

INTERNATIONAL UNION OF  
GEODESY AND GEOPHYSICS

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THAILAND

REPORT ON THE GEODETIC WORK

PERIOD

2007 – 2010

THE ROYAL THAI SURVEY DEPARTMENT

PRESENTED AT THE XXV GENERAL ASSEMBLY OF  
THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

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## Royal Thai Survey Department

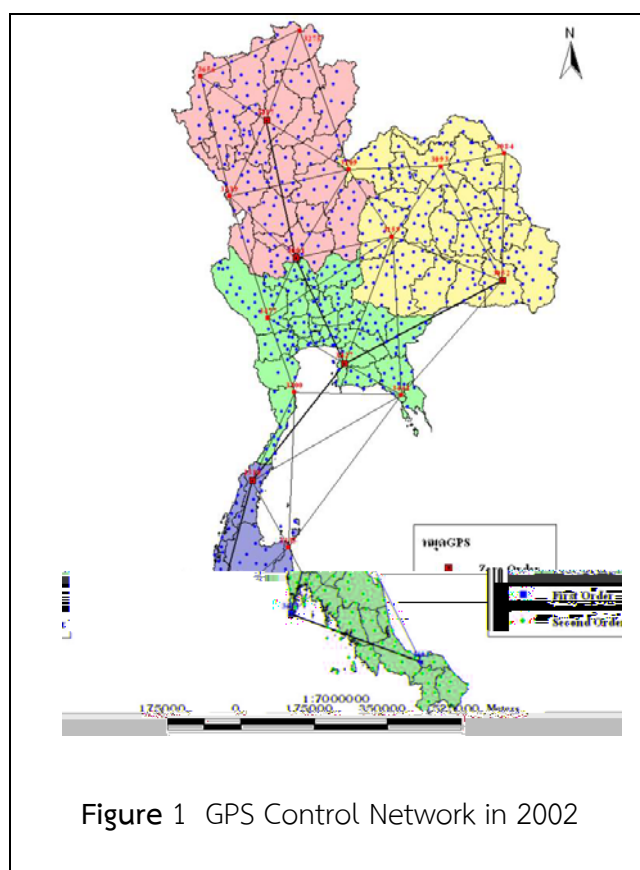
The Royal Thai Survey Department is responsible for land and air surveying activities and producing topographic maps for official and public use. In addition, it is also engaged in the field of Geodesy and Geophysics of which various activities were conducted during the period under review, 2007-2010. These are as follows:

### 1. Geodesy

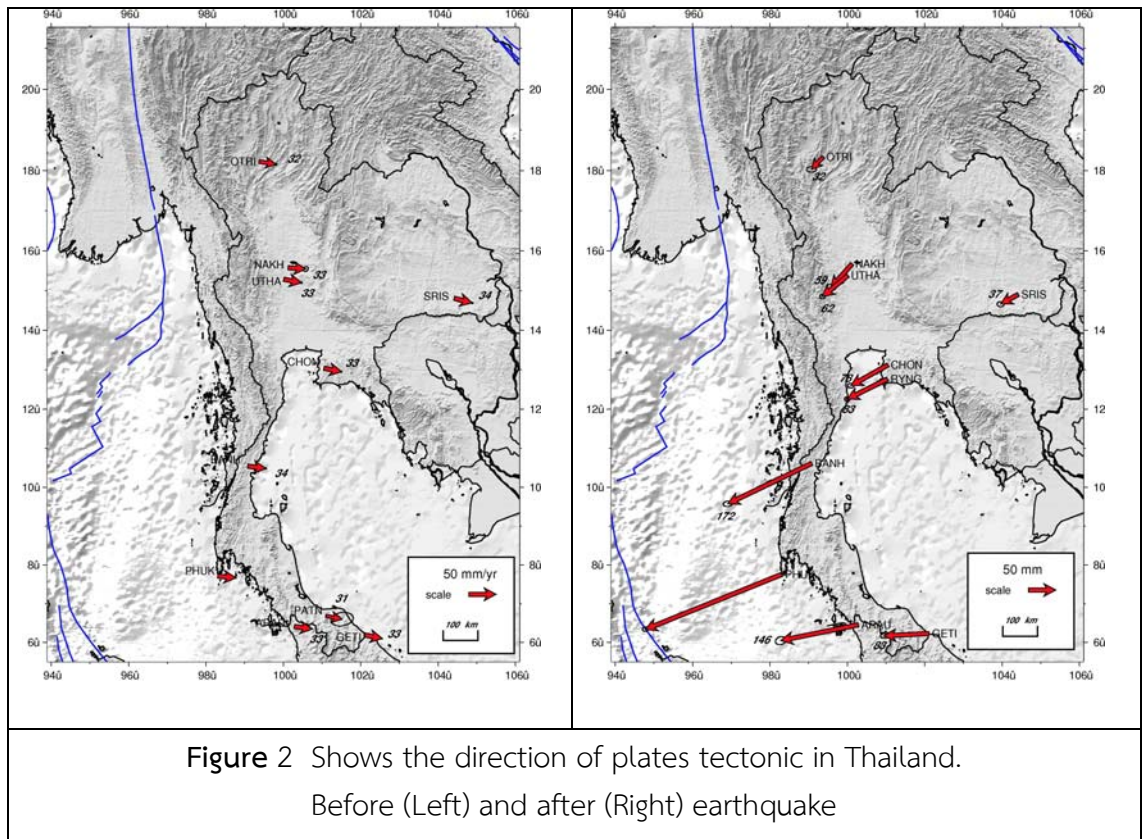
#### 1.1 Horizontal Control Network

The Royal Thai Survey Department (RTSD) through Geodesy and Geophysics Division is responsible for the establishment of Geodetic Network in Thailand using the Global Positioning System (GPS). The GPS observation has been performed since 1991 and its networks are continuously developed up until 2002. Now, the GPS network has been re-adjusted connectively with International Terrestrial Reference Frame 2000 (ITRF2000). So RTSD has about 700 GPS stations as shown in Figure 1

According to the earthquake on December 26, 2004 caused not only the serious plate motions in the north of Sumatra Island, Indian Ocean but also a huge tsunami which made the losses of inhabitant lives and their properties. This also resulted in the field of survey and mapping by increasing the discrepancy of positioning coordinates. In this respect, RTSD made a study and survey to monitor the movement of GPS bases caused by the said earthquake. The result from the study said that the movement of GPS bases was approximately 25 cms. in the south, 8 cm. in the central and 3 cms. in the north and northeast and the crustal movement continued to go further as shown in Figure 2. It may be concluded that GPS coordinates after earthquake deviated from the original coordinates before earthquake. The discrepancy of GPS coordinates depends on the areas, not the

