RECLAMATION
Managing Water in the West

Pressure Flushing of Reservoir Sediment

Reservoir Sediment Management & Analysis for Engineers

June 2018, Lawrence, KS, USA

Presented by

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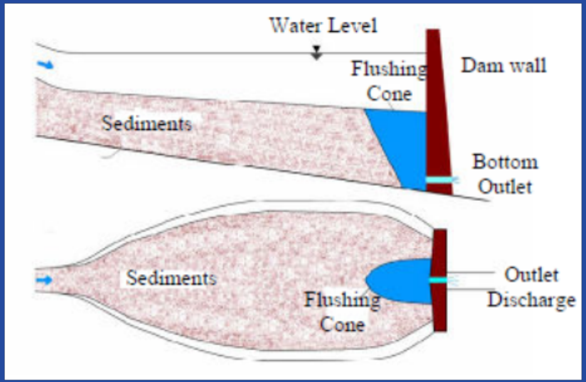
Pressure Flushing in Reservoirs

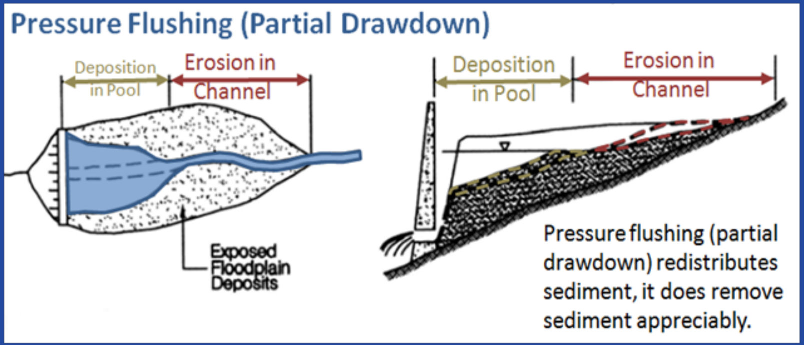
Reasons for Pressure Flushing of Reservoir Sediment:

1. Local flushing around low level outlet

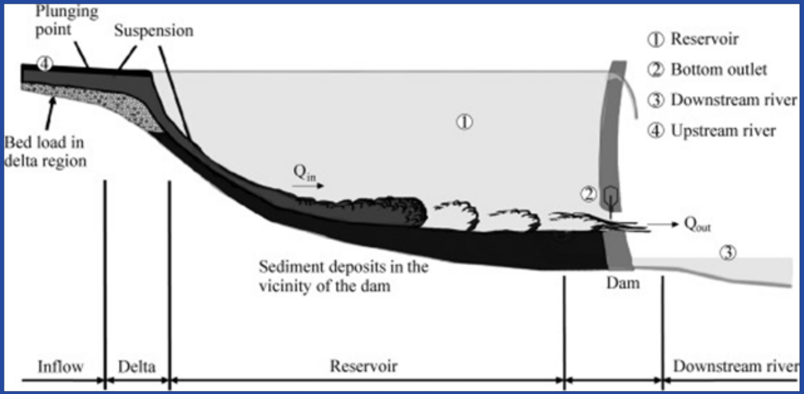


Shahmirzadi et al, 2018

2. Partial drawdown to redistribute sediment



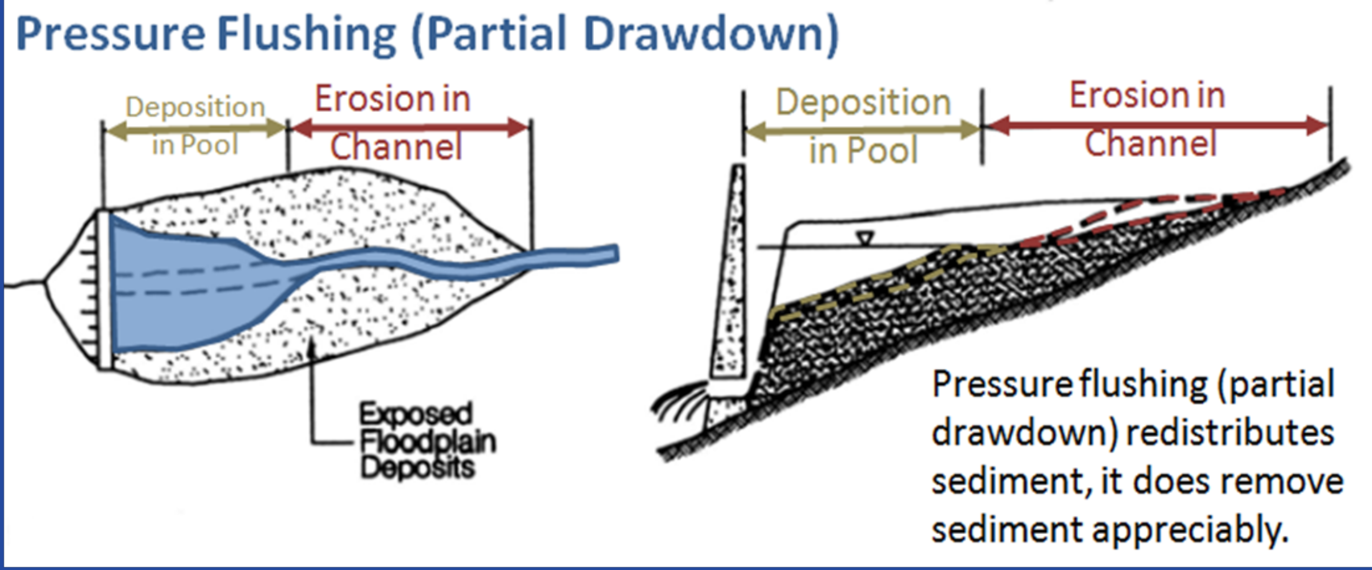
3. Timing of flush with turbidity currents



