# Workshop on:

## GIS–based River Discharge Modelling

Speaker:
Dr. ABOLGHASEM AKBARI
Faculty of Civil Engineering & Earth Resource, University Malaysia Pahang (UMP)
akbariinbox@yahoo.com / akbari@ump.edu.my

Date: 1-3 June 2016

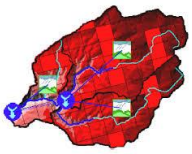
**Venue: Cube Room, Level 4, New IPS building, University Malaya, Kuala Lumpur, Malaysia**



**Watershed Modeling using HEC-GeoHMS**

- Watershed boundary delineation

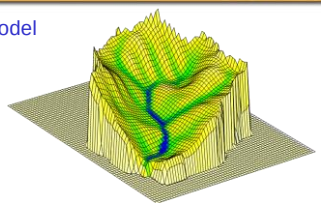
- Watershed parametrization







Digital Elevation Model (DEM)



with the invention of Geospatial Information Systems (GIS) and computer models, the role of digital elevation model (DEM) has become very important and effective tools in, Flood inundation process. Flood simulation mapping and landslide susceptibility mapping are as examples that effectively employ the DEM and its derivatives as one of the important modeling inputs. On the other hand, satellite based DEMs have been growing rapidly in recent years.

Since Miller and Laflamme who coined the original term, other expressions such as DEM,
Digital Height Models (DHM),
Digital Surface Model (DSM),
Digital Terrain Model (DTM),
Digital Ground Models (DGM) and
Digital Terrain Elevation Model (DTEM),
have been used by Maidment, Djokic and Ye, Vieux and Li et al. According to Li et al. the word DEM is widely used in United States,
DHM in Germany,
DGM in the United Kingdom
and DTEM was introduced and is used by United States Geological Survey (USGS)





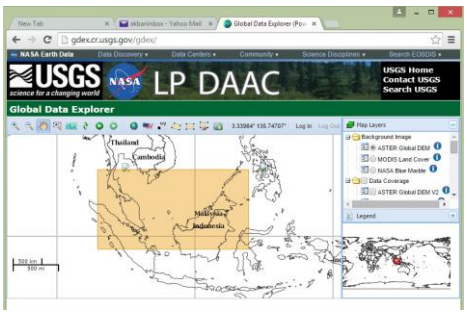
Recommended DEM cell sizes and their range of applications (After Maidment )

| Cell Size | Watershed Area ($km^2$) | Typical Application |
|---|---|---|
| 30 m | 5 | Urban watersheds |
| 90 m | 40 | Rural watersheds |
| 460 m | 1000 | River basins |
| 930 m | 4000 | Nations |
| 5.6 km | 150,000 | Continents |
| 9.3 km | 400,000 | Global |

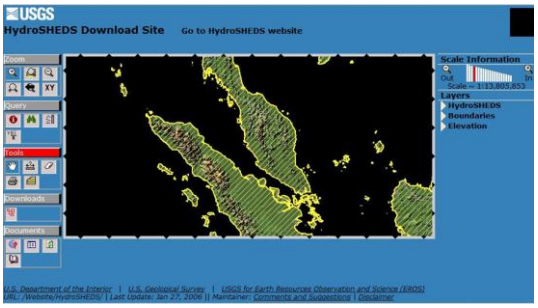




**Different sources of free satellite-based DEMs :**



## Different sources of free satellite-based DEMs :








## ASTER Satellite Sensor Specifications

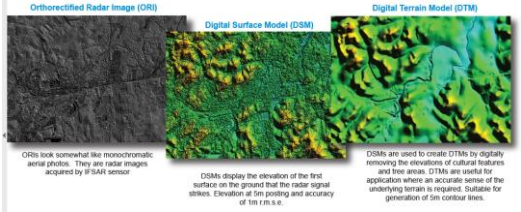
| | |
|---|---|
| **Launch Date** | **18 December 1999 at Vandenberg Air Force Base, California, USA** |
| **Equator Crossing** | **10:30 AM (north to south)** |
| **Orbit** | **705 km altitude, sun synchronous** |
| **Orbit Inclination** | **98.3 degrees from the equator** |
| **Orbit Period** | **98.88 minutes** |
| **Grounding Track Repeat Cycle** | **16 days** |
| **Resolution** | **15 to 90 meters** |



