INUNDATION CONTROL AT DENSELY POPULATED AREA CIGUGUR TENGAH

Asep Sulaeman *1)
Sudarta *2)
Isti Puji Rahayu *3)
Balai Sungai: Jl solo-kartosuro km 7 Surakarta
Email: spsulaeman@yahoo.co.id

High densely populated area resulted in a decreased function of water infiltration. Almost 100% of the lots into the building. So also happened in the region, particularly at Cigugur Tengah RW 14 and RW 15. Accompanied with bad drainage conditions resulted a lot of inundation when it rains. The design drainage improvements consists of: Control the inflow, modification weir, sluice and repair drainage system.
Keywords: High densely populated area, drainage system.

I. INTRODUCTION

I.1 Background

Central Cigugur ward, especially at RW 14 and RW 15, is an area that been selected as a model of a densely populated residential area development in research activities conducted by Research Center for Human Settlement, Agency for Research and Development, Department of Public Works. Central Cigugur ward is located in the District of South Cimahi, Cimahi, West Java.

This area was chosen as a model of development with consideration:

- located in the Cimahi city acces, so the Cimahi municipality desire to beautify this area;
- people in middle to lower economic groups need help to improve their environment quality;
- high dense residential both their population and building house, so the building development increasingly chaotic;
- the location close to business area caused many immigrants who settled here that increase the clutter of houses;
- residential infrastructure such as sanitation, roads and drainage are inadequate.

From a few wishes of the people who got responses from Researcher of Research Center for Human Settlement is an inundation flood control in this area. from these conditions, before the development of design that could be accepted by society is made, earlier we made efforts to control floodwaters.

I.2 **Problem Identification**

City development resulted in land use changes. Land use changes without environmentally approaches can damage the environment system. City development which is dominated by building without green space considertion make increasing runoff. In fact at Central Cigugur, drainage system give contribution on resulting frequent inundation. So concepts drainage system settings is required.

I.3 Problem definition

Activities undertaken are handling the concept of flood inundation on existing conditions and landscape development.

I.4 Objective

The objective of this paper is to design a control system of flood inundation on the population density location in RW 14 RW 15 Central Cigugur ward, South Cimahi.

I.5 Location

Location of this Densely Populated Regions Development Model Plan which has an area of 11.6 ha is located on the left side, Northeast of Ciputri River. Upstream side is restricted by the Railway Bandung - Jakarta, while the lower stream is restricted by Gajah Leuwi Road. Area of the model is a region of RW 14 and RW 15, Central Cigugur ward, District of South Cimahi, Cimahi, West Java Province.

