Fully Coupled 1-D Mobile Bed River Sediment Transport Model

(Unsteady Flow and Non-equilibrium Sediment Transport with Looped Network System)

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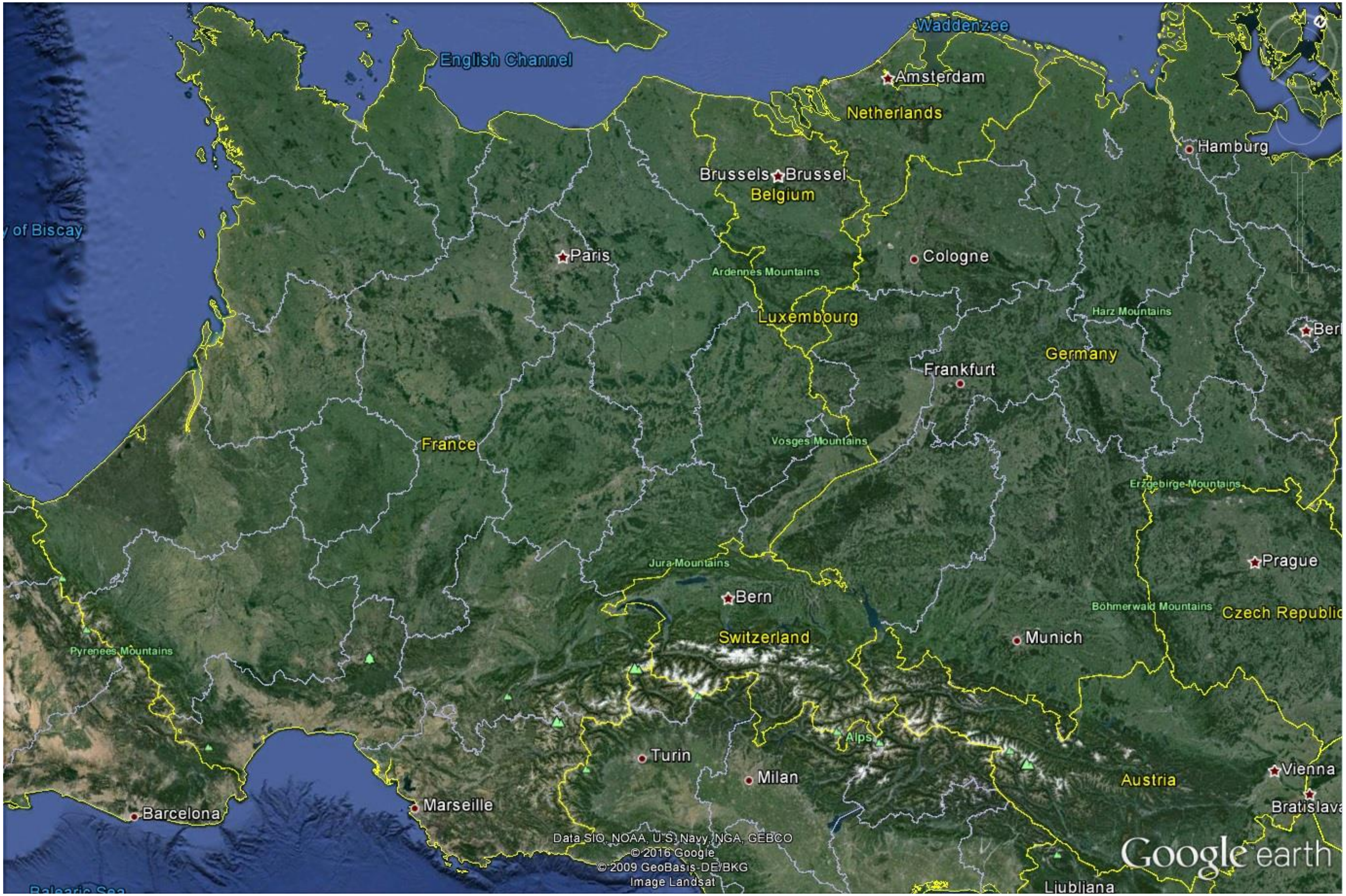
Objective

- Create a fully coupled 1-dimensional erodible bed with suspended and bed load sediment transport model with looped network system
- Conditions:
  - Unsteady flow
  - Separate sediment transport by Bed load and Suspended load
  - Non-equilibrium sediment transport
  - Looped network system
  - Trap efficiency (deposit and transported)
- Model application:
  - Belley area (18 km:11.3 miles) of upper Rhone River in France
  - France National Rhone River Authority (CNR)

Location



Waddenzee
English Channel
Amsterdam
Netherlands
Hamburg
Brussels
Brussel
Belgium
of Biscay
Paris
Cologne
Ardennes Mountains
Harz Mountains
Luxembourg
Germany
Frankfurt
France
Vosges Mountains
Erzgebirge Mountains
Jura Mountains
Prague
Bern
Böhmerwald Mountains
Czech Republic
Switzerland
Munich
Pyrenees Mountains
Alps
Turin
Milan
Vienna
Austria
Bratislava
Barcelona
Marseille
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2016 Google
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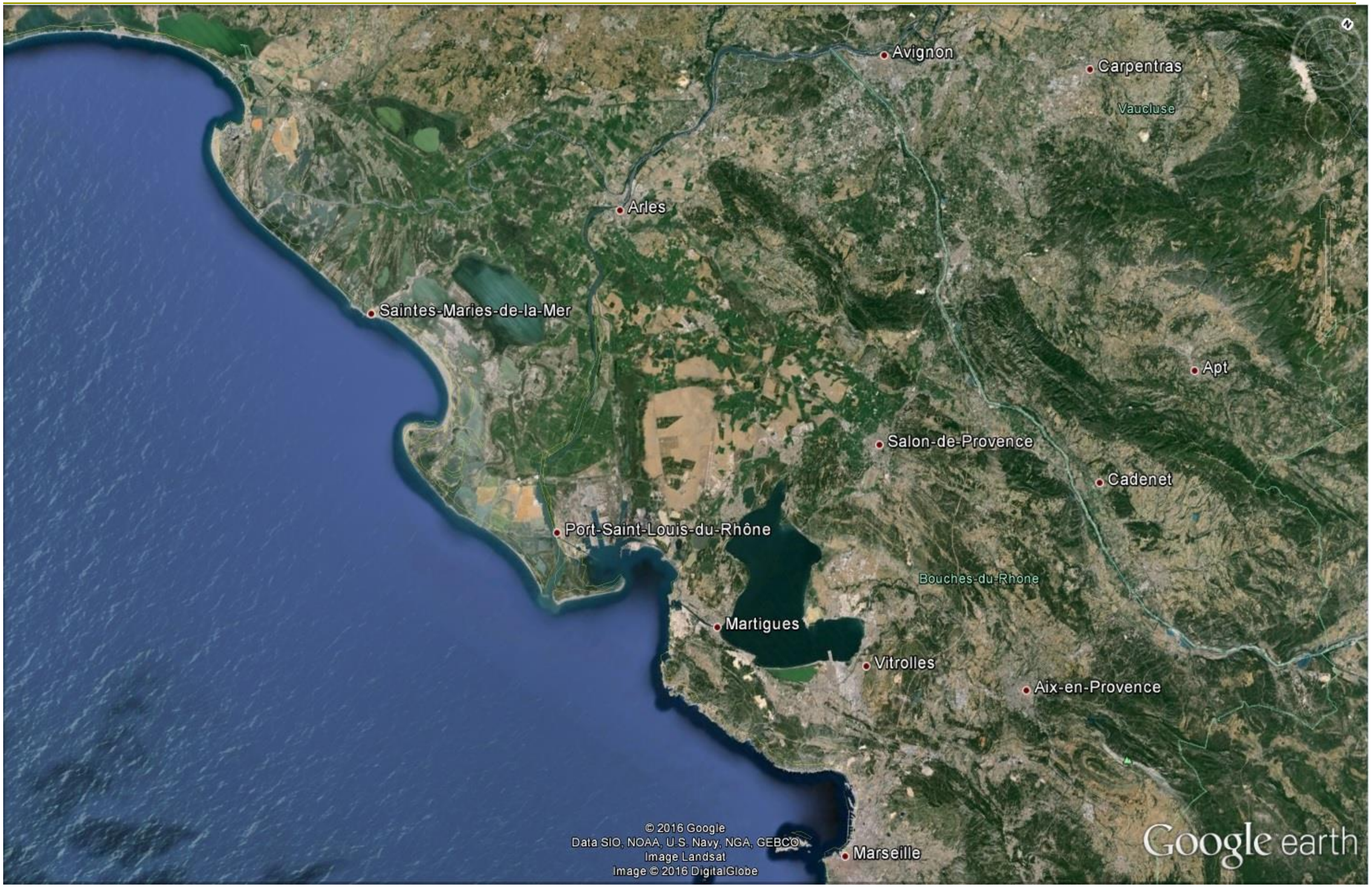
Image Landsat
Google earth
Ljubljana

Location – Southwest of France

Downstream of Rhone River- Marseille



Rhone River & Arve River

Practical Aspects of Computational River Hydraulics

J.A. Cunge, F.M. Holly, Jr
Société Grenobloise d'Etudes et d'Applications Hydrauliques, SOGREAH, Grenoble

A. Verwey
International Institute for Hydraulic and Environmental Engineering, Delft

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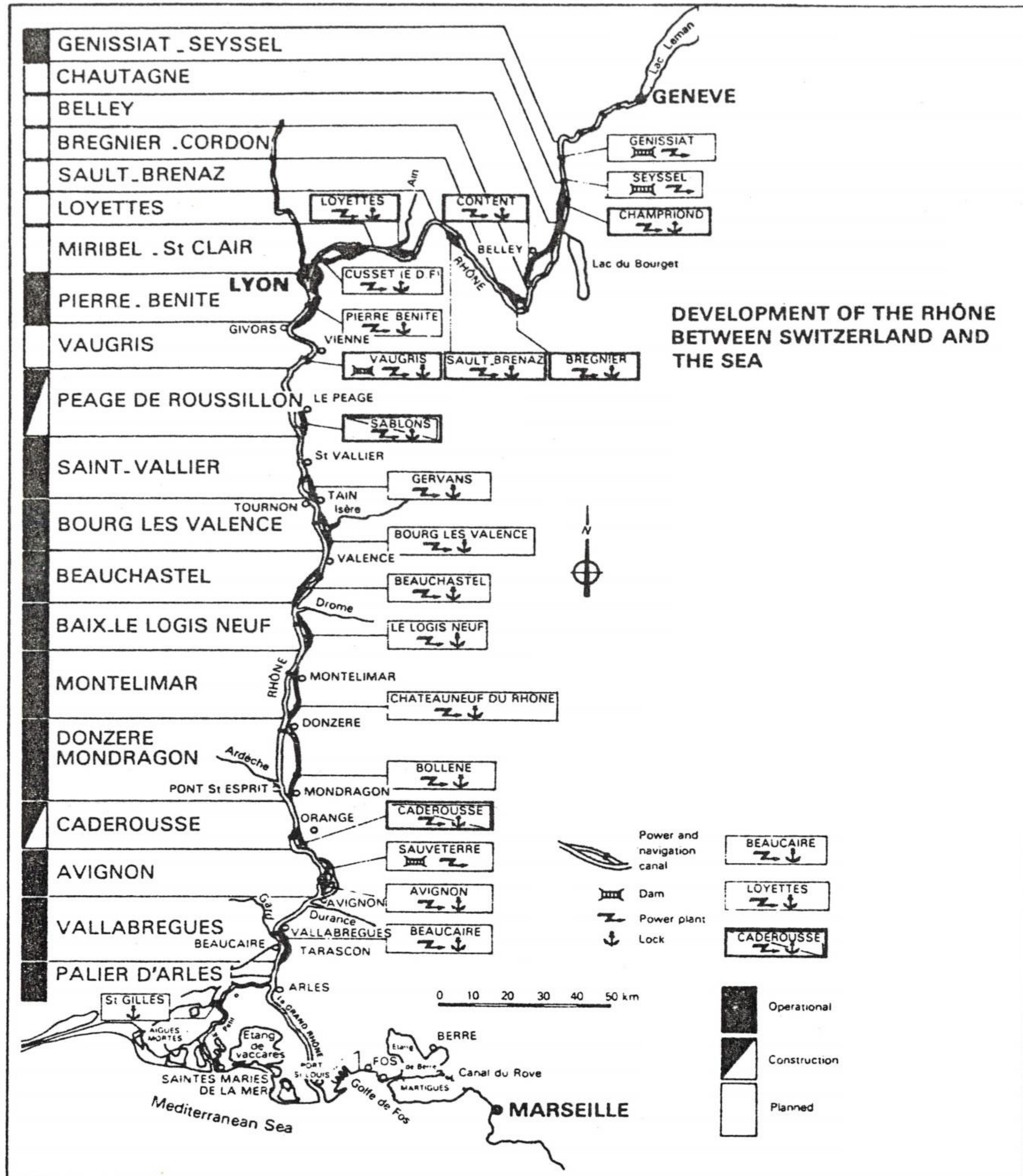
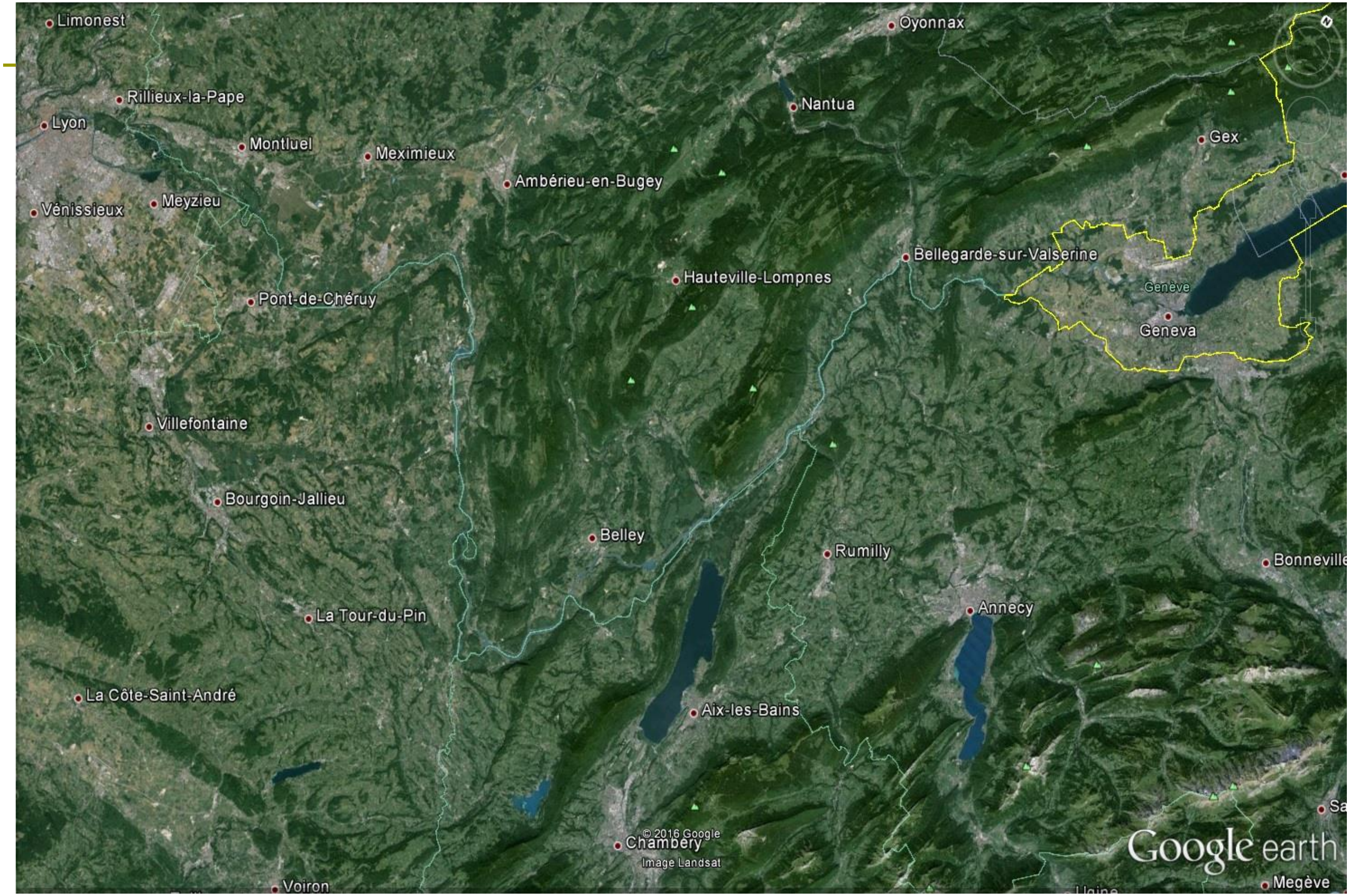
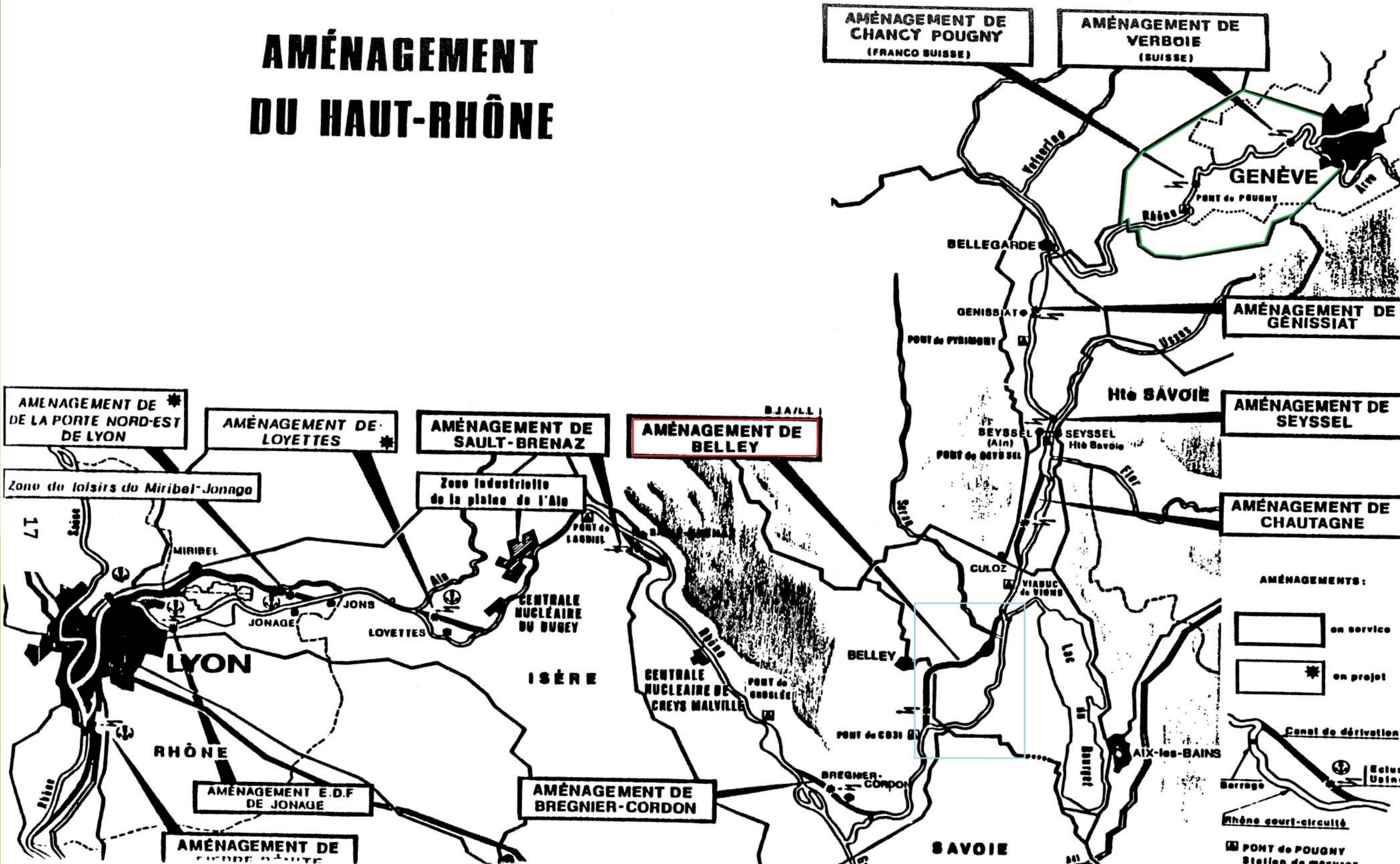


