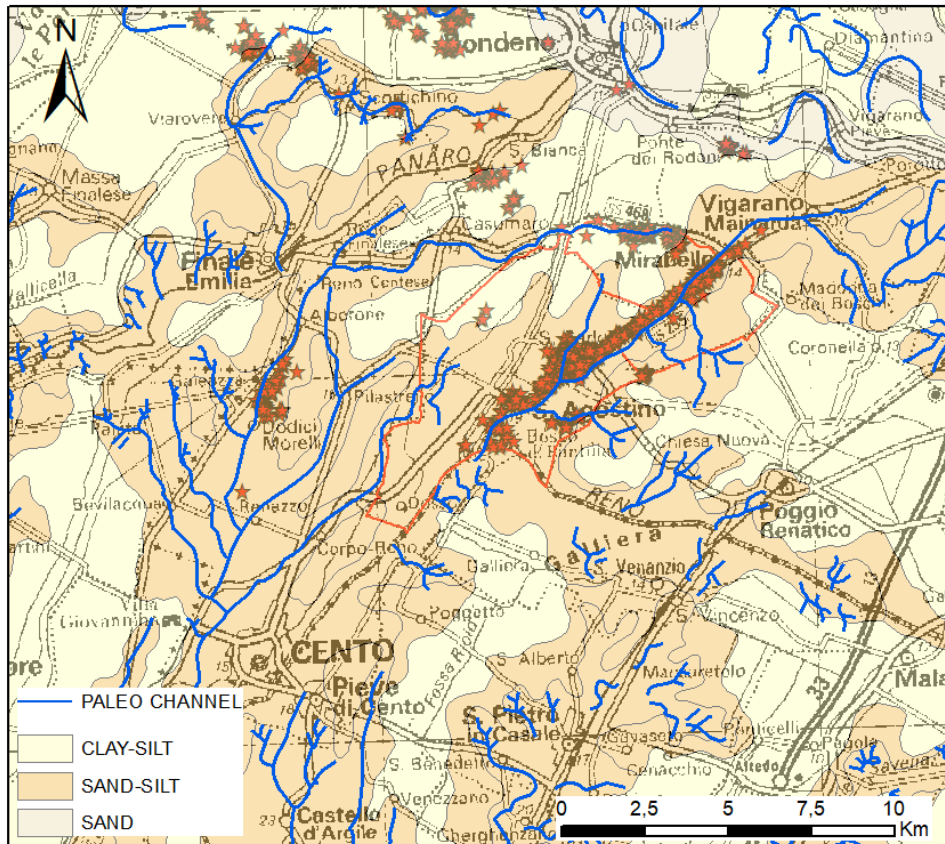


Geological map of the Pianura Emiliana with paleochannels (from SSGI - RER)



SGSS RER (2012)

Terre del Reno: geology

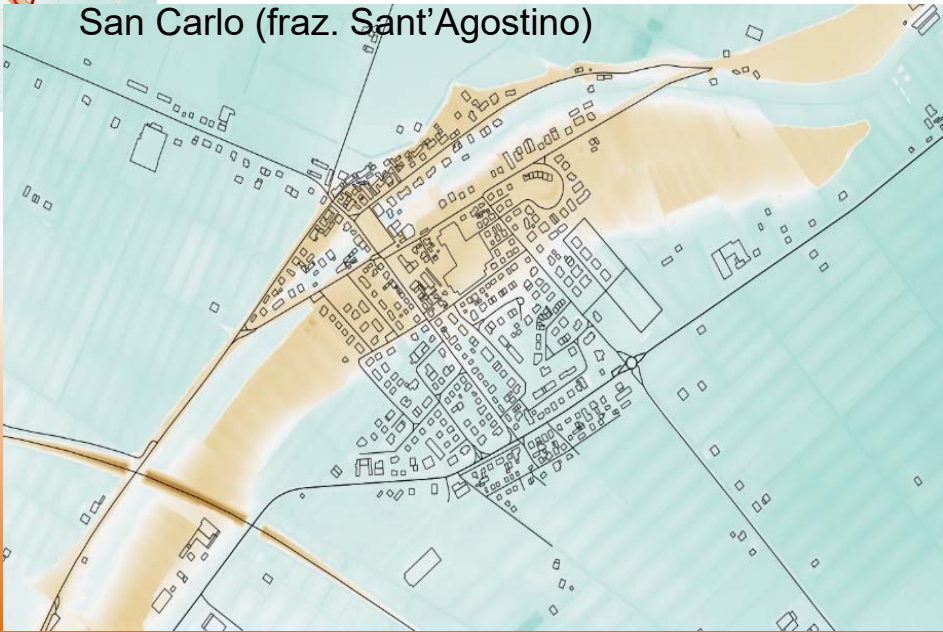
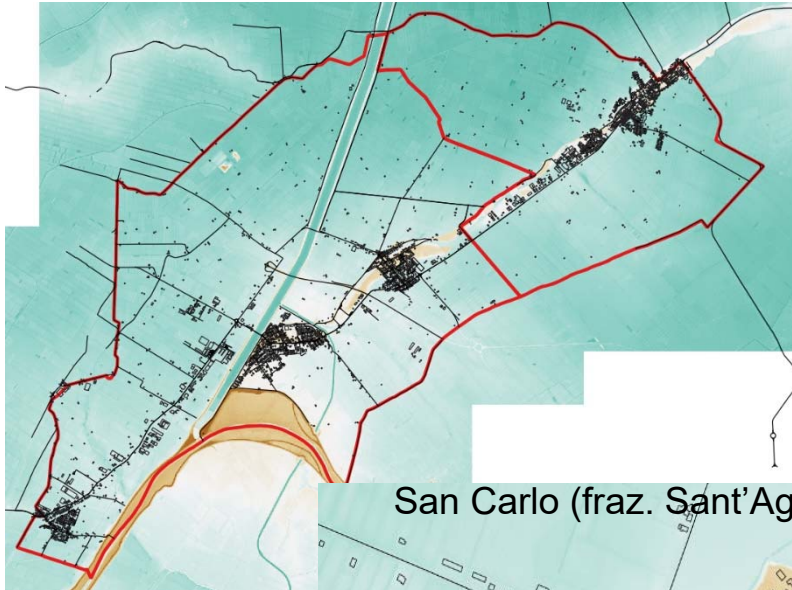


Legenda:

PIANA ALLUVIONALE ALLUVIAL PLAIN	
5	Sabbie medie e fini in strati di spessore decimetrico posanti intesamente ed intercalate a sabbie fini e fessime limose, subordinatamente limi argillosi, localmente sabbie medio e grossolane in corpi lenticolari e nastiformi. Depositi di canale o argine postalluviale. Al letto suoli a diverso grado di evoluzione. Medium and fine sand in beds tens of centimeters thick, changing laterally and/or intercalated in fine and very fine silty sand, smaller amount of clayey silt, locally medium and coarse sand in lenticular ribbon shaped bodies. Channel and gravelly levee. At the top, soils with various degree of evolution.
6	Limie sabbicose, sabbie fini e fessime, argille limose e subordinatamente sabbie limose-argillose intercalate in strati di spessore decimetrico. Depositi di argine distale. Al letto suoli a diverso grado di evoluzione. Sandy silt, fine and very fine sand, silty clay and smaller amounts of silty clayey sand intercalated in beds tens of centimeters thick. Distal levee deposits. At the top, soils with various degree of evolution.
7	Sabbie medie e fini, limi e argille limose intercalati in strati di spessore decimetrico, localmente sabbie medio e grossolane in corpi lenticolari e nastiformi. Depositi di canale e argine indifferenziati. Al letto suoli a diverso grado di evoluzione. Medium and fine sand, silt and silty clay intercalated in beds tens of centimeters thick, locally medium and coarse sand in lenticular and ribbon shaped bodies. Channel and undifferentiated levee deposits. At the top, soils with various degree of evolution.