Meshkati Shahmirzadi, Ebi & Dehghani, Amir & Sumi, Tetsuya & Mosaedi, Abolfazl & Meftah, M. (2018). Experimental Investigation of Pressure Flushing Technique in Reservoir Storages.
Chamoun et al 2016, "Managing reservoir sedimentation by venting turbidity currents: A review" International Journal of Sediment Research, Volume 31, Issue 3, September 2016, Pages 195-204

Pressure Flushing in Reservoirs with Partial Drawdown

- This condition will increase water velocity through deposited sediments, redistributing sediments in the lowered pool and transporting some sediment below dam



Cherry Creek Flush

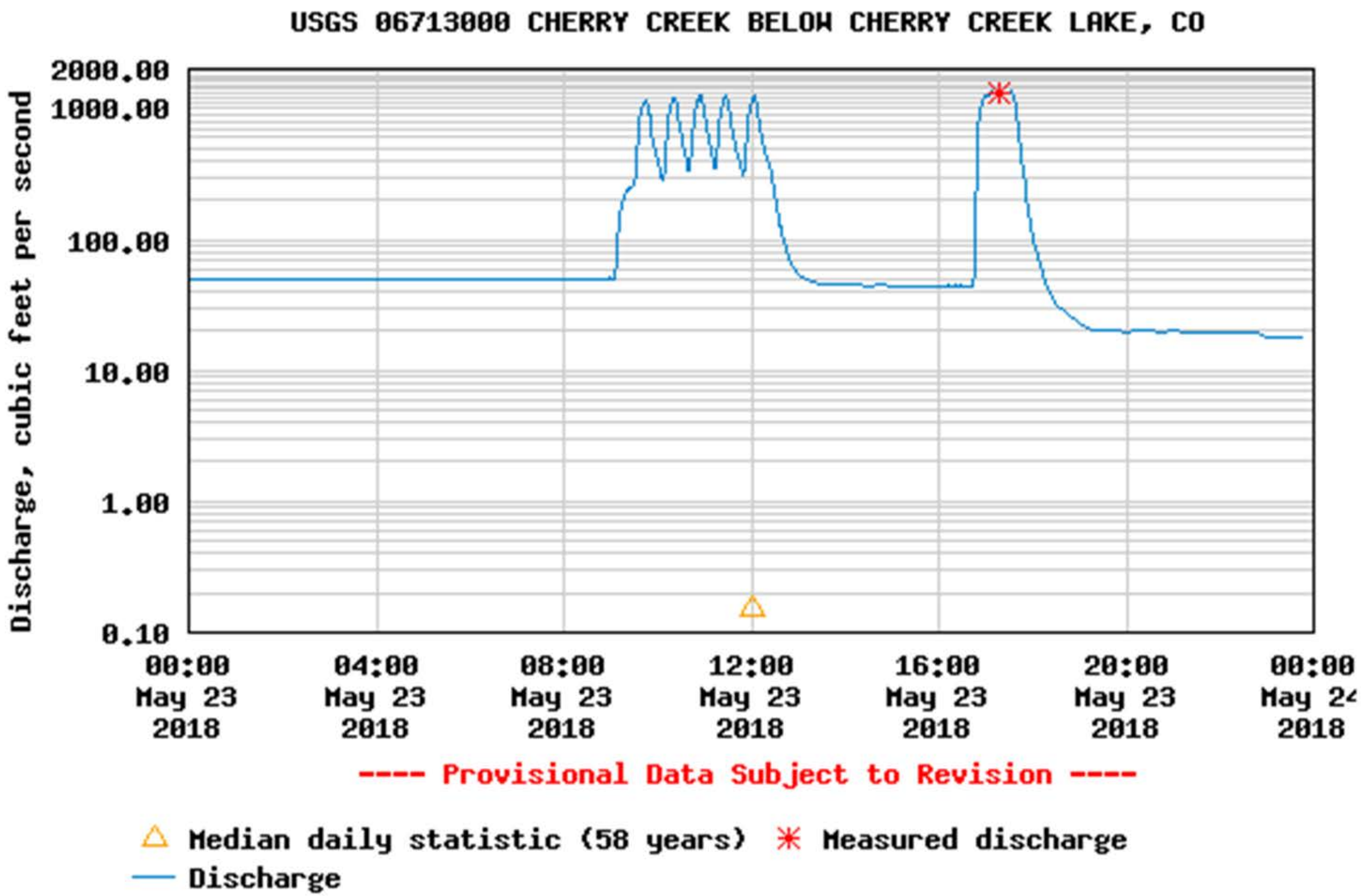
- Pressure flush to maintain operational capability at low level outlet
- Every year alternating high (1300 cfs) and low (250 cfs) flow

