January 11, 2022

MEMORANDUM

FOR : **THE OIC-REGIONAL DIRECTOR**
Concurrent Chief, Geosciences Division
This Office

FROM : **MERVIN DAVE T. VIRREY**
Geologist

JOHN ROED T. SALIG
Geologist

SUBJECT : **GEOLOGICAL SITE SCOPING REPORT FOR THE PROPOSED RECLAMATION SITE OF THE CORON BAY DEVELOPMENT PROJECT LOCATED IN THE MUNICIPALITY OF CORON, PROVINCE OF PALAWAN**

I. INTRODUCTION

In response to the request of the Provincial Government of Palawan, the undersigned technical personnel of the Mines and Geosciences Bureau (MGB) MIMAROPA Regional Office conducted a Geological Site Scoping (GSS) at the site of Coron Bay Development Project located along the coastal areas of Barangay Poblacion and other nearby barangays in the Municipality of Coron, Province of Palawan. The field assessment was conducted on December 2-4, 2021, through the assistance of the representatives of the project developer, 428 Hi-Tech Group, Inc.

The conduct of GSS is a requirement to the conditional endorsement issued by MGB MIMAROPA, which will be transmitted by the DENR MIMAROPA Regional Executive Director to the DENR Central Office for the issuance of Area Clearance by the Honorable Secretary.

The main objective of the field survey is to identify potential geologic hazards present in the area based on different factors such as geology and tectonic setting. The survey consisted mainly of flood susceptibility assessment, slope stability analysis and preliminary geologic inspection.

Field data obtained during the inspection were supported with relevant geologic information acquired from existing records and research works.

II. PROJECT DESCRIPTION

The Coron Bay Development Project is a 50-hectare reclamation project which is aimed to be a world-class Tourism Estate. It will serve as a Convergence Area where all amenities catering to tourists are clustered. It will have commercial and recreational centers, tourism facilities, government installations, and bay-walk and boulevard.

The project is estimated to cost P2,656 million – P2,256 million for the raw land reclamation, and P400 million for the horizontal development. The reclamation will have a total length of 2.8 kilometers with an average width of 200 meters. As part of the initial phase, 10 hectares was reclaimed and developed. Recently, another 20 hectares of raw land reclamation has been completed from the proposed 40 hectares reclamation area (Photo 1).

III. LOCATION AND ACCESSIBILITY

The Coron Bay Development Project site is located along the coast and immediate offshore area of Poblacion 1 to 5, and a part of Barangay Tagumpay in Municipality of Coron, Palawan (Figure 1). Coron, together with the Municipality of Busuanga, are both situated in Busuanga Island. The former comprises the eastern part of the island while the latter covers the western part. The project site is approximately centered at the geographic coordinates 120° 12' 1.132'' East and 11° 59' 52.725'' North (Luzon 1911 Projection).

From Manila, the Coron Bay Development project can be reached via air transport (40-minute travel) going to Francisco B. Reyes Airport in Coron, Palawan. Then, a 40-minute land travel along the Coron-Busuanga provincial road going to Coron proper is needed to reach the actual project site. It is accessible by all types of land transportation.

IV. TOPOGRAPHY AND DRAINAGE

The project site of Coron Bay Development Project is surrounded by rolling hills to mountainous terrain, with elevation averaging 150 meters above mean sea level (amsl). The highest point visible from the site is the peak of Mt. Tapyas with estimated elevation of 210 meters amsl (Photo 2). It is located about 800 meters north of the site.

The municipality of Coron has three (3) major river basins namely, Labangan River Basin, Pangayaran River Basin, and Borac River Basin (Figure 2). However, there are a number of unnamed minor river basins.

The nearest river channel from the project site is the Bacbac-Insikay River, located towards its north with an approximate distance of 2 kilometers. It drains a minor watershed, informally named herein as Bacbac-Insikay River Basin, into the Dipulao Sea on its south.

V. GENERAL GEOLOGY

The municipality of Coron is underlain by three (3) rock formations, namely: (1) Liminangcong Formation (chert), (2) Guinlo Formation, and (3) Coron Formation (Coron Limestone). Briefly described below, from oldest to youngest, are the lithologies of the aforesaid rock formations based on Mines and Geosciences Bureau (MGB) (2010).

Liminangcong Formation is made up of complexly folded and faulted hematite-bearing chert intercalated with black slate and reddish, bedded tuff which exposures are found at several sites in Busuanga Island. This formation is oldest from the rest, aged from Late Permian to Late Jurassic.

Coron Formation, aged from Late Triassic to Late Jurassic, consists dominantly of limestone with local interbeds of sandstone and shale or at places mainly carbonaceous clastic rocks and overlying Liminangcong Formation.

Lastly, Guinlo Formation, aged from Late Jurassic to Early Cretaceous, is comprised of mainly weakly metamorphosed massive, coarse-grained sandstone. The sandstone with few conglomerate interbeds exposed at Ariara, Cagbatang and Inoulay islands in the southern Calamian Island. The conglomerate is usually less than one meter thick, with clasts of quartz and siliceous rocks. The sandstone is white to gray and exhibits cross stratification.

Overlying these rock formations is the Quaternary Alluvium, which can be found in low-lying areas and comprised of loosely consolidated deposits of clays, silts, sand, pebbles, and cobbles that occupy river floodplains and almost flat-lying terrain.

The rocks in the vicinity of the project site belong to Liminangcong Formation and Quaternary Alluvium (Figure 3). The fill materials that were used in the reclamation were reported to come from a nearby quarry area, which is most likely part of Liminangcong Formation.

VI. GEOLOGIC HAZARDS

A. MASS WASTING HAZARD

Mass wasting refers to the downslope movement of soil and/or rock debris due to gravity (Highland and Bobrowsky, 2008). This is usually triggered by extended rainfall events, and occasionally by sudden ground shaking. Steep slopes, intense physical and chemical weathering, and weak soils are important factors that affect the occurrence of mass wasting events.

The project site is situated along the coast and is bounded on its north by a combination of narrow coastal plains, and rolling to mountainous terrain (Photo 2). The average elevation of the coastal plain in the vicinity of the site is around 3 meters above mean sea level (amsl), with a mean slope of roughly 5 degrees. Meanwhile, the highest elevation on the mountainous terrain nearest the site is approximately 195 meters amsl, with maximum slope of about 50 degrees. Based on the results of the 1:10,000-scale geohazard mapping activities conducted by MGB MIMAROPA in 2014, the coastal plain has low to nil susceptibility to landslide and other forms of mass movement while the mountainous terrain has moderate to high susceptibility to the same (Figure 4).

Mass movements may also occur in relatively flat areas as manifested by general subsidence and differential settlement (Aurelio, 2004). Naturally occurring recent deposits or poorly compacted back-filled areas are prone to these movements (Aurelio, 2004).

B. HYDROLOGIC HAZARDS

Hydrologic hazards refer to disastrous phenomena that involve the presence and distribution of water, usually occurring near bodies of water. These include riverine and coastal flooding wherein water overflows from waterways and inundates the usually dry land, and typically results from excessive rainfall and/or storm surges.

The nearest active channels from the site are two minor streams — one located about 1.1 kilometers to its northwest, and the other positioned around 400 meters to its southeast. The nearest major stream is Bacbac River which is situated approximately 2 kilometers to the north. Based on the results of the 1:10,000 scale geohazard mapping activities conducted by the MGB MIMAROPA in 2014, the site's significant distance from active river channels makes its susceptibility to riverine flooding nil (Figure 5).

However, as mentioned above, the project site can be found along the coast and extends a few hundred meters offshore. Based on the flood susceptibility map (Figure 5), the original coast was identified to have high susceptibility to flooding that may be caused by various coastal processes, such as storm surges.

Another hazard that may affect the project site is coastal erosion. Land reclamation changes the coastal configuration which may modify oceanographic parameters (Magesh & Krishnakumar, 2019). This may in turn lead to enhanced coastal erosion like what was observed in other reclaimed areas (e.g., Magesh & Krishnakumar, 2019).

C. SEISMIC-RELATED HAZARDS

The occurrence of seismic-related hazards in an area is highly dependent on the proximity to earthquake generators (e.g., faults, subduction zones, collision zones) and on the subsurface lithology.

Palawan is considered a seismically inactive region because of its distance from trenches, and the lack of active faults in the region. Based on the Distribution of Active Faults and Trenches Map (Figure 6) prepared by the Philippine Institute of Volcanology and Seismology (PHIVOLCS) in 2019, the nearest earthquake generator to the site is a segment of Manila Trench situated roughly 100 km to its northeast. While there is low seismic risk in the area, seismic activities still occur although they are not as frequent and as strong (in terms of magnitude) as those in regions traversed by active faults and trenches. In the 2014-2017 PHIVOLCS seismic maps, a number of shallow (0-35 km), low-magnitude earthquakes were recorded around Busuanga Island (Figure 7-11).

Depending on the energy released, and on the distance and depth of the source, ground shaking may affect the project site and its immediate vicinity. Associated with ground shaking are liquefaction (Figure 12) and consolidation settlement hazards. Reclamation projects are highly prone to these hazards because of the unconsolidated nature of the fill materials.

