are made directly by the buyers.

1-3 SUPPLY OF SODA ASH TO THE ASEAN MARKETS, AND PRICE FORMATION

1-3-1 Supply of Soda Ash to the ASEAN Markets

As is explained above, demand for soda ash in the ASEAN countries is being satisfied entirely by imports. Table II-5 gives soda ash import quantities and tabulations by source country.

In the past, almost all soda ash supplied in the world was synthetic ash. Plants for production of synthetic ash are operated in industrial countries in West Europe, the United Japan and elsewhere. In recent years, however, the discovery and development of natural ash in the United States and Kenya is diminishing cost competitiveness of synthetic ash relative to natural ash, and natural ash is becoming the dominant type of product in international trade.

The sources of ASEAN market imports of soda ash have undergone change in accordance with the above-mentioned change in the nature of soda ash trade, namely the shift from synthetic ash to natural ash. The major source of soda ash imported by the ASEAN region used to be Japan. Japan's share in the ASEAN market, however, has fallen from 32% in 1975 to 11% in 1977. Because there was a lull in domestic demand for soda ash in Japan in 1978, exports that year increased. At that time, however, there was a great difference between the export price and the domestic price, and the outlook was that if domestic demand recovered, exports would be reduced. In contrast to this situation, Kenya has maintained a 30-35% share of the ASEAN market. The U.S. share, which was about 15% in 1975 and 1976, rose to 24% and 20% in 1977 and 1978. Other than these two countries' shares, exports from West Europe account for 5-15% of the market. Among the West European exporters, France has maintained a relatively stable level of exports, and the other West European countries have intermittently continued exportation, although at low levels. The shares of East European countries and Korea have fluctuated greatly year to year. In other words, with the exception of France, in the case of the West European and East European countries, and Korea, when there has been a surplus of supply in their domestic markets or captive export markets, they have made spot exports to the ASEAN market.

1-3-2 Soda Ash Price Formation in the ASEAN Market

Table II-6 compares imports price of soda ash by import source. In that table it can be observed that in about 1975 each import price was roughly linked to the import price of

Table II-5 IMPORT OF SODA ASH IN ASEAN COUNTRIES BY IMPORT SOURCE

(000 tons)

	1975	1976	1977	1978
Import Sources				
Kenya	44.3 (33.7)	59.3 (30.1)	63.1 (29.8)	78.2 (34.8)
USA	21.1 (16.1)	29.7 (15.1)	51.7 (24.4)	45.7 (20.3)
Japan	42.1 (32.1)	26.8 (13.6)	22.7 (10.7)	67.2 (29.9)
W. Europe	11.6 (8.8)	28.1 (14.2)	28.7 (13.5)	11.8 (5.3)
E. Europe	2.3 (1.8)	22.5 (11.4)	30.5 (14.4)	18.1 (8.1)
Korea, Rep. of	5.0 (3.8)	22.7 (11.5)	7.9 (3.7)	1.0 (0.4)
Total (incl. Others)	131.3 (100.0)	197.2 (100.0)	211.9 (100.0)	224.7 (100.0)

(Notes) 1) Import amount to Singapore includes the amount to have been re-exported.
2) ( ): Percentage of total

Sources: Sources: See Table II-1.

Japanese ash, but thereafter the import prices were linked to the Kenya ash price. (Note, however, that as mentioned above the large quantities of Japanese exports which resulted due to the domestic supply surplus in Japan in 1978, are thought to have lowered the Japanese export price. Therefore Table II-6 alone is not adequate for evaluating the price situation in that year.)

This change has meant that rather than Japan, Kenya has become the price leader in the ASEAN market. The import price of American ash has been kept as the same level as that of Kenyan ash, or 10% higher than it. (In the market at the present time the price of American ash is about 10% higher than that of ash from Kenya, reflecting the superiority of the quality of the American product.) The export price of American soda ash (FOB) in 1978 was as follows.

Export Prices of USA Soda Ash, 1978

Destination	Export prices (FOB, US$/MT)
West Europe	84.8
Central America	91.6 – 94.8
Southeast Asia	77.5 – 79.3

Source: Trade Statistics, USA

As is obvious from this table, the export price of soda ash for the Southeast Asian market was low in comparison to the price of soda ash exports to other regions. One reason for this which may be cited is the existence of a spot market in Southeast Asia where East European, Korean and some West European suppliers were making export sales when their usual markets were in an over-supply position. Another reason would be that it was necessary for America to reduce its export price in order to maintain market share in the face of low prices

Table II-6 CHANGE IN THE IMPORT PRICE[1] OF SODA ASH IN ASEAN COUNTRIES

(CIF, US$/ton)

	1975	1976	1977	1978
Kenya	110.0	113.7	103.3	94.8
USA	161.9	111.5	99.0	105.2
Japan	210.1	136.5	154.6	119.9
W. Europe	127.2	116.6	111.0	140.4
E. Europe	145.6	100.8	96.3	122.4
Korea, Rep. of	191.4	120.0	111.9	113.0

(Note) 1) Weighted average price of CIF price in ASEAN countries.

Sources: See Table II-1.

for Kenyan products which were made possible by low production costs. From these conditions it may be observed that at least up until the present time America has not been the price leader in the ASEAN market.

1-3-3 Supply Outlook for Soda Ash in the ASEAN Market, and Projections of Its Price

As is evident from the foregoing, in view of the outlook for low competitiveness of synthetic soda ash as compared to natural ash, Kenya and the United States may be expected to be the major countries supplying soda ash to the ASEAN market.

In the case of Kenya, market share was maintained in the past by means of control of the price of the soda ash, but recently (1980) a change in that country's policy has become evident.

That is, whereas the price of Kenyan ash in the past was about 10% lower than that of American soda ash, prices in 1980 show that Kenyan price has been offered at the same level as that of American ash. It is presumed that this change is related to the program now being implemented by Kenya to increase production capacity. That is, it is thought that capital investment is necessary in order to increase production capacity, and in order to secure the investment it becomes difficult for Kenya to maintain its low sales price policy.

On the other hand, for the United States the outlook is for there to be a considerable surplus of supply over demand within the United States (regarding the outlook for the supply and demand balance of soda ash and caustic soda in America, refer to the SNC report) and whereas there is not necessarily going to be a steady pattern of exports to the West European market, plans are being made to expand exports to the Southeast Asian markets. In the past America exported only to the Philippines among all SoutheastAsian nations but since 1977 has also exported to Thailand.

From the above situation it is thought that in the future the American soda ash will become the price leader in the ASEAN market and as long as the price is in the range which Kenya can follow, the Kenyan price is expected to be set at 5-10% less than the American price.

Regarding the price formation of American soda ash, it is necessary to examine the relationship with prices in the domestic American market. There are some areas of use where soda ash and caustic soda compete. Further, soda ash is produced as a derivative from caustic soda in addition to being obtained as natural ash or made as synthetic ash (synthesized using salt, by the Solvay or other processes). Therefore, when the price of soda ash is relatively higher than that of caustic soda, not only does caustic soda dominate in the areas of use where the two compete but caustic soda will take over part of the demand areas hitherto exclusively those of soda ash, through conversion of caustic soda into soda ash, through this, the price of American soda ash will not be higher than that of caustic soda as long as production cost permits. Contrary to the above, when the caustic soda price is higher than the soda ash price, the soda ash price tends to approach the caustic soda price especially when the supply/demand situation of soda ash is tight. In this case of course a differential remains between the prices, reflecting the difference in Na_2O content, as well as the easier handling characteristic of caustic soda.

The outlook for the domestic American supply/demand balance of soda ash in about 1985 to tend to show a shortage of supply (cf. the SNC report). Therefore the domestic American price of soda ash may be expected to be linked to the caustic soda price. That is, it is expected that the U.S. ex-factory price of soda ash will be lower than that of caustic soda, to the extent of the premium for the difference in Na_2O content, and easier handling. On the other hand, in the ASEAN market, under the influence of increased supply of Kenyan ash, the supply-and-demand balance will tend to be one of a surplus of supply. It is therefore expected that the price of Kenya ash then will be set at the highest point in the range which will keep American ash out of the ASEAN market (i.e., at the point which is the highest level at which American producers will find it more profitable to ship to domestic users rather than export to the ASEAN nations). Reasoning on this basis, it is expected that in 1985 the price of soda ash in the ASEAN market will be at about US$225/t in average. These price relationships are depicted schematically in Figure II-2.

In the ASEAN region CIF prices vary country by country reflecting differences in the capacity of unloading facilities in importing ports, ship arrangements as well as volume of import lots. The following are the differences in CIF prices of each ASEAN country from an average CIF price in the ASEAN region which are given as index numbers.

Average price in ASEAN region (CIF)	100
Indonesia	101.92
Malaysia	102.23
Philippines	100.43
Singapore	101.68
Thailand	100.00

If it is assumed that the above differences would continue in the future, in 1985 CIF prices in the ASEAN countries are projected as follows:

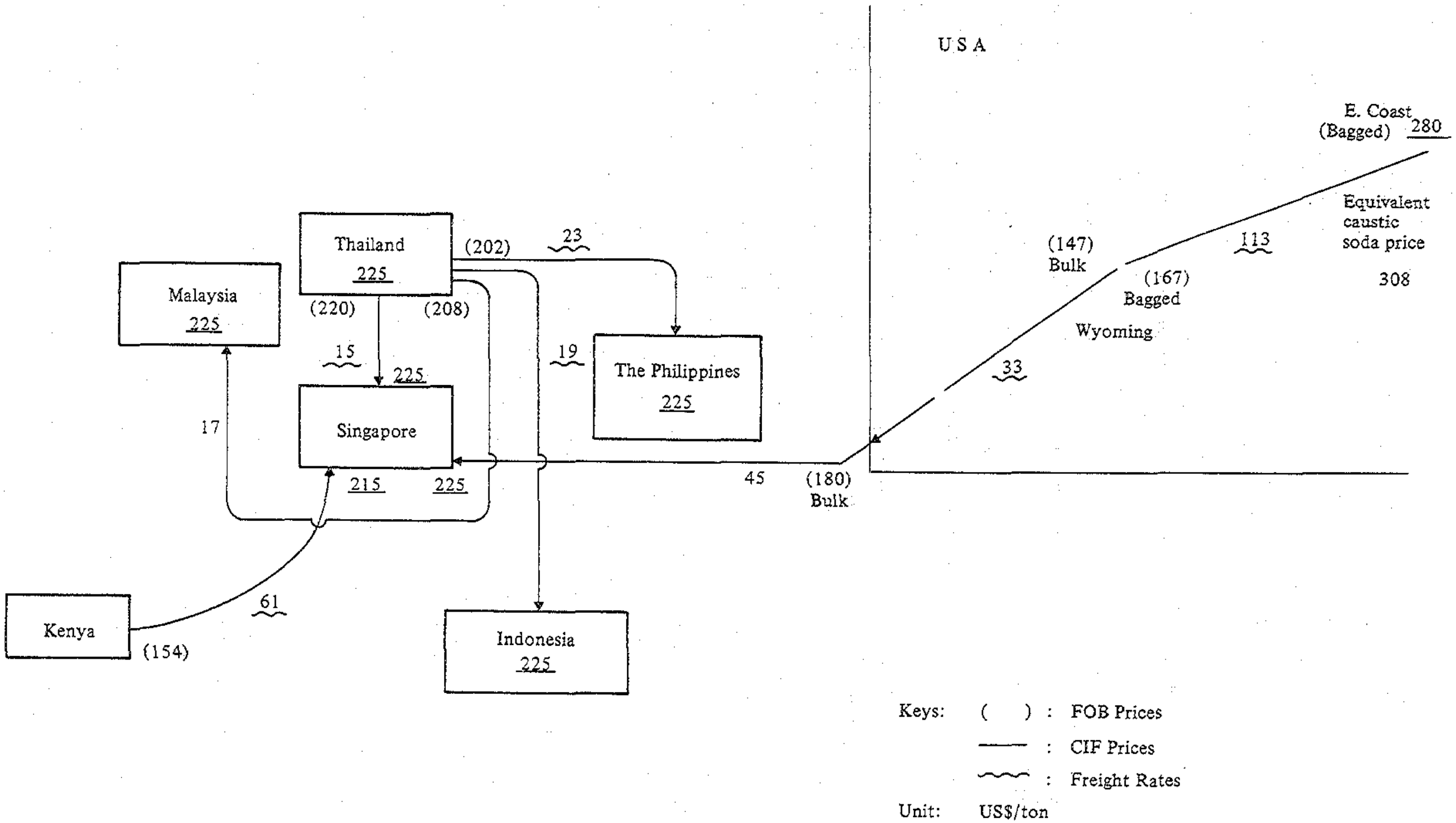


Figure II-2 PRICES AND FREIGHT RATES OF SODA ASH IN 1985

Average price in ASEAN region (CIF)	US$225/t
Indonesia	US$229/t
Malaysia	US$230/t
Philippines	US$226/t
Singapore	US$229/t
Thailand	US$225/t

1-3-4 Outlook for Sales Volume of this Project's Soda Ash

As is mentioned above, the major suppliers of soda ash to the ASEAN market have been Kenya, America and Japan, but in addition East European, Korean and other suppliers have made spot sales in the ASEAN market depending on domestic demand conditions, and conditions in usual export markets. If production as contemplated for this Project is begun and the product has price competitiveness, there is no doubt but that this Project will become the main source of supply of soda ash to the ASEAN region. Nevertheless it is still possible that there will continue to be spot sales as noted above. The question then is to what extent such spot sales will continue. It is extremely difficult to anticipate the answer to this. As one factor working to reduce future spot sales, there is the Preferential Trade Arrangement between the ASEAN nations. However, the PTA now does not provide preferential treatment on import duties of soda ash. It is, moreover, not known about to what extent the individual governments of ASEAN member countries may control importation of soda ash by private firms, in view of the fact that in these countries the importation of soda ash was free from the government' control. It seems necessary that arrangements on the above aspects be made among the ASEAN member states. In addition to the above questions, it would be necessary to take the following situations into consideration.

First, the ASEAN region is an important export market for Kenyan ash. Kenya is now progressing with a program to double natural ash production capacity, and once all physical arrangements for that have been completed, Kenya will undoubtedly start a strong export campaign. If Kenya encounters any difficulty in developing new markets, it will be expected that the export promotion effort aimed at ASEAN will be strengthened even to the extent of lowering price.

Second, users in the ASEAN region have had the bitter experience of having to suspend operations because of supply shortages in 1973-74. Because of this they will resist becoming dependent on only one source.

In view of the above discussion, it would be too optimistic to expect that the entire quantity of ASEAN market demand can be satisfied by the product of this Project. The quantity of soda ash produced by this Project which is believed to be marketable has been estimated on the basis of judgement of the Project's share of the ASEAN market, taking the above-described conditions into consideration. The marketable quantity of soda ash thereby obtained is as shown in Table II-7; it is expected to be 368,000 t in 1985 and 510,000 t in 1990.

Table II-7 PROJECTED SALES AMOUNT OF THAI SODA ASH IN ASEAN COUNTRIES

(000 tons)

	Thailand	Indonesia	Malaysia	Singapore	The Philippines	Total
1985	119.6	93.5	42.8	15.9	96.0	367.8
1986	129.6	99.9	45.8	16.0	101.9	393.2
1987	140.8	106.5	49.0	16.0	108.2	420.5
1988	151.9	113.3	52.3	16.2	112.8	446.5
1989	163.4	120.4	55.2	16.2	121.7	476.9
1990	175.3	127.6	59.4	18.4	129.1	509.8
1995	223.3	167.5	80.2	21.1	170.1	662.2

CHAPTER 2 SALT

2-1 THE SALT MARKET IN THE ASEAN NATIONS

2-1-1 Present Conditions and Outlook for Supply and Demand of Salt in the ASEAN Nations

Demand for salt in the ASEAN nations, by type of use, is estimated as is shown in Table II-8 (for details, see Annex II). There are almost no data on the actual quantities of salt demand and there are contradictions which make data which do exist to be unreliable. Therefore the estimations of salt demand have had to be made under this condition of data inadequacy.

The salt demand pattern in each of the ASEAN countries can be uniformly viewed as having the following composition.

1. Home consumption (cooking; table salt)
2. Salting of fish
3. Food industry consumption (production of sauces, catsup, canned foods, etc.)
4. Chemical industry consumption (production of caustic soda, soap, etc.)
5. Other uses (feedstuffs, etc.)

The composition of total ASEAN demand as of 1978 and according to this pattern was: home consumption, 61%, caustic soda production, 14%; all other uses, 26%.

Salt is generally classified in terms of being either industrial salt which is required to have a NaCl content of 96–97%, or ordinary salt. It is possible, of course, to use industrial salt as ordinary salt, but there is a price differential between the two that discourages this and a clear distinction is made between them in the ASEAN nations. Because almost all industrial salt is used in the chemical industry and particularly as a raw material for production of caustic soda, it is required to have a high NaCl content and high purity. For other uses, the presence of heavy metals etc. is a problem but the level of NaCl content is not much of a problem.

Table II-8 ESTIMATED CONSUMPTION OF SALT IN ASEAN COUNTRIES, 1978

(000 tons)

	Home Consumption	Caustic Soda	Fish Salting and Others	Total
Thailand	136.1	49.7	76.6	262.4
Indonesia	409.9	42.2	63.9	516.0
Malaysia	32.3	22.7	70.1	125.1
The Philippines	139.1	45.1	73.8	258.0
Singapore	7.0	4.8	22.2	34.0
Total	724.4	164.5	306.6	1,195.5
(% of Consumption Total)	(60.6)	(13.8)	(25.6)	(100.0)

For salt to be used to preserve fish, in particular low cost is desired. (Thereafter, for convenience, salt for the caustic soda industry is called "industrial salt" and salt for other use is called "ordinary salt".)

In Indonesia, basically, demand for salt is entirely met by solar salt produced domestically, and such self-sufficiency is a fundamental national policy. Because the volume of production of solar salt is easily influenced by weather conditions, Indonesia's salt production fluctuates considerably. Indonesia is now proceeding with a project intended to provide a domestic supply of industrial salt, production of which has been scheduled to start in 1981. Production capacity is to be 300,000 t/y of industrial salt, and it is intended to satisfy the country's entire demend, including that for industrial salt, from domestic sources. (Regarding the past performance of, and outlook for, production and imports of salt by Indonesia see Tables AII-13 and AII-14, in Annex II.)

Other than that for industrial salt, the entire Philippines demand for salt is satisfied by domestically produced solar salt. Industrial salt had been produced domestically, but increases in the cost of so doing resulted in loss of price competitiveness relative to imports, and with the exception of certain specific users all industrial salt is imported. Domestic industrial salt is protected by a mechanism wherein the import duty is waived only by the BOI, on the basis of approval by industrial salt producers. However, the import duty (50%) is levied on the FOB price which means that it isa low duty which has little actual effect. Consequently, one of the two domestic producers of industrial salt has halted production. Salt made by the other industrial salt company has a low NaCl content, and contains impurities due to pollution of the ocean, so that it is being used only for making soap. The country is dependent on imports for all of its requirements of industrial salt for caustic soda production. At the present time, however, progress is being made for a project which would use geothermal energy at a location other than that where solar salt is now being produced, to make high-grade industrial salt, and it is planned that production will begin during 1981. This plan calls for two companies to produce a total of 200,000 to 300,000 t/y and when production begins not only will it become possible to satisfy all of the domestic requirement but there will also be an exportable surplus. (Regarding the past performance of, and outlook for, production and imports of salt by the Philippines, see Table AII-24 in Annex II.)

There is no production at all of salt in Malaysia and Singapore; all requirements are met by imports. For industrial salt, imports from Australia and Ethiopia are the most important, and for ordinary salt, imports from Thailand are used. Because of restraints imposed by natural conditions, neither country is expected to commence production in the future.

Thailand's production of solar salt exceeds the level of domestic demand, and this country is an exporter. Export records for the past 10 years indicate considerable fluctuation as a consequence of changes in weather conditions, but with the exception of years when weather conditions were particularly bad, annual exports have been on the order of 90,000 to 100,000 t. Because recently weather conditions have been favorable, exports have increased, but the area devoted to salt drying beds has been declining. In view of these conditions, it is expected that the quantity of solar salt produced, and that exported, will remain about at the present level.

2-1-2 Target Markets for Rock Salt in the ASEAN Nations, and Outlook for Demand

On the basis of the above-described supply and demand conditions in the ASEAN nations, the market which can be identified as the target for sale of rock salt from this Project, within the ASEAN region, is Malaysia, Singapore and Thailand. Estimates of present supply and demand for salt in these three countries, and the future outlook, are as given in Table II-9 (for details, see Annex II).

From the viewpoint of the protection of the country's salt makers, the GOT has the policy of preventing rock salt from competing with solar salt in the market of solar salt of Thailand.

Therefore the market in Thailand which can be supplied by sale of rock salt from this Project is that portion of total demand remaining after the share supplied by solar salt is deducted. Further, in the case of Singapore and Malaysia which have been importers of Thai solar salt, the market which can be satisfied by this Project would be the demand in those two countries, from which the share held by Thai solar salt is subtracted. The scale of demand which can be expected for this Project was estimated on the basis of the reasoning given above. Results, as shown in Table II-9, are demand quantities of, in 1985, 81,000 t in Thailand, 8,000 t in Singapore, and 147,000 t in Malaysia, for a total of 236,000 t. In 1990 it would be 178,000 t in Thailand, 8,000 t in Singapore, and 199,000 t in Malaysia for a total of 385,000 t. (Note that supply quantities for soda ash production of this Project are not included herein.)

2-2 SALT SUPPLY AND PRICE FORMATION IN THE ASEAN MARKET

Table II-10 gives salt import quantities by source, for the Philippines, Malaysia and Singapore. Because the quantity imported by Thailand is extremely low and Indonesia imported salt only in years when domestic production was insufficient, these two countries are not shown in the table. Total imports for these three countries as of 1975 included a share of 39% accounted for by solar salt from Thailand, representing the largest share. After that year, Thai solar salt maintained a share of 30–40%. The share of Australian salt, in contrast to that, increased starting from 22% in 1975, and passed the level of 50% in 1978. The com-

Table II-9 PROJECTED DEMAND FOR SALT IN THAILAND, MALAYSIA AND SINGAPORE

(000 tons)

		Demand for Salt		Production	Import from Thailand	Available Market for Thai Rock Salt
		Domestic (A)	Export (B)	(C)	(D)	(A + B) − (C + D)
1978	Thailand	262.4	107.4	763.7	–	–
	Malaysia	125.1	–	–	57.7	–
	Singapore	34.0	–	–	26.7	–
	Total	421.5	107.4	763.7	84.4	–
1985	Thailand	347.2	96.0	362.0	–	81.2
	Malaysia	191.1	–	–	44.0	147.1
	Singapore	33.7	–	–	26.0	7.7
	Total	572.0	96.0	362.0	70.0	236.0
1990	Thailand	443.7	96.0	362.0	–	177.7
	Malaysia	242.9	–	–	44.0	198.9
	Singapore	34.2	–	–	26.0	8.2
	Total	720.8	96.0	362.0	70.0	384.8
1995	Thailand	510.7	96.0	362.0	–	244.7
	Malaysia	261.0	–	–	44.0	217.0
	Singapore	34.7	–	–	26.0	8.7
	Total	806.4	96.0	362.0	70.0	470.4

Table II-10 IMPORT OF SALT BY IMPORT SOURCE IN MALAYSIA, THE PHILIPPINES AND SINGAPORE

(000 tons)

	1975	1976	1977	1978
Import Sources:				
Australia	41.0 (22.4)	79.6 (39.8)	99.3 (46.6)	111.2 (50.2)
Ethiopia	12.8 (7.0)	10.4 (5.2)	13.6 (6.4)	– (–)
Thailand	71.7 (39.0)	60.4 (30.2)	64.0 (30.0)	83.5 (37.8)
India	20.9 (11.4)	35.6 (17.8)	26.6 (12.5)	– (–)
Total (Incl. Others)	183.3 (100.0)	200.0 (100.0)	213.2 (100.0)	221.3 (100.0)

(Notes) 1. Amount of import in Singapore includes the amount to have been re-exported.
2. ( ): Percentage of total.

Sources: See Table II-1.

bined share of Thai solar salt and Australian salt in 1978 was 88%.

The two countries which dominate world export trade in salt are Australia and Mexico. The largest importer is Japan, and Australia and Mexico compete in the Japanese market. Ocean freight is an important factor in the formation of the price of salt. Both Australia and Mexico use large vessels (60,000 DWT class) to ship salt to Japan, and also have sought to lower ocean freight costs by increasing loading capacity. In the case of salt, the size of the carrier is generally more influential on price than the distance the salt is transported. Partly because of this, the price of salt is primarly quoted in FOB terms. The Japan import price is the basis for the world price. The Japan import price is determined through the competition of Australia and Mexico, and it is thought that this price is the standard both countries use in setting the export price of salt. Figure II-3 shows schematically the above price formation relationships as of 1978. The price given here for Thai solar salt in terms of CIF price is higher than the Australian salt price, but it is thought that this is because Thai salt is a bagged product. (It is necessary to pack in bags salt to be shipped for use in salting fish.)

Figure II-4 similarly shows price relations as expected for 1985. According to this, in major export markets it is estimated that the export port FOB price for Thai rock salt to be competitive must be US$33/t for Malaysia-bound shipments, and US$26/t for Singapore-bound shipments.

However, these prices have been estimated on the assumption that the Thai rock salt quality is comparable to that of Australian salt. In actuality, as pointed out in 3–4, the quality of Thai salt seems to be somewhat inferior to that of Australian salt, although this is a preliminary judgement because of a limited number of samples available for analysis. For it to be used as industrial salt, the users face the burden of the additional cost of purifying Thai salt, and a discount is necessary to compensate for that cost. Further, in order to have a monopolistic share in an export market, if these conditions are considered the FOB price, as the 1985 price, must be US$29/t for Malaysia, and US$24/t for Singapore.

2-3 POSSIBILITY OF EXPORTS TO OUTSIDE THE ASEAN REGION

As noted above the cost of ocean freight accounts for a very high portion of the C&F price of rock salt. Moreover, ocean freight cost varies not only according to the distance but also the size of the vessel, and is influenced by the capacity of the material handling facilities used for loading and unloading in ports. The cost of shipping rock salt from Thailand to Japan is at about the same level as the cost of shipping salt from Australia to Japan, as shown in Figure II-4 if 15,000 to 20,000 DWT class vessels are used. Therefore, it is necessary for Thailand to use large vessels to export rock salt to the countries for which the competitor countries can use large vessels for export of their product. On the other hand, when exports

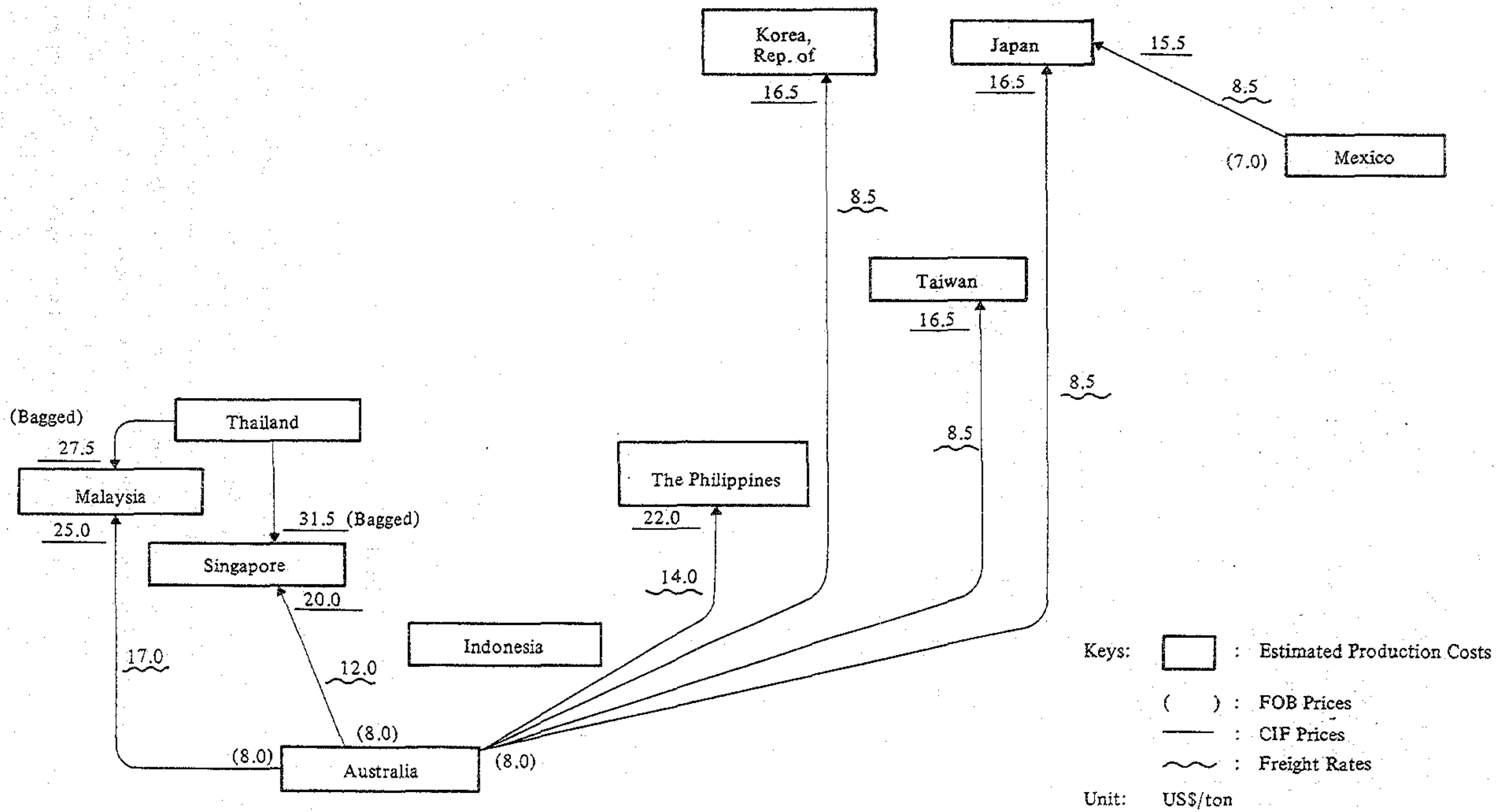


Figure II-3 PRICES AND FREIGHT RATES OF SALT IN 1978

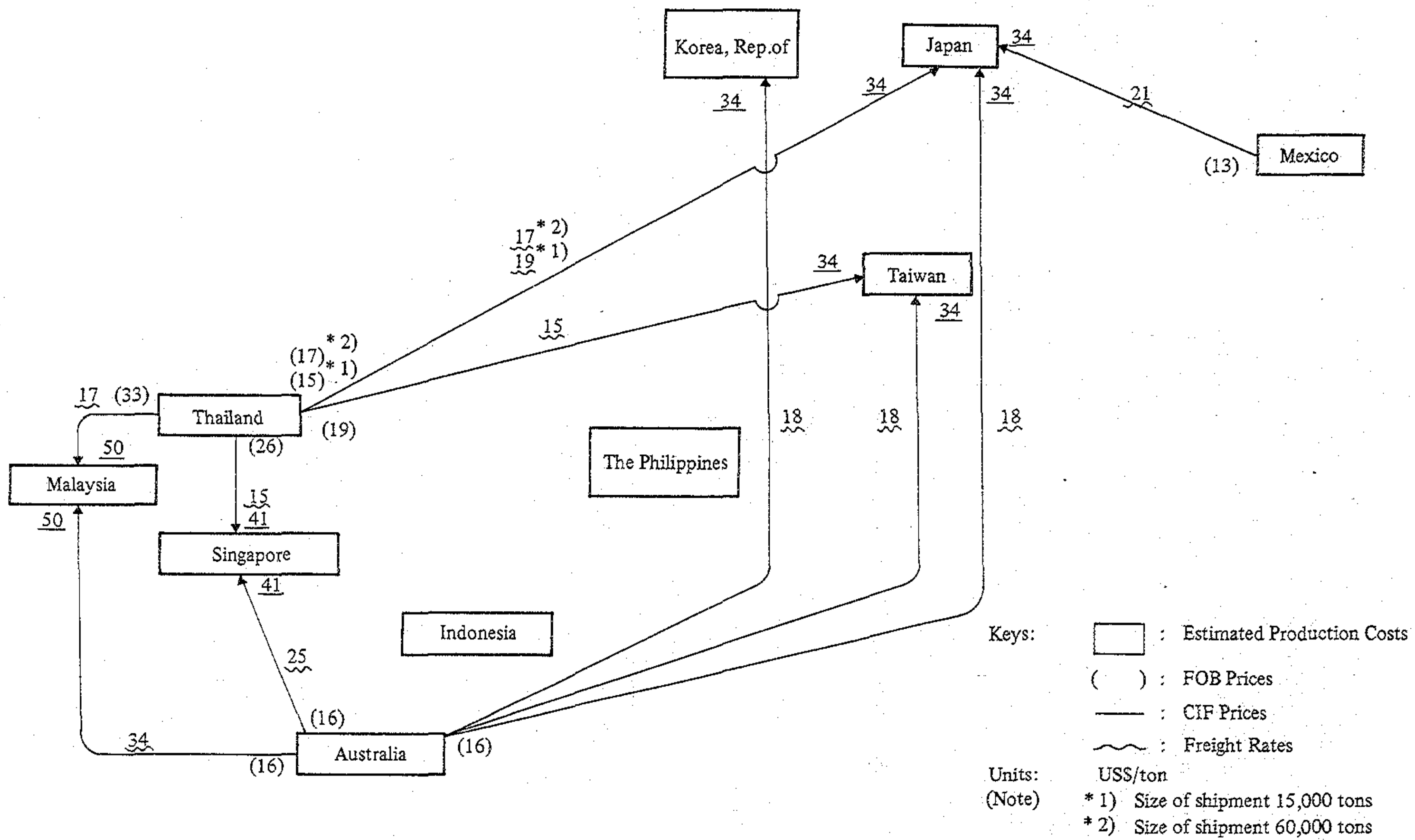


Figure II-4 PRICES AND FREIGHT RATES OF SALT IN 1985 are made to countries which for various reasons cannot accommodate large vessels, the long transport distances will greatly influence ocean freight costs. Therefore, Thailand would possess export competitiveness in the event that the exportation is made to countries which are not far away and which cannot be served by large vessels. If small vessels (15,000 to 20,000 DWT) are used, Taiwan is the only non-ASEAN country in which Thai rock salt is competitive, even assuming that the FOB price is reduced somewhat (see Annex II). Judging from the scale of the market in Taiwan, it is thought that it could import from Thailand about 100,000 t/y. If the export price for Taiwan is estimated by the method given in 3–2, in 1985 it would be US$19/t, FOB. If large vessels (60,000 DWT) can be used, it may be possible for Thailand to offer competitive prices for Korean and Japanese markets. In view of the fact that these countries have large demands, if appropriate efforts are made by Thailand, there may be possibilities for Thailand to export the rock salt to these markets to some extent. The FOB price for these market in 1985 may be US$17/t before any discount.

