ブラジル連邦共和国

スアッペ臨海工業開発計画

資料No. 5



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BOOK	IV	-	VOLUME 2
PART	2	-	HIGHWAY SYSTEM
PART	3	-	RAILROAD SYSTEM

BOOK IV - PART 2 HIGHWAY SYSTEM

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1.0 TRAFFIC STUDIES

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PART 2. - HIGHWAY SYSTEM

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1.0 TRAFFIC STUDIES

1.1 DIMENSIONING THE INTERNAL ROADS AND THE ACCESS ROAD TO THE INDUSTRIAL COMPLEX

For dimensioning the internal roads the location of the lst stage industries and the highway network planned to service them were taken into consideration.

The number of trips to work was based on the number of direct jobs provided by the Suape Industrial Comples in the 1st stage of implementation.

The flowchart in Figure 1-I was used to calculate the number of vehicles during rush hour.

A PASSENGER TRANSPORTATION

and a set of

The home-to-work trip hourly distribution contributes so much traffic during the peak period that it would be disadvantageous for the industries to transport cargo during this period. Therefore, dimensioning the roads can be based solely on the passenger traffic, admiting for a margin of safety an volume of cargo traffic equal to 10% of the average hourly cargo transported.

It is predicted that by the end of the 1st stage the Industrial Complex will have around 22,000 employees, as listed below, of whom 80% will travel from home to work and vice-versa during rush hours.

IV-2/1.1

JOB FORECAST FOR THE 1st STAGE

INDUSTRY

۰. ۲	Refinery	-	600
	Fertilizer Plant	_	100
	Aluminum	-	2,000
	Cement		1,500
	Others		1,000
	Subtotal	-	5,200

PORT/ADMINISTRATION AND OPERATION

ADMINISTRATION CENTER:	•	
Administration Headquarters	-	131
Businesses		335
Hotels		150
Restaurants	-	180
Subtotal		846
CONSTRUCTION	- 1	5,000
· TOTAL JOBS ·	- 2	1,646

Once the forecast residential areas are constructed at Suape, 70% of the hoursing demand will be met; this 70% is therefore fixed as the percentage of employees in the area.

Since these employees will be of a relatively low economic status and since the distances to be covered are vey short, it is presumed that heavy use will be made of public transportation; it may be assumed that 90% of the residents in the area will use public buses or buses supplied by the firms for which they work.

For the remaining 30%, a division of the job categories must be made in order to characterize two distinct economic ranges:

- Those with greater economic purchasing power

IV-2/1.2

Construction workers

For the first group, the percentage found in Recife (Transportation Study of Greater Recife), 50% using automobiles, was used. For the second ground, it was assumed that 90% will use public transportation and 10% will use automobiles (engineers working at the construction sites, etc.).

To convert the individual trips into a number of vehicles, it was assumed that there will be 36 passengers per bus and 1.5 passengers per car. The bus equivalence to passenger car units was assumed to be:

1 bus = 3 UCP's (passenger car units) (Coefficient for hilly ground) based on the Highway Capacity Manual -National Academy of Sciences - National Research Council -1965.

Using this methodology, the following traffic flow, represented in the flowchart in Figure 1-I, was obtained:

Passengers
1,108 UCP
1,532_UCP
549 UCP
1,530 ŲCP
255 UCP

Table 2

B

CARGO TRANSPORTATION BY TRUCK

In order to make the criteria uniform, the same cargo transportation volumes as used for dimensioning the paving, as well as the same type of truck, were adopted. The absence of peak periods in truck traffic shown in traffic counts made in Recife permits us to assume that the situation will be the same in Suape. For this reason, the daily truck traffic was divided uniformly by 14 daily working hours.

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As stated before, truck traffic should not occur during rush hours since it would be disadvantageous for the industries to have their trucks delayed in an hour of intense passenger traffic. Therefore, only a 10%portion of the hourly truck traffic was assumed to move during rush hours.

To convert the number of trucks into UCP's the factor of 5 was adopted, in keeping with the region's geographical conditions, yielding:

CARGO TRAFFIC

	ري مايود و کرد و ورو در	T :	rucks/o	day .	T	rucks/	hour	·	CP/nou:	<u>z 1</u>
3	Sections			<u>1995</u>	1980	11985	1995			1995
· 144	AA	481	684	*847 ~	34	49	·61	170	245	303
	BB I	399	513	*544	29	37	39	145	185	195
*	CC*	375	478	490	27	34	35	135	170	175
	DD!	24	્ર≈34⊶	50	2	3	4	10	15	20
	EE !	71	* 149	263	5	11	19	25	55	95

Note: L' - Equivalence Factor - 5 UCP = 1 truck

The participation of cargo transportation during rush hours (10% of the hourly cargo flow) results in:

3

* -

	-
SECTION	1995
- "AA	31 UCP
BB.	20 UCP
CC	18 UCP
DD .	2 UCP
EE	10_UCP

IV-2/1.4

C DIMENSIONING THE ROADS

Since only a small difference in work starting times is expected to occur in the industrial zone, the peak traffic period was assumed to be one hour long.

Thus for the various sections, the following traffic flows during the rush hour were used.

SECTION	PASSENGERS	CARGO	TOTAL
AX!	1,108	31	1,139 UCP
BB'	, 1,532	20	1,552 UCP
CC'	549 **	18	567 UCP
DD	1,530	2	1,532 UCP
EE!	· 255	10	265 UCP

The Suape Industrial Complex's internal traffic may be considered traffic with urban characteristics since the roads are characterized by peak period loads, close crossing distances and a large passenger movement.

The following formula was adopted for calculating the capacity of a two lane highway:

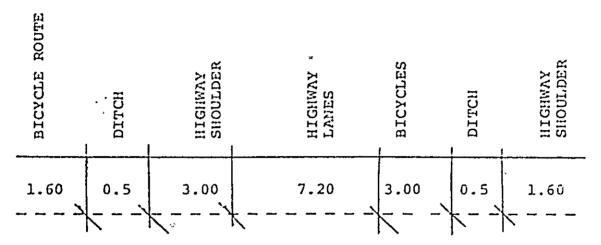
 $C = 2,000 \times W_L \times T_B \times T_T$

where W_L is a parameter that varies with the highway dimensions and T_B and T_T are parameters relative to the rates for buses and trucks.

Adopting the dimensions recommended in the Highway Capacity Manual and using the equivalence factors for buses and trucks, yields:

> $W_{L} = T_{T} = T_{B} = 1$; then C = 2,000 x 1 x 1 x 1 = 2,000 UCP's/hour

Since the traffic flows calculated for the various sections of the planned highway network are below the saturation level for a two land highway, a typical section of the following form was adopted:



For the points with the largest load on the roads it was concluded that the service level will be A if there is no traffic signalling installed and level D with traffic signalling.

By the end of the fist stage the highways will be operating at 75% of their saturation level, leaving a margin of 25%.

It is recommended that the shoulders receive the same surface treatment as the highway lanes in the places where bus stops will be necessary, and on hills where the heavier vehicles will greatly reduce speed.

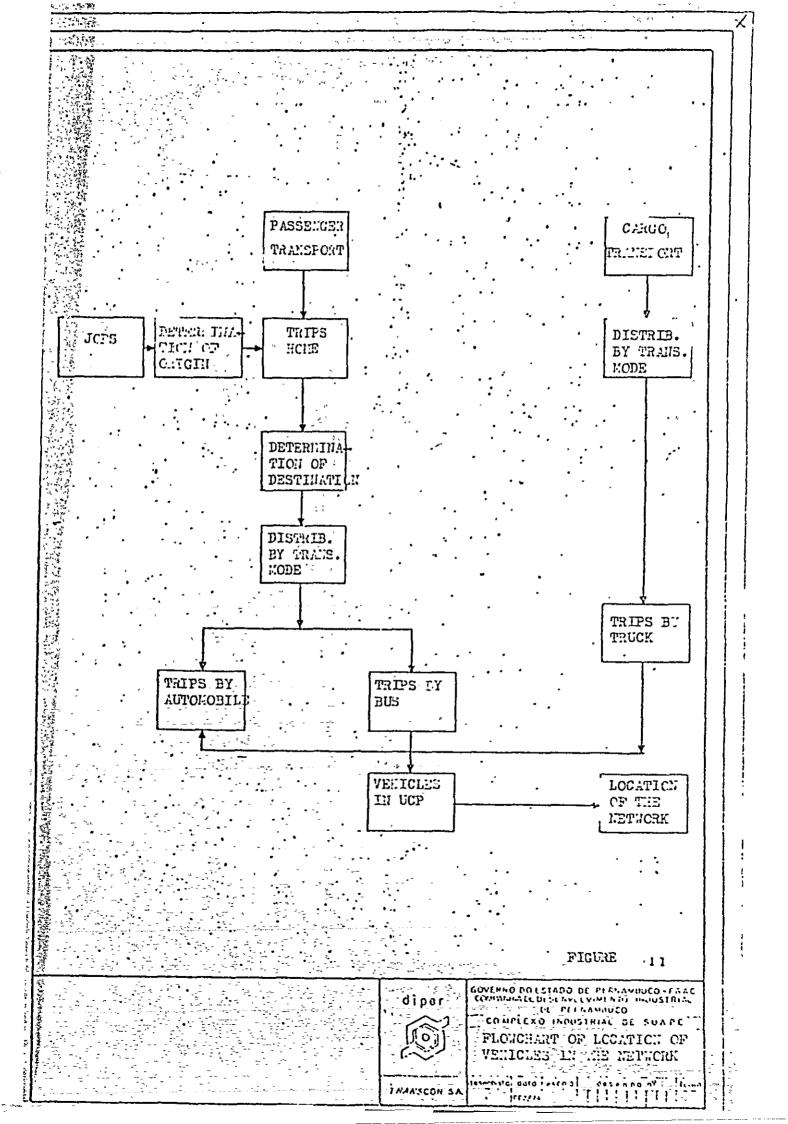
IV-2/1.6

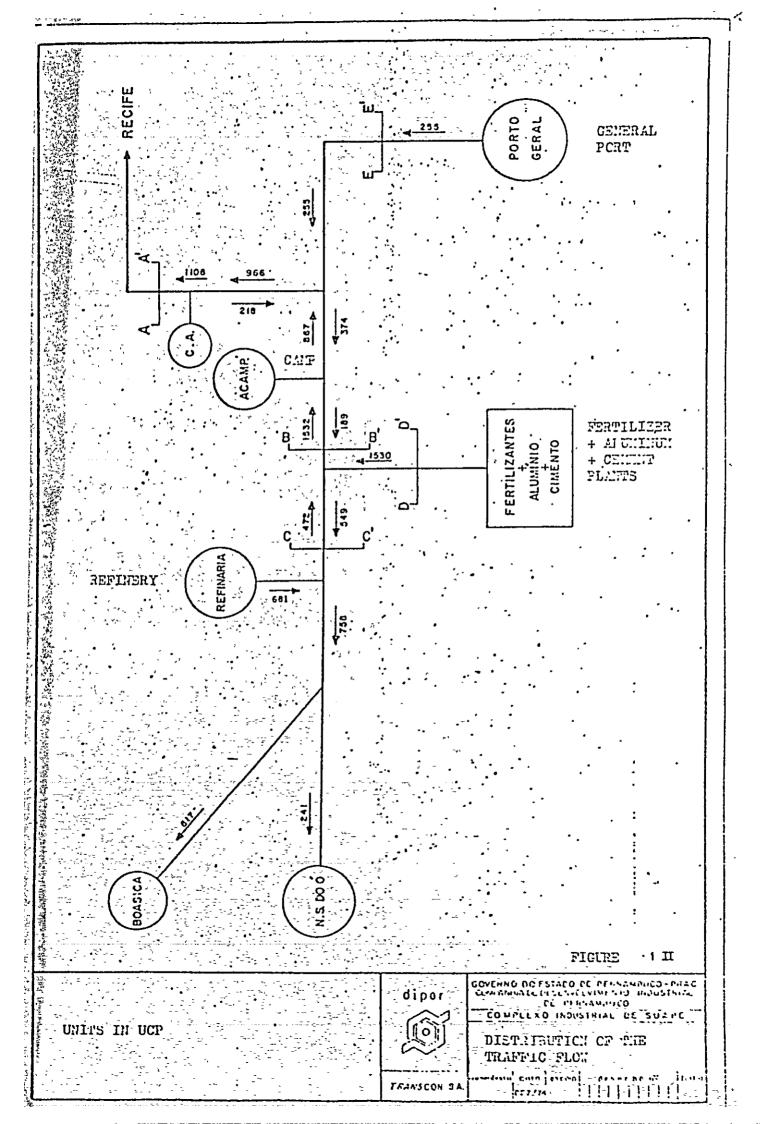
1.2 ACCESS ROADS TO THE INDUSTRIAL COMPLEX

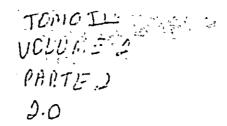
Section AA', cited in the preceding item, can be viewed as an extension of highway PE-60 since its cutt-off is situated at a point which will accomodate only the traffic connecting with the Industrial Complex's external area.

Considering the traffic flows set down in item C of 1.1.1 and comparing section AA's flow with the calculation of the two lane highway's capacity, it was concluded that during the first stage there would be no justification for widening the present highway PE-60. Only improvements to the present shoulders are suggested.

Since the distances to the closest cities (Cabo, Ponte dos Carvalhos, etc.) are approximately 20 km with quite hilly sections, the use of bicycles as means of commuting along the access roads to the Industrial Complex is not feasible, nor is construction of special bike routes justifiable.







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2.0 BASIC GEOMETRICAL DESIGN

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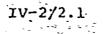
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BASIC GEOMETRICAL DESIGN

2.1 GENERAL CONSIDERATIONS

The planned highway network aims, during the first stage, at linking the various port terminals to a main distribution trunk road for the Industrial Complex. The network itself is interconnected with the stated and federal highway system through a main access road to highway PE-60.

The routes proposed are intended to fit simultaneously the region's technical and economic conditions and the port industrial complex's operating framework without hindering the functions for which the adjacent areas are designed.



2.2 HORIZONTAL PLAN AND PROFILE

2.2.1 CHARACTERISTICS

The philosophy expressed above guided the determination of the highway characteristics to be presented below. The highway system plan (scale 1:10,000) was based on aerial photographs on a 1:30,000 scale, restitution of the aerial photographic survey on a 1:10,000 scale and local reconnaisance.

The highway traffic characteristics demand that traffic flow continuously. Therefore, for the Main Access and the Main Distribution Trunk Road, horizontal radii larger than the minimum-(380 m) and a maximum slope of 2%, or a class "O" highway in a flat and hilly region, as per the classification scheme established in ENER's regulation no. 3,602.

The port access roads' characteristics permit them to be classed as class "1" roads with a minimum horizontal radius of 245 m and a maximum slope of 3%.

2.2.2 LENGTHS OF HIGHWAY TO BE CONSTRUCTED FOR THE FIRST STAGE

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The highway system is presented in Topographical Plan on a 1:10,000 scale and in profile on a 1:2,000 horizontal scale and a 1:200 vertical scale in the respective Book of Drawings. The average lengths on the plan yield the following values:

HIGHWAYS	LENGTHS
Main access	1.60
Main Distribution Trunk	5.60
Port Road 1	5.30
Rort Road 3	2.57
Port Road 4 (Part)	4.07



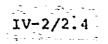
Port Road 5 (part)	2.60
Townsite access 1	3.75
Iownsite circuit	3.70
Secondary access to the Refinery	1.78
N S of Ø access (ZR1)	1.15
Access to the Cement Plant	1.20
Road 1 (ZR2)	2.40
Road 2 (ZR2)	1.50
Road 3 (2R2)	2,20
Road 4 (ZR2)	0.70
Road 5 (ZR2)	2.00
	42.12

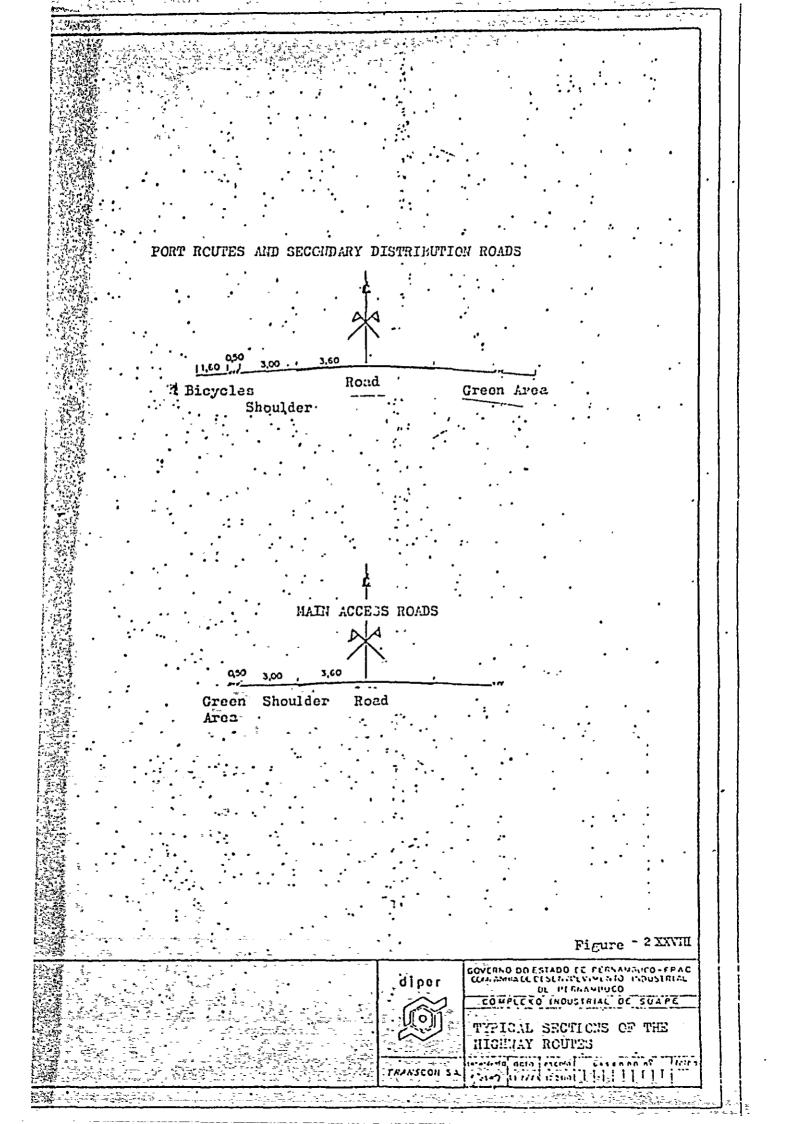
IV-2/2.3

2.3 TRANSVERSAL SECTIONS

Transversal sections for the highway system were designed to handle, all through the working life of the roads, the increases in heavy, medium and light traffic.

Figure 2.I shows the section to be used for the various highway sections for the first stage. For maximum utilization of the Industrial Complex, duplication of the section in the main access road and the main distribution trunk road was predicted.





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3.0 CONVENTIONAL CIVIL CONSTRUCTIONS

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3.0 CONVENTIONAL CIVIL CONSTRUCTIONS 3.1 GENERAL CONSIDERATIONS

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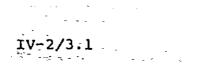
In order to protect the highway system infrastructure and the paved roads, drainage to capture surface and underground water was planned.

According to criteria in the following items, quantitative values for the following elements were arrived at:

- Cave and grade culverts
- Deep drains
- Gutters

24

- Benches
- Protection ditches
- Plant covering



3.2 ORIENTATION ADOPTED

3.2.1 CAVE BOTTOM CULVERTS

Information needed to pre-dimension cave bottom culverts was taken from aerial photographs (1:30,000 scale) and a topographic plan (1:10,000 scale). A 20 year replacement period was adopted for a projected 70mm/hour water fall rate.

