Risk Analysis for a Proposed Underground Library at MIT – Diaphragm Wall, Shaft and Tunnel System

By

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ABSTRACT

Based on 57 borings along the perimeter of the site (McDermott Court) an underground Library was designed to remedy the storage shortage for MIT library facilities. In order to address the effect of uncertain geologic conditions on the cost and duration of the project a risk analysis was preformed. To perform this type of analysis parameters for each geologic unit homogenous zones (4), parameter states (10) and their probabilistic profiles had to be identified and developed. The Risk Analysis performed in this thesis will aid in assessing the impact of the spatial variability of geologic characteristics on the diaphragm wall, shaft and tunnel system.

From the available geologic data the mean and standard deviation of the geologic layers in Zone 4 were found and used in a Monte Carlo simulation to estimate the cost and time of construction using 30% cost and 100% time differential, between the till and the other soils. The Monte Carlo simulation focused on critical construction activities affected by a change in geology and resulted in a mean cost of construction of $12,250,523 with a standard deviation of $278,894 and a mean duration of 133 days with a standard deviation of 9 days for 1080 random generations. This information was then used in an example application, to assess the risk of varying till thickness. This risk was found to be $29,595.74, which is less than the cost of exploration of $224,000 indicating that the focus of future subsurface investigations at McDermott Court should be on soil parameters such as permeability in the till and Cambridge Argillite, rather than the layer thickness or location. Further detailed risk analyses need to be performed in conjunction with a decision-making procedure to plan a suitable exploration program.

Thesis Supervisor: Herbert H. Einstein
Title: Professor of Civil and Environmental Engineering

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TO MY MOM AND DAD:

For supporting me in everything I do and their unconditional love, which has allowed me to become the woman I am today.

TO ALEX:

For being the one I love, your love and support has given me strength to overcome great obstacles. I look forward to spending the rest of my life with you.

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TABLE OF CONTENTS

ABSTRACT **2**
ACKNOWLEDGEMENTS **3**
LIST OF FIGURES **6**
LIST OF TABLES **8**
1 INTRODUCTION **9**
2 BACKGROUND OF LIBRARY PROJECT **10**
3 SITE **15**
3.1 DESKTOP STUDY **15**
3.1.1 ADJACENT BUILDINGS 16
3.1.2 SUBSURFACE UTILITIES 19
3.1.3 SOURCES OF DATA 20
3.2 SITE INVESTIGATION **23**
3.3 SUBSURFACE SITE MODEL USED IN PROJECT **23**
3.3.1 SUBSURFACE GEOLOGY 24
3.3.2 WATER TABLE 27
4 CONSTRUCTION **29**
4.1 CONSTRUCTION SEQUENCE OF PROJECT **36**
4.2 IDENTIFICATION OF SEQUENCES AFFECTED MOST BY A CHANGE IN GEOLOGIC PARAMETERS **42**
4.3 COST OF PROJECT **43**
5 GEOLOGY **45**
5.1 IDENTIFICATION OF OBJECTIVE AND SUBJECTIVE INFORMATION **45**
5.2 IDENTIFICATION OF HOMOGENEOUS ZONES **46**
5.2.1 PARAMETER IDENTIFICATION FOR EACH ZONE 48
5.2.2 PROBABILISTIC PARAMETER PROFILE 49
6 PERFORMANCE **53**
6.1 COST BREAKDOWN **54**
6.2 TIME BREAKDOWN **56**
6.3 MONTE CARLO SIMULATION **57**
6.4 UPDATING THE VARIABILITIES OF THE MODEL **64**
6.4.1 ORIGINAL PROPOSED GEOTECHNICAL INVESTIGATION AND MONITORING 64
6.4.2 ADDITIONAL INFORMATION & MODEL UPDATING 65
6.5 RISK **67**
6.5.1 DECISION BASIS 71
7 CONCLUSIONS & RECOMMENDATIONS **74**
8 REFERENCES: **76**
APPENDIX A **78**
APPENDIX B **86**
APPENDIX C **1080**
APPENDIX D **122**
APPENDIX E **145**
APPENDIX F **172**

APPENDIX G **2084**

LIST OF FIGURES

Figure 3.1-1 Library Space and Seating Comparison 12
Figure 3.1-2 Detail of Library Level 1 to 10.................... 12
Figure 3.1-3 Footprint of Library, egresses and shaft at McDermott Court 13
Figure 3.1-4 Library and emergency shaft exit cross-section 13
Figure 3.1-1 MIT Campus.................... 15
Figure 3.1-1 Surrounding Building of McDermott Court 2001 16
Figure 3.1-2 Subsurface Detail of Building 62 17
Figure 3.1-3 Subsurface Detail in the North-South direction of McDermott Court (see Figure 3.1-1 for plan view location and Figure 3.3-2 for legend): the underling gray zone (A) under Building 54 indicates the pile foundation bearing on the till (B)..... 18
Figure 3.1-4 Subsurface Detail of Building 18 19
Figure 3.1-5 Location of Subsurface Utilities.................... 20
Figure 3.1-6 Location of Borings in Building 62.................... 21
Figure 3.1-7 Location of Borings in Building 14.................... 22
Figure 3.1-8 Location of Borings for Old Science and Nuclear Engineering Building... 22
Figure 3.1-9 Plan View of Library Looking at Level 7 23
Figure 3.3-1 Cross-Sections of Subsurface Geology a) Cross-section A-A', b) Cross-Section B-B' (see Figure 3.3-2 and.................... 24
Figure 3.3-2 Enlargement of Cross Section A-A' Geology.................... 26
Figure 3.3-3 Enlargement of Cross Section B-B' Geology 27
Figure 3.3-4 Location of Groundwater Table in Till and Sand Layers (see Figure 3.3-5 for zoom view of the piezometric surface).................... 27
Figure 3.3-5 Zoom of Figure 3.3-4 28
Figure 3.3-1 Underground Library.................... 29
Figure 3.3-2 Diaphragm Wall Slurry Panel Detail in Plan View [Craun et al., 2001]...... 31
Figure 3.3-3 Slurry Wall Profile, Ring Beam & Mat Slab [Craun et al., 2001] 32
Figure 3.3-4 Library Internal Structure.................... 33
Figure 3.3-5 Roof Slab with 5 foot Cover of Backfill 33
Figure 3.3-6 Location of Shallow Egresses (1st Level).................... 34
Figure 3.3-7 Glass Dome looking from West of McDermott Court [Craun et al., 2001] 34
Figure 3.3-8 Inside Library Looking Outwards Building 54 [Craun et al., 2001]........... 35
Figure 4.3-1 Cost Breakdown of Library Components.................... 44
Figure 5.1-1 Location of the Four Main Bore Holes Used for the Cross-sections of Subsurface Geology 46
Figure 5.2-1 Homogeneous Zones at Site.................... 47
Figure 5.2-2 Histogram for Parameter 1 in Zone 4 (Upper Bound of the Silty Sand Layer) 49
P(E1) is the probability that the borehole has encountered the upper bound (UB) of the Silty Sand layer at 10 feet. 50
Figure 6.3-1 Bimodal Distribution Produced Using Equation 6.3-2 and Equation 6.3-3 58
Figure 6.3-2 Histogram of Monte Carlo Simulation for a 0% Cost Differential Between Till and Other Soil.................... 62

Figure 6.3-3 Histogram of Monte Carlo Simulation for a 30% Differential Between Till and Other Soil 63
Figure 6.3-4 Histogram of Monte Carlo Simulation for a 100% Time Differential Between Till and the Other Soil 63
Figure 6.5-1 Cost Histogram (2 simulation equals 1080 random generations) 67
Figure 6.5-2 Time Histogram (2 simulation equals 1080 random generations) 68
Figure 6.5-3 Cost-Time Scatter Diagram (for a 30% cost and 100% time range), Crosshairs Represent the Mean of the Cost and Time on the Respective Axes (see Table 6.5-1 for values). 69
Figure 6.5-4 Time-Cost Scatter Diagram (for a 30% cost and 100% time range), Crosshairs Represent the Mean of the Cost and Time on the Respective Axes (see Table 6.5-1 for values). 69
Figure 6.5-5 New Cost Differentials Resulting in a Layer Scatter 70

LIST OF TABLES

Table 3.1-1 Sizing of Library (Useable Space) 14
Table 4.2-1 Construction Activities (Section 4.1) Which Would be Affected by a Change in Geology 42
Table 5.2-1 Summary of Ranges Encountered for Each Parameter State 51
Table 5.2-2 Summary of Peak Probabilities for Each Corresponding Parameter at Their Corresponding Depth(s) or Thickness(es) 52
Table 5.2-1 Mean Thickness of Zones 53
Table 5.2-2 Mean Thicknesses of Zone 4 53
Table 6.1-1 Activities Affected by a Change in Geology and Their Costs 54
Table 6.1-2 Percentage Excavated of Original M.Eng Soil Model 55
Table 6.1-3 Example Cost Differential of 30% between the Till and Other Layers 56
Table 6.2-1 Activities Affected by a Change in Geology and Their Times 56
Table 6.2-2 Example Time Differential of 100% between the Till and Other Layers 57
Table 6.3-1 Mean and Standard Deviation for Simulations 62
Table 6.5-1 Mean and Standard Deviations for the Simulations 68
Table 6.5-2 Original Cost and the Altered Cost Used in the Simulation 70
Table 6.5-3 Data from Cost Histogram (Figure 6.5-1) 72
Table 6.5-4 Summary of Risk Based on Table 6.5-3 73

1 INTRODUCTION

Through the Master of Engineering Program in Civil and Environmental Engineering underground a group of students (M.Eng Library Group) addressed an ongoing storage problem for the Library facilities at MIT. Discussed in this thesis is the background of the M.Eng Library Project, the solution presented by the group an underground library, and focuses on the geology of the site.

The soil profile compiled for the design is based on boring dating from the early to mid 20^{th} century as no resent site investigations had been performed. In total there are 57 boring along the perimeter of the site were available to construct a soil model; however, no borings were available for the site of the proposed library (McDermott Court), which attribute a considerable amount of uncertainty that the subsurface soil conditions are as predicted by the M.Eng Library Group. In order to address the uncertainty presented by the geologic conditions on the cost and duration of the project risk analysis will be preformed for the purposes of this thesis. In order to perform this type of analysis parameters for each geologic unit homogenous zones, parameter states and their probabilistic profiles had to be identified and developed. These in turn were then used to assess the performance of the model with respect to cost and time. The model performance will allow for cost and time distribution to be developed using a Monte Carlo Analysis. These simulations will then be used for assessing the risk of the project with respect towards a variation in geology. The structures which will be most impacted by a changed in geology will be focused on, these are: the diaphram wall, shaft and deep tunnel system. These structures will be explained in future detail in Section 4.

The Risk Analysis performed in this these will aid in assessing the impact of the spatial variability of geologic characteristics on the diaphragm wall, shaft and tunnel system and how parameter uncertainty can impact the cost and duration of construction for these structures.

2 BACKGROUND OF LIBRARY PROJECT

The current library facilities are based both on and off campus. Facilities that are located on campus are as follows: five large libraries (Baker, Hayden-Science, Dewey, Rotch, and Lindgren) with five smaller ones on campus (Aeronautics and Astronautics, Hayden-Music, Schering-Plough, Retrospective Collection, and Hayden-Humanities), and the institute of Archives. The offsite facilities consist of the RSC offsite storage facility and the Harvard Depository.

The problem incurred by the library facilities is that the library collection has steadily increased for the past few decades at a steady rate while the facilities have not expanded to accommodate growth. The standard operating procedure for a library is to run at 80% shelf usage. The MIT facilities are currently running between 85-95% capacity and having to store 25% of their collection offsite. To compensate for the limited shelf availability and constant stream of incoming volumes, the libraries have had to remove older volumes and transfer them to offsite storage. In addition to the limited shelving, the libraries have also not increased their seating capacity for students and can only accommodate 10% of the student body. The acceptable minimum for library seating is 25%. Figure 3.1-1 shows a comparison of MIT to other institutions. Compared are space and seating; the graph depicts MIT and Georgia Tech as being tied for providing their communities with the lowest seating and space capacity. This helps to substantiate the claim that the MIT library system is strained beyond its designed capacity. The MIT Library facilities acknowledge their situation in a statement that was published on the MIT website in 1997 [macfadden.mit.edu:9500/space/#technology] which stated that "collections are becoming increasingly more fractured and complex in their organization requiring increased amounts of time to gather desired information."

It can be concluded that changes need to be made at MIT in order to resolve the functionality of the library. The M.Eng Library Project produced a solution that would alleviate these problems for the next twenty years: to construct an underground library that would allow the merger of a large percentage of the collection from Barker and

Hayden Libraries and increase the seating capacity to up to 35% of the student body. The underground library project would effectively solve both MIT's short- and long-term capacity problems. The space created through the amalgamation of the collection would allow for conference rooms and study areas to be constructed where once there were only stacks in existing libraries.

The location of the proposed library needs to be central to academic life, and therefore McDermott Court was chosen. The location, however, limits the size of the allowable footprint for the library. The size of the new library to accommodate twenty years of growth was calculated to be 240,000 sq.ft (see Table 3.1-1). In order to accommodate the required space and availability of land at McDermott Court, the library was designed to have ten underground levels. The first nine would function as library space and the tenth level would function as a maintenance level (see Figure 3.1-2). The library would be accessible via egress tunnels connecting to buildings 18, 54, 62, and 14. The M.Eng Library Group designed an emergency exit from the tenth level in case of fire. The tenth level was chosen as it is the deepest level and a fire on any overlying floors would trap people below. This would provide patrons with an alternate escape exit other than the conventional escape staircase. A footprint of the library can be seen in Figure 3.1-3. This shows the cross-section of the library with the connecting escape shaft.

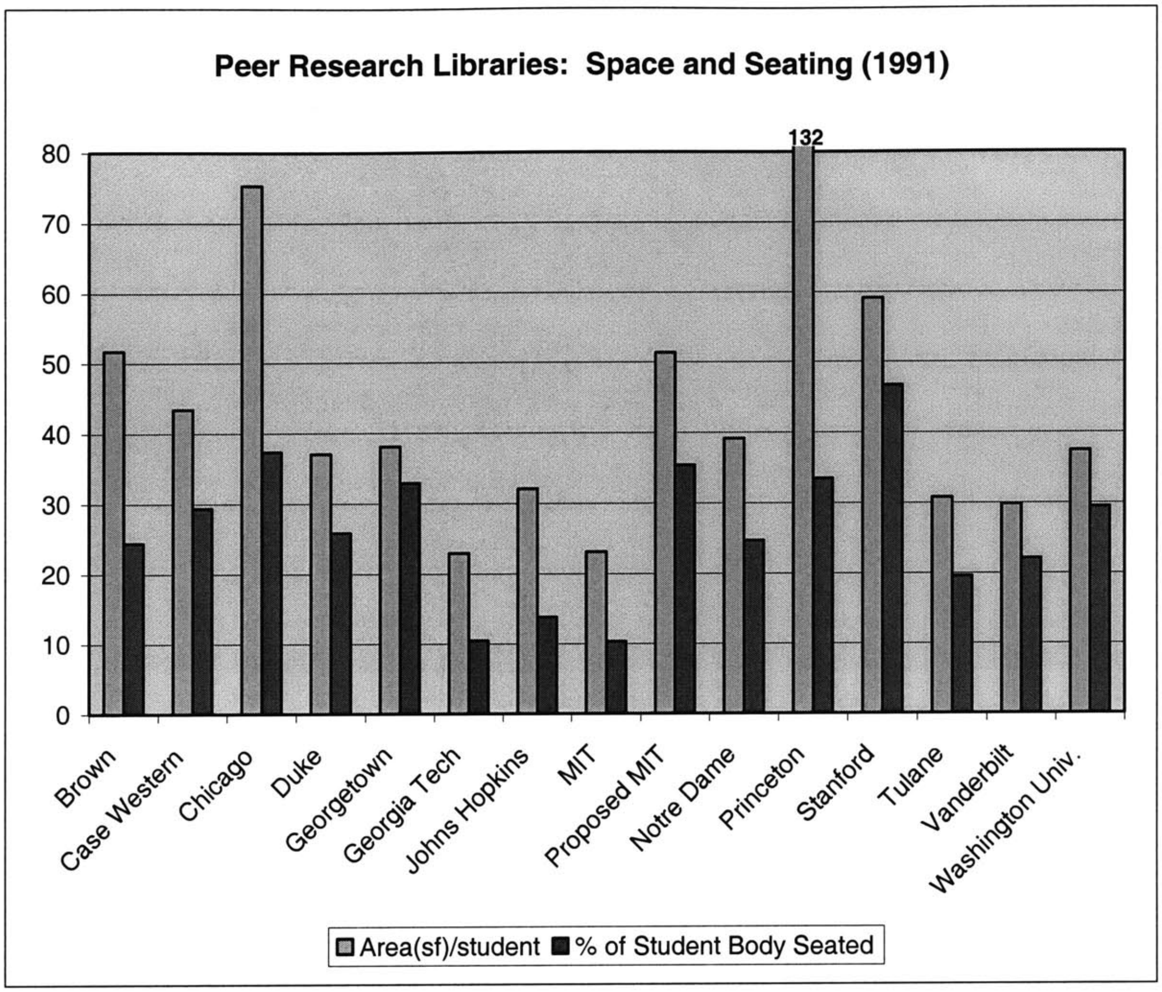


Figure 3.1-1 Library Space and Seating Comparison

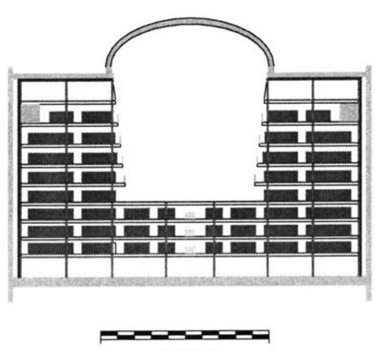


Figure 3.1-2 Detail of Library Level 1 to 10

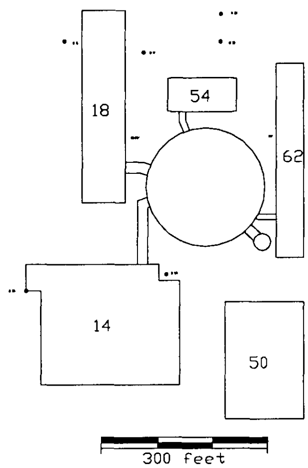


Figure 3.1-3 Footprint of Library, egresses and shaft at McDermott Court

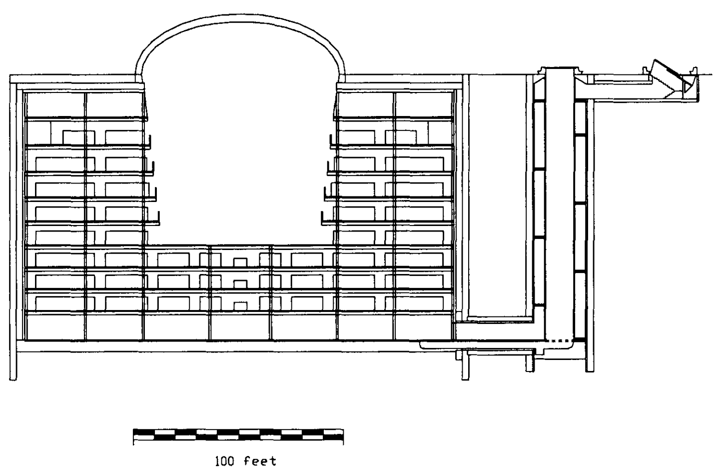


Figure 3.1-4 Library and emergency shaft exit cross-section

Table 3.1-1 Sizing of Library (Useable Space)

COLLECTIONS	½ On Campus Collections	148,000 x .5 =	74,000sf
	Entire Offsite Storage		42,000sf
	20 Year Growth	2800sf/yr x 20 =	56,000sf
MIXED-USE AREA	10% Student Seating/Mixed Use	1000 students x 25sf/student =	25,000sf
	Library Staff / Admin. / Other	20% of other space: 214,000 x .20 =	43,000sf
GRAND TOTAL:			**240,000sf**

3 SITE

McDermott Court is located on the eastern side of the MIT campus, in front of Building 54 and is affectionately referred to as "The Dot" by the student body (). The site is between Buildings 54, 62, 50, 14, and 18. The approximate dimensions of the site are 308 feet in length (from north to south) and 273 feet in width (from east to west). The footprint for the library encompasses "The Dot" the following chapter addresses the site's geologic and construction history.

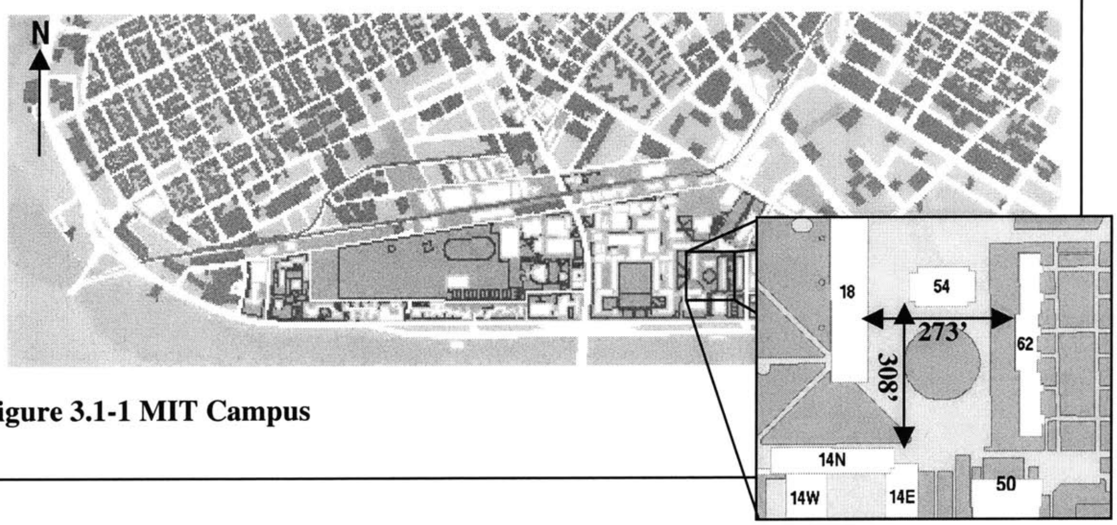


Figure 3.1-1 MIT Campus

3.1 DESKTOP STUDY

Because geotechnical investigations at the site were not conducted for this project, a *desktop* study of the site was performed utilizing Fermit data. Fermit is a database available both in hard copy and digital formats; it is a compilation of all available subsurface data from the MIT campus. Fermit data can be obtained from the archivist at MIT. Using Fermit, we were able to obtain information on the history of our site, local geology, building foundations, location of our water table, and subsurface utilities.

The building foundations surrounding McDermott Court were investigated through a desktop study. Below are the results of the foundation investigation. The site has a complex history of construction. Below is a brief synopsis of the buildings that surround the library footprint, as well as a brief detail describing previously existing buildings.

The construction history of the site begins with the construction of Building 50 in 1916 (Walker Memorial), followed by Building 62 in 1923-27, the Nuclear Engineering Center in 1937 (which no longer exists on campus), Building 14 in 1948-49, Building 54 in 1964, and Building 18 in 1967. Section 3.1.1 provides a brief synopsis of each individual building. The general soil profile underlying these buildings is the following:

1. Fill
2. Silty Sand
3. Sand
4. Boston Blue Clay
5. Glacial Till
6. Cambridge Argillite

More detail on the geology of the site is available in Section 3.3.1.

3.1.1 ADJACENT BUILDINGS

This section describes the individual building history of previously and currently existing buildings.

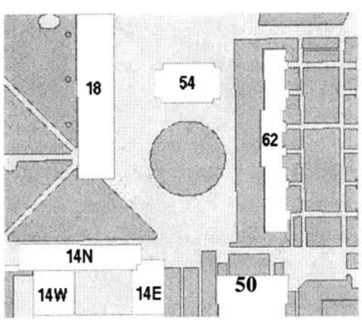


Figure 3.1-1 Surrounding Building of McDermott Court 2001

Building 50 was built on a foundation of timber piles bearing on the sand layer. The architects who designed the building are Stone and Webster Engineering Corporation. The approximate size of the building is 123.5'x187.5' with 2 floors and 1 basement at an elevation of +17.1' BCB (Boston City Base, datum). The cut-off for the woodpiles is +13.00 BCB. Approximately 2600 piles were used for the foundation of Building 50.

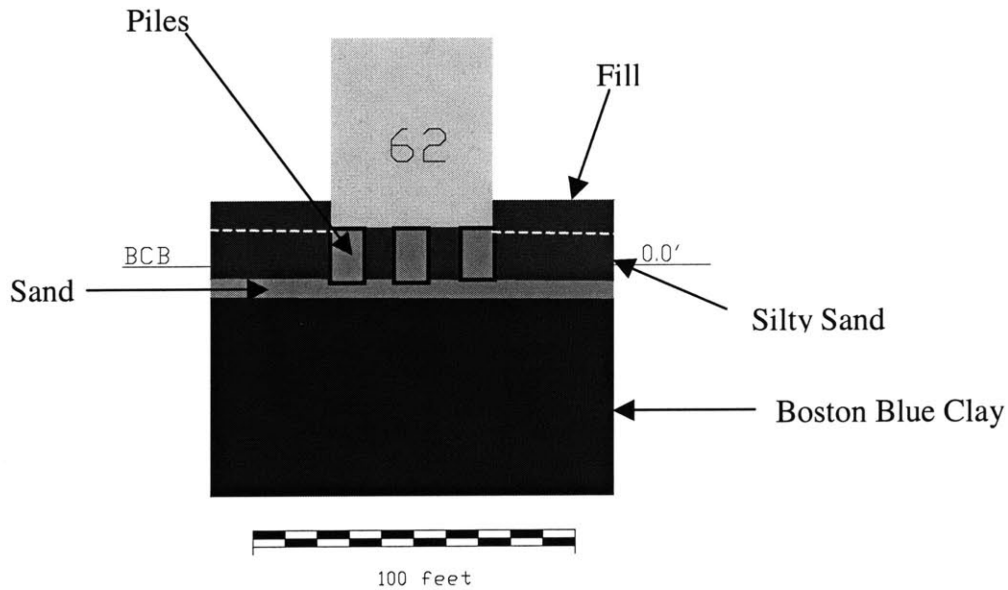


Figure 3.1-2 Subsurface Detail of Building 62

Building 62 sits on a foundation of timber piles, which bear on the sand layer as well. The architects who designed the building were Wells Bosworth in New York. The approximate size of the building is 37'x103' with 5 floors and 1 basement at an elevation of +14.6' BCB. The cut-off elevation of the piles is +12' BCB. A total of 1200 piles were used for the foundation of Building 62.

The Nuclear Engineering Center was built on a mat foundation bearing in the sand layer and was demolished prior to the construction of Building 54. There was no information that could be found that indicated who designed the building; however, it had 3 stories and no basement. This building was of great importance, as the subsurface investigation prior to construction provided 2 bore holes that were cored into the Cambridge Argillite.

Building 14 (Hayden Library) sits on a foundation of belled caissons. These caissons are separated into three groups: those that are end bearing on the sand layer, those bearing on the upper crust of the Boston Blue Clay, and those that are floating in the soft mid-layer of the Boston Blue Clay. The caissons have been belled to limit the pressure applied to the bearing soil. End-bearing caissons in the sand layer have a capacity of 4 tons/sq.ft., caissons bearing on the firm clay layer have a capacity of 2 tons/sq.ft., and the floating caissons located in the soft clay layer have a capacity of 1 ton/sq.ft (per sq.ft refers to the allowable load applied onto the soil by the caisson). In total, there are 150 caissons that form the foundation of Hayden Library. The approximate size of the building is 149'x219' with 4 floors and 1 basement at an elevation of +13.83 BCB. The architects who designed the building are Vorrhees, Walker, Poley & Smith of New York.

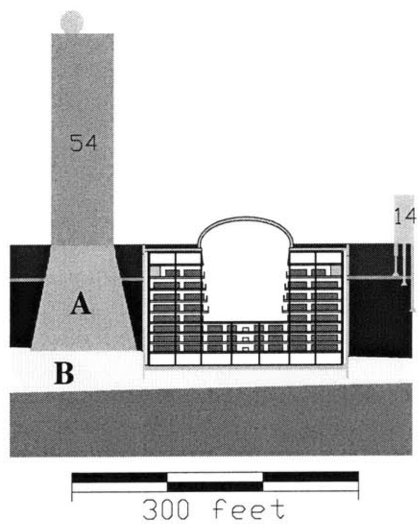


Figure 3.1-3 Subsurface Detail in the North-South direction of McDermott Court (see Figure 3.1-1 **for plan view location and** Figure 3.3-2 **for legend): the underling gray zone (A) under Building 54 indicates the pile foundation bearing on the till (B).**

Building 54 sits on a foundation of concrete piles which are end bearing on the glacial till layer. The foundation was designed for loads of 50 tons/pile. The foundation is made up of 408 piles and 36 pile caps (of varying sizes). The four corner piles are battered in both directions 6:1. The approximate size of the building is 54.5'x111.6' with 20 floors and 1 basement at an elevation of +10.5' BCB. The architect who designed the building is I.M. Pei & Associates of New York.

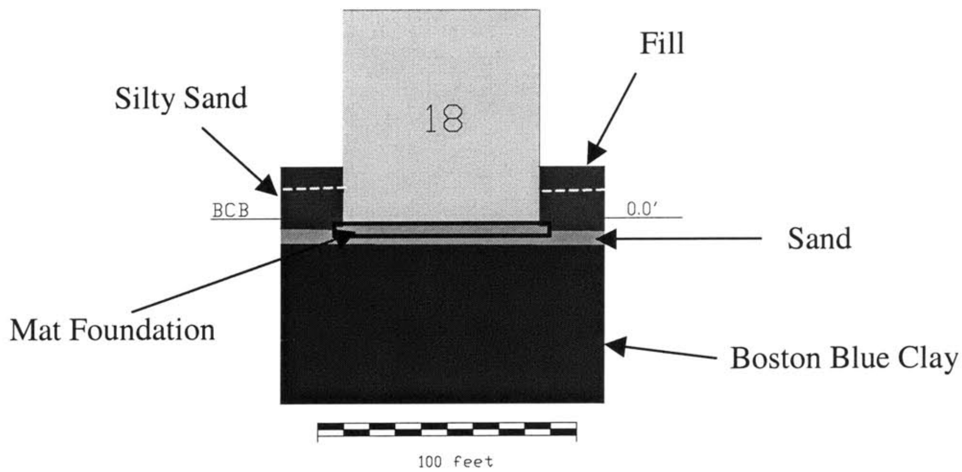


Figure 3.1-4 Subsurface Detail of Building 18

Building 18 sits on a mat foundation. The dimensions of the mat are 65.5 ft. x279.5 ft. and 4 ft thick. The raft foundation is assumed to be located in the sand layer. The elevator shaft in the south end of the building has a base elevation of – 7 ft. There is also an egress that connects Building 18 to Building 14 and Building 54 through the basement floors of the buildings; however, the path of the egress does not traverse the footprint of the library. The architect who designed the building is I.M. Pei & Associates of New York.

3.1.2 Subsurface Utilities

Under McDermott court a water line that traverses the court north-south to the center and the turns westward and heads into Building 18. See Figure 3.1-5. The pipe is the main water line for Building 18. The waterline runs directly through the middle of the proposed site and would have to be repositioned prior to excavation. There are also electrical cables that run in a north-south direction along Building 62. These cables will have to be moved, as the perimeter of the excavation will interfere with the cable path.

Another utility that runs along the perimeter of Building 62 are two fire hydrants. In September of 2000 new digital utilities were placed in the site area as well (referred to as "New Utilitiy" in Figure 3.1-5). These hydrants will have to be moved to new locations before library construction. The depth of the utilities, lie above the water table (with the a depth of 7 feet).

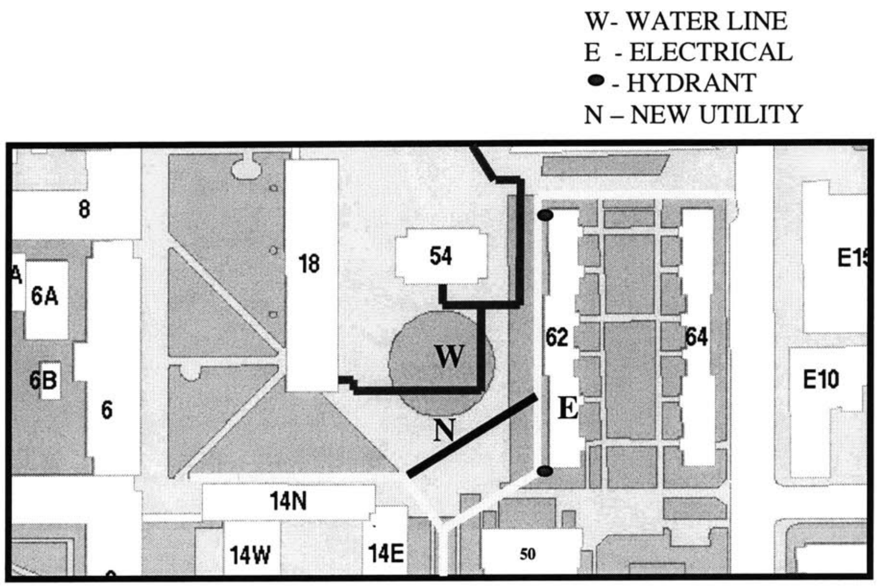


Figure 3.1-5 Location of Subsurface Utilities

3.1.3 Sources of Data

Sources of information for the site geology were available from borings obtained in 1927 during the construction of the Nuclear Engineering Center that was located just above Building 54, and borings from the construction of Building 62 and Building 14. The geologic profile produced from these borings is described in Section 3.3.1. In total there were 57 borings that are located along the north, east and south perimeters, which can be seen in Figure 3.1-6 through Figure 3.1-8.

Water levels were obtained from the Fermit piezometer data, specifically from the basement of Building 14; water levels were last recorded on June 29, 1973. There was only one piezometer which went to the till layer. This was peizometer 5A located in the basement of Building 14. See Figure 3.1-7. The water level was last recorded in 1973. There have been not been any entries since then. All the available entries showed little variation, and the mean level was used to assess the water table elevation in the till.

Additional data were obtained from Fermit. The majority of the information provided by Fermit was obtained from book N and the building plans were obtained from MIT's archivist Maryla Walters. The digital copy of Fermit could not be accessed as it was created in the mid-1980s and there were no modern readers that could decode the database.

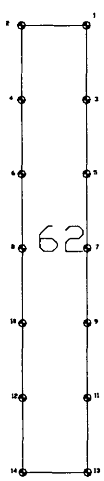


Figure 3.1-6 Location of Borings in Building 62

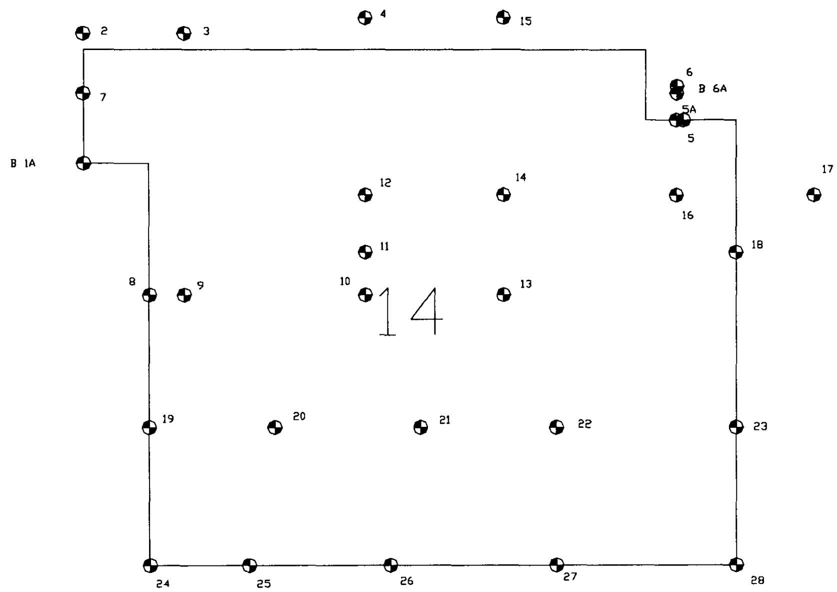


Figure 3.1-7 Location of Borings in Building 14

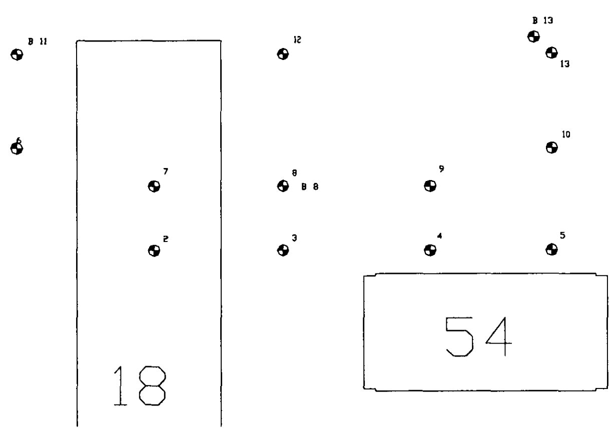


Figure 3.1-8 Location of Borings for Old Science and Nuclear Engineering Building

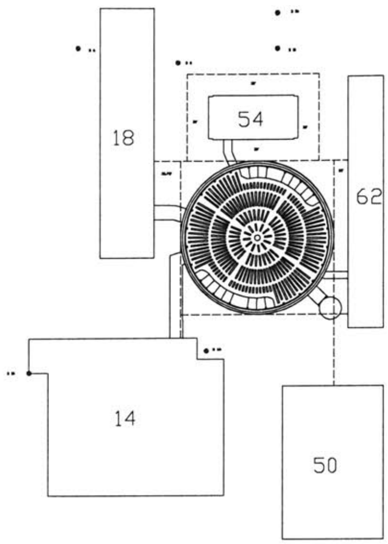


Figure 3.1-9 Plan View of Library Looking at Level 7

3.2 SITE INVESTIGATION

Because of a lack of geotechnical investigations at the site, a desktop study of the site had to be performed in order to obtain geological data. The data available from Fermit allowed one to compile a site model using: site history (Section 3.1.1), foundation information (Section 3.1.1), subsurface utilities (Section 3.1.2), local geology (Section 3.3.1), and water table location (Section 3.3.2). The M.Eng Library Group outlined the type of investigation which would have been done had they been able to do so (Sections 6.4.1.1 and 6.4.1.2).

3.3 SUBSURFACE SITE MODEL USED IN PROJECT

This section outlines the subsurface model used for the M.Eng Library Project; it details the subsurface geology (3.3.1) and the location of the water table (3.3.2) for the two-water bearing layers the sand and till layers. Figure 3.3-1 provides details of the subsurface geology at the site and will be addressed in Section 3.3.1; Figure 3.3-2 and

Figure 3.3-3 are enlargements of Figure 3.3-1 to show more details of the cross-sections.

3.3.1 SUBSURFACE GEOLOGY

The soil has been categorized into six categories: Fill, Silty Sand, Sand, Boston Blue Clay, Till, and Cambridge Argillite. The thickness and elevation of the soil layers vary between Building 14 and Building 54. The soil horizons have an inclination ranging between 0 and 4 degrees in the southwest and northeast directions. Cross-sections of the soil profile for McDermott Court can be seen below.

a)

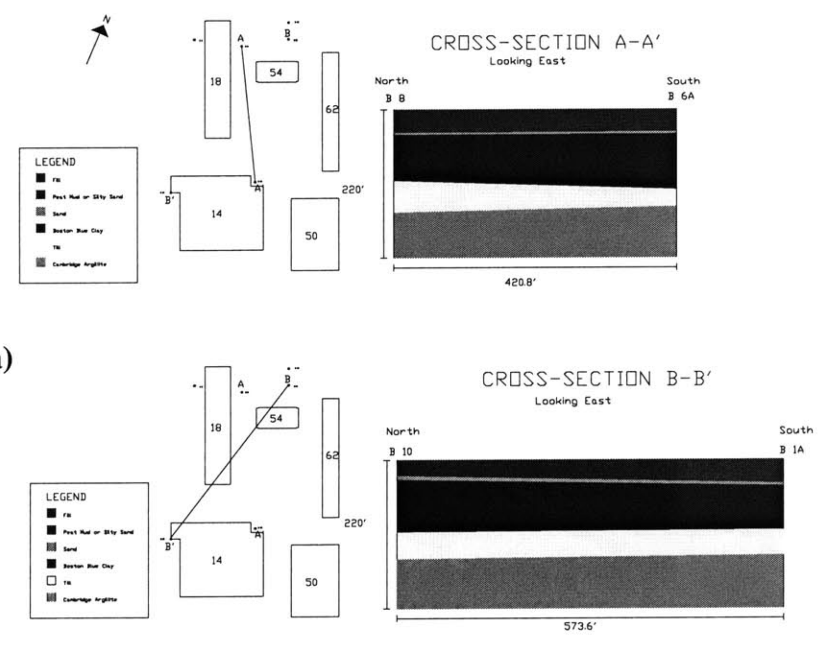


Figure 3.3-1 Cross-Sections of Subsurface Geology a) Cross-section A-A', b) Cross-Section B-B' (see Figure 3.3-2 and

Figure 3.3-3 **for enlargement of a) and b) respectivily)**

Fill:

The subterraneous fill at McDermott Court contains fill that has been dumped (uncontrolled); however it is mostly hydraulic [Ladd et al., 1965] and has an average thickness of 13.2 feet with a horizontal inclination.

Peat Mud or Silty Sand:

This layer is a soft compressible organic soil that ranges in classification from peat mud to silty sand. The deposit is composed of loose organic silts and sands with some pockets of peat. The deposit dips 0.5 degrees in the northeast direction.

Silty Sand:

The Silty Sand layer is composed of soft silts and fine sand; there are pockets of peat present within the horizon. This layer has an average thickness of 15 feet dipping 0.5 degrees in the northeast direction. The layer thins in the same direction, with the thicker end located under Building 14 (Hayden Library).

Boston Blue Clay (BBC):

BBC can be separated into three main consistencies. The first and uppermost layer is a weathered crust caused by desiccation, oxidation and capillary stress. It is this layer that is used for supporting many structures on the MIT campus. The crust has been pre-consolidated; however, the over-consolidation ratio decreases rapidly with depth producing a normally consolidated clay below (the average thickness of the crust is 10 feet, blow count ≥ 5). The second consistency is referred to as soft clay (average thickness approximately 55 feet, blow count ≤ 4) and the third consistency is considered to be a medium stiff clay with large amounts of sand (lowest 10 feet of deposit, blow count ≥ 5). It has been reported that the lowest 10 feet of the Boston Blue Clay contains the medium consistency clay unit; however this unit is not persistent throughout the MIT campus. The deposit dips at 4 degrees to the southeast and has an average thickness of 76 feet.

Glacial Till:

The Glacial Till is a very dense mixture of gravel, sand, silt, and clay, with the presence of glacial erratics. The till dips 2.5 degrees to the southwest with an average thickness of 40 feet. The till is generally non-stratified, producing a heterogeneous layer. Due to the complexity of deposition, the till is extremely variable with pockets and layers of sands and gravels, in addition to plastic silts and clays within the till matrix [Johnson, 1989].

Cambridge Argillite:

The bedrock is known as Cambridge Argillite; the upper surface is often highly weathered and fractures are present near the upper surface. The weathered surface dips 2.5 degrees to the southeast. Cambridge Argillite is gray-blue meta-sedimentary rock composed of silt and clay sized particles. Unaltered and unweathered Cambridge Argillite is considered to be sound. In previous projects in the Boston area, vertical cuts into the Argillite have remained stable with little or no support [Johnson, 1989].

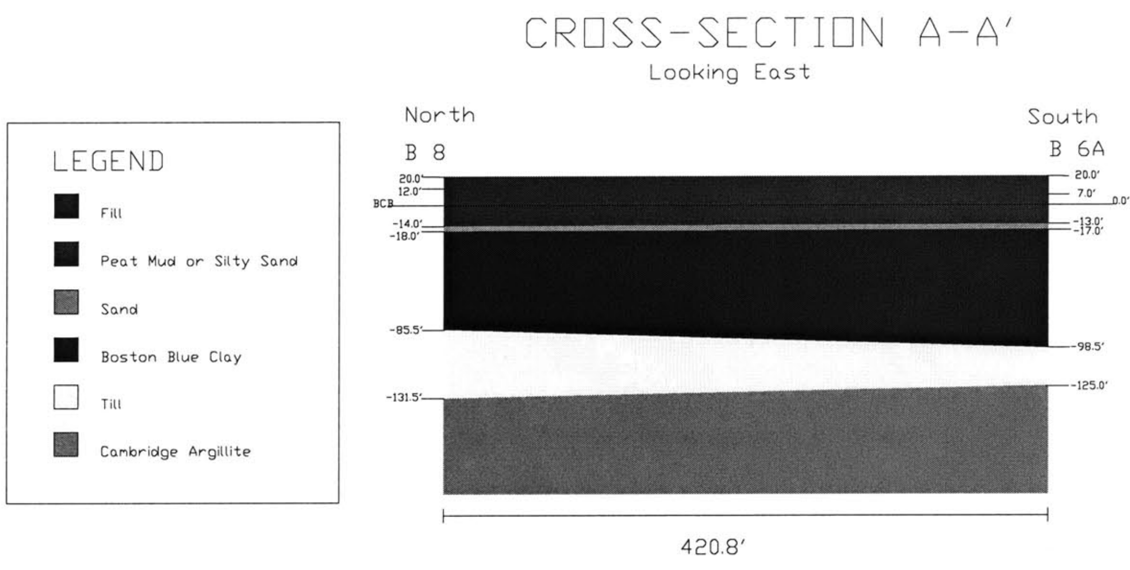


Figure 3.3-2 Enlargement of Cross Section A-A' Geology

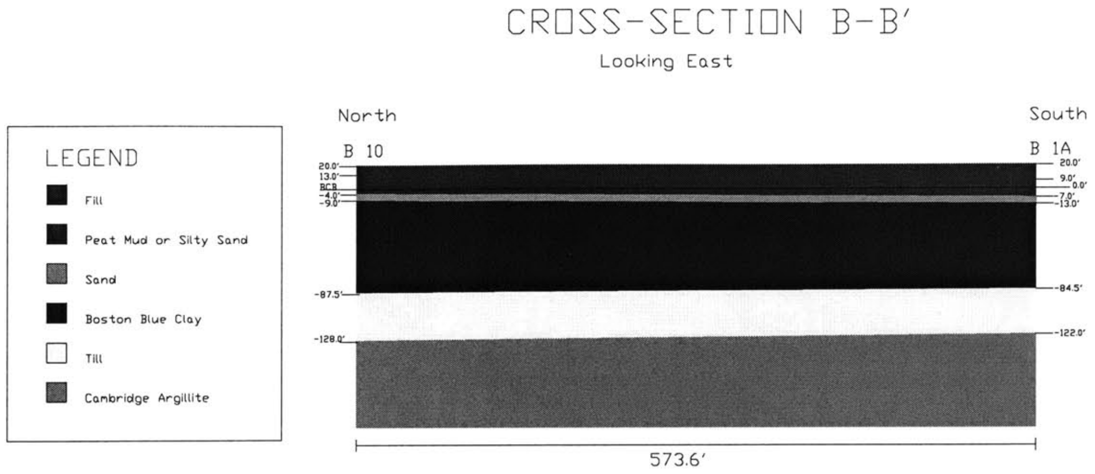


Figure 3.3-3 Enlargement of Cross Section B-B' Geology

3.3.2 WATER TABLE

Using Fermit data, we were able assess the piezometric surface (water surface) of the underlying soils. It is important to note that the clay acts as an impermeable layer, in essence, separating the two water-bearing soils (sand and till) into two separate aquifers.

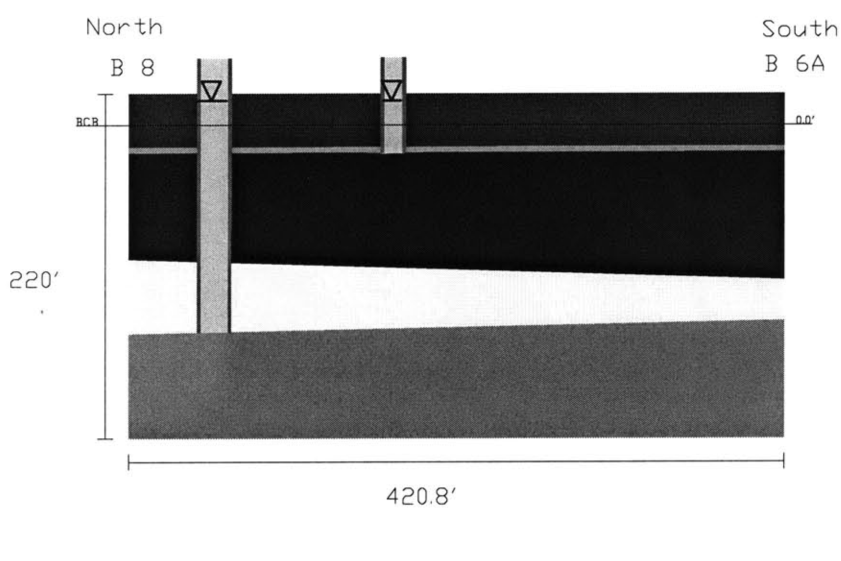


Figure 3.3-4 Location of Groundwater Table in Till and Sand Layers (see Figure 3.3-5 for zoom view of the piezometric surface)

The sand layer houses an unconfined aquifer with a water table that varies between +12 - +13 feet BCB (Boston City Base – datum) which can also be referred to as 7 – 8 feet below ground surface depending on the season. The clay layer acts as an aquitard and confines the water present in the till layer. The piezometric surface of the confined aquifer of the till is located between +11 - +12 feet BCB (9-8 feet below ground surface) dependent upon the time of year. See Figure 3.3-5.

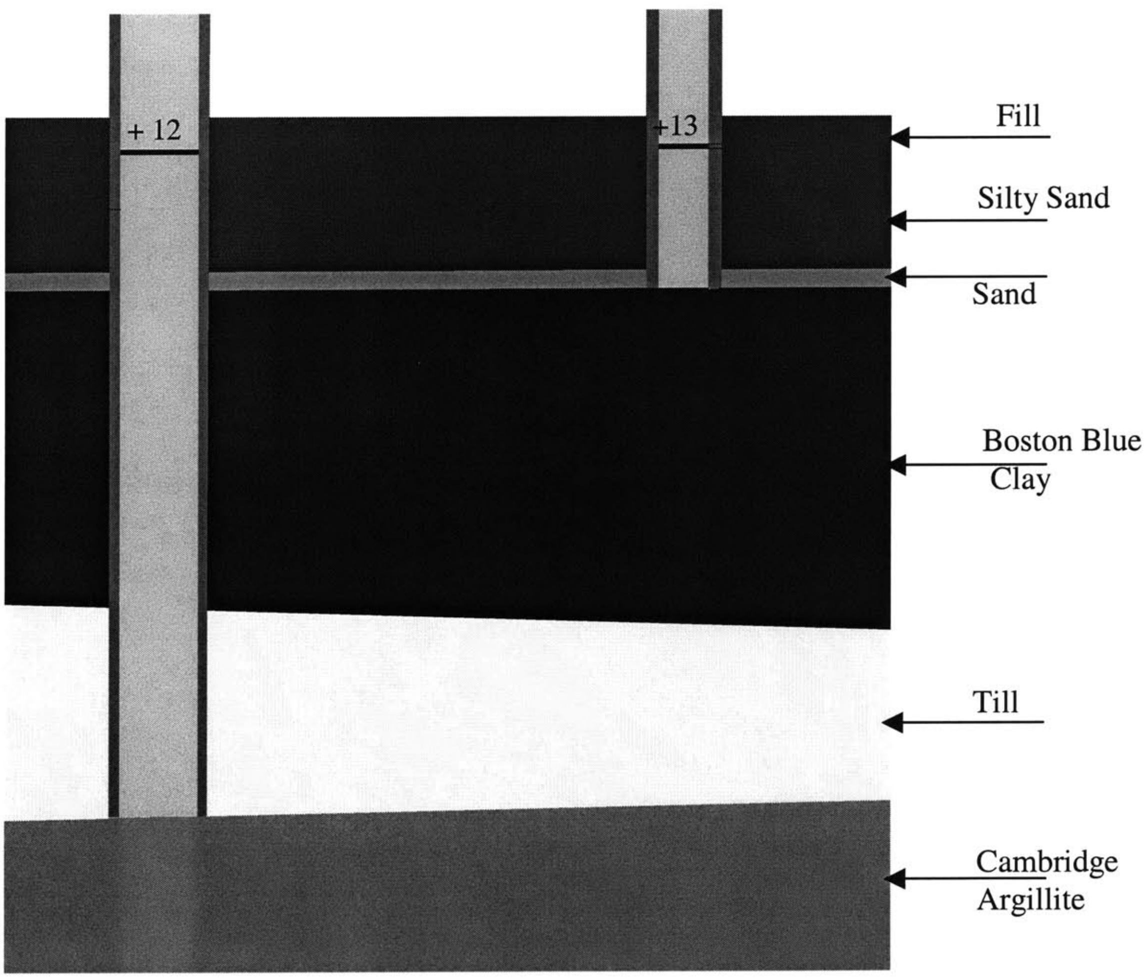


Figure 3.3-5 Zoom of Figure 3.3-4

4 CONSTRUCTION

The following is a brief outline of what the Library Group has identified as the 10 major steps in construction. For the interested reader these are outlined in detail in the M.Eng Library Group Project 2001 titled "Subterranean Library at MIT: A 21st Century Solution."

The Library structure was built using a diaphragm wall constructed using the slurry wall method; this type of design has been referred to as a Cofferdam in other projects. One such example was at London's Heathrow Airport where a structure of similar dimension as the library was used to repair a collapsed tunnel section. It is for this reason that the M.Eng Library Group used the term Cofferdam throughout their project report; however the author will be using the term Diaphragm Wall.

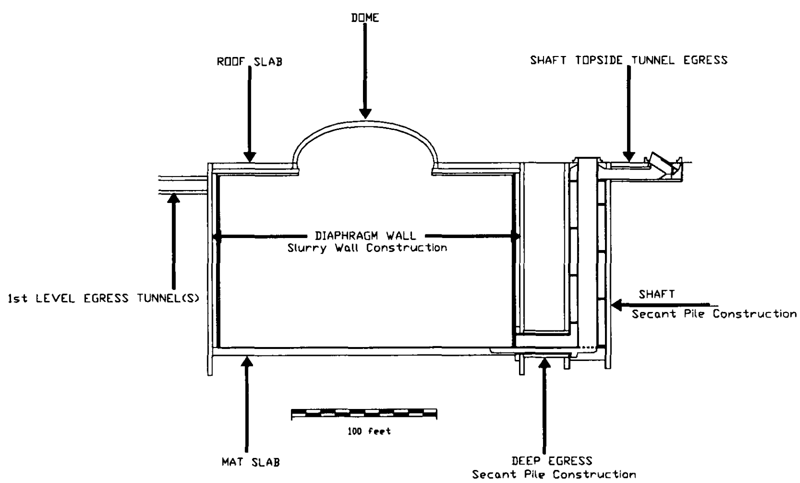


Figure 3.3-1 Underground Library

Site Preparation

This step will be the accurate surveying and placement of monitoring devices preparing the site for construction.

Shaft and Deep Egress System Installation

The shaft will be constructed using secant pile construction to a depth of 140 feet (-120 BCB) subsurface. Once the shaft has been constructed, the deep egress will be built from the base of the shaft. The egress will punch through the diaphragm wall and connect the shaft with the Library. See Figure 3.3-1.

Diaphragm Wall Installation and Excavation

The diaphragm wall made from 34 slurry wall segments will function as the permanent support for the excavation. The library will be built within the diaphragm wall. The diaphragm wall will function, as a pressure shell by resisting the horizontal earth pressures acting on it, and will help to minimize the drawdown of groundwater levels. See Figure 3.3-1.

Each individual wall panel for the Diaphragm Wall has an arc length of 19.7 feet at the panel midpoint and consists of two straight sections. There is a breakage angle of 10.6 degrees between the *two* straight sections [Craun et al, 2001]. Each panel is reinforced with steel caging. Each panel is constructed by excavating a straight section that is 10 feet in length and 3.3 feet wide and 140 feet deep. The second straight section of the panel is then excavated 10.6 degrees off the center axis of the first straight section (See Figure 3.3-2). Once the excavation of the panel is complete, the caging is lowered in; within the caging are grout tubes, which can be used to inject grout to form a grout curtain below the base of the diaphragm wall should a longer flow path be required due to a change in till permeability as the mixture of the gravel, sand, silt, and clay that forms the till layer can have high permeability sections. Therefore the implementation of the grout curtain is dependent on the permeability of the till. The excavation of the diaphragm wall interior will proceed to a depth of 130 feet below the surface (-110 BCB): the diaphragm wall has been designed with an addition 10 feet below to function as a cutoff wall for flow. Ring beams will be placed in 5 locations within the Diaphragm Wall to provide additional stability and stiffness against ground movements. See Figure 3.3-3.

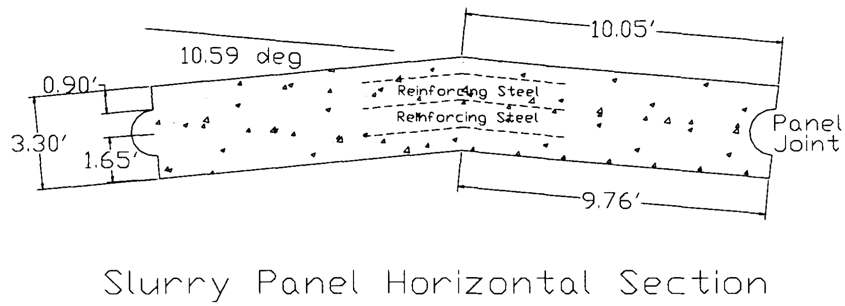


Figure 3.3-2 Diaphragm Wall Slurry Panel Detail in Plan View [Craun et al., 2001]

Library Foundation Installation

The foundation of the library will be placed at 130 feet below (see Figure 3.3-1) surface (-110 BCB); the foundation will be a reinforced mat foundation. Prior to placing the mat foundation, a geotextile fabric will be placed and covered with drainage gravel overlain by a second layer of geotextile. The formwork for the foundation will have piping to allow for the placement of tie-down anchoring into the bedrock (Cambridge Argillite) and pressure relief valves to aid in the regulation of excess water pressure below the foundation.

Internal Structure Erection

The internal structure of the library is a steel frame structure with pre-stressed, pre-cast, hollow-core decking for flooring and pre-cast exterior wall panels. See Figure 3.3-4

Roof Slab Installation

The function of the roof slab is to bear the weight of the overlying soil (see Figure 3.3-5) and life loads above the ground surface of the library (eg, the roof must be able to support large vehicles such as a fire truck). The roof slab is a reinforced concrete slab.