Fig. 4.2. Present and proposed development on the Rhône River in France

Rhone River (Geneva-Lyon)



Upper Rhone Management



Belley area management

- Every 3 years of flushing event at upstream reservoirs (Verbois & Chancy-Pougny in Swiss and Genissiat, Seyssel & Chautagne in France)
- Concerns:
  - Quantity of sediment deposit in Belley Reservoir
  - Suspended load for downstream nuclear power plant water intake facility near Lyon
  - Need flushing operation at Belley Reservoir

Fluvial Sediment

- Process of erosion, transport and deposition – very complex
- Entrainment and transportation - solid particle & fluid movement
- Solid particle - density, shape, size & status of surface
- Fluid movement - flow type, velocity & viscosity
- Predict a condition of equilibrium or erosion-deposition
- Determine the quantity transported by the river

Various Issues of Sediment Deposit

- Impact the carrying capacity (Conveyance) of river/channel
- Reduce the flood control capability
- Increase the damage by flooding
- Increase of maintenance/ management cost
- Reduce the original objective of structure

Hydraulics & Geometry

- Hydraulics
  - Governing equation
  - Steady flow, Unsteady flow
  - Subcritical, Supercritical
- Roughness coefficient: n value
- Energy coefficient / Momentum coefficient
- Branched network & looped network
  - Divergence
  - Confluence
  - Looped

Hydraulics & Sediment Transport Model

- Define the objective (purpose) of project
- Decide how and where to apply the model
- Boundary condition

  - Upstream & Downstream
- Bed Load, Suspended Load & Total Load
- Model coupling

  - Uncoupled model & Fully coupled model
- Roughness coefficient with bed form

  - Ripple, Dune & Anti-dune
- Scheme

  - Explicit & Implicit
- Selection of sediment transport formulas
- Application for real natural river

Bed Form

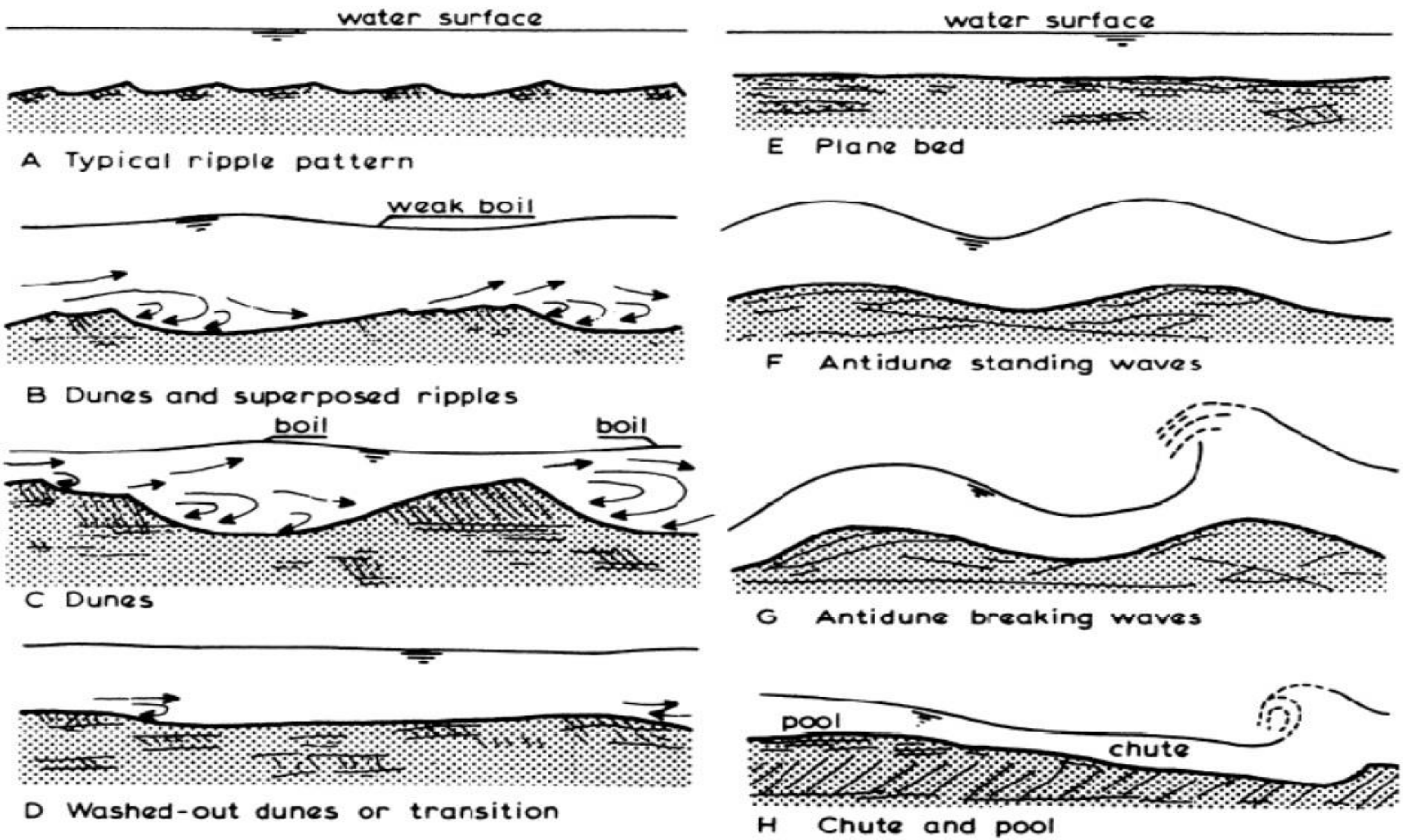
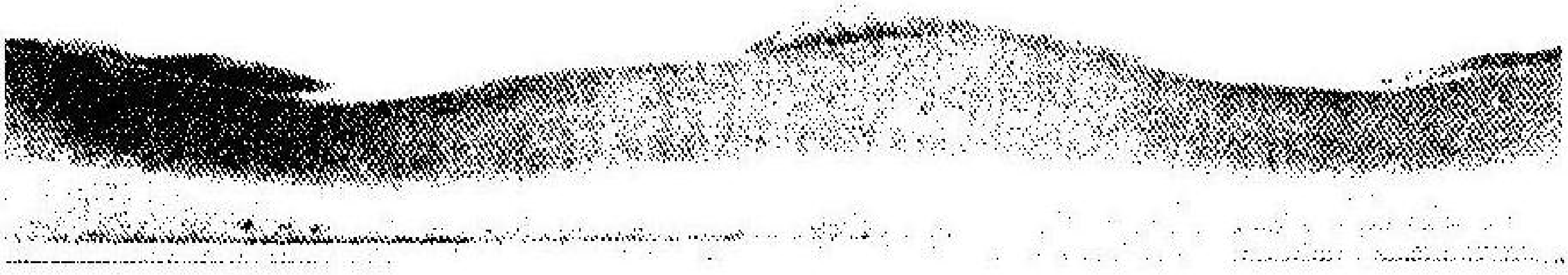


Figure 1-1. Bedform types under increasing Froude number (A to H) [Van Rijn, 1993; adopted from *Simons and Richardson*, 1966].

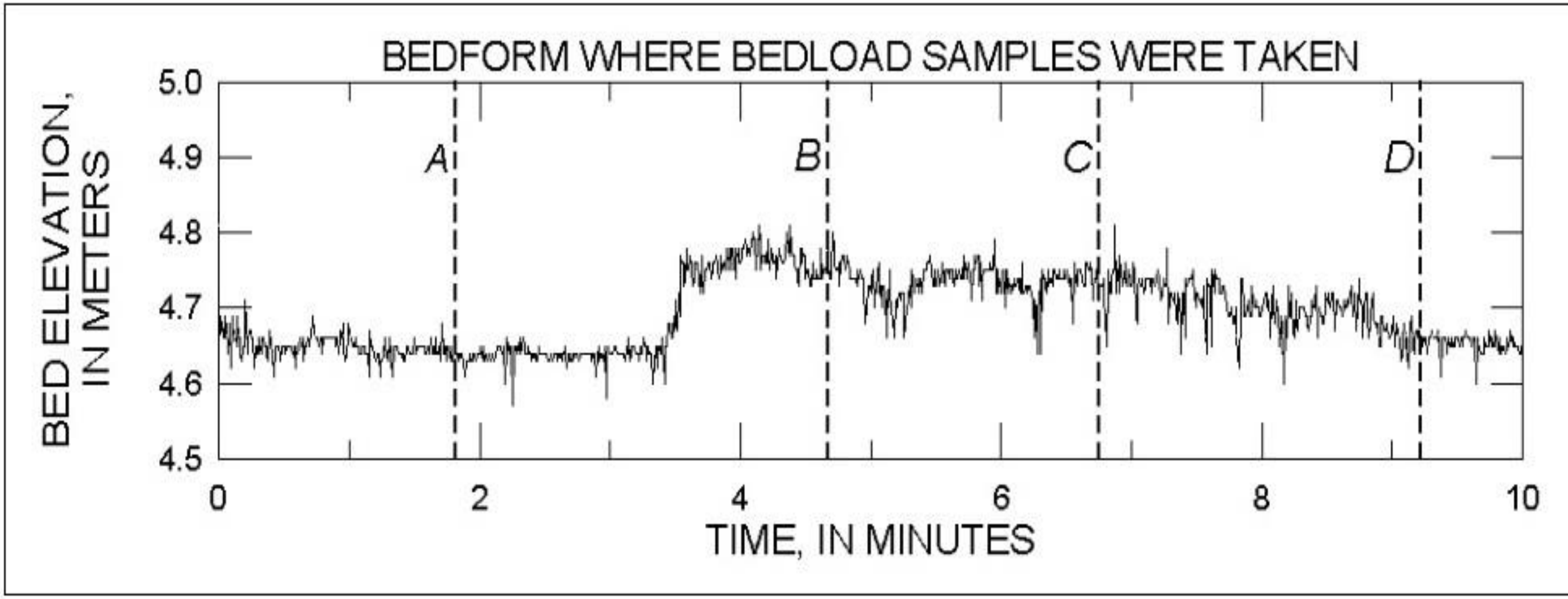
Bed Form Example

Ripples in Bed of Fine Sand in Flume 10.5 in. Wide; Hwang (1965) (Flow was to Left; Flow Depth = 0.241 ft, Mean Velocity = 1.25 fps, d_{50} = 0.230 mm, σ_g = 1.43)



Antidunes in Flume 10.5 in. Wide; Kennedy (1960) (Flow was to Left; Scale in Figure is in inches; Mean Flow Depth = 0.248 ft, Mean Velocity = 3.30 fps, Froude Number = 1.17, d_{50} = 0.233 mm, σ_g = 1.47)

Configuration of a Gravel Dune



Bedload samples corresponding to the dashed lines are shown below. The vertical scale bars are 10 centimeters or 4 inches long.

Research/ Study Process

- Selection of Sediment Transport Formulas
- Cross Section Data
- Drive Partial Differential Equation
- Create Numerical Model - Non-equilibrium Sediment Transport
- Test and Verification

Selection of Sediment Transport Formulas

- Many formulas developed after Duboys (1879)- Laboratory test & Field Measuring
- Application limit: not always clearly mentioned
- Selection of suitable formula:

  - Apply to real natural river condition

  - Difficult to select the proper formula

  - Different formulas give quite different results with the same hydraulic conditions
- Need sensitivity analysis with various hydraulic parameters (Q, V, depth, slope, Froude no.) for equilibrium sediment discharge
- Verification analysis with computer simulation for selected sediment transport formulas

Sediment transport formulas

Author	Dm	Velocity	Remark
Duboys(1879)	○	×	C
Schoklitsch(1935)	++	×	C
Shields(1936)	○	×	C
Meyer–Peter and Muller(1948)	○	×	C
Einstein – Brown(1950)	○	×	C
Einstein Bed Load function(1950)	++	○	T, S, C
Laursen(1958)	○	×	T
Shinohara–Tsubaki(1959)	○	×	T
Garde and Albertson(1961)	○	○	T
Colby(1964)	○	○	T
Engelund–Hansen(1967)	○	○	T
Inglis–Lacey(1968)	○	○	T
Toffaleti(1969)	++	○	T, S, C
Ackers–White(1973)	○	○	T
Yang(1973)	++	○	T
Engelund–Fredsoe(1976)	○	○	T, S, C
Holtorff(1983)	++	○	T, S, C
van Rijn(1984)	○	○	T, S, C
Celik and Rodi(1991)	○	○	S
Samaga, Ranga Raju and Garde(1986)	++	○	T, S, C
Rickenmann(1991)	○	○	C