The flow sections, determined by the Talbot empirical formula, were converted to pipe sections with \emptyset 1.00 m.

3.2.2 DEEP DRAINS

Deep drainage was indicated for all cuts with a red elevation greater than 3 meters.

3.2.3 GUTTERS

Gutters at the cut embankment bases were adopted.

3.2.4 BENCHES

Were adopted for the sides of the fills with a red elevation greater than 3 meters.

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IV-2/3.2

3.2.5 PROTECTION DITCHES
Were considered along all of the cuts.
3.2.5 PLANT COVERING

Grass covering of all the fill embankments was predicted. No such covering will be done on the cuts since most of them will be widened.

The area to be covered was estimated as the product of the fill extension times the mean height axonometrically projected over the embankment slopes. A one meter strip of grass covering was assumed in addition to the base of the fill embankment slopes.

IV-2/3.3

3.3 QUANTITATIVE DATA *

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Quantitative data for each drainage element for each section of the highway system, are presented in the following tables:

-	Culverts	Table 3/1
-	Deep Drains	Table 3/2
	Gutters	Table 3/3
~	Benches	Table 3/4
~	Protection Ditches	Table 3/5
-	Plant covering	Table 3/6
-	Summary Table	Table 3/7



TABLE 3/1

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CULVERTS SECTION. LENGTH IN MITTERS	
SECTION.	LENGTH IN MITERS
Main Access.	66
Distribution Trunk + Port Route I	657
2nd section Port Route I + secondary access	671
road to bulk products port Tomsite access road + Townsite Road 1	354
N S Ø Access + Port Route IV	· 191 · · ·
Road 2	83
Road 3	177
Roed 4	88
Road 5	205
Secondary access to Refinery	89
FOTAL -	2,580

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DEEP DRAINS - HIGHLAY AL		
SECTION	LENGTH (M)	
Distrib. Trunk + Port Route 1	3,160	
2nd section Port Route 1 + secondary access to	2,980	
bulk products port	700	
Port Route 3 + Port Route 4 + secondary access to Fertilizer.Flant	• · ·	
Secondary access to Cement Factory	930	
Main access ford Port Route V + Access to N S 0	- · · ·	
Townsite access 1 + Townsite Road 1	1,170	
Founsite circuit	· ! · 1,376	
loud II	, 708	
ond III 🤟 ·	1,580	
ozd III	-	
load V	1,870	
secondary access to the Refinery	· <u>1,060</u>	
CTAL	15,540	

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TABLE 3/3

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HIGHNAY - GUTTERS		
SECTION	- LENGTH	
Trunk + Port Route 1.	3,528	
Nain Access	928	
Port Route 3 + Port Route 4 + secondary access to fortilizer plant	1,890	
2nd section Port Route 1 + secondary access to	4,200	
bulk produčts plant Access to N S O + Port Route V	1,500	
Secondary access to Cement Factory	· -	
Townsite Access 1 + Townsite Road 1	2,070	
To:msite circuit	2,240	
Rozd II	710	
Road III	2,660	
Road IV	640	
Rozd V	1,870	
Secondary access to Refinery	. 1,460	
TOTAL	. 22,170	

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TABLE -3/4	
BELICINE.	······································
, SECTION	LENGTH - OBS
Dist. trunk + Port Noute 1 Main access	6,240 · · · · · · · · · · · · · · · · · · ·
Port Route 3, + Port Route 4 + Secondary access to fortilizer plant 1st section Port Route 1 + Secondary access to bulk products port Access to M S O + Port Route V	11,440 6,330
Secondary access to Cement Factory	2,440
Townsite açoess + Townsite road 1 Townsite circuit	2,900 2,200
Road II	1,830 1,090
Road TV	÷
load V	1,620
econdary accoss to the Refinery	<u> </u>

TABLE 3/5

PROTECTION DITCHES	• . •
SECTION	LENGTH IN CETERS
Dist. trunk + Port Route 1	3,530
Main access	930
Port Route 3 + Port Route 4 + Secondary	1,8600
access to fertilizer plant	4,200
1st section Port Route 1 + secondary access	1,400
to bulk products port	-
Access to H S O + Port Route V	.
Secondary access to Cement Plant	930
Townsite access + Townsite Road I	2,240
Townsite circuit	710
Road II	2,670
Road II	640
Road V	1,870
Secondary access to Fertilizer Plant	<u>1,460</u>
TOTAL	22,170

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TABLE 3/6

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SECTION	алел (м ²)
Main access	11,800
Dist. trunck + Port Route 1	56,000
2nd section Port Route 1 + secondary access to bulk products port Access to N S O	48,600
Port Route 3 + Port Route 4 + secondary access to Fertilizer Plant	20,000 79,500
Secondary access to Cement Factory	17,270
Townsite Access 1 + Townsite Road 1	40,300
Townsite circuit	19,810
Road II	13,000
Road III-	7,820
Road IV	
Road V	1,290
Secondary accessto the Refinery	. 14,790
•	16.700
TOTAL	· 346,880 ·

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TABLE 3/7

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QUANTITIES OF CONVENTIONAL CIVIL CONSTRUCTIONS (SUITARY)		
SERVICES	UNIT	- HICHNAY
Excavation: and laying of concrete pipes \$ 1.00 m	:	2,580
Deep drains		15,540
Concrete gutters		22,170
* Commercial benches		38,800
Protection ditches		22 ₁ 170
Plant covering		346,880

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4.0 EARTH MOVING

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4.0 EARTH MOVING • • 4

4.1 ORIENTATION ADOPTED

The basic design for earth moving took into consideration the following factors:

- Nature of the material to be excavated
- 'Crossing of the mangrove swamp areas
- Volumes of material to be excavated
- Volume of compacted fill
- Mean transport distance

4.2 CUTS

For purposes of calculating volumes, embankments with a 1:1 slope were adopted for the cuts. The present status of the work doesn't permit more detailed studies on the cut embankment slope stability.

Whenever the cut sub-grade material shows low support capacity, it is suggested that better quality material, with expansion less than or equal to 2%, be substituted.

4.3 BORROW MATERIAL

The results of volume calculations showed a clear predominance of fill volumes over cut volumes. Widening the cuts was indicated as the first choice for obtaining borrow material in a manner that preserves the region's natural landscape as much as possible and provides better drainage and visibility conditions.

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4.4 NATURE OF THE MATERIAL

The materials to be excavated were sampled by auger drillings at points where the route showed a section of cuts.

The samples obtained were laboratory tested for:

- Size consist
- Physical limits
- Compaction and
- California Bearing Resistance (CBR)

The results are presented in Tables 4/1 and 4/2.

The nature of the materials was found to be group A2 clayey and/or silty sands and group 7 clayey silty materials, as per the HRB classification system.

For subgrade materials, a good part of the group A7 materials could be used since a low bearing resistance capacity and a higher than recommended expansion were found in only two of the drill holes. All of the group A2 material will be used.

4.5.1 COMPOSITION

Embankment slopes for the fills constituted of cut and borrow materials were set a 3 (horizontal) : 2 (vertical) in order to determine values needed for calculation of volumes.

Use of materials with low bearing resistance (CBR less than 3) and high expansion (greater than 3%) in the fills is not recommended.

Material with expansion greater than 2% should not be used in the final layer (60 cm).

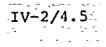
In sections, where the subgrade support capacity is such that, in spite of being greater than the recommended minimum, it leads to high pavement thickness, the fill should be topped with select materials. Materials from group A2 will be suitable.

4.5.2 FILLS IN MANGROVE SWAMPS

Special attention was given to this topic. However, defining solutions for crossing mangrove swamp regions does not fit in the scope of this phase's work. It is recommended that studies be conducted at a more advanced stage for specific solutions for each fill in mangrove swamp areas. The following are suggested:

BERMS F.

Are lateral equilibrium benches to reduce shearing tensions that occur in the fill's soft foundation layer. An example of the method is shown on page 4-I.



VERTICAL SAND DRAINS

Are columns of sand penetrated into the soft layer on which the fill will be lain. The serve to accelerate the condensing processes to occur in that layer.

DYNAMITING UNDESIRABLE MATERIAL

Consists in the elimination of the soft material by explosions either under the fill or at the base of the fill.

Use of the above suggested processes will be determined for each fill area after the characteristics of the soft material, the thickness of the layer in which it occurs, the height of fill over this soft layer and other factors, such as economy of the project design and execution time, have been checked.

In order to make cost estimates that are as realistic as possible, 2m, the value of the pole measurements taken in this region, was added to the red elevation quantities for the fill over mangrove swamps.

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4.6 PRESENTATION,

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Cut, borrow and fill volumes and mean transport distance are listed in Table 4/3.

The cut and fill volumes were determined from the mean of the red elevations taken from the profiles.

The value 1.3 was adopted for a coefficient of expansion. Therefore the volumes are increased by 30%.

The red elevations for fills over mangrove swamps were increased by 2 meters.

The high mean transport distances arise from the fact that borrow materials will be obtained by widening the cuts. It is not difficult to realize that, in addition to the considerations cited in item 4.3, shorter transport distances cannot be realized by performing lateral borrow operations because the fills that require the largest borrow volumes are located in low areas.

The proposed transversal sections plus two meters on each side were used as a basis for predicting quantities of deforesting, stump grubbing and clearing (Table 4/4). 4.7 QUANTITATIVE DATA

The excavation volumes and the transport distances were taken from Table 4/3. The fill volumes, without added measurements for expansion, were used for the compaction volumes. Quantities for earth moving work in the various highway system components are listed in Table 4/4.

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IV-2/4.10

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				TO 0.4 Icm	km 0.4-0.8km 0.8-1.5km	0.8-1.5km
Kain Access	69,000	41,000	28,000	, 1.	69,000	1 1 1 1
Dist. trunk + Port Route 1	363,000	226,000	137,000	114,000	74,000.	175,000
Port Route 3 + Port Route 4 + Secondary Access to Fertilinor Flant	617,000	35,000	582,000	13,000	57,000	647,000
Secondary access to Coment Plant	108,000	I	108,000	ı [.]	· · ·	108,000
Second section Fort Routell + Secondary access to bulk products port	385,000	228,000	157,000	125,000	260,000	: : :
Port Route 5 - Access to NSO	122,000	2,000	120,000		, I	.180,000
Road I	L186,000	62,000	124,000	35,000	57,000	9.4 ,000
Tomsite Circuit	102,000	49,000	53,000	47,000	· 000; 25	.1
Road II	78,000	80,000	1	80,000	<u>،</u> ،	1
Roud III	44,000	86,000	1	86,000	· · ·	I
Road IV .	5,000	7,000	۱ . <u>.</u>	7,000	• 1	
Road V	107,000	108,000	J 	108,000	۰. ار	۰. ۱
Secondary Access (Rofinery)	96,000	36,000	60,000	32,000	64,000.	I

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IV-2/4.11

DEFCRESTING, STULP GRUBBING AND CLEARIN	IG · ·
SECTION	ÁREA (m ²)
Main Access	38,000
Dist. trunk + Port Route 1	149,000
2nd section Port Route 1 + secondary access to bulk products port	164,000
Port House 3 + Port loute 4 + secondary access	180,000
to Fertilizer Plant Secondary access to Cement Factory	. 32,000
Toymsite Access 1 + Road I	138,000
Tomsite Circuit	77 ₀ 000 ,
Road II	35,000
Road III The state	50,000
Road IV	11,000
Road V	50,000
Secondary access to the Refinery	54,000
Port Route V	361,000
	1,107,000

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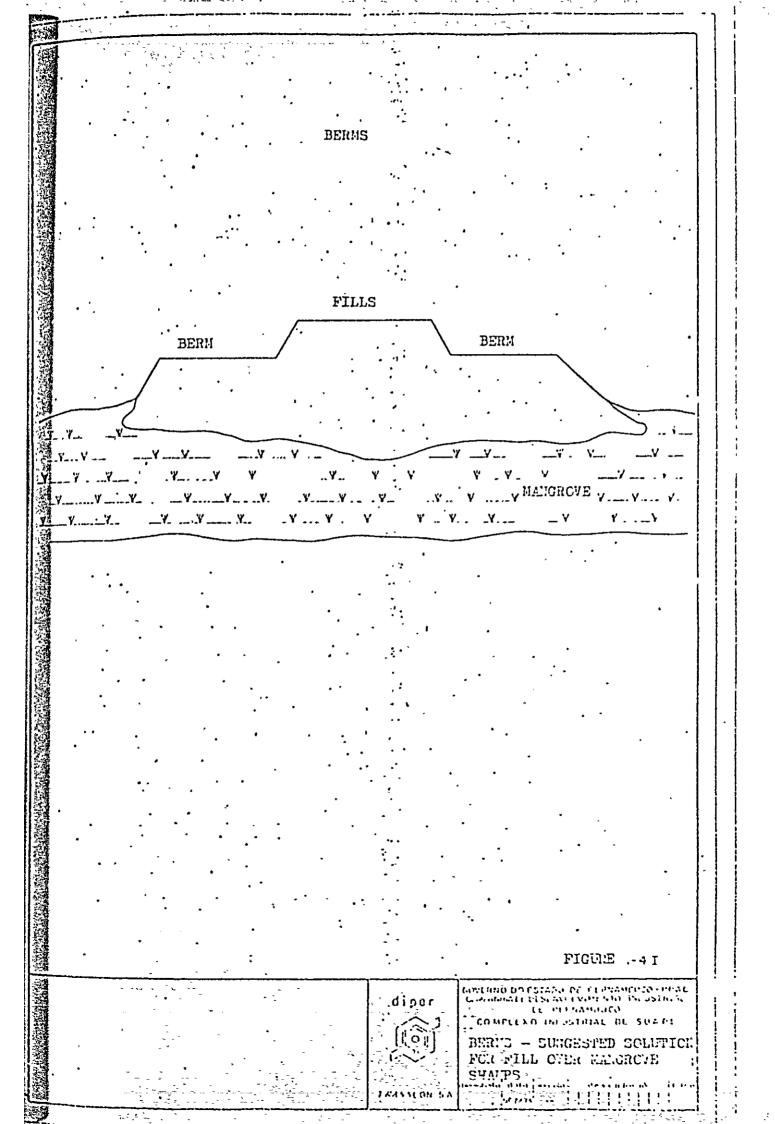
TABLE 4/4

