DUAL STATISTICAL APPROACH FOR CORRELATION OF SHEAR WAVE VELOCITY WITH THE SCPTu PARAMETERS

By

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DUAL STATISTICAL APPROACH FOR

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THE SCPTu PARAMETERS

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Title of Study: DUAL STATISTICAL APPROACH FOR CORRELATION OF SHEAR WAVE VELOCITY WITH THE SCPTu PARAMETERS

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Abstract: Over 30 years of research in the field of shear wave velocity (V_s) estimation, scores of researchers were successful in modeling V_s using the Seismic Cone Penetration Test (SCPT) parameters. Through this research work, by utilizing two different statistical approaches in modeling V_s from SCPT mechanical parameters, high performing models were produced. This work was done for predicting V_s for Kirkland Series soil using the different statistical approaches. One statistical approach was based on stepwise model selection functioning whereas the other one was emulating the Kolmogorov-Gabor polynomial series. The SCPT data was obtained from a standalone Oklahoma Department of Transportation (ODOT) funded project which spanned from February to August 2021. The parameters used for modeling V_s were depth, effective overburden stress, sleeve friction and uncorrected cone – tip resistance. The data processing of SCPT parameters consisted of 29 V_s profiles of datasets along with datasets of selected parameters, which were averaged to set up modeling process for averaged datasets of all parameters. All four variables were found to be positively correlated to one another. Sleeve friction was noted to be most positive correlated to V_s. After the extensive modeling process, models M15 as well as stepwise model yielded R^2 values of 0.9911 and 0.9621. These models were found to be optimal models produced statistically following the modeling process and were compared with select literary model functions. Additionally, the models of literature resulted in higher RMSE values whereas RMSE values as well as residual error plot showed lower values and variance.

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CHAPTER I

INTRODUCTION

1.1 Background

Shear Wave Velocity (SWV or V_s) is one of well researched topics in the fields such as Seismology, Geotechnical Engineering, and Earth Sciences related areas. Shear wave velocity is usually expressed as $V_s = \sqrt{\frac{G_{max}}{\rho}}$ (1) where G_{max} is small strain modulus of soil, ρ is density of soil and V_s is the shear wave velocity in a soil[1]. The practical applications associated with determining SWV are detection of potential liquefaction of soils, earthquake site response analyses along with moisture fluctuations and site classification[2]. Additionally, understanding the soil deformation with respect to small strains due to soil-infrastructure interactions is a crucial aspect that is encountered in geotechnical practice [3]. While there are several techniques and methods employed to determining the SWV profile of the site such as cross-hole testing (CHT), spectral analysis of surface waves (SASW) amongst other methods, Seismic Cone Penetration/Piezocone Testing (SCPT) has become one of the most effective methods of field testing that would yield V_s profiles in geotechnical engineering field[3]. In recent times, SCPT has become preferred testing technique of choice due to the ease of data collection and quantity of data collected is effortlessly assessed during the data collection in situ. While the SCPT does make the data collection more convenient, the overall prediction of the V_s is still a challenging task for all researchers in this field of study. Prediction of V_s is important because testing on a regular time basis and cost – related challenges.

Over the span of 30 years and more, researchers have created several models as shown in Table 2.1 to predict the V_s, commonly focused on the parameters such as Cone-tip resistance (q_c), sleeve friction (f_s). Moreover, over the years, in junction with rapid development of technology and evolving knowledge of using different statistical models, researchers had branched out in establishing a significant number of models for predicting V_s. Each model created had a unique look on the data processed along with given constraints that were factored into prediction process by the researchers. Although the numerous models were made to estimate V_s, all researchers have concluded in their studies that models produced by individual studies were all site dependent [4]. Given such conclusion, there is a need to solve the challenge of accurately estimating V_s for Kirkland series soil since no research has done in estimating V_s for Kirkland series soil accurately.

1.2 Aim and Objectives

The aim of this study is to predict V_s using only mechanical parameters from SCPT data collected and the goal of this study is to establish new model functions for estimating V_s for Kirkland series soil. For achieving the aim of the study, different objectives need to be met to acquire the necessary knowledge for modeling. The objectives of this thesis are the following points:

- Examine and analyze the correlations between the each of the mechanical variables utilized for modelling with the respect to V_s.
- Explore and experiment with the different approaches of modeling to fit the standardized data of V_s from the SCPT data.
- Compare and evaluate the limitations and statistical interpretations of the models created to the models used by previous researchers.

It is imperative that extensive literature review, data processing methods along with data analysis processes are executed thoroughly for accomplishing the objectives mentioned. With the appropriate preparations in place, the entire process of data analysis does promise a different perspective on modeling V_s in contrast to previous attempts of modelling in the literature. For several existing literary model functions, researchers have had applied singular statistical approach however in this study, dual statistical approach was implemented. Dual statistical approach is advantageous since this approach explores the extremes of most simple and complex modeling methods for creating model functions that provide contrasting outlooks overall.

1.3 Structure of Thesis

Below listed chapters' descriptions show how the thesis is structured:

Chapter 2 points out the literary models made for predicting V_s and the difference between the models presented.

Chapter 3 enlists how the data was acquired, data processing approaches and the significance of using chosen approaches.

Chapter 4 displays the results of the data processing and extensive modelling done for estimating V_s

Chapter 5 summarizes the findings of the data analysis, evaluation of the findings and limitations of the results

CHAPTER II

LITERATURE REVIEW

2.1 Seismic Cone Penetrating Test

Seismic Cone Penetrating Test (SCPT) is a common testing method of calculating the small strain shear modulus of the soil by measuring shear wave velocity through the soil.[5] SCPT equipment utilizes geophones in a soil downhole to receive seismic wave signals in terms of shear waves, transmitted from a source at ground level to geophone's depth which was installed inside the penetrating cone.

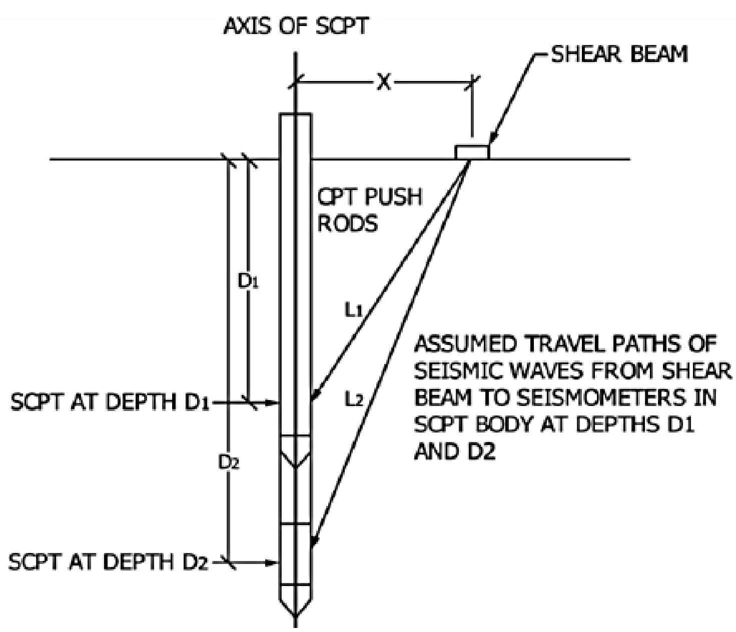

Figure 2.1: Schematic Illustration of SCPT from ASTM D7400

As indicated in figure 2.1[6], at the ground level, penetration rod is inserted into the downhole at different prescribed depths and seismic waves are generated at the ground level when the shear beams connecting to the right and left side of the equipment are triggered. The shear waves are detected by geophones inserted at depths (D-1 and D-2) and shear wave velocity is computed based on how shear waves propagate between the depth intervals in the soil and difference in wave arrival times at the depths mentioned. The shear wave velocity between two depths is calculated using the following equation where L – 1 and L – 2 are assumed travel paths of shear waves through soil as indicated in Figure 2.1:

$$V_s = \frac{L_2 - L_1}{D_2 - D_1} \quad (2)$$

All modern SCPT equipment compute a real time shear wave velocity profile for in situ testing as well as recording the data of other pertinent parameters such as cone – tip resistance, sleeve friction, pore water pressure using equipment software. For this study, below shown figure 2.2 was the SCPT equipment utilized for data collection, and transmission as part of ODOT project[6].

Figure 2.2: SCPT equipment used for data collection

2.2 Literature Model Functions

As previously mentioned, over the course of 3 decades, the researchers have produced numerous models to correlate the V_s to the SCPT parameters. The first model was proposed in 1983 by Sykora and Stokoe on the sandy soil[7]. From thereon, as the popularity and significance of establishing an empirical correlation between CPT parameters and V_s grew, researchers created models based on advancing statistical modeling which progressed the general improvement in knowledge in this field as well as experimental capabilities Researchers also explored extensively the different methods of correlations in terms of parameters used along with observing the interactions between parameters chosen and V_s. Additionally, as researchers have understood that soil type is one of the dependent factors on how the V_s profiles observed, researchers did start to account for the disposition of soil type at which SCPT data was obtained and gathered data on the basic soil properties for overall understanding.

Table 2.1: Compilation of existing literary model functions for estimating V_s

Authors	Soil Type	Model Functions with description of parameters used
Barrow and Stokoe (1983) [8]	All	$V_s = 154 + 0.64q_c$ Q_c – cone – tip resistance; V_s – shear wave velocity
Sykora and Stokoe (1983) [7]	Sand	$V_s = 134 + 0.52q_c$ $V_s = 54.8(q_c)^{0.29}$ Q_c – cone – tip resistance; V_s – shear wave velocity
Iyisan and Ansal (1993)[9]	All	$V_s = 160 + 0.9q_c$ $V_s = 45(q_c)^{0.41}$ Q_c – cone – tip resistance; V_s – shear wave velocity
Hegazy and Mayne (1995) [10]	Sand	$V_s = 12.02(q_c)^{0.319}(f_s)^{-0.0466}$ Q_c – cone – tip resistance; V_s – shear wave velocity ; F_s – sleeve friction
Iyisan (1996)[11]	1. Clay 2. Sand	1. $V_s = 55.3(q_c)^{0.377}$ 2. $V_s = 218 + 0.7q_c$ Q_c – cone – tip resistance; V_s – shear wave velocity
Piratheepan & Andrus (2002)[12]	1. Clay 2. Sand 3. All	1. $V_s = 11.9q_c^{0.269}f_s^{1.09}D^{0.127}$ 2. $V_s = 25.3q_c^{0.103}f_s^{0.029}D^{0.155}$ 3. $V_s = 32.3q_c^{0.089}f_s^{0.1219}D^{0.215}$ Q_c – cone – tip resistance; V_s – shear wave velocity F_s – sleeve friction; D - Depth
Tun (2003)[13]	All	$V_s = 109.29 + 52.674Ln(q_c)$ Q_c – cone – tip resistance; V_s – shear wave velocity
Madiai and Simoni (2004)[14]	All	1. $V_s = 211(q_c)^{0.23}$ 2. $V_s = 155(q_c)^{0.29}(f_s)^{-0.10}$ Q_c – cone – tip resistance; V_s – shear wave velocity
Hegazy and Mayne (2006)[15]	All	$V_{s1} = 0.0831q_{c1N}^{0.103}(\sigma'_{v0}/p_a)^{0.25}e^{1.786Ic}$ V_{s1} – normalized shear wave velocity; σ'_{v0} - effective vertical stress; q_{c1N} - normalized cone – tip resistance; p_a = 100 kPa; Ic – soil behavior index
Mayne(2006) [16]	All	$V_s = 18.5 + 118.8\log(f_s)$ V_s – shear wave velocity and f_s – sleeve friction
Mola-Abasi, Dikmen and Shooshpasha (2015) [17]	1. All 2. Clay	1. $V_s = 100[1.40 + 1.59f_s + 0.09q_c - 1.33f_s^2 - 0.002q_c^2 + 0.05(f_s)(q_c)$ 2. $V_s = 100[1.36 - 0.35f_s + 0.15q_c - 0.05f_s^2 - 0.018q_c^2 + 0.39(f_s)(q_c)$ Q_c – cone – tip resistance; V_s – shear wave velocity F_s – sleeve friction;

Tong, Che, Zhang, and Li (2018) [2]	All	$V_s = 37.7 q_c^{0.103} f_s^{0.109} Z^{0.146}$ Q_c – cone – tip resistance; V_s – shear wave velocity F_s – sleeve friction; Z - Depth

Based on the listed literary models in the table 2.1, there are several inferences that can be pointed out. It is indicative that early model functions for estimating V_s adopted simple linear correlations to one variable, which was Cone – tip resistance (q_c). While there were notions for expanding the modelling to nonlinear functions by a few researchers, there were no clear reasons identified apart from lack of accurate equipment and depth of understanding on the concept, for researchers to explore non-linear functions[15, 18]. In 1995, Hegazy and Mayne[10] did produce non-linear models dependent on parameters such as cone-tip resistance, sleeve friction and others. From thereon, many researchers have contributed to this field of study with a wide range of model functions while accounting for soil applicability and site specific data[2, 19, 20]. The wide range of functions which were created resulted in inclusion of several parameters that were not initially considered by previous researchers. Based on the models established from 1995 to 2018, there have been at least five variables apart from cone-tip resistance and sleeve friction, which were incorporated in the model functions based on the relevance of the research conducted. Authors such as Andrus[19], Robertson[20], Long & Donohue[21] amongst several others, explored and redefined the prediction models to integrate a diversified outlook on modelling by including several previous thought nonstandard parameters[2, 22]. The five more common variables were effective vertical stress (σ'_{v0}), pore water pressure(u), depth(D), soil type behavior index (Ic) and natural void ratio(e_0). Consequently, for considering the potential effects of different variables in modeling process, the researchers such as Andrus[19], Hegazy & Mayne[15], Tonni and Simonini[3] have been required to rely on complex mathematical and statistical methods to produce high performing model functions.

For instance, model function produced by Mola-Abasi and colleagues[17], was based on the Kolmogorov-Gabor polynomial series that results in polynomial termed parameters to estimate V_s. Although the author indicated that cone-tip resistance and sleeve friction were parameters used to model V_s, the proposed model does show complexity on how the parameters are applied. Thereby, it has become an option for researchers to lean toward models that are complex as well as utilize high-skilled yet popularized statistical methods such as machine learning. However, despite utilizing sophisticated tools and methods, it is evident that researchers have eventually prioritized in processing the data collected in a singular statistical modeling methodology. While the results obtained the researchers have relevance, the depth of understanding of the model function created attained would be limited. Hence, to provide more depth to the overall understanding, this study would show that using two statistical approaches would yield an insightful outlook on how the modeling should be performed and what prior information is beneficial to be used for ensuing process.

2.3 Background information on key concepts

Before the methodology used in this study is discussed, it is necessary to establish definitions over some of the concepts that will be utilized over the course of the work.

2.3.1 Kolmogorov – Gabor Polynomial series

Kolmogorov – Gabor Polynomial series, also known as, Wiener series[23] is generally expressed as below:

$$\boldsymbol{Y}(\boldsymbol{x_1}, \dots, \boldsymbol{x_n}) = \boldsymbol{a_0} + \sum_{i=1}^{n} \boldsymbol{a_i x_i} + \sum_{i=1}^{n} \sum_{j=1}^{n} \boldsymbol{a_{ij} x_i x_j} + \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{k=1}^{n} \boldsymbol{a_{ijk} x_i x_j x_k} + \cdots \quad \textbf{(3)}$$

Wiener series can be defined as the orthogonal expansion for nonlinear functionals which is closely related to Volterra series[23]. This polynomial series is prominently used in several fields such as data mining, pattern recognition, Gene Expression Programming (GEP), prediction modeling along with other data science purposes. This polynomial series is categorized under Group Method of Data Handling (GMDH). The researcher Mola-Abasi and his colleagues used this polynomial series as a statistical approach in his work of predicting V_s [17]. Based on the results of Mola-Abasi's work, this statistical approach produced high-performing model functions with great precision in predicting V_s while compared to prior estimation models. More importantly, the model function yielded using this polynomial series, is most complex model function created till now, in terms of linear modeling. Thereby, this polynomial series was selected to be used as one of the statistical methods due to its complexity.

2.3.2 Stepwise Regression

Stepwise Regression[24] is a method of fitting regression models where the choice of independent variables is carried out by an automatic procedure. In Stepwise Regression method, at each step, one variable is either added or subtracted from the available parameters based on certain preexisting criterion as shown in figure 2.1[25]. For instance, preexisting or prespecified criterion could be based on different statistical metrics such as

AIC (Akaike Information Criterion), Residual error, BIC (Bayesian Information Criterion). Stepwise Regression is used in data mining as well as prediction modeling in several fields such as biology, neuroscience amongst others.

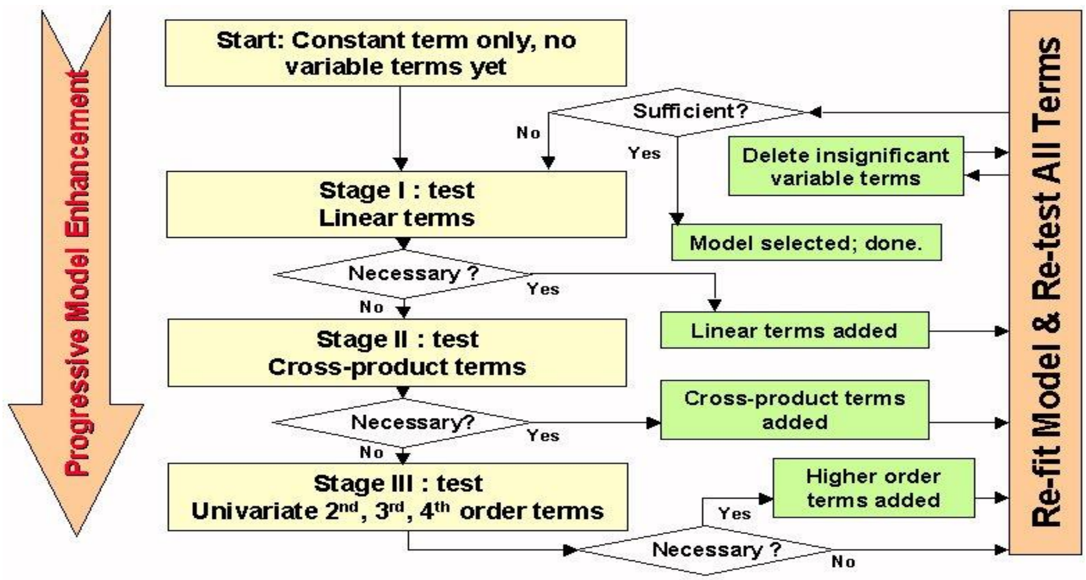

Figure 2.3: The flowchart of stepwise regression method

Forward selection refers to addition of each variable and testing the added variables with select criterion. The inclusion of each variable is done to improve the statistical significance of the model and the process is repeated until the model stops to improve past optimal significance. In the context of this study, Forward step regression is utilized as one of the approaches to modelling the SCPT parameters for predicting V_s.

CHAPTER III

METHODOLOGY OF DATA COLLECTION AND PROCESSING

3.1 Data Collection

The SCPT data was collected as part of a project funded by ODOT over the span of 7 months in 2021. The soil upon which the SCPT readings were collected was Kirkland soil series. The Kirkland series consists of very deep, well drained soils which formed due to material weathered from clayey sediments over shale of Permian age which is located across states such as Oklahoma, Kansas and Texas[26]. Kirkland series soil is one of the more common soils in the central Oklahoma. The site of the SCPT data collection was located near the intersection of State Highway 15 and Interstate 35 in the Noble County, Northern Oklahoma as shown in Figures 3.1a & b[6]. As per United States Department of Agriculture (USDA), the site contains Kirkland silt loam soil with the AASHTO classifications of A-4, A-6 and A-7-6 and the texture of the soil is defined to be silt loam and silty clay as shown in Table 3.1. The soil samples were taken to verify the classification of the soil and the classification of soil at varying range of depths was discerned.

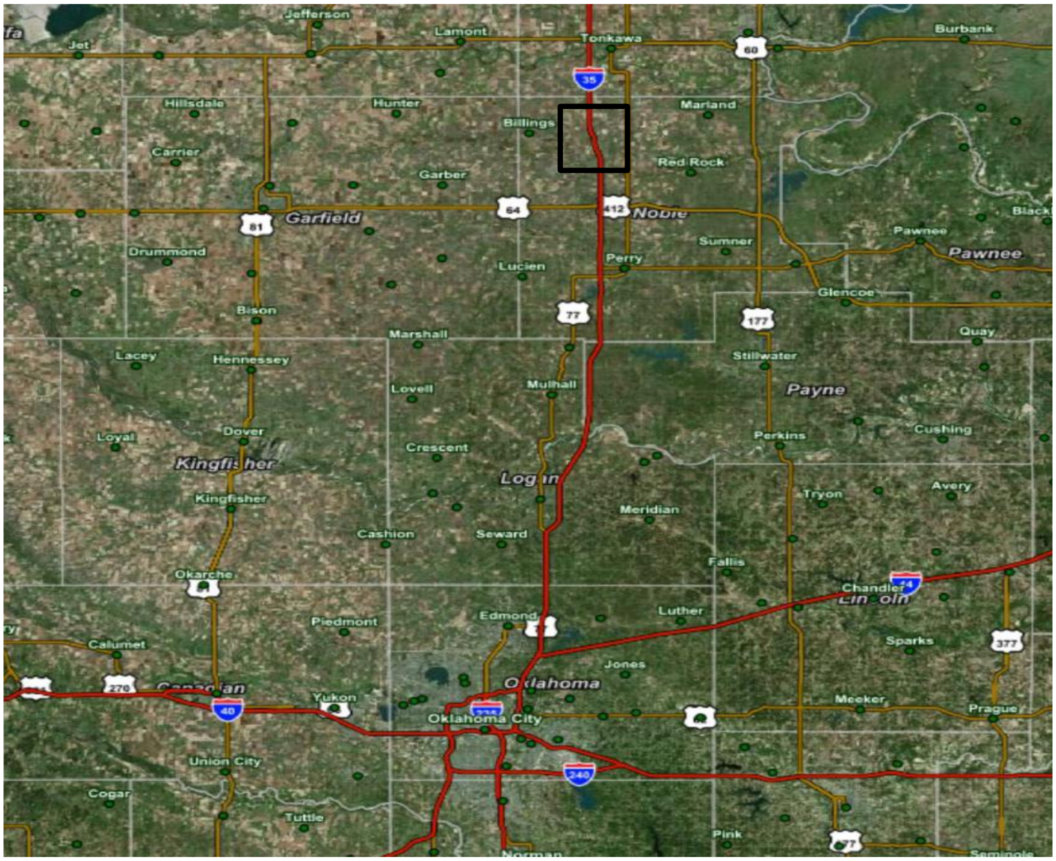

Figure 3.1a: Enlarged satellite image of North Central Oklahoma with square highlighting the area of the testing site.

Figure 3.1b: Focused Satellite image, courtesy of Google maps, showing the exact location of SCPT data collection site which is off the intersection of Oklahoma state highway 15 and I-35 in Noble County, Oklahoma. Rectangle box represents the testing site for SCPT data.

Table 3.1: Engineering properties of the Kirkland series soil at the site of SCPT data based on USDA records

Soil Name	Depth	USDA Texture	Classification		Fragments		% Passing sieve #				LL	PI
			Unified	AASHTO	> 10 in	3-10 in	4	10	40	200		
Kirkland	0 – 8	Silt Loam	CL CL-ML	A-4 A-6 A-7-6	0	0	100	100	92 – 100	79 – 97	23-43	6 – 19
	8 – 19	Clay, silty clay	CH	A-7-6	0	0	100	100	94 – 100	85 – 100	52 – 69	29 – 40
	19 – 28	Clay, silty clay	CH	A-7-6	0	0	100	100	94 – 100	86 – 100	52 – 69	29 – 40
	28 – 51	Clay, silty clay	CH	A-7-6	0	0	100	100	94 – 100	86 – 100	51 – 67	29 – 40
	51 – 82	Clay, silty clay	CH	A-7-6	0	0	100	100	95 – 100	88 – 100	51 – 67	29 – 40

During each SCPT data collection day, as per existing consensus agreed by technicians and primary researcher of the ODOT project, figure 3.2 shows data collection layout[6]. The figure indicates the points of testing by different colored dots such as green, black, yellow, and red representing CPT data obtained on a given day and the individual line represents line along which the sites of the CPTs were done for a given day. The distance between each CPT location was 5 feet and distance between lines of testing was 10 feet and a day’s testing consisted of four ports of CPT. After CPT, one or two soil samples were collected and labelling of the depth layering at which soils were collected was done methodically. The soil samples were not collected at the same ports as the CPTs rather in between two adjacent ports to access undisturbed soil. The soils sample were tested for basic soil properties in the laboratory along with other factors to ascertain simple understanding of soil behavior. Common geotechnical lab testing such as Atterberg Limits testing for plastic limits (PL), liquid limits (LL) amongst others were carried out systematically.

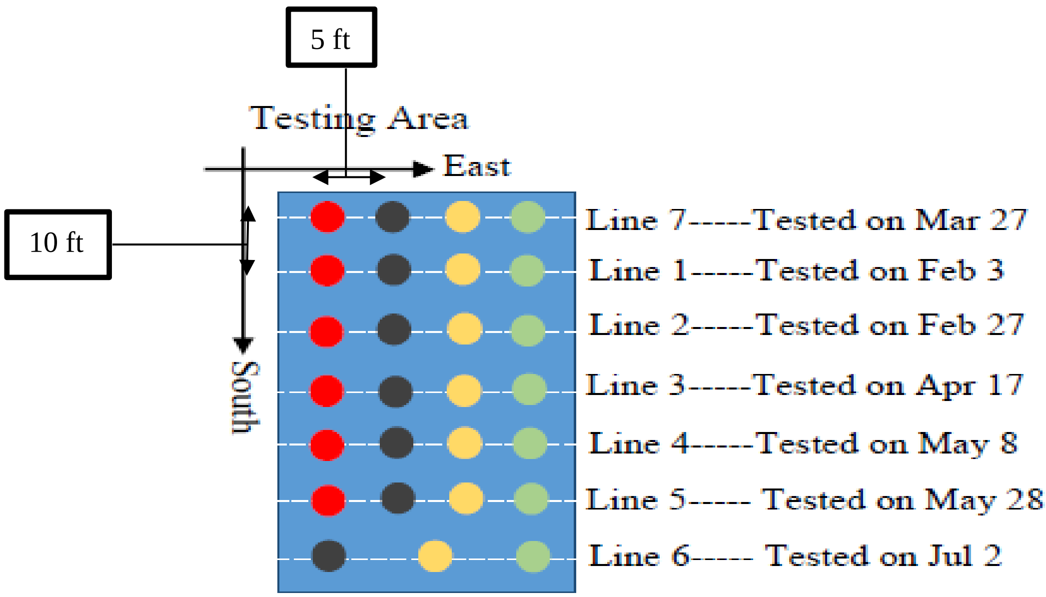

Figure 3.2: A Topographical layout for SCPT data collection site along with the date of each row of SCPT data collection. Each dot above represents a testing borehole: green dots are assigned as CPT – 1, yellow dots as CPT – 2, black dots as CPT – 3 & red dots as CPT – 4. Distance between each row of testing line is 10 ft and distance between each testing hole is 5 ft as indicated.

At the end of a day's work, CPT data for the day was transmitted to the interested parties, as further data analytics and other subsequent processes of data interpretation ensue. Data analytics and other subsequent processes includes the generating shear wave velocity profiles from raw data, data compilation of relevant parameters to V_s profiles. establishment of simple statistical inferences in terms of variance and covariances of the parameters, along with the application of statistical approaches chosen to create prediction model functions based on the parameters data.

