United Nations
Educational, Scientific and
Cultural Organization

UNESCO Chair on the Prevention and
Sustainable Management of Geo-Hydrological Hazards,
University of Florence, Italy

Rilevamento frane e misure correttive a basso impatto ambientale

Nicola Casagli

PRESIDENCY OF THE COUNCIL OF MINISTERS

Delegate Commissioner for the Montaguto landslide

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

Consiglio Nazionale delle Ricerche
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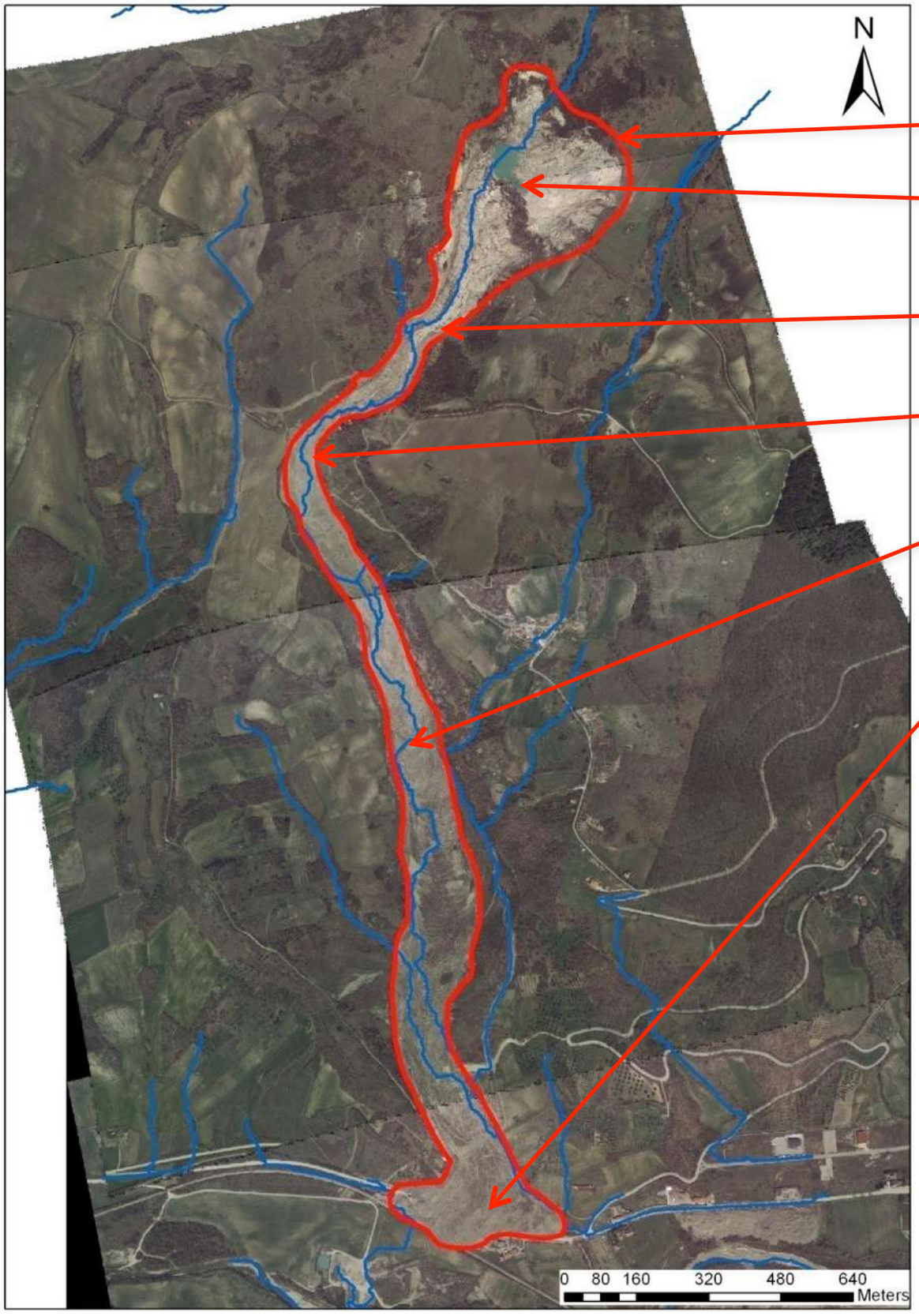
Montaguto landslide

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

- Roma-Napoli National railway
- National Road SS 90 “Delle Puglie”

Montaguto, May 2010

The landslide



- **Main headscarp**
- **Counterslope** landslide lakes
- **Upper track**
- **“Elbow”**
- **Main track**
- **Lower deposit** expanded in the valley floor, affecting National road and railway

- **Landslide volume:** 6 million m^3
- **Area:** 4.8 10^5 m^2
- **Peak velocity:** >3 m/day
- **Total length:** 3 km
- **Travel angle:** 8.4°

Before

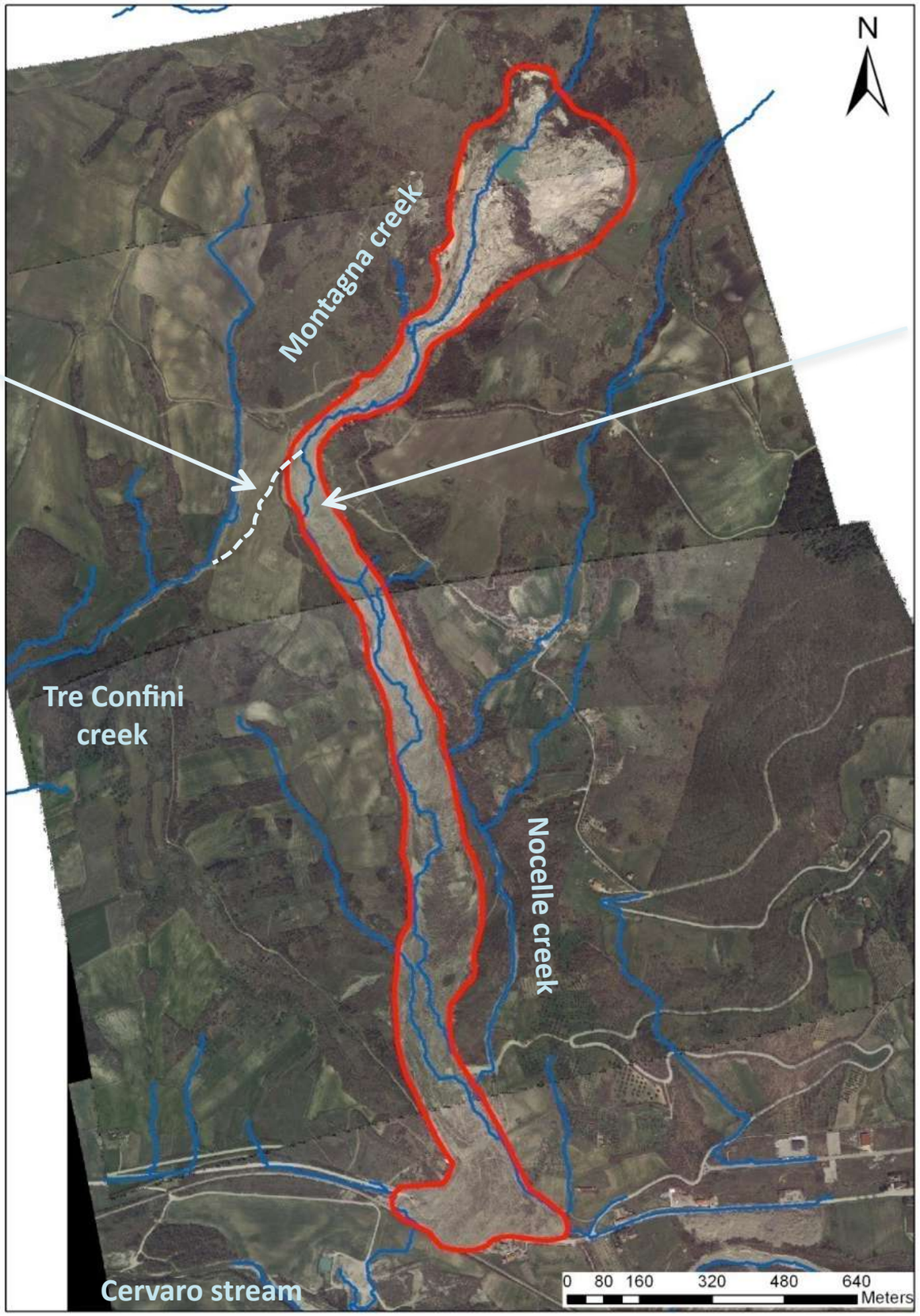

© 2010 Cnes/Spot Image
Image © 2010 GeoEye
© 2010 Tele Atlas
©2009 Google
Imagery Date: Oct 30, 2002
41° 14.280' N 15° 13.362' E elev 425 m
Eye alt 700 m

After


© 2010 Cnes/Spot Image
Image © 2010 GeoEye
© 2010 Tele Atlas
©2009 Google
Imagery Date: Oct 30, 2002
41° 14.280' N 15° 13.362' E elev 425 m
Eye alt 700 m

1990 Montagna creek deviation

natural original channel



deviated channel

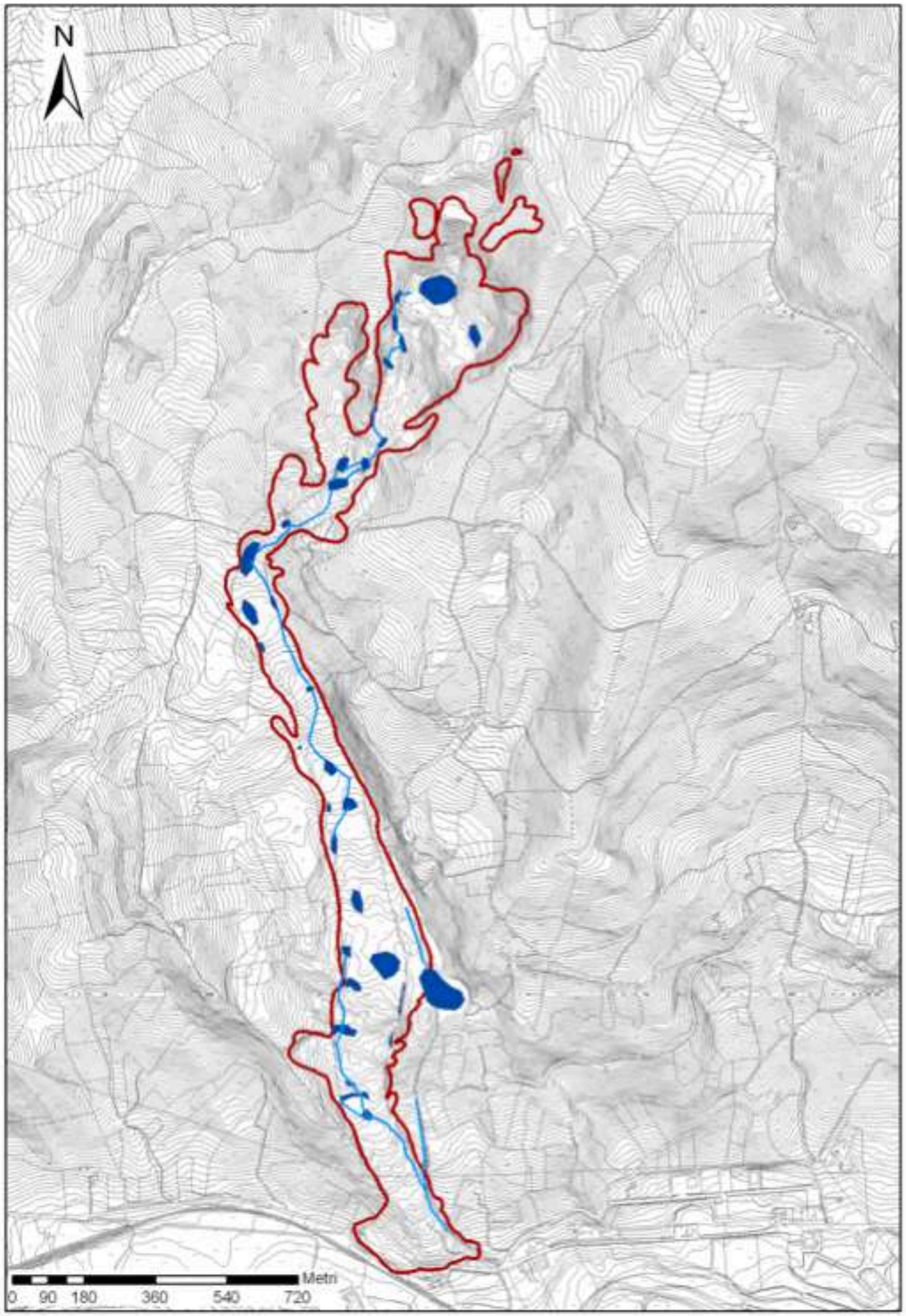

2002
Image © 2011 GeoEye
© 2011 Tele Atlas
Image NASA
41°14'56.06"N 15°13'18.46"E elev 623 m


2009
Image © 2011 GeoEye
© 2011 Tele Atlas
41°14'57.95"N 15°13'10.47"E elev 604 m


2010
Image © 2011 GeoEye
© 2011 Tele Atlas
41°14'57.95"N 15°13'10.47"E elev 604 m

Landslide lakes

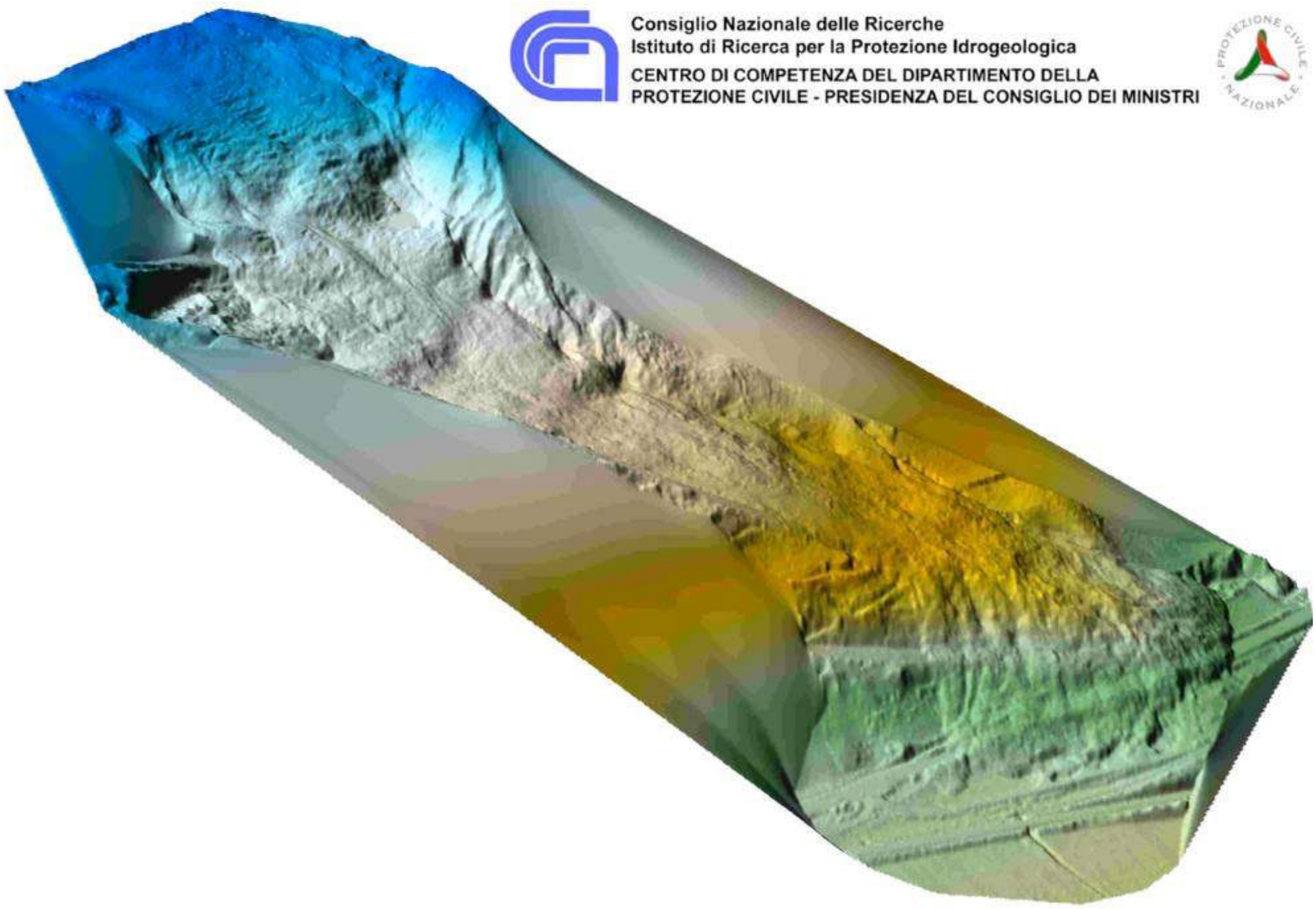
Cascini et al. (2009)