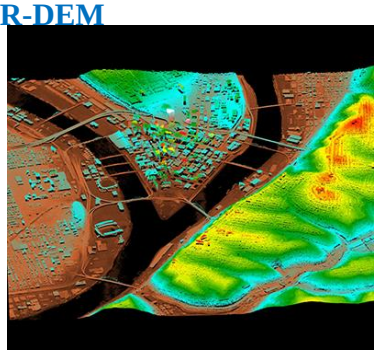


## ifSAR-DEM

| Product Deliverables | Pixel Size/Post Spacing | Accuracy (RMSE) |
|---|---|---|
| Type II Digital Surface Model (DSM) | 5.0m | 1.0m vertical<br>2.0m horizontal |
| Tropical Digital Terrain Model (DTM) | 5.0m | 1.0m vertical<br>2.0m horizontal |
| Type 1+ Orthorectified Radar Image (ORI) | 0.625m/1.25m | 1.0m vertical<br>2.0m horizontal |



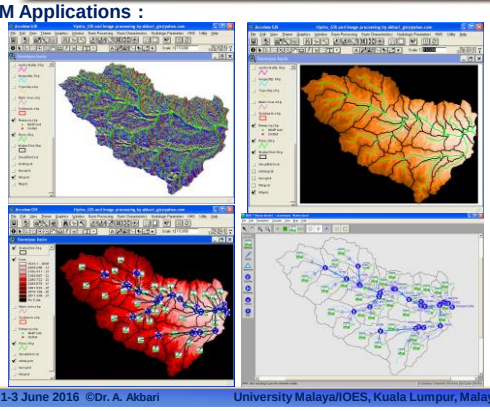
## LiDAR-DEM







## DEM Applications :

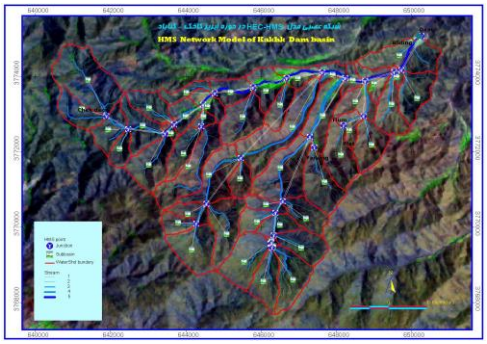


- Watershed delineation and rainfall runoff simulation

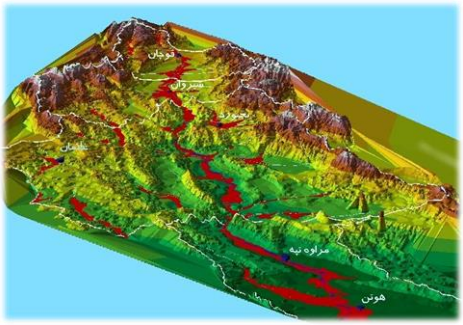




## Integration with Landsat image for better visualization :



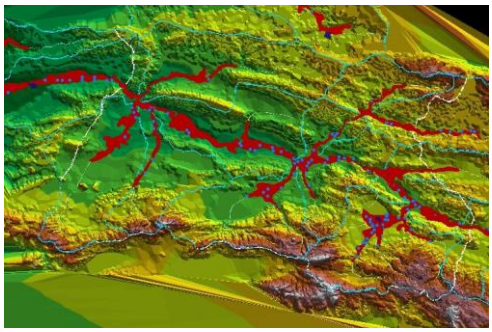
## Flood inundation modeling and visualization