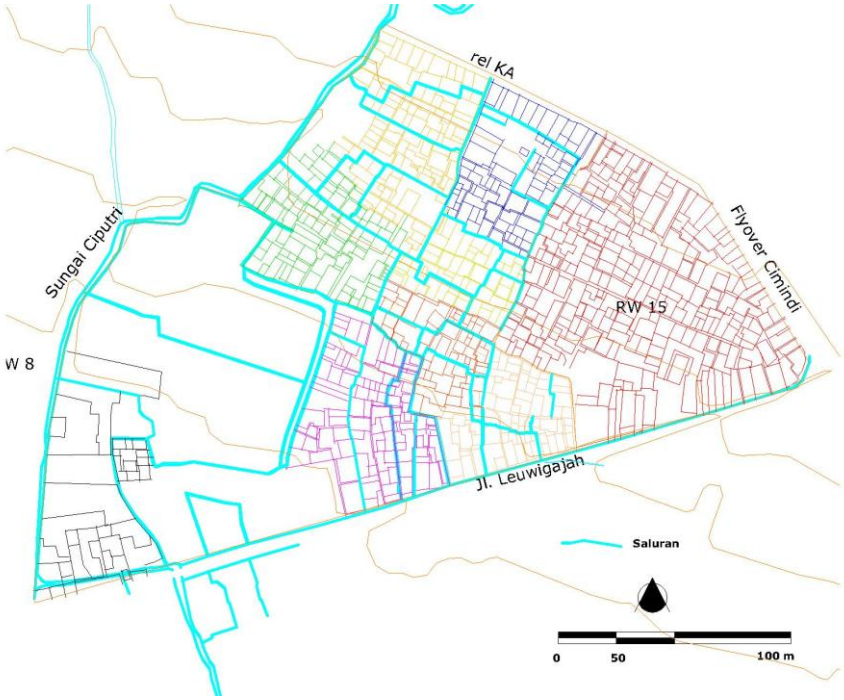


Fig 1. Drainage Network

II. LITERATURE REVIEW

2.1 Surface Flow

Runoff is influenced by many factors simultaneously. Generaly factor that influence grouped into 2 (two) namely meteorological factor and watershed characteristic.

1) Meteorological Factor
   Meteorological factors that influence towards surface flow i.a: rainfall intensity, rainfall duration, rainfall distribution
2) Watershed Characteristic
   Watershed characteristic cover these parameter : watershed area and shape, topography, land use.

2.2 The Change of Land Use

Based on population estimation until 2000, to accommodate the increasing population is needed house about 1.750.000 unit/year. With assumption, the average width of the lots is 100 m^2 that was established width (60% of total width) where 40% for network system and residential facilities, it's mean need 30.000 ha new land every year. (Kodoatie and Sugiyanto, 2002)

The change of land use that irregular and unwell planned give big contribution towards sharp increase in river discharge as natural drainage channel. For example, a River Drainage Area which was originally a forest has discharge 10 m^3/s, if it is changed into rice fields, then the river discharge will be 25 to 90 m^3/s

or there is discharge increasing in the amount of 2,5 to 9 times from original discharge. If the forest is changed become commercial or industrial area then the original discharge is 10 m^3/s will increase sharply to between 60 to 250 m^3/s or increase become 6 to 25 times from the original discharge. (Kodoatie and Sugiyanto, 2002)

While Prince George's County Maryland (1999) mention that for area which still natural and not yet built, produce surface flows about 10 – 30% from total rain. If the area was built will affect surface flow increases to 50 % of the total rainfall. Further efforts to prevent flood on some area usually made drainage, but with drainage can increasing the surface flow. The change of surface flows characteristic of a watershed will increasing volume and surface flow rate which would cause flood, increasing erotion, reduction in the charging of underground water, and role in reducing surface water quality and damage the ecological system.

Impact of the changes in land use will be strongly felt by community in downstream area. From the numbers above, normalization programs that enhance the capacity of river 2 – 4 times the discharge will not enough to overcome flood. For that we need a comprehensive program, integrated and environmentally sound management of water resources so that negative effects of excess water or flooding can be controlled.

2.3 Basic Concept of Environmentally Drainage Development

Development as much as possible to reduce the negative aspects of development of an area usually called as *Low Impact Development*-LID. The effectiveness of LID is depend on local conditions, such as weather, land and socioculture. Besides that not every place can use LID optimally because the use of LID can not replace all functions of a conventional drainage water management.

LID is a way of designing region with aim to maintain and mimicking the hydrological characteristics of an area before development. Hydrological function such as storage, infiltration and charging groundwater or to maintain volume and frequency of surface flow discharge during using the handling of rainwater flow on small scale that comprehensive and integrated, both retention and detention areas, impervious surface reduction and extend the groove flow and time of concentration. (Coffman, 2000)

The basic concept depicting the essence of LID is must process the overall area plan for achieving success and plans that can be implemented. These basic concept such as (Departement of Environmental Resources Maryland, 1999) : use of hydrology as a framework, thinking micromanagement, Controlling the flow of rain at its source, Use the simple and non-structural methode, Creating a multifunctional area. LID created as a system consisting of several parts, each of which has specific functions in the handler surface rainwater. The units of LID include : Bioretensi, infiltration wells, land filter, buffer vegetation, grass channel, vegetation buffers, rain barrels, infiltration channels and permeable pavement. Not all components must exist, but depends on land needs and condition so that the combination of units can function optimally LID

III. EXISTING CONDITION OF PLAN MODEL AREA

II.1 Existing Drainage Conditions

Ciputri Rivers which have upstream area in Bandung regency passed on the right side of Development Model and then flows into Bandung City before finally empties in the Citarum River. The average width of river about 2.00 m with a depth of about 2:00 m. In the upper side of Model (the upper Road Train) there is an intake with permanent weir that supply water for flushing the waste in the Model Region. In the

downstream region, there is weir to serve the intake water to flushing in the downstream region. The weir with flushing gate (recently renovated) cause backwater that often over flowed during floods into the surrounding area.