Monitoring activity
Installation 29th April 2010

GB-InSAR, LIDAR, thermal and optical imaging

DTM 2006



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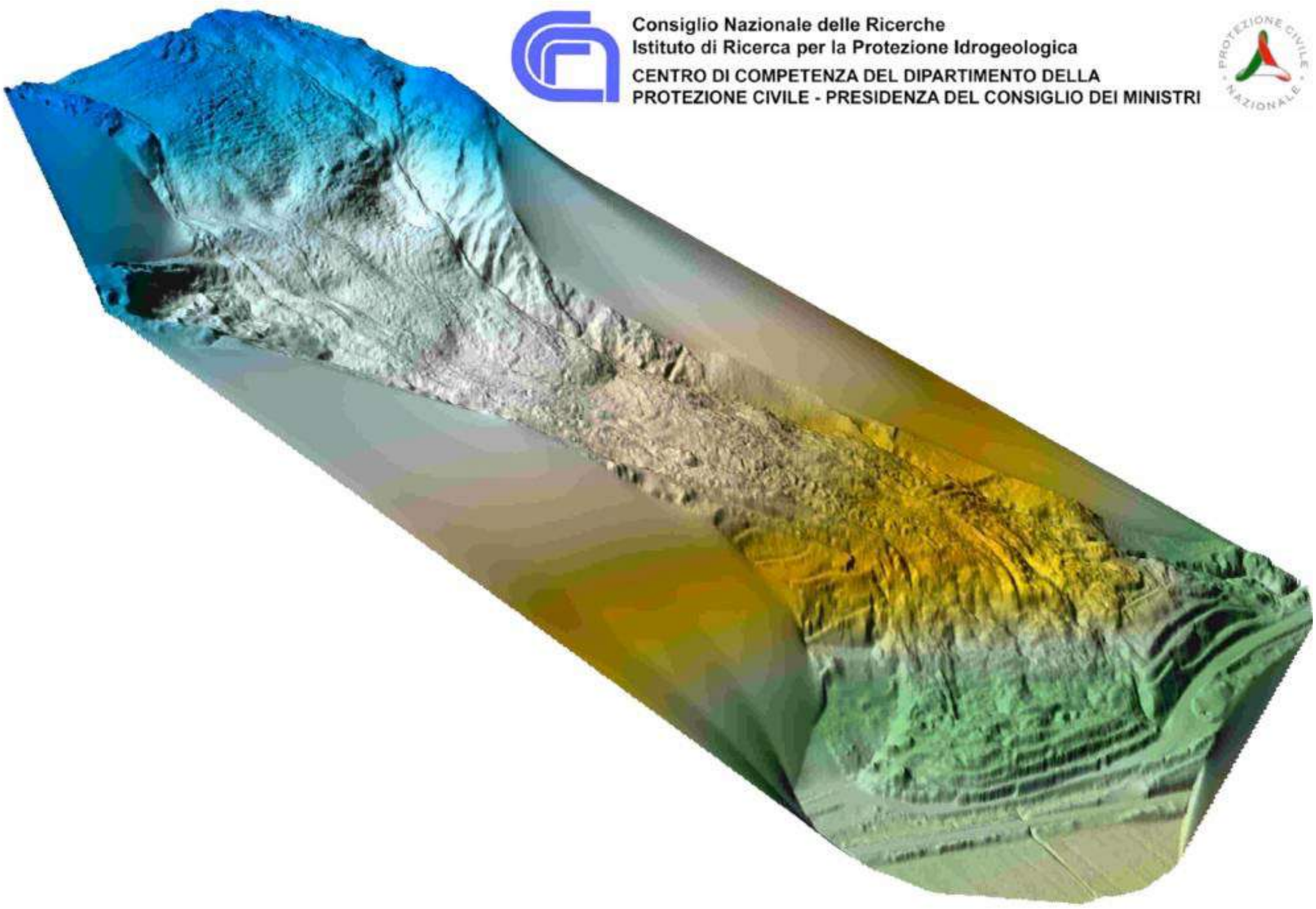
PROTEZIONE CIVILE - PRESIDENZA DEL CONSIGLIO DEI MINISTRI

DTM 2009



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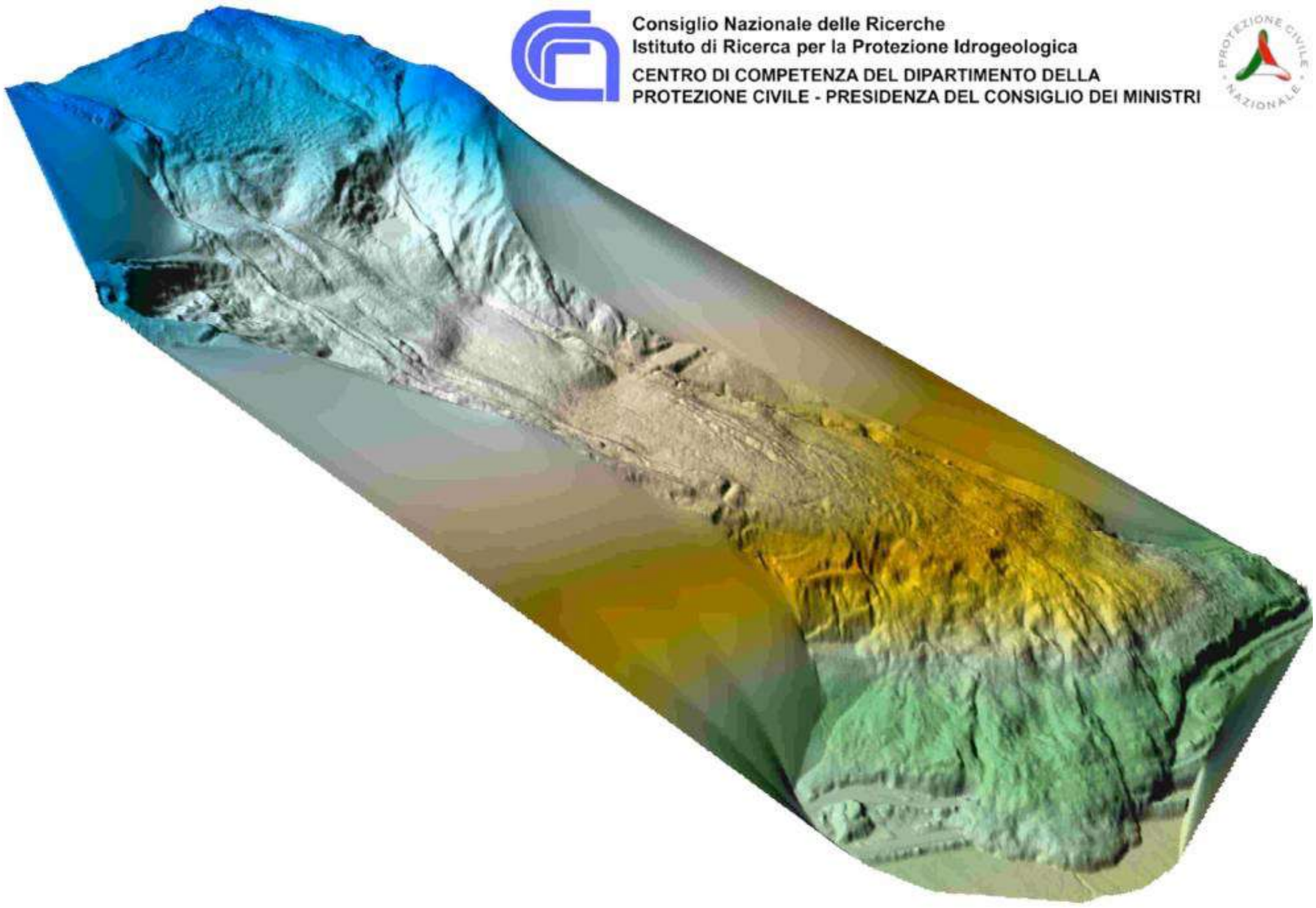
DTM 2010



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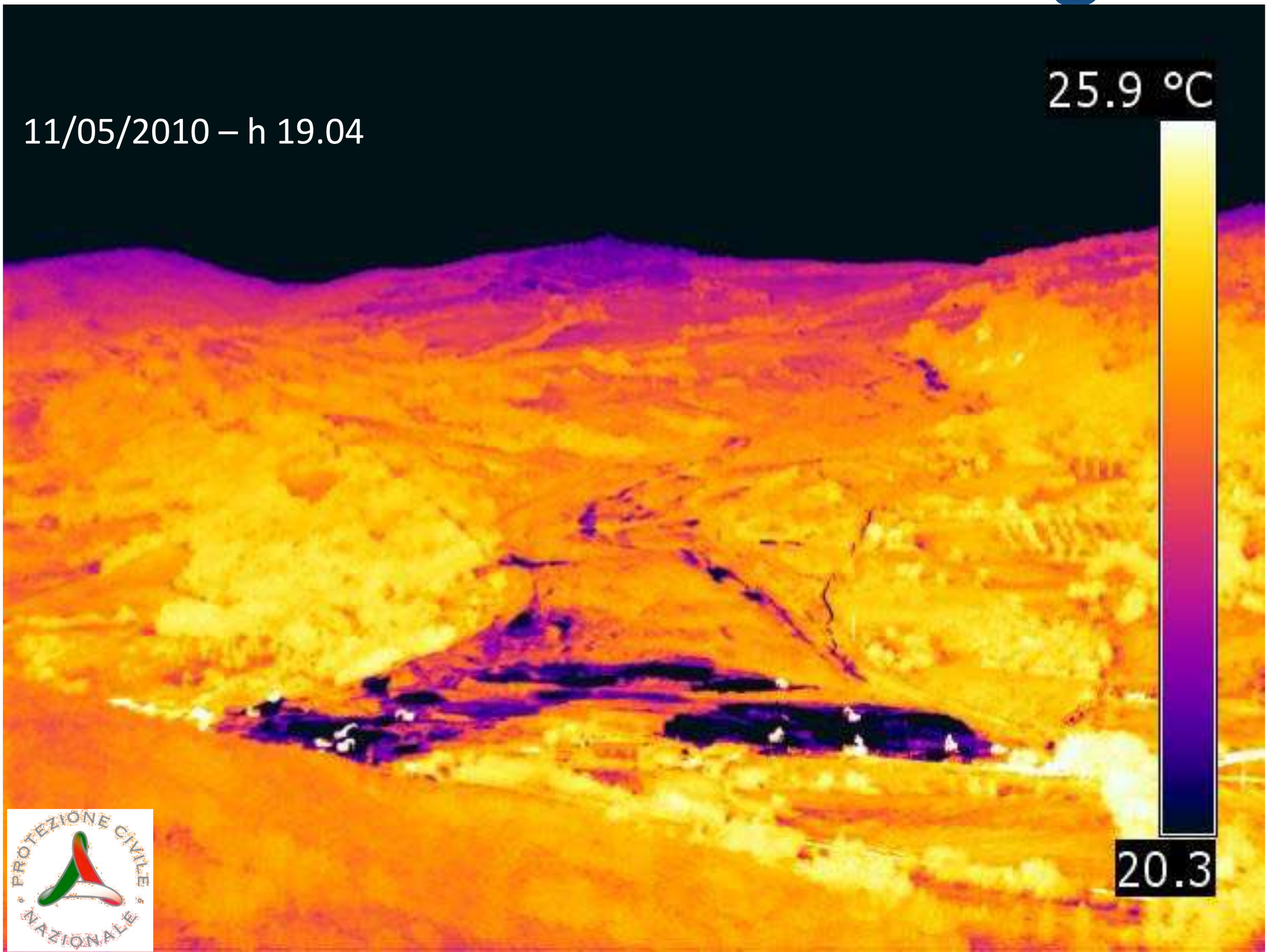
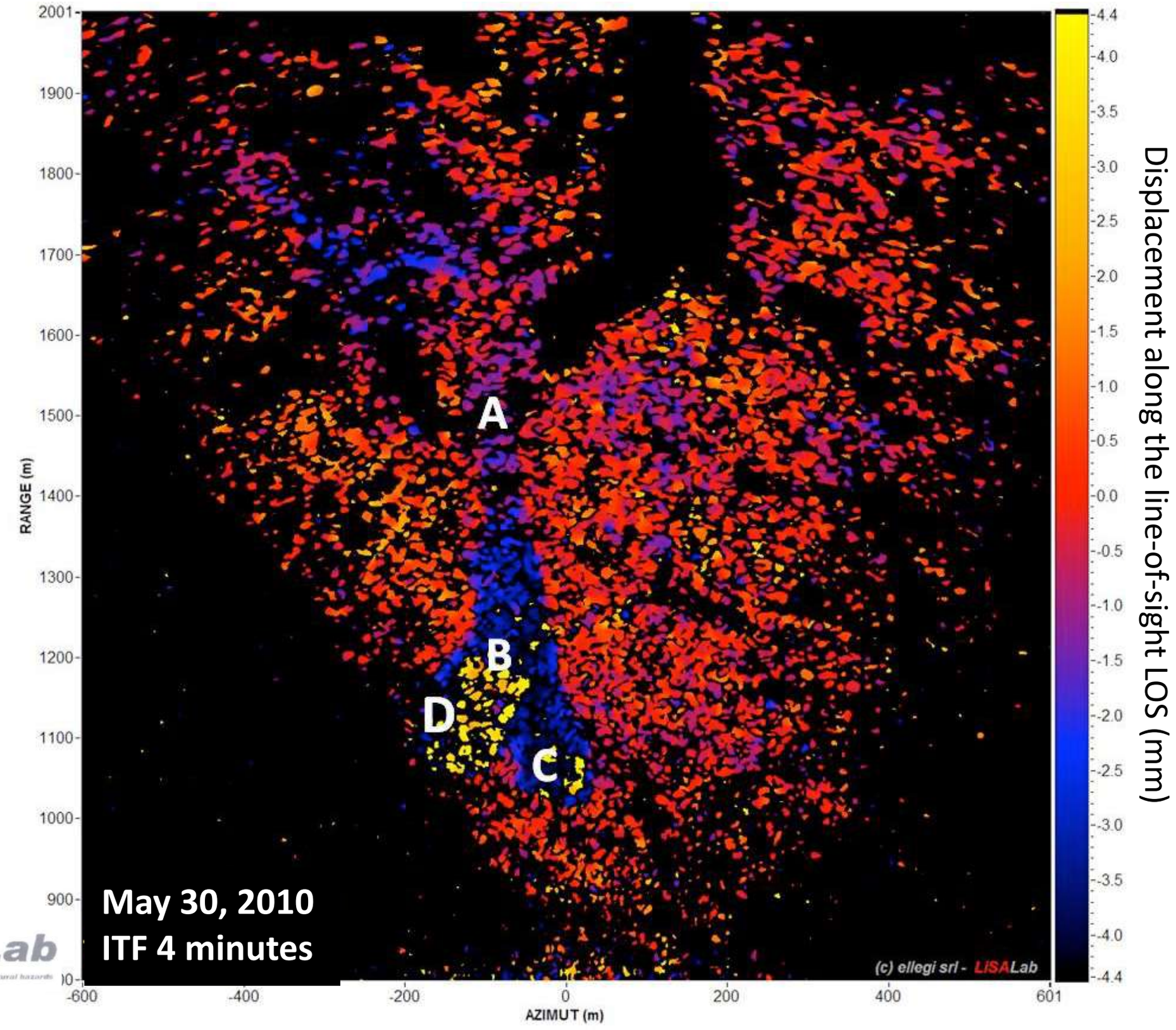
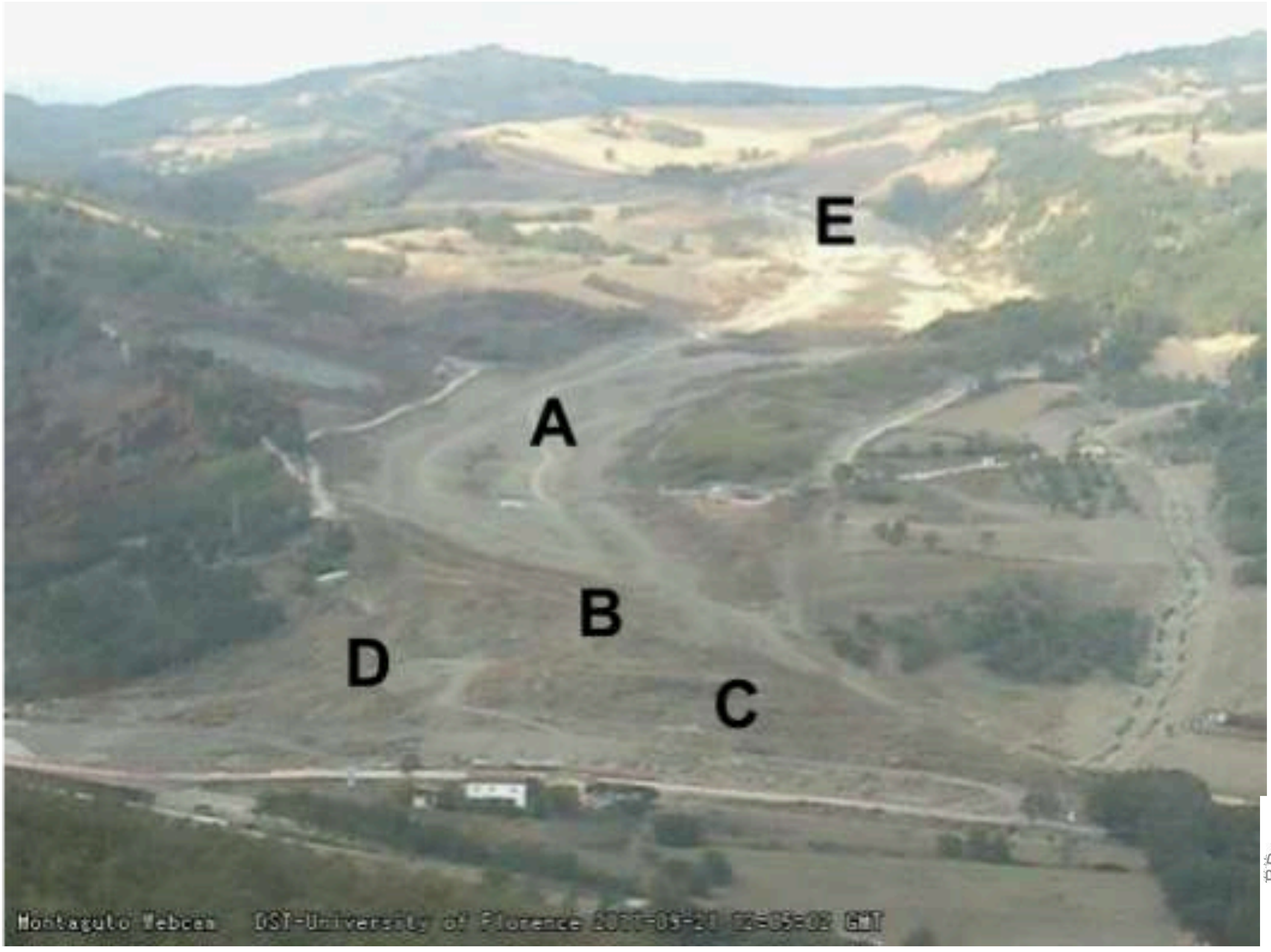
Thermal infrared image



