

火山流域における 土砂移動現象の観測

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山地河川での土砂移動観測の必要性

土砂災害後の
土砂流出監視

警戒避難情報
への活用

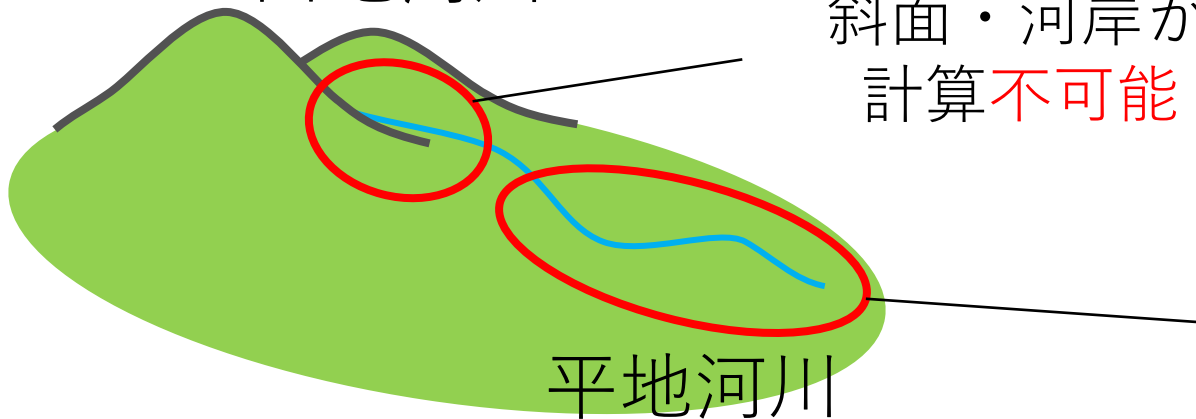
流砂系全体の
総合的土砂管理

山地河川

斜面・河岸からの土砂供給に依存
計算不可能 → 観測が不可欠

平地河川

水深・流量から
流砂量計算可能

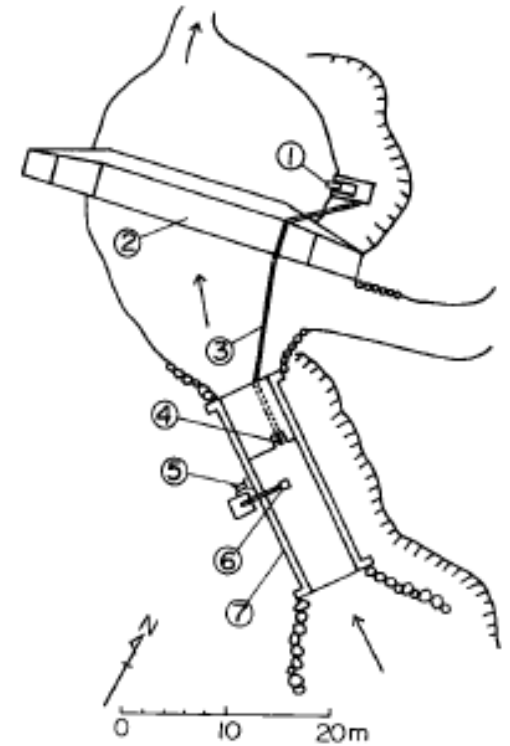


火山地域

岐阜県高山市
焼岳を源流とする山地流域

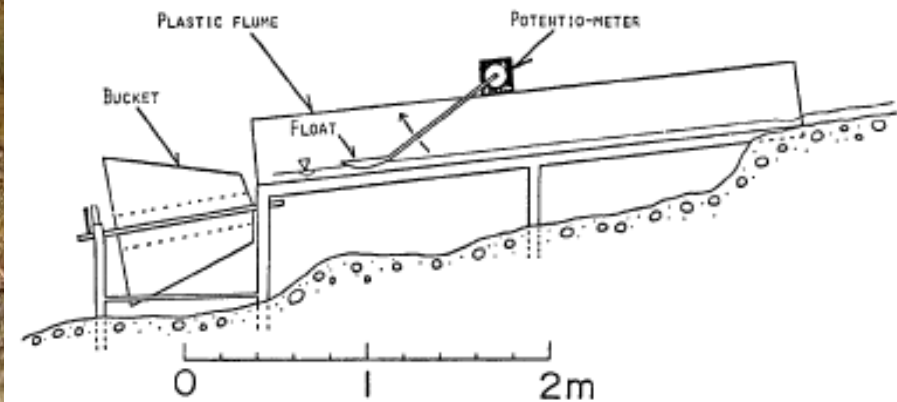


Basket type bed-load sampler (1970's)

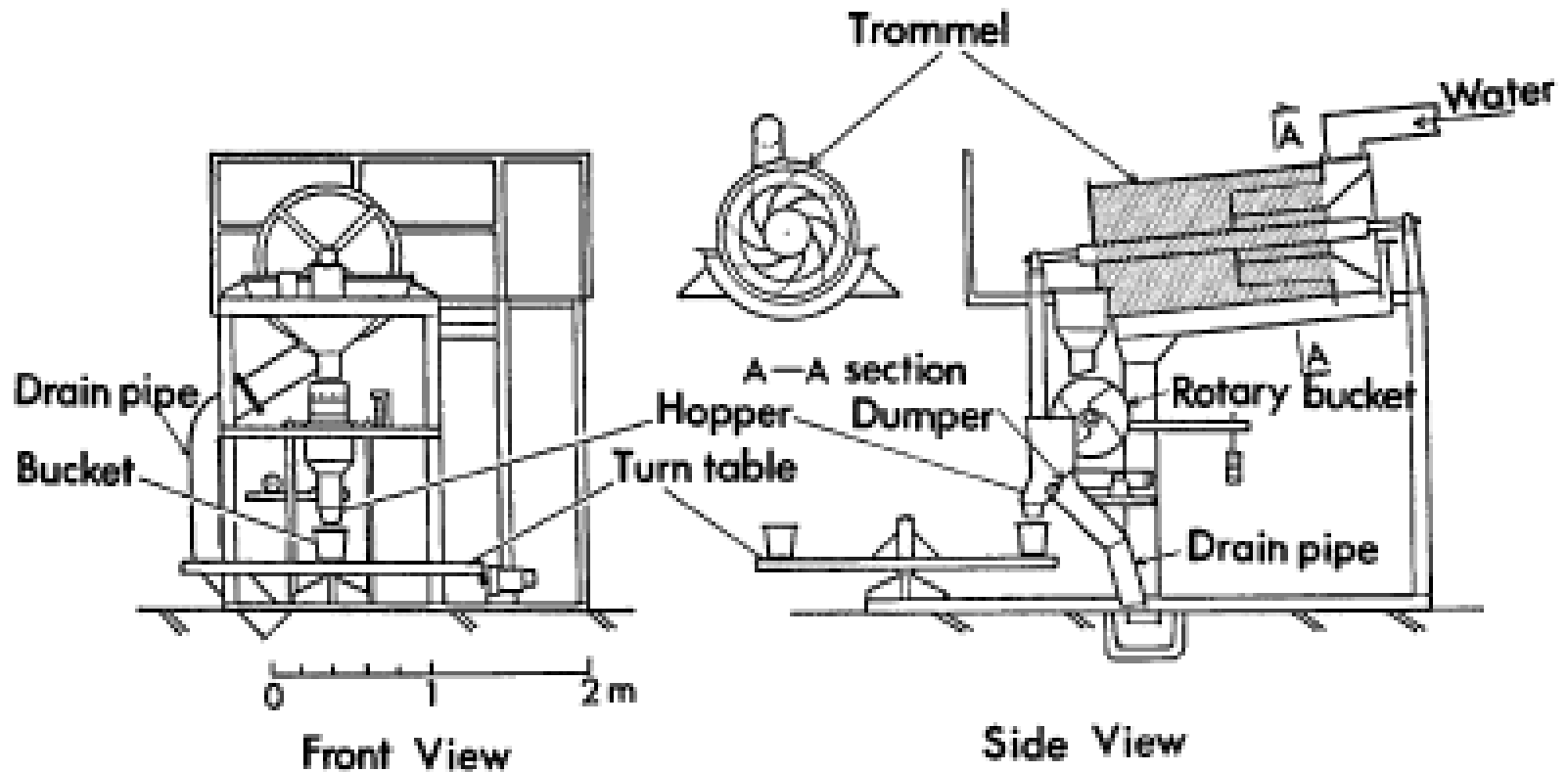


- ① Measuring bucket, ② Dam, ③ Pipe ($\phi 0.3$ m), ④ Sand trapping box, ⑤ camera, ⑥ Ultrasonic water gauge, ⑦ Concrete channel

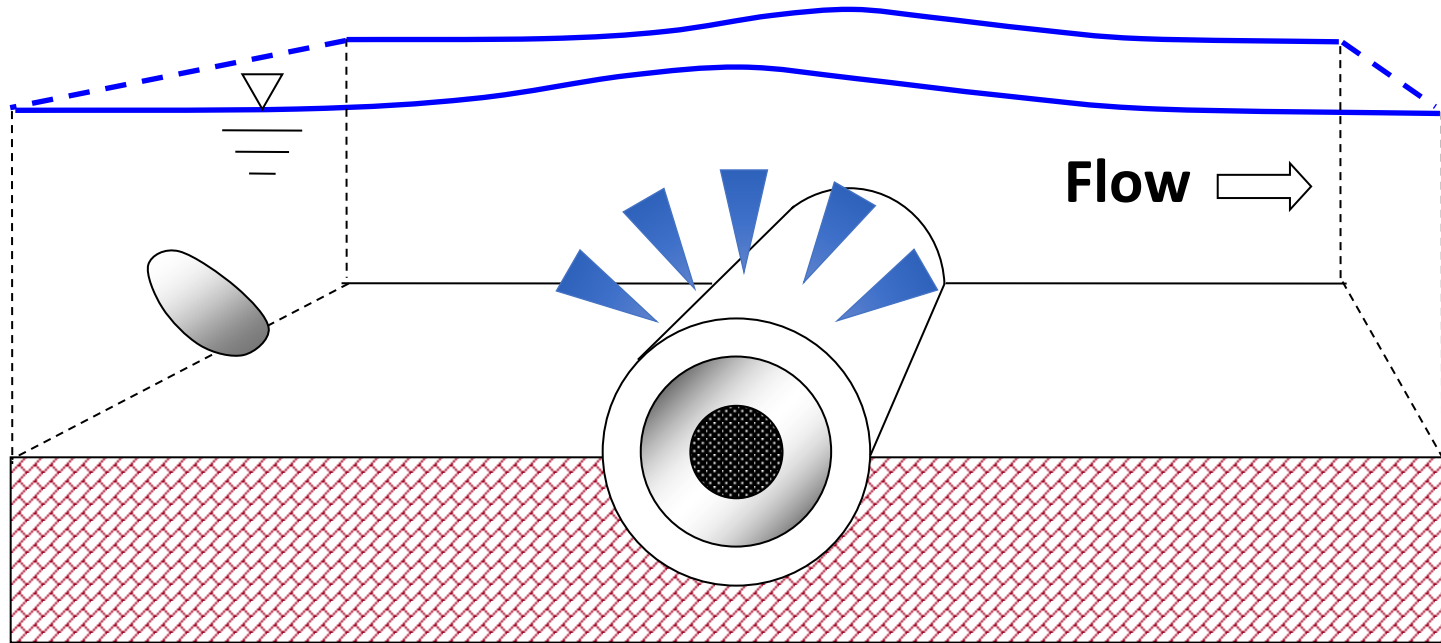
Tipping bucket bed-load sampler (1970's)

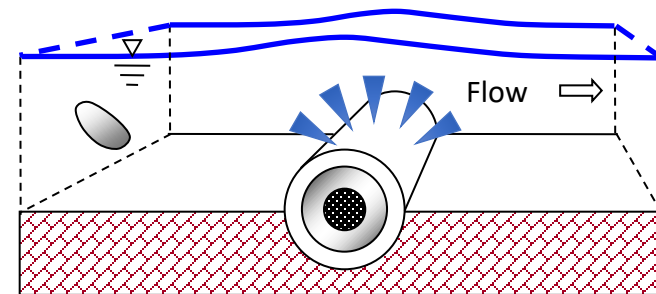
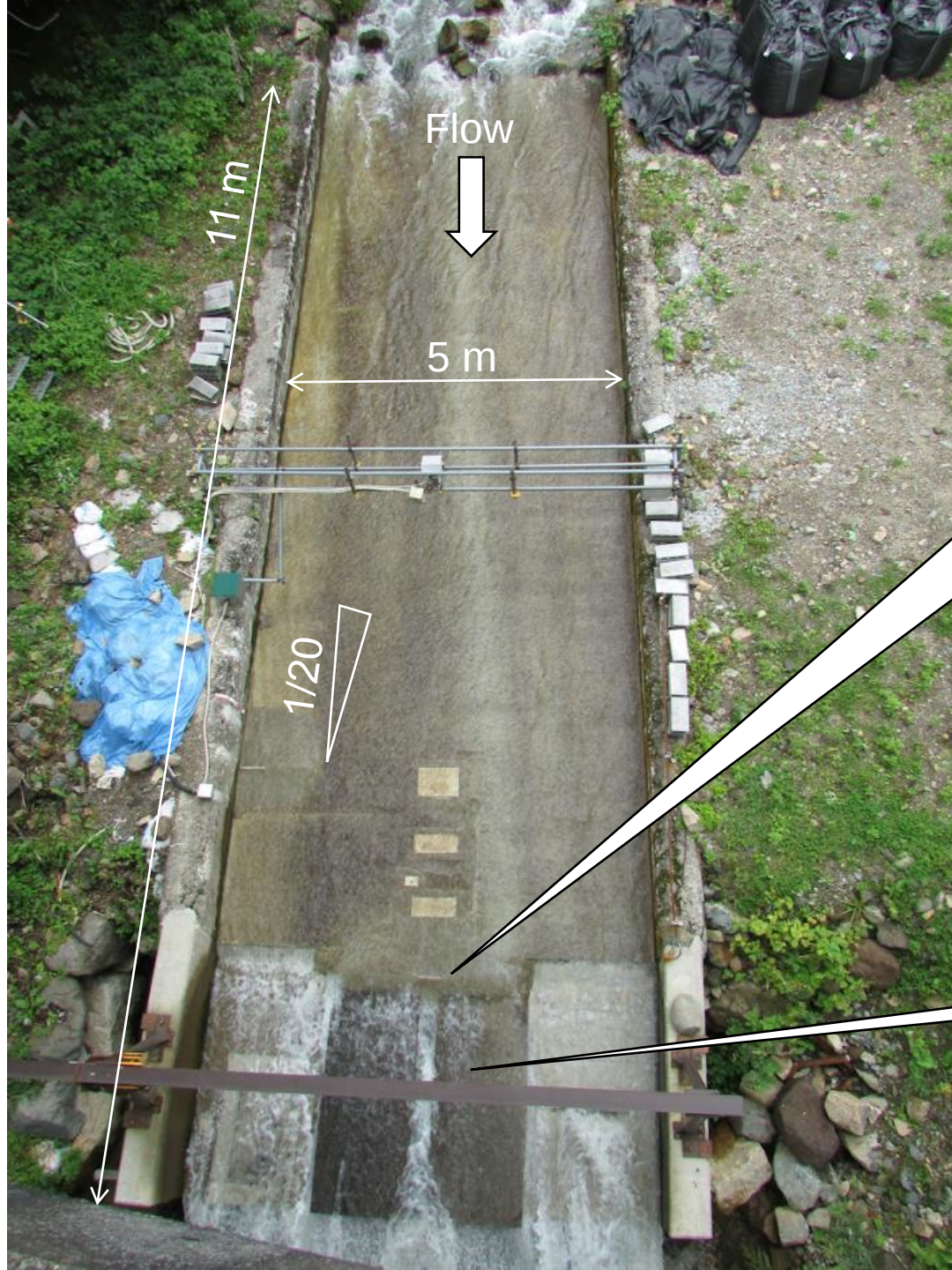


Rotating buckets bed-load sampler (1980's)

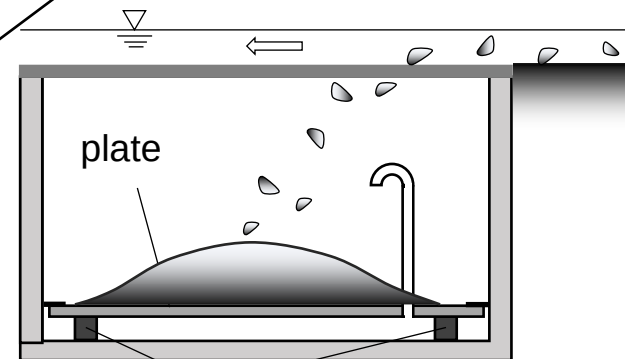


Japanese pipe microphone (1980's)