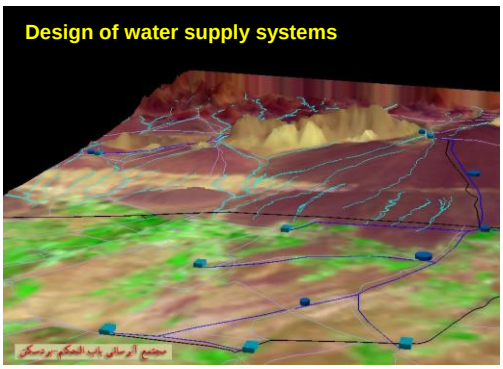

## Hazard mapping and visualization



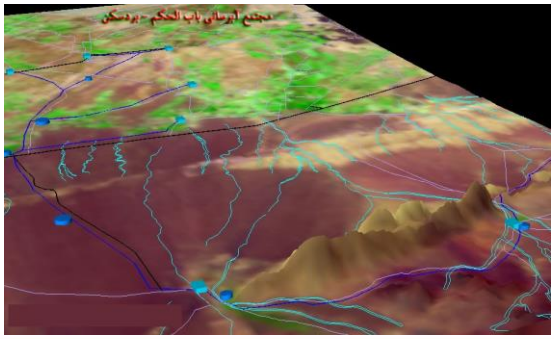




## Design of water supply systems



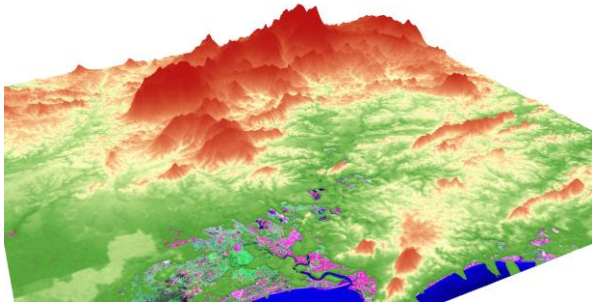
## Water supply systems







## Application in Tsunamis

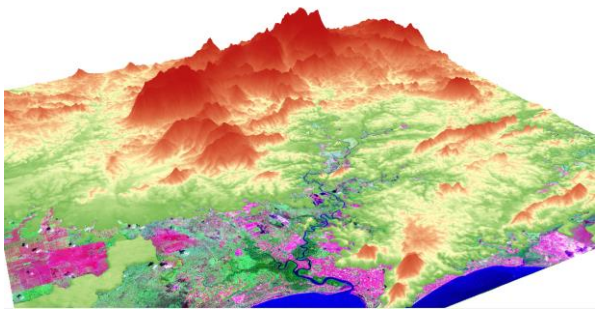


Tsunamis wave 10 m

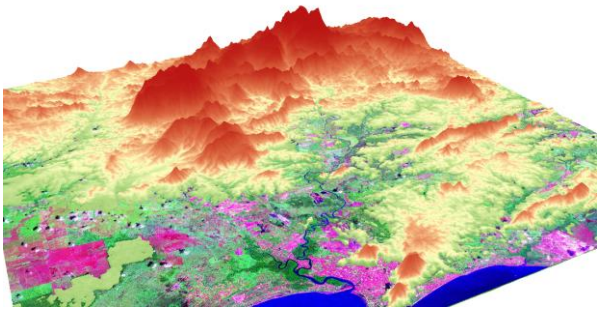








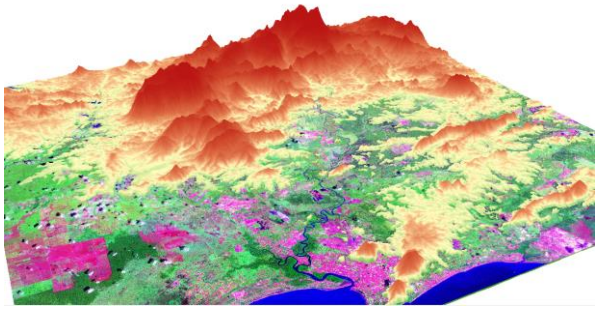
Tsunamis wave 20 m



Tsunamis wave 30 m



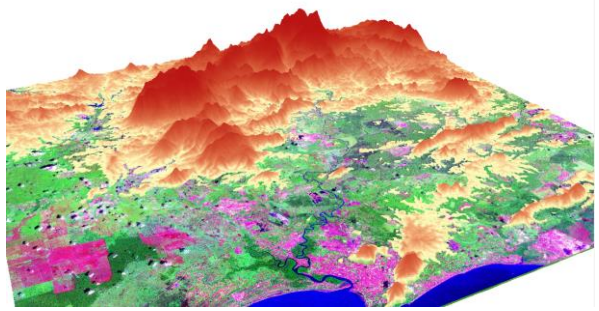




Tsunamis wave 40 m







Tsunamis wave 50 m

## DEM Optimization
## Hydrologically adjusted DEM or called Agree-DEM

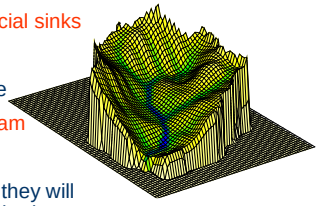
**Basic stapes:**
- **Smoothing (using average filter)**
