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PREFEASIBILITY STUDY OF COAL USE IN COSTA RICA

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Report on Task 2
Coal Reserves and Mine Plan Assessment

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by

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1.0 INTRODUCTION

Costa Rica's heavy dependence on oil imports is placing a severe drain on its foreign exchange earnings and comprises the country's national security interests. In addition, the country is excessively dependent on hydro-electric power. To deal with this situation the Government of Costa Rica has initiated a number of programs to develop indigenous fuels including low grade coal. Costa Rica's situation is typical of many developing nations where unexploited low grade coal is a potential solution to easing foreign debt and stimulation of economic development. The United States Government, acting through the Agency for International Development (USAID), is assisting the Government of Costa Rica in the exploration, assessment and development of Costa Rica's coal resources in order to further its national objectives.

The existence of coal in several locations of the country has been known for a long time. In 1981, the Instituto Costrricense de Electricidad (ICE) initiated a program of geological investigations in collaboration with Japan International Cooperation Agency (JICA). Later the responsibility for coal exploration in Costa Rica was transferred to Refinadora Costarricense de Petroleo (RECOPE) the national petroleum refining company. In 1983, a program for exploration was formulated by USAID in cooperation with the U.S. Geological Survey (USGS). Most of the work for this program was completed in the summer of 1985. The work included exploratory drilling, geophysical logging, collecting cores and cutting samples, coal analysis, and surface mapping.

The exploration program was followed by a Dravo International, Inc. mining feasibility study for the coal deposits in the Uatsi project area in Baja Talamanca coal field near Limon. The report dated January 1986 was based on exploration results as of December 1985 and concludes, with some qualifications, that extraction of coal from this deposit was technically feasible and that approximately 5 million tonnes could be recovered by open pit and underground mining.

RECOPE continued the exploration of the Uatsi and Zent coal deposits into 1986. In mid-November of 1986 Bechtel received the new drilling information to supplement the previous reserve reports and data obtained during Bechtel's April 1986 visit to discuss coal development and thermal power generation with the Costa Rican officials.

Bechtel's primary objectives for this part of the prefeasibility study are to review the Phase I Geological Reports, Dravo's Mining Feasibility Study Report, and RECOPE's subsequent geological investigation results developed for the Uatsi mine area; to provide comments on these reports and investigations and to make recommendations for the next phase of work.

Principal documents received by Bechtel from RECOPE to accomplish these objectives are as follows:

1. Prefeasibility Study Report for the Baja Talamanca Coal Development Project in the Republic of Costa Rica, Japan International Cooperation Agency, February 1983.

2. Mining Feasibility Study Uatsi Coal Project Costa Rica, Dravo International, Inc., January 1986.

3. Factibilidad Fase I Investigacion y Desarrollo De Los Recursos Carboniferos Projecto Uatsi Baja Talamanca Provincia De Limon, Refinadora Costarricence De Petroleo (RECOPE), 1985.

4. Coal: Research and Development National Program, RECOPE, August 1982.

5. U.S. Geological Survey, Project Report Costa Rica Investigation (IR) CS-30, 31,and 32 dated 1985, and Open-File Report 86-121 dated 1986.

6. Geologic drawings and drill hole information, Uatsi coal deposit.

7. Geologic drawings and drill hold information, Zent coal deposit.

Bechtel reviewed these documents for the assessment of the quantity and quality of the Uatsi coal reserves and the mine feasibility study prepared

by Dravo. Bechtel's findings and recommendations for the next phase of work are summarized in the Executive Summary of this report. Section 3 reports Bechtel's assessment of quantity and quality of the Uatsi reserves. This section also contains an explanation of the ground water and rock mechanics work to be conducted in the next phase of work. Although the Zent coal field is not part of the scope of work, the geologic information received on this deposit was given a cursory review and comments are included. The mine plan, capital expenditures and operating costs assessments are included in Section 4. A coal production cost estimate prepared by Bechtel and included in this section provides the basis for Bechtel's recommendations to continue with the next phase of work. Finally, the Appendix includes four isopach maps prepared by Bechtel and used as work sheets in the computation of the reserves.

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2.0 EXECUTIVE SUMMARY

Bechtel National, Inc. was selected to complete a pre-feasibility study of coal use in Costa Rica. This part of the study is dedicated to the assessment of the previous work on the coal reserves and mine plan for the potential mining of coal at Uatsi in Baja Talamanca, Costa Rica. The assessment was performed by the Mining and Metals Operations of Bechtel, Inc. in San Francisco, California.

Previous work in this coal deposit was completed by the Japan International Cooperation Agency (JICA), Refinadora Costarricense de Petroleo (RECOPE), the United States Geological Survey (USGS), and Dravo International, Inc. The JICA, RECOPE, and USGS efforts were directed towards the regional and local geology, and to the quantity and quality of the coal reserves. JICA recognized in their early investigation that small scale, labor intensive underground mining and a partly mechanized haulage system would be the only feasible method for exploiting this deposit. The Dravo study deals more with the mining aspect of the coal reserves and the associated costs of mining. Dravo discusses both open pit and underground mining methods.

Following are the principal findings covering the assessment of the pre-feasibility work completed for the Uatsi coal deposit and the recommendations for the next phase of work.

2.1 Findings

1. The Uatsi coal deposit is approximately 10 kilometers long and 2 kilometers wide and appears to have commercial value at this stage. Ten seams, ranging in thickness between several centimeters and two meters, were identified by exploratory drilling and outcrop measurements. The area is deformed by anticlines, synclines, and faults. Large fault displacements have divided the deposit into three potential mining areas bounded by faults - West, East, and North areas.

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2. Based on outcrop measurements and exploratory drilling including the most recent drilling at Uatsi, Bechtel estimates the coal reserves, greater than 0.6 meter in thickness, for the three areas as follows:

Area	Seam	Avg. Seam Thickness, m	Measured Tonnes	Indicated Tonnes	Inferred Tonnes	Total Tonnes
West	New V-9	1.15	1,190,270	719,740	719,330	2,629,340
West	V-1	0.89	287,050	797,420	557,830	1,642,310
North	V-9	1.45	401,000	1,096,620	490,470	1,988,090
East	V-7	1.08	633,020	1,979,400	3,087,670	5,700,110
Total			2,511,350	4,593,180	4,855,320	11,959,850

3. The coal reserves determined for the four seams show that only 2.5 million tonnes out of a total 12 million tonnes are measured reserves and that nearly half of the measured reserves are in the New V-9 Seam. This is an indication that considerably more drilling is required to increase the reserves in the measured category.

4. In the East area there are considerable reserves in the eastern end which were not included in the reserves of the V-7 Seam because of seam correlation difficulties. There are also indications that more reserves for this seam are located north of the Sandbox Syncline trough.

5. The drill logs and geologic sections prepared by RECOPE indicate that more than one or two seams in each of the areas have a mining potential; i.e., the seams are thick enough for mining and the interval between seams appears to be adequate for safe extraction.

6. There is reason to believe that with adequate drilling, the total coal reserves may be greatly improved which will aid in making this a potential viable mining project.

7. The coal quality information is inadequate to make any judgment on the characterization of this coal field. JICA samples are all outcrop samples and their proximate analysis were completed on an "air dried" basis rather than the "as received" basis which is the basis for power plant design. Analyses performed in Costa Rica are inconsistent and those performed in the U.S. have a wide variance between the "as received" moisture and the equilibrium moisture.

8. Bechtel selected actual sample analyses which are believed to be representative of the coal seams investigated rather than averaging the analyses. It appears that the calorific value for the New V-9, V-9, and V-1 seams will be approximately 4500 Kcal/kg with a moisture content of between 26 and 28 percent and an ash content of between 8 and 10 percent. The V-7 Seam samples appear to have a much higher ash content and a corresponding lower calorific value. The upper seams, New V-9 and V-9, have low sulfur contents ranging between 0.4 and 2.0 percent; whereas, the lower seams appear to progressively increase in sulfur content ranging upward to 4.0 percent. Based on the assessment, the median samples indicate that the coal classification is sub-bituminous C. There is also some evidence that the coal classifications range between lignite and sub-bituminous A. Although some analyses are suspect, there is a possibility that these coal ranges do exist because of the tectonic forces that have acted on the deposit.

9. The ultimate analysis samples selected were for the same samples selected for the proximate analysis. These values track well with Western United States sub-bituminous C coal.

10. The JICA report had the only mineral analysis of ash. Of interest in these ash samples is the fact that the V-1 and V-7 seams are bituminous ash and the V-9 Seam is a lignitic ash. Based on these analyses both types of ash are expected to have low to medium slagging and low fouling properties.

11. The ash fusion temperature samples selected correspond to the JICA mineral analysis of ash samples. The fusion temperature of the lignitic ash is lower than that of the two bituminous ash samples. There isn't any indications as to whether these determinations were make on a reducing or oxidizing atmosphere.

12. The Hardgrove grindability index determinations performed for this coal indicate grindability on the low end of the scale for a sub-bituminous C coal.

13. There was an absence of ground water information in the reviewed data. Ground water is an important factor to be considered in developing an effective mine plan. Bechtel has prepared a program for ground water assessment to be followed in the next phase of work.

14. Very little information on the strength of the roof and floor rock was available. These determinations indicate that the roof and floor are composed of weak materials. Bechtel has prepared a program to be followed in the next phase of work to better assess the roof and floor conditions.

15. Only cursory review was made of the Zent coal field information, because this coal field was not included in the Bechtel scope of work. The quality of coal in the Zent field is classified as carbonaceous shale and low grade coal. There are indications that considerable near surface reserves exist; however, geologic maps were not available to confirm this occurrence.

16. The Uatsi coal deposit lends itself to small scale underground mining and precludes any large scale mining because of the fault-bound areas. Surface mining is not justifiable because of the deep overburden and excessively high strip ratios (bank cubic meters of overburden to tonne of coal recovered is about 19 to 1).

17. Because of the large labor market and low labor rates, labor intensive methods of mining are considered more favorable for this deposit than a highly mechanized large scale mine.

18. The basic concept of the Dravo underground mine plan using semi-mechanized longwall mining and room and pillar mining in odd-shaped areas is a practical approach to mining these coal seams. There are some differences of opinion between Dravo and Bechtel on how the mining should be conducted. Major differences are confined to the number of main, sub-main, and panel entries, and the use of pneumatic picks instead of drilling and blasting of the coal to break it away from the solid face. Increase in the number of entries provides two intake and two exhaust entries which assures better ventilation throughout the mine. The pneumatic picks are considered a better choice than drilling and blasting because with blasting there is the potential of roof caves due to the weak roof conditions, constant delays for clearing the explosive fumes, safety hazards, and the destruction of equipment in the longwall panels.

19. The concept of using a rail system to transport the coal from within the mine is reasonable because of steep inclines expected to be encountered in the mine. As an alternate, conveyor belts should be investigated during the detail mine layout.

20. The ventilataion capacity selected by Dravo appears to meet the requirement for the early years of the mine. The actual size of the fan are dependent upon a number of factors and these will be determined in the detail mine planning.

21. The ground water conditions at Uatsi were not determined. Dravo provided pumps to dewater the mine, but the capacity requirements of these pumps are unknown until the ground water information is developed.

22. Spontaneous combustion is a concern in underground coal mining especially with the lower classification of coal such as occurs at Uatsi. Some preventive measures can be taken to decrease or eliminate this hazard.

23. The incoming primary electric power, 34.5 kV, is transformed to 2300/440/120 volts for surface use and 7200 volts for underground. Power centers in the mine reduce this voltage to 480 or 550 volts.

24. The surface facilities should be kept simple because this is a small operation and large expenditures are not justifiable. Picking tables are used to pick out non-coal materials before the run-of-mine coal is crushed in lieu of a coal washing plan. The warehouse and maintenance facilities should be small since most of the repairs will be made underground. Any major repairs would use the power plant facilities or other outside facilities. The miner's wash house should be adequate to allow the miners to change clothing and bathe before being transported by bus to their home.

25. The infrastructure will include the upgrading of 5 km of road between Bri Bri and the mine site, housing for a few key personnel, a potable water supply, and sewage treatment. The incoming 34.5 kV power line is planned to be extended by ICE to the Uatsi area, according to Bechtel's understanding.

26. Based on a reserve of 12.0 million tonnes and a 60 percent recovery factor, the mine capacity design is 240,000 tonnes per year of run-of-mine coal for 30 years.

27. The order of magnitude capital expenditure for a mine capable of sustaining a production rate of 240,000 tonnes per year is estimated by Bechtel at $10.8 million, including equipment, facilities, infrastructure, spare parts, working capital and interest during construction.

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28. The order of magnitude operating costs by Bechtel are estimated at $3.9 million per year or approximately $16 per tonne of coal. These costs include labor, materials and supplies, and fuel and power.

29. Costs were not assembled in previous studies that determined the overall cost of producing a tonne of coal for comparative purposes. Bechtel made an order of magnitude estimate of this overall cost in order to recommend whether the project should be continued or aborted. Bechtel received a cost estimate of $34 per tonne of coal delivered to Limon from Exxon Coal USA, Inc., owners with Carbocol of the Cerrajon coal mine in Columbia. This coal has a calorific value of 11,000 Btu/lb. The cost on a calorific basis is $1.40 per million Btu. The cost per tonne of the Uatsi coal as determined by Bechtel is approximately $26.50, and with a calorific value of 8000 Btu/lb, the cost on a calorific basis is $1.50 per million Btu. This is an order of magnitude cost estimate which has a range of minus 10 percent and plus 40 percent.

2.2 Recommendations

1. Based on the order of magnitude cost of $26.50 to produce a tonne of coal, it is recommended that the study of Uatsi coal field be continued.

2. The study should be performed by a qualified engineering firm that has experience in geology, all facets of coal exploration and sampling for coal analyses, mining engineering for small scale, multiple seam underground coal mines, and mining economics.

3. The geology of the deposit should be thoroughly reviewed to determine whether the three areas selected for mining are bona fide.

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4. Development exploration may be accomplished in two phases, such as, drilling on 250 meter centers during the first phase, and a second phase of fill-in drilling in areas that require better definition.

5. All of the holes should be geophysically logged for natural gamma, gamma gamma (density), resistivity, and a caliper measurement.

6. The depth of the drill holes should penetrate the V-1 Seam or the lower member of the Gatun Formation in order to get the full value from a drill hole.

