CAREER EPISODE 3

INTRODUCTION

CE 3.1 This project is about coal resource estimation in Bowen Basin of Queensland using 18 cored boreholes data which contains information regarding coordinate location and coal qualities such as inherent moisture, volatile matter, fixed carbon, and ash content. I was working as a graduate trainee for Western Australian School of Mines Advanced Resource Modelling and Estimation course from _________ to ________.

BACKGROUND

CE 3.2 The Compositing technique was used to produce a set of data that are defined on the same sample volume, was applied. Coal outcrop and Line of oxidation was also analyzed using Crucible Swelling Number (CSN) and top of coal data which resulted in excluding C444 borehole from tonnage calculation as it doesn't meet the requirement for coking coal type. The deposit resource was estimated using three geometrical methods, namely ballpark estimation, triangulation and polygonal methods.

CE 3.3 Resource estimation is fundamental stage in mining process as it is the core information for mine planning and economic analysis. It is basically the process of estimating tonnage, grade (quality), size, shape and location of deposit. The deposit resource that will be estimated in the project is coal which is located in the Bowen Basin of Queensland.

CE 3.4 The exploration was undertaken in Coal Bowen Basin of Queensland creating the database about the surveyed borehole and the quality of coal. The information derived from the surveyed borehole are borehole ID, coordinate location, collar coordinate and top of coal location.

CE 3.5 The sample from each borehole was tested in laboratory to obtain quality parameters, namely Inherent Moisture (IM), Ash Percentage (ASH), Volatile Matter (VM), Fixed Carbon (FC), Specific Energy (SE) and Crucible Swell Number (CSN).

CE 3.6

PERSONAL ENGINEERING ACTIVITY

CE 3.7 I .

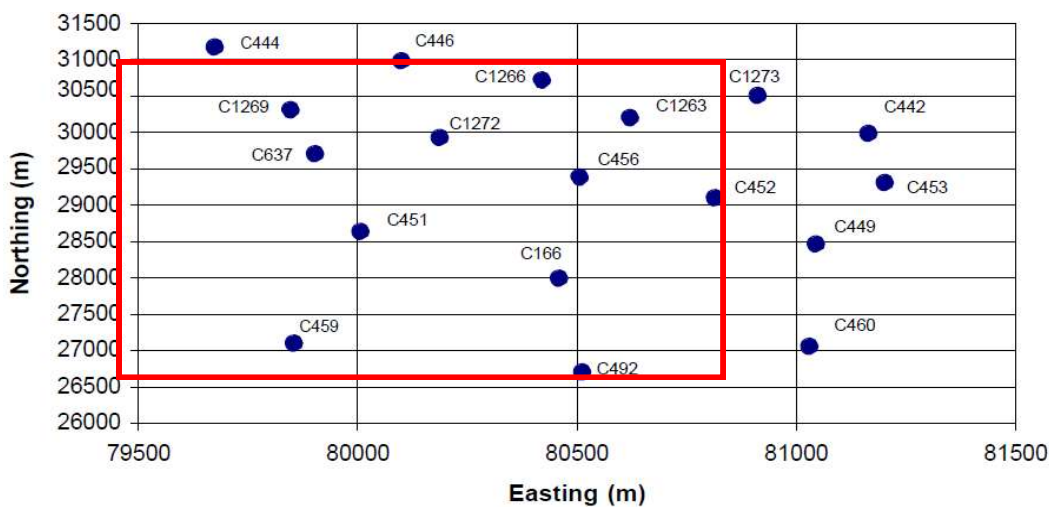
CE 3.8 The sample of coal extracted in each bore hole is represented by irregular lengths with slightly different quality. To produce a set of data that are defined on the same sample volume, those data should be combined to form weighted average or composite quality. As the borehole contains various samples, the calculation of composited coal quality should consider the average density of the sample. Before compositing the boreholes variables, the data was validated to make sure that the total quality of coal is 100 %.

