CE-432

Hydraulics Engineering Lec #1:

Introduction to Hydraulics

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Department of Civil Engineering

Course Outline

- Introduction of Hydraulic Engineering
- Steady Flow in Open Channels
  - Specific Energy and Critical Depth.
  - Flow over Humps and Constrictions.
  - Surface Profiles and Back Water Curves in channels of uniform sections.
  - Hydraulic Jump and its practical applications.
  - Critical Depth Meters, Broad Crested Weirs and Venturi Flume.
  - Surges in Open Channels.
- Unsteady Flow.
  - Unsteady flow through Pipelines.
  - Discharge through orifices and over weirs under varying heads
  - Water Hammer.
  - Instantaneous and Slow Closure of Valves.
- Introduction to Computational Hydraulics
  - Introduction to Numerical Models.
  - Introduction to HEC-RAS
- Dams
  - Types of Storage Dams.
  - Forces on Dams.
  - Design of Gravity Dams.
- Reservoir Engineering.
  - Regulation of Storage Reservoirs.
- Hydro Power Engineering
  - Selection of Hydropower Sites.
  - Components and Layout of Waterpower Scheme.
- Hydraulic Similitude
  - Similitude in Hydraulic Model Testing.
  - Similitude Requirements: Geometric, Kinematics and Dynamic Similarities.
  - Various Dimensionless Numbers and their Significance.
  - Physical Models, Techniques and Analysis.
- Sediment Transport in Open Channels
  - Properties of Individual Particles.
  - Fall Velocity, Movement of Bed and Suspended Load.
  - Collection and Analysis of Field Data
  - Methods for Estimation of Transport Capacity of Channels

Books

- Fluid Mechanics with Engineering applications

  By: Roberts L. Daugherty, Joseph B. Franzini, E. John Finnemore
- Open Channel Flow

  By: Ven Te Chow
- Hydraulic Structures

  By P. Novak, AIB Moffat, C. Nalluri, and R. Narayanan
- Reference Books:
  - Sediment Transport Technology

    By: Simon, Daryl and Senturk, Frat

Evaluation Methodology

- **Theory:**
  - Mid Semester Exam: (Close Book), Weightage: 30 %
  - Quiz I: Weightage: 10 %
  - Quiz II Weightage: 10 %
  - Class Participation + Attendance: 10%
  - End Semester Exam: (Close Book), Weightage: 40 %
- **Part-II:**
  - Lab Report & Viva Voce: 70 %
  - Lab Quiz: 20 %
  - Lab Attendance: 10 %

Lecture Delivery Plan

Week 1	Introduction of Hydraulic Engineering (03-09-2012)
Week 2	Steady flow in Open Channels, Velocity Distribution in Open Channel
Week 3	Specific Energy and Critical Depth
Week 4	Flow over Humps
Week 5	Flow through Constrictions
Week 6	Water Surface Profiles Computations
Week 7	Surface Profiles Types
Week 8	Hydraulic Jump and its practical applications
Week 9	Quiz 1 + Mid Semester Exam (Week starting 5-11-2012)
Week 10	Broad Crested Weirs and Venturi Flume, Critical Depth Meters
Week 11	Unsteady flow through Pipelines
Week 12	Discharge through Orifices and over Weirs under Varying Heads
Week 13	Water Hammer: Instantaneous and Slow Closure of Valves
Week 14	Quiz-2: (Week starting ??-??-2012)
Week 15	Surges in Open Channels
Week 16	Exam Preparation (Week starting ??-??-2012)

Hydraulics Engineering

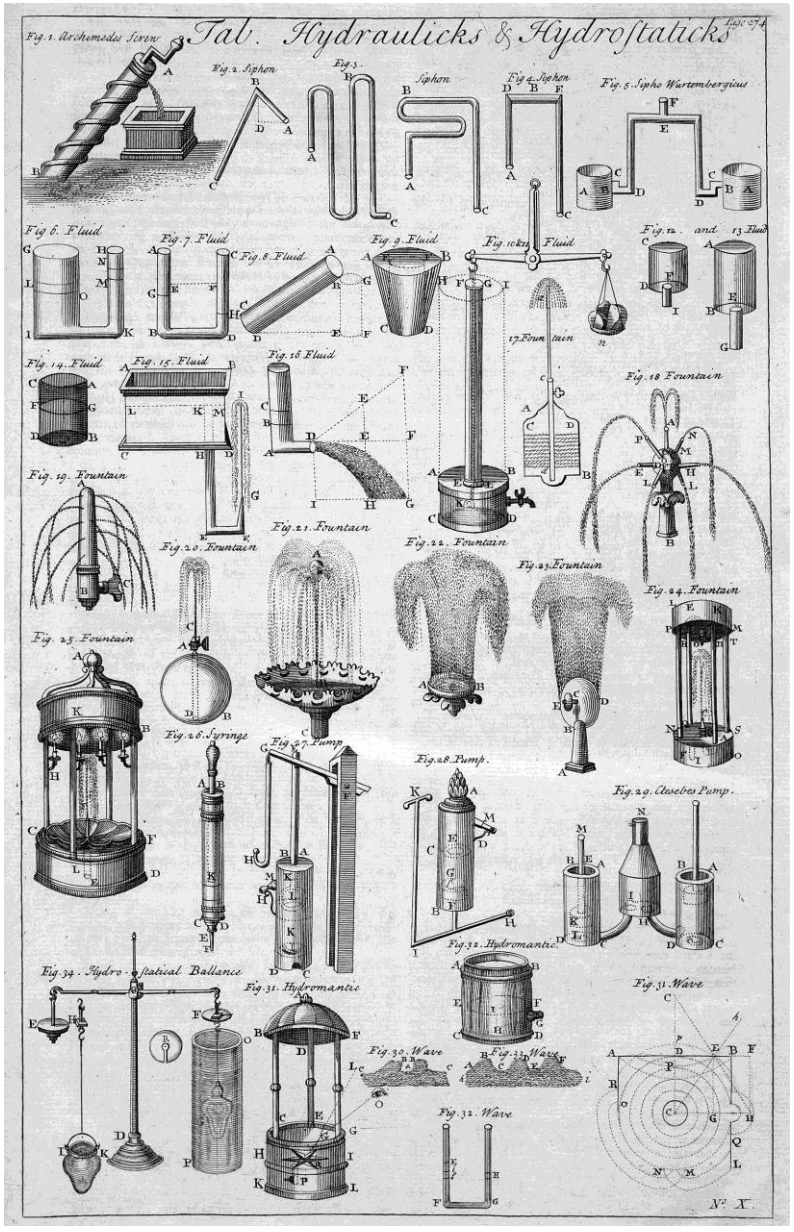
The term ‘hydraulics’ is related to the application of the Fluid Mechanics principles to water engineering structures, civil and environmental engineering facilities, especially hydraulic structures (e.g. canal, river, dam, reservoir and water treatment plant) [1].

