

5. Technical Note

Preparatory Survey on the Project for Improvement of Blantyre City Roads
in the Republic of Malawi

TECHNICAL NOTE

Blantyre City Assembly (BCA) and JICA preparatory Survey Team (JPST) discussed and confirmed the following. It is, however understood that the decision for the draft report will be made through the discussion with concerned parties during the analysis in Japan.

1. General

Basically Original Design of July 2007 will be referred except Item 3 to 10.
Design Standard/Criteria will be applied based on Local Standards, SATCC, AASHTO, Japanese Road Association (JRA) standards, etc.

2. Priority

- 1) Widening of existing road from 2-lane to 3-lane or 4-lane for the section-4.
- 2) Improvement of existing pavement structure
- 3) Installation of Pedestrian Walkway (With Inter Locking Block)
- 4) Installation of Bus Lay Bye (5 points for each lane)
- 5) Improvement of Drainage system along the roads
- 6) Improvement of 3 roundabouts intersections (Maselema, Yianakis, Illovo)
- 7) Installation/Improvement of Kerb Stones
- 8) Installation traffic Signs and Road markings
- 9) Installation of pedestrian crossings
- 10) Installation of Street Lights

3. Typical Cross Section

See attached figure.

- 1) Cross-section Slope will be improved from 2% to 3% for Section 4 & 5 based on Local standards.
- 2) Pavement type of Side walk will be revised to Inter Rocking Block.
- 3) Existing drainage will be utilized for section-3 basically.
- 4) Location of Drainage will be shifted from edge to shoulder for Section 5.

4. Bus Lay Bye

The Width has been revised from 2.925m to 3.67m~4.00m based on new Local Standards, but the length will be as in Phase I. Therefore this width will be applied to this project. But BCA accepted to reduce the width/length for both sides of Yianakis Bus Lay Bay with 1.0m width of pedestrian walkway because of limited space. The Bus lay Bye location at Right side of Chris and Company will be shifted from Chainage 53+20 to Chainage 57+80.

5. Street light

Street light will be installed to Roundabouts, Bus Lay Byes and Pedestrian Crossings. In terms of Road safety, JPST may propose to increase the number of street lights if approved.



6. Access Road

Approach length and Corner Radius for access Roads may be increased so far as side condition permit based on the Local Standards.

7. Signal/Hump

Existing Signals will be utilized. Therefore this project area has no installation of new signal.

Also No Hump will be applied for the project area.

8. Pavement Structure

Pavement structure will be analyzed and designed by JPST based on the results of Site Investigation, Data measured and collected, etc.

Design period will be 15 to 20 years.

9. Demolition/Relocation of Obstacles

BCA will relocate/demolish the obstacles (Fence, Utilities, Billboard, etc.) for widening at Section 4 by end of January, 2010.

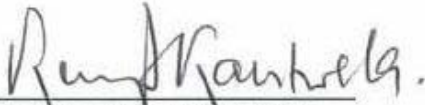
10. Roundabout

Maselema, Yianakis and Illovo will be improved based on original design of July 2007.


12 November 2009

Noted by

Noted by

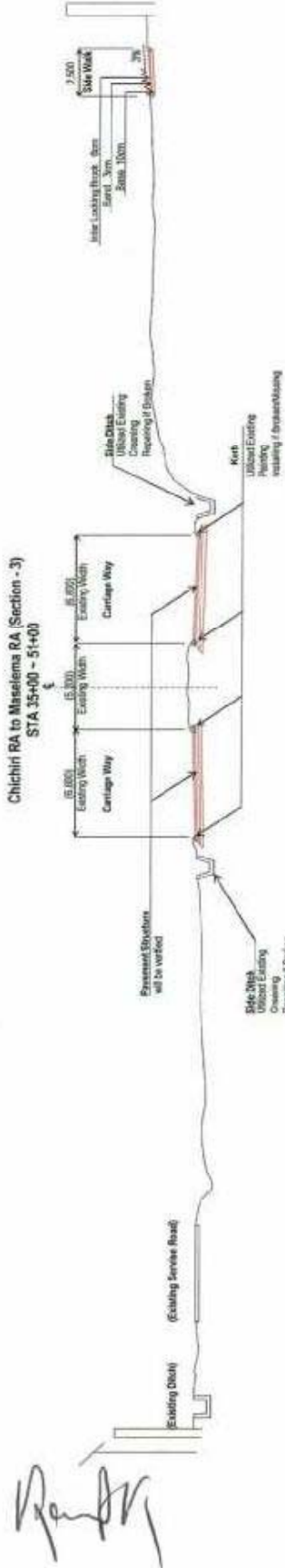


Eng. Kenneth L. A. Kantwela
Director of Engineering Services
Blantyre City Assembly

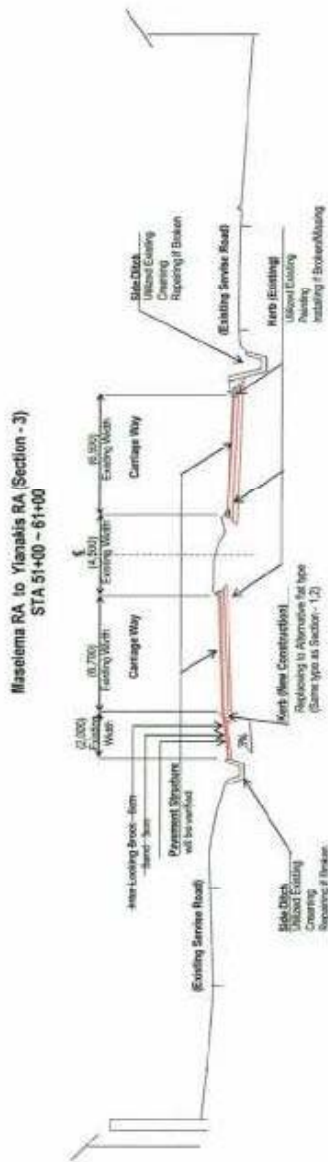


Mr. Tsuyoshi Yamaguku
Chief Consultant
JICA Preparatory Survey Team

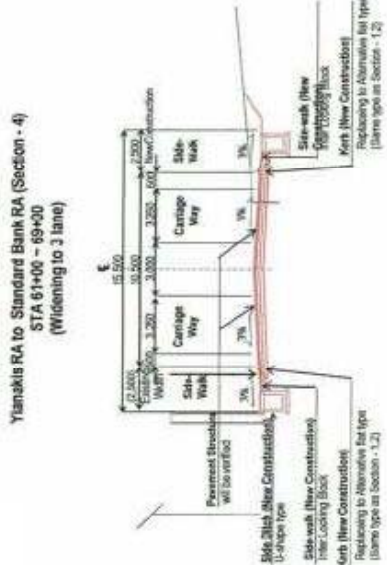
Chichiri RA to Maselema RA (Section - 3)
 STA 35+00 ~ 51+00



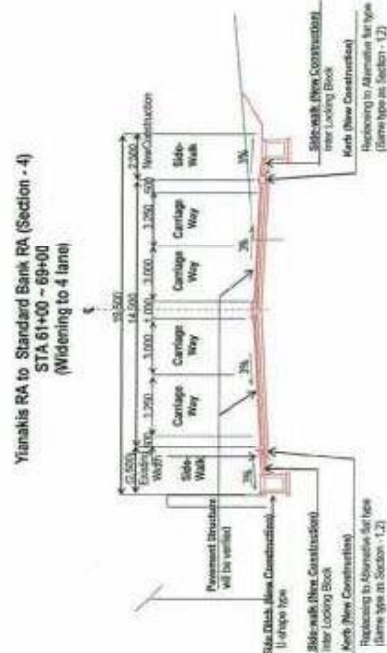
Maselema RA to Yanakis RA (Section - 3)
 STA 51+00 ~ 61+00



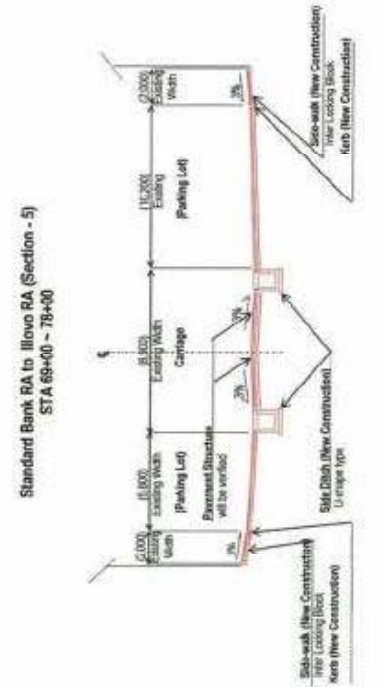
Yanakis RA to Standard Bank RA (Section - 4)
 STA 61+00 ~ 69+00
 (Widening to 3 lane)




Yanakis RA to Standard Bank RA (Section - 4)
 STA 61+00 ~ 69+00
 (Widening to 4 lane)



Standard Bank RA to Illovo RA (Section - 5)
 STA 69+00 ~ 78+00



MALAWI GOVERNMENT



NCE No 28 EIA CERTIFICATE No. 28.5.1



**ENVIRONMENT MANAGEMENT ACT
(No. 23 OF 1996)**

**CERTIFICATE OF APPROVAL
OF A PROJECT**

IN TERMS of section 26(3) of the Environment Management Act,
I, RAPHAEL PETER KABWAZA
Director of Environmental Affairs, hereby certify that
MASAUKO CHIPEMBERE HIGHWAY AND LIVINGSTONE ROAD PROJECT
Has been approved by the Minister under the Environment Management Act.

Dated this 9th day of may 2007

DIRECTOR OF ENVIRONMENTAL AFFAIRS



MALAWI GOVERNMENT



NCE No 28

EIA CERTIFICATE No. 28.5.1

ENVIRONMENT MANAGEMENT ACT
(No. 23 OF 1996)

NOTICE OF APPROVAL TO
PROCEED WITH PROJECT

RE: BLANTYRE CITY ASSEMBLY,
PRIVATE BAG 67, BLANTYRE, MALAWI

WHEREAS the Minister has in terms of section 24 (1) of the Environment Management Act specified by notice published in the Gazette, that is, Government Notice No. 58 of 1997, types and sizes of projects which shall not be implemented unless an environmental impact assessment is carried out.

WHEREAS MASAUKO CHIPEMBERE HIGHWAY AND LIVINGSTONE ROAD PROJECT is, pursuant to said Government Notice, of a type and/or size requiring environmental impact assessment prior to implementation;

WHEREAS BLANTYRE CITY ASSEMBLY has conducted an environmental impact assessment of the project and has submitted to the Director of Environmental Affairs, in respect of such assessment, Environmental Impact Assessment Report; and

WHEREAS section 26 (1) (d) of the Environment Management Act provides that the Director of Environmental Affairs may recommend to the Minister approval of a project for which an environmental impact assessment has been carried out, subject to such conditions as of approval as he may deem appropriate.

NOW, THEREFORE TAKE NOTICE THAT MASAUKO CHIPEMBERE HIGHWAY AND LIVINGSTONE ROAD PROJECT

Has been approved to proceed subject to the terms and conditions overleaf.

Recommended: [Signature]
Director of Environmental Affairs

Concurred: [Signature]
Chair, National Council for the Environment

Approved: [Signature]
Minister Responsible for Environmental Affairs

Attachments (where appropriate)

04-05-2007
Date
11-05-2007
Date
09-05-07
Date

This certificate is issued on condition that **BLANTYRE CITY ASSEMBLY** shall:

- a) Report regularly on the mitigation measures outlined in EIA report.
- B) Fully implement the Environmental Management Plan (EMP) and recommendations in the approved EIA report.