3.2 Data Consolidation

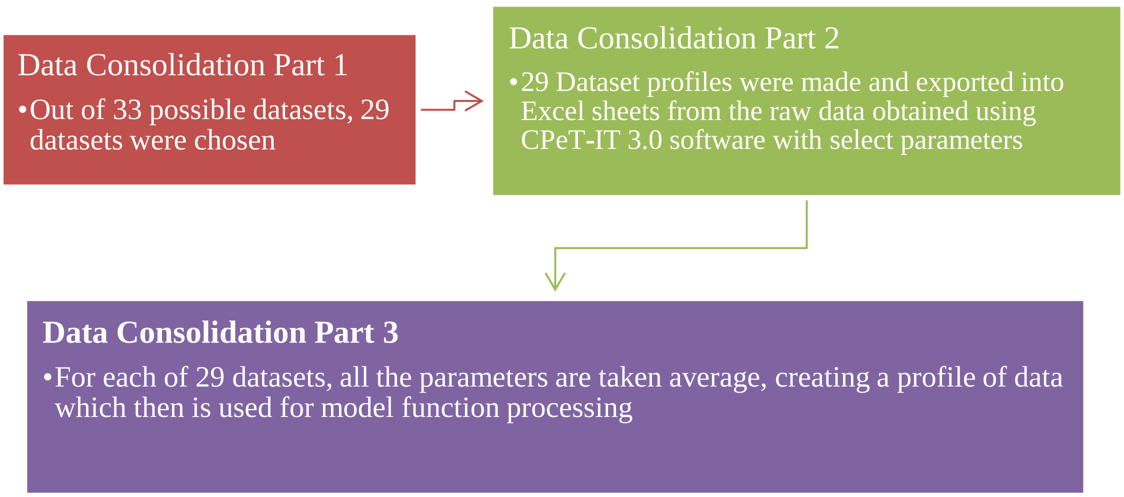

Figure 3.3: Flowchart of the Data Consolidation process

Over the 7 months span, 33 sets of SCPT data were obtained. Data consolidation and compilation was done in three parts. For part 1 of data processing as indicated in Figure 3.3, out of the 33 datasets, 29 were selected for further processes of data analysis whereas the remainder of the datasets were excluded based on incomplete and limited data collected. For part 2 of data consolidation process, for the chosen 29 datasets, the raw data on specific CPT parameters such as cone – tip resistance, sleeve friction, pore water pressure and depth were extracted from CPT files into excel spreadsheets. Then, using the software CPeT-IT 3.0 by Geologismiki[27], by inputting the extracted excel data sets of above mentioned parameters, the software produced the 29 V_s profiles for corresponding datasets of parameters inputted. The V_s profiles obtained using CPeT-IT 3.0 software represent the measured V_s from each individual day's datasets which were recorded. This software was only used for generating V_s profiles from the extracted data. The software created the shear wave velocity profiles using above mentioned equation (2) and extrapolating the shear wave velocity values for the corresponding depths from the raw data. Initial statistical inferences were obtained in conjunction with data consolidation process and based on the statistical data trends and graphical representation of data, further processing was taken into consideration.

Table 3.2: Example of a compilation of single dataset profile for CPT parameters

Depth (m)	qc (MPa)	fs (kPa)	Eff. stress (kPa)	Vs (m/s)
0.05	0.92	0.10	0.46	62.19
0.10	1.66	10.52	0.92	76.17
0.15	1.62	21.55	1.38	88.18
0.20	1.69	29.12	1.84	93.79
0.25	1.47	39.08	2.30	97.43
0.30	1.37	42.26	2.76	98.73
0.35	1.24	46.68	3.22	99.89
0.40	1.26	47.64	3.68	101.60
0.45	1.26	51.83	4.14	104.61
0.50	1.27	62.27	4.60	107.69
0.55	1.40	60.97	5.05	113.30
0.60	1.76	70.64	5.51	123.41
0.65	2.55	94.01	5.97	131.20
0.70	2.36	92.95	6.43	138.27
0.75	2.44	112.71	6.89	141.07
0.80	2.78	108.24	7.35	140.09
0.85	1.69	102.41	7.81	133.20
0.90	1.01	94.21	8.27	123.97
0.95	1.11	96.04	8.73	122.58
1.00	1.34	103.76	9.19	127.26
1.05	1.42	111.17	9.65	132.65

1.10	1.70	113.98	10.11	142.87
1.15	3.05	119.45	10.57	157.07
1.20	4.29	148.81	11.03	170.55
1.25	4.30	184.77	11.49	178.96
1.30	3.97	198.08	11.95	182.37
1.35	4.18	198.19	12.41	183.70
1.40	4.17	202.69	12.87	183.27
1.45	4.09	176.28	13.33	181.03
1.50	4.38	146.23	13.79	186.42
1.55	5.60	222.89	14.24	202.43
1.60	7.13	316.14	14.70	240.43
1.65	17.32	425.05	15.16	272.39
1.70	20.30	494.59	15.62	299.51
1.75	21.32	595.53	16.08	310.55
1.80	21.71	581.59	16.54	308.74
1.85	14.24	574.64	17.00	296.17
1.90	11.38	522.58	17.46	278.36
1.95	9.99	479.52	17.92	266.12
2.00	9.46	425.11	18.38	253.43
2.05	8.43	317.30	18.84	239.71
2.10	7.30	267.13	19.30	224.83
2.15	6.43	229.80	19.76	215.95
2.20	6.40	218.62	20.22	210.26
2.25	6.14	202.96	20.68	208.06
2.30	6.31	192.99	21.14	207.94
2.35	7.53	180.99	21.60	210.25
2.40	7.48	197.86	22.06	214.53
2.45	7.31	225.39	22.52	222.86
2.50	8.91	267.79	22.98	228.42
2.55	9.38	234.09	23.43	235.20
2.60	10.14	264.06	23.89	238.47
2.65	9.91	293.28	24.35	245.81
2.70	12.40	285.49	24.81	250.06
2.75	11.76	296.49	25.27	253.22
2.80	9.24	356.61	25.73	256.10
2.85	9.95	391.88	26.19	240.16
2.90	12.29	0.00	26.65	219.78
2.95	16.56	0.00	27.11	84.38

qc – cone-tip resistance; fs – sleeve friction; Eff. Stress – effective overburden stress

Table 3.3: Statistical breakdown of the data from table 3.2

Depth (m)		qc (MPa)		fs (kPa)		Eff. stress (kPa)		Vs (m/s)	
Mean	1.50	Mean	6.44	Mean	202.49	Mean	13.79	Mean	184.03
Standard Error	0.11	Standard Error	0.71	Standard Error	20.53	Standard Error	1.03	Standard Error	8.72
Median	1.50	Median	4.38	Median	184.77	Median	13.79	Median	183.70
Standard Deviation	0.86	Standard Deviation	5.43	Standard Deviation	157.70	Standard Deviation	7.89	Standard Deviation	67.01
Sample Variance	0.74	Sample Variance	29.46	Sample Variance	24870.19	Sample Variance	62.29	Sample Variance	4490.94
Range	2.90	Range	20.79	Range	595.53	Range	26.65	Range	248.35
Minimum	0.05	Minimum	0.92	Minimum	0.00	Minimum	0.46	Minimum	62.19
Maximum	2.95	Maximum	21.71	Maximum	595.53	Maximum	27.11	Maximum	310.55
Count	59.00	Count	59.00	Count	59.00	Count	59.00	Count	59.00
Confidence Level(95.0%)	0.22	Confidence Level(95.0%)	1.41	Confidence Level(95.0%)	41.10	Confidence Level(95.0%)	2.06	Confidence Level(95.0%)	17.46

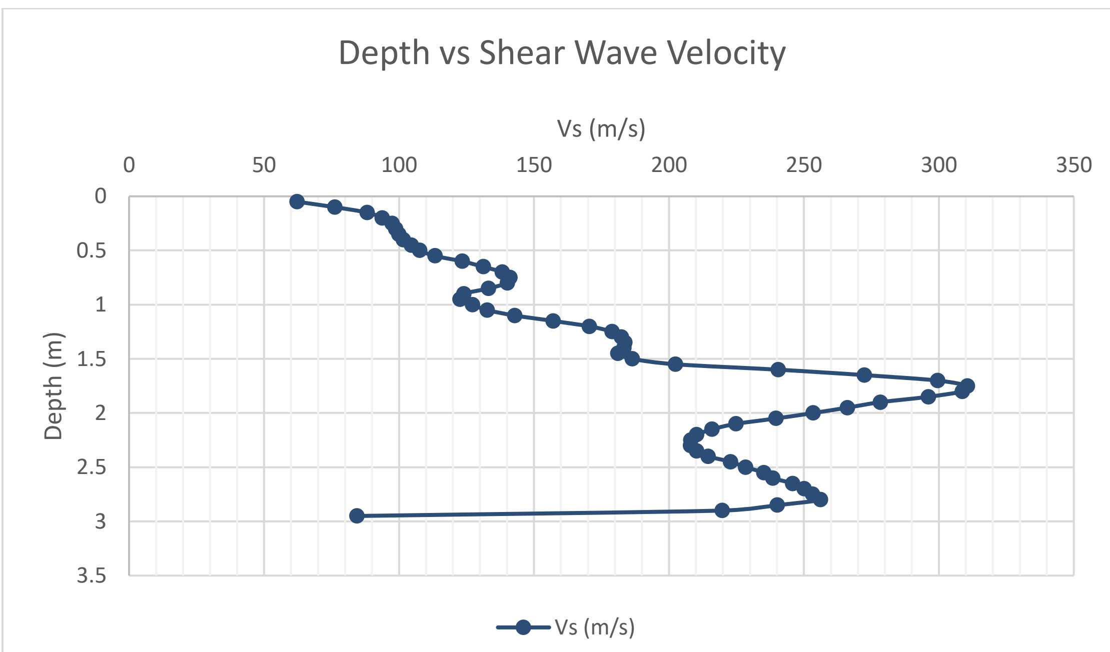

Figure 3.4: Graph of depth versus shear wave velocity for the data shown in table 3.2

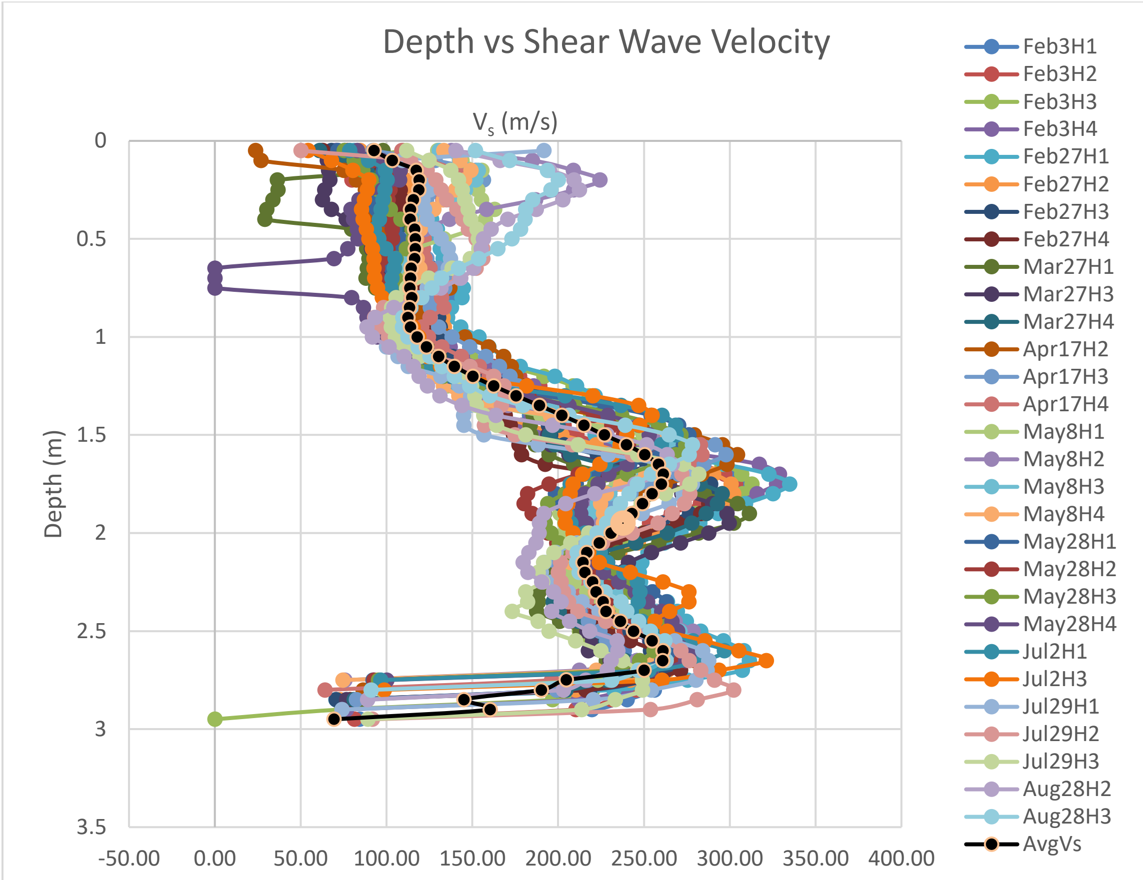

Figure 3.5: Graph of depth vs shear wave velocity for all V_s profiles used with black curve being the average V_s

From table 3.3 as well as figures 3.4 & 3.5, it was indicative that V_s does vary by a significant margin as do other parameters to different degrees. The reason for such variance in V_s could be attributed to several factors such as varying soil stratification, moisture content differentiation and so on. The variability observed could be also attributed to the time span of data collection, which spread over 7 months' time.

However, to model a function for predicting V_s, the datasets were required to be averaged to counteract the variance seen in measured V_s and other parameters values to produce an array of data used for the due process. Thereby, for part 3 of data consolidation process, each selected datasets were compiled together with respect to each parameters extracted data and average profile of these parameters which were cone-tip resistance, depth, sleeve friction, effective overburden stress (EOS) was generated. Moreover, EOS was chosen as a parameter to be used in modeling instead of pore water pressure because EOS is defined as the difference of vertical stress and pore water pressure of the soil[28]. With the averaging of parameters from the extracted data processed, average profile for each parameter was assembled with average V_s profile in a single data spreadsheet as shown in table 3.2 below.

Table 3.4: Collated average profile for each chosen parameter for 29 datasets

Depth(m)	AvgVs(m/s)	Avg.Qc(MPa)	Avg.Fs (MPa)	Avg.EfOS (MPa)
0.05	92.69	2.98	0.0123	0.00090
0.1	103.35	4.64	0.0259	0.00181
0.15	117.37	4.67	0.0556	0.00272
0.2	119.03	4.32	0.0677	0.00361
0.25	118.82	3.94	0.0605	0.00452
0.3	115.70	3.20	0.0616	0.00542
0.35	114.01	2.96	0.0562	0.00632
0.4	113.80	2.39	0.0643	0.00723
0.45	116.45	2.13	0.0696	0.00813
0.5	116.75	1.94	0.0732	0.00903
0.55	116.70	1.84	0.0700	0.00994
0.6	116.36	1.83	0.0682	0.01084
0.65	114.29	1.80	0.0663	0.01174
0.7	114.05	1.74	0.0649	0.01264
0.75	113.65	1.61	0.0654	0.01355
0.8	114.79	1.54	0.0647	0.01445
0.85	113.50	1.31	0.0618	0.01535
0.9	112.48	1.17	0.0648	0.01626
0.95	113.98	1.17	0.0682	0.01716
1	117.92	1.25	0.0742	0.01807
1.05	123.27	1.42	0.0838	0.01897
1.1	130.43	1.65	0.0918	0.01987
1.15	139.47	2.03	0.1043	0.02078

1.2	150.26	2.60	0.1223	0.02168
1.25	162.40	3.25	0.1452	0.02258
1.3	175.52	3.95	0.1742	0.02348
1.35	189.05	5.04	0.2082	0.02439
1.4	202.24	6.16	0.2466	0.02529
1.45	215.08	7.84	0.2583	0.02620
1.5	226.87	9.48	0.2986	0.02710
1.55	239.73	10.48	0.3344	0.02800
1.6	250.40	11.45	0.3768	0.02890
1.65	258.54	12.50	0.3985	0.02981
1.7	261.28	13.01	0.4171	0.03071
1.75	260.08	13.15	0.3900	0.03161
1.8	254.66	13.57	0.3615	0.03252
1.85	249.17	12.07	0.3400	0.03342
1.9	243.05	10.67	0.3346	0.03432
1.95	237.90	9.18	0.3318	0.03523
2	230.89	8.20	0.3177	0.03613
2.05	223.95	7.54	0.2612	0.03703
2.1	216.77	7.08	0.2441	0.03794
2.15	214.50	6.35	0.2331	0.03885
2.2	215.52	6.84	0.2364	0.03974
2.25	219.98	7.26	0.2512	0.04064
2.3	222.17	7.54	0.2706	0.04155
2.35	226.17	8.21	0.2373	0.04246
2.4	227.97	8.79	0.2731	0.04336
2.45	236.25	7.65	0.2918	0.04426
2.5	243.87	9.81	0.3241	0.04516
2.55	254.72	10.60	0.3571	0.04607
2.6	261.05	11.27	0.3993	0.04697
2.65	260.90	12.02	0.3929	0.04787
2.7	250.19	13.02	0.2783	0.04877
2.75	204.96	13.15	0.1832	0.04968
2.8	190.23	14.13	0.1182	0.05058
2.85	145.20	12.08	0.1098	0.05149
2.9	160.32	12.59	0.0000	0.05239
2.95	69.34	17.75	0.0000	0.05330

Avg.Vs – Average Shear Wave velocity; Avg.Qc – Average Cone – tip resistance.

During the compilation of each parameter's profile for modeling, the disparity in units of measurement between cone – tip resistance and sleeve friction along with effective overburden stress was resolved by assigning the given parameters a common unit of measurements in Mega Pascals (MPa). With the data compilation complete, the modelling process was initiated.

3.3 Modeling Methodology

Based on the correlations that were established by preceding authors and researchers, the initial approach to model V_s was simple. The initial approach of estimating V_s was to simply explore linear modeling applicability with the parameters in hand. However, to test the confines of the existing understanding of prediction modeling of V_s, it was necessary to explore other potential methods and techniques from the known approaches displayed by prior works. Thereby, the modified approach for this study was to explore two different methods of modelling and contrasting these methods. Additionally, the model functions produced would take following form which incorporates the usage of four mechanical variables:

$$V_s = f(q_c, f_s, D, EOS) + \epsilon \qquad (4)$$

First method of modeling was using forward stepwise regression, a model selection technique which is prevalent mainly in machine learning analytics in modern times. For this study, machine learning analytics were identified not viable since the datasets available were too few in numbers to properly implement the processes of machine learning. Although, machine learning was not option for analysis purposes of this research, model selection was still viable to lend perspective on how to consider modeling using simplified linear correlations. This method of modeling does yield a straightforward correlation between V_s and SCPT parameters. On a fundamental level, this method is a trial and error way of creating model functions based on what the statistical impact each parameter has on a given model function during the modeling process.

Second method of modelling was utilizing Kolmogorov – Gabor polynomial series for creating polynomial series model function. This approach was taken into consideration after reviewing the literary model proposed by Mola-Abasi and his colleagues[17]. In their work, the polynomial series was employed as model functioning method to compare the existing model functions which was applied to differing soil types. Additionally, the model functions created by their work which was based on the polynomial series were most complex in terms of linear equations wise amongst other model functions created till date, which was a strong reason to utilize the polynomial series as the template for modeling. While the models used in the literature created by Mola-Abasi consisted of only two parameters (q_c & f_s) in model function of V_s, for this study, there will be four parameters (q_c, D, EOS & f_s) of SCPT that will be employed to create the model function of V_s. The parameters depth and EOS were included since there have been prior literature model functions that consisted of these parameters along with q_c and f_s by various researchers[2, 3]. In most of prior literary works, parameters depth and EOS were only used as a multiplicative term instead of an additive term in the model functions. Hence, it was considered that the utilization of parameters of Depth and EOS as additive term could be beneficial for better understanding of these parameters' relevance.

Furthermore, as part of testing the model function using the polynomial series approach, forward step regression method was utilized for a deeper understanding of modeling process. With model functions being developed, the prediction of V_s for a specific soil series, Kirkland in this instance, would aid in better understanding of soil behavior for engineering practices in North Central Oklahoma.

CHAPTER IV

RESULTS

4.1 Basic Soil Properties Results

As part of verifying the engineering properties discerned through lab samples experimentation matches the engineering properties reported by USDA[29], basic soil properties such as Atterberg limits were conducted. The results of these soil properties are shown in Table 4.1. Based on the results obtained, it is evident that there is discrepancy between USDA report and observed values for parameters such as LL, PL, and Plasticity Index (PI). The observed values are noted by slightly lower than USDA recorded values. The discrepancies could be attributed to several factors such as recency of the USDA report[29], human activities of site in recent years. Based on the results of soil, the USCS soil classification is CL mostly except at depth 3.3 ft which was CH. However, based on the significant variance in silt % and fine sand % as well as lower clay% than USDA records, the soil type 'all' was identified as a safe metric for the comparison of literary model functions instead of clay or sand. Even though the site's soil was classified as silty clay, to compensate for the results, soil type 'all' was chosen.

Table 4.1: The Engineering Properties of Tested Kirkland series soil

Depth (ft)	Clay%	Silt%	Fine sand%	LL%	PL%	PI%	USCS soil classification
0.3	20	50	30	39.0	19.2	19.8	CL
0.8	25	52	23	40.0	18.5	21.5	CL
1.3	33	42	25	49.6	23.4	26.2	CL
2.0	31	34	35	41.3	21.8	19.5	CL
2.7	30	42	28	40.8	18.3	22.5	CL
3.3	52	35	13	59.0	23.8	35.2	CH
4.0	45	45	10	37.0	25.0	12.0	CL
4.7	25	59	16	39.0	23.6	15.4	CL
6.0	23	60	17	33.4	17.8	15.6	CL
6.7	32	55	13	36.2	21.1	15.1	CL
7.3	31	53	16	43.0	25.2	17.8	CL
7.9	38	48	14	44.8	26.3	18.5	CL

4.2 Preliminary Results of Mechanical Parameters

Prior to the modeling process, it was essential to understand the interactions of the parameters to each other to establish expected trends of how modelling process would perform. There were several analytical tools that were used to assess the behavior and interactions of parameters in a basic manner. For instance, the correlation between the parameters was a necessary part of analysis to observe the interactions.

Table 4.2: Correlations between each variable chosen for modeling

	Avs	Aqc	Depth	AFs	AEOS
Avs	1	0.698	0.692	0.968	0.692
Aqc	0.698	1	0.799	0.644	0.799
Depth	0.692	0.799	1	0.584	1
AFs	0.968	0.644	0.584	1	0.584
AEOS	0.692	0.799	1	0.584	1

AFs – Average sleeve friction, **Aqc** – Average Cone – Tip Resistance, **Avs** – Average Shear Wave Velocity and **AEOS** – Average Effective Overburden Stress

The correlations between the variables indicate several interesting statistical inferences:

- Strongest correlated variable to Avs is AFs.
- In general, all parameters were positive correlated to Avs.
- AEOS and Depth were perfectly positive correlated because AEOS is dependent on Depth as well as the effective soil unit weight was considered to a constant value of 903.3 N/m^3.

4.3 Model Fitting Results

With the understandings from the correlations and covariances from the parameters selected, the modelling approaches were implemented. All the modelling and data analysis was done using R software. Forward Stepwise Regression approach was applied to constructing each individual model functions and the goodness of fit for each function was recorded. Additionally, Stepwise Model selection function was fitted following the forward step modelling process.

After the extensive process of model fitting, below listed are model functions which were tested, definitions of a few terms and table 4.4 points the reported Coefficient of Determination (R^2) for each model. M stands for model.

$AFs^2 = AFs \times AFs$ (5)

$Aqc^2 = Aqc \times Aqc$ (6)

$AEOS^2 = AEOS \times AEOS$ (7)

$Depth^2 = Depth \times Depth$ (8)

M1: Avs = Aqc + AFs + AEOS + Depth (9)

M2: Avs = AFs + Depth (10)

M3: Avs = Aqc^2 + AFs + Depth (11)

M4: Avs = Aqc^2 + AFs + AEOS + Depth (12)

M5: Avs = Aqc^2 + AFs × Aqc + AEOS + Depth (13)

M6: Avs = Aqc^2 + AFs × Aqc + AEOS × Aqc + Depth (14)

M6 CT: Avs = Aqc^2 + AFs × Aqc + AEOS × Aqc + Depth × Aqc (15)

M7: Avs = Aqc^2 + AFs^2 + $AEOS^2$ + Depth(16)

M8: Avs = Aqc^2×Aqc + AFs + Depth (17)

M9: Avs = Aqc^2×Aqc + AFs + AEOS + Depth (18)

M10: Avs = Aqc^2×Aqc + AFs^2 + $AEOS^2$ + Depth (19)

M11: Avs = Aqc^2×Aqc + AFs^2 + $AEOS^2$ + Aqc × AFs × AEOS × Depth (20)

M12: Avs = Aqc + AFs + AFs^2 + Aqc^2 + AFs × Aqc + Depth (21)

M13: Avs = Aqc + AEOS + $AEOS^2$ + Aqc^2 + AEOS × Aqc + Depth (22)

M14: Avs = Aqc + AFs + AEOS + Depth + Aqc × AFs + Aqc × AEOS + AFs × AEOS + Depth × Aqc + Depth × AFs + Depth × AEOS + AFs^2 + Aqc^2 + $AEOS^2$ + $Depth^2$ (23)

M15: Avs = Aqc + AFs + Aqc × AFs + Aqc × AEOS + AFs × Depth + Aqc × Depth + AFs × AEOS (24)

SelectM: Avs = AFs + AEOS + Depth (25)

Table 4.3: List of Model functions created for the estimation of V_s

Model	Aqc	AFs	AEOS	Depth	Cross Terms	R^2 (Coefficient of Determination)
M1	1	1 *	1 *	1*	N/A	0.9615
M2	0	1 *	0	1*	N/A	0.9595
M3	2	1 *	0	1*	N/A	0.9614
M4	2	1 *	1	1	N/A	0.963
M5	2 *	1 *	1 *	1*	(AFs x Aqc)	0.9798
M6	2 *	1	1 *	1*	(AFs x Aqc)*; (AEOS x Aqc)*	0.9826
M6 CT	2	1*	1*	1*	(AFs x Aqc); (AEOS x Aqc)*; (Depth x Aqc)*	0.9873
M7	2 *	2 *	2	1*	N/A	0.9232
M8	3 *	1 *	0	1*	N/A	0.9798
M9	3 *	1 *	1	1	N/A	0.9802
M10	3 *	2 *	2 *	1*	N/A	0.9703
M11	3	2	2	1	Aqc x AFs x AEOS x Depth	0.9951
M12	1* & 2*	1* & 2*	0	1*	(AFs x Aqc)*	0.9812
M13	1* & 2	0	1* & 2	1	AEOS x Aqc	0.9127
M14	1* & 2	1* & 2	1 & 2	1 & 2	(AFs x Aqc)*; (AFs x AEOS)*; (AEOS x Aqc)* (AFs x Depth)*; (Aqc x Depth)* AEOS x Depth	0.9927
M15	1*	1*	0	0	(AFs x Aqc)*; (AFs x AEOS)*; (AEOS x Aqc)* (AFs x Depth)*; (Aqc x Depth)*	0.9911
SelectM	0	1*	1*	1*	N/A	0.9621

0 – Zeroth order term ; 1 – First Order Term ; 2 – Second Order Term ; * indicates the term deemed significant; M stands for model; CT – Cross Term

Table 4.4: Shortlisted Model Functions with Coefficients

Model	Model function with coefficients
M1	$Avs = 84.78 + 0.077Aqc + 387.4AFs - 1.502 \times 10^6 AEOS + 2.716 \times 10^4 Depth$
M2	$Avs = 83.78 + 398.2AFs + 13.46Depth$
M3	$Avs = 81.92 - 0.064Aqc^2 + 401.8AFs + 17.06Depth$
M4	$Avs = 83.17 - 0.050Aqc^2 + 392.6AFs - 1.249 \times 10^6 AEOS + 2.257 \times 10^4 Depth$
M5	$Avs = 72.68 - 0.629Aqc^2 + 7.784(AFs \times Aqc) - 1.274 \times 10^6 AEOS + 2.304 \times 10^4 Depth$
M6	$Avs = 61.31 - 0.505Aqc^2 + 12.16(AFs \times Aqc) - 147.8(Aqc \times AEOS) + 2.440 \times 10^4 Depth$
M6 CT	$Avs = 64.83 - 0.104Aqc^2 - 5.425(AFs \times Aqc) - 5.622 \times 10^5 (Aqc \times AEOS) + 1.015 \times 10^4 (Aqc \times Depth)$
M7	$Avs = 94.93 - 0.194Aqc^2 + 897.5AFs^2 - 1.090 \times 10^4 AEOS^2 + 40.61Depth$
M8	$Avs = 81.72 - 0.050Aqc^3 + 319.4AFs + 12.2Depth$
M9	$Avs = 78.35 - 0.036Aqc^3 + 317.5AFs - 9.152 \times 10^5 AEOS + 1.654 \times 10^4 Depth$
M10	$Avs = 63.87 - 0.049Aqc^3 + 515.8AFs^2 - 4.307 \times 10^4 AEOS^2 + 58.76Depth$
M11	$Avs = 63.27 - 0.055Aqc^3 + 187.4AFs^2 - 1.865 \times 10^8 AEOS^2 + 265(Aqc \times AFs \times AEOS \times Depth)$
M12	$Avs = 70.12 + 8.446Aqc + 327.2AFs - 418.8AFs^2 - 0.585Aqc^2 + 16.37(Aqc \times AFs) + 15.39Depth$
M13	$Avs = 8.622 + 28.80Aqc - 3.533 \times 10^6 AEOS - 4.596 \times 10^4 AEOS^2 - 0.776Aqc^2 - 319.6(Aqc \times AEOS) + 6.393 \times 10^4 Depth$
M14	$Avs = 62.15 + 8.311Aqc + 328AFs + 1.971 \times 10^5 AEOS - 3532Depth + 0.386Aqc^2 - 64.89AFs^2 - 1.928 \times 10^7 AEOS^2 + 6285Depth^2 - 27.57(Aqc \times AFs) - 5.421 \times 10^5 (Aqc \times AEOS) + 2.271 \times 10^7 (AFs \times AEOS) - 4.101 \times 10^5 (AFs \times Depth) + 9790(Aqc \times Depth)$

M15	$Avs = 7.87Aqc + 366AFs - 12.16(Aqc \times AFs) - 4.91 \times 10^5(Aqc \times AEOS) - 2.65 \times 10^5(AFs \times Depth) + 8.88 \times 10^3(Aqc \times Depth) + 1.47 \times 10^7(AFs \times AEOS) + 67.3$
SelectM	$Avs = 2.67 \times 10^4 Depth + 388AFs - 1.48 \times 10^6 AEOS + 84.8$

Table 4.5: AIC values comparison for the stepwise function model selection process

Model #	Model Function	AIC value
1	Avs = Aqc + AFs + AEOS + Depth	295.5
2	Avs = AFs + AEOS + Depth	293.5

The process of modelling both approaches yielded varying results. By using the stepwise model selection approach, model selection method resulted in omission of Aqc as a variable used for modeling based on AIC value of model. AIC is an estimator of predictor error and estimates the quality of each model[30]. When contrasting model functions, the model that yields a lower AIC value is deemed to be better fit of data. AIC value for the step model including Aqc was 295.5, which was higher than AIC value of the step model excluding Aqc as shown in the Table 4.5. Hence, the optimum model selected for better fit was the model with all other parameters except Aqc to predict Avs. Moreover, this statistic method of fitting also yielded a simple linear model to predict V_s.

