CHARACTERIZING SURFACE GROUND SETTLEMENT INDUCED BY UNDERGROUND TUNNEL EXCAVATION

MUHAMMAD FIRDAUS BIN MOHD YUSUF

CIVIL AND ENVIRONMENTAL ENGINEERING

UNIVERSITI TEKNOLOGI PETRONAS

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by

Muhammad Firdaus bin Mohd Yusuf

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Supervisor:

Associate Professor Ir. Dr. Hisham bin Mohamad

Dissertation submitted in partial fulfilment of the requirement for the

Bachelor of Engineering (Hons) Civil

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Universiti Teknologi PETRONAS
32610 Seri Iskandar, Perak Darul Ridzuan,
Malaysia

CERTIFICATION OF APPROVAL

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Approved by,

_____

(Associate Professor Ir. Dr. Hisham bin Mohamad)

UNIVERSITI TEKNOLOGI PETRONAS
BANDAR SERI ISKANDAR, PERAK

September 2016

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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MUHAMMAD FIRDAUS BIN MOHD YUSUF

ABSTRACT

The construction of underground tunnel, without a proper mitigation and proper design, a catastrophic event may be happen due to ground sedimentation. In the view of the issue of ground movement, it is possible to predict the ground sedimentation by plotting a Gaussian graph perpendicular alongside the direction of tunnel construction. The information obtained in the qualitative and quantitative data can be used to solve the geotechnical problems. This is to provide enough and reliable information to evaluate the performance of the structure and also the characteristics of the soil. The study is based at the location of Greater Kuala Lumpur (KL) and Selangor, specifically from Sungai Buloh Station, then across to KL and will end at Taman Desa Seroja Station for in total of 51km and 31 stations. The KL Kenny hills and limestone formation will give a different curve and how deep the ground sedimentation once the graph has been plotted. This research is focus in predict the ground movements of the settlements that happened during the parallel and stack of twin tunnels excavation of the underground by plotting a proper Gaussion Graph that shows the maximum ground sedimentation occurred during construction.

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Over the years I studied at Universiti Teknologi PETRONAS, this is the hardest subject that I have to go through. This project may be completed or not, however, I would like to thank you to my supervisors Associate Professor Dr. Hisham bin Mohamad and his PHD student En Syukri that were never give up teaching and guiding me to complete this final project. Without their supervision, I may not been able to do as far as right now.

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CHAPTER 1

INTRODUCTION

1.1 Background

Underground excavations and tunnels, is define as dissolving on-going process of a soluble rock, such as limestone by nature action or by excavation using machinery or blasting. In ages, the use of tunnel has become one of the important structure to help humankind to travel or transport goods from one place to another in shorter time without disturbing the existing of another transportation system. However, there are some tunnel that were designed specifically of a specific purpose like utility tunnel.

Ground movements are caused by the bored tunnel construction in soft ground. In urban areas their potential effects on buildings are an important in design and construction of tunnels. As the excavation is on the process, the ground settlement it continually development at the surface of the ground. Without any safety measure, the building topside will face severe damage due to ground settlement.

The tunnel boring machine (TBM) is a machine which has been developed in recent years and has revolutionised the tunnelling industry both making tunnelling a safer, more economical solution for creating underground space and opening the possibility of creating tunnels where it was not feasible before. There are three types of TBM are widely used, slurry machine, earth pressure balance machine and rock machine. All of this TBM have their own specific task and what kind of soil that it can excavate. However, most of TBM has the same characteristic design.

Bored tunnelling is one of the techniques. Inside of the bored tunnel, it is consist of segments of prefabricated reinforced concrete that well place together with bolts in both of transverse and longitudinal direction. However, during the construction, ground water can enter into the excavating tunnel via joint or voids. Conventional prevention is providing the segments with an inside groove to accommodate a watertight gasket. While excavated, the soil is mix with the slurry injected by the TBM

to create an uplift face pressure required to keep sustain the excavation process, as known as a closed machine. The soil excavated will transfer to the rear of the TBM and transported to the outside the tunnel by train.

1.2 Problem Statement

The construction of the new MRT transit project is part of a sustainable and integrated transport system for area around Greater Kuala Lumpur and Klang Valley. While it is an initiative to reduce congested road, the concern is the construction of tunnel under heavy dense high-rise buildings and structure at the surface will affect the stability of the soil, thus disturbing the foundation of buildings above.

According to Mair (1997), in any tunnelling project, stability during the construction is clearly a prime important to ensure all activities are run as smooth as possible, particularly in this case is in urban environments. Collapse of tunnel can give a serious impact, disturbing to the flow of construction as well as to the everyday routine and business.

Beside from the activities with the surface works, the tunnelling process tends to give rise to potential disturbance. One of them is tunnelling ground movements. It represent particular hazards in an urban environment due to the proximity to exciting buildings and infrastructure that may be disturbed. It also important to prevent unintentional lowering of the groundwater table. This may cause underground settlement below existing building.

Any excavation underground will cause disturbance to the ground movements with a settlement trough developing above and ahead of the tunnel. Analysis of certain number of cases about tunnel ground settlement has demonstrated that the resulting transverse settlement trough immediately after a tunnel has been constructed is well described by a Gaussian distribution curve (Mair, 1996). This prediction of ground movements and assessment of the potential implication on the infrastructure is

therefore an essential factor of the designing, planning and construction of a tunnelling project in the dense, urban environment.

1.3 Objectives

The following are the main objectives to achieve:

i. To predict the ground movements of the settlements that happened during the excavation of the underground.
ii. To obtain ground displacement parameters of KVMRT project by fitting exercise using MATLAB/ Microsoft Excel.
iii. To systematically tabulate the ground displacement parameters with type of tunnel configuration and soil characteristic.

1.4 Scope of Studies

The scope of studies will be involved obtaining and gathering the data from the Klang Valley Mass Rapid Transit (KVMRT) project. The KVMRT involves the construction of a rail-based public transport network comprising of three rail lines. The area involved across Greater KL/Klang Valley region. Together with the existing urban rail network, it will form the backbone of the public transport system. The first Mass Rapid Transit (MRT) line to be implement is the 51km Sungai Buloh-Kajang Line (SBK Line) starting at Sungai Buloh station and ended at Taman Desa Seroja station, Klang. Construction of the line began on 8 July 2011.

The length of the rail in total is 52.2km, respectively 13.5km in underground tunnel while the rest will be 38.7km elevated railway. The total stations in construction are 37 stations, 11 stations will located at underground and 26 stations located elevated above. This project targeted to reduce traffic congested around the area involved at have a capacity of 2,000,000 serves catchment population and 533,000 estimated daily ridership.

Limestone is well known for its highly erratic karstic features. Exposure of limestone, specifically at Kuala Lumpur are mainly found in tin mining areas. Such exposures

seldom exist today after the closure of the tin mines. Old mining lands are covered with remnants of heterogeneous nature from slime to sand.

The geology of Kuala Lumpur Limestone formation is dominates the majority area of Kuala Lumpur. The limestone is estimated to be about 1,850m thick, overlying graphitic schist known as Hawthornden Schist. The top of the sequence is Kenny Hill formation which occupies the heartland of Kuala Lumpur including areas at KLCC and Bukit Bintang.

CHAPTER 2

LITERATURE REVIEW

2.1 Ground Movements

2.1.1 Introduction

The ground movement is caused by the construction of bored tunnel in the soft ground. The cause is so significant because of their influence to the surface buildings, another tunnels system and utilities, such as underground piping and electrical wires. The ground movements and bored tunnel construction in soft ground has been study to ensure the stability of the tunnel and the ground movement is controllable.

2.1.2 Settlement

Case of a single tunnel in a "green field" condition, the process of the surface settlement trough above and ahead of the advancing heading is shown in Figure 1. Construction of the tunnel results in ground movements with a settlement trough developing above and ahead of tunnel. A series of records shown that the resulting transverse settlement trough immediately after a tunnel been constructed.

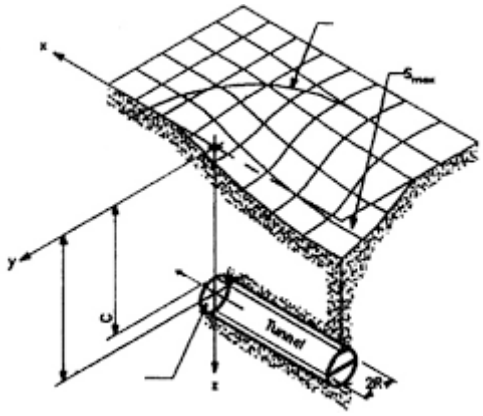


Figure 1: The ground settlement developed as the tunnel been constructed (Leca, 2007)

The shape of ground settlement can be well described using Gaussian curve in Figure 2, explaining the transverse settlement trough graph. The equation definition for the graph is in following:

$$S_V = S_{max} \exp^{\left(\frac{-y^2}{2i^2}\right)} \quad (1)$$

Where,

S_V = settlement

S_{max} = maximum settlement on the tunnel centre-line

y = horizontal distance from the tunnel centre-line

i = horizontal distance from the tunnel centre-line to the point of inflexion of the settlement trough

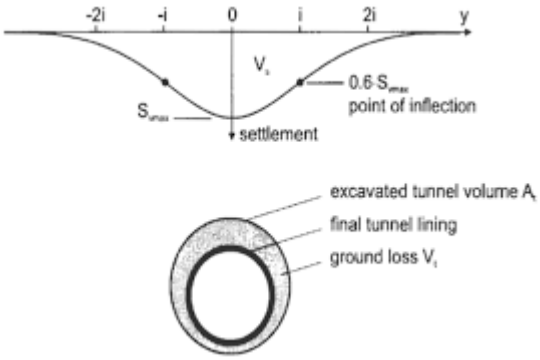


Figure 2: Gaussian curve used to describe the transverse settlement trough (Mooney et al)

O'Reilly and News (1982) showed that in dimension i was an approximately linear function of the depth of the depth z_o and broadly independent of tunnel construction method. Assumption given simple approximate relationship can be used and that values of the trough width parameter K for tunnels in different type of soil such as clay and sands or gravels. It can take as approximately 0.5 and 0.25 respectively.

$$i = Kz_o \tag{2}$$

However, the value of K may require some engineering and appropriate judgement since it heavily depends on the ground itself whether is primarily granular or cohesive, and whether it below or above water table.

The volume of the settlement trough, V_S is integrating from equation (1) to get

$$V_{S=\,S_{max}\;i\,\sqrt{2\pi}} \tag{3}$$

There are cases where the equation (3) need some modification (4) in order to get the approximate value for non-circular or inclined tunnels. Usually for shield tunnelling,

the volume lost is usually up to 1%, however, there are cases where the it can take to 3% were recorded in the soft marine clays of Singapore using earth-preasure balance (EPB) tunnelling machines (Shirlaw and Doran, 1988) and 0.2% was recorded using EPB machine in gravels below water table in Tokyo (Kanayasu et al, 1995).

2.1.3 Horizontal Movements

Damage to structures and services can be result from the horizontal movements. There are few case of histories where horizontal movements have been measured. Attewell (1978) and O'Reilly and New (1982) proposed that, the tunnel in clays, ground displacement vectors are directed towards the tunnel axis is generally constant but reasonable. According to Mair et al (1996), the vector of ground movement vertical and horizontal components S_v and respectively.

2.1.4 Longitudinal Settlement Trough

The excavation tunnel at the urban environment where a structure close to or directly above the tunnel centre-line might experience severe damage from the progressive longitudinal settlement trough generated ahead of the tunnel face as shown at Figure 1, than from the final transverse settlement profile after the tunnel face has passed beneath the building. The ground movement and associated building strains can be determined from the longitudinal settlement trough, which can be assumed to have cumulative probability curve (Mair, 1996). He assumed that the transverse settlement profile has a Gaussian shape that the longitudinal profile should have the form of cumulative probability curve, assuming all ground deformation takes place at constant volume which applicable to the tunnelling clays.

2.1.5 Multiple Tunnels

When there are two or more tunnels are constructed it generally assumed that the predicted ground movement for each tunnel acting independently can superimposed. For tunnels in close proximately, this assumption may be unconservative. Interaction can be taken into account by assuming a greater volume loss for the second tunnel and superimposing for the resulting ground movements. In some cases a building might be more adversely affected by a single tunnel than by a later combination of multiple tunnels (Mair, 1996). A symmetrical combined surface settlement profile would be present for two tunnels constructed side by side at the same level. Cording and Hansmire (1975) presented evidence of asymmetry above twin tunnels of 6.4m diameter with a clear separation of 4.6m driven through medium dense silty sands and gravels for the Washington Metro.

CHAPTER 3

METHODOLOGY

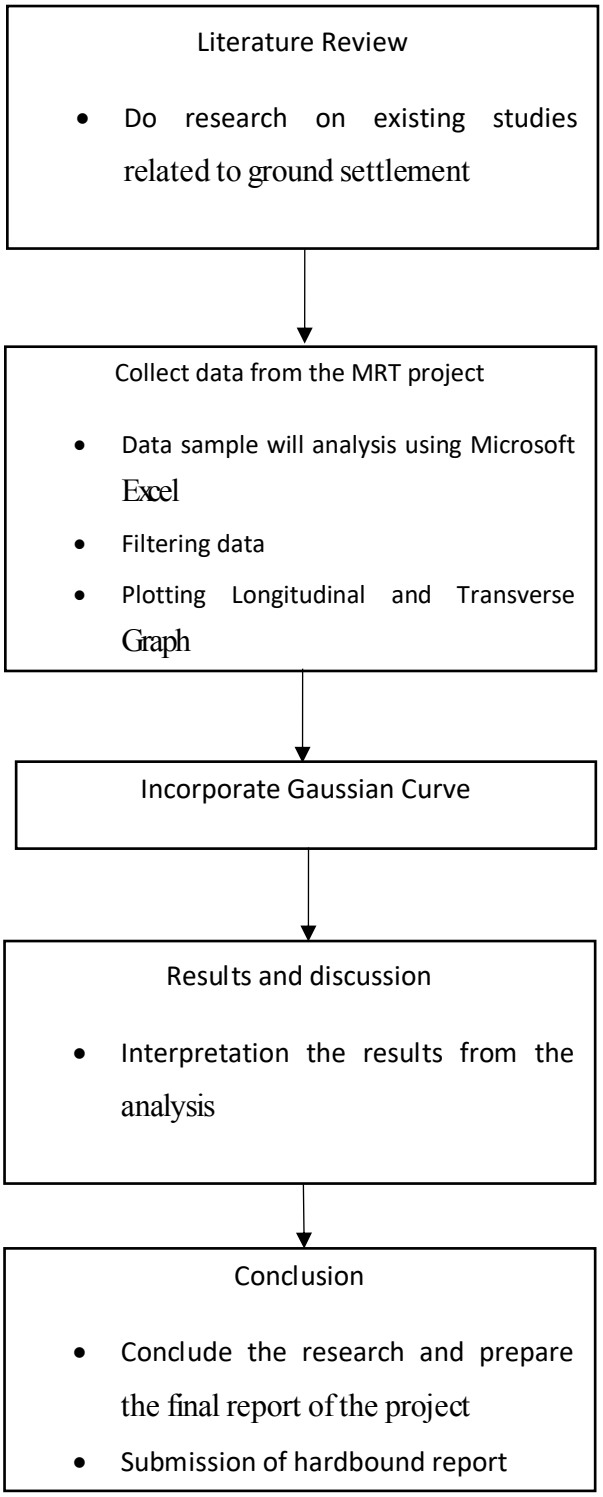
This research will adopt of descriptive methods. The project of MRT has provided the data needed to calculate the surface settlement by analysis data from the project using application MATLAB and Microsoft Excel.

Gaussian distribution curve calculation will be used to determine the settlement depth by applying the following expression:

$$S_V = S_{max} \exp^{\left(\frac{-y^2}{2i^2}\right)}$$

The project will focus on collection of data, process, filtering and applying programming equation. The data type gathered will ordinal variables where all the data already been in ordered. Quantitative data will be analysis and Gaussian graph will be generated based of the data provided. The soil settlement will be using settlement marker and geotechnical instruments such as rod extensometer and horizontal inclinometer, since it is related to the vertical deformation and lateral deformation most.

3.1 Project Flow Chart



3.2 Project Work

The data of KVMRT Project was taken courtesy from the company software Maxwell Geosystem. There are seven (7) data collected specifically from Semantan North Portal to Maluri South Portal. The data picked from the 'greenfield' location, as will be discuss later. The location is labelled CH1+200NB, CH1+400NB, CH1+524NB, CH1+590NB, CH1+968NB, CH2+100NB and CH2+300NB.