- **Majority filter (filling undefined pixels)**
- **Filling sinks**
- **Reconditioning**





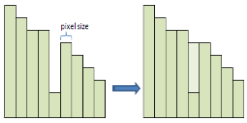
DEM creation results in artificial sinks in the landscape.

A sink is a set of one or more cells which has no downstream cells around it.



Unless these sinks are filled they will isolate portions of the watershed.

Filling sinks is the first step for processing a DEM for watershed delineation.



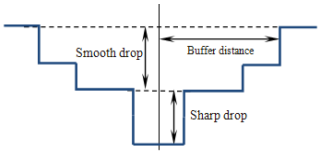

**Profile view of sink in DEM (left) and filled depression of DEM (right)**





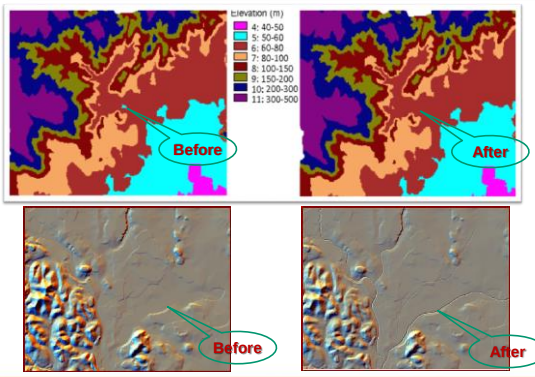

| | Buffer_dist | Smooth_drop | Sharp_drop |
|---|---|---|---|
| 2 | 40 | 2.0 | 2.0 |
| 1 | 20 | 1.0 | 1.0 |