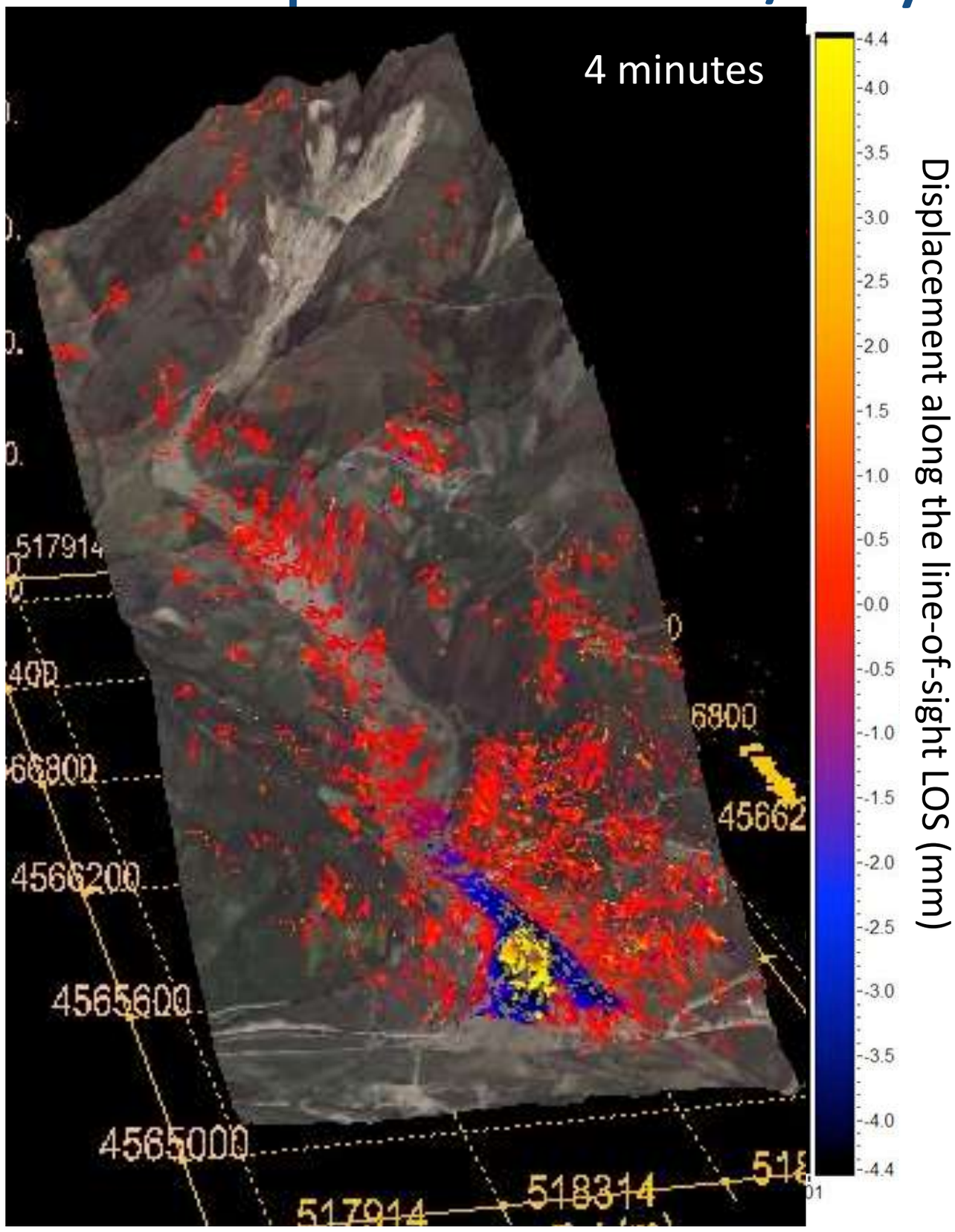
Interferogram (landslide foot)



GBInSAR monitoring sectors



Interferogram May 26th , 2010
maximum speed = 2.7 m/day



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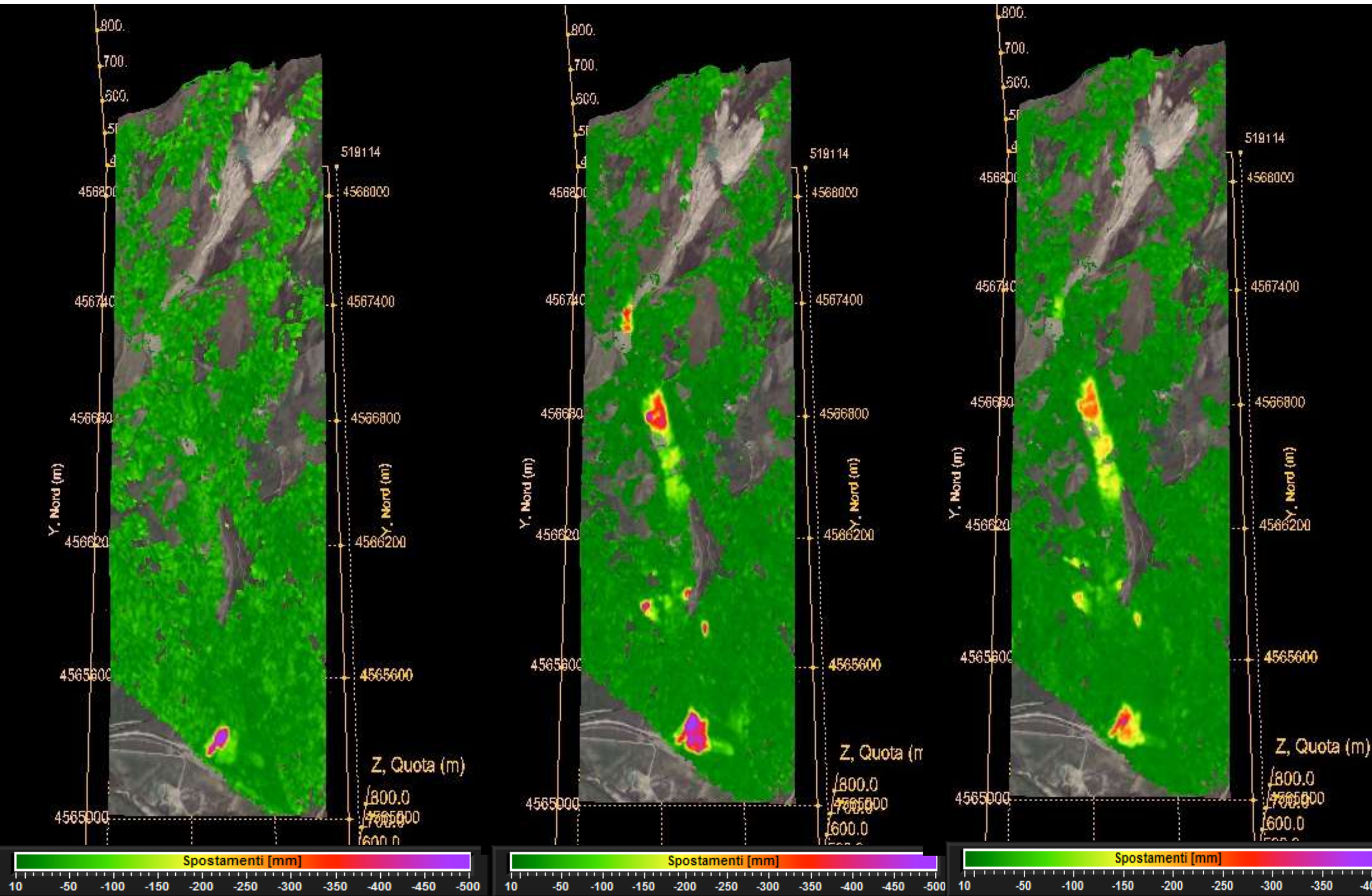
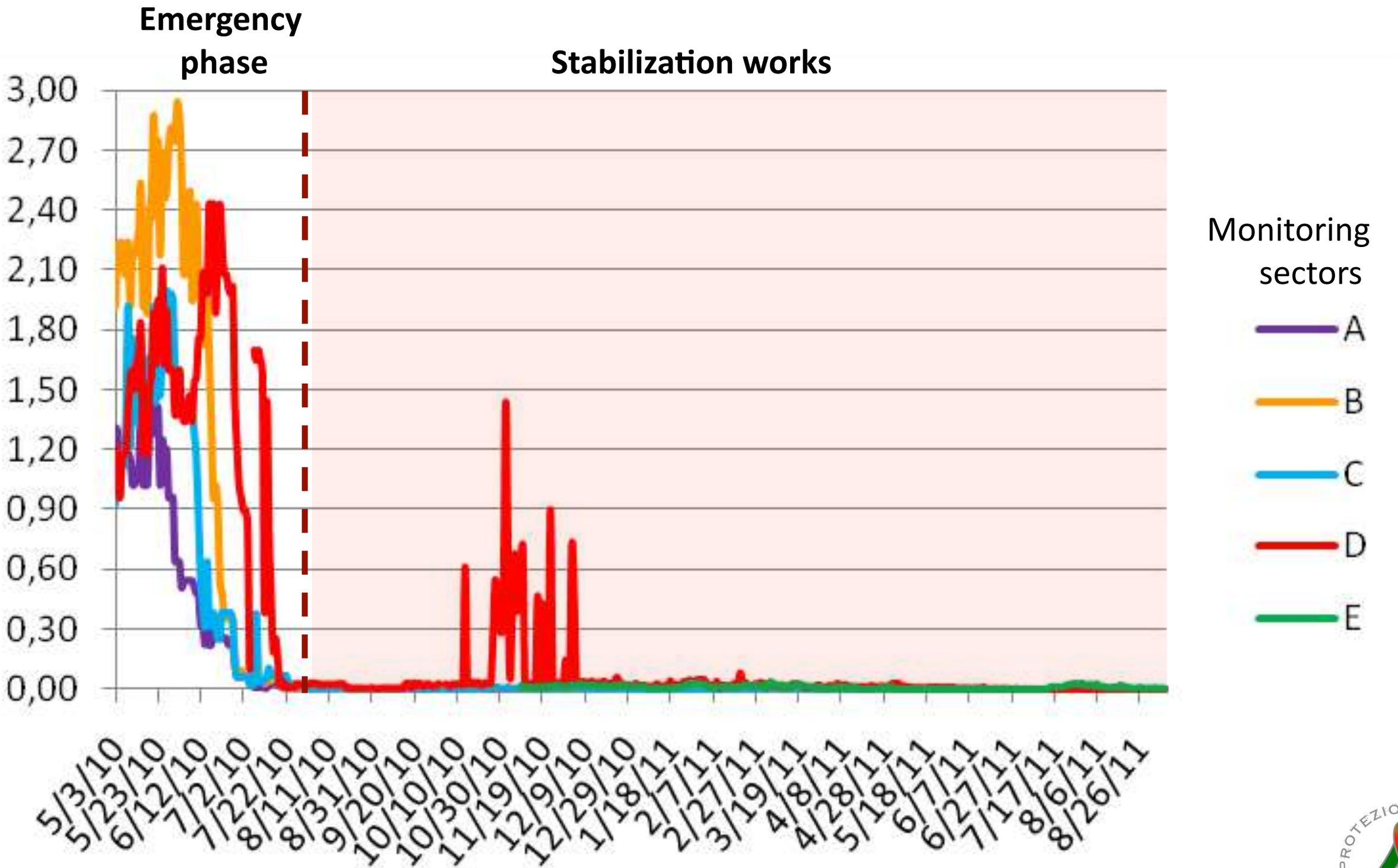
PROTEZIONE CIVILE NAZIONALE