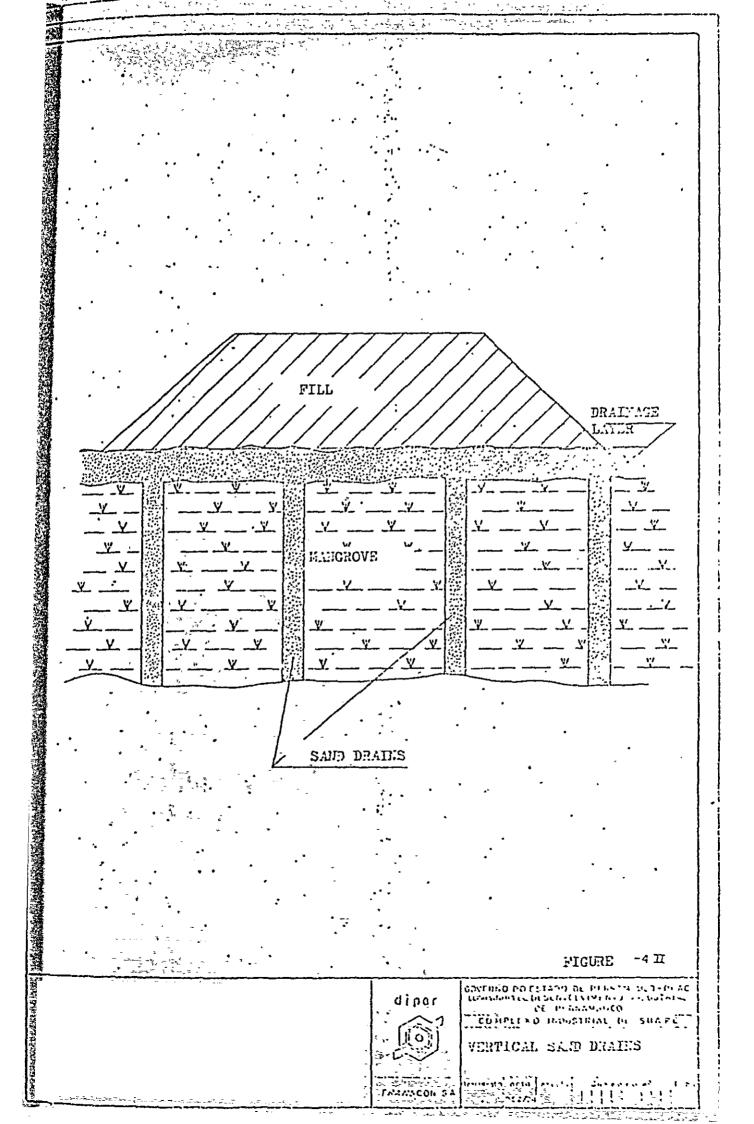
TABLE 4/5

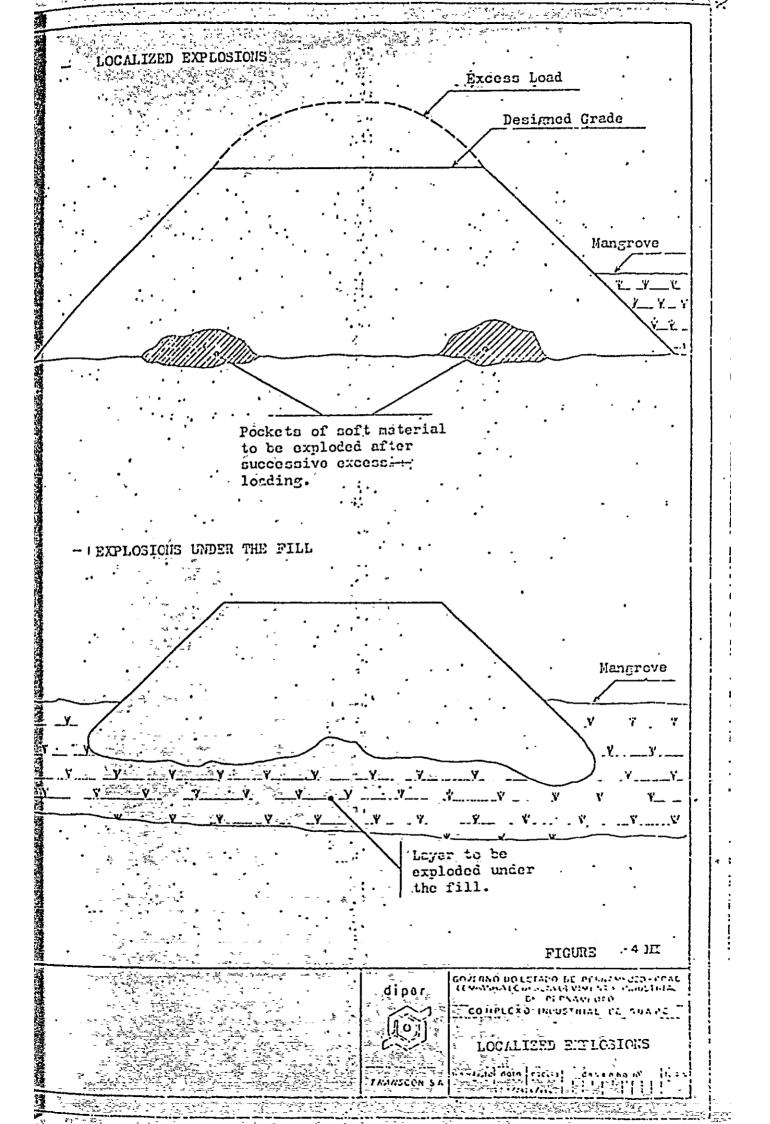
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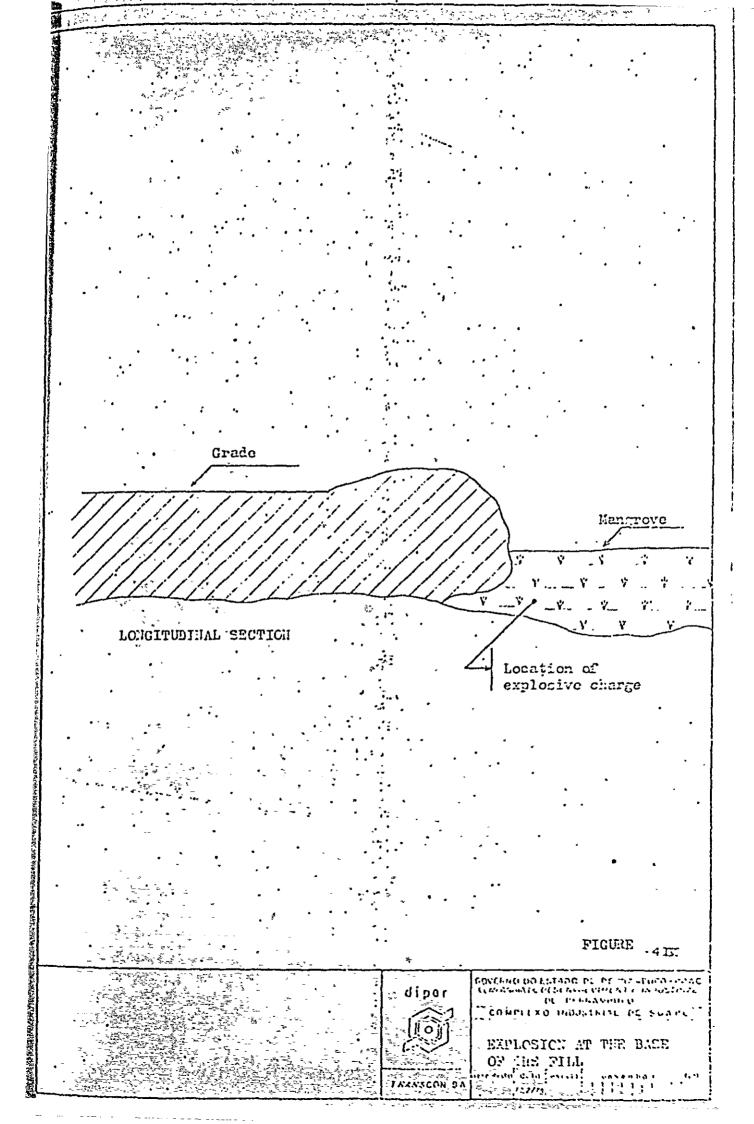
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ist category material with		
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- Cut and borrowing excavation of	•	
1st category material with transport		
distance from 0.4 to 0.8 km.	" ³ .	636,000 .
- Cut and borrowing excavation of	· .	
lst category material with trans-		
port distance from 0.8 to 1.5 km.	m ³	1,104,000
- Cut and borrowing excavation of		
2nd category materials with trans- '		
port distance up to 0.2 km.	m ³	960,000
- Cut and borrowing excavation of		
3rd category material with trans-	•	
port distance up to 0.2 km.	m ³	48,000
- Deforesting, stump grubbing and	m ²	1,107,000
clearing ~ Compaction	m ³	1,694,000

IV-2/4.13









TOMO IV PANTE O VOLUME 2 5.0

5.0 PAVING

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5.0 PAVING

5.1 CALCULATION OF NUMBER N

The number N, used to predimension paving was calculated for a projected period of 20 years (1975-1995 - 1st stage), based on the results of the dimensioning of the highway network: undivided two lane highways.

Murilo Lopes de Souza's Method for Design of Flexible Paving (Método de Projeto de Pavimentos Flexíveis) was used. This method gives the following expressed for the number N:

 $N = VT \times FE \times FC \times FR$ where:

VT is the volume of one way traffic during the projected period
FE is the axle factor
FC is the load factor
FR is the regional factor

5.1.1 TRAFFIC VOLUME (VT)

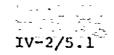
The traffic considered for the 1st stage is composed of cargo vehicles for transport of products originating in or destined for the port complex, and passenger vehicles (buses and automobiles) for transport of construction workers and industrial employees.

CARGO FLOW

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The economic studies conducted led to the cargo flow conclusions shown in Tables 5/1 through 5/4. Figure 5-I shows the cargo distribution according to origin, destination and type of cargo. Using information from these tables, the values of the cargos to be transported throughout the first stage on sections A, B, C, D and E were calculated in 1,000 tons.



SECTIONS	CARGO	CARGO (1,000 TONS)			
	ORIGIN - SUAPE	DESTINATION - SUAPE			
· · · · · · · · · · · · · · · · · · ·	83,019	26,268			
В	• 79,377	-			
C	72,394	-			
· - D	6,963	_			
· E	- 3,642	26,266			

Cargo transportation by two types of trucks was assumed: one with a 25 ton capacity to transport 70% of the cargo, and the other with a 12.5 ton capacity to transport the remaining 30% of the cargo. These vehicles are sketched schematically in Figure 5-II. Using the figures for the cargo tonnages to be transported and the determination of the types of trucks to carry the cargo the cargo traffic composition in a total number of trucks for the 1st stage was developed. See Table 5/5.

В

PASSENGER TRAFFIC FLOW

The flow distribution shown in Figure 5-III was derived from the dimensioning of the highway network.

The values indicated are for buses and automobiles (always a larger number) per day, in one direction. They will be used in dimensioning the paving under the assumption that the flow will occur more than once a day, i.e., in the opposite direction... In order to arrive at a total number of passenger vehicles during the 1st stage, it was assumed that the distribution dhown in Figure 5-III, corresponding to the end of the stage, 1995, will remain constant starting in 1980 because the production increases in the factories in operation will not imply any great increase in the number of employees. The excess number of passenger vehicles resulting from the assumption of a traffic level equal to that forecast for 1995 will be compensated for by the construction traffic which is impossible to forecast correctly. Therefore the paving will not be overdimensioned.

IV-2/5.2

It was assumed that the increase in passenger traffic in the years 1975 (zero) through 1980 will increase linearly (values in Figure 5-III), and from then on to the end of the first stage the increases will also be linear. The resulting total numbers of buses and automobiles for passenger traffic is shown in Table 5/6.

CALCULATION OF TRAFFIC VOLUME (VT) C · · · · ·

The sum of the cargo traffic volumes from Table 5/5 and . the passenger traffic volumes from Table 5/6 yield the total traffic volume for the projected period (VT) shown in Table 5/7.

5.1.2 AXLE FACTOR (F,E)

The axle factors for the various sections were calculated • using Table 5/7.

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. T . T . T Example for section A:

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3,060,596 Vehicles with 3 axles: Vehicles with 2 axles: 8,263,530 🕔 Total: 11,324,126 - 3 axles: 278. 2 axles: 73% $F.E. = 0.27 \times 3 + 0.73 \times 2 = 2.27$

The axle factors are shown below for all the highway sections:

	a sa ha sa sa a sa a sa a sa a sa a sa	
	SECTION	<u>F.E.</u>
	Section A.	2.27
	Section B	2.20
	Section C	2.28
	Section	2.03
٠	Section E	2.31
	Refinery Access	2.00
	N S. do O Access	2.00
	Townsite Access 1	2.00
	Tomsite Circuit	2.00
	Road I	2.00
•	Road II	2.00
	Rozd III	2.00
	Road IV	2.00

5.1.3

CARGO FACTOR (F.C)

Calculation of the cargo factor for each section may be found in Table 5/8. The loads por single axle and tandem vehicles were selected according to the types of vehicles and their equivalence factors. The percentage composition of the types of axle traffic and the operating equivalence ($5 \times F.EQ.$) were calculated, taking into consideration the frequency for vehicles with the single or tandem axles.

FC was found to be <u>Six F.F.O</u> ICO

5.1.4 REGIONAL FACTOR

The value 1.8 was assumed for the regional factor since the region has a mean annual rainfall of over 1,500 mm. 5.1.5. NUMBER """

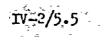
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A summary of the calculation of the number N for all the highway pactions is found in Table 5/9.

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5.2 DEFINITION OF PAVING

5.2.1 ORIENTATION ADOP FED

re the states Use of materials existing in the region for construction of the paving layers, within technologically recommendable conditions, was attempted.

Therefore a brief survey of materials was made, compatible with the study phase's requirements.

Once data on the existing materials were obtained, colutions were proposed for the paving phases. -

5.2.2 SUPGRADE

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The location of the 9 drill holes executed in the area led to the indication of the following values for the subgrade CBR:

- Port Access (Bulk Products Port) CBR 3
- Other Highway Sections CER 6

For the sections where the subgrade capacity is low but still higher than the minimum recommended support capacity, a layer of celect material for capping the fills and substituting for the cuts' upper a estadota da basera d layers was adopted. The paving for the port access (bulk products port) will have a subgrade reinforcement layer made up of material from Group A2 detected in some of the drill holes and abundant in the source areas surveyed by DER (referred to in the folloing iten).

~--- · The CBR values for the Group A2 materials found in the drill holes permit the adoption of a CBR value equal to 8 for subgrade reinforcement.

The results of tests run on samples obtained from the drill holes are listed in Tables 5/10 and 5/11.

The drill holes are located approximately at the following coordenates:

DRILL HOLE No."

LL HOLE No.	CCORDEL	
	• <u>N</u>	E
STL	9,079,450	279,500
ST2	9,081,250	279,350
ST3	9,082,750	279,250
ST4	9,075,880 -	279,200
ST5	9,074,900	278,230
576	9,071,750	278,430
ST7	9,075,700	282,450
ST8	9,076;500	281,450
ST9	. 9,073,050	261,300

5.2.3 MATERIALS SURVEY

DER (PE) furnished the results of studies done on ten source areas located along the line of access to Suspe projected by them and represented schematically in Figure 5-V.

The results of the DER studies are presented in Tables 5/12 through 5/42 and n in Figure 5-91. In general, the majority of the materials fall into Group A2, with low expansion, CBR greater than 20, with little or no plasticity.

IV-2/5.7

Observation of the results shown in Tables 5/10, 5/11, and 5/12

through 5/43 indicated the difficulty in finding materials with grossor size consists. A more intense search for more materials

is beyond the scope of this study.

Samples were taken from three areas where rocky materials appeared:

- Cape of Santo Agostinho (P2)

- Algodoais (P3).

- Ponto dos Carvalhos (P1)

The location of these areas is indicated schematically in Figure 5-VI: Abrasion tests were run on the samples with the Los Angeles testing machine and the results, Tables 5/44 through 5/46, proved that the wear porcentage permits use of the materials found in

these three areas.

Since the Cape of Santo Agostinho quarry is located in an area which is being hictorically and ecologically preserved, its use is not

recommended.

The choice of the Alcodozis, Ponte dos Carvalhos or other areas

detected during a more intense search for materials will depend on

the various tests to be run in the future.

To estimate the transport distance, the Ponte dos Carvalhos guarry,

which would give the worst transport distance situation, was used

for the present phase.

5.2.4 PRIMARY PAVING SOLUTIONS

The use of concrete for the short run is not recommended because h-stas.

during the first years of the road system implementation settling

of the fills will definitely occur over mangrove swamp and water-

logged groap.

It was therefore proposed to use flexible paving at first and to use concrete at a later phase when the fill stability is

consolidated and the traffic intensity so justifies.

The following sections deal with discussions of possible solutions for each paving component phase.

REINFORCENENT OF SUB-SOIL A

Will be used on sections with the subgrade's low support capacity demands. Normally, this will be done with Group A2 material presumed to be available near the routes.

SUB-BASE B

As per the section on Materials Survey, the construction of a sub-base stabilized by size consist with Group A2 materials . present along the Suane access line (Project DER-PE - PE-028). It is presumed that sub-base materials will be found in other areas, since drillings should Group A2 materials in the subgrade; however, the source areas lying along the project PE-28 line were taken as the basic source. Their use will mean the worst transport distance situation.

BASE

ter i ser The brief materials survey did not encounter materials that would naturally lend themselves to a base stabilized by size consist without blending. At a later date a more intense search could come up with a definitive decision on the use of this type of basel Sinco there is abundent-soil A2-4 present, two mixtures using

this material were projected for the base:

τν_2 /ς-0

CEMENT SOIL

The Brazilian Portland Cement Accociation recommends a percentage increase of from 5% to 9% for coment soil bases using A2-4 material. Therefore for basic design purposes a A2-4 soil base with 75 cement by woight was indicated.

Crushed Rock Soil

-

The soil A2-4 encountered has neither the support capacity nor the size consist composition to meet the requirements for materials to make up a base that is stabilized by size consist. The addition of crushed rock would correct such deficiencies and could lead to the adoption of this type of base.

Accommon size consist range was taken from the sub-base source areas and a mixture with crushed rock that yould place the mixture within one of the ranges required for the bace (see Figure 5-VII) was designed.

In general, the designed mixture is mode up of 70, soil and 30; crushed rock, by weight.

QUARRIES BASE (RANGE)	SOIL A2-4	CRUEITED ROCK
1" 100		100
3/B" 60 - 100	- •	0 - 15
4 - 50 - B5	100	0 - 5
10 40 - 70	98	
40 <u>25 - 45</u>	60	
200 5 - 20	20	
		• • .

The numbers above are the percentages passing through the indicated screens.

D COVERING.

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Progressive covering to be done in accordance with traffic increases was indicated for the highway system during the 1st stage. Covering suggestions included the double surface treatment with asphalt emulsion for the construction phase and the initial traffic generated during installation of the industries. When the traffic justifies, the pavement would be increased with a layer of bituminous concrete. This would all occur during the 1st stage, in accordance with the values found for the number N.

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5.3 PREDITENSIONING THE PAVELENT

The Murilo Lopes de Souga method was used to predimension the pavement, in accordance with the values of N for each sections and the subgrade CER considerations described in Item 5.2.2.

The coefficients proposed in the method are:

	Subgrade reinforcement	K - 0.71
-	Sub-base	к – ф.77
-	Base stabilized by size consist	K - 1.00
-	Soil cement base	K - 1.4
	Surface treatment	K - 1.2
	Bituminous concrete	K - 2.0

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Table 5/47 contains a summary of the pavement layers for each section.

5.4 QUANTITATIVE DATA

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Table 5/48 contains the quantitative estimates for the paving work, calculated based on the transversal sections proposed for

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the first stage, the thicknesses of the layers composing the

pavement, and the mean transport distances of 3.0 km, 10.0 km,

and 20 km, for reinforcement, sub-base and base, respectively.

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TABLE 5/5 - COMPOSITION OF CARGO TRAFFIC

SECTIONS	CVb.	25 ton	CAP.	L2.5 ton.	
han have been any	LOADED	UNLOADED	LOVDED	UIILO/DED	
• •					
SECTION A	2,324,532	736,064	1,992,456	630,912	
SECTION B.	2,222,556		1,905,048	· -	
SECTION C	2,027,032	-	1,737,456	-	
SECTION D	- 195 ₁ 524		167,592		
SEC PION JE	736,064	101,976	630,912	87,408	
•	ļ`	<u> </u>]		

TABLE 5/6 - COMPOSITION OF PASSENGER TRAFFIC

SECTION	VENICLES DAY (CNS		VEHICLES DUR	ING 1st STAG	
•			BUS	AUTO	
• •	BUS	AUTO	<u> </u>		
SECTION A	. 111	772	709,012	4,931,150	
SECTION B	207	915	1,322,212	5,844,562	
SECTION C	153	409	977,287	2,612,487	
SECTION D	225	856	1,437,187	5,467,700	
Section e	37	. 143	236,337	913,412	
ACCESS TO REFINERY	100	381 .	638,750	2,433,637	
ACCESS TO	49	131 ·	312,987	836,762	
N S DO O (1) MAIN ROAD (2)	104	278	664,300	1,775,725	
TO:NISITE CIRCUIT	52	139'	332 ₁ 150	887,862	
RQAD 2	26	70	166,075	447,125	
ROAD 3	26	70	166,075	447,125	
ROAD 4.	· 26	70	166,075	447,125	
ROND 5	26	70	166,075	447,125	
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(1) - Port Route V + Access to N S do 0.
(2) - Townsite Access 1 + Road 1

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- CONPOSITION OF TOTAL TRAFFIC FLOW - CARGO AND PASSENGERS	4
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TABLE 5/7	

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sus	TRAFFIC	\$,931,150 5,844,562 2,612,587 5,467,700	913, 412 2,433,637 836,762	1,775,725 887,862	447,125 447,125	447, İ25 447, 125		• •
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TABLE 5/8 - CARGO FACTOR

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TABLE 5/9	- 'NUMBER "N"

SECTION	V T	F.E.	F.C.	F.R.	N.
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SECTIONA	11,324,126	.2.27	7.59	1.8	3.5×10^8
SECTION	11,294,378	2.20	7.58	1.8	3.4×10^{6}
SECTION C	7,354,252	2.28	. 10.02	,1.8	$.3.0 \times 10^8$
Section D-	7,268,003	2.03	1.41	1.8	3.7×10^{7}
SECTION	2,706,109	2.31	10.02	1.8	1.1×10^8
ACCESS	3,072,387	2.00	0.20	·1.8	2.2×10^6
REFILERY ACCESS TO N S	1,149,749	2.00	0.28	1.8	1.1 × 10 ⁶
do 0 (1) MAIN ROAD (2)	·2,440,025	2.00	0.28	1.8	2.4×10^{6}
TO:CISITE_CIACUIT	1,220,012	2.00	0.28	1.8	1.2 × 10 ⁶
ROAD 2	613,200	2.00	• 0.28	1.8	6.0.x 10 ⁵
ROAD 3	613,200	2,00	0.28	1.8	6.0 × 10 ⁵
ROAD 4	. ē13,200	2.00	0.28	1.8	6.0×10^{5}
ROAD 5	, 613,200 [°]	2.00	0.28	1.8	6.0 × 10 ⁵
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1) Port Route V + A	ccess to NS	do 0	*		
2) Toumsite access	1 + Road 1				