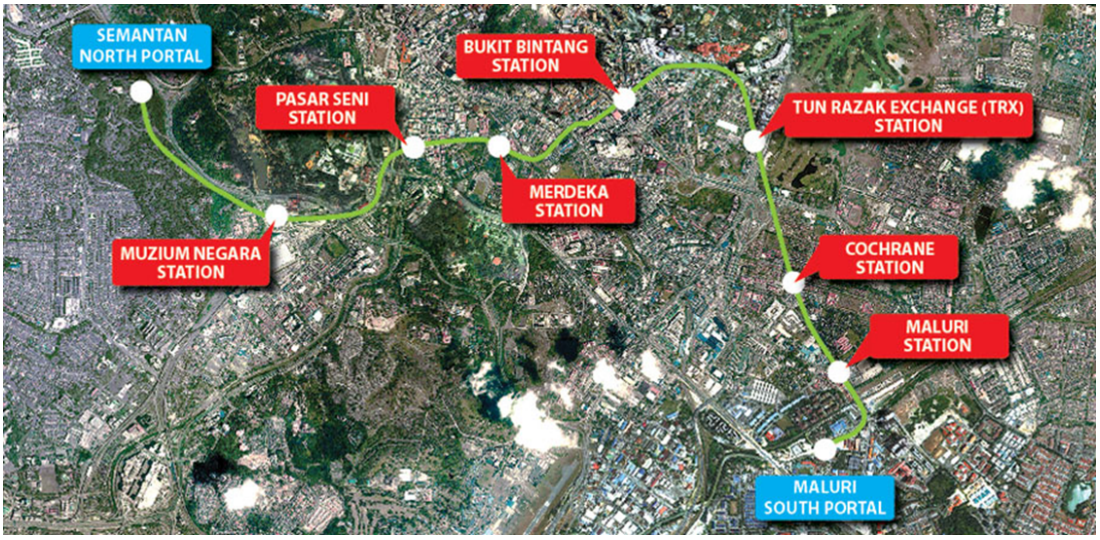


Figure 3: Location of Semantan North Portal to Maluri South Portal at the west side of Kuala Lumpur

3.3. Project Location

The location of the 'greenfield' is based on the drawing provided by the company. Below figure are some parts of the engineering drawing that has been scanned.

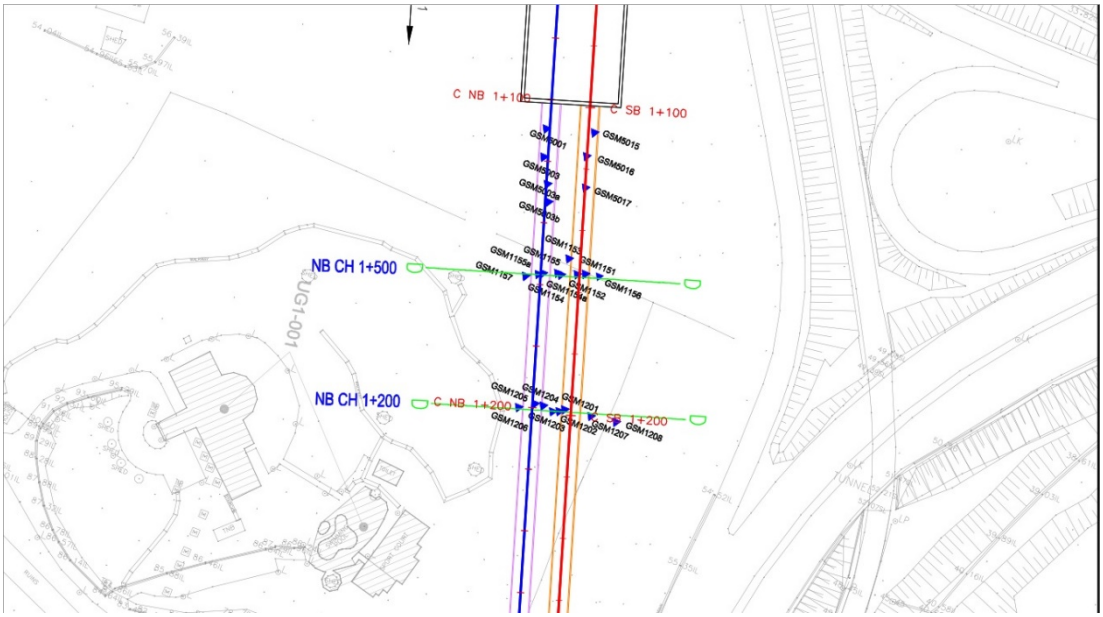


Figure 4: Chainage of CH1+200NB

Figure 5: Chainage of CH1+420NB

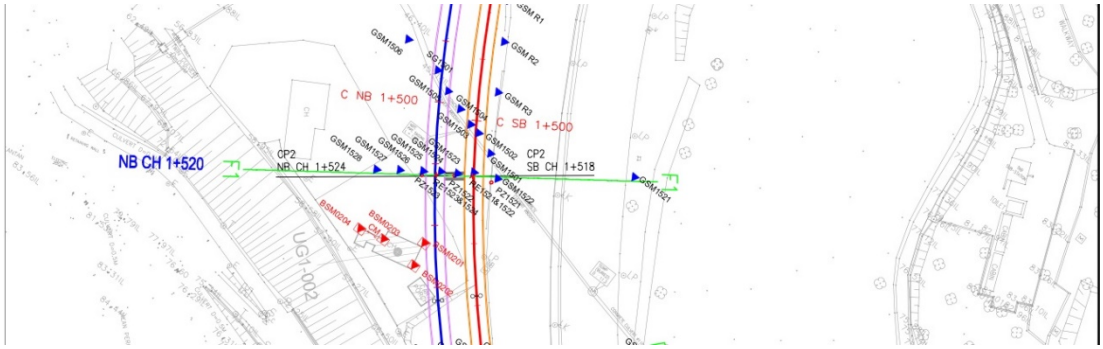


Figure 6: Chainage CH1+520NB

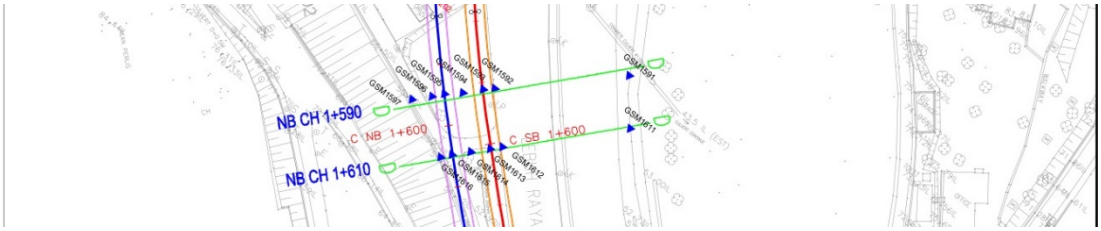


Figure 7: Chainage of CH1+590NB

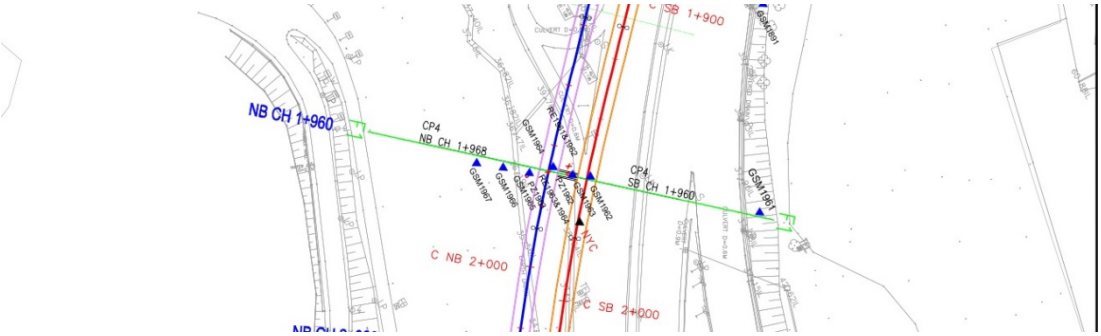


Figure 8: Chainage CH1+960NB

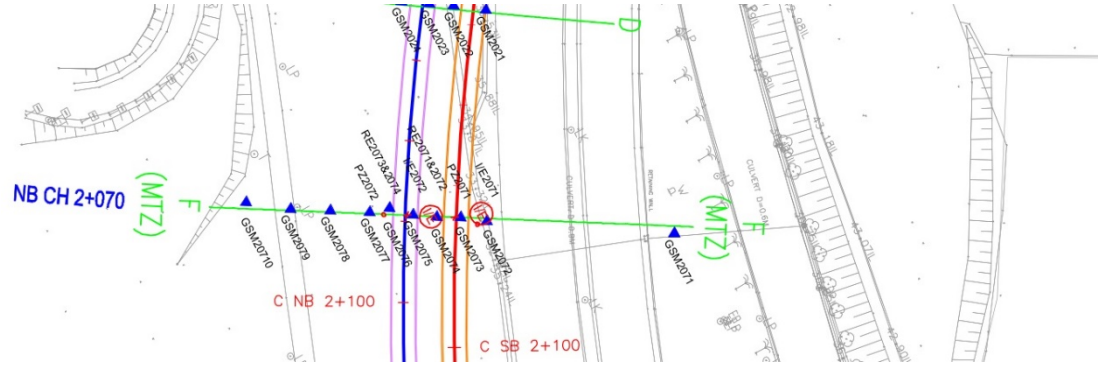


Figure 9: Chainage CH2+100NB

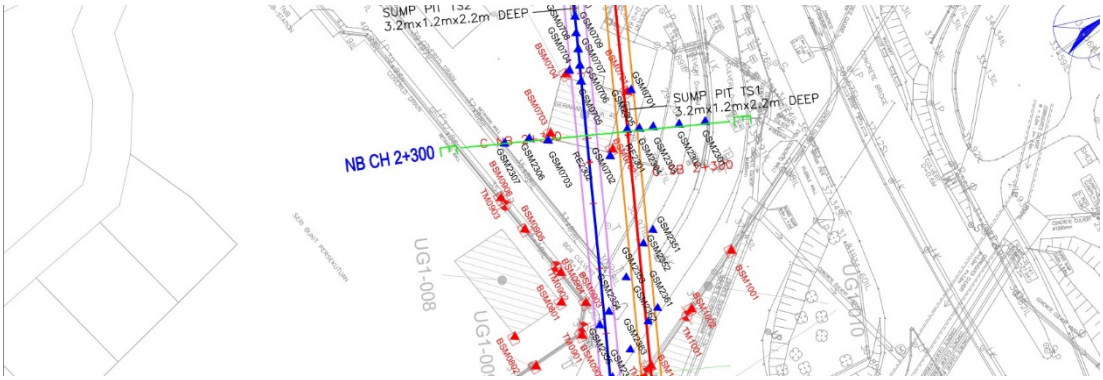


Figure 10: Chainage CH2+300NB

3.4 Data Preparation

All the raw data acquired has been formatted into Microsoft Excel. Thus, the data used for making longitudinal graph is Day and Settlement. Here, both of data will be plotted to get the graph. The data is prepared using Excel.

Table 1: NB 1+200 data of GSM and Day

	GSM1204	GSM1205	GSM1207	GSM1208	GSM1201	GSM1202	GSM1203	GSM1206
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
09/07/20 13 00:00	-6.34	-5.86	-2.78	-2	-6.01	-5.79	-5.54	-1.48
13/07/20 13 00:00	-7.3	-7.14	-2.94	-1.18	-6.06	-5.94	-7.27	-3.87
15/07/20 13 00:00	-7.65	-7.64	-2.25	-0.29	-5.33	-5.49	-7.82	-4.73
16/07/20 13 00:00	-8.08	-8.65	-3.23	-1.15	-5.61	-5.69	-8.45	-5.99
17/07/20 13 00:00	-8.33	-8.61	-3.25	-2.03	-5.79	-5.95	-8.55	-6.56
18/07/20 13 00:00	-8.58	-9.65	-2.32	-0.2	-5.14	-5.65	-8.21	-5.9
23/07/20 13 00:00	-10.08	-11.53	-2.61	-0.05	-5.99	-5.89	-8.78	-6.61
25/07/20 13 00:00	-10.16	-11.47	-2.71	-0.05	-5.99	-6.6	-9.85	-6.69
26/07/20 13 00:00	-11.02	-11.69	-3.44	-0.39	-6.75	-6.4	-9.05	-7.24
27/07/20 13 00:00	-10.54	-11.53	-3.09	-0.27	-6.47	-5.92	-8.91	-7.15
28/07/20 13 00:00	-10.67	-11.69	-3.31	-0.29	-6.44	-6.25	-8.91	-7.17

29/07/20 13 00:00	-10.58	-11.61	-3.16	-0.06	-6.53	-6.08	-9.14	-7.04
30/07/20 13 00:00	-10.97	-11.97	-2.68	-0.16	-5.57	-6.24	-8.74	-6.58
31/07/20 13 00:00	-10.92	-11.94	-2.57	-0.12	-5.55	-6.19	-8.71	-6.46
01/08/20 13 00:00	-10.96	-11.99	-2.59	-0.07	-5.69	-6.04	-8.67	-6.5
02/08/20 13 00:00	-10.54	-11.63	-2.45	-0.79	-5.98	-5.95	-8.8	-5.98
03/08/20 13 00:00	-10.73	-11.92	-2.29	-0.2	-5.34	-6.11	-8.52	-6.17
04/08/20 13 00:00	-10.93	-12.07	-2.61	-0.18	-5.66	-6.24	-8.75	-6.49
05/08/20 13 00:00	-10.99	-11.42	-2.77	-0.25	-5.98	-5.94	-8.79	-7.11
06/08/20 13 00:00	-11.04	-12.29	-2.65	-0.22	-5.76	-6.33	-8.75	-6.6
07/08/20 13 00:00	-10.85	-11.93	-2.54	-0.03	-5.53	-6.18	-8.64	-6.38
08/08/20 13 00:00	-11.97	-13.11	-3.12	-0.88	-6.39	-7.13	-9.19	-7.58
09/08/20 13 00:00	-11.92	-12.49	-3.3	-0.8	-6.43	-6.92	-9.91	-7.44
10/08/20 13 00:00	-12.22	-13.35	-3.37	-1.04	-6.84	-7.43	-10.74	-8.17
11/08/20 13 00:00	-11.16	-12.29	-4.73	-1.72	-7.11	-7.64	-10.96	-6.48
12/08/20 13 00:00	-11.19	-12.35	-4.74	-1.75	-6.49	-7.05	-10.52	-6.5
13/08/20 13 00:00	-15.06	-16.27		-1.53	-6.66	-8.02	-10.5	-7.91
14/08/20 13 00:00	-15.32	-16.51	-4.41	-1.43	-6.63	-7.45	-10.61	-8.38
15/08/20 13 00:00	-15.17	-16.24	-4.27	-1.12	-6.68	-7.1	-10.3	-8.04
16/08/20 13 00:00	-16.32	-17.35	-5.43	-1.34	-10.05	-9.51	-11.71	-8.04
17/08/20 13 00:00	-16.87	-17.62	-4.79	-1.01	-11.36	-10.58	-12.45	-8.61
18/08/20 13 00:00	-16.93	-17.81	-4.6	-0.51	-11.45	-10.8	-12.85	-8.67
19/08/20 13 00:00	-15.75	-16.86	-5.49	-1.63	-11.53	-10.66	-12.19	-8.29
20/08/20 13 00:00	-15.01	-16.48	-4.24	-0.54	-11.2	-10.44	-11.76	-8.43
22/08/20 13 00:00	-14.37	-15.82	-4.28	-0.25	-10.85	-9.82	-11.19	-7.85
23/08/20 13 00:00	-14.28	-15.67	-4.06	-0.19	-10.89	-9.77	-11.04	-7.81
24/08/20 13 00:00	-15.54	-16.32	-4.47	-0.32	-10.02	-9.63	-11.86	-8.63
25/08/20 13 00:00	-14.39	-15.86	-4.24	-0.28	-10.9	-9.89	-11.15	-7.77
26/08/20 13 00:00	-14.43	-15.81	-4.74	-1.11	-10.53	-9.84	-11.19	-8.02
27/08/20 13 00:00	-12.72	-14.75	-5.92	-1.49	-9.85	-9.13	-10.69	-8.2
28/08/20 13 00:00	-12.09	-14.05	-5.96	-1.63	-9.63	-8.93	-9.91	-8.23
29/08/20 13 00:00	-13.22	-14.86	-5.85	-1.07	-10.15	-9.68	-10.19	-7.88
30/08/20 13 00:00	-13.59	-14.74	-5.71	-1.07	-9.98	-8.85	-9.3	-7.96
31/08/20 13 00:00	-13.22	-14.17	-5.19	-0.53	-9.25	-8.68	-8.4	-8.15
01/09/20 13 00:00	-14.02	-15.32	-4.67	-0.91	-9.89	-8.84	-9.19	-8.53