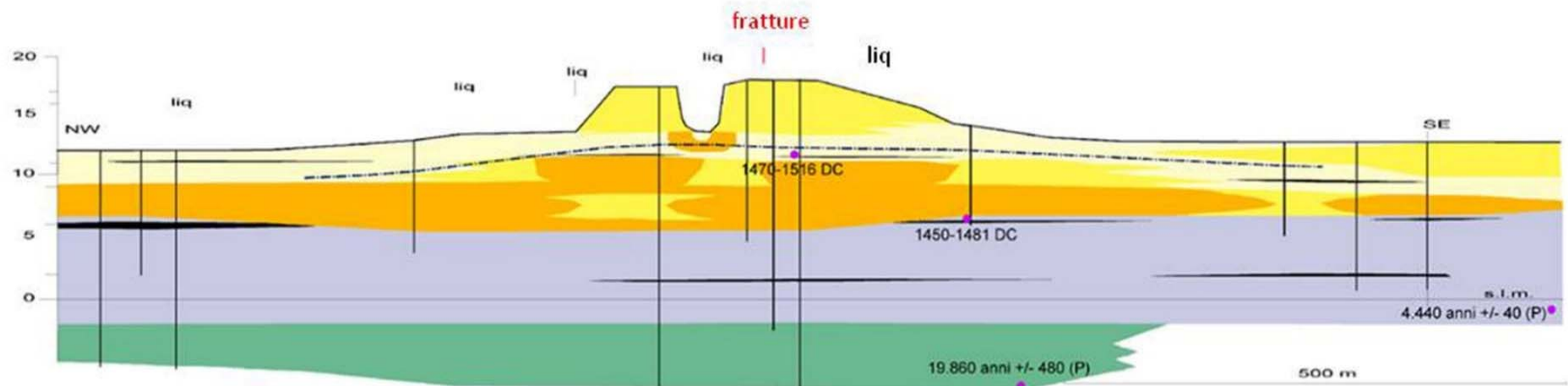


Terre del Reno: geology



Terre del Reno: geology

- sabbie di canale fluviale e rotta
- sabbie e limi di argine prossimale
- limi, argille e sabbie di argine distale e piana inondabile
- argille limose di "valle"
- torbe
- sabbie di canale fluviale (Pleistocene)
- livello falda (23 luglio 2012)
- datazione c14 (P = proiettato)

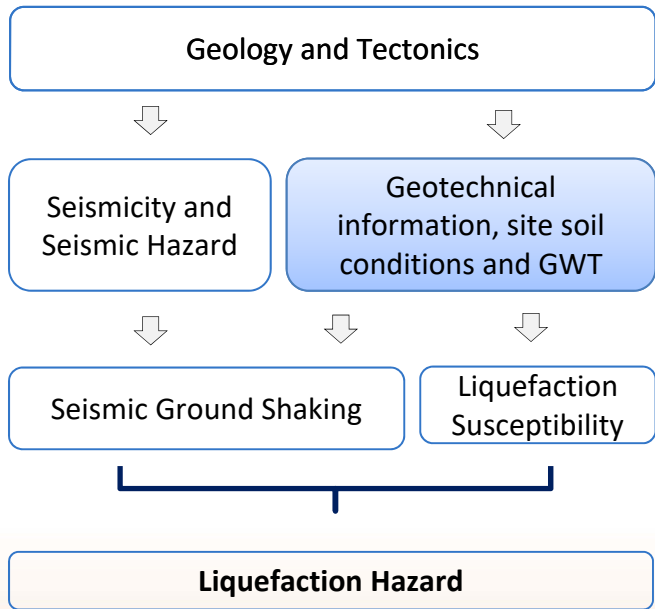


Sezione 1

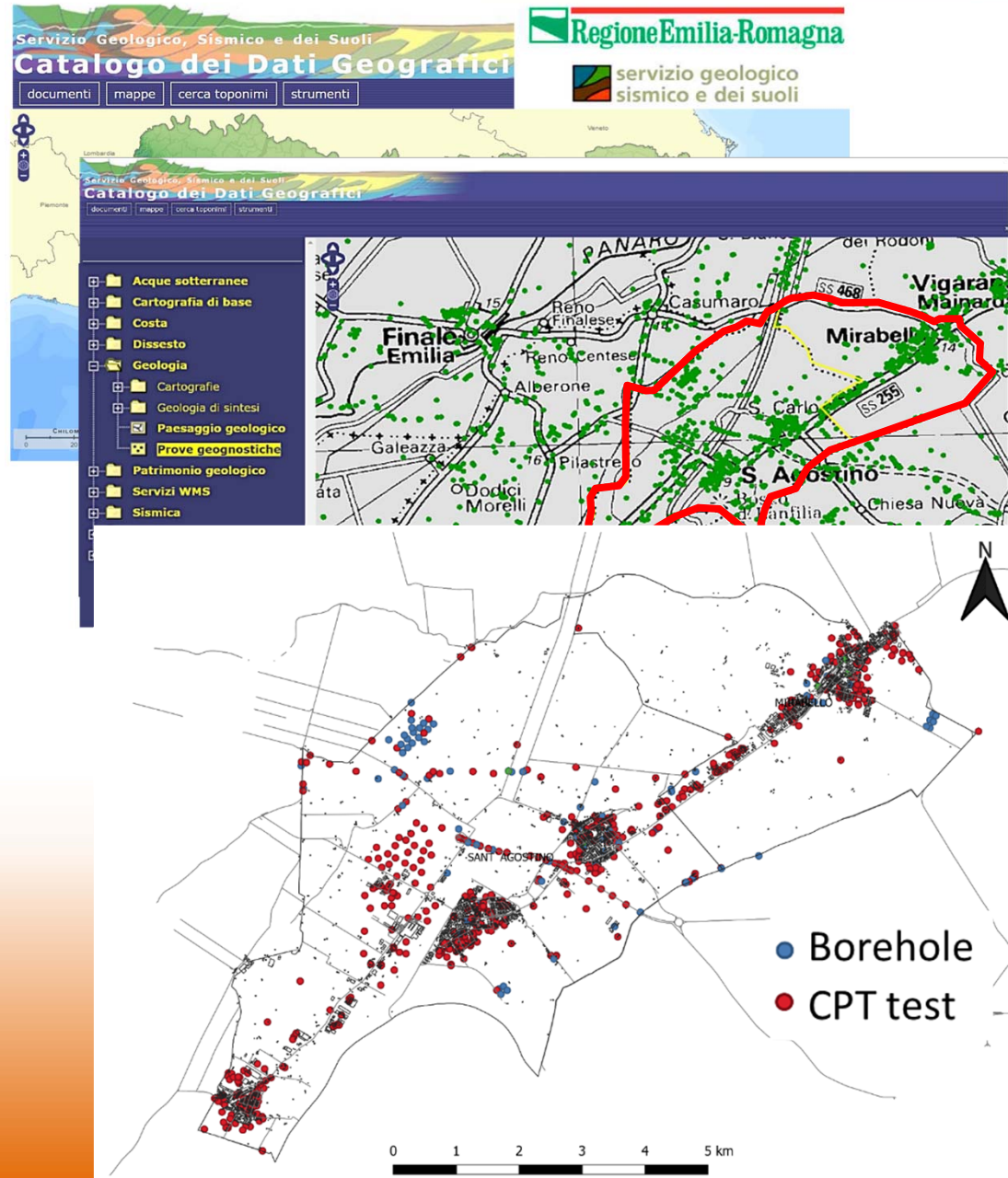
Calabrese, Martelli e Severi (2012)

