to push overburden to the low wall side. This activity will be helpful to achieve high productivity of dragline operations and also helpful to reduce the volume of rehandle. Considering the number of excavators employed and its mining activities, additional bulldozers should be able to improve efficiency of these mining equipment.

| Type | DE-110 | DET-250 | D-155 |
|---|---|---|---|
| Make | Russia | Russia | Komatsu |
| Power | - | 250 HP | 289 HP |
| Weight | 16.5 ton | 31.5 ton | 33 ton |
| Unit | 4 | 6 | 6 |
| Purchased | 1990 | 1988--1992 | 1992 x 3, 1993 x 3 |

Front end loader:

Currently, clean up of the coal surface is not adequate. It is also difficult to separate the partings or rock materials by electric rope shovel. For the purpose of solving these problems, it is recommended to introduce additional front end loaders.

Grader:

Conditions of the haul road is very important for rear dump truck operation. Trucks can run faster on the maintained haul road, and fuel consumption ratio should be also less on the maintained haul road. Sharp edged lumpy coal fell down from rear dump trucks will easily damage the tires of rear dump trucks.

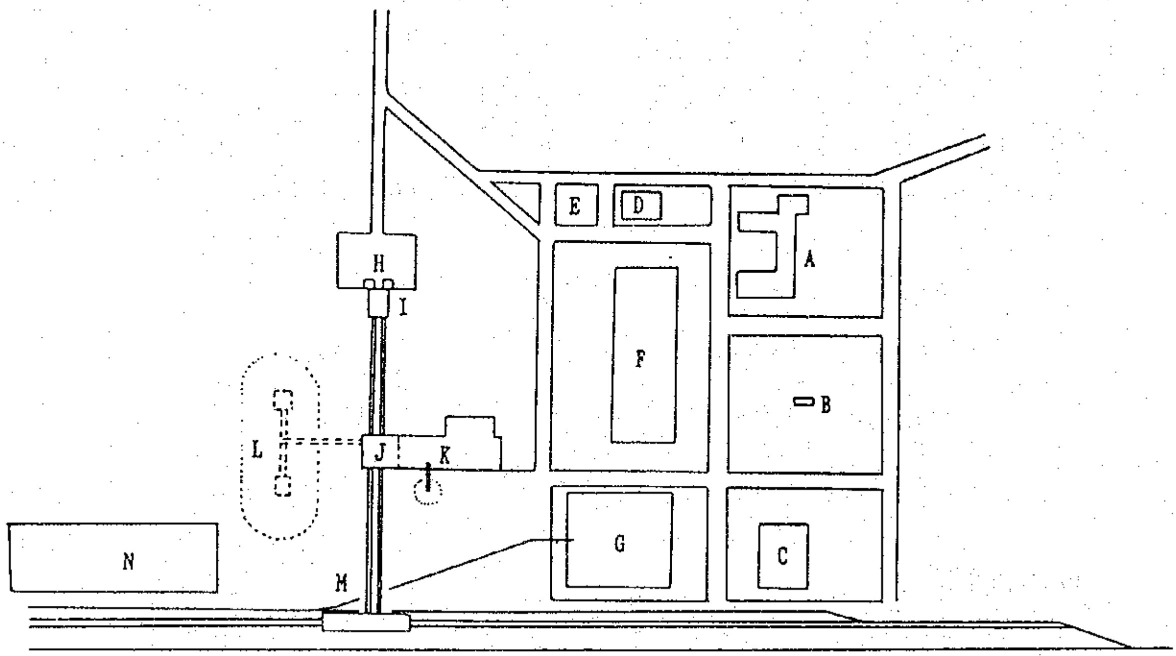
Water truck:

Geographical features of the area are almost flat and the window in the area is so strong. Dust control is essential for mine operations because dust disturbs mine operations, for example, the rear dump trucks cannot be driven faster and safer. $SiO_2$ contents of the rock dust will give negative effects on the workers' health. In order to prevent from the generation of rock dusts, water trucks are required to operate. Covering by asphalt is one of alternatives as a preventive method to suppress dust generation.

3.2.2 Surface facilities

(1) Workshop

Most of the mobile equipment is maintained at workshops while large equipment such as draglines and electric rope shovels are maintained at the operating areas. There are well




A : Mine office
B : Water supply system
C : Warehouse
D : Substation
E : Gas station
F : Workshop(mobile euipment)
G : Workshop(shovel, railway)
H : Coal hoppers
I : Crushing plant
J : Sizing plant
K : Hot water supply system
L : Coal stock facility
N : Equipment erection yard
M : Coal loading facility

Figure 3.4 Layout of Surface Facilities

designed workshops at Baganuur mine. They are consisted from a mobile equipment workshop, a heavy duty equipment workshop, a locomotive and wagon workshop, and an electrical workshop near the mine office. There is also a railway maintenance shop near the railway control station. Maintenance works are carried out by 2 shifts par day and 8 hours per each shift. Maintenance is carried out in accordance with the maintenance schedule. Consumable parts are also changed periodically. But due to the lack of spare parts, many parts could not be replaced by the designated time for the purpose of maintenance. Operating life of draglines and electric rope shovels is more than 12 years and 10 years respectively.

1) Mobile equipment workshop

The workshop is divided into garages such as maintenance rooms for light vehicles, mining equipment, Komatsu rear dump trucks, Belaz dump trucks, bulldozers, engines, sawmill, tire shop, warehouse, etc. Maintenance is conducted in each maintenance room. Work distributions are carried out at the garage. There are fuel tanks near the workshop. The stock capacity of diesel fuel tank is 350 tons and gasoline tank is 20 tons. The equipment is washed before maintenance at the car wash yard located in front of the workshop. Inside of the garage, there are inspection pit, overhead crane, etc. Daily maintenance is carried out, including tire change and oil change. Engine and transmission are repaired at the maintenance room.

2) Heavy duty equipment workshop

Daily maintenance of draglines and electric rope shovels is carried out at the operation site. Welding works of the bucket of draglines and electric rope shovels are conducted at the welding workshop. Two or three buckets are assigned to each equipment, and are repaired alternately.

3) Locomotive and wagon workshop

The railway tracks are led into the workshop. Inspection pit and overhead cranes are installed at the workshop. There are welding facilities, hydraulic press and balance of the wheels. Twelve wagons and one locomotive are possible to be repaired at the same time. About 20 wagons are repaired every month.

4) Electrical workshop

There is a room each for motor, electrical equipment and cable at the electrical workshop. At the motor repair room, there are some maintenance tools such as dryer, balance, etc. Rewinding of the motor is not carried out at the site. The shortage of insulation materials and spare parts is the main problems of the workshop. Maintenance equipment and the tools are not enough at the workshop so far. The following facilities are desired to be introduced.

Furnace for melting iron
Analyzer of the metal
Furnace for heat treatment
Induction heater
Vertical milling cutting machine
Gear cutting machine
Wheel repairing machine for wagon
Rolling mill
Surface treatment facilities
Point welding facilities
Gas arch cutting system
Technology for producing drill's funnel

Maintenance equipment, tools and skilled workers are required to increase mechanical availability of mining equipment.

The establishment of the Maintenance Center must be seriously studied. The Maintenance Center should be controlled by the Ministry of Energy, Geology and Mining. Concepts of the Center is proposed as follows:

- educate engineers and skilled workers for the heavy equipment.
- dispatch maintenance specialists to the coal mine in case of heavy break down.
- purchase and stock common spare parts.
- retain and use maintenance equipment.

Not only the coal mines but also the metal mines will be able to get the benefits from the proposed Maintenance Center. Detailed ideas will be studied in the Master Plan.

(2) Warehouse

Supply of spare parts is also important for supporting mining activities. In order to increase mechanical availability of mining equipment, spare parts have to be stocked with proper level. Currently 8,931 items are stocked in the warehouse. Numbers and items are controlled by a computer. But the system is not up-to-dated so purchasing timing and quantity are not properly controlled by the computer. The prime reason of the shortage of spare parts is the lack of fund for purchasing. The spare parts and materials are divided into 3 categories depending upon consumption rate and delivery time.

Warehouse consists of 3 rooms, which are for lubrication oil, big parts and small parts. But some of oils and big parts, for example, cables and wires are stocked on the floor in front of the warehouse. Following items are difficult to purchase:

Motors for draglines and electric rope shovels
Oil heaters for draglines
Wire ropes for electric rope shovels
Rollers for belt conveyers
Compressors for locomotives
Air cylinders for dump wagons

It is recommended to store the common parts at the proposed Maintenance Center. Most of coal mines are using the same equipment in Mongolia. Is this way the proposed Maintenance Center will be able to supply spare parts to coal mines quickly. Coal mines will be able to reduce stock level of the spare parts and can shorten the delivery time. As a result, mechanical availability of mining equipment will be improved and production will be also increased.

(3) Coal stock yard

Construction of the coal stock facilities was also planned. But at the construction period, the facilities were burned out by the fire on electric cables. Inside of the loading building, there are coal pockets. In the event of troubles at the loading facilities, the sizing facilities cannot continue to operate. Even if the sizing plant were stopped, it is possible to continue the coal loading from a temporary loading site. However, it is not possible to load sized coal into the freight cars in this case. Preventive apparatus for spontaneous combustion at the coal stock yard are required for constant delivery of coal to the users.

(4) Sizing and loading

Most of coal excavated from the pits are transported to the hopper located near the crushing plant. There are two hoppers with 100 tons capacity each. Hoppers are big enough for two rear dump trucks to discharge at the same time. From the bottom of the hopper, coal is fed into the crusher. The capacity of two crusher is between 550 tons and 900 tons per hour per unit. Designed crushing capacity is 3 million tons per year per unit. Actual capacity is about 2.6 million tons per year. Crushed coal is transported to the sizing plant by belt conveyers. Some of coals screened by the vibration screens are fed to the hot water supply boiler located nearby the sizing plant. The rest of coals are transported to the loading tower next to the sizing plant. There are small coal bins at the loading tower. Size of coal is 0-50mm, 0-300mm, etc. Iron materials in saleable coal are separated by the magnet catchers and other foreign materials are manually removed. Measuring of the coal weight is not conducted at mine site.

Pit 5 is located far from the hoppers of the crushing plant and by economical reason direct loading of coal into freight car is applied in this area. Near Pit 2, there is a temporary loading facility and coal is loaded directly into the freight cars by electric rope shovel. In this case, quality control is difficult and coal of large size is loaded into the freight cars without crushing. In 1992, about 38% of the coal produced at Baganuur coal mine are supplied to the users without crushing. By introducing a small skid mounted crushing plant at the loading point of Pit 5 and Pit 2, this sizing problem can be solved.

(5) Electric supply

Electricity used at the mine and the Baganuur city is supplied from the Central Energy System through a high voltage transmission line. There is a substation near the Baganuur city, and electricity is delivered to the mine site transformers from this substation by air line. There are 2 units of 110/6KV transformer and one unit of 110/10KV transformer. Electricity is distributed to mine equipment from the mine site transformers by air line or cable line. Heavy equipment such as draglines and electric rope shovels are operated with 6KV and small equipment such as

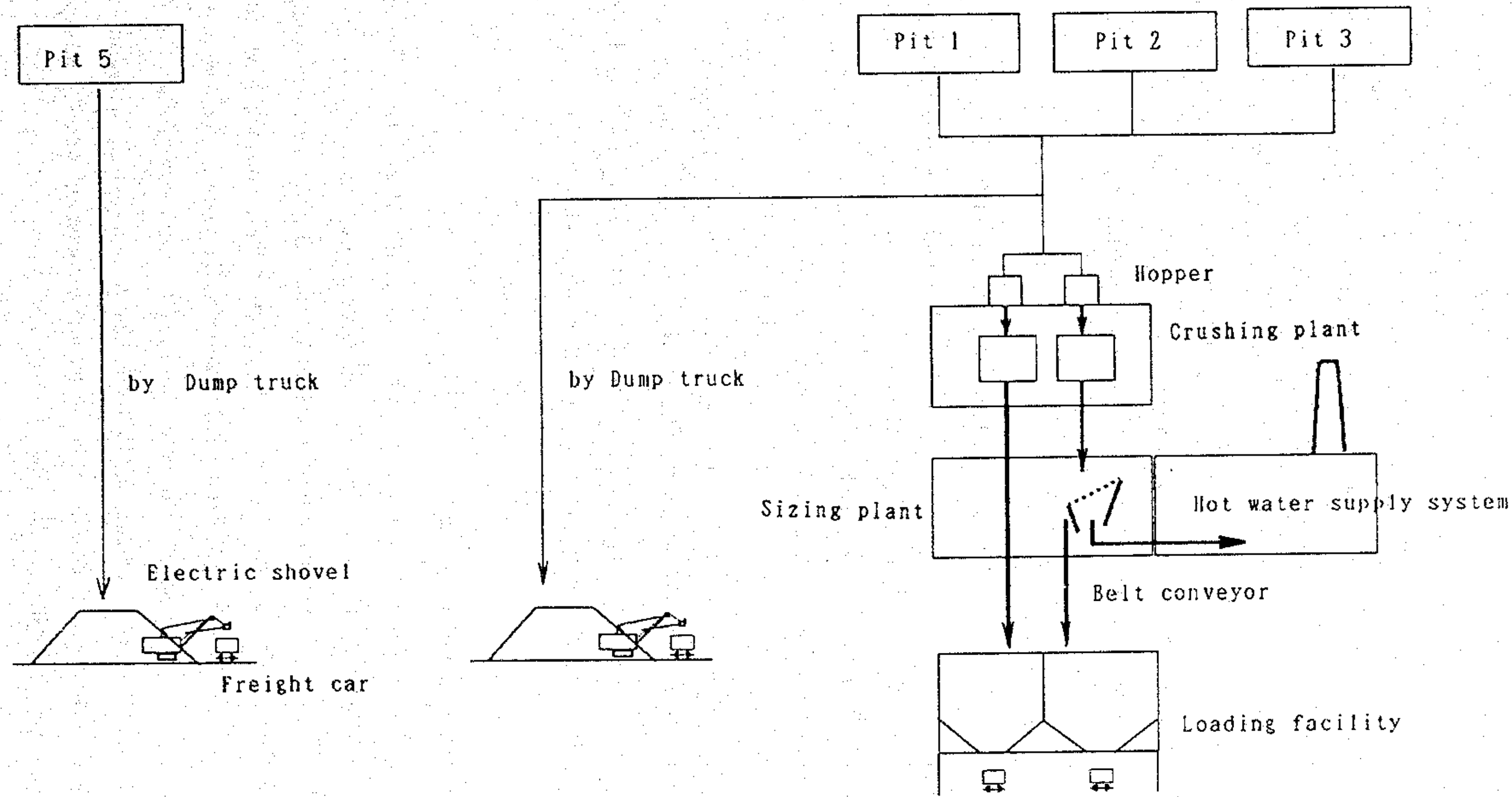



Figure 3.5 Simplified Coal Flow Chart

drilling machines and pumps are operated with 400V. Frequency of the electricity is 50 Hz. There are three transformers at the mine site and total capacity is 60 thousand KVA. The present capacity is still enough for the renovation plan. But some of mining equipment are located far from the transformer and are facing to the problem of low voltage. Introduction of movable transformer with the capacity of 35/6KV, 6,300KVA will be able to solve this problem. Budget of electricity usages was about 45 million kWh in 1993. Tariff of the electricity is 13.2Tg./kWh. In the feasibility study, electric consumption is estimated to be about 130 million kWh for the coal production of 6 million tons. It is better to prepare a generator for emergency in order to maintain minimum production.

(6) Communication

Internal telephone system is utilized for communication in the mine site and the Baganuur city. Although automatic exchanger with 600 lines was installed at the mine office, 400 lines are utilized and only three lines are assigned to connect to the external line. Wireless communication system with four different bands is utilized for earth moving equipment, coal winning equipment, mine management and railway transportation system.

Break down of the communication system is one of the problems. Low power of the wireless communication system is also another problem. Communication at behind the spoil piles or the coal winning areas are not so easy. Komatsu rear dump trucks don't have communication system so far. International telephone service is available although number of the lines are limited.

(7) Water supply and hot water supply

The source of potable water is a well located near the Herlen river. The water is sent to the pump station of the mining complex by pipe line. Distance from the well to the pump station is about 9km. There is a water tank located next to the coal loading tower and potable water is supplied to the mine site via this water tank. Operations of the water supply system are 3 shifts per day. Underground mine water is utilized as an industrial water. There are two lines of hot water supply from the boilers which were constructed in 1982 and 1988. Small size coals screened by the sizing plant are supplied to the boilers as a fuel and the industrial water is also supplied. It is estimated that demand of hot water will increase, therefore, the capacity of hot water supply system needs to be expanded.

(8) Dewatering

Underground water is necessary to be drained before start of overburden removal and is pumped up from the wells by submersible pumps. Annual rainfall of the district is about 260mm and maximum rainfall is about 60mm per day in summer time. There are 23 wells in the first row and other 33 wells are being prepared as the second row. In total, 17 pumps are in operation. Drained underground water is gathered by pipe lines to the sump with the capacity of 1,000 $m^3$. In order to prevent pipe lines from freezing, it is covered by soil. There is a water treatment facility in order to reduce iron contents in the drained water. Three units of 320 kW x 800 $m^3$/hour pumps are installed at the pump station and are used for delivery of the drained water. One unit is for operation and other two units are for standby and maintenance. Half of the drained water is utilized as an industrial water and is delivered to either the hot water supply system or other industrial usages. The remaining half of the drained water is discharged to the Herlen River.

The drainage activities are continued all the year around. Quantity of the drained water is about 800-1,200 $m^3$ per hour and annual quantity is 5 to 11 million $m^3$. There are 17 submersible pumps operating with the capacity of 21.6, 28.8 and 36$m^3$ per hour. Depth of the well is from 70 to 180m. Diameter of the casing pipe is 530mm at the top and 200-275mm at the bottom.

Iron contents in the drained water is high and is prohibited to discharge directly into the Herlen River. Dewatering of the underground water at the mine site may give negative effects on the natural lake named as the Baga Gun. If the drainage quantity is increased, water level of the lake may be lowered.

3.2.3 Current production data

Since 1989, planned total removal of overburden was 65.53 million BCM, but the actual result was 40.91 million BCM which was 62%. Production data from the commencement of production in 1978 are shown on Table 3.3. Production from Pit 5 was commenced although the early development of Pit 5 was not considered on mine plan in the feasibility study prepared by the former Soviet Union. However, Pit 5 was developed by shifting some mining equipment from Pit 1 because demand of coal has been increased in Mongolia.

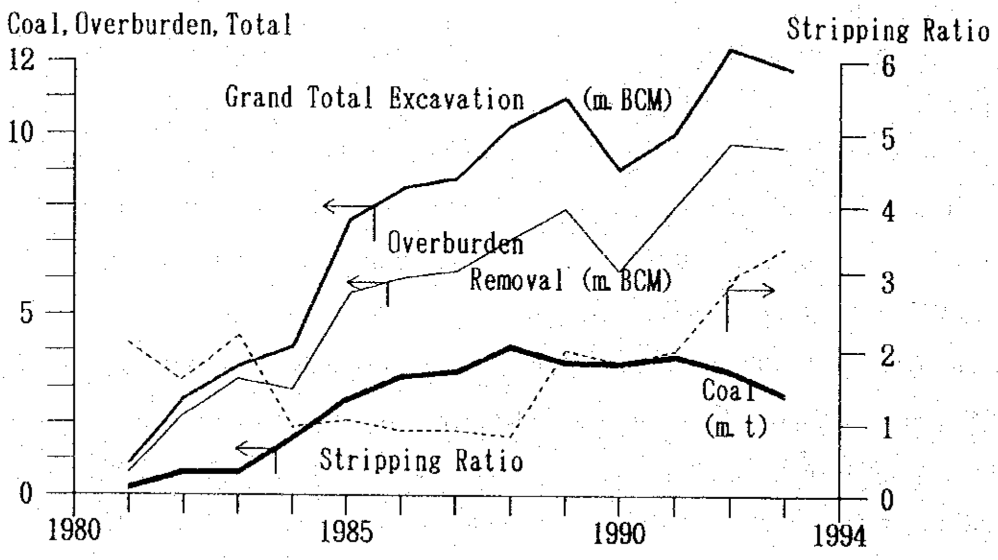



Figure 3.6 Actual Record of Baganuur Coal Mine

### 3.2.4 Organization and manpower

The organization of Baganuur coal mine consists of 6 departments with 26 sections which are shown in Figure 3.7 "Organization Chart".

Total employees were 1,733 as of Nov. 1993, including 37 for hospital and drainage. Manpower for production department was 847. Manpower for general technique department was 280. 1,513 of total employees were directly engaged in production activities. However, 386 employees at the railway department were seemed to be rather too excessive compared with 847 employees at the production department. Excess employees are stemmed from the railway system, and especially from labor intensive works associated with installation and removal of the railway track which is required for removal of overburden.

Regarding to quality and quantity of managers on management and production department, it appears to be adequate. However, there are the shortages of front line supervisors in the production departments and experienced professional engineers in the department of mechanical, electrical and maintenance department. Mining system installed at Baganuur coal mine is technically in high level. Therefore, knowledge and skill of operating those mining equipment are very important for effective and efficient operation of mining system. Education and training of mine

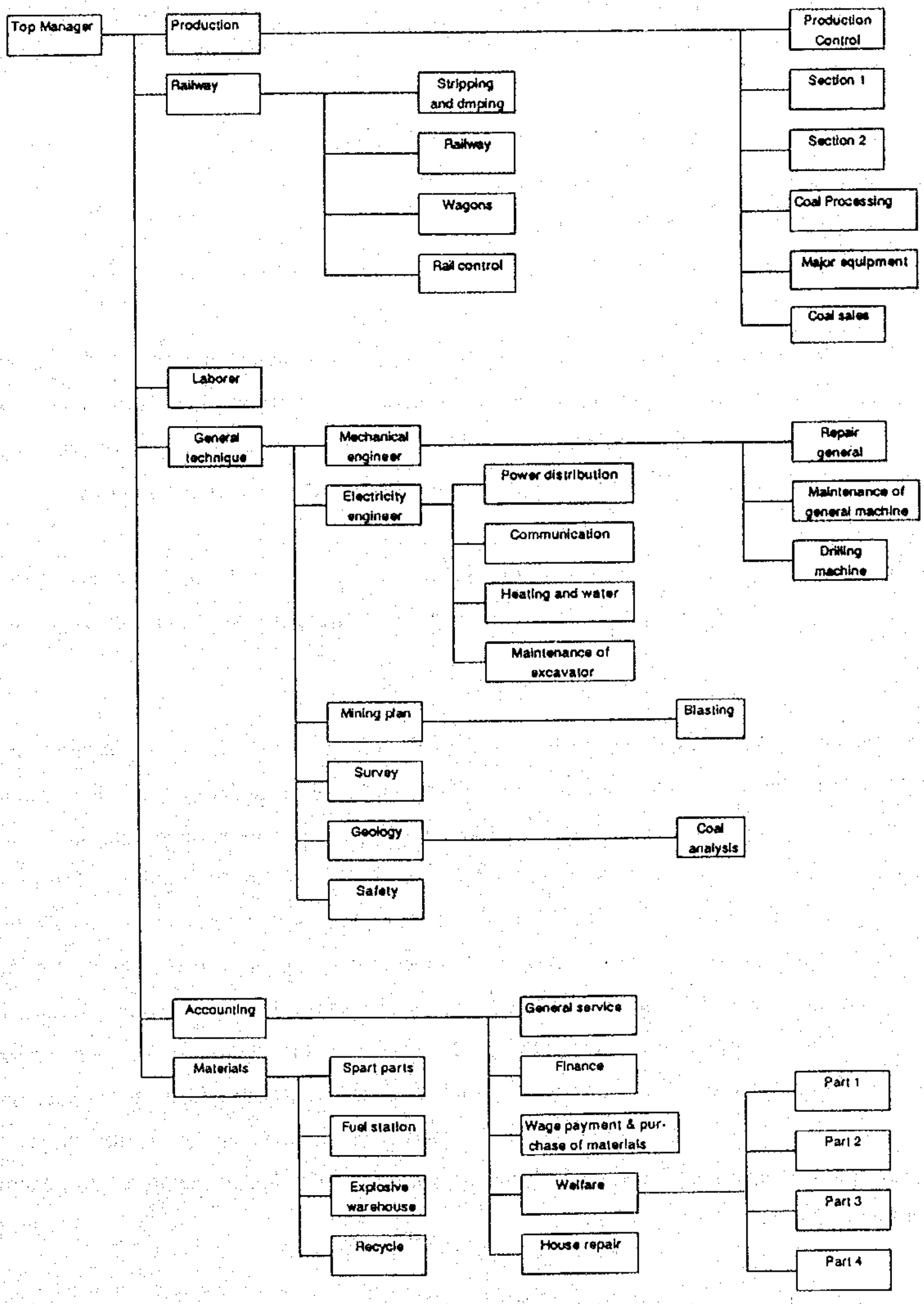



Figure 3.7 Organization Chart

employees are also very important to improve efficiency of operations. At the mine, remarkable efforts have been made by mine management on education and training of employees as following;

- Training of operators for locomotives and excavators
- Driving test for mobile vehicles by traffic police
- Mechanical training by qualified engineers
- Technical course at Mongol University under scholarship of Baganuur coal mine.

