

Prediction of Pore Water-Pressure Using Multiple Linear Regression (MLR)

by

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16364

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CERTIFICATION OF APPROVAL

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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS

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January 2016

CERTIFICATION OF ORIGINALITY

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

FATIN AMIRAH BINTI ABU BAKAR

ABSTRACT

Knowledge of pore water pressure responses to rainfall is required in any project related to slope stability analysis. Multiple Linear Regression (MLR) is an extension of linear regression and can be used to represent the relationship between dependent and independent variables. Multiple Linear Regression (MLR) was employed to develop the MLR model equation for prediction of pore water pressure responses to rainfall. For this purpose, the time series of pore water pressure and rainfall data were obtained and used to develop the MLR model. Total of 1416 data were collected through a field work of a slope in Universiti Teknologi PETRONAS. Data was divided into two groups as 990 for training and 426 for testing of pore water pressure. The input data was analyzed using linear regression and the performance of the MLR model was evaluated by different statistical measures such as the analysis of variance (ANOVA), coefficient of determination (R^2), root mean square error (RMSE) and the coefficient of efficiency (CE). Prediction results showed that MLR model equation has a better performance during training since testing has produced a high value of coefficient of determination, R^2 which is nearly to 1. The result of this study also showed that MLR model equation has performed satisfactorily in predicting linear behaviour of pore water pressure changes to rainfall.

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LIST OF ABBREVIATIONS

MLR – Multiple Linear Regression

ANN – Artificial Neural Network

UTP – Universiti Teknologi PETRONAS

R^2 – Coefficient of Determination

ANOVA - Analysis of Variance

RMSE - Root Mean Square Error

CE - Coefficient of Efficiency

PWP – Pore Water Pressure

df – degree of freedom

CHAPTER 1: INTRODUCTION

1.1 Background

There are many factors that can cause slope failure such as human-induced, climate changes, rainfalls and many more. Rainfall has been known as the main causes to slope failure in many tropical countries (Meen-Wah Gui et al., 2014) while wet and dry climatic conditions can cause variations in soils pore water pressure (Mustafa, Rezaur et al., 2012). Soil pore water pressure is the pressure exerted on its surrounding by water held in pore spaces in soil or rock.

The stability of the slopes are depends on the pore water pressure. There are negative and positive pore water pressure where negative pore water pressure gives additional shear strength to the soil slopes while positive or less negative pore water pressure will decrease the soil shear strength and may trigger slope instability. Therefore, knowledge of soil pore water pressure responses to rainfall variations is very important in this study since it is related to slope stability analysis (Mustafa, Rezaur et al., 2013).

Usually, information of pore water pressure variations responses to rainfall is obtained by field instrumentation programs. However, to collect fresh data is quite challenging and difficult. Moreover, it involved cost, time consuming and resource intensive especially if it involves large scale problems. Therefore, it could be convenient to use knowledge of rainfall and other readily available, associated variables to predicting pore water pressure.

A few studies have been performed to predict various water resources parameters by using Multiple Linear Regression (MLR) such as soil water content (Esmaelnejad, et al., 2015), soil water retention (Merdun, et al., 2006), bearing capacity of circular shallow footings (Orneck, et al., 2012), prediction of pore water pressure for dams (Tadesse, 2014).

1.2 Problem Statement

Information of pore water pressure is needed for this study since it is related to slope stability analysis. Therefore, it would be an advantage if pore water pressure can be predicted from the information of pore water pressure changes responses to rainfall that have been obtained through field instrumentation program which are often costly and time consuming.

Moreover, numerical modeling for estimation or prediction of hydrogeological variables is common in practice and recently has been applied to solve different hydrogeological related issues. Applications of Multiple Linear Regression (MLR) have been used for prediction pore water pressure for dams (Tadesse, 2014). Besides that, radial basis function and multilayer perceptron neural network also has been used for prediction of pore water pressure (Mustafa, Rezaur et. al., 2014).

However, it appears that the aspect of prediction of pore water pressure changes responses to rainfall using MLR has not been examined, probably because pore water pressure changes is said to be a highly non-linear process (Karthikeyan et. al., 2008), nevertheless the use of linear models in predicting pore water pressure should be thoroughly evaluated, as they are generally easier to implement. Therefore, the MLR modeling has been chosen for the prediction of pore water pressure changes responses to rainfall data.

1.3 Objectives

The main aim of this study is to predict pore water pressure changes in responses to rainfall by using Multiple Linear Regression with these following specific objectives:

- i) To develop Multiple Linear Regression model for prediction of pore water pressure changes responses to rainfall.
- ii) To evaluate the performance of the MLR model using different statistical measures.
- iii) Evaluate the suitability of Multiple Linear Regression in predicting pore water pressure changes responses to rainfall.

1.4 Scope of Study

This research will focus on evaluating responses of pore water pressure due to rainfall infiltration, at a selected slope in UTP (adjacent to Block 5).

Throughout this project, a certain scope will be followed:

- i) The application of Multiple Linear Regression (MLR) model for predicting pore water pressure variations responses to rainfall will be performed using SPSS software.
- ii) Only pore water pressure response at the depth of 0.6 m will be considered, as responses are more pronounced at shallow levels.
- iii) The performance of the MLR model will be evaluated using analysis of variance (ANOVA), coefficient of determination (R^2), root mean square error (RMSE) and the coefficient of efficiency (CE).

CHAPTER 2: LITERATURE REVIEW

2.1 Multiple Linear Regression

Basically multiple linear regression is a statistical technique and generalization of simple linear regression that represent the relationship between one dependent variable and two or more independent variables. Multiple Linear Regression which also known as predictor is the most common used to describe data and to explain the relationship between one dependent variable and two or more independent variables (Statitics Solutions, n.d.) such as predicting the value of Y for a given values of x_1, x_2, \dots, x_k .

There are four fundamental assumptions are need to be checked which are the errors from the model. The errors are the difference between the predicted value of the dependent variable and the actual value of the dependent variable. The assumptions made are the random x variables from the models are normally distributed and linearly related to y variables. Besides that, the errors from the model have constant variance, the mean of the errors is zero and the independent variables must be uncorrelated.

Besides that, there are 3 major uses for MLR. Firstly, is the analyzing data, second is estimating the model and lastly is validity and usefulness of the model. For the analyzing data, it can be used to analysed the strength of the effect that the independent variables have on a dependent variable. Next, it can be used to forecast effects or impacts of changes.

Multiple linear regression also is an extension of linear regression and can be used to represent the relationship between the dependent variable and some independent variables (Tadesse, 2014). Hence, from the multiple linear regression analysis, it helps to understand how much the dependent variable will change when independent variables change. In addition, MLR can be used for

estimating the model since trends and future value can be predicted from MLR analysis. Model fit also need to be considered when selecting the model for MLR analysis since adding independent variables to a MLR model will always increase its statistical validity.

In a statistical model, when the relationship between the independent variables and the dependent variable are almost linear, the MLR will shows the optimal result. It has been successfully proved that MLR can be used to predict pore water pressure since the multiple regression equation correlation coefficient of R^2 is approximately 1 (Tadesse, 2014). In addition, the prediction of soil water retention also shows that the overall performance of regression was better than Artificial Neural Network (ANN) (Merdun, et al., 2006). According to Mukhlisin & Abd Rahman (2014), they found that MLR has better efficiency in occasion of high stability of data compared to ANN.

Moreover, the differences between regression and ANN were not statically significant and regression performed better than ANN in predicting point and parametric variables of soil hydraulic parameters (Esmaeelnejad et al., 2015). While, Mustafa et al. (2012), they use time series of pore water pressure from one slope during training stage and successfully tested the RBFNN model for the time series data of pore water pressure at different slope. Besides that, Mustafa et al. (2013) also studied about ANN and they compare the performance of four different training algorithms and they suggested that Levenberg-Marquardt (LM) was advantageous due to its fast convergence and automated ability to adjust the learning rate.

Most of this studies were compared the method used by some evaluation criteria to predict the capabilities of both methods and also the capabilities of three methods for some studies. There were a few studies stated the overall performance of regression was better than Artificial Neural Network (ANN). Even though, the performance of regression was better than ANN, ANN produces promising results and it can be utilized by developing or using new

algorithms in future studies (Merdun, et al., 2006). Moreover, ANN seems to be a better model in prediction of pore water pressure. This is because ANN can model non-linear functions and it showed to perform better than MLR (Esmaeelnejad et al., 2015). Besides that, in regression method, hydraulics parameters were predicted one by one using basic soil properties, while in ANN, all dependent parameters are predicted from independent variables simultaneously.

The model performance can be rank as after ANN, MLR had a better accuracy after Rosetta. Even though, Rosetta software is widely used by many scientists for the estimation of soil water retention (SWR) and hydraulic conductivity parameters but MLR seems to performed better than Rosetta when the predictive capabilities of the three methods were compared using selected evaluation criteria (Esmaeelnejad et al., 2015). While, ANN has a better performance because linear regression like MLR is often appropriately used to model non-linear relationship and it is also limited to predict numerical output.

Therefore, in this study, multiple linear regression model was chosen in order to evaluate the suitability of MLR in predicting pore water pressure responses to rainfall since the prediction of pore water pressure seldom give an appropriate result in hydraulic conductivity. Moreover, MLR technique is being used because it is cheapest and easy to predict. Besides that, its correlation testing are using linear relationship and reasonable for us to predict the pore water pressure.

While for data sources, by having a small set of relevant data are much better than using a large and general data sets (Merdun, et al., 2006). Sometimes, by using a large data sometimes may cause such a low performance in predictions also increase the prediction error. A good model is when it has lowest error at RMSE.

CHAPTER 3: METHODOLOGY

3.1 Data Source and Study Area

The data used in this study was obtained from a field work of a slope in Universiti Teknologi PETRONAS (adjacent to block 5). The instruments of the slope were intended to evaluate the rainfall-induced slope failures in that area. Rainfall in that slope was monitored using a tipping bucket rain gauge (*Figure 3.4*) and pore water pressure variations responses to rainfall were monitored by pressure transducers fitted to individual tensiometers for automatic measurements (*Figure 3.3*). In each section of the slope, two tensiometers were installed in different depth (*Figure 3.2*).



Figure 3.1: Location of study area.

The data used in this study were the time series of rainfall and pore water pressure records in 2 month-period (February 1, 2015 to March 31, 2015). During this study, the amount of rainfall is very small due to the climatic change. Therefore, previous available data has been decided to be used in this study. 2 months of data which is February and March has been selected to be used in predicting pore water pressure for this study. Even though months of February and March are not producing a very high amount of rainfall but it seems to have a complete data compared to other months. This might happen because of the instruments error in collecting the data.

A total of 1416 data were taken and being used in this study. The selected data was divided into two parts which is for training data sets (990 data) was

used for training and the rest data set (426 data) was used for testing the predicted pore water pressure. The purpose of training is to develop the MLR model equation as well as to train the MLR model the patterns of pore water pressure variations responses to rainfall. While, the purpose of testing is to predict the pore water pressure responses to rainfall by substituting the data into the MLR model that have been developed. Next, the reliability of the predicted and observed pore water pressure for both training and testing will be evaluated and compared. All simulation was done by regression analysis using SPSS software and the outputs of the MLR model were denormalized before presented later.



Figure 3.2: Two tensiometer were installed in different depths.



Figure 3.3: Pressure transducer fitted at individual tensiometer.



Figure 3.4: Tipping Bucket Rain gauge.

3.2 MLR Model Development

The pore water pressure obtained from analysis result and the actual recorded pore water pressure values at selected depth were used in Multiple Linear Regression (MLR) as input. The input data will be analyzed using multiple linear regressions and the output will be determined. Besides that, multiple linear regression was also an extension of linear regression and was used to represent the relationship between a dependent variable and several independent variables. The major steps involved in developing the MLR model were the selection of input data, normalization of raw data, regression analysis and evaluation criteria for the model performance. These are briefly described below.

3.2.1 Input data selection

It is necessary to select an appropriate input data and determine the variables to be observed. Time series data from February 1, 2015 to March 31, 2015 (2 months) were used for the MLR modeling. Pore water pressure and rainfall data used for this study were at 1 hour intervals. The data periods stated above was selected because it provided most complete time series for the tensiometers compare to other data which contain break in time series record. This may happen because of the malfunction of the instrument or maintenance.

Therefore, they are not use in this study. In addition, only pore water pressure response at depth of 0.6 m will be considered, as responses are more pronounced at shallow levels. The statistics of the data used for modeling and validation of the MLR model are shown in Table 1.

3.2.2 Normalization of raw data

The input of raw data needs to be normalized before proceeding to modeling and validation of MLR. Normalization of data is to ensure fast processing and minimizes prediction error while modeling MLR. The pore water pressure and rainfall data were normalized by transforming the data to the range of 0 – 1 using the equation;

$$a_p = \frac{x_p - x_{min}}{x_{max} - x_{min}} \quad (1)$$

Where a_p = normalized or transformed data set; x_p = original data set that $1 \leq p \leq P$ and P = number of data; and x_{min} , x_{max} = minimum and the maximum value of the original data set, respectively.

3.2.3 Selection of input variables

After normalization data, the input variables need to be selected. A satisfactory prediction results can be obtained by the appropriate selection of the number of input variables to be applied in MLR model. The best correlated pore water pressure were selected as 5 antecedent pore water pressure observations and 2 antecedent rainfall observations which concluded from the correlation analysis (Mustafa, M. R., et al., 2012). Therefore, the changes of pore water pressure responses to rainfall could be modeled with 8 input variables for the development of MLR model. The variation of pore water pressure responses to rainfall was modeled as the pore water pressure at current time u_t is a function of present and two antecedent rainfall

observations (r_t, r_{t-1}, r_{t-2}) and five antecedent pore water pressure observations $(u_t, u_{t-1}, u_{t-2}, u_{t-3}, u_{t-4}, u_{t-5})$. The relationship of this function can be expressed as;

$$u_t = f(r_t, r_{t-1}, r_{t-2}, u_{t-1}, u_{t-2}, u_{t-3}, u_{t-4}, u_{t-5}) \quad (2)$$

The normalized data was divided into training and testing. 70% of the data is trained for predicted pore water pressure. After successful training, the rest of the data (30%) was used to test the prediction pore water pressure. All simulation is done by SPSS software. Outputs of the predicted pore water pressure were denormalized before the model performance's evaluation.

3.2.4 Regression analysis

After estimating the parameters from Eq. (2) the output data variables which are the predicted pore water pressure were obtained from the input variables using regression method. For this multiple linear regression analysis, the predicted pore water pressure was analyzed using SPSS software. The general forms of the regressions equations can be written as follows:

$$u_t = \beta_0 + \beta_1 r_t + \beta_2 r_{t-1} + \beta_3 r_{t-2} + \beta_4 u_{t-1} + \beta_5 u_{t-2} + \beta_6 u_{t-3} + \beta_7 u_{t-4} + \beta_8 u_{t-5} \quad (3)$$

Where u_t is the dependent variable which represent the predicted values of the variations of pore water pressure responses to rainfall, β_0 is the intercept or constant, β_1 until β_8 are regression coefficients, and $r_t, r_{t-1}, r_{t-2}, u_t, u_{t-1}, u_{t-2}, u_{t-3}, u_{t-4}, u_{t-5}$ are the independent variables referring to function of present and two antecedent rainfall observations and five antecedent pore water pressure observations.

The predicted values and the results obtained from the regression analysis were studied after obtaining calibrated MLR coefficients. Then, the results of the equation can be solved by using calibrated MLR coefficients. Furthermore, the predicted values of pore water pressure needs to be denormalized first before the evaluation of the model's performance. Next, the model performance will be evaluated by using different statistical measures.

3.2.5 Evaluation criteria

Usually the common method in evaluating the models is by plotting the observed values against the predicted values the correlation between them such as coefficient of determination, R^2 was used for the model evaluation. Ideally, the relationship between the observed and predicted values should be linear with a slope of unity and intercept of zero.

The accuracy of MLR model equations and the its performance was evaluated using different statistical measures such as the coefficient of determination (R^2), root mean square error (RMSE), the coefficient of efficiency (CE) and analysis of variance (ANOVA), defined as:

$$R^2 = 1 - \frac{\sum_{k=1}^N (u_k - \hat{u}_k)^2}{\sum_{k=1}^N (u_k - \bar{u})^2} \quad (4)$$

$$RMSE = \left[\frac{1}{N} \sum_{k=1}^N (\hat{u}_k - u_k)^2 \right]^{\frac{1}{2}} \quad (5)$$

$$CE = 1 - \frac{\sum_{k=1}^N (\hat{u}_k - u_k)^2}{\sum_{k=1}^N (\hat{u}_k - \bar{\hat{u}})^2} \quad (6)$$

where, \hat{u}_k and u_k are the predicted and observed values, $\bar{\hat{u}}$ is the mean of predicted target values, $\bar{u_k}$ is the mean of observed value u_k , and N is the total number of observations for which the error has been computed. The ideal value for RMSE should be zero and the value of CE and R^2 should be one since a good model and prediction should have lower in RMSE as well as high in R^2 which is approximately to 1. In addition, the analysis of variance (ANOVA) was performed using SPSS software in order to determine whether the coefficient of determination is significant or not.

The accuracy of predicted pore water water pressure was assessed from the trends pattern between measured and predicted data from the data set which develop the MLR model equation. While the reliability of the predicted pore water pressure needs to be assessed from the corresponden between observed and predicted pore water ressure for the data set other than the one use to develop the MLR model equation.

CHAPTER 4: RESULTS AND DISCUSSIONS

The statistics for rainfall and pore water pressure parameters used in the development of MLR modeling using multiple linear regression method are summarized in *Table 4.1*. This data sets consists of number of observation (N), maximum (Max.), minimum (Min.), sample mean (SM), standard deviation (SD), variance (VAR), and skewness (SKEW) for the data sets used in analyzing the data. Data analysis needs to be done before we can proceed to the selection of input data. Therefore, the result of the data analysis has been tabulated in *Table 4.1*.

Table 4.1: *The summary statistics of data set used for MLR modeling.*

Statistics	Training Slope Adjacent to Block 5 UTP (01-02-2015 to 14-03-2015)		Testing Slope Adjacent to Block 5 UTP (14-03-2015 to 31-03-2015)	
	Rainfall	PWP	Rainfall	PWP
N	990	990	426	426
Max.	42.5	-3.6	26.5	-4.1
Min.	0.00	-17.4	0.00	-18.6
SM	0.23	-9.75	0.21	-11.02
SD	2.08	1.93	1.79	2.28
VAR	4.32	3.71	3.19	5.22
SKEW	14.23	-0.01	11.40	0.46

*N = no. of observations; Max. = maximum; Min. = minimum; SM = sample mean; SD = standard deviation; VAR = variance; SKEW = skewness; PWP = pore water pressure; rainfall are in (mm) and pore water pressure are in (kPa).

The rainfall data are based on the daily data. In addition, it is also showed that the number of observation for rainfall and PWP for training are larger compared to testing. Besides that, the number of maximum and minimum of pore water pressure in training are large compare to pore water pressure in testing. However, normalization of data from the data obtain are needed in predicting the pore water pressure.

Besides that, *Table 4.1* also shows that the pore water pressure data used for testing the MLR model has slightly similar variability as the training data (variance of testing PWP = 5.22, against variance of training PWP = 3.71). However, it has larger variability in training than testing rainfall data (variance of training rainfall data = 4.32, variance of testing rainfall 3.19). The performance of prediction of pore water pressure during testing phase could attribute to larger variability in rainfall data used during testing if there is a slightly underperformance of the MLR model.

In addition, *Table 4.2* shows the strength of the relationship between model and dependent variable. The larger value indicates a strong relationship since the multiple correlation coefficient is the linear correlation between the observed and predicted values of the dependent variable. Moreover, coefficient of determination, R^2 is the squared value of the multiple correlation coefficients. It shows about 77.9% of the variation of pore water pressure is explained by the MLR model. Moreover, the standard error of the estimate in the model summary which is 0.066 is significantly small. Furthermore, residual is the difference between the observed and predicted values of the dependent variable.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.882 ^a	.779	.777	.066

Table 4.2: Model Summary.

Next, the generalization ability of the model is appraised by the observation of the model performance measures for both training and testing phases. The performance results for the training and testing were obtained during the development stage of MLR model. Next, the relationship between the measured and simulated result was studied using multiple linear regression method. The results of R^2 and regression coefficients values were obtained by applying the multiple linear regression equation is shown below in *Table 4.2* and *Table 4.3*.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.083	.010		8.222	.000
Rainfall_1hr	.040	.044	.014	.898	.369
Rainfall_ant1	.299	.045	.105	6.637	.000
Rainfall_ant2	.066	.046	.023	1.450	.147
PWP_ant1	.941	.032	.941	29.311	.000
PWP_ant2	.007	.044	.007	.154	.878
PWP_ant3	-.063	.043	-.063	-1.445	.149
PWP_ant4	.022	.043	.022	.508	.612
PWP_ant5	-.061	.031	-.061	-1.956	.051

Table 4.3: Coefficients.

After analyzing the training data using linear regression in SPSS software, the table of coefficients (*Table 4.3*) will be produced and the data coefficients from the table will be substituted into the general MLR model equation eq. (7).

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_{i,2} + \dots + \beta_{p-1} x_{i,p-1} \quad (7)$$

The MLR model equation was formed by substituting the coefficient data and the outcome can be described by the equation below:

$$u_t = 0.083 + 0.040 r_t + 0.299 r_{t-1} + 0.066 r_{t-2} + 0.941 u_{t-1} + 0.007 u_{t-2} + (-0.063) u_{t-3} + 0.022 u_{t-4} + (-0.061) u_{t-5} \quad (8)$$

The function of present and two antecedent rainfall observations and five antecedent pore water pressure observations was used as an input to a Multiple Linear Regression (MLR) analysis. MLR needs its coefficients to determine. Therefore, coefficient of MLR model equation was formed by the linear regression analyzing using SPSS software. Once MLR coefficients are estimated, substitute the MLR coefficients into MLR model equation as shown in Eq. (8).

From this model equation it can be seen that first antecedent of pore water pressure has more strength in predicting the outcome. In addition, the standard error of the predictors is 0.032. While for the t-statistics in *Table 4.3*, first antecedent pore water pressure has a higher t value with a significant value less than 0.05 and it shows the significant contribution to the model.

Moreover, the coefficient and the constant of this MLR model equation can be determined from *Table 4.3*. Therefore, the current or predicted pore water pressure can be determined by substituting the independent variables, $r_t, r_{t-1}, r_{t-2}, u_t, u_{t-1}, u_{t-2}, u_{t-3}, u_{t-4}, u_{t-5}$ referring to function of present and two antecedent rainfall observations and five antecedent pore water pressure observations. The output of predicted pore water pressure by regression analysis needs to be denormalized

before presented in the analysis result of relationship between the observed and trained time series of pore water pressure obtained during training and testing.

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	14.974	8	1.872	429.060	.000 ^b
Residual	4.258	976	.004		
Total	19.232	984			

Table 4.4: ANOVA result.

The ANOVA table is to tests the acceptability of the model from a statistical perspective. In *Table 4.4*, the regression row shows information of the variations considered by the model while the residual row shows information of the variations that are not considered by the model. Next, F-ratio shows a large value (429.060) and the significance value is zero. Moreover, by the addition of pore water pressure, the F-ratio shows an exceedingly large value and highly significant compared to the addition that has no positive correlation (Akinbinu, V. A., 2010). Therefore, ANOVA table is a useful test for the model in explaining the changes in the dependent variable since the relationship strength are not directly been observed.

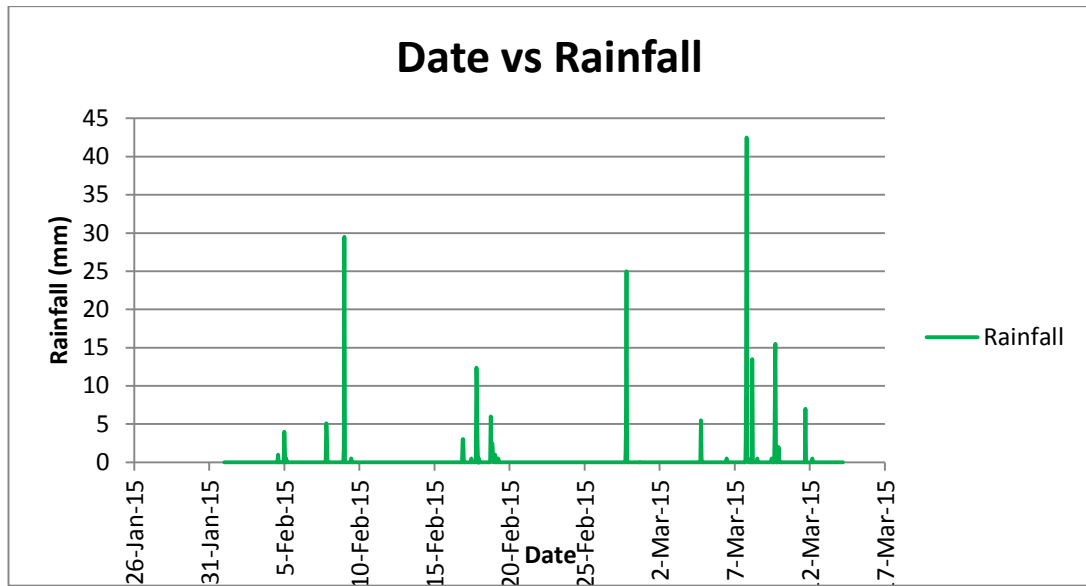


Figure 4.1 Date versus Rainfall Data.

Figure 4.1, shows the amount rainfall data that been used in this study. From the graph, it shows that rainfall data in the month of March having high value of rainfall compared to the month of February. Even though, the condition of rainfall in testing data is not a heavy rainfall but it sufficient enough to be use in predicting pore water pressure since it has a large value of rainfall compared to rainfall data in testing.

Next, *Figure 4.2* shows the corresponding of the observed and trained time series of pore water pressure obtained during training while *Figure 4.3* shows the corresponding of the observed and trained time series of pore water pressure obtained during testing. All data need to be denormalized before the evaluation of model performance. The pattern of predicted and observed pore water pressure during training was almost the same.

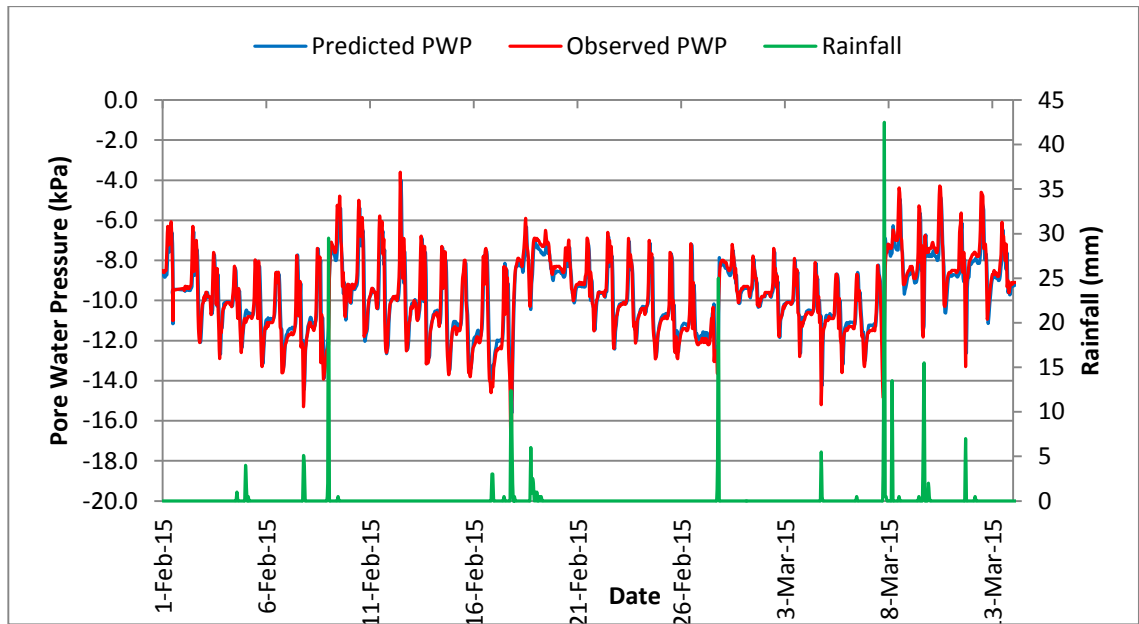


Figure 4.2 Observed and predicted time series of pore water pressures responses to rainfall for Training.

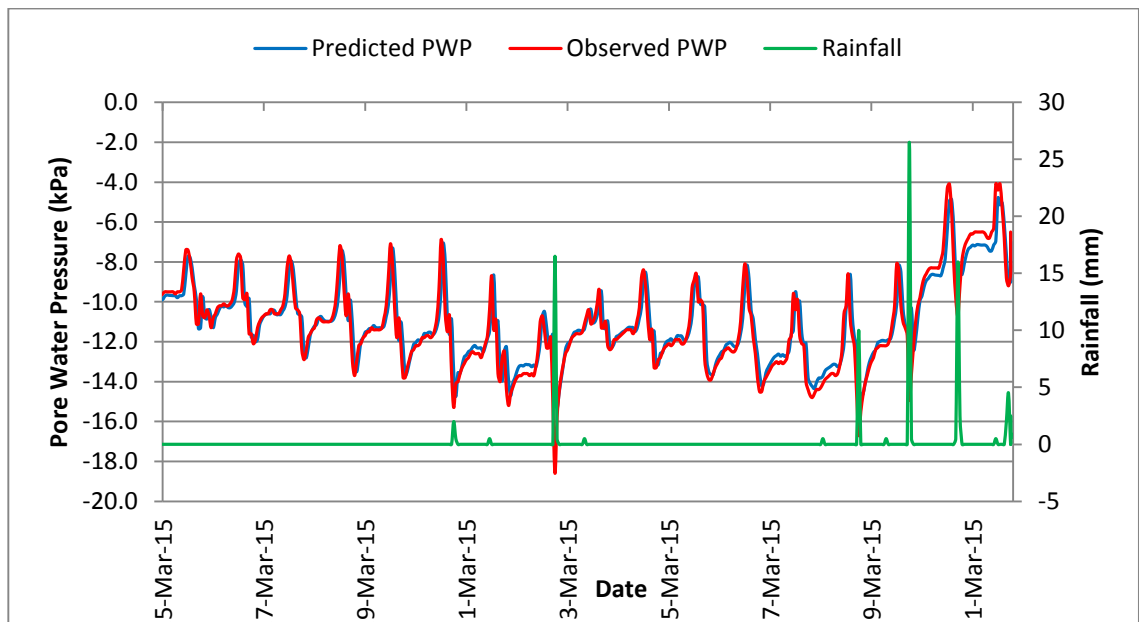


Figure 4.3 Observed and predicted time series of pore water pressures responses to rainfall for Testing.

Based on the observation, it shows that the result from the MLR model is slightly similar pattern as the result obtained from the observed data which is the recorded data from the instrumentation program. Moreover, the results show that the trend pattern in predicted pore water pressure during testing was slightly similar to the trends in observed pore water pressure. The MLR model might learn very well the pattern of pore water pressure during training and could be establish when subjected to other prediction environment.

This might happen because the MLR model has learned the trends of pore water pressure changes responses to rainfall during training very well and could be generalize when subjected to other prediction environment. Besides that, this plot also will help in checking assumption of normality of the error term.

The graphs plotted also showed that the value of pore water pressures are depends on the value of rainfall. The pore water pressures will increase when the value of rainfall increases and vice versa. This is because when there is heavy rainfall, pressure exerted by the water in soil are much higher compared to when there is no or low value of rainfall. When the pore water pressure increase, it will become positive or less negative pore water pressure and this is not really good to the soil slopes because this condition may trigger to slope failure.

The common method to evaluated model is by plotting the observed pore water pressure against the predicted pore water pressure and the correlation between them, coefficient of determination R^2 is used for model evaluation. Preferably, their relationship should be linear with a slope of unity and intercept zero.

Figure 4.4 and Figure 4.5 shows the comparison of the relationship between the predicted pore water pressure with the observed pore water pressure during training and testing. Initially, we need to determine whether the data set fit within the ranges of the tested PWP (*Figure 4.4*). Even though the graph in (*Figure 4.5*) shows that several data sets are fell outside these ranges, the R^2 value is high. This is

because in linear method, the relationship should be linear with a slope of unity and intercept of zero. However, the R^2 was plotted based on the best fitted line.

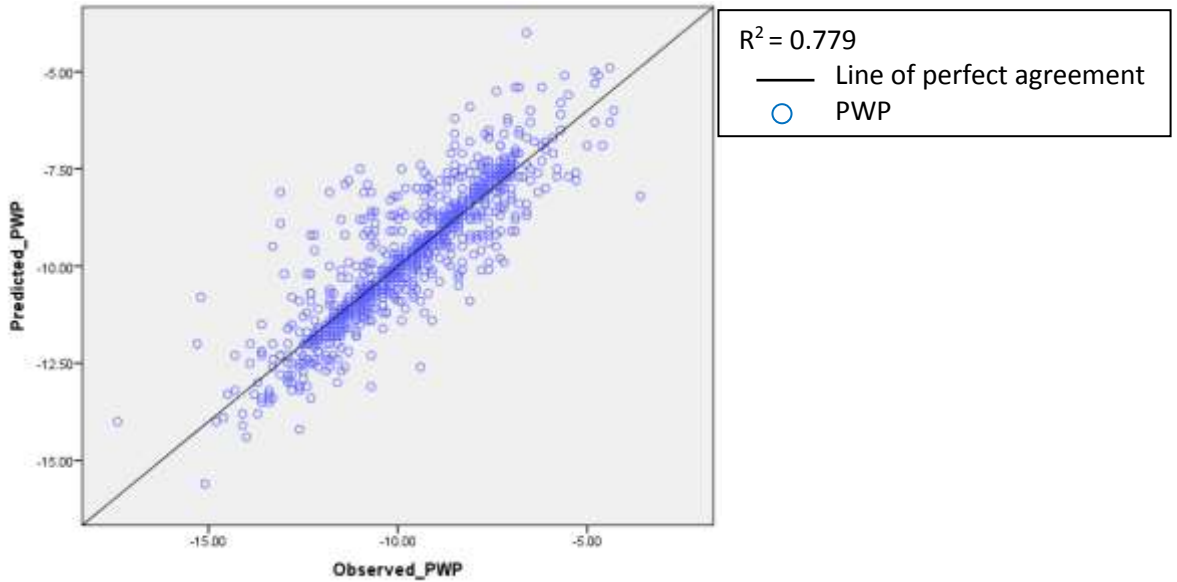


Figure 4.4: Plotting of observed and predicted pore water pressure for Training.

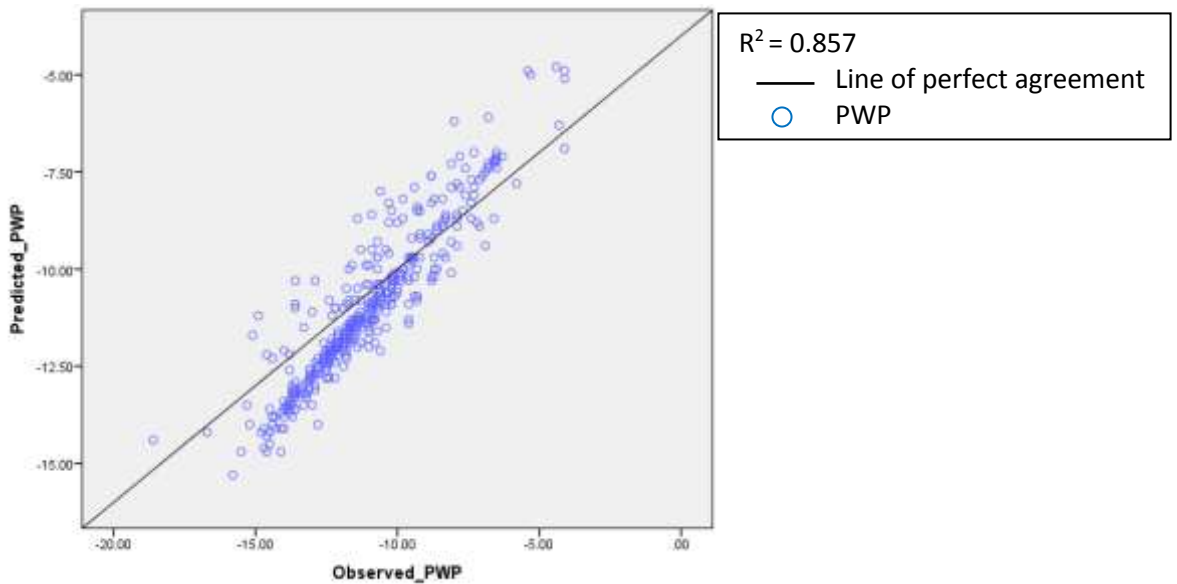


Figure 4.5: Plotting of observed and predicted pore water pressure for Testing.

The coefficient of determination, R^2 between the observed and predicted pore water pressure responses to rainfall for training is 0.779 while for testing is a bit higher which is 0.857. This R^2 is approximately to 1. From both *Figure 4.4* and *Figure 4.5* shows the level of accuracy for training and testing is fairly high with the higher R^2 value and lowest RMSE value. Hence, a good result will produce when the values from the model output is having the same pattern as the result obtained from the instrument readings. Therefore, the results of nearly perfect agreement between the trends in the plot of time series of observed and predicted pore water pressures during training and testing (*Figure 4.2* and *Figure 4.3*). The performance results for the training and testing that obtained during the development stage of the MLR model are shown in *Table 4.5*.

Data Sets	RMSE	R^2	CE
Training	0.905	0.779	0.716
Testing	0.859	0.857	0.807

Table 4.5: Summary of Statistical Performance Measure of The Predictive Model.

A comparison between training and testing performances suggested that testing would perform better than training because it shows a better performance. This is because testing produced lower errors measures at RMSE of 0.859 and higher coefficient of efficiency CE of 0.807 and coefficient of determination R^2 of 0.857 compared to training (*Table 4.5*). Testing seems to have lower RMSE compared to training. This might happen because of the number of observation or maximum and minimum value. From the data analysis, it shows that, training have a large value of number of observation compared to testing. Moreover, training have higher value of maximum and minimum compare to training. This is because by having a large number of data sometimes tend to produce much error compared of having less data or using a small scale area.

CHAPTER 5: PROJECT KEY MILESTONE AND PROJECT TIMELINE

The experimental study is meticulously planned as project timeline and project key milestone as shown in Figure 4.1, Figure 4.2, Figure 4.3 and Figure 4.4 respectively.

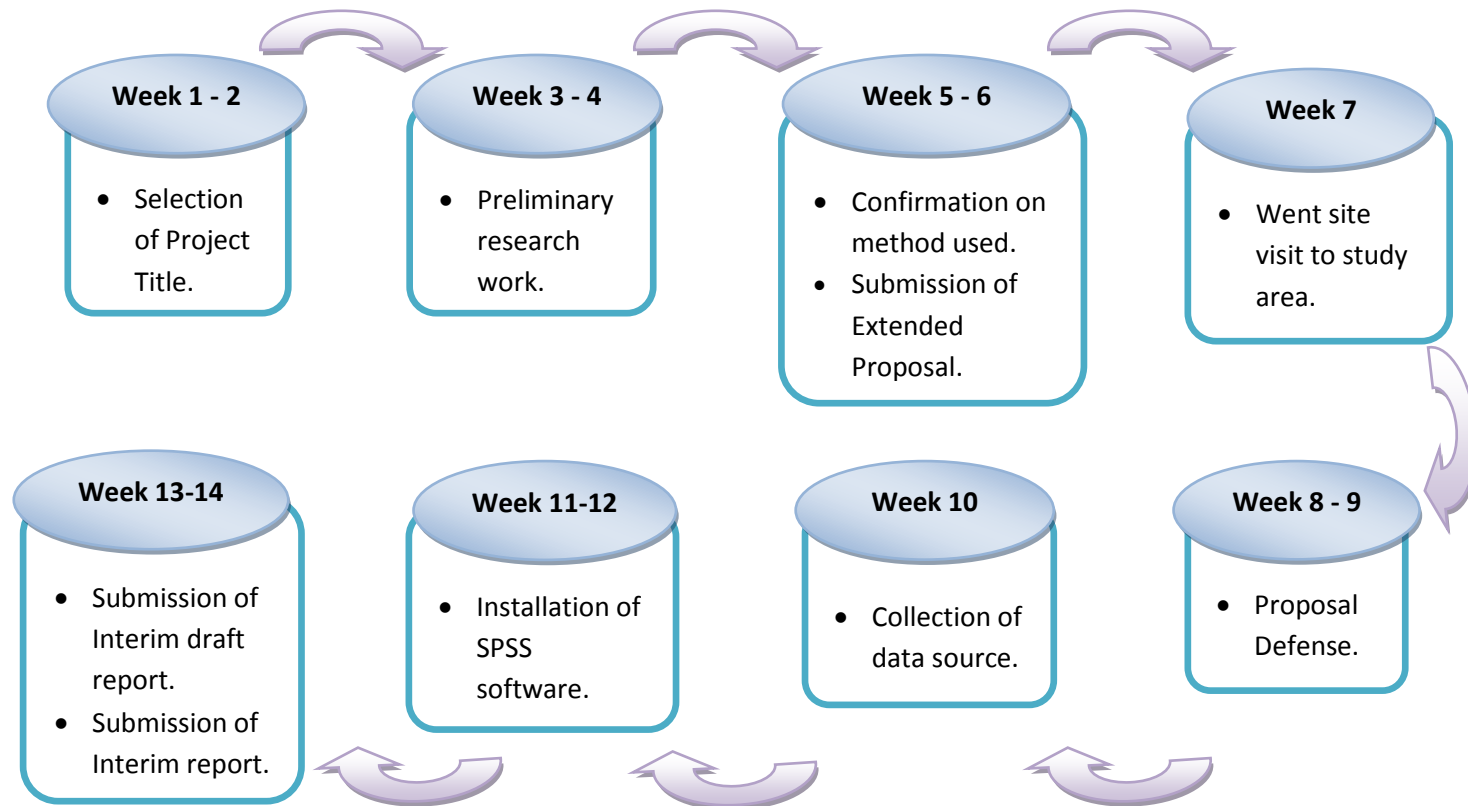


Figure 5.1: Project Timeline (FYP 1)

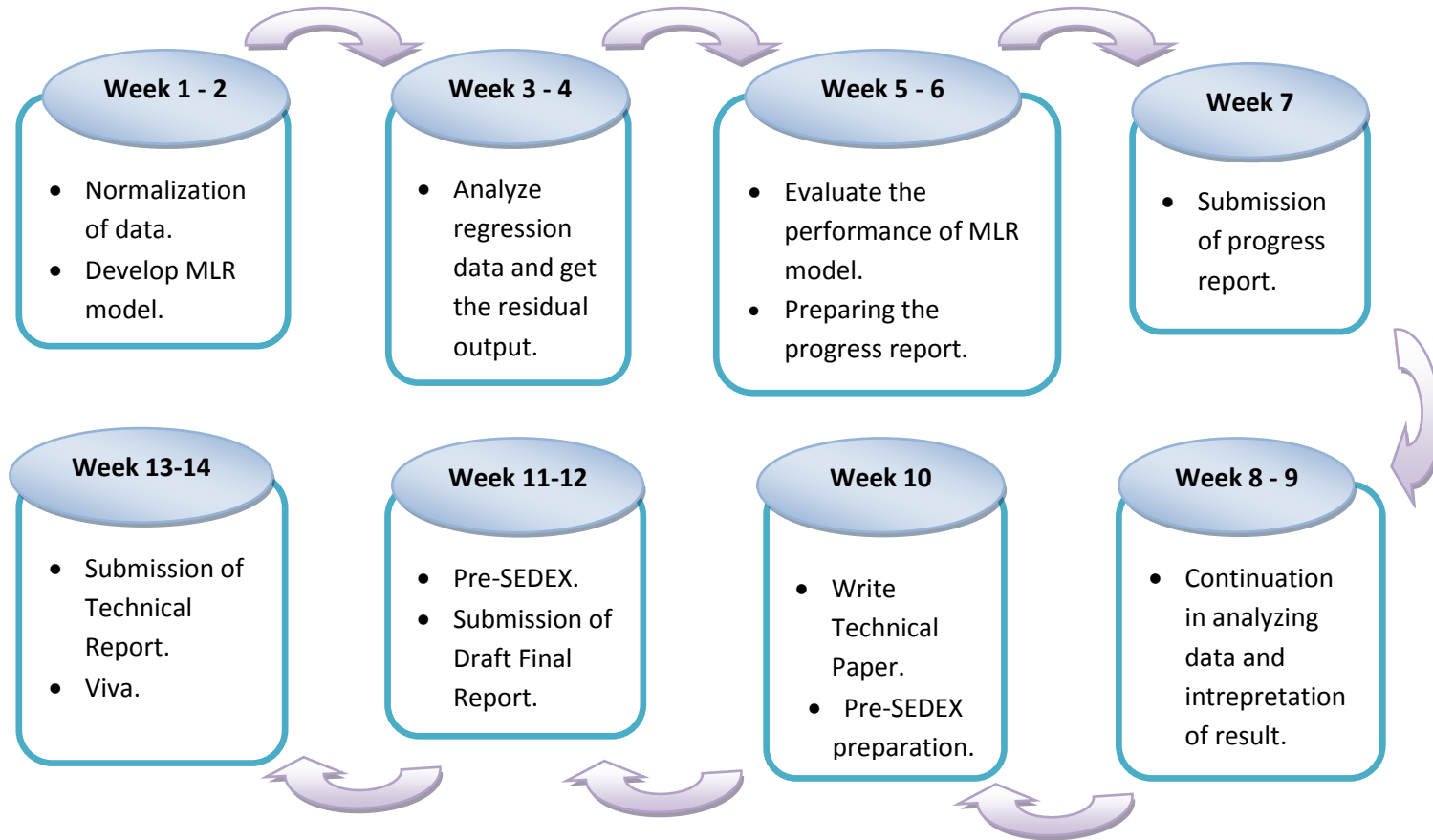


Figure 5.2: Project Timeline (FYP 2)

Project Key Milestone

Milestone





Process



Key

Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Selection of Project Title	Process	Process												
Preliminary Research Work		Process	Process	Process	Process									
Submission of Extended Proposal						Key								
Proposal Defense								Process	Process					
Continuation Work Project							Process			Process	Process	Process		
Submission of Interim Draft Report													Key	
Submission of Interim Report														Key

Figure 5.3: Project Key Milestone (FYP 1)

 Process  Key

Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Collecting data	Process													
Analyse data		Process	Process											
Selection of input data and normalization of raw data			Process	Process										
Calibration and verification of data					Process	Process								
Develop MLR model by using regression analysis						Process	Process							
Evaluate MLR model performance								Process	Process					
Check the suitability of the MLR model in prediction pore water pressure										Process				
Reporting result										Process	Process	Process	Process	
Viva														Key

Figure 5.4: Project Key Milestone (FYP 2)

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In conclusion, predicting pore water pressure in soil slopes is very important in order to prevent slope failure. The model equation of pore water pressure responses to rainfall has been developed using SPSS software and the performance of the model was evaluated using different statistical measures such as coefficient of determination (R^2), root mean square error (RMSE), coefficient of efficiency (CE) and analysis of variance (ANOVA). In addition, the results have showed that the pattern in predicted pore water pressure during testing is slightly similar with the pattern in observed pore water pressure.

Predicted pore water pressure during testing tends to produced lower errors at RMSE which is 0.859. Moreover, it is higher in coefficient of efficiency CE of 0.807 and coefficient of determination R^2 of 0.857 compared to training. Therefore, the MLR model in predicting pore water pressure changes responses to rainfall has produce a satisfactory predictive performance. This might because of the small scale area and data that were used and be considered in this study. By the used of smaller data, prediction error can be reduced. Thus, our model also will produce a good results and performance.

Even though, sometimes linear technique tends to produce less accurate result, but for this study, MLR technique is suitable to be used in predicting pore water pressure. Hence, MLR method still can be considered to be used in hydrological and non-hydrological prediction data parameter.

6.2 Recommendations

For the recommendation, by using data that have a high value of rainfall tends to give a better result in prediction of pore water pressure. In addition, predictions can be improved further by the additional of soil parameters such as parameters describing soil structure. By using more detailed input was generally better since previous studies also stated that having lowest RMSE as well as highest R^2 was found to be the model that used most detailed data. The results also shows that the used of MLR technique in predicting pore water pressure was applicable and practicable if more soil parameters were used in this study. Hence, future studies can be easily identified by adding more soil parameters.

REFERENCES

Mustafa, M. R., et al. (2012). "Prediction of pore-water pressure using radial basis function neural network." *Engineering Geology* 135-136: 40-47.

Sousa, S., et al. (2007). "Multiple linear regression and artificial neural networks based on principal components to predict ozone concentrations." *Environmental Modelling & Software* 22(1): 97-103.

Mustafa, M.R., et al. (2013). "Evaluation of MLP-ANN training algorithms for modeling soil pore-water pressure responses to rainfall." *J. Hydrol. Eng.* 2013. 18:50-57.

Mustafa, M.R., et al. (2015). "Artificial Neural Network Modeling for Spatial and Temporal Variations of Pore Water Pressure Responses to Rainfall." *Advances in Meteorology* 2015(2015),1-12.

Rahardjo, H., Ong, T.H., Rezaur, R.B., Leong, E.C., 2007. Factors controlling instability of homogeneous soil slopes under rainfall. *Geotechnical and Geoenvironmental Engineering*, ASCE 133 (12), 1532–1543.

Rahardjo, H., Leong, E.C., Rezaur, R.B., 2008. Characteristics of pore-water pressure distribution in residual soil slopes under tropical rainfalls. *Hydrological Processes* 22, 506–523.

Rezaur, R.B., Rahardjo, H., Leong, E.C., Lee, T.T., 2003. Hydrological behavior of residual soil slopes in Singapore. *Journal of Hydrologic Engineering*, ASCE 8, 133–144.

StatisticsSolutions, (n.d). Retrieved from <http://www.statisticssolutions.com>

STAT 501. (2015). The Multiple Linear Regression, 1-3. Retrieved from <https://onlinecourses.science.psu.edu>

Meen-Wah Gui & Yong-Ming Wu, 2014. "Failure of soil under water infiltration condition". *Engineering Geology* 181: 124-141.

Merdun, H., et al. (2006). "Comparison of artificial neural network and regression pedotransfer functions for prediction of soil water retention and saturated hydraulic conductivity." Soil and Tillage Research **90**(1-2): 108-116.

Ornek, M., Laman, M., Demir, A., Yildiz, A., 2012. Prediction of bearing capacity of circular footings on soft clay stabilized with granular soil. *Soils and Foundations* 52(1), 69–80.

TADESSE, A. A. (November 2014). CONSTRUCTION QUALITY MONITORING OF EMBANKMENT DAMS USING PORE WATER PRESSURE THE CASE OF KESEM DAM. Civil and Environmental Engineering (Major in Hydraulic Engineering). ADDIS ABABA, ADDIS ABABA UNIVERSITY. **Degree of Master of Science: 85.**

Mukhlisin M, Abd Rahman ASB, 2014. Prediction of Atterberg limits via ANN and ANFIS: a comparison. Proc Int Conf on Environmental Science and Geoscience (ESG '14), Venice, Italy. pp: 69-74. Retrieved from <http://www.europment.org/library/2014/venice/ENVIR.pdf>.

Leila Esmaelnejad, H. R., Javad seyedmohammadi, Mahmood Shabanpour (2015). "Selection of a suitable model for the prediction of soil water content in north of Iran." Spanish Journal of Agricultural Research **vol 13**(No. 1).

M. Karthikeyan, D. G. Toll, and K. K. Phoon, "Prediction of changes in pore-water pressure response due to rainfall events," in *Unsaturated Soils. Advances in Geo-Engineering*, D. G. Toll, C. E. Augarde, D. Gallipoli, and S. J. Wheeler, Eds. London: Taylor & Francis, 2008, pp. 829–834.

Akinbinu, V. A. (2010). "Prediction of fracture gradient from formation pressures and depth using correlation and stepwise multiple regression techniques." Journal of Petroleum Science and Engineering **72**(1-2): 10-17.

Mohamed, J., & Ali, S. (2006). "Development and comparative analysis of pedotransfer functions for predicting soil water characteristic content for Tunisian soil." **7th Edition.**

APPENDICES

Appendix 1

MLR model equation that was generated from SPSS software:

$$u_t = 0.083 + 0.040 (r_t) + 0.299 (r_{t-1}) + 0.066 (r_{t-2}) + 0.941(u_{t-1}) + 0.007(u_{t-2}) - 0.063(u_{t-3}) + 0.022(u_{t-4}) - 0.061(u_{t-5})$$

Appendix 2

The input data for testing and predicted pore water pressure that was determined by using MLR model equation.

Toe	PWP	1hr Rainfall	1 ant rainfall	2 ant rainfall	1 ant pwp	2 ant pwp	3 ant pwp	4 ant pwp	5 ant pwp	Predicted PWP
3/14/2015 11:00	0.82759	0	0	0	0.70345	0.65517	0.65517	0.64828	0.65517	0.68255
3/14/2015 12:00	0.77931	0	0	0	0.82759	0.70345	0.65517	0.65517	0.64828	0.80028
3/14/2015 13:00	0.79310	0	0	0	0.77931	0.82759	0.70345	0.65517	0.65517	0.75226
3/14/2015 14:00	0.67586	0	0	0	0.79310	0.77931	0.82759	0.70345	0.65517	0.75814
3/14/2015 15:00	0.64828	0	0	0	0.67586	0.79310	0.77931	0.82759	0.70345	0.65074
3/14/2015 16:00	0.68276	0	0	0	0.64828	0.67586	0.79310	0.77931	0.82759	0.61446
3/14/2015 17:00	0.66897	0	0	0	0.68276	0.64828	0.67586	0.79310	0.77931	0.65734
3/14/2015 18:00	0.54483	0	0	0	0.66897	0.68276	0.64828	0.67586	0.79310	0.64292
3/14/2015 19:00	0.53103	0	0	0	0.54483	0.66897	0.68276	0.64828	0.67586	0.53039
3/14/2015 20:00	0.56552	0	0	0	0.53103	0.54483	0.66897	0.68276	0.64828	0.51985
3/14/2015 21:00	0.59310	0	0	0	0.56552	0.53103	0.54483	0.66897	0.68276	0.55761
3/14/2015 22:00	0.60000	0	0	0	0.59310	0.56552	0.53103	0.54483	0.66897	0.58279
3/14/2015 23:00	0.60690	0	0	0	0.60000	0.59310	0.56552	0.53103	0.54483	0.59457
3/15/2015 0:00	0.62069	0	0	0	0.60690	0.60000	0.59310	0.56552	0.53103	0.60097
3/15/2015 1:00	0.62759	0	0	0	0.62069	0.60690	0.60000	0.59310	0.56552	0.61207
3/15/2015 2:00	0.62759	0	0	0	0.62759	0.62069	0.60690	0.60000	0.59310	0.61669
3/15/2015 3:00	0.62759	0	0	0	0.62759	0.62759	0.62069	0.60690	0.60000	0.61560
3/15/2015 4:00	0.62759	0	0	0	0.62759	0.62759	0.62759	0.62069	0.60690	0.61505
3/15/2015 5:00	0.62759	0	0	0	0.62759	0.62759	0.62759	0.62759	0.62069	0.61436
3/15/2015 6:00	0.62069	0	0	0	0.62759	0.62759	0.62759	0.62759	0.62759	0.61394

3/15/2015 7:00	0.62759	0	0	0	0.62069	0.62759	0.62759	0.62759	0.62759	0.60745
3/15/2015 8:00	0.62759	0	0	0	0.62759	0.62069	0.62759	0.62759	0.62759	0.61389
3/15/2015 9:00	0.63448	0	0	0	0.62759	0.62759	0.62069	0.62759	0.62759	0.61437
3/15/2015 10:00	0.70345	0	0	0	0.63448	0.62759	0.62759	0.62069	0.62759	0.62028
3/15/2015 11:00	0.77241	0	0	0	0.70345	0.63448	0.62759	0.62759	0.62069	0.68579
3/15/2015 12:00	0.77241	0	0	0	0.77241	0.70345	0.63448	0.62759	0.62759	0.75032
3/15/2015 13:00	0.73793	0	0	0	0.77241	0.77241	0.70345	0.63448	0.62759	0.74661
3/15/2015 14:00	0.67586	0	0	0	0.73793	0.77241	0.77241	0.70345	0.63448	0.71091
3/15/2015 15:00	0.62759	0	0	0	0.67586	0.73793	0.77241	0.77241	0.70345	0.64957
3/15/2015 16:00	0.51724	0	0	0	0.62759	0.67586	0.73793	0.77241	0.77241	0.60168
3/15/2015 17:00	0.51724	0	0	0	0.51724	0.62759	0.67586	0.73793	0.77241	0.50066
3/15/2015 18:00	0.62069	0	0	0	0.51724	0.51724	0.62759	0.67586	0.73793	0.50366
3/15/2015 19:00	0.54483	0	0	0	0.62069	0.51724	0.51724	0.62759	0.67586	0.61068
3/15/2015 20:00	0.53793	0	0	0	0.54483	0.62069	0.51724	0.51724	0.62759	0.54054
3/15/2015 21:00	0.56552	0	0	0	0.53793	0.54483	0.62069	0.51724	0.51724	0.53373
3/15/2015 22:00	0.54483	0	0	0	0.56552	0.53793	0.54483	0.62069	0.51724	0.56670
3/15/2015 23:00	0.50345	0	0	0	0.54483	0.56552	0.53793	0.54483	0.62069	0.53988
3/16/2015 0:00	0.53793	0	0	0	0.50345	0.54483	0.56552	0.53793	0.54483	0.50353
3/16/2015 1:00	0.55172	0	0	0	0.53793	0.50345	0.54483	0.56552	0.53793	0.53802
3/16/2015 2:00	0.57241	0	0	0	0.55172	0.53793	0.50345	0.54483	0.56552	0.55171
3/16/2015 3:00	0.57931	0	0	0	0.57241	0.55172	0.53793	0.50345	0.54483	0.56946
3/16/2015 4:00	0.57931	0	0	0	0.57931	0.57241	0.55172	0.53793	0.50345	0.57850
3/16/2015 5:00	0.58621	0	0	0	0.57931	0.57931	0.57241	0.55172	0.53793	0.57545
3/16/2015 6:00	0.57931	0	0	0	0.58621	0.57931	0.57931	0.57241	0.55172	0.58112
3/16/2015 7:00	0.57931	0	0	0	0.57931	0.58621	0.57931	0.57931	0.57241	0.57357
3/16/2015 8:00	0.58621	0	0	0	0.57931	0.57931	0.58621	0.57931	0.57931	0.57266
3/16/2015 9:00	0.60000	0	0	0	0.58621	0.57931	0.57931	0.58621	0.57931	0.57974
3/16/2015 10:00	0.64138	0	0	0	0.60000	0.58621	0.57931	0.57931	0.58621	0.59219
3/16/2015 11:00	0.73793	0	0	0	0.64138	0.60000	0.58621	0.57931	0.57931	0.63121

3/16/2015 12:00	0.75862	0	0	0	0.73793	0.64138	0.60000	0.58621	0.57931	0.72164
3/16/2015 13:00	0.74483	0	0	0	0.75862	0.73793	0.64138	0.60000	0.58621	0.73906
3/16/2015 14:00	0.60690	0	0	0	0.74483	0.75862	0.73793	0.64138	0.60000	0.72021
3/16/2015 15:00	0.60000	0	0	0	0.60690	0.74483	0.75862	0.73793	0.64138	0.58862
3/16/2015 16:00	0.62069	0	0	0	0.60000	0.60690	0.74483	0.75862	0.73793	0.57660
3/16/2015 17:00	0.48276	0	0	0	0.62069	0.60000	0.60690	0.74483	0.75862	0.60314
3/16/2015 18:00	0.48276	0	0	0	0.48276	0.62069	0.60000	0.60690	0.74483	0.47174
3/16/2015 19:00	0.44828	0	0	0	0.48276	0.48276	0.62069	0.60000	0.60690	0.47773
3/16/2015 20:00	0.46207	0	0	0	0.44828	0.48276	0.48276	0.62069	0.60000	0.45485
3/16/2015 21:00	0.50345	0	0	0	0.46207	0.44828	0.48276	0.48276	0.62069	0.46329
3/16/2015 22:00	0.52414	0	0	0	0.50345	0.46207	0.44828	0.48276	0.48276	0.51291
3/16/2015 23:00	0.53793	0	0	0	0.52414	0.50345	0.46207	0.44828	0.48276	0.53104
3/17/2015 0:00	0.54483	0	0	0	0.53793	0.52414	0.50345	0.46207	0.44828	0.54397
3/17/2015 1:00	0.55172	0	0	0	0.54483	0.53793	0.52414	0.50345	0.46207	0.54932
3/17/2015 2:00	0.55172	0	0	0	0.55172	0.54483	0.53793	0.52414	0.50345	0.55292
3/17/2015 3:00	0.56552	0	0	0	0.55172	0.55172	0.54483	0.53793	0.52414	0.55157
3/17/2015 4:00	0.56552	0	0	0	0.56552	0.55172	0.55172	0.54483	0.53793	0.56343
3/17/2015 5:00	0.55172	0	0	0	0.56552	0.56552	0.55172	0.55172	0.54483	0.56326
3/17/2015 6:00	0.55172	0	0	0	0.55172	0.56552	0.56552	0.55172	0.55172	0.54899
3/17/2015 7:00	0.55172	0	0	0	0.55172	0.55172	0.56552	0.56552	0.55172	0.54919
3/17/2015 8:00	0.56552	0	0	0	0.55172	0.55172	0.55172	0.56552	0.56552	0.54922
3/17/2015 9:00	0.57931	0	0	0	0.56552	0.55172	0.55172	0.55172	0.56552	0.56190
3/17/2015 10:00	0.62069	0	0	0	0.57931	0.56552	0.55172	0.55172	0.55172	0.57581
3/17/2015 11:00	0.71034	0	0	0	0.62069	0.57931	0.56552	0.55172	0.55172	0.61398
3/17/2015 12:00	0.75172	0	0	0	0.71034	0.62069	0.57931	0.56552	0.55172	0.69807
3/17/2015 13:00	0.72414	0	0	0	0.75172	0.71034	0.62069	0.57931	0.56552	0.73449
3/17/2015 14:00	0.64138	0	0	0	0.72414	0.75172	0.71034	0.62069	0.57931	0.70324
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3/17/2015 19:00	0.39310	0	0	0	0.42759	0.55172	0.56552	0.57241	0.64138	0.42706
3/17/2015 20:00	0.42069	0	0	0	0.39310	0.42759	0.55172	0.56552	0.57241	0.39867
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3/17/2015 22:00	0.48276	0	0	0	0.46897	0.42069	0.39310	0.42759	0.55172	0.47823
3/17/2015 23:00	0.49655	0	0	0	0.48276	0.46897	0.42069	0.39310	0.42759	0.49662
3/18/2015 0:00	0.50345	0	0	0	0.49655	0.48276	0.46897	0.42069	0.39310	0.50937
3/18/2015 1:00	0.53103	0	0	0	0.50345	0.49655	0.48276	0.46897	0.42069	0.51446
3/18/2015 2:00	0.53793	0	0	0	0.53103	0.50345	0.49655	0.48276	0.46897	0.53696
3/18/2015 3:00	0.53103	0	0	0	0.53793	0.53103	0.50345	0.49655	0.48276	0.54267
3/18/2015 4:00	0.52414	0	0	0	0.53103	0.53793	0.53103	0.50345	0.49655	0.53380
3/18/2015 5:00	0.52414	0	0	0	0.52414	0.53103	0.53793	0.53103	0.50345	0.52701
3/18/2015 6:00	0.52414	0	0	0	0.52414	0.52414	0.53103	0.53793	0.53103	0.52587
3/18/2015 7:00	0.52414	0	0	0	0.52414	0.52414	0.52414	0.53103	0.53793	0.52573
3/18/2015 8:00	0.53103	0	0	0	0.52414	0.52414	0.52414	0.52414	0.53103	0.52600
3/18/2015 9:00	0.55172	0	0	0	0.53103	0.52414	0.52414	0.52414	0.52414	0.53291
3/18/2015 10:00	0.59310	0	0	0	0.55172	0.53103	0.52414	0.52414	0.52414	0.55243
3/18/2015 11:00	0.68276	0	0	0	0.59310	0.55172	0.53103	0.52414	0.52414	0.59108
3/18/2015 12:00	0.78621	0	0	0	0.68276	0.59310	0.55172	0.53103	0.52414	0.67458
3/18/2015 13:00	0.75862	0	0	0	0.78621	0.68276	0.59310	0.55172	0.53103	0.76998
3/18/2015 14:00	0.63448	0	0	0	0.75862	0.78621	0.68276	0.59310	0.55172	0.73874
3/18/2015 15:00	0.54483	0	0	0	0.63448	0.75862	0.78621	0.68276	0.59310	0.61467
3/18/2015 16:00	0.62069	0	0	0	0.54483	0.63448	0.75862	0.78621	0.68276	0.52798
3/18/2015 17:00	0.52414	0	0	0	0.62069	0.54483	0.63448	0.75862	0.78621	0.59964
3/18/2015 18:00	0.38621	0	0	0	0.52414	0.62069	0.54483	0.63448	0.75862	0.51392
3/18/2015 19:00	0.33793	0	0	0	0.38621	0.52414	0.62069	0.54483	0.63448	0.38427
3/18/2015 20:00	0.38621	0	0	0	0.33793	0.38621	0.52414	0.62069	0.54483	0.35110
3/18/2015 21:00	0.44138	0	0	0	0.38621	0.33793	0.38621	0.52414	0.62069	0.39812

3/18/2015 22:00	0.44828	0	0	0	0.44138	0.38621	0.33793	0.38621	0.52414	0.45628
3/18/2015 23:00	0.46897	0	0	0	0.44828	0.44138	0.38621	0.33793	0.38621	0.46746
3/19/2015 0:00	0.47586	0	0	0	0.46897	0.44828	0.44138	0.38621	0.33793	0.48751
3/19/2015 1:00	0.48966	0	0	0	0.47586	0.46897	0.44828	0.44138	0.38621	0.49198
3/19/2015 2:00	0.48966	0	0	0	0.48966	0.47586	0.46897	0.44828	0.44138	0.50049
3/19/2015 3:00	0.50345	0	0	0	0.48966	0.48966	0.47586	0.46897	0.44828	0.50019
3/19/2015 4:00	0.49655	0	0	0	0.50345	0.48966	0.48966	0.47586	0.46897	0.51119
3/19/2015 5:00	0.49655	0	0	0	0.49655	0.50345	0.48966	0.48966	0.47586	0.50468
3/19/2015 6:00	0.49655	0	0	0	0.49655	0.49655	0.50345	0.48966	0.48966	0.50292
3/19/2015 7:00	0.49655	0	0	0	0.49655	0.49655	0.49655	0.50345	0.48966	0.50366
3/19/2015 8:00	0.50345	0	0	0	0.49655	0.49655	0.49655	0.49655	0.50345	0.50266
3/19/2015 9:00	0.53793	0	0	0	0.50345	0.49655	0.49655	0.49655	0.49655	0.50957
3/19/2015 10:00	0.57931	0	0	0	0.53793	0.50345	0.49655	0.49655	0.49655	0.54207
3/19/2015 11:00	0.67586	0	0	0	0.57931	0.53793	0.50345	0.49655	0.49655	0.58081
3/19/2015 12:00	0.79310	0	0	0	0.67586	0.57931	0.53793	0.50345	0.49655	0.66994
3/19/2015 13:00	0.72414	0	0	0	0.79310	0.67586	0.57931	0.53793	0.50345	0.77867
3/19/2015 14:00	0.57241	0	0	0	0.72414	0.79310	0.67586	0.57931	0.53793	0.70732
3/19/2015 15:00	0.46897	0	0	0	0.57241	0.72414	0.79310	0.67586	0.57931	0.55628
3/19/2015 16:00	0.53793	0	0	0	0.46897	0.57241	0.72414	0.79310	0.67586	0.45890
3/19/2015 17:00	0.44138	0	0	0	0.53793	0.46897	0.57241	0.72414	0.79310	0.52397
3/19/2015 18:00	0.33103	0	0	0	0.44138	0.53793	0.46897	0.57241	0.72414	0.44098
3/19/2015 19:00	0.33103	0	0	0	0.33103	0.44138	0.53793	0.46897	0.57241	0.33910
3/19/2015 20:00	0.36552	0	0	0	0.33103	0.33103	0.44138	0.53793	0.46897	0.35224
3/19/2015 21:00	0.39310	0	0	0	0.36552	0.33103	0.33103	0.44138	0.53793	0.38531
3/19/2015 22:00	0.42069	0	0	0	0.39310	0.36552	0.33103	0.33103	0.44138	0.41497
3/19/2015 23:00	0.42759	0	0	0	0.42069	0.39310	0.36552	0.33103	0.33103	0.44568
3/20/2015 0:00	0.44138	0	0	0	0.42759	0.42069	0.39310	0.36552	0.33103	0.45139
3/20/2015 1:00	0.44138	0	0	0	0.44138	0.42759	0.42069	0.39310	0.36552	0.46118
3/20/2015 2:00	0.44828	0	0	0	0.44138	0.44138	0.42759	0.42069	0.39310	0.45977

3/20/2015 3:00	0.46897	0	0	0	0.44828	0.44138	0.44138	0.42759	0.42069	0.46386
3/20/2015 4:00	0.46897	0	0	0	0.46897	0.44828	0.44138	0.44138	0.42759	0.48326
3/20/2015 5:00	0.47586	0	0	0	0.46897	0.46897	0.44828	0.44138	0.44138	0.48212
3/20/2015 6:00	0.47586	0	0	0	0.47586	0.46897	0.46897	0.44828	0.44138	0.48746
3/20/2015 7:00	0.46897	0	0	0	0.47586	0.47586	0.46897	0.46897	0.44828	0.48754
3/20/2015 8:00	0.47586	0	0	0	0.46897	0.47586	0.47586	0.46897	0.46897	0.47936
3/20/2015 9:00	0.49655	0	0	0	0.47586	0.46897	0.47586	0.47586	0.46897	0.48595
3/20/2015 10:00	0.53793	0	0	0	0.49655	0.47586	0.46897	0.47586	0.47586	0.50548
3/20/2015 11:00	0.63448	0	0	0	0.53793	0.49655	0.47586	0.46897	0.47586	0.54398
3/20/2015 12:00	0.80690	0	0	0	0.63448	0.53793	0.49655	0.47586	0.46897	0.63439
3/20/2015 13:00	0.74483	0	0	0	0.80690	0.63448	0.53793	0.49655	0.47586	0.79474
3/20/2015 14:00	0.55172	0	0	0	0.74483	0.80690	0.63448	0.53793	0.49655	0.73110
3/20/2015 15:00	0.48966	0	0	0	0.55172	0.74483	0.80690	0.63448	0.53793	0.53770
3/20/2015 16:00	0.54483	0	0	0	0.48966	0.55172	0.74483	0.80690	0.63448	0.47975
3/20/2015 17:00	0.34483	0	0	0	0.54483	0.48966	0.55172	0.74483	0.80690	0.53152
3/20/2015 18:00	0.22759	0.07547	0	0	0.34483	0.54483	0.48966	0.55172	0.74483	0.35017
3/20/2015 19:00	0.31034	0.01887	0.07547	0	0.22759	0.34483	0.54483	0.48966	0.55172	0.26569
3/20/2015 20:00	0.31724	0	0.01887	0.07547	0.31034	0.22759	0.34483	0.54483	0.48966	0.34764
3/20/2015 21:00	0.34483	0	0	0.01887	0.31724	0.31034	0.22759	0.34483	0.54483	0.34496
3/20/2015 22:00	0.36552	0	0	0	0.34483	0.31724	0.31034	0.22759	0.34483	0.37412
3/20/2015 23:00	0.37931	0	0	0	0.36552	0.34483	0.31724	0.31034	0.22759	0.40232
3/21/2015 0:00	0.39310	0	0	0	0.37931	0.36552	0.34483	0.31724	0.31034	0.40881
3/21/2015 1:00	0.40000	0	0	0	0.39310	0.37931	0.36552	0.34483	0.31724	0.42077
3/21/2015 2:00	0.41379	0	0	0	0.40000	0.39310	0.37931	0.36552	0.34483	0.42526
3/21/2015 3:00	0.42069	0	0	0	0.41379	0.40000	0.39310	0.37931	0.36552	0.43646
3/21/2015 4:00	0.41379	0	0	0	0.42069	0.41379	0.40000	0.39310	0.37931	0.44208
3/21/2015 5:00	0.41379	0	0	0	0.41379	0.42069	0.41379	0.40000	0.39310	0.43408
3/21/2015 6:00	0.41379	0	0	0	0.41379	0.41379	0.42069	0.41379	0.40000	0.43348
3/21/2015 7:00	0.40000	0	0	0	0.41379	0.41379	0.41379	0.42069	0.41379	0.43322

3/21/2015 8:00	0.42069	0	0	0	0.40000	0.41379	0.41379	0.41379	0.42069	0.41967
3/21/2015 9:00	0.44828	0	0	0	0.42069	0.40000	0.41379	0.41379	0.41379	0.43946
3/21/2015 10:00	0.47586	0	0	0	0.44828	0.42069	0.40000	0.41379	0.41379	0.46643
3/21/2015 11:00	0.56552	0.01887	0	0	0.47586	0.44828	0.42069	0.40000	0.41379	0.49173
3/21/2015 12:00	0.68276	0	0.01887	0	0.56552	0.47586	0.44828	0.42069	0.40000	0.58074
3/21/2015 13:00	0.49655	0	0	0.01887	0.68276	0.56552	0.47586	0.44828	0.42069	0.68490
3/21/2015 14:00	0.53103	0	0	0	0.49655	0.68276	0.56552	0.47586	0.44828	0.50253
3/21/2015 15:00	0.34483	0	0	0	0.53103	0.49655	0.68276	0.56552	0.47586	0.52658
3/21/2015 16:00	0.31724	0	0	0	0.34483	0.53103	0.49655	0.68276	0.56552	0.36044
3/21/2015 17:00	0.40000	0	0	0	0.31724	0.34483	0.53103	0.49655	0.68276	0.31976
3/21/2015 18:00	0.42069	0	0	0	0.40000	0.31724	0.34483	0.53103	0.49655	0.42129
3/21/2015 19:00	0.28966	0	0	0	0.42069	0.40000	0.31724	0.34483	0.53103	0.43688
3/21/2015 20:00	0.23448	0	0	0	0.28966	0.42069	0.40000	0.31724	0.34483	0.31926
3/21/2015 21:00	0.27586	0	0	0	0.23448	0.28966	0.42069	0.40000	0.31724	0.26862
3/21/2015 22:00	0.29655	0	0	0	0.27586	0.23448	0.28966	0.42069	0.40000	0.31083
3/21/2015 23:00	0.31724	0	0	0	0.29655	0.27586	0.23448	0.28966	0.42069	0.32992
3/22/2015 0:00	0.33103	0	0	0	0.31724	0.29655	0.27586	0.23448	0.28966	0.35371
3/22/2015 1:00	0.33793	0	0	0	0.33103	0.31724	0.29655	0.27586	0.23448	0.36981
3/22/2015 2:00	0.33793	0	0	0	0.33793	0.33103	0.31724	0.29655	0.27586	0.37302
3/22/2015 3:00	0.34483	0	0	0	0.33793	0.33793	0.33103	0.31724	0.29655	0.37139
3/22/2015 4:00	0.34483	0	0	0	0.34483	0.33793	0.33793	0.33103	0.31724	0.37649
3/22/2015 5:00	0.34483	0	0	0	0.34483	0.34483	0.33793	0.33793	0.33103	0.37585
3/22/2015 6:00	0.33793	0	0	0	0.34483	0.34483	0.34483	0.33793	0.33793	0.37499
3/22/2015 7:00	0.34483	0	0	0	0.33793	0.34483	0.34483	0.34483	0.33793	0.36866
3/22/2015 8:00	0.33793	0	0	0	0.34483	0.33793	0.34483	0.34483	0.34483	0.37468
3/22/2015 9:00	0.37241	0	0	0	0.33793	0.34483	0.33793	0.34483	0.34483	0.36867
3/22/2015 10:00	0.42759	0	0	0	0.37241	0.33793	0.34483	0.33793	0.34483	0.40048
3/22/2015 11:00	0.52414	0	0	0	0.42759	0.37241	0.33793	0.34483	0.33793	0.45365
3/22/2015 12:00	0.54483	0	0	0	0.52414	0.42759	0.37241	0.33793	0.34483	0.54214

3/22/2015 13:00	0.49655	0	0	0	0.54483	0.52414	0.42759	0.37241	0.33793	0.55999
3/22/2015 14:00	0.43448	0	0	0	0.49655	0.54483	0.52414	0.42759	0.37241	0.50774
3/22/2015 15:00	0.43448	0	0	0	0.43448	0.49655	0.54483	0.52414	0.42759	0.44645
3/22/2015 16:00	0.46897	0	0	0	0.43448	0.43448	0.49655	0.54483	0.52414	0.44362
3/22/2015 17:00	0.24138	0	0	0	0.46897	0.43448	0.43448	0.49655	0.54483	0.47766
3/22/2015 18:00	0.00000	0.62264	0	0	0.24138	0.46897	0.43448	0.43448	0.49655	0.29022
3/22/2015 19:00	0.19310	0.01887	0.62264	0	0.00000	0.24138	0.46897	0.43448	0.43448	0.22512
3/22/2015 20:00	0.28276	0	0.01887	0.62264	0.19310	0.00000	0.24138	0.46897	0.43448	0.28005
3/22/2015 21:00	0.33793	0	0	0.01887	0.28276	0.19310	0.00000	0.24138	0.46897	0.32838
3/22/2015 22:00	0.37931	0	0	0	0.33793	0.28276	0.19310	0.00000	0.24138	0.37608
3/22/2015 23:00	0.41379	0	0	0	0.37931	0.33793	0.28276	0.19310	0.00000	0.42873
3/23/2015 0:00	0.42759	0	0	0	0.41379	0.37931	0.33793	0.28276	0.19310	0.44819
3/23/2015 1:00	0.44828	0	0	0	0.42759	0.41379	0.37931	0.33793	0.28276	0.45454
3/23/2015 2:00	0.46897	0	0	0	0.44828	0.42759	0.41379	0.37931	0.33793	0.46948
3/23/2015 3:00	0.47586	0	0	0	0.46897	0.44828	0.42759	0.41379	0.37931	0.48646
3/23/2015 4:00	0.48276	0	0	0	0.47586	0.46897	0.44828	0.42759	0.41379	0.48999
3/23/2015 5:00	0.48276	0	0	0	0.48276	0.47586	0.46897	0.44828	0.42759	0.49484
3/23/2015 6:00	0.48276	0	0	0	0.48276	0.48276	0.47586	0.46897	0.44828	0.49365
3/23/2015 7:00	0.48966	0	0	0	0.48276	0.48276	0.48276	0.47586	0.46897	0.49210
3/23/2015 8:00	0.51724	0.01887	0	0	0.48966	0.48276	0.48276	0.48276	0.47586	0.49908
3/23/2015 9:00	0.54483	0	0.01887	0	0.51724	0.48966	0.48276	0.48276	0.48276	0.52955
3/23/2015 10:00	0.56552	0	0	0.01887	0.54483	0.51724	0.48966	0.48276	0.48276	0.55087
3/23/2015 11:00	0.51724	0	0	0	0.56552	0.54483	0.51724	0.48966	0.48276	0.56770
3/23/2015 12:00	0.52414	0	0	0	0.51724	0.56552	0.54483	0.51724	0.48966	0.52087
3/23/2015 13:00	0.54483	0	0	0	0.52414	0.51724	0.56552	0.54483	0.51724	0.52464
3/23/2015 14:00	0.58621	0	0	0	0.54483	0.52414	0.51724	0.56552	0.54483	0.54597
3/23/2015 15:00	0.63448	0	0	0	0.58621	0.54483	0.52414	0.51724	0.56552	0.58230
3/23/2015 16:00	0.50345	0	0	0	0.63448	0.58621	0.54483	0.52414	0.51724	0.62981
3/23/2015 17:00	0.50345	0	0	0	0.50345	0.63448	0.58621	0.54483	0.52414	0.50427

3/23/2015 18:00	0.52414	0	0	0	0.50345	0.50345	0.63448	0.58621	0.54483	0.49996
3/23/2015 19:00	0.44138	0	0	0	0.52414	0.50345	0.50345	0.63448	0.58621	0.52622
3/23/2015 20:00	0.42759	0	0	0	0.44138	0.52414	0.50345	0.50345	0.63448	0.44266
3/23/2015 21:00	0.43448	0	0	0	0.42759	0.44138	0.52414	0.50345	0.50345	0.43579
3/23/2015 22:00	0.46207	0	0	0	0.43448	0.42759	0.44138	0.52414	0.50345	0.44786
3/23/2015 23:00	0.46207	0	0	0	0.46207	0.43448	0.42759	0.44138	0.52414	0.47165
3/24/2015 0:00	0.46897	0	0	0	0.46207	0.46207	0.43448	0.42759	0.44138	0.47615
3/24/2015 1:00	0.47586	0	0	0	0.46897	0.46207	0.46207	0.43448	0.42759	0.48190
3/24/2015 2:00	0.48276	0	0	0	0.47586	0.46897	0.46207	0.46207	0.43448	0.48862
3/24/2015 3:00	0.48966	0	0	0	0.48276	0.47586	0.46897	0.46207	0.46207	0.49304
3/24/2015 4:00	0.49655	0	0	0	0.48966	0.48276	0.47586	0.46897	0.46207	0.49930
3/24/2015 5:00	0.49655	0	0	0	0.49655	0.48966	0.48276	0.47586	0.46897	0.50513
3/24/2015 6:00	0.49655	0	0	0	0.49655	0.49655	0.48966	0.48276	0.47586	0.50448
3/24/2015 7:00	0.48276	0	0	0	0.49655	0.49655	0.49655	0.48966	0.48276	0.50377
3/24/2015 8:00	0.49655	0	0	0	0.48276	0.49655	0.49655	0.49655	0.48966	0.49052
3/24/2015 9:00	0.53103	0	0	0	0.49655	0.48276	0.49655	0.49655	0.49655	0.50299
3/24/2015 10:00	0.57241	0	0	0	0.53103	0.49655	0.48276	0.49655	0.49655	0.53640
3/24/2015 11:00	0.67586	0	0	0	0.57241	0.53103	0.49655	0.48276	0.49655	0.57441
3/24/2015 12:00	0.70345	0	0	0	0.67586	0.57241	0.53103	0.49655	0.48276	0.67101
3/24/2015 13:00	0.64138	0	0	0	0.70345	0.67586	0.57241	0.53103	0.49655	0.69501
3/24/2015 14:00	0.53103	0	0	0	0.64138	0.70345	0.67586	0.57241	0.53103	0.62908
3/24/2015 15:00	0.46207	0	0	0	0.53103	0.64138	0.70345	0.67586	0.57241	0.52283
3/24/2015 16:00	0.49655	0	0	0	0.46207	0.53103	0.64138	0.70345	0.67586	0.45537
3/24/2015 17:00	0.36552	0	0	0	0.49655	0.46207	0.53103	0.64138	0.70345	0.49123
3/24/2015 18:00	0.36552	0	0	0	0.36552	0.49655	0.46207	0.53103	0.64138	0.37388
3/24/2015 19:00	0.39310	0	0	0	0.36552	0.36552	0.49655	0.46207	0.53103	0.37600
3/24/2015 20:00	0.40000	0	0	0	0.39310	0.36552	0.36552	0.49655	0.46207	0.41518
3/24/2015 21:00	0.42069	0	0	0	0.40000	0.39310	0.36552	0.36552	0.49655	0.41688
3/24/2015 22:00	0.43448	0	0	0	0.42069	0.40000	0.39310	0.36552	0.36552	0.44265

3/24/2015 23:00	0.44138	0	0	0	0.43448	0.42069	0.40000	0.39310	0.36552	0.45594
3/25/2015 0:00	0.44828	0	0	0	0.44138	0.43448	0.42069	0.40000	0.39310	0.45970
3/25/2015 1:00	0.44138	0	0	0	0.44828	0.44138	0.43448	0.42069	0.40000	0.46540
3/25/2015 2:00	0.44828	0	0	0	0.44138	0.44828	0.44138	0.43448	0.42069	0.45757
3/25/2015 3:00	0.46207	0	0	0	0.44828	0.44138	0.44828	0.44138	0.43448	0.46288
3/25/2015 4:00	0.46207	0	0	0	0.46207	0.44828	0.44138	0.44828	0.44138	0.47608
3/25/2015 5:00	0.46207	0	0	0	0.46207	0.46207	0.44828	0.44138	0.44828	0.47517
3/25/2015 6:00	0.44828	0	0	0	0.46207	0.46207	0.46207	0.44828	0.44138	0.47487
3/25/2015 7:00	0.44828	0	0	0	0.44828	0.46207	0.46207	0.46207	0.44828	0.46177
3/25/2015 8:00	0.46207	0	0	0	0.44828	0.44828	0.46207	0.46207	0.46207	0.46083
3/25/2015 9:00	0.48966	0	0	0	0.46207	0.44828	0.44828	0.46207	0.46207	0.47468
3/25/2015 10:00	0.53793	0	0	0	0.48966	0.46207	0.44828	0.44828	0.46207	0.50043
3/25/2015 11:00	0.64138	0	0	0	0.53793	0.48966	0.46207	0.44828	0.44828	0.54603
3/25/2015 12:00	0.66897	0	0	0	0.64138	0.53793	0.48966	0.46207	0.44828	0.64228
3/25/2015 13:00	0.68966	0	0	0	0.66897	0.64138	0.53793	0.48966	0.46207	0.66568
3/25/2015 14:00	0.59310	0	0	0	0.68966	0.66897	0.64138	0.53793	0.48966	0.67821
3/25/2015 15:00	0.60000	0	0	0	0.59310	0.68966	0.66897	0.64138	0.53793	0.58509
3/25/2015 16:00	0.58621	0	0	0	0.60000	0.59310	0.68966	0.66897	0.64138	0.58390
3/25/2015 17:00	0.39310	0	0	0	0.58621	0.60000	0.59310	0.68966	0.66897	0.57582
3/25/2015 18:00	0.34483	0	0	0	0.39310	0.58621	0.60000	0.59310	0.68966	0.39019
3/25/2015 19:00	0.32414	0	0	0	0.34483	0.39310	0.58621	0.60000	0.59310	0.35032
3/25/2015 20:00	0.32414	0	0	0	0.32414	0.34483	0.39310	0.58621	0.60000	0.34196
3/25/2015 21:00	0.34483	0	0	0	0.32414	0.32414	0.34483	0.39310	0.58621	0.34145
3/25/2015 22:00	0.36552	0	0	0	0.34483	0.32414	0.32414	0.34483	0.39310	0.37294
3/25/2015 23:00	0.37931	0	0	0	0.36552	0.34483	0.32414	0.32414	0.34483	0.39504
3/26/2015 0:00	0.39310	0	0	0	0.37931	0.36552	0.34483	0.32414	0.32414	0.40812
3/26/2015 1:00	0.40000	0	0	0	0.39310	0.37931	0.36552	0.34483	0.32414	0.42035
3/26/2015 2:00	0.42069	0	0	0	0.40000	0.39310	0.37931	0.36552	0.34483	0.42526
3/26/2015 3:00	0.42759	0	0	0	0.42069	0.40000	0.39310	0.37931	0.36552	0.44295

3/26/2015 4:00	0.43448	0	0	0	0.42759	0.42069	0.40000	0.39310	0.37931	0.44861
3/26/2015 5:00	0.42759	0	0	0	0.43448	0.42759	0.42069	0.40000	0.39310	0.45316
3/26/2015 6:00	0.42069	0	0	0	0.42759	0.43448	0.42759	0.42069	0.40000	0.44632
3/26/2015 7:00	0.42069	0	0	0	0.42069	0.42759	0.43448	0.42759	0.42069	0.43823
3/26/2015 8:00	0.43448	0	0	0	0.42069	0.42069	0.42759	0.43448	0.42759	0.43835
3/26/2015 9:00	0.46897	0	0	0	0.43448	0.42069	0.42069	0.42759	0.43448	0.45119
3/26/2015 10:00	0.52414	0	0	0	0.46897	0.43448	0.42069	0.42069	0.42759	0.48401
3/26/2015 11:00	0.64138	0	0	0	0.52414	0.46897	0.43448	0.42069	0.42069	0.53572
3/26/2015 12:00	0.72414	0	0	0	0.64138	0.52414	0.46897	0.43448	0.42069	0.64456
3/26/2015 13:00	0.68276	0	0	0	0.72414	0.64138	0.52414	0.46897	0.43448	0.71970
3/26/2015 14:00	0.57241	0	0	0	0.68276	0.72414	0.64138	0.52414	0.46897	0.67306
3/26/2015 15:00	0.54483	0	0	0	0.57241	0.68276	0.72414	0.64138	0.52414	0.56294
3/26/2015 16:00	0.46897	0	0	0	0.54483	0.57241	0.68276	0.72414	0.64138	0.53348
3/26/2015 17:00	0.41379	0	0	0	0.46897	0.54483	0.57241	0.68276	0.72414	0.46290
3/26/2015 18:00	0.33103	0	0	0	0.41379	0.46897	0.54483	0.57241	0.68276	0.41228
3/26/2015 19:00	0.28276	0	0	0	0.33103	0.41379	0.46897	0.54483	0.57241	0.34492
3/26/2015 20:00	0.28276	0	0	0	0.28276	0.33103	0.41379	0.46897	0.54483	0.30241
3/26/2015 21:00	0.31724	0	0	0	0.28276	0.28276	0.33103	0.41379	0.46897	0.31070
3/26/2015 22:00	0.33103	0	0	0	0.31724	0.28276	0.28276	0.33103	0.41379	0.34773
3/26/2015 23:00	0.34483	0	0	0	0.33103	0.31724	0.28276	0.28276	0.33103	0.36494
3/27/2015 0:00	0.35862	0	0	0	0.34483	0.33103	0.31724	0.28276	0.28276	0.37879
3/27/2015 1:00	0.37241	0	0	0	0.35862	0.34483	0.33103	0.31724	0.28276	0.39175
3/27/2015 2:00	0.37931	0	0	0	0.37241	0.35862	0.34483	0.33103	0.31724	0.40216
3/27/2015 3:00	0.38621	0	0	0	0.37931	0.37241	0.35862	0.34483	0.33103	0.40734
3/27/2015 4:00	0.37931	0	0	0	0.38621	0.37931	0.37241	0.35862	0.34483	0.41247
3/27/2015 5:00	0.38621	0	0	0	0.37931	0.38621	0.37931	0.37241	0.35862	0.40506
3/27/2015 6:00	0.37931	0	0	0	0.38621	0.37931	0.38621	0.37931	0.37241	0.41037
3/27/2015 7:00	0.38621	0	0	0	0.37931	0.38621	0.37931	0.38621	0.37931	0.40410
3/27/2015 8:00	0.40000	0	0	0	0.38621	0.37931	0.38621	0.37931	0.38621	0.40953