Telephone: 01 771 111
Telefax No.: 01 773 379

Our Reference No.: EAD/99/07/05

Your Reference No.....

Communications should be addressed to:
The Director of Environmental Affairs



ENVIRONMENTAL AFFAIRS DEPARTMENT
LINGADZI HOUSE
CITY CENTRE
PRIVATE BAG 394
LILONGWE 3
MALAWI

7th May 2007

The Chief Executive
Blantyre City Assembly
P/Bag 67
Blantyre

Dear Sir,

**REVIEW OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA) REPORT FOR
MASAUKO CHIPEMBERE HIGHWAY AND LIVINGSTONE ROAD
IMPROVEMENT PROJECT**

Following the meeting of the National Council for the Environment (NCE) held on 4th May 2007, we are pleased to inform you that your EIA Report for the above-captioned project was approved on condition that you will comply with mitigation measures outlined in the Environmental Management Plan (EMP).

An EIA Certificate is being prepared and you will be informed when it is ready. Meanwhile please find attached an invoice of MK3, 000,000 being payment for EIA fees.

The certificate can only be issued upon payment of the said fees. Please note that it is illegal to start implementing a prescribed project without an EIA certificate.

We look forward to your continued cooperation.

Yours faithfully,


Dr. A.M. Kamperewera

For :DIRECTOR OF ENVIRONMENTAL AFFAIRS

cc : Secretary for Energy, Mines and Natural Resource, P/Bag 350,
Lilongwe 3
: The Chairman, National Council for the Environment



The City Assembly of Blantyre

All correspondences to be addressed to:

THE CHIEF EXECUTIVE
TELEPHONE No. 670 211
TEL. ADDRESS "CITY"
TELEX No. 44536
FAX No. 265 670 417

EAA/36/1

THE SECRETARIAT
TOWN HALL
CIVIC CENTRE
PRIVATE BAG 67
BLANTYRE
MALAWI

29th January 2006

The Programme Officer
Japanese International Cooperation Agency (JICA)
PO BOX 30321
Capital City
Lilongwe 3

Fax: 01 771 125

Attention: Mr. G. Kapalamula

Dear Sir,

STAKEHOLDERS MEETINGS AND ACCEPTANCE FOR BLANTYRE CITY ROADS IMPROVEMENT PROJECT

Please refer to my letter dated 17th January 2007 of even reference. I wish to report that we had sensitization meetings with stakeholders for acceptance of the projects as follows:-

ITEM	DATE (S)	TIME	STAKEHOLDERS
1	22-01-2007	2:30 pm – 4:30 pm	Media <ul style="list-style-type: none">• Radios• Television• Print Media
2	23-01-2007	10:00 am – 12 noon	Public Institutions <ul style="list-style-type: none">• Hospital (s)• Churches• Education• Institutions

3	23-01-2007	2:30 pm – 4:30 pm	People living along the Main Road <ul style="list-style-type: none"> • Business • Residents
4	24-01-2007	10:00 am – 12:00 noon	Opinion Leaders <ul style="list-style-type: none"> • Members of Parliament • Chiefs • Community Development Committees
5	24-01-2007	10:00 am – 12:00 noon	Public Utility Services <ul style="list-style-type: none"> • Electricity • Water • Communication • Sewer
6.	25-01-2007	10:00 am – 12:00 noon	Road Users <ul style="list-style-type: none"> • Minibus Owners Association of Malawi • Truck Companies • Road Safety Council • Traffic Police • Ministry of Transport & Public Works • Consumer Association of Malawi

These meetings proved to be very useful and there were a lot of interest, comments and questions generated from the meetings. The meetings attracted a cross section of very important decision makers from each one of the stakeholders group (s). There was a good cover on Television and many radio stations who responded to our calls.

I have attached the copy of the paper that was presented, the lists of participants from each of the stakeholder groups. Most questions asked were similar, so please find appended below the questions or issues that need to be addressed by the Chief Consultant to this project when finalizing the project draft final report.

All stakeholders expressed happiness and willingness to support the project. Therefore we can say that it has been well received.

Questions and Comments

- 1.0 How will traffic flow during construction. What traffic control measures will be put in place. Will people living along the Highway be completely restricted during that time.

It was replied that traffic flow will be maintained through the highway during the construction period since there is enough space to work on.

- 2.0 There are many pedestrian crossings along the Highway which are dangerous especially at Ginnery Corner and the Polytechnic, what plans are there to safeguard pedestrians, including the disabled. Designers should put much thought into pedestrians crossing. The reply was given that the pedestrian crossings at schools, hospitals, colleges, institutions will be improved during the construction.
- 3.0 Is there enough room or space for the proposed roundabouts at the Traffic signed intersection at Mahatma Gandhi, and Johnstone Road Junctions?
- 4.0 There should not be space for bill boards and only Traffic Signs should be put up. It has been observed that a lot of traffic signs are missing from the road.
- 5.0 There is indeed need to consider drainage problems seriously. These should be well addressed so that there is no conflict between drainage outlets and proposed walkways and cycle track.
- 6.0 There is need to identify property, and infrastructure that needs to be removed, relocated and demolished. This is so to enable compensation procedures to be effected well before the start date of the project, the January 2008. Specific buildings that will be affected need to be identified now and owners notified in good time.
- 7.0 It was felt that one way systems should be implemented in Blantyre soon after the project to complement the same. It was noted that the Masauko Chipembere Highway will bring into Blantyre two carriageways flow of traffic which will cause a bottleneck at Larji Kurji Building roundabout. One way system would be good i.e. Haille Sellaisie Road, Victoria Avenue and Glyn Jones Roads as previously planned.
- 8.0 The stakeholders needed to be assured of the quality of work and duration of the construction period. Having experienced what

happened at Kenyatta Drive, where work took long and quality of work is very poor. We assured them that the project would be done to the highest quality and shortest possible shortest time.

- 9.0 The Federation of Disabled persons of Malawi (FEDOMA) requested that when designing technical elements, care should be taken to include the needs of the disabled. The walkway and cycle track should be mountable and accessible to wheelchairs and disabled alike. FEDOMA have given a copy of guidelines which is road note number 21. These are called enhancing the mobility of disabled people. A photocopy of the first page of Road Note No. 21 is attached and this may be looked up on the internet.
- 10.0 When installing street lights we should think how nature can assist like through the use of solar power to light or control street lights.
- 11.0 If services (underground) need to be removed or relocated there is a need to know the period of time this is expected to be done by. This is also so as not to delay the commencement of the project in January 2008.

In relation to the above it was observed that the road was narrow in certain places especially at or near the Shire Bus. The relocation of underground cables will be tricky especially the Malawi Telecommunication Limited (MTL) cables. Most cables also go in between the same narrow space.

- 12.0 Underground service providers^S say that they require enough time to relocate or reroute their plant especially that ordering the same take long time and that they are ordered from outside the country.
- 13.0 What assurance is there that Malawi Government will indeed pay compensation to all stakeholders who will be affected. The reply to this one is that the Malawi Government is a signatory to all the discussions held so far. And that the Japanese Government and Malawi Government are well aware of how these issues will be sorted out.
- 14.0 Another concern was if businesses along the Chipembere Highway will be affected by closure and if there will be detours as there is already too much traffic along the Highway.
- 15.0 It was stated that although we need to preserve the environment by keeping trees, some trees were said to be dangerously leaning into the road and a source of danger. The dangerous trees should be removed since they are eucalyptus and are harvestable.

- 16.0 The opinion leaders voiced their concerns in that the road appeared to be narrow between Yianikis and Stabic Bank in Limbe. They observed that there was congestion and a bottleneck for traffic moving into and from the Highway.
- 17.0 The treatment of Dalton Road/Livingstone Road junction is also a wonder. This is because it is almost impossible for traffic entering the Livingstone Road. There is a short distance which is two way from the junction to the Illovo roundabout. This need to be addressed by the consultants.
- 18.0 What type of bus shelters are being considered as the solid bus shelters were removed and replaced with fibre glass shelters which are not durable.
- 19.0 Are there any provisions for car parking on the street along the Livingstone Road and on the Chipembere Highway
- 20.0 The Project is welcome and should not fail at all.
- 21.0 What is the arrangement of the layout at end of the Highway at Stanbic Bank in Limbe.
- 22.0 What plans has the City got to improve the entry corridors between Blantyre and Limbe and even the implementation of the by passes project.
- 23.0 The City need to extend its limits so that services are available to the cities per urban areas. Road construction or improvement is one way of opening up the outlying areas.
- 24.0 The project should be completed by a good landscaping management.
- 25.0 The traffic growth should be taken into account when designing the Highway and carriageway.
- 26.0 Has the project taken into consideration the Independence Arch and height restrictions.

A. MEDIA

ITEM	NAME	CONTACT NO.	ORGANISATION
1	Maganizo Mazeze	01 830 278	Star Radio
2	Mike Kandulu	08 825 386	Nation Publication Ltd
3	Olunda Thomson	09 216 536	FM 101 Radio
4	Joyce Ng'oma	09 922 834	FM 101Radio
5	Daniel Kalaya	08 890 066	MBC – National Radio
6	Yohane Symon	09 274 550	Pride Magazine
7	Chikumbutso Njayo	09 946 128	The Weekly News
8	Orchestra Kamanga	09 724 250	Mana – News Agency
9	V. Mphande	08 920 920	TVM – Television
10	Steven Banda	09 382 634	Nation Newspaper
11	Enerstina Yobe	08 302 000	Blantyre City Assembly
12	Steven Kuyeri	08 856 592	Blantyre City Assembly
13	Kenneth L.A. Kantwela	08 843 735	Blantyre City Assembly

B. PUBLIC INSTITUTIONS

ITEM	NAME	CONTACT NO.	ORGANISATION
1	Enerstina Yobe	08 302 000	Blantyre City Assembly
2	Arthur Chokhotho	09 958 832	MBC – National Radio
3	E.B. Thombozi	08 825 629	Malawi College of Accountancy
4	W.F. Hill	09 429 645	University of Malawi Polytechnic
5	Dr. I. Ng'oma	08 841 947	University of Malawi Polytechnic
6	F.H. Nihaka	08 892 077	Worldwide Church of God
7	G. Wittika	08 833 591	Chichiri Integrated Pvt Schools
8	M. Chikalipo	08 362 505	FM 101 Radio
9	K. Kantwela	08 843 735	Blantyre City Assembly
11	R.T. Chigadula	09 950 360	District Education (Bt Urban)
12	V.J. Dacruz	09 912 509	Our Lady Wisdom of School
13	Kondwani Chalulu	98 502 604	Queen Elizabeth Central Hospital
14	S.M. Kuyeli	08 856 592	Blantyre City Assembly

C. ROAD USERS

ITEM	NAME	CONTACT NO.	ORGANISATION
1	Enerstina Yobe		Blantyre City Assembly
2	Kenneth Kantwela		Blantyre City Assembly
3	B.M. Ndhlovu		Limbe Police Station
4	Oliver Soko		Limbe Police Station
5	K.K. Phiri		Southern Region Police
6	L.C. Mwakapugha		Southern Region Police

7	C.K. Kumangirana		Roads Department (Lilongwe)
8	F.T. Msiska		National Roads Safety Council
9	L. J. Soko		Blantyre Police Station
10	W.H. Namasani		Blantyre Police Station
11	E.C. Zintambila		Road Traffic Department
12	Coxley Kamange		Minibus Owners Association of Malawi