Terre del Reno: geotechnical characterisation

Selena-LRG Flow Chart

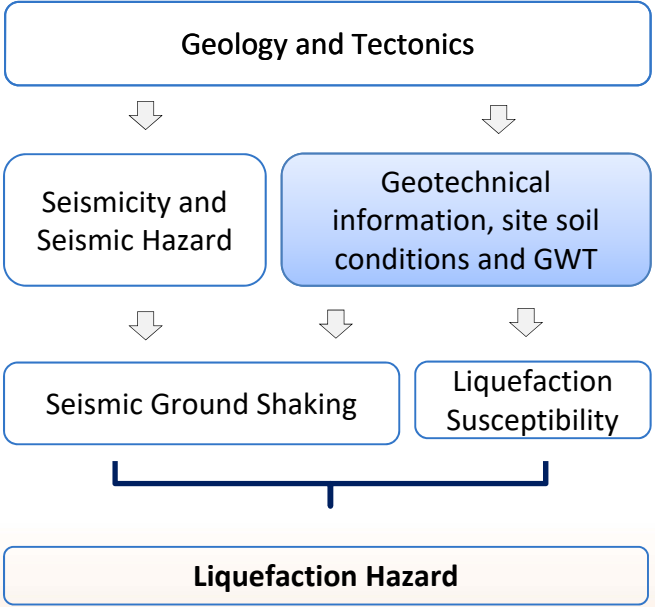


863 in situ tests
(CPT/CPTu, Borehole, Cross hole, Down hole, wells, ...)



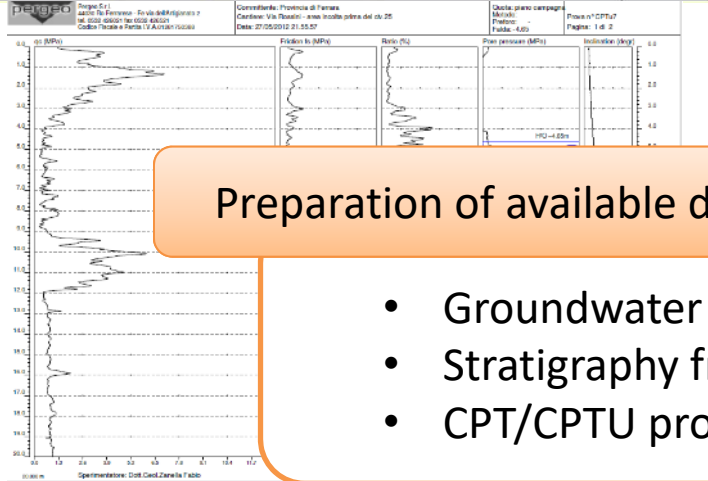
Terre del Reno: geotechnical characterisation

Selena-LRG Flow Chart



Servizio Geologico, Sismico e dei Suoli
Catalogo dei Dati Geografici

documenti mappe cerca toponimi strumenti



Regione Emilia-Romagna

servizio geologico sismico e dei suoli

DEMETRA S.R.L. 203010C158B
 VIA SERRA, 151, 46100 GUALFERRATO (PR) RIV. 26/12

PROVA PENETROMETRICA STATICA
LETTURE DI CAMPAGNA / VALORI DI RESISTENZA **CPT 1**

Prof. m	Letture di campagna	qc	fs	qs	p	Letture di campagna	qc	fs	qs	p	Letture di campagna	qc	fs	qs	p
	kg/cm²				kg/cm²	m	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²
0.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
1.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
2.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
3.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
4.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
5.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
6.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
7.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
8.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
9.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
10.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
11.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
12.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
13.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
14.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
15.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
16.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
17.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
18.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
19.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
20.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
21.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
22.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
23.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
24.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
25.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
26.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
27.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
28.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
29.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00
30.00	8.00	0.00	4.00	8.00	0.00	17.00	0.00	0.00	17.00	0.00	17.00	0.00	0.00	17.00	0.00

Preparation of available data

- Groundwater table
- Stratigraphy from boreholes
- CPT/CPTU profiles

Prof. m	Stratigrafia	Descrizione	Componenti	Componenti (%)	Sp. m	Sp. m	Sp. m	Sp. m	Sp. m	Sp. m	Sp. m	Sp. m	Sp. m	Sp. m	Sp. m	Sp. m
0.00	Riposto															
1.00	Sabbie finiessime e limose di colore rossastro, ben classate															
2.00	Sabbia limosa di colore beige															
3.00	Fievelo S.P.T.															
4.00	Sabbia limosa di colore beige															
5.00	Limone sabbioso di colore beige con qualche screziatura grigia															
6.00	Sabbia limosa di colore beige con screziature sgrigiolate sparse															
7.00	Fievelo S.P.T. - Frammento di legno a 5.20 m															
8.00	Sabbie finiessime di colore beige															
9.00	Sabbia limosa di colore grigio															
10.00	Fievelo S.P.T.															
11.00	Sabbie finiessime di colore grigio. Esigete prova di permeabilità Lefranc a 10.50 m															
12.00	Sabbie fini di colore grigio															
13.00	Sabbia media di colore grigio															
14.00	Fievelo S.P.T.															
15.00	Sabbia limosa di colore grigio															
16.00	Argilla limosa di colore grigio con frustoli e fossili															
17.00	Complesso indurito															
18.00	Argilla limosa con frustoli, più scura e decarbonata da 14.00 a 14.70 m															
19.00	Fievelo S.P.T.															
20.00	Argilla limosa con scarsi calcinelli. Da -16.60 a -10.90 m legno. Da -17.10 a -17.70 m decarbonato per sovrano organica scuro - grigio scuro tra 16.30 e 16.70 m															
21.00	Fievelo S.P.T.															
22.00	Argilla limosa di colore grigio scuro, decarbonata tra -19.20 e -19.40 m, pi...															