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HOISTURE CBR EXPANSION FIELD NAT MOISTURE USEABLE YES (Y) NO (N) OBSERVATIONS NOTES: HIGHWAY SAID/GRAVEL NO. NAME: THAT OF SAID/CRAVEL CD 5/11	Š	MAX DENSITY				27 - 5 2 F						
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EGISTER NO	-11	12	13	14.	15	16	13	18	19.	.20
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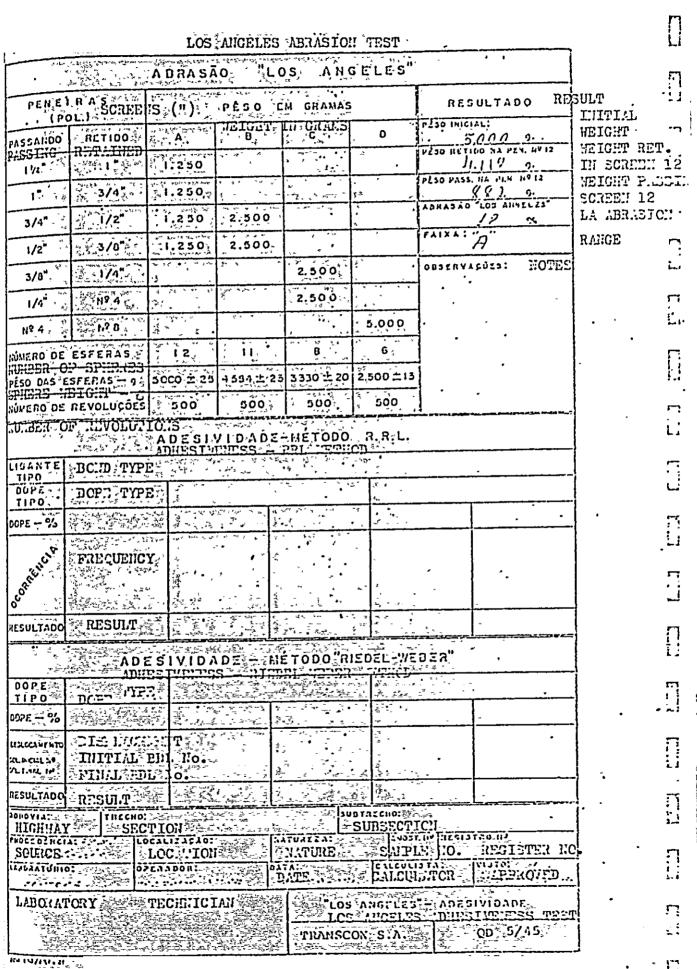
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IV-2/5.57

TABLE 5/47 - DIMENSIONING THE PAVEMENT

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SECTION	N	THICK- NESS	ŘĚF/	SUB- BASE	BASE	SURF- ACINC	Concrete
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MAIN ACCESS	3.5 x 10 ⁸	<u>,</u> 70		35.*	20	2.5	10 .
DIST. TRUIK (1)	3.2×10^8	70	· · ·	35	20	2.5	10
ACCESS FERTILZER	3.7 × 10 ⁷	63	, ,	40	20	2.5	5
PLAIT (2) ACCESS BULK PRODUCTS	1.1 × 10 ⁸	°, 96	50	25	, 20	2.5	10
PORT (3)				, - 40	20	2.5	-
MAIII HIGHIAY (4)	2.4 X 10	294 21 22 24 24 24 24 24 24 24 24 24 24 24 24					•
ACCESS - REFINERY ACCESS - II S. do 0 (5)	2.2 × 10	.54	ນ 	40	20	2.5	-
	1.1 × 10 ⁶	.~ 53 ·-	· • ·	, 4 <u>0</u>	20	2.5	-
TOINSITE CIRCUIT	1.2×10^{6}	53, -	· - ·	40	20	2.5	- .
ROAD 2	0.6.x×10 ⁶	52		40 [°]	['] 20	2.5	-
ROAD 3	0.6 × 10 ⁶	52		40	20	2.5	-
ROAD, 4	0.6 × 10 ⁶	52		40	20	2.5	·
ROAD 5		1		40	20	2.5	
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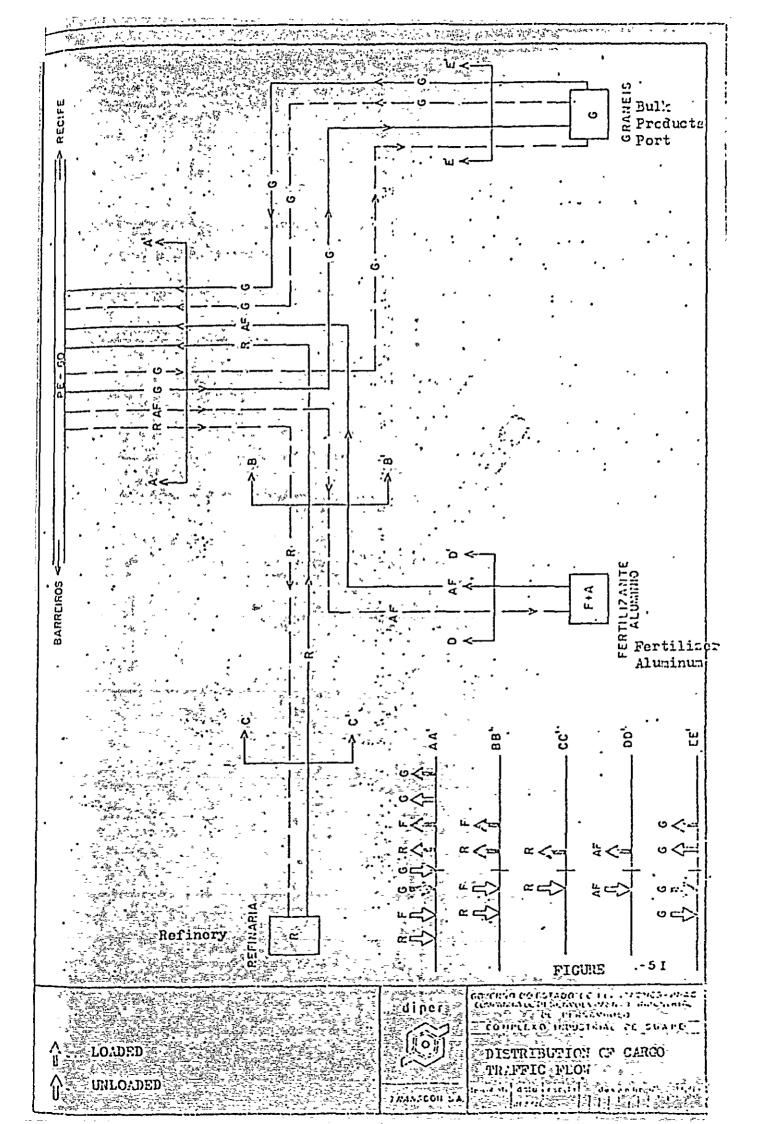
(1) - Dist. Trunk + Port Route 1 + Access to bulk products port
(2) - Port Route 3 + Section of Port Route 4 + Second. Access - Fertilizers
(3) - Section of Port Route 1 + Secundary Access to bulk products port
(4) - Tounsite Access 1 + Road 1
(5) - Section Port Route 5 + Access N.S. do 0

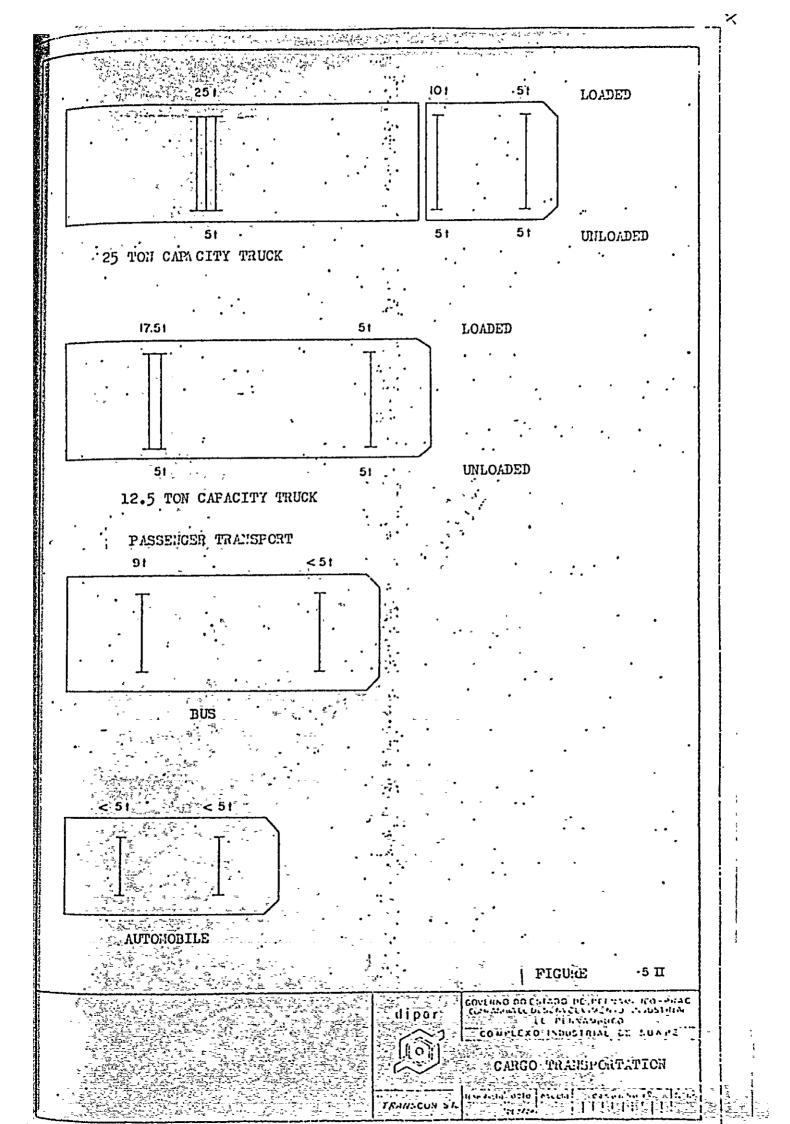
IV-2/5:58

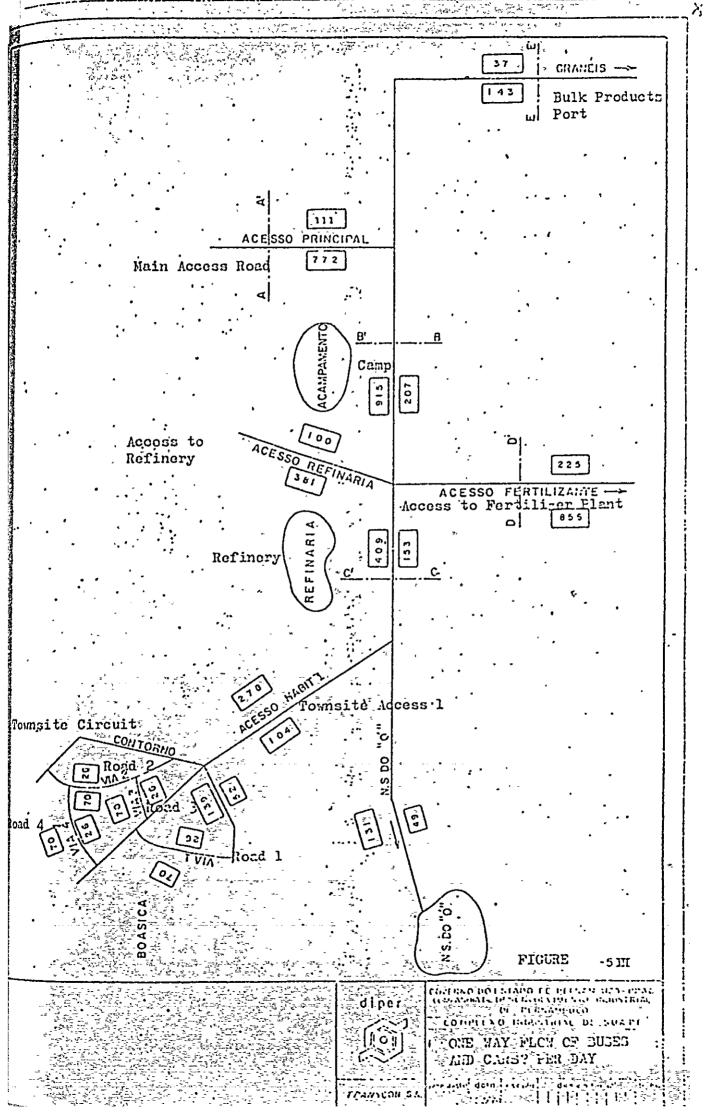
TABLE 5/48 - PAV	י <u>ָ</u> חַוֹּק <u></u> מ	UAITTITAT	IVE DATA	(SULMARY)
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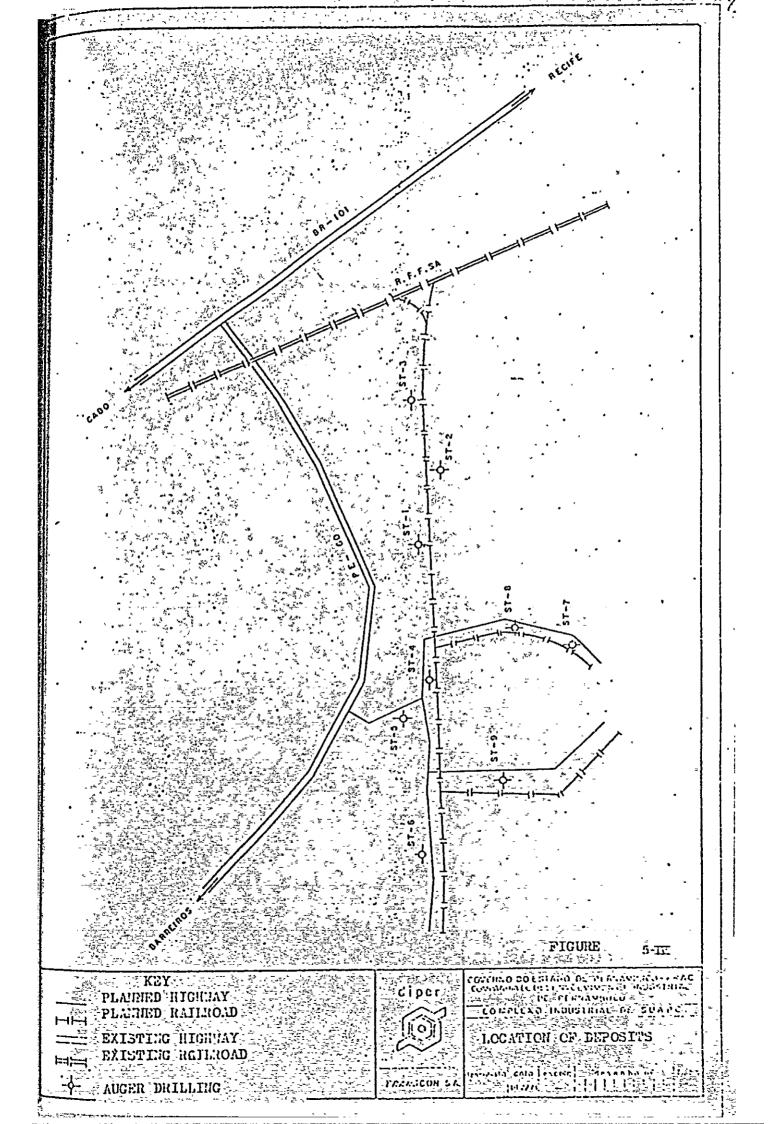
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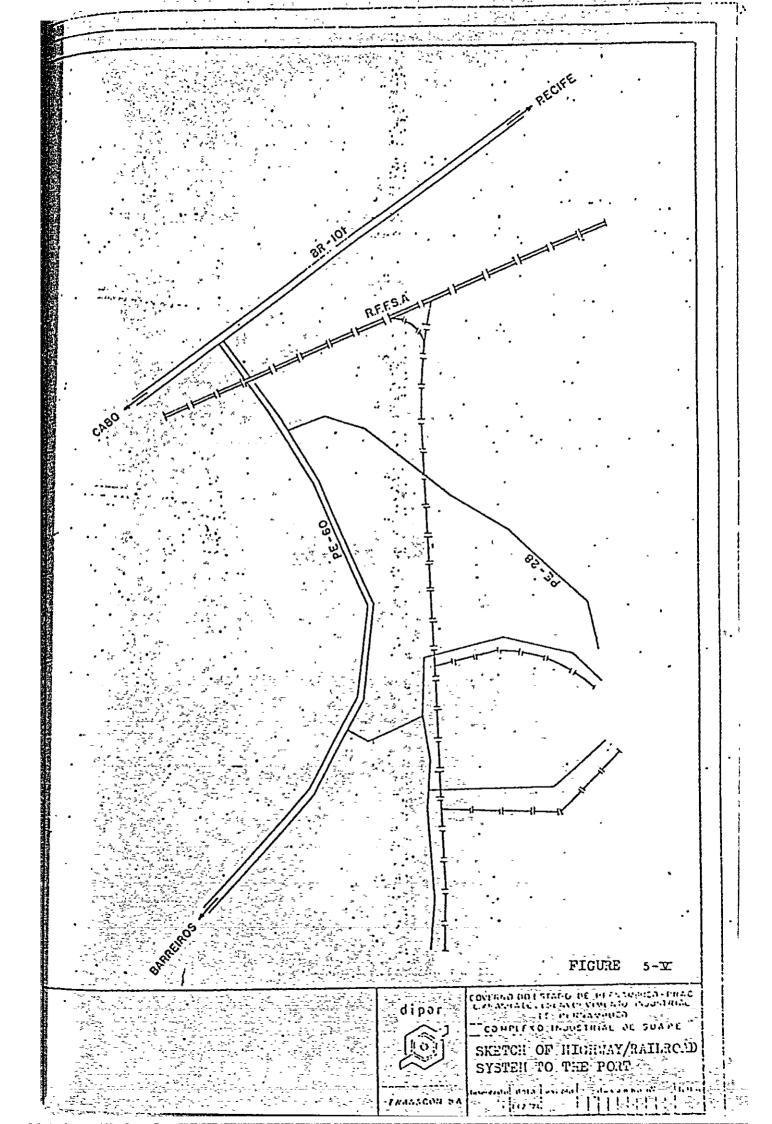
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ACCESS REF.		111,010 111,010	"		•		**	
ROAD 5		11,010 11,010 11,111	.	•				' .
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ROAD 3		111,118 115,158		*	•	•	•••	•
ROAD 2		210,61 ·	·	:		•	• •	•
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DISTRIBUTIO TRUIK LIIE (1) MAIN ACCESS UNIT SERVICES			*-	(1) - Dist. Trunk + Port Rte 1 + Sec Prod. Port	Port Rto 3 + Section Port Rte Fortilizor'Plant	cond. A	coss to d l	-
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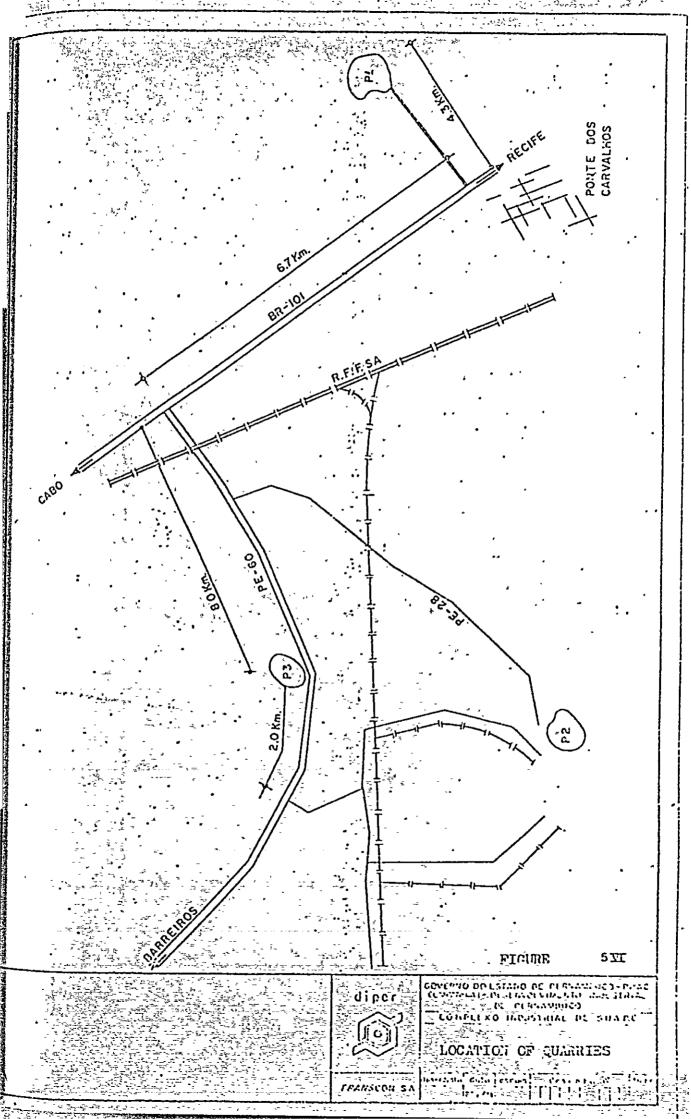


