Royal Netherlands Embassy

Project Report

Flood Protection & Urban Drainage

Banda Aceh Darussalam

August 2009

Sea Defence Consultants

ACEH AND NIAS SEA DEFENCE, FLOOD PROTECTION, ESCAPES AND EARLY WARNING PROJECT
BRR CONCEPT NOTE / INFRA 300GI

PROJECT REPORT

FLOOD PROTECTION & URBAN DRAINAGE

Banda Aceh Darussalam

SDC-R-70091

August 2009

Final

Document history

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Client:
Badan Rehabilitasi & Rekonstruksi
BRR NAD-NIAS

Stakeholders:
DINAS SDA-Prop / BRR Regional, DPJSDA, Kota Banda Aceh. Dinas Kebersihan& Pertamanan Kota, local community

Location:
Banda Aceh Darussalam

Mitigating measures:
Enlargement existing drains, cleaning of the drainage system, construction of new drains

Estimated budget:
Rp. 51.2 billion
US$: 5.1 million
(Excl. Land acquisition)

Planning:
Completion design: 11/2007
Completion tender doc's: 12/2007
Start construction: 2008


One of the few main drains

For further information:
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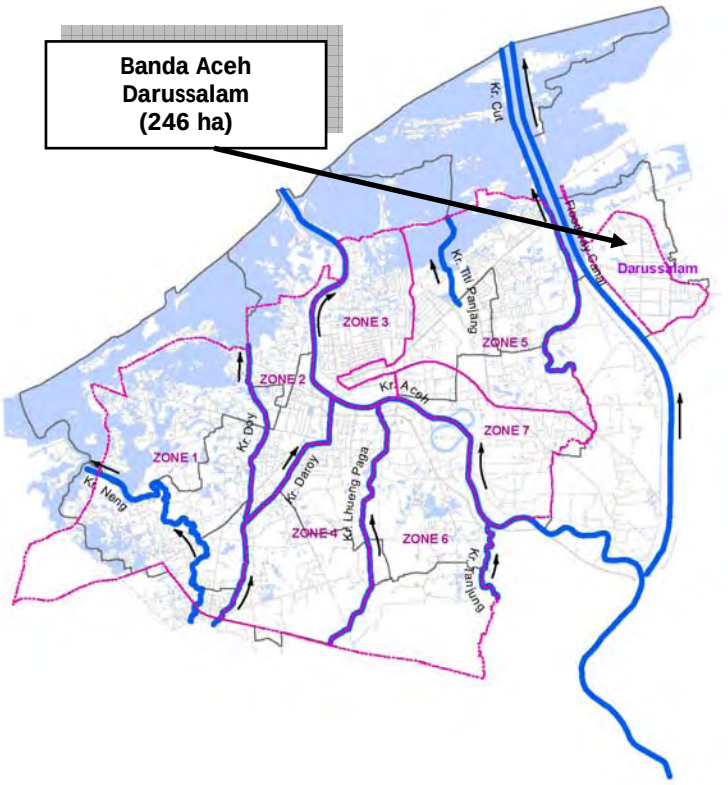
Banda Aceh Darussalam



Existing situation

Banda Aceh Darussalam is located east of the Floodway and covers an area of about 246 ha. Darussalam is important for its educational facilities. In this area the Syah Kuala University as well as many other education centers are located.
The ground level of the area is high enough to allow drainage by gravity into the main drain, parallel to the Floodway, and onward to the sea.

The road around Darussalam is located high compared to the area outside Darussalam. The road functions as a hydrological boundary preventing water to enter from outside Darussalam and the other way around.

Performance existing system

Same areas in Darussalam are regularly flooded. The system discharges by gravity into the main drain, parallel to the Floodway, and onward directly to the sea. The existing system has insufficient capacity to handle excess water. Insufficient capacity is caused by blocked drains due to sediments, garbage and vegetation in it. In addition dimensions (width and / or depth) of the main drains are too small to handle the excess water.

Man drain covered by vegetation

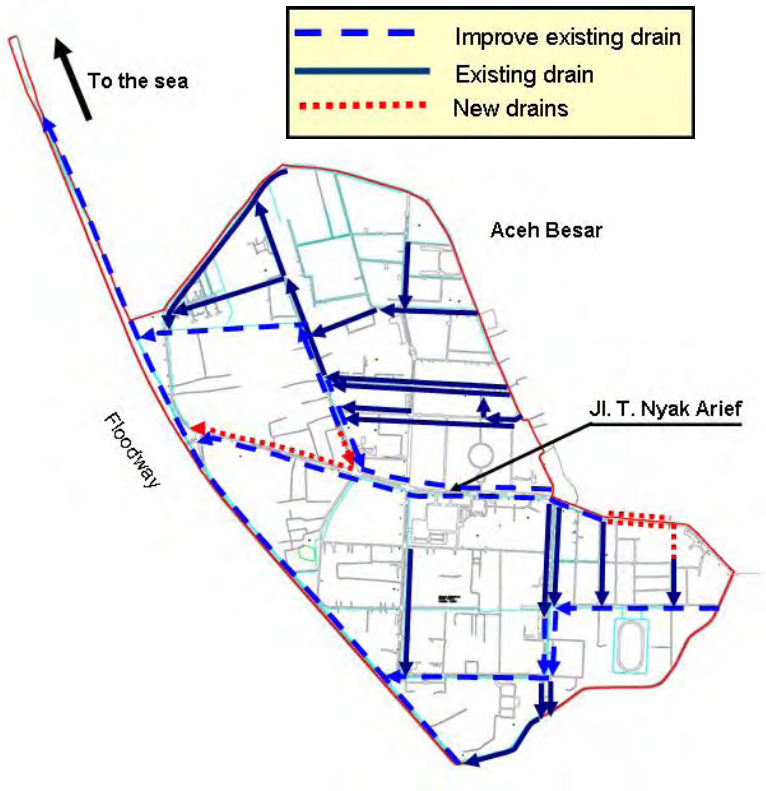
"Main drain" along the main road

Culvert in the drain parallel to the Floodway

O&M has to be implemented

Improvement works

The project concentrates on the primary and secondary drainage system in the urban area of Darussalam



1. Cleaning and rehabilitation of existing system and implementation of an Operation and Maintenance system.

2. Enlargement of the main drains and required structures taking into account the future impact of urbanization (spatial plan for 2016, source RTRW Banda Aceh).

3. Rehabilitation and enlarging of the existing main drain parallel to the Floodway taking into account the future impact of the urbanization as in the spatial plan 2016.

4. Extent / Construct new drains along the main road to allow re-direction of the existing drainage system based on the development until 2016.

Klien:
Badan Rehabilitasi & Rekonstruksi
BRR NAD-NIAS

Pemanku kepentingan (Stakeholders):
DINAS SDA-Prop / BRR Regional, DPJSDA, Kota Banda Aceh. Dinas Kebersihan& Pertamanan Kota, masya rakat lokal.

Lokasi:
Banda Aceh Darussalam

Tindakan Mitigasi:
Peningkatan saluran drainase yang ada, pembersihan sistem drainase, pembangunan saluran drainase baru

Estimasi biaya:
Rp. 51.2 milyar
US$: 5.1 juta
(Tidak termasuk pembebasan lahan)

Perencanaan:
Penyelesaian desain: November 2007
Penyelesaian dokumen tender: Desember 2007
Mulai konstruksi: 2008

Satu dari sedikit saluran drainase utama

Untuk informasi lebih lanjut:
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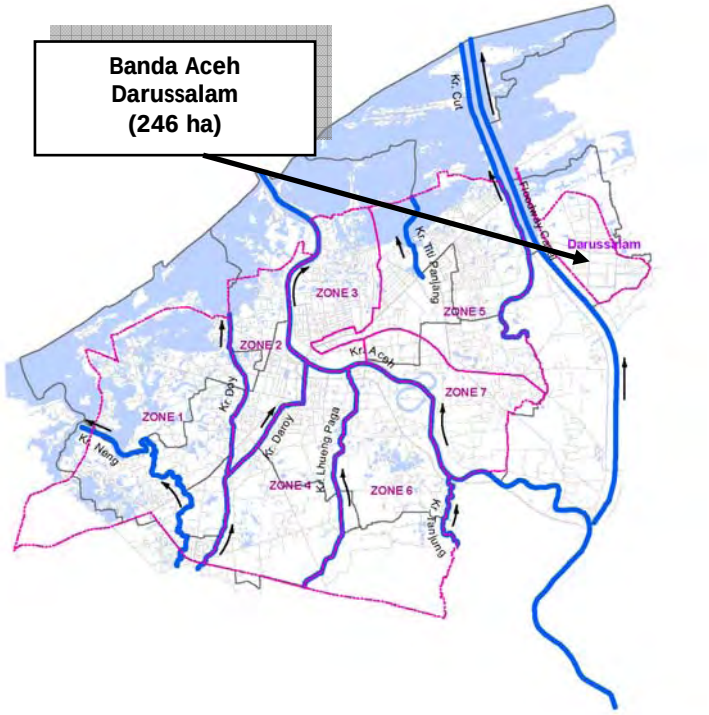
Banda Aceh Darussalam



Kondisi yang ada

Banda Aceh Darussalam terletak disebelah Timur banjir kanal dan meliputi luasan sekitar 246 ha. Zone Darussalam sangat penting untuk fasilitas-fasilitas pendidikan. Di daerah ini Universitas Syah Kuala dan juga banyak sekolah sekolah lain berada.
Permukaan tanah daerah ini cukup tinggi untuk mengalirkan air secara gravitasi menuju saluran drainase utama yang sejajar dengan banjir kanal dan langsung mengalir ke laut.

Jalan sekitar Darussalam terletak lebih tinggi dibanding jalan di luar Darussalam. Fungsi jalan sebagai batas hidrologi menahan air dari luar Darussalam untuk masuk dan sebagai jalan lain ke sekitarnya. Dari luar tidak ada limpasan yang berlebihan untuk diperhatikan.

Kinerja sistem yang ada

Di beberapa daerah di Darussalam secara regular tergenang. Sistem aliran secara gravitasi menuju saluran drainase utama sejajar dengan banjir kanal dan langsung mengalir ke laut. Sistem yang ada tidak mempunyai kapasitas yang cukup untuk mengalirkan air berlebih. Ketidak cukupan kapasitas disebabkan oleh tertutupnya saluran drainase oleh sedimen, sampah dan tumbuhan didalamnya. Juga dimensinya (lebar dan/atau kedalaman) saluran drainase utama terlalu kecil untuk mengalirkan air berlebih.

Saluran utama tertutup tumbuhan

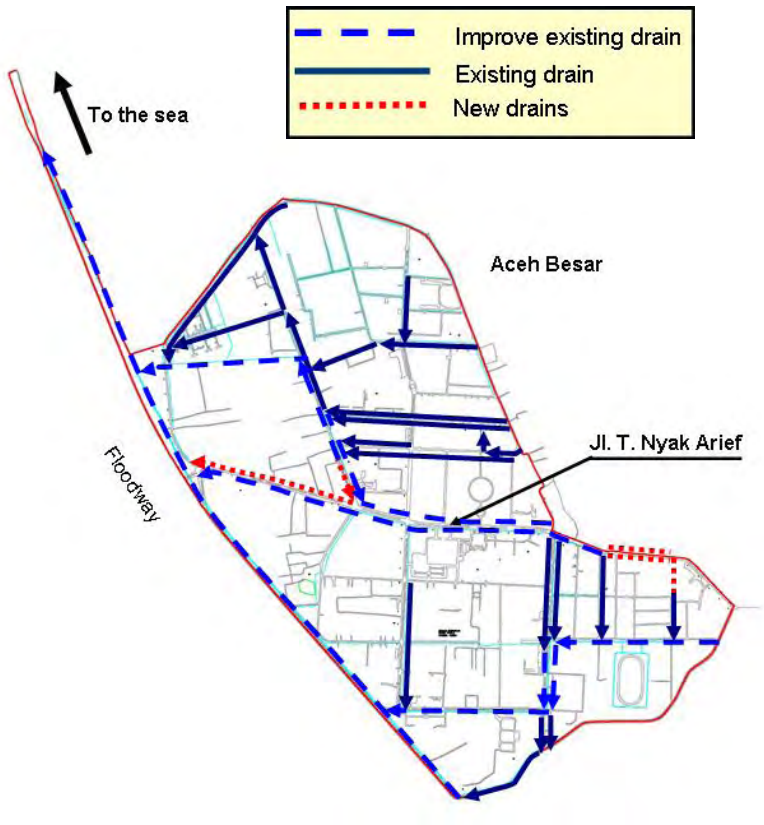
Saluran utama sepanjang jalan utama

Gorong-gorong di saluran drainase sejajar floodway

O&P harus dilaksanakan

Pekerjaan peningkatan

Proyek ini berkonsentrasi pada sistem drainase primer dan sekunder Darussalam



1. Pembersihan dan rehabilitasi sistem yang ada dan pelaksanaan Operasi & Pemeliharaan.

2. Penambahan dimensi saluran utama dan bangunan yang di perlukan dengan memperhatikan dampak urbanisasi (rencana tata ruang tahun 2016 sumber RTRW Banda Aceh).

3. Rehabilitasi dan penambahan dimensi saluran utama yang ada sejajar dengan banjir kanal dengan memperhatikan dampak urbanisasi sesuai rencana tata ruang 2016.

4. Membangun saluran drainase baru sepanjang jalan utama untuk perubahan arah sistem drainase yang ada berdasar pada pengembangan sampai 2016.

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GLOSSARY

BM	:	Benchmark [m]
BPS	:	Badan Pusat Statistik
BRR	:	Badan Rehabilitasi dan Rekonstruksi NAD - Nias
C	:	Runoff coefficient [-]
C_{10}	:	10 year storm runoff coefficient [-]
C_5	:	5 year storm runoff coefficient [-]
DED	:	Detailed Engineering Design
DPJSDA	:	Dinas Prasarana Jalan dan Sumber Daya Air
EIA	:	Environmental Impact Assessement
FPUD	:	Flood Protection & Urban Drainage
GRDP	:	Gross Regional Domestic Production
I_{60}	:	Rainfall Intensity for the duration of 1 hour [mm/hr]
IDF	:	Intensity Duration Frequency
IDP	:	Internal Displaced Person
IEE	:	Initial Environmental Examination
JICA	:	Japan International Cooperation System
Jl.	:	Jalan / street
Kr.	:	Krueng / River
LAT	:	Lowest Astronomical Tide [m to reference level]
LLWS	:	Lowest Low Water Spring [m to reference level]
MCA	:	Multi-criteria analysis
MDF	:	Multi Donor Fund
MHWN	:	Mean High Water Neap [m to reference level]
MHWS	:	Mean High Water Spring [m to reference level]
MLWN	:	Mean Low Water Neap [m to reference level]
MLWS	:	Mean Low Water Spring [m to reference level]
MoU	:	Memorandum of Understanding
MSL	:	Mean Sea Level [m to reference level]
NAD	:	Nangroe Aceh Darussalam
O & M	:	Operation & Maintenance
P	:	Return period [years]
SDA	:	Sumber Daya Air
SDA-Prop	:	Provincial water resources agency
SDC	:	Sea Defence Consultants
SID	:	Survey, Inventigasi dan Desain
SLR	:	Sea Level Rise [m]
SOP	:	Standard Operation Procedures
stn	:	Station
t	:	time [minutes]

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LOCATION REFERENCE ACEH AND NIAS

1 GENERAL INTRODUCTION

1.1 BACKGROUND

The consortium Sea Defence Consultants (SDC) was initiated to support the Rehabilitation and Reconstruction efforts of the Indonesian Government.

Works now are focused on repairing, reconstructing or replacing the sea defence and river flood protection works necessary for the economic recovery of the affected areas.
In addition, much of the destroyed housing is being replaced in 'at risk' areas which could be affected by future tsunamis. Rather than exclude the returning population, it is more practical to provide comprehensive and effective early warning systems, which together with a system of refuges, will provide the future population with security in the event of another disaster.

1.2 SCOPE OF THE DETAILED ENGINEERING DESIGN (DED)

Sea Defence Project will at the same time look ahead strategically in positioning a post-conflict Aceh to support economic growth; this latter will require an investment and development climate in which the risk of future disasters and flooding is considered manageable.

In general, the objectives of the DED are the preparation of detailed designs of proposed flood protection and drainage improvement, related works and tender documents for construction.

The scope of the detailed design included the following activities:

1. Field investigations to identify existing drainage system, conditions, bottlenecks, causes of flooding/poor drainage and possible improvement measures;
2. Assistance in topographic surveys including cross-sections, situation and longitudinal profiles of the primary and secondary drainage systems;
3. Design review of existing design;
4. Preparation of final designs, drawings, specifications and tender documents for the improvement works;
5. Preparation of bill of quantities, cost estimates and implementation plans;
6. Preliminary assessment of environmental, social and institutional impacts of proposed works.

The tender documents and drawings are presented as separate documents.

1.3 STRATEGY

The primary development objective of the Sea Defence Project is to put in place for the entire province of Aceh and Nias an appropriate strategy for sea defence, flood protection, multifunction escape construction, and early warning systems. Most important also will be the implementation of the capacity building program to support the management of the protection systems, which need to be put in place.

2 PROJECT SETTING

2.1 PROJECT DESCRIPTION

Banda Aceh is the capital of NAD and is also the centre of commerce, education and culture of the province. The city comprises 9 kecamatan (districts): Meuraxa, Baiturrahman, Kuta Alam, Ulee Kareng, Jaya Baru, Banda Raya, Leung Bata, Syiah Kuala, and Kuta Raja. The municipality consists of about 69 desa (or villages).

Banda Aceh with an area of 61 km^2 is located at the coast line of northern end of the Sumatra. The city had a population of 263,668 (54,751 households) in December 2004. The tsunami with a height of over 10 m destroyed large parts of the city entirely. Almost all buildings within a 2 km radius from the coastline were swept away.

The drainage system of Banda Aceh is divided into 7 zones and Darussalam. Darussalam is located in the east of Banda Aceh (see Figure 2-1). Darussalam covers an area of approximately 246 ha. Darussalam is important for its educational facilities. In this area the Syah Kuala University, as well as many other schools are located. In the west, Darussalam borders to the Floodway while at all other sides Aceh Besar forms the border.