DEM reconditioning using attributes table of stream network



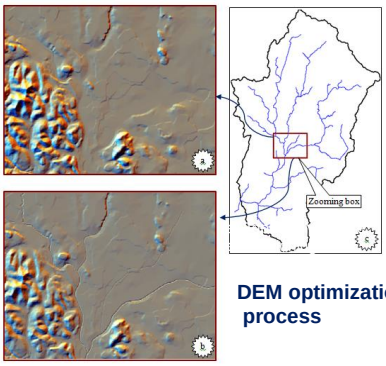

Schematic representation of DEM reconditioning

DEM optimization process







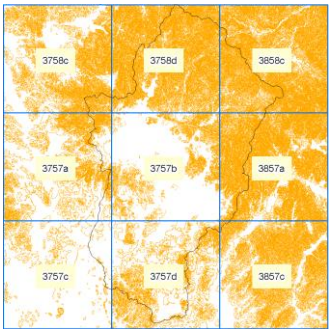




DEM optimization process





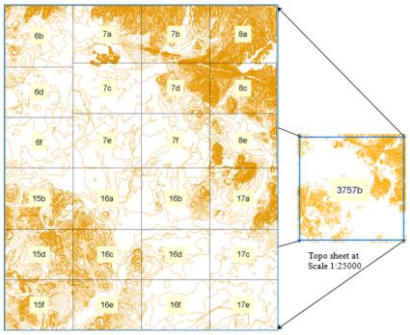
## Problem with cartographic product




Watershed-layout in map index of topo sheets at scale of 1:25000

## Problem with cartographic product

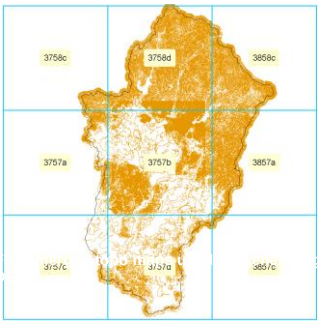
Filling void areas at sheet number 3757b (scale 1:25000) with topo sheets at scale 1:10000







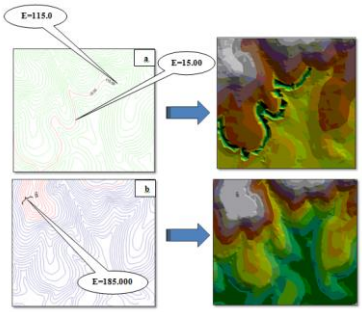

## Problem with cartographic product



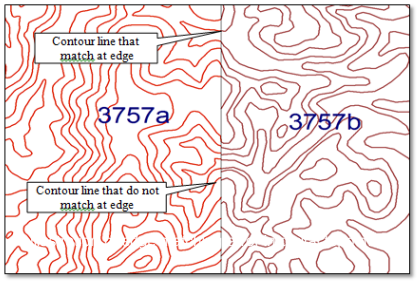





## Code consistency



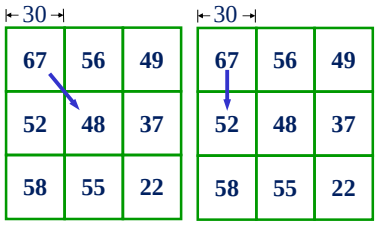
## Edge matching








## Hydrologic Slope
- Direction of Steepest Descent



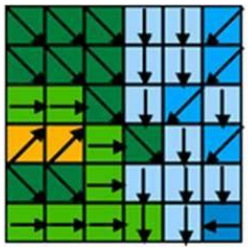

Slope: $\frac{67-48}{30\sqrt{2}} = 0.45$ $\frac{67-52}{30} = 0.50$



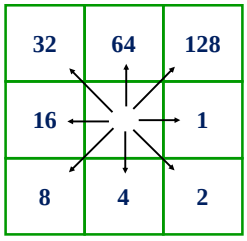


## Flow Direction Arrows
Based on Direction of Steepest Descent

| | | | | | |
|---|---|---|---|---|---|
| 78 | 72 | 69 | 71 | 58 | 49 |
| 74 | 67 | 56 | 49 | 46 | 50 |
| 69 | 53 | 44 | 37 | 38 | 48 |
| 64 | 58 | 55 | 22 | 31 | 24 |
| 68 | 61 | 47 | 21 | 16 | 19 |
| 74 | 53 | 34 | 12 | 11 | 12 |