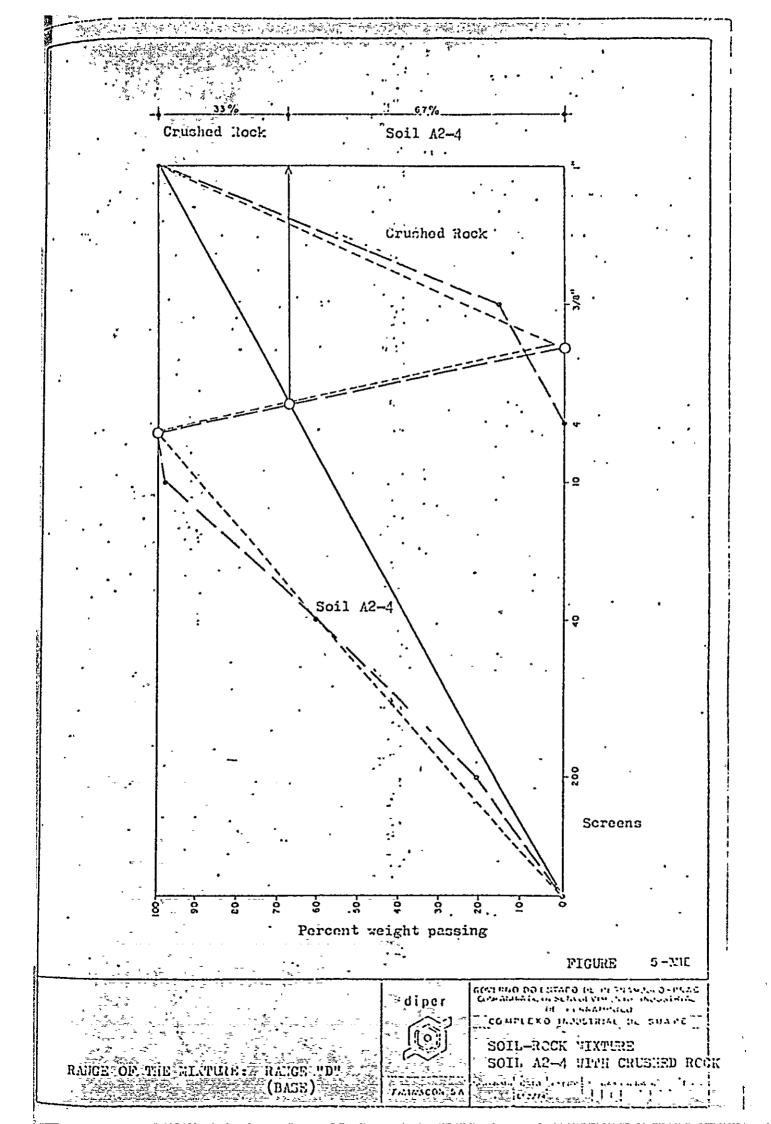














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6.0 SPECIAL CIVIL CONSTRUCTIONS

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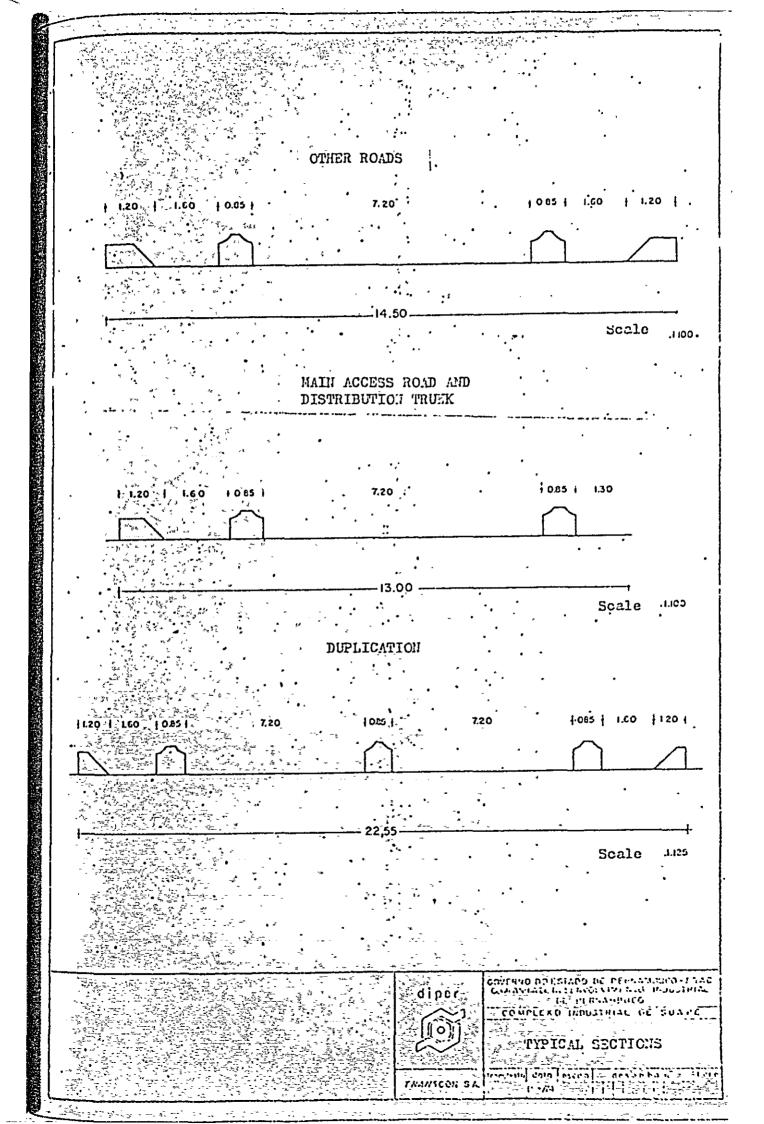
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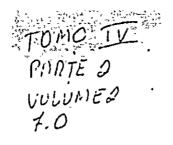
6.1 DESCRIPTIONS الم الم من ا

The following bridges were planned to overcome the water courses that will continue to cross the roadbeds even after hydrological work has been done:

Highway Section	Water Course	Span (m)	Width (m)
Port Route 1	Algodoais	52	14.50
Distribution Trunk	ipojuca Canal	24	13.00
Main Access Road	Tabatinga . River	· 40	13.00
Townsite Access 1	Ipojuca River	100	14.50
Distribution Trunk	Jasmin River		13.00
Distribution Trunk	Tabatinga River	40	13.00

The typical transversal section adopted allows for passage of pedestrians and bicycle riders, appropriately protected from the vehicle traffic. For the sections where the heaviest traffic will occur, and where a future "doubling the number of lines is expected in the future, the tranversal section is 13 m wide, and could be doubled with loss of only one shoulder.





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7.0 OVERALL BUDGET

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7.0 OVERALL BUDGET - HIGHWAY SYSTEM

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3	5			•	4 .		

Description	Cr\$
Conventional Civil Constructions	58,139.60
Special Civil Constructions	4,362,792
Earth Moving	. 19,389,910

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32,384,355

61,951,037

6,195,103

68,146,140

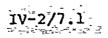
Engineering and Inspection

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SUBTOTAL

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Section Port Route 1	3	210,225	2, 2, 169	156,002	3,578	\$\$3,201.	6,240	312,020	05545	17,555,55,025	25,023	220.022
- + Seo. Access - Bulk.	123	274,165	026'2.	149,000	1,200	\$3,300	6,330	226,520	4,700	10231 82	دور دەن. د	121,500
	33,	137, 121	1,175	55, 500	2,070	c2,200	2.955	345,656	¢ crc *	5.5	(cc, 22) (cc)	- 652 1237
+ Tomcito Road 1	1	, , , , , , , , , , , , , , , , , , ,	•	۰.	1,505	45, COD	.,1	1	2,459	2,023,5	- esc (22 033 L	ເວລີ (ເວລ
- Port Route V	161	107,620	316.1.	C5, 800	2,240	67,203	2,200	110,000	2,240	ora ar certr	1013 61	43,525 [°]
	5	46,770	. 705	35,400	110	21,200	1,630	005'16	210	01550	020,61,022,6	(32,502
*	11	CLT .CE .	1,530	79,600	2,666	55,555	1,090	54,500	2, 672	csc1::	3,525	- 23,552
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-	205	115,511	115,517 - 1,870	005,66	1,370	36,100	1,620	1000,18	1,570	: csr *c	CCT.1.5.	25,975
	3	121/05	1,000	53,000	1,440	43, 600	1,770	005'23	1,460	2,305	1,305 26,709	41,750
Nte 3 + Rte 4 + Sec. Accoss Fertilizers	•	•	200	. 35,000	1,560	55,600	12,440	572,000	1,860	acc	\$,320 729 520	195,750
Accoss to Comont Factory.		•	•••	-	i		2140	•	;	•	27,276	
otal Drainage Cost (Cr\$ 5,813,980.00)	2,580	21,457,810 15,540	15,540	777,000 22,170	22,170	625, 200		38,800 1,540,000		22,170-1 210,050 245,050	C33 5:2	èsz ¹ 232

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IV-2/:.2

EARTH MOVING, BUDGET

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Services	Unit	Quantity	Unit.Cr\$	Subtotal (
Cut and fill excavation of	•			
1st category material with	-			1
transport distance up to				ļ
0.4 km	3 m	647,000	4.33	2,801,510
				}
Cut and fill excavation of			}	
1st category material with				
transport distance between	m ³ ,			3,879,600
0.4 and 0.8 km	m_,	636,000	6.10	5,019,000
Cut and fill excavation of				
1st category material with transport distance between	ļ		i.	
v0.8 and 1.5 km	3	1104,000	8.50	9,384,00
Cut excavation of 2nd cate-				
gory material with transpor	ų _		*. ·	
distance up to 0.2 km	m ³	96,000	12.00	384,00
		· · ·		
Cut excavation of 3rd cate-		× **		
gory material with transpor	t i			
distance up to 0.2 km		48,000	25.00	1,200,00
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Deforesting, stump grubbing	2		0.18	199,20
and clearing	m	1107,000	0.10	100700
	- m3-	1694,000	. 0.91	1,541,54
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TOTAL			-	19,389,9
(4) A V A FIAN, David To V, 2007 June 1997 The second state of the second state of			-	

IV-2/7.3

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Total Cost	ຈະໃດເຊັ່ມ ເຊິ່ງເຊັ່ມ ເຊິ່ງເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງ ເຊິ່ງເຊິ່ງ ເຊີ່ ເຊີ່ ເຊີ່ ເຊີ່ ເຊີ່ ເຊີ່ ເຊີ່ ເຊີ່		· ·	
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Unit Cost			•	
Total	10,000 10,00000 10,0000 10,0000 10,0000 10,0000 10,0000 10,0000 10,0000 10,00000000	212 022 232 232 232 232 232 232 232 232 23	•	
Secondary Access to Refinery		135,520 135,329	• •	
Road V	23, 200 23, 200 23, 700 23, 700		•	
Road IV		23, 369	• •	
Road III	25,259 - 10,250 - 26,555 - 26,555 	115,100	• •	
Road II	20,550 7,871 3,672 16,64	78,910 71,910	· ·	
Townsito Circuit	101,05 10,05 10	261,020 163,460	. :	
Townsito Access 1 +: Road 1	1,1,359 36,339 1,6,818 8,3,838 8,3,838 8,3,838 8,3,838 8,3,838 8,3,838 8,3,838 8,3,838 8,3,838 8,3,838 8,3,838 8,3,838 8,4,358 8,4,358 8,4,358 8,4,358 8,4,358 8,4,358 8,4,588 8,4,588 8,4,588 8,4,588 8,4,588 8,4,588 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,4,598 8,598		•.	
Section Port Rte 5 + Access to N S do 0		11. 12. 14. 14. 14. 14. 14. 14. 14. 14. 14. 14	•	
Secondary Accessito Bulk Products Port		220,313. 185,330 281,380	•	•
P Rto 3 + Sect P Rte 4 + Sec. Access Fertilizer Plant	22, 25, 25, 20, 20, 20, 20, 20, 20, 20, 20, 20, 20	311, 140 318, 029	•	
Dist. Trunk + Port Route 1	1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,	275,770	•	•
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SPECIAL CIVIL CONSTRUCTIONS - BUDGET

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Bridge	Length	Unit	Total
Port Route 1 over the			1
Algodoals Channel	52	14,973.97	778,646.20
Distribution Trunk over			
Ipõjuča Channel	24	15,456.85	370,964.35
Main Access Road over			
Tabatinga River	49	13,584.76	665,653.39
Townsite Access Road 1			
over Ipojuca [†] River	100	16,188.41	1,618,840.57
Distribution Trunk over			
Jasmin [®] River	9	27,736.57	249,629.17
Distribution Trunk over	ن ب	· · *	1
Tabatinga River	40	16,976.45	679,058.12
TOTAL			4,362,791.80
TOTAL	Ę		4,362,791

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BOOK IV - PART 3 RAILROAD SYSTEM

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3.0	EARTH. MOVING	IV-3/3.1
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1.0 TRAFFIC

PART 3 - RAILROAD SYSTEM

1.0 TRAFFIC

1.1 TRAFFIC FORECAST

Analagously to the highway system, the railroad system consists of a Distribution Trunk Line starting at a main yard connected with the 3rd RFFSA division's south line, three branch lines to the port and one branch line to the petroleum refinery.

ال الم يو الم معاد . وي ال

The Railroad Distribution Trunk Line starting from the main yard will run approximately parallel to the Highway Distribution Trunk Line and will branch off from there with one branch line running to the Collective Port, one branch line between Highway Port Routes II and III to Z-1 and Z-2 central, and another branch line approximately parallel to the Highway Port Route V for the coastal industrial zone.

The Railroad Distribution Trunk Line will be single tracked to the ZR-2 townsite since the possibility of extending passenger traffic from there to Recife has been forecast. The line would pass through a railroad station built next to the administration area, as described in the highway system section.

In the first stage the main yard module adequate to meet forecast demand, the Railroad Distribution Trunk Line, the branch lines to the collective port and to the aluminum and fertilizer plants will be installed.

Based on the forecast presented in Table 1/1 of Railroad Transport with origin or destination at Suape, the following annual and dialy railroad car cargos for 1980, 1985, 1995 and 2005 were obtained.

- Destination Bulk Products Port Subtotal A 250 42 $5,953$ 18 Port Subtotal Fortilizer Plant UNEA 7 30 234 1 LIQUID ANMONIA UNEA 7 30 234 1 LIQUID ANMONIA UNEA 7 30 234 1 Subtotal Plant 8 45 $1,139$ 4 2-ORIGIN-Fertilizer Plant 100 42 $2,301$ 8 SUBTOTAL Petroleum Refinery iquid Petroleum 145 $3,520$ 12	PRODUCT	ANNUAL TOIŃIAGE	RR CAR CAPACITY,	NO. of RR CARS/	RR CARS/DAY (YEAR 330 d)
2-ORIGIN-Petroleum Refinery iquid Petroleum	Bulk Products Port Subtotal A B - Destination - Fertilizer Plant LIQUID AMMONITA UNEA Subtotal B S-ORIGIN- Fertilizer Plant Subtotal	250 7 <u>30</u> 45 <u>100</u> 100	30 42	5,953 234 905 1,139 2,381 2,381	$ \begin{array}{c} 1.8 \\ . & 3 \\ . & 3 \\ . & 3 \\ . & 4 \\ . & 4 \\ . & . & . & . \\ . & . & . & . & . \\ . & . & . & . & . \\ . & . & . & . $
	2-ORIGIN-Petroleum Refinery iquid Petroleum erivatives				

		11 1909		
PRODUCT	ANNUAL TOINIAGE (1,000 t)	RR CAR CAPACITY in tons	No. of RR CARS/ YEAR	RR CARS/DAY (YEAR 330 d)
noctination				<u>51</u>
- Destination Bulk Products	<u>700</u>	42	16,667	
Port Subtotal A	700		16,667	51
				· , ·
- Destination - Fertilizer Plant	·			
LIQUID AMMONIA	• 17	30	· 567 · ·	2
UREA	· <u>103</u>	42	2,453	. 8
Subtotal B	120 .		3,020	10
		••	•	•••
-Origin- Fertilizer		42	4,762	<u>15</u> ·
Plant	200 200		4,762	15
Subtotal	•		•	25 <u></u> -
SUBTOTAL	320		7,782	
-Origin-Petroleum		•		
Refinery				
Liquid Potroleun				
Derivatives	480	30	<u>16,000</u>	49
Subtotal	480	· · · ·	16,000	49
TOTAL			,	125
	1,200		40, <u>349</u>	125

YEAR 1985

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*** ····	YE.	AR 1995		
PRODUCT	AIRIUAL TOMIACE (1,000 t)	RR CAR CAPACITY in tons	No. of RR CARS/ YEAR	RR CARS/DAY (YEAR 330 d)
A ₁ - Destination. Bulk Products Port Subtotal A B ₁ - Destination - Fertilizer Plant LIQUID MINONIA UNEA Subtotal B ₂ -Origin- Fertilizer Plant Subtotal SUBTOTAL B C ₂ -Origin-Petroleum Refinery Liquid Petroleum Derivatives	(1,000 t) <u>1,200</u> 1,200 <u>49</u> <u>101</u> 230 <u>250</u> <u>480</u> <u>480</u>	42 30 42 42	$\frac{28,572}{28,572}$ 28,572 1,634 $\frac{4,310}{5,944}$ 5,953 5,953 11,897 26,334	87 87 5 13 18 18 36
Subtotal	790		26,334	80
TOTAL	2,470		66. <u>803</u>	.203

YEAR 1995

~ »	*			
PRODUCT	ANNUAL TOINIAGE (1,000 t)	RR CAR CAP. CITY in tons	No. of RR CARS/ YEAR	RR CARS/DAY (YEAR 330 d)
		•		
Destination	• 1 300	. 42	30,953	94
Bulk Products	" <u>1,300</u>			<u>94</u> 94
Port	1,300		30,953	94
subtotal A	142 a 1 4	· · ·		
Destination	• • /			•••
Fertilizer Plant	,			
LICUID AMMONIA	~ 49	30	1,634	5
UREA	101 .	42	4.310	<u>13</u>
Subtotal	230	• •	5,944	· 18
	a internet			•••
Origin- Fertilizer				
Plant				•.*
Subtotal		4.2	5,953	าก
and the second second second second second second second second second second second second second second secon	250	42.		<u>18</u> 18
SUBTOTAL	250	** *	5,953 -	• •
	- <u>4</u> 80 .		11.897	. 36 -
and a second second second second second second second second second second second second second second second second second br>second second br>second second br>second second s second second		*	• .	
-Origin-Petroleun				
Refinery				····
Liquid Petrolcum	1 500	30	50,000	152
Derivatives				1. •
Subtotal	- 1;500=		50,000	152
			0.2 050	202
TOTAL	3,200		22,850	202

YEAR 2005

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1.2 TRAIN MOVEMENT

1.2.1 RUNNING TIMES

Even though the basic design's technical conditions are excellent, the velocity assumed for train traffic on the Suape line will be low. The distances between the releasing stations and between the switches for branch lines are so short that the mean velocity can be considered equal to 20 km/hour.