where

○ : This term exists explicitly in the formula

× : This term does not exist explicitly in the formula

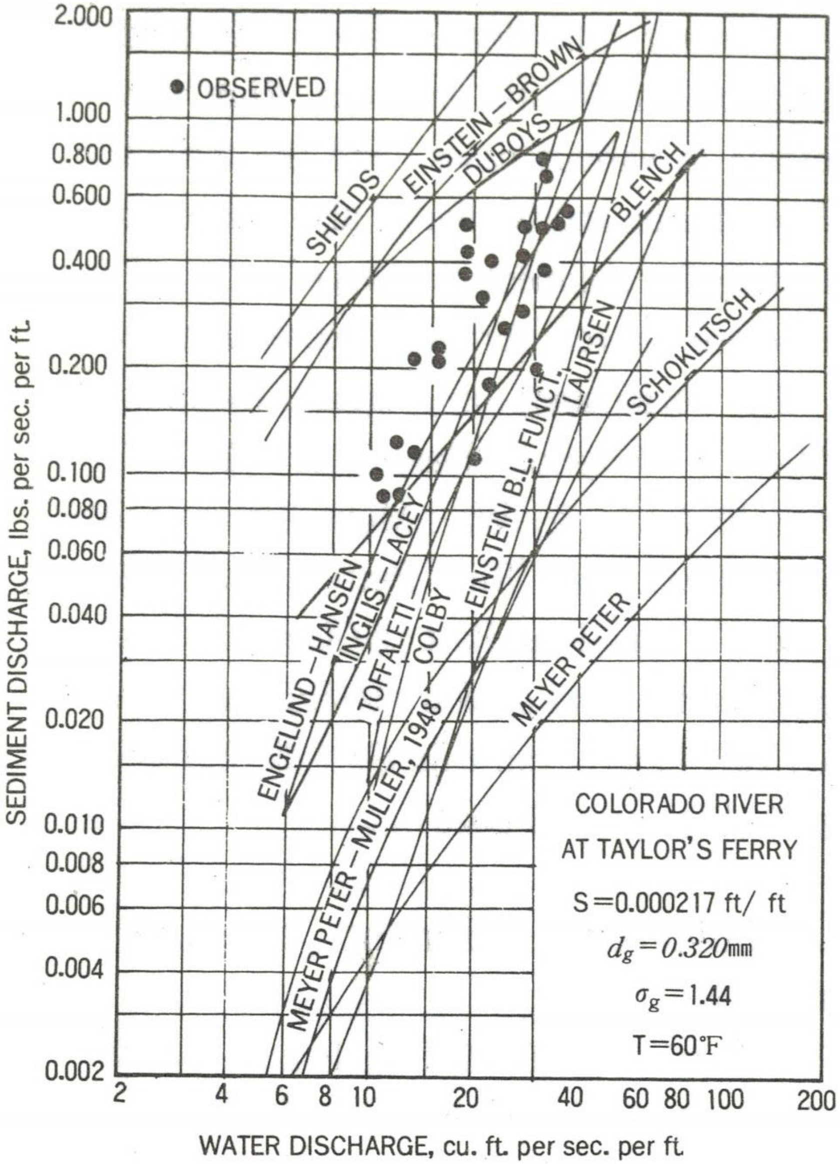
++ : Serveral Classes of Sediment

T : Total Load

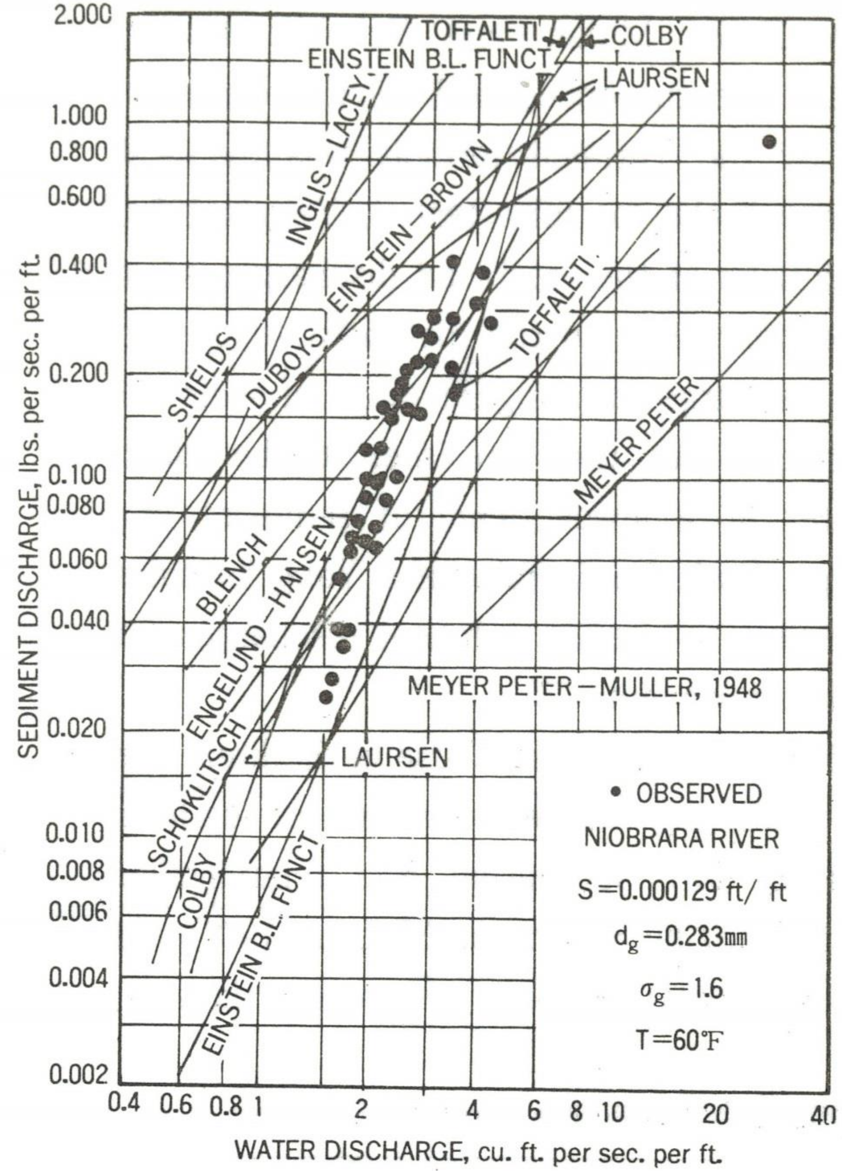
C : Bed Load

S : Suspended Load

Dm : Reperesentative Diameter



〈Fig. 1〉 Sediment discharge as function of water discharge for Colorado River(after Vanoni, 1977, Sedimentation Engineering)



〈Fig. 2〉 Sediment discharge as function of water discharge for Niobrara River(after Vanoni, 1977, Sedimentation Engineering)

Literature Study of Formula

- Shields, Einstein-Brown & Duboys – overestimate
- Meyer-Peter Muller – underestimate
- Schoklitsch – less slope the straight lines of fitted data
- Colby, Toffaleti and Engelund-Hansen – best agreement
- Einstein bed load function, Larsen & Inglis-Lacey – close to a mean line of data, but not fit the data
- Blench – small slope intersecting the data
- Yang, Engelund and Hansen, & Ackers and White – better than others in the field and laboratory data
- Bed-load prediction:

  -Einstein Brown formula seems to be 10 times greater than those predicted by Meyer-Peter Muller and Schoklitsch

Continue

- Suspended-load prediction:

  -Toffaleti was best among all the formulas tested
- Total-load Prediction: Yang's (1973) formula seems to be close to the measured suspended load discharge at a higher range of sediment discharge, but much greater at a lower range of sediment discharge
- Yang's (1973) formula very poor results for large-scale river (Flow depth> 1m)
- Engelund-Hansen (E & H), Ackers-White (A & W) and van Rijn were preferable in various cases
- Meyer-Peter Muller (MPM) is also tested because it was commonly used or cited
- van Rijn created four (4) formulas with bed load and suspended load separation

Van Rijn's Bed Load & Suspended Load

- Van Rijn Part I: Bed Load

  $q_b=0.053[(s-1)g^{0.5}D_{50}^{1.5}T^{2.1}/D^{*0.3}$

  or $q_b=C_bV_b\delta_b$

- Van Rijn Part II: Suspended Load

  $q_s=FVhCa$, $Ca=0.015D_{50}/a^*T^{1.5}/D^{*0.3}$

- Van Rijn Part III: Simplified Bed Load

  $q_b=0.005\{(V-Vcr)/[(s-1)gD_{50}]^{0.5}\}^{2.4}D_{50}^{1.2}V$

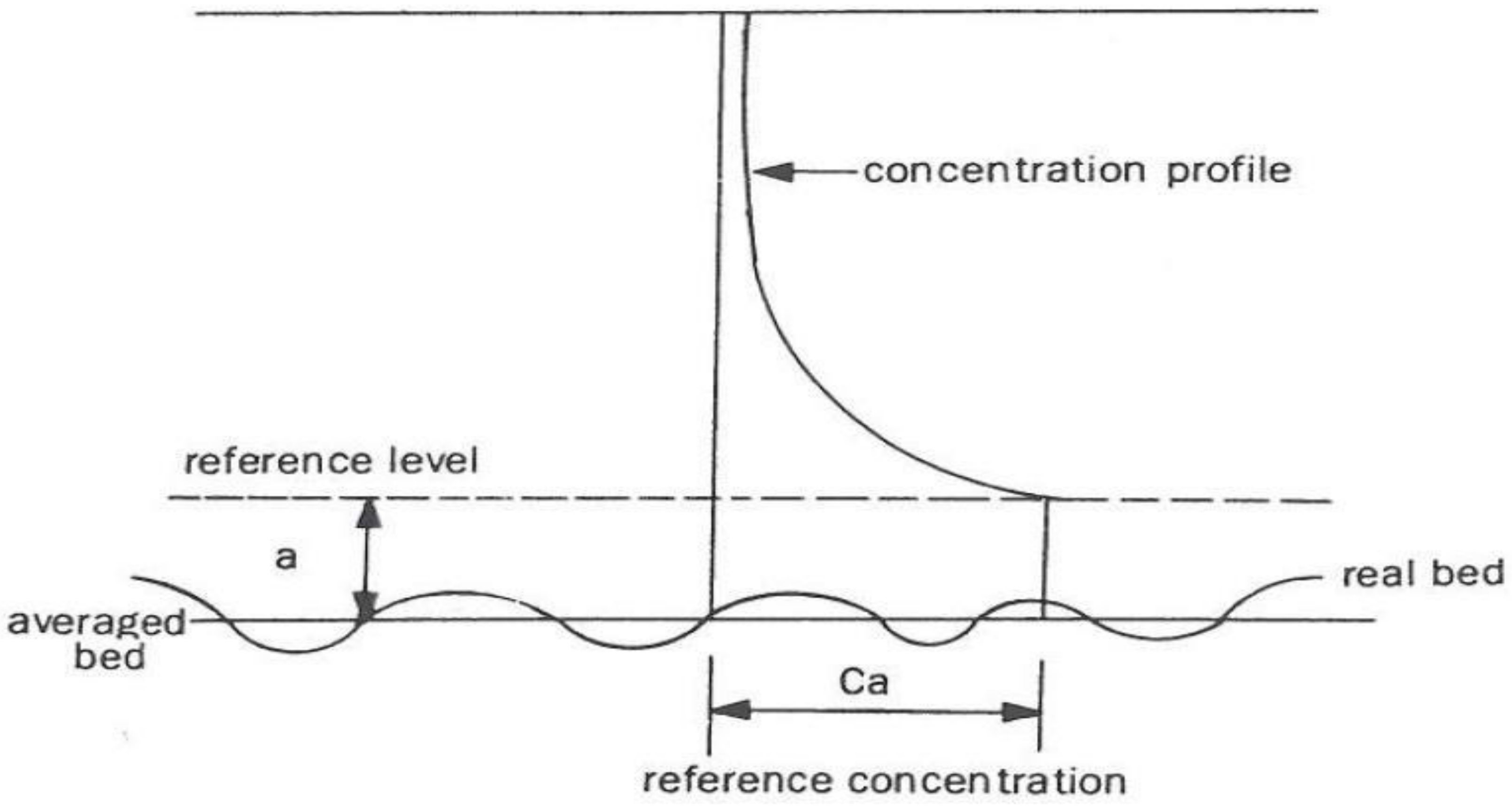
- Van Rijn Part III: Simplified Suspended Load

  $q_s=0.012\{(V-Vcr)/[(s-1)gD_{50}]^{0.5}\}^{2.4}D_{50}D_*^{-0.6}Vh^{-0.2}$

  $Vcr=0.19D_{50}^{0.1}\log(12R/3D_{90})$ for $100<D_{50}<500\mu m$

  $Vcr=8.5D_{50}^{0.6}\log(12R/3D_{90})$ for $500<D_{50}<2000\mu m$

Reference Level and Conenctration



⟨Fig. 3⟩ Definition sketch for reference level and reference concentration

Predicting Entrainment of Sediment into Suspension

〈Table. 2〉 Performance of various formula

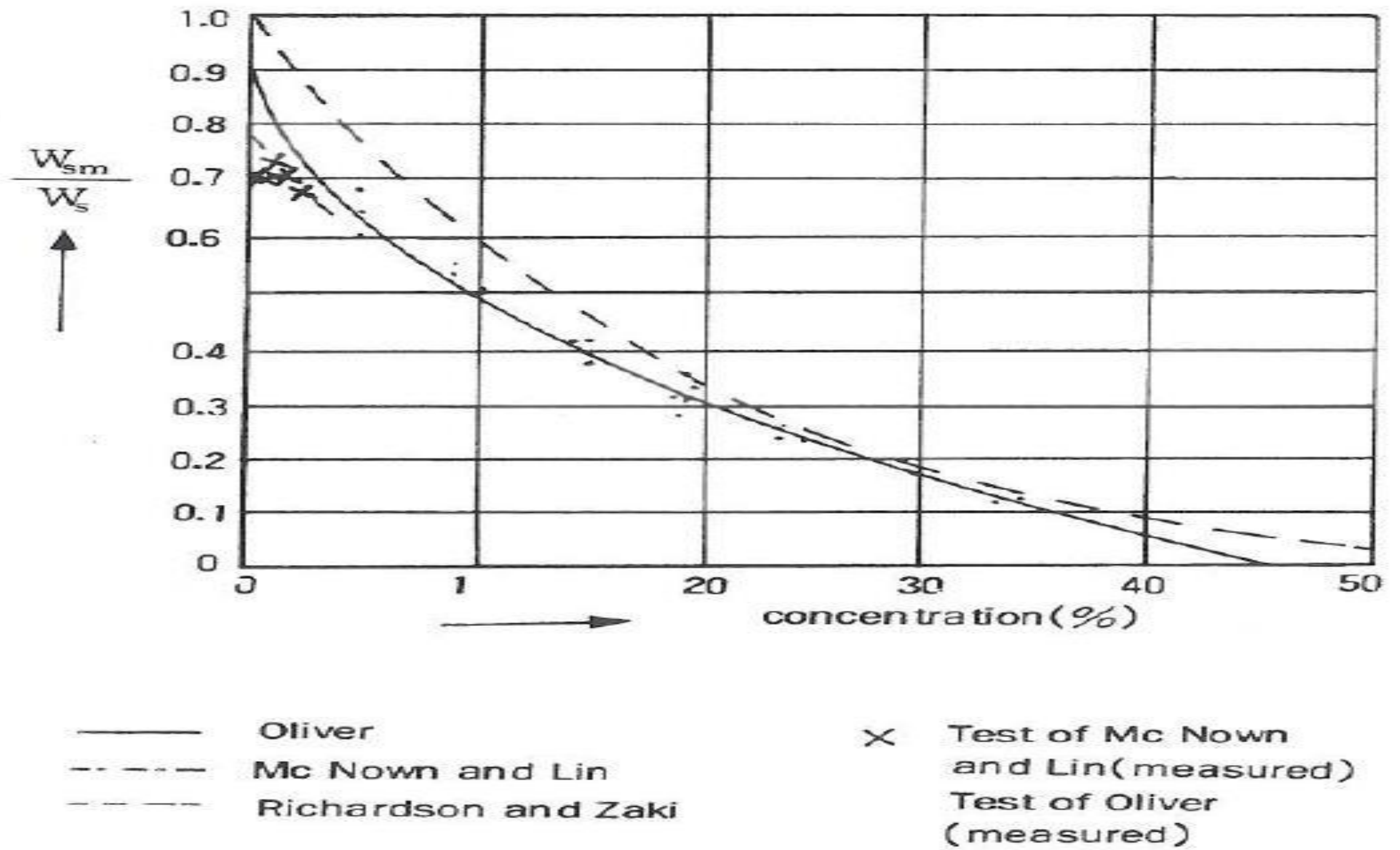
Formula	Me	Ad
Einstein(1950)	1.37	3.45
Engelund and Fredsoe(1976)	0.50	5.3
Smith and McLean(1977)	0.88	2.42
Itakura and Kish(1980)	6.70	2.22
van Rijn(1984)	1.31	2.19
Celik and Rodi(1984)	2.57	2.03
Akiyama and Fukushima(1986)	0.12	8.15
Proposed formulation	1.00	2.12

Where

Me : mean value of discrepancy ratio Caep/ Caeo

Ad : mean absolute deviation of discrepancy ratio Caep/ Caeo

Caeo, Caep : observed and predicted values of equilibrium near-bed sediement concentration



<Fig. 4> Comparison of the fall velocity formulas with measured data

Test Selected Sediment Transport Formulas

- Selected 7 transport formulas were tested
  - Engelund-Hansen (E & H)
  - Ackers-White (A & W)
  - Meyer-Peter Muller (MPM)
  - van Rijn: 4 formulas
- Test diameter of sediment between 0.005 mm(5 µm: very fine silt) and 100 mm (10 cm: small cobbles)
- Analyze the sensibility of the formulas
- Various hydraulic parameters (discharge, energy line, velocity, depth, width and Froude number)