D. OPINION LEADERS

ITEM	NAME	CONTACT NO.	ORGANISATION
1	Enerstina Yobe		Blantyre City Assembly
2	Kenneth Kantwela		Blantyre City Assembly
3	R.I. Kawiya		Blantyre City Assembly
4	Acting Chief Machinjiri		Traditional Chief
5	Halmes Chimombo Representative of Hon J. Banda		Blantyre City South Constituency
6	T/A Somba		Traditional Chief
7	J. Ndovi		Blantyre City Assembly
8	B.E.F. Nsitu		Blantyre City Assembly
9	Lester Makuluni		City South Constituency

E. PUBLIC UTILITY SERVICES

ITEM	NAME	CONTACT NO.	ORGANISATION
1	Kenneth Kantwela		Blantyre City Assembly
2	Enerstina Yobe		Blantyre City Assembly
3	R.I. Kawiya		Blantyre City Assembly
4	W. Senger		Malawi Telecommunication Ltd
5	J. Mtchuka		Malawi Telecommunication Ltd
6	W.B. Kawaga		Malawi Telecommunication Ltd
7	B.G.K Waya		Blantyre Water Board
8	L.T. Mwabutwa		Blantyre Water Board
9	James Kaphale		MACRA - Regulatory Authority

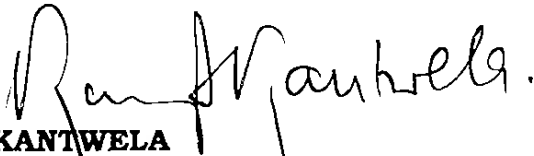
F. BUSINESS & RESIDENTS

ITEM	NAME	CONTACT NO.	ORGANISATION
1	E. Yobe	08 302 000	Blantyre City Assembly
2	K. Kantwela	08 843 743	Blantyre City Assembly
3	S.M. kuyeli	08 856 592	Blantyre City Assembly
4	C.M. Phiri		HTD Limited
5	H.A. Sidik		HTD Limited

6	I. Ibrahim	-	Petroda Limited
7	J.M Kayira	09 951 753	Automotive Products
8	S.C. Jalasi	08 854 734	World Vision
9	Lauro Phillips	08 714 433	Gesterner Ltd
10	D. Kausi	09 138 876	MCCCI - Chamber
11	W. Chawinga		Choice Bakery
12	J. Makina		Ingwe Linking Africa
13	R. Mussa		Gafferson LTD
14	M. Kotecha		HISCO LTD
15	M. Gondwe	08 590 015	Chichiri Lodge
16	F. Gondwe	08 866 893	Chichiri Lodge
17	R. Gondwe	09 134 848	Chichiri Lodge
18	Anton Beiber		Glave International LTD
19	W. Msiska		Chichiri Shopping Centre
20	A.R. Masangano		Chichiri
21	H.H. Amosi		H. Amosi House

We have attached other documents as stated above.

Yours faithfully



K L A KANTWELA
DIRECTOR OF ENGINEERING SERVICES
FOR: CHIEF EXECUTIVE

Attach:

KLAK/glc

BLANTYRE CITY ASSEMBLY

IMPROVEMENT OF BLANTYRE CITY ROADS

STAKEHOLDERS SENSITISATION MEETING

1.0 Introduction

In August 2001, the Government of the Republic of Malawi made a request for a Grant Aid for the project for Improvement of Blantyre City Roads. The Japanese Government having gone through the process necessary for the granting of aid for the project sent two study teams to Blantyre. These study teams were sent through Japan International Cooperation Agency (JICA), the official agency for the implementation Japanese government technical assistance. The Japanese Study Teams were as follows:-

1.1 Preliminary study on the Project to improvement of Blantyre City Roads.

The main objectives for the preliminary study team were:-

- To confirm the contents of the requested project.
- To make site surveys and collect necessary data and information to acquaint themselves with the present situation of the road network.
- To examine environmental and social consideration.

1.2 Basic Design Study on the Project for Improvement of the Blantyre City Roads.

The main objectives of this study are:-

- To identify and confirm the components of the Project which are:-
 - Widening of the existing roads from 2 lane to 4 lane from Lurji Kurji Building to Chichiri Roundabout and 2 lane to 3 lane from Yianikis Roundabout to Stabic Bank in Limbe.
 - Rehabilitation of existing roads and services roads.

- Replacement of traffic signal Intersections with roundabouts. Intersections (Mahatma Gandhi and Johnstone Intersections).
 - Improvement of existing 6 roundabouts (Larji Kurji, Clock Tower, Chichiri, Maselema, Yianikis and Illovo).
 - Improvement of drainage system along the roads. Masauko Chipembere Highway and Livingstone Road.
 - Improvement of existing bus stops and installation of new bus stops. (about 15 no.)
 - Installation of pedestrian walkway and cycle track.
 - Installation of side kerb stones.
 - Installation of Traffic Signs and road markings.
 - Installation of street lights.
 - Installation of pedestrian crossings (at schools, colleges, hospitals, and shopping centres)
 - Improvement and installation of pedestrian crossing signals.
- To appraise and evaluate the Technical and economical viability of the project.
 - To estimate the cost of the Project and prepare a schedule of Implementation.
 - To identify necessary works to be done by the Malawi (Blantyre City Assembly) prior to the commencement of the project, during and after the project.

These are as follows:-

- Land acquisition necessary for the improvement of the project.
- Ensure the safety of the consultants and contractors with the assistance of the Malawi Police Service if necessary (Equipment and Staff).
- Secure land for construction yard and to establish offices and Asphalt Plant.
- Relocation of existing utilities such telephone cables, water mains, electricity, sewers when and if necessary.
- Budget allocations for tax exemption of imported contraction materials.
- Assessment for and budget allocations for compensation of affected property.
- Take necessary activities to get environmental Impact Assessment Certificate done.
- Hold Stakeholders meetings to sensitise media, public institutions, people living along the main road, opinion leaders, public utilities, and road users.

2.0 Implementation Flow Chart

- The likely flow of works is as follows:-
 - 2.1 Applications done through request written in 2001
 - 2.2 Preliminary study done in June and July 2006.
 - 2.3 Basic Designs Study done in November and December 2006.
 - 2.4 Draft Final Report to be done in April 2007.
 - 2.5 Appraisal and Approval by the Japanese Government, may be done by end of May 2007

- 2.6 Detailed Designs to be done by October 2007.
- 2.7 Tender/contract signing by December 2007.
- 2.8 Construction to be started by January 2008.
- 2.9 Construction period of between one (1) year and two (2) years.

END OF MEETING



Blantyre City Assembly

Inter Departmental Memorandum

From: Director of Town Planning and Estates
To: Director of Engineering Services
Ref: TP/PM/22
Date: 09 December 2009
Subject: **MARKET VALUE OF COMMERCIAL AND INDUSTRIAL PLOTS ALONG MASAUKO CHIPEMBERE HIGHWAY**

Please be advised that the following are current commercial values of vacant plots along the Masauko Chipembere Highway as per Government rates:

- a) Commercial and industrial plots – **MK6,000,000** per Hectare ⁶
- b) Residential plots – **MK3,000,000** per Hectare.

Value of developed plots may vary depending on particular development on the plot.

A handwritten signature in black ink, appearing to be 'C. Chanza'.

C. Chanza
Director of Town Planning and Estates Services

cc : DAS

7. Design Data

1) Traffic Survey Result

(1) Traffic Volume

Table 3-1(1) Traffic Volume Result

	I: Light Vehicles		II: Medium Vehicles			III: Heavy Vehicles				IV: 2-Wheel Vehicles			V: Others		Remarks
	Sedan / Wagon	Pick-up / 4WD	Van / Mini Bus	Mini Truck	Standard & Large Bus	2-Axle Truck	3-Axle Truck	Articulated Truck	Motorbike, Bike/Trailer	Bicycle, Tricycle	Animal Cart	Walker			
Section-3 (18 hrs)	4,102	3,674	2,509	425	22	659	85	208	202	814	0	1,595	4:00 - 22:00		
	3,518	4,016	3,005	510	106	226	300	377	322	805	0	2,176	4:00 - 22:00		
	7,620	7,690	5,514	935	128	885	385	585	524	1,619	0	3,771			
Section-4 (12 hrs)	2,403	1,796	1,962	450	15	184	32	28	123	465	0	1,808	6:00 - 18:00		
	2,428	2,055	1,587	328	4	147	48	41	108	425	0	1,641	6:00 - 18:00		
	4,831	3,851	3,549	778	19	331	80	69	231	890	0	3,449			
Section-5 (12 hrs)	736	582	1,124	97	180	79	36	22	125	297	0	3,192	6:00 - 18:00		
	3,198	2,333	3,009	155	79	400	18	41	151	933	0	3,130	6:00 - 18:00		
	3,934	2,915	4,133	252	259	479	54	63	276	1,230	0	6,322			
Total	16,385	14,456	13,196	1,965	406	1,695	519	717	1,031	3,739	0	13,542			

*Note : Average data of 2 days, Nov. 10 and 12, 2009.

(2) Travel Speed

Table-3-1(2) TRAVEL SPEED SURVEY RESULT

	Cumulative Distance	Time (min)												
		Morning						Noon			Evening			
		6:00~	7:00~	8:00~	11:00~	12:00~	13:00~	16:00~	17:00~	18:00~				
Inbound	(km)													
Chichiri RA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maselema RA	1.71	2.03	2.02	2.07	1.92	1.98	1.83	1.97	2.50	2.15				
Yianakis RA	2.75	3.28	3.57	3.62	3.20	3.48	3.20	3.38	4.43	3.72				
Standard Bank IC	3.47	4.27	5.17	5.38	5.62	5.83	4.47	4.83	7.50	5.92				
Illovo RA	4.36	5.50	6.85	6.85	7.47	8.03	6.28	6.97	9.80	7.80				
Outbound	(km)													
Illovo RA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Standard Bank IC	0.89	1.58	3.33	3.15	2.55	2.12	2.38	2.93	3.33	2.42				
Yianakis RA	1.61	2.75	5.78	4.82	5.35	4.62	3.93	5.68	5.35	3.67				
Maselema RA	2.65	3.83	7.02	6.02	6.53	5.92	5.23	7.03	6.73	4.88				
Chichiri RA	4.36	5.75	9.33	8.20	8.90	8.05	7.42	9.15	17.42	6.77				