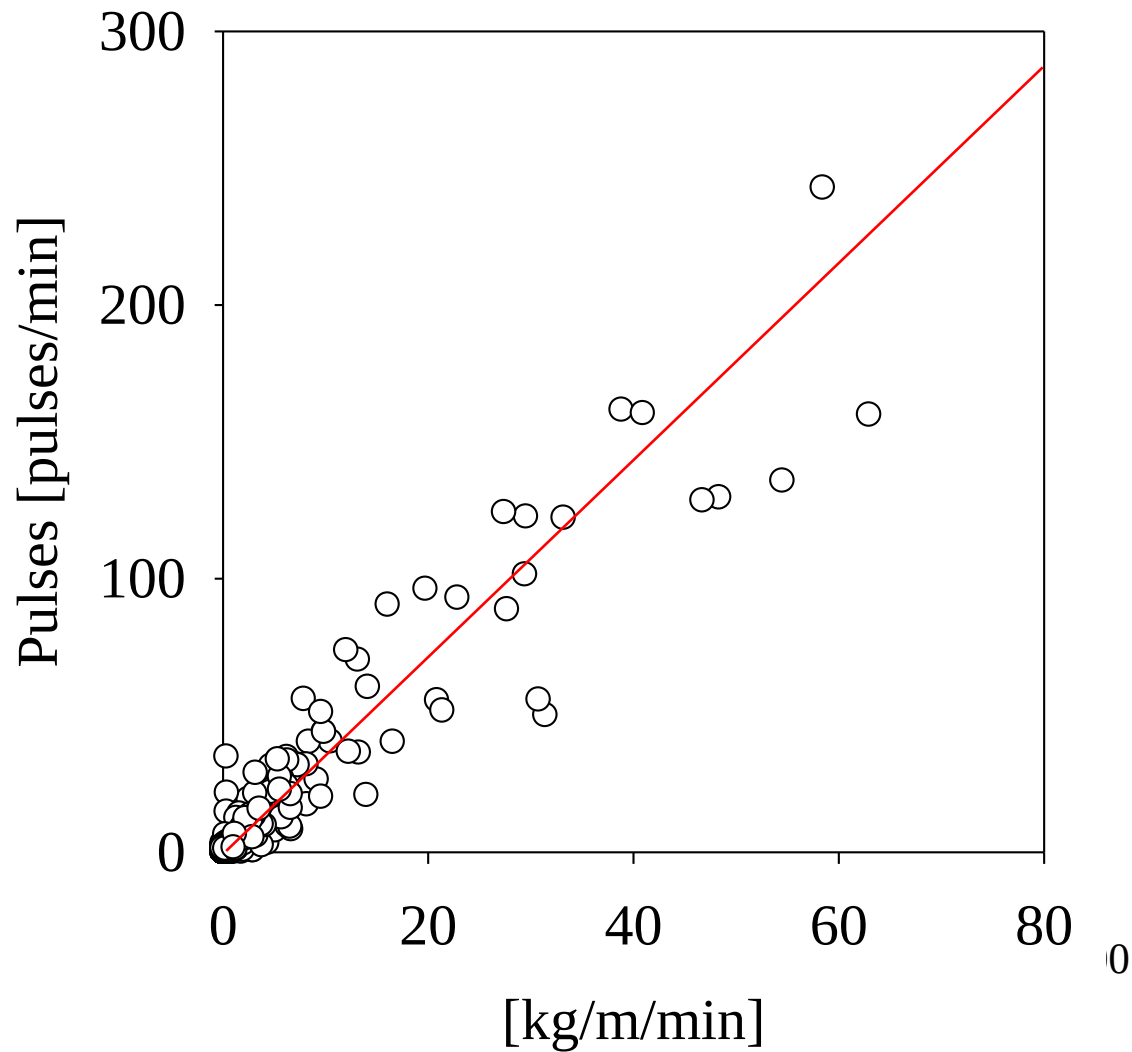
Pipe microphone



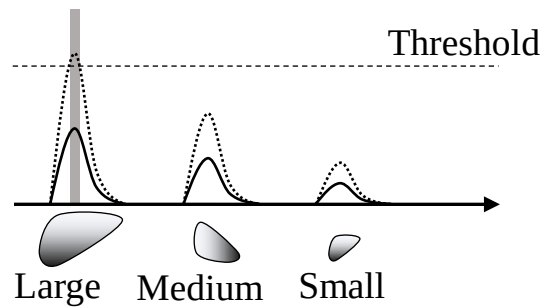
Load cells

Slot sampler

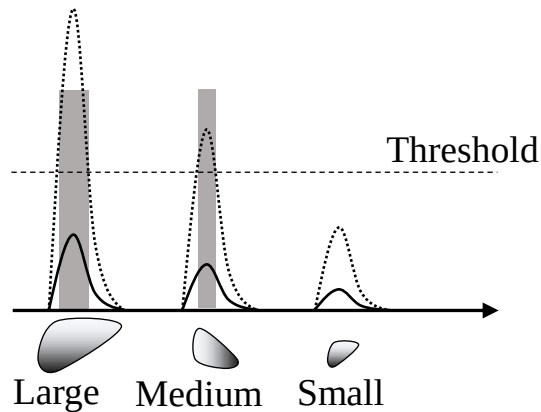
一般的なキャリブレーション



Amplification : $\times 2$



Amplification : $\times 4$



土砂粒径と増幅率の間の
相関を用いる方法



現地実験

Amplification A_k [-]	Diameter range d_k , [mm]	Representative mass, m_k [g]
1024	3.0 - 5.0	0.15
512	—	0.22
256	5.0 - 7.0	0.29
128	—	0.65
64	7.0 - 10.0	0.91
32	—	1.96
16	10.0 - 15.0	3.01
8	—	6.91
4	15.0 - 30.0	10.81
2	30.0 - 40.0	50.39

$$M_0 = \frac{C}{\alpha_{n,us} L} \sum_{k=1}^{n,us} \beta_k \frac{\Delta P_k \times m_k}{\gamma_k}$$

Pulse

Mass

Amplification

M_0 : Bedload mass per unit width
[kg/min]

k : Amplification factor

P_k : Pulse count for k [pulses/min]

ΔP_k : $\Delta P_k = P_k - P_{k-1}$

m_k : representative mass for k [kg]

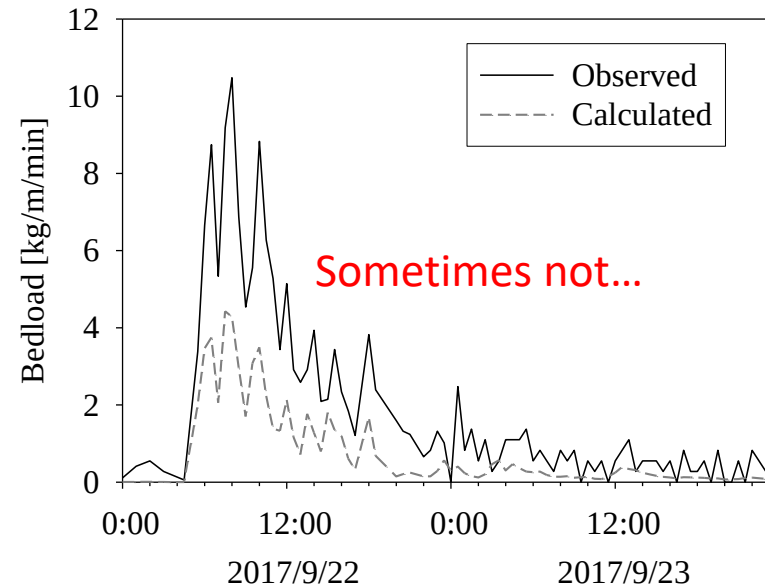
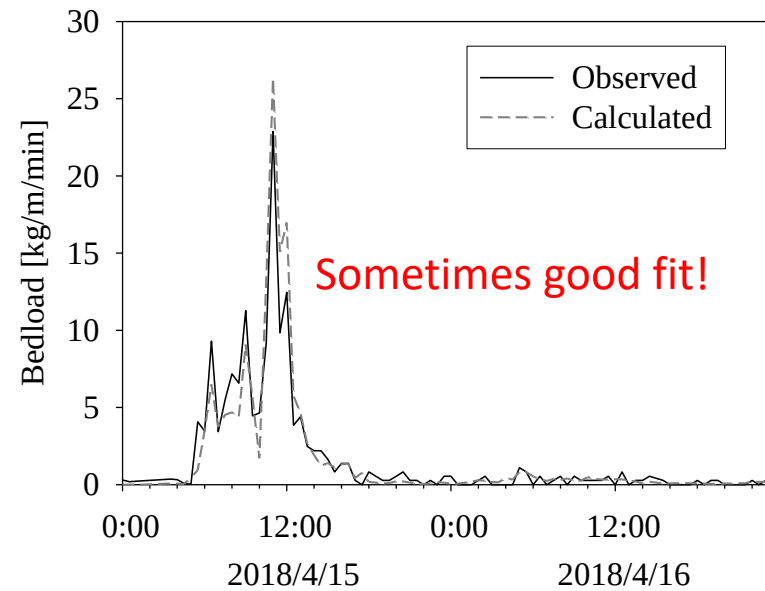
L : Pipe length [m]

C : Correction coefficient for total
bedload mass

$\alpha_{n,us}$: Ratio of bed load mass above
detection limit

β_k : Correction coefficient for m_k

γ_k : Collision rate considering
saltation





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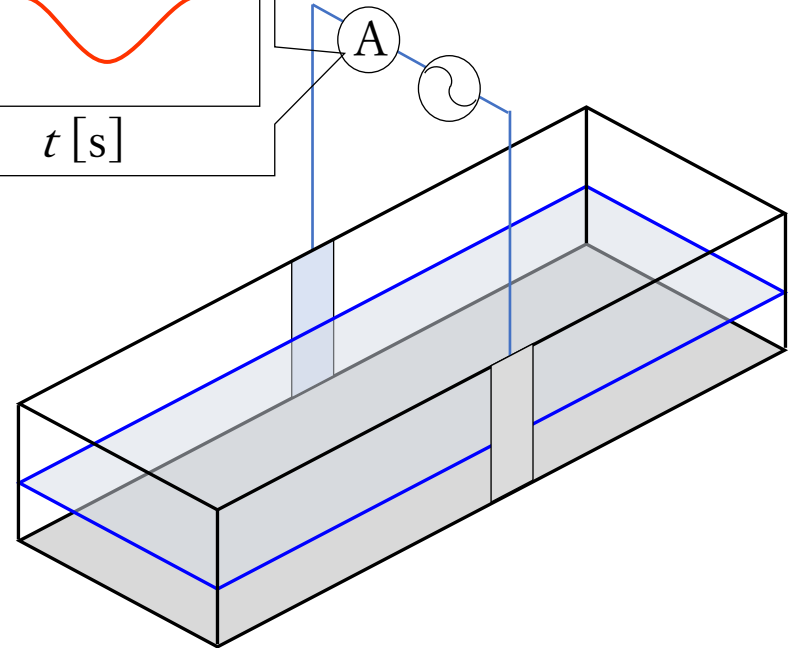
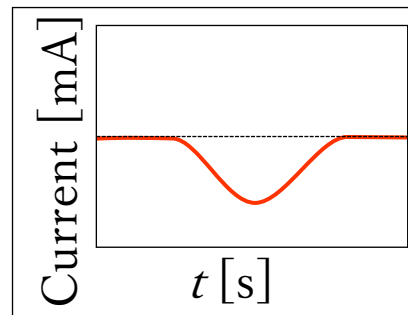
土砂で破壊されないために...

機器の強靱化

プレート化

パイプ
肉厚化

非接触法



計測原理

電氣伝導度 ← 電流値

$$\sigma = \left(\frac{I}{V} \right) \left(\frac{b_e}{A} \right)$$

$$l_e \times h$$

σ : 電氣伝導度[mS/m]

I : 電流[mA]

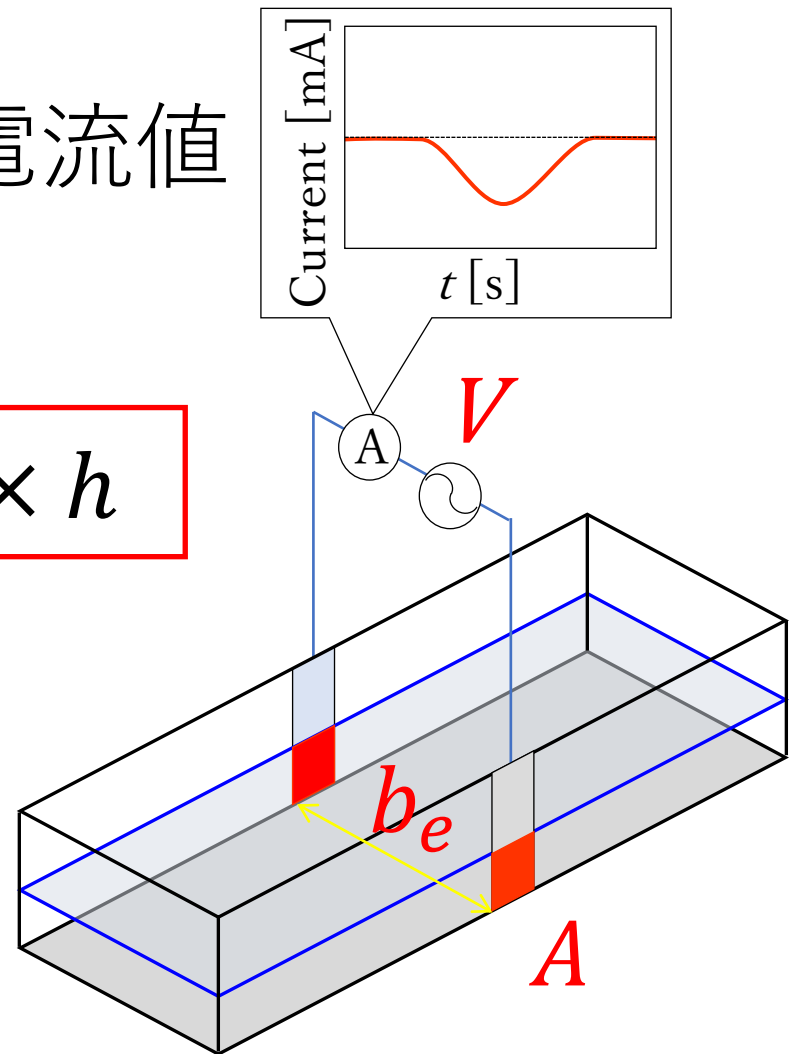
V : 電圧[V]

b_e : 電極間距離[m]

A : 電極面積[m²]

l_e : 電極幅[m]

h : 水深[m]