Cumulated displacement maps

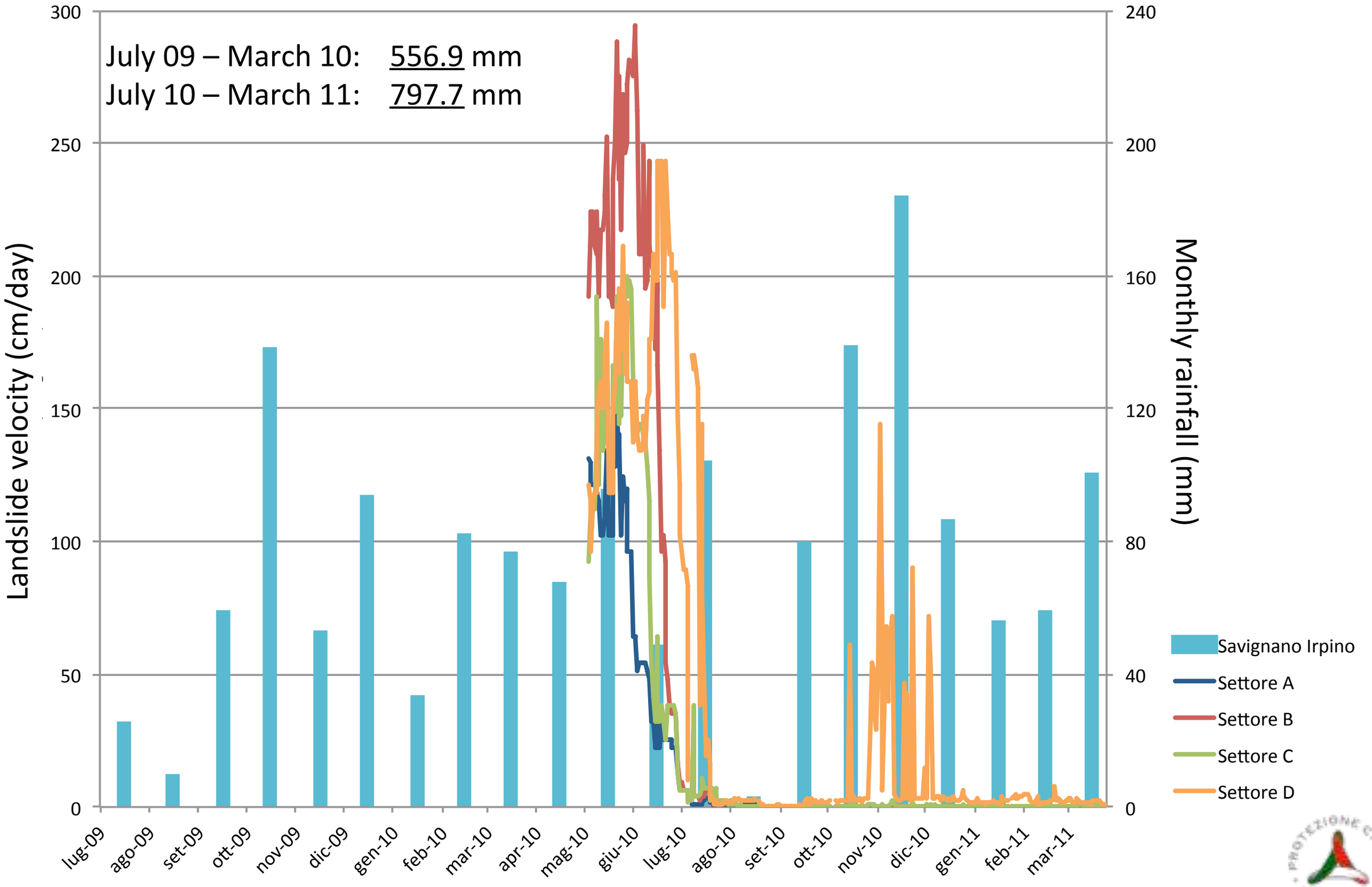
September 2010 | December 2010 | January 2011



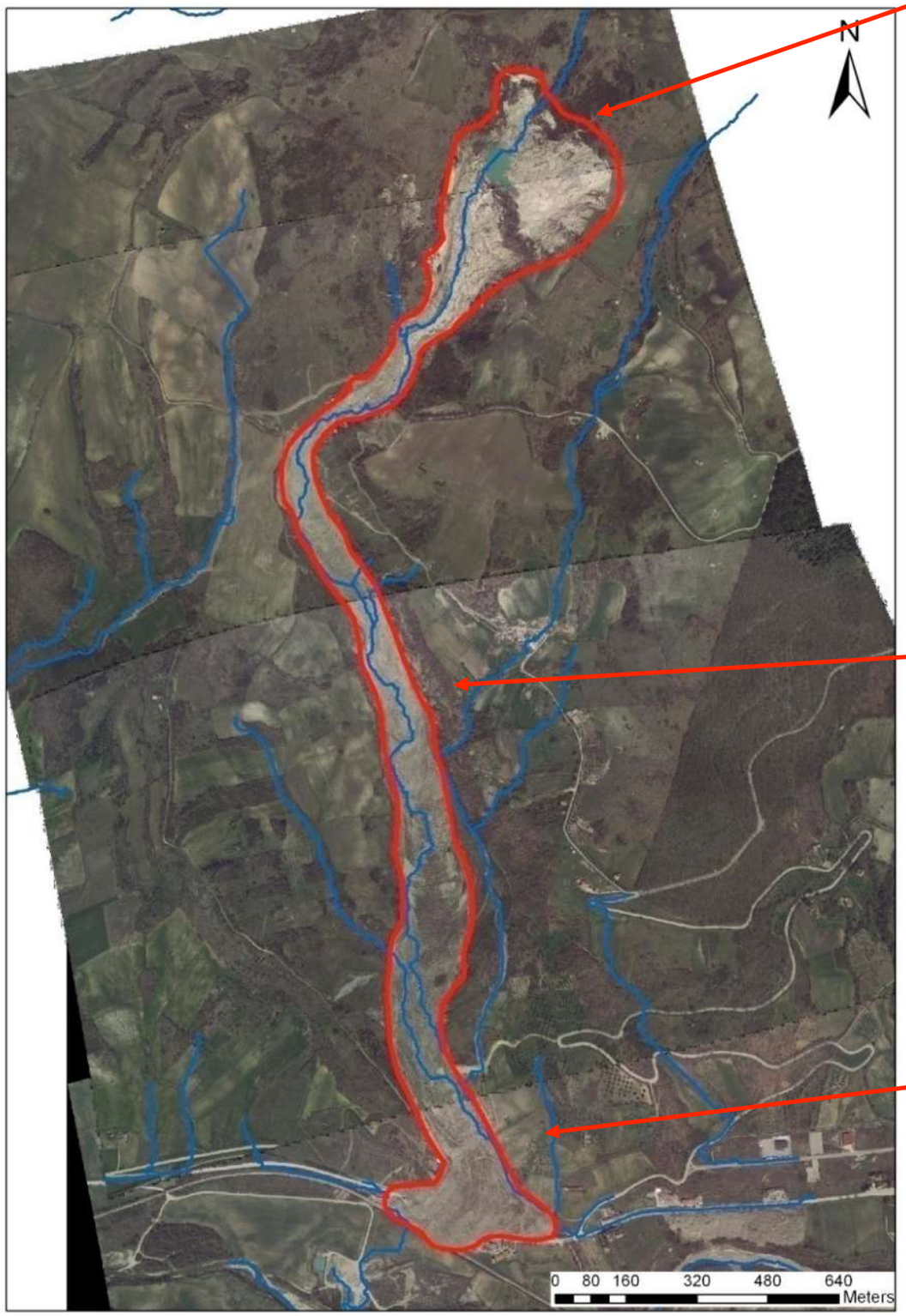
Recorded velocity (m/day)



Comparison with rainfall



Stabilization works



Upper sector (depletion zone)

- upstream surface drainage (diversion ditches)
- drainage wells
- re-profiling of the main scarp
- lake drainage
- modification of the slope profile
- surface drains (ditches)
- shallow drains (trenches with gabions)
- deep drains (drainage diaphragm)
- stream channels restoration to natural conditions

Middle sector (main track)

- modification of the slope profile
- surface drains coupled with deep trench drains
- left-bank stream channelization
- right-bank stream channelization

Lower sector (deposition zone)

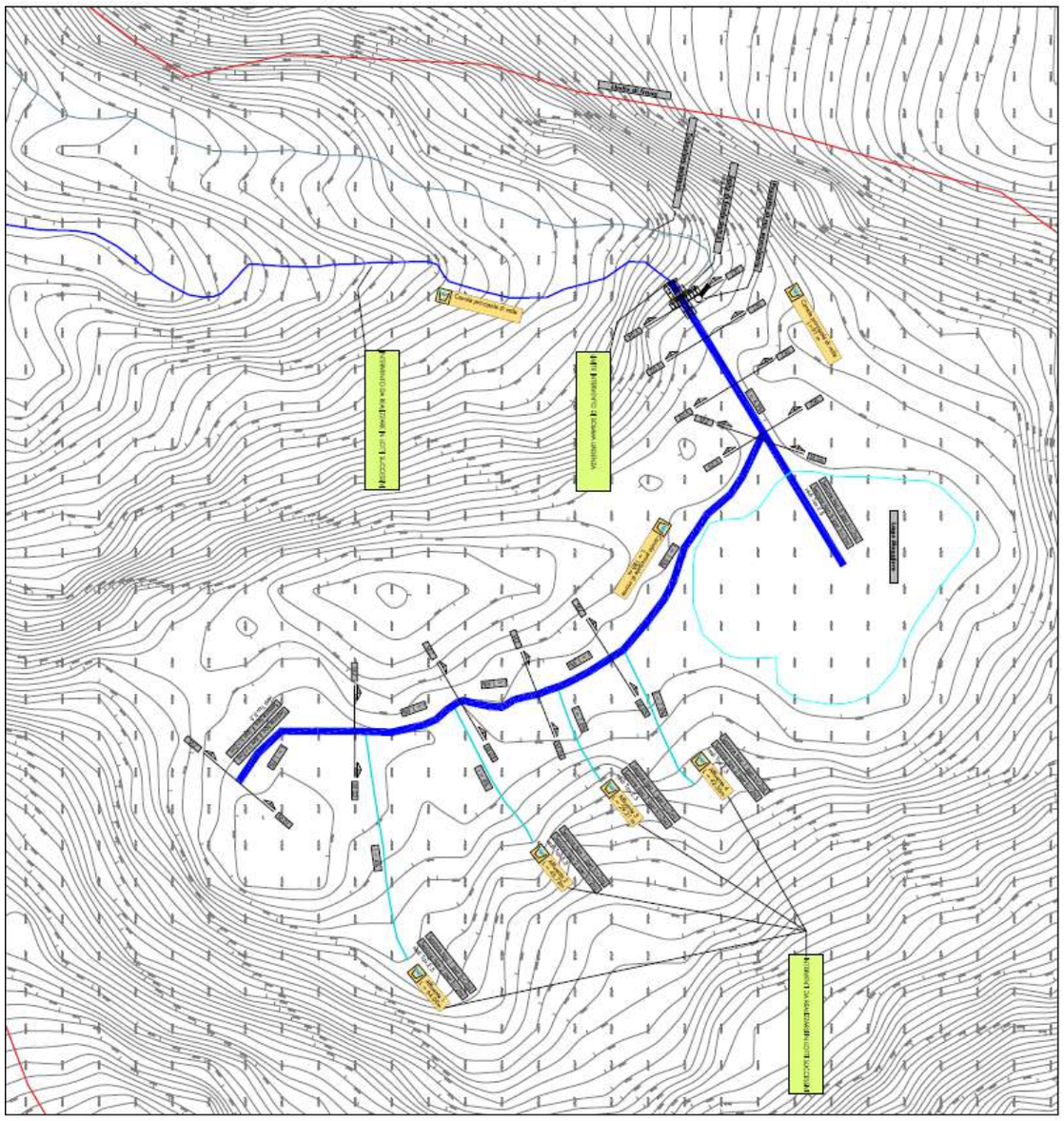
- re-profiling of landslide deposits on the right side
- gabion toe drain and buttressing
- landslide deviation on the left side
- surface drains coupled with deep trench drains
- left-bank stream channelization

Observational method

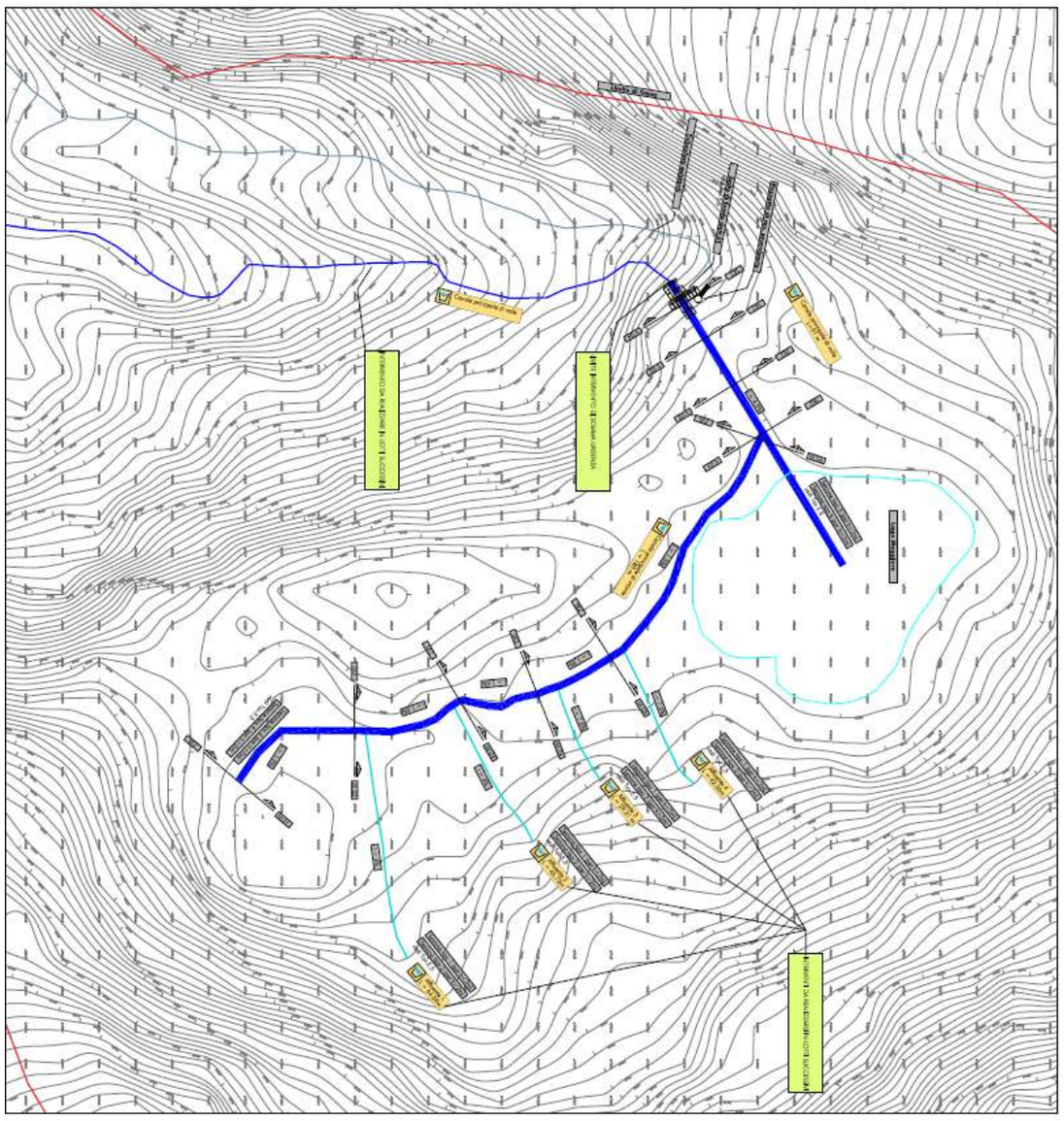
Advantages and Limitations of the Observational Method in Applied Soil Mechanics. Géotechnique, Volume 19 Issue 2, June 1969, pp. 171-187