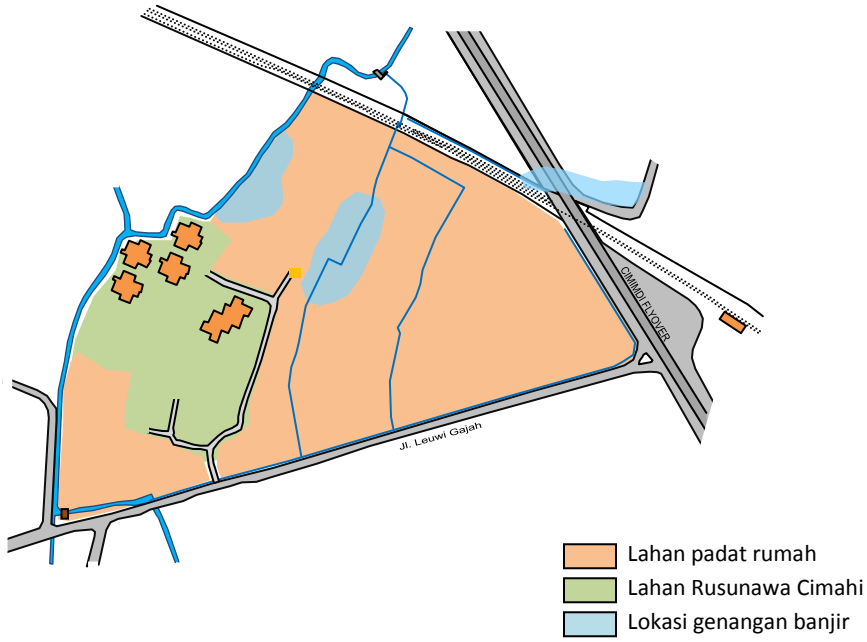


Fig 2. Model Development Plan Cigugur region

Ciputri river conditions that often overflow cause the drainage in this area that goes straight into the river is disrupted. From the upstream there is culvert that crossing rail into the region. This channel comes from the upstream drainage area and there are additional inflow from the intake in Ciputri. The function of channel as flushing of domestic waste in this region, but when the rain was increasing the load of surface flow drainage channel in the model.
With the highway in the east of the region, cause changes of some surface flow into the region and aggravate the load of drainage.
Drainage in the area is very irregular and dimensions of the channel being pressured by various interests mainly of houses and other facilities. Most of the drainage channel in the form of a closed channel by making use of road space environment.

IV. ANALYSIS OF FLOOD INUNDATION REDUCTION CONCEPT

IV.1 Simulation Existing Conditions

By simulating rainfall-runoff using EPA SWMM 5.0 using two year return period annual rainfall with intensity of 56.67 mm / day (data from Bappeda Cimahi muncipality), ± 11 ha area, Data channel divides by three different types of dimensions: in x width = 0.75 mx 1 m, in width x = 0.5 mx 0.8 m, in width x = 0.5 mx 0.5 m. additional inflow of surface runoff are considered from outside the catchment entering a channel with a discharge of 1 m3 / s. land cover conditions almost full of impervious area.