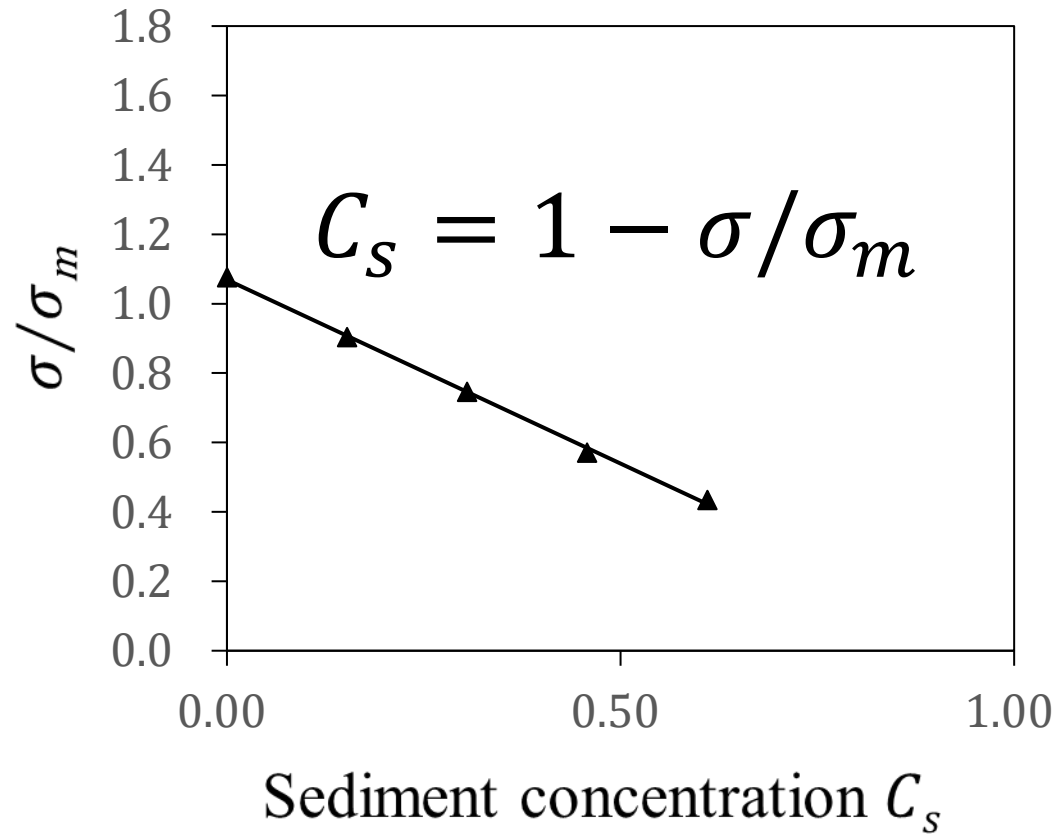


Water tank experiment



Tank L:19 cm, H: 19 cm, W: 19 cm
Electrode W: 19 cm, H: 10 cm

Result



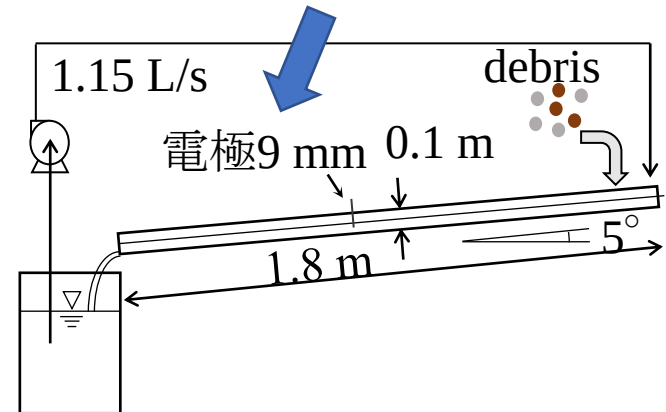
粒子移動計測実験 実験水路

投入土砂量: 150, 300, 450 cm³



全体図

負荷電圧: 5.0 V

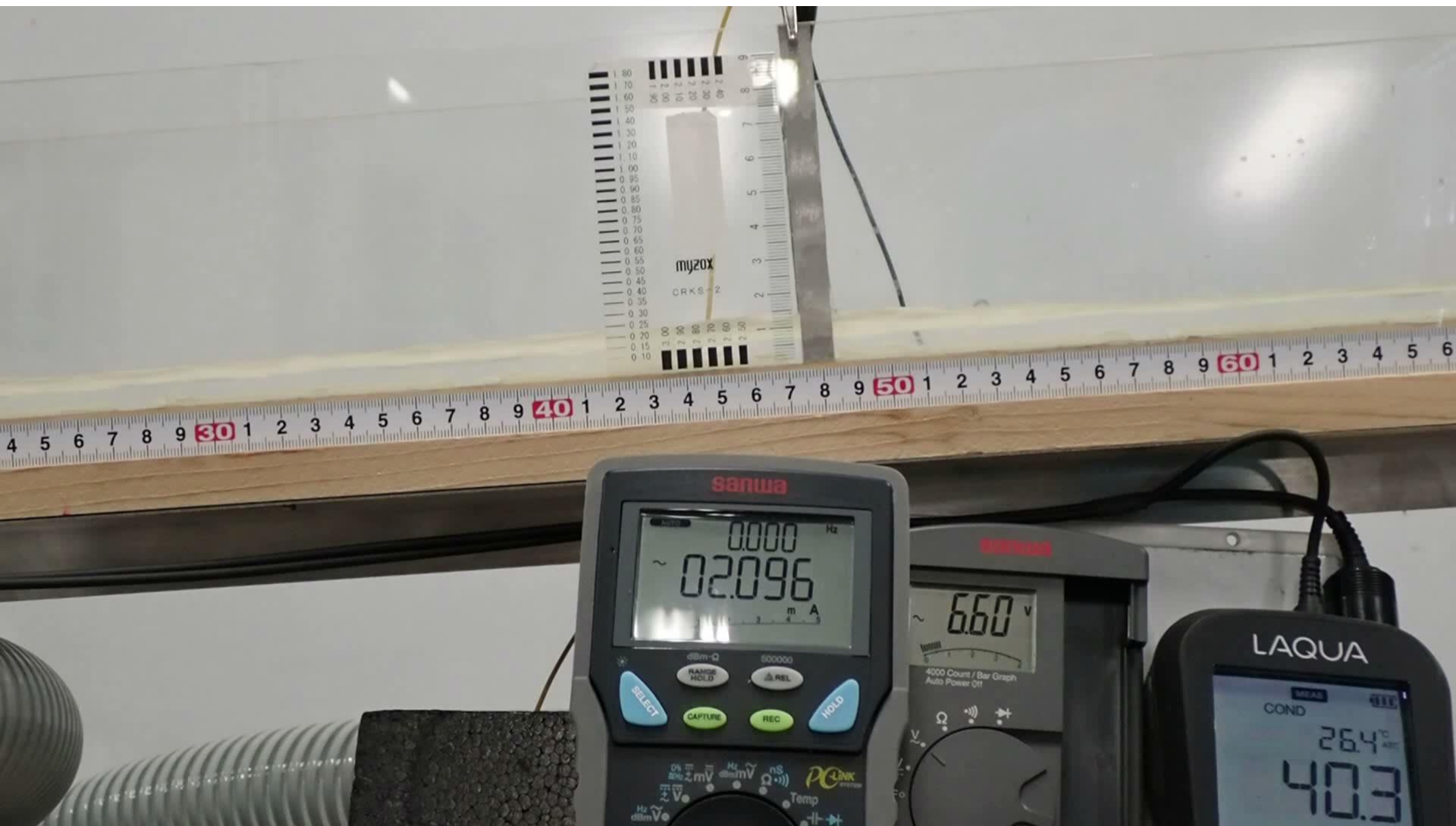


粒子移動計測の
実験装置概略側面図

Run01

供給量 : $V = 450 \text{ cm}^3$

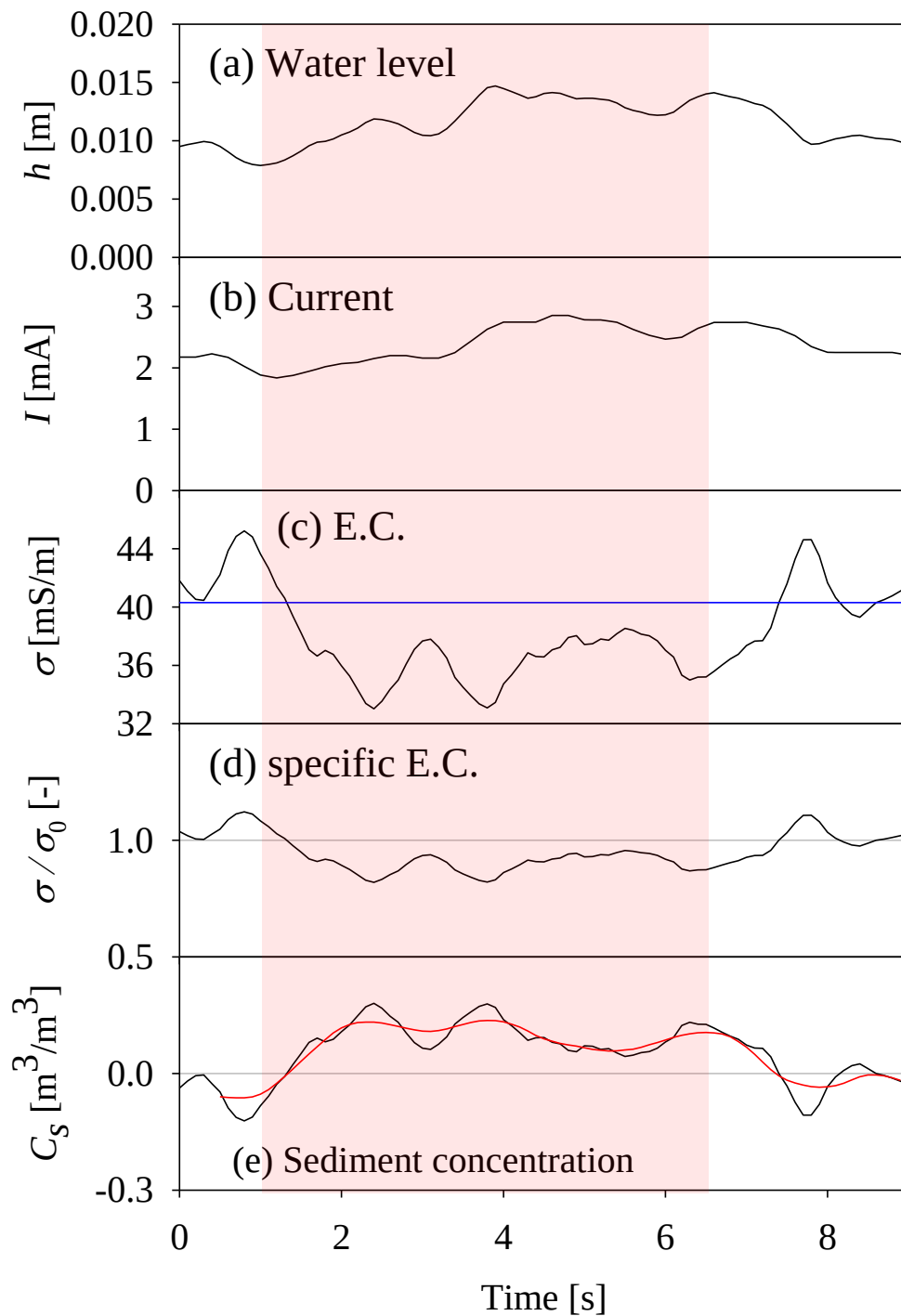
供給時間 : $\Delta t = 3 \text{ s}$



Run01

$$V = 450 \text{ cm}^3$$

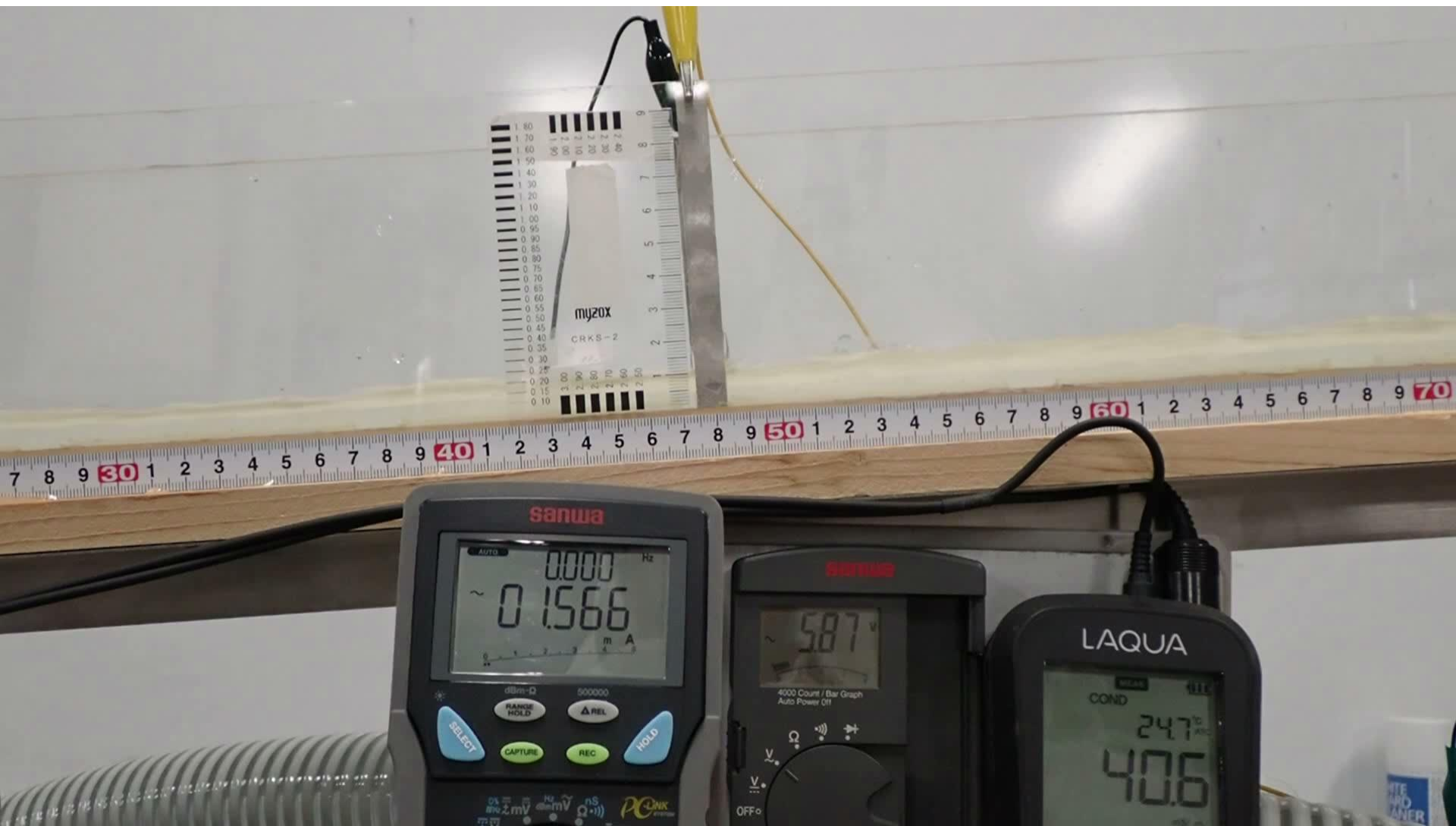
$$\Delta t = 3 \text{ s}$$



Run02

供給量 : $V = 450 \text{ cm}^3$

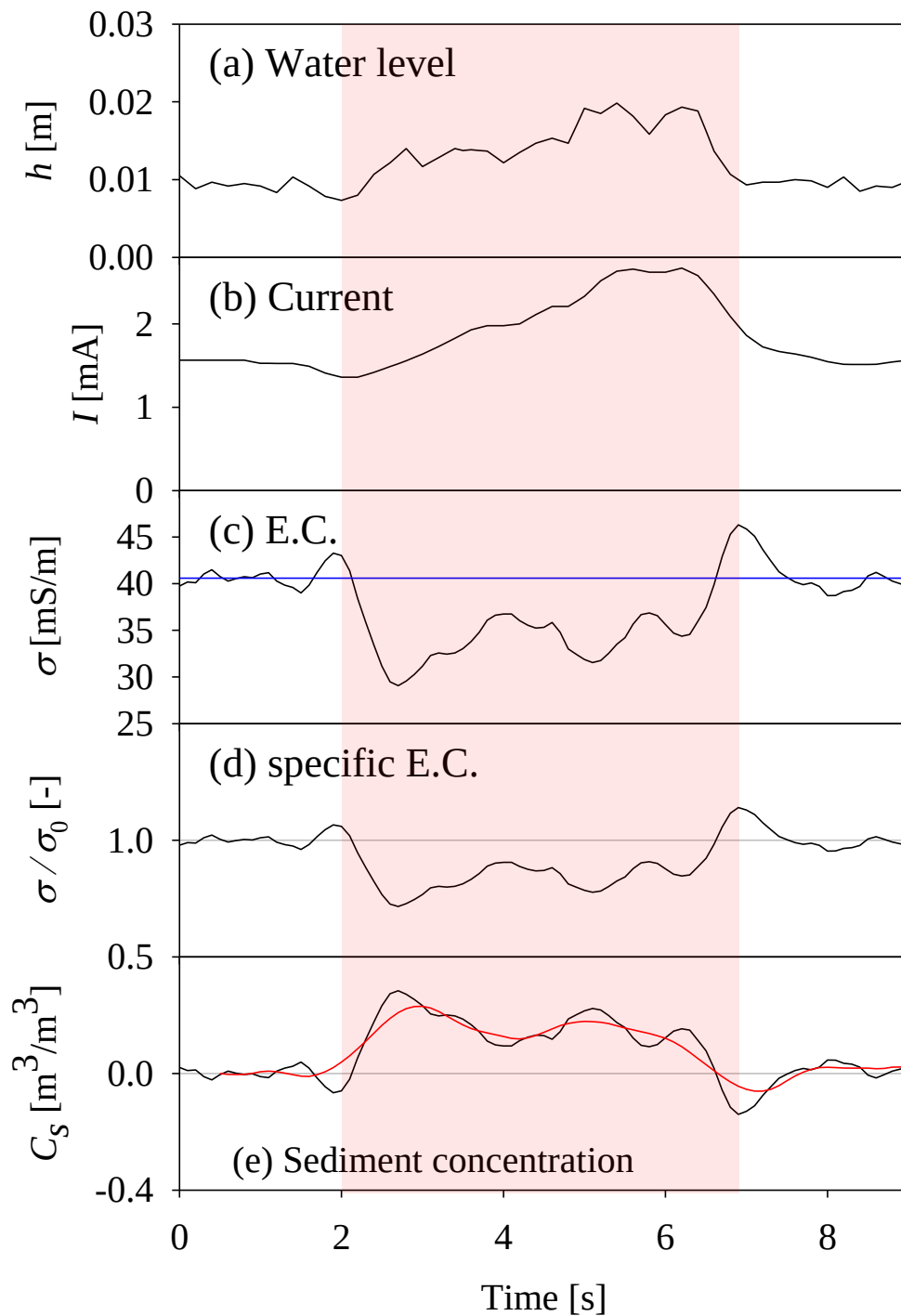
供給時間 : $\Delta t = 3 \text{ s}$



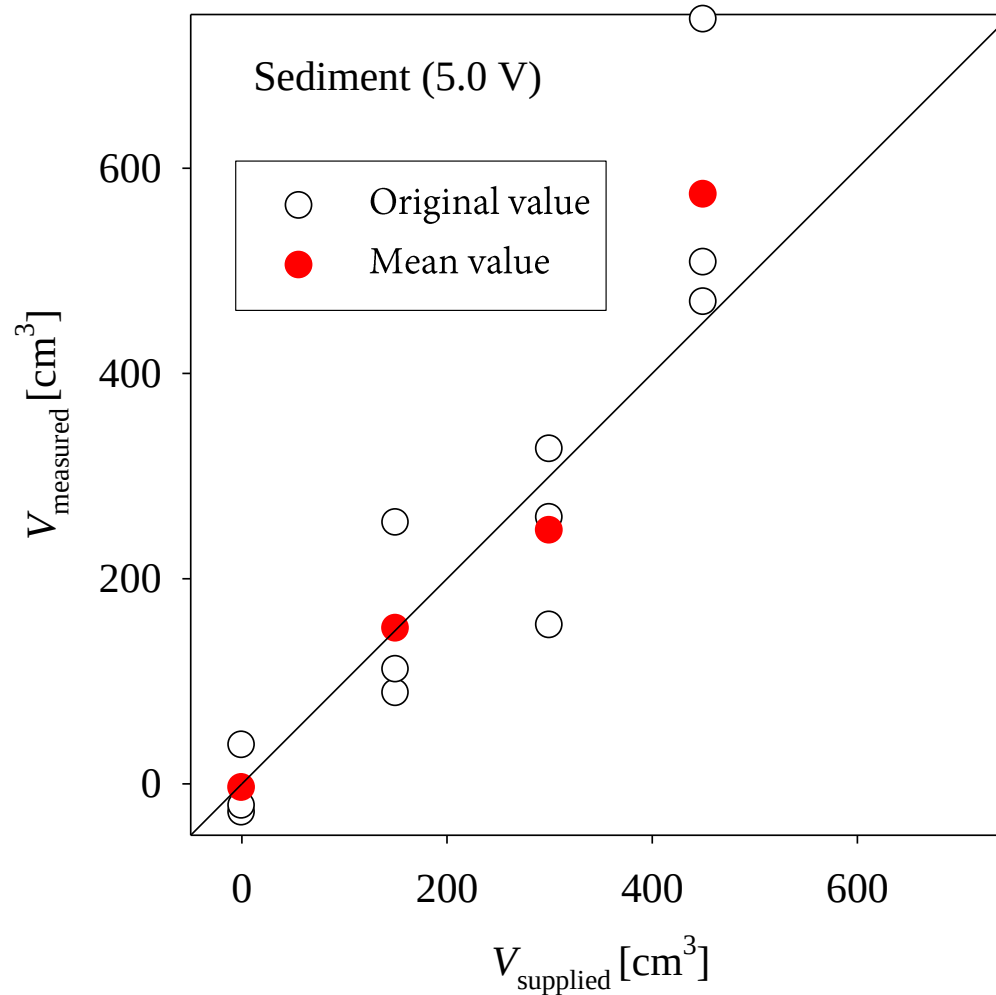
Run02

$$V = 450 \text{ cm}^3$$

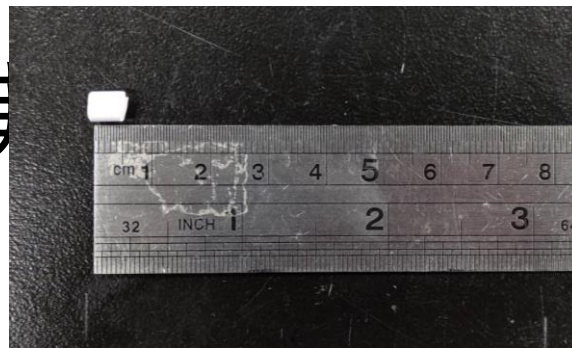
$$\Delta t = 3 \text{ s}$$



計測値の検証 (土砂)



