RELIABILITY IMPROVEMNET IN THE 33kV DISTRIBUTION FEEDER USING OPTIMUM POSITIONING OF AUTO RECLOSERS

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DECLARATION OF THE CANDIDATE AND SUPERVISORS

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the Masters dissertation under my supervision.

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ABSTRACT

In an era where Sri Lanka economy is going towards a drastically higher growth it is highly important to have a reliable electricity network in the country. To improve the reliability of the distribution network, Distribution Licensees improve the system capacity and at the same time install protective devices to reduce the interrupted area due to an electrical fault in the network. For this Auto Reclosers and Fuses are used in the Distribution Network.

In developed countries the installation of Protective devices are done optimally and techniques have been developed. In Sri Lanka, the process of planning, design and construction of transmission and medium voltage power lines is solely authoritative by Transmission Licensee and Five Distribution Licensees of the country. At present there is no proper way of selecting optimal location for the installation of Auto reclosers is practiced in either of these Licensees.

As the first step of this study, a research survey was done about the optimal location selection methods researched in other countries. A suitable objective function was modeled to find the optimal location to install an Auto Recloser with the constraint of finding two optimal locations in series.

This report will discuss the objective function formation to find the optimal location for the Auto Recloser and also as a supporting study a pilot project done on how to co-ordinate the fuses with the Auto Reclosers and the Circuit Breakers at the Grid Substation is also included.

Major Findings of this research: Optimal locations to install an Auto recloser for a feeder according to the SAIDI values of substations and the energy consumptions of bulk and retail consumers connected to that specific feeder.

Findings of the pilot project: how to co-ordinate the fuses installed on a feeder and how to decide the rating of a fuse to be installed on the feeder by maintaining the protection co-ordination with other protective devices on the feeder.

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LIST OF ABBREVIATIONS

AR	Auto Recloser
AEE	Area Electrical Engineer
CB	Circuit Breaker
CEB	Ceylon Electricity Board
CSC	Customer Service Center
DD1, 2, 3, 4	Distribution Division 1,2,3,4
EENS	Expected Energy Not Served
ENS	Energy Not Served
GA	Genetic Algorithm
GSS	Grid Sub Station
LKR	Sri Lankan Rupees
MINLP	Mixed Integer Non-Linear Programming
MV	Medium Voltage
NLIP	Non-Linear Integer Programming
SAIDI	System Average Interruption Duration Index
RTS	Reactive Tabu Search
TC	Time Vs Current
USD	US Dollars

LIST OF APPENDICES

Chapter 1

Introduction

1.1 Background/ Survey of Previous Work

Electricity plays a crucial part in day to day life in our lives and with the drastic improvement in technology a reliable electricity supply is a must. At the present time power sectors mainly focus on providing a reliable supply to the consumers. At the same time providing a reliable supply, the power sector focuses on maximizing their profits with cost optimization.

A highly reliable distribution network is a network which should have a lower number of interruptions or a network which could isolate interruptions with minimum consumers interrupting. To achieve this, the utility must do routine maintenance, way leave clearances and install protective devices in the system.

When installing protective devices such as Auto Reclosers and Fuses, these devices should be properly coordinated with one another. When the cost is compared, Cost of an Auto Recloser is higher than a Fuse but this huge cost difference is due to the fact that the Auto Recloser has so many additional features than a fuse. When installing an Auto Recloser, the utility must have a macro view of the network and should find an optimal location on the feeder.

There are several researches have been done to allocate protective devices optimally in distribution networks using different methods. One of those studies which is described in “Allocation of protective devices in distribution circuits using nonlinear programming models and genetic algorithms” by Luis G.W. da Silva, Rodrigo A.F. Pereira and Jose R.S. Mantovani. This research presents a Non-Linear Integer Programming (NLIP) model with binary values, to find optimal location for allocating protective devices in the main feeder and all the branches connected to the main feeder. In this study both technical and economical limitations are considered. The problem is solved by using the Genetic Algorithm (GA). [1]

"Optimised placement of control and protective devices in electric distribution systems through reactive tabu search algorithm" by Luis G. Wesz da Silva, Rodrigo A. Fernandes Pereira, Juan Rivier Abbad and Jose R. Sanches Mantovani is another research paper under the title of optimal location identification. The problem is modeled through Mixed Integer Non-Linear Programming (MINLP) with real and binary values. Reactive Tabu Search (RTS) is utilized to solve the problem in this study and the tests were carried out to a 13.8 kV, 134 nodes, overhead three-wire feeder with a delta-grounded wye connection substation transformer. [2]

To study more about the different techniques used to find the optimal location for devices on a distribution feeder, another research paper was referenced and that was "Enhancement in Distribution Systems using Optimal Allocation of Switcching Devices" by M.R. Haghifam, H. FAlaghi, M Ramezani, M PArsa and G. Shahryari. In this study a GA is proposed to find optimal number and locations for sectionlizers, tie points and tie lines. Cost of energy not supplied, cost of switches and tie lines are considered when designing the objective function and the results were obtained by simulating the results for a real distribution line in Iran. A window based computer planning package has been developed based on this study by Distribution Networks Laboratory in Tarbiat Modarres University, Tehran, Iran. Also this software was used to decide the sectionalizer locations and tie line positioning for distribution networks in Iran by the utilities. [3]

Another research paper which was referenced was "Optimal Feeder Switches and Pole Mounted RTUs Relocation on Electrical Distribution System considering Load Profile" by Pichit Jintagosonwit, Pichai Jintakosonwit and Naruemon Wattanapongsakorn. In this study optimal locations were considered by annual load curve changing and failure rate changing. GA was applied to find optimal locations from the objective function. [4]

One last research which was referenced was "Distribution Reliability Improvement through Optimal Location of Load Break Switches in 33 kV Network" by Ranjit Perera and S. P. Thushara. In this study, it presents a method to locate the Load Break Switches optimally and the optimal number of switches considering the nature of the different zones the feeder is going through and the number of customers fed from the feeder. [5]

Immune algorithm [11] and particle swarm optimization based on fuzzy expert systems [12] methods are also used for the optimal positioning of line switches on an distribution feeder.

1.2 Motivation

As the main and largest electricity provider in Sri Lanka, Ceylon Electricity Board has to maintain a healthy reliable distribution network for the betterment of the country's economy. When considering the reliability of distribution network, Electrical Protection of the network plays a crucial role. Auto Recloser is one of the protection devices used in the network and this is a smart device which is costly and it has several features which we can use for distribution protection and also we can use that as a device to collect data of the distribution system because this has the ability of collecting data.

Table 1.1: Cost of Protection devices used in the Distribution Network

No	Device	Price (LKR)
1	Auto Recloser 11 kV	1,209,720.00
2	Auto Recloser 33 kV	1,855,410.00
3	Fuses Link Expulsion	220 – 470
4	Copper Solid Link 11kV/33kV	3,805 / 4,435
5	Sectionalizer 36 kV	1,758,960.00

Source: Catalogue and Price Lists of Materials – 2015 [9]

As an AR is costly compared to other protective devices used for distribution protection such as Fuses, it is mandatory to choose an optimal location to install an AR. Following are reasons which motivated me to choose this specific study area for my research.

- No proper way is practiced to select an optimal location for the AR to install in CEB.
- To improve the reliability of the network.

- While studying the network, found that few ARs are installed at locations where LBSs should be installed (As an example Normally Open locations). This is a waste of money.

As an engineer who works in the Planning and Development branch of Distribution Division 4 of (DD4) Ceylon Electricity Board (CEB), faced several incidents where Area engineers requests ARs for locations where fuses should be installed. When installing ARs we have to make sure that ARs are co-ordinated with one another and also with the Circuit Breaker at the Grid Substation.

With the constraint of protection setting at the GSS the distribution divisions can install only 2 or 3 ARs in series, away from the GSS. So with this constraint the study was done.

In the existing network there are more than 50 ARs installed in the Distribution Division 4 network. In DD4 network, in some main feeders there are 2 ARs installed and in some there is only one AR installed and at the same time in some feeders there are no ARs installed. Feeder wise installed ARs are given in **Annex 1**.

1.3 Objectives

- The first objective of this study was to develop an algorithm to find an optimum location for an AR to be installed in the distribution line after the GSS.
- The second objective was to co-ordinate the installed or existing AR, with already installed fuses downstream and GSS circuit breaker upstream.

1.4 Problem Statement

The Distribution Network of CEB has divided into 4 divisions as DD1, DD2, DD3 and DD4. AEEs (Area Electrical Engineers) inform the respective provincial planning branch when an Auto Recloser is needed through a letter including the location and the GSS Feeder Number. AEE decide whether an AR needed to a specific Feeder or a spur, if there are higher interruptions on that feeder or spur going through high vegetation. Then the provincial planning engineer will forward the AR request to Regional planning branch. From there the appropriateness of installing an AR to that specific location is verified and sends the AR installation request with the protection settings to the Projects and Heavy Maintenance (PHM) Branch.

When checking the appropriateness of requested AR location Distribution Divisions follow different methods and there are no common guidelines to select an optimal location to install an AR. When selecting an AR location the CEB does not check for the optimal location. Following table tabulates the methods which have been practiced by the different distribution feeders for finalizing a location for AR.

Table 1.2: Steps followed by Distribution Divisions to select an AR location

No	Distribution Division	How an AR location is finalized
1	DD1	If the line is an express line then install ARs at the gantry location.
		If there are higher faults reported on a specific spur install an AR at the beginning of the spur.
		If the request is to install an AR on an Distributor, install the AR, 12 km away from GSS to maintain proper protection co-ordination.
		Only 4 ARs to be installed in series
2	DD2	Install ARs at Gantry locations.
		If the spur is long or have higher breakdown count install an AR at the beginning of that specific spur.
		If a Feeder is 40 – 50 km long install ARs in-between.
3	DD3	Install ARs at Gantry locations
		Only 2 or 3 ARs in series
		When installing an AR check the protection co-ordination with the GSS and choose the appropriate Time vs Current curve and maintain 0.3 sec time discrimination between the protection devices.

No	Distribution Division	How an AR location is finalized
4	DD4	Install ARs at Gantry locations
		Only 2 or 3 ARs in series
		When installing an AR check the protection co-ordination with the GSS and choose the appropriate Time vs Current curve and maintain 0.3 sec time discrimination between the protection devices.

Though there are these methods to choose the suitable AR location, there are some AR locations which do not come under these guidelines.

1.5. Scope of Work

For this research, scope of work is as follow.

01. Studied the Optimization problem solving done in the distribution network of other countries.
02. Studied the constraints which will affect the optimal location of the AR.
03. Selection of Feeders for the study.
04. Data collection: number of hours interrupted and interrupted consumers for each and every substation on the selected feeders, outage rate of feeders, SAIDI values for bulk and retail consumers, cost for the utility for one hour power interruption for bulk and retail consumers.

After the objective function was formulated the data from one feeder was fed into the function and got the results. Then the data from two other feeders were used to validate the objective function.

Accuracy of the results was depending upon the accuracy of data collection and collected data of interruptions of the substations.

Chapter 2

Mathematical Modeling

2.1 Theoretical Background

For a distribution network to reach a highly reliable level, the distribution utility must focus on coordinating the protection system. Before coordinating the protection devices the protection devices should be located optimally, minimizing the interruption cost and cost of breakdown recovery. The mathematical model is derived considering these two aspects, under the constraint of selecting 2 AR locations in series. The optimal location originated from this model is both technically and economically viable.

Auto Reclosers and Fuses are the protection devices used in the distribution network in CEB and in some Distribution Divisions Sectionalizers are used. Mostly K type fuses are used in the network. When considering the prices, installing a fuse instead of installing an Auto Recloser is cheaper. But installing Fuses to clear temporary faults may not be viable considering long term. As a solution for this ARs should be installed in the system, co-ordinated with the fuses installed downstream. If the utility can install several ARs on a feeder, they can improve the reliability of that specific feeder. But this is not viable economically. So a location has to be decided considering both technical view and economic view.

The mathematical model is derived to minimize the cost of reliability of a specific location. To find the cost of reliability an objective function has been derived using SAIDI values for a feeder, and that is described in the following section and SAIDI equation is given in chapter 3.

2.2 Objective Function

The proposed objective function is the sum of Breakdown Recovery Cost of location 'i' (B_{cost-i}) and the Cost of Interruption of location 'i' (CoI_i). The objective function for each section i of the feeder is derived by the following terms.

$$Minimize\ CoR_i = B_{cost-i} + CoI_i$$

$$subjected\ to\ 2\ locations\ in\ seiris\ and\ 0.3\ \sec\ time\ descrimination\ bbetween\ ARs$$

For a location i on the feeder;

CoR_i – Cost of Reliability

B_{cost-i} – Breakdown Recovery Cost

CoI_i – Cost of Interruption

The breakdown recovery cost was added to the objective function to check the economical viability of the system. When installing an AR to CEB distribution network, maximum number of ARs to be installed in series is limited to two or three numbers. This constraint is there because the protection settings of the Circuit Breaker (CB) at the GSS is kept at a lower value and because of this reason it would be difficult to have a proper co-ordination between the ARs when more than 3 ARs are connected in series. Hence, the number of ARs to be added to the feeder was not included in the objective function to check the economic viability. GSS is taken as the reference point, to obtain distances for the identified locations. The breakdown recovery cost is written as follows.

$$B_{cost-i} = \lambda_i . l_i (b.x + m)$$

For a location i on the feeder;

λ_i – Outage rate of the feeder, only for Auto tripping (interruptions/month)

l_i – Distance from Grid Sub Station (GSS) to the location i (km)

b – Consumed fuel per km for a Crew Cab (l/km) x - Fuel price (LKR./l)

m – Maintenance cost per km for a Crew Cab (LKR./km)

When calculating the cost of interruption, interruptions occurred only due to temporary faults were considered. The reason for this, because the optimal locations are selected for installation of ARs and the AR is mainly used to interrupt temporary faults in the network. For the cost interruption the consumers are divided as bulk consumers and retail consumers.

On a feeder, let's assume that an AR is installed at the location i, and for a temporary or permanent fault the AR will operate and interrupt the consumers connected downstream both retail and bulk consumers. To calculate the cost of interruption, SAIDI value of bulk consumers and the SAIDI values of retail consumers are to be calculated separately. When a consumer is interrupted it will be a loss for the utility. Losses for the utility due to interruption of power for one hour for both bulk and retail consumers are also included to this equation. The equation for cost of interruption is given below. This whole part should be multiplied by the temporary fault percentage for the specific section. From the latter part, the cost for the utility due to line tripping should be reduced.

$$CoI_i = \lambda_i\left[\left(SAIDI_{bulk(i-n)} \times f_{bulk}\right) + \left(SAIDI_{retail(i-m)} \times f_{retail}\right)\right] - \lambda_f\left[\left(SAIDI_{bulk(1-i)} \times f_{bulk}\right) + \left(SAIDI_{retail(1-i)} \times f_{retail}\right)\right]$$

$$SAIDI_{bulk(i-n)} = \frac{\sum_{j=i}^{n} IH_j . CNos_j}{CNos_{tot}}$$

$$SAIDI_{bulk(1-i)} = \frac{\sum_{k=1}^{i} IH_k . CNos_k}{CNos_{tot}}$$

$$SAIDI_{retail(i-m)} = \frac{\sum_{j=i}^{m} IH_j . CNos_j}{CNos_{tot}}$$

$$SAIDI_{retail(1-i)} = \frac{\sum_{k=1}^{i} IH_k . CNos_k}{CNos_{tot}}$$

For a location i on the feeder, with 'n' number of bulk substations and 'm' number of retail substations.

λ_i – Temporary fault percentage of feeder section of location i

λ_f – Auto Tripping percentage of the feeder

$SAIDI_{bulk(i-n)}$ – SAIDI value of bulk consumers downstream of location i (hrs)

$SAIDI_{retail(i-m)}$ – SAIDI value of retail consumers downstream of location i (hrs)

$SAIDI_{bulk(1-i)}$ – SAIDI value of bulk consumers from GSS to the location i (hrs)

$SAIDI_{retail(1-i)}$ – SAIDI value of retail consumers from GSS to the location i (hrs)

f_{bulk} – Cost for the utility for one hour power interruption for a bulk consumer

f_{retail} – Cost for the utility for one hour power interruption for a retail consumer

IH_j – Outage Hours for jth substation (hrs)

IH_k – Outage Hours for kth substation (hrs)

$CNos_j$ – Interrupted bulk consumers of jth substation

$CNos_k$ – Interrupted bulk consumers of kth substation

$CNos_{tot}$ – Total number of consumers of section i

Cost for the utility for one hour power interruption (f_{bulk} *and* f_{retail})

This has to be derived for both retail and bulk consumers. For this Cost of Expected Energy Not Served (EENS) was needed. From the study "Assessment of Economic Impact of Poor Power Quality" – USAID – SARI/E Program, October 2002 report it was given that the Cost of Energy Not Served (ENS) as 1.2 USD/kWh. This value was given to the whole network, but for this study two cost values for the both bulk and retail consumers are needed. The derivation of cost for the utility for one hour power interruption equation is given in the next page. [8]

The value which was found for this was from a research specially worked out for Sri Lanka, but the study was done in October 2002. To find an ENS from a research done recently several research papers were referred. [6] [7] But the values from those values couldn't be used for this study as those studies weren't done to South Asian region. So finally the Research done by USAID – SARI/E Program was used. [8]

From this value the cost for the utility for one hour power interruption is derived using the following equation. f_{bulk} *and* f_{retail} values can be derived for each and every feeder separately depending on the energy consumption respectively.

$$f_{bulk} = \frac{Cost_{EENS} \times EC_{bulk}}{24 \times 30 \times N_{bulk}} \; USD/Hrs$$

$$f_{retail} = \frac{Cost_{EENS} \times EC_{retail}}{24 \times 30 \times N_{retail}} \; USD/Hrs$$

f_{bulk} – Cost for the utility for one hour power interruption for a bulk consumer

f_{retail} – Cost for the utility for one hour power interruption for a retail consumer

$Cost_{EENS}$ – Cost of Expected Energy Not Served (USD/kWh)

EC_{bulk} – Energy Consumption of Bulk Consumers of the selected feeder (kWh)

EC_{retail}–Energy Consumption of Retail Consumers of the selected feeder (kWh)

N_{bulk} – Bulk consumers connected to the feeder

N_{retail} – Retail consumers connected to the feeder

With all these variables in hand, one can find an optimal location for an Auto Recloser to be installed. When there are several types of data and several equations it is easier to handle those when a data flow chart is plotted. The data flow chart of this study and the data to be collected are described in the next chapter.

Chapter 3

Data Collection, Data Analysis and Data Flow

3.1 Data Collection

The accuracy of the results of the mathematical model will depend on the accuracy of the collected data. Data collection is a crucial part in any of the research study. The following are the list of data collected and the data source is also mentioned in front. All these data were collected for the period of, from March 2012 to February 2013.

- Feeder data

  - Auto Tripping outage rate of the feeder – these data are obtained by the "Summary of 33 kV Feeder Trippings" Report prepared by the System Control branch of CEB. [10]
  - Energy Consumption of bulk and retail consumers – for each feeder the bulk and retail energy consumption is required. Energy consumption data were downloaded by the online data base of CEB.

  - Transformers connected to the feeder – from the updated AutoCAD maps from the provincial planning branch.
  - AutoCAD map of the selected feeders.
  - Total no. of faults and temporary no. of faults of each feeder section from the relevant area engineer.

- Transformer Data

  - Transformer Category – this information can be obtained by the online database of CEB and this is cross-checked by the respective area office.
  - Connected Consumers – from the online database of CEB
  - No. of Interruptions for a transformer and the duration – collection of this data was a bit time consuming as a proper data recording method for

transformer wise power interruption is not maintained. These data were collected from the Area office and CSC.

For this study only interruptions due to Over Current (OC) and Earth Fault (EF) were considered. Planned interruptions were not considered.

- Other

  - Maintenance and travel cost for a crew cab – the details were obtained from the respective CSC of the crew cab.
  - Cost of EENS – from a research paper. [8]

3.2 Feeder Selection

Three feeders were selected from the distribution division network to validate the mathematical model. When the feeders of the DD4 network considered some feeders have more than 4 ARs (at the gantry locations) while some other feeders doesn't have any AR. To validate the mathematical model 3 feeders were selected from the DD4 network. Following are the feeders selected and the feeders drawn on SynerGEE model are also given with the description.

- Ambalangoda Feeder 3 – 14907 consumers are connected to this feeder. There is a one gantry location with 4 outgoing feeders and there are 4 ARs installed at the starting point of the outgoing feeder. When the feeder tripping data was analyzed Ambalangoda Feeder 3 had higher number of tripping compared to other feeders on which ARs have been installed. Because of that reason this feeder was selected to validate the mathematical model. The feeder shown on geographical map is shown in the following figure. During the period in which the data collected, the ARs were not functioning properly due to protection settings were not coordinated with the GSS circuit breaker. Hence, the result does not depend on the already installed AR locations.

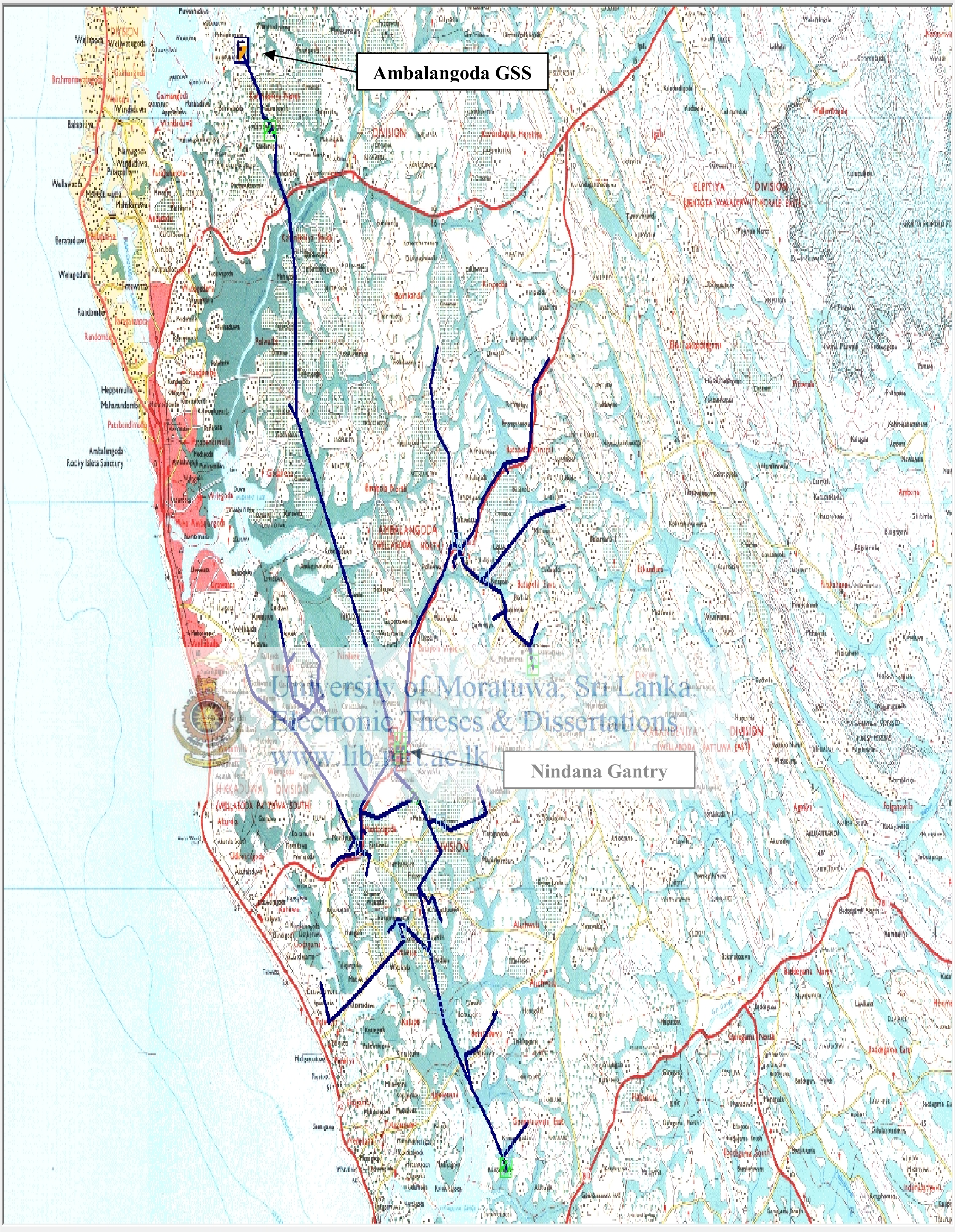


Figure 3.1 Geographical map of Ambalangoda Feeder 3

➢ Matara Feeder 7 – As shown in the below figure Matara F7 feeds more than 35,787 consumers in the Matara – Kamburupitiya area. Feeder 7 is divided into 3 outgoing feeders at the Kamburupitiya Gantry where only one AR is installed for one of the outgoing feeder which goes towards Andaluwa.

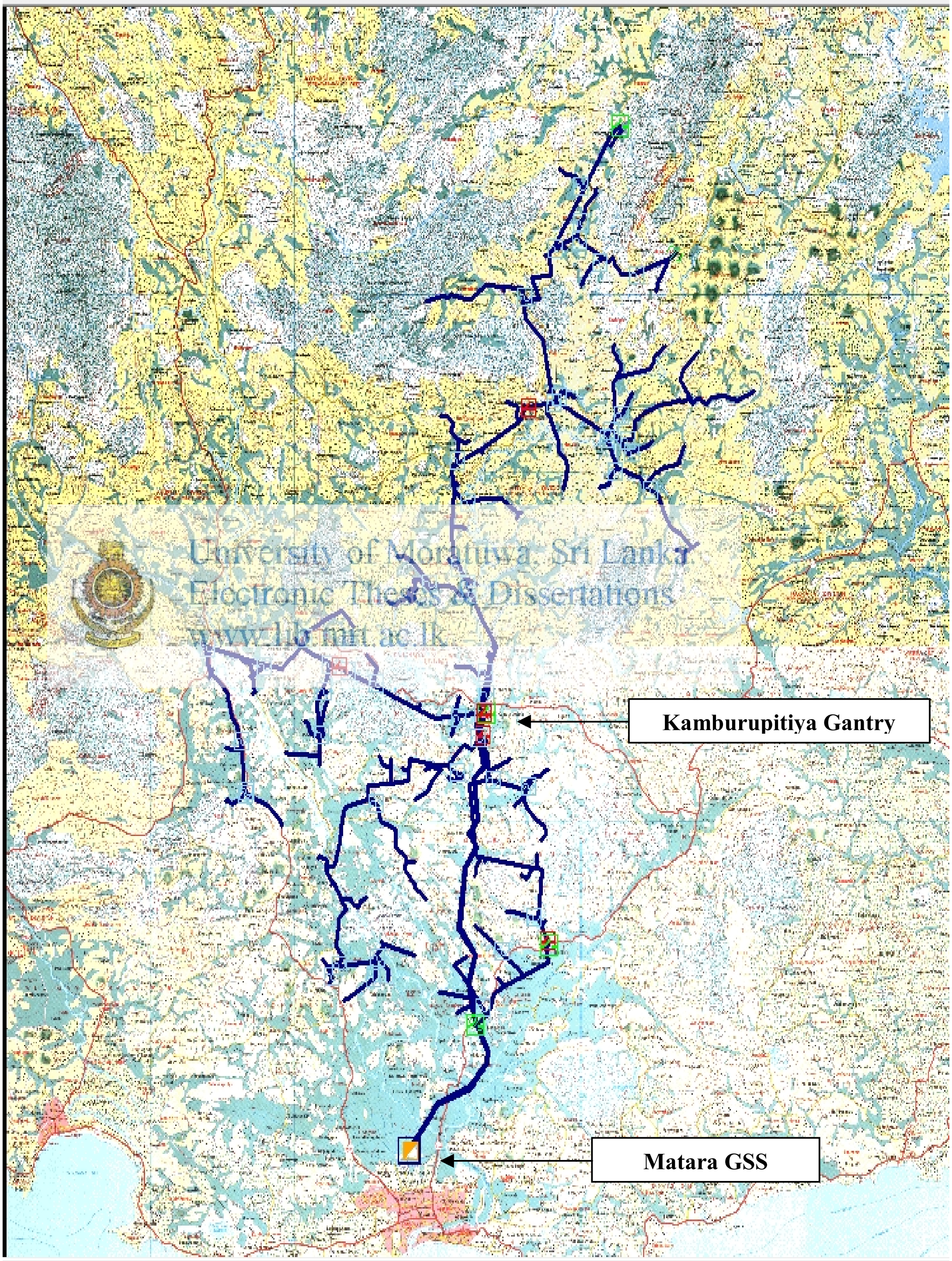


Figure 3.2 Geographical map of Matara Feeder 3

➢ Galle Feeder 8 – This feeder is a distributor and there are no gantry locations located on this feeder. There are no ARs installed on this feeder. 8950 consumers are fed from this feeder. This feeder had higher tripping rate compared to other feeders where no ARs are installed.

