9.2 Airside Infrastructures

9.2.1 Runway

The existing runway is planned to be overlaid to increase its LCN to 100. Its extension of 300 meters in length to the east is also planned based on the following reasons.

At present, an air route between Tokyo and Denpasar is operated by wide-bodied DC-10 aircraft which have a weight restriction of 25% of the take-off weight on the existing runway of 2,700m. In the year 1990 (Short Term Plan), the extension of the runway will be carried out to eliminate the need for any take-off weight restriction.

Concerning the direction of runway extension, the reasons for selection of east direction are as follows:

(a) Geographic condition

Both directions (east and west) of the existing runway are directly facing reefs in the sea. They are about 2m deep at the 09 side (the west) and about 1m deep at the 27 side (the east) at high tide.

The reef is about 150m long at the 09 side as shown in Fig. 9.2.1. Offshore from the edge of the reef it becomes steeply deeper. Hence, it is required to bring a lot of borrow soil for reclamation work and to construct an adequate breakwater for the extension of the runway.

On the other hand, as there is a reef about 3,000m long from the edge of the existing breakwater at the 27 side. Necessary soil of reclamation work at the 27 side will be much less compared with at 09 side, and there is no need to construct a breakwater.

Judging from geographic conditions, the runway extension on the 27 side will be more practical due to economic reasons and easiness of construction work.

(b) The Bali Tourist Resort Link Highway

Although the Bali Tourist Resort Link Highway was completed in 1980 at the east side of BIA, it poses no obstacles in case of eastward 300 meters extension of the runway, since this road was constructed in accordance with 75's Master Plan. (Refer to Fig.9.2.2)

(c) Soil condition in the extended runway area

There is a coral reef in the bottom of the sea extending offshore in the west side judging from the shoreline. Therefore, no problem is anticipated in soil condition on the west side.

On the east side, there is uncompacted soil on the bottom of the sea between the Bali Tourist Resort Link Highway and the east side of the airport. Settlement can be anticipated on any embankment or reclamation work done. The settlement time is, however, short due to sand content in the soil.

As the result of the Bali Tourist Resort Link Highway construction experience and making use of the quick settlement method, no big problem for the construction on the east side is anticipated either.

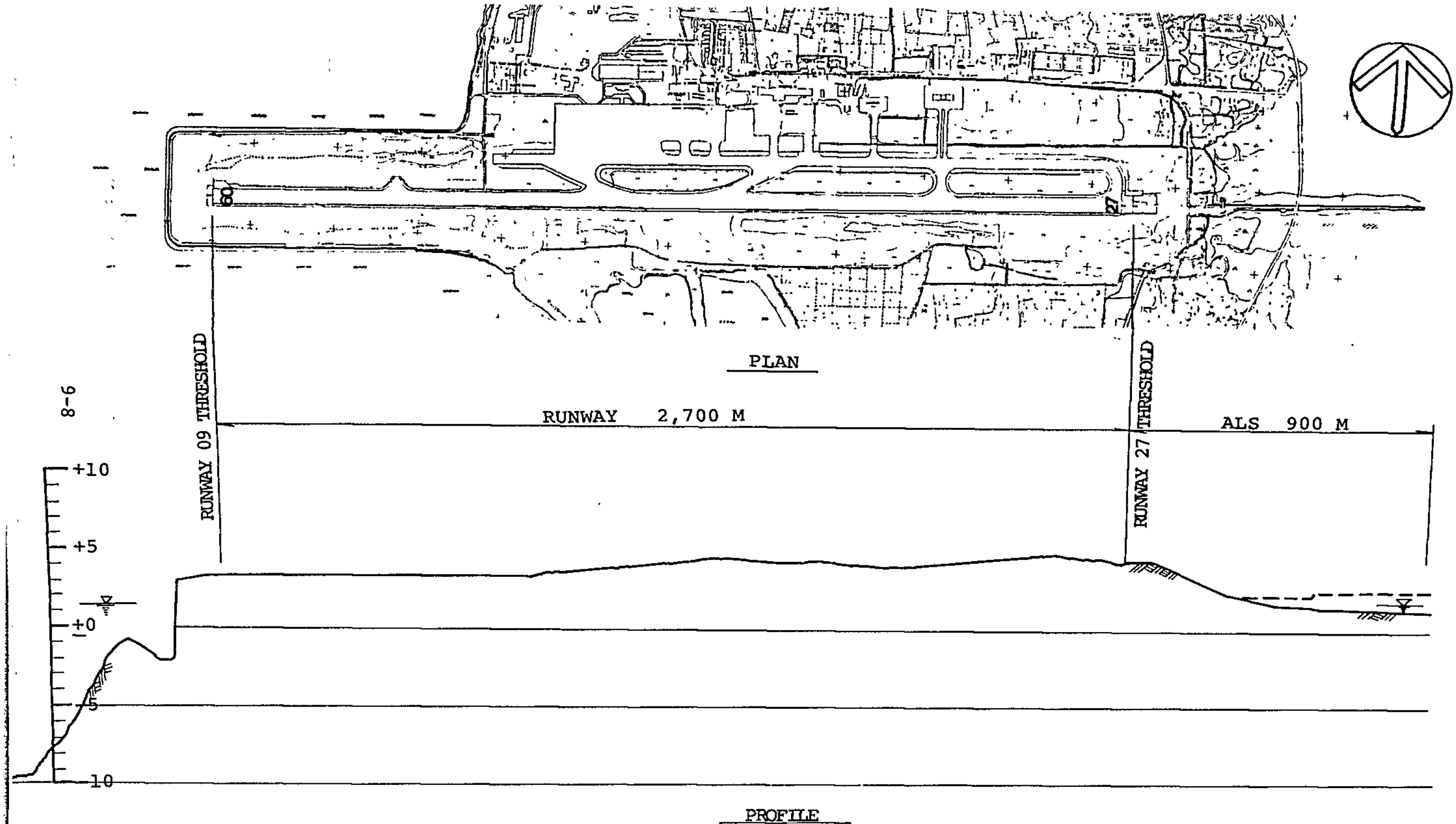


Fig. 9.2.1 EXISTING RUNWAY

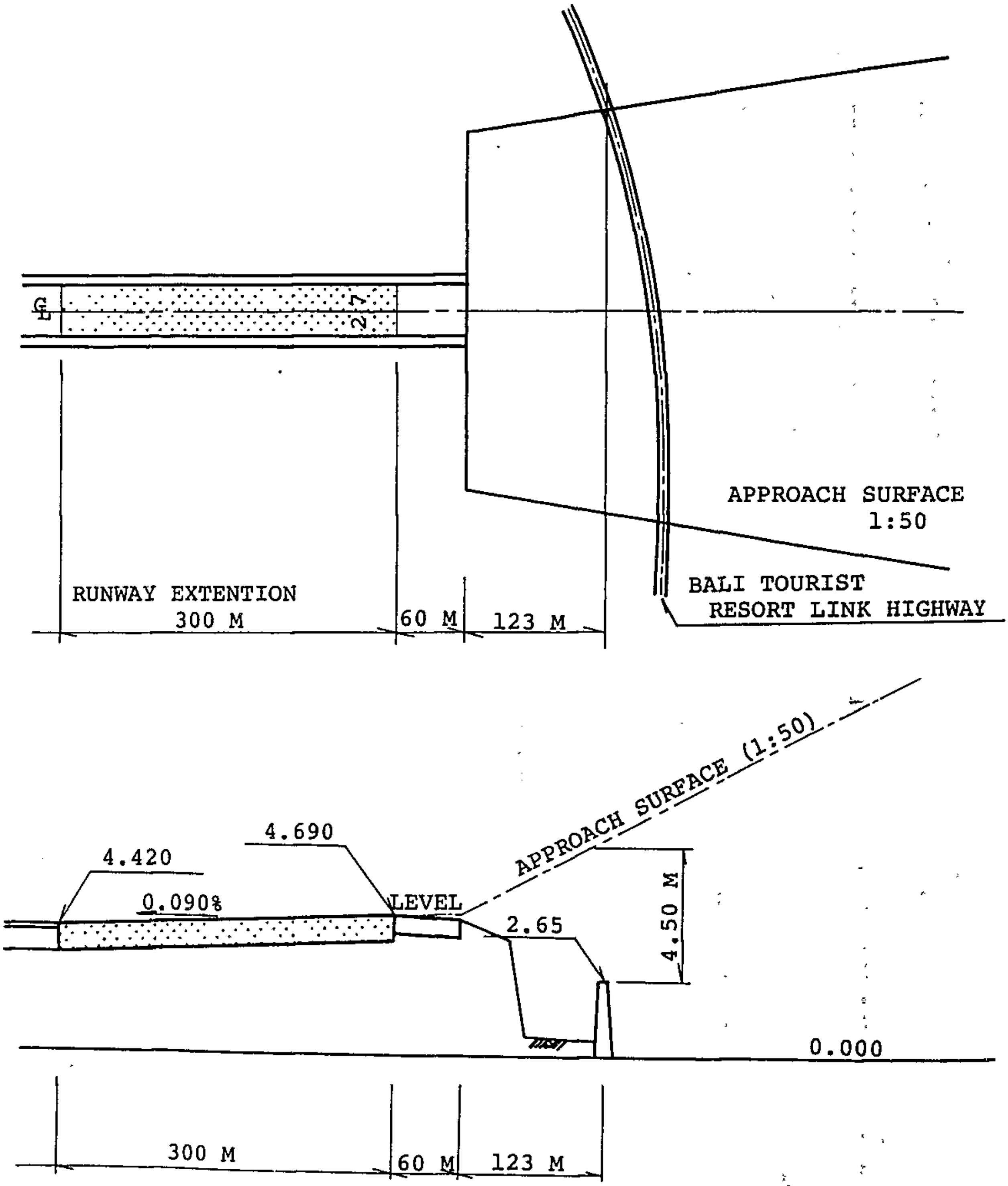


Fig.9.2.2 RELATION BETWEEN APPROACH SURFACE AND EXISTING ROAD
(For east runway extension)

9.2.2 Runway Strip

As mentioned in Section 5.2.2, the runway strip is planned to be developed 300 meters in width which is required to meet CAT-I ILS approach standards. Necessary works for this development of runway strip are as follows:

- Gradation and sodding works mainly for the area of outside of the existing runway strip are required.

- Relocation of Temples (Pura) shown in Fig. 9.2.3. Three temples are obstacles to the obstacle limitation surface. For temple A, only partial felling of the surreounding trees is required. However, temple B and C must be relocated to the outside of the airport since they are within the ILS glide slope critical area.
  It is understood that these temples are the symbolic and holy place for the religious Bali islanders, and therefore, the relocation of them is very difficult. From this point of view, it is expected that the concerned authority will execute this work with the mutual concent of the islanders.

9.2.3 Taxiways

Taxiways are planned to be developed with 23 meter widths and LCN100 as the bearing capacity of the pavement.

(1) Parallel taxiway

The location of parallel taxiway is planned to be on the north side of the runway with a distance of 180 meters between center lines. The necessary works and the planned phasing of work are as follows:
The development plan of parallel taxiway is shown in Fig. 9.2.4.

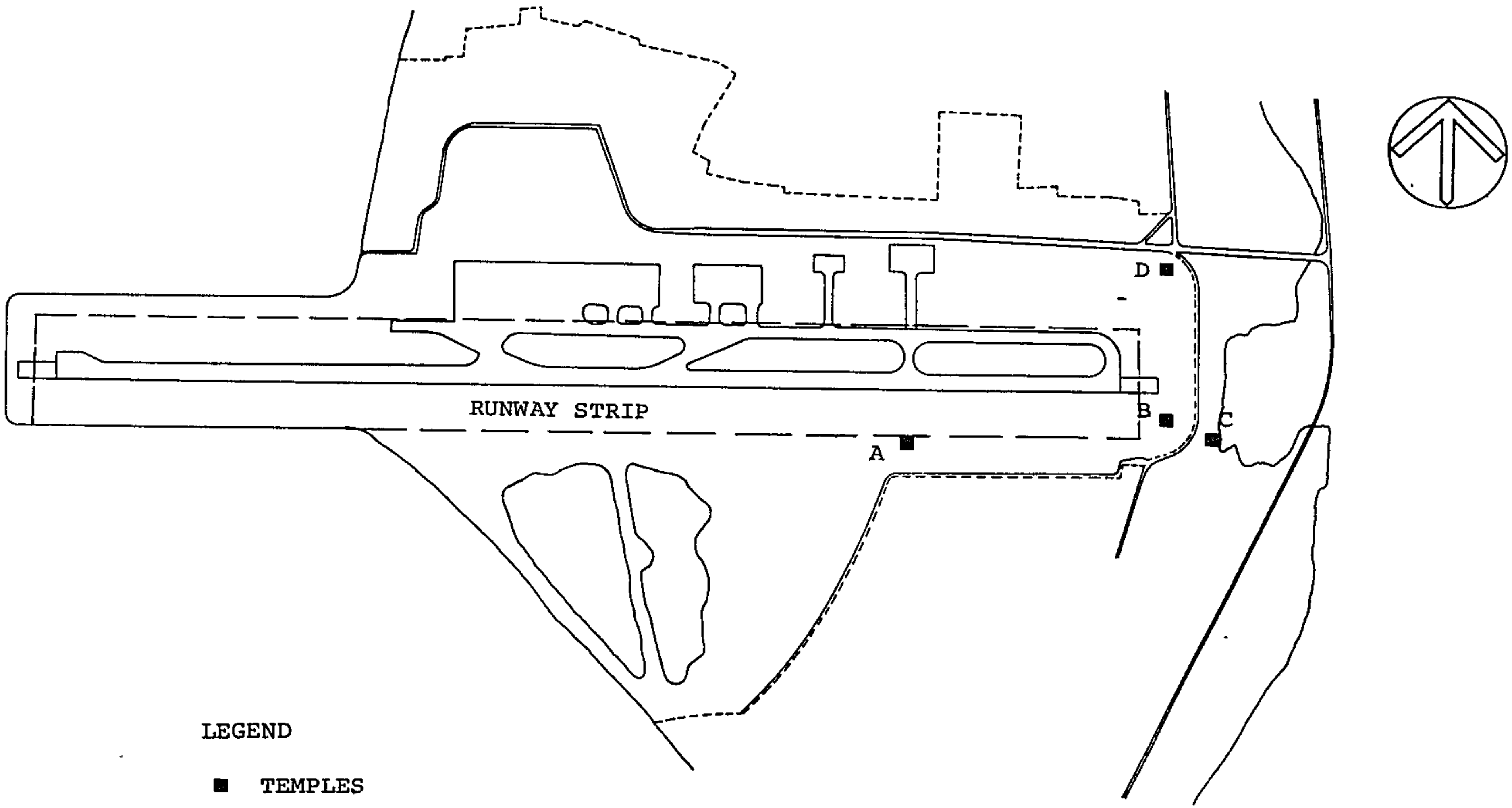


Fig. 9.2.3 LOCATION OF TEMPLE

-Works in the Short Term Plan:

The development of the parallel taxiway at the area-1 of Fig.9.2.4 is to secure safe aircraft operations. It is actually the relocation of parallel taxiway within the existing land of BIA. A new parallel taxiway in area-1 can be developed within the airport. For a new parallel taxiway in area-2 (in the west area) it will be necessary to construct sea embankments and a breakwater. The sea embankments are about 5 ha in area and the construction cost is estimated to be about 4.0 billion Rp.

A cementery is located in area-3 where the extension of the runway is to be constructed. It is anticipated that it will take time to coordinate with the neighbors and relocate the cementery outside the airport.

For the reasons stated above, the new parallel taxiway in area-1 is planned to be carried out in the Short Term Plan. In addition, even if the new parallel taxiway in area-1 is constructed, no problems are expected to place in airport operations, for the following reasons:

(a) New parallel taxiway 1,700m long is constructed. It is anticipated that less than MJ (DC-9-30) size aircraft including Small jets (SJ) and propeller driven aircraft require runway length - less than 1,700m. For example, DC-9-30 needs 1,400m and F-28 needs 1,420m.

(b) In accordance with the ICAO Airport Planning Manual, it is suggested that a fully paralell taxiway be provided if aircraft approaching by ILS are more than 4 times in peak

hour. Aircraft approaching by ILS are expected to be more than 7 times in peak hour in BIA in 1990 as shown in Table 3.7.9. However, aircraft which are smaller than MJ would use a fully parallel taxiway because the required runway length for the aircraft is less than 1,700m long.
Aircraft movements for J and WB are 2.4 times as described in Table 3.7.9, which is less than (the 4 times) indicated in the ICAO Airport Planning Manual.
Jambo and wide bodied aircraft require a runway length as shown in Table 5.2.1 in the previous section.
Because the new parallel taxiway is a 1,700m long, the aircraft should move 180 round on the runway in taking off at 0.9 side and in landing for Jumbo (J) B-747 and wide bodied aircraft (WB) at 27 side.
The aircraft movements for J and WB during peak hours are 2.4 times/hour as shown in Table 3.7.9.

Consequently, it is our judgement that the new parallel 1,700m long taxiway will not influence the airport operations.

- Construction works in Middle and Long Term Plans
  J, WB, and new MJ aircraft approaching by ILS are expected to be 3.9 times/hour in the year 2000 and are also forecast to be 6.7 times/hour in the year 2010 as shown in Table 3.7.9. Therefore, a fully parallel taxiway is planned to be constructed for the year 2000.

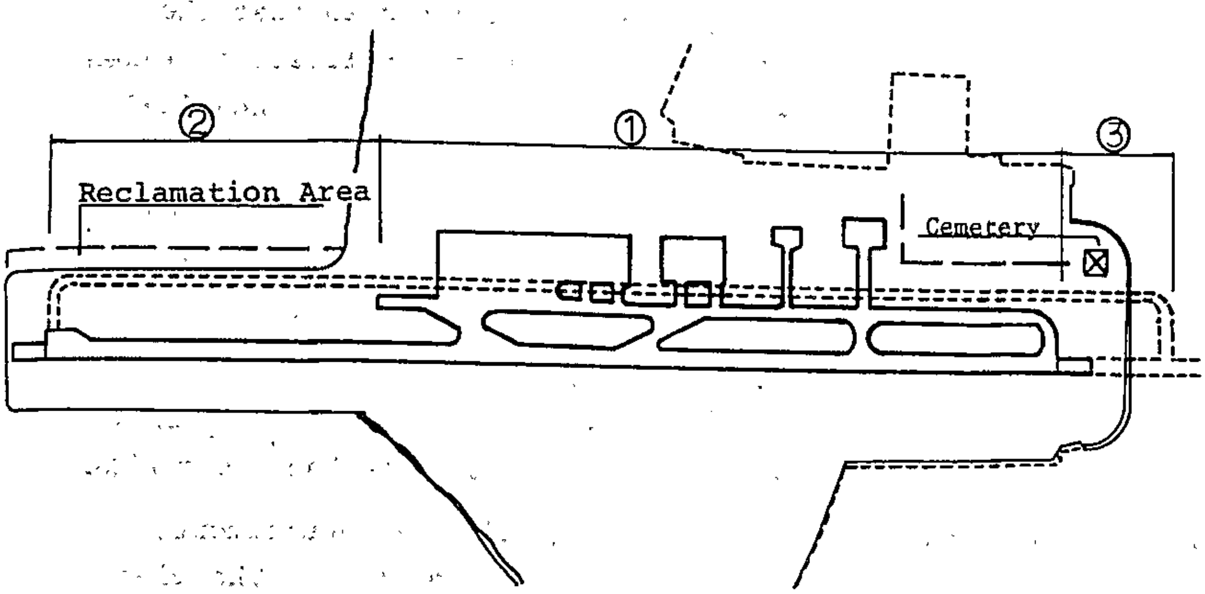


Fig. 9.2.4 THE DEVELOPMENT PLAN OF PARALLEL TAXIWAY

(2) Exit Taxiways

It is essential to utilize exit taxiways efficiently. The necessary development works are the overlay of pavement and the partial extensions of the existing taxiways due to the relocation of the parallel taxiway. The projected number of aircraft landings/take-offs for the Long Term Plan will not require the high speed exit taxiway as an absolute requirement.
However, from the viewpoint of effective utilization of existing facilities, the existing high speed exit taxiway are planned to be used with concerete overlay placed on them.
In addition to the above, two new exit taxiways are planned adjacent to the existing high speed exit taxiways considering the required minimum landing/take-off distances of the small aircraft and shortening their occupany time on the runway.

9.2.4 Apron

The development of the Apron is planned so that the maximum utilization of the existing facilities is taken into consideration and the expansion up to the final target year of 2010 is in phases.

Considering the present site conditions in the terminal area and the layout of the existing terminal facilities, the Apron is centered around the existing passenger terminal buildings and is planned to be extended in both east and west directions.

The final developed Apron layout for the Long Term Plan is established based on the facilities requirements studied and discussed in previous chapters. The plan shown in Fig.9.2.5 is considered the most suitable one in terms of location and from a functional point of view. The expansion of Short and Middle Term Plan is planned as follows:

(1) Short Term Plan

The main expansion is planned in the Apron B area because a new departure terminal building is planned adjacent to the west side of the existing international terminal building. The existing domestic terminal building will be used as a domestic departure terminal.

Apron A will be used without any improvement during this Phase.

(2) Middle Term Plan

The existing Apron A will be reconstructed during this phase in order to cope with the required number of aircraft stands and the area of apron. Since there is a 1.5 meter difference in elevation between Apron A and Apron B, and there is insufficient pavement strength to support large aircraft, it is essential that the cement concrete paved apron be reconstructed as shown in Fig. 9.2.7.

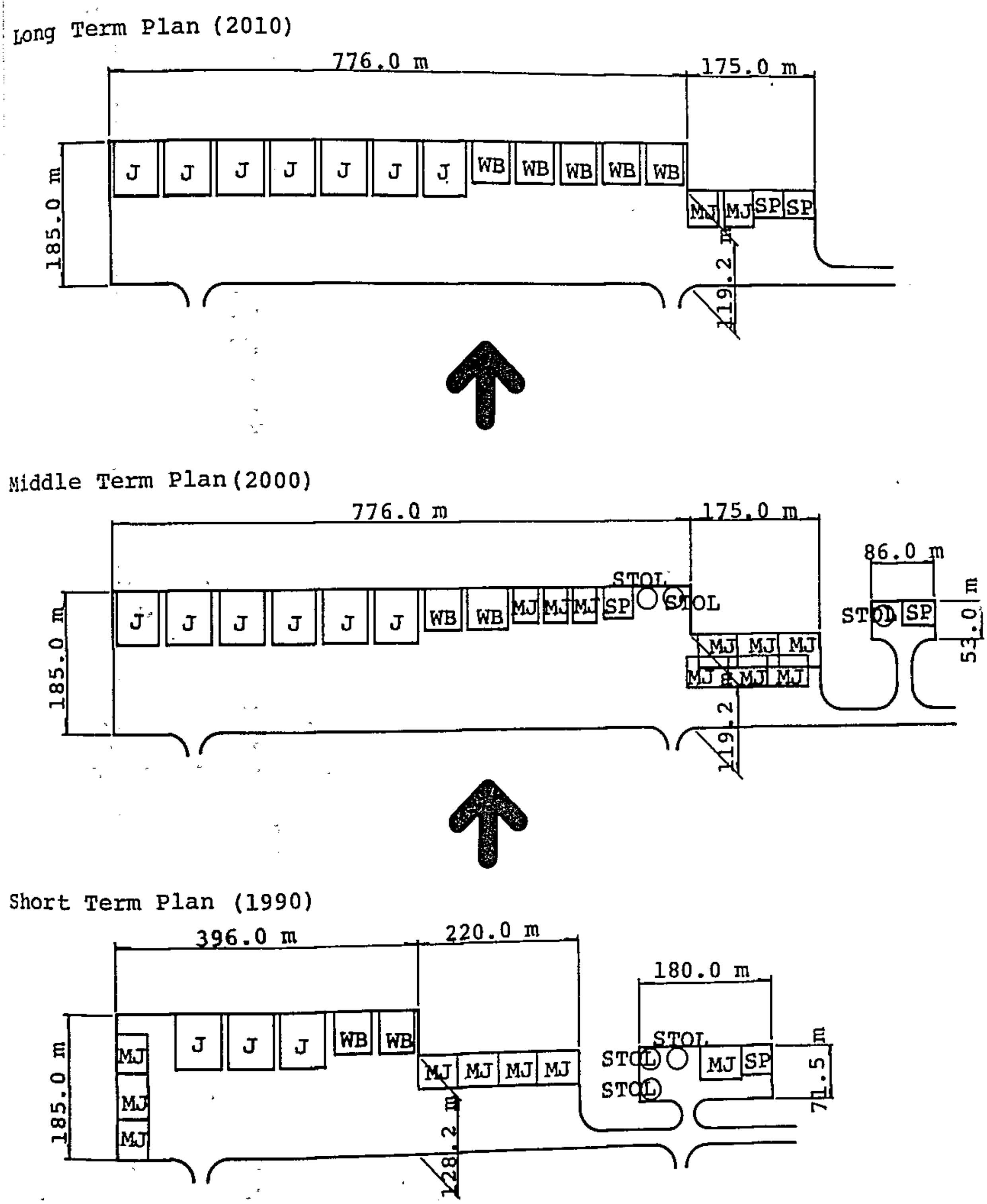
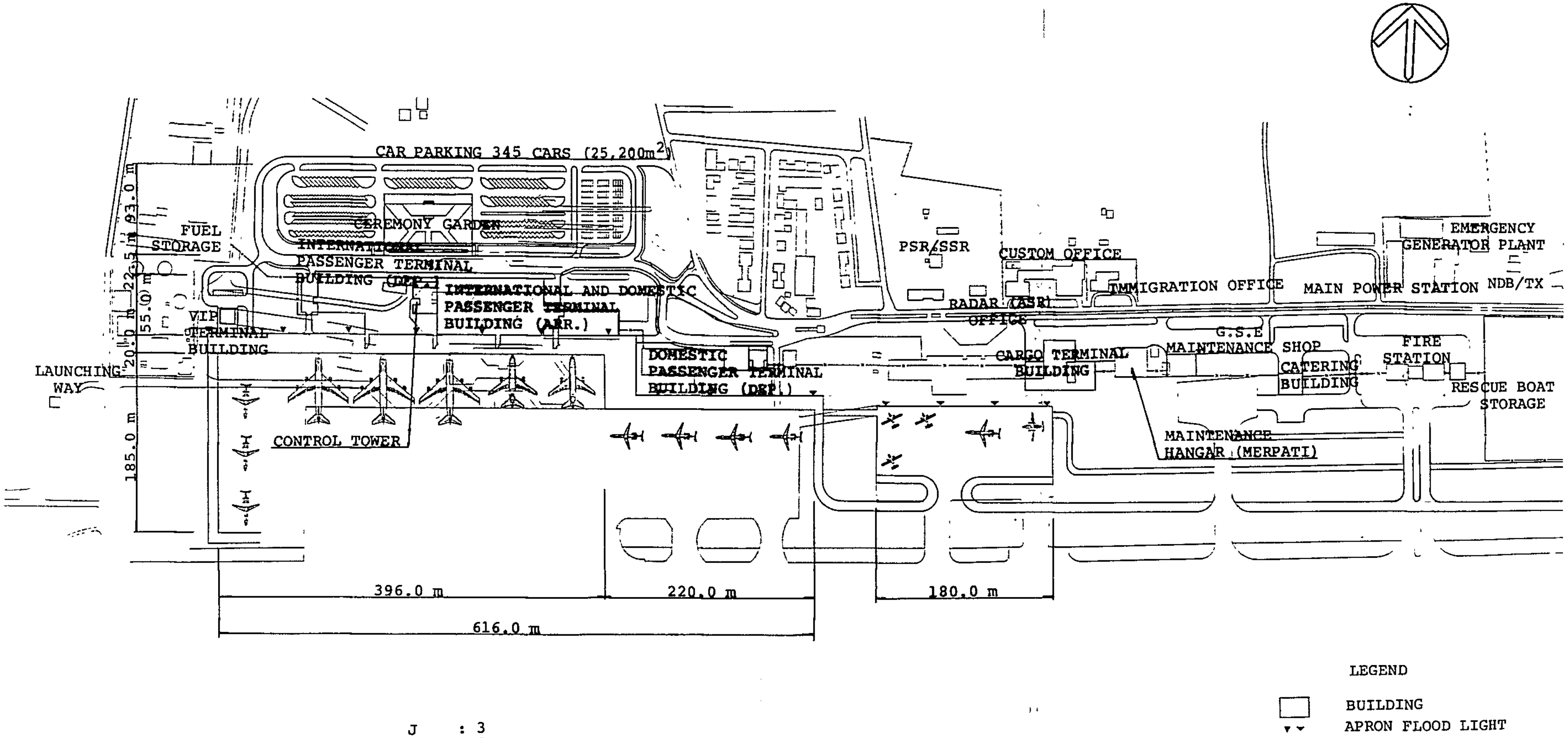


