

## Water use and drainage in Colombia

### Case Study: "The Stormwater Challenge in Barranquilla"

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## Colombia (South America)

Location:



Source: Wikipedia

Population: 45 million (2008) (DANE-Colombia)  
Urban Population: 80% approx.

Fertility rate: 2.5 children/woman

Gross Domestic Product (GDP):  
Rank: 29, \$374.4 billion (2006) (CIA Fact Book)

Life expectancy: 73 years

Main cities:  
Bogota, DC: 7.0 million  
Medellin: 2.3 million  
Cali: 2.1 million  
Barranquilla: 1.2 million

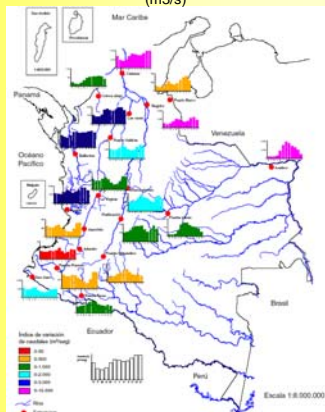
Main language: Spanish

Currency: Colombian Pesos  
1 Dollar = 1,900 Pesos approx. (Feb/2008)

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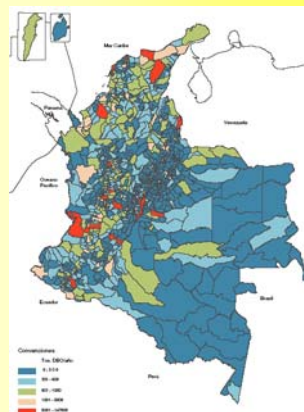
## Quantity and Quality Water Indicators

Multiannual monthly media flow rate variation (m3/s)



Source: IDEAM - Colombia

Municipal Annual BOD production (Ton/year)

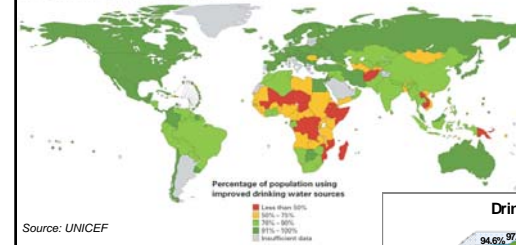


Source: IDEAM - Colombia

## Drinking Water Coverage

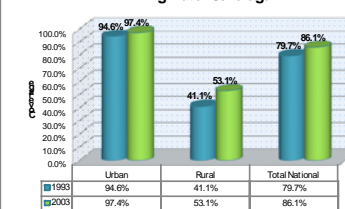
Good water coverage attained in most regions

Figure 1 Coverage with improved drinking water sources in 2002



Source: UNICEF

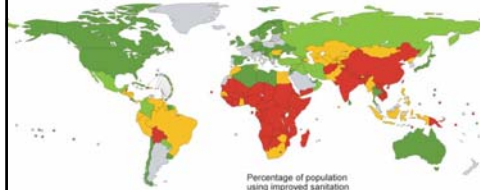
Drinking Water Coverage



Source: Corporación de Regulación de Agua Potable y Saneamiento Básico - CRA, Colombia

## Sanitation Coverage

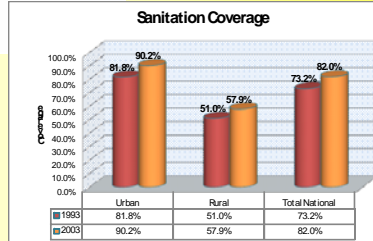
Half the developing world are still without improved sanitation  
 Figure 7 Sanitation coverage in 2002



Percentage of population using improved sanitation

- Less than 50%
- 50% - 75%
- 75% - 90%
- 91% - 100%
- Insufficient data

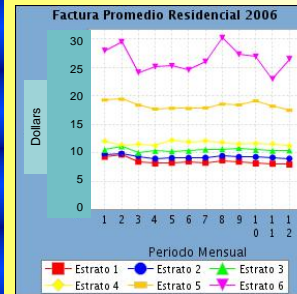
Source: UNICEF



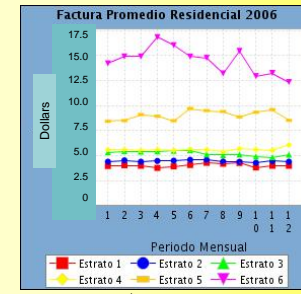
Source: Corporación de Regulación de Agua Potable y Saneamiento Básico - CRA, Colombia