Hydraulic Parameters

⟨Table. 3⟩ Hydraulic parameters used by computer simulation

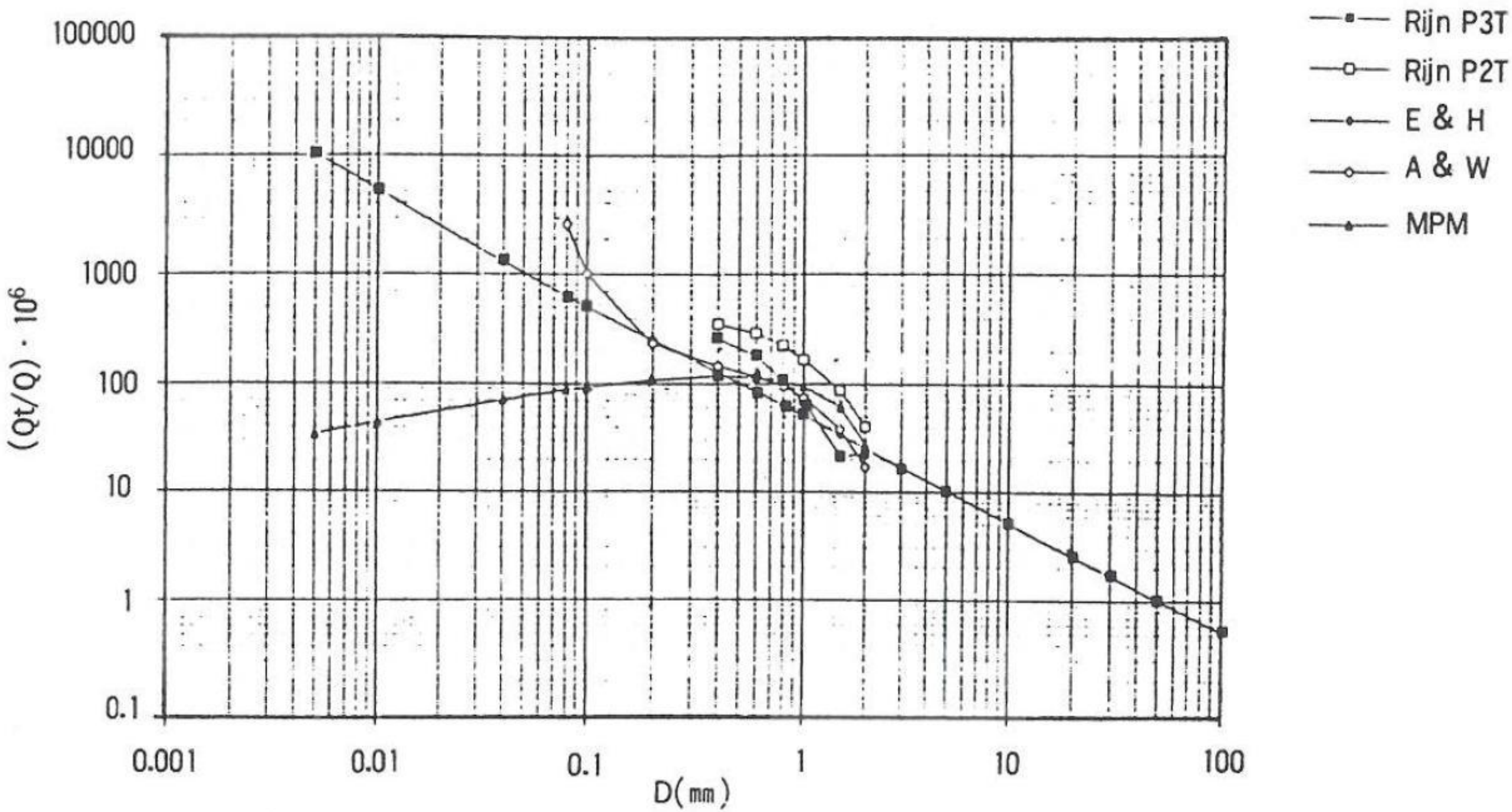
Depth h(m)	Width B(m)	Area A(m²)	n (Kst)	Hydraulic Radius R(m)	I	Velocity V(m/s)	Discharge Q(m³/s)	Froude number Fr	Remark
0.2	1.0	0.2	0.014 (72)	0.14	1/500 – 1/7500	0.88~0.23	0.17~0.05	0.62~0.16	Test 11~15
0.8	5.0	4.0	0.018 (56)	0.61	1/500 – 1/7500	1.78~0.46	7.12~1.84	0.64~0.16	Test 21~25
1.0	10	10	0.020 (50)	0.83	1/500 – 1/10000	1.98~0.44	19.8~4.44	0.63~0.14	Test 31~36
1.5	30	40	0.022 (46)	1.36	1/2500 – 1/12000	1.12~0.51	50.3~23.0	0.29~0.13	Test 41~45
4.5	200	900	0.031 (32)	4.31	1/2500 – 1/12000	1.71~0.78	1537~701	0.26~0.12	Test 51~55
10.0	300	3000	0.035 (29)	9.38	1/2500 – 1/20000	2.54~0.90	7622~2695	0.26~0.09	Test 61~66

where

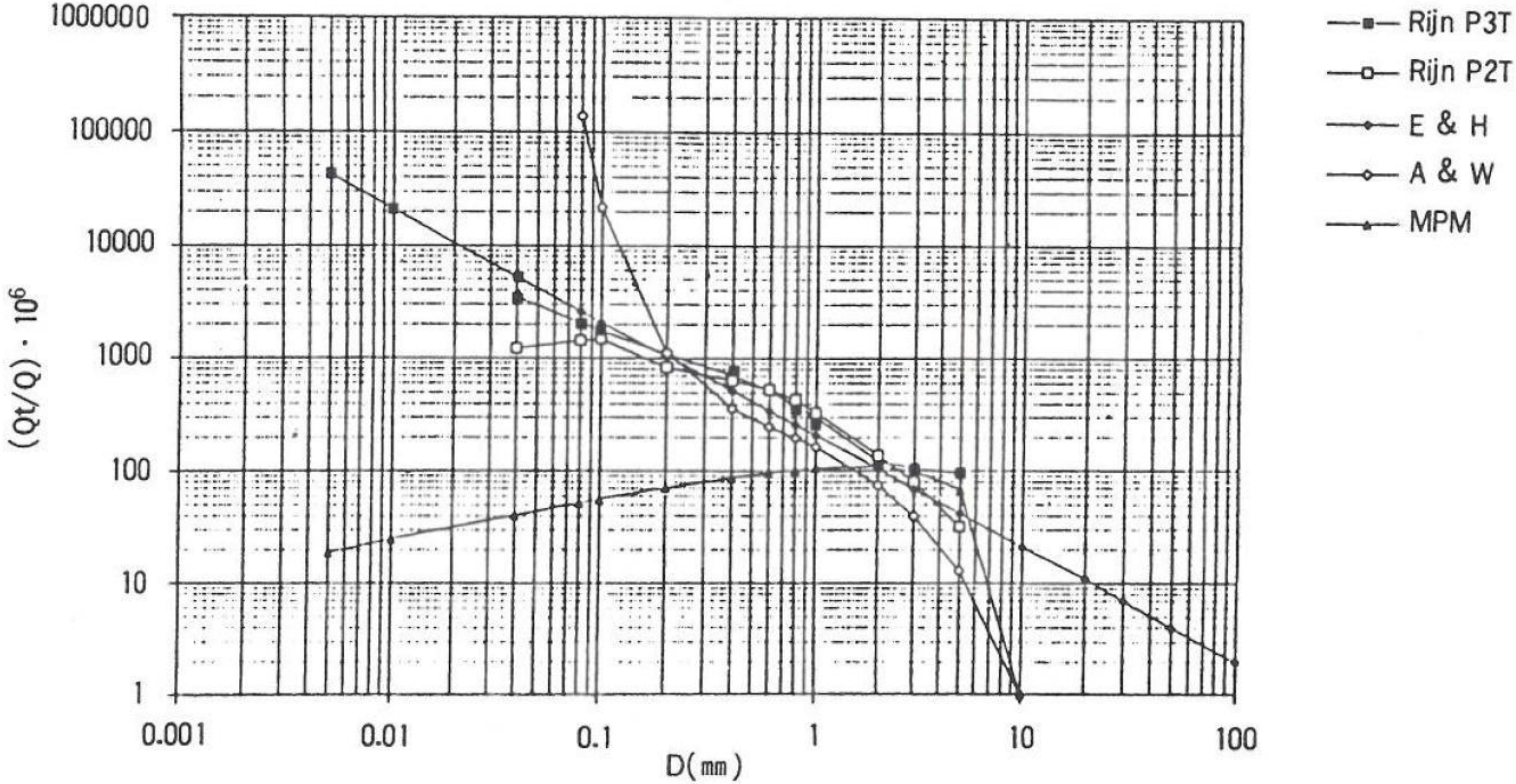
n : Manning roughness coefficient   I : Slope of energy grade line   Kst : Strickler coefficient

〈Table. 4〉 Hydraulic parameters for Test 11–66

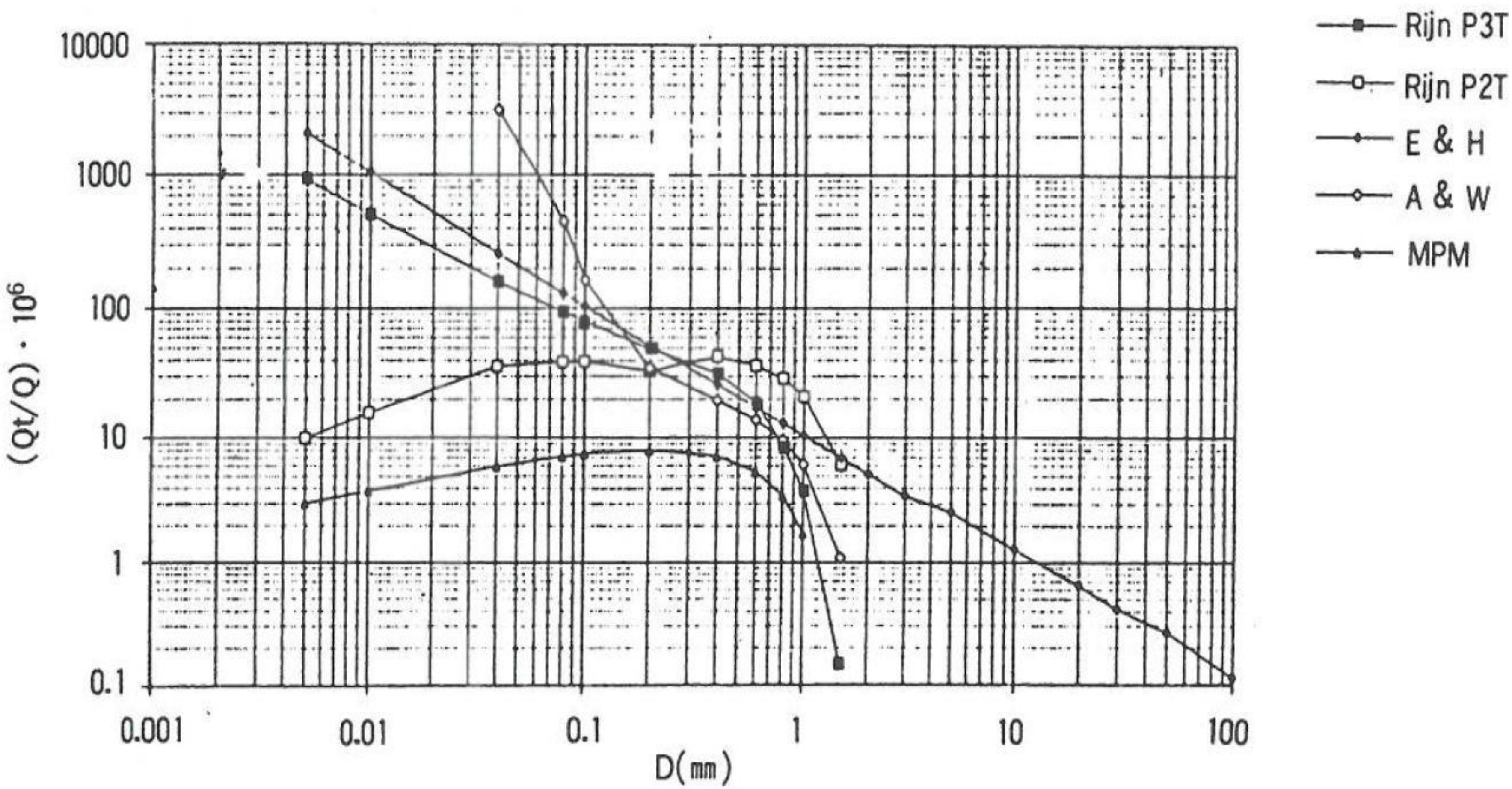
Test No.	Depth h(m)	Width B(m)	Area A(m²)	n	I	Velocity V(m/s)	Discharge Q(m³/s)	Froude number Fr
11	0.2	1.0	0.2	0.014	1/ 500	0.87	0.175	0.62
12					1/ 1000	0.62	0.123	0.44
13					1/ 2500	0.39	0.078	0.28
14					1/ 5000	0.28	0.055	0.20
15					1/ 7500	0.23	0.045	0.16
21	0.8	5.0	4.0	0.018	1/ 500	1.78	7.12	0.64
22					1/ 1000	1.26	5.03	0.45
23					1/ 2500	0.80	3.18	0.28
24					1/ 5000	0.56	2.25	0.20
25					1/ 7500	0.46	1.84	0.16
31	1.0	10.0	10.0	0.020	1/ 500	1.98	19.80	0.63
32					1/ 1000	1.40	14.00	0.45
33					1/ 2500	0.89	8.85	0.28
34					1/ 5000	0.63	6.26	0.20
35					1/ 7500	0.51	5.10	0.16
36						0.44	4.44	0.14
41	1.5	30.0	45.0	0.022	1/ 2500	1.12	50.31	0.29
42					1/ 5000	0.79	35.57	0.21
43					1/ 7500	0.64	29.00	0.17
44					1/ 10000	0.56	25.12	0.15
45					1/ 12000	0.51	22.94	0.13
51	4.5	200.0	900.0	0.031	1/ 2500	1.71	1537.0	0.26
52					1/ 5000	1.21	1087.0	0.18
53					1/ 7500	0.99	886.0	0.15
54					1/ 10000	0.85	768.0	0.13
55					1/ 12000	0.78	701.0	0.12
61	10.0	300.0	3000.0	0.035	1/ 2500	2.54	7622.0	0.26
62					1/ 5000	0.80	5389.0	0.18
63					1/ 7500	1.47	4394.0	0.15
64					1/ 10000	1.27	3811.0	0.13
65					1/ 12000	1.16	3479.0	0.12
66					1/ 2000	0.90	2695.0	0.09



〈Fig. 5〉 Relation between Qt/Q and solid diameter
(Test 12 : h=0.2m, I =1/ 1,000, n=0.014)

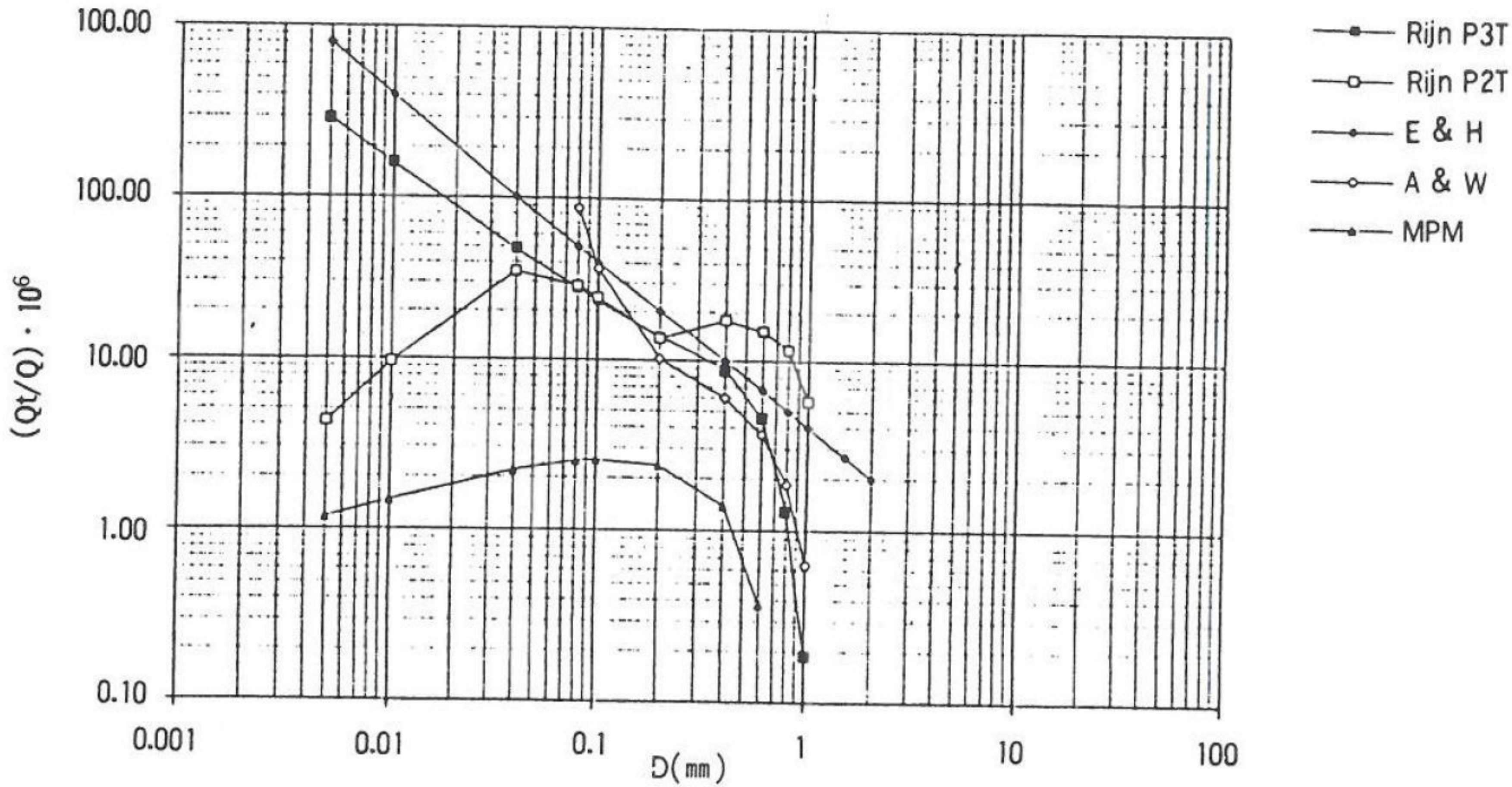


〈Fig. 6〉 Relation between Qt/Q and solid diameter
(Test 22 : h=0.8 m, I =1/1,000, n=0.018)