Beside the problems of unskilled operators being assigned to mining equipment, data show that stoppages of mining equipment are due to the absence of labors, which indicates that operators have inadequate recognitions on importance of their job at the mine. Certain areas on operating efficiency of mining equipment can be improved by fostering effective motivation of employees.

Problem areas identified in respect of organization and function at Baganuur coal mines are management of coal quality control, procurement of spare parts and maintenance of mining equipment.

Although problem areas on management of coal quality control are studied in the Master Plan, it is recommended that a new independent department should be created to co-ordinate production activities; dewatering schedule of underground water and pumping out surface water in the mining areas, determination of mining area based upon exploration drill (Zone of Oxidize and fresh coal), selection of mining sequence, blending of raw coal at crushing and screening plant, natural drying of raw coal and delivery schedule. Regular weekly meeting should be needed to advise production department coal quality supplied to the power plants in Ulanbaartar and corrective actions to be taken for satisfying specifications of coal quality stated in the contract. The most important function of this department is to ensure that supply of coal is timely with constant coal quality specified in the contract. This objective can be eventuated by containment of total moistures in coal produced. Department head of coal quality control should directly report to the director of Baganuur coal mine.

For the problem areas on procurement of spare parts and maintenance management of mining equipment, a training center should be established to educate and train employees. A computer soft, which is capable of issuing of purchasing order automatically when stock of spare parts reduced to the pre-determined level, must be introduced. Preventative maintenance system, which is based upon conditions of mining equipment, is needed, replacing present method of operating hour based maintenance. The details will be described in a section of training center in the Master Plan.

## 3.3 Issues of present Baganuur coal mine

### 3.3.1 Mining system and equipment

(1) Mining system

Actual results of stripping activity (see Table 3.4) show that total overburden removals was about 10.0 million BCM in 1992 and 1993 against the projected targets of 15.0 and 17.0 million BCM respectively. It is no doubt that performance has been very poor. Studying the results by Pit and stripping method, the following issues must be solved, especially in Pit 2.

1) Issues of stripping system

According to our analysis of production data, there is a big discrepancy between designed stripping capacity and actual capacity, which resulted in decrease of coal production by about 2 million tons per year. The major reasons for this decrease of coal production are identified to be delays on forward stripping work of overburden as well as issues related to transportation of overburden by the railway system.

Delays on removal work of overburden are illustrated in Figure 3.8. Present pit conditions is that forward removal of overburden by the shovel and railway system cannot keep up with the speed of removal of overburden by draglines. Furthermore, rows of pillar of overburden are left unremoved by the shovel and railway system. It is apparent that draglines can not commence removal of overburden until those pillars of overburden are removed by the shovel and truck system, because the floor for draglines must be well levelled. Although the shovel and truck system should be utilized to lower the bench height for draglines, it is now engaged for removal of pillars of overburden due to delays on removal of overburden by the shovel and railway system. Thus, draglines have to remove overburden regardless of the bench height where it can be operated. Therefore, draglines are forced to remove overburden where the bench height is too high for optimum operation. As a result, rehandle of overburden by dragline has been increasing beyond the economic percentage. Double and triple handling of overburden by draglines are required to expose the coal seam, because

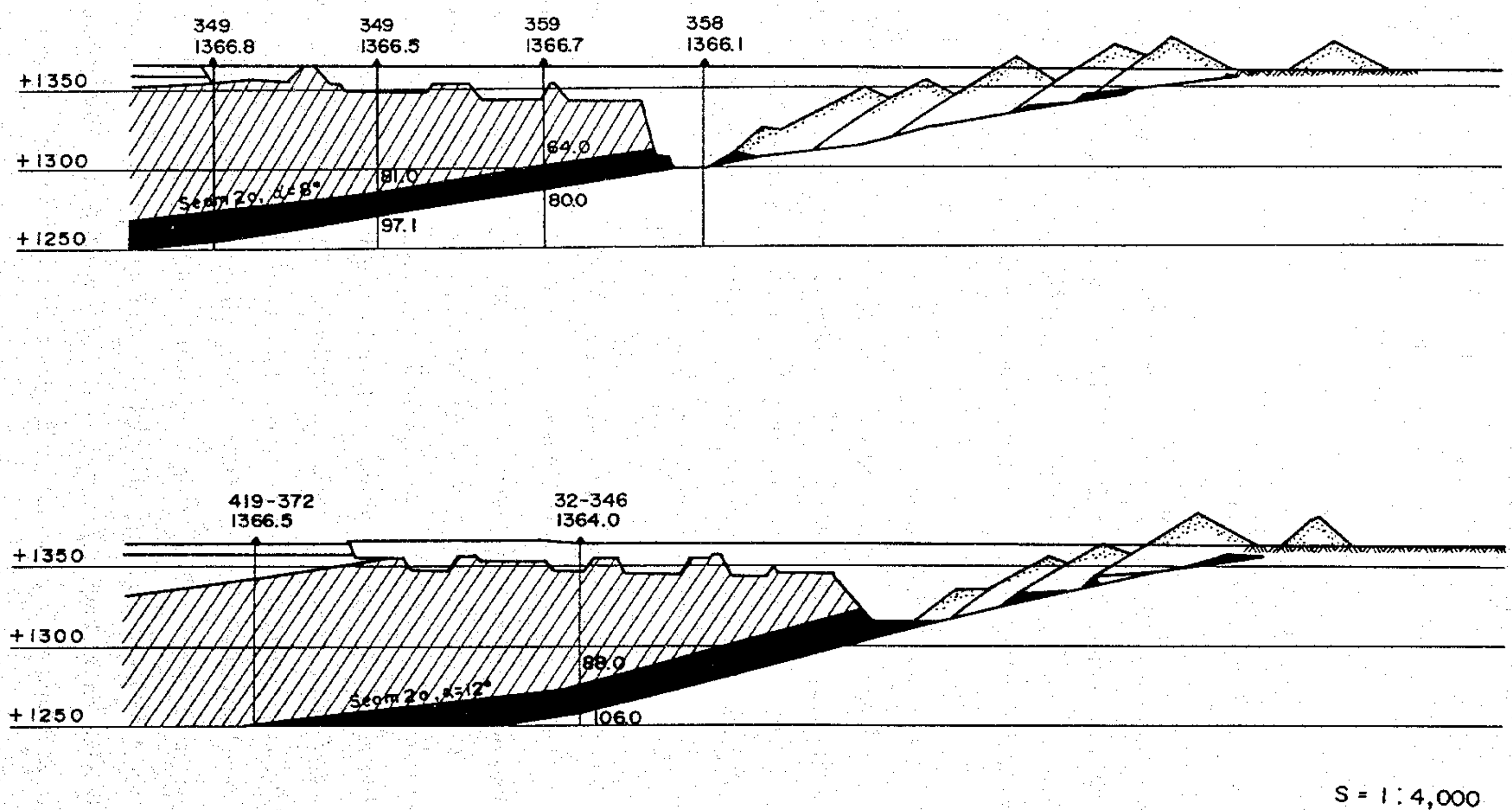



Figure 3.8 Delayed Overburden Removal

delays on removal of overburden by both the shovel and railway system and the shovel and truck system. Those circumstances are the prime reason why coal production has been decreasing in the past.

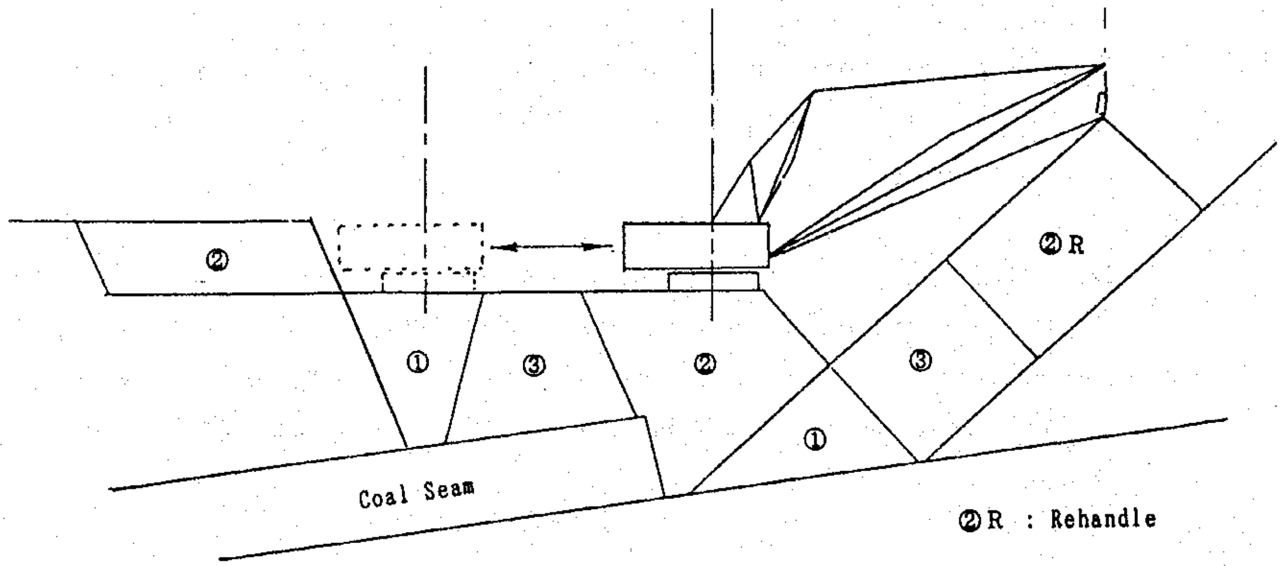
Due to delays in forward stripping of overburden and lack of spoil room in the low wall side, draglines are forced to rehandle, (or triple-handle often) extremely large quantity of overburden. Present rehandle is about 65 % which is generally considered to be too excessive. Delays on forward stripping of overburden are related to the shovel and railway system.

Installation and removal of the railway track and trolley lines are frequently required. Those works are very difficult for employees to carry out in the winter season because of extremely low outside temperature in Mongolia. It is also very difficult to level the ground for installation of the railway track under Mongolian weather such as rain, wind and cold temperature. Safe operation of a unit train has become difficult because the railway track has been installed on the soft and uneven ground or top of the working conditions mentioned above.

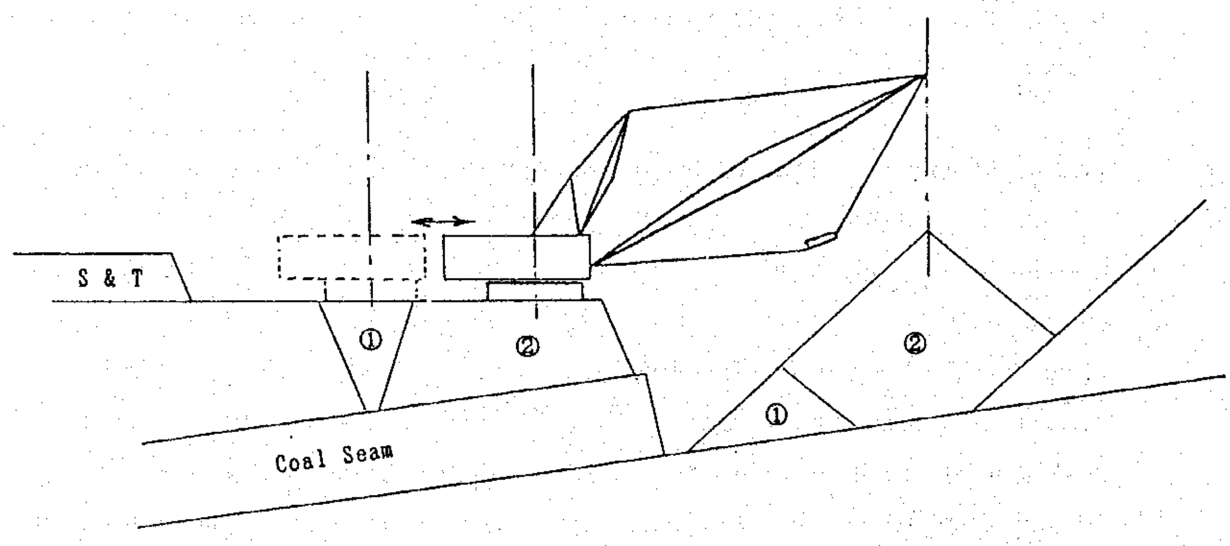
Present problems and proper removal of overburden by draglines are shown in Figure 3.9. It is obvious that the shovel and truck system must be reinforced to increase removal of overburden for reducing bench height for draglines. At present, draglines have to be chopped down prior to removal of overburden because bench height is beyond the capacity of dragline. This type of dragline operation is low productivity and high on rehandling of overburden. It means that less coal is exposed for mining of coal. Therefore, it is proposed that additional fleet of the shovel and truck system must be introduced to carry out forward removal of overburden so as to operate dragline at optimum bench height for decreasing rehandle volume.

2) Shovel and railway

Regarding to the shovel and railway system, it would have much bigger capacity if diesel locomotives were introduced for transportation of overburden. But the current electric locomotives are not so much capable of transporting overburden and necessitate to employ too excessive workers to operate. It also suppress production capacity of electric rope




Issues of Current Dragline Operation




Proposed Dragline Operation

Figure 3.9 Issues of Dragline Operation

shovels as mentioned in the section 3.2.1. On the other hand, scrapping the shovel and railway system would be too costly and wasteful for the time being.

Derailings of wagons on a rainy day are stemmed from poor maintenance of the railway track. To prevent from this kind of troubles, detailed daily inspection is essential. However, it is said that specialists for maintenance of the railway track are not enough and a number of railway specialists have been rather decreasing. When only one railway system is operated from the loading point of overburden to the unloading point of overburden, a point trouble on the railway system can stop a whole transporting system and removal of overburden. In order to make the shovel and railway system more flexible, double or triple railway tracks must be introduced for effective operations. And double and/or triple lines can also minimize waiting time of electric rope shovels for wagons. Such waiting time for wagons directly makes utilization of shovel excavators lower.

The current system is not so flexible against the troubles due to the long line of a single railway truck where any troubles can stop the whole operation. Other issues are as follows:

- Too many workers are employed for shifting temporary railway tracks and the maintenance which also takes rather a long time.
- Operations of railway system are not stable due to inadequate capability of workers which makes trains easier to derail. This trouble comes from decreasing skilled engineers, labors, lack of worker's motivation for their jobs and responsibility.
- Lack of railway tracks (double and/or tipple).
- Insufficient training of locomotive drivers
- Poor maintenance due to lack of spare parts.

All in all, availability of electric rope shovels is very low due to the shortage of spare parts. This is one of the critical reasons why efficiency of the railway system is so low.

3) Maintenance of mining equipment

In case of break down of Russian mining equipment, it is necessary to ask Russian engineers (mechanical or electrical specialist) to inspect the conditions of break down and to supervise the repair works. For example, dragline 90/20 was left without any repair work for 4 months, waiting Russian engineers to visit Baganuur coal mine in 1993. This typical case shows the importance of maintaining experts and the management is trying to increase those specialists through education and training with own expenses.

Generally speaking, acquiring skills of operation for the major mining equipment necessitates many years. However, such training period for operators has been less than a few years at present. Skilled operators for the major mining equipment are dominant factor to obtain effective results of operation and to sustain high availability of equipment. It can be said that utilization of mining equipment (electric rope shovels, rear dump trucks and locomotives) are expected to deteriorate year by year due to lack of spare parts and present poor maintenance practices.

4) Countermeasures to solve present issues

The following countermeasures must be implemented by renovation of Baganuur coal mine in order to increase production capacity of coal to 6 million tons per year.

- To increase removal of overburden by the shovel and railway subsystem. It can be accomplished by reviewing the length of railway track.
- To supplement removal of overburden by the truck and shovel system. Introduction of new medium size trucks and shovels is recommended for additional removal of overburden.
- To reduce rehandling volume of overburden by draglines. It is possible to reduce rehandling volume of overburden by lowering bench height of overburden for draglines.

(2) Mining equipment

1) Drilling equipment for overburden

Analysis of operating hours shows that utilization of drilling equipment is not so high due to low efficiency of electric rope shovels. Thus, frequency of the blasting of overburden is limited. Because removal of overburden has not been carried out systematically, a number of small pillars are left. It is difficult to drill blast holes for those pillars by drilling machine currently operated.

2) Dragline

Analysis of operation hours shows that down time and waiting time for spare parts are so long and availability are low. Utilization of stripping draglines is high enough, while utilization of waste dump dragline is low due to the low efficiency of the railway system. 20/90 dragline experienced long down time in 1993. It happened because the maintenance manual was not available and the important parts had not been changed periodically. Delay of removal of overburden by draglines was about 2 million BCM in the past two years.

3) Excavator for overburden removal

Availability of electric rope shovels is low, mainly caused by the shortage of spare parts. Low efficiency is one of the main reasons, stemming from low efficiency of the railway system.

4) Railway system

In original design of F/S done by INPS of the former Soviet Union, hybrid type of diesel and electric locomotives were planned to be introduced, but this kind of locomotives were not available from the former Soviet Union at that time. So electric locomotives were introduced instead of diesel and electric locomotives. In case of electric locomotives, it is necessary to install and remove the trolley lines. This is one of the reasons for high labor intensive works and low efficiency at present. Sharyngol coal mine is using diesel locomotives and productivity by the railway system is about 3 times of Baganuur coal mine. Of course, electric system has economical merits because imported fuel does not have to be used. As availability of electric rope shovels is very low due to the shortage of spare parts, this is one of the reasons for low efficiency of the railway system.

Considering the total railway system, the present system is not so efficient. Cycle time for both $8m^3$ shovel and $4m^3$ shovel are studied. Figure 3.10 shows the result of cycle time study. Of course, loading time of the bigger shovel is shorter than the smaller shovel. On the other hand, dumping time have no relation with the size of loading shovel. Dumping time is shorter than the loading time. After dumping the material, wagons will return to the loading site. But another fleet of wagons are still loading the materials. So one fleet of the wagon has to wait at the outside of the pit . This is one of the low efficiencies of the system. In case of $8m^3$ shovel, the loading capacity of shovel itself is about 2.4 million BCM per year for

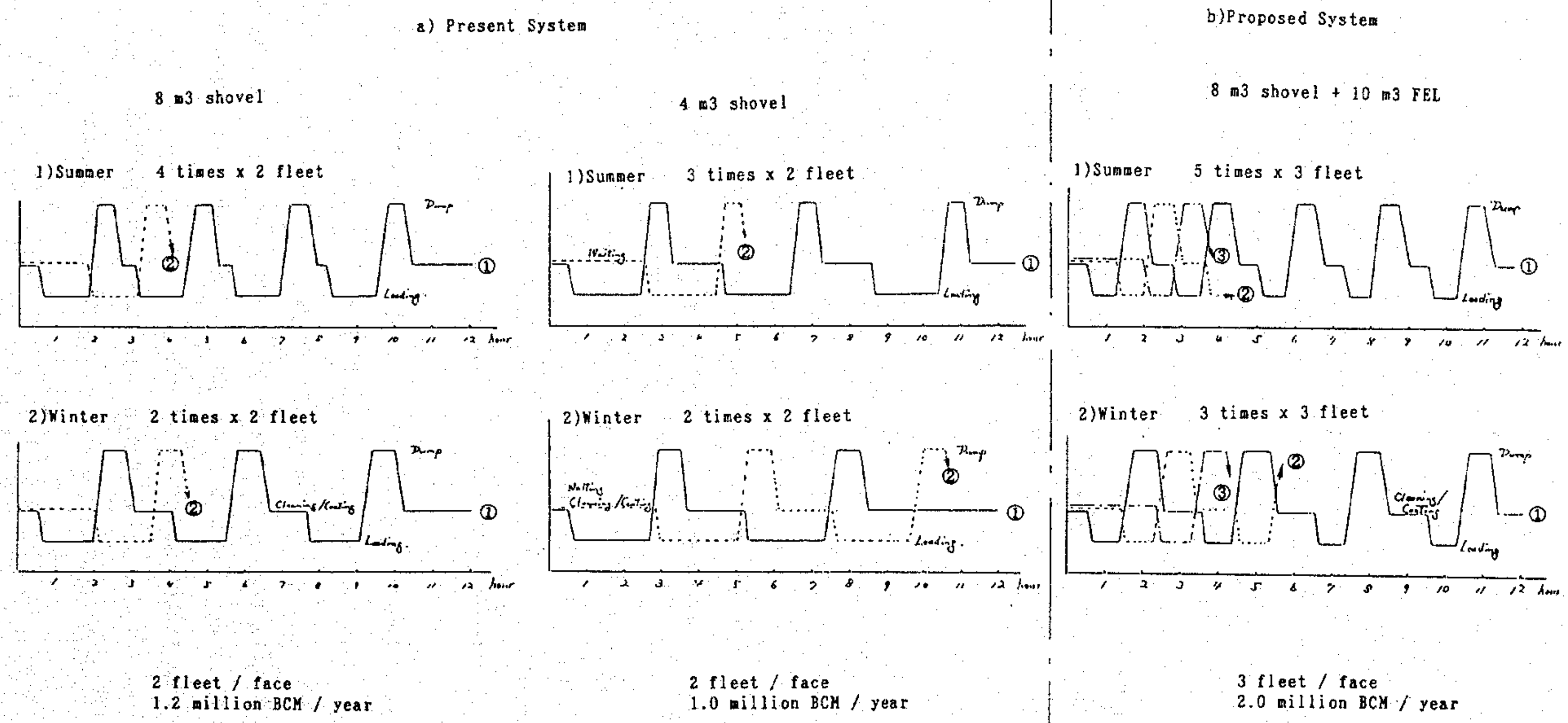



Figure 3.10 Cycle Time of Proposed Railway System

shovel and truck system. But due to the long waiting time for the wagon, loading capacity is only 1.2 million BCM. This problem can be solved by using much bigger shovel because the loading time will be shorter. Another alternative is to use two loading shovels for wagon loading. If FEL will be used as a supplemental loading equipment, three fleet of the wagons can be allocated for one bench, and the loading capacity of one face can be estimated to improve until 2 million BCM per year.