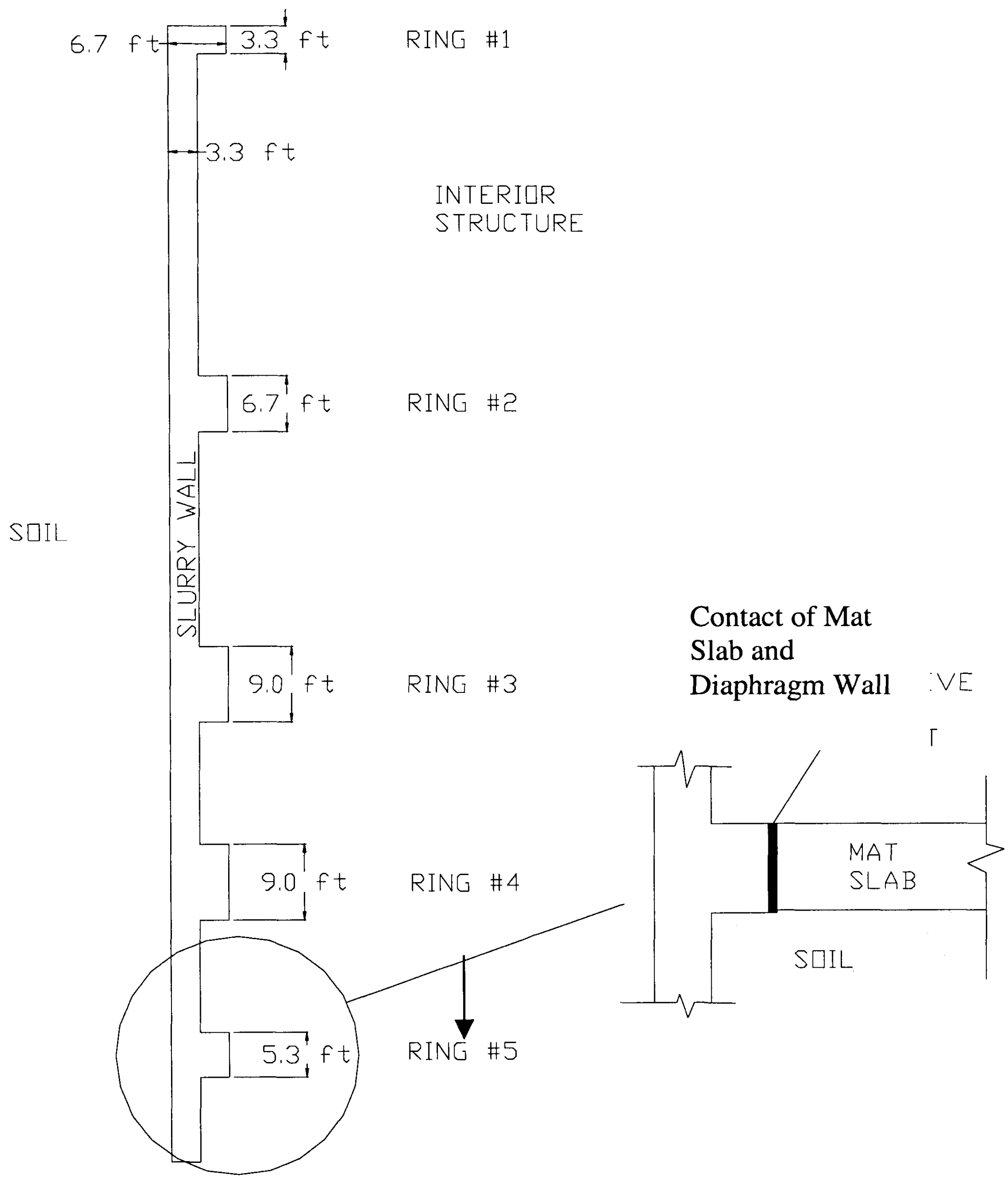


Figure 3.3-3 Slurry Wall Profile, Ring Beam & Mat Slab [Craun et al., 2001]

Shallow Egress System Installation and Utilities Connection

The Egress Tunnels (see Figure 3.3-1) will be constructed using cut and cover tunneling methods. These egresses will connect the first level of the library to the basements of the surrounding Building 18, 54, 62, and 14. See Figure 3.3-6. These tunnels will be capped after the completion of the structure to allow for material delivery after the erection of the dome

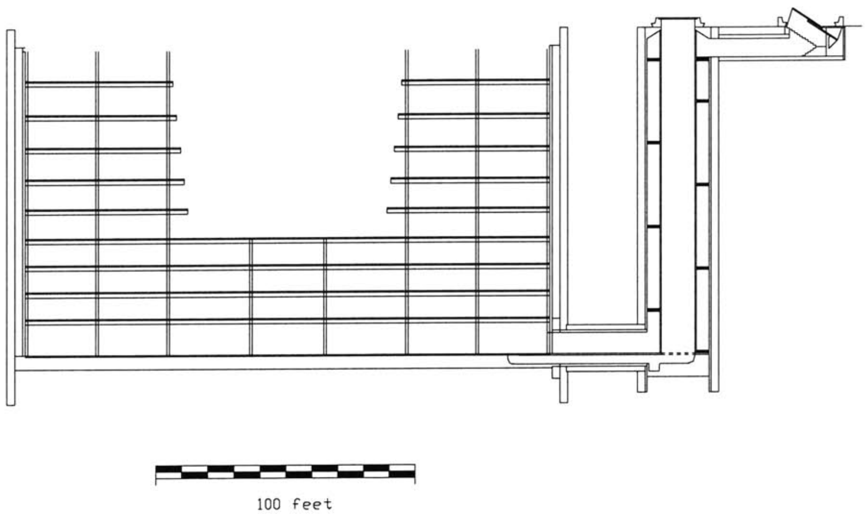


Figure 3.3-4 Library Internal Structure

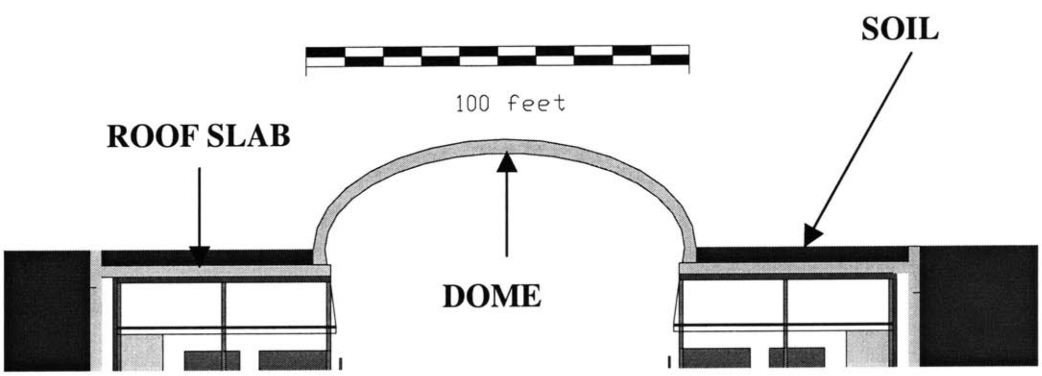


Figure 3.3-5 Roof Slab with 5 foot Cover of Backfill

Elliptical Dome Installation

Upon completion of the library structure the elliptical dome will be erected from the roof slab. See Figure 3.3-5, Figure 3.3-7 and Figure 3.3-8. The dome is constructed using 12 mm float glass sheets with cobalt oxide to produce a bluish color and the frame is made of tubular steel. The dome will be the signature mark of the Library and will be visible from the surface.

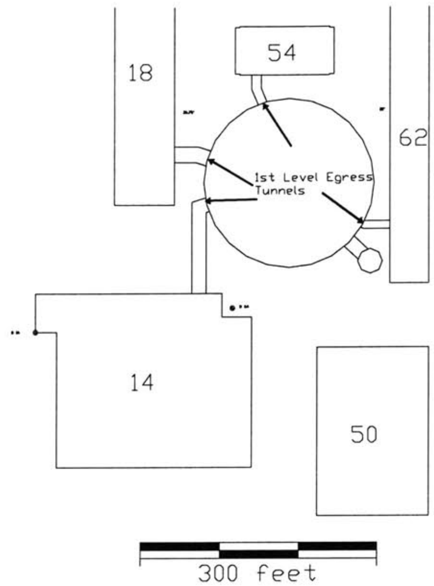


Figure 3.3-6 Location of Shallow Egresses (1st Level)

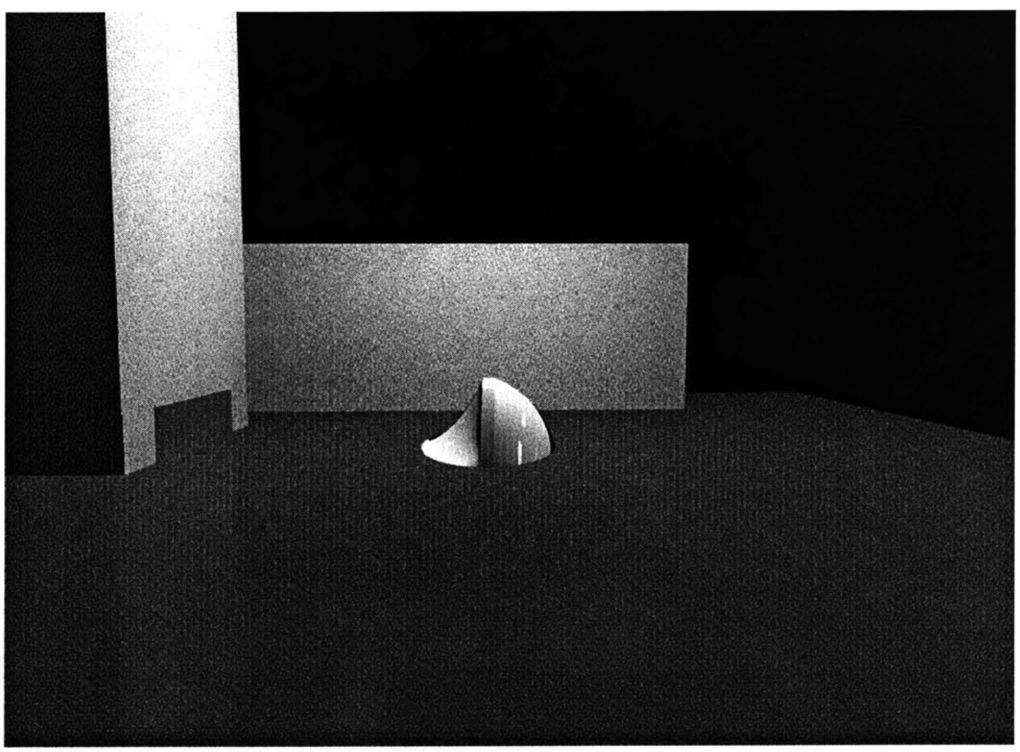


Figure 3.3-7 Glass Dome looking from West of McDermott Court [Craun et al., 2001]

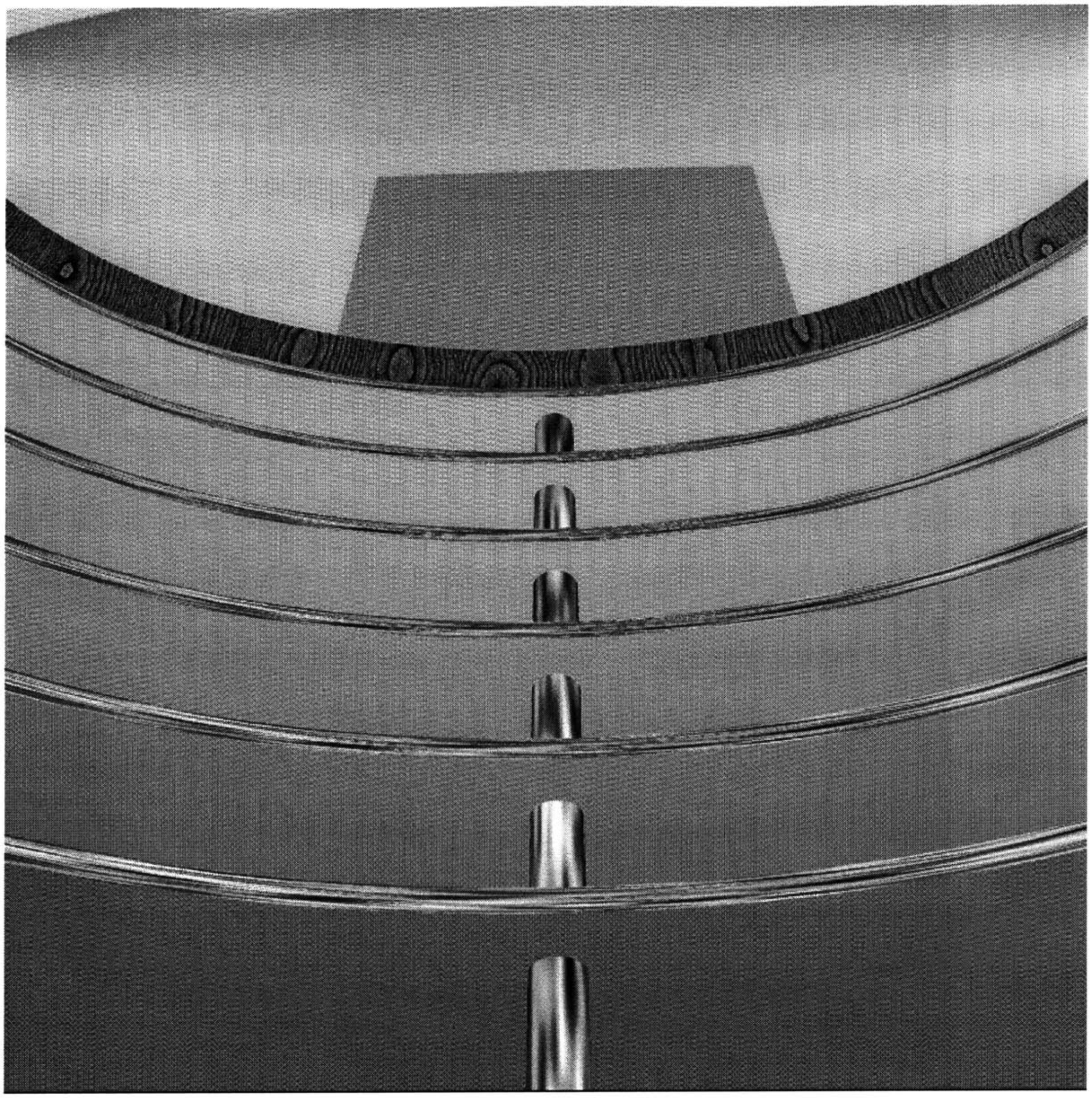


Figure 3.3-8 Inside Library Looking Outwards Building 54 [Craun et al., 2001]

Library Internal Finishing

This refers to the completion of all the required detailing and delivery prior to the library facilities taking possession of the project. This would include the delivery of the library collection, shelving, delivery of mechanical equipment, and the finishing of levels for usage.

Surface Landscaping

The landscaping will be completed at the end of the project.

The construction sequence for the project was further dissected into construction activities and is discussed in more detail in Section 4.1.

4.1 CONSTRUCTION SEQUENCE OF PROJECT

The construction sequence was broken down into 39 separate activities. These are described below. The start date was set to be June 15, 2002, which would ensure that the 2002 commencement would not be affected by construction. The projected finish date is March 26, 2004. The detailed Pert Chart (schedule) is available for review in Appendix A. Below the activities for the schedule are summarized.

Activity No.

1. Start –This will consist of site preparation activities. Duration: 15 days.

2. Shaft Secant Pile Installation – The secant piles will be drilled to a depth of 140 feet and then the concrete poured. See Figure 3.3-1. The cure time for the concrete was taken into consideration and the piles are to be drilled in an alternating pattern to minimize the delay caused by curing times. Duration: 35 days.

3. Shaft Excavation – During excavation, the Observational Method will used, which will allow for design modifications due to unforeseen ground conditions. Duration: 20 days.

4. Shaft Floor – The floor of the shaft will be constructed. Duration: 10 days.

5. Shaft Permanent Liner – The permanent liner will be constructed for the shaft. Duration: 11 days.

6. Guide Walls – The guide walls for the slurry trench will be placed about the perimeter of the library. Duration: 15 days.

7. Diaphragm Wall–The construction of the Slurry Wall will be done on a 24-hour work schedule. Duration: 45 days.

8. Connector Tunnel Secant Pile – The horizontal secant piles are drilled between the shaft and first panel of the Diaphragm Wall. See Figure 3.3-1. Duration: 15 days.

9. Egress Tunnel Walls – The walls of the first level egresses are cast in place and set. See Figure 3.3-1. Duration: 15 days.

10. Library Excavation/Ring Beam – The Diaphragm Wall excavation commences and the ring beams cast in place in at their designated elevations. See Figure 3.3-2. Duration: 90 days.

11. Connector Tunnel Excavation – The deep connector tunnel excavation will be done on a 24-hour schedule. Duration: 5 days.

12. Punch Hole –The deep egress tunnel punches through the slurrywall panel. Duration: 5 days.

13. Connector Permanent Liner – The permanent liner is cast. Duration: 5 days.

14. Shaft Finishing – The shaft is finished. Activities such as placing the stair sand and the placing the rough-in for ventilation are performed. Duration: 20 days.

15. Shaft Topside Tunnel Egress – The topside exit egress for the shaft is constructed and finished. See Figure 3.3-1. Duration: 30 days.

16. Mat Slab Drain – The base geotextile is laid, covered by 2 feet of gravel and then overlain by a top layer of geotextile. Duration: 10 days.

17. Mat Slab Rebar/Pour – The formwork for the mat slab and rebar are constructed, followed by the pouring of concrete. See Figure 3.3-1. Duration: 14 days.

18. Mat Slab Tie-Down – The tie-downs are installed and anchored to the bedrock from their designated locations within the previously constructed mat slab. Duration: 14 days.

19. Construct Steel Frame – The steel frame is constructed in sequence with the installation of the precast walls and floor slabs (Activity 21). See Figure 3.3-4. Duration: 130 days.

20. Install Elevators – The installation of the main interior elevators of the library is done after the completion of both the steel frame and precast concrete walls and floor. Duration: 14 days.

21. Precast Walls/Slab – The precast walls and floor slabs are installed in sequence with the steel frame. See Figure 3.3-4. Duration: 130 days.

22. Roof Slab – The construction of the formwork is done and followed by the pouring of the concrete slab in order to construct the roof. See Figure 3.3-1. Duration: 60 days.

23. Dome – The construction of the steel frame is done and followed by the placement of the glass panels to form the glass dome. See Figure 3.3-1. Duration: 45 days.

24. Egress Excavate (Main Entrances) – The first level egress tunnels are excavated and followed by the pouring of each tunnels concrete floor. Duration: 5 days.

25. Punch Slurrywall – An opening is punched through the slurrywall panel of the diaphragm wall from each egress tunnel on the first level. Duration: 10 days.

26. Egress Finishing (Utilities Coordinator) – Finishing the deep egress is the step where all activities that are not esthetic in nature are preformed, an example would be an activity such as ventilation rough-in. See Figure 3.3-1 and Figure 3.3-6. Duration: 20 days.

27. Ventilation –The ventilation throughout the library structure is completed and all the other rough-in ventilation in adjoining structures such as the egresses and the shaft are completed as well. Duration: 30 days.

28. Electrical/Mechanical/Fire Suppression System Installation – The installation of the electrical, mechanical, fire suppression system is completed on all floors of the library, egresses, and the shaft. Duration: 60 days.

29. Plumbing/Electrical/Finishing/Other Connections – The installation of the plumbing, electrical, esthetic finishing, and connections is completed on all library floors, egresses and the shaft. Duration: 60 days.

30. Egress Roof – The egresses are structurally completed with the placement a roof on each first floor egress tunnel. Duration: 16 days.

31. Egress Punch (surrounding buildings) – The foundations of connecting buildings (54, 62, 14, and 18) are punched through in order to connect them with the library via the connecting first level egresses. Duration: 20 days.

32. Lay Filter Fabric – Filter fabric is placed over the top of the library roof slab for drainage purposes. Duration: 10 days.

33. Backfill – Backfill is placed overtop the library roof and filter fabric until the ground surface elevation is obtained. Duration: 15 days.

34. Landscape – This activity is the standard implementation of laying sod, planting shrubs, and flowers to design specifications Duration: 20 days.

35. Modify Entrance Ways/Lobbies in Connecting Buildings – This activity involves the esthetic preparation of all the new entrance lobbies from the surrounding buildings (54, 62, 14, and 18). Duration: 20 days.

36. Finish Floors – Each floor is finished by preparing and painting walls, placing lighting fixtures and other similar activities which must be completed prior the furnishing of the structure. Duration: 50 days.

37. Furnish – The initial phase of this activity is the arrival, set-up and placement of all the new library furniture, shelving, and computers. The later phase of the activity will be the arrival of the library collection. Duration: 35days.

38. Punch List – This activity involves the solving of all unforeseen problems that the owner has mentioned prior to 100% completion of the project, such as electrical problems. Duration: 15 days.

39. OPEN – The library is ready to be used by the student body and is considered fully functional.

The schedule was developed to minimize the time of construction. From the construction schedule, the critical path for the project was found. See Appendix A. The critical path is the sequence of activities, which, if an activity is delayed, will extend the duration of the project; this results in an increase in cost for the project as well. The critical path of the project was found to be activities:

1 Start
6 Guide Walls
7 Diaphragm Wall
10 Library Excavation and Ring Beam
16 Mat Slab Drain
17 Mat Slab Rebar/Pour
18 Mat Slab Tie Down
19 Construct Steel Frame
20 Install Elevators
22 Roof Slab
23 Dome
32 Lay Filter Fabric
33 Backfill
34 Landscape
38 Punch List
39 Open

In order to minimize construction time, the other activities will occur concurrently with activities listed on the critical path.

4.2 IDENTIFICATION OF SEQUENCES AFFECTED MOST BY A CHANGE IN GEOLOGIC PARAMETERS

As the geologic model is based on four boreholes (which terminate in the Argillite) the level of confidence that the geology subsurface is as the predicted is uncertain. A change in depositional thickness may have a definite economic impact on the project. Therefore it is important to identify which activities in the construction sequence would be most affected by a change in geology. A change in geology could mean that the time of construction is shortened or lengthened, which would also impact the cost of construction. Table 4.2-1 identifies the construction activities which would be most affected by a change in geology. The activities mentioned in Table 4.2-1 all have the commonality that each activity requires soil to be excavated from the site.

Table 4.2-1 Construction Activities (Section 4.1) Which Would be Affected by a Change in Geology

Activity	Activity Name	Volume of Soil to Be Excavated (rounded to nearest 1000s)
2	Shaft Secant Pile Installation	102,000
3	Shaft Excavation	
11	Connector Tunnel Excavation	6,800
8	Connector Secant Pile	
7	Diaphragm Wall	287,000
10	Library Excavation/Ring Beam	4,486,000

The construction activities identified in Table 4.2-1 would be affected by a change in geology in the following ways. For activities 2 and 8, a change in geology would affect the drill rates of the secant piles. For example, if the upper bound of the glacial till is located at a higher elevation than anticipated, this would affect the type of excavator that would be required; for example for the diaphragm wall construction example a standard clam shell (for clay) would be used for excavating a slurry panel versus a hydro-milling which would be required for the till excavation as till requires much more force than excavating clay. The equipment needed for drilling till would be needed for longer periods than previously anticipated and would result in an increase in cost. Another impact would be that the time required for drilling would increase as the drilling rates for till are less than those of clay. This information was obtained from the engineers at Treviicos Corporation in January 2001. All this would be a negative effect on cost and time. Should the upper bound of the till be lower than anticipated, the opposite effect would occur: the time and cost would be reduced as the equipment cost would be less and drilling rates would be higher than those for till.

Of the activities most affected by a change in geology, only two (7, and 10) are on the critical path. Hence activities 7 and 10 would have the most impact on construction time with a change in the subsurface geology. While all the activities mentioned in Table 4.2-1 would have an impact on the final cost of the project, only two would affect the length of the project. See Appendix A for construction schedule and critical path.

4.3 COST OF PROJECT

The final cost of the library is $87.2 million dollars at a cost per square foot equaling approximately $295. The cost was derived by breaking down the entire project in to specific categories as can be seen in Figure 4.3-1. The costs were derived using unit costs provided by "RSMeans Heavy Construction Manual (2000)" and other RSMeans publications. A 25% contingency fee was added to the overall costs in order to account for components and operations not covered during the estimation process. The new total was then further increased by a further 17% to account for the increased material and labor cost in the Greater Boston area, when comparing Boston against the national average.

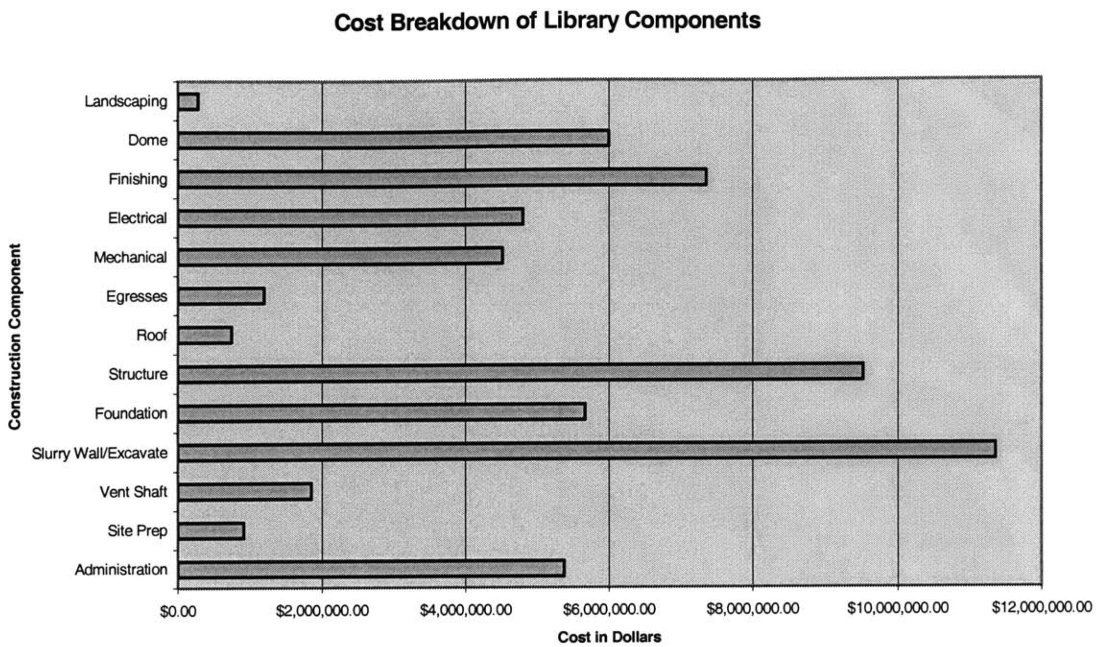


Figure 4.3-1 Cost Breakdown of Library Components

5 GEOLOGY

The construction of the library subsurface is affected by the ground conditions below. A change in a geologic unit will affect the time of excavation and hence the final cost. The subsurface geology used in the design of the underground library is described in Section 3.3. Based on this information, the library group designed a plan, construction procedure, and cost and time estimate. From the construction procedure, six activities have been identified (Section 4.2) as sequences that would be most affected by a change in geology with respect to time and cost. The uncertainty of the project is caused by a lack of geologic information at the site. Only partial geologic conditions at the site are known. The geology for the site had been based on four main boreholes, which penetrated into bedrock, but since that time two more bore holes that terminate in the bedrock have become available. The locations of the four main boreholes can be seen in Figure 5.1-1. The uncertainty of the geologic conditions at McDermott Court begins with the extent of the homogeneous zones. These zones have been have been interpreted by pre-existing borings and will be discussed further in Section 5.2.

5.1 IDENTIFICATION OF OBJECTIVE AND SUBJECTIVE INFORMATION

The geology along the construction path is only partially known. At present we do not know where a formation such as the till pinches out or peaks in the center of the library footprint. This is very important as this may have an impact on the time and cost of construction. The bore data available for the site is limited; however, the M.Eng group has designed the library based on the known information and developed a construction procedure. The uncertainty of the project is caused by the lack of information between borings. The library recognized these limitations and suggested that the Observational Method would be employed as an approach of dealing with the uncertainty of the project. For the purposes of this paper the boring data is considered to have been collected objectively and determination of uncertainties is treated subjectively relating the geologic model (Section 5) to the performance of the ground classes (Section 6).

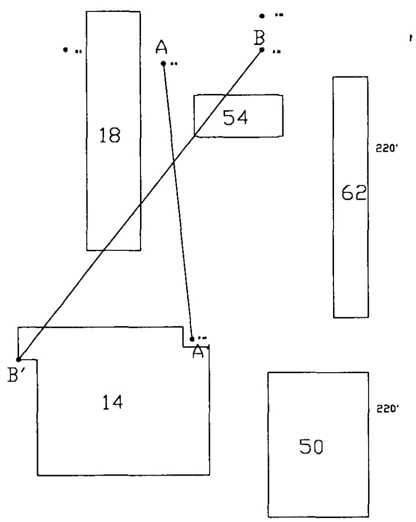


Figure 5.1-1 Location of the Four Main Bore Holes Used for the Cross-sections of Subsurface Geology

5.2 IDENTIFICATION OF HOMOGENEOUS ZONES

The site has been sectioned into four homogeneous zones. Each assigned zone has similar geologic characteristics. The geology of each zone is not constant. Figure 5.2-1 depicts these four zones. These zones were chosen as they represented the subsurface geology in terms of sub-areas in which the geology was represented by geologic data (bore holes) or sub-areas in which there was no available geologic data.

Zone 1 is based on borehole data available from the previously existing Science and Engineering Building. From the desktop study, thirteen boreholes were available, two of which reached depths in which the bedrock (Cambridge Argillite) was encountered. This zone is considered to be a sub-area of known geologic data.

Zone 2 is based on borehole data available from the subsurface history of Building 62. It should be noted that the available boring data did not reach depths where the bedrock was encountered. This zone is considered to be a sub-area of both known and unknown geologic data. A total of fourteen boreholes were available from the desktop study.

Zone 3 is based on borehole data available from the subsurface history of Building 14. Thirty boreholes were discovered from the desktop study, four of which encountered bedrock. This zone is considered to be a sub-area of known geologic data.

Zone 4 had no available geologic data. The zone is considered to be a sub-area of unknown geologic data. However the north, south and east perimeter of the zone and can be represented by the geologic data of their neighboring zones. Therefore the parameters for this profile were obtained from the geologic data available from its surrounding zones.

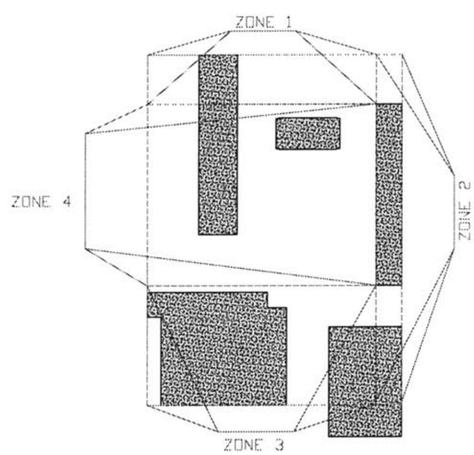


Figure 5.2-1 Homogeneous Zones at Site

5.2.1 PARAMETER IDENTIFICATION FOR EACH ZONE

In this section the parameter for each homogeneous zone will be defined. The parameter states for Zones 1, 3, and 4 are the same, while Zone 2 differs slightly. The parameter states are based on geologic units. Each parameter state is either based on location of the transition contact between two lithologies (upper bound of underlying geologic unit) or the thickness of the geologic unit. In examining all the borehole data transition order, the order in which the geologic units followed, which was based upon depth below surface not order of deposition, the sequencing pattern below emerged:

1. Fill
2. Silty Sand
3. Sand
4. Boston Blue Clay
5. Glacial Till
6. Cambridge Argillite

To accommodate the non-existence of a layer both the upperbound and the thickness of layers are included as "parameter states" as will be seen below:

Zones 1, 3, and 4 have the following ten geological parameter states: parameter state 1 – Upper Bound (UB) of Silty Sand, parameter state 2 – UB of Sand, parameter state 3 – UB of Boston Blue Clay (BBC), parameter state 4 – UB of Glacial Till, parameter state 5 – UB of Cambridge Argillite, parameter state 6 – Thickness of Fill layer, parameter state 7 – Thickness of Silty Sand layer, parameter state 8 – Thickness of Sand layer, parameter state 9 – Thickness of BBC, parameter state 10 – Thickness of Glacial Till.

Zone 2 has only six parameter states as the depth of the boring does not allow one to collect data on the till or argillite layers. The parameter states of this zone will maintain the same numbering scheme as those for Zones 1, 3, and 4. The six parameter states for this zone are as follows: parameter state 1 – UB of Silty Sand, parameter state 2 – UB of Sand, parameter state 3 – UB of Boston Blue Clay (BBC), parameter state 6 – Thickness of Fill layer, parameter state 7 – Thickness of Silty Sand layer, and parameter state 8 – Thickness of Sand layer.

5.2.2 PROBABILISTIC PARAMETER PROFILE

Probabilistic parameter profiles were derived for each zone. For each zone the boring data was compiled and then a histogram for each parameter state was produced. This was done to find the frequency of occurrence for each zone and its respective parameter states. The histograms of the parameter states (1-10) for Zones 1 through 4 can be seen in Appendix B, Appendix C, Appendix D, and Appendix E respectively. The data were analyzed to a precision of one-foot intervals. The histograms for parameter states 1 through 5 indicate ranges in which the upper bound of each geologic layer would be encountered and the frequency of these encounters; Figure 5.2-2 shows the histogram for parameter 1 (upper bound of Silty Sand) in Zone 4. The histograms for parameter states 6 through 10 indicate the ranges of thickness for each geologic unit and the frequency of these thicknesses.

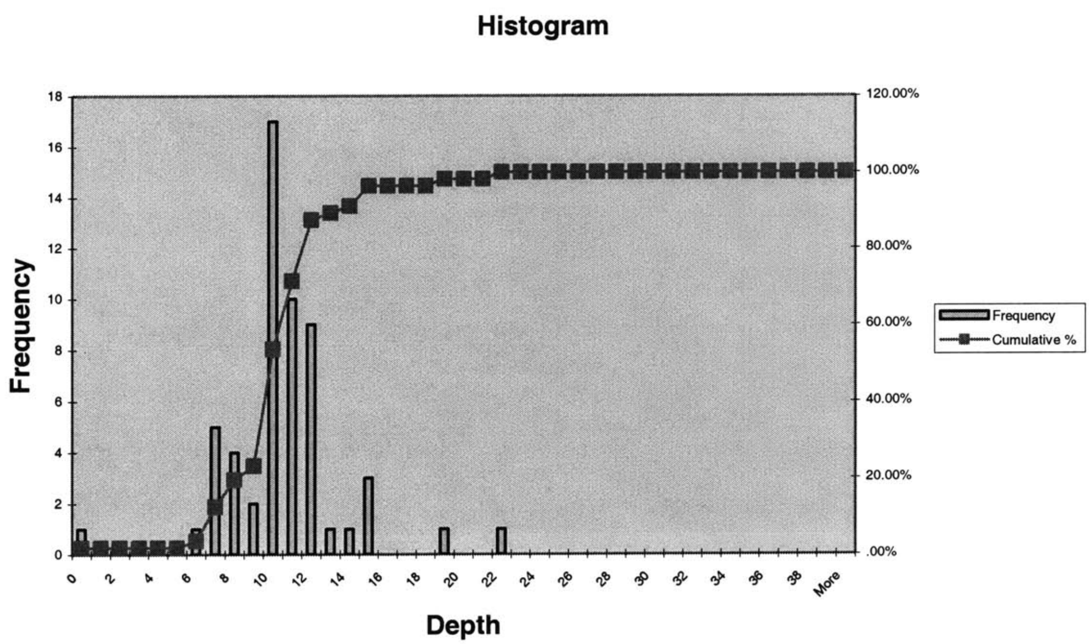


Figure 5.2-2 Histogram for Parameter 1 in Zone 4 (Upper Bound of the Silty Sand Layer)

In order to obtain the probabilistic parameter profile, the data had to be further examined. The data for each zone and its corresponding parameter states was separated into mutually exclusive events for each state.

For parameter states 1 through 5, this was done by declaring the following events per parameter state: the first event (E1) is where the borehole has encountered the desired geologic unit at a specific depth. For parameter states 6 through 10, this was done by declaring the following events per parameter states: the first event (E1) is where the borehole has encountered the desired geologic unit of a specific thickness. In order to get the probabilistic parameter state, we needed to find the probability of an event occurring at a corresponding depth for the UB parameters (states 1-5) or corresponding thicknesses for parameter states 6-10.

From the available data, the range per parameter state was obtained (eg, the UB of the Glacial Till ranges between a depth of 100 – 128 feet in Zone 4), and the frequency of occurrence (eg, two boring showed the glacial till has a depth of 128 feet). This information was then used to calculate the probabilistic parameter states. Below is a sample calculation for Zone 2 to find the probabilistic parameter state of parameter state 1 (Silty Sand) at a depth of 10 feet:

P(E1) is the probability that the borehole has encountered the upper bound (UB) of the Silty Sand layer at 10 feet.

$$P(E1) = \frac{\text{number of bore holes with the UB of Silty Sand at 10 m}}{\text{Number of boreholes encountering the Silty Sand}} = \frac{11}{14} = 0.786$$

The parameter states for each zone were found using the method above. These can be found in Appendix F. A summary of data from appendix F can be seen in Table 5.2-1 and Table 5.2-2. Table 5.2-1 presents a summary of the ranges encountred for each parameter state and Table 5.2-2 summarizes the peak probabilities encountered for each parameters at the corresponding depth(s) or thickness(es).

Table 5.2-1 Summary of Ranges Encountered for Each Parameter State

ZONE 1			
Parameter State	UB Range	Parameter State	Thickness Range
1	6 to 11	6	6 to 11
2	19 to 34	7	19 to 34
3	28 to 37	8	28 to 37
4	100 to 107	9	100 to 107
5	143 to 169	10	143 to 169
ZONE 2			
Parameter State	UB Range	Parameter State	Thickness Range
1	9 to 12	6	9 to 12
2	18 to 26	7	7 to 17
3	27 to 31	8	5 to 13
ZONE 3			
Parameter State	UB Range	Parameter State	Thickness Range
1	8 to 23	6	8 to 23
2	22 to 36	7	4 to 26
3	30 to 39	8	1 to 13
4	104 to 128	9	80 to 98
5	142 to 145	10	27 to 38
ZONE 4			
Parameter State	UB Range	Parameter State	Thickness Range
1	6 to 22	6	6 to 22
2	18 to 36	7	4 to 27
3	27 to 39	8	1 to 13
4	100 to 128	9	66 to 120
5	142 to 152	10	27 to 69

Table 5.2-2 Summary of Peak Probabilities for Each Corresponding Parameter at Their Corresponding Depth(s) or Thickness(es)

ZONE 1					
Parameter State	Depth	Probability	Parameter State	Thickness	Probability
1	7	0.416666667	6	7	0.416666667
2	20,22,30	0.153846154	7	16	0.2
3	30	0.384615385	8	4	0.230769231
4	100,102,104,106	0.25	9	77	0.5
5	142,149,152,169	0.25	10	47	0.5
ZONE 2					
Parameter State	Depth	Probability	Parameter State	Thickness	Probability
1	10	0.785714286	6	10	0.458333333
2	26	0.434782609	7	14	0.357142857
3	29,30	0.357142857	8	6,7	0.285714286
ZONE3					
Parameter State	Depth	Probability	Parameter State	Thickness	Probability
1	11	0.310344828	6	11	0.333333333
2	33	0.357142857	7	22	0.206896552
3	34	0.24137931	8	3	0.25
4	128	0.25	9	80	0.25
5	142,145	0.5	10	27,38	0.5
ZONE 4					
Parameter State	Depth	Probability	Parameter State	Thickness	Probability
1	10	0.309090909	6	10	0.309090909
2	33	0.2	7	14	0.127272727
3	30	0.196428571	8	4	0.160714286
4	128	0.166666667	9	77	0.166666667
5	145,149,152,169	0.166666667	10	47	0.333333333

6 PERFORMANCE

In order to determine the probabilistic ground class profile, the obtained boring data was treated semi-subjectively. The profile that was compiled is for Zone 4 as this area is where the library will be built. Parameter states for Zone 4 (Section 5.2.2) were used to construct the profile. The first step was to find mean thicknesses of Zone 1, Zone 2, and Zone 3. For the geologic data of Zone 1 a mean thickness per geologic layer was calculated, the same was done for Zone 2 and Zone 3. The mean thickness of the geologic layers represented in Zone 4 was obtained in two manners, the first by taking the mean of Zones 1, 2, and 3 (see Table 5.2-1), and the second by using the available borings that surround Zone 4. See Table 5.2-2.

Table 5.2-1 Mean Thickness of Zones

	MEAN THICKNESS (ft)			Average thickness estimated for Zone 4
	Zone 1	Zone 2	Zone 3	
Fill	8	10	12	10
Silty Sand	17	12	19	16
Sand	6	7	4	6
BBC	72		89	81
Till	50		32	41

Table 5.2-2 Mean Thicknesses of Zone 4

Unit	Range			Mean Thickness (μ)	Standard Deviation (σ)	"Max"=μ+σ	"Min"=μ-σ
Fill Thickness	6	to	22	10.1	3.4	13.4	6.7
Silty Sand Thickness	4	to	27	16.3	6.1	22.5	10.2
Sand Thickness	1	to	13	5.2	3.24	8.3	2.0
BBC Thickness	66	to	120	83.7	15.2	98.9	68.5
Glacial Till	27	to	69	44	14.1	58.1	29.9

It was concluded by the author that the mean thicknesses obtained by the latter of the two methods (Table 5.2-2) would be more representative of site conditions.
The values of $\mu \pm \sigma$ were the maximum and minimum used in the Monte Carlo Simulation (see Section 6.3) to obtain distributions (Sections 6.1and 6.2).

It is important to note that Sections 6.1 and 6.2 are based on activities identified which are most affected by a change in geology in Section 4.2 in Table 4.2-1. Therefore the cost breakdown is preformed for activities 2,3,7,8,10, and 11, and the time breakdown is preformed for only those activities on the critical path (activities 7 and 10). As only those activities on the critical path will affect the duration of the project; where as all the mentioned activities will effect the total cost of the project.

6.1 COST BREAKDOWN

Section 4.2 identified the activities most affected by a change in geology. Their associative costs were obtained from the M.Eng Library Project and recorded in Table 6.1-1.

Table 6.1-1 Activities Affected by a Change in Geology and Their Costs

Activity	Activity Name	Cost (rounded the nearest 100,000)
7	Diaphragm Wall	$ 6,500,000
10	Diaphragm Wall Excavation/Ring Beam	$4,200,000
2 & 3	Shaft Secant Pile Installation & Shaft Excavation	$ 1,300,000
11 & 8	Connector Tunnel Excavation & Connector Secant Pile	$ 300,000
	TOTAL COST	$ 12,300,000

From the dimensions of the library, shaft and tunnel plans, and the original geology at the proposed site, the volume of each geologic unit excavated was calculated for the each structure. The total volume that will be excavated is 490,000 CFT (rounded to the nearest 10,000s). The library excavation (activity 10) represents 92% of the total volume excavated. The representative percentage of volume excavated for each unit was then derived. See Table 6.1-2. The mean cost per cubic foot excavated was calculated by dividing the total cost of the activity by the volume of soil that must be excavated using the original model. These cost were then used to perform the Monte Carlo Simulation in Section 6.3.

In early January 2001, the M.Eng group went to the offices of Treviicos Corporation in Boston, MA; they learned that, when excavating for the soil for a Diaphragm Wall the engineers had been involved with in the area, costs for excavating the till were greater than for the other geologic units, and the time required for excavation were 2 to 3 times greater than that of the clay. This substantiates the assumption that a change in the till layer will have the most impact on construction. As the overall cost differential between the excavation of the till versus the other units is not known, the cost per layer was derived by back calculation; this was done by choosing varying increases between the till and other layers. Table 6.1-3 is the cost differential for the total excavation cost of the Diaphragm Wall based on a mean cost of $0.94/cft for Activity 10 (Library Excavation).

Table 6.1-2 Percentage Excavated of Original M.Eng Soil Model

	Diaphragm Wall	Library Excavation	Shaft Secant Pile Installation & Shaft Excavation	Connector Tunnel Excavation & Connector Secant Pile
Fill	8%	8%	8%	
Silty Sand	17%	17%	17%	
Sand	3%	3%	3%	
BBC	58%	58%	58%	20%
Till	13%	13%	13%	80%
Volume Excavated (rounded to the nearest 1000s)	287,000	4,486,000	102,000	6,800

Table 6.1-3 Example Cost Differential of 30% between the Till and Other Layers

	Library Excavation		Diaphragm Wall		Shaft		Tunnel	
	Percent Increase		Percent Increase		Percent Increase		Percent Increase	
		30%		30%		30%		30%
Layer	Costs/cft		Costs/cft		Costs/cft		Costs/cft	
Fill	$	0.91	$	21.78	$	12.62	$	32.85
Silty Sand	$	0.91	$	21.78	$	12.62	$	32.85
Sand	$	0.91	$	21.78	$	12.62	$	32.85
Boston Blue Clay	$	0.91	$	21.78	$	12.62	$	32.85
Glacial Till	$	1.18	$	28.32	$	16.40	$	42.71

This was done for 10% increments from 0% to 100% increase in cost of till excavation in comparison to the other geologic layers for each identified activity.

6.2 TIME BREAKDOWN

The time breakdown was performed in a similar manner to that of the cost breakdown except that the time was only considered for activities on the critical path. From the original model a time breakdown was back calculated for the activities listed in Table 3.1-1. The time breakdown for those activities on the critical path were then used to for the Monte Carlo Analysis in Section 6.3 (see Table 6.2-2 for time breakdown).

Table 6.2-1 Activities Affected by a Change in Geology and Their Times

Activity	Activity Name	Time
7*	Diaphragm Wall	45 days
10*	Library Excavation	90 days
2 & 3	Shaft Secant Pile Installation & Shaft Excavation	55 days
11 & 8	Connector Tunnel Excavation & Connector Secant Pile	20 days
	TOTAL Time	210 days
* Activity is on the critical path (see Section 4.2 and Appendix A)		

Table 6.2-2 Example Time Differential of 100% between the Till and Other Layers

	Diaphragm Excavation	Diaphram Wall
	Percent Increase	Percent Increase
	100%	100%
Layer	Day/cft	Day/cft
Fill	0.00001776	0.00013880
Silty Sand	0.00001776	0.00013880
Sand	0.00001776	0.00013880
Boston Blue Clay	0.00001776	0.00013880
Glacial Till	0.00003552	0.00027760

6.3 MONTE CARLO SIMULATION

A Monte Carlo Simulation was preformed to find the cost and time distributions as a result of a change in geology. This was done by using the minimum and maximum thickness values for each layer in Table 5.2-2 and randomly selecting a variable between the two values, then multiplying the random number generated for the layer by the area and cost per cft (time per cft for the time distribution) for each activity which the layer affects. For example the cost and time for the connecting tunnel between the shaft and library (see Figure 3.3-1) would not be included in the calculation for the Fill layer. A sample calculation for the Boston Blue Clay layer can be found below.

$$TC_{TOTAL\text{-}SAND} = T_{SAND} * [(C_{LIB\text{-}X\text{-}SD} * A_{LIB\text{-}X}) + (C_{DPGM\text{-}W\text{-}SD} * A_{DPGM\text{-}W}) + (C_{SHAFT\text{-}SD} * A_{SHAFT}) + (C_{TNL\text{-}SD} * A_{TNL})]$$

Equation 6.3-1

Where:
TC = Total cost for layer
A = Cross-sectional area of the structure
C = Cost of activity
T = Thickness of layer
LIB-X = Library Excavation
DPGM-W = Diaphragm Wall
SHAFT = Shaft
TNL = Deep Tunnel

This calculation was done for the following layers: Fill, Silty Sand, and Sand.

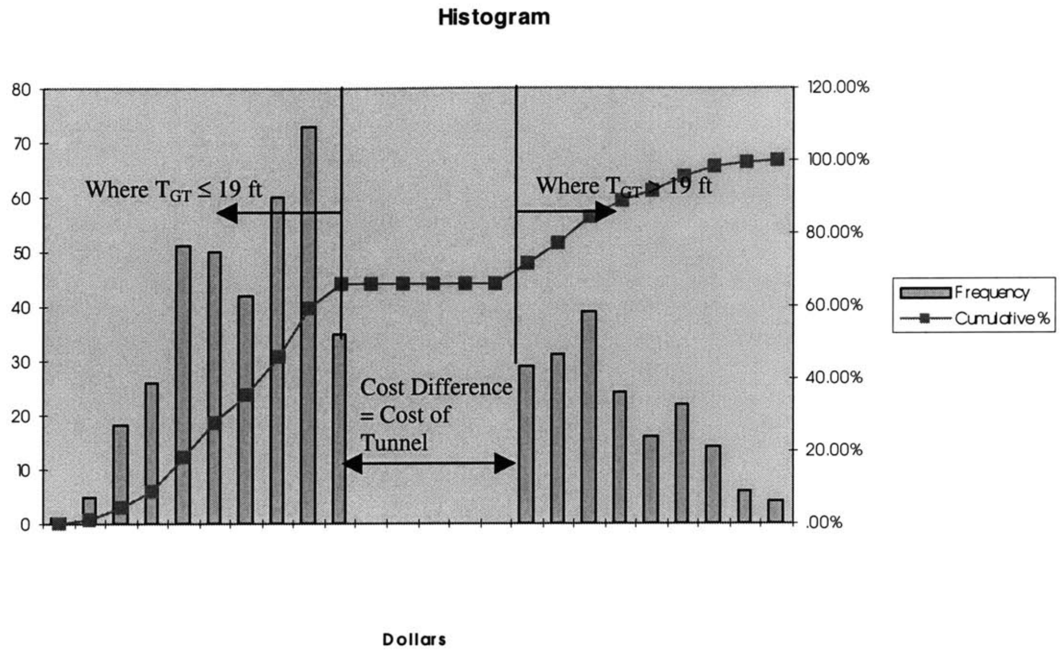


Figure 6.3-1 Bimodal Distribution Produced Using Equation 6.3-2 and Equation 6.3-3

A problematic situation encountered during the initial stages of the simulations was where there was no till present in the path of the diaphragm wall, Shaft, or connecting tunnel (deep egress). This resulted in a bimodal distribution of the cost and time distributions. See Figure 6.3-1. The bimodal distribution was initially attributed to cases where the randomly chosen thickness of the Fill, Silty Sand, Sand, and Boston Blue Clay where close to the possible maximum which in turn resulted in there being no Till present as the summed lengths of the other layers are greater than 130 feet (length of the planned excavation). Further inconsistencies were found in the simulation with respect to the total cost and total time calculations for the Boston Blue Clay and the Till layer. The inconsistencies were attributed to the manner in which the total cost calculation was initially programmed. The initial calculations used Equation 6.3-3, and one similar to Equation 6.3-2. While the programming error was easily rectified it helped to identify other inconsistencies in the model; such as the assumption that the till layer would range in thickness from 0 to 19 feet.

$$TC_{TILL} = T_{GT}*[(C_{LIB\text{-}X\text{-}TL}*A_{LIB\text{-}X})+(C_{DPGM\text{-}W\text{-}TL}*A_{DPGM\text{-}W})+ (C_{SHAFT\text{-}TL}*A_{SHAFT})]+ (T_{Gt}/19)*24*(C_{TNL\text{-}TL}*A_{TNL})$$

Equation 6.3-2

Where: 19 = the height of the tunnel

$T_{GT} = [130-(T_F+T_{SS}+T_{SD}+T_{BBC})]$ = Thickness of the Till in the library path.

Similary the TC for the BBC was calculated as follows:

$$TC_{BBC} = T_{BBC}*[(C_{LIB\text{-}X\text{-}BBC}*A_{LIB\text{-}X})+(C_{DPGM\text{-}W\text{-}BBC}*A_{DPGM\text{-}W})+ (C_{SHAFT\text{-}BBC}*A_{SHAFT})]+[1-(T_{GT}/19)]*24*(C_{TNL\text{-}BBC}*A_{TNL})$$

Equation 6.3-3

Where: 24 = the length of the tunnel

If the till thickness (T_{GT}) is greater that 19 ft the term ($1-T_{GT}/19$) in Equation 6.3-3 becomes negative value. This causes the total cost of the BBC (TC_{BBC}) to be less than its actual value; similarly in Equation 6.3-2 the ratio $T_{GT}/19$ has a value greater than 1 when the thickness of the till is larger than 19 ft, producing a total cost of the Glacial Till that is greater than its actual value. In addition when the sum of the Fill, Silty Sand, Sand and Boston Blue Clay layers were greater than 130, a negative thickness resulted in the till layer; this in fact had the greatest impact on producing incorrect results, as negative costs were encountered in the till layer using Equation 6.3-2 and the cost of the Boston Blue Clay layer would increase due to the term ($1-T_{GT}/19$) in Equation 6.3-3. This was dealt with by programming four IF statements into the simulation in the potentially affected layers, the Boston Blue Clay and Till. An IF statement returns a value for a specified condition if it evaluated to be TRUE and another if it is evaluated to be FALSE. See Equation 6.3-4.

IF(Logical_Test,Value_if_TRUE,Value_if_FALSE)

Equation 6.3-4

Where:

Logical_Test =	any value or expression that can be evaluated to either TRUE or FALSE.
Value_if_TRUE =	the value that is returned if the logical test is returned true.
Value_if_FALSE =	the value that is returned if the logical test is returned false.

We shall call these IF statements IF_{1BBC}, IF_{2GT} IF_{3BBC}, and IF_{4GT}. The first two IF statements were specifically relating to the cost of the deep tunnel. IF_{1BBC} is the IF statement programmed for the tunnel section in the Boston Blue Clay and IF_{2GT} two is for the tunnel section in the Glacial Till. These were used to eliminate the problems encountered by Equation 6.3-2 and Equation 6.3-3. The function of IF_{1BBC} (see Equation 6.3-5) is to return a zero value for the cost of the deep tunnel in the BBC layer if and only if the thickness of the till is greater than 19 ft. The importance of the value of 19 ft is that it is the height of the deep tunnel (see Figure 3.3-1), therefore if the till thickness is greater that 19 ft the soil that must be excavated to construct the tunnel will only be till. Should the T_{GT} layer be less than 19 ft, IF_{1BBC} will multiply the representative volume of Boston Blue Clay that must be excavated by the cost of excavation.

$$\mathbf{IF_{1BBC} = IF(T_{GT}>19,0,[1-(T_{GT<19}/19)]*24*(C_{TNL\text{-}BBC}*A_{TNL}))}$$

Equation 6.3-5

Where: $T_{GT<19}$ is a value less than 19

IF_{2GT} (see Equation 6.3-6) is the representative cost of the deep tunnel in the till. In this statement if and only if the thickness of the glacial till is greater than 19 ft, 100% of the cost of the tunnel will be included in the total cost of the till; however, if the thickness of the till is less than 19 ft a representative percentage of the volume that needs to be excavated will be multiplied by the cost of excavation. The simulation was then run again, and double checked against the base cost of $12,334,000 (see Section 6.1 and Figure 6.3-2).

During this calibration it was noticed that the cost would be correct except for circumstances where the sum of thicknesses of Fill, Silty Sand, Sand, Boston Blue Clay were greater than 130 ft.

$$\mathbf{IF_{2GT} = IF(T_{GT} > 19,[24*(C_{TNL\text{-}GT}*A_{TNL})],[24*(T_{GT}/19)*(C_{TNL\text{-}GT}*A_{TNL})])}$$

Equation 6.3-6

Where: T_{GT} is a value less than 19

If the sum of the Fill, Silty Sand, Sand and Boston Blue Clay thicknesses are greater than 130 there was a decrease in the total cost of the project as a negative thicknesses would be used in calculating the cost of the till, resulting in a negative cost. In the other layers the total thickness (would be greater than 130 ft) multiplied by the cost of construction resulting in a greater cost than the base. When summed these would result in a total cost that was less than the base cost. This was dealt with by programming IF statements which would alter the cost formulation dependent on the till thickness for both the till and Boston Blue Clay layer. The same was done for the total cost calculations of the till layer, IF_{4GT}. Equation 6.3-7 and Equation 6.3-8 are samples of IF statements programmed in to the simulation. These were then checked against a calibration simulation and all 540 calculations preformed produced the base cost of $12,334,000.

$$\mathbf{IF_{3BBC} = IF((T_F+T_{SS}+T_{SD}+T_{BBC}) < 130, [T_{BBC}*((C_{LIB\text{-}X\text{-}BBC}*A_{LIB\text{-}X})+(C_{DPGM\text{-}W\text{-}BBC}*A_{DPGM\text{-}W})+(C_{SHAFT\text{-}BBC}*A_{SHAFT}))+IF_{1BBC})], [T_{BBC}*((C_{LIB\text{-}X\text{-}BBC}*A_{LIB\text{-}X})+(C_{DPGM\text{-}W\text{-}BBC}*A_{DPGM\text{-}W})+(C_{SHAFT\text{-}BBC}*A_{SHAFT}))+T_{GT2}*((C_{LIB\text{-}X\text{-}BBC}*A_{LIB\text{-}X})+(C_{DPGM\text{-}W\text{-}BBC}*A_{DPGM\text{-}W})+(C_{SHAFT\text{-}BBC}*A_{SHAFT}))+24*C_{TNL\text{-}BBC}*A_{TNL}])}$$

Equation 6.3-7

Where: T_{GT} is a negative value as $(T_F+T_{SS}+T_{SD}+T_{BBC}) > 130$

$$\mathbf{IF_{4GT} = IF(T_{GT} <= 0,0,[T_{GT1}*((C_{LIB\text{-}X\text{-}TL}*A_{LIB\text{-}X})+(C_{DPGM\text{-}W\text{-}TL}*A_{DPGM\text{-}W})+(C_{SHAFT\text{-}TL}*A_{SHAFT}))+IF_{2GT}])}$$

Equation 6.3-8

Where: T_{GT1} is a value greater than 0

The implementation of the IF statements produced a normal distribution for both Cost and Time. Simulations were then done for a cost differential of 30% and a time differential of 100% (i.e. a cost and time increase for excavating the till), these are presented in Table 6.3-1, Figure 6.3-3, and Figure 6.3-4. Appendix G contains the raw data for a simulation of the cost differential at 30%.

Table 6.3-1 Mean and Standard Deviation for Simulations

	Calibration at 0% cost diff.	Cost Differential @ 30%		Time Differential (days) @ 100%	
		Simulation 1	Simulation 2	Simulation 1	Simulation 2
Mean	$ 12,334,934	$ 12,282,827	$ 12,260,892	133.4	132.6
Standard Deviation	$ 0.64	$ 270,650	$ 273,781	8.6	8.9

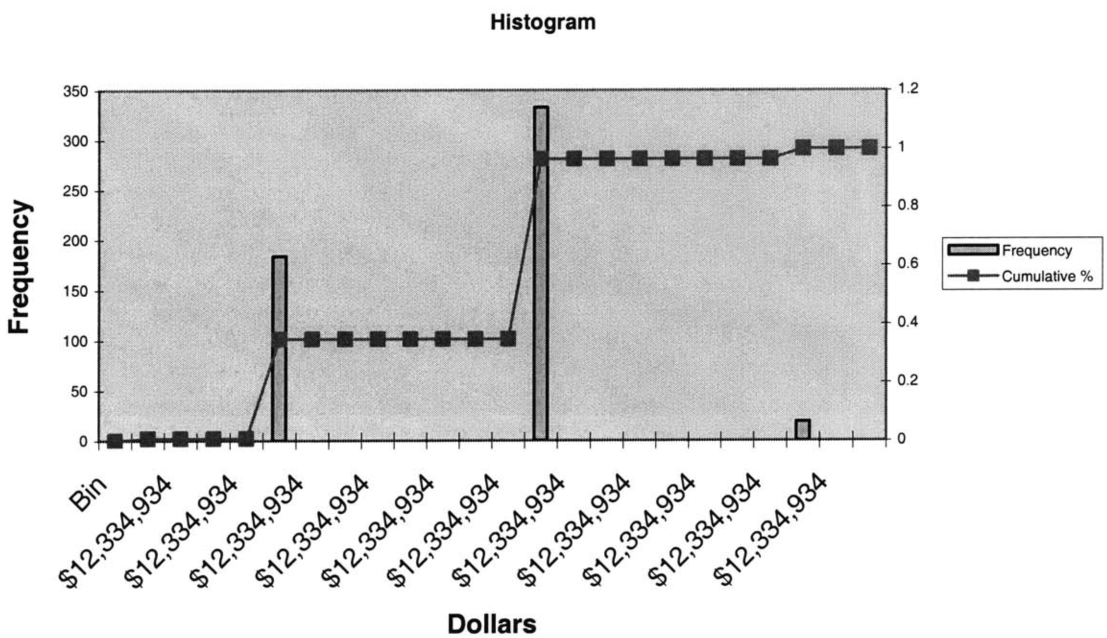


Figure 6.3-2 Histogram of Monte Carlo Simulation for a 0% Cost Differential Between Till and Other Soil

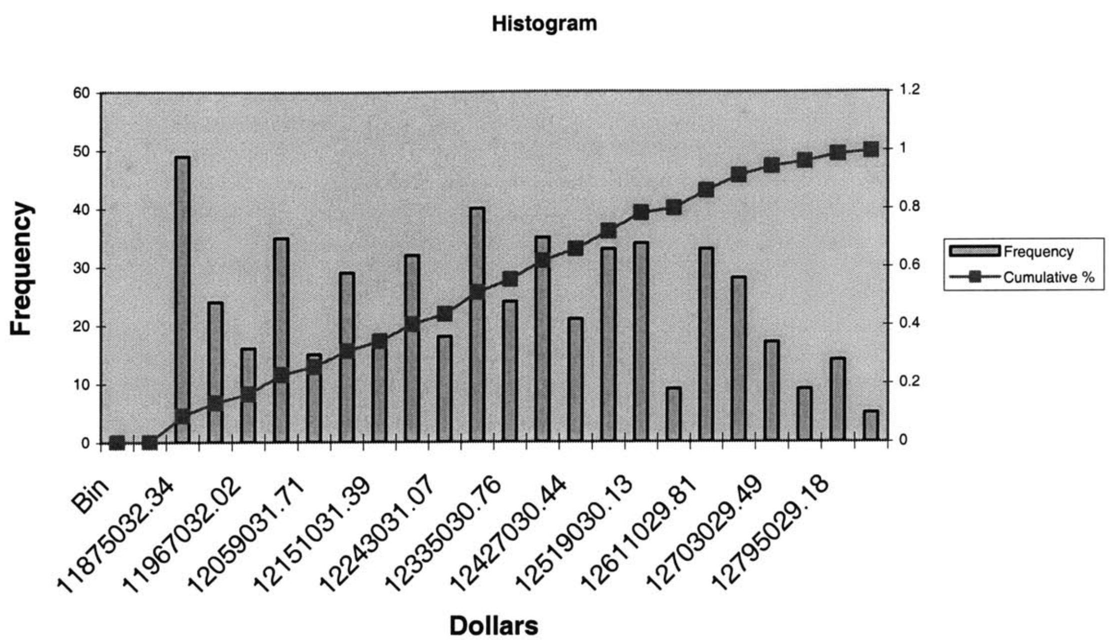


Figure 6.3-3 Histogram of Monte Carlo Simulation for a 30% Differential Between Till and Other Soil

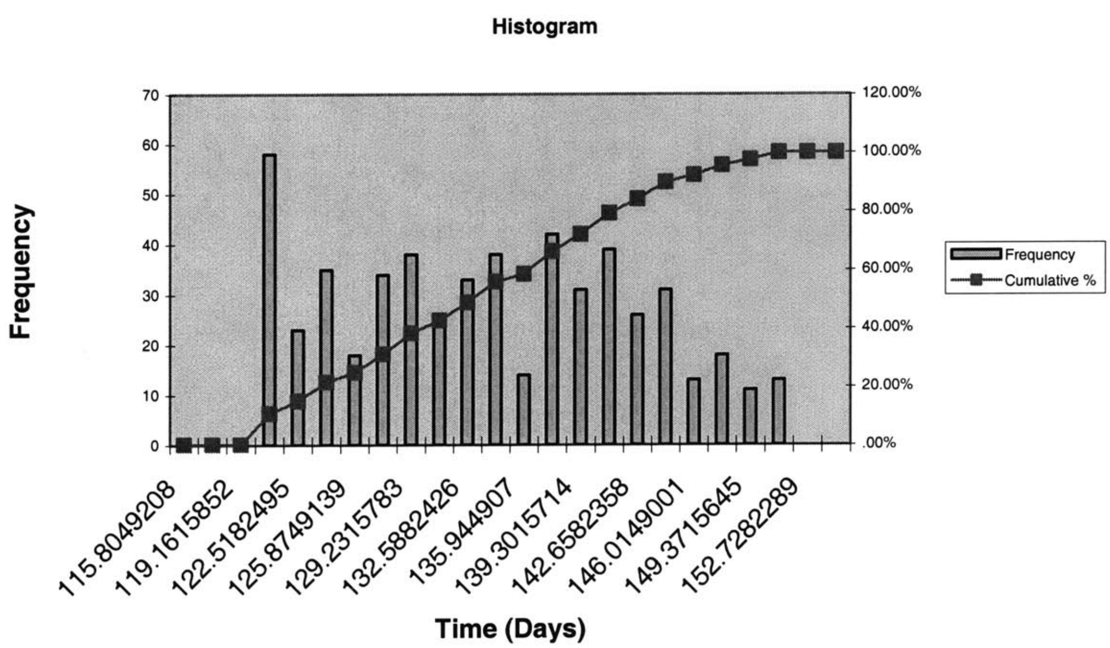


Figure 6.3-4 Histogram of Monte Carlo Simulation for a 100% Time Differential Between Till and the Other Soil

6.4 UPDATING THE VARIABILITIES OF THE MODEL

The M.Eng group recognized the presence of uncertainty in their design and stated in the report that geotechnical investigations should be preformed. Their recommendations are presented in Section 6.4.1. Additional uncertainty for the design of the library was the permeability of the till. Throughout the Greater Boston Area the variability of the permeability of the till has ranged greatly when comparing different construction projects. A search through Fermit did not produce any data on the permeability of the till; while there was abundant information on the clay layer.