Table 1: Results of the simulation on existing condition

Link	Type	Maximum Flow CMS	Time of Max Occurrence days	hr:min	Maximum Velocity m/sec	Max/ Full Flow	Max/ Full Depth	Total Minutes Surcharged
U1	CONDUIT	1.039	0	00:00	3.07	0.61	1.00	350

U2	CONDUIT	0.746	0	00:36	1.30	1.14	0.77	147
U3	CONDUIT	0.639	0	00:36	1.35	0.85	0.63	0
U4	CONDUIT	0.381	0	00:36	1.10	0.63	0.46	0
U8	CONDUIT	0.105	0	00:36	0.85	0.26	0.31	0
U5	CONDUIT	0.353	0	00:36	1.88	0.46	0.47	0
U6	CONDUIT	0.272	0	00:36	1.42	0.28	0.52	0
U7	CONDUIT	0.210	0	00:35	0.81	0.56	0.65	0
U9	CONDUIT	0.083	0	00:37	0.24	0.01	0.13	0
U10	CONDUIT	0.112	0	00:37	0.67	0.10	0.42	0
U11	CONDUIT	0.034	0	00:35	0.43	0.54	0.20	0
U13	CONDUIT	0.367	0	00:37	1.52	0.52	0.61	0
U12	CONDUIT	0.056	0	00:35	0.75	0.09	0.18	0
C7	CONDUIT	0.192	0	00:35	1.48	0.24	0.26	0
C1	CONDUIT	0.351	0	00:05	1.41	1.34	1.00	358
C2	CONDUIT	0.177	0	00:36	0.71	1.04	1.00	16
C3	CONDUIT	0.680	0	00:00	4.36	35.26	0.83	360
C4	CONDUIT	0.333	0	00:36	1.44	0.81	0.92	0
C5	CONDUIT	0.117	0	00:36	0.67	0.30	0.70	0
C8	CONDUIT	0.192	0	00:02	0.83	0.17	0.48	0
K1	CONDUIT	0.000	0	00:00	0.00	0.00	0.09	0
K2	CONDUIT	0.056	0	00:36	0.37	0.08	0.38	0
K4	CONDUIT	0.125	0	00:38	0.73	0.47	0.43	0
K3	CONDUIT	0.022	0	00:37	0.71	0.02	0.33	0
26	CONDUIT	0.663	0	00:07	1.27	1.90	0.73	357
SU1	CONDUIT	26.686	0	00:00	10.03	0.76	0.67	0
SU2	CONDUIT	11.028	0	00:00	5.61	1.25	0.83	2
SU3	CONDUIT	9.528	0	00:03	3.25	0.62	0.85	0
G1	CONDUIT	0.125	0	00:38	1.11	0.03	0.07	0
G2	CONDUIT	0.179	0	00:38	0.78	0.04	0.15	0
G3	CONDUIT	0.546	0	00:38	1.87	0.14	0.19	0
C6	CONDUIT	4.004	0	00:02	1.60	0.43	1.00	359
C9	CONDUIT	0.107	0	00:37	1.17	0.17	0.24	0
g4	CONDUIT	0.652	0	00:38	2.64	0.10	0.16	0
2	WEIR	5.768	0	00:04		1.00	0	