Fig. 9.2.5 APRON DEVELOPMENT PLANS



J : 3
WB : 2
MJ : 8
SP : 1
STOL : 3

INT'L BLDG. 18,400 m^2
DOM. BLDG. 13,200 m^2

Fig. 9.2.6 TERMINAL LAYOUT PLAN (1990) S=1:4,000

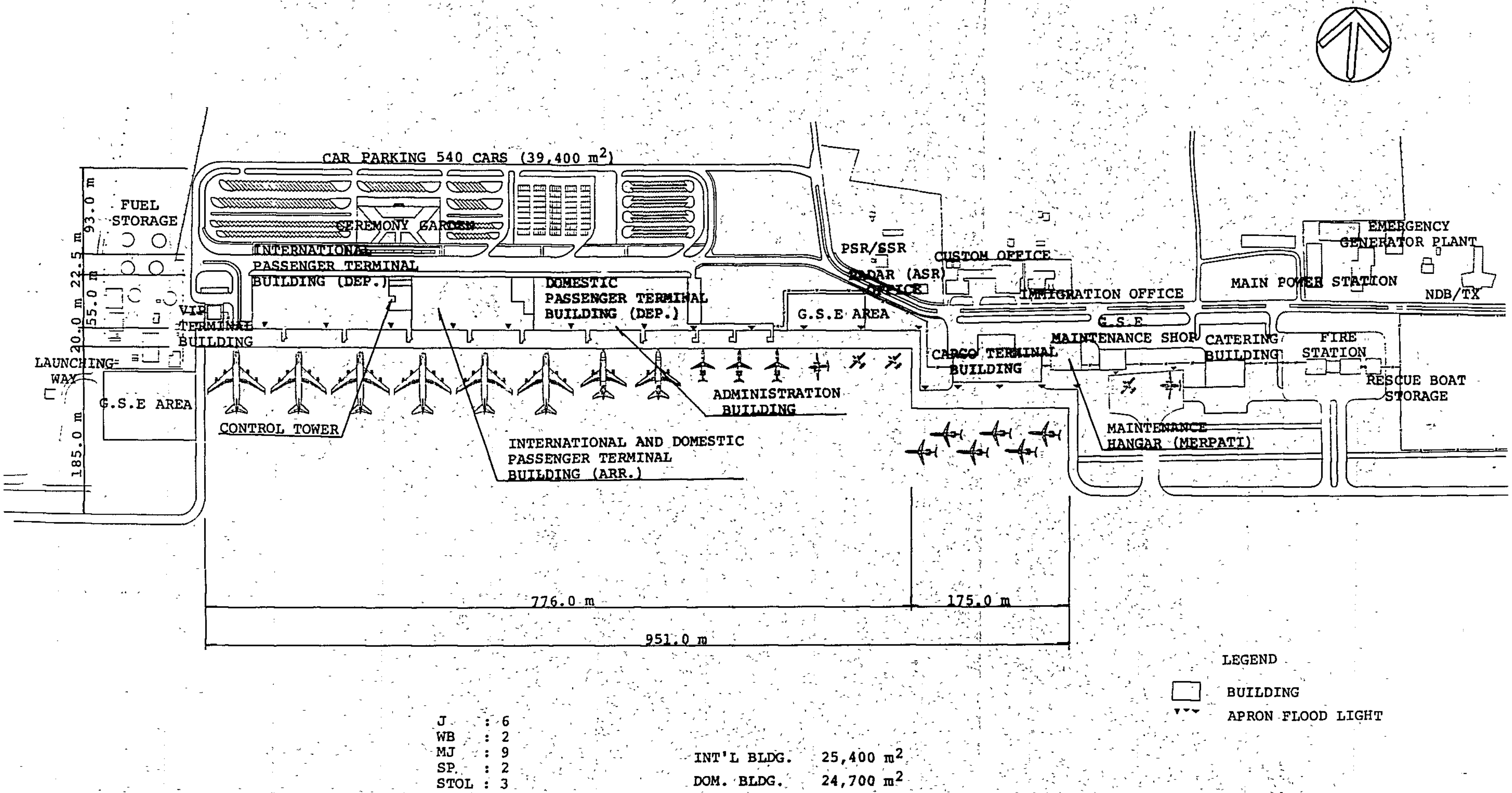
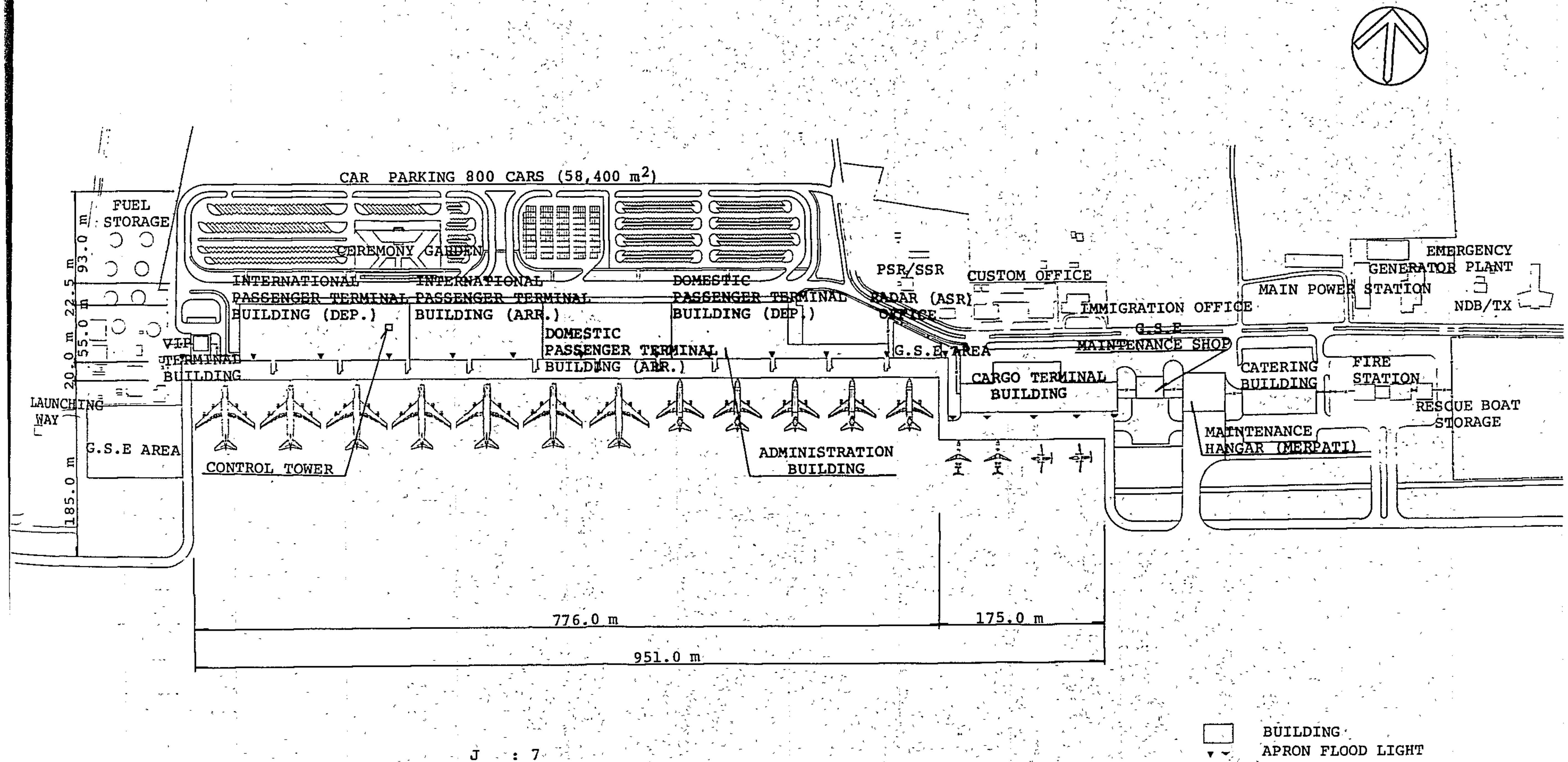


Fig. 9.2.7 TERMINAL LAYOUT PLAN (2000) S=1:4,000



J : 7
WB : 5
MJ : 2
SP : 2

INT'L BLDG. 35,000 m^2
DOM. BLDG. 38,000 m^2

Fig. 9.2.8 TERMINAL LAYOUT PLAN (2010) S=1:4,000

9.2.5 Pavement Structures

(1) Subgrade bearing capacity

According to DGAC's data concerning subgrade conditions, the existing subgrade soil at BIA is mostly coral sand with CBR values ranging from 9 to 11%. On this basis, the bearing capacity of the subgrade is planned for a CBR value of 9% or subgrade modulus of 5 kg/cu.cm. as design conditions for the pavement structure.

(2) Type of pavement

There are two major types of pavement structures commonly used for air fields; namely, the rigid pavement with portland cement concrete slab and the flexible pavement with asphalt concrete.

A comparative analysis of the characteristics of these twe type of pavements is shown in Table 9.2.2. The type of pavements considered suitable for various areas of BIA are summarized in Table 9.2.1 below.

Table 9.2.1 Type of Pavement

Area	Type of pavement	Note
Runway	Flexible	Reduction of the construction period.
Taxiways	Flexible	
Shoulders	Flexible	
Apron	Rigid	Avoiding rutting or deterioration due to channelized traffic and fuel spillage.
GSE maneuvering area	Rigid	

GSE: Ground Service Equipment

Table 9.2.2 Comparison between Rigid Pavement and Flexible Pavement

	Flexible Pavement	Rigid Pavement
Total thickness	104cm (CBR = 9%)	67cm (K_{75} = 5 kg/cm^3)
Joint	Not needed	Needed between panels
Load Bearing	Rutting may occur in case of channelized traffic and fuel spillage	Very little rutting
Cost	Rp.40,060 /m^2	Rp.40,080 /m^2
Construction Period	Relatively short	Relatively long
Maintenance and repair	Easier because spot repair is possible	Comparatively more difficult

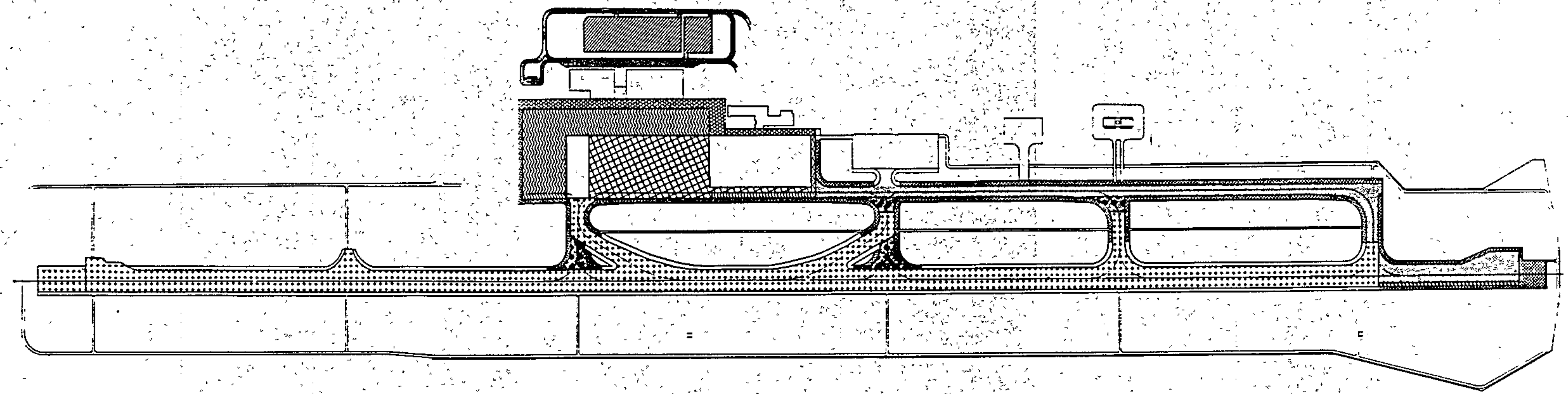
(3) Pavement structures

The total thickness of flexible pavement is determined to be 104cm based on 10,000 repetitive loadings from B747 class aircraft. The design characterristics are shown in APPENDIX 9.2.1.

This standard thickness of flexible pavement can be reduced by 10 to 50 percent considering the actual load application characteristics according to the "Airport Pavement Design Manual" of JCAB as indicated in Fig. 9.2.10.

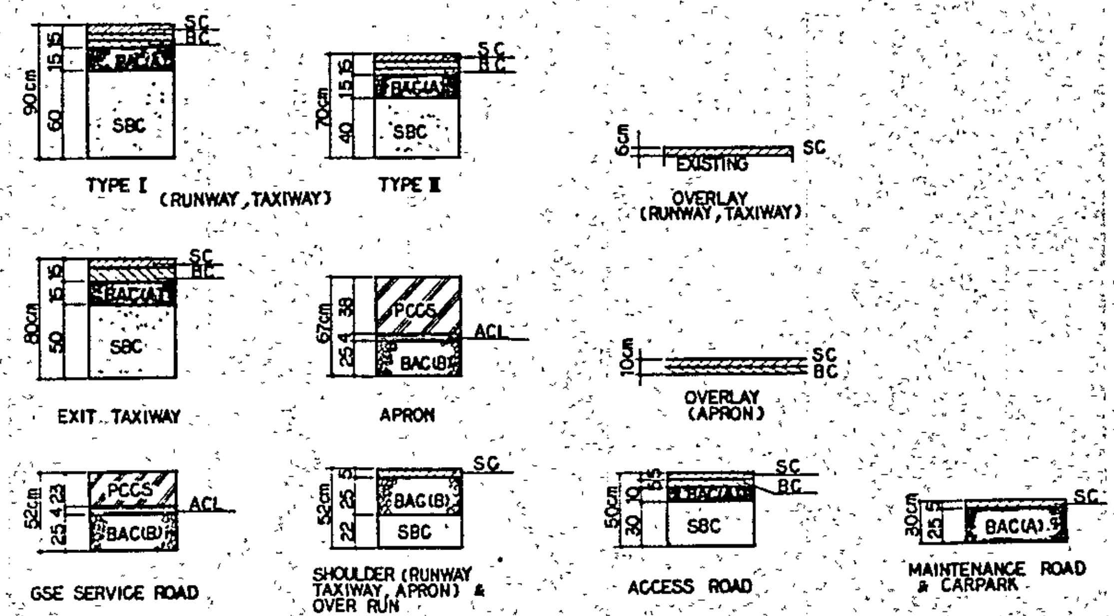
A 38cm thick portland cement concrete slab can be planned for the loading apron and 23cm for the GSE equipment manuevering area respectively, as shown in the APPENDIX 9.2.1.

The pavement for each specific area is planned on the basis of the above, and is shown in Fig.9.2.9.



LEGEND

SYMBOL	ITEMS
	RUNWAY / TAXIWAY TYPE I
	TYPE II
	OVERLAY (RUNWAY TAXIWAY)
	EXIT TAXIWAY
	APRON
	APRON OVERLAY
	GSE SERVICE ROAD
	SHOULDER
	ACCESS ROAD
	CARPARK

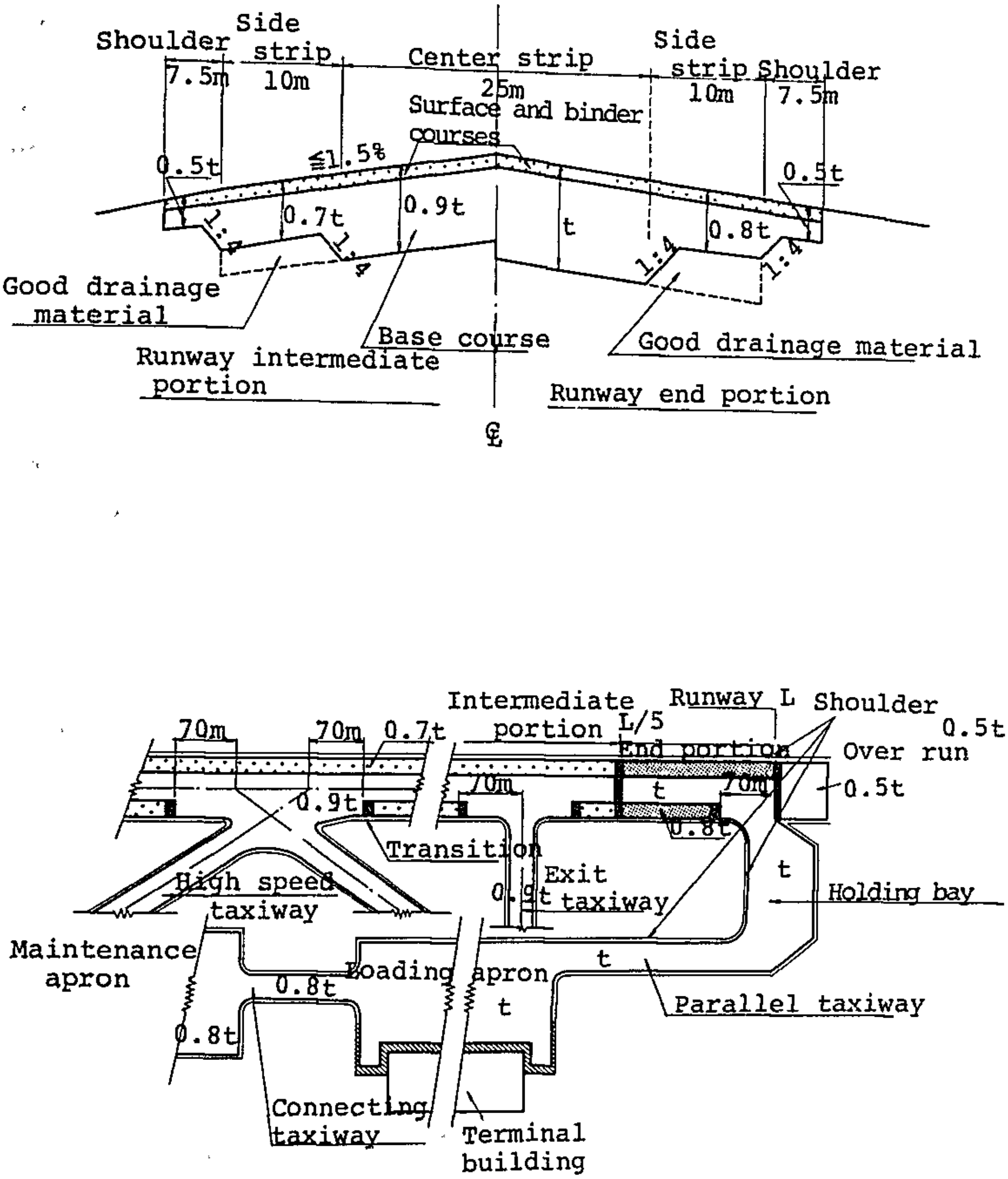


LEGEND

SYMBOL		ITEMS
	SC	SURFACE COURSE (ASPHALT CONCRETE)
	BC	BINDER COURSE (")
	BAC(A)	BASE COURSE (ASPHALT STABILIZED)
	BAC(B)	BASE COURSE (GRADED AGGREGATE)
	PCCS	PORTLAND CEMENT CONCRETE SLAB
	ACL	ASPHALT CONCRETE LEVELING COURSE
	SBC	SUBBASE COURSE (COMPACTED LIMESTONE)

Fig. 9.2.9 PAVEMENT PLAN

S=1:10000



t: Standard pavement thickness

L: Runway length

Fig. 9.2.10 REDUCTION OF STANDARD PAVEMENT THICKNESS

9.3 Obstacle Limitation Surfaces

There will be no obstructions which affect the obstacle limitation surfaces, as shown in Fig. 9.3.1.
Since the final approach for aircraft is just under the Bonoa seaport, the influence on the obstacle limitation surface is explained below.

The obstacle limitation surfaces which might influence development and operation of the Benoa seaport are the inner horizontal surfaces and take off climb surface extended from runway 27 toward the port.
On the other hand, obstructions consist both of fixed obstacles and moving obstacles. Sailing ships are considered moving obstacles. Fig. 9.3.2 and 5 show plans and longitudinal sections of obstacle surface on the basis of a runway length : 3000 m and 3600 m.
If the height of fixed obstacles is below the limiting height shown in Fig. 9.3.3 and 9.3.5, then these obstacles allow for construction or installations for development and operation of the port.
Height of inner horizontal surface of BIA is 50 m above sea level.
The location of the Benoa seaport is within the limit for inner horizontal surface, therefore, the height of ship should be less than 50 m. As reference data, the relationship between size of ships and height of mast is as follows:

Ship Gross Tonnage	Mast Height (m)
500 - 1000	15 - 26
1000 - 5000	20 - 35
5000 -10000	30 - 45
over 10000	30 - 50
Large passenger vessels (including oil tanker)	50 - 65

Source: Marine Construction Handbook, Japan

As an example:In the Yokohama port, the clearance between sea level and bottom of bay bridge is 49 m. taking into account 47 m high mast for a container vessel of 51000 G/T (or 31000 DWT). A limiting height of 50 m in the case of The Benoa seaport, therefore, will allow for the operation of the same class of ships as The Yokohama port and is sufficient for expected ships of 25000 DWT class for The Benoa seaport.

With regard to the expansion of The Benoa seaport in the future, since it is a shallow area in the west side (airport side) of The Benoa seaport, an expansion of the seaport development toward the west will require costly maintenance dredging at certain intervals. Based on this, it is definite that the future expansion of The Benoa seaport will be toward the east of the existing The Benoa seaport. Obstacle limitation surface of BIA,therefore, will not influence any seaport development in The Benoa seaport in the future. In conclusion, no problem is foreseen for the development of The Benoa seaport related to the runway extension of BIA.

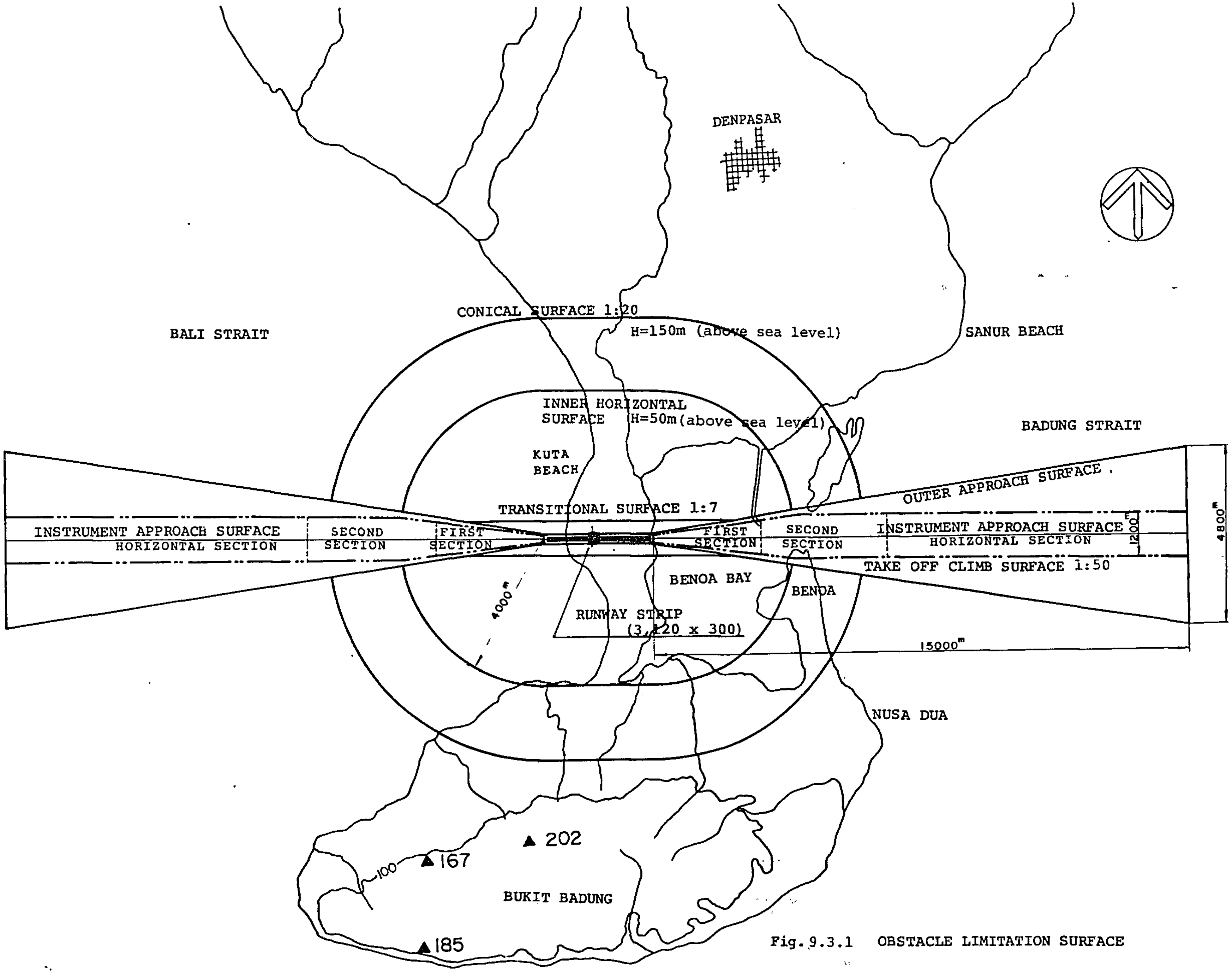


Fig. 9.3.1 OBSTACLE LIMITATION SURFACE

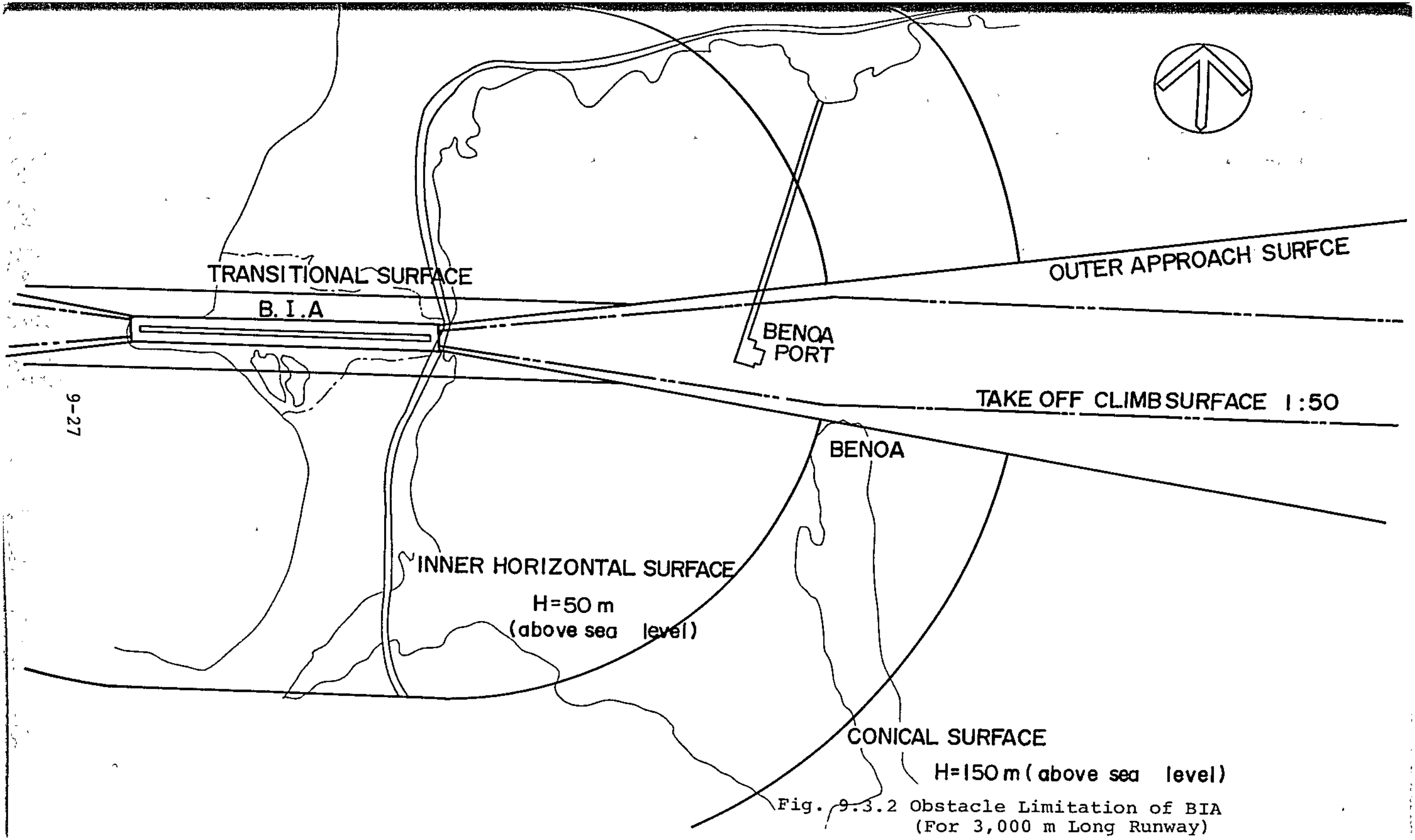


Fig. 9.3.2 Obstacle Limitation of BIA
(For 3,000 m Long Runway)