Cherry Creek Flush

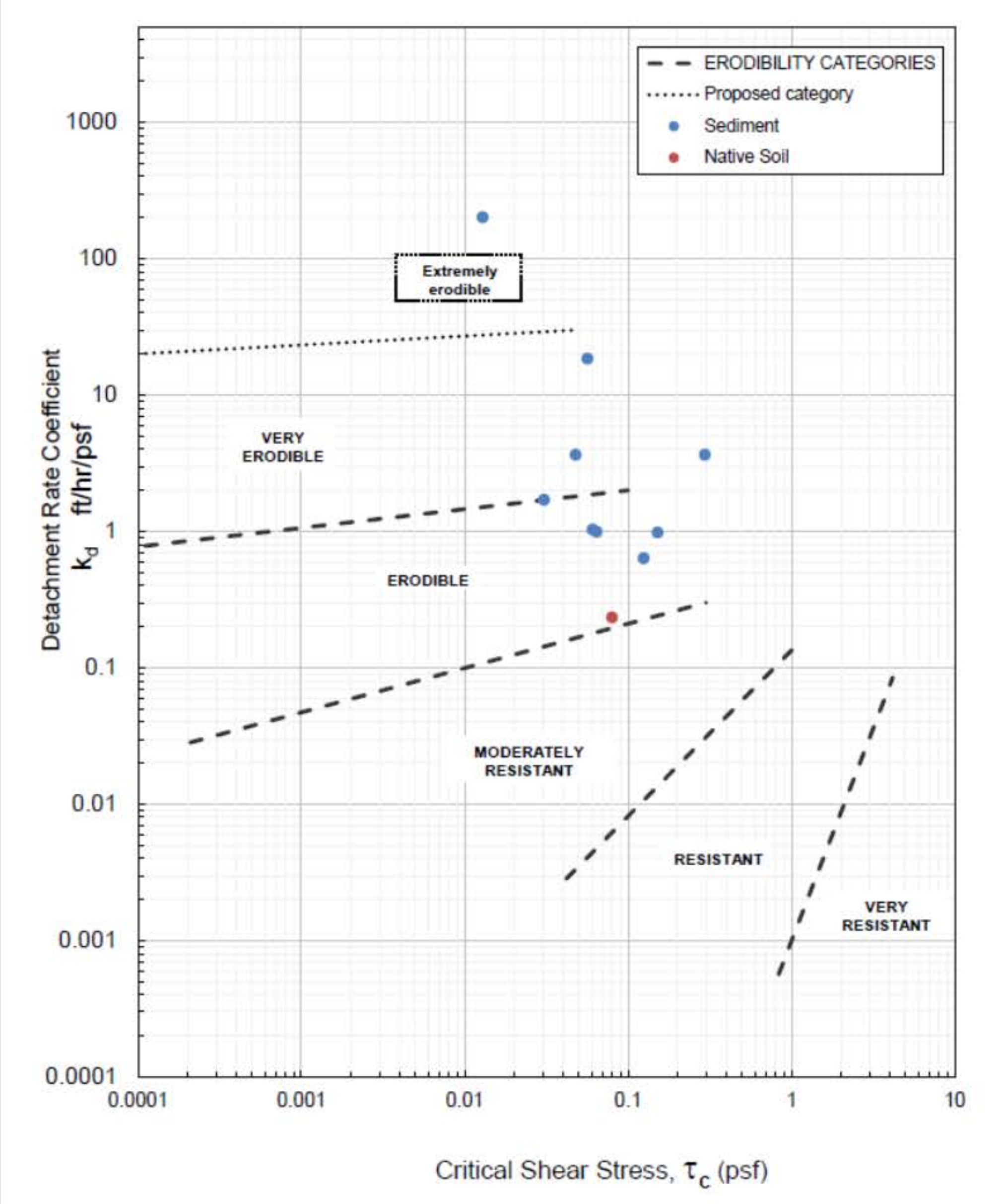
Monitoring

- Flow rates during flush
- Before and after surveys
- Reservoir Sediment Sampling
- Physical suspended sediment measurement
- LISST ABS continuous suspended sediment measurements
- Cross sections before and after
- Bed Material before and after