5) Rear dump truck for overburden transportation

Due to the hard operating conditions, operating life of Russian rear dump trucks is around 2.5 years. Main areas of the break down are transmission, engine and suspension. In case of Komatsu rear dump trucks, the equipment are not so old and conditions are still good. But purchase of consumable parts is difficult due to the shortage of repair funds. Main part of break down is suspension. Analysis of operating hours shows that break down and waiting time of spare parts are so long for Belaz rear dump trucks. If the old equipment is replaced and supplies of spare parts are smoother, availability and productivity can be improved. In case of Komatsu rear dump trucks, waiting time for spare parts is also long.

6) Drilling equipment for coal seam

Analysis shows that utilization is low. Due to delay of overburden removal, blasting of exposed coal is limited.

7) Electric rope shovels for coal winning

Utilization of electric rope shovels is low while availability is not so low. It is caused by delays in removal of overburden.

8) Rear dump truck for coal transportation

The rear same dump trucks are operated for transportation of overburden and coal. Availability is low due to the shortage of spare parts. Rear dump trucks are originally for transportation of overburden and size of the vessel is rather small. Rate of fuel consumption is less than coal hauler which has a larger size vessel and the same engine power.

9) Supporting equipment

Ideally it is better that draglines are supported by bulldozers. If bulldozers support draglines, rehandle of draglines can be reduced and productivity can be increased. Floor of the coal mining area is not cleaned and this is the reason for damages of the tire. Maintenance of the hauling road is essential for effective transportation. Water truck, crane and other service equipment are also important to keep the production.

3.3.2 Surface facilities

1) Workshop

Scheduled maintenance and preventive maintenance are supposed to be carried out at Baganuur coal mine. But due to the shortage of spare parts, sometimes it is difficult to replace the parts by the scheduled interval. Most of the parts can be purchased if the funds are available. Due to the recent violent inflation, it is difficult for the coal mine to prepare the necessary funds for purchase of spare parts. Another problem is a lack of maintenance manual for the Russian equipment. For example, the production of 20/90 dragline was ceased for 6 months in 1993. Preventive maintenance was not carried out because maintenance procedures were not known.

2) Warehouse

Many kinds of lubrication oil and large spare parts are stored outside of the warehouse. Quantity of parts is checked by a computer system, but the system is not updated. The system cannot output the timing of purchase order. Every item has a purchasing interval which depends on the consumption rate and delivery time. Due to the shortage of the funds for spare parts, purchasing of parts is delayed and it causes break down of equipment.

3) Coal stock yard

Coal stock facility for the permanent loading site is not utilized at the moment. Stock yards for temporary loading site are necessary to be improved by introducing a mobile crushing plant.

4) Sizing and loading

Selective mining is carried out at the mining pits, however, the thin partings in the coal seams are not separated. This is one of the reasons why salable coal has high ash contents and low calorific value. Iron materials are separated by the magnet catchers and other foreign materials are manually removed. From the economical point of view, a temporary loading site is located at Pit 2 and Pit 5. Pit 5 is located so far from the sizing plant, but it is not so in the case of Pit 2.

5) Electric supply

Mining equipment is facing with problems of low voltage. Distance from the transformers to the equipment is too far compared with the designed distance. As almost all of mining equipment is electric equipment, the mine cannot continue production in the event of electric failure.

6) Communication

Power rate of the wireless communication system is not high enough. Maximum talking distance is said to be 15 km but the actual distance is around 10 km. It is difficult to communicate between the operation center and some mining areas, especially the areas behind the dragline spoils and the coal winning face.

### 3.3.3 Funds

With respect to the present mining equipment and facilities utilized at Baganuur coal mine, annual funds have been accumulated for replacement and major overhaul. Ratio of replacement and overhaul in annual funds is said to be 60:40. However, those accumulated funds are not only in sufficient to replace equipment due to recent high inflation but also withdrawn for purchase of spare parts. As the matter of fact, those accumulated funds in the past have already been all expended. Therefore, additional capital is required for replacement and overhaul. Projection of the required funds is shown in Table 3.15.

Present price of the Russian equipment is very expensive compared with the past price and price of the spare parts is also getting expensive. Revalued total price of main equipment is estimated to be around 87 million US$ at the current price level. As shown in Table 3.15, about 6 million US$ is required for annual purchasing of spare parts, but only 2 million US$ is spent for the actual purchasing at present.

## 3.4 Evaluation of production capacity of existing coal mine

### 3.4.1 Operating efficiency

Analyses of operation data show that operating efficiency of each mining equipment is rather lower than the desired efficiency (see Table 3.12). Efficiency of the locomotives in the railway system is especially low, and this fact indicates that the railway system is a fundamental defect of the existing mining system.

Table 3.12 Efficiency of Mining Equipment

%, as of 1992

| Equipment | Existing equipment | | | Desired Efficiency |
|---|---|---|---|---|
| | Availability | Utilization | Efficiency | |
| Dragline | 74-90 | 67-93 | 61-78 | 77 |
| Electric shovel | 65-94 | 58-82 | 49-76 | 72 |
| Locomotive | 50 | 56 | 28 | 51 |
| Truck | 77 | 85 | 67 | 68 |

### 3.4.2 Improvement of existing coal mine

Analyses of operation data show that 11.9 million BCM per year of the current mining capacity can be increased to 17.3 million BCM per year by resolving above-mentioned issues, however, improved capacity of 17.3 million BCM/y is still lower than the design capacity of 21.7 million BCM per year.

Table 3.13 Capacity of Existing Baganuur Coal Mine

million BCM per year

| | Designed value | Current/actual | Improved/estimated |
|---|---|---|---|
| Dragline | 4.7+Rehandle | 5.5+Rehandle | 7.7+Rehandle |
| Shovel/railway | 12.3 | 2.0 | 3.6 |
| Shovel/truck | 4.7 | 4.4 | 6.0 |
| (Coal) | (4.7) | (2.2) | (3.1) |
| (Overburden) | (0.0) | (2.2) | (2.9) |
| Total | 21.7 | 11.9 | 17.3 |

After proposed additional fleet of shovel and truck system is introduced, prestripping of the overburden will be carried out by this shovel and truck system. In this case, dragline handling capacity can be increased from 7.7 to 8.5 million BCM with reduced rehandle ratio.

Shovel and railway system will be able to increase the handling capacity from 3.6 to 4.0 million BCM after introducing FEL. In total, 18.5 million BCM is expected for the existing equipment.

In addition to improvement of mining system, improvement of the supporting equipment and facilities are also required. The improvement of supporting equipment and facilities is recommended to be carried out in two stages. The first stage is to improve the existing system, and the second stage is to expand the mine. Table 3.14 shows the additional facility list for improvement of the existing system. About 11 million US$ is required for this investment. Years for installing equipment are also indicated in the Table 3.14.

Item A shows the required investment for workshop. Workshop tools described in Section 3.2.2 (1) are required to be introduced. And also, usual workshop tools are necessary as supplements.

Item B shows the required investment for warehouse. As mentioned in Section 3.3.2 (2), the computer system for spare parts management is not an updated system. In order to control the purchasing number and timing, more updated computers will be required.

Item C shows the required investment for stockyard of Pit 2 and Pit 5. As mentioned in Section 3.2.2 (3), preventive apparatus for spontaneous combustion at the coal stock yard will be required. For this purpose, watering system with water pipe and sprinkler must be introduced. Currently coal handling at the stock yard is not carried out efficiently. In order to solve this problem, Dozer shovels are required for each stock yard.

Item D shows the required investment for sizing and loading facilities. As mentioned in Section 3.2.2 (4), crushing facilities are not installed at loading sites of Pit 2 and Pit 5. This causes complaints regarding the coal size from the users. In order to supply the required size of coal, crushing plant must be introduced. Concept of the crushing plant is described in Figure 4.5. At the loading site, wagons are hauled by locomotive and the work is not an efficient one. Electric car puller can haul the wagon without using the locomotive. In order to support the 5 $m^3$ shovel which is used for wagon loading, one unit of dozer shovels must be introduced for each loading site.

Item E shows the required investment for power distribution. As described in Section 3.2.2 (5), the equipment located far from the sub-station is facing to the low voltage problem. In order to solve this problem, two units of movable transformers with a capacity of 36/6kv will be required. High voltage cables are also required for this new power distribution system. Concept of this modification is shown in Figure 4.6. In case of electric failure, it is impossible to operate almost all of the electrical equipment and facilities. In order to avoid such risks, introduction of two units of generators are recommended.

Item F shows the required investment for communication system. As mentioned in Section 3.2.2 (6), the current communication system has not enough power to communicate between mine office and equipment. High power wireless communication system for each mobile equipment and facilities as well as base station for the office will be desired.

Item G shows the required investment for drainage and water treatment system. As mentioned in Section 3.2.2 (8), dewatering activity before mining must be carried out. Drainage at two years before mining by wells, submersible pumps and pipe lines are necessary every five years. About 30 wells are estimated to be necessary as well as pumps and pipe lines. Mining area goes deeper and deeper, and well experienced boring constructors will be employed. This is the reason of the high cost works. Based on the existing contract data, 4 million US$ is estimated for this work. This is including the cost for water treatment facilities which will remove the iron contents of the underground water.

Item H shows the required investment for supporting equipment. Bulldozers are required for general purpose. Two units of Front End Loaders are required for selective mining which will contribute to the quality control. Two units of drill rigs with universal arm will be utilized for overburden blasting especially for remained pillars by unsystematic mining operation. In order to confirm the geological conditions, exploration machine with coring facilities are required. Water trucks are for watering to the road and pit. Service trucks are necessary as supplements for general purposes. In order to supply the good quality coal, a quality control system is also required. This investment is including laboratory facility, on line analyzer, etc. This matter will be described in Section 5.

### 3.4.3 Spare parts

To achieve above-mentioned improved capacity, spare parts, maintenance specialists and supporting facilities must be available as fundamental conditions. Table 3.15 shows the required parts cost for the existing equipment. Around 6 million US$ per year is necessary for purchase of spare parts purchasing at the present equipment price level. Those spare parts costs for the existing equipment are getting higher year by year and estimated to increase to 16 million US$ per year in the near future. Those spare parts costs include spare parts for overhaul and repairing, and consumables. For locomotives, wheels, engines and transmissions, compressors, etc. are included. For shovels, wire ropes, bucket tooth, motors, etc. are included. For wagons, wheels, air cylinders, etc. are included. For draglines, wire ropes, bucket tooth, motors, etc. are included. For crushing plants, conveyor rollers, belts, screens, etc. are included. For bulldozers, engines, and transmission parts are included. For dump trucks, engines, and transmission parts as well as tires are included.

Table 3.14 Required Supporting Equipment for Improvement of Existing System

| | Description | Unit Price US$1000 | Number of unit required | Initial Investment US$1000 | Life years | Yearly cost US$1000/y | Year to be Installed |
|---|---|---|---|---|---|---|---|
| A. | Workshop | | | | | | |
| | Workshop tools | 255 | 1 | 255 | 6 | 43 | 1996 |
| | Total item A | | | 255 | | 43 | |
| B. | Warehouse | | | | | | |
| | Computer system | 60 | 1 | 60 | 6 | 10 | 1996 |
| | Total item B | | | 60 | | 10 | |
| C. | Coal stock yard (Pit 5) | | | | | | |
| | Watering system | 43 | 1 | 43 | 10 | 4 | 1996 |
| | Dozer shovel 250 HP | 306 | 1 | 306 | 8 | 38 | 1996 |
| | Total item C | | | 349 | | 42 | |
| C'. | Coal stock yard (Pit 2) | | | | | | |
| | Watering system | 43 | 1 | 43 | 10 | 4 | 1996 |
| | Dozer shovel 250 HP | 306 | 1 | 306 | 8 | 38 | 1996 |
| | Total item C' | | | 349 | | 42 | |
| D. | Sizing & Loading (Pit 5) | | | | | | |
| | Crushing plant | 425 | 1 | 425 | 15 | 28 | 1996 |
| | Car puller | 170 | 1 | 170 | 10 | 17 | 1996 |
| | Dozer shovel 250HP | 306 | 1 | 306 | 8 | 38 | 1996 |
| | Total item D | | | 901 | | 83 | |
| D'. | Sizing & Loading (Pit 2) | | | | | | |
| | Crushing plant | 425 | 1 | 425 | 15 | 28 | 1996 |
| | Car puller | 170 | 1 | 170 | 10 | 17 | 1996 |
| | Dozer shovel 250HP | 306 | 1 | 306 | 8 | 38 | 1996 |
| | Total item D' | | | 901 | | 83 | |
| E. | Power distribution | | | | | | |
| | Movable transformer(35/6KV) | 167 | 2 | 334 | 10 | 33 | 1996 |
| | Cable | 85 | 1 | 85 | 10 | 9 | 1996 |
| | Generator for emergency | 204 | 2 | 408 | 15 | 27 | 1996 |
| | Total item E | | | 827 | | 69 | |
| F. | Communication | | | | | | |
| | High power wireless system | 128 | 1 | 128 | 8 | 16 | 1996 |
| | Total item F | | | 128 | | 16 | |
| G. | Drainage & water treatment | | | | | | |
| | Drainage and treatment system | 4,000 | 1 | 4,000 | 5 | 800 | 1996 |
| | Total item G | | | 4,000 | | 800 | |
| H. | Supporting equipment | | | | | | |
| | Bulldozer 400HP | 524 | 1 | 524 | 8 | 66 | 1996 |
| | Bulldozer 200HP | 306 | 1 | 306 | 8 | 38 | 1996 |
| | Front End Loader 5 m3 | 408 | 2 | 816 | 8 | 102 | 1996 |
| | Drill rig | 459 | 2 | 918 | 8 | 115 | 1996 |
| | Exploration machine | 102 | 1 | 102 | 8 | 13 | 1996 |
| | Water truck | 102 | 2 | 204 | 8 | 26 | 1996 |
| | Service truck | 51 | 5 | 255 | 8 | 32 | 1996 |
| | Quality monitoring system | 200 | 1 | 200 | 8 | 25 | 1996 |
| | Total - item H | | | 3,325 | | 417 | |
| | Total item A-H | | | 11,095 | | 1,605 | |
| | Local cost | | | 2,219 | | 321 | |
| | Grand total item A-H | | | 13,314 | | 1,926 | |
| | Capital for 20 years | | | | | 38,520 | |
| | Production (thousand ton) | 4,000 | | | | | |
| | Capital / ton | | | | | 0.5 | |

Table 3.15 Required Spare Parts Cost for Existing Equipment

| Name of the Item | unit | Original unit price (1000 Tg) | Current unit price (1000 US$) | Required Parts (%) | Parts cost (1000 US$/y |
|---|---|---|---|---|---|
| Electric Locomotive | 10 | 22,496 | 1950 | 1.4 | 273 |
| Steam Locomotive | 5 | 5,522 | 479 | 9.4 | 225 |
| Wagon | 106 | 398 | 36 | 5 | 191 |
| D/L 20/90 | 1 | 45,800 | 6000 | 7.8 | 468 |
| D/L 15/90 | 1 | 5,080 | 5500 | 7.8 | 429 |
| D/L 10/70 | 2 | 14,753 | 4500 | 7.8 | 702 |
| D/L 13/50 | 3 | 49,200 | 3500 | 7.8 | 819 |
| Shovel 8u | 4 | 6,700 | 1450 | 7.8 | 452 |
| Shovel 4y | 2 | 4,200 | 1300 | 7.8 | 203 |
| Shovel 5A | 5 | 5,080 | 676 | 7.8 | 264 |
| Shovel 4.6b | 4 | 3,800 | 600 | 7.8 | 187 |
| Drill 160 | 8 | 1,400 | 200 | 3 | 48 |
| Crushing plant | 1 | 50,000 | 2000 | 2.5 | 50 |
| Bulldozer DET250, 110 | 10 | 700 | 90 | 11 | 99 |
| Bulldozer Komatsu | 6 | 10,954 | 400 | 14 | 336 |
| D/T Belaz | 19 | 829 | 80 | 11 | 167 |
| D/T Komatsu | 20 | 10,000 | 380 | 14 | 1,064 |
| Grand total (US$) | | | | | 5,977 |
| Local cost (35%) | | | | | 2,092 |
| Grand total | | | | | 8,069 |

# 4 Renovation Study of Baganuur Coal Mine

## 4.1 Study of effective mining system

In this Section, a number of effective mining systems are studied and then the best mining system is chosen for renovation.

### 4.1.1 Mining equipment and application

Targets of the study is to select and find the required numbers of mining equipment which will enable Baganuur coal mine to increase 2.0 million tons of coal.

At first, production capacity of coal will be restored to about 4.0 million tons per year by rehabilitation of the existing mining equipment, providing all required spare parts and reducing rehandle volume of overburden by draglines. In order to increase production capacity of coal to 6.0 million tons per year, three cases of mining methods are studied. In stead of the present Russian prices of mining equipment and spare parts, the international prices are utilized for comparison of options examined.

Possible and effective mining systems are as follows;

1) Shovel and railway system

As mentioned already, the railway system has not been effective. These results stemmed from the lack of specified locomotives (diesel locomotive) and confinement of flexibility through the whole systems from the working faces to the dumping area. Two working levels of bench near the surface for this system are proposed, instead of current 3 or 4 levels. The railway should be shortened to less than 3.2 km (within Pit 2) from the end of the fixed railway track. A front end loader can be operated together with an electric rope shovel. Such combined system will enable to make width of the working face wider by 20 more meters so that double tracks of railway can be laid if necessary.

2) Shovel and truck system

The system can be applied on any portion of overburden, interburden and coal seam. Larger size of rear dump trucks and bigger size of buckets for electric rope shovel are proposed, because present sizes of rear dump trucks and electric rope shovels are rather small compared with those utilized in the western countries.

3) Dragline system

Dragline with the bigger size of bucket capacity is most suitable for the portion C (See Fig.4.1).Dragline is quite effective for removal of overburden. However, because of high initial capital cost, the use of draglines should be supplemental to production by rear dump trucks and electric rope shovels. Dragline with the bigger size of the bucket was studied to achieve faster face advancement. But delays in operations of forward stripping will prevent from such faster bench advance by draglines unless removal of overburden by forward stripping goes well.

4) Bucket Wheel Excavator

Though this system can be applied on any portions of overburden and interburden removal and coal mining, it is most suitable to use overburden removal in the Baganuur Coal Mine. If this system is adopted, there are two methods for transportation and discharge of overburden which is excavated by Buket Wheel Excavator. One of them is to utilize the existing railway system and the other is not to utilize it. In case of the former system, a loading facility for transshipping to wagons from the belt conveyors and belt conveyors for transporting overburden to this facility should be installed. In case of the latter system, a discharging facility for spreading overburden in the spoil area and longer belt conveyors for transporting overburden to discharging facility should be installed. If the former system will be introduced, Buket Wheel Excavator could not operated continually because the capacity of railway system is lower than that of Buket Wheel Excavator. Therefore, If Buket Wheel Excavator will be introduced, the latter system should be selected. In any case, introduction of this system will require high initial cost.

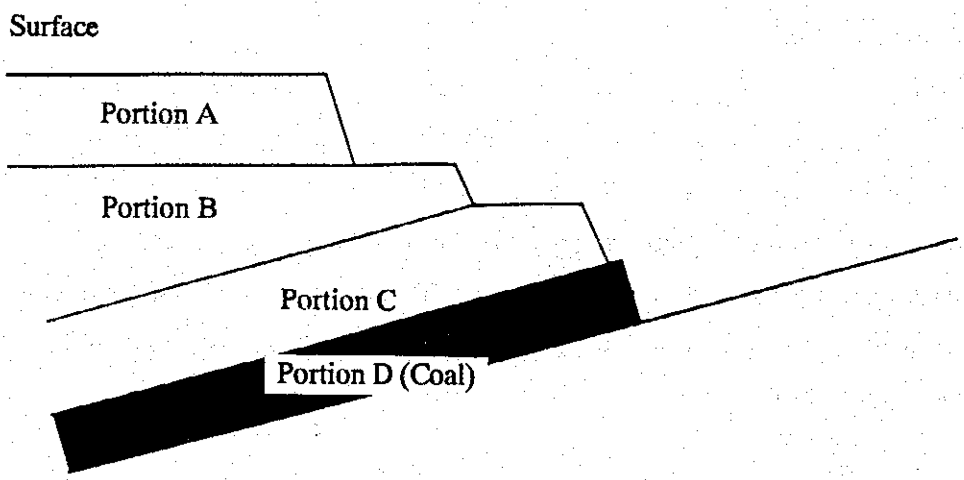
General application concepts of possible and effective mining system for removal of overburden and extraction of coal are shown in Figure 4.1. Sequence of mining activities are as follows;

Portion A - Removal of overburden by electric rope shovel and railway system or bucket wheel excavator system with belt conveyor

Portion B - Removal of overburden by fleets of electric rope shovels and rear dump trucks

Portion C - Removal of overburden by draglines

Portion D - Extraction of coal by fleets of electric rope shovels and rear dump trucks




Desired Adoption of Mining Equipment

| System | Dragline | Shovel & Railway | Shovel & Truck | BWE |
|---|---|---|---|---|
| Portion A | × | ○ | ○ | ○ |
| Portion B | × | × | ○ | ○ |
| Portion C | ○ | × | ○ | ○ |
| Portion D (Coal) | × | × | ○ | ○ |

Combination of mining equipment

| | : Case A | : Case B | : Case C | : Case D |
|---|---|---|---|---|
| Portion A | :Shovel & Railway | :Shovel & Railway | :Shovel & Railway | :Shovel & Railway |
| Portion B | :Shovel & Truck(S) | :Shovel & Truck(M) | :Shovel & Truck(L) | :BWE |
| Portion C | :Dragline | :Dragline | :Dragline | :Dragline |
| Portion D (Coal) | :Shovel & Truck | :Shovel & Truck | :Shovel & Truck | :Shovel & Truck |

Note (S) : Small size (M) : Medium size (L) : Large size

Figure 4.1 Desired Adoption and Combination of Mining Equipment

### 4.1.2 Study of effective mining system

#### (1) Basis for economics comparison

Tax, interest and royalty are not included in this cost comparison studies.

The following energy prices are used in cost comparison studies;

| | | | |
|---|---|---|---|
| Diesel oil | : | International price | (169 US$/t) x 1.1 |
| Gasoline | : | " | (186 US$/t) x 1.1 |
| Coal | : | " | (15.7 US$/t) x 0.7 |
| Electricity | : | " | (0.062 US$/Kwh) x 0.9 |

Note : ( ) shows prices (FOB) as of the end of 1993

(2) Economics of existing mining system

The present mining system and equipment have some said technical and economic advantages for use in Mongolia, particularly in operationability in cold weather conditions and less consumption of petroleum products as driving energy. However, it has been identified that delays on forward stripping of overburden is resulted from low utilization of the railway system which is described in details in the chapter 3.3.1, (1), 2) Shovel and railway. Therefore, replacement of the present railway system for transportation of overburden was examined to overcome the problems to restore production capacity of coal. One option is to replace the present railway system with a new shovel and truck system. The results of comparative study in terms of economic index are shown in Table 4.1.