- Definition
  - Branch of Civil Engineering concerned with the flow and conveyance of the fluid, especially water. [Wikipedia]

  Highly related to design of bridges, dams, canals, levees, water supply system, sanitation, irrigation system
- Difference between Hydraulics and Hydrology
- History of Hydraulics

[1.] The Hydraulics of Open Channel Flow: An Introduction, Second Edition, by Hubert Chanson. 2004. Elsevier Butterworth-Heinemann.

Historical Hydraulic Instruments



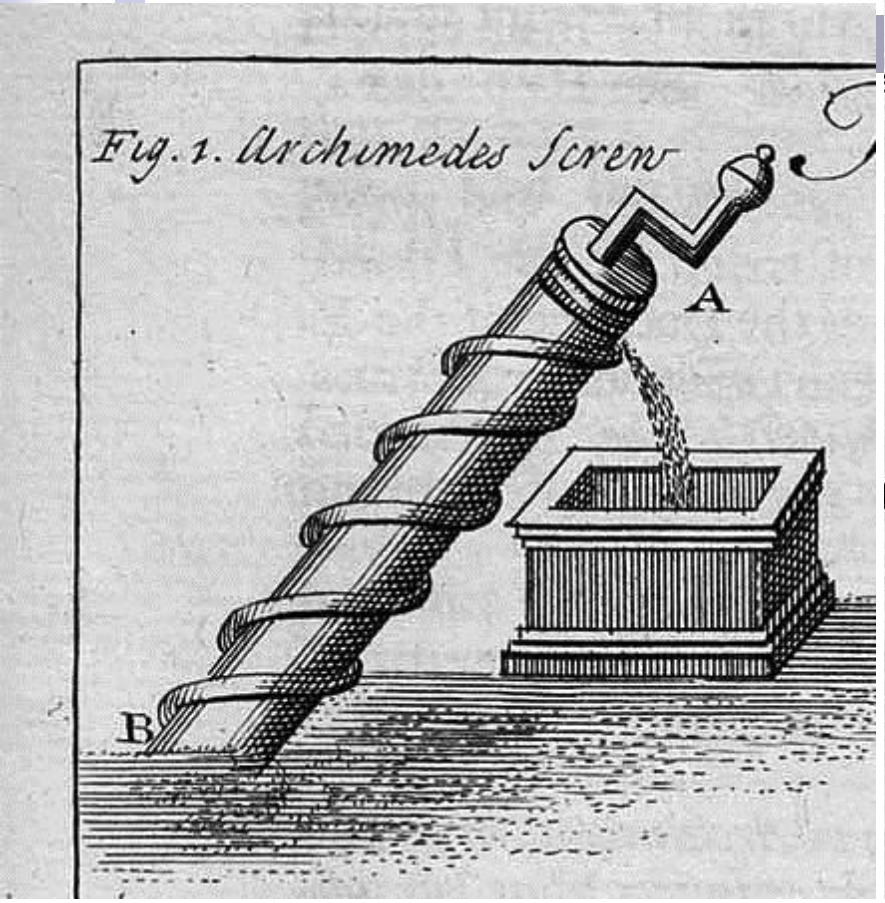
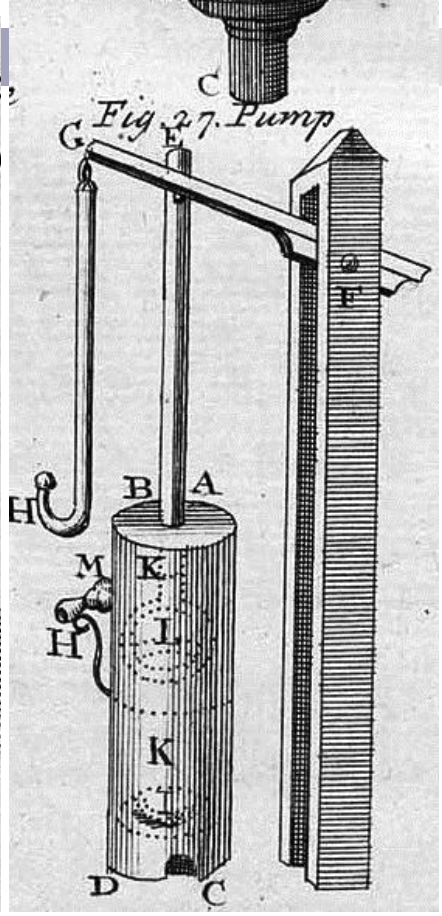