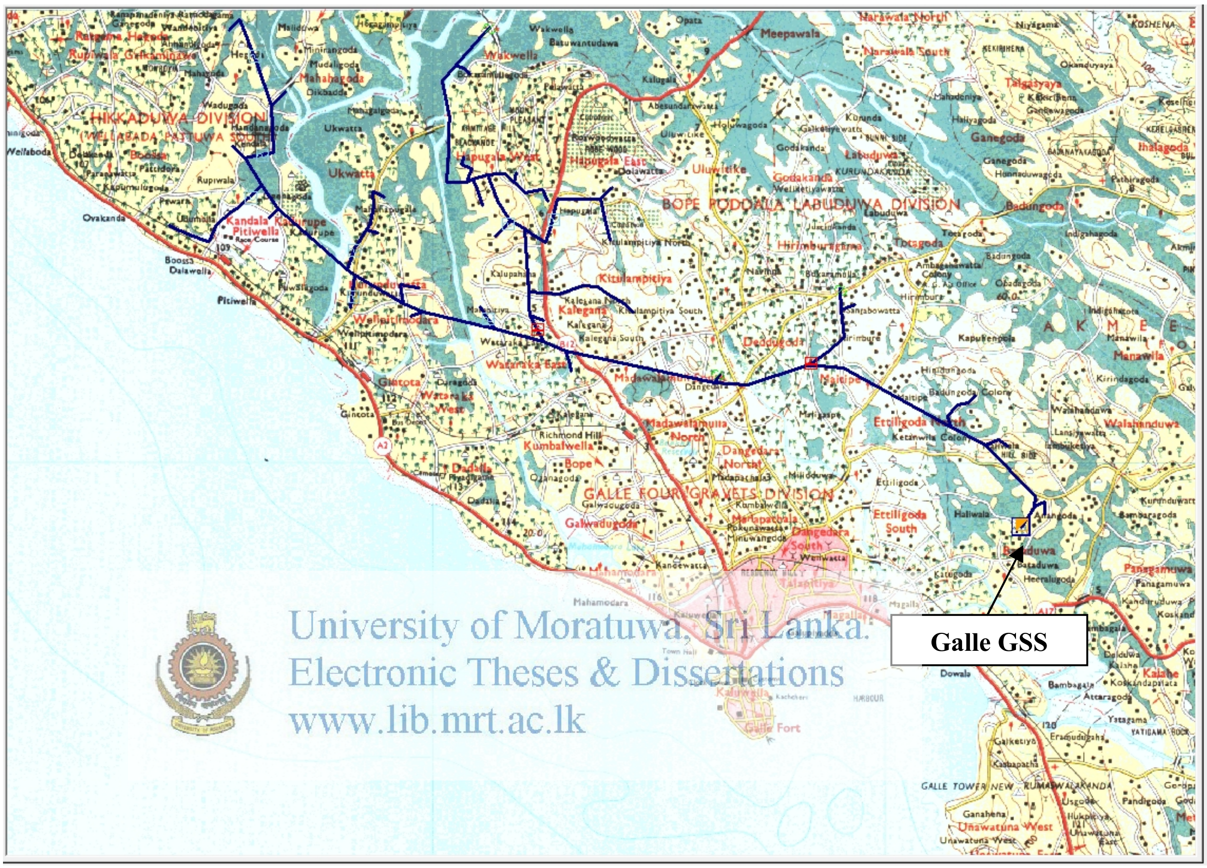


Figure 3.3 Geographical map of Galle Feeder 8

3.3 Data Analysis

The collected data should be analyzed accordingly to obtain results from the objective function by using them. The analyzed data are described in the following section.

- Outage rate of the feeder – when deciding the outage rate of the feeder only the auto tripping were considered. From March 2012 to Feb 2013 tripping data collected and got the average value. This value was taken as the outage rate of the feeder and percentage value is also calculated

$$Outage\ Rate = \left(\sum_{n=March\ 2012}^{n=February\ 2013} Auto\ Tripping_n\right)/12$$

Table 3.1: Outage rate of selected distribution feeders

Ambalangoda Feeder 3												
Month	**Mar 2012**	**Apr 2012**	**May 2012**	**Jun 2012**	**Jul 2012**	**Aug 2012**	**Sept 2012**	**Oct 2012**	**Nov 2012**	**Dec 2012**	**Jan 2013**	**Feb 2013**
Tripping	4	22	7	11	18	7	15	6	4	2	2	1
Outage rate	8.25											
Matara Feeder 7												
Month	**Mar 2012**	**Apr 2012**	**May 2012**	**Jun 2012**	**Jul 2012**	**Aug 2012**	**Sept 2012**	**Oct 2012**	**Nov 2012**	**Dec 2012**	**Jan 2013**	**Feb 2013**
Tripping	5	12	11	5	3	6	16	8	20	23	25	16
Outage rate	12.5											
Galle Feeder 8												
Month	**Mar 2012**	**Apr 2012**	**May 2012**	**Jun 2012**	**Jul 2012**	**Aug 2012**	**Sept 2012**	**Oct 2012**	**Nov 2012**	**Dec 2012**	**Jan 2013**	**Feb 2013**
Tripping	-	3	7	20	2	-	5	6	11	1	7	2
Outage rate	5.33											

- Energy consumption of Bulk and Retail consumers of the feeder – monthly energy consumption of retail and bulk consumers for an annum is considered and monthly average value is obtained.

Table 3.2: Bulk and Retail Energy consumption of selected feeders

Ambalangoda Feeder 3													
Month	**Mar 2012**	**Apr 2012**	**May 2012**	**Jun 2012**	**Jul 2012**	**Aug 2012**	**Sept 2012**	**Oct 2012**	**Nov 2012**	**Dec 2012**	**Jan 2013**	**Feb 2013**	**Avg**
Retail (MWh)	940.93	949.82	961.74	949.29	939.70	941.04	923.00	978.47	930.17	952.24	963.03	995.05	952.04
Bulk (MWh)	49.529	56.138	55.703	57.022	39.228	31.219	37.059	54.588	44.061	35.112	42.289	55.056	46.417
Matara Feeder 7													
Month	**Mar 2012**	**Apr 2012**	**May 2012**	**Jun 2012**	**Jul 2012**	**Aug 2012**	**Sept 2012**	**Oct 2012**	**Nov 2012**	**Dec 2012**	**Jan 2013**	**Feb 2013**	**Avg**
Retail (MWh)	1948.5	2008.1	2019.4	1940.2	1893.5	1874	1906.1	1988.6	1925.0	1975.2	1995.5	1956.3	1952.6
Bulk (MWh)	1583.6	1616.5	1648.6	1675.6	1706.3	1742.4	1776.2	1821.4	1857.7	1893.4	1924.0	1942.7	1765.7
Galle Feeder 8													
Month	**Mar 2012**	**Apr 2012**	**May 2012**	**Jun 2012**	**Jul 2012**	**Aug 2012**	**Sept 2012**	**Oct 2012**	**Nov 2012**	**Dec 2012**	**Jan 2013**	**Feb 2013**	**Avg**
Retail (MWh)	694.35	1440.5	1425.3	678.51	699.93	656.99	686.21	691.07	706.73	730.53	743.91	722.74	823.06
Bulk (MWh)	743.98	764.41	734.94	753.96	769.91	735.07	758.96	764.91	728.07	763.96	727.07	728.07	747.77

- Interruption Duration values of each Substation – From the collected interruption data calculate the customer interruption duration which is needed to calculate the SAIDI values. The equation to calculate the SAIDI values are given below. At the same time categorize the substations ons whether it's a Bulk transformer or a Retail transformer.

$$SAIDI = \frac{Total\ Customer\ interruption\ Duration}{Total\ Number\ of\ Customers}$$

$$Customer\ Interruption\ Duration$$
$$= Interrupted\ Hours \times No.of\ Interrupted\ conconsumers$$

Calculation of customer interruption duration done for few of the substations on Galle – Feeder 8 is given in the table below. The customer interruption duration calculation for the selected feeders is attached in Annexure 2.

Table 3.3: Customer Interruption Duration for substations on Galle Feeder 8

Sin No	Interrupted Hours											
	Mar 2012	Apr 2012	May 2012	Jun 2012	Jul 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013
GB 300	8.1396	1834.531	68.8296	39.6372	3521.999	1622.823	6070.723	1240.713	645.4311	1730.76	0	347.9588
GB 310	885.1492	9061.291	1541.496	1182.514	28577.7	27054.09	34524.86	3289.514	1176.146	883.2447	4454.05	2946.726
GB 320	163.4584	1977.903	66.552	3143.746	29648.16	9042.848	131943.2	1040.023	3817.822	10620.51	115.2542	4243.179
GB 321	10.1992	418.6626	447.866	1323.12	854.9471	8.5407	4607.088	1669.023	902.7845	1163.909	142.4686	909.2526
GB 330	5.3176	1.4996	2.1712	102.8537	972.7643	300.5571	4449.697	35.1256	128.9426	359.7522	4.0043	148.3178
GB 410	0.89	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04
GB 490	72.4878	4287.892	466.9888	396.7722	11475.6	36.972	3861.095	2989.722	980.0192	726.1903	1836.778	169.25
GB 530	5.2269	191.9936	116.194	32.006	1249.958	1023.258	5234.906	571.5968	82.0736	691.4944	1.3716	223.6878
GB 600	3.2123	573.3426	10133.78	1586.253	3432.88	150.228	10759.25	2001.306	1018.033	2341.344	72.4073	142.6403
GB 770	0.09	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04

On the above feeder, the Bulk transformer numbers are highlighted in color 'Red' while the retail transformer numbers are not highlighted.

- Temporary Fault percentages of each feeder section – the collection of these data were time consuming. The data were collected from Area Engineers and the respective ESs at the CSCs. For each and every spur the temporary percentage needed to be calculated. The temporary fault percentages for several spurs in Ambalangoda Feeder 3 line is given below. All the other temporary fault percentages of the selected feeders are given in Annex 8.

Table 3.4: Temporary Fault percentages for Nindanda Gantry – Gonapinuwala side feeder section on Ambalangoda Feeder 3

No	Name of the Section	Temporary Fault Percentage (%)
1	Supem Uyana Spur	100
2	Berathuduwa Spur	94
3	Dalawathumulla Spur	90
4	Kosgahawella Spur	90
5	Manampita Spur	95

Source: Area Engineer - Ambalangoda

- Breakdown Recovery Cost – This is the cost for a crew cab to travel one km when an AR is lockout and make it back to the normal operation after clearing the fault. To obtain this value two other variables should be analyzed.
  - Fuel consumed per km for a crew cab
  - Maintenance cost per km for a crew cab

Maintenance and Fuel consumption details are collected for a crew cab for a time span of 17 months and got an average value for Maintenance cost and fuel cost per km. 17 months time span was taken because for a time span of one year data was considered in some months the crew cab was not driven but maintenance was done and in some months there was no maintenance was done. To include all these variations a time span of 17 months was considered. Collected data and the relevant calculations are given below. Also to do a sensitivity study, whether the locations vary due to the used crew cab is also done. For this process, maintenance cost and fuel cost of 2 more crew cabs were considered. These values are attached in Annexed 9.

Table 3.5: Maintenance and Fuel Cost for Crew Cab No. 1

Year	Month	Consumed Fuel (l)	Driven km	Maintenance Cost (LKR)
2013	January	1,861	199.02	3,300.00
	February	1,887	208.41	11,472.00
	March	1,958	214.56	2,100.00
	April	1,979	217.8	-
	May	1,486	158.99	49,950.00
	June	0	0	-
	July	0	0	14,350.00
	August	7,54	73.32	144,900.00
	September	1,692	179.6	124,265.00
	October	1,963	215.96	31,922.00
	November	2,201	241.85	5,950.00
	December	1,973	217.43	-
2014	January	2,506	274.45	12,052.00
	February	1,872	206.01	-
	March	2,480	273.33	34,390.00
	April	1,694	187.44	3,950.00
	May	1,911	209.67	56,400.00
Total		28,217	3077.84	495,001.00

Source: Data was taken from the Accounts Branch – Southern Province

Fuel Consumption per km,

$$Fuel\ consumed\ per\ km = \frac{Consumed\ Fuel}{Driven\ km}$$

$$Fuel\ consumed\ per\ km = \frac{3077.84}{28{,}217} = 0.109\ l/km$$

Maintenance Cost per km,

$$Maintenance\ cost\ per\ km = \frac{Maintenance\ Cost\ for\ the\ time\ period}{Driven\ km}$$

$$Maintenance\ cost\ per\ km = \frac{495{,}001.00}{28{,}217} = 17.54\ Rs./km$$

- Location of the respective GSS on the AutoCAD map for a specific feeder. The Distance to each and every location marked on the map should be obtained from the SynerGEE model of the Distribution Network of DD4. How the distances are obtained from the SynerGEE model is shown in figure 3.1 and the distances obtained from the SynerGEE model are displayed in Annex 3.

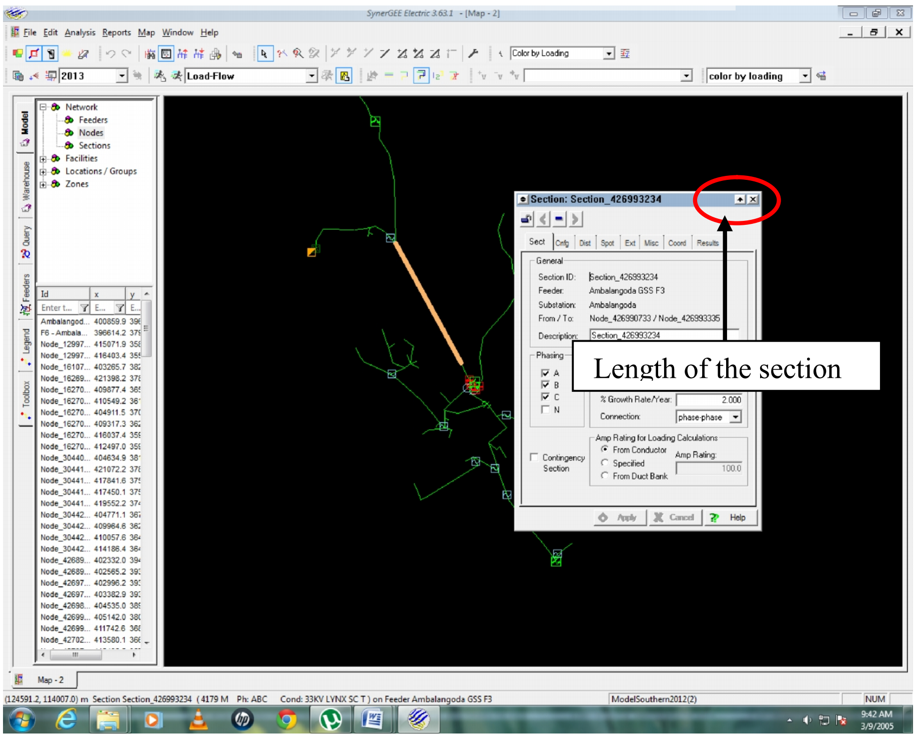


Figure 3.4 How the distances obtained from the SynerGEE model

3.4 Data Flow for the Study

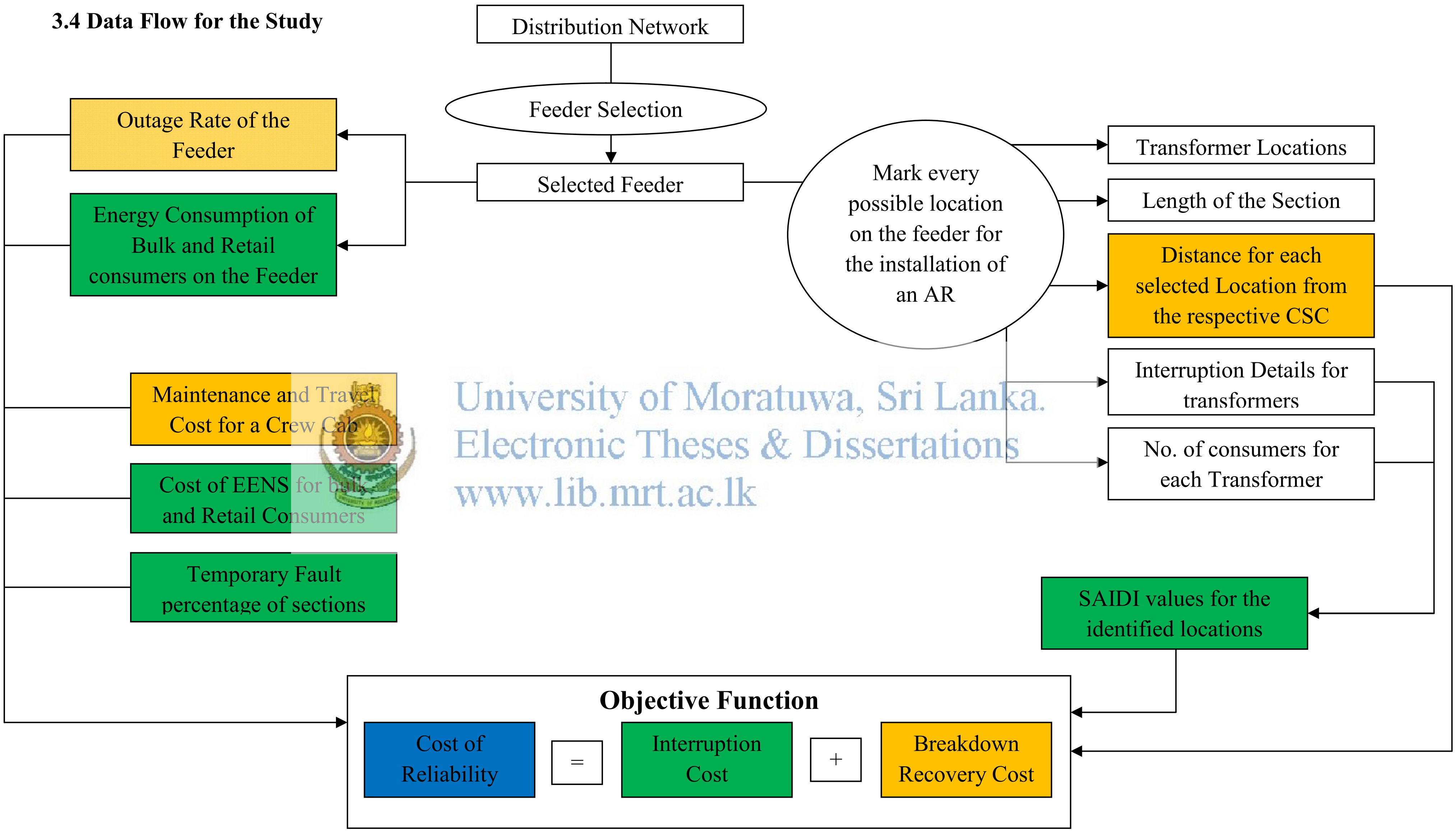


Figure 3.5 Data Flow for the Study

Chapter 4

Case Study

4.1 Introduction of the Selected Feeder

The first feeder selected for the case study was Ambalangoda Feeder 3. This feeder starts from Ambalangoda GSS and the feeder goes to Nindana Gantry, approximately for 10 km and from there the feeder is divided to 3 outgoing feeders. Three ARs are installed at the starting point of these 3 outgoing feeders. The feeders going towards Gonapinuwala and Kahatapitiya is approximately 7 km long and the other feeder going towards Kuleegoda is approximately 6 km long. On each feeder there are spur lines connected and these spur lines are 1 – 2 km long.

4.2 Location Identification for AR installation

The first step of the study is to mark every possible location for installing an AR on the selected feeder. The location identification was done according to following steps.

- On the main feeder,
  - Just after a spur line on the main feeder, is marked as a location.
  - DDLO locations or LBS locations.
- On a spur line
  - At the starting point of the spur line
  - After a substation on the spur line
  - DDLO location or LBS location on the spur line.

Identified locations on Ambalangoda Feeder 3 is marked the AutoCAD map given in the figure 4.1. On the figure, locations on the main feeder are marked in color Green and the locations on the spurs are marked in color Blue. Each location is given a number for identification and the numbering starts from the end point of the feeder.

When analyzing the locations, the locations on three outgoing feeders from the gantry should be analyzed separately. That means finally there should be 3 separate AR locations for the 3 feeders from the gantry.

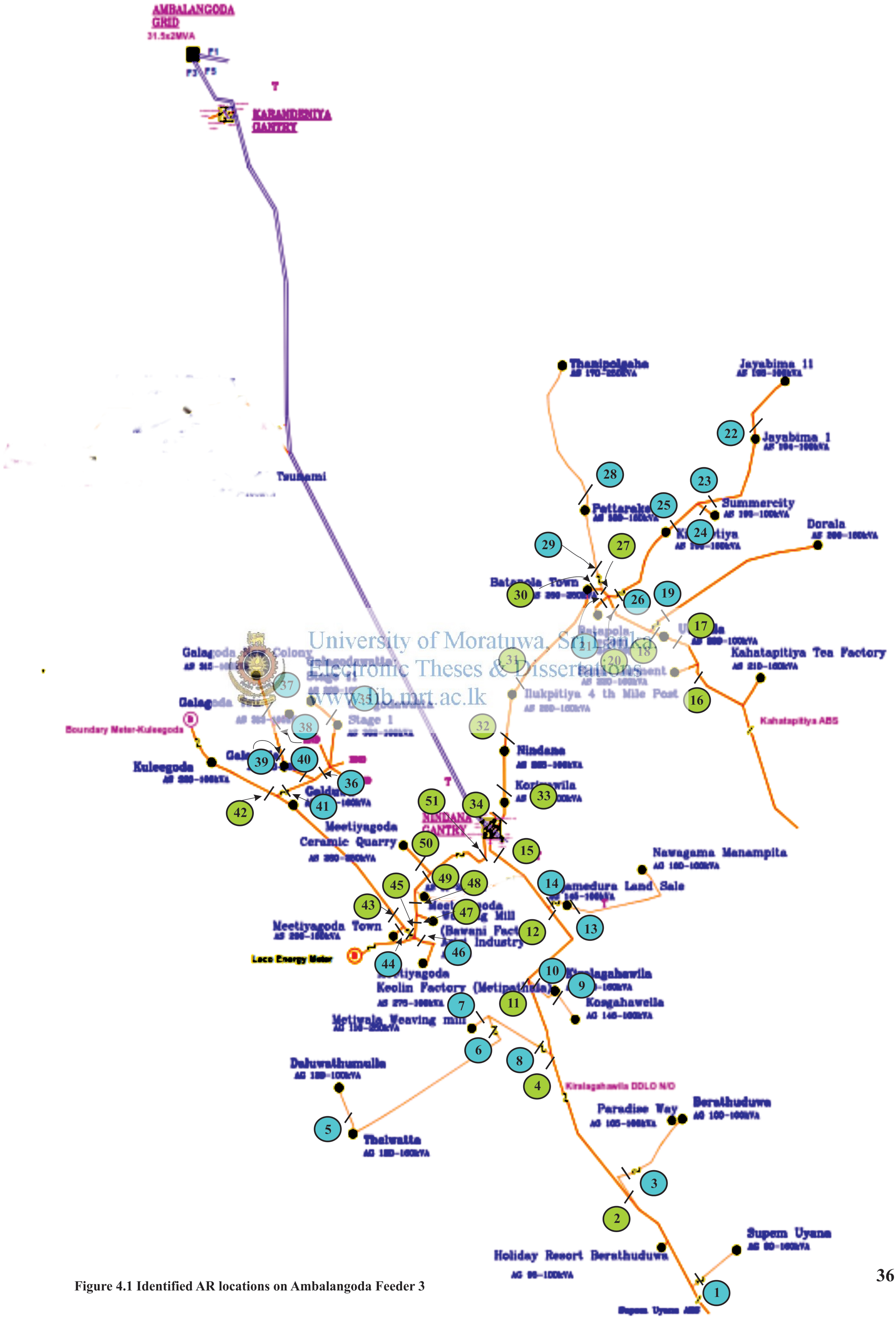


Figure 4.1 Identified AR locations on Ambalangoda Feeder 3

4.3 Supporting Calculations for Ambalangoda Feeder 3

First calculate the SAIDI values for identified locations using the calculated Interrupted Hours for each substation. For the locations which have both retail and bulk substations there should be two separate SAIDI values. At the same time obtain the distance from the GSS to the identified location from the SynerGEE model and the consumers connected on that specific location. The summarized SAIDI values for few of the identified AR locations on Ambalangoda Feeder 3 are tabulated below. The full calculation sheet is attached in Annexure 3.

Table 4.1: SAIDI values calculated for identified locations on Ambalangoda Feeder 3

Section	Distance from GSS (km)	Sin No.	Mar 2012	Apr 2012	May 2012	Jun 2012	Jul 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Consumers
1	**16.370**	**AG 090**	0.0113	8.5344	0.1948	0.0542	1.6854	0.3589	0.0744	4.2313	0.0051	0.0728	33.9430	0.0173	247
2	**15.794**	**AG 090**	0.0113	8.5344	0.1948	0.0542	1.6854	0.3589	0.0744	4.2313	0.0051	0.0728	33.9430	0.0173	247
		AG 095	0.45	0.63	0.23	0.35	0.56	0.006	0.04	0.89	0.24	0.02	0.98	0.005	1
3	**15.194**	**AG 100** **AG 105**	0.0113	7.4125	0.2532	0.8223	8.2620	1.4760	0.0594	30.835	0.3489	0.7323	43.3635	0.0245	439
4	**13.182**	**AG 095**	0.45	0.63	0.23	0.35	0.56	0.006	0.04	0.89	0.24	0.02	0.98	0.005	1
		AG 090 **AG 100** **AG 105**	0.0113	7.8165	0.2322	0.5457	5.8941	1.0738	0.0648	21.256	0.2251	0.4949	39.9716	0.0219	686
5	**16.219**	**AG 130**	0.3935	27.633	4.3736	0.2861	5.5689	7.9781	11.985	1.9058	8.9833	51.589	49.9256	16.431	415
6	**14.057**	**AG 120** **AG 130**	0.4020	14.345	2.3815	0.2321	5.5725	6.5818	10.036	3.0452	8.7793	34.490	48.7919	16.009	802
7	**14.057**	**AG 110**	1.1724	0.0072	0.3382	0.0005	0.0872	5.1922	9.2925	3.9273	0.0036	8.4285	54.6444	0.1158	433

The above calculated SAIDI value for each and every location includes the interrupted hours due to the permanent faults also. To get the temporary fault contribution, the SAIDI values given in table 4.1 should be multiplied by the temporary fault percentage of that specific feeder section and then from that the SAIDI value due to line tripping must be reduced. The SAIDI values due to line tripping for few of the identified AR locations on Ambalangoda Feeder 3 are tabulated below. These values are multiplied by line tripping percentage and reduced from the respective value of table 4.1. The result of the calculation for Ambalangoda Feeder 3 is attached in Annexure 3.

Table 4.2: SAIDI values calculated due to line tripping for identified locations on Ambalangoda Feeder 3

Section	Distance from GSS (km)	Type	Mar 2012	Apr 2012	May 2012	Jun 2012	Jul 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Consumers
1	16.370	Bulk	0.45	0.63	0.23	0.35	0.56	0.006	0.04	0.89	0.24	0.02	0.98	0.005	6
		Retail	5.07270	9.79535	4.47683	8.59960	4.88428	5.83010	6.50637	8.2242	10.4247	13.1389	12.9148	4.4138	13,496
2	15.794	Bulk	0.45	0.63	0.23	0.35	0.56	0.006	0.04	0.89	0.24	0.02	0.98	0.005	5
		Retail	5.07270	9.79535	4.47683	8.59960	4.88428	5.83010	6.50637	8.2242	10.4247	13.1389	12.9148	4.4138	13,496
3	15.194	Bulk	0.45	0.63	0.23	0.35	0.56	0.006	0.04	0.89	0.24	0.02	0.98	0.005	6
		Retail	5.14575	9.85057	4.5367	8.69758	4.71343	5.87219	6.59969	7.40398	10.5637	13.3057	12.30047	4.47701	13,304
4	13.182	Bulk	0.45	0.63	0.23	0.35	0.56	0.006	0.04	0.89	0.24	0.02	0.98	0.005	5
		Retail	5.24288	9.87547	4.61884	8.86108	4.77071	5.97649	6.72312	7.46400	10.7635	13.5560	11.89106	4.56137	13,507
5	16.219	Bulk	0.45	0.63	0.23	0.35	0.56	0.006	0.04	0.89	0.24	0.02	0.98	0.005	6
		Retail	5.12460	9.21657	4.40069	8.70009	4.80368	5.66182	6.21659	8.34694	10.2765	11.6995	12.15208	3.95815	13,328

4.4 Data Analysis for Ambalangoda Feeder 3

Other than SAIDI values for the locations there are few more inputs needed to be obtained for the objective function. The respective inputs with the calculations are given below.

- Auto tripping rate of the feeder
  - $\lambda_f = 8.25\, failures/month$
- Auto Tripping percentage of the Feeder
  - $\lambda_i = 58.4\ \%$
- Temporary Fault percentages of line sections (Annexure 8)
- Retail and Bulk consumer accounts
  - No. of Retails consumers = 14,901
  - No. of Bulk consumers = 6
- Retail and Bulk energy consumption
  - Retail Energy Consumption = 952,039.30 kWh
  - Bulk Energy Consumption = 46,417.05 kWh
- Exchange rate of 1 US Dollar to Sri Lankan Rupees = 132.90 LKR
- Cost for the utility for one hour power interruption
  - For retail consumers

$$f_{retail} = \frac{ENS \times EC_{bulk}}{24 \times 30 \times N_{bulk}} = \frac{1.2\frac{\$}{kWh} \times 132.90\frac{LKR}{\$} \times 952{,}039.3\, kWh}{24 \times 30 \times 14{,}901}$$

$$f_{retail} = 14.06\ \frac{LKR}{hr}$$

- For bulk consumers

$$f_{bulk} = \frac{ENS \times EC_{retail}}{24 \times 30 \times N_{retail}} = \frac{1.2\frac{USD}{kWh} \times 132.90\frac{LKR}{USD} \times 46{,}417.05\, kWh}{24 \times 30 \times 6}$$

$$f_{bulk} = 1{,}701.96\ \frac{LKR}{hr}$$

- Price of Lanka Auto Diesel = 95 LKR/liter
- Fuel Cost for the Crew Cab = 0.109 liter/km
- Maintenance cost for the Crew Cab = 17.54 LKR/km

4.5 Results from the Objective Function

From these analyzed data, calculated the breakdown recovery cost and the interruption cost for 12 months were calculated and obtained the average interruption cost. These values are tabulated in the following tables for each feeder going from Nindana Gantry. The results and the detailed calculations are attached in Annexure 3. As the first step the interruption cost and the breakdown recovery cost were calculated for every location marked on the map.

- Nindana Gantry – Gonapinuwala side Feeder

Table 4.3: CoR, Average CoI and B_{cost} for Nindana Gantry – Gonapinuwala side Feeder

Section No.	Distance from GSS (km)	Average Interruption Cost (LKR)	Breakdown Recovery Cost (LKR)	Cost of Reliability (LKR)
1	16.370	(371.41)	3,767.31	3,395.90
2	15.794	252.78	3,634.80	3,887.58
3	15.194	(325.41)	3,496.72	3,171.31
4	13.183	264.61	3,033.76	3,298.37
5	16.221	(229.29)	3,732.68	3,503.39
6	14.057	(267.21)	3,234.92	2,967.71
7	14.057	(340.98)	3,234.92	2,893.94
8	13.183	(292.30)	3,033.76	2,741.46
9	12.721	(367.97)	2,927.21	2,559.24
10	12.281	(303.84)	2,825.95	2,522.11
11	12.276	287.99	2,825.01	3,112.99
12	11.098	275.82	2,554.02	2,829.85
13	11.453	(74.30)	2,635.63	2,561.33
14	11.098	(128.29)	2,554.02	2,425.73
15	9.894	334.07	2,276.99	2,611.06

The rows highlighted in color 'Green' are the locations on the spur lines. From the locations on main lines Location No.15 has the minimum CoR and from the locations on spur lines Location No.14 has the minimum CoR. The location No. 15 and No. 14

are finalized as optimal locations (which are highlighted in color 'Yellow') on Nindana – Gonapinuwala Feeder.