Moreover, the area may still be vulnerable to tsunamis. Based on the 2007 tsunami hazard map of PHIVOLCS, the occurrence of a 7.9-magnitude earthquake along Manila Trench or an 8.2-magnitude earthquake along Negros Trench may cause a tsunami that will inundate the coastal areas of Coron, with an inferred tsunami wave height of 6.0 meters at the coastline (Figure 13).

More detailed and site-specific assessment of earthquake-related hazards may be requested from PHIVOLCS.

VII. CONCLUSION & RECOMMENDATIONS

In view of the above observations, the proponent is advised to submit an Engineering Geological and Geohazard Assessment Report (EGGAR). The EGGAR must contain an in-depth geologic study of the site and its immediate surroundings, discussing all the identified geohazards with recommendations of possible mitigation measures to reduce, if not totally eliminate, the impact of these geohazards to the project. The EGGAR must take into consideration the final design of the project.

Because of the location of the project site along the coast and on the immediate offshore area, discussion about coastal hazards, such as coastal flooding, coastal erosion, and storm surge hazards must be emphasized in the EGGAR. In the detailed assessment of storm surge hazards, historical occurrences of storm surges in the area must be studied together with available storm surge simulation data. Storm surge inundation computations from established models may be included in the report.

Furthermore, the proximity of the site to rolling and mountainous terrain poses a concern for the possible occurrence of mass movements. The low-lying areas, including the project site, will be the receiver of potential landslide debris. In addition, the unconsolidated fill materials are vulnerable to subsidence and differential settlement. Therefore, a detailed study on mass wasting hazards must be conducted.

Meanwhile, even though the occurrence of earthquakes around Busuanga Island is relatively infrequent, the project site may still experience seismic-related hazards such as ground shaking, liquefaction, and consolidation settlement. In addition, a high-magnitude earthquake originating from Manila or Negros Trench may cause a tsunami that may inundate the project site and adjacent areas. With these, a comprehensive discussion on earthquake generators, and on the degree of susceptibility to seismic-related hazards should be provided in the report.

Detailed geologic and geohazard mapping activities to be conducted in the area should provide baseline data necessary for geotechnical evaluation of the site. Lithological and structural variabilities must be highlighted in the characterization of ground conditions. The available geotechnical data must be incorporated and considered by the EGGAR preparer in the recommendations of the ensuing report. More detailed geotechnical analysis is suggested if excavation depths for the foundation exceed 3.5 meters (Aurelio, 2004).

The EGGAR must be duly signed by a licensed geologist as stipulated in the DENR Memorandum Order 2000-28. The said report must conform with the format specified in the MGB Memorandum Circular 2000-33 to be submitted to EMB MIMAROPA Regional Office together with this Geological Site Scoping Report (GSSR). The EGGAR should provide recommendations on possible mitigation methods to prevent or minimize the perceived impacts of the hazards in the proposed development site. Recommendations from the EGGAR should also address other hazards identified in and around the project area and should not be limited to the findings included in this report. The preparer should discuss his own findings should he found other hazards not covered in this report.

Prepared by:

MERVIN DAVE T. VIRREY
Geologist

JOHN ROED T. SALIG
Geologist

ANNEX 1: FIGURES

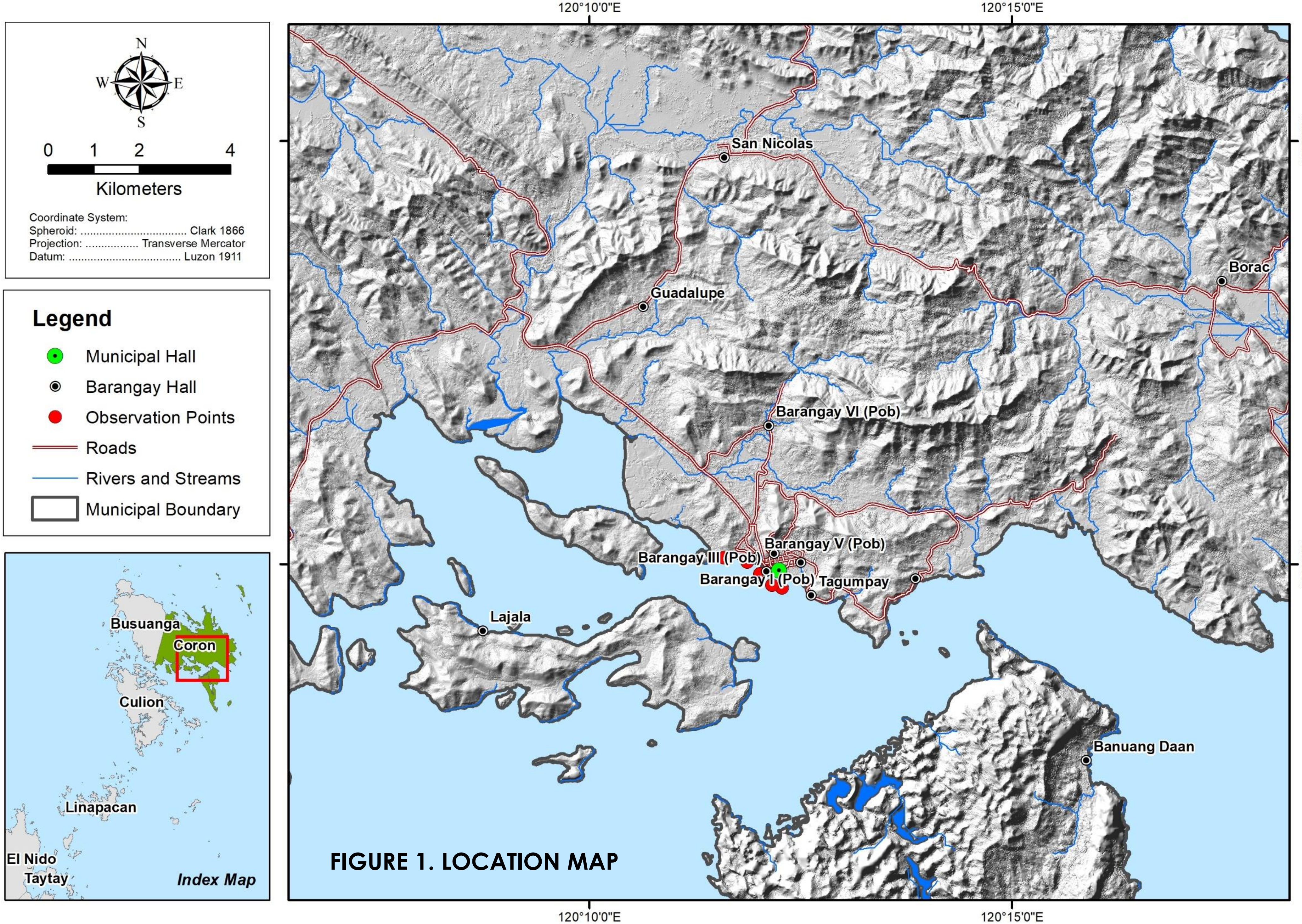


FIGURE 1. LOCATION MAP

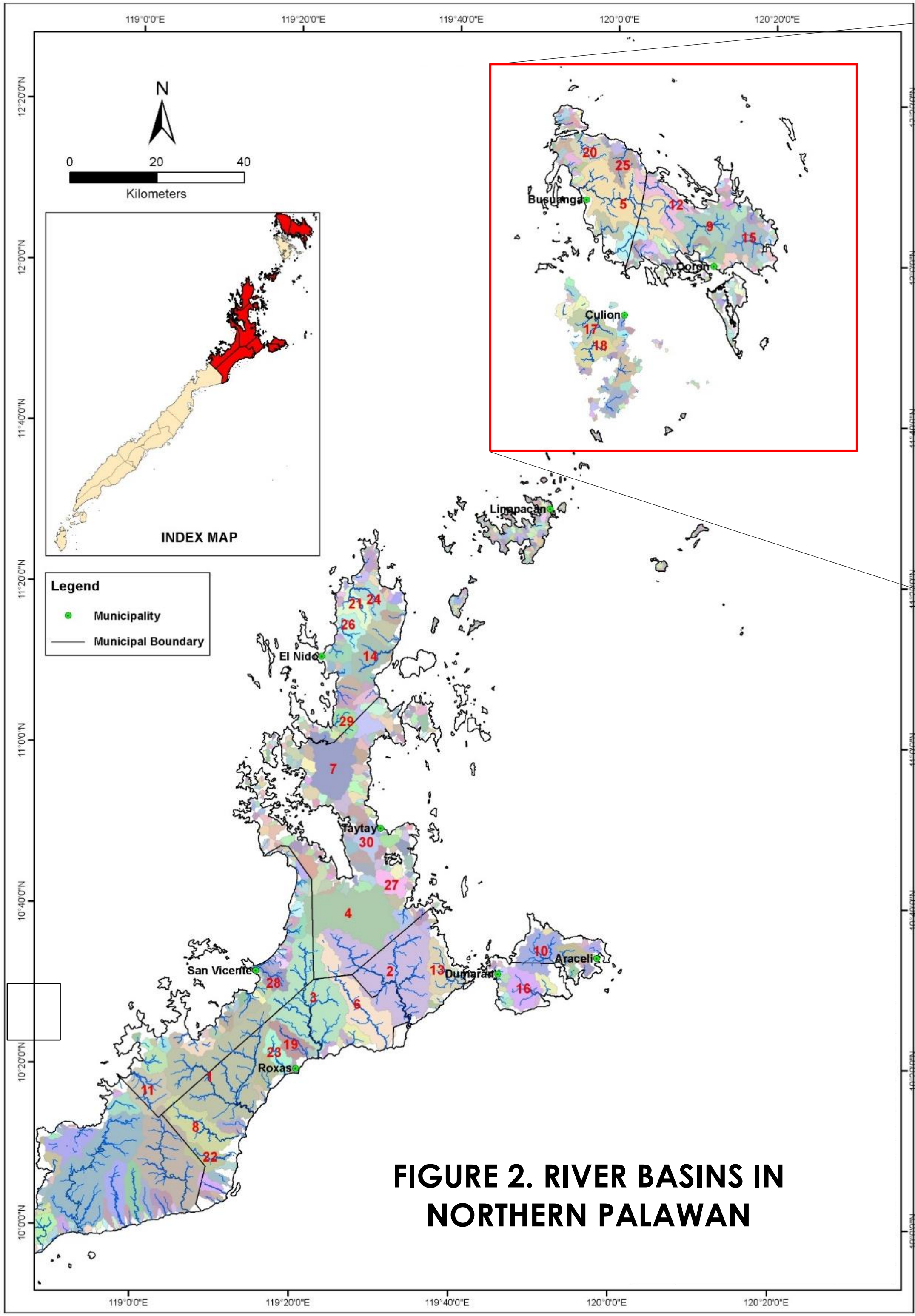
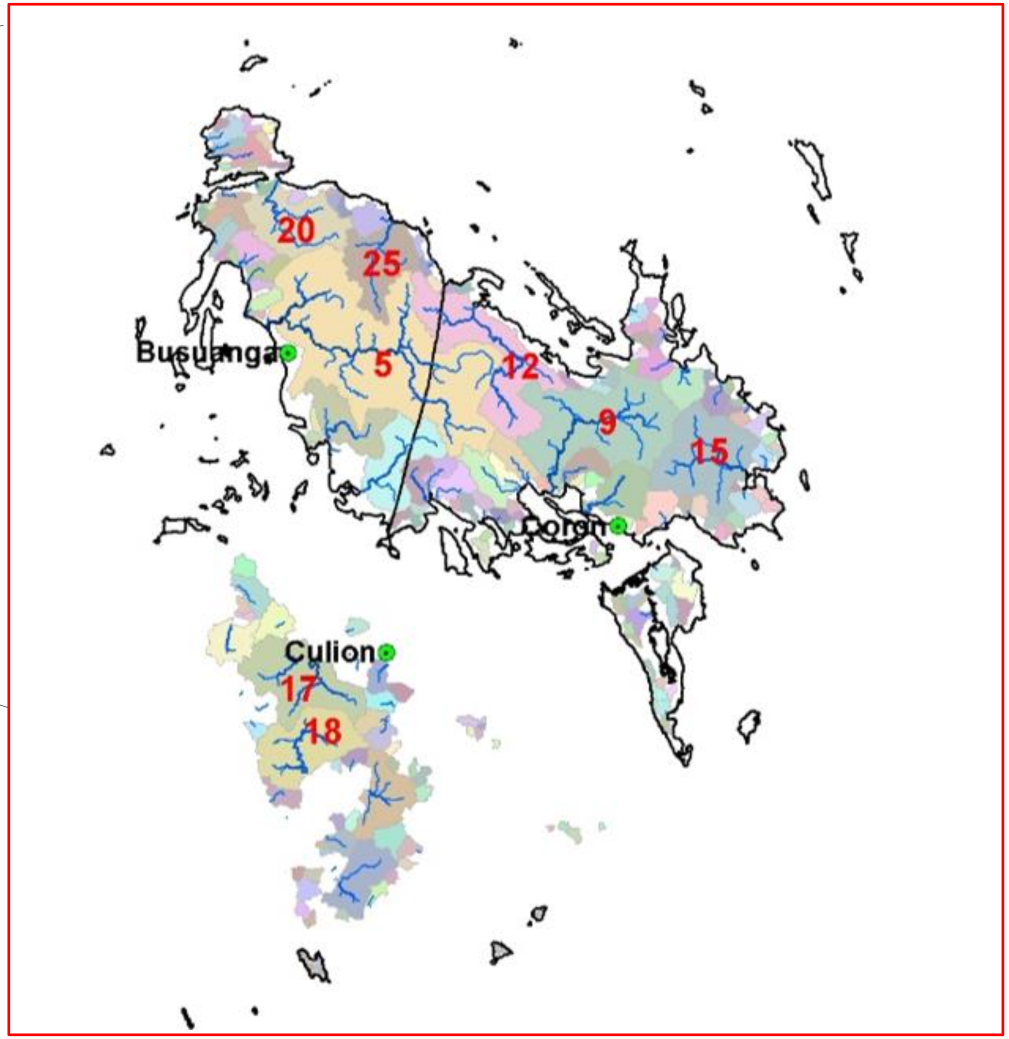


FIGURE 2. RIVER BASINS IN NORTHERN PALAWAN



River Basin Number	Name	Area (KM^2)
1	RIZAL RIVER BASIN	373.56
2	ILIAN RIVER BASIN	342.79
3	BARACBACAN RIVER BASIN	283.80
4	ABONGAN - MALINAO RIVER BASIN	207.42
5	BUSUANGA RIVER BASIN	191.27
6	TARADUNGAN RIVER BASIN	135.92
7	CATABAN RIVER BASIN	125.98
8	CARAMAY RIVER BASIN	96.31
9	LABANGAN RIVER BASIN	88.09
10	BOLOG RIVER BASIN	74.50
11	CARURAY RIVER BASIN	74.48
12	PANGAYARAN RIVER BASIN	66.66
13	LEGET RIVER BASIN	61.51
14	DEVIL RIVER BASIN	60.01
15	BORAC RIVER BASIN	56.99
16	CALASAG RIVER BASIN	56.70
17	CARIGMATAN RIVER BASIN	49.93
18	MARAMPILAN RIVER BASIN	42.80
19	TAGBULAN - MINARA RIVER BASIN	42.15
20	DITIPAC - CHINABAYAN RIVER BASIN	39.45
21	BAROTUAN RIVER BASIN	39.06
22	TULARIQUIN RIVER BASIN	37.09
23	UMALAD RIVER BASIN	35.77
24	TABERNA RIVER BASIN	34.55
25	BANALUAN RIVER BASIN	34.37
26	QUINAWAGAN RIVER BASIN	33.54
27	BALINATOG RIVER BASIN	29.95
28	INANDENG RIVER BASIN	29.17
29	ABERAWAN RIVER BASIN	29.03
30	ENBARCADERO RIVER BASIN	28.83