02/09/20 13 00:00	-13.09	-15.15	-6.29	-1.52	-9.81	-9.19	-10.8	-8.42
03/09/20 13 00:00	-12.06	-14.39	-5.71	-2.36	-8.72	-7.73	-9.59	-7.05
04/09/20 13 00:00	-11.96	-14.34	-6.04	-1.21	-9.91	-9	-8.57	-7.75
05/09/20 13 00:00	-12.15	-14.57	-5.91	-1.34	-9.73	-8.82	-9.04	-7.87
06/09/20 13 00:00	-11.5	-13.62	-5.13	-0.36	-8.55	-7.43	-7.15	-6.98
07/09/20 13 00:00	-11.4	-13.64	-5.13	-0.36				
08/09/20 13 00:00	-11.47	-13.69	-5.14	-0.01	-8.55	-7.43	-7.15	-6.98
09/09/20 13 00:00	-11.37	-13.61	-5.14	-0.36	-8.8	-7.47	-6.6	-6.24
10/09/20 13 00:00	-11.68	-13.87	-6.24	-0.01				
11/09/20 13 00:00	-10.96	-13.16	-6.24	-0.01	-8.8	-7.47	-6.6	-6.24
12/09/20 13 00:00	-10.88	-13.24	-6.26					
13/09/20 13 00:00	-10.92	-13.29	-6.33					
14/09/20 13 00:00	-11.05	-13.13	-6.27					
15/09/20 13 00:00	-11	-14.37	-6.38					
16/09/20 13 00:00	-10.95	-14.47	-14.47	-1.06	-8.75	-7.76	-7.12	-7.53
17/09/20 13 00:00	-11.39	-13.66	-13.66					
18/09/20 13 00:00	-11.33	-13.68	-13.68					
19/09/20 13 00:00	-10.95	-13.14	-13.14					
20/09/20 13 00:00								
21/09/20 13 00:00	-10.83	-13.02	-13.02					
22/09/20 13 00:00	-10.89	-13.12	-13.12					
23/09/20 13 00:00	-11.34	-13.61	-13.61	-1.02	-8.77	-7.71	-9.55	-6.26
24/09/20 13 00:00	-10.86	-13.13	-13.13					
25/09/20 13 00:00	-10.79	-13.18	-13.18					
26/09/20 13 00:00	-10.81	-13.19	-13.19					
28/09/20 13 00:00	-10.81	-13.19	-13.19					
29/09/20 13 00:00	-10.85	-13.22	-13.22					
30/09/20 13 00:00	-10.81	-13.15	-13.15	-0.99	-8.71	-7.77	-9.52	-6.32
01/10/20 13 00:00	-10.89	-13.1	-13.1					
02/10/20 13 00:00	-10.8	-13.11	-13.11					
07/10/20 13 00:00	-10.73	-13.18	-13.18	-0.94	-8.69	-7.8	-9.48	-6.38
14/10/20 13 00:00	-10.87	-13.09	-13.09	-1	-8.64	-7.86	-9.42	-6.29

Table 2: NB 1+420 data of GSM and Day

	GSM1424	GSM1423	GSM1422	GSM1421
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
07/08/2013 00:00	-0.27	-0.28	-0.1	-0.01
14/08/2013 00:00	-0.44	-0.01	-0.12	-0.07
28/08/2013 00:00	0	0	0	0
31/08/2013 00:00	-0.26	-0.49	0	-0.15
01/09/2013 00:00	-0.15	-0.65	-0.29	-0.21
02/09/2013 00:00	-0.11	-0.6	-0.07	-0.09
03/09/2013 00:00	-0.22	-0.31	-0.03	-0.23
04/09/2013 00:00	-0.13	-0.5	-0.01	-0.06
05/09/2013 00:00	-0.11	-0.23	-0.14	-0.19
06/09/2013 00:00	-0.49	-0.62	-0.01	-0.43
07/09/2013 00:00	-0.55	-1.3	-1.23	-1.24
08/09/2013 00:00	-0.52	-1.85	-1.72	-1.65
09/09/2013 00:00	-0.21	-1.37	-1.47	-1.24
10/09/2013 00:00	-0.55	-0.62	-0.58	-0.63
11/09/2013 00:00	-0.12	-1.24	-1.47	-1.23
12/09/2013 00:00	-0.88	-0.62	-1.41	-1.31
13/09/2013 00:00	0.06	-1.43	-1.51	-1.57
14/09/2013 00:00	-0.91	-1.43	-0.7	-0.88
15/09/2013 00:00	-1.16	-0.26	-0.33	-0.23
16/09/2013 00:00	-0.63	-0.33	-0.26	-0.39
17/09/2013 00:00	-0.85	-0.73	-0.56	-0.87
18/09/2013 00:00	-0.7	-0.46	-0.53	-0.67
19/09/2013 00:00	-0.65	-0.31	-0.54	-0.84
20/09/2013 00:00	0	0	0	0
21/09/2013 00:00	-0.84	-0.66	-1.35	-1.36
22/09/2013 00:00	-0.71	-0.42	-0.49	-0.64
23/09/2013 00:00	-0.89	-0.69	-0.63	-0.8
24/09/2013 00:00	-0.34	-1.01	-0.93	-1.07
25/09/2013 00:00	-0.66	-0.49	-0.47	-0.65
26/09/2013 00:00	-0.68	-0.51	-0.55	-0.85
28/09/2013 00:00	-0.68	-0.51	-0.55	-0.85
29/09/2013 00:00	-0.64	-0.61	-0.58	-0.73
30/09/2013 00:00	-0.65	-0.48	-0.89	-1.01
01/10/2013 00:00	-1.74	-0.08	-0.12	0
02/10/2013 00:00	-0.32	-0.98	-0.63	-0.79
03/10/2013 00:00	-0.39	-1.03	-0.56	-0.85
04/10/2013 00:00	-0.42	-0.96	-0.59	-0.87
05/10/2013 00:00	-0.48	-0.9	-0.51	-0.91
06/10/2013 00:00	-2.18	-0.98	-1.05	-0.43
07/10/2013 00:00	-2.13	-1.17	-0.77	-0.28

08/10/2013 00:00	-2.15	-1.21	-0.84	-0.3
09/10/2013 00:00	-2.03	-1.18	-0.83	-0.19
10/10/2013 00:00	-2.1	-1.11	-0.91	-0.26
11/10/2013 00:00	-2.15	-1.2	-0.95	-0.2
14/10/2013 00:00	-2.07	-1.09	-0.81	-0.29
18/10/2013 00:00	-2.19	-1.19	-0.83	-0.35
28/10/2013 00:00	-2.19	-1.12	-0.94	-0.63

Table 3: NB 1+520 data of GSM and Day

	GSM1525	GSM1526	GSM1527	GSM1528	GSM1501	GSM1523	GSM1524
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
09/09/2013 00:00	-0.03	0.21	-0.26	0.07	2	0.03	-0.05
10/09/2013 00:00	-0.26	-0.01	-0.04	-0.05	0.66	-0.04	-0.09
11/09/2013 00:00	-0.23	0.21	-0.26	0.07	0.6	0.18	-0.01
12/09/2013 00:00	0.07	0.43	0.01	0.28	0.53	0.3	0.01
13/09/2013 00:00	0.75	0.46	0.13	0.18	0.78	0.66	0.78
14/09/2013 00:00	-0.22	0.16	-0.05	0.04	-1.95	-0.41	-0.24
15/09/2013 00:00	-0.08	-0.06	-0.27	-0.25	-0.09	0.03	-0.4
16/09/2013 00:00	-0.06	0.32	0.11	0.29	0.24	-0.05	-0.15
17/09/2013 00:00	-1.35	0.13	0.18	0.09	-0.78	-0.44	-1.29
18/09/2013 00:00	-7.02	-0.29	0.53	0.93	-1.42	-2.47	-5.18
19/09/2013 09:00	-9.82	-1.98	-0.53	-0.09	-0.78	-1.79	-6.6
19/09/2013 12:00	-9.43	-1.06	0.38	0.84	-0.89	-1.93	-6.08
19/09/2013 16:00	-10.09	-0.55	1.08	1.48	-0.94	-2.44	-6.71
20/09/2013 09:00	-9.8	-1.42	-0.1	0.4	-1.43	-2.16	-7.42
20/09/2013 12:00	-9.57	-1.17	0.28	0.59	-1.45	-1.69	-6.36
20/09/2013 16:00	-10.03	-1.49	-0.07	0.44	-1.51	-2.51	-6.68
21/09/2013 09:00	-10.68	-1.49	-0.07	0.44	-1.42	-2.99	-7.28
21/09/2013 12:00	-10.63	-1.12	0.38	0.96	-1.54	-2.95	-7.33
21/09/2013 16:00	-10.69	-1.6	-0.08	1.07	-1.51	-3.03	-7.29
22/09/2013 09:00	-10.74	-1.33	0.27	1.08	-1.72	-2.81	-7.77
22/09/2013 12:00	-10.24	-1.83	-0.5	0.27	-1.76	-2.44	-7.02

22/09/2013 16:00	-10.19	-1.92	-0.43	0.21	-1.79	-2.49	-7.08
23/09/2013 09:00	-10.24	-1.45	-0.13	1.02	-1.84	-2.61	-7.17
23/09/2013 12:00	-10.19	-0.83	0.47	1.55	-1.89	-2.68	-7.23
23/09/2013 16:00	-10.24	-1.11	0.1	1.29	-1.79	-2.73	-7.18
24/09/2013 09:00	-10.67	-0.78	0.56	1.66	-0.8	-2.86	-7.62
24/09/2013 12:00	-10.61	-0.49	0.64	1.91	-0.77	-2.79	-7.69
24/09/2013 16:00	-10.56	-1.61	-0.38	0.75	-0.83	-2.72	-7.73
25/09/2013 09:00	-10.23	-1.13	0.17	1.11	-1.09	-2.64	-7.6
25/09/2013 12:00	-10.28	-0.47	0.3	1.58	-0.99	-2.69	-7.52
25/09/2013 16:00	-10.21	-0.38	0.36	1.52	-1.05	-2.73	-7.55
26/09/2013 09:00	-10	-0.52	-0.11	1.43	-1.61	-2.44	-7.28
26/09/2013 12:00	-9.97	0.03	0.44	2.1	-1.59	-2.41	-7.22
26/09/2013 16:00	-10.05	0.01	0.36	2.16	-1.54	-2.53	-7.35
28/09/2013 09:00	-10.02	-0.58	-0.15	1.41	-1.57	-2.45	-7.28
28/09/2013 12:00	-10.09	-0.66	-0.19	1.37	-1.64	-2.49	-7.23
28/09/2013 16:00	-10.17	-0.61	-0.25	1.31	-1.69	-2.58	-7.32
29/09/2013 09:00	-10.1				-1.72	-2.53	-7.29
29/09/2013 12:00	-10.07	-0.68	-0.22	1.24	-1.75	-2.59	-7.39
29/09/2013 16:00	-10.2	-0.74	-0.29	1.29	-1.82	-2.48	-7.56
30/09/2013 12:00	-9.89	-1.45	-0.8	0.99	-1.79	-2.58	-8.41
30/09/2013 16:00	-9.82	-1.39	-0.75	0.92	-1.83	-2.53	-8.45
01/10/2013 09:00	-9.79	-1.72	-0.37	1.62	-1.32	-2.62	-8.53
01/10/2013 12:00	-10.45	-0.59	-0.37	1.45	-1.38	-2.55	-8.81
01/10/2013 16:00	-10.5	-0.75	-0.23	1.71	-1.33	-2.69	-8.69
02/10/2013 09:00	-10.46	-0.94	-0.19	1.51	-1.29	-2.69	-8.91
02/10/2013 12:00	-10.42	-0.71	-0.33	1.69	-1.23	-2.64	-8.98
02/10/2013 16:00	-10.39	-0.94	-0.19	1.51	-1.28	-2.73	-9.03
03/10/2013 09:00	-10.33	-1.95	-0.47	0.92	-1.34	-2.78	-9.09
03/10/2013 12:00	-10.29	-0.93	0.54	1.41	-1.38	-2.83	-9.01
03/10/2013 16:00	-10.97	-0.99	0.61	1.46	-1.33	-3.33	-9.42
04/10/2013 09:00	-10.91	-1.01	0.66	1.52	-1.44	-3.38	-9.48
04/10/2013 12:00	-10.88	-1.08	0.59	1.42	-1.49	-3.43	-9.51
04/10/2013 16:00	-10.82	-1.12	0.55	1.48	-1.38	-3.48	-9.55
05/10/2013 09:00	-10.22	-0.98	0.25	1.91	-1.33	-2.62	-8.69

05/10/2013 12:00	-10.01	-0.94	0.33	1.97	-1.31	-2.58	-8.64
05/10/2013 16:00	-10.06	-1.12	0.17	1.8	-1.39	-2.54	-8.7
06/10/2013 09:00	-10.08	-1.17	0.11	1.87	-1.34	-2.6	-8.62
06/10/2013 12:00	-10.13	-1.2	0.24	1.84	-1.29	-2.51	-8.58
06/10/2013 16:00	-10.16	-1.22	0.21	1.92	-2.07	-2.55	-8.54
07/10/2013 09:00	-10.08	-1.25	0.28	1.98	-1.98	-2.61	-8.59
07/10/2013 12:00	-10.02	-1.43	-0.17	1.93	-1.91	-2.66	-8.63
07/10/2013 16:00	-10.09	-1.39	-0.2	1.88	-2.03	-2.58	-8.68
08/10/2013 09:00	-10.13	-1.36	-0.17	1.81	-1.99	-2.53	-8.6
08/10/2013 12:00	-10.19	-1.29	-0.14	1.85	-2.09	-2.65	-8.52
08/10/2013 16:00	-10.15	-1.18	-0.12	1.99	-2.02	-2.62	-8.57
09/10/2013 09:00	-10.2	-1.13	-0.23	1.93	-2.05	-2.69	-9.39
09/10/2013 12:00	-10.11	-1.16	-0.27	1.91	-2	-2.73	-9.47
09/10/2013 16:00	-10.71	-1.2	-0.29	1.89	-0.95	-2.9	-9.34
10/10/2013 09:00	-10.78	-1.12	-0.33	1.86	-0.89	-2.84	-8.95
10/10/2013 12:00	-10.75	-1.51	-0.55	1.48	-0.85	-2.88	-8.93
10/10/2013 16:00	-10.86	-1.16	-0.31	1.99	-1.66	-2.97	-9.52
11/10/2013 09:00	-10.83	-1.12	-0.38	1.91	-1.7	-2.92	-9.59
11/10/2013 12:00	-11.5	-1.2	-0.34	1.95	-1.61	-2.89	-9.55
11/10/2013 16:00	-9.65	-1.23	1.02	1.56	0.15	-1.91	-8.4
12/10/2013 09:00	-9.69	-1.29	1.13	1.51	0.11	-1.97	-8.35
12/10/2013 16:00	-9.47	-1.5	0.61	1.14	-1.32	-1.69	-8.09
13/10/2013 09:00	-10	-1.45	0.67	1.07	-0.87	-2.59	-8.81
13/10/2013 12:00	-9.93	-1.39	0.6	1.09	-0.83	-2.54	-8.88
13/10/2013 16:00	-9.43	-1.34	1.06	1.17	0.2	-1.91	-8.21
14/10/2013 09:00	-10.09	-0.47	1.33	1.14	-0.81	-2.38	-8.72
14/10/2013 12:00	-10.17	-0.4	1.29	1.07	-0.89	-2.44	-8.78
14/10/2013 16:00	-10.65	-0.35	1.23	1.11	-5.17	-3.62	-9.61
15/10/2013 09:00	-10.51	-0.38	1.31	1.04	-24.41	-6.8	-11.09
15/10/2013 12:00	-10.36	-0.72	1.25	0.93	-26.72	-7.82	-11.74
15/10/2013 16:00	-10.61	-0.77	1.21	0.98	-29.7	-10.58	-13.24
16/10/2013 09:00	-10.73	-0.8	1.24	0.95	-35.75	-22.2	-19.4
16/10/2013 16:00	-10.49	-1.26	1.02	1.67	-34.46	-23.25	-20.27
17/10/2013 09:00	-11.47	-1.22	1.06	1.62	-38.31	-26.27	-22.43

17/10/2013 12:00	-11.41	-1.17	1.09	1.6	-38.3	-27.34	-22.5
17/10/2013 16:00	-11.43	-1.14	1.14	1.75	-38.25	-27.49	-22.73
18/10/2013 09:00	-12.42	-1.09	1.28	2.37	-39.26	-29.34	-24.06
18/10/2013 12:00	-12.27	-1.02	1.17	2.42	-39.23	-29.41	-24.22
18/10/2013 16:00	-12.36	-1.08	1.22	2.31	-39.39	-29.42	-24.25
19/10/2013 09:00	-12.18	-1.76	0.67	1.37	-39.41	-29.52	-24.29
19/10/2013 12:00	-12.05	-1.62	0.7	1.53	-39.4	-29.58	-24.35
19/10/2013 16:00	-12.09	-1.66	0.74	1.32	-39.46	-29.55	-24.38
20/10/2013 09:00	-11.63	-2.08	0.72	1.23	-39.18	-29.28	-24.04
20/10/2013 12:00	-11.72	-2.03	0.61	1.13	-39.26	-29.21	-24
20/10/2013 16:00	-11.7	-2.05	0.66	1.19	-39.22	-29.26	-23.95
21/10/2013 09:00	-11.69	-1.97	0.7	1.12	-39.3	-29.34	-23.87
21/10/2013 12:00	-11.61	-1.93	0.76	1.22	-39.25	-29.29	-23.82
21/10/2013 16:00	-12.04	-1.99	0.72	1.27	-39.29	-29.74	-24.46
22/10/2013 09:00	-12.09	-2.09	0.63	1.3	-39.35	-29.67	-24.52
22/10/2013 12:00	-11.92	-2.04	0.68	1.32	-39.4	-29.59	-24.47
22/10/2013 16:00	-12.27	-2.08	0.69	1.37	-39.32	-28.92	-24.87
23/10/2013 09:00	-12.3	-2.13	0.73	1.21	-39.28	-28.77	-24.95
23/10/2013 12:00	-12.18	-2.19	0.77	1.25	-39.23	-28.72	-25
23/10/2013 16:00	-11.2	-1.29	0.95	1.6	-39.35	-29.18	
24/10/2013 09:00	-12.63	-1.23	1.13	1.52	-39.39	-30.58	
25/10/2013 09:00	-12.7	-1.3	1.23	1.55	-39.48	-30.47	-25.28
26/10/2013 09:00	-12.75	-1.3	1.28	1.59	-39.43	-30.41	-25.37
27/10/2013 09:00	-12.12	-1.25	1.22	1.51	-39.5	-30.01	-24.83
28/10/2013 09:00	-12.17	-1.14	1.17	1.63	-39.36	-29.89	-24.88
04/11/2013 09:00	-12.09	-1.19	1.12	1.68	-40.27	-30.34	-25.22
11/11/2013 09:00	-12.02	-1.26	1.03	1.53	-40.39	-30.39	-25.37
03/12/2014 18:01	-0.28					-0.38	-0.45
10/12/2014 18:01	-0.37	-0.2	-0.62	-0.04		-0.19	-0.26
17/12/2014 18:01	0.1	0.11	-0.24	0.19		0.06	-0.07
24/12/2014 18:01	0.26	0.43	-0.11	0.42		0.31	0.12
31/12/2014 18:01	0.27					0.14	-0.06
03/01/2015 18:01	0.3					0.19	0.21
04/01/2015 18:01	0.41					0.44	0.14