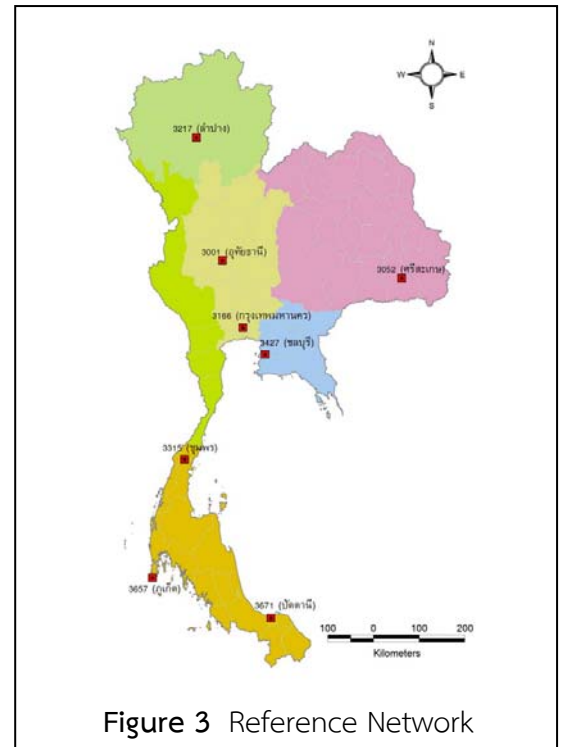


same results within the whole network. The discrepancy in the north and northeast is less than in the south. Different crustal movement made the GPS network distorted and too big to calculate the correct error distribution. So, RTSD made a new GPS network to replace the previous one.



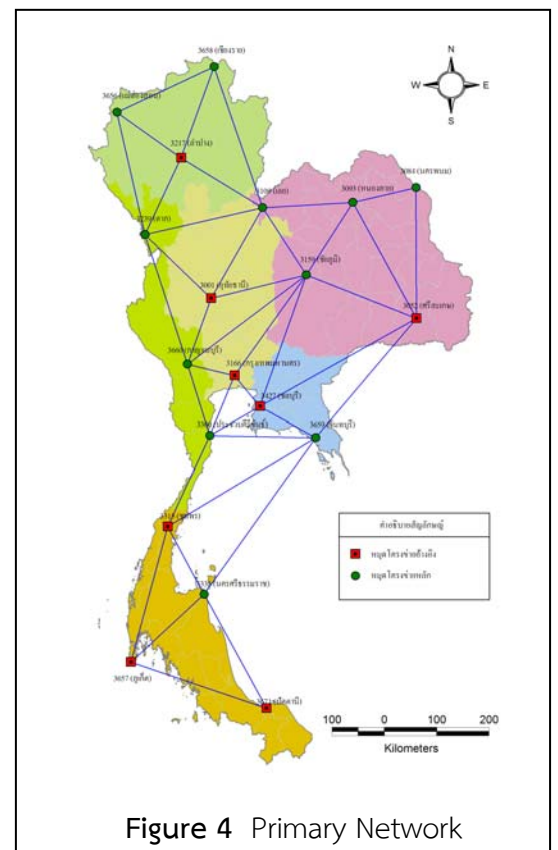
The new GPS network had been conducted since 2005 and completed in 2007, After that, extensive modifications to the network were simultaneously carried out in order to make the network acquiring high accuracy and reliability in accordance with the international standards based on the principle of control system and FGCC (Federal Geodetic Control Committee). Standard of the United States. Forms and operational procedures as follows :

1) **Reference Network**, Reference Network which is classified as a Class A by FGCC has 8 stations, GPS 3427 (Chonburi), GPS 3657 (Phuket) GPS 3217 (Lampang) GPS 3001 (Uthai) GPS 3052 (Sisaket) GPS 3315 (Chumphon) and GPS 3671 (Pattani), and GPS Base Station or GPS 3166 (Bangkok). Observed data from the said stations were sent to DEOS (Delf University of the Netherlands) for data processing by using GIPSY software program. The reference coordinates coming out from the said processing are in ITRF2000 datum (epoch 2005.7) as shown on Figure 3.



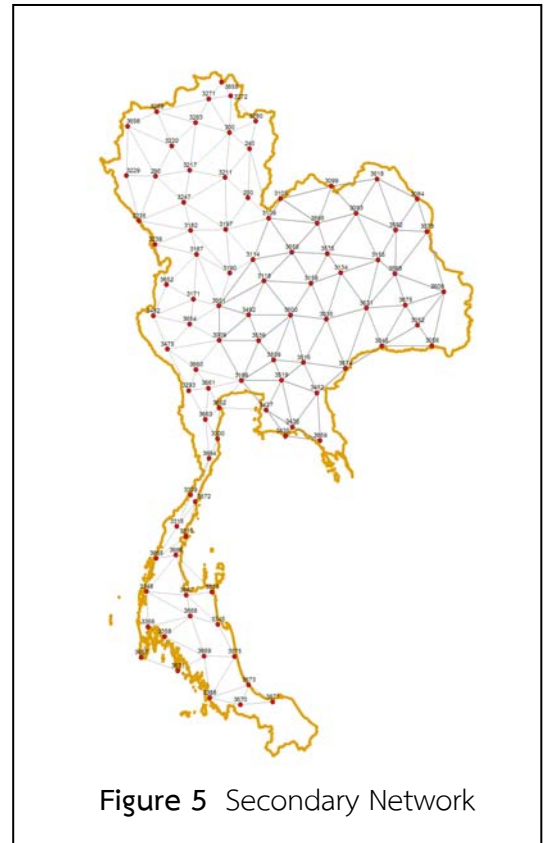
**Figure 3** Reference Network

2) **Primary Network**, Primary Network which was coming out from the extension of Reference Network consists of 11 stations to cover the whole country of Thailand. They are GPS 3656 GPS 3658 GPS 3239 GPS 3109 GPS 3093 GPS 3084 GPS 3159 GPS3659 GPS 3660 GPS 3300 and GPS 3335. Most of the aforesaid stations were established before tsunami. Some of them were newly set up because the previous stations were destroyed and out of proper positions. Each station in the Primary Network was set up at the spacing of about 200-250 kms. Observation period lasts 12 hours. Data from the observation were then processed with Trimble Geomatics Office Software. Coordinates from the said observation are classified as class B of FGCC standard with the loop closure not exceeding of 1 ppm. For the adjusted observation, reference network was tied to primary network (11 stations) amounting to 19 stations as shown in Figure 4



**Figure 4** Primary Network

3) **Secondary Network**, Secondary Network is designed network after tsunami. This network consists of 94 stations (including Reference Network and Primary Network) which was 700 stations less than the old network. Most stations in this network selected from the original stations which were on good condition and proper positions and the rest stations were the stations of the Department of Lands and other government agencies. Each station has it spacing of 50-100 kms. with observation period of 6 hours. Data from the observation were then processed with Trimble Geomatics Office Software. Coordinates from the said observation are classified as class B of FGCC standard with loop closure not exceeding 1.0 ppm. Reference Network and Primary Network were tied for the adjusted observation as shown in Figure 5



The result of survey which simultaneously tracked the plates tectonic after the earthquake on Thailand said that the accumulation of plate movement in Phuket Province, as of November 2008, was 66.4 cms., 20.7 cms. In the central, 8.1 cms. in the north as shown in Table 1 and Figure 6. Having considered only a portion of plate tectonic, it was found that the volume of plate tectonic after the earthquake was 2.6 times of the one during the earthquake.