Ralph Peck and Karl Terzaghi
at Lake Maracaibo in 1956
(From The Terzaghi & Peck Libraries NGI, Oslo)

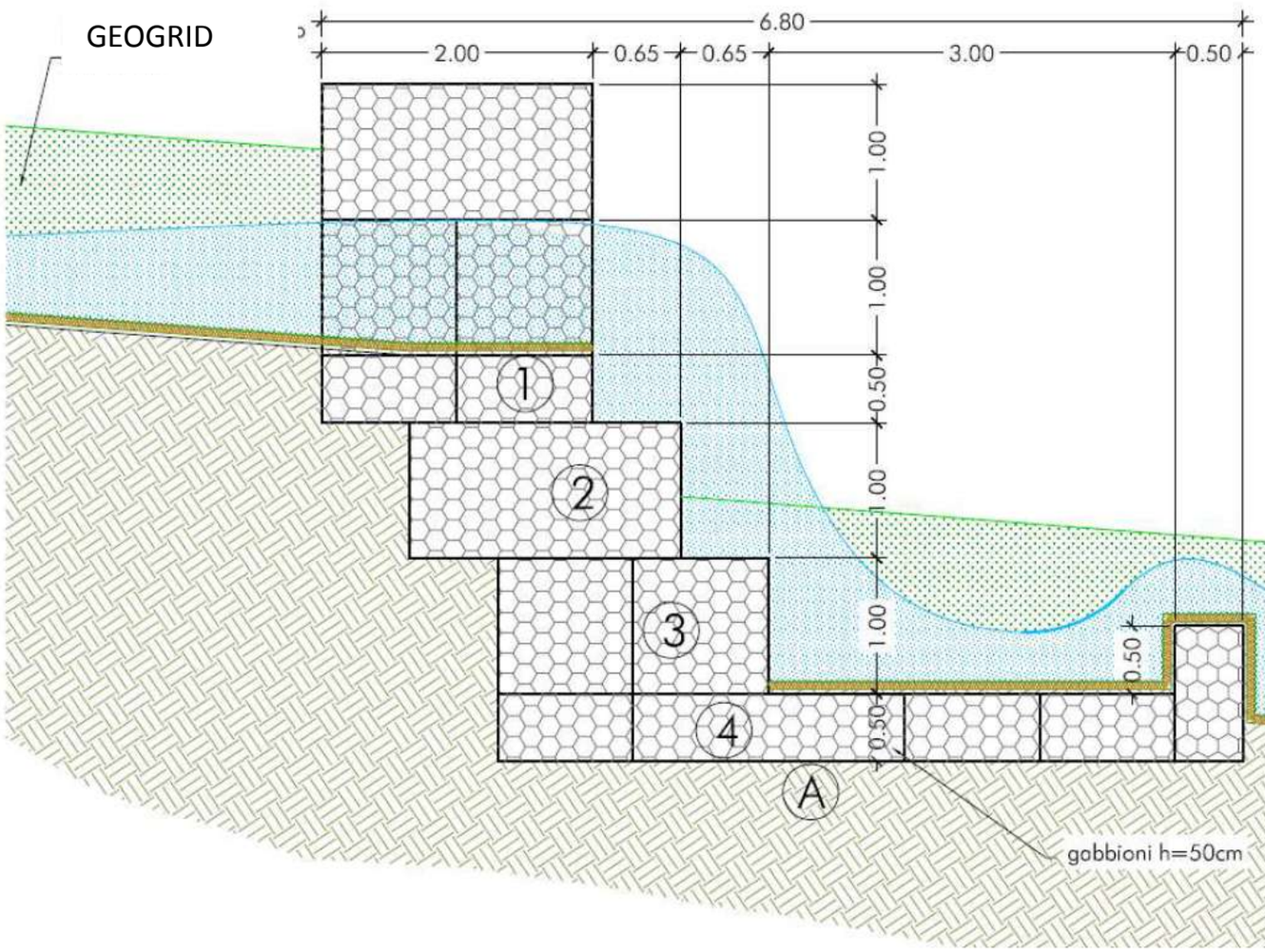
Upper sector: Before drainage



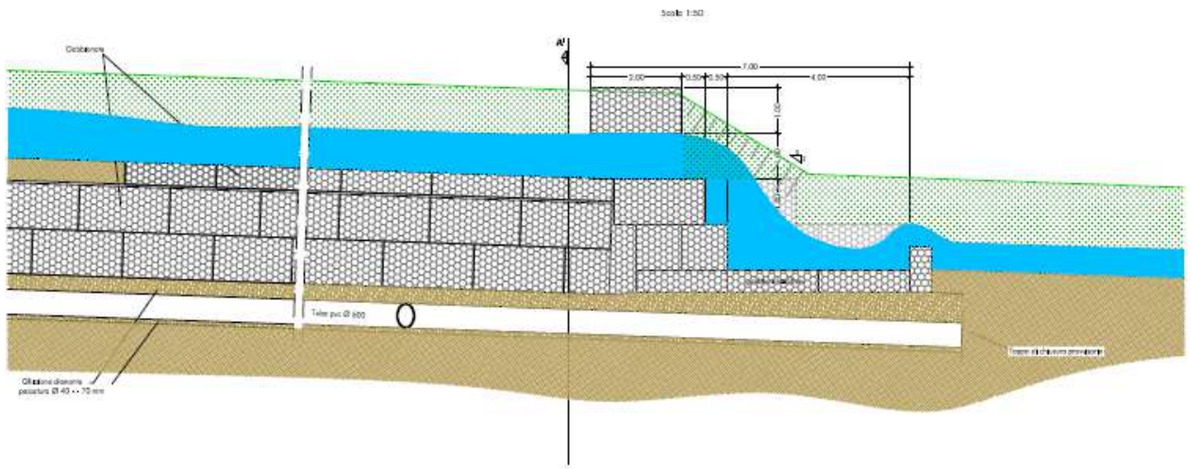
Upper sector: After drainage

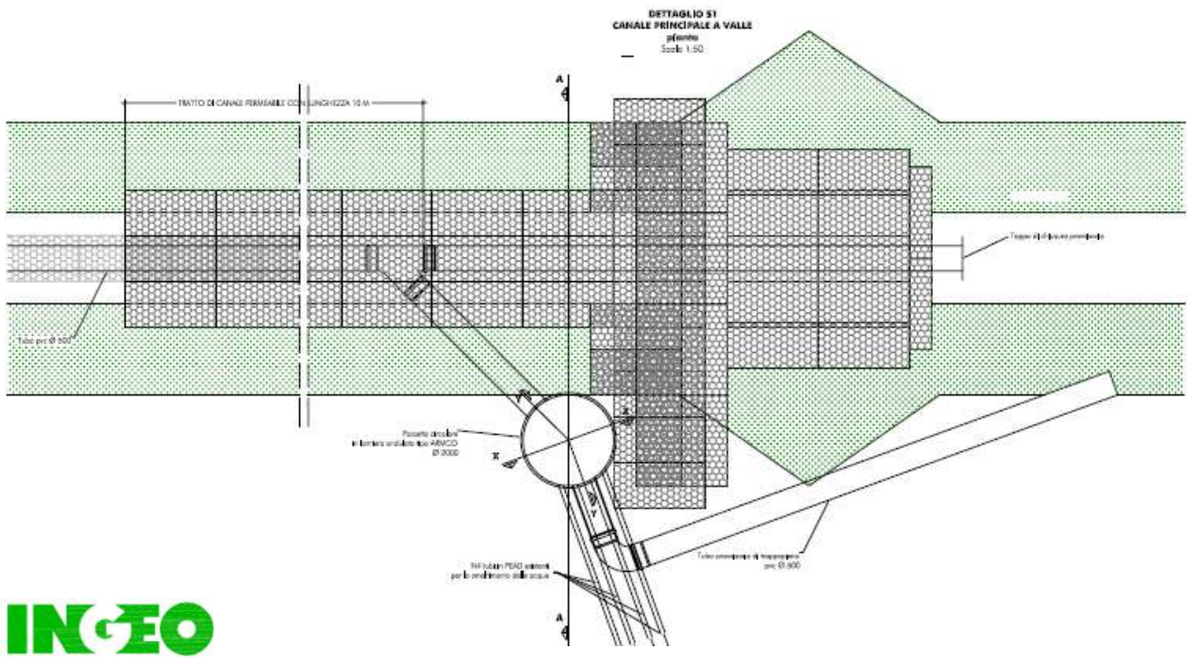


Gabion weir


GEOGRID
6.80
2.00
0.65
0.65
3.00
0.50
1.00
1.00
0.50
1.00
0.50
0.50
1
2
3
4
A
gabbioni h=50cm

Drainage trench and well





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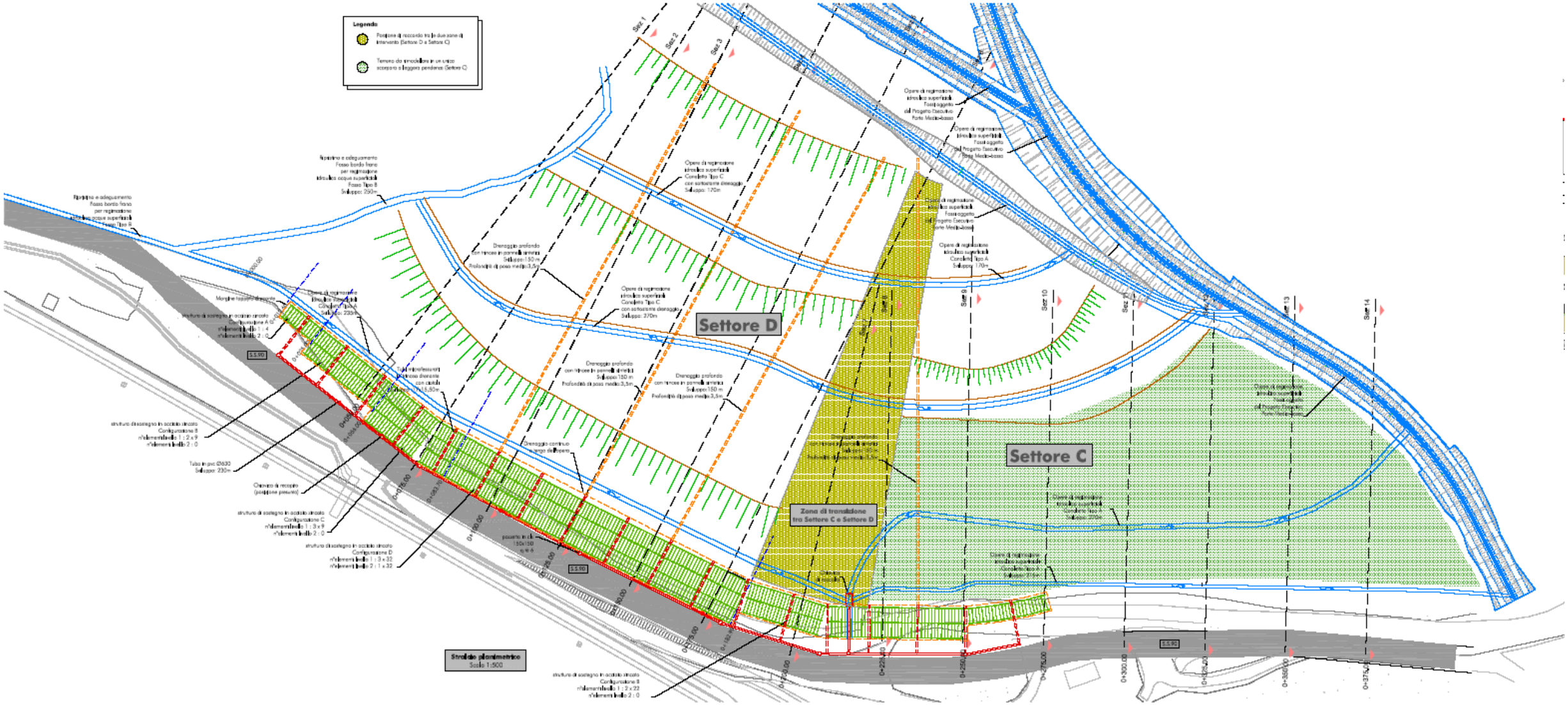
PROTEZIONE CIVILE NAZIONALE