2-4 MARKETABILITY OF THAI ROCK SALT

Table II-11 compared the assumed quality for rock salt excavated as part of this Project (see Part III), and the quality of Austrailian salt. The NaCl component of the Project's rock salt presents no problem even if use is to be for industrial salt. The content of insoluble matter and of sulfates however, is high. This is a universal problem with regard to rock salt, and although the rock salt from this Project can be classified as high in quality, among the rock salt from various sources, because users must bear the cost of refining the salt for use as industrial salt, some discount of course will be necessary. Nevertheless, the rock salt supplied by this Project is within the range of usability as industrial salt and is judged to be salable, at the discounted price indicated above.

Table II-11 COMPARISON OF ASSUMED GRADE OF ROCK SALT MINED FOR THIS PROJECT AND AUSTRALIAN SALT

(%)

	Assumed Grade of Rock Salt Mined in this Project	Australian Salt (Shark Bay) Mean Grade
Water	0.1 – 0.2	2.05
Insoluble Matter	0.5 or less	0.04
SO4	1.0 or less	0.16
Ca	0.4 or less	0.05
Mg	0.08 or less	0.04
K	0.001 or less	0.02
NaCl	97 or more	97.17

CHAPTER 3 AMMONIUM CHLORIDE

3-1 THE AMMONIUM CHLORIDE MARKET IN THE ASEAN REGION

The only country in the world which is exporting ammonium chloride for use as fertilizer is Japan. Historical data for Japanese exports of ammonium chloride to the ASEAN nations are shown in Table II-12. From this table it is evident that the only country which imports ammonium chloride in large quantities is Thailand. Although Malaysia and the Philippines have taken some exports from Japan, the quantities are small, and moreover imports have been irregular.

Ammonium chloride is one of the nitrogen fertilizers and the form of the nitrogen is an ammonia-form, the same as ammonium sulfate, but whereas ammonium sulfate has a sulfate ion, ammonium chloride has a chlorine ion. The presence of this chlorine ion has adverse effects on certain plants. Because of this factor even in countries where there is widespread use of ammonium chloride fertilizer its use is limited to certain crops, unlike other nitrogen fertilizer. In the case of Japan use of ammonium chloride is limited almost entirely to paddy rice and it is not used for upland crops. The reason for this is that because chlorine ions buld up in the soil of fields, whereas they are removed from paddies by the flushing effect of irrigation, adverse effects can result in field crops fertilized with ammonium chloride. Further, where the second crop (after paddy rice) in a paddy is susceptible to the effects of chlorine ions (such as potatoes and tobacco), ammonium chloride is not used.

In ASEAN nations other than Thailand also, in the past there has been some substitution of ammonium chloride for ammonium sulfate but the quantities involved have been very small. The principal nitrogen fertilizers used in these countries are urea and ammonium sulfate (in the case of Malaysia, urea, ammonium sulfate and ammonium nitrate). As is noted above, because the source of supply of ammonium chloride has been limited to Japan, and supply capability has been limited, the use of ammonium sulfate and urea, as the most readily available nitrogen fertilizer, has become widespread in these countries. Further, as a result of production and exportation of urea by Malaysia and Indonesia, as ASEAN Industrial Projects, greater demand for these fertilizers is expected, except within Thailand, and for this reason, it is difficult to consider the ASEAN region, except Thailand, as a market for ammonium chloride fertilizer.

Table II-12 EXPORT OF AMMONIUM CHLORIDE FROM JAPAN

(000 tons)

Fertilizer Year [1]	1975/76	1976/77	1977/78	1978/79
Destination:				
China	477.5	282.8	274.4	232.7
The Philippines	–	6.0	17.0	20.0
Thailand	21.5	57.6	72.3	72.6
Malaysia	1.3	18.3	7.8	17.0
Indonesia	4.4	–	–	2.8
Total (incl. Other Countries)	505.3	366.2	372.0	346.1

(Note) 1) Fertilizer year is from July to June.

Sources: Ministry of Agriculture, Forestry and Fisheries, Japan, "Pocket Fertilizer Yearbook".

3-2 PRESENT CONDITIONS AND OUTLOOK FOR AMMONIUM CHLORIDE DEMAND IN THAILAND

Differing considerably from the other ASEAN countries, in Thailand ammonium chloride accounts for about 13% (1978) of nitrogen fertilizer consumption. This is because a Japanese ammonium chloride maker has a joint venture in Thailand which produces mixed fertilizer.

The most commonly used fertilizer in Thailand is compound fertilizer, including nitrogen and phosphorus or nitrogen, phosphorus and potassium. At present most of the imported ammonium chloride is used to make mixed fertilizer but some of it is used as straight fertilizer. But because these fertilizers contain chlorine ions, there is some danger of adverse effects as noted in 3-1, and at present ammonium chloride (including mixed fertilizers which contain ammonium chloride) is primarily used for paddy rice in regions where irrigation is practiced.

The Ministry of Agriculture and Cooperatives assigns high importance to this Project since it would provide a domestic source of ammonium chloride, and is considering the idea of increasing efforts on behalf of use of this fertilizer and already has begun to collect test data regarding use of this fertilizer for various crops. A conclusion reached as a result of this is that the fertilizer is suitable for paddy rice, even for the paddy rice grown in rain-fed areas and even where tobacco is grown as the second crop after paddy rice. Regarding other crops, however, final conclusions have not yet been made.

The present conditions and outlook for fertilizer consumption in Thailand, by crop, are as shown in Table II-13. Paddy rice is the crop for which the largest portion of fertilizer is consumed; sugarcane is second in importance. On the basis of the foregoing data related to fertilizer consumption in Thailand, the demand for ammonium chloride in the future has been projected using the following assumptions.

1. In addition to being used as straight fertilizer for paddy rice, ammonium chloride is used in compound fertilizer for paddy rice.

2. All straight fertilizer used for paddy rice is ammonium chloride.

3. With 80% of the compound fertilizer used for paddy rice produced domestically, to the extent permitted by production technology, maximum use is made of ammonium chloride as a raw material for making that compound fertilizer. Results of the projections are shown in Table II-14; it is expected that ammonium chloride demand in Thailand will

Table II-13 PROJECTED DEMAND FOR FERTILIZER BY CROP, THAILAND

(000 tons)

		Actual or Estimated 1)							Projected			
		1973	1974	1975	1976	1977	1978	1979	1980	1985	1990	1995
Rice	North	4.5	4.1	6.9	7.0	12.0	15.8	13.8	15.8	23.3	30.6	37.8
	Northeast	66.2	53.6	86.8	102.6	136.2	169.0	160.4	173.3	241.3	306.9	371.1
	Central	149.9	126.0	137.0	169.1	227.8	278.7	243.7	282.3	399.4	517.4	637.8
	Total	232.2	193.7	242.9	293.2	397.2	482.9	432.3	489.3	685.2	879.2	1,074.0
Sugarcane		43.2	48.6	70.8	162.1	170.0	138.2	127.1	159.2	191.1	213.2	234.0
Tobacco		19.5	26.0	26.0	20.0	24.5	24.6	22.3	23.7	24.7	25.8	26.8
Other Upland Crops		23.7	14.0	22.0	23.6	41.2	51.8	51.0	59.6	92.5	127.6	163.5
Rubber		39.3	35.0	40.0	37.1	47.9	47.8	50.5	57.9	113.9	130.6	138.9
Fruits		22.2	21.4	40.3	41.1	57.1	62.9	58.6	65.8	82.2	93.9	102.9
Vegetables		27.8	34.4	36.0	40.9	45.1	47.1	45.7	55.8	61.8	70.5	77.8
Total		407.9	373.1	478.0	618.0	783.0	855.3	787.6	911.3	1,251.4	1,540.8	1,817.9

(Note) 1) Estimated based on the information from Office of Agricultural Economics, Ministry of Agriculture and Cooperatives.

Table II-14 PROJECT DEMAND FOR AMMONIUM CHLORIDE, THAILAND

(000 tons)

	1985	1986	1987	1988	1989	1990	1995
Direct Application (A)	45.6	48.2	50.8	53.4	56.0	58.6	71.6
Raw Material for Compound Fertilizer							
Potential Demand	308.4	326.7	344.6	361.9	378.8	395.3	470.6
Projected Demand (B)	237.5	261.4	275.7	289.5	303.0	314.6	361.6
Total Projected Demand (A) + (B)	283.1	309.6	326.5	342.9	359.0	373.2	433.2

be 238,000 t in 1985, and 315,000 t in 1990. In order for the projected demand to be made an actuality, it is required that additional facilities for making compound fertilizers or mixtures using ammonium chloride are expanded so as to meet increasing demands. These facilities do not require large investment, and can be constructed within a short period. If it is assured that there can be supply of ammonium chloride to compound or mixed fertilizer makers at a reasonable price and also if the Government will take appropriate measures to give them incentives, private sector enterprises will undertake such expansion.

3-3 POSSIBILITY OF EXPORTATION OF AMMONIUM CHLORIDE TO OUTSIDE THE ASEAN REGION

Historical data for ammonium chloride from Japan to countries other than those of the ASEAN group are shown in Table II-12. According to this table, the only country which has been a relatively stable importer has been China. It is believed that in China ammonium chloride is used as a substitute for other nitrogen fertilizers.

The outlook for nitrogen fertilizer supply and demand in China, as shown in Table II-15, is such that continued large scale importation of nitrogen fertilizer is expected. It is thought that the share of ammonium chloride in this import requirement will be determined by its price competitiveness with other nitrogen fertilizer (ammonium sulphate and urea). If this Project can export ammonium chloride at a price which is competitive with ammonium sulphate and urea, it is judged that it will be fully possible to export to China, as long as the quantities exported will not be great.

3-4 OUTLOOK FOR AMMONIUM CHLORIDE PRICE

The ammonium chloride price will be determined within the framework of price relationships of the other nitrogen fertilizers. The leading nitrogen fertilizer is urea, and the ammonium chloride price as estimated on the basis of its relation to the urea price is as shown in Table II-16.

Table II-15 PROJECTION OF SUPPLY/DEMAND OF NITROGEN FERTILIZER IN CHINA

(000 tons in terms of Nitrogen Nutrient)

	Estimated [1]		Projected										
	1977	1978	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Supply (A)	4,600	5,664	6,212	6,288	6,346	6,561	6,975	7,470	7,928	8,269	8,434	8,471	8,471
Demand (B)	5,900	6,913	7,848	7,788	8,104	8,432	8,772	9,124	9,525	9,919	10,309	10,693	11,072
Balance (A) – (B)	–1,300	–1,249	–1,272	–1,500	–1,758	–1,871	–1,797	–1,654	–1,597	–1,650	–1,875	–2,222	–2,601

Source: 1) FAO.

Table II-16 PROJECTION OF AMMONIUM CHLORIDE PRICE IN THAILAND, 1985

(US$/ton)

	Import Price (C&F Thailand) (A)	Port Charges Taxes, and Unloading Charges (B)	Ex-Warehouse Price in Thailand (A + B) x 1.05[1)]
Urea	235	28	276
Ammonium Sulphate	130	27	165
Ammonium Chloride			150[2)]

(Notes) 1) Including 5% importers, margin.

2) Ammonium chloride price was calculated taking into account the difference in the nitrogen nutrient content. That is:

$$(\text{Ammonium chloride price}) = (\text{Urea price } 276) \times \frac{25\%}{46\%} = 150$$

PART III

TECHNICAL ASPECTS OF DEVELOPMENT PLANNING OF THE ROCK SALT MINE

PART III TECHNICAL ASPECTS OF DEVELOPMENT PLANNING OF THE ROCK SALT MINE

CHAPTER 1 BAMNET NARONG ROCK SALT DEPOSIT

1-1 INTRODUCTION

1-1-1 Location and Access

The Bamnet Narong rock salt deposits are located in Bamnet Narong, Chaiyaphum Province, in the western portion of the Khorat Plateau (see 1-2-1 below) in Northeastern Thailand (refer to Figure III-1).

This region is relatively well furnished with transportation services. It is served by Route 205 (paved, 2 lanes) which links it with Nakhon Rachasima city, and the national railway passes over the deposit in an east-west direction. The distance between the approximate center of the deposit and Bamnet Narong station is about 7 km, measured as a straight line on the map.

The center of the Bamnet Narong deposit as determined by use of a 1/50,000 map, "Amphoe Bamnet Narong," is approximately at the intersection of northern latitude 15°28' and eastern longitude 101°44' (in terms of straight-line distances, it is at about 70 km northwest of Nakhon Rachasima, about 45 km southwest of Chaiyaphum city, and about 230 km northeast of Bangkok).

1-1-2 Physiography

The site of the deposits are at the elevation of 200-211 m above sea level and is almost flat. The higher portion of the area is wilderness with bush, and almost all of the low land zone is used for paddy cultivation, where one crop a year is grown.

1-1-3 Climate

The climate is tropical and characterized by alternation of rainy and dry seasons. The rainy season lasts from May through October; during that time afternoon squalls are common. There is virtually no rainfall during the dry season, when arid climate conditions prevail. Meteorological statistics for 1951-1975, for Chaiyaphum city, are given in Table III-1. On the basis of these statistics, the drought index is 3.3.*

* Drought index $I = P/(T + 10)$, where I = drought index; P = annual rainfall (cm) and T = mean annual temperature in deg. C.

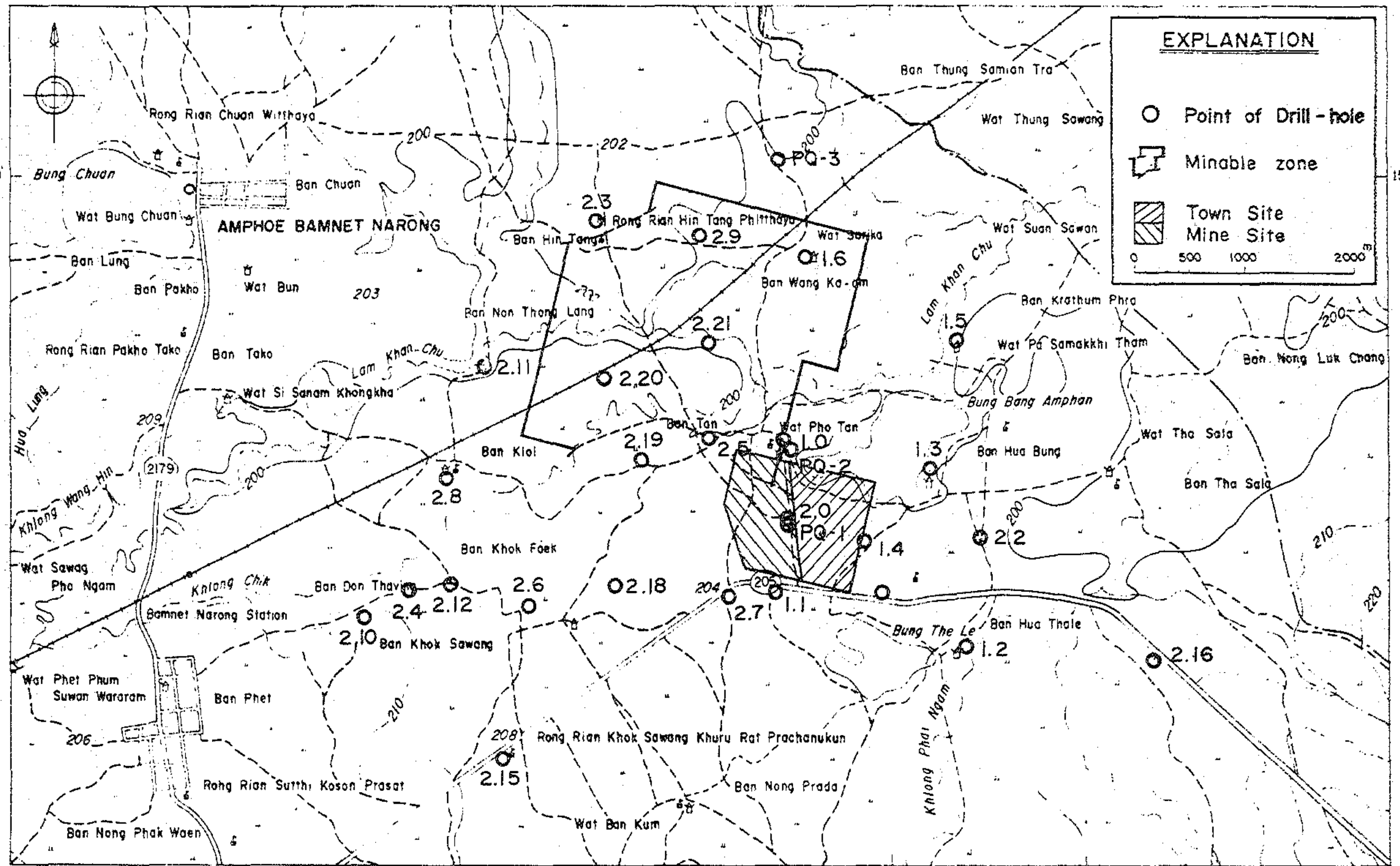


Fig. III-1. Index Map of Bamnet Narong Area

1-1-4 Previous Studies

In 1957 the Thai Ministry of Industry, Department of Mineral Resources, implemented exploratory drilling for underground water in the Bamnet Narong area (Ban Phet School, H2-20) at which occasion the presence of a salt layer and a salt-with-shale layer (at 465-585 feet and 320-465 feet below the surface, respectively) was confirmed.

As a result of subsequent (about 1977) exploratory drilling for rock salt and potash in the Bamnet Narong area, the Department of Mineral Resources confirmed that the area contained excellent deposits of rock salt.

Further, the Ministry of Industry commissioned the Canadian firm SNC to undertake a feasibility study for development of a rock salt mine in the Bamnet Narong area and this study was made by SNC with its commencement in May, 1977 and accomplishment in September, 1978. The main aspects of this feasibility study are as follows.

1. Location:	Bamnet Narong area
2. Surveying:	For preparation of a 1/10,000 topographic map
3. Exploratory drillholes:	16
4. Minable zone:	At approximate center of deposit
5. Depth of mining:	350-300 ft below surface (within a range of 50 ft)
6. Estimated reserves:	318,000,000 t
7. Parameters for estimation of the reserves:	A) Area: 9,750,000 m^2 B) Mining height: 15 m C) Volume: (A) x (B) = 146,250,000 m^3 D) Specific gravity: 2.18 E) Reserves: (C) x (D) = 318,825,000 t
8. Purity:	96.09% NaCℓ

Table III-1 CLIMATOLOGICAL DATA FOR THE PERIOD 1951 – 1975

Station CHAIYAPHUM
Index Station 48 403
Latitude 15° 48′ N.
Longitude 102° 02′ E.

Elevation of station above MSL	181.00 meters
Height of barometer above MSL	183.00 meters
Height of thermometer above ground	1.50 meters
Height of wind vane above ground	14.50 meters
Height of raingauge	1.00 meters

	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Pressure (+1000 or 900 mbs.)													
Mean	13.81	11.73	09.75	08.14	06.45	05.46	05.69	05.50	06.94	10.31	12.79	13.83	09.21
Ext. Max.	25.64	24.20	22.63	21.35	13.87	12.84	12.36	13.14	14.29	19.03	22.51	24.59	25.64
Ext. Min.	03.18	01.92	01.03	98.52	98.98	96.26	97.04	97.18	98.08	01.64	03.76	02.94	96.26
Mean daily range	5.60	5.98	5.92	5.16	4.92	4.15	3.88	4.05	4.34	4.62	4.72	5.12	4.87
Temperature (°C)													
Mean	24.6	26.9	29.3	30.4	29.7	28.8	28.1	27.7	27.3	27.3	26.1	24.6	27.6
Mean Max.	30.0	32.4	34.7	35.7	34.3	32.5	31.9	31.4	30.8	30.5	30.0	29.4	31.9
Mean Min.	16.9	19.7	22.3	23.9	24.5	24.2	23.8	23.6	23.9	23.0	20.6	17.7	22.0
Ext. Max.	36.7	39.3	40.5	42.5	40.4	40.5	37.3	35.7	35.3	33.9	35.0	35.5	42.5
Ext. Min.	6.3	11.5	12.3	17.8	21.3	21.3	20.4	20.5	21.0	17.7	11.4	8.2	6.3
Relative Humidity (%)													
Mean	53.0	53.0	54.0	58.0	67.0	72.0	74.0	76.0	79.0	72.0	63.0	57.0	65.0
Mean Max.	78.5	76.8	78.4	81.2	85.9	88.4	89.6	91.1	92.4	87.0	82.2	80.8	84.4
Mean Min.	36.6	35.5	36.6	40.8	50.9	58.4	60.3	63.0	66.2	58.5	48.2	41.1	49.7
Ext. Min.	13.0	11.0	14.0	14.0	25.0	31.0	36.0	42.0	43.0	30.0	21.0	16.0	11.0
Dew Point (°C)													
Mean	13.6	15.5	18.0	20.5	25.5	23.0	22.7	22.9	23.1	21.4	18.0	14.8	19.7
Evaporation (mm)													
Mean-Piché	127.4	138.6	157.5	145.3	113.3	95.5	91.8	80.1	60.3	80.2	99.1	117.7	1306.8
-Pan						No Observation							
Cloudiness (0–8)													
Mean	3.0	3.1	3.6	4.3	5.7	6.5	6.7	6.9	6.6	5.0	3.9	3.3	4.9
Visibility (Km)													
0700 L.S.T.	5.7	4.7	4.8	7.5	10.5	10.2	10.2	9.8	9.5	9.5	8.1	6.4	8.1
Mean	7.7	6.2	6.0	8.4	11.1	11.4	11.1	10.8	10.3	10.9	10.7	9.7	9.5
Wind (Knots)													
Prevailing wind	NE	E	E	W	W	SW	W	W	W	NE	NE	NE	–
Mean Wind Speed	5.2	5.5	5.6	5.8	5.8	6.3	6.2	5.7	5.0	5.2	5.8	5.8	–
Max. Wind Speed	33 ENE	33 S	39 N,E, SW	39 S, NW	35WSW	33 S,W, NW	33S,W	27 N, SW,W	33S,SW	27 E SE	27S	25NNE	–
Rainfall (mm)													
Mean	4.8	18.2	56.8	87.4	162.0	140.9	152.6	147.5	323.8	124.7	17.3	3.8	1239.8
Mean rainy days	1.2	2.3	5.5	7.7	14.1	13.1	15.1	16.9	19.1	10.1	1.9	1.0	108.0
Greatest in 24 hr.	19.6	79.2	65.9	95.9	141.6	93.3	149.4	91.5	158.0	119.3	67.3	32.6	158.0
Day/Year	31/74	28/75	5/69	7/63	23/59	26/68	12/62	27/66	2/69	25/66	7/63	12/72	2/69
Number of days with													
Haze	23.3	25.7	26.1	16.9	1.4	0.0	0.0	0.0	0.6	3.4	9.9	16.8	124.1
Fog	0.8	0.2	0.6	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.2	0.2	2.3
Hail	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.4
Thunderstorm	0.0	1.7	6.4	12.1	16.3	8.5	7.8	8.0	11.9	5.1	0.5	0.0	78.3
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Remarks: 1. Data for 1954 – 1975
2. Pressure 1957 – 1975
3. Evaporation 1959 – 1975

(By Meteorogical Department of Thailand)

SNC recommended to the Ministry of Industry as a result of its study that at least five additional borings be made in order to obtain detailed information.

1-2 BAMNET NARONG ROCK SALT DEPOSIT

1-2-1 Geological Conditions in Northeastern Thailand

The Khorat Plateau in Northeastern Thailand lies in the range of 14°–19° northern latitude and 101°–106° eastern longitude. The northern edge of the plateau lies within Laos and its eastern edge lies within Cambodia.

The Khorat Plateau is composed of sedimentary layers known as the Khorat Series which would have been deposited from the Triassic to Cretaceous Age.

The general stratigraphy of the region, and a geological map, are given as Table III-2 and Figure III-2 respectively.

The Khorat Series is divided into Upper, Middle and Lower; rock salt layers or signs of rock salt are present in each but the rock salt layer in the Upper Khorat Series is most pronounced. The Lower Khorat Series contains Triassic red sandstone, siltstone and conglomerate. This series is subdivided into Phu Khadung Formation and Nam Phong Formation of which the former is of greater thickness, 2,465 m (Borax and Stewart, 1965). Drillings at the Pa Mong Dam site indicate that gypsum and rock salt traces are present in the Phu Khadung Formation. The Middle Khorat Series is composed of Jurassic red and grey sandstone, and siltstone and is said to be 500–590 m thick. This series is subdivided into Phu Phan, Sao Khua and Phra Wihan Formations. Drillings at the Pa Mong dam site indicate that traces of rock salt are present in the Sao Khua Formation. The Upper Khorat Series is composed of Cretaceous sedimentary rock and is subdivided into the Maha Sarakam and Khok Kruat Formations. The Khok Kruat Formation is composed of sandstone, siltstone and shale. The Maha Sarakam Formation, forms the Sakon Nakhon Basin and the Khorat Basin, and it is composed of sandstone, siltstone, shale, salt and gypsum (anhydrite gypsum). Its thickness is said to be 700 m. This formation has been confirmed to be Cretaceous by use of fossils recovered from it (Kobayashi, 1963).

The geological structures of the Khorat Plateau region are featured with the board basin structures developed in the north and the south and the Phu Pan uplift extending approximately east-to-west between the two basin structures. The basin structure to the north is called the Sakon Nakhon basin and is 21,000 km^2 in area, and the one to the south is called the Khorat basin and is 36,000 km^2 in area.

Table III-2 STRATIGRAPHY OF NORTHEASTERN THAILAND
(Herbert S. Jacobson and Charles T. Pierso 1969)

Age	Rock Units			Character
Quaternary			Unnamed	Unconsolidated clay, sand, and gravel; laterite.
Tertiary			Unnamed	Basalt flows (only overlying, Khorat Series on Khorat Plateau).
Cretaceous	Khorat Series	Upper	Maha Sarakam Formation	Sandstone, siltstone, shale, salt, and anhydrite-gypsum.
Cretaceous	Khorat Series	Upper	Khok Kruat Formation	Sandstone, siltstone, and shale.
Jurassic	Khorat Series	Middle	Phu Phan Formation	Massive sandstones with conglomerate sandstone, siltstone, and shale.
Jurassic	Khorat Series	Lower	Sao Khua Formation	Sandstone, siltstone, and conglomerate (including basal conglomeate).
Jurassic	Khorat Series	Lower	Phra Wihan Formation	
Triassic	Khorat Series	Lower	Phu Khadung Formation	
Triassic	Khorat Series	Lower	Nam Phong Formation	
Triassic			Unnamed	Andesite, rhyolite, tuff, agglomerate.
Triassic			Unnamed	Granodiorite and other intrusive rocks.
Permian			Ratburi Limestone	Massive limestone with shale and sand-stone
Carboniferous			Unnamed	Sandstone, silstone, shale, tuff and limestone.
Devonian			Unnamed	Sandstone, quartzite, phyllitic shale, slat, and limestone.
Silurian and older			Unnamed	Argillite, quartzite, slate, phyllite, schist.

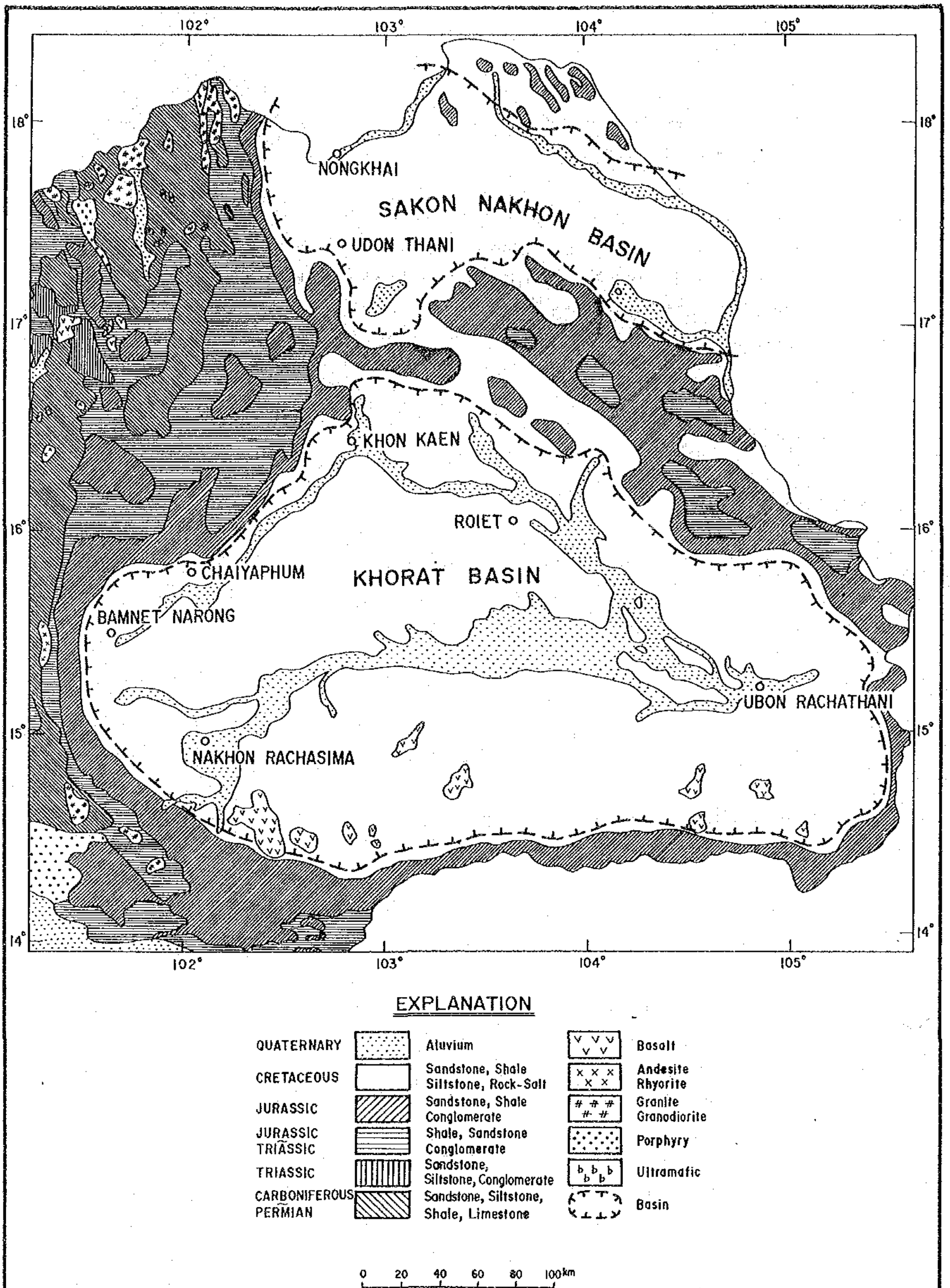


Fig.III-2. Geological map of northeastern Thailand

Map modified from The geologic map of Thailand
compiled by Jumchet C. Javanaphet (1969)

In these basins, evaporite (rock salt, gypsum, etc.) in the Maha Sarakam Formation is well developed, and in places potash is present in upper salt beds.