**Table 1** shows the ratio of the as cumulative magnitude of the movement and motion during earthquakes.

Area	Magnitude movement during the earthquake	Accumulative Magnitude of the Movement up Until November 2008.	Ratio of accumulative magnitude of movement to the movement about the earthquake.
North	3	8.1	2.7
Central.	8	20.7	2.6
South	28	66.4	2.4
MEAN			2.6

Accumulative magnitude of movement caused by the earthquakes in Sumatra-Andaman and Nias earthquake before and after the earthquake can be calculated from the following formular :

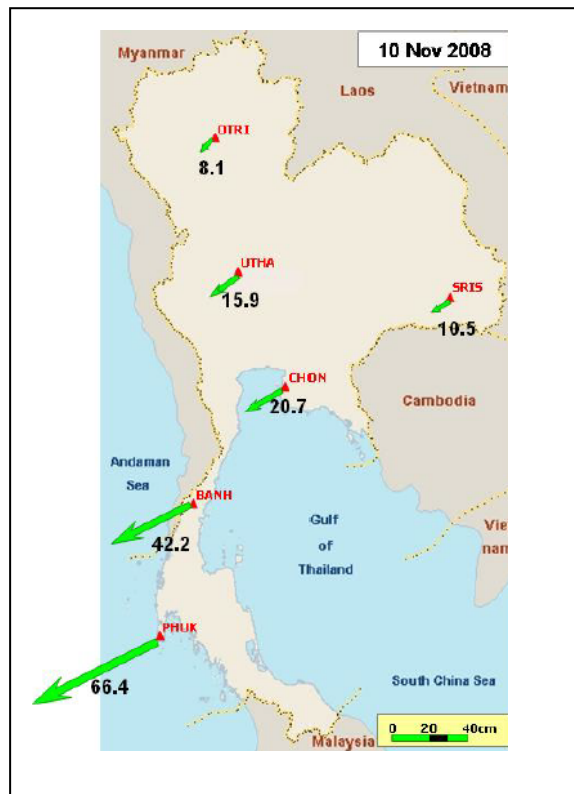
$$\text{Disp} = \text{Pos}(t) - \text{Pos}(t_{\text{ref}}) - (t - t_{\text{ref}}) * \text{Vel}$$

Then  $\text{Disp}$  = Formation of the movement

$\text{Pos}(t)$  = The coordinates at time of consideration

$\text{Pos}(t_{\text{ref}})$  = Coordinates the time reference

$\text{Vel}$  = Speed of movement. A large portion of the continental crust



**Figure 6** Pictures the movement of the stations flat accumulated evidence in the underlying network Since the earthquake of Sumatra - Andaman and Nias up to November 2008

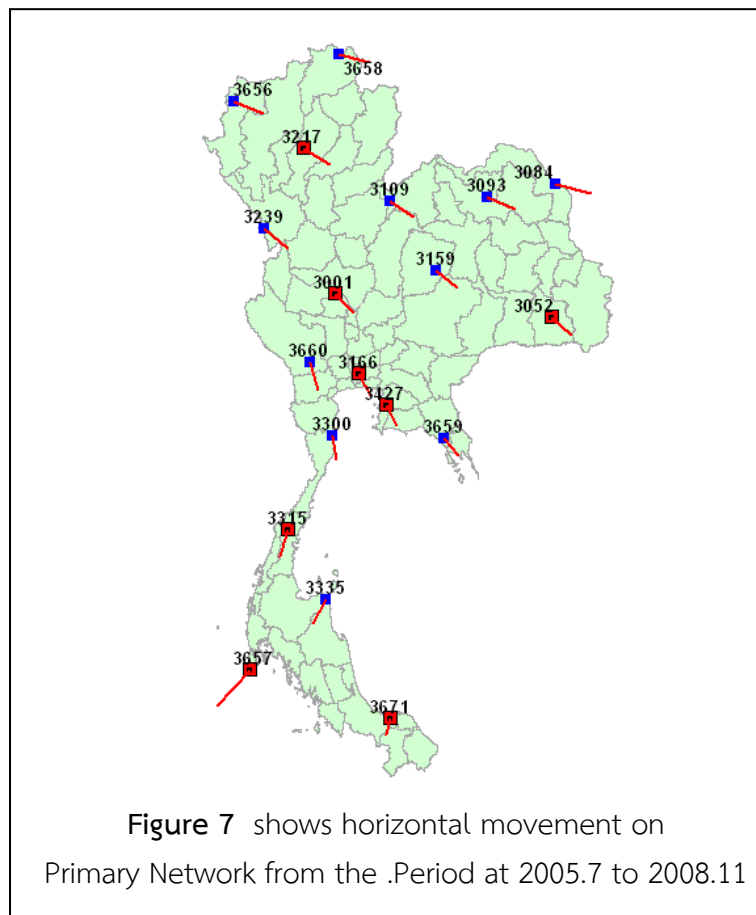
Current geodetic network in Thailand has been operated after the earthquake in accordance with ITRF2000 epoch 2005.7. The impact of plate tectonic at post seismic which has been still active causes geodetic network of Thailand distorted. Magnitude of distortion which occurred at post seismic is bigger than the one occurred during seismic as shown in Table 2

Table 2 shows the magnitude of plate movement caused by the earthquake.

Area	Magnitude of Plate Movement during an earthquake.	Magnitude of plate Movement after the earthquake	Accumulative Magnitude of Plate Movement
North	3	5.1	8.1
Central	8	12.7	20.7
South	28	38.8	66.4

\* As of November 2008.