*** *******

Therefore we have the following values for running times.

1) From the main yard to releasing station 1 -Distance = 5.79 km; t = $\frac{5.79}{20}$ = 18 minutes

- 2) From releasing station 1 to releasing station 2 -Distance = 4.96 km; t = $\frac{4.96}{20}$ = 15 minutes
- 3) From releasing station2 to the Refinery -Distance = 2.57 km; t = $\frac{2.57}{20}$ - 8 minutes
- 4) From releasing station 1 to the Bulk Products Port Distance = 5.00 km; t = $\frac{5.00}{20}$ = 15 minutes

5) From releasing station 2 to the Fertilizer Plant -Distance = 5.61 km; t = $\frac{5.61}{20}$ ~ 17 minutes

1.2.2 TRAINS

A YEAR - 1980 - SCHEMATIC 1 (FIGURE 1-I)

In this year, in accordance with the daily cargo flows and railroad cars to be handled, the following trains should run on the Suape line.

18 railroad cars carrying sugar should arrive daily at the bulk products port for unloading. These 18 cars will make up just 1 train. 8 railroad cars to be loaded with fertilizers and b 4 carrying ammonia and urea to be unloaded should arrive daily at the fertilizer plant. These 12 cars will make up just 1 train. . . . 39 railroad cars should arrive daily at the С petroleum refinery to be loaded with petroleum derivatives. These 39 cars will make up 2 trains of 19 to 20 Cars each. •••• The graph for 1980 in Figure 1-II diagrams the movement of the trains, 24 hours a day. B YEAR - 1985 - SCHEMATIC 2 (FIGURE 1-III) In this year; in accordance with the daily cargo flows and railroad cars to be handled, the following trains should run on the Suape line. a____51 railroad cars carrying sugar should arrive daily at the bulk products port for unloading. These 51 cars will make up 2 trains of 25 to 26 cars pach. 15 railroad cars to be loaded with fertilizers and 10 carrying anumonia and urea to be unloaded should arrive daily at the fertilizer plant.

and the second second second second second second second second second second second second second second second

These 25 cars will make up just 1 train.

 c_1 49 railroad cars should arrive daily at the petroleum refinery to be loaded with petroleum derivatives.

147 - 16 19 - 19 - 16 19 - 19 - 16 These 49 cars will make up 2 trains of 24 to 25 cars each.

The graph for 1985 in Figure 1-II diagrams the movement of the trains, 24 hours a day.

C. MARYEAR - 1995 - SCHEMATIC 3 (FIGURE 1-IV)

• • • •

In this year, in accordance with the daily cargo flows and railroad cars to be handled, the following trains should run on the Suape line.

a2 87 railroad cars carrying sugar should arrive daily at the bulk products port for unloading.

These 87 cars will make up 4 trains of 21 to 22 carsieach.

18 railroad cars to be loaded with fertilizers and 18 carrying ammonia and urea to be unloaded should arrive daily at the fertilizer plant.

These 36 cars will make up 2 trains of 18 cars each.

c2 80 railroad cars to be loaded with petroleum derivatives should arrive daily at the petroleum refinery

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These cars will make up 3 trains of 26 to 27 cars each The graph for 1995 in Figure 1-V diagrams the movement And the second sec D YEAR - 2005 - SCHEMATIC 4 In this year, in accordance with the daily cargo flows and railroad cars to be moved, the following trains should run on the Suape line. The second second second second second second second second second second second second second second second s , a 344.94 railroad cars carrying sugar should arrive daily at the bulk products port for unloading. These 94 cars will make up 4 trains of 23 to 24 cars each. b, 22-18 railroad cars to be loaded with fertilizers and 18 carrying ammonia and urea to be unloaded should arrive daily at the fertilizer plant. These 36 cars will make up 2 trains of 18 cars each. . cather 152 railroad cars should arrive daily at the petroleum refinery to be loaded with petroleum derivatives. £. Ŧ These 152 cars will make up 5 trains of 30 to 31 cars each. The graph for 2005 in Figure 1-VII diagrams the movement of the trains, 24 hours a day.

IV-3/1.10

The bulk products terminals, the fertilizer plant and the petroleum refinery should all have sidings for the switching needed to position the cars for loading and/or unloading and for returning the locomotive to the head of the train.

As can be seen from the diagrams showing the train schedules, their length of time in the terminals appears to be sufficient for loading and/or unloading the cars. In the event that the terminal facilities don't have the necessary capacity for loading the cars in the projected lengths of time, supplementary sidings will be indispensable for accomodating the train that is arriving as well as the one which remains loading or unloading. They will also permit the mandatory maneuvers of removing one train and placing the other at the loading and/or unloading sites.

The railroad cars that enter and leave Suape will be weighed by an automatic electronic scale located near releasing station no. 1, before the first branching.

1.2.3 COMMUNICATIONS

Operation of trains on the line demands a communication system linking the terminals, the releasing stations and the main yard.

····

Based on the basic design level graph made of the trains, consultants recommend that a selective call telephone system be installed. The system could eventually be connected to the system already existing for the RFFS/A's third Northeast division, at whose southern line the Suape railroad yard and line originate. It is also indispensible that the locomotives, releasing stations and yard control tower be equipped with hand talk radios capable of covering the Complex's entire area. This device will make possible direct communication between the control tower and interested parties and will permit more speed and safety in operating and switching trains.

IV-3/1.11

1.2.4 RELEASING OF TRAINS

Even though it might be possible to use the selective call telephone system to release the trains between the Suape yard and the various terminals, for safety reasons the consultants recommend that a staff electric releasing system be installed. This equipment would be installed at the railroad yard and releasing stations 1 and 2 (See schematics 1, 2, 3 and 4), (Figures 1-I/III/IV/VI).

As can be inferred from the train graphs there is no need for a more sophisticated releasing system unless there is a desire to economize on labor.

Each releasing station will have to be manned 24 hours a days by one operator, just like the station at the main yard.

Switchmen would not be needed on the line. They would be replaced by the releasing station operators or by the train crew switchmen who would, in any event, have to perform switching at the terminals.

Thus the two stations would need nine persons (four employees for each stations plus one as a cover for holidays and leaves). No train would leave a terminal without first having been authorized to do so by the operator of the respective releasing stations through the selective call telephone system. This will assure better control and traffic safety.

1.2.5 SIGNALLING

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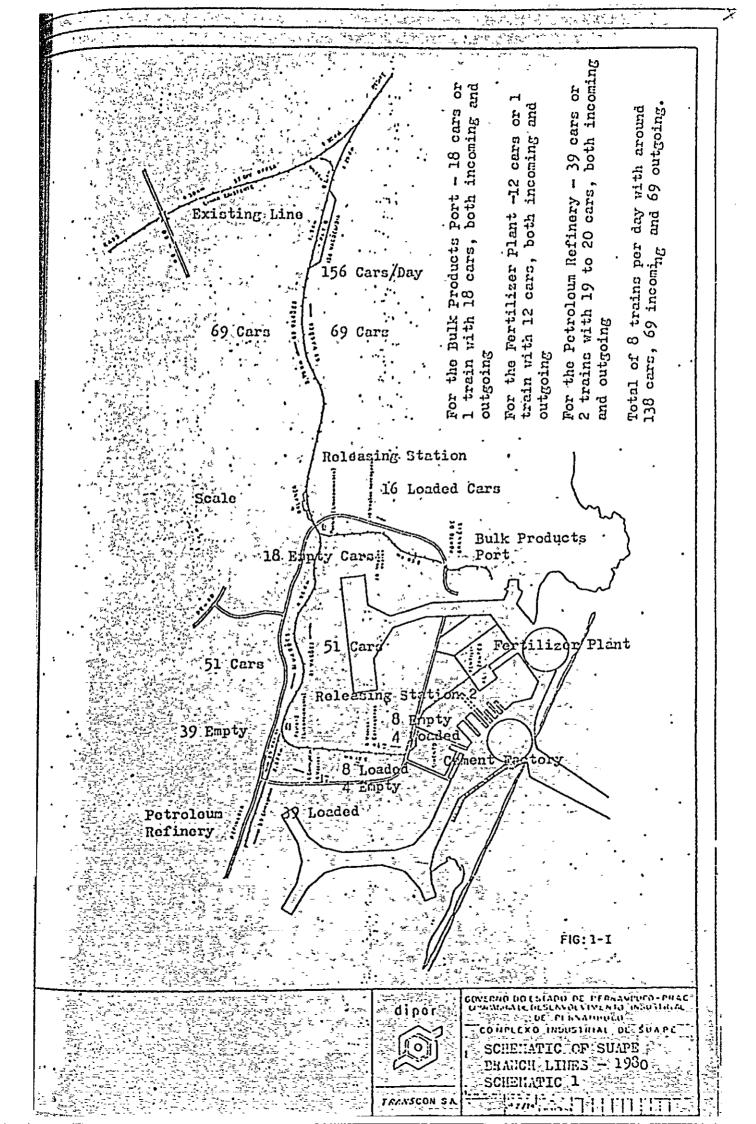
Light signals, working on local batteries and operated by the releasing station operators, could be used to indicate to the locomotive engineer how close the train is to the switching devices in front of which the train has to stop or slow down in order to receive the releasing signal.

IV-3/1.12

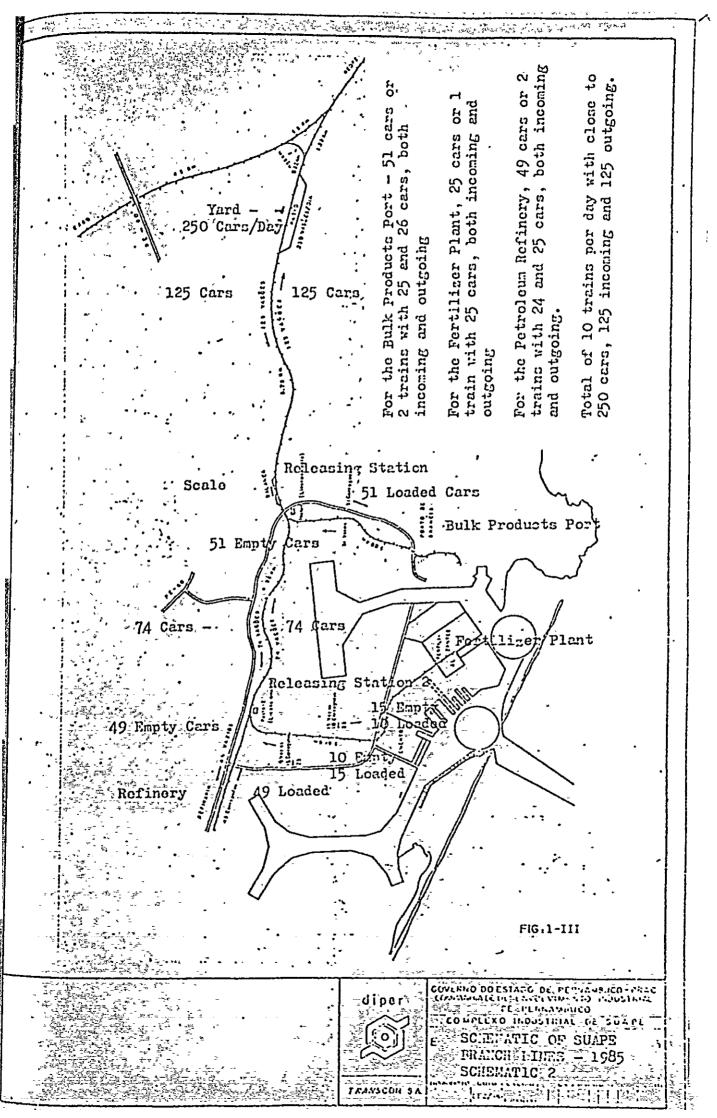
In general two consecutive signals would be installed in each direction. The first would be the approach or warning signal and the second would be the full stop or proceed at slow speed signal. The signal characteristics would comply with the Brazilian railroad signalling standards.

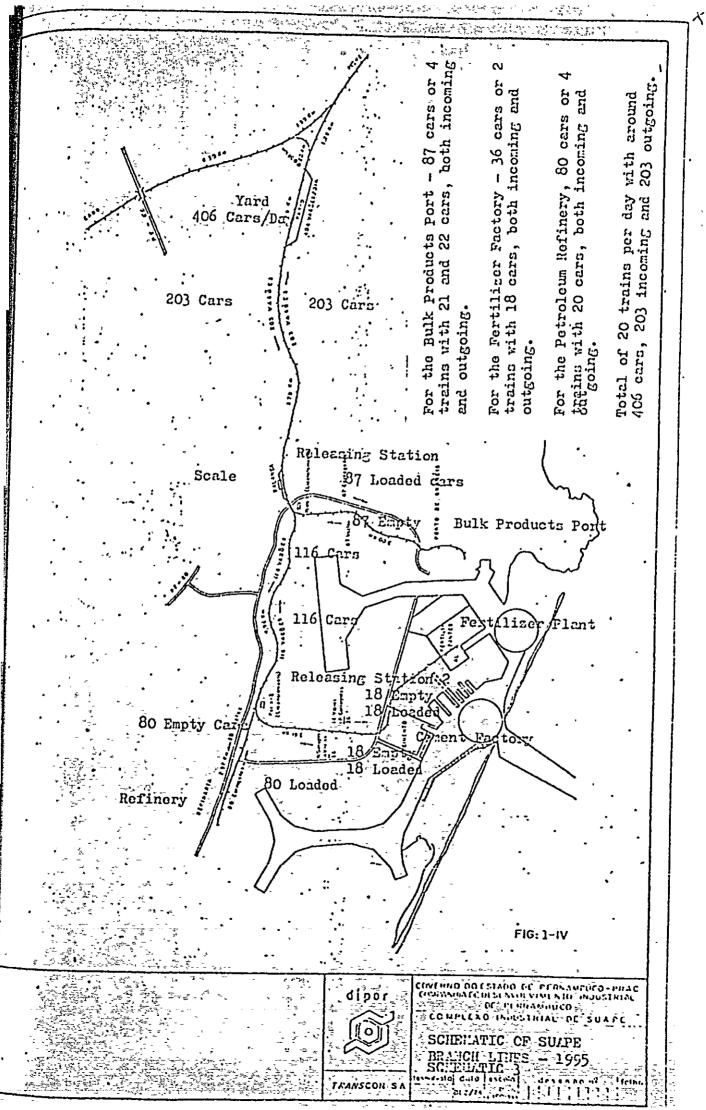
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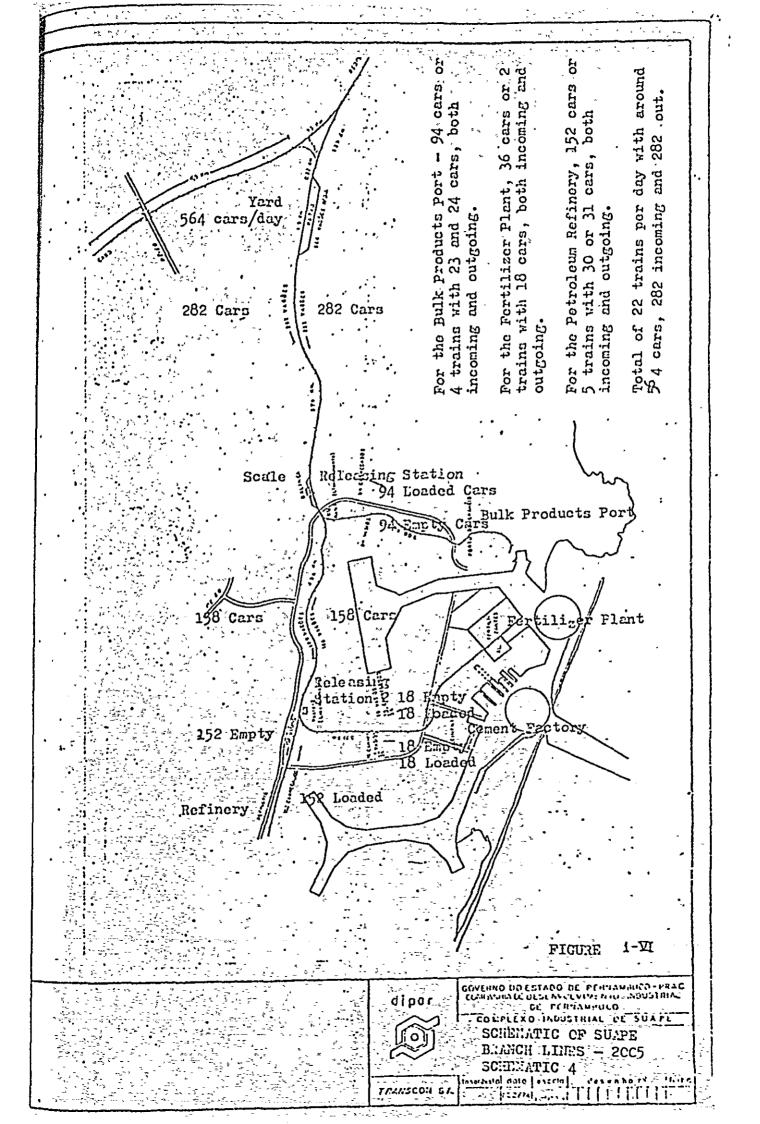


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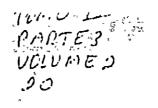




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		FIG: 1-V
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2:0 BASIC GEOMETRICAL DESIGN

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2.1. CONSIDERATIONS

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The railroad network links the various port branch lines to the principal line that connects with the RFFSA. Traffic in the network is directed by the operations control center located in the shunting yard. The routes proposed are intended to fit simultaneously the region's technical and economic conditions and the port industrial complex's operating framework without hindering the functions for which the adjacent areas are designed. HORIZONTAL PLAN AND PROFILE

2.2.1 CHARACTERISTICS

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private sidings.

The philosophy expressed above guided the determination of the railroad's characteristics.

The track system was drafted on a 1:10,000 scale based on aerial photographs on a 1:30,000 scale, restitution of this aerial photographic survey on a 1:10,000 scale, and local reconhaisance.

The Railroad Distribution Trunk Line and the main branch were designed with a minimum horizontal radius of 350 m and a maximum grade of 0.5%.

The port branch lines have a minimum horizontal radius of 245 m and a maximum grade of 0.5%.

The following additional factors were considered in the basic design horizontal plan and profile.

- Minimum height of landfill in the low areas that will assure uninterrupted traffic even in the case of floods. A geometric levelling of the floodwater marks from the 1970 flood was made and the elevation arrived at was 3.80 m at Usina Salgado.

Elevation of the port apron = 2.70 m.

- Dredging of the main waterways crossed: Ipojuca, Pindorama, Tabatinga, Jasmim, Algodoais and Prego.

Highway/railroad crossings.

Railroad branch line crossings of the RFFSA.

- Railroads grades compatible with future

IV-3/2.2 ...

PRESENTATION

2.2.2

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The railroad system is presented in a topographic plan on a 1:10,000 scale and in profile on a 1:2,000 horizontal scale and a 1:200 vertical scale. See the respective volume of drawings.