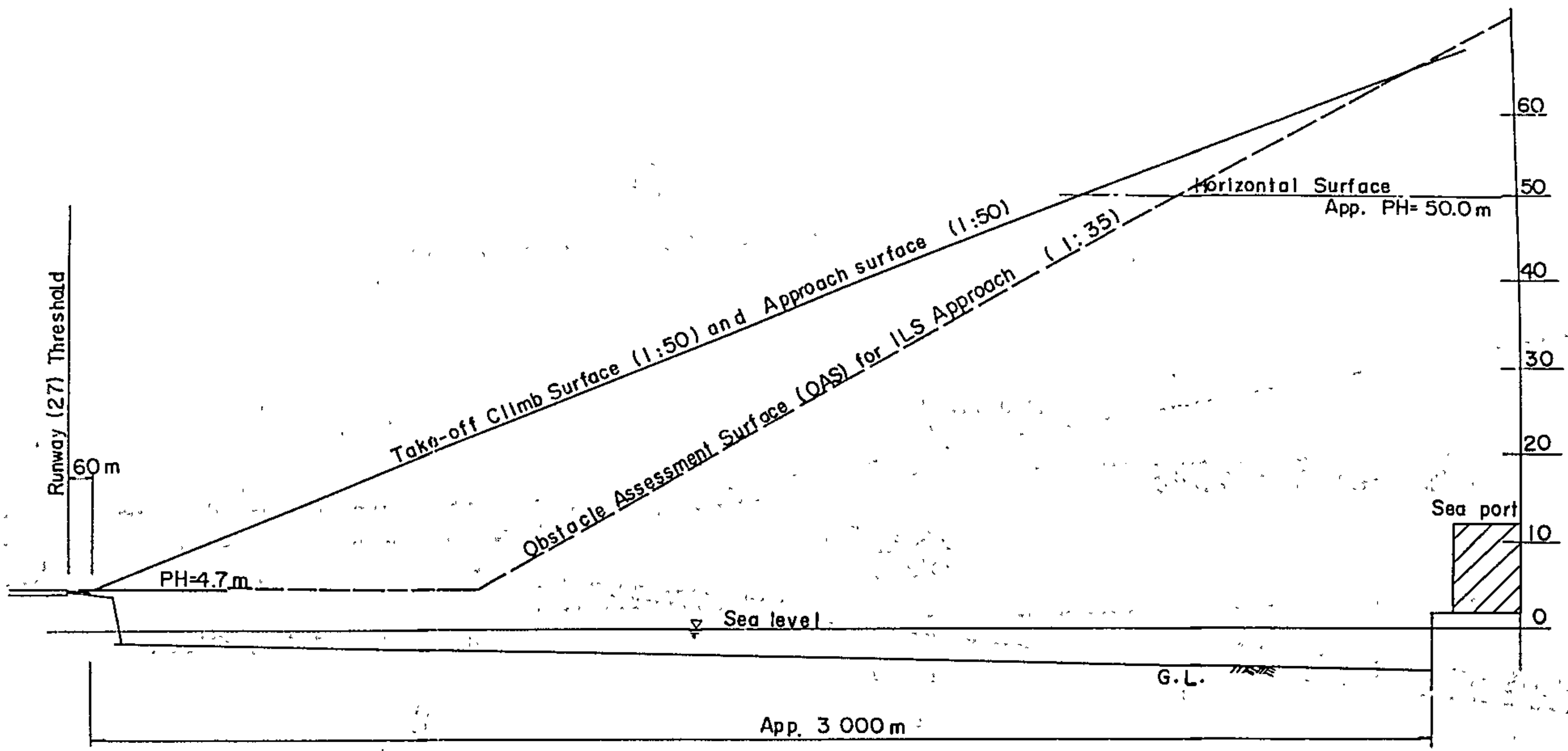


Fig. 9.3.3 The relationship between obstacle limitation surface for BIA and Benoa seaport (For a 3,000 m long Runway)

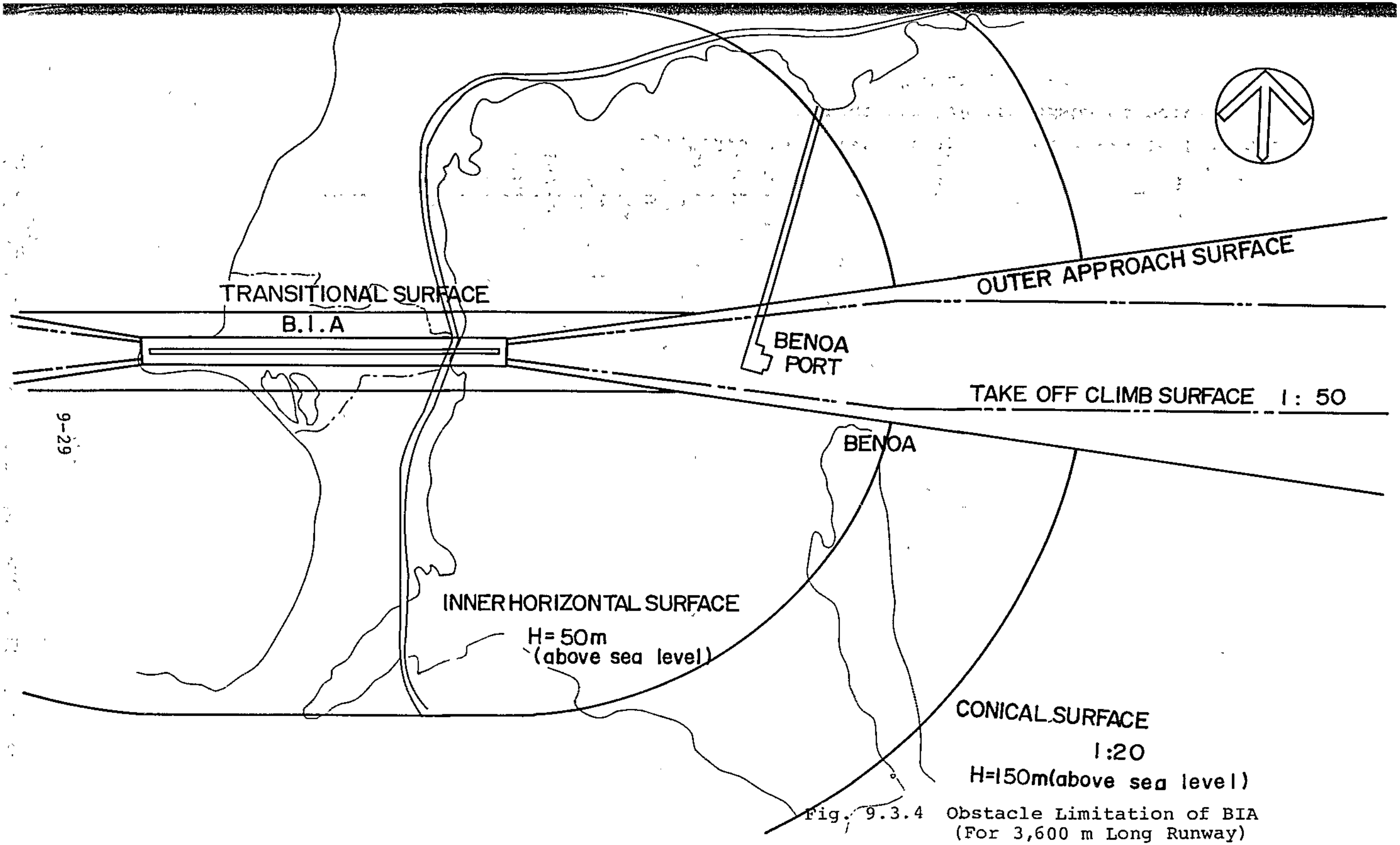


Fig. 9.3.4 Obstacle Limitation of BIA
(For 3,600 m Long Runway)

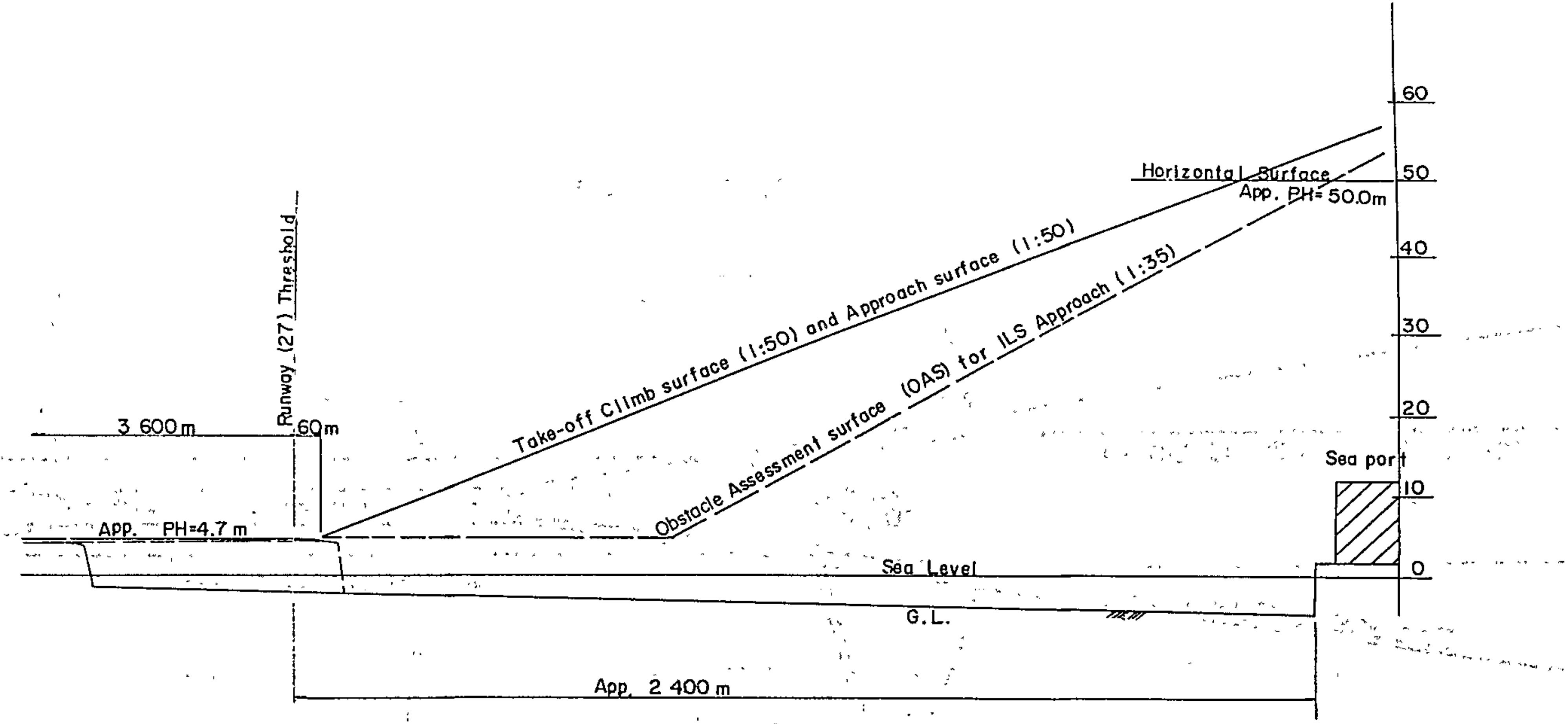


Fig. 9.3.5 The relationship between obstacle limitation surface for BIA and BENOA seaport (for 3,600 m long Runway)

9.4 Site Preparation

9.4.1 Grading Plan

Generally speaking, balancing earth movement (cut and fill) for a development project at an existing airport is difficult because of restrictions related to the existing facilities.

At the Bali International Airport, reclamation work is required for each of the development plans.

A large quantity of fill must be transported from outside the site.

The present grading plan shows one constant side slope from the center line of the runway down to the taxiway as shown in Fig. 9.4.1.

The new parallel taxiway is planned at a higher elevation than the existing one in order to provide more rapid storm runoff.

Accordingly a new storm water drainage ditch is required between the runway and the taxiway.

Figs.9.4.2 and 9.4.3 indicate the grading plan based on a consideration of minimizing earth work.

The reclaimed portion in the Short Term Plan requires some additional fill to compensate for the anticipated settlement of 60cm within approximately 4 meters height of the embankment. This situation is explained in supplementary data attached in the APPENDIX 9.4.1.

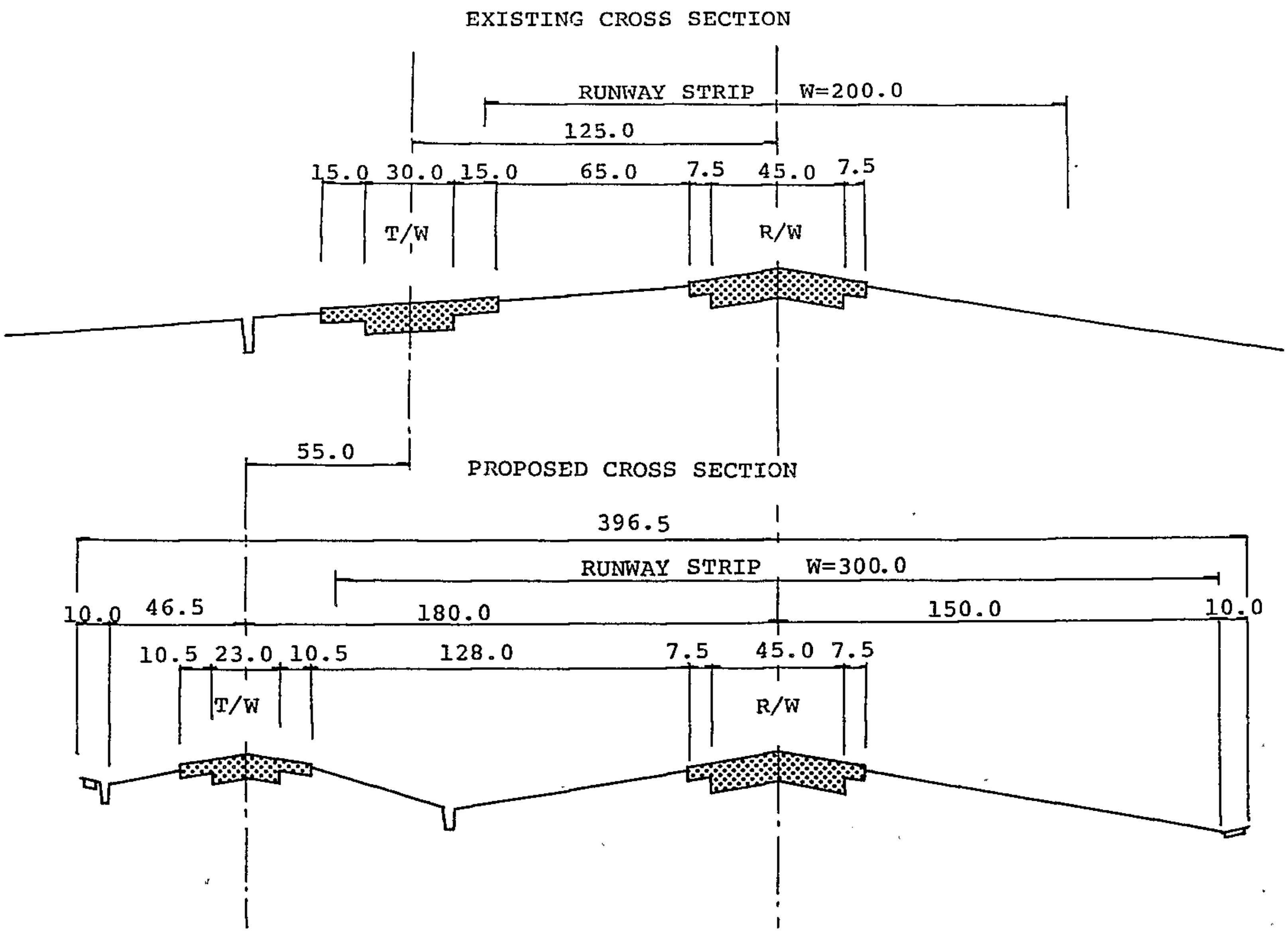
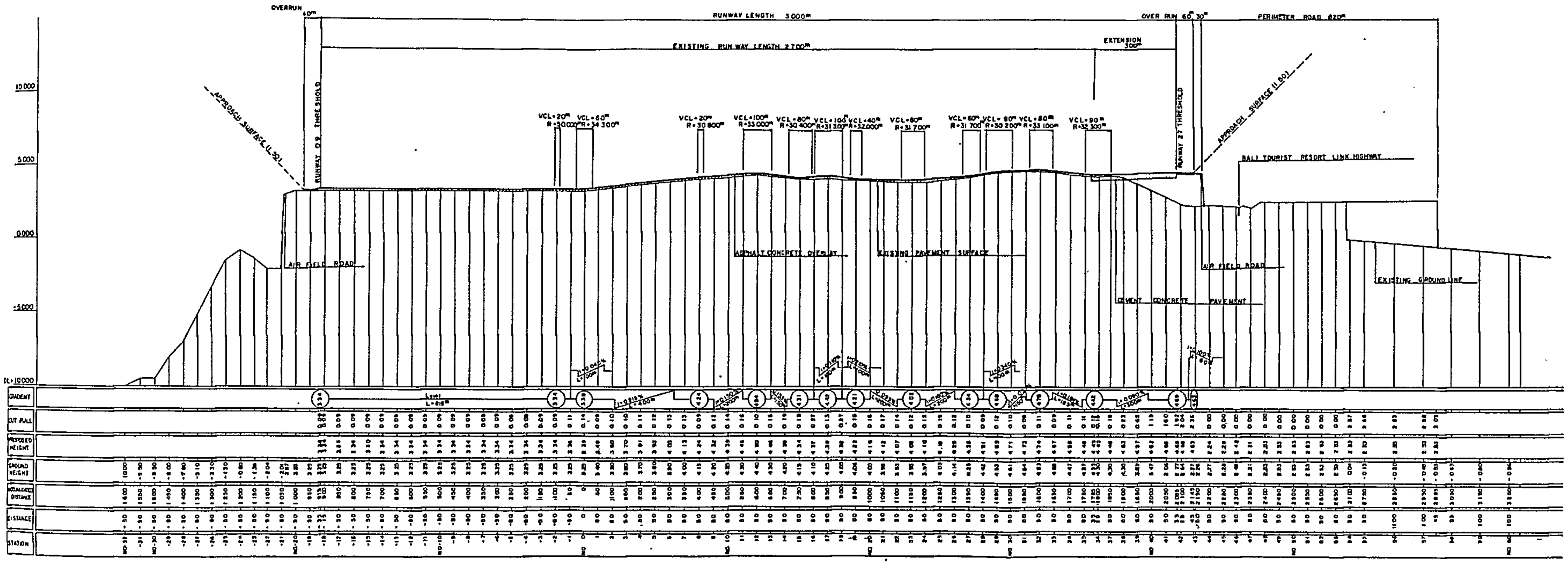


Fig. 9.4.1 CROSS SECTION OF EXISTING AND PROPOSED RUNWAY



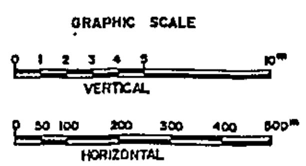


Fig. 9.4.2 RUNWAY PROFILE

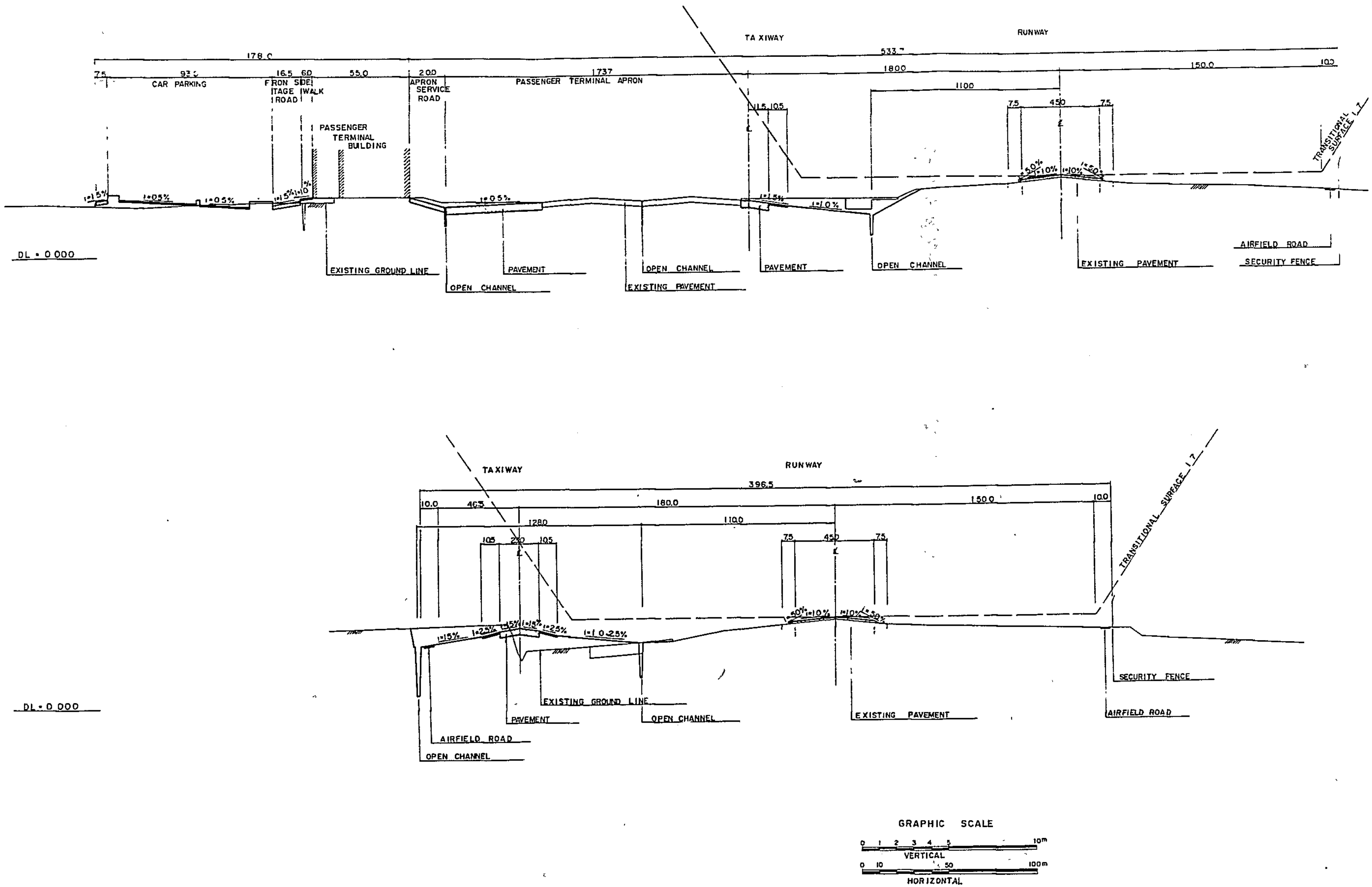


Fig 9.4.3 TYPICAL CROSS SECTION

9.4.2 Stormwater Drainage System Plan

(1) General

The area to be developed for BIA is almost flat and lies between approx. elevation 2.5 and 5 meters above MSL. The existing stormwater drainage system is inefficient particularly the existing piping network in the runway strip which is not functioning properly due to the lack of an effective surface water collection system.
In general, it is difficult to achieve a smooth and efficient stormwater drainage system for an airport such as BIA located adjacent to the sea, since the water flow from the airport is influenced by tide levels and land reclamation will be required in order to achieve an effective stormwater drainage system.
Accordingly, it is essential to adopt the open channel system as much as possible to obtain the hydraulic heads. A ponding system may be adopted where the required hydraulic heads cannot be obtained or the necessary earth cover for the underground piping cannot be provided.

Based on the above considerations, the stormwater drainage system for each of the specified in Short Term Plan is planned as indicated in Fig.9.4.4 and an outline of the system is summarized as follows:

(2) Drainage system for specific areas:

(a) Intermediate area between runway and taxiway.
A trapezodal open ditch system is planned for surface water collection and collected surface water will be discharged to the sea through underground piping.
The slope of the open ditch is planned to be 0.1 percent because of insufficient differences in elevation between the height of runway strip and the sea.

(b) Apron area

A U-shaped channel system with grating inlet is planned which is the same as the existing system. Collected surface water will be discharged to the sea through the newly constructed underground piping. The existing reinforced concerete inlet cover is considered to be insufficient in strength for B-747 class heavy aircraft loads and therefore it is recommended that the existing concerete covers be replaced with steel grating. It should also be noted that the capacity of existing piping in this area is not sufficient for run-off from the new apron and terminal buildings. Therefore, an additional drainage pipe line is to be installed parallel with the existing line.

(c) North-east area of the newly constructed fire station

Trapezodal channels the same as existing ones are planned in parallel with the runway to which underground piping from the runway strip will be connected.

(d) Glide path area

There are strict regulations concerning the gradation for the glide-path area and any irregular protuberances are not permitted, therefore, a trapezod open channel is planned along the outer perimeter of the glide-path area.

In addition to the above, evaluation of the existing stormwater drainage system and design criteria of stormwater drainage system on the Short Term Plan are explained in APPENDIX 9.4.2. and 9.4.3.