Fig. 1. Archimedes Screw
A
B


C
Fig. 27. Pump
G
E
F
H
B
A
M
K
H
I
K
D
C

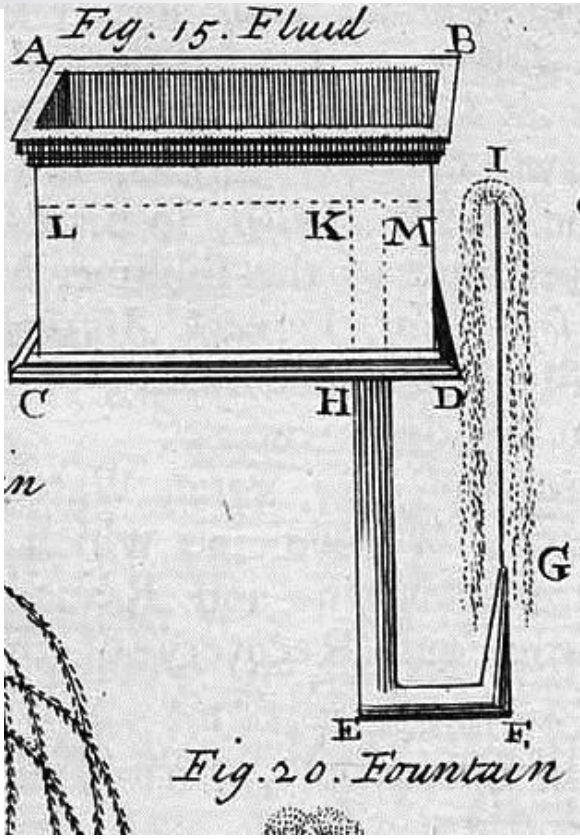


Fig. 15. Fluid
A
B
I
L
K
M
C
H
D
n
G
E
F
Fig. 20. Fountain

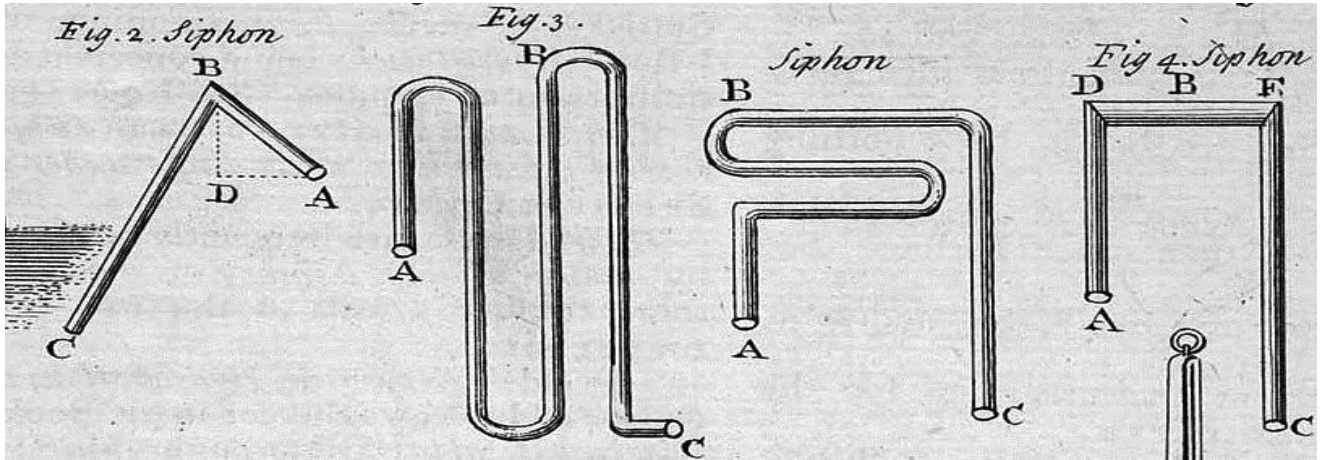


Fig. 2. Siphon
B
D
A
C
Fig. 3.
B
A
C
Siphon
B
A
C
Fig 4. Siphon
D
B
F
A
C

History

- Egyptian:
  - Signs of use of canals for water supply and irrigation by Egyptian
  - One of major contribution by Pharohs was construction of canals
  - Draw water from canal/river by Swape or Shuduf
    - Shuduf is a bucket attached to a pivoted boom through a string. The boom is balanced by a counter weight on far end.

FIGURE 1.3 Shadufs of the Amarna period, from the tomb of Nefer-Hotep at Thebes. Note irrigation of date palms and other orchard trees and the apparent tank or pool (lower right). The water pattern in the lowest margin suggests lifting out of an irrigation canal. (Davies, 1933, pls. 46 and 47). Figure as presented in Butzer (1976).