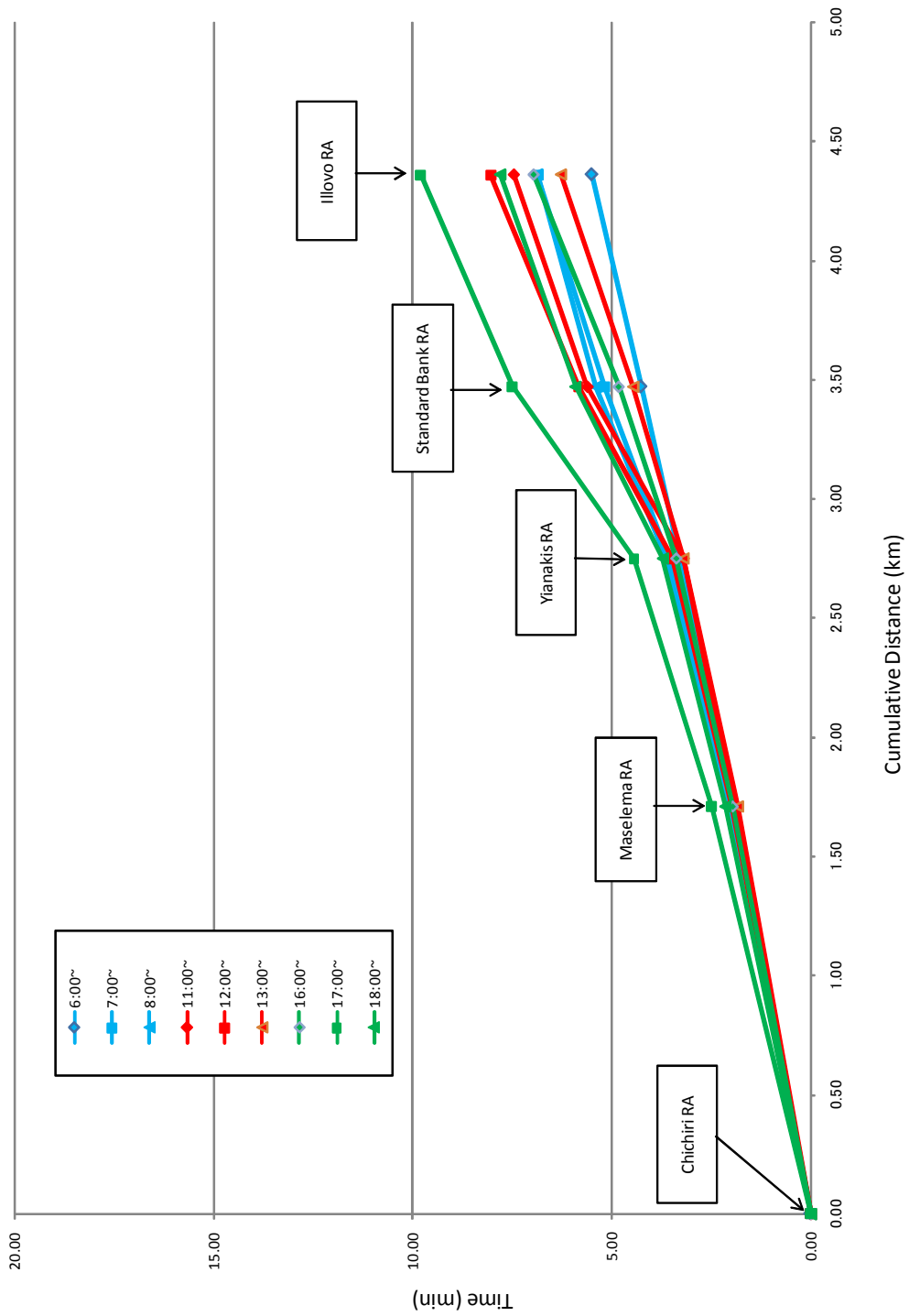


Table-3-1 (3) TRAVEL SPEED SURVEY RESULT OF INBOUND (From Chichiri RA to Illovo RA)

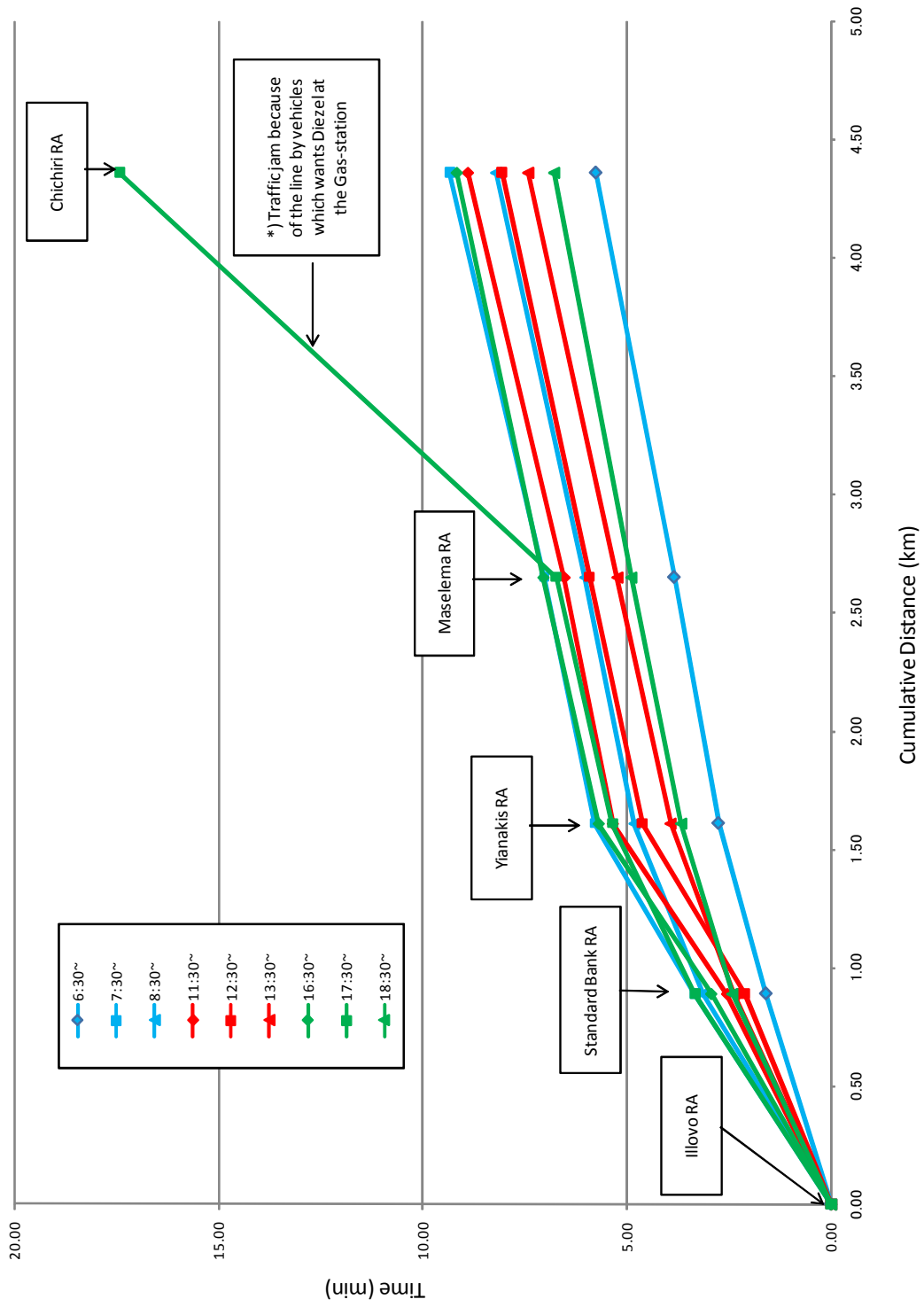


Table-3-1 (4) TRAVEL SPEED SURVEY RESULT OF OUTBOUND (From Illovo RA to Chichiri RA)

2) Crack Investigation

Investigation Measure

The cracking ratio was defined as the emerging ratio of cracks in assumed mesh of 0.5 meters square on the road surface. The investigation on cracking ratio in the whole routes was carried out by visual inspection. The rehabilitated parts by asphalt overlay and patching are also counted as emergence of cracks.



Investigation Result

Cracking ratio in the whole routes is as shown in the Figure 3-2(1).

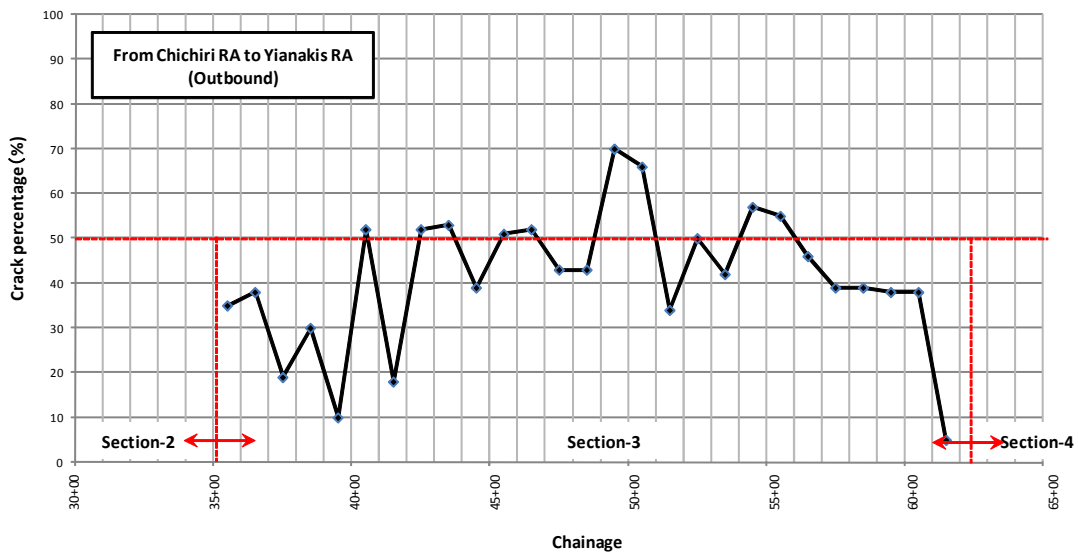


Figure 3-2(1) Results of Crack Investigation, Section-3 (Outbound, from Chichiri RA to Yianakis RA)

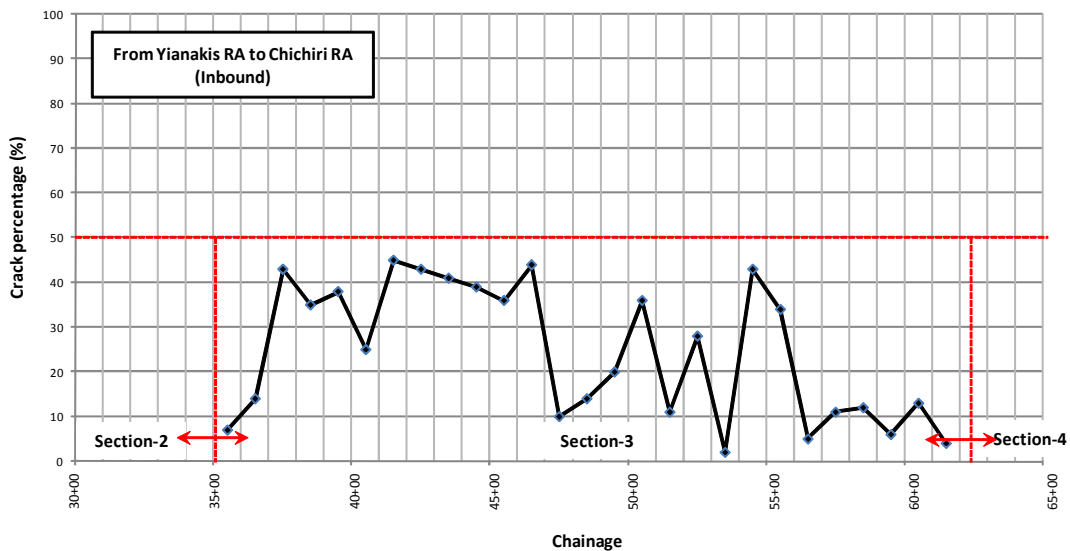


Figure 3-2(2) Results of Crack Investigation, Section-3 (Inbound, from Yianakis RA to Chichiri RA)