- Nindana Gantry – Kahatapitiya side Feeder

Table 4.4: CoR, Average CoI and B_{cost} for Nindana Gantry – Kahatapitiya side Feeder

Section No.	Distance from GSS (km)	Average Interruption Cost (LKR)	Breakdown Recovery Cost (LKR)	Cost of Reliability (LKR)
16	14.852	(365.34)	3,418.02	3,052.67
17	14.338	534.43	3,299.66	3,834.08
18	14.206	509.13	3,269.19	3,778.32
19	14.206	(362.47)	3,269.19	2,906.72
20	13.533	439.85	3,114.47	3,554.32
21	13.534	(2.60)	3,114.54	3,111.94
22	16.289	(296.95)	3,748.63	3,451.68
23	15.008	(311.70)	3,453.80	3,142.11
24	15.008	(315.08)	3,453.80	3,138.72
25	14.571	(311.71)	3,353.23	3,041.52
26	13.534	(287.45)	3,114.58	2,827.14
27	13.424	302.29	3,089.41	3,391.69
28	14.325	(279.15)	3,296.64	3,017.50
29	13.424	(301.33)	3,089.41	2,788.07
30	13.288	319.11	3,057.95	3,377.06
31	11.669	303.37	2,685.34	2,988.71
32	10.749	307.84	2,473.64	2,781.48
33	10.126	305.08	2,330.33	2,635.42
34	9.895	292.54	2,277.17	2,569.71

The rows highlighted in color 'Green' are the locations on the spur lines. From the locations on main lines Location No. 34 has the minimum CoR and from the locations on spur lines Location No. 29 has the minimum CoR. The location No. 34 and No. 29

are finalized as optimal locations (which are highlighted in color ‘Yellow’) on Nindana – Kahatapitiya Feeder.

- Nindana Gantry – Kuleegoda side Feeder

Table 4.5: CoR, Average CoI and B_{cost} for Nindana Gantry – Kuleegoda side Feeder

Section No.	Distance from GSS (km)	Average Interruption Cost (LKR)	Breakdown Recovery Cost (LKR)	Cost of Reliability (LKR)
35	14.719	(290.20)	3,387.32	3,097.11
36	13.967	(330.85)	3,214.85	2,884.00
37	14.835	(373.76)	3,414.08	3,040.32
38	14.361	(376.12)	3,304.88	2,928.76
39	12.896	(378.07)	2,967.85	2,589.78
40	13.970	(335.21)	3,214.85	2,879.64
41	13.470	(337.49)	3,099.95	2,762.45
42	13.470	(392.26)	3,099.95	2,707.69
43	11.536	(357.95)	2,654.91	2,296.97
44	11.536	(358.99)	2,654.91	2,295.92
45	11.383	(355.29)	2,619.70	2,264.41
46	11.383	478.51	2,619.70	3,098.21
47	11.113	516.11	2,557.55	3,073.66
48	10.866	539.37	2,500.54	3,039.91
49	10.565	521.16	2,431.39	2,952.55
50	10.565	419.90	2,431.39	2,851.29
51	9.895	530.50	2,277.17	2,807.67

The rows highlighted in color ‘Green’ are the locations on the spur lines. From the locations on main lines Location No. 45 has the minimum CoR and from the locations on spur lines Location No. 44 has the minimum CoR. The location No. 45 and No. 44 are finalized as optimal locations (which are highlighted in color ‘Yellow’) on Nindana – Kuleegoda Feeder.

4.6 Sensitivity Analysis

Sensitivity analysis was done to check whether the optimal locations found from the objective function would vary with the breakdown vehicle used. For this fuel consumption and maintenance records of two breakdown vehicles were used. The calculated fuel consumption and maintenance costs are as follows. The collected records are given in Annex

Vehicle No. 1 (Sensitivity Analysis – 1)

Fuel Consumption per km,

$$Fuel\ consumed\ per\ km = \frac{Consumed\ Fuel}{Driven\ km}$$

$$Fuel\ consumed\ per\ km = \frac{10{,}574}{35{,}560} = 0.297\ l/km$$

Maintenance Cost per km,

$$Maintenance\ cost\ per\ km = \frac{Maintenance\ Cost\ for\ the\ time\ period}{Driven\ km}$$

$$Maintenance\ cost\ per\ km = \frac{614{,}802.00}{35{,}560} = 17.29\ Rs./km$$

Vehicle No. 2 (Sensitivity Analysis – 2)

Fuel Consumption per km,

$$Fuel\ consumed\ per\ km = \frac{Consumed\ Fuel}{Driven\ km}$$

$$Fuel\ consumed\ per\ km = \frac{1{,}781.27}{16{,}970} = 0.105\ l/km$$

Maintenance Cost per km,

$$Maintenance\ cost\ per\ km = \frac{Maintenance\ Cost\ for\ the\ time\ period}{Driven\ km}$$

$$Maintenance\ cost\ per\ km = \frac{74{,}825.00}{16{,}970} = 4.41\ Rs./km$$

The Cost of Reliability of the case study and the Cost of Reliability calculated for the two sensitivity analysis are given in the following tables for the three outgoing feeders from the Nindana Gantry of Ambalangoda Feeder 3, with the observations discussed at the bottom of each table. With keeping the SAIDI values as it is, breakdown recovery cost is varied by changing the maintenance cost and the fuel consumption cost.

- Nindana Gantry – Gonapinuwala side

Section No.	Cost of Reliability for the Case Study	Cost of Reliability for Sensitivity Analysis – 1	Cost of Reliability for Sensitivity Analysis – 2
1	3,395.90	5,774.19	1,571.33
2	3,887.58	6,182.22	2,127.19
3	3,171.31	5,378.78	1,477.80
4	3,298.37	5,213.57	1,829.07
5	3,503.39	5,859.82	1,695.60
6	2,967.71	5,009.90	1,400.99
7	2,893.94	4,936.14	1,327.22
8	2,741.46	4,656.66	1,272.16
9	2,559.24	4,407.17	1,141.54
10	2,522.11	4,306.12	1,153.46
11	3,112.99	4,896.41	1,744.80
12	2,829.85	4,442.19	1,592.89
13	2,561.33	4,225.19	1,284.85
14	2,425.73	4,038.08	1,188.78
15	2,611.06	4,048.51	1,508.28

The Optimum location (which has the lowest Cost of Reliability) for the spur lines has changed for the sensitivity analysis – 2. The optimum location finalized for the main line remains unchanged with the change of cost values.

- Nindana Gantry – Kahatapitiya Side

Section No.	Cost of Reliability for the Case Study	Cost of Reliability for Sensitivity Analysis – 1	Cost of Reliability for Sensitivity Analysis – 2
16	3,052.67	5,210.45	1,397.27
17	3,834.08	5,917.14	2,236.01
18	3,778.32	5,842.15	2,195.00
19	2,906.72	4,970.54	1,323.40
20	3,554.32	5,520.48	2,045.94
21	3,111.94	5,078.14	1,603.52
22	3,451.68	5,818.17	1,636.16
23	3,142.11	5,322.48	1,469.37
24	3,138.72	5,319.10	1,465.99
25	3,041.52	5,158.40	1,417.50
26	2,827.14	4,793.36	1,318.69
27	3,391.69	5,342.02	1,895.44
28	3,017.50	5,098.66	1,420.88
29	2,788.07	4,738.40	1,291.82
30	3,377.06	5,307.53	1,896.04
31	2,988.71	4,683.96	1,688.16
32	2,781.48	4,343.07	1,583.45
33	2,635.42	4,106.55	1,506.80
34	2,569.71	4,007.28	1,466.84

In this part of the study, the optimal location for the main line has changed in the sensitivity analysis – 2, while the optimum location for the spur lines remains unchanged.

- Nindana Gantry – Kuleegoda side

Section No.	Cost of Reliability for the Case Study	Cost of Reliability for Sensitivity Analysis – 1	Cost of Reliability for Sensitivity Analysis – 2
35	3,097.11	5,235.51	1,456.58
36	2,884.00	4,913.53	1,327.00
37	3,040.32	5,195.62	1,386.83
38	2,928.76	5,015.12	1,328.15
39	2,589.78	4,463.38	1,152.41
40	2,879.64	4,909.17	1,322.64
41	2,762.45	4,719.44	1,261.10
42	2,707.69	4,664.67	1,206.34
43	2,296.97	3,973.00	1,011.15
44	2,295.92	3,971.96	1,010.11
45	2,264.41	3,918.22	995.65
46	3,098.21	4,752.02	1,829.44
47	3,073.66	4,688.23	1,835.00
48	3,039.91	4,618.50	1,828.86
49	2,952.55	4,487.47	1,774.99
50	2,851.29	4,386.21	1,673.73
51	2,807.67	4,245.24	1,704.80

For the outgoing feeder goes towards Kuleegoda side, both the optimal locations for the main line and spur line remains unchanged.

When considering the optimal locations with the change in cost values of the objective function, it is visible that the locations have changed in the sensitivity analysis – 2, which has a lower maintenance cost per km compared to other 2 scenarios. Following observations were identified for the optimal location change with the change of maintenance cost per km and fuel consumption per km.

- The optimal location does not change with the variation in fuel consumption per km.
- Maintenance cost per km is lower than 7.6 LKR/km the optimal locations vary.

Figure 4.2 Finalized Optimal Locations on Ambalangoda Feeder 3

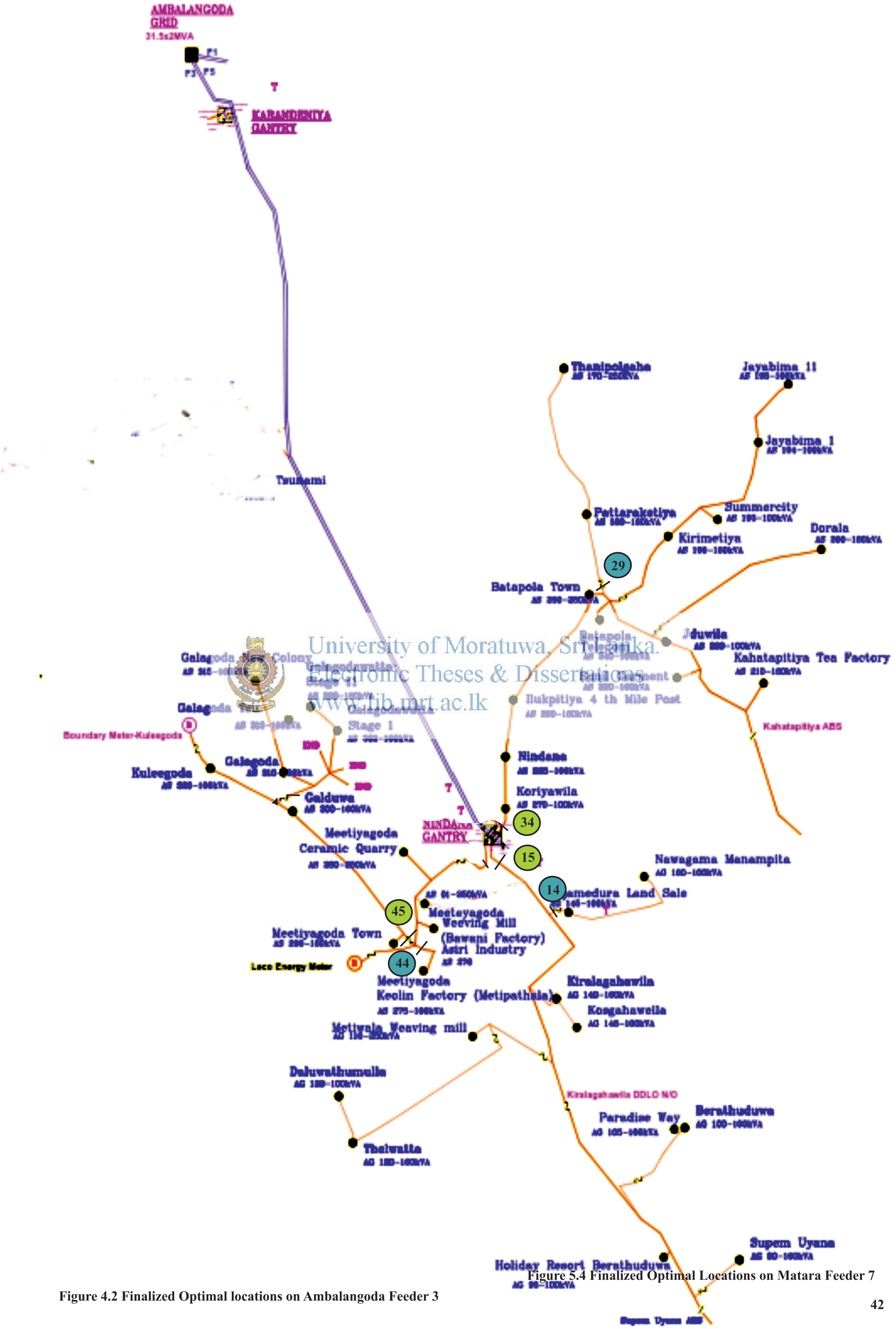


Figure 5.4 Finalized Optimal Locations on Matara Feeder 7

Figure 4.2 Finalized Optimal locations on Ambalangoda Feeder 3

Chapter 5

Model Validation

5.1 Introduction

To validate the model two other feeders were selected from the DD4 network. Those feeders are Galle Feeder 8 and Matara Feeder 7. A brief description about the two feeders is given below.

- Galle Feeder 8 – This feeder starts from Ambalangoda GSS and goes towards Boossa and the length of the main feeder is approximately 10 km long. This feeder doesn't have any gantry locations and no ARs are installed. There are several spur lines connected to Galle Feeder 8 and the longest spur is about 2 – 3 km long.

- Matara Feeder 7 – This feeder starts from Matara GSS and goes towards Kamburupitiya Gantry. At the Kamburupitiya Gantry the feeder is divided into 3 outgoing feeders and from these feeders the supply is given to Weligama side, Hakmana side and Andaluwa side. At the gantry location only one AR is installed and that is on the Andaluwa side feeder.

5.2 Model Validation – 1st Case : Galle Feeder 8

5.2.1 Location Identification for AR installation

As described in 4.2 in the previous chapter the location identification for Galle Feeder 8 was done in the same manner.

Identified locations on Galle Feeder 8 are marked on the AutoCAD map given in the following figure. On the figure, locations on the main feeder are marked in color Green and the locations on the spurs are marked in color Blue. Each location is given a number for identification and the numbering starts from the end point of the feeder.

Figure 5.1 Identified AR Locations on Galle Feeder 8

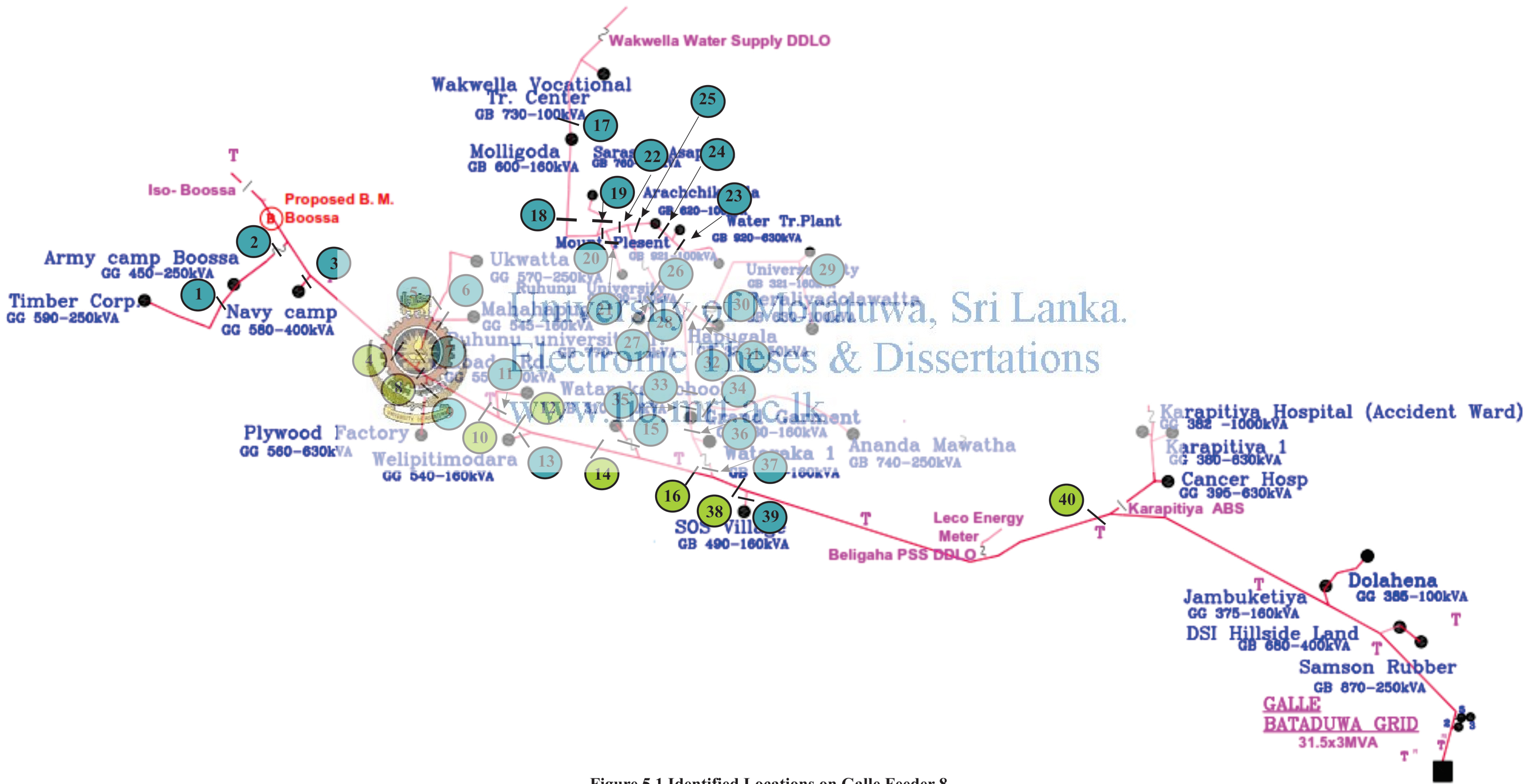


Figure 5.1 Identified Locations on Galle Feeder 8

5.2.2 Supporting Calculations for Galle Feeder 8

The SAIDI calculations for the identified locations were done in the same manner as described in section 4.2 in the previous chapter. The summarized SAIDI values for few of the identified AR locations on Galle Feeder 8 are tabulated below.

Table 5.1 SAIDI values calculated for identified locations on Galle Feeder 8

Section	Distance from GSS (km)	Sin No.	Mar 2012	Apr 2012	May 2012	Jun 2012	Jul 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Consumers
1	**10.559**	**GG 590**	0.00981	0.00207	0.03981	0.00849	0.05471	0.01660	0.01622	0	0	0.00472	0.009811	0.06	53
2	**10.108**	**GG 590**	0.00981	0.00208	0.03981	0.00849	0.05472	0.01660	0.01623	0	0	0.00472	0.009811	0.06	53
		GG 450	0.9978	1.0833	0.3972	0.53	1	0.48	0.1635	0	0	0.24	0.503	0.3036	1
3	**9.809**	**GG 580**	0.89	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04	1
4	**8.704**	**GG 590**	0.00981	0.00208	0.03981	0.00849	0.05472	0.01660	0.01623	0	0	0.00472	0.009811	0.06	53
		GG 450 **GG 580**	0.9439	0.66165	0.2086	0.755	0.5025	0.465	0.39675	0.115	0.175	0.4	0.2545	0.1718	2
5	**9.201**	**GG 570**	0.393	1.11695	0.15573	5.98842	24.9504	17.933	54.3223	1.41461	5.17284	79.9453	9.592048	7.91179	546
6	**9.201**	**GG 545**	50.2463	0.03684	0.00799	7.38130	16.6444	1.14195	0.00645	0.29571	0.18081	0.66557	8.670893	0.03536	568
7	**8.704**	**GG 545** **GG 570**	25.8119	0.56623	0.08040	6.69861	20.7154	9.37168	26.6280	0.84411	2.62754	39.5227	9.122375	3.89580	1114
8	**8.588**	**GG 560**	0.9978	17.2723	0.18533	0.14883	64.5983	0.36546	40.5532	0.56732	3.58485	2.80374	0.52293	0.89696	1065

The SAIDI values due to line tripping for few of the identified AR locations on Galle Feeder 8 are tabulated below.

Table 5.2: SAIDI values calculated due to line tripping for identified locations on Galle Feeder 8

Section	**Distance from GSS (km)**	**Type**	**Mar 2012**	**Apr 2012**	**May 2012**	**Jun 2012**	**Jul 2012**	**Aug 2012**	**Sept 2012**	**Oct 2012**	**Nov 2012**	**Dec 2012**	**Jan 2013**	**Feb 2013**	**Consumers**
1	**10.56**	**Bulk**	1.0079	0.2100	0.0175	0.8575	0.0044	0.3938	0.5513	0.2013	0.3063	0.4900	0.0053	0.0350	8
		Retail	6.5651	8.2461	1.8925	4.4961	30.5372	8.0553	43.0654	4.5616	4.8208	11.9937	7.4384	4.0152	8,888
2	**10.11**	**Bulk**	1.0079	0.2100	0.0175	0.8575	0.0044	0.3938	0.5513	0.2013	0.3063	0.4900	0.0053	0.0350	8
		Retail	6.5657	8.2469	1.8927	4.4960	30.5383	8.0557	43.0702	4.5621	4.8214	11.7179	6.8728	3.6740	8,887
3	**9.81**	**Bulk**	1.0248	0.2057	0.0171	0.8400	0.0043	0.3857	0.5400	0.1971	0.3000	0.4800	0.0051	0.0343	7
		Retail	6.5321	8.1984	1.8837	4.4993	30.3595	8.0088	42.8110	4.5346	4.7922	11.9509	7.4526	4.0270	8,941
4	**8.70**	**Bulk**	1.0248	0.2057	0.0171	0.8400	0.0043	0.3857	0.5400	0.1971	0.3000	0.4800	0.0051	0.0343	7
		Retail	6.8568	8.6171	1.9758	4.6858	30.1491	6.2207	44.4260	4.6599	5.0213	12.5346	7.7829	4.1536	8,490
5	**9.20**	**Bulk**	1.0079	0.2100	0.0175	0.8575	0.0044	0.3938	0.5513	0.2013	0.3063	0.4900	0.0053	0.0350	8
		Retail	6.9314	8.6590	1.9960	4.4024	30.7113	7.3634	42.0624	4.7375	4.7675	7.5286	7.3135	3.7743	8,395
6	**9.20**	**Bulk**	1.0079	0.2100	0.0175	0.8575	0.0044	0.3938	0.5513	0.2013	0.3063	0.4900	0.0053	0.0350	8
		Retail	3.5666	8.7521	2.0109	4.3037	31.2899	8.4747	45.7148	4.8221	5.1051	12.7165	7.3700	4.2977	8,373

5.2.3 Data Analysis for Galle Feeder 8

The inputs needed for the objective function with the calculations are given below.

- Auto tripping rate of the feeder
  - $\lambda_f = 5.33\ failures/month$
- Auto Tripping percentage of the Feeder
  - $\lambda_i = 54.5\ \%$
- Temporary Fault percentages of line sections (Annexure 6)
- Retail and Bulk consumer accounts
  - No. of Retails consumers = 8,941
  - No. of Bulk consumers = 8
- Retail and Bulk energy consumption
  - Retail Energy Consumption = 823,063.4 kWh
  - Bulk Energy Consumption = 747,769.3 kWh
- Exchange rate of 1 US Dollar to Sri Lankan Rupees = 132.90 LKR
- Cost for the utility for one hour power interruption
  - For retail consumers

$$f_{retail} = \frac{ENS \times EC_{bulk}}{24 \times 30 \times N_{bulk}} = \frac{1.2\frac{USD}{kWh} \times 132.90\frac{LKR}{USD} \times 823{,}063.4\ kWh}{24 \times 30 \times 8{,}941}$$

$$f_{retail} = 20.25\ \frac{LKR}{hr}$$

  - For bulk consumers

$$f_{bulk} = \frac{ENS \times EC_{retail}}{24 \times 30 \times N_{retail}} = \frac{1.2\frac{\$}{kWh} \times 132.90\frac{LKR}{\$} \times 747{,}769.3\ kWh}{24 \times 30 \times 8}$$

$$f_{bulk} = 20{,}563.76\ \frac{LKR}{hr}$$

- Price of Lanka Auto Diesel = 95 LKR/liter
- Fuel Cost for the Crew Cab = 0.109 liter/km
- Maintenance cost for the Crew Cab = 17.54 LKR/km

5.2.4 Results from the Objective Function

With the analyzed data, the results from the objective function were obtained. On this feeder there are no gantry locations and as a result of this, all the identified locations were considered as a whole and selected the optimal locations.

Table 5.3 CoI, Average CoI and B_{cost} for the locations on Galle Feeder 8

Section No.	Distance from GSS (km)	Average Interruption Cost (LKR)	Breakdown Recovery Cost (LKR)	Cost of Reliability (LKR
1	10.56	(3,935.29)	1,569.89	(2,365.40)
2	10.11	(3,934.21)	1,502.88	(2,431.33)
3	9.81	(3,891.88)	1,458.41	(2,433.48)
4	8.70	1,667.41	1,294.05	2,961.46
5	9.20	(3,613.02)	1,367.96	(2,245.06)
6	9.20	(3,808.24)	1,367.96	(2,440.27)
7	8.70	(3,711.72)	1,294.05	(2,417.67)
8	8.59	1,866.70	1,276.93	3,143.62
9	8.59	(3,935.02)	1,276.93	(2,658.09)
10	7.96	1,864.61	1,183.99	3,048.60
11	7.96	(3,867.47)	1,183.99	(2,683.48)
12	7.72	1,840.55	1,148.35	2,988.90
13	7.72	(3,935.95)	1,148.35	(2,787.60)
14	6.91	1,837.03	1,027.98	2,865.01
15	6.91	(3,596.77)	1,027.98	(2,568.80)
16	6.36	1,823.48	946.28	2,769.75
17	9.56	(3,853.04)	1,421.82	(2,431.23)
18	8.63	(3,804.23)	1,283.35	(2,520.88)
19	8.63	(3,873.57)	1,283.35	(2,590.22)
20	8.56	(3,827.53)	1,272.45	(2,555.08)
21	8.56	(3,480.53)	1,272.45	(2,208.08)
22	8.39	(3,815.30)	1,247.96	(2,567.34)
23	8.73	(1,312.75)	1,297.59	(15.16)

24	8.58	(1,249.75)	1,276.08	26.32
25	8.39	(1,174.68)	1,247.96	73.28
26	7.83	(1,159.47)	1,163.88	4.42
27	7.83	(3,891.88)	1,163.88	(2,728.00)
28	7.65	264.26	1,136.77	1,401.03
29	8.90	(3,753.39)	1,322.99	(2,430.40)
30	7.92	(3,770.85)	1,178.20	(2,592.65)
31	7.92	(3,502.84)	1,178.20	(2,324.63)
32	7.65	(3,612.75)	1,136.81	(2,475.94)
33	6.94	278.24	1,032.32	1,310.56
34	6.94	(3,920.05)	1,032.32	(2,887.74)
35	6.79	356.66	1,008.89	1,365.54
36	6.69	348.98	993.96	1,342.94
37	6.36	340.34	946.32	1,286.66
38	6.09	(361.03)	906.09	545.06
39	6.09	(4,110.53)	906.09	(3,204.44)
40	3.31	1,138.56	491.72	1,630.27
41	3.58	2,991.00	532.69	3,523.69
42	3.31	2,990.52	491.72	3,482.23
43	1.69	(832.13)	251.81	(580.33)
44	1.69	(3,940.31)	251.81	(3,688.51)
45	1.27	(815.39)	188.11	(627.28)
46	1.27	(3,893.52)	188.11	(3,705.41)
47	0.35	(739.72)	52.25	(687.48)
48	0.10	-	15.22	15.22

The rows highlighted in color 'Green' are the locations on the spur lines. From the locations on main lines Location No. 38 has the minimum CoR and from the locations on spur lines Location No. 25 has the minimum CoR. The location No. 38 and No. 26 are finalized as optimal locations (which are highlighted in color 'Yellow') on Galle Feeder 8.

Figure 5.2 Finalized Optimal Locations on Galle Feeder 8

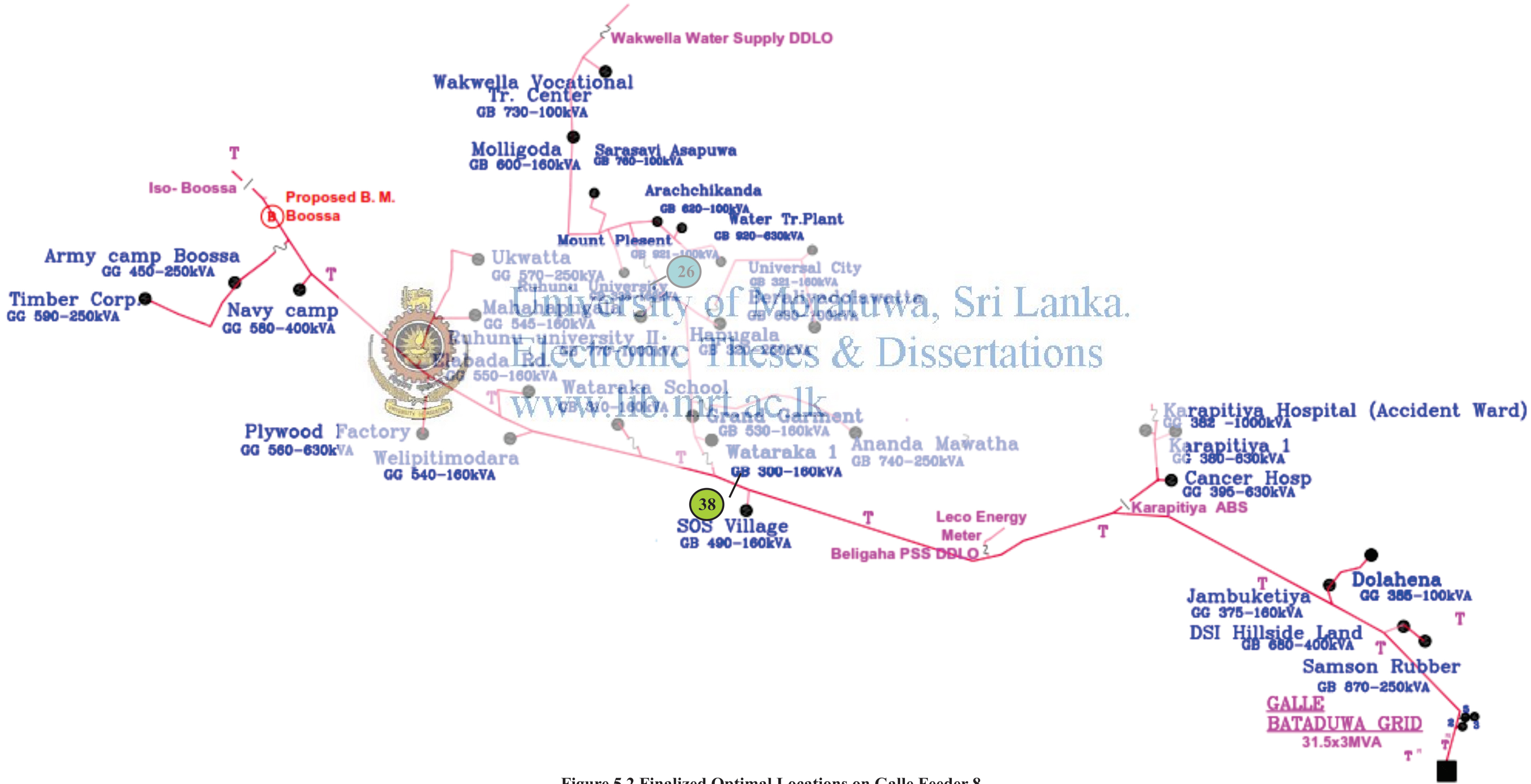


Figure 5.2 Finalized Optimal Locations on Galle Feeder 8

5.3 Model Validation – 2nd Case : Matara Feeder 7

5.3.1 Location Identification for AR installation

As described in 4.2 in the previous chapter the location identification for Matara Feeder 7 was done in the same manner.