Various Civilizations in Chronological Order

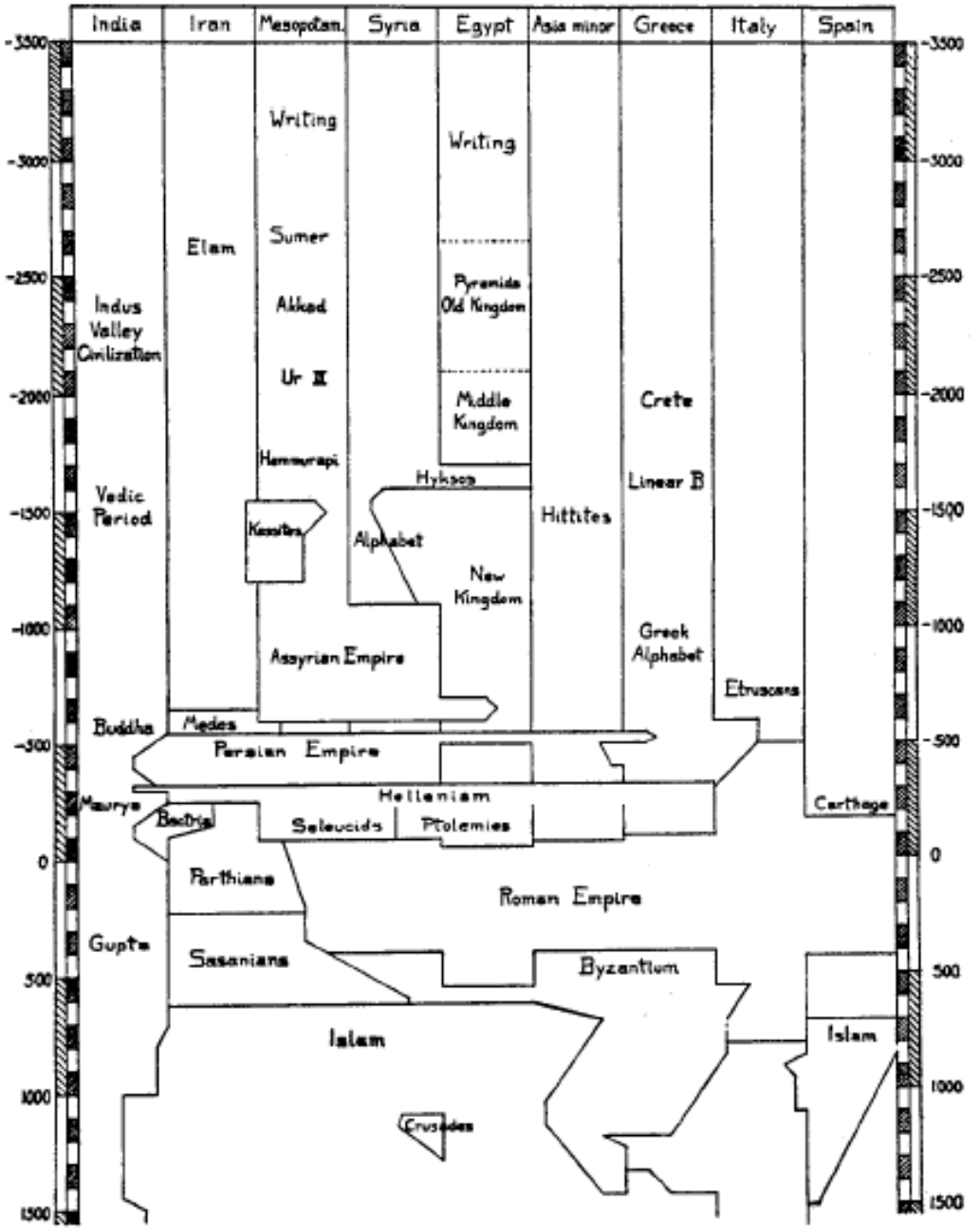


FIGURE 1.2 Chronology and location of different civilizations ranging from India to Western Europe. (Neugebauer, 1993)

History

- Mesopotamia
  - Mesopotamia is Greek Word meaning “Land between two rivers” i.e. Tigris and Euphrates
  - Sumerian (~ 2500 BC) built walled cities and for that dug canals, which are considered as first engineering works
  - They fought over water rights
  - They had written rules about maintenance of canals. e.g. rule below is 6th c. BC rule:

> *“The gentleman who opened his wall for irrigation purposes, but did not make his dyke strong and hence caused a flood and inundated a field adjoining his, shall give grain to the owner of the field on the basis of those adjoining.”*

  - Mesopotamian agriculture declined because of salty soils.
  - Tigris & Euphtates carried silt 6 times more than Nile, and such posed bigger problems of flooding and course changes than that in Egypt (Nile valley)
  - Mangols destroyed their irrigation system in 1258 AD

Qanat or Karaiz

Karaiz: A system of tunnels used to bring water from an underground source in the hills down to the foothills.

- Developed by Armenian
- Asyrian (Mesopotamia) Ruler Saragon Destroyed it in Armenia and brought it to Asyria in 715 BC
- Spread in Africa, and Persia
- Still in use in Pakistan, Afghanistan, Iran

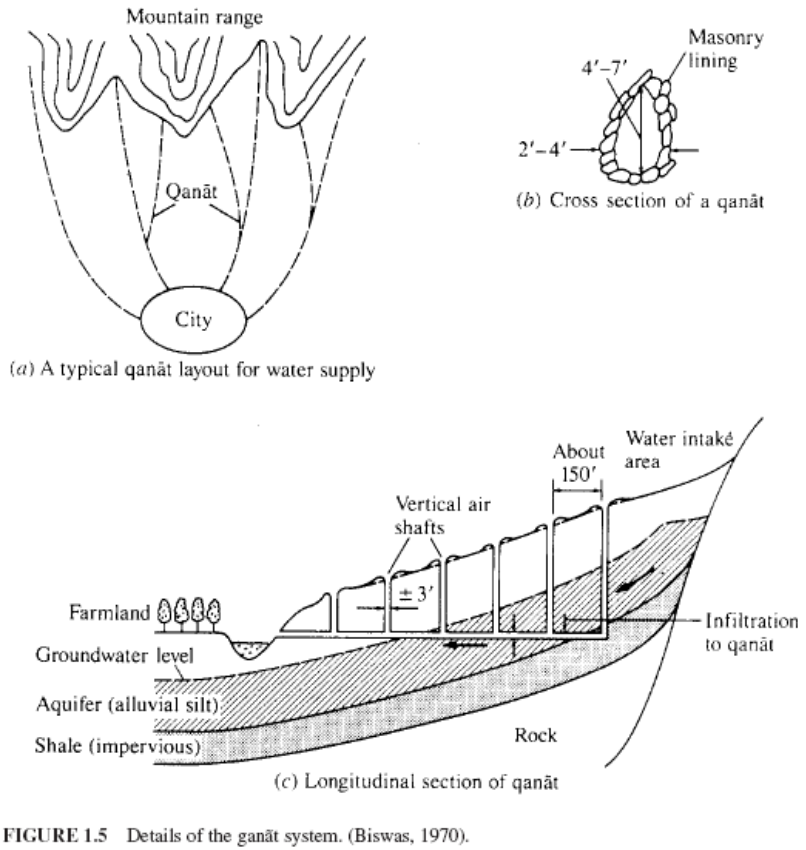


FIGURE 1.5 Details of the ganāt system. (Biswas, 1970).

Ref: Hyd. Des. Hand Book by Larry W Mays

Dams

- The **Sadd-el-Kafara** dam (Dam of the Pagans) in Egypt, situated on the eastern bank of the Nile near Heluan approximately 30 km south of Cairo, in the Wadi Garawi, has been referred to as the world's oldest large dam (Garbrecht, 1985).
- It was built between 2,950 and 2,690 B.C.
- Although the **Jass drinking-water reservoir** in Jordon and the diversion dams on the **Kasakh River** in Russia are probably older, they are much smaller than the Sadd-el-Kafara (Dam of the Pagans).
- It is unlikely that the Sadd-el-Kafara dam was built to supply water for drinking or irrigation because the dam lies too far from the Alabaster quarries situated upstream to have supplied the labor force with drinking water. Furthermore, there is a vast supply of water and fertile land in the nearby Nile valley.
- The apparent purpose of the dam was to protect installations in the lower wadi and the Nile valley from frequent, sudden floods.
- The dam was destroyed during construction by a flood; consequently, it was never completed.
- To date, the dam's abutments still exist.