7. The ratio of rotary drill holes to core drill holes should be approximately one to one.

8. Core recovery of the coal sample must be at least 90 percent.

9. Coal testing should include at least the following analyses: proximate, ultimate, sulfur forms, calorific value, mineral analysis of ash, fusion temperatures - oxidizing and reducing atmosphere, Hardgrove grindability index.

10. If the coal analyses are to be performed in Costa Rica, the technicians would benefit from additional training.

11. A thorough ground water study is required and it is recommended that this study follow the plans described on pages 3-10 through 3-12.

12. A rock mechanics investigation is recommended and it should be performed as indicated on pages 3-12 through 3-15.

13. All coal seams that have any potential of being recovered should be mapped. These maps should include the coal isopach, the structure contour, the overburden and interburden isopach, and

quality isopleths of ash, calorific value, sulfur or other characteristics.

14. The mining engineer should layout a mine plan covering all mineable coal seams in order that maximum recovery of the reserves are attained.

15. The mine capacity should be increased above the 240,000 tonnes per year in accordance with the additional proven reserves.

16. The capital expenditure and operating costs of plus or minus 10 percent should be determined for the new mine plan.

17. More information should be secured from the proper authority in order to develop the total cost of producing coal. This should include such items as debt service, land ownership, coal royalties, taxes, profit, etc.

18. Based on Bechtel's very limited and preliminary assessment of the Zent coal deposit, a limited level of effort should be made by the RECOPE geologists to determine the amount of near surface reserves that can be readily mined by shallow open pits. These reserves are basic in determining whether to pursue or abandon this deposit for further consideration. This fuel may be a good candidate for fluidized bed combustion technology.

IV

3.0 COAL RESERVES

Coal reserve information for the Uatsi coal deposit and the Zent coal deposit were reviewed. More attention was given to the Uatsi coal because this deposit is better developed and appears to be a better potential coal source.

3.1 Uatsi Coal Reserves

Based on preliminary drilling and outcrop exploration, this deposit is represented by at least 10 coal seams. These seams are identified as V-1 Seam through V-9 Seam, inclusively and the New V-9 Seam in ascending order. The deposit has been deformed by anticlines, synclines and faults. Fault displacements, ranging from several meters to a few hundred meters, have divided the coal deposit into fault-bounded areas. Three areas have been delineated by these faults as potential mining areas and have been named the West, East, and North areas.

In previous studies the New V-9 Seam and the V-1 Seam were considered mineable in the West Area, the V-9 Seam in the North Area, and the V-7 Seam in the East Area. Based on drill hole information and geologic sections, there appear to be other seams in these areas that are prospects for potential mining. This, of course, will require development drilling to determine the structure and to assure the correlation of the coal seams.

Bechtel's coal reserves study includes the three areas and four seams indicated above. The study incorporated the new drilling information received on November 11, 1986. Coordinates and elevations of the new drill holes were not provided; however, these drill holes were plotted on a topographic map received with the new information. Seam correlation of the new drill holes was checked against the structure contour projections provided by RECOPE in the information package received in April 1986. Coal seam isopachs of the four seams were developed using the new drill information. These isopachs are included in Appendix A.

The results of the coal reserve study are summarized in Table 1 below.

Table 1. Uatsi Coal Reserve Summary

Area	Seam	Average Seam Thickness (m)	Measured Tonnes	Indicated Tonnes	Inferred Tonnes	Total Tonnes
West	New V-9	1.15	1,190,270	719,740	719,330	2,629,340
West	V-1	0.89	287,060	797,420	557,830	1,642,310
North	V-9	1.45	401,000	1,096,620	490,470	1,988,090
East	V-7	1.08	633,020	1,979,400	3,087,690	5,700,110
Total			2,511,350	4,593,180	4,855,320	11,959,850

3.1.1 Reserve Criteria

Criteria for determining the reserves was as follows:

Specific gravity of coal	1.5 g/cm^3
Minimum coal thickness	0.6 metres
Distance from drill hole	
Measured reserves	0 to 125 metres
Indicated reserves	125 to 250 metres
Inferred reserves	250 to 500 metres
Distance from outcrop measurement	
Measured reserves	Not applicable
Indicated reserves	0 to 125 metres
Inferred reserves	125 to 250 metres

3.1.1.1 Specific Gravity

Coal ranking for this deposit ranges between lignite and subbituminous A with subbituminous C being the median rank based on samples tested. Specific gravity tests were performed for the Japan International Cooperation Agency (JICA) on 17 air dried coal samples which averaged 1.575 g/cm^3.

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Eight samples taken of the main seams in the Carbon Volio area averaged 1.601. Coal with its full amount of bed moisture would have a lower specific gravity than air dried coal, but because there is lack of additional information to confirm the JICA results, the 1.5 specific gravity used in this evaluation appears reasonable. Only two specific gravity tests were performed in Costa Rica. Both tests were performed on high quality coal which is not representative of the deposit.

3.1.1.2 Minimum Coal Thickness

A coal thickness cut-off of 0.6 metres was used in determining the coal reserve. This is the lowest height that a coal miner can work without placing too much strain on his body. The reserves at this thickness are minimal.

3.1.1.3 Measured, Indicated and Inferred Reserves

Based on the limited number of drill holes that have penetrated some of the coal seams and the variations in coal seam thicknesses where there is adequate drilling, Bechtel established the following criteria for reserve classification: coal reserves within a distance of 125 meters from a drill hole were classified as measured; between 125 and 250 meters as indicated reserves and between 250 and 500 meters as inferred reserves. A more conservative approach was taken for those reserves identified from outcrop measurements, since these are generally less reliable than drill data.

3.1.2 Coal Analyses

Coal analyses were performed at three locations; namely, Japan, Costa Rica, and the United States.

3.1.2.1 Japan Coal Analyses

The samples used for the JICA report are channel samples of the outcrops. Analyses provided by JICA include: Proximate, Ultimate, Calorific Value, total Sulfur, Non-Combustible Sulfur, Specific Gravity, Mineral Analysis of Ash, Ash Fusion Temperature (does not include initial deformation temperature and does not designate if temperatures are taken in oxidizing or reducing atmosphere), Free Swelling Index, Hardgrove Grindability Index, Maceral Analysis, Washability Test.

The proximate, total sulfur, calorific values, and specific gravity were performed on an air dried moisture basis. Because of the low moisture content of the samples, all samples indicate that their rank is either a high grade subbituminous B or a low grade subbituminous A. This ranking is believed to be too high as is indicated by the tests performed in Costa Rica and the United States. Despite the air dried basis for the JICA tests, the consistency of the analyses is excellent. Other analyses determined for JICA, which involves moisture content, were done on a dried coal basis and appear to have good consistency. The sulfur content in the ultimate analysis consists of combustible sulfur only; whereas the ASTM ultimate includes total sulfur.

3.1.2.2 Costa Rica Coal Analyses

Bechtel's review of the available data shows that determination of moisture, volatile matter and calorific value are not consistent. The reason for these inconsistencies are not known. Perhaps, they may have been caused in transferring data from one document to another or maybe due to errors in the

performance of the test. The moisture content of coal for tests performed in Costa Rica range between 14.8 and 30.10 percent. One non-coal sample had a 12.2 percent moisture, which is consistent with its high ash content of 57.2 percent. Following is an example comparing two analyses to demonstrate the error detected in the Costa Rican analyses with a low moisture content:

Seam	V-9	V-9
Hole #/Sample #	PCV-11/L22070585	T011612
Where Performed	Costa Rica	Japan
% Moisture	15.2	15.1
% Ash	9.9	9.9
% Volatile Matter	41.5	40.7
% Fixed Carbon	33.4	34.3
% Sulfur	2.06	1.20
Calorific Value Kcal/kg	4143	5200

The test performed in Japan is on an air dried basis, it has about the same moisture and ash content as the Costa Rican analysis, but it has a much higher calorific value. Based on other analysis of this deposit, the moisture content should be higher than the 15.2 percent reported by about 10 percent or more in order to have a calorific value of 4143 Kcal/kg.

Another example to demonstrate some of the inconsistency in the Costa Rican laboratory analyses is of three samples taken from the same seam, and in the same drill hole as shown below:

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Seam	New V-9	New V-9	New V-9
Hole #/Sample #	PCV-7/ L19070585	PCV-7/ L16290485	PCV-7/ L12290485
Sampling Interval	20.7 m to 21.0 m	21.0 m 21.92 m	22.0 m to 22.4 m
% Moisture	14.8	24.5	25.6
% Ash	6.3	19.3	9.7
% Volatile Matter	38.1	34.5	42.10
% Fixed Carbon	40.8	21.8	22.6
% Sulfur	0.81	0.40	0.6
Calorific Value Kcal/kg	4940	5161	4765

Samples L19070585 and L12290485 are ranked as subbituminous B and Sample L16290485 as subbituminous A. This occurrence is very unlikely. If the calorific value of Sample L16290485 had been reported as 4161 instead of 5161 Kcal/kg, then all three samples would be ranked as subbituminous B and within a range of 65 Kcal/kg on a moist, mineral-matter free basis. In comparing the moisture content of Samples L19070585 and L12290485 with their respective calorific values it appears that the moisture content in Sample L19070585 is low and that a value of 24.8 or higher instead or 14.8 percent is more in line for this sample.

Two other samples analyzed in Costa Rica have questionably low value volatile matter contents. These samples are as follows:

Seam	U-6		New V-9	
Hole #/Sample #	PCU-3/L10220485		PCV-12/L04180285	
	AR*	DM-MF*	AR	DM-MF
% Moisture	30.1		27.9	
% Ash	11.0		7.5	
% Volatile Matter	10.1	6.04	11.9	17.54
% Fixed Carbon	43.8	93.96	52.6	82.46
% Sulfur	2.24		0.28	
Calorific Value Kcal/kg	4067		5962	

*AR - as received, DM-MF - dried, mineral-matter free.

Sample L10220485 ranks as anthracite and Sample L04180285 as low-volatile bituminous coal according to the Parr classification of coal. Although there has been folding and faulting in this deposit, which has a tendency to de-volatilize the coal, the high moisture content and the corresponding calorific values of each sample make the low volatile matter content suspect.

3.1.2.3 United States Coal Analyses

In comparing the "as received" moisture content for five of the seven samples tested and their respective equilibrium moistures, it appears that the samples have an excessive amount of moisture. Because of the high moisture content, most of these samples are classified as lignite. On an equilibrium moisture basis, the samples would fall within the subbituminous C classification. The following example illustrates the difference between the analyses using the two different moisture bases:

Basis	As Received	Equilibrium Moisture
Seam	U-6	U-6
Hole #/Sample #	PCU-1/W226187	PCU-1/W226187
% Moisture	40.03	23.58
% Ash	22.47	28.63
% Volatile Matter	21.14	26.93
% Fixed Carbon	16.36	20.85
% Sulfur	2.47	3.92
Moist, Mineral-Matter Free Btu/lb	6049	8515
Classification	Lignite	Subbituminous C

3.1.3 Assessment of Coal Quality

It is difficult to characterize the quality of the Uatsi coal deposit based on the number of drill holes and samples available. The assessment is further complicated because of the air dried basis analyses performed in Japan, the inconsistencies of the analyses performed in Costa Rica, and the suspected high moisture of the samples tested in the United States. For the coal quality assessment, Bechtel has selected analyses that may be typical for each of the seams considered in the mineable reserves of Table 1. Analyses from the JICA report as well as those performed in Costa Rica and the United States were used in the assessment. Analyses of individual samples that may represent each of the coal seams considered as the mineable reserves were selected rather than using the average analyses. The results of the preliminary coal quality assessment is tabulated in Table 2.

3.1.3.1 Proximate Analysis

The New V-9 Seam and the V-9 Seam appear to be of good quality with a calorific value of about 4500

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Kcal/kg on an as received basis and a sulfur content considerably lower than the other seams considered. The V-1 Seam also appears to have a good calorific value but it may have the highest sulfur content. The V-7 Seam tested as the lowest quality because of its higher ash content which is due to a parting within the seam. It's sulfur content is lower than that found in the V-1 Seam but this may be caused by the dilution of non-coal material. Table 2 also indicates the estimated proximate low and high values based on the review of other sample analyses.

3.1.3.2 Ultimate Analysis

The ultimate analysis selected for the assessment are of the same sample used for the proximate analysis assessment. The carbon and hydrogen content of these samples are within reason for a subbituminous C coal.

3.1.3.3 Mineral Analysis of Ash

The JICA report is the only source of this analysis. Of interest in these analyses is that the V-1 and the V-7 ash samples are of the bituminous type ash and the V-9 ash is a lignitic type ash. Other tests performed by the Japanese indicate that the V-5 ash is a bituminous type and that the U-3 and U-6 are a lignitic type ash. Based on these analyses, both types of ash are expected to have low to medium slagging and low fouling.