粒子移動計測実験水路

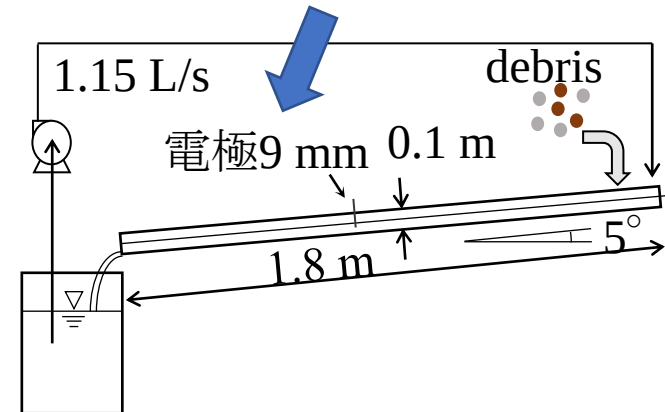


投入粒子量: 150, 300 cm³ (ABS樹脂 粒径約5 mm)



全体図

負荷電圧: 5.0 V



粒子移動計測の実験装置概略側面図

供給量： $V = 150 \text{ cm}^3$

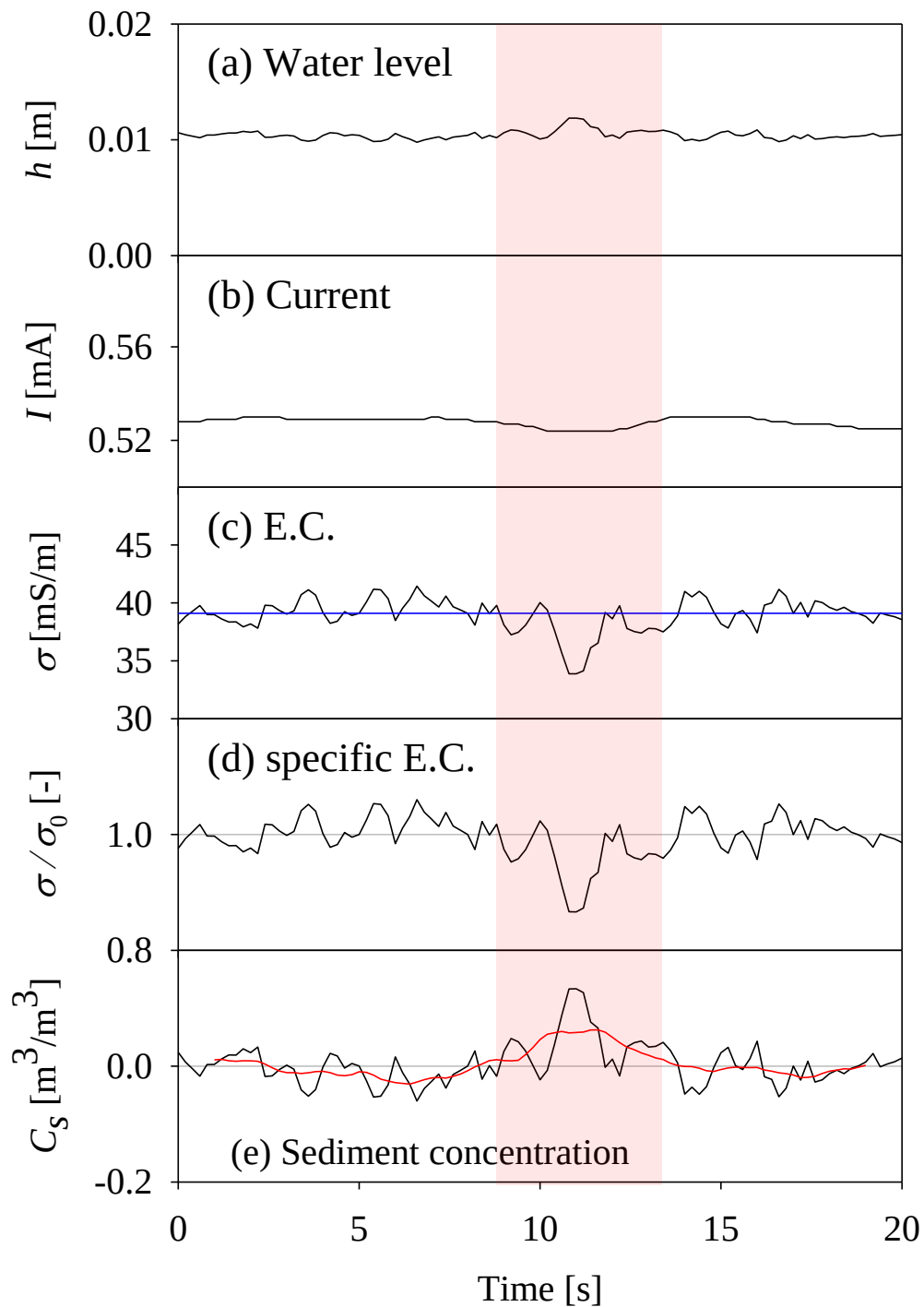
供給時間： $\Delta t = 3 \text{ s}$



Run01

$V = 150 \text{ cm}^3$

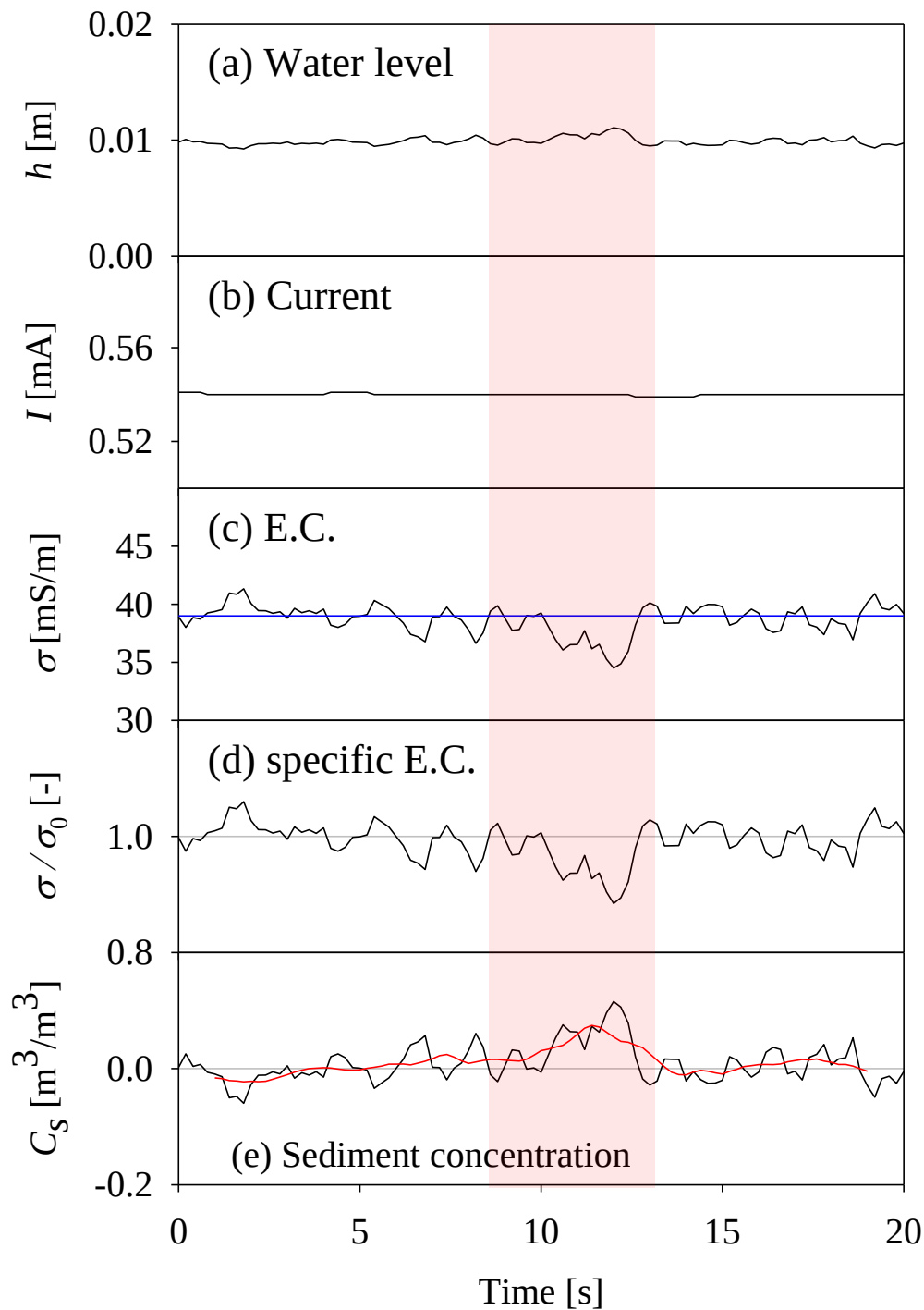
$\Delta t = 3 \text{ s}$



Run02

$V = 150 \text{ cm}^3$

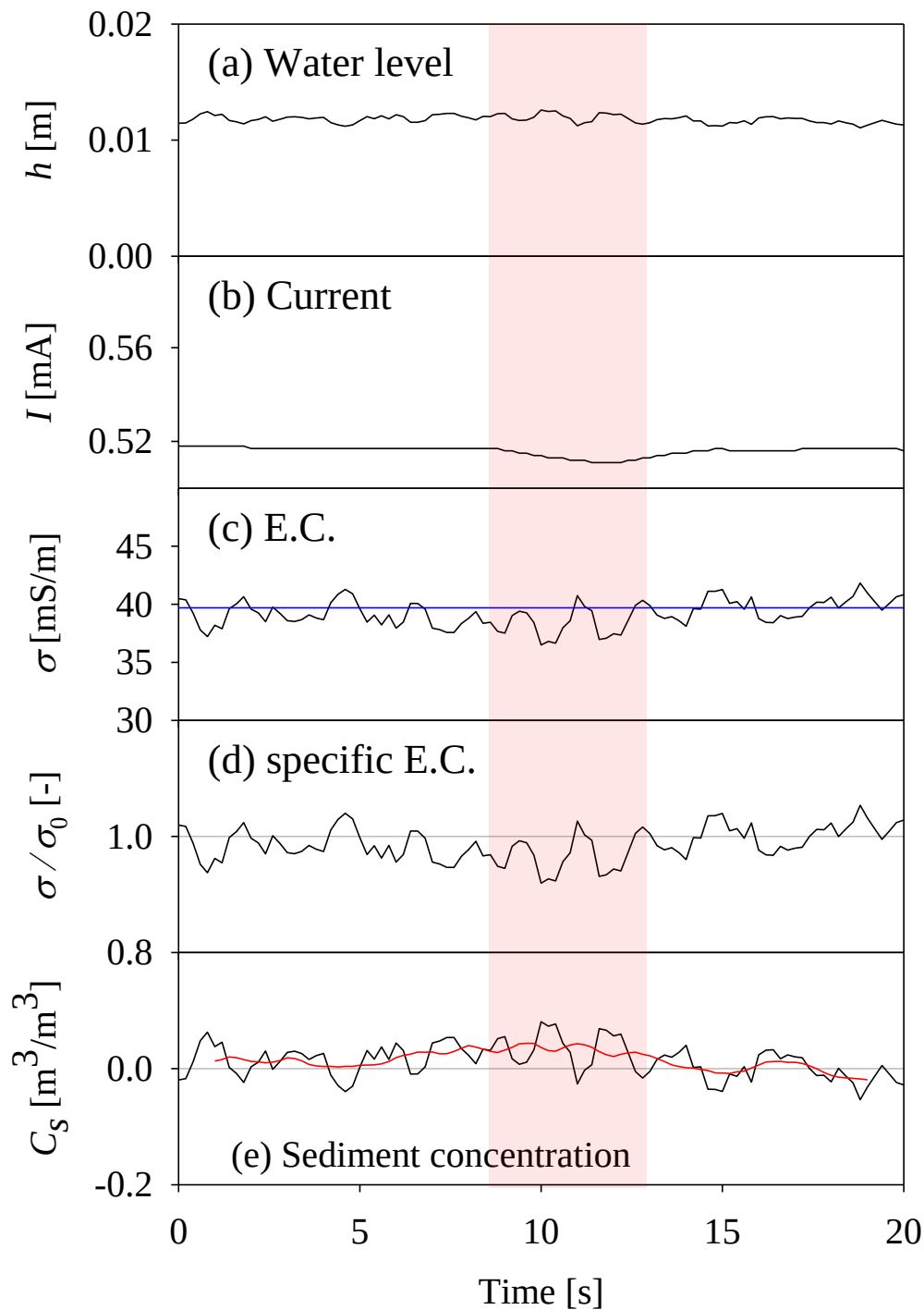
$\Delta t = 3 \text{ s}$



Run03

$$V = 150 \text{ cm}^3$$

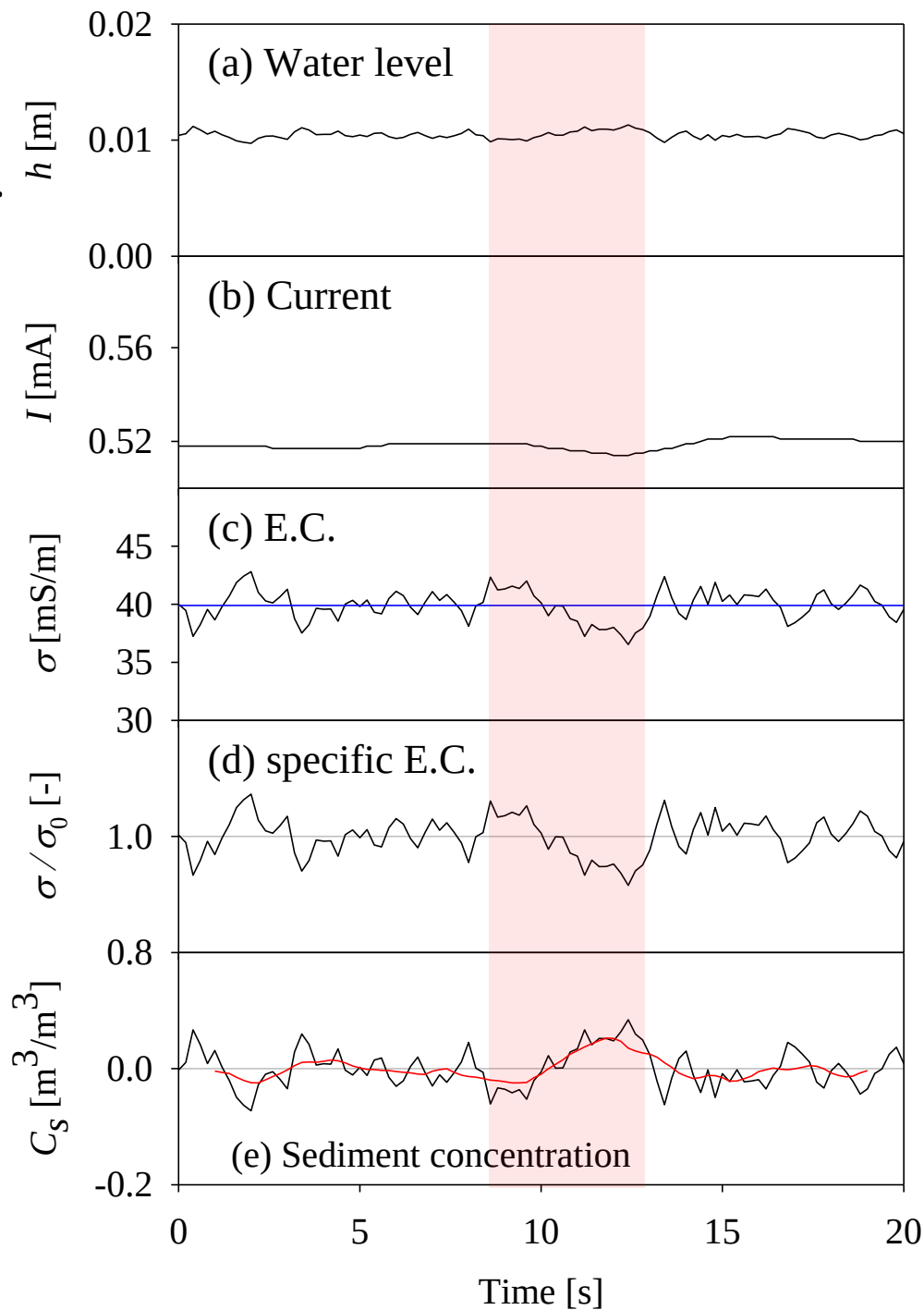