TGP

Statistics – Three Gorges Project, Yangtze River, China

Catchment Area	1.8 million km^2
River length to dam	3,600 km
River length total (World's Third Longest)	6,400 km
Average annual discharge	14,300 m^3/s
Annual discharge	451 billion m^3
Average annual sediment load	530 million tonnes
1 in 1,000 year flood (175m)	98,800 m^3/s
1 in 10,000 year flood (180.4m)	124,300 m^3/s
Total reservoir capacity (to 175m)	39.3 billion m^3
Flood control capacity (145m -175m)	22.15 billion m^3
Flood protection	from 1 in 5 year to 1 in 100 year
Population protected	15 million
Active regulation storage (155m-175m)	16.5 billion m^3
Dead capacity (below 145m)	17.15 billion m^3
Reservoir surface area	1084 km^2
Reservoir length	660 km (to Chongqing)
Farmland inundated	27,820 ha
Affected population	844,000 (rising to 1.1 million)
Population centres affected	2 cities, 11 county seats and 116 tow
Dam type	Concrete Gravity
Base rock	Granite
Basic Seismic Intensity/Protection	VI/VII
Crest elevation	185m
Maximum height	181m
Length	2309.47m
Spillway total length	483m
Design discharge	72,220 m^3/s

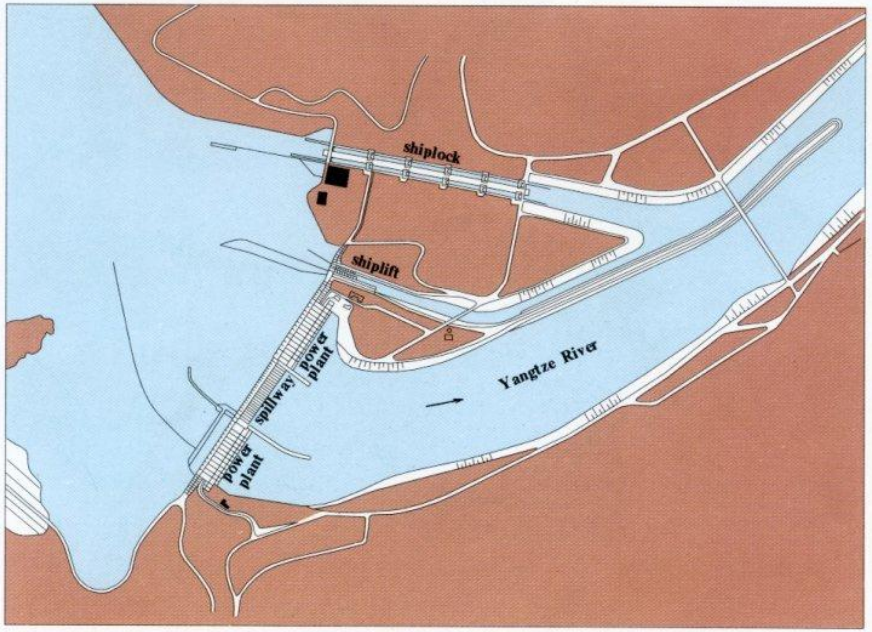


Fig. 2—1 Layout of the Three Gorges Project

TGP

Number of outlets	23 high, 23 low
Maximum flow velocity	39.5m/s
Power capacity	18,400 MW
Francis turbines	26 @ 710 MW
Underground powerhouse, right bank	6 units, future
Annual power output	84.7 TWh
Average head	90m (71-113m)
Shiplock (10,000 tonne vessels)	Twin, 5 bay locks, 280mx34mx5m
Shiplift	120mx18mx3.5m (3,000 tonnes)
Earth and rock excavation	102.829 million m^3
Earth and rock fill	31.979 million m^3
Concrete volume	27.935 million m^3
Rebar	462,300 tonnes
Metal work (gates etc)	256,500 tonnes
Construction period	17 years (1993-2009)
Cost (static)	90 billion Yuan (US$ 11 billion)
Construction	50 billion Yuan (US$ 6 billion)
Resettlement	40 billion Yuan (US$ 5 billion)
Cost including interest and charges	200 billion Yuan (US$ 25 billion)

Shiplock

The boats leaving the final shiplock at 113 meters lower level.