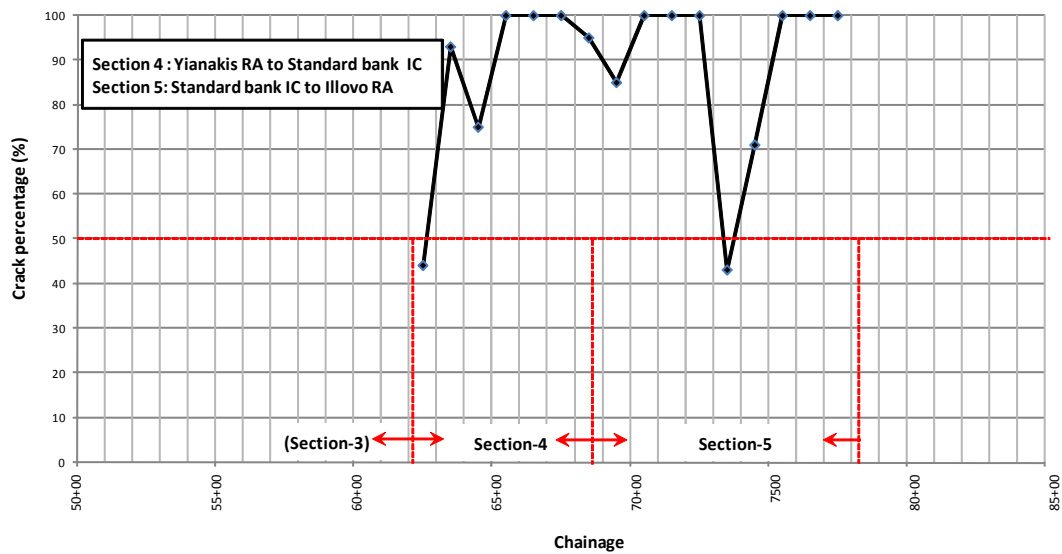


Figure 3-2(3) Results of Crack Investigation, Section-4&5

Considerations

The following are considerations obtained from the investigation on cracking ratio and condition of crack on the road surface.

Section-3

- As can be seen in Figure 3-2(1), several parts having cracking ratio of more than 50% exist in outbound. According to Figure 3-2(4), in case that cracking ratio exceeds 50% in the particular part, all layers of the part should be replaced with new pavement.
- Although lots of cracks exist, roughness of the road is relatively maintained. It is, therefore, conceivable that cracks are not resulted from sub-base course, but deterioration of the road surface.
- In case that cracking ratio exceeds 30%, asphalt overlay or partial replacement is possible repairing measure as shown in Figure 3-2(4). As can be seen in Figure 3-2(1) and (2), cracking ratio exceeds 30% in more or less the whole route of the section-3. Therefore, improvement works are required in the almost whole routes. In case that cracking ratio of more than 50%, all layers including sub-base course should be replaced with new pavement structure.
- The repairing works for the section-3 are classified into mainly two (2) types, such as replacement of surface course and replacement of all layers including sub-base course. The classification can be determined based on the results of Benkelman Beam Testing (See 3-3).

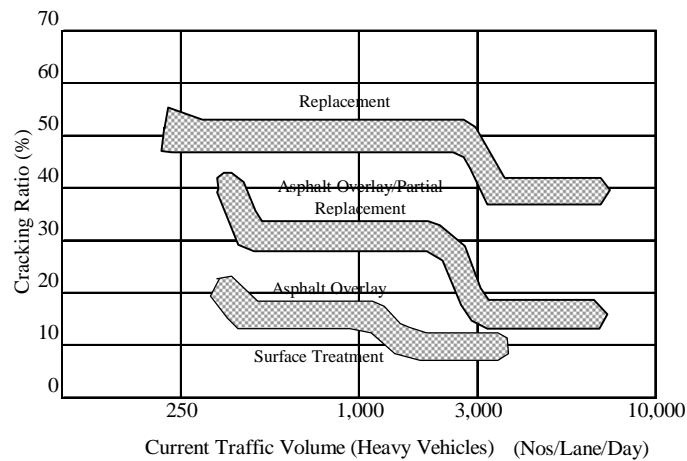


Figure 3-2(4) Determinant for Repairing Measure

Section-4 and 5

- The roughness in these sections is not well-maintained due to frequent repair.
- As can be seen in Figure 3-2(3), cracking ratio exceeds 50% in the almost whole route of these sections.
- The cracks emerge on the part of asphalt overlay or repaired potholes, those are relatively recently constructed.
- “The guideline for road maintenance and repairing” published by Japan Road Association (JRA) stipulates repairing measures in various cracking ratio as follows:
 - Cracking ratio > 30%: asphalt overlay or partial replacement; and
 - Cracking ratio > 50%: replacement for all layers including sub-base course.
- Therefore, replacement for all layers including sub-base course is applicable as the repairing measure to both section-4 and 5.

3) Benkelman Beam Testing

Investigation Measure

Benkelman Beam Testing (hereinafter referred to as BBT) is conducted by measuring the deflection of asphalt surface in the event of passage of loaded dump truck. For the section-3, so as to clarify the present conditions of road, proper repairing measure to be adopted, and the applicable range to be repaired, BBT was carried out at the intervals of 200 m along inbound and outbound. The numbers of location where BBT conducted were 28 in total.



(Test Results)

Results of Benkelmen Beam Testing are as shown in Figure 3-3(1) and (2).

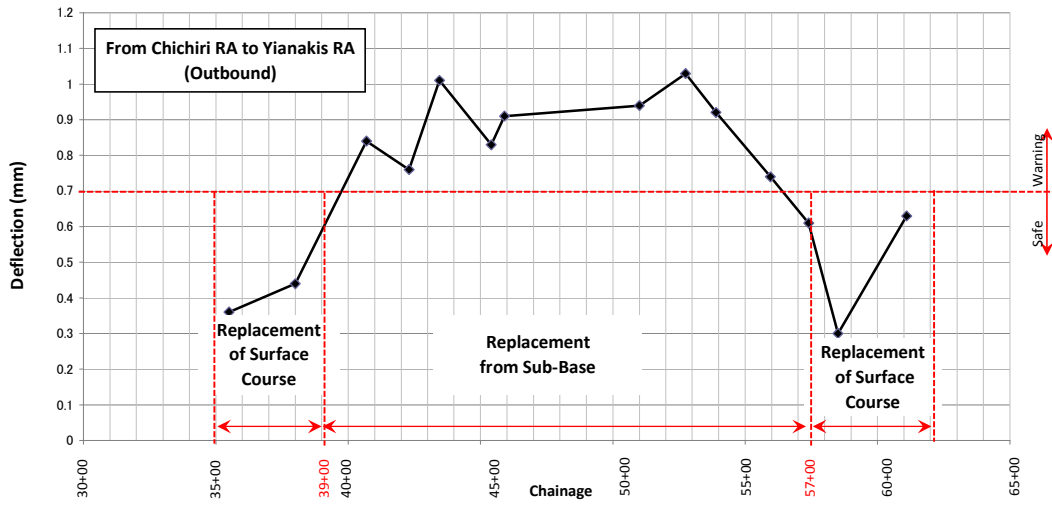


Figure 3-3(1) Benkelmen Beam Testing Results, Repairing Measure, and Applicable Range (Outbound, from Chichiri RA to Yianakis RA)

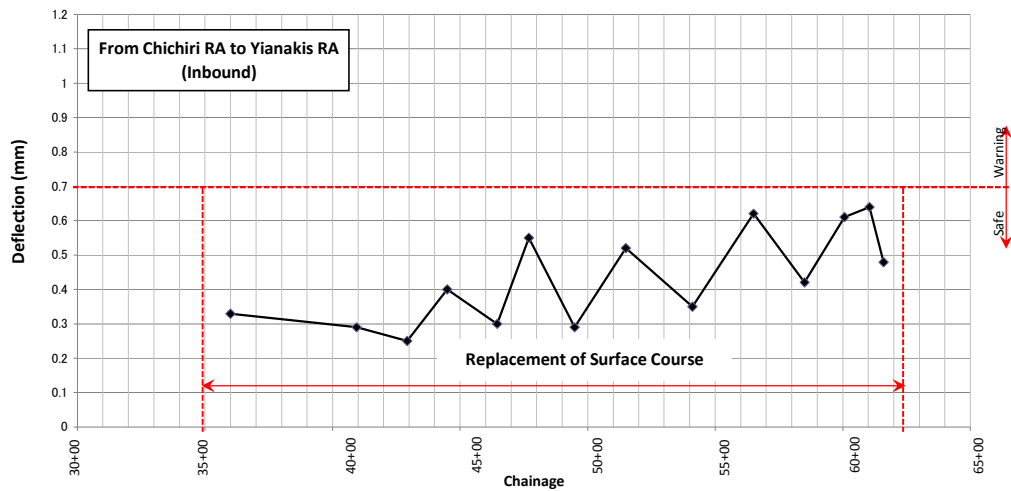


Figure 3-3(2) Benkelmen Beam Testing Results, Repairing Measure, and Applicable Range (Inbound, from Yianakis RA to Chichiri RA)

Considerations

“Draft, Technical Recommendation for Highways 12, Flexible pavement Rehabilitation Investigation and Design 1997(South Africa)” provides the evaluation criteria on road conditions in various deflections resulting from BBT as shown below;

<u>Deflection (mm)</u>	<u>Condition</u>
>0.7	Satisfactory
0.7 to 1.2	Warning
1.2>	Severe

As can be seen in Figure 3-3(1) outbound, investigation result shows the deflection between 0.7 mm and 1.2 mm categorized as “warning” are detected in the station number ranging 39+00 and 57+00, whereas the conditions categorized as “satisfactory” are detected in all other section. Judging from these test results, the condition of base course in the section-3 is relatively good and cracks on road surface are mainly caused by deterioration. The cracking range has been expanding day by day. Consequently, repairing budget for pavement undertaken by the local government has been increasing year after year as well. Moreover, the project should play an important role to minimize the repairing expenditure by implementing an appropriate pavement works.

The proposed repairing works are as follows:

Replacement for all layers including sub-base course is applied to outbound, the range between 39+00 and 57+00:

Replacement of sub-base course is applied to the following range:

For inbound, the whole range;

For outbound, range between 35+00 and 39+00; and

For outbound, range between 57+00 and 61+80.

For the range between 34+35 and 35+00, since replacement of pavement was carried out in the phase-1, no rehabilitation will be carried out in this phase.

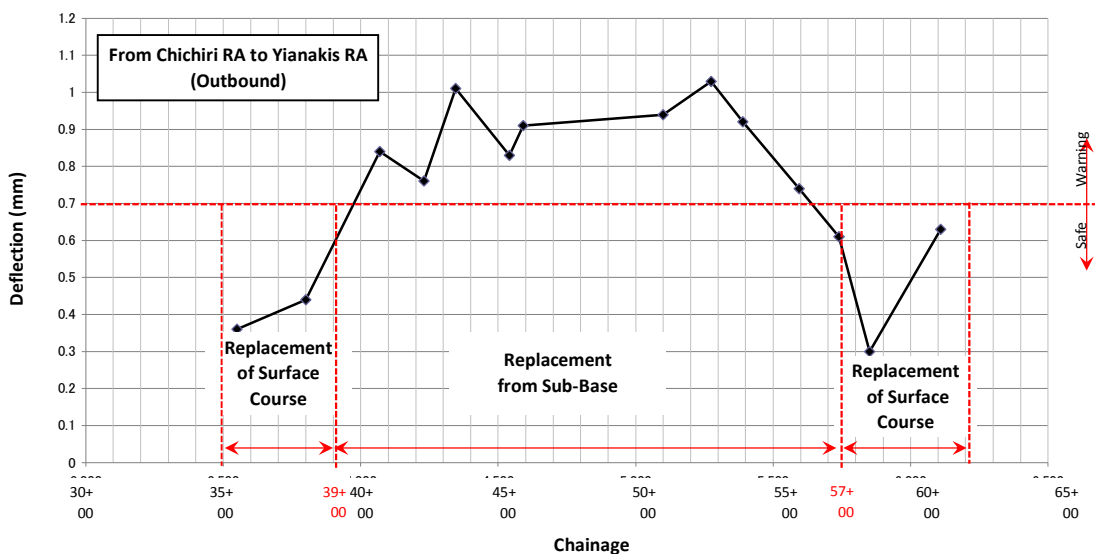


Table 3-3(1) Result of Benkelmen Beam Testing with Repair Method at Outbound direction

4) Dynamic Cone Penetration

Investigation Measure

Dynamic Cone Penetration (hereinafter referred to as DCP), a simple test, aiming at measuring CBR (California Bearing Ratio) was executed at five (5) points of respective sections, that accounts for fifteen (15) points in total.