$$\Delta t = 3 \text{ s}$$



Run04

$V = 150 \text{ cm}^3$

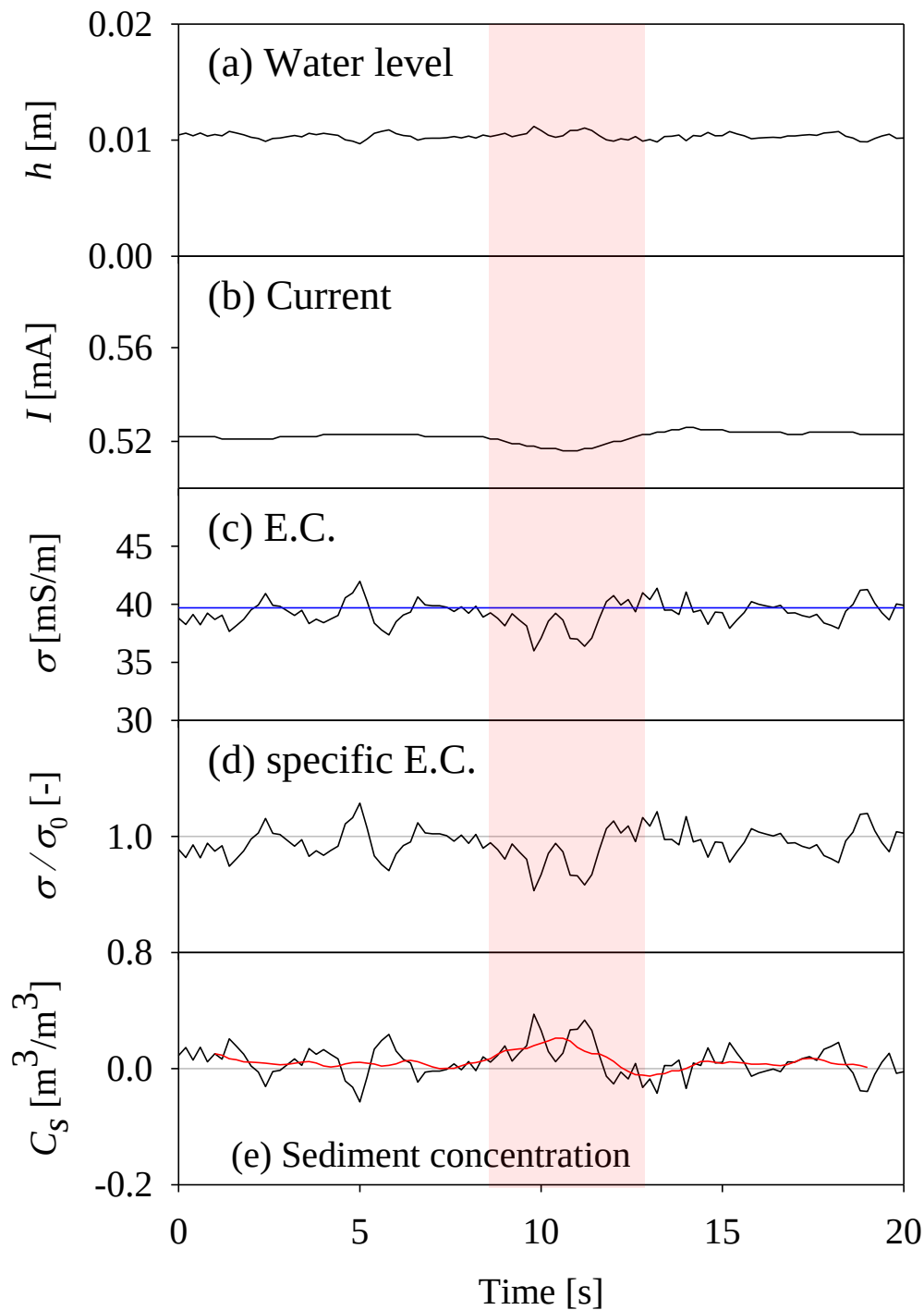
$\Delta t = 3 \text{ s}$



Run05

$V = 150 \text{ cm}^3$

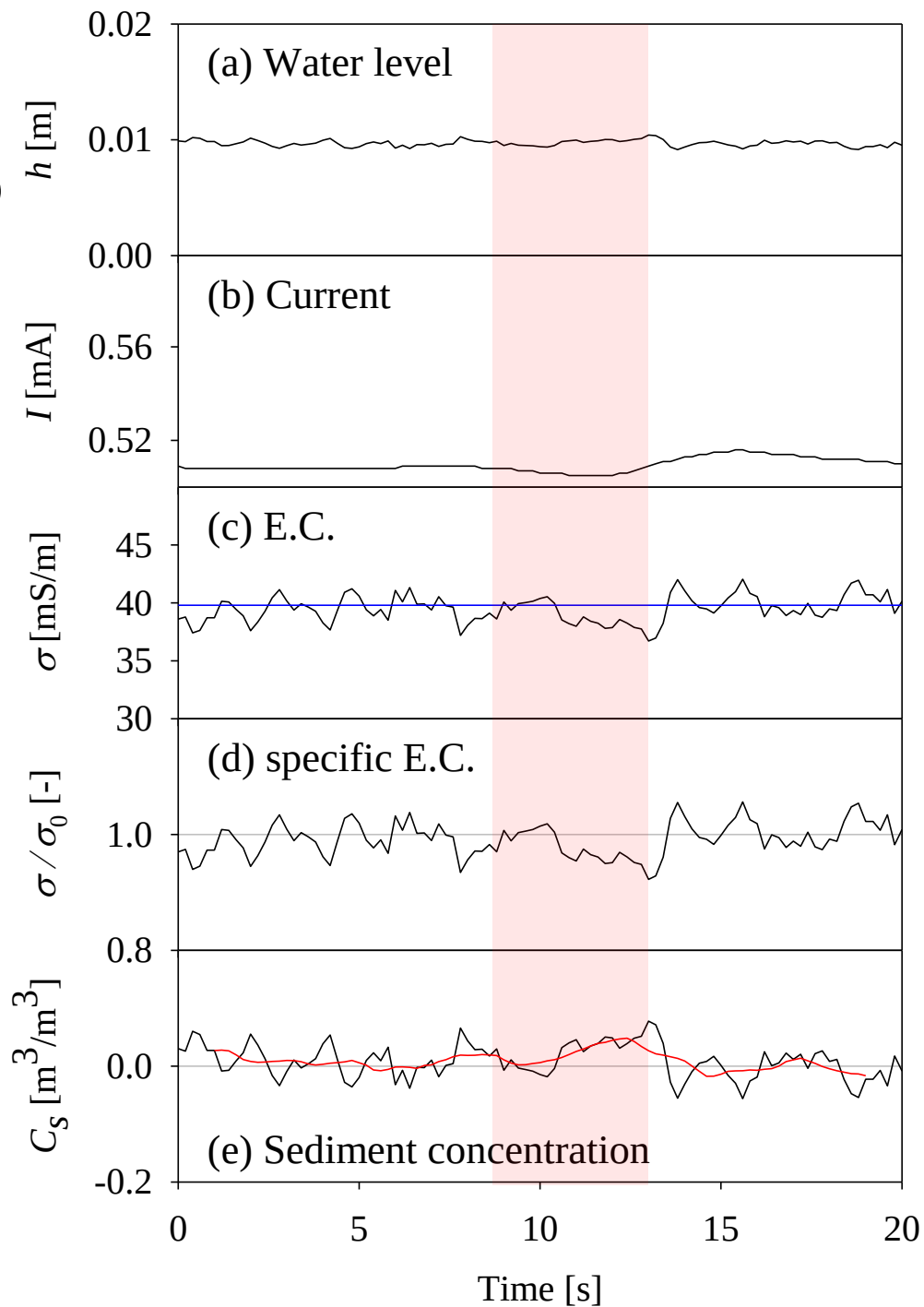
$\Delta t = 3 \text{ s}$



Run06

$V = 150 \text{ cm}^3$

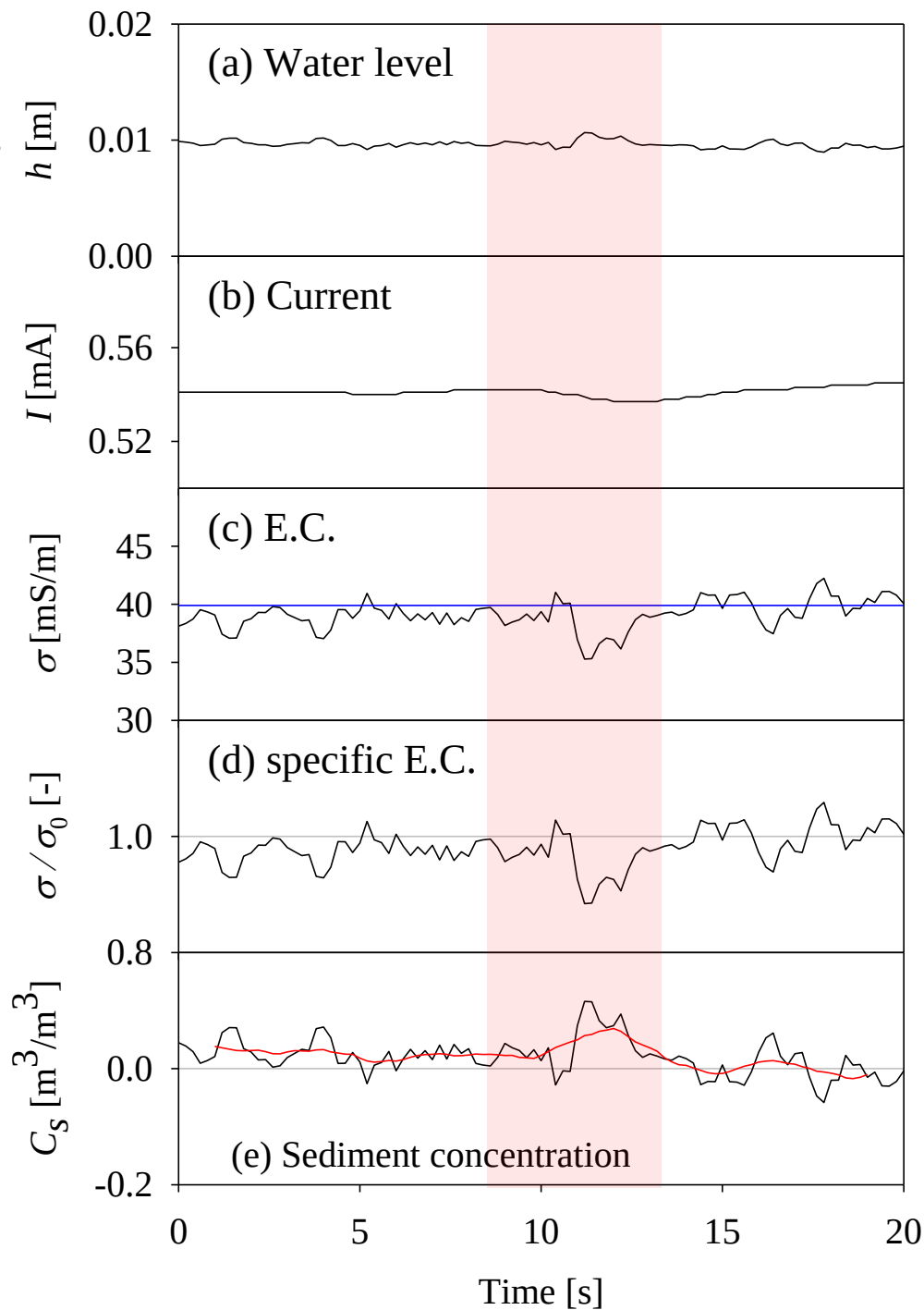
$\Delta t = 3 \text{ s}$



Run07

$V = 150 \text{ cm}^3$

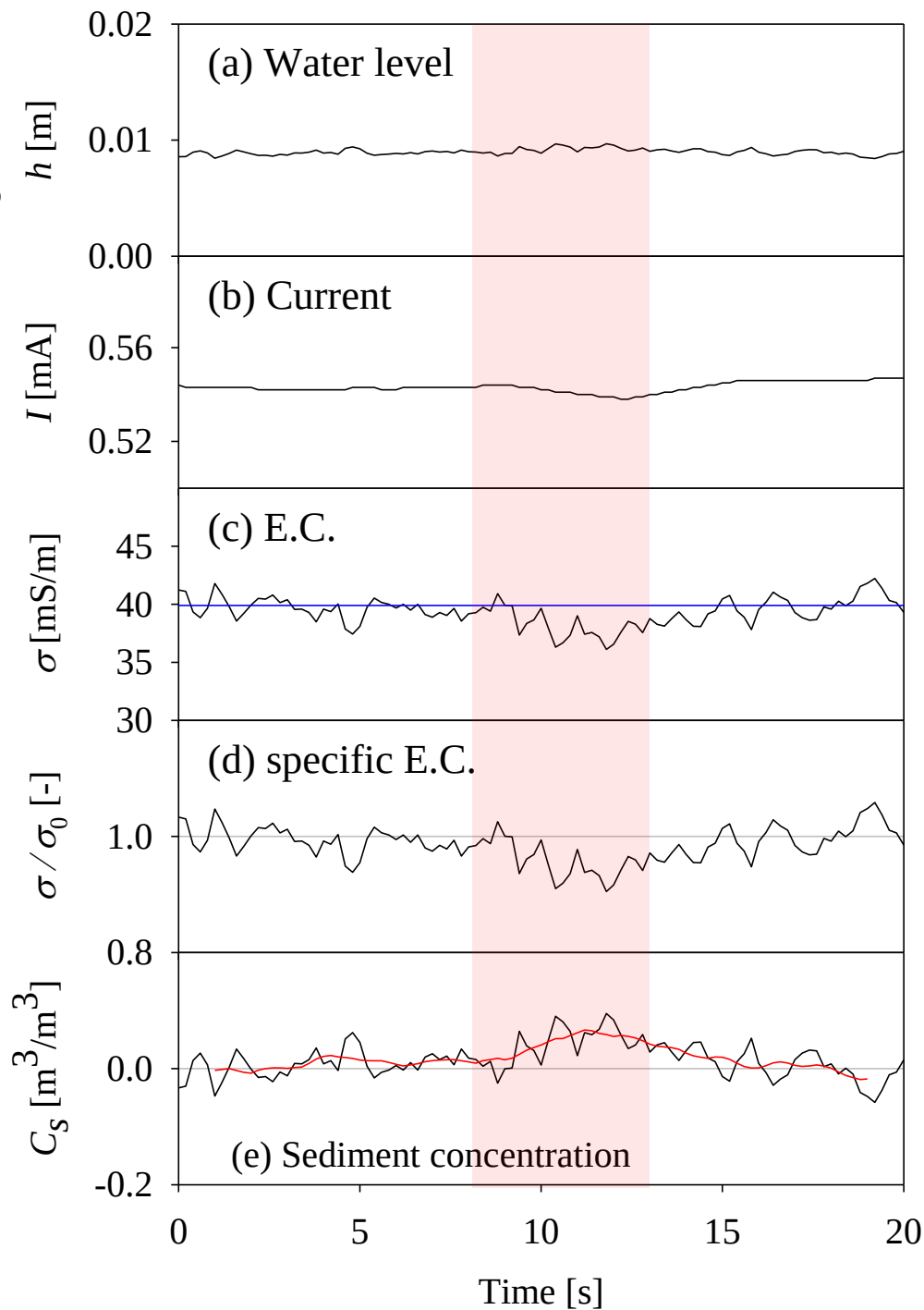
$\Delta t = 3 \text{ s}$



Run08

$V = 150 \text{ cm}^3$

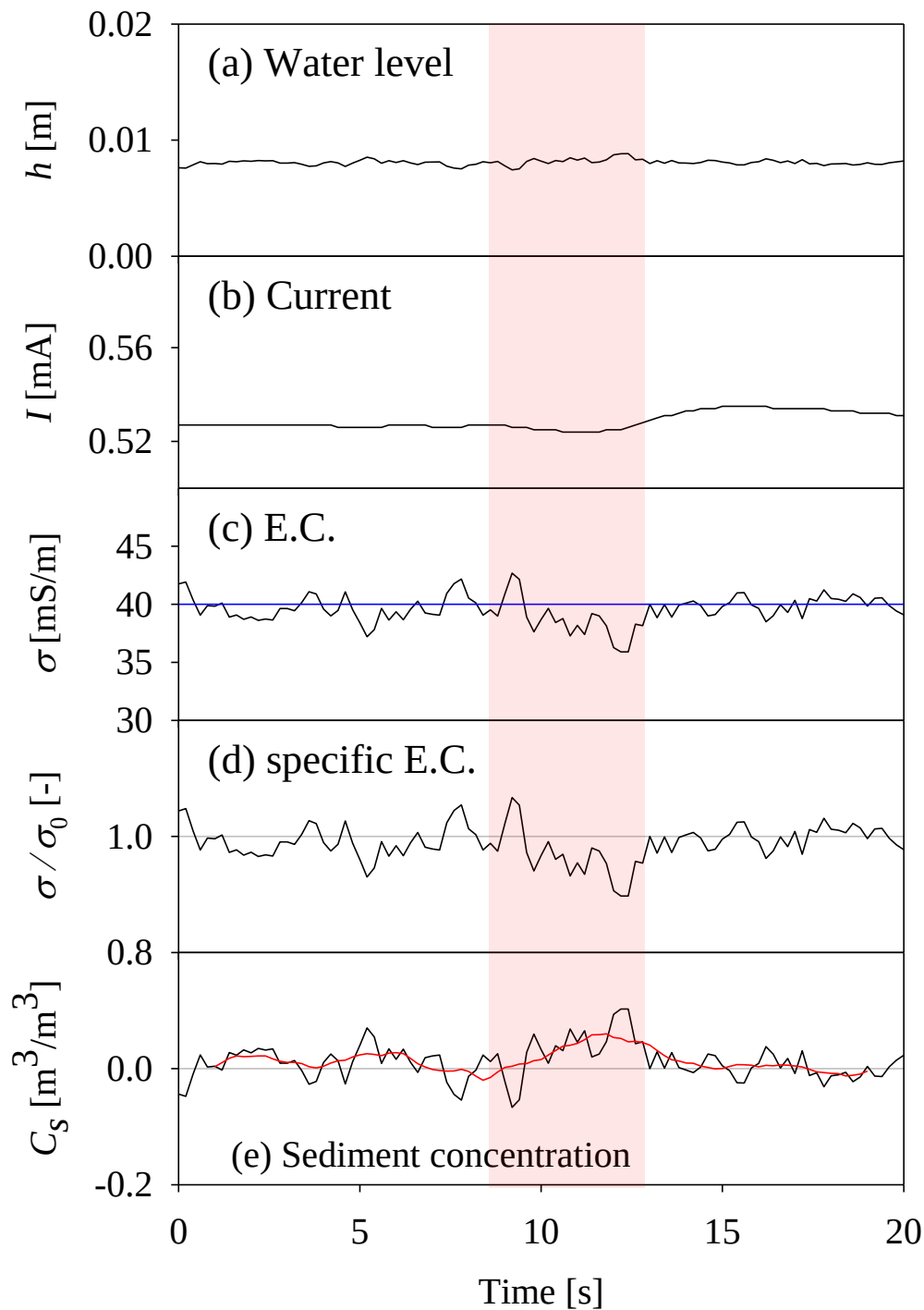