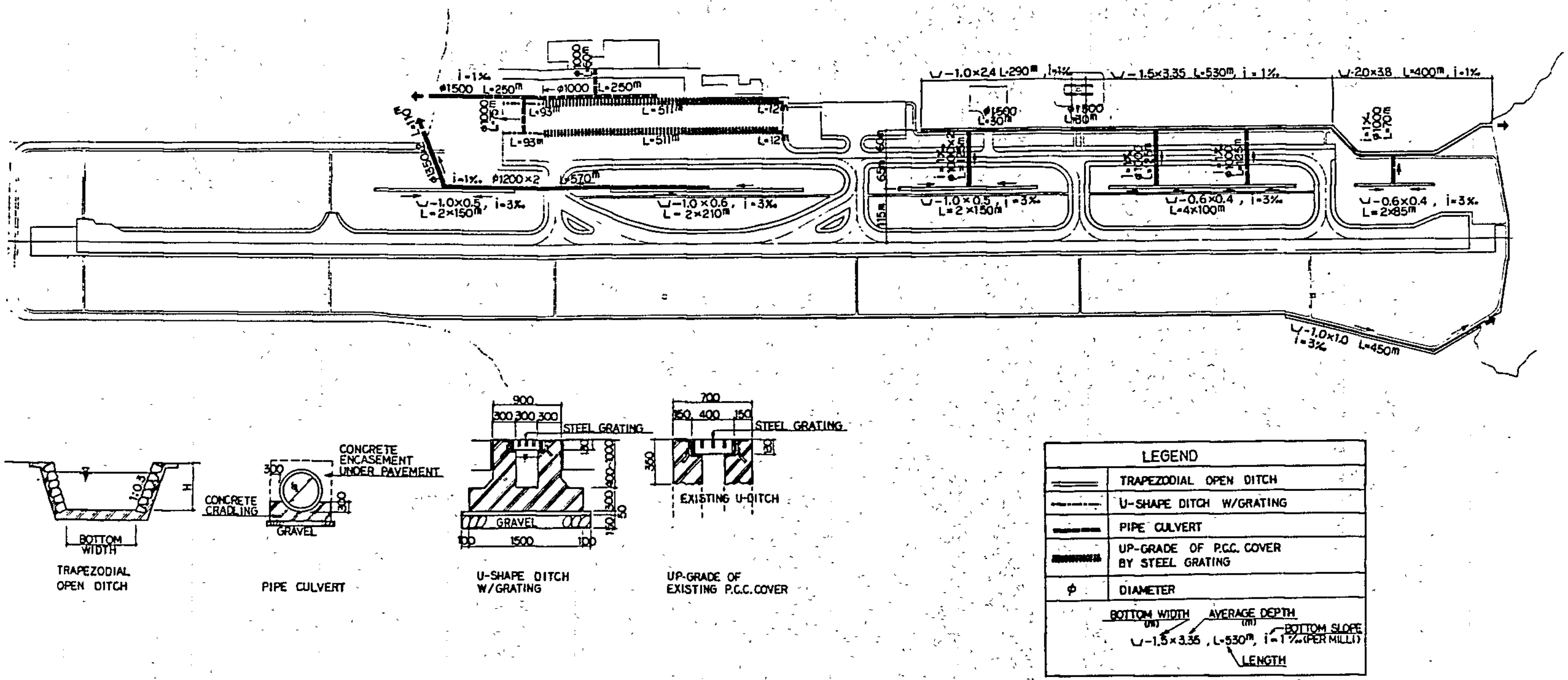


Fig. 9.4.4 STORM WATER DRAINAGE SYSTEM PLAN

S=1:10,000

9.5 Air Navigation Aids

9.5.1 Navigation Aids

In relation to the extension of the runway, relocation of taxiway, extension of Apron and renovation and expansion of the passenger building for each plan, the following work has been completed on Air Navigational Aids and the Airfield Lighting System as planned for each phase.

(1) Short Term Plan

- relocation of Glide Path
- supplement of Middle Marker
- supplement of DME
- additional work related to Airfield Lighting such as Runway edge, Taxiway edge light
- relocation of Approach Light System at 27 side
- relocation of VASIS unit at 27 side
- installation of Apron flood light
- arrangement of control console & panels in the Control Tower

(2) Middle Term Plan

- additional work related to Airfield Lighting such as Runway edge, Taxiway edge, and Apron flood light

(3) Long Term Plan

- installation of ILS,LLZ on 27 side
- relocation of ILS,LLZ on 09 side
- additional work related to Airfield Lighting such as Runway edge, Taxiway edge, and Apron flood light

The relevant work for Runway and Taxiway edge light is planned to conform with ANNEX 10 or 14 and others of ICAO. The following paragraphs describe the development plan for Navigation Aids Systems.

9.5.2 Installation of ILS on 27 Side

It was necessary to install the ILS, LLZ on the 27 side based on the analysis of wind coverage data. Taking into consideration the site and meteological conditions, however, there is no problem related to the existing situated condition where installed the ILS, LLZ was installed on reverse side of the 09 side. There is, therefore, no necessity to take prompt action to modify it. For the Long Term Plan of the project, however, the ILS LLZ shall be installed on the regular position in light of the purpose of the Project, which is to satisfy ICAO standards for providing safe operation of the aircraft. The runway shall be provided with CAT-I ILS for the long-term plan, and a new MLS will be established, and shall be applied from this phase.

9.5.3 Approach and Departure Procedure

The current terminal area, Standard Arrival routes, Instrument Approach and Standard Instrument Departure Procedures for BIA are shown in the APPENDIX 9.5.1-6. The procedure by Denpaser VOR (Bali VOR BLI) which is located 3.5 NM of South side from BIA is used for the intermediate approach, but isn't used for the final straight approach procedure because of the unsuitable location for it.

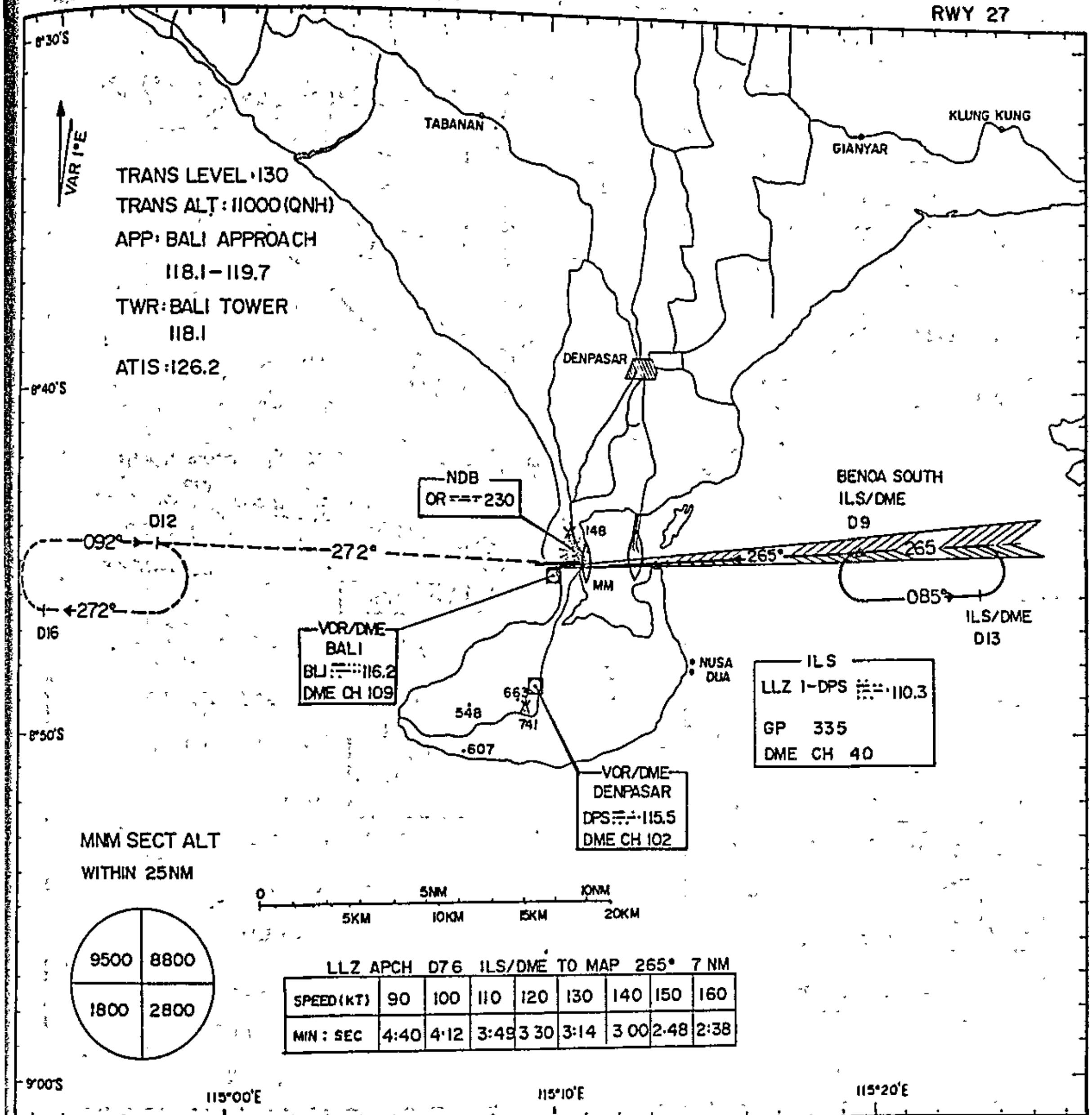
It is conceivable to establish a more effective STAR, SID and Instrument Approach procedures as shown in Figs. 9.5.1 and 9.5.2 when DME is co-located on the Denpasar VOR.

Considering the aircraft noise problem for BENOA and Nusa Dua Area around the final approach area, the Glide Path angle of ILS should be modified from 2.75° to 3° when the runway length is extended more than 300 m.

INSTRUMENT APPROACH CHART – ICAO

AERODROME ELEV 10 FT

BALI INTL/NGURAH RAI
INDONESIA
VOR/ILS RWY 27

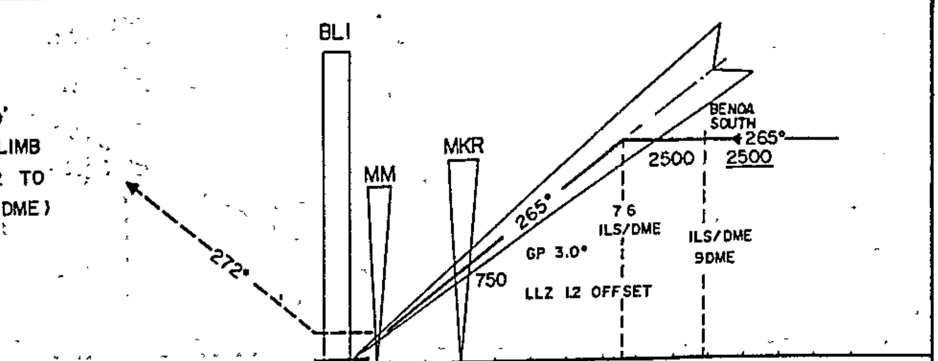


LLZ APCH D7.6 ILS/DME TO MAP 265° 7 NM

SPEED (KT)	90	100	110	120	130	140	150	160
MIN : SEC	4:40	4:12	3:49	3 30	3:14	3 00	2:48	2:38

MISSED APPROACH

AT DH CLIMB TO 500'
THEN RIGHT TURN CLIMB
TO 3000 ON R-272 TO
KUTA (BLI R-272/12 DME)
AND HOLD.
CONTACT ATC.



STA TO RWY 27

	ILS DH 260' ALS AVBL	ILS DH 260' ALS OUT	MM OUT DH 260' ALS AVBL	MM OUT DH 260' ALS OUT	GP OUT MDA 320' ALS AVBL	GP OUT MDA 320' ALS OUT	CIRCLING
	RVR OR VIS	RVR OR VIS	RVR OR VIS	RVR OR VIS	RVR OR VIS	RVR OR VIS	MDA – VIS
A							460' – 1900M
B	1000M	1200M	1000M	1200M	1200M	1400M	520' – 2800M
C							1160' – 3700M
D	1200M		1200M			1600M	1160' – 4600M

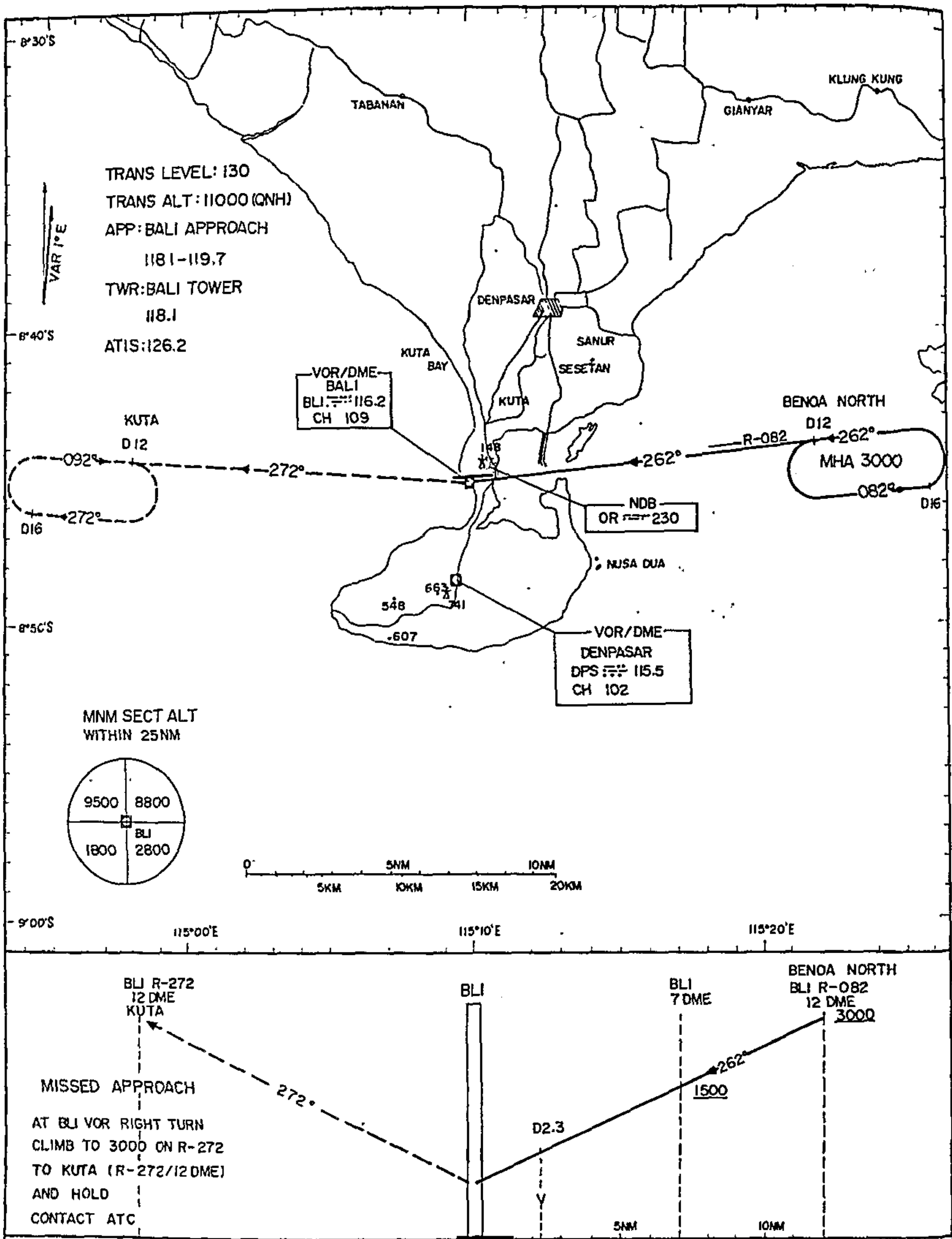
Fig. 9.5.1

INSTRUMENT APPROACH CHART– ICAO

AERODROME ELEV 10 FT

BALI INTL / NGURAH RAI INDONESIA

VOR / DME RWY 27



	STA TO RWY 27 MDA 460' ALS AVBL	STA TO RWY 27 MDA 460' ALS OUT	CIRCLING MDA – VIS
A			460' – 1900M
B	VIS RVR 1200 M	VIS RVR 1600M	520' – 2800M
C			1160' – 3700M
D	VIS RVR 1400M	VIS 2600M	1160' – 4600M

Fig. 9.5.2

9.5.4 Apron Floodlighting

The apron floodlighting system is designed to conform with the Airport Terminal Reference Manual of I.A.T.A and Airport Design Manual by ICAO. These manuals outline the primary function of apron floodlighting as follows:

- to assist the pilot to taxi his aircraft into and out of the final parking position
- to provide lighting suitable for embarkation and disembarkation of passengers, and for personnel to load and unload cargo, for refueling and other apron service functions
- to maintain airport security

In these matters, the recommended levels of illumination are as follows:

- horizontal illumination - 20 lux with a uniformity ratio (average to minimum) of not more than 4 to 1.
- vertical illumination - 20 lux at a height of 2 meters above the apron in the relevant direction

Direct lighting in the direction of a control tower and landing aircraft shall be avoided. The color of apron lighting is preferred to be as close to daylight as possible. Generally, it will be a combination of high-pressure mercury lamps and halogen lamps. Taking into account the relation of the parking configuration and buildings, the floodlighting poles will be installed on the top of buildings. The layout for apron floodlighting is shown in the APPENDIX 9.5.8.

9.6 Passenger, Cargo Terminal Facilities and Other Buildings

9.6.1 General

Passenger terminal facility planning should be dssigned to provide effective passenger and baggage flow efficiently within a terminal area located between the "airside" and the "landside."

Passenger terminal facilities should satisfy functional requirements such as passenger and baggage flow routes, and facility requirements for number of peak hour passengers etc. They must also be planned for BIA to express Balinese traditional architectural style and characteristics for the terminal buildings in order to provide a suitable eastern air gateway to Indonesia.

Bali island is well known around the world as a "tropical paradise." The island has special characteristics related to the sun, the sea, sand and smiles. That is, always sunshine in the blue sky, beautiful coral reefs in the blue sea and wonderful sandy beaches. The Balinese people always smile and express happiness to visitors from anywhere in the world with a hearty welcome to them whenever.

Considering the Balinese characteristics stated above, tropical plants, Balinese historical sculpture, artcraft carvings, and wall carvings, will be provided in the building decor and the areas surrounding the buildings, as much as possible, in order that visitors will enjoy seeing them and experience architecturally esthetic feelings, while in and around the buildings.

The design criteria to be applied to the passenger terminal facilites, are as follows:

(1) Passenger ternimal buildings should be desinged to provide adequate facility requirements based on the number of peak hour passengers.

(2) The buildings should be compatible with wide body aircraft B-747.

(3) Existing terminal facilities should be utilized as much as possible in terms of the effective use of the existing terminal facilities.

(4) It should be possible to expand the buildings easily in the future and future aircraft design should be considered.

(5) The buildings must be compatible with mixed flights operated between Denpasar and Jakarta by Garuda.

(6) Since the buildings are being utilized by the public, it will be necessary to provide adequate facilities for physically handicap visitors.

Perspective drawing of International Passegner Terminal Buildings for the year 1990 the Short Term Plan is shown in the end of this section.

9.6.2 <u>Internaitonal Passegner Terminal Building</u>

(1) Arrival Passenger Terminal Building

In the Short Term Plan (the year 1990) existing internaitonla passenger terminal builidng is planned to accommodate both international and domestic arrival passengers. Since the building was designed to function as one complete building unit, the building cannot in fact be expanded on the 2nd floor.

In addition, an arrival passenger terminal building normally requires more 1st floor area than in a departure passenger teminal building.

The total floor area for the arrival passenger terminal building will be about 9,700m^2 including expansion of the 1st floor.

Thereafter, the arrival passegner terminal building will be utilized solely as an international arrival building in the development plans for in the year 2000 Middle Term Plan and in the year 2010 Long Term Plan.

(2) Departure Passenger Terminal Building

A new international departure passenger terminal building will be constructed west of the international and domestic arrival passegner terminal building in the Short Term Plan as shown in DWGs. 9.6.1 - 9.6.4. The new departure building will be two stories and will be constructed of reinforced concrete with 7m x 7m spans that will be designed for the most economical sturcture. The total floor area for the new building will be about 10,700m^2 including the Control Tower. In the Middle and Long Term Plan, facility requirement for the building will be expanded based on increasing passegner vloumes.

The layout for both the arrival building and the new departure building are shown in DWGs. 9.6.1 - 9.6.4, and Boarding Bridge installation is also explained in the APPENDIX 9.6.1.

9.6.3 Domestic Passenger Terminal Building

The existing domestic passegner terminal builidng is planned to be used only for a domestic departure passenger terminal building in the 1990 development plan. The departure building will be renovated within the entire terminal area with a total floor area of 3,350m^2.

In 1990, development plan a one and a half level concept cannot be applied to the departure building because the aircraft stand in a parallel parking configuration as shown in Fig. 9.2.5.

In the year 2000 development plan a new domestic passenger terminal builidng will be planned to be constructed to the east of the international arrival passenger terminal building as shown in Fig. 9.2.6, and a total floor area of 24,700m^2 must be provided. The building will be designed as a linear concept with one and one half levels. The 1990 Renovation Plan for the building is shown in DWGs. 9.6.5 and 9.6.6.

9.6.4 Cargo Terminal Building

Since the existing cargo terminal builidng is badly deteriorated, a new cargo terminal building will be constructed in the 1990 development plan and will be located west of MNA's Hangar as shown in Fig. 9.2.6.

The builidng will consist mainly of a cargo storage area and an office area with a total floor area of 3,045m^2 as shown in DWGs. 9.6.7 - 9.6.9. The cargo storage area will be a one storely building (steel frame structure) and will have a floor area of about 2,310m^2 excluding break down and make up area located facing the Apron. The office area will be a one storey reinforced concrete structure and will be about 750m^2 in area.
In the Middle and Long Term Plan, facility requirements for the cargo terminal building which includes the existing MNA hangar building will be expanded based on increasing cargo volumes.

9.6.5 Existing MNA Hangar Building

The existing MNA hangar building will be planned to be used for a maintenance hangar in the 1990 development plan. In the 2000 development plan the building may be used for a part of the cargo terminal building taking into consideration effective use of the existing facilities.

9.6.6 New MNA Hangar

A new MNA hangar will be constructed in the existing Zamrud's hangar in the 2000 development plan and will have a total floor area of about 1,800m^2. This hangar will be utilized as a maintenance building for YS-11 class aircraft as the basis for MNA. The existing Zamrud's hangar will be removed in the 2000 development plan. The new hangar will consist of a maintenance hangar area, office areas, storages and maintenance training area. The hangar will be a one storey building (steel frame structure), and there will be a two storey steel frame structure for the offices, storage, etc.

9.6.7 GSE Workshop Building

The existing GSE Workshop Building will be moved to a location adjacent to the west end of the Zumrad Hanger due to the apron extension which is included in the 1990 development plan as shown in Fig. 9.2.6. The workshop can be utilized in the future.

9.6.8 Ancillary Facilities at Terminal Building

The ancillary service system at the Passenger Terminal building should conform with basic requirements mentioned in the Airport Terminals Reference Manual by IATA which are as follows:

- Airline office communication system within the airport.
- Airline office communication system between the town office and the airport.
- Telephone, telegraph and postal service at the airport for use by passengers, crews, cargo interests, greeters, visitors and staffs.
- Communication service between airline office in the terminal and personnel on the apron.

The above mentioned items are the basic requirements for the Airport Communication Systems.
In addition, an efficient public service system will include the following.

- provision of integrated visual information
- visual information display
- public address system
- flight information display
- closed circuit television

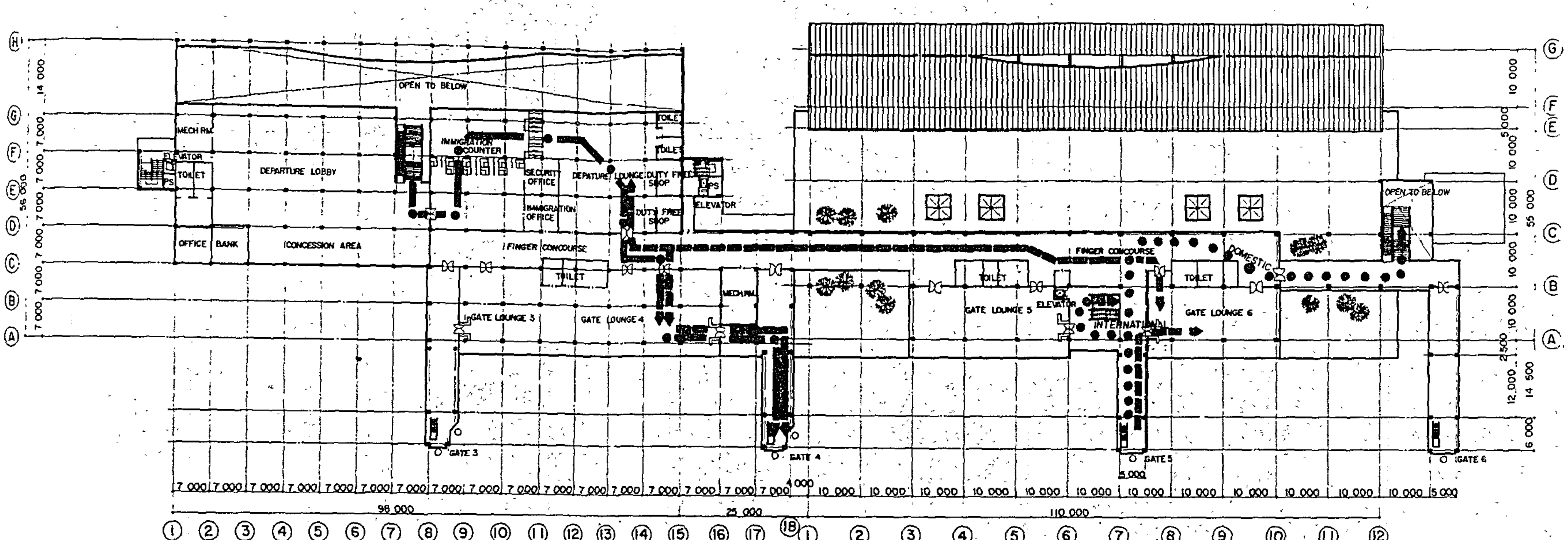
For the Cargo Terminal Building, it is considered that a good communication system with the features shown below is necessary:

- pneumatic tubes
- message conveyors
- teletype machines
- ground radio

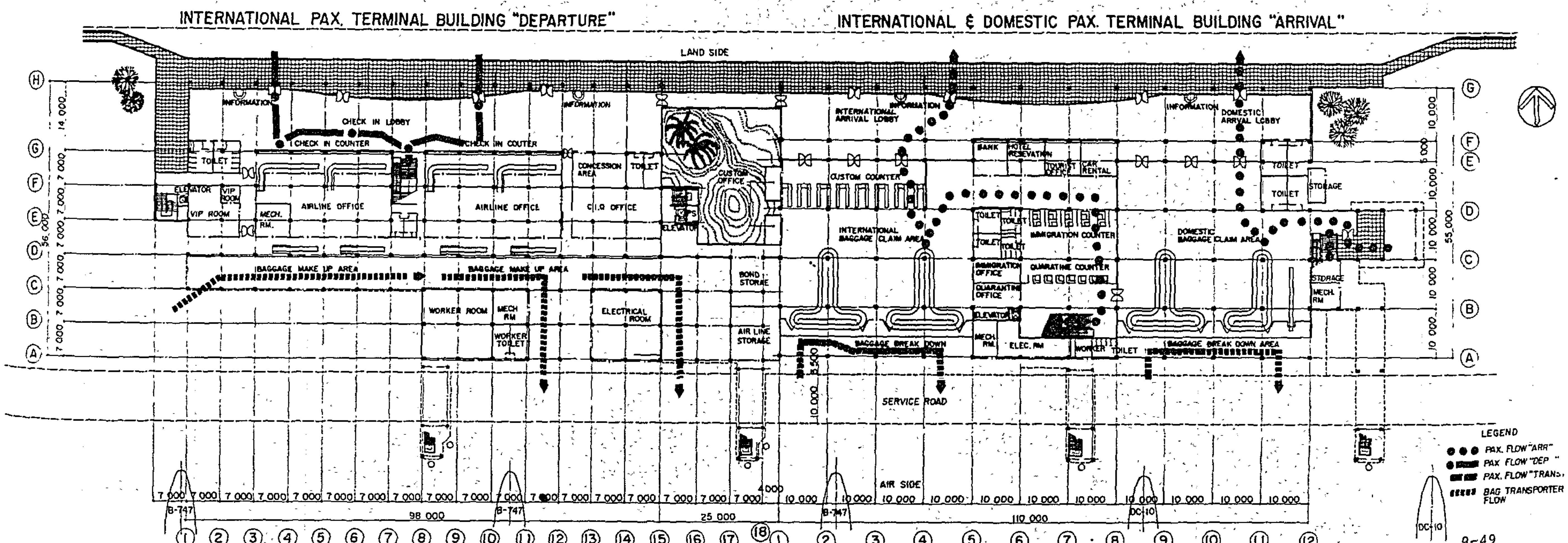
In additon to the above mentioned items, it is common to install the following systems for ancillary service in the Passenger and Cargo Terminal Buildings, for the purpose of providing a high level service to airport users.