The lengths measured in the plan yield the following values:

Length (km)

Railroad Distribution Trunk Line and	
main branch line (Recife)	16.74
Main line (Cabo)	0.58
Port branch line 1 (Collective port)	3.17
Port branch line 2 (Fertilizer plant)	5.22
TOTAL -	75.71

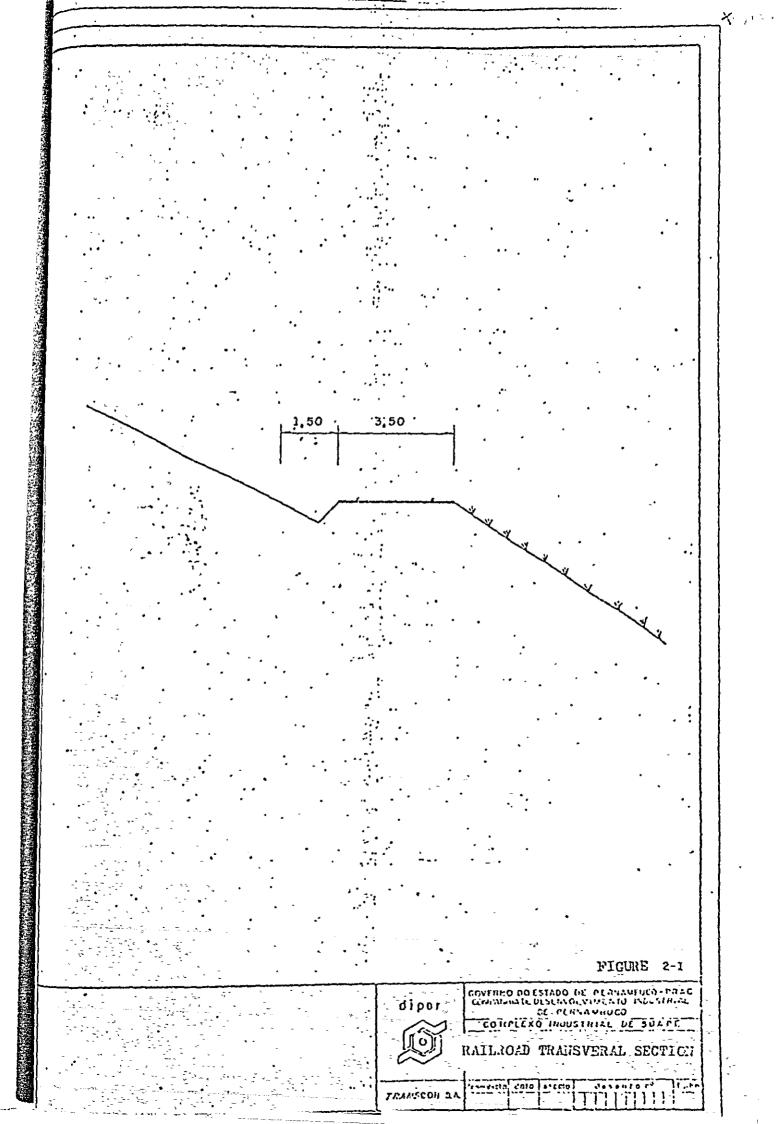
.IV-3/2.3

2.3 TRANSVERSAL SECTIONS For the first stage the transversal section shown in

For the first stage the transversal section shown in Figure 2-I was adopted.

The Main Shunting Yard's section is shown in Chapter 5.0.

IV-3/2.4





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3.0 EARTH MOVING

3.0 EARTH MOVING

3.1 ORIENTATION ADOPTED

The basic design for earth moving took into consideration the following factors:

Nature of the material to be excavated
 Crossing of the mangrove swamp areas
 Volumes of material to be excavated
 Volume of compacted fill
 Mean transport distance

IV-3/3.1

For purposes of calculating volumes, embankments with a 1:1 slope were adopted for the cuts. Whenever the cut sub-bed material shows low support

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capacity, it is suggested that better quality material,

with expansion less than or equal to 2%, be substituted.

The results of volume calaculations showed a clear predominance of fill volumes over cut volumes. Widening the cuts was indicated as the first choice for obtaining borrow material in a manner that preserves the region's natural landscape as much as possible and provides better drainage and visibility conditions. The materials to be excavated were sampled by auger drillings at points where the route showed a section of cuts. د دم نیز شده هر به

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The samples obtained were laboratory tested for:

Size consist

Physical Limits

Compaction and

California Bearing Resistance (CBR)

The results are presented in Tables 3/1 and 3/2.

The nature of the materials was found to be group A2 clayey and/or silty sands and group A7 clayey silty materials, as per the HRB classification system. angely star g - mer

For subgrade materials, a good part of the group A7 materials could be used since a low bearing.resistance capacity and a higher than recommended expansion were found in only two of the drill holes. All of the group "A2 material will be used.



3.5 FILLS

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3.5.1 COMPOSITION

Embankment slopes for the fills constituted of cut and borrow materials were set at 3 (horizontal) : 2 (vertical) in order to determine values needed for calculation of volumes.

Use of materials with low bearing resistance (CBR less than 3) and high expansion (greater than 3%) in the fills is not recommended.

Material with expansion.greater than 2% should not be used in the final layer (60 cm).

In sections where the subgrade support capacity is such that, in spite of being greater than the recommended minimum, it leads to high pavement thickness, the fill should be topped with select materials. Materials from group A2 will be suitable.

3.5.2 . FILLS IN MANGROVE SWAMPS

Special attention was given to this topic. However, defining solutions for crossing mangrove swamp regions does not fit in the scope of this phase's work. It is recommended that studies be conducted at a more advanced stage for specific solutions for each fill in mangrove swamp areas. The following are suggested:

Berms

Vertical sand drains

Dynamiting undesirable material

Berms

Are lateral equilibrium benches to reduce shearing tensions that occur in the fill's soft foundation layer.



Vertical sand drains Are columns of sand penetrated into the soft layer on which the fill will be lain. They serve to accelerate the condensing processes to occur in that layer. Dynamiting undesirable material Consists in the elimination of the soft material by explosions either under the fill or at the base of the fill. Use of the above suggested processes will be determined for each fill area after the characteristics of the soft material, the thickness of the layer in which it occurs, the height of fill over this soft layer and other factors, such as economy of the project design and execution time, have been checked.

In order to make cost estimates that are as realistic as possible, 2m, the value of the pole measurements taken in this region, was added to the red elevation quantities for the fill over mangrove swamps. 3.6 PRESENTATION Cut, borrow and fill volumes and mean transport distance are listed in Table 3/3. . به م The cut and fill volumes were determined from the mean of the red elevations taken from the profiles. in stri The value 1.3 was adopted for a coefficient of expansion. Therefore the volumes are increased by 30%. ٠. ۱ The red elevations for fills over mangrove swamps were fincreased by 2 meters. al the second and the The high mean transport distances arise from the fact that borrow materials will be obtained by widening the cuts. It is not difficult to realize that, in addition to the considerations cited in item 3.3, shorter transport distances cannot be realized by performing lateral borrow operations because the fills that require the largest borrow volumes are located in low areas. a start a subsection of the second start and t The proposed transversal sections plus two meters on each side were used as a basis for predicting quantities of deforesting, stump grubbing and clearing (Table 3/4). a de la construcción de la construcción de la construcción de la construcción de la construcción de la constru Construcción de la construcción de la construcción de la construcción de la construcción de la construcción de Construcción de la construcción de la construcción de la construcción de la construcción de la construcción de Construcción de la construcción de la construcción de la construcción de la construcción de la construcción de Construcción de la construcción de la construcción de la construcción de la construcción de la construcción de Construcción de la construcción de la construcción de la construcción de la construcción de la construcción de The excavation volumes and the transport distances were taken from Table 3/3. ī. The fill volumes, without added measurements for expansion, were used for the compaction volumes. Quantities for

earth moving work in the various railroad system components are listed in Table 3/5.

IV-3/3.7

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TABLE 3/3

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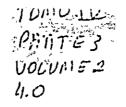
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	Collective Port Branch Line	115,818
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11-3/3.11

SERVICES	UUTT	QUANTITY RAILROAD	NOTE
	•		
Excavation in cuts and borrow areas of 1st category matorial with transport distance up.to 0.4 km	е К	43,000	
Excavation inreuts and borrow areas of lst category- material with transport distance botween 0.4 and 0.8 km	. ⁶ E	134,000	
Excevation in cuts and borrow areas of 1st category material with transport distance between 0.8 and 1.5 km	т С	1,069,000	•
Excevation in cuts of 2nd dategory meterial with transport distance.up to 0.2 km	m E	46,000	tuo solimes
Excavation in cuts of 3rd category material with transnort distance up to 0.2 km	•	•	· ·
	е Справля С С С С С С С С С С С С С С С С С С С	23,000	58.5 cut volumes
Deforesting, stump grubbing and clearing	N E	543,000	• .
- Compaction	. ^m e	000 ⁴ 166	-
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IV-3/3.12

TABLE 3/5



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4.0 CONVENTIONAL CIVIL CONSTRUCTIONS

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CONVENTIONAL CIVIL CONSTRUCTIONS 4.0=

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CONSIDERATIONS 4.1

Ingorder to protect the railroad subgrade and track structure, drainage to capture surface and underground water was planned.

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According to criteria in the following item, quantitative values for the following elements were arrived at:

- Cave and grade culverts

🚽 Deep drains

Gutters ----

- Benches

- Water races

- Protection ditches

- Plant covering

4.2 CRIENTATION ADOPTED

4.2.1 CAVE BOTTOM CULVERTS

Information needed to pre-dimension cave bottom culverts was taken from aerial photographs (1:30,000 scale) and topographic plan (1:10,000 scale). A 20 year replacement period was adopted for a projected 70 mm/hour water fall rate.

The flow sections, determined by the Talbot empirical formula, were converted to pipe sectons with Ø 1.00 m.

4.2.2 DEEP DRAINS

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Deep drainage was indicated for all cuts with a red
 elevation greater than 3 meters.

Two lines of deep drains were set for the railroad branch lines.

4.2.3 GUTTERS

. Gutters at the cut embankment bases were adopted.

PROTECTION DITCHES

Were considered along all of the cuts.

4.2.5 PLANT COVERING

Grass covering of all the fill embankments was predicted. No such covering will be done of the cuts since most of them will be widened. The area to be covered was estimated as the product of the fill extension times the mean height axonometrically projected over the embankment slopes.

IV-3/4.2

A one meter strip of grass covering was assumed in addition to the base of the fill embankment slopes.

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Quantitative data for each indicated civil construction, for each portion of the railroad sections, are presented in Table 4.1.

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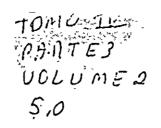
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		TRE OF	•	- 1,482 m	12,160 m	15,820 m ^c	15,804 m	2 259,500 m ²	
	•	· COLLECTIVE PORT BRANCH LITE	•	190 H	4,380 m	. 4 ³ 900 m	4,974 m	79,800 #	
N QUANTITIÊS	SECTIONS	FEATLIZER PLANT NAATLIZER	•	, ,	. 120 m	4 026	930 m	.44,700 m ²	
TABLE 4/1 CIVIL CONSTRUCTION QUANTITIES	•	KAIN BRANCH +. DISTRIBUTION TRUER LILE		1,292 m	7,660 m	. m 000 ot	E 006 f	135,000 m ²	
5	CONVENTION	CONSTRUCTIONS		Culverts (pipes & 1.00 m)	Doop Drains	Guttero	Protection Ditches	Plant Covering	

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IV-3/4.5



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5.0 RAILROAD OPERATION

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RAILROAD OPERATION

DESCRIPTION

5.1

At the start of the Suape branch line, linked to the RFFS/A Northeast Division, there should be constructed a marshalling yard. A layout of the yard is shown in Figure 5-1.

The yard will be composed of 11 lines: 4 for receiving and dispatching, 6 for classification and 1 for turn around switching. The 4 lines will have 10 m of midway between each two adjacent track centers. This large width was planned to permit inspection of long trains by a railroad vehicle running along a 6 m wide paved strip.

The vehicle would be equipped to handle small, relatively quick repairs. If more time is needed to make the repairs, the railroad car would be marked and switched to the maintenance shop.

The other 7 lines have a normal 4.25 m midway between each two adjacent track centers and 6 of them would be used for classifying the cars destined for or coming from the Port Industrial Complex's Terminals. At each end of the yard there will also be a maintenance shop for cars and a maintenance shop for locomotives. Horizontal plans and sections of the suggested layouts for the maintenance shops are shown in Figures 5-II/III. Two lines for loading and unloading containers and one line for loading and unloading incoming or outgoing cars, probably heading for or coming from industries in the vicinity of Cabo, were planned for the land available at the edges of the yard.

A road will also be needed on the western side of the yard (alongside the sea), which will give access to the container loading/unloading areas at the edges of the yard, to the maintenance shops and to the yard's administration building.

IV-3/5.1

In the event of an emergency, the road could also be used to supply the locomotive shop's fuel reservoir and to provide the material consumed by both shops.

'Naturally, the road will be connected with the Complex's road system. .

· OPERATIONS 5.2

In general, lines 1 and 2 will be used to receive trains coming from the 3rd Northeast Division's lines. 14. ⁻ ⁻ ⁻ 3. 9. ex. 1 The cars brought in by these trains will have only three destinations: the bulk products port, the fortilizer

plant, and the refinery.

national and an and a second

The shunting locomotives will marshall the trains, separating them in 3 of the yard's 6 classification lines, one line for each of the three destinations.

The other, 3 classification lines will be reserved for trains coming from the Industrial Complex's 3 terminals. The cars brought in by these trains will be switched to the departure lines (3 and 4) according to their destinations; in this manner the trains that will return to the 3rd Northeast Division, and on to all 1m gauge track in the nationwide railroad network, will be formed.

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Line 11 will be used for turning locomotives and as an auxiliary switching line. It therefore will be occupied for only short periods of time.

The receiving lines, which will be quite long, will keep up with the nationwide trend of using long multiple traction trains, and will handle trains of up to 100 cars:

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The two departure lines will also be able to form rather long trains. The shorter of the two, line 4, will have a useful length greater than 1,200 m.

For greater shunting speed and afety, all of the locomotives that run on the Suape branch line should be equipped with radios so that they can maintain contact with the control tower, other locomotives, switchmen and the releasing stations.

As can be seen from the layout, the yard only occupies one side of the central track. The other side is reserved for yard expansion which should occur when the single side becomes insufficient for marshalling operations.

Initially there will also be no need for automatic signalling or turnout rods for the switching devices. Starting in 1955 however, the number of cars to be moved could possibly demand installation of light signalling with the track circuit and turnout rods.

As shown in the suggested layout, the paved strip which will be used by vehicles for inspection and maintenance of cars on lines 1, 2, 3 and 4 will cross tracks 10 times, 5 times at each end. Therefore, for the safety of these movements, the vehicles themselves should also be equipped with radios for communication with the control tower.

Figure 5-IV shows a section of the track structure that will be used on the main brach, sub-branches and yard lines.

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IV-3/5.4

5.3 LOCOMOTIVES TO BE USED

5.3.1 LEVEL AND TANGENT RESISTANCE A Empty cars Approximate tare = 16 tons V = 20 km/hour . . . No. of axles = 4 $A \approx 8 \text{ m}^2$ R = 4.4 kg/ton $R_n = 0.65 + \frac{13.2}{W} + 0.01394V + \frac{0.00944AV^2}{W.N}$ (Davis Formula) W = Weight/axle in tons N = No. of axles $A = Frontal area in m^2$ \dot{v} = Velocity in km/hour $R_n = 0.65 + \frac{13.2}{4} + 0.01395 \times 20 + \frac{0.000944A.20^2}{4.4} = 4.4 \text{ km/to}$ Loaded cars 2.1 - 42 ton load $R_n = 0.65 + \frac{13.2}{14.5} + 0.01395 \times 20 + \frac{0.000944 \times 8 \times 20^2}{14.5 \times 4}$ $R_n = 1.9 \text{ kg/ton}$ 2.2 - .30 ton load $R_{n} = 0.65 + \frac{13.2}{11.5} + 0.01395 \times 20 + \frac{0.000944 \times 8 \times 20^{2}}{11.5 \times 4}$ $R_n = 2.1 \text{ kg/ton}$ 2.3 - 25 ton load $R_n = 0.65 + \frac{13.2}{10.25} + 0.01395 \times 20 + \frac{0.000944 \times 8 \times 20^2}{10.25 \times 4}$ $R_n = 2.3 \text{ kg/ton}$

C. A. Locomotives Weight = 60 tons $A = 10 m^2$ V = 20 km/hour $R_n = 0.65 + \frac{13.2}{W} + 0.00931 \times V + \frac{0.00453 \times A \times V^2}{WN}$ $R_n = 0.65 = \frac{13.2}{15} + 0.00931 \times 20 + \frac{0.00453 \times 10 \times 20^2}{15 \times 4}$ $R_n = 0.65 + 0.88 + 0.1862 + 0.30 =$ $R_n = 2.0 \text{ kg/ton}$ 5.3.2 CURVE RESISTANCE $R_{c} = \frac{500}{H}$ H = 245 m (minimum curve radius on the section) $R_{c} = \frac{500}{245} = 2.1 \text{ kg/ton}$ 5.3.3 GRADE RESISTANCE $R_r = 10 \times i$ i = 0.5% (maximum slope on the section, as per the profile) ${}^{1}R_{r} = 10 \times 0.5 = 5 \text{ kg/ton}$ NUMBER OF LOCOMOTIVES 5.3.4 In 1980 Α Train P (bulk products port) The worst alternative would be a train with 18 cars loaded with the maximum weight (42 + 16 = 58 tons) $R_n = 1.9 \text{ kg/ton}$ $R_{c}^{n} = 2.1 \text{ kg/ton}$ $R_{r}^{n} = 5.0 \text{ kg/ton}$ $R_{+} = 9.0 \text{ kg/ton}$

> 18 cars at 58 tons = 19 x 58 = 1,044 tons 1,044 tons x 9.0 kg/ton = 9,396 kg

Assuming that the locomotive weighs 60 tons:

 $\frac{R_n}{R_c} \approx 2.0$ $\frac{R_c}{R_c} \approx 2.1$ $\frac{R_r}{R_r} \approx 5.0$

9.1 kg/ton

60 tons x 9.1 kg/ton = 545 kg

Total resistance = 9,396 kg + 546 kg = 9,942 kg

Therefore, <u>l diesel-electric locomotive</u> with 60 tons of adherent and total weight, 12,000 kg of continuous tractive force and around 900 CV of power (models GE-UlOB, GM-G8 or similar) will be sufficient to pull train P, since the total resistance will be 9,942 kg,/12,000 kg continuous tractive force will be provided by the lighter of the two cied locomotives.

Train F (fertilizer plant)

The trains will have only 12 cars. Therefore <u>1 locomotive</u> with the characteristics of the locomotive described above will be more than sufficient.

Train R (Refinery)

. Trains with a maximum of 20 cars with 30 tons of cargo and . approximately 18 tons of tare.

$$R_n \stackrel{=}{\sim} 2.1$$

$$R_c \stackrel{=}{\sim} 2.1$$

$$R_r \stackrel{=}{\sim} \frac{5.0}{9.1 \text{ kg/ton}}$$

20 cars x 48.6 = 960 tons; 960 x 9.1 kg/ton = 8,736 kg.

Since the train's total resistance is less than 9,396 kg, one locomotive equal to the one described for train P will be sufficient. Therefore a total of three locomotives will be sufficient to move the trains between the marshalling yard and the Complex's industrial and port terminals. ¥

It is estimated that two locomotives will be needed for switching:

It is indispensable that a reserve locomotive always be on hand to substitute when one of the others has to be repaired or overhauled. Thus, the total number of locomotives will be increased to six locomotives, all with the above described characteristics, in 1980.