The Maha Sarakam Formation which is present in the Khorat Plateau is mostly evaporite which was deposited in three major cycles. Each cycle has formed a layer: the salt bed, anhydrite bed, and reddish clay bed. The salt bed consists of the lower salt bed (thickness up to 450 m), the middle salt bed (up to 111 m) and the upper salt bed (up to 65 m) of which the lower salt bed is one of the thickest in the world (R.J. Hite and T. Japakasetr, 1979).

Columnar-stratigraphic sections of the Maha Sarakam Formation in the Khorat Plateau are as provided in Figure III-3.

1-2-2 Geology of the Bamnet Narong Area

The Bamnet Narong area is composed of the Maha Sarakam Formation. Columnar stratigraphic sections obtained as a result of additional drilling (four drill holes) performed at the time of the first evaluation study are shown in Figure III-4.

In Correlate with the general stratigraphy of the Maha Sarakam Formation in the Khorat Plateau (Figure III-3), it is found that the evaporite layer in the Bamnet Narong area does not contain the upper salt bed and also even the middle salt bed in places.

Columnar stratigraphic sections as obtained by 25 drillings in the area are shown in Figure III-5.

Through analysis of these data, the geology of the area may be summarized as follows.

1. Salt beds of this area have as the basement green and red siltstone (thought to be the Khok Kruat Formation) above which are the lower salt beds.

2. In some places there is no middle salt bed and only the lower bed is present.

3. Several meters of anhydrite exists between the lower salt bed and basement siltstone. Also, in some places there is a band of anhydrite, almost one meter thick, near the center of the lower salt bed. The uppermost part of the lower salt bed is covered throughout with an anhydrite layer.

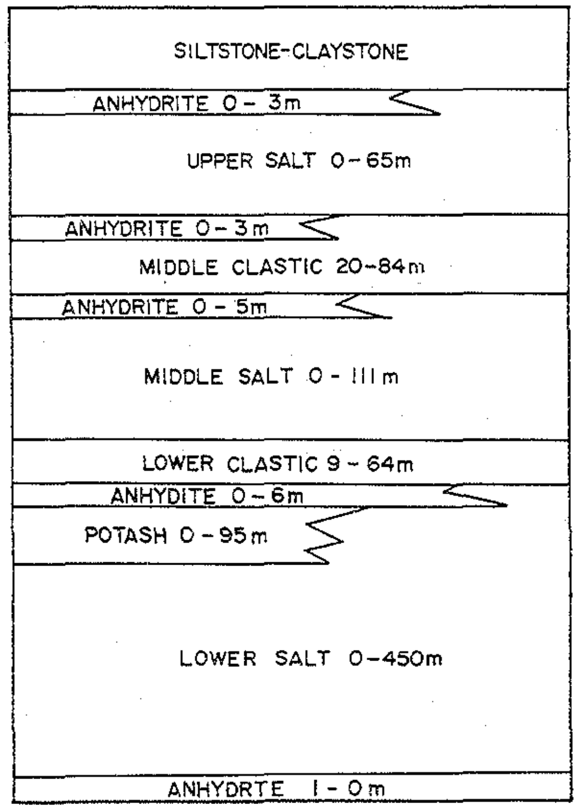


Fig.III-3. Informal stratigraphic nomenclature of the Maha Sarakham Formation of Cretaceous age.

(by R. J. Hite and T. Tapakastr, 1979)

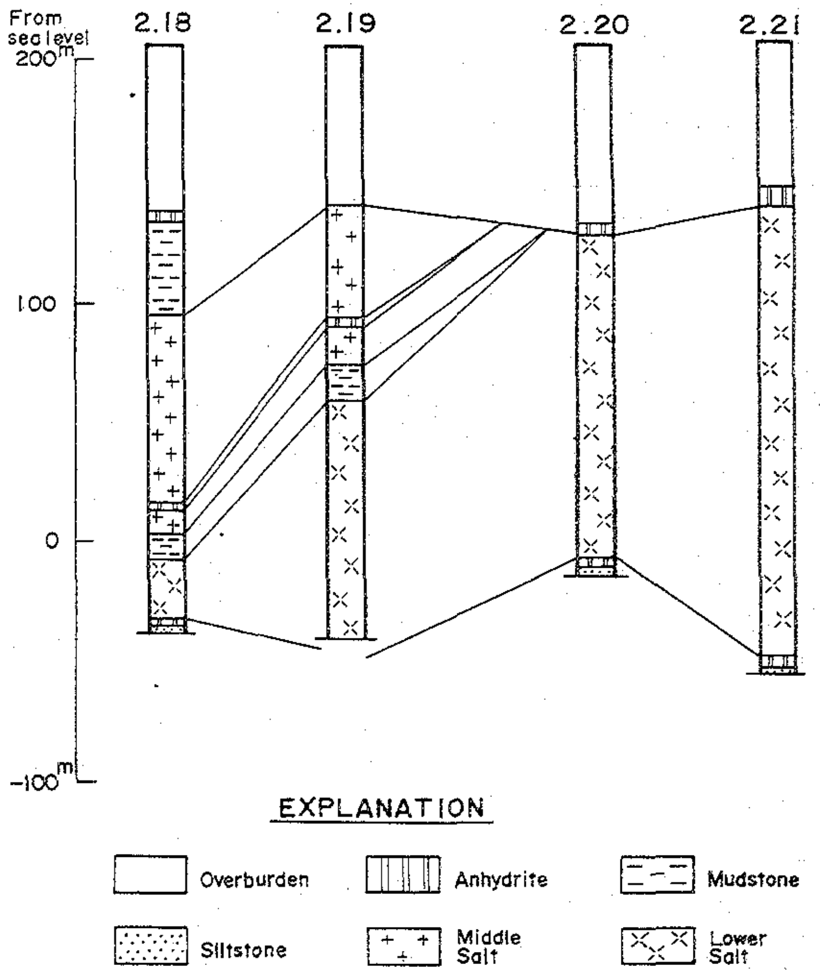
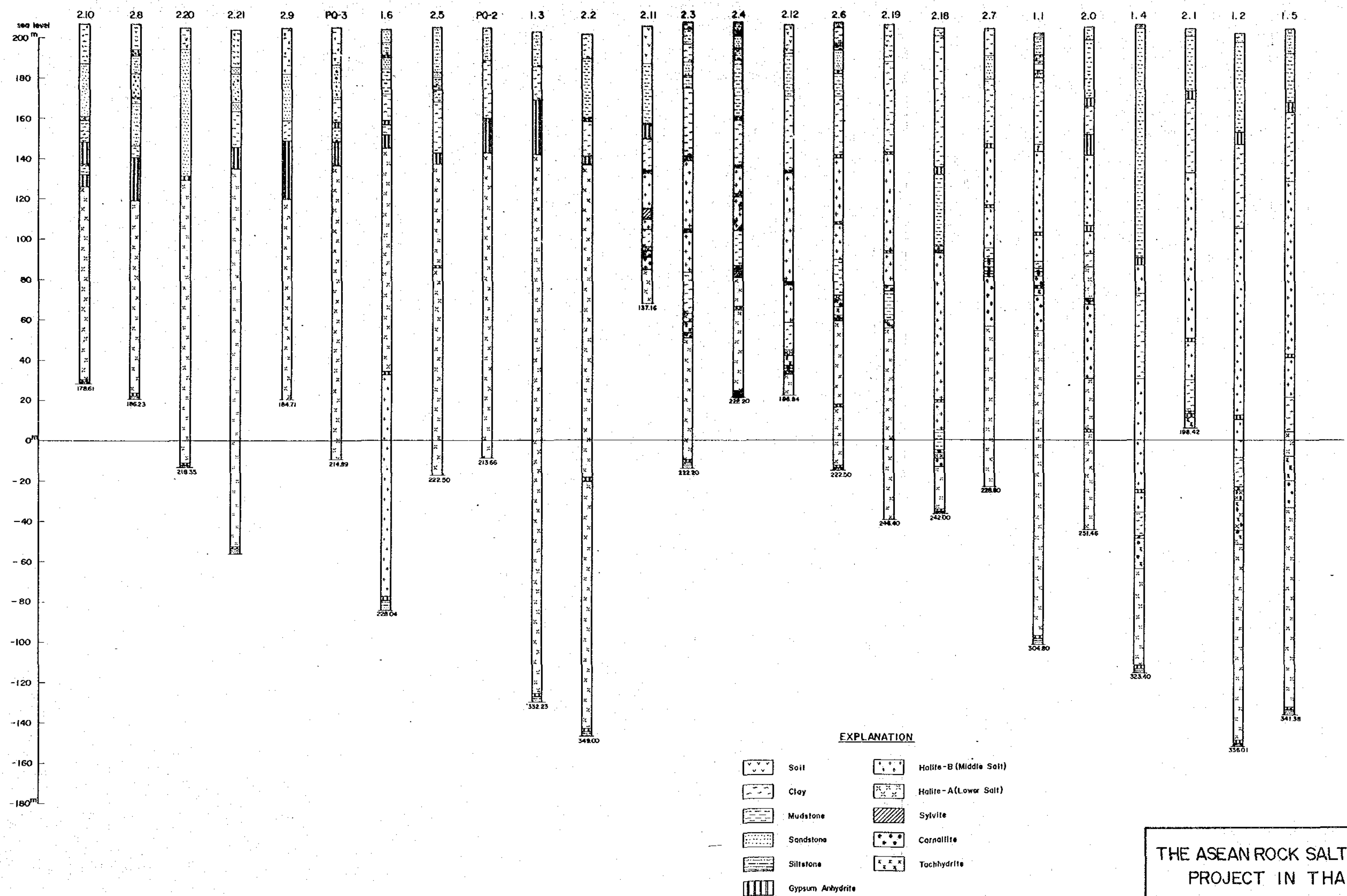


Fig.III-4. Columnar-stratigraphic sections. of additional drill holes at Bamnet Narong.

Fig. III - 5. COLUMNAR SECTIONS OF DRILL HOLES IN THE BAMNET - NARONG SITE



THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND	
COLUMNAR SECTIONS OF DRILL HOLES IN THE BAMNET-NARONG SITE	
J I C A	FIG. III - 5

4. The lower salt bed is superior in quality in comparison to the middle salt bed.

5. Although the middle salt bed is positioned above the lower salt bed, a clay bed of 1 to 1.5 m is distributed between the two salt beds.

6. A thin anhydrite layer (1-3 m) exists at the lower portion of the middle salt bed. Further, in some places an anhydrite layer is found in the upper portion as well.

7. Regarding potash, the existence of carnalite, sylvite and tachyhydrite has been confirmed, and these are present primarily in the upper part of the lower salt bed.

8. There are two types, namely the lower salt bed is covered by the middle salt bed, or the middle salt bed is not present. The K and Br content and distribution pattern for the two are different, suggesting that the two were formed at the same age but in different deposition boundaries.

In this Evaluation Study, conforming to the usage of the first evaluation study report, the lower salt bed is referred to as Halite-A and the middle salt bed is referred to as Halite-B. Further, when Halite-A is covered by Halite-B, the area is called D-area, and where only Halite-A is present, the area is called S-area.

1-2-3 Structure of the Salt Deposits

Based on the drilling data produced from the previous explanatory drillings (the initial and additional drillings) in the area, the following drawings have been prepared for use for analysis.

1. East-west geological profiles (1-5 profiles)
2. North-south geological profiles (A-G profiles)
3. Supplementary geological profiles (1-6 profiles)
4. Structure map of base of Halite-A
5. Structure map of top of Halite-A
6. Structure map of top of Halite-B
7. Distribution map of Halite-D and Halite-S areas

Of these, 2,4,5,6 and 7 are provided as Figures-III-7 to III-11 in this Part III. Topographic map of rock salt deposits in the Bamnet Narong area is also provided as Figure III-6.

The form of the Bamnet Narong salt deposits, as determined from these drawings, is as follows.

1. The basement of Halite-A is characterized by a mild monocline (angle of inclination, nearly 2 deg.) which extends from the west side to the east side of the basement, and has a stable geological structure (Figure III-8).

2. The top of Halite-A presents a complicated structure; considerable deep concave portions can be seen in its southwestern, southeastern and northeastern portions (Figure III-9).

3. Shallow depressions may be seen in the southwestern and southeastern portions of the Halite-B top. These depressions are above the concave parts of the Halite-A top and it is thought that at the time of formation they have been strongly influenced by the structure of the Halite-A (Figure III-10).

4. The Halite-A present in S-area is developed in the approximate center of this area, and is thought to extend further to the north (Figure III-11).

5. The Halite-A presents a dome rising in its approximate center; in thick places the salt bed is more than 250 m thick (Figure III-7).

It is thought from the surrounding geological structures, that the Halite-A has formed a dome.

1-2-4 Quality of the Salt Deposits

Results of analysis of the salt from Halite-A, S-area and Halite-A and Halite-B from D-area are shown in Table III-3 and Figure III-12. From the table and figure, it is evident that the quality of the salt in the Halite-A of S-area is the best of the three. Salt analysis was performed according to the method of the Japan Tobacco and Salt Monopoly Corporation.

1-2-5 Specific Gravity of the Salt

The results of tests conducted at the time of the first evaluation study have been used as the source of data on the specific gravity of the salt. Samples were taken from 87 locations. The conditions for measuring specific gravity were that after samples were taken from the drill core they were cut to form and kept at constant 60°C for 24 hours, after that the specific gravity was determined through precision measurement of the dimensions of, and weighing of, the samples. The results of this work are given in Table III-4.

As the specific gravity of rock salt (90% or more NaCℓ) from the mining area, 2.2 is used.

1-3 DETERMINATION OF THE MINABLE ZONE

1-3-1 The Minable Zone

The minable zone in Bamnet Narong is defined as consisting of the following.

1. Minable rock salt bed: S-area, Halite-A
2. Minable range: central portion (5,262.555 m^2)
3. Mining level: 61-73 m above sea level.

The reason for defining the minable zone in this way is as follows.

Selection of the S-area, Halite-A: As is mentioned earlier in this Chapter, the salt reserves comprise three layers. Of these the S-area, Halite-A presents a weak dome in the center, and the deposits present a stable thickness. Further, in terms of quality of the salt, that of S-area, Halite-A is higher than that of D-area, Halite-A and Halite-B. (see Table III-3).

Determination of the range of mining: S-area, Halite-A has a distribution such as shown in Figure III-11; to the southeast side is a swamp of about 800 m by 1,500 m, and drilling at 1.3 and 2.2 disclosed a high level of sulfates at those points. Because of these points it was decided that the minable area should be in the center of the deposits.

Determination of mining level: The mining level was determined to be from 61 m to 73 m from sea level, in view of the geological structure and geological conditions of the upper bed in particular, as well as the scale of mining and economic considerations. For details, see 2-2 and 4-1.

1-3-2 Quality of Rock Salt in the Minable Zone

Average values of the main components of rock salt from the minable zone are as follows.

H_2O	0.13%	I.M.	0.51%
Mg	0.01%	K	0.01%
NaCl	97.39%	Ca	0.44%
		SO_4	1.04%

These are the averages for 212 samples (but 109 samples in the case of I.M. and H_2O) taken from five drillings in the minable zone.

The mining level, 61–73 m, is in the upper part of S–area, Halite–A, but because Halite –A does not show a clear vertical distribution pattern, the averages used are the averages for the entire minable zone.

Assay values for drillcores used to arrive at the above averages are as follows.

Drilling	Ca		Mg		K		SO_4		NaCl		H_2O		I.M.		
	x	S.D	x	S.D	x	S.D	x	S.D	x	S.D	x	S.D	x	S.D	N
RS 1.6	0.60	0.232	0.024		0.020		1.34		96.22		-	-	-	-	40
RS 2.5	0.48	0.204	0.034		0.015		1.21		97.45		-	-	-	-	44
RS 2.9	0.43		0.019		0.011		0.82		97.05		-	-	-	-	19
RS 2.20	0.33	0.130	0.003	0.0009	0.006	0.0012	0.78	0.330	97.69	1.006	0.19	0.129	0.72	0.524	46
RS 2.21	0.41	0.141	0.003	0.0015	0.007	0.0017	0.99	0.354	97.98	0.701	0.09	0.026	0.35	0.240	63
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	total
Average	0.44		0.010		0.011		1.04		97.39		0.13		0.51		212

x : Mean Value S.D : Standard deviation N : Number of analyses

Some core samples indicate that a deeper layer than that selcted for the mining level has rock salt deposits containing lower SO_4 content. However, there are not sufficient samples available for determining whether such low SO_4 rock salt is prevalent or not, so the above averages were used as the basis for assuming the quality of the produced rock salt.

1-3-3 Minable Halite

Minable halite reserves in the minable zone have been determined to be as shown below.

		Area(m^2)	Height(m)	Volume(m^3)	S.G.	Reserves(tons)
A.	Halite Reserve of Minable Zone	5,262,555	1.2	63,150,660	2.2	138,931,452
B.	Minable Halite	1,404,593	1.2	16,855,116	2.2	37,081,255
C.	Ratio(B/A x 100)					26.69%

The halite reserve of the minable zone is determined by multiplying the area mined by the height of mining. Therefore the values given above for the reserves represent those of a limited area and differ from what is generally referred to as geological reserves.

Minable halite comprises the halite reserves less the volume of the pillars etc. Details regarding the mining method and specifications are given in 4-2.

As indicated above the minable halite of the minable zone is calculated to be 37.1 million tons, which is sufficient for 30 years of mining at the rate used by the Evaluation Team (1.2 million t/y).

This quantity of minable halite presents an ample safety margin for the Project, in regard to the possible need to change the mine face because of unforeseable circumstances, or expand production, etc., and is sufficient for mining 1.2 million t/y.

Moreover, it is considered possible to extend operations in the future to the deeper salt beds and to salt beds to the north, and in view of this it may be stated that the scale of the reserves is huge.

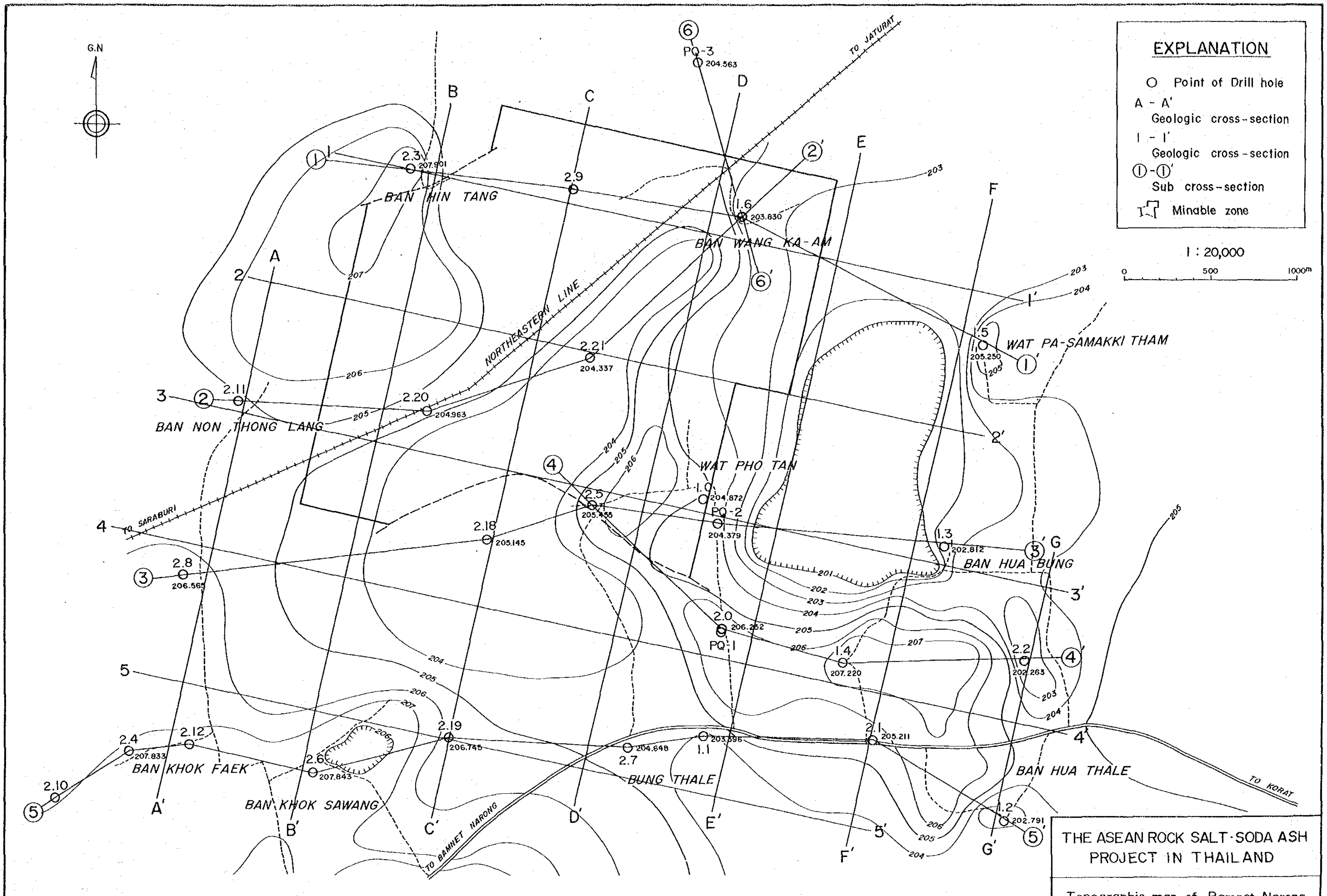


Fig. III-6. Topographic map of Bamnet Narong Rock Salt deposit

THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

Topographic map of Bamnet Narong Rock Salt deposit

JICA | FIG. III - 6

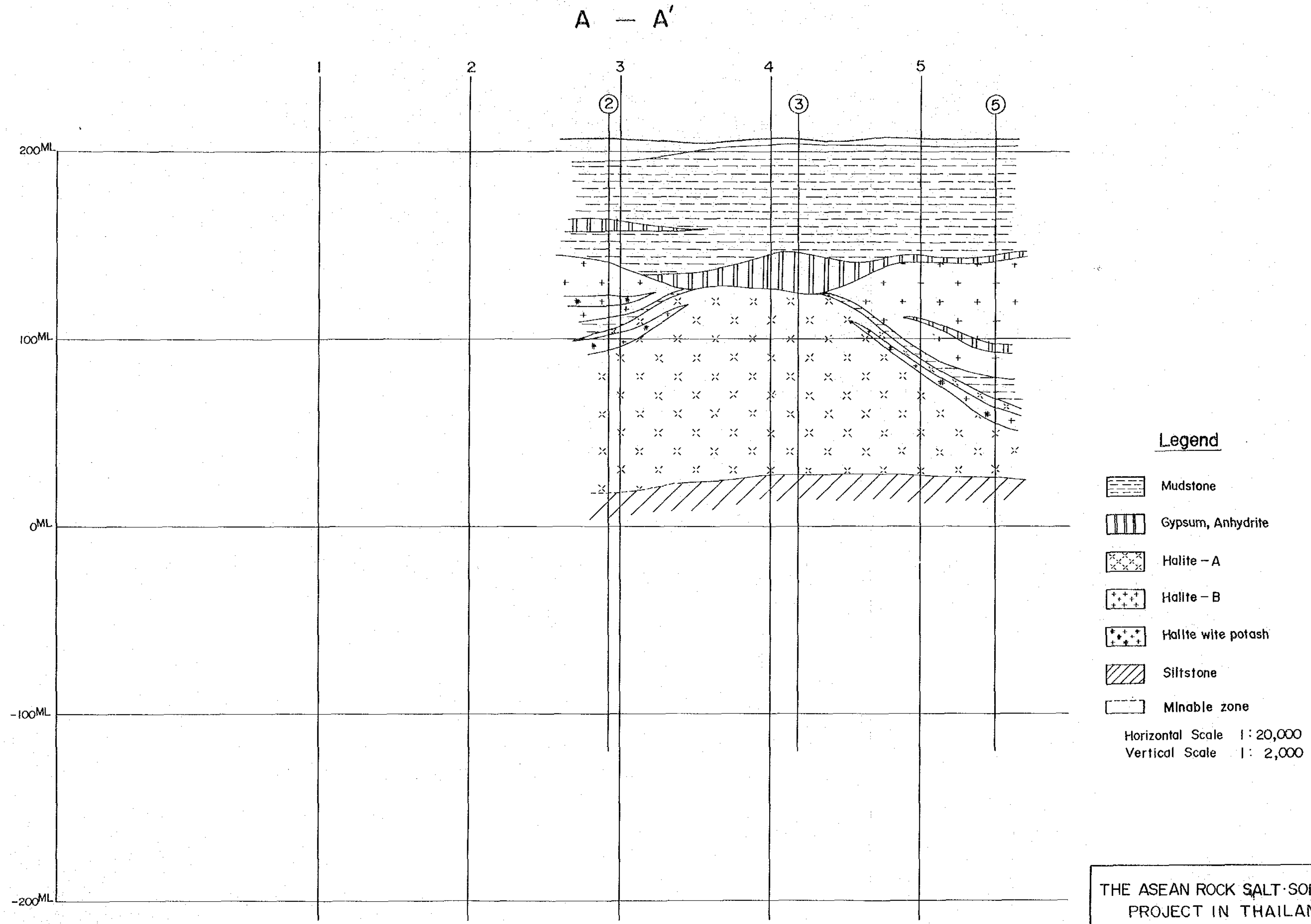


Fig.Ⅲ-7 (a). Schematic profile of the rock salt bed at Bamnet Narong (Along A – A' Fig.Ⅲ-6)

THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

Schematic profile of the rock salt bed at Bamnet Narong (Along A-A' Fig.Ⅲ-6)

JICA | FIG. Ⅲ-7 (a)

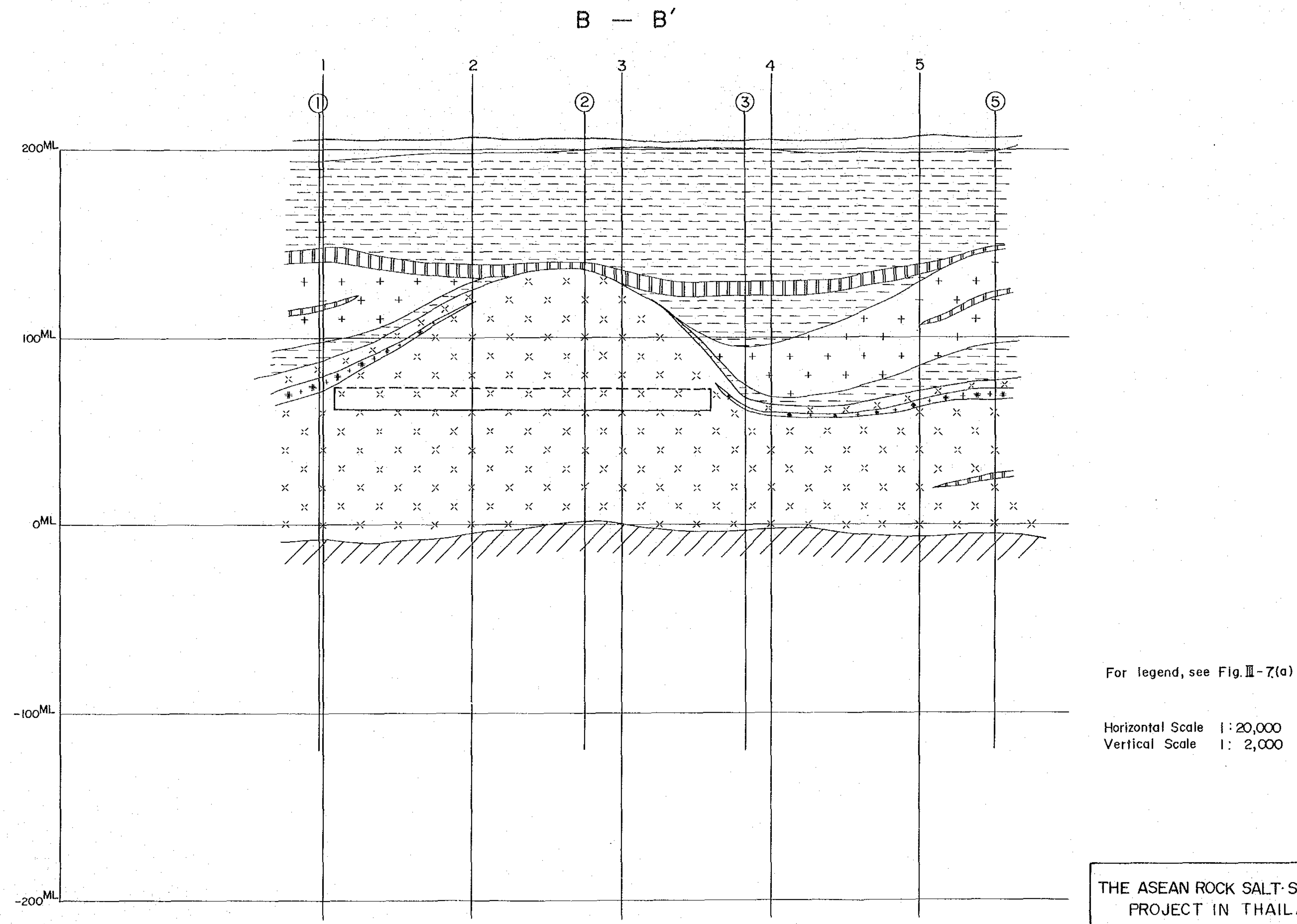
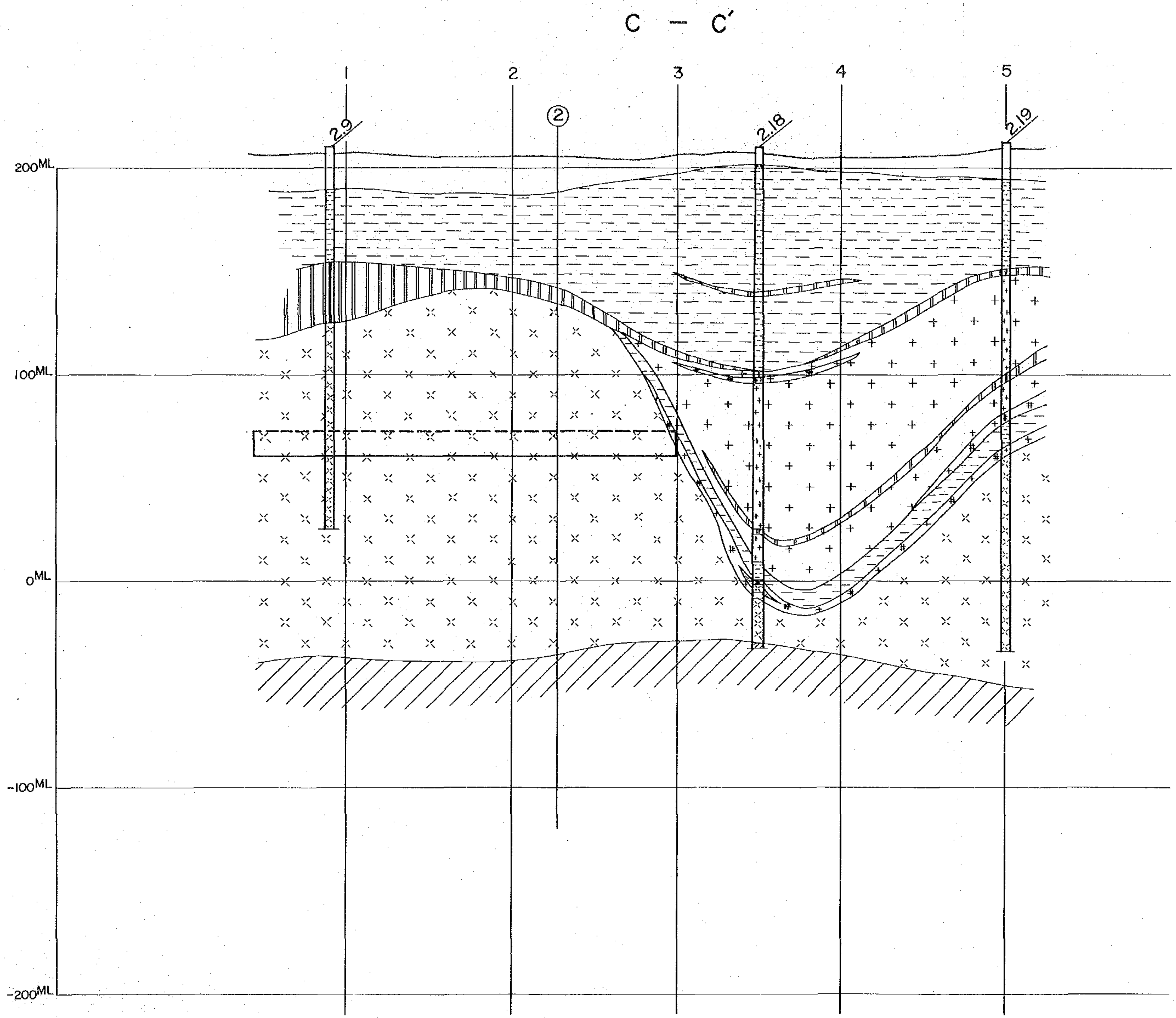