05/01/2015 18:01	-0.19					-0.49	-0.54
06/01/2015 18:01	0.17	-0.22	-0.41	-0.12		-0.11	-0.45
07/01/2015 18:01	-0.75					-0.59	-0.86
08/01/2015 18:01	-0.26					-0.41	-0.55
09/01/2015 18:01	0.23					-0.23	-0.24
10/01/2015 18:01	-0.64	-0.39	-0.4	-0.05		-0.48	-1.02
11/01/2015 18:01	-0.24					-0.73	-0.56
12/01/2015 18:01	-0.47					-0.62	-0.8
13/01/2015 18:01	-0.43					-0.51	-0.68
14/01/2015 18:01	-0.39					-0.38	-0.87
15/01/2015 18:01	-0.58					-0.63	-0.79
16/01/2015 18:01	-0.77					-0.88	-0.71
17/01/2015 18:01	-0.96					-0.67	-0.63
18/01/2015 18:01	-1.55					-0.69	-2.12
19/01/2015 18:01	-1.38					-0.51	-1.73
20/01/2015 18:01	-1.21					-0.33	-1.6
21/01/2015 18:01	-1.04					-0.15	-1.47
22/01/2015 18:01	-1.28					-0.41	-1.78
23/01/2015 18:01	-1.52	-0.08	-0.17	0.33		-0.59	-1.58
24/01/2015 18:01	-1.4	-0.32	-0.39	-0.06		-0.48	-1.89
25/01/2015 18:01	-1.5	-0.19	-0.35	0.13		-0.56	-1.74
26/01/2015 18:01	-1.55	-0.29	-0.24	0.02		-0.45	-1.93
27/01/2015 18:01	-1.51	-0.1	-0.36	0.09		-1.38	-2.9
28/01/2015 18:01	-1.42	-0.2	-0.46	0.15		-0.95	-2.47
29/01/2015 18:01	-1.73					-1.85	-2.8
30/01/2015 18:01	-1.62					-1.73	-2.65
31/01/2015 18:01	-1.54					-1.89	-2.79
01/02/2015 18:01	-1.63					-1.7	-2.63
02/02/2015 18:01	-1.74					-1.85	-2.94
03/02/2015 18:01	-1.4					-1.43	-2.66
04/02/2015 18:01	-1.6					-1.59	-2.9
05/02/2015 18:01	-1.64					-1.94	-2.81
06/02/2015 18:01	-1.5					-1.83	-2.94
07/02/2015 18:01	-1.72					-1.65	-2.66

08/02/2015 18:01	-1.53					-1.91	-2.9
09/02/2015 18:01	-1.73					-1.82	-2.72
10/02/2015 18:01	-1.69					-1.66	-2.93
11/02/2015 18:01	-1.83					-1.86	-2.67
12/02/2015 18:01	-1.76					-1.49	-2.9
13/02/2015 18:01	-1.63					-1.76	-2.65
14/02/2015 18:01	-1.82					-1.96	-2.97
15/02/2015 18:01	-1.7					-1.82	-2.78
16/02/2015 18:01	-2.15					-2.66	-3.45
17/02/2015 18:01	-1.99					-2.46	-3.3
18/02/2015 18:01	-2.1					-2.72	-3.41
20/02/2015 18:01	-2.06					-2.56	-3.4
21/02/2015 18:01	-1.94					-2.4	-3.2
22/02/2015 18:01	-2.1					-2.59	-3.33
23/02/2015 18:01	-1.99					-2.37	-3.402
24/02/2015 18:01	-2.11					-2.56	-3.27
25/02/2015 18:01	-2.13					-2.43	-3.44
26/02/2015 18:01	-2.13					-2.43	-3.44
27/02/2015 18:01	-2.22					-2.59	-3.26
28/02/2015 18:00	-2.11					-2.35	-3.46
01/03/2015 18:00	-2.19					-2.46	-3.4
02/03/2015 18:00	-2.27					-2.6	-3.44
03/03/2015 18:00	-2.16					-2.43	-3.53
04/03/2015 18:00	-2.02					-2.26	-3.74
05/03/2015 18:00	-2					-2.51	-3.56
06/03/2015 18:00	-2.11					-2.66	-3.38
07/03/2015 18:00	-2.26					-2.81	-3.2
08/03/2015 18:01	-2.19					-2.6	-3.51
09/03/2015 18:01	-2.23					-2.54	-3.41

Table 4: NB 1+590 data of GSM and Day

	GSM1595	GSM1596	GSM1597	GSM1592	GSM1593	GSM1594
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
22/09/2013 00:00	0.11	0.38	0.33	-0.26	0.43	-0.29
23/09/2013 00:00	0.79	0.5	1.13	0.23	0.63	0.47
24/09/2013 00:00	0.02	-0.17	0.2	-0.35	0.72	-0.43
25/09/2013 00:00	-0.83	-1.27	-0.49	0.01	1.12	0.36
26/09/2013 00:00	-2.02	-2.55	-1.51	0.01	0.77	-0.45
27/09/2013 00:00	-1.18	-1.98	-1.03	0.57	1.52	-0.49
28/09/2013 00:00	-0.9	-1.29	-0.64	0.98	1.92	1.1
29/09/2013 00:00	-1.14	-1.95	-1.12	0.51	1.43	1.15
30/09/2013 00:00	-2.63	-3.42	-2.92	-0.34	1.9	0.02
01/10/2013 00:00	-1.63	-2.57	-2.06	0.52	1.55	-0.89
02/10/2013 00:00	-1.29	-2.04	-1.41	0.6	1.53	0.32
03/10/2013 00:00	-1.43	-2.06	-1.49	1.55	1.58	0.37
04/10/2013 00:00	-1.61	-2.36	-1.68	0.2	1.66	0.07
05/10/2013 00:00	-1.53	-2.28	-1.62	0.26	1.61	0.19
06/10/2013 00:00	-2.14	-2.85	-2.21	0.14	1.58	-0.01
07/10/2013 00:00	-2.11	-2.74	-2.24	0.17	1.52	-0.05
08/10/2013 00:00	-3.3	-3.85	-3.39	0.15	1.47	-0.83
09/10/2013 00:00	-2.15	-2.62	-2.66	0.23	1.41	-0.9
10/10/2013 00:00	-1.11	-1.7	-1.22	0.27	1.39	-0.74
11/10/2013 00:00	-1.48	-2.39	-1.83	0.21	1.33	-0.8
12/10/2013 00:00	-1.36	-2.33	-1.78	0.16	1.37	-0.78
13/10/2013 00:00	-1.43	-2.22	-1.68	0.2	1.44	-0.81
14/10/2013 00:00	-1.48	-2.35	-1.61	0.26	1.4	-0.88
15/10/2013 00:00	-1.56	-2.43	-1.68	0.27	1.48	-0.94
16/10/2013 00:00	-0.78	-1.69	-1.11	0.35	1.42	0.79
17/10/2013 00:00	-0.79	-2.79	-2.31	-1.26	1.1	0.72
18/10/2013 00:00	-1.24	-2.16	-1.44	0.53	1.78	0.98
19/10/2013 00:00	-1.58	-2.5	-2.11	0.47	1.65	0.53
20/10/2013 00:00	-1.88	-2.48	-2.01	0.5	1.59	0.42
21/10/2013 00:00	-1.77	-2.37	-2.09	0.58	1.52	0.46
22/10/2013 00:00	-2.18	-2.95	-2.34	-1.28	0.43	-0.71

23/10/2013 00:00	-3.56	-4.07	-3.17	-2.59	-1.48	-2.51
24/10/2013 00:00	-5.48	-5.07	-3.23	-4.3	-3.33	-2.99
25/10/2013 00:00	-5.46	-5.06	-2.98	-4.98	-4.86	-6.57
26/10/2013 00:00	-6.13	-5.8	-3.55	-4.58	-5.05	-6.7
27/10/2013 00:00	-6.59	-6.15	-4.06	-5.12	-5.08	-7.02
28/10/2013 00:00	-7.2	-6.88	-4.47	-5.23	-5.92	-7.6
29/10/2013 00:00	-6.64	-6.42	-4.12	-5.55	-5.47	-7.54
01/11/2013 00:00	-6.7	-6.57	-4.4	-5.62	-5.72	-7.47
04/11/2013 00:00	-7.37	-7.39	-5.15	-6.51	-5.99	-7.96
11/11/2013 00:00	-7.46	-7.32	-5.23	-6.58	-5.85	-8.13

Table 5: NB 1+960 data of GSM and Day

	GSM1964	GSM1965	GSM1966	GSM1967	GSM1962	GSM1963
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
25/10/2013 00:00	0	0	0	0	0	0
26/10/2013 00:00	-0.52	-0.46	-0.36	-0.08	-0.68	-0.38
27/10/2013 00:00	-1.19	-0.6	-0.14	0.2	-0.66	-0.94
28/10/2013 00:00	-3.76	-0.84	-0.56	-0.35	-1.84	-2.77
29/10/2013 00:00	-5.58	-2.38	-0.88	0.16	-2.1	-4.66
30/10/2013 00:00	-6.96	-3.82	-1.72	0.11	-2.47	-5.35
31/10/2013 00:00	-5.96	-2.85	-1.28	0.02	-2.11	-4.72
01/11/2013 00:00	-6.02	-2.9	-1.36	0.08	-2.19	-4.81
02/11/2013 00:00	-5.99	-2.98	-1.3	0.04	-2.14	-4.88
03/11/2013 00:00	-5.94	-3	-1	0.1	-1.84	-4.77
04/11/2013 00:00	-5.88	-3.07	-0.94	0.18	-1.97	-4.84
05/11/2013 00:00	-5.95	-2.91	-1.06	0.05	-1.99	-4.75
06/11/2013 00:00	-6.03	-2.97	-1.17	-0.04	-2.04	-4.83
07/11/2013 00:00	-6.1	-3.05	-1.23	-0.01	-2.09	-4.91
08/11/2013 00:00	-6.01	-3.1	-1.29	-0.07	-1.93	-4.83
09/11/2013 00:00	-6.06	-3.16	-1.37	-0.12	-2	-4.89
10/11/2013 00:00	-6.12	-3.26	-1.4	-0.11	-2.16	-4.94
11/11/2013 00:00	-6.24	-3.22	-1.49	-0.18	-2.27	-5.01
12/11/2013 00:00	-6.67	-3.41	-1.7	-0.38	-2.66	-5.33
13/11/2013 00:00	-6.79	-3.63	-1.78	-0.75	-2.58	-5.51
14/11/2013 00:00	-6.92	-3.67	-1.87	-0.8	-2.61	-5.58
15/11/2013 00:00	-6.96	-3.74	-1.82	-0.71	-2.68	-5.63
16/11/2013 00:00	-6.94	-3.94	-2	-0.79	-2.6	-5.61
19/11/2013 00:00	-7.06	-4.17	-2.07	-0.9	-2.86	-5.74
20/11/2013 00:00	-7.14	-4.36	-2.25	-0.88	-2.89	-5.65
21/11/2013 00:00	-7.3	-4.42	-2.3	-0.81	-2.98	-6.23
23/11/2013 00:00	-7.24	-4.48	-2.14	-0.88	-3.03	-6.34
24/11/2013 00:00	-7.44	-4.74	-2.24	-0.97	-3.09	-6.43
25/11/2013 00:00	-8.46	-4.67	-1.93	-0.7	-6.15	-8.63
26/11/2013 00:00	-8.46	-4.67	-1.93	-0.7	-6.15	-8.63
27/11/2013 00:00	-8.57	-4.2	-2.22	-0.72	-5.1	-8.2

28/11/2013 00:00	-10.34	-5.16	-2.41	-0.84	-8.37	-11.04
29/11/2013 00:00	-10.55	-5.25	-2.48	-0.88	-9.23	-11.628
01/12/2013 00:00	-9.66	-4.62	-2.25	-0.84	-8.85	-11.83
06/12/2013 00:00	-9.71	-4.72	-2.14	-0.72	-9.02	-11.45
09/12/2013 00:00	-9.8	-4.81	-2.21	-0.68	-9.09	-11.53
10/12/2013 00:00	-9.8	-4.81	-2.21	-0.68	-9.09	-11.53
16/12/2013 00:00	-9.98	-4.89	-2.33	-0.84	-9.21	-11.62
23/12/2013 00:00	-10.07	-4.96	-2.24	-0.66	-9.3	-11.76
30/12/2013 00:00	-10.14	-4.83	-2.31	-0.56	-9.24	-11.82
03/12/2014 18:01	-0.12	0.02	-0.14	-0.67	-0.63	-0.2
10/12/2014 18:01	-0.34	-0.21	-0.44	-0.18	-0.4	-0.49
17/12/2014 18:01	-0.16	-0.07	-0.23	-0.26	-0.42	-0.25
24/12/2014 18:01	-0.03	0.08	-0.18	-0.24	-0.35	-0.01
26/12/2014 18:01	0.36	0.34	0.16	-0.11	-0.38	0.14
27/12/2014 18:01	0.28	0.36	0.24	0.22	-0.31	0.11
28/12/2014 18:01	-0.34	-0.03	-0.14	-0.07	-0.98	-0.16
30/12/2014 18:01	0.11	0.19	0	-0.03	-0.65	-0.18
31/12/2014 18:01	0.05	0.25	0.28	0.38	-0.72	-0.41
01/01/2015 18:01	-0.01	0.31	-0.11	0.21	-0.79	-0.22
02/01/2015 18:01	-0.24	-0.05	0.01	0.31	-0.73	-0.56
03/01/2015 18:01	0.3	0.32	0.19	0.66	-0.84	-0.04
04/01/2015 18:01	-0.98	-1.1	-0.65	-0.47	-1.54	-1.16
05/01/2015 18:01	-1.08	-0.51	-0.5	-0.23	-1.49	-1.23
06/01/2015 18:01	-0.62	-0.28	-0.35	-0.63	-1.33	-0.9
07/01/2015 18:01	-1.45	-0.7	-0.61	-0.34	-2.19	-1.79
08/01/2015 18:01	-1.08	-0.49	-0.57	-0.37	-1.77	-1.32
09/01/2015 18:01	-0.25	-0.02	0.01	0.1	-1.73	-1.35
10/01/2015 18:01	-0.55	-0.1	-0.18	-0.17	-1.93	-1.38
11/01/2015 18:01	-0.72	-0.18	-0.37	-0.44	-1.67	-1.41
12/01/2015 18:01	-0.89	-0.38	-0.56	-0.71	-1.76	-1.52
13/01/2015 18:01	-1.42	-0.66	-0.45	0.02	-1.95	-1.36
14/01/2015 18:01	-1.1	-0.44	-0.39	-0.31	-1.42	-1.2
15/01/2015 18:01	-1.14	-0.59	-0.33	-0.52	-1.61	-1.37
16/01/2015 18:01	-1.83	-0.96	-0.66	-0.06	-2.27	-2.32

17/01/2015 18:01	-1.37	-0.75	-0.58	-0.43	-1.82	-1.95
18/01/2015 18:01	-1.37	-0.67	-0.25	0.3	-2.15	-1.64
19/01/2015 18:01	-1.16	-0.59	-0.47	0.05	-2.48	-1.56
20/01/2015 18:01	-1.3	-0.78	-0.71	-0.2	-2.56	-1.74
21/01/2015 18:01	-1.44	-0.97	-0.59	-0.45	-2.41	-1.92
22/01/2015 18:01	-1.58	-0.68	-0.47	-0.7	-2.26	-1.86
23/01/2015 18:01	-1.72	-0.77	-0.35	-0.62	-2.11	-1.81
24/01/2015 18:01	-1.48	-0.57	-0.28	-0.64	-2.26	-1.53
25/01/2015 18:01	-1.91	-1.13	-0.71	-0.23	-2.74	-2.51
26/01/2015 18:01	-1.67	-0.89	-0.48	-0.37	-2.54	-2.18
27/01/2015 18:01	-1.74	-1	-0.55	-0.4	-2.65	-2.27
28/01/2015 18:01	-1.62	-0.36	-0.27	0.31	-2.04	-1.97
29/01/2015 18:01	-1.69	-0.57	-0.34	0.1	-2.26	-2.14
30/01/2015 18:01	-1.8	-0.89	-0.53	-0.02	-2.08	-2.4
31/01/2015 18:01	-1.23	-0.46	-0.16	0.12	-1.95	-1.44
01/02/2015 18:01	-1.5	-0.62	-0.28	0.03	-2.09	-1.68
02/02/2015 18:01	-1.79	-0.37	-0.45	-0.17	-2.28	-1.94
03/02/2015 18:01	-1.56	-0.65	-0.76	0.16	-2.45	-1.62
04/02/2015 18:01	-1.71	-0.62	-0.87	0.13	-1.86	-2.05
05/02/2015 18:01	-1.62	-0.75	-0.65	-0.04	-2.12	-1.85
06/02/2015 18:01	-1.72	-0.69	-0.81	0.02	-2.05	-1.97
07/02/2015 18:01	-1.59	-0.57	-0.95	0.16	-1.94	-1.78
08/02/2015 18:01	-1.73	-0.76	-0.74	-0.03	-2.09	-1.94
09/02/2015 18:01	-1.61	-0.56	-0.98	-0.12	-1.92	-1.85
10/02/2015 18:01	-1.83	-0.78	-0.71	0.03	-2.11	-2.07
11/02/2015 18:01	-1.98	-0.97	-0.9	-0.28	-2.45	-2.49
12/02/2015 18:01	-1.82	-0.66	-0.7	-0.12	-2.31	-2.32
13/02/2015 18:01	-1.63	-0.94	-0.84	-0.3	-2.28	-2.17
14/02/2015 18:01	-1.99	-0.81	-0.72	-0.19	-2.41	-2.34
15/02/2015 18:01	-1.84	-1.01	-0.87	-0.31	-2.32	-2.13
16/02/2015 18:01	-1.97	-1.16	-0.6	0.07	-2.12	-2.23
17/02/2015 18:01	-1.8	-1.03	-0.67	-0.11	-2.35	-2.45
18/02/2015 18:01	-1.92	-1.18	-0.57	-0.32	-2.14	-2.39
20/02/2015 18:01	-1.73	-1.13	-0.83	-0.01	-2.2	-2.34