According to the comparison between the coordinates from the Reference Network and Primary Network at the time of 2005.7 and the coordinates at the time of 2008.11 based on ITRF2000, it was found that stations were distorted due to the impact from the earthquake together with the plate tectonic as shown in Figure 7

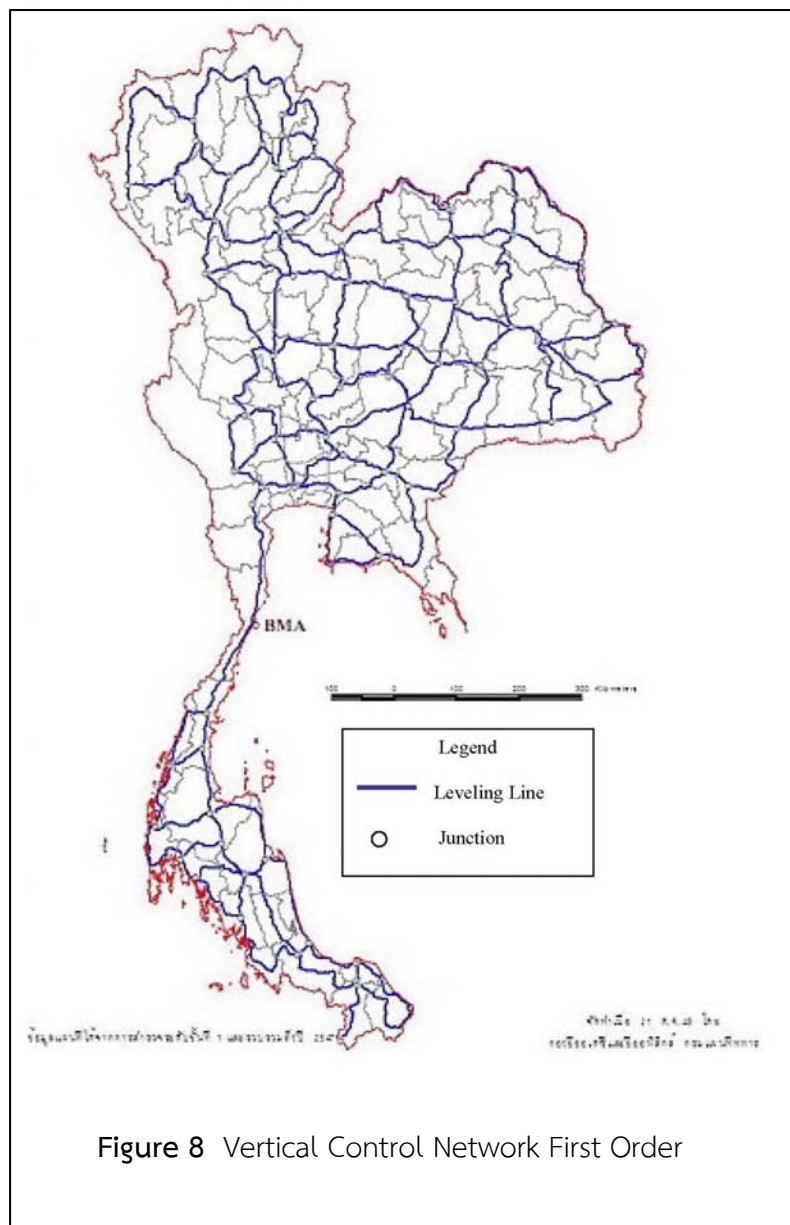


Although the national network was readjusted in order to meet high accuracy, the network is still distorted due to the impact of post seismic. Magnitude of post seismic movement at the present is bigger than the one at coseismic. The

impact of post seismic still remains so RTSD continue to monitor closely to the said movement.

### 1.2 Vertical Control Network

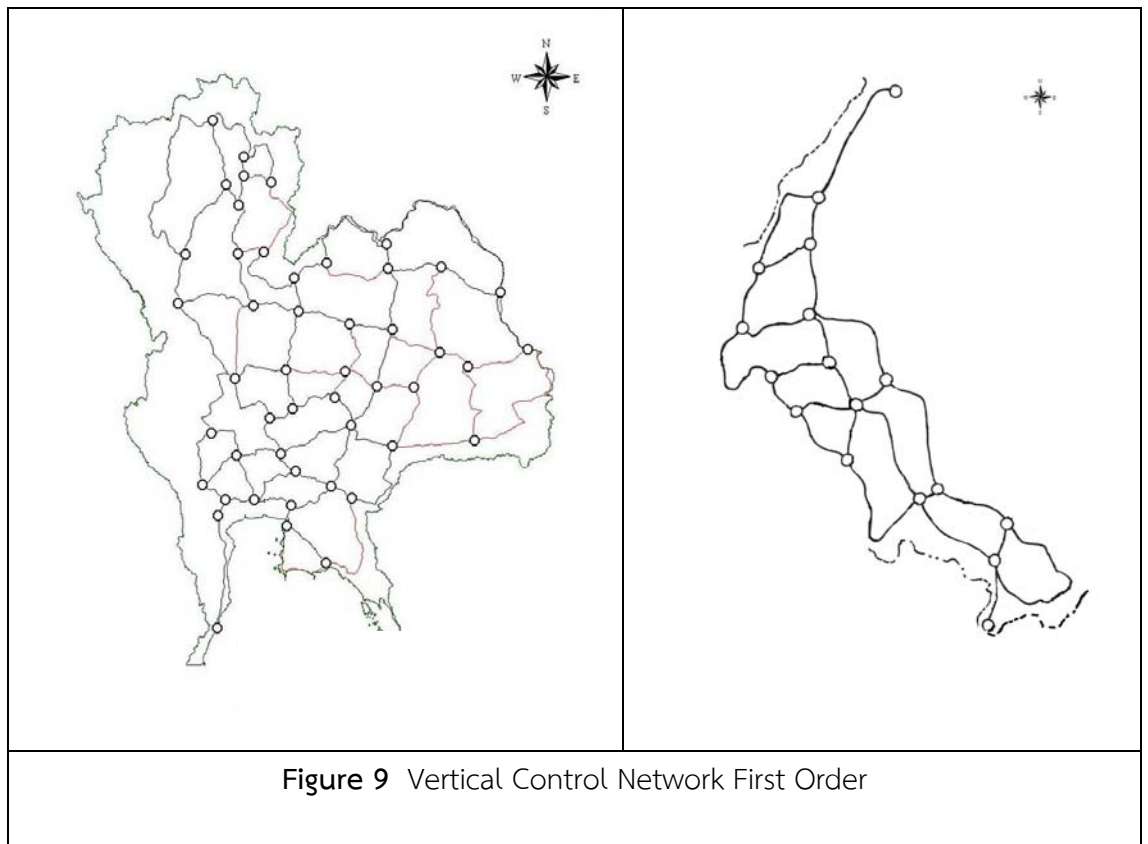
RTSD has set up vertical control network since 1912 using mean sea level at Ko Lak , Prachaup Kirikhan province as a vertical reference point and using vertical point of BM. A with the height 1.4477 meters as a reference point in order to tie with the first order leveling as shown in Figure 8.



In 1982, the first order of vertical control network was firstly adjusted. The network throughout the country was divided into two parts (northern part of Ko Lak



and southern part of Ko Lak) due to suitability of geographical locations and unity of the network (Figure 9).