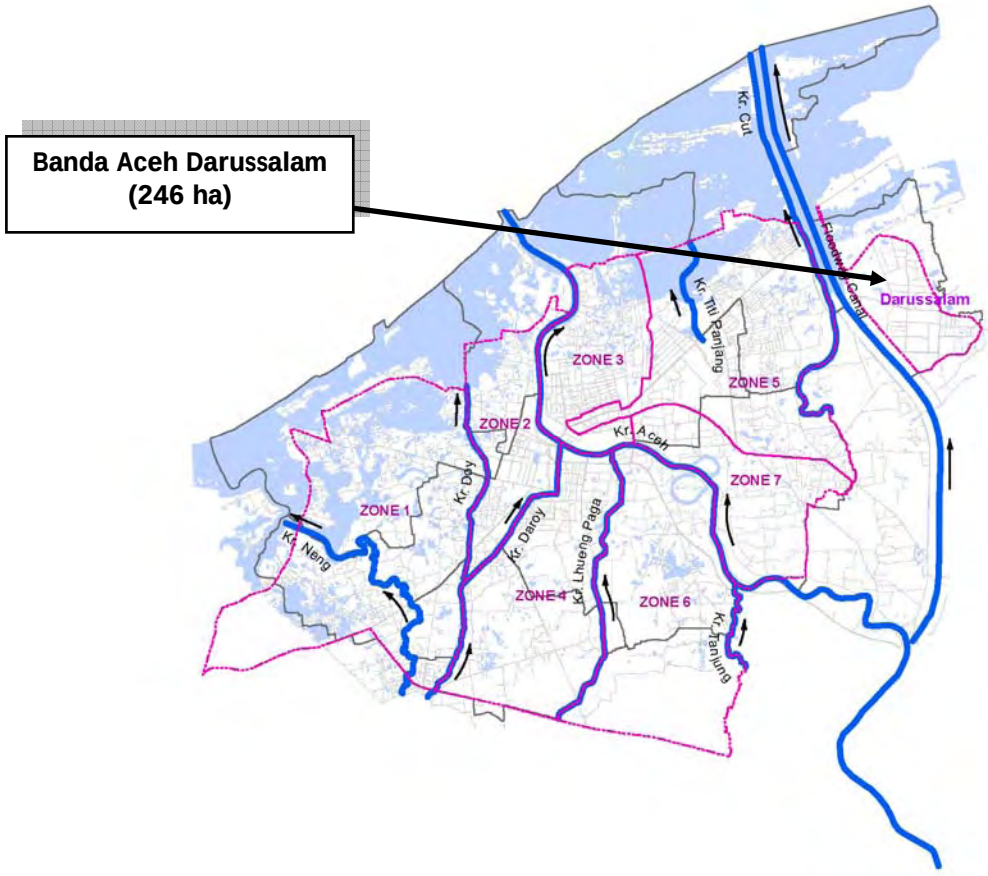


Figure 2-1: Location of Banda Aceh Darussalam

The road around Darussalam is located high compared to the area outside Darussalam. The road functions as a hydrological boundary preventing water from outside Darussalam to enter and the other way around. From outside no input of excess water needs to be taken into account.

The ground level of the area is high enough to allow drainage by gravity into the main drain, located parallel to the Floodway, and onward directly to the sea.

This project concentrates on the design of the primary and secondary drainage system in Darussalam. Solutions are defined to mitigate the flooding problems. Existing designs are reviewed and implemented when possible.

2.2 BEFORE AND AFTER THE TSUNAMI

This chapter provides general information concerning the tsunami impact in Banda Aceh. The impact differs per zone with most impact in the coastal zones. The tsunami impact in Darussalam is limited.

Most socio-economic data presented in this section is derived from the Statistics Agency (BPS) from Banda Aceh and a comprehensive report and database prepared by a JICA study team in 2005: "Study on the Urgent Rehabilitation and Reconstruction Plan for Banda Aceh in the Republic of Indonesia".

2.2.1 Human Impact

As per April 2005 the total number of human casualties in Banda Aceh City reached 71,474. This corresponds to about 27 % of the whole population before the disaster. The most affected areas are Meuraxa, Kuta Raja and Jaya Baru (see Table 2-1). The number of casualties in these Kecamatan accounted for 72 % of the total number of casualties city-wide. The casualty rates in Meuraxa and Kuta Raja Kecamatan were extremely high, respectively 80 and 75 % (JICA, 2005).

Table 2-1: Relevant population figures from 2001 - 2005

No	Kecamatan	POPULATION				
		2001	2002	2003	2004	2005
1	Meuraxa	27.468	28.158	28.294	34.592	2.221
2	Jaya Baru	20.902	21.137	21.271	21.305	12.340
3	Banda Raya	17.563	17.802	17.873	23.995	24.257
4	Baiturrahman	33.399	33.331	33.960	37.715	33.582
5	Lueng Bata	13.477	15.064	16.901	19.232	19.284
6	Kuta Alam	52.824	50.338	53.840	54.718	35.033
7	Kuta Raja	17.467	18.420	18.877	21.632	2.978
8	Syiah Kuala	26.401	26.577	28.216	32.590	25.418
9	Ulee Kareng	13.722	15.169	16.291	19.319	22.768
	Total	223.223	225.996	235.523	265.098	177.881

Source: BPS Banda Aceh 2005

Casualties, missing persons and survivors have been assessed by JICA (2005) and are represented in the following map.

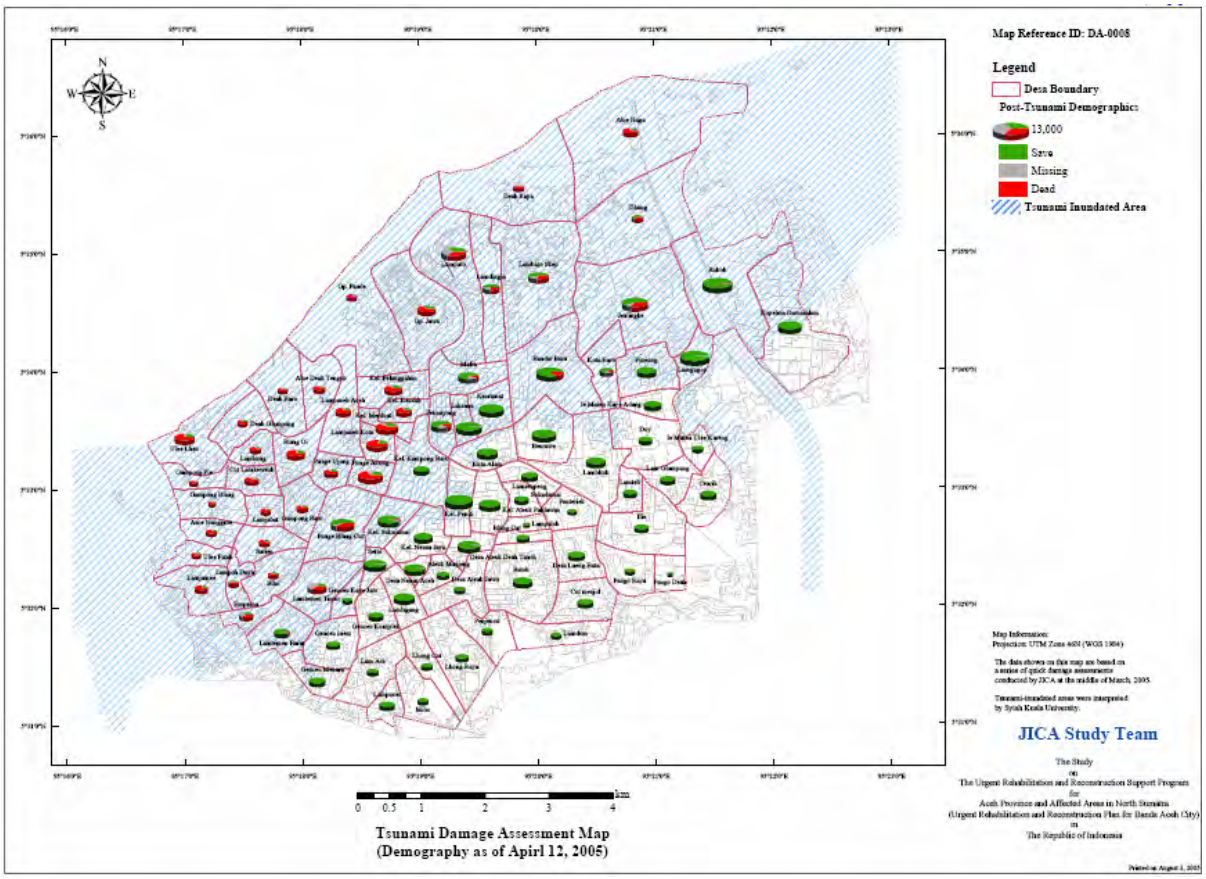


Figure 2-2: Post-tsunami demography by JICA (2005)

2.2.2 Refugees / Internal Displaced Persons (IDPs)

By April 2005 some 65,500 dislocated people were living in shelter and/or temporary accommodation. JICA (2005) distinguishes two categorized them into two; one is to return to their original place of residence and the other resettles in the new residential areas. The required number of houses is estimated at 23,900 in 2009, consisting of 13,100 for the dislocated people and 10,800 houses for influx of population.

The number of IDPs drastically decreased in 2005. A later survey conducted by BPS shows that about 75 % of the IDPs returned to their original residence. However a large group of about 23.670 people stayed in barracks and other temporary shelter.

Table 2-2: IDPs in Banda Aceh

No	Kecamatan	IDPs	Ex-IDPs	non-IDPs	Total
1	Meuraxa	731	1.459	7	2.197
2	Jaya Baru	2.050	9.014	1.267	12.331
3	Banda Raya	4.849	1.053	18.183	24.085
4	Baiturrahman	3.108	11.439	17.714	32.261
5	Lueng Bata	1.588	4.171	13.352	19.111
6	Kuta Alam	3.742	21.812	8.561	34.115
7	Kuta Raja	2.728	200	45	2.973
8	Syiah Kuala	2.129	14.838	8.250	25.217
9	Ulee Kareng	2.745	4.393	15.005	22.143
	Total	23.670	68.379	82.384	174.433

Source: Census 2005

2.2.3 Infrastructure

The tsunami hit the northern shoreline of Banda Aceh and completely destroyed whole wooden houses and reinforced-concreted buildings within a radius of 2 km (see Figure 2-3:). The number of totally and partially collapsed houses and buildings located in the tsunami inundation Zone (up to 4 km in land) reached 12,972, which is about 50.4 % of the total number of houses and buildings (JICA, 2005).

Damage to infrastructure is summarized in the following table.

Table 2-3: Damage to the infrastructure

Roads	Out of 457 km in total length, about 70 % was damaged.
Bridges	There were 54 bridges: 4 bridges were totally collapsed, 3 bridges were heavily damaged and 3 were lightly damaged.
Ferry Terminal	The terminal was destroyed completely by the tsunami.
Water Supply	About 75 % of water supply pipes (385 km long in total) were not in operation. The volume of water supply reduced from 37,600 m^3/day (pre-disaster) to 28,400 m^3/day (post-disaster).
Drainage	Drainage infrastructure was heavily damaged in the inundation zone.
Electricity	Electricity supply was cut to most of the inundation zone.
Sanitation	Sewerage treatment plant with a capacity of about 50 m^3/day located in the coastal area at the left bank of the Kr. Aceh was totally destroyed.
Seawall	Seawall of 1,340 m long at Ulee Lheu and 750 m long at Syiah Kuala collapsed.
Floodway	Dikes of 400 m long at both side of floodway collapsed.

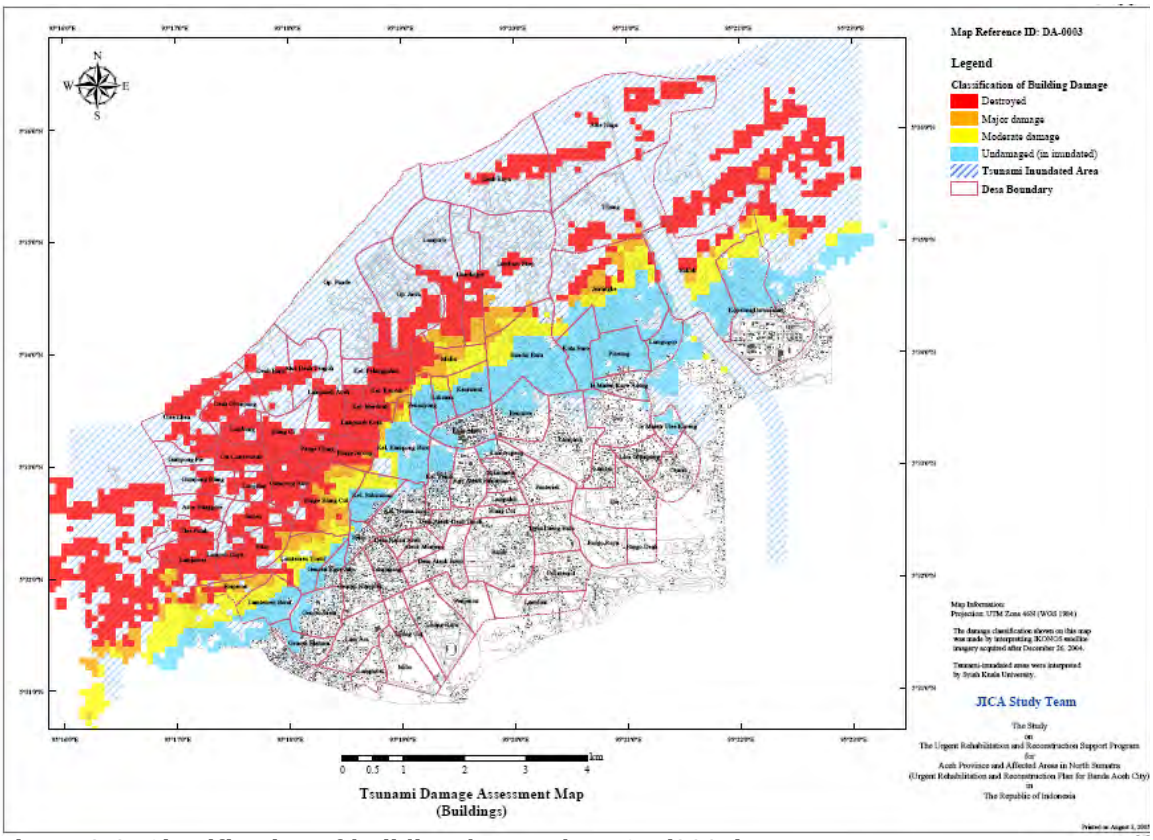


Figure 2-3: Classification of building damage by JICA (2005)

2.2.4 Flooding in Banda Aceh Darussalam

The flooding problem in Banda Aceh Darussalam already existed before the 2004 tsunami. Areas in Darussalam are flooded after heavy rainfall due to the absence of drains as well as insufficient capacity of the existing system. The insufficient capacity is caused by too small dimensions but also due to blocking by garbage, vegetation and sediments. Some drains were damaged due to the heavy earthquake.

Concerning the available drainage system, lack of Operation and Maintenance (O & M) resulted in blocked drains by garbage and sediments.

2.3 NON-TECHNICAL

This chapter provides general information concerning Banda Aceh. Population data are already presented in Chapter 2.2. Available, reliable statistical data after the tsunami is still limited. Though BPS published an overview in 2005, still many post-tsunami data is missing.

2.3.1 Social

According to BPS 2005, the number of registered unemployed people increased by about 20% in Banda Aceh after the tsunami, from 20,378 persons to 25,840 persons. Many fishermen lost their job and main source of income.

Education facilities in Banda Aceh were according to appropriate standards. Each district had education facilities from pre-school facilities to senior high school facilities. Each district had at least a minimum of one senior high school. Several universities are located in Banda Aceh, with Syiah Kuala University as the most prominent.

Health facilities in Banda Aceh are in according with appropriate standards. However compared to North Sumatra Banda Aceh still lacks technology and specialism.

2.3.2 Environment

Most predominant land use before disaster was presumed to be residential/commercial area, more than 30 % of the entire city area, followed by swamp/open water, most of which was used as fish ponds, one of main economic activities.

There was no existing land use map before the disaster struck Banda Aceh. The land use map after the disaster was developed by ARRIS (JICA) and is presented in Figure 2-4.

The mangrove areas in and around Banda Aceh have been cleared and converted into fish / shrimp ponds, leaving mangrove areas in shallow lagoons or near river mouths. Based on satellite images pre-tsunami two important areas can be identified: a) shallow lagoon near Ulee Lhee (Meuraxa), and b) shallow water near Alue Nhaga (Syiah Kuala). The mangrove forest of Banda Aceh was almost completely destructed by the tsunami.

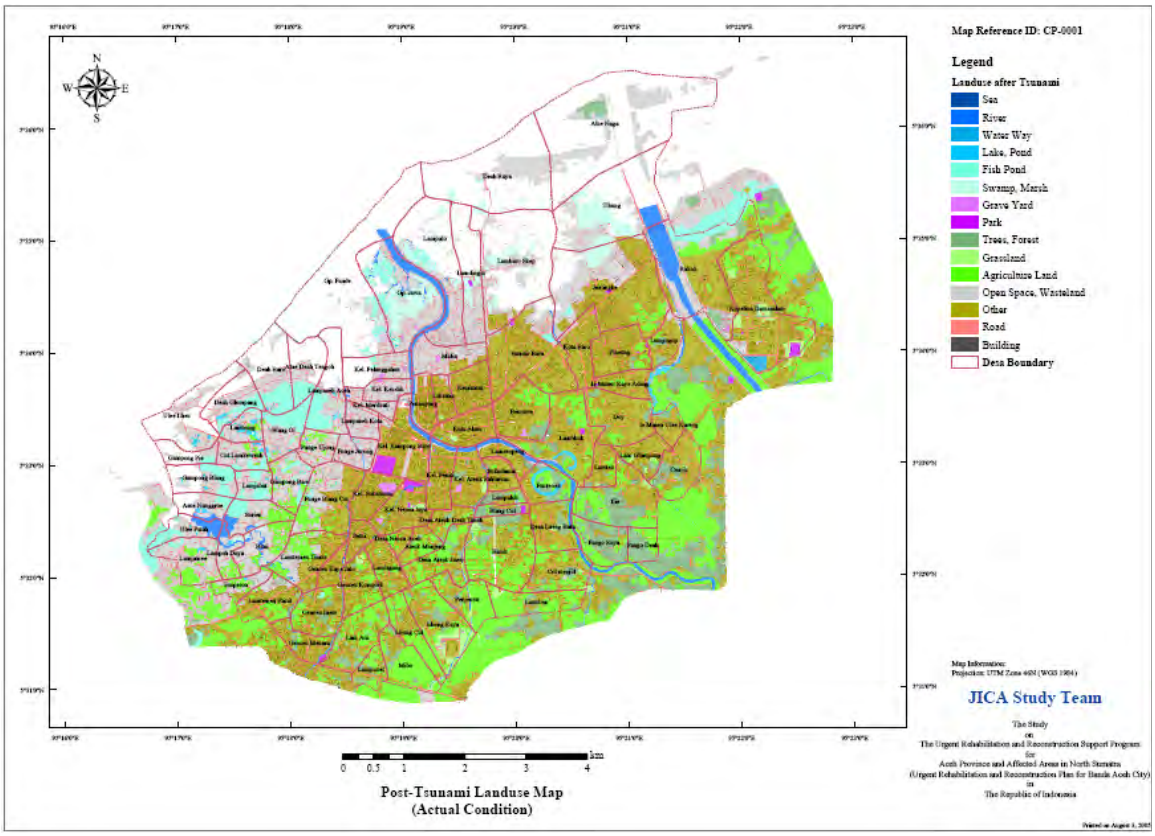


Figure 2-4: Post-tsunami land use map by JICA 2005

2.3.3 Institutional

The organizational structure of the Municipality is presented in the following figure.