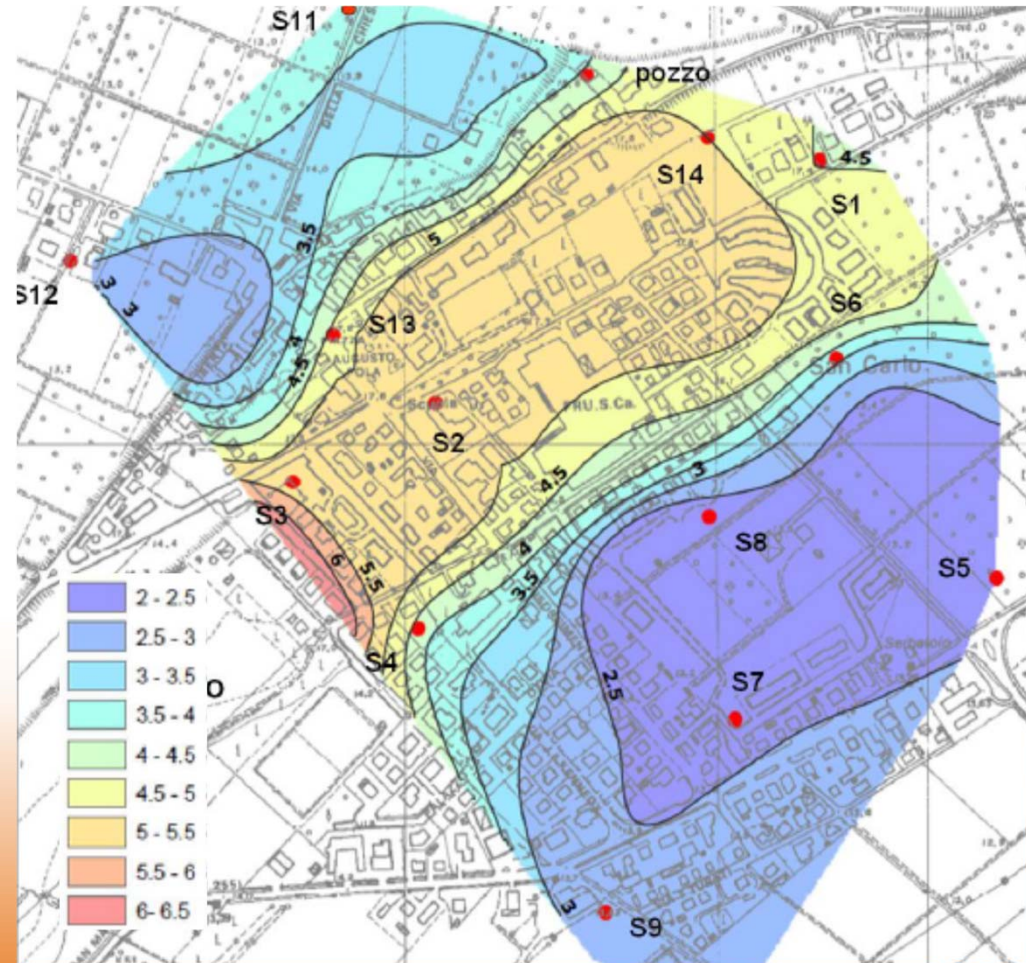
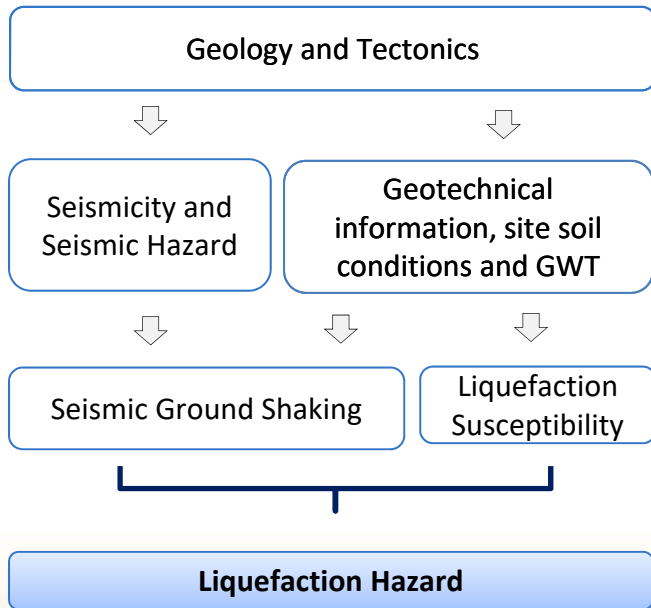
203010C158B



Terre del Reno: geotechnical characterisation

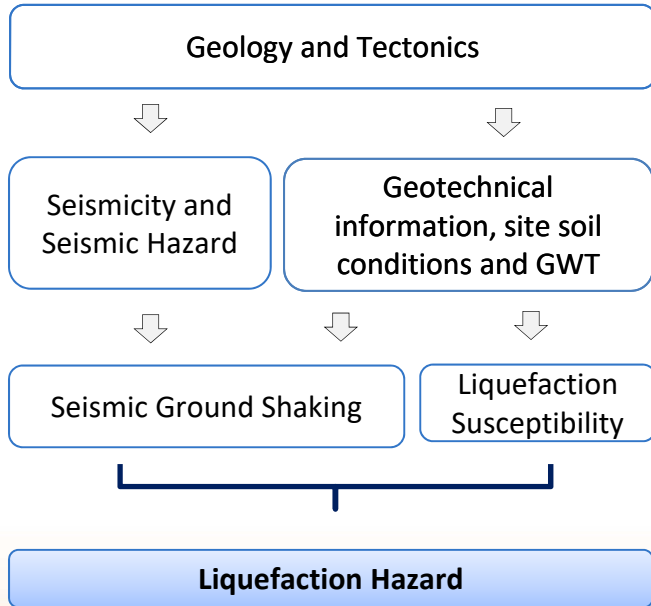
Map of groundwater depth at San Carlo (July 23 2012)

Selena-LRG Flow Chart



Terre del Reno: geotechnical characterisation

Selena-LRG Flow Chart



Microzonazione sismica

Linee guida per la gestione del territorio in aree interessate da liquefazione (LQ)

$$I_L = \int_0^{20} F(z)w(z)dz \quad w(z) = 10 - 0.5z$$

F= 1-F_L se F_L ≤ 1.0

F=0 se F_L > 1.0

dove F_L è il fattore di sicurezza alla liquefazione alla quota considerata.

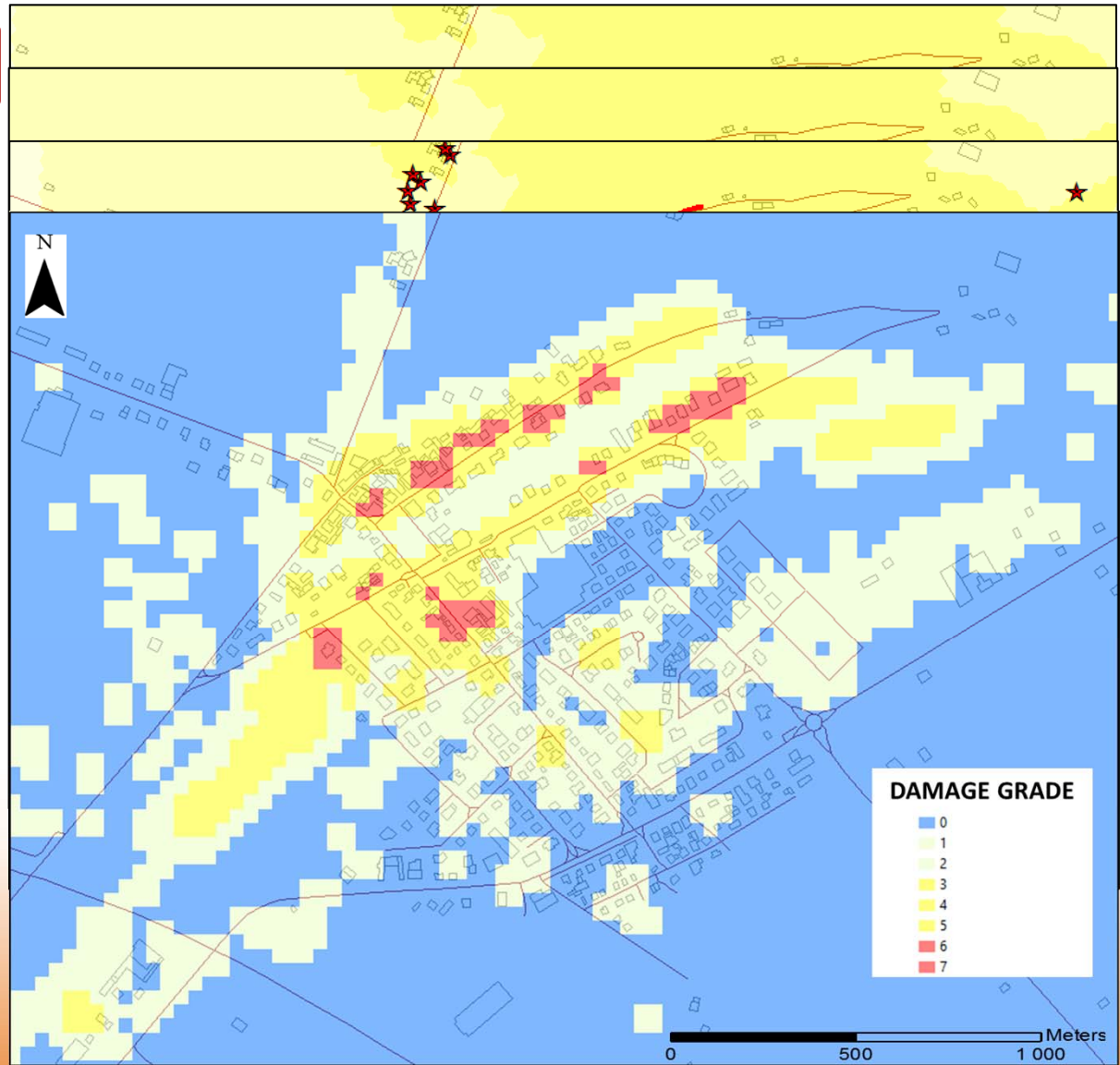
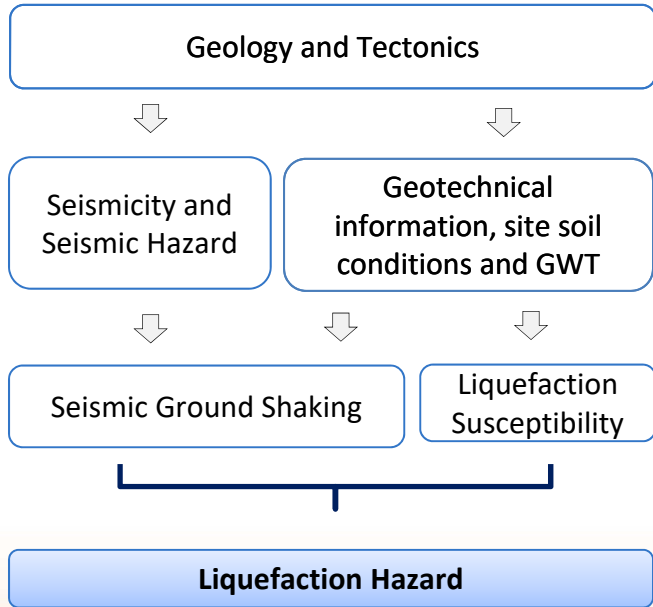
IL	Classi
0 < IL ≤ 2	Nulla- Basso
2 < IL ≤ 5	Moderato
5 < IL ≤ 15	Alto
IL > 15	Molto Alto