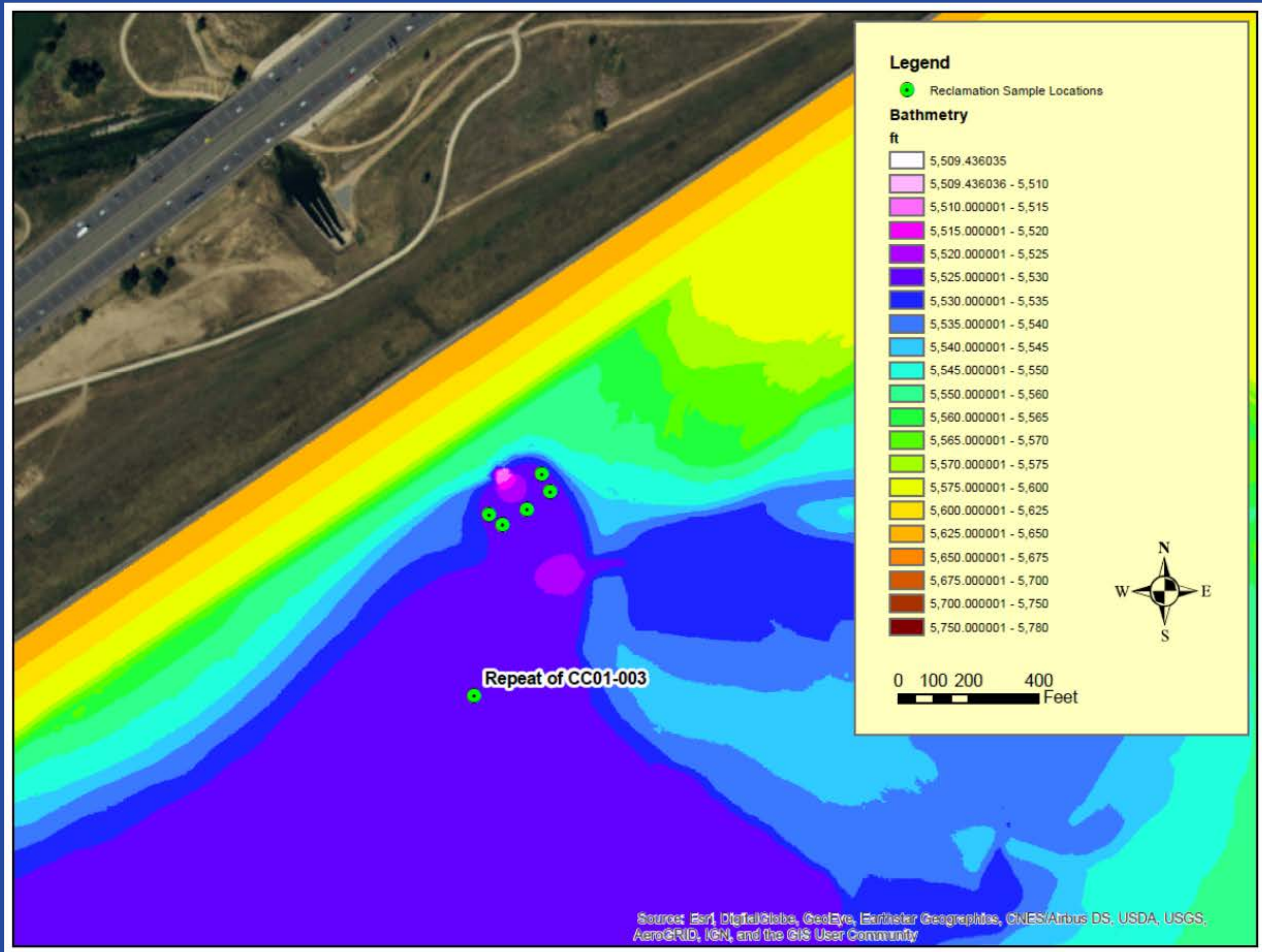
Cherry Creek Flush: Flow Rate



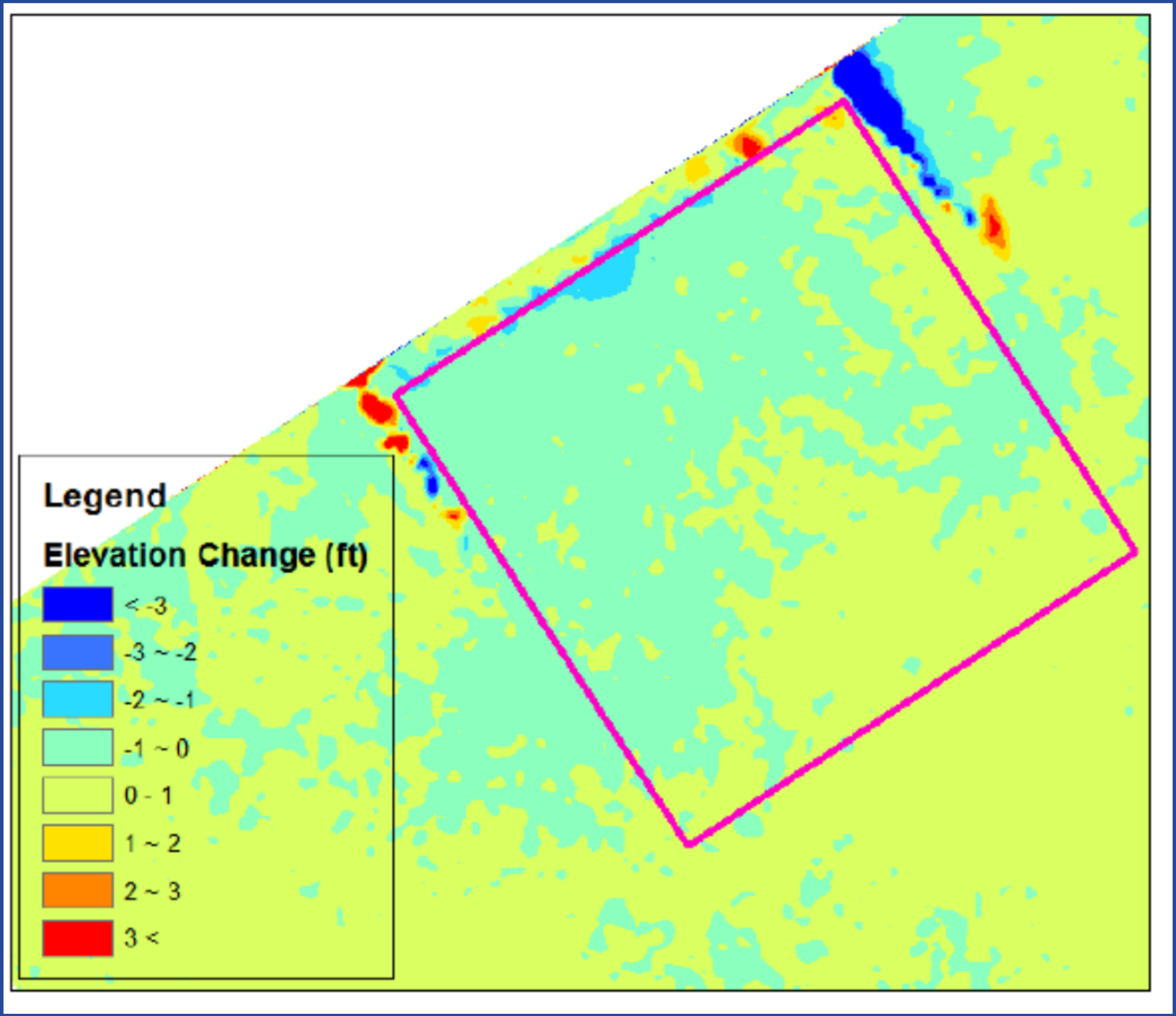
Cherry Creek Flush: Reservoir Sediment



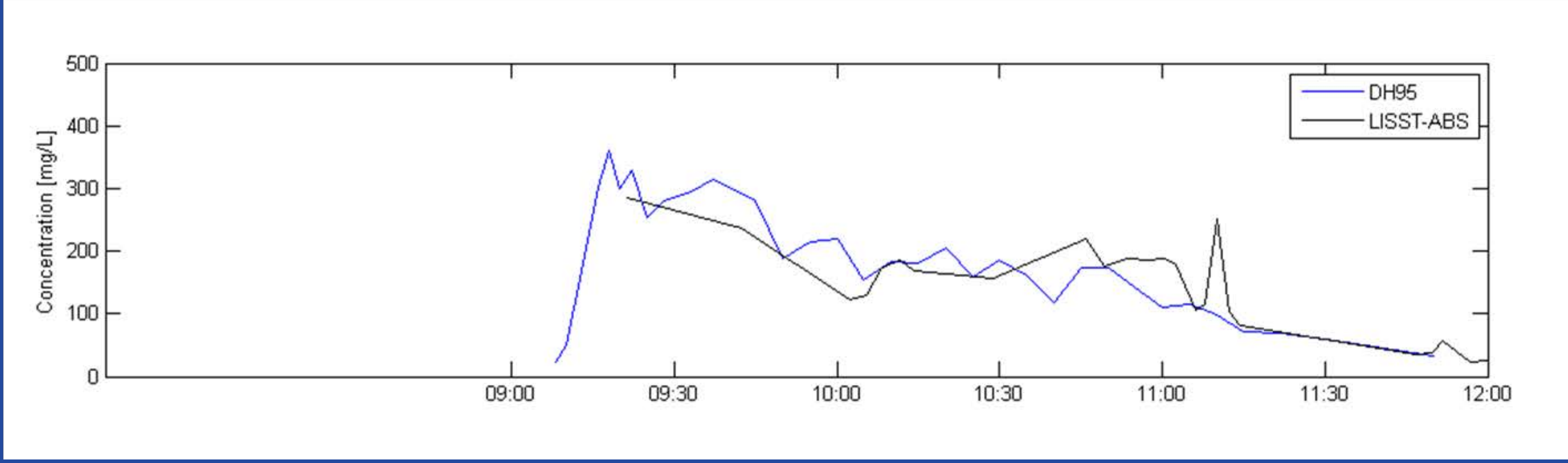
Cherry Creek Flush: Multibeam Survey



Cherry Creek Flush: Elevation Change for small flush undetectable