Table 4.1 Comparison Study of Economics Indexes

| Cost index | unit | Existing system | | | New system |
|---|---|---|---|---|---|
| Mining system | | Railway | Others | Total | Shovel & Truck |
| Base(capacity) | m.BCM/y | 3.6 | 13.7 | 17.3 | 12.6 |
| Operating cost | m.$/y | 5.6 | 18.3 | 23.9 | 14.4 |
| Spare parts | | (4.6) | (12.5) | (17.1) | ( 8.5) |
| Consumable | | (1.0) | ( 5.8) | ( 6.8) | ( 5.9) |
| Capital cost *1 | m.$/y | 7.2 | 14.7 | 21.9 | 8.4 |
| Equipment | | (6.4) | (12.6) | (19.0) | ( 7.8) |
| Labor etc. | | (0.8) | ( 2.1) | ( 2.9) | ( 0.6) |
| Total cost | m.$/y | 12.8 | 33.0 | 45.8 | 22.8 |
| Cost index | | | | | |
| Before life span *2 | | 1.8 | 1.4 | 1.5 | - |
| With replacement *3 | | 3.6 | 2.4 | 2.6 | 1.8 |

Note *1 : Tax and interest are not included in estimate of annual capital cost.
*2 : Cost index does not include replacement cost of the existing equipment and railway system.
*3 : Cost index includes the periodic replacement cost of the equipment and the railway system.

The results of economic comparison between the existing systems including railway system and a new mining system of truck and shovel shows the following conclusions:

- Immediate replacement of the railway system is not economical. However, it should be replaced with a new mining system of truck and shovel when operating life of the railway system ends.
- When operating life of the existing equipment ends replacement by the Russian made equipment is not economical.

(3) Basic plan of overall mining system

The overall present mining system was reviewed and the following basic mining systems are evaluated to overcome the issues of removal of overburden.

| | |
|---|---|
| Overburden removal of shallow zone | : Existing shovel, FEL and railway |
| Overburden removal of middle zone | : New additional system |
| Overburden removal of bottom zone | : Existing dragline |
| Coal excavation | : Existing and new shovel and truck |

As it was mentioned before, the present railway system to be assigned for the shallow zone of overburden should be replaced with the new fleets of shovel and truck when the operating life ends.

(4) Economics comparison of new mining systems

Comparative study was implemented to select a new additional mining system to be used for removal of overburden at the middle zone.

Case A : 8 $m^3$ shovel and 50 ton dump truck
B : 12 $m^3$ shovel and 80 ton dump truck
C : 16 $m^3$ shovel and 120 ton dump truck
D : Bucket wheel excavator and conveyer

The main required equipment and their initial investment cost for each case are listed on Table 4.2. Estimated production costs of each case are shown on Table 4.3.

## Table 4.2 Additional Equipment and Investment for Each Mining System

| Case A Item | unit | Unit Price (1,000 US$) | Initial capital (1,000 US$) | Life year | Depreciation 1,000 US$/y |
|---|---|---|---|---|---|
| FEL 10 m3 | 3 | 867 | 2,601 | 8 | 325 |
| 8 m3 shovel | 4 | 3,248 | 12,992 | 8 | 1,624 |
| Bulldozer 400 HP | 12 | 524 | 6,288 | 8 | 786 |
| Grader 254 HP | 3 | 366 | 1,098 | 8 | 137 |
| Dump Truck 50 ton | 48 | 584 | 28,032 | 8 | 3,504 |
| Coal Truck 40 ton | 14 | 440 | 6,160 | 8 | 770 |
| Total | | | 57,171 | | 7,146 |
| Case B | | | | | |
| FEL 10 m3 | 3 | 867 | 2,601 | 8 | 325 |
| 12 m3 shovel | 3 | 4,009 | 12,027 | 21 | 573 |
| Bulldozer 400 HP | 11 | 524 | 5,764 | 8 | 721 |
| Grader 254 HP | 3 | 366 | 1,098 | 8 | 137 |
| Dump Truck 80 ton | 27 | 790 | 21,330 | 8 | 2,666 |
| Coal Truck 40 ton | 14 | 440 | 6,160 | 8 | 770 |
| Total | | | 48,980 | | 5,192 |
| Case C | | | | | |
| FEL 10 m3 | 3 | 867 | 2,601 | 8 | 325 |
| 16 m3 shovel | 2 | 4,722 | 9,444 | 21 | 450 |
| Bulldozer 400 HP | 10 | 524 | 5,240 | 8 | 655 |
| Grader 254 HP | 3 | 366 | 1,098 | 8 | 137 |
| Dump Truck 120 ton | 18 | 970 | 17,460 | 8 | 2,183 |
| Coal Truck 40 ton | 14 | 440 | 6,160 | 8 | 770 |
| Total | | | 42,003 | | 4,520 |
| Case D | | | | | |
| FEL 10 m3 | 3 | 867 | 2,601 | 8 | 325 |
| BWE | 2 | 5,460 | 10,920 | 21 | 520 |
| BW | 2 | 2,801 | 5,602 | 21 | 267 |
| Belt conveyor 3 km | 2 | 10,200 | 20,400 | 8 | 2,550 |
| Belt conveyor 2.5 km | 2 | 8,500 | 17,000 | 8 | 2,125 |
| Belt conveyor 2 km | 2 | 6,800 | 13,600 | 8 | 1,700 |
| Spreader | 2 | 8,769 | 17,538 | 21 | 835 |
| Tripper | 2 | 3,128 | 6,256 | 21 | 298 |
| Pipe layer | 2 | 320 | 640 | 8 | 80 |
| Bulldozer 400 HP | 10 | 524 | 5,240 | 8 | 655 |
| Grader 254 HP | 3 | 366 | 1,098 | 8 | 137 |
| Coal Truck 40 ton | 14 | 440 | 6,160 | 8 | 770 |
| Total | | | 107,055 | | 10,262 |

Note:
Tax is not considered
Straight line method is applied for depreciation

## Table 4.3 Comparison Study of Estimated Production Cost

Presumption:
- Case A: 8 m3 shovel & 50 ton Dump trucks
- Case B:12 m3 shovel & 80 ton Dump trucks
- Case C:16 m3 shovel & 120 ton Dump trucks
- Case D:Bucket Wheel Excavator
- Royalty, Interest, Tax, Inflation are not considered
- Exchange rate 400 Tg/US$

| Overburden removal (million) | Unit | Current | | Improved | | Renovation Case A | | Case B | | Case C | | Case D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dragline | BCM | 5.5 | | 7.7 | | 8.5 | | 8.5 | | 8.5 | | 8.5 | |
| Shovel & Railway | BCM | 2.0 | | 3.6 | | 4.0 | | 4.0 | | 4.0 | | 4.0 | |
| Shovel & Truck (40 ton) | BCM | 2.2 | | 2.9 | | 4.7 | | 4.7 | | 4.7 | | 4.7 | |
| Shovel & Truck (50 ton) | BCM | | | | | 8.0 | | | | | | | |
| Shovel & Truck (80 ton) | BCM | | | | | | | 8.0 | | | | | |
| Shovel & Truck(120 ton) | BCM | | | | | | | | | 8.0 | | | |
| BWE | BCM | | | | | | | | | | | 8.0 | |
| Total | BCM | 9.7 | | 14.2 | | 25.2 | | 25.2 | | 25.2 | | 25.2 | |
| **Coal extraction (million)** | | | | | | | | | | | | | |
| Shovel & Truck (40 ton) | ton | 2.9 | | 4.0 | | 1.6 | | 1.6 | | 1.6 | | 1.6 | |
| Shovel & Truck (40 ton coal truck) | ton | | | | | 4.4 | | 4.4 | | 4.4 | | 4.4 | |
| Total | ton | 2.9 | | 4.0 | | 6.0 | | 6.0 | | 6.0 | | 6.0 | |
| Density | ton/BCM | 1.29 | | 1.29 | | 1.29 | | 1.29 | | 1.29 | | 1.29 | |
| Total | BCM | 2.2 | | 3.1 | | 4.7 | | 4.7 | | 4.7 | | 4.7 | |
| Grand Total | | 11.9 | | 17.3 | | 29.9 | | 29.9 | | 29.9 | | 29.9 | |
| Stripping Ratio | | 3.3 | | 3.6 | | 4.2 | | 4.2 | | 4.2 | | 4.2 | |
| **Additional Investment (million US$)** | | | | | | Add. | Total | Add. | Total | Add. | Total | Add. | Total |
| Mining equipment | | | | | | 57.2 | 57.2 | 49.0 | 49.0 | 42.0 | 42.0 | 107.1 | 107.1 |
| Supporting facilities | | | | 12.0 | | 4.9 | 16.9 | 4.9 | 16.9 | 5.3 | 17.3 | 4.9 | 16.9 |
| Total additional investment | | 0.0 | | 12.0 | | 62.1 | 74.1 | 53.9 | 65.9 | 47.3 | 59.3 | 112.0 | 124.0 |
| **Material & Energy** | | | | | | | | | | | | | |
| Diesel (ton) | | 4.5 | | 6.5 | | 15.0 | 21.5 | 10.5 | 17.0 | 11.2 | 17.7 | 11.7 | 18.2 |
| Electric (kWh) | | 30.9 | | 45.0 | | 6.4 | 51.4 | 14.5 | 59.5 | 10.7 | 55.7 | 21.3 | 66.3 |
| Explosive(ton) | | 2.3 | | 3.3 | | 2.4 | 5.7 | 2.4 | 5.7 | 2.4 | 5.7 | 2.4 | 5.7 |
| **Manpower** | | | | | | | | | | | | | |
| Total (persons) | | 1,590 | | 1,600 | | 520 | 2,120 | 380 | 1,980 | 310 | 830 | 360 | 1,960 |
| **Additional Electric Power** | | | | | | | | | | | | | |
| Mining quipment(kW) | | 0 | | 0 | | 2,520 | | 5,700 | | 4,200 | | 4,200 | |
| **Variable cost/year** | | | | | | | | | | | | | |
| Material & Energy | | mil.Tg | mil.US$ | mil.Tg | mil.US$ | mil.US$ | mil.US$ | mil.US$ | mil.US$ | mil.US$ | mil.US$ | mil.US$ | mil.US$ |
| Parts cost | | 881 | 2.2 | 1,280 | 17.1 | 9.9 | 27.0 | 8.5 | 25.6 | 9.5 | 26.6 | 11.9 | 29.0 |
| Diesel | | 306 | 0.8 | 442 | 1.1 | 3.3 | 4.4 | 2.3 | 3.4 | 2.5 | 3.6 | 1.3 | 2.4 |
| Lubricans | | 46 | 0.1 | 66 | 0.2 | 0.5 | 0.7 | 0.4 | 0.6 | 0.4 | 0.6 | 0.2 | 0.4 |
| Electricity | | 371 | 0.9 | 540 | 1.4 | 0.4 | 1.8 | 0.8 | 2.2 | 0.6 | 2.0 | 2.6 | 4.0 |
| Explosives | | 465 | 1.2 | 667 | 1.7 | 1.2 | 2.9 | 1.2 | 2.9 | 1.2 | 2.9 | 1.2 | 2.9 |
| Other Variable | | 202 | 0.5 | 294 | 0.7 | 0.6 | 1.3 | 0.6 | 1.3 | 0.6 | 1.3 | 0.6 | 1.3 |
| Other facility | | | | | 1.7 | 0.6 | 2.3 | 0.6 | 2.3 | 0.6 | 2.3 | 0.6 | 2.3 |
| Total variable cost | | 2,271 | 5.7 | 3,289 | 23.9 | 16.5 | 40.4 | 14.4 | 38.3 | 15.4 | 39.3 | 18.4 | 42.3 |
| **Fixed cost/year** | | | | | | | | | | | | | |
| Depreciation, mining equipment | | | | | 16.4 | 8.2 | 24.6 | 7.0 | 23.4 | 6.1 | 22.5 | 13.8 | 30.2 |
| Depreciation, other facility | | | | | 1.9 | 0.8 | 2.7 | 0.8 | 2.7 | 0.8 | 2.7 | 0.8 | 2.7 |
| Labor cost | | 940 | 2.4 | 953 | 2.4 | 0.8 | 3.2 | 0.6 | 3.0 | 0.5 | 2.9 | 0.5 | 2.9 |
| Other fixed cost | | 487 | 1.2 | 487 | 1.2 | 0.0 | 1.2 | 0.0 | 1.2 | 0.0 | 1.2 | 0.0 | 1.2 |
| Total fixed cost/year | | 1,427 | 3.6 | 1,440 | 21.9 | 9.8 | 31.7 | 8.4 | 30.3 | 7.4 | 29.3 | 15.1 | 37 |
| Total cost | | 2,758 | 9.3 | 3,776 | 45.8 | 26.3 | 72.1 | 22.8 | 68.6 | 22.8 | 68.6 | 33.5 | 79.3 |
| Mining cost index | US$/BCM | | 0.8 | | 2.6 | 2.1 | 2.4 | 1.8 | 2.3 | 1.8 | 2.3 | 2.7 | 2.7 |
| Production cost | US$/ton | | 3.2 | | 11.5 | 13.2 | 12.0 | 11.4 | 11.4 | 11.4 | 11.4 | 16.8 | 13.2 |

Note:
- Production cost for existing equipment is based on the re-evaluated price.
- Improved case is subject to the enough parts supply and proper maintenance.
- In case parts supply is not sufficient, cannot achieve 4.2 million ton/year
- Dragline handling volume can be increased from 7.7 to 8.5 with reducing the rehandle volume after new S&T system are introduced.
- Railway handling volume can be increased from 3.6 to 4 with improving the system after new FELs are introduced.

Case B was chosen for our proposed renovation because the cost index is the lowest as shown in Table 4.3. Although the cost index of Case C is the same as Case B, there is no merit to introduce bigger fleets of shovel and truck for a while,when one considers the maintenance facilities and skills, labor cost, change of the pit design, etc.

### 4.1.3 Study of coal recovery ratio

The design philosophy of Baganuur coal mine was reviewed by JICA study team. As a result, principal changes of design basis are to increase coal recovery ratio for the purpose of effective exploitation of Baganuur coal resources. The following three cases were compared to select the optimum recovery ratio.

Case 1 : Present mining plan (up to 170m from the surface)

Case 2 : Intermediate depth of Case 1 and Case 3

Case 3 : Maximum mining depth (up to 200m from the surface)

Table 4.4 Comparison Study of Economics of Coal Recovery Ratio

| | Unit | Case 1 | Case 2 | Case 3 |
|---|---|---|---|---|
| Depth of mining | m | 170 | 190 | 200 |
| Minable coal | m. ton | 260 | 400 | 480 |
| Coal recovery ratio | % | 54 | 83 | base[*1] |
| Total coal production | m. ton/y | 6 | 6 | 6 |
| Life of mine | years | 43 | 67 | 80 |
| Required total capacity | m. BCM/y | 24 | 27 | 30 |
| by existing system | | (17.3) | (17.3) | (17.3) |
| by additional system | | ( 6.7) | ( 9.7) | (12.6) |
| Stripping ratio (average) | BCM/ton | 3.2 | 3.7 | 4.2 |
| Additional shovel/truck[*2] | fleet | 1.6 | 2.3 | 3 |
| Initial cost of <*2>[*3] | m. US$ | 29 | 41 | 54 |
| Total operation cost[*3] | m. US$/y | 31.6 | 35.0 | 38.3 |
| Existing system | | (23.9) | (23.9) | (23.9) |
| Additional system | | ( 7.7) | (11.1) | (14.4) |
| Total capital cost[*3] | m. US$/y | 26.4 | 28.4 | 30.3 |
| Existing system | | (21.9) | (21.9) | (21.9) |
| Additional system | | ( 4.5) | ( 6.5) | ( 8.4) |
| Total cost[*3] | m. US$/y | 58.0 | 63.4 | 68.6 |
| Coal cost index[*4] | US$/ton | 9.7 | 10.6 | 11.4 |

Note *1 : About 85% of measured coal reserves is assumed to be minable coal and it is defined as 100% (base).
Coal resources below 200m from the surface is excluded due to no geological date available.

*2 : Number of fleets is adopted as the base case for each case, therefore, number of fleets is not an integral.

*3 : These include costs of both existing and additional systems. Tax, interest and royalty are not included.

*4 : Total cost is divided by 6 m.t/y of coal.

Case 3 is selected because Case 3 shows an acceptable increase in the coal cost index, while the large volume of additional coal production is available. Stripping ratio to be used in the study of renovation is 4.2 (average).

## 4.2 Recommended mining equipment

### 4.2.1 Recommended equipment

In accordance with the study of effective mining system, Case B was selected for the renovation study and the required additional equipment are summelized in Table 4.5.

Table 4.5 Additional Equipment List

| Equipment | Required number | Life (years) | | Unit price (m. US$)*2 | Major use |
|---|---|---|---|---|---|
| | | S*1 | L*1 | | |
| 12 $m^3$ shovel | 3 | 15 | 21 | 4.0 | Overburden removal |
| 80 ton dump truck | 27 | 6 | 8 | 0.8 | Ditto |
| 40 ton coal truck | 14 | 6 | 8 | 0.4 | Coal transport |
| 10 $m^3$ FEL | 3 | 6 | 8 | 0.9 | Overburden removal |
| Bulldozer 400 HP | 11 | 6 | 8 | 0.7 | Multi-purpose |
| Grader 254 HP | 3 | 6 | 8 | 0.4 | Road maintenance |

Note *1: " S " is short-life case and " L " is long-life case.
*2: All cost and fees for manufacturing, packing, transportation, field assembly and training are included in unit price.

1) 12$m^3$ electric rope shovel

Three units of electric shovels with 12$m^3$ dipper capacity will be used for overburden removal.

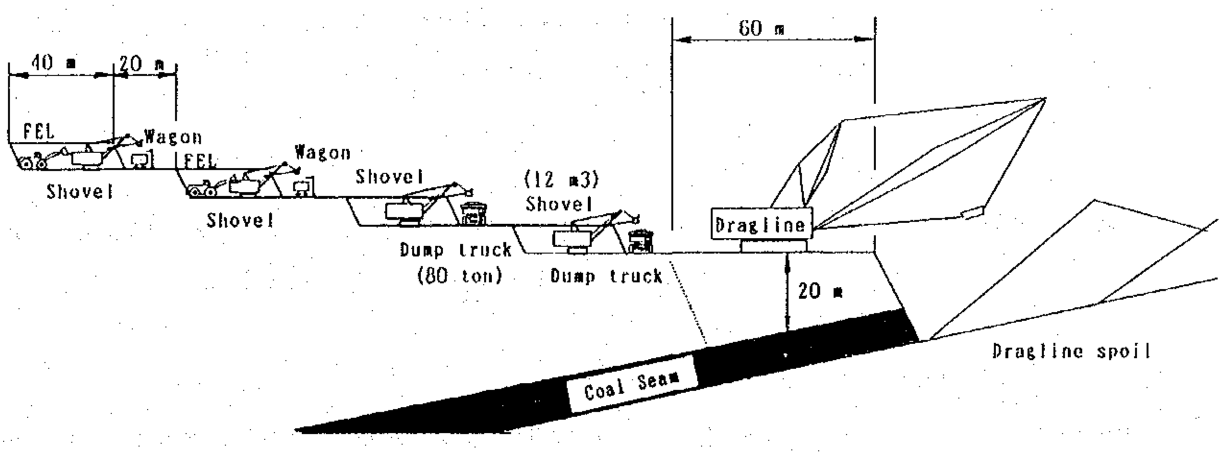



Figure 4.2 Proposed O/B Removal System (section)

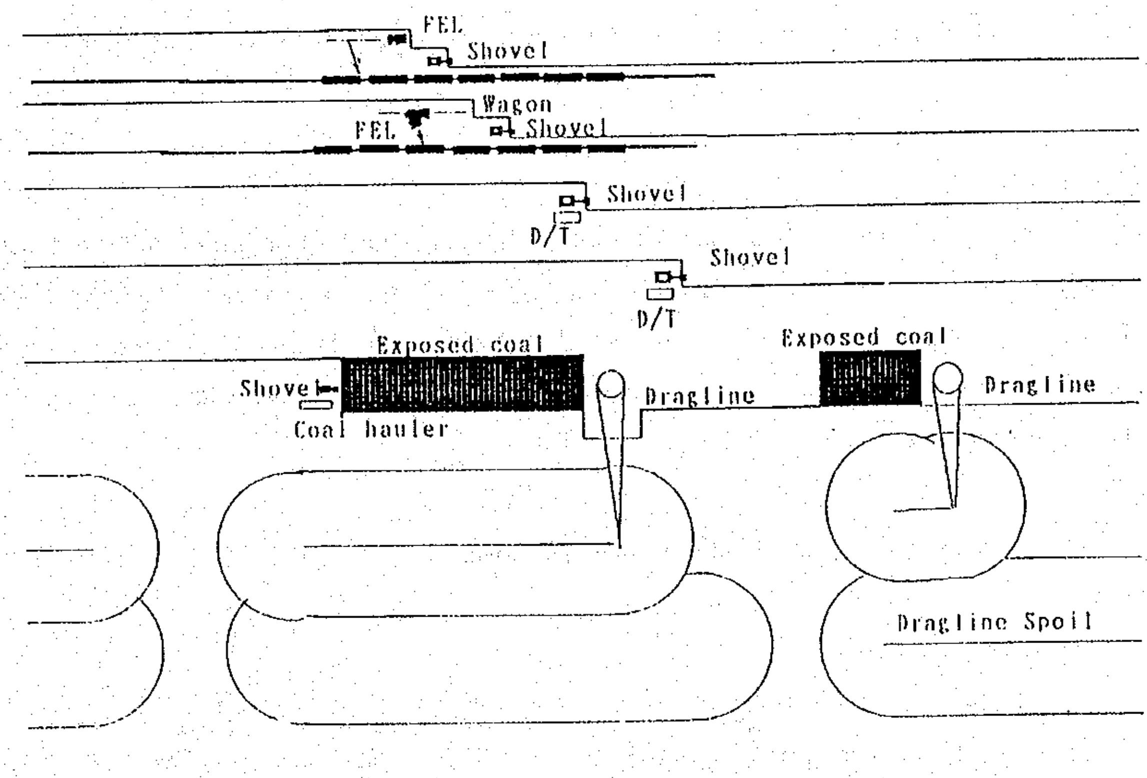



Figure 4.3 Proposed O/B Removal System (plan)

2) 80 ton rear dump truck

Nine units of 80 ton rear dump trucks will be required for each electric rope shovel. In total, 27 units of dump trucks are required for overburden removal.

3) Rear dump truck for coal transportation

As described in Section 3.3.1, coal transportation by rear dump trucks for heavy material is not a efficient work. So 14 units of coal trucks will be recommended to introduce.

4) $10m^3$ Front End Loader

In order to improve the loading efficiency for the shovel and wagon system, introduction of the FEL will be considered to be effective. This idea is like to introduce much bigger shovels. This investment will be canceled if the shovel and wagon system is not an economical method.

5) Bulldozer

Bulldozers will be utilized for the supporting works of the big shovels. As mentioned, by introducing the supporting bulldozers, loading efficiency of the shovels will be improved.