Fig. Ⅲ-7 (b). Schematic profile of the rock salt bed at Bamnet Narong (Along B – B' Fig. Ⅲ-6)

THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

Schematic profile of the rock salt bed at Bamnet Narong (Along B-B' Fig. Ⅲ-6)

JICA | FIG. Ⅲ-7 (b)



For legend, see Fig. III-7(a)

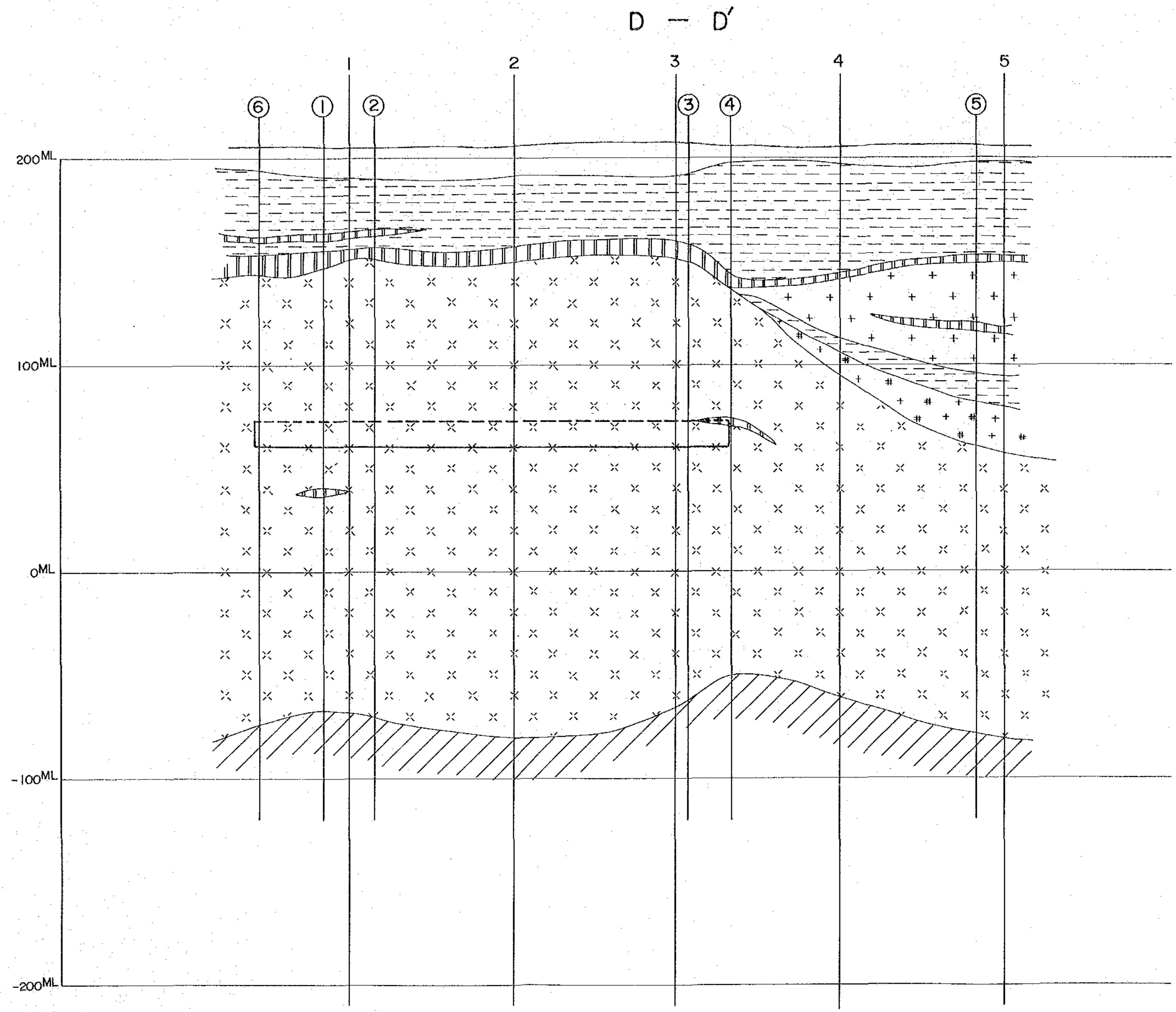
Horizontal Scale 1 : 20,000
Vertical Scale 1 : 2,000

THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

Schematic profile of the rock salt bed at Bamnet Narong (Along C-C′ Fig. III-6)

JICA | FIG. III-7 (c)

Fig. III-7 (c). Schematic profile of the rock salt bed at Bamnet Narong (Along C-C′ Fig. III-6)

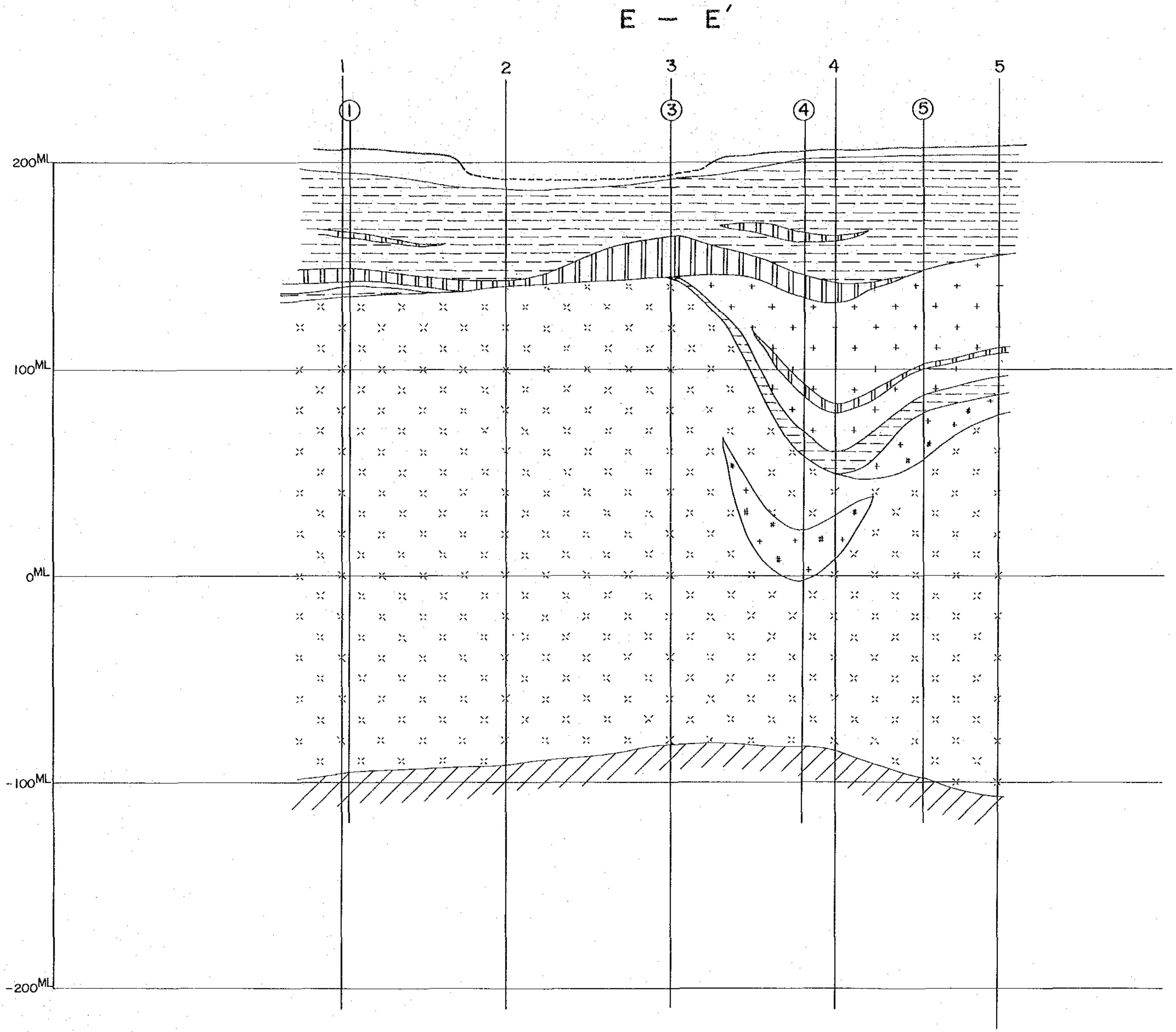


For legend, see Fig.Ⅲ-7(a)

Horizontal Scale 1 : 20,000
Vertical Scale 1 : 2,000

Fig.Ⅲ-7 (d). Schematic profile of the rock salt bed at Bamnet Narong (Along D – D′ Fig.Ⅲ-6)

THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND	
Schematic profile of the rock salt bed at Bamnet Narong (Along D–D′ Fig.Ⅲ-6)	
J I C A	FIG. Ⅲ-7 (d)



For legend, see Fig.Ⅲ-7.(a)

Horizontal Scale 1 : 20,000
Vertical Scale 1 : 2,000

THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

Schematic profile of the rock salt bed at Bamnet Narong (Along E-E′ Fig.Ⅲ-6)

JICA | FIG.Ⅲ-7. (e)

Fig.Ⅲ-7 (e). Schematic profile of the rock salt bed at Bamnet Narong (Along E-E′ Fig.Ⅲ-6)

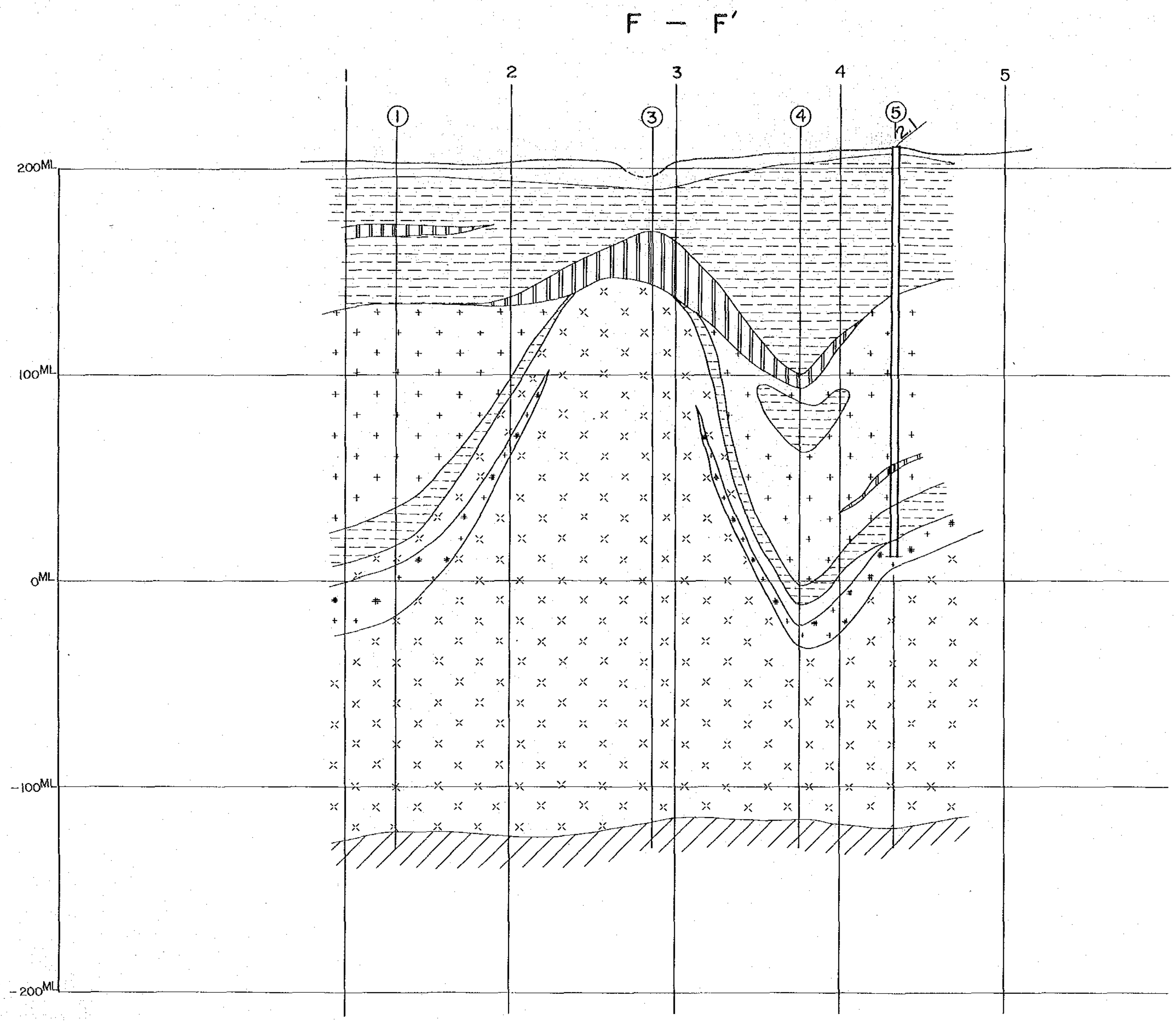


Fig.III-7(f). Schematic profile of the rock salt bed at Bamnet Narong (Along F-F' Fig.III-6)

THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

Schematic profile of the rock salt bed at Bamnet Narong (Along F-F' Fig.III-6)

JICA | FIG. III-7.(f)

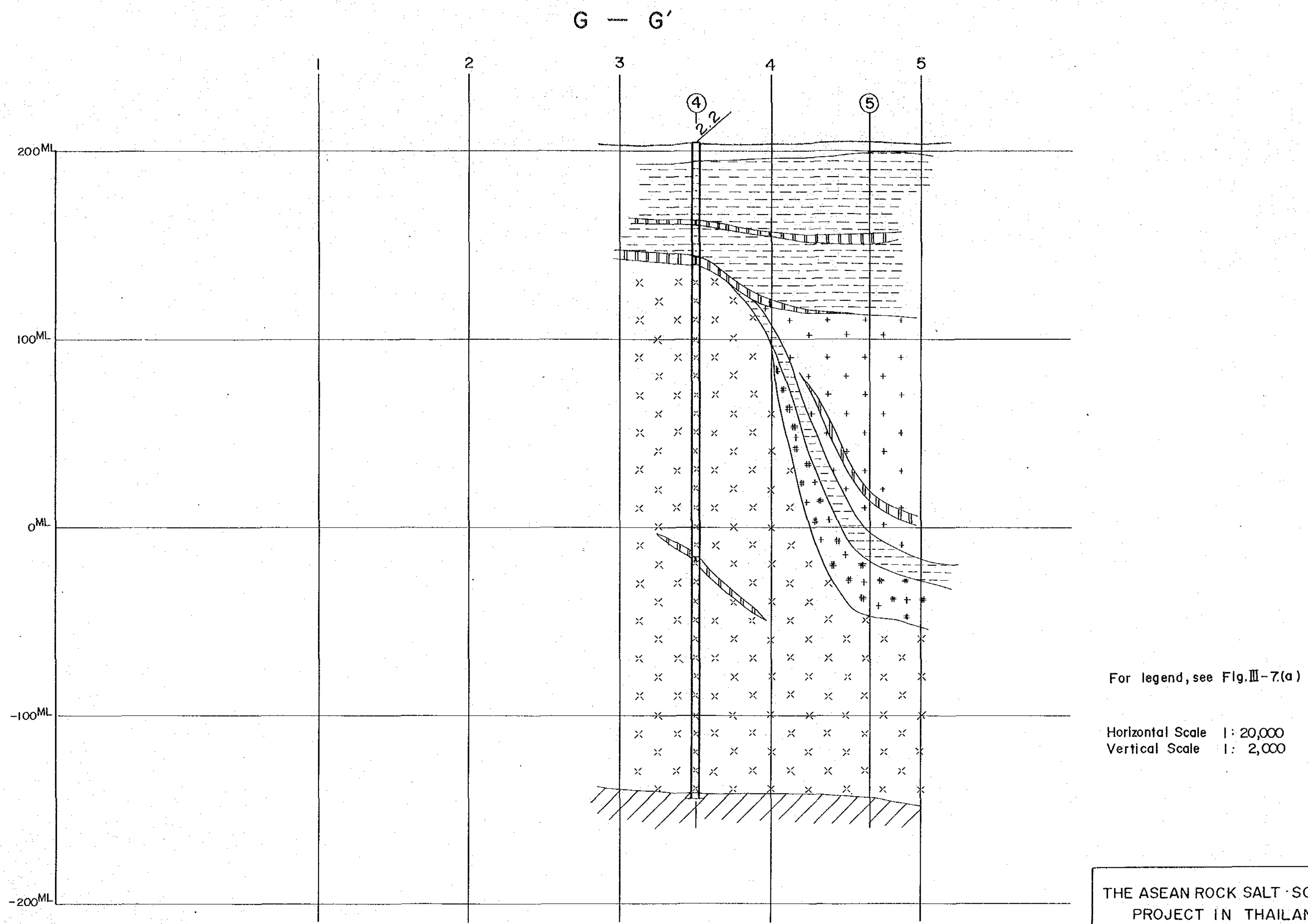


Fig. III-7 (g). Schematic profile of the rock salt bed at Bamnet Narong (Along G – G' Fig. III-6)

THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND	
Schematic profile of the rock salt bed at Bamnet Narong (Along G-G' Fig. III-6)	
JICA	FIG. III-7 (g)

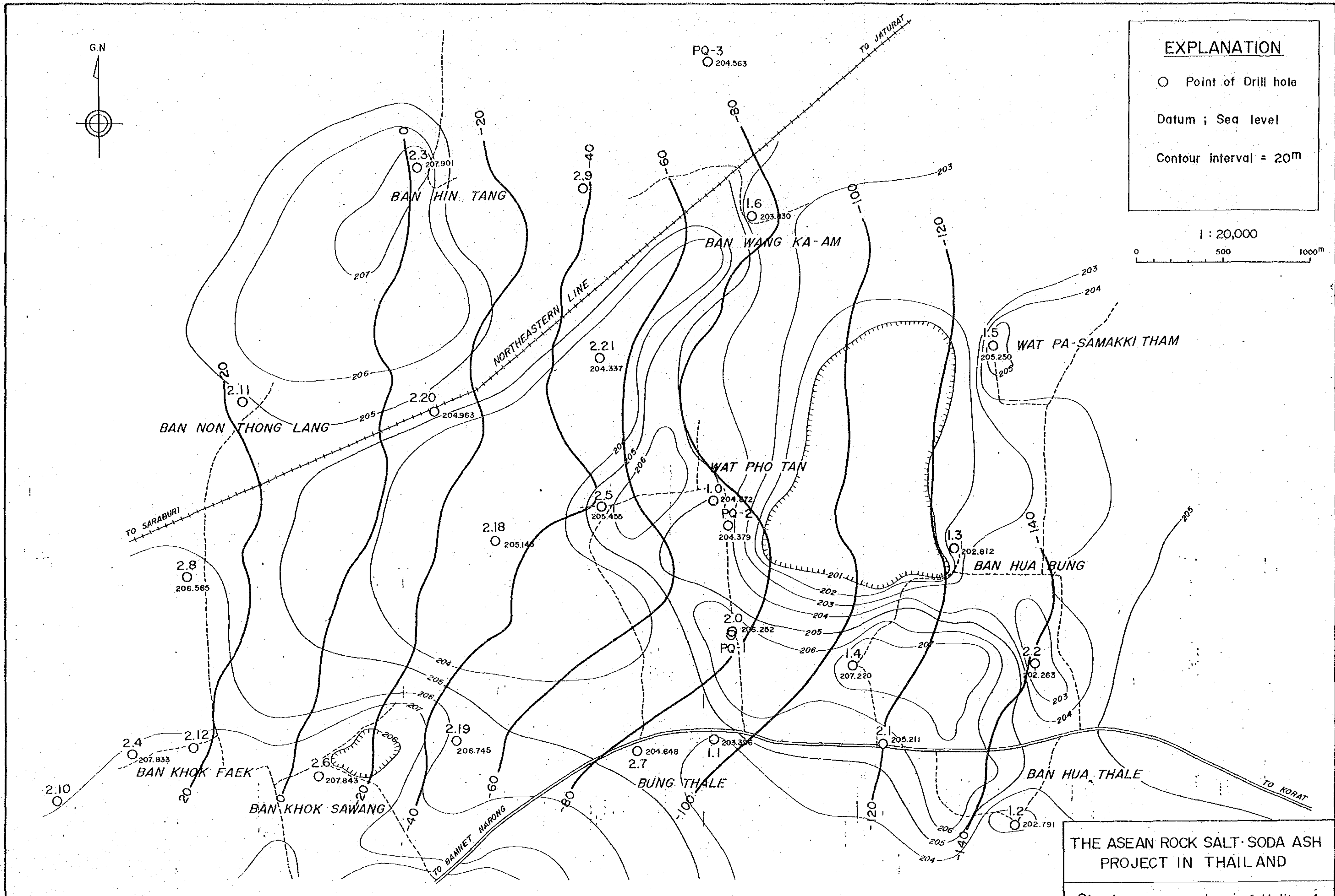


Fig.III-8. Structure map on base of Halite-A bed at Bamnet Narong

THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

Structure map on base of Halite-A bed at Bamnet Narong

JICA | FIG. III-8

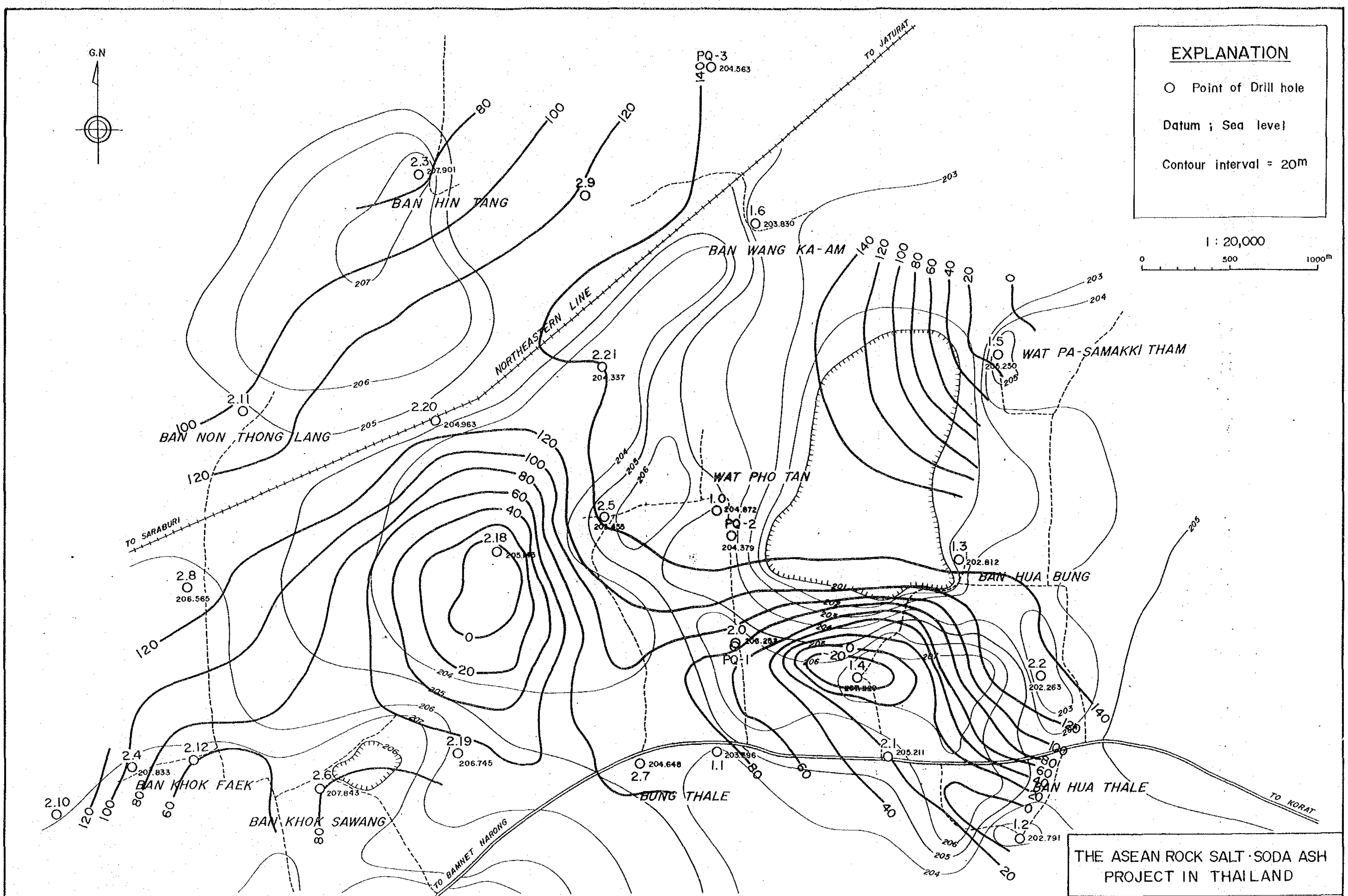


Fig. III-9. Structure map on top of Halite-A bed at Bamnet Narong

THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

Structure map on top of Halite-A bed at Bamnet Narong

JICA | FIG. III-9

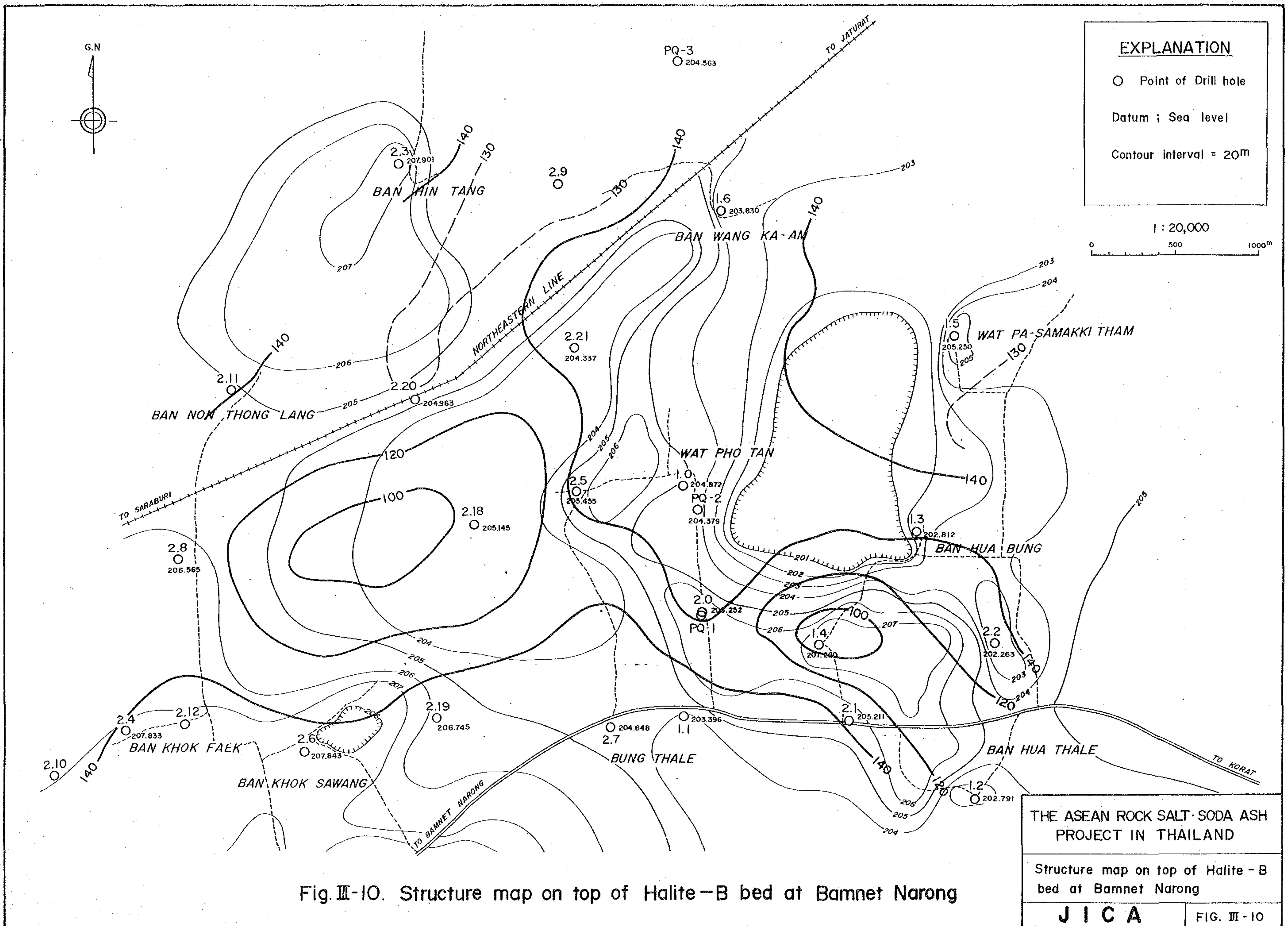


Fig. III-10. Structure map on top of Halite-B bed at Bamnet Narong

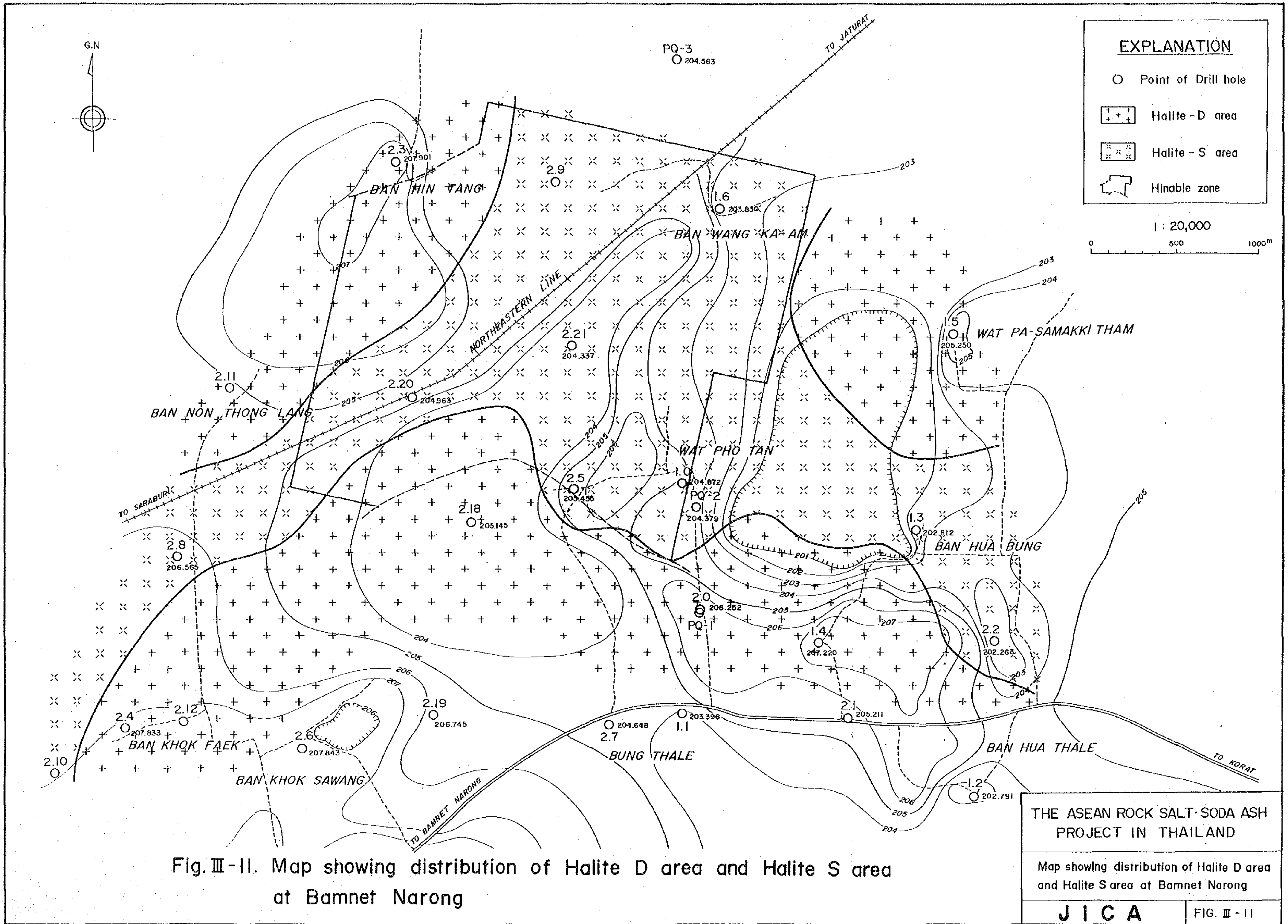


Fig. III-11. Map showing distribution of Halite D area and Halite S area at Bamnet Narong

THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND	
Map showing distribution of Halite D area and Halite S area at Bamnet Narong	
J I C A	FIG. III - 11

Table III-3 CALCULATION RESULT OF THE CONTENTS OF CHEMICAL COMPONENT OF ROCK SALT FROM ADDITIONAL DRILLING CORE AT BAMNET NARONG

			H_2O	I.M	Cℓ	SO_4	Ca	Mg	K	Na	NaCℓ	N
Halite - A	D-area	RS 2.18	0.19%	1.04%	58.90%	1.03%	0.44%	0.032%	0.05%	38.08%	96.79%	8
		RS 2.19	0.08	1.36	58.87	1.01	0.42	0.008	0.02	38.14	96.96	31
		Average	0.10	1.29	58.88	1.01	0.43	0.013	0.02	38.13	96.92	Total 39
	S-area	RS 2.20	0.19	0.72	59.30	0.78	0.33	0.003	0.006	38.43	97.69	46
		RS 2.21	0.09	0.35	59.48	0.99	0.41	0.003	0.007	38.55	97.98	63
		Average	0.13	0.51	59.40	0.90	0.37	0.003	0.007	38.50	97.86	Total 109
	Average		0.12	0.71	59.26	0.93	0.39	0.006	0.01	38.40	97.61	Total 148
Halite - B		RS 2.18	0.21	1.65	58.37	1.26	0.52	0.040	0.16	37.68	95.77	30
		RS 2.19	0.30	1.94	57.55	1.62	0.68	0.045	0.11	37.15	94.45	19
		Average	0.25	1.76	58.05	1.40	0.58	0.042	0.14	37.47	95.24	Total 49
Average			0.15	0.97	58.96	1.05	0.44	0.015	0.04	38.17	97.02	Total 197

I.M; Water-insolubles

N; Number of analysis

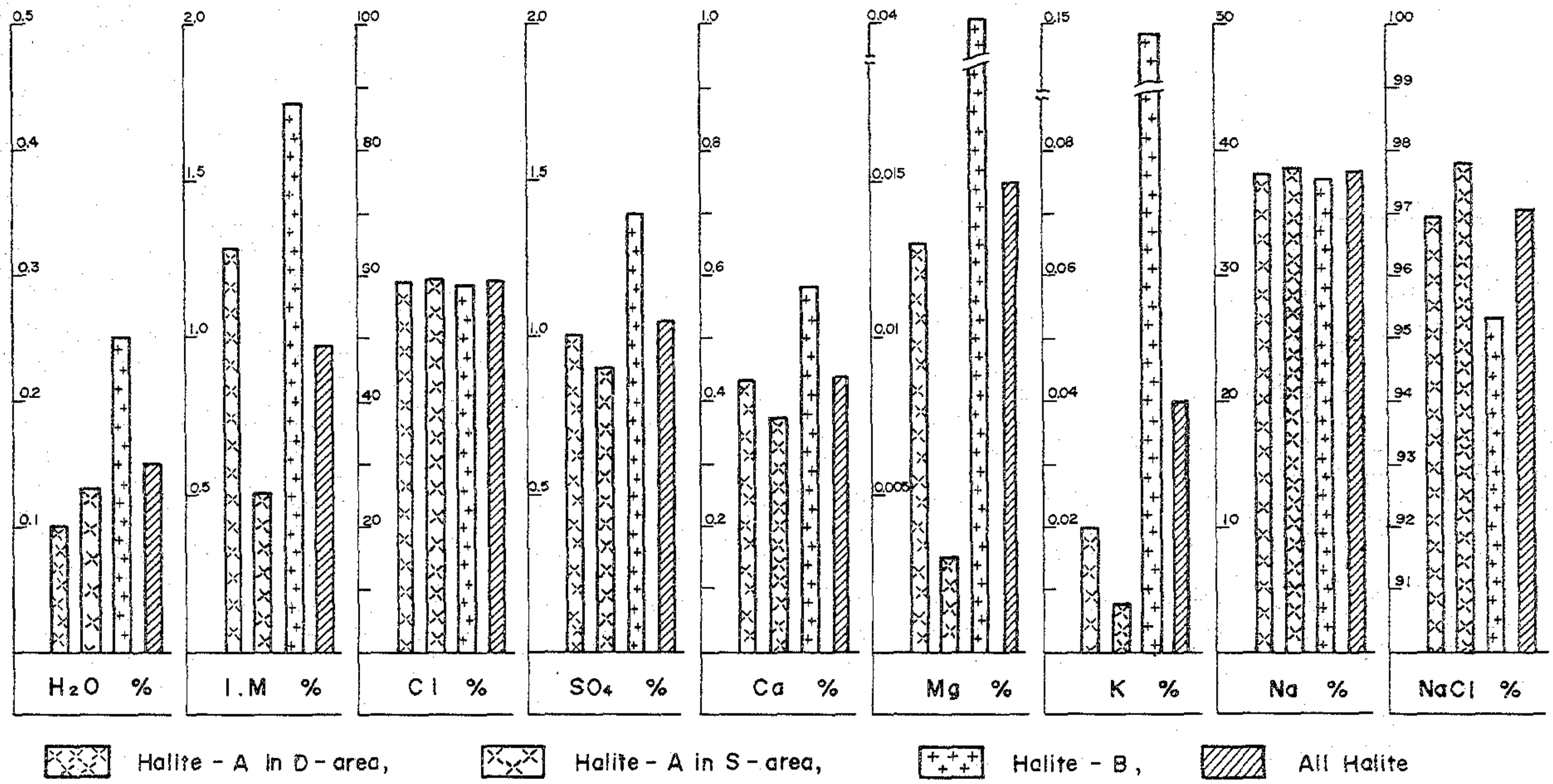


Fig.III-12. Average contents of rock salt components of Bamnet - Narong

(Refer to calculation in Table 4·5)

Table III-4 RESULT OF SPECIFIC GRAVITY MEASUREMENT

Test Price No.	Locality	Dimension Diameter (mm)	Dimension Length (mm)	Specific Gravity
18– 3	RS. 18, Halite B	85.20	176.0	2.2
4	ditto	85.15	175.2	2.2
7	ditto	85.00	177.0	2.2
8	ditto	85.00	174.5	2.2
18	RS. 18, Halite A	84.80	165.3	2.2
19	ditto	85.20	177.2	2.2
20	ditto	85.25	176.6	2.2
21	ditto	85.20	177.5	2.2
3–1	RS. 18, Halite B	85.00	45.8	2.2
4–1	ditto	85.20	45.4	2.2
4–2	ditto	85.20	45.9	2.2
7–1	ditto	85.20	41.5	2.2
7–2	ditto	85.20	47.0	2.2
8–1	ditto	85.10	46.6	2.2
8–2	ditto	85.20	45.0	2.3
18–1	RS. 18, Halite A	85.30	47.0	2.2
18–2	ditto	85.30	44.8	2.2
18–3	ditto	85.30	48.9	2.0
18–6	ditto	39.75	89.4	2.2
19–1	ditto	85.30	47.9	2.2
19–2	ditto	85.30	41.1	2.2
20–1	ditto	85.10	44.9	2.2
20–2	ditto	85.30	44.7	2.2
21–1	ditto	85.10	44.0	2.2
21–2	ditto	85.30	45.0	2.2
19–4	RS. 19, Halite B	85.00	175.50	2.2
5	ditto	85.00	175.50	2.2
9	ditto	85.10	177.40	2.2
10	ditto	85.00	175.20	2.2
15	RS. 19, Halite A	85.30	176.20	2.2
16	ditto	85.20	137.90	2.2
17–1	ditto	85.00	127.00	2.2
17–2	ditto	85.00	166.50	2.2
18	ditto	85.20	176.40	2.2
4–1	RS. 19, Halite B	85.00	44.60	2.2
4–2	ditto	85.30	44.80	2.2
5–1	ditto	85.20	44.10	2.1
5–2	ditto	85.10	50.70	2.3
9–1	ditto	85.20	44.10	2.1
9–2	ditto	85.10	44.70	2.3
10–1	ditto	85.20	44.70	2.2
10–2	ditto	85.10	44.00	2.2
15–1	RS. 19, Halite A	85.20	44.60	2.2
15–2	ditto	85.20	46.10	2.2
16–1	ditto	85.20	49.80	2.0

Test Price No.	Locality	Dimension Diameter (mm)	Dimension Length (mm)	Specific Gravity
18– 1	RS. 19, Halite A	85.10	44.3	2.2
18– 2	ditto	85.10	47.1	2.2
18– 3	ditto	85.30	45.2	2.1
14	ditto	39.75	71.7	2.1
20– 5	RS. 20, Halite A	85.00	178.50	2.2
6	ditto	85.00	175.60	2.2
14	ditto	85.20	174.10	2.2
15	ditto	85.30	173.50	2.2
18	ditto	85.00	173.50	2.1
19	ditto	84.95	174.50	2.2
5–1	ditto	84.80	44.40	2.3
5–2	ditto	85.00	47.40	2.2
6–1	ditto	85.00	43.50	2.1
6–2	ditto	85.00	44.10	2.2
14–1	ditto	85.50	45.30	2.1
14–2	ditto	84.50	47.00	2.2
15–1	ditto	85.00	46.70	2.2
15–2	ditto	85.00	47.00	2.1
18–1	ditto	85.00	42.00	2.2
18–2	ditto	85.00	41.00	2.2
19–1	ditto	85.00	46.80	2.2
19–2	ditto	85.00	44.60	2.2
21– 7	RS. 20, Halite A	49.30	93.7	2.1
8	ditto	49.40	103.9	2.1
9	ditto	49.30	83.2	2.1
11–1	ditto	49.30	90.2	2.1
24	ditto	49.40	77.3	2.1
25	ditto	49.40	102.8	2.1
32	ditto	49.20	97.7	2.1
11	ditto	49.40	100.75	2.1
13	ditto	49.30	66.55	2.1
10–1	ditto	49.30	96.70	2.2
10–2	ditto	49.30	95.60	2.2
12–1	ditto	49.30	99.0	2.2
15–2	ditto	49.30	97.95	2.2
7–1	ditto	49.30	95.00	2.2
20–2	ditto	49.30	99.00	2.2
21–2	ditto	49.30	104.40	2.2
17–1	ditto	49.30	99.65	2.1
18–2	ditto	49.30	97.55	2.1
14–2	ditto	49.00	104.40	2.2
16–1	ditto	49.00	103.40	2.2

CHAPTER 2 SITE SELECTION

2-1 MINING ZONE

As mentioned in 1-3, the Halite-A of S-area is selected as the mining zone in view of the quality and structure, and other characteristics of the deposit. (For the horizontal distribution of the Halite-A, refer to Figure III-ll.)

2-2 MINING LEVEL

It is desirable that the mining level be as close to the surface of the ground as possible, but to prevent ground subsidence and penetration of surface water it is necessary to maintain a certain thickness of rock salt as a crown pillar. The thickness of the crown pillar was determined from the physical properties of the rock salt[1], as calculated from the rock mechanic formula. For details, see Annex III-1.

The thickness of the overburden was assumed from Figure III-7 to be 84 m, to be on the safe side, and using a safety factor of 4, the thickness of the crown pillar was determined to be 45 m. Therefore, from the surface of the ground to the roof of the proposed mining level, 84 + 45 = 129 m are to be maintained. Because the average surface elevation is 202 m over the sea level, this means that the elevation of the roof of the mining level is 73 m over the sea level.

2-3 MINE SITE

In selecting the location of the mine site within the mining zone, the following were taken as criteria.

1. The mine site should be at a suitably high elevation so that no water would enter the shaft at a time of floods.

2. The site must be suitable for laying a railway spur.

3. There should be no need to relocate existing homes.

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1) Chapter 4, the first-stage evaluation for the ASEAN Rock Salt – Soda Ash Project (Thailand).

4. The site should be close to the highway.

On the basis of these considerations, the location selected as shown in Figure III-1 and Figure III-13 is adjacent to the national highway.

2-4 TOWN SITE

A site adjacent to the mining site was selected as the location of the town. An existing road is between these two sites. It is planned that, after the start of mine operation, the road will be used for access between the national highway and the mine, and as a road serving the mine town: it cannot be taken over for the exclusive use of the mine because it is the only road serving habitants in the area.

CHAPTER 3 SCALE OF PRODUCTION

3-1 QUANTITY OF PRODUCTION

The market study and soda ash plant requirements indicate the production of rock salt at the rate of 1.2 million t/y in minimum. The basic scale of mining was determined in accordance with this production plan to be 2,000 t per shift (quantity shipped from the mine). With 300 days of annual operation, and working two shifts a day, this means 1.2 million t/y. If shipment of more than that quantity is required, by working three shifts, production of 1.8 million t/y is possible. In the latter case, mine facilities installed for the former case can be used without additional installments, because the scale of per-shift production is not changed and the daily working hours are extended. The additional facilities required to increase production to 1.8 million t/y are only worker housing.

Therefore although all discussions and descriptions are based on 1.2 million t/y production, the mine facilities presented in this chapter should meet the 1.8 million t/y production.

3-2 QUANTITY OF MINING OF CRUDE SALT

As is noted in 4—3 , the waste ratio of 20% of expected. Therefore in order to ship the above-noted quantity of rock salt, it is necessary to mine 1.25 times the quantity to be shipped.

3-3 PRODUCT SPECIFICATIONS

All rock salt shipped from the mine is to be larger than 1.2 mm and smaller than 15 mm, in order to minimize dust from salt and sticking which may occur during the handling and transportation of the product.

Regarding product quality, on the basis of the average composition of salt samples produced by exploratory drillings in the Halite-A of S-Area as indicated in 1-3-2, and the crushing and screening described in 4-1, the quality is assumed to be as follows.

Component	Average quality
Water	0.1% – 0.2%
Insoluble matter	Less than 0.5%
SO_4	Less than 1.0%
Ca	Less than 0.4%
Mg	Less than 0.08%
K	Less than 0.001%
NaCℓ	More than 97%

It must be noted, however, that the above figures are yet on a preliminary basis, because of a limited number of samples used for analysis. Some samples indicate that higher purity of rock salt exists in the part deeper than the proposed mining level, although those analyses are insufficient to use for determining whether such higher purity of rock salt is prevalent or not. It is recommended that the Thai authorities continue their further efforts for collection and analysis of additional samples and finally determine the quality of rock salt as well as the mining level, by referring to the analysis of additional samples.

CHAPTER 4 MINE DESIGN

4-1 CONCEPT

The rock salt produced at and shipped from the mine, as noted in 3-3, is to be particles of 1.2 mm to 15 mm.

The anhydrite present in the salt bed in widths of several dozen centimeters would lower the quality of rock salt produced for shipment from the mine, and is a cause for a high I.M. (insoluble matter) component.

However, even if during mining the presence of anhydrite is noted, there is no method of separately removing it at the mine face. The anhydrite is comparatively harder than the rock salt and it is difficult to crush. It is therefore planned that particles larger than 15 mm which are screened out as oversize at the mine's crushing and screening plant are not to be considered as product but rather will be processed as waste to somewhat lower the I.M. content.

In broad terms, there are two methods for transporting halite from 80 m below the surface to the surface: the skip method through a vertical shaft or the belt conveyor method along an inclined shaft. These two methods may be compared as follows.

	Skip method	Belt conveyor method
Extent of construction work	Low	High
Unit construction cost	High	Low
Difficulty of construction	Hard	Easy
Equipment cost	High	Low
Maintenance cost	High	Low
Moving heavy equipment	Hard	Easy

Evaluating the two on the basis of the above, it is concluded that for a depth of 140 m, the belt conveyor method along an inclined shaft is preferable. Therefore it is proposed to open two shafts on the basis of the assumption that there will be trackless mining, one shaft for intake air and one for return air.

The belt conveyor is to be installed in the inclined shaft for return air, and the miners' lift and material transport will make use of the intake air shaft. (Regarding a general layout of decline shaft, see Figure III-26). The mining zone will be split into units of 322 m by 610 m, and a barrier pillar 70 m thick will be left between each panel. Therefore the minable area of each unit will be 252 m by 540 m (see Figure III-14). The objective in providing a barrier pillar is as follows.

1. To prevent unforeseen failure of the main drift.

2. To prevent failure of the main drift due to stress concentration caused by progress of excavation work.

3. In the event of seepage or penetration of surface water, to minimize the area which must be abandoned.

The width of the mine face in a panel, and the width of pillars, have been determined by use of rock salt mechanical formula to be 12 m and 34 m, respectively (see Annex III-1). The height of the mine face has been set at 12 m, in order that the pillar will not be too long and in order to have safe working conditions.

It is planned to use blasting at the mine face. Use of the continuous miner method is an alternative to blasting but the initial investment cost is higher in the former case: about US$860,000, 4.6 times as much as needed if blasting is adopted. Also, because grindability is high, the volume of material handled is increased. The continuous miner method therefore seems to be not suitable in the case of rock salt. In view of the rock salt mines existing in various countries, most of these mines do not use the continuous miner method.[1] Before holes are drilled for explosives, a 5 inch undercut is made at floor level completely across the heading at the mine face by a cutting machine, and the cut space falls, as a free face.

Loading is done by use of a tractor-shovel (L.H.D.) for underground use only, and loading and hauling are done at the same time. Transportation from the mine face to the crushing and screening plant is to be by a conveyor. It will be necessary to lengthen the conveyor as the mine face advances, by about 325 m a year.

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1) L.P. Bush,: "LHD/feeder-breaker System Cuts Costs at International Salt Co's Cleveland Mine." *Engineering & Mining Journal*, September, 1974, p120–122.

A stationary crushing and screening plant is to be used; it is to be installed prior to the start of commercial mine operation. This plant will not be moved as the mine face advances; the conveyor from the mine face to the plant, however, will be lengthened as necessary.

In the SNC report, the proposal is made to use dump trucks for transportation of rock salt from the mine face to the crushing and screening plant, and to move a part of the plant as the mine face advances. The Evaluation Team, however, noting that the use of dump trucks would entail a higher requirement for ventilating air volume, and that there are difficulties encountered in moving the plant, prefers to recommend the foregoing method.

In order to minimize bad influences which noise, vibration and dust from the screening and crushing plant, and ventilating air equipment, would have on the lives and environment of local people, it is planned that the plant and equipment will be installed within the mine. Screening waste will be disposed of in mined-out areas, and will be used as sealing materials in place of air blocks, as well as keep the drift floors level.

The facilities of the mine, as described in the subsequent paragraphs of this part, is based on the foregoing concept. It must be noted the design is still in a conceptual design stage, although it provides the basis sufficient for financial evaluation, and therefore it is necessary that development of design bases for final design work be conducted in the implementation stage for the purpose of inviting contractors. In this connection it is recommended that further efforts be made by Thai authorities to prepare necessary data through various activities particularly including rock mechanic tests and soil tests.

4-2 MINING

4-2-1 Operation

The mine operation plan is based on working a 6-day week, two shifts a day, and 300 days a year. The yield of product is expected to be 80%, and as noted in 3-2 the basic quantity of salt to be mined is 2,500 t/d. Regarding the mine panels, it is planned to excavate two panels in each side of the drift containing a belt conveyor (see Figure III-15). It is expected that one shift will mine 1,250 t from one panel. The sectional area at the mine face will by 12 m by 12 m, and blasting will advance the face 4 m per blast, so one blast will produce 1,250 t. Therefore, by proceeding with two panels at one time, 2,500 t will be mined in one day of work. Regarding the basis for determining the width of the mine face, see Annex III-1.

4-2-2 Undercutting

Before drilling blast holes, by using a cutting machine, undercut will be made at the floor part of the mine face so that it makes a space of 5 inches in height and 4 m in depth. In addition to using this space as a free face, it will help prevent back-break to the floor, and maintain a good surface. By using a 295 HP cutting machine it will be possible for one shift to cut two mine faces.

4-2-3 Drilling

After the undercut has been completed, the mine face is to be drilled by use of an electric auger drill with two booms. There are to be 123 drillholes in a mine face. The intervals between outer holes are to be 60 cm near the roof and 1 m near the side walls, to prevent back-break to the pillars, and the smoothblasting method is to be employed. For the other holes, the undercut part is to be a free face, the burden line is to be 1 m, and spacing is to be 2 m. In the corners near the roof, a radius of 1.5 m or more is to be used, to prevent stress concentration caused by blasting.

4-2-4 Blasting

After the holes are drilled, explosives are charged at the mine face. Charging is done on a table lifter, using pneumatic or ANFO chargers. The explosives are 90% ANFO and 10% dynamite (primer). Detonators are from one-step to 15-step detonators; detonation is done progressively from bottom to top, Explosive charges in peripheral holes are weaker, to prevent back-break effect and are detonated with a one-step delay in accordance with use of the smooth blasting technique. Blasting is done after each shift of workers has left the mine at the end of their shift, and the air in the mine can be replaced. Therefore, the explosives workers' working hours start and end one hour after that of the others.

4-2-5 Scaling

Scaling of the mine face is performed after blasting. Entry by ordinary mineworkers is not permitted until scaling is completed. The procedure of scaling is for a worker to perform checking by hitting and looking, first on the higher portions of the mine face from the table lifter of a modified crane. After taking care of the smaller pieces a rock breaker is used for the larger ones.

4-2-6 Bolting

Roof bolts are inserted after scaling has been completed. In principle they are placed only in the roof. The bolts, 1 inch in diameter, are placed from the table lifter in 34 mm holes drilled by use of portable drills. In general, 1.5 meters-long roof bolts are used, but at the intersection of headings 2-3 m bolts are to be used. With the objective of providing support for 50% of the mine face roof, the spacing of bolts is to be one per square meter.

4-2-7 Loading

After insertion of roof bolts, a loader is moved to the mine face and used to load blasted rock salt onto the conveyor which has been extended to the end of the panel. It is proposed that use be made of a tractor shovel (L.H.D.), for which there has been considerable technical improvement in recent times. Pieces larger than 250 mm are to be crushed by use of rock breaker or blasted by portable drills before loading. The work described in the foregoing sections 4-2-2 to 4-2-7 is a work flow for one cycle of mining work.

4-2-8 Pre-production Work

It is calculated that the quantity of rock salt to be mined from one panel is about 1.7 million tons. Because excavation of two panels will proceed simultaneously, the two panels will yield about 3.4 million tons. Because it is planned that the annual basic quantity of mining is to be 1.5 million tons, mining of two panel will be completed in about 2.3 years (1.7 million tons x 2 panels ÷ 1.5 million t/y = 2.3 years). During this 2.3 years it will be necessary to undertake pre-production work for the next two panels. This pre-production work will largely comprise opening of the main drifts in the pillars, and the access drifts which are to link the main drift and panel. The conventional practice is to use either a V-cut or burn cut to open drifts for pre-production work. It will be sufficient for one shift to advance 1.4 m in opening these drifts. Therefore, two shifts will not be required for preproduction work as one will suffice. A roof bolt is to be driven for each one square meter of drift advance.

4-2-9 Ventilation

Diesel-powered equipment to be used in the mine will require 3 m^3/minute of air supply per kilowatt[1] and, moreover, 3 m^3/minute are needed for every person.[2]

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1) Ministry of International Trade and Industry directive #54.

2) Ministry of Labour, Technical Standard Report, March 1979, "Report on Technical Standards for Ventilation Equipment for Underground Construction Work."

The maximum values for diesel-powered equipment to be used in the present mine at one time are as follows.

L.H.D.	2 units	488 P.S.
Compressor	1	180
Grader	1	145
Tractor	1	76
Dump truck for waste removal	1	300
Table lifter	1	155
Total		1,344

Further, it is expected that the number of workers in the mine on one shift will be 49. Therefore, the required air volume is calculated as follows.

$$1{,}344 \text{ PS} \div 0.75 \times 3 \text{ m}^3\text{/minute} + 49 \text{ persons} \times 3 \text{ m}^3\text{/minute} = 5{,}523 \text{ m}^3$$

In order to obtain this volume of air, a 220 HP ventilator will be required (for details see Annex III-2). The ventilating circuit is as shown in outline in Figure III-15.

4-2-10 Mining Equipment

A list of the mining equipment is provided as Table III-5.

4-2-11 Maintenance and Repair

The machinery and equipment listed in Table III-6 will be required for the maintenance and repair of the mining equipment.

It is envisioned that minor repair work and routine maintenance work will be performed by mine employees, but for overhaul and large-scale repair work outside services will be employed. The mechanics team of the mine's equipment maintenance group will work in two shifts, and periodically make the rounds of the mine faces, to grease up, lubricate and inspect equipment. The electrical team will work three shifts, and inspect power receiving equipment and seek to prevent and cope with accidental breakdowns.

Table III-5 MINING EQUIPMENT

Item	Specifications	Q'ty
Main face equipment		
Undercutter	295 HP: cut length 4.5m	1
Excavation jumbo	2 booms; electric-powered; hydraulic augur drill	1
Roof bolter	14 t modified crane overall ht., 14m	1
Table lifter for scaling	14 t modified crane	1
Small crusher for scaling	Modified backhoe 155 PS.	1
Table lifter for charging	Effective working ht., 18m	1
Compressor for instruments	$17m^3$, 180 PS	1
Tractor for pulling compressor	8 t capacity; 76 PS	1
Jeep patrol	Diesel	1
Loading equipment		
L.H.D.	$61m^3$; 231 PS	2
Mine truck	20 t capacity; $15.2m^3$	1
Bulldozer	203 PS; w/ripper; 23.8 t	1
Waste processing equipment		
L.H.D.	$3.8m^3$; electric powered 200 PS	1
Excavation equipment		
Excavation jumbo	All hydraulic impact type; 2 booms	1
ANFO charger	For insertion of ANFO	1
Compressor for above	$17m^3$; 180 PS	1
Tractor for hauling	8 t capacity; 76 PS	1
Table lifter for charging	Working height 6m	1
Leg hammer	24kg	4
Coal pick	7kg	4
L.H.D.	$6.1m^3$; diesel drive	1
Ventilating equipment		
Main ventilator	$5{,}500m^3$; 220 PS	1
Spot ventilator	$700m^3$; 30 PS	3

Table III-6 MAINTENANCE EQUIPMENT

Item	Specifications	Q'ty
Repair and maintenance equipment		
Motor grader	7.4 t capacity; weight 13.05 t	1
Vibrating roller	Weight; 10.5 t	1
Tractor for hauling	8 t capacity; 76 PS	2
Welding equipment	250A, 17.5KVA	3
Truck with crane	2 t lift	2
Sprinkler truck	$10\ m^3$	1
Sprayer	$5m^3/H$	1
Pump	22KV	2
Power hoist	5m Lift, 5 t	4
Welding machine w/engine	Weight, 2 t	1

4-3 CRUSHING AND SCREENING

The crushing and screening plant for the mine is to have the following characteristics.

Production capacity: Annual mine production capacity per shift is to be 600,000 t, so that two shifts will produce 1.2 million tons and three shifts will produce 1.8 million tons. The plant should have the capacity to accommodate this quantity of output.

Operation hours: The plant will be operated six hours per shift, 300 days a year.

Yield of product: 80%. It is anticipated that lumpy waste will be 5%, and that fine waste (smaller than 1.2 mm) will be 15%, and that final product will be 80% of the crude quantity.

Quantity processed: The quantity of treated crude salt processed per hour is to be as follows.

$$600{,}000 \text{ t/shift} \div 300 \text{ d/y} \div 6 \text{ hr/d} \div 0.8 \times 1.03 = 430 \text{ t/hr}$$

In this case, the handling and stock loss will be 3%.

Flowsheet: The crude rock salt is to be transported from the excavation face to the crushing and screening plant by belt conveyor. The product of the plant is to be of one uniform grade. The flowsheet is provided as Figure III-17.

Material balance: Ultimately the material balance is to be determined on the basis of data gained from trial crushing and screening of rock salt excavated at the time of mine development work. Because such data are not available at this time, the material balance given in the SNC report is used here as the basis for a tentative material balance (see following diagram).

Description: Crude rock salt crushed to within 250 mm at the mining face is transported to the crushing and screening plant by the trunk conveyor in the main drift. At the plant the arriving crude is charged into a 100 t hopper after which it is fed by a grizzly feeder to the primary impact crusher. (Regarding a general layout, see Figure III-16, -18, -19, and -20.) Crushed product reduced to within 100 mm by the impact crusher is passed through the primary double-deck screen by which means it is separated out into lumpy waste over 60 mm, intermediate products less than 15 mm, and the products to be transferred to the secondary crusher are from 15 to 60 mm. The third one of the above three is then transferred as secondary feed to the secondary impact crusher. Product from the secondary impact crusher is passed through 20 mm and 15 mm secondary screens, and product greater than 20 mm is sent to the waste conveyor as lumpy waste, and product which is 15–20 mm is recirculated as circulating load to the secondary impact crusher. Salt (15 mm) which has passed the primary double-deck screen and secondary double-deck screen is sent to the hopper of the tertiary screen. The tertiary screen is a double-deck screen with 5 mm and 1.2 mm mesh and from it salt which is 5–15 mm, and 1.2–5 mm, is sent as final product to the final product salt storage. Salt less than 1.2 mm is sent to the waste stockpile as fine waste.

4-4 CONVEYING AND LOADING

The general nature of conveying and loading of salt is as follows.

Capacity: Annual capacity per shift is 600,000 t/y. Therefore when two shifts are worked, annual capacity is 1.2 million tons and when three shifts are worked it is 1.8 million tons. Capacity for conveying salt per hour is as follows.