Suspended Sediment Concentration



Erosion during pressure flush

- Far from intake:

$$V_{reservoir} = Q/A_{reservoir} \sim 0$$

- At intake gates:

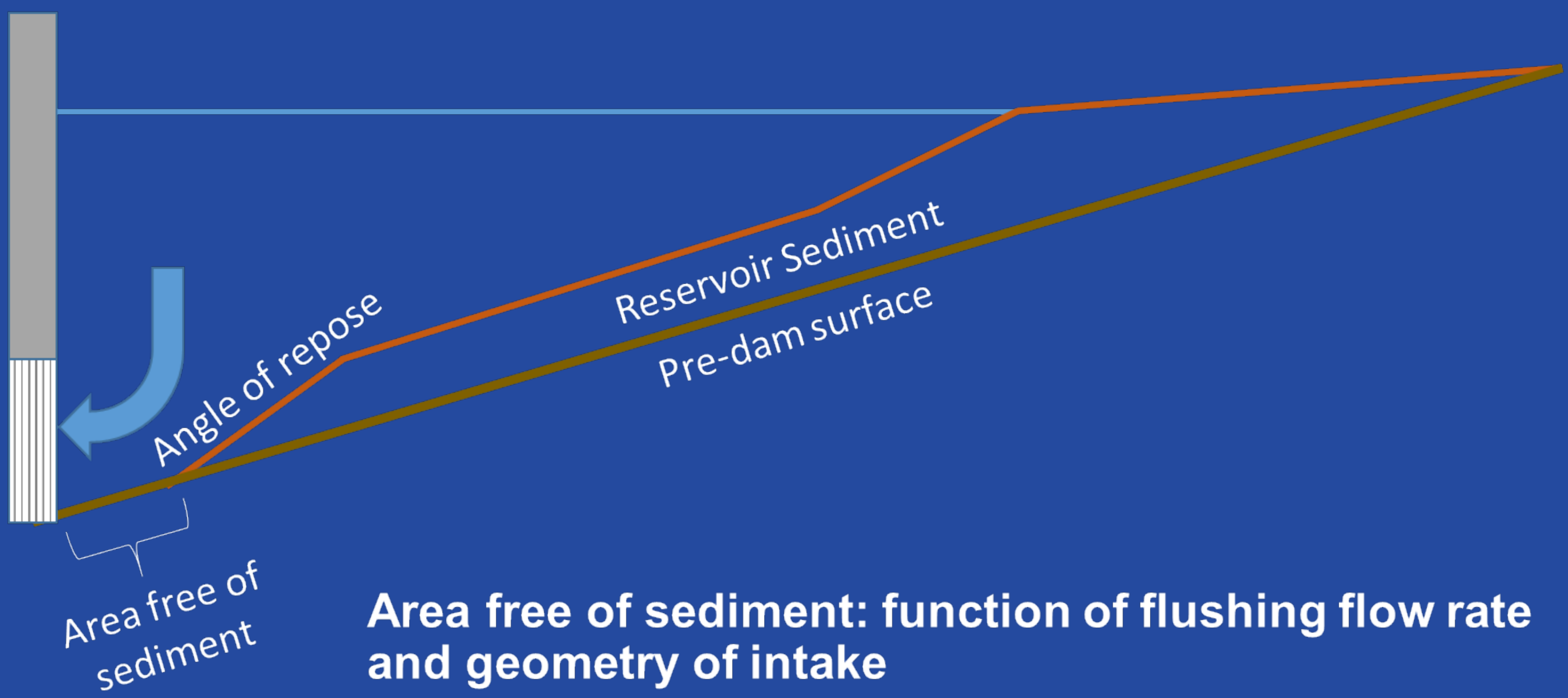
$$V_{intake} = Q/A_{intake} \sim \text{ high}$$