3.1.3.4 Ash Fusion Temperature

The ash fusion temperatures performed in Japan correspond with the ash samples used for the mineral analyses. The ash fusion temperatures are higher for the bituminous type ash than they are for the

TABLE 2 - PRELIMINARY COAL QUALITY ASSESSMENT SUMMARY

PROXIMATE ANALYSIS

Area	Seam	Hole # Seam Range	Moist (%)	Ash (%)	V.M. (%)	FC (%)	S (%)	Cal V (Kcal/kg)	Performed In
West	New V-9	PCV-16	26.87	9.77	27.55	35.81	0.58	4464	Costa Rica
		Est. Low*	24.0	6.0	34.0	20.0	0.4	4000	
		Est. High	30.0	20.0	42.0	30.0	1.0	5000	
West	V-1	L-8	25.0	7.83	36.87	30.3	3.21	4755	Costa Rica
		Est. Low	23.0	8.0	25.0	20.0	2.7	3500	
		Est. High	30.0	30 0	40.0	30.0	4.0	5000	
North	V-9	L-5	26.67	8.14	36.03	29.16	0.89	4597	Costa Rica
		Est. Low	23.00	7.0	25.00	20.0	0.7	4000	
		Est. High	30.00	15.0	40.00	30.0	2.1	5000	
East	V-7	PCV-1	26.00	21.50	28.90	23.60	1.48	3672	USA
		Est. Low	23.00	20.00	25.00	20.0	--	--	
		Est. High	30.00	--	40.00	30.0	3.0	4000	
Average Proximate			26.09	11.81	32.33	29.71	1.54	4373	Costa Rica
Low Range			23.0	6.0	25.0	20.0	0.4	3500	and USA
High Range			30.0	21.5	42.0	30.0	4.0	5000	

ULTIMATE ANALYSIS

Area	Seam	Hole #	C %	H_w %	N_w %	S %	O_w %	Ash%	Performed In
West	New V-9	PCV-16	62.52	4.75	0.92	1.08	17.37	13.35	Costa Rica
West	V-1	L-8	64.45	4.87	1.43	4.28	14.53	10.44	Costa Rica
North	V-9	L-5	64.99	5.25	1.16	1.21	16.29	11.10	Costa Rica
East	V-7	PCV-1	51.29	4.41	0.95	2.00	12.30	29.05	USA
Average Ultimate			60.91	4.82	1.12	2.14	15.12	15.99	

MINERAL ANALYSIS OF ASH

Composition of Ash (%)	V-1 T011915	V-7 M012708	V-9 T011604	New V-9
SiO_2	35.24	37.09	25.37	
Al_2O_3	30.83	26.21	22.25	None
Fe_2O_3	28.94	15.42	11.17	Available
CaO	1.46	8.10	17.19	
MgO	0.44	1.43	2.88	
Na_2O	0.27	0.15	0.23	
K_2O	0.25	0.13	0.27	
SO_3	1.04	10.01	18.75	
TiO_2	1.23	1.13	1.35	
P_2O_5	0.22	0.19	0.12	
MnO	0.03	0.07	0.20	
Performed in	Japan	Japan	Japan	

ASH FUSION TEMPERATURE

	V-1 T011915 °C	V-7 M012708 °C	V-9 T011604 °C	V-7 PCV-1 °C
Initial Deformation	1420	1310	1230	1298
Softening Temperature	1450	1340	1260	1343
Fluid Temperature	1480	1370	1290	1354
Performed in	Japan	Japan	Japan	USA

HARDGROVE GRINDABILITY INDEX

Seam	Hole #	Index	Performed In
V-9	L-5	41.4	Costa Rica
V-1	L-8	40.4	Costa Rica
V-7	PCV-1	46.0	USA

*Estimated low and high ranges are based on all sources.

lignitic type ash. The ash fusion temperature performed in the US for the V-7 Seam ash sample compares favorably with the Japanese results for the ash of this coal seam, but it is not known whether these tests were done in an oxidizing or reducing atmosphere. Fusion temperature done in a reducing atmosphere are lower than those in an oxidizing atmosphere.

3.1.3.5 Hardgrove Grindability Index

There are not sufficient samples to make a judgment on the grindability index, but a subbituminous C coal generally has an index between a mid 40 to a mid 50.

3.1.4 Ground Water

The presence of ground water is an important factor to be considered in developing an effective mine plan. For example, the stability of slopes are significantly affected by ground water, and inflows to underground mine workings must be controlled so that the workings are not flooded. Water in more permeable formations may be confined under considerable pressure by relatively impermeable materials, such as shales or coal horizons. Encountering such confined ground water could endanger underground mining, if it is not anticipated and controlled before advancing into such areas. To assess the impact of ground water on a mine plan and to determine the extent of ground water control needed, requires information on its occurrence, a definition of aquifer characteristics, and establishment of a ground water monitoring program to measure water levels (pore pressures) and hydraulic gradients. The data required for evaluation of conditions can be developed in a phased manner, so that information gathered in each phase is used in guiding further investigation. A three-phase program is proposed; a preliminary study to evaluate available data and a reconnaissance field effort, a feasibility phase to

provide limited direct measurement of in-situ conditions, and, if the first two phases are favorable, a program for mine design. Scope of the first two phases, to the point of providing a feasibility assessment, is described:

3.1.4.1 Preliminary Study

The initial phase of investigation should begin with a collection and review of available data. This includes previous geologic mapping and subsurface exploration, and reported information for existing water wells and springs of the area. A field reconnaissance should be conducted of the project area to locate and measure any springs and wells not previously identified. These data will provide an understanding of the stratigraphy and structure of the area, with which to identify the probable aquifers, confining beds, and potential ground water barriers, such as faults. Samples for water quality analysis can be collected, and on-site measurement of pH, dissolved oxygen, and other basic parameters will provide data on corrosive waters present. Critical areas can be selected for initial ground water exploration and testing.

3.1.4.2 Feasibility Study

In the initial phase of investigation, a number of small diameter exploratory holes should be selected for permeability testing and for completion as observation wells. These holes can be selected in coordination with other exploration needs, combining efforts to collect geological and geotechnical data as well as sampling for coal. The number of holes and depth of testing will depend on the extent of mining considered, and the complexity of potential aquifers, and structural discontinuities (barriers).

For a first approximation, six holes, average depth of 150 metres, (or to the depth of planned exploration), should be planned for permeability testing. Probable testing methods would be constant-head and falling-head injection type tests, utilizing double pneumatic packers, with a maximum test interval of 10 metres. After permeability testing, each of these holes would be completed as observation wells, selecting an interval, or intervals (aquifer, or permeable sand zone) to be monitored, based on the testing and other exploration completed. Two monitoring wells, each open to different intervals may be constructed in an exploratory hole, provided it is at least six inches diameter to the depth of the uppermost monitored interval.

The observation well pairs will provide a measure of potential hydraulic gradients between intervals, the hydrostatic pore pressure, and, with the permeability testing, the potential inflows of water that may be encountered. Preliminary evaluation of the extent and methods for ground water control (i.e.; dewatering systems) and areas needing detailed investigation for the mine design phase may be prepared from these data collected in the feasibility phase.

3.1.5 Rock Mechanics

The main rock mechanics investigations in underground mining are related to:

1. Design of pillars or stopes

2. Layout of pillar and/or stopes in the orebody, taking into account their location and orientation relative to the geological structure and in-situ stress state; and

3. Mine stability.

The implementation of a rock mechanics investigation requires

1. Site characterization
2. Design analysis and
3. Rock performance monitoring.

3.1.5.1 Site Characterization

The main geological features of coal deposits are the shape, dip, thickness, and structural irregularities such as folds, overthrusts and faults on a macro scale, and fissures and cracks on a micro scale. These features will affect coal mineability and strata stability.

The exploration will give information on bedding planes, folds, faults and shear zones, as well as minor geological details such as fissures.

3.1.5.2 Drilling and Core-Logging

The aim of drilling is to obtain a continuous sample of the rock mass in as nearly undisturbed a form as possible. Weak materials such as weathered rock, fault gouge, clay seams must be recovered in <u>undisturbed</u> form.

The location of ground water table and artesian conditions, if any, are to be noted.

Undisturbed samples are best obtained by using a double tube core barrel, and in special cases a triple tube core barrel may be used.

The core diameter must be at least 50 mm diameter. However, since the rocks and coal seem to be very weak, it would be preferable to take 80 mm diameter core samples. Color photographs of the cores should be taken. The logging must include information on the rock types encountered with information on point load index, discontinuities (joint, bedding plane, drilling break), presence and nature of infilling materials. Values of RQD must also be included.

3.1.5.3 Preserving Core Samples

The core samples selected for testing in the laboratory must be preserved at their natural moisture content. Special care must be exercised in protecting the samples from environmental changes until ready for testing. Undisturbed samples of coal must also be made available and should not be allowed to dry during transportation to the testing laboratory and storage.

3.1.5.4 Rock and Coal Property Evaluation

Unconfined and triaxial compression tests must be performed on undisturbed samples of roof and floor rocks. Triaxial compression tests at low confining pressures are needed to estimate the shear strength parameters of the roof and floor rocks to simulate low confinements at pillar-roof and pillar-floor boundaries. Tensile strength tests (direct or indirect) must also be conducted.

Direct shear tests on shaley material must be performed to estimate the peak and residual shear strength parameters.

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Volume change tests must be performed on roof and floor materials as they are allowed to come into contact with water and release of confining pressure. The results of these tests will be helpful to assess potential roof sag and floor heave in the coal mine.

Index values tests such as slake durability index tests, permeability tests on roof and floor rocks must also be conducted.

3.1.5.5 Strength of Coal

Coal, like most of the rocks decreases in strength with increases in size of specimen. However, for preliminary exploration, it is not possible to obtain samples of coal of different sizes. Empirical relationships based on past tests on coal samples performed elsewhere may have to be used for preliminary estimates of pillar strength.

Unconfined compressions tests on coal samples of 80 mm dia. must be conducted. Brazilian tensile strength tests may be required to determine the tensile strength.

3.1.5.6 Information on Coal Strength

Published information on unconfined compressive strength of coal indicates that:

1. It is highly variable depending upon its chemical makeup and presence or absence of fissures and other planes of weakness.

2. Determined strength values are functions of volume and shape of the specimen.

For West Virginia coal, the reported value of unconfined compressive strength is 2,500 psi. For coal in the United Kingdom, the value varies between 3,000 psi and 10,000 psi. In-situ tests on South African coal specimens measuring up to 5 ft cube showed that the strength decreased from 1,500 psi for a 5 inch cube to 650 psi for a 5 ft. cube.

A rough classification of the strength of coal depending upon hardness is given below:

Very hard coal	-	3000 psi to 6000 psi
Hard coal	-	2250 psi to 3750 psi
Soft coal	-	450 psi to 1500 psi
Very soft coal	-	450 psi to 0 psi

For preliminary calculations, a strength value of 1,000 psi is recommended, assuming the coal is soft. However, it is necessary to perform strength tests on samples of coal recovered from the site to arrive at a rational value of in-situ strength.

3.1.5.7 The various tests for rocks mentioned in the rock mechanics section are described under the following ASTM numbers and the suggested test methods:

Test	ASTM
Unconfined Compressive Strength	D2938
Triaxial Compression Strength (undrained test)	D2664
Elastic Constants	D3148
Brazilian Tensile Strength	D3967
Direct Tensile Strength	D2936
Permeability of Rocks	D4525
Moisture Content	D2216

	Suggested Method
Direct Shear Test, p. 135 Slake Durability Test, p. 81 Determining Swell Characteristics, p. 81	Rock Characterization Testing and Monitoring, International Society for Rock Mechanics Pergamon Press, 1981

3.1.6 Overview of the Uatsi Coal Reserves

As noted in Table 1, Uatsi Coal Reserve Summary, approximately 20 percent of the reserves fall into the measured category and the remaining reserves are nearly equally divided between indicated and inferred reserves. Most of the measured reserves (47 percent) are located in the New V-9 Seam of the West area. Approximately 45 percent of the New V-9 Seam are measured. Measured reserves in the other seams range between 10 and 20 percent of the totals. There is a need for considerable fill-in drilling of all seams to remove some of the risks associated with mining. Because of the tectonics that occurred in this area, there is a need for a better definition of the structure before the mining is started. A drill hole pattern on 250 metre centers with an extra hole in the center of the square area formed by four drill holes is suggested. These holes should be extended to the lower member of the Gatun Formation, where practical, in order to penetrate all of the mineable seams. In the review of the map showing the general correlation of drill holes prepared by RECOPE, there is an indication that more than one or two seams in an area have the potential to be mined. In the West area only the New V-9 Seam and the V-1 Seam were considered in the mineable reserves; however, the V-9 Seam may have potential as well as some of the lower seams. There is more than one potential mineable seam in the North and East areas; possibly as many as five. More structural information is required to correlate all of these seams. There is reason to believe that

the reserves are greater than the 12 million tonnes as shown in Table 1.

The characterization of the coal field quality is at best sketchy. Much more data on coal quality is required before this can be considered as a fuel source for a power generating plant, a cement plant, or other industrial uses. The laboratory work must be reliable with sample splits checked by an independent laboratory. Because a large percentage of the analyses performed to date is questionable, it is suggested that a sound program be planned to include sufficient samples and to perform all tests required for boiler design.

The additional drilling completed by RECOPE has defined more mineable reserves for the V-7 Seam in the East area. Bechtel has not included the reserves on the eastern end of this area because of the uncertainty of the correlation of the six PCU designated drill holes. In the West area, the additional drilling in the New V-9 Seam indicated that the seam thickness was not as great as previously projected and the amount of mineable reserves are not as large as predicted. The new drilling did not penetrate the V-1 Seam in the West area and the mineable reserves for the seam remain about the same as previous estimates. Additional drilling in the North area did confirm previous estimates of the V-9 Seam reserve. A comparison of Bechtel's results with previous estimates follows:

		Bechtel		Others	
Area	Seam	Average Seam Thickness (m)	Mineable Reserves Tonnes x 10^3	Average Seam Thickness (m)	Mineable Reserves Tonnes x 10^3
West	V-1	0.89	1,642	1.02	1,645
West	New V-9	1.15	2,629	1.52	3,248
East	V-7	1.08	5,700	1.03	1,426
North	V-9	1.45	1,988	1.51	2,003
Total			11,959		8,322

3.2 Zent Coal Reserves

Drill hole information, an area geological map, and the Corina sub-area geological map was included with the information received on November 11, 1986. The review of this area is not included in Bechtel's scope of work; however, a cursory review was made of the drill hole and outcrop sections. As indicated in this information, the coal is of low grade and mostly carbonaceous shale. In some areas this coal is located near the surface and has a thickness of one to two meters. Although this coal may have a very high ash content, its calorific value may be sufficient to burn in a circulating fluidized bed combustor. This could be an inexpensive source of fuel if the areal extent of the near surface coal is sufficient to fuel a power generating plant and if the fuel can be burned in a fluidized bed combustor. More geologic work is required to allow use of the existing data for preparation of the coal seam correlation, structure maps, coal isopachs and overburden isopachs. It would also be important to have proximate analyses of this coal.

4.0 MINE PLAN

After reviewing the JICA report, Dravo's mining feasibility report and the geologic information prepared by RECOPE, it is Bechtel's opinion that the development of the Uatsi coal deposit lends itself to small scale underground mining. The area is deformed by faults, anticlines and synclines which makes it unsuitable for large scale underground mining.

The major portion of the reserve is under thick overburden and it is, therefore, not amenable to open pit mining. This was demonstrated in the Dravo report where an open pit mine plan in the New V-9 Seam recovered only 741,000 tonnes from an in-situ reserve of 3.25 million tonnes of coal greater than 0.8 metre in thickness. the average stripping ratio of overburden to coal was 19.9 bank m^3/tonne, which is excessively high. To recover the remaining reserves of this seam, underground mining methods were to be employed. Capital expenditure for equipment, facilities and infrastructure for the open pit mine was estimated by Dravo at about $5.0 million. In addition, contract mining services in the amount of $1.45 million was required to augment the stripping operation because the selected equipment was unable to handle all of the overburden. In only one year out of ten did the planned open pit mine meet the annual production demand of 150,000 tonnes. Based on these findings, it is concluded that open pit mining at Uatsi is not justifiable.