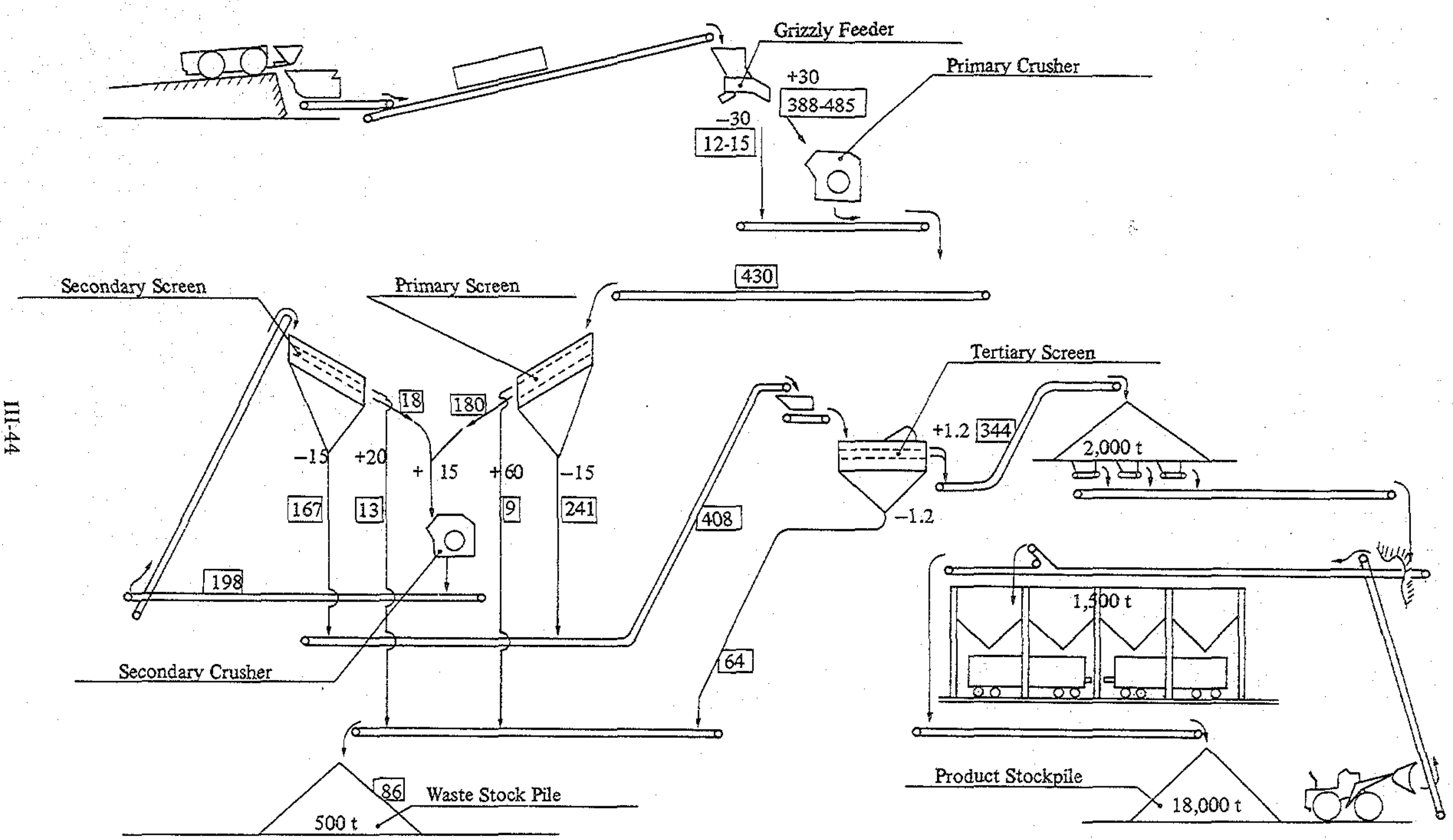
$$600{,}000\ t \div 300\ d \div 6\ hr \times 1.15 = 384\ t \fallingdotseq 390\ t$$

In this case, 15% allowance is expected. Loading capacity is to be such that one train (1,000 t) can be loaded in 2 hours.

Flowsheet: See Figure III-17.

Description: Product salt moved from the final product salt storage in the mine by the belt feeder is conveyed to the surface of the ground by the inclined shaft conveyor and sent to the shuttle conveyor above the loading bunker. From the loading bunker which is as long as four freight cars and which has 1,500 t capacity product salt is passed through the air cylinder driven gate on the floor of the bunker directly into the freight cars below. When the loading bunker has been filled, product salt which has been moved to the surface by the inclined shaft conveyor is sent to the stockpile stacking conveyor and stockpiled to the extent of 16,000 t stockpile capacity. Re-

MATERIAL BALANCE



claim from the stockpile is moved by pay loader, and the reclaimed product is conveyed to hopper and then by belt conveyor to the loading bunker. The surface stockpile will be used to hold product salt until railway cars can be loaded in accordance with the freight train schedule. (see Figures III-21 and III-22.)

4-5 TEMPORARY CRUSHING AND SCREENING

In order to process rock salt excavated during the phase of mine development, temporary crushing and screening equipment is to be installed on the surface of the ground. Waste resulting from this crushing and screening is temporarily stockpiled until it can be transferred to a waste disposal area in the mine, thereby preventing any nuisance or pollution. This equipment, as shown in the diagram below, is relatively simple, and is to have capacity for processing 120 t/hr.

The equipment is to be sold after completion of construction.

Outline specifications of the equipment are provided in Table III-7.

Temporary Crushing and Screening Flow Diagram

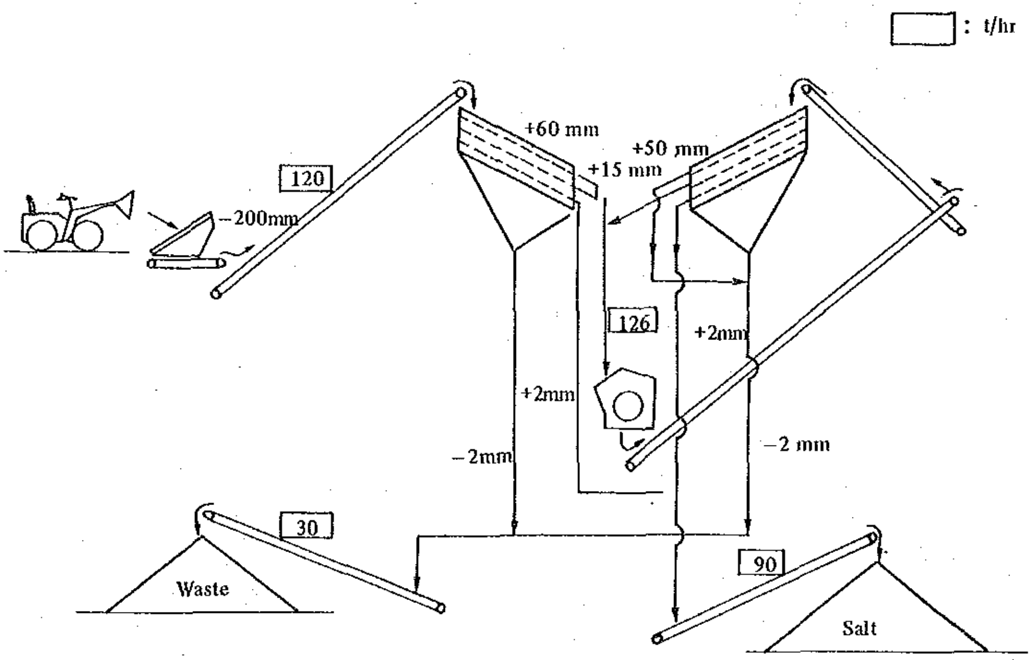


Table III-7 CRUSHING AND SCREENING EQUIPMENT

Item	Specifications	Q'ty
Grizzly	200mm	1
Hopper	15 t	1
Belt feeder	36" x 4mL, 5KW	1
Belt conveyor	24" x 35mL, 7.5KW	1
Primary screen	4' x 10', 3 stage, 60mm, 15mm, 2mm	1
Belt Conveyor	24" x 10mL, 3.7KW	1
Belt Conveyor	24" x 8mL, 5.5KW	1
Impeller-breaker	PEH/25/40, 160KW	1
Belt Conveyor	24" x 35mL, 7.5KW	1
Belt Conveyor	24" x 35mL, 7.5KW	1
Secondary screen	4' x 10', 3 stage 50mm, 15mm, 2mm	2
Belt Conveyor	18" x 8mL, 3.7KW	1
Belt Conveyor	18" x 8mL, 3.7KW	1
Belt Conveyor	18" x 6mL, 3.7KW	1
Belt Conveyor	18" x 20mL, 5.5KW	1
Belt Conveyor	18" x 12mL, 3.7KW	1
Belt Conveyor	24" x 20mL, 5.5KW	1

4-6 GROUND MINE FACILITIES

4-6-1 Access Road

From Route 205 to a point part-way to the mine site, an existing road is to be improved for use as the access road, and from that point to the entrance of the inclined shaft a new road is to be constructed. The effective width of both the improved existing road and the new road is to be 6 m, and the road is to be a 30 cm gravel road.

4-6-2 Buildings

See Figures III-13, III-23, and III-24.

Building	Area of building (m) x (m) = m2	Area of grading (m) x (m) = m2
Office	30 x 20 x 2(*) = 1,200	40 x 70 = 2,800
Work	30 x 20 = 600	60 x 50 = 3,000
Storehouse	30 x 15 = 450	50 x 50 = 2,500
Sub-station	5 x 10 = 50	20 x 40 = 800
Fuel storage	5 x 7 = 35	20 x 30 = 600
Guard house	4 x 6 = 24	15 x 15 = 225
Garage	10 x 20 = 200	30 x 50 = 1,500
Scale	3 x 5 = 15	
Total	= 2,574	11,425

(Note) * floors

A simple barbed wire fence is to be installed around each building.

4-7 ELECTRIC POWER

4-7-1 Electric Facilities

Electric power required for the mine is to be received from EGAT network (as 3-phase, 115 KV, 50 Hz). A 60 km transmission line must be installed for supply of this power. Power is to be stepped down to 3 KV at the mine's power receiving station and distributed to equipment in the mine, auxiliary and offsite facilities outside of the mine and to the mine town. The power receiving station facilities are to consist of one main power transformer (3-phase, 115 KV/3KV, 4,500 KVA).

4-7-2 Electric System

The power receiving facility is to be a 3-phase, 115 KV, 3-wire system. The site distribution facility is to be a 3-phase, 3 KV, 3-wire system. The power facility high voltage system is to be a 3-phase, 3 KV, 3-wire system and the low voltage system is to be a 3-phase, 380 V, 3-wire system. Lighting and other miscellaneous equipment shall include a 3-phase system (3-phase, 380 V/220 V, 4-wire system) and single-phase system (1-phase, 220 V, 2-wire system).

4-7-3 Electric Equipment

The electric capacity of the equipment at the mine is to be as follows.

Excavation equipment	905 KW
Crushing equipment	1,538.8
Loading equipment	868
Ancillary equipment	670
Total	3,981.8 KW

4-7-4 Capacity of Power Receiving Station

The estimated maximum demand power based on the demand factor for each of the above is as follows.

Excavation equipment	905 KW	x 0.8	=	724 KVA
Crushing equipment	1,538.8	x 0.65	=	1,000
Loading equipment	868	x 0.65	=	564
Ancillary equipment	469	x 0.75	=	351
Total				2,639 KVA

CHAPTER 5 INFRASTRUCTURAL FACILITIES

5-1 TOWN SITE

5-1-1 Grading

The location of the mine town is to be to the east of the mine site, and to the south side of the swamp. The site is at the bottom of a mild slope facing the swamp, and is level almost throughout. The site is to be graded in stepped manner and in accordance with the topography. Precautions are to be taken to balance cut and fill, and to have water drain towards the swamp. The area for each structure is to be as follows.

Name of structure	Unit area (m) x (m) = (m^2)	Q'ty	Area (m^2)
Laborer's quarters	20 x 11 = 220	127	27,940
Engineers and foreman quarter	20 x 12.5 = 250	18	4,500
Chief and superintendent house	20 x 16.5 = 330	6	1,980
Director house	20 x 25 = 500	1	500
Guest house	50 x 40 = 2,000	1	2,000
Dormitory	30 x 55 = 1,650	1	1,650
Hospital	40 x 25 = 1,000	1	1,000
Shopping area	60 x 50 = 3,000	1	3,000
Temple	30 x 20 = 600	1	600
School	20 x 50 = 1,000	1	1,000
Tennis court	50 x 40 = 2,000	1	2,000
Ground	180 x 90 = 16,200	1	16,200
Water supply facility	60 x 40 = 2,400	1	2,400
Total			66,770

5-1-2 Roads

Roads are to be made for the housing and utilities areas, and to subdivide the town. The effective width of the roads is to be 6 m and total width is to be 7 m, including ditches. The roads are to be macadam, paved with 5 cm of laterite, rolled and on 30 cm of gravel base.

5-1-3 Housing

See Figures III-27, III-28 and III-29.

Name of structure	Unit area (m) x (m) = (m^2)	Q'ty	Area (m^2)
Laborers' quarters	5.4 x 10 = 54	127	6,858
Engineer and foreman quarter	7.2 x 10.4 = 75	18	1,350
Chief and superintendent house	8.0 x 12.5 = 100	6	600
Director house	10.0 x 15.0 = 150	1	150
Foreign engineer house	10.0 x 15.0 = 150	5	750
Dormitory	38.0 x 12.0 = 460	1	460
Guest house	30.0 x 13.5 = 405	1	405
Total			10,573

(Note) For public buildings, only grading is to be done; the hospital, shopping buildings, temple and school are not included in the scope of this Project.

5-1-4 Drainage

A house inlet is to be provided for sewage from every house and sewage is to be introduced to a septic tank installed near the swamp, from which treated sewage can be discharged into the swamp. Drainage is to be processed separately from sewage. Ditches on the sides of the roads will drain into the main pipe, under the center of the road. An open channel will be made in the periphery of the town site, to carry drainage from the main pipes into the swamp.

5-1-5 Piping Plan

Water will flow to each building by gravity flow from the water tank. Fire plugs are to be installed according to a rational plan. Pipes to be used are to be iron and 6", 3", 2", 25 mm and 13 mm in diameter.

5-1-6 Fence

A simple barbed wire fence is to be installed around the town site.

5-2 WATER SUPPLY

Refer to Figure III-25.

5-2-1 Water Resources

Water is to be obtained from the Amphoe Bamnet Narong swamp, 8 km away.

5-2-2 Volume of Water Supply

The volume of water supply in taken as 1 m^3/min, according to the calculation shown below.

<u>Service water for domestic use</u>

Number of workers:	about 300 (1.8 million t)
Total population:	300 persons x 5 persons/household = 1,500 persons
Water requirement per day:	300ℓ/d = 0.3 m^3/d
Drinking water and water for other uses:	1,500 persons x 0.3 m^3/d = 450 m^3/d
Water requirement per minute:	450 m^3/24 hr/60 min = 0.313 m^3/min
Maximum water supply: (50% increase):	0.313 m^3/min x 1.5 = 0.47 m^3/min
Service water for mine Wetting down roads	0.313 m^3/shift = 30 m^3/8hrs/60 min = 0.06 m^3/min = 0.1 m^3/min
Equipment:	0.4 m^3/min
	0.5 m^3/min
Total water supply requirement	0.47 + 0.5 = 0.97 m^3/min Say 1 m^3/min

5-2-3 Description of Water Supply

The water supply is summarized as follows.

1. Water-intake facilities: intake well, pump, 30 kw x 2 units

2. Service pipe line: ϕ6" 1 line

3. Settling tank: 4 m x 14.0 m x 5 m (L x W x D)

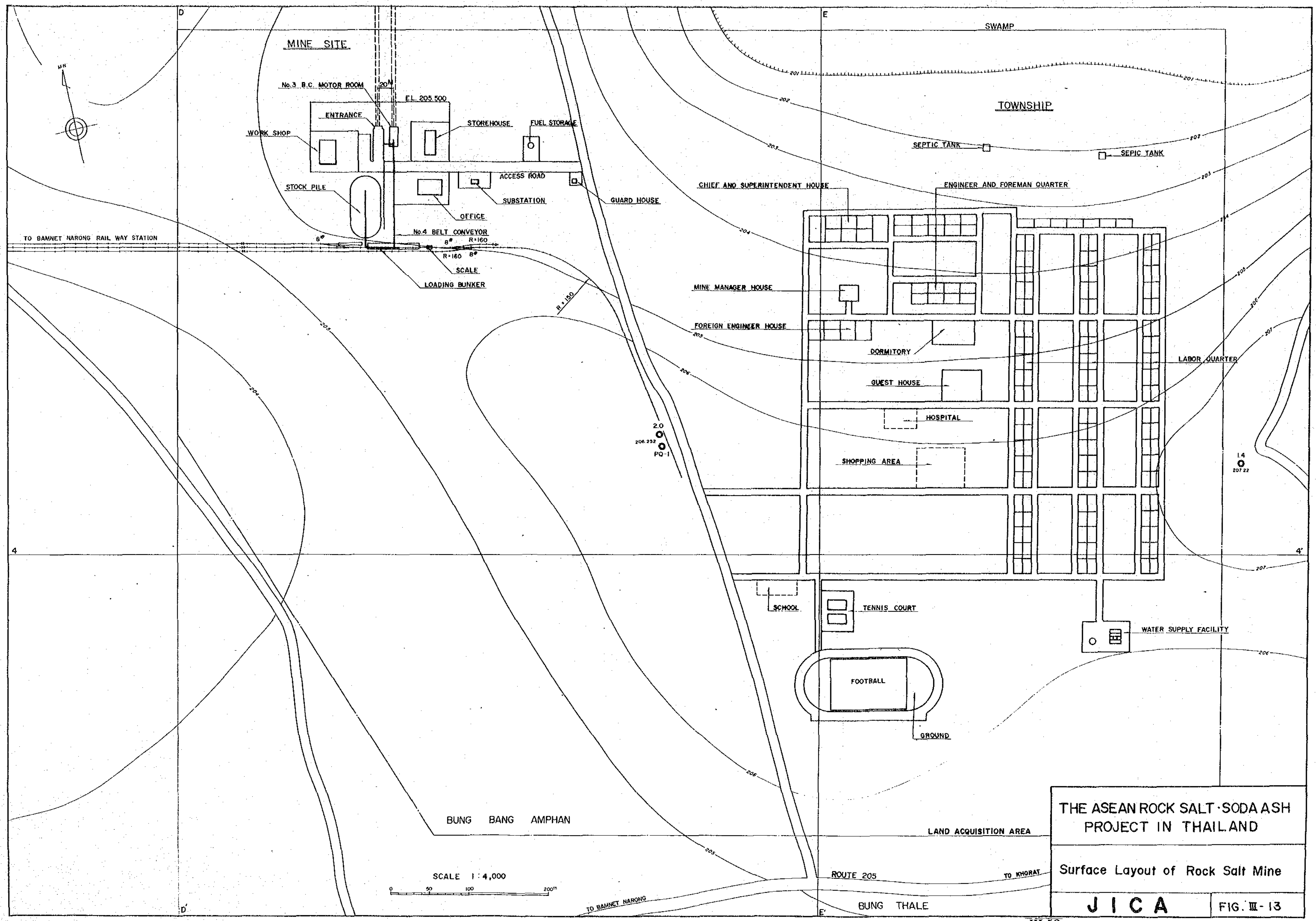
4. Filter basin: 4 m x 5 m x 5 (depth) m 2 x units

5. Clear water receiver with chlorination equipment:
   4 m x 5 m x 3.5 (depth) m 2 x units

6. Pump: 11 kw x 2 units

7. Water-tower: 60 m^3 capacity tank

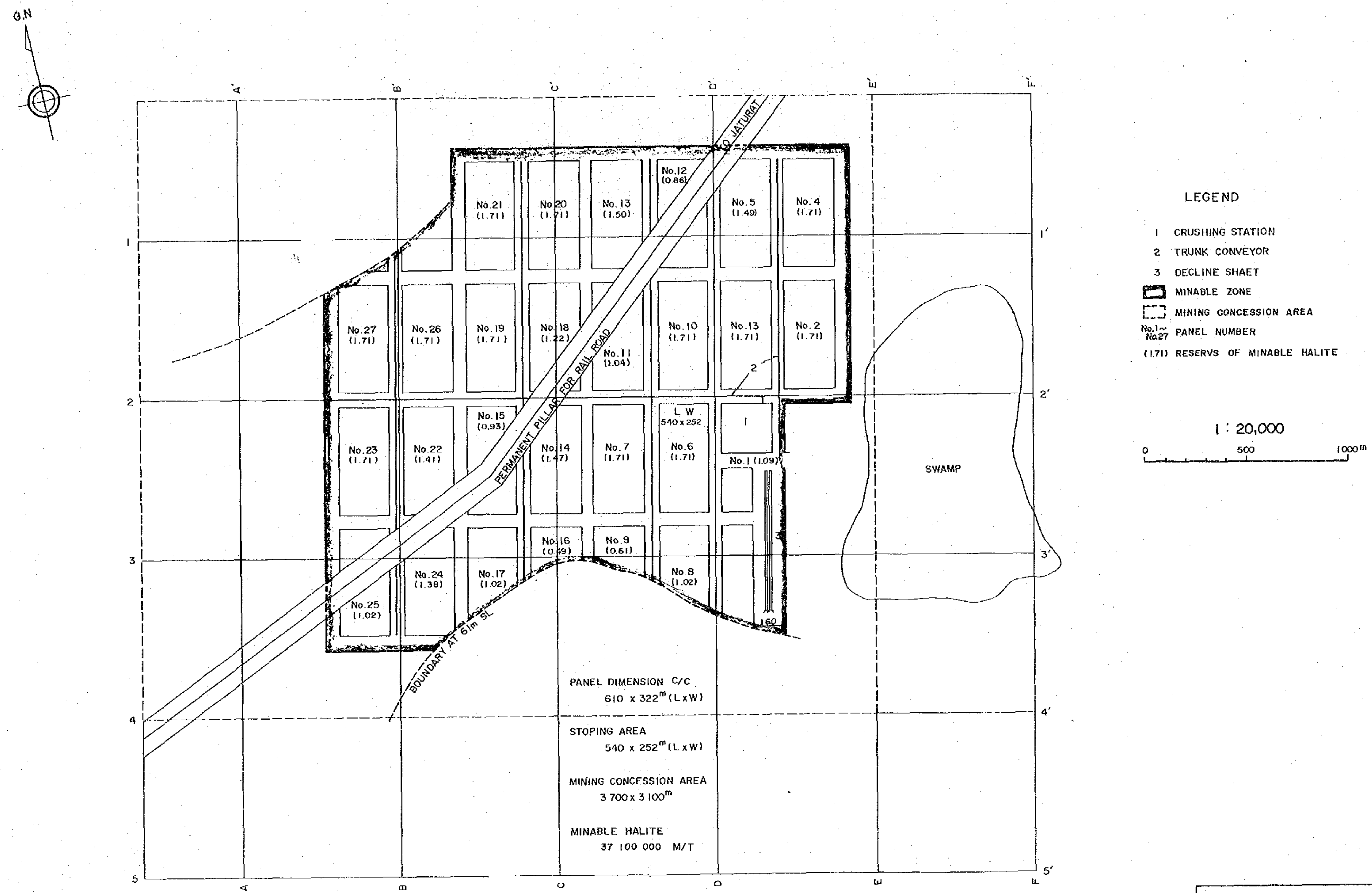
8. Distributing pipe: ϕ6" (main pipe)



THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

Surface Layout of Rock Salt Mine

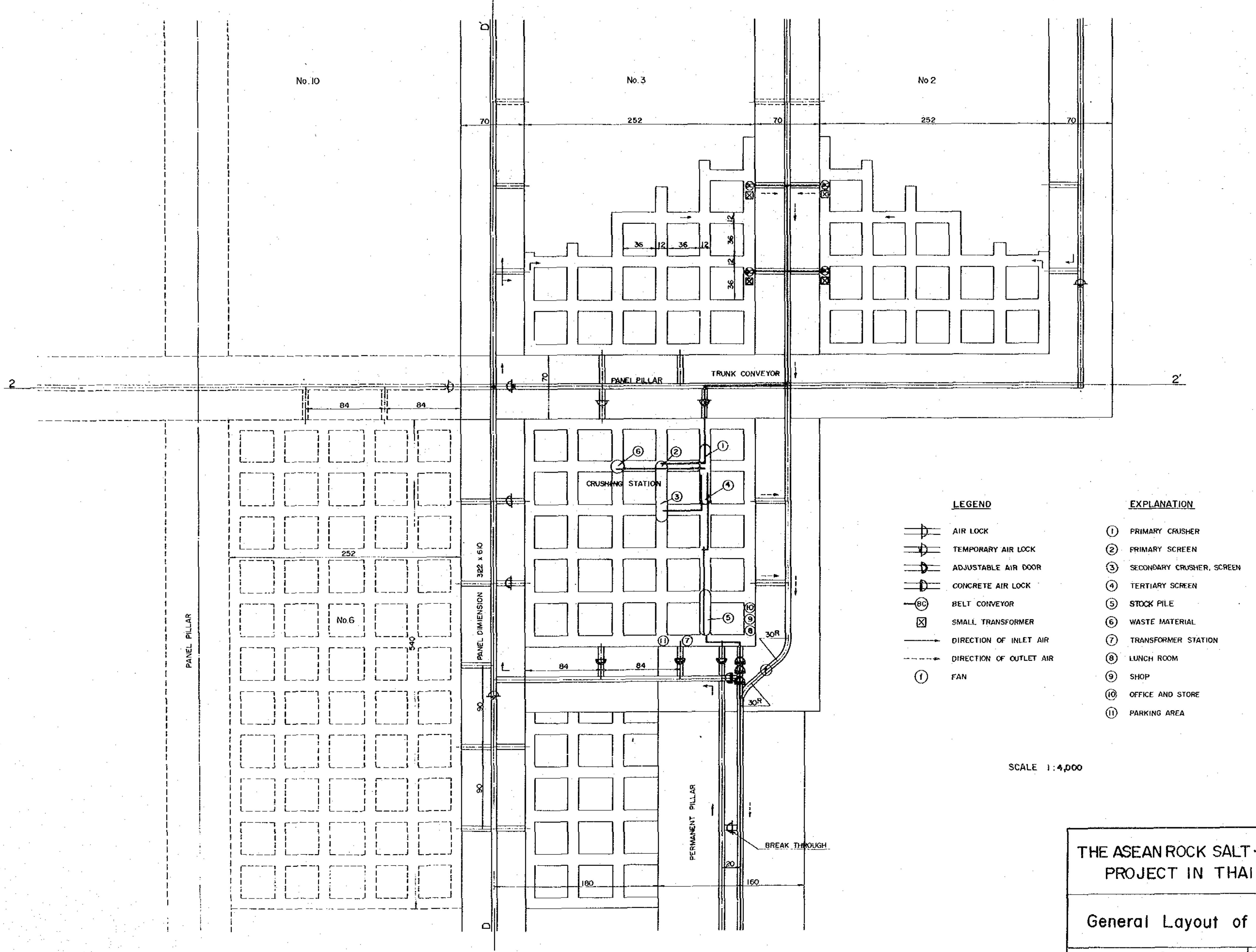
JICA FIG. III-13



THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

Underground Layout of Rock Salt Mine

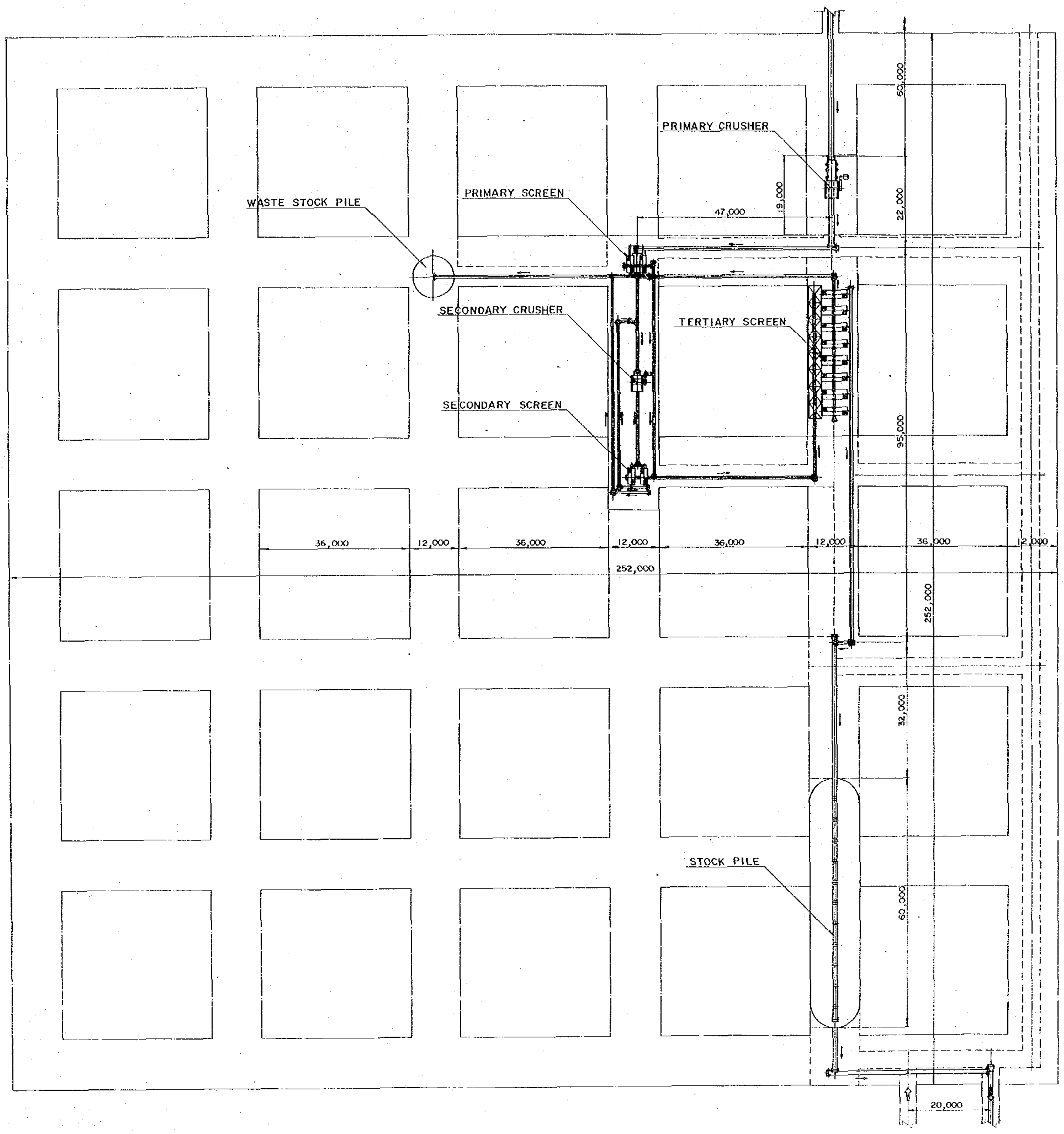
JICA | FIG. III-14



THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

General Layout of Mining

JICA | FIG. III-15



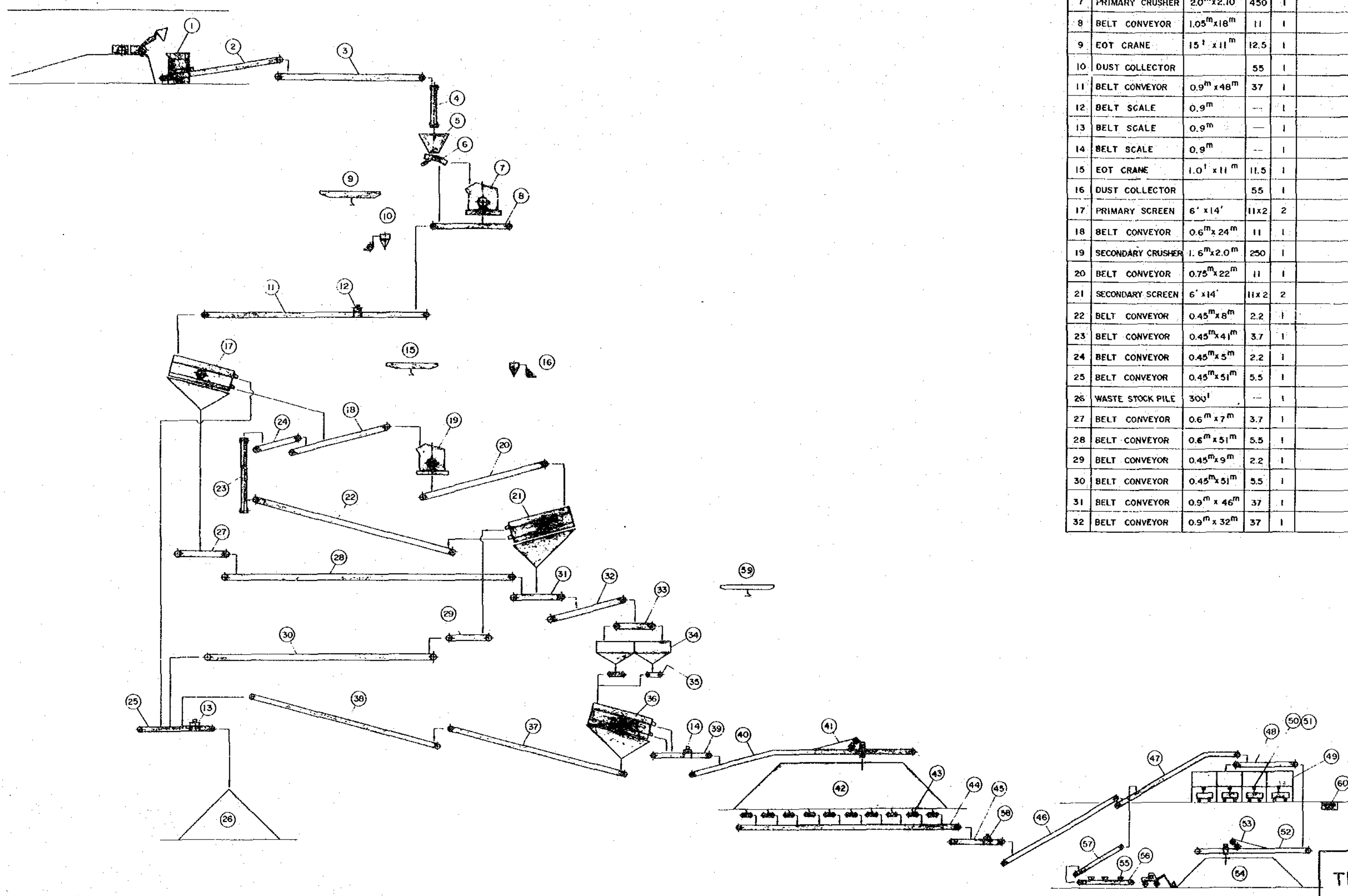
THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