From 2007 to 2010, RTSD has re-surveyed on the south of Thailand because checking of network in the said area was not performed for along time together with the impact of disaster occurred in 2004 which may reduce the reliability of the network as shown on Figure 10



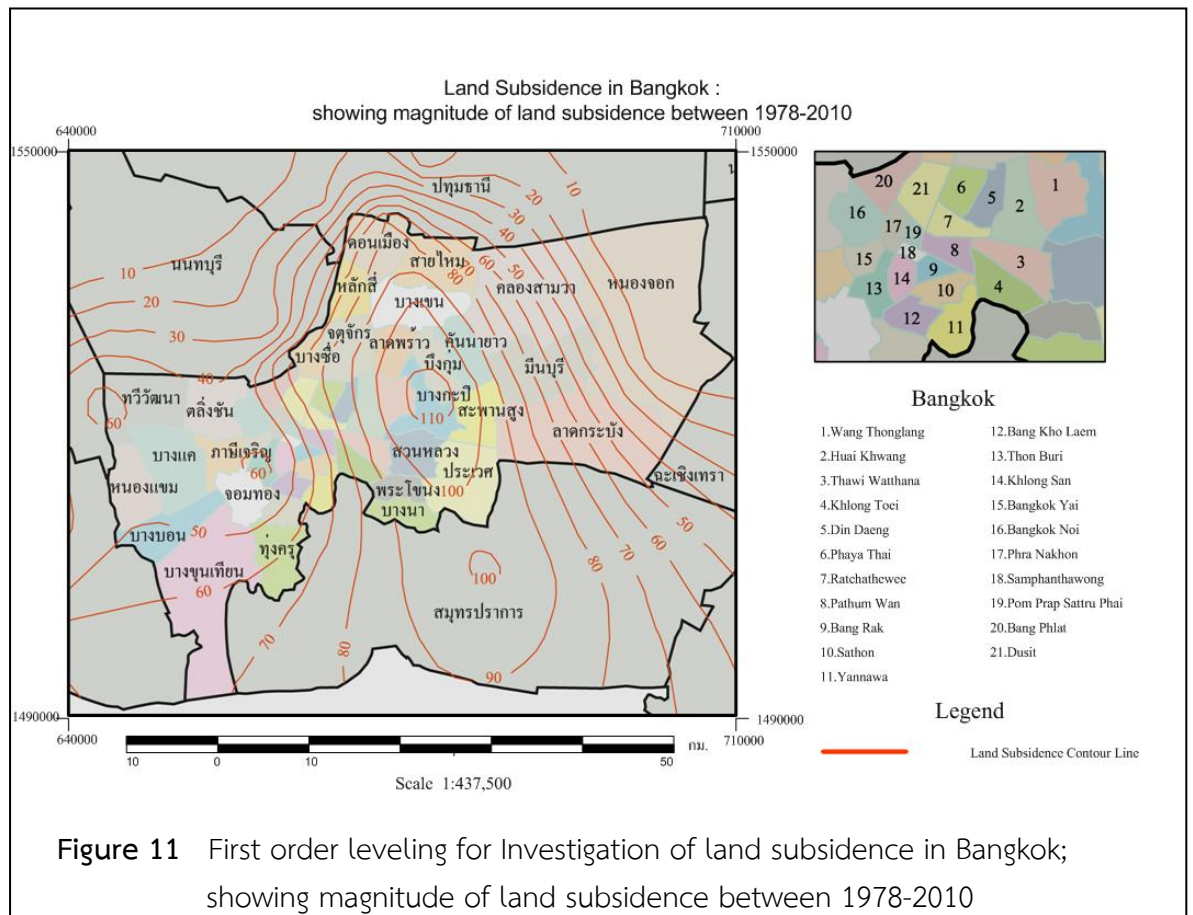
**Legend**

- Leveling in 1997
- Leveling in 2005
- Leveling in 2007
- Leveling in 2008
- Leveling in 2009

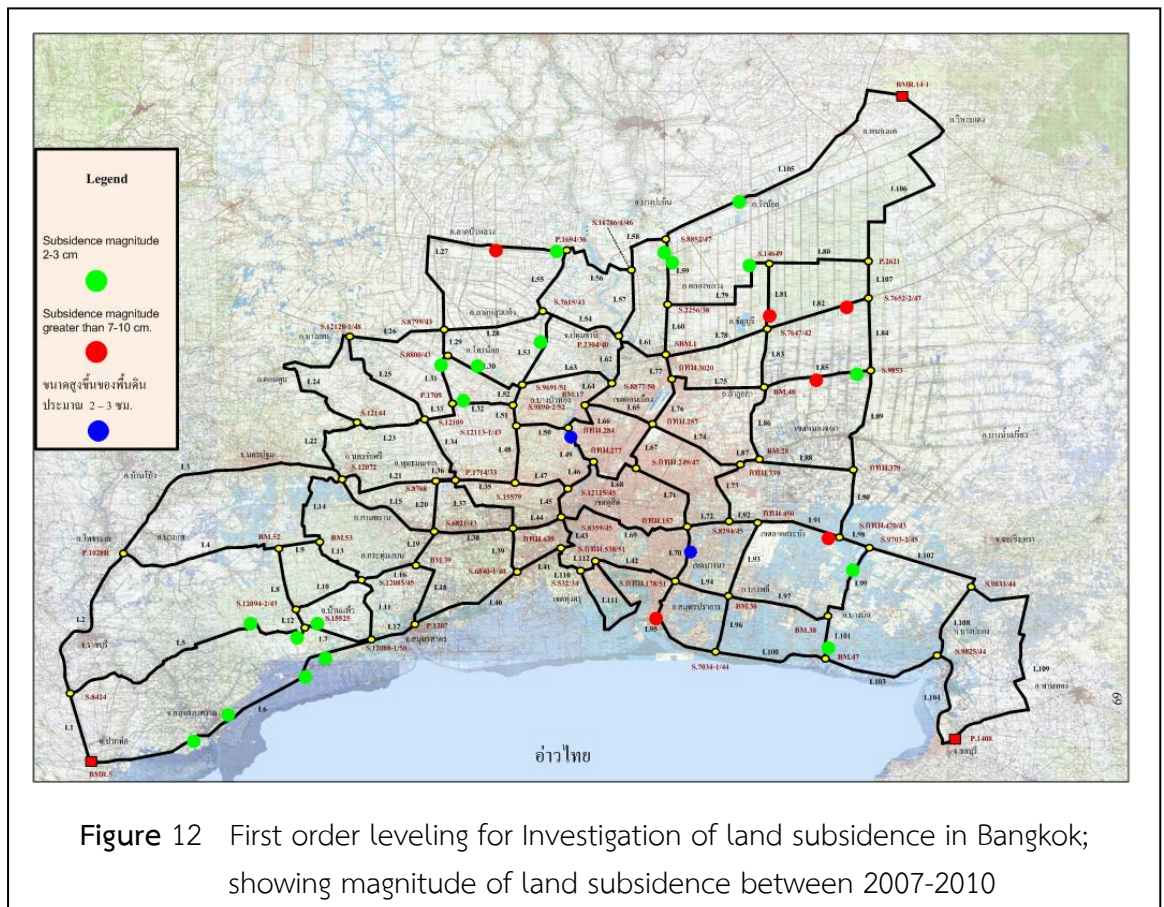
Figure 10 Operations in the past year 2007-2010