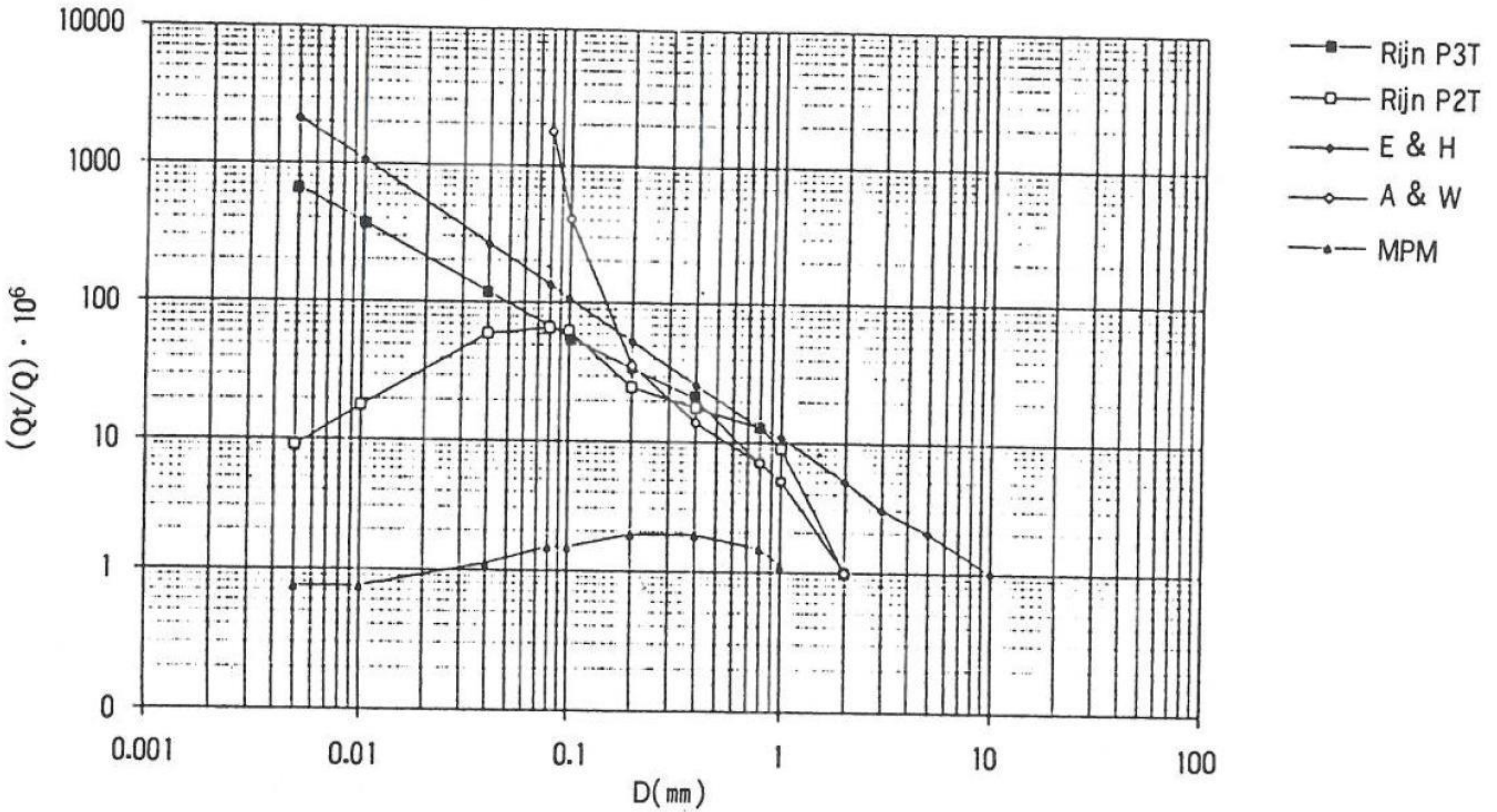


〈Fig. 7〉 Relation between Qt/Q and solid diameter

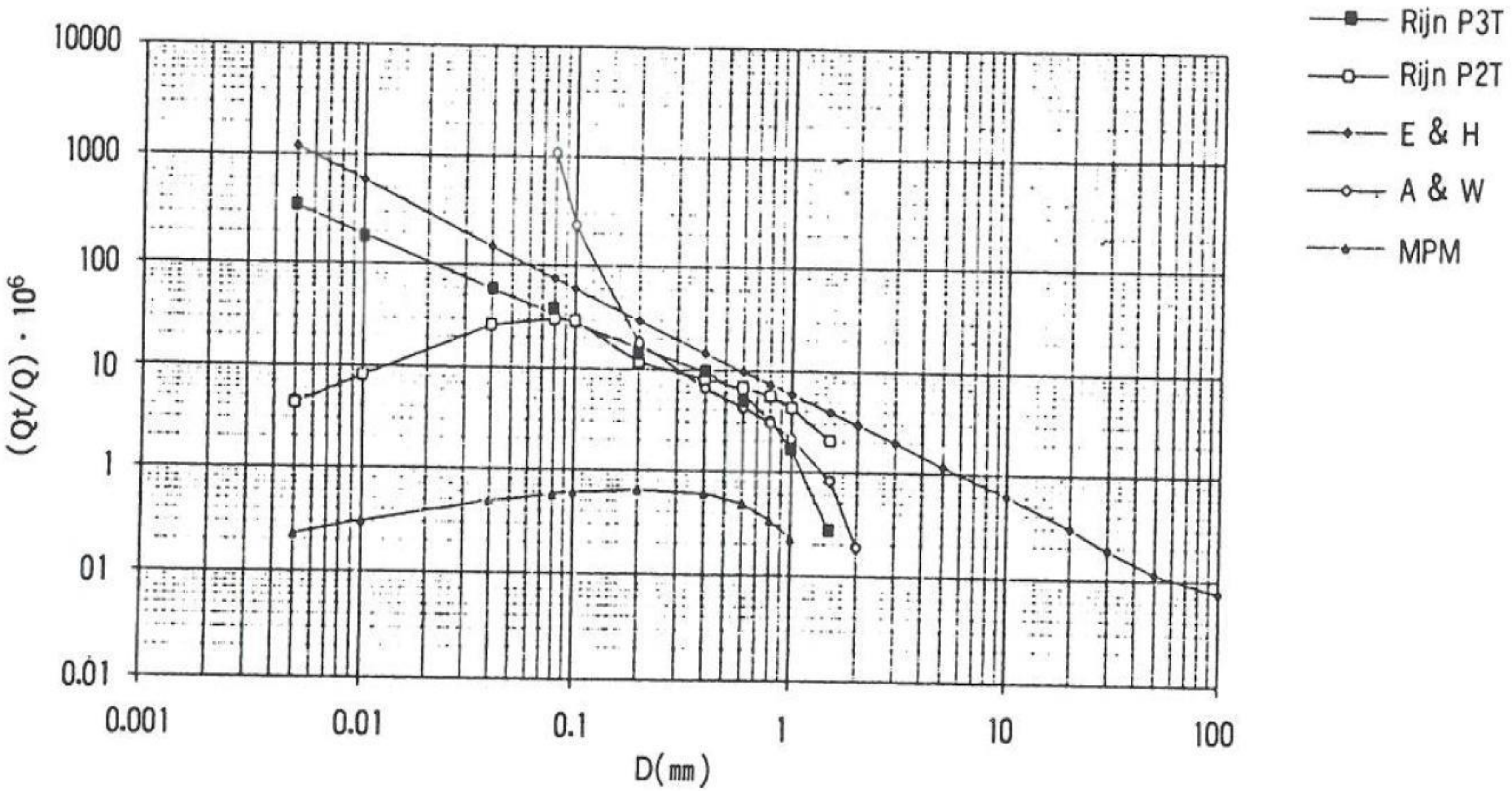
(Test 34 : h=1.0m, I =1/5,000, n=0.020)



〈Fig. 8〉 Relation between Qt/Q and solid diameter
(Test 44 : h=1.5m, I =1/10,000, n=0.022)



〈Fig. 9〉 Relation between Qt/Q and solid diameter
(Test 54 : h=4.5 m, I =1/10,000, n =0.031)



〈Fig. 10〉 Relation between Qt/Q and solid diameter
(Test 66 : h = 10 m, I = 1/20,000, n = 0.035)

MPM formula

- Increase abnormally with sediment diameter and diminish rapidly in all cases
- For the depth of 1.5 m, MPM gives constant sediment discharge
- Applicable to steep slope of energy grade line to small depth
- Original formula based on the experience of uniform flow in laboratory:

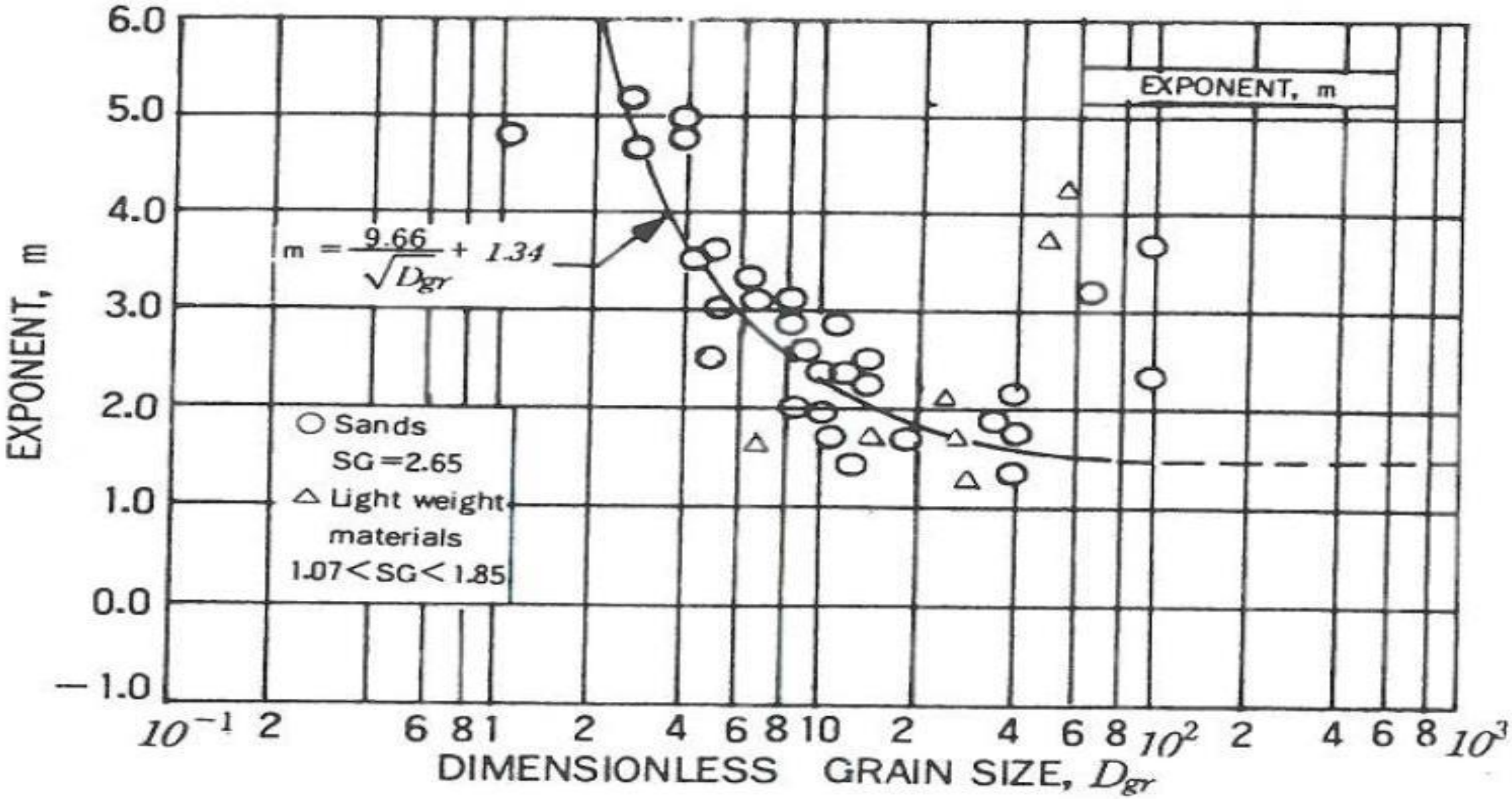
-Slope: 1/50 - 1/2500

-Diameter: 0.4 mm - 30 mm

-Depth: $1\ \text{cm} < h < 1.2\text{m}$

A & W and E & H

- Abrupt increase of sediment discharge for the fine sand (D<0.2 mm)
- For coarse sand (D>1 mm) with mild slope of energy grade (I<1/7500), it diminish rapidly
- Give an unacceptable sudden variation at a limit of application because of the exponential coefficient, m in the formula
- E&H formula gives the results varying in a good sense for 0.005 mm- 100 mm



〈Fig. 11〉 Exponent, m, used by A & W formula

Van Rijn

- Van Rijn part 1 and II formula generally applicable for the range of 0.1 mm<D<2 mm with a mild slope of energy grade line and deep water
- Careful for using this formula for a small depth and very fine sand
- Van Rijn part III is applicable for the range of 0.005 mm<D<2 mm except for a small depth (h<0.8 mm)
- Need attention for a small depth with a mild slope

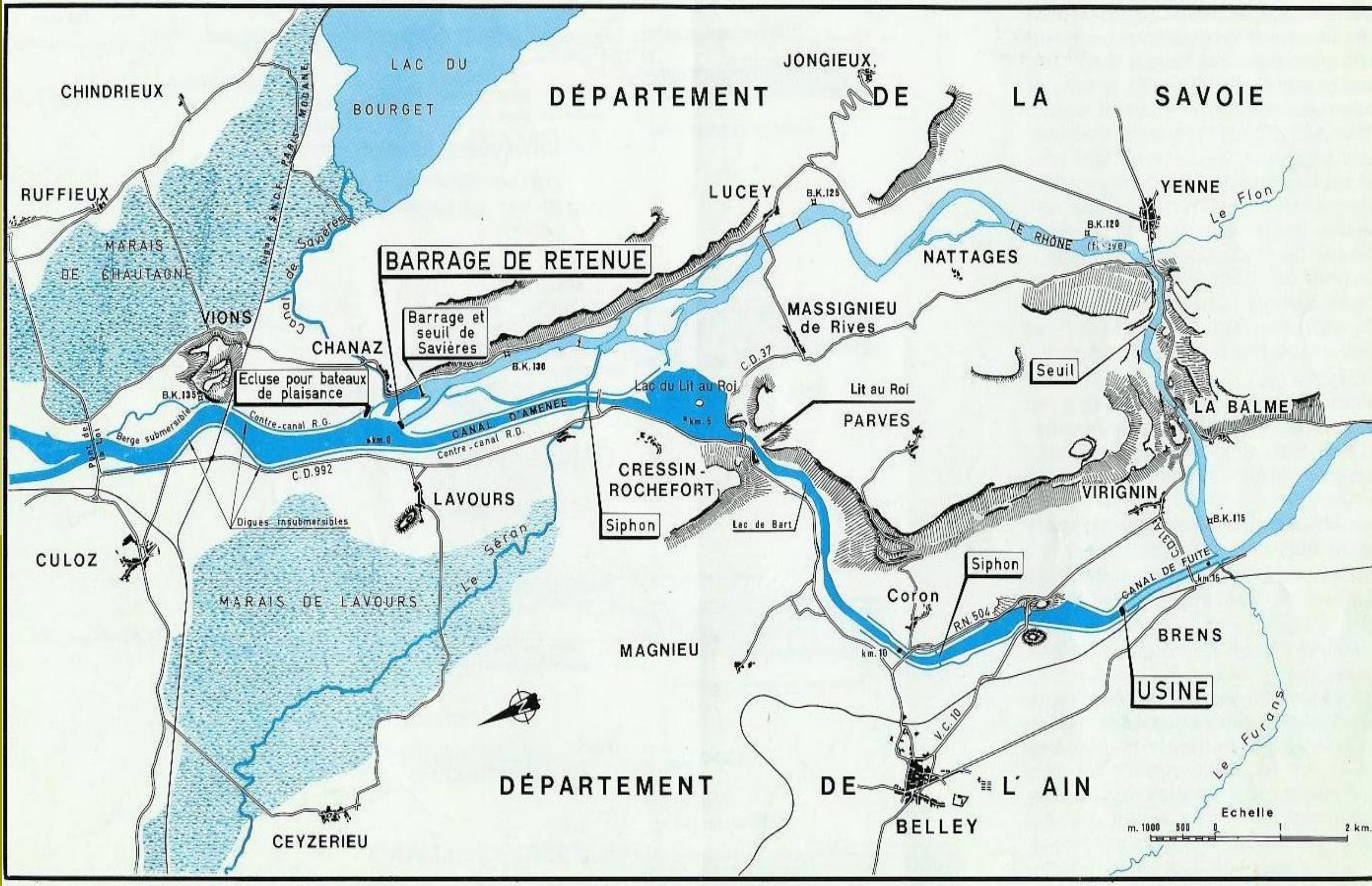
Numerical Model - Non-equilibrium Sediment Transport

- Create fully coupled one-dimensional mobile bed model
- Condition of unsteady flow
- Non-equilibrium sediment transport
- With looped network system
- Mobile Cross Section
- 4 Governing equation plus additional equations

  - Continuity - Motion
  - Conservation of material in suspension
  - Conservation of bed-material
  - Sediment transport formula
  - Roughness coefficient (considering Bed Form)
  - Pick-up function and Fall velocity