On the other hand, using forward step regression method and eventually converging toward the polynomial series method, the modeling process lead to mixed results and perhaps ambiguous interpretations. While M11 gave the best goodness of fit or coefficient of determination of all the models, M11 can't be considered as an optimal model since none of the terms in the model function were found to be significant statistically. In the case of M15, which was derived after modifying the M14 function by excluding the terms which were not significant, followed the polynomial series modeling method. Even though M14 had a better reported R^2, it couldn't be considered as the optimal model for same reasons as M11. However, M15 can be picked as the optimal model since all the terms were noted to be significant and did show relatively similar R^2 value in comparison to M14 and M11. Furthermore, when comparing the R^2 values for model selection approach model to polynomial series approach model, M15 did show better R^2 value than stepwise model functions.

4.4 Comparison of Models

As M15 and stepwise model functions were considered as the optimal functions following extensive modeling process, these models were compared with the literary models. The criteria used for selecting literary models was based on several factors such as usage of similar units of measurements parameters, similarity in the kind of model fitted, and most importantly, applicability of model to soil type 'all'. The models in the literature used for comparison were Mola-Abasi [17] polynomial series model for 'all' type soil (2018) along with Tun 2003[13], Madiai and Simoni 2004[14], Barrow & Stokoe (1983)[8], and Iyisan & Ansal (1993)[9]. These models were shortlisted after the understanding that AFs or f_s multiplicate models were not viable for comparison since some data of AFs was zero in value. Hence, any model with a multiplicative variable would yield undefined results for R^2 and Root Mean Square Error (RMSE).

Table 4.6: RMSE, MSE and R^2 values compared between the literary model functions and model functions selected from this study

Model	MSE	RMSE	R^2
M15	31.97	5.7	0.9911
SelectM	135.49	11.6	0.9621
LitM1	585.64	24.2	0.8365
LitM2	1481.48	38.5	0.5862
LitM3	1513.21	38.9	0.5774
LitM4	1866.24	43.2	0.4788
LitM5	1866.24	43.2	0.4788

Below are the equations of the model functions used for comparing with literature model functions:

M15: $Avs = 7.87Aqc + 366AFs - 12.16(Aqc \times AFs) - 4.91 \times 10^5(Aqc \times AEOS) - 2.65 \times 10^5(AFs \times Depth) + 8.88 \times 10^3(Aqc \times Depth) + 1.47 \times 10^7(AFs \times AEOS) + 67.3$ (26)

SelectM: $Avs = 2.67 \times 10^4 Depth + 388AFs - 1.48 \times 10^6 AEOS + 84.8$ (27)

Below listed were the literature models used in equation format:

LitM1: $Avs = 100(1.40 + 1.59AFs + 0.09Aqc - 1.33AFs^2 - 0.002*Aqc^2 + 0.05AFs \times Aqc)$ [Mola-Abasi 2015] [17](28)

LitM2: $Avs = 109.29 + 52.674\log(Aqc)$ [Tun 2003] [13] (29)

LitM3: $Avs = 211(Aqc)^{0.23}$ [Madiai 2004] [14](30)

LitM4: $Avs = 154 + 0.64Aqc$ [Barrow and Stokoe 1983] [8](31)

LitM5: Avs = 160 + 0.9Aqc [Iyisan and Ansal 1993] [9](32)

Based on the table 4.5 results, it is evident that models created using both approaches in this study were greater values of coefficient of determination than the literary model functions used. Furthermore, the RMSE values for the literary model functions were larger than the models produced by this study. MSE and RMSE values indicate that model functions created in this study had smaller variance between the predicted values and measured values of Avs. This was illustrated in the figure 4.1 below:

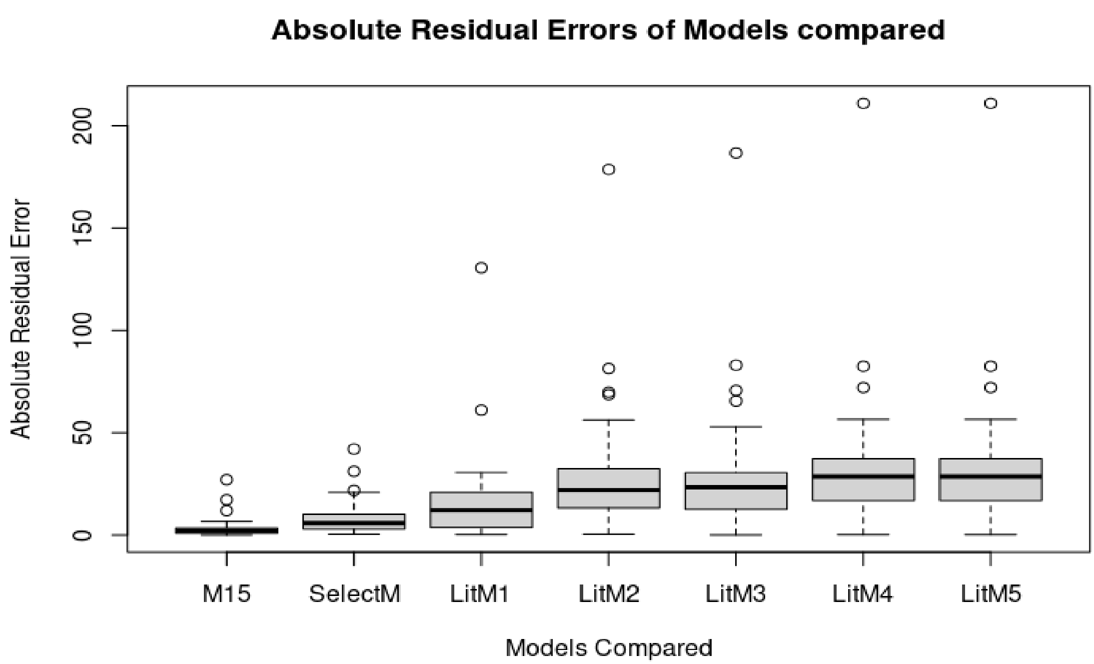

Figure 4.1: Absolute residual errors of the models compared in the form of boxplots

Figure 4.1 indicated that the M15 and SelectM show the least absolute residual errors when compared to literature models which reaffirmed the performance of the created model functions being better functioning in predicting V_s than models of literature.

The alternative method of representing the performance of the model functions selected from this study to the select literature model functions is illustrated in below Figure 4.2 where the graph of predicted V_s values from the model functions is plotted against average V_s values extracted from data consolidation process.

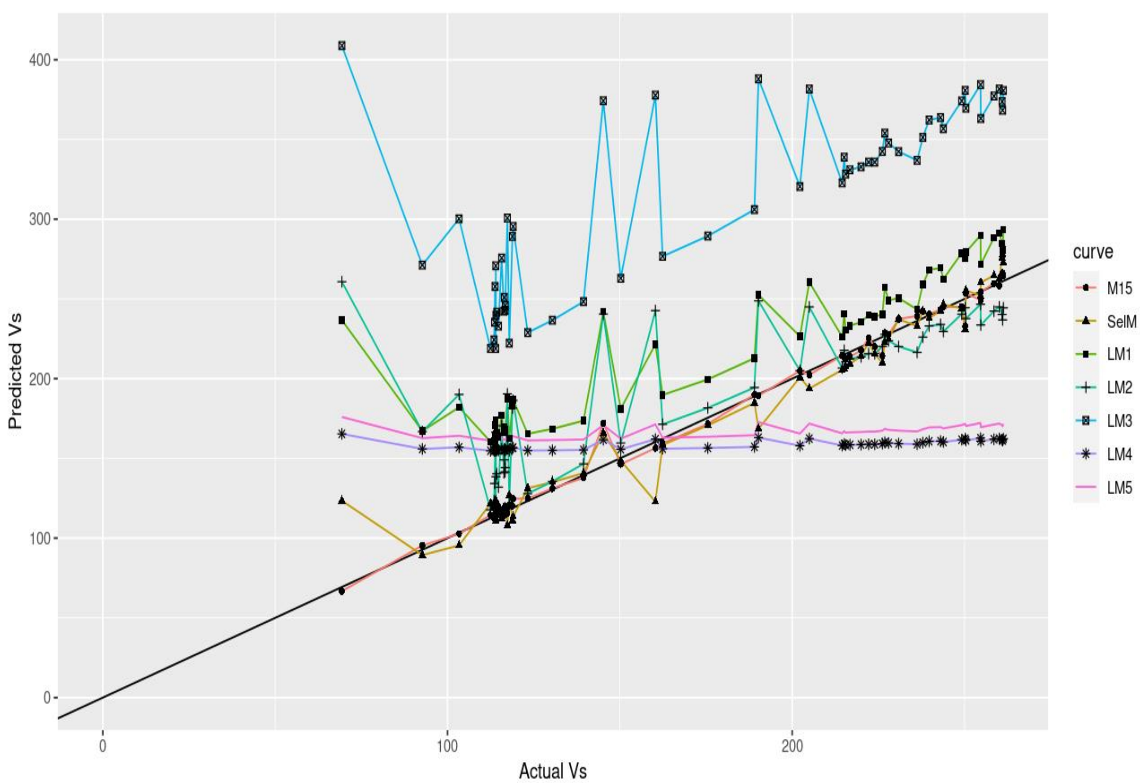

Figure 4.2: Scatter plot of Predicted V_s versus Actual V_s for the model functions selected for comparison.

In figure 4.2, it was evident that model functions SelectM (or SelM) as well as M15 performed better than literature model functions since both model functions' curves were almost coincident with the black line. Black line represents the ideal model function performance where the predicted values were equal to actual values for shear wave velocity. On the other hand, the literature model functions represented in the figure 4.2 display a significant variance in performance of predicted to actual values.

CHAPTER V

CONCLUSION

5.1 Summary of the data analysis

The data analysis showed that using two different approaches of modeling, one method being stepwise model selection and the other method being Kolmogorov – Gabor polynomial series, yielded greatly positive results in terms of coefficient of determination and RMSE. Additionally, there were several points of observations made about the parameters during the entire process of modelling.

The crucial points of observations were:

1) Through this data analysis process, it was discovered that sleeve friction had the strongest correlation to predicting V_s than other mechanical parameters used.
2) Cone – tip resistance was omitted as a variable in the stepwise model selection method since the statistical method deemed the variable to be not significant in fitting the linear model for V_s. Additionally, by AIC values comparison, better fitted model was the one without Aqc term.
3) The statistical inferencing becomes ambiguous when the models become complex by virtue of including cross terms of the variables used. The exact interpretation of such cross terms was not explicable.

4) There was a significant difference in RMSE values when compared to the literary models used and the models created. The RMSE values did indicate that estimation of V_s was optimized and RMSE values of model functions made were smaller than model functions of literature.
5) Polynomial series modeling approach did not distinctly produce optimum results by a significant margins since the difference between simple model method and complex was only 0.03 of R^2 value. This indicates that complex methods may not be required for modelling of V_s.
6) Although M11 yielded the best coefficient of determination value of 0.9951, it was deemed as not the most optimal model function since all the terms were found to be not significant in fitting the data. M15 which produced a 0.9911 coefficient of determination was deemed as the most optimal model function due to all of its terms being statistically significant in the fitting the data.
7) Boxplots of the absolute residual errors for compared model functions as well as scatterplot of predicted versus actual values of V_s were presented which were reaffirming the fact that the model functions created and chosen in the study performed better than select literature model functions.
8) Although model functions in this study performed better than the compared literature model functions, it needs to be acknowledged that there is no certainty that the model functions created would be performing well, when used for comparison to a different data profile of shear wave velocity from a different site. These model functions were generated for the shear wave velocity data profile for Kirkland series soil only.

Additionally, there were some factors that need to be considered about the SCPT data itself. For instance, the maximum depth of SCPT data was 2.95 m whereas the other literature works have had SCPT data with depth excess of 3m. In that aspect, this study did focus low depths SCPT data prediction of V_s. Another aspect was that this SCPT data was collected over 7 months period indicating a probable changes in physio-chemical properties such as specific gravity, organic matter content and porosity in soil could have affected the mechanical parameters of the soil and data as well. Moreover, even in the instance that the data was subject to variability due to physio-chemical factors, the modeling approaches implemented in this study didn't account for physio-chemical parameters such as pore water pressure from SCPT data.

While this thesis did achieve its objectives, there are more aspects that can be considered for future research in the line of study of modeling V_s, which are:

- Exploring the additional SCPT parameters such as OCR (over consolidation ratio), IC, natural void ratio and pore water pressure.
- Establishing a potential correlation to resilient modulus or other possible concepts of geotechnical engineering
- Examining the different analytical methods for perhaps create a universal method for estimate V_s which is not site specific.

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APPENDICES

APPENDIX A

EXTRACTED SCPT DATA

During the data analysis process, the chosen parameters from the raw SCPT data were extracted and processed in a manner to establish single averaged profile of the parameters from 29 datasets. With that, the 29 V_s profiles corresponding to 29 datasets of parameters was averaged into a single average V_s profile for prediction process. Below is each dataset profile selected for data processing that contains each parameter including V_s.

Table A.1: February 3 CPT – 1 data compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 1a	0.05	0.92	0.10	15.44	0.31	0.46	62.19
CPT 1a	0.10	1.66	10.52	2.70	0.76	0.92	76.17
CPT 1a	0.15	1.62	21.55	46.39	1.23	1.38	88.18
CPT 1a	0.20	1.69	29.12	2.20	1.87	1.84	93.79
CPT 1a	0.25	1.47	39.08	-19.48	2.44	2.30	97.43
CPT 1a	0.30	1.37	42.26	-17.02	3.15	2.76	98.73
CPT 1a	0.35	1.24	46.68	-18.35	3.55	3.22	99.89
CPT 1a	0.40	1.26	47.64	-15.95	3.89	3.68	101.60
CPT 1a	0.45	1.26	51.83	12.56	4.26	4.14	104.61
CPT 1a	0.50	1.27	62.27	21.15	4.45	4.60	107.69

CPT 1a	0.55	1.40	60.97	0.35	4.37	5.05	113.30
CPT 1a	0.60	1.76	70.64	59.67	3.94	5.51	123.41
CPT 1a	0.65	2.55	94.01	8.48	3.86	5.97	131.20
CPT 1a	0.70	2.36	92.95	-7.83	4.08	6.43	138.27
CPT 1a	0.75	2.44	112.71	-15.76	4.15	6.89	141.07
CPT 1a	0.80	2.78	108.24	-22.56	4.69	7.35	140.09
CPT 1a	0.85	1.69	102.41	-17.22	5.58	7.81	133.20
CPT 1a	0.90	1.01	94.21	-9.07	7.70	8.27	123.97
CPT 1a	0.95	1.11	96.04	-8.20	8.52	8.73	122.58
CPT 1a	1.00	1.34	103.76	-13.63	8.04	9.19	127.26
CPT 1a	1.05	1.42	111.17	-18.39	7.38	9.65	132.65
CPT 1a	1.10	1.70	113.98	-23.25	5.59	10.11	142.87
CPT 1a	1.15	3.05	119.45	-23.53	4.23	10.57	157.07
CPT 1a	1.20	4.29	148.81	-24.03	3.90	11.03	170.55
CPT 1a	1.25	4.30	184.77	-24.65	4.24	11.49	178.96
CPT 1a	1.30	3.97	198.08	-25.73	4.67	11.95	182.37
CPT 1a	1.35	4.18	198.19	-27.49	4.87	12.41	183.70
CPT 1a	1.40	4.17	202.69	-29.16	4.65	12.87	183.27
CPT 1a	1.45	4.09	176.28	-31.10	4.16	13.33	181.03
CPT 1a	1.50	4.38	146.23	-31.10	3.88	13.79	186.42
CPT 1a	1.55	5.60	222.89	-28.25	4.01	14.24	202.43
CPT 1a	1.60	7.13	316.14	-23.06	3.21	14.70	240.43
CPT 1a	1.65	17.32	425.05	-21.10	2.76	15.16	272.39
CPT 1a	1.70	20.30	494.59	-16.69	2.57	15.62	299.51
CPT 1a	1.75	21.32	595.53	-24.06	2.64	16.08	310.55
CPT 1a	1.80	21.71	581.59	-16.51	3.06	16.54	308.74
CPT 1a	1.85	14.24	574.64	-10.69	3.55	17.00	296.17
CPT 1a	1.90	11.38	522.58	-17.60	4.43	17.46	278.36
CPT 1a	1.95	9.99	479.52	-24.21	4.63	17.92	266.12
CPT 1a	2.00	9.46	425.11	-25.45	4.39	18.38	253.43
CPT 1a	2.05	8.43	317.30	-28.50	4.01	18.84	239.71
CPT 1a	2.10	7.30	267.13	-32.09	3.68	19.30	224.83
CPT 1a	2.15	6.43	229.80	-41.35	3.56	19.76	215.95
CPT 1a	2.20	6.40	218.62	-41.56	3.44	20.22	210.26
CPT 1a	2.25	6.14	202.96	-43.32	3.26	20.68	208.06
CPT 1a	2.30	6.31	192.99	-46.04	2.89	21.14	207.94
CPT 1a	2.35	7.53	180.99	-46.30	2.68	21.60	210.25
CPT 1a	2.40	7.48	197.86	-46.55	2.71	22.06	214.53

CPT 1a	2.45	7.31	225.39	-48.43	2.92	22.52	222.86
CPT 1a	2.50	8.91	267.79	-46.93	2.84	22.98	228.42
CPT 1a	2.55	9.38	234.09	-47.65	2.70	23.43	235.20
CPT 1a	2.60	10.14	264.06	-46.11	2.69	23.89	238.47
CPT 1a	2.65	9.91	293.28	-47.50	2.60	24.35	245.81
CPT 1a	2.70	12.40	285.49	-47.35	2.57	24.81	250.06
CPT 1a	2.75	11.76	296.49	-52.21	2.81	25.27	253.22
CPT 1a	2.80	9.24	356.61	-55.23	3.38	25.73	256.10
CPT 1a	2.85	9.95	391.88	-55.51	2.38	26.19	240.16
CPT 1a	2.90	12.29	0.00	-54.08	1.01	26.65	219.78
CPT 1a	2.95	16.56	0.00	-56.54	0.00	27.11	84.38

Table A.2: February 3 CPT – 2 data compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 2	0.05	1.32	0.11	22.43	0.01	0.46	70.95
CPT 2	0.10	1.81	0.14	11.56	0.01	0.92	76.72
CPT 2	0.15	1.61	0.08	72.23	0.00	1.38	87.20
CPT 2	0.20	1.93	-0.01	45.40	0.32	1.84	79.93
CPT 2	0.25	1.84	17.31	-9.14	0.83	2.30	89.06
CPT 2	0.30	1.54	26.69	-26.30	1.70	2.76	96.81
CPT 2	0.35	1.62	40.88	-37.75	2.59	3.22	102.46
CPT 2	0.40	1.57	54.54	-37.20	3.26	3.68	109.13
CPT 2	0.45	1.74	64.60	-18.60	3.61	4.14	114.47
CPT 2	0.50	1.90	68.13	-20.55	3.72	4.60	117.24
CPT 2	0.55	1.72	66.40	-27.19	3.79	5.05	119.26
CPT 2	0.60	1.82	71.30	-7.54	3.92	5.51	120.71
CPT 2	0.65	1.88	74.36	-24.06	3.86	5.97	121.17
CPT 2	0.70	1.71	62.91	-29.21	3.35	6.43	122.89
CPT 2	0.75	2.31	59.67	-13.77	2.57	6.89	127.07
CPT 2	0.80	3.14	61.55	-13.84	2.37	7.35	125.52
CPT 2	0.85	1.62	46.38	-13.13	2.82	7.81	121.62
CPT 2	0.90	1.14	58.13	-7.76	4.72	8.27	113.35
CPT 2	0.95	1.01	73.43	-2.38	6.42	8.73	115.92
CPT 2	1.00	1.26	87.52	-2.72	6.86	9.19	124.13
CPT 2	1.05	1.65	107.78	-4.52	6.91	9.65	134.53

CPT 2	1.10	1.87	135.13	-6.23	6.49	10.11	146.05
CPT 2	1.15	2.55	151.00	-5.96	5.20	10.57	162.44
CPT 2	1.20	4.48	177.32	-6.62	4.50	11.03	177.60
CPT 2	1.25	5.01	213.24	-23.68	4.35	11.49	189.31
CPT 2	1.30	4.88	234.54	-22.36	4.73	11.95	195.47
CPT 2	1.35	4.97	253.68	-25.75	5.05	12.41	198.62
CPT 2	1.40	4.98	259.45	-25.98	4.84	12.87	201.37
CPT 2	1.45	5.65	240.62	-27.21	4.71	13.33	203.44
CPT 2	1.50	5.49	258.92	-26.81	4.52	13.79	210.93
CPT 2	1.55	6.85	313.12	-29.16	4.57	14.24	230.37
CPT 2	1.60	10.02	449.21	-19.59	4.34	14.70	256.48
CPT 2	1.65	13.26	544.04	-15.83	3.70	15.16	283.01
CPT 2	1.70	18.68	559.21	11.93	3.27	15.62	297.05
CPT 2	1.75	18.57	547.98	16.51	2.71	16.08	303.33
CPT 2	1.80	21.62	486.74	-18.92	2.54	16.54	295.90
CPT 2	1.85	16.90	415.86	-30.24	2.54	17.00	282.95
CPT 2	1.90	12.26	386.50	-36.17	3.09	17.46	265.84
CPT 2	1.95	9.46	391.86	-33.54	3.82	17.92	253.25
CPT 2	2.00	8.45	373.99	-32.18	4.26	18.38	242.86
CPT 2	2.05	7.45	312.99	-36.58	4.32	18.84	232.53
CPT 2	2.10	6.43	276.29	-39.77	4.09	19.30	222.40
CPT 2	2.15	6.44	240.91	-46.94	4.09	19.76	216.52
CPT 2	2.20	5.93	251.45	-48.88	4.34	20.22	215.89
CPT 2	2.25	5.60	286.51	-46.75	4.73	20.68	219.99
CPT 2	2.30	6.41	309.91	-47.08	4.71	21.14	222.80
CPT 2	2.36	6.50	274.44	-48.54	4.41	21.69	224.66
CPT 2	2.40	6.59	275.03	-47.65	4.41	22.06	222.66
CPT 2	2.45	5.87	285.84	-45.98	4.31	22.52	227.58
CPT 2	2.50	7.81	312.12	-48.02	3.95	22.98	238.54
CPT 2	2.55	10.35	350.62	-47.19	3.67	23.43	253.89
CPT 2	2.60	11.29	417.60	-48.15	3.25	23.89	262.44
CPT 2	2.65	12.67	345.10	-45.51	3.31	24.35	266.68
CPT 2	2.70	11.30	405.08	-48.18	3.58	24.81	256.85
CPT 2	2.75	6.47	338.31	-50.42	3.69	25.27	252.92
CPT 2	2.80	10.83	310.76	-51.89	3.87	25.73	245.53
CPT 2	2.85	8.30	340.99	-52.10	2.22	26.19	231.03
CPT 2	2.90	10.22	0.00	-52.14	0.99	26.65	210.39
CPT 2	2.95	16.01	0.00	-49.57	0.00	27.11	81.36

Table A.3: February 3 CPT – 3 Data compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 3	0.05	2.15	0.04	9.02	0.00	0.46	109.67
CPT 3	0.11	2.34	-0.01	4.26	0.20	1.01	78.57
CPT 3	0.16	1.73	12.13	58.78	0.57	1.47	86.77
CPT 3	0.20	1.96	22.45	47.21	1.24	1.84	93.33
CPT 3	0.25	1.78	33.61	-0.14	1.78	2.30	98.64
CPT 3	0.30	1.59	39.20	36.60	2.46	2.76	101.79
CPT 3	0.35	1.51	47.25	-20.57	2.99	3.22	105.27
CPT 3	0.40	1.67	55.96	-23.55	3.55	3.68	109.23
CPT 3	0.45	1.57	64.84	-21.17	3.99	4.14	112.80
CPT 3	0.50	1.54	69.47	-14.85	4.37	4.60	113.43
CPT 3	0.55	1.44	64.67	-12.74	4.52	5.05	113.50
CPT 3	0.60	1.40	64.38	20.00	4.50	5.51	112.09
CPT 3	0.65	1.32	58.35	8.14	4.50	5.97	111.01
CPT 3	0.70	1.25	56.18	24.44	4.28	6.43	110.72
CPT 3	0.75	1.39	55.08	18.12	3.89	6.89	110.94
CPT 3	0.80	1.44	47.70	14.02	4.14	7.35	110.63
CPT 3	0.85	1.04	57.56	0.61	5.04	7.81	109.29
CPT 3	0.90	0.88	64.37	-1.35	6.86	8.27	108.75
CPT 3	0.95	0.91	71.99	-1.03	7.47	8.73	111.71
CPT 3	1.00	1.09	78.22	-1.08	7.23	9.19	118.99
CPT 3	1.05	1.42	96.33	0.53	6.70	9.65	132.38
CPT 3	1.10	2.15	137.05	-1.14	6.03	10.11	148.95
CPT 3	1.15	3.07	166.65	-1.12	4.71	10.57	171.12
CPT 3	1.20	5.54	202.85	-1.31	4.11	11.03	191.73
CPT 3	1.25	6.81	265.00	11.56	3.94	11.49	208.72
CPT 3	1.30	7.18	301.93	9.67	4.35	11.95	218.20
CPT 3	1.35	6.65	330.94	8.66	4.89	12.41	220.55
CPT 3	1.40	5.94	333.98	3.59	5.13	12.87	219.04
CPT 3	1.45	6.20	299.85	-2.90	5.13	13.33	214.94
CPT 3	1.50	5.65	277.89	-7.77	4.29	13.79	221.81
CPT 3	1.55	9.24	326.92	-8.68	3.45	14.24	244.77
CPT 3	1.60	15.56	444.14	7.05	3.16	14.70	270.56

CPT 3	1.65	16.24	525.45	-1.61	2.94	15.16	295.38
CPT 3	1.70	21.25	589.57	19.48	2.90	15.62	306.97
CPT 3	1.75	21.13	583.67	-19.08	2.61	16.08	312.87
CPT 3	1.80	22.47	522.48	-5.29	2.47	16.54	307.45
CPT 3	1.85	20.27	470.99	-20.46	2.45	17.00	296.15
CPT 3	1.90	15.46	430.90	-29.05	2.74	17.46	280.30
CPT 3	1.95	11.57	395.36	-35.89	3.19	17.92	264.20
CPT 3	2.00	10.16	359.95	-36.93	3.27	18.38	249.53
CPT 3	2.05	9.74	273.03	-37.82	2.86	18.84	237.30
CPT 3	2.10	9.59	210.32	-41.55	2.40	19.30	223.95
CPT 3	2.15	8.28	180.07	-49.23	2.34	19.76	216.46
CPT 3	2.20	7.51	204.02	-50.92	2.65	20.22	213.78
CPT 3	2.25	7.03	220.51	-51.15	2.91	20.68	214.98
CPT 3	2.30	7.41	212.83	-51.08	2.70	21.14	214.14
CPT 3	2.35	8.05	172.68	-49.92	2.32	21.60	211.73
CPT 3	2.40	8.04	159.49	-46.62	1.98	22.06	208.23
CPT 3	2.45	8.24	148.44	-49.50	1.80	22.52	209.58
CPT 3	2.50	9.64	158.19	-51.82	1.62	22.98	212.39
CPT 3	2.55	10.42	152.50	-50.86	1.46	23.43	218.43
CPT 3	2.60	12.22	160.17	-50.21	1.40	23.89	226.25
CPT 3	2.65	13.63	195.98	-48.88	1.42	24.35	229.62
CPT 3	2.70	11.60	174.73	-52.01	1.40	24.81	234.43
CPT 3	2.75	14.64	185.07	-56.61	1.54	25.27	235.80
CPT 3	2.80	12.01	229.50	-58.58	1.11	25.73	220.09
CPT 3	2.85	10.70	0.00	-59.61	0.66	26.19	196.79
CPT 3	2.90	11.97	0.00	-62.49	0.00	26.65	73.64