### 1.3 Leveling for Investigation of Land Subsidence in Bangkok

The Royal Thai Survey Department has carried out the first order leveling in the Bangkok area and nearby vicinity covered the area about 7,000 square kilometers in order to assist the office of the National Environment Board in the investigation of land subsidence caused by the withdrawal of ground water. The Project has been initiated since 1978. Until 2010, 33 observations have been repeated over the same area. After using proper measures to control the withdrawal of ground water, it was found that the magnitude of land subsidence were significantly decreased.



**Figure 11** First order leveling for Investigation of land subsidence in Bangkok; showing magnitude of land subsidence between 1978-2010



## 2. Geophysics.

### 2.1 Land Gravity Survey

Gravity survey has been initiated by RTSD since 1937 at located in RTSD at Lat. 45 06 N, Long. 100 29 40 E, and 2.999 meters in height. The Cambridge Pendulum Apparatus was firstly used in observation by the relative method in relation with the absolute gravity station located in Teddington, England. This station is called "g0" as shown in Figure 13.

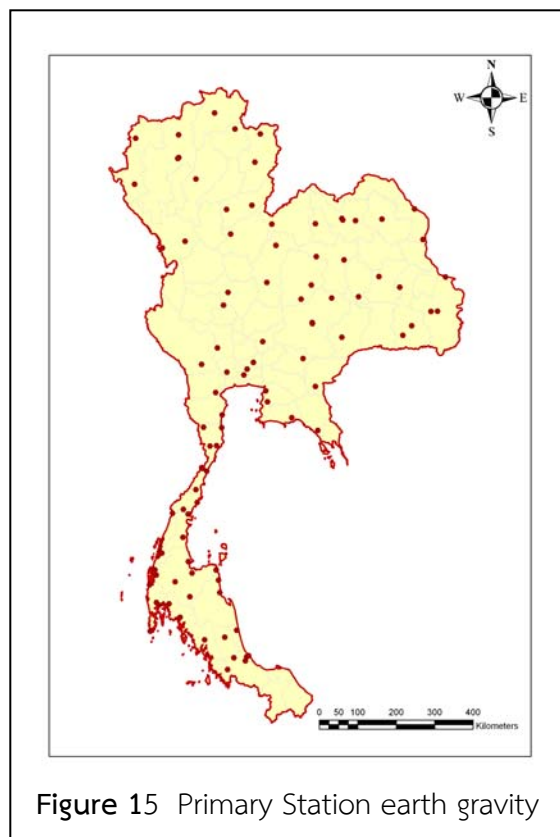
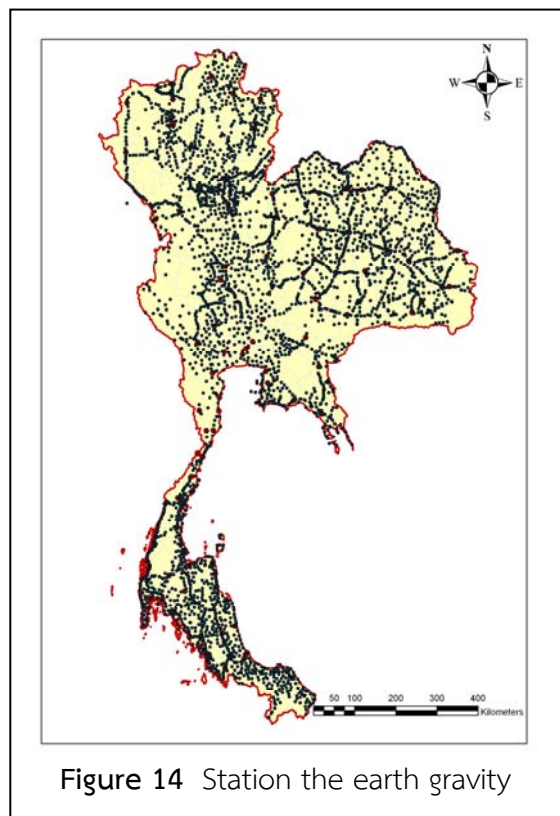


Figure 13 First Station Earth's gravity

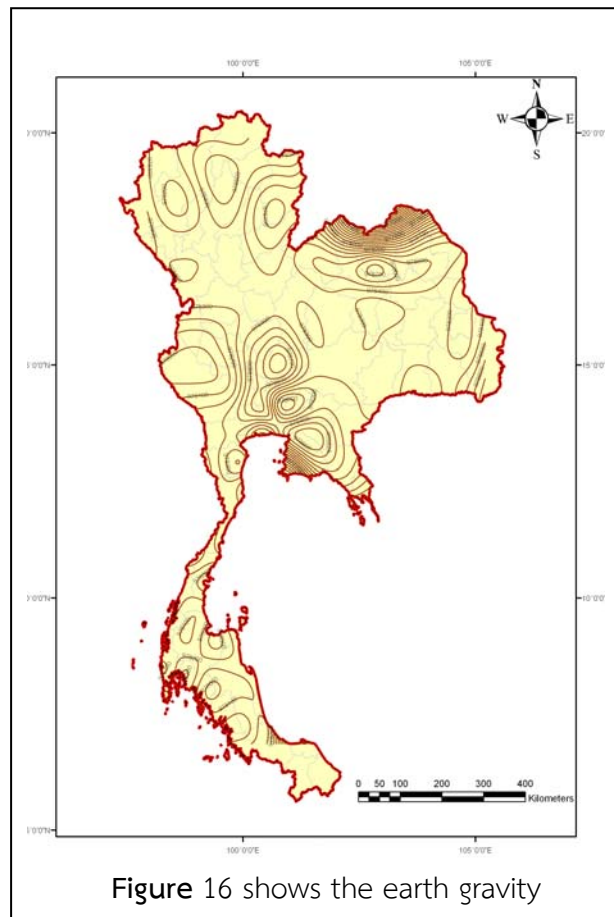
Later, the national gravity network was extended to various parts of the country. 42 gravity stations were established to cover the whole country.