Shiplock

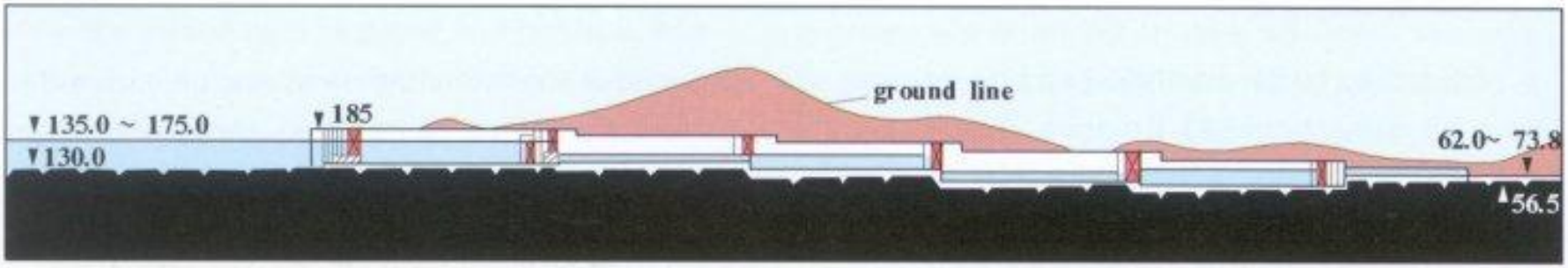


Fig. 2—4 The Sketch of the Shiplock Cross Section

Shiplift

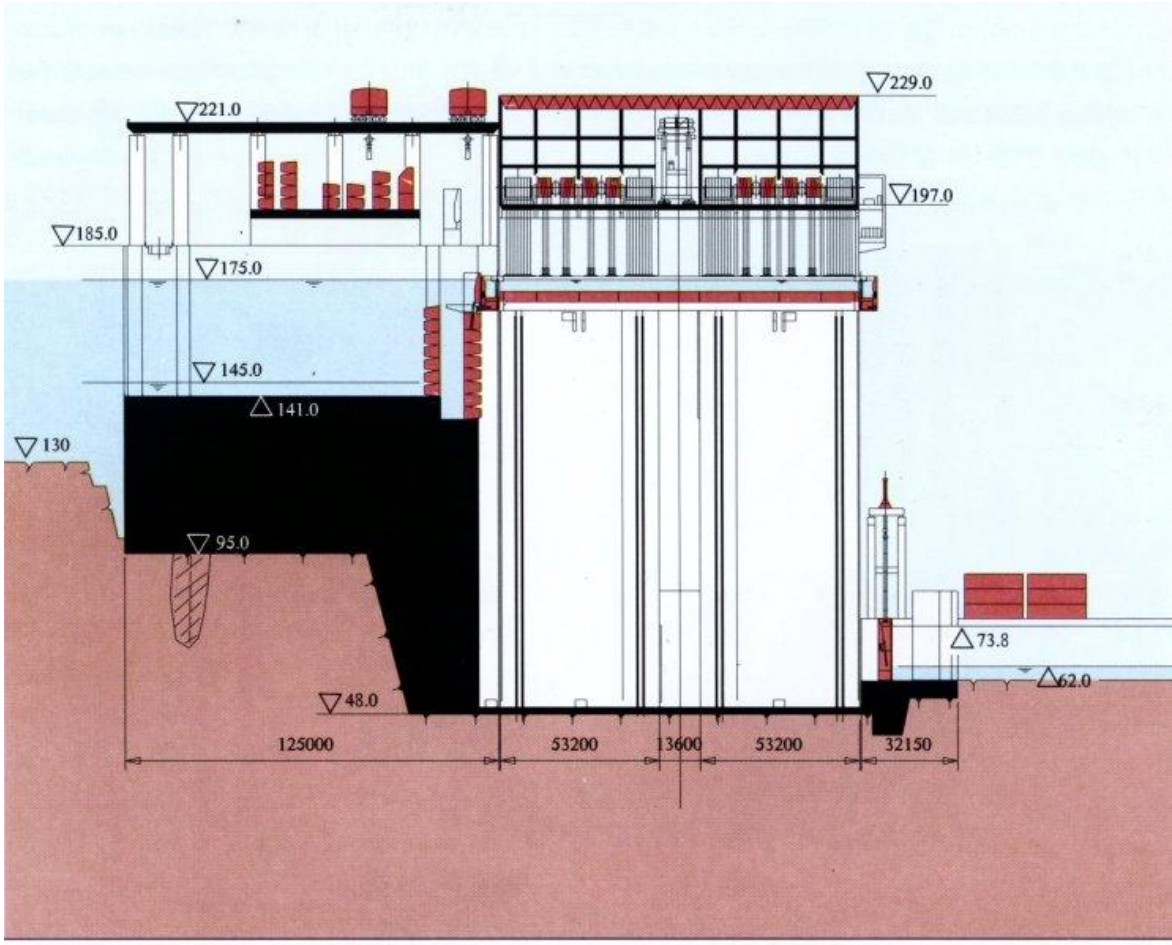
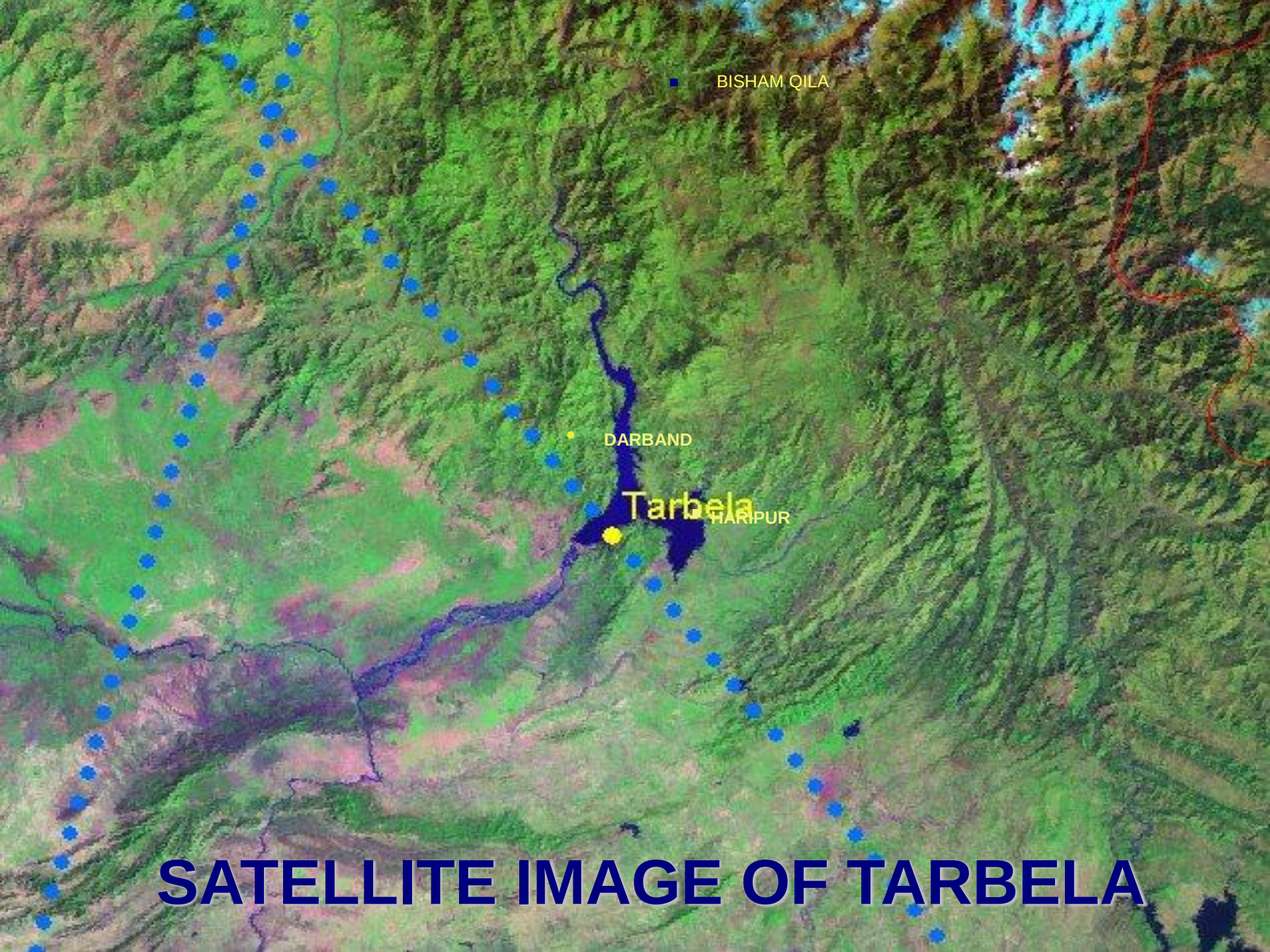
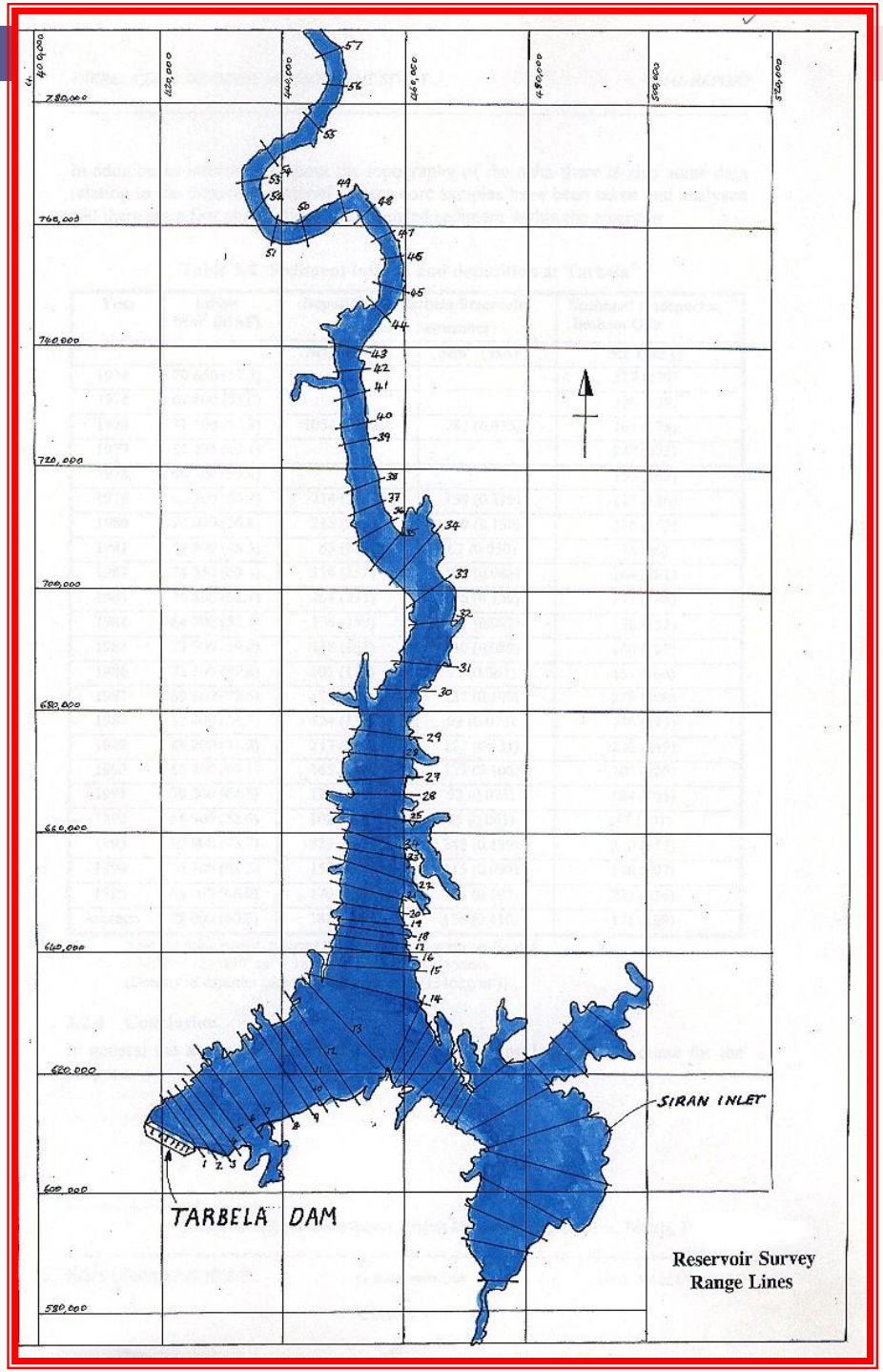