$\Delta t = 3 \text{ s}$



Run09

$$V = 150 \text{ cm}^3$$

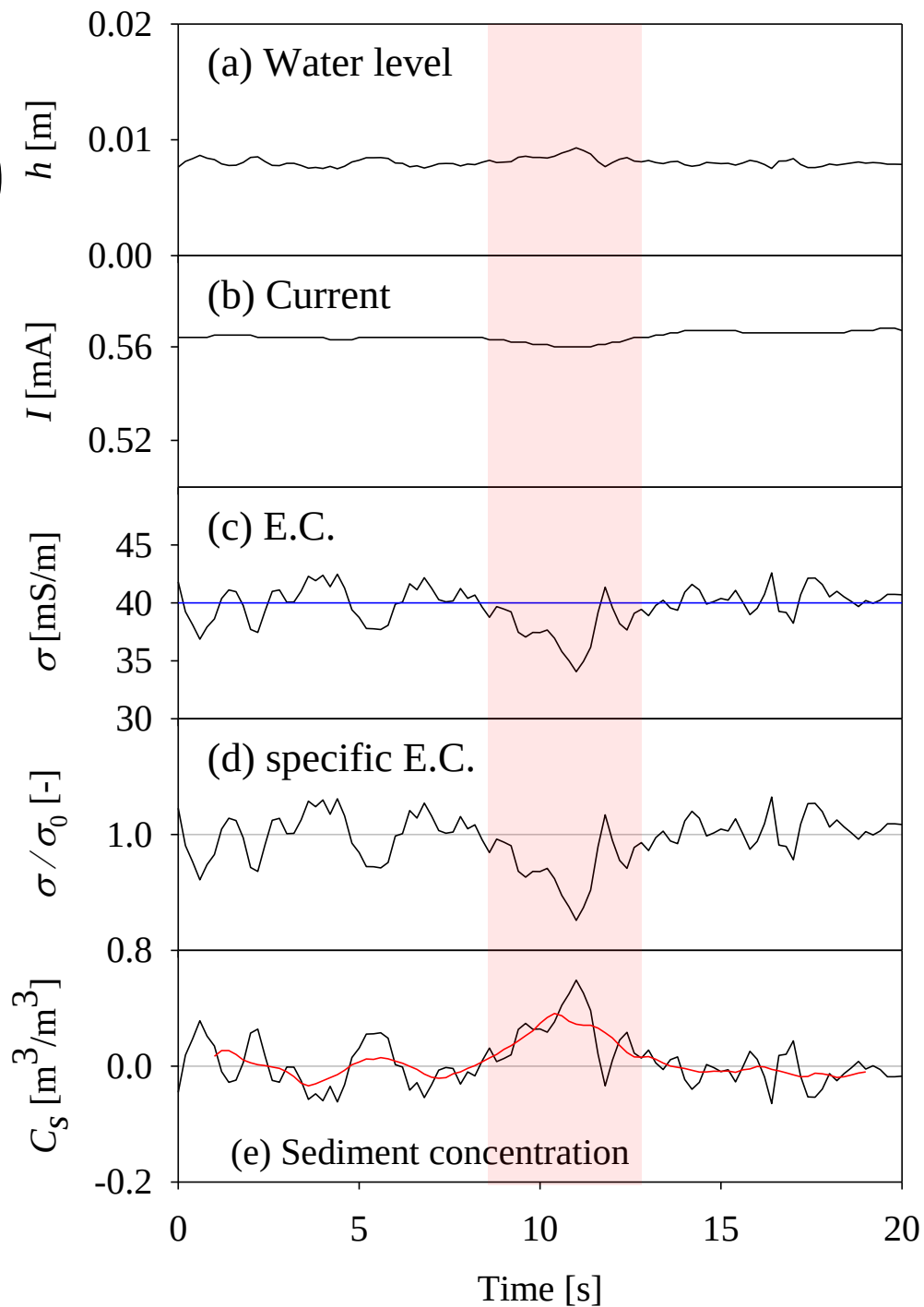
$$\Delta t = 3 \text{ s}$$



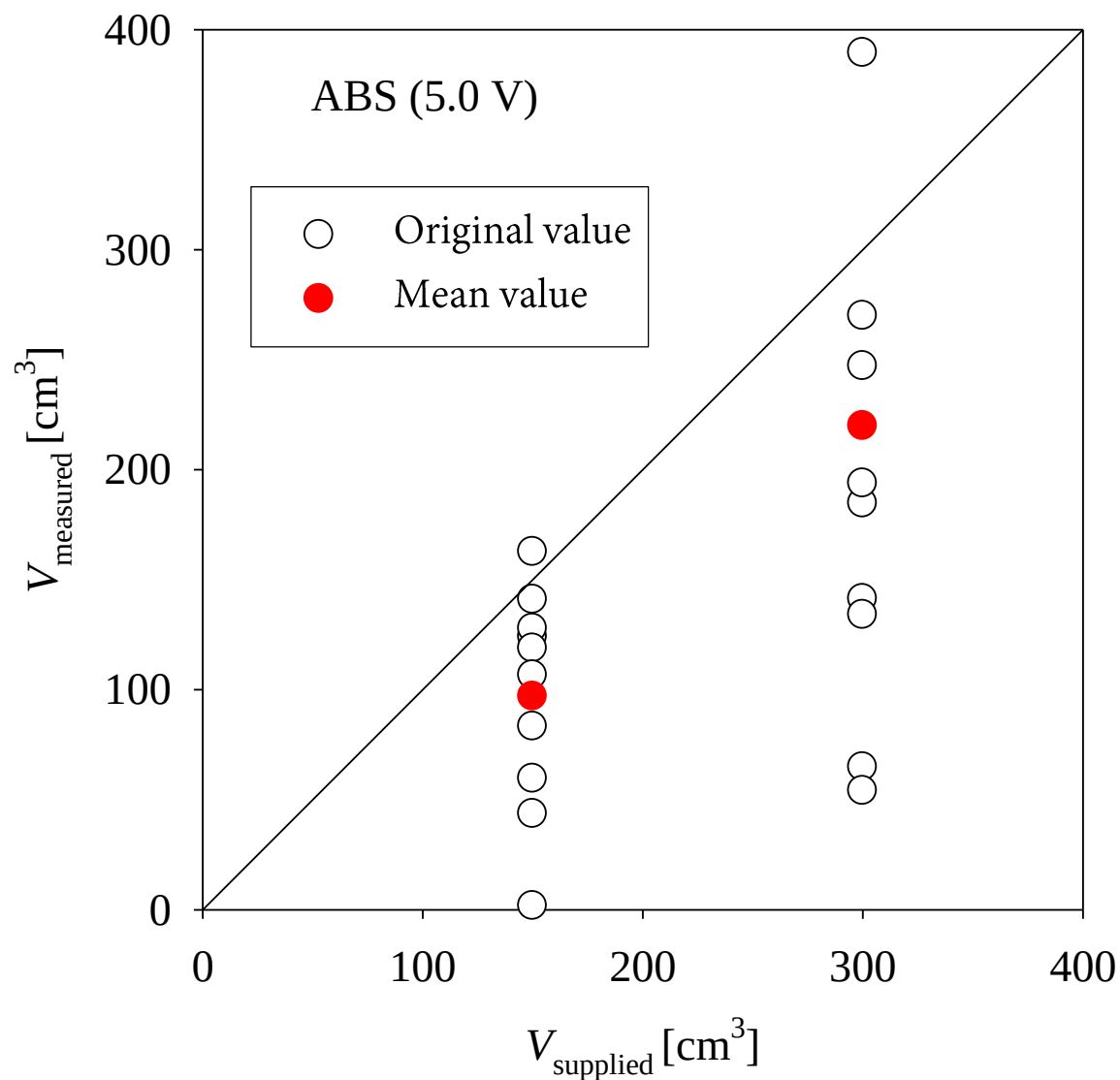
Run10

$$V = 150 \text{ cm}^3$$

$$\Delta t = 3 \text{ s}$$



計測値の検証 (ABS樹脂)



電極板



電極板



電気伝導度計

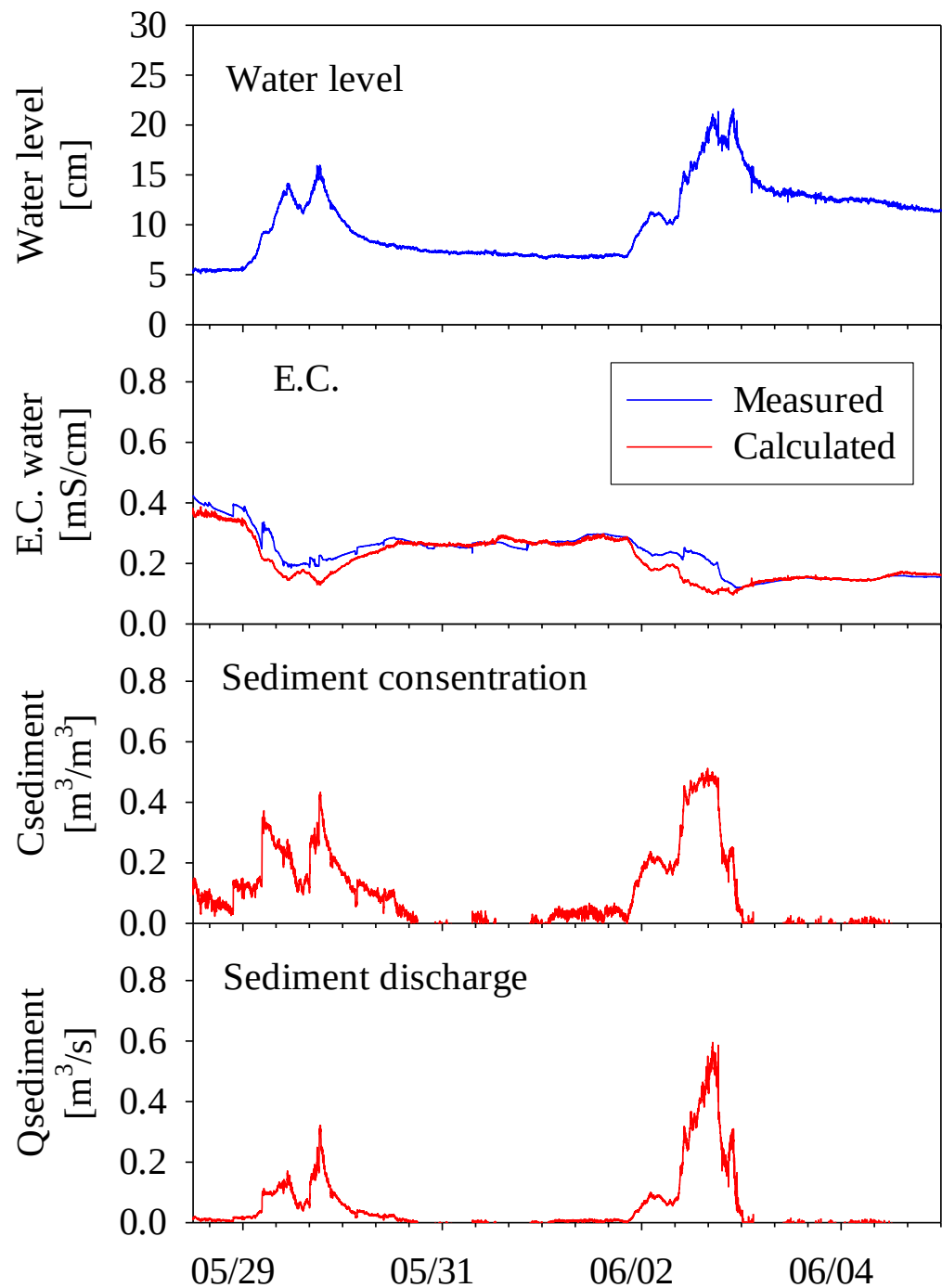
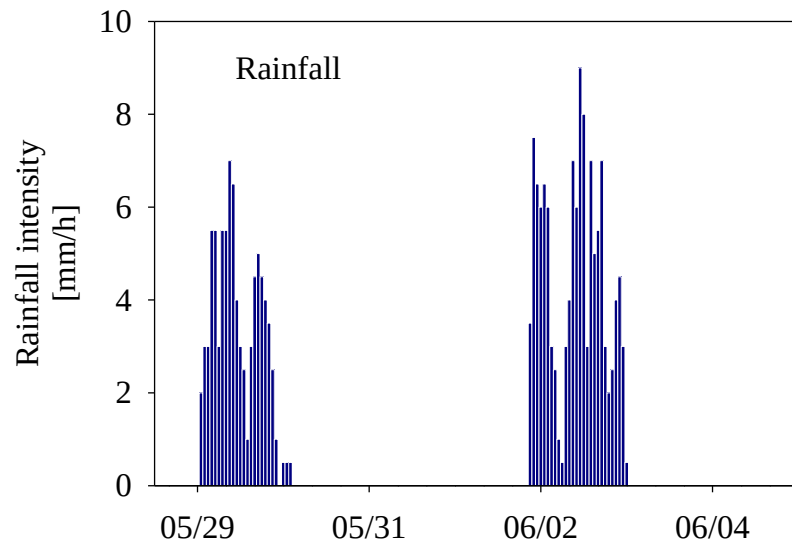


水位計



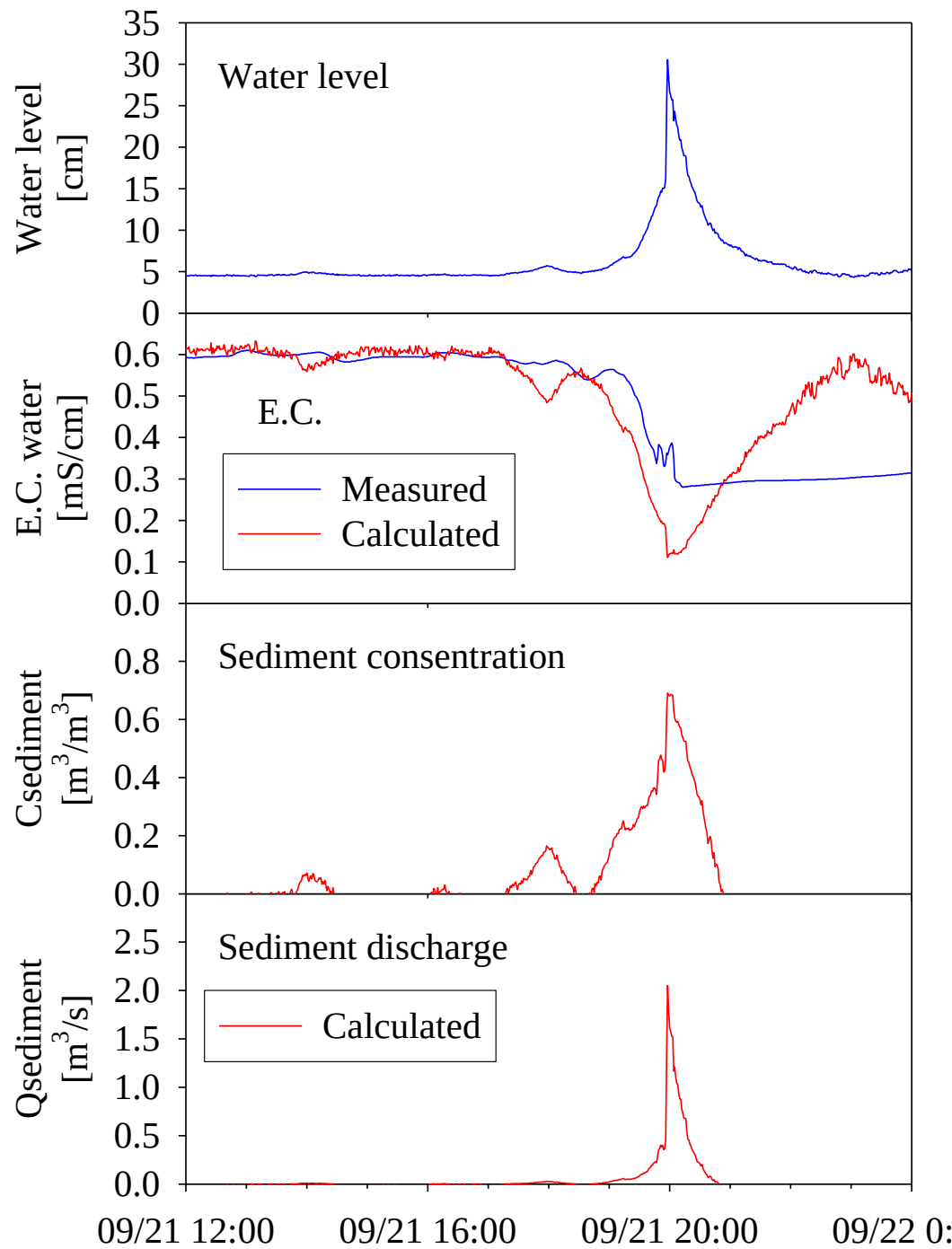
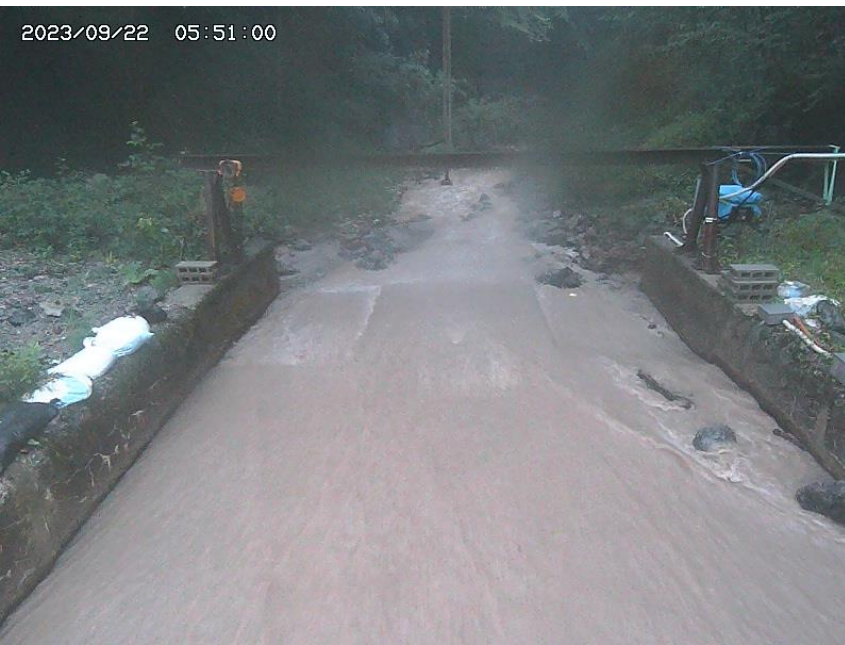
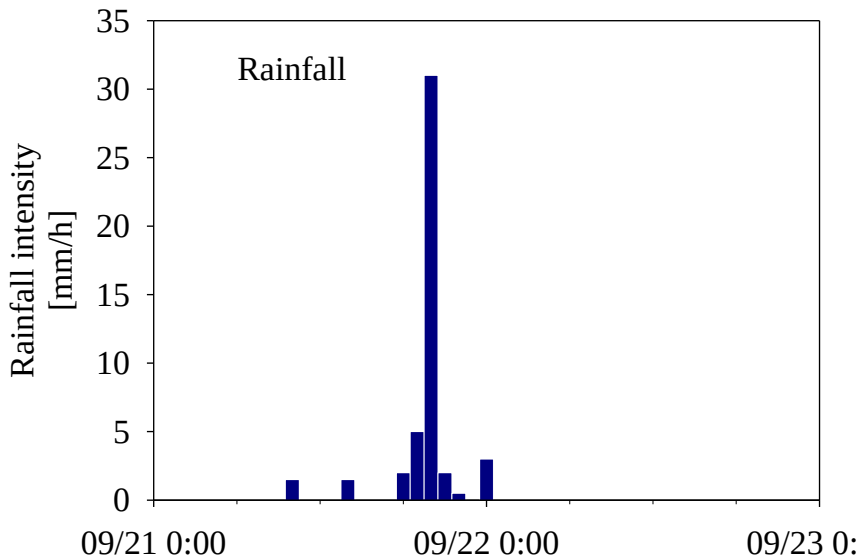
Hodaka