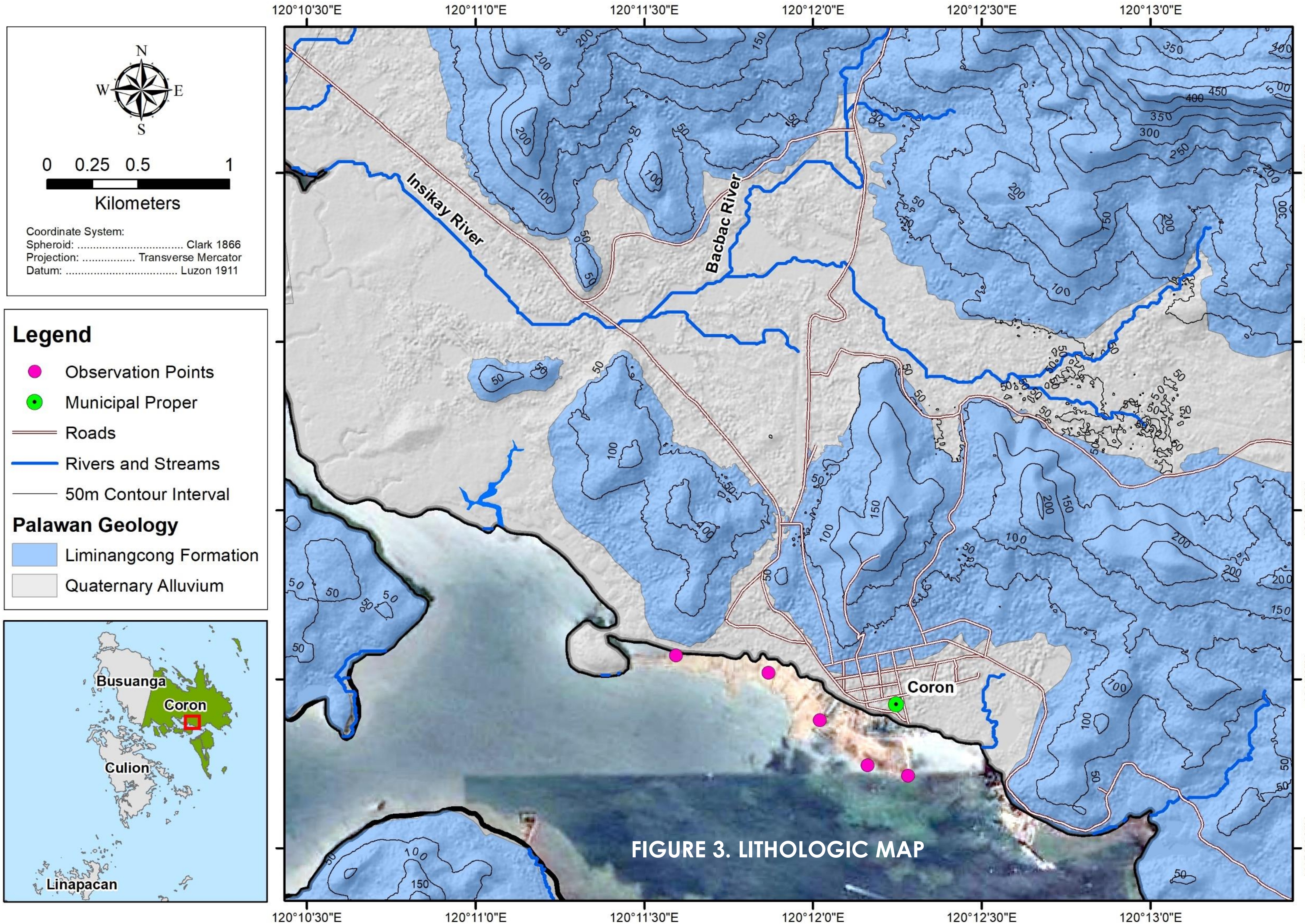


FIGURE 3. LITHOLOGIC MAP

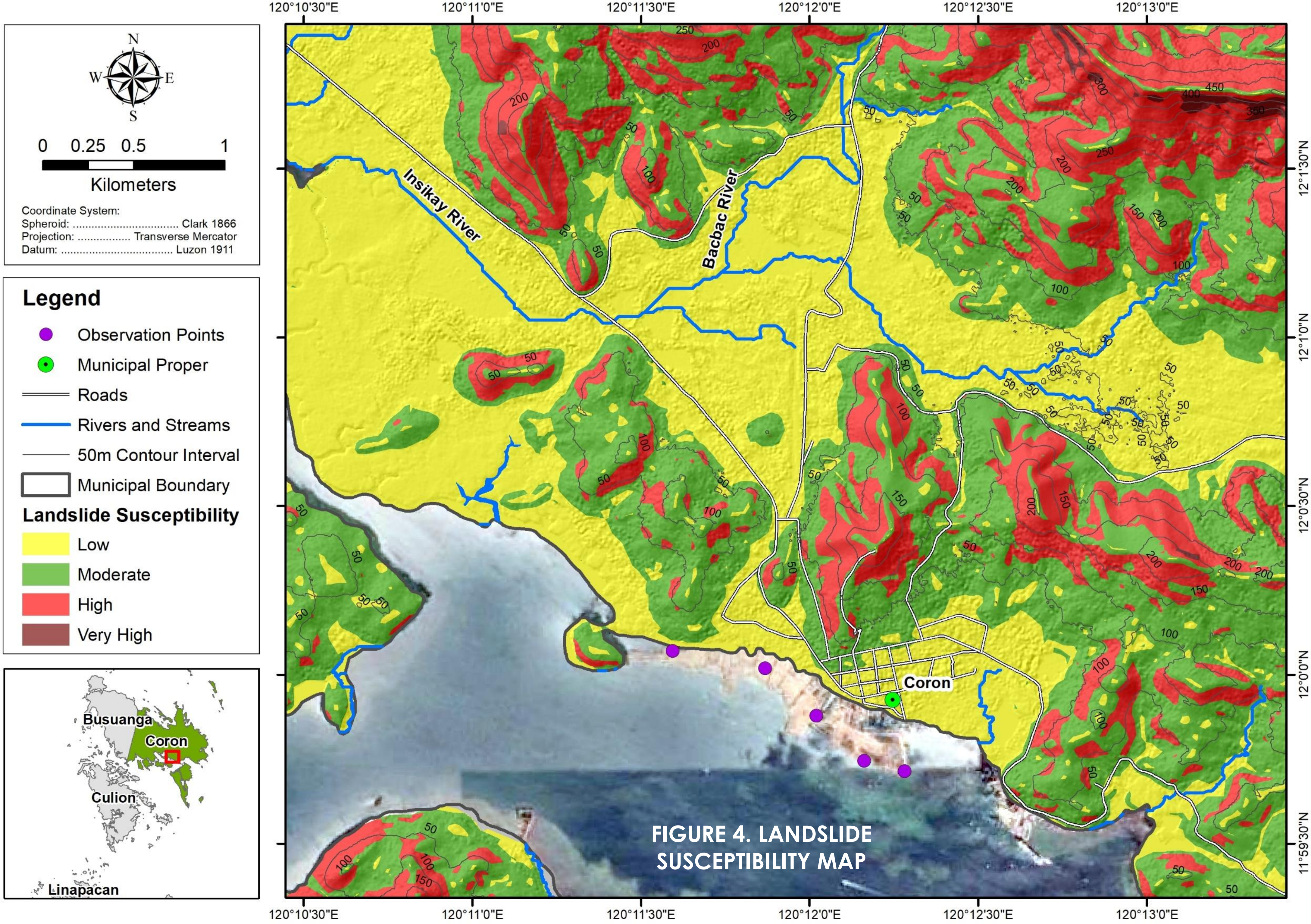