Table A.4: February 3 CPT – 4 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 4	0.05	1.63	-0.04	18.21	0.18	0.46	70.49
CPT 4	0.10	2.15	9.83	4.33	0.56	0.92	84.00
CPT 4	0.15	2.33	24.41	76.29	1.01	1.38	98.33
CPT 4	0.20	2.65	38.02	3.16	1.42	1.84	105.06
CPT 4	0.25	2.22	40.10	10.24	1.83	2.30	107.17
CPT 4	0.30	1.72	42.61	8.94	2.34	2.76	104.84

CPT 4	0.35	1.46	43.39	-13.06	2.96	3.22	102.79
CPT 4	0.40	1.32	46.87	-19.17	3.56	3.68	103.01
CPT 4	0.45	1.28	54.02	-11.57	4.06	4.14	104.56
CPT 4	0.50	1.28	56.41	-9.18	4.18	4.60	106.19
CPT 4	0.55	1.35	52.70	-3.67	4.15	5.05	108.68
CPT 4	0.60	1.44	59.62	10.36	4.16	5.51	111.30
CPT 4	0.65	1.44	64.02	9.30	4.27	5.97	115.11
CPT 4	0.70	1.60	68.21	-9.39	4.46	6.43	117.41
CPT 4	0.75	1.51	70.90	-11.00	4.65	6.89	119.29
CPT 4	0.80	1.47	74.03	-12.30	5.18	7.35	119.85
CPT 4	0.85	1.36	79.77	-11.68	5.98	7.81	120.45
CPT 4	0.90	1.22	87.62	-14.80	7.02	8.27	121.09
CPT 4	0.95	1.16	94.75	-10.72	7.55	8.73	124.07
CPT 4	1.00	1.41	103.77	-7.94	7.45	9.19	129.70
CPT 4	1.05	1.66	116.89	-9.96	7.19	9.65	137.09
CPT 4	1.10	1.86	133.75	-9.71	6.95	10.11	144.22
CPT 4	1.15	2.15	143.55	-14.78	5.62	10.57	158.20
CPT 4	1.20	3.98	171.47	-15.93	4.72	11.03	172.88
CPT 4	1.25	4.81	201.19	-17.00	4.26	11.49	185.79
CPT 4	1.30	5.04	216.22	-19.45	4.29	11.95	191.09
CPT 4	1.35	4.86	213.62	-21.17	4.50	12.41	190.44
CPT 4	1.40	4.21	204.43	-19.95	4.72	12.87	184.49
CPT 4	1.45	3.47	173.82	-19.95	5.57	13.33	178.68
CPT 4	1.50	2.78	204.65	-18.88	6.29	13.79	190.28
CPT 4	1.55	5.26	345.31	11.77	5.55	14.24	233.47
CPT 4	1.60	12.79	605.26	7.49	4.58	14.70	281.93
CPT 4	1.65	19.05	748.40	2.50	3.86	15.16	317.17
CPT 4	1.70	22.51	744.10	93.93	3.40	15.62	328.88
CPT 4	1.75	21.93	667.55	51.17	2.98	16.08	327.26
CPT 4	1.80	22.86	595.54	35.87	2.90	16.54	315.88
CPT 4	1.85	17.63	548.10	-11.41	3.15	17.00	302.33
CPT 4	1.90	12.71	534.63	11.02	3.84	17.46	285.64
CPT 4	1.95	10.84	496.70	6.83	4.45	17.92	271.19
CPT 4	2.00	9.51	440.58	3.43	4.51	18.38	258.35
CPT 4	2.05	8.49	363.55	-8.06	4.26	18.84	245.97
CPT 4	2.10	8.06	306.33	-13.56	4.03	19.30	234.78
CPT 4	2.15	7.09	283.46	-29.89	3.83	19.76	226.27
CPT 4	2.20	6.78	249.73	-30.42	3.80	20.22	220.14

CPT 4	2.25	6.48	239.78	-32.07	3.76	20.68	217.29
CPT 4	2.30	6.40	249.08	-32.85	3.53	21.14	217.46
CPT 4	2.35	7.39	226.58	-33.33	3.30	21.60	220.74
CPT 4	2.40	8.00	243.42	-32.09	3.07	22.06	224.69
CPT 4	2.45	8.29	256.70	-38.76	2.99	22.52	232.75
CPT 4	2.50	10.04	286.82	-37.07	3.01	22.98	241.92
CPT 4	2.55	10.69	328.59	-30.42	3.16	23.43	253.32
CPT 4	2.60	11.07	390.22	-33.51	3.12	23.89	260.04
CPT 4	2.65	12.48	348.49	-32.44	2.98	24.35	262.77
CPT 4	2.70	12.44	332.79	-31.81	2.74	24.81	262.29
CPT 4	2.75	12.47	342.77	-27.21	2.87	25.27	261.10
CPT 4	2.80	10.98	352.29	-35.67	2.05	25.73	239.18
CPT 4	2.85	10.45	0.00	-35.76	1.01	26.19	211.82
CPT 4	2.90	13.59	0.00	-35.53	0.00	26.65	76.79

Table A.5: February 27 CPT – 1 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 1	0.05	1.61	16.89	7.14	1.33	0.46	81.26
CPT 1	0.10	1.51	29.09	1.86	1.92	0.92	88.84
CPT 1	0.15	1.54	43.68	42.95	2.38	1.38	104.86
CPT 1	0.20	3.06	72.60	-37.32	2.89	1.84	116.52
CPT 1	0.25	2.40	85.73	-48.57	3.39	2.30	123.94
CPT 1	0.30	1.91	90.69	-44.95	4.30	2.76	122.22
CPT 1	0.35	1.87	88.63	-34.82	4.62	3.22	123.08
CPT 1	0.40	2.15	94.01	-33.29	4.55	3.68	126.34
CPT 1	0.45	2.20	99.81	-41.62	4.61	4.14	129.72
CPT 1	0.50	2.12	103.34	-44.90	4.79	4.60	130.44
CPT 1	0.55	1.99	97.80	-48.41	5.07	5.05	131.36
CPT 1	0.60	2.03	108.22	-47.38	5.05	5.51	133.00
CPT 1	0.65	2.21	106.88	-37.80	4.99	5.97	134.81
CPT 1	0.70	2.13	101.43	-43.85	3.80	6.43	141.99
CPT 1	0.75	3.84	101.63	-38.47	3.30	6.89	144.78
CPT 1	0.80	3.10	95.66	-20.57	3.26	7.35	143.97
CPT 1	0.85	1.92	90.90	-17.97	4.66	7.81	137.89
CPT 1	0.90	1.53	118.09	-15.10	6.78	8.27	135.54
CPT 1	0.95	1.69	138.76	-4.19	7.46	8.73	143.34
CPT 1	1.00	2.38	160.43	-21.28	7.30	9.19	153.83

CPT 1	1.05	2.65	191.42	10.72	6.27	9.65	159.58
CPT 1	1.10	2.87	143.53	-33.74	5.93	10.11	168.24
CPT 1	1.15	3.73	212.76	-47.15	4.93	10.57	177.97
CPT 1	1.20	5.07	218.18	-7.83	4.36	11.03	198.10
CPT 1	1.25	7.52	279.61	-34.78	4.39	11.49	210.79
CPT 1	1.30	6.34	333.55	-41.05	4.88	11.95	221.62
CPT 1	1.35	6.35	371.75	-51.01	5.71	12.41	224.40
CPT 1	1.40	6.36	380.71	-51.11	5.62	12.87	223.77
CPT 1	1.45	6.22	310.98	-53.46	5.87	13.33	221.37
CPT 1	1.50	5.29	356.22	-58.07	6.08	13.79	221.57
CPT 1	1.55	5.95	393.18	-58.05	6.05	14.24	235.71
CPT 1	1.60	9.15	482.93	-57.87	5.92	14.70	259.26
CPT 1	1.65	11.04	668.43	-61.00	4.97	15.16	296.79
CPT 1	1.70	19.93	841.63	-54.43	4.77	15.62	322.87
CPT 1	1.75	19.29	885.83	-52.41	4.40	16.08	334.82
CPT 1	1.80	17.98	789.66	-47.12	4.44	16.54	325.21
CPT 1	1.85	15.56	669.89	-58.19	4.57	17.00	309.10
CPT 1	1.90	12.19	627.37	-59.52	4.83	17.46	293.36
CPT 1	1.95	10.98	573.60	-62.65	5.28	17.92	282.60
CPT 1	2.00	10.24	561.91	-65.52	5.34	18.38	271.50
CPT 1	2.05	8.65	457.12	-68.79	5.36	18.84	261.80
CPT 1	2.10	8.13	427.77	-71.22	5.46	19.30	252.34
CPT 1	2.15	7.44	434.18	-72.44	5.89	19.76	248.78
CPT 1	2.20	6.68	446.94	-74.88	6.57	20.22	247.24
CPT 1	2.25	6.40	463.61	-76.41	7.06	20.68	248.11
CPT 1	2.30	6.72	483.69	-77.75	6.77	21.14	254.82
CPT 1	2.35	8.50	512.88	-77.96	6.24	21.60	263.73
CPT 1	2.40	9.39	537.02	-78.88	6.27	22.06	269.48
CPT 1	2.45	7.95	567.60	-78.08	6.28	22.52	274.67
CPT 1	2.50	9.65	589.22	-78.59	6.29	22.98	283.02
CPT 1	2.55	11.43	665.94	-79.01	5.84	23.43	296.27
CPT 1	2.60	12.83	722.65	-79.95	5.76	23.89	308.30
CPT 1	2.65	13.42	779.97	-80.91	5.48	24.35	311.48
CPT 1	2.70	13.40	668.76	-81.71	5.17	24.81	307.39
CPT 1	2.75	12.71	591.01	-82.06	3.30	25.27	275.43
CPT 1	2.80	12.15	0.00	-84.16	1.71	25.73	232.53
CPT 1	2.85	9.83	0.00	-86.09	0.00	26.19	70.54

Table A.6: February 27 CPT – 2 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)

CPT 2	0.05	1.22	16.71	41.64	1.39	0.46	84.65
CPT 2	0.10	2.69	38.28	5.07	1.72	0.92	95.50
CPT 2	0.15	1.93	46.05	5.96	2.04	1.38	108.18
CPT 2	0.20	2.40	59.74	153.12	2.47	1.84	111.12
CPT 2	0.25	2.26	57.52	-31.59	2.70	2.30	114.13
CPT 2	0.30	1.88	60.17	-10.79	3.03	2.76	113.50
CPT 2	0.35	1.83	62.77	-27.83	3.43	3.22	113.74
CPT 2	0.40	1.80	65.84	-22.98	3.63	3.68	115.66
CPT 2	0.45	1.84	69.41	-15.86	3.78	4.14	117.38
CPT 2	0.50	1.81	69.85	-21.68	4.04	4.60	117.93
CPT 2	0.55	1.60	72.11	-25.32	4.37	5.05	119.84
CPT 2	0.60	1.76	82.96	-20.96	4.70	5.51	122.24
CPT 2	0.65	1.80	86.42	-24.01	4.95	5.97	124.48
CPT 2	0.70	1.62	86.31	-33.12	5.29	6.43	122.52
CPT 2	0.75	1.31	76.42	-7.36	5.57	6.89	120.28
CPT 2	0.80	1.38	76.85	21.17	5.63	7.35	121.13
CPT 2	0.85	1.60	88.24	23.01	5.52	7.81	127.68
CPT 2	0.90	1.92	105.76	17.25	5.71	8.27	132.96
CPT 2	0.95	1.78	108.54	-6.41	6.11	8.73	133.80
CPT 2	1.00	1.45	99.86	-5.70	7.07	9.19	129.91
CPT 2	1.05	1.14	100.16	-5.38	8.45	9.65	127.95
CPT 2	1.10	1.19	119.32	2.94	9.32	10.11	129.96
CPT 2	1.15	1.37	125.81	-1.77	9.28	10.57	136.11
CPT 2	1.20	1.59	139.81	-7.58	8.71	11.03	141.94
CPT 2	1.25	1.78	146.48	-8.45	8.32	11.49	147.60
CPT 2	1.30	1.95	155.85	-9.62	8.05	11.95	151.53
CPT 2	1.35	2.01	159.38	-10.58	8.22	12.41	155.80
CPT 2	1.40	2.09	181.94	-9.96	7.50	12.87	164.08
CPT 2	1.45	3.12	199.27	-3.43	6.36	13.33	183.51
CPT 2	1.50	5.28	285.23	-5.61	5.86	13.79	202.26
CPT 2	1.55	5.64	337.34	-5.38	5.98	14.24	222.21
CPT 2	1.60	6.69	429.87	-4.61	5.29	14.70	242.64
CPT 2	1.65	11.12	473.27	7.61	4.21	15.16	270.07
CPT 2	1.70	16.92	557.90	29.92	3.68	15.62	290.50
CPT 2	1.75	16.68	615.11	-25.10	3.62	16.08	300.84
CPT 2	1.80	15.44	603.24	16.40	3.64	16.54	302.35
CPT 2	1.85	17.16	577.52	71.46	3.75	17.00	295.52
CPT 2	1.90	13.03	529.50	-26.12	3.96	17.46	284.88

CPT 2	1.95	9.99	483.74	-19.57	4.65	17.92	269.72
CPT 2	2.00	8.83	466.32	-33.26	5.02	18.38	256.78
CPT 2	2.05	7.94	393.28	-29.94	5.02	18.84	246.80
CPT 2	2.10	7.28	345.65	-40.47	4.77	19.30	235.87
CPT 2	2.15	6.63	301.80	-46.39	4.48	19.76	227.78
CPT 2	2.20	6.59	270.28	-45.22	4.42	20.22	222.55
CPT 2	2.25	6.10	280.07	-44.81	4.60	20.68	222.19
CPT 2	2.30	6.03	309.09	-46.93	5.17	21.14	226.13
CPT 2	2.35	6.18	355.64	-42.75	4.81	21.60	234.27
CPT 2	2.40	8.61	335.96	-38.97	4.50	22.06	241.56
CPT 2	2.45	8.53	357.72	-39.11	4.05	22.52	245.23
CPT 2	2.50	8.50	343.19	-44.42	3.88	22.98	249.86
CPT 2	2.55	10.45	364.00	-34.45	3.68	23.43	255.72
CPT 2	2.60	11.04	394.58	-32.10	3.32	23.89	262.30
CPT 2	2.65	12.37	363.50	-28.29	2.91	24.35	263.67
CPT 2	2.70	13.36	312.80	-29.90	2.43	24.81	263.79
CPT 2	2.75	14.92	309.55	-48.29	1.48	25.27	242.07
CPT 2	2.80	13.83	0.00	-53.84	0.80	25.73	210.37
CPT 2	2.85	10.07	0.00	-57.30	0.00	26.19	72.94

Table A.7: Feb 27 CPT – 3 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 3	0.05	1.16	0.96	9.96	0.45	0.46	67.97
CPT 3	0.10	1.66	15.97	4.19	0.90	0.92	79.65
CPT 3	0.15	1.69	23.96	2.25	1.57	1.38	91.39
CPT 3	0.20	1.65	38.75	73.31	1.95	1.84	98.45
CPT 3	0.25	2.00	41.83	-1.12	2.26	2.30	103.65
CPT 3	0.30	1.84	43.53	-17.39	2.25	2.76	106.22
CPT 3	0.35	1.84	42.20	36.52	2.33	3.22	106.96
CPT 3	0.40	1.84	42.97	22.97	2.40	3.68	108.76
CPT 3	0.45	1.85	48.07	17.48	2.62	4.14	111.22
CPT 3	0.50	1.83	53.95	5.78	2.95	4.60	113.80
CPT 3	0.55	1.77	58.98	5.31	3.41	5.05	117.24
CPT 3	0.60	1.84	72.84	1.69	3.75	5.51	121.81
CPT 3	0.65	2.04	80.41	2.96	3.85	5.97	126.58

CPT 3	0.70	2.19	80.69	0.85	4.08	6.43	128.01
CPT 3	0.75	1.75	83.20	0.57	4.15	6.89	128.04
CPT 3	0.80	1.90	78.78	9.94	4.43	7.35	127.17
CPT 3	0.85	1.83	80.44	7.12	4.35	7.81	128.73
CPT 3	0.90	1.89	85.39	2.88	4.73	8.27	130.46
CPT 3	0.95	1.80	95.02	9.27	5.43	8.73	131.39
CPT 3	1.00	1.50	101.33	-7.98	6.35	9.19	132.27
CPT 3	1.05	1.54	110.08	-12.25	5.81	9.65	131.52
CPT 3	1.10	1.87	73.14	-9.89	5.44	10.11	138.56
CPT 3	1.15	2.35	129.54	-14.14	5.80	10.57	143.49
CPT 3	1.20	1.84	148.12	-15.21	6.61	11.03	154.79
CPT 3	1.25	2.67	175.25	3.47	6.51	11.49	165.54
CPT 3	1.30	3.67	208.37	2.73	5.72	11.95	179.84
CPT 3	1.35	4.44	232.49	-8.71	5.56	12.41	190.12
CPT 3	1.40	4.44	257.06	-9.39	5.41	12.87	193.47
CPT 3	1.45	4.35	226.00	-12.44	5.23	13.33	194.36
CPT 3	1.50	4.74	224.18	-32.78	4.78	13.79	195.69
CPT 3	1.55	5.26	234.11	-32.64	4.63	14.24	203.50
CPT 3	1.60	6.07	283.98	-31.85	4.61	14.70	222.87
CPT 3	1.65	8.96	417.13	-32.09	4.08	15.16	251.85
CPT 3	1.70	14.55	504.94	-32.46	3.44	15.62	274.51
CPT 3	1.75	16.75	462.62	-22.86	2.54	16.08	288.81
CPT 3	1.80	22.58	402.52	-28.25	2.16	16.54	290.42
CPT 3	1.85	20.27	421.43	-42.64	2.21	17.00	288.00
CPT 3	1.90	14.57	443.01	-42.40	2.83	17.46	276.47
CPT 3	1.95	10.03	405.39	-42.51	3.71	17.92	260.43
CPT 3	2.00	8.40	373.65	-44.00	3.75	18.38	238.80
CPT 3	2.05	7.60	195.07	-45.84	3.93	18.84	231.42
CPT 3	2.10	7.22	342.65	-45.11	4.49	19.30	222.09
CPT 3	2.15	4.43	325.49	-49.53	5.29	19.76	228.80
CPT 3	2.20	7.30	333.00	-47.72	5.32	20.22	229.14
CPT 3	2.25	7.14	343.42	-48.55	4.92	20.68	233.39
CPT 3	2.30	6.14	333.96	-52.07	4.96	21.14	231.14
CPT 3	2.35	6.58	306.05	-52.72	4.69	21.60	229.92
CPT 3	2.40	7.36	301.43	-52.92	4.53	22.06	229.52
CPT 3	2.45	6.35	309.92	-53.24	4.58	22.52	233.49
CPT 3	2.50	7.30	349.44	-54.66	4.76	22.98	241.95
CPT 3	2.55	8.87	410.67	-53.26	4.70	23.43	253.56

CPT 3	2.60	9.40	439.64	-53.05	3.85	23.89	253.72
CPT 3	2.65	10.24	246.44	-55.78	3.65	24.35	262.73
CPT 3	2.70	12.48	484.40	-55.76	4.13	24.81	262.91
CPT 3	2.75	7.17	502.48	-57.45	3.25	25.27	251.93
CPT 3	2.80	10.73	0.00	-60.45	1.76	25.73	218.41
CPT 3	2.85	10.65	0.00	-61.88	0.00	26.19	70.80

Table A.8: Feb 27 CPT – 4 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 4	0.05	0.88	-0.13	14.31	0.17	0.46	62.88
CPT 4	0.10	2.18	7.17	11.45	0.63	0.92	80.44
CPT 4	0.15	2.18	26.11	6.16	1.21	1.38	95.77
CPT 4	0.20	1.90	42.20	7.14	1.90	1.84	104.45
CPT 4	0.25	2.24	51.87	9.65	2.41	2.30	108.04
CPT 4	0.30	1.83	49.83	-6.02	2.75	2.76	109.23
CPT 4	0.35	1.55	52.58	-14.59	3.26	3.22	107.30
CPT 4	0.40	1.45	54.89	-17.02	3.81	3.68	108.88
CPT 4	0.45	1.56	66.12	-20.53	4.17	4.14	112.21
CPT 4	0.50	1.63	72.00	-21.39	4.26	4.60	115.38
CPT 4	0.55	1.64	67.19	-22.45	4.34	5.05	115.92
CPT 4	0.60	1.48	66.06	-22.84	4.58	5.51	114.88
CPT 4	0.65	1.31	68.78	-18.90	5.06	5.97	114.16
CPT 4	0.70	1.28	70.66	-16.51	5.42	6.43	115.10
CPT 4	0.75	1.35	74.41	10.43	5.48	6.89	117.53
CPT 4	0.80	1.44	78.33	8.91	5.13	7.35	121.90
CPT 4	0.85	1.76	81.03	7.40	5.36	7.81	123.55
CPT 4	0.90	1.35	84.85	-2.81	5.41	8.27	125.03
CPT 4	0.95	1.49	83.69	1.76	5.94	8.73	124.52
CPT 4	1.00	1.45	86.72	0.61	6.32	9.19	124.39
CPT 4	1.05	1.15	88.75	-1.60	7.39	9.65	125.01
CPT 4	1.10	1.19	104.61	-2.23	7.91	10.11	128.65
CPT 4	1.15	1.57	115.89	-1.45	7.69	10.57	134.81
CPT 4	1.20	1.68	120.86	-5.04	7.25	11.03	139.79
CPT 4	1.25	1.73	124.27	-10.51	6.56	11.49	143.32
CPT 4	1.30	2.13	117.78	-11.71	5.32	11.95	152.07

CPT 4	1.35	3.30	138.33	-12.64	4.53	12.41	162.57
CPT 4	1.40	3.78	160.69	-13.45	4.65	12.87	169.17
CPT 4	1.45	2.95	166.80	-14.07	5.20	13.33	172.19
CPT 4	1.50	3.10	182.92	-14.23	5.75	13.79	174.01
CPT 4	1.55	3.46	197.08	-14.07	5.80	14.24	177.14
CPT 4	1.60	3.29	191.28	-14.35	5.39	14.70	178.77
CPT 4	1.65	3.66	172.33	-14.20	6.01	15.16	192.53
CPT 4	1.70	4.94	350.92	-15.95	4.63	15.62	228.75
CPT 4	1.75	12.80	466.87	-1.28	3.97	16.08	261.45
CPT 4	1.80	14.93	480.53	1.49	3.17	16.54	283.20
CPT 4	1.85	17.46	484.40	-4.39	3.18	17.00	287.79
CPT 4	1.90	14.36	523.61	-11.85	3.51	17.46	283.03
CPT 4	1.95	10.46	475.64	-11.52	4.08	17.92	269.66
CPT 4	2.00	9.39	396.61	-8.36	4.05	18.38	250.26
CPT 4	2.05	8.34	268.61	-11.32	3.57	18.84	233.05
CPT 4	2.10	7.16	224.01	-14.04	3.16	19.30	217.65
CPT 4	2.15	6.54	202.80	-24.03	3.01	19.76	209.34
CPT 4	2.20	6.52	181.80	-26.50	3.05	20.22	207.26
CPT 4	2.25	6.39	207.56	-26.59	3.23	20.68	207.95
CPT 4	2.30	6.01	221.43	-27.26	3.13	21.14	205.96
CPT 4	2.35	6.23	154.33	-28.18	3.05	21.60	208.26
CPT 4	2.40	7.16	214.85	-28.54	3.14	22.06	209.15
CPT 4	2.45	5.81	234.05	-27.17	3.28	22.52	220.48
CPT 4	2.50	8.62	258.64	-28.45	3.29	22.98	228.91
CPT 4	2.55	9.35	288.40	-29.83	2.96	23.43	242.01
CPT 4	2.60	11.20	316.17	-29.64	3.01	23.89	256.88
CPT 4	2.65	13.23	413.14	-30.34	2.85	24.35	268.43
CPT 4	2.70	14.62	383.19	-29.69	2.98	24.81	271.40
CPT 4	2.75	11.22	367.54	-31.41	1.87	25.27	249.38
CPT 4	2.80	14.38	0.00	-33.45	0.96	25.73	216.15
CPT 4	2.85	12.57	0.00	-30.88	0.00	26.19	78.71

Table A.9: March 27 CPT – 1 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 1	0.05	2.55	0.09	9.27	0.00	0.46	97.91

CPT 1	0.10	3.04	0.11	1.83	0.00	0.92	98.79
CPT 1	0.15	2.06	0.08	17.84	0.00	1.38	104.92
CPT 1	0.20	3.11	0.09	71.37	-0.01	1.84	36.41
CPT 1	0.25	3.25	-0.71	-12.14	-0.02	2.30	36.82
CPT 1	0.30	2.26	-0.77	-36.09	-0.03	2.76	33.83
CPT 1	0.35	1.79	-0.75	-4.63	-0.04	3.22	30.21
CPT 1	0.40	1.78	-0.73	-8.85	-0.04	3.68	29.18
CPT 1	0.45	1.87	-0.55	-11.18	0.05	4.14	79.69
CPT 1	0.50	1.83	3.84	-27.39	0.26	4.60	84.32
CPT 1	0.55	1.63	10.78	-21.77	0.60	5.05	88.52
CPT 1	0.60	1.44	14.61	-14.66	0.90	5.51	89.77
CPT 1	0.65	1.27	13.71	-5.93	1.05	5.97	88.77
CPT 1	0.70	1.15	12.31	10.52	1.13	6.43	88.06
CPT 1	0.75	1.17	14.60	72.41	1.36	6.89	93.57
CPT 1	0.80	1.57	26.59	117.62	1.37	7.35	100.72
CPT 1	0.85	1.98	24.14	5.96	1.65	7.81	108.49
CPT 1	0.90	1.81	38.04	3.25	1.89	8.27	110.87
CPT 1	0.95	1.54	38.43	-19.27	2.93	8.73	112.86
CPT 1	1.00	1.22	57.24	-4.33	3.80	9.19	116.45
CPT 1	1.05	1.60	69.95	-8.85	3.73	9.65	125.41
CPT 1	1.10	2.51	71.47	-23.44	3.27	10.11	130.79
CPT 1	1.15	2.17	64.08	14.44	3.50	10.57	135.92
CPT 1	1.20	2.00	98.36	18.65	3.93	11.03	145.41
CPT 1	1.25	3.34	133.01	0.39	3.77	11.49	163.18
CPT 1	1.30	5.05	160.66	-6.10	3.27	11.95	178.04
CPT 1	1.35	5.61	164.55	-8.14	3.16	12.41	185.89
CPT 1	1.40	5.23	176.13	-19.01	3.07	12.87	185.44
CPT 1	1.45	5.04	147.15	-17.14	3.16	13.33	183.80
CPT 1	1.50	4.89	155.86	-22.39	2.91	13.79	184.12
CPT 1	1.55	5.85	155.50	-17.96	2.84	14.24	186.78
CPT 1	1.60	5.76	156.13	-18.21	2.44	14.70	194.69
CPT 1	1.65	8.20	171.91	-8.91	1.99	15.16	209.14
CPT 1	1.70	12.65	200.94	-11.53	1.58	15.62	233.18
CPT 1	1.75	19.27	259.87	15.44	1.59	16.08	258.49
CPT 1	1.80	20.50	370.38	-5.82	1.82	16.54	285.22
CPT 1	1.85	22.71	508.33	-25.54	2.27	17.00	304.49
CPT 1	1.90	21.82	600.16	-10.61	2.82	17.46	311.43
CPT 1	1.95	16.28	605.75	-19.88	3.41	17.92	302.36

CPT 1	2.00	12.45	519.00	-29.83	3.77	18.38	281.78
CPT 1	2.05	11.12	376.36	-30.90	3.53	18.84	258.62
CPT 1	2.10	9.42	267.90	-33.54	2.97	19.30	234.75
CPT 1	2.15	7.40	185.09	-41.21	2.31	19.76	212.51
CPT 1	2.20	7.51	107.80	-38.92	1.92	20.22	197.99
CPT 1	2.25	6.98	126.69	-40.07	1.82	20.68	193.26
CPT 1	2.30	6.41	145.36	-42.73	1.74	21.14	188.89
CPT 1	2.35	6.53	74.20	-42.64	1.77	21.60	188.63
CPT 1	2.40	6.61	126.59	-44.35	1.89	22.06	187.50
CPT 1	2.45	5.36	148.06	-39.45	2.25	22.52	200.77
CPT 1	2.50	8.42	183.18	-43.60	2.34	22.98	213.04
CPT 1	2.55	9.66	217.73	-42.27	2.35	23.43	227.55
CPT 1	2.60	9.89	256.61	-42.93	1.97	23.89	225.97
CPT 1	2.65	10.53	117.80	-40.71	1.80	24.35	228.13
CPT 1	2.70	11.89	206.38	-40.48	1.72	24.81	224.81
CPT 1	2.75	9.24	219.21	15.49	1.27	25.27	217.11
CPT 1	2.80	12.50	0.00	-45.11	0.56	25.73	199.29
CPT 1	2.85	17.56	0.00	-37.00	0.00	26.19	86.42