It is also Bechtel's opinion that the small scale underground mining operations should be labor intensive because of the large labor market and the low labor costs indicated in the Dravo report. Base pay for operating labor is reported at 25,000 colones per month and 35,000 colones per month for supervisory personnel based on a 48 hour week. In addition, employees receive 60 percent of their base pay in social benefits. The exchange rate was 53.15 colones equals US $1.

Comments in this section are limited to Dravo's underground mine plan.

4.1 Underground Mine Plan

Dravo's underground mine plan consists of mining the remaining reserves in the New V-9 Seam of the West Area, the V-1 Seam in the West Area, the V-9 Seam in the North Area, and the V-7 Seam in the East Area. As reported in Section 3.0 Coal Reserves of this report, the geologic sections prepared by RECOPE indicate that seams other than the ones mentioned above in each of the three areas have mining potential. Development drilling and geologic interpretations of the data are required to determine the coal seam structure, areal extent and quality. Based on the RECOPE geologic sections, the interval between seams, in most cases, is adequate to permit multiple seam mining in each of the three areas. A proper mine design for the maximum recovery of the reserves can be accomplished with additional geologic data.

The conceptual mine plan prepared by Dravo is for the purpose of developing capital expenditure and operating cost estimates as well as a mine production schedule. Bechtel agrees with Dravo's overall concept; that is, the use of semi-mechanized longwall mining and room and pillar mining. However, there are some differences on how the mining should be conducted.

4.1.1 Main and Sub-main Entries

Dravo's opening to the mine includes three main entries, 3.5 metres wide, on 60 metre centers, and with cross-cuts on 60 metre centers. The main entry is driven on the strike of the coal seam. The sub-mains have the same configuration as the main entries and they are driven in the direction of the dip on the left and right side of the main entries.

Based on a very preliminary assessment of the roof conditions, it appears that the roof materials may be weak and may require a narrower span than 3.5 metres to eliminate some of the failures that may occur. A cross-sectional opening in the shape of a trapazoid with the top 0.5 metres

narrower than the base may provide added support. Because of the narrow entries, the main and sub-main entries should consist of five entries each, driven on 20 metre centers instead of 60 metres. Two mains will be for the intake air and two mains for the return air. The center main will be for haulage and it will be on a neutral air split. The cross-cuts should be driven on 30 to 35 metre centers instead of 60 metres in order to decrease the distance between the working face and the mine-car loading point. With narrow-timbered entries, a shuttle car proposed by Dravo to transport coal from the face may not be maneuverable. A small diesel front end loader or ram-car would be a better choice for this activity.

4.1.2 Longwall Panel Entries

Dravo proposed a single entry longwall system which is difficult to support and maintain. The gate road, which is 5 metres wide, is maintained by a solid wall of timber 0.67 metres wide and a masonry wall 0.67 metres wide butted against the timer wall. The alternative recommended method is the two entry panel system. In this system two entries, 3 metres wide, are driven on 20 metre centers over the full length of the panel. One entry serves as the intake air entry and the access road for bringing supplies to the longwall panel. The second entry serves as the return air entry and the coal transport entry.

4.1.3 Coal Mining

Dravo proposes to drill and blast the coal from the face of the development entries as well as the longwall face. In the development entry, blasting may worsen the condition of the roof which is indicated to consist of weak materials. At the longwall face the blasting may destroy the chain conveyor and the hydraulic props. Blasting always presents a safety hazard and it requires certified personnel to handle

explosives. Because of the low labor rates and a large labor market, mining coal with pneumatic picks could eliminate some of the safety hazards associated with underground mining. It also has the benefit of selective mining; that is, partings in the coal can be thrown in the gob area of the longwall panel, and in the entry development, it can be transported from the mine in separate mine cars.

In the Dravo plan, it is believed that only one longwall panel is worked at a time. Upon completion of a panel the equipment is moved to the next panel. since the major coal production will be from a longwall panel, at least two panels should be in operation in case one runs into a problem which may take an extended period of time to correct.

4.1.4 Coal Transport System

The Dravo transport plan utilizes a rail system to transport coal out of the mine. A battery locomotive in the main entry moves the mine cars in and out of the mine. In the sub-mains, rope haulage is used with a drum hoist pulling-up or lowering the mine cars on the inclined road. It is assumed that a battery locomotive is used to move the mine cars in the longwall panel roadway.

As an alternate to rail haulage, belt conveyors or a combination of belt conveyors and rope haulage should be investigated during the detail mine layout.

In the final mine design, consideration should be given to sloping up or down to a coal seam from within the mine rather than opening new portals for isolated coal pockets of mineable thickness.

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4.1.5 Ventilation

The Jeffery 8HU72 main fan and the use of the IR 50HP 10,000 cfm face fans appear to be adequate for the early years of the mine. As the mine progresses, more ventilation capacity may be required. The mine exhaust fan must generate 340 cubic metres/min at the last open cross cut to meet the U.S. Department of Interior's Mine Safety and Health Administration minimum requirement. This standard is recommended for this project. The actual size of the fan is dependent upon the number of working places, entry openings, leakage and other factors that will be determined in the detail mine planning. The ventilation system should include a diesel power plant which automatically takes over during power outages.

4.1.6 Mine Drainage

Dravo has provided capital for pumps to dewater the mine. Until some information on the groundwater situation is developed, it is not possible to comment on the adequacy of this estimate or the treatment of the mine water before it is discharged into a natural drainage.

4.1.7 Spontaneous Combustion

Spontaneous combustion is a concern in underground coal mines. The greater oxidation that occurs with the younger coals, such as the Uatsi deposit, presents a greater threat to spontaneous combustion. Some preventive measures can be taken to eliminate this hazard; such as, provide good ventilation to all parts of the mine, seal-off the depleted longwall panels, minimize the exposure time of those small areas worked by room and pillar as shown in Dravo's mine plan, construct all stopping with proper materials and techniques, and patrol workings to detect any rise in temperature of the atmosphere. Leakage of air and water

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through faults may be another source of spontaneous combustion.

4.1.8 Electrical System

The incoming primary electric power, 34.5 kV, is transformed to 2300/440/120 volts for surface use (voltage maybe different in Costa Rica than in U.S.) and 7200 volts for underground. Power centers in the mine reduce this voltage to 480 or 550 volts.

4.1.9 Surface Facilities

As the coal is delivered to the surface from the mine, it will be spread over picking tables where laborers will remove non-coal materials. The coal is then crushed and transported to the power plant. Other facilities will include a mine office, miner's wash house, warehouse and maintenance facilities, and laboratory. The mine office will be for key personnel and administrative workers. A wash house is important because it is planned to transport the workers back and forth to work rather than building a colony at the mine. The warehouse and maintenance facilities will be small. Most of the repairs will take place underground. Any machine shop or major work will be done at the power plant facilities or other outside facilities. A first aid station, lamp area, and mine rescue equipment will be part of the miners wash house.

4.1.10 Infrastructure

It is Bechtel's understanding the 34.5 kV power line has been extended by ICE to the site and no further expenditure is required. The 5 km road between Bri Bri and the minesite needs to be upgraded. Some housing will be provided for the key personnel. A potable water supply and sewage treatment are required for the mine facilities.

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4.2 Production Schedule

The production schedule is based on a 60 percent recovery factor of the in-situ reserves instead of the 65 percent used by Dravo. Forty percent of the production is estimated to be derived from development work, and room and pillar mining at 45 percent recovery and sixty percent from the longwall operation at 70 percent recovery. Dravo had a 90 percent recovery for the long wall operation using a single entry system. Based on a reserve of 12.0 million tonnes and a 30 year operating schedule, the design capacity of the mine is 240,000 tonnes per year of run of mine (ROM) coal.

The mine is scheduled to operate 2 shifts, 300 days per year. In a mature mine situation the following production plan is envisioned:

	No. of Employees	Tonnes/ Man Shift	No. of Shifts	Tonnes/ Day
Development	88	3	2	264
Room and Pillar	20	3	1	60
Longwall	80	6	2	480
Total				804

The capital expenditure and operating cost and other analyses that follow in this section are based on a mature mine capable of sustaining a production rate of 240,000 tonnes of coal per year.

4.3 Capital Expenditure Estimate

Table 4-1 Equipment, Surface Facilities and Miscellaneous Items List, Cost, and Equipment and Facilities Life include those items included in the Dravo report as well as other items and additional equipment that are required to complete the mine plan. Some items in the Dravo report were deleted because of the Bechtel modified plan which is labor intensive. No attempt was made to obtain new prices since the Dravo prices are only one year old and they have probably not changed very much, nor to verify the Dravo estimates. The prices for other

items were taken from in-house reports. The costs also include an estimate for development drilling, engineering and special studies, spare parts inventory, working capital and interest during construction. Since this review is a low key effort, no engineering was performed to arrive at these costs but the following assumptions were made:

1. Development drilling would require 250 holes with an average depth of 200 metres at a cost of $15 per metre. One third of the holes will be cored to extract coal samples.

2. Spare parts inventory is estimated to be 10% of the equipment and facilities cost.

3. Working capital is made up of one month payroll and two months of accounts receivable for coal at the cost of $20 per tonne.

4. Interest during construction is based on a three year period, equal amounts expended each year, and an interest rate of 12 percent per annum.

Excluded from the estimate are ocean freight, duty, and inland freight.

There are a number of unknown factors concerning this deposit, such as the condition of the roof and floor materials, ground water, faults and other geologic features that may adversely affect a mining operation. The order of magnitude capital costs presented in Table 4-1 is based on the known geologic features and assumes all other conditions as normal.

4.4 Operating Cost Estimates

The operating cost were determined by Bechtel for labor, materials and supplies, and power and fuel, based on some factors from the Dravo report.

4.4.1 Labor Costs

The labor requirements were determined for the direct operating labor, support labor, absentee labor, supervision and administrative. This determination is presented in Table 4-2 Manpower and Labor Cost. The labor rates are taken from the Dravo report and are as follows:

Base pay for operating labor is 25,000 colones/month
Base pay for supervisory labor is 35,000 colones/month
Social benefits for all personnel are 60 percent of their base pay. Conversion rate is 53.15 colones equals U.S. $1.

4.4.2 Material and Supplies

The material and supplies annual costs are based on 10 percent of the equipment and facilities costs in Table 4-1. Timber costs are included in the estimate at the rate of 1000 colones per cubic metre. Explosives may or may not be used in entry development or air overcasts. However, if used, the amount will be insignificant and no allowance is included in this estimate.

4.4.3 Power and Fuel

The electric power cost is based on the connected horsepower and the expected hours of operation of each motor driven piece of equipment. The price of electricity is 2.35 colones/kw-hr.

Hourly fuel consumption rates were determined for each diesel driven piece of equipment and the expected operating hours of this equipment. Cost of diesel fuel is 19 colones/litre and gasoline is 24 colones/litre. A lump sum estimate was made for the gasoline consumption.

4.5 Coal Production Cost Estimate

A simple cost accounting was performed to determine the cost of producing a tonne of coal at an annual production rate of 240,000 tonnes per year. Although this is an order of magnitude estimate (minus 10% to plus 40%), it is believed to be reasonable as presented in Table 4-3 Estimated Cost of Producing Coal - 240,000 tonnes/yr. The costs presented are F.O.B. the mine.

The labor, materials and supplies, and fuel and power estimating methods were outlined in the prior section on operating cost estimates. The following describes the methods used in determining the other costs in Table 4-3.

4.5.1 Debt Repayment and Interest

The debt assumed is 75 percent of the total capital expenditure as determined in Table 4-1. The loan is for a period of 15 years following the development of the mine at an interest rate of 12 percent per annum. The capital recovery factor under these terms is 0.14682. Useful life of the equipment and facilities are shown on Table 4-1. The capital expenditure does not include replacement equipment. It is assumed that earnings from the operation will pay for this expenditure. All of the above are assumptions made by Bechtel for the purpose of this study only and in no way is intended to indicate actual loan conditions.

4.5.2 Royalty

One dollar per tonne was arbitrarily assigned.

4.5.3 Insurance

The insurance cost estimate is based on 2 percent of the capital expenditure items in Table 4-1 items A through J.

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4.5.4 Taxes Ad Valorem

A market value of 50 percent of the total capital expenditure excluding the interest during construction is assumed. Of this amount 25 percent is assessed. The assessment rate is $1.50 per $100 of assessed value.

5.4.5 Administrative and General

Ten percent of the labor cost was assumed for this item.

5.4.6 Profit

A 25 percent return on equity was assumed.

In converting the cost per tonne to cost per million Btu, a calorific value of 8000 Btu per pound "as received" was used.

Table 4-1

Equipment, Surface Facilities and Miscellaneous Items
List, Cost, Equipment and Facilities Life

DESCRIPTION	UNIT COST	No. of UNITS	TOTAL COST	Useful LIFE-YR
A. Haulage				
150-ton Battery Locomotive with Battery and Charger	$ 185,100	3	$ 555,300	15
250 HP Drum Hoist	330,000	1	330,000	30
80 HP Drum Hoist	120,000	1	120,000	30
1-Tonne Mine Cars	4,800	100	480,000	15
*Mine Track	$25/metre	4000	100,000	30
*Diesel Scooptram	128,000	5	640,000	15
B. Face Equipment				
*Pneumatic picks with lines, couplers, tools	500	40	20,000	5
*Longwall Conveyor, 60 tph with motor and starter	20,000	2	40,000	5
*Hydraulic Props with sliding bars, hoses, power pack	1,500	360	540,000	10
Pneumatic Drill	3,000	3	9,000	3
*Miscellaneous Tools	20,000	1 lot	20,000	4
C. Ventilation				
Main Fan with motor, starter, motor house, controls	91,500	1	91,500	30
Fan House Ductwork	35,000	1	35,000	30
Auxiliary Face Fans, 5000 cfm	2,500	6	15,000	8
*Ventilation Tubing	$20/metre	1000	20,000	4
D. Water Control				
Turbine Pump, 250 HP	15,000	2	30,000	15
Face Pump, 20 HP	3,000	4	12,000	4
*Water Line	$6/metre	1000	12,000	15

Table 4-1 (cont.)