During the period 1952 - 2007, RTSD has established over 40 sub gravity stations with the spacing of 10 kms. Using the relative method with Lacoste & Romberg gravity meters. Up until now there are about 4,181 sub gravity stations located all over the country as shown in figure 14. The aforesaid sub gravity stations which RTSD has are still under the specified standard. There are still some gaps in the network since the said gaps are mostly in the inaccessible areas, forests and mountainous areas where sub gravity stations are hardly established. In those areas, vehicles such as airplane or boat are recommended to use for gravity survey, or using advanced technology such as satellite gravimeter.

After having investigated the status of 42 gravity stations in 2007, it was found that there are only 7 stations left while the rest were destroyed. As a result of this, RTSD has established new 93 gravity stations in 2008 throughout the country for substitution and extension the density of the network as shown on Figure 15



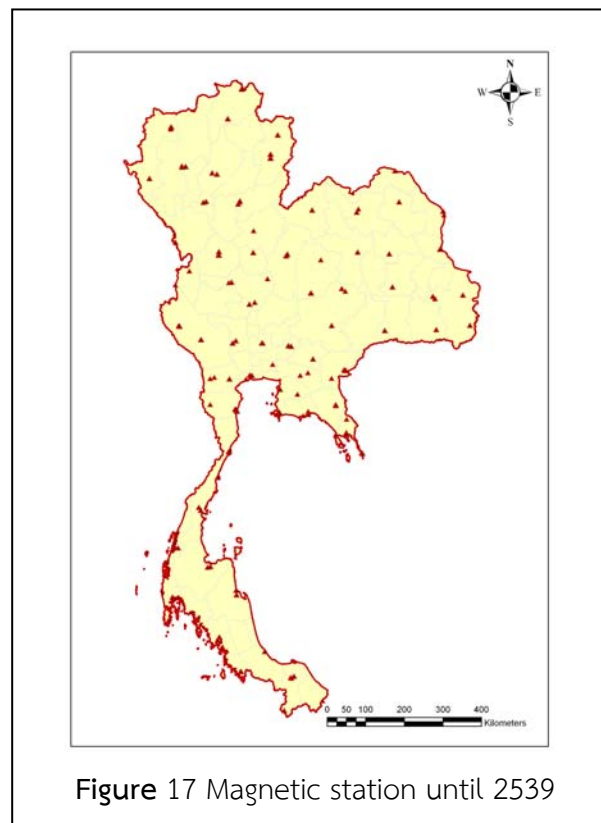
For gravimetric stability evaluation, re-observation above stations should be repeated with 5 iterations. RTSD has conducted the said observation from 2008 to 2010. 93 stations were observed with 2 iterations. The result of that observation is demonstrated in Figure 16 and RTSD is still observing for the rest rounds.



## 2.2 Geomagnetic Survey.

Geomagnetic survey has been firstly carried out by RTSD on May 5, 1906 in Nakornsrihammarat province to observe three geomagnetics elements using the DIP CIRCLE and Indian Pattern Magnetometer. Those geomagnetic elements namely magnetic declination, magnetic inclination and horizontal intensity were observed by Mr. R.W.Giblin, A.J.Irwin, and S.W.Masterman. The second station located in Sra Prathum Palace was later observed on May 26, 1956. After that some geomagnetic stations were extended to various parts of the country.

In August 1918, 7 geomagnetic stations were re-observed by Capt. Luang Ronnaratvipharkkit and Lt. Wichean Sasawanawin. After that, 7 existing stations and 2 additional stations located in



Prachinburi and Nakhonratchasima provinces were reobserved by the Thai survey team headed by Maj. Luang Ronnaratvipharkkit.

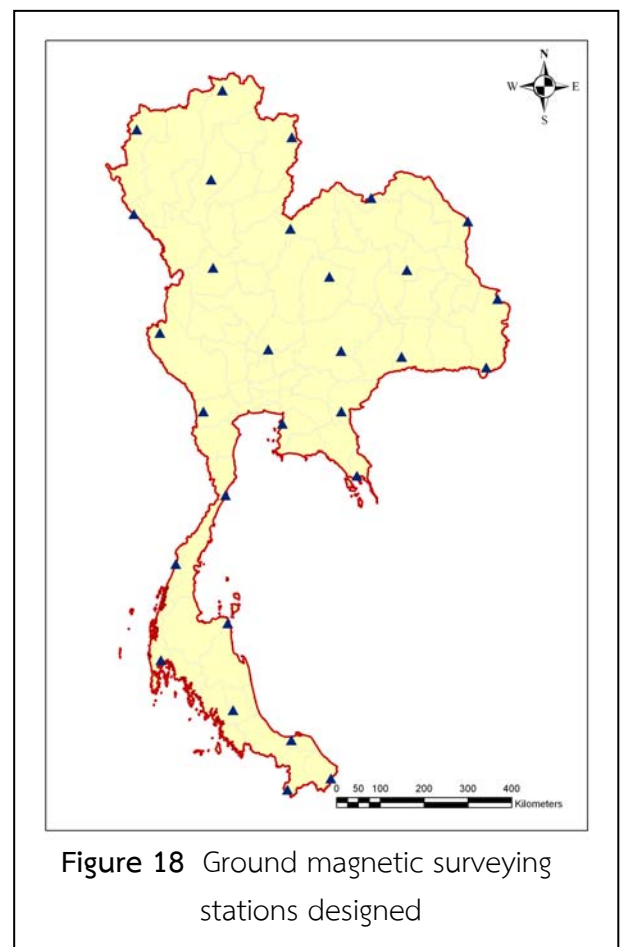
Magnetic observed areas in Thailand in 1959 had divided into 5 regions. The observation was conducted per region per year. The instrument was changed from time to time due to long time use and out of date. Until 1996, MAG-01 H Fluxgate Declinometer / Inclinator from England was brought to substitute the old existing one namely GSI Precise (First Order) Magnetometer from Japan which was long used for 15 years. After that, there is no longer magnetic observation. So it can be concluded that 324 stations were observed at the beginning until 1996 as shown in Figure 17.