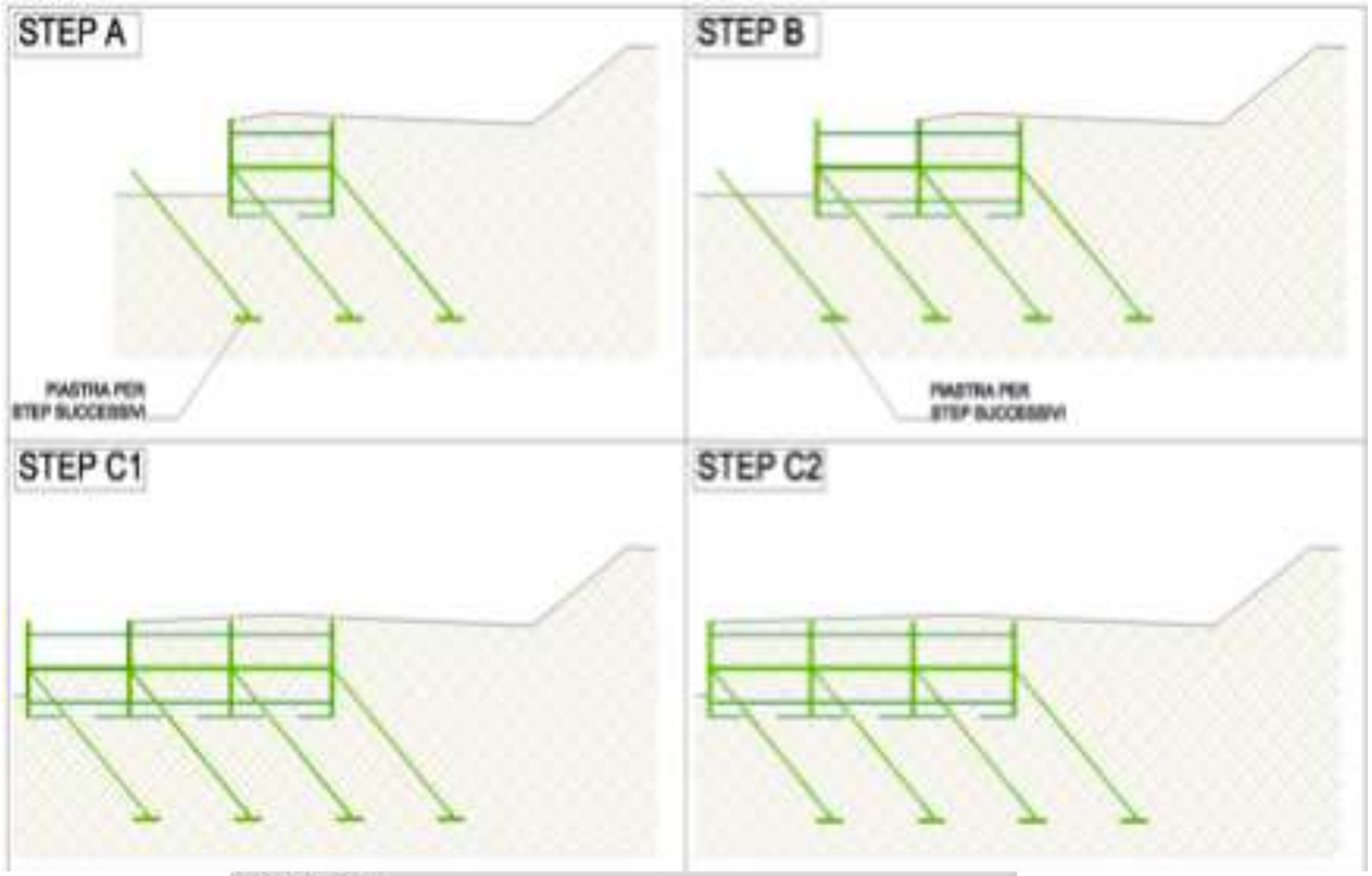
Lower sector stabilization

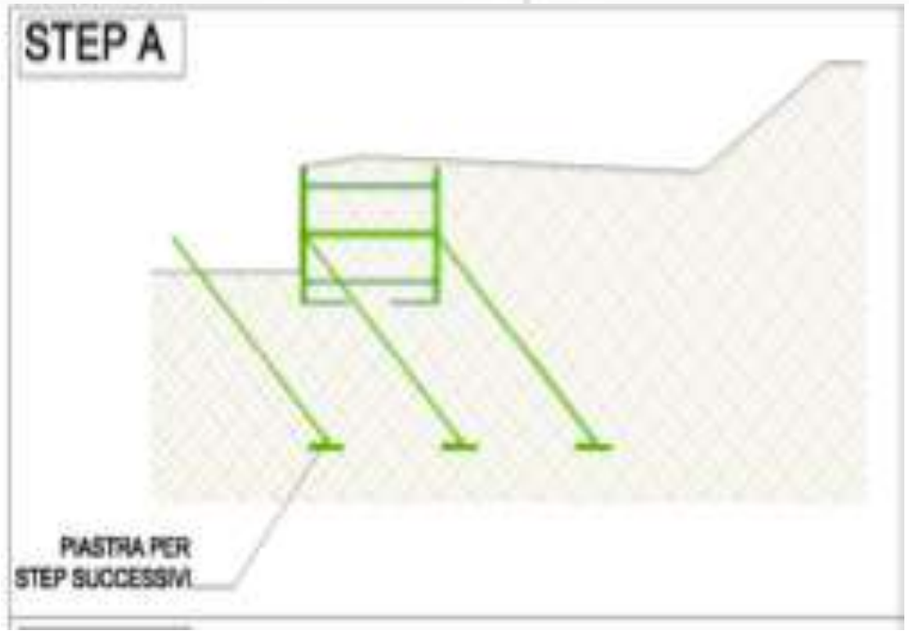


Gabion toe drain and buttressing

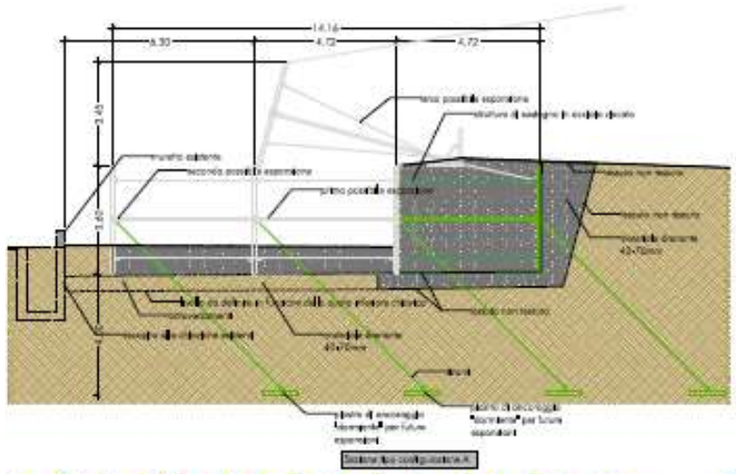
- Gabion modules 3.6 x 3.1 x 4.7 m
- Anchored concrete plates

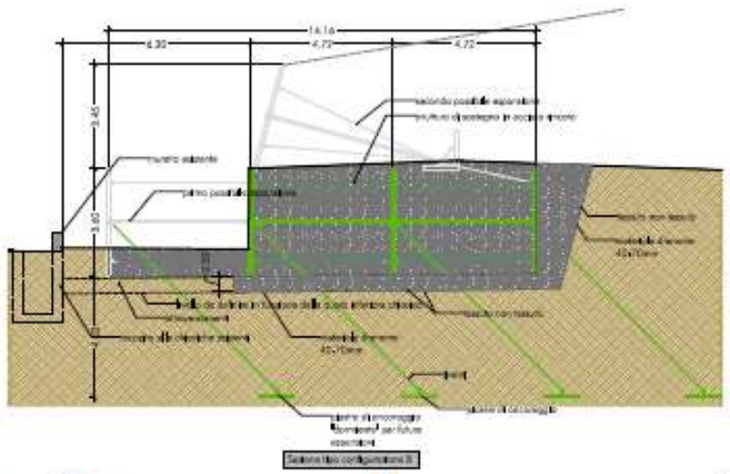
- **Toe buttressing**
- **Drainage**
- **Support and reinforcement**