General Layout of Crushing and Screening Plant

JICA

FIG. III-16

ITEM NO.	DESCRIPTION	SIZE OR CAPACITY	KW	QTY	REMARKS	ITEM NO.	DESCRIPTION	SIZE OR CAPACITY	KW	QTY	REMARKS
1	HOPPER			1		33	SHUTTLE CONVEYOR	$0.9^{m} \times 15^{m}$	75+55	1	
2	BELT CONVEYOR	$1.05^{m} \times 40^{m}$	22x2	2		34	HOPPER	$20^{t} \times 8$	—	8	
3	BELT CONVEYOR	$1.05^{m} \times 120^{m}$	37x2	2		35	BELT FEEDER	$1.2^{m} \times 3^{m}$	37x8	8	
4	BELT CONVEYOR	$1.05^{m} \times 100^{m}$	37	1		36	TERTIARY SCREEN	7' x 20'	19x2 x8	8	
5	HOPPER	50^{t}	—	1		37	BELT CONVEYOR	$0.45^{m} \times 35^{m}$	3.7	1	
6	GRIZZLY FEEDER	6' x 16'	30	1		38	BELT CONVEYOR	$0.45^{m} \times 45^{m}$	5.5	1	
7	PRIMARY CRUSHER	$2.0^{m} \times 2.10^{m}$	450	1		39	BELT CONVEYOR	$0.9^{m} \times 85^{m}$	37	1	
8	BELT CONVEYOR	$1.05^{m} \times 18^{m}$	11	1		40	BELT CONVEYOR	$0.9^{m} \times 93^{m}$	45	1	
9	EOT CRANE	$15^{t} \times 11^{m}$	12.5	1		41	TRIPPER	0.9^{m}	5.5	1	
10	DUST COLLECTOR		55	1		42	STOCK PILE	$2{,}000^{t}$	—	1	
11	BELT CONVEYOR	$0.9^{m} \times 48^{m}$	37	1		43	BELT FEEDER	$1.05^{m} \times 3^{m}$	3.7x10	10	
12	BELT SCALE	0.9^{m}	—	1		44	BELT CONVEYOR	$1.05^{m} \times 68^{m}$	22	1	
13	BELT SCALE	0.9^{m}	—	1		45	BELT CONVEYOR	$0.9^{m} \times 38^{m}$	15	1	
14	BELT SCALE	0.9^{m}	—	1		46	BELT CONVEYOR	$0.9^{m} \times 810^{m}$	300	1	
15	EOT CRANE	$1.0^{t} \times 11^{m}$	11.5	1		47	BELT CONVEYOR	$0.9^{m} \times 135^{m}$	55	1	
16	DUST COLLECTOR		55	1		48	SHUTTLE CONVEYOR	$0.9^{m} \times 36^{m}$	11+5.5	1	
17	PRIMARY SCREEN	6' x 14'	11x2	2		49	LOADING BUNKER	$1{,}500^{t}$	—	1	
18	BELT CONVEYOR	$0.6^{m} \times 24^{m}$	11	1		50	CUT GATE	$1.2^{m} \times 1.0^{m}$	—	8	
19	SECONDARY CRUSHER	$1.6^{m} \times 2.0^{m}$	250	1		51	COMPRESSOR	$7\ kg/cm^2$	110x2	2	
20	BELT CONVEYOR	$0.75^{m} \times 22^{m}$	11	1		52	BELT CONVEYOR	$0.9^{m} \times 70^{m}$	22	1	
21	SECONDARY SCREEN	6' x 14'	11x2	2		53	TRIPPER	0.9^{m}	5.5	1	
22	BELT CONVEYOR	$0.45^{m} \times 8^{m}$	2.2	1		54	STOCK PILE	$16{,}000^{t}$	—	1	
23	BELT CONVEYOR	$0.45^{m} \times 41^{m}$	3.7	1		55	HOPPER	5^{m^3}	—	3	
24	BELT CONVEYOR	$0.45^{m} \times 5^{m}$	2.2	1		56	BELT CONVEYOR	$0.9^{m} \times 105^{m}$	22	1	
25	BELT CONVEYOR	$0.45^{m} \times 51^{m}$	5.5	1		57	BELT CONVEYOR	$0.9^{m} \times 15^{m}$	7.5	1	
26	WASTE STOCK PILE	300^{t}	—	1		58	BELT SCALE	0.9^{m}		1	
27	BELT CONVEYOR	$0.6^{m} \times 7^{m}$	3.7	1		59	EOT CRANE	$10^{t} \times 8^{m}$	11.5	1	
28	BELT CONVEYOR	$0.6^{m} \times 51^{m}$	5.5	1		60	WAGON SCALE	80^{t}		1	
29	BELT CONVEYOR	$0.45^{m} \times 9^{m}$	2.2	1							
30	BELT CONVEYOR	$0.45^{m} \times 51^{m}$	5.5	1							
31	BELT CONVEYOR	$0.9^{m} \times 46^{m}$	37	1							
32	BELT CONVEYOR	$0.9^{m} \times 32^{m}$	37	1							

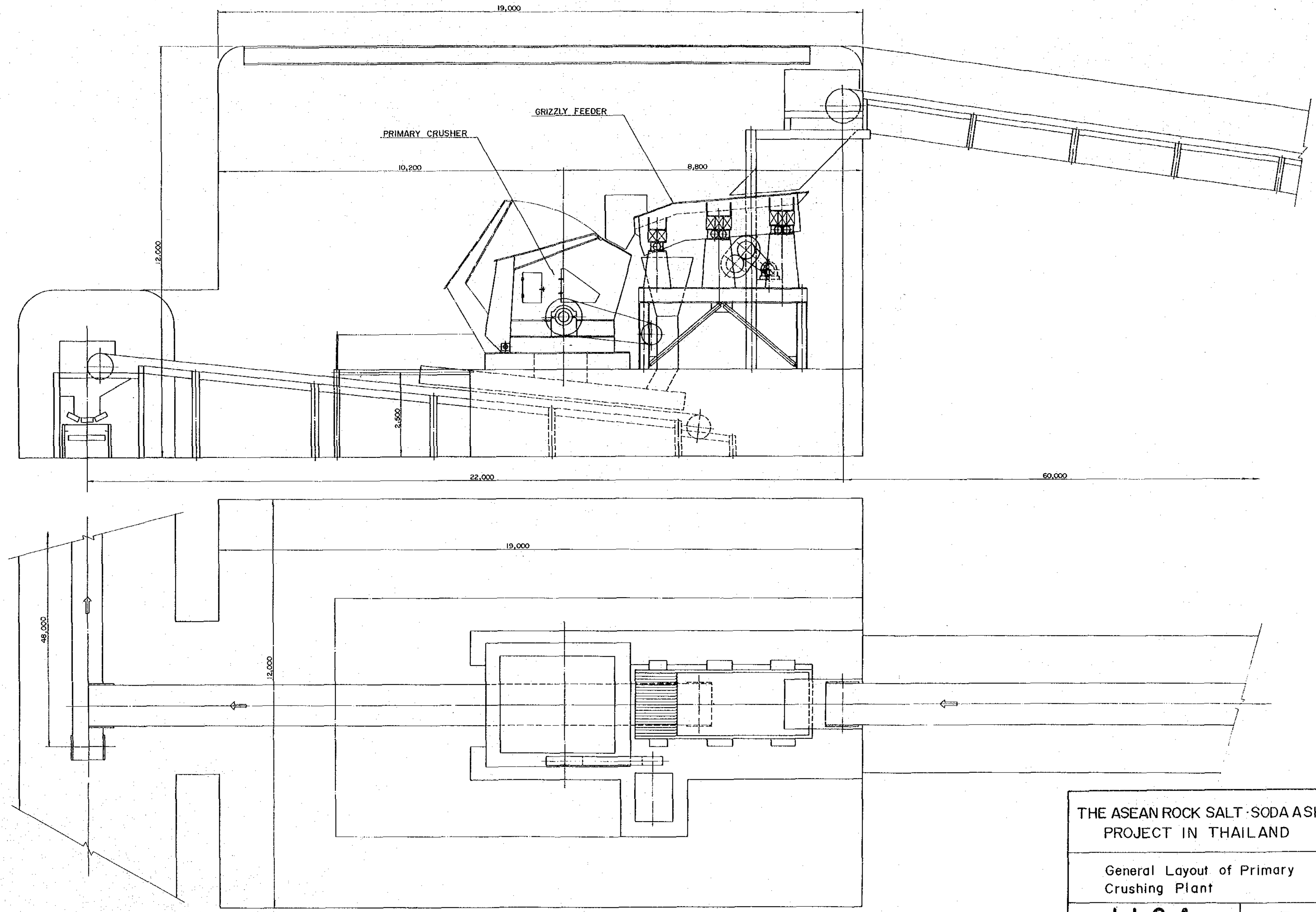


THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

Mine Flow Sheet

JICA

FIG. III-17

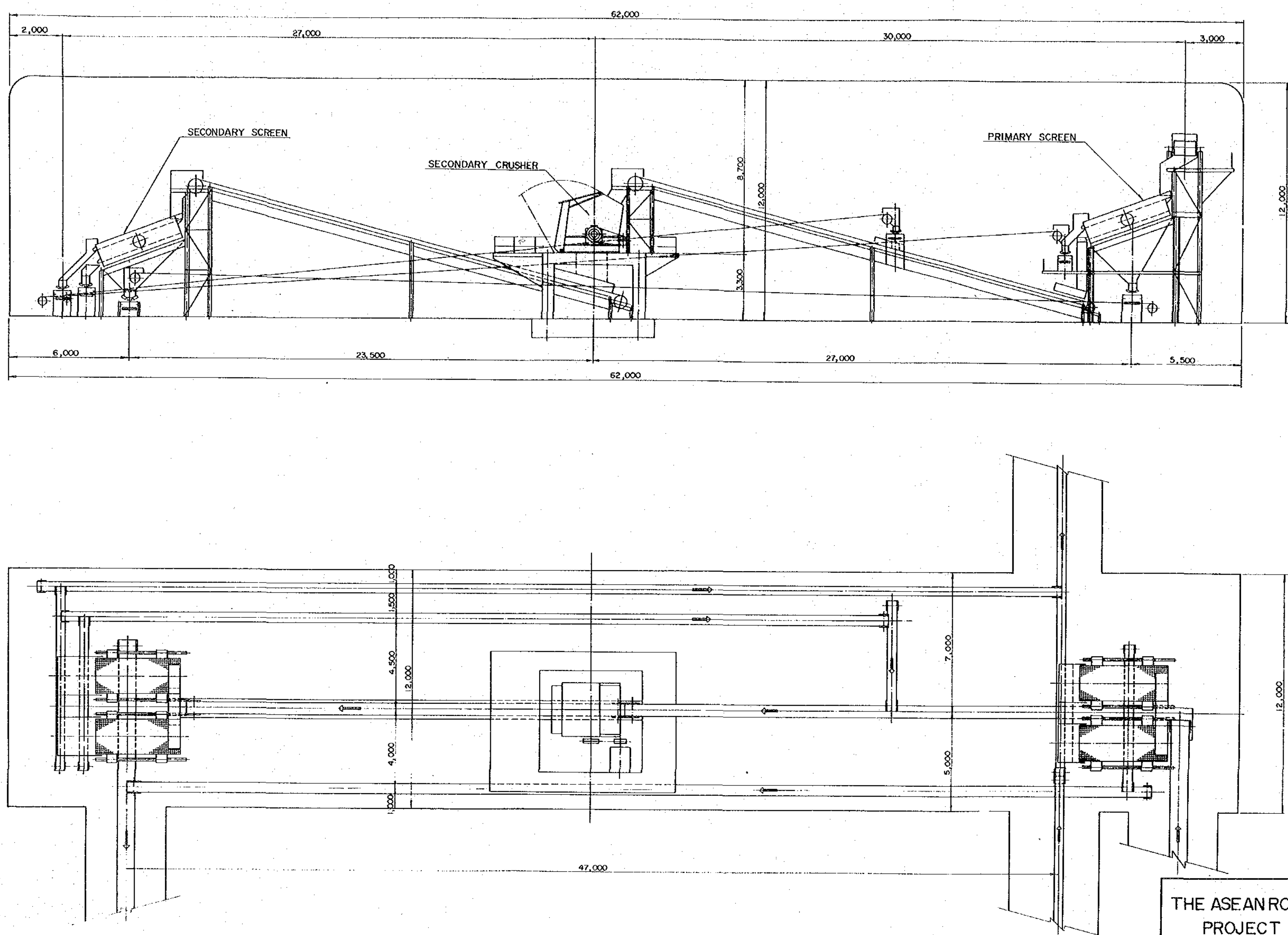


THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

General Layout of Primary Crushing Plant

JICA

FIG. III - 18

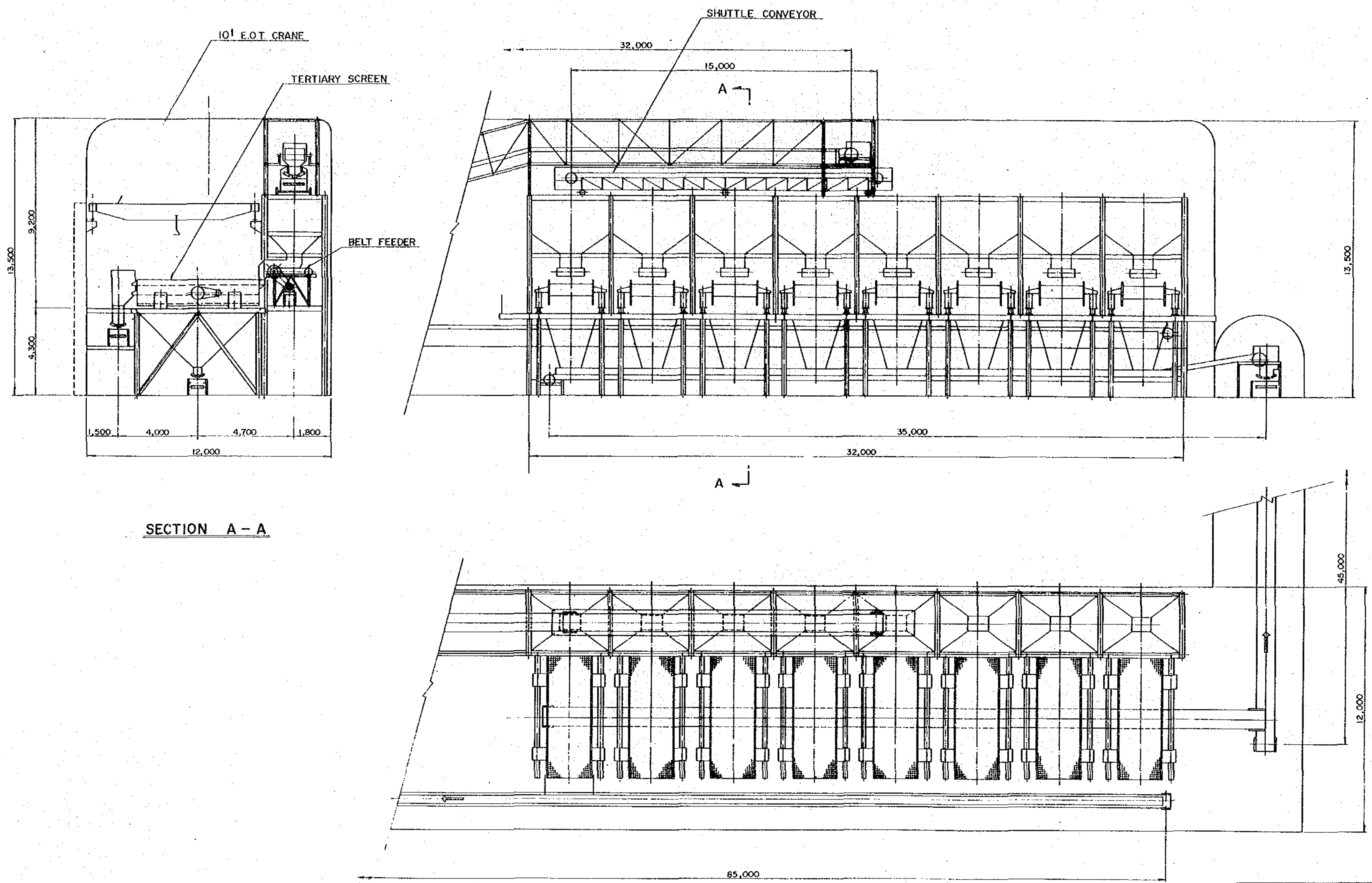


THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

General Layout of Secondary Crushing Plant

JICA

FIG. III – 19

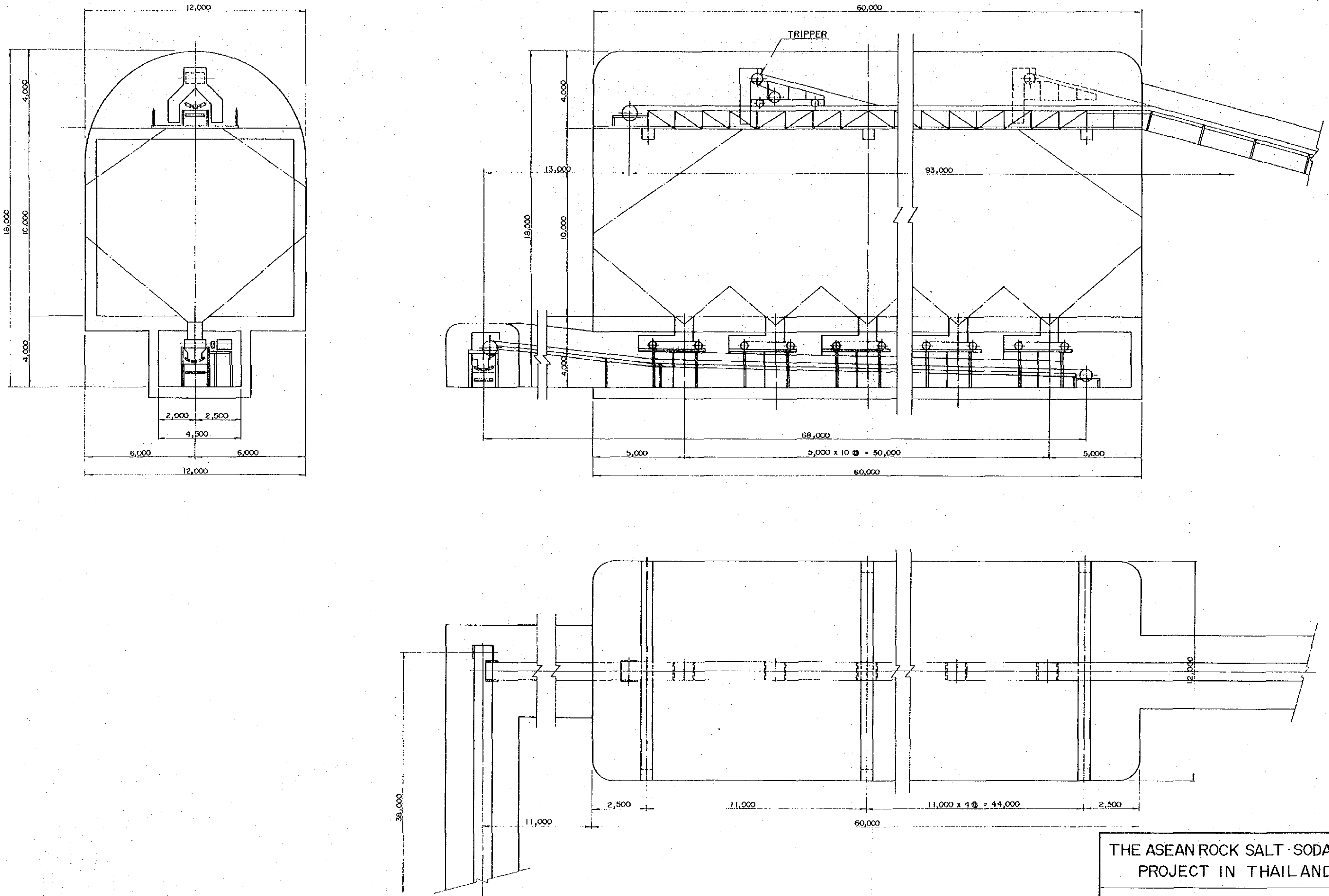


THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

General Layout of Screening Plant

JICA

FIG. III -20

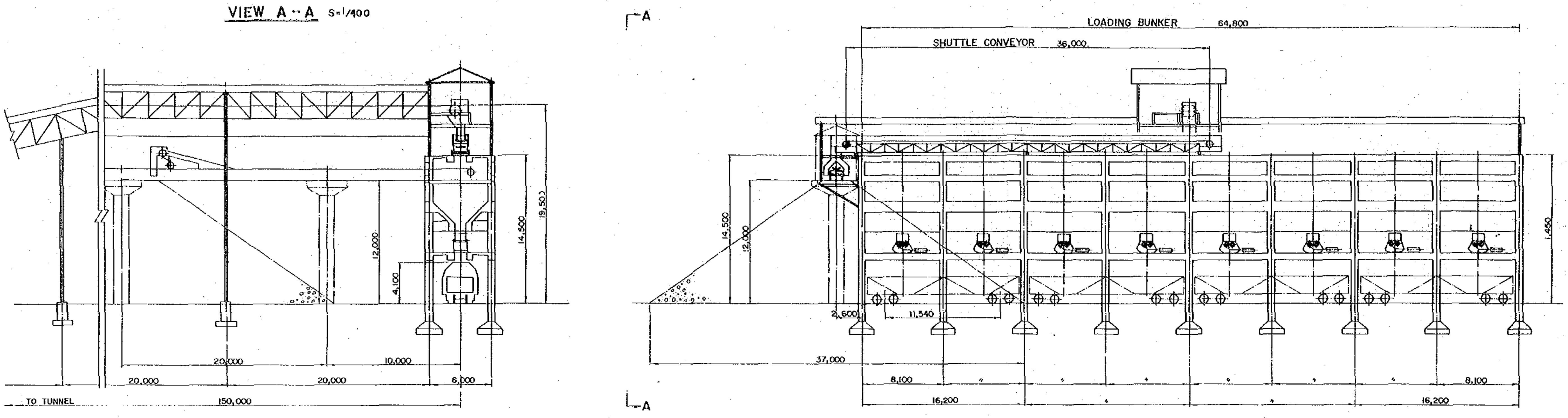


THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

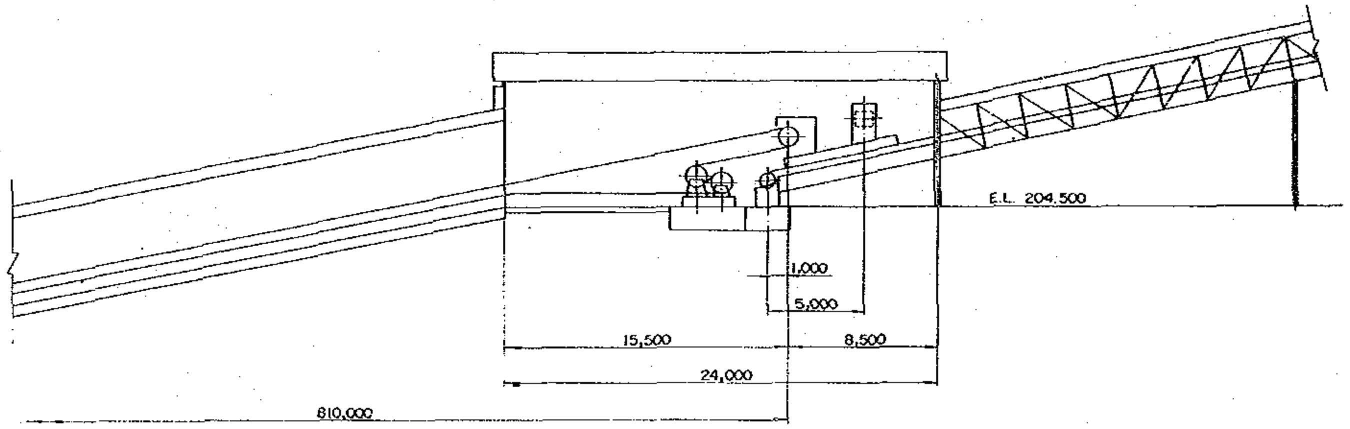
General Layout of Underground Stockpile

JICA FIG. III-21

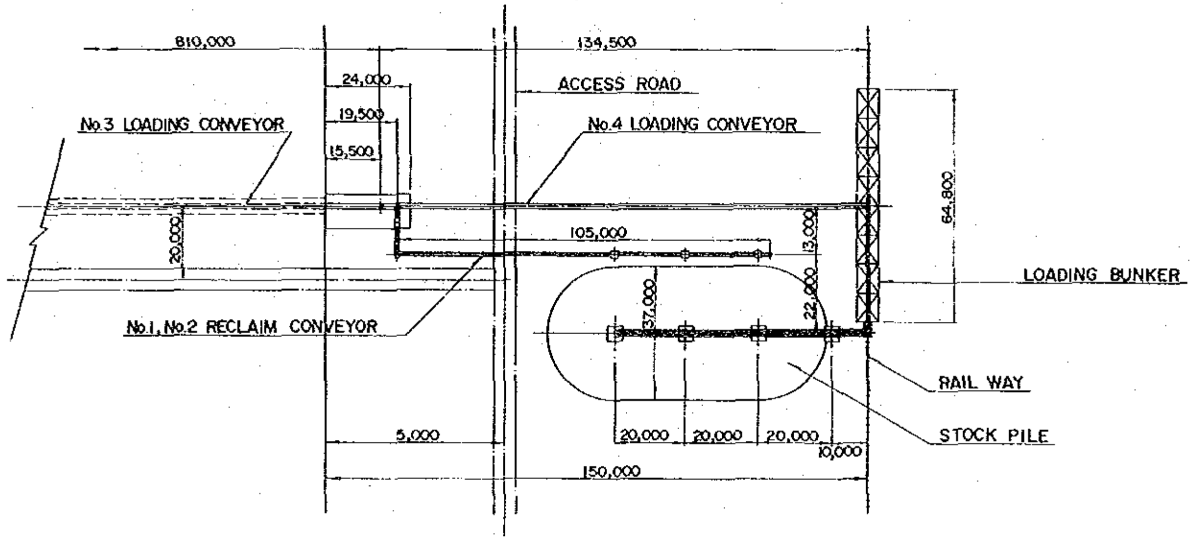
VIEW A - A S=1/400



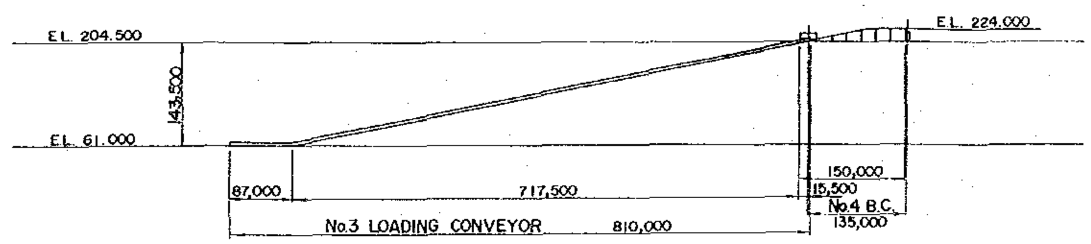
LAY OUT OF No.3 B.C. MOTOR ROOM S=1/400



KEY PLAN FOR LOADING FACILITY S=1/2,000



PROFILE FOR LOADING CONVEYOR S=1/10,000



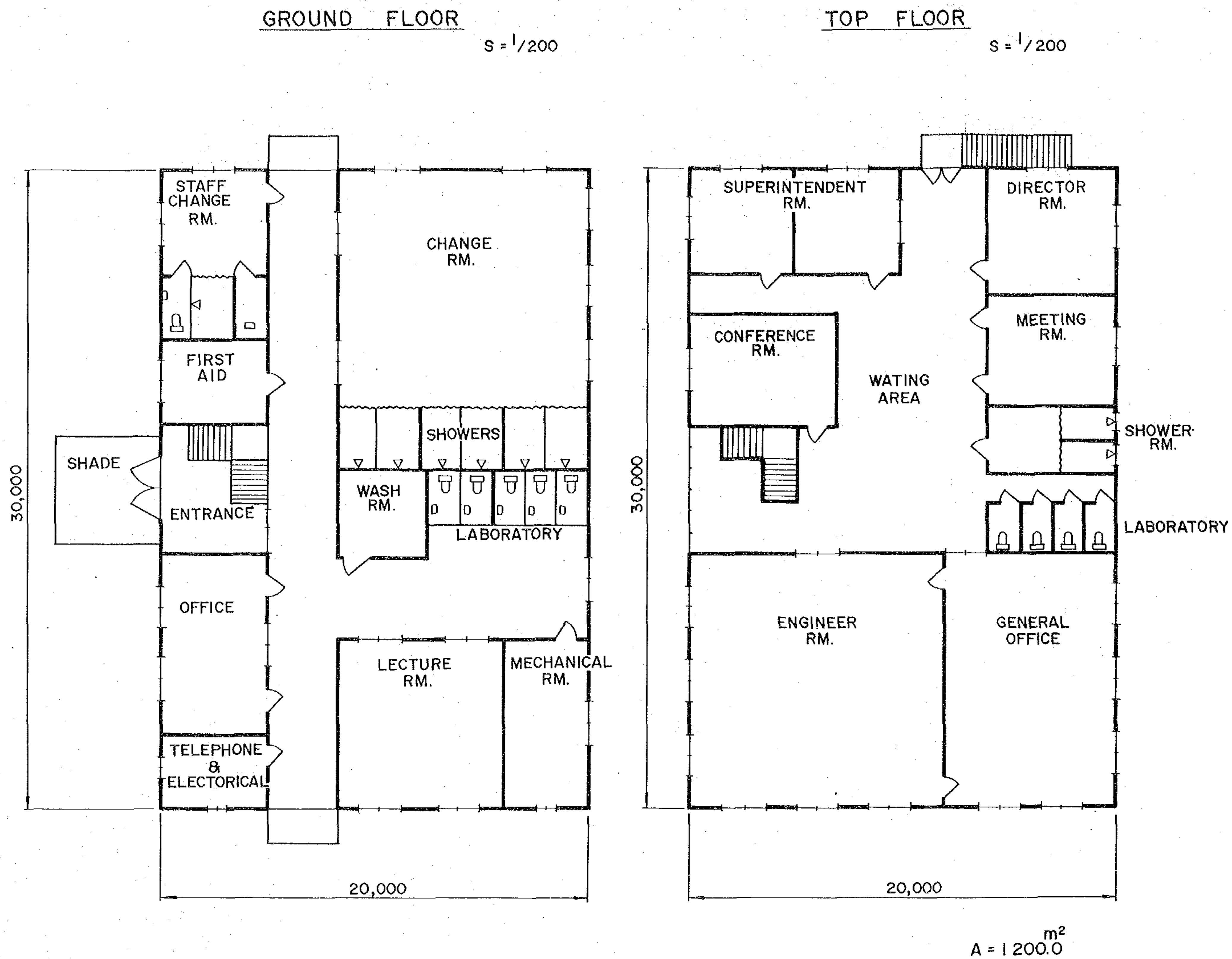
THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

General Layout of Loading Facility

JICA

FIG. III-22.