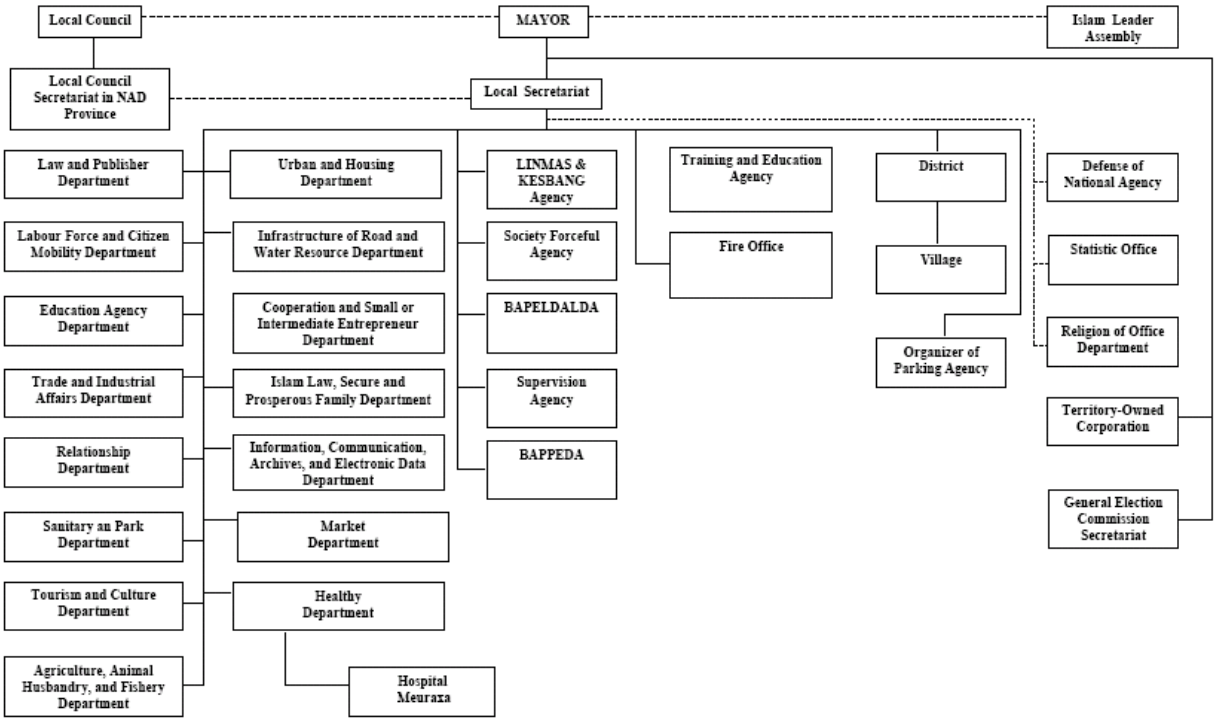


Figure 2-5: Organizational structure of Banda Aceh Municipality

Sea Defence Project will focus on rehabilitation and improvement of drainage infrastructure at macro / sub-macro level and at zone level (primary and secondary drains). The most important government institutions related to flood control and urban drainage for Banda Aceh are presented in the next table. These include Bappeda for spatial planning and coordination, Dinas Sumberdaya Air Provinsi for the macro and sub-macro system, Dinas Prasarana Jalan dan Sumberdaya Air for development/planning of micro-system, and Dinas Kebersihan & Pertamanan responsible for operation & maintenance of the micro drainage system.

Table 2-4: Government institutions and responsibilities

Urban drainage activity	Responsible
Planning & development of macro / sub macro	Dinas SDA-Prop/BRR Regional
O&M of macro & sub macro drains	Dinas SDA-Prop/BRR Regional
Planning & development of micro drains	DPJSDA-Kota Banda Aceh
O&M of micro drains	DPJSDA-Kota Banda Aceh
O&M Pump station and zone outlet gate	DPJSDA-Kota Banda Aceh
O&M of micro drains (specifically for waste and garbage)	DKP Kota (Gardening & Hygiene)

Above definitions come from the local government in Banda Aceh. Here the explanations are given:
Definitions: Macro: Kr. Neng, Kr. Doy, Kr. Aceh, Kr. Titpanjang, Kr. Cut
Sub-macro: Kr. Tanjung, Kr. Lueng Paga, Kr. Daroy
Micro: drainage system in the zones

Bappeda (District Planning & Development Agency)
Bappeda has the responsibility for coordination of programming, planning, and budgeting of each sectoral agency in accordance with the multi year development work program. In addition, Bappeda is needed for monitoring & evaluation of program implementation performance as achieved by each sectoral agency. Bappeda is also responsible for special studies and programs of macro and multi-sector problems, like spatial planning.

Dinas Prasarana Jalan dan Sumber Daya Air (Roads & Water Resources Infrastructure Agency) - DPJSDA
DPJSDA is an implementing agency of the Municipal Government of Banda Aceh which is in charge of roads and water resources infrastructures. The Sub-Dinas Sumberdaya Air (Division of water resources) will be in charge of urban drainage, especially after the decentralization of BRR. Dinas Prasarana Jalan dan Sumber Daya Air is also responsible for the O & M of pump house and installation.

Dinas Tata Kota (Urban Management Agency)
Dinas Tata Kota (Perkotaan & Permukiman) of Banda Aceh is responsible for the spatial planning of Banda Aceh City. It is also responsible for the enforcement of city regulations regarding land use and urban development.

Dinas Kebersihan & Pertamanan (Gardening & Hygiene)
Dinas Kebersihan is responsible for the O & M of urban drainage system in Banda Aceh, especially regarding the management of effluents, mud and garbage. The Dinas is responsible for cleaning mud and garbage of the micro drainage system.

2.3.4 Economy

Gross Regional Domestic Production (GRDP) per capita of Banda Aceh City was US$ 350 approximately in 2002, being about a half of the national average (US$ 710). Main economic activities are commerce and fish cultivation, but the latter was almost completely destroyed by the tsunami. GRDP per sector in Banda Aceh is presented in Table 2-5.

As is presented in Table 2-5, the dominant productive sector in Banda Aceh is trade and small-scale industry. According to BPS, some 422 small-scale industry enterprises were registered and some 405 informal units. The agricultural sector is small and is dominated by fishery.

Table 2-5: GRDP per sector in Banda Aceh (2000 – 2005) in million Rp.

No	Sector	2000	2001	2002	2003	in %	2004	in %	2005	in %
1	Agriculture	129.014	138.785	152.540	163.836	10	160.495	9	123.671	6
2	Mining and Energy	0	0	0	0	0	0	0	0	0
3	Industry	42.465	46.682	54.430	60.212	4	77.926	4	83.087	4
4	Electricity and Water Supply	6.182	7.615	11.122	14.220	1	15.940	1	11.119	1
5	Construction	112.335	121.446	129.971	137.817	8	140.423	8	157.976	8
6	Trade, hotels and restaurants	450.099	474.574	508.658	547.910	33	593.015	33	613.179	31
7	Transport and Communication	286.191	305.432	330.937	361.921	22	402.844	22	457.263	23
8	Banks and Financial Services	11.650	23.051	63.731	85.300	5	106.201	6	142.647	7
9	Services	178.675	200.426	241.669	273.074	17	314.710	17	373.185	19
	Total	1.216.610	1.318.011	1.493.058	1.644.289		1.811.554		1.962.128	

2.4 TECHNICAL

2.4.1 Geography

Darussalam has an area of almost 246 ha and is located in the south of Banda Aceh and bounded by:

North : Aceh Besar
South : Aceh Besar
West : Floodway
East : Aceh Besar

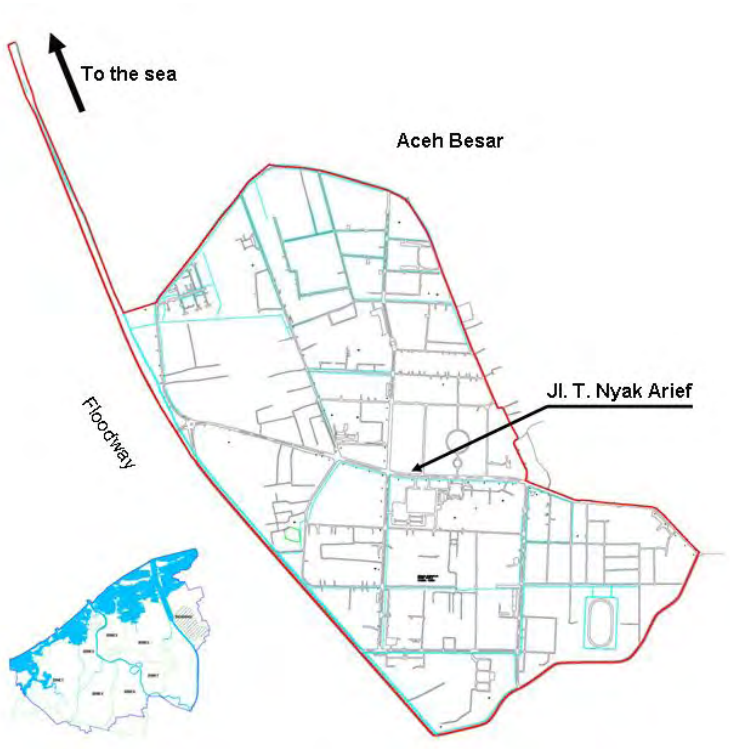


Figure 2-6: Banda Aceh - Darussalam

2.4.2 Existing condition

When available, water is discharged through a system of rectangular drains to the main drain located parallel to the Floodway and that is connected with sea. Water is not discharged into the Floodway. The flow directions of the main system are show in the Figure 2-7.

Figure 2-7: Flow direction main drainage system

Primary and secondary drainage system Darussalam

Drains

The drainage system in Darussalam is in poor condition or not even present. The existing drains are often full with rubble, garbage and sediments blocking the smooth flow of the water towards the main drain located parallel to the Floodway. In addition the dimensions of the drains, including the main drain parallel to the Floodway, are too small to handle the heavy rainfall with inundation as a result. Along Jl. T. Nyak Arief The available drain is in poor condition and has sufficient capacity. Along part of that road a drain is not available.

Some examples of the bottlenecks are show in the pictures below

Figure 2-8: Existing conditions in Darussalam

3 DESIGN PREPARATIONS AND PROCESS

3.1 RELATED DESIGNS AND IMPLEMENTED WORK BY OTHERS

In Banda Aceh Darussalam the following projects related to Flood Protection & Urban Drainage (FPUD) are ongoing and or implemented (see Table 3-1). Concerning the FPUD works carried out by SDC, existing designs, will be implemented when possible.

Table 3-1: Related projects in Banda Aceh Darussalam

Name / contact	Scope	Status	Deadline
SID Kanal Banjir Kota Banda Aceh (Lanjutan), KontrakNo. KU.08.08/PBPP/BRR/115, Tanggal 25 Nopember 2005, PT Global Parasindo Jaya	▪ SID zone 5, 7 and Darussalam ▪ Topographic survey; ▪ Geological and soil investigation; ▪ Inventory of the drainage system ▪ DED of drainage system and retarding basins; ▪ Bill of quantities and cost estimations;	Finished	2006

3.2 PROBLEMS PERCEIVED

The main areas subject to frequent inundation are shown in Figure 3-1. It should be noted that the areas show are indicative only.

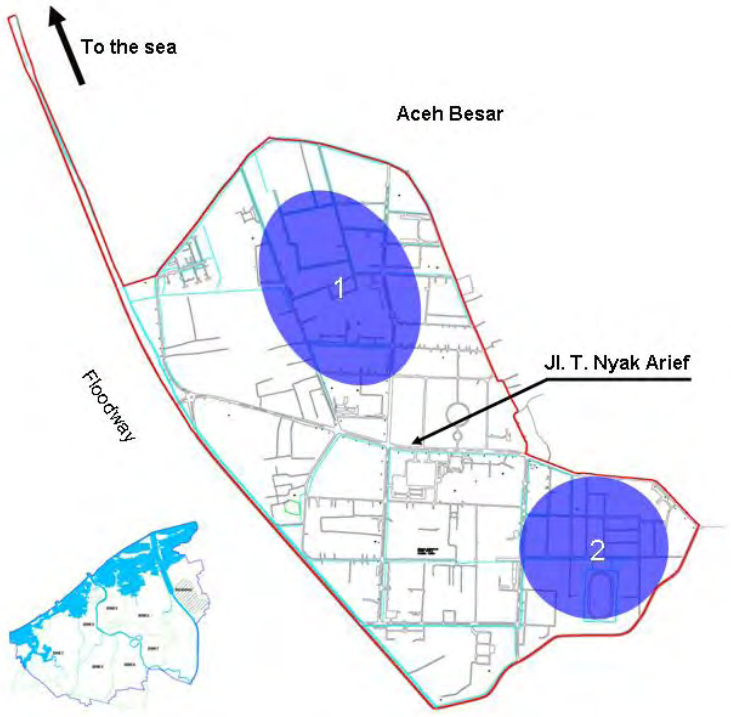


Figure 3-1: Inundation areas Banda Aceh Darussalam

The problem and causes are listed in Table 3-2.

Table 3-2: Problem and cause

Location	Problem	Cause
1. Unsyiah and IAIN Campus	Inundation in the campus area	▪ Channel are blocked by garbage and sediment ▪ Some area are lower than channel ▪ Slope channel not sufficient ▪ Some channel have insufficient capacity ▪ No tertiary drain in some location
2. Housing Campus	Inundation of the housing area	▪ Channels are blocked by garbage and sediment ▪ Same channel have insufficient capacity ▪ Some area are lower than channel ▪ No maintenance

3.3 PUBLIC CONSULTATION MEETINGS

3.3.1 PCM 1 – Request to include

Starting the Banda Aceh SDC Drainage Project, Darussalam was not included in one of the seven defined zones of Banda Aceh and thus not included in the scope of SDC. During the first Public Consultation Meeting of Banda Aceh Zone 5, 28 March 2007, representatives of the local community indicated that Darussalam is also a problem area. The area is regularly flooded. Representatives of the local community requested to include Darussalam in their scope. BRR / Kota Banda Aceh honoured this request. Since Darussalam is a small area it was decided to directly include it in PCM-2 of Banda Aceh Zone 5.

Reporting / design of Darussalam is done separately because the design of Banda Aceh Zone 5 is in a much advanced stage already.

3.3.2 PCM – 2 Memorandum of Understanding (MoU)

During the second consultation meeting of Banda Aceh Zone 5, Thursday 31 2007, the proposed design of Darussalam was explained to the stakeholders. The design of Darussalam was included in the MoU of Banda Aceh Zone 5.

Figure 3-2: PCM-2 meeting on 31-05-2007 – signing MoU

At the end of the meeting all stakeholders (6 from the local government and about 30 of the local community) present signed the MoU. A copy of the signed MoU is provided in Appendix B.

3.4 SURVEYS, INVESTIGATIONS AND MODELLING

3.4.1 Topographical survey

Reference point for the SDC survey on which all existing and new surveys will be linked to is: BTJ01 (official benchmark (BM) from Bakosurtanal). The coordinates used are:

X : 759,119.7937 m
Y : 615,943.1773 m
Z : +2.393 m

By SDC order, PT Tigenco Graha Persada executed topographical survey works in Banda Aceh Darussalam. The results are described in the report "Topographic Survey Phase 3 Packet 1-A – Banda Aceh Zone 5 and Darussalam", registration number SDC-RD-70262.

3.4.2 Geotechnical survey

Geotechnical survey was executed by Geoteknika Konsulindo in Banda Aceh, including Darussalam. The results of the survey are described in the report: Final report of geotechnical investigation for the proposed of Aceh and Nias Sea Defence, Flood Protection, Refuges, and Early Warning System in Banda Aceh – Nanggroe Aceh Darussalam Province, registration number: SDC-RD-70044/45/46/201/202.

3.4.3 Hydrological analysis

Introduction
The principal aim of the hydrology study is the derivation of flood hydrographs for various design return periods for the major river basins in Aceh province. These hydrographs will form the basis for the assessment of the inundation, either by modelling efforts or less sophisticated methods, depending on the local conditions (risk level, data availability, topography, etc.).

For the urban / rural areas storm water calculations are made defining the catchments areas and design discharges per drain.

For a more detailed description of the hydrology, reference is made to the document Hydrology prepared by the SDC [2].

Methodology
The derivation of the design flood hydrographs for various return periods is based on the application of a calibrated rainfall-runoff model to the various basins of study. For this purpose the HEC-HMS model is used. Calibration of the model is done for a number of river basins spread out over the coastal area of the province of Aceh such that the resulting model parameters can be applied to the other river basins for which design floods need to be calculated.
After the calibration of the model the rainfall-runoff simulations will be based on the design rainfall storms for the particular return periods that are published as part of the PMP study for the province of Aceh [3]. These are 24-hour total rainfall values, which need to be converted into rainfall storm graphs using typical hourly storm distributions for the region with durations from 3 – 12 hours. Although such distributions are available from the same report, they are considered to produce too low hourly intensities and new hourly distributions have been derived using the original data from the report. The combination of the 24-hour rainfall values for particular return periods in combination with the newly derived hourly distribution will form the input towards the HEC-HMS rainfall-runoff model.

For each of the river basins for which a design flood need to be calculated, one of the model calibration parameter sets is chosen and some adjustments are made depending on the size of the basin and the topographic characteristics (e.g. slope). The subsequent application of the model with the design rainfall results in the required design flood.

Analysis urban drainage
The peak discharges for the design of the drains were calculated using the rational method. This method can be applied since all catchments areas of the main drains are less then 300 ha. The key parameters to be selected are the sub-catchments, frequency of design storms, catchments run-off coefficients and time of concentration. Here the results of the hydrological analysis are shown. For a more detailed description references is made to Appendix C.

A. Sub-catchments and run-off coefficients
The sub-catchments of Banda Aceh Darussalam are shown in Figure 3-3. In the calculation of the storm water run-off, the catchments were assumed to be fully developed. Therefore the selection of run-off coefficients for the various land use categories and values applied there are reflected anticipated future catchments conditions, i.e. including future spatial planning.

According to the spatial plan of Banda Aceh Darussalam (see Figure 3-4), from Rencana RTRW Kota Banda Aceh, the area is dominated by residential (medium-high density) type of land use. The business district and shopping centre comprises only about 30 % of the area, except for the Darussalam area, at the North – East of Zone 5 where the area is dominated by Educational facility to about 70 %.

Considering these type of land use and the adopted design criteria, the frequency of design storm should be set at a minimum return period of 5 years

According to the design guidelines [1]:

- For the residential type of land use (30 houses/ha), the runoff coefficient C is taken as C_{10} = 0.55. (i.e the 10 year storm runoff coefficient). For the frequency of design storm of 5 years $C_5 = 0.95 \times C_{10} = 0.52$.