## Drinking Water and Sanitary Sewer Cost

Monthly Average Drinking water bill



Monthly Average Sewer bill



(Source: CRA - SIA Colombia)

Annual Average Water Consumption: 74 L/person/day  
 Average drinking water charge/m<sup>3</sup>: \$0.8/m<sup>3</sup>

(Source: Super Intendencia de Servicios Públicos - Colombia: Informe 2006)

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## Some Interesting Water Issues in Colombia

- Magdalena River: Flooding and Navigability Issues
- Environmental Recovering of the Bogota River
- Improvement of Drinking Water Service in Colombia
- Improvement of Sanitation Coverage in Colombia
- The Stormwater System Challenge in Barranquilla

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## The Stormwater System Challenge in Barranquilla



Arroyo Peligroso = Dangerous stream

(Source: [labatrosuradebarranquilla.blogspot.com/](http://labatrosuradebarranquilla.blogspot.com/))

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## The Stormwater System Challenge in Barranquilla



- Barranquilla is currently lacking of a Stormwater Sewer System.
- Stormwater runoff flows on the streets, causing paralysis in the city.
- This situation occurs every year during the raining season.
- At least 20 rain events cause high risk situations every year.
- Cars have been dragged and people killed. The situation is worse downstream, where thousand of citizens are in high risk.

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1986

<http://www.arroyosdebarranquilla.org/Galeria.htm>

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1988

<http://www.arroyosdebarranquilla.org/Galeria.htm>

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Today is even worse!!

<http://www.arroyosdebarranquilla.org/Galeria.htm>

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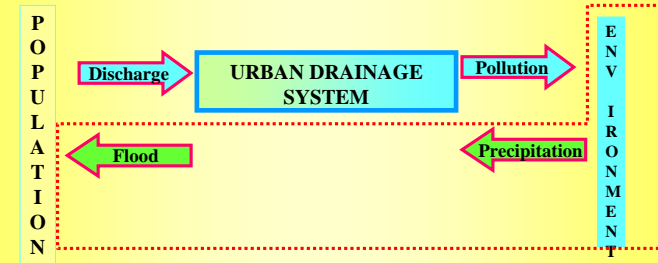
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## The Stormwater System Challenge in Barranquilla

<http://youtube.com/watch?v=nL89vix-TSk>

<http://www.youtube.com/watch?v=PPmhbq9OMjs&feature=related>

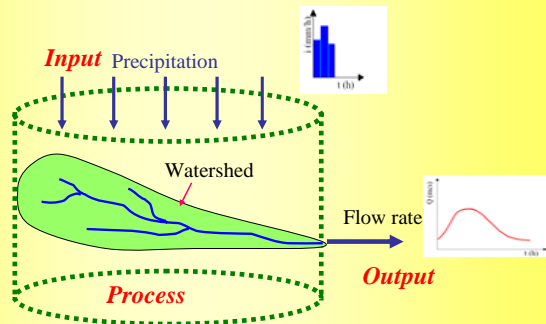
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Butler, 2000

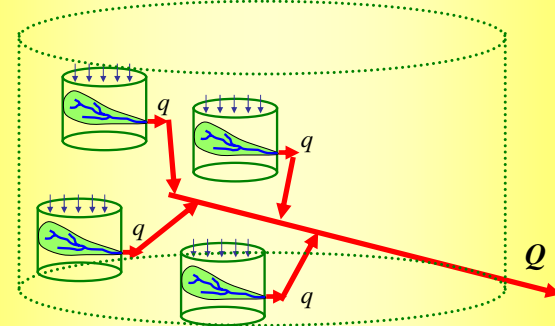
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## Precipitation – Watershed – Runoff