Map of Modeling Boundary

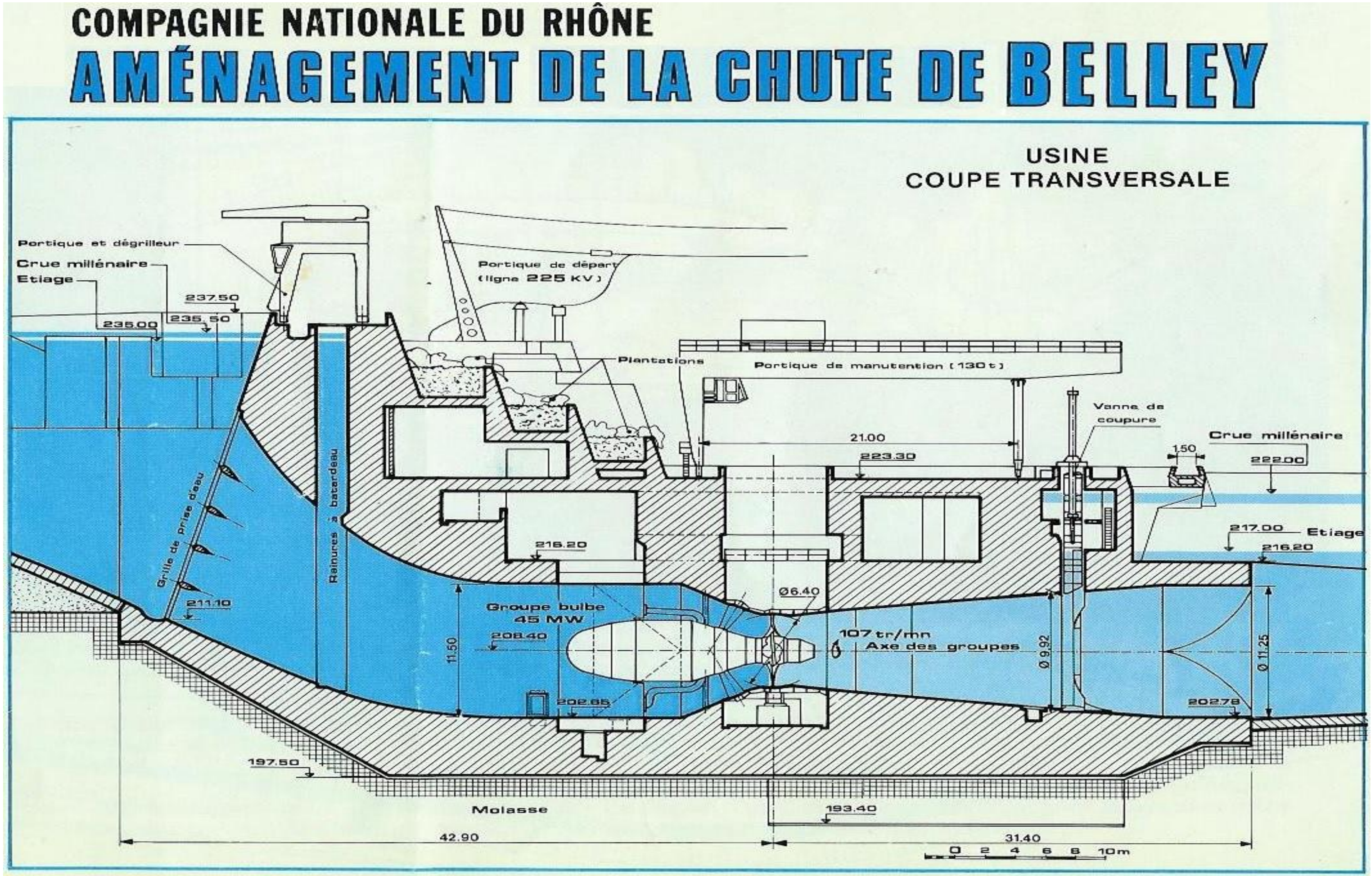
PLAN D'ENSEMBLE DE L'AMENAGEMENT



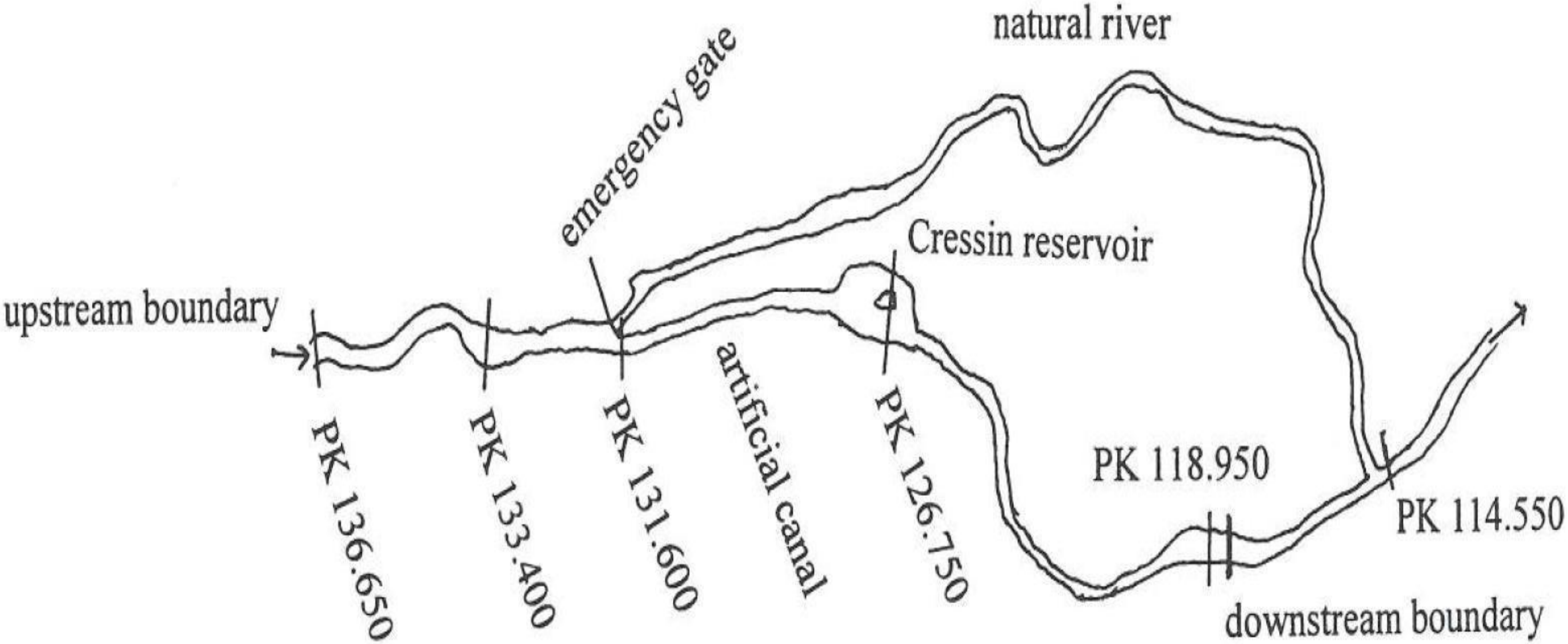
Chanez Diversion

Cressin Lake

Brens Hydropower Plant (440 GWh/ yr)

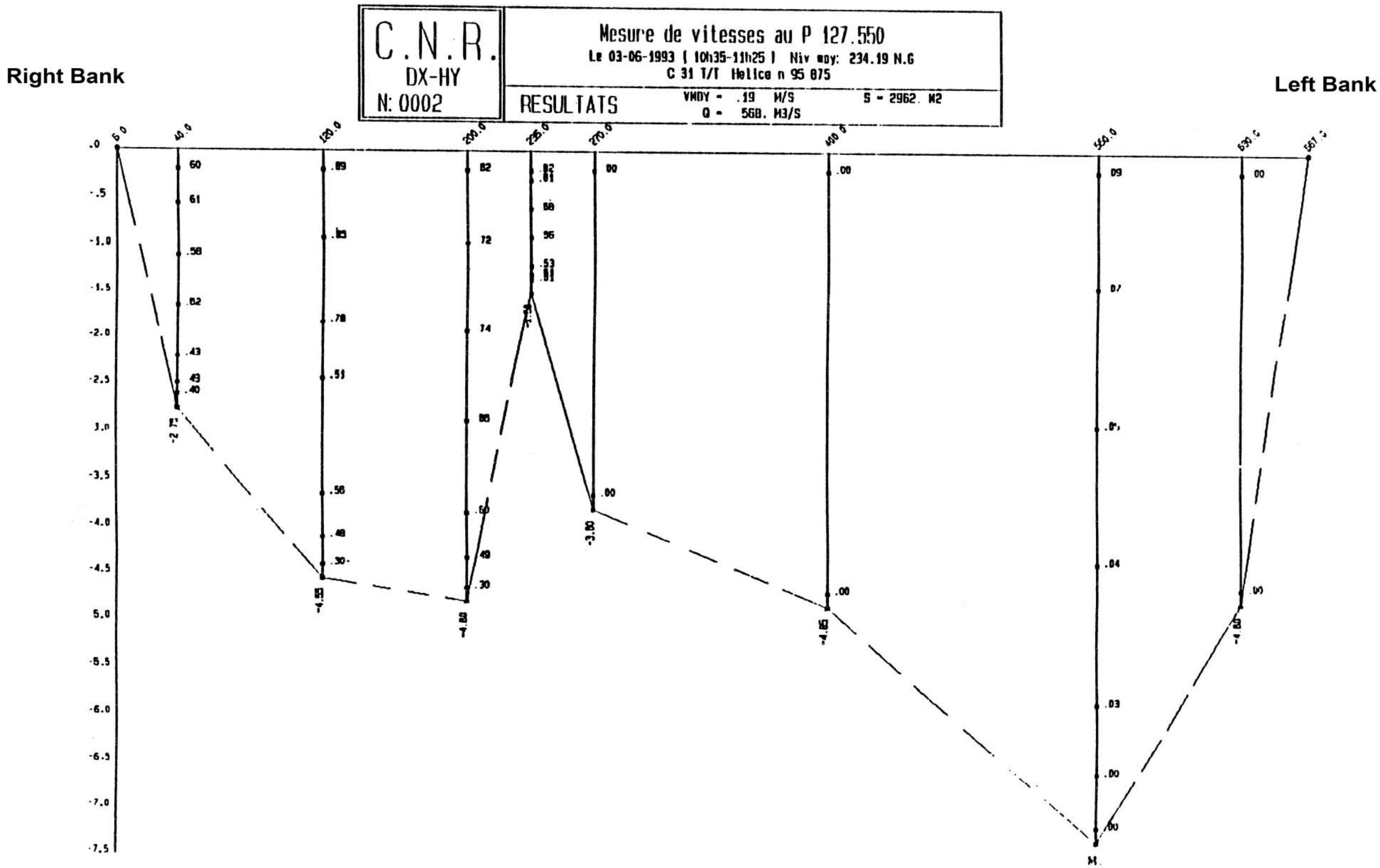


Map of Belley Reservoir



Map of Belley Reservoir

Cross Section & Velocity Data (CNR)



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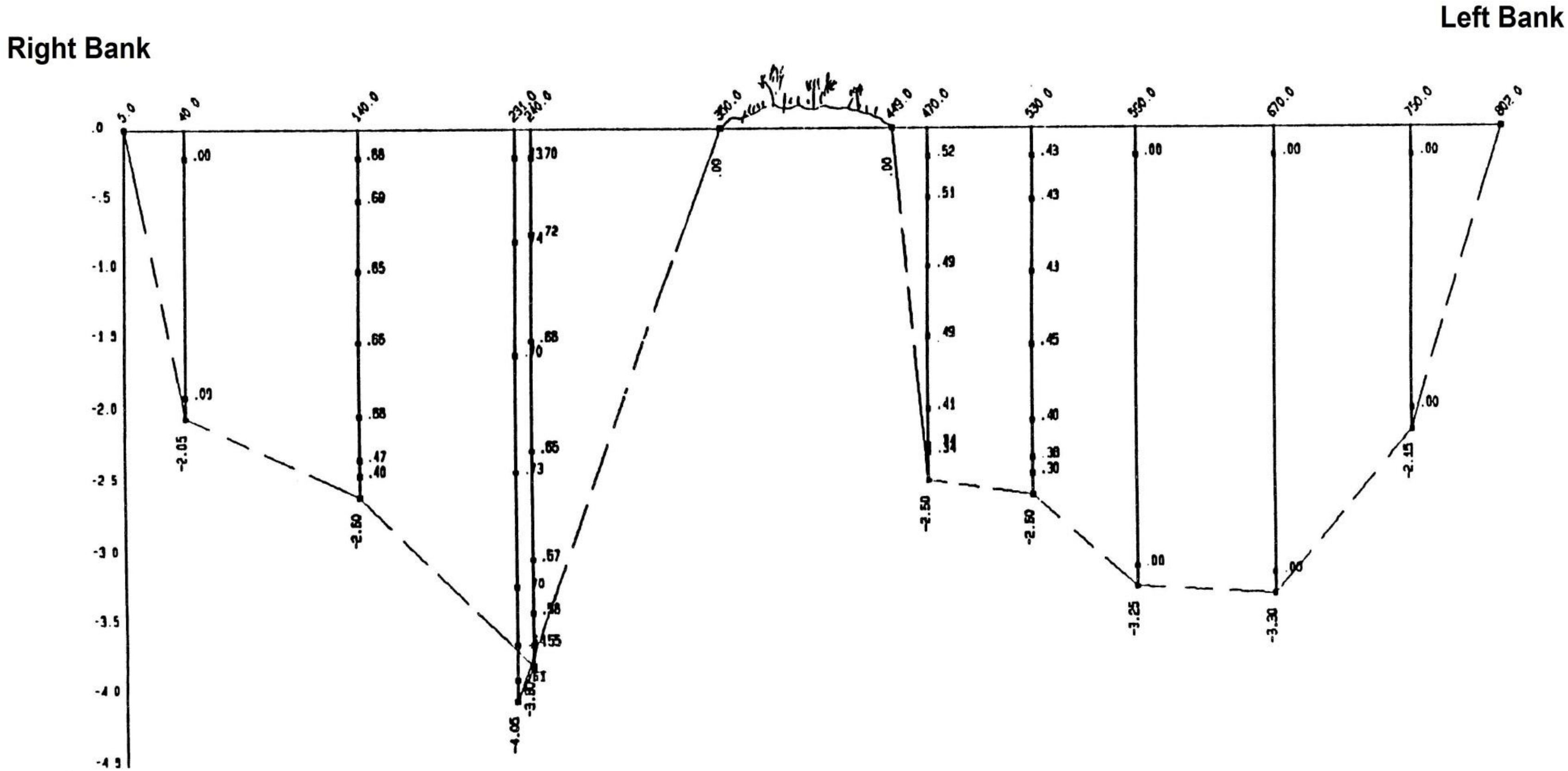
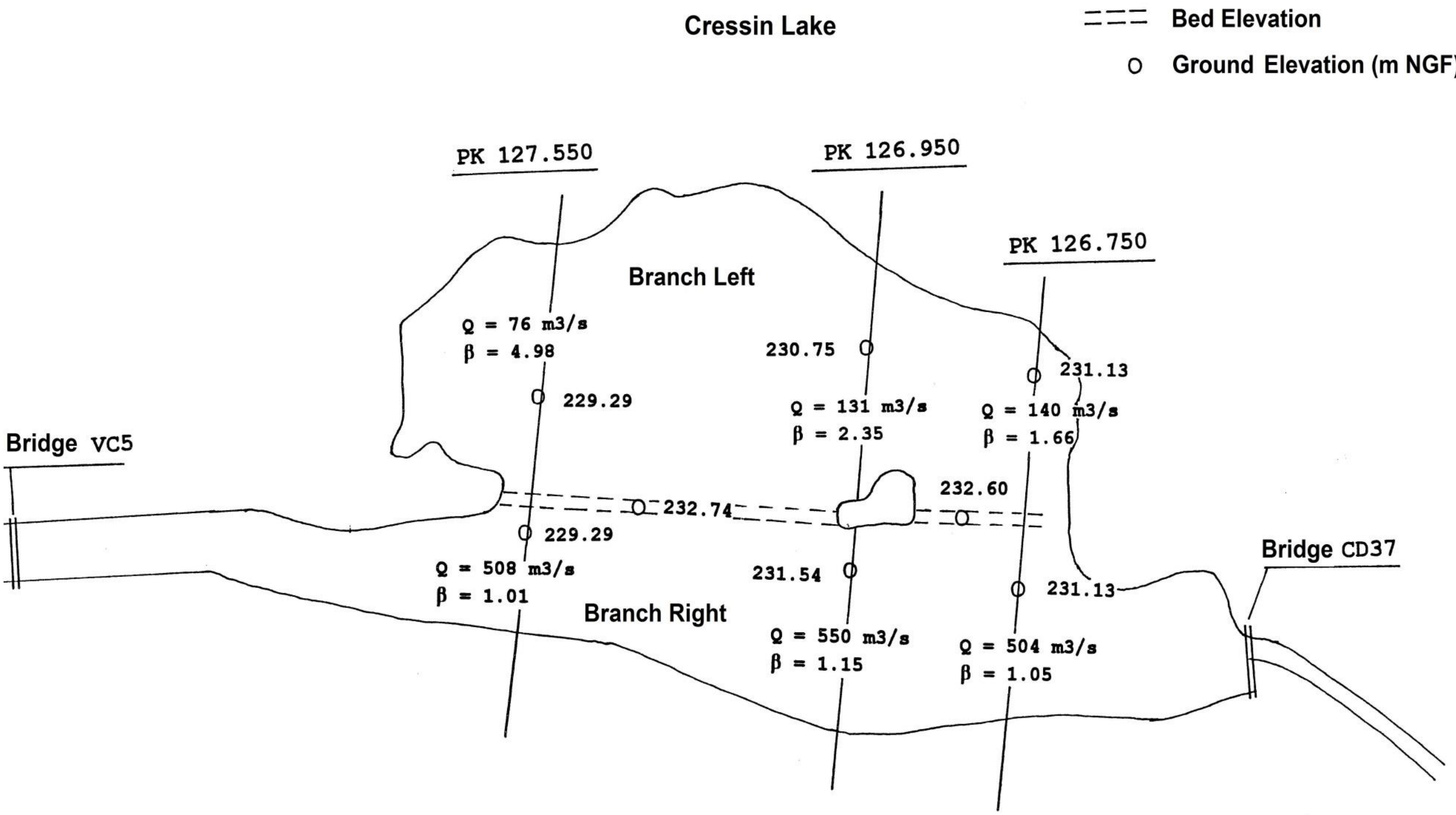
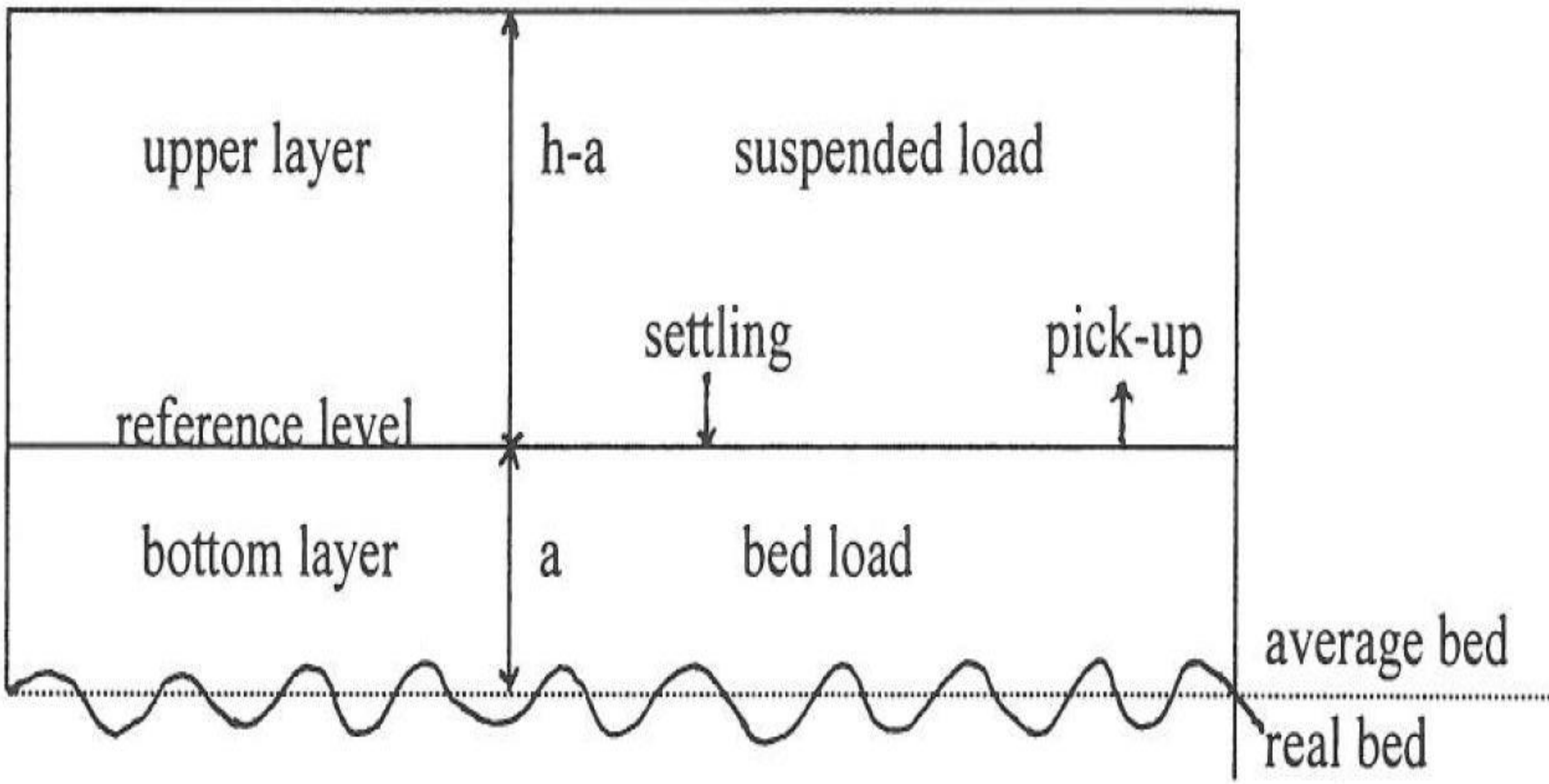
C.N.R. DX-HY N: 0003	Mesure de vitesses au P 126.950 Le 03-06-1993 (11h30-12h40) Niv moy: 234.16 N.G C 31 T/T Helice n 95 875
	RESULTATS VMOY = .32 M/S S = 1685. M2 Q = 533. M3/S