Tabella 2 – Indice del potenziale di Liquefazione medio (IL) e relativa classificazione



Terre del Reno: geotechnical characterisation

Selena-LRG Flow Chart



Terre del Reno: evidences of damage

Regione Emilia-Romagna
Agency for the reconstruction

MUDE platform

Private building

SFINGE platform

Industrial building

FENICE platform

Public building



Kaipoi, 2010



Emilia, 2012



Kaipoi, 2010



Emilia, 2012



Peru 2007



Emilia, 2012



Kaipoi, 2010



Emilia, 2012



Terre del Reno: evidence of damage

Masonry buildings	Reinforced buildings	Classification of damages
		Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage)
		Grade 2: Moderate damage (slight structural damage, moderate non-structural damage)
		Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)
		Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage)
		Grade 5: Destruction (very heavy structural damage)

Dolce et al. (2017)

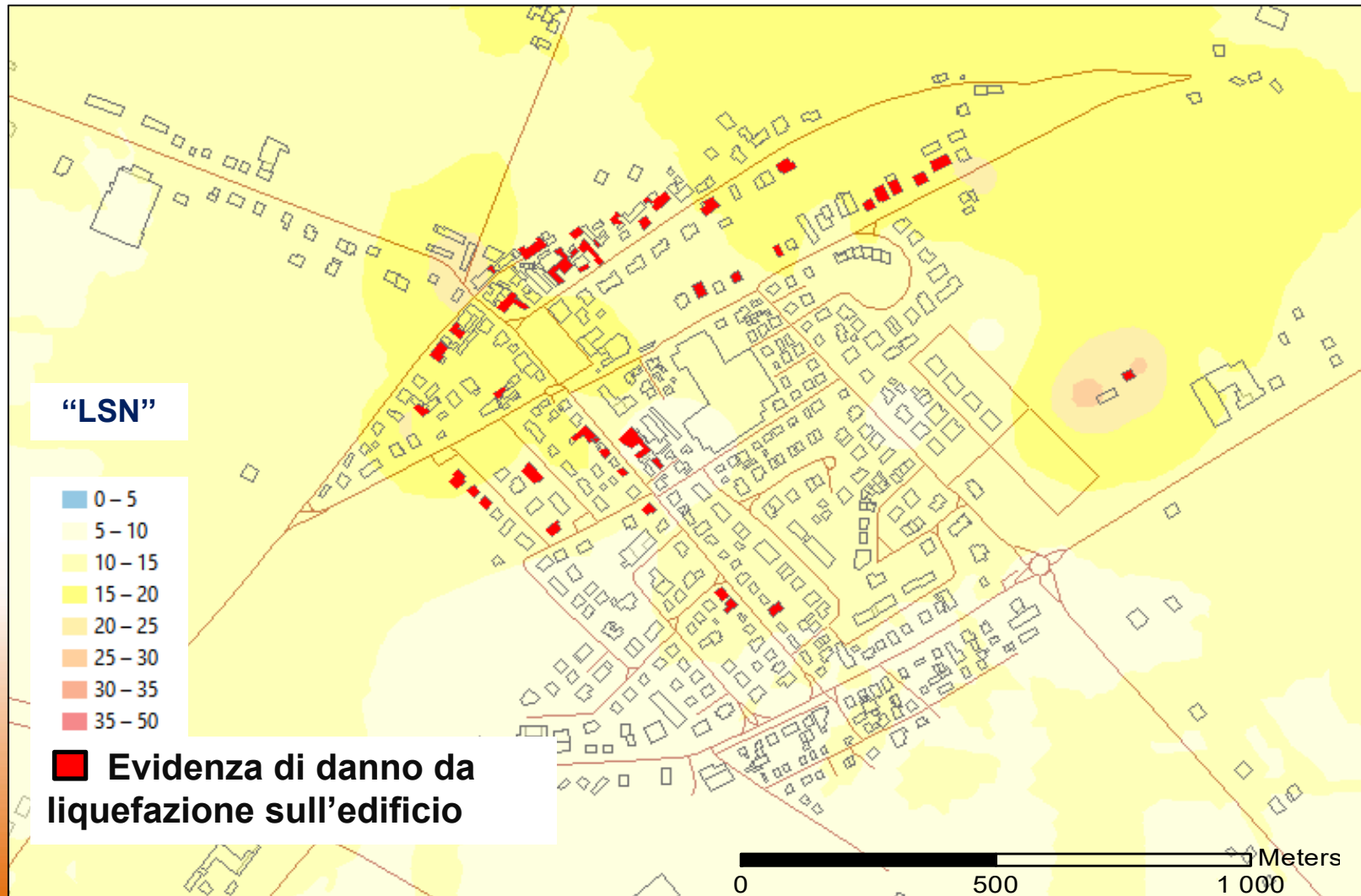
Classification of damage

Land Damage Groupings		Dwelling Foundation Damage Categories			
Grouping	Criteria / Description	Type of Damage	Minor	Moderate	Major
Blue (1)	No observed ground cracking or ejected liquefied material	Stretching 	0 to 5mm	5 to 30mm	>30mm
Green (2)	Minor ground cracking but no observed ejected liquefied material	Hogging 	0 to 20mm	20 to 50mm	>50mm
Light Orange (3)	No lateral spreading but minor to moderate quantities of ejected material	Dishing 	0 to 20mm	20 to 50mm	>50mm
Dark Orange (4)	No lateral spreading but large quantities of ejected material	Racking/Twisting 	0 to 10mm	10 to 30mm	>30mm
Red (5)	Moderate to major lateral spreading; ejected material often observed	Tilting 	0 to 20mm	20 to 50mm	>50mm
Dark Red (6)	Severe lateral spreading; ejected material often observed	Abrupt Differential Movement 	0 to 10mm	10 to 20mm	>20mm
		Global Settlement 	0 to 50mm	50 to 100mm	>100mm