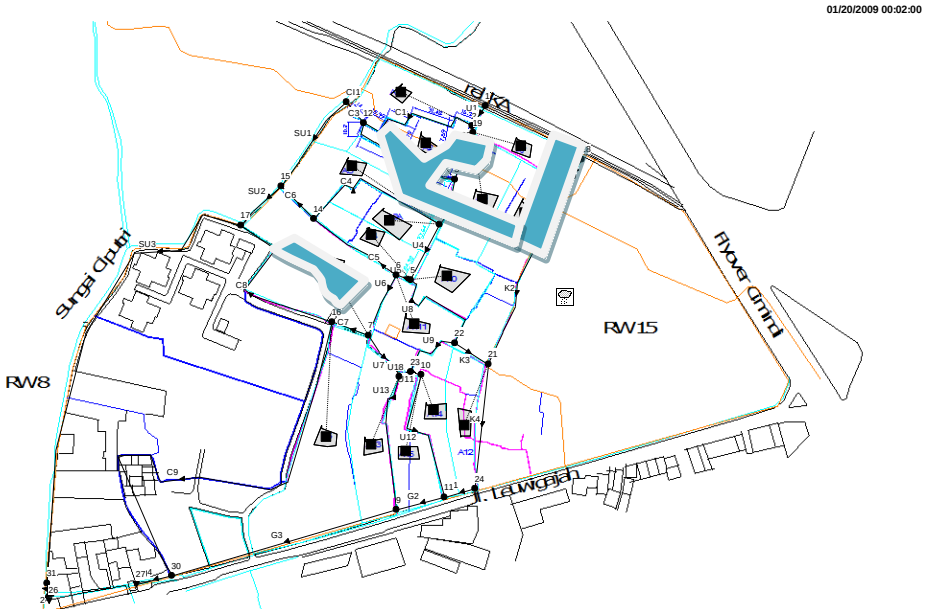


FIG 3. Simulation drainage

Considering impervious land use coverage almost 100% of the total area and the existing drainage network conditions are so complicated and inadequate dimensions, its resulted inundation occurs every rainfall. From the simualtion we can see that overflows happened on drainage that flows into the Ciputri River, this overflows occured as a result of the drainage outlet elevation is lower than the river water level Ciputri so happens backwater.

In addition there are overflows occurred on main drainage chanel . its occurs because of inflow from outer drainage catchment. That resulted the channel capacity is inadequte.

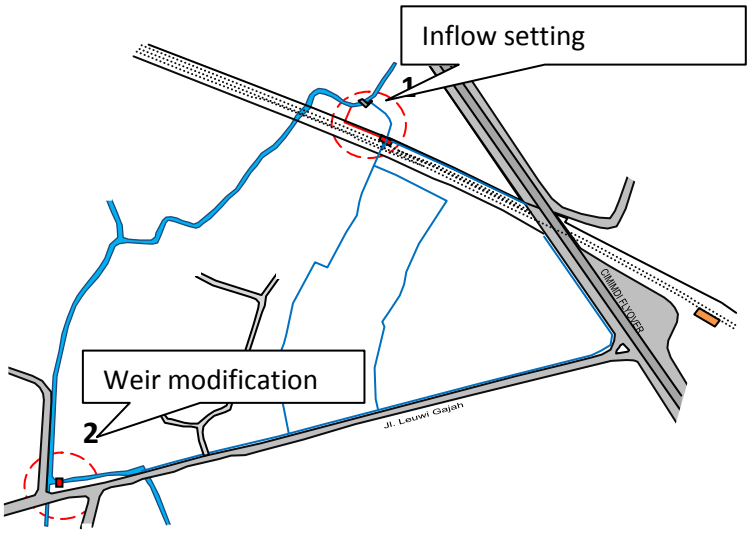
IV.2 Improvement Drainage Concept

From Bapeda of Cimahi municipalality obtained information that has not been prepared for Cimahi City Drainage Master Plan. Drainage Work is still carried out based on the fragmentary local conditions. Therefore, the improvement of drainage systems in the area of development models, there is no reference.

Drainage improvements aim to eliminate inundation in the residential population during the rainfall. Considering the inundation that occurs is influenced by hydrological conditions of the external and internal drainage area model, it is also related to the improvement of external control and internal improvements.

A. External Control

Considering the hydrological conditions of the model, there are 2 (two) repair activities can be applied to reduce the load of runoff that caused inundation in the area i.e: controlling the inflow model and the modification of weir / sluice.



External Improvement Works Location

To compare this change made the same simulations with the existing condition but changing the inflow discharge of 1 m3 / s becomes 0 m3 / s and long sections of weir from 0.8 m to be 2 m. The simulation results shown in the table below.

Link	Type	Maximum Flow CMS	Time Of Max occurrence days hr:min	Max Velocity m/sec	Maximum Full Flow	Max / Full Depth	Total Minutes Surcharged

U1	CONDUIT	0.845	0	00:00	2.82	0.50	0.40	0
U2	CONDUIT	0.107	0	00:37	0.54	0.16	0.26	0
C1	CONDUIT	0.058	0	00:01	0.74	0.22	0.41	0
C2	CONDUIT	0.051	0	00:37	0.45	0.30	0.46	0
C3	CONDUIT	0.417	0	00:00	3.16	21.60	0.59	94
C4	CONDUIT	0.104	0	00:37	1.20	0.25	0.37	0