- For the business district type of land use, the runoff coefficient C is taken as C_{10} = 0.90. (i.e. the 10 year storm runoff coefficient). For the frequency of design storm of 5 years $C_5 = 0.95 \times C_{10} = 0.855$.

The runoff coefficient used are (weighted from the above coefficients): C = 0.72 (0.3* 0.52 + 0.7*0.855). The 0.72 run-off coefficient will be applied for all drains in Darussalam.

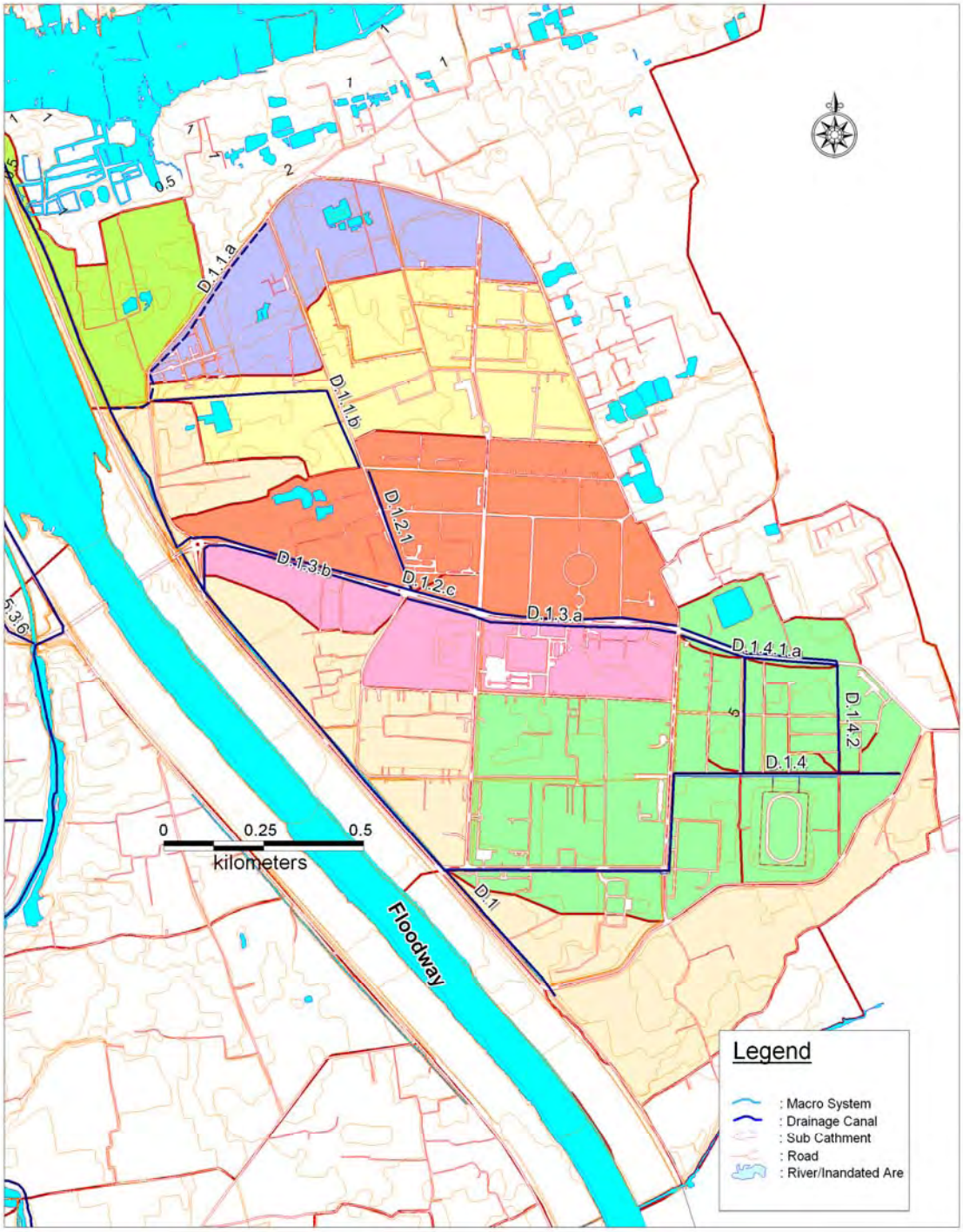


Figure 3-3: Sub-catchments in Banda Aceh Darussalam

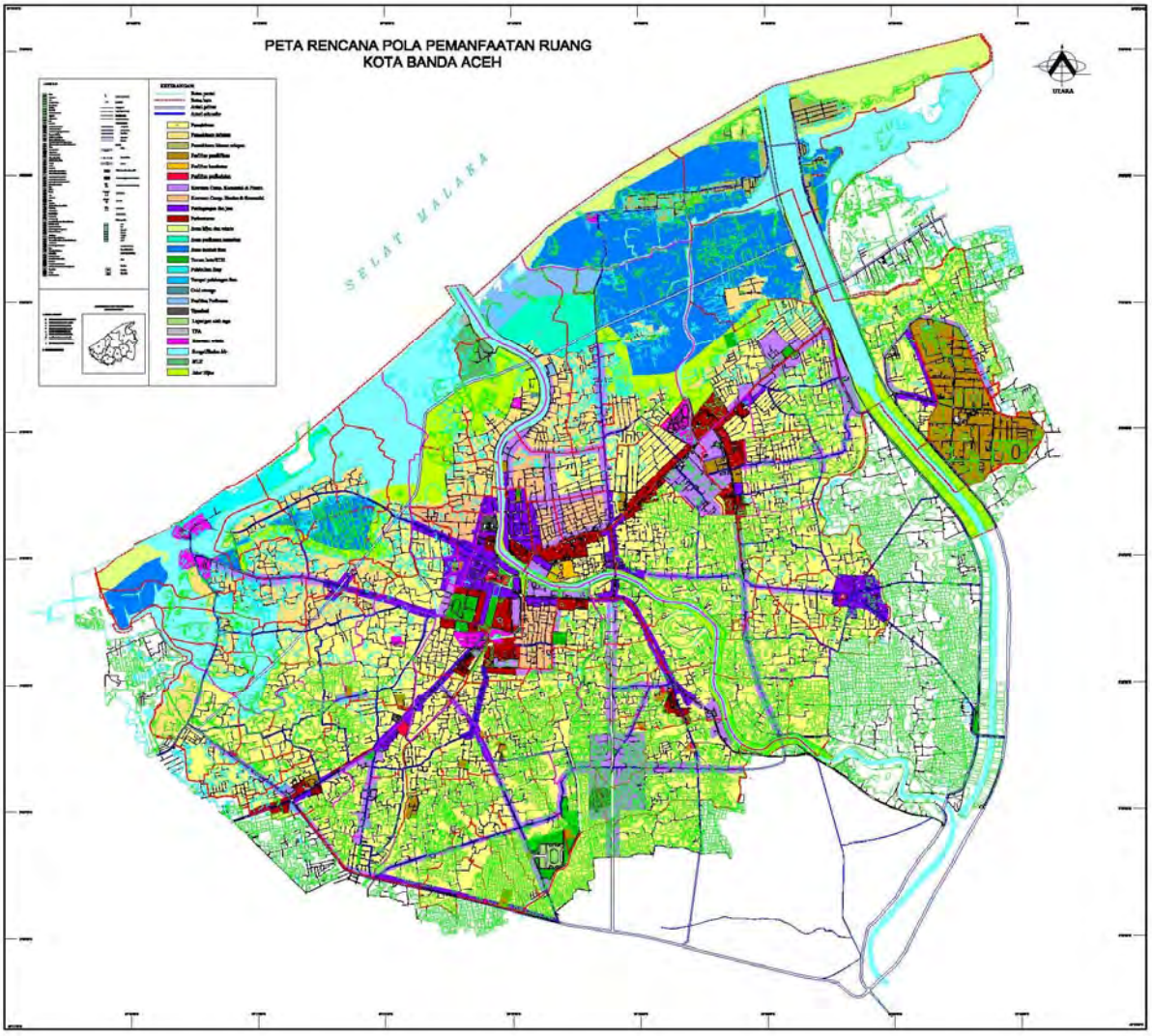


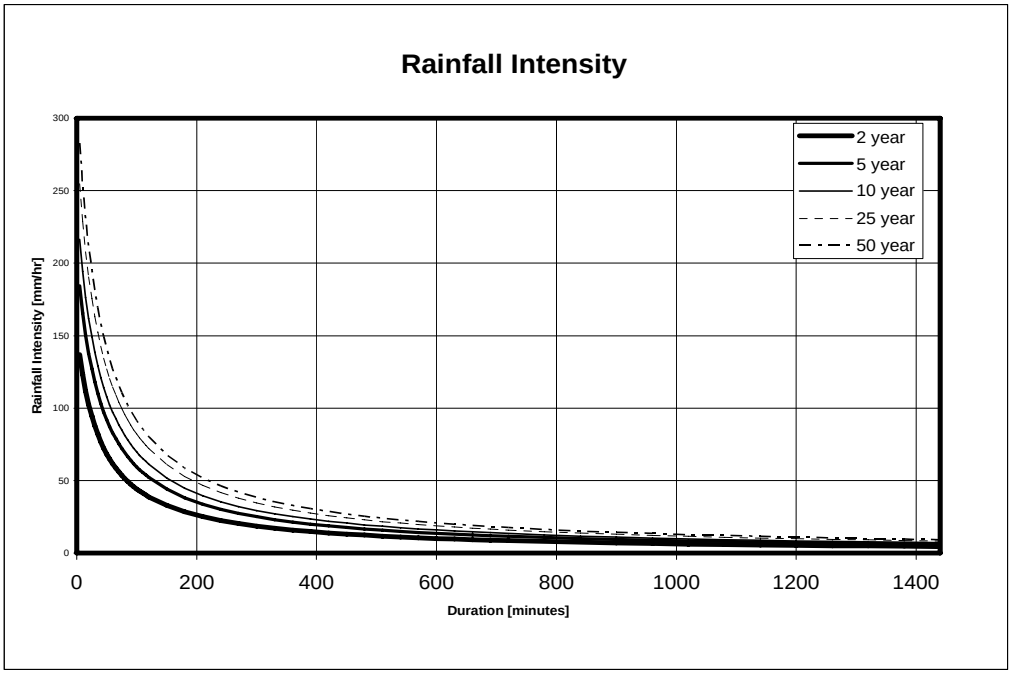
Figure 3-4: Spatial plan Banda Aceh (source: RTRW Kota Banda Aceh)

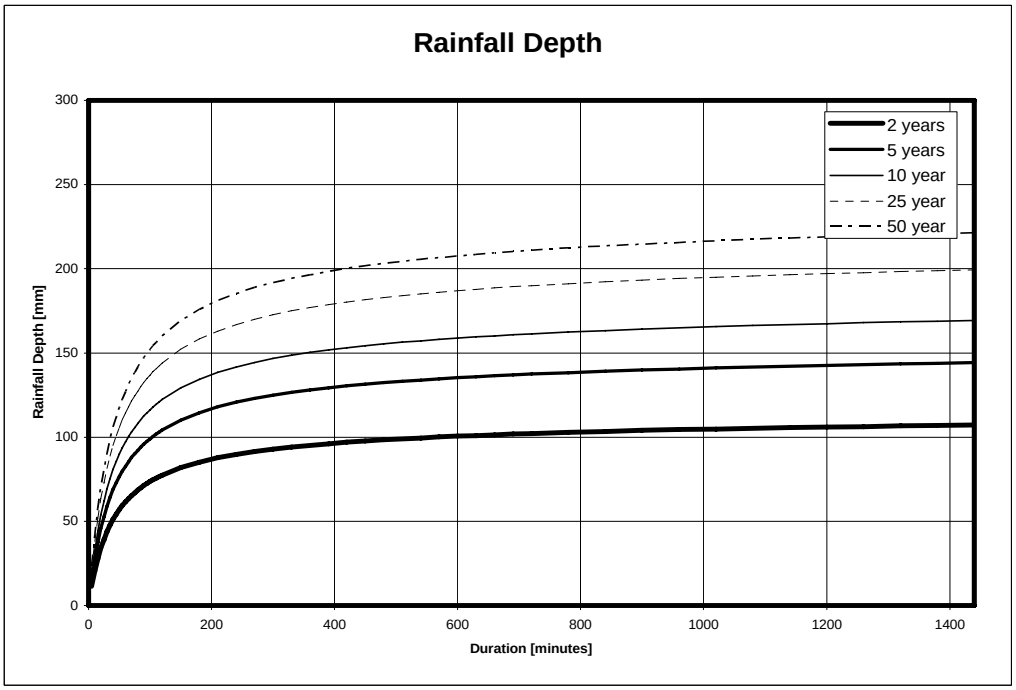
B. IDF and design storm

For the purpose of qualifying potential runoff from urban catchments areas in Banda Aceh Darussalam area, the following approach can be applied:

Intensity-Duration-Frequency (IDF) Curves

Using the data from the rainfall station: Ulee Kareng (stn 106b), the following IDF curves were prepared. The IDF relations for this study were derived by using the I_{60} of 3 hours duration pattern of Annual Maximum of Daily Rainfall for each corresponding study area and return period [2].





P [years]	Rainfall [mm]
2	107
5	144
10	169
25	199
50	221

Figure 3-5: IDF curves for Banda Aceh Zone Darussalam

Design storms

Design storms are rainfall events which are specified by total rainfall and their temporal distribution. A design storm can be derived from statistical analysis of historical storms whereby rainfall characteristics are evaluated including rainfall depth (interrelationship with IDF curve), time-to-peak, peak-intensity, amount of rainfall before time to peak etc. the design storm for Banda Aceh is provided below.

t [minutes]	Return Period [years]				
	2	5	10	25	50
15	1.7	2.3	2.8	3.2	3.6
30	2.4	3.2	3.7	4.4	4.9
45	3.4	4.6	5.4	6.4	7.1
60	5.5	7.4	8.6	10.2	11.3
75	10.4	13.9	16.4	19.3	21.4
90	27.9	37.6	44.1	51.9	57.7
105	15.9	21.4	25.1	29.6	32.9
120	7.3	9.8	11.6	13.6	15.1
135	4.3	5.7	6.7	7.9	8.8
150	2.8	3.8	4.4	5.2	5.8
165	2.0	2.7	3.2	3.7	4.2
180	1.5	2.1	2.4	2.8	3.1
	85.1	**114.6**	**134.5**	**158.3**	**175.8**

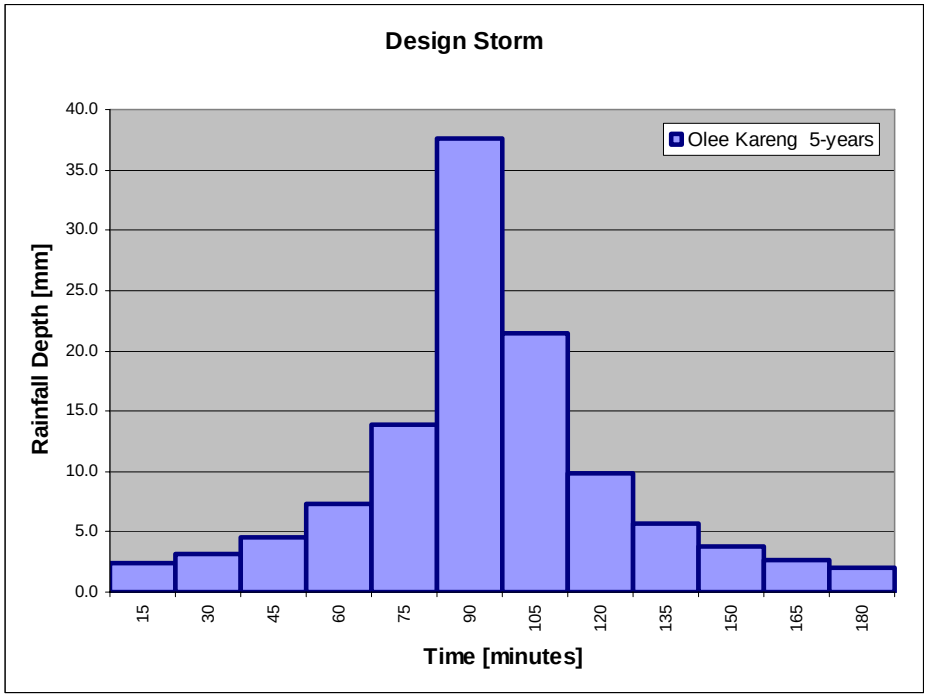


Figure 3-6: Design storm for Banda Aceh Darussalam

D. Design discharges

In the following table the design discharges per drain are provided. For location of the drains reference is made to Appendix A.

Table 3-3: Design discharges main drains Darussalam per return period

Main Canal	Catchment Area (ha)	Peak Discharge (m^3/sec)			Discharge in
		2 Years	5 Years	10 Years	
D.1	251,48	11,61	16,44	19,78	Sea
D.1.1	55,48	2,59	3,99	5,02	Main Canal D.1
D.1.2	44,15	2,07	3,06	3,77	Main Canal D.1
D.1.3	21,59	0,97	1,46	1,82	Main Canal D.1
D.1.4	56,32	2,61	3,87	4,77	Main Canal D.1

3.4.4 Modelling

In the analysis and design use are made of the following modelling software:

- HEC-HMS (Hydrology)
- SOBEK-Rural
- HEC-RAS

A brief introduction is given here.

HEC-HMS
HEC-HMS is designed to simulate the precipitation-runoff processes of dendritic watershed systems. It is designed to be applicable in a wide range of geographic areas for solving the widest possible range of problems. This includes large river basin water supply and flood hydrology, and small urban or natural watershed runoff. Hydrographs produced by the program are used directly or in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation.

SOBEK-Rural
SOBEK-Rural gives regional water managers a high-quality tool for modelling irrigation systems, drainage systems, natural streams in lowlands and hilly areas. Applications are typically related to optimizing agricultural production flood control, irrigation, canal automation, reservoir operation, and water quality control. SOBEK-Rural can also answer questions about increased pollution loads in response to growing urbanisation. SOBEK-Rural offers the support you need for effective planning, design and operation of new and existing water systems. In the project SOBEK-Rural will be applied to simulate flow in river drainage systems to check drainage capacity under extreme circumstances.

HEC-RAS
HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking, multi-user network environment. HEC-RAS is designed to perform one-dimensional hydraulic calculation for a full network of natural and constructed channels with steady and unsteady flow simulation.

The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction (Manning's equation) and contraction/expansion (coefficient multiplied by the change in velocity head). The momentum equation is utilised in situations where the water surface profile is rapidly varied. These situations include mixed flow regime calculations (i.e., hydraulic jumps), hydraulics of bridges, and evaluating profiles at river confluence (stream junctions). The effects of various obstructions such as bridges, culverts, weirs, spillways, pumps, reservoirs and other structures in the floodplain will be considered in the computations.