28 May – 5 June, 2023



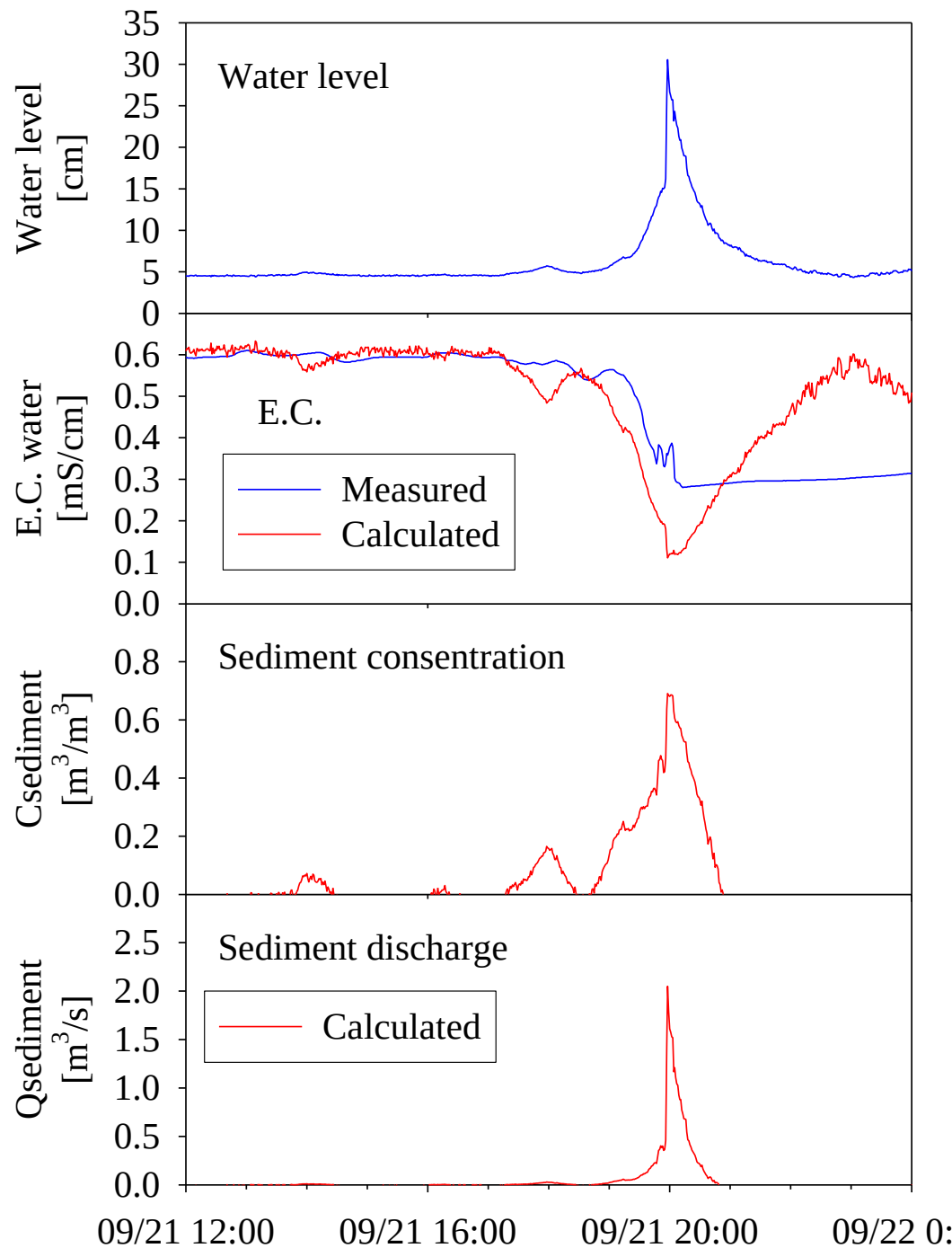
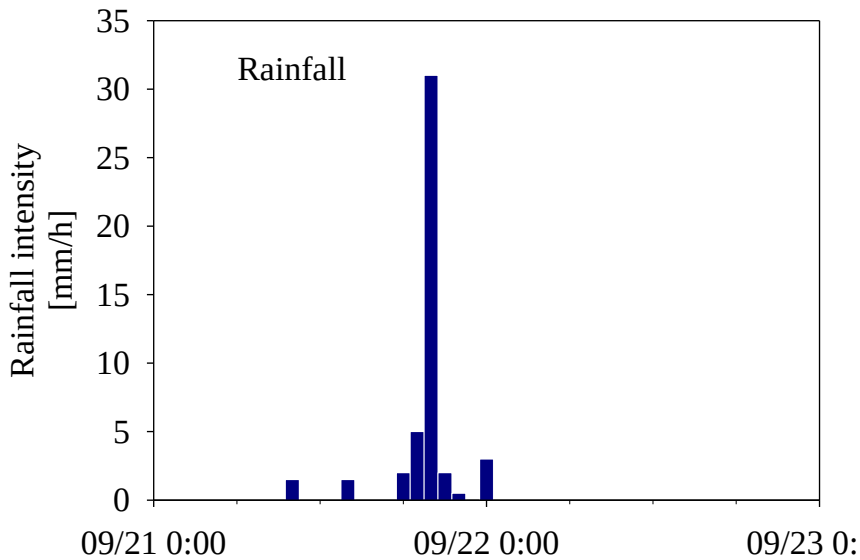
Hodaka

21 September, 2023



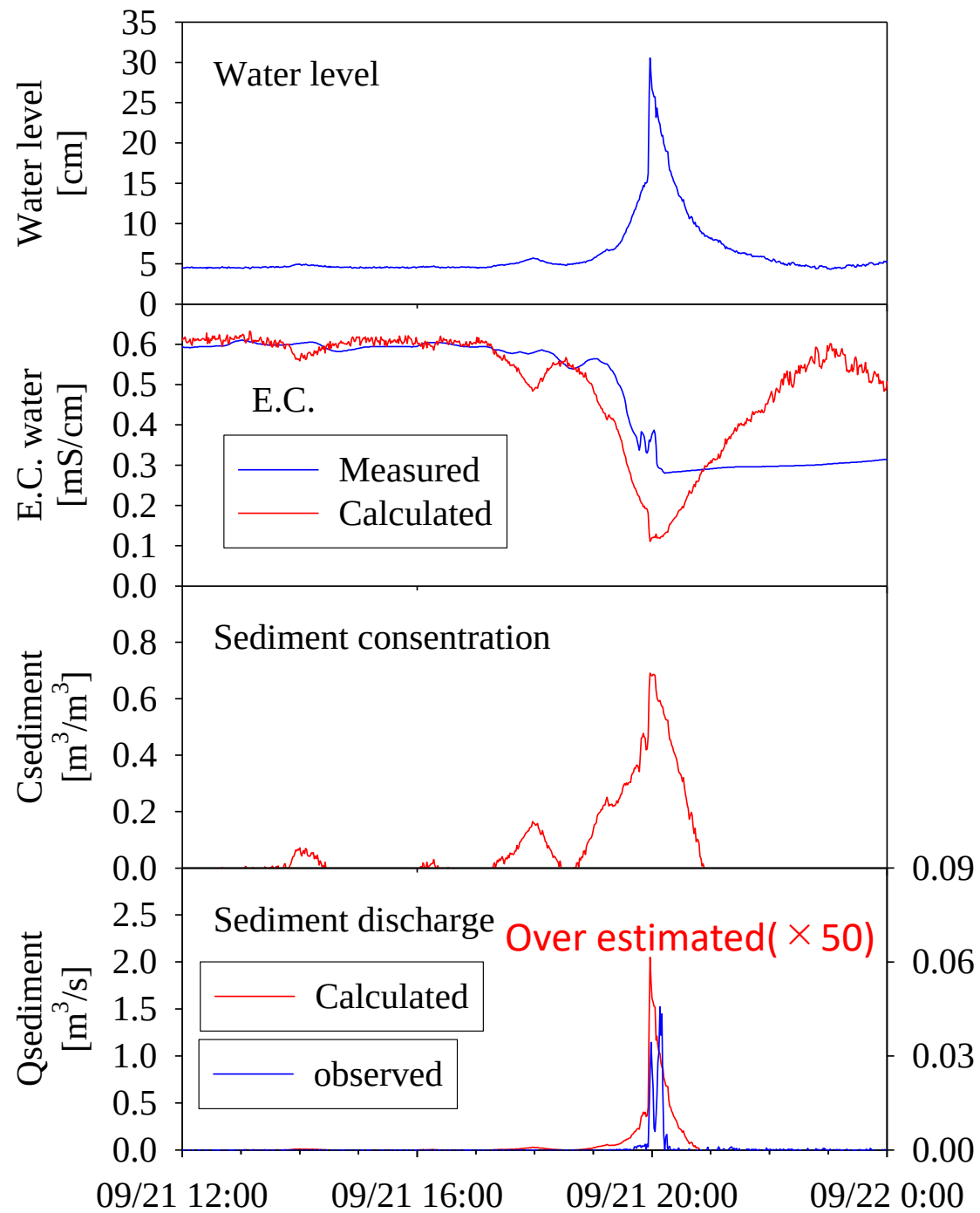
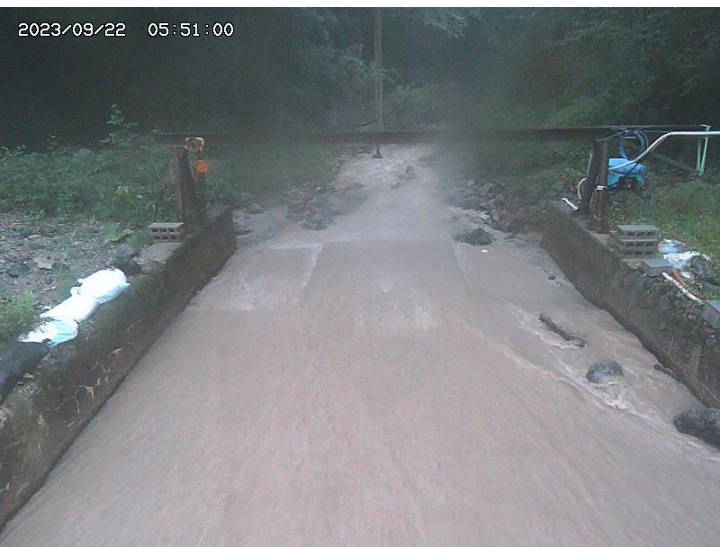
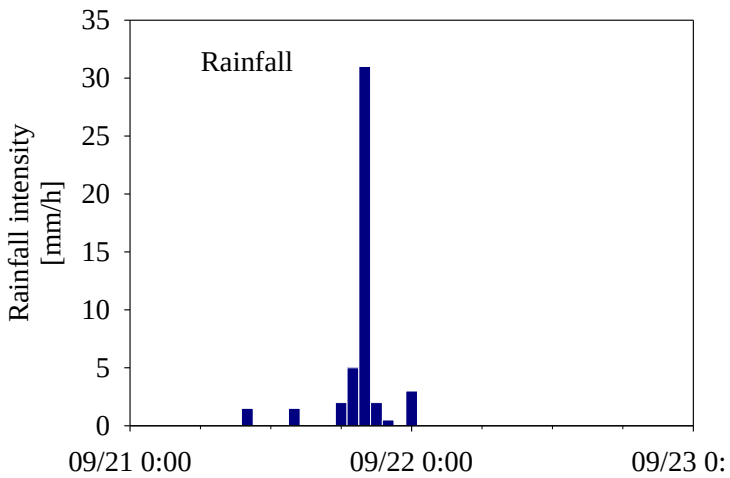
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21 September, 2023



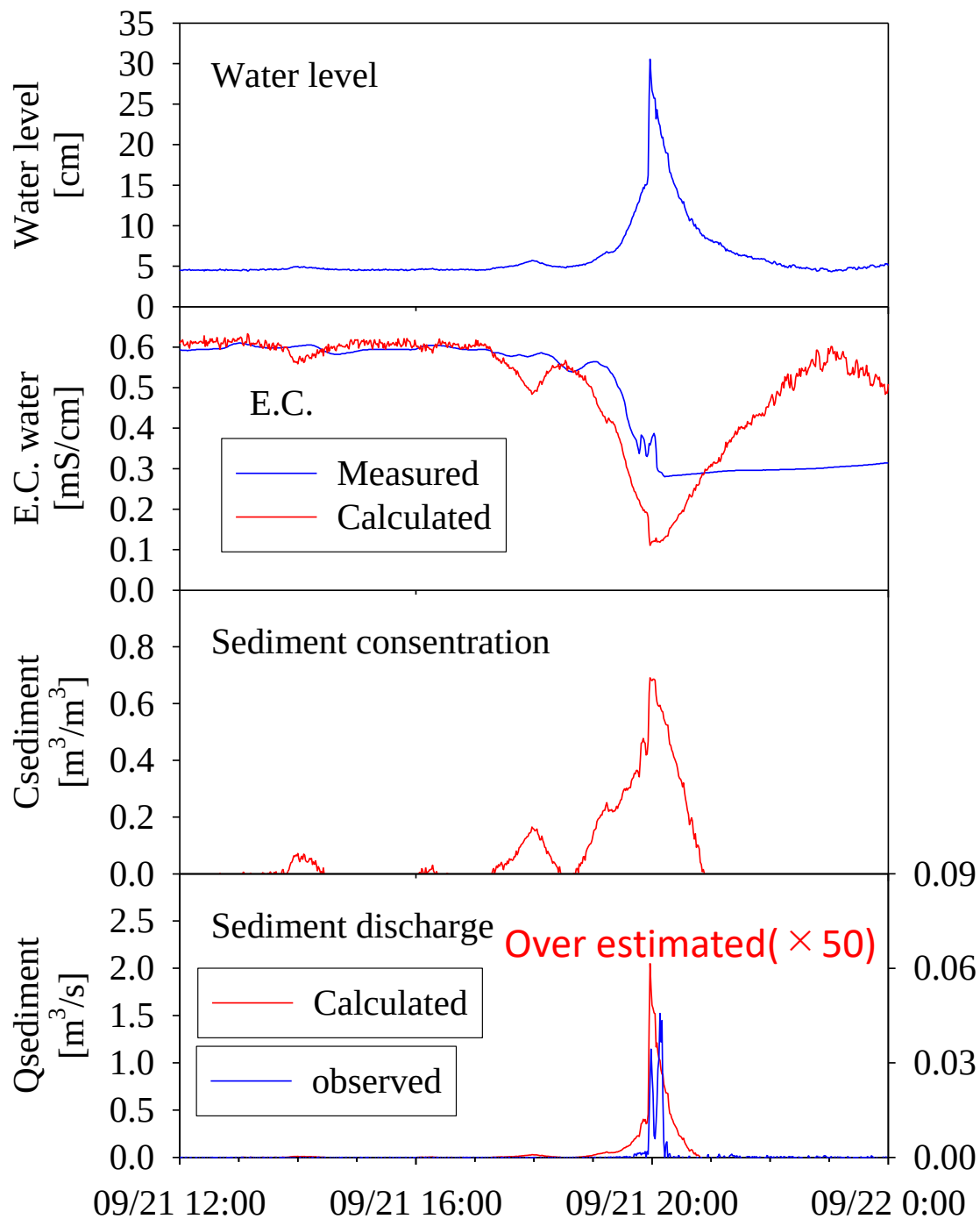
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21 September, 2023