The M.Eng group in their design tried to compensate for the lack of geologic information in Zone 4 by proposing a plan for geotechnical investigations and monitoring (see Section 6.4.1). They also recognized the importance of updating and used the Observational Method approach which reduces the uncertainties without formal probabilistic representation.

6.4.1 ORIGINAL PROPOSED GEOTECHNICAL INVESTIGATION AND MONITORING

The following sections outline the proposed geotechnical investigation of McDermott Court proposed by the M.Eng group.

6.4.1.1 Geotechnical Investigation

As the scope of the M.Eng Library Project did not allow one to conduct a site investigation to be performed, only a desktop study was done. The proposed geotechnical investigation they M.Eng group outlined is as follows. Twelve peripheral borings would be advanced behind the slurry wall for soil sampling only. A borehole drilled at the center of the library location would obtain not only soil samples but rock samples as well. Fourteen additional borings would be advanced within the slurry wall to sample soil and rock.

6.4.1.2 Site Monitoring and Instrumentation

Inclinometer tubes would be installed in the slurry wall in every other panel running the full height of the wall. These would also double as groundwater observation wells for the till inside the excavation because a screened inlet was designed to be exposed to the till layer at the bottom of the wall.

The exterior of the slurry wall would have six observation wells in the upper aquifer and six that extend into either the glacial till or argillite. Five inclinometers would be installed outside the slurry wall to track any possible ground movements. Laser prismatic surveying and GPS would be conducted for points within the influence of construction and buildings surrounding the site. These devices would measure horizontal and vertical displacements across the site in order to detect possible areas of settlement or lateral ground movement. The existing groundwater wells on campus would continue to monitor the groundwater levels encountered during construction. Crack gauges would also be installed in adjacent buildings and vibration monitoring would occur during heavy construction activities. Sound monitoring would ensure that excessive noise levels will not be reached during construction of the library as well.

6.4.1.3 Observational Method

As the shaft would be the first structure to be excavated to the till layer, it would be used as a test pit in which to employ the Observational Method . This would allow one to alter the design of the library should unforeseen subsurface conditions be encountered. One primary concern is the permeability of the till, which can vary dramatically. There are numerous accounts in the Boston area of till variations within localized areas. If the permeability of the till is found to be much less than anticipated, the current design may be altered resulting in a sizable cost saving. The excavated shaft and other exploratory borings would provide us with more accurate argillite properties and fracture geometries. This may have impacts on the anchor design, which will be used to control potential uplift pressures against the mat foundation of the library.

6.4.2 ADDITIONAL INFORMATION & MODEL UPDATING

The permeability of the till and argillite is identified as a parameter, that can potentially have a large impact on the project. To further update the geologic model, the collection of additional data is required, not only to update the already existing parameters but to add new parameters. It is necessary to do this as there is no actual representation of the geologic data at the proposed library site. The next step to further represent the ground conditions would be to incorporate the uncertainty of permeability in the till layer into the ground class distribution. This would have to be done through field tests. If the project were further advanced we would consider using the posterior analysis with formal Bayes' updating to aid us in deciding whether additional exploration is necessary.

Updating the model would be done through observations, such as new borings. These new observations would then be used to refine the predicted subsurface geology, such as geologic tests revealing different parameters distributions than were originally predicted; for example, the introduction of permeability distributions of the glacial till would be updated with testing, as their are no distributions for till permeability in this thesis. Initally the originally predicted permeability maybe based on the permeability of till at a different location, for example Post Office Square in Boston, MA. By conducting tests at McDermott Court we would be to incorporate the permeability of the till on site. Should the till permeability vary considerably from the permeability of Post-Office Square we would then be able to update our model to incorporate this adjustment and alter our predicted distributions for the Till permeability of McDermott Court. This would allow us to predict what the till conditions are for areas of our construction site which have not been excavated. This would also allow for us to formally update the risk of encountering an uncertainty of our geologic conditions. It is important to note that the newly obtained information from the exploration is reformulated into a likelihood function. The likelihood function expresses the probability that the new data represents, insitu conditions, it also allows us to express how well the boring represent the subsurface at McDermott Court. Therefore updating allows us to incorporate new data, alter parameter distributions accordingly, and assess whether the newly obtained data is representative of the subsurface geology.

6.5 RISK

What is the risk to the project if there is a change in geology? The risk is that the cost and duration of the project will be affected. The next step is to identify which geologic units would have the most impact on the cost of the project. The unit that the M.Eng group believed would impact the design most was the till layer. Based on the group's assessment this chapter will examine what effects the till will have on the cost and duration of the project.

In Section 6.3 a Monte Carlo Analysis for a cost differential of 30% and a time differential of 100% was performed producing distributions as those shown in Figure 6.5-1and Figure 6.5-2. Table 6.5-1 summarizes the mean cost and time for Figure 6.5-1 and Figure 6.5-2 and their respective standard deviations.

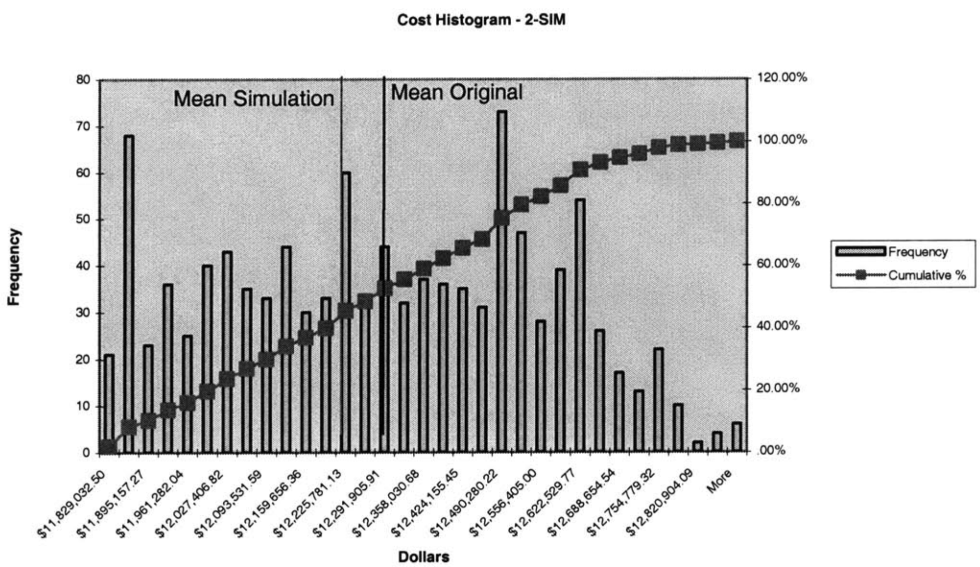


Figure 6.5-1 Cost Histogram (2 simulation equals 1080 random generations)

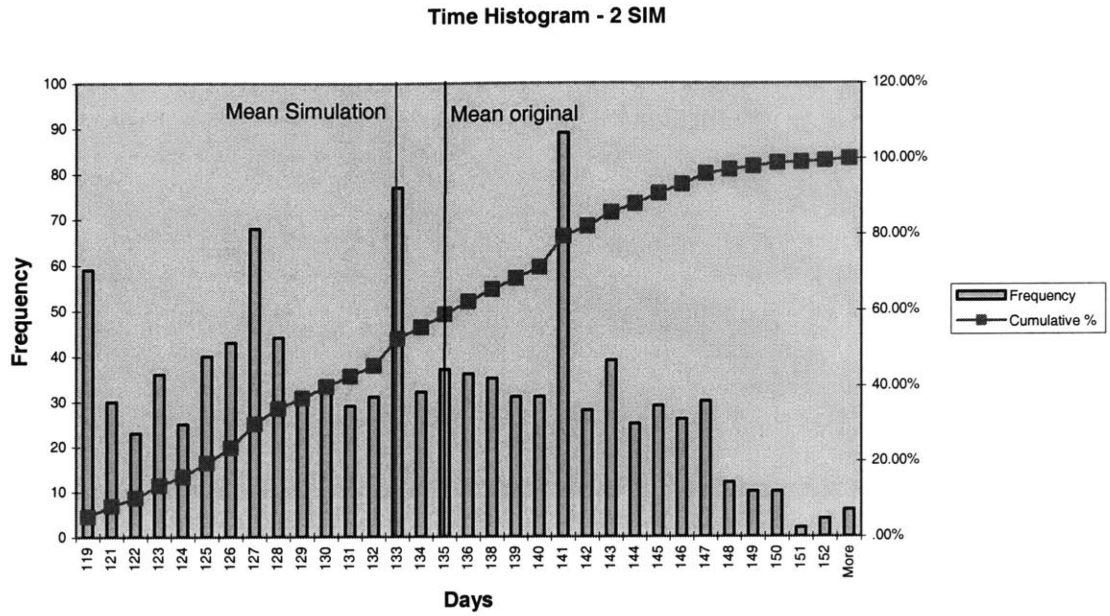


Figure 6.5-2 Time Histogram (2 simulation equals 1080 random generations)

Table 6.5-1 Mean and Standard Deviations for the Simulations

	Construction Cost	Construction Time
MEAN	$12,271,606.26	133.1
STD.DEV	$ 269,885.97	8.5

These values were then used to construct Cost-Time and Time-Cost scattergrams using 2 simulations (1080 random generations in total). See Figure 6.5-3 and Figure 6.5-4. Figure 6.5-3 and Figure 6.5-4 show that the relationship between the cost and time variables is linear, that there is high positive correlation as the variables lie near a straight line with a positive correlation. The resulting relationship between cost and duration is:

Cost = $31,725*duration(days) + $8,000,000 and Duration = 0.00003*cost-235.5days

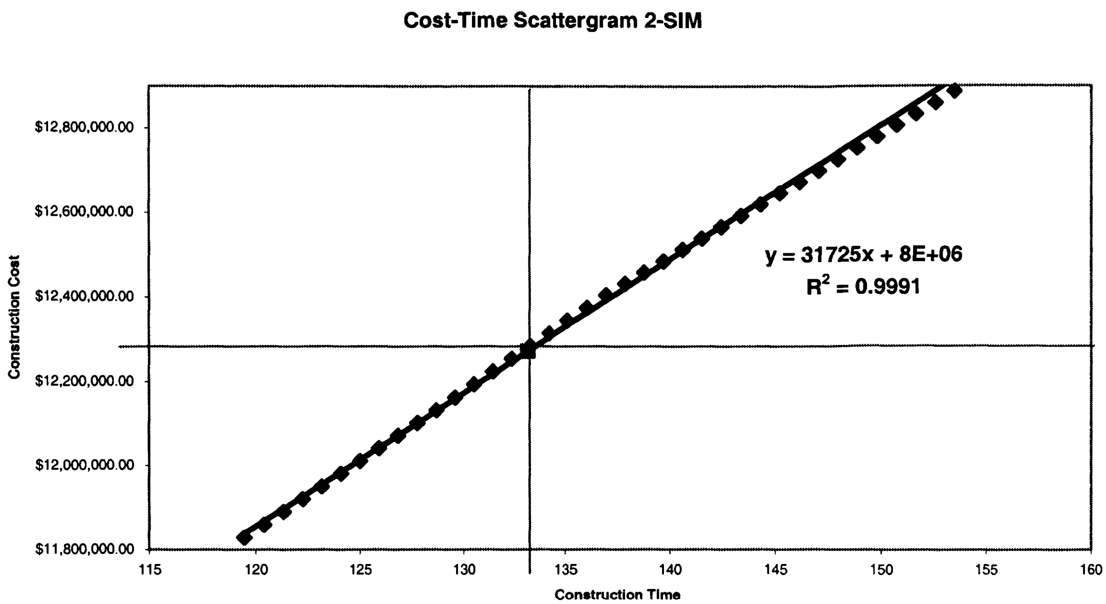


Figure 6.5-3 Cost-Time Scatter Diagram (for a 30% cost and 100% time range), Crosshairs Represent the Mean of the Cost and Time on the Respective Axes (see Table 6.5-1 for values).

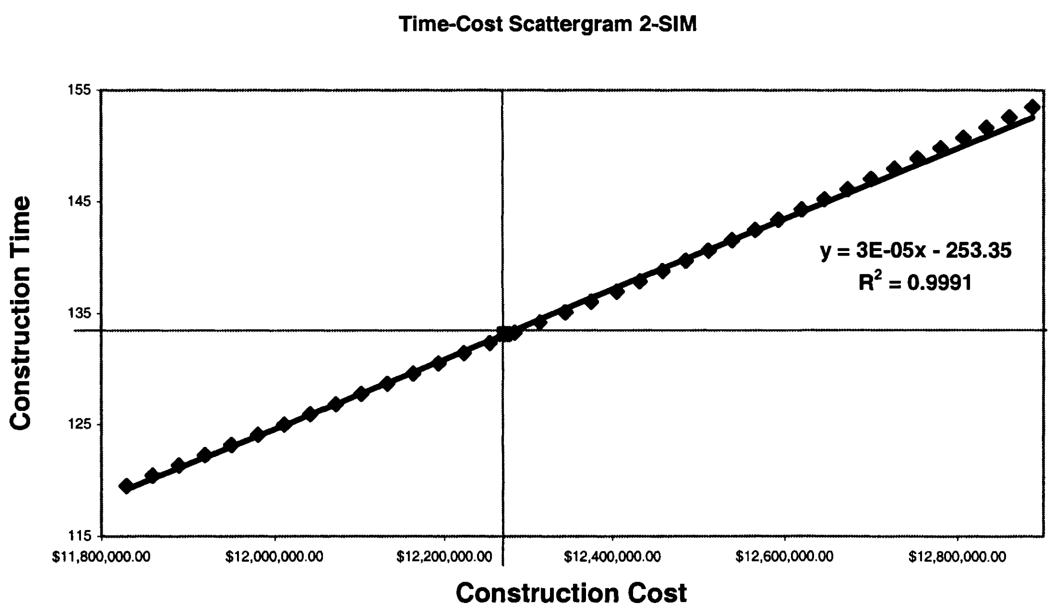


Figure 6.5-4 Time-Cost Scatter Diagram (for a 30% cost and 100% time range), Crosshairs Represent the Mean of the Cost and Time on the Respective Axes (see Table 6.5-1 for values).

In order to verify the results presented in Figure 6.5-3 and Figure 6.5-4, an additional simulation was performed. In this simulation the costs applied to the activities were varied as shown in Table 6.5-2; it is important to note that the linear time relationship was maintained. The results produced a scatter diagram that maintained a high positive correlation while the scatter increased. See Figure 6.5-5.

Table 6.5-2 Original Cost and the Altered Cost Used in the Simulation

	Library Excavation		Diaphram Wall		Shaft		Tunnel	
	Percent Increase	Percent Increase	Percent Increase	Percent Increase	Percent Increase	Percent Increase	Percent Increase	Percent Increase
	Original	**Altered**	**Original**	**Altered**	**Original**	**Altered**	**Original**	**Altered**
	Costs/cft	Costs/cft	Costs/cft	Costs/cft	Costs/cft	Costs/cft	Costs/cft	Costs/cft
Fill	$ 0.91	$ 0.40	$ 21.78	$ 15.00	$ 12.62	$ 7.00	$ 32.85	$ 23.00
Silty Sand	$ 0.91	$ 0.50	$ 21.78	$ 25.00	$ 12.62	$ 8.00	$ 32.85	$ 26.00
Sand	$ 0.91	$ 1.10	$ 21.78	$ 20.00	$ 12.62	$ 16.00	$ 32.85	$ 35.00
Boston Blue Clay	$ 0.91	$ 1.30	$ 21.78	$ 25.00	$ 12.62	$ 16.00	$ 32.85	$ 40.00
Glacial Till	$ 1.18	$ 1.50	$ 28.32	$ 30.00	$ 16.40	$ 20.00	$ 42.71	$ 50.00
Mean Cost	**$ 0.96**	**$ 0.96**	**$ 23.09**	**$ 23.00**	**$ 13.37**	**$ 13.40**	**$ 34.82**	**$ 34.80**

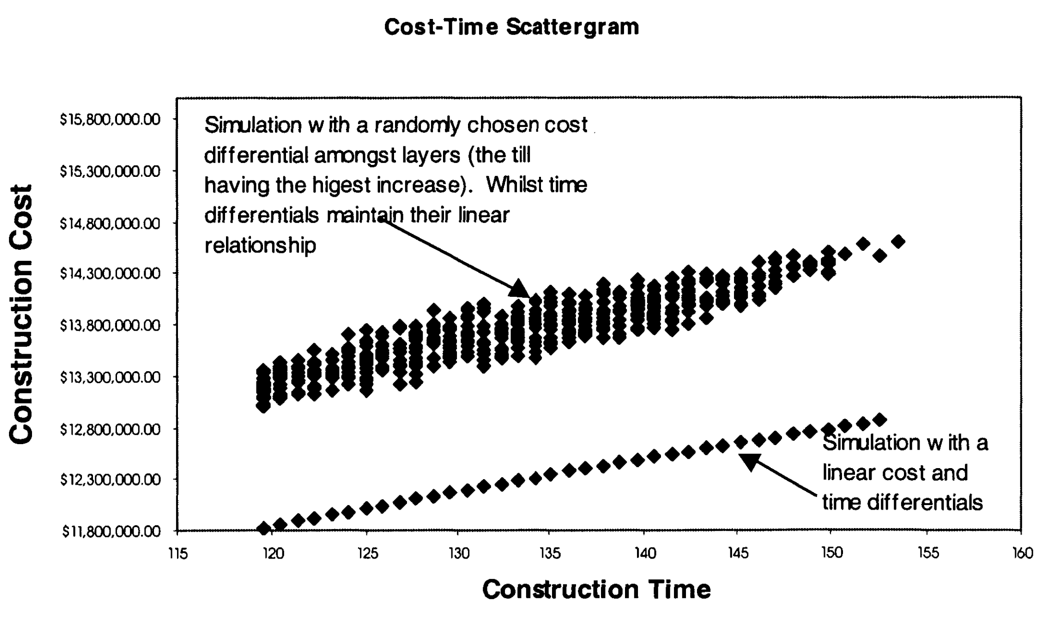


Figure 6.5-5 New Cost Differentials Resulting in a Layer Scatter

The next step is to assess the risk to the project if there is an increase in Till volume at the site. From the histograms in Figure 6.5-1and Figure 6.5-2, cost and time respectively, we can obtain the mean and standard deviation, and using these we can obtain the risk associated with a change in geology for activities 2, 3, 7, 8, 10, and 11 based on cost. In order to find the risk we need to find the cumulative risk for each bin beyond one standard deviation of the mean in the positive direction, using Equation 6.5-1.

$$\text{Risk} = \sum_{\mu_{overall}+\sigma_{overall}}^{\infty} P(a \leq X \leq b) * [\mu_{a,b} - (\mu_{overall} + \sigma_{overall})]$$

Equation 6.5-1

Where: Bin = the range between two values (i.e. between \$12,225,781 – 12,259,656)

$P(a \leq X \leq b)$ = frequency/($\sum$ frequency) of a specified bin

$\mu_{a,b}$ = the mean of the specified bin

$\mu_{overall}$ = the mean of the simulation

$\sigma_{overall}$ = the standard deviation of the overall simulation

The total risk for these activities based on a change in Till thickness \$29,595.74. The risk breakdown can be found in Table 6.5-4.

6.5.1 Decision Basis

In the previous section we found the associated risk for a change in geology. In Section 6.4.1 the proposed subsurface investigation that the M.Eng group had outlined was found to cost \$224,000. This monetary value was used to assess whether more exploration would be beneficial to the project by comparison with the value of risk. The risk for the activities most affected by a change in till thickness was found to be \$29,595.74, this is approximately a tenth the cost of exploration. Therefore in the opinion of the author the budgeted \$224,000 is better spent on determining other subsurface classifications such as detailed soil properties. Clearly, a similarly detailed risk analysisi and decision making procedure would have to be implemented before spending money on this

Table 6.5-3 Data from Cost Histogram (Figure 6.5-1)

Mean	$ 12,250,523.04		
Std.Dev	$ 278,894.14		
BETWEEN			*PROBABILTY*
a	b	*Frequency*	P(a≤X≤b)
$ 11,829,032.50	$ 11,862,094.88	21	1.9%
$ 11,862,094.88	$ 11,895,157.27	68	6.3%
$ 11,895,157.27	$ 11,928,219.66	23	2.1%
$ 11,928,219.66	$ 11,961,282.04	36	3.3%
$ 11,961,282.04	$ 11,994,344.43	25	2.3%
$ 11,994,344.43	$ 12,027,406.82	40	3.7%
$ 12,027,406.82	$ 12,060,469.20	43	4.0%
$ 12,060,469.20	$ 12,093,531.59	35	3.2%
$ 12,093,531.59	$ 12,126,593.97	33	3.1%
$ 12,126,593.97	$ 12,159,656.36	44	4.1%
$ 12,159,656.36	$ 12,192,718.75	30	2.8%
$ 12,192,718.75	$ 12,225,781.13	33	3.1%
$ 12,225,781.13	$ 12,258,843.52	60	5.6%
$ 12,258,843.52	$ 12,291,905.91	33	3.1%
$ 12,291,905.91	$ 12,324,968.29	44	4.1%
$ 12,324,968.29	$ 12,358,030.68	32	3.0%
$ 12,358,030.68	$ 12,391,093.07	37	3.4%
$ 12,391,093.07	$ 12,424,155.45	36	3.3%
$ 12,424,155.45	$ 12,457,217.84	35	3.2%
$ 12,457,217.84	$ 12,490,280.22	31	2.9%
$ 12,490,280.22	$ 12,523,342.61	73	6.8%
$ 12,523,342.61	$ 12,556,405.00	47	4.4%
$ 12,556,405.00	$ 12,589,467.38	28	2.6%
$ 12,589,467.38	$ 12,622,529.77	39	3.6%
$ 12,622,529.77	$ 12,655,592.16	54	5.0%
$ 12,655,592.16	$ 12,688,654.54	26	2.4%
$ 12,688,654.54	$ 12,721,716.93	17	1.6%
$ 12,721,716.93	$ 12,754,779.32	13	1.2%
$ 12,754,779.32	$ 12,787,841.70	22	2.0%
$ 12,787,841.70	$ 12,820,904.09	10	0.9%
$ 12,820,904.09	$ 12,853,966.47	2	0.2%
$ 12,853,966.47	++	10	0.9%
SUM		1080	100.0%

Table 6.5-4 Summary of Risk Based on Table 6.5-3

Mean	$12,250,523.04			
Std.Dev	$ 278,894.14			
BETWEEN		*Frequency*	*PROBABILITY*	RISK
a	b		P(a≤X≤b)	$= P(a \le X \le b) * \mu_{a,b}$
$12,523,342.61	$12,556,405.00	47	4.4%	$ 455.06
$12,556,405.00	$12,589,467.38	28	2.6%	$ 1,128.27
$12,589,467.38	$12,622,529.77	39	3.6%	$ 2,765.44
$12,622,529.77	$12,655,592.16	54	5.0%	$ 5,482.19
$12,655,592.16	$12,688,654.54	26	2.4%	$ 3,435.52
$12,688,654.54	$12,721,716.93	17	1.6%	$ 2,766.73
$12,721,716.93	$12,754,779.32	13	1.2%	$ 2,513.71
$12,754,779.32	$12,787,841.70	22	2.0%	$ 4,927.46
$12,787,841.70	$12,820,904.09	10	0.9%	$ 2,545.89
$12,820,904.09	$12,853,966.47	2	0.2%	$ 570.40
$12,853,966.47	++	10	0.9%	$ 3,005.09
SUM		**47**	**4.4%**	**$ 29,595.74**

7 CONCLUSIONS & RECOMMENDATIONS

The mean thickness and standard deviation of the geologic layers represented in Zone 4 were obtained by using the available boring data which surround McDermott Court: for the Fill layer 10.1 ± 3.4 ft., for the Silty Sand layer 16.3 ± 6.1 ft., for the Sand layer 5.2 ± 3.2 ft., for the Boston Blue Clay layer 83.7 ± 15.2 ft., and the Glacial Till layer 44.0±14.1 ft. This information was used in a Monte Carlo simulation to estimate cost and time of construction using a 30% cost differential and 100% time differential between the till layer and the other soils. The findings from the Monte Carlo simulation showed that the mean cost was $12,250,523 with a standard deviation of ± $278,894 and the mean time was 133 with a standard deviation of ± 9 days for 1080 random generations. The risk for the project was then found by finding the cumulative risk beyond one standard deviation in the positive direction; this was found to be $29,595.74, which is approximately 10% of the cost of exploration, and 0.25% of the cost of the critical activities (2, 3, 7, 8, 10, and 11), $12,334,000. A value for the risk (associated with a change in thickness of till) less than the cost of exploration indicates that the focus of the investigation should be geared towards soil parameters such as permeability in the till and Cambridge Argillite, rather than the layer thickness or location. Without doubt there is a need for further exploration; however before spending funds on exploration a detailed risk analysis and a decision making procedure needs to be implemented to plan a suitable exploration program. Such an exploration program and the associated risk analysis might include:

- Till permeability
- Sand lenses with high permeability in the till
- Cambridge Argillite permeability
- Impact of varying permeability on:
    - Tie-downs
    - Uplift pressures
    - Basal heave during construction

The permeability of the till and argillite could be found using the Fermit database as the location of all the piezometers on campus are noted. These piezometers could be used to obtain confirmation on the hydraulic conductivity. It is important to note that only some piezometers may still work as they have not been in use for extended periods of time, as well not all working piezometer would extend to depths in which the till or argillite is encountered.

8 REFERENCES:

Archives. Building Plan MG00U58.01. Department of Facilities. M.I.T.1950

Archives. Building Plan MG00U58.01. Department of Facilities. M.I.T.1972

Archives. Building Plan MG14s02.00. Department of Facilities. M.I.T.1948

Archives. Building Plan MG14s03.00. Department of Facilities. M.I.T. 1948

Archives. Building Plan MG14s04.00. Department of Facilities. M.I.T. 1948

Archives. Building Plan MG14s05.00. Department of Facilities. M.I.T. 1948

Archives. Building Plan MG14s06.00. Department of Facilities. M.I.T. 1948

Archives. Building Plan MG14s07.00. Department of Facilities. M.I.T. 1948

Archives. Building Plan MG18s01.00. Department of Facilities. M.I.T. 1967

Archives. Building Plan MG18s02.00. Department of Facilities. M.I.T. 1967

Archives. Building Plan MG18s03.00. Department of Facilities. M.I.T. 1967

Archives. Building Plan MG18s06.00. Department of Facilities. M.I.T. 1967

Archives. Building Plan MG50s01.00. Department of Facilities. M.I.T. 1967

Archives. Building Plan MG50s01.00. Department of Facilities. M.I.T. 1916

Archives. Building Plan MG50s02.00. Department of Facilities. M.I.T. 1916

Archives. Building Plan MG50s03.00. Department of Facilities. M.I.T. 1916

Archives. Building Plan MG54s01.00. Department of Facilities. M.I.T. 1916

Archives. Building Plan MG54s02.00. Department of Facilities. M.I.T. 1916

Archives. Building Plan MG54s11.00. Department of Facilities. M.I.T. 1964

Archives. Building Plan MG62s01.05. Department of Facilities. M.I.T. 1923

Archives. Plan – East Campus Plot Plan Cable Redistribution. Department of Facilities. M.I.T. 1988

Archives. Plan – East Conduit Distribution. Department of Facilities. M.I.T. 1988

Archives. Plan 105A SS 1A. Department of Facilities. M.I.T. 1971

Archives. Plan 105A ST 1A. Department of Facilities. M.I.T. 1979

Archives. Plan 105A wa 1A. Department of Facilities. M.I.T. 1979

Archives. Plan 105B CH 1A. Department of Facilities. M.I.T. 1972

Becker, James M. and Haley, "Mark X. Up/Down Construction – Decision Making Performance." Design and Performance of Earth Retaining Structures Proceeding/ Geotechnical Engineering Division of Cornell University. Ithaca, New York: June 18 – 21, 1990.

Chatfield, Chris. Statistics for Technology A course in Applied Statistics.Chapman & Hall. London, UK:1996

De Fries-Von Arnim, K.C. The Predicition of Heaves and Pore Pressures Induced By Excavations, M.S. Thesis, Department of Civil Engineering, M.I.T., 1967.

Einstein, Herbert, H. "Risk and Risk Analysis in Rock Engineering." Keynot Lecture Swedish Rock Mechanics Day. 1995.

Einstein, H. H. "Reliabilty in Rock Engineering." Preprint Geotechnical Congress. Boulder, Colorado: 1991

Einstein, H. H. "Application of Probabilistic Approaches in Geotechnical Engineering and Engineering Geology." Probmat. 1993

Fermit. Book – N Piezometer Data. Department of Facilities. M.I.T. 1971

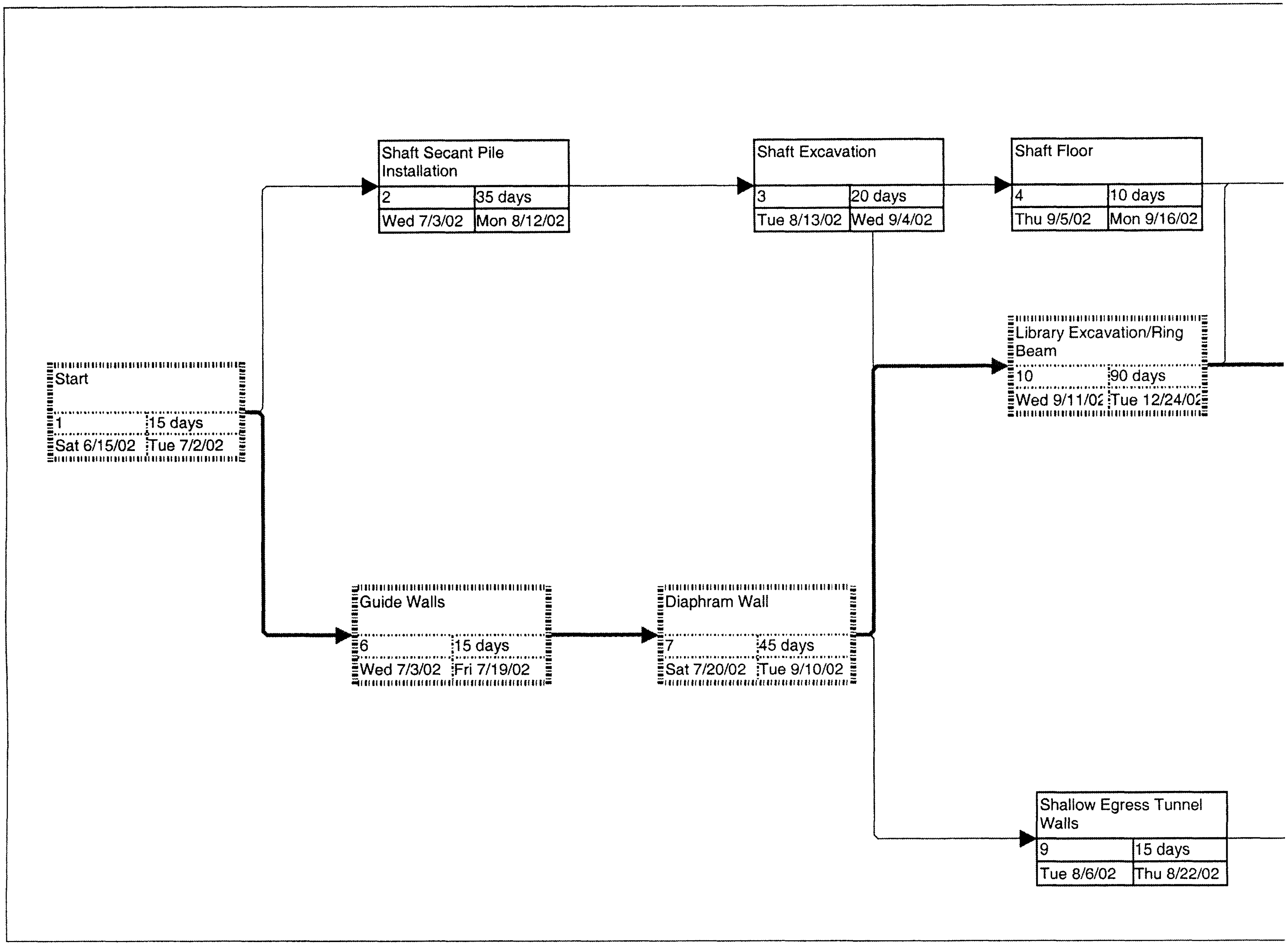
Fermit. Second Progress Report on Foundation Evaluation and Research. Department of Facilities. M.I.T. 1967

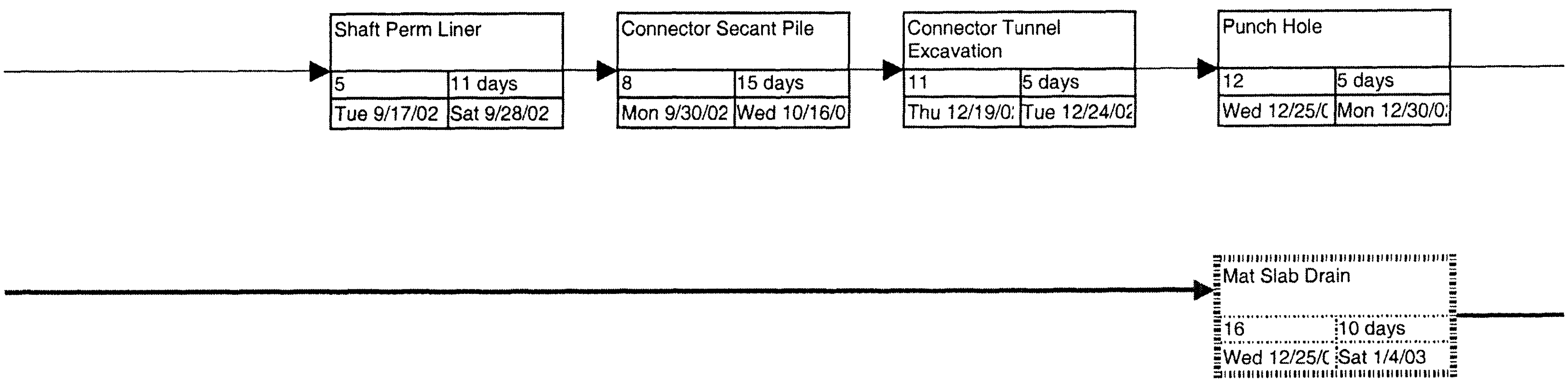
Johnson, E.G. Geotechnical Charateristics of the Boston Area. Civil Engineering Practice. v.1 Spring, 1989

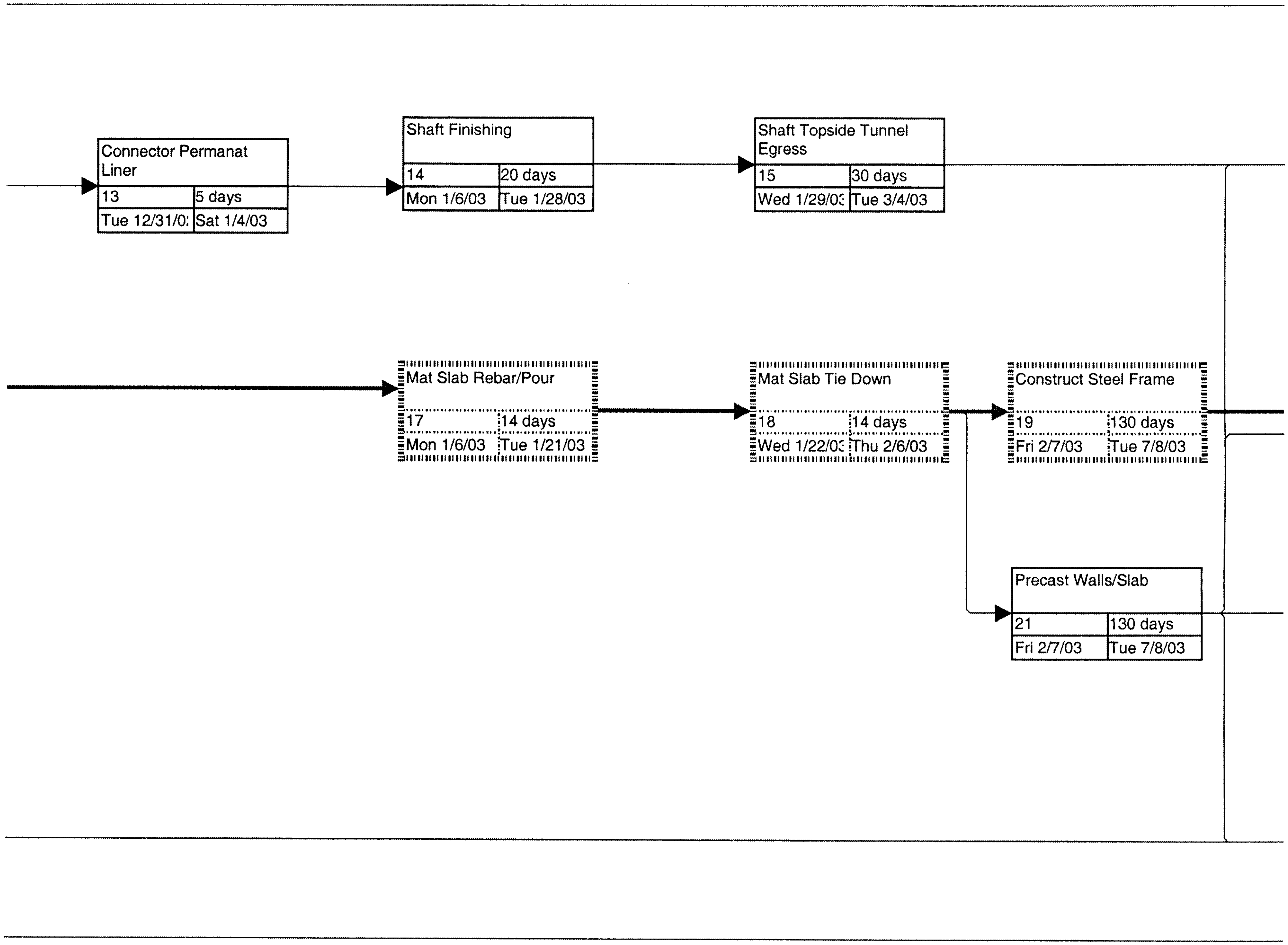
Ladd, C.C. and Lusher, L. Engineering Properties of the Soils Underlying the MIT Campus. Research Report R65-58, Soil Mechanics Publication 185, Devember 1965.

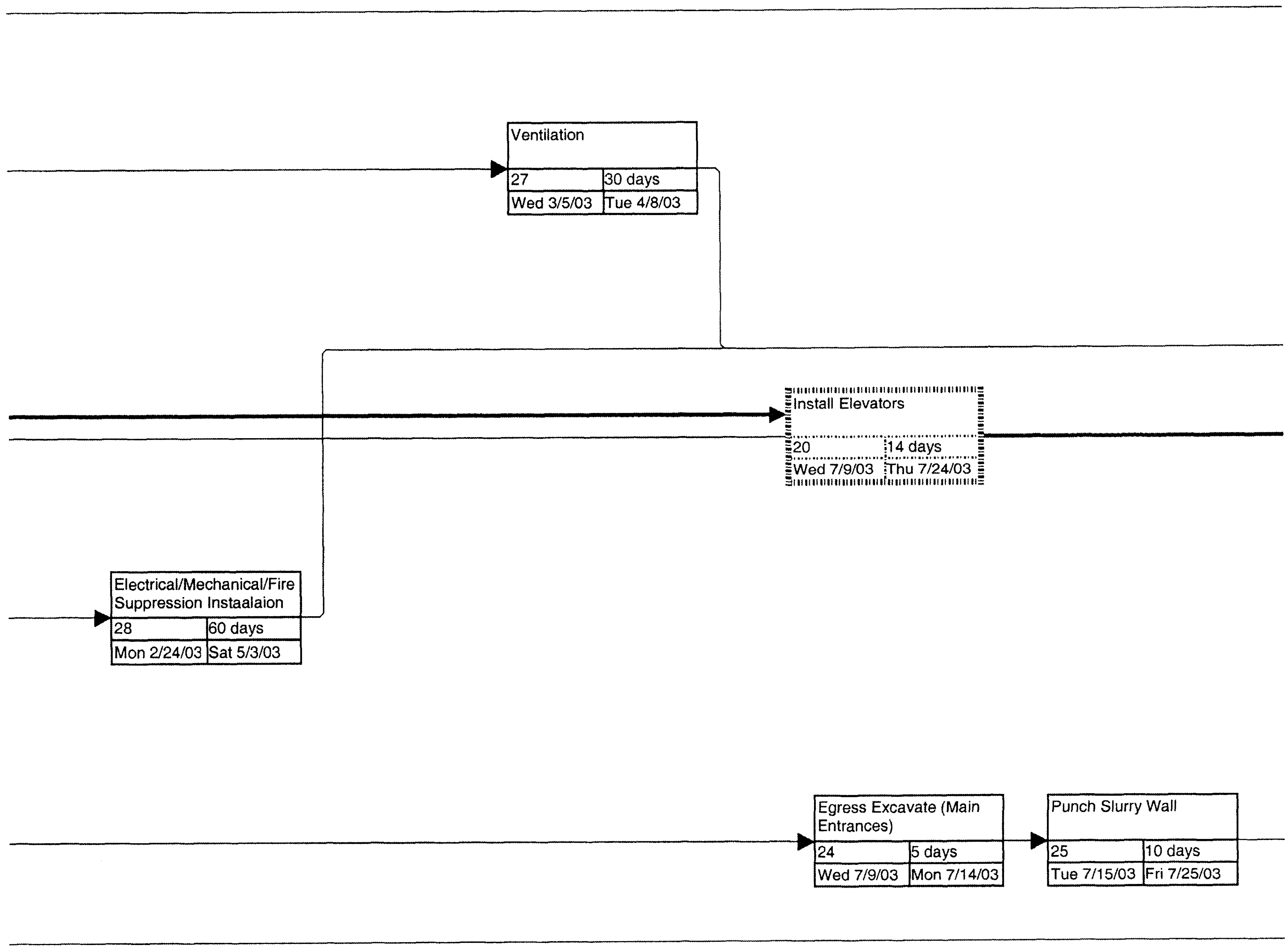
Whittle, A. J. Course Notes 1.364. Department of Civil Engineering. M.I.T: 2000

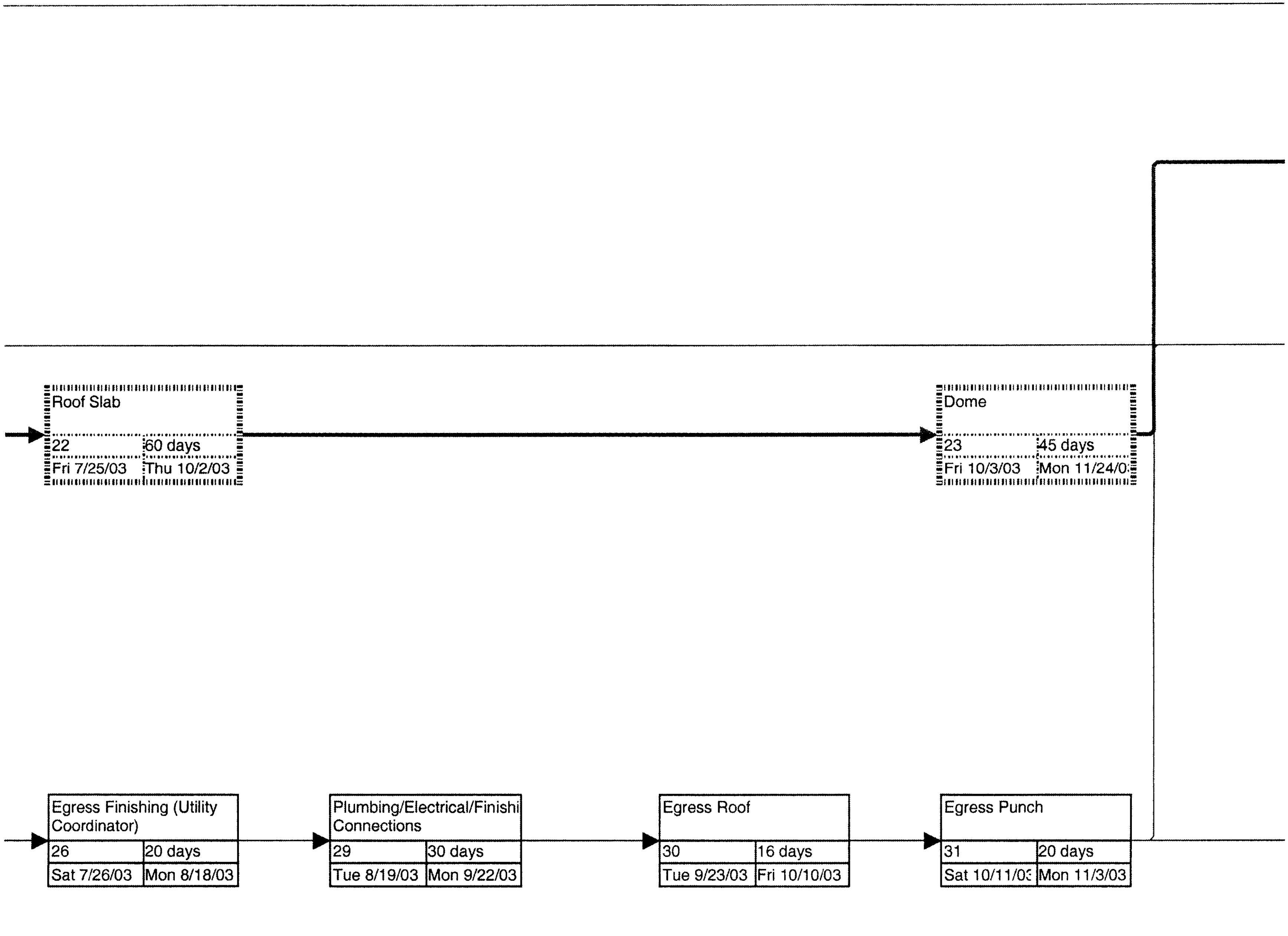
APPENDIX A
Project Scheduling

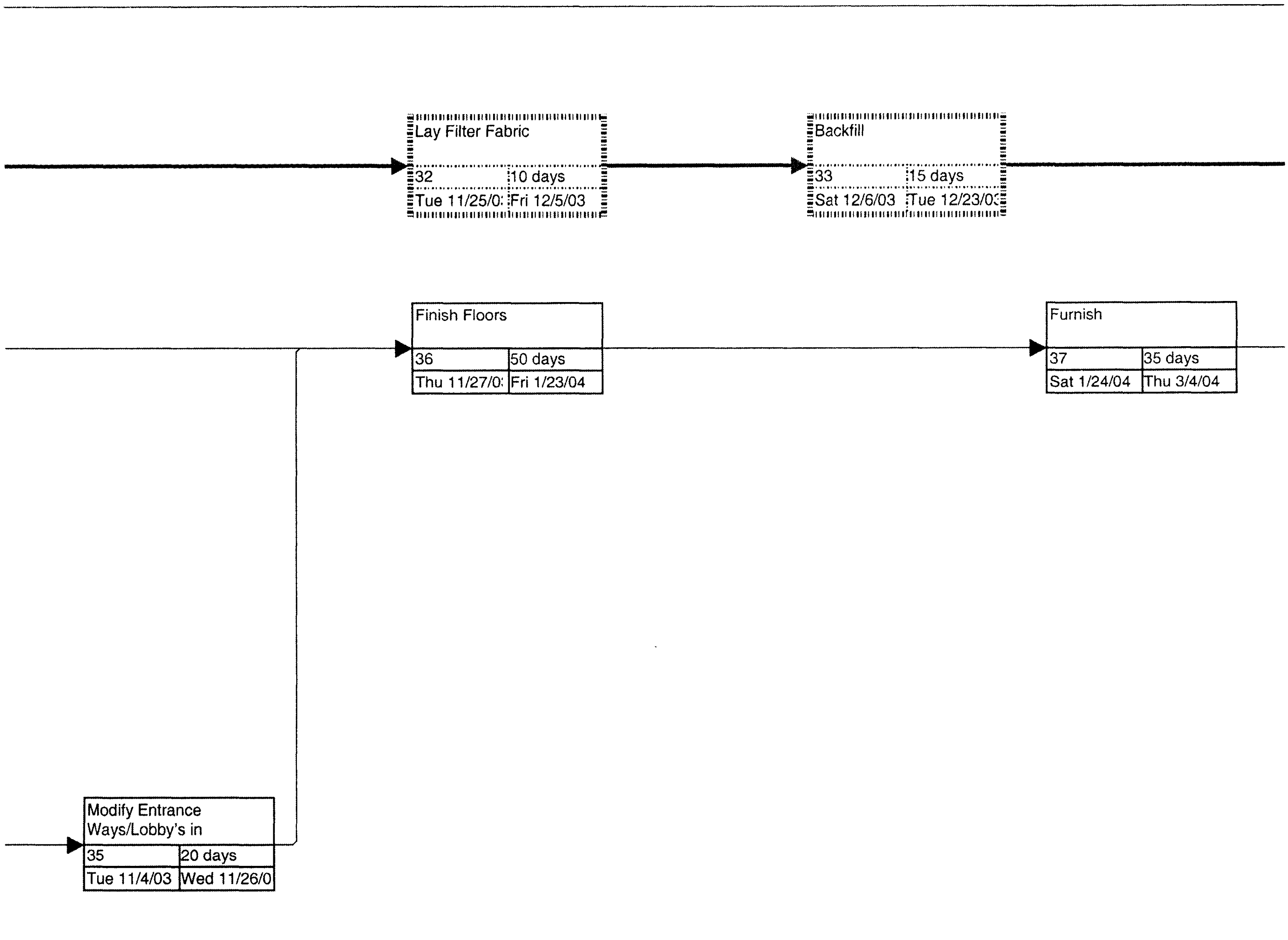

Start
1
15 days
Sat 6/15/02
Tue 7/2/02
Shaft Secant Pile Installation
2
35 days
Wed 7/3/02
Mon 8/12/02
Shaft Excavation
3
20 days
Tue 8/13/02
Wed 9/4/02
Shaft Floor
4
10 days
Thu 9/5/02
Mon 9/16/02
Library Excavation/Ring Beam
10
90 days
Wed 9/11/02
Tue 12/24/02
Guide Walls
6
15 days
Wed 7/3/02
Fri 7/19/02
Diaphram Wall
7
45 days
Sat 7/20/02
Tue 9/10/02
Shallow Egress Tunnel Walls
9
15 days
Tue 8/6/02
Thu 8/22/02

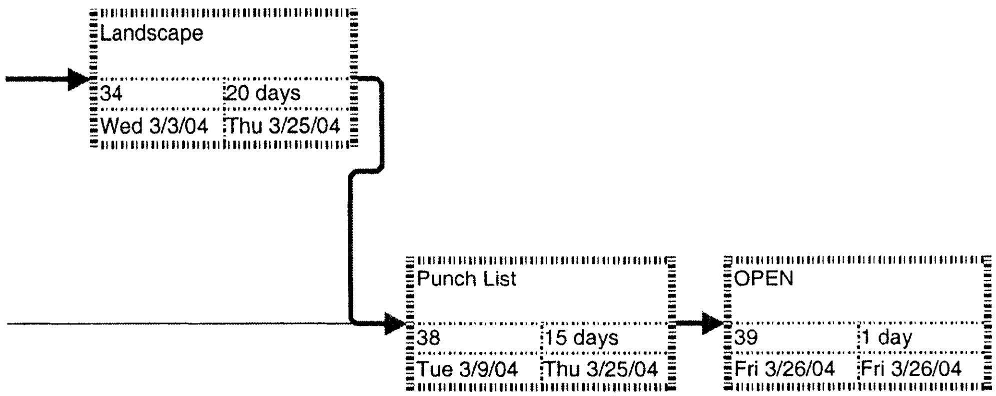

Shaft Perm Liner
5
11 days
Tue 9/17/02
Sat 9/28/02
Connector Secant Pile
8
15 days
Mon 9/30/02
Wed 10/16/0
Connector Tunnel Excavation
11
5 days
Thu 12/19/0
Tue 12/24/02
Punch Hole
12
5 days
Wed 12/25/(
Mon 12/30/0
Mat Slab Drain
16
10 days
Wed 12/25/(
Sat 1/4/03


Connector Permanat Liner
13
5 days
Tue 12/31/0:
Sat 1/4/03
Shaft Finishing
14
20 days
Mon 1/6/03
Tue 1/28/03
Shaft Topside Tunnel Egress
15
30 days
Wed 1/29/0:
Tue 3/4/03
Mat Slab Rebar/Pour
17
14 days
Mon 1/6/03
Tue 1/21/03
Mat Slab Tie Down
18
14 days
Wed 1/22/0:
Thu 2/6/03
Construct Steel Frame
19
130 days
Fri 2/7/03
Tue 7/8/03
Precast Walls/Slab
21
130 days
Fri 2/7/03
Tue 7/8/03


Ventilation
27
30 days
Wed 3/5/03
Tue 4/8/03
Install Elevators
20
14 days
Wed 7/9/03
Thu 7/24/03
Electrical/Mechanical/Fire Suppression Instaalaion
28
60 days
Mon 2/24/03
Sat 5/3/03
Egress Excavate (Main Entrances)
24
5 days
Wed 7/9/03
Mon 7/14/03
Punch Slurry Wall
25
10 days
Tue 7/15/03
Fri 7/25/03


Roof Slab
22
60 days
Fri 7/25/03
Thu 10/2/03
Dome
23
45 days
Fri 10/3/03
Mon 11/24/0
Egress Finishing (Utility Coordinator)
26
20 days
Sat 7/26/03
Mon 8/18/03
Plumbing/Electrical/Finishi Connections
29
30 days
Tue 8/19/03
Mon 9/22/03
Egress Roof
30
16 days
Tue 9/23/03
Fri 10/10/03
Egress Punch
31
20 days
Sat 10/11/0
Mon 11/3/03

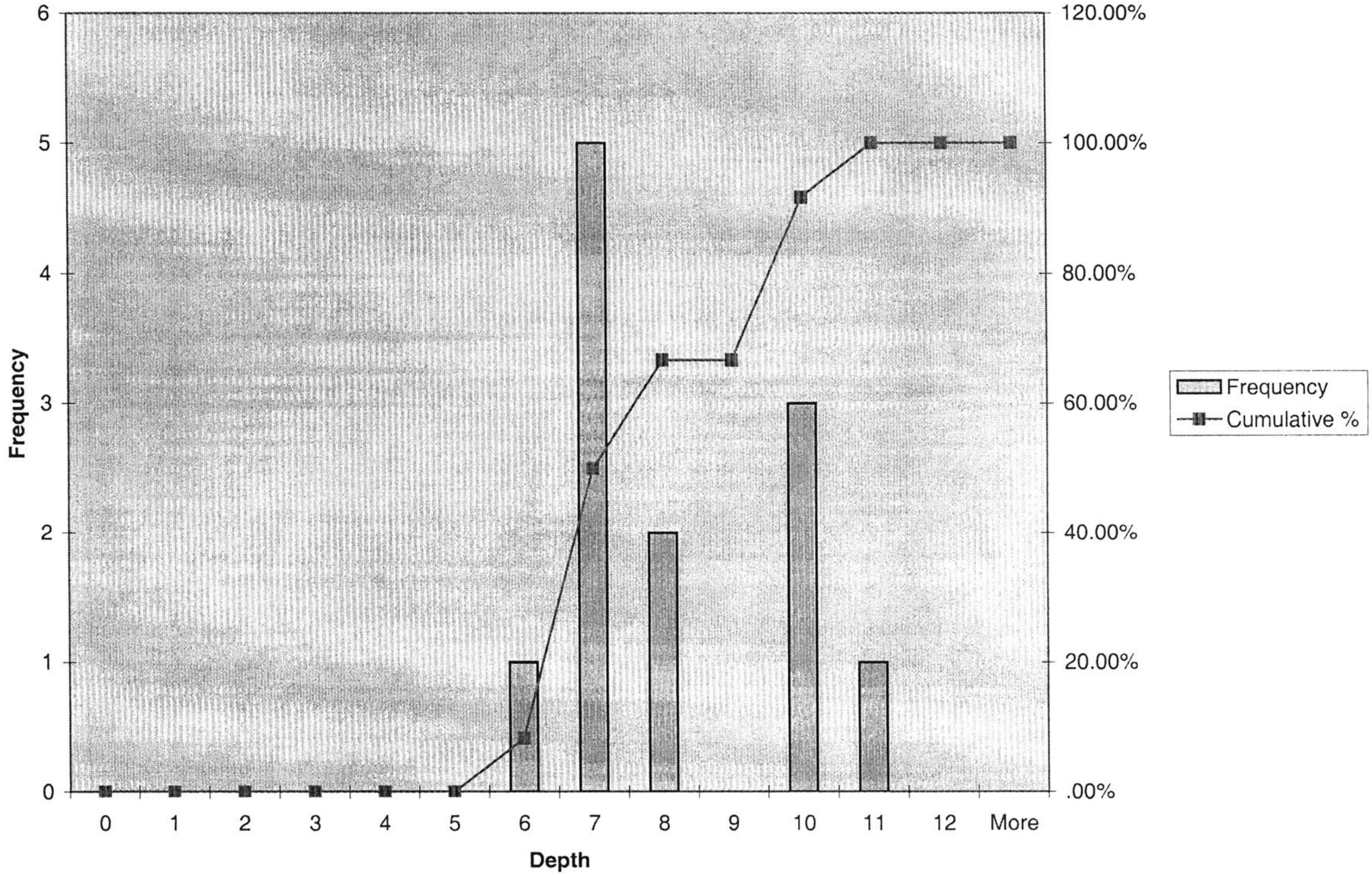

Lay Filter Fabric
32
10 days
Tue 11/25/0:
Fri 12/5/03
Backfill
33
15 days
Sat 12/6/03
Tue 12/23/0:
Finish Floors
36
50 days
Thu 11/27/0:
Fri 1/23/04
Furnish
37
35 days
Sat 1/24/04
Thu 3/4/04
Modify Entrance
Ways/Lobby's in
35
20 days
Tue 11/4/03
Wed 11/26/0


Landscape
34
20 days
Wed 3/3/04
Thu 3/25/04
Punch List
38
15 days
Tue 3/9/04
Thu 3/25/04
OPEN
39
1 day
Fri 3/26/04
Fri 3/26/04