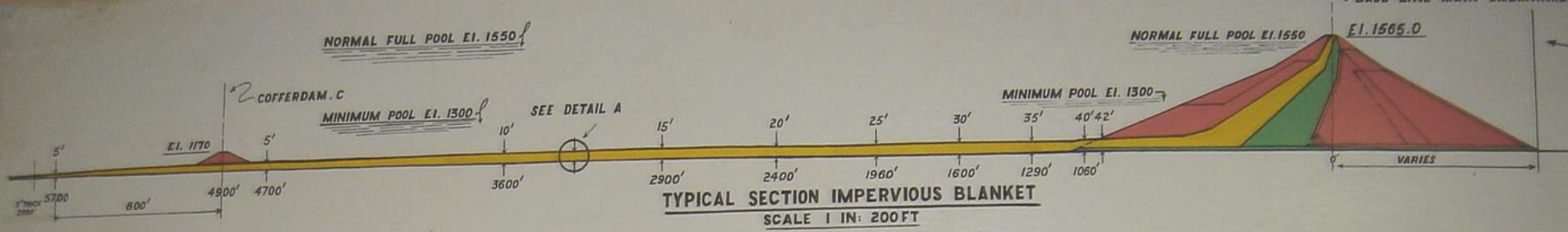
Fig. 2—5 The Sketch of the Shiplift Cross Section