3.5 BOUNDARY CONDITIONS

The described tidal values are derived from the baseline studies executed by SDC and linked to the official BM on land. In the table below the following is shown:

- Results baseline study done by SDC, tidal range referring to MSL;
- Tidal levels referring to official BM BTJ01;
- Tidal levels including 10 cm sea level rise in 25 years (SLR) [1].

Table 3-4: Tidal levels Banda Aceh

Level	Referring MSL	Referring to BM	Incl. SLR
HAT	1.05	1.22	1.32
HHWS	0.85	1.02	1.12
MHWS	0.65	0.82	0.92
MHWN	0.20	0.37	0.47
MSL	0.00	0.17	0.27
MLWN	-0.20	-0.03	0.07
MLWS	-0.60	-0.43	-0.33
LLWS	-0.80	-0.63	-0.53
LAT	-0.90	-0.73	-0.63

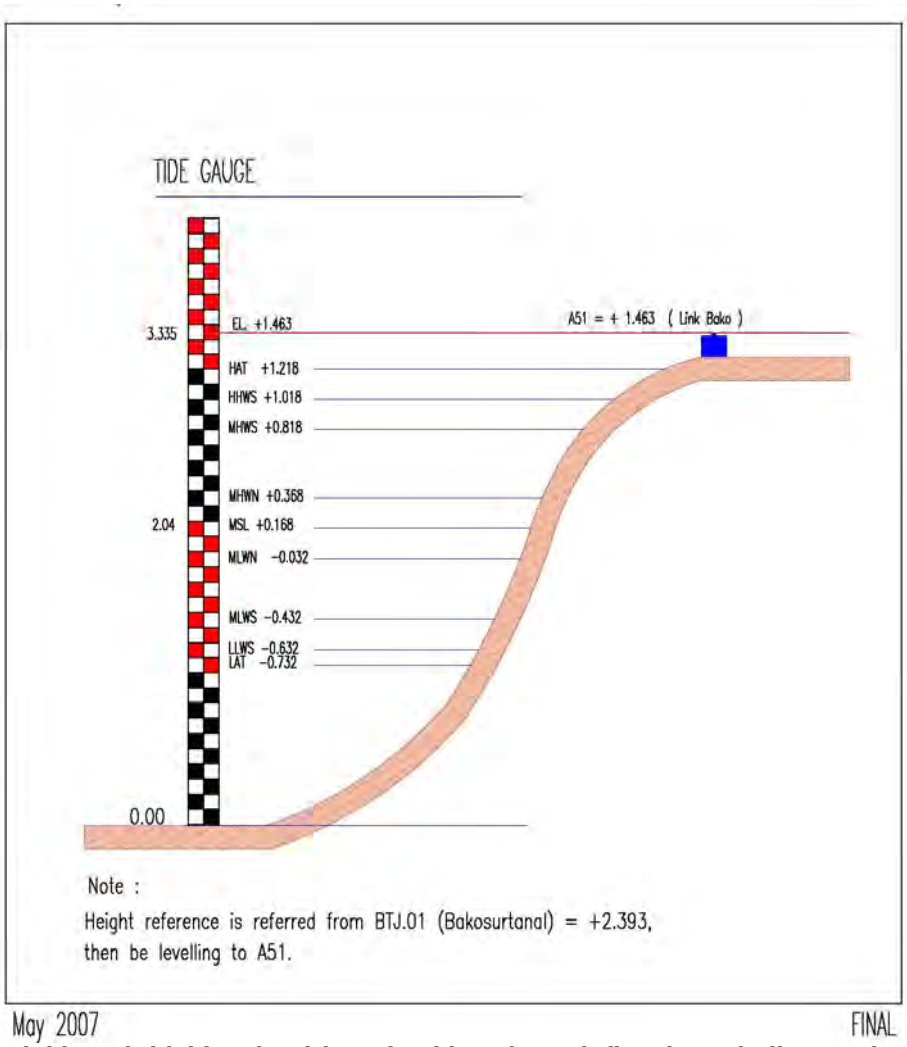


Figure 3-7: Linking of tidal levels with on-land bench mark (levels excluding sea level rise)

3.6 DESIGN GUIDELINES AND DESIGN CRITERIA

3.6.1 Design guidelines

For Aceh and Nias, SDC has set up design guidelines for FPUD works in Aceh and Nias [1]. Reference to the existing design guidelines used in Indonesia is made. In addition, attention is given to other aspects required for developing a sustainable solution, social aspects, communication with stakeholders and O & M.

3.6.2 Cycle and safety level

Life cycle design
The various structures will be designed based on an expected lifetime of 25 years, starting in 2007.

Safety level for Banda Aceh Darussalam
According to the Guidelines the design discharge for macro and urban drainages a 25 years return period and 5 years return period are used respectively. Design water level along the channel and at the outfall structure will be checked by using the flow modelling program, SOBEK-Rural. This modelling program will be applied to simulate flow in drainage systems to check drainage capacity under extreme circumstances, the backwater effect of tidal levels fluctuations to the flow of river or drainage systems. In Table 3-5 the proposed return periods for Banda Aceh Darussalam are given.

Table 3-5: Return periods (P)

Element	P [years]
River/major drain dike or boundary embankments	25
Culvert	5
Retarding basin	5
Channel /drains	5

3.6.3 Freeboard

According to the design guidelines applied by SDC (see Chapter 3.6.1) a freeboard has to be applied. Applying freeboard results in larger drains and thus more land acquisition. Land acquisition is a difficult and expensive issue. Therefore SDC has made the following choices related to freeboard:

- Due to the existing land acquisition / space problems the required additional space for the drains should be minimized. Therefore it is chosen that freeboard will not be applied in areas with existing drainage channels;
- Freeboard will only be applied in new development areas.

For Banda Aceh Darussalam this means that all drains will be calculated without freeboard.

3.7 REVIEW OF COMPLETED DESIGN WORK

A. Review design

Name Consultant	:	**PT Global Parasindo Jaya**
Name report(s)	:	Survey Investigasi dan Desain (SID) Kanal Banjir Kota Banda Aceh (Lanjutan). Reports: Hydrology analysis (Analisa hidrologi); Inventory report (Laporan inventarisasi saluran); Analisa Kesesuaian dan Tata guna Lahan; Design report (Nota penjelasan); Final report (Laporan Akhir); Executive summary (Laporan Ringkas); Drawing (Gambar Perencanaan
Status report	:	DED

B. Main conclusions
The main conclusions are:

- The reference point for topographic surveys (SDC) used BM Bakosurtanal i.e BM BTJ 01 (X = 759119.794, Y = 615943.177, Z = + 2.393 m). The design of PT Global is not linked to BTJ01. When SDC links the two benchmarks a difference of -0.99 m is found.
- PT Global did not include impact of tidal variations in their design. This overestimates the discharge capacity of the system. It is important to include the impact of the tidal variations.
- The design discharge calculations based on the hydrology analysis by PT. Global differ from the design discharges values on the drawing. The design discharges on the drawing are higher but still too low compared to the calculations by SDC.
- Structures like culverts are not included in the design of PT Global. These structures also require improvements. Without improvement of these structures the flooding problem will not be solved according to the design guidelines. The design pf PT Global is thus not complete.
- In the design of PT Global extra drain width is required. However, at some locations widening the drain is not possible.
- The design by PT. Global does not solve the inundation problem according to the design guidelines. The design must be reviewed. SDC will improve the design according to the design guidelines

For a more detailed description of the design review reference is made to Appendix D.

SDC has prepared a new design for Darussalam and will be discussed in the following chapters.

4 PROPOSED WORKS - DESIGN

4.1 MITIGATING OPTIONS AND RECOMMENDATION

This paragraph describes the mitigating options. In case there are several options possible a recommendation will be given. First the existing system is analysed to identify the bottlenecks in the system followed by the analysis of different mitigating options.

4.1.1 Cleaning of the drainage system

The existing drainage system in Darussalam is in poor condition. The drains have insufficient capacity caused by small dimensions and blocking. For the whole drainage system the following measures have to be taken:

- Remove solid waste and sediments from the drainage system;
- Remove concrete debris from the drains to enhance flow (also e.g. bridge abutments narrowing the flow profile);
- Implement an Operation and Maintenance (O & M) program.

4.1.2 Rektorat IAIN / Unsyiah (Area 1)

Problem and cause
Inundation of the campus area occurs during heavy rainfall due to insufficient capacity of the drainage system in this area. Insufficient capacity is caused by too small dimensions of the drains and culverts as well as blocking in the system by garbage, sediments and vegetation. In some locations the drains are located too high for the water to flow into them.

Mitigating options
To mitigate the flooding problems the existing drainage system should be upgraded as well a new drain constructed. In improving, see Figure 4-1, the situation of Rektorat IAIN / Unsyiah the following works are included:

- Improve existing drainage system by cleaning and rehabilitation the drains;
- Construction of a new drain along Jl. T. Nyak Arief to discharge the water to the collector drain located parallel to the Floodway

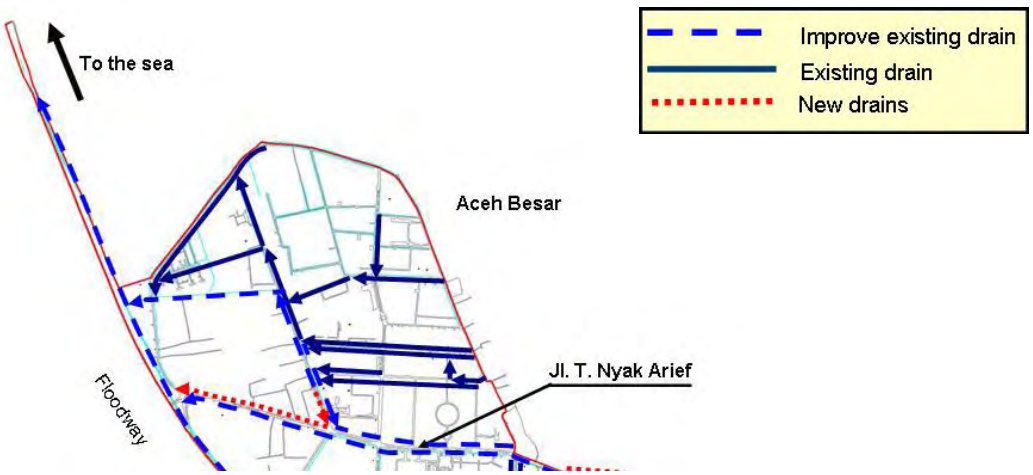


Figure 4-1: Proposed improvements Rektorat IAIN / Unsyiah

4.1.3 Kopelma Darussalam (Area 2)

Problem and cause
Inundation of the housing area occurs during heavy rainfall due to insufficient capacity of the drainage system in this area. Insufficient capacity is caused by too small dimensions of the drains and culverts as well as blocking in the system by garbage, sediments and vegetation. In some locations the drains are located too high for the water to flow into them.

Mitigating options
To mitigate the flooding problems the existing drainage system should be upgraded as well a new drain constructed. In improving, see Figure 4-2, the situation of Kopelma the following works are included:

- Improve existing drainage system by cleaning and rehabilitation the drains;
- Construction of new drains to improve the discharge of water.

Figure 4-2: Proposed improvements Kopelma

4.2 DETAILED ENGINEERING DESIGN (DED)

After agreement with the local stakeholder concerning the proposed final design the DED will be prepared. In this paragraph a detailed description will be provided when the DED is completed.

4.3 LAND REQUIRED

To implement the above described mitigating solutions, additional land is required. A total approximately 1.2 ha is required, see Table 4-1. The location of the drains is shown in Appendix A.

Table 4-1: Structural improvement drains

Name	Location	Length [m]	Design width [m]	Extra required [m] *1	Extra required [m²]
D.1c	Masjid Muhajirin	419	9.50	2.50	1,048
D.1d - e	Parallel to Floodway	1,278	12.00	3.00	3,834
D.1.2a	Jl. T. Nyak Arief	482	0.90	2.50	1,206
D.1.2b	Jl. T. Nyak Arief	676	1.20	1.30	879
D.1.2c	Jl. T. Nyak Arief	592	1.70	3.30	1,953
D.1.2.1	Jl. Kuta Inang Balee	338	0.90	0.80	271
D.1.3a	Jl. T. Nyak Arief	471	0.74	0.74	348
D.1.3c	Jl. T. Nyak Arief	588	1.20	1.20	705
D.1.4c	Jl. Seulanga & Jl. Hasan Kolle	430	2.20	1.10	473
D.1.4d	Jl. Tgk. Tanoh Abee	524	2.85	1.55	812
D.1.4.2	-	252	0.91	2.51	633
Total					**12,162**

*1 : Including 0.8 m free area for construction at each side of the drain

4.4 PROJECT COSTS

4.4.1 Construction costs

In the following table the estimated construction costs, based on the recommended solutions for Darussalam are defined. Costs for land acquisition are not included.

Table 4-2: Estimated project costs Darussalam

Bill No	Description	Page	Total (Rp)	Total (USD)
1	General		1,766,617,460.00	176661.746
2	Drainage System		39,905,174,081.00	3,990,517.41
3	Total for Daywork (Provisional Sum)		2,330,000,000.00	233,000.00
	Subtotal of Bills	(A)	44,001,791,541.00	4,400,179.15
	Specified Provisional Sums included in subtotal of Bills	(B)	2,330,000,000.00	233,000.00
	Total of Bills Less Specified Provisional Sums (A - B)	(C)	41,671,791,541.00	4,167,179.15
	Add Provisional (Sum) for Contingency Allowance	(D)	2,500,307,000.00	250,030.70
	Bid Price before VAT 10 % (A + D)	(E)	46,502,098,541.00	4,650,209.85
	Tax 10 %	(F)	4,650,209,854.10	465,020.99
	Bid Price after VAT 10 % (Carried forward to Form of Bid)	(G)	51,152,000,000.00	5,115,200.00
	(E + F)			

1 USD = 10,000 Rp

4.4.2 Operation & maintenance costs

The cost for annual operation and maintenance is estimated as 3% of the total new investment. Annual operation and maintenance would be used for staff salary, labour wages for maintaining facilities, material for repairing works and running cost for facilities. Additional O&M annual cost estimated for Darussalam is Rp. 1.6 billion.

5 IMPLEMENTATION AND IMPACTS

5.1 IMPLEMENTATION SCHEDULE

Tender documents will be prepared conform WB format. The drainage improvement and rehabilitation works will be included into one package

The implementation schedule is shown in Figure 5-1.

	2009					2010											2011								Duration
Work	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	(months)
DED / Project report																										3
Tender documents																										2
Procurement																										4
Construction works																										18

Figure 5-1: Implementation schedule

During the month October it is assumed that limited works will be executed due to the Idul Fitri.

5.2 ENVIRONMENTAL IMPACT

SDC conducted an Initial Environmental and Examination (IEE) in Darussalam in order to meet the feasibility study requirements for funding either by BRR – MDF finance facility or other donors. IEE is done to review proposed project by SDC whether the project is technically sound, economically justified, environmentally and socially acceptable and financially sustainable. This will ensure that mitigating measures and other social and environmental safeguards can be incorporated in the design and engineering phase.

Different components have been studied to examine the impact of the project, components included physical, chemical, biology and social economic conditions. These factors form the basis of the IEE check list, which presents the level of impact per component. This results in a scoring table which finally determines whether an EIA (AMDAL) is required, or an Environmental Monitoring and Management Plan (UKL/UPL) or Standard Operation Procedures (SOP).

In Table 5-1 the activity and its impact for the improvement works in Darussalam are provided.

Table 5-1: Activity and impact improvement Darussalam

Activity	Impact
Improvement of primary drains (2.0 km)	▪ The improvement of the drains can have impact / damage other networks (e.g. water supply and electricity) that are located parallel to the drains. ▪ The improvement of the drains requires land acquisition. ▪ Difference in land prices between the local community and the local government
Improvement of secondary drains (6.1 km)	▪ The improvement of the drains can have impact / damage other networks (e.g. water supply and electricity) that are located parallel to the drains. ▪ The improvement of the drains requires land acquisition. ▪ Difference in land prices between the local community and the local government

Construct new secondary drain (476 m)	▪ The improvement of the drains can have impact / damage other networks (e.g. water supply and electricity) that are located parallel to the drains. ▪ The improvement of the drains requires land acquisition. ▪ Difference in land prices between the local community and the local government

Pre-Construction Phase

Physical component
The following likely impacts have been found:
- Disturbance to public facilities located parallel to the drain like water supply pipes from PDAM, electricity cables but also fences of houses and other buildings.

Changes in the physical environment may have a negative and permanent impact.

Biological component
There is no significant potential impact on the biological component.

Socio-economics component
The following likely impacts have been found:
- Eligibility of life, mobilization of the contractor can cause effects like traffic jam and dust;
- Conflict social (land acquisition).

Construction Phase
The "on-site" impact of the project during construction is relatively high. The construction activities will disturb local communities through disturbed access to the project site, traffic, noise and dust. However, duration is limited and with proper mitigating measures and effective management, the final impact might be acceptable.

Other factors that are considered:
- Sensitivity of the environment.
- Legal exposure.
- Community relations.

Post Construction Phase
In the post construction phase the impact is caused by the waste from the households, like garbage, plastic, bottles, paper etc, usually thrown into drainage channel.

Result IEE
Based on this analysis, SDC advised the Bapedalda province to **conduct a AMDAL (EIA)** (Analisis Mengenai Dampak Lingkungan/ Environment Impact Assessment), because more than 5 km of new drains are constructed.

For a detailed description of the IEE study reference is made to the report: IEE Banda Aceh Zone 5 and Darussalam, registration number: SDC-R-70019.

5.3 LAND ACQUISITION

The improvement works in Darussalam require land acquisition. In accordance with the procedure governing land acquisition and resettlement action planning (LARAP) of the Government of Indonesia, it has been ascertained that for Improvement and the new drains area, the proposed interventions do not require LARAP.
However, if in case of the drainage projects, people are in need of temporary resettlement or that part of their property is damaged / claimed, it is recommended to arrange for adequate compensation.

For a detailed description of the IEE study reference is made to the report: IEE Banda Aceh Zone 5 & Darussalam, registration number: SDC-R-70019.

5.4 SOCIO- ECONOMICS

The project location of Darussalam consists of 2 villages, Rukoh Village and Kopelma Darussalam Village. The number of households and people in the area are shown in the table below. The areas are often flooded due to insufficient capacity of the drainage system. In the area about 75% owning livelihood in the commercial sector & service, while 25% work as Government officer or private sector employees.

Table 5-2: Number of household / person influenced by the design

Sub District / Villages	Impact no. of household	Impact no. of people
Rukoh (Syiah Kuala)	636	8,815
Kopelma Darussalam (Syiah Kuala)	918	6,212
Total	**1,554**	**15,027**

Source : Potensi Desa Kota Banda Aceh 2006

The community gets its water from well or through supply pipes from PDAM (water Supply Agency). This is important to know because construction works can damage the pipe network and cause a stop of water supply to the different households. This can have impact on the health situation of the community.