DESCRIPTION	UNIT COST	No. of UNITS	TOTAL COST	Useful LIFE-YR
E. Mine Power				
2500 KVA Substation 34.5 kV/8 kV	126,000	1	126,000	30
*Distribution Panel	35,000	1	35,000	30
*High Voltage Distribution Cable, 8 kV	$20/metre	3000	60,000	30
*Breaker	15,000	1	15,000	15
*Transformer, 200 kVA 8 kV/2300 V, mine fan	12,000	1	12,000	15
*Transformer 8 kV/440 V, belts, all buildings 500 kVA	17,000	1	17,000	15
*Section Power Center, 100 kVA	10,000	5	50,000	15
Mine Telephone System	20,000	1	20,000	30
F. Safety Equipment				
*First Aid Equipment	20,000	1 lot	20,000	5
*Mining Helmets, Safety Toe Shoes, Belts	$75/Employee	300	22,500	4
Electric Cap Lamps	90	300	27,000	5
Lamp Charger with Rack	2,500	6	15,000	10
*CO Sensors and Heat Detector	10,000	1	10,000	10
Flame Safety Lamps	135	30	4,000	5
*Anemometres	200	10	2,000	5
*Breathing Apparatus and Gas Masks	40,000	1 lot	40,000	10
*Personnel Self Rescuers	100	300	30,000	5
G. Site Preparation				
*Grading and Preparing Site for facilities, face-up portals	120,000	1	120,000	30

Table 4-1 (cont.)

DESCRIPTION	UNIT COST	No. of UNITS	TOTAL COST	Useful LIFE-YR
*Lighting and Fence	30,000	1	30,000	30
H. General Surface Facilities				
*Bathhouse, office, shop, warehouse, training room, simulated, mine training building complete with showers, lockers, hangers, toilets, furniture, air conditioning	600,000	1 lot	600,000	30
*Emergency Diesel Power Generator and Room	150,000	1	150,000	15
Laboratory Equipment	140,000	1	140,000	30
Forklift, 3 short ton	57,000	1	57,000	15
Steam Cleaner	3,500	1	3,500	5
Diesel Fuel Tank, 6000 gal	4,500	1	4,500	30
Gasoline Tank, 500 gal	1,000	1	1,000	30
Water Tank, 4000 gal	3,500	1	3,500	30
Powder Magazine	3,000	1	3,000	30
Ambulance	20,400	1	20,400	30
Fire Engine	63,000	1	63,000	30
40 Passenger Bus	41,100	4	164,400	5
*Flatbed Truck	12,000	1	12,000	5
Pickup Truck	10,000	2	20,000	5
Air Compressor, 750 cfm, 150 psi	56,800	4	227,200	15
I. Surface Coal Handling				
*Crushing Plant, 400 tph, with hopper, feeder, picking belt, screen, and crusher	250,000	1	250,000	30
*Stacking Conveyor	60,000	1	60,000	30

Table 4-1 (cont.)

DESCRIPTION	UNIT COST	No. of UNITS	TOTAL COST	Useful LIFE-YR
Haul Truck	256,800	1	256,800	6
*Front-End Loader	321,000	1	321,000	6
J. Infrastructure				
*Septic Tank	10,000	1	10,000	30
Water Well and Pump	40,000	1	40,000	30
*Water Line	10,000	1	10,000	30
Road, 5 km	94,000	1	94,000	30
*Housing	8,000	12	96,000	30
K. Engineering				
*Development Drilling including coal analysis	$15/metre	50,000	750,000	30
*Special Studies and Detail Engineering	500,000	1	500,000	30
L. Miscellaneous				
*Spare Parts and Supply Inventory (10% of $60 million)	600,000			
*Consumable Inventory 1/12 of $120,000	10,000			
*Working Capital Labor (1/12 x $2,522,000) Receivables (2/12 x 240,000 t x $20/t)	1,010,000			
Subtotal Miscellaneous	$ 1,620,000			
Subtotal A-K	7,562,600			
Subtotal Capex	9,182,600			
*Interest During Construction**	1,653,000			
Total	$10,835,600			

*Denotes Bechtel estimates

**Interest During Construction

Period - 3 years

Interest Rate Assumed - 12%

Capital Expenditure - $9,182,600

Equity (25%) - $2,295,600

Debt (75%) - $6,887,000

Expenditure in 3 equal amounts per year

1st year, $2,295,700 x 12% =	$	275,500
2nd year, $4,591,400 x 12% =		551,000
3rd year, $6,886,100 x 12% =		826,500
		$1,653,000

Table 4-2

Man Power and Labor Cost

	No. of Work Areas	No. of Miners	No. of Equipment Operators	No. of Foreman	Employees per Shift	Total Employees
I. Operating Labor						
A. Development						
1. Main Entries	5	10	1	1		
2. Sub-main Entries	10	20	1	1		
3. Panel Entries	4	8	1	1		
		38	3	3	44	88
B. Room and Pillar	8	16	2	2		
		16	2	2	20	20
C. Longwall	2	36	2	2	40	80
Subtotal						188
II. Support Labor						
1. Locomotive Operator					3	6
2. Hoistmen					2	4
3. Ventilation					6	6
4. Track Maintenance					2	2
5. Roof Support Maintenance					3	3
6. Mechanic/Welder					4	8
7. Electrician					2	4
8. Rock Dusting					2	2
9. Pump Man					1	2
10. Utility					3	3
11. Picking Table					2	4
Subtotal						44

Table 4-2 (cont.)

III. Absentee Labor

5% of 232	6	12
Subtotal		12
Subtotal Worker		244

IV. Supervision and Administration

	1st Shift	2nd Shift	3rd Shift	Total
Mine Manager	1			1
Mine Engineer	1			1
Training and Safety	2			2
Environmental	1			1
Personnel	2			2
Purchasing	1			1
Surveying	3			3
Draftsman	1			1
Mine Superintendent	1	1		2
Maintenance	1	1		2
Outside Foreman	1	1		2
Nurse	2	2		4
Watchman	1	1	1	3
Clerical	4	2		6
Subtotal				31

V. Total Labor Cost

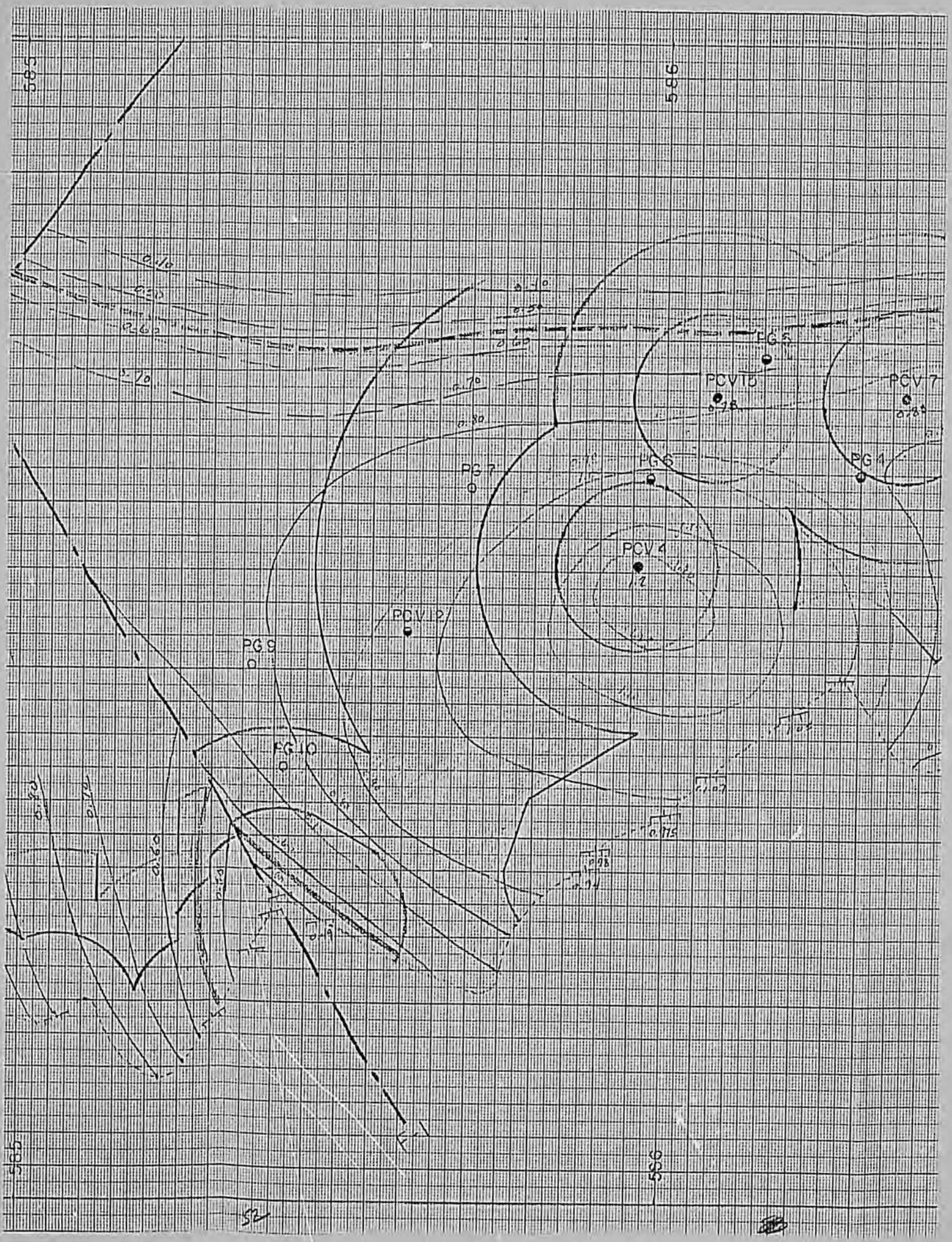
	No. of Employees	Rate/ Month	Social Cost	Cost/ Month	Cost/ Year
Operating Labor	188	$470	$280	$ 750	$1,692,000
Support Labor	44	470	280	750	396,000
Absentee Labor	12	—	280	280	40,320
Supervision & Administr.	31	660	400	1060	394,320
Total	275				$2,522,640

Table 4-3

Estimated Cost of Producing Coal - 240,000 tonne/year

		Annual Cost	Cost/ tonne	Cost/ 10^6 Btu
1.	Labor	$2,522,000	$10.51	0.596
2.	Materials and Supplies	713,000	2.97	0.168
3.	Fuel and Power	624,000	2.60	0.147
4.	Debt Repayment and Interest	1,193,000	4.97	0.282
5.	Royalty	240,000	1.00	0.057
6.	Insurance	126,000	0.53	0.030
7.	Taxes Ad Valorem	17,000	0.07	0.004
8.	Administrative and General	252,000	1.05	0.060
9.	Profit	677,000	2.82	0.160
	Total	$6,362,000	$26.52	1.504