- Between near and far:

$$V \propto r^{-2}$$

Velocity quickly decreases with distance from intake

Geometry of cone

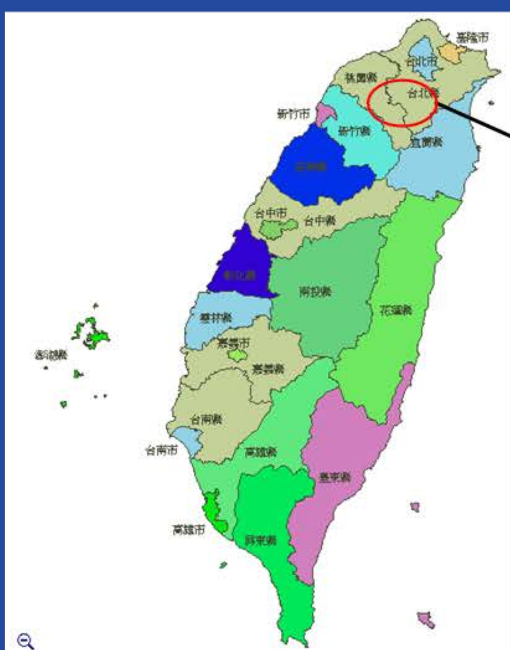


Area free of sediment: function of flushing flow rate and geometry of intake

Angle of repose: Fine high water content sediment could be as low as 1V:10H

Shihmen Reservoir in Taiwan

- **Location**
  - Taoyuan County
  - DaHan River
  - Build in 1956-1964
- **Functions**
  - Municipal Use & Irrigation
  - Power Generation
  - Flood Protection



Shihmen Reservoir

- **Height:** 133 m
- **Length:** 360 m
- **Storage (Design):** 309 million-m^3 at 245m Max EL
  - 252 m-m^3 Effective

Normal Scene: Clear Water

During Typhoon

Large amount of sediments enters reservoir during large storm

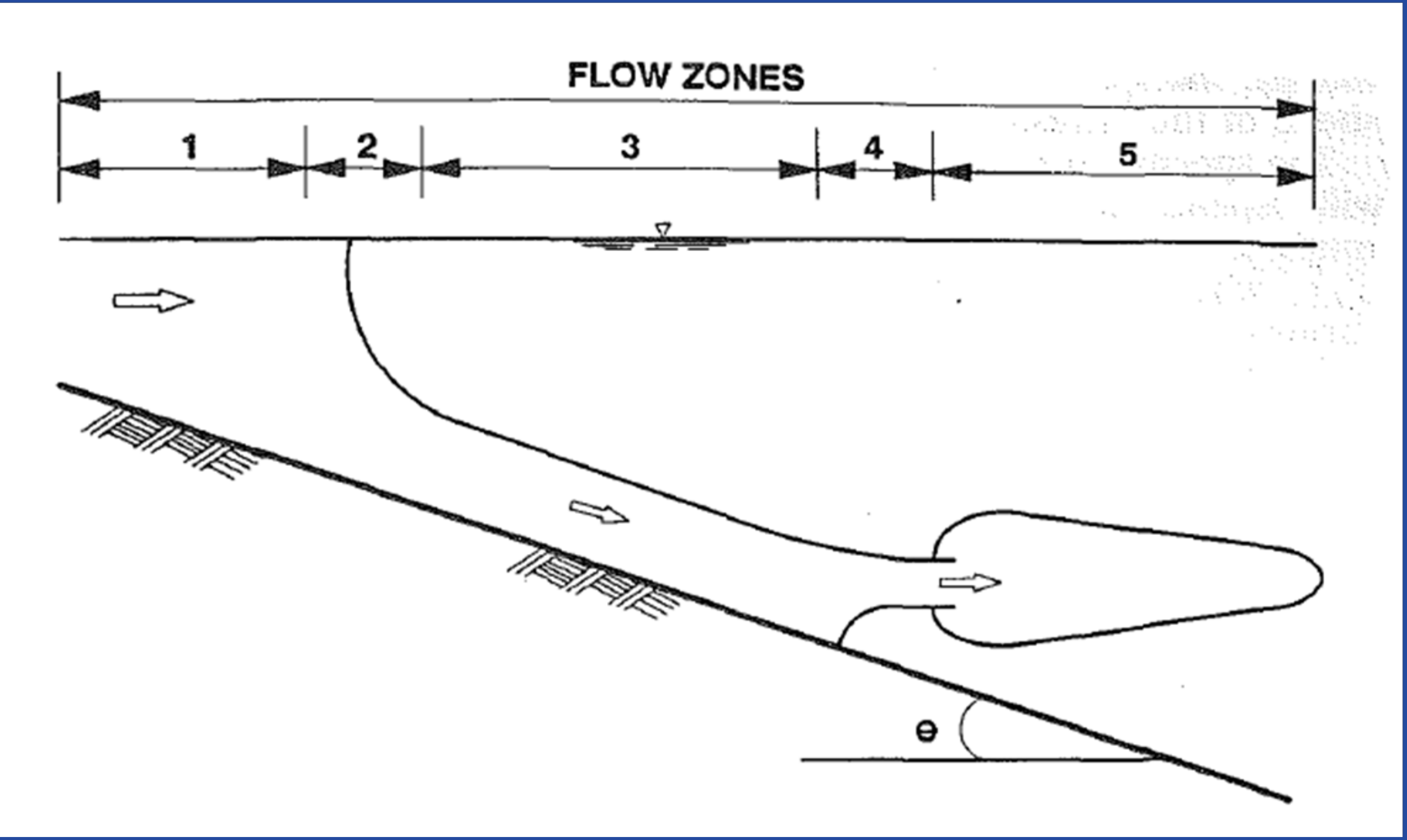
- Photo: during typhoon 海棠(July 2005)

What's Happening?