From the simulation can be seen that the overflow that occurred only at Chanel C3 that has a low elevation outflow compared to the position of the riverbed. While the lack of inflow, making the main drainage capacity is able to drain the water. Control of the inflow from outside the model and modiifikasi weir can be done with:

1) Control inflows

Flow control is done by the principle:

- excess return flows from upstream dumped into the River Ciputri.
- Fulfilled the need for flushing
- large discharge channels are controlled in order to not overflow and cause inundation

To meet the above requirements it is necessary to the installation of floodgates on the channel train to cross the road and dump into the river channel mebuat Ciputri.

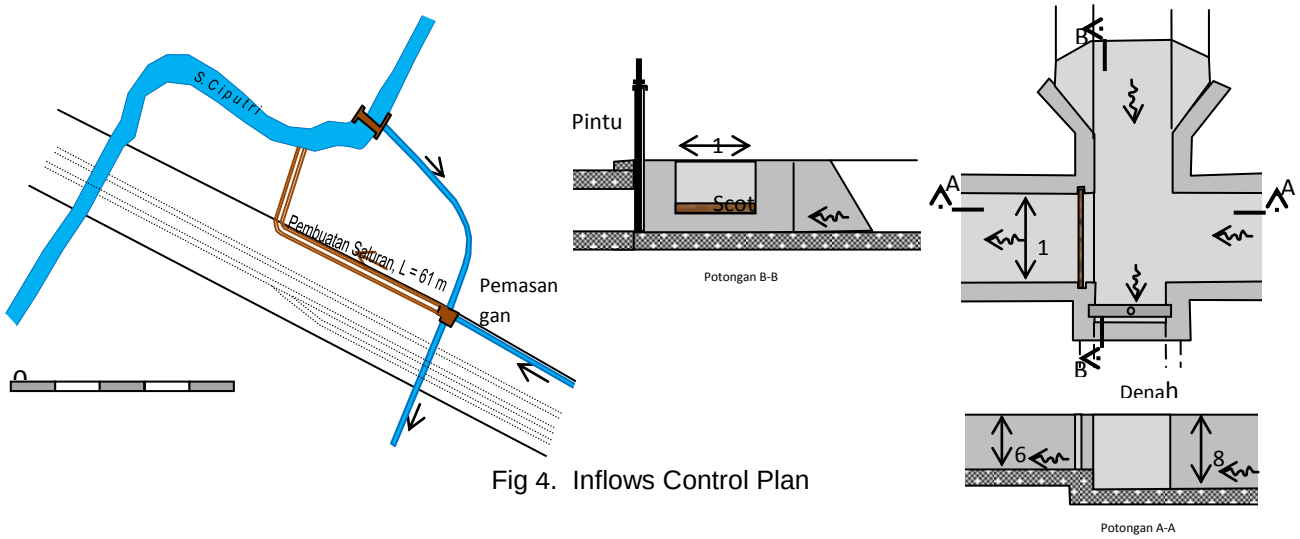


Fig 4. Inflows Control Plan

. 2) Modification of Weir and Sluice

The existing weir and sluice technically inadequate because the water intake for flushing when the normal discharge need to raise surface elevation that can be made by additional weir with wooden beams, while when flooding is limited to drain the water becouse it is done by opening the sluice that 80 cm wide only.

To improve the performance of the should be modified into an automatic motion, so that:

- Water surface elevation can be regulated
- Sluice open automatically at the time of flood.

Weir made of steel doors with the form as described in the following figure 5.