$$IM + Ash + VM + FC = 100\ \%$$

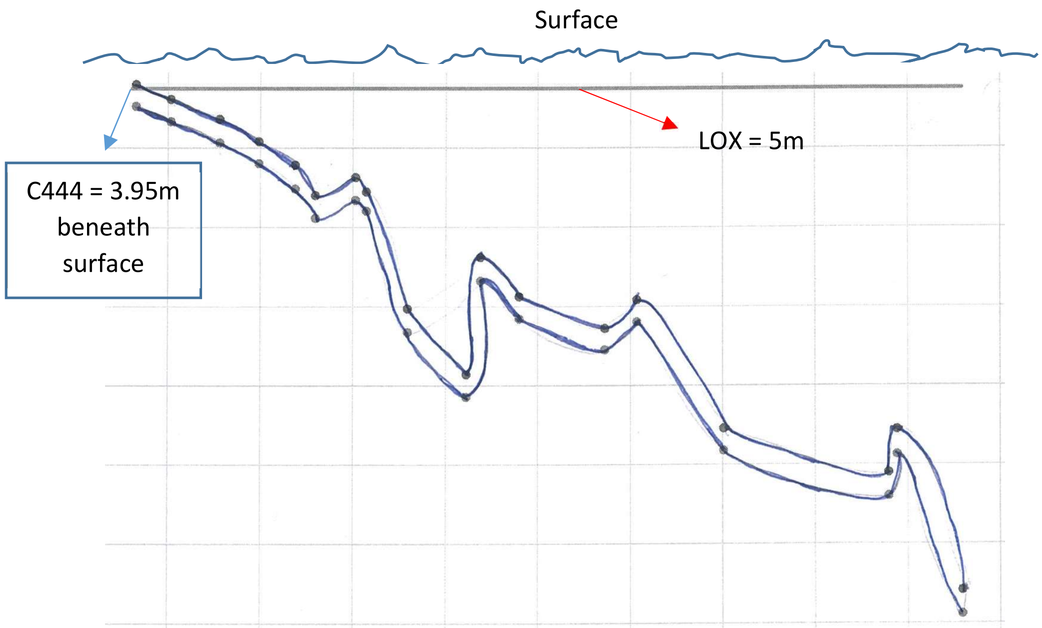
The composited variables were quantified using following formula:

$$Composite\ (Variable) = \frac{\Sigma\, Variable\ x\ Thickness\ x\ Density}{\Sigma\, Thickness\ x\ Density}$$

CE 3.9 The analysis of coal quality describes that coal type in the project is coking coal. The working section to be mined was determined by the Crucible Swelling number (CSN) which is the number that defines, by reference to a series of standard profiles, the size and shape of the residue produced when a standard weight of coal is heated under standard conditions. Figure shows the working section to be mined in the project.



CE 3.10 The line of oxidation (LOX) determines the tonnage calculation as the oxidized coal affects the rank of coal. The exposure of coal to the atmosphere may reduce the quality of coal by altering the chemical and physical properties. LOX was assumed at five meters' depth from the surface. As can be seen in figure below, the top of coal in borehole C444 is 3.95 m from the surface which is above the LOX, thus, the C44 is excluded from tonnage calculation. The C44 may also be a sign of outcrop as the top of coal is near the surface.



CE 3.11 After I had set up the working section to be mined based on CSN and LOX, the next stage was calculating the amount of coal deposit in the mining lease. The methods used for resource estimation in the project were ballpark estimation, triangulation and polygonal method.

CE 3.12 The ballpark estimation measured the rough area of a rectangular created from outmost point of borehole and multiplying it by the average density and thickness of all borehole. Table below presents the resource estimation using ballpark method.

Area (m^2)	6,015,625
Average Thickness (m)	5.74
Average Density (t/m^3)	1.43
Volume (BCM)	34,547,381
Tonnage (tones)	49,458,183

CE 3.13 The triangulation method is the geometric method of estimating mineral resource which connects the borehole points to create triangle. Each area of triangles within the mining lease was calculated, then multiplied with the average thickness and density that contributed to form the triangular shape. There are 20 triangles within the area that results in 35,286,542 tons of coal

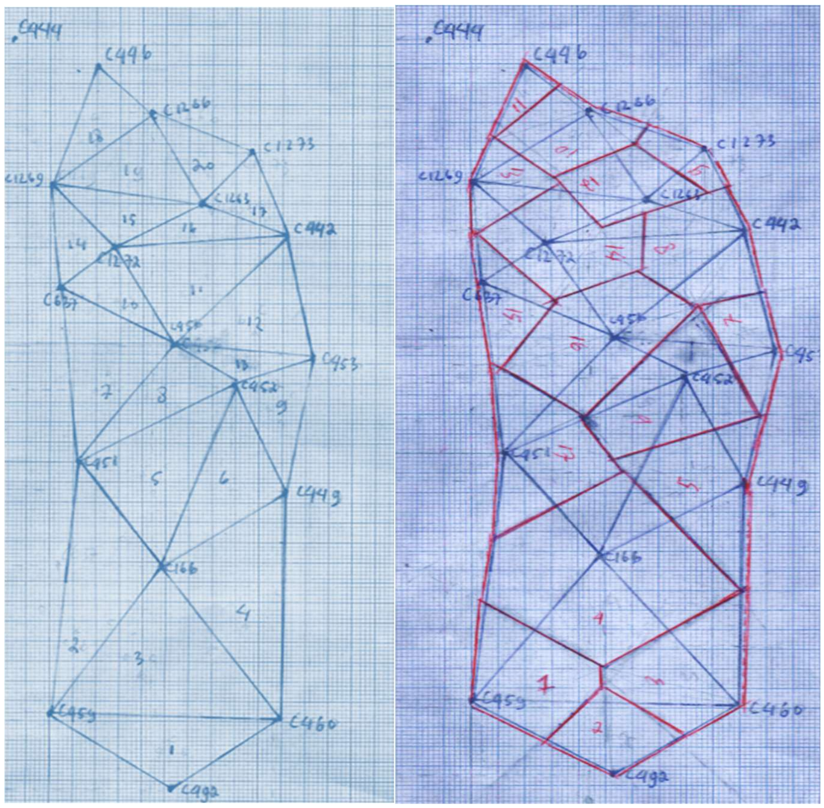
Triangle	Area (m^2)	Average Thickness (m)	Average Density (t/m^3)	Volume (m^3)	Tonnage (tones)
1	269,766	6.10	1.43	1,646,469	2,354,351
2	375,936	5.64	1.44	2,121,534	3,057,809
3	526,010	5.97	1.43	3,138,524	4,503,116