Identified locations on Matara Feeder 7 are marked on the AutoCAD map given in figure 5.6. Locations on the main feeder are marked in color Green and the locations on spur lines are marked in color Blue.

5.3.2 Location Identification for AR installation

The SAIDI calculations for the identified locations were done in the same manner as described in section 4.2 in the previous chapter. A sample SAIDI values for few of the identified AR locations on Matara Feeder 7 are tabulated in table 5.4.

5.3.3 Data Analysis for Matara Feeder 7

The inputs needed for the objective function with the calculations are given below.

- Auto tripping rate of the feeder
  - $\lambda_f = 12.5\ failures/month$
- Auto Tripping percentage of the Feeder
  - $\lambda_i = 63.0\ \%$
- Temporary Fault percentages of line sections (Annexure 6)
- Retail and Bulk consumer accounts
  - No. of Retails consumers = 35,352
  - No. of Bulk consumers = 22
- Retail and Bulk energy consumption
  - Retail Energy Consumption = 1,952,627.4 kWh
  - Bulk Energy Consumption = 1,765,690.9 kWh
- Exchange rate of 1 US Dollar to Sri Lankan Rupees = 132.90 LKR
- Cost for the utility for one hour power interruption
  - For retail consumers

$$f_{retail} = \frac{ENS \times EC_{bulk}}{24 \times 30 \times N_{bulk}} = \frac{1.2\frac{USD}{kWh} \times 132.90\frac{LKR}{USD} \times 1{,}952{,}627.4 \ \ kWh}{24 \times 30 \times 8{,}941}$$

$$f_{retail} = 12.15 \ \frac{LKR}{hr}$$

- For bulk consumers

$$f_{bulk} = \frac{ENS \times EC_{retail}}{24 \times 30 \times N_{retail}} = \frac{1.2\frac{\$}{kWh} \times 132.90\frac{LKR}{\$} \times 1{,}765{,}690.9 \, kWh}{24 \times 30 \times 8}$$

$$f_{bulk} = 17{,}393.37 \ \frac{LKR}{hr}$$

- Price of Lanka Auto Diesel = 95 LKR/liter
- Fuel Cost for the Crew Cab = 0.109 liter/km
- Maintenance cost for the Crew Cab = 17.54 LKR/km

Table 5.4 SAIDI values calculated for identified locations on Matara Feeder 7

Section	Distance from GSS (km)	Sin No.	Mar 2012	Apr 2012	May 2012	Jun 2012	Jul 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Consumers
1	**29.644**	**MT 345**	1.0817	8.4436	-	0.2776	2.5310	1.3906	1.8392	-	0.5823	-	-	11.1667	543.00
2	**29.83**	**MK 410**	1.1099	8.7000	-	0.2833	2.5833	1.4167	1.8667	-	0.5833	-	-	11.1667	166.00
3	**29.83**	**MK 415** **MK 420**	1.0893	8.5149	-	0.2815	2.5664	1.4097	1.8575	-	0.5805	-	-	11.1667	611.00
4	**29.64**	**MK 410** **MK 415** **MK 420**	1.0937	8.5544	-	0.2819	2.5700	1.4112	1.8595	-	0.5811	-	-	11.1667	777.00
5	**28.43**	**MT 345** **MK 410** **MK 415** **MK 420**	1.0888	8.5089	-	0.2801	2.5540	1.4027	1.8511	-	0.5816	-	-	11.1667	1,320.00
6	**28.00**	**Mt 344**	1.0589	8.4544	-	0.2793	1.8567	-	1.8491	-	0.5806	-	-	-	425.00

A sample of SAIDI values due to line tripping for few of the identified AR locations on Galle Feeder 8 are tabulated below.

Table 5.5: SAIDI values calculated due to line tripping for identified locations on Matara Feeder 7

Section	Distance from GSS (km)	Type	Mar 2012	Apr 2012	May 2012	Jun 2012	Jul 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Consumers
1	**29.644**	**Bulk**	2.2393	10.6446	0.0997	0.6862	3.1403	0.1288	2.0047	0.4858	0.8183	0.4906	0.4753	2.2680	13,123.00
		Retail	3.5933	7.8150	0.0233	0.4717	2.9200	0.2500	1.3067	2.4750	0.5833	0.1500	-	0.3250	10.00
2	**29.83**	**Bulk**	2.2066	10.5799	0.0969	0.6747	3.1227	0.1637	1.9998	0.4723	0.8117	0.4769	0.4620	2.5165	13,500.00
		Retail	3.5933	7.8150	0.0233	0.4717	2.9200	0.2500	1.3067	2.4750	0.5833	0.1500	-	0.3250	10.00
3	**29.83**	**Bulk**	2.2450	10.6527	0.1002	0.6881	3.1418	0.1213	2.0047	0.4884	0.8196	0.4931	0.4778	2.2216	13,055.00
		Retail	3.5933	7.8150	0.0233	0.4717	2.9200	0.2500	1.3067	2.4750	0.5833	0.1500	-	0.3250	10.00
4	**29.64**	**Bulk**	2.2596	10.6778	0.1015	0.6933	3.1490	0.1046	2.0065	0.4947	0.8226	0.4995	0.4839	2.1064	12,889.00
		Retail	3.5933	7.8150	0.0233	0.4717	2.9200	0.2500	1.3067	2.4750	0.5833	0.1500	-	0.3250	10.00
5	**28.43**	**Bulk**	2.3114	10.7761	0.1060	0.7116	3.1762	0.0481	2.0139	0.5164	0.8332	0.5214	0.5052	1.7080	12,346.00
		Retail	3.5933	7.8150	0.0233	0.4717	2.9200	0.2500	1.3067	2.4750	0.5833	0.1500	-	0.3250	10.00
6	**28.00**	**Bulk**	2.2297	10.6246	0.0988	0.6825	3.1565	0.1846	2.0029	0.4815	0.8162	0.4862	0.4711	2.7057	13,241.00
		Retail	3.5933	7.8150	0.0233	0.4717	2.9200	0.2500	1.3067	2.4750	0.5833	0.1500	-	0.3250	10.00

5.3.4 Results from the Objective Function

With the analyzed data, the results from the objective function were obtained. On this feeder there is a gantry at Kamburupitiya and the locations identified on three outgoing feeders from the Gantry were compared separately. The following table tabulates the CoR values of Kamburupitiya Gantry – Matara side Feeder.

Table 5.6: CoR, Average CoI and B_{cost} for Kamburupitiya Gantry – Matara side Feeder

Section No.	Distance from GSS (km)	Average Interruption Cost (LKR)	Breakdown Recovery Cost (LKR)	Remarks
1	29.64	(16,406.79)	10,336.60	(6,070.19)
2	29.83	(16,406.51)	10,399.64	(6,006.87)
3	29.83	(16,406.62)	10,399.64	(6,006.98)
4	29.64	(16,406.52)	10,336.60	(6,069.93)
5	28.43	(16,406.45)	9,911.79	(6,494.66)
6	28.00	(16,420.15)	9,763.74	(6,656.42)
7	28.00	(16,420.18)	9,763.74	(6,656.44)
8	25.92	(16,411.94)	9,036.93	(7,375.00)
9	24.78	(16,411.74)	8,639.33	(7,772.42)
10	24.78	(16,399.97)	8,639.33	(7,760.65)
11	24.20	(16,410.69)	8,437.78	(7,972.90)
12	24.00	(14,363.03)	8,368.05	(5,994.98)
13	23.70	(16,410.03)	8,264.42	(8,145.61)
14	23.70	(14,362.89)	8,264.42	(6,098.47)
15	22.06	(14,362.83)	7,692.19	(6,670.64)
16	23.34	(16,418.62)	8,139.52	(8,279.11)
17	22.50	(16,418.50)	7,846.03	(8,572.47)
18	20.84	(16,416.92)	7,265.36	(9,151.56)
19	20.84	(16,411.12)	7,265.36	(9,145.76)
20	20.84	(14,162.42)	7,265.36	(6,897.06)
21	19.70	15,424.35	6,867.40	22,291.75
22	19.70	(10,079.69)	6,867.40	(3,212.29)

23	18.58	(11,573.17)	6,478.37	(5,094.80)
24	17.58	(16,419.18)	6,131.29	(10,287.89)
25	17.47	(11,573.96)	6,093.14	(5,480.82)
26	16.57	(16,414.30)	5,777.72	(10,636.58)
27	16.92	(16,416.34)	5,899.58	(10,516.75)
27*	16.87	(10,942.05)	5,882.25	(5,059.80)
28	15.64	(10,942.55)	5,452.43	(5,490.12)
29	28.59	27,362.41	9,968.87	37,331.28
30	28.22	27,362.70	9,838.22	37,200.92
31	28.00	27,358.34	9,764.68	37,123.02
32	26.92	27,353.29	9,386.21	36,739.51
33	26.67	(16,412.94)	9,299.46	(7,113.48)
34	26.16	(16,417.10)	9,120.34	(7,296.76)
35	24.34	29,727.41	8,485.55	38,212.96
36	23.52	29,726.70	8,200.75	37,927.44
37	23.34	(16,411.46)	8,140.01	(8,271.46)
38	21.97	32,101.91	7,661.54	39,763.45
39	21.77	32,101.53	7,591.80	39,693.33
40	21.61	32,101.34	7,534.61	39,635.95
41	19.99	32,100.69	6,971.97	39,072.66
42	19.74	(16,418.55)	6,883.75	(9,534.79)
43	17.00	32,100.25	5,928.77	38,029.02
44	18.91	(16,402.51)	6,593.51	(9,809.00)
45	19.01	(16,401.46)	6,627.50	(9,773.95)
46	17.31	(16,401.71)	6,035.99	(10,365.72)
47	17.14	2,109.76	5,975.25	8,085.01
48	17.00	9,928.63	5,928.77	15,857.40
49	16.31	9,928.29	5,686.57	15,614.86
50	15.60	9,927.45	5,439.18	15,366.63
51	14.60	23,475.57	5,089.86	28,565.43

The rows highlighted in color ‘Green’ are the locations on the spur lines. From the locations on main lines Location No. 50 has the minimum CoR and from the locations on spur lines Location No. 47 has the minimum CoR. The location No. 50 and No. 47 are finalized as optimal locations (which are highlighted in color ‘Yellow’) on Kamburupitiya Gantry – Matara side Feeder

- Kamburupitiya Gantry – Semidale side Feeder

Table 5.7: CoR, Average CoI and B_{cost} for Kamburupitiya Gantry – Semidale side Feeder

Section No.	Distance from GSS (km)	Average Interruption Cost (LKR)	Breakdown Recovery Cost (LKR)	Remarks
52	30.32	(13,795.92)	10,572.24	(3,223.68)
53	29.80	(13,795.93)	10,390.02	(3,405.91)
54	28.75	(5,526.62)	10,025.29	4,498.67
55	28.26	(7,137.33)	9,855.48	2,718.15
56	26.65	(7,137.38)	9,291.58	2,154.20
57	26.39	(7,137.41)	9,200.92	2,063.51
58	25.78	(7,137.41)	8,988.01	1,850.60
59	25.71	(7,137.42)	8,963.67	1,826.25
60	23.52	(7,137.46)	8,202.39	1,064.92
61	23.63	17,814.88	8,240.64	26,055.51
62	22.99	14,695.97	8,016.50	22,712.47
63	22.31	(13,934.31)	7,779.04	(6,155.26)
64	21.52	15,359.96	7,503.09	22,863.05
65	23.21	(13,940.22)	8,092.48	(5,847.75)
66	21.93	(13,940.26)	7,647.80	(6,292.46)
67	21.92	(13,940.48)	7,642.15	(6,298.33)
68	21.16	(13,940.27)	7,377.91	(6,562.36)
69	20.97	(13,940.33)	7,312.40	(6,627.94)
70	19.39	10,929.99	6,761.78	17,691.78
71	18.89	(13,937.75)	6,587.44	(7,350.31)
72	18.24	10,929.50	6,361.14	17,290.64
73	17.31	10,920.93	6,036.16	16,957.10
74	15.84	(13,925.94)	5,524.88	(8,401.06)
75	15.04	10,278.77	5,245.79	15,524.56

The rows highlighted in color 'Green' are the locations on the spur lines. From the locations on main lines Location No. 75 has the minimum CoR and from the locations on spur lines Location No. 59 has the minimum CoR. The location No. 60 and No. 59 are finalized as optimal locations (which are highlighted in color 'Yellow') on Kamburupitiya Gantry – Semidale side Feeder.

- Kamburupitiya Gantry – Andaluwa side Feeder

Table 5.8: CoR, Average CoI and B_{cost} for Kamburupitiya Gantry – Andaluwa side Feeder

Section No.	Distance from GSS (km)	Average Interruption Cost (LKR)	Breakdown Recovery Cost (LKR)	Remarks
76	34.85	(316,398.36)	12,152.74	(304,245.63)
77	34.80	(316,398.22)	12,134.33	(304,263.89)
78	33.79	(316,398.41)	11,783.16	(304,615.25)
79	37.68	(316,399.84)	13,138.96	(303,260.88)
80	36.38	(316,399.84)	12,684.76	(303,715.08)
81	35.14	(316,400.09)	12,251.24	(304,148.85)
82	35.07	(316,400.05)	12,227.01	(304,173.05)
83	33.87	(316,400.32)	11,811.27	(304,589.05)
84	33.99	(316,400.62)	11,850.53	(304,550.09)
85	33.56	(316,400.95)	11,700.80	(304,700.15)
86	32.80	(316,401.16)	11,436.98	(304,964.17)
87	32.32	(316,400.49)	11,269.58	(305,130.91)
88	29.83	(316,400.56)	10,401.03	(305,999.52)
89	31.94	(316,400.84)	11,137.39	(305,263.45)
90	29.80	(316,400.96)	10,390.50	(306,010.46)
91	29.57	(316,401.43)	10,310.90	(306,090.53)
92	27.79	(316,401.43)	9,689.71	(306,711.72)
93	27.43	(316,401.43)	9,563.94	(306,837.49)
94	27.43	(358,257.95)	9,565.89	(348,692.06)
94*	27.40	(358,259.72)	9,554.04	(348,705.68)
95	34.58	(316,398.66)	12,059.25	(304,339.41)

96	33.94	(316,398.42)	11,832.99	(304,565.43)
97	32.19	(316,398.51)	11,224.46	(305,174.05)
98	31.96	(316,398.43)	11,145.38	(305,253.05)
99	30.67	(316,398.86)	10,693.55	(305,705.31)
100	30.62	(316,398.30)	10,675.94	(305,722.36)
101	29.55	(316,399.06)	10,304.83	(306,094.23)
102	34.39	(316,398.44)	11,989.90	(304,408.54)
103	34.15	(316,398.29)	11,908.06	(304,490.23)
104	33.37	(316,398.54)	11,634.03	(304,764.51)
105	32.02	(316,398.58)	11,165.81	(305,232.77)
106	30.97	(316,398.63)	10,800.49	(305,598.14)
107	31.36	(316,400.07)	10,934.28	(305,465.79)
108	30.39	(316,399.69)	10,595.36	(305,804.33)
109	31.22	(316,399.92)	10,886.34	(305,513.58)
110	30.83	(316,399.96)	10,748.64	(305,651.32)
111	30.00	(316,399.80)	10,460.87	(305,938.93)
112	30.21	(316,400.19)	10,535.24	(305,864.95)
113	29.49	(316,402.25)	10,282.34	(306,119.91)
114	29.40	(316,402.74)	10,252.39	(306,150.35)
115	27.46	(316,402.16)	9,573.29	(306,828.87)
116	27.15	(357,340.94)	9,467.42	(347,873.51)
117	27.01	(316,399.73)	9,418.78	(306,980.95)
118	25.65	(357,574.91)	8,942.61	(348,632.29)
119	25.15	(357,574.39)	8,769.07	(348,805.31)
120	23.80	2,984,119.95	8,299.60	2,992,419.55
121	23.26	2,984,119.95	8,110.75	2,992,230.70
122	23.42	52,422.79	8,166.61	60,589.40
123	22.65	52,423.28	7,897.07	60,320.35
124	21.95	2,225,736.95	7,653.90	2,233,390.85
125	21.75	2,225,737.60	7,585.66	2,233,323.26
126	22.44	(316,378.68)	7,823.78	(308,554.90)
127	20.71	2,253,763.65	7,222.75	2,260,986.39

128	19.62	2,253,782.82	6,842.78	2,260,625.60
129	19.42	(316,365.12)	6,773.05	(309,592.08)
130	18.87	18,504.37	6,581.20	25,085.57
131	18.56	18,504.68	6,471.50	24,976.18
132	20.11	(316,369.76)	7,010.95	(309,358.80)
133	18.65	(316,369.81)	6,504.10	(309,865.71)
134	18.21	20,005.03	6,348.87	26,353.90
135	16.83	20,005.07	5,868.45	25,873.52
136	16.44	(322,100.98)	5,733.92	(316,367.06)
137	16.07	16,696.22	5,601.77	22,297.98
138	15.95	(520,730.24)	5,562.79	(515,167.46)
139	15.20	57,578.97	5,300.92	62,879.89
140	15.10	(316,377.10)	5,265.88	(311,111.22)
141	14.67	58,358.88	5,114.30	63,473.19

The rows highlighted in color 'Green' are the locations on the spur lines. From the locations on main lines Location No. 137 has the minimum CoR and from the locations on spur lines Location No. 123 has the minimum CoR. The location No. 137 and No. 123 are finalized as optimal locations (which are highlighted in color 'Yellow') on Kamburupitiya Gantry – Andaluwa side.

All the finalized optimal locations of Matara Feeder 7 are marked on the figure 5.4.

Figure 5.3 Finalized Optimal Locations on Matara Feeder 7

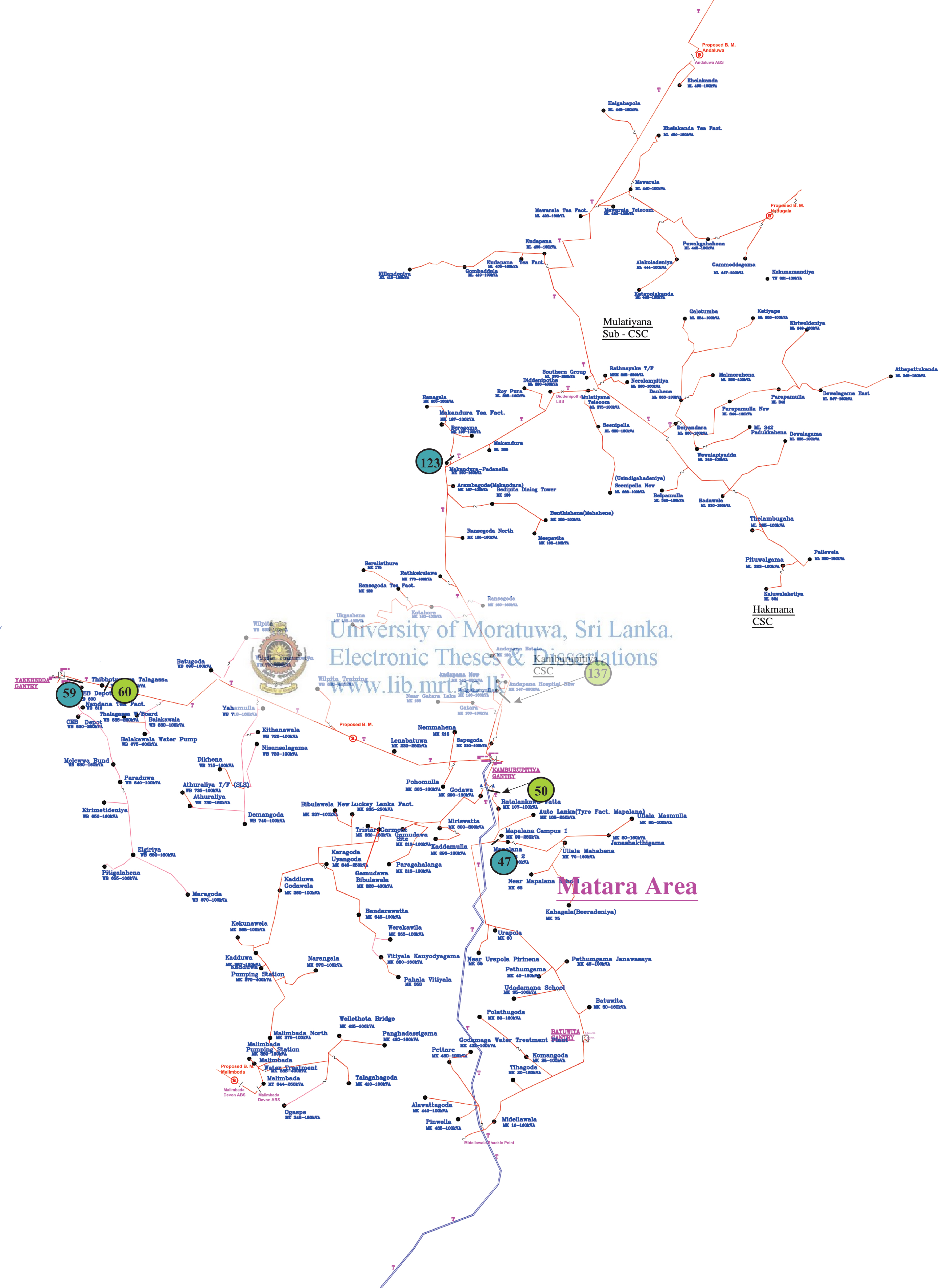


Figure 5.3 Finalized Optimal Locations on Matara Feeder 7

Protection Co-ordination of Fuses with the Auto Recloser

6.1 Present Scenario

Distribution feeders are mostly protected against electrical fault by DDLO fuses of type K. However, at present the rating of the fuses is selected considering only the electrical load on the line, thus loosing co-ordination. If fuses were properly selected protection co-ordination can be achieved, so that the temporary faults are cleared by the A/R and permanent faults are cleared by the fuses, thus improving the reliability of supply. The reliability of the network cannot be achieved only by optimally positioning the ARs, also by maintaining proper protection co-ordination between the protection devices.

6.2 Theoretical Background of Protection Co-ordination

6.2.1 Fuse-Fuse Co-ordination

Fuse element typically have a minimum melting time and a total clearing time. The minimum melting time is the time characteristic in which the fuse element first begins to melt due to the fault current. The total clearing time is the time in which the fuse element will completely melt thus isolating the faulty section.

Wherever, there is more than one fuse on a spur line, they should be selected to coordinate with each other in such a way that total clearance time for a main fuse should not exceed 75% of the minimum melting time of the backup fuse as shown in the following graph. The fuses co-ordinate with other fuses with the time vs current curves are shown in Annex 4.

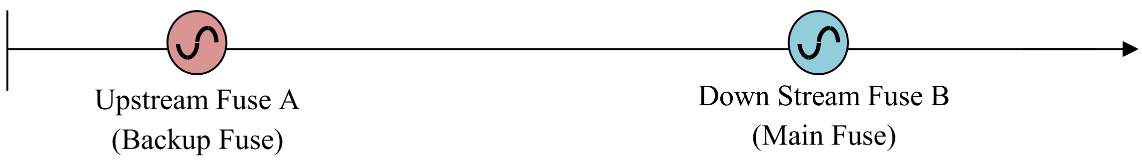


Figure 6.1 Backup Fuse and Main Fuse on a Feeder

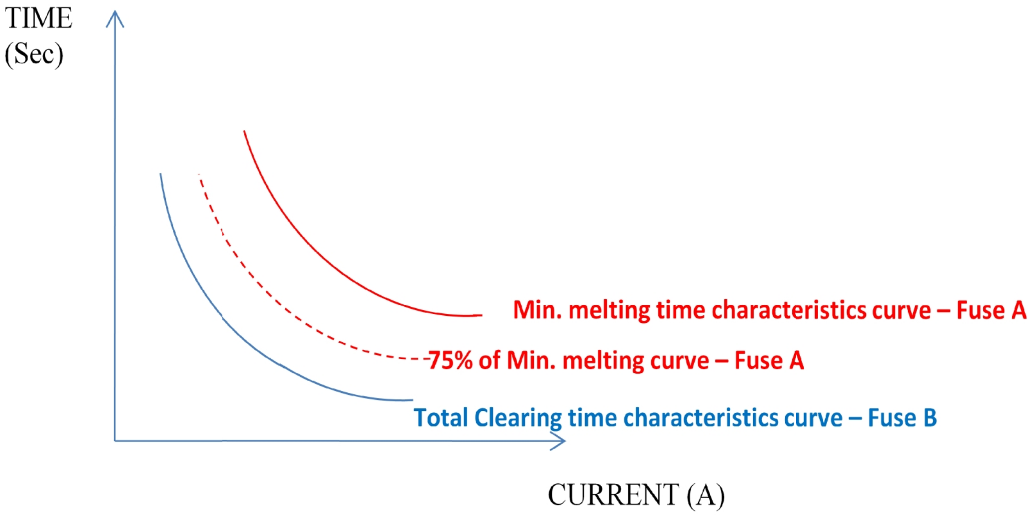


Figure 6.2 Fuse to Fuse co-ordination from TC curve

6.2.2 Fuse – Auto Recloser Co-ordination

Reclosers also have several operating curves and for this particular application two curves namely Curve for the 1st trip and the curve for the 2nd trip. Characteristic curves of fuses are selected so that they are within the two selected operating curves of the AR as shown in the figure and the principle of operation is described below.

- When fault take place at the downstream of a fuse, OC curve for the 1st trip of the AR will operate and interrupts the fault current.
- After the reclose time the AR will restore the power and if the fault persists the fault current will be interrupted by the fuse, as OC curve for the 2nd trip of the AR is in function after the 1st trip.

One curve is selected for Earth Fault which is typically 10 times lower than the curve for the 2nd trip. At the same time Recloser curves should maintain 0.3 sec time discrimination with the Time-Current Curve of the Circuit Breaker at the GSS. This is illustrated with real time values in the graph given in Annex 5.

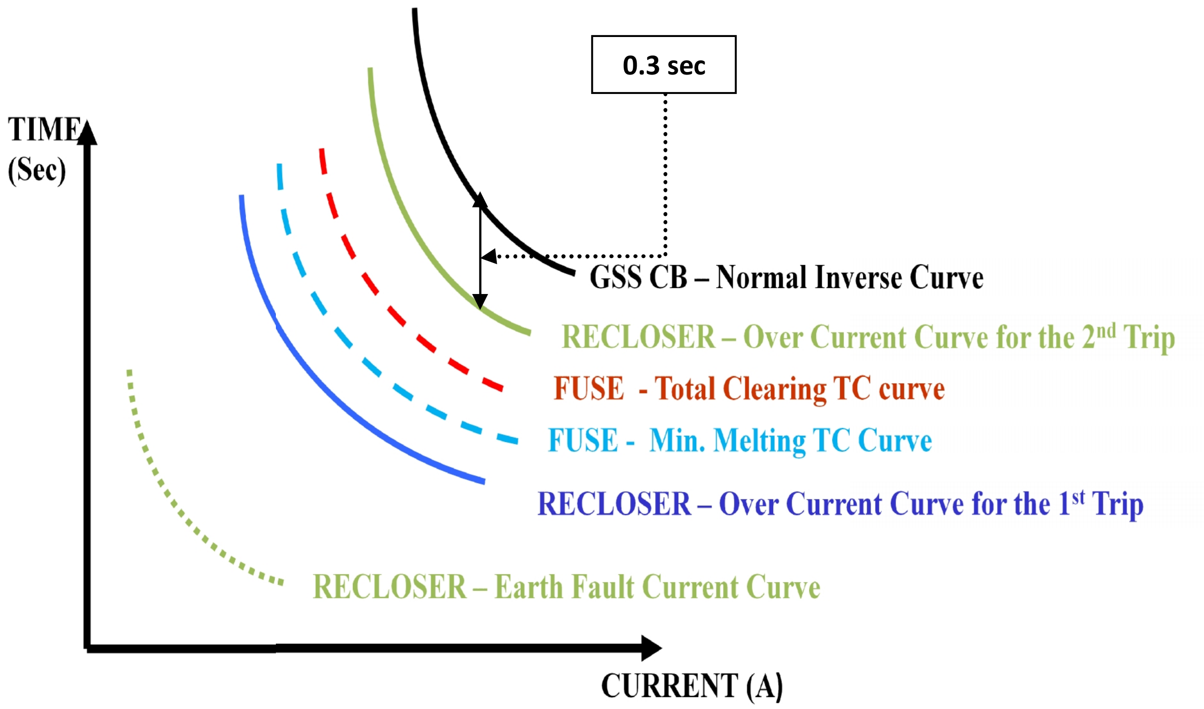


Figure 6.3 Fuse – AR co-ordination from TC curve

6.3 How a Distribution Network which is properly co-ordinated should work for faults

Let's consider a properly co-ordinated feeder as sketched below.