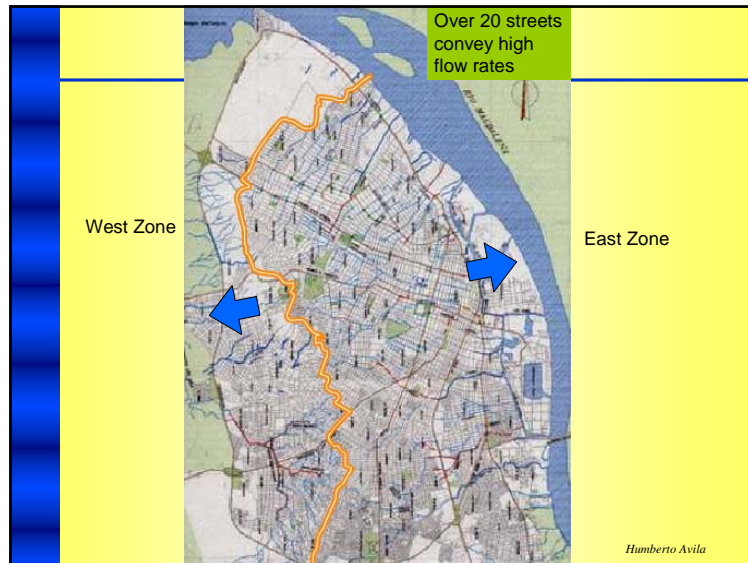


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## Precipitation – Watershed – Runoff



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## Rain Characteristics in Barranquilla

Total annual average: 800 mm/year

- Intensity: 100 mm/day (max).
- Duration: 90 a 120 min.
- Raining Season: May to November. Highest intensity in September and October.
- Typical raining time: Between 11:00 am and 4:00 pm (Fonade)
- Lack of high resolution hydrologic data!!
- Rain data every 5 min?
- Spatial distribution of rains?
- Several new weather stations have been installed recently.

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## Urban Watershed Characteristics

- Lack of Stormwater Sewer System
- High percentage of Impervious areas
- Gardens are not designed for infiltration purposes



Barranquilla



Westchester Environment Magazine Jan-Feb, 2003, Vol. 2003 No. 1  
[www.fcwc.org/WEArchive/010203\\_wb/rain.htm](http://www.fcwc.org/WEArchive/010203_wb/rain.htm)

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## Urban Watershed Characteristics

Topography: High slopes cause dangerous high velocity flows and road damages.



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## Urban Watershed Characteristics

- Some main streets are Main channels!!



84<sup>th</sup> Street and 53<sup>th</sup> Avenue

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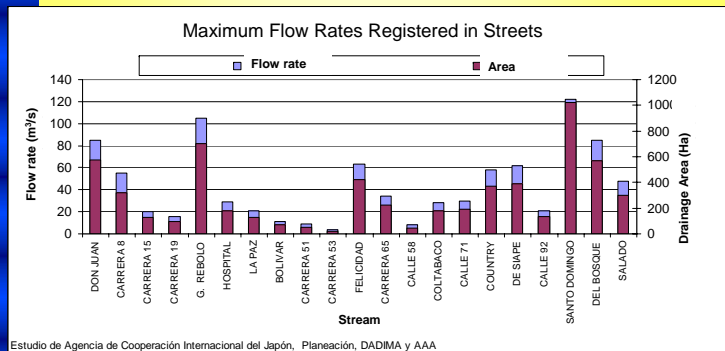
## Urban Watershed Characteristics

- High sediment and litter transport cause environmental problems.
- Natural streams are affected by high peak flows and pollutants associated with stormwater runoff.



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## Maximum Flow Rates



100 m³/s = 3,500 ft³/s  
1 Ha = 2.5 acres

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## Characteristics of Street Streams