400
585
0.10
0.50
0.60
0.70
PG 9
PCV 9
399
PG 10
585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586
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PCV 7
PG 7
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PG 4
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0.40
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0.98
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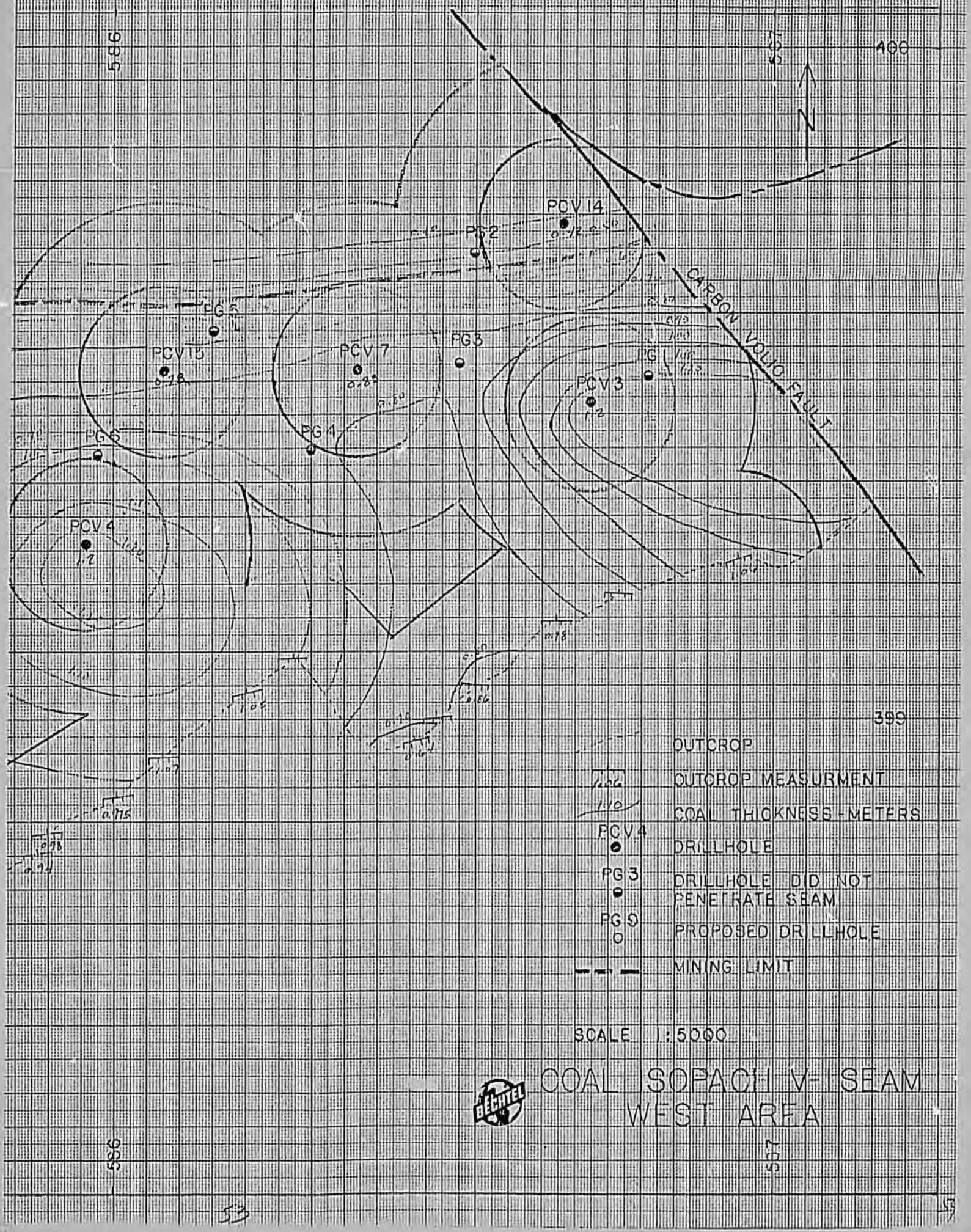
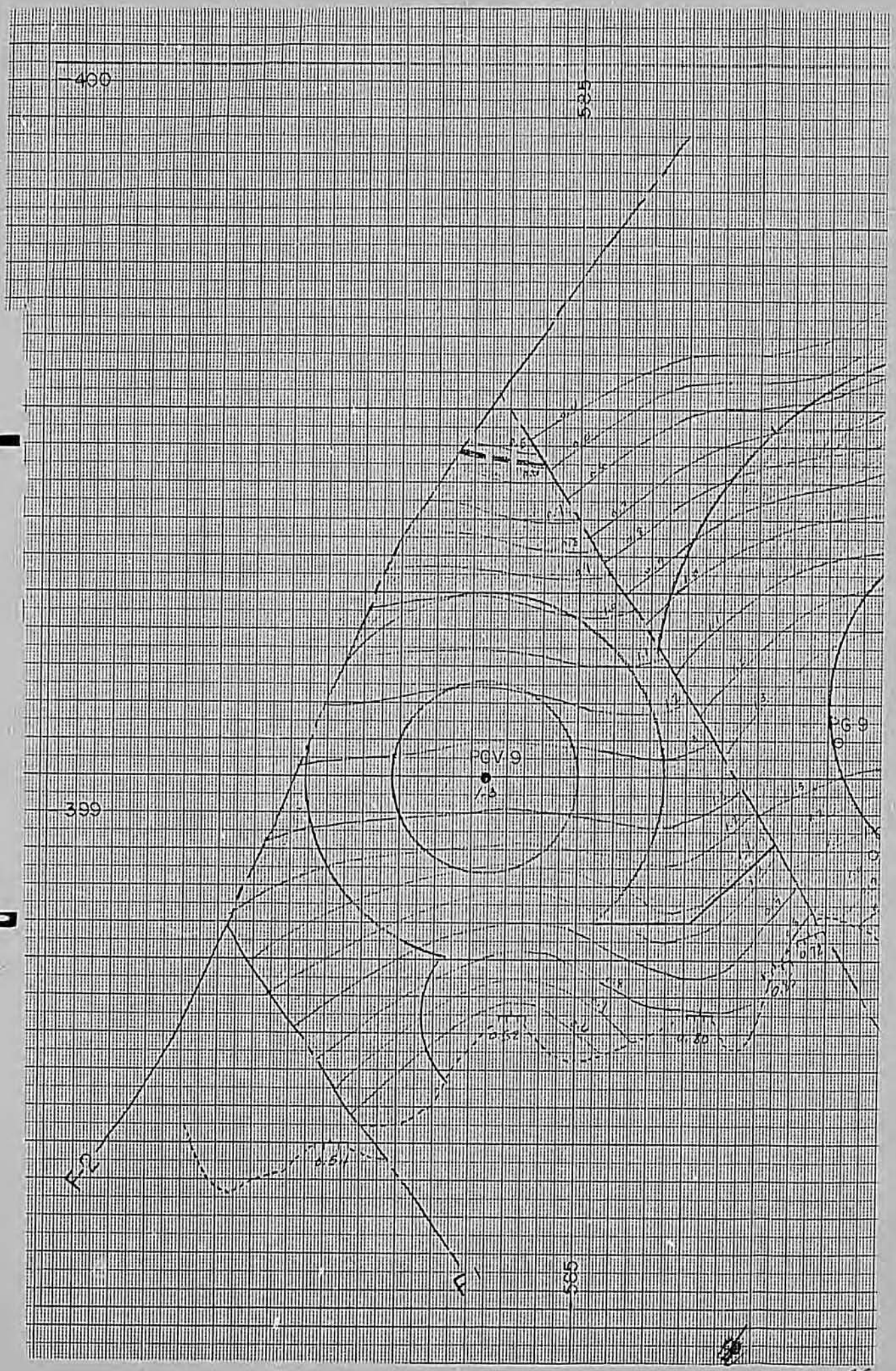
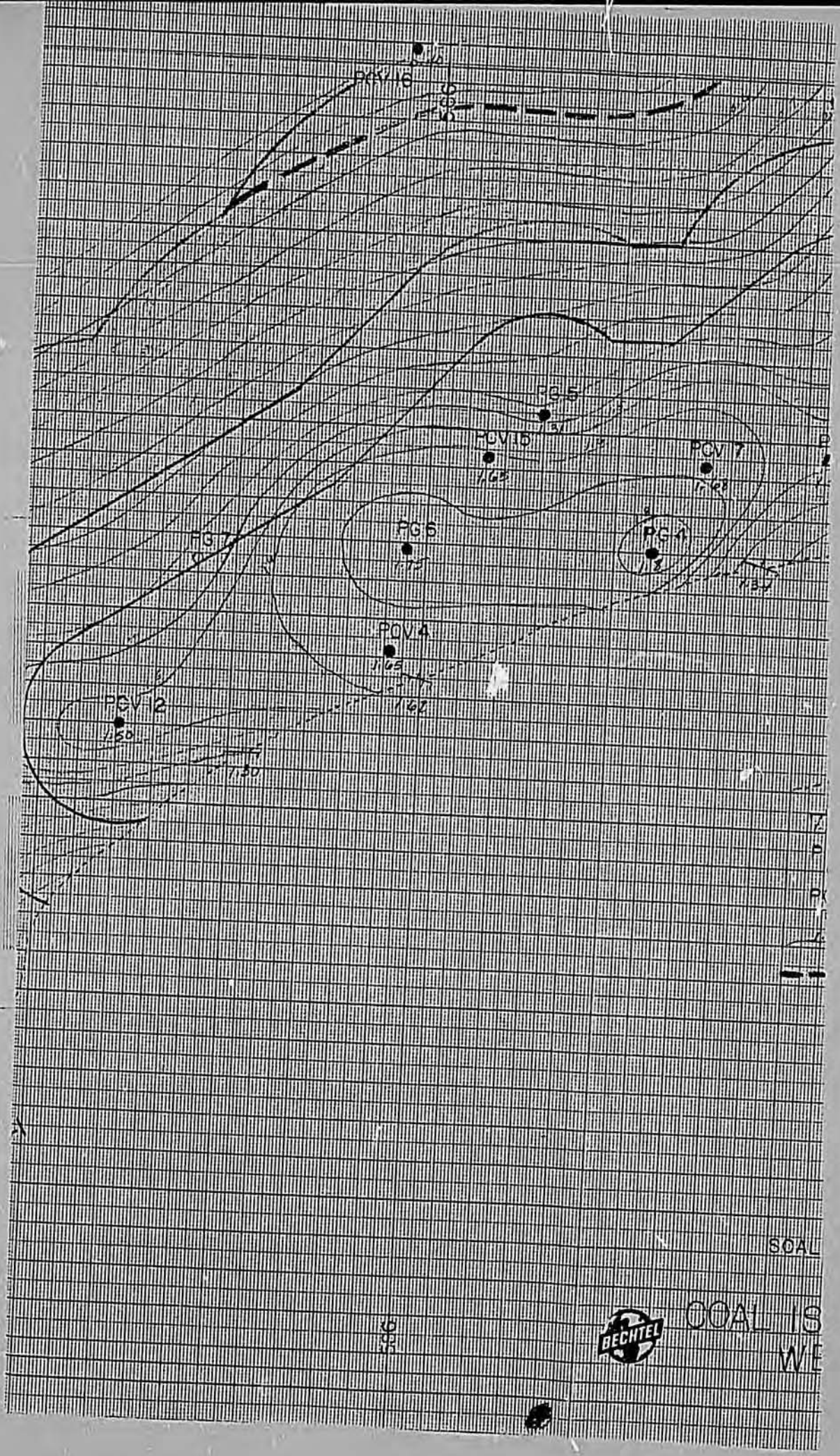

N
400
399
PCV 14
PG 2
PG 6
PCV 16
PCV 7
PG 3
PG 1
PCV 3
PG 4
PG 5
PCV 4
CARBON VOLIO FAULT
OUTCROP
OUTCROP MEASURMENT
COAL THICKNESS - METERS
PCV 4
DRILLHOLE
PG 3
DRILLHOLE DID NOT PENETRATE SEAM
PG 9
PROPOSED DRILLHOLE
MINING LIMIT
SCALE 1:5000
COAL SOPACH V-1 SEAM
WEST AREA


400
535
PGV 9
PG 9
399
F2
F1
535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PG 5
PCV 15
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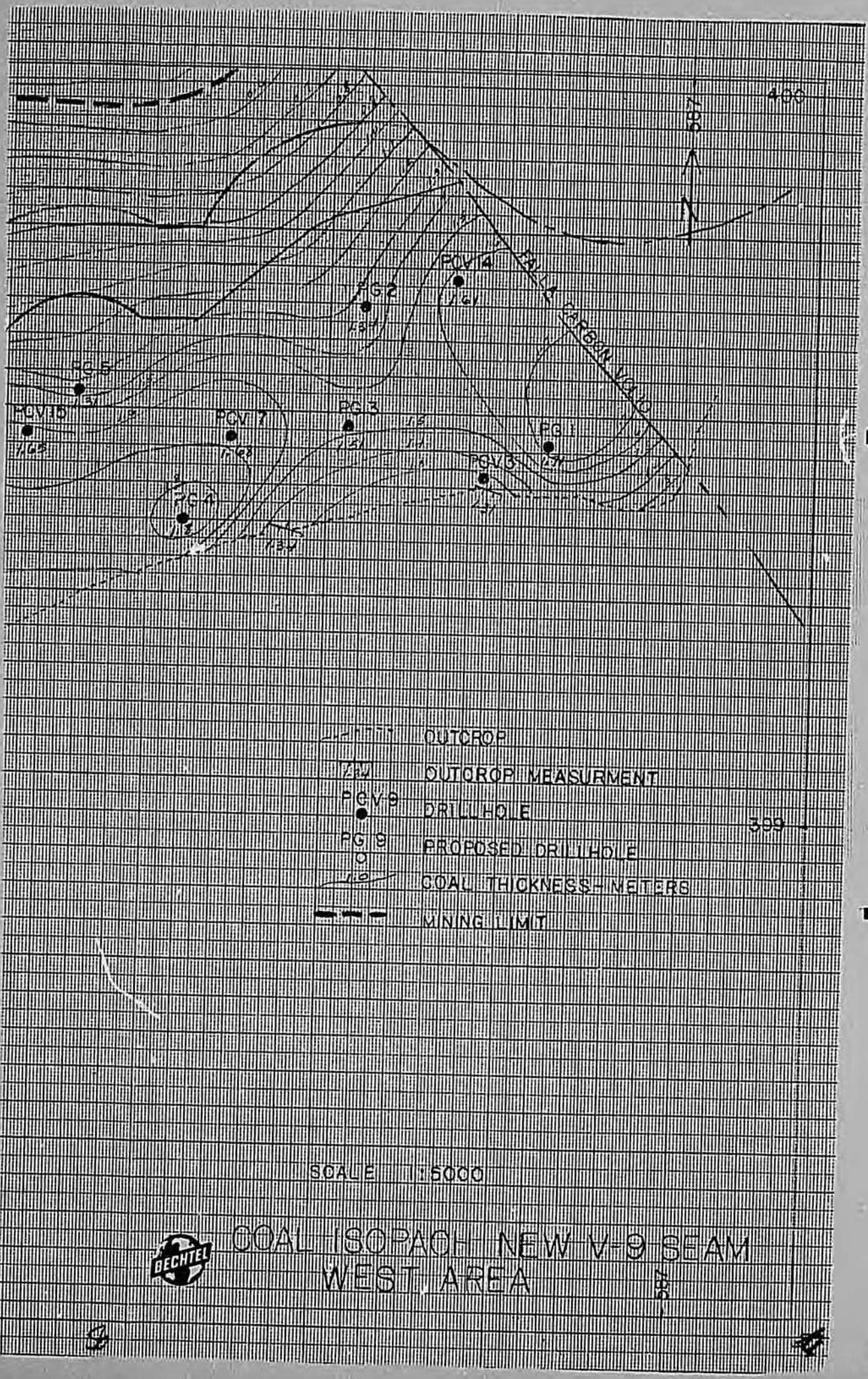
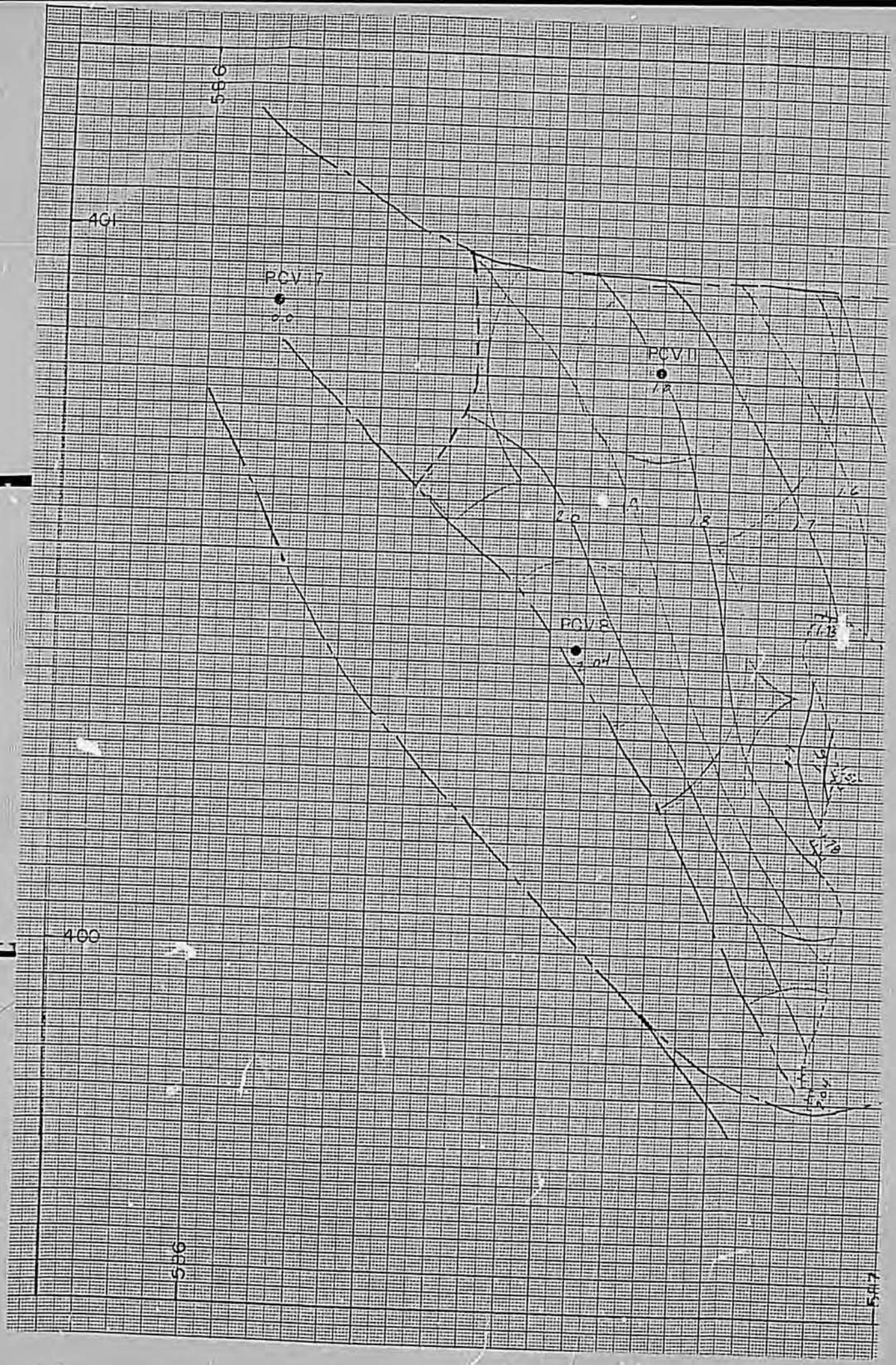
PCV 4
PCV 12
SOAL
COAL IS
WE
BECHTEL