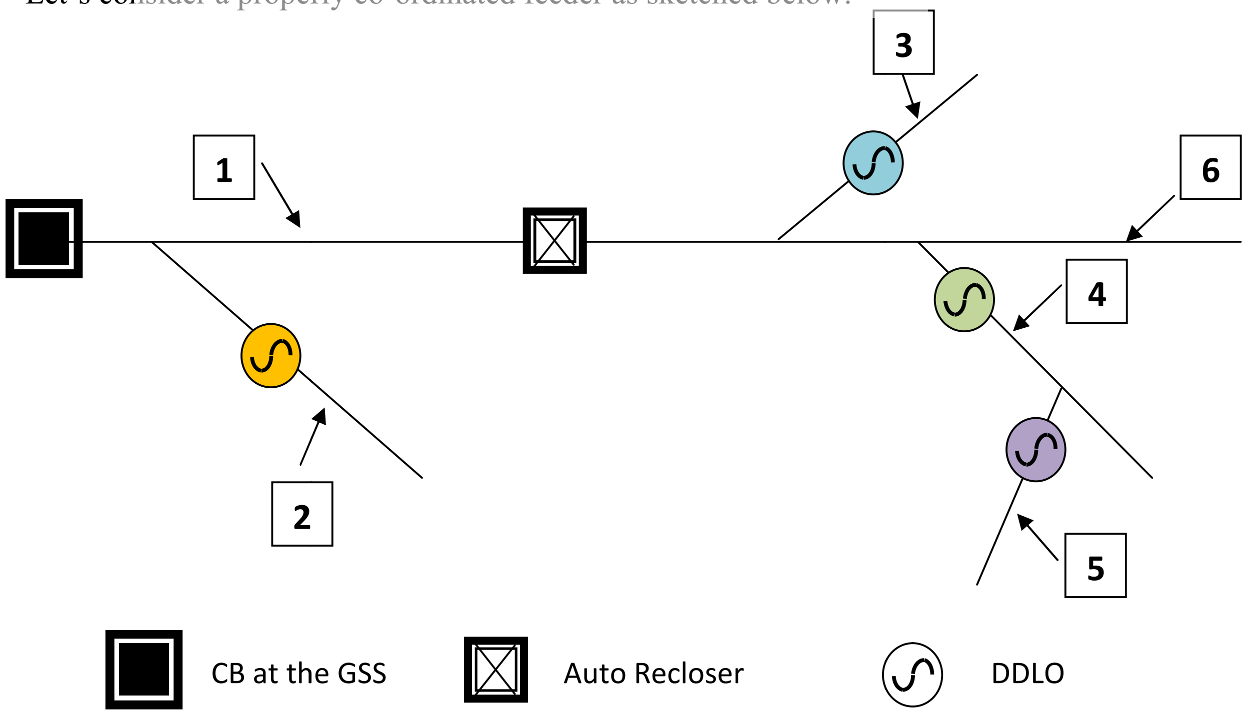


Figure 6.4 Properly co-ordinated distribution feeder

Table 6.1 Operation of Protection devices for permanent and temporary faults

Fault Location	Permanent Fault	Temporary Fault	
		Fault current less than the thermal rating of fuses	**Fault current exceeds thermal rating of fuses**
Location 1	Over Current Relay of GSS CB operates	Earth Fault Relay of GSS CB operates	Earth Fault Relay of GSS CB operates
Location 2	Fuse Should operates	Earth Fault Relay of GSS CB operates	Should operates
Location 3	Fuse should operate.	Earth Fault Relay of Auto Recloser operates.	At the onset of the fault AR operates. If the fault persists fuse should operate.
Location 4	Fuse should operate.	Earth Fault Relay of Auto Recloser operates.	At the onset of the fault AR operates. If the fault persists fuse should operate.
Location 5	Fuse should operate.	Earth Fault Relay of Auto Recloser operates.	At the onset of the fault AR operates. If the fault persists fuse should operate.
Location 6	Over Current Relay of Auto Recloser operates.	Earth Fault Relay of Auto Recloser operates.	Earth Fault Relay of Auto Recloser operates.

The recommendations and conclusions on how to select a fuse are given in Chapter 7. The following part describes the fuse selection done for Matara Feeder 7 according to the recommendations given in the Chapter 7 and the fuses were changed on November 2014.

6.4 Pilot Project: Matara Feeder 7

6.4.1 Overview of Feeder 7 of Matara GSS

Table 6.2 General statistics of Matara Feeder 7

Parameter	**Description**
Conductor type	Lynx
Total Line length	193.949 km
No of SS	143
CSCs covered by the feeder	Hittetiya CSC, Kamburupitiya CSC, Mulatiyana Sub CSC, Hakmana CSC
No of AR	01
No of Fuses	47

Table 6.3 Protection settings of Matara Feeder 7 Circuit Breaker

Description	**Over Current Protection**	**Earth Fault Protection**
Current Setting	1.05 A	0.1 A
TMS	0.1	0.1
Curve	Normal Inverse	Normal Inverse
Instantaneous Setting	4 A	0.4 A
CT Ratio	400:1	400:1

There are one A/R and 47 fuses in the above feeder. The AR is installed on the main feeder at Kamburupitiya Gantry, 14 km from the GSS (Figure 3.2). The A/R covers only the feeder going towards Andaluwa side from the gantry. No A/Rs are connected to the other 2 outgoing feeders from the gantry.

Table 6.4 Protection settings of Kamburpitiya Gantry – Andaluwa side AR

Description	**Over Current Protection**	**Earth Fault Protection**
Curve for the 2nd Tripping		
Current Setting	400 A	40 A
TMS	1	1
Curve	Non Standard Curve - 112	Non Standard Curve - 112
Instantaneous Setting	1400 A	140
Curve for the 1st Tripping		
Current Setting	400 A	
TMS	1	
Curve	Non Standard Curve - 101	
Instantaneous Setting	1400 A	

6.4.2 Proposed Fuse ratings for the already installed fuses on Matara Feeder 7

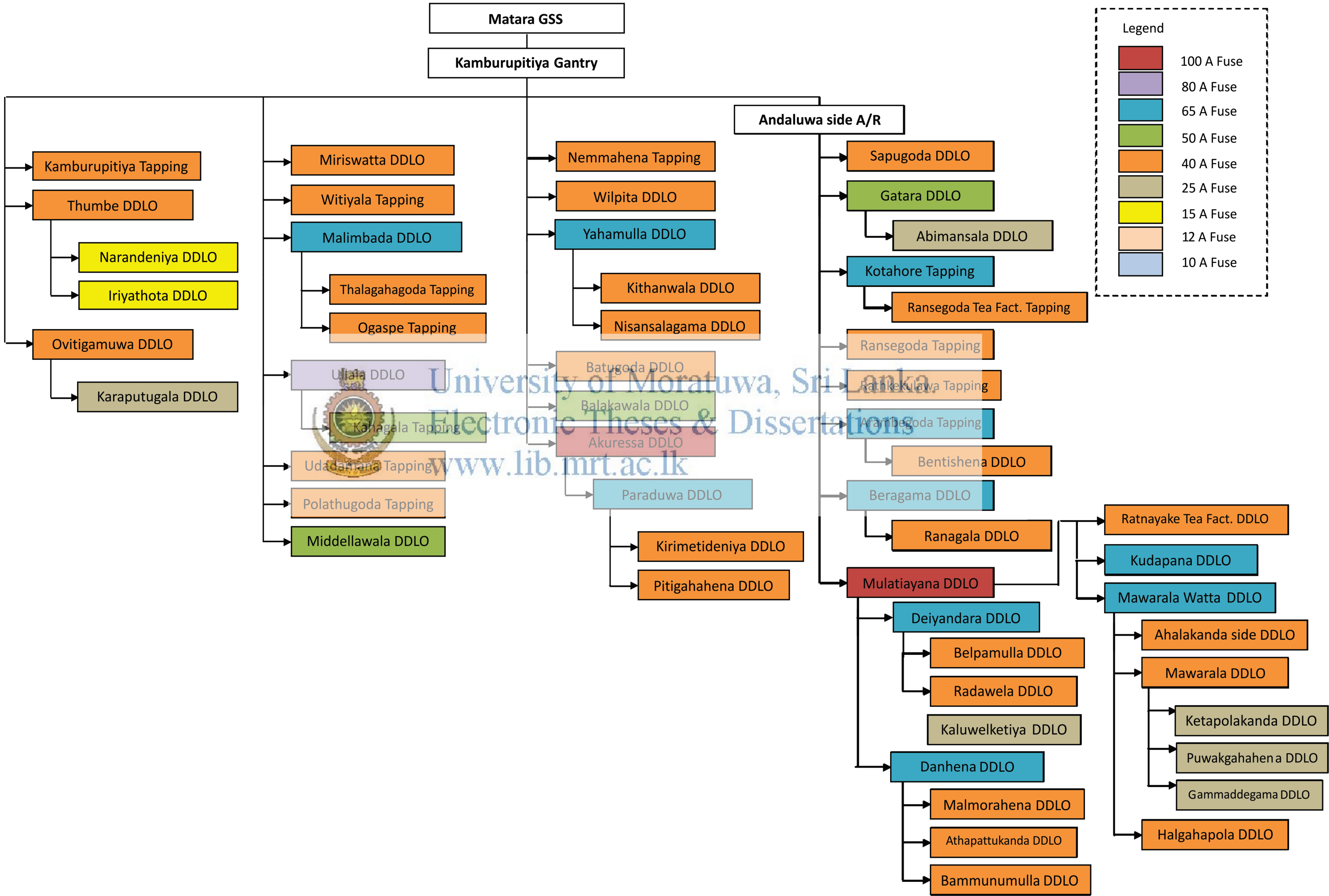
The proposed fuse ratings for the Matara Feeder 7 are tabulated on the following table and more descriptive color chart is also given in figure 6.5.

Table 6.5 Proposed Fuse Ratings

No	Name	Series Position	Fuse Rating (A)	Subs Connected
1	Kamburupitiya Tapping	1st	40	2
2	Thumbe DDLO	1st	40	2
3	Narandeniya DDLO	2nd	15	1
4	Iriyathota DDLO	2nd	15	1
5	Ovitigamuwa DDLO	1st	40	3
6	Karaputugala DDLO	2nd	25	1
7	Miriswatta DDLO	1st	40	1
8	Witiyala Tapping	1st	40	1
9	Malimbada DDLO	1st	65	4
10	Thalagahagoda Tapping	2nd	40	1
11	Ogaspe Tapping	2nd	40	1
12	Ullala DDLO	1st	80	5
13	Kahagla Tapping	2nd	50	2
14	Udadamana Tapping	1st	40	1
15	Polathugoda Tapping	1st	40	1
16	Middellawala DDLO	1st	50	3
17	Nemmahena Tapping	1st	40	2
18	Wilpita DDLO	1st	40	1
19	Yahamulla Tapping	1st	65	7
20	Kithanwala Tapping	2nd	40	1
21	Nisansalagama Tapping	2nd	40	2
22	Batugoda DDLO	1st	40	1
23	Balakawela DDLO	1st	50	3
24	Akuressa DDLO	1st	100	9
25	Paraduwa DDLO	2nd	65	4
26	Kirimetideniya DDLO	3rd	40	1
27	Pitigalahena DDLO	3rd	40	1
28	Sapudgoda DDLO	1st	40	1
29	Gatara DDLO	1st	50	2

30	Kotahore Tapping	1st	65	4
31	Abimandala DDLO	2nd	25	1
32	Ransegoda Tea Factory Tapping	2nd	40	2
33	Ransegoda Tapping	1st	40	1
34	Rathkekulawela Tapping	1st	40	1
35	Arambegoda Tapping	1st	65	3
36	Bentishena DDLO	2nd	40	1
37	Beragama DDLO	1st	65	3
38	Ranagala DDLO	2nd	40	1
39	Mulatiyana DDLO	1st	100	35
40	Deiyandara DDLO	2nd	65	7
41	Belpamulla DDLO	3rd	40	1
42	Radawela DDLO	3rd	40	4
43	Keluwelketiya DDLO	4th	25	1
44	Danhena DDLO	2nd	65	4
45	Malmorahena Tapping	3rd	40	1
46	Athapattukanda Tapping	3rd	40	5
47	Bammunumulla DDLO	3rd	40	1
48	Ratnayake Tea Factory Tapping	2nd	40	2
49	Kudapana DDLO	2nd	65	4
50	Mawaralawatta DDLO	2nd	65	7
51	Ahalakanda side DDLO	3rd	40	1
52	Mawarala DDLO	3rd	40	4
53	Ketapolakanda Tapping	4th	25	2
54	Puwakgahahena Tapping	4th	25	1
55	Gammedagama DDLO	4th	25	1
56	Halgahapola DDLO	3rd	40	1

Recommended Fuse Ratings for Matara Feeder 7 – Matara Grid Substation



Chapter 7

Discussion, Conclusion and Recommendation

7.1 Discussion

Each and every research paper which was studied by me on optimal positioning of protective devices on a distribution feeder has considered technical and economical factors when deciding the optimal location. However the method and the constraints used for the solution and derived mathematical model is different from one another.

In the research paper “Allocation of protective devices in distribution circuits using nonlinear programming models and genetic algorithms”, the mathematical model is formulated to improve the SAIFI value of the network and the permanent and temporary fault index in each section of the circuit and the number of customers are considered. [1]

The work has been carried out in “Optimized placement of control and protective devices in electric distribution systems through reactive tabu search algorithm” research paper, and the objective function is the sum of placement of switches and protective devices and the cost of interruption due to permanent and temporary faults. The results give optimal locations for all the protective devices in the network such as Auto Reclosers, Fuses and Sectionlizers. [2]

“Optimal Feeder Switches and Pole Mounted RTUs Relocation on Electrical Distribution System considering Load Profile” technical research paper, annual load curve changing and failure rate changing data are used to represent the optimal location for the feeder switches and pole mounted RTUs. [4]

The research paper “Distribution Reliability Improvement through Optimal Location of Load Break Switches in 33 kV Network” present a method to decide best number of load break switches considering the nature of different zones the line is going through and the distribution of customers the line is serving. The mathematical model gives the sum of cost of unserved energy due to interruptions and cost of breakers in an annual basis. [5]

This objective function of this research has been derived using the SAIDI value of each substation and the energy consumption of bulk and retail consumers connected to a feeder. The sum of Breakdown recovery cost and the cost of interruption (derived by using the SAIDI value for bulk and retail consumers connected to the feeder) gives the objective function. The optimal location is the location with minimum cost. For the locations on main lines and spur lines, the location with the minimum Cost of Reliability should be considered separately and obtain the optimal location. As CEB distribution network is a simple network compared to the systems used in the research papers referred, no special algorithm is used.

7.2 Conclusions

When selecting the optimal location from the derived objective function following conclusions were finalized.

1. When selecting optimal locations for an AR, the priority should be given to Temporary Faults occur on any location.

   a. On most of the spur lines on a feeder, at the starting point of the spur a DDLO has been installed. As a result of this when there is either a temporary or a permanent fault occur downstream the fuse, the fuse will operate and interrupt the consumers connected downstream. When a fuse is blown that cannot be identified as whether it is due to permanent fault or temporary fault. The calculated SAIDI values for a specific location include the interruption due to both types of faults. So the SAIDI should be multiplied by the temporary fault percentage of that section where the location is situated and get the SAIDI value for the temporary faults.
   b. After obtaining the SAIDI value for temporary faults, then another correction needed to be done. This SAIDI value contains the interrupted hours due to line tripping occurred due to the operation of CB at the GSS. From the SAIDI value at a specific location, the SAIDI value due to line tripping should be reduced.

2. When coordinating the protection devices in the distribution network, the protection should be arranged in such a way where the ARs respond to temporary devices and the Fuses respond to permanent devices.
3. When selecting locations on the feeder to search for the optimal location, it is suitable to select only the locations where fuses are already installed.

7.3 Recommendations

7.3.1 Recommendations for Optimal Location of Auto Reclosers

- Introduce a proper method and a database to record the accurate details of the interruptions, interrupted substations and interrupted hours.
- Research to find the Energy Not Served (ENS) for Sri Lanka in the present developments and economy.
- Develop a software program for this study using Excel Macro, as it can be used in any computer without any additional cost.
- This study was developed to find 2 optimal locations in series. Hence, further develop to find the number of optimal locations to install ARs on a feeder.

7.3.2 Recommendations for Fuse selection

- It is not possible to select a fuse for a DDLO on the feeder between GSS and the AR that coordinate with both the breaker at GSS and the AR. Therefore there is no any use of having a DDLO on the main feeder before the AR.
- The maximum rating of a fuse on a spur line between the GSS and the AR is 125A.
- The maximum number of fuses in series on a spur line, not covered by AR should be limited to 3 or 4 and some of the possible combinations are as follows.

Table 7.1 Proposed Fuse Ratings which are not connected after an AR

Combination	1St Fuse	2nd Fuse	3rd Fuse	4th Fuse	5th Fuse
01	125	80	50	25	12
02		65	40	15	-
03		50	25	12	-
04		40	15	-	-
05		25	12	-	-
06	100	65	40	15	-
07		50	25	12	-
08		40	15	-	

125K – 65K – 25K – 12K
100K – 50K – 15K
} Combinations are also possible

- The maximum number of fuses in series on a spur line, covered by AR should be limited to 3 and the possible combinations are as follows. 125 A K-type fuse is not possible. Refer Annex 8.

Table 7.2 Proposed Fuse Ratings for fuses connected downstream an AR

Combination	1St Fuse	2nd Fuse	3rd Fuse
01	100	65	40
02		50	25
03		40	-
04	80	50	25
05		40	-
06		25	-

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Annexures

Annexure 1 - Auto Recloser Location - Region 4

GSS	Feeder No	Distance to AR (km)	AR Location	Auto Recloser Name	Distance to AR from the previous AR(km)	AR location	Auto Recloser Name
Ambalangoda	Feeder 1	15.132	Thanabaddegama Tapping	Thanabaddegama	15.868	Ketandola	Ketandola
	Feeder 2	28.228	Thalgaswala Gantry	Udugama	9.017	Udugama Bar Junction	Bar Junction AR
				Thalgaswala			
				Kurundugaha			
	Feeder 3	9.903	Nindana Gantry	Karandeniya AR			
				Gonapinuwala AR			
				Meetiyagoda AR			
	Feeder 4	5.184	Magala Gantry	Elpitiya side AR	13.471	Ahungalla PSS	Induruwa side
							Balapitiya side
	Feeder 6	9.36	Uragasmanhadiya	Uragasmanhandiya			
Galle	Feeder 1	13.106	Indigasketiya Pump House	Hegoda			
				Divithura			
				Agaliya			
				Pump House			
	Feeder 2	12.398	Citrus	Citrus	5.396	Mabotuwana	Mabotuwana Tapping
	Feeder 3	10.214	Waulugala	Waulugala			
	Feeder 4	14.986	Mawella Gantry	Mawella			
	Feeder 5	18.18	Gonapinuwala Gantry	PSS side	1.089	Gonapinuwala PSS	Nalagasdeniya side
				Baddegama side			Pinkanda side
	Feeder 6	12.751	Udumullagoda	Udumullagoda			
	Feeder 7	19.183	Baddegma Gantry	Wanduramba			
				Elpitiya			
				Goonapinuwala			
		6.22	Thotagoda	Thotagoda AR			
Matara	Feeder 2	9.065	Thlijjawila Gantry	Semidale side	12.372	Hikgoda	Hikgoda AR
		12.694	Semidale Gantry	Imaduwa side			
	Feeder 3	17.535	Pitadeniya Gantry	Rathmale Side			
				Dandeniya Side			
				Matara Side	10.038	Gandara	Gandara
				Tangalle Side			
	Feeder 6	10.296	Udukawa Gantry	Thelijjawila side			
				Load star factory			
				Galbokka side	7.64	Galbokka PSS	Ahangama Side 11 kV
							Matara Side 11 kV
	Feeder 7	14.597	Kamburupitiya Gantry	Andaluwa side			

	Feeder 8	7.221	Meddawatta PSS	11 kV side			
		7.96	Devinuwara PSS	11 kV side			
		3.945	Weherahena	Weherahena			
Beliatta	Feeder 4	15.417	Tangalle Gantry	Beliatta Side			
				Wadigala Side			
				Dickwella Side			
				Tangalle Town Side			
	Feeder 6	16.472	Tumbe	Tumbe			
Deniyaya	Gen Feeder 1	16.526	Morawaka Gantry	Waralla side			
	Feeder 1	8.999	Alakoladeniya	Alakoladeniya AR	5.291	Katuwana	Katuwana AR
	Feeder 2	2.864	Beralapanthara	Beralapanathara AR			
		14.433	Pasgoda	Pasgoda AR			
	Feeder 3	2.445	Deniyaya Gantry	Pallegama side			
Hambantota	Feeder 3	29.453	22nd Junction	22nd Junction AR			
		39.334	Saman Rice Mill	Saman Rice Mill AR			
	Feeder 5	22.044	Open Prison	Open Prison AR			
		28.665	Kasingama	Kasingama AR			
		49.676	Kataragama	Kataragama Bus Stand AR			
	Feeder 6	10.299	Harbour PSS	Harbour side			
		16.835	Bolana	Bolana Water Board AR			
Embilipitiya	Feeder 6	27.831	Nonagama Gantry	Lunama side			
Ratmalana	Feeder 3	2.193	Thelawala PSS	Transformer Feeder			
				LECO Feeder			
	Feeder 9	2.978	Angulana PSS	Transormer - 3			
				LECO Feeder			
Panadura	Feeder 4	16.475	Uggalboda Gantry	Uggalboda			
	Feeder 5	4.941	Kahatawela Gantry	Deniya			
				Piliyandala - Kahatuduwa			
		9.612	Kahathuduwa Gantry	Homagama			
				Koralaima			
Matugama	Feeder 2	20.763	Lathpandura	Lathpandura			
		29.108	Athweltota	Kalawana			
	Feeder 3	14.441	Kithulgoda Gantry	Athwelthota			
				Pelawatta			
				Kallumale			
				Sirikandura			
	Feeder 5	35.251	Miriswatta	Elpitiya			
	Feeder 7	13.815	Fullerton Gantry	Payagala			
				Naththupana			
				Gamegoda			
	Feeder 8	3.017	Malaboda	Malaboda			

Annexure 2.1 - Customer Interruption Duration for Ambalangoda Feeder 3

sin no	Interrupted Hours												Consumers
	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12	
AG 95	0.45	0.63	0.23	0.35	0.56	0.006	0.04	0.89	0.24	0.02	0.98	0.005	1
AG 90	2.7911	2107.9968	48.112	13.392	416.2928	88.66	18.3768	1045.122	1.2597	17.9826	8383.926	4.27	247
AG 100	2.5086	1886.1024	42.486	1.095	365.9348	19.8338	25.4664	10395.63	136.869	161.1206	10316.833	0.021	222
AG 105	2.4521	1367.9897	68.6664	359.8776	3261.1032	628.1496	0.6264	3140.77	16.2945	160.3677	8719.7438	10.7532	217
AG 130	163.3025	11467.654	1815.044	118.7315	2311.0935	3310.8966	4973.6007	790.9239	3728.0634	21409.531	20719.13	6818.6628	415
AG 120	159.0957	37.1907	94.9311	67.3767	2158.0164	1967.6787	3075.2784	1651.305	3312.938	6251.5724	18411.997	6020.596	387
AG 110	507.6492	3.1176	146.4406	0.2165	37.7576	2248.2226	4023.648	1700.511	1.5516	3649.539	23661.008	50.138	433
AG 140	1823.7344	2849.8764	24.708	745.764	8311.2746	1901.3738	10314.744	4610.104	16970.757	5559.723	2.006	4.352	349
AG 146	1055.5712	12.4419	1940.5545	33.165	0.7437	1042.9086	5876.1118	1206.493	2.6136	46.5696	441.3391	3.0618	202
AG 145	930.1568	0.8366	11.7882	2612.6616	1024.4229	459.4566	5214.352	2345.024	71.7325	2707.915	417.8125	158.0182	178
AG 160	3467.6628	11639.606	613.1032	98063.711	6672.7465	19841.176	3689.5628	15203.31	6871.856	25127.585	7019.2743	71.9758	636
AS 315	2.6703	596.2122	17.121	7.3401	84.2112	1958.1952	250.063	15.3416	30.5308	3399.0534	79.9084	2.6625	129
AS 313	1.3936	480.6672	251.3368	5.9176	68.4216	849.7528	604.4143	42.5081	24.7612	2346.8859	64.1784	73.9724	104
AS 310	4.8776	1668.4698	647.316	20.4271	417.1545	8622.0498	2089.0436	323.4063	2510.4052	20775.021	4264.402	297.891	364
AS 305	59.8584	929.334	24.2452	75.309	1719.1005	2309.697	1205.3145	0	1116.5476	15415.473	81.446	161.568	196
AS 302	55.5828	1540.0112	693.056	70.2884	1127.5446	931.4578	922.9948	97.7886	41.496	2810.1346	28.9744	152.3115	182
AS 320	97.0884	1673.3794	13.392	46.476	2207.3115	2551.7002	1102.3454	1165.853	199.4418	0	1094.695	2747.5025	362
AS 300	284.2386	2366.7786	39.3176	183.445	2711.7066	7956.0492	17.2857	2439.723	3458.0777	23.0256	4063.7584	5054.511	479
AS 290	1527.96	3380.032	571.7118	1053.8528	663.956	8417.4965	6352.3044	1745.212	4346.6844	949.7954	1012.6248	14316.624	642
AS 275	1.05	0.54	0.3	0.55	0.32	0.76	0.23	0.88	0.54	0.33	0.43	0.98	1
AS 001	4.5087	1741.635	482.774	19.9796	1962.339	39.601	65.142	0	163.3325	5035.4995	294.1176	369.759	399
AS 276	0.23	0.88	0.54	0.33	0.43	0.98	1.05	0.54	0.3	0.55	0.32	0.76	1
AS 280	0.55	0.34	0.24	0.32	0.67	0.56	0.76	0.45	0.88	0.66	0.32	0.67	1
AS 220	0.76	0.45	0.88	0.66	0.32	0.67	0.55	0.34	0.24	0.32	0.67	0.56	1
AS 240	0.23	0.35	0.56	0.006	0.04	0.89	0.24	0.02	0.98	0.005	0	0	1
AS 210	1535	4191.4199	12659.427	19.479	2415.3976	1622.0703	2421.5464	2233.6	5912.3961	6251	8837.344	2693.15	913
AS 230	16981.776	13515.115	10811.5	90.7649	6055.661	958.2135	2386.848	2849.98	20046.831	548.5053	3736.9524	1437.0741	720
AS 200	619.6905	72.039	72.216	641.8527	2035.3743	4170.584	4844.3676	17085.59	15137.034	242.382	104.404	7976.423	891
AS 190	3789.4932	31981.32	12682.025	2354.2365	3976.236	86.9056	106.428	2890.388	8989.0642	905.5215	21929.393	512.4504	603
AS 193	50.2752	426.4176	169.6592	23.7402	40.164	0.8808	0.905	19.696	5.2832	4.6437	113.6238	1.8172	8
AS 194	12391.315	2562.8792	43.1376	71.1776	2202.6786	2.162	963.8413	5243.012	1259.0886	6643.329	6381.6216	6780.1575	477
AS 198	8291.2752	24751.091	33.7513	4536.6744	381.75	89.64	4046.864	6343.195	8368.1648	1161.2205	3732.624	591.744	507
AS 180	3782.1042	1209.604	9617.08	849.026	2828.3514	92.6936	2.9011	2740.392	125.0762	12363.222	2298.5837	191.7426	441
AS 170	5711.9453	3292.989	14.8035	3796.4589	3714.3301	320.0733	278.7218	17563.41	11974.651	30909.097	15434.689	523.5267	703
AS 250	128.8185	3686.4423	6149.4378	9.9187	752.4154	2341.482	13826.772	897.605	3360.71	669.2004	4849.922	817.2495	785
AS 260	1054.1844	2845.9125	51.5533	111.384	661.2522	2588.8032	73.0235	4341.721	3122.1531	622.1068	668.414	976.374	618
AS 265	3444.5162	0	57.8144	25.515	1058.3992	921.5448	99.8568	1817.733	13683.478	1150.4289	2341.78	264.8701	409
AS 270	530.5125	21.484	558.8984	44.2656	4691.3706	432.224	8955.5466	93.577	5703.7508	22.5492	3175.5213	487.6828	525