- Electric clock system
- Cable Television

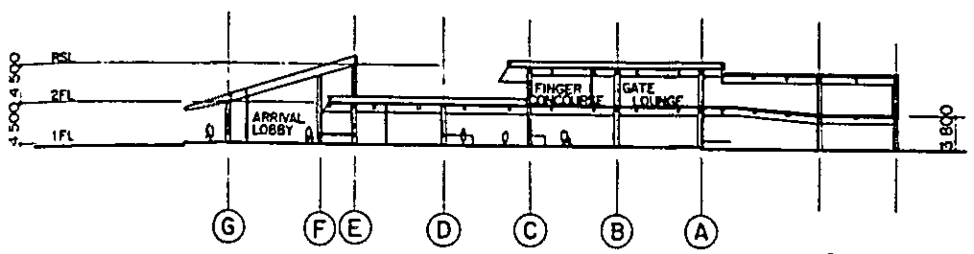
These system are not requirements, but are desirable to install. The adoption of the expanded system shall be made based on the scale, service level and future plan of the terminal building.



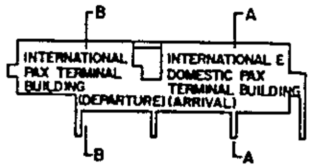
DWG 9·6·2 INTERNATIONAL PAX. TERMINAL BUILDING "DEPARTURE", INTERNATIONAL & DOMESTIC PAX. TERMINAL BUILDING "ARRIVAL", 2ND. FLOOR PLAN S=1:800

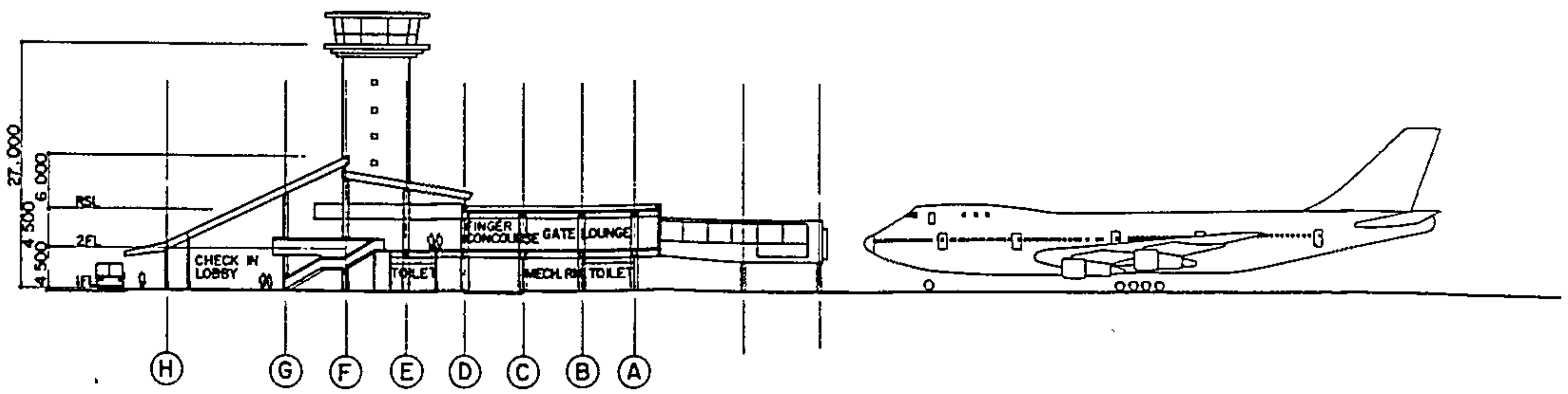


DWG 9·6·1 INTERNATIONAL PAX. TERMINAL BUILDING "DEPARTURE", INTERNATIONAL & DOMESTIC PAX. TERMINAL BUILDING "ARRIVAL" 1ST. FLOOR PLAN S=1:800

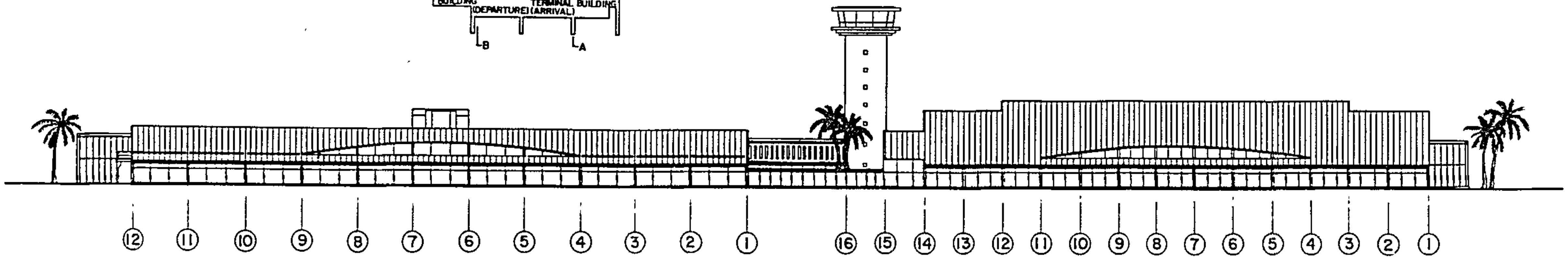


A-A SECTION



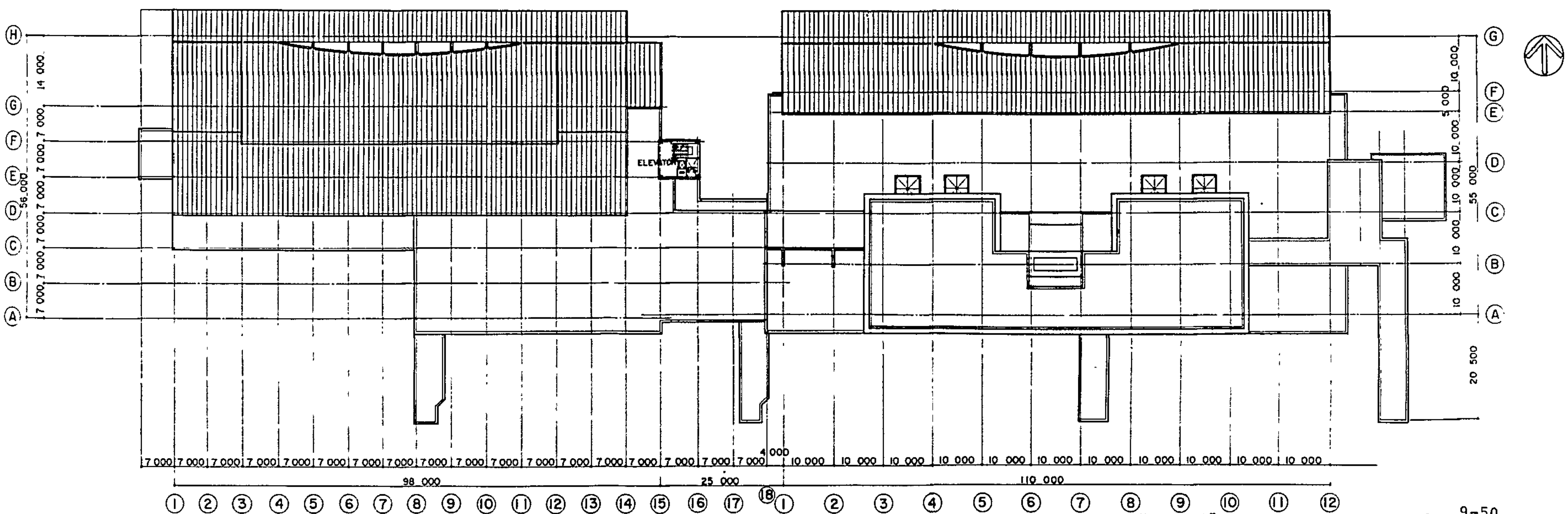


B-B SECTION



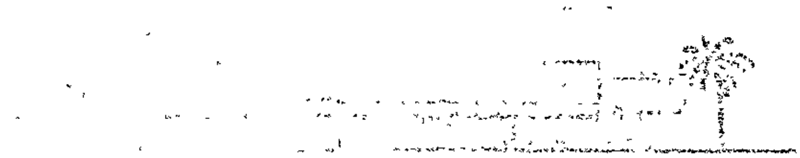
NORTH ELEVATION

DWG 9·6·4 INTERNATIONAL PAX. TERMINAL BUILDING "DEPARTURE", INTERNATIONAL & DOMESTIC PAX. TERMINAL BUILDING "ARRIVAL", S=1:800

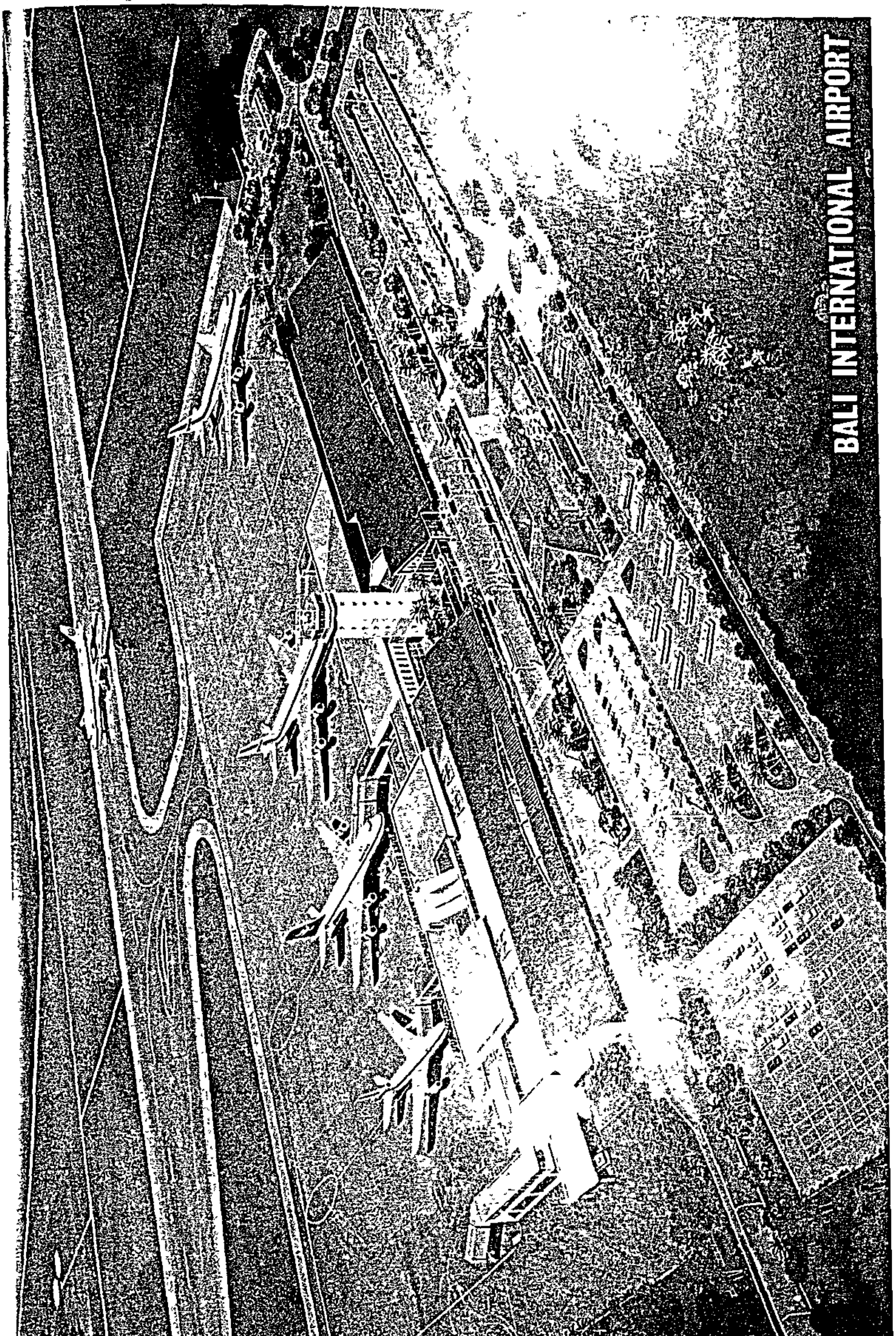


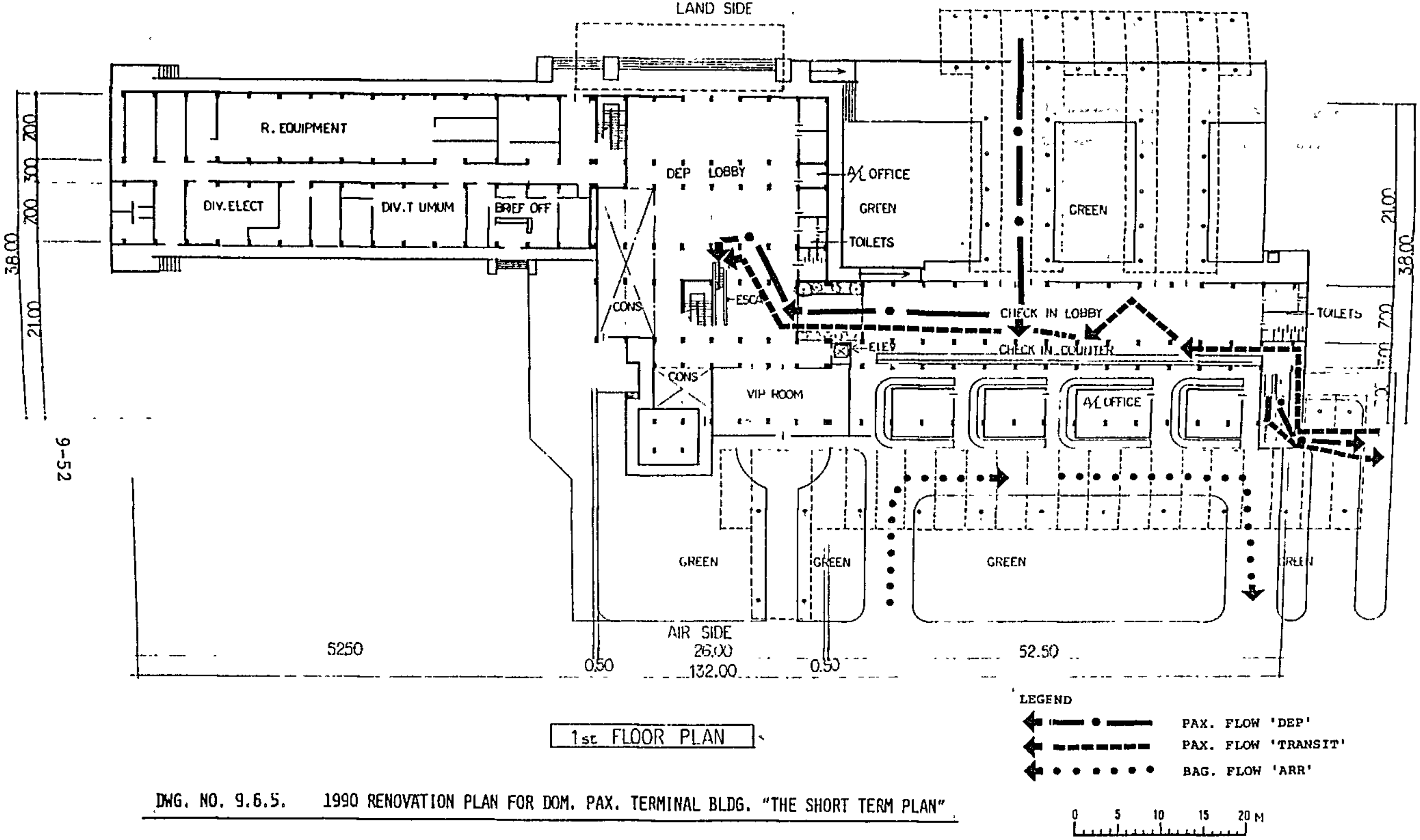
DWG 9·6·3 INTERNATIONAL PAX. TERMINAL BUILDING "DEPARTURE" INTERNATIONAL & DOMESTIC PAX. TERMINAL BUILDING "ARRIVAL" ROOF PLAN S=1:800

A-A SECTION



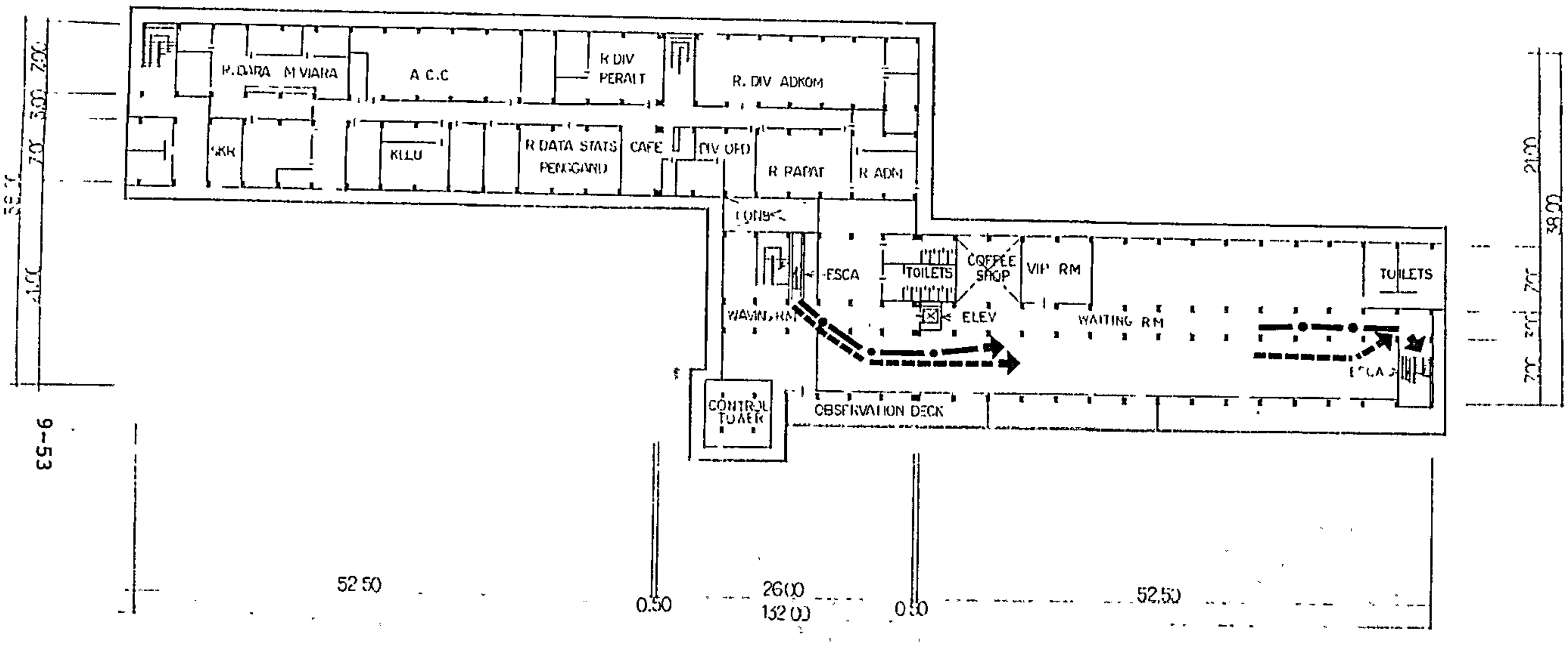
DWG 9-5-3


BALI INTERNATIONAL AIRPORT



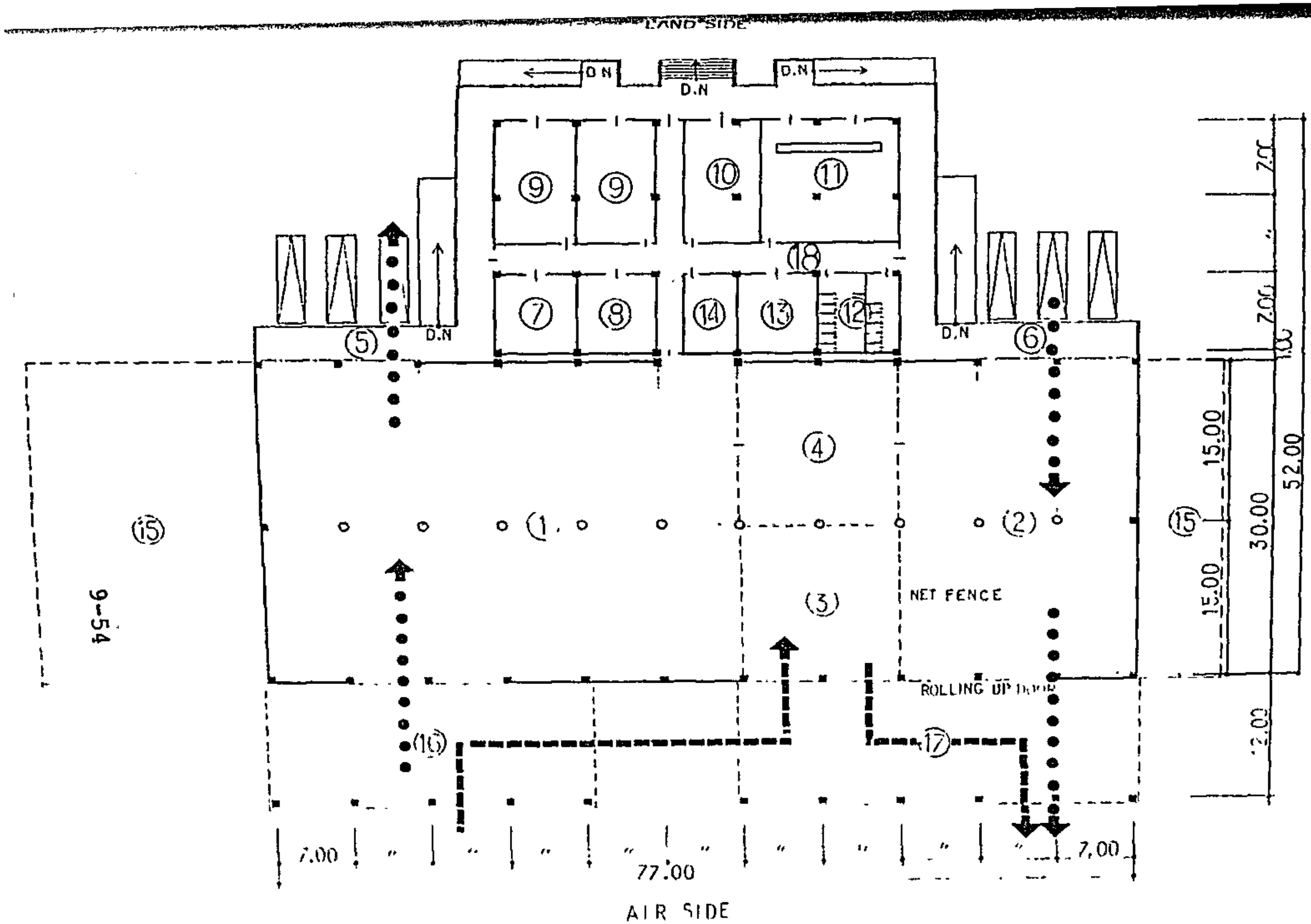
1st FLOOR PLAN

DWG. NO. 9.6.5. 1990 RENOVATION PLAN FOR DOM. PAX. TERMINAL BLDG. "THE SHORT TERM PLAN"



2nd FLOOR PLAN

DWG. NO. 9.6.6. 1990 RENOVATION PLAN FOR DOM. PAX. TERMINAL BLDG. "THE SHORT TERM PLAN"



1st FLOOR PLAN

DWG. NO. 9.6.7. CARGO TERMINAL BUILDING "THE SHORT TERM PLAN (1990)"

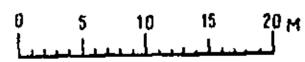
LEGEND

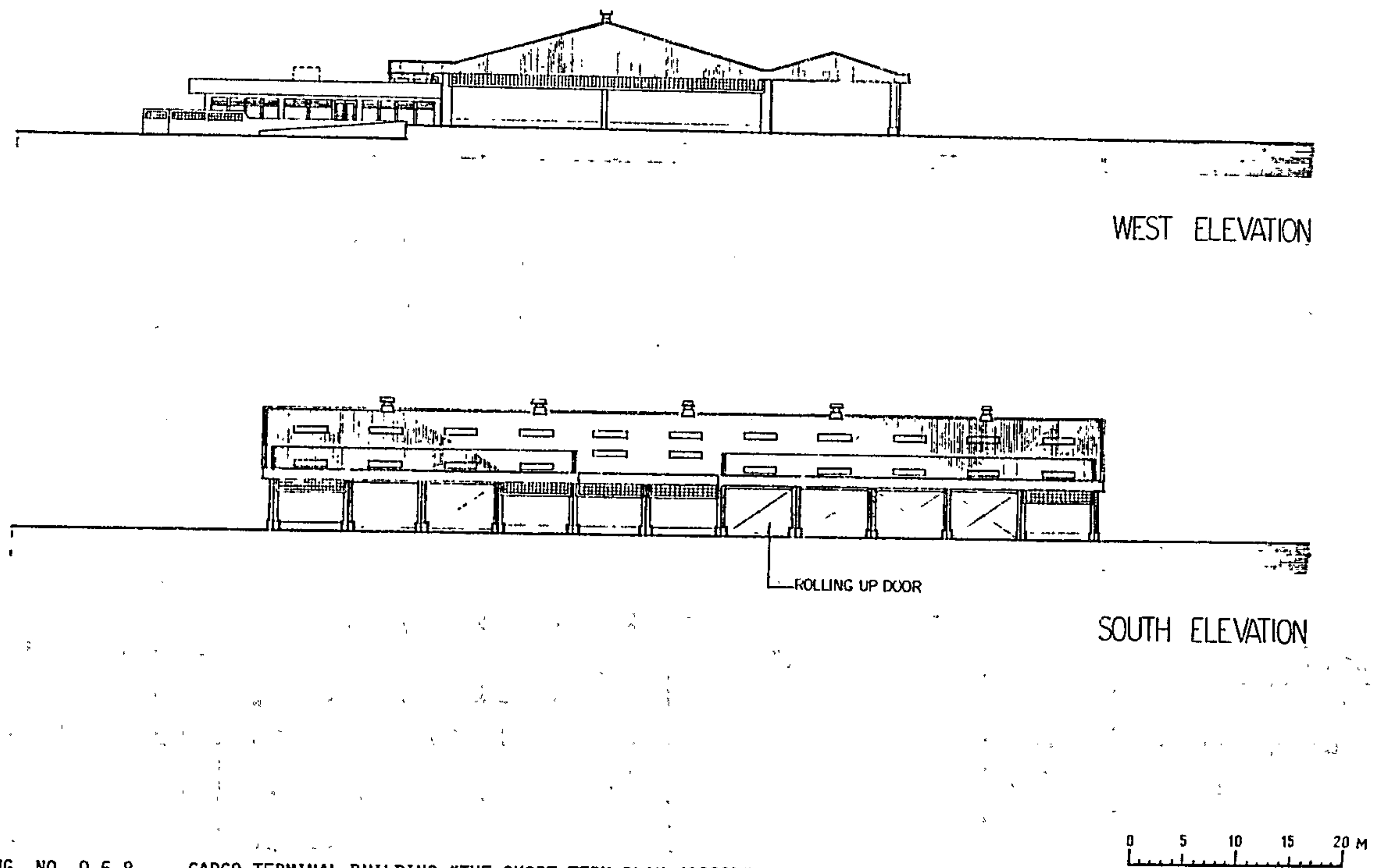
(1)	STORAGE (IN-BOUND)
(2)	" (OUT-BOUND)
(3)	TRANSIT STORAGE
(4)	BOUND STORAGE
(5)	TRUCK DOCK (IN-BOUND)
(6)	" " (OUT-BOUND)
(7)	FREEZER & COLD STORAGE
(8)	" " "
(9)	AGENT OFFICE
(10)	CUSTOM OFFICE
(11)	A/L OFFICE
(12)	TOILETS
(13)	SUB-STATION
(14)	STORAGE
(15)	FUTURE EXPANSION
(16)	BREAK-DOWN AREA
(17)	MAKE-UP AREA
(18)	CORRIDOR