Table A.10: March 27 CPT – 3 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 3	0.05	1.57	0.05	2.22	0.00	0.46	75.84
CPT 3	0.10	1.05	0.05	1.33	0.20	0.92	65.45
CPT 3	0.15	1.19	7.72	8.71	0.41	1.38	66.30
CPT 3	0.20	0.94	5.43	0.28	0.64	1.84	67.06
CPT 3	0.25	0.63	4.48	-13.18	0.88	2.30	64.01
CPT 3	0.30	0.49	8.15	-19.52	1.82	2.76	62.80
CPT 3	0.35	0.38	14.34	-26.77	4.12	3.22	67.94
CPT 3	0.40	0.44	30.63	-26.74	5.64	3.68	76.54
CPT 3	0.45	0.72	40.37	-24.79	6.40	4.14	84.89
CPT 3	0.50	0.69	45.95	-23.16	6.57	4.60	89.57
CPT 3	0.55	0.63	46.63	-20.02	7.27	5.05	91.23
CPT 3	0.60	0.67	51.25	-17.39	7.37	5.51	94.25
CPT 3	0.65	0.80	56.36	-12.73	7.06	5.97	98.49
CPT 3	0.70	0.89	58.06	-11.93	6.33	6.43	104.70

CPT 3	0.75	1.17	65.77	-11.68	5.56	6.89	111.16
CPT 3	0.80	1.43	70.00	-3.34	5.56	7.35	114.94
CPT 3	0.85	1.15	72.62	-7.29	5.82	7.81	114.04
CPT 3	0.90	0.95	62.81	-8.27	7.15	8.27	108.08
CPT 3	0.95	0.63	59.51	-12.33	8.20	8.73	104.85
CPT 3	1.00	0.73	67.11	-12.65	7.78	9.19	108.61
CPT 3	1.05	1.21	73.00	-12.98	6.38	9.65	118.27
CPT 3	1.10	1.58	83.82	-13.89	5.54	10.11	128.89
CPT 3	1.15	1.91	102.72	-13.61	5.33	10.57	141.07
CPT 3	1.20	2.55	134.80	-14.14	4.12	11.03	161.64
CPT 3	1.25	5.34	165.74	-14.47	3.67	11.49	179.51
CPT 3	1.30	5.74	199.36	-14.02	3.62	11.95	192.69
CPT 3	1.35	5.34	229.74	-14.53	4.05	12.41	198.47
CPT 3	1.40	5.54	243.98	-14.32	4.15	12.87	199.93
CPT 3	1.45	5.73	214.77	-15.14	3.96	13.33	198.22
CPT 3	1.50	5.24	194.51	-14.59	3.69	13.79	194.00
CPT 3	1.55	5.08	182.96	-20.94	3.72	14.24	195.74
CPT 3	1.60	5.94	226.75	-20.82	3.58	14.70	206.28
CPT 3	1.65	7.93	268.46	-21.47	3.02	15.16	232.41
CPT 3	1.70	14.43	357.97	-18.33	1.90	15.62	247.80
CPT 3	1.75	20.36	185.56	-9.69	1.65	16.08	264.76
CPT 3	1.80	19.85	358.18	-10.85	1.61	16.54	272.09
CPT 3	1.85	18.99	410.47	-15.83	2.09	17.00	290.06
CPT 3	1.90	21.41	490.72	-25.75	2.59	17.46	298.40
CPT 3	1.95	16.93	580.83	-24.95	3.20	17.92	299.70
CPT 3	2.00	12.92	568.32	-18.00	3.82	18.38	287.68
CPT 3	2.05	11.84	443.09	-19.64	3.97	18.84	271.31
CPT 3	2.10	10.22	376.70	-20.94	3.64	19.30	254.33
CPT 3	2.15	8.84	304.19	-29.55	3.58	19.76	240.86
CPT 3	2.20	7.84	280.86	-30.88	3.60	20.22	231.37
CPT 3	2.25	7.28	277.21	-31.20	3.65	20.68	227.99
CPT 3	2.30	7.62	271.99	-31.52	3.68	21.14	222.92
CPT 3	2.35	6.30	230.84	-32.53	3.57	21.60	218.35
CPT 3	2.40	6.36	220.51	-33.70	3.35	22.06	214.36
CPT 3	2.45	7.19	213.54	-35.12	3.06	22.52	215.23
CPT 3	2.50	7.41	208.00	-35.85	2.76	22.98	216.65
CPT 3	2.55	7.88	198.80	-36.03	2.76	23.43	220.07
CPT 3	2.60	8.10	237.57	-35.72	2.15	23.89	217.64

CPT 3	2.65	9.88	117.86	-35.92	2.25	24.35	230.38
CPT 3	2.70	11.43	305.37	-34.80	2.43	24.81	232.98
CPT 3	2.75	7.65	279.65	-33.68	1.71	25.27	231.20
CPT 3	2.80	15.09	0.00	-33.58	0.82	25.73	202.29
CPT 3	2.85	11.24	0.00	-37.69	0.00	26.19	76.72

Table A.11: March 27 CPT – 4 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 4	0.05	1.02	-0.35	1.54	0.14	0.46	61.07
CPT 4	0.10	1.70	5.92	1.72	0.59	0.92	75.55
CPT 4	0.15	1.79	21.20	3.14	1.08	1.38	88.57
CPT 4	0.20	1.79	29.62	14.64	1.43	1.84	95.41
CPT 4	0.25	1.99	29.01	22.56	1.51	2.30	98.25
CPT 4	0.30	1.87	26.73	-6.71	1.67	2.76	99.53
CPT 4	0.35	1.56	34.72	-3.99	2.01	3.22	100.71
CPT 4	0.40	1.56	39.00	-7.67	2.47	3.68	103.14
CPT 4	0.45	1.64	43.60	-9.92	2.87	4.14	105.93
CPT 4	0.50	1.47	51.29	-11.69	3.52	4.60	108.68
CPT 4	0.55	1.36	62.31	-13.43	4.07	5.05	110.80
CPT 4	0.60	1.50	62.22	-12.28	4.42	5.51	114.13
CPT 4	0.65	1.56	70.21	-2.31	4.39	5.97	117.50
CPT 4	0.70	1.63	73.18	-1.42	4.32	6.43	122.97
CPT 4	0.75	2.05	82.76	-0.07	4.53	6.89	125.54
CPT 4	0.80	1.64	84.90	-1.23	4.70	7.35	125.96
CPT 4	0.85	1.50	76.17	-1.52	5.22	7.81	122.69
CPT 4	0.90	1.39	75.24	-0.52	5.21	8.27	121.19
CPT 4	0.95	1.43	73.59	5.48	5.51	8.73	120.01
CPT 4	1.00	1.21	73.43	5.14	5.98	9.19	119.24
CPT 4	1.05	1.11	77.65	6.87	6.48	9.65	119.88
CPT 4	1.10	1.29	83.08	9.14	6.11	10.11	123.47
CPT 4	1.15	1.57	82.14	9.60	5.45	10.57	132.70
CPT 4	1.20	2.18	109.92	9.81	5.01	11.03	143.70
CPT 4	1.25	2.70	131.35	9.46	4.75	11.49	160.78
CPT 4	1.30	4.00	180.90	12.44	4.41	11.95	181.73
CPT 4	1.35	5.99	247.22	18.35	4.75	12.41	197.60

CPT 4	1.40	5.10	289.46	16.70	5.06	12.87	203.41
CPT 4	1.45	4.52	253.74	15.12	5.53	13.33	199.88
CPT 4	1.50	4.50	238.14	13.67	5.08	13.79	194.94
CPT 4	1.55	4.71	205.39	5.14	4.21	14.24	198.00
CPT 4	1.60	6.48	217.77	5.66	3.87	14.70	207.19
CPT 4	1.65	7.19	288.79	4.88	3.85	15.16	228.05
CPT 4	1.70	9.89	401.55	7.03	3.73	15.62	258.72
CPT 4	1.75	16.01	543.98	9.44	3.17	16.08	282.62
CPT 4	1.80	19.25	484.64	14.66	2.53	16.54	295.49
CPT 4	1.85	21.77	413.71	12.05	1.93	17.00	292.79
CPT 4	1.90	23.40	347.58	6.76	1.72	17.46	286.17
CPT 4	1.95	19.36	350.07	-0.52	1.88	17.92	277.77
CPT 4	2.00	13.95	368.25	-3.10	2.31	18.38	263.72
CPT 4	2.05	10.76	297.65	-5.48	2.72	18.84	245.22
CPT 4	2.10	8.39	232.92	-7.47	2.75	19.30	225.24
CPT 4	2.15	6.92	185.01	-17.48	2.62	19.76	210.96
CPT 4	2.20	6.96	164.09	-16.72	2.40	20.22	203.77
CPT 4	2.25	7.21	156.57	-17.25	2.22	20.68	201.28
CPT 4	2.30	6.96	147.47	-18.06	2.16	21.14	197.61
CPT 4	2.35	6.08	132.30	-18.95	2.15	21.60	197.07
CPT 4	2.40	6.97	150.52	-19.89	2.06	22.06	200.69
CPT 4	2.45	8.40	158.75	-18.74	2.11	22.52	211.71
CPT 4	2.50	9.13	206.34	-19.66	2.27	22.98	219.34
CPT 4	2.55	8.32	221.70	-18.47	2.82	23.43	227.67
CPT 4	2.60	7.90	287.01	-17.78	2.94	23.89	231.91
CPT 4	2.65	9.74	254.04	-19.39	2.83	24.35	239.09
CPT 4	2.70	11.04	270.83	-19.81	2.43	24.81	242.69
CPT 4	2.75	11.57	262.40	-18.55	1.53	25.27	227.93
CPT 4	2.80	12.30	0.00	-24.77	0.68	25.73	204.59
CPT 4	2.85	14.88	0.00	-22.47	0.00	26.19	81.21

Table A.12: April 17 CPT – 2 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 2	0.05	1.04	0.07	11.60	0.00	0.46	23.85
CPT 2	0.10	1.52	-0.19	2.25	0.00	0.92	27.02

CPT 2	0.15	2.07	0.06	-1.90	0.13	1.38	75.17
CPT 2	0.20	1.99	7.54	-0.39	0.41	1.84	82.47
CPT 2	0.25	1.43	14.94	41.19	0.96	2.30	87.61
CPT 2	0.30	1.41	23.85	8.80	1.45	2.76	89.38
CPT 2	0.35	1.42	23.12	-11.50	1.69	3.22	92.01
CPT 2	0.40	1.37	24.13	-10.49	1.60	3.68	93.65
CPT 2	0.45	1.57	22.87	23.78	1.54	4.14	96.61
CPT 2	0.50	1.73	24.96	-3.32	1.64	4.60	100.54
CPT 2	0.55	1.67	33.79	-19.24	1.97	5.05	104.98
CPT 2	0.60	1.70	41.50	-23.78	1.79	5.51	104.54
CPT 2	0.65	1.77	16.45	-14.41	2.08	5.97	117.60
CPT 2	0.70	3.10	78.20	-31.57	2.45	6.43	128.55
CPT 2	0.75	2.83	93.33	-44.93	3.44	6.89	136.98
CPT 2	0.80	1.75	91.71	-49.21	4.24	7.35	130.57
CPT 2	0.85	1.45	69.35	-44.53	4.98	7.81	122.78
CPT 2	0.90	1.46	70.01	-40.55	4.94	8.27	121.16
CPT 2	0.95	1.54	79.16	-40.11	4.55	8.73	130.45
CPT 2	1.00	2.56	103.03	-38.44	4.07	9.19	145.76
CPT 2	1.05	3.72	134.75	-46.59	4.03	9.65	159.55
CPT 2	1.10	3.61	159.69	-63.23	4.12	10.11	168.18
CPT 2	1.15	3.81	163.12	-58.65	4.38	10.57	172.66
CPT 2	1.20	4.04	177.87	-57.32	4.30	11.03	175.36
CPT 2	1.25	4.09	170.95	-57.63	4.13	11.49	176.87
CPT 2	1.30	4.22	160.23	-59.24	4.22	11.95	178.66
CPT 2	1.35	4.12	192.66	-62.20	4.24	12.41	194.82
CPT 2	1.40	7.13	302.23	-52.14	4.20	12.87	222.76
CPT 2	1.45	10.64	422.39	-58.23	3.96	13.33	253.83
CPT 2	1.50	13.59	516.37	-52.19	3.66	13.79	279.31
CPT 2	1.55	17.22	577.03	-58.99	3.37	14.24	295.69
CPT 2	1.60	18.95	582.41	-43.00	3.20	14.70	304.52
CPT 2	1.65	18.71	593.73	-58.10	3.36	15.16	298.44
CPT 2	1.70	12.92	521.33	-53.63	3.74	15.62	283.55
CPT 2	1.75	10.14	444.25	-54.98	4.08	16.08	262.43
CPT 2	1.80	9.47	361.29	-56.08	4.12	16.54	244.89
CPT 2	1.85	7.36	303.02	-60.66	4.19	17.00	232.85
CPT 2	1.90	6.45	310.40	-61.28	4.72	17.46	225.75
CPT 2	1.95	6.21	329.48	-61.23	5.29	17.92	226.57
CPT 2	2.00	6.23	356.92	-58.76	5.41	18.38	226.03

CPT 2	2.05	6.01	308.42	-62.83	5.33	18.84	222.69
CPT 2	2.10	5.54	279.30	-62.86	5.00	19.30	216.73
CPT 2	2.15	5.48	261.10	-63.23	4.58	19.76	215.32
CPT 2	2.20	6.42	256.71	-63.67	4.30	20.22	215.02
CPT 2	2.25	5.99	249.24	-66.84	4.18	20.68	216.17
CPT 2	2.30	5.92	258.27	-65.49	4.32	21.14	215.80
CPT 2	2.35	5.93	260.32	-65.22	4.05	21.60	219.44
CPT 2	2.40	7.36	258.31	-66.48	4.02	22.06	223.97
CPT 2	2.45	7.01	294.81	-68.50	4.00	22.52	232.46
CPT 2	2.50	8.01	340.43	-56.28	4.13	22.98	244.34
CPT 2	2.55	10.00	396.13	-61.63	3.50	23.43	266.99
CPT 2	2.60	16.58	471.90	-68.84	3.47	23.89	278.25
CPT 2	2.65	12.01	469.62	-68.77	3.74	24.35	279.55
CPT 2	2.70	8.71	452.51	-69.41	3.07	24.81	247.64
CPT 2	2.75	9.36	0.00	-64.97	1.22	25.27	223.17
CPT 2	2.80	19.10	0.00	-65.77	0.00	25.73	86.35

Table A.13: April 17 CPT – 3 Data Compilation

CPT Name	**Depth (m)**	**qc (MPa)**	**fs (kPa)**	**u2 (kPa)**	**Rf**	**Eff. stress (kPa)**	**Vs (m/s)**
CPT 3	0.05	1.45	31.78	36.60	2.82	0.46	92.20
CPT 3	0.10	1.92	73.04	23.44	1.26	0.92	128.43
CPT 3	0.15	10.72	73.19	20.48	1.08	1.38	151.96
CPT 3	0.20	9.25	89.62	6.67	0.95	1.84	156.43
CPT 3	0.25	4.06	65.53	7.81	1.43	2.30	142.98
CPT 3	0.30	2.22	66.75	1.26	2.50	2.76	123.38
CPT 3	0.35	1.78	68.94	12.40	3.72	3.22	116.20
CPT 3	0.40	1.60	73.06	39.60	4.41	3.68	115.08
CPT 3	0.45	1.56	76.10	21.79	4.79	4.14	116.24
CPT 3	0.50	1.60	79.09	6.41	4.98	4.60	118.01
CPT 3	0.55	1.60	81.45	-3.25	4.96	5.05	120.38
CPT 3	0.60	1.72	82.94	-6.14	4.90	5.51	123.47
CPT 3	0.65	1.86	89.21	-9.34	4.24	5.97	130.28
CPT 3	0.70	2.70	93.41	-41.33	4.31	6.43	133.51
CPT 3	0.75	1.98	98.51	-45.57	4.53	6.89	133.91
CPT 3	0.80	1.66	94.36	-45.98	5.77	7.35	128.32

CPT 3	0.85	1.33	92.41	-44.31	6.60	7.81	125.48
CPT 3	0.90	1.33	96.75	-40.98	7.28	8.27	125.61
CPT 3	0.95	1.41	105.37	-33.67	7.17	8.73	130.31
CPT 3	1.00	1.71	115.50	-34.68	6.57	9.19	138.30
CPT 3	1.05	2.25	130.42	-38.35	6.01	9.65	148.48
CPT 3	1.10	2.73	154.79	-37.45	5.59	10.11	157.72
CPT 3	1.15	3.07	163.39	-40.30	5.00	10.57	165.81
CPT 3	1.20	3.82	161.56	-41.78	4.33	11.03	172.02
CPT 3	1.25	4.41	163.03	-41.38	3.77	11.49	176.48
CPT 3	1.30	4.63	159.16	-41.80	3.62	11.95	179.50
CPT 3	1.35	4.57	170.16	-43.87	3.50	12.41	188.22
CPT 3	1.40	6.41	215.38	-44.49	3.42	12.87	205.06
CPT 3	1.45	8.69	286.31	-39.60	3.10	13.33	235.35
CPT 3	1.50	14.41	412.37	-22.63	3.02	13.79	269.43
CPT 3	1.55	18.94	570.83	-27.40	3.10	14.24	291.45
CPT 3	1.60	16.89	574.70	-23.13	3.20	14.70	297.79
CPT 3	1.65	16.07	513.12	41.44	3.40	15.16	284.95
CPT 3	1.70	11.74	433.59	-30.97	3.43	15.62	270.35
CPT 3	1.75	10.96	384.11	-46.07	3.70	16.08	254.41
CPT 3	1.80	9.03	353.76	-40.41	3.79	16.54	242.51
CPT 3	1.85	7.50	303.38	-48.06	3.87	17.00	230.36
CPT 3	1.90	7.12	255.68	-49.42	3.61	17.46	221.09
CPT 3	1.95	7.25	230.21	-50.93	3.34	17.92	214.37
CPT 3	2.00	6.53	210.44	-55.88	3.17	18.38	208.69
CPT 3	2.05	6.10	187.30	-57.29	3.23	18.84	202.48
CPT 3	2.10	5.37	182.91	-58.72	3.50	19.30	198.04
CPT 3	2.15	4.67	193.71	-55.26	3.52	19.76	199.42
CPT 3	2.20	6.28	195.89	-55.90	3.31	20.22	203.84
CPT 3	2.25	6.83	198.52	-56.79	3.02	20.68	206.97
CPT 3	2.30	6.28	189.53	-60.75	2.92	21.14	208.52
CPT 3	2.35	6.92	196.24	-60.89	2.74	21.60	208.25
CPT 3	2.40	7.34	176.77	-59.24	2.40	22.06	212.79
CPT 3	2.45	9.04	185.64	-60.84	2.17	22.52	217.63
CPT 3	2.50	9.67	202.54	-57.85	2.10	22.98	224.34
CPT 3	2.55	10.03	214.21	-59.61	2.09	23.43	228.20
CPT 3	2.60	10.39	210.67	-60.38	1.87	23.89	233.20
CPT 3	2.65	13.35	206.39	-60.13	1.87	24.35	234.26
CPT 3	2.70	10.31	219.89	-66.73	2.00	24.81	234.80

CPT 3	2.75	9.28	231.40	-64.60	1.42	25.27	217.43
CPT 3	2.80	12.18	0.00	-67.90	0.63	25.73	198.98
CPT 3	2.85	15.59	0.00	-63.00	0.00	26.19	82.43

Table A.14: April 17 CPT – 4 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 4	0.05	3.11	36.09	12.93	1.40	0.46	109.02
CPT 4	0.10	3.51	64.36	3.02	1.76	0.92	125.14
CPT 4	0.15	4.81	100.84	-6.03	2.08	1.38	140.89
CPT 4	0.20	5.29	117.86	17.60	2.53	1.84	147.59
CPT 4	0.25	3.36	122.40	18.77	3.25	2.30	143.90
CPT 4	0.30	2.29	115.99	19.24	4.58	2.76	132.83
CPT 4	0.35	1.76	100.78	-40.41	5.54	3.22	124.85
CPT 4	0.40	1.60	95.23	-35.92	5.92	3.68	121.66
CPT 4	0.45	1.64	98.46	-32.89	6.14	4.14	121.69
CPT 4	0.50	1.56	99.52	-38.42	6.32	4.60	121.96
CPT 4	0.55	1.45	94.54	-38.21	6.42	5.05	121.64
CPT 4	0.60	1.48	92.64	-38.69	5.84	5.51	122.32
CPT 4	0.65	1.74	84.18	-35.18	4.97	5.97	125.40
CPT 4	0.70	2.06	84.44	-48.43	4.94	6.43	124.06
CPT 4	0.75	1.26	79.77	-52.30	4.45	6.89	130.54
CPT 4	0.80	2.67	100.66	-66.76	4.63	7.35	132.04
CPT 4	0.85	2.04	94.08	-61.12	5.43	7.81	133.56
CPT 4	0.90	0.91	107.99	-57.64	7.64	8.27	125.43
CPT 4	0.95	1.02	98.71	-52.25	10.26	8.73	120.44
CPT 4	1.00	1.11	102.09	-50.30	9.42	9.19	124.35
CPT 4	1.05	1.25	116.26	27.01	9.45	9.65	132.27
CPT 4	1.10	1.55	150.77	15.46	8.57	10.11	143.57
CPT 4	1.15	2.23	164.40	-32.34	7.86	10.57	154.03
CPT 4	1.20	2.49	176.95	-45.73	7.19	11.03	159.82
CPT 4	1.25	2.45	172.52	-57.39	6.72	11.49	163.19
CPT 4	1.30	2.83	170.69	-62.31	6.27	11.95	165.64
CPT 4	1.35	3.02	174.93	-60.18	5.84	12.41	177.22
CPT 4	1.40	4.35	247.99	-57.36	5.10	12.87	198.04
CPT 4	1.45	7.18	316.58	-51.13	4.19	13.33	233.63

CPT 4	1.50	13.11	465.16	-49.46	3.50	13.79	262.98
CPT 4	1.55	16.21	494.85	-45.72	3.17	14.24	282.81
CPT 4	1.60	16.74	498.69	3.00	2.74	14.70	283.77
CPT 4	1.65	17.09	379.57	-33.18	2.69	15.16	276.09
CPT 4	1.70	13.11	386.31	-24.08	2.87	15.62	256.50
CPT 4	1.75	7.20	305.67	-49.10	3.34	16.08	239.49
CPT 4	1.80	8.32	264.27	-53.70	3.52	16.54	223.20
CPT 4	1.85	7.48	238.97	-59.33	3.44	17.00	218.15
CPT 4	1.90	6.01	244.96	-71.22	3.90	17.46	213.49
CPT 4	1.95	5.64	260.57	-65.42	4.58	17.92	211.24
CPT 4	2.00	5.31	269.30	-72.32	4.66	18.38	211.56
CPT 4	2.05	5.83	249.44	-70.19	4.73	18.84	210.24
CPT 4	2.10	5.12	248.88	-75.16	4.80	19.30	208.57
CPT 4	2.15	4.75	253.62	-75.30	5.11	19.76	208.62
CPT 4	2.20	5.23	267.29	-71.31	5.12	20.22	211.00
CPT 4	2.25	5.49	268.61	-73.65	5.01	20.68	214.33
CPT 4	2.30	5.51	275.05	-73.92	4.64	21.14	213.63
CPT 4	2.35	5.67	228.68	-75.88	4.39	21.60	218.48
CPT 4	2.40	6.99	292.31	-75.64	4.53	22.06	221.92
CPT 4	2.45	5.89	316.52	-70.40	4.35	22.52	235.78
CPT 4	2.50	9.33	355.02	-72.57	4.28	22.98	248.50
CPT 4	2.55	10.46	424.23	-70.35	4.10	23.43	262.63
CPT 4	2.60	10.53	460.70	-70.44	4.15	23.89	268.06
CPT 4	2.65	10.63	426.37	-66.30	4.01	24.35	260.98
CPT 4	2.70	8.77	311.55	-71.29	2.79	24.81	231.88
CPT 4	2.75	7.14	0.00	-75.21	1.22	25.27	196.19
CPT 4	2.80	9.59	0.00	-76.22	0.00	25.73	64.13

Table A.15: May 8 CPT – 1 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 1	0.05	7.00	22.05	4.69	0.32	0.46	129.87
CPT 1	0.10	11.50	37.61	7.88	0.51	0.92	143.91
CPT 1	0.15	8.29	78.23	14.55	0.82	1.38	155.65
CPT 1	0.20	6.25	97.82	27.45	1.35	1.84	149.52
CPT 1	0.25	3.85	73.10	18.73	1.33	2.30	153.21

CPT 1	0.30	9.05	84.45	-7.45	0.72	2.76	155.28
CPT 1	0.35	12.29	24.49	5.43	0.60	3.22	162.99
CPT 1	0.40	8.99	72.91	1.72	0.60	3.68	157.70
CPT 1	0.45	5.89	65.87	8.96	1.23	4.14	150.25
CPT 1	0.50	2.39	73.45	13.79	2.04	4.60	133.60
CPT 1	0.55	1.61	62.50	0.37	3.58	5.05	117.01
CPT 1	0.60	1.30	53.77	1.65	3.99	5.51	110.06
CPT 1	0.65	1.29	50.93	11.45	4.09	5.97	108.12
CPT 1	0.70	1.29	53.59	-5.06	4.53	6.43	107.35
CPT 1	0.75	0.98	56.32	-4.14	4.95	6.89	105.93
CPT 1	0.80	0.97	49.88	-4.45	5.73	7.35	104.73
CPT 1	0.85	0.93	58.52	-5.75	5.83	7.81	105.82
CPT 1	0.90	0.99	59.54	-9.51	5.90	8.27	109.13
CPT 1	0.95	1.15	62.65	-1.40	5.89	8.73	112.33
CPT 1	1.00	1.13	70.02	-2.16	6.11	9.19	116.18
CPT 1	1.05	1.18	78.94	2.72	6.45	9.65	119.66
CPT 1	1.10	1.29	83.48	-3.78	6.23	10.11	122.26
CPT 1	1.15	1.36	76.37	-4.77	6.03	10.57	124.47
CPT 1	1.20	1.39	83.47	-4.36	6.07	11.03	128.41
CPT 1	1.25	1.58	102.75	-2.85	6.12	11.49	135.56
CPT 1	1.30	1.97	115.80	-5.98	6.01	11.95	144.59
CPT 1	1.35	2.32	134.15	-14.96	5.63	12.41	161.39
CPT 1	1.40	3.79	204.94	-13.38	4.80	12.87	189.99
CPT 1	1.45	7.33	306.05	-12.30	3.78	13.33	224.23
CPT 1	1.50	12.27	372.86	-7.05	3.12	13.79	249.51
CPT 1	1.55	14.33	380.09	1.77	2.66	14.24	263.64
CPT 1	1.60	15.77	375.72	-7.86	2.68	14.70	265.78
CPT 1	1.65	12.78	394.74	-0.77	2.90	15.16	261.69
CPT 1	1.70	10.78	368.91	-9.30	3.06	15.62	249.61
CPT 1	1.75	10.04	265.45	-12.05	2.77	16.08	234.11
CPT 1	1.80	9.04	192.92	-11.78	2.29	16.54	215.53
CPT 1	1.85	7.28	144.57	-31.27	2.08	17.00	204.44
CPT 1	1.90	7.51	158.98	-29.76	2.17	17.46	201.00
CPT 1	1.95	7.38	176.13	-29.97	2.36	17.92	203.84
CPT 1	2.00	7.00	181.77	-34.16	2.61	18.38	203.60
CPT 1	2.05	6.23	178.53	-32.90	2.76	18.84	202.30
CPT 1	2.10	6.29	178.22	-34.43	2.78	19.30	201.08
CPT 1	2.16	6.51	171.18	-31.87	2.68	19.85	202.15

CPT 1	2.20	6.72	173.38	-33.67	2.56	20.22	204.44
CPT 1	2.25	7.33	180.76	-32.90	2.47	20.68	209.21
CPT 1	2.30	8.18	193.64	-31.91	2.36	21.14	216.74
CPT 1	2.35	9.48	214.21	-35.43	2.33	21.60	225.37
CPT 1	2.40	10.22	241.03	-34.25	2.38	22.06	237.87
CPT 1	2.45	12.09	301.23	-28.63	2.50	22.52	249.57
CPT 1	2.50	12.79	334.85	-28.59	2.52	22.98	259.73
CPT 1	2.55	13.86	339.78	-39.15	2.60	23.43	261.44
CPT 1	2.60	11.93	329.13	-33.15	2.65	23.89	259.29
CPT 1	2.65	11.45	316.52	-37.45	2.81	24.35	257.82
CPT 1	2.70	11.96	347.02	-33.79	1.76	24.81	240.52
CPT 1	2.75	14.36	0.00	-33.01	0.70	25.27	222.99
CPT 1	2.80	23.13	0.00	-31.98	0.00	25.73	97.55