6) Supporting equipment

Bulldozers

It is recommended to utilize bulldozers as supporting equipment for draglines. Bulldozers will enable to clean up the working floor of dragline. Bulldozers can be also used for cable handling. Push dozing by bulldozers will enable to reduce rehandle volume by draglines. It is necessary to introduce bulldozers for the railway system. FEL cannot excavate overburden and bulldozers with point ripper must support the FEL.

Recommended specifications of bulldozer are as follows:

Overburden removal

| | |
|---|---|
| Power | 400 HP |
| Weight | 46,000 kg approx. |

Coal handling & supporting work

| | |
|---|---|
| Power | 200 HP |
| Weight | 24,000 kg approx. |

Motor Grader:

Motor Grader is necessary for road maintenance. Clean up of the floor of the coal seam will enable to reduce the tire damages. Major specification of the recommended motor grader are as follows:

Power 254 HP
Blade width 4.5 m approx.

Water truck:

For the purpose of reducing the dust generation, water trucks must be increased its availability and utilization. Old rear dump trucks are possible to be modified to water trucks.

EFL

Due to the limited equipment flexibility, soil and rocks are difficult to be separated from coal. This is one of the reasons why calorific value of coal is low. It is recommended to utilize Front End Loader for the purpose of implementing selective mining.

4.2.2 Recommended surface facilities

Installation of the following surface facilities, including equipment, are recommended to achieve smooth operation of Baganuur coal mine at 6 million tons per year capacity. Most of the equipment for environmental protection are included in those facilities. Operation costs for this purpose are also included.

In order to achieve smooth operation of Baganuur coal mine at 6 million tons per year capacity, introduction of the surface facility and equipment listed on Table 4.6 are recommended. Estimated investment for these facilities and equipment is about 16 million US$. As mentioned before, about 11 million out of 16 million US$ had already budgeted for the investment plan for improvement of the existing system, required investment for expansion is about 5 million US$.

(1) Workshop

The shortage of spare parts is a serious problem. It is necessary to provide funds for purchasing spare parts urgently. Maintenance tools and facilities are also necessary to supplement. In order to carry out maintenance of larger rear dump trucks, the modification of the garage and workshop will be required.

## Table 4.6 Required Supporting Equipment for Mine Expansion

| | Description | Unit Price US$1000 | Number of unit required | Initial Investment US$1000 | Life years | Yearly cost US$1000/y | Year to be Installed |
|---|---|---|---|---|---|---|---|
| A. | Workshop | | | | | | |
| | Garage modification | 300 | 1 | 300 | 20 | 15 | 1998 ( 300 ) |
| | Workshop modification | 200 | 1 | 200 | 20 | 10 | 1998 ( 200 ) |
| | Workshop tools | 425 | 1 | 425 | 6 | 71 | 1996 , 1998 ( 170 ) |
| | Total item A | | | 925 | | 96 | ( 670 ) |
| B. | Warehouse | | | | | | |
| | Expansion | 200 | 1 | 200 | 20 | 10 | 1998 ( 200 ) |
| | Computer system | 60 | 1 | 60 | 6 | 10 | 1996 |
| | Total item B | | | 260 | | 20 | ( 200 ) |
| C. | Coal stock yard (Pit 5) | | | | | | |
| | Watering system | 50 | 1 | 50 | 10 | 5 | 1996 , 1998 ( 7 ) |
| | Dozer shovel 250 HP | 306 | 1 | 306 | 8 | 38 | 1996 |
| | Total item C | | | 356 | | 43 | ( 7 ) |
| C'. | Coal stock yard (Pit 2) | | | | | | |
| | Watering system | 100 | 1 | 100 | 10 | 10 | 1996 , 1998 ( 57 ) |
| | Dozer shovel 250 HP | 306 | 2 | 612 | 8 | 77 | 1996 , 1998 ( 306 ) |
| | Total item C' | | | 712 | | 87 | ( 363 ) |
| D. | Sizing & Loading (Pit 5) | | | | | | |
| | Crushing plant | 425 | 1 | 425 | 15 | 28 | 1996 |
| | Car puller | 170 | 1 | 170 | 10 | 17 | 1996 |
| | Dozer shovel 250HP | 306 | 2 | 612 | 8 | 77 | 1996 , 1998 ( 306 ) |
| | Total item D | | | 1,207 | | 122 | ( 306 ) |
| D'. | Sizing & Loading (Pit 2) | | | | | | |
| | Crushing plant | 680 | 1 | 680 | 15 | 45 | 1996 , 1998 ( 255 ) |
| | Conveyor with spreader | 680 | 1 | 680 | 10 | 68 | 1998 ( 680 ) |
| | Conveyor with hopper car | 255 | 1 | 255 | 10 | 26 | 1998 ( 255 ) |
| | Loading silo | 100 | 1 | 100 | 20 | 5 | 1998 ( 100 ) |
| | Car puller | 170 | 1 | 170 | 10 | 17 | 1996 |
| | Dozer shovel 250HP | 306 | 2 | 612 | 8 | 77 | 1996 , 1998 ( 306 ) |
| | Total item D' | | | 2,497 | | 238 | ( 1596 ) |
| E. | Power distribution | | | | | | |
| | Movable transformer(35/6KV) | 167 | 4 | 668 | 10 | 67 | 1996 , 1998 ( 334 ) |
| | Cable | 85 | 1 | 85 | 10 | 9 | 1996 |
| | Generator for emergency | 204 | 2 | 408 | 15 | 27 | 1996 |
| | Total item E | | | 1,161 | | 103 | ( 334 ) |
| F. | Communication | | | | | | |
| | High power wireless system | 128 | 1 | 128 | 6 | 21 | 1996 |
| | Total item F | | | 128 | | 21 | ( 0 ) |
| G. | Drainage & water supply | | | | | | |
| | Drainage system | 4,000 | 1 | 4,000 | 5 | 800 | 1996 |
| | Total item G | | | 4,000 | | 800 | ( 0 ) |
| H. | General purpose equipment | | | | | | |
| | Bulldozer 400HP | 524 | 2 | 1,048 | 8 | 131 | 1996 , 1998 ( 524 ) |
| | Bulldozer 200HP | 306 | 2 | 612 | 8 | 77 | 1996 , 1998 ( 306 ) |
| | Front End Loader 5 m3 | 408 | 2 | 816 | 8 | 102 | 1996 |
| | Drill rig | 459 | 2 | 918 | 8 | 115 | 1996 |
| | Exploration machine | 102 | 1 | 102 | 8 | 13 | 1996 |
| | Water truck | 102 | 3 | 306 | 8 | 38 | 1996 , 1998 ( 102 ) |
| | Service truck | 51 | 10 | 510 | 8 | 64 | 1996 , 1998 ( 255 ) |
| | Quality monitoring system | 200 | 1 | 200 | 8 | 25 | 1996 |
| | Total - item H | | | 4,512 | | 565 | ( 1,187 ) |
| Total item A-H | | | | 15,758 | | 2,095 | ( 7,264 ) |
| Local cost | | | | 3,152 | | 419 | |
| Grand total item A-H | | | | 18,910 | | 2,514 | |
| Capital for 20 years | | | | | | 50,280 | |
| Production (thousand ton) | | 6,000 | | | | | |
| Capital / ton | | | | | | 0.4 | |

1) Garage modification

Regarding the modification of the garage, entrance of the garage must be enlarged. And the structure of the inspection pits must be modified for the bigger size equipment.

2) Workshop modification

The workshop is also necessary to be modified for the larger trucks and shovels without any additional construction because the workshop for the railway and wagons can be used for this purpose.

3) Workshop tools

Daily inspection and simple maintenance must be carried out by coal mine, while overhaul and big scale maintenance should be ordered outside companies. The following general workshop tools are necessary to supplement for the purpose of maintaining a different type of equipment such as rear dump trucks, bulldozers, shovels, draglines, etc.

- Chassis repair tools
- Undercarriage rebuilding tools
- Engine repair tools
  (for diagnostic, repair, test and inspection)
- Transmission repair tools
  (for repair, test and inspection)
- Tire service tools
  (for repair, balancing)
- Hydraulic component service tools
  (for rebuilding, testing)
- Fuel injection service tools
- Electric component repair tools
- General tools
- Machine tools
  (Heat treatment furnace, Small blast furnace, Grinding machine, Welding facilities, Press machine, Shearing machine, Gear shaper, plating facilities, Magnetic prospecting facilities)
- Cable repair tools
- Electric devices repair tools
  (for motor, electric distribution facilities, communication system)
- Analyzers and measuring instruments
- Metal component analyzer

Regarding the workers, training and experience are not adequate and number of skilled workers are limited. It is recommended to study on the establishment of the Training Center controlled by the Ministry of Energy, Geology and Mining. This matter is described in the part II: Master Plan Study for Coal Development, Utilization and Preliminary Action Plans.

(2) Warehouse

In order to achieve the production target, it is necessary to maximize availability of the existing equipment. Due to the violent inflation in Mongolia, the funds prepared for purchasing spare parts are depreciating its value. It is required to prepare the funds as soon as possible. Some spare parts and lubricants are stocked at the out side of the warehouse. As an introduction of a different type of the equipment will be recommended, number of the spare parts items will become bigger. It is recommended to enlarge the space of the warehouse. The computer system for procurement control is better to be up graded.

| | | |
|---|---|---|
| Warehouse | : | Expansion (400m$^2$) |
| Computer system | : | Introduction of stock control system |

(3) Coal stock yard

Coal stock yard with proper capacity will be required. The coal stock yard enables the sizing plant to continue the operation. As coal is easy to start burning, the preventive system for spontaneous combustion will be required at the coal stock yard. Thus, the following facilities for Pit 5 and Pit 2 will be required.

Coal stock yard (Pit 5)

| | | |
|---|---|---|
| Capacity of coal stock yard | : | 100,000 ton (two months production) |
| Watering system | | |
| Steel pipe (4 inch) | : | 1,200 m |
| Sprinkler | : | 50 units |
| Dozer shovel (250 HP) | : | 1 unit |

Coal stock yard (Pit 2)

| | | |
|---|---|---|
| Capacitiy of coal stock yard | : | 400,000 ton (two months production) |
| Watering system | | |
| Steel pipe (4 inch) | : | 2,400 m |
| sprinkler | : | 100 units |

Dozer shovel (250 HP) : 2 units

(4) Sizing and loading

In order to avoid the problems of size distribution on coal produced at Pit 5 and Pit 2, it is recommended to introduce a crushing plant and conveyor system at the temporary train loading site. Figure 4.4 shows the proposed coal handling facilities. In case of small scale loading facility, a skid mounted crushing plant with a capacity of 500 ton per hour will be required. A conveyor system with hopper car and train loading silo will be also required. In order to load the coal to the hopper car, dozer shovels will be necessary. Stock capacity of two months production will be recommended. In case of the big scale loading facility, stationary sizing and screening plant will be recommended. A concept of the plant is shown in Figure 4.4. The following facilities and equipments for Pit 5 and Pit 2 must be required.

Sizing and loading facilities ( Pit 5)

Mobile crushing plant:

| | |
|---|---|
| Jaw crusher with crawler (500 ton/hour x 250 kW) | : 1 unit |
| Belt conveyor (36 inch x 500 ton/hour x 120 kW x 200 m) | : 2 unit |
| Dozer shovel (250 PH) | : 1 unit |
| Electric car puller (90 kW) | : 2 unit |
| (Capacity of puller : 30 freight cars) | |

Sizing and loading facilities (Pit 2)

Stationary crushing plant:

| | |
|---|---|
| Crusher (800 ton/hour x 250 kW) | : 1 unit |
| Belt conveyor (36 inch 800 ton/hour x 30 kw 50 m) | : 2 units |
| Conveyor with spreader (36 inch x 800 ton/hour x 200 kW x 400 m) | : 2 units |
| Conveyor with hopper car (36 inch x 800 ton/hour x 200kW x 400 m) | : 2 units |
| Loading silo (capacity of stock:1,000 ton) | : 1 set |
| Dozer shovel (250 HP) | : 2 units |
| Electric car puller (90 kW) | : 1 unit |
| (Capacity of puller :30 freight cars) | |

(5) Electric supply

In order to maximize availability of existing equipment, repairing materials and spare parts must be purchased smoothly. Measuring apparatus such as an electric tester or an oscillograph are

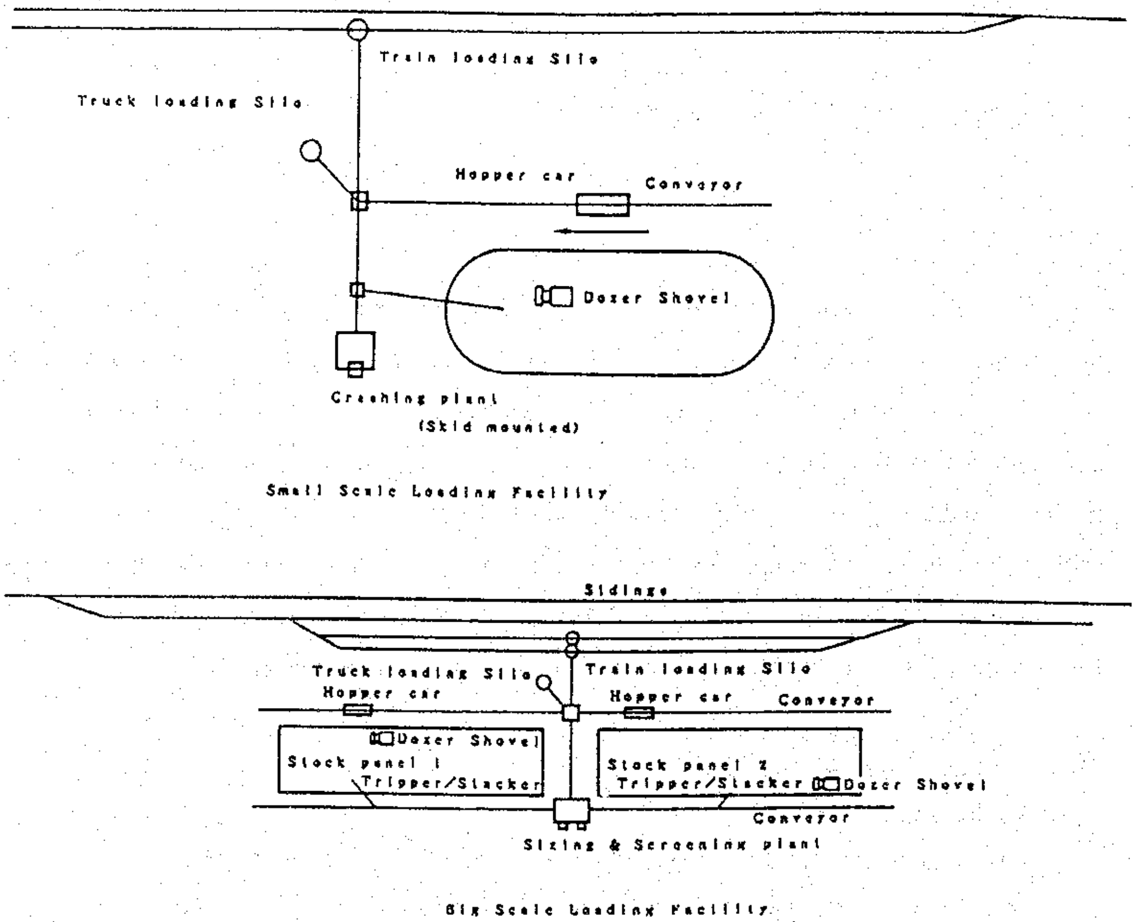



Figure 4.4 Proposed Coal Handling Facilities

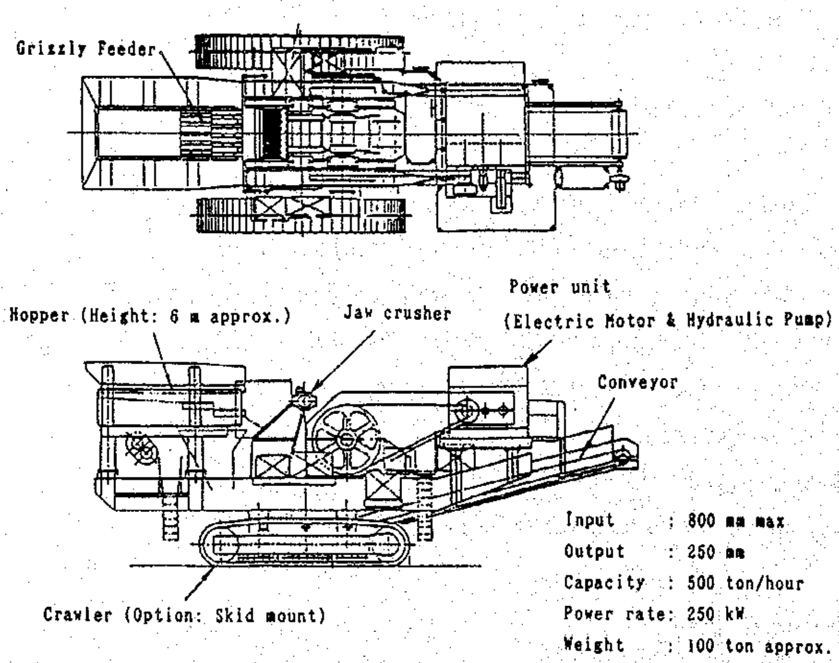



Figure 4.5 Conceptual Design of Mobile Crusher

required to fill up. In the renovation plan, some electric equipment will be introduced. The major equipment is 2 units of electric rope shovels for shovel and truck operation. Sub-station of the mine site will experience the problems of low voltage when larger mining equipment starts its operation. It is recommended to introduce movable transformer for power distribution. Regarding the problems of low voltage, it is recommended to introduce movable transformers with a capacity of 35/6KV 6,300KVA. Currently 4 units of movable transformer are required including 1 unit for new electric shovels. Diesel generator for emergency is needed to maintain supply of electricity as drainage system or hot water supply system must be operated continuously especially in the winter season. Thus, the following electric equipment will be required.

| | | |
|---|---|---|
| Movable transformer (35/6 kV, 6,300 KVA) | : | 4 units |
| Power line (36 kV Aerial cable x 10 km) | : | 1 set |
| Generator for emergency (1,000 KVA x 440 V, diesel) | : | 2 unit |

(6) Communication

The following high power wireless communication system will be required in order to achieve reliable communication.

High power wireless system

| | | |
|---|---|---|
| communication distance | : | 20 km (between office and each equipment) |
| Base statopm (installed in the mine office) | : | 1 unit |
| Movable station (loaded in equipments such as shovel, dump truck, etc.) | : | 100 units |

(7) Water supply

The water supply system has not been facing serious problems so far. The system must be maintained in good conditions.

(8) Dewatering

As mentioned 3.2.2 (8) dewatering activity before mining must be carried out. Drainage at two years before mining by wells, submersible pumps and pipe lines are necessary every five years.

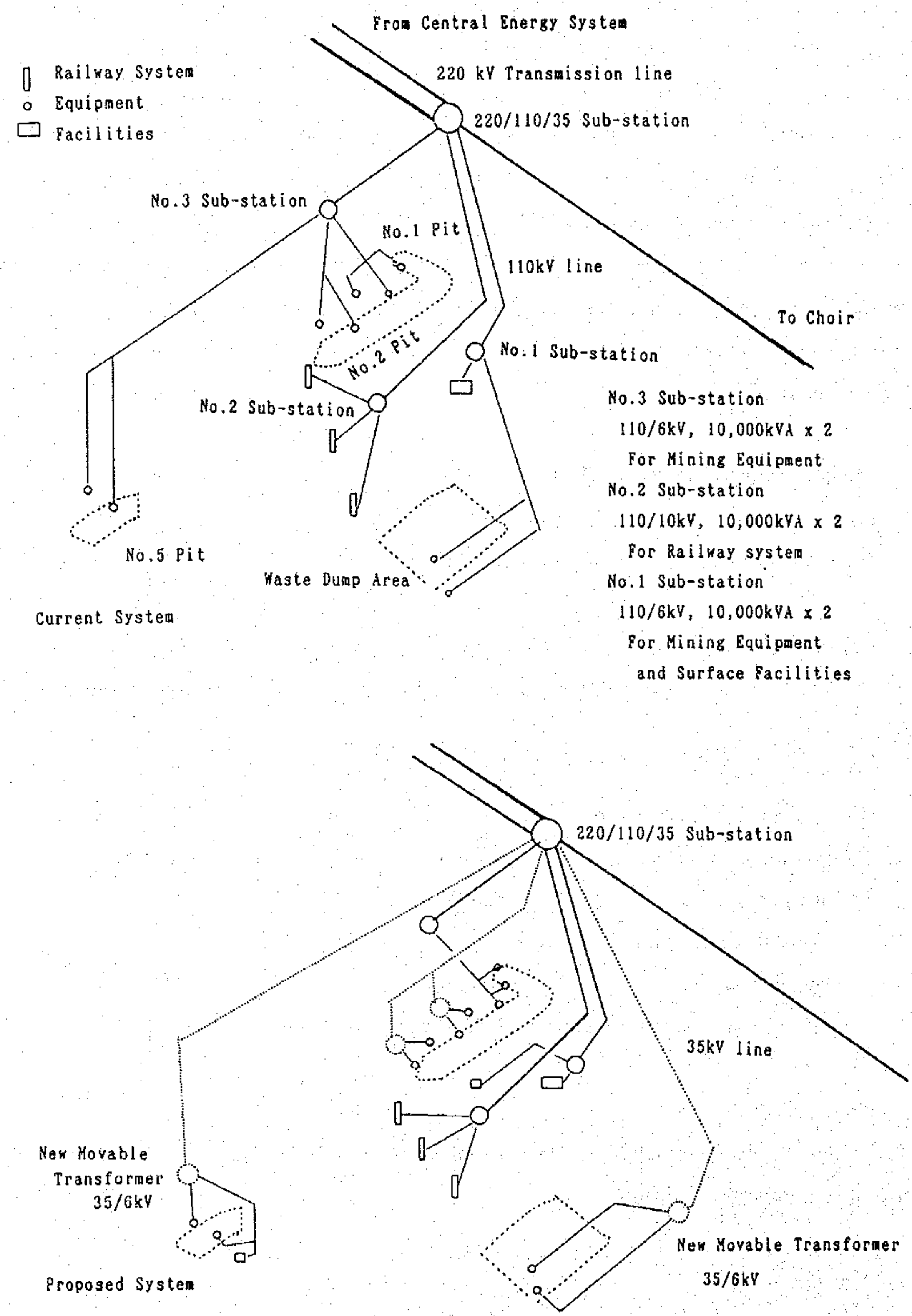



Figure 4.6 Proposed Power Distribution System

About 30 wells are estimated to be required as well as pumps and pipe lines. Mining area move into deeper and deeper, and well experienced boring contractor must be employed. This is the reason of the high cost works. Based on the existing contract data, 4 million US$ is estimated for this work. This is including the cost for water treatment facilities which will remove the iron contents of the underground water. The dewatering work is will be ordered outside company and the following facilities will be required.

| | | |
|---|---|---|
| Dewatering well (diameter : 500 mm, depth : 25 m) including the well of monitoring water level | : | 35 wells |
| Electric submersible pump (0.5 $m^3$/min x 250 m x 40 kW) including electric bulb and pumping pipe | : | 30 units |
| Steel pipe (12 inch) | : | 4,000 m |
| Water treatment facilities | : | 1 set |

(9) General purpose equipment

It is recommended to introduce the following equipments for general purpose.

| | | | |
|---|---|---|---|
| Bulldozer (400 HP) | for supporting | : | 2 units |
| Bulldozer (200 HP) | for supporting | : | 2 units |
| Front End Loader | for selective mining | : | 2 units |
| Drill rig (universal head type) | | : | 2 units |
| Exploration machine (wire-line system) for coring | | : | 1 unit |
| Water truck | | : | 3 units |
| Service truck for transporting parts and labors | | : | 10 units |
| Coal quality control system | | | |
| On-line moisture analyzer | | : | 3 units |
| Equipment for laboratorium | | : | 1 set |

## 4.3 Study of infrastructure

(1) Road

There are two ways to go to the Baganuur City from the Ulaanbaatar City. One way is by a railway and another way is by roads. The sealed road is limited only to the areas near the Ulaanbaatar City. Less than 1% of the roads in Mongolia are sealed. In the rainy days, the roads become so slippery and bumpy. It is better to cover with asphalt or ballast. The width of a road is wide enough and traffic is not heavy at present. The distance from the Ulaanbaatar City to the Baganuur City is about 110 km. Gas charging is possible at gas stations of towns between Ulaanbaatar and Baganuur. A ticket distributed by the Oil Corporation are required to purchase gas. There are no crossing on the railway and bridge. Coal is supplied by small trucks to the consumers around Baganuur coal mine. Total delivery of coals by those trucks is about 70 thousand tons per year. The consumers bring their own trucks and some of them have to transport coal more than 200km.