21/02/2015 18:01	-1.86	-1.15	-0.73	-0.3	-2.29	-2.48
22/02/2015 18:01	-1.82	-1.23	-0.9	-0.14	-2.4	-2.54
23/02/2015 18:01	-2	-1.28	-0.78	-0.37	-2.27	-2.25
24/02/2015 18:01	-1.9	-1.12	-1.13	-0.2	-2.39	-2.5
25/02/2015 18:01	-2.02	-1.03	-0.94	-0.14	-2.28	-2.61
26/02/2015 18:01	-2.02	-1.03	-0.94	-0.14	-2.28	-2.61
27/02/2015 18:01	-2.06	-1.21	-0.94	-0.22	-2.35	-2.29
28/02/2015 18:00	-1.99	-1.27	-1.14	-0.37	-2.19	-2.52
01/03/2015 18:00	-2.33	-0.91	-0.42	0.46	-2.22	-2.75
02/03/2015 18:00	-2.25	-1.04	-0.57	0.26	-2.28	-2.64
03/03/2015 18:00	-2.13	-1.23	-0.54	-0.03	-2.17	-2.48
04/03/2015 18:00	-1.97	-1.38	-0.46	-0.32	-2.02	-2.34
05/03/2015 18:00	-2.14	-1.25	-0.74	-0.14	-2.14	-2.51

Table 6: NB 2+100 data of GSM and Day

	GSM2075	GSM2076	GSM2077	GSM2078	GSM2079	GSM2071	GSM2072	GSM2073	GSM2074
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
04/11/2013 00:00	0	0	0	0	0	0	0	0	0
05/11/2013 00:00	-0.96	-0.1	0.23	-0.02	-0.12	-0.18	-0.23	-0.11	-1.21
06/11/2013 00:00	-1.11	-0.15	0.15	-0.08	-0.17	-0.23	-0.3	-0.3	-1.62
07/11/2013 00:00	-1.17	-0.07	0.11	-0.14	-0.21	-0.16	-0.25	-0.24	-1.79
08/11/2013 00:00	-1.22	-0.62	0.03	-0.11	-0.09	-0.05	-0.37	-0.3	-1.86
09/11/2013 00:00	-1.29	-0.74	-0.08	-0.26	-0.23	-0.28	-0.41	-0.38	-1.93
10/11/2013 00:00	-1.36	-0.78	-0.04	-0.48	-0.48	-0.67	-0.49	-0.48	-2.03
11/11/2013 00:00	-1.62	-1.99	-0.8	-0.59	-1.29	-0.89	-0.59	-0.57	-2.13
12/11/2013 00:00	-1.77	-2.11	-0.93	-0.65	-0.9	-0.35	-0.68	-0.76	-2.47
13/11/2013 00:00	-1.96	-2.32	-0.88	-0.89	-0.78	-0.29	-0.77	-1.1	-2.77
14/11/2013 00:00	-2.08	-2.5	-0.82	-0.78	-0.75	-0.17	-0.72	-1.05	-2.92
15/11/2013 00:00	-0.83	-1.31	0.15	-0.48	-0.57	-0.2	-0.36	-0.2	-1.76
16/11/2013 00:00	-0.75	-1.16	0.03	-0.56	-0.71	-0.31	-0.11	0.1	-1.6
19/11/2013 00:00	-0.69	-1.1	0.16	-0.46	-0.63	-0.23	-0.16	0.17	-1.42
20/11/2013 00:00	-0.54	-0.92	0.1	-0.49	-0.54	-0.38	-0.23	0.03	-1.35
21/11/2013 00:00	-0.5	-1	0	-0.41	-0.47	-0.4	-0.1	0.19	-1.27
23/11/2013 00:00	-0.34	-1.12	-0.16	-0.66	-0.69	-0.5	-0.32	0.11	-1.05
24/11/2013 00:00	-0.28	-1.02	-0.12	-0.63	-0.58	-0.41	-0.19	0.16	-1.13
25/11/2013 00:00	-0.11	-0.73	-0.18	-0.77	-0.61	-0.32	-0.21	0.09	-1.07
26/11/2013 00:00	0.04	-0.62	-0.27	-0.87	-0.57	-0.39	-0.28	0.16	-1.14

27/11/2013 00:00	-0.02	-0.81	-0.52	-0.81	-0.46	0.06	-0.32	0.05	-1.29
28/11/2013 00:00	0.14	-0.78	-0.43	-0.78	-0.4	-0.15	-0.08	0.21	-1.26
29/11/2013 00:00	0.08	-0.91	-0.5	-0.67	-0.51	-0.11	0.04	0.1	-1.22
01/12/2013 00:00	0.26	-0.92	-0.52	-0.64	-0.63	-0.28	0.13	0.07	-1.03
04/12/2013 00:00	-1.08	-0.3	-0.1	-0.54	-0.4	-0.15	-0.53	-2.06	0.25
05/12/2013 00:00	-1.14	-0.22	0.03	-0.59	-0.55	-0.01	-0.35	-1.93	0.08
06/12/2013 00:00	-1.34	-0.45	-0.19	-0.38	-0.45	-0.22	-0.27	-2.4	-0.21
07/12/2013 00:00	-1.25	-0.51	-0.02	-0.26	-0.38	-0.17	-0.33	-2.59	-0.29
08/12/2013 00:00	-1.32	-0.34	-0.08	-0.17	-0.49	-0.36	-0.41	-2.73	-0.48
09/12/2013 00:00	-1.41	-0.29	0.03	0.02	-0.4	-0.22	-0.27	-2.8	-0.53
10/12/2013 00:00	-1.19	-0.41	-0.16	-0.08	-0.58	-0.29	-0.32	-2.88	-0.62
11/12/2013 00:00	-1.28	-0.5	-0.02	-0.21	-0.63	-0.15	-0.4	-2.69	-0.73
12/12/2013 00:00	-1.14	-0.33	0.03	-0.12	-0.5	-0.2	-0.54	-2.92	-0.8
14/12/2013 00:00	-1.32	-0.53	-0.16	-0.28	-0.72	-0.18	-0.55	-3.01	-0.87
15/12/2013 00:00	-1.26	-0.36	0	-0.07	-0.48	-0.03	-0.63	-2.88	-0.79
16/12/2013 00:00	-1.11	-0.43	-0.11	-0.03	-0.61	-0.09	-0.7	-3.05	-0.72
23/12/2013 00:00	-1.18	-0.53	-0.23	-0.09	-0.41	-0.15	-0.75	-3.12	-0.81
30/12/2013 00:00	-1.3	-0.59	-0.31	-0.17	-0.48	-0.2	-0.5	-2.93	-0.76
06/01/2014 00:00	-1.24	-0.42	-0.13	-0.22	-0.53	0.02	-0.52	-2.99	-0.89

Table 7: NB 2+300 data of GSM and Day

	GSM2301	GSM2302	GSM2303	GSM2304	GSM2306
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
13/07/2014 00:00	-0.03	0	-0.32	0.32	-0.9
14/07/2014 17:00	-0.55	-0.44	-0.54	-0.04	-1.49
15/07/2014 17:00	-0.51	-0.61	-0.62	-0.21	-1.47
16/07/2014 17:00	-0.44	-0.25	-0.39	0.01	-1.38
17/07/2014 17:00	-0.6	-0.64	-0.7	-0.22	-1.55
18/07/2014 00:00	-0.36	-0.38	-0.46	0.05	-1.24
19/07/2014 00:00	-0.05	-0.11	-0.11	0.45	-0.98
20/07/2014 00:00	-0.03	-0.27	-0.03	0.6	-1.03
21/07/2014 00:00	-0.22	-0.18	-0.17	0.43	-1.28
22/07/2014 00:00	0.34	0.37	-1.43	0.85	-0.79
23/07/2014 00:00	0.34	0.37	-1.43	0.85	-0.79
24/07/2014 00:00	-1.45	-1.56	-1	-0.74	-2.12
25/07/2014 00:00	-0.3	-0.03	-0.05	0.35	-1.05
26/07/2014 00:00	-0.63	-0.46	-0.52	0.13	-1.5
27/07/2014 00:00	-1.52	-1.35	-1.2	-1.03	-2.72
28/07/2014 00:00	-1.44	-1.15	-1.01	-0.76	-2.5
29/07/2014 00:00	-1.68	-1.45	-1.36	-1.08	-2.32
30/07/2014 00:00	-1.75	-1.49	-1.38	-1.37	-2.71
31/07/2014 00:00	-4.23	-3.97	-3.81	-3.57	-5.16
01/08/2014 00:00	-4.28	-4.06	-3.93	-3.74	-5.55
02/08/2014 00:00	-4.28	-4.34	-4.4	-3.83	-5
03/08/2014 00:00	-4.16	-3.88	-4.56	-3.73	-5.14
04/08/2014 00:00	-4.35	-4.34	-4.35	-4.02	-5.33
05/08/2014 00:00	-4.46	-4.32	-4.1	-3.88	-5.45
06/08/2014 00:00	-4.82	-4.72	-4.43	-4.32	-5.82
07/08/2014 00:00	-4.82	-4.72	-4.43	-4.32	-5.82
08/08/2014 00:00	-4.78	-4.55	-4.32	-4.24	-5.88
09/08/2014 00:00	-4.88	-4.37	-4.38	-4.19	-5.83
10/08/2014 00:00	-4.18	-4.17	-4.05	-4.07	-5.47
11/08/2014 00:00	-4.38	-4	-4.49	-4.24	-5.67
12/08/2014 00:00	-4.83	-4.83	-4.6	-4.43	-6.08

13/08/2014 00:00	-5.95	-5.56	-5.55	-5.32	-6.79
14/08/2014 00:00	-4.31	-4.47	-4.25	-4.08	-5.47
15/08/2014 00:00	-3.33	-3.33	-3.05	-2.86	-4.36
16/08/2014 00:00	-3.02	-3.14	-2.9	-2.64	-4.1
17/08/2014 00:00	-3.39	-3.16	-3.2	-2.9	-4.21
18/08/2014 00:00	-1.64	-1.83	-1.86	-1.18	-3.65
19/08/2014 00:00	-4.25	-4.39	-4.81	-3.74	-6.28
20/08/2014 00:00	-5.13	-4.8	-5.49	-4.21	-6.12
21/08/2014 00:00	-5.01	-5.32	-5.57	-4.78	-6.87
22/08/2014 00:00	-5.01	-5.14	-5.44	-4.61	-6.79
23/08/2014 00:00	-6.04	-5.22	-5.39	-4.44	-6.67
24/08/2014 00:00	-5.57	-5.71	-5.79	-5.04	-7.28
25/08/2014 00:00	-5.48	-5.41	-5.42	-4.9	-6.77
26/08/2014 00:00	-3.23	-3.83	-4.01	-3.18	-5.18
27/08/2014 00:00	-3.22	-3.45	-3.67	-2.69	-4.67
28/08/2014 00:00	-2.81	-2.86	-2.81	-2.15	-3.87
29/08/2014 00:00	-2.14	-2.66	-2.79	-1.86	-3.92
30/08/2014 00:00	-1.14	-1.5	-1.8	-0.87	-2.96
31/08/2014 19:00	-0.42	-1.19	-1.28	-0.2	-2.5
01/09/2014 19:00	-2.68	-3.06	-3.47	-2.39	-4.99
02/09/2014 19:00	-4.91	-4.7	-5.39	-4.03	-6.93
03/09/2014 19:00	-2.82	-3.01	-3.49	-2.23	-4.87
04/09/2014 19:00	-2.01	-2.49	-2.87	-1.24	-4.33
05/09/2014 19:00	-2.37	-2.58	-2.84	-1.97	-4.4
06/09/2014 19:00	-2.37	-2.58	-2.84	-1.97	-4.4
07/09/2014 19:00	-1.39	-1.68	-2.17	-0.66	-3.74
09/09/2014 19:00	-1.39	-1.68	-2.17	-0.66	-3.74
10/09/2014 19:00	-1.48	-1.94	-2.17	-0.97	-3.57
14/09/2014 19:00	-1.21	-2.23	-2.29	-1.14	-3.84
19/09/2014 19:00	-1.21	-2.23	-2.29	-1.14	-3.84
21/09/2014 19:00	-1.44	-2.21	-2.11	-1.44	-3.5
05/10/2014 18:01	-1.32	-1.91	-1.56	-0.98	-2.63

3.5 Project Activities

These are the main activities in conducting the project:

i. Background study and analyse from previous related journal
ii. Collect data from MRT project
iii. Analyse the data obtained
iv. Recommendation and project reports towards the data finding
v. Final Year Project report writing finalisation

3.6 Gantt Chart

Table 8: Gantt chart Planning for September 2016 Semester

No	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	4th Jan 2017
1	Literature Review															
2	Preliminary Research Work															
3	Data Analysis for Longitudinal Graph and Gaussian Graph															
4	Pre-SEDEX															
5	Submission of Final report															
6	Submission of Technical Report															
7	VIVA presentation															
8	Hardbound Thesis submission															

3.7 Key Project Milestones

- 1st week of May 2016: Propose project title
- 9th week of May 2016: Proposal defend
- 14th week of May 2016: Interim Report submission

- 1st – 9th week of Sept 2016: Data Analysis for Longitudinal Graph and Gaussian Graph
- 3rd week of Sept 2016: Submission of Progress report
- 10th week of Sept 2016: Pre-SEDEX presentation
- 12th week of Sept 2016: Submission of dissertation report
- 13th week of Sept 2016: Submission of Technical writing
- 14th week of Sept 2016: VIVA presentation

- 4th January 2017 : Submission of Thesis Hardbound

CHAPTER 4

RESULT AND DISSCUSION

4.1 Longitudinal Graph

Once the data has been categories into X (Day) and Y (Settlement), it can be plot to shot the behaviour of each chainage.