- Coarse Sediments Were Blocked Upstream or Deposited in the Delta
  - Up to 123 check dams were constructed upstream to reduce the sediment supply to Shihmen Reservoir
    - ~ 35 million-m^3 in storage capacity
  - All check dams were almost full by 1996 (賀伯颱洪)
- Fine Sediment Enters the Reservoir in the form of Turbidity Current

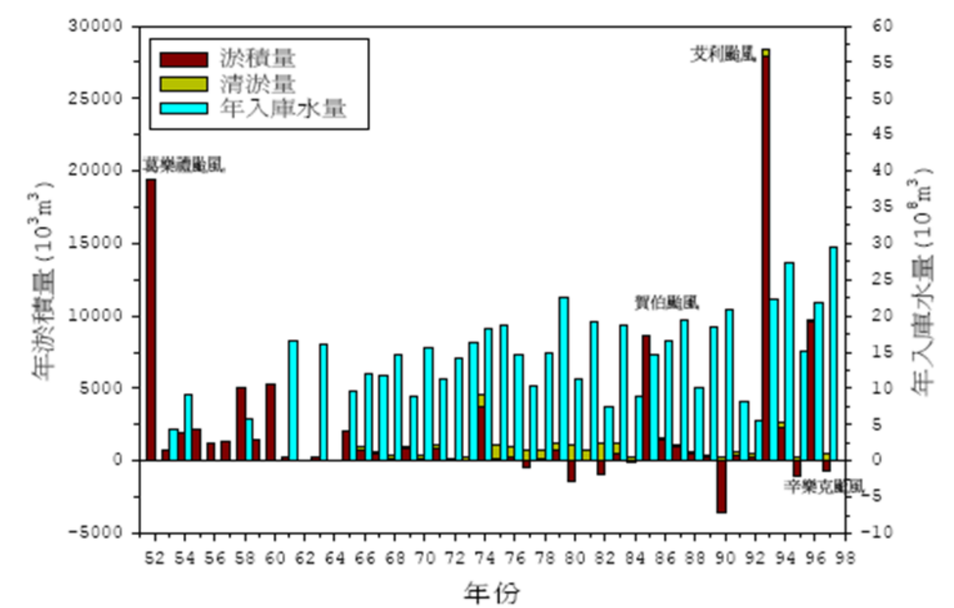
Fine Sediment Turbidity Current

- Formed when a turbid stream enters a less turbid larger receiving water

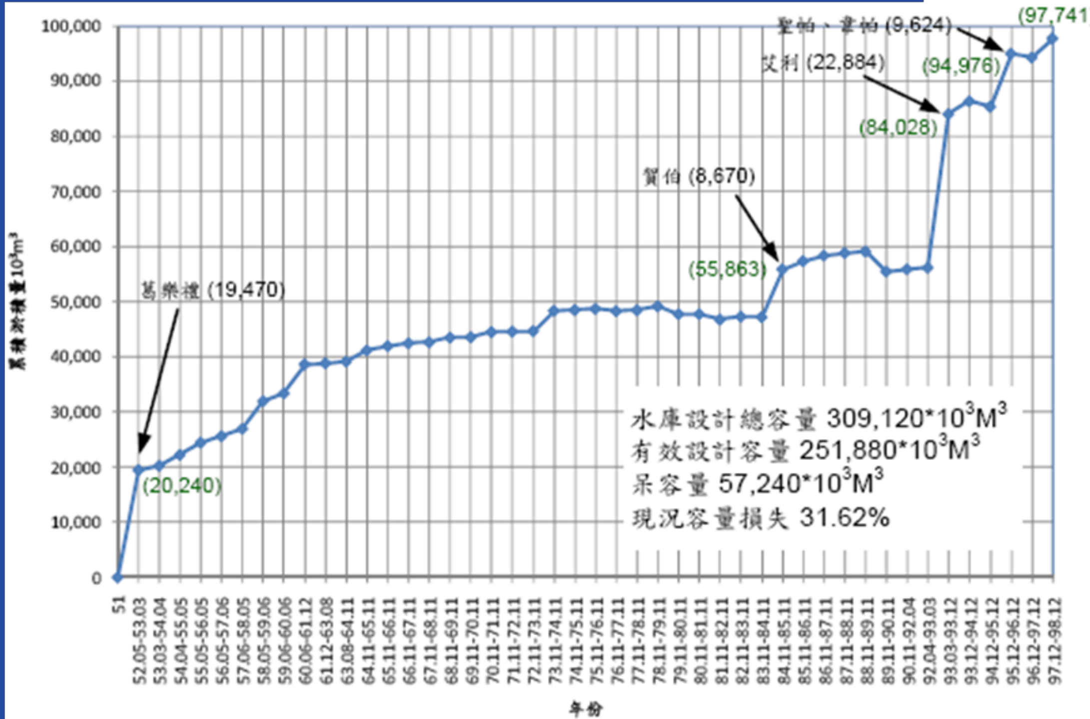


Consequences

- **Loss of Reservoir Capacity**
  - More than 30% capacity has been lost by 2009
  - Another 25 years estimated life (195m)
- **Water Supply and Quality Issues**