5.5 ECONOMIC FEASIBILITY

The frequency of inundation is about 3 days per year during the rainy season. For about 1-2 days the average inundation depth is around 30-50 cm. The inundation area is estimated to be approximately 41 ha. The inundation in Darussalam affects about 1,242 people in 184 households. Urbanisation of the area will increase the number of affected households.

Though the impact is not destructive, floods still damage houses, furniture and equipment. Floods also cause loss in economic activity, especially public services and commercial activities. The losses caused by floods are predicted at Rp 188 million every year with most loss in the household sector. Associated problems which are included in cost-benefit analysis include health issues, loss of income, material losses (furniture etc.), decreased value of assets etc.

To solve these floods in Banda Aceh Darussalam, the project proposes to construct new and upgrade existing drainage system including culverts and bridges. The total construction costs are estimated around Rp. 51.2 Billion.

The calculations of the economic CBA, using the collected data on all quantifiable damages and impact on land value as well as indicative cost figures for the drainage measures and maintenance cost, presented below:

Economic Ratio's	Economic CBA	Project Feasibility Criteria
Total Net Benefit (Undiscounted, in MRp)	26,604	Positive (> 0)
B/C (undiscounted)	2,75	> 1
NPV at 6% (MRp)	3,995	Positive (> 0)
IRR	8%	> 6%

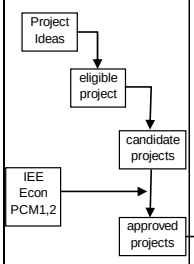
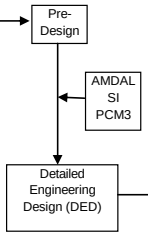
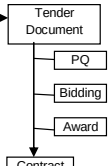
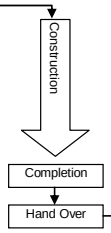
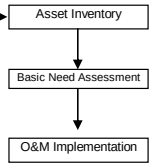
It can be concluded that this project is financially/economically feasible.

For a detailed description of the economic analysis reference is made to the document Cost-Benefit analysis Flood Protection & Urban Drainage Darussalam, registration number SDC-R-70097.

5.6 INSTITUTIONS

The roles and responsibilities of the different institutions involved in the improvement of the drainage system and the design, construction and O&M of the storage reservoir is presented in the following table.

Table 5-3: Institutional role sharing on urban drainage project management

	Item	Planning	Design	Tendering	Implementation	Operation&Maintenance
1.	Mechanism					
2.	Financing	RNE	RNE	BRR	BRR (MDF)	APBD II
3.	Construction Supervision				SDC or third party	
4.	Monitoring & Evaluation	BRR	BRR	BRR	BRR	
5.	Responsible Agencies - Principal - Tech. Assistance - Assistance (prov) - Assistance (district)	Dinas SDA Prop SDC	Dinas SDA Prop SDC	Regional BRR (Satker)	Regional BRR (Satker) Dinas SDA Prop (PBPP) Dinas PJSDA kota	DPJSDA and Dinas KP
6.	Future R&U, and O&M - Macro System - Micro System - Pump Station				Dinas SDA Prop (PBPP) DPJSDA	DPJSDA D.Kebersihan & Prtmn DPJSDA

In summary the roles and responsibilities of the different agencies are as follows:

Kantor Kecamatan: should ensure that the project is properly embedded in the local community development plans and aspirations. Liaison with relevant agencies at district/kota level, in particular Bappeda, Dinas Prasarana Jalan & Sumberdaya Air (DPJSDA), Dinas Tata Kota, Dinas Kebersihan & Pertamanan.

Bappeda: is responsible for the overall coordination at city level (Kota Banda Aceh). In this capacity, they should ensure that a future spatial plan takes into consideration the drainage infrastructure and dike. Areas within the resulting floodplain and the area directly behind the beach should be barred from future housing development.

Dinas Prasarana Jalan & Sumberdaya Air (Banda Aceh) : responsible for rehabilitation and upgrading as well as maintenance of micro system of drainage infrastructure (the macro system is handled by Provincial Dinas SDA). Dinas Prasarana Jalan & Sumberdaya Air will have a role in monitoring the progress of the works and need for periodic maintenance such as regular cleaning of drainage infrastructure and dredging of the river mouth (or maintenance and operation of the pump and gates).

Dinas Sumberdaya Air NAD Province : responsible for rehabilitation and upgrading as well as maintenance of macro system and sub macro system at NAD Province area, included macro system and sub-macro of Banda Aceh City, like : Kr. Aceh, Kr. Lumpaga, Kr. Daroy, Kr. Doy, Kr. Neng, Kr. Lhueng Paga, Kr. Titi Panjang, Kr. Cut and Kr. Tanjung.

Dinas Tata Kota : related with the spatial plan of Banda Aceh City, regarding law enforcement of city regulation about the land use and urban arrangement in order to maintain the development asset plan.

Dinas Kebersihan & Pertamanan: As the responsible agency for the operation & maintenance programme, the Dinas Kebersihan & Pertamanan generally manages urban effluent, mud and garbage. Dinas Kebersihan & Pertamanan is responsible for O & M of drainage system, carry out mud and garbage cleaning in the micro and sub-micro drainage system.

5.7 OPERATION AND MAINTENANCE

Operation and maintenance of the drainage system of Banda Aceh is a complex task. At this moment there is a serious lack of information of the existing system. Part of the system was damaged and in some cases already repaired. Concerning the data of the existing system and the already repaired network no access to a structural database is available.
The responsibility for the O&M is spread among different stakeholders.

The different objects of the drainage system requiring regular or incidental maintenance are listed below:

Open drains	: removal sediment, sludge, garbage and weed; repair damages;
Closed drains	: removal sediment, sludge garbage and weed; repair damages;
Culverts	: removal sediment, sludge and garbage;

For a proper O&M SDC advises prepare database with all the information of the drainage system as it is constructed. It will contain all relevant data concerning amount, sizes, quality and location of the drains and gates.

This database can be used in a management system to carry out the O&M works of the drainage system in a more rational way. It is a tool to prepare a maintenance action plan and to calculate the yearly required budget.

A brief description of the O&M works is provided below. For a more detailed description including e.g. technical, financial, institutional and community aspects reference is made to the O&M document for Banda Aceh prepared by SDC.

5.7.1 Operation

Operation of the drainage system mainly involves the pumping stations with required facilities and the gates that do not work automatically. In Zone Darussalam no pumping stations and no gates are constructed.

5.7.2 Maintenance

The most vital parts of the system are the outfall structures, which deserve special attention and proper maintenance have a high priority.

The following maintenance activities can be distinguished:

- Daily or regular maintenance;
- Periodical maintenance;
- Incidental maintenance.

Daily or regular maintenance
The following activities must be carried out throughout the year on a regular basis.

- Cleaning of canals, because of the small depth of the canals it is necessary to clean the canals regularly because of the growth of weed and sediments;

- Cleaning of structures, at the outfall structures floating debris must be removed from the trash racks daily.

Periodical maintenance

- Painting of steel parts of structures. High salinity of the water may cause corrosion. Therefore, painting of steel parts is very important.
- Remodelling of drains and embankments. If slope failures occur during the wet season, they should be repaired properly in the dry season.

Incidental maintenance

The water management system is designed in such a way that it is unlikely that unforeseen maintenance works are required. However, a budget must be available to overcome short comings or damage caused by extreme situations.

5.7.3 Yearly maintenance

Each year an inspection of the vital parts of the whole drainage system must be made. Based on this inspection the required maintenance activities must be selected and carried out. The whole system requires a systematic inspection of functioning

In a separate study it will be analysed what personnel requirement is necessary for the operation and maintenance, institution handling, budget and involvement of community in O&M. In study, technical aspect of activity of O&M also will be elaborated detailed. Some regular maintenance works can be contracted outside the organisation of the stakeholder.

Operation & Maintenance manual
Proper Operation & Maintenance is important for good functioning of the drainage system. SDC is preparing an Operation & Maintenance manual. Is this manual the existing situation in Banda Aceh is described. Different aspects are described like institutional, financial, technical and community. A recommendation is given to improve the existing situation in Banda Aceh.

6 REFERENCES

[1] Design guidelines Flood Protection & Urban Drainage; version 1 – February 2007; Sea Defence Consultants; registration number: SDC-R-60002.

[2] Hydrology Flood Protection & Urban Drainage; version 1 – November 2006; Sea Defence Consultants; registration number: SDC-R-60009.

[3] CV Dypersi Consult (2003): "Laporan Utama (Main report) Studi Probable Maximum Precipitation (PMP) Provinsi Nangroe Aceh Darussalam"; 20 Augustus 2003

[4] Project Report Macro Drainage System in Banda Aceh; version 1 – June 2007; Sea Defence Consultants; registration number: SDC-R-70033

[5] Laporan Initial Environmental Examination (IEE) di Banda Aceh Zone 5, 2007; Sea Defence Consultants, registration number: SDC-R-70019.

[6] Cost Benefit Analysis Flood Protection and Urban Drainage Darussalam, September 2007; Sea Defence Consultants, registration number: SDC-R-70097.

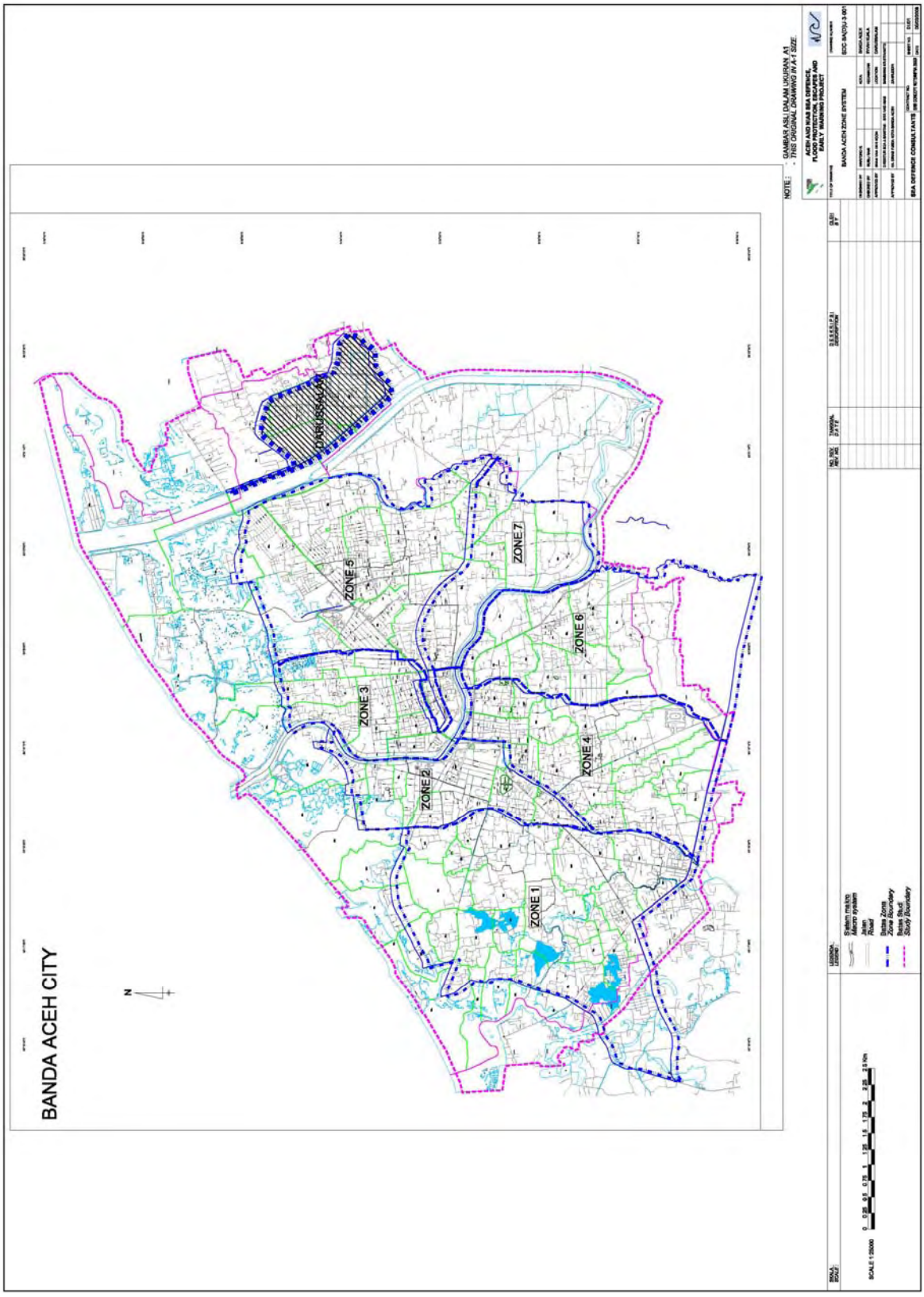
[7] Tender Document Package IV, April 2008: Sea Defence Consultants, registration number: SDC-R-80027.

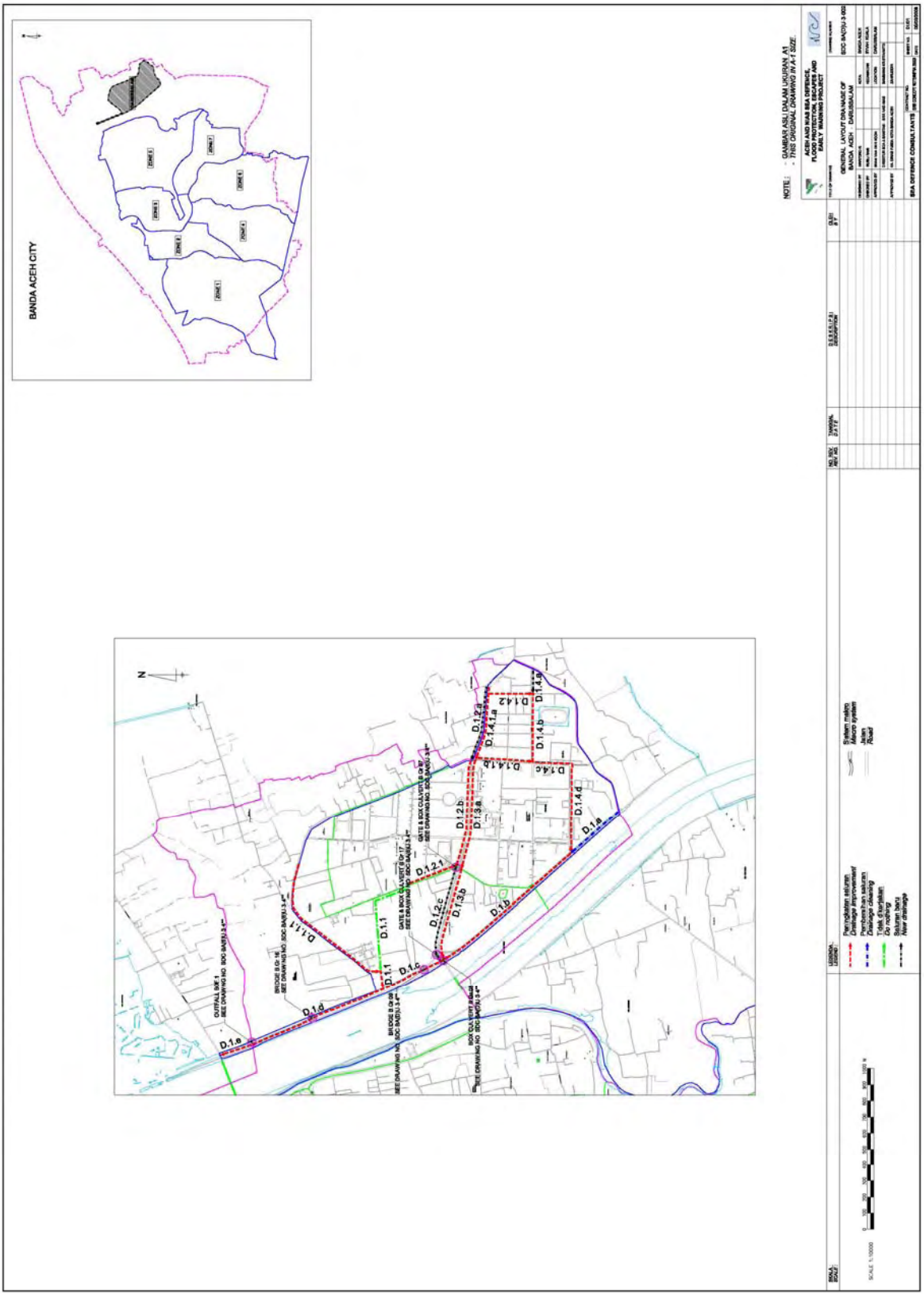
APPENDICES

APPENDIX A: MAPS DARUSSALAM

The following drawings are included:

- Banda Aceh Darussalam System (SDC-BA(D)U-3-001)
- General layout drainage of Banda Aceh Darussalam (SDC-BA(D)-3-002)


BANDA ACEH CITY
DARUSSALAM
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
ZONE 7
N
ACEH AND NIAS SEA DEFENCE, FLOOD PROTECTION, ESCAPES AND EARLY WARNING PROJECT
BANDA ACEH ZONE SYSTEM
SEA DEFENCE CONSULTANTS


BANDA ACEH CITY
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ZONE 6
ZONE 7
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D.1.3
D.1.4
D.1.5
D.1.6
D.1.a
D.1.b
D.1.c
D.1.d
D.1.e
Sistem makro
Macro system
Alam
Asal
Pengolahan saluran
Drainage improvement
Tambahan baru saluran
Drainage new building
Tidak di lanjutkan
Do nothing
Saluran alam
River drainage
GENERAL LAYOUT DRAINAGE OF
BANDA ACEH - DARUSSALAM
EDC BADSU-3 005
SEA DEFENCE CONSULTANTS

APPENDIX B: PCM - MOU

MEMORANDUM KESEPAHAMAN

STRATEGI
PROTEKSI BANJIR DAN DRAINASE
KOTA BANDA ACEH ZONA-5

31 MEI 2007

MEMORANDUM KESEPAHAMAN

Pada hari ini Kamis tanggal tiga puluh satu bulan Mei tahun dua ribu tujuh, kami yang bertanda tangan di bawah ini sebagai para wakil pemangku kepentingan dalam hal ini adalah Pemerintah Daerah dan Wakil Masyarakat di wilayah kecamatan Syiahkuala, kecamatan Kuta Alam dan kecamatan Ulee Kareng, Kota Banda Aceh, menyatakan memahami dan menyetujui "Strategi Proteksi Banjir dan Drainase Kota Banda Aceh zona-5 dan Darussalam" yang telah dipresentasikan pada hari ini oleh *Sea Defence Consultants*.

Hasil-hasil tersebut tercapai setelah melalui tahapan berikut, yaitu:

Konsultasi Publik-I : 1) Penjelasan hasil identifikasi masalah banjir,
2) Draft strategi penanggulangan masalah, serta
3) Tanggapan dan masukan dari masyarakat dan pemangku kepentingan.