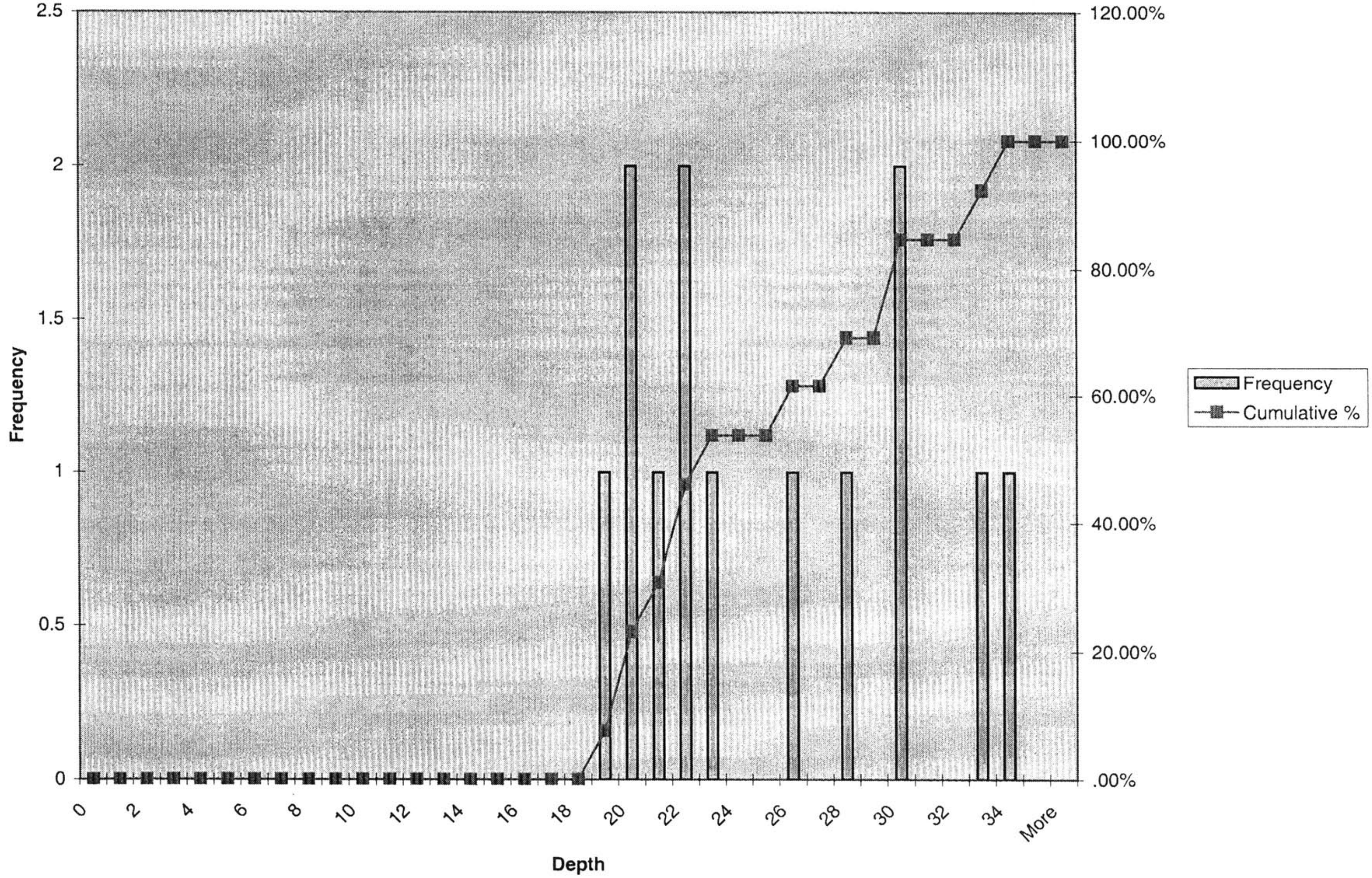
APPENDIX B

Zone 1 data and Corresponding Parameter Histograms

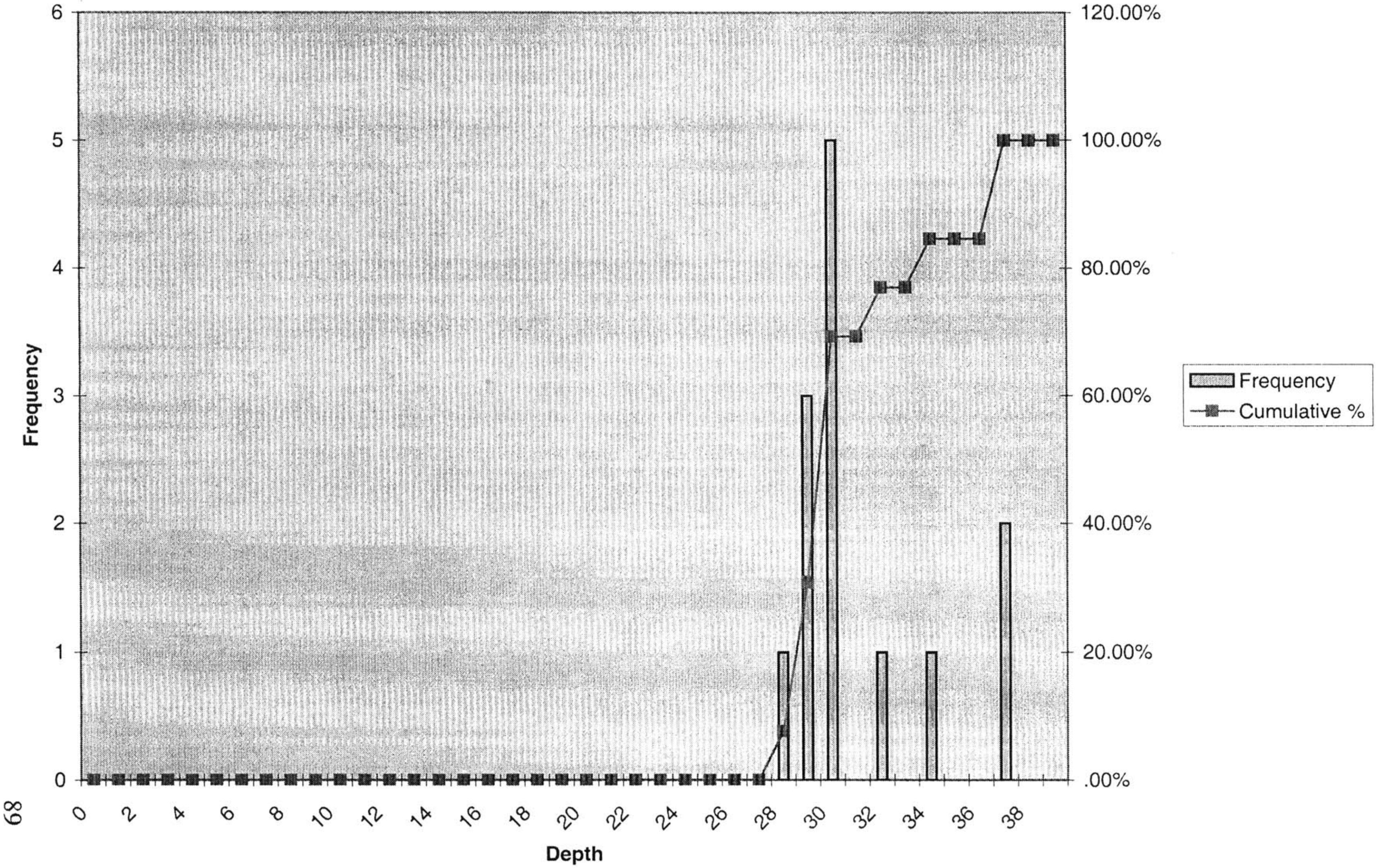
Histogram for Upper Bound of Silty Sand



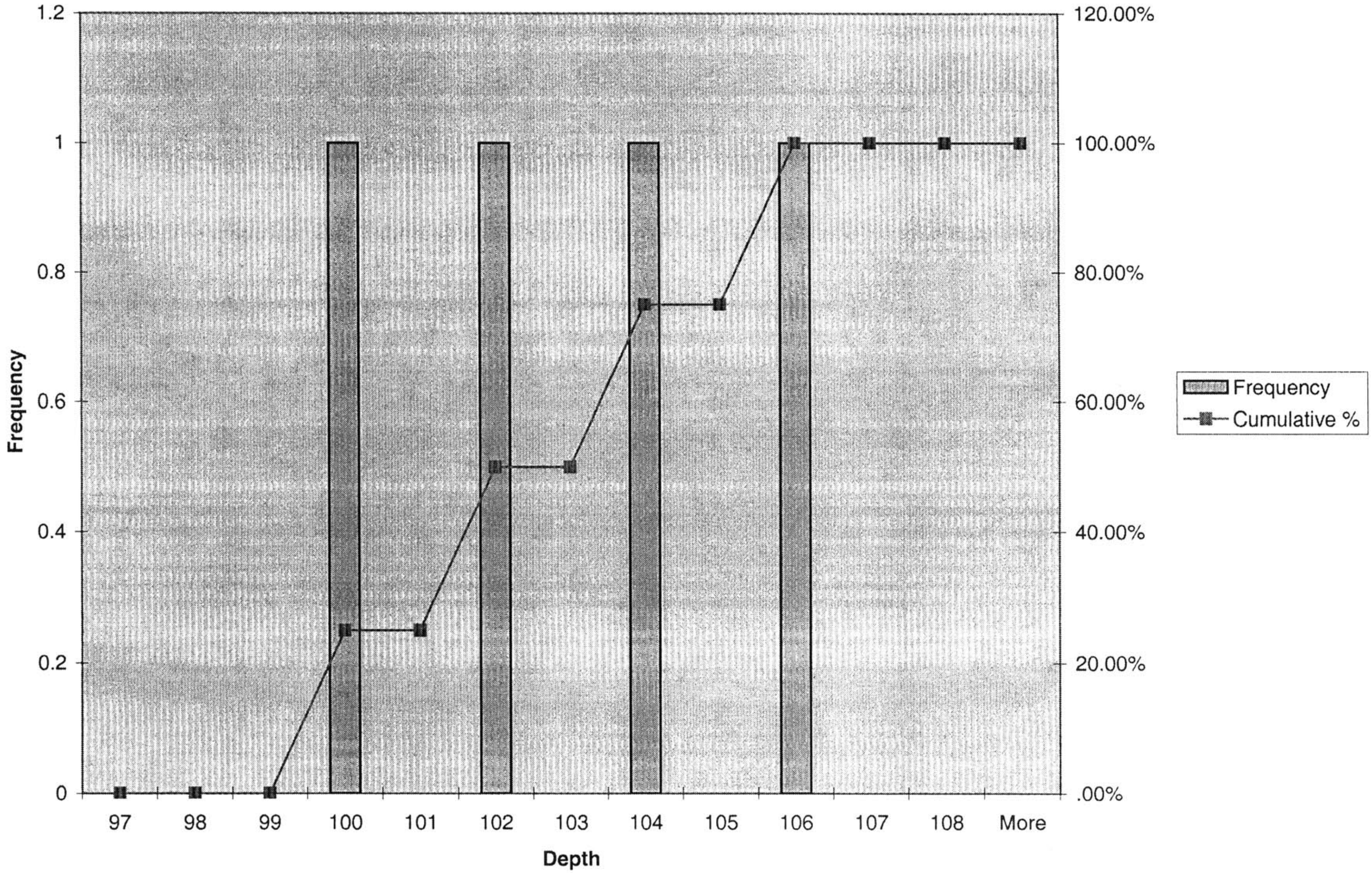
Histogram for Upper Bound of Sand



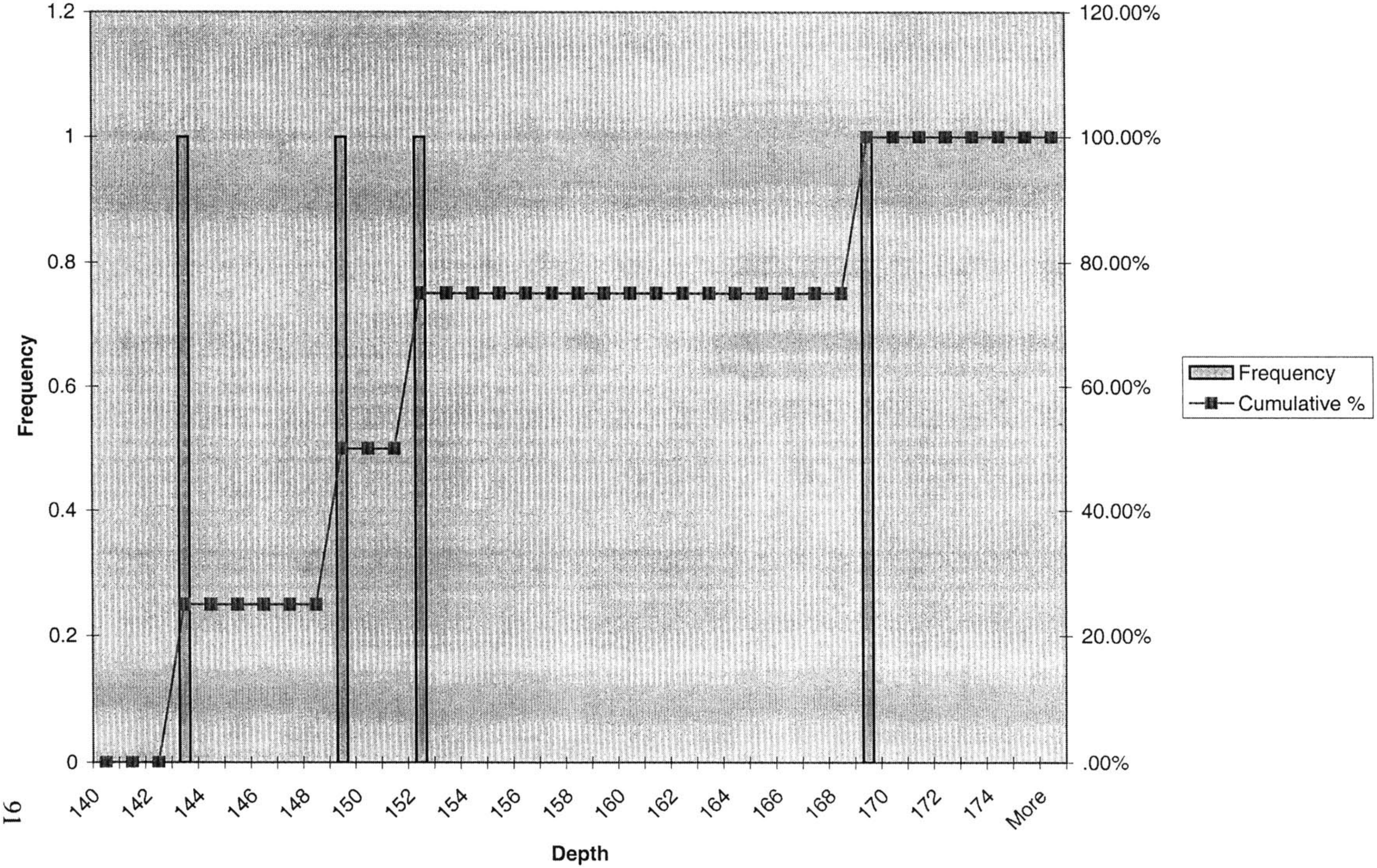
Histogram for Upper Bound of Boston Blue Clay



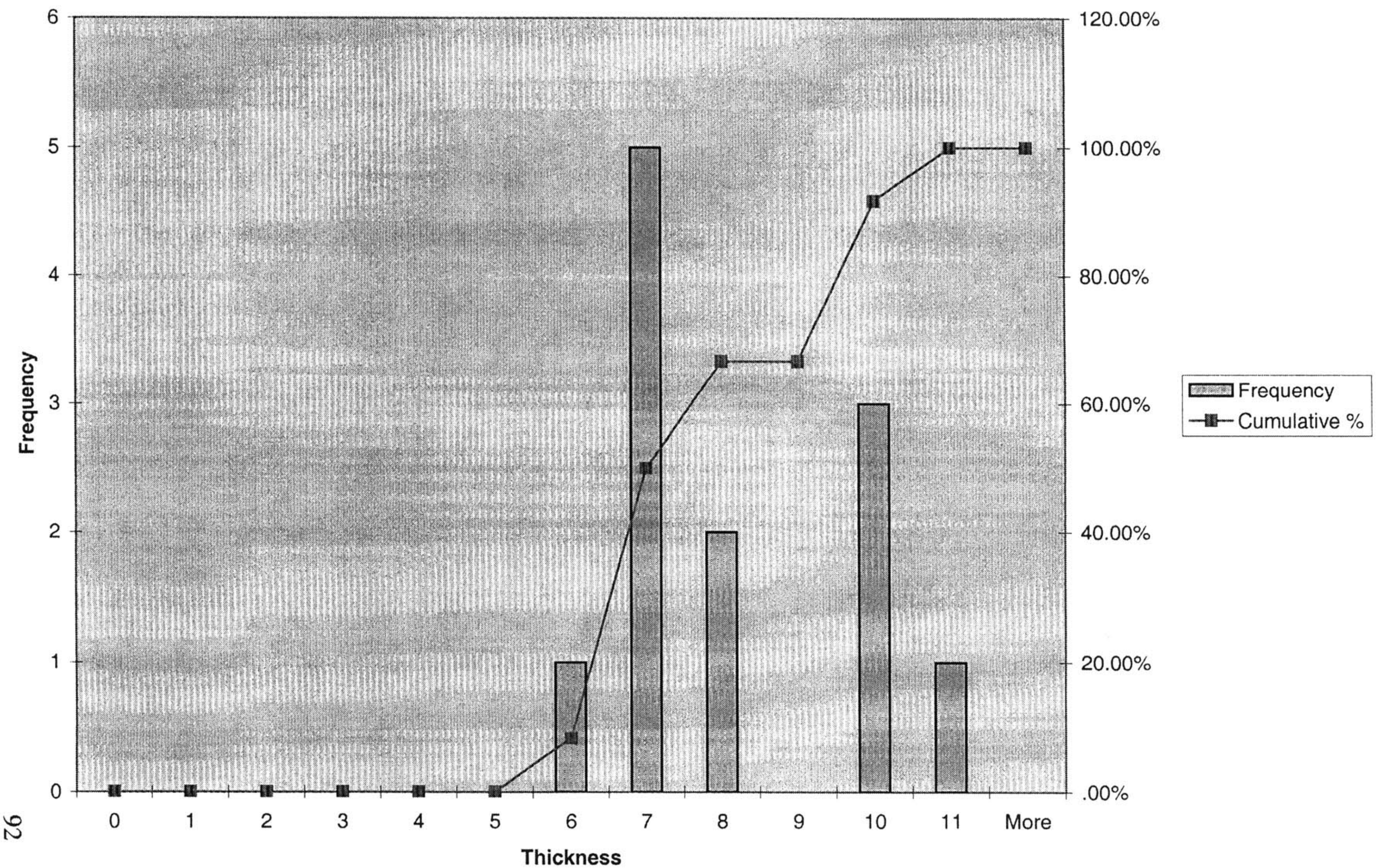
Histogram for Upper Bound of Glacial Till



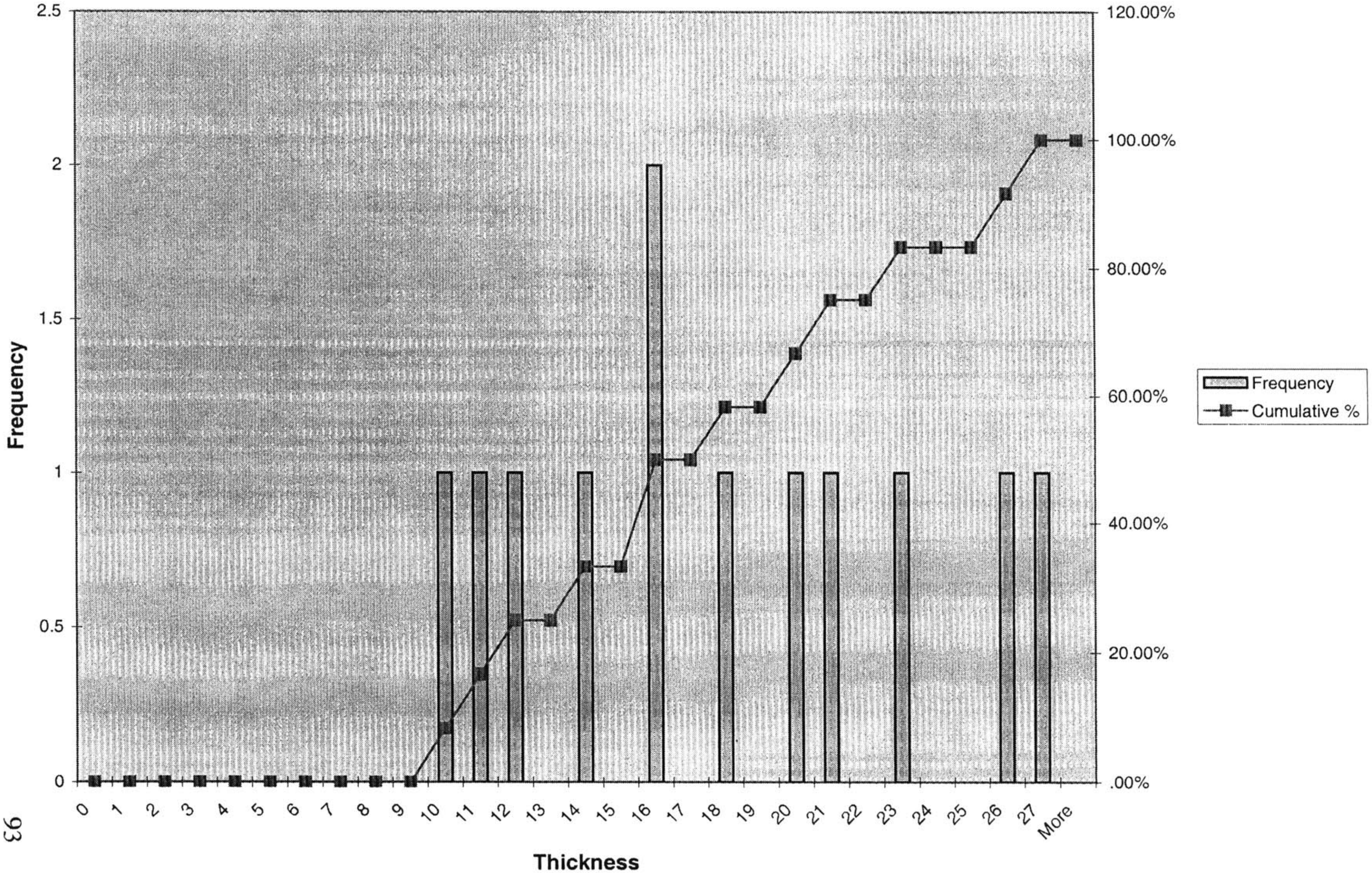
Histogram for Upper Bound of Cambridge Argillite

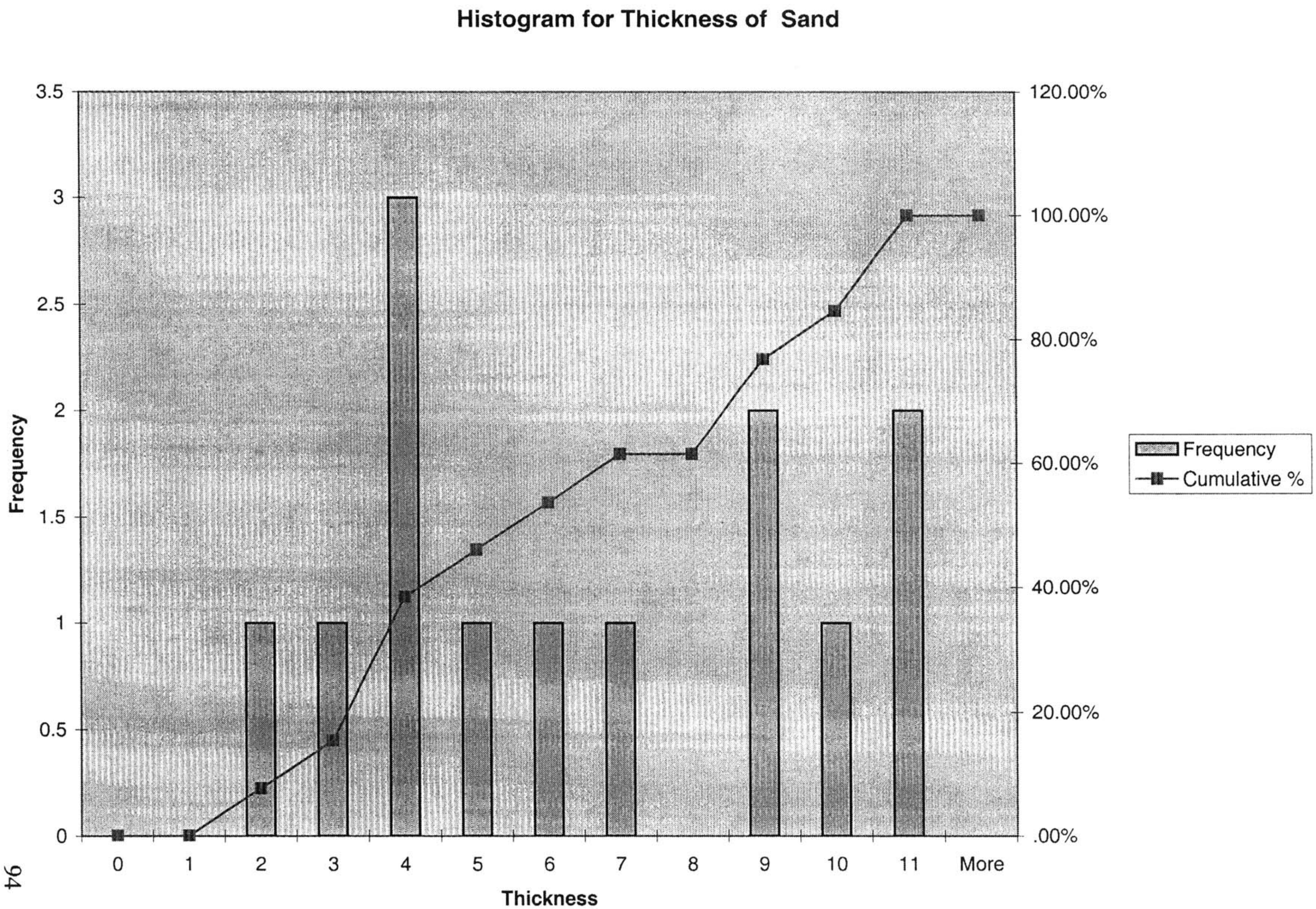


Histogram for Thickness of Fill

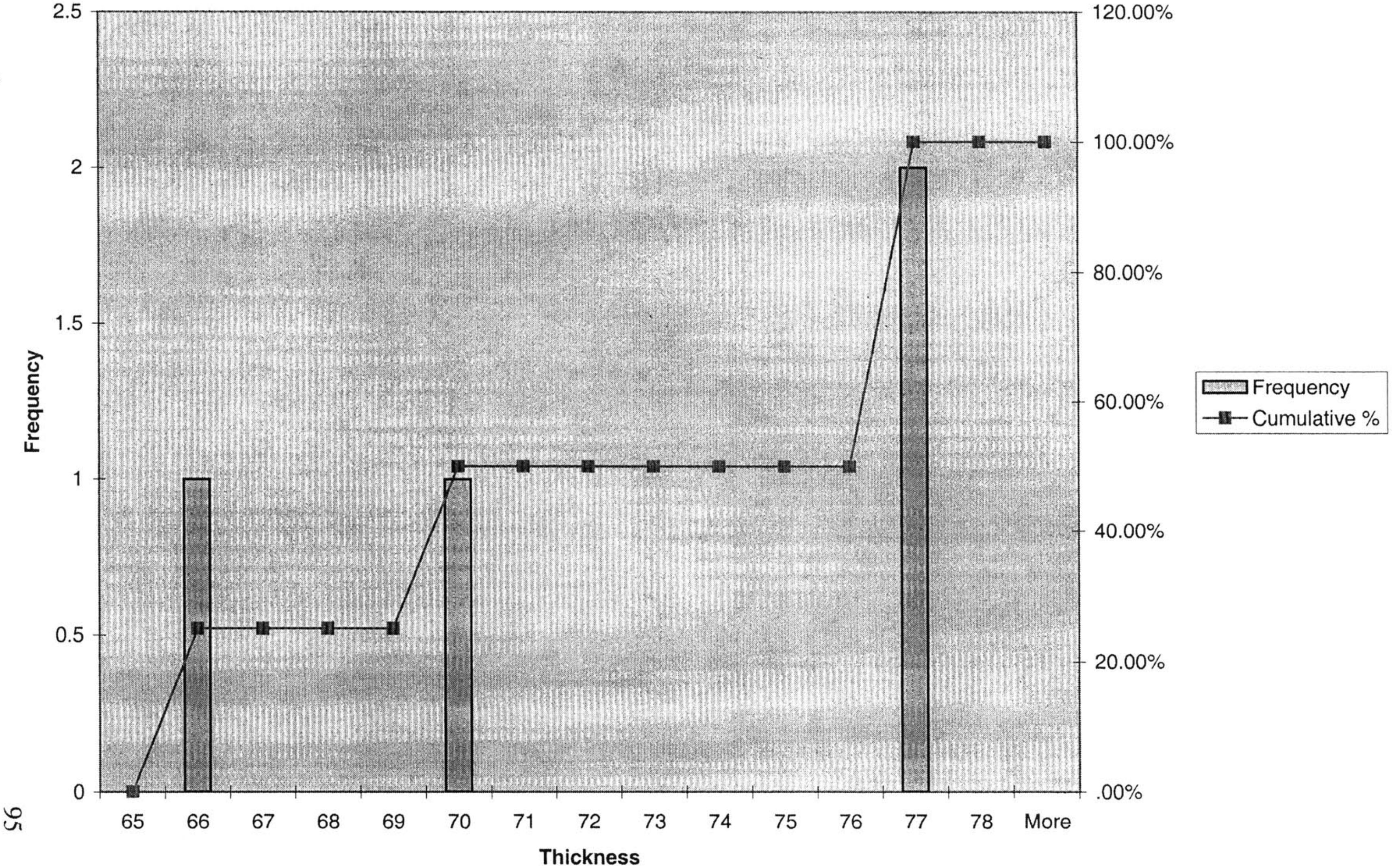


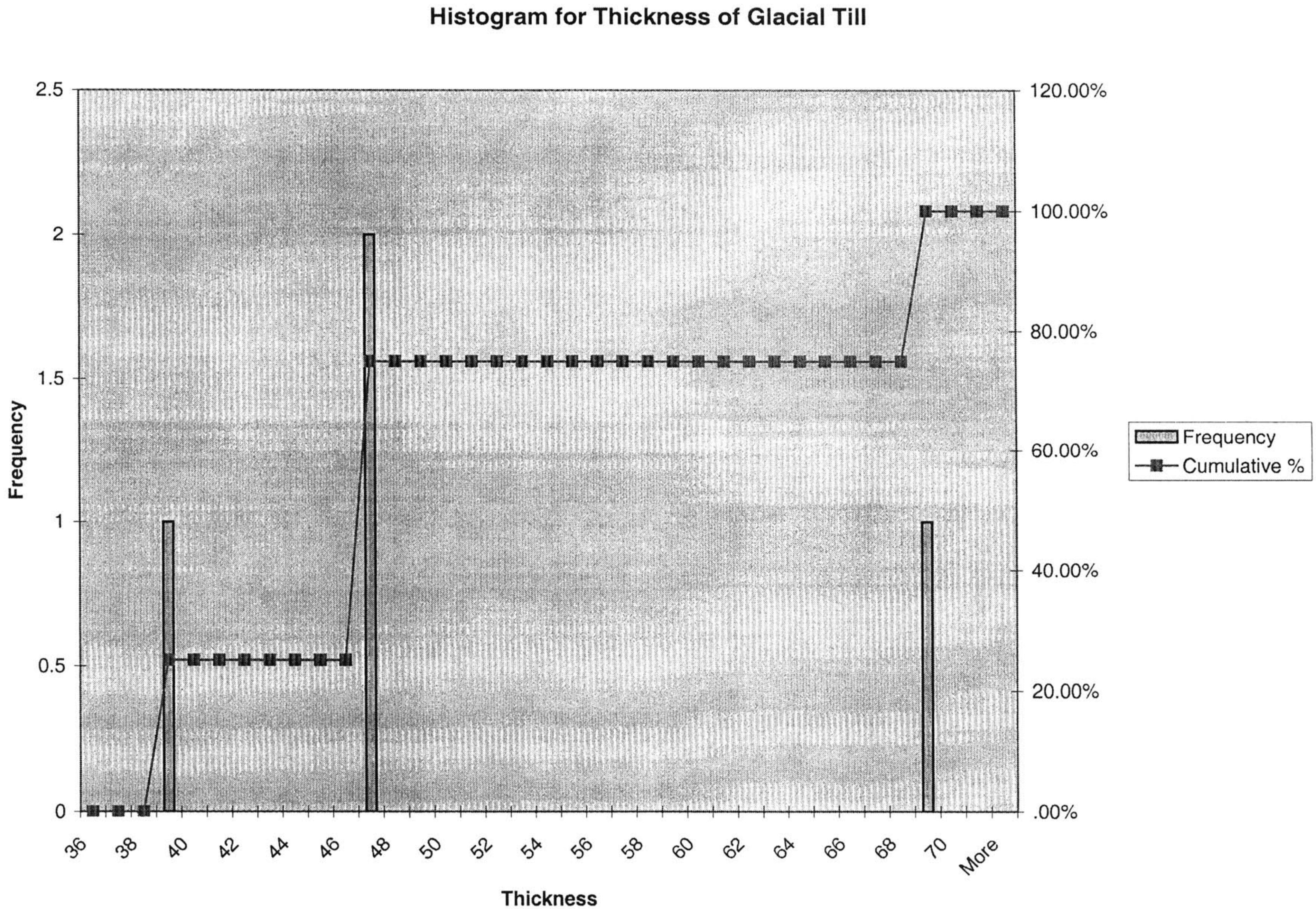
Histogram for Thickness of Silty Sand




Histogram for Thickness of Sand
Frequency
Thickness
3.5
3
2.5
2
1.5
1
0.5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
0
1
2
3
4
5
6
7
8
9
10
11
More
Frequency
Cumulative %

Histogram for Thickness of Boston Blue Clay




Histogram for Thickness of Glacial Till
Frequency
0
0.5
1
1.5
2
2.5
.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
70
More
Thickness
Frequency
Cumulative %

Upper bound of		Silty Sand layer
Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	1	8.33%
7	5	50.00%
8	2	66.67%
9	0	66.67%
10	3	91.67%
11	1	100.00%
12	0	100.00%
More	0	100.00%

Upper bound of	Sand Layer	
Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	0	.00%
8	0	.00%
9	0	.00%
10	0	.00%
11	0	.00%
12	0	.00%
13	0	.00%
14	0	.00%
15	0	.00%
16	0	.00%
17	0	.00%
18	0	.00%
19	1	7.69%
20	2	23.08%
21	1	30.77%
22	2	46.15%
23	1	53.85%
24	0	53.85%
25	0	53.85%
26	1	61.54%
27	0	61.54%
28	1	69.23%
29	0	69.23%
30	2	84.62%
31	0	84.62%
32	0	84.62%
33	1	92.31%
34	1	100.00%
35	0	100.00%
More	0	100.00%

Upper bound of		Boston Blue Clay Layer
Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	0	.00%
8	0	.00%
9	0	.00%
10	0	.00%
11	0	.00%
12	0	.00%
13	0	.00%
14	0	.00%
15	0	.00%
16	0	.00%
17	0	.00%
18	0	.00%
19	0	.00%
20	0	.00%
21	0	.00%
22	0	.00%
23	0	.00%
24	0	.00%
25	0	.00%
26	0	.00%
27	0	.00%
28	1	7.69%
29	3	30.77%
30	5	69.23%
31	0	69.23%
32	1	76.92%
33	0	76.92%
34	1	84.62%
35	0	84.62%
36	0	84.62%
37	2	100.00%
38	0	100.00%
More	0	100.00%

Upper bound of		Glacial Till Layer
Bin	*Frequency*	*Cumulative %*
97	0	.00%
98	0	.00%
99	0	.00%
100	1	25.00%
101	0	25.00%
102	1	50.00%
103	0	50.00%
104	1	75.00%
105	0	75.00%
106	1	100.00%
107	0	100.00%
108	0	100.00%
More	0	100.00%

Upper bound of		Cambridge Argillite Layer
Bin	*Frequency*	*Cumulative %*
140	0	.00%
141	0	.00%
142	0	.00%
143	1	25.00%
144	0	25.00%
145	0	25.00%
146	0	25.00%
147	0	25.00%
148	0	25.00%
149	1	50.00%
150	0	50.00%
151	0	50.00%
152	1	75.00%
153	0	75.00%
154	0	75.00%
155	0	75.00%
156	0	75.00%
157	0	75.00%
158	0	75.00%
159	0	75.00%
160	0	75.00%
161	0	75.00%
162	0	75.00%
163	0	75.00%
164	0	75.00%
165	0	75.00%
166	0	75.00%
167	0	75.00%
168	0	75.00%
169	1	100.00%
170	0	100.00%
171	0	100.00%
172	0	100.00%
173	0	100.00%
174	0	100.00%
175	0	100.00%
More	0	100.00%

Thickness of geologic uni Fill Layer

Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	1	8.33%
7	5	50.00%
8	2	66.67%
9	0	66.67%
10	3	91.67%
11	1	100.00%
More	0	100.00%

Thickness of geologic unit	Silty Sand layer	
Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	0	.00%
8	0	.00%
9	0	.00%
10	1	8.33%
11	1	16.67%
12	1	25.00%
13	0	25.00%
14	1	33.33%
15	0	33.33%
16	2	50.00%
17	0	50.00%
18	1	58.33%
19	0	58.33%
20	1	66.67%
21	1	75.00%
22	0	75.00%
23	1	83.33%
24	0	83.33%
25	0	83.33%
26	1	91.67%
27	1	100.00%
More	0	100.00%

Thickness of geologic unit Sand Layer

Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	1	7.69%
3	1	15.38%
4	3	38.46%
5	1	46.15%
6	1	53.85%
7	1	61.54%
8	0	61.54%
9	2	76.92%
10	1	84.62%
11	2	100.00%
More	0	100.00%

Thickness of geologic unit Boston Blue Clay Layer

Bin	*Frequency*	*Cumulative %*
65	0	.00%
66	1	25.00%
67	0	25.00%
68	0	25.00%
69	0	25.00%
70	1	50.00%
71	0	50.00%
72	0	50.00%
73	0	50.00%
74	0	50.00%
75	0	50.00%
76	0	50.00%
77	2	100.00%
78	0	100.00%
More	0	100.00%

Thickness of geologic unit Glacial Till Layer

Bin	*Frequency*	*Cumulative %*
36	0	.00%
37	0	.00%
38	0	.00%
39	1	25.00%
40	0	25.00%
41	0	25.00%
42	0	25.00%
43	0	25.00%
44	0	25.00%
45	0	25.00%
46	0	25.00%
47	2	75.00%
48	0	75.00%
49	0	75.00%
50	0	75.00%
51	0	75.00%
52	0	75.00%
53	0	75.00%
54	0	75.00%
55	0	75.00%
56	0	75.00%
57	0	75.00%
58	0	75.00%
59	0	75.00%
60	0	75.00%
61	0	75.00%
62	0	75.00%
63	0	75.00%
64	0	75.00%
65	0	75.00%
66	0	75.00%
67	0	75.00%
68	0	75.00%
69	1	100.00%
70	0	100.00%
71	0	100.00%
More	0	100.00%

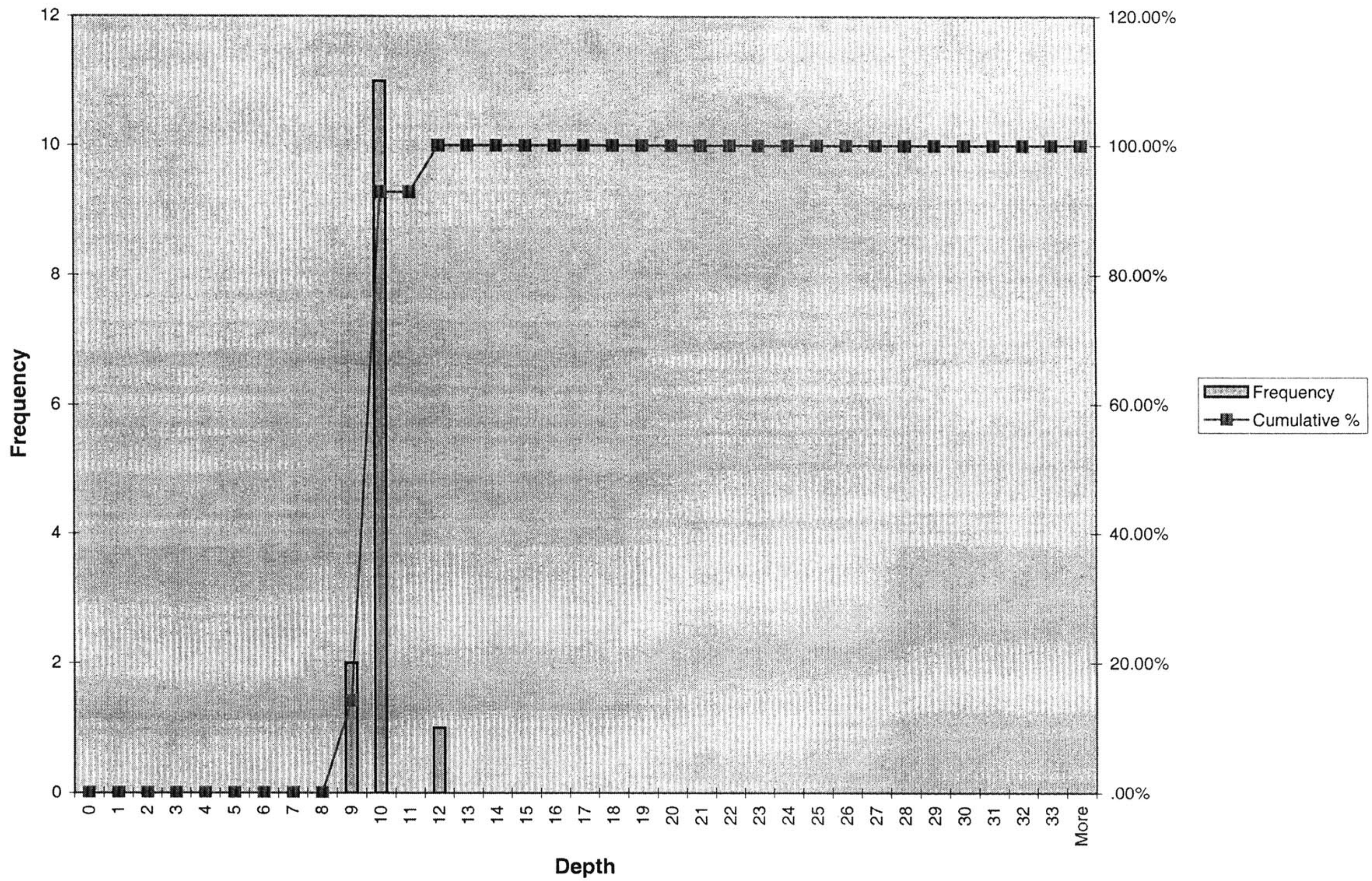
	BORINGS														
Top of geologic unit elevation	2	3	4	5	8	7	6	9	10	12	13	B11	B13	Mean Dept	STD. DEV
Fill Layer	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Silty Sand layer	7.692308	6.923077	7.692308	5.384615	6.153846	9.230769	6.923077	10.76923	6.923077	6.153846	0	9.230769	9.230769	8.5	2.8
Sand Layer	30	27.69231	25.38462	19.23077	21.53846	29.23077	32.30769	21.53846	22.30769	33.07692	19.23077	20.76923	18.46154	28.4	7.0
Boston Blue Clay Layer	31.53846	30	28.46154	28.46154	28.46154	33.84615	36.15385	30	27.69231	36.15385	30	29.23077	29.23077	35.3	5.7
Glacial Till Layer					105.3846		101.5385		103.8462		100		0	105.0	42.3
Cambridge Argillite Layer					151.5385		148.4615		142.3077		168.4615		0	156.1	63.9

	BORINGS														
THICKNESS of geologic unit	2	3	4	5	8	7	6	9	10	12	13	B11	B13	Mean Thic	STD. DEV
Fill Layer	7.692308	6.923077	7.692308	5.384615	6.153846	9.230769	6.923077	10.76923	6.923077	6.153846		9.230769	9.230769	7.7	1.6
Silty Sand layer	22.30769	20.76923	17.69231	13.84615	15.38462	20	25.38462	10.76923	15.38462	26.92308		11.53846	9.230769	17.4	5.7
Sand Layer	1.538462	2.307692	3.076923	9.230769	6.923077	4.615385	3.846154	8.461538	5.384615	3.076923	10.76923	8.461538	10.76923	6.0	3.2
Boston Blue Clay Layer					76.92308		65.38462		76.15385		70			72.1	5.5
Glacial Till Layer					46.15385		46.92308		38.46154		68.46154			50.0	12.9

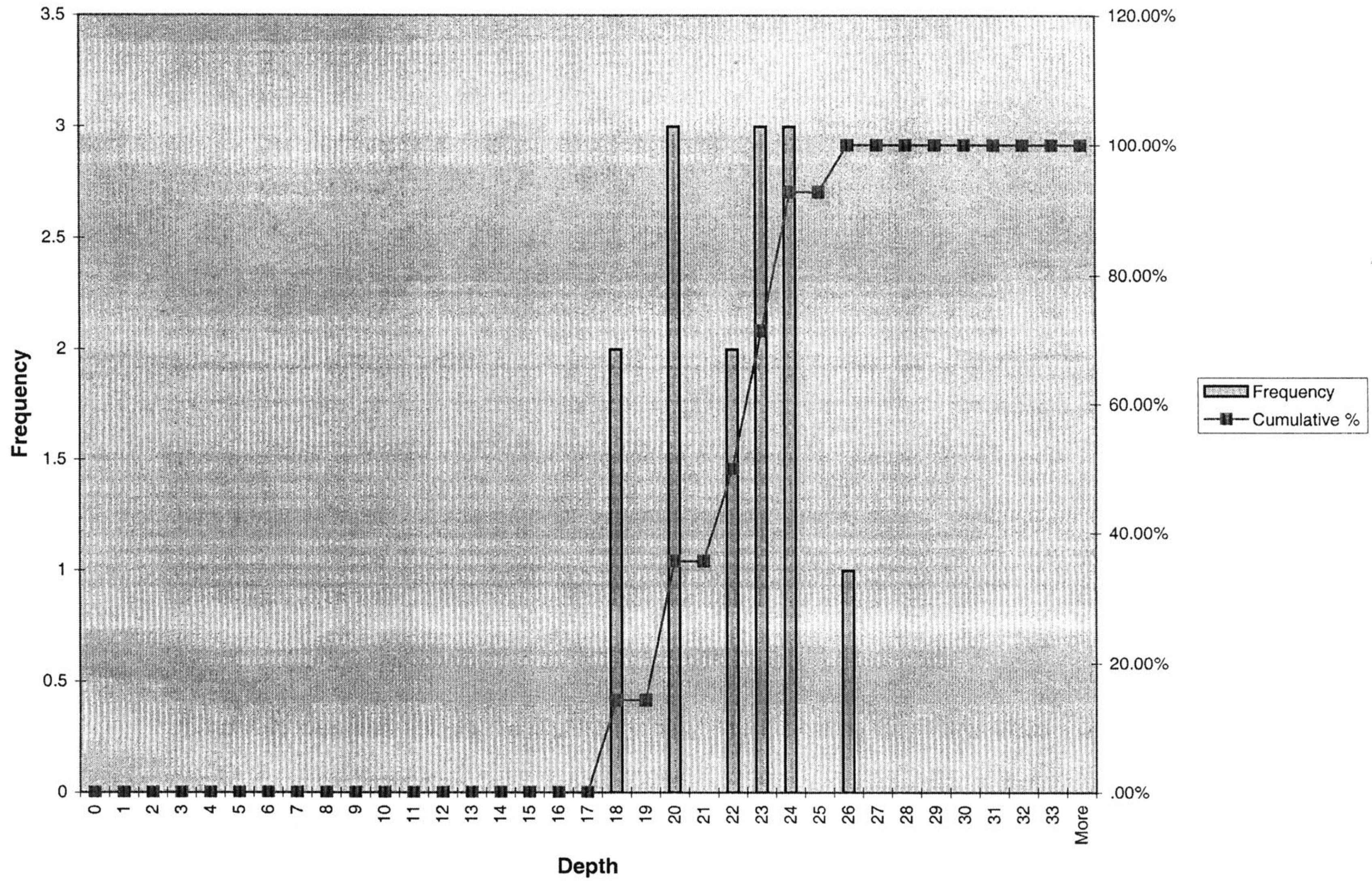
APPENDIX C

Zone 2 data and Corresponding Parameter Histograms

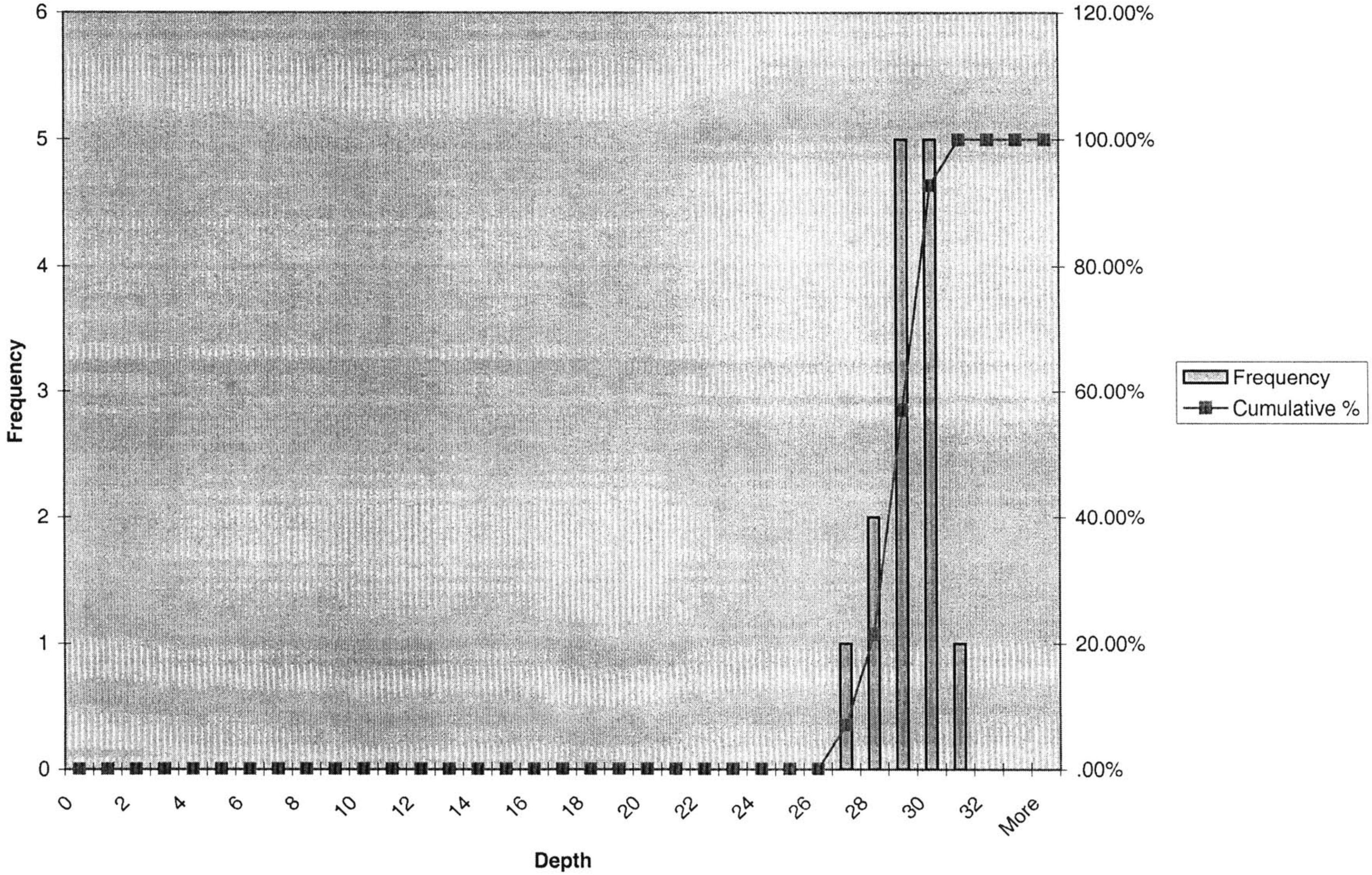
Histogram for Upper Bound of Silty Sand



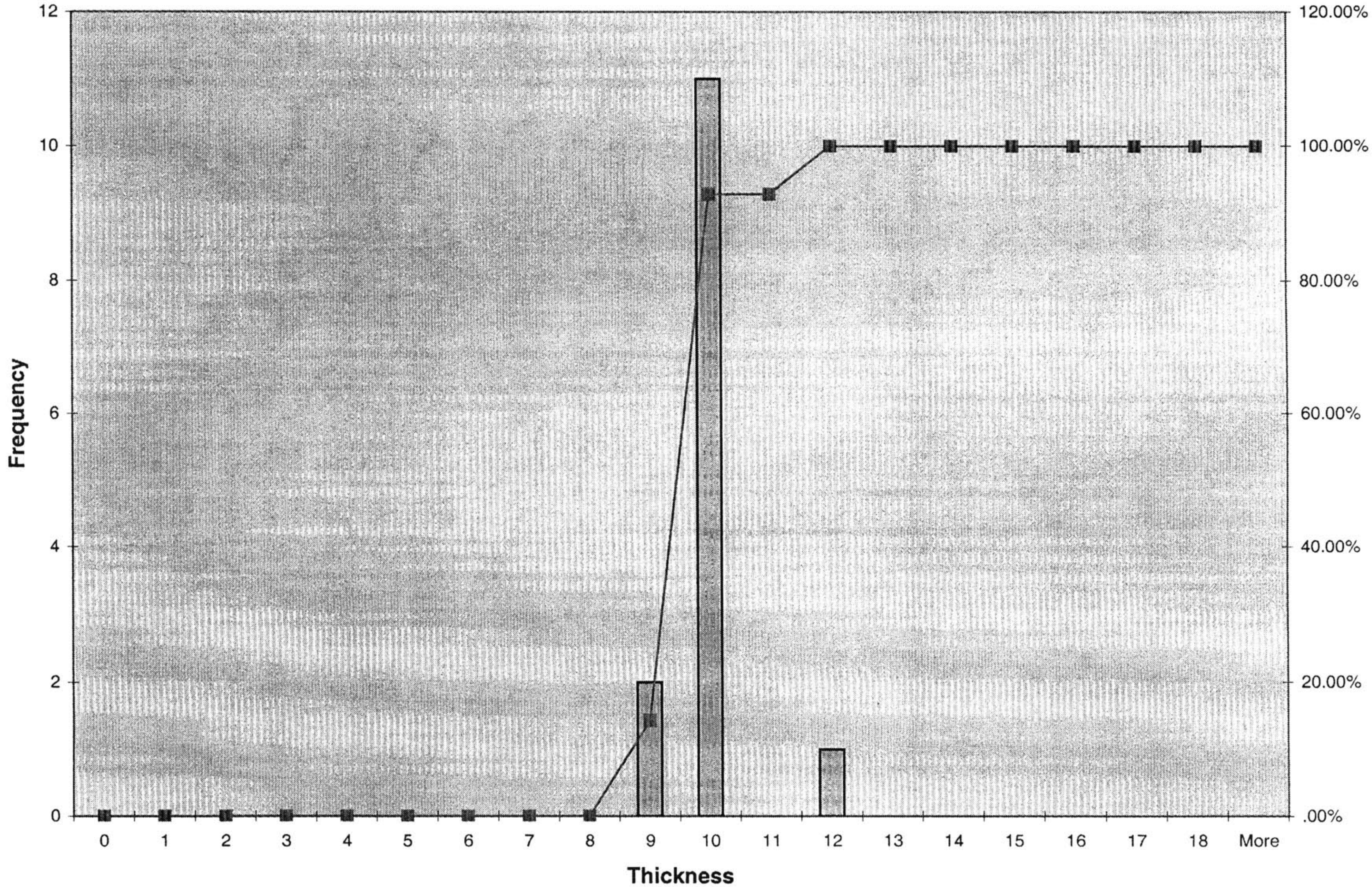
Histogram for Upper Bound of Sand

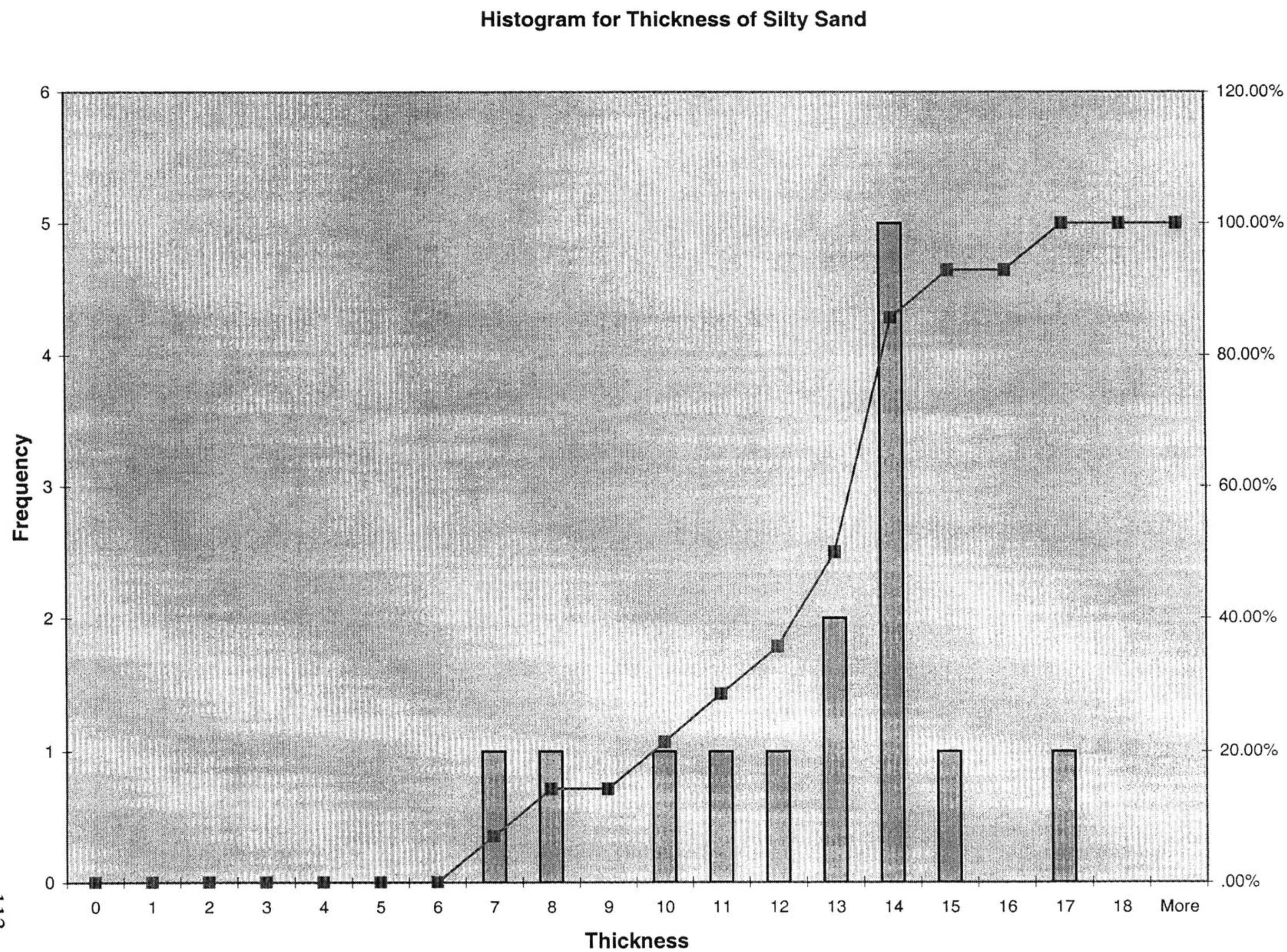


Histogram for Upper Bound of Boston Blue Clay

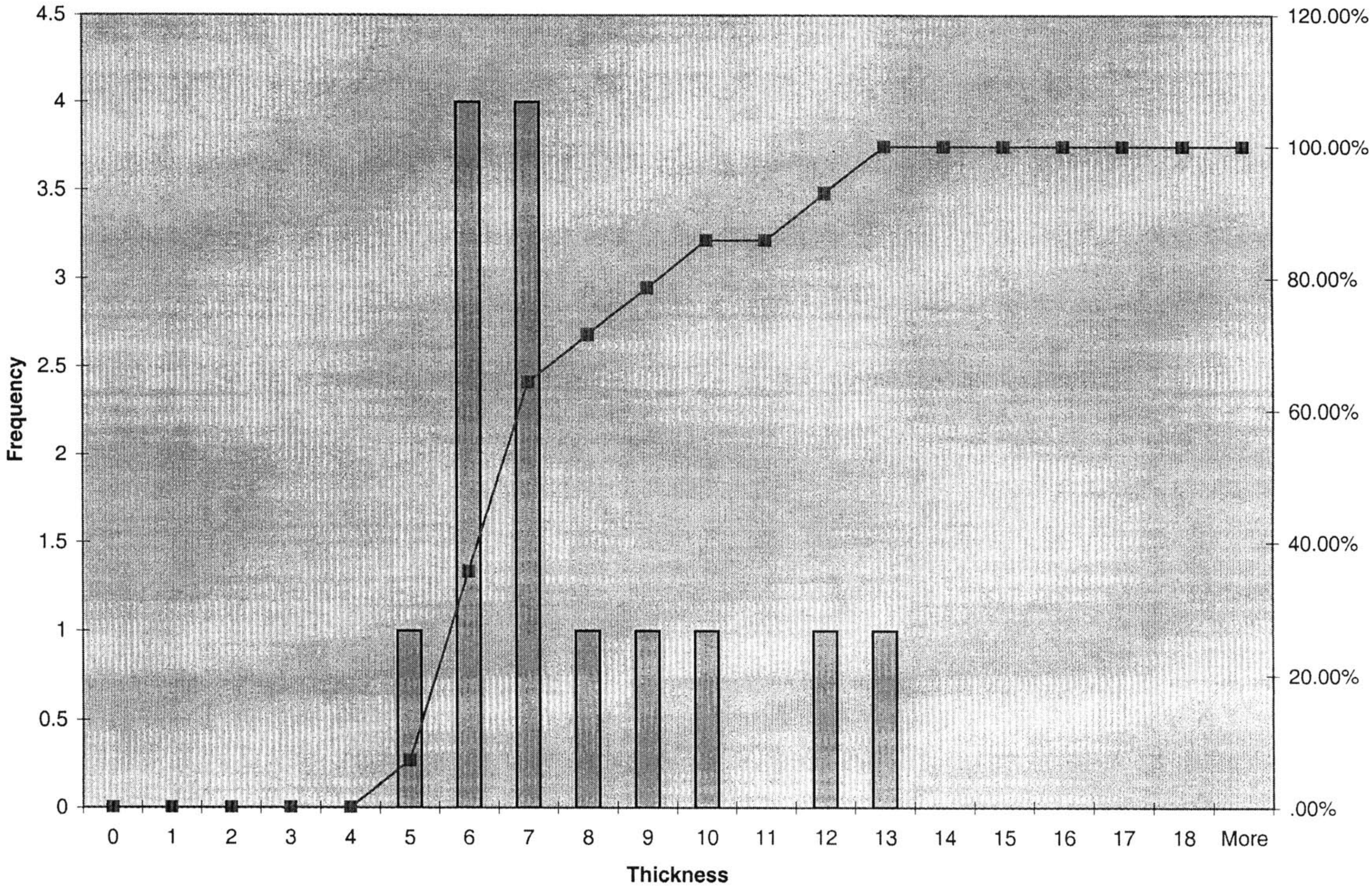


Histogram for Thickness of Fill




Histogram for Thickness of Silty Sand
Frequency
0
1
2
3
4
5
6
.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 More
Thickness

Histogram for Thickness of Sand



Upper bound of		Silty Sand layer
Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	0	.00%
8	0	.00%
9	2	14.29%
10	11	92.86%
11	0	92.86%
12	1	100.00%
13	0	100.00%
14	0	100.00%
15	0	100.00%
16	0	100.00%
17	0	100.00%
18	0	100.00%
19	0	100.00%
20	0	100.00%
21	0	100.00%
22	0	100.00%
23	0	100.00%
24	0	100.00%
25	0	100.00%
26	0	100.00%
27	0	100.00%
28	0	100.00%
29	0	100.00%
30	0	100.00%
31	0	100.00%
32	0	100.00%
33	0	100.00%
More	0	100.00%

Thickness of geologic unit Fill Layer

Bin	Frequency	Cumulative %
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	0	.00%
8	0	.00%
9	2	14.29%
10	11	92.86%
11	0	92.86%
12	1	100.00%
13	0	100.00%
14	0	100.00%
15	0	100.00%
16	0	100.00%
17	0	100.00%
18	0	100.00%
More	0	100.00%

Upper bound of	Sand Layer	
Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	0	.00%
8	0	.00%
9	0	.00%
10	0	.00%
11	0	.00%
12	0	.00%
13	0	.00%
14	0	.00%
15	0	.00%
16	0	.00%
17	0	.00%
18	2	14.29%
19	0	14.29%
20	3	35.71%
21	0	35.71%
22	2	50.00%
23	3	71.43%
24	3	92.86%
25	0	92.86%
26	1	100.00%
27	0	100.00%
28	0	100.00%
29	0	100.00%
30	0	100.00%
31	0	100.00%
32	0	100.00%
33	0	100.00%
More	0	100.00%

Thickness of geologic unit	Silty Sand layer	
Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	1	7.14%
8	1	14.29%
9	0	14.29%
10	1	21.43%
11	1	28.57%
12	1	35.71%
13	2	50.00%
14	5	85.71%
15	1	92.86%
16	0	92.86%
17	1	100.00%
18	0	100.00%
More	0	100.00%