Cressin Lake (Confluence & Divergence)



Definition Sketch



Definition Sketch in the Sediment Transport Model

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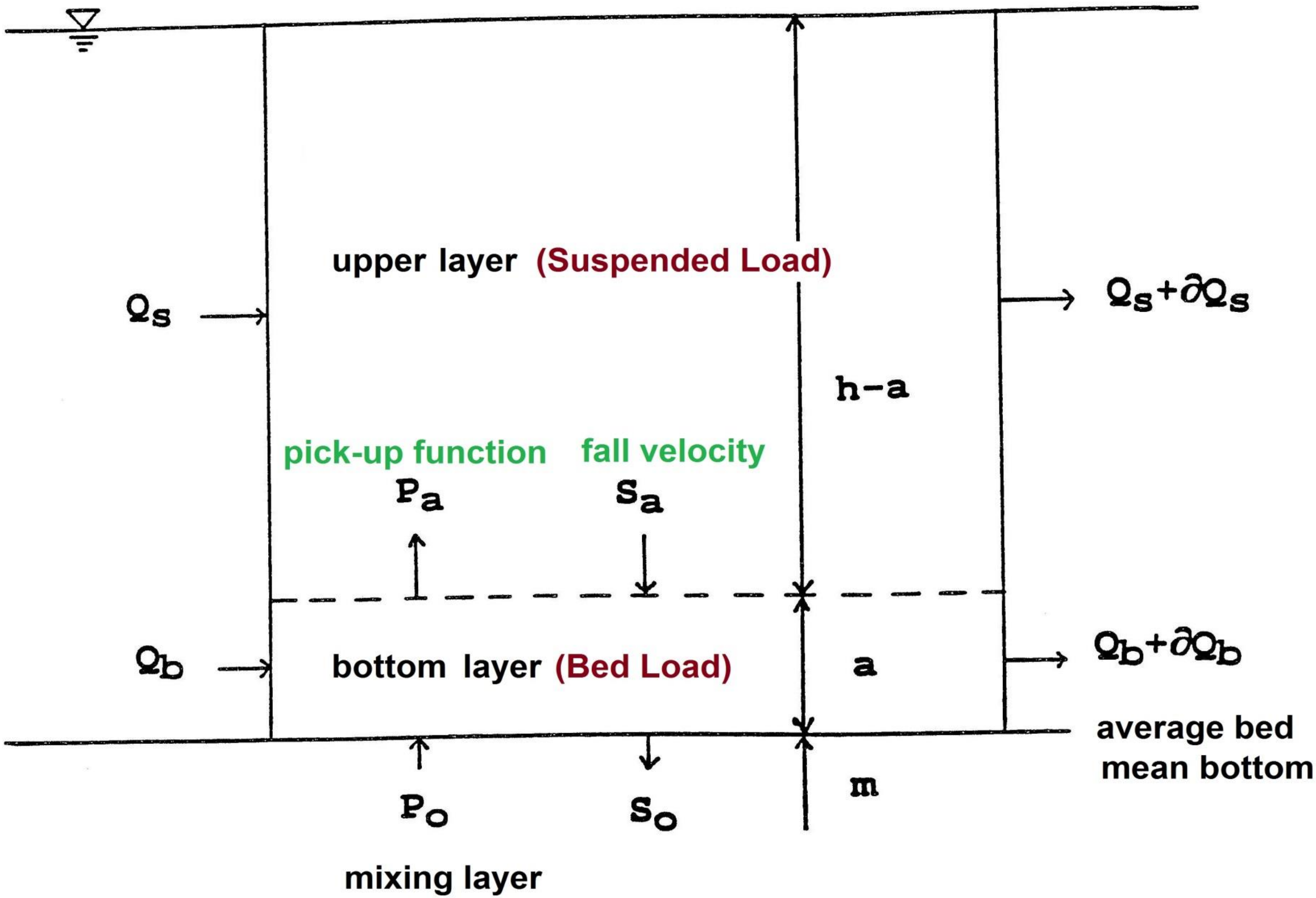


upper layer (Suspended Load)
Qs
Qs+∂Qs
h-a
pick-up function
fall velocity
Pa
Sa
Qb
bottom layer (Bed Load)
a
Qb+∂Qb
average bed
mean bottom
Po
So
m
mixing layer

Governing Equations

Fluid continuity equation:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = B\frac{\partial z}{\partial t} + \frac{\partial Q}{\partial x} = q \qquad (1)$$

Fluid motion equation:

$$\frac{\partial z}{\partial t} + \frac{1}{gA}\frac{\partial}{\partial x}(\beta\frac{Q^2}{A}) + \frac{Q^2}{K^2} + \frac{1}{gA}\frac{\partial Q}{\partial t} + \frac{Ke}{2g}\frac{\partial (Q/A)^2}{\partial x} = 0 \qquad (2)$$

Suspended material conservation equation:

$$\frac{\partial CA}{\partial t} + \frac{\partial Qs}{\partial x} = S - qC \qquad (3)$$

Bed material conservation equation:

$$(1\text{-}p)\frac{\partial Ab}{\partial t} + \frac{\partial Qb}{\partial x} + S = 0 \qquad (4)$$

in which x = streamwise coordinate; t = time; A = wetted cross-sectional area; Q = discharge; Z = water-surface elevation above a datum; B = flow width; q = lateral flow; g = gravitational acceleration; β = momentum correction coefficient; K = conveyance; Ke = coefficient of expansion-contraction; C = average sediment concentration; Qs = volumetric suspended load; S = sediment flux between bottom layer and waterstream; Ab = bottom layer cross-section; Qb = bed load.

Discretization of Equation

$$\frac{\partial f}{\partial t} = \frac{1}{\Delta t} [\psi \, \Delta f_{i+1} + (1-\psi) \, \Delta f_i]$$

$$\frac{\partial f}{\partial x} = \frac{1}{\Delta x} [(f_{i+1} + \theta \Delta f_{i+1}) - (f_i + \theta \Delta f_i)]$$

$$f(x,t) = \psi (f_{i+1} + \theta \Delta f_{i+1}) + (1-\psi) (f_i + \theta \Delta f_i)$$

which i and n = gird point, θ = the weighting factors for time, ψ = the weighting factors for space

Solution for Algebraic System

$$\Delta Q_i = F_i \, \Delta Z_i + G_i \Delta Zb_i + H_i \, \Delta C_i + K_i$$

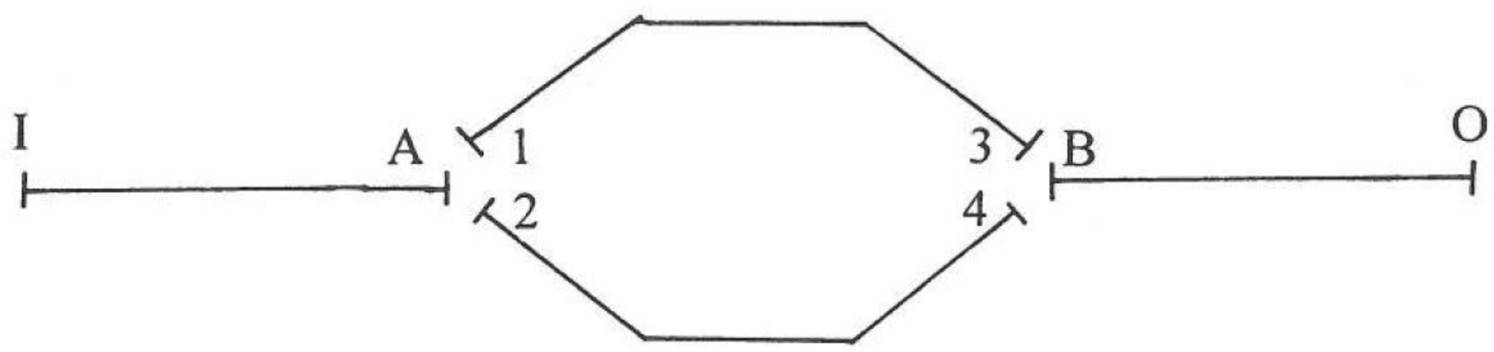
$$\Delta C_i = F_j \, \Delta Z_i + G_j \, \Delta Zb_i + H_j \, \Delta Q_i + K_j$$

in which F_i, F_j, G_i, G_j, H_i, H_j, K_i and K_j are known coefficients for the given time.

$$\Delta Q_{i+1} = F_{i+1} \, \Delta Z_{i+1} + G_{i+1} \, \Delta Zb_{i+1} + H_{i+1} \, \Delta C_{i+1} + K_{i+1}$$

$$\Delta C_{i+1} = F_{j+1} \, \Delta Z_{i+1} + G_{j+1} \, \Delta Zb_{i+1} + H_{j+1} \, \Delta Q_{i+1} + K_{j+1}$$

Looped Network



Looped Network

For divergence (A12), the following compatibility condition is used: (FIG.)

$$Z_A = Z_1 = Z_2,\ Zb_A = Zb_1 = Zb_2,\ C_A = C_1 = C_2,\ Q_A = Q_1 + Q_2$$

For confluence (B34), the following compatibility condition is used:

$$Z_B = Z_3 = Z_4,\ Zb_B = Zb_3 = Zb_4,\ C_3Q_3 + C_4Q_4 = C_BQ_B,\ Q_B = Q_3 + Q_4$$

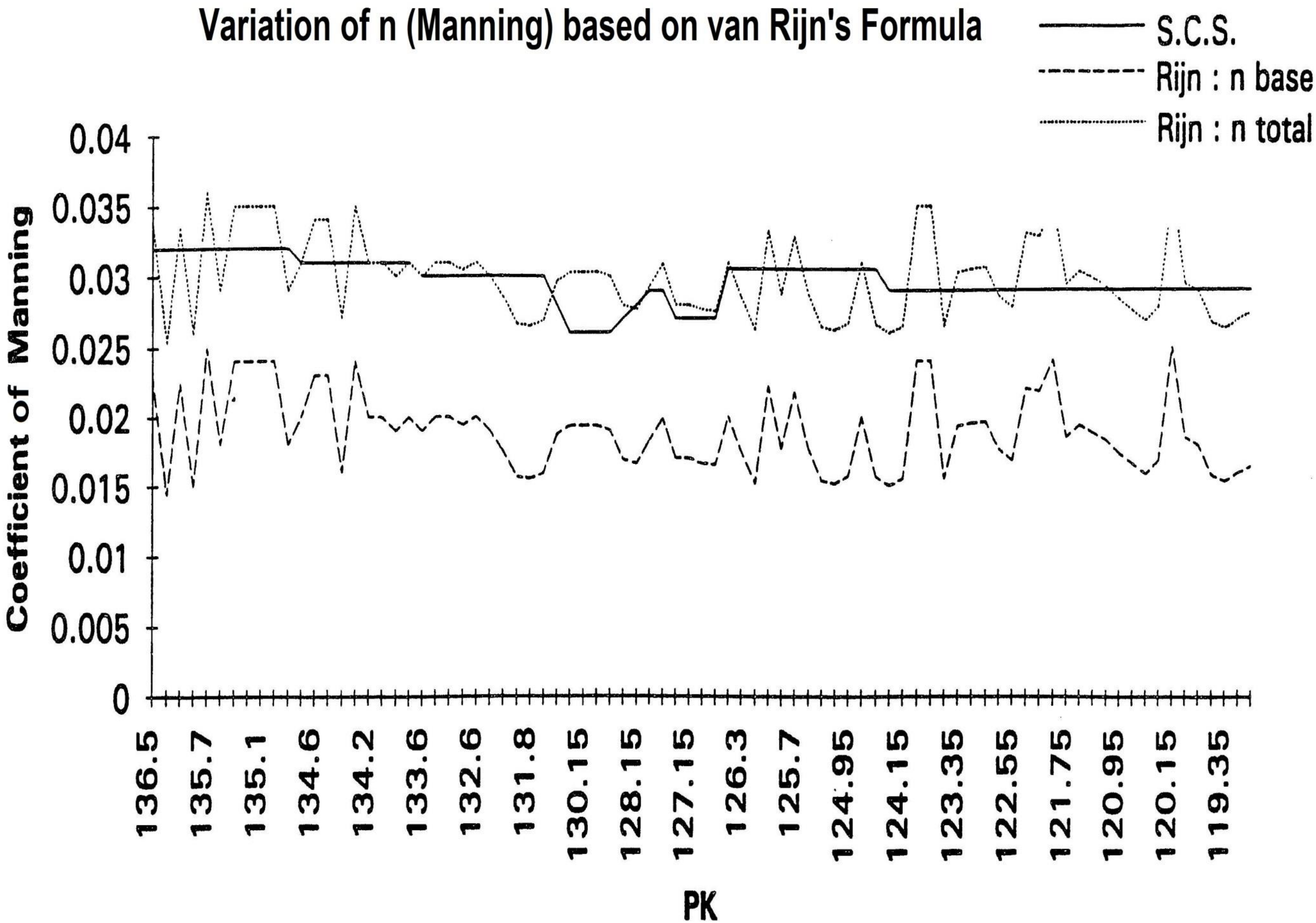
Application to River

The size distribution for bed material and suspended load are:

Bed material: $D_{16} = 0.034$ mm, $D_{50} = 0.150$ mm, $D_{84} = 0.288$ mm, $D_{90} = 0.375$ mm
Suspended load: $D_{16} = 3.4$ μm, $D_{50} = 11.5$ μm, $D_{84} = 28.0$ μm, $D_{90} = 36.0$ μm