Investigation Results

The results of investigation conducted this time and the last time are shown in Table below.

Table3-4 Comparing Estimated CBR-value resulting from DCP with CBR-value of Laboratory Test

Section	Previous Result (DCP and Laboratory Testing)					Result of this time (DCP Testing)				
	NO.	Chainage	Estimate CBR value from DCP testing (%)	Pit No.	CBR value from Labo test	Design CBR (%)	No.	Chainage	Estimate CBR value from DCP testing (%)	
Sec. -3	18	35+00	27.5	3-1	5	4.3	D-1	35+50	10	
	19	37+00	impossible to penetrate							
	20	39+00	impossible to penetrate							
	21	41+00	impossible to penetrate	3-2	7					
	22	43+00	33.5							
	23	45+00	32.1	3-3	4					
	24	47+00	27.3					D-2	48+00	8
	25	49+00	impossible to penetrate							
	26	51+00	17.4	3-4	5					
	27	53+00	impossible to penetrate					D-3	53+00	14
	28	55+00	73.7	3-5	20			D-4	55+00	50
29	57+00	81.4				D-5	57+00	11		
30	59+00	impossible to penetrate								
31	61+00	68.4	3-6	6						
Sec. -4	32	63+50	impossible to penetrate	4-1	21	17.3	D-6	62+00	20	
	33	65+50	50.2				D-7	63+50	12	
	34	67+50	67.3	4-2	18		D-8	65+00	11	
							D-9	66+00	14	
					D-10	67+50	12			
Sec. -5	35	70+50	impossible to penetrate			17.3	D-11	69+00	14	
	36	73+50	73.6	5-1	21		D-12	70+50	21	
	37	75+00	impossible to penetrate				D-13	73+00	15	
	38	77+00	68.3	5-2	18		D-14	75+00	14	
							D-15	76+50	33	

Consideration

Estimated CBR value based on the results of DCP executed in this survey were relatively close to those of the Basic Design Study. Therefore, design CBR value to be used for proposed pavement design is same as those of the Basic Design, 4.3% in the section-3 and 17.3% in the section-4 and 5.

5) Pavement Design

(1) Pavement Design Result by Japanese Road Association (JRA) (TA Method)

1. Classification of Traffic

1)Section - 3

(Traffic Volume of heavy vehicle)=(1,270+585)=1,855
 $1,855 \div 2(\text{direction}) \times 1.85(15\text{years later})=1,373$

(per day of 2-lanes in 2009)

(per day of 1-lane in 2026)

(C class; $1,000 < \text{Traffic Volume} < 3,000$)

2)Section-4

*)After Section - 4's widening to 4-lane in the future, Heavy Vehicles come to Section - 4 from Section - 3.
 Therefore Design Traffic Volume in Section-4 should be same as Section-3

3)Section-5

(Traffic Volume of heavy vehicle)=(60+72)=134
 $134 \times 1.85(15\text{years later})=250$

(per day of 2-lanes in 2009)

(per day of 1-lane in 2027)

(B Class; $250 < \text{Traffic Volume} < 1,000$)

2. Pavement Design

1)Section -3

N= 7,000,000 (C Class, 1,000~3,000/day/1-lane)
 CBR= 4 ($4 < \text{CBR} = 4.3 < 6$)

$$TA = \frac{3.84 * N^{0.16}}{CBR^{0.3}} = 32$$

	a	h(cm)
Asphalt Surface	1.00	10
Granular base (Soaked CBR > 80)	0.35	35
Granular Subbase (Soaked CBR > 30)	0.25	40
Total		85

$$T = a_1h_1 + a_2h_2 + a_3h_3 = 32.25 > TA$$

2)Section-4

N= 7,000,000 (C Class, 1,000~3,000/day/1-lane)
 CBR= 12 ($12 < \text{CBR} = 17.3 < 20$)

$$TA = \frac{3.84 * N^{0.16}}{CBR^{0.3}} = 23$$

	a	h(cm)
Asphalt Surface	1.00	10
Granular base (Soaked CBR > 80)	0.35	20
Granular Subbase (Soaked CBR > 30)	0.25	25
Total		55

$$T = a_1h_1 + a_2h_2 + a_3h_3 = 23.25 > TA$$

3)Section-5

N= 1,000,000 (B Class, 250~1,000/day/1-lane)
 CBR= 12 ($12 < \text{CBR} = 17.3 < 20$)

$$TA = \frac{3.84 * N^{0.16}}{CBR^{0.3}} = 17$$

	a	h(cm)
Asphalt Surface	1.00	5
Granular base (Soaked CBR > 80)	0.35	20
Granular Subbase (Soaked CBR > 30)	0.25	20
Total		45

$$T = a_1h_1 + a_2h_2 + a_3h_3 = 17.00 = TA$$

(2) Pavement Design Result

Table - Pavement Design Result

Section -3 (Re-construction) Outbound (39+00 ~ 57+00)		Section -3 (Replace of Surface) Inbound (All), Outbound(35+00 ~ 39+00, 57+00 ~ 61+80)	
Surface	Asphalt Concrete Surface Course=5cm Binder Course=5cm	10.0cm	5.0cm (10.0cm) Replace Utilize Existing material
Base	Granular (Soaked CBR>80%)	35.0cm	(15.0cm) Keep Existing
Subbase	Granular (Soaked CBR>30%)	40.0cm	
Traffic Class = C			
CBR=4			
Total		85.0cm	5.0cm
Section -4 (Re-construction) All (61+80 ~ 69+00)		Section -5 (Re-construction) All (69+00 ~ 77+90)	
Traffic Class = C		Traffic Class = B	
Surface	Asphalt Concrete	10.0cm	5.0cm
Base	Granular (Soaked CBR>80%)	20.0cm	20.0cm
Subbase	Granular (Soaked CBR>30%)	25.0cm	20.0cm
Traffic Class = C			
CBR=12			CBR=12
Total		55.0cm	45.0cm

6) Drainage Design

(1) Rainfall Data

Place: Chichiri
Term: 1999 – 2008

Chichiri Daily Rainfall Data for 1999

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	14.3	0.0	9.5	1.4	0.0	0.0	0.0	0.0	0.0	12.8	0.0
2	0.0	19.2	0.0	18.5	2.4	0.0	0.0	0.0	0.4	0.0	0.0	10.4
3	101.1	0.2	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0
4	16.7	0.0	3.4	5.5	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
5	7.4	0.0	3.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0
6	24.2	0.0	126.0	1.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	4.0	8.0	0.0	4.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	28.1	0.0	5.1	11.3	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
9	18.3	30.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.2	0.0
10	28.6	3.0	2.1	3.4	0.0	0.0	0.0	0.0	0.0	0.0	21.9	14.0
11	0.0	0.0	0.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0	2.1	7.6
12	1.0	0.0	2.5	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8
13	57.0	32.6	41.1	4.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	6.8
14	36.5	1.1	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5
15	5.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.3
17	40.0	0.0	16.8	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0
18	29.3	0.0	0.0	0.0	0.1	0.0	1.7	0.0	0.0	0.0	4.9	0.0
19	32.0	73.8	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	16.0	0.0
20	3.4	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	18.2
21	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
22	5.0	35.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	3.0	4.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	15.5
24	17.7	62.0	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	8.1	3.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
26	7.9	1.8	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	4.0	11.1	18.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	8.4	0.7	2.5	2.2	0.0	0.0	0.0	0.0	0.0	7.92	0.0	0.0
29	24.0		3.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7
30	10.2		1.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	31.9		9.5		0.0	0.0	0.0	0.0	0.0	0.0		0.0
Total	569.6	305.7	266.7	93.5	4.8	0.0	7.2	0.0	0.4	81.3	92.1	92.8

Total 1,514.1

Chichiri Daily Rainfall Data for 2000

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	7.3	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
2	0.0	86.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.5
5	5.5	0.8	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.4	23.9
6	0.0	0.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	21.9
7	0.0	0.0	0.8	0.0	14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	7.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2	0.0	3.5	0.0
9	23.0	3.0	1.7	12.2	2.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0
10	32.9	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
11	10.9	10.4	1.2	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	42.5	7.9	15.3	7.1	0.1	0.0	0.0	0.0	0.0	0.0	3.0	0.0
13	0.0	0.0	3.2	2.1	0.0	0.0	0.0	0.0	0.0	0.0	25.4	26.9
14	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.6
15	3.3	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	1.0
16	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0
17	23.0	27.0	0.0	4.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	27.3	0.0	6.9	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	38.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5	0.0
20	0.0	0.0	15.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	20.8
23	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.2
24	0.0	67.7	29.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
25	22.0	6.2	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
26	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5	0.0
27	0.2	63.5	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.2	25.9	5.9
28	8.4	0.0	2.1	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.3	0.0
29	5.7	0.0	0.0	2.5	0.0	0.5	0.0	0.0	0.0	2.1	0.0	5.0
30	0.0		0.0	0.7	0.0	0.0	0.0	0.0	0.0	30.9	8.4	2.0
31	16.0		8.7		0.0					2.1		9.6
Total	312.2	283.8	127.7	32.1	22.4	9.9	0.0	0.0	0.2	35.3	153.1	173.3

Total 1,150.0

Chichiri Daily Rainfall Data for 2001

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1.2	8.0	7.4	4.0	0.0	0.0	0.0	0.7	0.0	0.0	9.5	0.0
2	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.7	0.0	1.5	23.9	0.0	0.0	0.0	0.0	0.0	0.0	5.8	1.0
4	0.1	13.5	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
5	0.0	6.9	42.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0	0.0	4.9
6	0.0	10.3	0.3	4.0	0.0	1.2	0.0	1.7	0.0	0.0	0.0	0.0
7	0.0	18.7	0.0	0.0	9.2	0.0	0.0	0.4	0.0	0.0	0.0	16.8
8	0.0	49.7	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0
9	0.0	2.3	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
10	0.0	4.5	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.5
11	1.7	3.6	8.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	1.8	11.2	4.8	1.6	5.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0
13	27.8	1.5	1.7	1.8	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	16.0	0.0	13.1	4.4	0.6	0.0	0.1	0.0	0.0	0.0	6.8	2.2
15	11.3	13.1	0.0	0.0	0.0	0.0	0.4	0.0	15.9	0.0	0.0	0.0
16	1.7	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	19.3	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.1	21.0
18	7.2	45.1	13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.5	0.1
19	0.0	9.2	48.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
20	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.6	55.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	44.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6	32.1
23	0.0	33.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	21.0
24	0.0	24.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	4.8	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.9
27	13.1	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.7
28	7.0	1.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	26.8
29	1.4		0.0	0.0	1.5	0.0	2.2	0.0	0.0	0.0	0.0	20.2
30	12.6		4.4	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.3
31	41.3		4.0		0.0		0.0	0.0	0.0	0.0		0.6
Total	175.6	390.1	261.6	48.0	17.5	2.2	3.9	4.0	15.9	23.0	90.6	247.4