COAL ISOPACH NEW V-9 SEAM
WEST AREA

57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PCV 7
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PCV 11
1.8
2.0
1.9
1.8
1.7
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PCV 8
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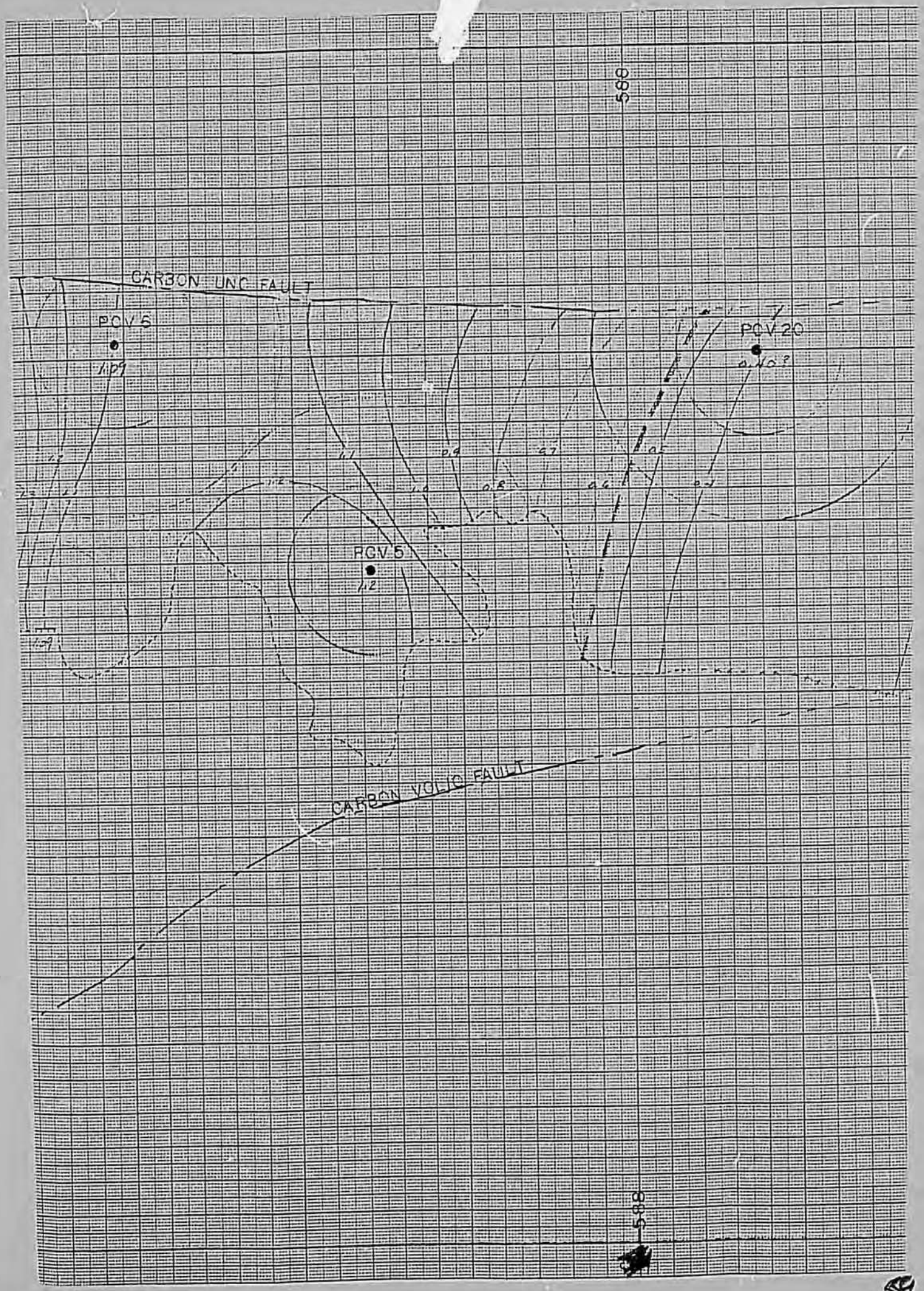
1.4
1.5
1.6
1.8
400
5-6
5-7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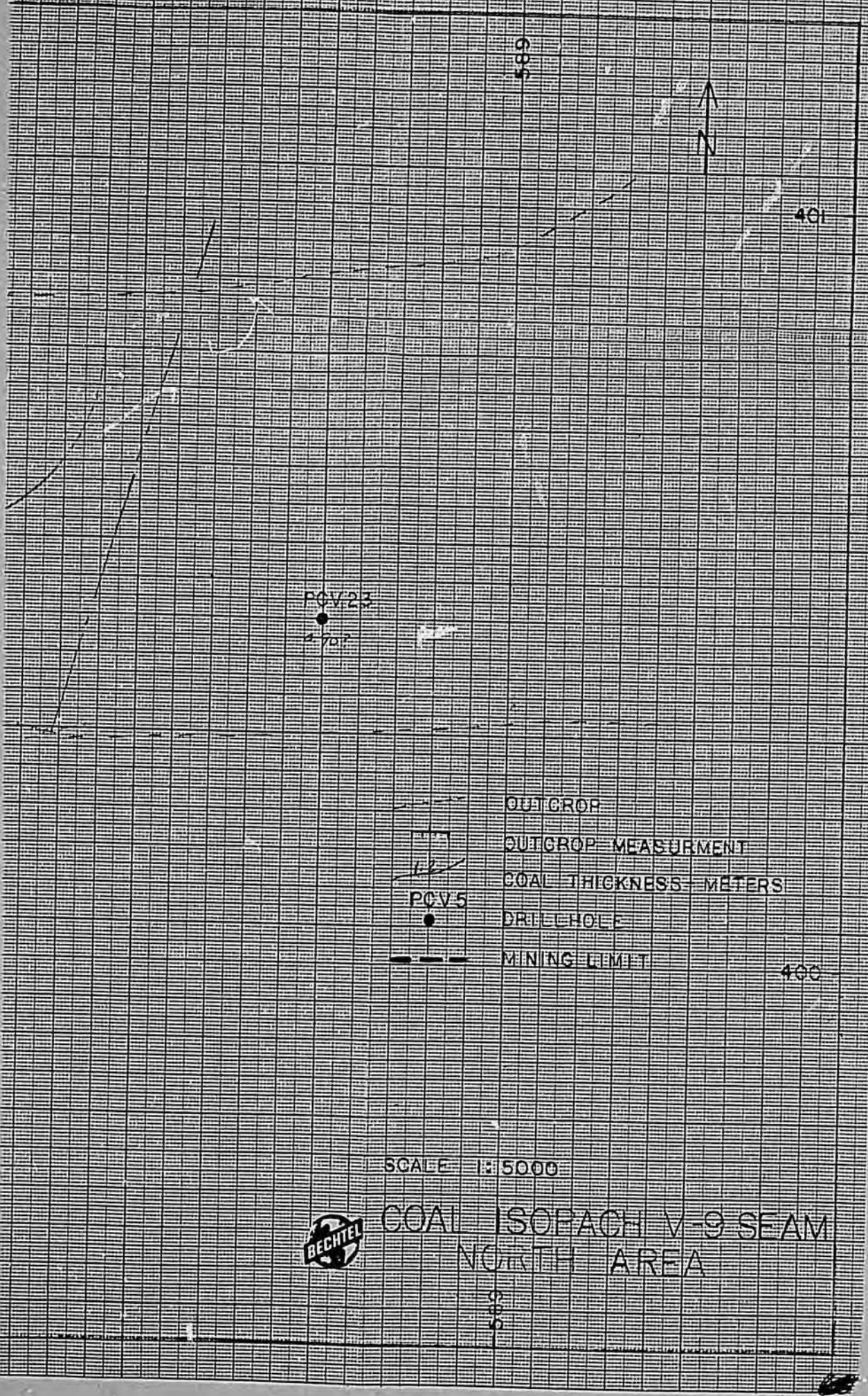
PCV 5
PCV 20
PCV 5
CARBON VOLIO FAULT
588



BECHTEL

COAL ISOPACH V-9 SEAM
NORTH AREA

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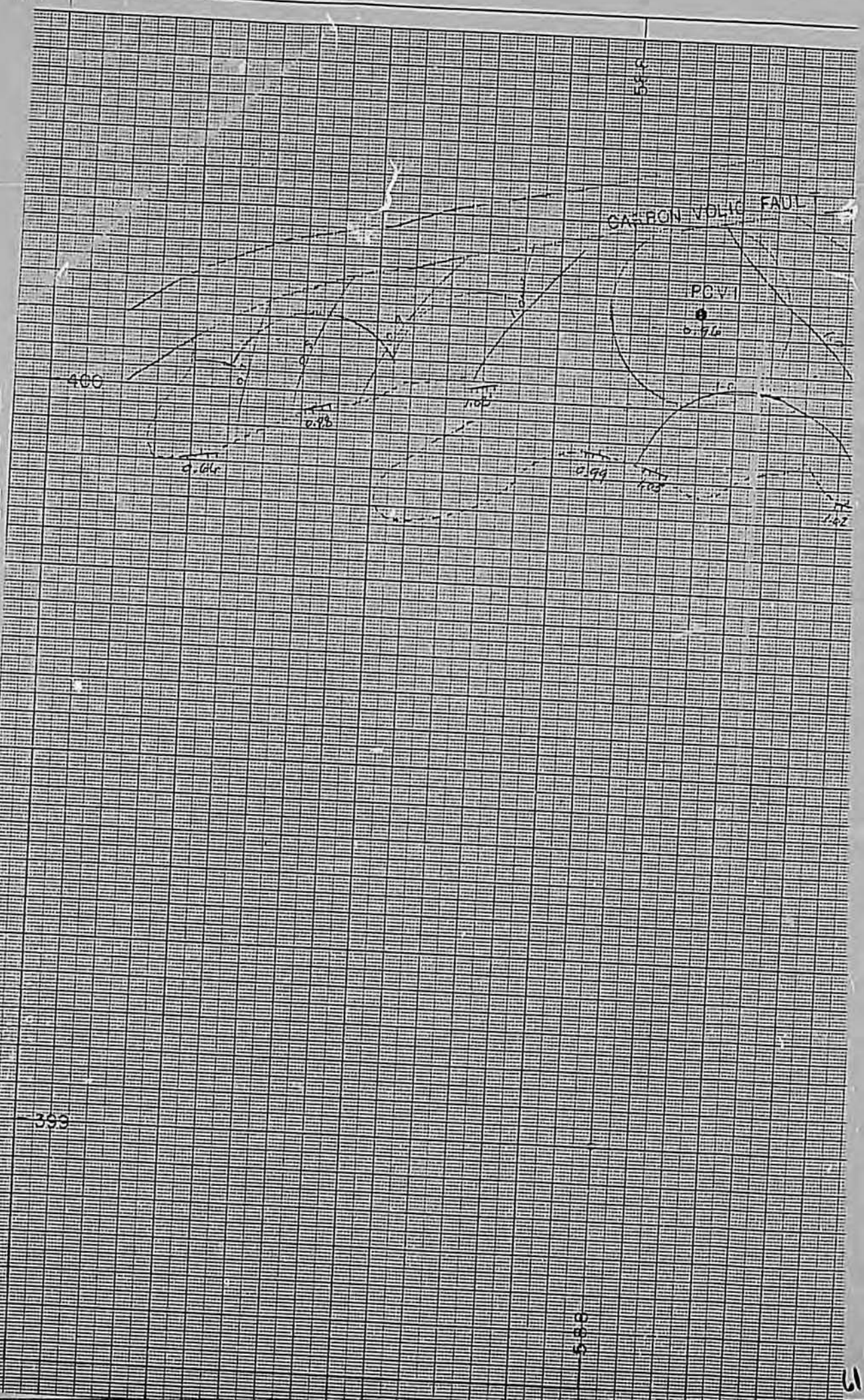
CARRON VOLIC FAULT
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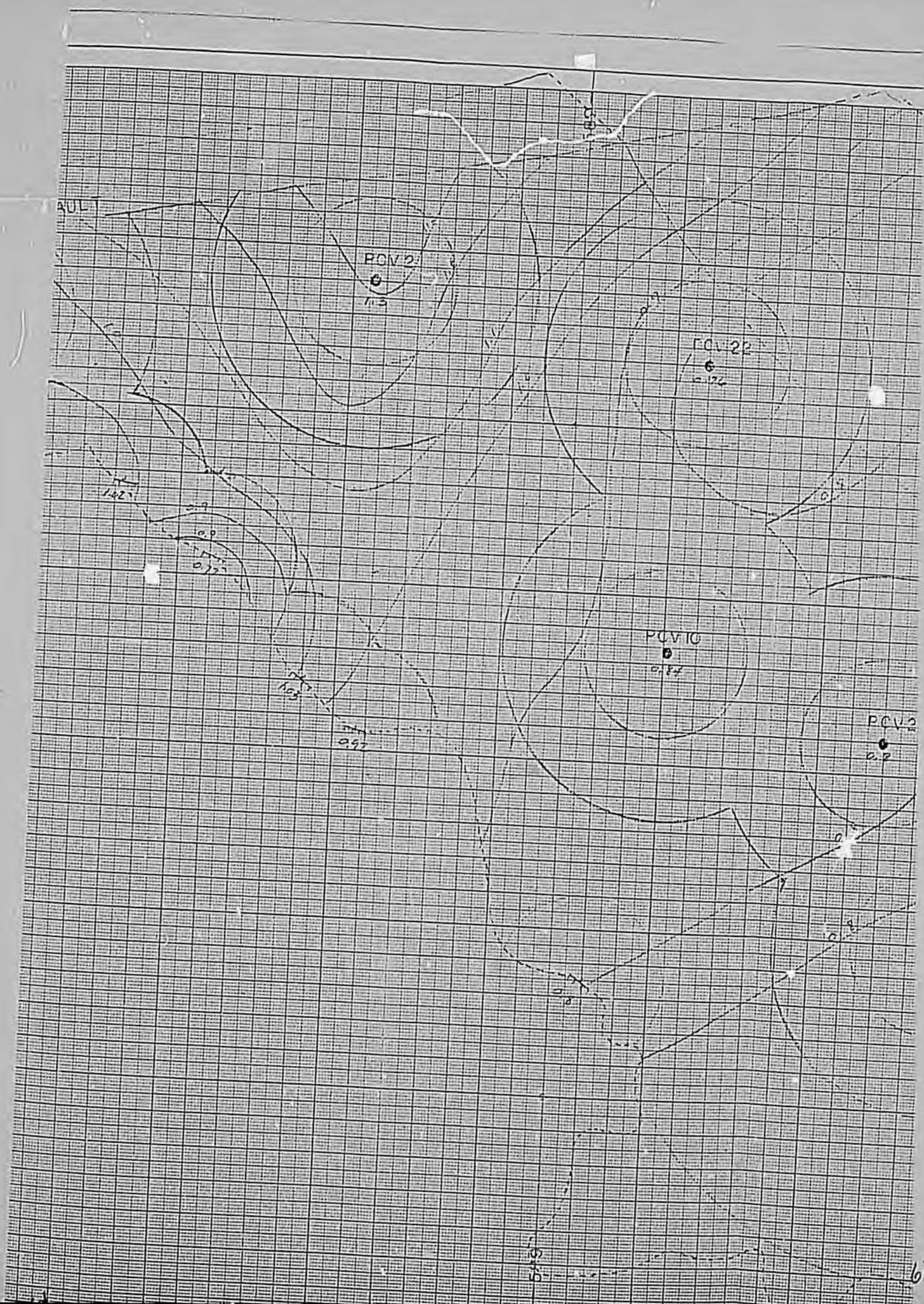
0.99
1.42
-399