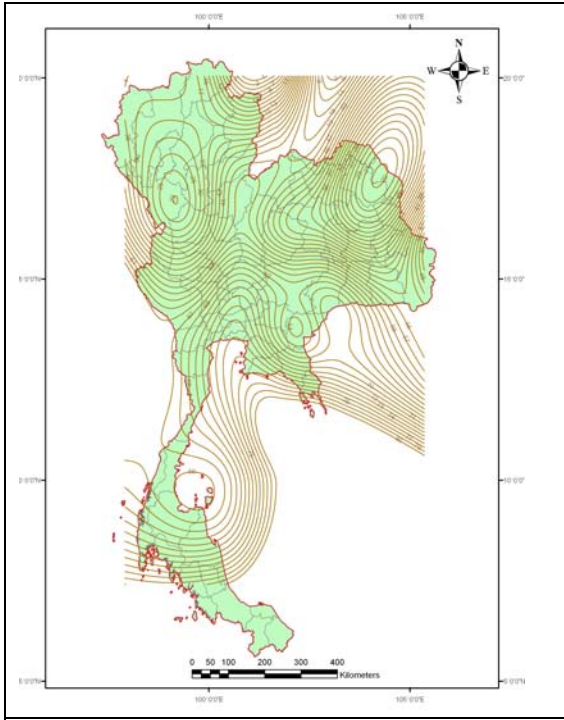
Magnetic observation is conducted not only supported to RTSD activities but also other government agencies such as Department of Mineral Resources and office of National Energy. This observation plays a vital role investigate natural resources which includes oil and natural gas. At present, geomorphology has changed rapidly for example sudden movement of tectonics plates causing a huge earthquake on December 26, 2004. Huge earthquakes that occurred frequently in this region has resulted in magnetic fields in this region. This is the reason why RTSD has to perform magnetic observation simultaneously in order to check and monitor closely to the movement of tectonics plates.

In 2007, MAG – 01 H Fluxgate Declinometer / Inclinator was repaired and RTSD also purchased one more MAG –

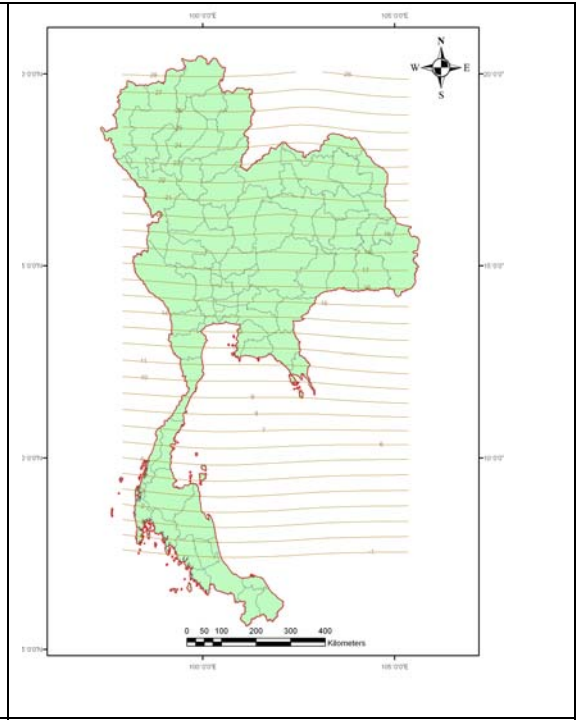
01H Fluxgate Declinometer/ Inclinator from England in 2008. 29 magnetic stations with the spacing of 200 km. were constructed over the country (Figure 18) in order to replace the old ones which were lost, destroyed and out of proper positions. From 2009 - 2010, 26 stations located in northern, central, southern, and northeast were re-observed.

According to the result coming from the observation during 2009-2010, one error on declination was found on each region (northern, northeast and south) as shown in Figure 19. RTSD still continues to study the said errors. Inclination and magnetic total intensity were normal as shown on Figure 20 and 21 respectively.

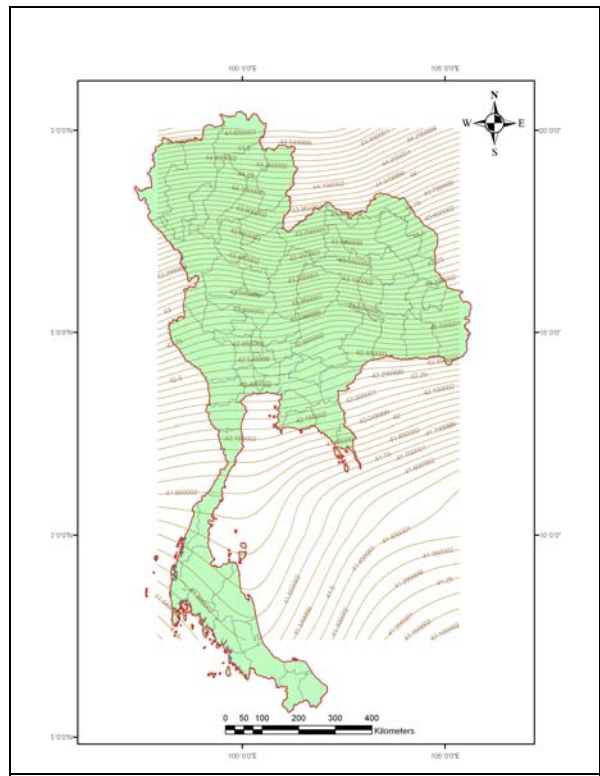




**Figure 19** Shows Isogonal Line of surveyed results. Survey from 2010 to 2011 (Mumbai and the Region)



**Figure 20** Shows Isoclinal Line of surveyed results. Survey from 2010 to 2011 (Mumbai and way down).



**Figure 21** Chart of Total Intensity of surveyed results from 2010 to 2011. (Density, magnetic field)



### **3. Joint research projects.**

Geodetic Earth Observation Technologies for Thailand: Environmental Change Detection and Investigation (GEO2TECDI) is a joint research project between Thailand and Europe under the Thailand-EC Cooperation. This Project aims to enhance skills and joint research capabilities of Thai researchers in applying and exploiting three space geodetic techniques namely Global Navigation Satellite System (GNSS) Interferometric Synthetic Aperture Radar (InSAR) and Satellite Altimetry (SALT) for the detection, monitoring and modeling of land surface motion and deformation due to tectonic processes, land subsidence and sea level change. Thai researchers consist of staffs from Chulalongkorn University, Royal Thai Survey Department, Royal Thai Naval Academy, Hydrographic Department and Geo-Informatics and Space Technology Development Agency while the EU side consists of staffs from University of Delft, the Netherlands Institute of Ecole Normale Superieure, France. And the University of Darmstadt, Germany.

### **4. Conclusion**

Geodesy and Geophysics activities of RTSD in the latest 4 years (2007-2010) have focused and participated in the high accuracy survey work whether it is horizontal or vertical surveying, in order to monitor the situation of the earth which is being changed over the years. The disasters caused by earthquakes and the movement of tectonic plates will result directly to the reference coordinates on the map. The results of the GPS measurements have been conducted to improve the control network to be more accurate and reliable.

In the next four years, RTSD will continue to focus on participating in scientific research and educational institutions to track the threat posed by the global environment. Moreover, RTSD will support the establishment of permanent stations or GPS base station project covering the entire country to monitor the movement of tectonic plates in this region more accurately and reliably, also prepared to cope with other natural disasters that may occur in the future.