-6 歷年入庫水量與水庫年淤積量關係圖



2- 4 石門水庫累計淤積量圖(至民國98年止，北區水資源局)

Increased Sediment Supply

- 4 time more than the original estimate
- Impact of 921 Earthquake (in 1999; 2,415 death)
  - Steep Watershed Valley
  - Geological Weathering and Climate Change
  - Landslides and Soil Erosion

Typhoon Aere

- **Time**: August 23-26, 2004 **Rainfall**: 973 mm
- **Peak Discharge**: 8,594 cms **Deposit**: 27.9 mill-m^3
- **Reservoir Capacity Loss**: 11%
- **SSC** > 100 g/L for 3 weeks
- Water supply stopped for 17 days

Government Mandates after Aere

- 25 billion NTD (~ 780 million USD)
- Water Supply Ensured (>1 million people)
- Reservoir Life Extended/Sustained

Authorized Projects

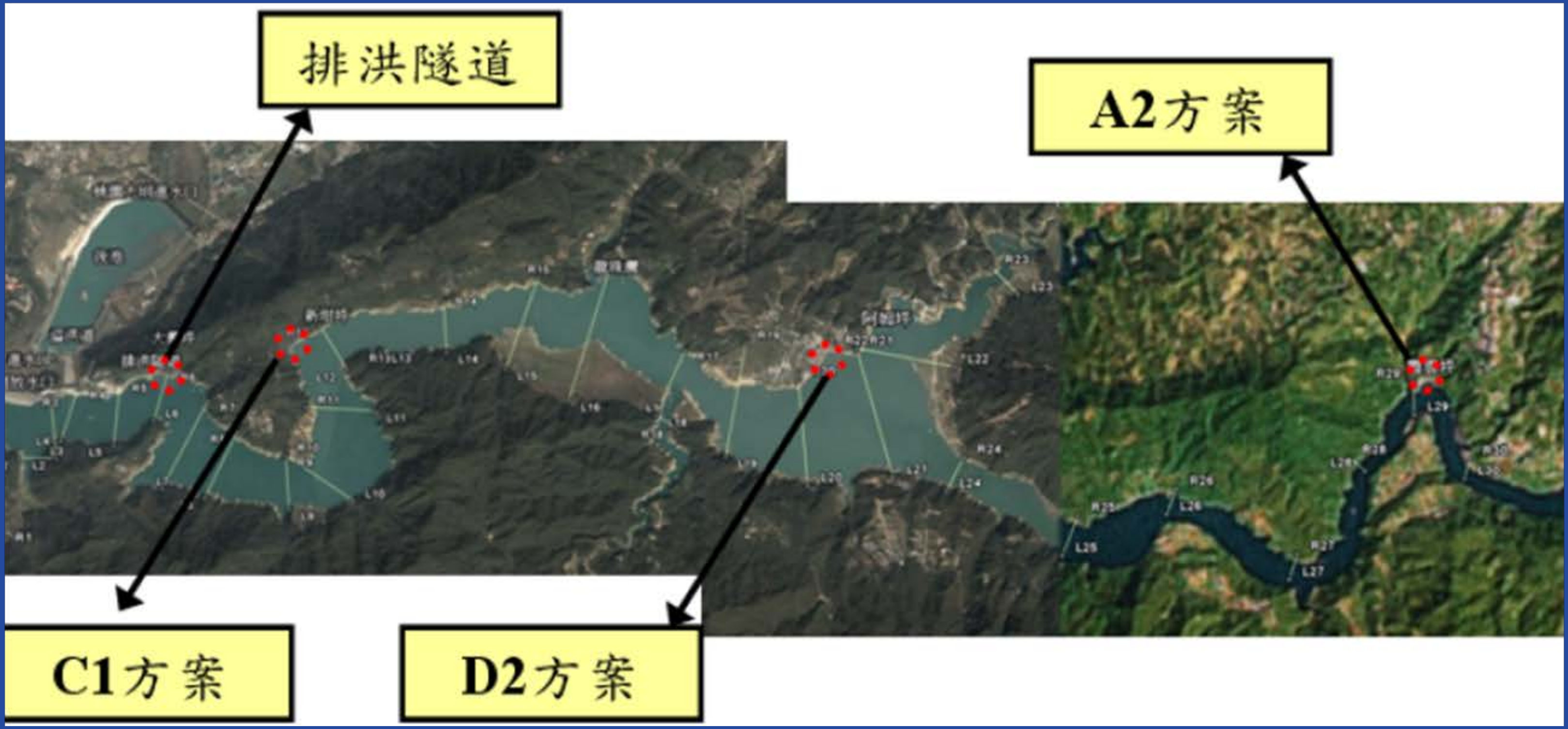
- Upstream
  - Watershed and Land Management
- Reservoir: Desilting
  - Dredging
  - Existing Outlet Modifications
  - New Bypass Tunnels (Desilting)
- Downstream

Existing Outlet Modifications

- **Powerhouse Intake**
  - One of the two intakes (#2) is dedicated for sluicing
  - 300 cms capacity; 171 m EL
- **Permanent River Outlet**
  - Up to 31.5 cms; 169.5 m EL (rarely used before)
- **Diversion Tunne**
  - 2,400 cms capacity
  - 220 m EL
  - Under Study: 190 m E
- **Spillway**
  - 11,400 cms capacity
  - 235m EL
- **Water Intakes**
  - 193 m EL & Up

New Bypass Tunnels (Desilting)

- Plan A, B, C and D   (A & B are out)
- Typical Design: 12m diam; 1600 cms capacity



Sediment Pass through with Turbidity Currents

Shihmen Reservoir, Taiwan

Flushing during spillway flow