Eight Direction Pour Point Model

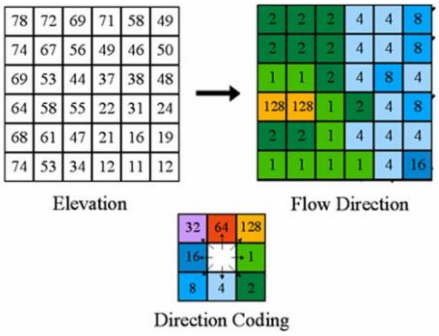



ArcGIS Flow Direction Encoding





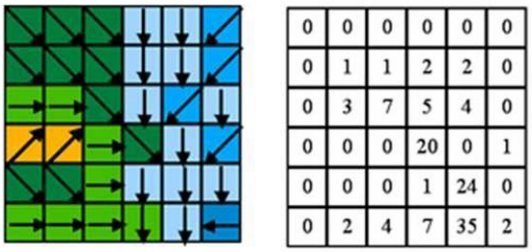
ArcGIS Flow Direction Raster Encoding







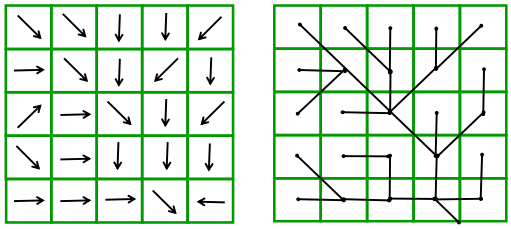

Flow Accumulation
Number of Cells Contributing Flow




Flow Direction

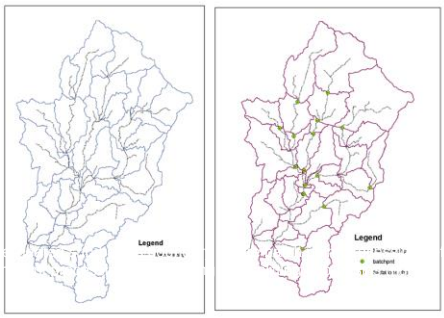
Flow Accumulation
Value = Number of Cells Flowing Into

## Delineating Surface Water Drainage



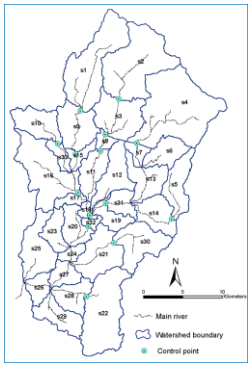


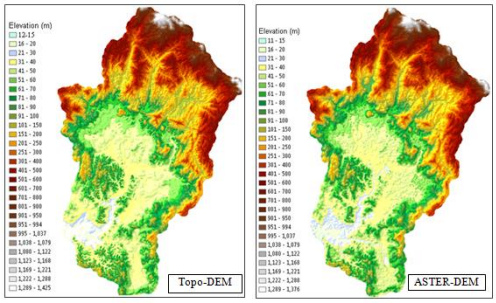






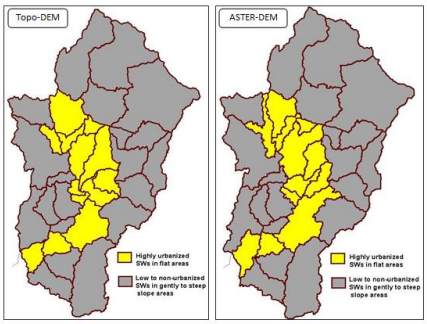



Elevation (m)
Topo-DEM
Elevation (m)
ASTER-DEM



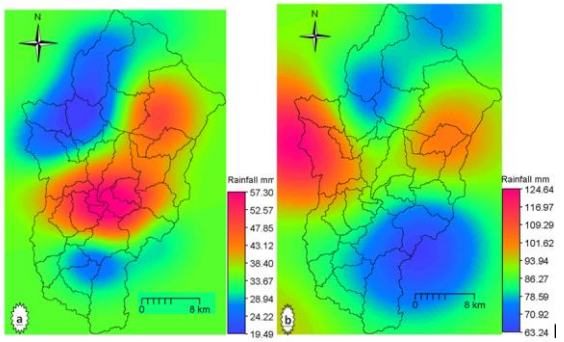



Topo-DEM
Highly urbanized SWs in flat areas
Low to non-urbanized SWs in gently to steep slope areas
ASTER-DEM
Highly urbanized SWs in flat areas
Low to non-urbanized SWs in gently to steep slope areas