(2) Railway

From the main railway line which is crossing the country, a branch line is extended to Baganuur coal mine. The branch line was constructed in 1980 when development of the Baganuur coal mine was commenced. Diesel locomotives are hauling freight cars and passenger cars. The distance from the Ulaanbaatar city to Baganuur coal mine is about 200km and it takes about 4 or 5 hours. Double track-lines are installed only at the stations although most of the lines are single tracked. These conditions are the reason why the transportation capacity is limited. The main consumers of coal produced at Baganuur coal mine are the power stations and industrial users in the Ulaanbaatar City. Usually one fleet of train consists of two locomotives and 25 freight cars. 65 tons of coal are loaded into a freight car, so transportation capacity is 1,625 tons per a fleet. 150 freight cars per day are delivered in summer season and 220 freight cars per day are delivered in winter season . Current transportation capacity of the railway is more than 4 million tons per year, therefore, a serious study will be required for transportation of 6 million ton per year. This matter is described in the part II.

(3) Communication

Domestic and international call are available although the number of lines are limited. Facsimile services are not yet available.

(4) Water supply

Potable water is pumped up from the well located near the Herlen River. The water is sent to the pump station at the mining complex and is delivered to the mine and the Baganuur City. Underground water from the mining area is not suitable for drinking due to high iron contents. Underground water from the mining area is utilized as an industrial water after treatment. Hot water supply system is utilized at Baganuur coal mine and the Baganuur City. Industrial water is heated by coal fired boiler and is delivered through the insulated pipe line.

(5) Electric supply

There are three coal fired power stations in the Ulaanbaatar City, one power station in Darhan and another power station in Erdenet. Total capacity is 796 MW. These five power stations are interconnected with the Central Energy System by high voltage transmission lines. The Central Energy System is linked to the former Soviet Union Energy System. Mongolia imports the electricity from Russia if the demand is big. Substation of the Baganuur area is linked to the Central Energy System. Capacity is adequate enough for covering the district. Low voltage electricity is distributed from the substation to the Baganuur City. Voltage is 220V and frequency is 50Hz. There is a plan to construct a coal fired power station with a capacity of 150MW x 5 units at the Baganuur City. The construction work was commenced but it was discontinued due to the unavoidable reasons which were not explained.

(6) Labor force

The population of the Baganuur City is about 17 thousand. It is envisaged that there will be no difficulty to recruit workers required for mine expansion.

(7) Township

The Baganuur City is located at 120 km South-East of the Ulaanbaatar City. Baganuur City was constructed in 1980 when the coal mine development was commenced. Ulaanbaatar and Baganuur cities are connected by a railway and roads. The Baganuur City is about 1,300 meters above sea level. Population of the Baganuur City is around 17,000 and most of them are related to the coal industry. Annual rainfall is about 260 mm, and the climate of the area is rather comfortable. About 1,100 mine workers are living in apartments, and other workers are living in the gers. In these days construction cost of apartments is becoming expensive, so construction of some apartments are stopped the works before completion. In Baganuur City, there are schools, kindergartens, hospitals, supermarkets, gas stations and so on. Electricity is distributed from the substation of Baganuur coal mine. This electricity is transmitted from the Central Energy System through high voltage transmission line. Potable water is supplied from the wells near the Herlen River. Hot water is delivered from the boiler of the mine site. There is an inhabited town located at 7 km from the Baganuur City to provide accommodations for

800 families which was the former town of Russian military forces. This town can be renovated with small expenditures if additional accommodations are required.

(8) Land

Geographical features around the Baganuur area are almost flat and about 1,300 meters above sea level. There are few objects which can interrupt the strong winds. Many days people experience strong wind. The land is a plain and there are no big trees in this area. The Herlen River is streaming about 9 km from Baga Gun City. There is a small lake named as the Baganuur near the mine.

(9) Industry

Only coal industry and pasturage are the main industries around this area.

4.4 Schedule of renovation

(1) Renovation work

Project schedule for renovation is assumed on the basis of the delivery time of equipment, while impact of coal demand is not reflected.

Project schedule

| | |
|---|---|
| Order of spare parts | : End of 1994 |
| Arrival of spare parts | : End of 1995 |
| Funding for capacity-up | : 1995-96 |
| Order of equipment | : End of 1996 |
| Arrival of equipment & field work | : End of 1997 |

(2) Production plan

| | |
|---|---|
| 1995 | : 3.5 million tons per year |
| 1996,1997 | : 4.0 million tons per year |
| 1998 | : 5.0 million tons per year |
| 1999 | : 6.0 million tons per year |

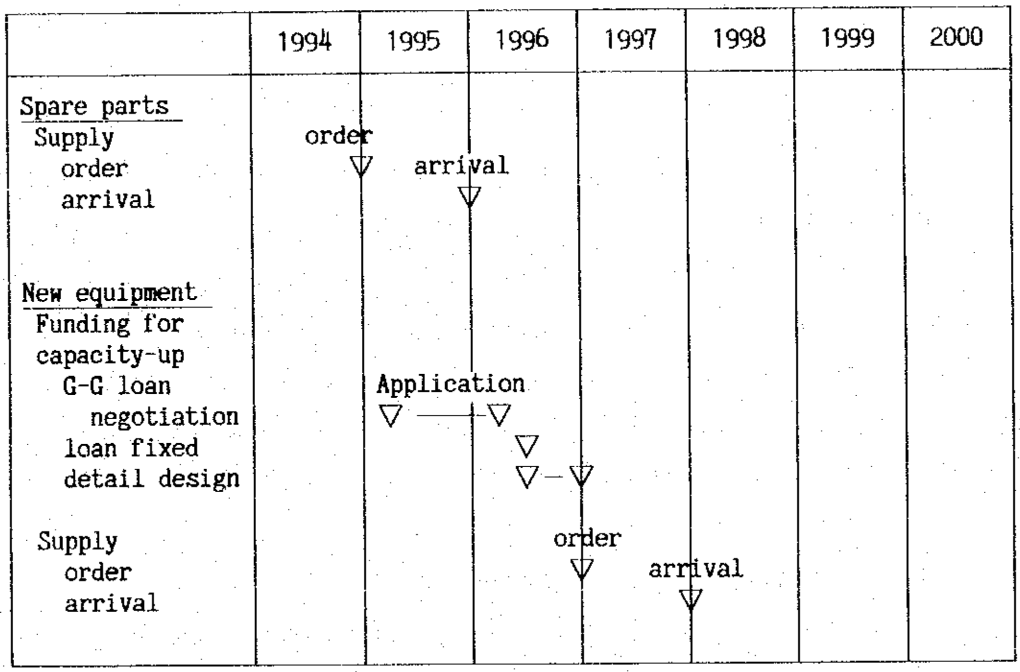



Figure 4.7 Time Schedule for Introduction of New Mining Fleets

# 5 Study of Quality Control System

## 5.1 Issues of coal quality

At present, the majority of coal produced at Baganuur coal mine is delivered to the users without crushing and inspection of coal quality. High moisture contents cause freezing of coal in the railway wagon on the way to Ulaanbaatar in winter. It also causes pluggings of the pipeline at the power plants throughout the year. Frequently, the thin interburdens were excavated and mixed into coal, resulting in reduced calorific value of the product coal. The users have been requesting to minimize the fluctuation of coal quality, particularly in moisture contents. Actual coal quality received by the power stations in Ulaanbaatar is shown in Table 5.1.

## 5.2 Recommended quality control system and equipment

Management must introduce a new thought for quality control of coal into the Baganuur coal mine. The factors to be taken into consideration are as follows;

- Proper dewatering of the underground water in the mining area ahead of removal of overberden and mining of coal.
- Proper pumping of surface water at the mining pits ahead of mining of coal.
- Prevention of frozen coal being delivered to the power stations.
- Cease of the oxidized coal being mined.
- Prevention of overburden being slided down over the exposed coal.
- Introduction of metal detector and magnetic catcher.
- Regular sampling of coal for analysis of coal quality and better communication for forward planning.
- Reinforcement and improvement of the coal drying process for the boilers at the power stations.
- Improvement of coal quality control system at the mine site.

### 5.2.1 Recommended quality control system

In order to meet the requirement of the users, the mine have to make every effort to control quality of coal. It is necessary to reduce ash contents and free moistures of coal, and to control maximum size of coal. For the purpose of not supplying the oxidized coal to the power plants, managements of the mine have to pay attention for control of coal quality. Considering total energy efficiency in

## Table 5.1 Actual Coal Quality Received by the Power Stations

<Baganuur coal>

| NO. 2 | T.M. (ar) | ash (db) | V.M. (daf) | T.S. (db) | C.V. (ar, low) | NO. 3 | T.M. (ar) | ash (db) | V.M. (daf) | T.S. (db) | C.V. (ar, low) | NO. 4 | T.M. (ar) | ash (db) | V.M. (daf) | T.S. (db) | C.V. (ar, low) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 93-1 | | | | | | | 32.5 | 26.9 | 41.1 | 0.38 | 2,566 | | 32.3 | 27.2 | 40.1 | 0.42 | 2,559 |
| 2 | | | | | | | 33.3 | 13.2 | 42.6 | 0.38 | 3,396 | | 32.6 | 13.2 | 42.1 | 0.43 | 3,440 |
| 3 | | | | | | | 32.2 | 14.6 | 42.3 | 0.51 | 3,386 | | 30.6 | 15.4 | 43.5 | 0.48 | 3,404 |
| 4 | | | | | | | 33.7 | 10.0 | 42.2 | 0.43 | 3,667 | | 33.5 | 11.1 | 43.5 | 0.60 | 3,493 |
| 5 | 31.7 | 14.4 | 42.8 | 0.72 | 3,437 | | 29.7 | 13.7 | 44.0 | 0.48 | 3,598 | | 32.0 | 10.7 | 43.5 | 0.54 | 3,599 |
| 6 | 32.9 | 11.5 | 41.4 | 0.58 | 3,557 | | 31.4 | 13.2 | 40.8 | 0.47 | 3,537 | | 33.1 | 9.7 | 42.6 | 0.62 | 3,632 |
| 7 | 32.2 | 15.0 | 41.8 | 0.42 | 3,306 | | 31.5 | 17.5 | 43.2 | 0.44 | 3,141 | | 34.8 | 8.3 | 42.3 | 0.55 | 3,538 |
| 8 | 36.0 | 8.4 | 42.6 | 0.64 | 3,437 | | 34.7 | 8.3 | 42.3 | 0.66 | 3,589 | | 34.8 | 9.2 | 43.1 | 0.67 | 3,524 |
| 9 | 34.7 | 12.4 | 43.2 | 0.45 | 3,347 | | 35.9 | 9.9 | 41.8 | 0.76 | 3,399 | | 34.1 | 11.7 | 43.5 | 0.51 | 3,380 |
| 10 | 33.8 | 17.0 | 41.2 | 0.60 | 3,135 | | 33.6 | 12.2 | 38.6 | 0.57 | 3,524 | | 31.6 | 13.2 | 43.3 | 0.48 | 3,499 |
| 11 | 32.6 | 13.1 | 41.7 | 0.55 | 3,383 | | 33.6 | 14.1 | 40.0 | 0.48 | 3,325 | | 32.7 | 15.4 | 43.8 | 0.54 | 3,205 |
| 12 | 34.7 | 13.8 | 43.0 | 0.47 | 3,304 | | 35.4 | 13.4 | 43.1 | 0.74 | 3,270 | | 32.2 | 14.3 | 44.5 | 0.54 | 3,375 |
| Ave. | 33.9 | 12.7 | 42.4 | 0.57 | 3,380 | | 33.2 | 13.2 | 42.1 | 0.52 | 3,408 | | 32.9 | 12.5 | 43.1 | 0.54 | 3,433 |
| 94-1 | 33.4 | 14.4 | 42.1 | 0.43 | 3,339 | | 34.0 | 13.4 | 42.4 | 0.59 | 3,401 | | 30.5 | 15.0 | 44.8 | 0.40 | 3,481 |
| 2 | 34.2 | 16.5 | 42.6 | 0.49 | 3,142 | | 33.6 | 12.3 | 44.0 | 0.49 | 3,471 | | 32.3 | 16.5 | 43.0 | 0.47 | 3,266 |
| 3 | 33.5 | 15.3 | 42.1 | 0.53 | 3,261 | | 32.5 | 14.5 | 45.9 | 0.51 | 3,457 | | 32.4 | 11.7 | 44.3 | 0.51 | 3,555 |
| 4 | 31.4 | 13.5 | 41.2 | 0.52 | 3,573 | | 31.4 | 14.0 | 41.8 | 0.51 | 3,525 | | 32.3 | 12.2 | 42.9 | 0.50 | 3,532 |
| 5 | 32.1 | 15.5 | 41.4 | 0.41 | 3,407 | | 30.7 | 17.4 | 41.7 | 0.46 | 3,358 | | 33.0 | 14.6 | 41.6 | 0.83 | 3,407 |
| 6 | 34.4 | 11.5 | 43.1 | 0.47 | 3,446 | | 32.2 | 9.6 | 44.2 | 0.38 | 3,740 | | 37.6 | 7.4 | 43.9 | 0.40 | 3,472 |
| 7 | 32.8 | 12.8 | 43.7 | 0.41 | 3,541 | | 32.2 | 10.9 | 44.3 | 0.38 | 3,668 | | 29.5 | 18.1 | 42.2 | 0.50 | 3,364 |
| 8 | 33.7 | 12.6 | 46.1 | 0.33 | 3,407 | | 31.8 | 18.0 | 44.5 | 0.38 | 3,161 | | 34.6 | 9.7 | 46.0 | 0.48 | 3,390 |
| Ave. | 33.0 | 14.5 | 42.4 | 0.45 | 3,379 | | 32.4 | 12.9 | 43.6 | 0.46 | 3,520 | | 32.5 | 12.9 | 43.8 | 0.51 | 3,471 |

view of the national interest in Mongolia, the power stations also have to look at the way of improvement for the system and management.

(1) Control of free moisture contents

High moisture contents of coal are identified to be the problems in mining, coal handling and combustion. Therefore, it is desirable to reduce moisture contents of coal. Coal produced at the Baganuur coal mine exceeds 30% in total moistures that consist of 20% of free moistures approximately. It is absolutely necessary to carry out dewatering of the underground water from the wells in order to improve the slope stability of spoils in summer and to reduce the usage of explosives required for blasting in winter. Dewatering of the underground water from the wells is effective to reduce free moistures when it is carried out ahead of coal mining at the pit. Rain fall and other surface waters which flow in the pit must be pumped out by drainage pumps instead of being penetrated into the floor of the pit.

There are very few cases of the forced drying of lignite coal at the mine site in the world. The same thing can be said for coal preparation of lignite coal. Generally speaking, methods of the forced coal drying for lignite coal are hot air drying, etc. However, it is generally said that the forced coal drying and coal preparation of lignite coal are not economical way to carry out at the mine site and dried lignite may create spontaneous combustion problem. Although these methods at the mine site are capable of improving calorific values of lignite coal, it is not only the huge capital investment is required for the drying facilities, but also the energy required for the forced drying is wasted. On the other hand, it is possible to use the waste heat of power generation in case of coal drying implemented at the power station, thus, loss of the energy is a small amount. Regarding spontaneous combustion, it is no problem to carry out the forced drying at the power station because the dried coal will be consumed directly. If the forced drying is carried out at the mine site, the dried coal will not be consumed right away. Therefore, the dried coal may cause the spontaneous combustion during storage and transportation.

For the counter measures to reduce free moisture contents of coal, it is judged that drainage of the underground water ahead of coal mining at the pit and natural dying at the coal stock yard prior to the train loading are most economical method because the construction of drying facilities and its operating costs are not required. Nevertheless, total moisture of coal prior to train loading must be carefully monitored in order to eliminate troubles of coal being frozen during transportation. It is recommended to introduce the on-line moisture monitor at the loading facilities.

(2) Ash control

Improvement of coal quality can be achieved by adopting either the method of selecting mining of coal or coal preparation to separate ash from coal.

As a result of float and sink test of coal produced at the Shivee-Ovoo coal mine, it is judged that no benefits can be gained from coal preparation, which requires a large amount of capital investment, because washability of lignite coal is found to be not good. Tendency toward lignite coal is the same in the world. It is possible to improve quality of run of mine coal by cleaning dirts over the exposed surface of coal seam, removal of the partings and prevention of spoil pile being sliding down which was stacked by dragline.

Wastes over the exposed surface of the coal seam must be removed by either motor grader or front end loader ahead of coal mining. With respect to the floor of the coal seam, operating skills of electric rope shovel by operator must be improved not to dig the floor with coal. Removal of the parting by dragline, which is carried out at present, is not effective and inaccurate. This method must be replaced by a front end loader. It is desirable to remove the parting with thickness of 30cm and to limit the height of spoil pile stacked by dragline for reducing its failure. Those countermeasures will not only improve quality of run of mine coal, but also contribute to improve the ratio of coal and safety.

(3) Control of coal size

Power stations require small size coal while the general industry and household prefer to receive lumpy coal. There are no problems at the receiving facilities of coal for the power stations if the size of coal is less than 300mm. At present, the lumpy coal over the sales specifications is delivered to the power stations due to poor management of coal size at the coal mine, resulting in the increased cost of handling at the power stations. It is possible to reduce the consumption of electricity required for crushing at the power station if crushing of coal is done as much as possible at the mine site. On the other hand, crushing of coal at the mine will create problems of aiding spontaneous combustion and increasing free moistures of coal. Also, in case of crushing coal done at the mine site, power factor of the electricity will be lower due to loss occurring during power transmission. Therefore, there are no merits to carry out crushing of coal at the mine site more than it is required. H owever, the contracted size of 300mm must be adhered to prevent from the adverse effects at the power stations. Although there is no merit to introduce a large and complicated crushing and sizing facilities, it is necessary to introduce an alternate method to replace with direct train loading of coal. Introduction of small crushing plant is absolutely necessary at least.

(4) Countermeasures at the power stations

It is ideal to utilize the waste heat of power generation to dry coal ahead of combustion at the power stations. Also, important task is to alter specification of the boilers to match with quality of coal. The way of blending coal must be examined for obtaining proper coal quality through monitoring of coal quality.

### 5.2.2 Recommended equipment

Following equipment and plants must be introduced and reinforced;

Quality control equipment (on line analyzers)

Quality control equipment (off line analyzer, see Table 5.2)

Crushing and sizing plant

Small scale FEL and trucks for thin parting removal

Dewatering system

Table 5.2 Recommended Facilities for Laboratorium

| | Name of the item | Specification | unit | price (1,000 US$) |
|---|---|---|---|---|
| 1 | Automatic scale | +-0.001g | 1 | 8.2 |
| 2 | Cycle mill | -200 mesh | 1 | 11.2 |
| 3 | Ro-tap sieve shaker | 240 rpm, 0-60min. timer | 1 | 5.6 |
| 4 | Riffle Sampler | Receptacle until 60kg | 1 | 17.8 |
| 5 | Digital calorimeter | 1,000-8,000cal | 1 | 38.2 |
| 6 | Sulfur Analyzer | Max. temperature 1,400degrees | 1 | 23.1 |
| 7 | PH meter | Digital | 1 | 3.1 |
| | Total, Foreign | | | 107.2 |
| | Total Local cost | | | 21.4 |
| | Grand total | | | 128.6 |

## 5.3 Expected product quality of Baganuur coal

Expected quality of coal products is calculated by a weighting average of the thickness of coal seam and its coal reserves, based on Table 2.3. In order to calculate the estimated quality of coal products, the dilution of upper and lower interburden and parting is considered and the total moisture contracted with the power station is used. The conditions of calculation are as follows;

(1) The total thickness of dilution from the upper and lower interburden of each seam is 10cm. In order to minimize this dilution, it is necessary to clean up the surface of exposed seam by small equipment and to leave about 30cm of coal at the bottom of coal seam on the excavation of coal.

(2) Average percentage of dilution from the partings is assumed to be 6%. This percentage is defined as to match the ratio of the thickness of coal and parting which is calculated from a typical geological columnar section (see Figure 2.3).

(3) Total moisture is assumed to be 35%.

(4) The quality of interburden and parting is assumed as follows;

| | | | |
|---|---|---|---|
| Ash | : | 70% | (air dry basis) |
| Calorific value | : | 1,000 kcal/kg | (air dry basis) |

The results of calculation are shown on Table 5.3 and the details of calculation are shown on Table 5.4.