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PCV 22
PCV 10
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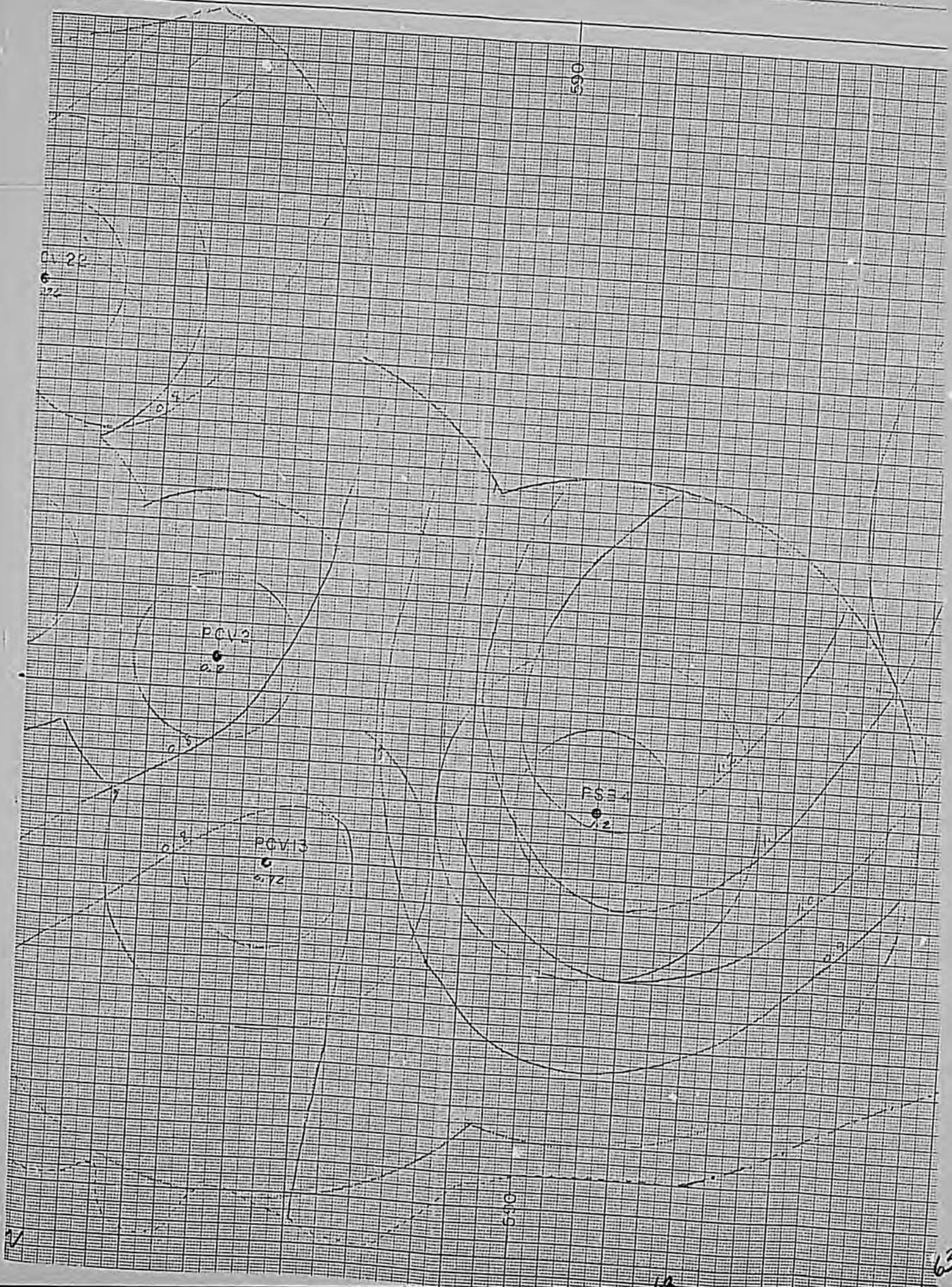
1.42
0.77
0.97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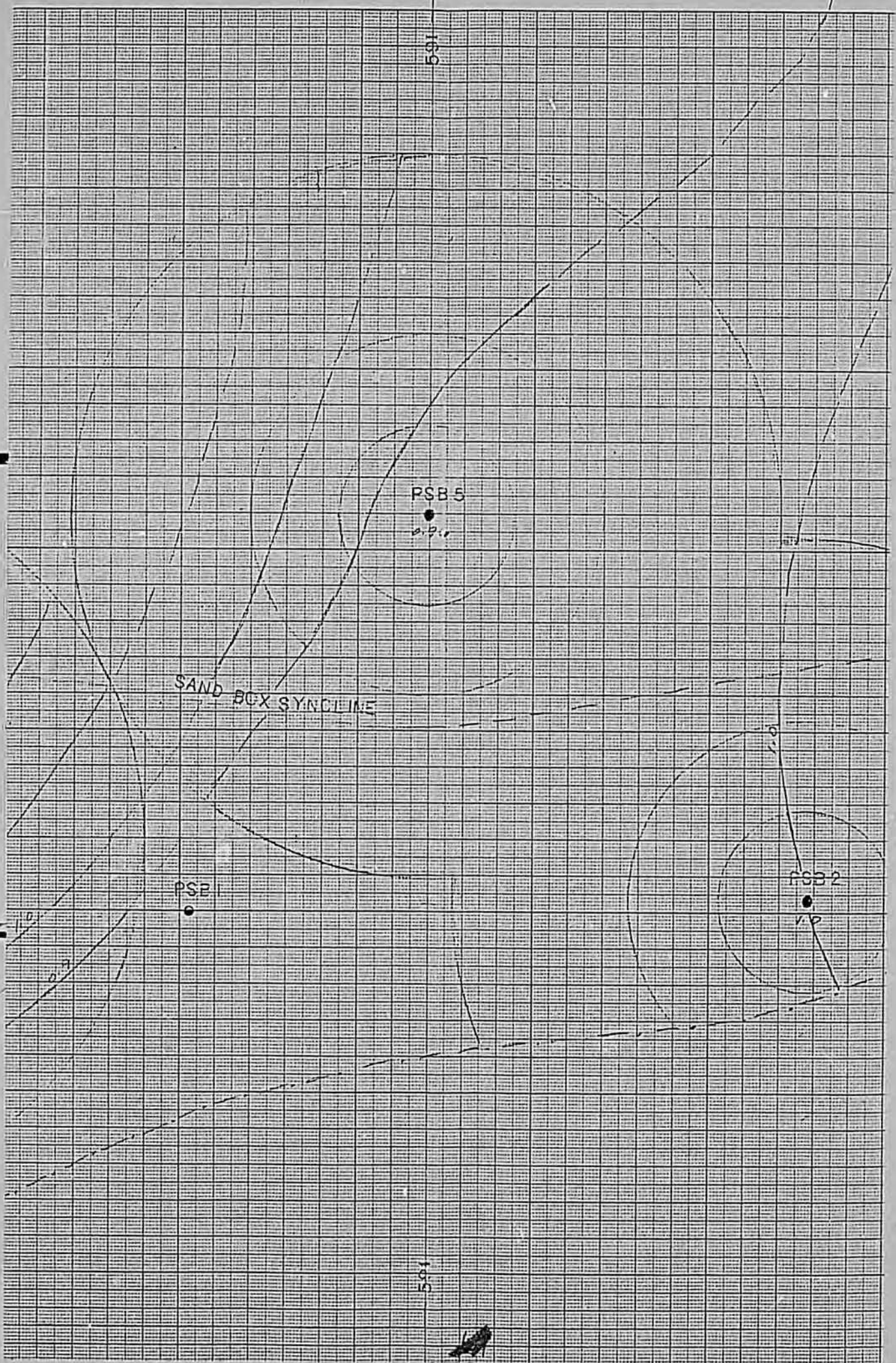
PCV 2
PCV 3
PS 2
590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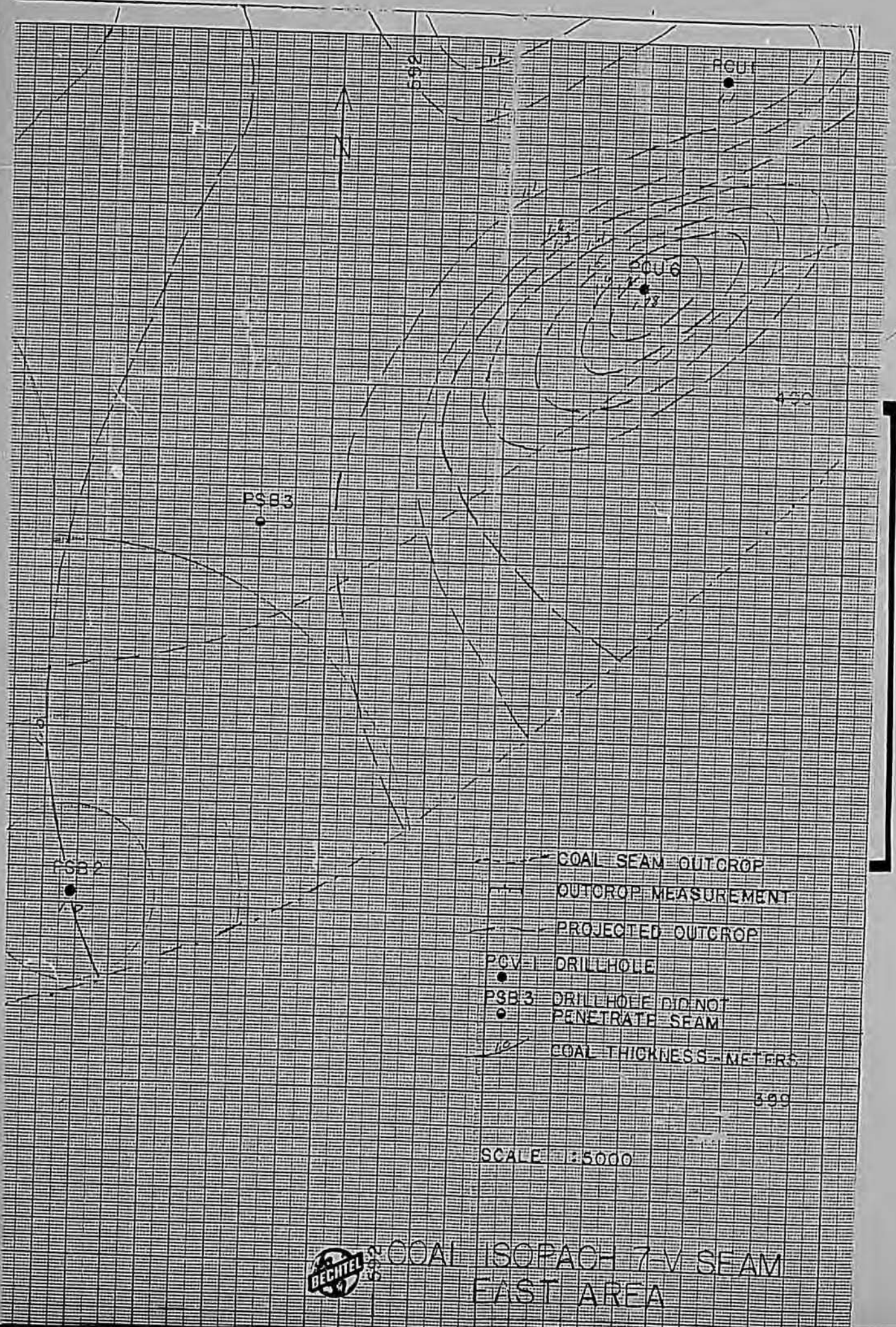
PSB 5
SAND BOX SYNCLINE
PSB 1
PSB 2
591



COAL ISOPACH 7-V SEAM
EAST AREA

65