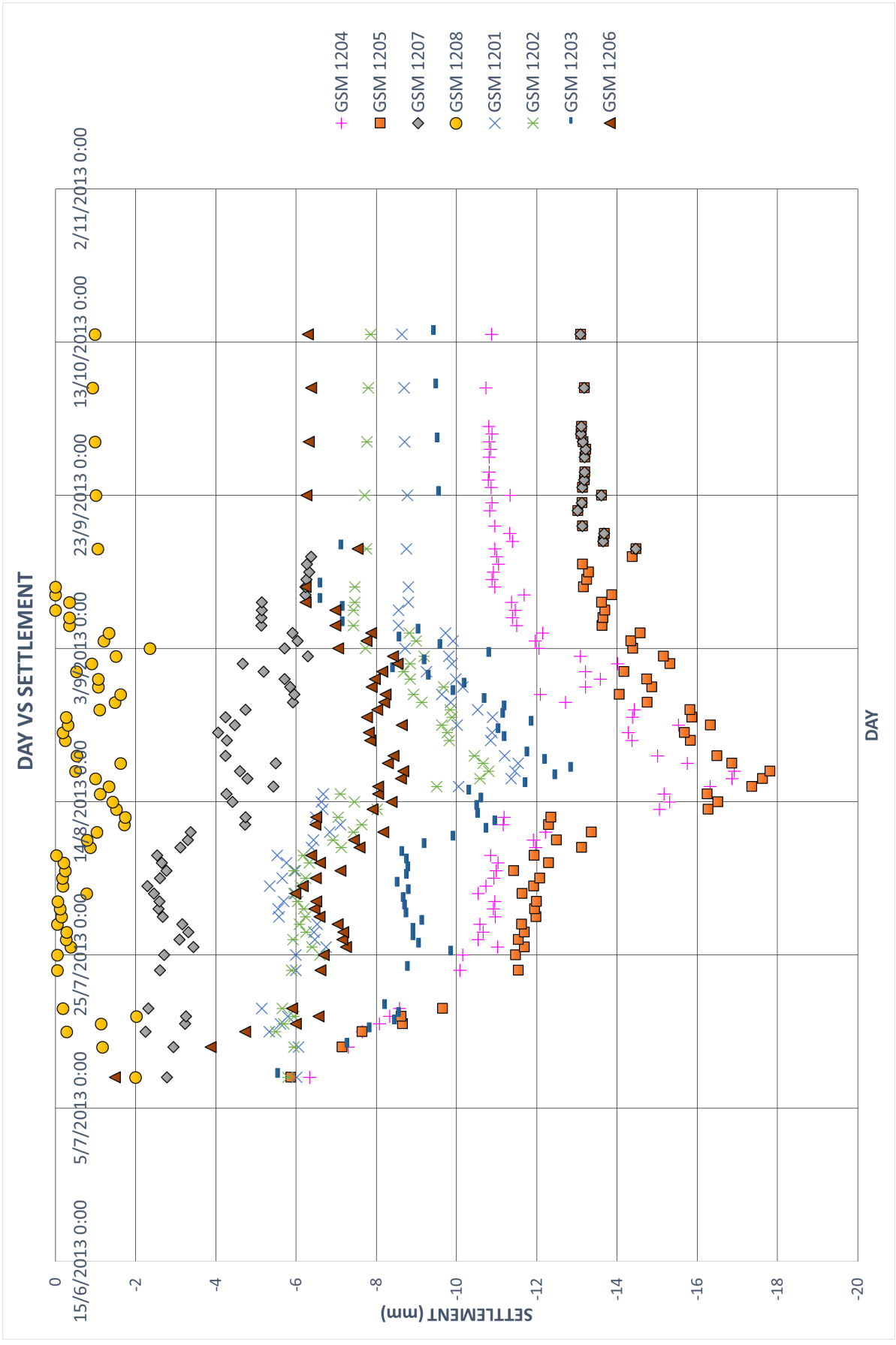


Figure 11: The longitudinal graph plotted for chainage GSM 1+200NB

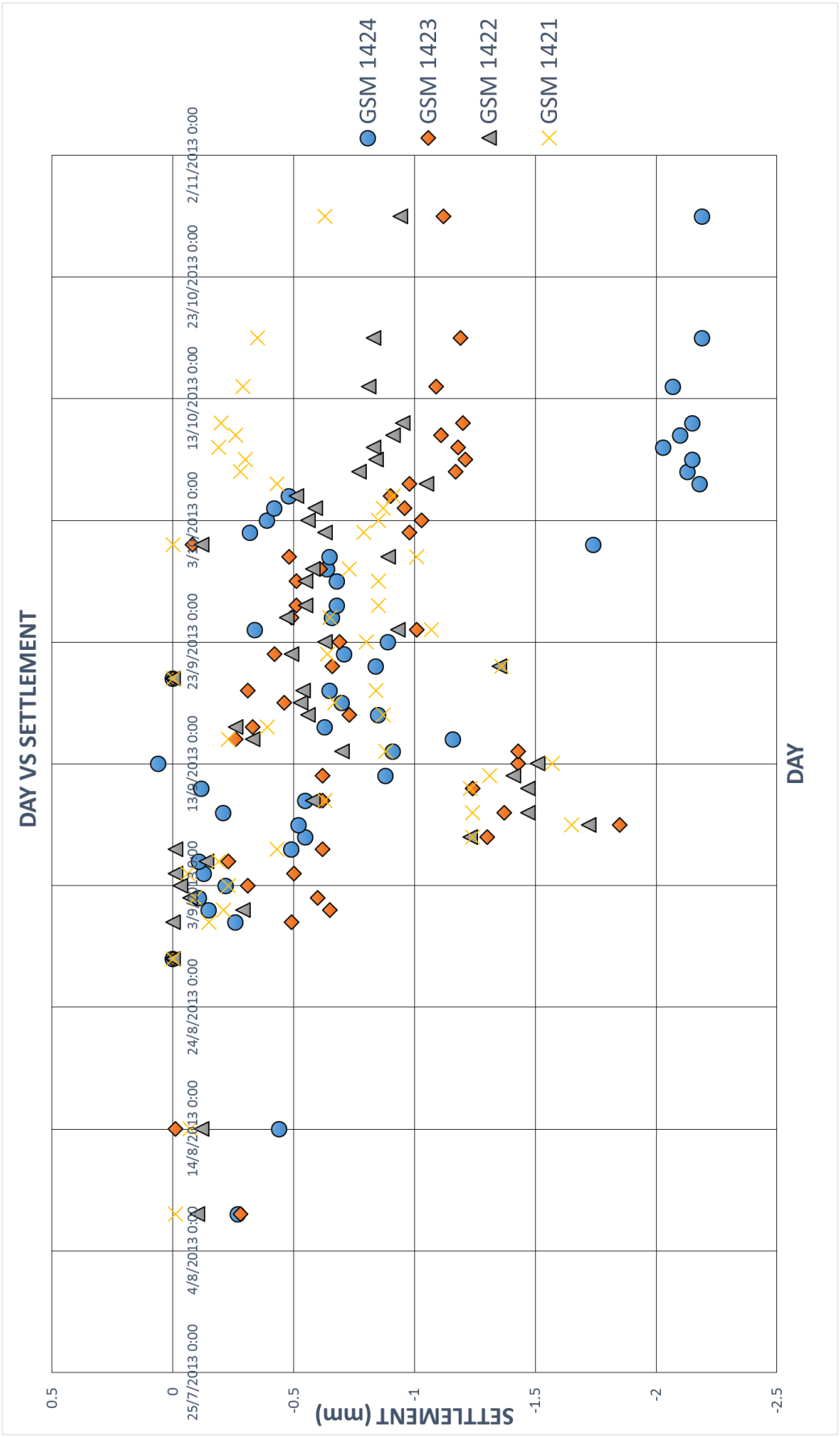


Figure 12: The longitudinal graph plotted for chainage GSM 1+420NB

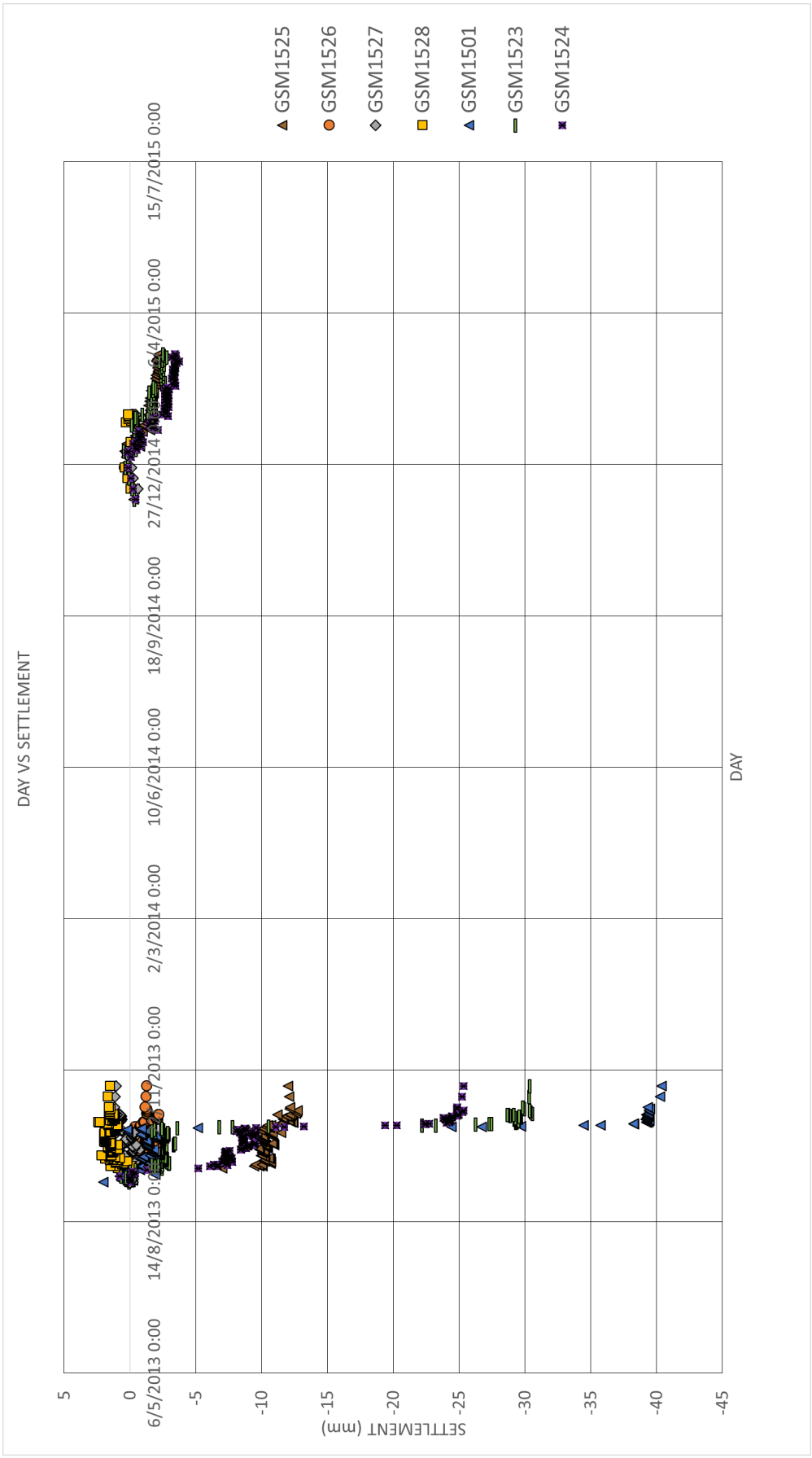


Figure 13: The longitudinal graph plotted for chainage GSM 1+520NB

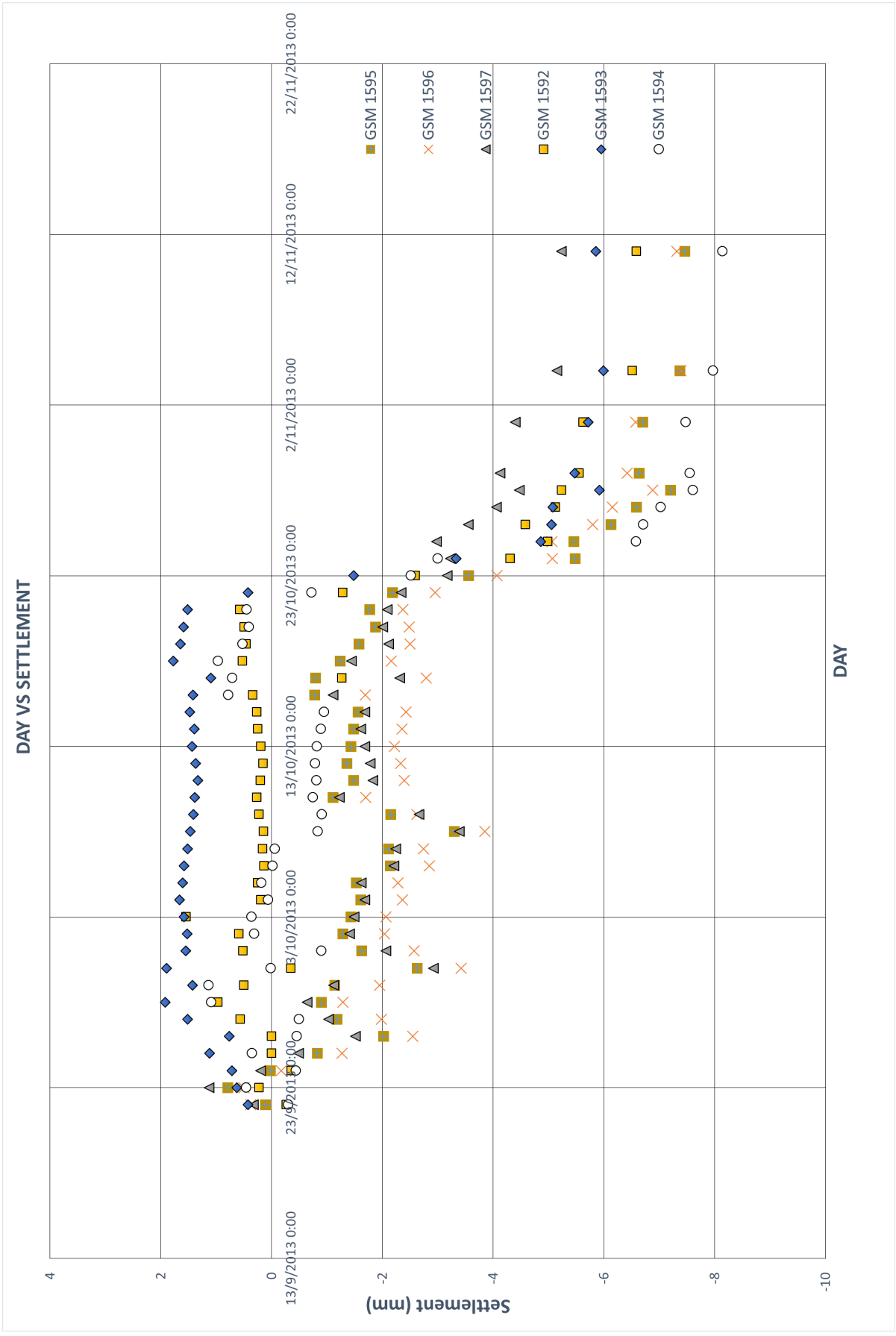


Figure 14: The longitudinal graph plotted for chainage GSM 1+590NB

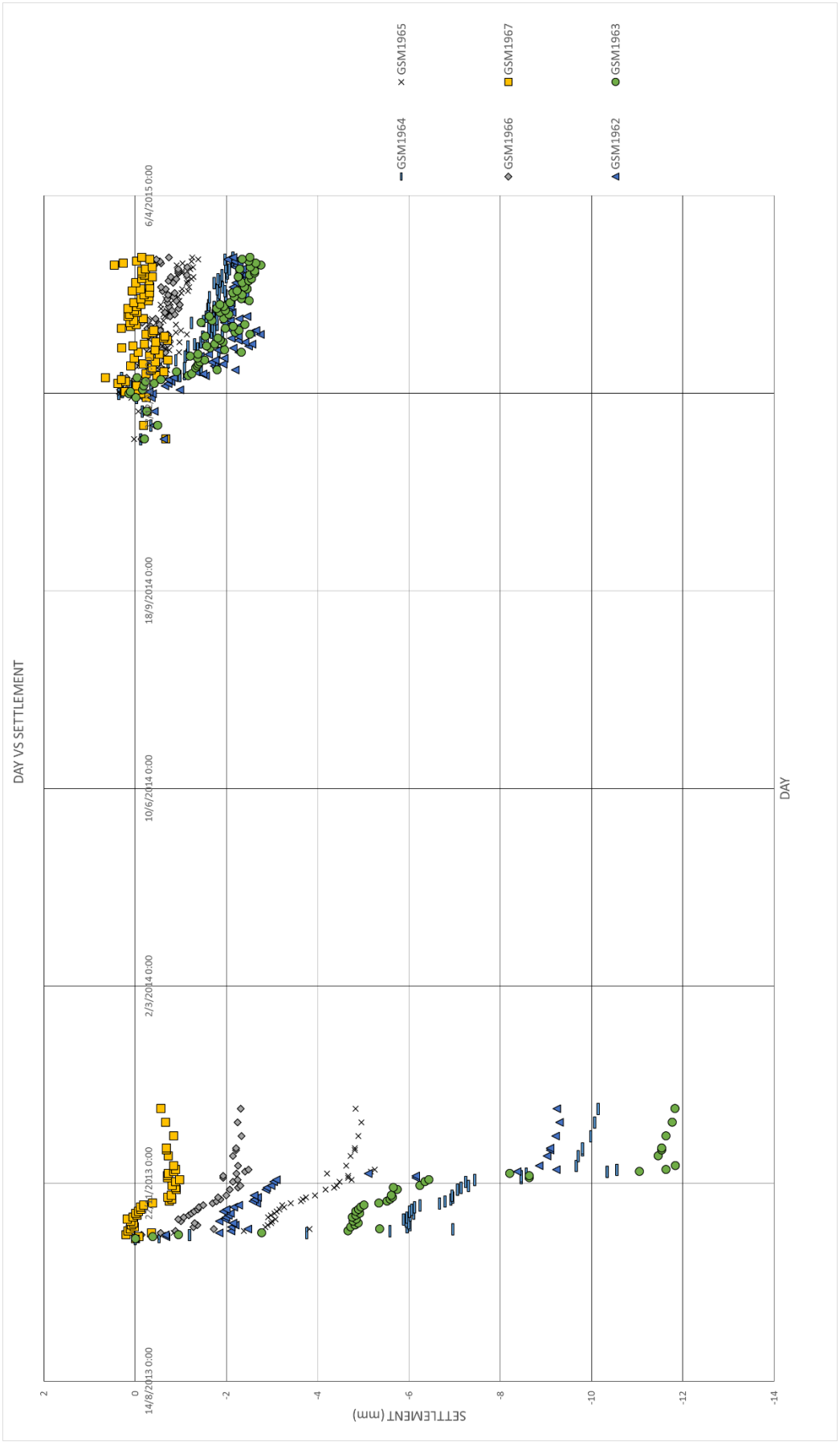


Figure 15: The longitudinal graph plotted for chainage GSM 1+960NB

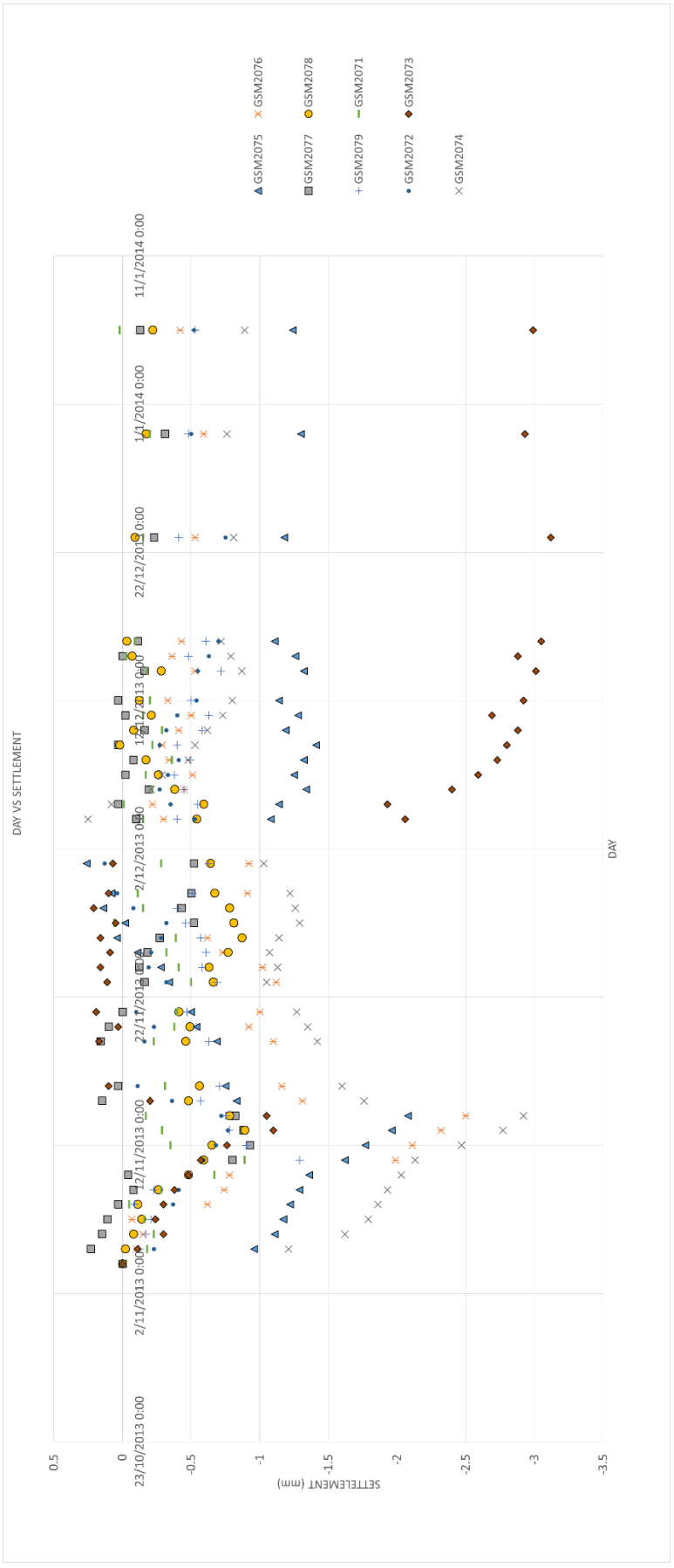


Figure 16: The longitudinal graph plotted for chainage GSM 2+100NB

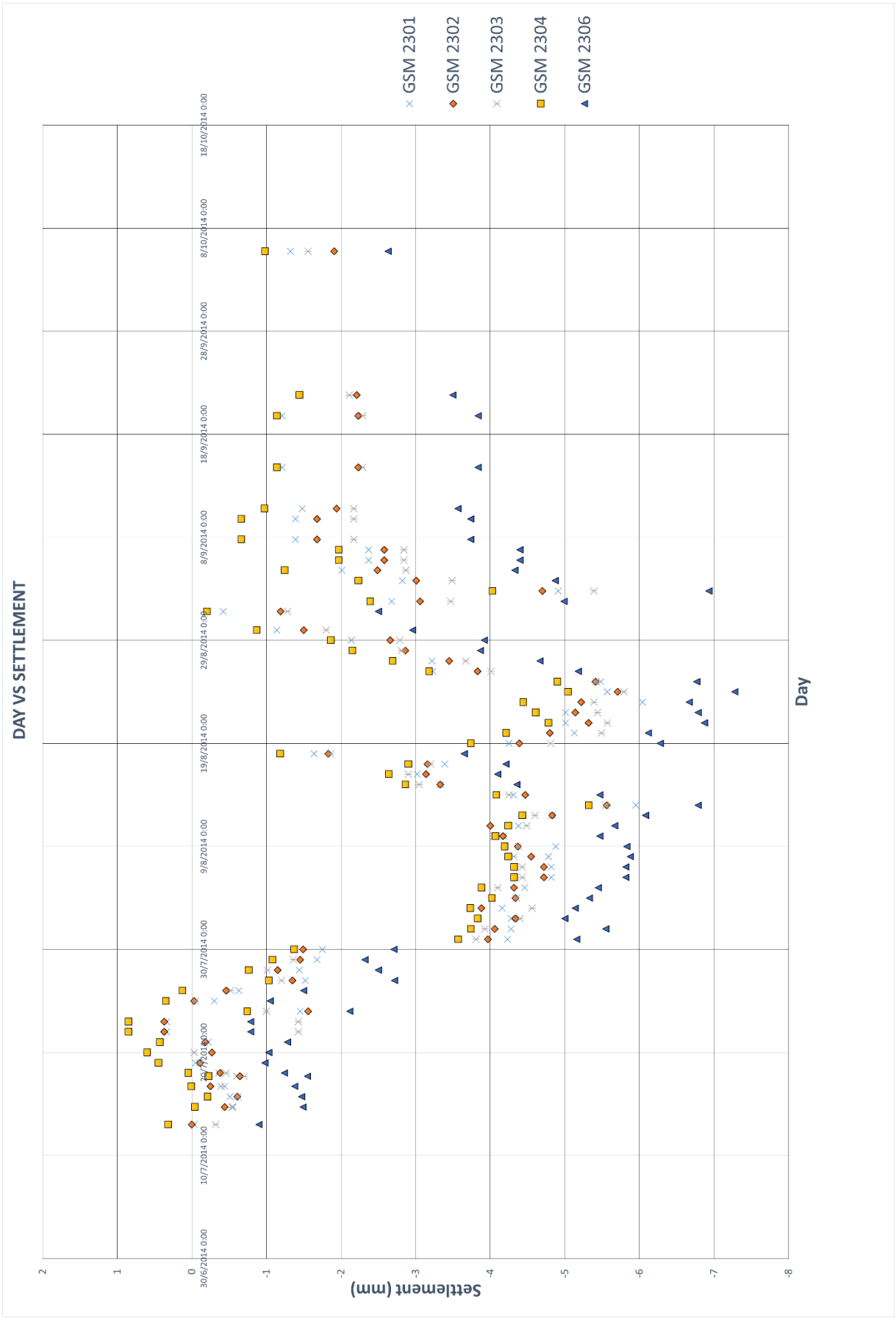


Figure 17: The longitudinal graph plotted for chainage GSM 2+300NB

4.2 Transverse (Gaussian) Curve Graph

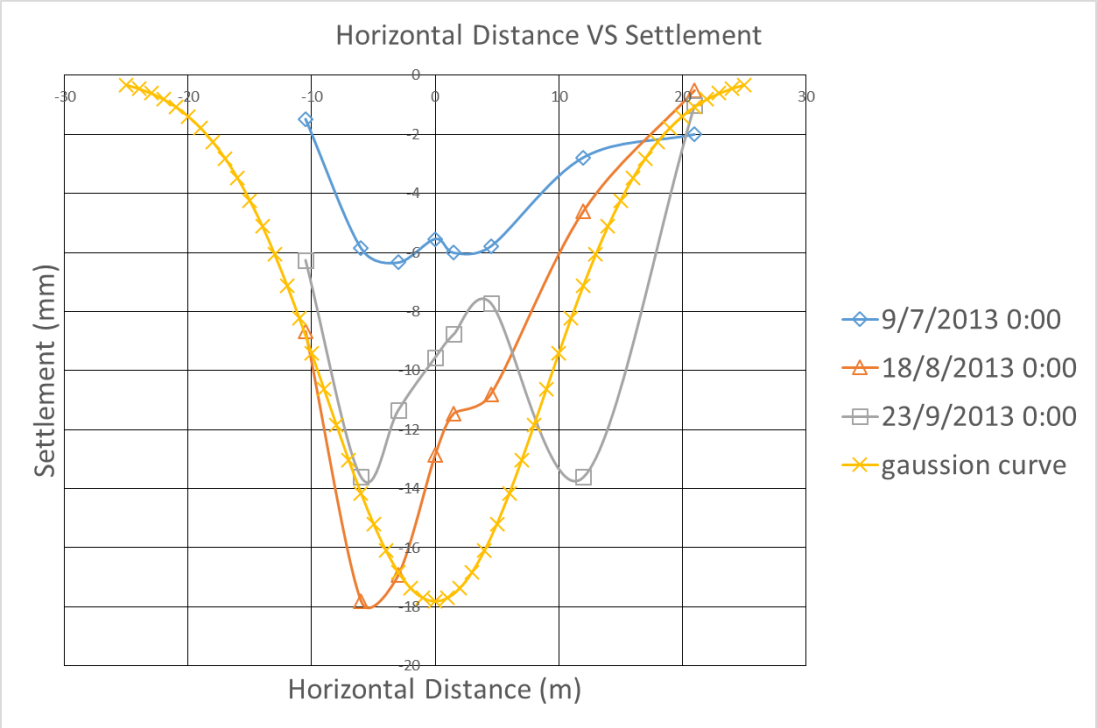


Figure 18: The transverse graph plotted for chainage GSM 1+200NB

Table 8: NB 1+200 data of Date and X (i) value

X (m)	-10.5	-6	-3	0	1.5	4.5	12	21
	GSM1206	GSM1205	GSM1204	GSM1203	GSM1201	GSM1202	GSM1207	GSM1208
Date								
9/7/2013 0:00	-1.48	-5.86	-6.34	-5.54	-6.01	-5.79	-2.78	-2