Annexure 2.2 - Customer Interruption Duration for Galle Feeder 8

Sin No	Interrupted hours												Customers
	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12	
GB 300	8.1396	1834.5312	68.8296	39.6372	3521.9988	1622.8226	6070.7226	1240.713	645.4311	1730.76	0	347.9588	204
GB 310	885.1492	9061.2907	1541.4956	1182.5137	28577.697	27054.086	34524.858	3289.514	1176.1463	883.2447	4454.0495	2946.7255	527
GB 320	163.4584	1977.9032	66.552	3143.7457	29648.164	9042.8484	131943.2	1040.023	3817.8222	10620.511	115.2542	4243.1788	707
GB 321	10.1992	418.6626	447.866	1323.12	854.9471	8.5407	4607.0884	1669.023	902.7845	1163.9088	142.4686	909.2526	152
GB 330	5.3176	1.4996	2.1712	102.8537	972.7643	300.5571	4449.6973	35.1256	128.9426	359.7522	4.0043	148.3178	23
GB 410	0.09	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04	1
GB 420	0.09	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04	1
GB 421	0.09	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04	1
GB 490	72.4878	4287.892	466.9888	396.7722	11475.596	36.972	3861.0945	2989.722	980.0192	726.1903	1836.7776	169.25	523
GB 530	5.2269	191.9936	116.194	32.006	1249.9584	1023.2576	5234.9056	571.5968	82.0736	691.4944	1.3716	223.6878	131
GB 600	3.2123	573.3426	10133.783	1586.2528	3432.88	150.228	10759.251	2001.306	1018.033	2341.344	72.4073	142.6403	353
GB 620	9.1707	1129.128	214.061	307.0629	1310.5845	87.604	5769.0648	16.023	221.8586	1092.4272	583.407	368.244	231
GB 630	32.5875	46.275	18.988	1382.3788	6303.8074	101.184	18514.636	2183.21	4477.6569	6904.5225	2714.6875	2241.246	375
GB 680	18.9126	1965.4045	3.0845	0	1345.9716	0	2.4505	72.9072	905.9184	920.9664	409.5706	10.4796	158
GB 730	0.8463	369.5355	2612.3916	410.0824	887.4775	298.4436	129.843	6.615	0	16.3891	14.841	37.647	93
GB 740	165.4448	13051.447	482.5126	20155.879	53675.238	168.9778	63069.699	10009.88	11165.188	21632.391	37429.633	12438.494	848
GB 760	0	433.008	1.8335	229.8624	1054.4346	1513.521	2597.5782	75.6512	364.1372	1064.2176	0	300.15	194
GB 770	0.09	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04	1
GB 870	0.09	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04	1
GB 920	1.8333	0	0	0	0	0	0	0	0	0	0	0	1
GB 921	229.1172	2376.4212	171.7524	52.8683	2613.4964	49.3498	2627.7924	0	57.517	48.816	696.87	554.6688	228
GG 375	26162.928	1066.0632	32.538	107.0871	5376.6464	217.854	2618.5592	2000.597	6788.068	4623.9952	277.02	67.124	495
GG 380	102.924	7720.488	22.9608	1574.4456	1358.6065	28.3585	5.4825	128.6345	139.3568	405.7012	739.3924	1564.56	216
GG 382	0.89	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04	1
GG 385	1.6936	7472.6304	69.5836	38.3104	5885.7564	108.5072	45.7452	866.9376	1495.584	175.1464	89.886	43.7644	292
GG 395	0.029	127.956	1.1915	0.5248	80.6268	1.4864	0.6288	12.0408	20.772	2.4496	0.633	0.1541	5
GG 450	0.9978	1.0833	0.3972	0.53	1	0.48	0.1635	0	0	0.24	0.503	0.3036	50
GG 540	136.3946	132.1848	46.0192	178.3742	15449.226	18782.398	5587.9461	980.7864	216.504	181.116	36.4046	422.964	398
GG 545	28539.898	20.9223	4.536	4192.5762	9454.0281	648.6285	3.663	167.962	102.7026	378.045	4925.0672	20.0838	568
GG 550	519.0915	26.7652	12.5628	91.465	4444.006	164.7232	7491.768	9808.681	1498.599	1537.5365	740.304	175.3856	555
GG 560	1062.657	18395.002	197.372	158.5056	68797.155	389.2166	43189.132	604.1964	3817.8675	2985.9821	556.92	955.259	1065
GG 570	214.578	609.855	85.0272	3269.6745	13622.902	9791.4201	29659.96	772.3795	2824.372	43650.228	5237.2584	4319.84	546
GG 580	0.09	0.24	0.02	0.98	0.005	0.45	0.63	0.23	0.35	0.56	0.006	0.04	1
GG 590	0.52	0.11	2.11	0.45	2.9	0.88	0.86	0	0	0.25	0.52	0.32	53

Annexure 2.2 - Customer Interruption Duration for Matara Feeder 7

Sin No.		Interrupted Hours												Customers
		Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	
K	435	2,198.93	2,508.80	0.00	63.75	1,211.25	187.50	420.00	1,864.50	131.83	0.00	0.00	245.92	227
K	440	2,346.18	2,676.80	0.00	68.00	1,292.00	200.00	448.00	1,980.00	140.00	0.00	0.00	260.00	240
K	430	2,365.82	2,755.20	0.00	69.98	1,329.68	205.83	461.07	2,037.75	144.67	0.00	0.00	269.75	249
K	432	29.45	33.60	0.00	0.85	16.15	2.50	5.60	24.75	1.75	0.00	0.00	3.25	3
K	010	251.10	2,444.70	0.00	80.47	534.87	0.00	532.00	0.00	166.25	0.00	0.00	0.00	287
K	020	704.70	6,820.80	0.00	223.27	1,484.07	0.00	1,467.20	0.00	460.83	0.00	0.00	0.00	797
K	025	310.50	3,001.50	0.00	98.03	651.63	0.00	645.87	0.00	204.17	0.00	0.00	0.00	356
K	050	8,633.50	4,089.00	0.00	134.02	890.82	0.00	2,967.07	318.00	279.42	400.00	0.00	0.00	481
K	030	325.80	3,175.50	0.00	104.55	694.95	0.00	688.80	0.00	217.00	558.00	0.00	0.00	376
K	035	220.50	2,148.90	0.00	70.27	467.07	0.00	462.93	0.00	1,645.83	375.00	0.00	0.00	252
K	045	209.70	2,035.80	0.00	66.30	440.70	0.00	440.53	0.00	137.67	354.00	0.00	0.00	237
K	040	106.20	1,035.30	0.00	34.00	226.00	0.00	225.87	0.00	70.58	181.50	0.00	0.00	121
K	060	404.10	3,958.50	0.00	129.20	858.80	0.00	856.80	0.00	267.75	688.50	0.00	0.00	460
K	055	286.20	2,766.60	0.00	90.67	602.67	0.00	604.80	0.00	189.58	487.50	0.00	0.00	325
K	090	448.20	4,402.20	0.00	144.22	960.50	0.00	953.87	0.00	298.67	768.00	0.00	0.00	516
K	100	0.90	8.70	0.00	0.28	1.88	0.00	1.87	0.00	0.58	1.50	0.00	0.00	1
K	070	288.00	5,012.47	0.00	92.65	617.73	0.00	617.87	0.00	194.83	501.00	723.67	3,649.90	339
K	065	302.40	5,592.40	0.00	96.90	644.10	0.00	640.27	0.00	201.25	517.50	747.50	3,725.27	346
K	075	215.10	3,919.60	0.00	67.72	450.12	0.00	446.13	0.00	139.42	358.50	517.83	2,573.23	239
K	080	285.30	5,012.47	0.00	91.80	610.20	0.00	604.80	0.00	191.92	492.00	715.00	3,553.00	330
K	085	331.20	5,790.80	0.00	106.82	710.02	0.00	709.33	0.00	224.00	574.50	838.50	4,166.70	387
K	105	45.00	435.00	0.00	14.17	0.00	0.00	93.33	0.00	29.17	75.00	0.00	0.00	50
K	107	106.20	1,035.30	0.00	34.00	226.00	0.00	225.87	0.00	70.58	181.50	0.00	0.00	122
K	410	184.25	1,444.20	0.00	47.03	428.83	235.17	309.87	0.00	96.83	0.00	0.00	1,853.67	166
K	420	365.15	2,862.30	0.00	94.07	857.67	470.33	619.73	0.00	193.67	0.00	0.00	3,729.67	334
K	415	300.38	2,340.30	0.00	77.92	710.42	391.00	515.20	0.00	161.00	0.00	0.00	3,093.17	277
T	345	587.37	4,584.90	0.00	150.73	1,374.33	755.08	998.67	0.00	316.17	0.00	0.00	6,063.50	543
T	344	450.02	3,593.10	0.00	118.72	789.12	0.00	785.87	0.00	246.75	0.00	0.00	0.00	425
K	385	15.63	121.80	0.00	3.97	26.37	0.00	26.13	0.00	8.17	0.00	0.00	0.00	14
K	380	419.87	3,288.60	0.00	108.80	723.20	0.00	724.27	0.00	228.08	0.00	0.00	0.00	391
K	375	304.85	5,073.75	0.00	78.77	525.45	0.00	520.80	0.00	162.75	0.00	0.00	0.00	280
K	373	1,280.53	3,986.63	318.25	418.75	428.80	0.00	377.07	0.00	118.42	0.00	0.00	1,098.67	206
K	370	3.35	18.45	0.00	0.28	1.88	0.00	1.87	0.00	2.33	0.00	0.00	0.00	4
K	367	429.92	7,915.05	0.00	122.12	811.72	0.00	808.27	0.00	254.33	0.00	0.00	0.00	438
K	365	185.37	3,062.70	0.00	46.75	312.63	0.00	309.87	0.00	96.83	0.00	0.00	0.00	166
K	360	441.08	6,549.75	0.00	101.15	674.23	0.00	668.27	0.00	211.17	0.00	0.00	0.00	363
K	340	374.08	2,923.20	0.00	1,019.63	2,501.20	0.00	625.33	0.00	196.00	0.00	0.00	0.00	338
K	353	270.23	2,114.10	0.00	922.83	2,976.75	0.00	459.20	0.00	492.00	0.00	576.33	329.33	247
K	350	398.65	3,219.00	0.00	1,408.73	4,544.10	0.00	700.00	0.00	760.00	0.00	886.67	508.00	381
K	355	232.27	1,835.70	0.00	802.30	2,587.95	0.00	399.47	0.00	428.00	0.00	501.67	288.00	216
K	345	341.70	2,670.90	0.00	1,163.90	3,766.50	0.00	576.80	0.00	620.00	0.00	730.33	418.67	314
K	337	32.38	252.30	0.00	87.48	214.60	0.00	54.13	0.00	16.92	0.00	0.00	0.00	29
K	335	1.12	8.70	0.00	3.02	7.40	0.00	1.87	0.00	0.58	0.00	0.00	0.00	1
K	330	1.12	8.70	0.23	0.28	1.88	0.00	1.87	0.00	0.58	0.00	0.00	0.00	1
K	320	618.63	4,828.50	129.97	158.38	1,052.78	0.00	1,047.20	0.00	330.75	0.00	0.00	0.00	573
K	310	158.57	1,270.20	34.30	42.22	282.50	0.00	278.13	0.00	87.50	0.00	0.00	0.00	153
K	315	254.60	2,001.00	53.90	66.02	438.82	0.00	436.80	175.50	137.08	0.00	0.00	0.00	235
K	295	1,319.27	3,254.80	640.67	88.40	589.48	0.00	589.87	0.00	184.33	0.00	0.00	0.00	320
K	300	341.70	2,697.00	72.33	88.12	585.72	0.00	580.53	0.00	182.00	0.00	0.00	0.00	313
K	290	282.52	2,201.10	59.27	71.97	478.37	0.00	476.00	0.00	149.33	0.00	0.00	0.00	257
B	600	437.40	4,236.90	488.00	787.32	919.07	0.00	912.80	0.00	286.42	0.00	0.00	0.00	492
B	610	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
B	620	364.50	3,532.20	407.00	659.60	770.28	0.00	769.07	0.00	241.50	0.00	0.00	0.00	416
B	630	383.40	3,732.30	431.00	700.02	817.37	0.00	812.00	0.00	253.75	0.00	0.00	0.00	441
B	640	367.20	3,567.00	411.00	666.07	775.93	0.00	772.80	0.00	242.67	0.00	0.00	0.00	419
B	650	0.00	0.00	0.00	1.62	1.88	0.00	1.87	0.00	0.58	0.00	0.00	0.00	1

B	**660**	492.30	4,776.30	550.00	892.40	1,041.48	0.00	1,032.27	0.00	324.33	0.00	0.00	0.00	561
B	**655**	198.00	1,931.40	223.00	360.52	421.87	0.00	423.73	0.00	133.58	0.00	0.00	0.00	230
B	**670**	339.30	3,314.70	381.00	617.57	719.43	0.00	713.07	0.00	222.83	0.00	0.00	0.00	383
B	**185**	355.50	3,462.60	398.00	645.05	751.45	0.00	744.80	0.00	233.92	0.00	0.00	0.00	405
B	**685**	0.90	8.70	1.00	1.62	1.88	0.00	1.87	0.00	0.58	0.00	0.00	0.00	1
B	**680**	320.40	3,105.90	358.00	578.77	674.23	0.00	672.00	0.00	211.17	0.00	0.00	0.00	364
B	**675**	4.50	43.50	5.00	8.08	9.42	0.00	9.33	0.00	2.92	0.00	0.00	0.00	5
B	**690**	412.20	4,010.70	462.00	746.90	871.98	0.00	866.13	0.00	270.67	0.00	0.00	0.00	467
B	**693**	216.00	2,096.70	241.00	389.62	453.88	0.00	453.60	0.00	142.92	0.00	0.00	0.00	249
B	**700**	169.20	1,626.90	189.00	305.55	357.83	0.00	354.67	0.00	110.83	0.00	0.00	0.00	191
B	**695**	120.60	1,165.80	135.00	219.87	256.13	0.00	253.87	0.00	79.92	0.00	0.00	0.00	139
B	**710**	333.90	3,253.80	377.00	609.48	713.78	0.00	711.20	0.00	224.00	0.00	0.00	0.00	386
B	**725**	39.60	391.50	45.00	72.75	84.75	0.00	87.73	0.00	27.42	0.00	0.00	0.00	47
B	**720**	164.70	1,618.20	189.00	305.55	355.95	0.00	352.80	0.00	110.25	0.00	0.00	0.00	191
B	**715**	88.20	861.30	99.00	160.05	186.45	0.00	184.80	0.00	57.75	0.00	0.00	0.00	100
B	**730**	495.90	4,793.70	552.00	892.40	1,041.48	0.00	1,032.27	0.00	322.58	0.00	0.00	0.00	556
B	**735**	0.90	8.70	1.00	1.62	1.88	0.00	1.87	0.00	0.58	0.00	0.00	0.00	1
B	**740**	45.90	443.70	51.00	82.45	96.05	0.00	95.20	0.00	29.75	0.00	0.00	0.00	53
K	**220**	387.90	3,819.30	440.00	125.52	839.97	0.00	836.27	0.00	262.50	0.00	0.00	0.00	452
K	**305**	107.10	1,044.00	240.00	34.28	227.88	292.42	224.00	0.00	430.00	0.00	685.67	641.30	121
K	**215**	58.50	574.20	134.00	19.27	128.07	164.33	128.80	0.00	247.25	0.00	391.00	365.70	69
K	**210**	591.87	1,696.50	0.00	55.82	371.02	1,122.90	367.73	0.00	165.00	1,178.10	600.60	1,566.15	197
K	**140**	1,030.40	2,949.30	0.00	96.33	642.22	1,943.70	636.53	0.00	284.17	2,034.90	1,043.47	2,742.75	345
K	**130**	1,278.80	3,645.30	0.00	119.57	798.53	2,416.80	1,565.10	0.00	353.33	2,534.70	1,292.20	3,402.60	428
K	**135**	3.12	17.40	0.17	0.57	3.77	15.07	7.40	0.00	2.50	24.35	9.10	59.35	3
K	**147**	3.07	8.70	0.00	0.28	1.88	5.70	1.87	0.00	0.83	5.95	3.03	7.95	1
K	**143**	199.33	565.50	0.00	18.98	126.18	381.90	126.93	0.00	57.50	410.55	209.30	548.55	69
K	**150**	591.87	1,679.10	0.00	54.97	365.37	1,122.90	369.60	0.00	165.83	1,190.00	609.70	1,605.90	202
K	**180**	1,134.67	3,323.40	0.00	109.93	730.73	2,211.60	1,251.20	1,368.50	488.75	2,326.45	1,189.07	3,550.10	393
K	**175**	484.53	1,545.77	0.00	45.05	299.45	917.70	518.40	570.50	203.75	969.85	500.50	1,490.50	165
K	**182**	407.87	1,330.53	0.00	38.53	256.13	780.90	435.20	479.50	172.50	821.10	418.60	1,255.63	139
K	**183**	389.47	1,104.90	0.00	36.27	241.07	735.30	416.00	455.00	162.50	773.50	394.33	1,174.33	130
K	**160**	1,521.07	4,367.40	0.00	143.37	1,121.63	2,884.20	942.67	0.00	420.83	3,004.75	1,537.90	4,030.65	507
K	**170**	1,223.60	3,532.20	0.00	115.32	2,665.85	5,168.90	761.60	0.00	341.67	2,439.50	1,243.67	3,275.40	412
K	**165**	1,131.60	3,227.70	0.00	106.82	711.90	2,154.60	705.60	0.00	315.83	2,255.05	1,149.63	3,005.10	378
K	**168**	300.53	870.00	0.00	28.90	192.10	632.70	209.07	0.00	93.33	666.40	342.77	898.35	113
K	**185**	591.87	1,705.20	0.00	56.38	374.78	1,134.30	371.47	0.00	166.67	1,190.00	606.67	1,590.00	200
K	**186**	303.60	878.70	0.00	28.90	192.10	587.10	192.27	0.00	87.50	624.75	318.50	834.75	105
K	**187**	1,855.33	5,350.50	0.00	175.38	1,167.67	3,545.40	1,161.07	0.00	520.00	3,712.80	1,901.90	5,000.55	629
K	**190**	1,751.07	5,011.20	0.00	165.47	1,099.87	3,340.20	1,093.87	0.00	493.33	3,522.40	1,804.83	4,738.20	596
K	**195**	472.27	1,339.80	12.83	43.92	640.67	2,536.83	560.58	935.17	129.17	922.25	1,562.15	2,674.23	157
K	**197**	3.07	8.70	0.08	0.28	4.13	16.37	3.62	6.03	0.83	5.95	9.95	17.03	1
K	**200**	1,475.07	4,106.40	39.58	135.43	1,975.73	7,856.00	1,750.47	2,926.17	409.17	2,921.45	4,915.30	8,414.47	494
L	**385**	3.07	8.70	0.00	0.28	1.88	5.70	1.87	0.00	0.83	5.95	3.03	17.03	1
L	**390**	953.73	2,749.20	0.00	89.53	602.67	1,824.00	597.33	0.00	267.50	1,909.95	973.70	2,551.95	321
L	**375**	1,066.22	2,157.60	0.00	70.27	467.07	268.67	462.93	0.00	143.50	0.00	0.00	0.00	247
L	**380**	2,577.05	5,280.90	0.00	172.55	1,148.83	660.83	1,140.53	0.00	356.42	0.00	0.00	0.00	610
L	**383**	241.73	495.90	0.00	16.15	107.35	61.75	106.40	0.00	33.25	0.00	0.00	0.00	57
L	**365**	4.32	8.70	0.00	0.28	1.88	1.08	1.87	0.00	0.58	0.00	0.00	0.00	1
L	**360**	1,286.37	2,653.50	0.00	86.42	574.42	330.42	569.33	0.00	178.50	0.00	0.00	0.00	306
L	**370**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
L	**400**	779.10	2,592.60	0.00	84.43	561.23	323.92	558.13	0.00	174.42	0.00	0.00	0.00	299
L	**405**	2.65	8.70	0.00	0.28	1.88	1.08	1.87	0.00	0.58	0.00	0.00	0.00	1
L	**410**	1,354.15	4,480.50	0.00	146.20	969.92	557.92	965.07	0.00	301.58	0.00	0.00	0.00	517
L	**415**	132.50	435.00	0.00	14.17	94.17	54.17	93.33	0.00	29.17	0.00	0.00	0.00	55
L	**420**	241.15	809.10	0.00	26.92	178.92	102.92	177.33	0.00	55.42	0.00	0.00	0.00	95
L	**430**	908.95	3,010.20	0.00	98.32	653.52	375.92	647.73	0.00	201.83	0.00	0.00	0.00	346
L	**440**	1,091.80	3,662.70	0.00	120.42	802.30	461.50	795.20	0.00	248.50	0.00	0.00	0.00	426
L	**450**	127.20	426.30	0.00	14.17	94.17	54.17	93.33	0.00	29.17	0.00	0.00	0.00	50
L	**444**	251.75	843.90	0.00	28.05	186.45	107.25	184.80	0.00	57.75	0.00	0.00	0.00	99
L	**443**	564.45	1,896.60	0.00	61.77	410.57	236.17	406.93	0.00	126.58	0.00	0.00	0.00	219

L	**445**	1,433.65	4,750.20	0.00	154.98	1,030.18	593.67	1,022.93	0.00	316.75	0.00	0.00	0.00	543
L	**447**	469.05	1,583.40	0.00	51.57	346.53	199.33	343.47	0.00	106.17	0.00	0.00	0.00	182
L	**442**	320.65	1,078.80	0.00	35.42	235.42	135.42	233.33	0.00	72.92	0.00	0.00	0.00	124
L	**460**	850.65	2,844.90	0.00	92.65	615.85	354.25	610.40	0.00	190.75	0.00	0.00	0.00	327
L	**350**	1,346.20	4,558.80	0.00	149.03	990.63	569.83	981.87	0.00	303.92	0.00	0.00	0.00	521
L	**353**	980.50	3,288.60	0.00	107.38	713.78	410.58	707.47	0.00	221.08	0.00	0.00	0.00	379
L	**352**	164.30	556.80	0.00	18.13	120.53	69.33	119.47	0.00	37.33	0.00	0.00	0.00	64
L	**354**	209.35	704.70	0.00	22.95	152.55	87.75	151.20	0.00	47.25	0.00	0.00	0.00	81
L	**355**	628.05	2,096.70	0.00	68.28	453.88	261.08	449.87	0.00	140.58	0.00	0.00	0.00	241
L	**342**	280.90	930.90	0.00	31.17	207.17	119.17	205.33	0.00	64.17	0.00	0.00	0.00	110
L	**345**	773.80	2,575.20	0.00	83.87	557.47	320.67	552.53	0.00	172.67	0.00	0.00	0.00	294
L	**344**	198.75	661.20	0.00	22.10	146.90	84.50	145.60	0.00	45.50	0.00	0.00	0.00	77
L	**346**	201.40	678.60	0.00	22.10	146.90	84.50	145.60	0.00	45.50	0.00	0.00	0.00	78
L	**349**	492.90	1,618.20	0.00	52.70	350.30	201.50	347.20	0.00	108.50	0.00	0.00	0.00	186
L	**347**	781.75	2,601.30	0.00	84.72	563.12	323.92	558.13	0.00	174.42	0.00	0.00	0.00	299
L	**348**	588.30	2,001.00	0.00	65.17	433.17	249.17	429.33	0.00	133.58	0.00	0.00	0.00	229
L	**340**	1,523.75	5,098.20	0.00	166.60	1,109.28	642.42	1,106.93	0.00	345.92	0.00	0.00	0.00	593
L	**330**	1,264.05	4,202.10	0.00	136.85	911.53	526.50	907.20	0.00	282.92	0.00	0.00	0.00	485
L	**335**	535.30	1,774.80	0.00	58.37	389.85	224.25	386.40	0.00	120.75	0.00	0.00	0.00	207
L	**325**	580.35	1,940.10	0.00	63.18	419.98	242.67	418.13	0.00	130.67	0.00	0.00	0.00	224
L	**320**	972.55	3,262.50	0.00	106.53	711.90	409.50	705.60	0.00	219.92	0.00	0.00	0.00	377
L	**323**	588.30	1,974.90	0.00	64.32	427.52	245.92	423.73	0.00	131.83	0.00	0.00	0.00	226
L	**324**	400.15	1,357.20	0.00	44.48	295.68	170.08	309.87	0.00	96.83	0.00	0.00	0.00	166

Annexure 3 - Supporting Calculation for Ambalangoda Feeder 3

Gonapinuwala — Other Subs SAIDI

Temp %	Section	Type	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12
-0-.584	1	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.07	9.80	4.48	8.60	4.88	5.83	6.51	8.22	10.42	13.14	12.91	4.41
	2	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.07	9.80	4.48	8.60	4.88	5.83	6.51	8.22	10.42	13.14	12.91	4.41
	3	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.15	9.85	4.54	8.70	4.71	5.87	6.60	7.40	10.56	13.31	12.30	4.48
	4	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.24	9.88	4.62	8.86	4.77	5.98	6.72	7.46	10.76	13.56	11.89	4.56
	5	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.12	9.22	4.40	8.70	4.80	5.66	6.22	8.35	10.28	11.70	12.15	3.96
	6	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.27	9.49	4.52	8.96	4.78	5.68	6.16	8.47	10.33	11.57	11.09	3.61
	7	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.11	10.09	4.53	8.72	4.98	5.75	6.30	8.29	10.57	13.05	11.95	4.47
	8	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.41	9.82	4.67	9.27	4.94	5.70	6.06	8.63	10.69	11.67	9.59	3.73
	9	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.98	9.92	4.32	8.57	4.90	5.74	6.05	8.18	10.39	13.09	13.46	4.40
	10	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.97	9.96	4.43	8.74	4.40	5.75	5.43	8.05	9.38	13.02	13.81	4.52
	11	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.72	9.93	4.93	9.77	4.89	5.96	6.40	7.89	11.29	12.32	7.82	3.95
	12	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.74	10.17	4.99	10.18	4.39	5.99	5.28	7.76	10.34	12.43	8.16	4.14
	13	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.96	9.36	4.57	1.37	4.55	4.50	6.42	7.39	10.2	11.61	13.40	4.54
	14	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.96	9.49	4.63	1.19	4.54	4.52	6.10	7.31	10.34	11.56	13.55	4.59
	15	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.77	9.84	5.32	1.34	3.99	4.52	4.84	6.69	10.4	10.73	8.09	4.44

Relevant SAIDI

Temp Fault %	Section	Type	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12
1	1	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.01	8.53	0.19	0.05	1.69	0.36	0.07	4.23	0.01	0.07	33.94	0.02
1	2	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	0.01	8.53	0.19	0.05	1.69	0.36	0.07	4.23	0.01	0.07	33.94	0.02
0.94	3	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.01	7.41	0.25	0.82	8.26	1.48	0.06	30.83	0.35	0.73	43.36	0.02
0.97	4	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	0.01	7.82	0.23	0.55	5.89	1.07	0.06	21.26	0.23	0.49	39.97	0.02
0.9	5	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.39	27.63	4.37	0.29	5.57	7.98	11.98	1.91	8.98	51.59	49.93	16.43
0.9	6	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.40	14.35	2.38	0.23	5.57	6.58	10.04	3.05	8.78	34.49	48.79	16.01
0.9	7	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	1.17	0.01	0.34	0.00	0.09	5.19	9.29	3.93	0.00	8.43	54.64	0.12
0.9	8	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.67	9.32	1.67	0.15	3.65	6.09	9.78	3.35	5.70	25.35	50.84	10.44
0.9	9	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	5.23	0.06	9.61	0.16	0.00	5.16	29.09	5.97	0.01	0.23	2.18	0.02
0.9	10	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	5.23	5.19	3.57	1.41	15.09	5.34	29.38	10.56	30.80	10.17	0.80	0.01
0.95	11	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	0.44	8.78	1.15	0.29	4.45	4.30	6.31	9.75	3.75	16.48	46.96	6.72
0.93	12	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	1.50	7.98	1.69	0.54	6.82	4.53	11.45	9.93	9.78	15.07	36.67	5.22
0.95	13	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	5.45	18.30	0.96	154.19	10.49	31.20	5.80	23.90	10.80	39.51	11.04	0.11
0.95	14	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	5.40	14.30	0.77	123.68	9.46	24.94	10.94	21.56	8.53	34.20	9.14	0.28
0.94	15	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	2.47	9.55	1.46	31.0	7.47	9.59	11.3	12.8	9.47	19.81	29.8	4.00

Kahatapitiya

Temp %	Section	Type	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12
0.584	15	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.22	10.1	3.73	9.05	4.98	6.01	6.66	8.56	10.5	13.34	13.5	4.43
	16	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.22	10.1	3.73	9.05	4.98	6.01	6.66	8.56	10.5	13.34	13.5	4.43
	17	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.12	9.63	3.06	9.58	4.78	6.29	6.86	8.83	9.47	14.08	14.0	4.58
	18	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	5.28	10.4	4.70	8.98	5.00	5.80	6.46	7.39	9.77	13.78	14.2	4.01
	19	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.40	10.3	3.29	10.2	4.98	6.42	6.97	8.01	8.88	15.18	15.1	4.23
	20	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.98	9.77	4.40	8.45	4.83	5.73	6.39	8.15	10.2	12.90	13.2	4.33
	21	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.55	8.28	4.57	8.43	4.98	5.94	6.33	7.99	10.0	13.31	13.5	4.46
	22	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	3.74	8.39	4.73	8.74	5.00	6.17	6.49	7.87	10.2	13.29	13.5	4.09
	23	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.98	9.75	4.39	8.45	4.83	5.74	6.39	8.16	10.2	12.91	13.2	4.34
	24	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	3.74	8.36	4.72	8.74	5.00	6.17	6.49	7.88	10.2	13.30	13.5	4.09
	25	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	3.62	6.14	3.91	8.98	4.92	6.47	6.81	8.03	10.0	13.88	12.3	4.25
	26	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	2.58	5.90	2.49	11.2	5.12	7.46	7.59	7.83	8.41	16.79	14.3	4.11
	27	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.81	10.0	4.64	8.61	4.80	6.02	6.71	7.25	9.87	11.23	12.8	4.53
	28	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	4.68	10.3	4.03	8.84	4.75	6.22	6.95	7.28	10.2	10.64	13.0	4.67
	29	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	1.81	6.17	1.69	12.2	5.03	8.42	8.58	6.49	8.12	13.95	14.1	4.58
	30	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	1.97	6.32	1.07	13.4	5.45	8.98	7.66	7.04	8.51	15.29	14.9	4.94
	31	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	2.00	6.47	1.15	14.6	5.83	9.40	8.32	7.04	8.82	16.54	16.1	5.24
	32	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	1.60	6.86	1.22	15.5	6.03	9.83	8.81	7.20	7.30	17.38	16.8	5.52
	33	B	0.45	0.63	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01
		R	1.65	7.45	1.23	16.8	5.78	10.6	8.11	7.80	7.00	18.86	17.7	5.91