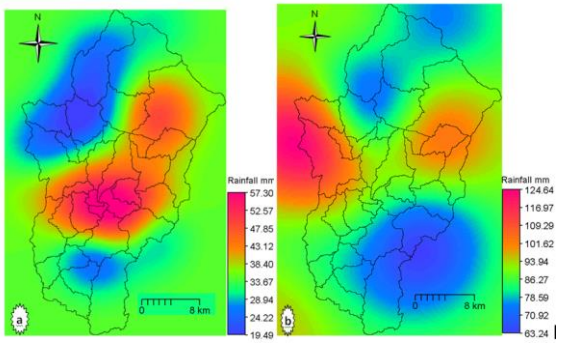



Legend
Stream flow Gauge
Rain Gauge
Kuala Lumpur Boundary
Main river
Watershed Boundary





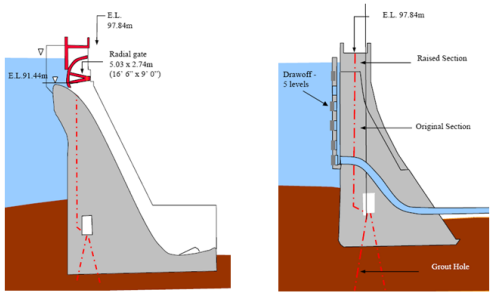


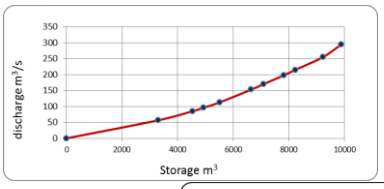






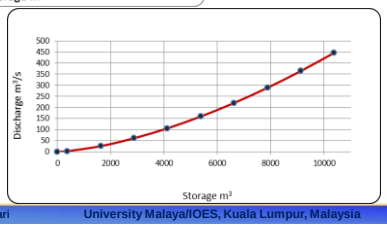




Cross section of Klang Gate Dam. Taken from Gibson and Dodge (1983)



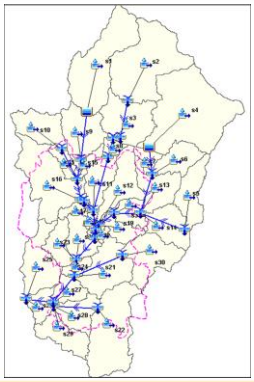

Storage-discharge relationship of Klang Gate Dam

Storage-discharge relationship of Batu Dam



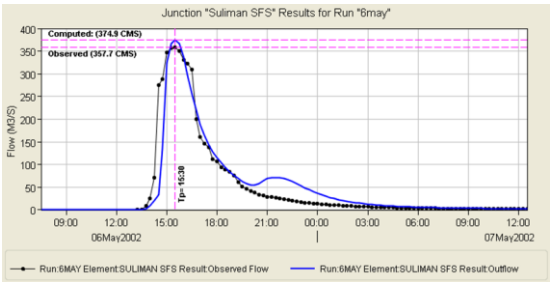




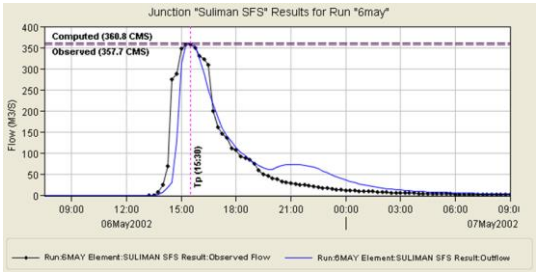










Observed and simulated flood hydrograph resultant from modified-CN for event 6-May at Sulaiman Bridge.




Observed and simulated flood hydrograph resultant from modified-CN for event 6-May at Sulaiman Bridge.





**Exercise 2**

- Open your ArcMap and active your HEC-GeoHMS extension
- Generate Agree-DEM for raw DEM provided on d:\data
- Delineate watershed boundary for the Klang Gates Dam watershed
- Calculate the following watershed characteristics for each subbasin:
  (i) form factor,
  (ii) compactness coefficient,
  (iii) elongation ratio, and
  (iv) circularity ratio.





# Thank you

**akbariinbox@yahoo.com**