Table A.16: May 8 CPT – 2 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 2A	0.05	7.35	30.97	8.89	0.35	0.46	137.90
CPT 2A	0.10	13.85	39.25	8.54	1.52	0.92	184.96
CPT 2A	0.15	10.64	414.15	23.55	2.56	1.38	208.81
CPT 2A	0.20	7.33	362.35	47.83	2.49	1.84	224.39
CPT 2A	0.25	19.28	153.16	-6.61	1.86	2.30	209.13
CPT 2A	0.30	9.24	150.82	66.05	0.83	2.76	186.90
CPT 2A	0.35	10.14	17.23	-6.43	0.91	3.22	158.43
CPT 2A	0.40	4.09	46.65	5.45	0.82	3.68	136.64
CPT 2A	0.45	1.98	68.33	6.02	2.48	4.14	122.54
CPT 2A	0.50	1.28	67.25	34.63	4.33	4.60	112.77
CPT 2A	0.55	1.23	59.41	26.50	5.05	5.05	108.33
CPT 2A	0.60	1.16	59.50	2.50	5.23	5.51	107.04
CPT 2A	0.65	1.04	60.84	-8.87	5.56	5.97	105.97
CPT 2A	0.70	0.98	56.83	-10.72	6.10	6.43	105.05
CPT 2A	0.75	0.91	60.64	-21.12	6.59	6.89	104.62
CPT 2A	0.80	0.86	62.84	-22.02	6.80	7.35	105.00
CPT 2A	0.85	0.92	58.27	-16.42	6.61	7.81	105.48
CPT 2A	0.90	0.93	56.91	-12.21	6.07	8.27	106.06
CPT 2A	0.95	0.96	54.54	-5.72	5.93	8.73	106.91

CPT 2A	1.00	0.96	57.23	4.17	5.89	9.19	109.57
CPT 2A	1.05	1.08	65.17	12.47	6.16	9.65	114.05
CPT 2A	1.10	1.18	76.88	5.20	6.45	10.11	118.56
CPT 2A	1.15	1.20	81.60	1.37	6.65	10.57	123.42
CPT 2A	1.20	1.37	91.07	6.41	6.72	11.03	129.30
CPT 2A	1.25	1.62	108.50	3.10	6.35	11.49	138.68
CPT 2A	1.30	2.15	127.20	4.98	5.76	11.95	150.52
CPT 2A	1.35	2.91	149.40	-1.86	5.26	12.41	170.88
CPT 2A	1.40	4.68	236.36	2.02	3.42	12.87	204.15
CPT 2A	1.45	11.81	278.24	5.81	2.91	13.33	239.01
CPT 2A	1.50	15.24	409.32	37.69	2.68	13.79	260.21
CPT 2A	1.55	13.95	413.21	1.42	2.88	14.24	268.27
CPT 2A	1.60	13.22	400.72	38.37	2.85	14.70	265.43
CPT 2A	1.65	14.14	365.37	-1.92	2.87	15.16	261.06
CPT 2A	1.70	11.89	362.08	2.70	2.93	15.62	253.70
CPT 2A	1.75	9.89	324.08	-4.63	3.29	16.08	242.53
CPT 2A	1.80	8.05	294.99	5.85	3.48	16.54	229.61
CPT 2A	1.85	6.97	248.37	-16.47	3.41	17.00	221.06
CPT 2A	1.90	7.63	229.15	-17.06	3.19	17.46	217.64
CPT 2A	1.95	7.81	236.51	-20.41	3.11	17.92	219.05
CPT 2A	2.00	7.54	248.50	-19.39	3.23	18.38	218.91
CPT 2A	2.05	6.99	237.01	-22.89	3.39	18.84	217.70
CPT 2A	2.10	6.79	237.96	-23.25	3.58	19.30	216.32
CPT 2A	2.15	6.49	249.59	-19.35	3.70	19.76	219.09
CPT 2A	2.20	7.22	269.76	-24.63	3.88	20.22	224.41
CPT 2A	2.25	7.49	301.82	-13.95	4.12	20.68	232.00
CPT 2A	2.30	7.58	347.31	-19.57	4.27	21.14	239.86
CPT 2A	2.35	8.72	365.81	-20.37	4.34	21.60	247.36
CPT 2A	2.40	9.15	391.79	-22.45	4.06	22.06	257.31
CPT 2A	2.45	11.32	427.39	-20.80	4.01	22.52	268.07
CPT 2A	2.50	12.15	487.29	-29.41	3.61	22.98	278.60
CPT 2A	2.55	14.65	460.23	-25.20	3.55	23.43	282.20
CPT 2A	2.60	12.84	459.16	-26.03	3.55	23.89	275.10
CPT 2A	2.65	9.46	391.51	-30.72	2.65	24.35	245.86
CPT 2A	2.70	9.80	0.00	-31.01	1.20	24.81	212.49
CPT 2A	2.75	13.37	0.00	-21.74	0.00	25.27	75.68

Table A.17: May 8 CPT – 3 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 3	0.05	5.90	34.15	11.80	0.61	0.46	130.72
CPT 3	0.10	8.94	59.28	0.43	0.77	0.92	142.58
CPT 3	0.15	7.57	79.84	35.55	1.11	1.38	153.44
CPT 3	0.20	5.62	107.62	6.56	1.69	1.84	151.98
CPT 3	0.25	4.22	106.79	-8.89	2.71	2.30	145.99
CPT 3	0.30	2.46	119.63	0.87	4.18	2.76	136.84
CPT 3	0.35	1.65	122.00	8.23	6.40	3.22	127.14
CPT 3	0.40	1.39	110.65	-1.88	7.96	3.68	120.77
CPT 3	0.45	1.20	105.07	-7.67	8.59	4.14	117.12
CPT 3	0.50	1.10	101.02	-16.01	8.77	4.60	113.83
CPT 3	0.55	1.01	84.61	4.56	8.55	5.05	110.78
CPT 3	0.60	0.94	75.56	13.36	7.78	5.51	107.97
CPT 3	0.65	0.96	67.27	10.18	7.25	5.97	105.89
CPT 3	0.70	0.90	60.98	-10.36	7.17	6.43	104.79
CPT 3	0.75	0.82	64.85	13.02	7.22	6.89	104.10
CPT 3	0.80	0.86	60.87	8.41	7.39	7.35	103.30
CPT 3	0.85	0.77	56.10	2.31	6.99	7.81	101.88
CPT 3	0.90	0.75	49.99	12.25	6.83	8.27	101.28
CPT 3	0.95	0.80	53.42	8.85	6.61	8.73	103.09
CPT 3	1.00	0.88	58.38	18.68	6.83	9.19	107.01
CPT 3	1.05	0.93	67.55	16.98	7.30	9.65	110.37
CPT 3	1.10	0.90	72.73	15.37	7.89	10.11	115.97
CPT 3	1.15	1.12	93.03	24.39	8.05	10.57	123.02
CPT 3	1.20	1.37	107.13	7.85	7.51	11.03	131.82
CPT 3	1.25	1.68	113.50	8.23	7.13	11.49	141.90
CPT 3	1.30	2.11	147.73	19.84	6.49	11.95	162.27
CPT 3	1.35	3.88	237.57	10.14	5.32	12.41	198.57
CPT 3	1.40	8.40	380.50	8.16	3.69	12.87	233.58
CPT 3	1.45	14.19	358.56	30.05	3.15	13.33	257.71
CPT 3	1.50	14.26	423.27	34.16	2.66	13.79	264.87
CPT 3	1.55	14.69	364.90	10.49	2.63	14.24	267.89
CPT 3	1.60	15.51	380.34	29.53	2.61	14.70	264.35
CPT 3	1.65	12.72	375.55	9.62	2.97	15.16	259.93

CPT 3	1.70	9.90	376.64	-19.24	3.45	15.62	250.15
CPT 3	1.75	9.07	339.70	-18.83	3.76	16.08	240.52
CPT 3	1.80	8.17	304.47	-17.80	3.93	16.54	230.20
CPT 3	1.85	6.25	279.54	-33.92	4.17	17.00	222.80
CPT 3	1.90	6.37	280.83	-37.04	4.62	17.46	218.11
CPT 3	1.95	5.86	291.72	-38.38	4.85	17.92	216.48
CPT 3	2.00	5.30	276.85	-39.15	5.05	18.38	212.72
CPT 3	2.05	5.12	252.16	-43.26	5.03	18.84	209.86
CPT 3	2.10	5.22	256.71	-40.25	4.98	19.30	208.20
CPT 3	2.15	4.97	251.78	-35.81	4.72	19.76	212.14
CPT 3	2.20	6.28	267.95	-36.45	4.31	20.22	216.91
CPT 3	2.25	7.01	266.87	-35.19	3.80	20.68	225.61
CPT 3	2.30	8.34	286.94	-38.05	3.25	21.14	233.35
CPT 3	2.35	10.35	279.95	-37.48	3.02	21.60	247.18
CPT 3	2.40	12.41	370.23	-40.04	2.99	22.06	256.50
CPT 3	2.45	11.61	375.46	-31.72	3.17	22.52	263.44
CPT 3	2.50	11.52	380.17	-29.14	3.17	22.98	270.97
CPT 3	2.55	15.00	452.79	-33.34	3.42	23.43	277.20
CPT 3	2.60	12.10	488.59	-39.08	3.73	23.89	276.80
CPT 3	2.65	9.44	419.58	-39.31	4.31	24.35	270.14
CPT 3	2.70	9.90	447.08	-42.52	2.60	24.81	248.71
CPT 3	2.75	14.03	0.00	-44.31	0.98	25.27	230.30
CPT 3	2.80	21.76	0.00	-38.53	0.00	25.73	95.03

Table A.18: May 8 CPT – 4 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 4	0.05	5.42	53.99	12.53	1.13	0.46	133.40
CPT 4	0.10	6.64	90.32	15.35	1.37	0.92	142.95
CPT 4	0.15	5.71	98.61	30.58	1.68	1.38	149.21
CPT 4	0.20	4.93	101.00	1.31	2.08	1.84	145.47
CPT 4	0.25	3.56	95.86	-5.04	2.84	2.30	140.24
CPT 4	0.30	2.40	112.53	-3.74	4.12	2.76	133.14
CPT 4	0.35	1.88	114.42	-3.35	5.78	3.22	127.54

CPT 4	0.40	1.55	109.86	-10.86	6.68	3.68	123.31
CPT 4	0.45	1.44	100.56	-15.56	7.04	4.14	119.73
CPT 4	0.50	1.31	91.72	-32.87	6.83	4.60	117.61
CPT 4	0.55	1.33	85.01	-28.68	6.44	5.05	117.21
CPT 4	0.60	1.42	84.11	-15.33	6.21	5.51	117.98
CPT 4	0.65	1.36	85.85	2.34	6.02	5.97	119.40
CPT 4	0.70	1.44	83.82	-30.05	6.05	6.43	117.00
CPT 4	0.75	1.13	66.97	-35.87	6.02	6.89	112.01
CPT 4	0.80	0.88	55.46	-33.80	6.13	7.35	104.83
CPT 4	0.85	0.80	48.74	-10.61	6.09	7.81	101.95
CPT 4	0.90	0.88	51.16	-4.26	6.22	8.27	104.28
CPT 4	0.95	0.97	64.29	-1.79	6.84	8.73	110.25
CPT 4	1.00	1.05	82.25	1.65	7.56	9.19	116.45
CPT 4	1.05	1.13	90.83	-3.50	7.85	9.65	121.82
CPT 4	1.10	1.26	96.40	-9.64	7.73	10.11	124.38
CPT 4	1.15	1.23	91.79	-11.80	7.43	10.57	126.46
CPT 4	1.20	1.32	94.06	-14.00	7.21	11.03	128.05
CPT 4	1.25	1.40	98.12	-7.24	6.90	11.49	133.19
CPT 4	1.30	1.71	113.10	-4.67	6.10	11.95	142.22
CPT 4	1.35	2.45	127.86	5.72	6.52	12.41	159.41
CPT 4	1.40	3.08	230.89	2.39	4.40	12.87	195.48
CPT 4	1.45	9.64	308.23	8.36	3.12	13.33	237.17
CPT 4	1.50	17.27	395.58	15.18	2.52	13.79	263.84
CPT 4	1.55	17.04	404.55	4.24	2.24	14.24	276.00
CPT 4	1.60	18.00	373.37	13.08	2.36	14.70	272.81
CPT 4	1.65	14.18	381.57	3.10	2.46	15.16	263.64
CPT 4	1.70	11.61	324.12	-4.97	2.81	15.62	251.09
CPT 4	1.75	9.97	298.88	-16.70	2.87	16.08	236.54
CPT 4	1.80	8.53	239.48	-24.86	2.92	16.54	228.15
CPT 4	1.85	8.42	248.40	-26.00	3.04	17.00	224.71
CPT 4	1.90	8.22	277.66	-26.81	3.30	17.46	226.41
CPT 4	1.95	7.83	280.01	-25.84	3.59	17.92	226.36
CPT 4	2.00	7.18	275.59	-31.10	3.82	18.38	220.93
CPT 4	2.05	5.94	243.03	-34.05	3.99	18.84	214.80
CPT 4	2.10	5.74	233.19	-33.52	4.23	19.30	207.70
CPT 4	2.15	4.92	225.04	-32.18	4.29	19.76	207.29
CPT 4	2.20	5.63	239.94	-33.49	4.30	20.22	212.37
CPT 4	2.25	6.73	276.85	-30.92	4.15	20.68	220.19

CPT 4	2.30	6.95	284.01	-35.14	3.53	21.14	221.71
CPT 4	2.35	7.70	193.32	-33.01	3.37	21.60	226.65
CPT 4	2.40	8.53	302.13	-33.12	3.72	22.06	228.86
CPT 4	2.45	6.19	337.73	-30.79	3.84	22.52	246.56
CPT 4	2.50	12.06	387.76	-30.54	3.99	22.98	258.11
CPT 4	2.55	11.20	450.62	-33.12	3.85	23.43	271.50
CPT 4	2.60	10.98	478.10	-36.95	4.16	23.89	274.74
CPT 4	2.65	11.49	471.04	-35.69	2.80	24.35	253.77
CPT 4	2.70	11.48	0.00	-37.13	1.35	24.81	222.34
CPT 4	2.75	12.01	0.00	-33.80	0.00	25.27	74.57

Table A.19: May 28 CPT – 1 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 1	0.05	1.23	-0.22	8.65	0.16	0.46	71.74
CPT 1	0.10	3.31	9.60	9.47	0.41	0.92	88.75
CPT 1	0.15	3.07	22.03	0.00	0.69	1.38	98.13
CPT 1	0.20	1.80	25.00	41.22	0.99	1.84	95.08
CPT 1	0.25	1.38	14.96	15.78	1.29	2.30	89.28
CPT 1	0.30	1.43	19.91	18.12	1.49	2.76	89.47
CPT 1	0.35	1.42	28.37	-11.25	1.91	3.22	94.15
CPT 1	0.40	1.41	33.25	-1.54	2.41	3.68	98.88
CPT 1	0.45	1.46	41.48	-16.98	2.72	4.14	104.79
CPT 1	0.50	1.78	51.27	-32.80	2.99	4.60	107.68
CPT 1	0.55	1.45	47.12	-43.11	3.20	5.05	107.04
CPT 1	0.60	1.15	41.37	2.10	3.72	5.51	103.82
CPT 1	0.65	1.11	48.91	-38.35	4.31	5.97	102.95
CPT 1	0.70	1.07	52.40	-42.55	4.89	6.43	103.84
CPT 1	0.75	0.98	52.04	-24.74	5.10	6.89	104.23
CPT 1	0.80	1.02	51.04	-23.04	4.87	7.35	104.25
CPT 1	0.85	1.07	45.84	-21.55	4.45	7.81	104.53
CPT 1	0.90	1.07	43.55	-21.76	4.16	8.27	104.29
CPT 1	0.95	1.05	42.80	-26.87	4.02	8.73	104.31
CPT 1	1.00	1.07	41.45	-25.63	4.04	9.19	105.12

CPT 1	1.05	1.08	44.60	-25.91	4.18	9.65	107.83
CPT 1	1.10	1.18	52.77	-24.14	4.37	10.11	113.33
CPT 1	1.15	1.43	63.58	-25.32	4.52	10.57	123.28
CPT 1	1.20	1.92	87.71	-27.95	4.55	11.03	137.56
CPT 1	1.25	2.67	122.32	-31.48	4.49	11.49	159.37
CPT 1	1.30	4.36	191.02	-40.53	3.54	11.95	192.20
CPT 1	1.35	9.50	270.45	-43.94	2.76	12.41	227.31
CPT 1	1.40	15.18	339.41	-40.44	2.29	12.87	254.24
CPT 1	1.45	17.96	364.78	-44.62	2.22	13.33	270.20
CPT 1	1.50	17.16	413.11	-45.98	2.44	13.79	276.15
CPT 1	1.55	15.21	447.98	-36.27	2.88	14.24	272.97
CPT 1	1.60	12.02	417.10	-38.96	3.04	14.70	257.60
CPT 1	1.65	9.77	258.95	-47.24	3.06	15.16	241.77
CPT 1	1.70	9.33	275.35	-48.72	2.81	15.62	220.43
CPT 1	1.75	6.30	179.74	-61.67	2.58	16.08	210.47
CPT 1	1.80	7.74	146.49	-65.56	2.31	16.54	198.38
CPT 1	1.85	6.91	156.61	-66.80	2.27	17.00	200.97
CPT 1	1.90	7.12	190.19	-65.91	2.68	17.46	206.31
CPT 1	1.95	7.27	223.69	-67.10	2.97	17.92	212.37
CPT 1	2.00	7.28	229.46	-68.50	3.11	18.38	214.16
CPT 1	2.05	7.00	214.59	-69.21	2.98	18.84	216.87
CPT 1	2.10	8.40	229.77	-69.94	3.07	19.30	219.46
CPT 1	2.15	7.50	258.10	-70.62	3.25	19.76	226.23
CPT 1	2.20	8.08	290.89	-69.78	3.41	20.22	233.17
CPT 1	2.25	9.66	309.44	-69.84	3.37	20.68	244.38
CPT 1	2.30	10.89	364.30	-70.38	3.37	21.14	255.03
CPT 1	2.35	11.38	401.42	-69.80	3.34	21.60	263.18
CPT 1	2.40	12.47	392.43	-70.06	3.50	22.06	264.94
CPT 1	2.46	10.46	404.37	-70.99	3.58	22.61	265.06
CPT 1	2.50	10.83	408.96	-71.57	3.98	22.98	260.93
CPT 1	2.55	9.13	394.80	-71.91	4.13	23.43	262.45
CPT 1	2.60	10.17	438.01	-73.40	4.09	23.89	269.72
CPT 1	2.65	13.14	490.50	-73.12	2.28	24.35	260.35
CPT 1	2.70	17.53	0.00	-72.87	1.00	24.81	236.69
CPT 1	2.75	18.34	0.00	-72.42	0.00	25.27	92.22

Table A.20: May 28 CPT – 2 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 2	0.05	1.43	-0.65	10.36	0.24	0.46	77.22
CPT 2	0.10	3.75	17.51	9.71	0.62	0.92	92.02
CPT 2	0.15	2.33	29.37	2.25	1.09	1.38	103.57
CPT 2	0.20	1.92	40.48	17.78	1.78	1.84	102.47
CPT 2	0.25	1.94	39.90	-40.80	2.03	2.30	102.08
CPT 2	0.30	1.71	32.31	-30.03	2.08	2.76	100.91
CPT 2	0.35	1.49	34.12	-39.88	2.26	3.22	99.59
CPT 2	0.40	1.45	37.85	-50.40	2.65	3.68	101.08
CPT 2	0.45	1.46	43.78	-54.30	2.99	4.14	103.30
CPT 2	0.50	1.40	46.48	-52.99	3.28	4.60	103.55
CPT 2	0.55	1.21	42.34	-49.81	3.56	5.05	100.91
CPT 2	0.60	0.97	37.71	-51.01	3.98	5.51	97.21
CPT 2	0.65	0.85	39.40	-50.67	4.37	5.97	94.75
CPT 2	0.70	0.83	37.61	-53.95	4.94	6.43	95.40
CPT 2	0.75	0.83	45.49	-52.71	5.49	6.89	99.41
CPT 2	0.80	0.96	59.18	-43.68	6.04	7.35	105.28
CPT 2	0.85	1.08	67.14	-40.02	6.24	7.81	110.08
CPT 2	0.90	1.09	67.43	-42.36	6.36	8.27	112.37
CPT 2	0.95	1.06	68.94	-36.03	6.16	8.73	113.21
CPT 2	1.00	1.15	64.73	-36.17	5.86	9.19	114.55
CPT 2	1.05	1.22	65.56	-39.64	5.29	9.65	117.50
CPT 2	1.10	1.43	69.26	-39.79	4.93	10.11	121.72
CPT 2	1.15	1.61	74.16	-43.51	4.57	10.57	129.03
CPT 2	1.20	2.08	89.41	-46.42	4.43	11.03	139.00
CPT 2	1.25	2.60	114.21	-33.58	3.86	11.49	158.24
CPT 2	1.30	4.80	161.28	-39.26	3.11	11.95	182.88
CPT 2	1.35	8.07	204.94	-48.66	2.64	12.41	205.14
CPT 2	1.40	9.85	231.83	-51.54	2.32	12.87	220.61
CPT 2	1.45	11.29	241.69	-56.96	2.14	13.33	231.25
CPT 2	1.50	13.16	261.36	-52.78	2.14	13.79	238.21
CPT 2	1.55	12.44	286.55	-46.39	2.38	14.24	241.02
CPT 2	1.60	10.15	302.88	-48.52	2.65	14.70	236.79
CPT 2	1.65	9.46	259.50	-50.86	2.62	15.16	226.70

CPT 2	1.70	8.97	186.48	-53.76	2.12	15.62	211.73
CPT 2	1.75	8.07	114.21	-58.38	1.55	16.08	194.63
CPT 2	1.80	7.46	79.10	-59.63	1.28	16.54	182.14
CPT 2	1.85	6.68	90.73	-61.01	1.34	17.00	180.08
CPT 2	1.90	6.74	109.97	-61.90	1.68	17.46	184.82
CPT 2	1.95	6.57	134.38	-65.15	2.06	17.92	191.38
CPT 2	2.00	6.45	161.61	-64.72	2.17	18.38	194.09
CPT 2	2.05	6.84	134.83	-65.34	2.35	18.84	199.23
CPT 2	2.10	7.12	181.41	-67.19	2.57	19.30	201.31
CPT 2	2.15	5.94	194.43	-66.64	2.76	19.76	210.74
CPT 2	2.20	8.55	218.99	-67.62	2.67	20.22	218.97
CPT 2	2.25	9.82	233.81	-67.33	2.54	20.68	231.02
CPT 2	2.30	10.37	276.25	-66.71	1.87	21.14	222.71
CPT 2	2.35	10.38	60.06	-67.40	1.97	21.60	227.92
CPT 2	2.40	10.71	283.78	-69.00	2.44	22.06	222.19
CPT 2	2.45	4.95	290.63	-69.14	3.17	22.52	241.65
CPT 2	2.50	12.60	319.44	-70.44	3.77	22.98	245.91
CPT 2	2.55	9.22	398.25	-70.35	3.79	23.43	263.99
CPT 2	2.60	10.29	497.25	-70.75	4.46	23.89	277.26
CPT 2	2.65	13.69	581.68	-69.94	2.47	24.35	271.67
CPT 2	2.70	19.74	0.00	-73.28	1.14	24.81	246.06
CPT 2	2.75	17.54	0.00	-71.37	0.00	25.27	92.74

Table A.21: May 28 CPT – 3 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 3	0.05	1.55	9.98	19.08	0.81	0.46	75.38
CPT 3	0.10	1.48	17.36	5.85	1.29	0.92	81.15
CPT 3	0.15	1.22	27.59	18.39	1.92	1.38	86.14
CPT 3	0.20	1.30	32.02	2.77	2.20	1.84	90.99
CPT 3	0.25	1.62	31.56	6.02	2.15	2.30	95.27
CPT 3	0.30	1.59	33.65	-9.07	2.26	2.76	98.78
CPT 3	0.35	1.46	40.22	-30.47	2.87	3.22	102.31
CPT 3	0.40	1.46	55.00	-36.29	3.55	3.68	108.37
CPT 3	0.45	1.74	69.62	-46.05	3.77	4.14	115.00
CPT 3	0.50	1.97	69.71	-49.53	4.11	4.60	115.60

CPT 3	0.55	1.24	63.10	-48.17	4.68	5.05	111.62
CPT 3	0.60	0.96	60.59	-51.48	6.27	5.51	105.55
CPT 3	0.65	0.88	67.22	-41.71	7.37	5.97	104.62
CPT 3	0.70	0.89	71.20	-39.51	7.72	6.43	105.28
CPT 3	0.75	0.89	64.85	-38.47	7.45	6.89	105.21
CPT 3	0.80	0.87	59.27	-31.56	6.70	7.35	105.44
CPT 3	0.85	0.99	58.16	-34.48	6.30	7.81	107.82
CPT 3	0.90	1.08	66.80	-30.19	6.40	8.27	111.98
CPT 3	0.95	1.11	77.34	-27.19	6.68	8.73	114.73
CPT 3	1.00	1.08	73.48	-26.66	6.85	9.19	115.82
CPT 3	1.05	1.08	71.95	-27.21	6.56	9.65	117.02
CPT 3	1.10	1.22	75.40	-31.36	6.25	10.11	119.19
CPT 3	1.15	1.29	75.94	-34.54	5.86	10.57	123.54
CPT 3	1.20	1.52	83.58	-32.80	5.35	11.03	132.96
CPT 3	1.25	2.27	111.25	-28.32	4.66	11.49	153.51
CPT 3	1.30	4.15	174.30	-28.36	4.37	11.95	179.73
CPT 3	1.35	5.99	255.25	-36.88	3.63	12.41	209.61
CPT 3	1.40	10.20	307.76	-34.94	2.95	12.87	237.10
CPT 3	1.45	14.90	352.62	-36.17	2.55	13.33	258.44
CPT 3	1.50	16.57	403.53	-45.73	2.51	13.79	271.50
CPT 3	1.55	15.97	433.29	-40.20	2.77	14.24	274.37
CPT 3	1.60	13.38	435.73	-41.38	3.21	14.70	268.53
CPT 3	1.65	10.58	412.34	-41.55	3.54	15.16	256.47
CPT 3	1.70	9.56	336.22	-44.21	3.53	15.62	240.18
CPT 3	1.75	8.01	244.92	-47.97	3.15	16.08	221.31
CPT 3	1.80	6.47	174.73	-54.04	2.81	16.54	204.26
CPT 3	1.85	5.97	154.94	-51.27	2.51	17.00	194.03
CPT 3	1.90	6.31	139.96	-57.43	2.46	17.46	192.02
CPT 3	1.95	6.02	154.11	-59.92	2.63	17.92	192.50
CPT 3	2.00	5.36	169.96	-60.82	3.12	18.38	195.92
CPT 3	2.05	5.48	200.40	-62.68	3.41	18.84	200.73
CPT 3	2.10	6.24	211.13	-63.89	3.50	19.30	207.56
CPT 3	2.15	6.62	229.86	-64.78	3.31	19.76	218.52
CPT 3	2.20	8.76	273.88	-63.80	3.47	20.22	230.33
CPT 3	2.25	8.79	333.96	-63.39	3.63	20.68	243.59
CPT 3	2.30	9.71	380.27	-65.09	3.10	21.14	242.38
CPT 3	2.35	10.68	190.60	-68.18	2.98	21.60	251.39
CPT 3	2.40	12.36	404.81	-71.36	3.49	22.06	249.69

CPT 3	2.45	6.33	427.43	-63.36	4.27	22.52	260.02
CPT 3	2.50	10.39	408.34	-68.80	4.40	22.98	254.13
CPT 3	2.55	10.11	341.55	-66.50	3.83	23.43	255.78
CPT 3	2.60	8.88	372.09	-67.38	4.43	23.89	255.80
CPT 3	2.65	7.96	478.30	-67.71	2.55	24.35	247.41
CPT 3	2.70	16.56	0.00	-67.12	1.06	24.81	232.48
CPT 3	2.75	20.67	0.00	-67.74	0.00	25.27	95.32