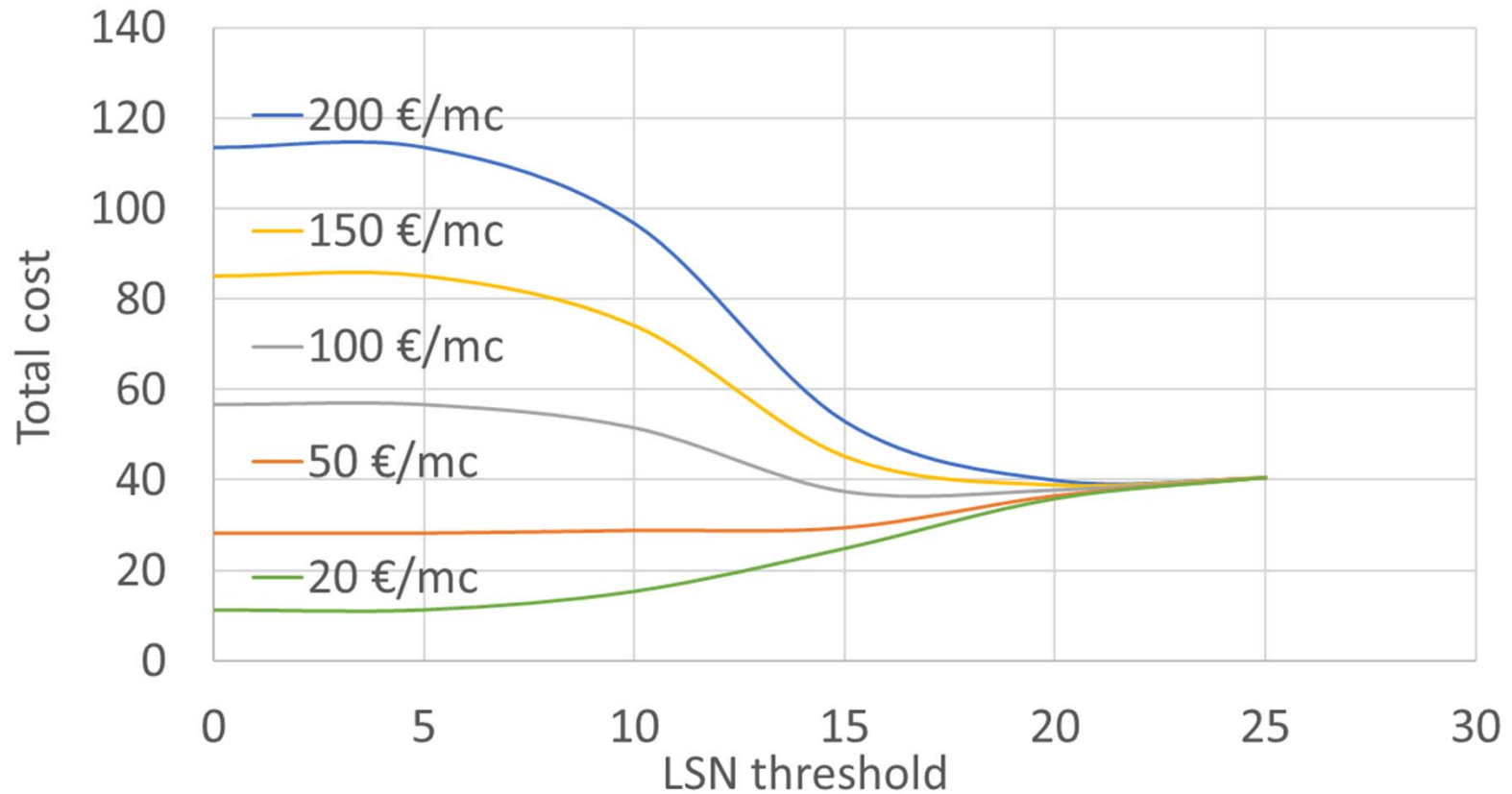
Van Ballegooy (2014)