Upper bound of	Boston Blue Clay Laye	
Bin	*Frequency*	*'umulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	0	.00%
8	0	.00%
9	0	.00%
10	0	.00%
11	0	.00%
12	0	.00%
13	0	.00%
14	0	.00%
15	0	.00%
16	0	.00%
17	0	.00%
18	0	.00%
19	0	.00%
20	0	.00%
21	0	.00%
22	0	.00%
23	0	.00%
24	0	.00%
25	0	.00%
26	0	.00%
27	1	7.14%
28	2	21.43%
29	5	57.14%
30	5	92.86%
31	1	100.00%
32	0	100.00%
33	0	100.00%
More	0	100.00%

Thickness of geologic unit Sand Laye

Bin	Frequency	Cumulative %
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	1	7.14%
6	4	35.71%
7	4	64.29%
8	1	71.43%
9	1	78.57%
10	1	85.71%
11	0	85.71%
12	1	92.86%
13	1	100.00%
14	0	100.00%
15	0	100.00%
16	0	100.00%
17	0	100.00%
18	0	100.00%
More	0	100.00%

ratio 0.769231

Datum 21.5 feet

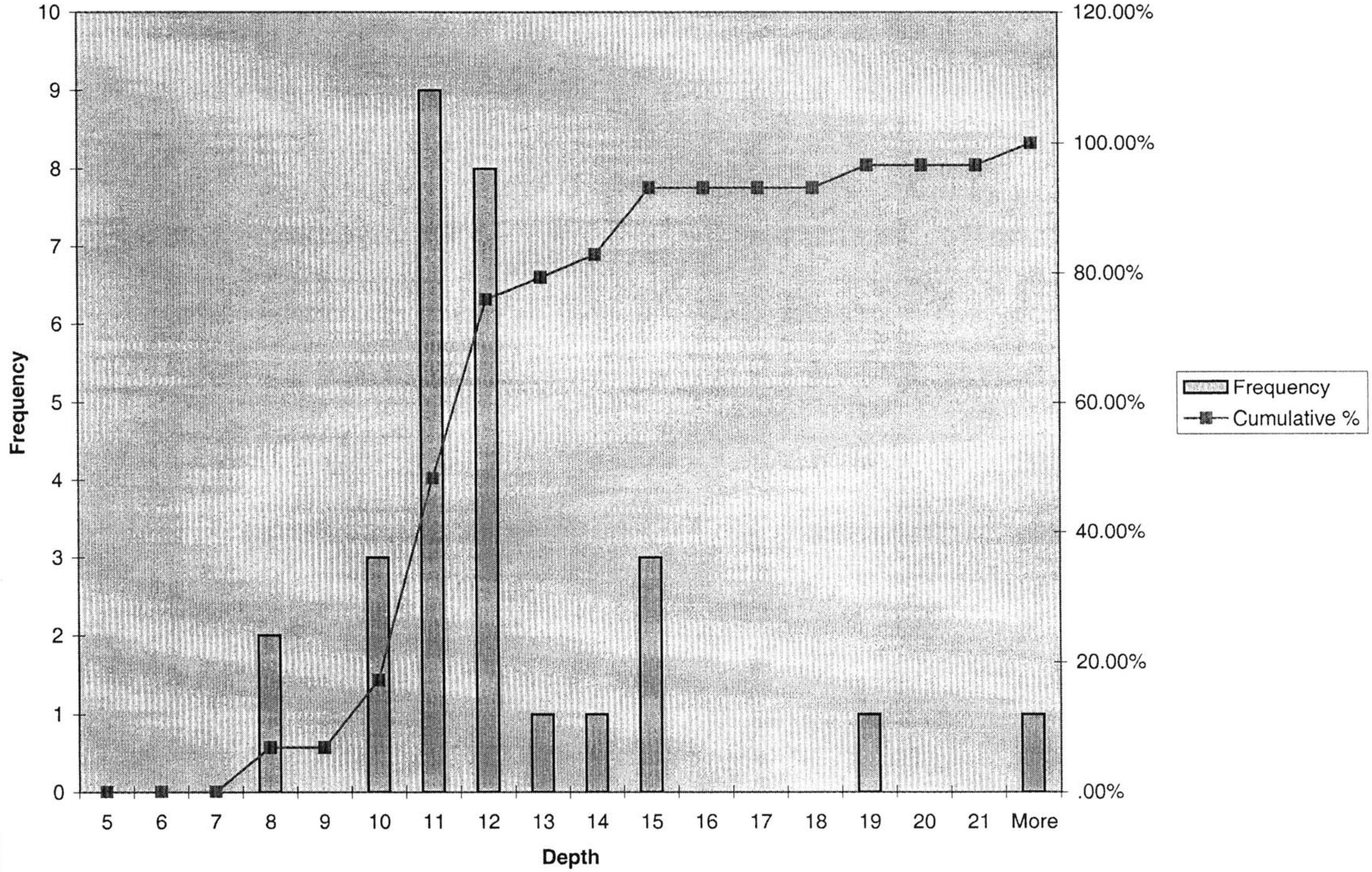
Top of geologic unit elevation	BORINGS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Mean Dept	STD. DEV
Fill Layer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Silty Sand layer	11.53846	10	10	9.615385	8.461538	9.230769	8.846154	9.230769	10	9.230769	9.230769	9.230769	9.230769	9.230769	10.8	1.5
Sand Layer	17.69231	17.69231	19.23077	20	20	21.53846	23.07692	22.30769	23.84615	22.30769	23.07692	21.53846	25.38462	22.30769	24.7	4.2
Boston Blue Clay Layer	30	29.23077	28.46154	28.46154	26.92308	28.46154	27.69231	28.46154	29.23077	27.69231	28.46154	29.23077	30.76923	29.23077	32.8	4.5
Glacial Till Layer																
Cambridge Argillite Layer																

THICKNESS of geologic unit	BORINGS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Mean Thicl	STD. DEV
Fill Layer	11.53846	10	10	9.615385	8.461538	9.230769	8.846154	9.230769	10	9.230769	9.230769	9.230769	9.230769	9.230769	9.5	0.7
Silty Sand layer	6.153846	7.692308	9.230769	10.38462	11.53846	12.30769	14.23077	13.07692	13.84615	13.07692	13.84615	12.30769	16.15385	13.07692	11.9	2.7
Sand Layer	12.30769	11.53846	9.230769	8.461538	6.923077	6.923077	4.615385	6.153846	5.384615	5.384615	5.384615	7.692308	5.384615	6.923077	7.3	2.4
Boston Blue Clay Layer																
Glacial Till Layer																

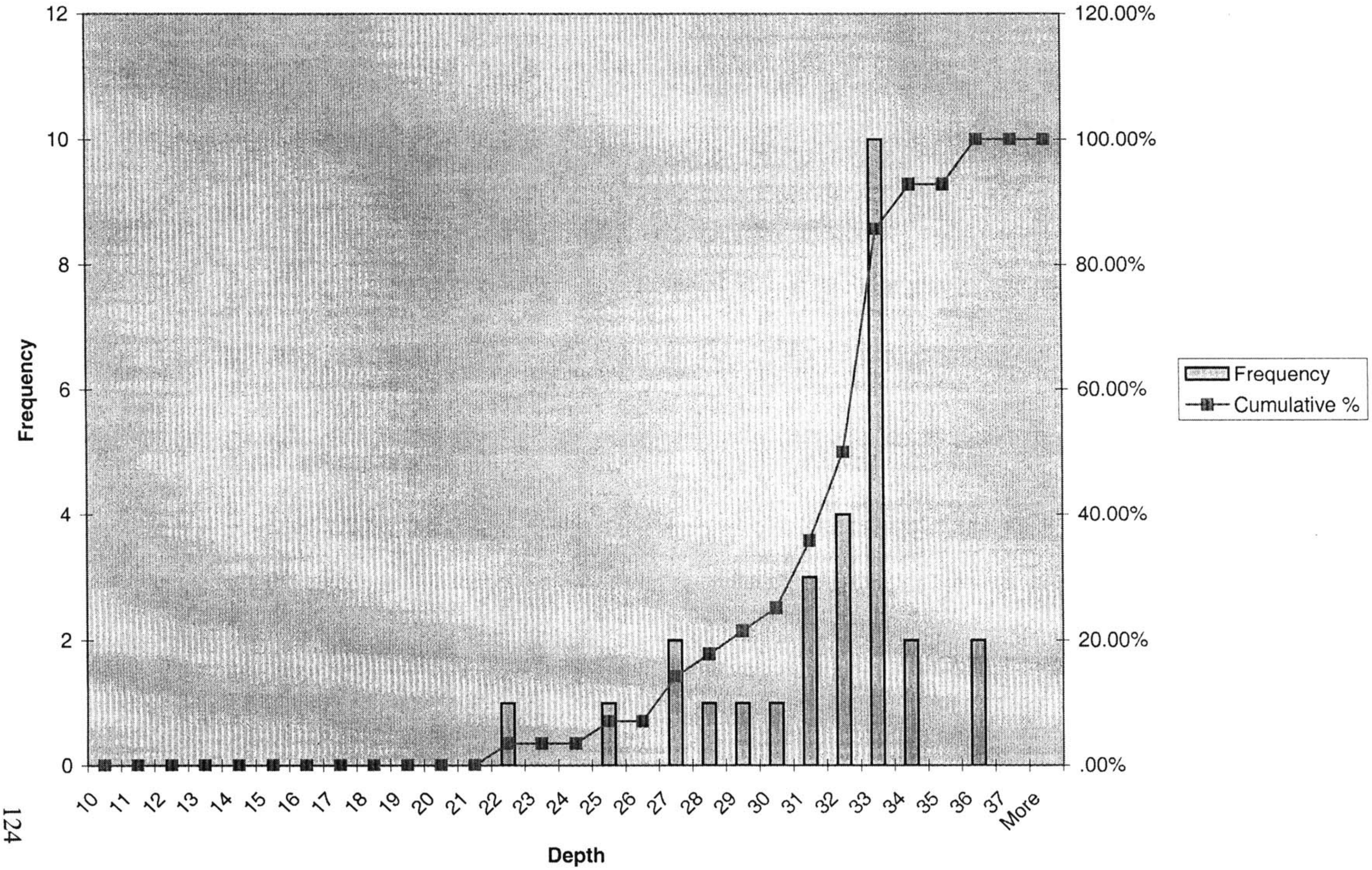
APPENDIX D

Zone 3 data and Corresponding Parameter Histograms

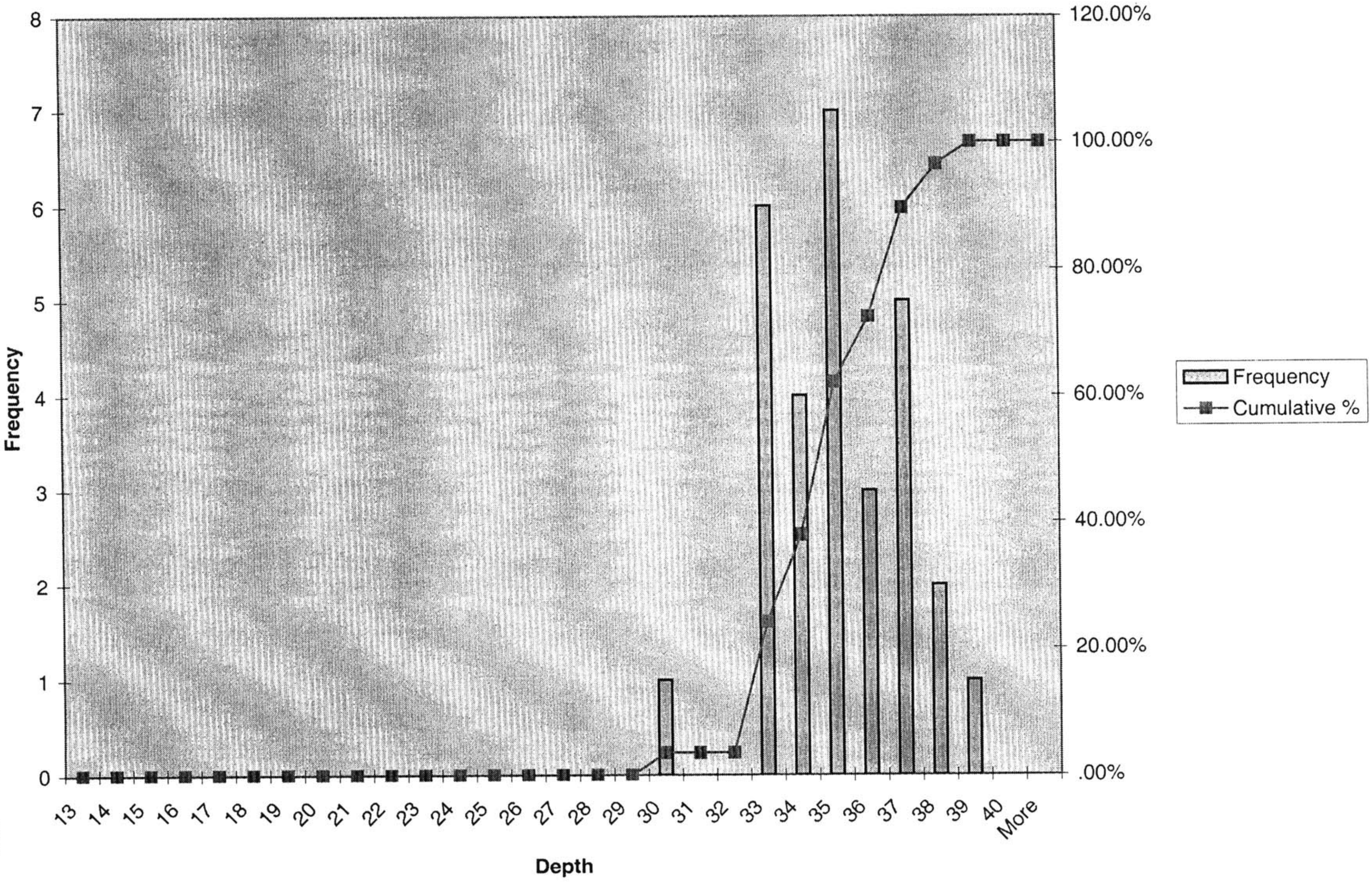
Histogram or Upper bound Layer of Silty Sand



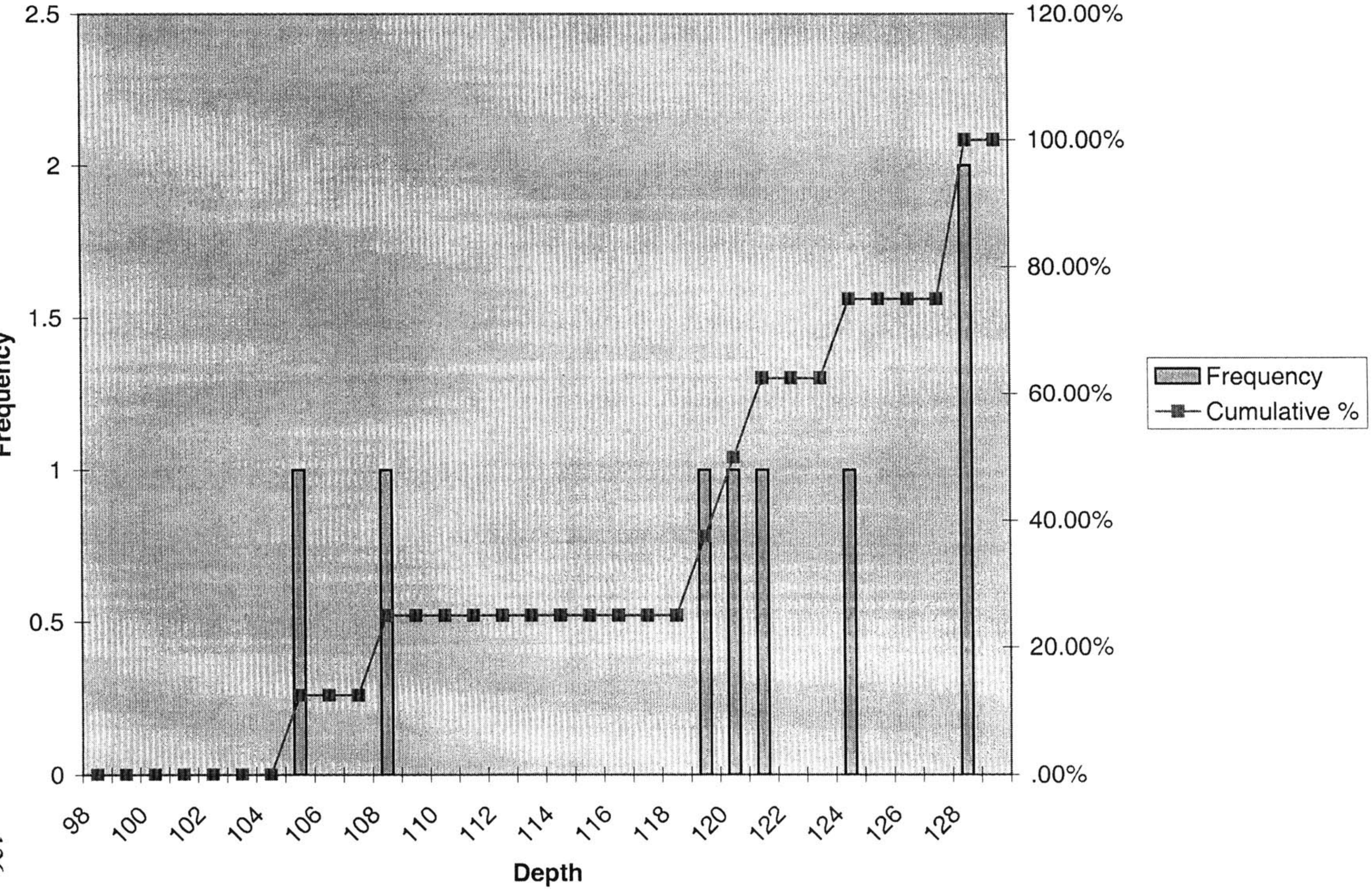
Histogram for Upper Bound Layer of Sand



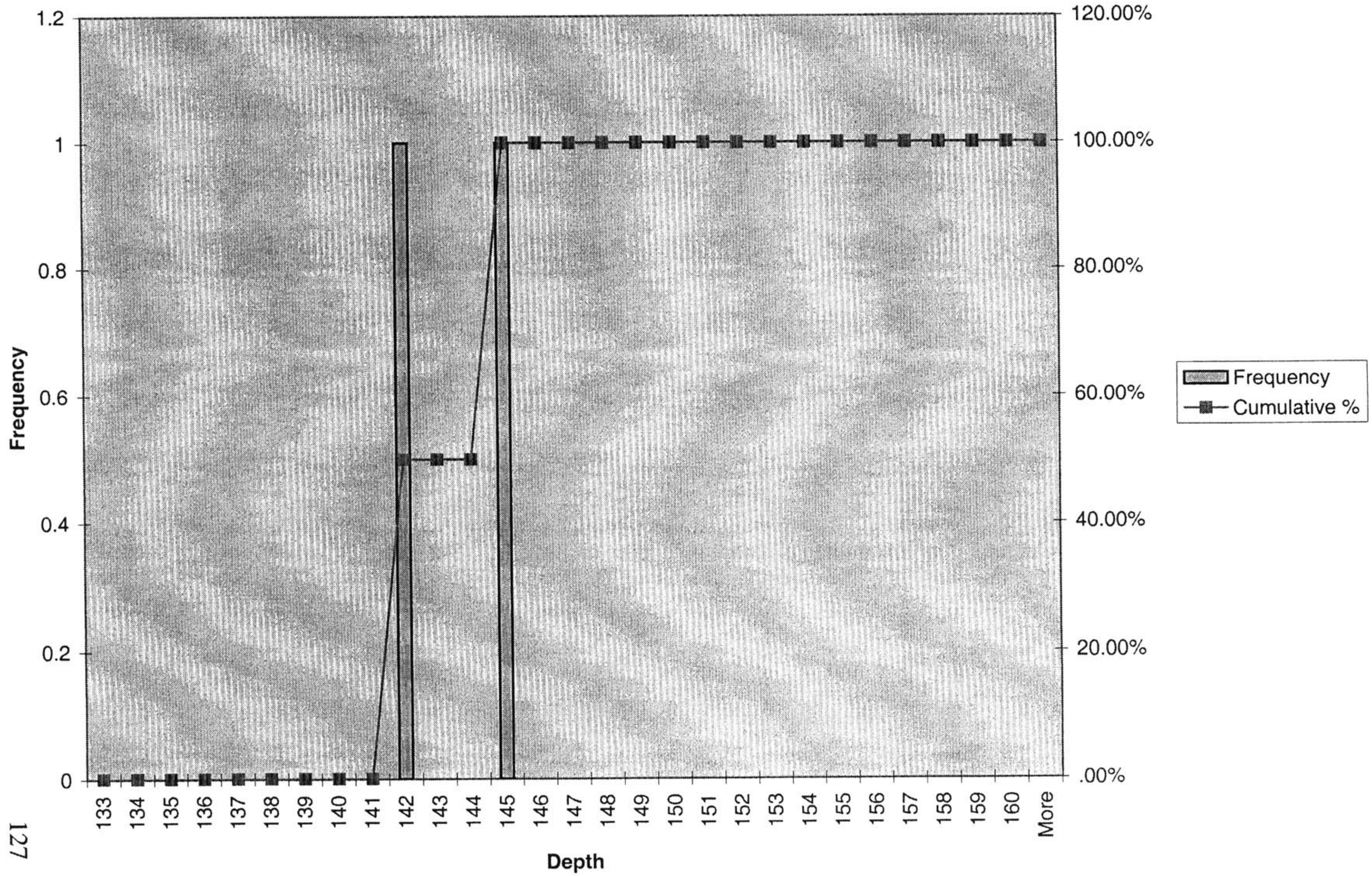
Histogram for the Upper Bound Layer of Boston Blue Clay

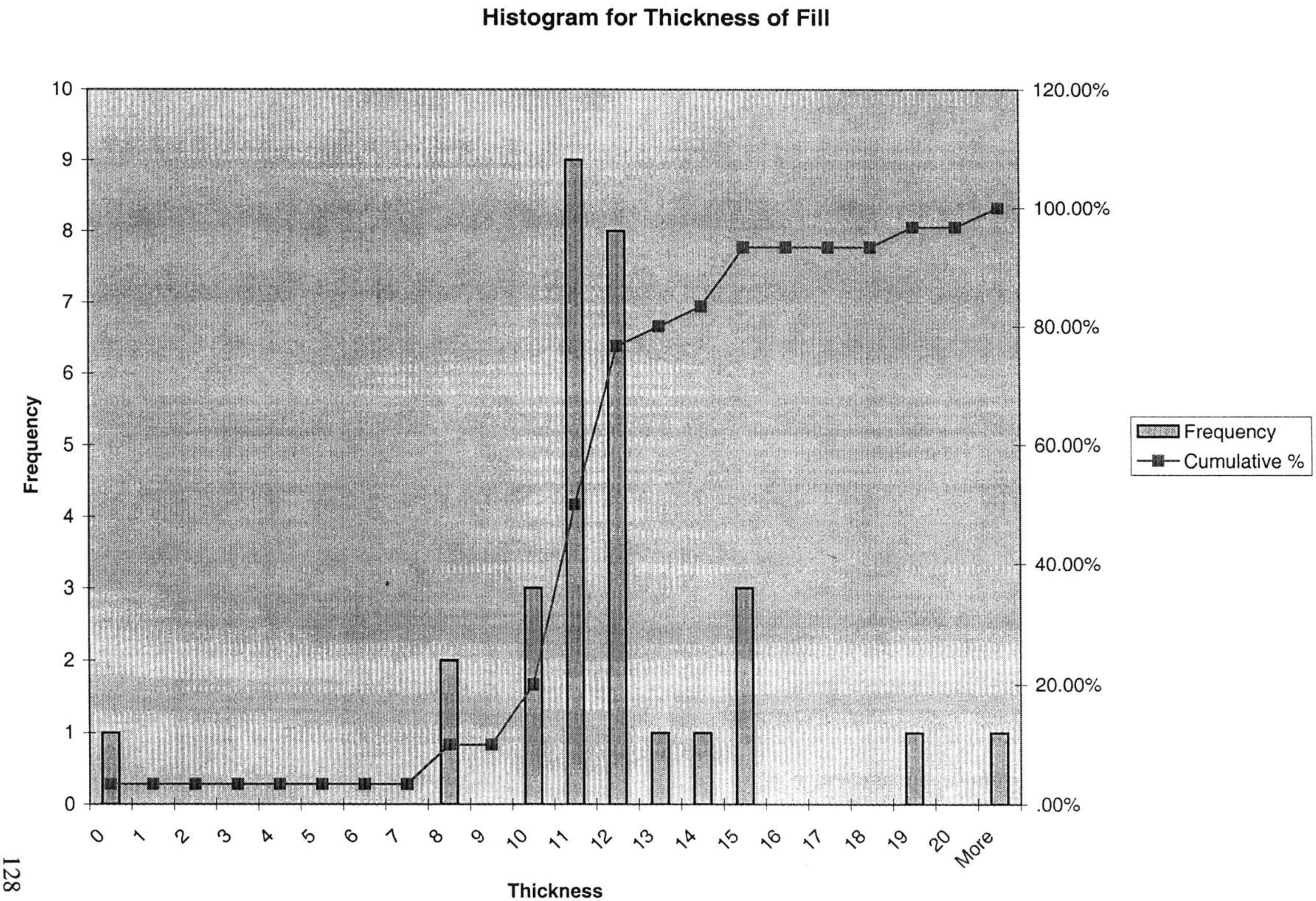


Histogram for Upper Bound of Glacial Till

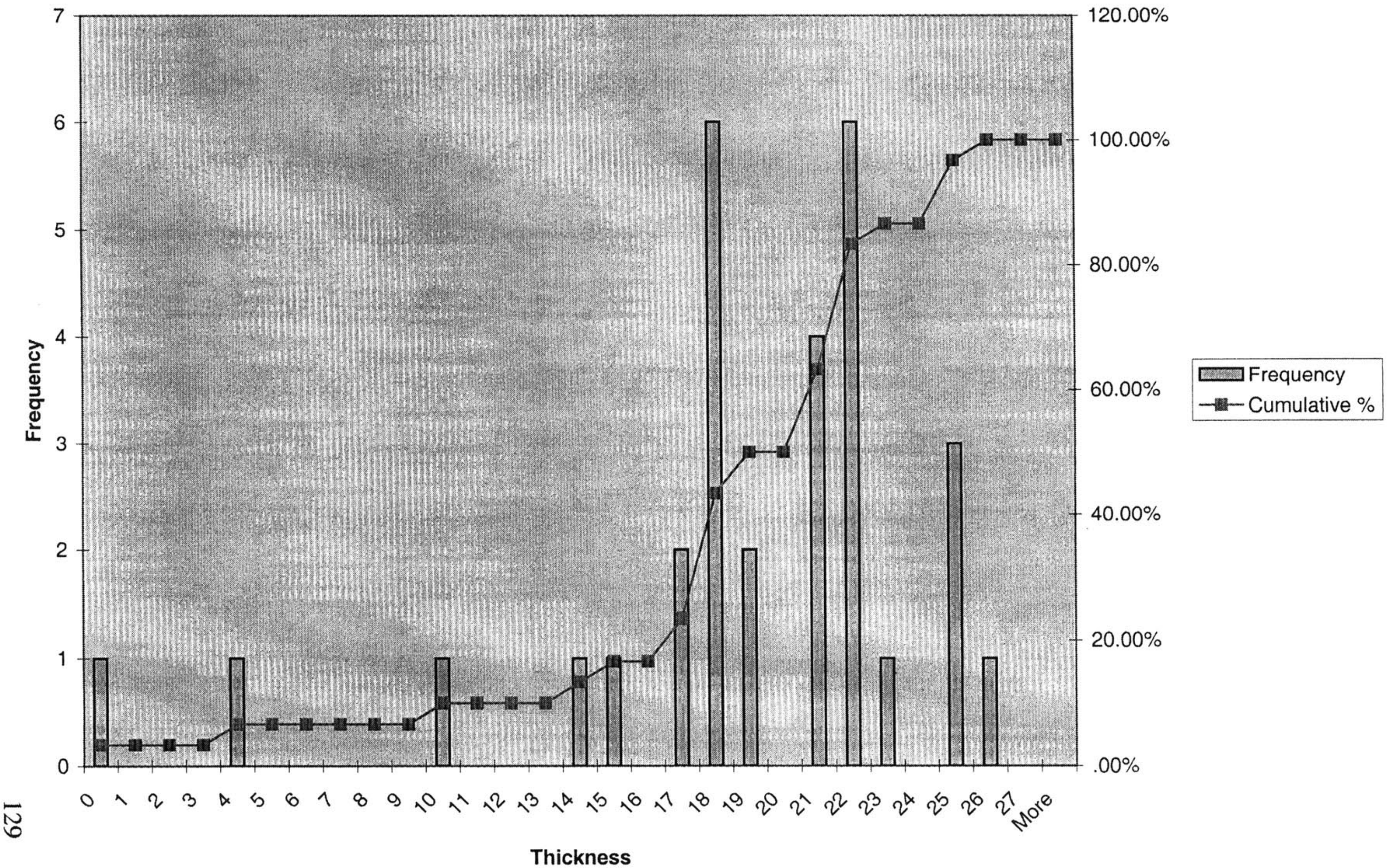


Histogram for Upper Bound of Cambridge Argilllite

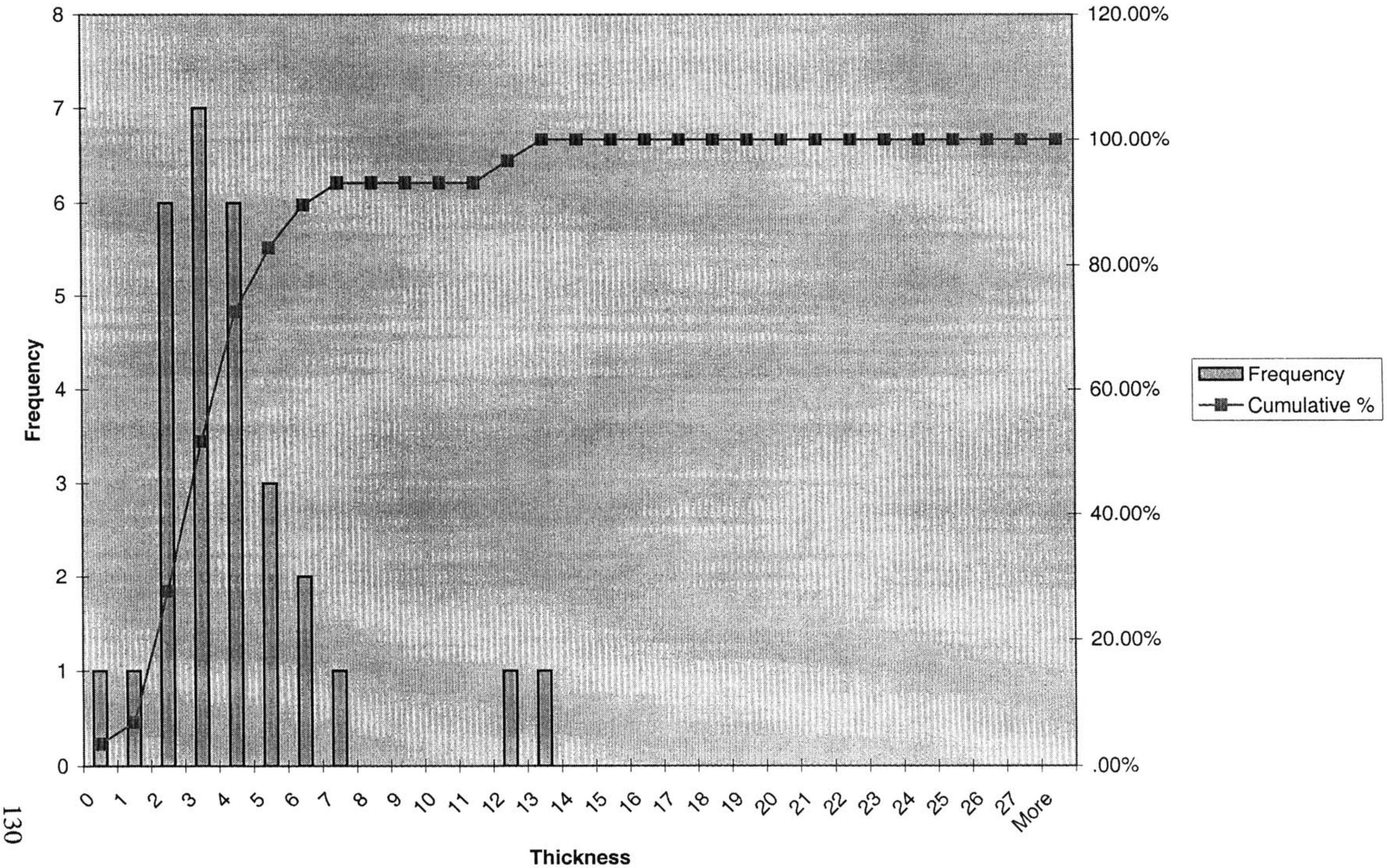


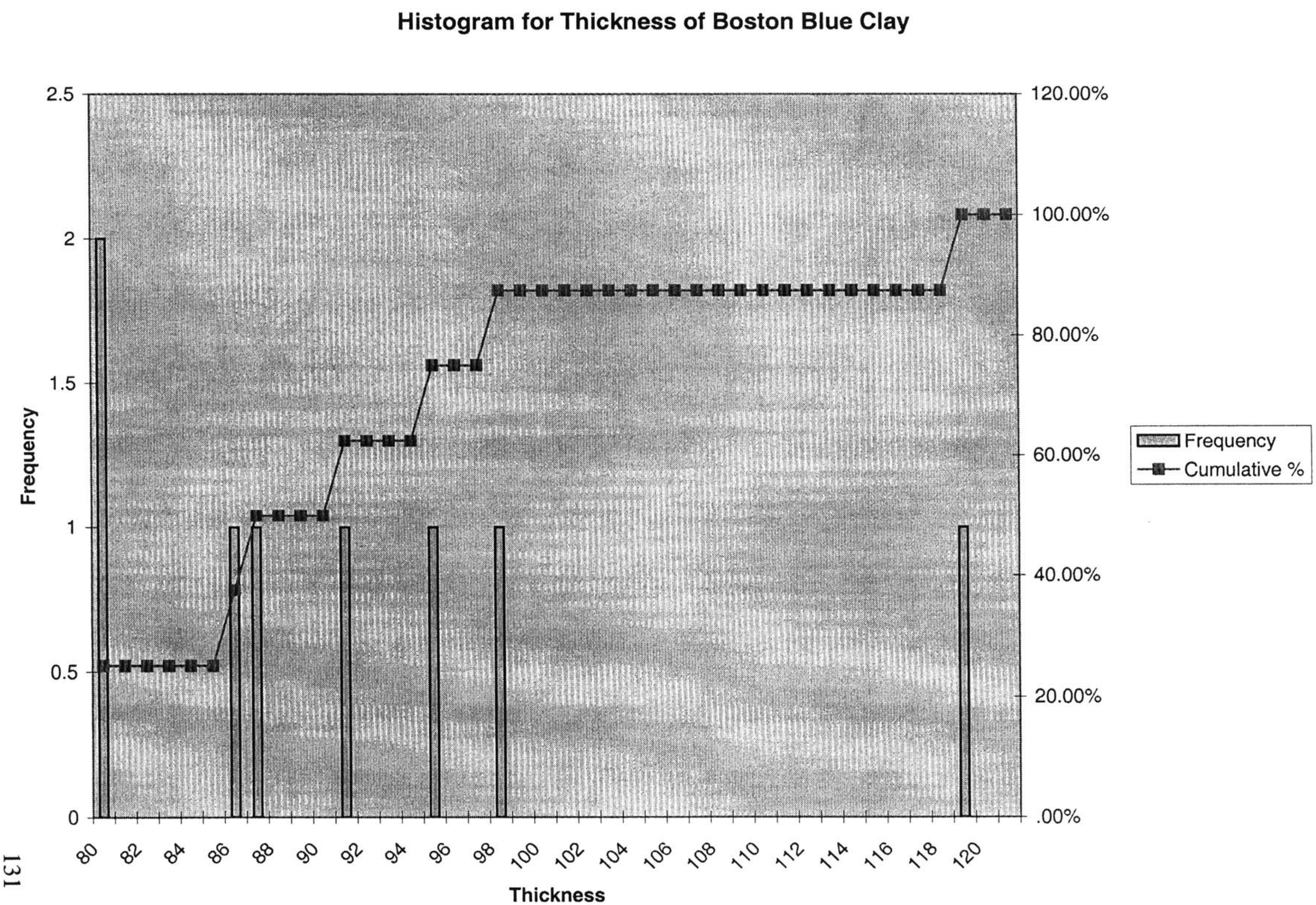

Histogram for Thickness of Fill
Frequency
Thickness
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
More
.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
Frequency
Cumulative %

Histogram for Thickness of Silty Sand

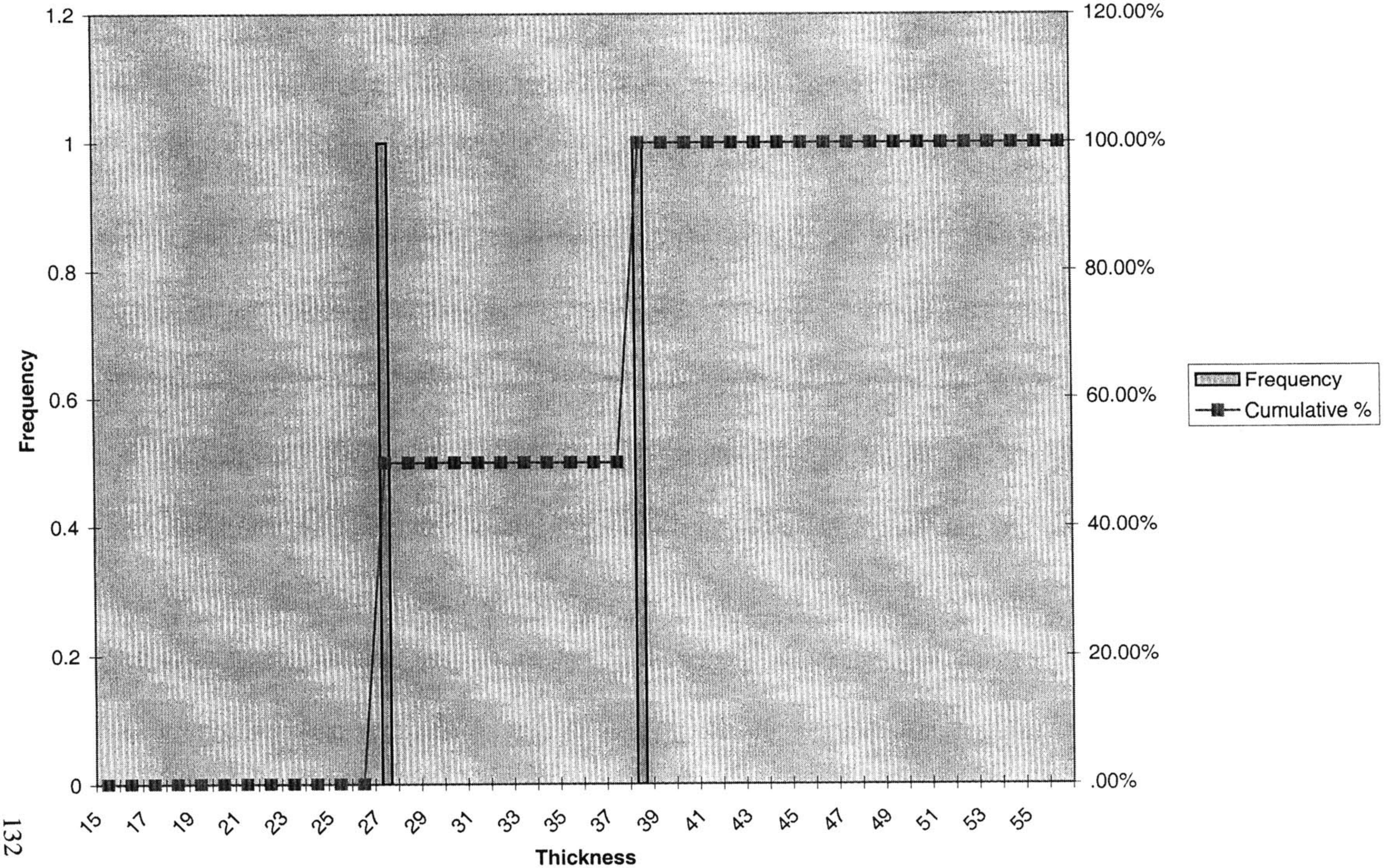


Histogram for Thickness of Sand




Histogram for Thickness of Boston Blue Clay
Frequency
2.5
2
1.5
1
0.5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
80
82
84
86
88
90
92
94
96
98
100
102
104
106
108
110
112
114
116
118
120
Thickness
Frequency
Cumulative %

Histogram for Thickness of Glacial Till



For upper bound of	Silty Sand layer	
Bin	*Frequency*	*Cumulative %*
5	0	.00%
6	0	.00%
7	0	.00%
8	2	6.90%
9	0	6.90%
10	3	17.24%
11	9	48.28%
12	8	75.86%
13	1	79.31%
14	1	82.76%
15	3	93.10%
16	0	93.10%
17	0	93.10%
18	0	93.10%
19	1	96.55%
20	0	96.55%
21	0	96.55%
More	1	100.00%

For upper bound of		Sand Layer
Bin	*Frequency*	*Cumulative %*
10	0	.00%
11	0	.00%
12	0	.00%
13	0	.00%
14	0	.00%
15	0	.00%
16	0	.00%
17	0	.00%
18	0	.00%
19	0	.00%
20	0	.00%
21	0	.00%
22	1	3.57%
23	0	3.57%
24	0	3.57%
25	1	7.14%
26	0	7.14%
27	2	14.29%
28	1	17.86%
29	1	21.43%
30	1	25.00%
31	3	35.71%
32	4	50.00%
33	10	85.71%
34	2	92.86%
35	0	92.86%
36	2	100.00%
37	0	100.00%
More	0	100.00%

For upper bound of		Boston Blue Clay Layer
Bin	*Frequency*	*Cumulative %*
13	0	.00%
14	0	.00%
15	0	.00%
16	0	.00%
17	0	.00%
18	0	.00%
19	0	.00%
20	0	.00%
21	0	.00%
22	0	.00%
23	0	.00%
24	0	.00%
25	0	.00%
26	0	.00%
27	0	.00%
28	0	.00%
29	0	.00%
30	1	3.45%
31	0	3.45%
32	0	3.45%
33	6	24.14%
34	4	37.93%
35	7	62.07%
36	3	72.41%
37	5	89.66%
38	2	96.55%
39	1	100.00%
40	0	100.00%
More	0	100.00%

For upper bound of		Glacial Till
Bin	*Frequency*	*Cumulative %*
98	0	.00%
99	0	.00%
100	0	.00%
101	0	.00%
102	0	.00%
103	0	.00%
104	0	.00%
105	1	12.50%
106	0	12.50%
107	0	12.50%
108	1	25.00%
109	0	25.00%
110	0	25.00%
111	0	25.00%
112	0	25.00%
113	0	25.00%
114	0	25.00%
115	0	25.00%
116	0	25.00%
117	0	25.00%
118	0	25.00%
119	1	37.50%
120	1	50.00%
121	1	62.50%
122	0	62.50%
123	0	62.50%
124	1	75.00%
125	0	75.00%
126	0	75.00%
127	0	75.00%
128	2	100.00%
More	0	100.00%

Layer
%

For upper bound of		Cambridge Argillite Layer
Bin	*Frequency*	*Cumulative %*
133	0	.00%
134	0	.00%
135	0	.00%
136	0	.00%
137	0	.00%
138	0	.00%
139	0	.00%
140	0	.00%
141	0	.00%
142	1	50.00%
143	0	50.00%
144	0	50.00%
145	1	100.00%
146	0	100.00%
147	0	100.00%
148	0	100.00%
149	0	100.00%
150	0	100.00%
151	0	100.00%
152	0	100.00%
153	0	100.00%
154	0	100.00%
155	0	100.00%
156	0	100.00%
157	0	100.00%
158	0	100.00%
159	0	100.00%
160	0	100.00%
More	0	100.00%

THICKNESS of geologic unit Fill Layer

Bin	Frequency	Cumulative %
0	1	3.33%
1	0	3.33%
2	0	3.33%
3	0	3.33%
4	0	3.33%
5	0	3.33%
6	0	3.33%
7	0	3.33%
8	2	10.00%
9	0	10.00%
10	3	20.00%
11	9	50.00%
12	8	76.67%
13	1	80.00%
14	1	83.33%
15	3	93.33%
16	0	93.33%
17	0	93.33%
18	0	93.33%
19	1	96.67%
20	0	96.67%
More	1	100.00%

THICKNESS of geologic unit	Silty Sand layer	
Bin	*Frequency*	*Cumulative %*
0	1	3.33%
1	0	3.33%
2	0	3.33%
3	0	3.33%
4	1	6.67%
5	0	6.67%
6	0	6.67%
7	0	6.67%
8	0	6.67%
9	0	6.67%
10	1	10.00%
11	0	10.00%
12	0	10.00%
13	0	10.00%
14	1	13.33%
15	1	16.67%
16	0	16.67%
17	2	23.33%
18	6	43.33%
19	2	50.00%
20	0	50.00%
21	4	63.33%
22	6	83.33%
23	1	86.67%
24	0	86.67%
25	3	96.67%
26	1	100.00%
27	0	100.00%
More	0	100.00%

THICKNESS of geologic unit Sand Layer

Bin	Frequency	Cumulative %
0	1	3.45%
1	1	6.90%
2	6	27.59%
3	7	51.72%
4	6	72.41%
5	3	82.76%
6	2	89.66%
7	1	93.10%
8	0	93.10%
9	0	93.10%
10	0	93.10%
11	0	93.10%
12	1	96.55%
13	1	100.00%
14	0	100.00%
15	0	100.00%
16	0	100.00%
17	0	100.00%
18	0	100.00%
19	0	100.00%
20	0	100.00%
21	0	100.00%
22	0	100.00%
23	0	100.00%
24	0	100.00%
25	0	100.00%
26	0	100.00%
27	0	100.00%
More	0	100.00%

THICKNESS of geologic unit	Boston Blue Clay Laye	
Bin	*Frequency*	*umulative %*
80	2	25.00%
81	0	25.00%
82	0	25.00%
83	0	25.00%
84	0	25.00%
85	0	25.00%
86	1	37.50%
87	1	50.00%
88	0	50.00%
89	0	50.00%
90	0	50.00%
91	1	62.50%
92	0	62.50%
93	0	62.50%
94	0	62.50%
95	1	75.00%
96	0	75.00%
97	0	75.00%
98	1	87.50%
99	0	87.50%
100	0	87.50%
101	0	87.50%
102	0	87.50%
103	0	87.50%
104	0	87.50%
105	0	87.50%
106	0	87.50%
107	0	87.50%
108	0	87.50%
109	0	87.50%
110	0	87.50%
111	0	87.50%
112	0	87.50%
113	0	87.50%
114	0	87.50%
115	0	87.50%
116	0	87.50%
117	0	87.50%
118	0	87.50%
119	1	100.00%
120	0	100.00%
More	0	100.00%

THICKNESS of geologic unit Glacial Till Layer

Bin	*Frequency*	*Cumulative %*
15	0	.00%
16	0	.00%
17	0	.00%
18	0	.00%
19	0	.00%
20	0	.00%
21	0	.00%
22	0	.00%
23	0	.00%
24	0	.00%
25	0	.00%
26	0	.00%
27	1	50.00%
28	0	50.00%
29	0	50.00%
30	0	50.00%
31	0	50.00%
32	0	50.00%
33	0	50.00%
34	0	50.00%
35	0	50.00%
36	0	50.00%
37	0	50.00%
38	1	100.00%
39	0	100.00%
40	0	100.00%
41	0	100.00%
42	0	100.00%
43	0	100.00%
44	0	100.00%
45	0	100.00%
46	0	100.00%
47	0	100.00%
48	0	100.00%
49	0	100.00%
50	0	100.00%
51	0	100.00%
52	0	100.00%
53	0	100.00%
54	0	100.00%
55	0	100.00%
More	0	100.00%

ratio 0.714285714

Datum 21.5 feet

	BORINGS														
Top of geologic unit elevation	1	2	3	4	5	6	6A	7	8	9	10	11	12	13	14
Fill Layer	0	0	0	0	0	0		0	0	0	0	0	0	0	0
Silty Sand layer	11	10.16667	12	12	11.5	10		12.5	11.5	12	8	8	9.5	11.5	10.5
Sand Layer	27.14285714	31.5	33.5	31	29.5	26.5		30.5		26.5	32.5	32.5	30.5	32.5	31.5
Boston Blue Clay Layer	33	33	36	33	34	30		33	34.5	33	36	37.5	34	35	34.5
Glacial Till Layer	104.5			127.4	121	127.5833	118.5	123.5				108	120		
Cambridge Argillite Layer	142						145								

	BORINGS														
THICKNESS of geologic unit	1	2	3	4	5	6	6A	7	8	9	10	11	12	13	14
Fill Layer	11	10.16667	12	12	11.5	10	0	12.5	11.5	12	8	8	9.5	11.5	10.5
Silty Sand layer	16.14285714	21.33333	21.5	19	18	16.5	0	18	23	14.5	24.5	24.5	21	21	21
Sand Layer	5.857142857	1.5	2.5	2	4.5	3.5	0	2.5		6.5	3.5	5	3.5	2.5	3
Boston Blue Clay Layer	71.5			94.4	87	97.58333	118.5	90.5				70.5	86		
Glacial Till Layer	37.5						26.5								

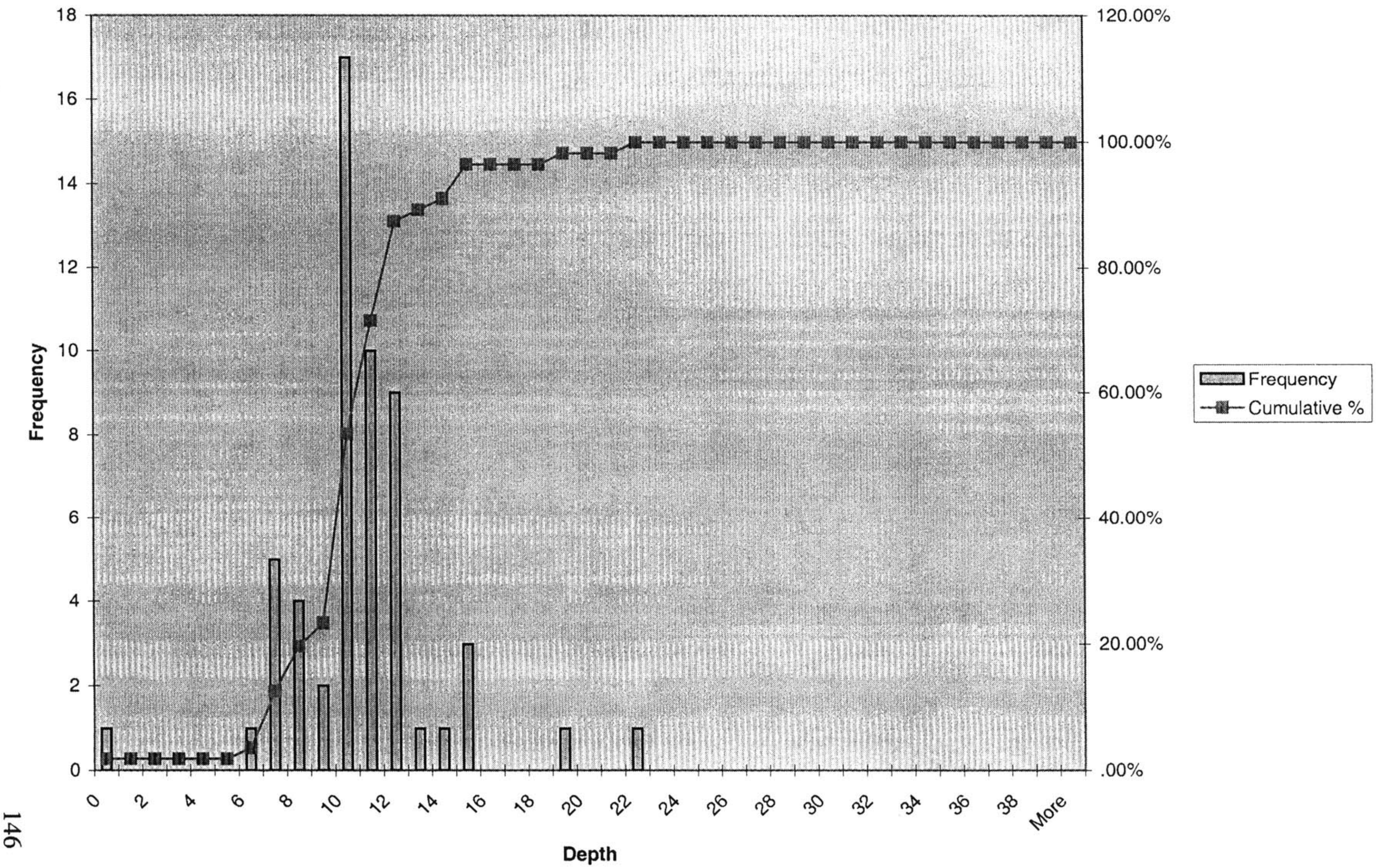
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Mean Depth of upp	STD. DEV
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
14.5	15	21.5	15	11	11	11	14	12	18.5	10.5	11	12	10	11	12.0	2.8
31.66667	32.5	31.5	33	33	35.5	33	33	32.5	22	28.5	25	33.5	36	32.5	31.0	3.2
34	34.5	33	37	35.5	37	35	36.66667	33.5	34.5	34.5	36.5	38	38.5	36.5	34.9	1.9
															118.8	8.5
															143.5	2.1

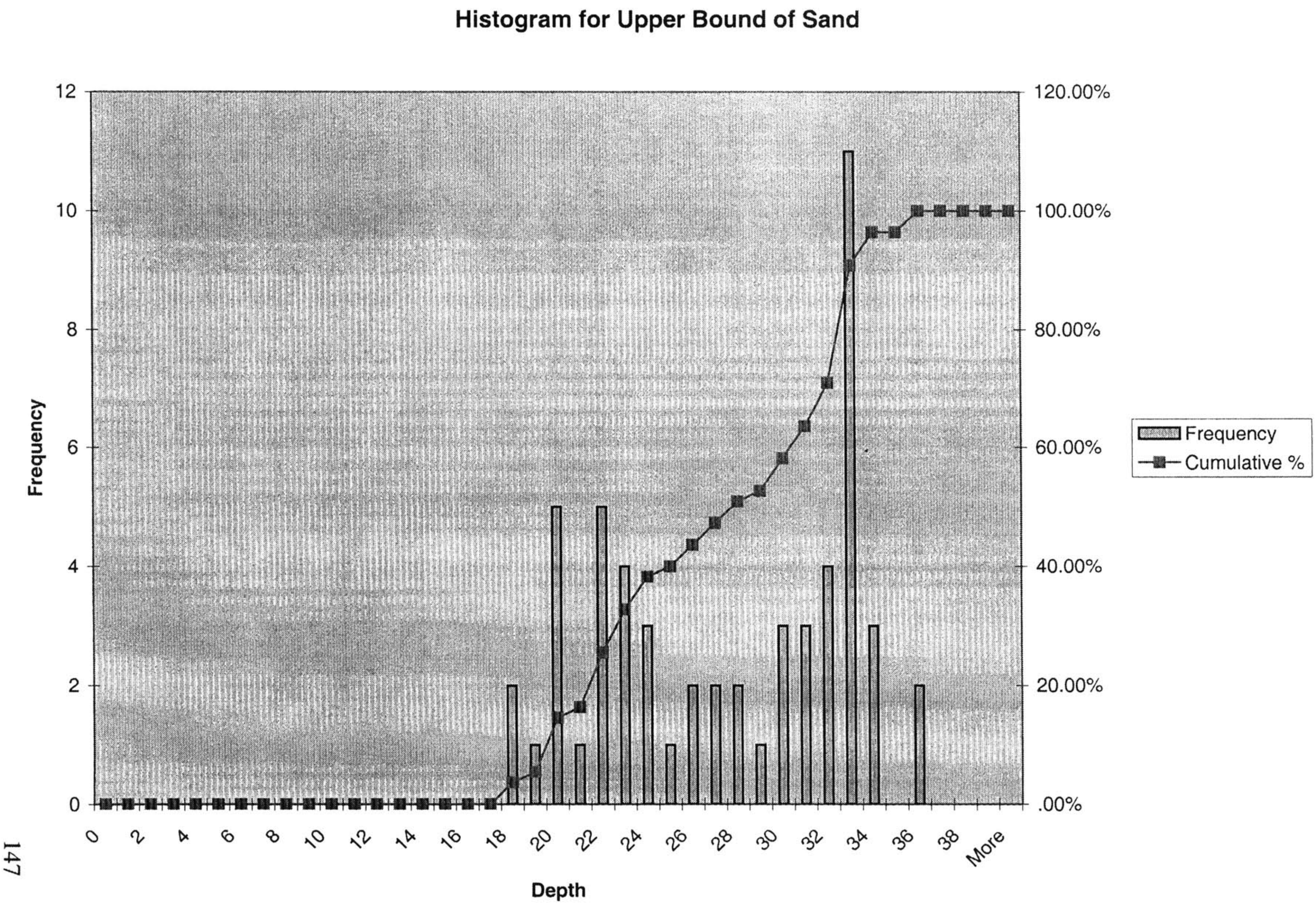
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Mean Thickness of	STD. DEV
14.5	15	21.5	15	11	11	11	14	12	18.5	10.5	11	12	10	11	11.6	3.5
17.16667	17.5	10	18	22	24.5	22	19	20.5	3.5	18	14	21.5	26	21.5	18.5	5.7
2.333333	2	1.5	4	2.5	1.5	2	3.666667	1	12.5	6	11.5	4.5	2.5	4	3.7	2.8
															89.5	15.3
															32.0	7.8