OFFICE



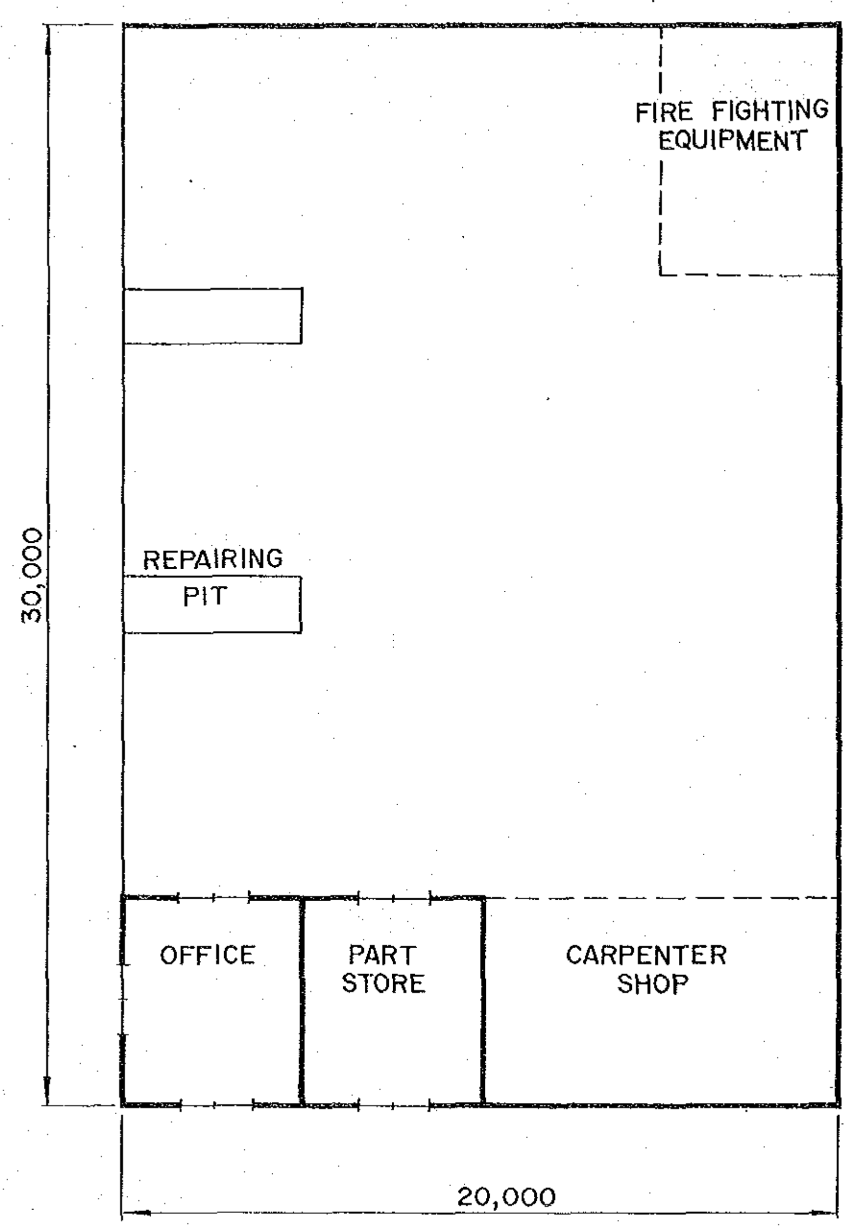
THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

General Layout of Mine Site Housing (A)

JICA | FIG. III-23

WORK SHOP

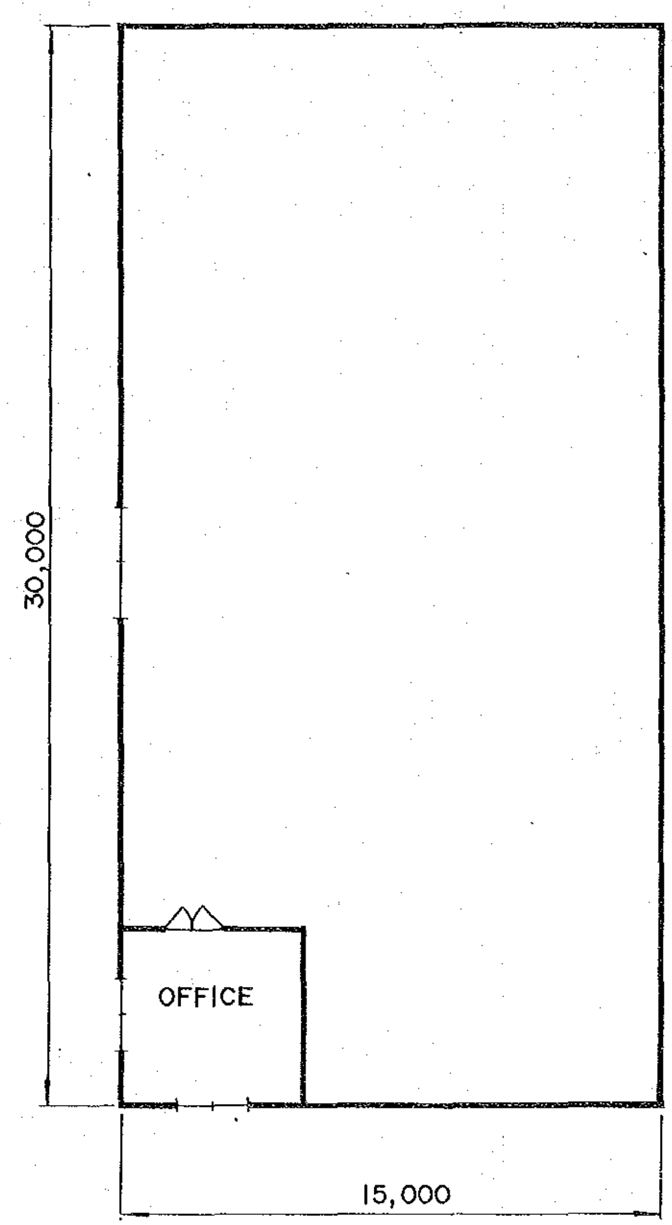
S = 1/200



A = 600.0 m²

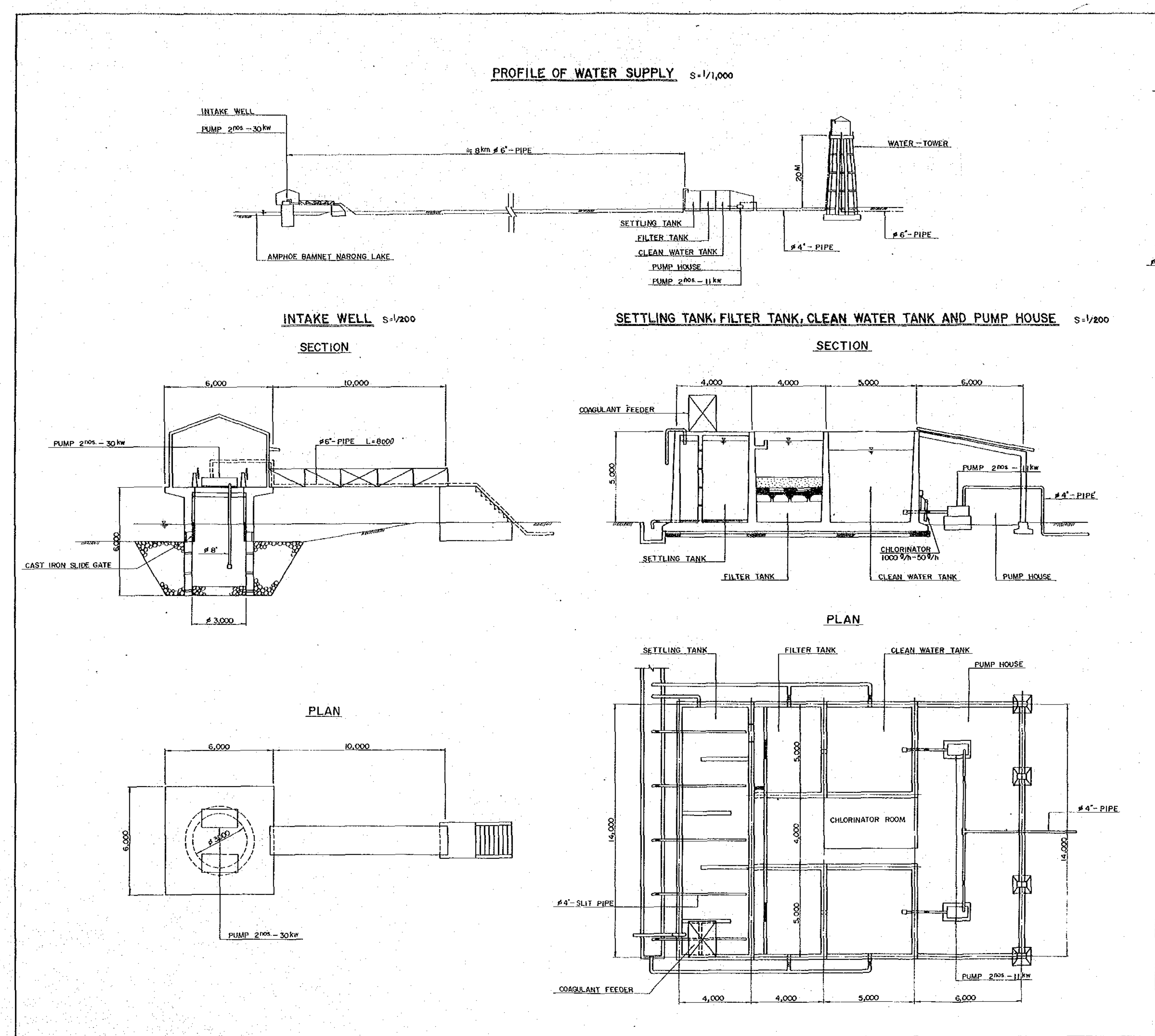
STORE HOUSE

S = 1/200



A = 450.0 m²

THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND	
General Layout of Mine Site Housing (B)	
JICA	FIG. III−24



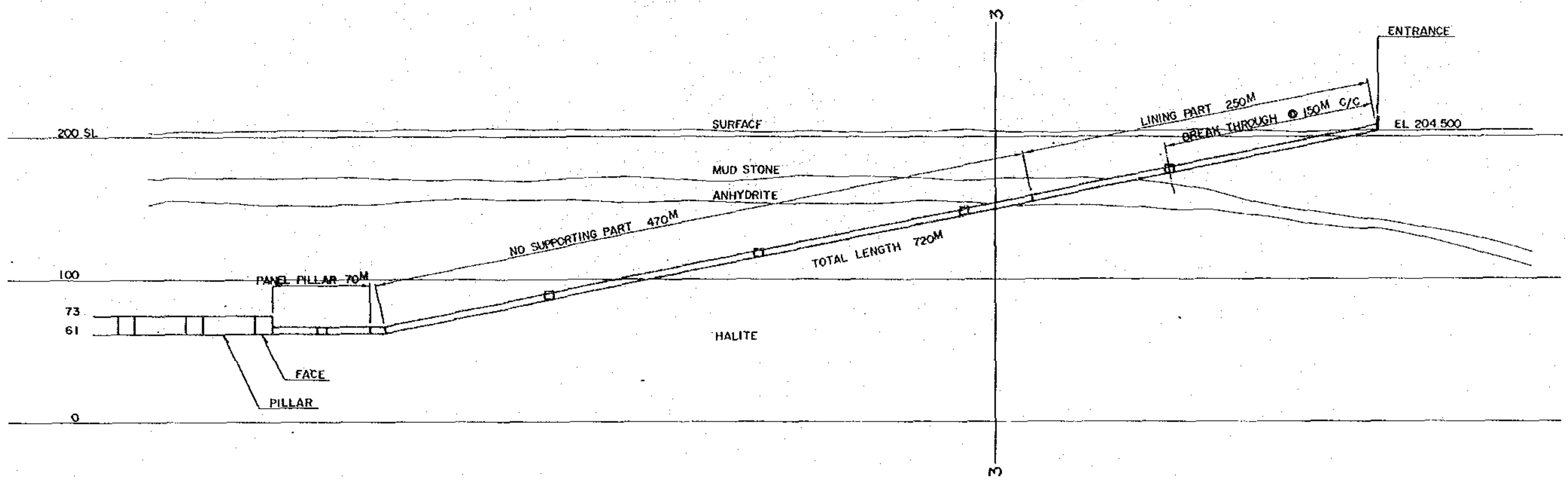
THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

General Layout of Water Supply

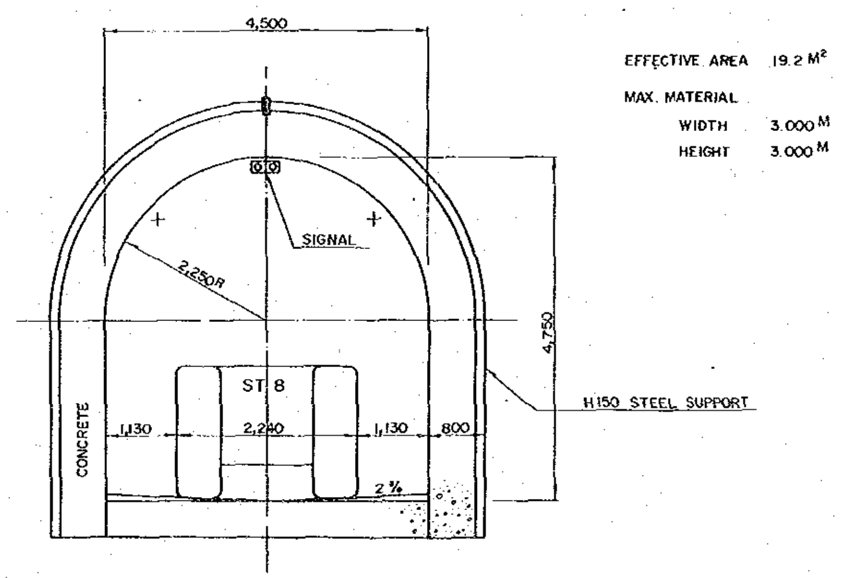
JICA

FIG. III – 25

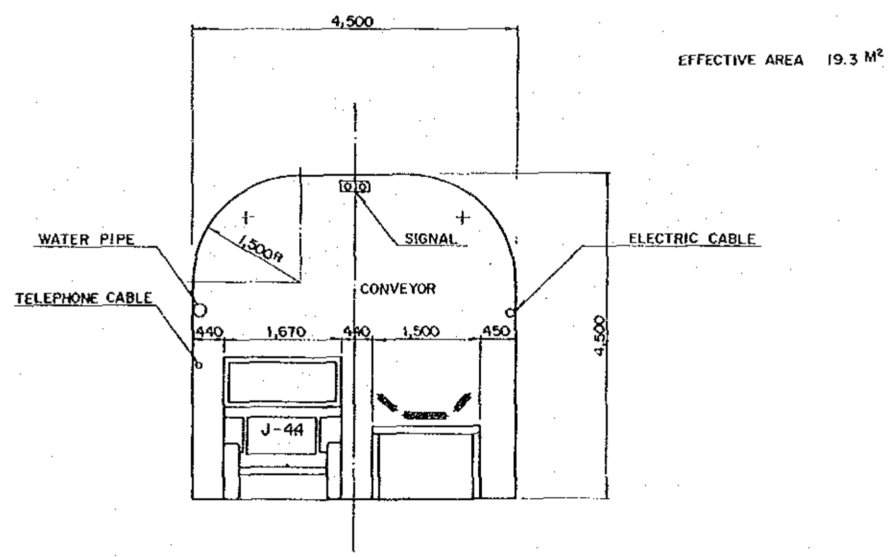
LONGITUDINAL SECTION OF THE DECLINE SHAFT S=1/4,000



CONCRETE LINING DECLINE SHAFT – INLET S=1/500



NO SUPPORTING DECLINE SHAFT – OUTLET S=1/500



THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

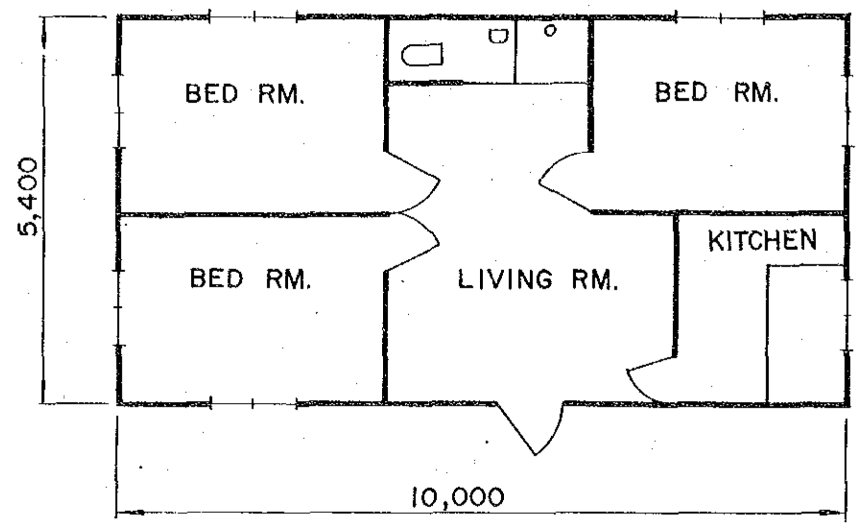
General Layout of Decline Shaft

JICA	FIG. III –26.

TOWNSITE HOUSING

LABOR QUARTER

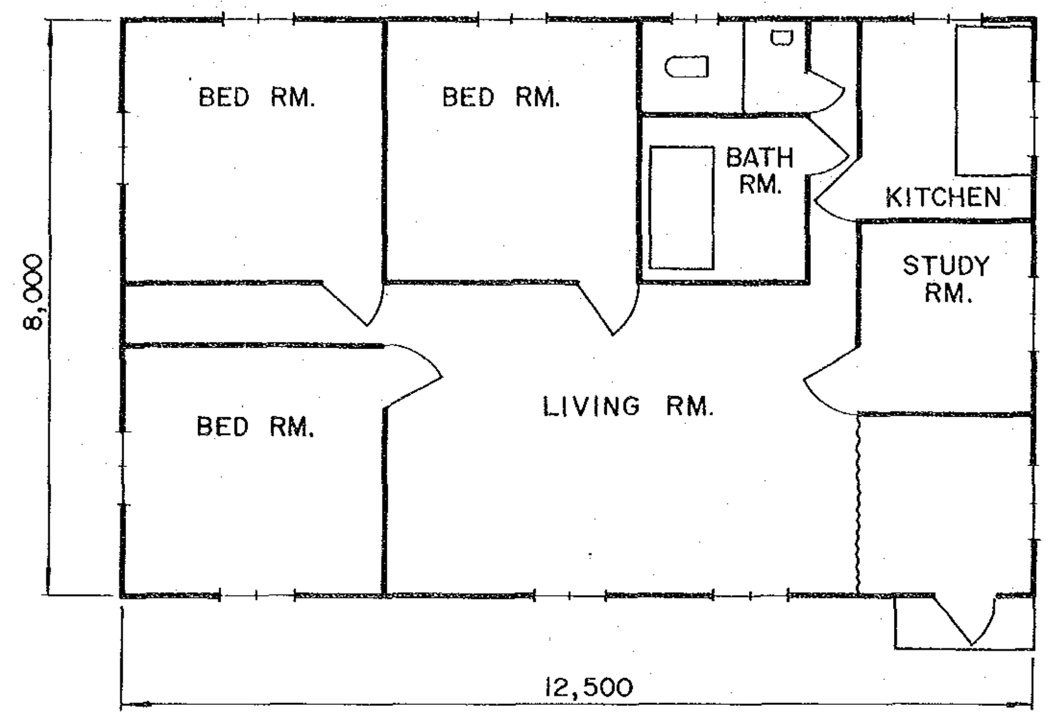
S = 1/100



A = 54.0 m²

CHIEF AND SUPERINTENDENT HOUSE

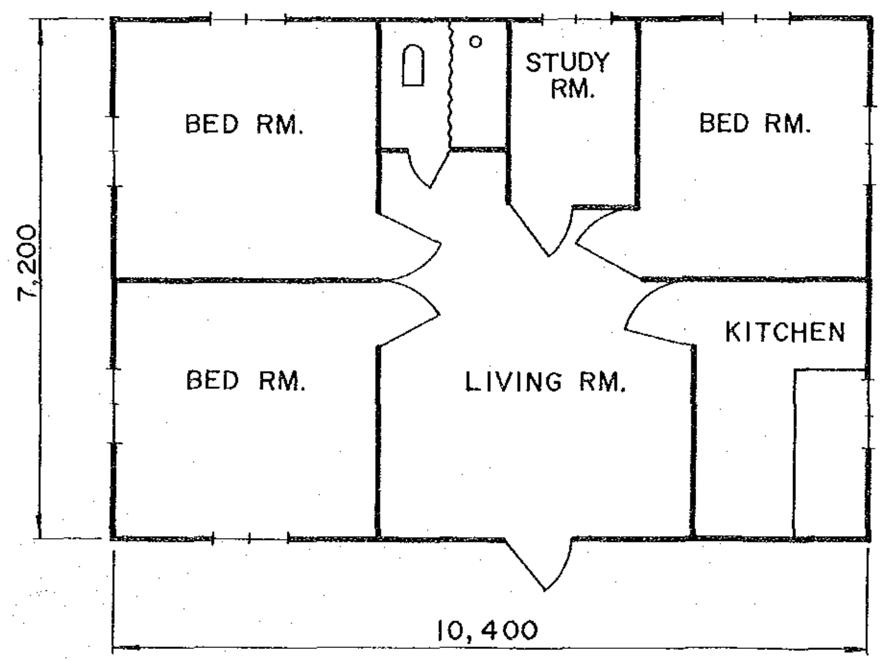
S = 1/100



A = 100.0 m²

ENGINEER AND FOREMAN QUARTER

S = 1/100



A ≒ 75.0 m²

THE ASEAN ROCK SALT·SODA ASH PROJECT IN THAILAND

General Layout of Town Site Housing (A)

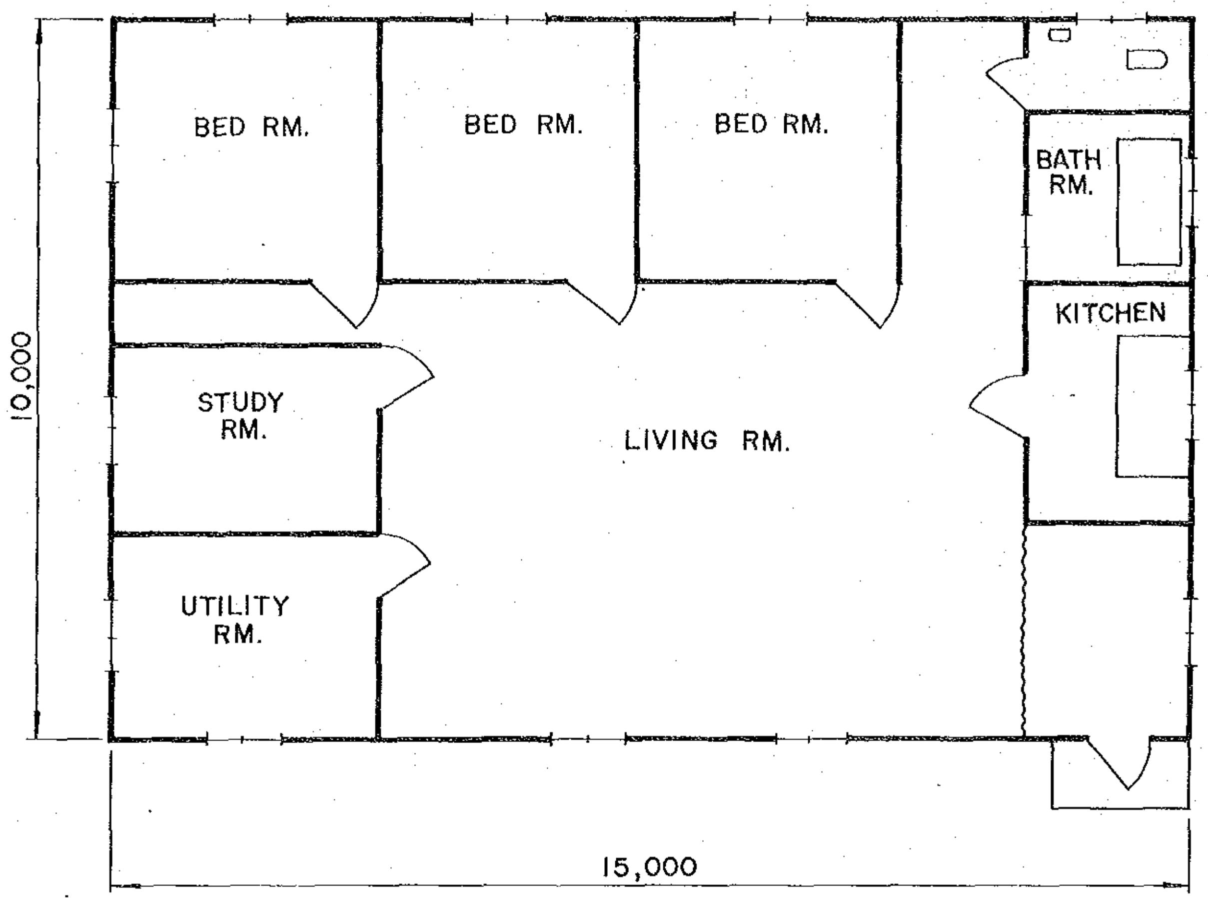
JICA

FIG. III-27

TOWNSITE HOUSING

DIRECTOR AND FOREING ENGINEER

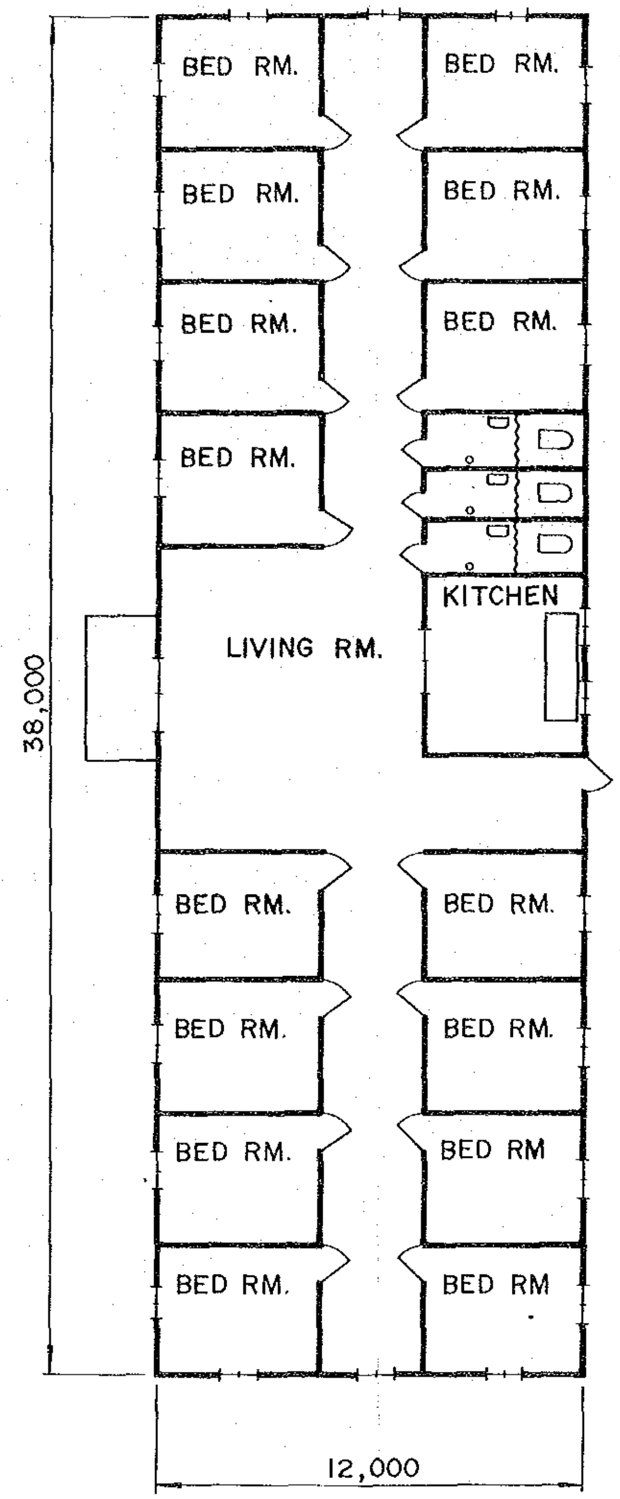
S = 1/100



$A = 150.0\ m^2$

DORMITORY

S = 1/200



$A = 460.0\ m$

THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

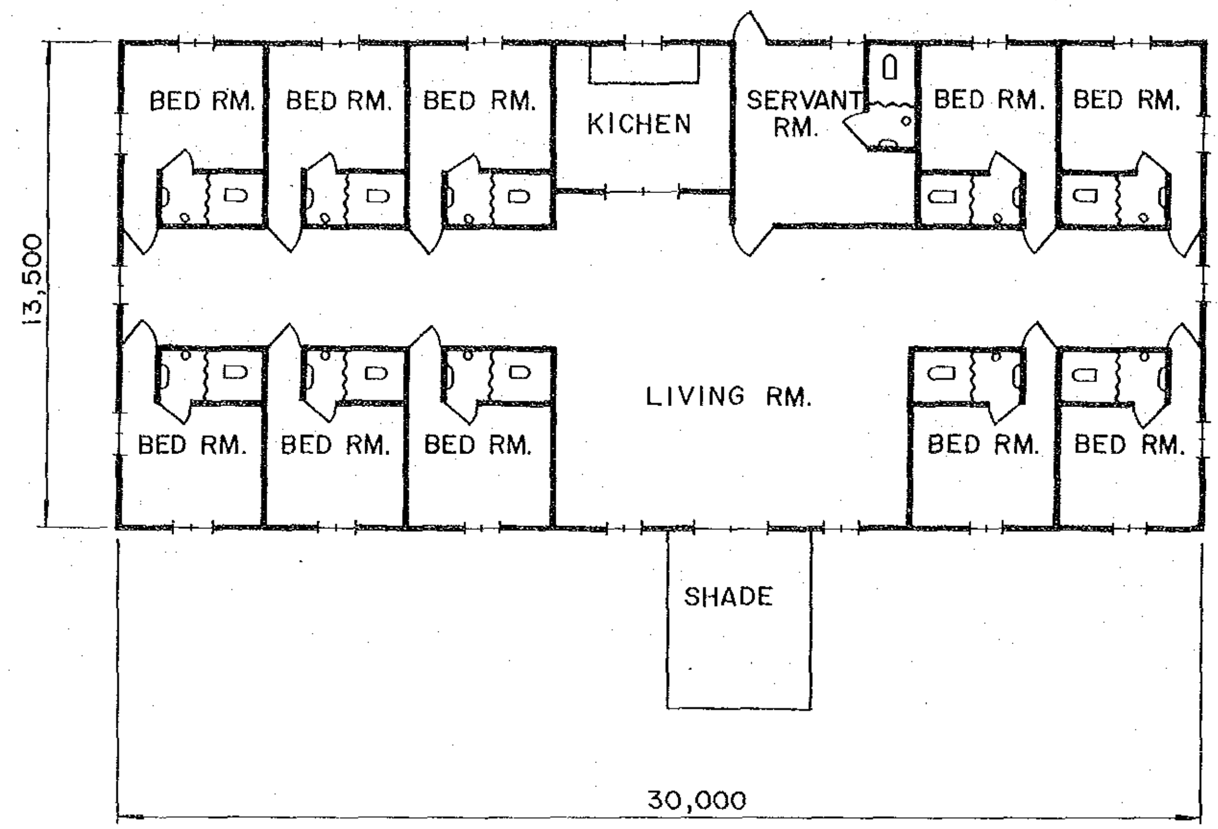
General Layout of Town Site Housing (B)

JICA | FIG. III-28

TOWNSITE HOUSING

GUEST HOUSE

S = 1/200



$A = 405.0\ m^2$

THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND	
General Layout of Town Site Housing (C)	
JICA	FIG. III-29.