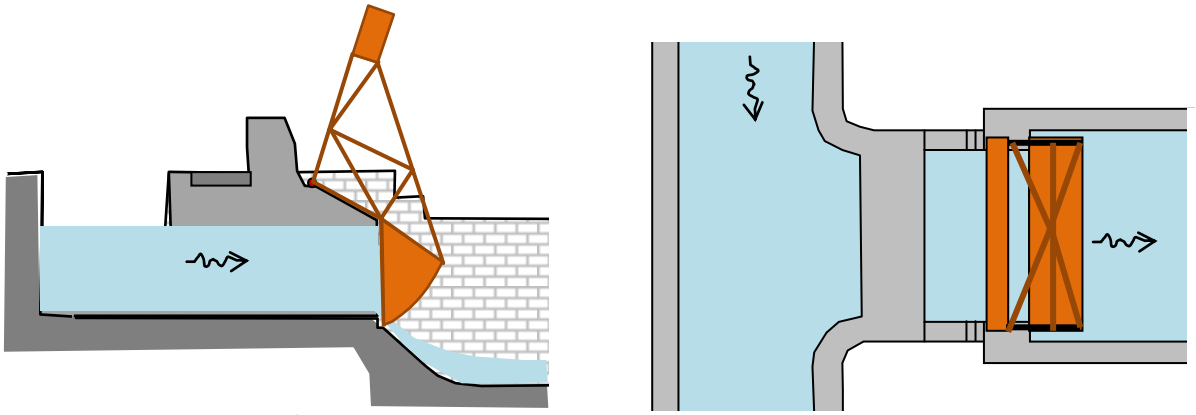


Fig.5 Sluice image

B. Internal Improvement

Internal Improvement of drainage is adjustment the micro drainage network within the model area. Drainage network is designed to adjust with the possible development of the region.

Alternative 1. Improvement of drainage system on the condition of Status Quo

Work such as repairs of existing drainage chanel, which are cleaning, dredging and channel settings. This will increase the channel capacity and accelerate flow velocity.

IV.3 Improving the drainage system by following the development of a densely populated area

Research Center for Human Settlement is studying the development of residential areas of high population density the same location. Schematic model to be developed can be seen in Figure 6. Densely populated area development approach by considering the adequacy of open spaces. The provision of green open spaces provide opportunities for environmentally sound management of hydrology. Approach to developing an environmentally sound drainage filososfi change from the original drainage water as fast as spending becomes drainse capable of intercepting and storing water as long as possible while maintaining the aesthetic environment.

Development of environmentally sound drainage can do with a lot of combinations. One combination that is possible by the installation of bioretenstion, grass channels, vegetation cover and permeable pavement. Development Bioretenstion location plotted each building lots so drainage flows will disconected that cause reduce velocity and time concentration.

Bioretention needs done by dividing each buildings with an area average of 1 ha. By using the calculation method Manual LIDs from Prince George's County, Maryland, needed two bioretenstion size 12 x 12 m with 0.60 meters depth and storage inundation high as 12 cm and a void ratio of 30%, bioretensi must be equipped with outlet channel. With multifunctional approach, bioretention location can be placed on the location of the park, so the impression of a pool of water can be eliminated, and would give it more aesthetic value and security.

Problems that will be faced is bioretenstion is the necessity of making regular maintenance, which, if there is no maintenance cause function will be lost and the water will overflow.