SATELLITE IMAGE OF TARBELA


SIRAN INLET
TARBELA DAM
Reservoir Survey
Range Lines


DIVERSION CHANNEL
COFFERDAM C
INDUS RIVER
IMPERVIOUS BLANKET
IRRIGATION TUNNEL
AUXILIARY SPILLWAY
AUXILIARY DAM 2
SERVICE SPILLWAY
SERVICE SPILLWAY CHUTE
SPILLWAY OUTLET CHANNEL
INTAKE CHANNEL
BUTTRESS DAM
MAIN EMBANKMENT DAM
SWITCHYARD
TAILRACE
POWER HOUSE
IRRIGATION OUTLET
POWER TUNNELS
615,000
420,000
415,000
430,000
600,000



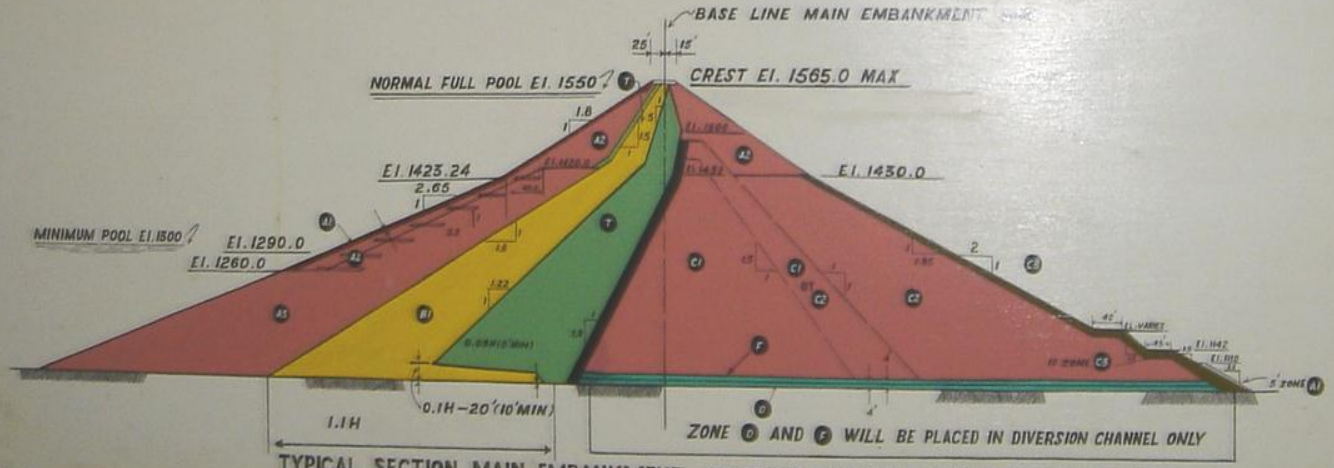
TYPICAL SECTION IMPERVIOUS BLANKET

SCALE 1 IN: 200 FT

DETAIL A

NOT TO SCALE

TYPICAL SECTION MAIN EMBANKMENT — [illegible] AREA



TYPICAL SECTION MAIN EMBANKMENT - DIVERSION CHANNEL & RIGHT ABUTMENT AREA

REFERENCE DRAWINGS

11 NY 200 — GENERAL PROJECT PLAN

22 NY 130 — MAIN EMBANKMENT DAM DETAIL

22 NY 200 — MAIN EMBANKMENT DAM — DRAI

5		
4		
3		
2		
1		
KEY		

2005 5 11

Hydraulics & Civil Engineers

- Storage and Diversion Structures & Their Components
  - Spillways, Tunnels, Hydropower, Navigational locks, Fish Ladder
- Conveyance Structures
  - Canals, Pipes, Aqueducts, Flumes, Outlets, Head regulators, Cross Regulators
- Mechanized Transfer
  - Pumps, Tubewells
- Hydropower
  - Water Wheels and Turbines
- Drainage
  - Ditches and Drains, Open Drains, Tubewells, Tile Drains
- Sediment Erosion, Transport, and Deposition
- Flood Control Structures
- Drinking Water Supply
- Water Treatment

Wonders of Hydraulics/Civil Engg.

Delta Works, Netherlands

Itaipu Dam: 196m high,
Power: 18@715MW=12870MW

Panama: 8m km long,
Joining Atalantic & Pacific Oceans

Ref: http://www.7wonders.org/wonders/civil-engineering-wonders.aspx

Channel Tunnel - France
Channel Tunnel is the largest engineering project in history of the humanity
More about Channel Tunnel | Photos: 3 | Videos:

CN Tower - Canada
The CN Tower one of the largest engineering works of our time and tourism centre in the world more recognizable.
More about CN Tower | Photos: 1 | Videos:

Delta Works - Netherlands
The Delta Works is one of the most impressive structures in the world with its hydraulic system improves water balance which protects Netherlands from storms and high sea levels.
More about Delta Works | Photos: 1 | Videos:

Empire State Building - United States
The Empire State Building in New York City is one of the most famous skyscrapers in the world known over for its history, architecture, and as a symbol of American industry.
More about Empire State Building | Photos: 1 | Videos:

Itaipu Dam - Brazil
The Itaipu Dam is one of the largest operational hydroelectric power plant output of any dam in the world.
More about Itaipu Dam | Photos: 5 | Videos:

Panama Canal - Panama
The Panama Canal is a major ship canal connecting the Atlantic and Pacific oceans is also one of the biggest and most difficult engineering projects ever undertaken before.
More about Panama Canal | Photos: 1 | Videos:

The Golden Gate Bridge - United States
The Golden Gate Bridge is one of the longest suspension bridges in the world and has become an internationally recognized symbol of San Francisco and California.
More about The Golden Gate Bridge | Photos: 1 | Videos: