



DEPARTEMEN TEKNIK SIPIL
SEKOLAH VOKASI
UNIVERSITAS GADJAH MADA

Analisis Hidrologi dan Drainase

Konsep Hidrologi

13.02.2020

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Website: <http://wakhidatik.staff.ugm.ac.id/>

Concept

what

- Hydrology : the science of water (occurrence, circulation, distribution of water on earth & earth's atmosphere)
- **Two basic concepts: hydrologic cycle & water balance**

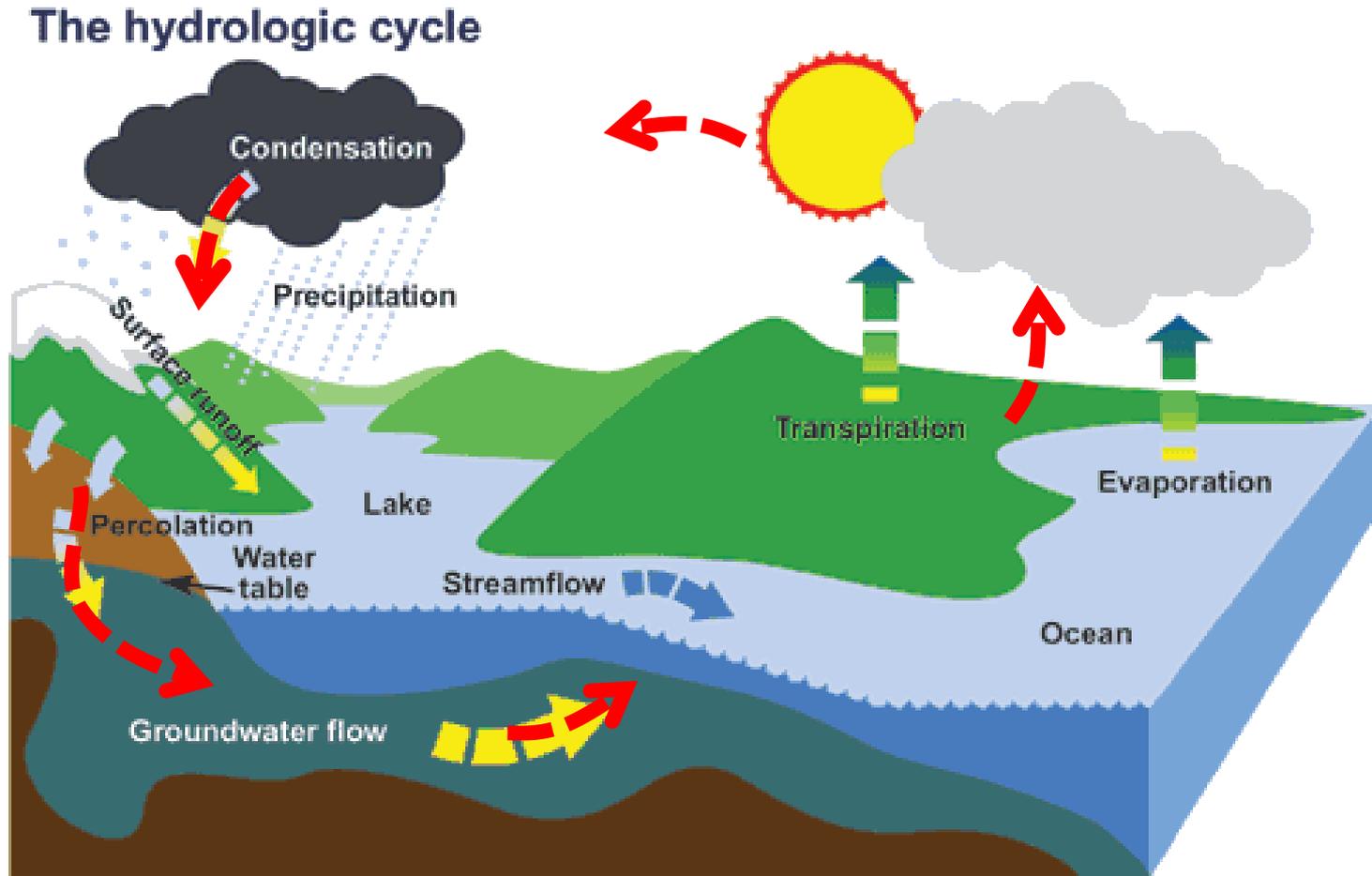
why

- Need to estimate water resources
- **Need to predict flood & drought, and how to combat them** ←
- etc

where

Irrigation facility, **drainage facility**, flood defense, water supply, waste water facility, power plant / pembangkit listrik tenaga air (PLTA), dll

Hydrologic Cycle: Siklus Hidrologi



<https://www.canada.ca/en/environment-climate-change/services/water-overview/basics/hydrologic-cycle.html>

Hydrologic cycle (1)

Evaporation

- Liquid to gas
- Driven by sun
- Occurs on raindrops, free water surfaces (seas, lakes), etc
- Evapotranspiration

Evaporation & evapotranspiration (water – water vapor) → **Condensation** (water vapor - liquid) – small droplets – bigger droplets – saturated → **precipitation**

Precipitation

- Rain, snow, hail (small ice particles)
- Become: runoff (surface, subsurface)
- Interception : rainfall will first intercepted by vegetation cover (i.e. leaves)

Hydrologic cycle (2)

Infiltration

- Water movement **into** soil
- Affect the soil moisture

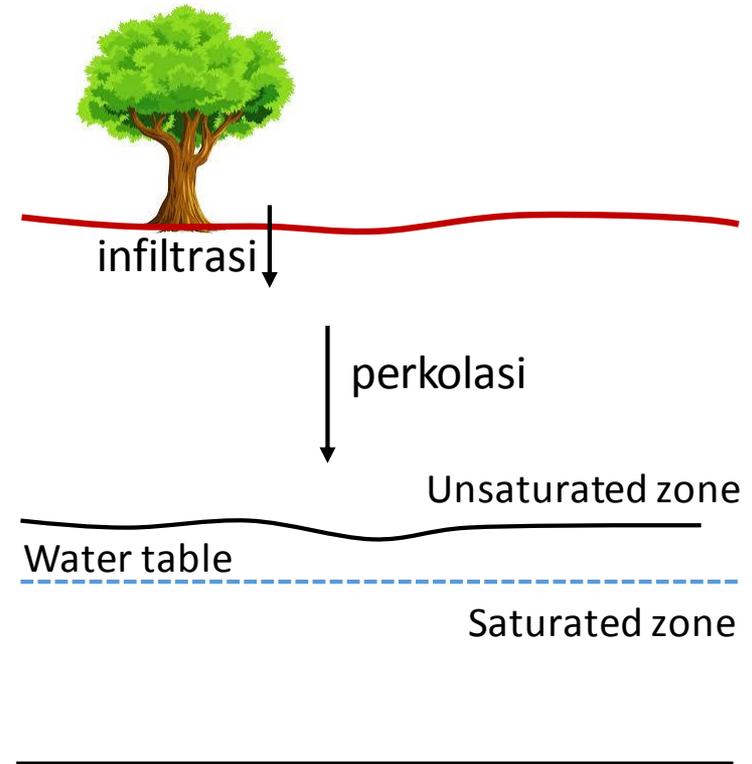
Percolation

- Movement of water **through** the soil, and it's layers, by gravity and capillary forces
- Recharge the groundwater

Runoff

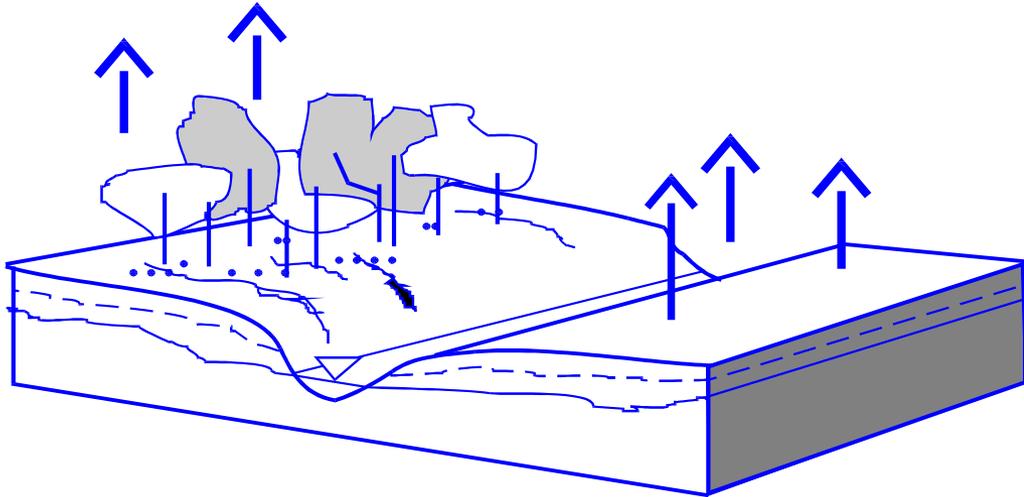
- After the water saturated the soil → surface runoff

Streamflow



.... and repeat back to evaporation...

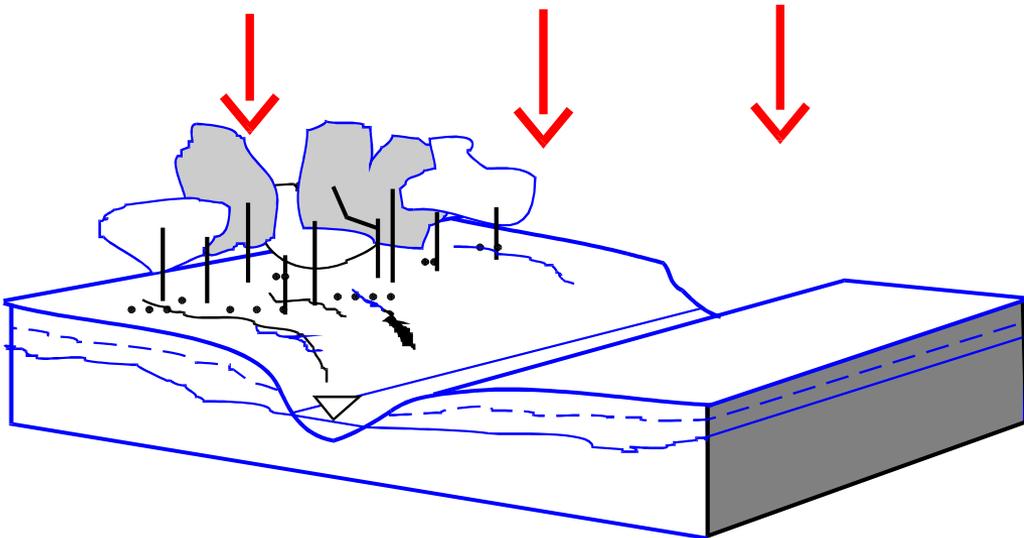
Siklus Limpasan (1)



TAHAP I:

Akhir musim kemarau

- Evaporasi dominan
- Belum ada hujan
- Permukaan kering



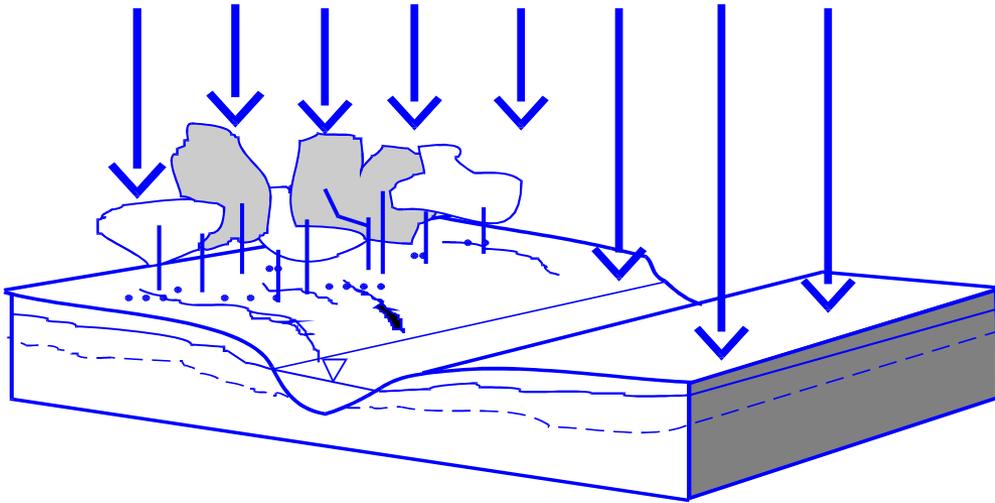
TAHAP II:

Awal musim penghujan

- Mulai ada hujan sedikit
- Belum cukup membentuk surface runoff

Ref: Sri Harto, BR., "Hidrologi: Teori, Masalah, dan Penyelesaian". Naffiri Offset: Yogyakarta. 2000

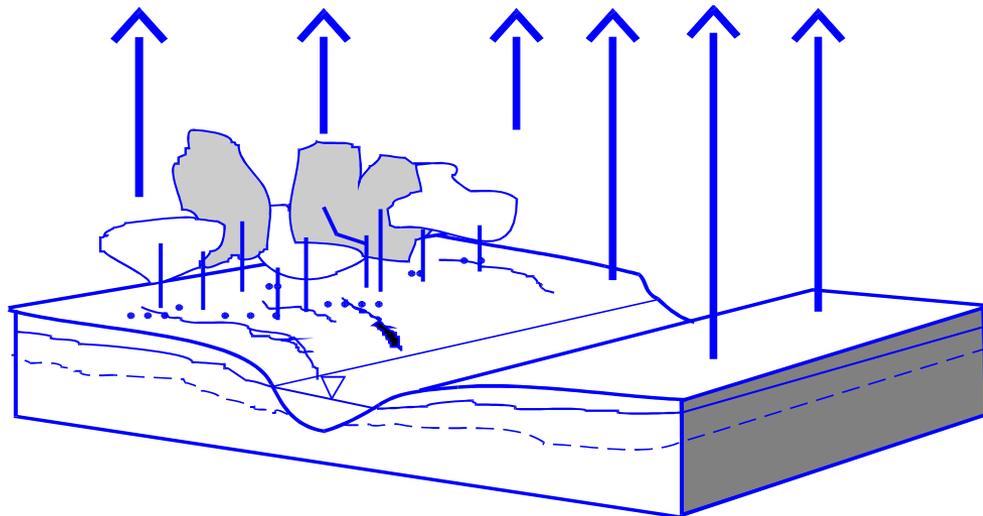
Siklus Limpasan (2)



TAHAP III:

Puncak musim penghujan

- Soil moisture capacity tercapai
- Surface runoff dominan
- Sering terjadi banjir



TAHAP IV:

Awal musim kemarau

- Pengaturan subsurface flow
- Penguapan intensif
- Soil moisture berkurang

Ref: Sri Harto, BR., "Hidrologi: Teori, Masalah, dan Penyelesaian". Naffiri Offset: Yogyakarta. 2000

Pola Perubahan Hidrologi (Question)

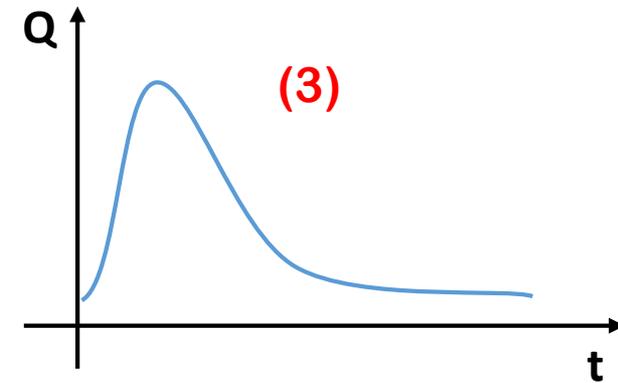
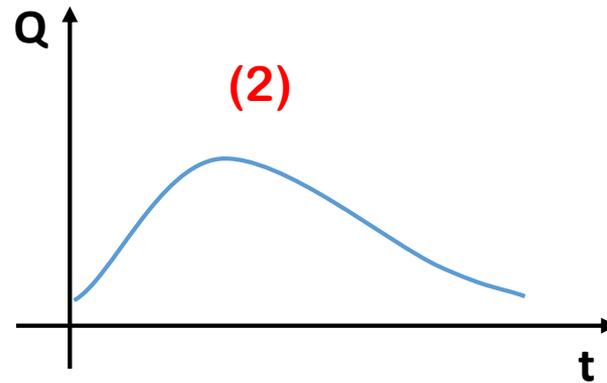
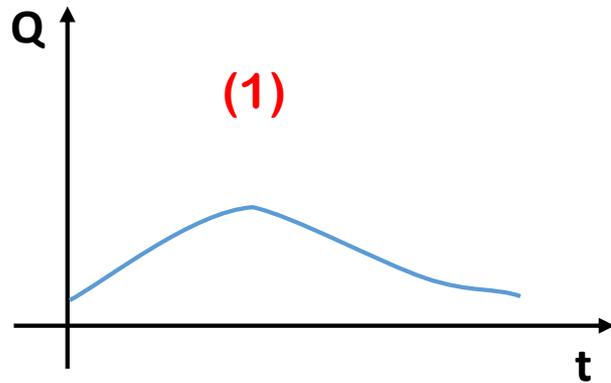
(A)



(B)



(C)



Pola Perubahan Hidrologi (Answer)

(C)



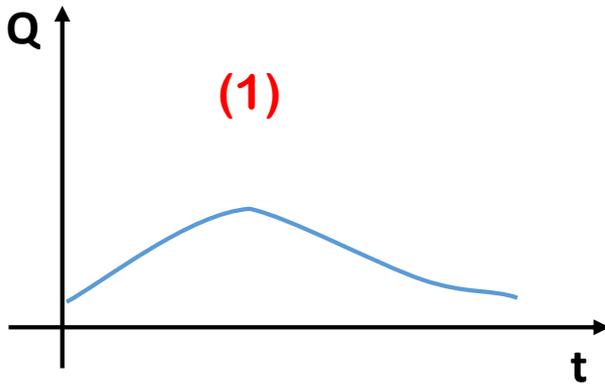
(A)



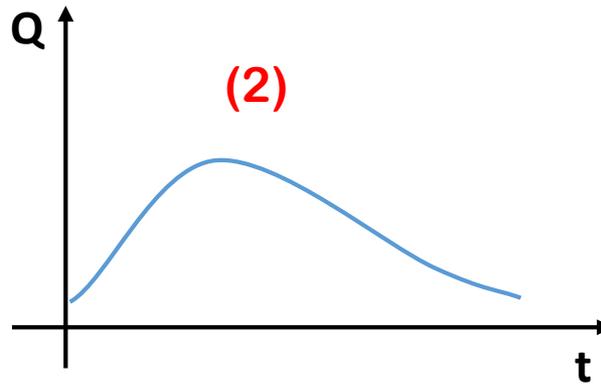
(B)



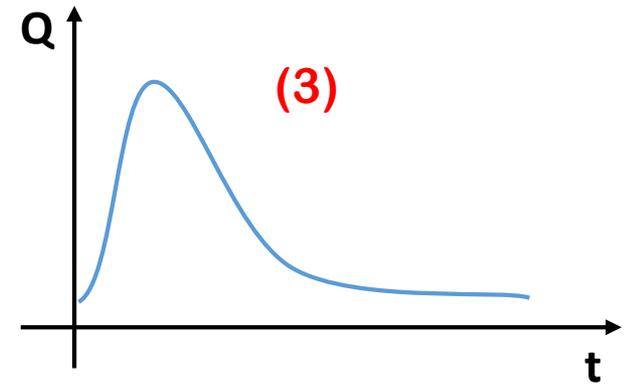
(1)



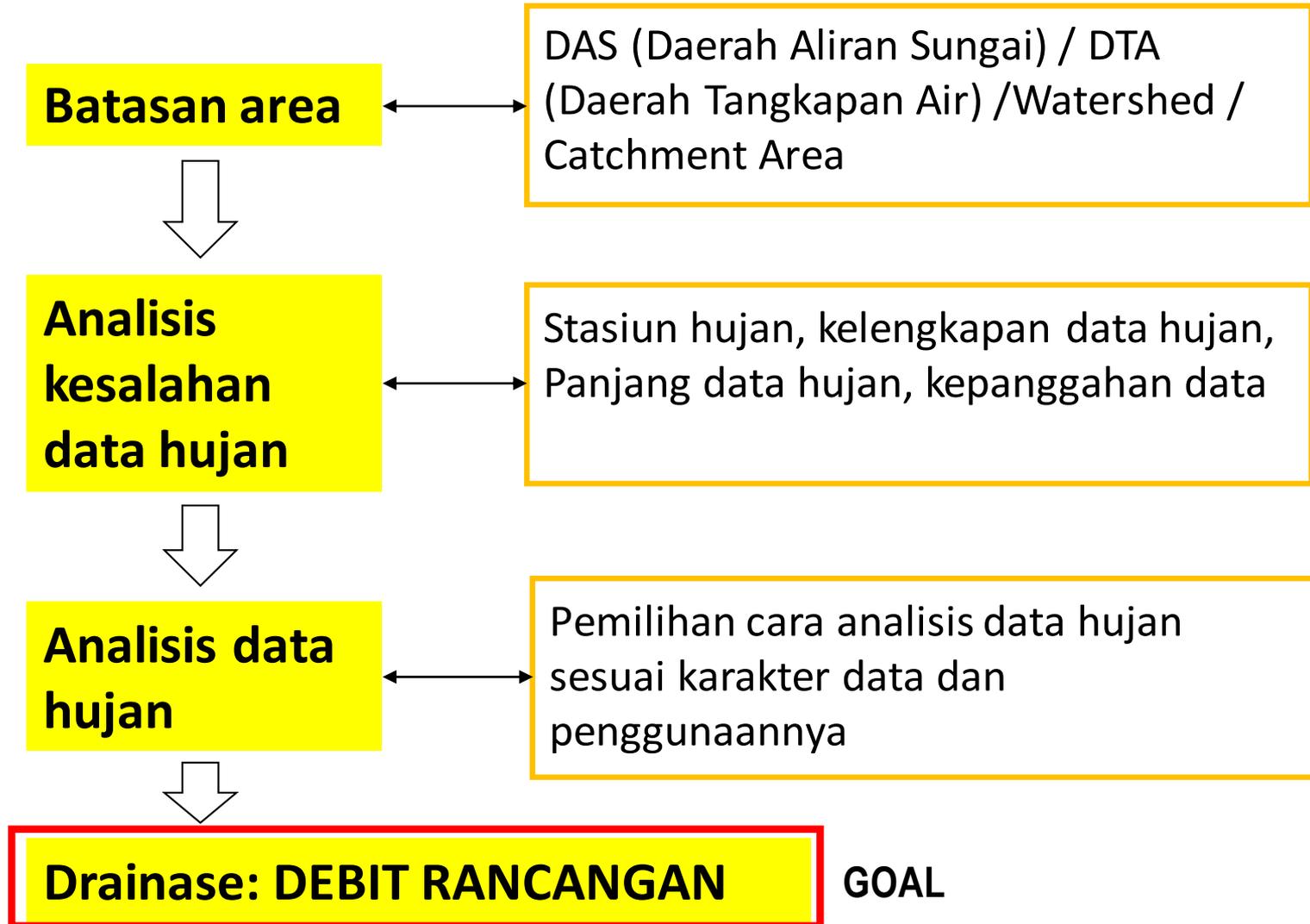
(2)



(3)



Konsep Urutan Analisis Hidrologi

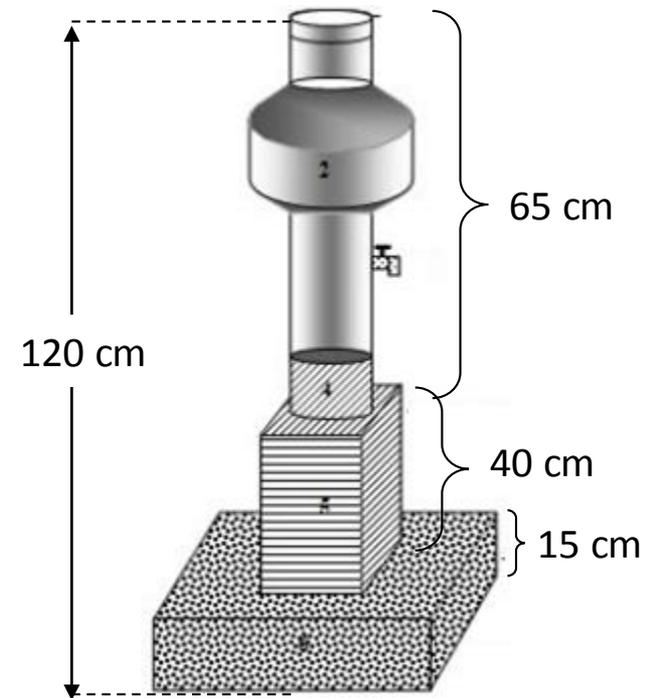


Pengukuran Curah Hujan

Pengertian²

- Intensitas hujan, i (mm)
 - Tinggi air per satuan waktu (mm/menit, mm/jam, mm/hari)
- Kejadian hujan:
 - Hujan actual
 - Hujan rencana
- Agihan hujan
 - Agihan hujan jam-jaman
 - Agihan hujan harian
 - Agihan hujan bulanan / tengah bulanan
- Hyetograph
- Pencatat/Penakar hujan

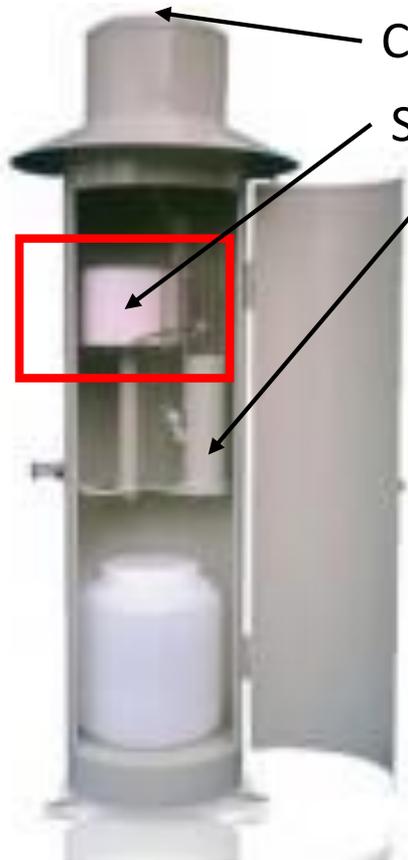
Alat Ukur / Penakar Hujan Manual



- Menghitung volume air selama 24 jam
- Alat dibuka dan diukur secara teratur setiap hari (periodik) pada pukul 07:00,
- Hanya mengukur jumlah hujan, tidak dapat diketahui durasi hujan dan intensitas hujan maksimum pada suatu kejadian hujan

ARR: Automatic Rainfall Recorder (1)

ARR tipe Hellmann



Corong penangkap, luas 200 cm^2

Silinder pemutar kertas grafik

Tabung pelampung

- Silinder terus berputar sesuai waktu
- Air hujan masuk → pelampung bergerak → membuat grafik pada kertas silinder.
- Apabila ketinggian grafik mencapai 10 mm (angka maksimal), air terbuang melalui syphon, grafik turun ke 0 (nol) lagi, pencatatan diteruskan..

<http://www.th-friedrichs.de/en/products/rain/rain-gauge/hellmann-rain-gauge/>

Contoh hasil pencatatan data hujan

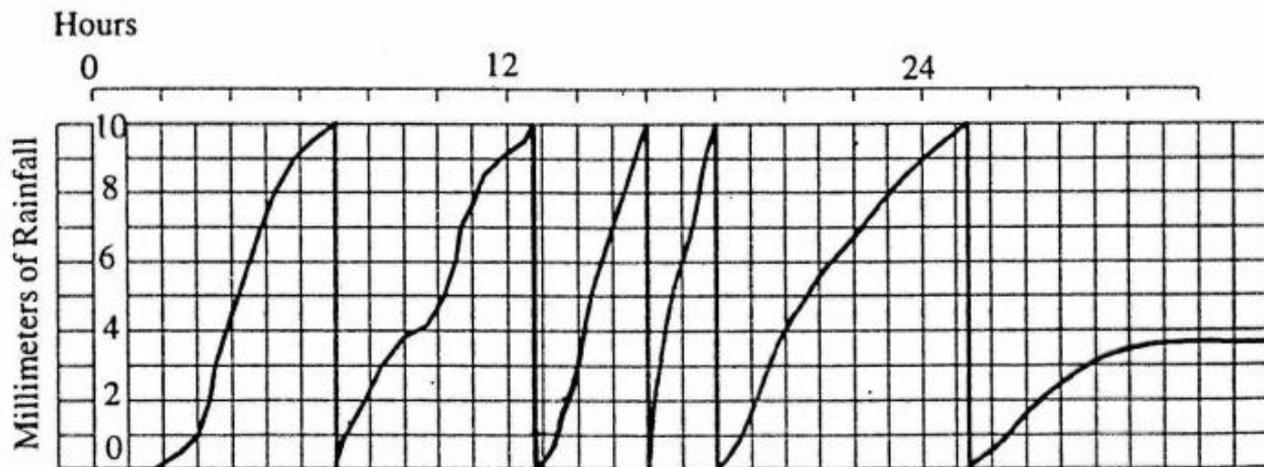
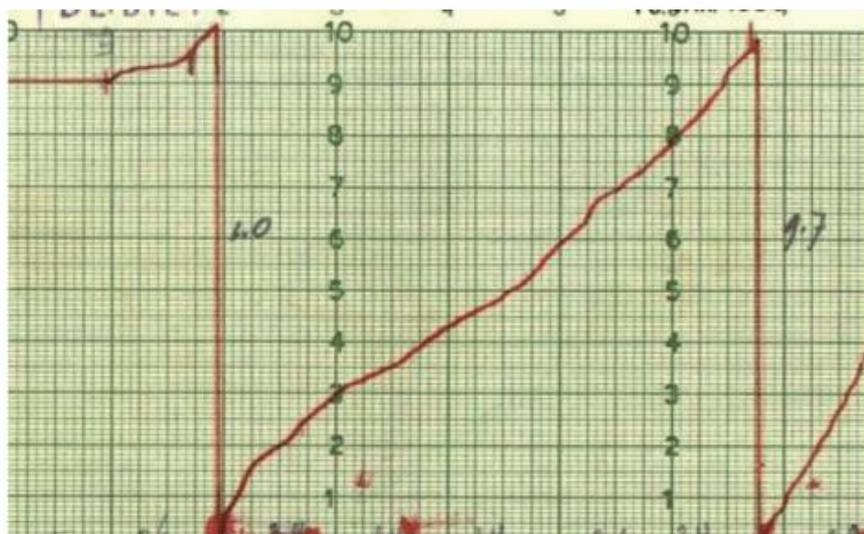


Fig. Recording from a natural syphon-type gauge (schematic)

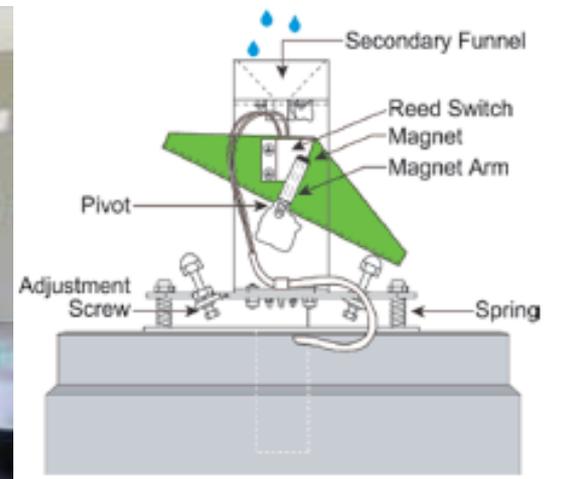
<https://civilclassroom.files.wordpress.com/2014/05/precipitation.pdf>



<https://www.knmi.nl/kennis-en-datacentrum/achtergrond/recovery-and-disclosure-of-historical-meteorological-observations-hisklim>

ARR: Automatic Rainfall Recorder (2)

ARR tipe Tipping Bucket



- Mencatat setiap jungkit via sensor yang terpicu oleh magnet
- Kapasitas wadah: 0.5 mm each sides

Video: Missisipi WMO Youtube Channel

<https://www.youtube.com/watch?v=ygLV8upFQ4>

Contoh hasil pencatatan data hujan

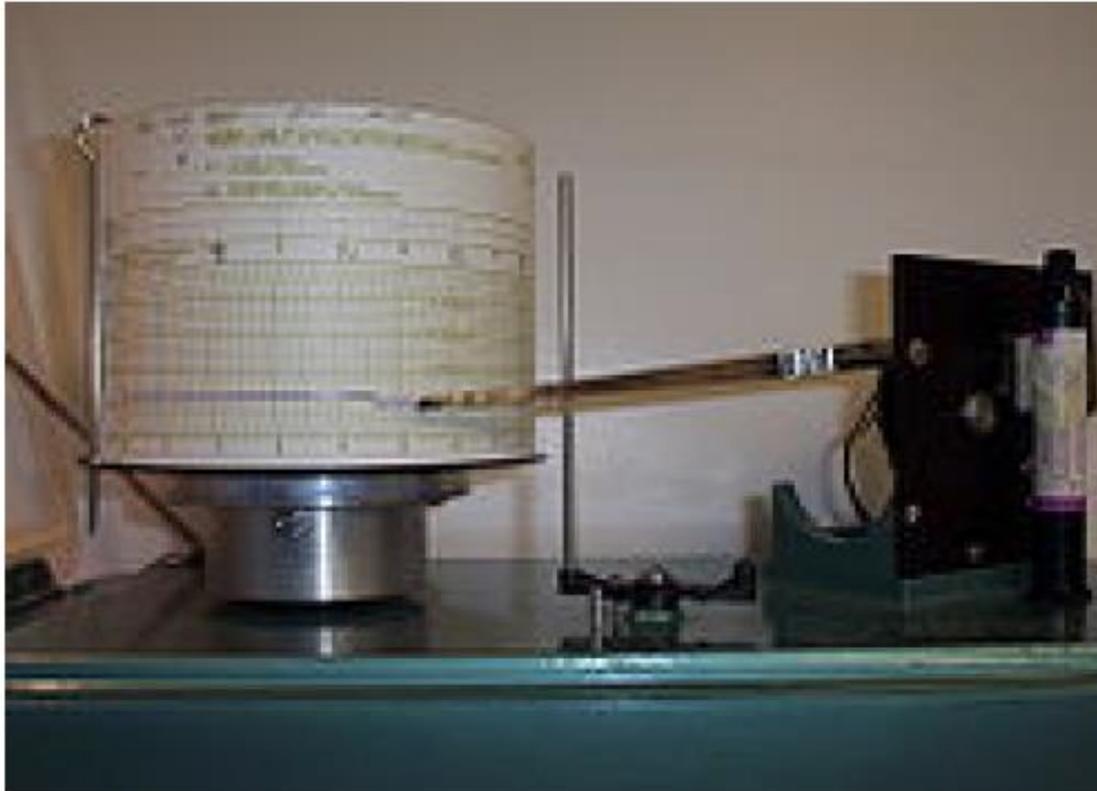


Fig. 1 Tipping bucket rain gauge recorder.

Sumber: Trang, Bui Thi Thu, et al. "Analysis of Storm Pattern for Design Urban Drainage System in the Monsoon Areas of Vietnam." *Journal of Environmental Science and Engineering A* (2018): 49.

https://www.researchgate.net/publication/327121168_Serial_Number_68

Contoh rekap data hujan

DATA HUJAN D.I.YOGYAKARTA TAHUN : 2017

Stasiun : Bronggang

Bulan : Januari

Tahun : 2017

No.Kad. :

Kecamatan : Cangkringan

Kabupaten : Sleman

Propinsi : D.I.Yogyakarta.

Pada Dasar : K. Opak

No. Stasiun :

Lokasi Stasiun : S. 07. 67800 / E. 110.45042

Tinggi Dari Muka Laut :

Tahun Pendirian : 2003

Dibangun Oleh : DPUP.DIY

Tanggal	H.B	H.O	J A M																								
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	5	6.7	0.9	0.1	0.8	1.8	1.6	0.1	0.2	0.2	0	0.9	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	3.5	2.7	0	0	0	0	0	0	0	0.6	1.6	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	18.5	18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.8	5.8	2.9	0.3	0.1	0	0	0	0	0	
5	7.5	8.1	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	2.4	2.8	2.1	0.4	0.1	0.1	0.1	0	
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	0	11.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.7	2.5	5.2	1.4	0.7	0.7	0.1	
8	12.5	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	18.7	1.8	0	0	0	0	0	0	0	
9	15	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.1	0	0	0	0	0	0	0	0	0	
10	1.5	11.5	0	0	0	0	0	0	0	0	0	0	0	4.3	6.3	0.9	0	0	0	0	0	0	0	0	0	0	
11	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	3.3	0.2	0	0	0	0	0	0	
12	3.5	8.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	5.4	2	0.2	0.2	0.2	0	0	0	
13	19.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.2	0	0	0	0	0	0	
14	23	21.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0.8	0.8	1.2	1.7	2.1	12.8	1.5	
15	0	4	0.5	0.2	0.2	0.2	0.4	0.1	0	0	0	0	0	0	0	0.3	0	0	0	0	0.3	1.8	0	0	0	0	
16	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	
17	9	8.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	1.7	4.1	1	0.1	0.1	0	0.4	0.5	
18	23.5	22.9	0.3	0.1	0.3	0.1	0	0	0	0	0	0	0	0	0	0	2.9	6.5	0	0	6.6	2.8	2.6	0.2	0.2	0.3	0
19	23	0.1	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
20	0	21.6	0	0	0	0	0	0	0	0	0	3.1	3.6	5.4	3	1.8	1.8	1.8	0.8	0.2	0.1	0	0	0	0	0	
21	0	0.6	0	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	13	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.2	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	36	28.6	0	0	0	0	0	0	0	0	0	0.1	0.4	0	20.4	5.8	0.9	1	0	0	0	0	0	0	0	0	
25	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
26	6	11.1	1.2	2.8	1	0	0	0	0	0	0	0	0	0	0	0	0.1	5.9	0.1	0	0	0	0	0	0	0	
27	28	28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	8.3	12.3	1	1.9	0.3	0.1	0.3	1.1	1.5	0	
28	8.3	8.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	7	0.8	0	0	0	0	0	
29	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0.8	1.3	0.5	0.1	0	0	0	0	
30	9.5	9.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	6.6	0.9	0.1	0	0	0	0	
31	53	40.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.4	8.2	0.2	5.4	2.8	5.7	1.4	0.1	0.1	0.1

Jumlah	339.3	306
Rata-2	10.95	9.87
Maximum	53	40.4
Minimum	0.5	0.1
H.H	24	27

Keterangan : H.H : Jumlah Hari Hujan
H.O : Hujan Otomatik
H.B : Hujan Biasa

— : Tidak Ada Data
* : Data Diragukan
Hujan dalam mm (milimeter)

Syarat Pemasangan Alat Penakar Hujan

General rule

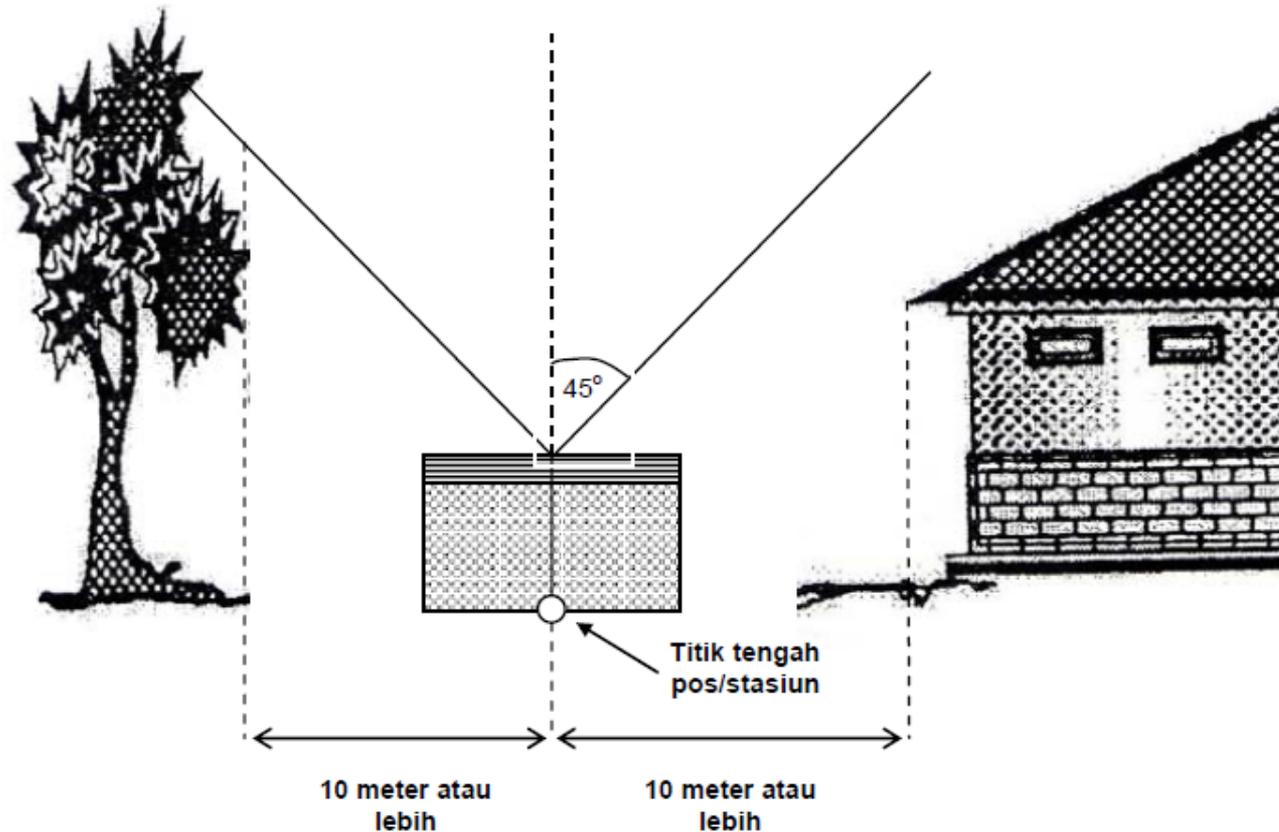
- Tidak dipasang di tempat yang terlalu terbuka (over exposed), seperti di puncak gedung, puncak bukit, etc
- Tidak dipasang di tempat yang terlalu tertutup (under exposed), seperti di antara dua gedung tinggi
- Mudah memperoleh tenaga pengamat

Syarat Pemasangan Alat Ukur (1)

KemenPU

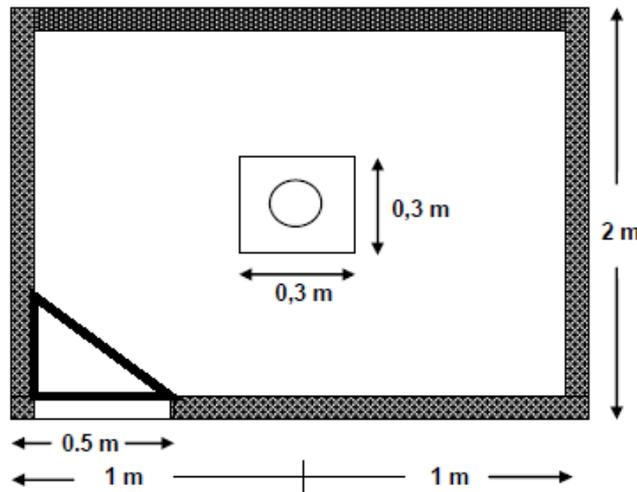
Sumber: Prosedur dan Instruksi Kerja Survei Penempatan dan Pembangunan Pos Hidrologi, KemenPU

A. Cara pemasangan pos hujan dan stasiun klimatologi



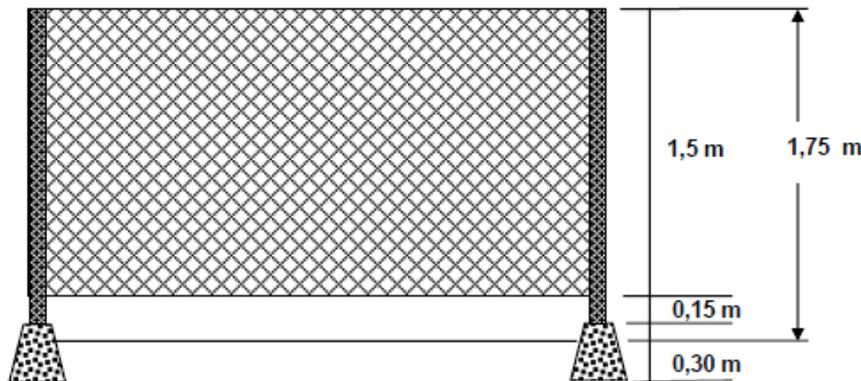
Syarat Pemasangan Alat Ukur (2)

B. Pemasangan pos hujan biasa/manual



Keterangan :

1. Tinggi pagar pos 1,75 meter.
2. Pagar terbuat dari besi dan kawat harmonika.
3. Pintu pos diberi gembok.
4. Corong penampung air hujan dengan luas penampang 100 cm^2 .
5. Leher penakar hujan (diameter 13 cm), terbuat dari seng/paralon.
6. Alat dilengkapi tabung penampung air hujan 3 liter terbuat dari seng/paralon dan kran pembuang air.
7. Buat dan pasang papan keterangan pos.



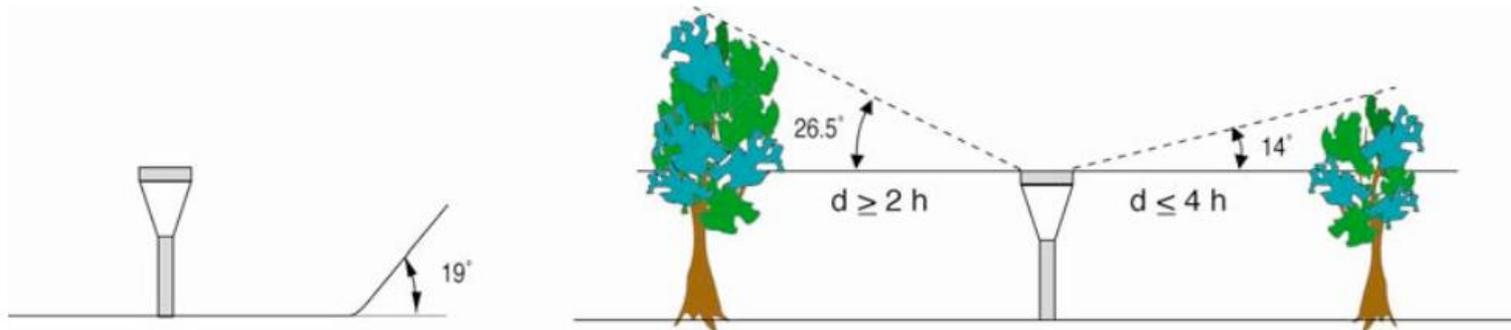
Logo	Nama Instansi Pengelola
Nama Pos : No. Reg.	
Desa :	
Kec./Kab :	
Propinsi :	
Geografis : LU/LS BT	
Elevasi : dpal.	
Dibangun oleh ;	
DILARANG MENGGANGGU/MERUSAK BANGUNAN MILIK NEGARA	

Standar Pemasangan Alat Ukur WMO (1)

WMO

Class 1

- Flat, horizontal land, surrounded by an open area, slope less than $1/3$ (19°). Raingauge surrounded by obstacles of uniform height, seen under an elevation angle between 14° to 26° (obstacles at a distance between 2 to 4 times their height);

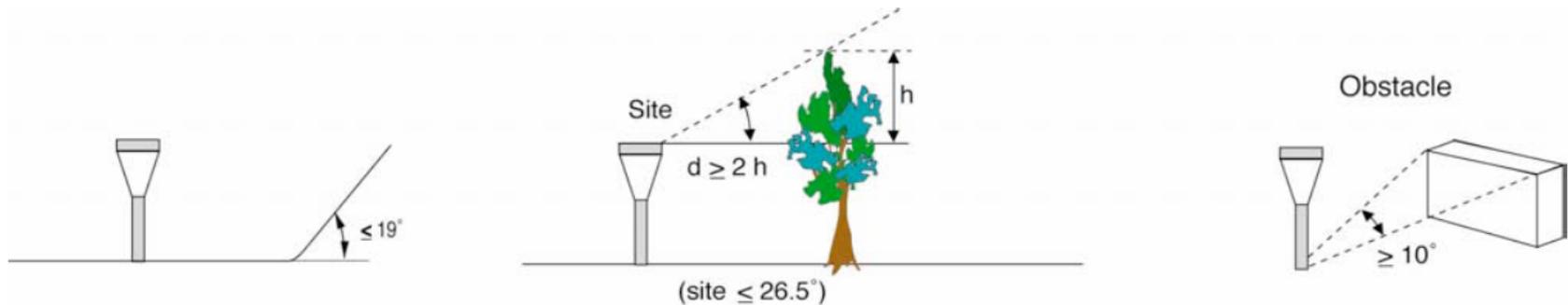


https://library.wmo.int/doc_num.php?explnum_id=4939

Standar Pemasangan Alat Ukur WMO (2)

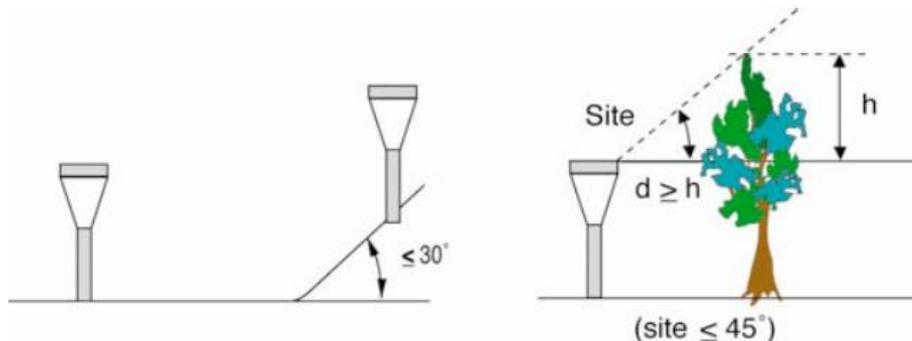
Class 2 (additional estimated uncertainty added by siting up to 5%)

- Flat, horizontal land, surrounded by an open area, slope less than $1/3$ (19°);
- Possible obstacles must be situated at a distance at least twice the height of the obstacle (with respect to the catchment's height of the raingauge).



Class 3 (additional estimated uncertainty added by siting up to 15%)

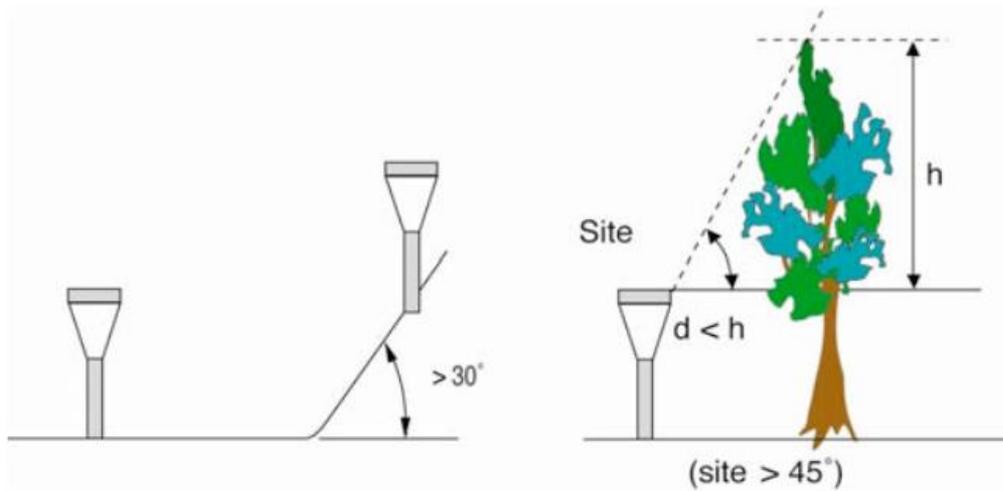
- Land is surrounded by an open area, slope less than $1/2$ ($\leq 30^\circ$);
- Possible obstacles must be situated at a distance greater than the height of the obstacle.



Standar Pemasangan Alat Ukur WMO (3)

Class 4 (additional estimated uncertainty added by siting up to 25%)

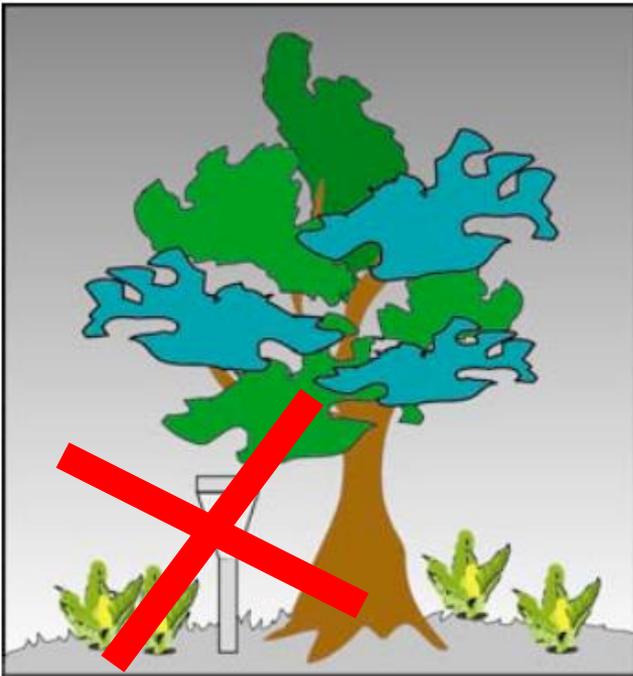
- Steeply sloping land ($>30^\circ$);
- Possible obstacles must be situated at a distance greater than one half ($1/2$) the height of the obstacle.



Standar Pemasangan Alat Ukur WMO (4)

Class 5 (additional estimated uncertainty added by siting up to 100%)

- Obstacles situated closer than one half ($1/2$) their height (tree, roof, wall, etc.).



Thought...

Apabila di sekitar kampus **Dept. Teknik Sipil**, atau di sekitar **Sekolah Vokasi** akan **ditempatkan satu alat pengukur curah hujan**, di mana saja **potensi lokasi alat**?

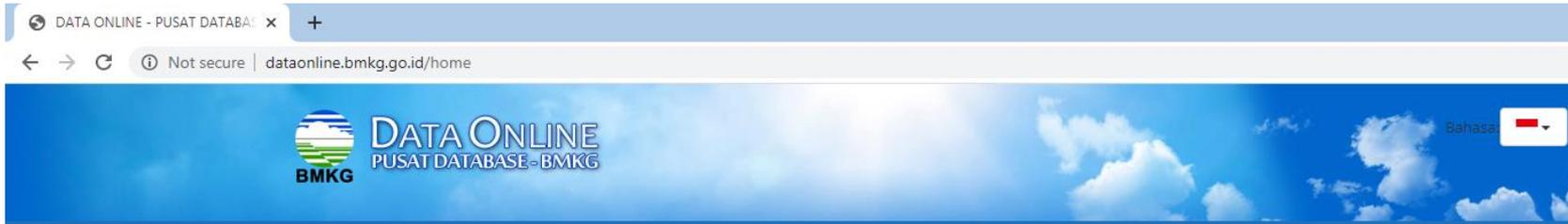


Di mana saja bisa memperoleh data hujan?

- BBWS (Balai Besar Wilayah Sungai) terkait
- PSDA (Dinas Pengelolaan Sumber Daya Air) terkait
- BMKG (Badan Meteorologi, Klimatologi, dan Geofisika)
- Lain2
 - Area kampus
 - Area industri
 - Area tambang
- Satellite
 - TRMM
 - GPM
 - ...

Downloadable Rainfall Data: BMKG

<http://dataonline.bmkg.go.id/home>



Masuk ke aplikasi

Email

Kata Sandi

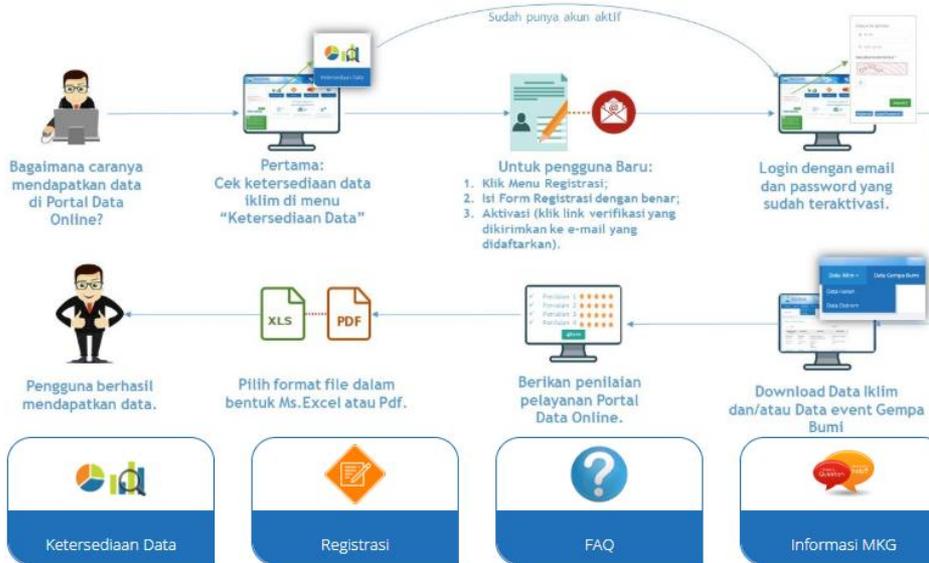
Masukkan kode berikut *

Masuk

Registrasi Lupa Password ?

“ Aplikasi DATA ONLINE - PUSAT DATABASE - BMKG adalah aplikasi layanan data untuk pengguna, baik untuk kalangan internal BMKG maupun eksternal yang terdiri dari kalangan Perguruan Tinggi, Instansi Kementrian/Lembaga, Swasta, dan Masyarakat pengguna data MKKUG

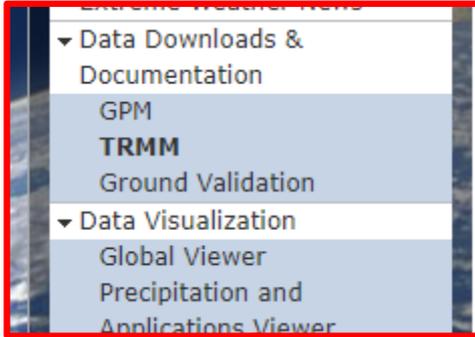
ALUR PENGUNJUNG PORTAL DATA ONLINE



Parameter yang tersedia	
Data Iklim	Data Kejadian Gempabumi
<ul style="list-style-type: none"> Curah Hujan Temperatur: Maksimum, Minimum, Rata-rata 	

Downloadable Rainfall Data: NASA

<https://pmm.nasa.gov/data-access/downloads/trmm>



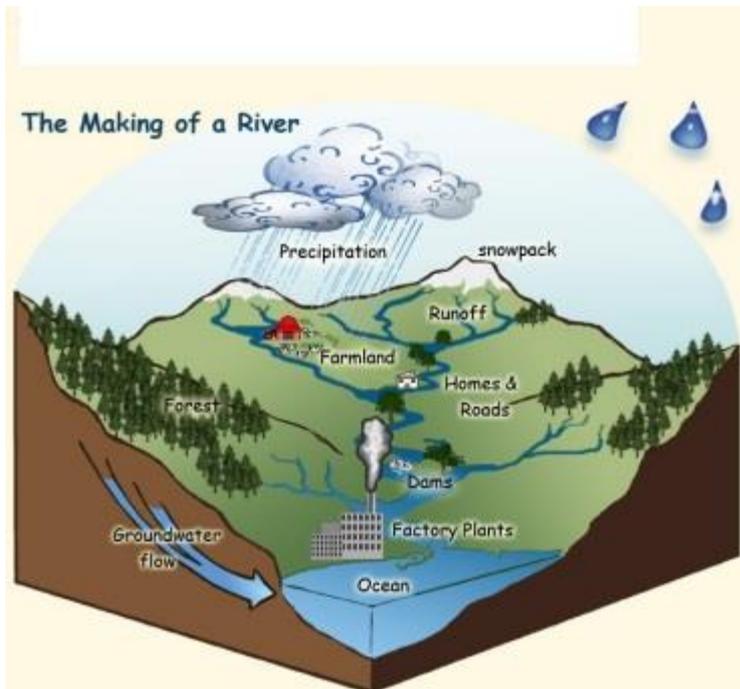
A screenshot of the TRMM Data Downloads webpage. The page features a navigation bar with tabs for 'Home', 'GPM', 'TRMM', 'Science', 'Applications', 'Meetings', 'Data Access', 'Resources', and 'Education'. The main content area is titled 'PRECIPITATION MEASUREMENT MISSIONS' and 'TRMM Data Downloads'. It includes an 'UPDATE' section stating that the TRMMOpen FTP server has been shut down as of December 31st, 2019, and that historical TMPA data will be made available on the GPM FTP servers. The page also features a section titled 'TRMM Mission Comes to an End' and a section titled 'The GPM IMERG dataset now includes TRMM-era data going back to June 2000'. A red box highlights the 'Data Access' sidebar menu, which is identical to the one shown in the previous image. The page also includes social media links for Twitter, Facebook, and YouTube, and a search bar at the top right.

Note: always look for ground measurement as the main data instead of satellite data

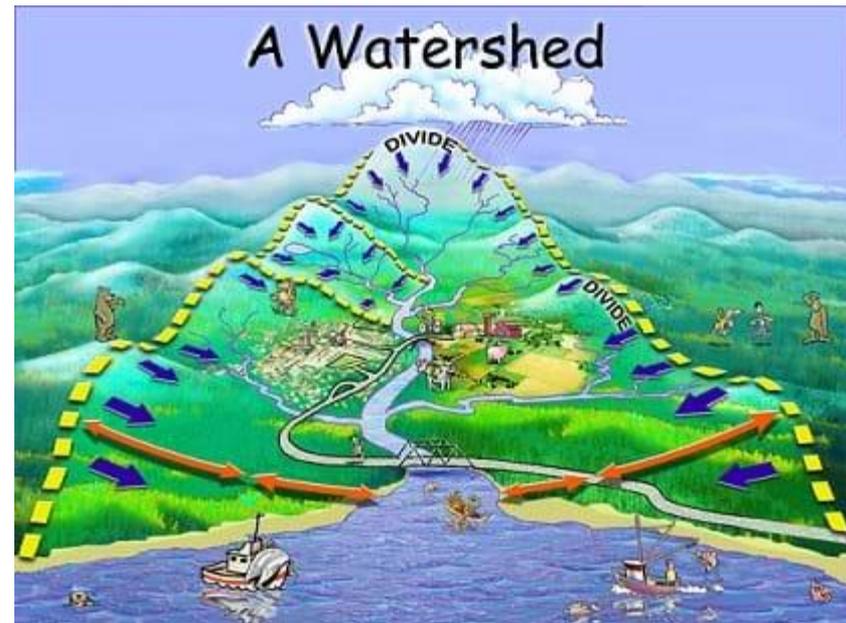
Watershed / Catchment Area

Pengertian²

- Daerah aliran sungai / watershed / drainage basin / catchment area / river basin
- Daerah tangkapan air / catchment area

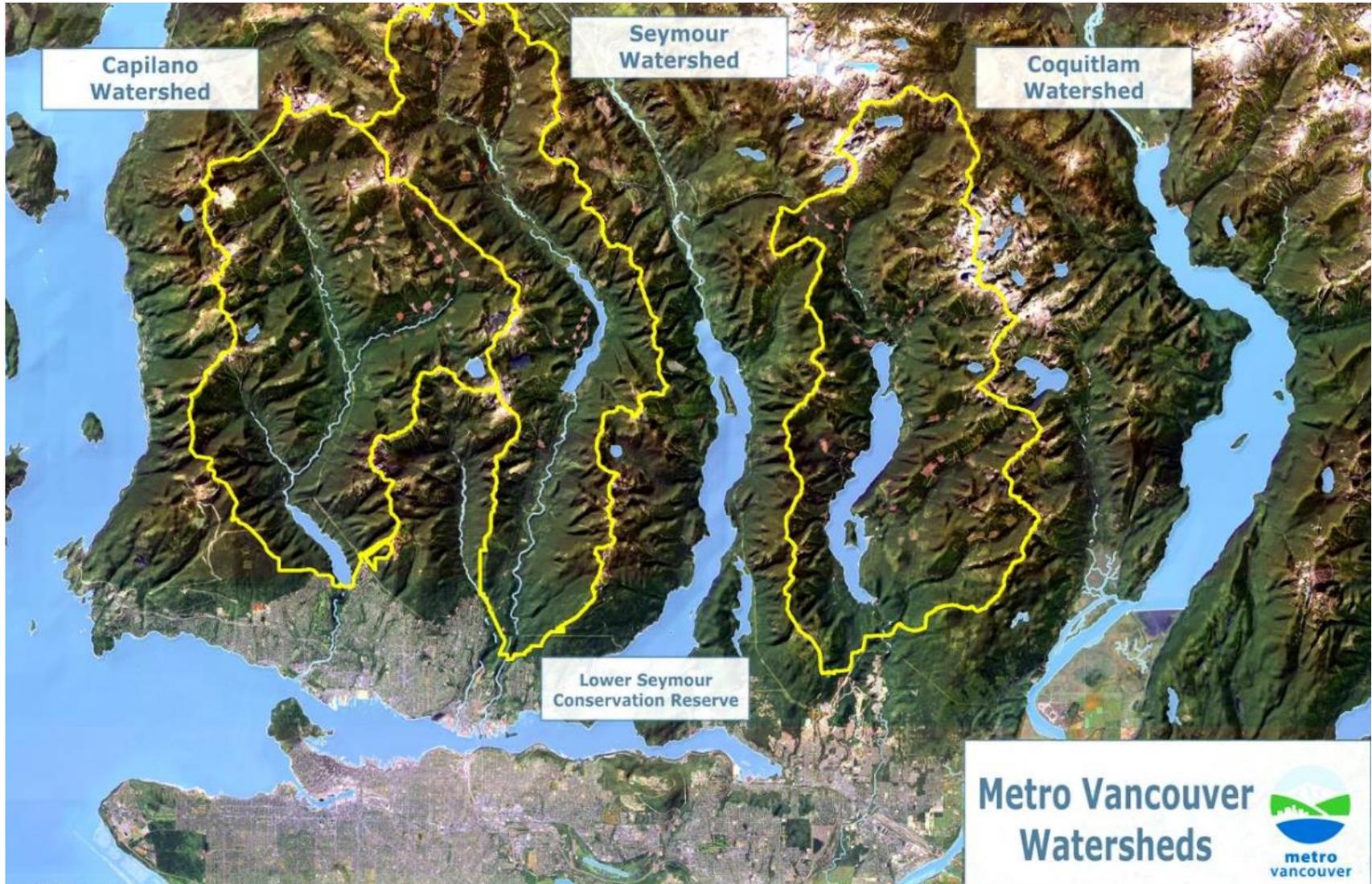


<https://www.akronohio.gov/cms/Water/Watershed/index.html>



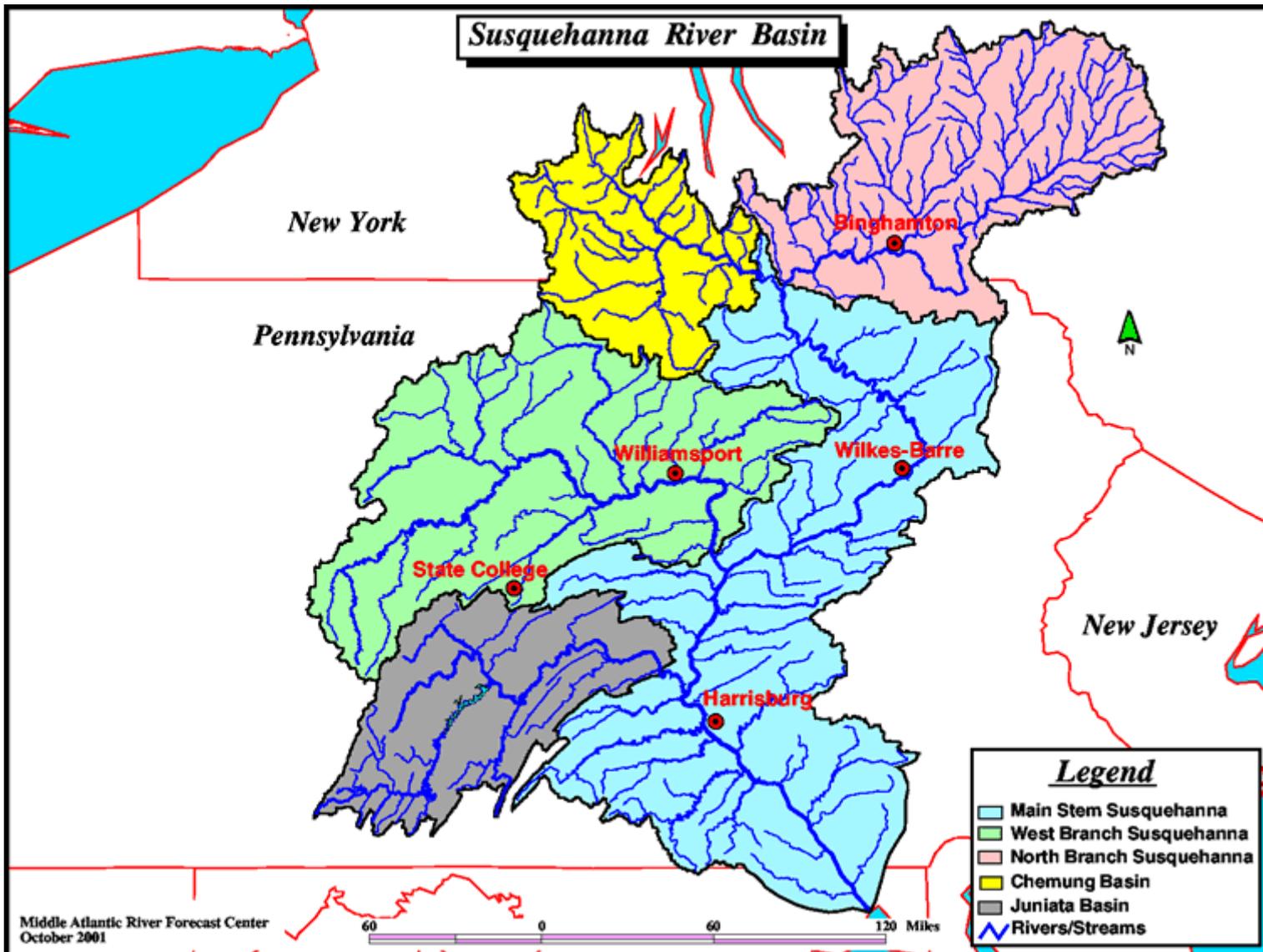
https://www.teachengineering.org/lessons/view/cub_watershed_lesson01

Pengertian DAS



<https://opentextbc.ca/geology/chapter/13-2-drainage-basins/>

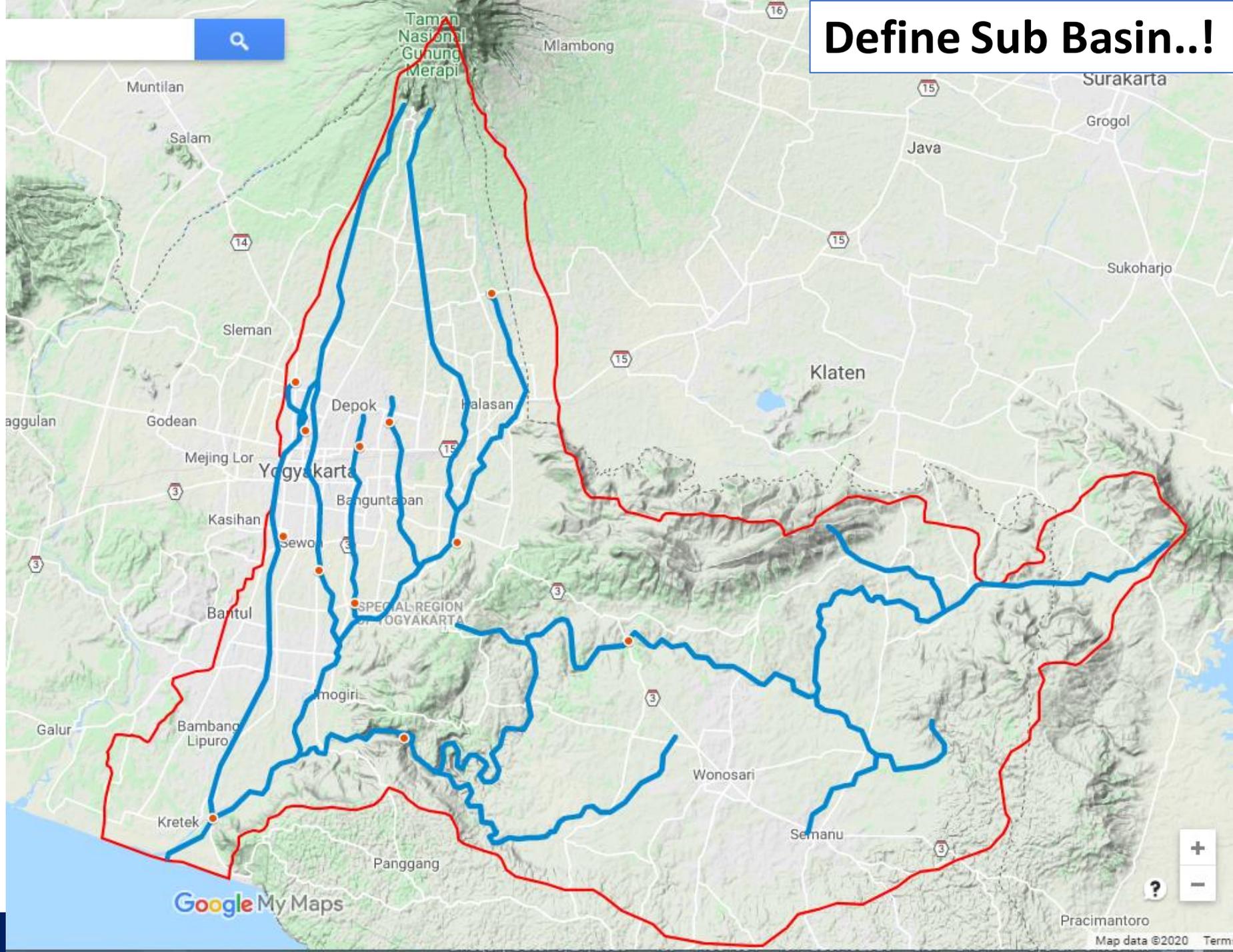
Pengertian DAS & Sub DAS



Contoh DAS (Sungai menuju pantai selatan Jawa)



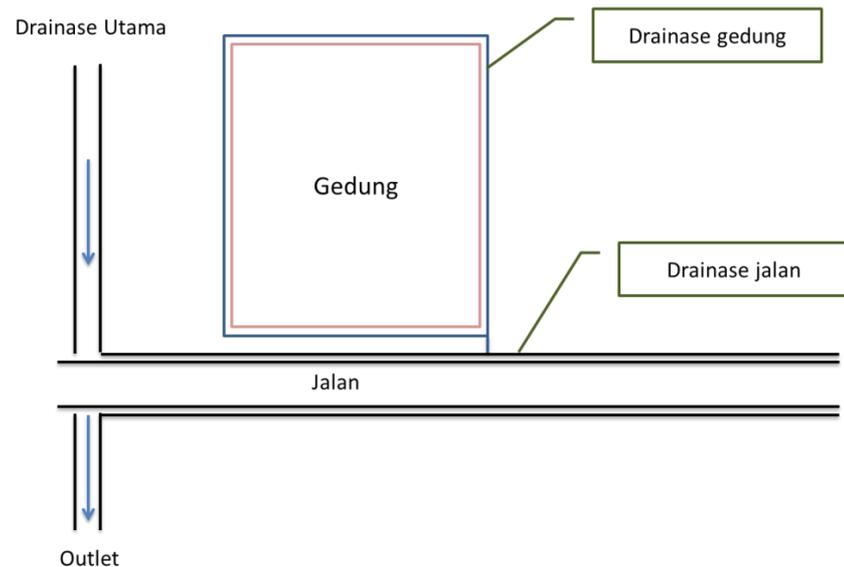
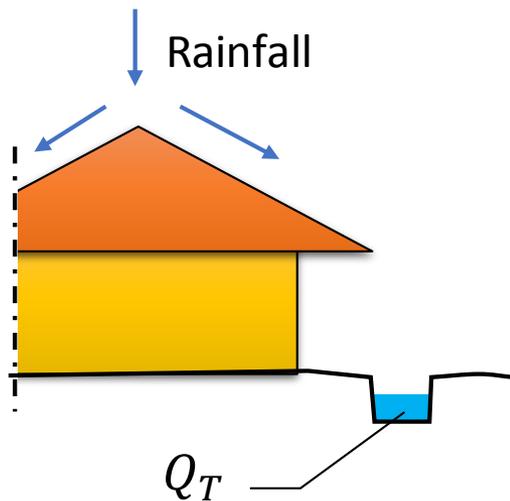
Define Sub Basin..!



Catchment Area for Urban Drainage

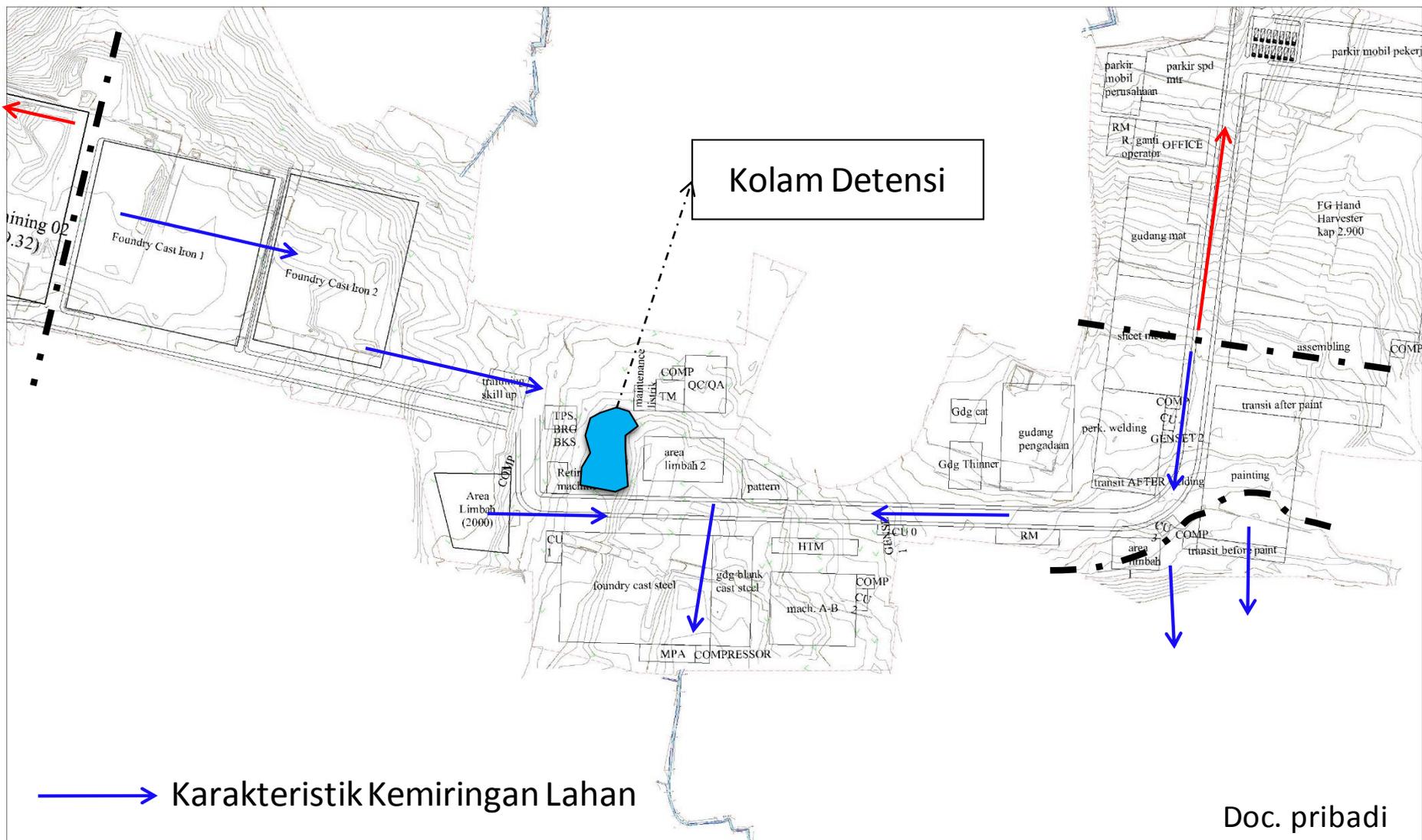
Daerah Tangkapan Air (Untuk Drainase Urban)

Konsep tata saluran sederhana untuk drainase sebuah kawasan

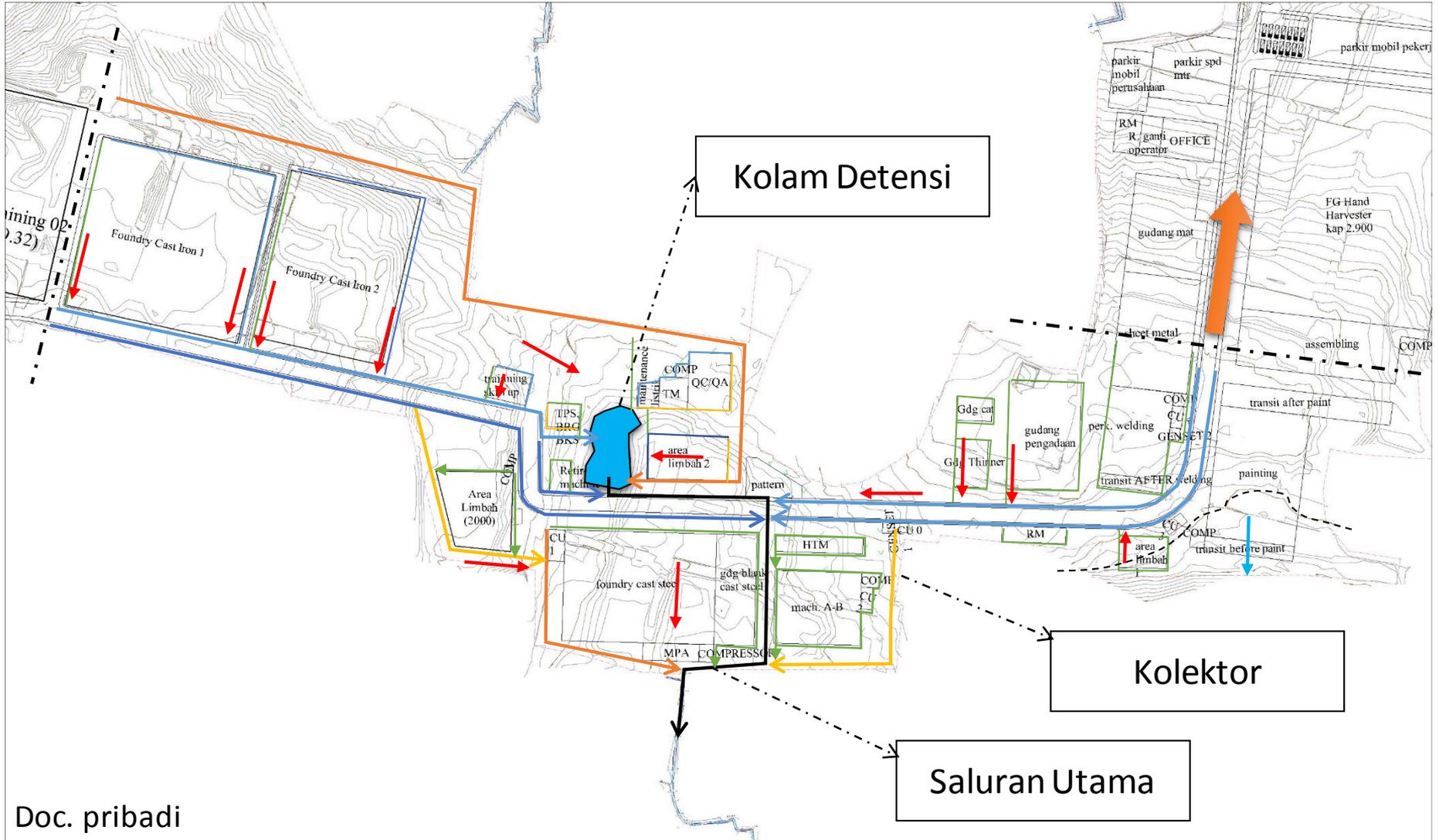


*untuk konsep dan aplikasi drainase berwawasan lingkungan, akan disampaikan pada pertemuan 6 – 9.

Contoh kasus



Contoh kasus



Doc. pribadi

Thought.....

1. Bisakah Saudara menghitung luas catchment area di saluran drainase di sekitar kampus?
2. Coba identifikasi saluran drainase di sekitar Dept. Teknik Sipil, beserta luas beban daerah tangkapan air (*catchment area*) nya..