APPENDIX E

Zone 4 data and Corresponding Parameter Histograms

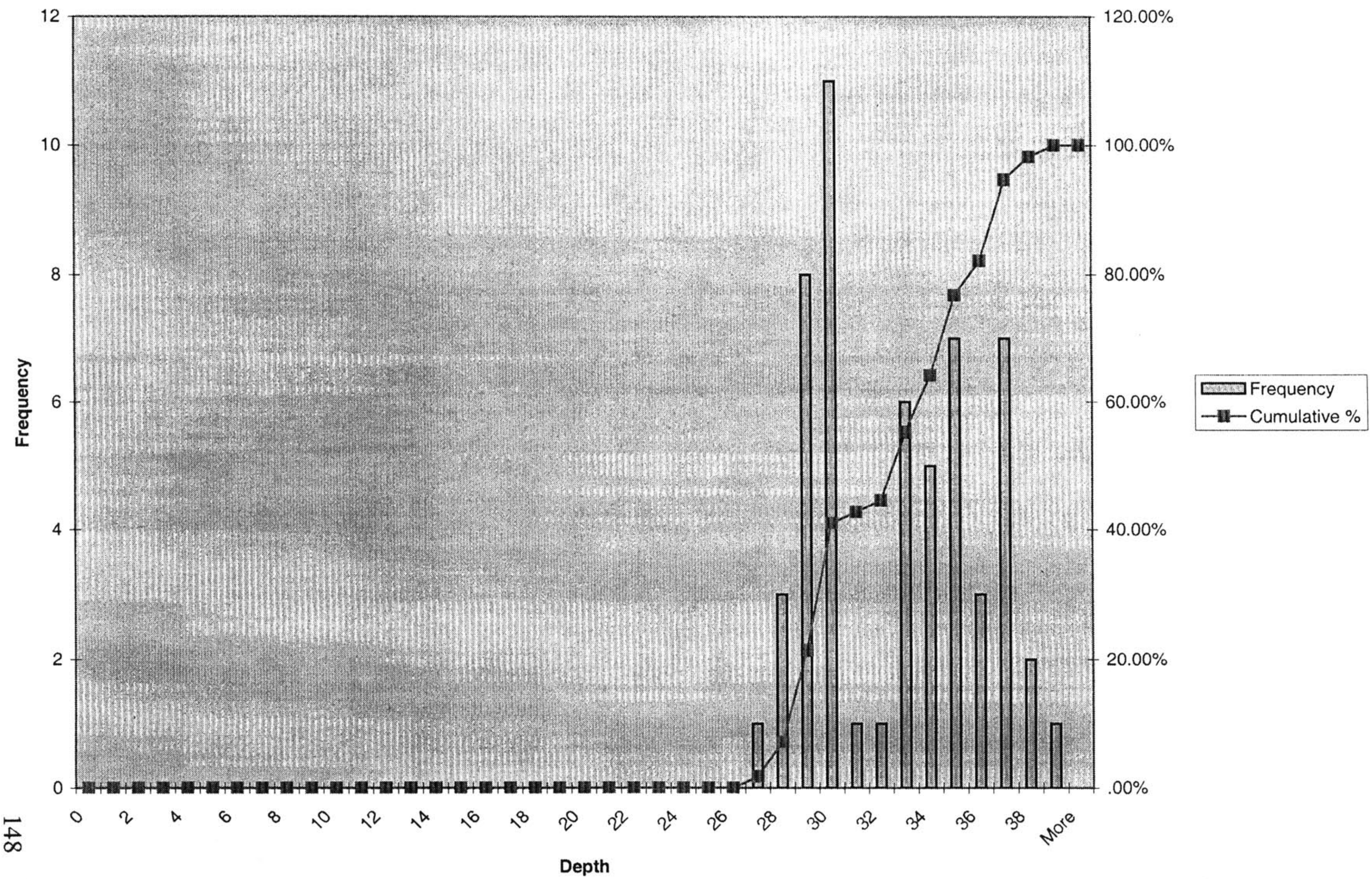
Histogram for Upper Bound of Silty Sand



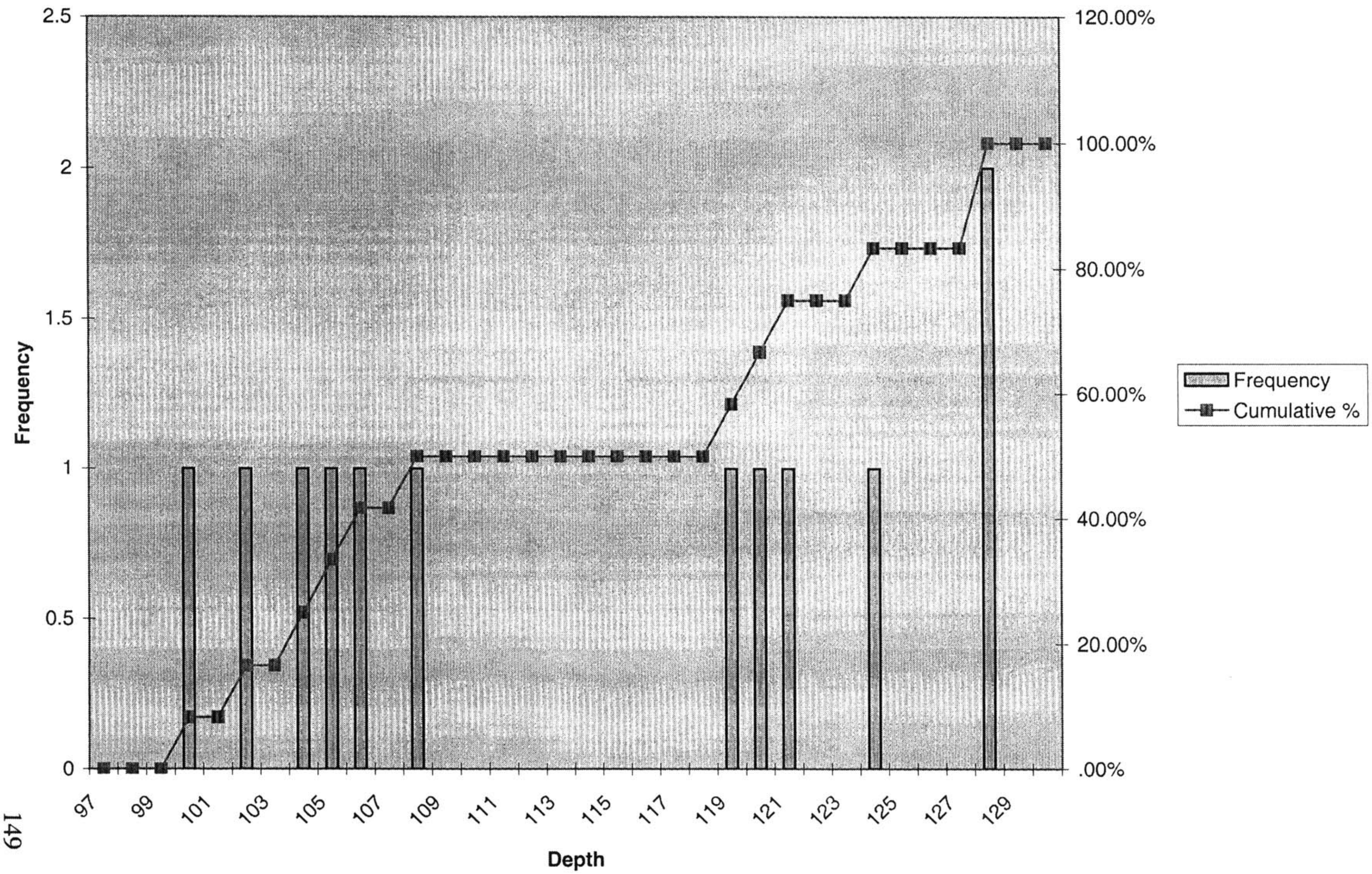


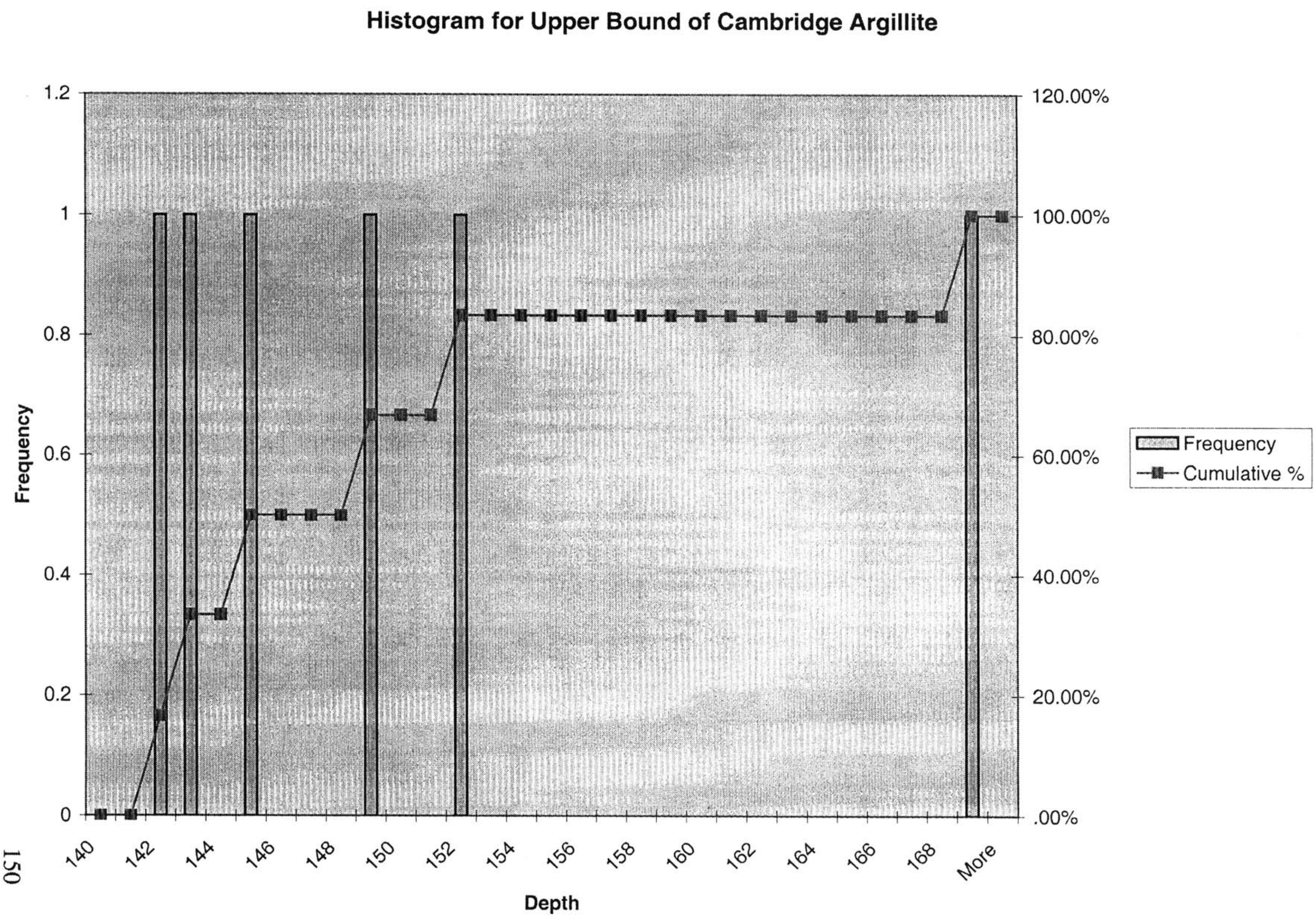
Histogram for Upper Bound of Sand
Frequency
12
10
8
6
4
2
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
More
Depth
Frequency
Cumulative %

Histogram for Upper Bound of Boston Blue Clay

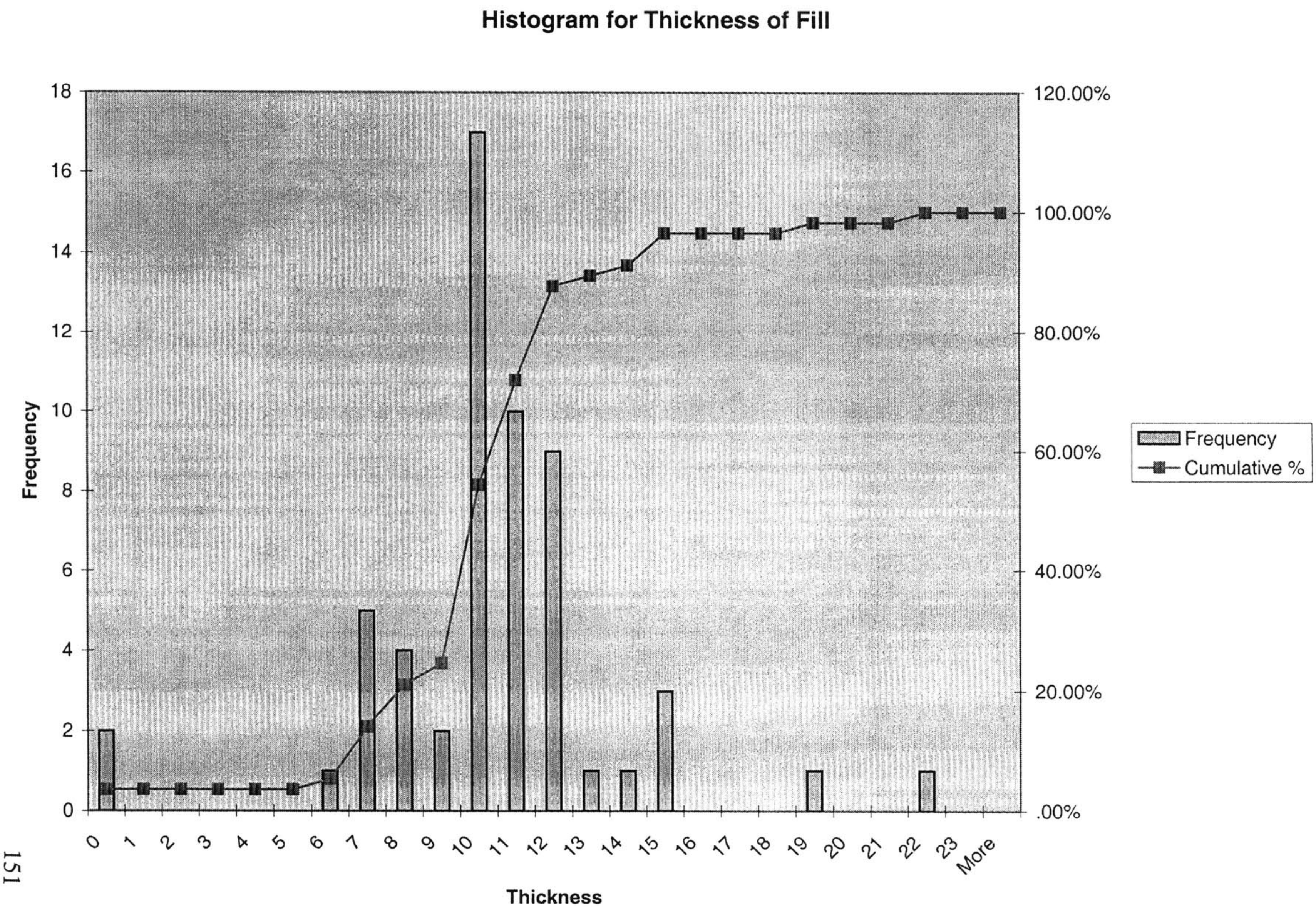


Histogram for Upper Bound of Glacial Till

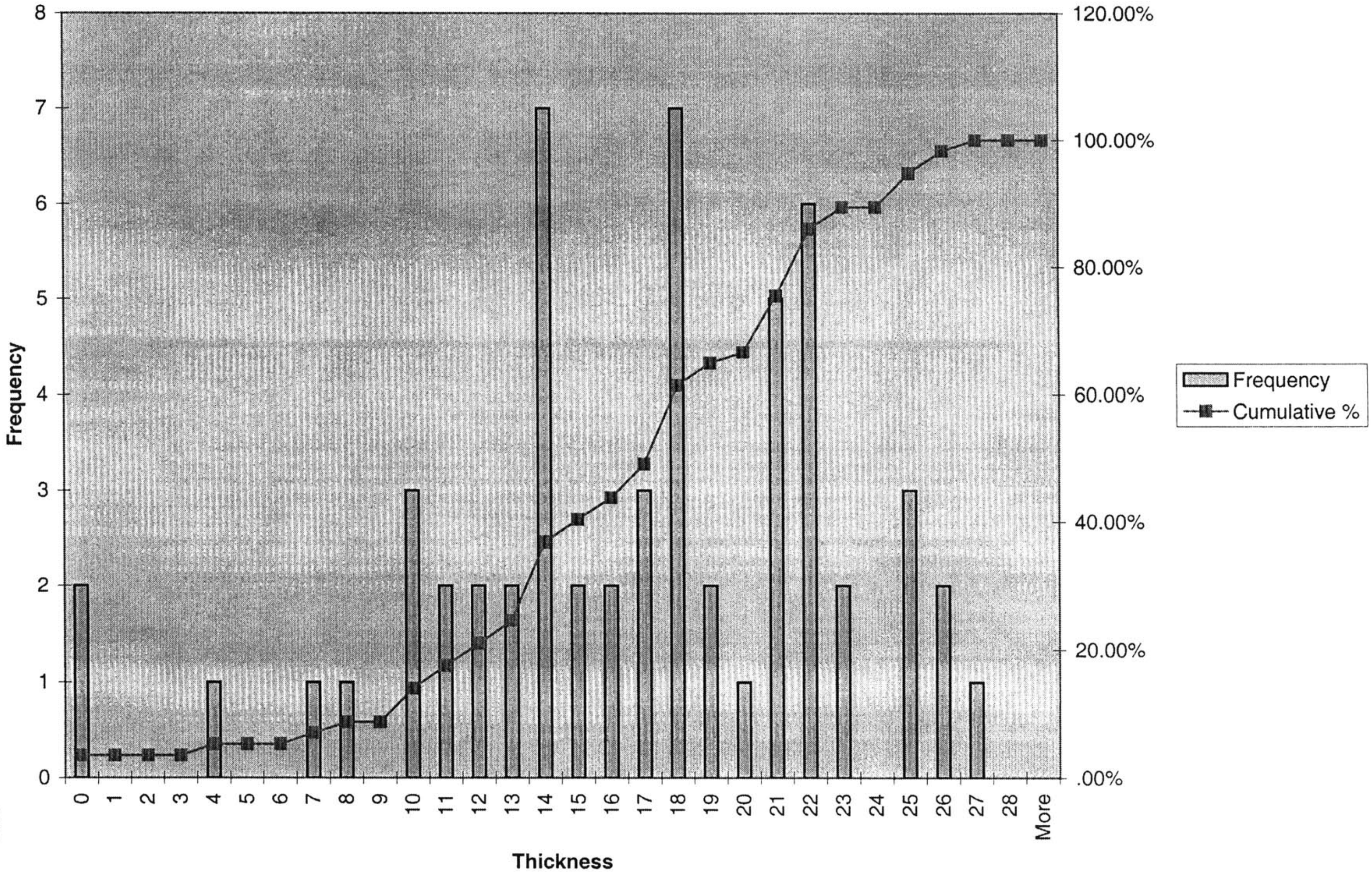




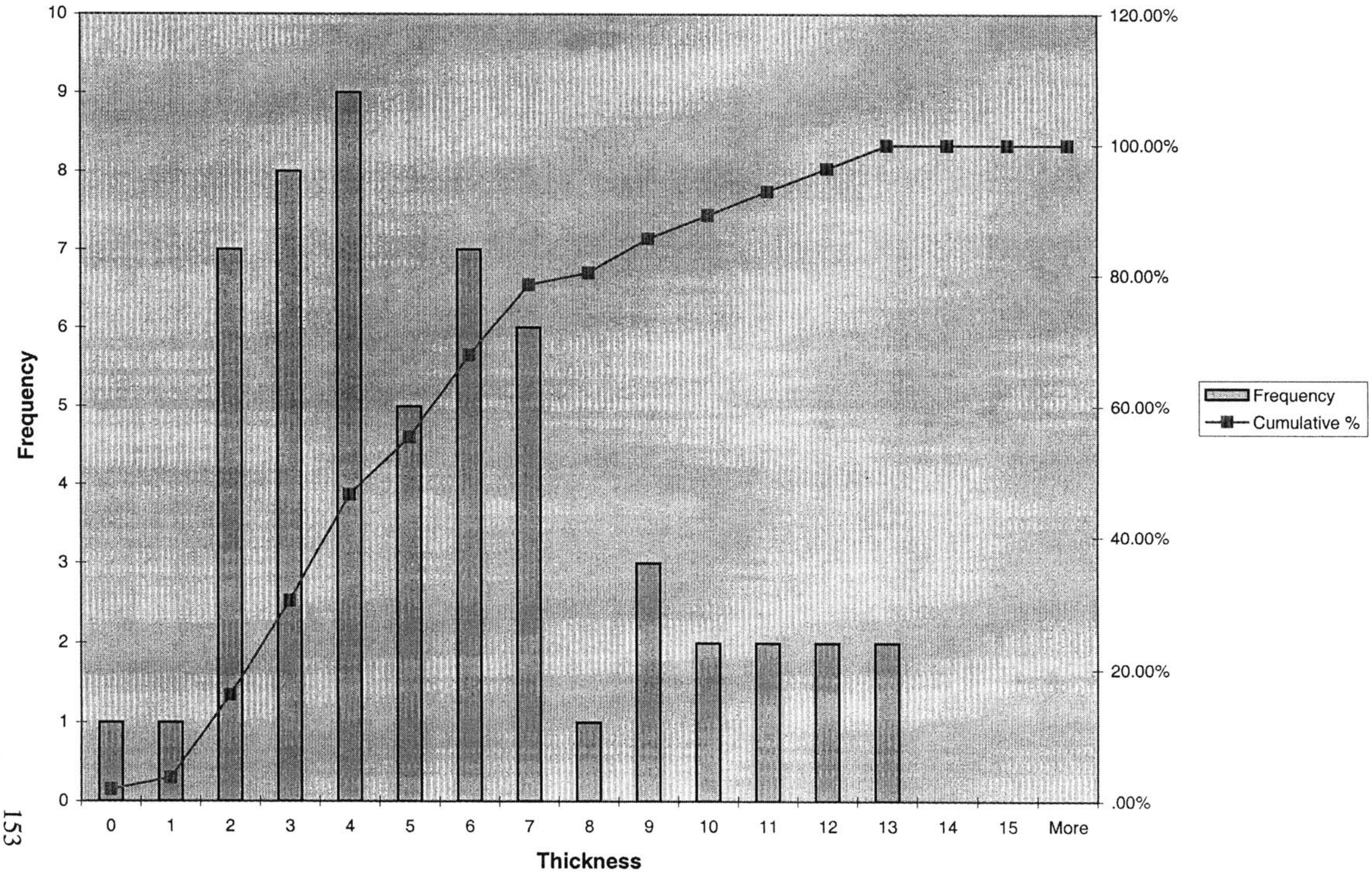
Histogram for Upper Bound of Cambridge Argillite
Frequency
0
0.2
0.4
0.6
0.8
1
1.2
.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
140
142
144
146
148
150
152
154
156
158
160
162
164
166
168
More
Depth
Frequency
Cumulative %


Histogram for Thickness of Fill
Frequency
18
16
14
12
10
8
6
4
2
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
More
Thickness
Frequency
Cumulative %

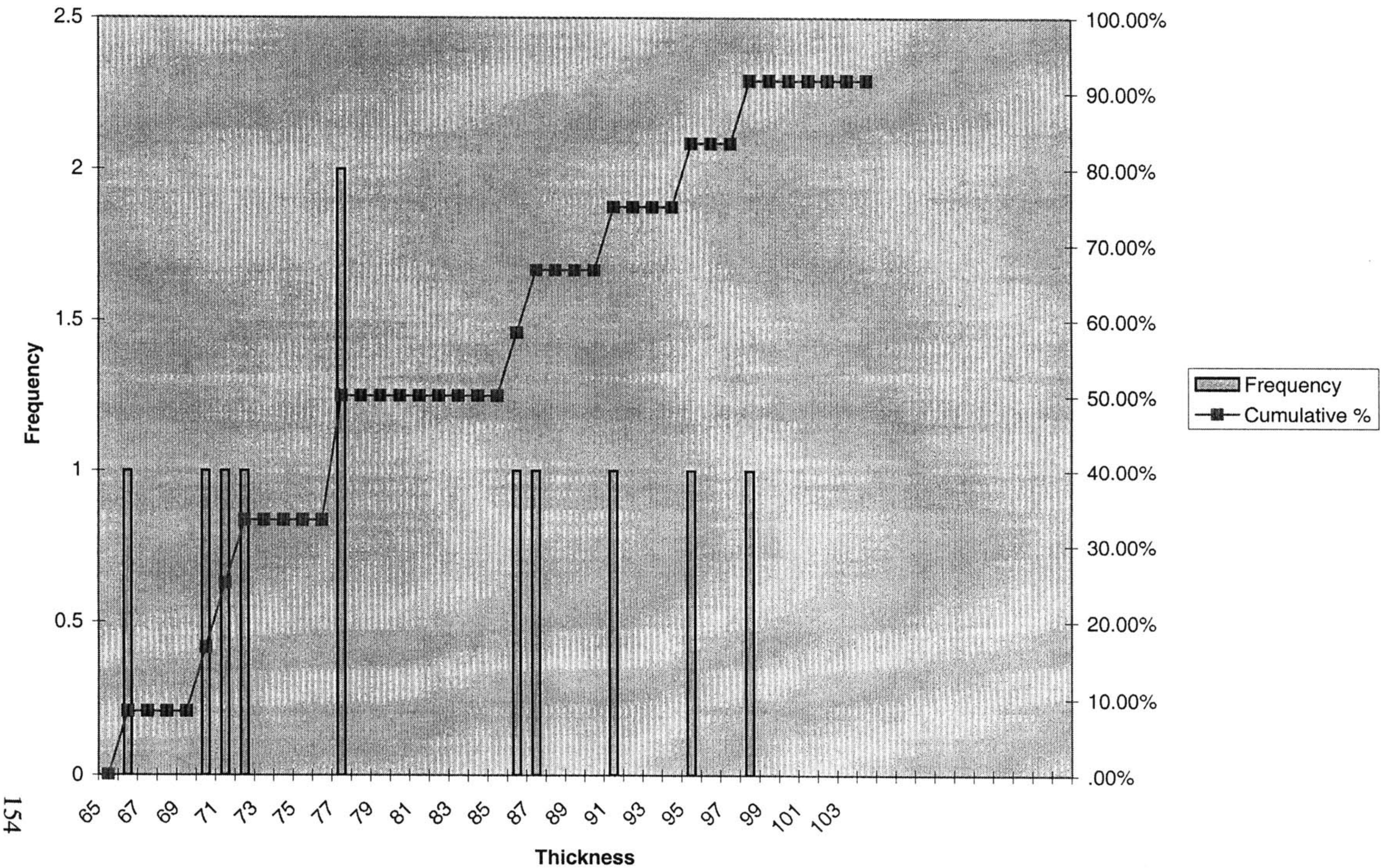
Histogram for Thickness of Silty Sand



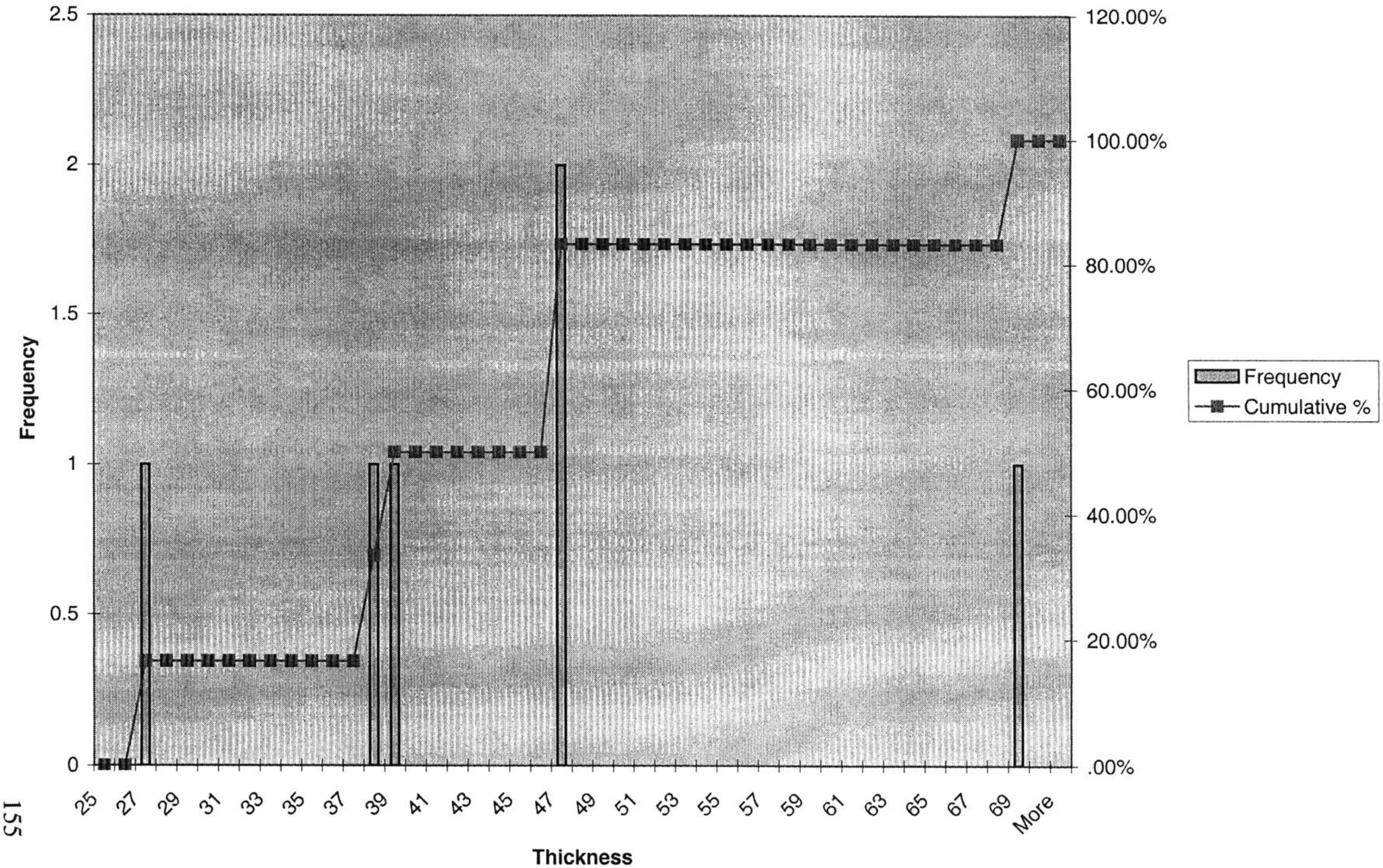
Histogram for Thickness of Sand



Histogram for Thickness of Boston Blue Clay



Histogram for Thickness of Glacial Till



For upper bound of Silty Sand layer

Bin	Frequency	Cumulative %
0	1	1.79%
1	0	1.79%
2	0	1.79%
3	0	1.79%
4	0	1.79%
5	0	1.79%
6	1	3.57%
7	5	12.50%
8	4	19.64%
9	2	23.21%
10	17	53.57%
11	10	71.43%
12	9	87.50%
13	1	89.29%
14	1	91.07%
15	3	96.43%
16	0	96.43%
17	0	96.43%
18	0	96.43%
19	1	98.21%
20	0	98.21%
21	0	98.21%
22	1	100.00%
23	0	100.00%
24	0	100.00%
25	0	100.00%
26	0	100.00%
27	0	100.00%
28	0	100.00%
29	0	100.00%
30	0	100.00%
31	0	100.00%
32	0	100.00%
33	0	100.00%
34	0	100.00%
35	0	100.00%
36	0	100.00%
37	0	100.00%
38	0	100.00%
39	0	100.00%
More	0	100.00%

For upper bound of Sand Layer

Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	0	.00%
8	0	.00%
9	0	.00%
10	0	.00%
11	0	.00%
12	0	.00%
13	0	.00%
14	0	.00%
15	0	.00%
16	0	.00%
17	0	.00%
18	2	3.64%
19	1	5.45%
20	5	14.55%
21	1	16.36%
22	5	25.45%
23	4	32.73%
24	3	38.18%
25	1	40.00%
26	2	43.64%
27	2	47.27%
28	2	50.91%
29	1	52.73%
30	3	58.18%
31	3	63.64%
32	4	70.91%
33	11	90.91%
34	3	96.36%
35	0	96.36%
36	2	100.00%
37	0	100.00%
38	0	100.00%
39	0	100.00%
More	0	100.00%

For upper bound of Boston Blue Clay Layer

Bin	*Frequency*	*Cumulative %*
0	0	.00%
1	0	.00%
2	0	.00%
3	0	.00%
4	0	.00%
5	0	.00%
6	0	.00%
7	0	.00%
8	0	.00%
9	0	.00%
10	0	.00%
11	0	.00%
12	0	.00%
13	0	.00%
14	0	.00%
15	0	.00%
16	0	.00%
17	0	.00%
18	0	.00%
19	0	.00%
20	0	.00%
21	0	.00%
22	0	.00%
23	0	.00%
24	0	.00%
25	0	.00%
26	0	.00%
27	1	1.79%
28	3	7.14%
29	8	21.43%
30	11	41.07%
31	1	42.86%
32	1	44.64%
33	6	55.36%
34	5	64.29%
35	7	76.79%
36	3	82.14%
37	7	94.64%
38	2	98.21%
39	1	100.00%
More	0	100.00%

For upper bound of Glacial Till Layer

Bin	*Frequency*	*Cumulative %*
97	0	.00%
98	0	.00%
99	0	.00%
100	1	8.33%
101	0	8.33%
102	1	16.67%
103	0	16.67%
104	1	25.00%
105	1	33.33%
106	1	41.67%
107	0	41.67%
108	1	50.00%
109	0	50.00%
110	0	50.00%
111	0	50.00%
112	0	50.00%
113	0	50.00%
114	0	50.00%
115	0	50.00%
116	0	50.00%
117	0	50.00%
118	0	50.00%
119	1	58.33%
120	1	66.67%
121	1	75.00%
122	0	75.00%
123	0	75.00%
124	1	83.33%
125	0	83.33%
126	0	83.33%
127	0	83.33%
128	2	100.00%
129	0	100.00%
More	0	100.00%

For upper bound of Cambridge Argillite Layer

Bin	*Frequency*	*Cumulative %*
140	0	.00%
141	0	.00%
142	1	16.67%
143	1	33.33%
144	0	33.33%
145	1	50.00%
146	0	50.00%
147	0	50.00%
148	0	50.00%
149	1	66.67%
150	0	66.67%
151	0	66.67%
152	1	83.33%
153	0	83.33%
154	0	83.33%
155	0	83.33%
156	0	83.33%
157	0	83.33%
158	0	83.33%
159	0	83.33%
160	0	83.33%
161	0	83.33%
162	0	83.33%
163	0	83.33%
164	0	83.33%
165	0	83.33%
166	0	83.33%
167	0	83.33%
168	0	83.33%
169	1	100.00%
More	0	100.00%

THICKNESS of geologic unit Fill Layer

Bin	*Frequency*	*Cumulative %*
0	2	3.51%
1	0	3.51%
2	0	3.51%
3	0	3.51%
4	0	3.51%
5	0	3.51%
6	1	5.26%
7	5	14.04%
8	4	21.05%
9	2	24.56%
10	17	54.39%
11	10	71.93%
12	9	87.72%
13	1	89.47%
14	1	91.23%
15	3	96.49%
16	0	96.49%
17	0	96.49%
18	0	96.49%
19	1	98.25%
20	0	98.25%
21	0	98.25%
22	1	100.00%
23	0	100.00%
More	0	100.00%

THICKNESS of geologic unit   Silty Sand layer

Bin	*Frequency*	*Cumulative %*
0	2	3.51%
1	0	3.51%
2	0	3.51%
3	0	3.51%
4	1	5.26%
5	0	5.26%
6	0	5.26%
7	1	7.02%
8	1	8.77%
9	0	8.77%
10	3	14.04%
11	2	17.54%
12	2	21.05%
13	2	24.56%
14	7	36.84%
15	2	40.35%
16	2	43.86%
17	3	49.12%
18	7	61.40%
19	2	64.91%
20	1	66.67%
21	5	75.44%
22	6	85.96%
23	2	89.47%
24	0	89.47%
25	3	94.74%
26	2	98.25%
27	1	100.00%
28	0	100.00%
More	0	100.00%

THICKNESS of geologic unit Sand Layer

Bin	*Frequency*	*Cumulative %*
0	1	1.79%
1	1	3.57%
2	7	16.07%
3	8	30.36%
4	9	46.43%
5	5	55.36%
6	7	67.86%
7	6	78.57%
8	1	80.36%
9	3	85.71%
10	2	89.29%
11	2	92.86%
12	2	96.43%
13	2	100.00%
14	0	100.00%
15	0	100.00%
More	0	100.00%

THICKNESS of geologic unit Boston Blue Clay Layer

Bin	*Frequency*	*Cumulative %*
65	0	.00%
66	1	8.33%
67	0	8.33%
68	0	8.33%
69	0	8.33%
70	1	16.67%
71	1	25.00%
72	1	33.33%
73	0	33.33%
74	0	33.33%
75	0	33.33%
76	0	33.33%
77	2	50.00%
78	0	50.00%
79	0	50.00%
80	0	50.00%
81	0	50.00%
82	0	50.00%
83	0	50.00%
84	0	50.00%
85	0	50.00%
86	1	58.33%
87	1	66.67%
88	0	66.67%
89	0	66.67%
90	0	66.67%
91	1	75.00%
92	0	75.00%
93	0	75.00%
94	0	75.00%
95	1	83.33%
96	0	83.33%
97	0	83.33%
98	1	91.67%
99	0	91.67%
100	0	91.67%
101	0	91.67%
102	0	91.67%
103	0	91.67%
104	0	91.67%
105	0	91.67%
106	0	91.67%
107	0	91.67%
108	0	91.67%
109	0	91.67%
110	0	91.67%
111	0	91.67%
112	0	91.67%
113	0	91.67%
114	0	91.67%
115	0	91.67%
116	0	91.67%
117	0	91.67%
118	0	91.67%
119	1	100.00%

THICKNESS of geologic unit Glacial Till Layer

Bin	*Frequency*	*Cumulative %*
25	0	.00%
26	0	.00%
27	1	16.67%
28	0	16.67%
29	0	16.67%
30	0	16.67%
31	0	16.67%
32	0	16.67%
33	0	16.67%
34	0	16.67%
35	0	16.67%
36	0	16.67%
37	0	16.67%
38	1	33.33%
39	1	50.00%
40	0	50.00%
41	0	50.00%
42	0	50.00%
43	0	50.00%
44	0	50.00%
45	0	50.00%
46	0	50.00%
47	2	83.33%
48	0	83.33%
49	0	83.33%
50	0	83.33%
51	0	83.33%
52	0	83.33%
53	0	83.33%
54	0	83.33%
55	0	83.33%
56	0	83.33%
57	0	83.33%
58	0	83.33%
59	0	83.33%
60	0	83.33%
61	0	83.33%
62	0	83.33%
63	0	83.33%
64	0	83.33%
65	0	83.33%
66	0	83.33%
67	0	83.33%
68	0	83.33%
69	1	100.00%
70	0	100.00%
More	0	100.00%

ZONE 1 - BORINGS

Top of geologic unit elevation	2	3	4	5	8	7	6	9	10	12
Fill Layer	0	0	0	0	0	0	0	0	0	0
Silty Sand layer	7.692308	6.923077	7.692308	5.384615	6.153846	9.230769	6.923077	10.76923	6.923077	6.153846
Sand Layer	30	27.69231	25.38462	19.23077	21.53846	29.23077	32.30769	21.53846	22.30769	33.07692
Boston Blue Clay Layer	31.53846	30	28.46154	28.46154	28.46154	33.84615	36.15385	30	27.69231	36.15385
Glacial Till Layer	0	0	0	0	105.3846	0	101.5385	0	103.8462	0
Cambridge Argillite Layer	0	0	0	0	151.5385	0	148.4615	0	142.3077	0

ZONE 1 - BORINGS

THICKNESS of geologic unit	2	3	4	5	8	7	6	9	10	12
Fill Layer	7.692308	6.923077	7.692308	5.384615	6.153846	9.230769	6.923077	10.76923	6.923077	6.153846
Silty Sand layer	22.30769	20.76923	17.69231	13.84615	15.38462	20	25.38462	10.76923	15.38462	26.92308
Sand Layer	1.538462	2.307692	3.076923	9.230769	6.923077	4.615385	3.846154	8.461538	5.384615	3.076923
Boston Blue Clay Layer	0	0	0	0	76.92308	0	65.38462	0	76.15385	0
Glacial Till Layer	0	0	0	0	46.15385	0	46.92308	0	38.46154	0

ZONE 2 - BORINGS

13	B11	B13	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	0	0	0	0	0	0
0	9.230769	9.230769	11.53846	10	10	9.615385	8.461538	9.230769	8.846154	9.230769	10
19.23077	20.76923	18.46154	17.69231	17.69231	19.23077	20	20	21.53846	23.07692	22.30769	23.84615
30	29.23077	29.23077	30	29.23077	28.46154	28.46154	26.92308	28.46154	27.69231	28.46154	29.23077
100	0	0	0	0	0	0	0	0	0	0	0
168.4615	0	0	0	0	0	0	0	0	0	0	0

ZONE 2 - BORINGS

13	B11	B13	1	2	3	4	5	6	7	8	9
0	9.230769	9.230769	11.53846	10	10	9.615385	8.461538	9.230769	8.846154	9.230769	10
0	11.53846	9.230769	6.153846	7.692308	9.230769	10.38462	11.53846	12.30769	14.23077	13.07692	13.84615
10.76923	8.461538	10.76923	12.30769	11.53846	9.230769	8.461538	6.923077	6.923077	4.615385	6.153846	5.384615
70	0	0	0	0	0	0	0	0	0	0	0
68.46154	0	0	0	0	0	0	0	0	0	0	0

10	11	12	13	14	1	2	3	4	5	6	6A
0	0	0	0	0	0	0	0	0	0	0	0
9.230769	9.230769	9.230769	9.230769	9.230769	11	10.16667	12	12	11.5	10	0
22.30769	23.07692	21.53846	25.38462	22.30769	27.14286	31.5	33.5	31	29.5	26.5	0
27.69231	28.46154	29.23077	30.76923	29.23077	33	33	36	33	34	30	0
0	0	0	0	0	104.5	0	0	127.4	121	127.5833	118.5
0	0	0	0	0	142	0	0	0	0	0	145

10	11	12	13	14	1	2	3	4	5	6	6A
9.230769	9.230769	9.230769	9.230769	9.230769	11	10.16667	12	12	11.5	10	0
13.07692	13.84615	12.30769	16.15385	13.07692	16.14286	21.33333	21.5	19	18	16.5	0
5.384615	5.384615	7.692308	5.384615	6.923077	5.857143	1.5	2.5	2	4.5	3.5	0
0	0	0	0	0	71.5	0	0	94.4	87	97.58333	118.5
0	0	0	0	0	37.5	0	0	0	0	0	26.5

							ZONE 3 -BORINGS				
7	8	9	10	11	12	13	14	15	16	17	18
0	0	0	0	0	0	0	0	0	0	0	0
12.5	11.5	12	8	8	9.5	11.5	10.5	14.5	15	21.5	15
30.5	0	26.5	32.5	32.5	30.5	32.5	31.5	31.66667	32.5	31.5	33
33	34.5	33	36	37.5	34	35	34.5	34	34.5	33	37
123.5	0	0	0	108	120	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

							ZONE 3 -BORINGS				
7	8	9	10	11	12	13	14	15	16	17	18
12.5	11.5	12	8	8	9.5	11.5	10.5	14.5	15	21.5	15
18	23	14.5	24.5	24.5	21	21	21	17.16667	17.5	10	18
2.5	0	6.5	3.5	5	3.5	2.5	3	2.333333	2	1.5	4
90.5	0	0	0	70.5	86	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

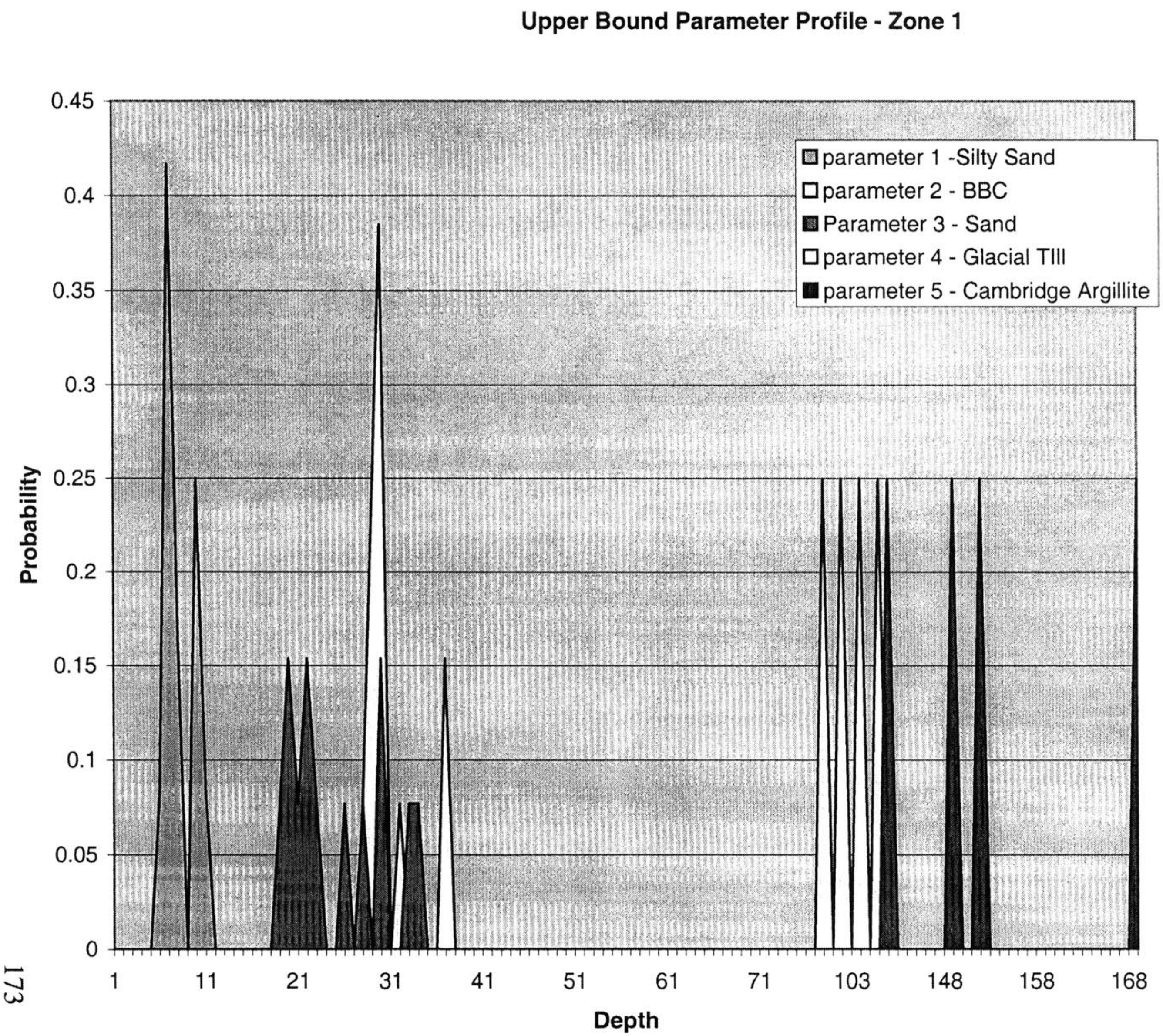
19	#REF!	21	22	23	24	25	26	27	28	29
0	#REF!	0	0	0	0	0	0	0	0	0
11	#REF!	11	14	12	18.5	10.5	11	12	10	11
33	#REF!	33	33	32.5	22	28.5	25	33.5	36	32.5
35.5	#REF!	35	36.66667	33.5	34.5	34.5	36.5	38	38.5	36.5
0	#REF!	0	0	0	0	0	0	0	0	0
0	#REF!	0	0	0	0	0	0	0	0	0

19	#REF!	21	22	23	24	25	26	27	28	29
11	#REF!	11	14	12	18.5	10.5	11	12	10	11
22	#REF!	22	19	20.5	3.5	18	14	21.5	26	21.5
2.5	#REF!	2	3.666667	1	12.5	6	11.5	4.5	2.5	4
0	#REF!	0	0	0	0	0	0	0	0	0
0	#REF!	0	0	0	0	0	0	0	0	0

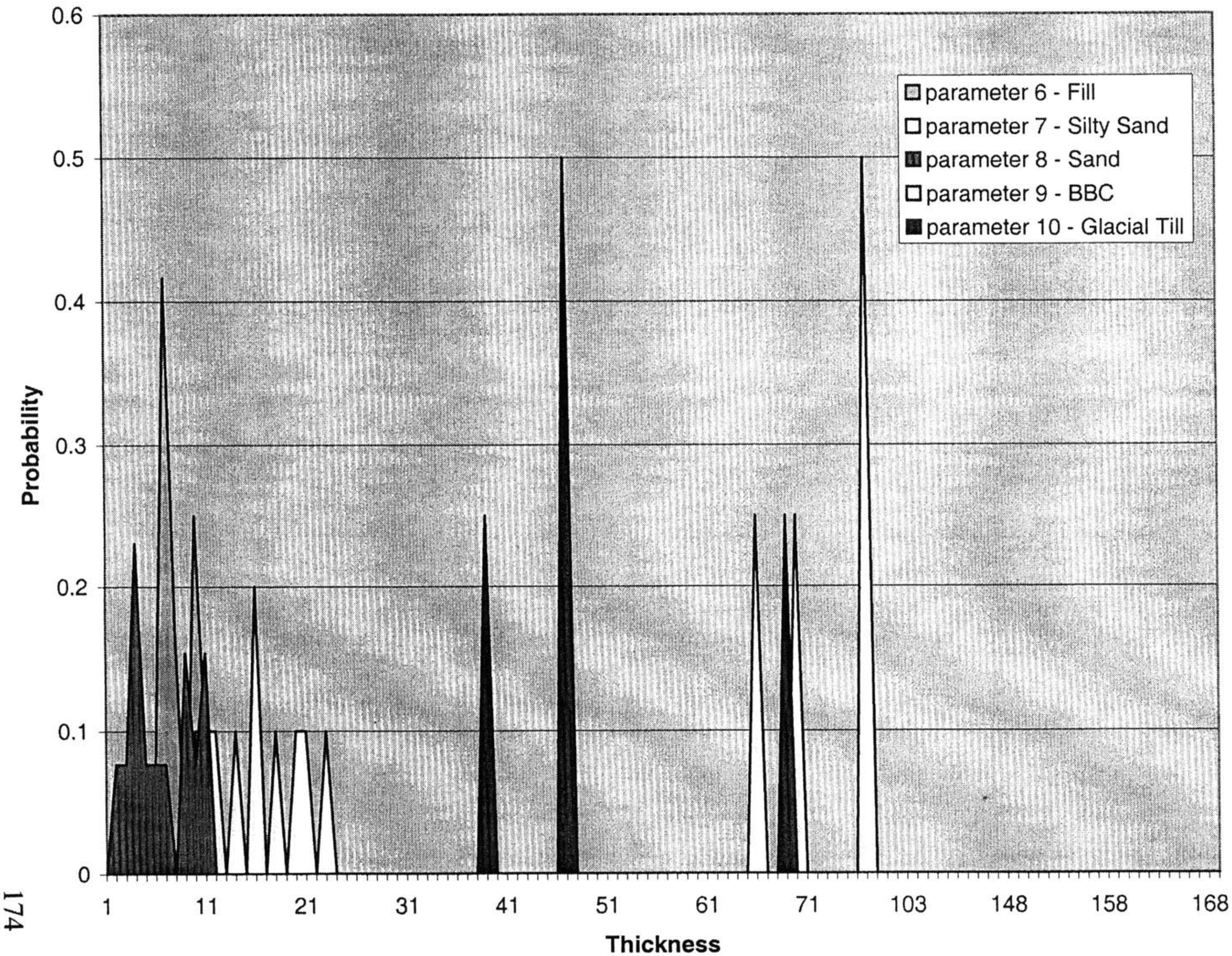
Mean Depth of upper contact	STD. DEV
0.0	0.0
10.2	3.2
26.9	5.4
32.3	3.3
113.4	10.5
149.6	9.9

Mean Thickness of Layer	STD. DEV
10.0	3.4
16.2	6.1
5.2	3.1
83.7	15.2
44.0	14.1

APPENDIX F
Performance


Upper Bound Parameter Profile - Zone 1
Probability
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
11
21
31
41
51
61
71
103
148
158
168
Depth
parameter 1 -Silty Sand
parameter 2 - BBC
Parameter 3 - Sand
parameter 4 - Glacial TIll
parameter 5 - Cambridge Argillite

Thickness Parameter Profile - Zone 1



Silty Sand	12	6	to	11
Sand	13	19		34
BBC	13	28		37
Glacial Till	4	100		107
Cambridge Argillite	4	143		169

Fill Thickness	12	6	to	11				
Silty Sand Thickness	10	19		34				
					1	1	3	
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

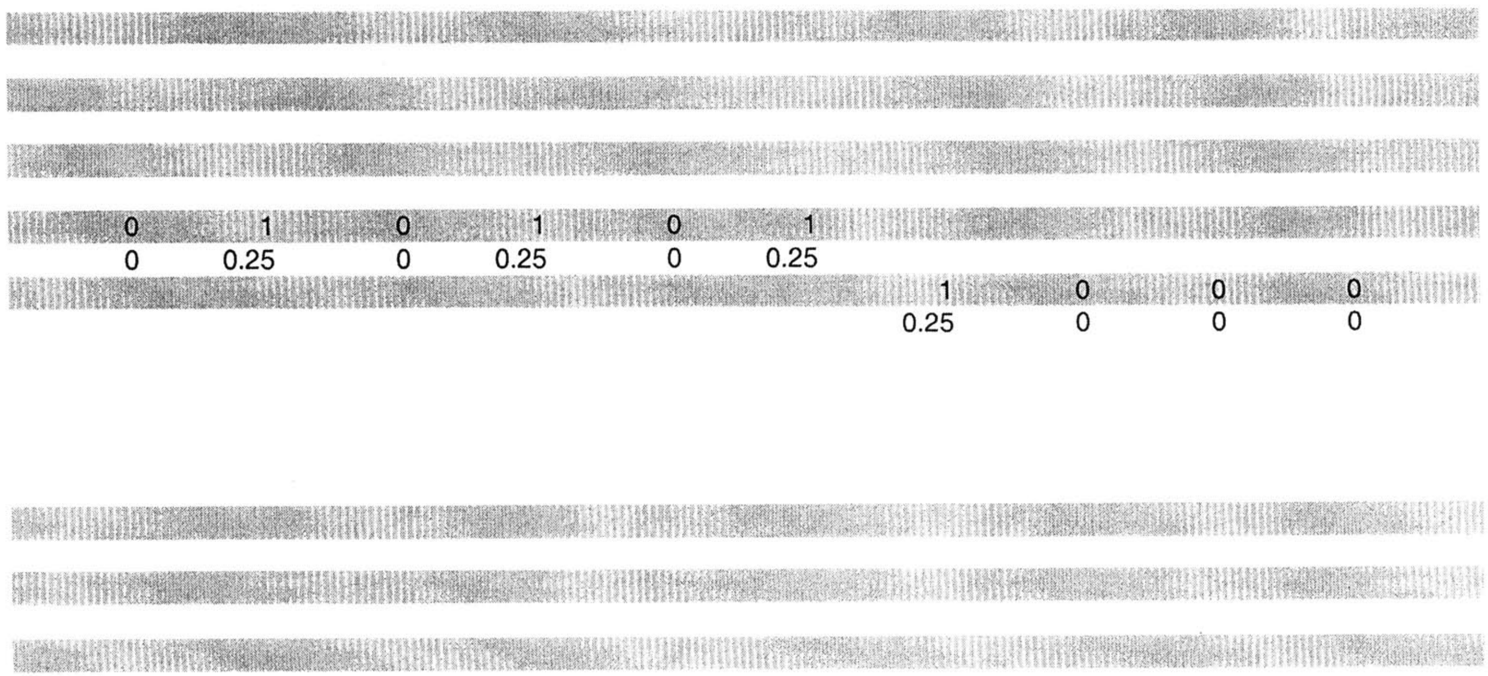
0.416667	0.166667	0	0.25	0.083333

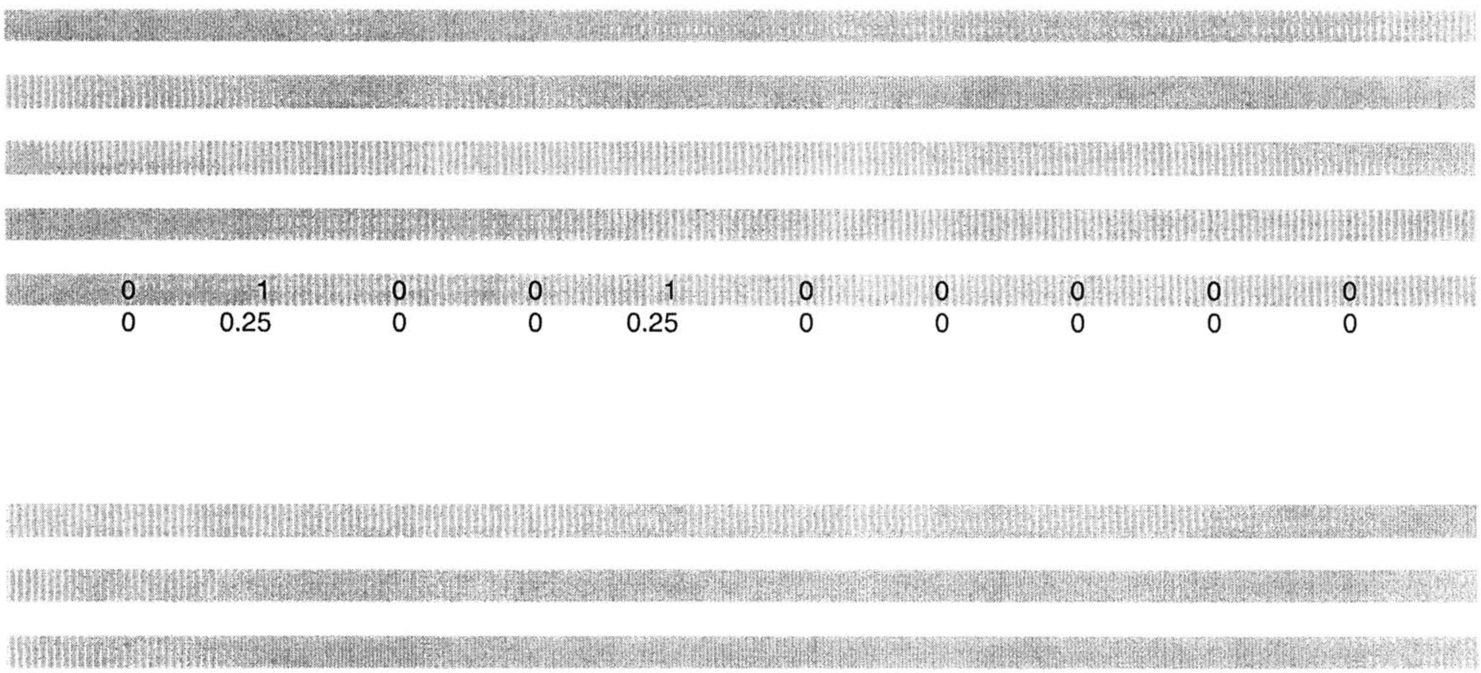
0.416667	0.166667	0	0.25	0.083333					
			1	1	1	0	1	0	2
			0.1	0.1	0.1	0	0.1	0	0.2
1	0	2	1	2					

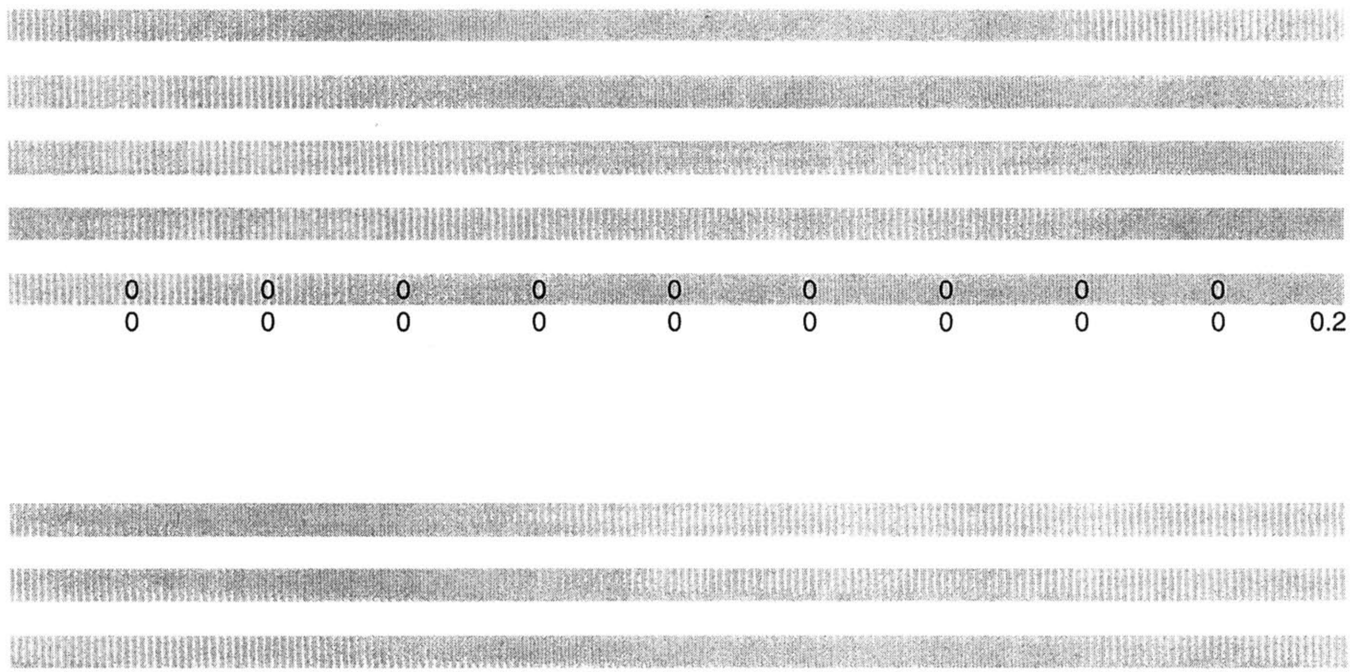
1	2	1	2	1	0	0	1	0	1	
0.076923	0.153846	0.076923	0.153846	0.076923	0	0	0.076923	0	0.076923	
									1	
									0.076923	0.23076

0	1	1	0	1	0
0	0.1	0.1	0	0.1	0

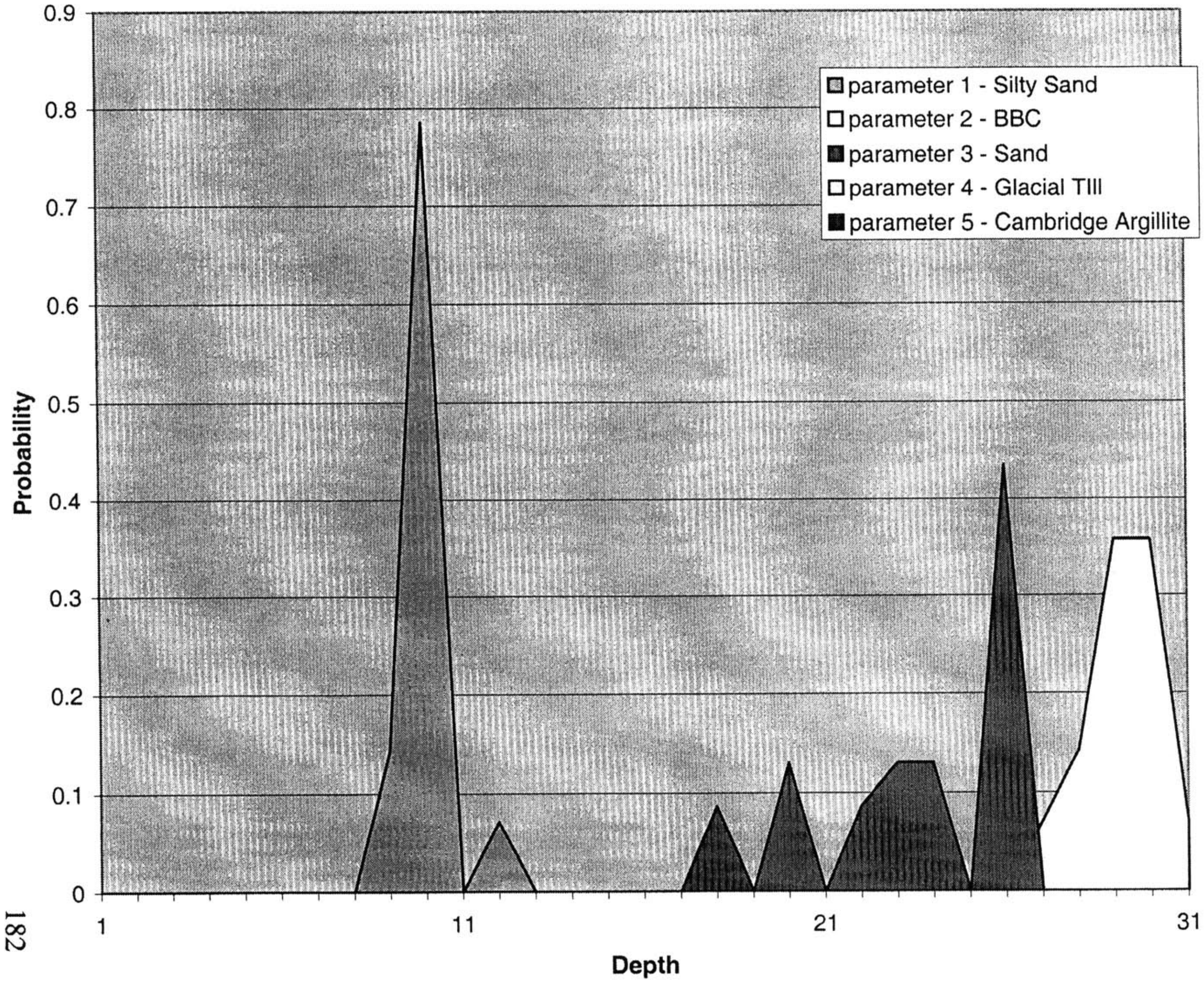
0	0	1	1			
0	0	0.076923	0.076923			
0	1	0	1	0	0	2
0	0.076923	0	0.076923	0	0	0.153846