Table A.22: May 28 CPT – 4 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 4	0.05	1.02	32.14	1.85	3.73	0.46	83.09
CPT 4	0.10	1.30	60.38	22.57	4.23	0.92	97.28
CPT 4	0.15	1.88	85.17	-13.97	4.84	1.38	107.99
CPT 4	0.20	1.65	87.50	-57.14	5.97	1.84	107.73
CPT 4	0.25	0.66	75.91	-53.54	8.43	2.30	97.55
CPT 4	0.30	0.38	60.42	-42.80	14.68	2.76	83.88
CPT 4	0.35	0.34	61.62	-39.09	18.95	3.22	79.39
CPT 4	0.40	0.32	67.84	-55.94	21.44	3.68	80.75
CPT 4	0.45	0.33	74.83	-52.39	24.50	4.14	82.99
CPT 4	0.50	0.29	80.41	-41.67	28.77	4.60	83.45
CPT 4	0.55	0.20	74.56	-40.20	33.22	5.05	77.44
CPT 4	0.60	0.10	33.02	-47.81	61.32	5.51	69.48
CPT 4	0.65	0.00	58.26	-48.86	-52.18	5.97	0.00
CPT 4	0.70	-0.35	56.89	-44.65	-49.56	6.43	0.00
CPT 4	0.75	0.02	64.78	-45.97	-89.66	6.89	0.00
CPT 4	0.80	0.14	78.68	-45.15	63.52	7.35	79.62
CPT 4	0.85	0.22	75.78	-45.80	40.65	7.81	86.53
CPT 4	0.90	0.24	75.43	-45.42	33.98	8.27	88.59
CPT 4	0.95	0.23	73.58	-43.71	29.07	8.73	90.92
CPT 4	1.00	0.33	74.55	-44.10	24.47	9.19	94.68
CPT 4	1.05	0.41	82.93	-45.95	19.00	9.65	101.71
CPT 4	1.10	0.63	97.01	-51.73	13.92	10.11	112.05
CPT 4	1.15	1.04	105.85	-54.05	9.59	10.57	128.27
CPT 4	1.20	1.84	131.07	-61.62	7.04	11.03	144.84
CPT 4	1.25	2.71	154.22	-57.96	6.31	11.49	162.65

CPT 4	1.30	3.40	214.65	-64.38	5.66	11.95	181.79
CPT 4	1.35	5.07	261.87	-66.16	5.28	12.41	206.25
CPT 4	1.40	7.51	366.39	-60.55	4.80	12.87	229.07
CPT 4	1.45	9.31	421.32	-45.70	4.45	13.33	247.02
CPT 4	1.50	10.64	433.71	-16.01	4.41	13.79	252.98
CPT 4	1.55	9.19	430.24	-52.10	4.68	14.24	253.62
CPT 4	1.60	8.42	457.16	-52.50	5.27	14.70	247.25
CPT 4	1.65	7.09	411.42	-49.05	5.71	15.16	240.29
CPT 4	1.70	6.33	376.62	-55.23	5.59	15.62	229.65
CPT 4	1.75	6.12	302.65	-55.01	5.34	16.08	223.15
CPT 4	1.80	6.02	305.72	-56.17	5.35	16.54	215.53
CPT 4	1.85	4.61	285.76	-57.80	5.60	17.00	213.34
CPT 4	1.90	5.18	291.94	-60.48	5.74	17.46	213.12
CPT 4	1.95	5.68	307.63	-58.80	5.72	17.92	216.50
CPT 4	2.00	5.19	316.80	-59.22	5.51	18.38	215.19
CPT 4	2.05	5.15	256.74	-60.18	5.46	18.84	213.02
CPT 4	2.10	5.24	275.54	-60.41	5.35	19.30	211.87
CPT 4	2.15	5.05	291.79	-57.70	5.28	19.76	218.81
CPT 4	2.20	6.56	320.74	-57.41	5.01	20.22	226.34
CPT 4	2.25	7.26	331.62	-57.84	4.79	20.68	235.27
CPT 4	2.30	7.50	368.18	-59.49	4.68	21.14	244.83
CPT 4	2.35	9.13	417.03	-59.54	4.69	21.60	252.17
CPT 4	2.40	9.05	417.91	-60.18	4.37	22.06	260.32
CPT 4	2.45	10.76	426.48	-60.75	4.21	22.52	266.37
CPT 4	2.50	11.41	469.00	-63.11	4.84	22.98	269.75
CPT 4	2.55	7.55	541.09	-65.52	5.88	23.43	270.08
CPT 4	2.60	7.64	552.34	-66.20	6.25	23.89	279.23
CPT 4	2.65	12.73	647.79	-63.25	2.97	24.35	274.37
CPT 4	2.70	20.09	0.00	-62.47	1.18	24.81	254.29
CPT 4	2.75	21.92	0.00	-61.05	0.00	25.27	100.18

Table A.23: July 2 CPT – 1 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 1	0.05	2.30	0.05	-11.52	0.05	0.46	78.58
CPT 1	0.10	3.04	3.47	-12.49	0.52	0.92	89.64

CPT 1	0.15	2.12	35.38	-1.94	1.27	1.38	99.32
CPT 1	0.20	1.61	47.17	1.88	2.50	1.84	100.37
CPT 1	0.25	1.35	44.55	14.52	3.15	2.30	99.13
CPT 1	0.30	1.29	42.54	5.39	3.28	2.76	97.91
CPT 1	0.35	1.25	40.91	35.94	3.30	3.22	96.77
CPT 1	0.40	1.10	37.15	8.91	3.61	3.68	95.86
CPT 1	0.45	0.97	41.98	-30.47	4.46	4.14	93.01
CPT 1	0.50	0.66	42.20	-3.52	4.85	4.60	95.46
CPT 1	0.55	1.13	48.99	-5.16	5.00	5.05	99.58
CPT 1	0.60	1.18	56.75	-11.13	4.67	5.51	105.01
CPT 1	0.65	1.14	54.80	-10.01	4.41	5.97	104.50
CPT 1	0.70	1.10	38.96	-4.12	4.24	6.43	103.14
CPT 1	0.75	1.05	45.55	4.58	4.32	6.89	102.58
CPT 1	0.80	1.00	51.54	0.81	4.96	7.35	106.04
CPT 1	0.85	1.13	60.40	-1.17	4.98	7.81	108.27
CPT 1	0.90	1.17	52.25	-0.25	4.83	8.27	110.15
CPT 1	0.95	1.15	53.87	0.74	4.76	8.73	111.54
CPT 1	1.00	1.21	62.26	7.43	5.05	9.19	114.76
CPT 1	1.05	1.30	68.97	5.52	5.35	9.65	118.08
CPT 1	1.10	1.29	72.09	2.34	5.30	10.11	120.66
CPT 1	1.15	1.41	70.82	3.81	5.27	10.57	126.26
CPT 1	1.20	1.78	93.13	3.30	5.31	11.03	138.74
CPT 1	1.25	2.51	138.90	2.22	5.00	11.49	161.83
CPT 1	1.30	4.52	208.90	0.52	3.69	11.95	204.00
CPT 1	1.35	11.88	349.43	-12.69	3.09	12.41	236.71
CPT 1	1.40	13.97	379.51	-21.33	2.82	12.87	260.53
CPT 1	1.45	14.61	413.02	15.46	2.77	13.33	268.47
CPT 1	1.50	15.27	423.68	7.45	3.06	13.79	268.65
CPT 1	1.55	11.53	431.10	-3.14	3.26	14.24	260.21
CPT 1	1.60	9.92	341.64	0.28	3.63	14.70	245.13
CPT 1	1.65	8.07	300.29	-6.05	3.81	15.16	227.53
CPT 1	1.70	5.59	255.92	-9.78	3.57	15.62	214.96
CPT 1	1.75	7.24	188.69	-19.35	3.27	16.08	207.00
CPT 1	1.80	6.85	199.02	-20.44	3.03	16.54	207.04
CPT 1	1.85	6.28	229.90	-21.83	3.30	17.00	204.73
CPT 1	1.90	5.64	190.98	-24.77	3.77	17.46	205.10
CPT 1	1.95	5.53	237.22	-26.28	4.08	17.92	207.39
CPT 1	2.00	5.98	270.49	-6.99	4.31	18.38	215.54

CPT 1	2.05	6.84	282.72	-10.58	4.38	18.84	220.77
CPT 1	2.10	6.47	290.98	-24.51	4.27	19.30	224.48
CPT 1	2.15	7.03	294.43	-26.48	4.38	19.76	228.70
CPT 1	2.20	7.47	332.63	-12.90	4.16	20.22	238.36
CPT 1	2.25	9.47	368.81	-20.71	4.07	20.68	246.18
CPT 1	2.30	9.35	367.91	-22.45	3.47	21.14	247.61
CPT 1	2.35	10.23	269.63	-18.15	3.26	21.60	246.79
CPT 1	2.40	10.07	328.96	-17.75	3.45	22.06	242.61
CPT 1	2.45	7.02	344.48	-11.62	4.12	22.52	248.93
CPT 1	2.50	9.32	414.19	-19.10	4.84	22.98	258.26
CPT 1	2.55	10.15	522.36	-15.37	4.87	23.43	278.53
CPT 1	2.60	12.56	622.85	-12.19	4.45	23.89	296.96
CPT 1	2.65	16.92	618.67	-5.22	2.59	24.35	284.15
CPT 1	2.70	18.37	0.00	2.32	1.11	24.81	252.79
CPT 1	2.75	20.57	0.00	-7.85	0.00	25.27	96.67

Table A.24: July 2 CPT – 3 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 3	0.05	0.61	0.07	2.82	0.01	0.46	54.38
CPT 3	0.10	1.05	0.09	-4.76	0.60	0.92	67.93
CPT 3	0.15	1.64	19.76	3.19	0.71	1.38	80.45
CPT 3	0.20	1.97	13.25	-18.92	0.94	1.84	89.77
CPT 3	0.25	1.84	18.04	-20.46	0.82	2.30	88.88
CPT 3	0.30	1.50	12.34	-36.22	0.97	2.76	87.23
CPT 3	0.35	1.25	14.18	-28.84	1.21	3.22	85.43
CPT 3	0.40	1.16	20.53	-30.77	1.65	3.68	86.36
CPT 3	0.45	1.06	22.33	-31.39	2.19	4.14	88.19
CPT 3	0.50	0.96	26.48	-24.26	2.54	4.60	89.72
CPT 3	0.55	1.04	28.49	-25.27	2.76	5.05	91.72
CPT 3	0.60	1.06	29.17	-23.51	2.59	5.51	92.69
CPT 3	0.65	1.06	23.87	-21.77	2.51	5.97	92.75
CPT 3	0.70	1.01	25.45	-20.25	2.43	6.43	93.19
CPT 3	0.75	1.08	27.08	-13.29	2.53	6.89	94.80
CPT 3	0.80	1.10	27.94	-12.64	2.77	7.35	97.65
CPT 3	0.85	1.11	35.75	-12.18	3.36	7.81	103.09

CPT 3	0.90	1.24	52.12	-12.62	4.11	8.27	110.21
CPT 3	0.95	1.38	65.08	-14.07	4.64	8.73	115.49
CPT 3	1.00	1.33	65.60	-12.47	5.04	9.19	118.82
CPT 3	1.05	1.34	72.79	-12.62	5.20	9.65	121.34
CPT 3	1.10	1.49	77.45	-12.60	4.86	10.11	123.85
CPT 3	1.15	1.65	67.24	-12.80	4.68	10.57	131.45
CPT 3	1.20	2.16	103.24	-12.62	5.08	11.03	146.22
CPT 3	1.25	2.91	171.10	-8.91	4.52	11.49	181.64
CPT 3	1.30	7.55	296.34	-8.47	3.91	11.95	220.23
CPT 3	1.35	11.90	407.61	-7.26	3.46	12.41	246.83
CPT 3	1.40	12.29	395.64	-1.97	3.20	12.87	254.80
CPT 3	1.45	11.50	340.41	-0.59	2.98	13.33	247.55
CPT 3	1.50	10.46	286.30	-6.69	3.02	13.79	240.00
CPT 3	1.55	9.31	318.04	-7.42	3.49	14.24	236.11
CPT 3	1.60	7.79	356.43	-8.54	4.19	14.70	231.95
CPT 3	1.65	6.59	318.23	-9.78	4.76	15.16	224.37
CPT 3	1.70	5.78	284.73	-11.09	4.78	15.62	214.30
CPT 3	1.75	5.34	244.26	-13.13	4.62	16.08	208.69
CPT 3	1.80	5.60	242.91	-13.47	4.45	16.54	207.06
CPT 3	1.85	5.65	251.14	-14.29	4.26	17.00	205.76
CPT 3	1.90	5.34	213.10	-15.53	4.25	17.46	204.10
CPT 3	1.95	5.18	222.01	-16.70	4.17	17.92	204.17
CPT 3	2.00	5.73	241.51	-14.84	4.16	18.38	208.76
CPT 3	2.05	6.26	249.84	-14.93	3.78	18.84	212.05
CPT 3	2.10	6.73	217.21	-14.98	3.69	19.30	217.81
CPT 3	2.15	7.31	281.58	-15.46	4.04	19.76	223.90
CPT 3	2.20	6.66	337.52	-9.73	3.98	20.22	242.04
CPT 3	2.25	11.60	398.09	-11.93	3.77	20.68	261.15
CPT 3	2.30	13.77	472.48	-13.02	3.30	21.14	276.18
CPT 3	2.35	14.40	442.23	-13.54	3.39	21.60	276.27
CPT 3	2.40	10.93	408.70	-14.47	3.59	22.06	265.07
CPT 3	2.45	8.47	363.16	-12.85	4.26	22.52	256.37
CPT 3	2.50	8.63	421.47	-15.33	4.44	22.98	263.50
CPT 3	2.55	12.22	516.15	-14.84	4.52	23.43	285.48
CPT 3	2.60	14.77	672.06	-13.10	3.79	23.89	305.30
CPT 3	2.65	19.63	579.87	-14.20	3.40	24.35	321.31
CPT 3	2.70	22.00	663.79	-13.47	2.15	24.81	293.69
CPT 3	2.75	16.29	0.00	-11.04	1.08	25.27	260.50

CPT 3	2.80	22.91	0.00	-12.58	0.00	25.73	98.77

Table A.25: July 29 CPT – 1 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 1	0.05	3.09	0.01	6.44	0.00	0.46	191.69
CPT 1	0.10	7.47	0.03	19.59	0.10	0.92	109.05
CPT 1	0.15	6.99	17.63	5.96	0.20	1.38	122.74
CPT 1	0.20	6.76	25.19	17.60	0.31	1.84	125.96
CPT 1	0.25	6.37	19.38	2.77	0.31	2.30	125.12
CPT 1	0.30	6.01	13.89	-0.10	0.28	2.76	121.31
CPT 1	0.35	5.02	15.63	8.36	0.42	3.22	122.23
CPT 1	0.40	4.20	34.66	4.81	0.73	3.68	123.67
CPT 1	0.45	3.59	43.46	4.36	1.27	4.14	128.51
CPT 1	0.50	3.34	63.15	5.56	1.70	4.60	131.90
CPT 1	0.55	3.43	69.12	5.77	1.91	5.05	135.91
CPT 1	0.60	3.69	67.60	9.74	1.91	5.51	137.20
CPT 1	0.65	3.42	64.86	18.49	1.95	5.97	135.92
CPT 1	0.70	2.90	63.05	13.35	2.26	6.43	131.09
CPT 1	0.75	2.04	61.08	15.71	2.80	6.89	123.74
CPT 1	0.80	1.45	55.19	13.82	3.48	7.35	114.59
CPT 1	0.85	1.12	44.54	9.80	3.87	7.81	106.92
CPT 1	0.90	1.00	38.75	4.95	3.79	8.27	101.75
CPT 1	0.95	0.97	33.98	20.04	3.48	8.73	100.27
CPT 1	1.00	1.06	32.98	20.07	3.09	9.19	102.72
CPT 1	1.05	1.33	37.22	21.93	1.86	9.65	100.03
CPT 1	1.10	1.43	1.01	19.54	1.94	10.11	106.64
CPT 1	1.15	1.69	48.41	15.19	2.43	10.57	112.71
CPT 1	1.20	1.55	64.32	5.41	2.60	11.03	131.71
CPT 1	1.25	3.74	68.33	-21.33	1.99	11.49	142.56
CPT 1	1.30	4.48	61.75	-31.14	1.50	11.95	149.05
CPT 1	1.35	4.32	57.42	-35.51	1.42	12.41	148.93
CPT 1	1.40	3.91	60.79	-37.02	1.36	12.87	145.01
CPT 1	1.45	3.65	43.30	-37.42	1.57	13.33	145.13
CPT 1	1.50	3.51	68.90	-36.79	1.77	13.79	156.67
CPT 1	1.55	5.74	115.31	10.43	1.78	14.24	188.31

CPT 1	1.60	12.16	195.88	-32.47	1.78	14.70	229.14
CPT 1	1.65	18.36	335.42	-38.40	2.06	15.16	259.76
CPT 1	1.70	15.94	427.56	-29.69	2.41	15.62	274.24
CPT 1	1.75	14.51	414.61	-27.30	2.34	16.08	278.23
CPT 1	1.80	20.91	356.91	-26.18	2.14	16.54	272.80
CPT 1	1.85	15.53	320.64	-13.97	2.00	17.00	264.58
CPT 1	1.90	12.20	296.10	-19.47	2.32	17.46	249.03
CPT 1	1.95	10.38	266.87	-23.34	2.47	17.92	235.98
CPT 1	2.00	9.20	221.02	-25.08	2.39	18.38	222.44
CPT 1	2.05	7.87	168.40	-28.08	2.01	18.84	210.86
CPT 1	2.10	8.79	130.68	-27.99	1.67	19.30	198.80
CPT 1	2.15	7.36	102.63	-27.43	1.43	19.76	192.13
CPT 1	2.20	7.39	101.99	-28.30	1.51	20.22	190.30
CPT 1	2.25	7.41	128.54	-29.55	1.70	20.68	196.50
CPT 1	2.30	7.87	155.31	-31.02	1.82	21.14	205.85
CPT 1	2.35	9.58	168.05	-32.10	1.76	21.60	213.97
CPT 1	2.40	10.59	170.71	-33.45	1.87	22.06	223.80
CPT 1	2.45	10.46	234.82	-34.60	2.25	22.52	235.15
CPT 1	2.50	10.61	305.47	-23.78	2.56	22.98	249.75
CPT 1	2.55	13.48	344.48	-27.47	2.70	23.43	267.95
CPT 1	2.60	16.30	438.48	-29.85	2.87	23.89	284.15
CPT 1	2.65	15.59	518.06	-29.26	3.02	24.35	287.75
CPT 1	2.70	13.52	413.26	-27.92	2.87	24.81	286.73
CPT 1	2.75	16.98	393.31	-29.35	2.87	25.27	280.22
CPT 1	2.80	12.80	434.87	-27.58	2.08	25.73	254.33
CPT 1	2.85	10.07	0.00	-29.16	1.23	26.19	220.35
CPT 1	2.90	12.48	0.00	-31.22	0.00	26.65	74.07

Table A.26: July 29 CPT – 2 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 2	0.05	4.31	-0.05	3.05	0.00	0.46	50.17
CPT 2	0.10	7.37	-0.06	6.64	0.04	0.92	113.94
CPT 2	0.15	8.32	7.57	9.71	0.12	1.38	123.72

CPT 2	0.20	8.02	20.99	4.08	0.22	1.84	128.63
CPT 2	0.25	6.57	21.78	-0.10	0.37	2.30	131.88
CPT 2	0.30	6.06	34.35	0.87	0.66	2.76	134.99
CPT 2	0.35	5.17	62.18	7.31	1.18	3.22	140.95
CPT 2	0.40	4.17	85.31	4.83	1.90	3.68	144.46
CPT 2	0.45	3.75	101.04	5.20	2.59	4.14	147.75
CPT 2	0.50	3.93	120.40	5.73	2.86	4.60	152.19
CPT 2	0.55	4.29	121.43	3.81	2.89	5.05	156.19
CPT 2	0.60	4.32	120.28	2.65	2.72	5.51	156.11
CPT 2	0.65	4.08	102.84	18.14	2.62	5.97	152.18
CPT 2	0.70	3.48	88.39	22.66	2.58	6.43	142.53
CPT 2	0.75	2.34	64.06	18.28	2.68	6.89	128.69
CPT 2	0.80	1.44	42.12	21.02	2.70	7.35	111.47
CPT 2	0.85	1.01	23.35	19.82	2.55	7.81	98.30
CPT 2	0.90	0.94	21.34	22.11	2.20	8.27	93.02
CPT 2	0.95	1.08	22.17	26.78	2.15	8.73	95.38
CPT 2	1.00	1.21	26.14	26.99	2.47	9.19	101.10
CPT 2	1.05	1.24	39.51	24.67	3.18	9.65	110.61
CPT 2	1.10	1.57	62.76	26.96	3.27	10.11	128.76
CPT 2	1.15	3.19	94.28	31.72	3.12	10.57	148.63
CPT 2	1.20	4.26	124.95	-2.25	3.14	11.03	162.46
CPT 2	1.25	3.91	137.47	17.94	3.30	11.49	168.49
CPT 2	1.30	3.96	137.25	-1.65	3.29	11.95	169.26
CPT 2	1.35	4.32	125.70	-27.31	2.79	12.41	166.97
CPT 2	1.40	4.36	89.63	-29.30	2.11	12.87	160.50
CPT 2	1.45	4.22	56.31	-34.14	1.86	13.33	156.99
CPT 2	1.50	4.17	91.52	-32.80	2.07	13.79	174.69
CPT 2	1.55	7.82	187.65	-19.98	2.32	14.24	208.35
CPT 2	1.60	12.61	291.83	-26.48	2.31	14.70	243.25
CPT 2	1.65	16.61	374.90	-28.30	2.28	15.16	261.91
CPT 2	1.70	15.66	358.21	-27.22	2.25	15.62	272.15
CPT 2	1.75	17.46	385.73	-25.77	2.05	16.08	275.32
CPT 2	1.80	20.54	357.25	-33.54	1.99	16.54	276.65
CPT 2	1.85	17.06	351.78	-15.47	2.10	17.00	273.65
CPT 2	1.90	14.13	377.33	-25.70	2.60	17.46	266.50
CPT 2	1.95	11.55	383.21	-28.25	3.03	17.92	258.23
CPT 2	2.00	10.36	332.08	-32.30	2.99	18.38	243.21
CPT 2	2.05	8.96	208.16	-33.43	2.64	18.84	225.92

CPT 2	2.10	7.69	171.43	-34.89	2.34	19.30	208.69
CPT 2	2.15	6.46	159.73	-27.17	2.32	19.76	201.44
CPT 2	2.20	6.75	153.66	-29.55	2.31	20.22	200.09
CPT 2	2.25	7.24	158.88	-33.79	2.22	20.68	201.86
CPT 2	2.30	7.31	159.67	-35.38	1.91	21.14	203.13
CPT 2	2.35	8.78	127.06	-37.84	1.79	21.60	206.11
CPT 2	2.40	8.95	160.95	-38.71	1.99	22.06	211.47
CPT 2	2.45	7.56	215.92	-26.62	2.55	22.52	227.76
CPT 2	2.50	10.53	313.45	-33.01	2.99	22.98	244.24
CPT 2	2.55	11.77	363.35	-35.00	3.17	23.43	262.06
CPT 2	2.60	12.47	424.74	-35.25	3.20	23.89	271.48
CPT 2	2.65	13.61	421.79	-36.60	3.06	24.35	276.29
CPT 2	2.70	14.45	391.33	-34.75	2.84	24.81	283.01
CPT 2	2.75	16.78	460.40	-35.19	3.36	25.27	291.02
CPT 2	2.80	12.46	616.92	-11.23	4.27	25.73	302.20
CPT 2	2.85	12.64	711.10	-19.72	3.34	26.19	281.11
CPT 2	2.90	14.68	0.00	-25.70	1.52	26.65	253.80
CPT 2	2.95	19.54	0.00	-29.10	0.00	27.11	91.85

Table A.27: July 29 CPT – 3 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 3	0.05	6.38	0.16	27.67	0.09	0.46	111.78
CPT 3	0.10	8.41	19.39	-7.35	0.25	0.92	124.72
CPT 3	0.15	7.95	36.46	-5.56	0.46	1.38	137.45
CPT 3	0.20	6.80	51.23	-2.91	0.74	1.84	142.05
CPT 3	0.25	6.00	66.54	-6.14	1.00	2.30	144.20
CPT 3	0.30	5.75	68.10	-3.53	1.22	2.76	145.56
CPT 3	0.35	5.23	71.91	-1.35	1.49	3.22	147.53
CPT 3	0.40	4.78	94.42	-1.01	1.86	3.68	149.09
CPT 3	0.45	4.34	100.80	0.28	2.37	4.14	152.83
CPT 3	0.50	4.32	123.19	3.59	2.52	4.60	153.55
CPT 3	0.55	4.35	104.27	2.66	2.57	5.05	153.88
CPT 3	0.60	4.07	100.41	3.37	2.10	5.51	148.77

CPT 3	0.65	4.16	59.16	0.50	1.94	5.97	138.25
CPT 3	0.70	2.30	44.68	4.40	1.86	6.43	124.60
CPT 3	0.75	1.47	43.56	6.44	2.66	6.89	111.78
CPT 3	0.80	1.17	43.61	7.88	3.50	7.35	105.52
CPT 3	0.85	1.02	41.42	7.89	3.86	7.81	102.93
CPT 3	0.90	1.03	39.49	5.72	3.90	8.27	102.29
CPT 3	0.95	1.05	40.06	8.57	3.91	8.73	102.80
CPT 3	1.00	1.00	41.33	18.55	3.88	9.19	105.30
CPT 3	1.05	1.20	45.23	27.30	4.16	9.65	110.14
CPT 3	1.10	1.31	60.25	22.91	3.37	10.11	119.40
CPT 3	1.15	2.28	56.53	19.89	2.61	10.57	132.28
CPT 3	1.20	3.52	69.16	-17.06	2.16	11.03	142.55
CPT 3	1.25	3.70	79.33	-27.79	2.28	11.49	149.63
CPT 3	1.30	3.29	90.41	-31.85	2.81	11.95	151.54
CPT 3	1.35	2.74	103.66	-32.35	3.29	12.41	152.39
CPT 3	1.40	3.04	103.59	-29.12	3.36	12.87	156.73
CPT 3	1.45	3.82	114.94	-27.05	3.21	13.33	164.18
CPT 3	1.50	4.20	136.31	-21.03	3.04	13.79	181.13
CPT 3	1.55	6.74	196.76	-26.77	2.78	14.24	211.69
CPT 3	1.60	12.44	315.62	-26.60	2.58	14.70	246.41
CPT 3	1.65	16.89	418.06	-36.24	2.63	15.16	272.93
CPT 3	1.70	16.88	480.89	-39.73	2.73	15.62	281.94
CPT 3	1.75	15.18	437.00	-43.25	2.78	16.08	276.65
CPT 3	1.80	13.91	360.44	-39.79	2.72	16.54	262.49
CPT 3	1.85	11.37	303.41	-36.38	2.76	17.00	248.44
CPT 3	1.90	9.35	291.24	-37.25	2.87	17.46	236.99
CPT 3	1.95	9.04	259.98	-38.09	2.79	17.92	228.25
CPT 3	2.00	8.83	207.35	-38.71	2.52	18.38	217.77
CPT 3	2.05	7.37	166.86	-40.36	2.32	18.84	207.30
CPT 3	2.10	6.70	156.22	-42.06	2.32	19.30	197.45
CPT 3	2.15	5.82	137.70	-38.28	2.21	19.76	191.53
CPT 3	2.20	6.11	117.04	-39.29	2.13	20.22	188.39
CPT 3	2.25	6.07	128.73	-40.94	2.14	20.68	191.00
CPT 3	2.30	6.39	151.64	-40.41	1.43	21.14	181.13
CPT 3	2.35	7.07	-2.40	-41.30	1.28	21.60	182.20
CPT 3	2.40	7.36	117.75	-42.08	1.38	22.06	173.27
CPT 3	2.45	2.81	121.82	-36.27	2.07	22.52	188.35
CPT 3	2.50	7.59	128.17	-38.28	1.93	22.98	194.73

CPT 3	2.55	9.77	139.02	-37.84	1.55	23.43	210.09
CPT 3	2.60	10.63	166.28	-38.89	1.71	23.89	224.92
CPT 3	2.65	11.61	242.80	-39.18	1.97	24.35	237.68
CPT 3	2.70	12.25	269.23	-38.90	2.33	24.81	246.30
CPT 3	2.75	10.67	291.94	-28.79	2.56	25.27	249.11
CPT 3	2.80	10.73	300.54	-31.93	2.89	25.73	249.10
CPT 3	2.85	9.95	312.52	-34.30	1.83	26.19	233.28
CPT 3	2.90	12.88	0.00	-34.07	0.75	26.65	213.75
CPT 3	2.95	18.87	0.00	-34.91	0.00	27.11	89.11

Table A.28: August 28 CPT – 2 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 2	0.05	6.75	34.34	5.10	0.54	0.46	140.39
CPT 2	0.10	12.98	73.30	1.83	0.67	0.92	166.26
CPT 2	0.15	15.38	128.63	4.27	0.95	1.38	194.86
CPT 2	0.20	15.05	208.82	3.23	1.26	1.84	209.34
CPT 2	0.25	13.78	219.04	1.05	1.64	2.30	212.50
CPT 2	0.30	10.78	222.72	1.86	1.82	2.76	202.67
CPT 2	0.35	8.44	157.50	-1.21	2.00	3.22	187.19
CPT 2	0.40	6.19	128.04	-0.92	1.95	3.68	170.59
CPT 2	0.45	5.36	104.06	-0.99	2.06	4.14	160.88
CPT 2	0.50	4.83	105.75	0.46	2.08	4.60	156.49
CPT 2	0.55	4.73	100.49	1.77	2.13	5.05	155.20
CPT 2	0.60	4.70	96.96	2.25	2.09	5.51	153.90
CPT 2	0.65	4.41	91.71	2.84	1.94	5.97	150.63
CPT 2	0.70	4.17	68.94	3.05	1.75	6.43	143.29
CPT 2	0.75	3.40	48.96	2.32	1.43	6.89	131.75
CPT 2	0.80	2.66	28.31	2.31	1.17	7.35	117.80
CPT 2	0.85	1.93	15.80	2.39	0.87	7.81	104.24
CPT 2	0.90	1.57	9.47	4.69	0.67	8.27	93.39
CPT 2	0.95	1.29	6.66	6.03	0.64	8.73	88.62
CPT 2	1.00	1.21	9.98	5.57	0.87	9.19	91.87
CPT 2	1.05	1.53	18.58	5.96	1.23	9.65	101.58