Konsultasi Publik-II: 1) Penjelasan hasil perbaikan draft strategi berdasarkan tanggapan dan usulan pada konsutasi publik I,
2) Tanggapan dan masukan tambahan pada konsultasi publik II
3) Kesepakatan terhadap penanggulangan masalah banjir pada wilayah Kota Banda Aceh zona-5 yang meliputi:

1. Rekonstruksi stasiun pompa Bandar Baru dengan sistem dan dan kapasitas sesuai kebutuhan (Taman Ratu Safiatuddin)
2. Pembangunan kolam tampungan dan stasiun pompa Jeulingke dengan luas kurang lebih 0. 65 ha.
3. Pembangunan kolam tampungan Titi panjang dengan luas kurang lebih 40 ha.
4. Rehabilitasi dan pembersihan saluran drainase kota Banda Aceh zone 5 untuk memperlancar aliran air drainase dan menghilangkan hambatan-hambatan seperti pada bangunan persilangan.
5. Peningkatan kapasitas saluran dan gorong-gorong zona 5 dan Darussalam dengan melebarkan dan atau mendalamkan saluran yang ada.
6. Pembangunan saluran dan gorong-gorong baru zona 5 dan Darussalam untuk memperbaiki system drainase yang ada.
7. Untuk implementasi point 1 sampai dengan 6, diperlukan lahan extra untuk mendukung implementasi tersebut.

Kami memahami bahwa "Strategi Proteksi Banjir dan Drainase Kota Banda Aceh Zona-5 dan Darussalam" yang disepakati ini merupakan dasar kesepakatan yang akan ditindak lanjuti dengan detail desain. Oleh karena itu para pemangku kepentingan setempat, baik pemerintah maupun masyarakat berhak mendapat informasi kegiatan selanjutnya,

mengenai perkembangan status, proses kemajuan dan tindak lanjut yang akan dilaksanakan.
Demikian Memorandum Kesepahaman ini dibuat dan ditandatangani untuk dipergunakan sebagaimana mestinya.

Banda Aceh, 31 Mei 2007

No	Nama	Jabatan	Institusi	Tanda tangan
Atas nama Pemerintah Propinsi, Kota Banda Aceh dan BRR				
1	ANISRULLAH	TIM TEKNIS	BRR Satker IKP	1
2	SOFYANUDDIN	KASUBDIN	DPJSDA	2
3	SUBKI	Kasubdin	Tata Kota	3
4	SURYA DARMA	[illegible] - SDA	BRR - SDA	4
5				5
6				6
7				7
Atas nama Pemerintah Kecamatan				
8	HARAPAN M. [illegible]	Sekcam C.K. Alam	Kecamatan Kuta Alam	8
9	Gamun [illegible]	[illegible]	Kecamatan Syiah Kuala	9
10			Kecamatan Ulee Kareng	10
Atas nama Masyarakat				
11	A. Gani Aman	Tokoh masyarakat	Keuchik K. Alam	11
12	Muhammad [illegible]	Ky. Gampong	— .. —	12
13	Dra Hj. Hamidah. S	T. Perempuan	Kopma	13
14	Dra Hj. NURHAYATI IBR	T. Perempuan	PEURADA	14
15	Hafizah	Tokoh Wali	Bandar [illegible] Ulee	15
16	ARMANISAH	Tokoh P	Kareng.	16
17	ROSMANIAH	Tokoh m.		17
18	UYA	— 11 —	Lamgugob	18
19	[illegible]	Ketua [illegible]	B. [illegible]	19
20	Amiruddin	— 11 —	Lamgugob	20
21	[illegible]	[illegible]		21
22	ERTI. S.Pd	Tokoh perempuan	Doy	22
23	YUSNIAR S.Ag	"	Lamglumpang	23
24	Drs. H. Husni Ibrahim	TGP. Peurada	Gp. Peurada	24
25	AZANI A. RANI	KECHIK	Gp Pineung	25
26	[illegible]	Keuchik	[illegible]	26
27	Dr [illegible]	Tokoh	[illegible]	27
28	Drs Hj Hanifah, S			28

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69					69
Atas nama Konsultan Sea Defence					
70	SUYITNO	Drainage Eng	SDC	70	
71	E. KLAASSEN	Comp. Leader FPWD	SDC		71
72	J. Kraaij	Polder and Drain. Sp.	SDC	72	
73					73

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APPENDIX C: HYDROLOGY ANALYSIS

List of Contents

A. IDF and design storm

Rainfall data used for Banda Aceh Urban Area Zone Darussalam is: Olee Kareng (106 b)

-Olee Kareng (106 b)

Rainfall Station : Olee Kareng (106 b)

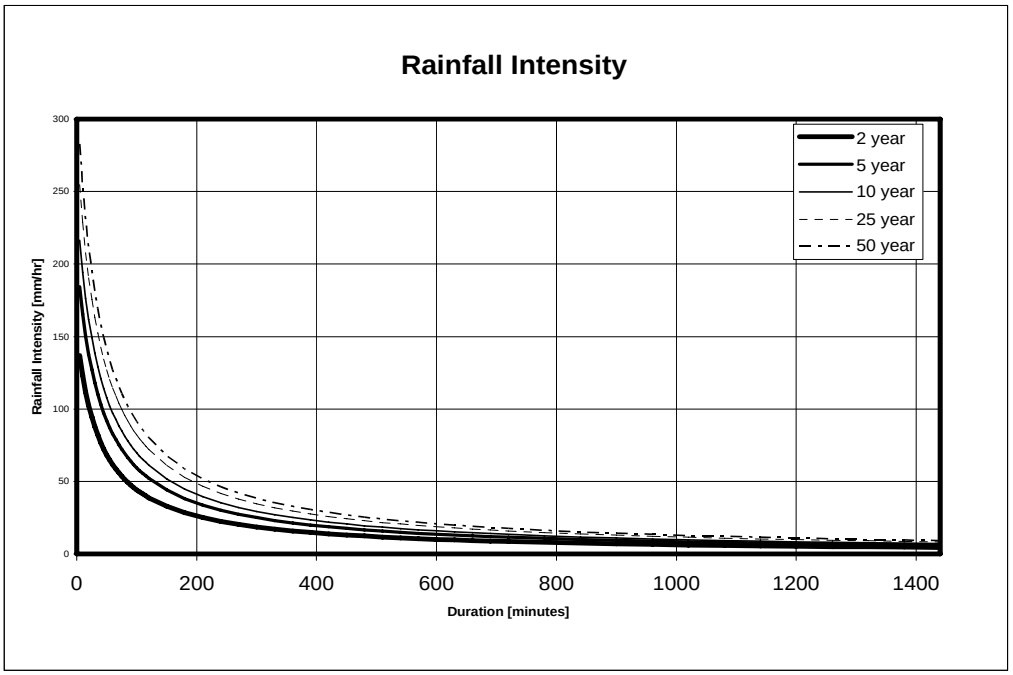
Rainfall Intensity [mm/hr]

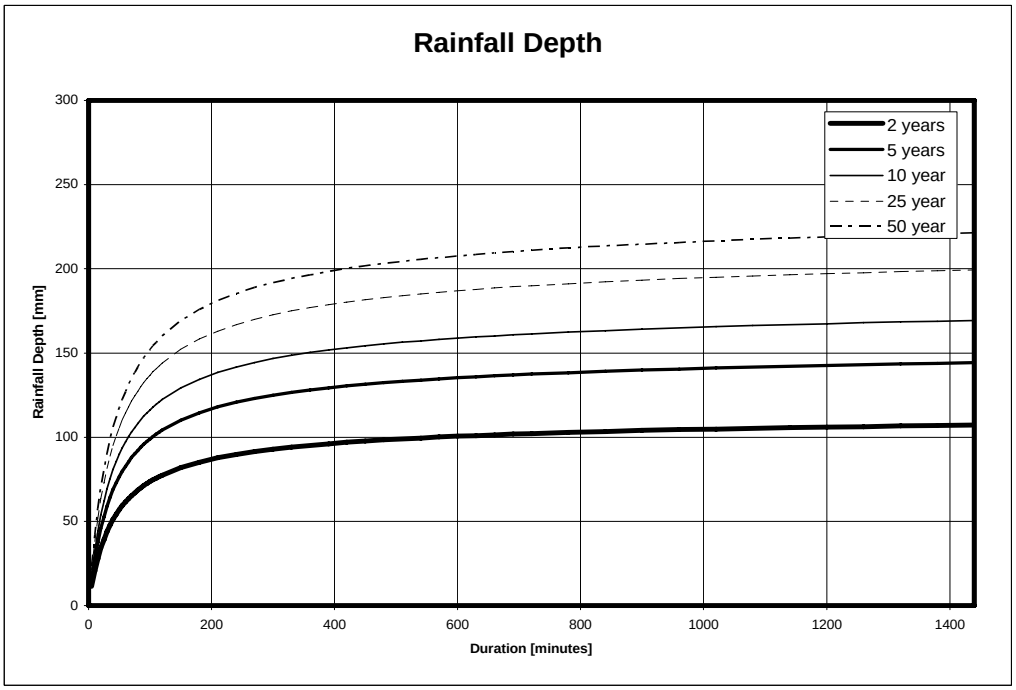
Return Period		2 year	5 year	10 year	25 year	50 year
I 60		53.5	72	84.5	99.5	110.5
t	**Kd**	[mm/hr]	[mm/hr]	[mm/hr]	[mm/hr]	[mm/hr]
5	2.56	*137*	*184*	*216*	*255*	*283*
10	2.30	*123*	*166*	*194*	*229*	*254*
15	2.09	*112*	*150*	*176*	*208*	*231*
20	1.91	*102*	*138*	*162*	*190*	*211*
25	1.77	*94*	*127*	*149*	*176*	*195*
30	1.64	*88*	*118*	*139*	*163*	*181*
35	1.53	*82*	*110*	*129*	*152*	*169*
40	1.43	*77*	*103*	*121*	*143*	*159*
45	1.35	*72*	*97*	*114*	*134*	*149*
50	1.28	*68*	*92*	*108*	*127*	*141*
55	1.21	*65*	*87*	*102*	*120*	*134*
60	1.15	*62*	*83*	*97*	*114*	*127*
65	1.10	*59*	*79*	*93*	*109*	*121*
70	1.05	*56*	*75*	*88*	*104*	*116*
75	1.00	*54*	*72*	*85*	*100*	*111*
80	0.96	*51*	*69*	*81*	*96*	*106*
85	0.92	*49*	*66*	*78*	*92*	*102*
90	0.89	*48*	*64*	*75*	*88*	*98*
95	0.86	*46*	*62*	*72*	*85*	*95*
100	0.83	*44*	*59*	*70*	*82*	*91*
105	0.80	*43*	*57*	*67*	*79*	*88*
110	0.77	*41*	*56*	*65*	*77*	*85*
115	0.75	*40*	*54*	*63*	*74*	*83*
120	0.72	*39*	*52*	*61*	*72*	*80*
150	0.61	*33*	*44*	*52*	*61*	*68*
180	0.53	*28*	*38*	*45*	*53*	*59*
210	0.47	*25*	*34*	*40*	*47*	*52*
240	0.42	*22*	*30*	*35*	*42*	*46*
270	0.38	*20*	*27*	*32*	*38*	*42*
300	0.35	*19*	*25*	*29*	*35*	*38*
330	0.32	*17*	*23*	*27*	*32*	*35*
360	0.30	*16*	*21*	*25*	*29*	*33*
390	0.28	*15*	*20*	*23*	*27*	*31*
420	0.26	*14*	*19*	*22*	*26*	*29*
450	0.24	*13*	*18*	*21*	*24*	*27*
480	0.23	*12*	*17*	*19*	*23*	*25*
510	0.22	*12*	*16*	*18*	*22*	*24*
540	0.21	*11*	*15*	*17*	*21*	*23*
570	0.20	*11*	*14*	*17*	*20*	*22*
600	0.19	*10*	*14*	*16*	*19*	*21*
630	0.18	*10*	*13*	*15*	*18*	*20*
660	0.17	*9*	*12*	*15*	*17*	*19*
690	0.17	*9*	*12*	*14*	*16*	*18*
720	0.16	*9*	*11*	*13*	*16*	*18*
780	0.15	*8*	*11*	*12*	*15*	*16*
840	0.14	*7*	*10*	*12*	*14*	*15*
900	0.13	*7*	*9*	*11*	*13*	*14*
960	0.12	*7*	*9*	*10*	*12*	*13*
1020	0.12	*6*	*8*	*10*	*11*	*13*
1080	0.11	*6*	*8*	*9*	*11*	*12*
1140	0.10	*6*	*7*	*9*	*10*	*11*
1200	0.10	*5*	*7*	*8*	*10*	*11*
1260	0.09	*5*	*7*	*8*	*9*	*10*
1320	0.09	*5*	*7*	*8*	*9*	*10*
1380	0.09	*5*	*6*	*7*	*9*	*10*
1440	0.08	*4*	*6*	*7*	*8*	*9*

Cumulative Rainfall Depth [mm]

t	duration hr	Return Period				
[minutes]	60	2 year	5 year	10 year	25 year	50 year
5	0.08	*11*	*15*	*18*	*21*	*24*
10	0.17	*21*	*28*	*32*	*38*	*42*
15	0.25	*28*	*38*	*44*	*52*	*58*
20	0.33	*34*	*46*	*54*	*63*	*70*
25	0.42	*39*	*53*	*62*	*73*	*81*
30	0.50	*44*	*59*	*69*	*82*	*91*
35	0.58	*48*	*64*	*75*	*89*	*99*
40	0.67	*51*	*69*	*81*	*95*	*106*
45	0.75	*54*	*73*	*86*	*101*	*112*
50	0.83	*57*	*77*	*90*	*106*	*118*
55	0.92	*59*	*80*	*94*	*110*	*123*
60	1.00	*62*	*83*	*97*	*114*	*127*
65	1.08	*64*	*85*	*100*	*118*	*131*
70	1.17	*65*	*88*	*103*	*122*	*135*
75	1.25	*67*	*90*	*106*	*125*	*138*
80	1.33	*69*	*92*	*108*	*127*	*142*
85	1.42	*70*	*94*	*110*	*130*	*144*
90	1.50	*71*	*96*	*113*	*133*	*147*
95	1.58	*72*	*98*	*114*	*135*	*150*
100	1.67	*74*	*99*	*116*	*137*	*152*
105	1.75	*75*	*100*	*118*	*139*	*154*
110	1.83	*76*	*102*	*120*	*141*	*156*
115	1.92	*77*	*103*	*121*	*142*	*158*
120	2.00	*77*	*104*	*122*	*144*	*160*
150	2.50	*82*	*110*	*129*	*152*	*169*
180	3.00	*85*	*115*	*134*	*158*	*176*
210	3.50	*88*	*118*	*138*	*163*	*181*
240	4.00	*90*	*121*	*142*	*167*	*185*
270	4.50	*91*	*123*	*144*	*170*	*189*
300	5.00	*93*	*125*	*147*	*173*	*192*
330	5.50	*94*	*127*	*149*	*175*	*194*
360	6.00	*95*	*128*	*150*	*177*	*197*
390	6.50	*96*	*129*	*152*	*179*	*198*
420	7.00	*97*	*130*	*153*	*180*	*200*
450	7.50	*98*	*131*	*154*	*182*	*202*
480	8.00	*98*	*132*	*155*	*183*	*203*
510	8.50	*99*	*133*	*156*	*184*	*204*
540	9.00	*100*	*134*	*157*	*185*	*206*
570	9.50	*100*	*135*	*158*	*186*	*207*
600	10.00	*101*	*135*	*159*	*187*	*208*
630	10.50	*101*	*136*	*159*	*188*	*209*
660	11.00	*101*	*136*	*160*	*189*	*209*
690	11.50	*102*	*137*	*161*	*189*	*210*
720	12.00	*102*	*137*	*161*	*190*	*211*
780	13.00	*103*	*138*	*162*	*191*	*212*
840	14.00	*103*	*139*	*163*	*192*	*214*
900	15.00	*104*	*140*	*164*	*193*	*215*
960	16.00	*104*	*141*	*165*	*194*	*216*
1020	17.00	*105*	*141*	*166*	*195*	*217*
1080	18.00	*105*	*142*	*166*	*196*	*217*
1140	19.00	*106*	*142*	*167*	*196*	*218*
1200	20.00	*106*	*143*	*167*	*197*	*219*
1260	21.00	*106*	*143*	*168*	*198*	*220*
1320	22.00	*107*	*144*	*168*	*198*	*220*
1380	23.00	*107*	*144*	*169*	*199*	*221*
1440	24.00	*107*	*144*	*169*	*199*	*221*