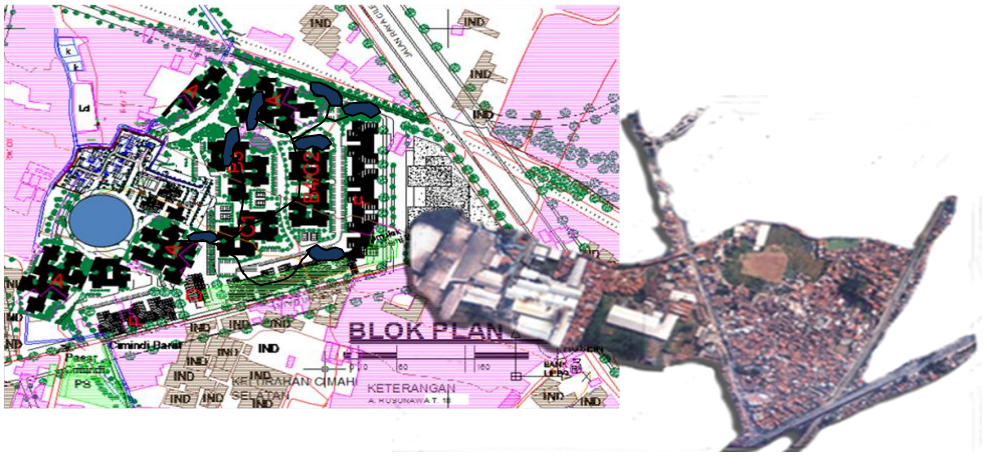


Fig 6. Development schematic model

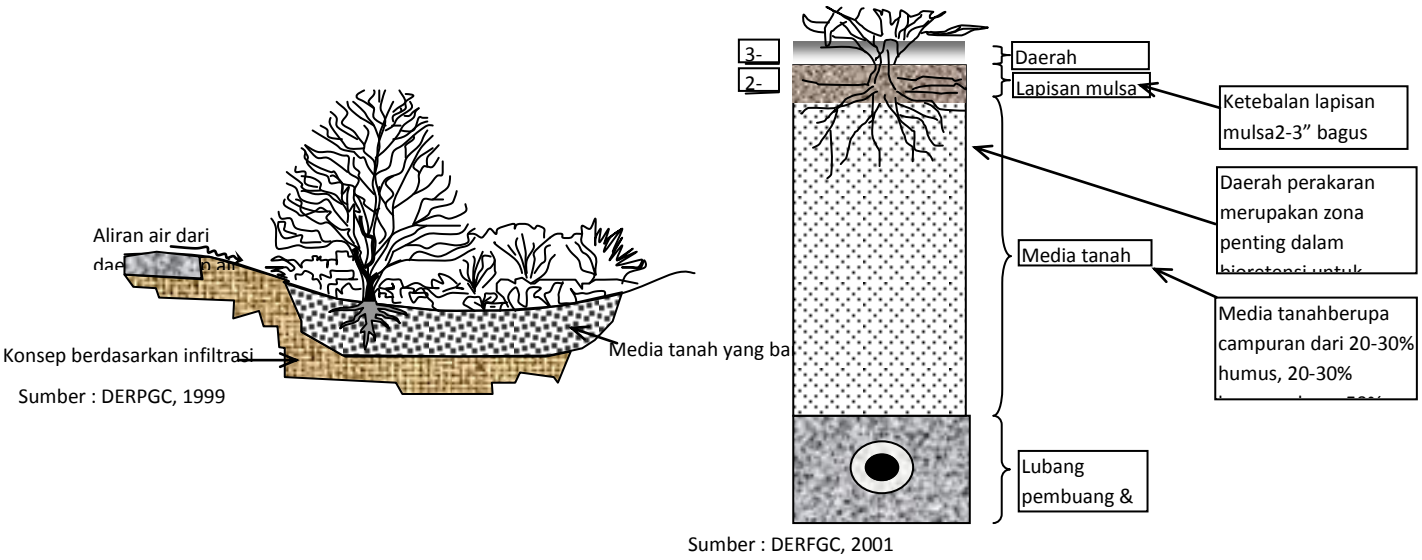


Fig 6. Bioretention Concept

V. CONCLUSION

1. Land condition in densely populated areas have an impermeable land cover type because nearly 100% of water used as building lots.
2. In densely populated areas is almost entirely rainfall becomes runoff.
3. Inundation occurs due to an irregular drainage networks, Inflow from outside the catchment area, and threre is weir on downstream of Ciputri River that cause backwater
4. Drainage control concept: Control the Inflow from Outside catchment, Weir Modification and sluice, and improvement drainage network system.
5. Within the framework of development of the region required environmentally sound drainage system , one combination that might be done with the installation such as bioretention, grass channel, vegetation cover and impermeable pavement.

IV. Bibliography

1. **Department of Environmental Resources** (**DERPGC), June 1999**: "***Low Impact Development Design Strategies***", Integrated Design Approach, Prince George's County, Maryland.
2. **Suripin : Sistem Drainasi Perkotaan Yang Berkelanjutan**, Andi, Yogyakarta, 2004.
3. **United States Environmental Protection Agency** (USEPA), **June 2007**: "***SWMM User's Manual Version 5.0 (Revision)***", Cincinnati, Ohio.