FIGURE 4. LANDSLIDE SUSCEPTIBILITY MAP

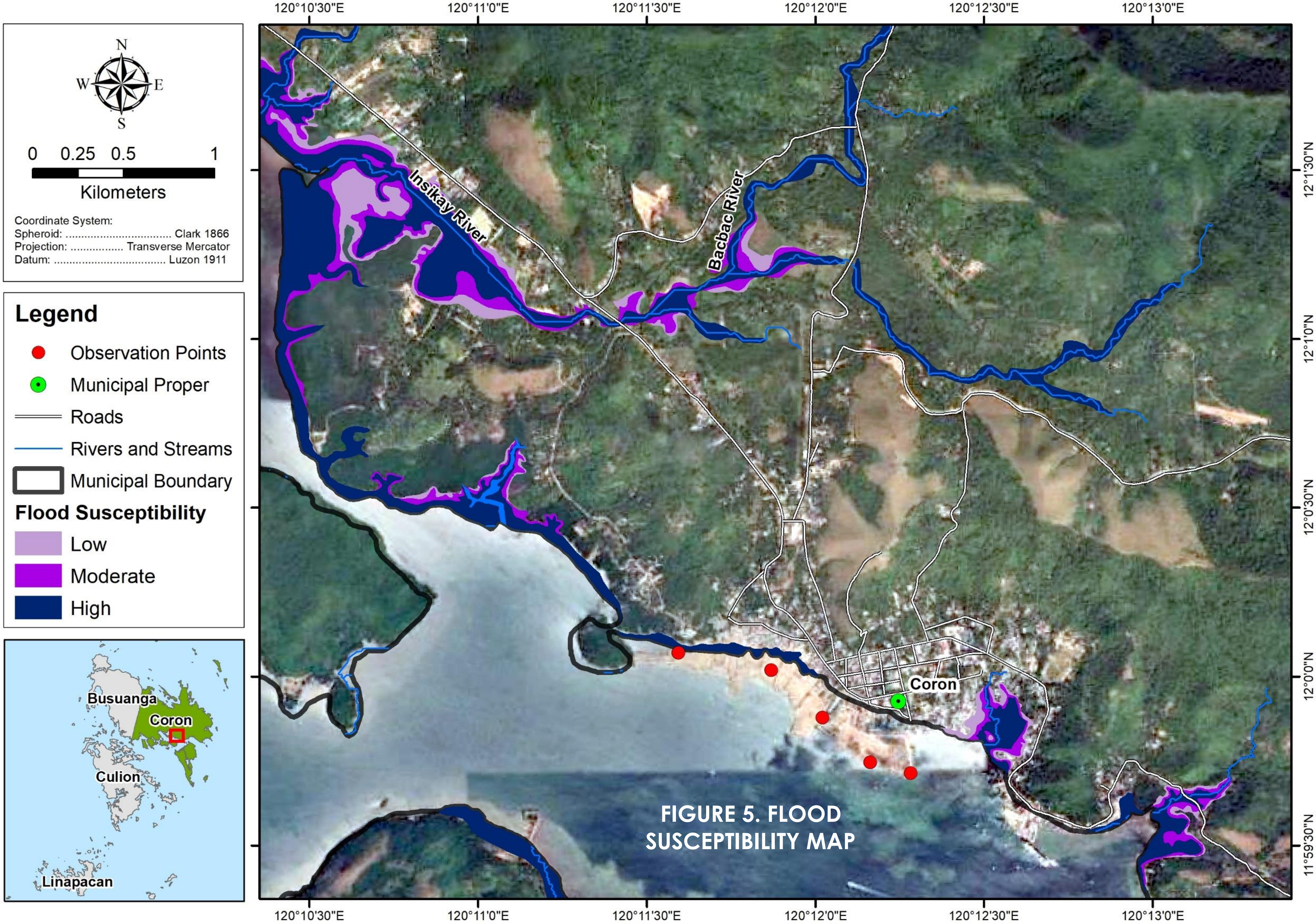
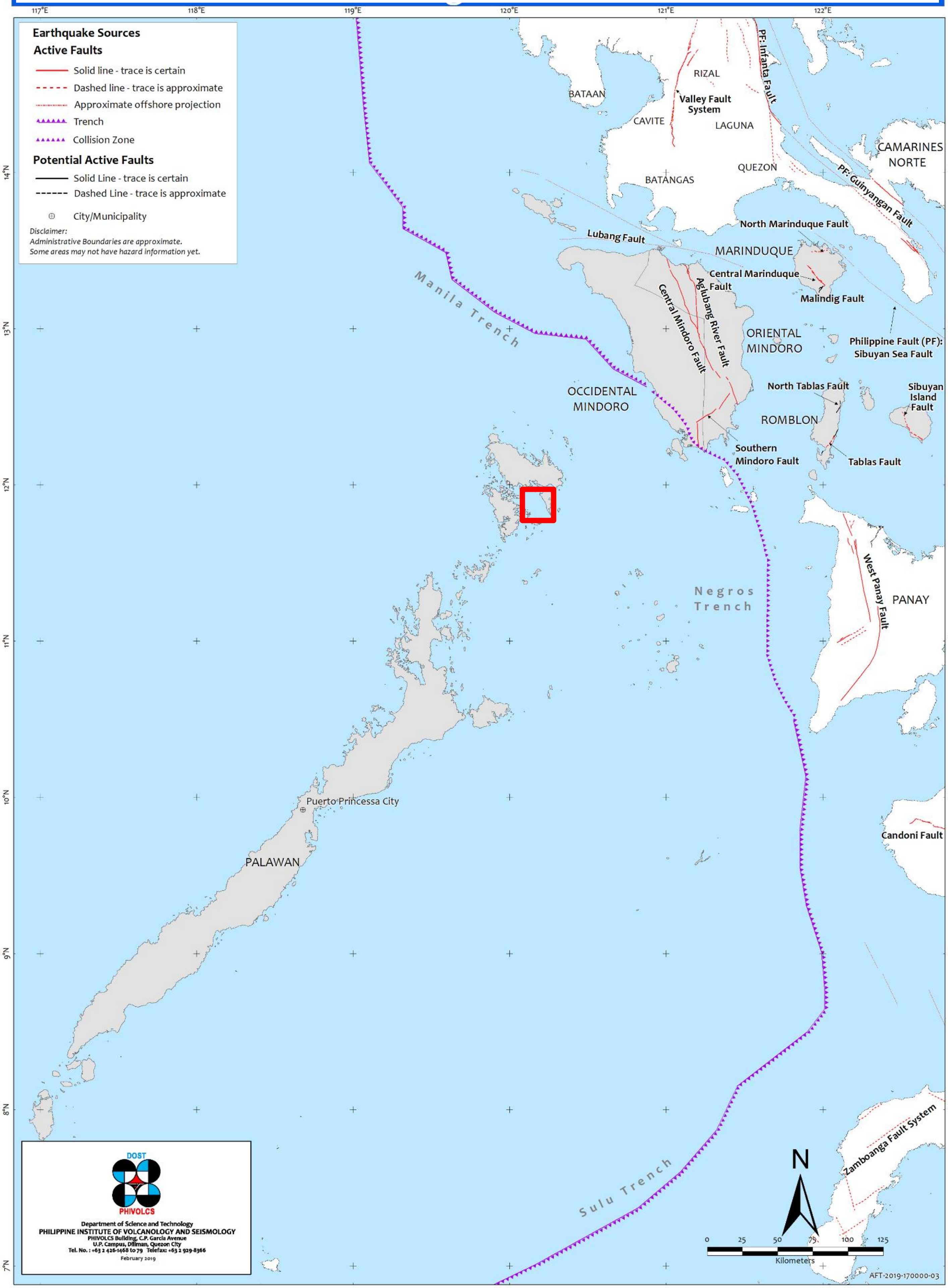