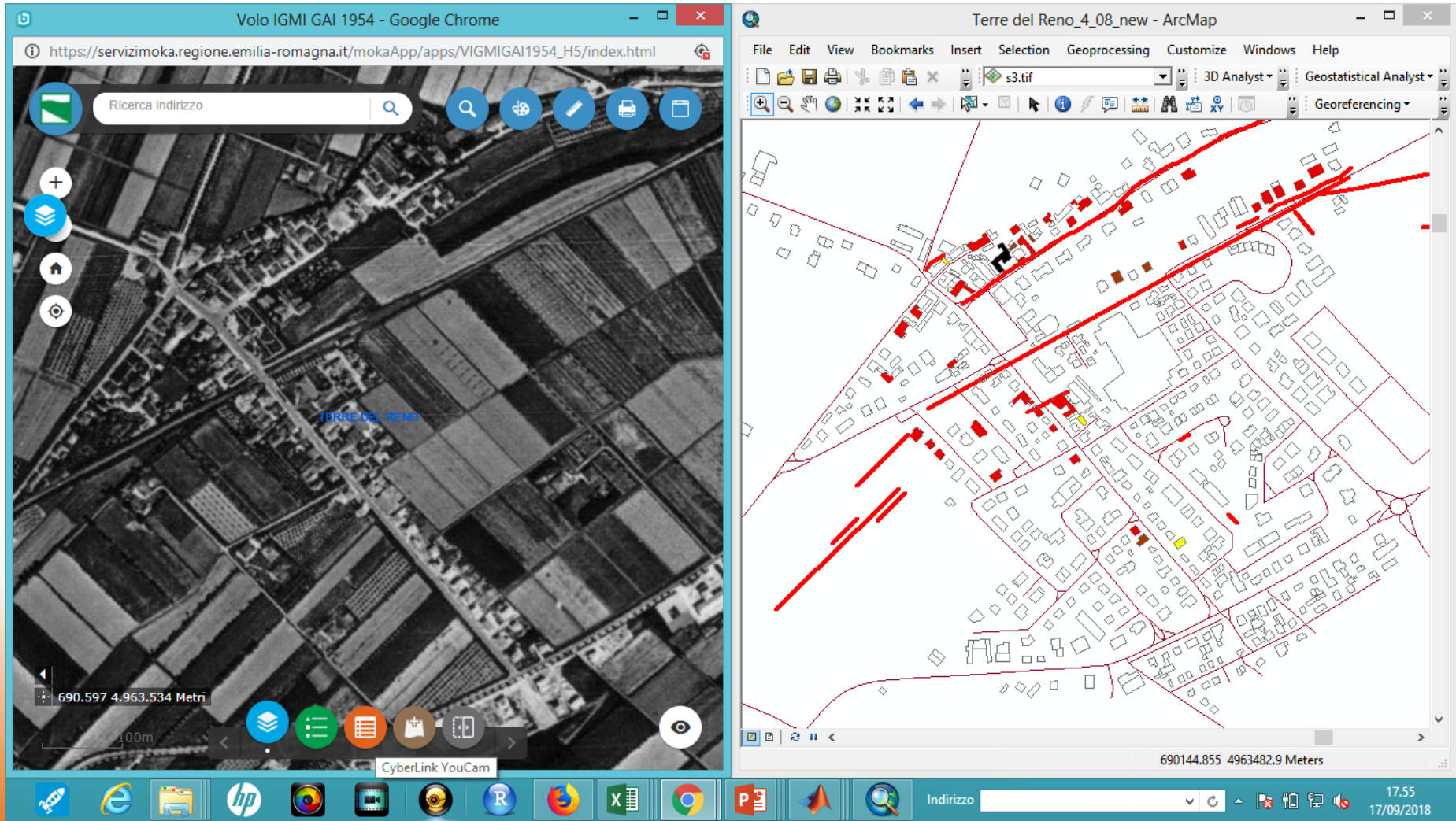
Terre del Reno: evidences of damage



Terre del Reno: damage

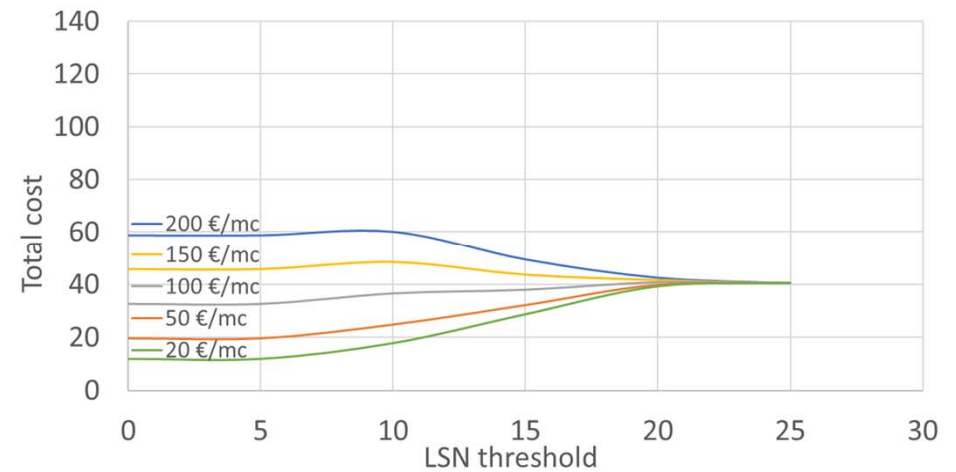
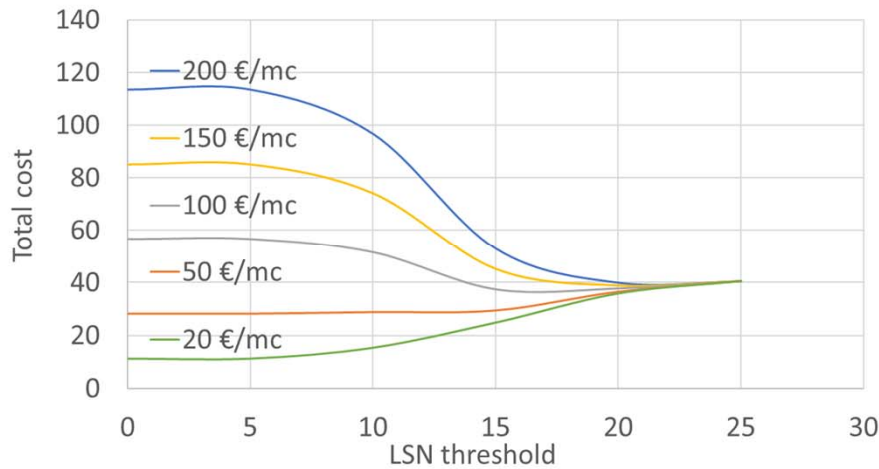
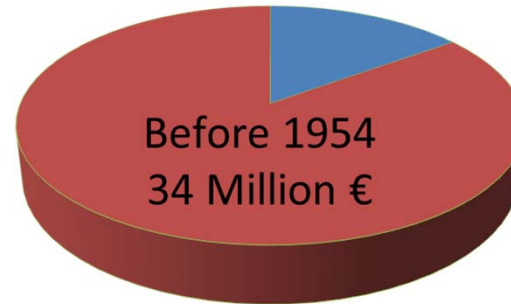


Terre del Reno: damage



Terre del Reno: damage

Total damage 40 Million €

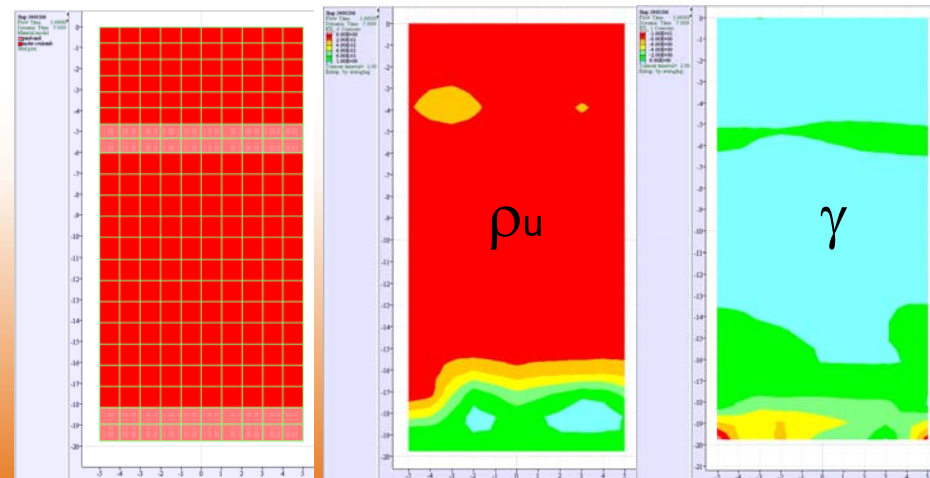
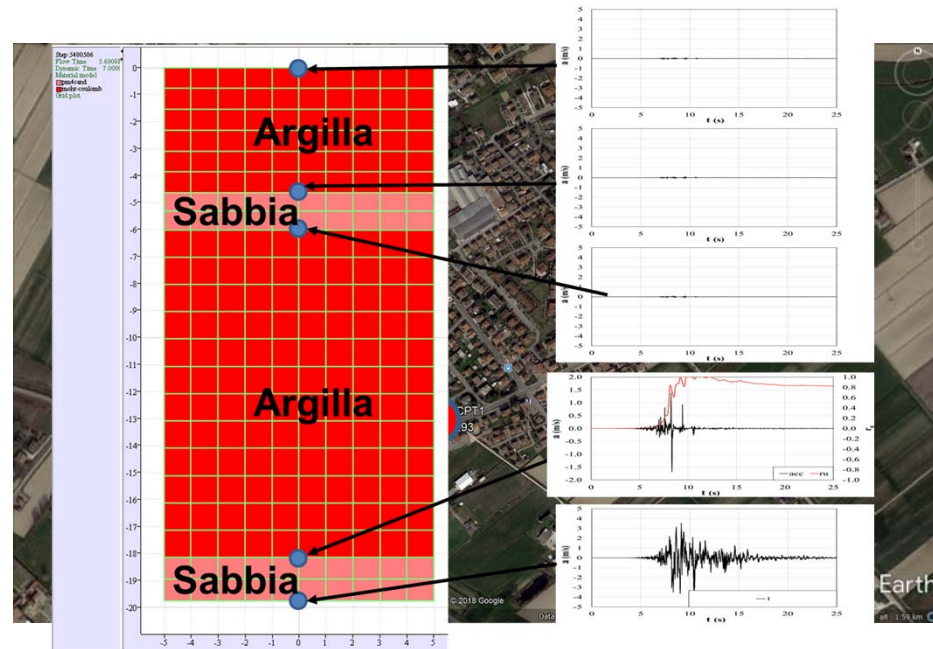
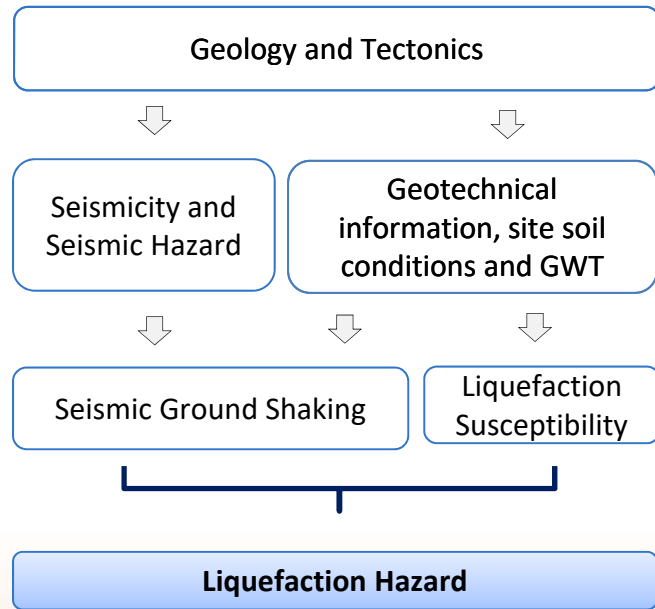