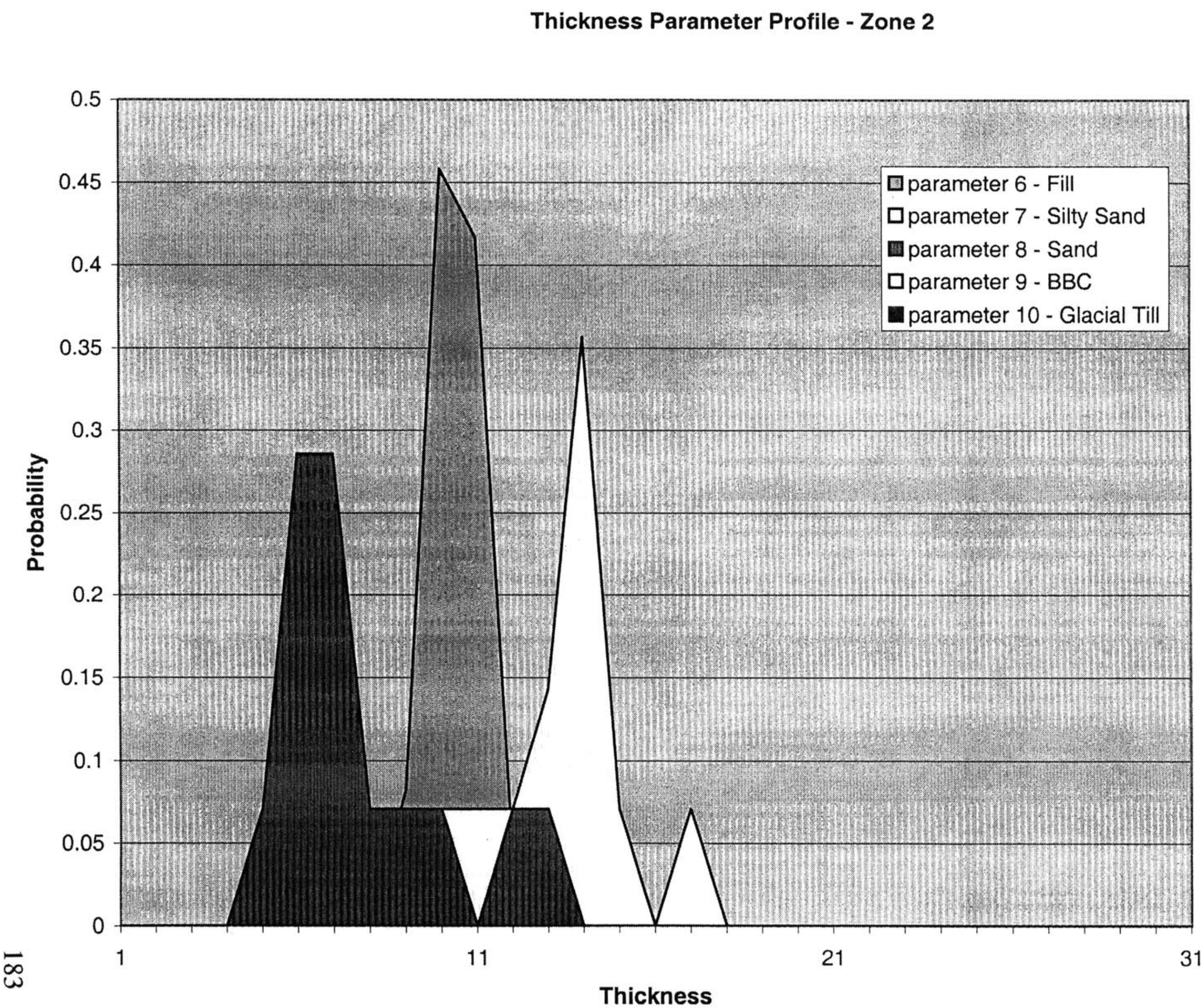

0 1 0 1 0 1
0 0.25 0 0.25 0 0.25
1 0 0 0
0.25 0 0 0


0 1 0 0 1 0 0 0 0 0
0 0.25 0 0 0.25 0 0 0 0 0


0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0.2

Upper Bound Parameter Profile - Zone 2




Thickness Parameter Profile - Zone 2
Probability
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
11
21
31
Thickness
parameter 6 - Fill
parameter 7 - Silty Sand
parameter 8 - Sand
parameter 9 - BBC
parameter 10 - Glacial Till

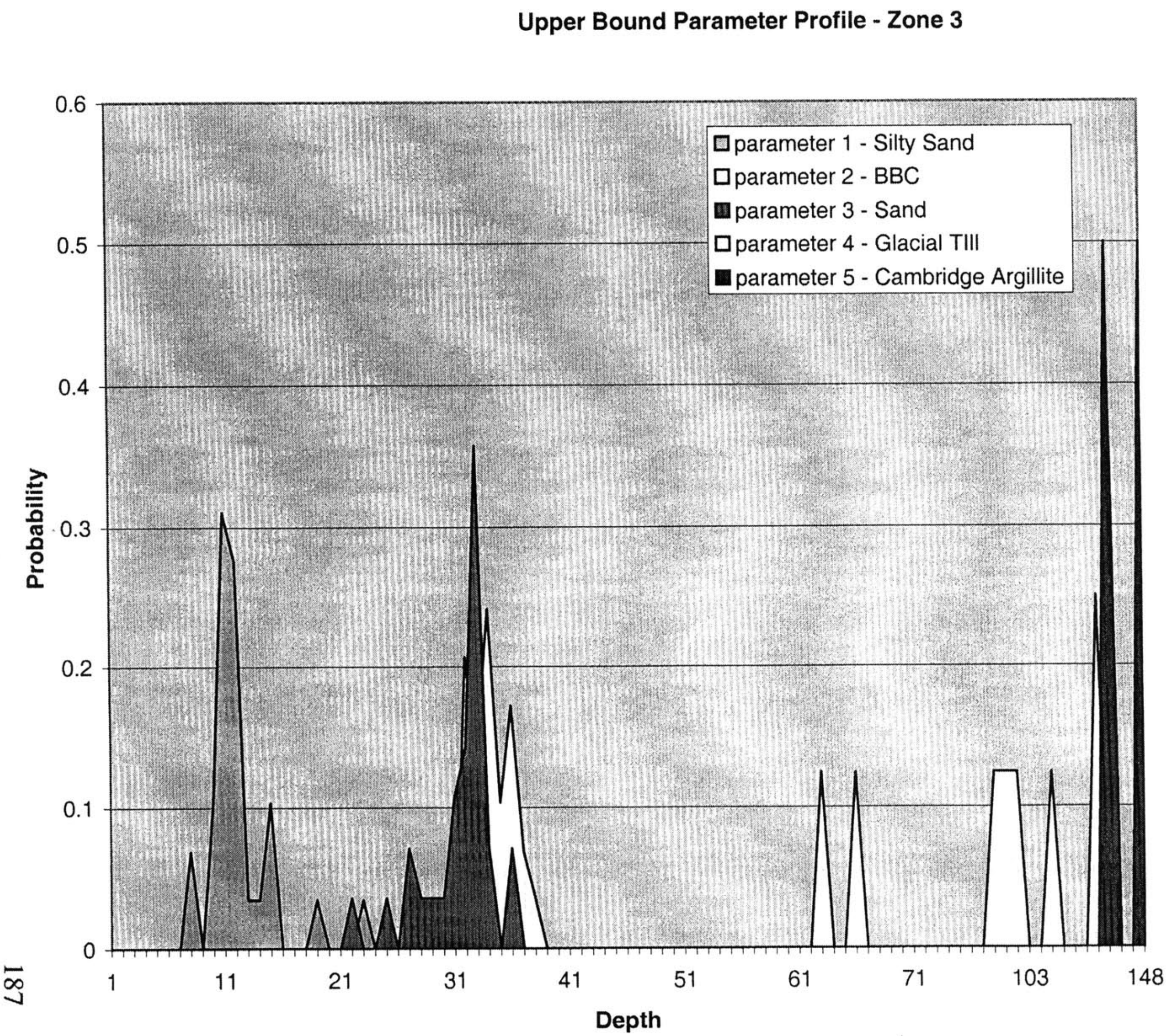
Silty Sand	14	9	to	12	
Sand	23	18		26	
BBC	14	27		31	

Fill Thickness	24	9	to	12	
Silty Sand Thickness	14	7		17	0

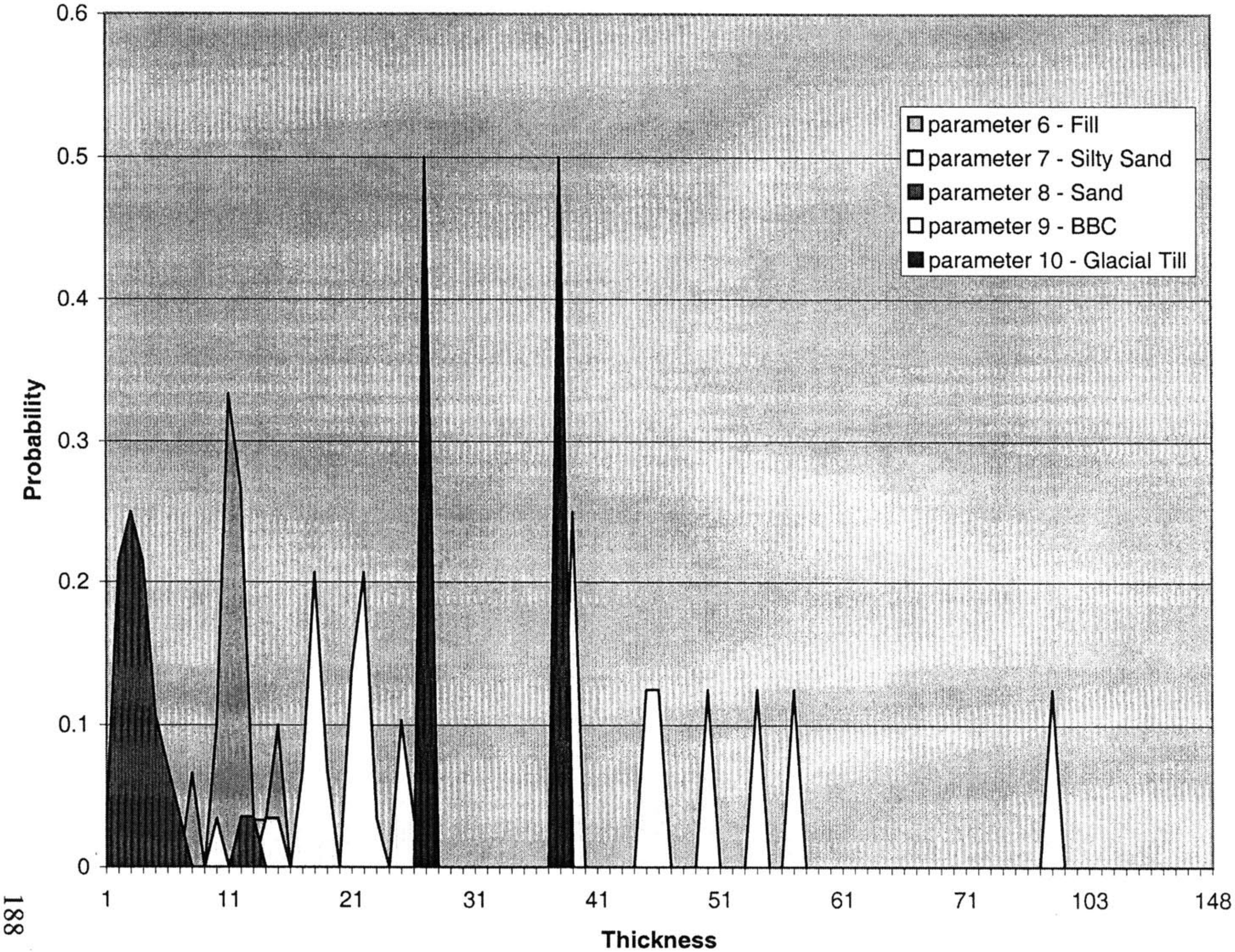
		0.142857	0.785714	0	0.071429					

		0.083333	0.458333	0.416667	0.041667					
1	1	0	1	1	1	2	5	1	0	
0.071429	0.071429	0	0.071429	0.071429	0.071429	0.142857	0.357143	0.071429	0	0.07142

0	3	0	2	3	3	0	10			
0	0.130435	0	0.086957	0.130435	0.130435	0	0.434783			
								1	2	
								0.071429	0.142857	0.35714


Upper Bound Parameter Profile - Zone 3
parameter 1 - Silty Sand
parameter 2 - BBC
parameter 3 - Sand
parameter 4 - Glacial TIll
parameter 5 - Cambridge Argillite
Probability
0.6
0.5
0.4
0.3
0.2
0.1
0
1
11
21
31
41
51
61
71
103
148
Depth

Thickness Parameter Profile - Zone 3



Silty Sand	29	8	to	23				
Sand	28	22		36				
BBC	29	30		39				
Glacial Till	8	104		128				
Cambridge Argillite	2	142		145				

Fill Thickness	30	8	to	23				
								1
Silty Sand Thickness	29	4		26				0.034483
					1	6	7	6
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

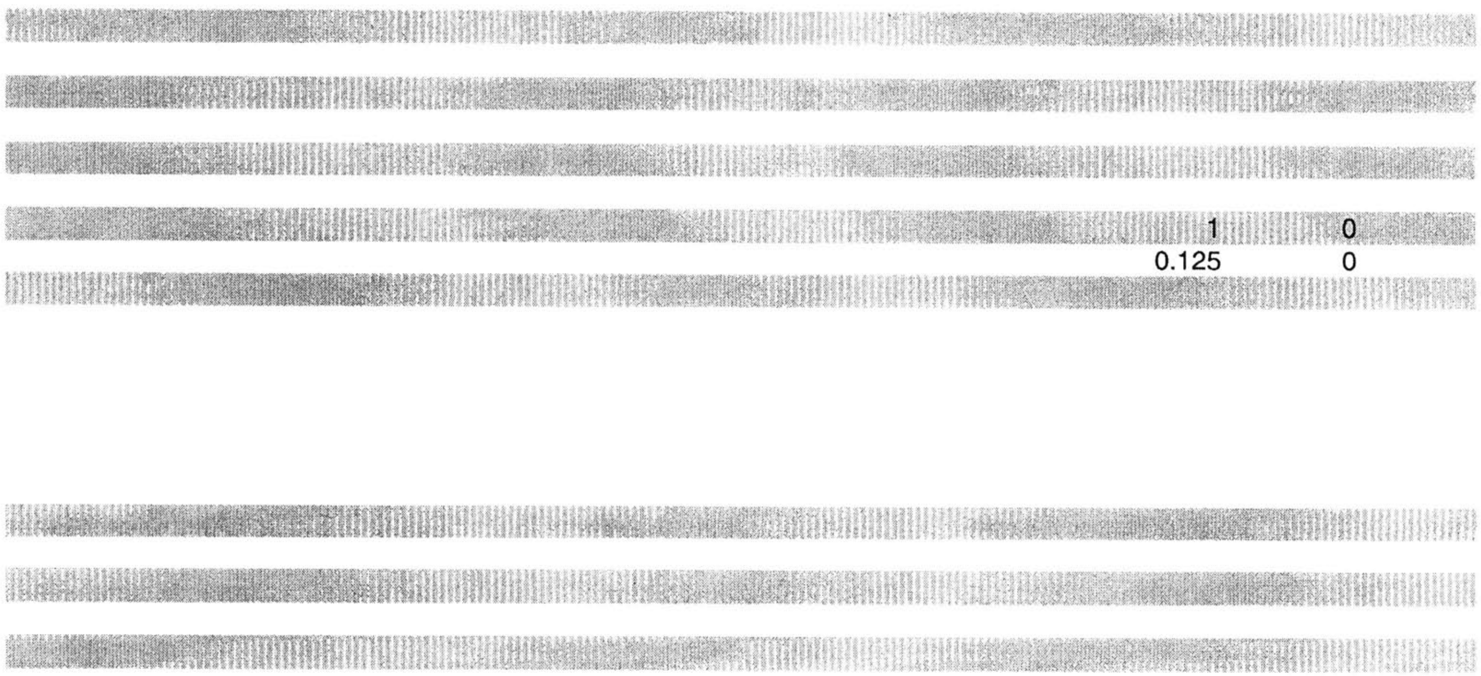
	0.068966	0	0.103448	0.310345	0.275862	0.034483	0.034483	0.103448	0	

	0.066667	0	0.1	0.333333	0.266667	0.033333	0.033333	0.1	0	
0	0	0	1	0	0	0	1	1	0	
0	0	0	0.034483	0	0	0	0.034483	0.034483	0	0.06896
1	0	0	0	0	1	1				

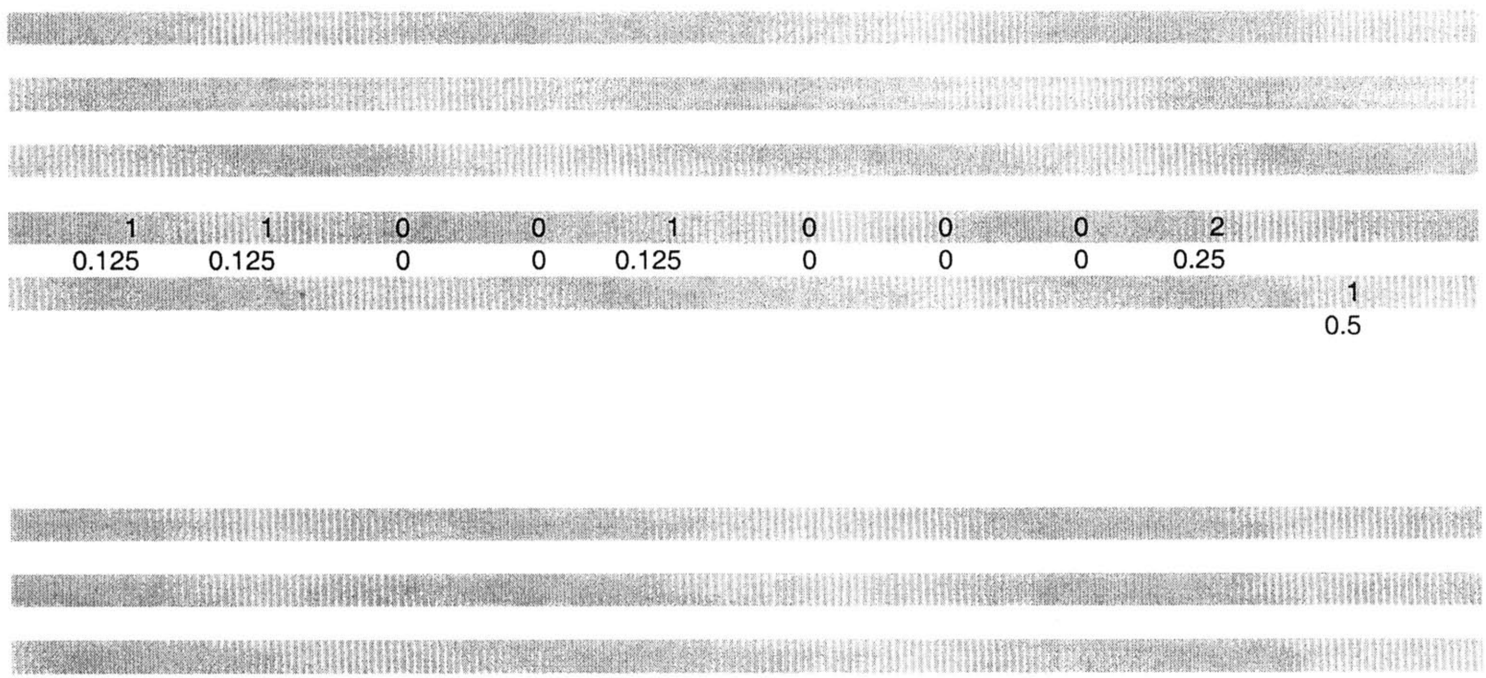
0.034483	0	0	0	0.034483						
			1	0	0	1	0	2	1	
			0.035714	0	0	0.035714	0	0.071429	0.035714	0.03571
										0.03448

0.033333	0	0	0	0.033333			
2	0	4	6	1	0	3	1
0.068966	0	0.137931	0.206897	0.034483	0	0.103448	0.034483

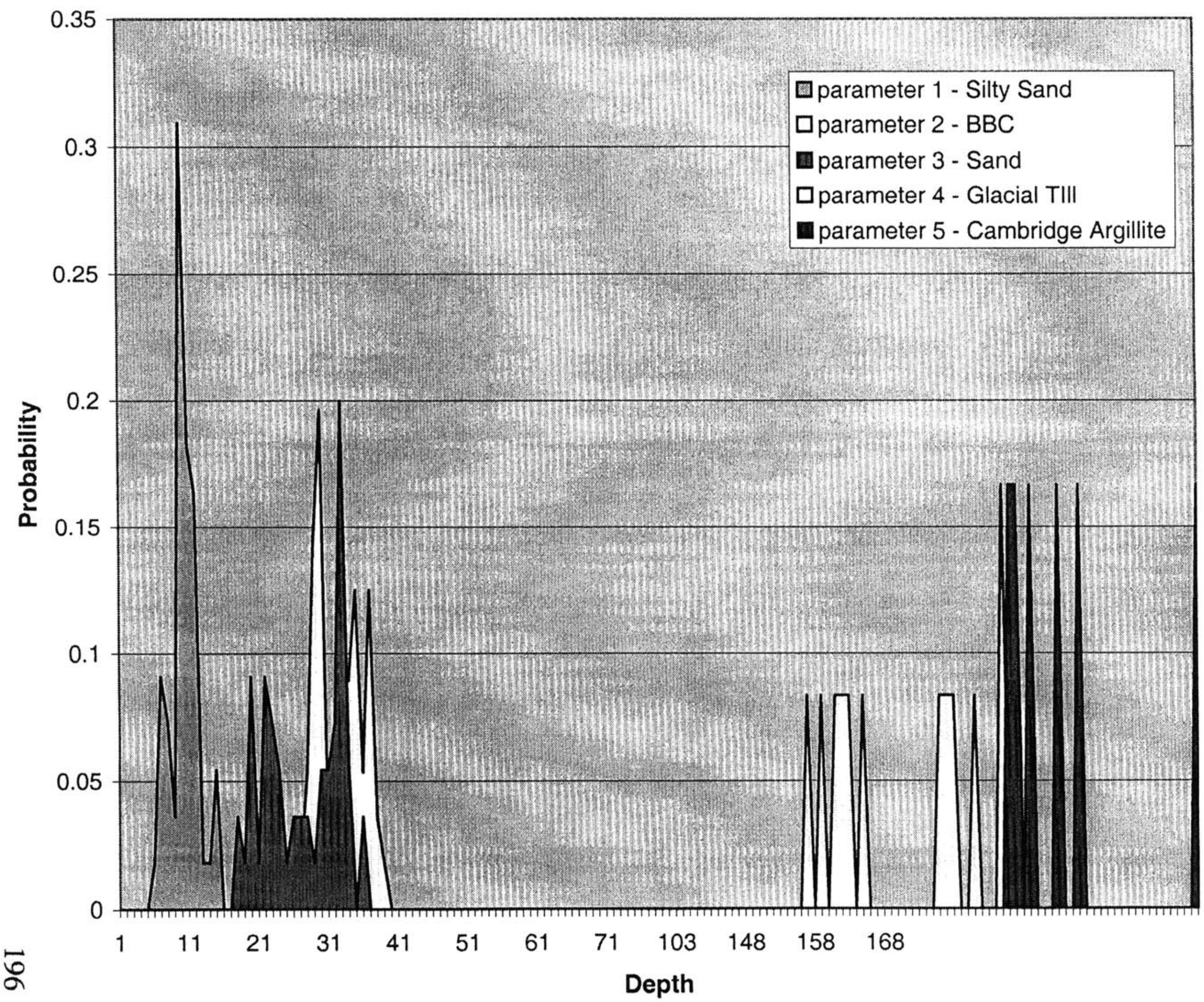
3	4	10	2	0	2		
0.107143	0.142857	0.357143	0.071429	0	0.071429		
0	6	4	7	3	5	2	1
0	0.206897	0.137931	0.241379	0.103448	0.172414	0.068966	0.034483

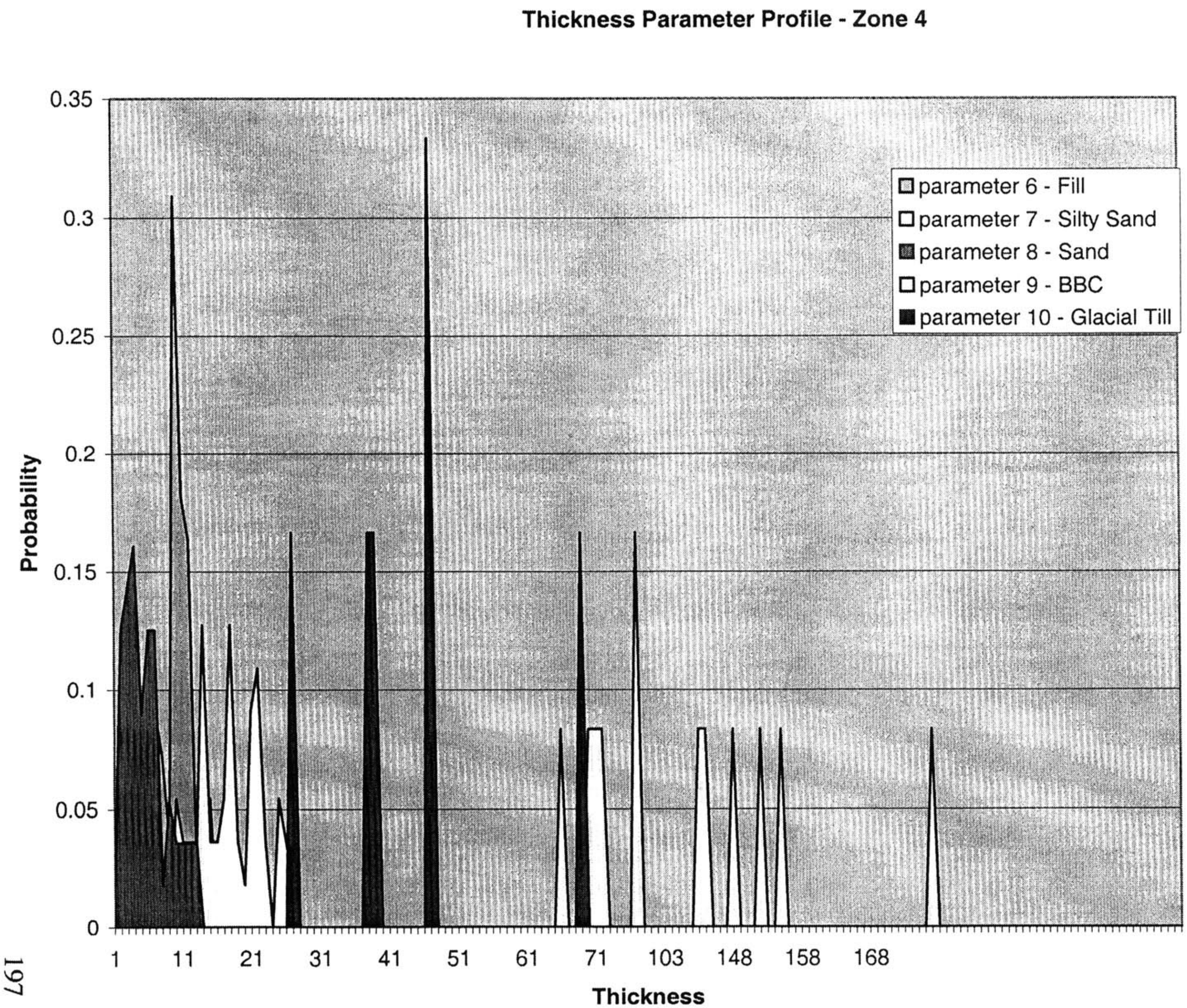

1 0
0.125 0

0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0


1 1 0 0 1 0 0 0 2
0.125 0.125 0 0 0.125 0 0 0 0.25
1
0.5

Upper Bound Parameter Profile - Zone 2




Thickness Parameter Profile - Zone 4
Probability
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
parameter 6 - Fill
parameter 7 - Silty Sand
parameter 8 - Sand
parameter 9 - BBC
parameter 10 - Glacial Till
1
11
21
31
41
51
61
71
103
148
158
168
Thickness

Silty Sand	55	6	to	22
Sand	55	18		36
BBC	56	27		39
Glacial Till	12	100		128
Cambridge Argillite	6	142		152

Fill Thickness	55	6	to	22					
								1	
Silty Sand Thickness	55	4		27				0.018182	
					1	7	8	9	
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

0.090909	0.072727	0.036364	0.309091	0.181818	0.163636	0.018182	0.018182	0.054545	0	

0.090909	0.072727	0.036364	0.309091	0.181818	0.163636	0.018182	0.018182	0.054545	0	
1	1	0	3	2	2	2	7	2	2	
0.018182	0.018182	0	0.054545	0.036364	0.036364	0.036364	0.127273	0.036364	0.036364	0.05454
7	1	3	2	2	2	2				

0.018182	0	0	0.018182							
1	5	1	5	4	3	1	2	2	2	
0.018182	0.090909	0.018182	0.090909	0.072727	0.054545	0.018182	0.036364	0.036364	0.036364	0.01818
								1	3	
								0.017857	0.053571	0.14285

0.018182	0	0	0.018182					
2	1	5	6	2	0	3	2	1
0.036364	0.018182	0.090909	0.109091	0.036364	0	0.054545	0.036364	0.018182

3	4	11	3	0	2			
0.054545	0.072727	0.2	0.054545	0	0.036364			
1	1	6	5	7	3	7	2	1
0.017857	0.017857	0.107143	0.089286	0.125	0.053571	0.125	0.035714	0.017857

1
0.083333

0	1	1	1	0	1	0	0	0	0
0	0.083333	0.083333	0.083333	0	0.083333	0	0	0	0

0	0	0	0	1	1	1	0	0	1
0	0	0	0	0.083333	0.083333	0.083333	0	0	0.083333

0	2								
0	0.166667								
		1	1	0	1	0	0	0	1
		0.166667	0.166667	0	0.166667	0	0	0	0.166667

1	0	0	0	0	0	0	0	0	0
0.166667	0	0	0	0	0	0	0	0	0

0	0	0	0	0	
0	0	0	0	0	0.16666

APPENDIX G

Monte Carlo Analysis for Cost Differential at 30%

Diaphragm Excav	Diaphragm Wall	Shaft	Tunnel
34504.23778	2207.188751	781.2917876	
34504.23778	2207.188751	781.2917876	
34504.23778	2207.188751	781.2917876	
34504.23778	2207.188751	781.2917876	283.528737
34504.23778	2207.188751	781.2917876	283.528737

Diaphragm Excavatiion

Percent Increase 0%	Percent Increase 10%	Percent Increase 20%
Costs/cft	Costs/cft	Costs/cft
0.943700581	0.931600559	0.919806898
0.943700581	0.931600559	0.919806898
0.943700581	0.931600559	0.919806898
0.943700581	0.931600559	0.919806898
0.943700581	1.024760614	1.103768278

Diaphram Wall

Percent Increase 0%	Percent Increase 10%	Percent Increase 20%
Costs/cft	Costs/cft	Costs/cft
22.63024889	22.34008639	22.05727056
22.63024889	22.34008639	22.05727056
22.63024889	22.34008639	22.05727056
22.63024889	22.34008639	22.05727056
22.63024889	24.57409503	26.46872468

Shaft

Percent Increase 0%	Percent Increase 10%	Percent Increase 20%
Costs/cft	Costs/cft	Costs/cft
13.10716846	12.93910983	12.77530629
13.10716846	12.93910983	12.77530629
13.10716846	12.93910983	12.77530629
13.10716846	12.93910983	12.77530629
13.10716846	14.23302081	15.33036755

Tunnel

Percent Increase 0%	Percent Increase 10%	Percent Increase 20%
Costs/cft	Costs/cft	Costs/cft
40.74381239	37.72381706	35.12062147
40.74381239	37.72381706	35.12062147
40.74381239	37.72381706	35.12062147
40.74381239	37.72381706	35.12062147
40.74381239	41.49619877	42.14474577

Unit	Range		
Fill Thickness	6	to	
Silty Sand Thickness	4	to	
Sand Thickness	1	to	
BBC Thickness	66	to	
Glacial Till	27	to	

Percent Increase	Percent Increase	Percent Increase
30%	40%	50%
Costs/cft	Costs/cft	Costs/cft
0.908308111	0.897093273	0.886151996
0.908308111	0.897093273	0.886151996
0.908308111	0.897093273	0.886151996
0.908308111	0.897093273	0.886151996
1.180800544	1.255930582	1.329227993

Percent Increase	Percent Increase	Percent Increase
30%	40%	50%
Costs/cft	Costs/cft	Costs/cft
21.78152587	21.51259039	21.25021497
21.78152587	21.51259039	21.25021497
21.78152587	21.51259039	21.25021497
21.78152587	21.51259039	21.25021497
28.31598363	30.11762654	31.87532246

Percent Increase	Percent Increase	Percent Increase
30%	40%	50%
Costs/cft	Costs/cft	Costs/cft
12.61559828	12.45983407	12.30786939
12.61559828	12.45983407	12.30786939
12.61559828	12.45983407	12.30786939
12.61559828	12.45983407	12.30786939
16.40027776	17.4437677	18.46180408

Percent Increase	Percent Increase	Percent Increase
30%	40%	50%
Costs/cft	Costs/cft	Costs/cft
32.85350965	30.86134342	29.09696592
32.85350965	30.86134342	29.09696592
32.85350965	30.86134342	29.09696592
32.85350965	30.86134342	29.09696592
42.70956255	43.20588078	43.64544888

	Mean Thickness	Std.Dev.
22	10.06230319	3.383175926
27	16.33853865	6.138092085
13	5.154042386	3.151129884
120	83.70373932	15.16512511
69	44	14.07639764

Percent Increase 60%	Percent Increase 70%	Percent Increase 80%
Costs/cft	Costs/cft	Costs/cft
0.87547439	0.865051039	0.854872967
0.87547439	0.865051039	0.854872967
0.87547439	0.865051039	0.854872967
0.87547439	0.865051039	0.854872967
1.400759024	1.470586766	1.53877134

Percent Increase 60%	Percent Increase 70%	Percent Increase 80%
Costs/cft	Costs/cft	Costs/cft
20.9941625	20.74420712	20.50013362
20.9941625	20.74420712	20.50013362
20.9941625	20.74420712	20.50013362
20.9941625	20.74420712	20.50013362
33.59066	35.2651521	36.90024051

Percent Increase 60%	Percent Increase 70%	Percent Increase 80%
Costs/cft	Costs/cft	Costs/cft
12.15956687	12.01479571	11.87343127
12.15956687	12.01479571	11.87343127
12.15956687	12.01479571	11.87343127
12.15956687	12.01479571	11.87343127
19.45530699	20.42515271	21.37217629

Percent Increase 60%	Percent Increase 70%	Percent Increase 80%
Costs/cft	Costs/cft	Costs/cft
27.52342117	26.11133725	24.83707577
27.52342117	26.11133725	24.83707577
27.52342117	26.11133725	24.83707577
27.52342117	26.11133725	24.83707577
44.03747387	44.38927332	44.70673639

Max	Min
13.4	6.7
22.5	10.2
8.3	2.0
98.9	68.5
58.1	29.9

Percent Increase	Percent Increase
90%	100%
Costs/cft	Costs/cft
0.844931617	0.835218826
0.844931617	0.835218826
0.844931617	0.835218826
0.844931617	0.835218826
1.605370072	1.670437652

Percent Increase	Percent Increase
90%	100%
Costs/cft	Costs/cft
20.2617368	20.02882089
20.2617368	20.02882089
20.2617368	20.02882089
20.2617368	20.02882089
38.49729992	40.05764179

Percent Increase	Percent Increase
90%	100%
Costs/cft	Costs/cft
11.73535469	11.6004526
11.73535469	11.6004526
11.73535469	11.6004526
11.73535469	11.6004526
22.29717392	23.2009052

Percent Increase	Percent Increase
90%	100%
Costs/cft	Costs/cft
23.68139796	22.62848657
23.68139796	22.62848657
23.68139796	22.62848657
23.68139796	22.62848657
44.99465612	45.25697315

Simulation 1

Mean	$	12,282,827.01
Std.Dev	$	270,650.46

Bin	*Frequency*	*Cumulative %*
$ 11,829,032.50	0	.00%
$ 11,875,032.34	49	9.07%
$ 11,921,032.18	24	13.52%
$ 11,967,032.02	16	16.48%
$ 12,013,031.87	35	22.96%
$ 12,059,031.71	15	25.74%
$ 12,105,031.55	29	31.11%
$ 12,151,031.39	18	34.44%
$ 12,197,031.23	32	40.37%
$ 12,243,031.07	18	43.70%
$ 12,289,030.92	40	51.11%
$ 12,335,030.76	24	55.56%
$ 12,381,030.60	35	62.04%
$ 12,427,030.44	21	65.93%
$ 12,473,030.28	33	72.04%
$ 12,519,030.13	34	78.33%
$ 12,565,029.97	9	80.00%
$ 12,611,029.81	33	86.11%
$ 12,657,029.65	28	91.30%
$ 12,703,029.49	17	94.44%
$ 12,749,029.34	9	96.11%
$ 12,795,029.18	14	98.70%
$ 12,841,029.02	5	99.63%
More	2	100.00%

Simulation 2

Mean	$	12,250,523.04
Std.Dev	$	278,894.14

	Bin	*Frequency*	*Cumulative %*
$	11,829,032.50	0	.00%
$	11,876,196.77	59	10.93%
$	11,923,361.04	30	16.48%
$	11,970,525.31	15	19.26%
$	12,017,689.58	46	27.78%
$	12,064,853.85	17	30.93%
$	12,112,018.12	22	35.00%
$	12,159,182.39	16	37.96%
$	12,206,346.66	43	45.93%
$	12,253,510.93	35	52.41%
$	12,300,675.21	25	57.04%
$	12,347,839.48	33	63.15%
$	12,395,003.75	17	66.30%
$	12,442,168.02	39	73.52%
$	12,489,332.29	29	78.89%
$	12,536,496.56	12	81.11%
$	12,583,660.83	27	86.11%
$	12,630,825.10	28	91.30%
$	12,677,989.37	20	95.00%
$	12,725,153.64	5	95.93%
$	12,772,317.91	13	98.33%
$	12,819,482.18	5	99.26%
$	12,866,646.45	3	99.81%
More		1	100.00%

RAW DATA FOR MONTE CARLO

Random Numbers

Fill	SS	SD	BBC
9	16	6	72
10	16	3	89
11	19	5	92
11	12	7	75
13	17	3	82
11	19	6	88
10	21	7	74
13	20	8	93
10	21	6	92
13	19	7	78
7	12	8	87
7	17	7	71
8	21	4	71
10	17	5	95
8	20	7	98
12	19	3	86
12	13	3	79
10	20	4	86
11	13	8	79
8	19	7	72
13	15	4	81
7	19	6	93
8	22	8	81
12	17	7	83
11	22	5	89
7	12	3	84
12	11	3	76
13	21	8	76
8	16	6	83
11	14	8	82
11	18	5	73
13	22	6	84
12	17	8	92
8	19	5	88
11	16	8	80
12	12	4	85
13	22	3	71
8	20	5	90
11	17	8	98
11	19	8	95

	FILL		SS	
MEAN	$	890,083.69	$	1,471,184.02
STD.DEV.	$	181,727.51	$	306,676.30

GT		Hist for Fill		Hist for SS
27	$	803,455.93	$	1,428,366.10
12	$	892,728.81	$	1,428,366.10
3	$	982,001.69	$	1,696,184.74
25	$	982,001.69	$	1,071,274.57
15	$	1,160,547.46	$	1,517,638.98
6	$	982,001.69	$	1,696,184.74
18	$	892,728.81	$	1,874,730.51
-4	$	1,160,547.46	$	1,785,457.62
1	$	892,728.81	$	1,874,730.51
13	$	1,160,547.46	$	1,696,184.74
16	$	624,910.17	$	1,071,274.57
28	$	624,910.17	$	1,517,638.98
26	$	714,183.05	$	1,874,730.51
3	$	892,728.81	$	1,517,638.98
-3	$	714,183.05	$	1,785,457.62
10	$	1,071,274.57	$	1,696,184.74
23	$	1,071,274.57	$	1,160,547.46
10	$	892,728.81	$	1,785,457.62
19	$	982,001.69	$	1,160,547.46
24	$	714,183.05	$	1,696,184.74
17	$	1,160,547.46	$	1,339,093.22
5	$	624,910.17	$	1,696,184.74
11	$	714,183.05	$	1,964,003.39
11	$	1,071,274.57	$	1,517,638.98
3	$	982,001.69	$	1,964,003.39
24	$	624,910.17	$	1,071,274.57
28	$	1,071,274.57	$	982,001.69
12	$	1,160,547.46	$	1,874,730.51
17	$	714,183.05	$	1,428,366.10
15	$	982,001.69	$	1,249,820.34
23	$	982,001.69	$	1,606,911.86
5	$	1,160,547.46	$	1,964,003.39
1	$	1,071,274.57	$	1,517,638.98
10	$	714,183.05	$	1,696,184.74
15	$	982,001.69	$	1,428,366.10
17	$	1,071,274.57	$	1,071,274.57
21	$	1,160,547.46	$	1,964,003.39
7	$	714,183.05	$	1,785,457.62
-4	$	982,001.69	$	1,517,638.98
-3	$	982,001.69	$	1,696,184.74

SD		BBC		GT	
$	494,803.21	$	7,528,196.56	$	1,878,194.52
$	147,730.90	$	838,385.26	$	1,183,410.72

To GRAPH

	Hist for SD		Hist for BBC		Hist for GT
$	535,637.29	$	6,427,647.45	$	3,424,103.45
$	267,818.64	$	8,027,649.88	$	1,576,209.78
$	446,364.41	$	8,401,364.39	$	394,052.45
$	624,910.17	$	6,695,466.09	$	3,191,993.96
$	267,818.64	$	7,367,441.09	$	1,970,262.23
$	535,637.29	$	8,008,974.24	$	788,104.89
$	624,910.17	$	6,617,959.42	$	2,364,314.67
$	714,183.05	$	8,168,844.37	$	-
$	535,637.29	$	8,424,896.80	$	131,350.82
$	624,910.17	$	7,033,881.98	$	1,707,560.60
$	714,183.05	$	7,802,039.29	$	2,101,613.04
$	624,910.17	$	6,338,374.57	$	3,540,158.20
$	357,091.52	$	6,338,374.57	$	3,308,048.71
$	446,364.41	$	8,669,183.03	$	394,052.45
$	624,910.17	$	8,704,481.65	$	-
$	267,818.64	$	7,783,363.65	$	1,313,508.15
$	267,818.64	$	7,052,557.62	$	2,959,884.47
$	357,091.52	$	7,783,363.65	$	1,313,508.15
$	714,183.05	$	7,052,557.62	$	2,495,665.49
$	624,910.17	$	6,427,647.45	$	3,075,939.21
$	357,091.52	$	7,254,635.79	$	2,232,963.86
$	535,637.29	$	8,467,104.86	$	656,754.08
$	714,183.05	$	7,325,233.04	$	1,444,858.97
$	624,910.17	$	7,503,778.80	$	1,444,858.97
$	446,364.41	$	8,133,545.75	$	394,052.45
$	267,818.64	$	7,498,922.02	$	3,075,939.21
$	267,818.64	$	6,784,738.97	$	3,540,158.20
$	714,183.05	$	6,867,102.42	$	1,576,209.78
$	535,637.29	$	7,433,181.56	$	2,232,963.86
$	714,183.05	$	7,367,441.09	$	1,970,262.23
$	446,364.41	$	6,516,920.33	$	2,959,884.47
$	535,637.29	$	7,663,648.92	$	656,754.08
$	714,183.05	$	8,424,896.80	$	131,350.82
$	446,364.41	$	7,961,909.41	$	1,313,508.15
$	714,183.05	$	7,188,895.33	$	1,970,262.23
$	357,091.52	$	7,611,727.32	$	2,232,963.86
$	267,818.64	$	6,338,374.57	$	2,727,774.98
$	446,364.41	$	8,175,753.80	$	919,455.71
$	714,183.05	$	8,615,208.77	$	-
$	714,183.05	$	8,436,663.01	$	-

TOTAL	
$	12,262,462.00
$	273,094.78

	Total
$	12,619,210.22
$	12,192,773.22
$	11,919,967.68
$	12,565,646.49
$	12,283,708.40
$	12,010,902.86
$	12,374,643.58
$	11,829,032.50
$	11,859,344.22
$	12,223,084.94
$	12,314,020.12
$	12,645,992.08
$	12,592,428.35
$	11,919,967.68
$	11,829,032.50
$	12,132,149.76
$	12,512,082.76
$	12,132,149.76
$	12,404,955.30
$	12,538,864.62
$	12,344,331.85
$	11,980,591.13
$	12,162,461.49
$	12,162,461.49
$	11,919,967.68
$	12,538,864.62
$	12,645,992.08
$	12,192,773.22
$	12,344,331.85
$	12,283,708.40
$	12,512,082.76
$	11,980,591.13
$	11,859,344.22
$	12,132,149.76
$	12,283,708.40
$	12,344,331.85
$	12,458,519.03
$	12,041,214.58
$	11,829,032.50
$	11,829,032.50

9	18	5	89
10	21	4	90
13	20	7	71
13	20	5	71
13	15	7	98
13	12	8	92
7	19	5	73
10	14	3	79
7	22	6	74
7	13	4	97
13	15	5	72
11	19	7	78
7	12	6	84
8	13	4	78
10	11	6	77
11	20	4	89
7	20	5	89
13	13	4	94
13	22	5	69
8	13	5	94
8	14	5	85
13	20	5	92
12	21	3	87
12	12	7	71
8	22	6	80
12	17	4	71
10	12	5	82
10	18	5	86
13	16	3	80
13	13	6	84
8	12	6	75
12	19	5	92
7	15	5	94
13	11	8	74
11	21	3	91
13	16	6	71
9	20	8	92
9	18	5	69
8	16	7	84
7	11	5	90
13	12	8	70
9	12	4	97
7	13	8	93
11	18	4	89
12	13	7	81
12	22	7	98
7	13	6	81
7	17	6	70
9	19	7	75
12	11	6	90
11	22	5	89
8	17	7	83

9	$	803,455.93	$	1,606,911.86
5	$	892,728.81	$	1,874,730.51
19	$	1,160,547.46	$	1,785,457.62
21	$	1,160,547.46	$	1,785,457.62
-3	$	1,160,547.46	$	1,339,093.22
5	$	1,160,547.46	$	1,071,274.57
26	$	624,910.17	$	1,696,184.74
24	$	892,728.81	$	1,249,820.34
21	$	624,910.17	$	1,964,003.39
9	$	624,910.17	$	1,160,547.46
25	$	1,160,547.46	$	1,339,093.22
15	$	982,001.69	$	1,696,184.74
21	$	624,910.17	$	1,071,274.57
27	$	714,183.05	$	1,160,547.46
26	$	892,728.81	$	982,001.69
6	$	982,001.69	$	1,785,457.62
9	$	624,910.17	$	1,785,457.62
6	$	1,160,547.46	$	1,160,547.46
21	$	1,160,547.46	$	1,964,003.39
10	$	714,183.05	$	1,160,547.46
18	$	714,183.05	$	1,249,820.34
0	$	1,160,547.46	$	1,785,457.62
7	$	1,071,274.57	$	1,874,730.51
28	$	1,071,274.57	$	1,071,274.57
14	$	714,183.05	$	1,964,003.39
26	$	1,071,274.57	$	1,517,638.98
21	$	892,728.81	$	1,071,274.57
11	$	892,728.81	$	1,606,911.86
18	$	1,160,547.46	$	1,428,366.10
14	$	1,160,547.46	$	1,160,547.46
29	$	714,183.05	$	1,071,274.57
2	$	1,071,274.57	$	1,696,184.74
9	$	624,910.17	$	1,339,093.22
24	$	1,160,547.46	$	982,001.69
4	$	982,001.69	$	1,874,730.51
24	$	1,160,547.46	$	1,428,366.10
1	$	803,455.93	$	1,785,457.62
29	$	803,455.93	$	1,606,911.86
15	$	714,183.05	$	1,428,366.10
17	$	624,910.17	$	982,001.69
27	$	1,160,547.46	$	1,071,274.57
8	$	803,455.93	$	1,071,274.57
9	$	624,910.17	$	1,160,547.46
8	$	982,001.69	$	1,606,911.86
17	$	1,071,274.57	$	1,160,547.46
-9	$	1,071,274.57	$	1,964,003.39
23	$	624,910.17	$	1,160,547.46
30	$	624,910.17	$	1,517,638.98
20	$	803,455.93	$	1,696,184.74
11	$	1,071,274.57	$	982,001.69
3	$	982,001.69	$	1,964,003.39
15	$	714,183.05	$	1,517,638.98

$	446,364.41	$	8,062,948.50	$	1,182,157.34
$	357,091.52	$	8,199,286.21	$	656,754.08
$	624,910.17	$	6,338,374.57	$	2,495,665.49
$	446,364.41	$	6,338,374.57	$	2,727,774.98
$	624,910.17	$	8,704,481.65	$	-
$	714,183.05	$	8,377,831.97	$	656,754.08
$	446,364.41	$	6,516,920.33	$	3,308,048.71
$	267,818.64	$	7,052,557.62	$	3,075,939.21
$	535,637.29	$	6,606,193.21	$	2,727,774.98
$	357,091.52	$	8,777,131.55	$	1,182,157.34
$	446,364.41	$	6,427,647.45	$	3,191,993.96
$	624,910.17	$	7,010,349.56	$	1,970,262.23
$	535,637.29	$	7,498,922.02	$	2,727,774.98
$	357,091.52	$	6,963,284.74	$	3,424,103.45
$	535,637.29	$	6,874,011.85	$	3,308,048.71
$	357,091.52	$	8,098,247.12	$	788,104.89
$	446,364.41	$	8,062,948.50	$	1,182,157.34
$	357,091.52	$	8,544,611.53	$	788,104.89
$	446,364.41	$	6,159,828.80	$	2,727,774.98
$	446,364.41	$	8,497,546.70	$	1,313,508.15
$	446,364.41	$	7,599,961.11	$	2,364,314.67
$	446,364.41	$	8,436,663.01	$	-
$	267,818.64	$	7,907,935.15	$	919,455.71
$	624,910.17	$	6,338,374.57	$	3,540,158.20
$	535,637.29	$	7,200,661.53	$	1,838,911.41
$	357,091.52	$	6,338,374.57	$	3,308,048.71
$	446,364.41	$	7,320,376.26	$	2,727,774.98
$	446,364.41	$	7,771,597.44	$	1,444,858.97
$	267,818.64	$	7,153,596.71	$	2,364,314.67
$	535,637.29	$	7,557,753.06	$	1,838,911.41
$	535,637.29	$	6,695,466.09	$	3,656,212.94
$	446,364.41	$	8,413,130.60	$	262,701.63
$	446,364.41	$	8,509,312.91	$	1,182,157.34
$	714,183.05	$	6,606,193.21	$	3,075,939.21
$	267,818.64	$	8,300,325.30	$	525,403.26
$	535,637.29	$	6,338,374.57	$	3,075,939.21
$	714,183.05	$	8,424,896.80	$	131,350.82
$	446,364.41	$	6,159,828.80	$	3,656,212.94
$	624,910.17	$	7,545,986.85	$	1,970,262.23
$	446,364.41	$	8,058,091.72	$	2,232,963.86
$	714,183.05	$	6,249,101.69	$	3,424,103.45
$	357,091.52	$	8,788,897.76	$	1,050,806.52
$	714,183.05	$	8,420,040.03	$	1,182,157.34
$	357,091.52	$	8,074,714.71	$	1,050,806.52
$	624,910.17	$	7,254,635.79	$	2,232,963.86
$	624,910.17	$	8,168,844.37	$	-
$	535,637.29	$	7,231,103.38	$	2,959,884.47
$	535,637.29	$	6,249,101.69	$	3,772,267.69
$	624,910.17	$	6,695,466.09	$	2,611,720.23
$	535,637.29	$	8,128,688.97	$	1,444,858.97
$	446,364.41	$	8,133,545.75	$	394,052.45
$	624,910.17	$	7,456,713.97	$	1,970,262.23

$	12,101,838.04
$	11,980,591.13
$	12,404,955.30
$	12,458,519.03
$	11,829,032.50
$	11,980,591.13
$	12,592,428.35
$	12,538,864.62
$	12,458,519.03
$	12,101,838.04
$	12,565,646.49
$	12,283,708.40
$	12,458,519.03
$	12,619,210.22
$	12,592,428.35
$	12,010,902.86
$	12,101,838.04
$	12,010,902.86
$	12,458,519.03
$	12,132,149.76
$	12,374,643.58
$	11,829,032.50
$	12,041,214.58
$	12,645,992.08
$	12,253,396.67
$	12,592,428.35
$	12,458,519.03
$	12,162,461.49
$	12,374,643.58
$	12,253,396.67
$	12,672,773.95
$	11,889,655.95
$	12,101,838.04
$	12,538,864.62
$	11,950,279.40
$	12,538,864.62
$	11,859,344.22
$	12,672,773.95
$	12,283,708.40
$	12,344,331.85
$	12,619,210.22
$	12,071,526.31
$	12,101,838.04
$	12,071,526.31
$	12,344,331.85
$	11,829,032.50
$	12,512,082.76
$	12,699,555.81
$	12,431,737.17
$	12,162,461.49
$	11,919,967.68
$	12,283,708.40

7	11	6	79
7	13	8	83
11	13	6	90
8	19	4	79
13	15	8	88
9	13	6	71
10	15	6	73
9	16	6	96
10	21	5	82
9	13	8	94
12	20	7	90
7	11	7	97
10	19	6	85
9	18	6	98
9	16	5	82
13	17	6	87
8	17	6	80
12	22	8	79
8	22	8	83
11	22	3	84
12	16	3	79
8	21	8	81
11	22	4	79
11	22	8	82
8	17	8	95
8	17	4	77
12	14	6	87
13	15	3	70
10	19	3	91
11	18	8	71
8	21	6	84
13	21	3	77
13	17	5	80
10	22	7	71
7	13	6	88
12	18	4	92
10	19	8	93
8	21	3	98
10	16	5	71
11	18	5	86
8	15	3	86
7	16	4	71
9	20	5	83
10	15	8	82
7	17	6	84
8	21	3	96
12	16	5	75
13	20	3	91
11	20	4	97
10	14	3	81
13	11	5	92
11	14	8	75

27	$	624,910.17	$	982,001.69
19	$	624,910.17	$	1,160,547.46
10	$	982,001.69	$	1,160,547.46
20	$	714,183.05	$	1,696,184.74
6	$	1,160,547.46	$	1,339,093.22
31	$	803,455.93	$	1,160,547.46
26	$	892,728.81	$	1,339,093.22
3	$	803,455.93	$	1,428,366.10
12	$	892,728.81	$	1,874,730.51
6	$	803,455.93	$	1,160,547.46
1	$	1,071,274.57	$	1,785,457.62
8	$	624,910.17	$	982,001.69
10	$	892,728.81	$	1,696,184.74
-1	$	803,455.93	$	1,606,911.86
18	$	803,455.93	$	1,428,366.10
7	$	1,160,547.46	$	1,517,638.98
19	$	714,183.05	$	1,517,638.98
9	$	1,071,274.57	$	1,964,003.39
9	$	714,183.05	$	1,964,003.39
10	$	982,001.69	$	1,964,003.39
20	$	1,071,274.57	$	1,428,366.10
12	$	714,183.05	$	1,874,730.51
14	$	982,001.69	$	1,964,003.39
7	$	982,001.69	$	1,964,003.39
2	$	714,183.05	$	1,517,638.98
24	$	714,183.05	$	1,517,638.98
11	$	1,071,274.57	$	1,249,820.34
29	$	1,160,547.46	$	1,339,093.22
7	$	892,728.81	$	1,696,184.74
22	$	982,001.69	$	1,606,911.86
11	$	714,183.05	$	1,874,730.51
16	$	1,160,547.46	$	1,874,730.51
15	$	1,160,547.46	$	1,517,638.98
20	$	892,728.81	$	1,964,003.39
16	$	624,910.17	$	1,160,547.46
4	$	1,071,274.57	$	1,606,911.86
0	$	892,728.81	$	1,696,184.74
0	$	714,183.05	$	1,874,730.51
28	$	892,728.81	$	1,428,366.10
10	$	982,001.69	$	1,606,911.86
18	$	714,183.05	$	1,339,093.22
32	$	624,910.17	$	1,428,366.10
13	$	803,455.93	$	1,785,457.62
15	$	892,728.81	$	1,339,093.22
16	$	624,910.17	$	1,517,638.98
2	$	714,183.05	$	1,874,730.51
22	$	1,071,274.57	$	1,428,366.10
3	$	1,160,547.46	$	1,785,457.62
-2	$	982,001.69	$	1,785,457.62
22	$	892,728.81	$	1,249,820.34
9	$	1,160,547.46	$	982,001.69
22	$	982,001.69	$	1,249,820.34

$	535,637.29	$	7,052,557.62	$	3,424,103.45
$	714,183.05	$	7,409,649.14	$	2,495,665.49
$	535,637.29	$	8,140,455.18	$	1,313,508.15
$	357,091.52	$	7,052,557.62	$	2,611,720.23
$	714,183.05	$	8,008,974.24	$	788,104.89
$	535,637.29	$	6,338,374.57	$	3,888,322.43
$	535,637.29	$	6,516,920.33	$	3,308,048.71
$	535,637.29	$	8,758,455.91	$	394,052.45
$	446,364.41	$	7,402,739.71	$	1,576,209.78
$	714,183.05	$	8,544,611.53	$	788,104.89
$	624,910.17	$	8,246,351.04	$	131,350.82
$	624,910.17	$	8,788,897.76	$	1,050,806.52
$	535,637.29	$	7,694,090.77	$	1,313,508.15
$	535,637.29	$	8,883,027.42	$	-
$	446,364.41	$	7,332,142.47	$	2,364,314.67
$	535,637.29	$	7,907,935.15	$	919,455.71
$	535,637.29	$	7,141,830.50	$	2,495,665.49
$	714,183.05	$	7,170,219.69	$	1,182,157.34
$	714,183.05	$	7,527,311.21	$	1,182,157.34
$	267,818.64	$	7,604,817.89	$	1,313,508.15
$	267,818.64	$	7,052,557.62	$	2,611,720.23
$	714,183.05	$	7,313,466.83	$	1,576,209.78
$	357,091.52	$	7,111,388.65	$	1,838,911.41
$	714,183.05	$	7,461,570.75	$	919,455.71
$	714,183.05	$	8,680,949.24	$	262,701.63
$	357,091.52	$	6,874,011.85	$	3,075,939.21
$	535,637.29	$	7,860,870.32	$	1,444,858.97
$	267,818.64	$	6,249,101.69	$	3,656,212.94
$	267,818.64	$	8,265,026.68	$	919,455.71
$	714,183.05	$	6,338,374.57	$	2,843,829.72
$	535,637.29	$	7,593,051.68	$	1,444,858.97
$	267,818.64	$	6,909,310.48	$	2,101,613.04
$	446,364.41	$	7,188,895.33	$	1,970,262.23
$	624,910.17	$	6,338,374.57	$	2,611,720.23
$	535,637.29	$	7,891,312.17	$	2,101,613.04
$	357,091.52	$	8,389,598.18	$	525,403.26
$	714,183.05	$	8,525,935.89	$	-
$	267,818.64	$	8,972,300.30	$	-
$	446,364.41	$	6,338,374.57	$	3,540,158.20
$	446,364.41	$	7,783,363.65	$	1,313,508.15
$	267,818.64	$	7,689,233.99	$	2,364,314.67
$	357,091.52	$	6,338,374.57	$	4,004,377.18
$	446,364.41	$	7,480,246.39	$	1,707,560.60
$	714,183.05	$	7,367,441.09	$	1,970,262.23
$	535,637.29	$	7,534,220.64	$	2,101,613.04
$	267,818.64	$	8,770,222.12	$	262,701.63
$	446,364.41	$	6,695,466.09	$	2,843,829.72
$	267,818.64	$	8,312,091.51	$	394,052.45
$	357,091.52	$	8,704,481.65	$	-
$	267,818.64	$	7,231,103.38	$	2,843,829.72
$	446,364.41	$	8,330,767.15	$	1,182,157.34
$	714,183.05	$	6,695,466.09	$	2,843,829.72

$	12,619,210.22
$	12,404,955.30
$	12,132,149.76
$	12,431,737.17
$	12,010,902.86
$	12,726,337.67
$	12,592,428.35
$	11,919,967.68
$	12,192,773.22
$	12,010,902.86
$	11,859,344.22
$	12,071,526.31
$	12,132,149.76
$	11,829,032.50
$	12,374,643.58
$	12,041,214.58
$	12,404,955.30
$	12,101,838.04
$	12,101,838.04
$	12,132,149.76
$	12,431,737.17
$	12,192,773.22
$	12,253,396.67
$	12,041,214.58
$	11,889,655.95
$	12,538,864.62
$	12,162,461.49
$	12,672,773.95
$	12,041,214.58
$	12,485,300.90
$	12,162,461.49
$	12,314,020.12
$	12,283,708.40
$	12,431,737.17
$	12,314,020.12
$	11,950,279.40
$	11,829,032.50
$	11,829,032.50
$	12,645,992.08
$	12,132,149.76
$	12,374,643.58
$	12,753,119.54
$	12,223,084.94
$	12,283,708.40
$	12,314,020.12
$	11,889,655.95
$	12,485,300.90
$	11,919,967.68
$	11,829,032.50
$	12,485,300.90
$	12,101,838.04
$	12,485,300.90