Temp Fault %	Section	Type	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12
0.9	15	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	1.68	4.59	13.8	0.02	2.65	1.78	2.65	2.45	6.48	6.85	9.68	2.95
0.9	16	B	0.76	0.45	0.88	0.66	0.32	0.67	0.55	0.34	0.24	0.32	0.67	0.56
		R	1.68	4.59	13.8	0.02	2.65	1.78	2.65	2.45	6.48	6.85	9.68	2.95
0.9	17	B	0.76	0.45	0.88	0.66	0.32	0.67	0.55	0.34	0.24	0.32	0.67	0.56
		R	11.3	10.8	14.3	0.07	5.19	1.58	2.94	3.11	15.9	4.16	7.70	2.53
1	18	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.70	0.08	0.08	0.72	2.28	4.68	5.44	19.1	16.9	0.27	0.12	8.95
0.95	19	B	0.76	0.45	0.88	0.66	0.32	0.67	0.55	0.34	0.24	0.32	0.67	0.56
		R	7.58	7.02	9.30	0.04	3.36	1.02	1.91	2.01	10.2	2.69	4.98	1.64
0.96	20	B	0.23	0.35	0.56	0.01	0.04	0.89	0.24	0.02	0.98	0.01	-	-
		R	-	-	-	-	-	-	-	-	-	-	-	-
0.96	21	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	16.3	48.8	0.07	8.95	0.75	0.18	7.98	12.5	16.5	2.29	7.36	1.17
0.96	22	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	21.0	27.7	0.08	4.68	2.63	0.09	5.09	11.7	9.78	7.93	10.2	7.49
0.96	23	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	6.28	53.3	21.2	2.97	5.02	0.11	0.11	2.46	0.66	0.58	14.2	0.23
0.96	24	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	20.9	27.9	0.25	4.67	2.65	0.09	5.05	11.7	9.71	7.87	10.3	7.43
0.96	25	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	15.3	37.4	8.11	4.38	4.14	0.11	3.21	9.09	11.6	5.46	20.1	4.94
0.95	26	B	0.50	0.40	0.72	0.33	0.18	0.78	0.40	0.18	0.61	0.16	0.34	0.28
		R	10.6	18.8	8.84	1.72	3.66	0.67	2.41	4.75	10.8	3.77	10.8	2.92
0.93	27	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	8.13	4.68	0.02	5.40	5.28	0.46	0.40	24.9	17.0	43.97	21.9	0.74
0.93	28	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	8.30	3.94	8.42	4.06	5.72	0.36	0.25	17.7	10.5	37.83	15.5	0.63
0.95	29	B	0.50	0.40	0.72	0.33	0.18	0.78	0.40	0.18	0.61	0.16	0.34	0.28
		R	10.1	15.5	8.75	2.23	4.11	0.60	1.94	7.58	10.7	11.17	11.8	2.42
0.95	30	B	0.50	0.40	0.72	0.33	0.18	0.78	0.40	0.18	0.61	0.16	0.34	0.28
		R	8.81	14.1	8.63	1.94	3.70	0.91	3.97	6.74	9.93	9.83	11.1	2.24
0.95	31	B	0.50	0.40	0.72	0.33	0.18	0.78	0.40	0.18	0.61	0.16	0.34	0.28
		R	8.15	13.2	7.84	1.78	3.45	1.22	3.62	6.77	9.48	9.01	10.2	2.18
0.95	32	B	0.50	0.40	0.72	0.33	0.18	0.78	0.40	0.18	0.61	0.16	0.34	0.28
		R	8.17	12.5	7.39	1.68	3.40	1.28	3.42	6.63	10.8	8.65	9.94	2.09
0.95	33	B	0.50	0.40	0.72	0.33	0.18	0.78	0.40	0.18	0.61	0.16	0.34	0.28
		R	7.67	11.6	6.95	1.57	3.79	1.24	4.36	6.19	10.8	8.06	9.67	2.01

Kuleegoda

Temp %	Section	Type	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12
0.584	34	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.0	9.8	4.5	8.6	4.8	5.6	6.4	8.3	10.3	12.0	13.5	4.4
	35	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.1	9.9	4.5	8.7	4.8	5.7	6.4	8.4	10.4	11.9	13.7	4.4
	36	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.0	9.8	4.4	8.5	4.9	5.6	6.4	8.2	10.3	12.8	13.4	4.4
	37	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.0	9.8	4.4	8.5	4.9	5.7	6.4	8.2	10.3	12.8	13.4	4.4
	38	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.1	9.9	4.5	8.6	4.9	5.6	6.4	8.3	10.4	12.7	13.5	4.4
	39	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.2	10.0	4.5	8.8	5.0	5.1	6.5	8.5	10.5	11.5	13.6	4.5
	40	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.4	10.1	4.6	9.1	4.9	5.0	6.5	8.7	10.7	10.4	14.0	4.6
	41	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.1	9.9	4.5	8.7	4.8	5.7	6.5	8.3	10.5	13.3	13.6	4.2
	42	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.7	10.5	4.9	9.7	4.9	4.5	6.8	9.1	11.2	11.1	14.5	4.3
	43	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.1	10.0	4.6	8.8	5.0	5.4	6.2	8.4	10.4	13.5	13.9	3.5
	44	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.9	10.8	5.2	10.2	5.1	4.0	6.7	9.4	11.4	11.7	15.2	3.3
	45	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.0	9.8	4.4	8.4	4.8	5.7	6.4	8.2	10.2	12.9	13.3	4.3
	46	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.9	10.8	5.2	10.2	5.1	4.0	6.7	9.4	11.4	11.7	15.2	3.3
	47	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.9	10.8	5.2	10.2	5.1	4.0	6.7	9.4	11.4	11.7	15.2	3.3
	48	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	6.1	11.0	5.3	10.5	5.1	4.1	6.9	9.8	11.8	11.6	15.8	3.3
	49	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	5.0	9.8	4.4	8.4	4.8	5.7	6.4	8.2	10.2	12.9	13.3	4.3
	50	B	0.5	0.6	0.2	0.4	0.6	0.0	0.0	0.9	0.2	0.0	1.0	0.0
		R	6.1	11.0	5.3	10.5	5.1	4.1	6.9	9.8	11.8	11.6	15.8	3.3

Other Subs SAIDI

Temp Fault %	Section	Type	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12
0.96	34	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.3	4.7	0.1	0.4	8.8	11.8	6.1	-	5.7	78.7	0.4	0.8
0.96	35	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.3	6.5	1.9	0.4	7.5	8.6	5.6	0.3	3.1	48.2	0.3	0.8
0.9	36	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.0	4.6	0.1	0.1	0.7	15.2	1.9	0.1	0.2	26.3	0.6	0.0
0.9	37	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.0	4.6	2.4	0.1	0.7	8.2	5.8	0.4	0.2	22.6	0.6	0.7
0.9	38	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.0	4.6	1.2	0.1	0.7	12.1	3.7	0.2	0.2	24.7	0.6	0.3
0.9	39	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.0	4.6	1.5	0.1	1.0	19.1	4.9	0.6	4.3	44.4	7.4	0.6
0.93	40	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.1	5.3	1.7	0.2	3.5	15.0	5.2	0.5	3.8	45.9	4.6	0.7
0	41	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.3	4.6	0.0	0.1	6.1	7.0	3.0	3.2	0.6	-	3.0	7.6
0.62	42	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.3	5.1	0.9	0.2	4.6	13.9	3.4	2.2	4.1	24.7	5.3	4.7
0	43	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	2.4	5.3	0.9	1.6	1.0	13.1	9.9	2.7	6.8	1.5	1.6	22.3
0.62	44	B	-	-	-	-	-	-	-	-	-	-	-	-
		R	0.8	5.1	0.9	0.6	3.7	13.7	5.1	2.4	4.8	18.6	4.3	9.3
0.9	45	B	1.1	0.5	0.3	0.6	0.3	0.8	0.2	0.9	0.5	0.3	0.4	1.0
		R	-	-	-	-	-	-	-	-	-	-	-	-
0.55	46	B	1.1	0.5	0.3	0.6	0.3	0.8	0.2	0.9	0.5	0.3	0.4	1.0
		R	0.8	5.1	0.9	0.6	3.7	13.7	5.1	2.4	4.8	18.6	4.3	9.3
0.55	47	B	0.6	0.7	0.4	0.4	0.4	0.9	0.6	0.7	0.4	0.4	0.4	0.9
		R	0.8	5.1	0.9	0.6	3.7	13.7	5.1	2.4	4.8	18.6	4.3	9.3
0.55	48	B	0.6	0.7	0.4	0.4	0.4	0.9	0.6	0.7	0.4	0.4	0.4	0.9
		R	0.7	5.0	1.0	0.5	3.8	11.8	4.4	2.0	4.2	17.8	3.8	8.1
0.95	49	B	0.6	0.3	0.2	0.3	0.7	0.6	0.8	0.5	0.9	0.7	0.3	0.7
		R	-	-	-	-	-	-	-	-	-	-	-	-
0.61	50	B	0.6	0.6	0.4	0.4	0.5	0.8	0.7	0.6	0.6	0.5	0.4	0.8
		R	2.2	5.0	0.8	1.5	4.1	9.5	3.6	6.6	6.7	22.9	7.4	6.7

Cost of Interruption

Section	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12	Avg
1	(488.8)	(586.6)	(262.6)	(417.7)	(573.0)	(48.8)	(92.1)	(892.6)	(324.0)	(126.7)	(603.0)	(41.0)	(371.4)
2	277.1	485.6	128.8	178.0	380.1	(38.6)	(24.0)	622.1	84.4	(92.7)	1,064.9	(32.4)	252.8
3	(489.4)	(609.1)	(262.5)	(408.4)	(486.1)	(34.7)	(93.1)	(538.0)	(320.7)	(119.4)	(502.1)	(41.4)	(325.4)
4	252.7	439.4	116.4	164.6	409.1	(30.5)	(28.0)	813.2	72.4	(91.4)	1,091.2	(33.9)	264.6
5	(484.4)	(352.3)	(209.4)	(415.7)	(525.6)	48.5	60.8	(929.0)	(209.3)	536.7	(442.2)	170.4	(229.3)
6	(485.4)	(522.6)	(235.6)	(418.5)	(525.4)	30.7	36.6	(915.6)	(212.3)	321.5	(447.9)	167.9	(267.2)
7	(474.4)	(708.9)	(261.5)	(419.5)	(596.4)	12.5	26.1	(903.0)	(325.3)	(20.4)	(380.9)	(40.2)	(341.0)
8	(483.2)	(588.9)	(245.9)	(422.0)	(551.0)	24.4	34.2	(913.0)	(254.1)	205.0	(409.6)	96.4	(292.3)
9	(422.0)	(706.8)	(142.6)	(416.1)	(596.8)	12.2	278.6	(876.2)	(323.7)	(124.4)	(1,056.9)	(40.9)	(368.0)
10	(422.0)	(642.3)	(219.9)	(401.7)	(401.9)	14.5	287.4	(817.2)	74.2	2.0	(1,077.3)	(41.9)	(303.8)
11	239.2	428.2	118.2	141.7	368.1	12.2	56.6	619.8	106.8	131.3	1,173.3	60.4	288.0
12	237.5	391.9	116.6	129.6	382.9	13.6	129.9	590.1	184.3	106.8	989.5	37.2	275.8
13	(415.2)	(458.6)	(253.2)	1,699.7	(453.9)	373.7	(15.0)	(626.1)	(178.1)	412.4	(936.7)	(40.7)	(74.3)

Section	Type	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12
1	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.95	2.81	-2.42	-4.97	-1.17	-3.05	-3.73	-0.57	-6.08	-7.60	26.40	-2.56
2	B	0.19	0.26	0.10	0.15	0.23	0.00	0.02	0.37	0.10	0.01	0.41	0.00
	R	-2.95	2.81	-2.42	-4.97	-1.17	-3.05	-3.73	-0.57	-6.08	-7.60	26.40	-2.56
3	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.99	1.22	-2.41	-4.31	5.01	-2.04	-3.80	24.66	-5.84	-7.08	33.58	-2.59
4	B	0.17	0.24	0.09	0.14	0.22	0.00	0.02	0.34	0.09	0.01	0.38	0.00
	R	-3.05	1.81	-2.47	-4.65	2.93	-2.45	-3.86	16.26	-6.07	-7.44	31.83	-2.64
5	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.64	19.49	1.37	-4.82	2.21	3.87	7.16	-3.16	2.08	39.60	37.84	12.48
6	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.71	7.37	-0.50	-5.02	2.22	2.61	5.43	-2.21	1.87	24.29	37.43	12.30
6*	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-1.93	-5.89	-2.34	-5.09	-2.83	1.32	4.69	-1.31	-6.17	-0.04	42.20	-2.51
7	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.55	2.65	-1.23	-5.28	0.40	2.16	5.26	-2.02	-1.11	16.00	40.16	7.21
8	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	1.80	-5.74	6.12	-4.86	-2.86	1.29	22.65	0.60	-6.06	-7.44	-5.89	-2.56
9	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	1.80	-1.14	0.62	-3.83	11.01	1.45	23.27	4.80	22.25	1.55	-7.34	-2.62
9*	B	0.16	0.23	0.08	0.13	0.20	0.00	0.01	0.33	0.09	0.01	0.36	0.00
	R	-2.93	2.54	-1.78	-5.43	1.37	0.60	2.25	4.65	-3.04	8.46	40.05	4.08
10	B	0.16	0.22	0.08	0.12	0.19	0.00	0.01	0.31	0.08	0.01	0.34	0.00
	R	-1.96	1.49	-1.34	-5.44	3.78	0.72	7.57	4.70	3.06	6.76	29.34	2.44
11	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	2.28	11.92	-1.75	145.68	7.31	27.01	1.76	18.39	4.30	30.75	2.66	-2.54

14	(415.8)	(513.1)	(256.4)	1,293.9	(467.6)	289.9	56.2	(656.7)	(209.6)	341.8	(963.3)	(38.9)	(128.3)
15	257.9	427.1	115.0	611.2	405.3	93.2	134.1	653.6	184.5	185.7	921.8	19.4	334.1

12	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	2.24	8.04	-1.97	116.80	6.33	21.05	6.83	16.21	2.06	25.73	0.76	-2.41
13	B	0.16	0.22	0.08	0.12	0.20	0.00	0.01	0.32	0.09	0.01	0.35	0.00
	R	-1.05	3.23	-1.73	28.40	4.69	6.37	7.82	8.13	2.78	12.35	23.34	1.17

Section	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12	Avg
16	(468.8)	(644.9)	(64.3)	(421.8)	(560.3)	(30.4)	(57.1)	(920.5)	(233.8)	(33.1)	(949.2)	0.1	(365.3)
17	695.3	121.0	1,433.4	701.5	(15.7)	1,110.0	879.0	(341.8)	174.7	511.5	191.1	953.2	534.4
18	826.5	158.0	1,344.1	630.3	(15.3)	1,035.2	822.8	(372.0)	277.7	431.5	84.3	886.8	509.1
19	(480.8)	(710.8)	(266.1)	(411.8)	(566.5)	10.2	(18.6)	(683.8)	(87.1)	(129.3)	(1,089.1)	84.1	(362.5)
20	745.4	66.6	1,210.0	579.3	(64.8)	980.6	769.6	(404.1)	186.3	379.8	(9.1)	838.8	439.9
21	(112.4)	(170.3)	593.1	(408.0)	(535.0)	1,310.3	275.4	(920.9)	1,178.5	(118.1)	(1,083.2)	(40.6)	(2.6)
22	(263.9)	(76.6)	(265.2)	(303.9)	(588.0)	(52.5)	9.3	(791.9)	(111.8)	(100.2)	(991.9)	(26.8)	(296.9)
23	(194.4)	(343.9)	(266.5)	(360.4)	(564.4)	(55.4)	(28.6)	(800.3)	(199.1)	(28.6)	(955.1)	56.2	(311.7)
24	(403.4)	(31.9)	3.6	(379.7)	(532.7)	(51.6)	(90.8)	(920.4)	(314.3)	(118.5)	(903.5)	(37.7)	(315.1)

Section	Type	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12
14	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-1.53	-1.33	11.69	-5.26	-0.26	-1.74	-1.24	-2.55	0.34	-0.94	1.77	0.36
15	B	0.42	0.08	0.75	0.46	-0.01	0.67	0.53	-0.18	0.10	0.31	0.10	0.56
	R	-1.53	-1.33	11.69	-5.26	-0.26	-1.74	-1.24	-2.55	0.34	-0.94	1.77	0.36
16	B	0.42	0.06	0.69	0.42	-0.03	0.63	0.49	-0.20	0.09	0.29	0.06	0.52
	R	7.80	4.57	11.73	-5.53	2.09	-2.19	-1.24	-2.23	9.41	-4.31	-0.97	-0.30
17	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.39	-6.02	-2.67	-4.55	-0.71	1.15	1.50	14.29	10.77	-7.78	-8.18	6.34
18	B	0.46	0.04	0.66	0.39	-0.04	0.60	0.47	-0.21	0.08	0.28	0.03	0.50
	R	-2.57	0.25	6.45	-5.96	0.11	-2.83	-2.35	-2.87	4.07	-6.44	-4.37	-1.00
19	B	-0.04	-0.05	0.37	-0.20	-0.29	0.80	0.19	-0.50	0.74	-0.01	-0.57	0.00
	R	-2.91	-5.71	-2.57	-4.93	-2.82	-3.35	-3.73	-4.76	-5.98	-7.54	-7.76	-2.53
20	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	13.04	39.10	-2.61	3.13	-2.23	-3.31	3.49	6.60	9.02	-5.71	-1.27	-1.55
21	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	17.99	20.09	-2.69	-0.89	-0.55	-3.52	0.79	6.00	2.81	-0.62	1.35	4.35
21*	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	3.12	42.28	16.52	-2.26	1.70	-3.25	-3.63	-2.55	-5.39	-7.02	5.02	-2.33

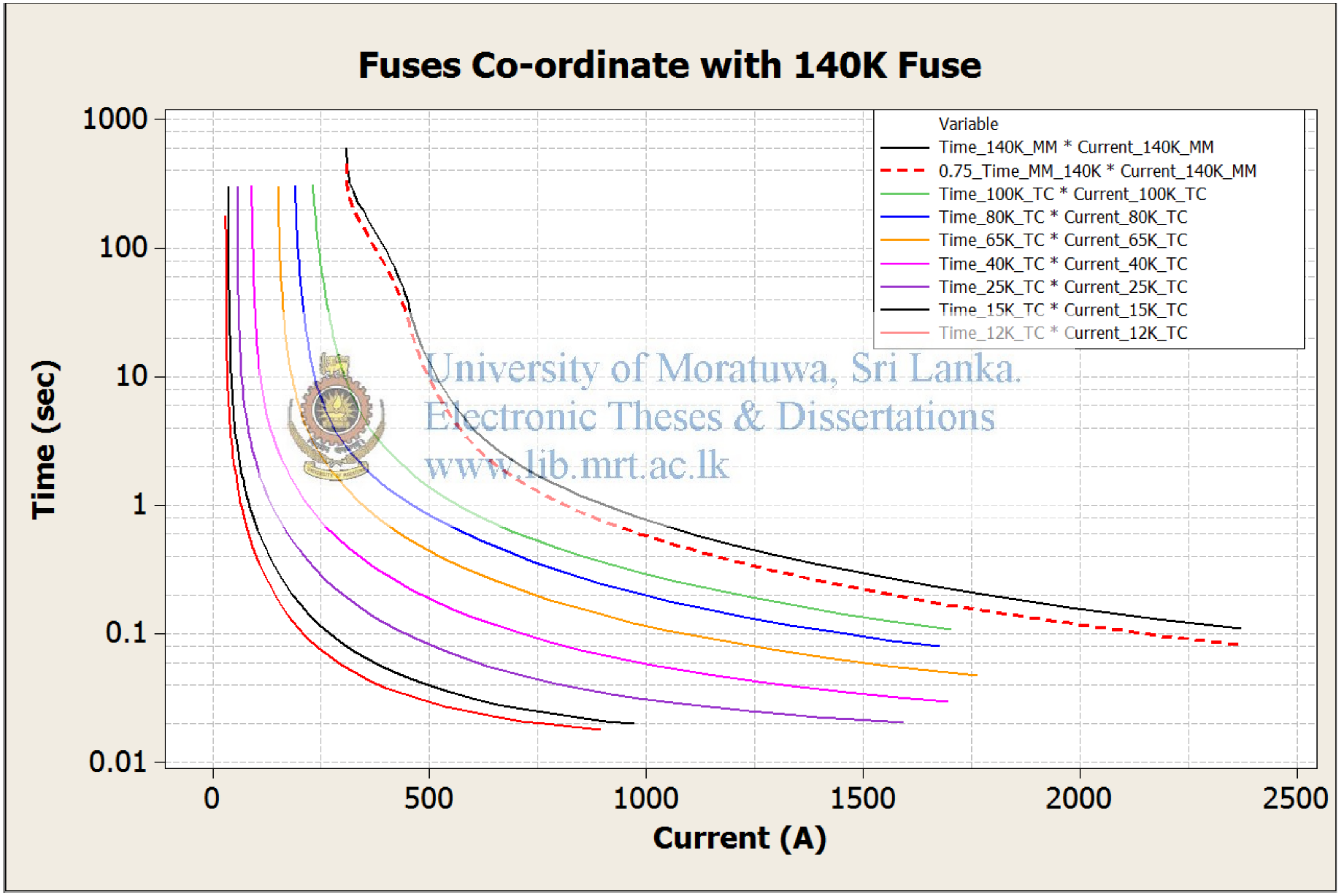
25	(196.0)	(341.0)	(264.2)	(360.6)	(564.2)	(55.4)	(29.2)	(801.3)	(200.1)	(29.4)	(954.7)	55.5	(311.7)
26	(269.5)	(176.6)	(152.5)	(363.1)	(541.7)	(57.6)	(52.8)	(829.2)	(165.1)	(60.9)	(806.6)	26.1	(287.4)
27	473.4	204.2	1,006.1	109.3	(265.9)	1,176.1	554.6	(601.9)	799.4	148.7	(419.4)	442.6	302.3
28	(380.6)	(646.1)	(266.4)	(346.4)	(525.5)	(49.3)	(89.6)	(610.5)	(92.1)	475.0	(786.2)	(32.2)	(279.1)
29	(377.2)	(658.2)	(149.3)	(366.3)	(519.2)	(52.2)	(93.5)	(707.4)	(181.1)	397.9	(874.5)	(35.0)	(301.3)
30	473.1	168.8	1,024.9	114.0	(255.7)	1,180.7	547.4	(549.8)	813.0	273.2	(397.6)	437.3	319.1
31	454.5	140.1	1,015.0	94.0	(268.1)	1,166.9	574.5	(569.3)	786.9	240.3	(421.3)	426.9	303.4
32	445.5	144.7	1,030.7	94.2	(267.3)	1,194.3	578.9	(561.0)	801.9	227.5	(429.2)	433.9	307.8
33	449.0	131.2	1,024.2	85.5	(269.6)	1,191.5	572.2	(564.1)	832.8	215.8	(437.9)	430.4	305.1
34	442.0	106.5	1,005.1	67.3	(266.1)	1,171.3	583.3	(578.9)	823.4	191.8	(456.1)	421.0	292.5

22	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	17.88	20.29	-2.53	-0.90	-0.54	-3.52	0.75	5.93	2.74	-0.68	1.38	4.30
23	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	12.65	31.99	5.42	-1.08	1.06	-3.67	-0.93	3.94	5.22	-2.92	11.92	2.21
23*	B	0.21	0.00	0.54	0.11	-0.16	0.72	0.34	-0.35	0.43	0.14	-0.26	0.26
	R	8.56	14.04	6.76	-4.97	0.42	-3.74	-2.19	-0.15	5.15	-6.30	1.74	0.31
24	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	4.75	-1.42	-2.69	0.10	2.21	-3.08	-3.54	19.50	10.42	35.21	13.37	-1.94
25	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	4.98	-2.28	5.64	-1.31	2.66	-3.29	-3.82	12.61	4.09	29.72	7.08	-2.13
25*	B	0.21	0.01	0.54	0.11	-0.16	0.73	0.35	-0.35	0.43	0.14	-0.26	0.26
	R	8.54	11.03	7.23	-5.04	0.92	-4.35	-3.19	3.33	5.38	2.35	2.88	-0.40
26	B	0.21	0.00	0.54	0.11	-0.16	0.72	0.34	-0.35	0.43	0.14	-0.26	0.26
	R	7.22	9.48	7.40	-6.06	0.26	-4.40	-0.78	2.16	4.26	0.21	1.60	-0.80
27	B	0.21	0.01	0.55	0.11	-0.16	0.74	0.35	-0.35	0.44	0.14	-0.25	0.26
	R	6.58	8.83	6.77	-6.86	-0.12	-4.33	-1.42	2.32	3.85	-1.09	0.23	-0.99
28	B	0.21	0.01	0.55	0.11	-0.16	0.74	0.35	-0.35	0.44	0.14	-0.25	0.26
	R	6.82	7.87	6.31	-7.47	-0.29	-4.53	-1.90	2.10	6.05	-1.93	-0.39	-1.24
29	B	0.21	0.01	0.54	0.11	-0.16	0.73	0.35	-0.35	0.43	0.14	-0.26	0.26
	R	6.32	6.59	5.82	-8.36	0.18	-5.02	-0.63	1.26	6.12	-3.44	-1.28	-1.56

Section	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12	Avg
35	(485)	(640)	(263)	(413)	(472)	113	(6)	(952)	(243)	988	(1,079)	(29)	(290)
36	(485)	(615)	(239)	(414)	(490)	68	(13)	(950)	(281)	560	(1,082)	(30)	(331)
37	(488)	(646)	(263)	(417)	(588)	148	(67)	(951)	(320)	223	(1,076)	(41)	(374)
38	(488)	(644)	(232)	(417)	(588)	59	(13)	(946)	(320)	182	(1,076)	(31)	(376)
39	(489)	(649)	(251)	(418)	(589)	100	(46)	(950)	(321)	188	(1,077)	(37)	(378)
40	(490)	(650)	(246)	(420)	(586)	194	(30)	(946)	(270)	448	(992)	(34)	(335)
41	(490)	(642)	(245)	(420)	(553)	143	(27)	(950)	(278)	475	(1,030)	(34)	(337)
42	(489)	(649)	(265)	(417)	(519)	36	(54)	(912)	(318)	(129)	(1,047)	56	(392)
43	(492)	(648)	(257)	(425)	(538)	133	(53)	(930)	(279)	201	(1,026)	19	(358)
44	(489)	(642)	(255)	(399)	(585)	116	34	(919)	(238)	(112)	(1,068)	249	(359)
45	(488)	(646)	(259)	(423)	(549)	144	(26)	(930)	(269)	133	(1,041)	92	(355)
46	1,120	148	210	453	(90)	1,150	272	441	532	397	(403)	1,511	479
47	494	227	226	466	(32)	1,373	346	493	604	666	(346)	1,677	516
48	110	502	420	288	57	1,550	1,008	218	410	844	(435)	1,499	539
49	107	486	412	277	52	1,507	986	198	391	823	(453)	1,467	521
50	401	(168)	115	89	464	833	1,111	(239)	1,070	919	(577)	1,020	420
51	155	298	320	232	222	1,327	1,051	131	681	1,021	(428)	1,355	530

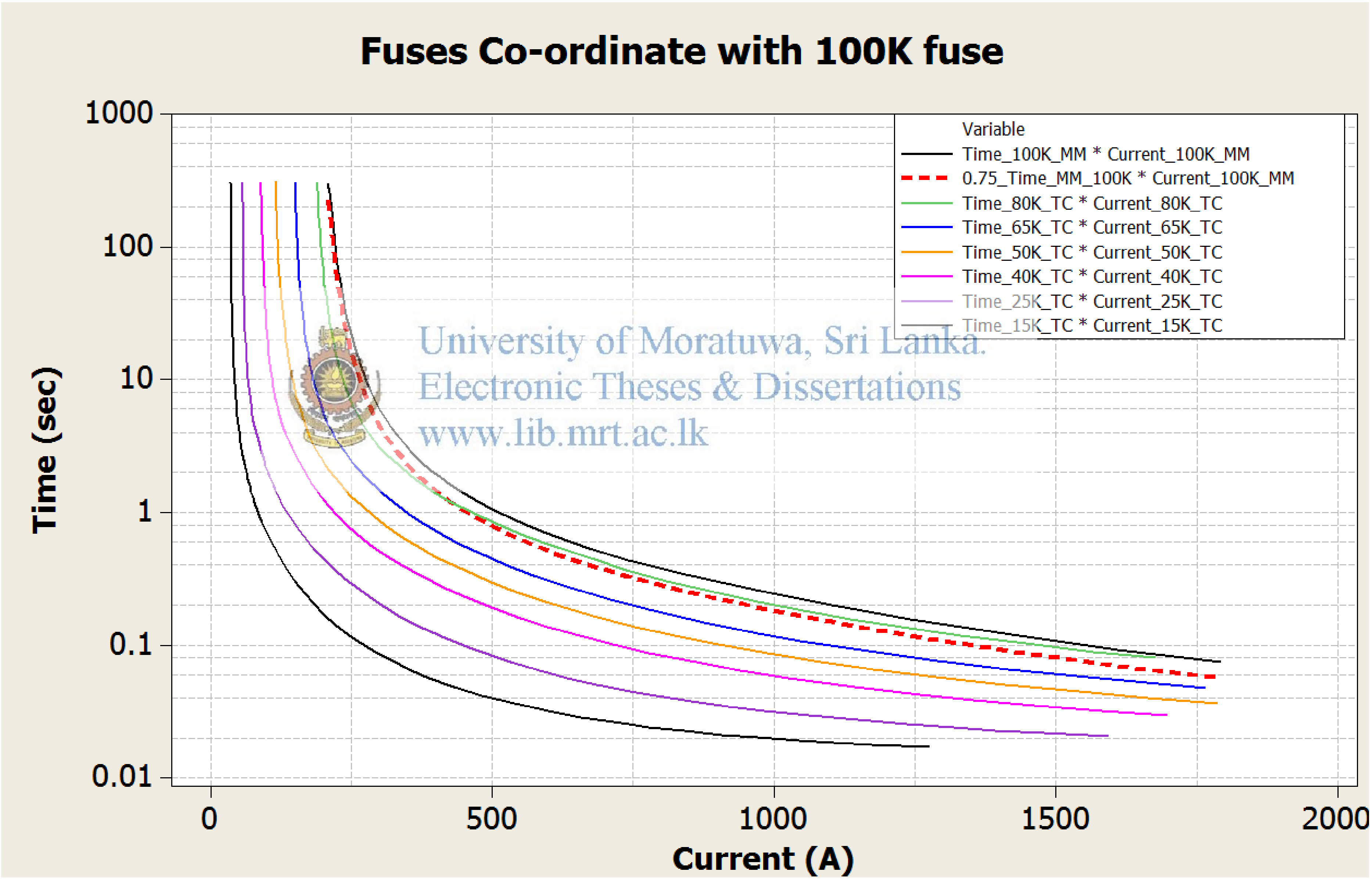
Section	Type	Feb-13	Jan-13	Dec-12	Nov-12	Oct-12	Sep-12	Aug-12	Jul-12	Jun-12	May-12	Apr-12	Mar-12
30	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.66	-1.01	-2.48	-4.62	5.99	8.49	2.42	-4.83	-0.32	71.67	-7.46	-1.74
31	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.69	0.77	-0.71	-4.68	4.76	5.27	1.89	-4.63	-3.03	41.26	-7.69	-1.76
32	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.92	-1.39	-2.47	-4.93	-2.23	10.97	-1.93	-4.69	-5.81	17.31	-7.25	-2.54
32*	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.92	-1.25	-0.23	-4.91	-2.20	4.59	1.90	-4.40	-5.79	14.40	-7.22	-1.86
33	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.94	-1.60	-1.57	-4.97	-2.27	7.56	-0.46	-4.62	-5.87	14.78	-7.33	-2.28
34	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-3.03	-1.71	-1.26	-5.10	-2.06	14.24	0.67	-4.39	-2.27	33.28	-1.27	-2.07
35	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-3.01	-1.09	-1.18	-5.14	0.28	10.61	0.90	-4.66	-2.83	35.24	-3.98	-2.06
36	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.98	-1.63	-2.61	-4.95	2.69	3.02	-1.04	-1.94	-5.64	-7.74	-5.20	4.35
37	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-3.15	-1.54	-2.04	-5.46	1.29	9.85	-0.93	-3.26	-2.87	15.70	-3.68	1.71
38	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.98	-1.10	-1.87	-3.65	-2.00	8.66	5.27	-2.47	0.02	-6.53	-6.68	18.05
40	B	-0.26	-0.37	-0.13	-0.20	-0.33	0.00	-0.02	-0.52	-0.14	-0.01	-0.57	0.00
	R	-2.92	-1.41	-2.14	-5.37	0.51	10.65	0.95	-3.24	-2.14	10.86	-4.77	6.91
41	B	0.68	0.13	0.14	0.31	-0.03	0.70	0.19	0.30	0.36	0.30	-0.17	0.91
	R	-2.91	-5.71	-2.57	-4.93	-2.82	-3.35	-3.73	-4.76	-5.98	-7.54	-7.76	-2.53
42	B	0.31	0.15	0.15	0.32	-0.02	0.72	0.20	0.32	0.37	0.30	-0.16	0.93
	R	-2.98	-1.41	-2.14	-5.37	0.51	10.65	0.95	-3.24	-2.14	10.86	-4.77	6.91
43	B	0.09	0.31	0.26	0.21	0.03	0.82	0.58	0.15	0.26	0.41	-0.22	0.82
	R	-2.98	-1.41	-2.14	-5.37	0.51	10.65	0.95	-3.24	-2.14	10.86	-4.77	6.91
44	B	0.09	0.30	0.26	0.21	0.03	0.81	0.58	0.15	0.25	0.40	-0.22	0.81
	R	-3.17	-1.70	-2.20	-5.66	0.64	8.65	0.11	-3.78	-3.00	9.91	-5.60	5.67
45	B	0.26	-0.05	0.09	0.09	0.30	0.52	0.68	-0.10	0.68	0.60	-0.27	0.62
	R	-2.91	-5.71	-2.57	-4.93	-2.82	-3.35	-3.73	-4.76	-5.98	-7.54	-7.76	-2.53
46	B	0.11	0.19	0.21	0.18	0.12	0.72	0.62	0.07	0.40	0.48	-0.23	0.76
	R	-2.24	-1.72	-2.36	-4.74	0.95	6.64	-0.60	0.54	-0.54	15.00	-2.16	4.37