-Olee Kareng (106 b



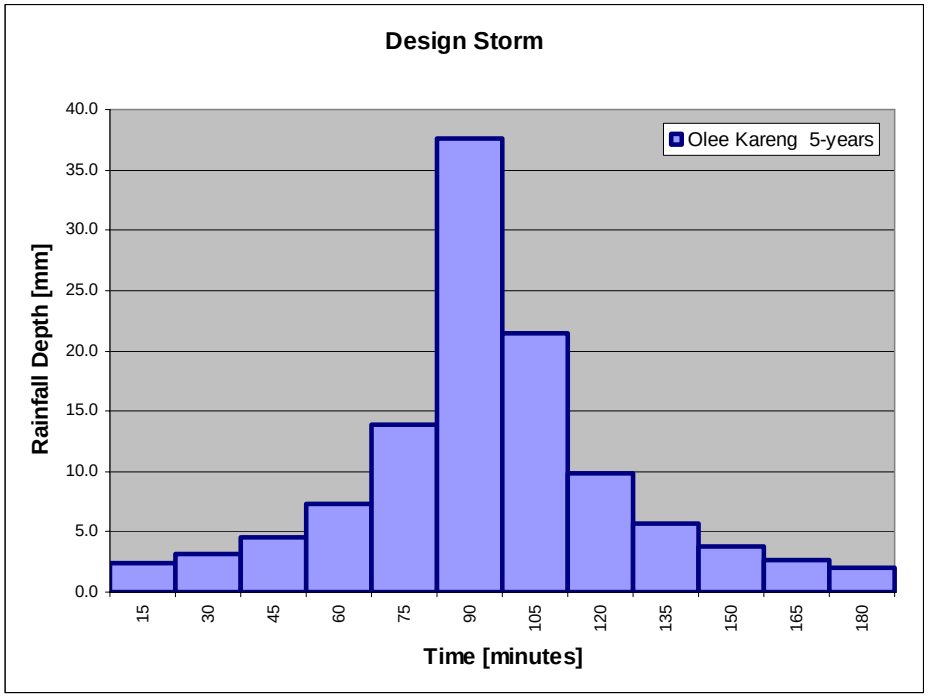


P [years]	Rainfall [mm]	P [years]	Rainfall [mm]
2	107	25	199
5	144	50	221
10	169		

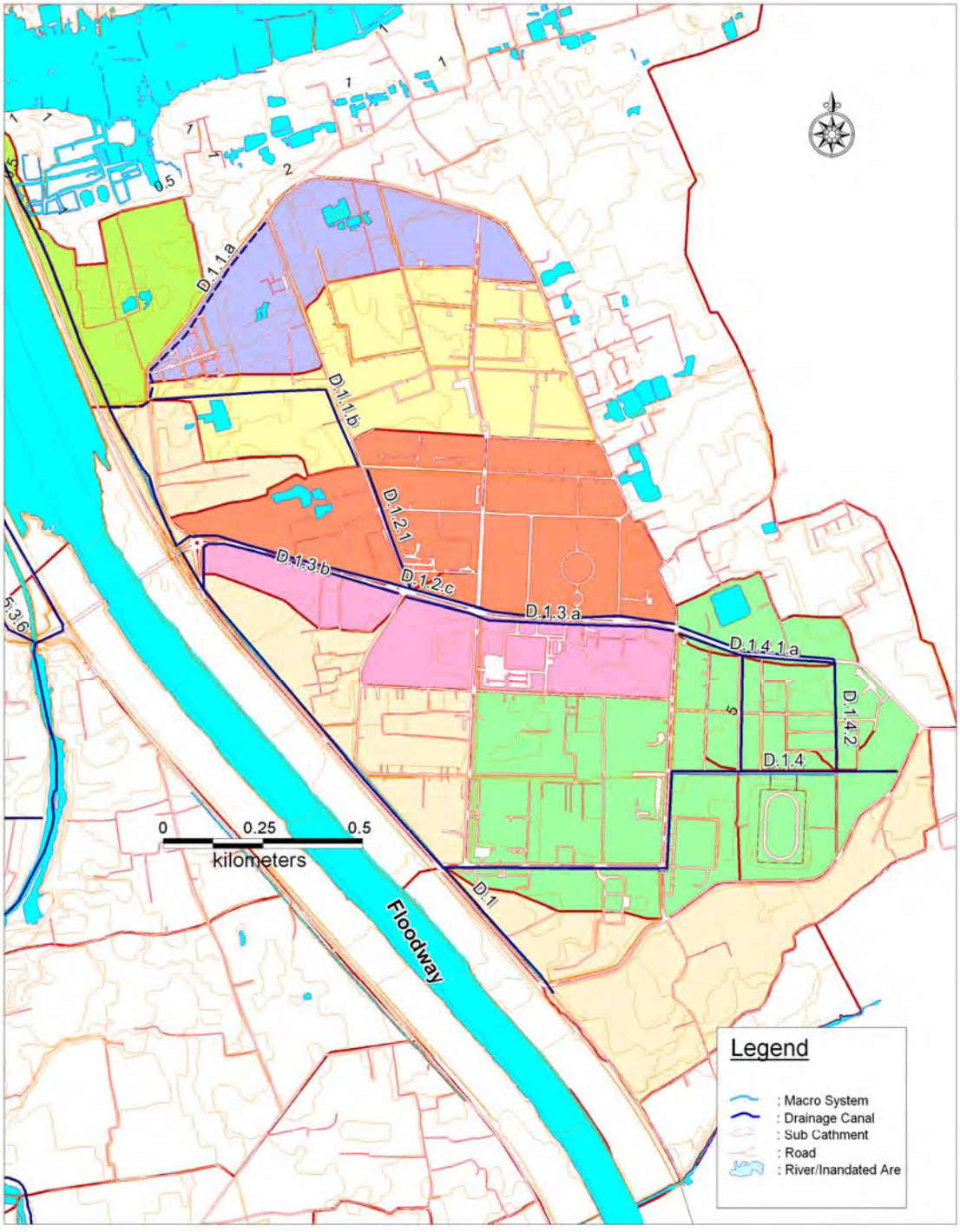
Design storms

Design storms are rainfall events which are specified by total rainfall and their temporal distribution. A design storm can be derived from statistical analysis of historical storms whereby rainfall characteristics are evaluated including rainfall depth (interrelationship with IDF curve), time-to-peak, peak-intensity, amount of rainfall before time to peak etc. the design storm for Banda Aceh is provided below.

t [minutes]	Return Period [years]				
	2	5	10	25	50
15	1.7	2.3	2.8	3.2	3.6
30	2.4	3.2	3.7	4.4	4.9
45	3.4	4.6	5.4	6.4	7.1
60	5.5	7.4	8.6	10.2	11.3
75	10.4	13.9	16.4	19.3	21.4
90	27.9	37.6	44.1	51.9	57.7
105	15.9	21.4	25.1	29.6	32.9
120	7.3	9.8	11.6	13.6	15.1
135	4.3	5.7	6.7	7.9	8.8
150	2.8	3.8	4.4	5.2	5.8
165	2.0	2.7	3.2	3.7	4.2
180	1.5	2.1	2.4	2.8	3.1
	85.1	**114.6**	**134.5**	**158.3**	**175.8**



B. Canal system and sub-catchments area



C. Peak discharges for main canal

- As shown in Table (Main Canal for Zone Darussalam) the catchments area of each canal system is less than 300 ha (except for Kr Titipanjang and Kr Cut), so the rational method can be applied, but the Kr Titipanjang and Kr Cut will be solved by using HEC HMS Model.

- Sub catchments is dominated by residential (medium-high density) type of land use, the business district and shopping centre only about 30 % of the area, except for the Darussalam area, at the North – East of Zone 5 where the area is dominated by Educational facility to about 80 % (see the spatial plan for Banda Aceh city, from JICA Team Study on the urgent rehabilitation and reconstruction support program for Aceh Province and affected areas in North Sumatra in Republic of Indonesia).

- Considering these type of land use and the adopted design criteria, the frequency of design storm should be set at a minimum return period of 5 years

- Refer to the Table of the design criteria, for the residential type of land use (30 houses/ha), the runoff coefficient C is taken as C_{10} = 0.55. (i.e the 10 year storm runoff coefficient). For the frequency of design storm of 5 years C_5 = 0.95 x C_{10} = 0.52.

- For the business district type of land use, the runoff coefficient C is taken as C_{10} = 0.90. (i.e. the 10 year storm runoff coefficient). For the frequency of design storm of 5 years C_5 = 0.95 x C_{10} = 0.855.

- The runoff coefficient for this area is taken as the weighted average of the above coefficients, or as C = 0.72. is from (0.2* 0.52 + 0.8*0.855)

- For all canal system in Zone Darussalam, the runoff coefficient of C = 0.72 will be used.

Area	Main Canal	Catchment Area (ha)	Peak Discharge (m^3/sec)			Discharge in
			2 Years	5 Years	10 Years	
Banda Aceh	**Darussalam**	**206,48**				
	D.1	251,48	11,61	16,44	19,78	Sea
	D.1.1	55,48	2,59	3,99	5,02	Main Canal D.1
	D.1.2	44,15	2,07	3,06	3,77	Main Canal D.1
	D.1.3	21,59	0,97	1,46	1,82	Main Canal D.1
	D.1.4	56,32	2,61	3,87	4,77	Main Canal D.1
Total Sub Area Darussalam		**251,48**				

Total Area Darussalam : 206.48 ha
Total Canal Sub Area Darussalam : 251.48 ha
Inflow to Area Darussalam : 39.00 ha

Table :Computation for stormwater of detailed urban drainage system by Rational Method
Location **: Banda Aceh Darussalam Area**

	Drain line	Rainfall Parameters													
		Input					Output								
		Length of section	Sub area	Area reduc factor	Runoff coeff	Return Period	Cumul. Length of drain	Average Velocity	Flow time	Time of con-centr.	Inten-sity	R-off coeff	Area total	Peak Flow	Cs * Qp
		Ld[m]	A [ha]	Cs	C	T [year]	Ld [m]	Vass [m/s]	td [min]	tc [min]	I [mm/h]	Cav	A [ha]	Q [m3/s]	[m3/s]
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
	Banda Aceh City														
1	***Nama Saluran Drainase : D.1***														
	D.1 0-1	414	31,25	1,00	0,72	5	414	0,50	14	190,9	36,4	0,72	31,25	**2,28**	2,20
	D.1 1-2	931	19,17	1,00	0,72	5	1.345	0,50	31	190,4	36,5	0,72	106,74	**7,79**	7,21
	D.1 2-3	100	0,35	1,00	0,72	5	1.445	0,50	3	191,0	36,4	0,72	128,68	**9,37**	9,29
	D.1 3-4	386	8,32	1,00	0,72	5	1.831	0,50	13	191,3	36,4	0,72	181,15	**13,18**	12,75
	D.1 4-5	1.200	14,85	1,00	0,72	5	3.031	0,50	40	193,3	36,1	0,72	251,48	**18,14**	16,44
2	***Nama Saluran Drainase : D.1.1.a***														
	D.1.1.a 0-0 (D.1)	200	22,13	1,00	0,72	5	200	0,50	7	189,9	36,6	0,72	55,48	**4,06**	3,99
3	***Nama Saluran Drainase : D.1.1.b***														
	D.1.1.b 0-1 (D.1.)	638	33,35	1,00	0,72	5	638	0,50	21	189,8	36,6	0,72	33,35	**2,44**	2,31
4	***Nama Saluran Drainase : D.1.2***														
	D.1.2 0-1	660	19,00	1,00	0,72	5	660	0,50	22	189,1	36,7	0,72	25,03	**1,84**	1,74
	D.1.2 1-3 (D.1)	660	9,42	1,00	0,72	5	660	0,50	22	189,3	36,7	0,72	44,15	**3,24**	3,06
5	***Nama Saluran Drainase : D.1.2.1***														
	D.1.2.1 0-1 (D.1.2)	320	9,70	1,00	0,72	5	320	0,50	11	191,8	36,3	0,72	9,70	**0,70**	0,68
6	***Nama Saluran Drainase : D.1.3***														
	D.1.3 0-1	610	5,63	1,00	0,72	5	610	0,50	20	186,6	37,1	0,72	6,36	**0,47**	0,45
	D.1.3 1-2 (D.1)	677	15,23	1,00	0,72	5	677	0,50	23	195,2	35,8	0,72	21,59	**1,54**	1,46
7	***Nama Saluran Drainase : D.1.4***														
	D.1.4 0-1	160	3,60	1,00	0,72	5	160	0,50	5	195,8	35,7	0,72	3,60	**0,26**	0,25
	D.1.4 1-2	250	6,80	1,00	0,72	5	410	0,50	8	190,6	36,5	0,72	16,00	**1,17**	1,14
	D.1.4 2-3	420	8,90	1,00	0,72	5	830	0,50	14	194,0	36,0	0,72	30,10	**2,16**	2,09
	D.1.4 3-1 (D.1)	550	26,22	1,00	0,72	5	1.380	0,50	18	193,9	36,0	0,72	56,32	**4,05**	3,87
8	***Nama Saluran Drainase : D.1.4.1***														
	5.4.4.1 0-2 (D.1.4)	290	5,20	1,00	0,72	5	290	0,50	10	190,0	36,6	0,72	5,20	**0,38**	0,37
9	***Nama Saluran Drainase : D.1.4.2***														
	D.1.4.2 0-1	400	5,60	1,00	0,72	5	400	0,50	13	192,7	36,2	0,72	5,60	**0,40**	0,39
	D.1.4.2 1-1 (D.1.4)	270	6,03	1,00	0,72	5	270	0,50	9	193,5	36,0	0,72	6,03	**0,43**	0,42
1	***Nama Saluran Drainase : D.1.4.2.1***														
	5.4.4.2 0-1 (D.1.4.3)	400	0,73	1,00	0,72	5	400	0,50	13	194,0	36,0	0,72	0,73	**0,05**	0,05

Note:
Type 1- Trapezoidal if Ss>0, rectangular if Ss =0
type 2- Combined trapezoidal and rectangular only if trapezoidal d= 1.0 m,
type 3- Combined rectangular and circular bed, with R=B
type 4- for full flow if d=D and partial flow if d<D, practical d = 0.75 D
type 5- box conduit with full flow only, B=width, d=heigth

type channel	manning's [n]
concrete line	0.015
Concrete rubble masonry	0.020

APPENDIX D: DESIGN REVIEW

Project information

Location	:	Banda Aceh
Project owner	:	Departemen Pekerjaan Umum Dirjen SDA - SKS BRR Pengendalian Banjir dan Pengamanan Pantai (PBPP) Provinsi Nangroe Aceh Darussalam
Fiscal year	:	2005

Design information

Name Consultant	:	PT. Global Parasindo Jaya
Name Report	:	Survey Investigasi dan Desain (SID) Kanal Banjir Kota Banda Aceh (Lanjutan). Reports: Hydrology analysis (Analisa hidrologi); Inventory report (Laporan inventarisasi saluran); Analisa Kesesuaian dan Tata guna Lahan; Design report (Nota penjelasan); Final report (Laporan Akhir); Executive summary (Laporan Ringkas); Drawing (Gambar Perencanaan)
Scope of work	:	Topographic Survey; Geology and Soil Mechanic Investigations; Hydrology and Hydraulic Analysis; Detail Engineering Design: Channel; Management DPS; Economic Analysis
Status Report	:	DED
Estimated Start Tender	:	--

Review by SDC

Reviewer	:	Pak Hariyono
Date	:	September 2007

In the design review use is made of the following documents:

- Design guidelines Flood Protection & Urban Drainage; version 1 – February 2007; Sea Defence Consultants; registration number: SDC-R-60002;
- Hydrology Flood Protection & Urban Drainage; version 1 – November 2006; Sea Defence Consultants; registration number: SDC-R-60009.

B. DESIGN REVIEW

No	Scope	PT. Global P.J.	SDC	Remarks
A	**TOPOGRAPHIC AND TIDAL SURVEYS**			
1	BM Reference point	PBPP.08 X = 760950.451 Y = 616362.302 Z = + 2.597 m Linking by SDC : Z = + 1.604 m	BM BTJ.01 X = 759119.794 Y = 615943.177 Z = + 2.393 m	SDC made a link between PBPP.08 with NTJ01 and found a difference of - 0.99 m.
2	Tidal Surveys	Unavailable data	Linked to BM BTJ 01 HAT = + 1.218 m HHWS = + 1.018 m MSL = + 0.168 m LLWS = - 0.632 m LAT = - 0.732 m	Tidal variations not included in the design of PT Global. Overestimating the discharge capacity
3.	Geotechnical	- Test pit - Sondir - Hand boring - Laboratory test	- Sondir - Boring machine - Laboratory test	
B	**HYDROLOGY AND HYDRAULIC ANALISIS**			
1	**Hydrology**			
	Rainfall station	Banda Aceh (107)	Ulee Kareng (106b)	
	Rainfall depth, R.24	R2 yr = 119.36 mm R5 yr = 160.73 mm R10 yr = 188.12 mm	R2 yr = 107 mm R5 yr = 144 mm R10 yr = 169 mm	
	Method (discharge)	Rational Method	Rational Method	
	Sub-catchments areas (comparison results per drain see table end of review)	The catchments areas are less then according to the field condition	Boundary of Catchments areas following the up to date condition, according to the spatial plan of 2016.	Boundary of catchments area SDC different from PT. Global. Areas of PT Global are too low.
	Run-off coefficient (comparison results per drain see table end of review)	Under estimation	Refer to reference/ design guideline	Coefficients PT. Global not according to guidelines and are too low.
2	**Hydraulic analysis**			
	Method (comparison results per drain see table end of review)	• Manning equation • Qdesign = Q 5 yr. • n = 0.015 • without tide effect (steady flow) • with free board	• Manning equation • Qdesign = Q 5 yr. • n = 0.015, 0.02 and 0.022 • with tide effect (unsteady flow) • Main drain: with Secondary drain : without freeboard	In the design the tidal variations at the project boundary are not included by PT Global but do have impact in the discharge. Capacity is overestimated.
3	**Detail Engineering Design**			
	Channels	Design of rehabilitation, improvement & new channels.	Do nothing/ cleaning, rehabilitation, improvement and new channels	Due to underestimation of the required discharge the dimensions are

				sometimes too small. There is at some locations also no space available to widen the drains. The design does not solve the inundation problem according to the design guidelines.
	Structures	No design	Design of rehabilitation, improvement and new structures	The structures are not included but several needs to be improved. The design does not solve the inundation problem according to the design guidelines.
4	**Drawing**			
	Discharge	Hydrology calculation different from drawing.		Q_{design} <<< $Q_{drawing}$. Still the Q used at the drawing is too low
	Long section	Have followed the PU drawing standard	Following the PU design standard	
	Cross section	Unavailable	Following the PU drawing standard	Must to follow the drawing standard
	Freeboard	With freeboard	Main drain : With freeboard Secondary drain : No freeboard	The existing main drain have freeboard is sufficient

Table of Comparing of Sub-catchment's Area, Coefficient Run-off and Design Discharge by PT Global and SDC:

Designed PT Global	Catchments area	Runoff coeff.	Discharge	Reviewed by SDC	Catchments area	Runoff coeff.	Discharge
NC	CA (ha)	C	Q (m^3/s)	NC	CA (ha)	C	Q (m^3/s)
10.1.c	42.75	0.43	1.13	5.4.a	31.25	0.72	2.20
10.1.d	50.50	0.56	1.67	(incl.5.4.b)			
10.1.e	82.75	0.35	2.00	5.4.b	134.71	0.72	9.29
10.1.f	100.25	0.33	2.30	5.4.c	181.15	0.72	12.75
10.1.g	225.75	0.23	2.73	5.4.e	251.48	0.72	16.44
10.1.1	6.00	0.52	0.23	5.4.2.a	5.60	0.72	0.39
10.1.2	8.00	0.50	0.21	5.4.3.a	5.63	0.72	0.45
10.1.3	11.25	0.54	0.33	5.4.4.c	30.10	0.72	2.09
10.1.5	24.00	0.47	0.43	5.4.4.d	56.32	0.72	3.87
10.1.6	17.00	0.56	0.56	5.4.3.c	21.59	0.72	1.46
10.1.7.a	18.50	0.56	0.63	5.4.2.c	44.15	0.72	3.06
10.1.7.b	125.50	0.26	2.54	5.4.1.a	55.48	0.72	3.99

C. CONCLUSION

- The reference point for topographic surveys (SDC) used BM Bakosurtanal i.e BM BTJ 01 (X = 759119.794, Y = 615943.177, Z = + 2.393 m). The design of PT Global is not linked to BTJ01. When SDC links the two benchmarks a difference of -0.99 m is found.
- PT Global did not include impact of tidal variations in their design. This overestimates the discharge capacity of the system. It is important to include the impact of the tidal variations.
- The design discharge calculations based on the hydrology analysis by PT. Global differ from the design discharges values on the drawing. The design discharges on the drawing are higher but still too low compared to the calculations by SDC.
- Structures like culverts are not included in the design of PT Global. These structures also require improvements. Without improvement of these structures the flooding problem will not be solved according to the design guidelines. The design pf PT Global is thus not complete.
- In the design of PT Global extra drain width is required. However, at some locations widening the drain is not possible.
- The design by PT. Global does not solve the inundation problem according to the design guidelines. The design must be reviewed. SDC will improve the design according to the design guidelines.