Total 1,279.8

Chichiri Daily Rainfall Data for 2002

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	1.8	107.0	0.0	1.2	0.0	3.0	0.0	0.0	0.0	0.0	0.0
2	3.6	30.6	0.0	0.0	0.0	0.0	8.0	0.5	0.0	0.0	0.0	0.0
3	0.0	52.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
4	0.0	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
5	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2
6	0.0	0.0	78.0	9.7	0.0	0.0	0.0	0.0	12.2	1.6	1.6	0.0
7	0.0	0.0	10.0	31.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	10.5	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
9	4.9	0.0	31.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	13.3
10	0.0	0.0	31.0	0.0	0.4	0.0	0.0	0.0	2.2	0.0	0.0	67.0
11	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.1	0.1	7.7
12	17.4	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0	0.0	0.0	62.5
13	24.0	0.0	2.0	4.9	0.0	0.0	0.0	0.0	0.7	0.0	0.0	4.1
14	39.7	0.0	112.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0
15	7.1	0.0	14.0	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0
16	0.0	0.0	0.0	39.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	28.8	3.2	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	3.5	46.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
19	0.0	0.0	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.1
20	82.0	1.5	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.1	0.1	8.8
21	0.9	0.0	32.7	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	7.5
22	1.6	0.0	14.2	0.0	0.0	9.0	0.0	0.0	0.0	0.5	0.5	1.1
23	0.0	12.8	13.0	1.2	0.0	0.0	0.0	0.7	0.0	0.0	0.0	15.9
24	0.0	0.0	43.0	0.0	0.0	0.0	0.0	10.3	0.0	25.0	25.0	46.2
25	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.9
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	19.5	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	14.1		94.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	25.5		0.0		0.0		0.0	0.0	0.0	0.0		0.0
Total	274.8	199.4	646.9	137.1	8.0	15.5	11.0	15.3	16.4	28.0	28.0	297.1

Total 1,677.5

Chichiri Daily Rainfall Data for 2003

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	23.3	32.9	15.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	19.5	30.0	0.9	0.0	0.0	0.0	0.7	0.0	3.6	0.0	0.0	0.0
4	7.2	56.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
5	9.8	1.3	1.7	2.9	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0
6	0.0	18.7	0.0	1.0	0.0	0.0	4.7	0.0	0.0	0.0	14.0	0.0
7	0.0	1.5	22.4	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
8	5.2	32.7	23.1	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	1.0
9	21.0	15.7	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	9.4	6.2	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0
11	49.3	1.3	0.8	0.5	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
12	0.1	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.1
13	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.2	0.0	0.0	0.0
15	0.0	0.0	0.0	0.5	7.4	0.0	0.0	0.0	0.0	0.0	0.0	1.7
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0
17	0.0	32.3	36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	3.9	0.0	0.0	1.3	0.6	0.5	0.0	0.0	0.0	0.0	0.8	0.0
19	12.7	0.0	0.0	0.0	2.7	1.4	0.0	0.0	0.0	0.0	0.0	2.3
20	2.2	0.0	27.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.8
21	3.3	14.2	13.0	0.0	0.0	0.0	0.0	1.0	0.0	0.2	0.0	0.0
22	0.5	37.5	3.7	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0
23	14.5	1.5	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4
24	2.8	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	10.3	2.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4
27	0.0	0.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.3
28	0.0	0.0	8.1	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	18.1
29	6.3		1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	2.7		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
31	8.9		11.9		0.0		0.0	0.0	0.0	0.0		0.0
Total	247.9	301.5	207.8	6.9	11.2	7.2	15.1	4.0	3.8	0.2	23.5	82.1

Total 911.2

Chichiri Daily Rainfall Data for 2004

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
3	0.0	14.6	12.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
4	0.0	0.0	47.4	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	15.5	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1.3
6	0.0	0.0	34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	6.1
7	2.8	0.0	0.0	39.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	1.4	0.0	0.0	31.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	10.9	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	4.0
10	1.4	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	18.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	36.9	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	19.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
15	7.6	0.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3
16	0.0	24.5	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	8.1	1.5
17	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	21.6	0.0	12.6	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.8	0.0
19	3.9	38.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	22.1	2.1	0.0	27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	38.5	3.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.2	0.0	0.0
22	16.4	21.4	0.0	0.0	0.2	0.0	0.0	3.0	0.0	0.0	0.0	7.4
23	0.4	13.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	5.2
24	0.0	0.0	0.0	1.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	83.0
25	5.9	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1
26	15.5	0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.1
27	0.9	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.1	0.0	0.0	23.0
28	19.8	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.5
29	9.5	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
30	22.0		5.1	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.6	0.0
31	19.3		21.0		3.5		0.0	0.0	0.0	0.0		26.0
Total	246.7	184.7	171.5	120.3	20.5	0.0	0.0	4.0	0.4	0.2	23.5	274.4

Total 1,046.2

Chichiri Daily Rainfall Data for 2005

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
2	0.0	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
3	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	2.0
6	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.5
7	4.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0
8	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	31.0
9	39.2	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.8	0.0
10	13.0	10.3	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
12	1.5	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
13	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5
14	0.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.5
15	0.5	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.9
16	0.0	24.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.4
17	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0
18	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	47.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0
21	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
22	12.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.5
24	22.5	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5
25	15.0	5.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	11.5
26	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
27	10.5	46.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5	30.0
28	1.4	3.5	0.0	1.0	0.0	0.0	0.0	0.0	28.0	0.0	6.0	0.0
29	4.3		0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	9.0	28.5
30	0.0		0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	9.5	8.5
31	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5
Total	215.6	103.8	6.2	15.5	0.0	3.4	11.8	0.0	29.7	0.0	81.9	261.6

Total 729.5

Chichiri Daily Rainfall Data for 2006

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	26.0	5.3	22.3	7.5	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
2	12.5	4.8	7.0	0.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	1.5	0.0	11.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	5.5	23.0	11.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
5	0.0	3.9	25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.6
6	78.5	17.0	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.2	2.1	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8
8	0.0	0.0	1.2	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	20.0
9	0.0	0.0	22.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
10	13.9	0.0	0.0	1.5	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
11	9.0	7.1	4.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	7.1	2.6
12	2.0	0.0	28.5	58.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	13.4
13	9.5	19.6	0.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	18.0	14.0
14	21.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.6	12.0
15	15.0	14.9	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	22.0
16	28.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
17	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
18	1.8	46.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	15.9
19	0.0	4.1	7.3	1.5	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.9
20	2.2	1.5	0.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
21	7.0	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	1.3	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0
23	0.0	7.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0
24	3.0	0.9	5.5	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	36.5	51.5	6.2	1.5	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.5
26	21.8	48.5	11.5	0.8	0.0	4.5	0.0	0.0	0.0	0.0	6.2	13.6
27	3.7	1.2	0.5	1.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.7
28	0.5	0.0	28.0	1.2	0.0	0.0	0.0	0.0	0.0	1.5	0.0	16.4
29	0.0		14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
30	0.0			0.0	0.0	0.0	0.0	0.0	28.5	0.0	0.0	0.0
31	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0
Total	300.4	289.4	249.3	83.7	2.8	5.7	3.4	0.0	30.0	1.9	186.0	216.3

Total 1,368.9

Chichiri Daily Rainfall Data for 2007

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	30.1	5.0	0.0	11.3	0.0	1.0	0.0	0.0	0.0	0.0	1.0	4.5
2	16.4	30.5	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	4.5	52.0
3	24.9	0.0	2.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	1.5
4	1.9	0.5	0.5	0.0	0.9	0.0	1.0	0.0	0.0	0.0	0.0	0.0
5	31.2	0.0	0.0	0.0	2.5	0.0	0.0	2.0	0.0	0.0	0.0	9.0
6	23.2	0.0	9.8	0.0	5.7	0.0	0.0	0.5	0.0	0.0	0.0	0.0
7	1.8	0.0	15.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	21.9	0.0	7.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	4.5	2.0
9	2.2	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	7.5
10	0.0	9.6	1.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	6.5	25.5
11	0.9	18.5	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
12	0.0	58.4	32.8	2.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	8.0
13	0.0	16.5	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.0
14	0.7	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	2.5
16	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	6.5	0.0	1.5	0.0	0.0	3.5	0.0	9.0	0.0
18	12.6	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	16.8
19	102.1	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	19.0
20	4.9	0.0	0.0	10.5	0.0	2.0	0.0	0.0	0.0	0.0	0.0	2.5
21	4.8	39.5	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0
22	0.0	12.6	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	17.3
23	0.0	14.0	4.5	0.0	0.0	0.5	0.0	0.0	0.0	13.5	0.0	34.0
24	0.0	30.6	5.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	73.0
25	0.5	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
26	13.6	28.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2
27	0.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	25.8
28	16.4	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	4.0
29	3.8		1.5	0.0	0.0	0.0	0.0	0.0	0.0	4.0	6.0	18.6
30	0.0		36.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
31	25.0		1.5		0.0	0.0	0.0	0.0	0.0	0.0		0.0
Total	339.6	269.9	160.9	32.5	9.5	10.0	16.1	2.5	3.5	20.0	50.8	374.2

Total 1,289.5

Chichiri Daily Rainfall Data for 2008

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5	3.0
2	0.0	0.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	3.7	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	10.0
4	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
5	0.0	1.5	47.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
6	1.5	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0
8	0.0	6.7	17.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	10.0	2.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0	0.0	12.0
10	26.5	9.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	15.5
11	26.0	0.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
12	33.5	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	1.0
13	19.3	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0
14	19.8	0.0	4.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	5.0	16.5
15	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	2.6
16	14.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5
17	16.7	0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.0
18	3.0	0.0	0.0	0.0	1.3	0.0	0.0	4.6	0.0	0.0	0.0	21.2
19	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	5.5
20	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5
21	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0
22	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
23	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.5
24	36.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0
25	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0
26	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5
27	3.2	7.7	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
28	8.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.2
29	2.4	35.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	24.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	3.4		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3
Total	396.5	68.4	127.1	0.0	1.3	8.8	4.1	15.6	0.0	13.5	36.0	333.8