4	415,206	5.85	1.44	2,430,337	3,487,829
5	356,874	5.54	1.43	1,975,895	2,832,748
6	264,983	5.60	1.43	1,483,024	2,116,859
7	293,816	5.69	1.46	1,671,816	2,442,240
8	174,123	5.58	1.42	971,605	1,380,255
9	157,472	5.72	1.41	900,215	1,269,303
10	118,875	5.51	1.45	655,001	950,053
11	268,203	5.46	1.42	1,464,390	2,082,200
12	259,645	5.83	1.42	1,513,731	2,141,930
13	80,230	5.77	1.40	462,928	649,643
14	86,909	5.61	1.45	487,557	707,209
15	129,904	5.53	1.41	718,368	1,015,294
16	110,328	5.44	1.42	600,551	854,952
17	94,188	5.67	1.43	534,048	762,489
18	129,904	5.87	1.43	762,968	1,090,246
19	189,625	5.91	1.42	1,120,683	1,588,017
20	110,266	5.74	1.42	633,294	901,589
Total	4,412,263			24,659,646	35,286,542

CE 3.14 A third option Polygonal method is a geometric method which creates the polygon based on the perpendicular bisectors between a sample and all its neighbours. The area of each polygon was calculated and multiplied by the density and thickness to determine the tonnage. The total tonnage of the area is the sum of tonnage from all polygons.

Polygon	Area (m^2)	Thickness (m)	Density (t/m^3)	Volume (m^3)	Tonnage (tones)
1	246,516	5.92	1.43	1,459,372	2,083,983
2	172,249	6.02	1.43	1,036,937	1,486,591
3	331,658	6.37	1.43	2,112,661	3,017,264
4	751,014	5.61	1.45	4,213,188	6,101,462
5	337,288	5.58	1.43	1,882,068	2,689,475
6	361,866	5.6	1.41	2,026,448	2,847,160
7	136,039	5.97	1.40	812,153	1,133,766
8	286,773	5.78	1.44	1,657,548	2,386,868
9	54,938	5.54	1.43	304,354	434,950
10	169,674	6.04	1.41	1,024,833	1,444,161
11	32,742	5.58	1.45	182,701	264,916
12	184,881	5.69	1.41	1,051,971	1,487,663
13	131,311	6.04	1.41	793,117	1,117,634
14	288,284	4.86	1.42	1,401,062	1,984,838
15	135,478	5.93	1.53	803,386	1,225,738
16	483,007	5.74	1.41	2,772,458	3,906,393
17	328,838	5.4	1.45	1,775,726	2,570,856
Total	4,432,554.92			25,309,984	36,183,719

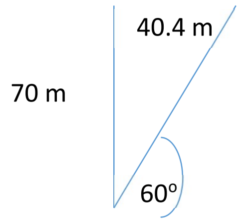
CE 3.15 The figure depicts the geometric methods, triangulation and polygonal, used for resource estimation. There are 20 triangles and 17 polygons created from those methods which have different result of total area since the polygonal method added assumption for lease boundary.



CE 3.16 According to the JORC code, the resource is classified by three categories namely inferred, indicated and measured. The category is divided based on the increasing level of geological knowledge and confidence. Each borehole was made as point of observation for interpolation while radius of the interpolation was determined by the average of distance between observation point (boreholes).

CE 3.17 The average distance between boreholes in the project is 757 m which was used as the radius to determine the measured resource area. In practice, the determination of geological complexity is also influenced by the geological complexity. The radius of interpolation should be assumed smaller if the geological condition is extremely complex. The increase of radius will change the resource category to be indicated and inferred.