Table 5.3 Expected Product Quality

| | | As received basis | Air dry basis | Dry basis | Dry ash free basis |
|---|---|---|---|---|---|
| Total Moisture | % | 35.0 | | | |
| Surface Moisture | % | 26.8 | | | |
| Inherent Moisture | % | | 11.2 | | |
| Ash | % | | 17.0 | 19.1 | |
| Volatile Matter | % | | 31.8 | 35.8 | 44.3 |
| Fixed Carbon | % | | 40.0 | 45.1 | 55.7 |
| Total Surfur | % | | 0.63 | 0.71 | 0.88 |
| Calorific Value (HCV) | kcal/kg | 3,563 | 4,868 | 5,780 | 6,780 |
| Calorific Value (LCV) | kcal/kg | 3,221 | 4,620 | | |
| Size | mm | 0-300 | | | |

# Table 5.4 Calculation Sheet of Expected Product Quality

1. Average Coal Quality of Each Seam on table 2.1

| | T.M. (ar) | I.M. (ad) | ash (db) | V.M. (daf) | F.C. | T.S. (db) | C.V. (daf) | C.V. (ar) | ash | C (daf) | H (daf) | N (daf) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 28.9 | 11.0 | 14.8 | 42.7 | | 0.73 | 6,854 | 3,829 | | 73.14 | 4.60 | 1.00 |
| 2a | 29.8 | 11.4 | 14.2 | 44.1 | | 0.67 | 6,828 | 3,761 | | 72.82 | 4.68 | 0.99 |
| 3,1 | 31.2 | 11.2 | 18.7 | 44.2 | | 0.85 | 6,670 | 3,548 | | 71.66 | 4.66 | 0.91 |
| 3,2 | 32.8 | 11.3 | 16.9 | 45.0 | | 0.81 | 6,671 | 3,379 | | 71.11 | 4.79 | 0.87 |
| 3,3 | 33.3 | 11.5 | 14.7 | 44.0 | | 0.76 | 6,633 | 3,412 | | 70.77 | 4.64 | 0.87 |
| | | | | | | | (high) | (low) | | | | |

2. To change data (into air dry basis and dry basis) dry basis

| | T.M. (ar) | I.M. (ad) | ash (ad) | V.M. (ad) | F.C. (ad) | T.S. (ad) | C.V. (ad) | C.V. (ar) | ash (db) | C (db) | H (db) | N (db) | S.M. (ar) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 28.9 | 11.0 | 13.2 | 32.4 | 43.4 | 0.65 | 5,197 | 4,152 | 14.8 | 62.32 | 3.92 | 0.85 | 20.1 |
| 2a | 29.8 | 11.4 | 12.6 | 33.5 | 42.5 | 0.59 | 5,191 | 4,113 | 14.2 | 62.48 | 4.02 | 0.85 | 20.8 |
| 3,1 | 31.2 | 11.2 | 16.6 | 31.9 | 40.3 | 0.75 | 4,815 | 3,731 | 18.7 | 58.26 | 3.79 | 0.74 | 22.5 |
| 3,2 | 32.8 | 11.3 | 15.0 | 33.2 | 40.5 | 0.72 | 4,917 | 3,725 | 16.9 | 59.09 | 3.98 | 0.72 | 24.2 |
| 3,3 | 33.3 | 11.5 | 13.0 | 33.2 | 42.3 | 0.67 | 5,007 | 3,774 | 14.7 | 60.37 | 3.96 | 0.74 | 24.6 |
| | | | | | | | (high) | (high) | | | | | |

3. Quality of overburden and interburden (air dry basis)

| | I.M. | ash | V.M. | F.C. | T.S. | C.V. |
|---|---|---|---|---|---|---|
| O/B | 10.0 | 70.0 | 15.0 | 5.0 | 0.6 | 1,000 |

4. Estimated quality of each seam with overburden and interburden

| | T.M. (ar) | I.M. (ad) | ash (ad) | V.M. (ad) | F.C. (ad) | T.S. (ad) | C.V. (ad) | C.V. (ar) | ash (db) | C (db) | H (db) | N (db) | S.M. (ar) | C.V. (ar) | H (ar) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 28.9 | 10.9 | 16.9 | 31.3 | 40.9 | 0.65 | 4,921 | 3,928 | 19.0 | 59.25 | 3.73 | 0.81 | 20.2 | 3,612 | 2.6495 |
| 2a | 29.8 | 11.3 | 16.2 | 32.3 | 40.1 | 0.59 | 4,925 | 3,898 | 18.3 | 59.50 | 3.82 | 0.81 | 20.8 | 3,574 | 2.6844 |
| 3,1 | 31.2 | 11.1 | 20.0 | 30.8 | 38.1 | 0.74 | 4,575 | 3,541 | 22.5 | 55.55 | 3.61 | 0.71 | 22.6 | 3,220 | 2.4855 |
| 3,2 | 32.8 | 11.2 | 18.6 | 32.0 | 38.2 | 0.71 | 4,659 | 3,526 | 21.0 | 56.20 | 3.79 | 0.69 | 24.3 | 3,192 | 2.544 |
| 3,3 | 33.3 | 11.4 | 16.9 | 32.0 | 39.7 | 0.67 | 4,733 | 3,563 | 19.1 | 57.26 | 3.75 | 0.70 | 24.7 | 3,228 | 2.5041 |
| 3(ave) | 31.8 | 11.2 | 19.4 | 31.2 | 38.3 | 0.73 | 4,609 | 3,485 | 21.8 | 55.87 | 3.66 | 0.71 | 24.4 | 3,161 | 2.4593 |
| | | | | | | | (high) | (high) | | | | | | (low) | |

5. Estimated average quality of mine

| T.M. (ar) | I.M. (ad) | ash (ad) | V.M. (ad) | F.C. (ad) | T.S. (ad) | C.V. (ad) | C.V. (ar) | ash (db) | C (db) | H (db) | N (db) | S.M. (ar) | C.V. (ar) | H (ar) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29.9 | 11.2 | 17.0 | 31.8 | 40.0 | 0.63 | 4,868 | 3,842 | 19.1 | 58.80 | 3.77 | 0.79 | 21.1 | 3,520 | 2.6427 |
| 35.0 | 11.2 | 17.0 | 31.8 | 40.0 | 0.63 | 4,868 | 3,563 | 19.1 | 58.80 | 3.77 | 0.79 | 26.8 | 3,221 | 2.4505 |
| | | | | | | (high) | (high) | | | | | | (low) | |

6. Thickness of coal, overburden and interburden

| | coal(-0.3m) | O/B | I/B | total |
|---|---|---|---|---|
| 2 | 9.54 | 0.10 | 0.57 | 0.67 |
| 2a | 12.97 | 0.10 | 0.78 | 0.88 |
| 3,1 | 13.61 | 0.10 | 0.82 | 0.92 |
| 3,2 | 9.46 | 0.10 | 0.57 | 0.67 |
| 3,3 | 7.40 | 0.10 | 0.44 | 0.54 |

Mixed ratio(6%) 0.06

7. Thickness of each coal seam and coal reserves

| seam | pit | thickness (m) | reserves (m. ton) |
|---|---|---|---|
| 2 | 4 | 6.81 | 7 |
| 2 | 5 | 10.13 | 72 |
| total | | 9.84 (ave.) | 79 |
| 2a | 1 | 10.22 | 26 |
| 2a | 2 | 17.30 | 60 |
| 2a | 4 | 12.23 | 22 |
| 2a | 5 | 10.83 | 57 |
| total | | 13.27 (ave.) | 165 |
| 3,1 | 3 | 13.91 | 36 |
| 3,2 | 3 | 9.76 | 10 |
| 3,3 | 3 | 7.70 | 6 |

<Calculation method>

I. Estimated quality of each seam with overburden and interburden

Estimated quality = (Qc * Tc + Qr * Tr) / (Tc + Tr)

- Qc : quality of coal
- Qr : quality of overburden and interburden
- Tc : Thickness of coal seam
- Tr : Thickness of overburden and interburden

II. Estimated average quality of mine

$$\text{Estimated average quality} = \sum_{i=1,5} Qeqi * Ri \Big/ \sum_{i=1,5} Ri$$

- Qeqi : estimated quality of each seam
- Ri : reserves of each seam
- i : number of seams

## 6. Environmental Study

### 6.1 General

The main purpose of Environmental Study for the renovation of Baganuur coal mine is to preserve a living, natural and social environment. The study was carried out in the Baganuur open pit mining area and mainly consists of investigation and environmental examination. The work flow of Environmental Study is shown in Figure 6.1.

Environmental items for open pit coal mine are selected, using matrix method as shown in Table 6.1, based on the existence of influence by the environmental factors of mining activities. The environmental factors consist mainly of stripping of overburden, transportation and piling of spoils, mining of coal, transportation of coal, sizing and loading of coal at plant site, pumpage of groundwater, water treatment and drainage, activities at office and other facilities. The environmental items consist finally of air quality, water quality, noise/vibration, soil contamination, land, water, soil, fauna and flora, landscape and social conditions including waste, cultural heritage, hazards, resettlement and water rights. These items are just the same with the items of field investigation and environmental examination.

The components of environmental examination is to project the environmental impacts which will be caused by increasing the production capacity to six million tons per year, as a result of renovation of mining, and to examine the environmental management and monitoring plan.

### 6.2 Legislation

The current environmental legislation in Mongolia as shown in Table 6.2, mainly consist of the Land Resources Law, the Air Protection Law, the Water Law, the Forestry Law, the Hunting Law and Government Regulation No. 121 on the Environmental Impact Assessment Procedure. The Government Regulation No. 121 was newly instituted in June, 1994.

The environmental quality standards for air, water and noise are shown in Tables 6.3, 6.4 and 6.5 respectively.

These environmental standards are the aim of environmental management for each environmental item. And then, the aim of other items, including land, water, fauna and flora, landscape and social conditions is to minimize the influence by the project.

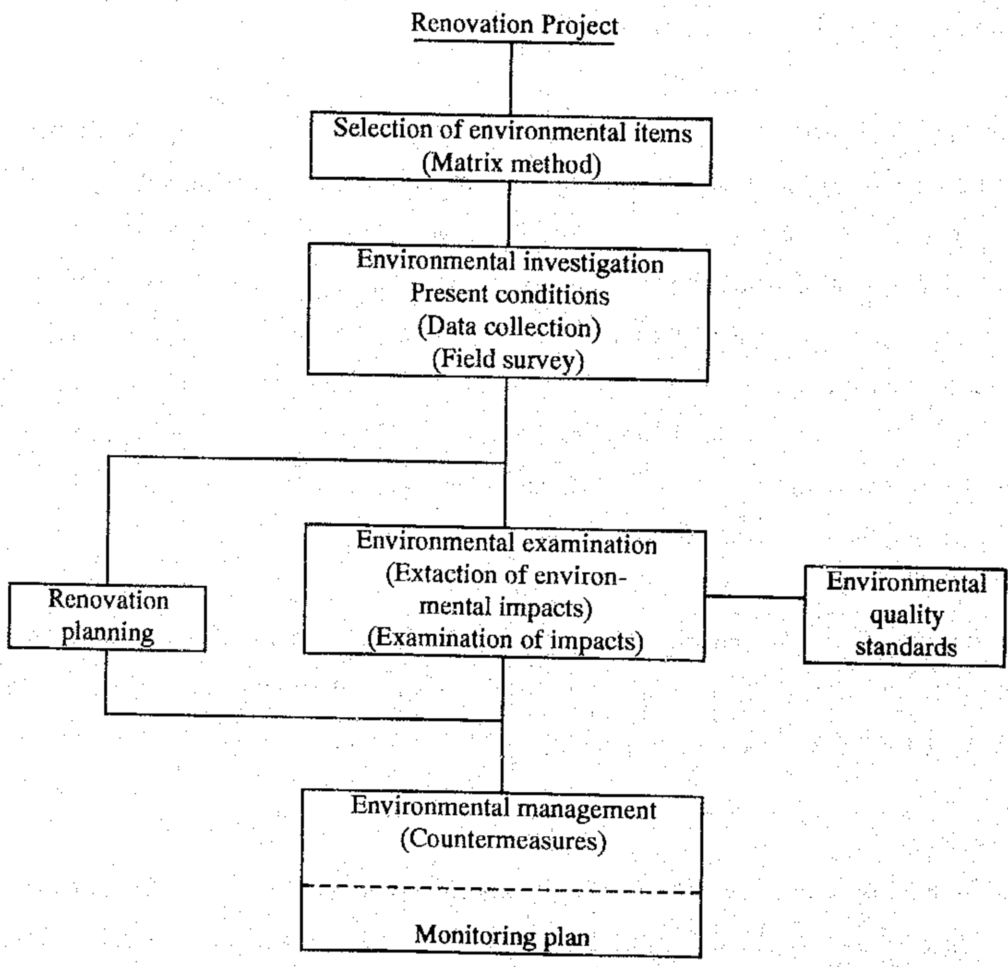



Figure 6.1 Flow of Environmental Study

Table 6.1 Selection of Environmental Items

| Environmental items | Environmental factors *1,*2: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | *3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. Living environment | | | | | | | | | | | | | |
| 1) Air quality | ○ | - | ○ | - | ○ | ○ | ○ | ○ | ○ | - | ○ | - | ◎ |
| 2) Water quality | - | ○ | ○ | - | ○ | - | ○ | ○ | ○ | ○ | - | ○ | ◎ |
| 3) Soil contamination | - | - | - | - | - | - | ○ | ○ | - | - | - | ○ | ◎ |
| 4) Noise/Vibration | ○ | - | - | ○ | ○ | - | - | - | ○ | - | - | - | ◎ |
| 5) Land subsidence | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6) Odor | - | - | - | - | - | - | - | - | - | - | - | - | - |
| II. Natural environment | | | | | | | | | | | | | |
| 7) Meteorology | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 8) Land | - | ○ | ○ | - | - | - | - | - | - | ○ | - | - | ◎ |
| 9) Water | - | ○ | ○ | - | - | - | - | - | - | - | - | - | ◎ |
| 10) Soil | - | ○ | ○ | - | - | - | - | - | - | - | - | - | ◎ |
| 11) Fauna/Flora | - | ○ | ○ | - | - | - | ○ | ○ | - | - | - | - | ◎ |
| 12) Landscape | - | ○ | ○ | - | - | - | ○ | ○ | - | - | - | - | ◎ |
| III. Social environment | | | | | | | | | | | | | |
| 13) Waste | - | - | - | - | - | - | ○ | ○ | - | - | - | ○ | ◎ |
| 14) Cultural heritage | - | ○ | ○ | - | - | - | - | - | - | - | - | - | ◎ |
| 15) Traffic | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 16) Hazards | - | ○ | ○ | - | - | - | ○ | ○ | - | - | - | - | ◎ |
| 17) Resettlement | - | ○ | ○ | - | - | - | ○ | ○ | - | - | - | - | ◎ |
| 18) Split of communities | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 19) Safety | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 20) Water rights | - | ○ | ○ | - | - | - | - | - | - | - | - | - | ◎ |

*1: 1: Heavy machines
2: Stripping of overburden
3: Mining of coal
4: Groundwater pumping
5: Transportation of coal
6: Transportation of spoils
7: Coal stockyard
8: Waste dump area
9: Plantsite
10: Treatment water and drainage
11: Loading of coal
12: Waste

*2: ○: Influential, - : Non influence

*3: ◎: Environmental items selected

Table 6.2 Laws and Regulations Related to Environmental Aspects

| No. | : | Laws and Regulations |
|---|---|---|
| 1) | : | Hunting Law of Mongolia |
| 2) | : | Conservation of Animal Resources and Controlling of Hunting, Decree No. 1979 |
| 3) | : | Ministerial Ordinance, No. 72/100, 1979, concerning Enforcement of Decree No. 1979-2 |
| 4) | : | Decision of Cabinet Conference concerning some Countermeasures of Hunting, No. 62, 1979 |
| 5) | : | Enforcement Regulation of Hunting of Mongolia |
| 6) | : | Regulations of Hunting Club of Mongolia |
| 7) | : | On the Use of Hunting Gun |
| 8) | : | Ministerial Ordinance concerning Control of Dealing of Bullet of Hunting Gun |
| 9) | : | Tax concerning Hunting of Animals |
| 10) | : | Regulation concerning Fishing Areas for Sports |
| 11) | : | Decision of Cabinet Conference concerning Several Countermeasures for Wolf Hunting, No. 41, 1974 |
| 12) | : | Control of Natural Conservation of Mongolia |
| 13) | : | Forest Law of Mongolia |
| 14) | : | Enforcement Regulation of Forest of Mongolia |
| 15) | : | Decision of Cabinet Conference concerning Penal Regulation against the Damage to the Forest Resources, No. 22, 1988 |
| 16) | : | Ministerial Ordinance, No. 31/A109, 1988, of Enforcement for Decision of Cabinet Conference No. 22, 1988 |
| 17) | : | Regulation Concerning Damage of Forest Resources |
| 18) | : | Decision of Cabinet Conference concerning Penal Regulation against the Damage of Forest Resources and Judicial Precedent, July 1988 |
| 19) | : | Law of Land Use of Mongolia |
| 20) | : | Enforcement Regulation of Land Use of Mongolia |
| 21) | : | Law of River Improvement of Mongolia |
| 22) | : | Enforcement Regulation of River Improvement of Mongolia |
| 23) | : | Decision of Cabinet Conference, No. 127, 1976, concerning Usage and Protection of Water Resources |
| 24) | : | Land Act of Mongolia |
| 25) | : | Regulation concerning Mining Claim of Quarry for Construction |
| 26) | : | Regulation and Enforcement concerning Mining Claim for Rare Mineral Resources |
| 27) | : | 17.2.3.17-80 :Natural Environmental Conservation :Air Quality :Air Pollution and Environmental Standard Value |
| 28) | : | 17.2.1.01-78 :Technical Terms and Explanation of Air Quality, Stack Gas, Air Pollution and Meteorology |
| 29) | : | 17.2.1.17-80 :Technical Teams and Explanation of Air Pollution from Engine |
| 30) | : | 14047-88 :Water Quality Control and Regulation of River |
| 31) | : | 17.1.1.14-80 :Environmental Standards for Water Quality |
| 32) | : | 17.1.1.10-79 :Technical Teams and Explanation of the Conservation of Water Resources |
| 33) | : | 17.5.1.19-92 :General Requirement for Land Reclamation |
| 34) | : | 17.0.0.06-79 :Standard and Basic Regulation of Natural Environmental Conservation System |
| 35) | : | Air Pollution Control Law of Mongolia |
| 36) | : | On the Air Pollutant, Ordinance from the Senior Health Officer of Mongolia, No. 11, 1989 |
| 37) | : | Environmental Standards for Noise at the Residential and Specific Facilities |
| 38) | : | Recommendation for Reclamation of the Changed Land, No. 116/276, 1989 |
| 39) | : | Ministerial Ordinance concerning Conservation of Water Resources |
| 40) | : | On the Evaluation standards for Drinking Water and Chemical Analysis Method, Directorate of statistics, 1983 |
| 41) | : | Water Quality Standards before Treatment at Sewage Plant, No.241/197/219, 1980 |

Table 6.3 Environmental Standards for Air Quality

| Items | Standard value ($mg/m^3$) Average value/day | Measured Value of a time |
|---|---|---|
| $SO_2$ | 0.05 | 0.5 |
| $NO_2$ | 0.085 | 0.4 |
| CO | 1.0 | 3.0 |
| Dust | 0.15 | 0.5 |

Table 6.4 Environmental Standards for Water Quality

(1) Raw water for drinking water

| Items | Unit | Classification of raw water I | II |
|---|---|---|---|
| 1. Suspended solids | mg/l | 0.25 | 0.75 |
| 2. Floating matter | | No oil film, floating solid, etc. | |
| 3. Odor/taste | | < 2 bal, without taste of fish | |
| 4. Color | cm | < 20 | < 10 |
| 5. Temperature | | Less 3 °C than average temperature of hot season within 10 years | |
| 6. pH | | 6.5 - 8.5 | 6.5 - 8.5 |
| 7. Dissolved ions | mg/l | Residue < 800 Cl<300, $SO_4$<400 | < 2 bal |
| 8. Dissolved oxygen | mg/l | < 4 | < 4 |
| 9. Biochemical oxygen demand | mg/l | 3.0 | 5.0 |
| 10. Bacteria | | No Colon bacilli | < 1,000 pcs/l, |
| 11. Poisonous substances | | Should not include | |

(2) Drinking water

| Items | Unit | Standards |
|---|---|---|
| a. Treated drinking water | | |
| 1. Odor/taste | | < 2 bal at 20 °C |
| 2. Color | | < 20 |
| 3. Transparency | cm | < 30 |
| 4. pH | | 6.5 - 9.5 |
| 5. Total ion | mg/l | < 1,000 |
| 6. Cl | mg/l | 350 |
| 7. $SO_4$ | mg/l | 500 |
| 8. F | mg/l | 1.4 |
| 9. Al | mg/l | 0.1 |
| 10. As | mg/l | 0.05 |
| 11. Cu | mg/l | 3 |
| 12. Zn | mg/l | 5 |
| 13. Total Fe | mg/l | 0.3 |
| 14. Hardness | mg/KB | < 7 |
| 15. Bacteria | | 100 /1 mg |
| 16. Colon bacilli | | < 3 |
| b. Well water | | |
| 1. Odor/taste | | < 2 bal at 20 °C |
| 2. Color | | < 35 |
| 3. Transparency | cm | < 30 |
| 4. Hardness | mg/KB | < 10 |
| 5. Bacteria | | 100 /1 mg |
| 6. Colon bacilli | | < 10 |
| 7. Nitrate | mg/l | 10 |

(3) Fishery water

| Items | : Unit | : Usage of water I | : II *1 |
|---|---|---|---|
| 1. Suspended solid | : mg/l | : 0.25 | : 0.75 |
| 2. Floating matter | : | : No oil film, floating solid, etc. | |
| 3. Odor/taste/color | : | : No influence to fishes | |
| 4. Temperature | : | : Less 5°C than standard temperature | |
| 5. pH | : | : 6.5 - 8.5 | : |
| 6. Dissolved Oxygen | : mg/l | : > 6.0 | : 4.0 *2 |
| 7. Biochemical oxygen demand | : mg/l | : 3.0 | : 4.0 |
| 8. Poisonous substances | : | : Should not include | |

*1 I : For rare fish which are sensitive to dissolved oxygen.
II : For other fish.

*2 Freezing condition during winter.

(4) Effluent standard at sewage treatment plant

| Items | : Standard value mg/l | : Rate of elimination % |
|---|---|---|
| 1. Suspended solid | : 500 | : 92 - 95 |
| 2. Biochemical oxygen demand | : 400 | : 92 - 95 |
| 3. Chemical oxygen demand | : 500 | : 65 - 80 |
| 4. Cu | : 0.5 | : 80 |
| 5. Oils | : 25 | : 85 - 90 |
| 6. Surface-active agent | : 20 | : 70 - 80 |
| 7. Sulphite dyes | : 25 | : 90 |
| 8. Pb | : 0.1 | : 50 |
| 9. Se | : 0.1 | : 50 |
| 10. Cr | : 2.5 | : 80 |
| 11. As | : 0.1 | : 50 |
| 12. Hg | : 0.005 | : - |
| 13. Zn | : 1.0 | : 70 |
| 14. $SO_4$ | : 1.0 | : 99.5 |
| 15. Ni | : 0.5 | : 50 |
| 16. Cd | : 0.1 | : 60 |
| 17. Co | : 0.1 | : 50 |
| 18. Total-Nitrogen | : 30 | : 25 |

Table 6.5 Environmental Standards for Noise

| Location | Time | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | Ave. | Peak |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | dB(A) Frequency(Hz) | | | | | | | | | |
| Resort, sanatorium | 7 - 23 | 67 | 57 | 49 | 44 | 40 | 37 | 35 | 33 | 45 | 60 |
| | 23 - 7 | 59 | 48 | 40 | 34 | 30 | 27 | 25 | 23 | 35 | 50 |
| Housing, resort handicapped, kindergarten | 7 - 23 | 75 | 66 | 59 | 54 | 60 | 47 | 45 | 43 | 55 | 70 |
| | 23 - 7 | 67 | 57 | 49 | 44 | 40 | 37 | 35 | 33 | 45 | 60 |
| Clinic, school, library | | 75 | 66 | 59 | 54 | 50 | 47 | 45 | 43 | 55 | 70 |
| Hotel,dormitory | 7 - 23 | 79 | 70 | 63 | 58 | 55 | 52 | 50 | 49 | 60 | 75 |
| | 23 - 7 | 71 | 61 | 54 | 49 | 45 | 42 | 40 | 38 | 50 | 65 |
| Hospital, sanatorium | | 59 | 48 | 40 | 34 | 30 | 27 | 25 | 23 | 35 | 50 |

## 6.3 Present conditions in the Baganuur district

Baganuur Coal Mine is located in the eastern part of Tov Aimag (Prefecture), approximately 110 km east-southeast of Ulaanbaatar (Capital). The administrative municipality, including the Baganuur Coal Mine and the survey area, is Baganuur Duureg (District) of Bayandelger Sum (Town) as shown in Figure 6.2.

Baganuur townsite was built for the development of the Baganuur Coal Mine and has been grown by the coal industry.