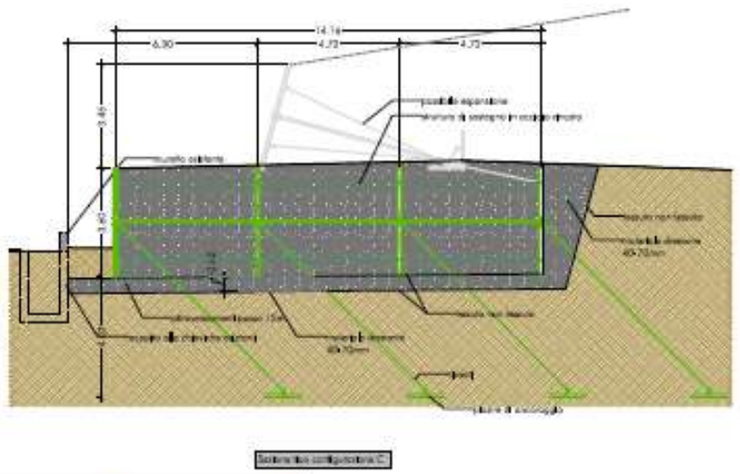


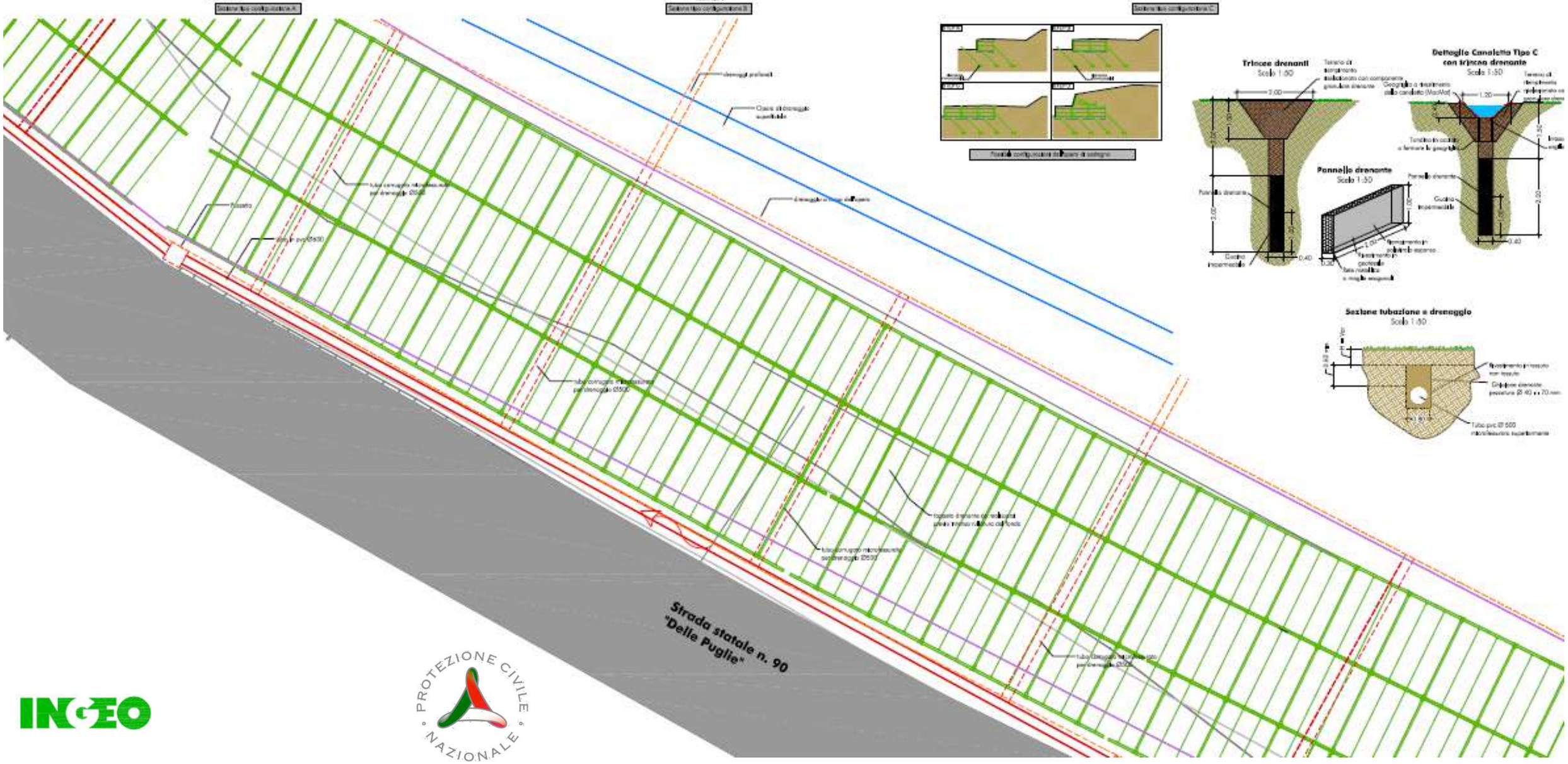


Gabion toe drain and buttressing

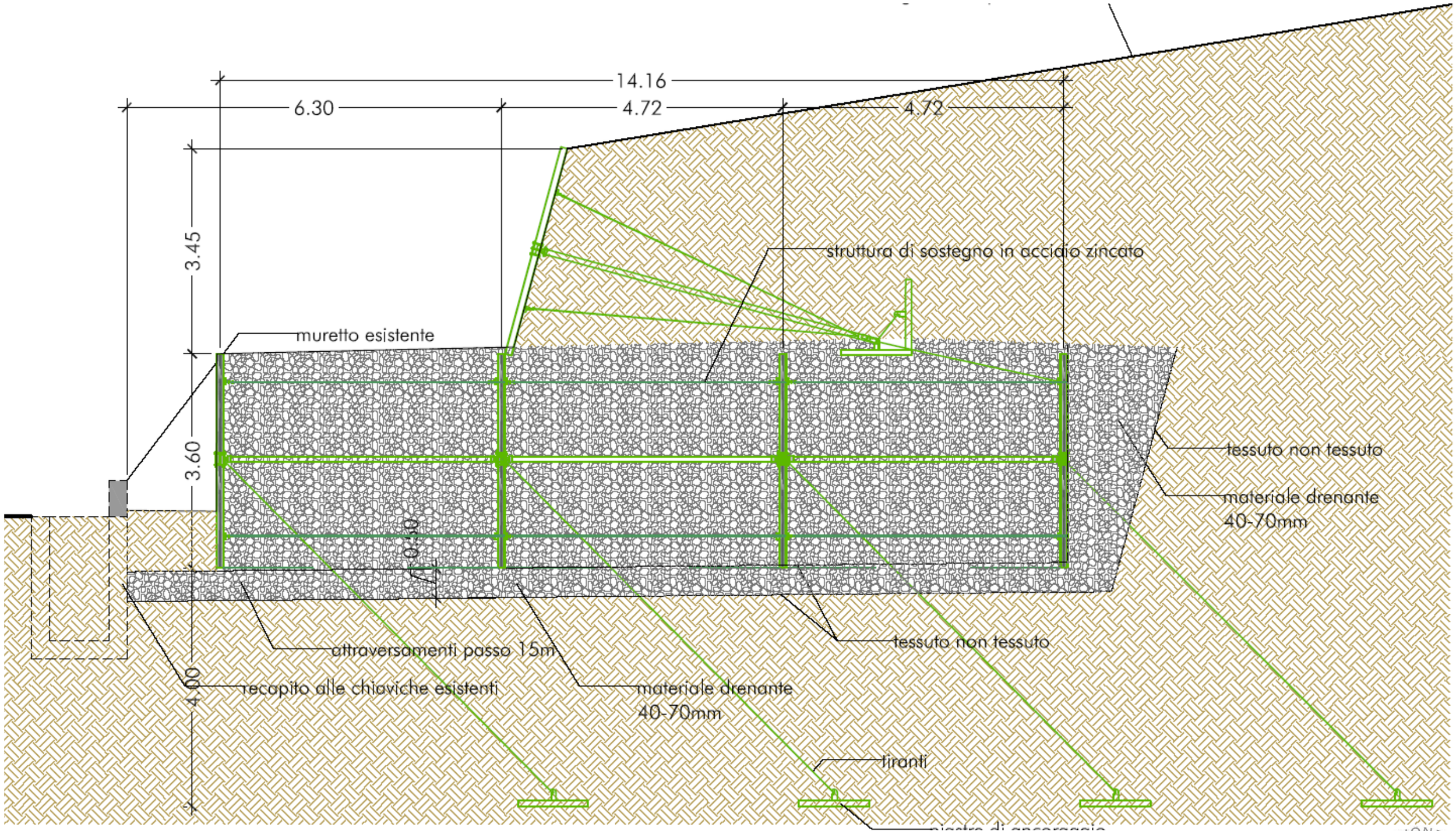




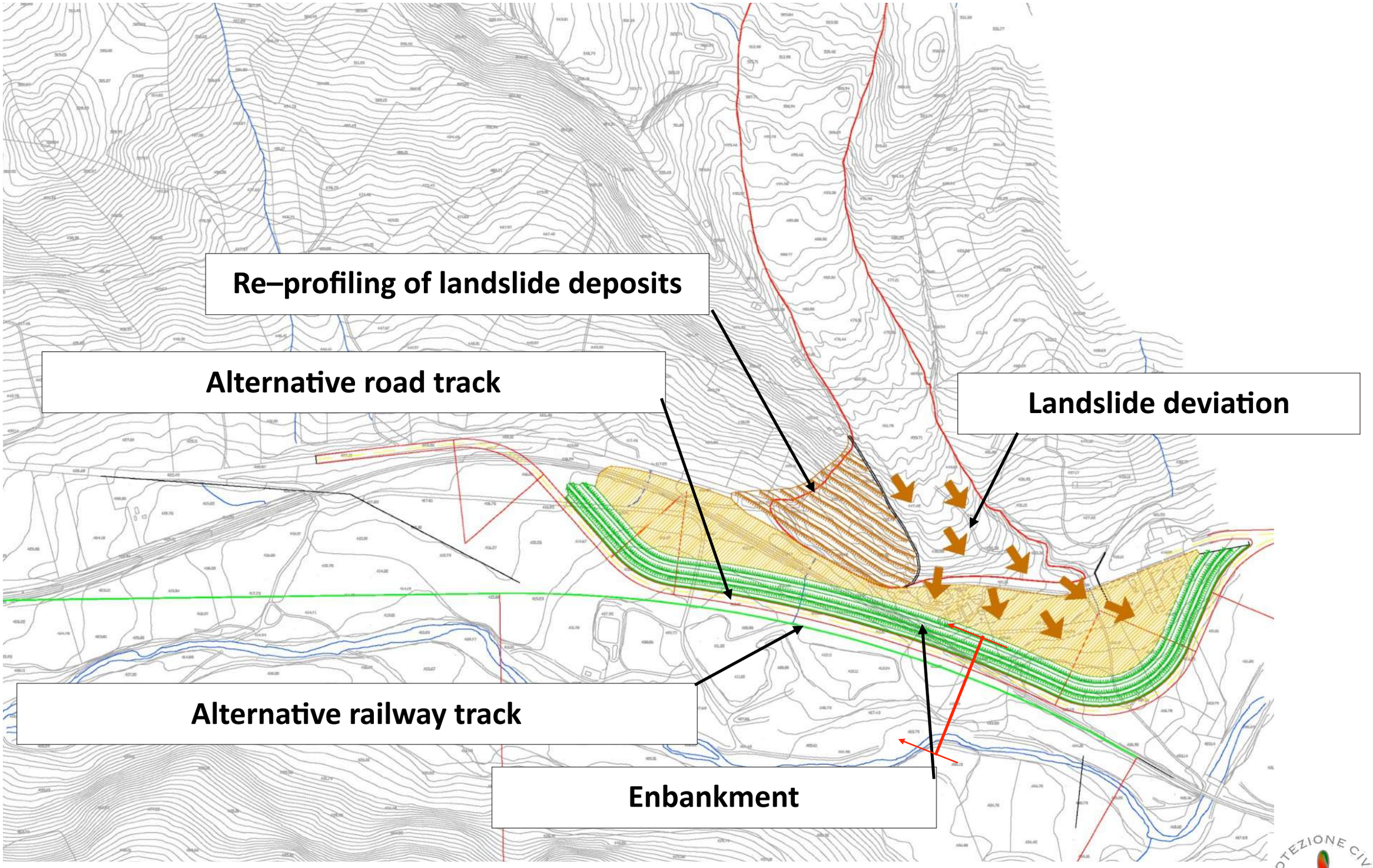




Gabion toe drain and buttressing



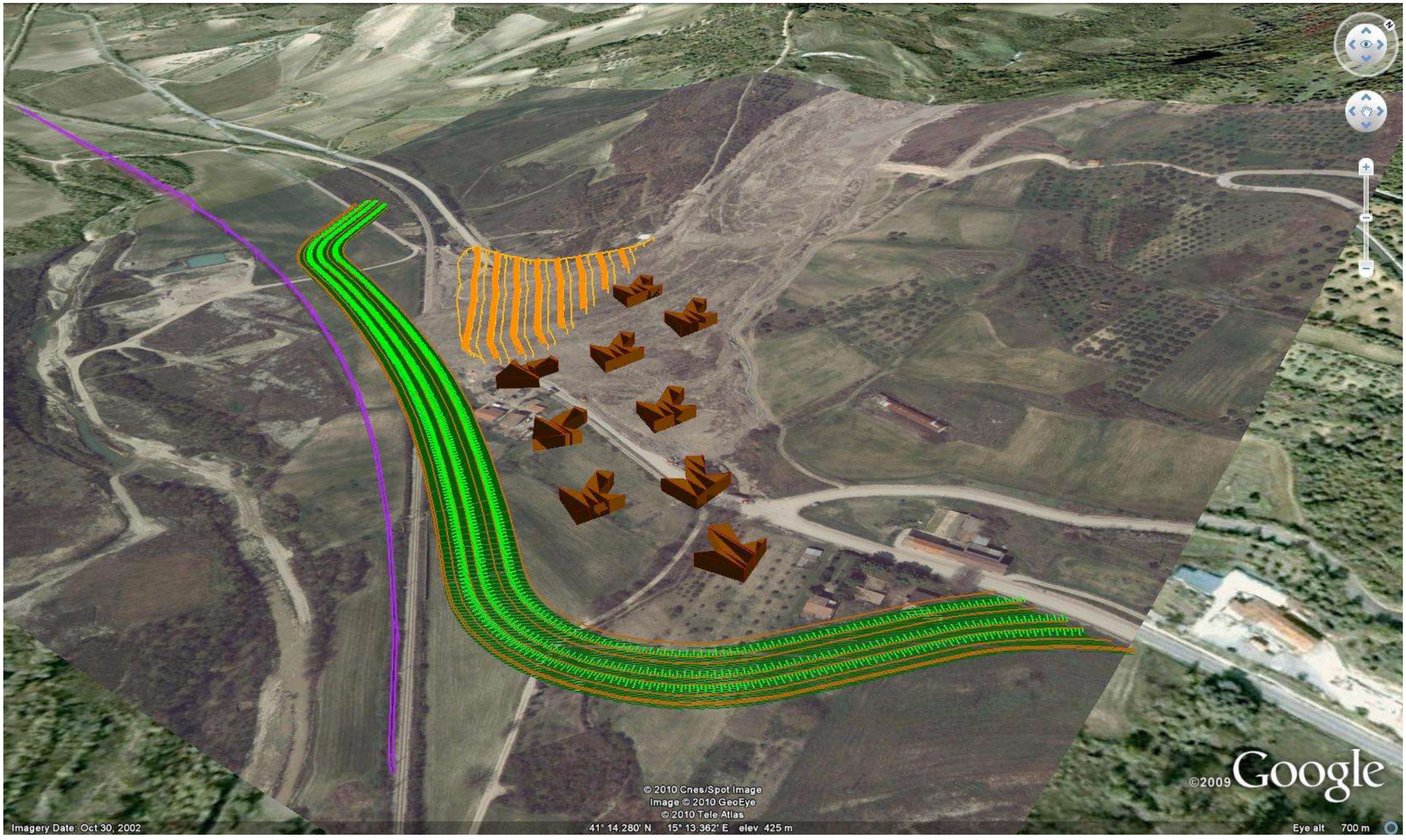
Proposal for infrastructure protection (1st solution)