CPT 2	1.10	1.98	29.39	5.54	1.49	10.11	110.28
CPT 2	1.15	1.98	34.12	6.18	1.78	10.57	115.76
CPT 2	1.20	1.82	39.72	5.72	2.16	11.03	118.98
CPT 2	1.25	1.88	48.90	11.65	2.75	11.49	123.91
CPT 2	1.30	1.94	66.76	10.61	3.42	11.95	131.14
CPT 2	1.35	2.09	86.35	10.20	3.94	12.41	143.95
CPT 2	1.40	3.03	125.81	13.81	3.85	12.87	163.76
CPT 2	1.45	4.96	176.73	28.39	3.06	13.33	196.69
CPT 2	1.50	10.49	263.16	27.21	2.60	13.79	228.52
CPT 2	1.55	14.35	335.05	15.24	2.62	14.24	251.58
CPT 2	1.60	13.10	395.44	9.34	2.62	14.70	263.48
CPT 2	1.65	14.99	383.60	-3.10	2.70	15.16	266.50
CPT 2	1.70	14.71	378.23	-4.97	2.68	15.62	259.34
CPT 2	1.75	10.25	306.63	-13.13	2.86	16.08	244.84
CPT 2	1.80	8.07	258.07	-19.08	2.90	16.54	221.31
CPT 2	1.85	6.62	159.31	-13.98	2.55	17.00	204.37
CPT 2	1.90	6.73	128.58	-17.93	2.02	17.46	191.72
CPT 2	1.95	6.82	118.41	-27.39	1.78	17.92	189.15
CPT 2	2.00	7.05	118.43	-31.27	1.72	18.38	188.97
CPT 2	2.05	6.91	119.49	-34.32	1.72	18.84	187.10
CPT 2	2.10	6.07	107.20	-36.14	1.92	19.30	183.00
CPT 2	2.15	4.73	112.59	-29.87	2.06	19.76	179.58
CPT 2	2.20	5.26	111.58	-30.67	2.04	20.22	182.44
CPT 2	2.25	6.83	118.06	-31.27	1.98	20.68	190.48
CPT 2	2.30	7.12	149.56	-33.08	1.99	21.14	197.39
CPT 2	2.35	7.13	150.80	-34.32	2.06	21.60	201.85
CPT 2	2.40	7.68	150.53	-35.46	2.96	22.06	196.29
CPT 2	2.45	1.79	190.27	56.30	3.01	22.52	206.72
CPT 2	2.50	9.43	228.86	-3.19	2.95	22.98	218.43
CPT 2	2.55	10.94	234.81	-13.02	2.36	23.43	234.36
CPT 2	2.60	9.92	250.00	-18.93	2.42	23.89	234.83
CPT 2	2.65	9.06	237.93	-22.98	2.66	24.35	230.92
CPT 2	2.70	8.03	229.14	-24.76	2.79	24.81	228.57
CPT 2	2.75	8.37	242.40	-26.19	1.62	25.27	216.24
CPT 2	2.80	12.73	0.00	-26.46	0.61	25.73	203.03
CPT 2	2.85	18.85	0.00	-27.39	0.00	26.19	88.95

Table A.29: August 28 CPT – 3 Data Compilation

CPT Name	Depth (m)	qc (MPa)	fs (kPa)	u2 (kPa)	Rf	Eff. stress (kPa)	Vs (m/s)
CPT 3	0.05	10.44	38.43	1.23	0.41	0.46	151.83
CPT 3	0.10	14.64	68.79	-3.56	0.59	0.92	171.80
CPT 3	0.15	15.00	131.26	13.64	0.88	1.38	193.83
CPT 3	0.20	14.63	189.04	-5.91	1.21	1.84	200.18
CPT 3	0.25	10.84	169.90	-9.56	1.46	2.30	195.80
CPT 3	0.30	8.83	142.97	-2.90	1.76	2.76	185.25
CPT 3	0.35	7.18	159.08	-3.30	2.36	3.22	181.11
CPT 3	0.40	5.60	207.32	-8.13	3.41	3.68	180.71
CPT 3	0.45	4.82	234.22	-5.36	4.32	4.14	178.21
CPT 3	0.50	4.44	200.81	2.68	4.55	4.60	173.15
CPT 3	0.55	4.00	168.19	1.58	3.96	5.05	164.89
CPT 3	0.60	3.91	120.45	-2.29	3.39	5.51	153.61
CPT 3	0.65	3.01	82.13	-5.65	2.71	5.97	141.97
CPT 3	0.70	2.80	61.23	-4.69	2.53	6.43	132.05
CPT 3	0.75	2.33	62.41	-2.08	2.62	6.89	126.45
CPT 3	0.80	1.88	59.80	-2.90	2.96	7.35	120.45
CPT 3	0.85	1.50	46.57	-2.20	3.24	7.81	114.20
CPT 3	0.90	1.27	44.32	-4.52	3.32	8.27	109.51
CPT 3	0.95	1.25	42.87	2.57	3.67	8.73	109.31
CPT 3	1.00	1.24	51.15	2.91	3.80	9.19	112.51
CPT 3	1.05	1.46	56.48	0.16	4.17	9.65	118.39
CPT 3	1.10	1.60	71.95	3.90	4.40	10.11	125.36
CPT 3	1.15	1.79	85.09	1.24	4.74	10.57	132.53
CPT 3	1.20	2.00	98.09	1.42	5.06	11.03	139.46
CPT 3	1.25	2.14	116.45	4.26	5.39	11.49	148.55
CPT 3	1.30	2.60	148.83	8.14	5.71	11.95	160.14
CPT 3	1.35	3.19	187.60	18.60	5.14	12.41	179.67
CPT 3	1.40	5.49	242.95	-1.31	3.72	12.87	206.26
CPT 3	1.45	10.40	279.54	-41.92	2.62	13.33	239.17
CPT 3	1.50	17.79	358.43	-54.55	2.13	13.79	264.65
CPT 3	1.55	20.44	397.06	-40.38	2.18	14.24	278.20
CPT 3	1.60	15.98	427.30	-52.54	2.36	14.70	276.41
CPT 3	1.65	14.46	375.53	-41.49	2.84	15.16	264.72

CPT 3	1.70	10.56	359.86	-32.38	2.87	15.62	254.41
CPT 3	1.75	11.57	314.58	-53.05	3.08	16.08	246.24
CPT 3	1.80	10.09	315.77	-56.61	3.00	16.54	241.37
CPT 3	1.85	9.17	294.06	-45.77	3.17	17.00	236.30
CPT 3	1.90	8.92	281.11	-62.24	3.22	17.46	231.41
CPT 3	1.95	8.18	270.44	-64.29	3.34	17.92	228.28
CPT 3	2.00	7.63	272.64	-68.15	3.30	18.38	222.62
CPT 3	2.05	7.34	219.47	-68.55	3.29	18.84	216.84
CPT 3	2.10	6.51	213.48	-71.11	3.28	19.30	211.14
CPT 3	2.15	6.06	218.76	-62.08	3.33	19.76	210.70
CPT 3	2.20	6.96	216.55	-63.59	3.38	20.22	212.30
CPT 3	2.25	6.65	228.34	-65.86	3.53	20.68	219.11
CPT 3	2.30	7.21	289.23	-65.56	3.60	21.14	227.42
CPT 3	2.35	8.81	297.53	-63.30	3.36	21.60	236.65
CPT 3	2.40	10.06	288.38	-63.73	3.20	22.06	240.00
CPT 3	2.45	8.83	299.17	-59.79	2.96	22.52	246.88
CPT 3	2.50	12.19	330.51	-60.66	3.18	22.98	253.90
CPT 3	2.55	11.03	388.29	-61.44	3.01	23.43	262.27
CPT 3	2.60	12.67	360.47	-64.87	3.56	23.89	261.45
CPT 3	2.65	8.58	398.78	-56.34	4.27	24.35	262.96
CPT 3	2.70	8.23	497.11	-45.08	2.93	24.81	246.93
CPT 3	2.75	13.83	0.00	-53.21	1.20	25.27	231.26
CPT 3	2.80	19.46	0.00	-47.08	0.00	25.73	90.98

APPENDIX B

Literature Review

Table 2.1 compilation of some of the existing literary models for estimating V_s

Authors	**Soil Type**	**Model Functions with description of parameters used**
Barrow and Stokoe (1983)	All	$V_s = 154 + 0.64q_c$ Q_c – cone – tip resistance; V_s – shear wave velocity
Sykora and Stokoe (1983)	Sand	$V_s = 134 + 0.52q_c$ $V_s = 54.8(q_c)^{0.29}$ Q_c – cone – tip resistance; V_s – shear wave velocity
Iyisan and Ansal (1993)	All	$V_s = 160 + 0.9q_c$ $V_s = 45(q_c)^{0.41}$ Q_c – cone – tip resistance; V_s – shear wave velocity
Hegazy and Mayne (1993)	Sand	$V_s = 12.02(q_c)^{0.319}(f_s)^{-0.0466}$ Q_c – cone – tip resistance; V_s – shear wave velocity ; F_s – sleeve friction
Iyisan (1996)	3. Clay 4. Sand	3. $V_s = 55.3(q_c)^{0.377}$ 4. $V_s = 218 + 0.7q_c$ Q_c – cone – tip resistance; V_s – shear wave velocity
Piratheepan (2002)	4. Clay 5. Sand 6. All	4. $V_s = 11.9q_c^{0.269}f_s^{1.09}D^{0.127}$ 5. $V_s = 25.3q_c^{0.103}f_s^{0.029}D^{0.155}$ 6. $V_s = 32.3q_c^{0.089}f_s^{0.1219}D^{0.215}$ Q_c – cone – tip resistance; V_s – shear wave velocity F_s – sleeve friction; D - Depth
Tun (2003)	All	$V_s = 109.29 + 52.674Ln(q_c)$ Q_c – cone – tip resistance; V_s – shear wave velocity

Madiai and Simoni (2004)	All	3. $V_s = 211(q_c)^{0.23}$ 4. $V_s = 155(q_c)^{0.29}(f_s)^{-0.10}$ Q_c – cone – tip resistance; V_s – shear wave velocity
Hegazy and Mayne (2006)	All	$V_{s1} = 0.0831 q_{c1N}^{0.103}(\sigma'_{v0}/p_a)^{0.25} e^{1.786Ic}$ V_{s1} – normalized shear wave velocity; σ'_{v0} - effective vertical stress; q_{c1N} - normalized cone – tip resistance; p_a = 100 kPa; Ic – soil behavior index
Mayne(2006)	All	$V_s = 18.5 + 118.8\log(f_s)$ V_s – shear wave velocity and f_s – sleeve friction
Mola-Abasi, Dikmen and Shooshpasha (2015)	3. All 4. Clay	3. $V_s = 100[1.40 + 1.59 f_s + 0.09q_c - 1.33f_s^2 - 0.002q_c^2 + 0.05(f_s)(q_c)$ 4. $V_s = 100[1.36 - 0.35f_s + 0.15q_c - 0.05f_s^2 - 0.018q_c^2 + 0.39(f_s)(q_c)$ Q_c – cone – tip resistance; V_s – shear wave velocity F_s – sleeve friction;
Tong, Che, Zhang, and Li (2018)	All	$V_s = 37.7q_c^{0.103}f_s^{0.109}Z^{0.146}$ Q_c – cone – tip resistance; V_s – shear wave velocity F_s – sleeve friction; Z – Depth

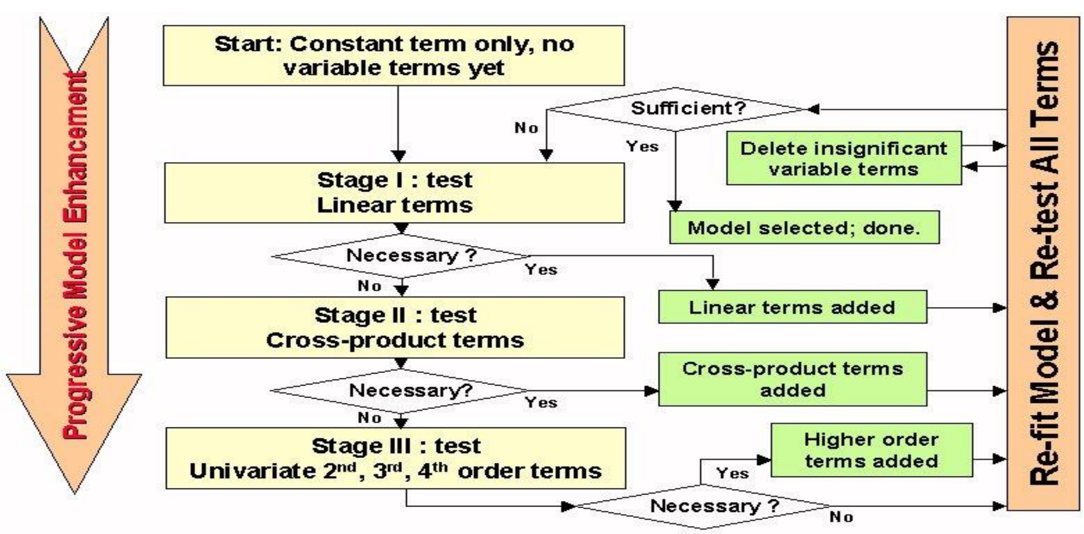

Figure 2.1 The flowchart of stepwise regression method

APPENDIX C

Additional Pictures

Figure C.1: Satellite image of site of SCPT data collection site

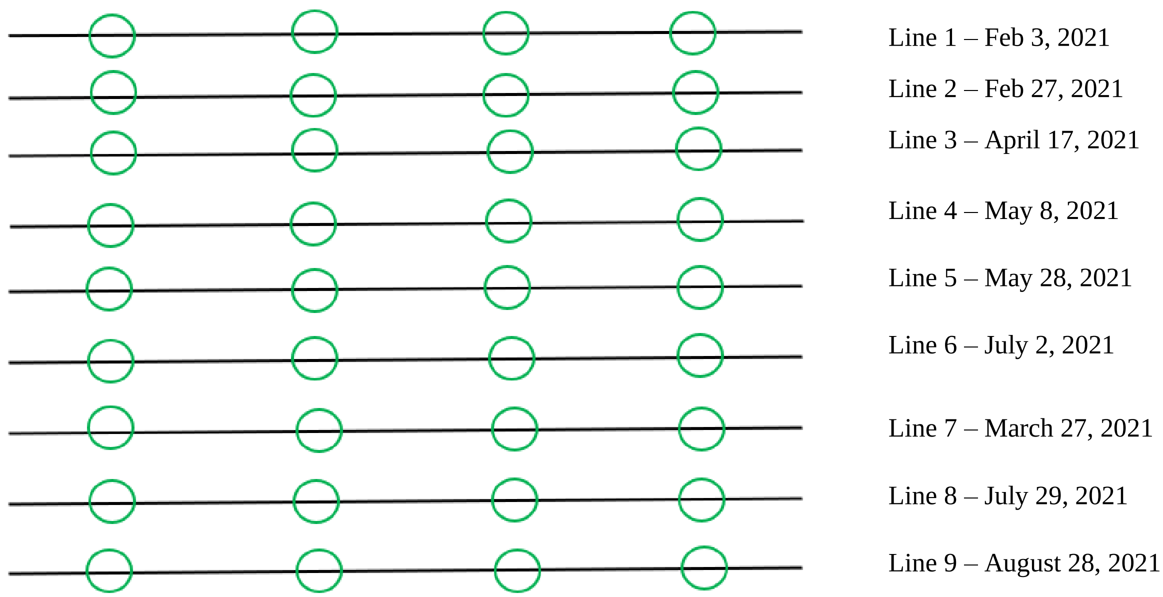

Figure C.2: The planned layout for SCPT data collection process along with dates at which the SCPT data were collected

Figure C.3: A student about to stroke the shear beam to trigger seismic waves for the SCPT data collection process

APPENDIX D

Rcode Information

Table D.1: the engineering properties of tested Kirkland series soil

Depth (ft)	Clay%	Silt%	Fine sand%	LL%	PL%	PI%
0.3	20	50	30	39.0	19.2	19.8
0.8	25	52	23	40.0	18.5	21.5
1.3	33	42	25	49.6	23.4	26.2
2.0	31	34	35	41.3	21.8	19.5
2.7	30	42	28	40.8	18.3	22.5
3.3	52	35	13	59.0	23.8	35.2
4.0	45	45	10	37.0	25.0	12.0
4.7	25	59	16	39.0	23.6	15.4
6.0	23	60	17	33.4	17.8	15.6
6.7	32	55	13	36.2	21.1	15.1
7.3	31	53	16	43.0	25.2	17.8
7.9	38	48	14	44.8	26.3	18.5

```
############ Load Packages #############

library(Rcpp)

library(readxl)


############## Read Data ###############

data1=read_excel("Combined compilation.xlsx")

names(data1)

attach(data1)
```

```
data1

#########  Model 1:
M1 = lm(Avs ~ Aqc + AFs + AEOS, data = data1)
summary(M1)

####### Expression of Variables #######
AFs2 = AFs*AFs
Aqc2 = Aqc*Aqc
AEOS2 = AEOS*AEOS

######## Model 2:
M2 = lm(Avs ~ AFs, data = data1)
summary(M2)

######## Model 3:
M3 = lm(Avs ~ Aqc2 + AFs, data = data1)
summary(M3)

######## Model 4:
M4 = lm(Avs ~ Aqc2 + AFs + AEOS, data = data1)
summary(M4)

######## Model 5:
M5 = lm(Avs ~ Aqc2 + AFs*Aqc + AEOS, data = data1)
summary(M5)
```

```
######## Model 6:
M6 = lm(Avs ~ Aqc2 + AFs*Aqc + AEOS*Aqc, data = data1)
summary(M6)

######## Model 7:
M7 = lm(Avs ~ Aqc2 + AFs2 + AEOS2 , data = data1)
summary(M7)

######## Model 8:
M8 = lm(Avs ~ Aqc2*Aqc + AFs, data = data1)
summary(M8)

######## Model 9:
M9 = lm(Avs ~ Aqc2*Aqc + AFs + AEOS, data = data1)
summary(M9)

######## Model 10:
M10 = lm(Avs ~ Aqc2*Aqc + AFs2 + AEOS2,data = data1)
summary(M10)

######## Model 11:
M11 = lm(Avs ~ Aqc2*Aqc + AFs2 + AEOS2 + Aqc*AFs*AEOS, data = data1)
summary(M11)

######## Model 12:
M12 = lm(Avs ~ Aqc + AFs + AFs2 + Aqc2 + AFs*Aqc, data = data1)
summary(M12)
```

```
######## Model 13:

M13 = lm(Avs ~ Aqc + AEOS + AEOS2 + Aqc2 + AEOS*Aqc, data = data1)

summary(M13)


######## Model 14:

M14 = lm(Avs ~ Aqc + AFs + AEOS + Aqc*AFs + Aqc*AEOS + AFs*AEOS + Aqc2
+ AFs2 + AEOS2, data = data1)

summary(M14)


######## Model 15:

M15 = lm(Avs ~ Aqc + AFs + AEOS + Aqc*AFs + Aqc*AEOS + Aqc2 + AFs2 +
AEOS2, data = data1)

summary(M15)


######## Model 16:

M16 = lm(Avs ~ Aqc + AFs + AEOS + Aqc*AFs + Aqc2 + AFs2 + AEOS2, data =
data1)

AvsM16 = Aqc + AFs + AEOS + Aqc*AFs + Aqc2 + AFs2 + AEOS2

summary(M16)

MSEM16 = MSE(AvsM16,Avs)

MSEM16


######## Step Function Model Selection

data2 = data1[,-3]

Mstep = lm(Avs ~ ., data = data2)

selectM = step(Mstep)

summary(selectM)
```

```
AvsStep = AFs + AEOS

MSEStep = MSE(AvsStep,Avs)

MSEStep


######### Literature Model 1 Mola-Abasi:

LitM1 = model.frame(avslm1 = 100*(1.40 + 1.59*AFs + 0.09*Aqc - 1.33*AFs2 -
0.002*Aqc2 + 0.05*AFs*Aqc), data = data1)

avs = 100*(1.40 + 1.59*AFs + 0.09*Aqc - 1.33*AFs2 - 0.002*Aqc2 + 0.05*AFs*Aqc)

summary(LitM1)

LitM1


library(MLmetrics)

MSElitM1 = MSE(avs,Avs)


######## Literature Model 2 Tun 2003:

LitM2 = model.frame(avslm2 = 109.29 + 52.674*log(Aqc), data = data1)

avs2 = 109.29 + 52.674*log(Aqc)

LitM2

MSELitM2 = MSE(avs2,Avs)

MSELitM2

RMSELitM2 = sqrt(MSELitM2)

RMSELitM2


######## Literature Model 3 1st Madiai 2004:

LitM3 = model.frame(avslm3 = 211*(Aqc)^0.23 , data = data1)

avs3 = 211*(Aqc)^0.23

LitM3

MSELitM3 = MSE(avs3,Avs)
```

```
MSELitM3

######## Literature Model 4 Barrow and Stokoe 1983:
LitM4 = model.frame(avslm4 = 154 + 0.64*Aqc , data = data1)
avs4 = 154 + 0.64*Aqc
LitM4
MSELitM4 = MSE(avs4,Avs)
MSELitM4
RMSELitM4 = sqrt(MSELitM4)
RMSELitM4

######## Model comparison Lit Model 1:
M.dum = lm(Avs ~ avs, data = data1)
summary(M.dum)

######## Model comparison Lit Model 2:
M.dum2 = lm(Avs ~ avs2, data = data1)
summary(M.dum2)

######## Model comparison Lit Model 3:
M.dum3 = lm(Avs ~ avs3, data = data1)
summary(M.dum3)

######## Model comparison Lit Model 4:
M.dum4 = lm(Avs ~ avs4, data = data1)
summary(M.dum4)
```

```
######## Models with Depth added
######## Model 1 with depth
M1.d = lm(Avs ~ Aqc + AFs + AEOS + Depth, data = data1)
summary(M1.d)

######## Model 2 with depth:
M2.d = lm(Avs ~ AFs + Depth, data = data1)
summary(M2.d)

######## Model 3 with depth:
M3.d = lm(Avs ~ Aqc2 + AFs + Depth, data = data1)
summary(M3.d)

######## Model 4 with depth:
M4.d = lm(Avs ~ Aqc2 + AFs + AEOS + Depth, data = data1)
summary(M4.d)

######## Model 5 with depth:
M5.d = lm(Avs ~ Aqc2 + AFs*Aqc + AEOS + Depth, data = data1)
summary(M5.d)

######## Model 6 with depth:
M6.d = lm(Avs ~ Aqc2 + AFs*Aqc + AEOS*Aqc + Depth, data = data1)
summary(M6.d)

######## Model 6 with depth cross term:
M6.dc = lm(Avs ~ Aqc2 + AFs*Aqc + AEOS*Aqc + Depth*Aqc, data = data1)
```

summary(M6.dc)

######## Model 7 with Depth:

M7.d = lm(Avs ~ Aqc2 + AFs2 + AEOS2 + Depth, data = data1)

summary(M7.d)

######## Model 8 with Depth:

M8.d = lm(Avs ~ Aqc2*Aqc + AFs + Depth, data = data1)

summary(M8.d)

######## Model 9 with Depth:

M9.d = lm(Avs ~ Aqc2*Aqc + AFs + AEOS + Depth, data = data1)

summary(M9.d)

######## Model 10 with Depth:

M10.d = lm(Avs ~ Aqc2*Aqc + AFs2 + AEOS2 + Depth,data = data1)

summary(M10.d)

######## Model 11 with Depth:

M11.d = lm(Avs ~ Aqc2*Aqc + AFs2 + AEOS2 + Aqc*AFs*AEOS*Depth, data = data1)

summary(M11.d)

######## Model 12 with Depth:

M12.d = lm(Avs ~ Aqc + AFs + AFs2 + Aqc2 + AFs*Aqc + Depth, data = data1)

summary(M12.d)

######## Model 13 with Depth:

```
M13.d = lm(Avs ~ Aqc + AEOS + AEOS2 + Aqc2 + AEOS*Aqc + Depth, data =
data1)

summary(M13.d)


######## Model 14 with Depth:

M14.d = lm(Avs ~ Aqc + AFs + AEOS + Aqc*AFs + Aqc*AEOS + AFs*AEOS +
Aqc2 + AFs2 + AEOS2 + Depth + Depth*AFs + Depth*Aqc + Depth*AEOS +
Depth2, data = data1)

summary(M14.d)


######## Model 15 with Depth:

M15.d = lm(Avs ~ Aqc + AFs + Aqc*AFs + Aqc*AEOS + AFs*Depth + Aqc*Depth
+ AFs*AEOS, data = data1)

summary(M15.d)



######## Step Function Model Selection

Mstep1 = lm(Avs ~ ., data = data1)

selectM1 = step(Mstep1)

summary(selectM1)

AvsStep1 = AFs + AEOS + Depth

MSEStep1 = MSE(AvsStep1,Avs)

MSEStep1

RMSEStep1 = sqrt(MSEStep1)

RMSEStep1


AvsOp = Aqc + AFs + Aqc*AFs + Aqc*AEOS + AFs*Depth + Aqc*Depth +
AFs*AEOS

MSEAvsOp = MSE(AvsOp,Avs)
```

```
MSEAvsOp

RMSEAvsOp = sqrt(MSEAvsOp)

RMSEAvsOp


######### Literature Model 1 Mola-Abasi:

LitM1 = model.frame(Avs = 100*(1.40 + 1.59*AFs + 0.09*Aqc - 1.33*AFs2 -
0.002*Aqc2 + 0.05*AFs*Aqc), data = data1)

avs = 100*(1.40 + 1.59*AFs + 0.09*Aqc - 1.33*AFs2 - 0.002*Aqc2 + 0.05*AFs*Aqc)

summary(LitM1)

LitM1

MSElitM1

RMSElitM1 = sqrt(MSElitM1)

RMSElitM1

cor(Avs,avs)


######## Model comparison Lit Model 1:

M.dum = lm(Avs ~ avs, data = data1)

summary(M.dum)


######## Literature Model 2 Tun 2003:

LitM2 = model.frame(Avs = 109.29 + 52.674*log(Aqc), data = data1)

avs2 = 109.29 + 52.674*log(Aqc)

LitM2

MSELitM2 = MSE(avs2,Avs)

MSELitM2

RMSELitM2 = sqrt(MSELitM2)

RMSELitM2

######## Model comparison Lit Model 2:
```

```
M.dum2 = lm(Avs ~ avs2, data = data1)

summary(M.dum2)


######## Literature Model 5 Iyisan and Ansal (1993):

LitM5 = model.frame(avslm5 = 160 + 0.9*Aqc, data = data1)

avs5 = 160 + 0.9*Aqc

LitM5

MSELitM5 = MSE(avs5,Avs)

MSELitM5

RMSELitM5 = sqrt(MSELitM5)

RMSELitM5

######## Model comparison Lit Model 5:

M.dum5 = lm(Avs ~ avs5, data = data1)

summary(M.dum5)



boxplot(abs(resid(M15.d)),abs(resid(selectM1)),abs(resid(M.dum)),abs(resid(M.dum
2)),abs(resid(M.dum3)),abs(resid(M.dum4)),abs(resid(M.dum5)),xlab = "Models
Compared",ylab = "Absolute Residual Error", names =
c("M15","SelectM","LitM1", "LitM2","LitM3","LitM4","LitM5"),main =
"Absolute Residual Errors of Models compared")


df <- data.frame(Avs=Avs, M15 = M15.d$fitted.values, M14 = M14.d$fitted.values,
SelM = selectM$fitted.values, LM1 = LitM1$`(avslm1)`, LM2 =
LitM2$`(avslm2)`,LM3 = LitM3$`(avslm3)`,LM4 = LitM4$`(avslm4)`,LM5 =
LitM5$`(avslm5)`)

df.m <- melt(df, id.vars = 'Avs', variable.name = 'curve')

ggplot(df.m, aes(Avs,value)) + geom_line(aes(colour = curve)) +

 + geom_point(aes(shape=curve))
```

```
ggplot(df.m, aes(Avs, value,xmin = 0, ymin = 0)) + xlab("Actual Vs") +
ylab("Predicted Vs") + geom_abline(slope = 1) + geom_line(aes(colour = curve)) +
geom_point(aes(shape=curve))
```

VITA

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Master of Science

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