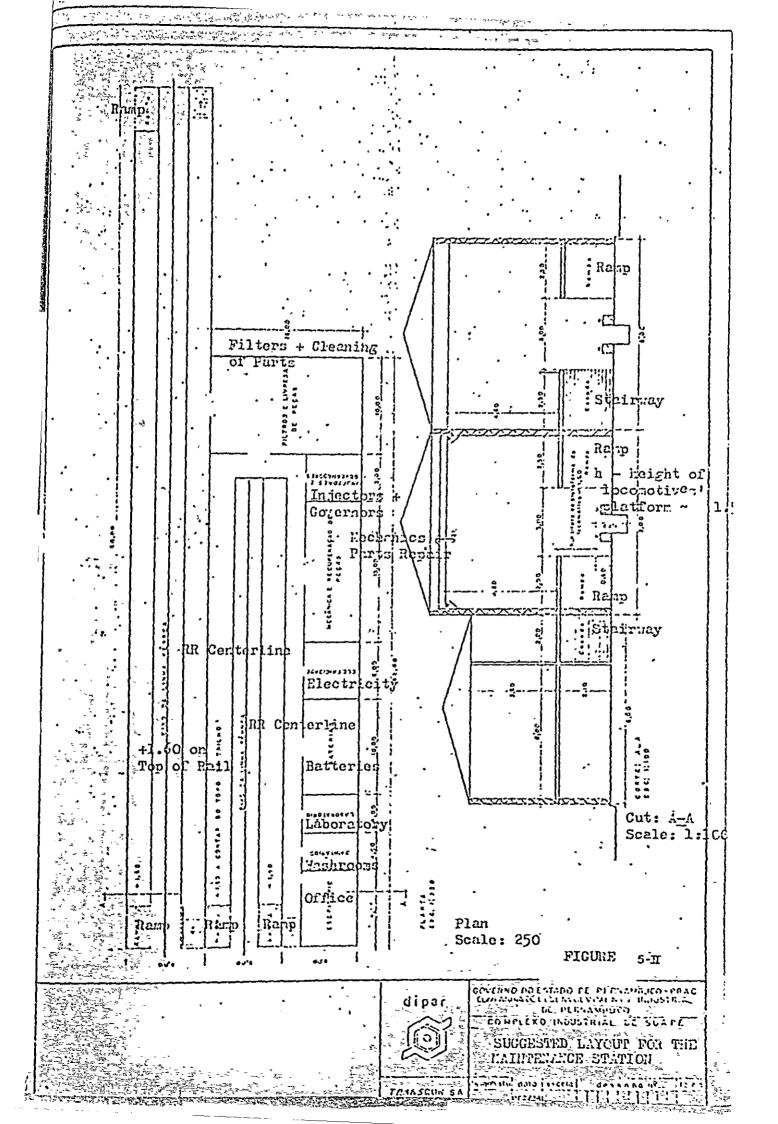
The same calculation process yields around 7 for the number of locomotives to be needed in 1985, around 8 in 1995 and around 10 in 2005. .

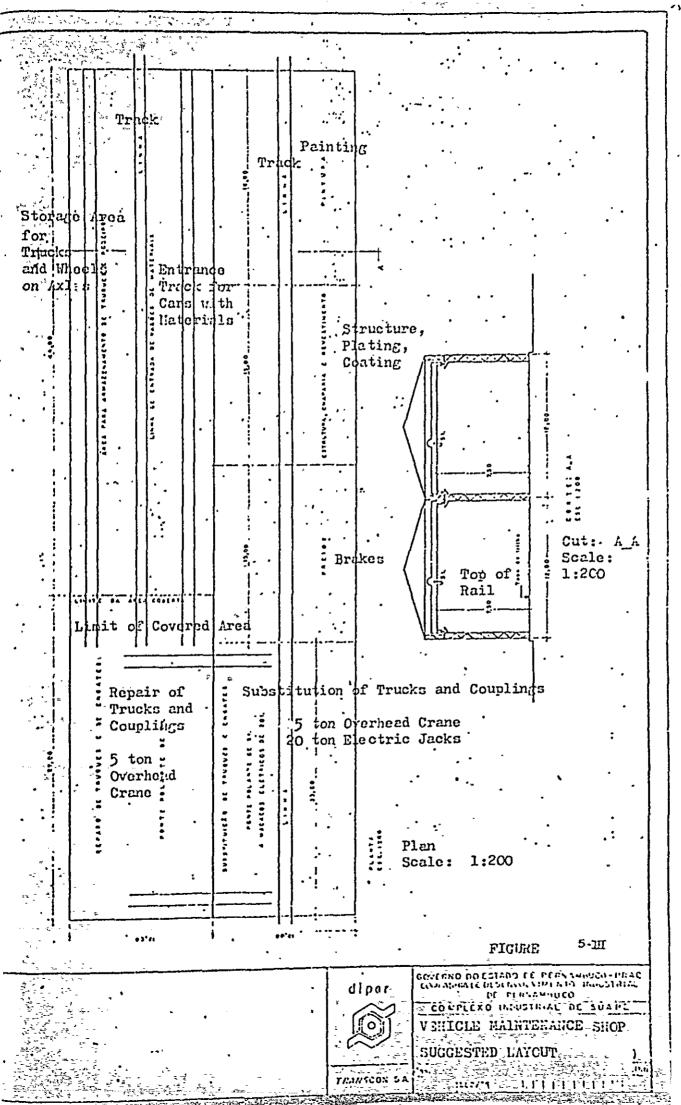
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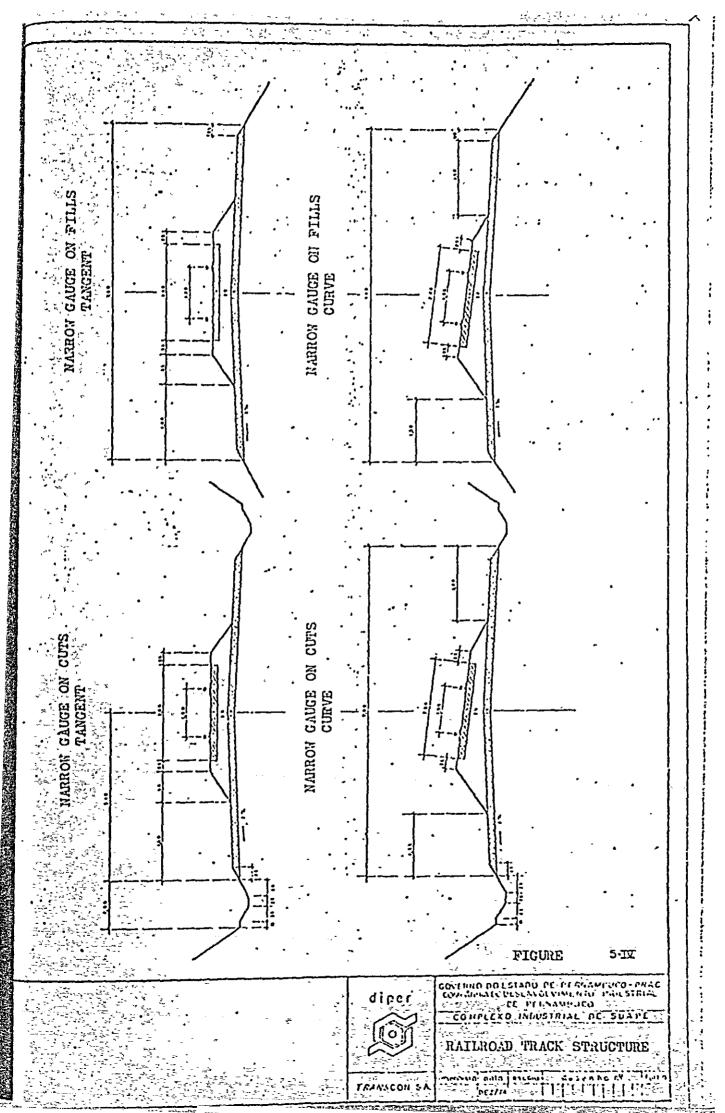
KEY TO FICULE 5-I

Porto - Port Area Verdo - Green area Rocho - Back up Area P/ Containers - Area for containers Agua tratada - Treatod water Oleo diesel - Diesel fuel Linha p/carga e descarga de containers - Containers loading and unlocding track Posto de revisão de locomotivas - Locomotive maintenance shop Administração do patio - Yará administration building Torre de controle - Control Tover "Estrada de Rodagem Pavimentada - Paved Road Linha de descarga de vagões - Railroad car unloading track Posto de revisão de vegões - Car Maintenance shop Linha de carga e descarga - Loading and Unloading track Linha de carga e descarga de containers - Containers locding and unlocding track Portão - Gate

SUGGESTED LAYOUT FOR THE FUTURE SUAPE RAILROAD MARSHALLING YAND









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6.0 SPECIAL CIVIL CONSTRUCTIONS

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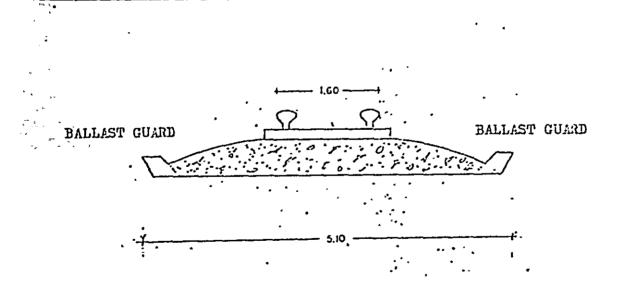
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SPECIAL CIVIL CONSTRUCTIONS

6 1 DESCRIPTION OF THE WORKS

The following bridges were planned to overcome the water courses that will continue to cross the railroad bed even after Hydrologic work has been done:

Railroad Section	Water Course	Span (m)	Width (m)
Main Distribution	Algodoais River	21	5.10
Main Distribution Trúnk Line	Prego	18	5.10
Port Branch Line 1	Canal (Algodoais)	40	5.10
Main Distribution Trunk Line	Tabatinga River	40	5.10
Main Distribution & Trunk Line	Jasmin River.	10	5.10
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7.0 OVERALL BUDGET

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7.0	OVERALL BUDGET
7.1	SUBGRADE
7.1.1	EARTH MOVING
Ϋ́Α	MAIN BRANCH AND DISTRIBUTION TRUNK LINE, EXCLUDING YARD
-	lst category material with average transport distance up to 0.4 km
	Qty. 36,200 $m^3 \times \$ 4.33 = \$ 156,746.00$
-	1st category material with average transport distance from.0.4 to 0.8 km
_	Qty. 124,000 m ³ x \$ 6.10 = \$ 756,400.00
	1st category material with average transport distance from 0.8 to 1.5 km Qty. 151,000 m ³ x \$ 8.50 = \$1,283,500.00
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	2nd category material with average transport distance up to 0.4 km
	Qty. 25,200 m ³ x \Rightarrow 6.72 = \Rightarrow 169,344.00
-	3rd category material with average transport distance up to 0.4 km
	Qty. 12,600 $m^3 \times $129.07 = $366,282$
	Subtotal = $$2,732,272$.
B	CABO BRANCH LINE
	lst category material with average transport distance from 0.8 to 1.5 km
•	Qty. 19,000 $m^3 x \$ 8.50 = \$ 161,500.00$
Ċ	FERTILIZER PLANT BRANCH LINE
	lst category material with average transport distance from 0.8 to 1.5 km
	Qty. 269,000 m ³ x \$ 8.50 = \$ 2,286,500.00

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IV-3/7.1

COLLECTIVE PORT BRANCH LINE D CT نامامیسی کرد. مراجع کرد می مدین مراجع کرد می مراجع "Ist category material with average transport distance up to 0.4 km Qty. 6,800 $m^3 \times \$ 4.33 = \$$ 29,444.00 lst category material with average transport distance from 0.4 to 0.8 km Qty. 10,000 $m^3 \times \$$ 6.10 = \$ 61,000.00 1st category material with average transport distance from 0.8 to 1.5 km Qty. 160,000 $m^3 \times \$$ 8.50 = \$1,360,000.00 2nd category material with average transport distance up to 0.4 $\,\rm km$ Qty. 21,300 m^3 x \$ 6.21 = \$ 143,136.00 3rd category material with average transport distance up to 0.4 km Qty. 10,650 $m^3 \times $29.07 = $309,595.50$ Subtotal = \$1,903,175.50:). 7.1.2 DEFORESTING, STUMP GRUBBING AND CLEARING ́А-, MAIN BRANCH LINE AND DISTRIBUTION TRUNK LINE, EXCLUDING YARD, BUT INCLUDING CABO BRANCH LINE Qty. 151,118 $m^2 \times \$ 0.18 = .\$$ 27,201.20 . B FERTILIZER PLANT BRANCH LINE Oty. 151,818 $m^2 \times $0.18 = $$ 20,847.20 7.1.3 CONVENTION CIVIL CONSTRUCTIONS CULVERTS WITH Ø 1.00 m PIPES A . Main branch line and distribution trunk line excluding yard

IV-3/

5. - 4 -1,292 m x \$ 563.50 = \$ 728,040.00Collective Port Branch Line 190 m x 563.50 = \$ 107,065.00 DEEP DRAINS ' م Main branch line and distribution trunk line, excluding yard 7,660 m x \$ 50.00 = \$ 383,000.00Fertilizer Plant Branch Line $120 \text{ m} \times \$ 50.00 = \$ 6,000.00$ Collective Port Branch Line $4,380 \times 50.00 = 219,000.00$ GUTTERS Main branch line and distribution trunk line excluding yard $10,000 \text{ m} \times \$ 30.00 = \$ 300,000.00$ Fertilizer Plant Branch Line 920 m x \$ 30.00 =\$ 27,600.00Collective Port Branch Line 4,900 m x \$ 30.00 =\$ 147,000.00_____D PROTECTION DITCHES Main branch line and distribution trunk line excluding yard 9,900 m x \$ 5.00 =\$ 49,500.00Fertilizer Plant Branch Line $930 \text{ m} \times \$ 5.00 = \$ 4,650.00$

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IV-3/7.3

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Collective Port Branch Line 4,974 m x \$ 5.00 = \$ 24,870.00 PLANT COVERING Main branch line and distribution trunk line, excluding yard $135,000 \text{ m}^2 \times \$ 2.50 = \$ 337,500.00$ Fertilizer Plant Branch Line 79,800 m^2 x \$ 2.50 = \$ 199,500.00 Collective Port Branch Line 44,700 $m^2 \times \$ 2.50 = \$ 111,750.00$ COMPACTION Main branch line and distribution trunk line, .excluding yard $(368,000 \div 1.30) \times \$ 0.91 \approx \$ 257,600.00$ Fertilizer Plant Branch Line $(269,000 \div 1.30) \times \$ 0.01 = \$ 188,300.00$, Collective Port Branch Line $(182,000 \div 1.30) \times \$ 0.91 = \$ 127,400.00$ 7.1.4 SPECIAL CIVIL CONSTRUCTIONS Main branch line and distribution trunk line, excluding yard $128 \times \$ 17,000.00 = \$ 2,176,000.00$ Collective Port Branch Line $40 \times \$ 17,000.00 = \$ 680,000.00$

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IV-3/7.4

SUBGRADE TOTAL

Main branch line and distribution trunk line, excluding yard Length = 15.32 km Cost/km = \$ 466,880.87 Fertilizer Plant Branch Line Length = 5.71 km Cost/km = \$ 478,718.23 Collective Port Branch Line Length = 5.00 km Cost/km = \$ 664,052.00 Total = \$ 13,227,203.70

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7.2	TRACK STRUCTURE
7:2.1	MAIN BRANCH LINE AND DISTRIBUTION TRUNK LINE, EXCLUDING YARD
A	15.41 km x $$500,000.00 = $7,705,000.00$
7.2.2	COLLECTIVE PORT BRANCH LINE 5.00 km x \$ 500,000.00 = \$ 2,500,000.00
7.2.3	FERTILIZER PLANT BRANCH LINE
	5.71 km x \$ 500,000.00 = \$ 2,855,000.00
7.2.4	TRACK STRUCTURE TOTAL
	. = \$ 13,060,000.00
	Contingencies $102 = 1,306,000.00$
	\$ 14,366,000.00
	or, approximately
	\$ 14,500,000.00
	Length = 26 km Cost/km = \$ 558,000

7.3	TELECOMMUNICATIONS AND SIGNALLING	
7.3.1	MAIN BRANCH LINE AND DISTRIBUTION TRUNK LINE EXCLUDING YARD	
	15.41 km x \$ 40,000.	.00 = \$ 616,400.00
7.3.2 COLLECTIVE PORT BRANCH LINE		NCH LINE
я •	5.00 km x \$ 40,000	.00 = \$ 200,000.00
7.3.3	FERTILIZER PLANT BR	ANCH LINE
• À .	• 5.61 km x \$ 40,000	.00 = \$ 224,400.00
7.3.4	TELECOMMUNICATIONS AND SIGNALLING TOTAL	
•		\$ 1,040,800.00
•	Contingencies 10% =	
		\$ 1,144,880.00
		or, approximately
		\$ 1,200,000.00
	Length = 26 km	Cost/km = \$46,000.00

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7:4		MAIN YARD	
7.4.1		SUBGRADE	
A		EARTH MOVING	
	-	lst category material with distance from 0.8 to 1.5 km	average transport
		Qty. $470,000 \text{ m}^3 \times \$ 8.50 =$	\$ 3,995,000.00
В		DEFORESTING, STUMP GRUBBING	AND CLEARING
ء ج-	-	Qty. 160,000 $m^2 \times $ 0.18 =$	\$ 28,800.00
с	•	DRAINAGE WORKS IN GENERAL	
.	-	Estimated \$ 700,000.00	
D		- COMPACTION	
د م بالا	- · ·	(470,000 ÷ 1.3) × \$ 0.01 =	\$ 329,000.00
E		SUBGRADE TOTAL =	\$5,052,800.00
7.4.2	2.	TRACK STRUCTURE	· ·
Â		TRACKS - Length = 13.7 km.	
	٠	13.7 x \$ 500,000.00 =	\$6,850,000.00
		TURNOUTS = 32	
°" ≆ <u>₹</u> "=		32 x \$ 40,000.00 ≈	\$1,280,000.00
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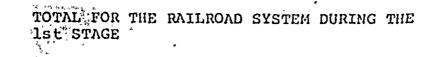
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TRACK STRUCTURE TOTAL 87130,000.00 COMPLEMENTARY WORKS RAILROAD CAR MAINTENANCE SHOP: Building: 1,128 m²; \$1,200 x 1,128 = \$ 1,400,000.00 Encilities **≈** \$ 300,000.00 Equipment 700,000.00 **≈** \$ _ ≈ \$ 2,400,000.00 LOCOMOTIVE MAINTENANCE SHOP: Building: 1,824 m² Unit cost ~ 1,400 (due to elevated platforms) $1,400 \times 1,824$ ≈ \$ 2,600,000.00 Facilities (including oil, water, ≈ \$ 2,400,000.00 y sand supplies) ≈ \$ <u>500,000.00</u> `Équipment ≈ \$ 5,500,000.00 ADMINISTRATION BUILDING AND CONTROL TOWER Building: 750 m^2 Unit cost \approx \$1,100/m²; Ξ\$ \$1,100 x 76 850,000.00 Tower: 80 m^2 Unit cost = \$3,000 (due to height) Building = \$3,000 x 80 ĩş. 250,000.00 **≈** \$ Facilities 200,000.00 ≈ \$ 500,000.00 Equipment ≈ \$ 1,800,000.00

ۣ ؚۛڝؖڔؖؖڹ	LIGHTING YARD = \$ 800,000.00	
े के 25 ि हे 2	CONTAINER LOADING AND UNLOADING EQ = \$ 1,400,000.00	UIPMENT
F	SCALE FOR WEIGHING RAILROAD CARS	≅ \$ 500,000.00
G	PAVING ROADS	= \$1,500,000.00
7.4.4	MAIN MARSHALLING YARD TOTAL:	= \$27,082,800.00
•	Contingencies 10%	= <u>\$ 2,708,280.00</u>
	-	\$29,791,080.00



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\$ 58,718,283.70 or approximately Cr\$ 59 x 10⁶

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