STREAM NAME	A.I	L	S%	O	LAND USE
	(Ha)	(Km)	Prom	(m³/s)	
DON JUAN	572	7	0.74	85	RESIDENCIAL, VACANTE
CARRERA 8	320	4.2	1.15	55	RESIDENCIAL, INDUSTRIAL
CARRERA 15	126	3	1.05	20	RESIDENCIAL, INDUSTRIAL
CARRERA 19	97	1.8	1.1	16	RESIDENCIAL
G. REBOLO	705	5.5	1.25	105	RESIDENCIAL, INDUSTRIAL
HOSPITAL	181	4.5	1.1	29	RESIDENCIAL, COMERCIAL
LA PAZ	129	3.2	1.45	21	RESIDENCIAL, COMERCIAL
BOLIVAR	70	1.7	1.2	11	COMERCIAL
CARRERA 51	51	1.2	1.93	9	RESIDENCIAL, INDUSTRIAL
CARRERA 53	20	0.7	1.7	4	RESIDENCIAL, INDUSTRIAL
FELICIDAD	424	5.6	1.93	63	RESIDENCIAL, INDUSTRIAL, COMERCIAL
CARRERA 65	226	4.7	1.95	34	RESIDENCIAL, COMERCIAL, EDUCACIONAL, MILITAR
CALLE 58	45	1.7	1.6	8	RESIDENCIAL, INDUSTRIAL
COLTABACO	176	4.7	1.86	28	RESIDENCIAL, INDUSTRIAL, COMERCIAL
CALLE 71	189	2.6	2.06	30	RESIDENCIAL, INDUSTRIAL, COMERCIAL
COUNTRY	371	4.9	2.16	58	RESIDENCIAL, INDUSTRIAL, COMERCIAL, MILITAR
DE SIAPE	389	5.2	2.6	62	RESIDENCIAL, INDUSTRIAL, COMERCIAL, EDUCACIONAL
CALLE 92	131	2.1	2	21	RESIDENCIAL, EDUCACIONAL
SANTO DOMINGO	1020	11.41	1.1	122	RESIDENCIAL, INDUSTRIAL
DEL BOSQUE	569	10.12	1.3	85	RESIDENCIAL, COMERCIAL
SALADO	298	6.33	1.95	48	RESIDENCIAL, COMERCIAL, INDUSTRIAL, MILITAR

Supercritical Flow !

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## Consequences

- Pedestrians and cars have been dragged by the high energy currents. Sadly, many people have been killed by the street currents.
- The economy of the city is greatly affected during rain events. The street currents isolate areas of the city, making impossible the traffic of vehicles and pedestrians.
- Citizens located in downstream areas are always at high risk, especially the low income population whose houses are located near the streams.
- The infrastructure of the city is affected. The high velocity flows damage the streets and the maintenance budget becomes insufficient every year.
- The city becomes less attractive for investment due to the serious consequences to the transport service.
- Additional consequences may be identified !

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## Potential Solutions

### Complete and detailed diagnosis of the problem:

- ✓ Hydrology and Hydraulics.
- ✓ Identification of high risk areas in the city and their needs.
- ✓ Vulnerability of receiving water bodies (creaks and lakes) to implement solutions environmentally effective in terms of quantity and quality of runoff.
- ✓ Other solution...

*The objective is not to convey the runoff fast and dirty, but wisely and clean!*

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## Potential Solutions

### Peak flow reduction and pollution prevention:

- ✓ Increase the effective permeable areas in the city to reduce the peak flows; rain gardens are suitable.
- ✓ Build temporary storage structures to increase the time at peak. The storage structures can be built in small scale (houses) and in large scale (detention ponds and tanks).
- ✓ Implement stormwater quality controls for small-storm hydrology.
- ✓ Other solutions...

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## Potential Solutions

### Conveying System

- Build a conveying system in the whole city is expensive but totally necessary. The construction can be conducted in phases. If a 2-decade-investment Master Plan is suitable, why not?!
- Bridges and box culverts with a low-urban- impact architecture design may be built on streets where no sewer pipes are suitable.
- **However**, the conveying system is only a part of a stormwater sewer system, and it is insufficient by itself, especially when high peak flows are present and for water quality purposes.
- The conveying system should operate with other stormwater structures such as rain gardens, detention ponds, temporary tanks, etc.

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## Potential Solutions

Several local and international companies and agencies have suggested solutions for this challenge:

1920 Herbard & Company  
1956 Town Planning Colaborative  
1982 Arzuza and Arzuza  
1983 Japan International Cooperation Agency  
1985 Hernado Heilbron  
Some other companies ...

However, non of these solutions have been implemented either for not being entirely conclusive or for their high cost of investment.

*Humberto Avila*

*Barranquilla has now two challenges: Solve its past and plan its future. We are still working on these challenges.*

Thanks !

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*Humberto Avila*