13	15	5	95
11	15	6	97
7	13	6	95
8	18	5	94
13	16	3	80
11	16	4	94
9	18	6	95
10	13	4	81
7	20	4	70
9	17	4	93
7	18	3	81
7	12	8	97
7	17	4	94
7	22	5	93
10	13	7	96
7	20	3	69
11	15	4	70
12	17	4	80
11	13	5	72
9	14	4	77
9	16	4	73
12	12	8	76
12	12	3	93
9	20	3	79
7	18	3	88
7	19	7	69
7	18	3	72
11	17	5	76
7	20	6	94
10	14	7	70
13	20	4	82
8	22	8	91
9	21	8	90
11	22	4	92
9	15	5	77
7	14	7	75
8	14	4	72
12	18	7	81
9	22	8	72
9	13	4	92
13	13	3	70
8	21	6	82
11	21	6	74
9	19	7	92
8	16	6	73
8	17	6	85
12	18	4	79
9	22	7	95
8	20	4	71
10	11	5	87
13	18	6	83
13	21	3	98

2	$ 1,160,547.46	$ 1,339,093.22
1	$ 982,001.69	$ 1,339,093.22
9	$ 624,910.17	$ 1,160,547.46
5	$ 714,183.05	$ 1,606,911.86
18	$ 1,160,547.46	$ 1,428,366.10
5	$ 982,001.69	$ 1,428,366.10
2	$ 803,455.93	$ 1,606,911.86
22	$ 892,728.81	$ 1,160,547.46
29	$ 624,910.17	$ 1,785,457.62
7	$ 803,455.93	$ 1,517,638.98
21	$ 624,910.17	$ 1,606,911.86
6	$ 624,910.17	$ 1,071,274.57
8	$ 624,910.17	$ 1,517,638.98
3	$ 624,910.17	$ 1,964,003.39
4	$ 892,728.81	$ 1,160,547.46
31	$ 624,910.17	$ 1,785,457.62
30	$ 982,001.69	$ 1,339,093.22
17	$ 1,071,274.57	$ 1,517,638.98
29	$ 982,001.69	$ 1,160,547.46
26	$ 803,455.93	$ 1,249,820.34
28	$ 803,455.93	$ 1,428,366.10
22	$ 1,071,274.57	$ 1,071,274.57
10	$ 1,071,274.57	$ 1,071,274.57
19	$ 803,455.93	$ 1,785,457.62
14	$ 624,910.17	$ 1,606,911.86
28	$ 624,910.17	$ 1,696,184.74
30	$ 624,910.17	$ 1,606,911.86
21	$ 982,001.69	$ 1,517,638.98
3	$ 624,910.17	$ 1,785,457.62
29	$ 892,728.81	$ 1,249,820.34
11	$ 1,160,547.46	$ 1,785,457.62
1	$ 714,183.05	$ 1,964,003.39
2	$ 803,455.93	$ 1,874,730.51
1	$ 982,001.69	$ 1,964,003.39
24	$ 803,455.93	$ 1,339,093.22
27	$ 624,910.17	$ 1,249,820.34
32	$ 714,183.05	$ 1,249,820.34
12	$ 1,071,274.57	$ 1,606,911.86
19	$ 803,455.93	$ 1,964,003.39
12	$ 803,455.93	$ 1,160,547.46
31	$ 1,160,547.46	$ 1,160,547.46
13	$ 714,183.05	$ 1,874,730.51
18	$ 982,001.69	$ 1,874,730.51
3	$ 803,455.93	$ 1,696,184.74
27	$ 714,183.05	$ 1,428,366.10
14	$ 714,183.05	$ 1,517,638.98
17	$ 1,071,274.57	$ 1,606,911.86
-3	$ 803,455.93	$ 1,964,003.39
27	$ 714,183.05	$ 1,785,457.62
17	$ 892,728.81	$ 982,001.69
10	$ 1,160,547.46	$ 1,606,911.86
-5	$ 1,160,547.46	$ 1,874,730.51

$	446,364.41	$	8,680,949.24	$	262,701.63
$	535,637.29	$	8,871,261.21	$	131,350.82
$	535,637.29	$	8,598,585.79	$	1,182,157.34
$	446,364.41	$	8,556,377.74	$	656,754.08
$	267,818.64	$	7,153,596.71	$	2,364,314.67
$	357,091.52	$	8,556,377.74	$	656,754.08
$	535,637.29	$	8,680,949.24	$	262,701.63
$	357,091.52	$	7,231,103.38	$	2,843,829.72
$	357,091.52	$	6,249,101.69	$	3,656,212.94
$	357,091.52	$	8,443,572.44	$	919,455.71
$	267,818.64	$	7,231,103.38	$	2,727,774.98
$	714,183.05	$	8,812,430.17	$	788,104.89
$	357,091.52	$	8,521,079.12	$	1,050,806.52
$	446,364.41	$	8,490,637.27	$	394,052.45
$	624,910.17	$	8,746,689.71	$	525,403.26
$	267,818.64	$	6,159,828.80	$	3,888,322.43
$	357,091.52	$	6,249,101.69	$	3,772,267.69
$	357,091.52	$	7,165,362.91	$	2,232,963.86
$	446,364.41	$	6,427,647.45	$	3,656,212.94
$	357,091.52	$	6,874,011.85	$	3,308,048.71
$	357,091.52	$	6,516,920.33	$	3,540,158.20
$	714,183.05	$	6,784,738.97	$	2,843,829.72
$	267,818.64	$	8,408,273.82	$	1,313,508.15
$	267,818.64	$	7,052,557.62	$	2,495,665.49
$	267,818.64	$	7,914,844.58	$	1,838,911.41
$	624,910.17	$	6,159,828.80	$	3,540,158.20
$	267,818.64	$	6,427,647.45	$	3,772,267.69
$	446,364.41	$	6,784,738.97	$	2,727,774.98
$	535,637.29	$	8,579,910.15	$	394,052.45
$	624,910.17	$	6,249,101.69	$	3,656,212.94
$	357,091.52	$	7,414,505.92	$	1,444,858.97
$	714,183.05	$	8,335,623.92	$	131,350.82
$	714,183.05	$	8,234,584.83	$	262,701.63
$	357,091.52	$	8,424,896.80	$	131,350.82
$	446,364.41	$	6,874,011.85	$	3,075,939.21
$	624,910.17	$	6,695,466.09	$	3,424,103.45
$	357,091.52	$	6,427,647.45	$	4,004,377.18
$	624,910.17	$	7,313,466.83	$	1,576,209.78
$	714,183.05	$	6,427,647.45	$	2,495,665.49
$	357,091.52	$	8,295,468.52	$	1,576,209.78
$	267,818.64	$	6,249,101.69	$	3,888,322.43
$	535,637.29	$	7,390,973.50	$	1,707,560.60
$	535,637.29	$	6,617,959.42	$	2,364,314.67
$	624,910.17	$	8,401,364.39	$	394,052.45
$	535,637.29	$	6,516,920.33	$	3,424,103.45
$	535,637.29	$	7,647,025.94	$	1,838,911.41
$	357,091.52	$	7,076,090.03	$	2,232,963.86
$	624,910.17	$	8,436,663.01	$	-
$	357,091.52	$	6,338,374.57	$	3,424,103.45
$	446,364.41	$	7,790,273.08	$	2,232,963.86
$	535,637.29	$	7,515,545.01	$	1,313,508.15
$	267,818.64	$	8,525,935.89	$	-

$	11,889,655.95
$	11,859,344.22
$	12,101,838.04
$	11,980,591.13
$	12,374,643.58
$	11,980,591.13
$	11,889,655.95
$	12,485,300.90
$	12,672,773.95
$	12,041,214.58
$	12,458,519.03
$	12,010,902.86
$	12,071,526.31
$	11,919,967.68
$	11,950,279.40
$	12,726,337.67
$	12,699,555.81
$	12,344,331.85
$	12,672,773.95
$	12,592,428.35
$	12,645,992.08
$	12,485,300.90
$	12,132,149.76
$	12,404,955.30
$	12,253,396.67
$	12,645,992.08
$	12,699,555.81
$	12,458,519.03
$	11,919,967.68
$	12,672,773.95
$	12,162,461.49
$	11,859,344.22
$	11,889,655.95
$	11,859,344.22
$	12,538,864.62
$	12,619,210.22
$	12,753,119.54
$	12,192,773.22
$	12,404,955.30
$	12,192,773.22
$	12,726,337.67
$	12,223,084.94
$	12,374,643.58
$	11,919,967.68
$	12,619,210.22
$	12,253,396.67
$	12,344,331.85
$	11,829,032.50
$	12,619,210.22
$	12,344,331.85
$	12,132,149.76
$	11,829,032.50

13	20	3	87
7	17	8	90
8	17	6	72
10	14	5	79
11	16	5	96
8	22	8	95
9	22	7	80
10	18	3	96
12	11	7	88
12	11	5	93
8	17	6	75
12	17	7	75
10	13	6	86
8	11	5	98
8	13	8	81
9	16	3	87
7	12	3	78
13	12	7	71
10	18	6	85
11	20	4	69
11	16	7	81
7	20	7	92
10	21	6	82
9	20	5	94
7	19	4	87
12	19	8	78
7	18	6	77
8	20	7	97
9	21	6	72
10	19	8	86
11	15	5	88
9	16	6	83
10	14	5	86
9	16	4	78
13	11	4	89
7	19	6	87
13	21	8	86
9	18	6	87
13	20	4	80
9	22	6	69
9	17	4	78
8	14	8	84
11	15	7	72
13	13	5	69
8	14	6	73
11	18	4	72
7	11	6	76
10	11	5	75
10	18	4	78
8	15	5	98
8	13	4	76
7	21	7	98

7	$	1,160,547.46	$	1,785,457.62
8	$	624,910.17	$	1,517,638.98
27	$	714,183.05	$	1,517,638.98
22	$	892,728.81	$	1,249,820.34
2	$	982,001.69	$	1,428,366.10
-3	$	714,183.05	$	1,964,003.39
12	$	803,455.93	$	1,964,003.39
3	$	892,728.81	$	1,606,911.86
12	$	1,071,274.57	$	982,001.69
9	$	1,071,274.57	$	982,001.69
24	$	714,183.05	$	1,517,638.98
19	$	1,071,274.57	$	1,517,638.98
15	$	892,728.81	$	1,160,547.46
8	$	714,183.05	$	982,001.69
20	$	714,183.05	$	1,160,547.46
15	$	803,455.93	$	1,428,366.10
30	$	624,910.17	$	1,071,274.57
27	$	1,160,547.46	$	1,071,274.57
11	$	892,728.81	$	1,606,911.86
26	$	982,001.69	$	1,785,457.62
15	$	982,001.69	$	1,428,366.10
4	$	624,910.17	$	1,785,457.62
11	$	892,728.81	$	1,874,730.51
2	$	803,455.93	$	1,785,457.62
13	$	624,910.17	$	1,696,184.74
13	$	1,071,274.57	$	1,696,184.74
22	$	624,910.17	$	1,606,911.86
-2	$	714,183.05	$	1,785,457.62
22	$	803,455.93	$	1,874,730.51
7	$	892,728.81	$	1,696,184.74
11	$	982,001.69	$	1,339,093.22
16	$	803,455.93	$	1,428,366.10
15	$	892,728.81	$	1,249,820.34
23	$	803,455.93	$	1,428,366.10
13	$	1,160,547.46	$	982,001.69
11	$	624,910.17	$	1,696,184.74
2	$	1,160,547.46	$	1,874,730.51
10	$	803,455.93	$	1,606,911.86
13	$	1,160,547.46	$	1,785,457.62
24	$	803,455.93	$	1,964,003.39
22	$	803,455.93	$	1,517,638.98
16	$	714,183.05	$	1,249,820.34
25	$	982,001.69	$	1,339,093.22
30	$	1,160,547.46	$	1,160,547.46
29	$	714,183.05	$	1,249,820.34
25	$	982,001.69	$	1,606,911.86
30	$	624,910.17	$	982,001.69
29	$	892,728.81	$	982,001.69
20	$	892,728.81	$	1,606,911.86
4	$	714,183.05	$	1,339,093.22
29	$	714,183.05	$	1,160,547.46
-3	$	624,910.17	$	1,874,730.51

$	267,818.64	$	7,907,935.15	$	919,455.71
$	714,183.05	$	8,163,987.59	$	1,050,806.52
$	535,637.29	$	6,427,647.45	$	3,424,103.45
$	446,364.41	$	7,052,557.62	$	2,843,829.72
$	446,364.41	$	8,770,222.12	$	262,701.63
$	714,183.05	$	8,436,663.01	$	-
$	624,910.17	$	7,224,193.95	$	1,576,209.78
$	267,818.64	$	8,758,455.91	$	394,052.45
$	624,910.17	$	7,938,377.00	$	1,576,209.78
$	446,364.41	$	8,420,040.03	$	1,182,157.34
$	535,637.29	$	6,695,466.09	$	3,075,939.21
$	624,910.17	$	6,695,466.09	$	2,495,665.49
$	535,637.29	$	7,724,532.61	$	1,970,262.23
$	446,364.41	$	8,878,170.64	$	1,050,806.52
$	714,183.05	$	7,231,103.38	$	2,611,720.23
$	267,818.64	$	7,813,805.50	$	1,970,262.23
$	267,818.64	$	6,963,284.74	$	3,772,267.69
$	624,910.17	$	6,338,374.57	$	3,424,103.45
$	535,637.29	$	7,682,324.56	$	1,444,858.97
$	357,091.52	$	6,159,828.80	$	3,308,048.71
$	624,910.17	$	7,278,168.21	$	1,970,262.23
$	624,910.17	$	8,389,598.18	$	525,403.26
$	535,637.29	$	7,414,505.92	$	1,444,858.97
$	446,364.41	$	8,591,676.36	$	262,701.63
$	357,091.52	$	7,837,337.91	$	1,707,560.60
$	714,183.05	$	7,033,881.98	$	1,707,560.60
$	535,637.29	$	6,874,011.85	$	2,843,829.72
$	624,910.17	$	8,704,481.65	$	-
$	535,637.29	$	6,427,647.45	$	2,843,829.72
$	714,183.05	$	7,818,662.27	$	919,455.71
$	446,364.41	$	7,950,143.21	$	1,444,858.97
$	535,637.29	$	7,444,947.76	$	2,101,613.04
$	446,364.41	$	7,724,532.61	$	1,970,262.23
$	357,091.52	$	6,963,284.74	$	2,959,884.47
$	357,091.52	$	8,015,883.67	$	1,707,560.60
$	535,637.29	$	7,860,870.32	$	1,444,858.97
$	714,183.05	$	7,877,493.31	$	262,701.63
$	535,637.29	$	7,872,636.53	$	1,313,508.15
$	357,091.52	$	7,212,427.74	$	1,707,560.60
$	535,637.29	$	6,159,828.80	$	3,075,939.21
$	357,091.52	$	6,963,284.74	$	2,843,829.72
$	714,183.05	$	7,534,220.64	$	2,101,613.04
$	624,910.17	$	6,427,647.45	$	3,191,993.96
$	446,364.41	$	6,159,828.80	$	3,772,267.69
$	535,637.29	$	6,516,920.33	$	3,656,212.94
$	357,091.52	$	6,427,647.45	$	3,191,993.96
$	535,637.29	$	6,784,738.97	$	3,772,267.69
$	446,364.41	$	6,695,466.09	$	3,656,212.94
$	357,091.52	$	6,963,284.74	$	2,611,720.23
$	446,364.41	$	8,925,235.47	$	525,403.26
$	357,091.52	$	6,784,738.97	$	3,656,212.94
$	624,910.17	$	8,704,481.65	$	-

$	12,041,214.58
$	12,071,526.31
$	12,619,210.22
$	12,485,300.90
$	11,889,655.95
$	11,829,032.50
$	12,192,773.22
$	11,919,967.68
$	12,192,773.22
$	12,101,838.04
$	12,538,864.62
$	12,404,955.30
$	12,283,708.40
$	12,071,526.31
$	12,431,737.17
$	12,283,708.40
$	12,699,555.81
$	12,619,210.22
$	12,162,461.49
$	12,592,428.35
$	12,283,708.40
$	11,950,279.40
$	12,162,461.49
$	11,889,655.95
$	12,223,084.94
$	12,223,084.94
$	12,485,300.90
$	11,829,032.50
$	12,485,300.90
$	12,041,214.58
$	12,162,461.49
$	12,314,020.12
$	12,283,708.40
$	12,512,082.76
$	12,223,084.94
$	12,162,461.49
$	11,889,655.95
$	12,132,149.76
$	12,223,084.94
$	12,538,864.62
$	12,485,300.90
$	12,314,020.12
$	12,565,646.49
$	12,699,555.81
$	12,672,773.95
$	12,565,646.49
$	12,699,555.81
$	12,672,773.95
$	12,431,737.17
$	11,950,279.40
$	12,672,773.95
$	11,829,032.50

13	18	3	90
10	14	3	82
13	11	6	89
9	12	3	97
12	13	7	93
11	13	3	74
11	22	8	76
13	15	4	75
9	18	7	88
11	14	5	71
9	16	3	87
11	22	5	89
13	15	6	83
10	11	3	88
13	21	3	79
9	19	4	88
12	14	5	88
7	20	5	77
9	18	8	75
7	13	3	98
7	16	8	93
7	15	4	89
11	16	6	96
12	15	6	75
12	18	4	77
10	22	6	95
9	15	3	94
8	15	6	89
9	21	5	97
8	13	4	86
9	11	6	97
11	20	8	86
7	15	3	78
8	12	8	83
13	12	5	79
11	11	6	97
9	22	5	88
10	13	7	96
12	18	6	94
9	20	8	74
11	12	5	91
7	21	4	84
7	13	4	86
12	21	8	78
8	14	8	84
10	11	4	97
11	15	6	94
13	14	4	85
13	18	7	72
11	15	3	78
13	20	3	74
9	11	6	73

6	$	1,160,547.46	$	1,606,911.86
21	$	892,728.81	$	1,249,820.34
11	$	1,160,547.46	$	982,001.69
9	$	803,455.93	$	1,071,274.57
5	$	1,071,274.57	$	1,160,547.46
29	$	982,001.69	$	1,160,547.46
13	$	982,001.69	$	1,964,003.39
23	$	1,160,547.46	$	1,339,093.22
8	$	803,455.93	$	1,606,911.86
29	$	982,001.69	$	1,249,820.34
15	$	803,455.93	$	1,428,366.10
3	$	982,001.69	$	1,964,003.39
13	$	1,160,547.46	$	1,339,093.22
18	$	892,728.81	$	982,001.69
14	$	1,160,547.46	$	1,874,730.51
10	$	803,455.93	$	1,696,184.74
11	$	1,071,274.57	$	1,249,820.34
21	$	624,910.17	$	1,785,457.62
20	$	803,455.93	$	1,606,911.86
9	$	624,910.17	$	1,160,547.46
6	$	624,910.17	$	1,428,366.10
15	$	624,910.17	$	1,339,093.22
1	$	982,001.69	$	1,428,366.10
22	$	1,071,274.57	$	1,339,093.22
19	$	1,071,274.57	$	1,606,911.86
-3	$	892,728.81	$	1,964,003.39
9	$	803,455.93	$	1,339,093.22
12	$	714,183.05	$	1,339,093.22
-2	$	803,455.93	$	1,874,730.51
19	$	714,183.05	$	1,160,547.46
7	$	803,455.93	$	982,001.69
5	$	982,001.69	$	1,785,457.62
27	$	624,910.17	$	1,339,093.22
19	$	714,183.05	$	1,071,274.57
21	$	1,160,547.46	$	1,071,274.57
5	$	982,001.69	$	982,001.69
6	$	803,455.93	$	1,964,003.39
4	$	892,728.81	$	1,160,547.46
0	$	1,071,274.57	$	1,606,911.86
19	$	803,455.93	$	1,785,457.62
11	$	982,001.69	$	1,071,274.57
14	$	624,910.17	$	1,874,730.51
20	$	624,910.17	$	1,160,547.46
11	$	1,071,274.57	$	1,874,730.51
16	$	714,183.05	$	1,249,820.34
8	$	892,728.81	$	982,001.69
4	$	982,001.69	$	1,339,093.22
14	$	1,160,547.46	$	1,249,820.34
20	$	1,160,547.46	$	1,606,911.86
23	$	982,001.69	$	1,339,093.22
20	$	1,160,547.46	$	1,785,457.62
31	$	803,455.93	$	982,001.69

$	267,818.64	$	8,187,520.00	$	788,104.89
$	267,818.64	$	7,320,376.26	$	2,727,774.98
$	535,637.29	$	8,039,416.09	$	1,444,858.97
$	267,818.64	$	8,777,131.55	$	1,182,157.34
$	624,910.17	$	8,467,104.86	$	656,754.08
$	267,818.64	$	6,606,193.21	$	3,656,212.94
$	714,183.05	$	6,855,336.22	$	1,707,560.60
$	357,091.52	$	6,695,466.09	$	2,959,884.47
$	624,910.17	$	7,985,441.83	$	1,050,806.52
$	446,364.41	$	6,338,374.57	$	3,656,212.94
$	267,818.64	$	7,813,805.50	$	1,970,262.23
$	446,364.41	$	8,133,545.75	$	394,052.45
$	535,637.29	$	7,480,246.39	$	1,707,560.60
$	267,818.64	$	7,867,779.76	$	2,364,314.67
$	267,818.64	$	7,111,388.65	$	1,838,911.41
$	357,091.52	$	7,961,909.41	$	1,313,508.15
$	446,364.41	$	7,950,143.21	$	1,444,858.97
$	446,364.41	$	6,874,011.85	$	2,727,774.98
$	714,183.05	$	6,695,466.09	$	2,611,720.23
$	267,818.64	$	8,866,404.43	$	1,182,157.34
$	714,183.05	$	8,455,338.65	$	788,104.89
$	357,091.52	$	7,992,351.26	$	1,970,262.23
$	535,637.29	$	8,781,988.33	$	131,350.82
$	535,637.29	$	6,695,466.09	$	2,843,829.72
$	357,091.52	$	6,874,011.85	$	2,495,665.49
$	535,637.29	$	8,436,663.01	$	-
$	267,818.64	$	8,509,312.91	$	1,182,157.34
$	535,637.29	$	8,027,649.88	$	1,576,209.78
$	446,364.41	$	8,704,481.65	$	-
$	357,091.52	$	7,677,467.79	$	2,495,665.49
$	535,637.29	$	8,800,663.97	$	919,455.71
$	714,183.05	$	7,842,194.69	$	656,754.08
$	267,818.64	$	6,963,284.74	$	3,424,103.45
$	714,183.05	$	7,409,649.14	$	2,495,665.49
$	446,364.41	$	7,052,557.62	$	2,727,774.98
$	535,637.29	$	8,824,196.38	$	656,754.08
$	446,364.41	$	8,008,974.24	$	788,104.89
$	624,910.17	$	8,746,689.71	$	525,403.26
$	535,637.29	$	8,615,208.77	$	-
$	714,183.05	$	6,606,193.21	$	2,495,665.49
$	446,364.41	$	8,217,961.85	$	1,444,858.97
$	357,091.52	$	7,557,753.06	$	1,838,911.41
$	357,091.52	$	7,677,467.79	$	2,611,720.23
$	714,183.05	$	7,057,414.39	$	1,444,858.97
$	714,183.05	$	7,534,220.64	$	2,101,613.04
$	357,091.52	$	8,788,897.76	$	1,050,806.52
$	535,637.29	$	8,568,143.94	$	525,403.26
$	357,091.52	$	7,647,025.94	$	1,838,911.41
$	624,910.17	$	6,427,647.45	$	2,611,720.23
$	267,818.64	$	6,963,284.74	$	2,959,884.47
$	267,818.64	$	6,606,193.21	$	2,611,720.23
$	535,637.29	$	6,516,920.33	$	3,888,322.43

$	12,010,902.86
$	12,458,519.03
$	12,162,461.49
$	12,101,838.04
$	11,980,591.13
$	12,672,773.95
$	12,223,084.94
$	12,512,082.76
$	12,071,526.31
$	12,672,773.95
$	12,283,708.40
$	11,919,967.68
$	12,223,084.94
$	12,374,643.58
$	12,253,396.67
$	12,132,149.76
$	12,162,461.49
$	12,458,519.03
$	12,431,737.17
$	12,101,838.04
$	12,010,902.86
$	12,283,708.40
$	11,859,344.22
$	12,485,300.90
$	12,404,955.30
$	11,829,032.50
$	12,101,838.04
$	12,192,773.22
$	11,829,032.50
$	12,404,955.30
$	12,041,214.58
$	11,980,591.13
$	12,619,210.22
$	12,404,955.30
$	12,458,519.03
$	11,980,591.13
$	12,010,902.86
$	11,950,279.40
$	11,829,032.50
$	12,404,955.30
$	12,162,461.49
$	12,253,396.67
$	12,431,737.17
$	12,162,461.49
$	12,314,020.12
$	12,071,526.31
$	11,950,279.40
$	12,253,396.67
$	12,431,737.17
$	12,512,082.76
$	12,431,737.17
$	12,726,337.67

12	15	7	94
8	20	5	78
13	15	8	84
11	21	7	71
7	22	6	89
11	16	6	98
7	11	3	77
8	17	8	88
7	14	3	95
10	17	6	92
8	22	3	80
11	11	5	98
7	19	7	72
10	21	8	77
8	19	4	87
10	16	4	84
8	17	5	97
10	13	7	82
10	13	4	73
12	22	4	82
11	13	8	80
9	12	8	97
8	21	8	70
12	20	3	83
11	13	3	97
7	18	5	92
10	12	6	98
10	19	5	72
7	18	6	94
7	21	7	76
12	20	3	94
8	13	6	92
8	13	8	70
12	16	7	79
10	20	3	69
10	15	4	92
12	15	5	74
10	15	4	73
9	19	5	74
11	16	6	88
10	13	7	94
9	12	8	69
13	22	4	88
7	18	7	78
10	20	8	96
8	13	8	96
7	12	4	72
9	11	6	82
7	17	5	69
13	12	4	69
9	22	5	87
11	11	4	74

2	$	1,071,274.57	$	1,339,093.22
19	$	714,183.05	$	1,785,457.62
10	$	1,160,547.46	$	1,339,093.22
20	$	982,001.69	$	1,874,730.51
6	$	624,910.17	$	1,964,003.39
-1	$	982,001.69	$	1,428,366.10
32	$	624,910.17	$	982,001.69
9	$	714,183.05	$	1,517,638.98
11	$	624,910.17	$	1,249,820.34
5	$	892,728.81	$	1,517,638.98
17	$	714,183.05	$	1,964,003.39
5	$	982,001.69	$	982,001.69
25	$	624,910.17	$	1,696,184.74
14	$	892,728.81	$	1,874,730.51
12	$	714,183.05	$	1,696,184.74
16	$	892,728.81	$	1,428,366.10
3	$	714,183.05	$	1,517,638.98
18	$	892,728.81	$	1,160,547.46
30	$	892,728.81	$	1,160,547.46
10	$	1,071,274.57	$	1,964,003.39
18	$	982,001.69	$	1,160,547.46
4	$	803,455.93	$	1,071,274.57
23	$	714,183.05	$	1,874,730.51
12	$	1,071,274.57	$	1,785,457.62
6	$	982,001.69	$	1,160,547.46
8	$	624,910.17	$	1,606,911.86
4	$	892,728.81	$	1,071,274.57
24	$	892,728.81	$	1,696,184.74
5	$	624,910.17	$	1,606,911.86
19	$	624,910.17	$	1,874,730.51
1	$	1,071,274.57	$	1,785,457.62
11	$	714,183.05	$	1,160,547.46
31	$	714,183.05	$	1,160,547.46
16	$	1,071,274.57	$	1,428,366.10
28	$	892,728.81	$	1,785,457.62
9	$	892,728.81	$	1,339,093.22
24	$	1,071,274.57	$	1,339,093.22
28	$	892,728.81	$	1,339,093.22
23	$	803,455.93	$	1,696,184.74
9	$	982,001.69	$	1,428,366.10
6	$	892,728.81	$	1,160,547.46
32	$	803,455.93	$	1,071,274.57
3	$	1,160,547.46	$	1,964,003.39
20	$	624,910.17	$	1,606,911.86
-4	$	892,728.81	$	1,785,457.62
5	$	714,183.05	$	1,160,547.46
35	$	624,910.17	$	1,071,274.57
22	$	803,455.93	$	982,001.69
32	$	624,910.17	$	1,517,638.98
32	$	1,160,547.46	$	1,071,274.57
7	$	803,455.93	$	1,964,003.39
30	$	982,001.69	$	982,001.69

$	624,910.17	$	8,591,676.36	$	262,701.63
$	446,364.41	$	6,963,284.74	$	2,495,665.49
$	714,183.05	$	7,604,817.89	$	1,313,508.15
$	624,910.17	$	6,338,374.57	$	2,611,720.23
$	535,637.29	$	8,098,247.12	$	788,104.89
$	535,637.29	$	8,883,027.42	$	-
$	267,818.64	$	6,874,011.85	$	4,004,377.18
$	714,183.05	$	7,973,675.62	$	1,182,157.34
$	267,818.64	$	8,575,053.37	$	1,444,858.97
$	535,637.29	$	8,377,831.97	$	656,754.08
$	267,818.64	$	7,165,362.91	$	2,232,963.86
$	446,364.41	$	8,913,469.26	$	656,754.08
$	624,910.17	$	6,427,647.45	$	3,191,993.96
$	714,183.05	$	6,932,842.89	$	1,838,911.41
$	357,091.52	$	7,849,104.12	$	1,576,209.78
$	357,091.52	$	7,534,220.64	$	2,101,613.04
$	446,364.41	$	8,847,728.80	$	394,052.45
$	624,910.17	$	7,332,142.47	$	2,364,314.67
$	357,091.52	$	6,516,920.33	$	3,772,267.69
$	357,091.52	$	7,426,272.13	$	1,313,508.15
$	714,183.05	$	7,153,596.71	$	2,364,314.67
$	714,183.05	$	8,835,962.59	$	525,403.26
$	714,183.05	$	6,249,101.69	$	2,959,884.47
$	267,818.64	$	7,492,012.59	$	1,576,209.78
$	267,818.64	$	8,812,430.17	$	788,104.89
$	446,364.41	$	8,342,533.35	$	1,050,806.52
$	535,637.29	$	8,925,235.47	$	525,403.26
$	446,364.41	$	6,427,647.45	$	3,075,939.21
$	535,637.29	$	8,556,377.74	$	656,754.08
$	624,910.17	$	6,784,738.97	$	2,495,665.49
$	267,818.64	$	8,603,442.57	$	131,350.82
$	535,637.29	$	8,307,234.73	$	1,444,858.97
$	714,183.05	$	6,249,101.69	$	3,888,322.43
$	624,910.17	$	7,087,856.24	$	2,101,613.04
$	267,818.64	$	6,159,828.80	$	3,540,158.20
$	357,091.52	$	8,330,767.15	$	1,182,157.34
$	446,364.41	$	6,606,193.21	$	3,075,939.21
$	357,091.52	$	6,516,920.33	$	3,540,158.20
$	446,364.41	$	6,606,193.21	$	2,959,884.47
$	535,637.29	$	7,973,675.62	$	1,182,157.34
$	624,910.17	$	8,544,611.53	$	788,104.89
$	714,183.05	$	6,159,828.80	$	4,004,377.18
$	357,091.52	$	8,044,272.86	$	394,052.45
$	624,910.17	$	6,963,284.74	$	2,611,720.23
$	714,183.05	$	8,436,663.01	$	-
$	714,183.05	$	8,734,923.50	$	656,754.08
$	357,091.52	$	6,427,647.45	$	4,352,541.42
$	535,637.29	$	7,320,376.26	$	2,843,829.72
$	446,364.41	$	6,159,828.80	$	4,004,377.18
$	357,091.52	$	6,159,828.80	$	4,004,377.18
$	446,364.41	$	7,907,935.15	$	919,455.71
$	357,091.52	$	6,606,193.21	$	3,772,267.69

$	11,889,655.95
$	12,404,955.30
$	12,132,149.76
$	12,431,737.17
$	12,010,902.86
$	11,829,032.50
$	12,753,119.54
$	12,101,838.04
$	12,162,461.49
$	11,980,591.13
$	12,344,331.85
$	11,980,591.13
$	12,565,646.49
$	12,253,396.67
$	12,192,773.22
$	12,314,020.12
$	11,919,967.68
$	12,374,643.58
$	12,699,555.81
$	12,132,149.76
$	12,374,643.58
$	11,950,279.40
$	12,512,082.76
$	12,192,773.22
$	12,010,902.86
$	12,071,526.31
$	11,950,279.40
$	12,538,864.62
$	11,980,591.13
$	12,404,955.30
$	11,859,344.22
$	12,162,461.49
$	12,726,337.67
$	12,314,020.12
$	12,645,992.08
$	12,101,838.04
$	12,538,864.62
$	12,645,992.08
$	12,512,082.76
$	12,101,838.04
$	12,010,902.86
$	12,753,119.54
$	11,919,967.68
$	12,431,737.17
$	11,829,032.50
$	11,980,591.13
$	12,833,465.13
$	12,485,300.90
$	12,753,119.54
$	12,753,119.54
$	12,041,214.58
$	12,699,555.81

13	20	6	70
7	21	8	97
9	12	6	80
7	11	7	92
11	14	6	94
11	11	6	76
12	15	4	81
11	18	3	88
13	22	8	85
12	11	3	97
11	18	6	74
13	16	5	71
13	12	4	70
13	22	3	91
11	19	7	74
9	15	4	85
7	19	7	91
7	13	3	84
9	17	8	90
12	22	5	82
13	15	3	70
10	15	6	94
10	19	4	79
8	13	3	93
13	17	7	89
12	11	4	70
11	15	6	79
10	16	7	77
8	20	5	82
8	16	7	86
12	21	6	70
9	18	5	75
8	13	5	98
13	21	7	89
12	20	3	94
10	18	6	77
12	11	3	70
12	13	7	80
13	20	8	75
7	17	5	75
9	11	8	94
13	16	8	89
10	18	6	75
9	15	6	86
12	12	6	97
9	13	8	91
7	22	3	69
8	13	6	94
12	13	8	72
13	13	6	76
9	20	5	76
12	22	6	76

21	$	1,160,547.46	$	1,785,457.62
-3	$	624,910.17	$	1,874,730.51
23	$	803,455.93	$	1,071,274.57
13	$	624,910.17	$	982,001.69
5	$	982,001.69	$	1,249,820.34
26	$	982,001.69	$	982,001.69
18	$	1,071,274.57	$	1,339,093.22
10	$	982,001.69	$	1,606,911.86
2	$	1,160,547.46	$	1,964,003.39
7	$	1,071,274.57	$	982,001.69
21	$	982,001.69	$	1,606,911.86
25	$	1,160,547.46	$	1,428,366.10
31	$	1,160,547.46	$	1,071,274.57
1	$	1,160,547.46	$	1,964,003.39
19	$	982,001.69	$	1,696,184.74
17	$	803,455.93	$	1,339,093.22
6	$	624,910.17	$	1,696,184.74
23	$	624,910.17	$	1,160,547.46
6	$	803,455.93	$	1,517,638.98
9	$	1,071,274.57	$	1,964,003.39
29	$	1,160,547.46	$	1,339,093.22
5	$	892,728.81	$	1,339,093.22
18	$	892,728.81	$	1,696,184.74
13	$	714,183.05	$	1,160,547.46
4	$	1,160,547.46	$	1,517,638.98
33	$	1,071,274.57	$	982,001.69
19	$	982,001.69	$	1,339,093.22
20	$	892,728.81	$	1,428,366.10
15	$	714,183.05	$	1,785,457.62
13	$	714,183.05	$	1,428,366.10
21	$	1,071,274.57	$	1,874,730.51
23	$	803,455.93	$	1,606,911.86
6	$	714,183.05	$	1,160,547.46
0	$	1,160,547.46	$	1,874,730.51
1	$	1,071,274.57	$	1,785,457.62
19	$	892,728.81	$	1,606,911.86
34	$	1,071,274.57	$	982,001.69
18	$	1,071,274.57	$	1,160,547.46
14	$	1,160,547.46	$	1,785,457.62
26	$	624,910.17	$	1,517,638.98
8	$	803,455.93	$	982,001.69
4	$	1,160,547.46	$	1,428,366.10
21	$	892,728.81	$	1,606,911.86
14	$	803,455.93	$	1,339,093.22
3	$	1,071,274.57	$	1,071,274.57
9	$	803,455.93	$	1,160,547.46
29	$	624,910.17	$	1,964,003.39
9	$	714,183.05	$	1,160,547.46
25	$	1,071,274.57	$	1,160,547.46
22	$	1,160,547.46	$	1,160,547.46
20	$	803,455.93	$	1,785,457.62
14	$	1,071,274.57	$	1,964,003.39

$	535,637.29	$	6,249,101.69	$	2,727,774.98
$	714,183.05	$	8,615,208.77	$	-
$	535,637.29	$	7,141,830.50	$	2,959,884.47
$	624,910.17	$	8,283,702.32	$	1,707,560.60
$	535,637.29	$	8,556,377.74	$	656,754.08
$	535,637.29	$	6,784,738.97	$	3,308,048.71
$	357,091.52	$	7,242,869.59	$	2,364,314.67
$	267,818.64	$	7,961,909.41	$	1,313,508.15
$	714,183.05	$	7,788,220.43	$	262,701.63
$	267,818.64	$	8,800,663.97	$	919,455.71
$	535,637.29	$	6,606,193.21	$	2,727,774.98
$	446,364.41	$	6,338,374.57	$	3,191,993.96
$	357,091.52	$	6,249,101.69	$	3,888,322.43
$	267,818.64	$	8,335,623.92	$	131,350.82
$	624,910.17	$	6,606,193.21	$	2,495,665.49
$	357,091.52	$	7,611,727.32	$	2,232,963.86
$	624,910.17	$	8,276,792.89	$	788,104.89
$	267,818.64	$	7,498,922.02	$	2,959,884.47
$	714,183.05	$	8,187,520.00	$	788,104.89
$	446,364.41	$	7,438,038.33	$	1,182,157.34
$	267,818.64	$	6,249,101.69	$	3,656,212.94
$	535,637.29	$	8,556,377.74	$	656,754.08
$	357,091.52	$	7,064,323.82	$	2,364,314.67
$	267,818.64	$	8,372,975.20	$	1,707,560.60
$	624,910.17	$	8,121,779.54	$	525,403.26
$	357,091.52	$	6,249,101.69	$	4,120,431.92
$	535,637.29	$	7,052,557.62	$	2,495,665.49
$	624,910.17	$	6,874,011.85	$	2,611,720.23
$	446,364.41	$	7,367,441.09	$	1,970,262.23
$	624,910.17	$	7,748,065.03	$	1,707,560.60
$	535,637.29	$	6,249,101.69	$	2,727,774.98
$	446,364.41	$	6,695,466.09	$	2,959,884.47
$	446,364.41	$	8,901,703.05	$	788,104.89
$	624,910.17	$	8,168,844.37	$	-
$	267,818.64	$	8,603,442.57	$	131,350.82
$	535,637.29	$	6,874,011.85	$	2,495,665.49
$	267,818.64	$	6,249,101.69	$	4,236,486.67
$	624,910.17	$	7,153,596.71	$	2,364,314.67
$	714,183.05	$	6,754,297.13	$	1,838,911.41
$	446,364.41	$	6,695,466.09	$	3,308,048.71
$	714,183.05	$	8,521,079.12	$	1,050,806.52
$	714,183.05	$	8,121,779.54	$	525,403.26
$	535,637.29	$	6,695,466.09	$	2,727,774.98
$	535,637.29	$	7,736,298.82	$	1,838,911.41
$	535,637.29	$	8,847,728.80	$	394,052.45
$	714,183.05	$	8,241,494.26	$	1,182,157.34
$	267,818.64	$	6,159,828.80	$	3,656,212.94
$	535,637.29	$	8,509,312.91	$	1,182,157.34
$	714,183.05	$	6,427,647.45	$	3,191,993.96
$	535,637.29	$	6,784,738.97	$	2,843,829.72
$	446,364.41	$	6,784,738.97	$	2,611,720.23
$	535,637.29	$	6,843,570.01	$	1,838,911.41

$	12,458,519.03
$	11,829,032.50
$	12,512,082.76
$	12,223,084.94
$	11,980,591.13
$	12,592,428.35
$	12,374,643.58
$	12,132,149.76
$	11,889,655.95
$	12,041,214.58
$	12,458,519.03
$	12,565,646.49
$	12,726,337.67
$	11,859,344.22
$	12,404,955.30
$	12,344,331.85
$	12,010,902.86
$	12,512,082.76
$	12,010,902.86
$	12,101,838.04
$	12,672,773.95
$	11,980,591.13
$	12,374,643.58
$	12,223,084.94
$	11,950,279.40
$	12,779,901.40
$	12,404,955.30
$	12,431,737.17
$	12,283,708.40
$	12,223,084.94
$	12,458,519.03
$	12,512,082.76
$	12,010,902.86
$	11,829,032.50
$	11,859,344.22
$	12,404,955.30
$	12,806,683.27
$	12,374,643.58
$	12,253,396.67
$	12,592,428.35
$	12,071,526.31
$	11,950,279.40
$	12,458,519.03
$	12,253,396.67
$	11,919,967.68
$	12,101,838.04
$	12,672,773.95
$	12,101,838.04
$	12,565,646.49
$	12,485,300.90
$	12,431,737.17
$	12,253,396.67

12	11	6	83
9	18	8	95
10	13	7	81
13	14	7	98
8	17	6	83
9	14	6	69
11	13	8	70
9	12	3	73
9	13	8	79
10	21	6	75
10	12	6	97
7	13	3	76
9	21	6	96
11	12	8	76
11	21	4	84
11	17	7	73
7	13	3	93
9	21	7	96
13	17	5	92
12	14	3	87
7	15	8	84
7	18	8	77
9	20	8	98
12	15	7	70
12	11	7	81
12	13	6	95
13	14	7	75
12	14	8	73
7	11	5	70
7	20	6	76
10	18	5	76
13	19	4	98
11	18	6	70
8	13	4	93
9	11	6	86
7	20	5	69
8	21	3	90
11	11	8	71
13	16	8	87
13	13	7	73
12	13	7	71
10	22	5	76
10	14	4	82
11	15	8	98
12	19	7	73
8	16	5	84
10	13	4	91
9	16	3	80
13	19	6	75
13	18	6	75
7	14	3	81
10	21	6	82

18	$	1,071,274.57	$	982,001.69
0	$	803,455.93	$	1,606,911.86
19	$	892,728.81	$	1,160,547.46
-2	$	1,160,547.46	$	1,249,820.34
16	$	714,183.05	$	1,517,638.98
32	$	803,455.93	$	1,249,820.34
28	$	982,001.69	$	1,160,547.46
33	$	803,455.93	$	1,071,274.57
21	$	803,455.93	$	1,160,547.46
18	$	892,728.81	$	1,874,730.51
5	$	892,728.81	$	1,071,274.57
31	$	624,910.17	$	1,160,547.46
-2	$	803,455.93	$	1,874,730.51
23	$	982,001.69	$	1,071,274.57
10	$	982,001.69	$	1,874,730.51
22	$	982,001.69	$	1,517,638.98
14	$	624,910.17	$	1,160,547.46
-3	$	803,455.93	$	1,874,730.51
3	$	1,160,547.46	$	1,517,638.98
14	$	1,071,274.57	$	1,249,820.34
16	$	624,910.17	$	1,339,093.22
20	$	624,910.17	$	1,606,911.86
-5	$	803,455.93	$	1,785,457.62
26	$	1,071,274.57	$	1,339,093.22
19	$	1,071,274.57	$	982,001.69
4	$	1,071,274.57	$	1,160,547.46
21	$	1,160,547.46	$	1,249,820.34
23	$	1,071,274.57	$	1,249,820.34
37	$	624,910.17	$	982,001.69
21	$	624,910.17	$	1,785,457.62
21	$	892,728.81	$	1,606,911.86
-4	$	1,160,547.46	$	1,696,184.74
25	$	982,001.69	$	1,606,911.86
12	$	714,183.05	$	1,160,547.46
18	$	803,455.93	$	982,001.69
29	$	624,910.17	$	1,785,457.62
8	$	714,183.05	$	1,874,730.51
29	$	982,001.69	$	982,001.69
6	$	1,160,547.46	$	1,428,366.10
24	$	1,160,547.46	$	1,160,547.46
27	$	1,071,274.57	$	1,160,547.46
17	$	892,728.81	$	1,964,003.39
20	$	892,728.81	$	1,249,820.34
-2	$	982,001.69	$	1,339,093.22
19	$	1,071,274.57	$	1,696,184.74
17	$	714,183.05	$	1,428,366.10
12	$	892,728.81	$	1,160,547.46
22	$	803,455.93	$	1,428,366.10
17	$	1,160,547.46	$	1,696,184.74
18	$	1,160,547.46	$	1,606,911.86
25	$	624,910.17	$	1,249,820.34
11	$	892,728.81	$	1,874,730.51

$	535,637.29	$	7,421,415.35	$	2,364,314.67
$	714,183.05	$	8,704,481.65	$	-
$	624,910.17	$	7,231,103.38	$	2,495,665.49
$	624,910.17	$	8,793,754.54	$	-
$	535,637.29	$	7,444,947.76	$	2,101,613.04
$	535,637.29	$	6,159,828.80	$	4,004,377.18
$	714,183.05	$	6,249,101.69	$	3,540,158.20
$	267,818.64	$	6,516,920.33	$	4,120,431.92
$	714,183.05	$	7,052,557.62	$	2,727,774.98
$	535,637.29	$	6,707,232.30	$	2,364,314.67
$	535,637.29	$	8,824,196.38	$	656,754.08
$	267,818.64	$	6,784,738.97	$	3,888,322.43
$	535,637.29	$	8,615,208.77	$	-
$	714,183.05	$	6,784,738.97	$	2,959,884.47
$	357,091.52	$	7,604,817.89	$	1,313,508.15
$	624,910.17	$	6,516,920.33	$	2,843,829.72
$	267,818.64	$	8,361,208.99	$	1,838,911.41
$	624,910.17	$	8,525,935.89	$	-
$	446,364.41	$	8,401,364.39	$	394,052.45
$	267,818.64	$	7,825,571.70	$	1,838,911.41
$	714,183.05	$	7,534,220.64	$	2,101,613.04
$	714,183.05	$	6,874,011.85	$	2,611,720.23
$	714,183.05	$	8,525,935.89	$	-
$	624,910.17	$	6,249,101.69	$	3,308,048.71
$	624,910.17	$	7,231,103.38	$	2,495,665.49
$	535,637.29	$	8,657,416.83	$	525,403.26
$	624,910.17	$	6,695,466.09	$	2,727,774.98
$	714,183.05	$	6,516,920.33	$	2,959,884.47
$	446,364.41	$	6,249,101.69	$	4,584,650.91
$	535,637.29	$	6,784,738.97	$	2,727,774.98
$	446,364.41	$	6,784,738.97	$	2,727,774.98
$	357,091.52	$	8,615,208.77	$	-
$	535,637.29	$	6,249,101.69	$	3,191,993.96
$	357,091.52	$	8,384,741.40	$	1,576,209.78
$	535,637.29	$	7,689,233.99	$	2,364,314.67
$	446,364.41	$	6,159,828.80	$	3,656,212.94
$	267,818.64	$	8,163,987.59	$	1,050,806.52
$	714,183.05	$	6,338,374.57	$	3,656,212.94
$	714,183.05	$	7,919,701.36	$	788,104.89
$	624,910.17	$	6,516,920.33	$	3,075,939.21
$	624,910.17	$	6,338,374.57	$	3,424,103.45
$	446,364.41	$	6,808,271.39	$	2,232,963.86
$	357,091.52	$	7,320,376.26	$	2,611,720.23
$	714,183.05	$	8,793,754.54	$	-
$	624,910.17	$	6,516,920.33	$	2,495,665.49
$	446,364.41	$	7,522,454.44	$	2,232,963.86
$	357,091.52	$	8,206,195.64	$	1,576,209.78
$	267,818.64	$	7,141,830.50	$	2,843,829.72
$	535,637.29	$	6,718,998.51	$	2,232,963.86
$	535,637.29	$	6,707,232.30	$	2,364,314.67
$	267,818.64	$	7,231,103.38	$	3,191,993.96
$	535,637.29	$	7,414,505.92	$	1,444,858.97

$	12,374,643.58
$	11,829,032.50
$	12,404,955.30
$	11,829,032.50
$	12,314,020.12
$	12,753,119.54
$	12,645,992.08
$	12,779,901.40
$	12,458,519.03
$	12,374,643.58
$	11,980,591.13
$	12,726,337.67
$	11,829,032.50
$	12,512,082.76
$	12,132,149.76
$	12,485,300.90
$	12,253,396.67
$	11,829,032.50
$	11,919,967.68
$	12,253,396.67
$	12,314,020.12
$	12,431,737.17
$	11,829,032.50
$	12,592,428.35
$	12,404,955.30
$	11,950,279.40
$	12,458,519.03
$	12,512,082.76
$	12,887,028.86
$	12,458,519.03
$	12,458,519.03
$	11,829,032.50
$	12,565,646.49
$	12,192,773.22
$	12,374,643.58
$	12,672,773.95
$	12,071,526.31
$	12,672,773.95
$	12,010,902.86
$	12,538,864.62
$	12,619,210.22
$	12,344,331.85
$	12,431,737.17
$	11,829,032.50
$	12,404,955.30
$	12,344,331.85
$	12,192,773.22
$	12,485,300.90
$	12,344,331.85
$	12,374,643.58
$	12,565,646.49
$	12,162,461.49

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13	17	6	79
10	12	5	76
9	16	6	88
13	16	8	87
11	12	5	96
10	15	7	70
12	21	6	78
11	21	4	89
7	11	8	72
7	12	6	89
8	21	5	83
11	21	8	98
9	14	6	87
11	13	6	75
12	11	6	80
7	21	5	77
9	16	8	97
7	20	4	79
13	19	7	95
8	20	5	72
10	14	7	95
8	18	3	89
9	19	6	86
7	21	8	93
11	12	6	90
10	14	8	97
12	17	3	88
11	16	7	82
12	16	4	91
11	19	4	71
8	22	5	85
8	19	6	71
11	13	6	74
9	16	4	93
10	17	4	91
12	14	8	88
8	19	7	90
13	13	7	90
11	21	3	98
10	12	6	95
8	16	8	76
10	13	3	87
12	11	7	76
10	13	4	69
11	17	4	89
12	12	6	88
7	19	8	89
9	17	3	98
9	15	6	85
7	16	6	96

11	$ 982,001.69	$ 982,001.69
-2	$ 892,728.81	$ 1,785,457.62
15	$ 1,160,547.46	$ 1,517,638.98
27	$ 892,728.81	$ 1,071,274.57
11	$ 803,455.93	$ 1,428,366.10
6	$ 1,160,547.46	$ 1,428,366.10
6	$ 982,001.69	$ 1,071,274.57
28	$ 892,728.81	$ 1,339,093.22
13	$ 1,071,274.57	$ 1,874,730.51
5	$ 982,001.69	$ 1,874,730.51
32	$ 624,910.17	$ 982,001.69
16	$ 624,910.17	$ 1,071,274.57
13	$ 714,183.05	$ 1,874,730.51
-8	$ 982,001.69	$ 1,874,730.51
14	$ 803,455.93	$ 1,249,820.34
25	$ 982,001.69	$ 1,160,547.46
21	$ 1,071,274.57	$ 982,001.69
20	$ 624,910.17	$ 1,874,730.51
0	$ 803,455.93	$ 1,428,366.10
20	$ 624,910.17	$ 1,785,457.62
-4	$ 1,160,547.46	$ 1,696,184.74
25	$ 714,183.05	$ 1,785,457.62
4	$ 892,728.81	$ 1,249,820.34
12	$ 714,183.05	$ 1,606,911.86
10	$ 803,455.93	$ 1,696,184.74
1	$ 624,910.17	$ 1,874,730.51
11	$ 982,001.69	$ 1,071,274.57
1	$ 892,728.81	$ 1,249,820.34
10	$ 1,071,274.57	$ 1,517,638.98
14	$ 982,001.69	$ 1,428,366.10
7	$ 1,071,274.57	$ 1,428,366.10
25	$ 982,001.69	$ 1,696,184.74
10	$ 714,183.05	$ 1,964,003.39
26	$ 714,183.05	$ 1,696,184.74
26	$ 982,001.69	$ 1,160,547.46
8	$ 803,455.93	$ 1,428,366.10
8	$ 892,728.81	$ 1,517,638.98
8	$ 1,071,274.57	$ 1,249,820.34
6	$ 714,183.05	$ 1,696,184.74
7	$ 1,160,547.46	$ 1,160,547.46
-3	$ 982,001.69	$ 1,874,730.51
7	$ 892,728.81	$ 1,071,274.57
22	$ 714,183.05	$ 1,428,366.10
17	$ 892,728.81	$ 1,160,547.46
24	$ 1,071,274.57	$ 982,001.69
34	$ 892,728.81	$ 1,160,547.46
9	$ 982,001.69	$ 1,517,638.98
12	$ 1,071,274.57	$ 1,071,274.57
7	$ 624,910.17	$ 1,696,184.74
3	$ 803,455.93	$ 1,517,638.98
15	$ 803,455.93	$ 1,339,093.22
5	$ 624,910.17	$ 1,428,366.10

$	624,910.17	$	8,128,688.97	$	1,444,858.97
$	624,910.17	$	8,525,935.89	$	-
$	535,637.29	$	7,099,622.45	$	1,970,262.23
$	446,364.41	$	6,784,738.97	$	3,424,103.45
$	535,637.29	$	7,950,143.21	$	1,444,858.97
$	714,183.05	$	7,919,701.36	$	788,104.89
$	446,364.41	$	8,723,157.29	$	788,104.89
$	624,910.17	$	6,249,101.69	$	3,540,158.20
$	535,637.29	$	7,033,881.98	$	1,707,560.60
$	357,091.52	$	8,110,013.33	$	656,754.08
$	714,183.05	$	6,427,647.45	$	4,004,377.18
$	535,637.29	$	7,980,585.05	$	2,101,613.04
$	446,364.41	$	7,480,246.39	$	1,707,560.60
$	714,183.05	$	8,258,117.25	$	-
$	535,637.29	$	7,825,571.70	$	1,838,911.41
$	535,637.29	$	6,695,466.09	$	3,191,993.96
$	535,637.29	$	7,141,830.50	$	2,727,774.98
$	446,364.41	$	6,874,011.85	$	2,611,720.23
$	714,183.05	$	8,883,027.42	$	-
$	357,091.52	$	7,052,557.62	$	2,611,720.23
$	624,910.17	$	8,347,390.13	$	-
$	446,364.41	$	6,427,647.45	$	3,191,993.96
$	624,910.17	$	8,657,416.83	$	525,403.26
$	267,818.64	$	8,027,649.88	$	1,576,209.78
$	535,637.29	$	7,783,363.65	$	1,313,508.15
$	714,183.05	$	8,514,169.68	$	131,350.82
$	535,637.29	$	8,128,688.97	$	1,444,858.97
$	714,183.05	$	8,871,261.21	$	131,350.82
$	267,818.64	$	7,961,909.41	$	1,313,508.15
$	624,910.17	$	7,379,207.30	$	1,838,911.41
$	357,091.52	$	8,265,026.68	$	919,455.71
$	357,091.52	$	6,338,374.57	$	3,191,993.96
$	446,364.41	$	7,694,090.77	$	1,313,508.15
$	535,637.29	$	6,338,374.57	$	3,308,048.71
$	535,637.29	$	6,606,193.21	$	3,308,048.71
$	357,091.52	$	8,431,806.23	$	1,050,806.52
$	357,091.52	$	8,253,260.47	$	1,050,806.52
$	714,183.05	$	7,985,441.83	$	1,050,806.52
$	624,910.17	$	8,187,520.00	$	788,104.89
$	624,910.17	$	8,175,753.80	$	919,455.71
$	267,818.64	$	8,704,481.65	$	-
$	535,637.29	$	8,622,118.20	$	919,455.71
$	714,183.05	$	6,784,738.97	$	2,843,829.72
$	267,818.64	$	7,790,273.08	$	2,232,963.86
$	624,910.17	$	6,784,738.97	$	3,075,939.21
$	357,091.52	$	6,159,828.80	$	4,236,486.67
$	357,091.52	$	8,062,948.50	$	1,182,157.34
$	535,637.29	$	7,938,377.00	$	1,576,209.78
$	714,183.05	$	8,086,480.92	$	919,455.71
$	267,818.64	$	8,937,001.68	$	394,052.45
$	535,637.29	$	7,635,259.73	$	1,970,262.23
$	535,637.29	$	8,734,923.50	$	656,754.08

$	12,162,461.49
$	11,829,032.50
$	12,283,708.40
$	12,619,210.22
$	12,162,461.49
$	12,010,902.86
$	12,010,902.86
$	12,645,992.08
$	12,223,084.94
$	11,980,591.13
$	12,753,119.54
$	12,314,020.12
$	12,223,084.94
$	11,829,032.50
$	12,253,396.67
$	12,565,646.49
$	12,458,519.03
$	12,431,737.17
$	11,829,032.50
$	12,431,737.17
$	11,829,032.50
$	12,565,646.49
$	11,950,279.40
$	12,192,773.22
$	12,132,149.76
$	11,859,344.22
$	12,162,461.49
$	11,859,344.22
$	12,132,149.76
$	12,253,396.67
$	12,041,214.58
$	12,565,646.49
$	12,132,149.76
$	12,592,428.35
$	12,592,428.35
$	12,071,526.31
$	12,071,526.31
$	12,071,526.31
$	12,010,902.86
$	12,041,214.58
$	11,829,032.50
$	12,041,214.58
$	12,485,300.90
$	12,344,331.85
$	12,538,864.62
$	12,806,683.27
$	12,101,838.04
$	12,192,773.22
$	12,041,214.58
$	11,919,967.68
$	12,283,708.40
$	11,980,591.13

7	19	3	89
12	16	3	70
13	15	6	77
13	21	3	94
7	13	7	94
7	14	7	93
13	22	6	91
13	19	8	85
7	13	6	69
8	12	5	89
7	15	4	78
7	22	7	92
9	21	4	85
8	12	4	84
13	13	5	91
8	12	4	93
9	17	4	79
13	15	3	90
13	18	6	86
7	17	3	97
11	15	6	93
10	11	6	91
13	19	6	93
9	18	8	70
11	18	4	69
12	14	4	75
12	22	5	82
8	15	3	87
11	19	8	82
8	14	6	92
10	14	3	71
10	19	7	78

12	$	624,910.17	$	1,696,184.74
29	$	1,071,274.57	$	1,428,366.10
19	$	1,160,547.46	$	1,339,093.22
-1	$	1,160,547.46	$	1,874,730.51
9	$	624,910.17	$	1,160,547.46
9	$	624,910.17	$	1,249,820.34
-2	$	1,160,547.46	$	1,964,003.39
5	$	1,160,547.46	$	1,696,184.74
35	$	624,910.17	$	1,160,547.46
16	$	714,183.05	$	1,071,274.57
26	$	624,910.17	$	1,339,093.22
2	$	624,910.17	$	1,964,003.39
11	$	803,455.93	$	1,874,730.51
22	$	714,183.05	$	1,071,274.57
8	$	1,160,547.46	$	1,160,547.46
13	$	714,183.05	$	1,071,274.57
21	$	803,455.93	$	1,517,638.98
9	$	1,160,547.46	$	1,339,093.22
7	$	1,160,547.46	$	1,606,911.86
6	$	624,910.17	$	1,517,638.98
5	$	982,001.69	$	1,339,093.22
12	$	892,728.81	$	982,001.69
-1	$	1,160,547.46	$	1,696,184.74
25	$	803,455.93	$	1,606,911.86
28	$	982,001.69	$	1,606,911.86
25	$	1,071,274.57	$	1,249,820.34
9	$	1,071,274.57	$	1,964,003.39
17	$	714,183.05	$	1,339,093.22
10	$	982,001.69	$	1,696,184.74
10	$	714,183.05	$	1,249,820.34
32	$	892,728.81	$	1,249,820.34
16	$	892,728.81	$	1,696,184.74

$	267,818.64	$	8,027,649.88	$	1,576,209.78
$	267,818.64	$	6,249,101.69	$	3,656,212.94
$	535,637.29	$	6,874,011.85	$	2,495,665.49
$	267,818.64	$	8,525,935.89	$	-
$	624,910.17	$	8,509,312.91	$	1,182,157.34
$	624,910.17	$	8,420,040.03	$	1,182,157.34
$	535,637.29	$	8,168,844.37	$	-
$	714,183.05	$	7,752,921.81	$	656,754.08
$	535,637.29	$	6,159,828.80	$	4,352,541.42
$	446,364.41	$	7,980,585.05	$	2,101,613.04
$	357,091.52	$	6,963,284.74	$	3,308,048.71
$	624,910.17	$	8,413,130.60	$	262,701.63
$	357,091.52	$	7,682,324.56	$	1,444,858.97
$	357,091.52	$	7,498,922.02	$	2,843,829.72
$	446,364.41	$	8,253,260.47	$	1,050,806.52
$	357,091.52	$	8,372,975.20	$	1,707,560.60
$	357,091.52	$	7,052,557.62	$	2,727,774.98
$	267,818.64	$	8,152,221.38	$	1,182,157.34
$	535,637.29	$	7,818,662.27	$	919,455.71
$	267,818.64	$	8,812,430.17	$	788,104.89
$	535,637.29	$	8,467,104.86	$	656,754.08
$	535,637.29	$	8,206,195.64	$	1,576,209.78
$	535,637.29	$	8,436,663.01	$	-
$	714,183.05	$	6,249,101.69	$	3,191,993.96
$	357,091.52	$	6,159,828.80	$	3,540,158.20
$	357,091.52	$	6,695,466.09	$	3,191,993.96
$	446,364.41	$	7,438,038.33	$	1,182,157.34
$	267,818.64	$	7,790,273.08	$	2,232,963.86
$	714,183.05	$	7,426,272.13	$	1,313,508.15
$	535,637.29	$	8,319,000.94	$	1,313,508.15
$	267,818.64	$	6,338,374.57	$	4,004,377.18
$	624,910.17	$	6,998,583.36	$	2,101,613.04

$	12,192,773.22
$	12,672,773.95
$	12,404,955.30
$	11,829,032.50
$	12,101,838.04
$	12,101,838.04
$	11,829,032.50
$	11,980,591.13
$	12,833,465.13
$	12,314,020.12
$	12,592,428.35
$	11,889,655.95
$	12,162,461.49
$	12,485,300.90
$	12,071,526.31
$	12,223,084.94
$	12,458,519.03
$	12,101,838.04
$	12,041,214.58
$	12,010,902.86
$	11,980,591.13
$	12,192,773.22
$	11,829,032.50
$	12,565,646.49
$	12,645,992.08
$	12,565,646.49
$	12,101,838.04
$	12,344,331.85
$	12,132,149.76
$	12,132,149.76
$	12,753,119.54
$	12,314,020.12