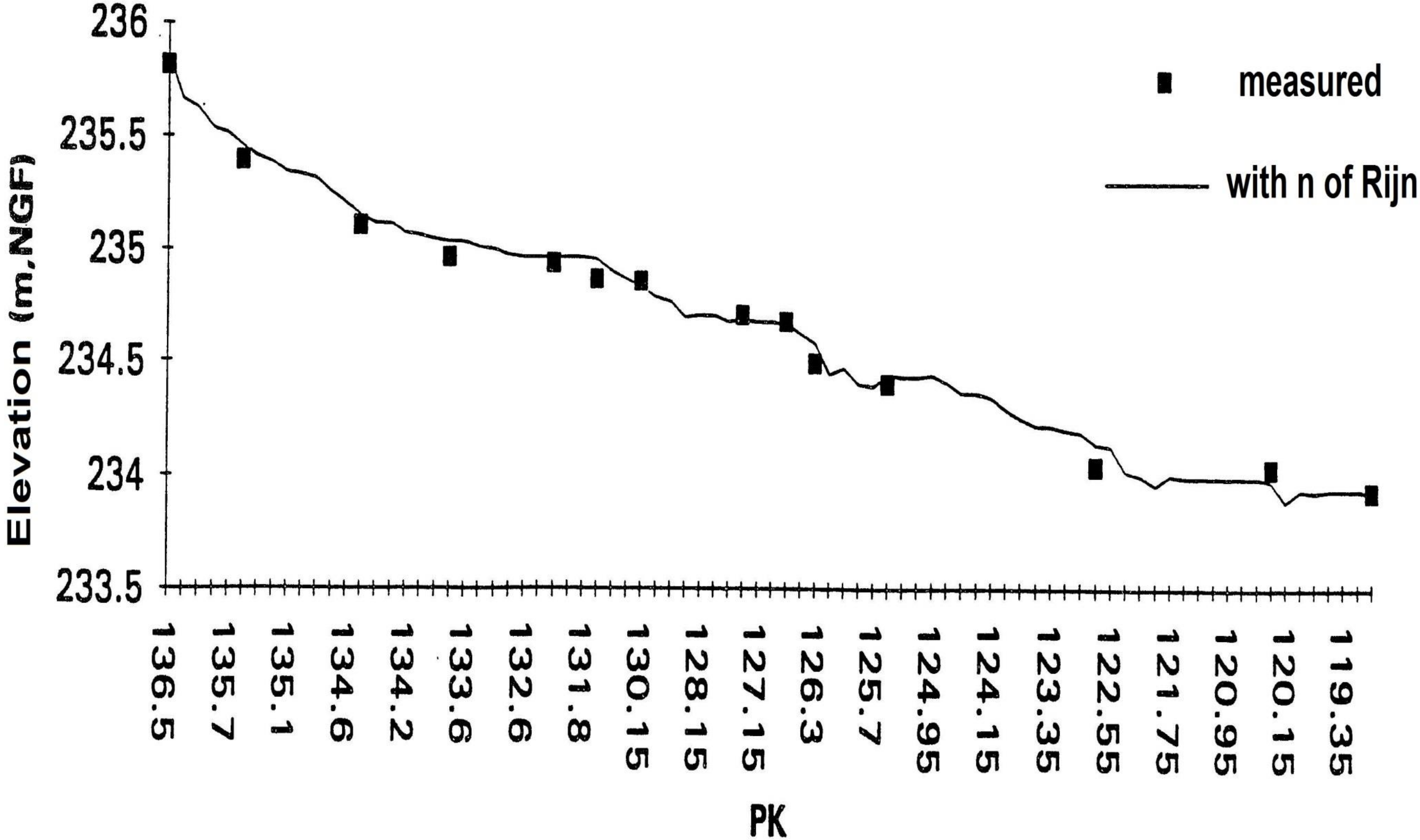
Using $\Delta t = 5$ minute and D = 11.5 μm for the condition of Q = 700 m^3/s, Z = 233.93 m, Zb = 255 m and varying C, the concentration variation along the Belley reservoir shows as follows: (FIG. 5)

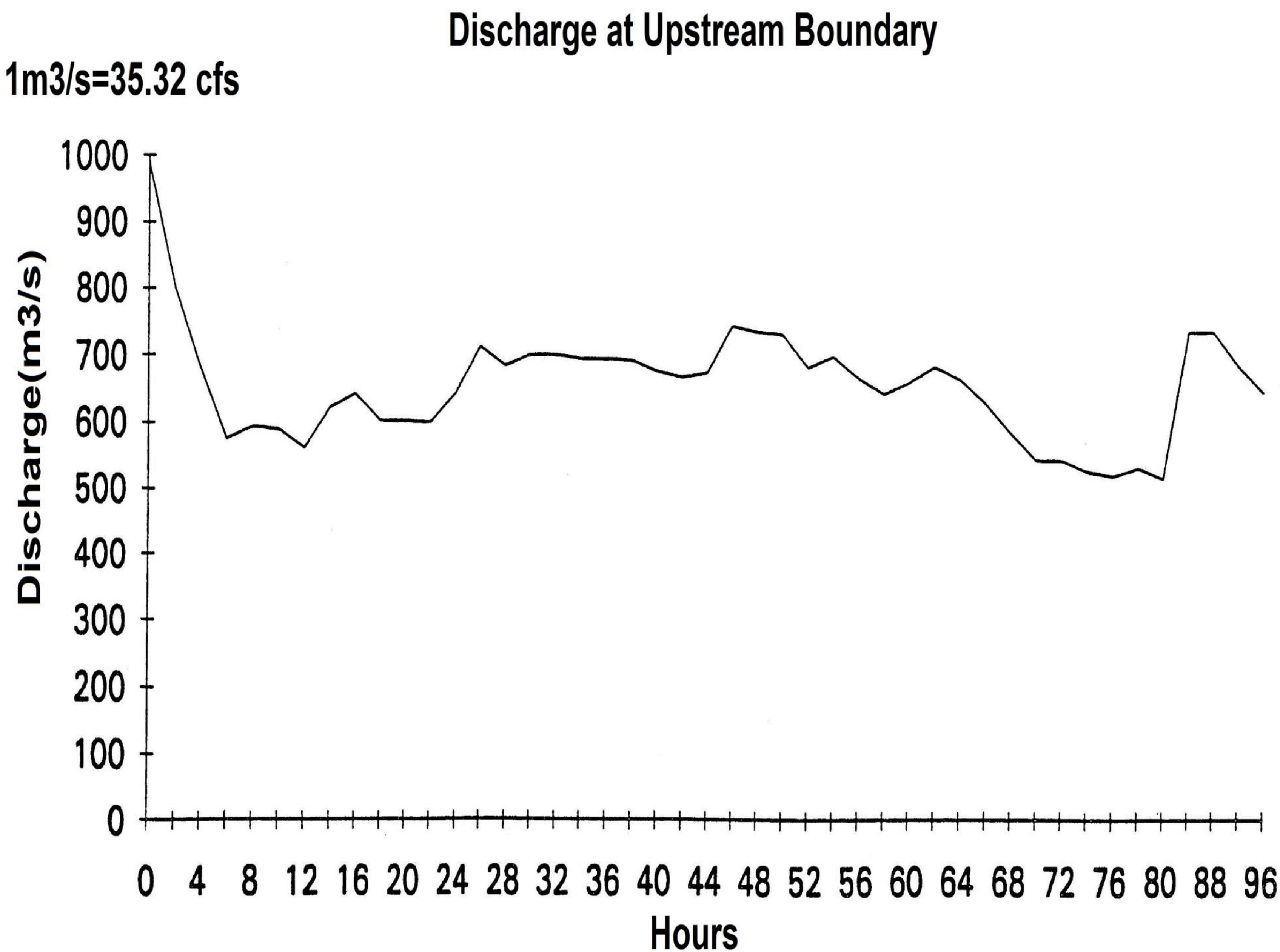
The flushing operation in 1990 is lasted about 4 days. The discharge during 4 days changes with minimum Q = 512 m^3/s and maximum Q = 990 m^3/s. During flushing the concentration variation is observed with minimum C = 0.7 g/l and maximum C = 9 g/l. The concentration variation for 5 μm, 11.5 μm, 20 μm, and 30 μm are also given in the following figure. (FIG.6)



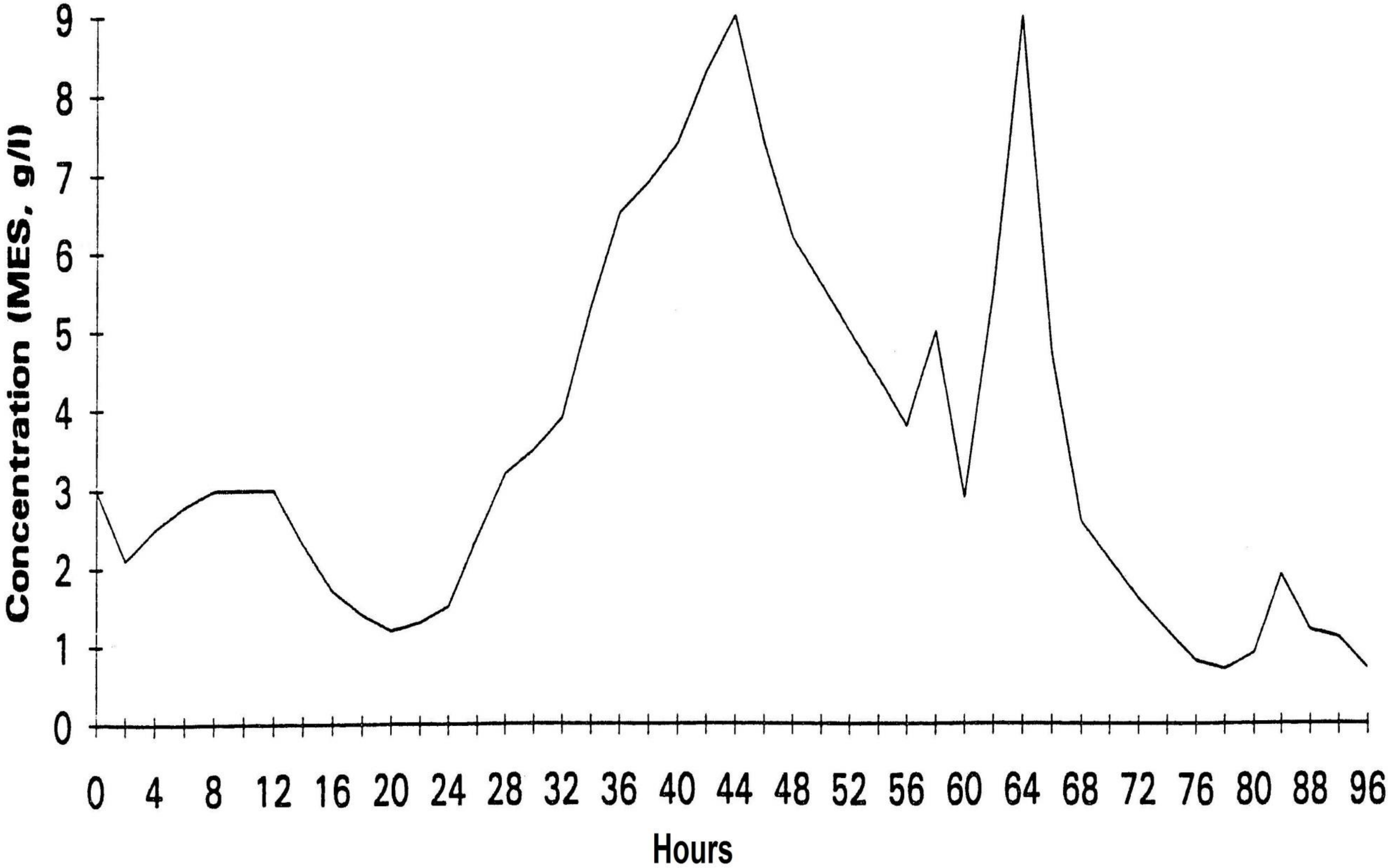
Variation of n (Manning) based on van Rijn's Formula
S.C.S.
Rijn : n base
Rijn : n total
Coefficient of Manning
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
136.5
135.7
135.1
134.6
134.2
133.6
132.6
131.8
130.15
128.15
127.15
126.3
125.7
124.95
124.15
123.35
122.55
121.75
120.95
120.15
119.35
PK

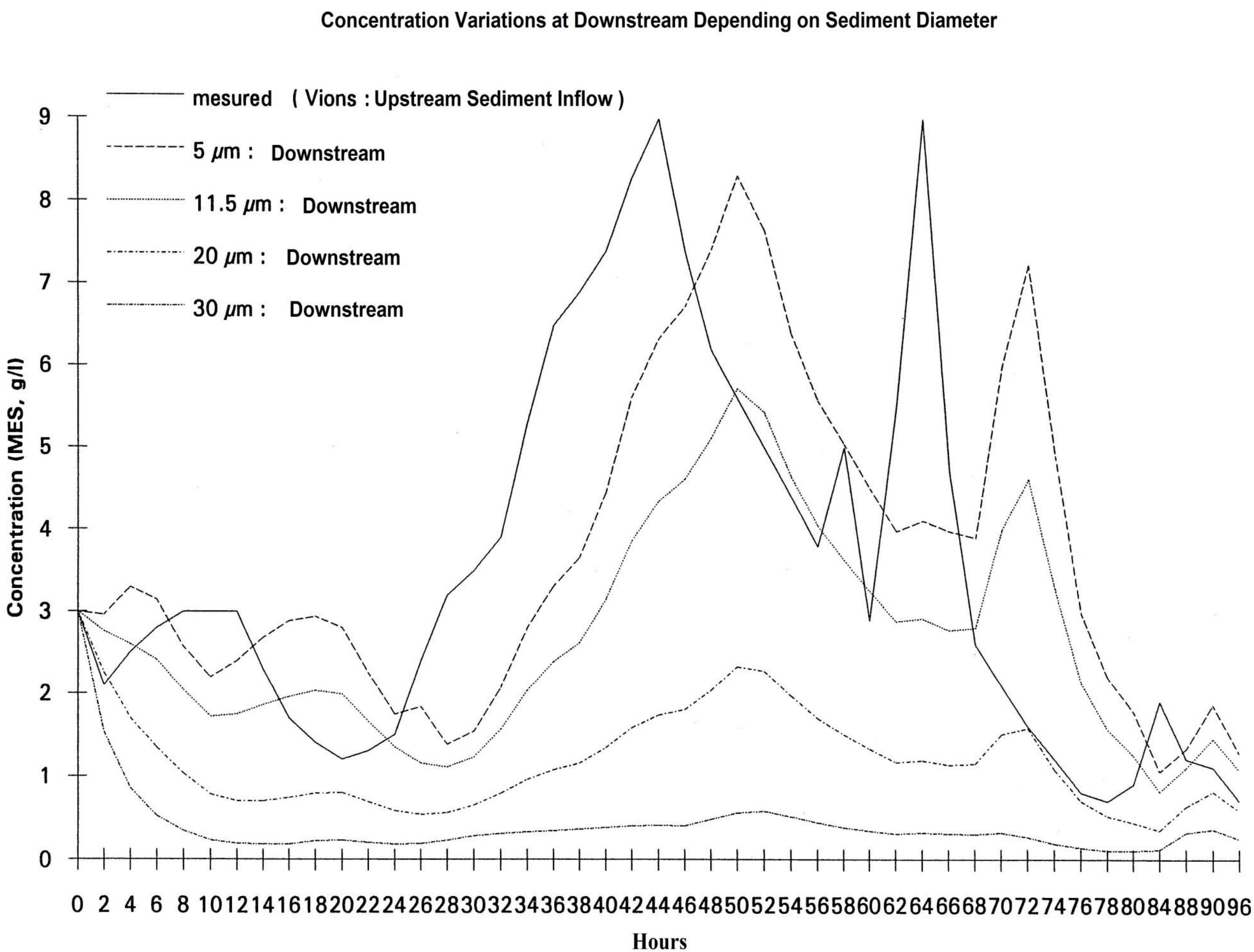
Water Surface Profile (Q = 715 m3/s , Z = 233.93 m , Zb = 225 m ; May 25 , 1990)




Discharge at Upstream Boundary
1m3/s=35.32 cfs
Discharge(m3/s)
1000
900
800
700
600
500
400
300
200
100
0
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80 88 96
Hours

Variation of concentration at Upstream (Vions)





Concentration Variations at Downstream Depending on Sediment Diameter
mesured (Vions : Upstream Sediment Inflow)
5 μm : Downstream
11.5 μm : Downstream
20 μm : Downstream
30 μm : Downstream
Concentration (MES, g/l)
0 1 2 3 4 5 6 7 8 9
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80 84 88 90 96
Hours

Trap Efficiency

TABLE 1. Trap Efficiency of Sediment

Diameter(μm)	Inflow(m^3)	Deposit(m^3)	Outflow(m^3)	Trap(%)
5.0	295,000	3,000	292,000	1
11.5	295,000	84,000	211,000	28
20.0	295,000	201,000	94,000	68
30.0	295,000	284,000	31,000	89

Results

- D=5 μm – almost transported to downstream
- D=30 μm – almost deposited in reservoir
- Sediment inflow – 295,000 m^3
- Suppose:

  - D=5 μm (30%) – very fine silt

  - D=11.5 μm (30%) – fine silt

  - D=20 μm (20%) – medium silt

  - D=30 μm (20%) – coarse & medium silt
- Trap efficiency=Deposit/inflow=119,000/295,000

  = 40% =0.4

Continue

- D=5 μm pass through the reservoir
- D=30 μm 89% deposited in the reservoir
- Trap efficiency of model simulation (=0.4) gives reasonably good result comparing the measurement (=0.49) in 1990

O'Conner Lakes of Feather River (Q= 65,000 cfs, Jan. 4, 2006)

O'Conner Lakes of Feather River

(Q= 65,000 cfs, Jan. 4, 2006) → 210,000 cfs (100yr)

Debris/Sediment Trap after Flooding

Sediment Deposit after removing Debris

(Q= 65,000 cfs, Jan. 4, 2006 at O'Conner Lakes, Feather River)

Feather River Sediment Deposit

Next Step

- Apply to channels and natural rivers system (Sacramento River, Feather River & San Joaquin River)
- Combined with GIS and Water Quality Model
- Combined with 2-D hydraulic model
- Long term maintenance, Channel capacity study, Project planning

- Need to consider the change of bed elevation due to major flood events with mobile bed model

- Consider cumulative impact of sediment deposit and erosion

- Environmental restoration

    - carefully designed or planned for heavy sediment carrying/ transporting stream

- HEC-RAS Sediment Model – unsteady version of sediment transport: not available

CHAPTER 17

Performing a Sediment Transport Analysis

This chapter shows how to perform a mobile bed sediment transport analysis with HEC-RAS. A sediment model requires a geometry file, a quasi-unsteady flow file, a sediment file and a sediment analysis plan file. Instructions on creating a geometry file can be found in Chapter 6 of this User's Manual. The other three files are described in this chapter.

P17-1

Transport Function

A transport function can be selected from the drop down box near the top of the form. There are currently seven transport functions to select from:

- Ackers and White
- Englund — England and Hansen
- Copeland's form of Laursen
- Meyer, Peter and Muller
- Toffaleti
- Yang (sand and gravel eqns.)
- Wilcock

p17-2

Fall Velocity Methods

Several methods are available for computing fall velocity and the user should select the most appropriate algorithm. The options include:

- Ruby
- Toffaleti
- Van Rijn
- Report 12 (Default method in HEC-6)

p17-3

Q & A

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