18/8/2013 0:00	-8.67	-17.81	-16.93	-12.85	-11.45	-10.8	-4.6	-0.51
23/9/2013 0:00	-6.26	-13.61	-11.34	-9.55	-8.77	-7.71	-13.61	-1.02

Table 9: NB 1+200 data of Smax, I, k and Zo

Smax actually (mm)	i (m)	k (m)	Zo (m)
-17.81	8.858	0.45	19.684

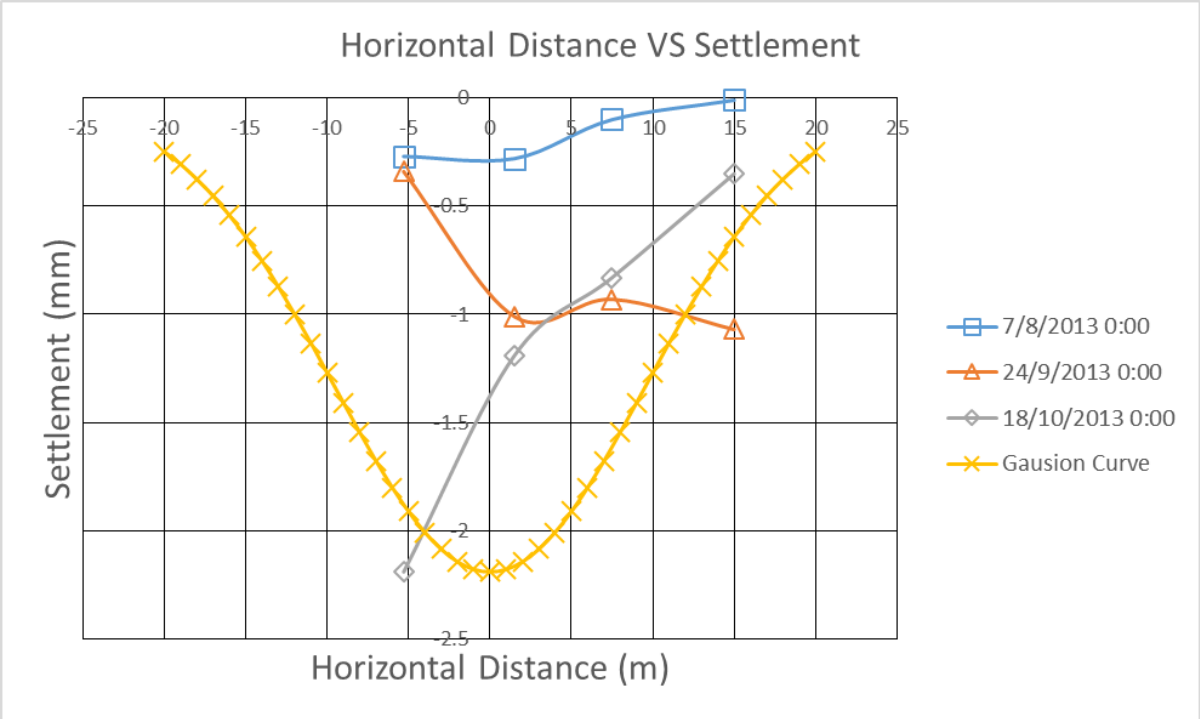


Figure 19: The transverse graph plotted for chainage GSM 1+420NB

Table 10: NB 1+420 data of Date and X (i) value

x (m)	-5.3	1.5	7.5	15
	GSM1424	GSM1423	GSM1422	GSM1421
7/8/2013 0:00	-0.27	-0.28	-0.1	-0.01
24/9/2013 0:00	-0.34	-1.01	-0.93	-1.07
18/10/2013 0:00	-2.19	-1.19	-0.83	-0.35

Table 11: NB 1+420 data of Smax, I, k and Zo

Smax actually (mm)	i (m)	k (m)	Zo (m)
-2.19	9.578	0.45	21.284

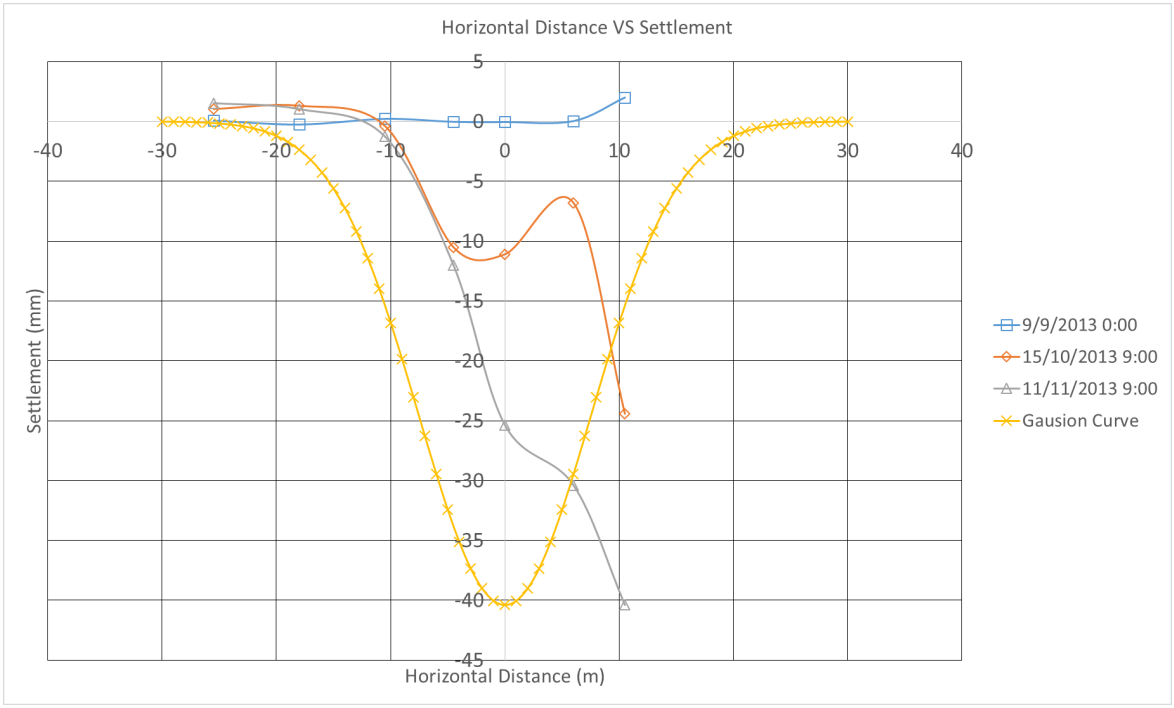


Figure 20: The transverse graph plotted for chainage GSM 1+520NB

Table 12: NB 1+520 data of Date and X (i) value

x (m)	-25.5	-18	-10.5	-4.5	0	6	10.5
	GSM1528	GSM1527	GSM1526	GSM1525	GSM1524	GSM1523	GSM1501
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
9/9/2013 0:00	0.07	-0.26	0.21	-0.03	-0.05	0.03	2
15/10/2013 9:00	1.04	1.31	-0.38	-10.51	-11.09	-6.8	-24.41
11/11/2013 9:00	1.53	1.03	-1.26	-12.02	-25.37	-30.39	-40.39