Total 1,005.1

(2) Probability Rainfall Calculation by Normal Probability Distribution Method

① Rank	② Xi Rainfall	③ logXi	④ Xi+b	⑤ log(Xi+b)	⑥ (log(Xi+b))^2	Abstract																								
1	126.0	2.1004	176.9783	2.2479	5.0531	$\log X_o = \frac{\sum \log X_i}{n} = 1.90878$ $\therefore X_o = 81.0554$																								
2	112.0	2.0492	162.9783	2.2121	4.8935																									
3	102.1	2.0090	153.0783	2.1849	4.7738																									
4	95.0	1.9777	145.9783	2.1643	4.6841																									
5	86.0	1.9345	136.9783	2.1367	4.5653	<table border="1"> <tr> <td></td> <td>Xs</td> <td>Xt</td> <td>$b = \frac{X_s \cdot X_t - X_o^2}{2X_o - (X_s + X_t)}$</td> </tr> <tr> <td>1</td> <td>126.0</td> <td>47.5</td> <td>51.361</td> </tr> <tr> <td>2</td> <td>112.0</td> <td>56.0</td> <td>50.595</td> </tr> <tr> <td>3</td> <td></td> <td></td> <td></td> </tr> <tr> <td>4</td> <td></td> <td></td> <td></td> </tr> <tr> <td colspan="3" style="text-align: center;">計</td> <td>101.957</td> </tr> </table>		Xs	Xt	$b = \frac{X_s \cdot X_t - X_o^2}{2X_o - (X_s + X_t)}$	1	126.0	47.5	51.361	2	112.0	56.0	50.595	3				4				計			101.957
	Xs	Xt	$b = \frac{X_s \cdot X_t - X_o^2}{2X_o - (X_s + X_t)}$																											
1	126.0	47.5	51.361																											
2	112.0	56.0	50.595																											
3																														
4																														
計			101.957																											
6	83.0	1.9191	133.9783	2.1270	4.5243																									
7	78.5	1.8949	129.4783	2.1122	4.4614																									
8	60.0	1.7782	110.9783	2.0452	4.1830																									
9	56.0	1.7482	106.9783	2.0293	4.1180																									
10	47.5	1.6767	98.4783	1.9933	3.9734																									
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42																														
43																														
Total	846.1	19.0878		21.2530	45.2300																									
Total/n	84.61	1.9088		2.12530	4.52300																									

$\sqrt{2\sigma} = 0.11642$

Year	Probability Rainfall
2	82.466 mm/day
3	93.819 (For Side Ditch)
4	100.666
5	105.547 (For Cross Drainage)
10	119.160 (For River Crossing)
20	131.289
30	137.940
40	142.511
50	145.990
100	156.758



Daily rainfalls are converted to hourly using following formula in the condition of concentration time = 10 min.

$$X' = (24 * 60 / t)^{(2/3)} * X / 24$$

Table of Exceedance Probability Constant

Probability Year	Probability	Exceedance Probability Constant	Legend
2	1/2	0.00000	
3	1/3	0.30457	
4	1/4	0.47694	
5	1/5	0.59512	
10	1/10	0.906194	
20	1/20	1.163088	
30	1/30	1.296788	
40	1/40	1.385977	
50	1/50	1.452452	
100	1/100	1.651006	

Provability Yaer	Hourly Rainfall X'
2	94.400 mm/hour
3	107.396 (For Side Ditch)
4	115.234
5	120.822 (For Cross Drainage)
10	136.404 (For River Crossing)
20	150.289
30	157.902
40	163.135
50	167.117
100	179.443

(3) Design Condition

	No.	Chainage	Gradient	Distance (m)	Catchment Width (m)	Catchment Area(ha)	Remarks
Side Ditch	S-1	34+35 - 36+90	6.70%	255	10	1.13	
	S-2	36+90 - 41+30	4.70% ↙	440	10	0.70	
	S-3	41+30 - 45+60	0.86%	430	10	0.43	
	S-4	45+60 - 48+70	2.10% ↘	310	10	0.31	
	S-5	48+70 - 52+30	1.82% ↙	360	10	0.36	
	S-6	52+30 - 55+50	1.86% ↘	320	10	0.32	
	S-7	55+50 - 60+80	5.30% ↙	530	10	0.53	
	S-8	60+80 - 63+20	4.56% ↘	240	10	0.24	
	S-9	63+20 - 64+80	7.80%	160	10	0.40	
	S-10	64+80 - 66+00	5.00% ↙	120	10	0.12	
	S-11	66+00 - 67+50	3.80% ↘	150	10	0.15	
	S-12	67+50 - 68+40	7.40% ↙	90	10	0.09	
	S-13	68+40 - 70+30	0.40% ↘	190	10	0.19	
	S-14	70+30 - 71+20	7.50% ↙	90	10	0.09	
	S-15	71+20 - 72+90	0.20% ↘	170	10	0.17	
	S-16	72+90 - 73+70	4.20%	80	10	0.25	
	S-17	73+70 - 74+90	2.44%	120	10	0.42	
	S-18	74+90 - 75+40	6.70% ↙	50	10	0.30	
	S-19	75+40 - 76+90	4.50%	150	10	0.25	
	S-20	76+90 - 77+90	0.50%	100	10	0.10	
Cross Drainage	C-1	48+70	0.50%			0.67	(S-4)+(S-5)
	C-2	55+50	0.50%			0.85	(S-6)+(S-7)
	P-1	64+80	0.50%			10.00	*River Sec.
	P-2	67+50	0.50%			10.00	*Ricer Sec.
	C-3	70+30	0.50%			0.28	(S-13)+(S-14)
	C-4	73+70	0.50%			1.49	SUM(S-15~S-20)

(4) Calculation of Discharge

Calculation of Discharge for Side Ditch

No.	Catchments Area A ha	Return Period	Reinfall R mm/hr	Discharge Coefficient C	Discharge Q cu.m/sec
C=0.8					
Residential Area	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0	3 3 3 5 3 3 3 3 5 3	107.4 107.4 107.4 107.4 107.4 107.4 107.4 107.4 107.4 107.4	0.60 0.60 0.60 0.60 0.60 0.60 0.60 0.60 0.60 0.60	0.090 0.179 0.269 0.358 0.448 0.537 0.627 0.716 0.806 0.895
C=0.6					
Residential Area with wide garden	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0	3 3 3 5 3 3 3 3 5 3	107.4 107.4 107.4 107.4 107.4 107.4 107.4 107.4 107.4 107.4	0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40	0.060 0.119 0.179 0.239 0.298 0.358 0.418 0.477 0.537 0.597
C=0.4					

※) $Q=A \cdot R \cdot C / 360$

Calculation of Discharge for Cross Drainage

No.	Catchments Area A ha	Return Period	Reinfall mm/hr	Discharge Coefficient C	Discharge Q cu.m/sec
C=0.8					
Residential Area	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0	5 5 5 5 5 5 5 5 5 5	120.8 120.8 120.8 120.8 120.8 120.8 120.8 120.8 120.8 120.8	0.60 0.60 0.60 0.60 0.60 0.60 0.60 0.60 0.60 0.60	0.101 0.201 0.302 0.403 0.503 0.604 0.705 0.805 0.906 1.007
C=0.6					
Residential Area with wide garden	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0	5 5 5 5 5 5 5 5 5 5	120.8 120.8 120.8 120.8 120.8 120.8 120.8 120.8 120.8 120.8	0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40	0.067 0.134 0.201 0.268 0.336 0.403 0.470 0.537 0.604 0.671
C=0.4					

(5) Calculation of Velocity and Depth

Calculation of Velocity and Depth For Pipes

No.	Pipe Dia. ϕ (m)	Roughness n	Catchments Area (ha)	Return Period	Rainfall (mm/hr)	Discharge Coefficient	Discharge Q(m ³ /sec)	Gradient i(%/100)	Velocity V(m/sec)	W. Depth (m)	Sec. Area (m ²)	R (m)	Spec.	Remarks
S-1	0.594	0.013	1.5	3	107.4	0.8	0.358	0.067	4.542	0.194	0.079	0.109	DP-600	Side Ditch, (34+35~36+90)
S-2	0.594	0.013	1.0	3	107.4	0.8	0.239	0.047	3.567	0.173	0.067	0.099	DP-600	Side Ditch, (36+90~41+30)
S-3	0.594	0.013	0.5	3	107.4	0.8	0.119	0.009	1.593	0.187	0.075	0.106	DP-600	Side Ditch, (41+30~45+60)
S-4	0.594	0.013	0.5	3	107.4	0.8	0.119	0.021	2.192	0.149	0.054	0.087	DP-600	Side Ditch, (45+60~48+70)
S-5	0.594	0.013	0.5	3	107.4	0.8	0.119	0.018	2.083	0.154	0.057	0.090	DP-600	Side Ditch, (48+70~52+30)
S-6	0.594	0.013	0.5	3	107.4	0.8	0.119	0.019	2.099	0.153	0.057	0.090	DP-600	Side Ditch, (52+30~55+50)
S-7	0.594	0.013	1.0	3	107.4	0.8	0.239	0.053	3.725	0.168	0.064	0.096	DP-600	Side Ditch, (55+50~60+80)
S-8	0.594	0.013	0.5	3	107.4	0.8	0.119	0.046	2.886	0.123	0.041	0.074	DP-600	Side Ditch, (60+80~63+20)
S-9	0.594	0.013	0.5	3	107.4	0.8	0.119	0.078	3.488	0.107	0.034	0.065	DP-600	Side Ditch, (63+20~64+80)
S-10	0.594	0.013	0.5	3	107.4	0.8	0.119	0.050	2.981	0.120	0.040	0.072	DP-600	Side Ditch, (64+80~66+60)
S-11	0.594	0.013	0.5	3	107.4	0.8	0.119	0.038	2.705	0.128	0.044	0.077	DP-600	Side Ditch, (66+60~67+50)
S-12	0.594	0.013	0.5	3	107.4	0.8	0.119	0.074	3.423	0.109	0.035	0.066	DP-600	Side Ditch, (67+50~68+40)
S-13	0.594	0.013	0.5	3	107.4	0.8	0.119	0.004	1.208	0.229	0.098	0.124	DP-600	Side Ditch, (68+40~70+30)
S-14	0.594	0.013	0.5	3	107.4	0.8	0.119	0.075	3.440	0.108	0.035	0.066	DP-600	Side Ditch, (70+30~71+20)
S-15	0.594	0.013	0.5	3	107.4	0.8	0.119	0.002	0.937	0.278	0.127	0.142	DP-600	Side Ditch, (71+20~72+90)
S-16	0.594	0.013	0.5	3	107.4	0.8	0.119	0.042	2.803	0.125	0.042	0.075	DP-600	Side Ditch, (72+90~73+70)
S-17	0.594	0.013	0.5	3	107.4	0.8	0.119	0.024	2.299	0.144	0.052	0.085	DP-600	Side Ditch, (73+70~74+90)
S-18	0.594	0.013	0.5	3	107.4	0.8	0.119	0.067	3.306	0.111	0.036	0.068	DP-600	Side Ditch, (74+90~75+40)
S-19	0.594	0.013	0.5	3	107.4	0.8	0.119	0.045	2.872	0.123	0.041	0.074	DP-600	Side Ditch, (75+40~76+90)
S-20	0.594	0.013	0.5	3	107.4	0.8	0.119	0.005	1.310	0.216	0.091	0.118	DP-600	Side Ditch, (76+90~77+90)
C-1	0.594	0.013	1.0	5	120.8	0.8	0.268	0.005	1.615	0.344	0.166	0.162	DP-600	Cross Drainage, (48+70)
C-2	0.594	0.013	1.0	5	120.8	0.8	0.268	0.005	1.615	0.344	0.166	0.162	DP-600	Cross Drainage, (55+50)
C-3	0.594	0.013	0.5	5	120.8	0.8	0.134	0.005	1.354	0.230	0.099	0.124	DP-600	Cross Drainage, (70+30)
C-4	0.594	0.013	1.5	5	120.8	0.8	0.403	0.005	1.736	0.463	0.232	0.180	DP-600	Cross Drainage, (73+70)
P-1	1.460	0.013	10.0	50	136.4	0.8	3.031	0.005	2.959	0.859	1.024	0.401	DP-1500	River Crossing, (64+80)
P-2	1.460	0.013	10.0	50	136.4	0.8	3.031	0.005	2.959	0.859	1.024	0.401	DP-1500	River Crossing, (67+50)

※) Open Drainage Area is bigger than Pipes, therefore calculation for open drainage should be abbreviated because of seftier than pipes.