LEGEND

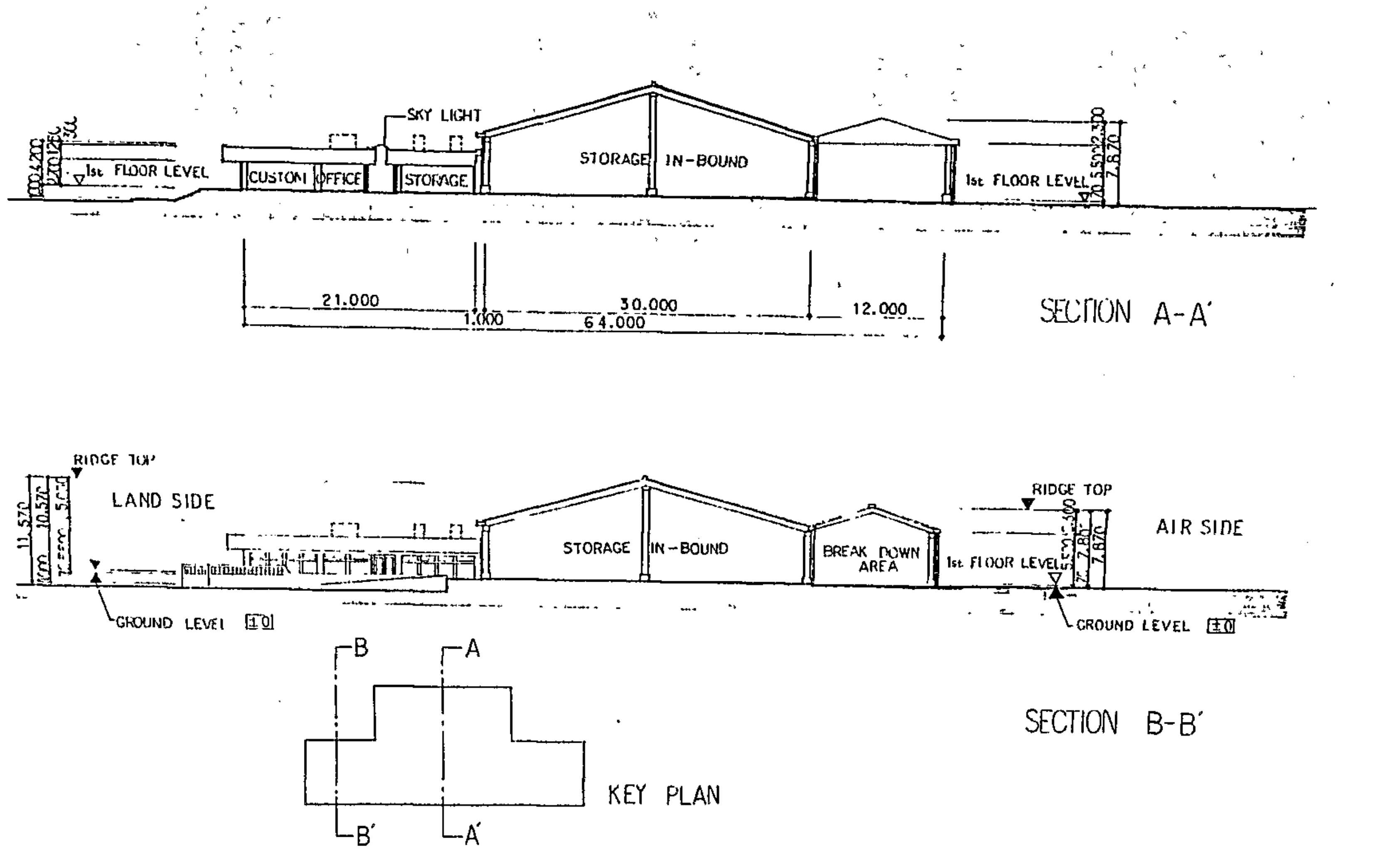
CARGO FLOW 'IN-BOUND & OUT-BOUND'

CARGO FLOW 'TRANSIT'





DWG. NO. 9.6.8. CARGO TERMINAL BUILDING "THE SHORT TERM PLAN (1990)"



DWG. NO. 9.6.9. CARGO TERMINAL BUILDING "THE SHORT TERM PLAN (1990)"

9.7 Administration and Operational Facilities

9.7.1 Administration Building

The existing administration area is situated in the existing domestic passenger terminal building and will be used in the 1990 development plan. In the year 2000 development plan an administration area will be planned to be located on the third floor of the new domestic passenger terminal building and will be about 3,500m^2 in total floor area.

9.7.2 Control Tower

A new Control Tower will be constructed to be located in the new international departure passenger terminal building in the 1990 development plan. The height of the control tower has been determined to be approx. 27m in accordance with FAA standards.

9.7.3 Rescue and Fire-Fight

The existing facilities and facility requirements are as shown in Table 5.6.2 and 6.5.1. The shortfall values of discharge rate and CO_2 can be rectified by using additional type D foam tenders. In conclusion, the number of additional vehicles to satisfy the requirements of CAT-9 in Short Term Plan are as follows:

Foam tenders	Type A-1:	Water tank - 1
"	Type B-1:	Rescue tender - 2
"	Type C-1:	Ambulance - 1
"	Type D-4:	Jeep Comand - 1

In addition to the abovementioned requirements, taking into consideration, the location of BIA (being surrounded by sea on both sides), it is recommended that rescue boats be provided.

The rescue boats will be utilized by rescuers for rescue of injured persons.

A rescue boat will be equipped with a carriage so that it is easy to tow it from the storage area and to release it to the sea.
Two launching ways and their access roads to be used for rescue boats are planned as shown on Fig. 9.7.1. In addition, there are many locations surrounding the airport where the rescue boat can be launched other than from permanent launching ways.

Storage for rescue boats will be provided at the new fire station building taking into consideration maintenance and rescue performance and the specification of the boats is outlined below.

RESCUE BOAT : 3 F.R.P boats for a five seater with towing carriage.

9.7.4 Other Buildings

(1) Other Office and Facility Buildings

Other office such as the immigration office, customs office, post office, quarantine offices, security office, telephone office, police station and meterological office located in north of the airport adjacent to the access road will be utilized both in the 1990 and 2000 development plans. Other facilities buildings such as NDB TX and Radar situated at the same place will also be utilized until the 2010 development plans.

In the 2010 development plan one cluster where the security office, post office,police station, telephone office, metrological office, two temporary garage buildings and about 24 living quarters. located in north of the airport facing the existing domestic passenger terminal building, will be removed, and these offices will be relocated to the 3rd floor of the international departure passenger terminal building because car parking will be expanded.

(2) Living Quarters

The existing living quarters (about 120 units) located in north of the airport next to a golf course, will not be influenced by the airport development plan for each of the key years 1990, 2000 and 2010. Living quarters can be expanded either to the west or to the east in accordance with current zoning map implemented by the authority office - BUPATI.

Since the number of airport employees is expected to increase to about 800, in the 1990 development plan the required living quarters will be constructed.

(3) An Emergency Building

The purpose of an emergency building will be utilized not only for emergency cases such as aircraft crash, a large fire, but also for transmigration as public amenity. Proposed locations are two places as shown in Fig. 9.7.2.

The building will be constructed newly in the year 1990 : the Short Term Plan.

The building will be a one story steel frame structure or brick wall structure with total floor area of about 500 sq.m (i,e. existing emergency room has a total floor area of 490 sq.m.).

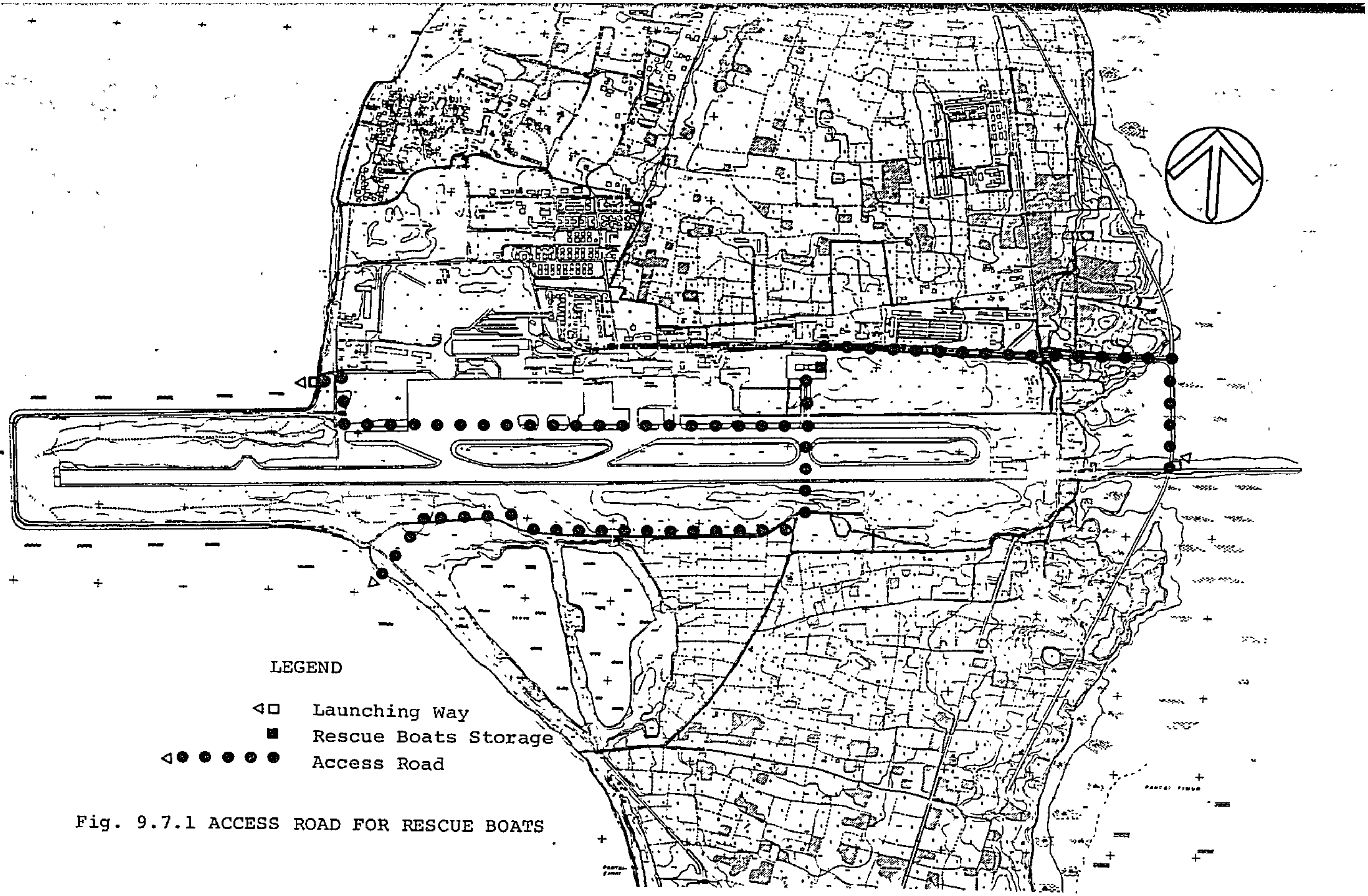


Fig. 9.7.1 ACCESS ROAD FOR RESCUE BOATS

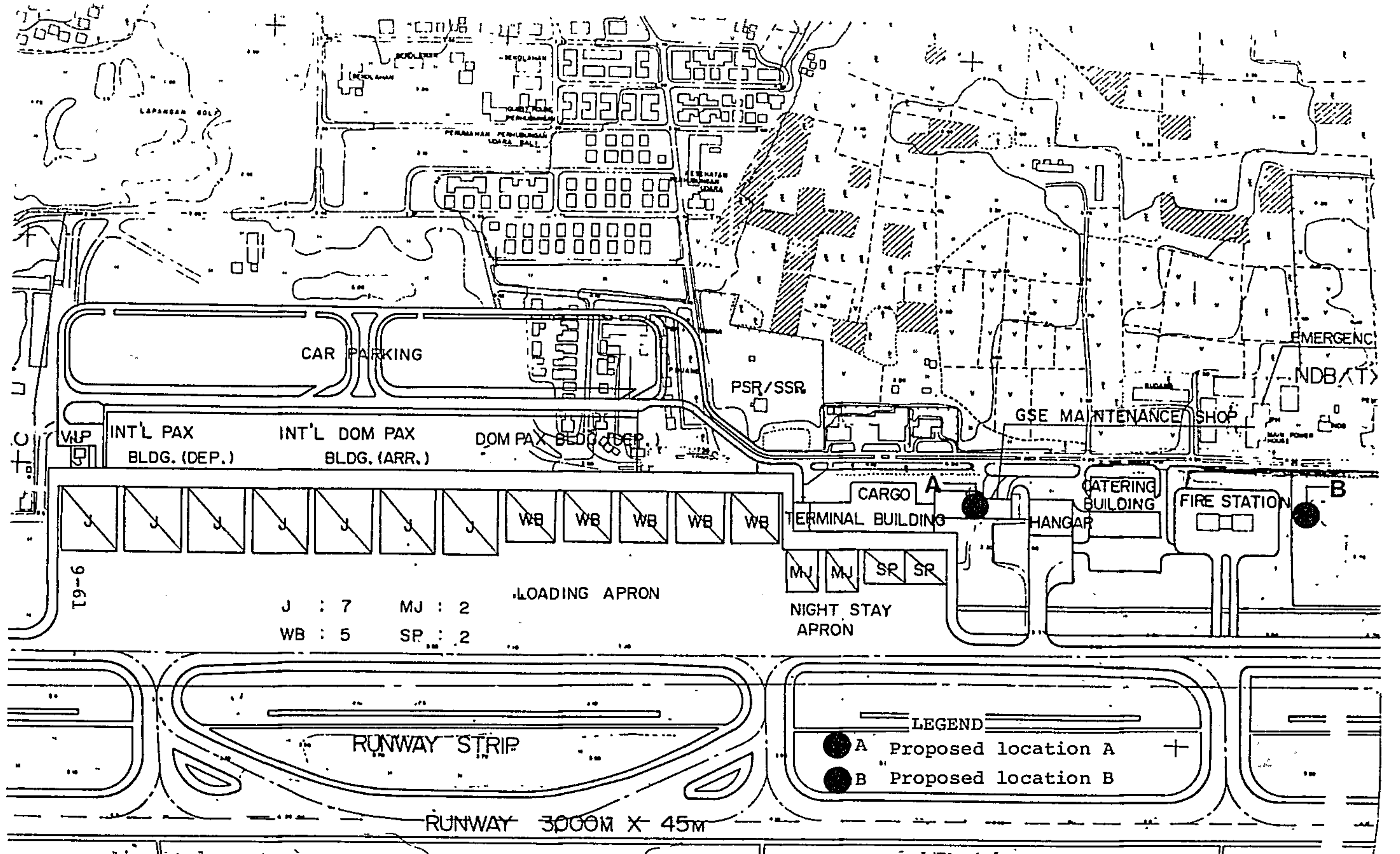


Fig. 9.7.2 PROPOSED LOCATIONS OF EMBRGENCY BUILDING

9.8 Service Facilities

9.8.1 Aviation Fuel Supply System

For the servicing of small aircraft, the refueler system is efficient since the location of aircraft stands is not usually fixed. The hydrant system, however, is efficient for the servicing of large aircraft with many aircraft stands as in the future BIA, for the following reasons:

- Large number of pieces of Ground Service Equipment (GSE) will be required and these GSE will cause traffic congestion on the apron.
- Such traffic congestion will cause bad effects on the safe refueling operation in case of the use of a refueler system.
- For the large aircraft, the nose-in aircraft parking system prevails and the location of aircraft stands is fixed, therefore, effective and safe refueling operation can only be made using a hydrant system.

Based on the above point of views, the hydrant system for large aircraft stand has been chosen for the Long Term Plan which requires a considerable number of large aircraft stands.

9.8.2 Power supply and Generating System

The requirements for electricity will increase in proportion to the implementation of the development plan for airport facilities and buildings.

The capacity of the Generator System can be estimated with a load factor of 70% on the installed capacity. The requirements for electrical capacity for these systems are as follows:

ITEM	1990	2000	2010
Electricity Requirements (KVA)	3,500	5,600	8,100
Emergency Load Capacity (KVA)	2,500	3,900	5,700
Generator's Unit Capacity (KVA)	2,850 x 1	2,850 x 2	2,850 x 2

In the development of the Power Supply System, it is planned to retain the current basic concept for the distribution network. The tentative plan is shown in the APPENDIX 9.8.1.

The existing sub-station building will be expanded with an additional floor area of about $100m^2$ for a total floor area of about $330m^2$ which will be required for additional transformed and other equipment to be installed in the Short Term Plan. In the year 2000 development plan a new sub-station room will be planned to be expanded in the new domestic passenger terminal building and will have a total floor area of about $400m^2$ which is necessary for new equipment to be installed.

The capacity of the generator will be enlarged step by step in parallel with the development plan in each phase and the current Main Power House will be renovated. The existing emergency generating plant will be used until the necessary renovation work required for new generators to be installed in the 1990 development plan. In the year 2000 development plan a new emergency generating plant building will be constructed within the existing plant. The building will be about $1000m^2$ to accommodate a total generating capacity of about 5,700KVA.

9.8.3 Water Supply System

The introduction and adoption of a water supply system will be established based on the analysis results of the water quality tests. The water quality check on existing well are not to be executed during the field survey periods. The underground water generally seems to be suitable for potable water. Standard of water quality is explained in the APPENDIX 9.8.2.

9.8.4 Sewage Disposal Facility

The current facility is the type of the septic tank and cesspool tank. This is installed at some places. With the development of the existing international passenger terminal building and car parking area, it will be necessary to remove it partially. It shall be considered, therefore, to plan a regular type sewage disposal facility for the Short Term Plan. To study the system, it will be necessary to confirm and establish the total handling volume and minimum limitations for improvement of the treated water.

It is difficult to study the system in detail without the establishment of the abovementioned conditions. For the reference, the simple system is shown in the APPENDIX 9.8.3 as reference only.

9.8.5 Catering Building

A new catering building will be constructed with a total floor area of $700m^2$ in the 1990 development plan and it will be a one storey building (reinforced concrete structure). The building will be located between the new fire station and Zamrud's Hangar.

9.8.6 Security Plan

The fundamental classified facilities for the airport operations such as main substation, transmitting station, PSR/SSR Radar facility and the water treatment plant shall be provided with controlled access from the public and shall be given to suitable security control.

Main substation, emergency generating plant, transmitting station and PSR/SSR facilities are planned to be remain at the existing locations, because the present locations are already isolated from the public area, and ACC, ATC and telecommunication center are to be isolated adjacent to PSR/SSR facilities at the Middle Term Plan (2000).

The water treatment plant will remain at the existing location for the reason that the facility is judged to be a second rank of classified facility in term of security.

The sewage treatment plant should be located at a suitable site considering only engineering factors.

At BIA, it is recommended that the plant be constructed at the north-east side of the Aviation Fueling Facility.

Layout plan of these fundamental classified facilities are shown in Fig. 9.8.1.

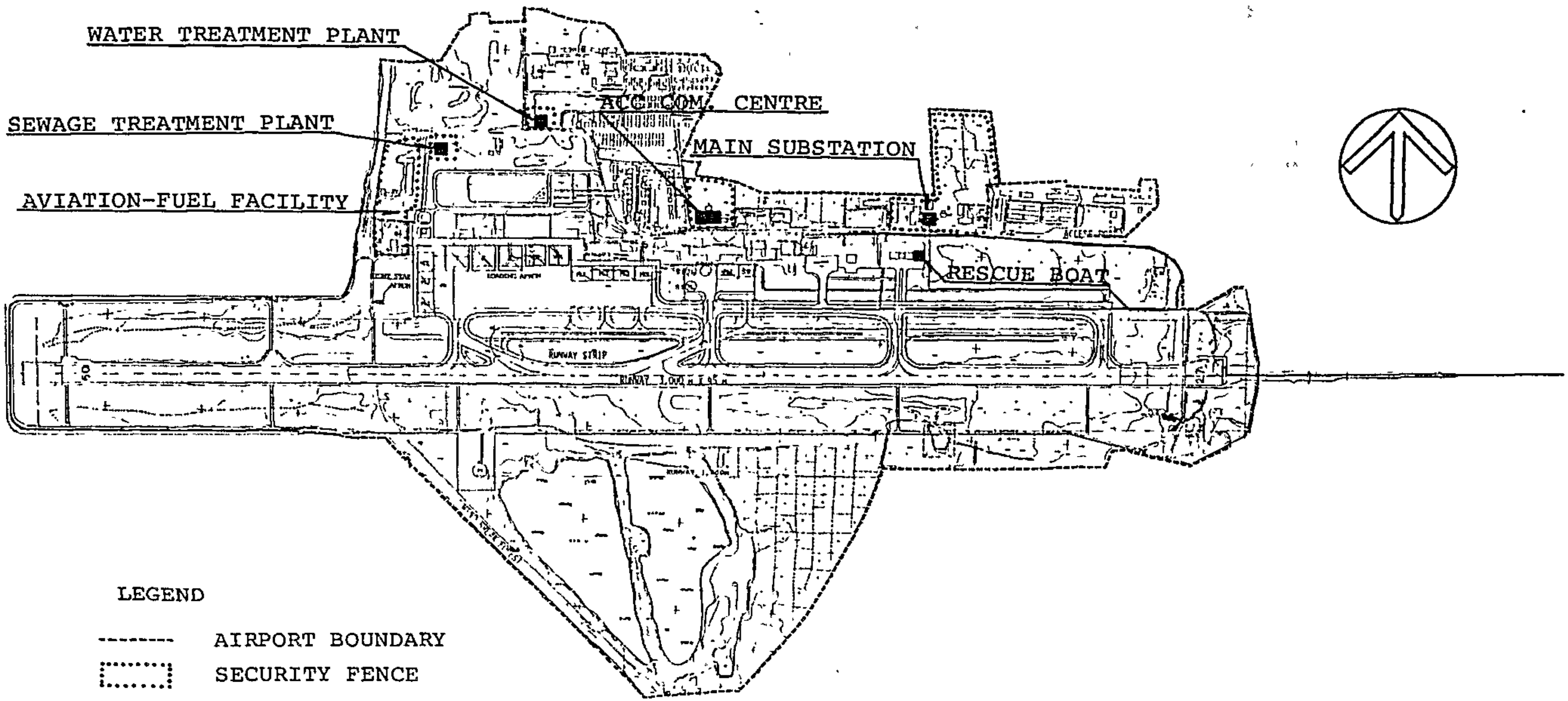


Fig. 9.8.1 LAYOUT PLAN OF FUNDAMENTAL CLASSIFIED FACILITIES

9.9 Access Road and Car Parking

9.9.1 Access Road

The present access road to the Airport from the highway can accommodate the vehicular traffic demand forecast for the Long Term Plan.

No additional development is, therefore, planned for the access road.

9.9.2 Car Parking

The car parking area is planned as an expansion of the existing one.

The overall dimensions for the Car Parking area are 100 meters long and 650 meters wide considering the walking distance from the Car Parking area to the terminals for the target year.

For the Short Term Plan , a car parking area with a capacity for 325 vehicles is to be completed by expanding the area reserved in front of the present international terminal building. During the Middle Term Plan and thereafter, the Car Parking area will be expanded in both directions to the east and west as necessary. In this connection, the existing office are to be relocated to the new domestic passenger building during the Middle Term Plan. No further problems are foreseen as a result of this expansion.

9.10 Comparison between Development Plan and 75's Master Plan

Table 9.10.1shows the results of a comparison between the Development Plan for this study and the 75's Master Plan concerning air traffic demand, airport facility requirements, layout plan, etc. Outlines of the comparison showing the major items are summarized as follows: 75's Master Plan DWGs are shown in the APPENDIX 9.10.1-9.10.5.

9.10.1 Air Traffic Demand Forecast

The forecast value of annual passenger demand for this study shows lower values than 75's Master Plan (68 and 58 percent of forecast values of 75's Master Plan at 1990 and 1995 respectively). The reason for this variation are the big differences in the air traffic trends and the conditions of the Indonesian economy when the forecast was made.

9.10.2 Forecast Aircraft Mix

The shares of jumbo jet aircraft and small propeller aircraft (STOL) in the forecast aircraft mix in this Development Plan are much larger than those of 75's Master Plan. The use of wide-bodied aircraft such as B-747 is an international tendency which has been introduced in Indonesia on air routes with large demand in order to improve the efficiency and transport capacity for air travel. The increase of small propeller/STOL aircraft is the result of basic airport infrastructure development on the many islands of Indonesia. The recent large growth in the economy of Indonesia stimulated the increase of per capita income and promotion of regional exchange. All these factors have caused the growth of air traffic demand.

The above mentioned structural changes in the Indonesian air traffic system are the main reasons for the difference in aircraft mix between this Development Plan and the 75's Master Plan.

9.10.3 Instrument Landing System (ILS)

In the 75's Master Plan, the following plan was made concerning the radio navigational aids:

Phase I	(1985)	CAT I with off-set Localizer
Phase II	(1990)	CAT II with on-course Localizer

The above plan is understood to upgrade the ILS in proportion to the growth of air traffic demand.

In this Development Plan, however, it is considered essential to upgrade the existing ILS with improvement of physical conditions such as runway length, distance of center lines between runway and parallel taxiway, location of apron, etc. rather than the upgrading of ILS categories. The 75's Master Plan intended to upgrade ILS without improvement of physical conditions; however, these physical conditions rather than ILS grade are strongly related to the safe operation of aircraft in terms of the meteorological conditions for BIA.

9.10.4 Terminal Concept

The terminal concept of 75's Master Plan is an L-shaped modified linear concept. The major reasons for selection of this concept are as follows:

- Effective utilization of void area adjacent to the terminal buildings
- Utilization of existing terminal facilities such as domestic passenger terminal building, etc.

In contrast, the terminal concept of this Development Plan is the linear concept because it can cope with the long-term air traffic demand and effectively utilize the existing terminal facilities. Further more, it will be easier to comply with changes of aircraft or changes in aircraft mix as they occur.

9.10.5 Terminal Building

In the 75's Master Plan, International Terminal Buildings are planned to be 1 and 1-1/2 level concepts with a decentralized function on the L-shaped terminal concept, and 3 Domestic Terminal Buildings are planned to be 1 level concept with decentralized function as shown in the APPENDIX 9.10.5.

On the contrary, in terms of about 10 million annual passengers a centralized function is efficiently suitable for the development plan of BIA, and a terminal building is planned to be 1-1/2 level concept judging from function and utilization viewpoints.