FIGURE 5. FLOOD SUSCEPTIBILITY MAP

FIGURE 6. DISTRIBUTION OF ACTIVE FAULTS AND TRENCHES IN REGION IV-B



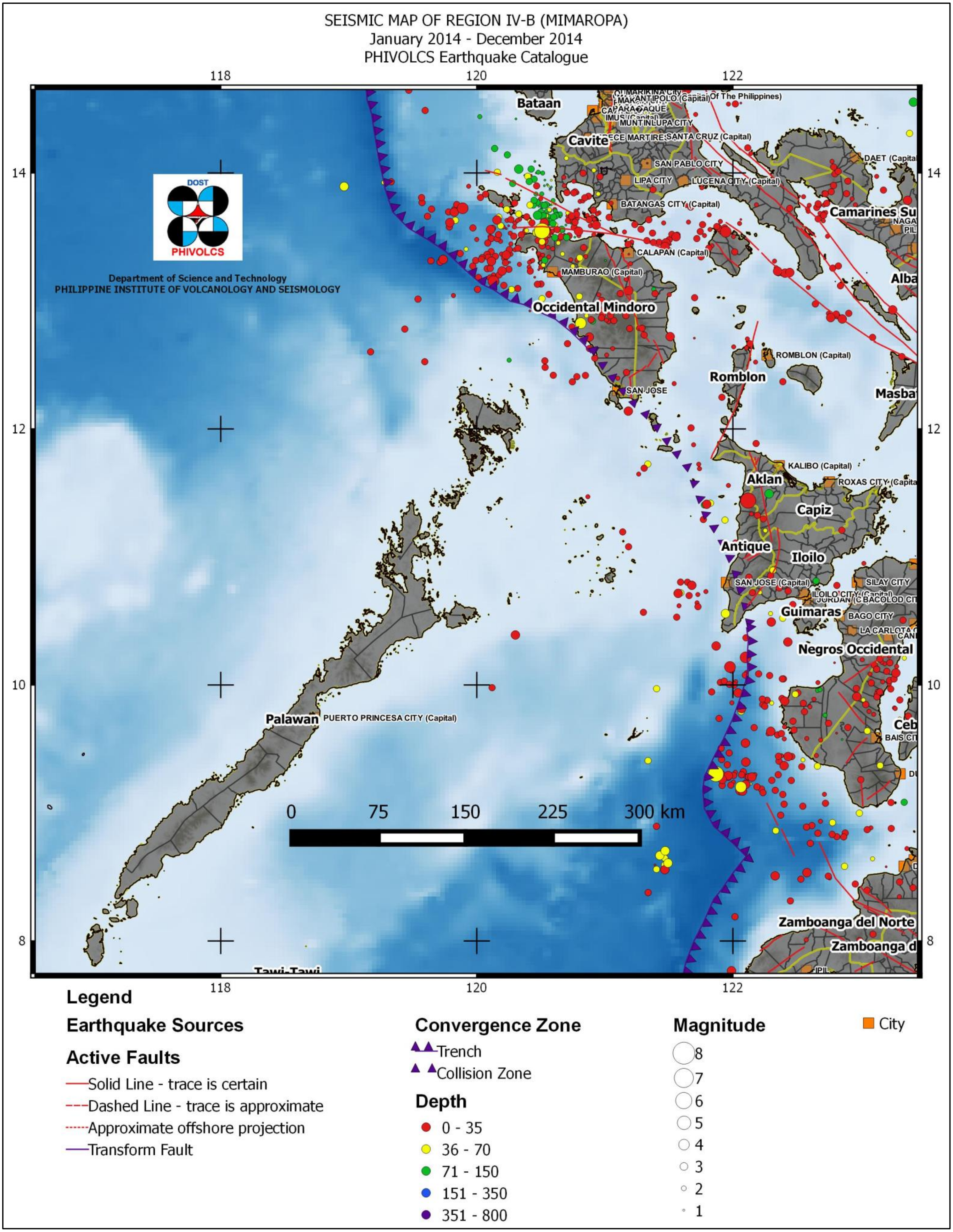


FIGURE 7. 2014 SEISMIC MAP

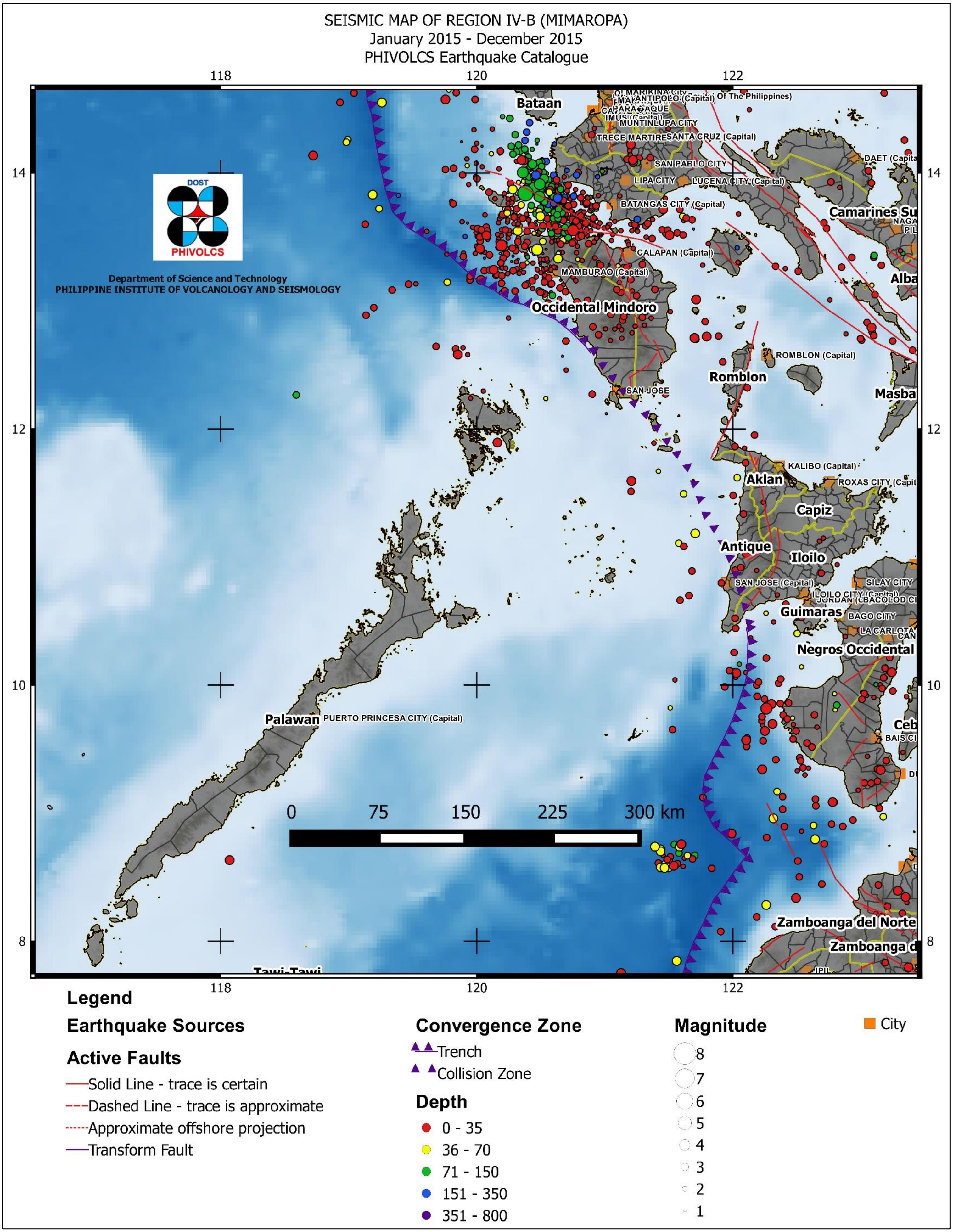


FIGURE 8. 2015 SEISMIC MAP

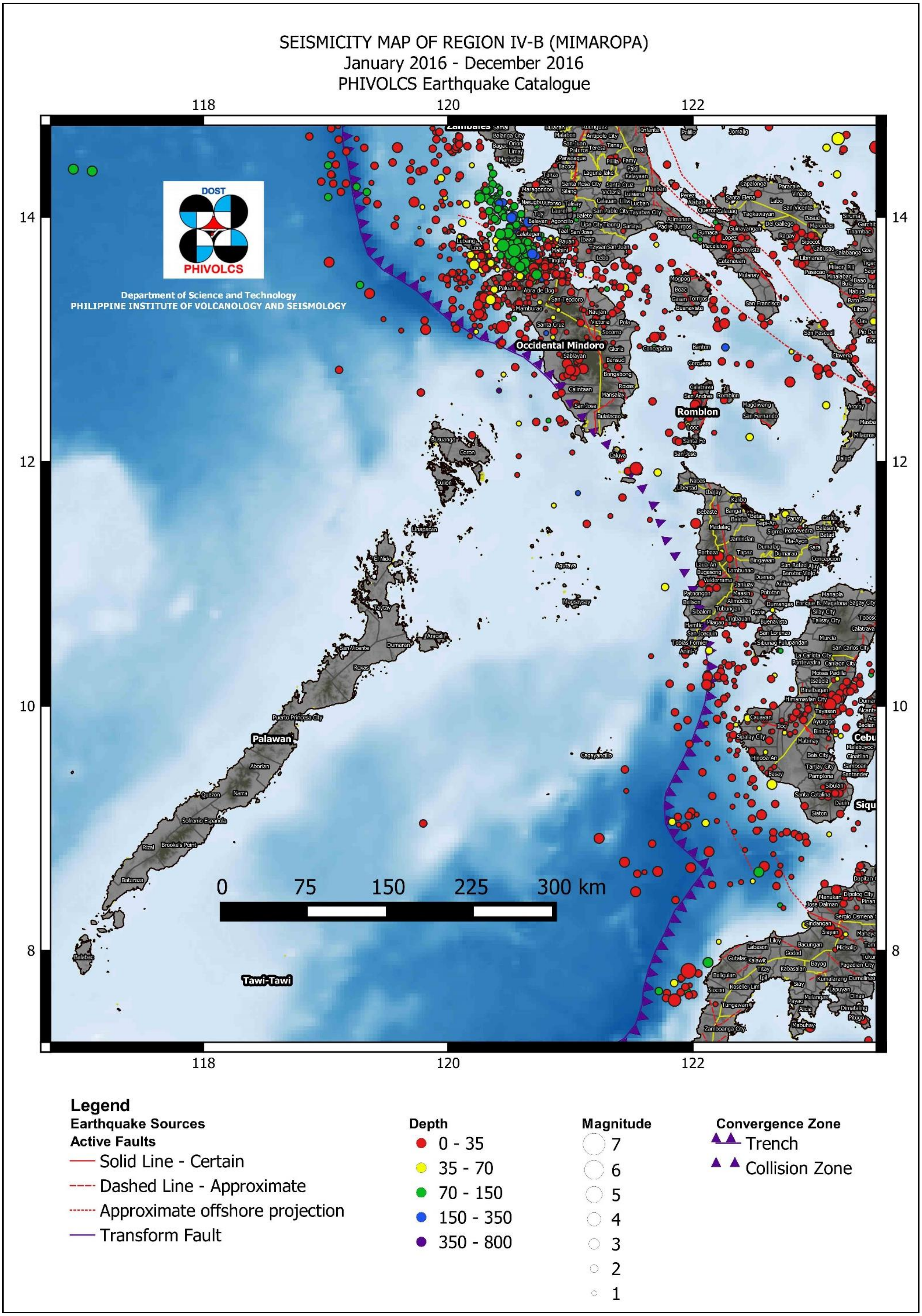


FIGURE 9. 2016 SEISMIC MAP

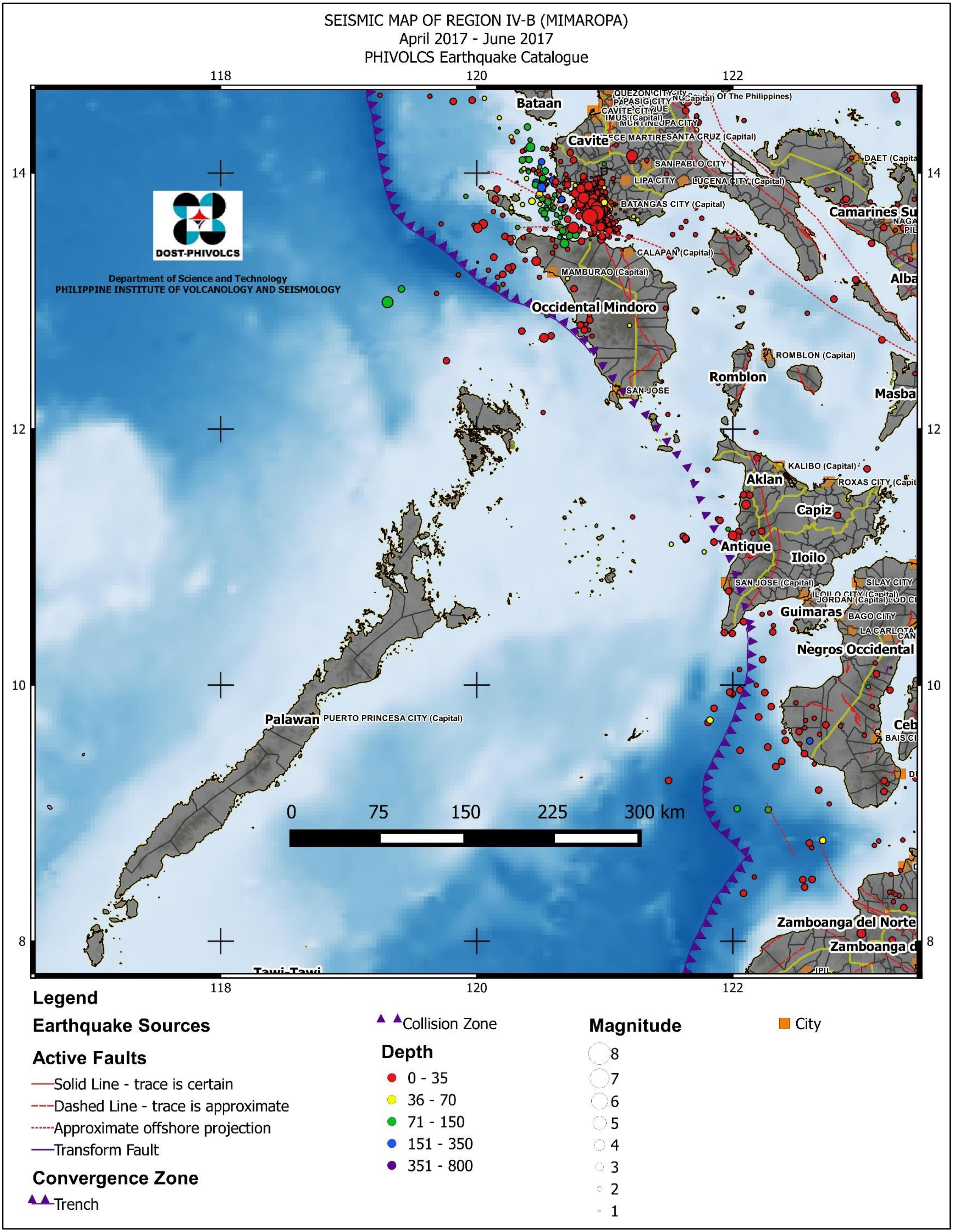


FIGURE 10. 2ND QUARTER 2017 SEISMIC MAP

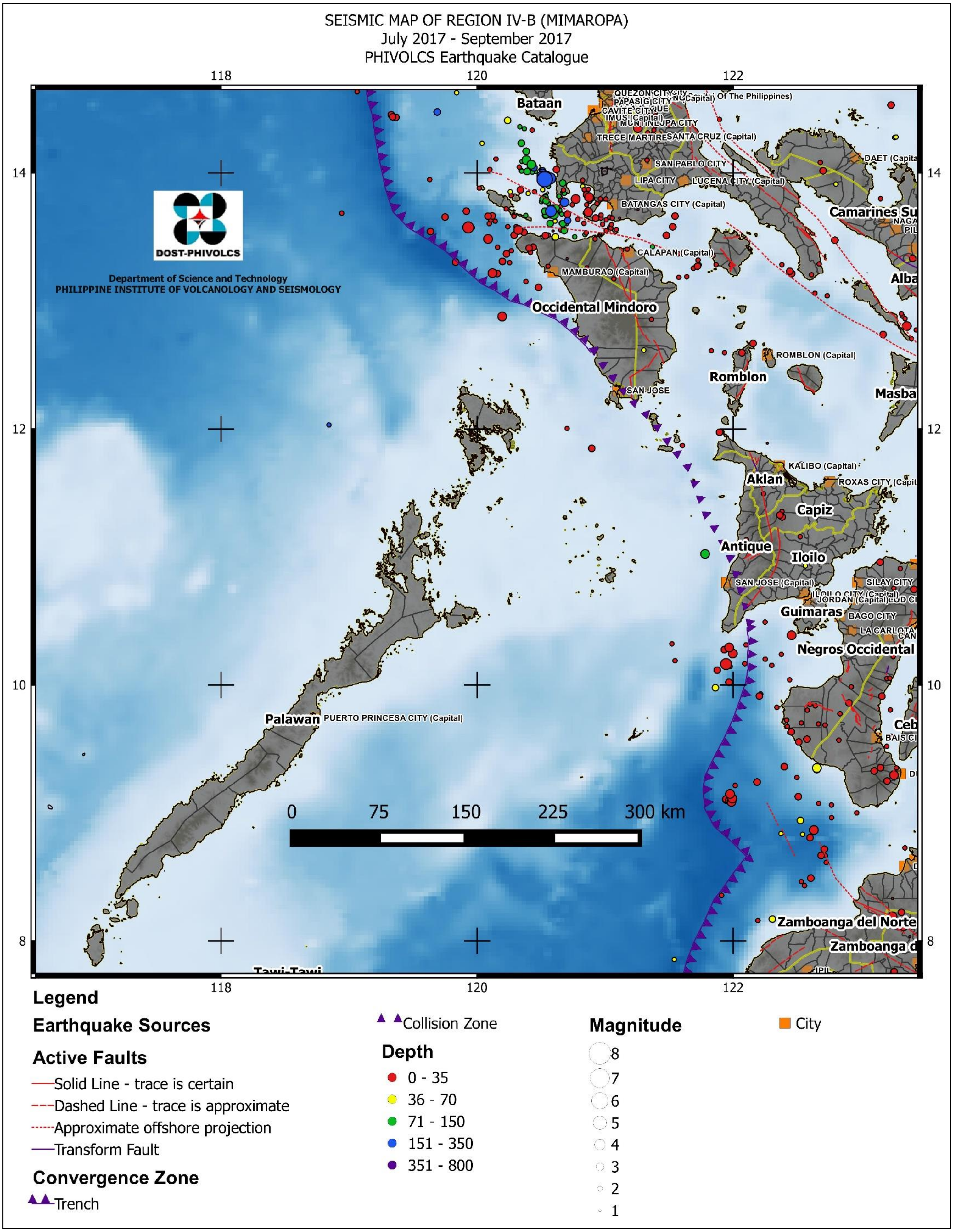
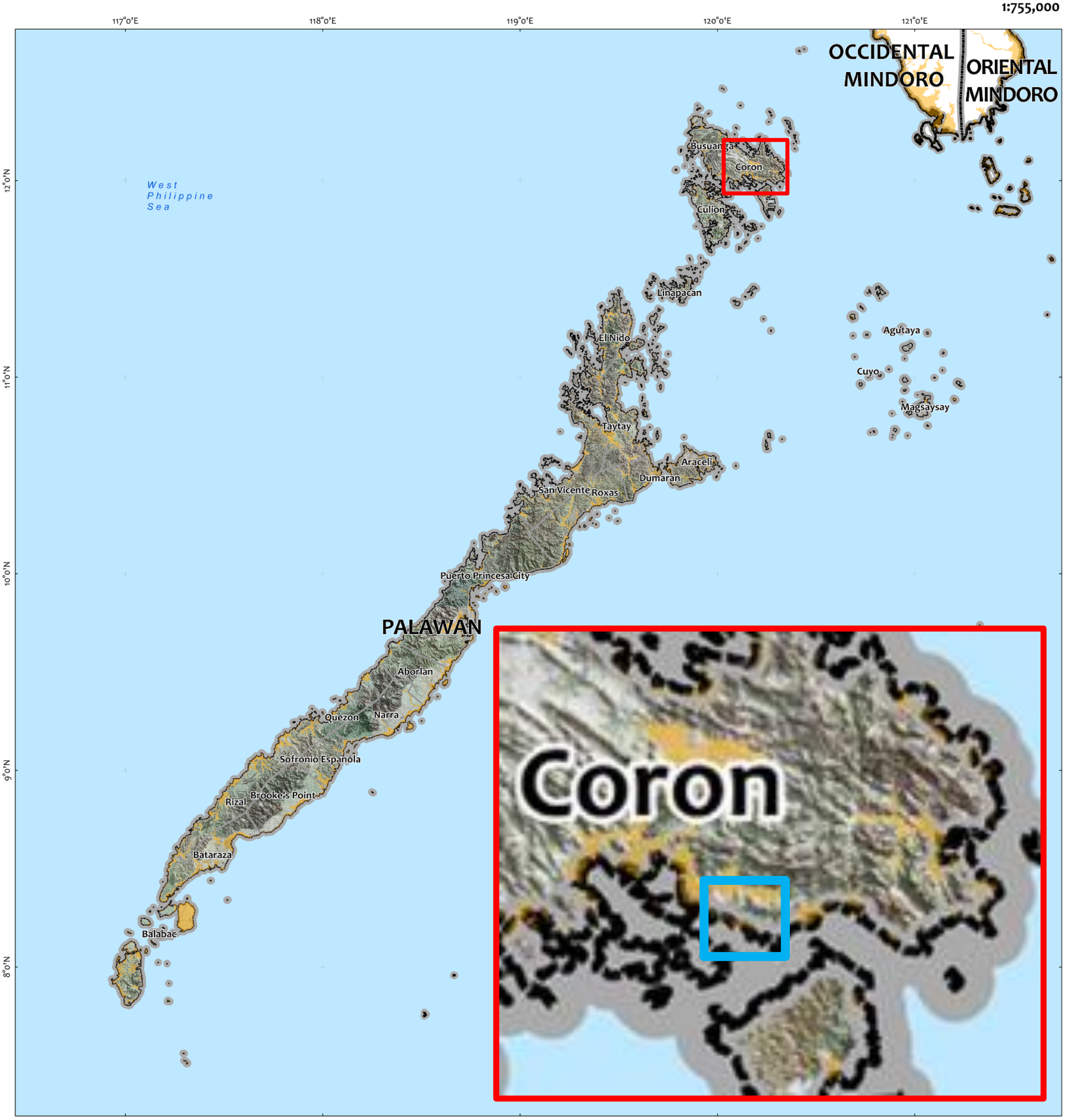


FIGURE 11. 3RD QUARTER 2017 SEISMIC MAP

FIGURE 12. LIQUEFACTION HAZARD MAP

Province of Palawan

Palawan
1:755,000



Legend

Liquefaction Susceptibility

- Prone

- Provincial boundary
- Municipal boundary
- Road / Highway
- Built-up area / settlement
- River / Stream

Explanation

The Provincial-scale Liquefaction Hazard Map of Palawan was based on geology, presence of active faults, historical accounts of liquefaction, geomorphology and hydrology of the area.