Unit cost (€/mc)	20	50	100	150	200
Ideal cost (Million €)	1.5	3.8	7.6	11.5	15



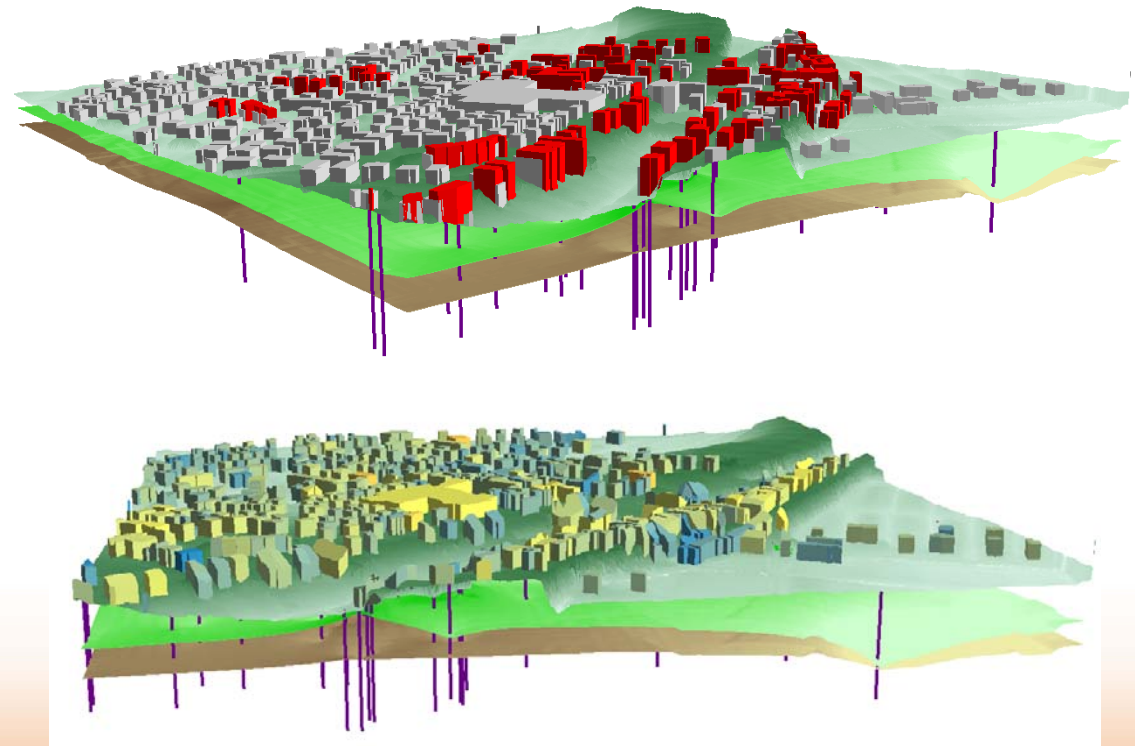
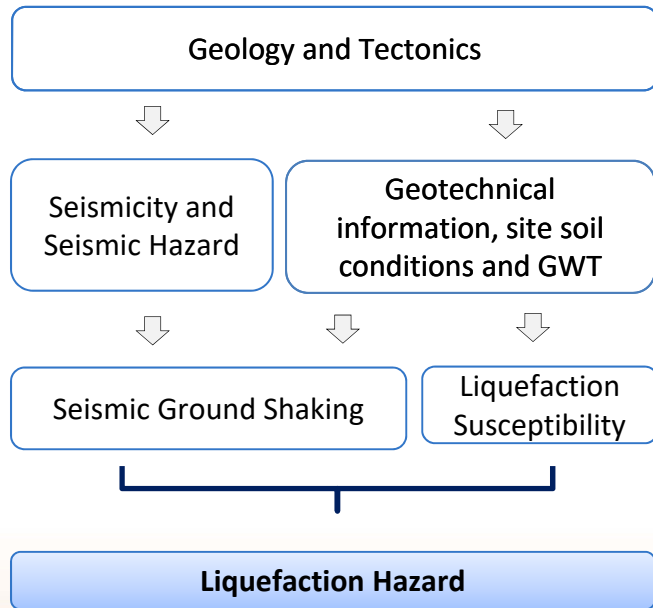
Terre del Reno: geotechnical characterisation

Selena-LRG Flow Chart



Terre del Reno (2012)

Selena-LRG Flow Chart



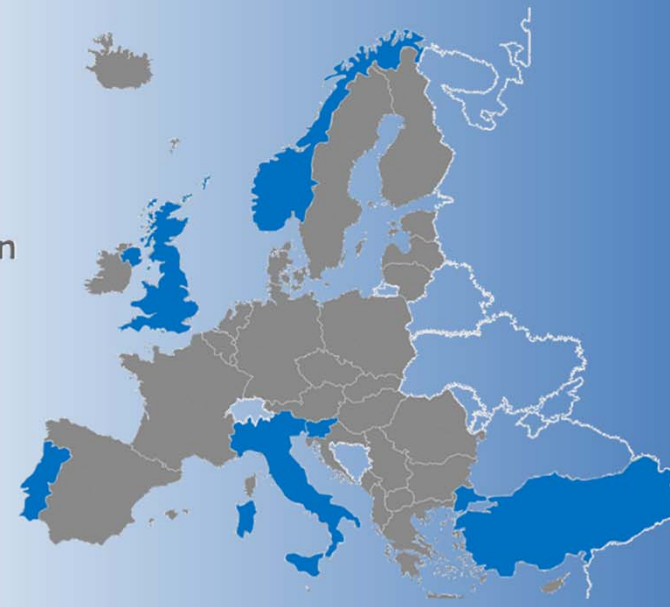


European
Commission

Horizon 2020
European Union funding
for Research & Innovation

liquefact
ACT

www.liquefact.eu



GRAZIE PER L'ATTENZIONE,

Giuseppe Modoni

Università di Cassino e del Lazio Meridionale

Telefono +39.776.2993738

E-mail modoni@unicas.it