Annex 4.1

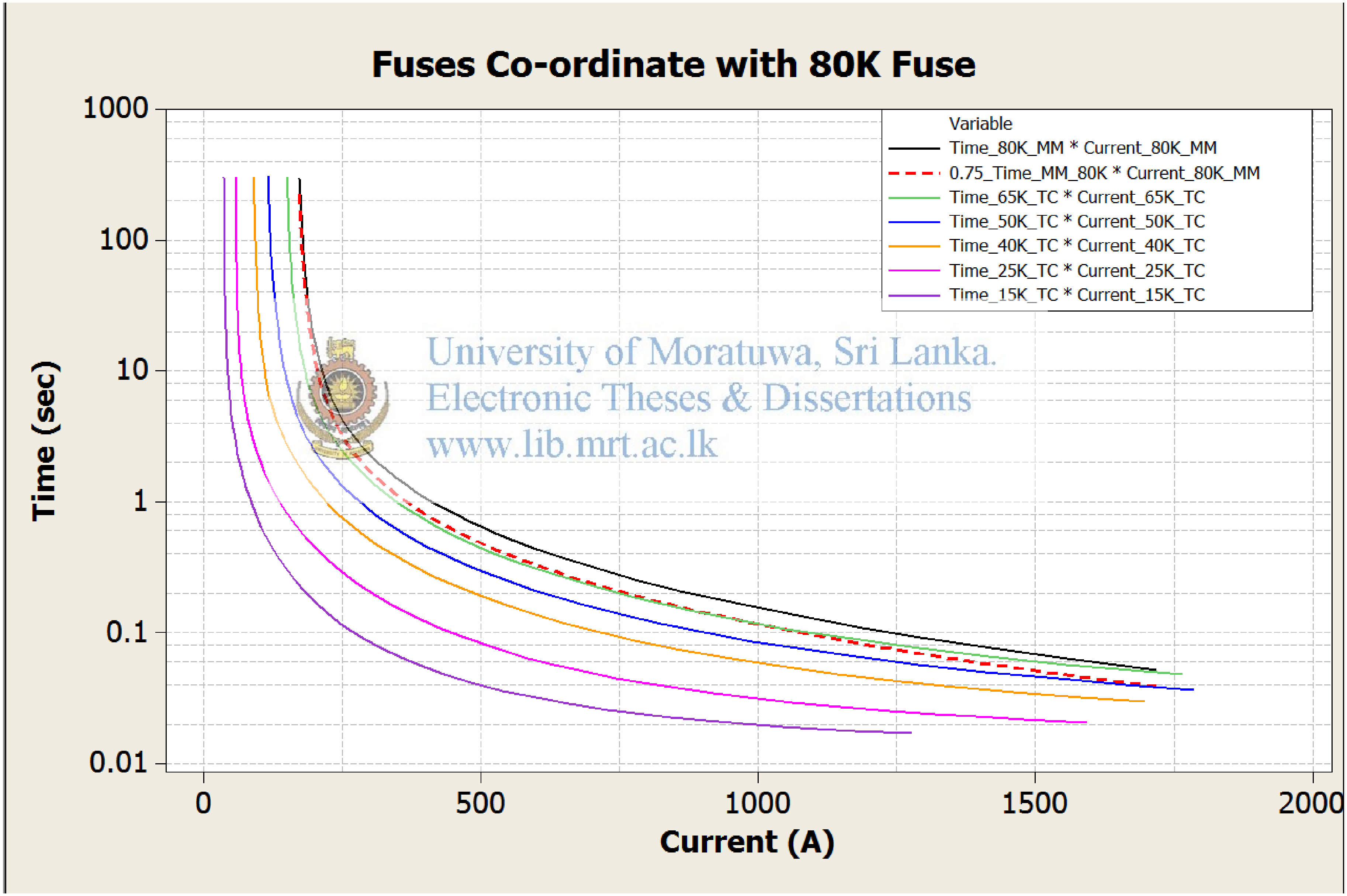


Fuses Co-ordinate with 140K Fuse
Time (sec)
1000
100
10
1
0.1
0.01
0
500
1000
1500
2000
2500
Current (A)
Variable
Time_140K_MM * Current_140K_MM
0.75_Time_MM_140K * Current_140K_MM
Time_100K_TC * Current_100K_TC
Time_80K_TC * Current_80K_TC
Time_65K_TC * Current_65K_TC
Time_40K_TC * Current_40K_TC
Time_25K_TC * Current_25K_TC
Time_15K_TC * Current_15K_TC
Time_12K_TC * Current_12K_TC

Annex 4.2

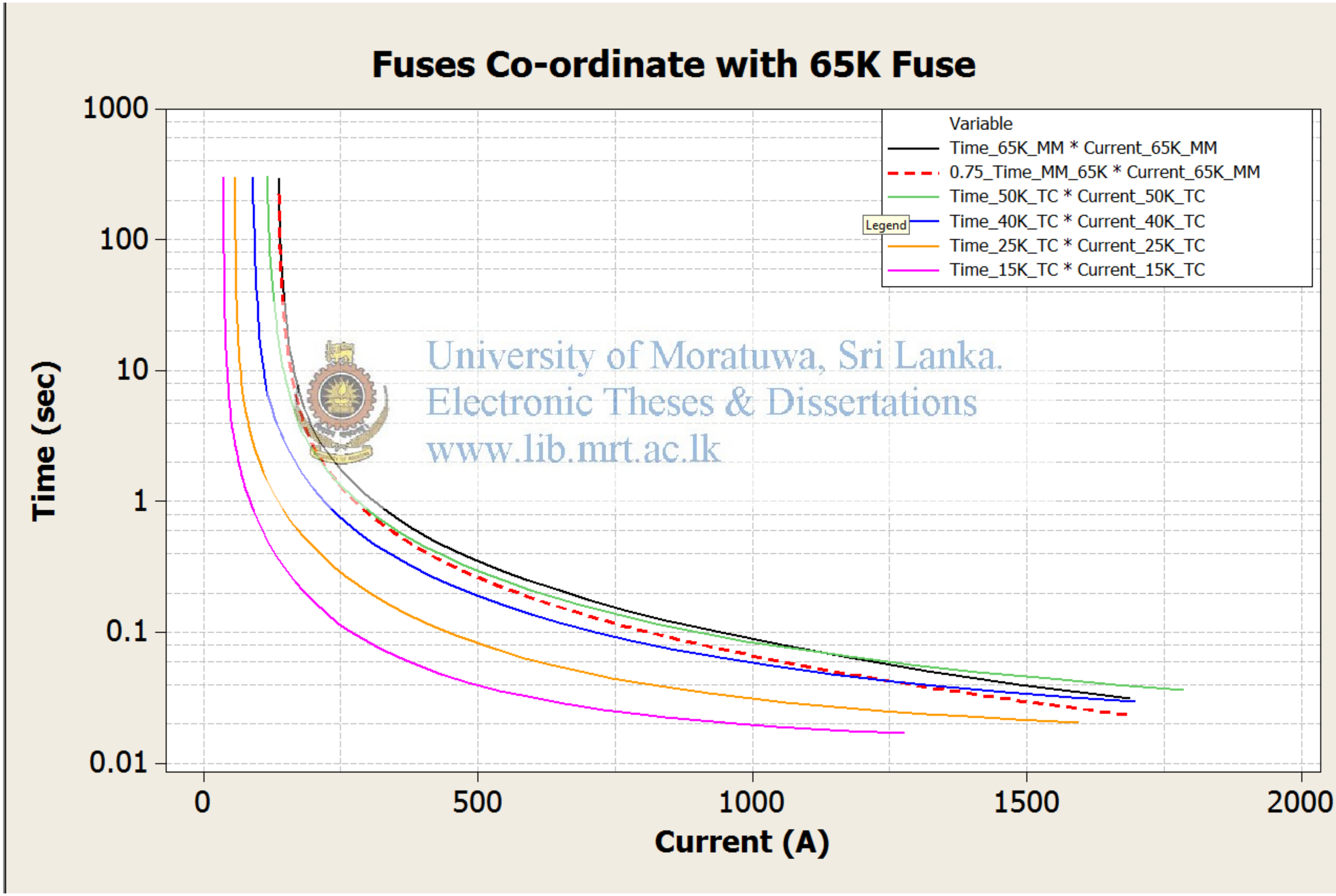

Fuses Co-ordinate with 100K fuse
Time (sec)
1000
100
10
1
0.1
0.01
0
500
1000
1500
2000
Current (A)
Variable
Time_100K_MM * Current_100K_MM
0.75_Time_MM_100K * Current_100K_MM
Time_80K_TC * Current_80K_TC
Time_65K_TC * Current_65K_TC
Time_50K_TC * Current_50K_TC
Time_40K_TC * Current_40K_TC
Time_25K_TC * Current_25K_TC
Time_15K_TC * Current_15K_TC

Annex 4.3



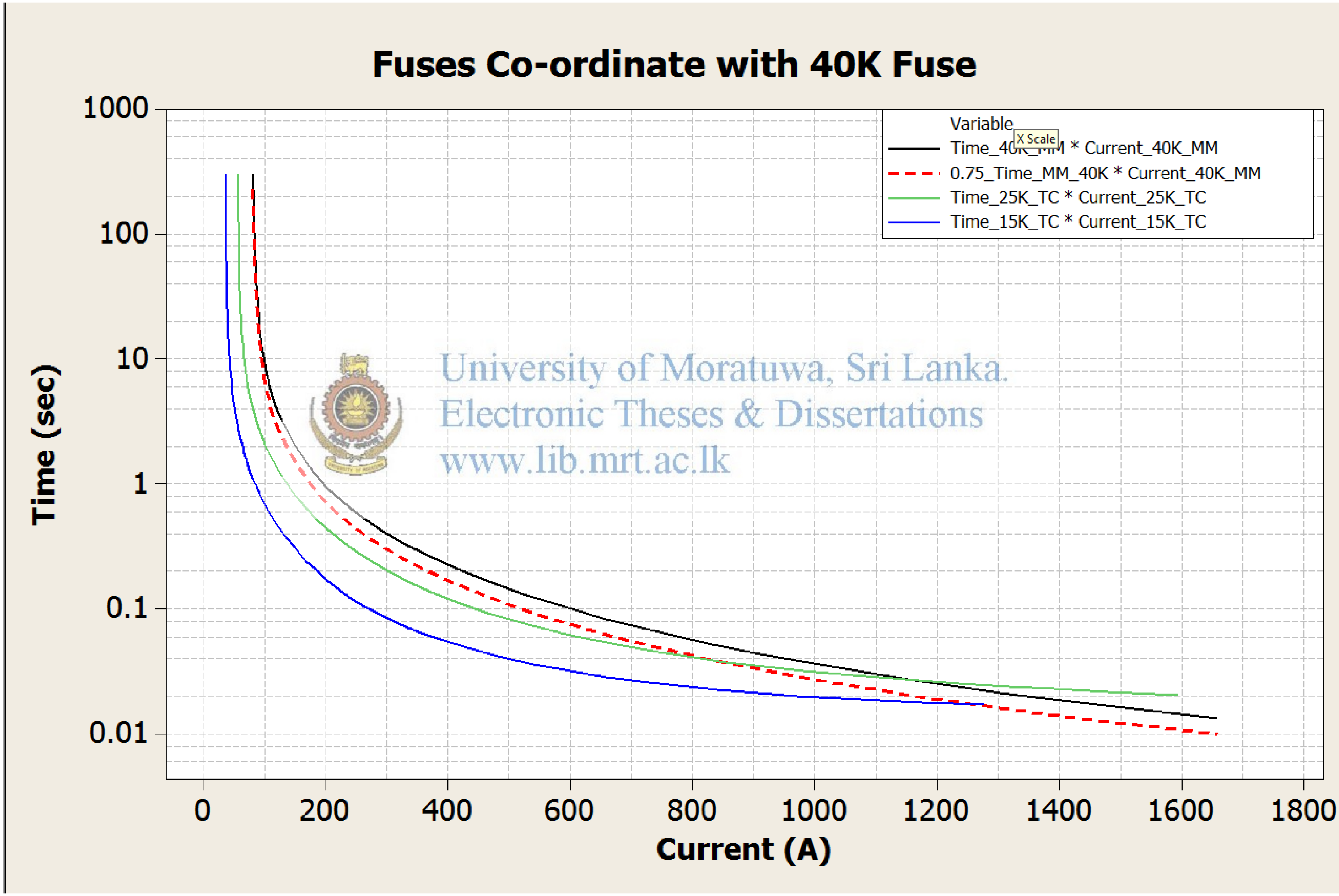
Fuses Co-ordinate with 80K Fuse
Time (sec)
1000
100
10
1
0.1
0.01
0
500
1000
1500
2000
Current (A)
Variable
Time_80K_MM * Current_80K_MM
0.75_Time_MM_80K * Current_80K_MM
Time_65K_TC * Current_65K_TC
Time_50K_TC * Current_50K_TC
Time_40K_TC * Current_40K_TC
Time_25K_TC * Current_25K_TC
Time_15K_TC * Current_15K_TC

Annex 4.4



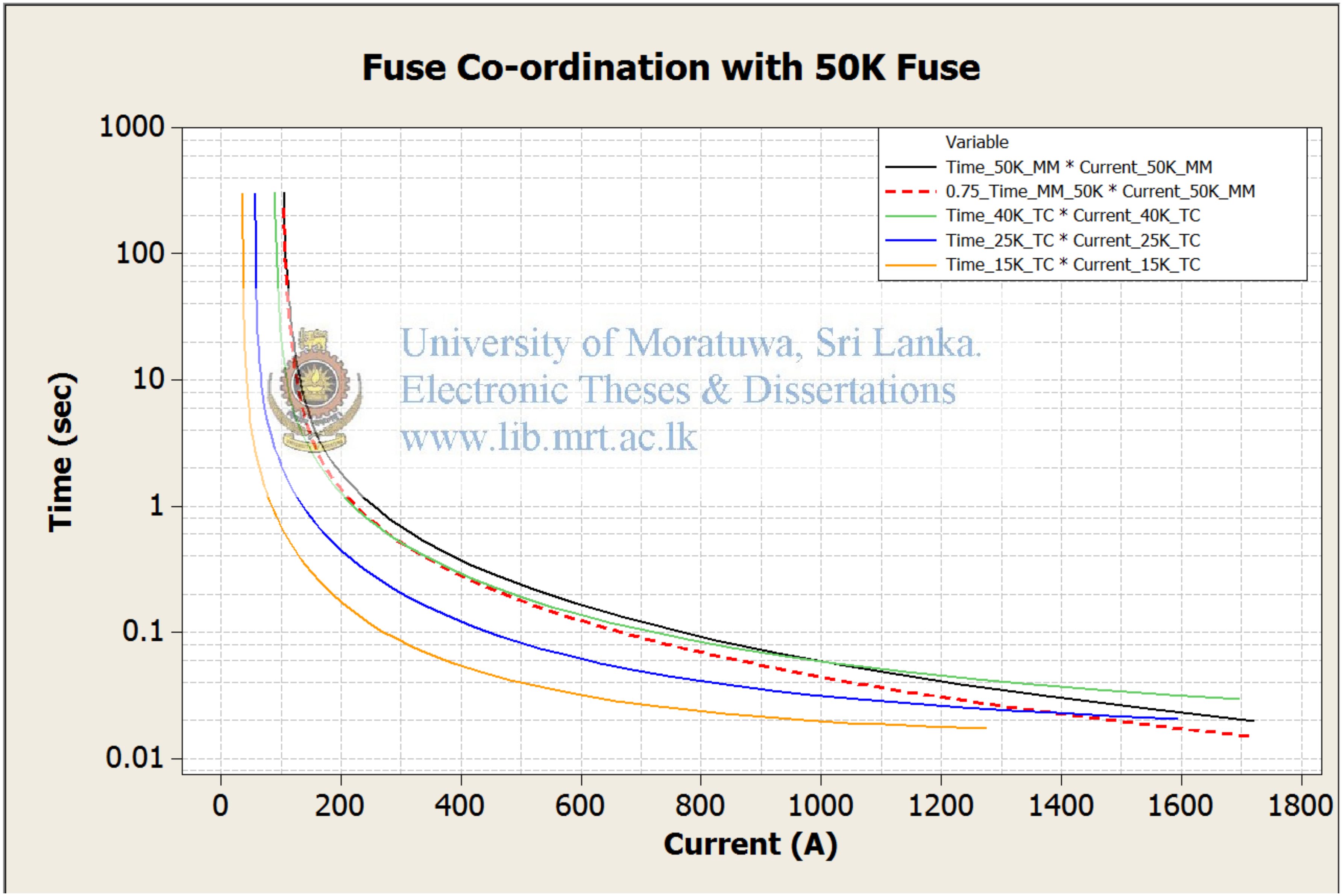
Fuses Co-ordinate with 65K Fuse
Time (sec)
Current (A)
1000
100
10
1
0.1
0.01
0
500
1000
1500
2000
Variable
Time_65K_MM * Current_65K_MM
0.75_Time_MM_65K * Current_65K_MM
Time_50K_TC * Current_50K_TC
Time_40K_TC * Current_40K_TC
Time_25K_TC * Current_25K_TC
Time_15K_TC * Current_15K_TC
Legend

Annex 4.6

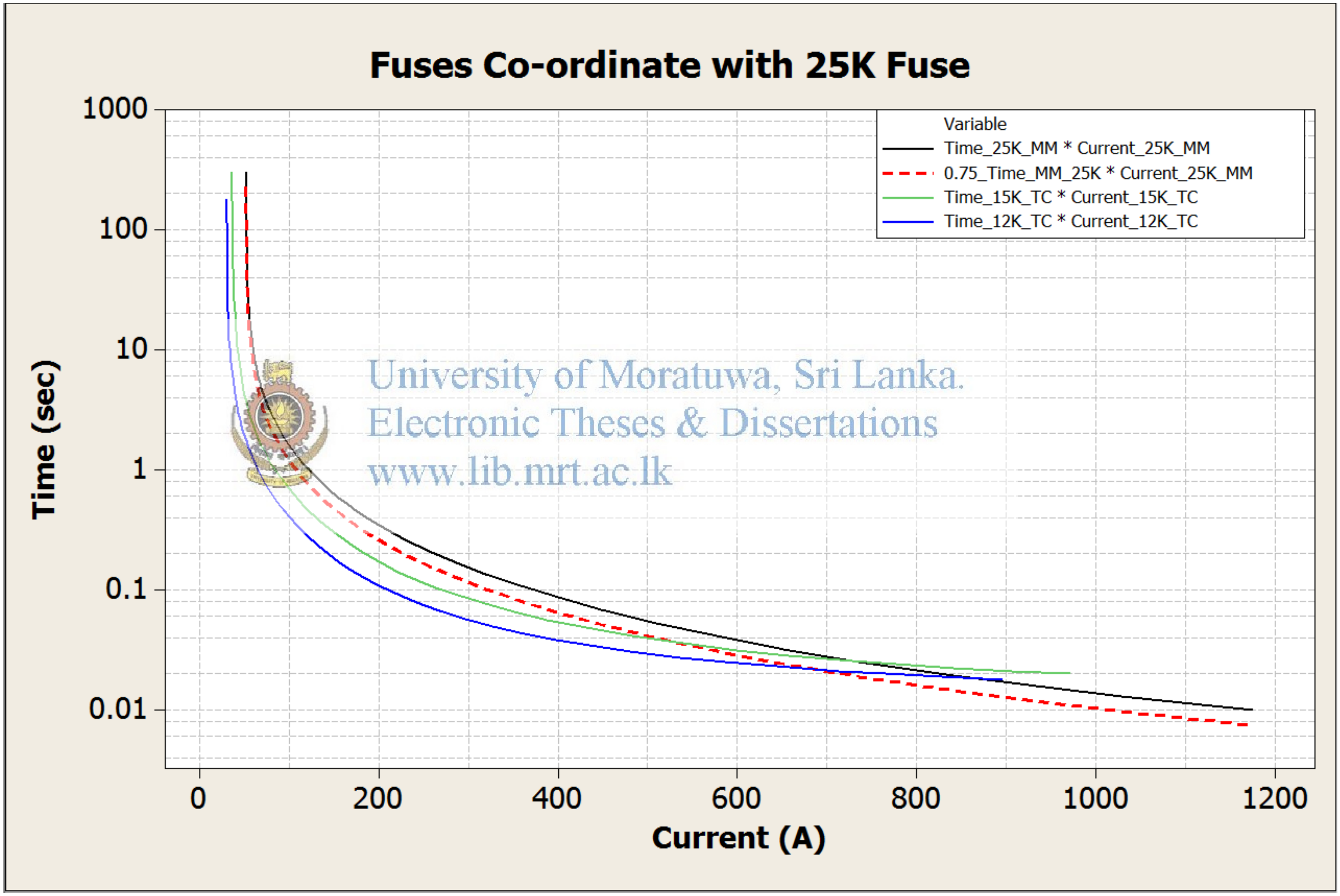


Fuses Co-ordinate with 40K Fuse
Time (sec)
1000
100
10
1
0.1
0.01
Current (A)
0
200
400
600
800
1000
1200
1400
1600
1800
Variable
Time_40K_MM * Current_40K_MM
0.75_Time_MM_40K * Current_40K_MM
Time_25K_TC * Current_25K_TC
Time_15K_TC * Current_15K_TC

Annex 4.5

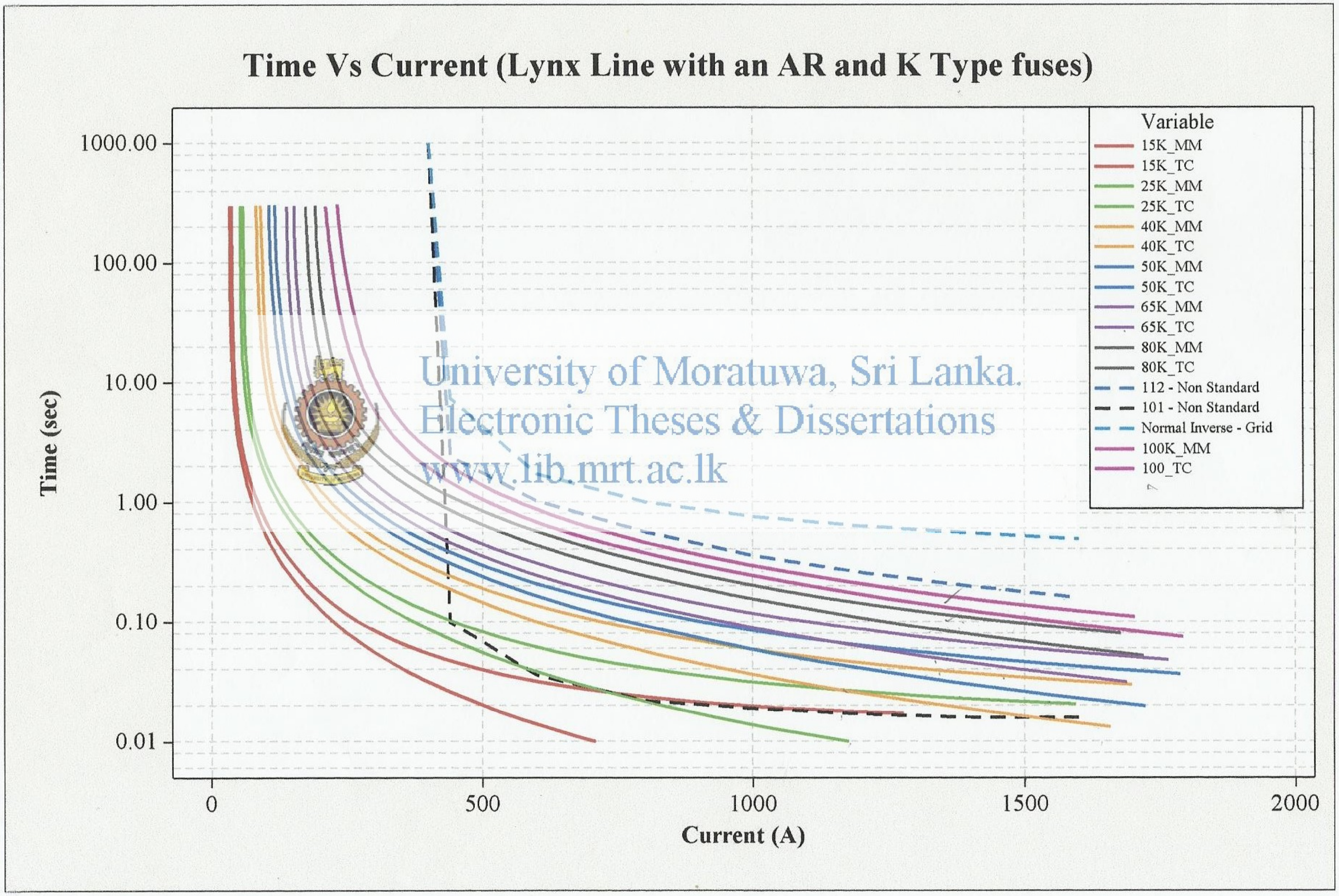

Fuse Co-ordination with 50K Fuse
Time (sec)
1000
100
10
1
0.1
0.01
0
200
400
600
800
1000
1200
1400
1600
1800
Current (A)
Variable
Time_50K_MM * Current_50K_MM
0.75_Time_MM_50K * Current_50K_MM
Time_40K_TC * Current_40K_TC
Time_25K_TC * Current_25K_TC
Time_15K_TC * Current_15K_TC

Annex 4.7



Fuses Co-ordinate with 25K Fuse
1000
100
10
1
0.1
0.01
Time (sec)
0
200
400
600
800
1000
1200
Current (A)
Variable
Time_25K_MM * Current_25K_MM
0.75_Time_MM_25K * Current_25K_MM
Time_15K_TC * Current_15K_TC
Time_12K_TC * Current_12K_TC

Annex 5



Time Vs Current (Lynx Line with an AR and K Type fuses)
Time (sec)
1000.00
100.00
10.00
1.00
0.10
0.01
Current (A)
0
500
1000
1500
2000
Variable
15K_MM
15K_TC
25K_MM
25K_TC
40K_MM
40K_TC
50K_MM
50K_TC
65K_MM
65K_TC
80K_MM
80K_TC
112 - Non Standard
101 - Non Standard
Normal Inverse - Grid
100K_MM
100_TC

Annexure 6 - Temporary Fault percentage of Spur lines

Temporary Fault % of Spurs of Matara Feeder 7		
No	**Name of the Section**	**Temporary fault percentage**
1	Halgahapola spur	90
2	ehelakanda spur	76
3	Gammedagama tapping	80
4	Mawarala spur	78
5	Kudapana tapping	76
6	Rathnayaka tapping	80
7	Pallewela spur	90
8	Danhena Tapping	80
9	Padukkahena spur	80
10	Atapattukanda Tapping	90
11	Ranagala Tapping	80
12	Meepawila Tapping	85
13	Rathkekulawala spur	90
14	Kotahore Tapping	90
15	Gatara Tapping	90
16	Polgahamulla Spur	90
17	Maragoda Spur	90
18	Balakawela Water Pump Tapping	96
19	Yahamulla Tapping	60
20	Nemmahena Tapping	70
21	Pettare Tapping	80
22	Polathugoda Tapping	90
23	Udadamana Tapping	96
24	Masmulla Spur	80
25	Malimboda Tapping	90
26	Vitiyala Tapping	94
27	Miriswatta Tapping	100

Temporary Fault % of Spurs of Galle Feeder 8		
No	**Name of the Section**	**Temporary fault percentage**
1	Timber Corp Spur	0
2	Ukwatta Tapping	90
3	Welipitimodara Tapping	90
4	Wakwella Spur	95
5	Beraliyadolawatta	90
6	Ananda Mw Spur	0
7	Karapitiya Spur	80

Temporary Fault % of Spurs of Ambalagoda Feeder 3		
No	**Name of the Section**	**Temporary fault percentage**
1	Supem Uyana Tapping	100
2	Berathuduwa Spur	94
3	Daluwathumulla Spur	90
4	Manampita Tapping	95
5	Dorala Tapping	100
6	Summercity Tapping	96
7	Thanipolgaha Tapping	95
8	Kuleegoda Tapping	0
9	Galagoda Spur	96
10	Keoline Factory Spur	90