3/27/2015 9:00	0.46207	0	0	0	0.40000	0.38621	0.37931	0.38621	0.37931	0.42357
3/27/2015 10:00	0.47586	0	0	0	0.46207	0.40000	0.38621	0.37931	0.38621	0.48106
3/27/2015 11:00	0.62069	0	0	0	0.47586	0.46207	0.40000	0.38621	0.37931	0.49418
3/27/2015 12:00	0.56552	0	0	0	0.62069	0.47586	0.46207	0.40000	0.38621	0.62653
3/27/2015 13:00	0.60000	0	0	0	0.56552	0.62069	0.47586	0.46207	0.40000	0.57528
3/27/2015 14:00	0.47586	0	0	0	0.60000	0.56552	0.62069	0.47586	0.46207	0.59474
3/27/2015 15:00	0.44828	0	0	0	0.47586	0.60000	0.56552	0.62069	0.47586	0.48399
3/27/2015 16:00	0.44138	0	0	0	0.44828	0.47586	0.60000	0.56552	0.62069	0.44494
3/27/2015 17:00	0.31724	0	0	0	0.44138	0.44828	0.47586	0.60000	0.56552	0.45020
3/27/2015 18:00	0.28966	0	0	0	0.31724	0.44138	0.44828	0.47586	0.60000	0.33024
3/27/2015 19:00	0.26897	0	0	0	0.28966	0.31724	0.44138	0.44828	0.47586	0.31081
3/27/2015 20:00	0.26207	0	0	0	0.26897	0.28966	0.31724	0.44138	0.44828	0.30050
3/27/2015 21:00	0.27586	0	0	0	0.26207	0.26897	0.28966	0.31724	0.44138	0.29330
3/27/2015 22:00	0.28966	0	0	0	0.27586	0.26207	0.26897	0.28966	0.31724	0.31450
3/27/2015 23:00	0.28966	0	0	0	0.28966	0.27586	0.26207	0.26897	0.28966	0.32923
3/28/2015 0:00	0.29655	0	0	0	0.28966	0.28966	0.27586	0.26207	0.26897	0.32957
3/28/2015 1:00	0.31034	0.01887	0	0	0.29655	0.28966	0.28966	0.27586	0.26207	0.33667
3/28/2015 2:00	0.32414	0	0.01887	0	0.31034	0.29655	0.28966	0.28966	0.27586	0.35405
3/28/2015 3:00	0.33103	0	0	0.01887	0.32414	0.31034	0.29655	0.28966	0.28966	0.36145
3/28/2015 4:00	0.33793	0	0	0	0.33103	0.32414	0.31034	0.29655	0.28966	0.36608
3/28/2015 5:00	0.34483	0	0	0	0.33793	0.33103	0.32414	0.31034	0.29655	0.37163
3/28/2015 6:00	0.34483	0	0	0	0.34483	0.33793	0.33103	0.32414	0.31034	0.37719
3/28/2015 7:00	0.33793	0	0	0	0.34483	0.34483	0.33793	0.33103	0.32414	0.37612
3/28/2015 8:00	0.34483	0	0	0	0.33793	0.34483	0.34483	0.33793	0.33103	0.36892
3/28/2015 9:00	0.37241	0	0	0	0.34483	0.33793	0.34483	0.34483	0.33793	0.37510
3/28/2015 10:00	0.42069	0	0	0	0.37241	0.34483	0.33793	0.34483	0.34483	0.40112
3/28/2015 11:00	0.55172	0	0	0	0.42069	0.37241	0.34483	0.33793	0.34483	0.44615
3/28/2015 12:00	0.57931	0	0	0	0.55172	0.42069	0.37241	0.34483	0.33793	0.56863
3/28/2015 13:00	0.68966	0	0	0	0.57931	0.55172	0.42069	0.37241	0.34483	0.59265

3/28/2015 14:00	0.53103	0	0	0	0.68966	0.57931	0.55172	0.42069	0.37241	0.68780
3/28/2015 15:00	0.47586	0	0	0	0.53103	0.68966	0.57931	0.55172	0.42069	0.53751
3/28/2015 16:00	0.43448	0	0	0	0.47586	0.53103	0.68966	0.57931	0.55172	0.47014
3/28/2015 17:00	0.27586	0	0	0	0.43448	0.47586	0.53103	0.68966	0.57931	0.44156
3/28/2015 18:00	0.13103	0.37736	0	0	0.27586	0.43448	0.47586	0.53103	0.68966	0.30036
3/28/2015 19:00	0.21379	0	0.37736	0	0.13103	0.27586	0.43448	0.47586	0.53103	0.27177
3/28/2015 20:00	0.26897	0	0	0.37736	0.21379	0.13103	0.27586	0.43448	0.47586	0.27315
3/28/2015 21:00	0.31034	0	0	0	0.26897	0.21379	0.13103	0.27586	0.43448	0.30890
3/28/2015 22:00	0.33793	0	0	0	0.31034	0.26897	0.21379	0.13103	0.27586	0.34950
3/28/2015 23:00	0.36552	0	0	0	0.33793	0.31034	0.26897	0.21379	0.13103	0.38293
3/29/2015 0:00	0.38621	0	0	0	0.36552	0.33793	0.31034	0.26897	0.21379	0.40264
3/29/2015 1:00	0.40000	0	0	0	0.38621	0.36552	0.33793	0.31034	0.26897	0.41811
3/29/2015 2:00	0.42759	0	0	0	0.40000	0.38621	0.36552	0.33793	0.31034	0.42758
3/29/2015 3:00	0.43448	0	0	0	0.42759	0.40000	0.38621	0.36552	0.33793	0.45126
3/29/2015 4:00	0.44138	0	0	0	0.43448	0.42759	0.40000	0.38621	0.36552	0.45584
3/29/2015 5:00	0.44138	0	0	0	0.44138	0.43448	0.42759	0.40000	0.38621	0.45968
3/29/2015 6:00	0.44138	0	0	0	0.44138	0.44138	0.43448	0.42759	0.40000	0.45906
3/29/2015 7:00	0.44138	0.01887	0	0	0.44138	0.44138	0.44138	0.43448	0.42759	0.45785
3/29/2015 8:00	0.44828	0	0.01887	0	0.44138	0.44138	0.44138	0.44138	0.43448	0.46247
3/29/2015 9:00	0.47586	0	0	0.01887	0.44828	0.44138	0.44138	0.44138	0.44138	0.46414
3/29/2015 10:00	0.52414	0	0	0	0.47586	0.44828	0.44138	0.44138	0.44138	0.48890
3/29/2015 11:00	0.57931	0	0	0	0.52414	0.47586	0.44828	0.44138	0.44138	0.53409
3/29/2015 12:00	0.72414	0	0	0	0.57931	0.52414	0.47586	0.44828	0.44138	0.58476
3/29/2015 13:00	0.70345	0	0	0	0.72414	0.57931	0.52414	0.47586	0.44828	0.71857
3/29/2015 14:00	0.57931	0	0	0	0.70345	0.72414	0.57931	0.52414	0.47586	0.69602
3/29/2015 15:00	0.52414	0	0	0	0.57931	0.70345	0.72414	0.57931	0.52414	0.56821
3/29/2015 16:00	0.50345	0	0	0	0.52414	0.57931	0.70345	0.72414	0.57931	0.51654
3/29/2015 17:00	0.47586	0	0	0	0.50345	0.52414	0.57931	0.70345	0.72414	0.49522
3/29/2015 18:00	0.25517	1.00000	0	0	0.47586	0.50345	0.52414	0.57931	0.70345	0.51112

3/29/2015 19:00	0.34483	0.01887	1.00000	0	0.25517	0.47586	0.50345	0.52414	0.57931	0.57068
3/29/2015 20:00	0.44138	0	0.01887	1.00000	0.34483	0.25517	0.47586	0.50345	0.52414	0.43003
3/29/2015 21:00	0.52414	0	0	0.01887	0.44138	0.34483	0.25517	0.47586	0.50345	0.46568
3/29/2015 22:00	0.57931	0	0	0	0.52414	0.44138	0.34483	0.25517	0.47586	0.53417
3/29/2015 23:00	0.60690	0	0	0	0.57931	0.52414	0.44138	0.34483	0.25517	0.59601
3/30/2015 0:00	0.64828	0	0	0	0.60690	0.57931	0.52414	0.44138	0.34483	0.61380
3/30/2015 1:00	0.67586	0	0	0	0.64828	0.60690	0.57931	0.52414	0.44138	0.64539
3/30/2015 2:00	0.68966	0	0	0	0.67586	0.64828	0.60690	0.57931	0.52414	0.66606
3/30/2015 3:00	0.70345	0	0	0	0.68966	0.67586	0.64828	0.60690	0.57931	0.67387
3/30/2015 4:00	0.71034	0	0	0	0.70345	0.68966	0.67586	0.64828	0.60690	0.68443
3/30/2015 5:00	0.71034	0	0	0	0.71034	0.70345	0.68966	0.67586	0.64828	0.68823
3/30/2015 6:00	0.71034	0	0	0	0.71034	0.71034	0.70345	0.68966	0.67586	0.68603
3/30/2015 7:00	0.71034	0	0	0	0.71034	0.71034	0.71034	0.70345	0.68966	0.68506
3/30/2015 8:00	0.71034	0	0	0	0.71034	0.71034	0.71034	0.71034	0.70345	0.68437
3/30/2015 9:00	0.73793	0	0	0	0.71034	0.71034	0.71034	0.71034	0.71034	0.68395
3/30/2015 10:00	0.77241	0	0	0	0.73793	0.71034	0.71034	0.71034	0.71034	0.70991
3/30/2015 11:00	0.88276	0	0	0	0.77241	0.73793	0.71034	0.71034	0.71034	0.74255
3/30/2015 12:00	0.98621	0	0	0	0.88276	0.77241	0.73793	0.71034	0.71034	0.84489
3/30/2015 13:00	1.00000	0	0	0	0.98621	0.88276	0.77241	0.73793	0.71034	0.94144
3/30/2015 14:00	0.91034	0	0	0	1.00000	0.98621	0.88276	0.77241	0.73793	0.94727
3/30/2015 15:00	0.73103	0	0	0	0.91034	1.00000	0.98621	0.88276	0.77241	0.85681
3/30/2015 16:00	0.60690	0.01887	0	0	0.73103	0.91034	1.00000	0.98621	0.88276	0.68288
3/30/2015 17:00	0.54483	0.60377	0.01887	0	0.60690	0.73103	0.91034	1.00000	0.98621	0.59349
3/30/2015 18:00	0.64828	0.09434	0.60377	0.01887	0.54483	0.60690	0.73103	0.91034	1.00000	0.69845
3/30/2015 19:00	0.73793	0	0.09434	0.60377	0.64828	0.54483	0.60690	0.73103	0.91034	0.68722
3/30/2015 20:00	0.77931	0	0	0.09434	0.73793	0.64828	0.54483	0.60690	0.73103	0.72259
3/30/2015 21:00	0.80000	0	0	0	0.77931	0.73793	0.64828	0.54483	0.60690	0.75562
3/30/2015 22:00	0.81379	0	0	0	0.80000	0.77931	0.73793	0.64828	0.54483	0.77579
3/30/2015 23:00	0.82759	0	0	0	0.81379	0.80000	0.77931	0.73793	0.64828	0.78197

3/31/2015 0:00	0.82759	0	0	0	0.82759	0.81379	0.80000	0.77931	0.73793	0.78919
3/31/2015 1:00	0.83448	0	0	0	0.82759	0.82759	0.81379	0.80000	0.77931	0.78634
3/31/2015 2:00	0.83448	0	0	0	0.83448	0.82759	0.82759	0.81379	0.80000	0.79101
3/31/2015 3:00	0.83448	0	0	0	0.83448	0.83448	0.82759	0.82759	0.81379	0.79052
3/31/2015 4:00	0.83448	0	0	0	0.83448	0.83448	0.83448	0.82759	0.82759	0.78924
3/31/2015 5:00	0.83448	0	0	0	0.83448	0.83448	0.83448	0.83448	0.82759	0.78939
3/31/2015 6:00	0.82759	0	0	0	0.83448	0.83448	0.83448	0.83448	0.83448	0.78897
3/31/2015 7:00	0.81379	0	0	0	0.82759	0.83448	0.83448	0.83448	0.83448	0.78248
3/31/2015 8:00	0.81379	0	0	0	0.81379	0.82759	0.83448	0.83448	0.83448	0.76946
3/31/2015 9:00	0.83448	0	0	0	0.81379	0.81379	0.82759	0.83448	0.83448	0.76979
3/31/2015 10:00	0.84828	0	0	0	0.83448	0.81379	0.81379	0.82759	0.83448	0.78998
3/31/2015 11:00	1.00000	0.01887	0	0	0.84828	0.83448	0.81379	0.81379	0.82759	0.80398
3/31/2015 12:00	0.97931	0	0.01887	0	1.00000	0.84828	0.83448	0.81379	0.81379	0.95127
3/31/2015 13:00	1.00000	0	0	0.01887	0.97931	1.00000	0.84828	0.83448	0.81379	0.92805
3/31/2015 14:00	0.91724	0	0	0	1.00000	0.97931	1.00000	0.84828	0.83448	0.93561
3/31/2015 15:00	0.81379	0	0	0	0.91724	1.00000	0.97931	1.00000	0.84828	0.86168
3/31/2015 16:00	0.67586	0.07547	0	0	0.81379	0.91724	1.00000	0.97931	1.00000	0.75576
3/31/2015 17:00	0.64828	0.16981	0.07547	0	0.67586	0.81379	0.91724	1.00000	0.97931	0.65852
3/31/2015 18:00	0.68966	0	0.16981	0.07547	0.64828	0.67586	0.81379	0.91724	1.00000	0.66142
3/31/2015 19:00	0.73793	0.09434	0	0.16981	0.68966	0.64828	0.67586	0.81379	0.91724	0.67086
3/31/2015 20:00	0.77931	0.01887	0.09434	0	0.73793	0.68966	0.64828	0.67586	0.81379	0.73557
3/31/2015 21:00	0.80690	0.03774	0.01887	0.09434	0.77931	0.73793	0.68966	0.64828	0.67586	0.76446
3/31/2015 22:00	0.83448	0	0.03774	0.01887	0.80690	0.77931	0.73793	0.68966	0.64828	0.78941
3/31/2015 23:00	0.83448	0	0	0.03774	0.83448	0.80690	0.77931	0.73793	0.68966	0.80146