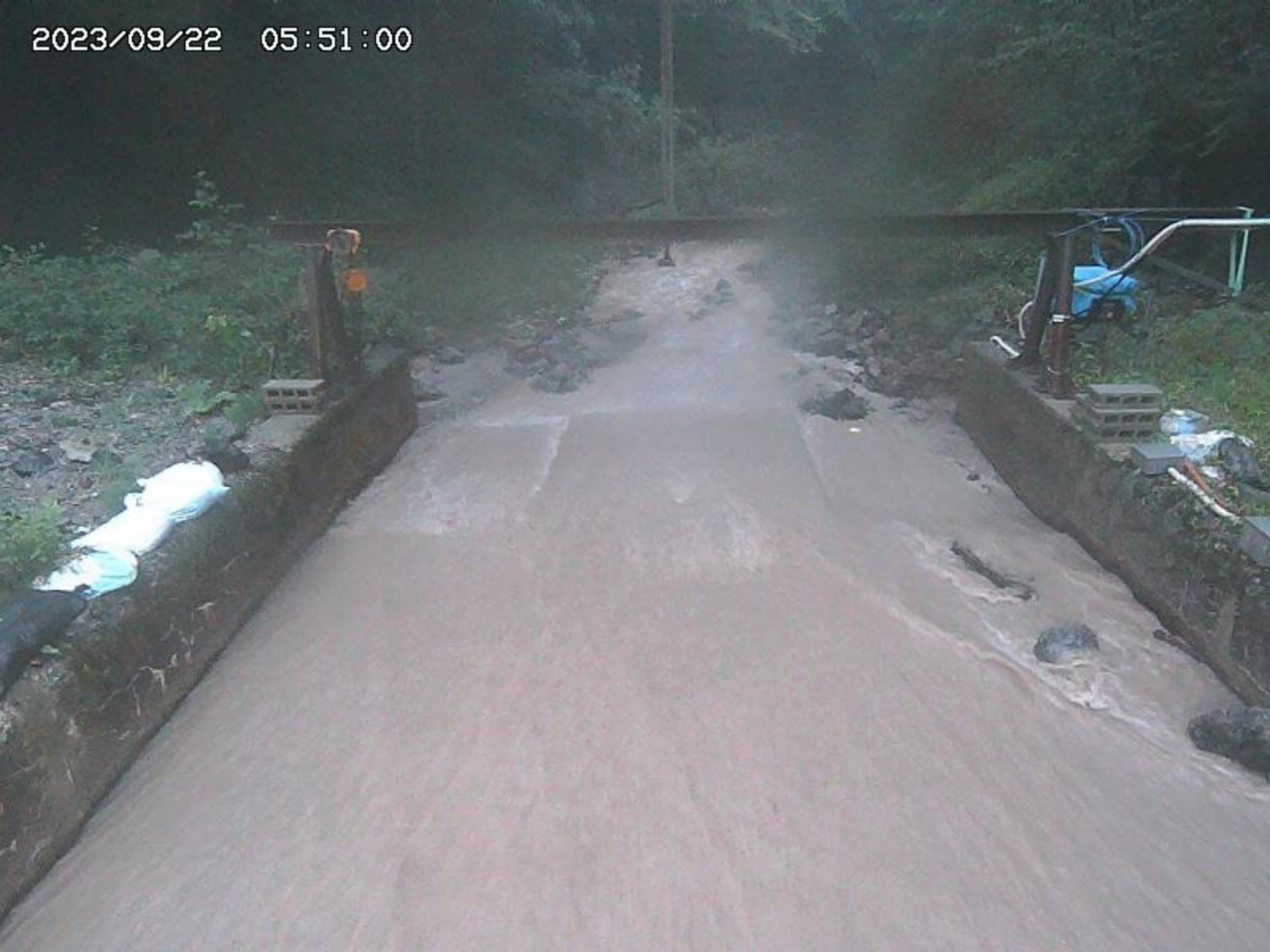


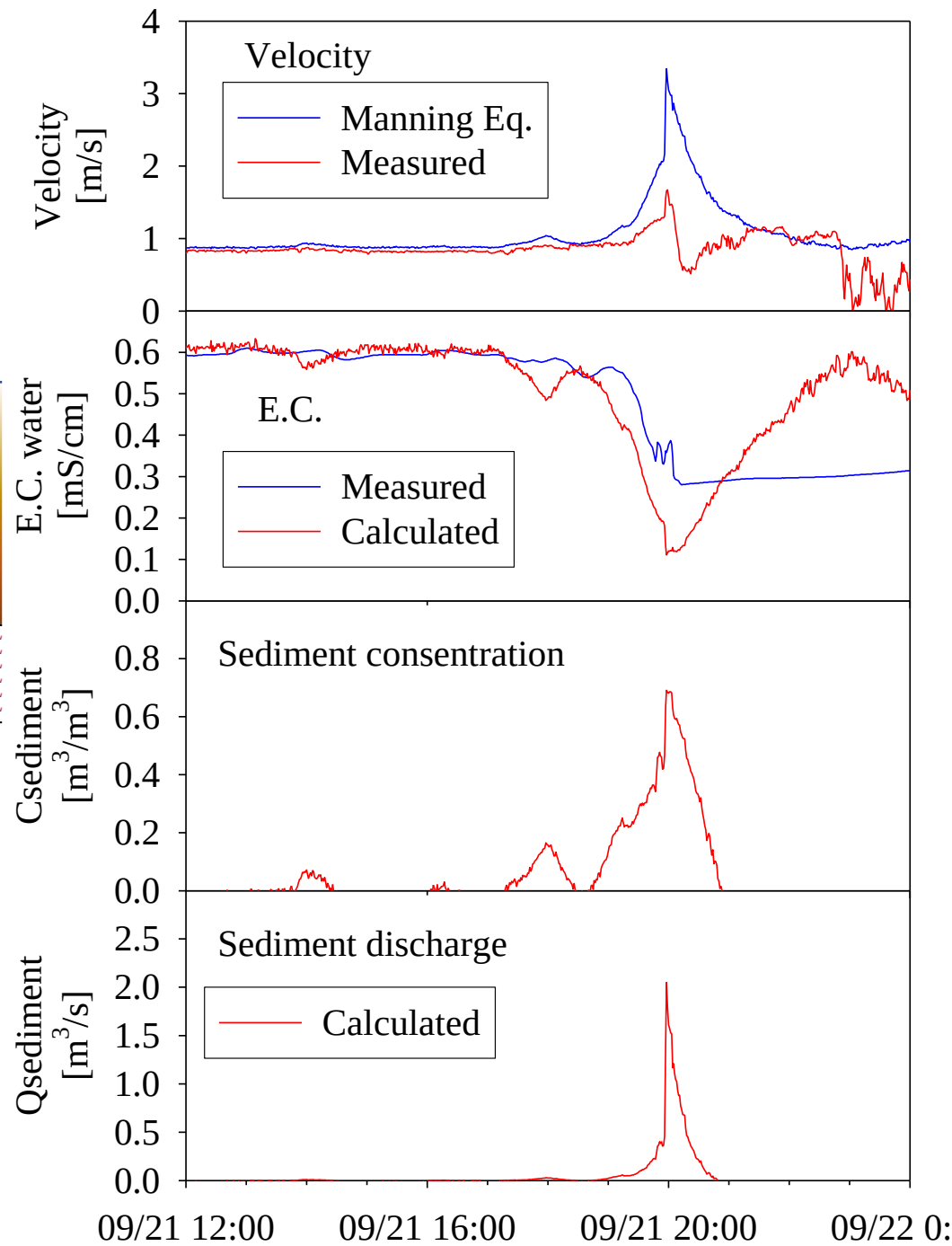
原因 1

- 土砂移動 $\ll$ 水流
- 土砂が河床をゆっくり移動？
- 一次的に土砂堆積
- 土砂濃度が大



2023/09/22 05:51:00



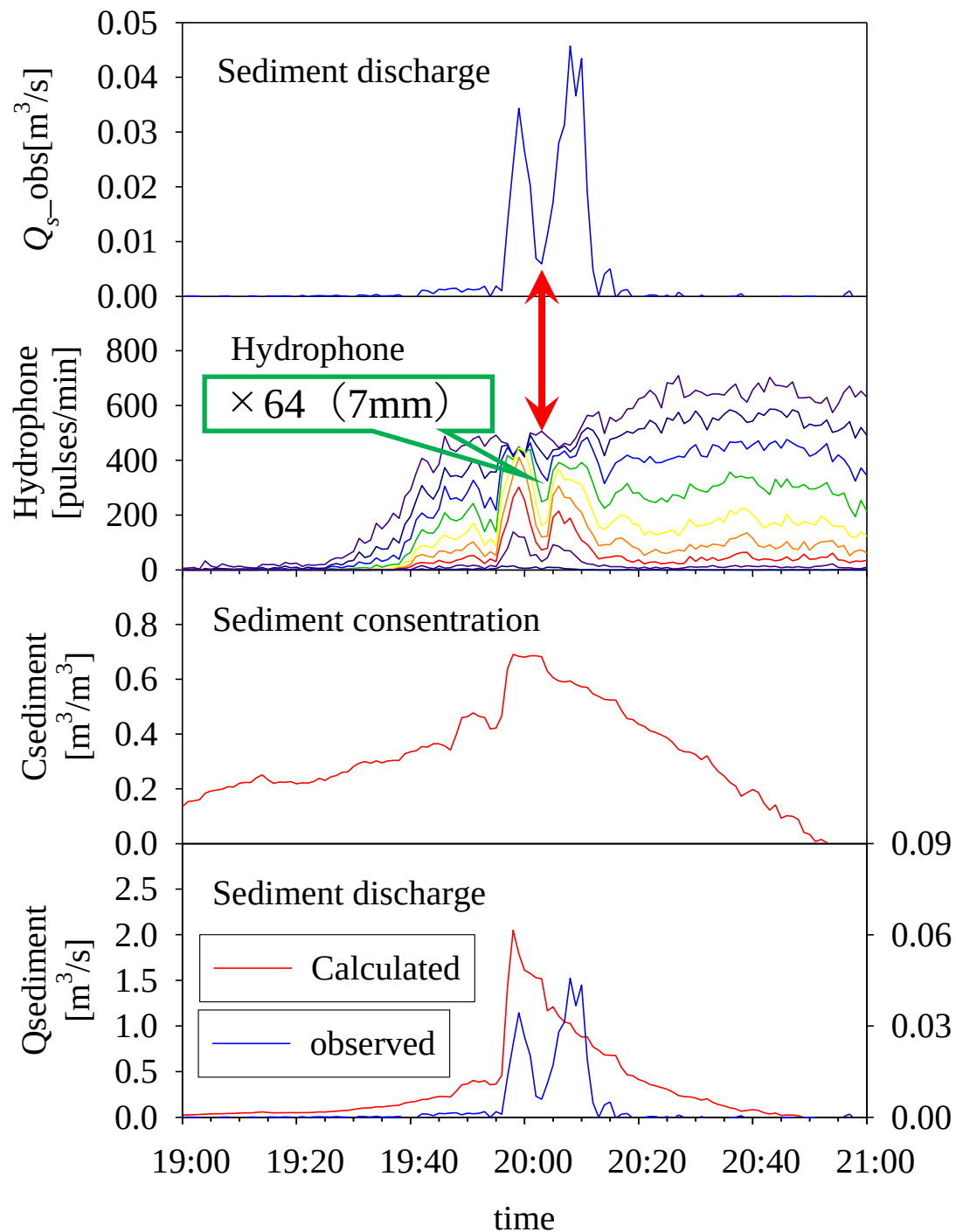


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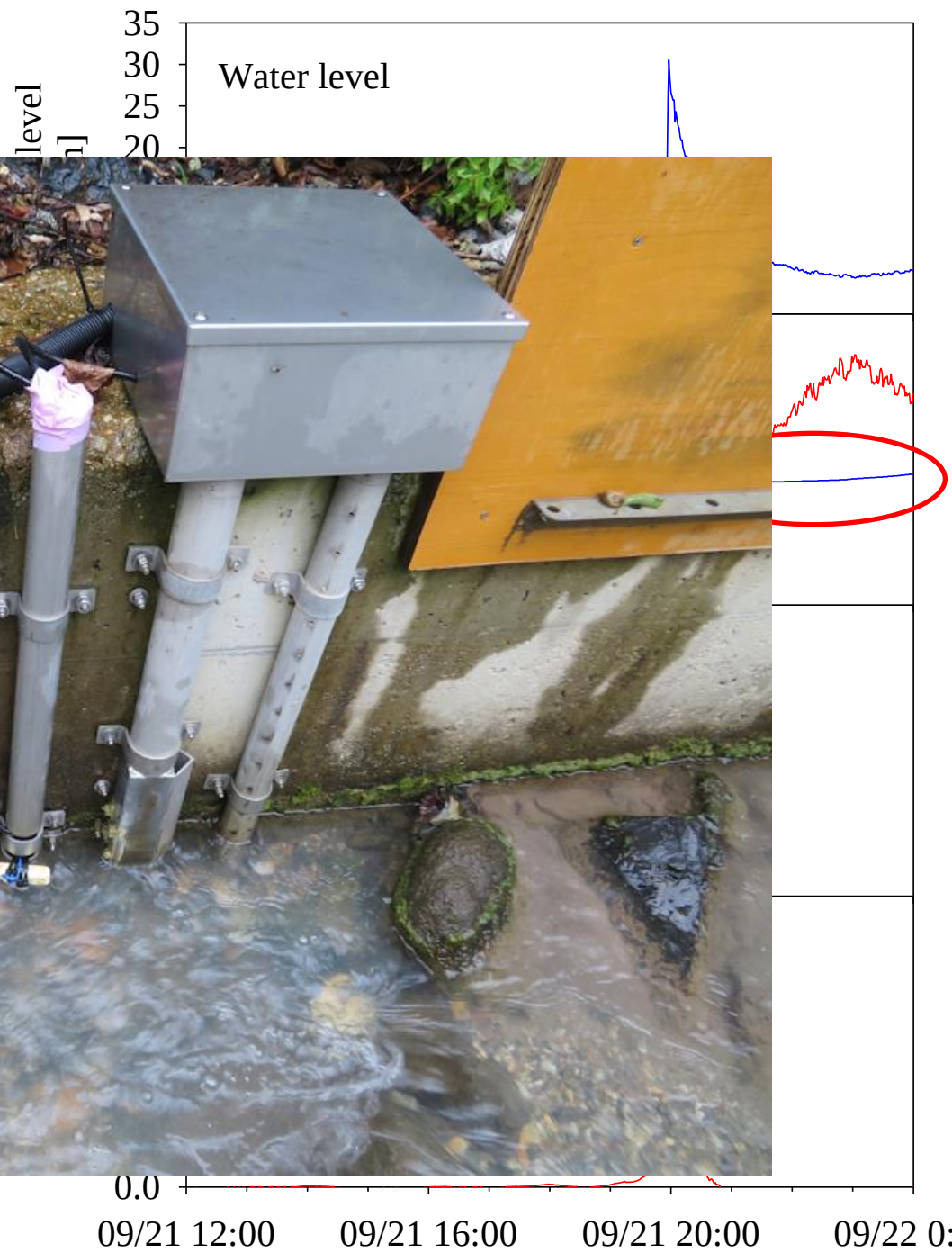
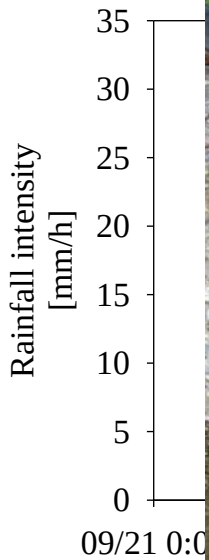
原因 2

- スロットサンプラーに捕捉される土砂は、掃流砂の一部
- 浮遊砂や粒径の小さい掃流砂は一旦ピットに入っても再流出



Hodaka

21 September, 2023



まとめ

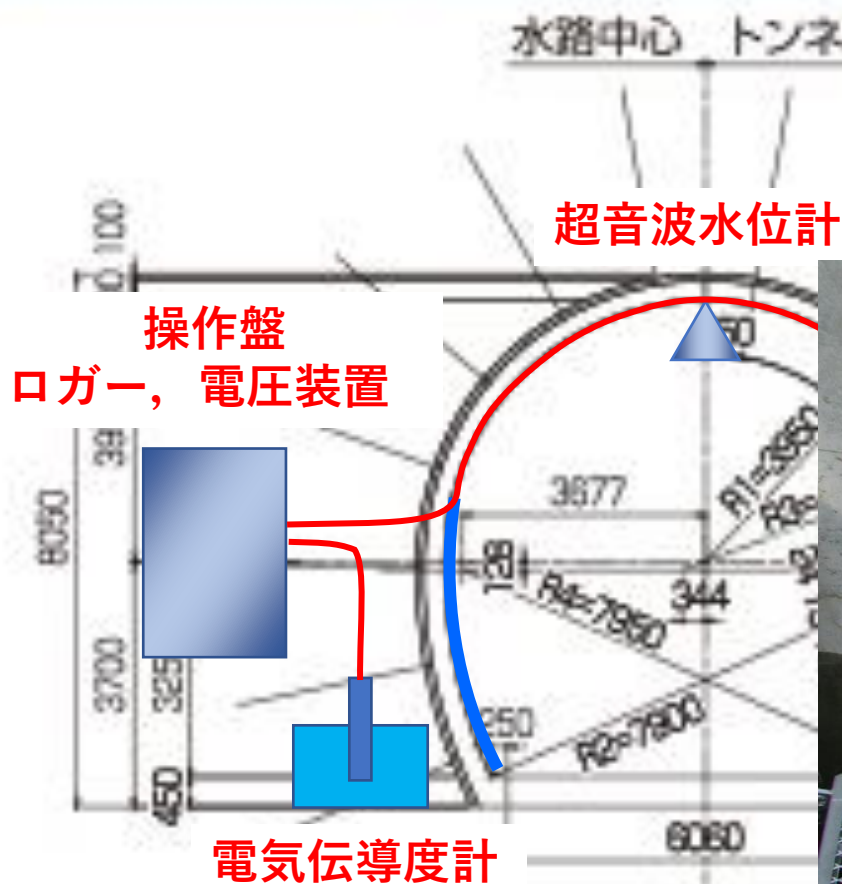
- 土砂の代わりに**ABS**樹脂を用いた水路実験によって、計測が可能であることを実証
- 穂高の試験水路において、現地検証を実施
- 土砂濃度，土砂流量を過大評価
 - 大規模土砂移動の場合、土砂移動速度が遅く、一旦河床に堆積している可能性
 - スロットサンプラーでは、粒径の小さな掃流砂が捕捉されずに流下している可能性
- 土砂移動を検出できない場合も
 - 濁り成分付着による電気電導度計の計測不良

設置案



設置案

土砂バイパストンネル標準断面図(一般部)



設置位置候補： 津之浦下流砂防堰堤