The presence of liquefaction hazard does not restrict construction of any structure and development. However, proper engineering consideration must be taken into account (e.g. strict adherence to the National Building Code of the Philippines.)

PHIVOLCS-DOST takes the necessary steps to continually improve the accuracy of the liquefaction information reflected in this map. The Liquefaction Hazard Map may be revised as new information becomes available.

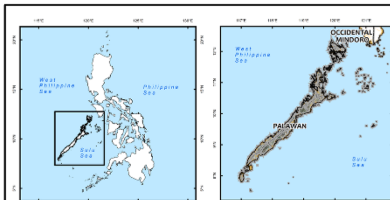
Limitations

1. All hazard zone boundaries are approximate.
2. This map is semi-detailed and may be used only for land-use, emergency response and mitigation planning. Site specific evaluation is needed for construction of major structures and lifelines.
3. Administrative boundaries are approximate.
4. Coastal boundaries of the hazard are based on the latest location of the coast as shown in the most recent Google Satellite Imagery (2013-2017) available or Interferometric Synthetic Aperture Radar- Digital Terrain Model (IfSAR-DTM, 2013). The boundaries may change through time, as coasts are continuously subjected to processes that may contribute to their erosion or aggradation.

Data Sources

1. Hazard data from Philippine Institute of Volcanology and Seismology (PHIVOLCS-DOST), 2015-2018.
2. Base maps are National Mapping and Resource Information Authority (NAMRIA) 1:50,000 topographic maps, 1993 and IfSAR-DTM, 2013.
3. Administrative boundaries are adopted from Philippine GIS data, 2011.

To cite this map, please use: Philippine Institute of Volcanology and Seismology. Liquefaction Hazard Map of the Province of Palawan. [Map] Version 1. 1:755,000. Quezon City, Philippines:PHIVOLCS-DOST, October 2018.



0 30 60 90 120
Kilometers

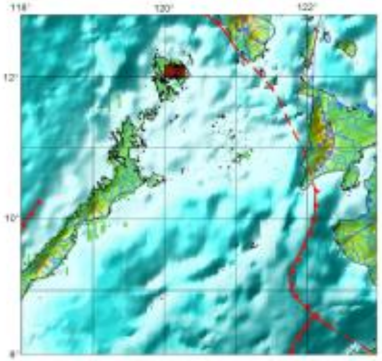
Geographic Coordinate System.....WGS 1984
Datum.....WGS 1984
Prime Meridian.....Greenwich
Angular Unit.....Degree

Date Published: October 2018
Product Code: LIQ 2018 175300-01

Department of Science and Technology
PHILIPPINE INSTITUTE OF VOLCANOLOGY AND SEISMOLOGY
PHIVOLCS Bldg., C.P. Garcia Avenue, U.P. Campus, Diliman, Quezon City 1101
Tel. Nos.: +63 2 426-1468 to 79 loc 129; Telefax: +63 2 920-7058
website: www.phivolcs.dost.gov.ph
email: phivolcs_mail@phivolcs.dost.gov.ph

FIGURE 13. TSUNAMI HAZARD MAP

Coron
Palawan



Legend:

Tsunami Inundation Area

3 m — Tsunami Wave Height at Coastline

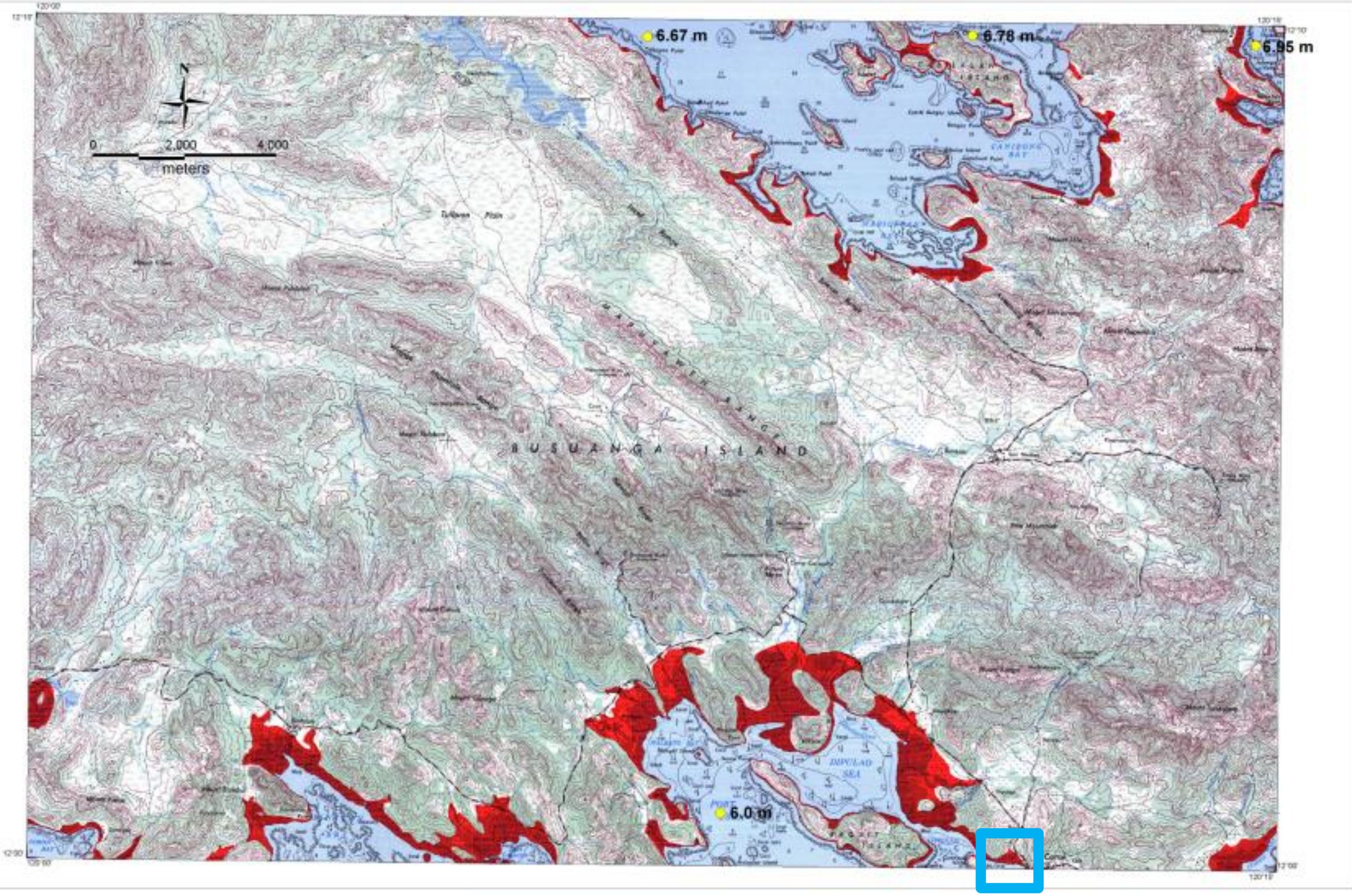
Earthquake Parameters Used in Modeling:

Source - Manila Trench / Negros Trench
Magnitude - 7.9 / 8.2

Data Source:

Modelling results using REDAS Software based on empirical equations of Abe (1989), Hall and Watt (1953), Prist (1995), and Hills and Mader (1999)

1:50,000 topographic map (Coron Sheet - 3056 III; 1993-reprint, NAMRIA)



Map Prepared By:

Philippine Institute of Volcanology and Seismology (PHIVOLCS)
Department of Science and Technology (DOST)
Under the DOST-GIA Program
December 2007

TSUNAMI RISK MITIGATION PROGRAM '06-'07

PHIVOLCS DOST

Explanation:

This indicative map is based on maximum computed wave height and inundation using worst case scenario earthquakes from major offshore source zones.
The indicated wave height decreases away from the shoreline.

ANNEX 2. FIELD PHOTOS

Photo 1. Twenty (20) hectares of the remaining 40 hectares has already been reclaimed. Yellow arrow points to the new coast at the edge of the reclaimed area.

Photo 2. Mt. Tapyas on the immediate north of the project site. Yellow arrow points to the original coast.

Photo 3. Narrow strips of unfilled areas serve as temporary drainage

REFERENCES

Aurelio, M.A. (2004). Engineering Geological and Geohazard Assessment (EGGA) system for sustainable infrastructure development: the Philippine experience. In Free & Aydin (Eds.) (2004). Engineering Geology for Sustainable Development in Mountainous Areas. Geological Society of Hong Kong.

Highland, L.M., & Bobrowsky, P. (2008). The Landslide Handbook—A Guide to Understanding Landslides. Reston, Virginia: U.S. Geological Survey Circular 1325, 129.

Magesh, N., & Krishnakumar, S. (2019). World Seas: An Environmental Evaluation (2nd ed., pp. 169-184). Academic Press.

Mines and Geosciences Bureau (MGB), (2010). Geology of the Philippines, 2nd edition. Mines and Geosciences Bureau, Quezon City.