CE 3.18 The geotechnical evaluation is also important when upgrading the resource to reserve. The angle of pit is designed as safe as possible which will determine the width of coal seam roof should be mined with particular depth. For example, in this project, it is assumed that 60º is the safe angle for pit. To mine 70 m depth, the coal seam roof should be mined at width of 40.4 m.

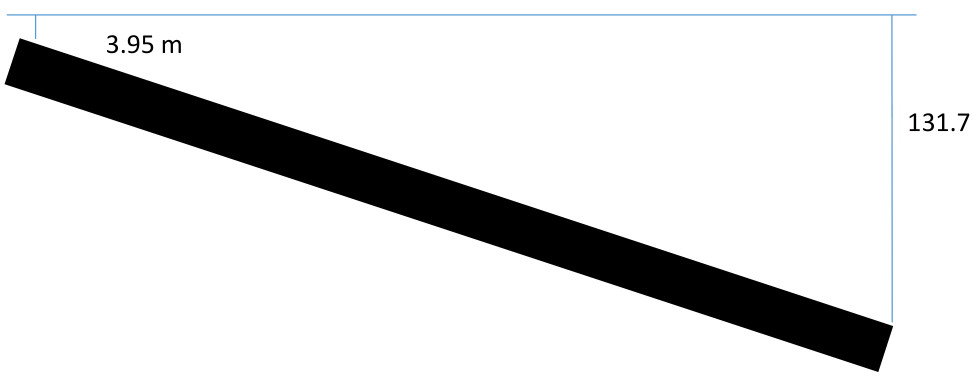


Another consideration to convert from resource to reserve is to include the loss and dilution of deposit as it always occurs in practice. The reserve estimation is more precise after applying these factors.

CE 3.19 In surface mining, before mining the coal deposit, the material which covers the coal must be extracted earlier. Thus, the estimation of overburden volume is important as it will be used in economic evaluation regarding the material movement cost. The same methods for coal estimation were applied for overburden which are ballpark estimation, triangulation and polygonal methods.

CE 3.20 The volume of overburden was determined by multiplying the cross-section area of overburden to the easting distance. The shape of area as shown in figure is trapezoid, thus the formula used to determine the area is

$$Area\ of\ Trapezium = \left(\frac{TOC1 + TOC2}{2} \Delta North\ lease\ boundary\right)$$



The volume of overburden can be calculated using following formula:

$$Volume = \left(\frac{TOC1 + TOC2}{2} \Delta North\ lease\ boundary\right) \times \Delta East\ lease\ boundary$$

$$Volume = \left(\frac{3.95 + 131.7}{2} X4279.76\right) \times 1355.26 = \mathbf{393,399,171\ m3}$$

CE 3.21 The calculation of overburden volume using triangulation method has the same procedure as coal's tonnage estimation. The thickness used to calculate the volume was the average of top of coal that contributed to form the triangle.

CE 3.22 The overburden volume estimation using polygonal method was determined by multiplying the area of polygon with the thickness of overburden or top of coal. The overburden volume came out to be 273,740,173.96 m^3.

CE 3.23 The economic analysis is comprised of the cost and profit estimation. The cost associated with the mining to the marketing process is shown in table below.

Cost	Value	Unit
Material Movement	4	$/bcm
Capital depreciation	6	$/tonne mined
Washing Coal	5	$/tonne feed
transport to ship	25	$/tonne product
overheads	7	$/tonne product
government tax	20	$/tonne product

CE 3.24 The cost associated to the mining to selling process consists of material movement cost, capital depreciation, washing coal, transport cost, overhead, tax and minimum profit margin. The material movement cost considers two material which are coal and overburden. Processing yield if the coal being washed is assumed to be 70 %, thus the tonnage of coal from the resource is reduced by 30%.

CE 3.25 The profit estimation was determined by subtracting the revenue of selling coal to the total cost spent. The revenue is the price of coking coal multiplied by the coking coal tonnage after applying the yield factor. The profit estimation is shown

	Ballpark	Triangulation	Polygonal
Revenue ($)	6,231,731,049.10	4,446,104,289.16	4,559,148,555.71
Total Cost ($)	4,575,414,998	3,283,363,270	3,291,237,944
Profit ($)	**1,656,316,050.98**	**1,162,741,019.55**	**1,267,910,612.13**

SUMMARY

CE 3.26 I estimated the coal resource in Bowen Basin of Queensland using three geometrical methods and classified as measured resource. I also determined the Mine working section considering the coal quality. The economic evaluation resulted in highest profit in ballpark estimation since it has the highest volume of resource. However, triangulation and polygonal are considered more accurate and representative estimation than ballpark's as those methods only included the calculation of area from connecting borehole points.