Table 9.10.1 COMPARISON TABLE OF 75's MASTER PLAN AND DEVELOPMENT PLAN

	ITEM \ YEAR		Present condition (1980)	75's Master Plan 1985	75's Master Plan 1990	75's Master Plan 1996	Development Plan 1985	Development Plan 1990	Development Plan 1995	Remarks
AIR TRAFFIC FORECAST	1. Annual Passenger (x 1,000)	INT'L	316	910	1,474	2,742	854	1,313	1,860	
		DOM	554	1,346	2,372	3,652	722	1,302	1,874	
		TOTAL	870	2,256	3,846	6,384	1,576	2,615	3,734	
	2. Annual Cargo Valume (Ton)		3,000	6,542	11,153	18,513	5,500	9,300	14,500	
	3. Annual Aircraft Movements		19,300	24,100	41,900	70,800	22,100	25,100	25,800	
	4. Peak Hour Passengers			1,716	3,066	5,170	470	770	1,030	
	5. Peak Hour Aircraft Movements		12	17.9	31.2	51.0	11.4	12.7	13.2	
FACILITY REQUIREMENT	6. Runway		$2,700^m x 45^m$	$3,000^m x 45^m$			$3,000^m x 45^m$			
	7. Runway Strip		$2,900^m x 200^m$	$3,120^m x 300^m$			$3,120^m x 300^m$			
	8. Taxiway		$1,750^m x 30^m$		Complete Parallel Twy			Existing Para.Twy to be Relocated		
	9. Passenger Terminal Apron (No of A/C Stand)		DOM 2:MJ 7:SJ 6:SP/STOL INT'L 3:J/WB	DOM 3:SJ INT'L 1:WB 1:MJ 1:SJ	DOM 5:WB INT'L 4:WB 3:MJ	DOM 9:WB INT'L 8:WB 6:MJ	DOM 2:J 1:WB 6:SJ/MJ 2:SP 6:STOL INT'L 1:J 1:WB	DOM 2:J 1:WB 8:SJ/MJ 1:SP 3:STOL INT'L 1:J 1:WB	DOM 2:J 2:WB 10:SJ/MJ 2:SP/STOL INT'L 3:J	
	10. Passenger Terminal BLDG. (m^2)	INT'L	6,070	5,849	7,994	15,778	12,000	18,400	24,000	
		DOM	3,350	3,394	7,923	13,353	7,700	13,200	18,600	
	11. Cargo Terminal BLDG. (m^2)		1,800	350	800	1,500	1,700	2,800	4,400	
	12. Administration BLDG. (m^2)		2,300	3,040	3,500	4,040	2,500	2,500	2,500	
	13. Air Navigation Systems		ILS CAT-I PSR/SSR C-VOR NDB TX,RX			ILS CAT-II ILS/LLZ TO BE RELOCATED		Add. DME M.M.		
	14. Car Parking (No of Lot)		180	340	447	726	195	325	440	
	15. Access Road (No of Lanes for each direction)		2	1	1	1	1	1	1	
	16. Fuel Supply (Kl)			2-Day Storage 1,700	5,000	9,800	7-Day Storage	6,780	8,490	Storage Capacity
	17. Rescue and Fire-Fighting		CAT-7	CAT-8	CAT-8	CAT-8	CAT-9	CAT-9	CAT-9	
LAYOUT PLAN	18. Terminal Concept		Linear Concept	L-Type Linear Concept			Linear Concept			
	19. Parking Configuration for the Aircraft		Parallel Parking (Self-Manuevering	Nose in,Pushout				J,WB: Nose in, Pushout Others: Self-Manuevering		

CHAPTER 10

SUBSIDIARY STUDIES

CHAPTER 10 SUBSIDIARY STUDIES

10.1 Environmental studies

The following environmental assessment factors are generally studied for the development of an airport.

(a) Air and water quality
(b) Ambient noise levels
(c) Ecological processes
(d) Natural environment

These factors should be studied in order to determine how the development plan can best be implemented.

Bali has been blessed with a wonderful natural environment including the sun, sea and sand. Therefore, the development plan should be carefully planned to be compatible with the environment in and around the airport.

(a) Air and water quality

With regard to air pollution, the environmental impact from airport operations will be minimum to the residents surrounding the airport in terms of the anticipated aircraft movements including ground service equipment and other facilities in the airport. Airport operations in general have not been found up to the present to have any significant polluting influence. Sources of water pollution generally include domestic sewage from airport facilities, industrial waste and high temperature water degradation. It is suggested that a sewage treatment plant be installed for the Int'l PAX. Terminal Buildings in order to avoid any water contamination along the beaches from domestic sewage.

There is no significant amount of industrial waste produced at the airport. There are high temperature cooling water effluents from the emergency generators in the airport. No significant influence, however, will occur since the generators are operated only for emergency proposes.

(b) Ambient noise levels
As will be mentioned in section 10.2, ambient noise levels are obviously the most serious environmental aspect in the development of the airport. One of the most effective means of reducing noise impact is through proper land use planning for the areas affected by aircraft noise. A more datailed explanation is presented in section 10.4, consideration on future land use.

(c) Ecological process
With regard to ecologcal processes such as wildlife, plantations etc., no protected species of wildlife or plantation are located in or surrounding the airport land.

(d) Natural environment
Coastal erosion in the north-west area adjacent to BIA is seriously affecting natural environmental coditions. Therefore, study of this factor should be made as soon as possible.

10.2 Aircraft Noise

10.2.1 Calculation of Aircraft Noise

(1) Formula

Although many evaluation meaures exist in the world, they are all aimed at qualifying the aircraft nosie effect by noise level and frequency.

WECPNL (Weighted Equivalent Continuous Perceived Noise Level) which is used in Japan has been applied as a noise evaluation measure for this study.

The evaluation measure, WECPNL is basically obtained from ECPNL (Effective Continuous Perceived Noise Level) which has been defined by ICAO so that the independently developed noise evaluation measures in the world can be compared on an international basis.

WECPNL is a modified version of ECPNL reflecting the perceived severeness of flight noise at night with larger weights on night flights than daytime flights.

WECPNL is given by the following formula:

$$\text{WECPNL (i)} = 10 \log_{10} [\sum^{j} \text{anti log(EPNL ij)/j}] + 10 \log_{10} N - 39.4$$

where, j: Type of aricraft and type of flight patterns

N: Total weighted number of flight at "i" point
$(= N_1 + 3 N_2 + 10 N_3)$

N_1: Number of flights from 7 am to 7 pm

N_2: Number of flights from 7 pm to 10 pm

N_3: Number of flights from 10 pm to 7 am

i: Any selected point

For the BIA project, the applicable time is considered to be one hour earlier than the above mentioned ones, because of the time difference between Bali and the rest of Indonesia.

(2) Basic Conditions for Noise Calculation

The take-off profile has been determined, as shown in Fig. 10.2.1, to be function of distance to destination and type of aircraft as shown in Fig. 10.2.2. Hence, the distance to aircraft from any point, (the so called; Slant Distance) is calculated as shown in Fig. 10.2.3. Since EPNL (Effective Perceived Noise Level) for every aircraft has been obtained as a fucntion of the slant distance as is indicated in Fig. 10.2.3. $EPNL_{ij}$ at "i" point can be calculated based on each aircraft type and flight pattern.

- Number of aircraft movements hourly and daily were established based on Chapter 3; Air Transport Demand Forecast and are shown in Table 10.2.1.
- Other conditions are summarized in Table 10.2.1.

Accordingly, WECPNL at "i" point can be calculated using the aforementioned formula.

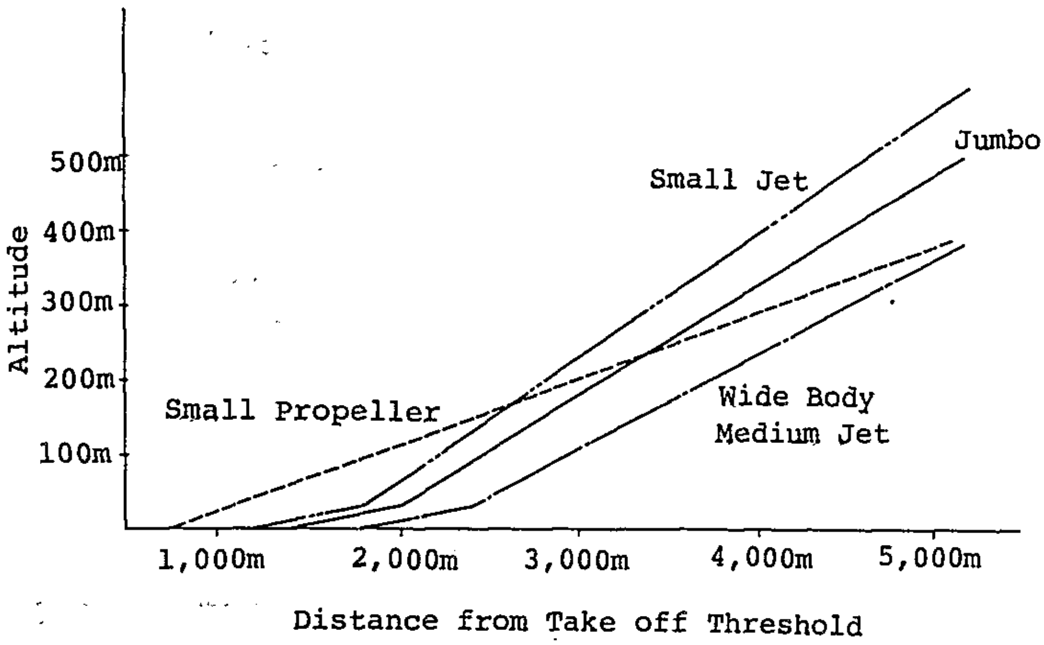


Fig. 10.2.1 TAKE OFF PROFILE

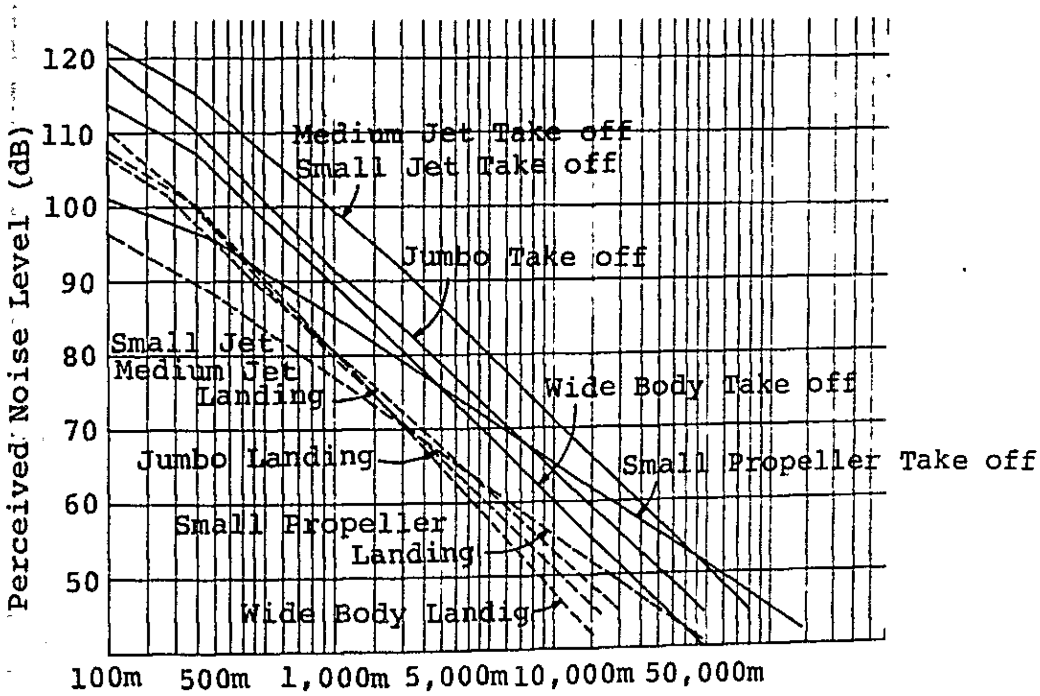


Fig. 10.2.2 PNL AND DISTANCE FROM AIRCRAFT

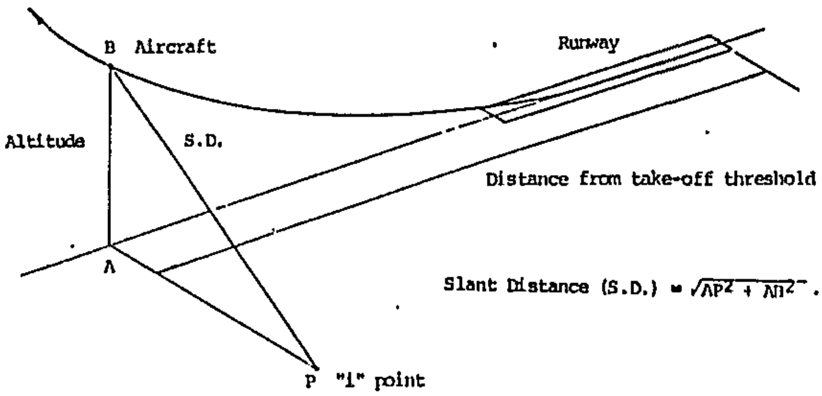


Fig. 10.2.3 SLANT DISTANCE

Table 10.2.1 Number of Daily Flights

Year	Aircraft	6:00 - 18:00	18:00 - 21:00	21:00 - 06:00	Total
1990	JUMBO	7.26	1.98	2.76	12.00
	WIDE-BODY	8.47	2.31	3.22	14.00
	M/S JET	40.00	-	-	40.00
	PROPELLER	18.00	-	-	18.00
	TOTAL	73.73	4.29	5.98	84.00
2000	JUMBO	19.36	5.28	7.36	32.00
	WIDE-BODY	12.10	3.30	4.60	20.00
	M/S JET	32.00	-	-	32.00
	PROPELLER	16.00	-	-	16.00
	TOTAL	79.46	8.58	11.96	100.00
2010	JUMBO	31.46	8.58	11.96	52.00
	WIDE-BODY	33.88	9.24	12.88	56.00
	M/S JET	10.00	-	-	10.00
	PROPELLER	14.00	-	-	14.00
	TOTAL	89.34	17.82	24.84	132.00

Table 10.2.2 Basic Conditions for Noise Calculation

Item	Conditions	
Targetted Year	Long Term Plan : 2010	
Traffic Pattern	As shown on Figures	
Ratio of RWY Use	For JKT, SUB, JOG, TYO	RWY09: 80% RWY27: 20%
	For Others	RWY09: 40% RWY27: 60%
Number of Flights	As tabulated in Tables	
Runway Length	3,000m	
Glide Slope Angle	RWY09: 2.5° RWY27: 3.0°	
Background Sound Pressure Level	40 dB	

10.2.2 Calculated Noise Contours

A high speed computer was used and the contours were plotted using an XY plotter.
Fig.10.2.4 shows the WECPNL noise contours for BIA for the year 2010. The WECPNL noise levels for the year 1990 and 2000 are comparatively lower than those for 2010.

As seen from Fig.10.2.4, the calculated noise contours show a relatively wide area covered by WECPNL 70.
The reasons for this result are summarized as follows:
Based on the time table of scheduled flights at BIA for the year 1981, about 25 percent of the international flights are scheduled to depart/arrive at BIA between 21:00 and 06:00. Due to the geographic position of BIA

on the world air traffic system, the flight schedule of the routes between BIA and Japan or Australia are predominantly at night.
This flight tendency is considered to continue in the future due to the geographic position of BIA and therefore the input conditions for the calculation of noise contours have been made in line with present flight schedules.

It is noted that the WECPNL noise levels at BIA, based on the above considerations, could be reduced if some countermeasures were taken to prohibit midnight flights as are presently being executed in many countries such as England (Heathrow), Japan (Narita & Osaka), etc.

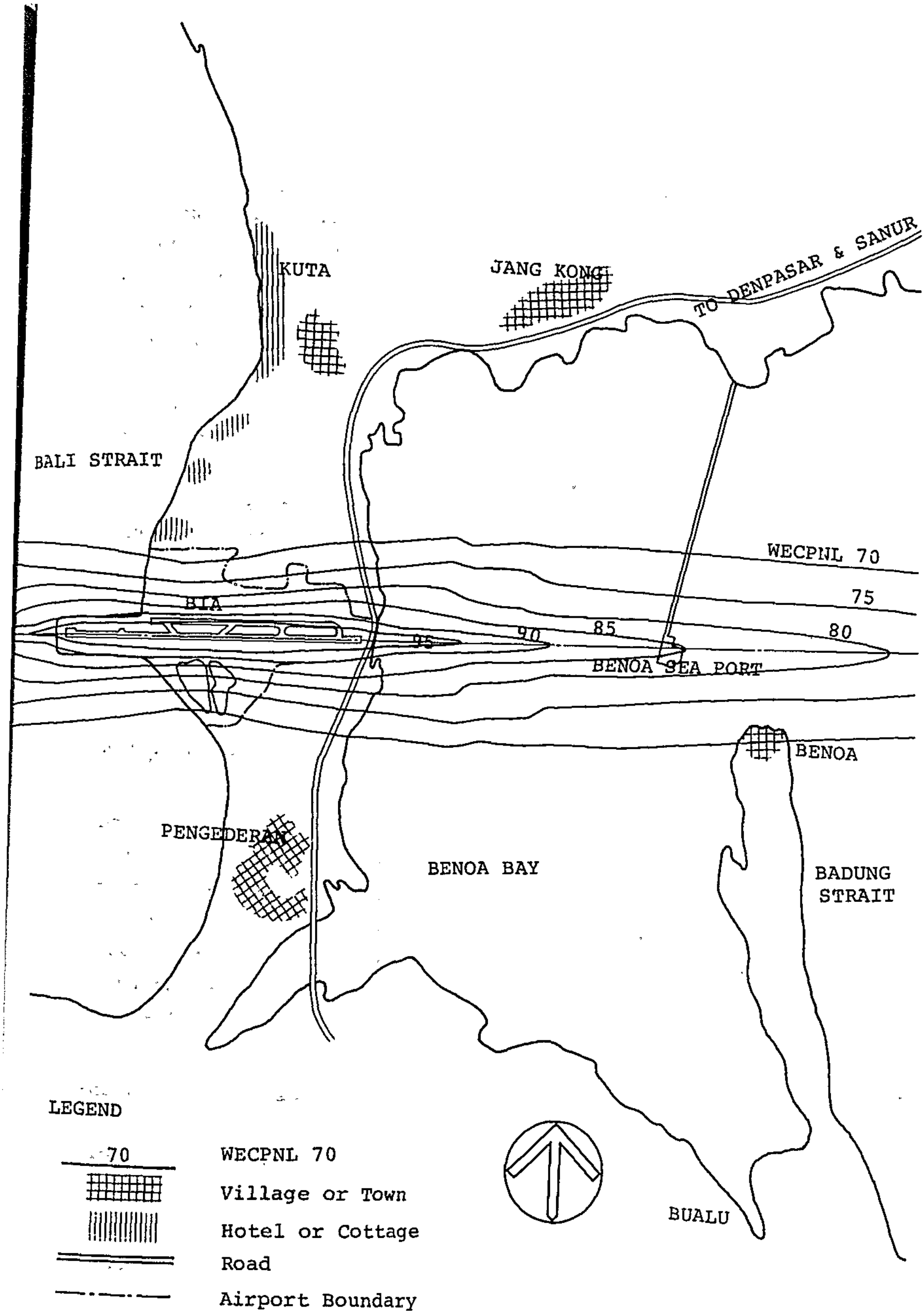


Fig. 10.2.4 WECPNL NOISE CONTOUR (THE YEAR 2010)
S=1:50,000

10.3 Birds Hazard - Flying Birds

One of the specific environmental conditions to be considered is the bird hazard. BIA is surrounded by the sea, ponds and forest. The increase in air traffic demands recently has caused many accidents due to abnormal aircraft operations, damage to aircraft bodies, etc. brought about by collision of aircraft with birds. The importance of countermeasures for this bird hazard is recognized internationally. These measures must be carefully evaluated. Ecological surveys of bird migration habits and investigations into the development of a suitable method for distracting them or scaring them away are being implemented in many countries.

Generally, "water" and "trees" which surround an airport are the biggest reasons for attracting birds.

BIA is surrounded mostly by "water and trees" as shown in Fig.10.3.1, and for this reason the conditions at BIA are considered to provide potential for bird problems.

At this moment, an analysis is under way to clarify the relationship of cause and effect between "water and trees" and bird problems. However, the proportion of areas covered by "water and trees" to the total area of the airport and its vicinity is considered to be an index showing the potential cause for a bird problems. Fig.10.3.2 shows the proportions of areas occupied by water and trees to the total area measured from the center line of the runway.

ICAO standards recommend that any shrubs and trees within at least 180 meters from the runway centerline should be cut back and pits, ditches, swamp areas, etc. within the airport should be drained or backfilled with suitable fill material as much as possible.

Considering this point of view and Fig.10.3.2, BIA has a favorable condition in that there are less areas of water and trees (below 10%) within 180 meters from the runway centerline.

Table 10.3.1 shows the records of bird problem occurrences at BIA within the past three years.

Table 10.3.1 Bird Problem in BIA

Date	Bird Problem
22 Jun., 1981	DHC-6-M-2-3110 collided with birds while taking off
20 - 23 Sep., 1981	Many bodies of birds were found on the runway
15 Oct., 1981	GA878 was delayed in take-off position for about 14 minutes due to a flock of birds flying the runway

All of these bird problem are not so serious. The size of birds observed at BIA are relatively small thereby providing only a limited hazard. Birds flocking are rarely observed (usually at night) and on the runway where they can keep warmer than on unpaved areas.

Based on the above statements, it is considered that specific measures for distracting or scaring birds away are not required to be included in this development plan. It must be noted however, that the existing conditions at BIA may not allow for future incrases in the traffic demand viz. increasing aircraft movements. It is therefore recommended that a detailed ecological survey of birds be executed and a study of the most effective method/devices for scaring birds away from BIA be undertaken in order to provide for safe aircraft operations.

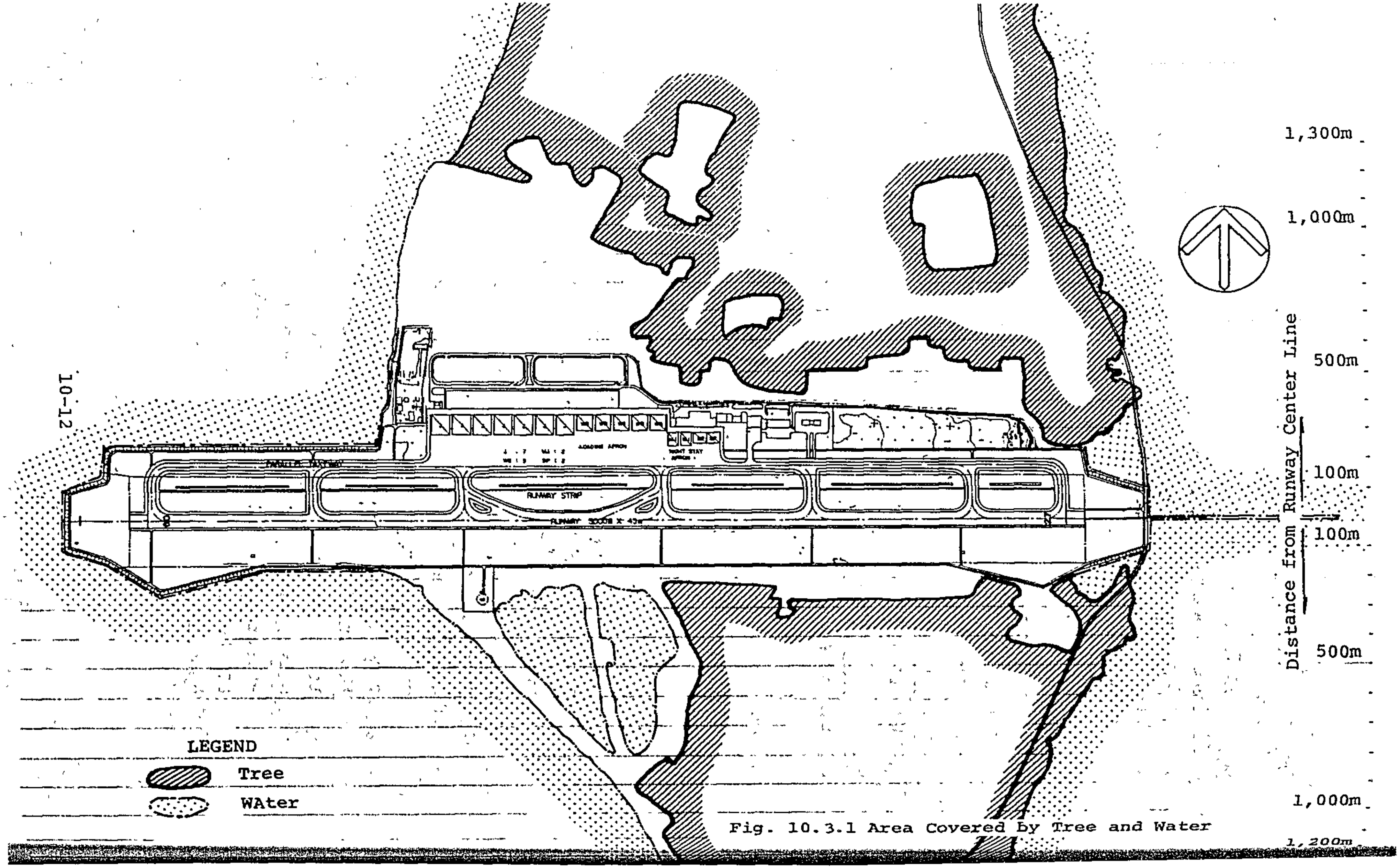


Fig. 10.3.1 Area Covered by Tree and Water

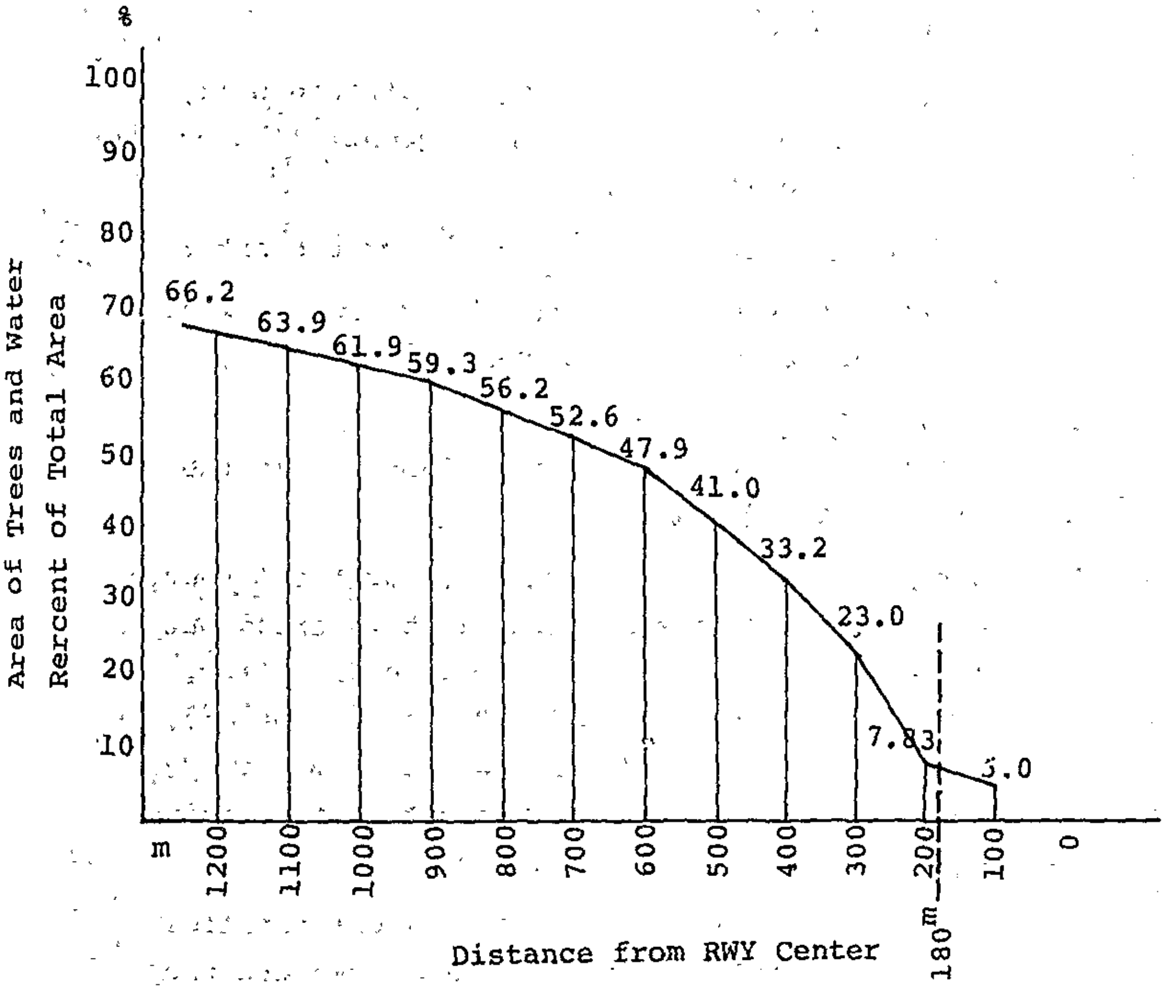


Fig. 10.3.2 RELATIONSHIP BETWEEN DISTANCE FROM RUNWAY AND BIRD HABITANCE AREA

10.4 Consideration on Future Land Use

10.4.1 General

Future Land Use planning in the vicinity of the airport is studied based on the following information:

(1) Base map of the area

(2) Land use zoning and population density planning in the vicinity controlled by the authority, BUPATI.