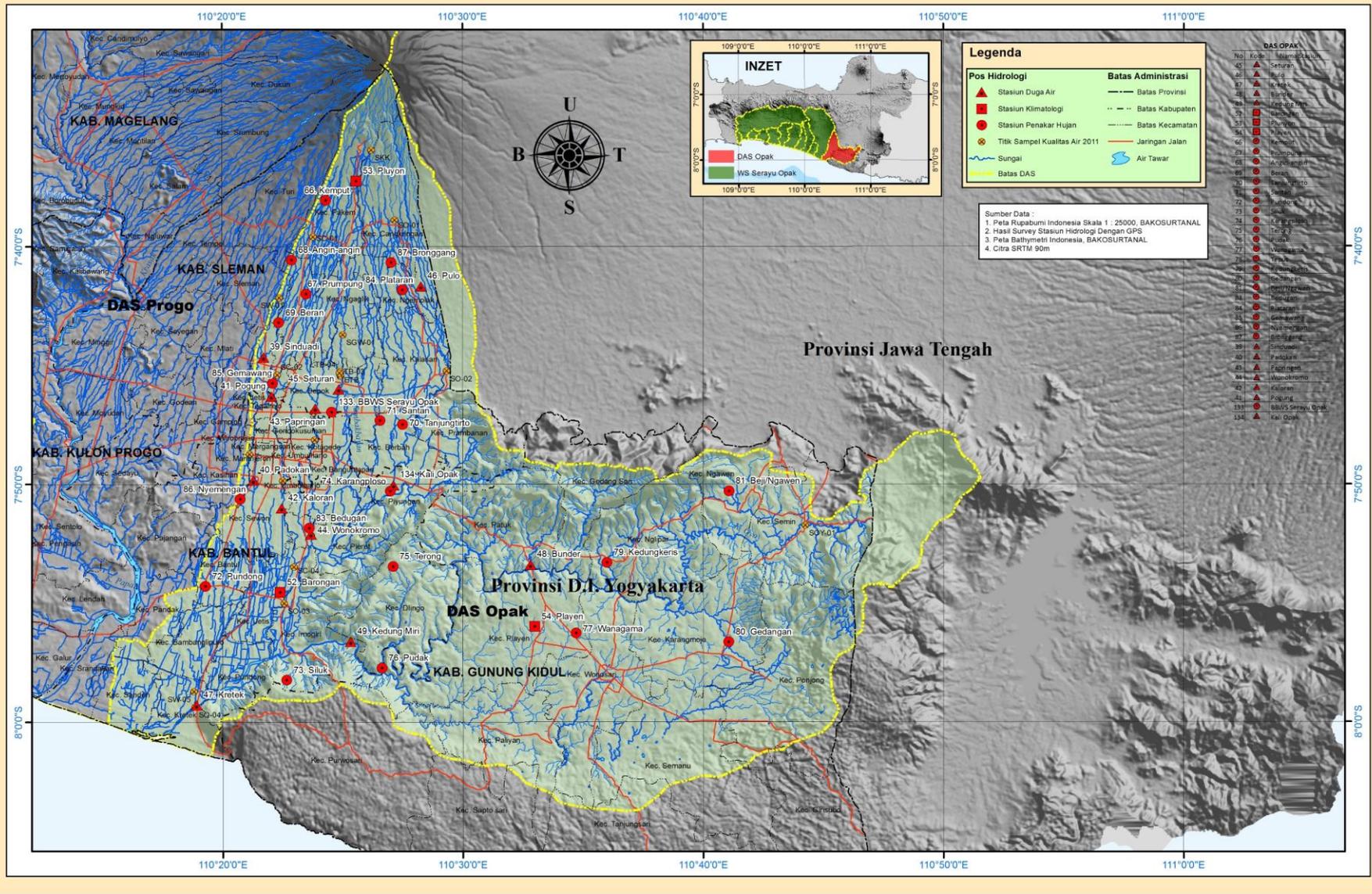
Bisa jadi akan menjadi salah satu tugas di MatKul ini... ☺

Sebaran Stasiun Penakar Hujan

PETA LOKASI STASIUN HIDROLOGI - DAS OPAK



Skala 1 : 275.000 pada Kertas A3



Legenda

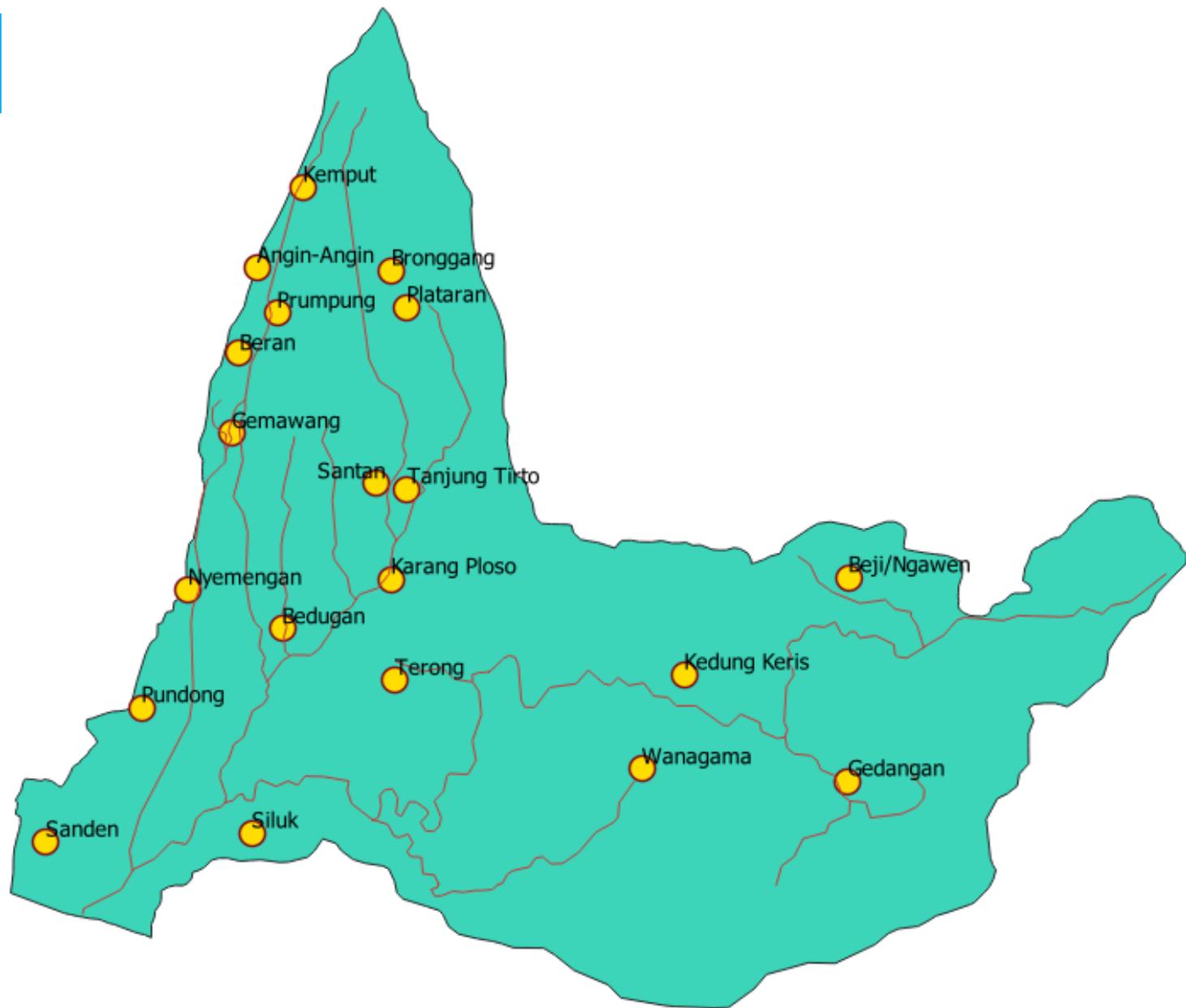
Pos Hidrologi	Batas Administrasi
▲ Stasiun Duga Air	— Batas Provinsi
■ Stasiun Klimatologi	- - - Batas Kabupaten
● Stasiun Penakar Hujan	--- Batas Kecamatan
○ Titik Sampel Kualitas Air 2011	— Jaringan Jalan
— Sungai	— Air Tawar
— Batas DAS	

Sumber Data :
 1. Peta Rupabumi Indonesia Skala 1 : 25000, BAKOSURTANAL
 2. Hasil Survey Stasiun Hidrologi Dengan GPS
 3. Peta Bathymetri Indonesia, BAKOSURTANAL
 4. Citra SRTM 90m

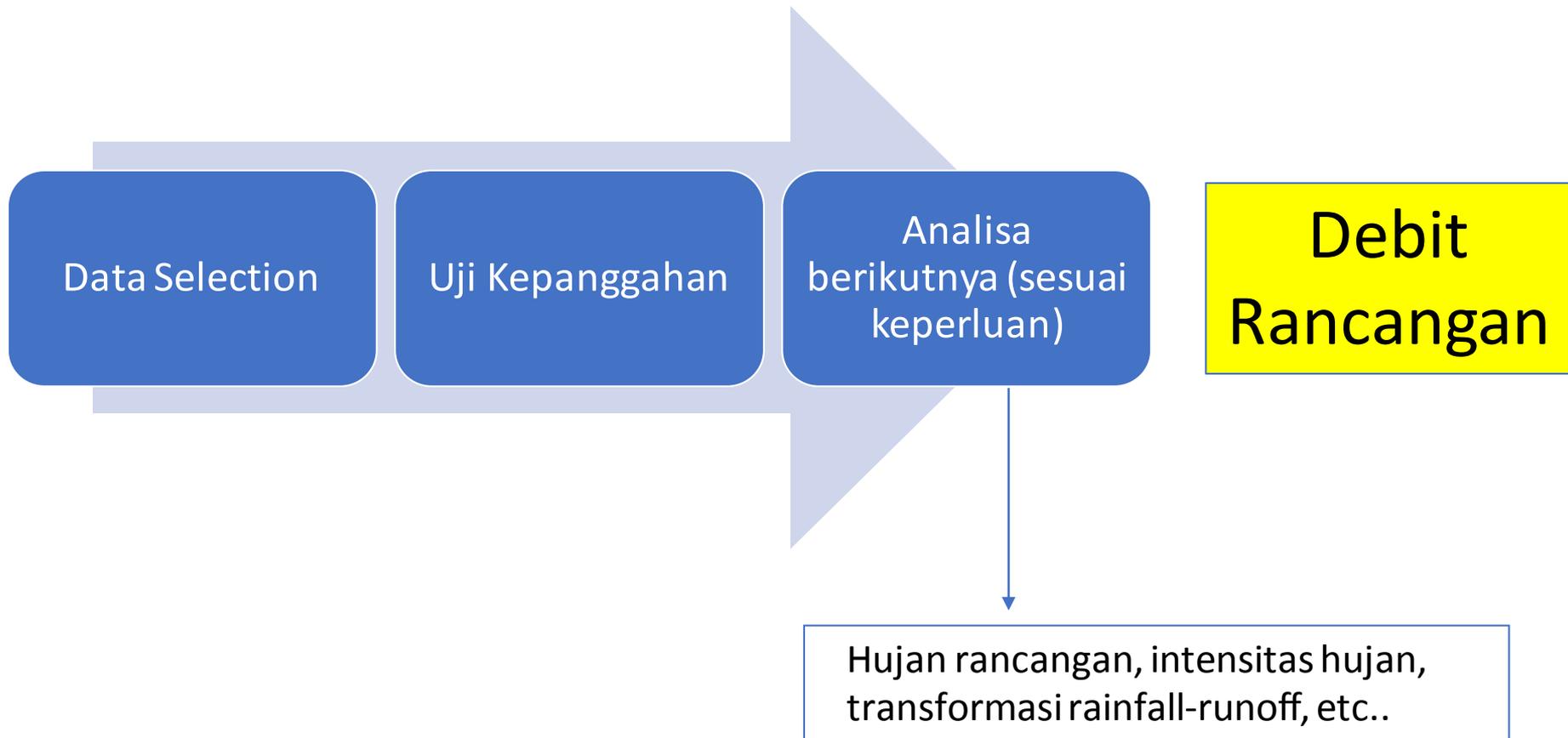
DAS OPAK

161	Kec. Magelang Selatan
45	▲ Serayu
46	▲ Pulo
47	▲ Karang
48	▲ Banjir
49	▲ Kedung Mini
50	▲ Karangmoyo
51	▲ Playen
52	▲ Wanagama
53	▲ Gedangan
54	▲ Playen
55	▲ Karangmoyo
56	▲ Gedangan
57	▲ Wanagama
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59	▲ Karangmoyo
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61	▲ Wanagama
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121	▲ Wanagama
122	▲ Playen
123	▲ Karangmoyo
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127	▲ Karangmoyo
128	▲ Gedangan
129	▲ Wanagama
130	▲ Playen
131	▲ Karangmoyo
132	▲ Gedangan
133	▲ Wanagama
134	▲ Playen
135	▲ Karangmoyo
136	▲ Gedangan

Contoh



Overview Analisa Data Hujan



(Details will be discussed next week)

What's next

Materi pertemuan berikutnya

- Cara uji kepengangan data hujan & Latihan
- Cara menghitung hujan rerata & latihan
- ...

See you next week!