Therefore, there are no other remarkable industries and historical monuments before development of the townsite.

### 6.3.1 Social conditions

(1) Population

The population and rate of birth of Baganuur District are 17,000 and 1.2% in 1993 respectively.

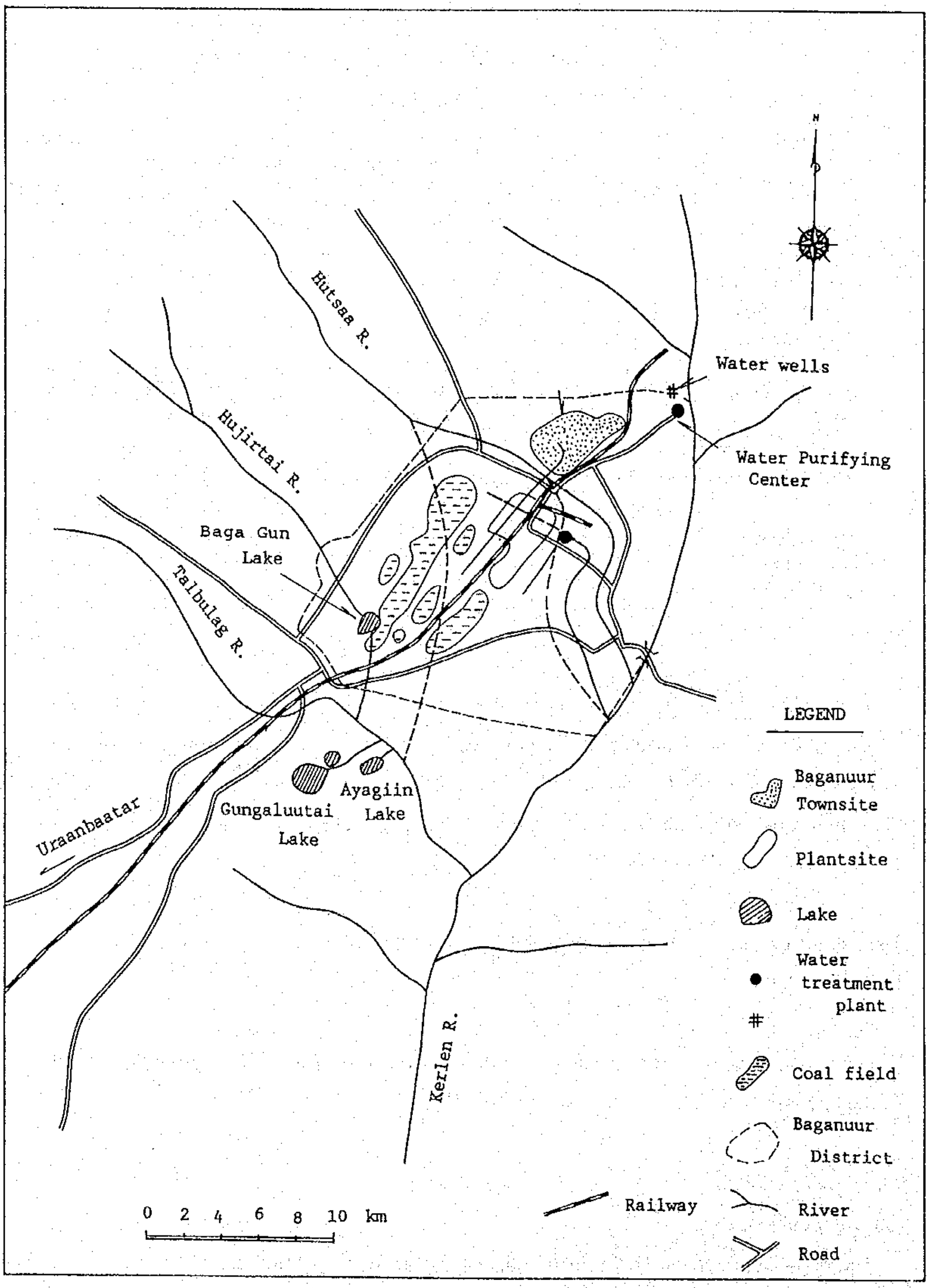



Figure 6.2 Baganuur District

(2) Education

Educational condition in the district is shown in Table 6.6.

Table 6.6 Educational Condition in Baganuur District

| School | Number | Name | Students |
|---|---|---|---|
| 1. 10 years elementary school | 2 | No. 66<br>No. 95 | 2,300 |
| 2. 8 years elementary school<br>&<br>6 years elementary school | 1<br><br>1 | No. 64<br><br>No. 98 | 1,100 |

(3) Medical condition

Medical condition in the district is shown in Table 6.7.

Table 6.7 Medical Condition in Baganuur District

| Medical facility | Beds | Doctor | Nurse and worker |
|---|---|---|---|
| 1. General hospital (Emergency hospital) | 248 | 50 | 150 |
| 2. Infectious hospital | 150 | - | - |
| 3. Health center | - | - | - |

(4) Water treatment

Drinking water for Baganuur townsite and coal plant site is supplied from Baganuur Water Purifying Center, located at the right bank of the upper stream of Kherlen River, approximately 10 km northeast of Baganuur townsite (see Figure 6.2). Source for raw water is groundwater, situated in an aquifer between -33 m and -44 m deep, pumped from five water wells located at the pumping station, with a combined average pumping volume of 400 $m^3$/hour.

Industrial water and heating water supplied to the townsite and plantsite is groundwater treated to be utilized, and it is pumped, approximately 15,000 $m^3$/day in volume, from the coal mine area.

Sewage water is drained to the Kherlen River, located approximately 15 km south-southeast, after being treated biologically at the Baganuur Sewage Treatment Plant, as shown in Figure 6.2. The average volume of treated water is 5,600 $m^3$/day. The rate of treatment of sewage is only between 86 and 93 % of the new required standard.

(5) Traffic conditions

The number of cars and traffic accidents are shown in Tables 6.8 and 6.9 respectively.

Table 6.8 Vehicles (1993)

| Number of car | : | 457 |
|---|---|---|
| 1. Passenger car | : | 172 |
| 2. Truck | : | 182 |
| 3. Bus | : | 48 |
| 4. Special motor vehicle | : | 16 |
| 5. Others | : | 39 |

Table 6.9 Traffic Accidents

| Year : | Traffic accident | : | Traffic fatalities |
|---|---|---|---|
| 1990 : | 1 | : | - |
| 1991 : | 2 | : | 1 |
| 1992 : | 5 | : | - |
| 1993 : | 8 | : | 5 |

(6) Other facilities

Other public facilities and others in the district are shown in Table 6.10.

Table 6.10 Public Facilities and Others

| Facilities | Number | Remarks |
|---|---|---|
| 1. Police station | 1 | |
| 2. Post office | 1 | |
| 3. Fire department | 1 | |
| 4. TV/radio studio | 1 | |
| 5. Public hall | 1 | |
| 6. Railway station | 1 | |
| 7. Sports stadium | 1 | |
| 8. Culture center | 1 | |
| 9. Theater | 1 | 340 seats |
| 10. Cinema | 2 | 300 seats |
| 11. Other | | |
| - Hot water plant | 1 | Coal mine site |
| - Bank | 2 | Ardyn Bank<br>Hotsh Bank |
| - Hotel | 2 | |
| - Newspaper | | Ardyn Errhe, Mongol Tamga, etc. |

(7) Industry

The first industry of the district mainly consists of stock farms, agriculture coal and metal minings. The domestic animals including cattle, horse, sheep, goat, camel,etc. are 34,000 heads. The agricultural land planting potato, cabbage, etc., is only 100 ha because of cold temperature and strong wind. The coal mining is the biggest industry in the district and provides to work for 1,500 people.

The second industry consists of bakery, brewery, beverage, meat and other dairy products. All of these products are very small.

The third industry consists of transportation, railway and small scale of radio/TV studio, hotel, newspaper, restaurant, and stores.

(8) Land use

Land use in Baganuur District mainly consists of stock farm grass-land with subordinate of coniferous forest, agricultural farm, and mining area.

6.3.2 Natural conditions

(1) Water

Rivers in the district belong to the Kherlen River system, which consists of the Kherlen River and its tributaries, including Hutsaa River, Hujirtai River and Talbulag River as shown in Figure 6.2. The river system shows a lattice pattern. Water course of Hutsaa River has been artificially changed to the northern part of the coal mining area as shown in Figure 6.2 by development of coal mining. There are three lakes in the southern part of the district, namely Baga Gun Lake, Gungaluutai Lake and Ayagiin Am Lake. Baga Gun Lake is adjacently located in the southeastern edge to the Baganuur Coal Mine area.

(2) Meteorology

The climate of the district belongs to Subpolar winter dry climate (Dw) by Keppen. Precipitation, average temperature, wind speed and dominant wind direction in the district in 1993 is 255 mm, -1.4 °C, 1.4 m/sec and N - NE respectively as shown in Table 6.11 and Figure 6.3.

Table 6.11 Meteorological Data in Baganuur District

(1) Precipitation (mm)

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | 0.2 | 0.3 | 3.4 | 4.6 | 48.2 | 33.6 | 55.1 | 40.8 | 32.4 | 2.3 | 0.3 | 1.2 | 222.4 |
| 1993 | 0.6 | 0.9 | 0.1 | 4.0 | 16.0 | 49.7 | 89.4 | 61.3 | 11.5 | 6.7 | 9.3 | 5.6 | 255.1 |

(2) Temperature (°C)

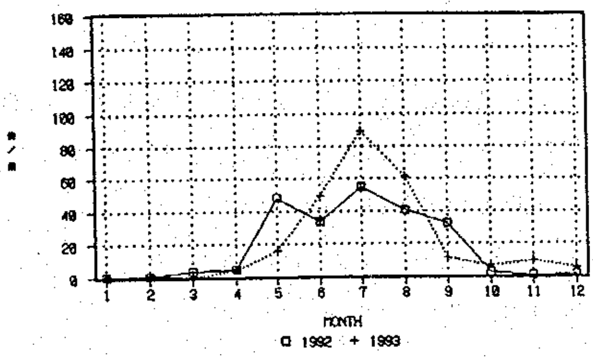
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | -18.0 | -14.5 | -8.5 | -0.2 | 10.6 | 14.1 | 15.4 | 13.8 | 6.1 | -2.6 | -11.5 | -22.4 | -1.4 |
| 1993 | -25.3 | -15.8 | -4.5 | -1.3 | 7.8 | 12.8 | 15.2 | 12.3 | 4.0 | -1.9 | -19.6 | -22.1 | -3.2 |

(3) Wind speed (m/sec)

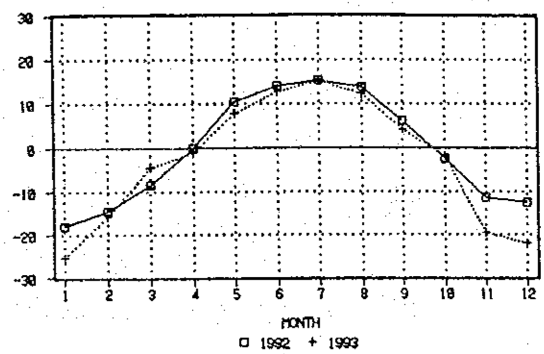
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | 0.2 | 1.4 | 1.1 | 2.9 | 1.7 | 2.0 | 2.0 | 1.5 | 2.7 | 2.1 | 1.7 | 1.0 | 1.7 |
| 1993 | 0.5 | 1.7 | 2.1 | 3.7 | 4.7 | 3.0 | 2.6 | 2.1 | 2.7 | 2.3 | 0.7 | 1.4 | 2.3 |

(4) Wind direction

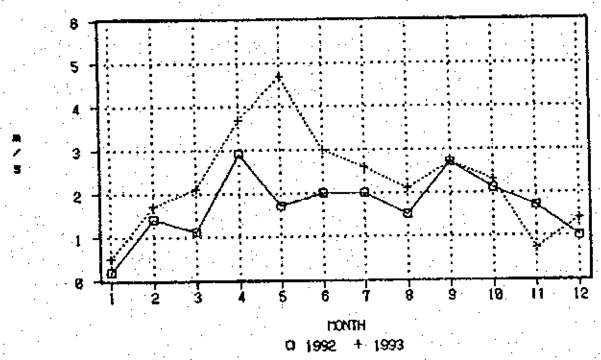
| Year : | NE | E | SE | S | SW | W | NW | N |
|---|---|---|---|---|---|---|---|---|
| 1992 : | 16.2 | 37.2 | 4.4 | 1.5 | 9.0 | 8.2 | 15.5 | 8.0 |
| 1993 : | 34.2 | 4.5 | 2.7 | 5.7 | 14.5 | 5.1 | 11.1 | 22.2 |



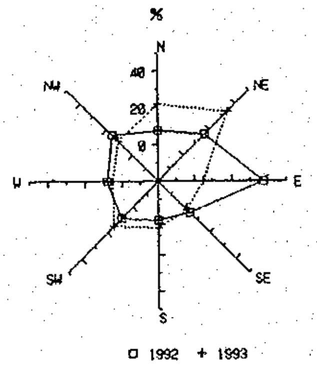

(1) Precipitation




(2) Temperature(° C)




(3) Wind speed




(4) Wind direction

Figure 6.3 Meteorological Condition in Baganuur District

### 6.4 Environmental conditions in the survey area

The survey area covers an area of approximately 50 $km^2$ and corresponds to the wide valley consisting of several tributaries of Kherlen River as shown in Figures 6.2 and 6.4.

#### 6.4.1 Living environment (Pollution)

(1) Air quality

1) Air quality

Air quality in Baganuur District and the survey area in 1989 is shown in Table 6.12. The concentrations of $SO_2$ and $NO_2$ in the industrial zone are almost similar to that of townsite and less than the standard value. The main facilities for emitting soot and dust in the district are allocated in a heat supply plant situated in the coal mine site (industrial zone). Control of pollutants at the heat supply plant has not been enforced at the present time.

Table 6.12 Air Quality in Baganuur District and Survey Area

($ug/m^3$)

| No.: Location *1 | $SO_2$ | | $SO_3$ | | $NO_2$ | | Soot & dust | |
|---|---|---|---|---|---|---|---|---|
| | Ave. | Max. | Ave. | Max. | Ave. | Max. | Ave. | Max. |
| 1 : Sewage treatment plant | 11 | 22 | 92 | 201 | 30 | 81 | 80 | 110 |
| 2 : Industrial zone *2 | 14 | 35 | 105 | 523 | 31 | 74 | - | - |
| 3 : Center of townsite of Baganuur | 15 | 36 | 89 | 232 | 30 | 84 | - | - |
| 4 : Ulaanbaatar | 18 | 64 | 130 | 630 | 34 | 210 | 100 | 160 |
| 5 : Standard value *3 | 50 | 500 | - | - | 85 | 400 | 150 | 500 |

Source :Baganuur symposium, 1989

*1 : See Figure 6.2.

*2 : Plantsite in Baganuur Coal Mine.

*3 : Environmental standard for air quality of Mongolia.

2) Dust

Dust, mainly consisting of coal and clay, is generated by dump trucks of coal and topsoil transportation at mine roads and blasting at open pits. The dust during warm season is assumably dispersed to the surrounding mine area and it influences infinitesimally to flora and fauna including domestic animals.

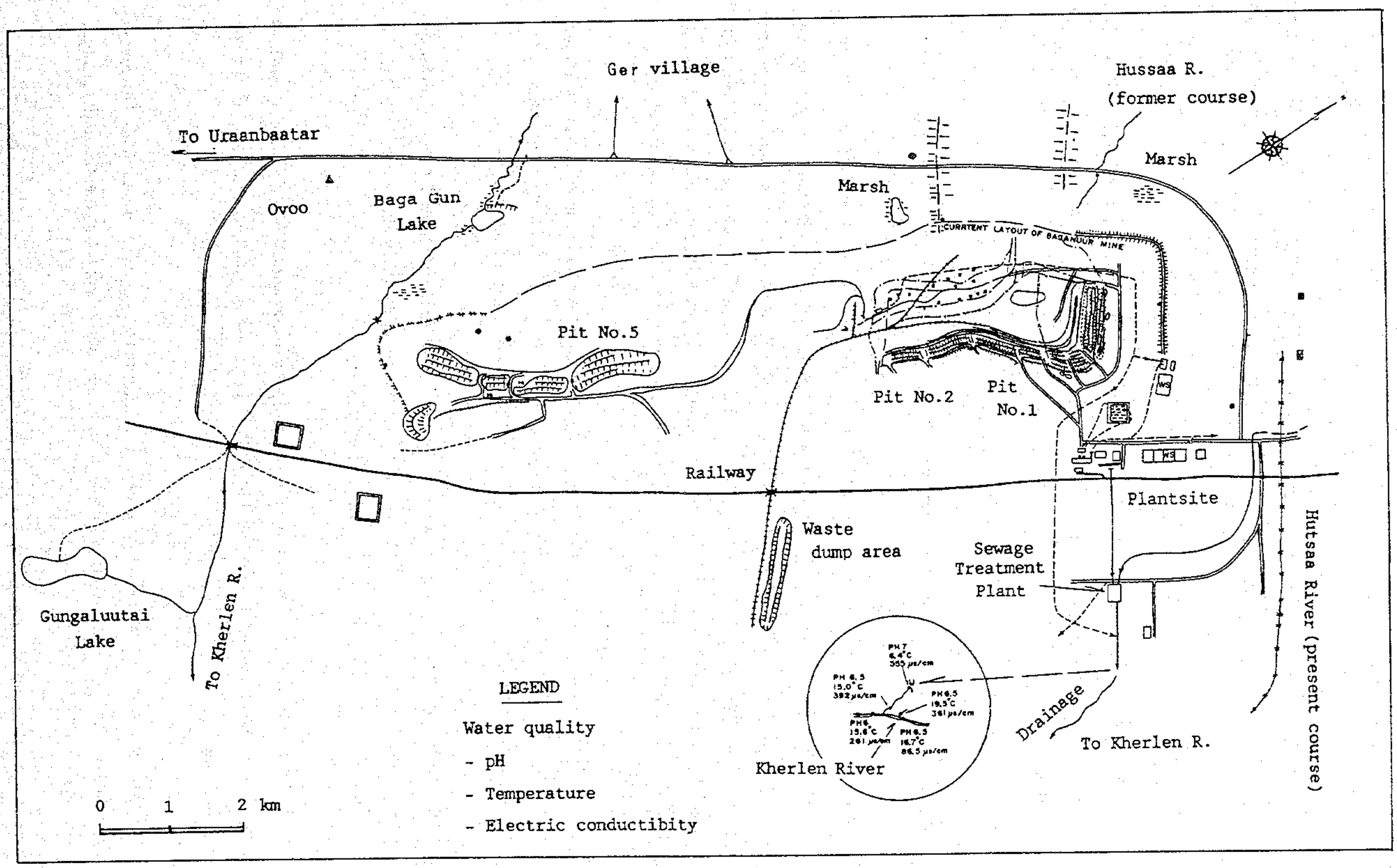



Figure 6.4 Baganuur Survey Area

At present, three sprinkler trucks, 32 $m^3$ in capacity, are operated for dust control. However, it is not enough to sprinkle whole area of mine during dry season from April to July.

3) Smoke

Smoke, which has been occasionally generated by spontaneous combustion of coal at open pit and coal stockyard, is said to influence on residents and domestic animals around the coal mine.

(2) Water quality

Water quality in Baganuur District is shown in Table 6.13, Table 6.14 and Figure 6.4.

Groundwater ranging in volume from 20,000 to 36,000 $m^3$ per day is pumped up at the mine site. It contains much ferric (0.6 % $Fe^{2+}$) as shown in Table 6.14. Half volume of groundwater pumped, approximately 15,000 $m^3$, is used as an industrial water for mine site and townsite after chemically excluded soluble iron. Rest volume of groundwater pumped is drained to the tributary of Kherlen River (Outflow No.1), together with treated sewage water of Baganuur townsite and mine site, the effluent flows out to the main stream of the Kherlen River.

Treated sewage water contains more contaminant than groundwater pumped and surface water of Kherlen River. Therefore, water quality at the lower part of junction between tributary and Kherlen River certainly indicates worse than that of the upper part of Kherlen River.

Water quality between inflow and outflow of Baga Gun Lake in Hujirtai River is different, especially on the electric conductivity. This phenomenon indicates that Baga Gun Lake is possibly to play a function of biological purification.

Seeped water in the open pits is pumped up, transported to the settlement pond located north of the mining area and drained to the tributary of the Kherlen River together with rest of the treated groundwater.

Seeped water from the waste dump area is presently not recognized in the place. However, suspended water in the waste dump is thought to be successively infiltrated to the underground.

Table 6.13 Water Quality in Baganuur District

(mg/l)

| No. | Location *1 | | $NH_4$ | P | Fe |
|---|---|---|---|---|---|
| 1 | Kherlen River | No. 1 | 0.34 | 0.002 | 0.01 |
| 2 | Kherlen River | No. 2 | 0.27 | 0.004 | 0.08 |
| 3 | Kherlen River | No. 3 | 0.31 | 0.021 | 0.04 |
| 4 | Hutsaa River | No. 4 | 0.43 | 0.486 | 0.10 |
| 5 | Hutsaa River | No. 5 | 0.60 | 0.070 | 0.22 |

source: Baganuur Symposium, 1989

*1 : See Figure 6.4.

Table 6.14 Water Quality in the Survey Area

July,1994

| No. | Location *1 | pH | T.*2 | E.C.*3 | Fe*4 | N*5 |
|---|---|---|---|---|---|---|
| 1 | Hutsaa River No. 1 | 6.8 | 14.1 | 233 | < 0.1 | < 0.2 |
| 2 | Hutsaa River No. 2 | 7.5 | 20.6 | 597 | - | - |
| 3 | Hujirtai River No.1 | 7.5 | 18.3 | 445 | - | - |
| 4 | Baga Gun Lake | 8.0 | 24.1 | 303 | < 0.1 | 0.2 |
| 5 | Hujirtai River No.2 | 7.5 | 24.2 | 292 | - | - |
| 6 | Baga Guniinuur | 8.0 | 20.1 | 1,113 | - | - |
| 7 | Well station | 6.9 | 16.9 | 131 | < 0.1 | < 0.2 |
| 8 | Groundwater at mine site (pumped) | 6.5 | 7.8 | 308 | 0.6 | < 0.2 |
| 9 | Sewage treatment center (treated) | 6.5 | 12.0 | 266 | 0.3 | 3.0 |
| 10 | Drain pipe | 6.8 | 6.4 | 555 | - | - |
| 11 | Outflow No. 1 | 6.5 | 15.0 | 392 | 0.1 | 0.25 |
| 12 | Pit No. 5 | 6.5 | 15.0 | 733 | < 0.1 | < 0.2 |
| 13 | Kherlen River No. 1 | 6.5 | 16.7 | 87 | < 0.1 | < 0.2 |
| 14 | Kherlen River No. 2 | 6.5 | 15.6 | 261 | < 0.1 | 0.2 |

*1 : See Figure 6.4.

*2 : Temperature (℃).

*3 : Electric conductivity ( μ S/cm).

*4 : Ferric ($Fe^{2+}$).

*5 : Nitrogen as ammonium ($NH_4$-N).

(3) Soil contamination

The quality of soil quality in Baganuur District as shown in Table 6.15 is relatively less than those of Darhan and Ulaanbaatar. The soil contamination in the survey area cannot be recognized.