(3) Aircraft noise and other environmental impact

(4) Environmental standards on aircraft noise in Japan, France, USA, etc.

10.4.2 Base Map of the Area

The base map indicates the current land use in the area as shown in Fig. 10.4.1.

The runway will divide the area into north and sourth areas. Villages are interspersed in both areas but in the north area there are also many communities, commercial centers etc.; namely, Pertamina cottage, airport staff communicty living quarters, military base camps, a town located in the northeast abutting on the east end of the airport, etc.

There are two major roads which are almost parallel with each other: one across the north area and the other across the south area.

The Bali tourist resort link highway was completed in 1980. The topography of the land in the area is quite flat.

10.4.3 Land Use Zoning and Population Density Planning

A land use zoning map has been issued by BUPATI for the north area. The land use zones are classified into 7 categories as listed below.

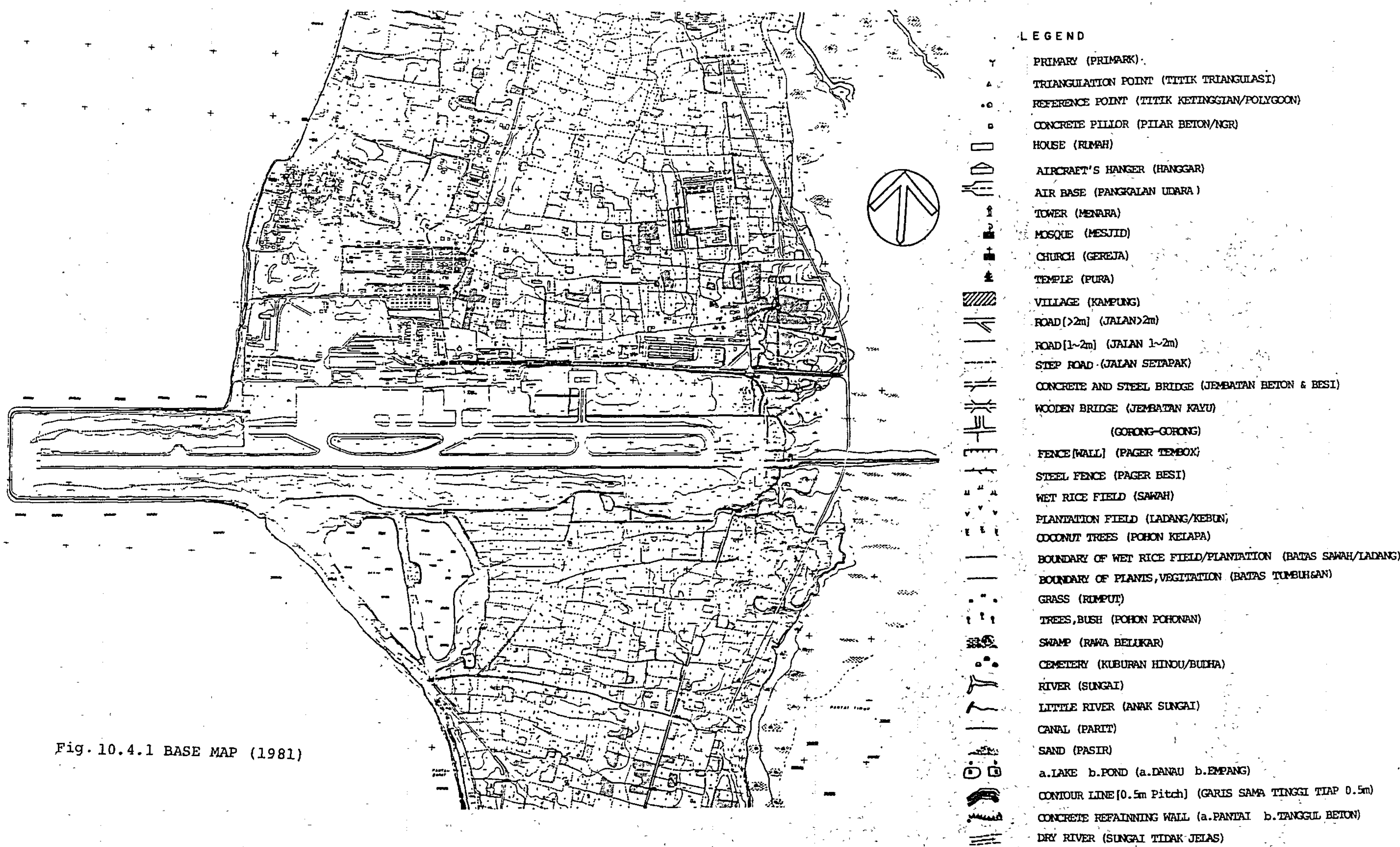


Fig. 10.4.1 BASE MAP (1981)

(1) Mixed area for housing and preservation

(2) Balinese style housing zone

(3) Housing and offices for the airport staff

(4) Military land use area

(5) Hotels and cottages

(6) Green belt or forest

(7) Airport

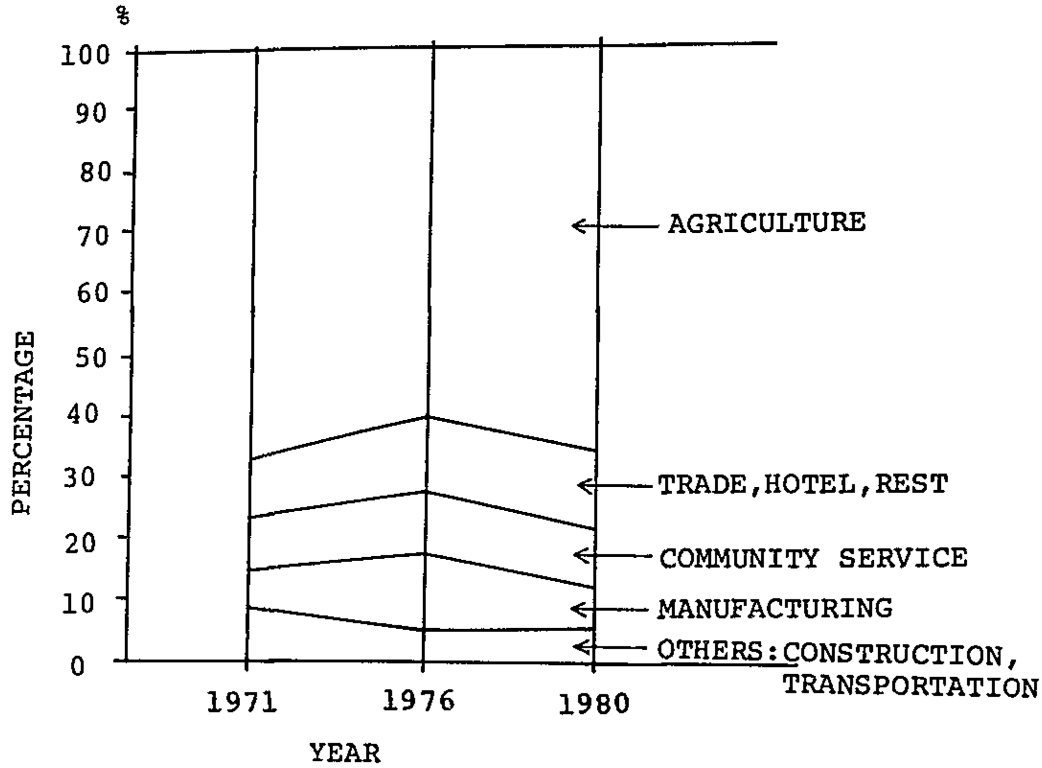
The land use zoning map is shown in Fig. 10.4.4

There is, however, no specific land use zoning in the south area. Land use for the airport development is already considered to be provided in the land use zoning map. Architectural regulations for Bali state that the height of buildings should not exceed the height of the coconut trees located around the building in order for buildings to be compatible with the natural environment. A control tower is, however, exempt for reasons of air traffic control operations and safety.

Concerning population density planning, the population in Bali has been increasing as shown in Fig. 10.4.2. The economically active manpower in Bali is shown in Fig. 10.4.3. It is noted that population density planning prepared by BUPATI, as shown in Fig.10.4.5, controls population density in harmony with the natural environment and the economic activities in the vicinity. The agricultural sector employs about 60% of the total econimically active population and this trend will continue for the future.

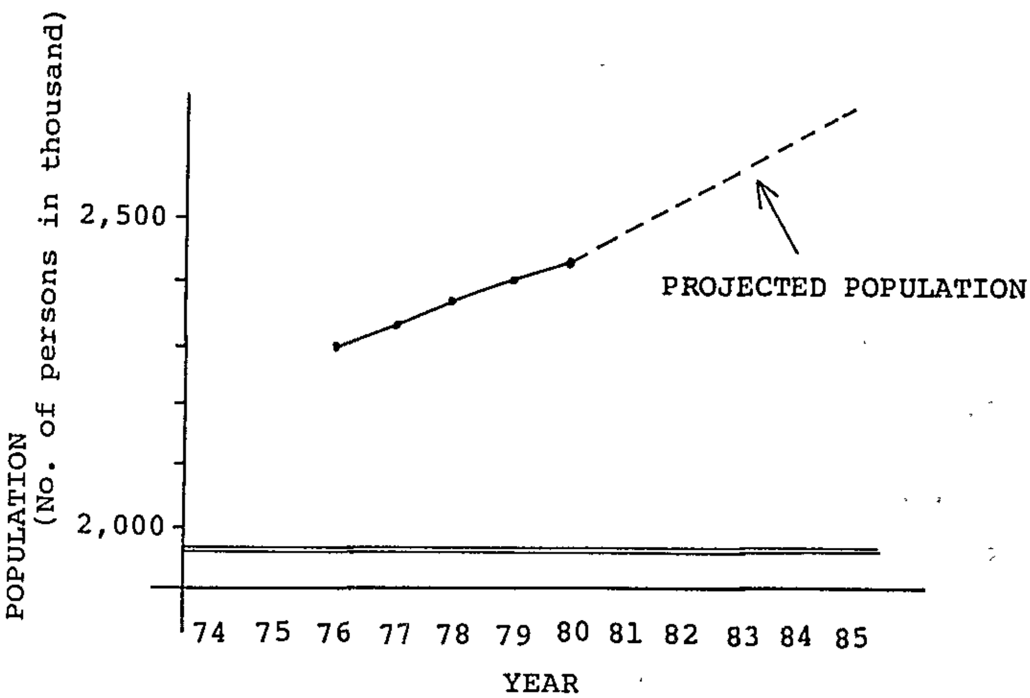
The second major employer is the commercial sector which employs about 15% of the total manpower. Judging from the economical active population it can be said that Bali has an agricultural economic base.

Fig. 10.4.3 GROWTH OF ECONOMICALLY ACTIVE POPULATION IN BALI, 1971-80



	1971	1976	1980
TOTAL MANPOWER	1,411,000	936,000	1,266,000
TOTAL POPULATION		2,302,000	2,459,000
EMPLOYEMENT RATE OF TOTAL POPULATION		40 %	51 %

Fig. 10.4.2 POPULATION GROWTH ON BALI ISLAND



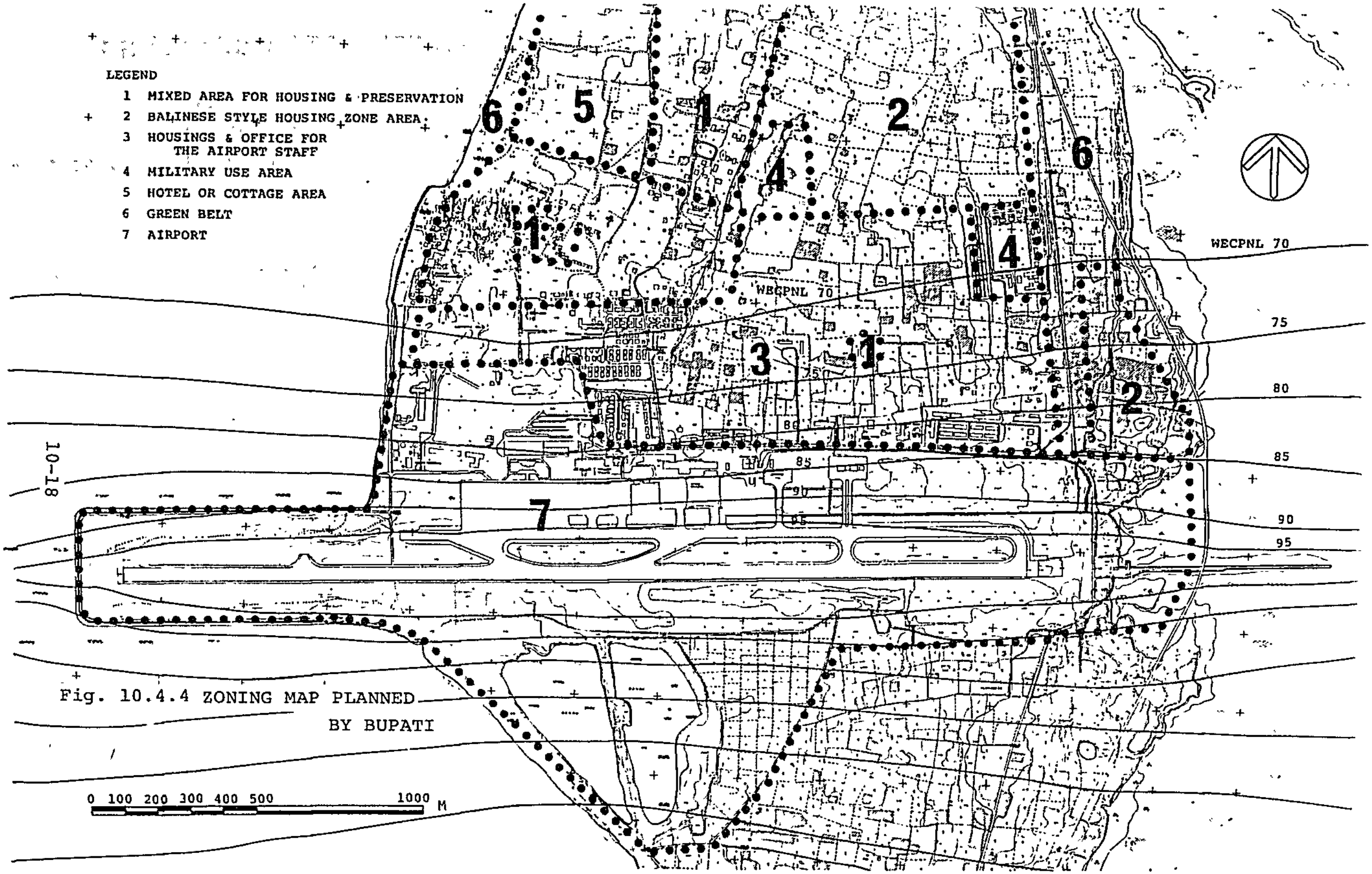


Fig. 10.4.4 ZONING MAP PLANNED BY BUPATI

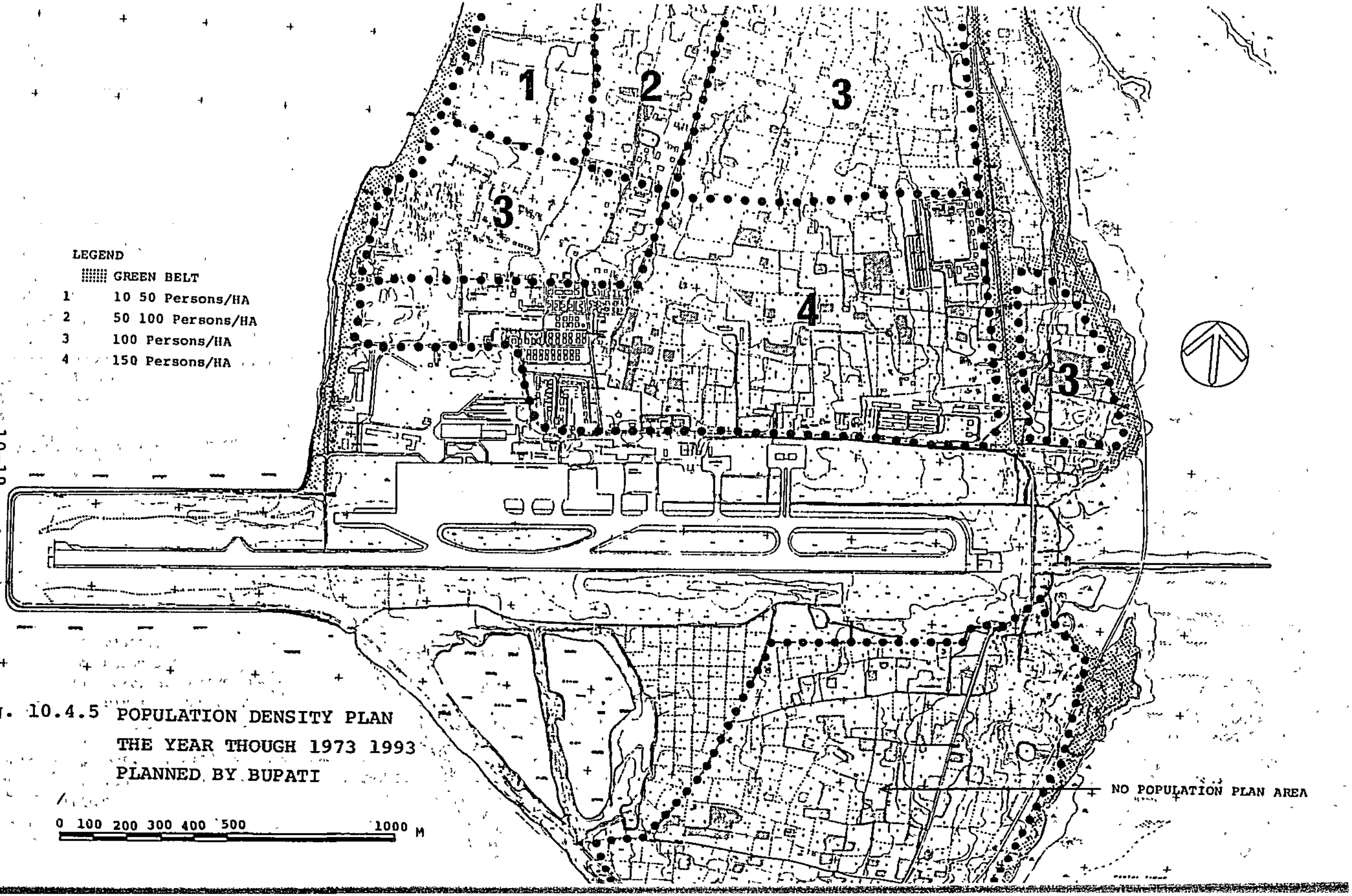


Fig. 10.4.5 POPULATION DENSITY PLAN
THE YEAR THOUGH 1973 1993
PLANNED BY BUPATI

10.4.4 Aircraft Noise

One of the major land use problems is the control of aircraft noise in the area. The theoretical WECPNL noise contour for the year of 2010 based on flight patterns is shown in Fig.10.2.4.

The major communities affected by aircraft noise in the area are shown in Fig.10.4.4. The noise contours for the major residential areas are shown below. They indicate that the noise impact on residents in the area may be a serious problem.

Name of Community Town	Range of WECPNL values
Community living quarters for airport staff	70 to 75
A town located in the northeast of the vicinity abutting on the airport boundary	70 to 85

A specific noise standard for Bali was studied based on the following standards in order to provide a basis for implementing suitable land use controls on aircraft noise.

(1) Japanese standard

(2) American standard

(3) French standard

The proposed standard to be adopted was based on the Japanese standard since the Japanese one is the most severe among the three foreign country standards, and in view of the high value of preserving the environment. The proposed standard is shown in Table 10.4.1.

Table 10.4.1 LAND USE CONTROLS ON AIRCRAFT NOISE

WI CPNL Values	Proposed Standard for Bali	Japanese Standard	American Standard	French Standard
	—	—	—	—
65	—	—	Less than 78 Necessary noise reduction measures are required for schools, hospitals, churches Compatible with residential, commercial, hotel, offices, outdoor recreational, industrial.	Less than 74 BLDGS are permitted.
70	More than 70 No new schools, hospitals are permitted. Necessary noise reduction measures are required for existing schools, hospitals.	More than 70 No construction of schools, hospitals, etc. are permitted.		
75	More than 75 Necessary noise reduction measures are also required for hotels or cottages	More than 75 No new residences are permitted	More than 78 Commercial, outdoor recreational and industrial are permitted Schools, hospitals, churches, theaters, etc. are not permitted	More than 74 No New residences are permitted.
80	More than 80 No new residences and hotels are basically permitted. Noiseproof measures are absolutely necessary.	More than 80 Noiseproof construction for existing residences is required.		More than 79 No school, hospital, residential bldg. and public bldg are permitted.
85	More than 85 No new residence, hotels and other public BLDGS are absolutely permitted. Agricultural and Outdoor recreational land use are recommended.		More than 88 Outdoor recreational (non-spectator) is only permitted. Necessary noise reduction measures for industrial and commercial bldg. are required.	More than 86 No building are permitted.
90	More than 90 The existing residences are removed with compensation.	More than 90 The existing residences are removed with compensation.		
95	More than 95 Agricultural and Plantation use are recommended only.			
100				

In conclusion, it is recommended that an actual WECPNL noise survey be carried out. Based upon this noise survey and proposed standard, the final land use zoning can be adopted with the development plan for Bali International Airport. In any case, the land use zoning should be integrated with areawide comprehensive planning to deal with the impact of aircraft noise.

10.5 Airport Organization

The existing airport organization chart is shown in Fig. 10.5.1.

According to the airport authority, there have been no problems in airport operations and maintenance to date. It is necessary, however, to reconsider the capacity and organization required by the development plan in relation with the development of the airport and the maintenance of service level and functional matters in the airport's operations. For this study, attention shall be paid to the characteristics of each division's role. For this reason, the role of each division is established based on the existing airport organization.

The descriptions are given in Table 10.5.1.

There are some sections which have no relation with between passenger handling volume and number of airport staff based on functional matters. The study of the airport organization, however, is generally considered to have a mutual relation with them.

Table 10.5.2 shows the forecast demand for the numbers of airport staff for each target year based on the data of BIA.

Detailed explanation is mentioned in the APPENDIX 10.5.1.

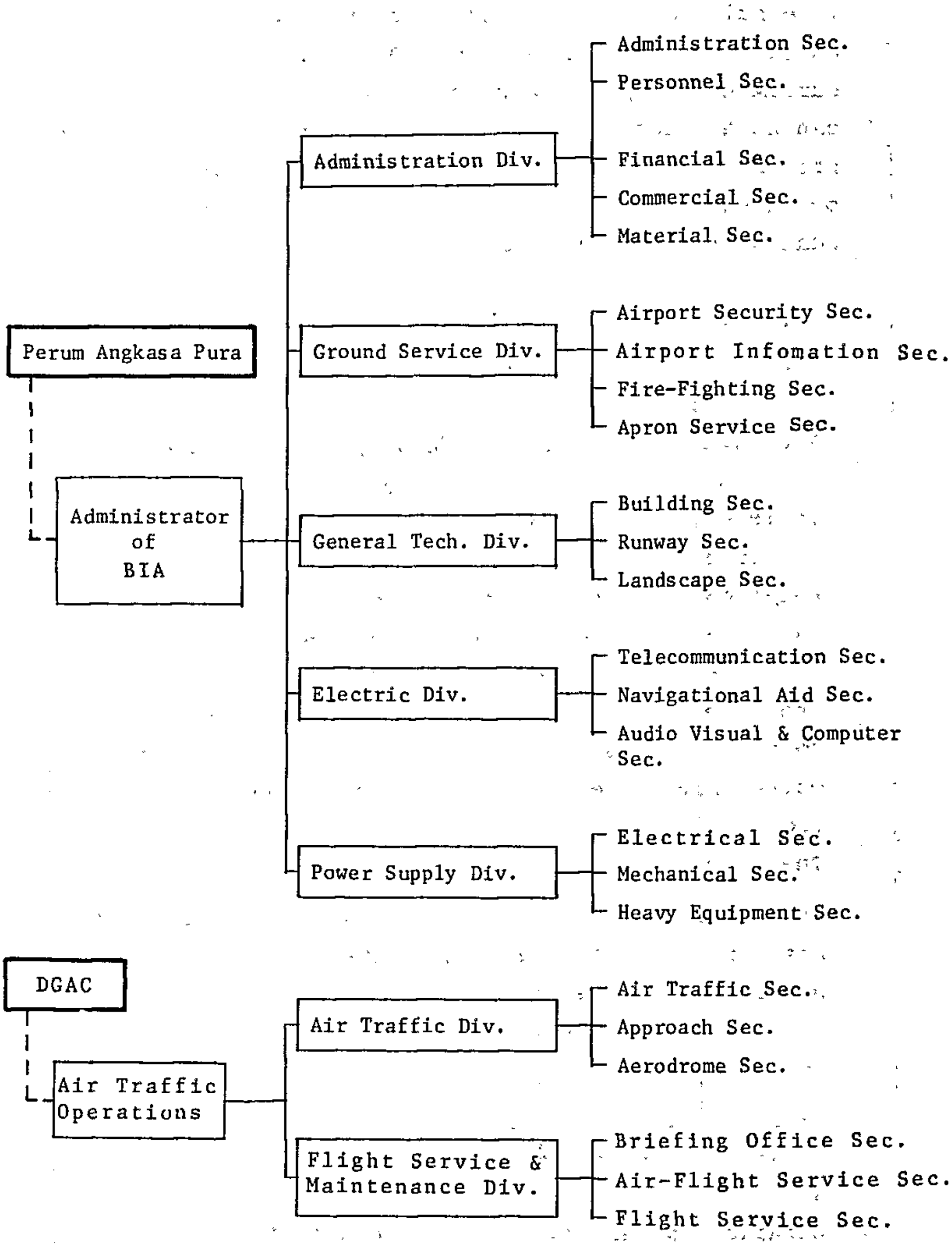


Fig. 10.5.1 BIA'S EXISTING AIRPORT ORGANIZATION

Table 10.5.1 Classification of Division

Division	Main Work Item	Relationship to Development Plan
Administration	- Control of management in miscellaneous affairs for BIA Authority - General affairs of Personnel, Financial and Commercial and Public relations affairs - Control of expendables and material	- Related to the airport demand and service level of airport authority
Ground Service	- Security of Airport - Airport Information service - Fire fighting and rescue service - Apron ground service	- Related to handling capacity of passengers and others
General Technical	- Maintenance works for buildings, runway & taxiway, apron, and landscape, etc.	- Related to the airport facility demand
Electric	- Maintenance and operation of telecommunication, Navigational aids, and Audio visual systems, etc.	- Related to the airport facility demand level
Power Supply	- Maintenance and operation of Power Supply Equipments, Air conditioning, Plumbing-systems and heavy equipment for ground service	- Related to the airport facility demand
Air Traffic	- Operation and maintenance of Final approach, Landing, Terminal and Long-range aids System & Equipment	- Related to traffic capacity and service level
Flight Service & Maintenance	- Information service for Airlines	- No relation with the airport capacity but has coordination with service level

Table 10.5.2 Number of Airport Staff for Each Target Year

Year	Number of Staff			Remarks (No. at Present)
	1990	2000	2010	
Airport Manager	1	1	1	1
Director of Administration Division Administration Section Personal Section Financial Section Commercial Section Materrial Section	97	133	145	(52)
Director of Ground Service Division Airport Security Section A/P Information Section Fire-fighting Section Apron Service Section	318	437	477	(171)
Director of General Tech Division Building Section Runway Section Landscape Section	45	61	67	(24)
Director of Electric Division Telecommunication Section Navigational Aid Section Audio Visual & Computer Section	76	104	114	(41)
Director of Power Supply Division Electrical Section Mechanical Section Heavy Equipment Section	104	143	156	(56)
Director of Air Traffic Operation Division	5	5	5	(5)
Director of Air Traffic Division Air Traffic Section Approach Section Aerodrome Section	87	120	130	(47)
Director of Flight Service & Maintenance Division Briefing Office Section Air-flight Service section Flight Service Section	70	96	105	(70)
Total	800	1100	1200	435