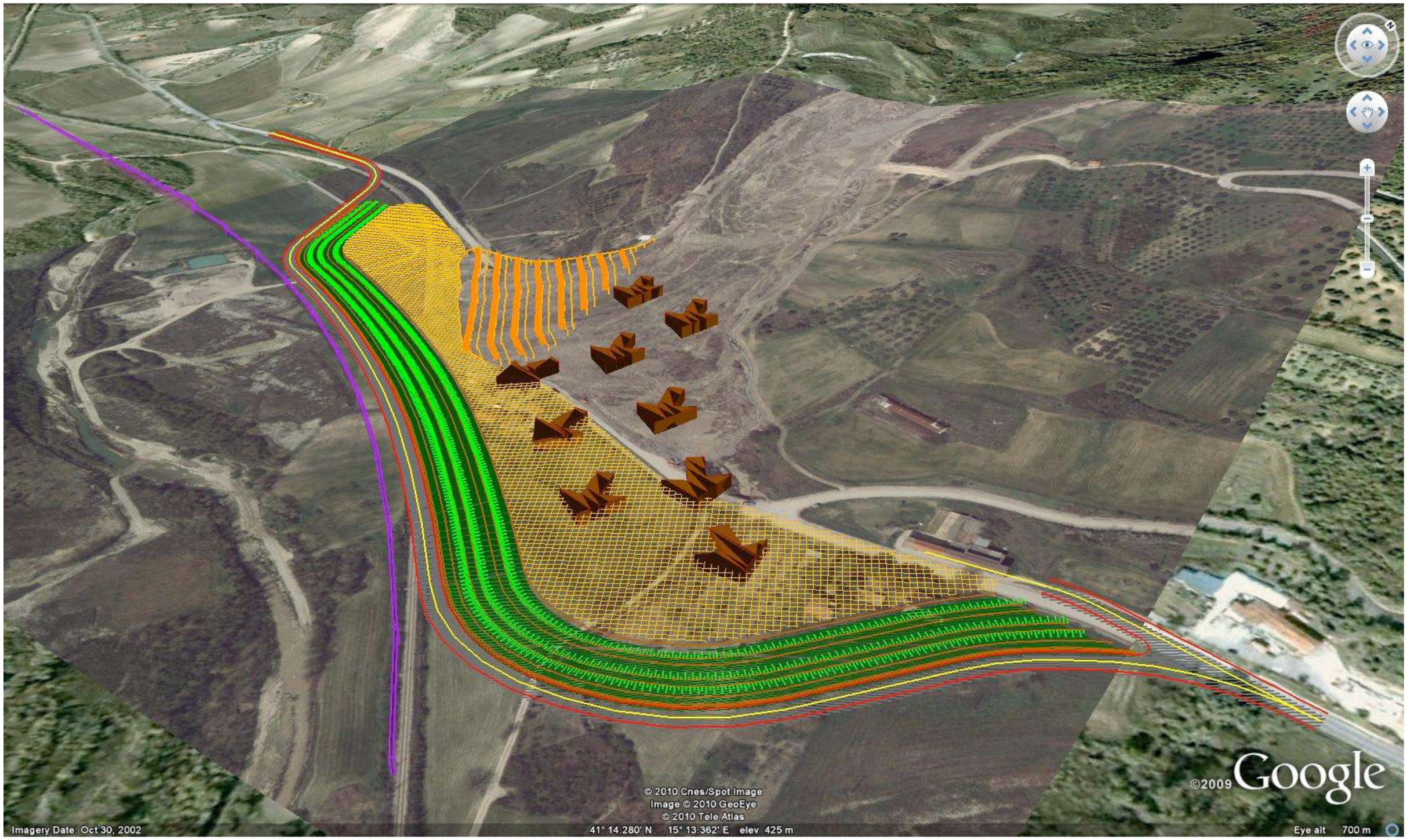
1. Profiling and landslide deviation

2. New railway track

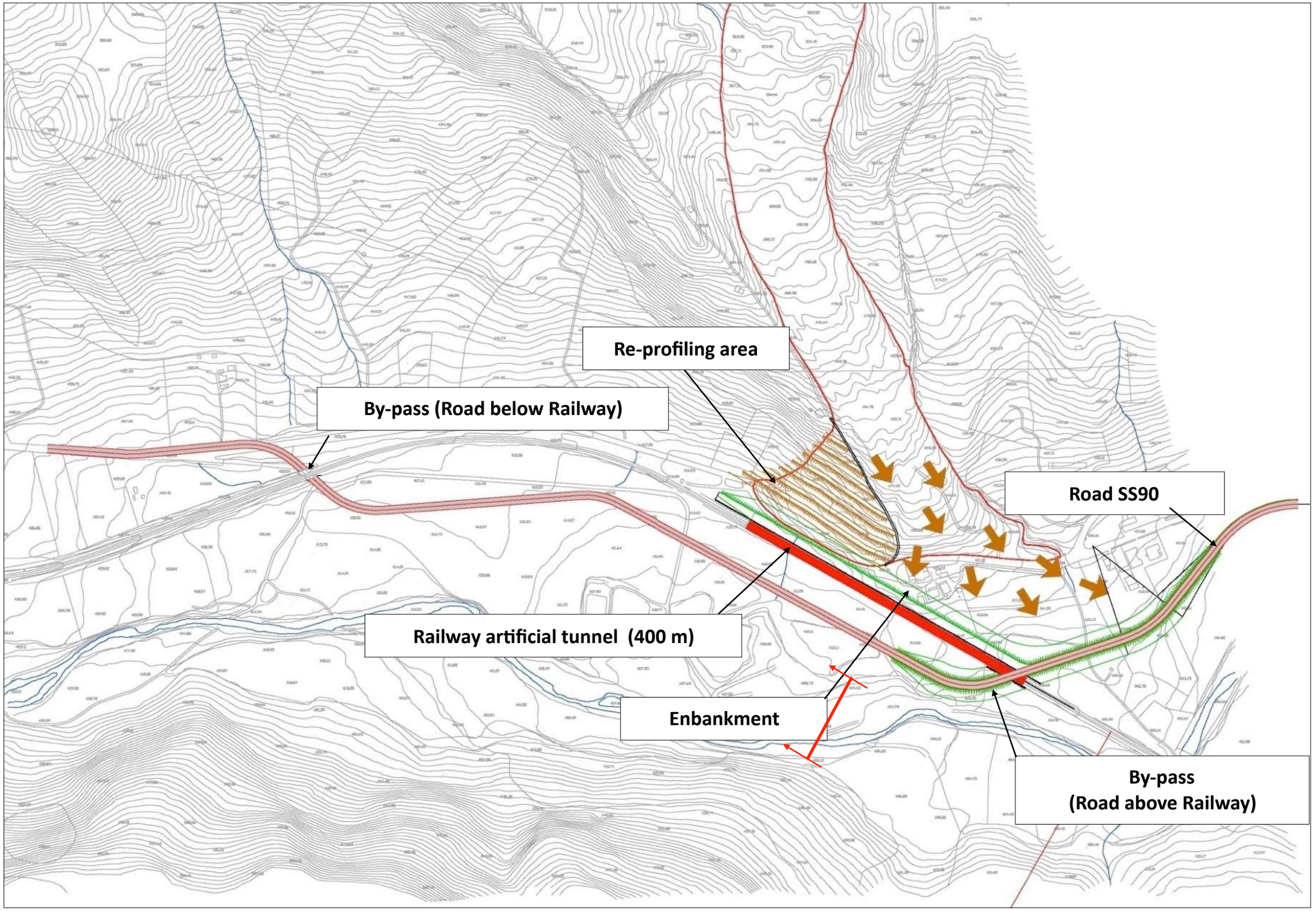
3. Embankment



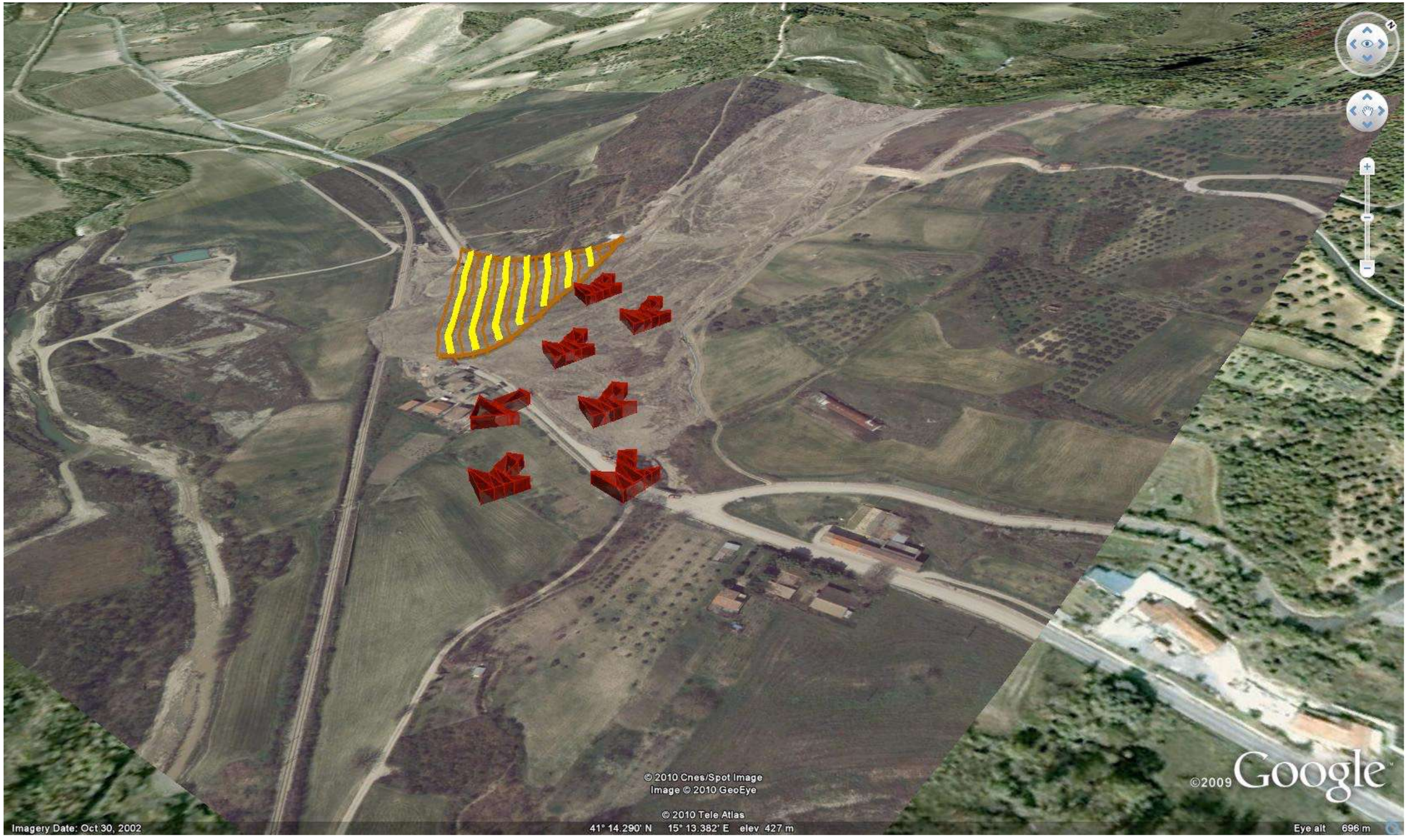
4. New road track



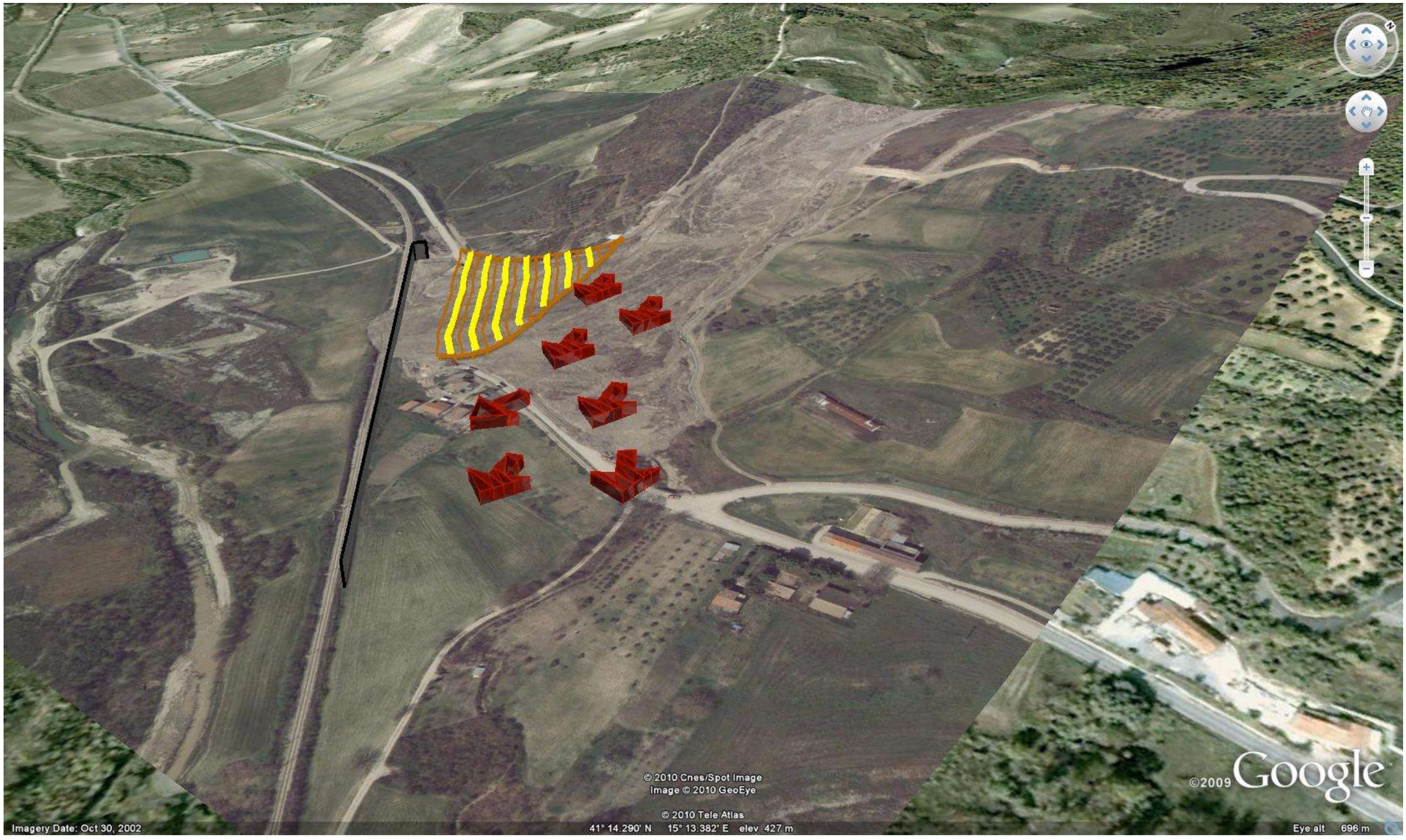
Proposal for infrastructure protection (2nd solution)



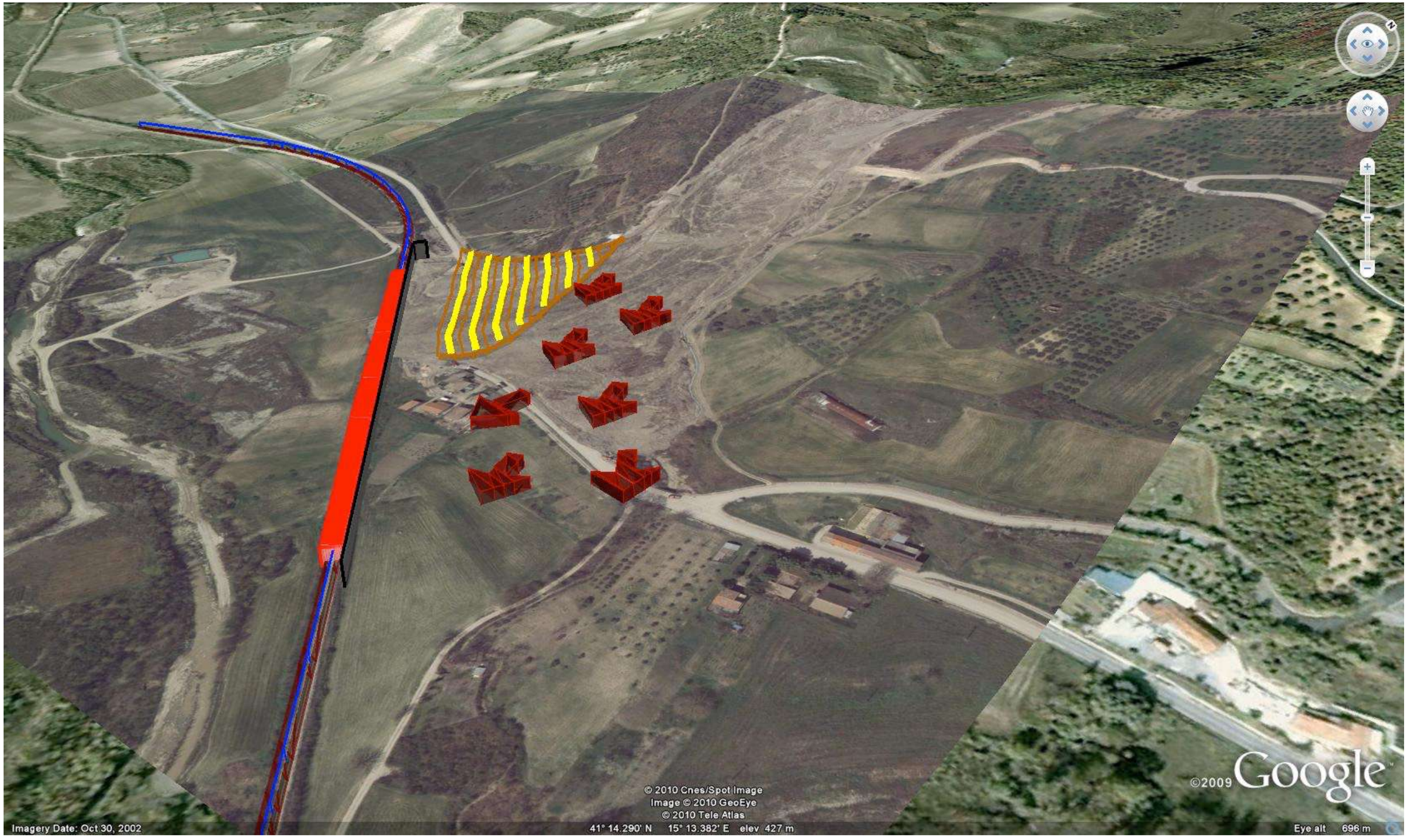
1. Profiling and landslide deviation



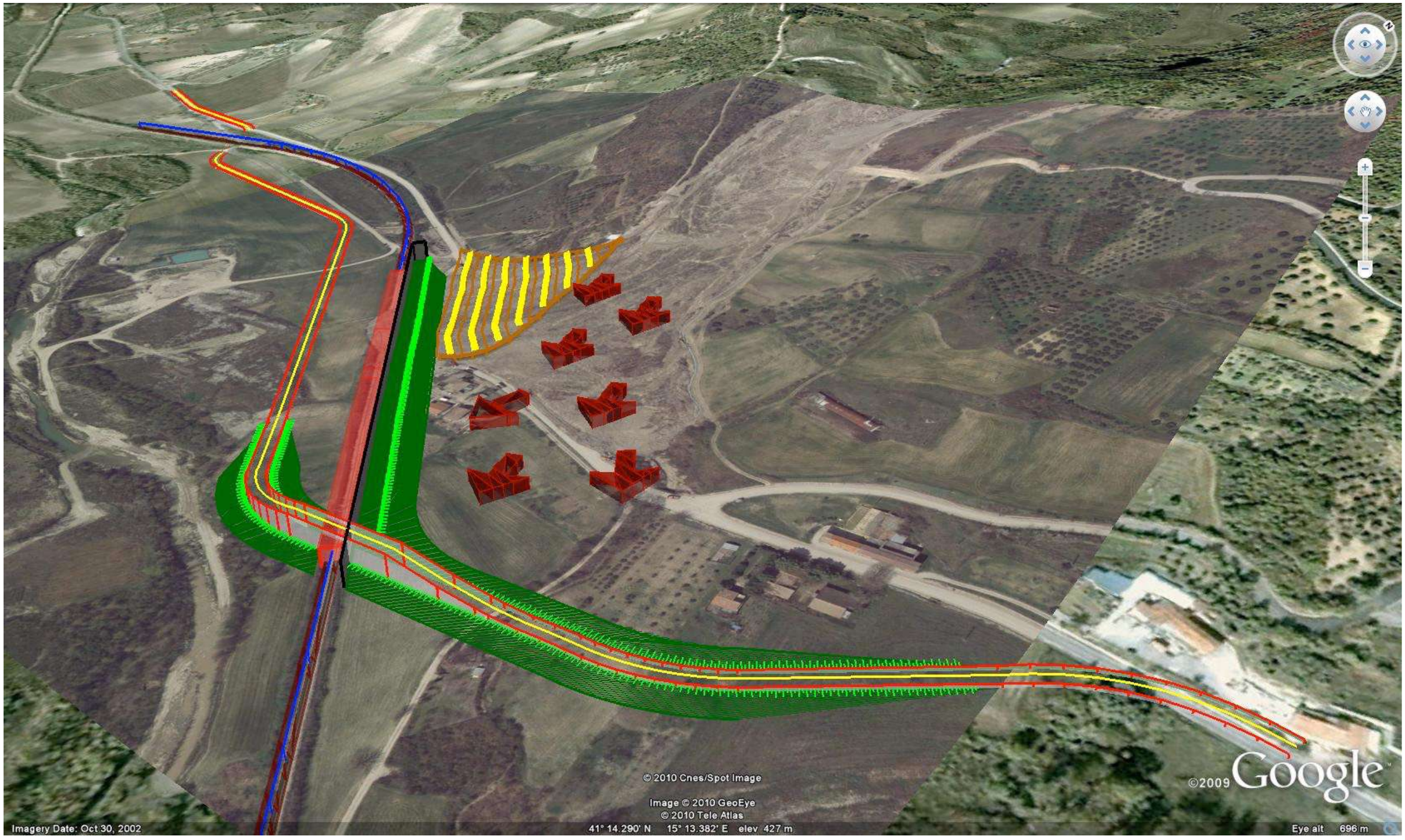
2. Railway protection wall



3. Artificial tunnel for the railway



4. New road track



16 months after

May 2010

September 2011

Conclusion

- Support to emergency management
- Problem solution in less than 16 months
- Monitoring with new tecnologies for fast track diagnosis and design
- Continuous monitoring of the effectiveness of stabilization works
- Observational design method based on radar monitoring
- Landslide stabilization based on drainage and engineering solutions at low environmental impact
- Two solutions for the protection of the infrastructures in the valley bottom

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GB-InSAR monitoring and observational method for landslide emergency management: the Montaguto earthflow (AV, Italy)

Federica Ferrigno, Giovanni Gigli, Riccardo Fanti, Emanuele Intrieri, and Nicola Casagli

Department of Earth Sciences, University of Florence, Via La Pira 4, Florence, Italy

Correspondence to: Federica Ferrigno (federica.ferrigno@unifi.it)

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