Table 13: NB 1+520 data of Smax, I, k and Zo

Smax actually (mm)	i (m)	k (m)	Zo (m)
-40.39	7.553	0.45	16.784

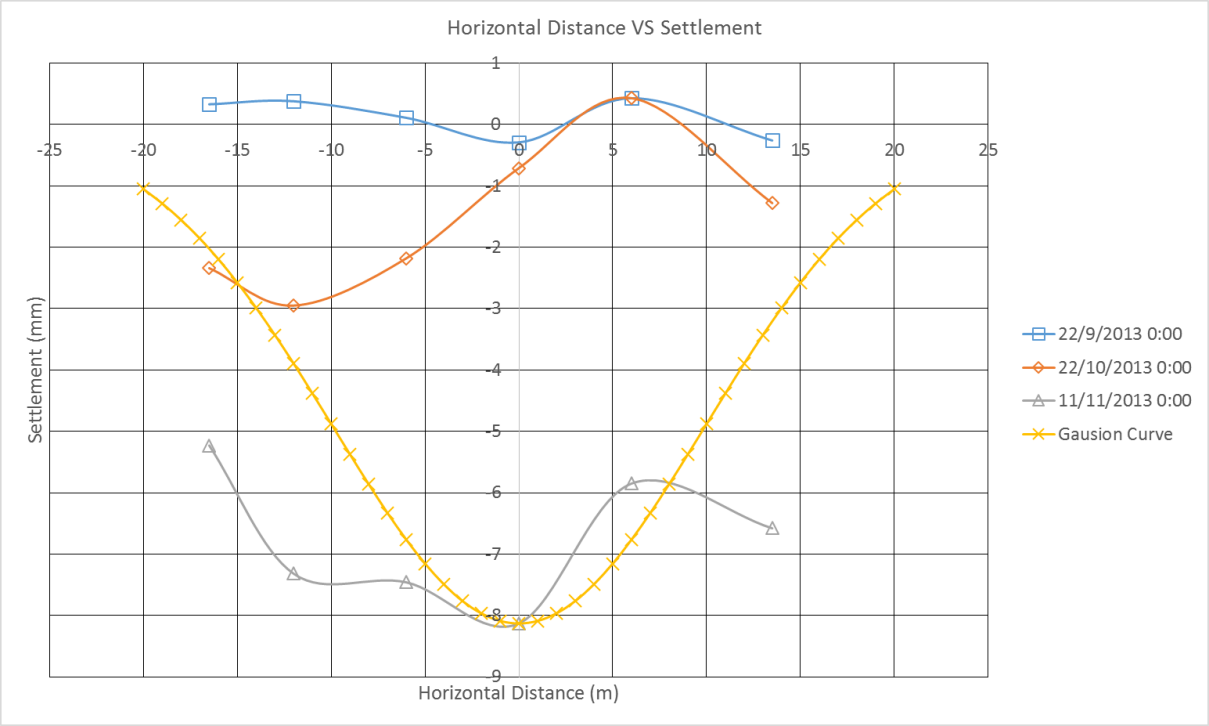


Figure 21: The transverse graph plotted for chainage GSM 1+590NB

Table 13: NB 1+590 data of Date and X (i) value

x (m)	-16.5	-12	-6	0	6	13.5
	GSM1597	GSM1596	GSM1595	GSM1594	GSM1593	GSM1592
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
22/9/2013 0:00	0.33	0.38	0.11	-0.29	0.43	-0.26
22/10/2013 0:00	-2.34	-2.95	-2.18	-0.71	0.43	-1.28
11/11/2013 0:00	-5.23	-7.32	-7.46	-8.13	-5.85	-6.58

Table 14: NB 1+590 data of Smax, I, k and Zo

Smax actually (mm)	i (m)	k (m)	Zo (m)
-8.13	9.893	0.45	21.984

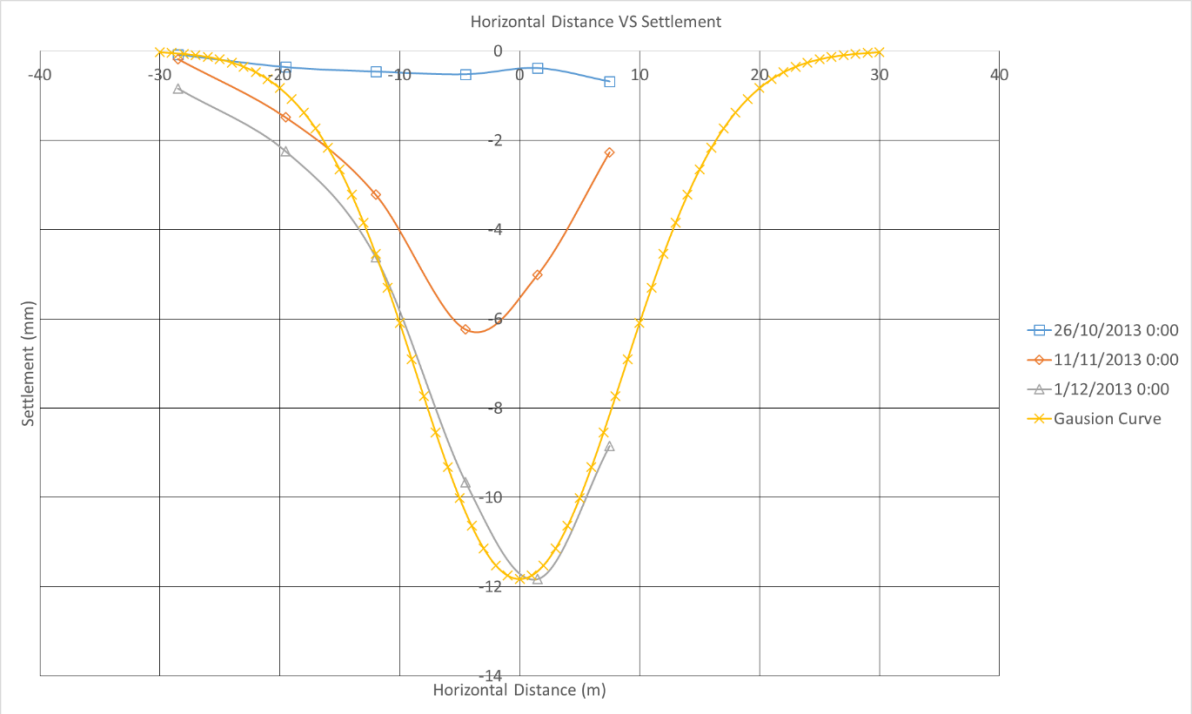


Figure 22: The transverse graph plotted for chainage GSM 1+960NB

Table 15: NB 1+960 data of Date and X (i) value

x (m)	-28.5	-19.5	-12	-4.5	1.5	7.5
	GSM1967	GSM1966	GSM1965	GSM1964	GSM1963	GSM1962
26/10/2013 0:00	-0.08	-0.36	-0.46	-0.52	-0.38	-0.68
11/11/2013 0:00	-0.18	-1.49	-3.22	-6.24	-5.01	-2.27
1/12/2013 0:00	-0.84	-2.25	-4.62	-9.66	-11.83	-8.85

Table 16: NB 1+960 data of Smax, I, k and Zo

Smax actually (mm)	i (m)	k (m)	Zo (m)
-11.83	8.678	0.45	19.284

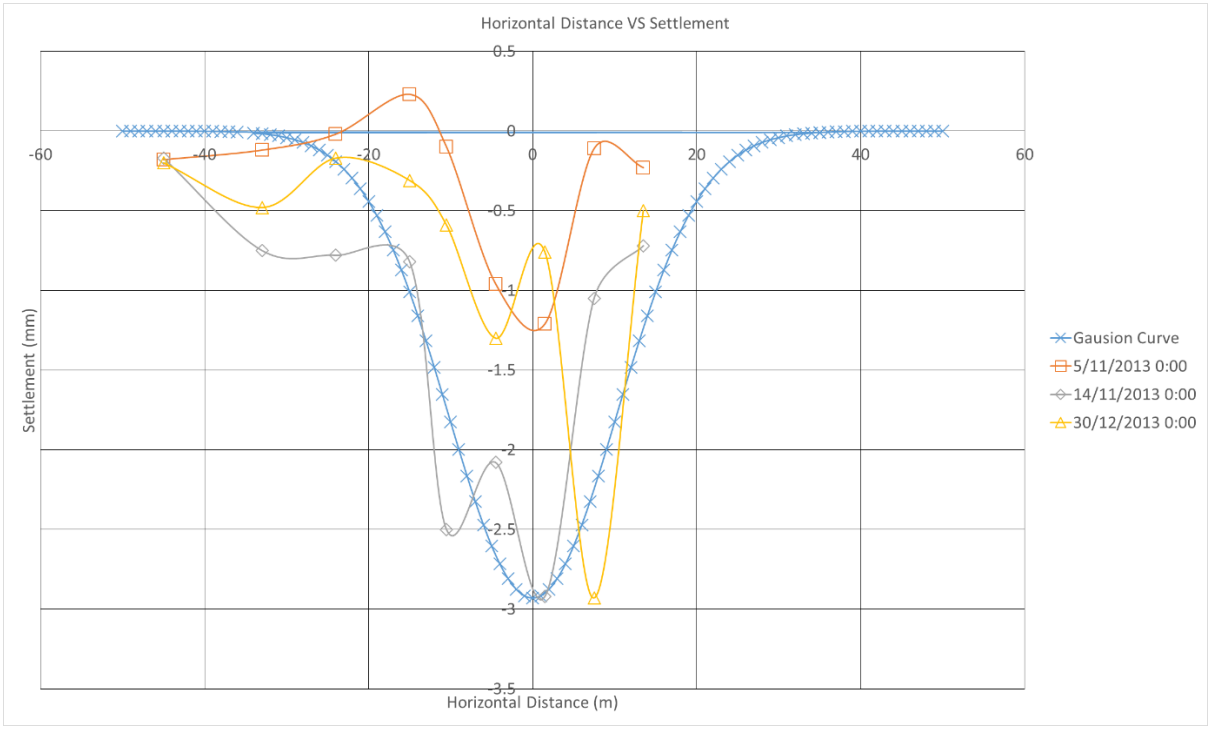


Figure 23: The transverse graph plotted for chainage GSM 2+100NB

Table 17: NB 2+100 data of Date and X (i) value

x (m)	-45	-33	-24	-15	-10.5	-4.5	1.5	7.5	13.5
	GSM2071	GSM2079	GSM2078	GSM2077	GSM2076	GSM2075	GSM2074	GSM2073	GSM2072
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
5/11/2013 0:00	-0.18	-0.12	-0.02	0.23	-0.1	-0.96	-1.21	-0.11	-0.23
14/11/2013 0:00	-0.17	-0.75	-0.78	-0.82	-2.5	-2.08	-2.92	-1.05	-0.72
30/12/2013 0:00	-0.2	-0.48	-0.17	-0.31	-0.59	-1.3	-0.76	-2.93	-0.5

Table 18: NB 2+100 data of Smax, I, k and Zo

Smax actually (mm)	i (m)	k (m)	Zo (m)
-2.93	10.2777	0.45	22.837

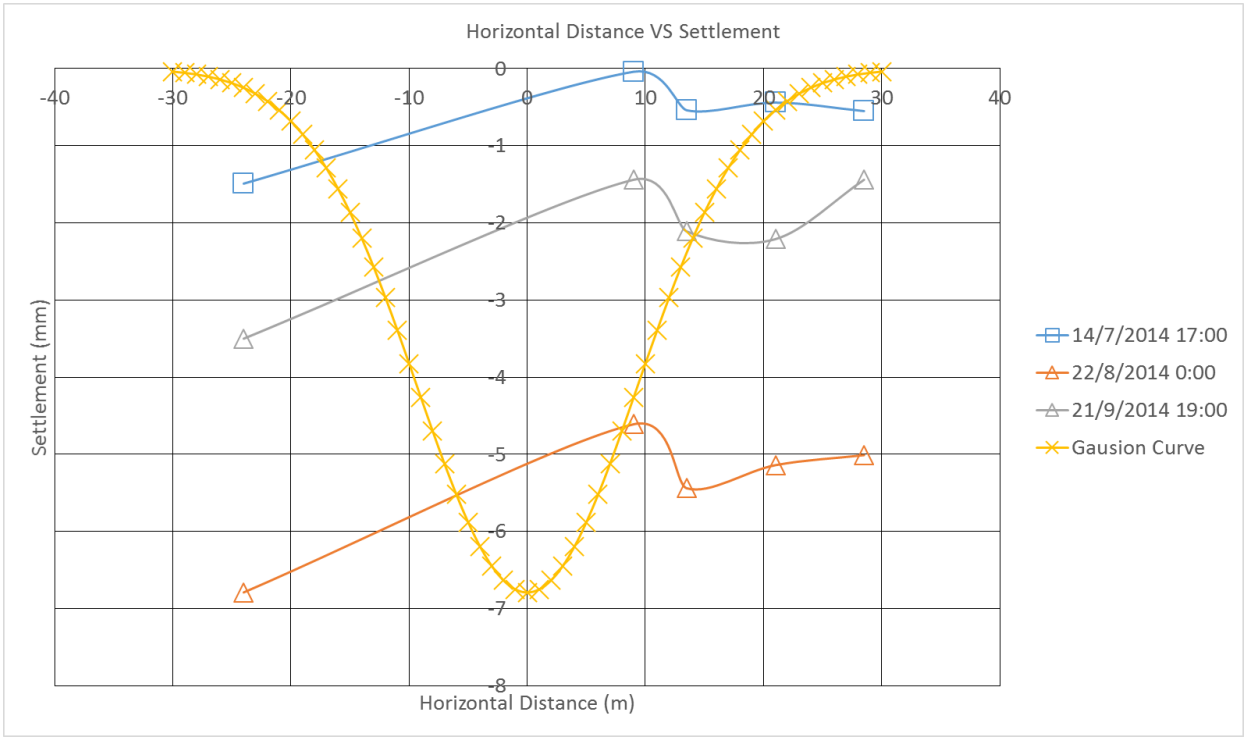


Figure 24: The transverse graph plotted for chainage GSM 2+300NB

Table 19: NB 2+300 data of Date and X (i) value

x (m)	-24	9	13.5	21	28.5
	2306	2304	2303	2302	2301
Date	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)	Change in Level (mm)
14/7/2014 17:00	-1.49	-0.04	-0.54	-0.44	-0.55
22/8/2014 0:00	-6.79	-4.61	-5.44	-5.14	-5.01
21/9/2014 19:00	-3.5	-1.44	-2.11	-2.21	-1.44

Table 20: NB 2+300 data of Smax, I, k and Zo

Smax actually (mm)	i (m)	k (m)	Zo (m)
-6.79	9.3285	0.45	20.73

4.3 Discussion

Above graph show the settlement across the array is well distributed. The excavation started on 9th July 2013 and end 14th October 2013. In the beginning of the day, settlement occur linearly as the TBM moved by. However, on 17th to 20th at the same year, the settlement fall drastically before it gain stability linearly increase before it uniformly stable.

Above graph show the settlement across the array is well distributed. The excavation started on 7th August 2013 and end 28th October 2013. In the beginning of the day, settlement occur in small declination as the TBM moved by. GSM 1424 show a major declination that the other because of the marker is located at the centre of the TBM movement. This may result higher settlement that the other GSM.

Above graph show the settlement across the array. The excavation started on 9th September 2013 and stopped 11th November 2013 but some GSM is continue operation until 9th March 2015. In the beginning of the day, overburden pressure happened at GSM1528, GSM 1527 and GSM1501 as the TBM moved by, yet, settlement at another GSM occurred as predicted. All of these GSM were located away from the pathway of TBM. This can explain that the overburden pressure under the ground has pushed the surrounding soil upward and may cause unintended unstable structure above the ground.

Above graph show the settlement across the array. The excavation started on 22th September 2013 and stopped 11th November 2013. In the beginning of the day, overburden pressure happened at GSM1593, GSM 1592 and GSM1594 and another GSM occurred as predicted. However, in this case, the overburden pressure happened exactly under the TBM. This can be explain the grout injected during excavated cause the overburden pressure.

Above graph show the settlement across the array. The excavation started on 25th October 2013 and stopped on 30th December 2013. The settlement occurred as expected but drastically decline of settlement cause mitigation take into action. After approximately a year, the underground is monitored again on 3rd December 2014 and end 5th March 2015.

Above graph show the settlement across the array is well distributed. The excavation started on 4th November 2013 and end 6th January 2014. The settlement happened as predicted yet overburden pressure happened because of injection of grout during excavation. As the time passed by, post consolidation happened make the soil more stable.

Above graph show the settlement across the array is well distributed. The excavation started at 13th July 2013 and end at 5th October 2014. In the beginning of the day, settlement occur linearly as the TBM moved by until 7th August 2014. After that, the graph shows linearly increase before it uniformly stable.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As we can see from the longitudinal and transverse (Gaussian) graph, we can conclude that there are two situation that will be happen. There were seven (7) data that has been analyses at the selected 'greenfield' in order to get the most accurate result. The data suggested that there were situation where upward movement happened, due to injection of grouting. Second, the settlement occurred as predicted. The maximum settlement are in the following; -17.81mm for GSM1+200, -2.19mm for GSM1+420, -40.39mm for GSM1+520, -8.13mm for GSM1+590, -11.83mm for GSM1+960, -2.93mm for GSM2+100 and -6.79mm for GSM2+300. However, there a lot more need to be continue in order to give a full conclusion of this project as the volume lost and max settlement of Gaussian curved has not been calculated.

5.2 Recommendation

The data given courtesy by the company have errors where measurement was not uniformly and some spiked of data occurred during recorded, suspected due to defective of GSM or unexpected vigorous movement of above ground. Moreover, restricted region of 'greenfield' give us limited accuracy of settlement occurred, due to the region has already well developed with fixed structures.

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