DYNAMIC NATURE OF H-Q RATING CURVE AND NEW APPROACH TO ITS DEVELOPMENT AND MAINTENANCE

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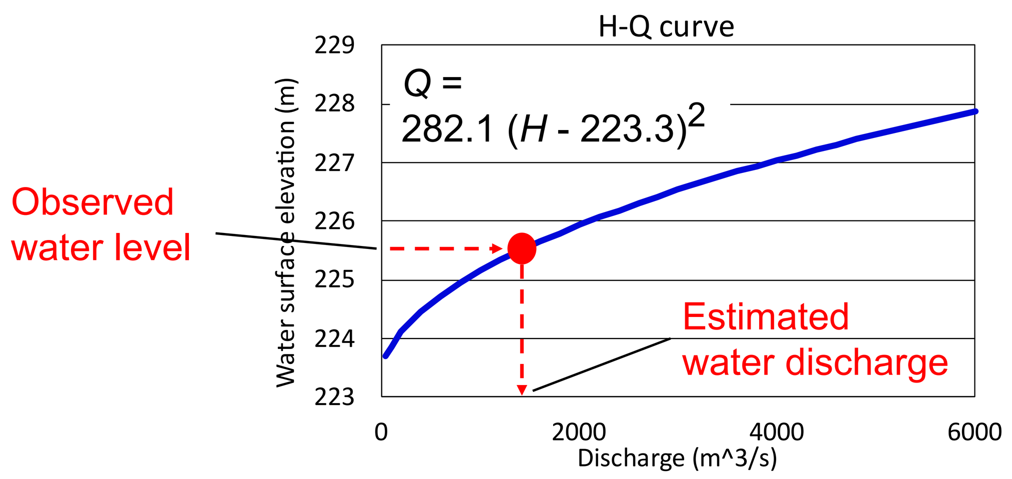
WHAT IS H-Q RATING CURVE?

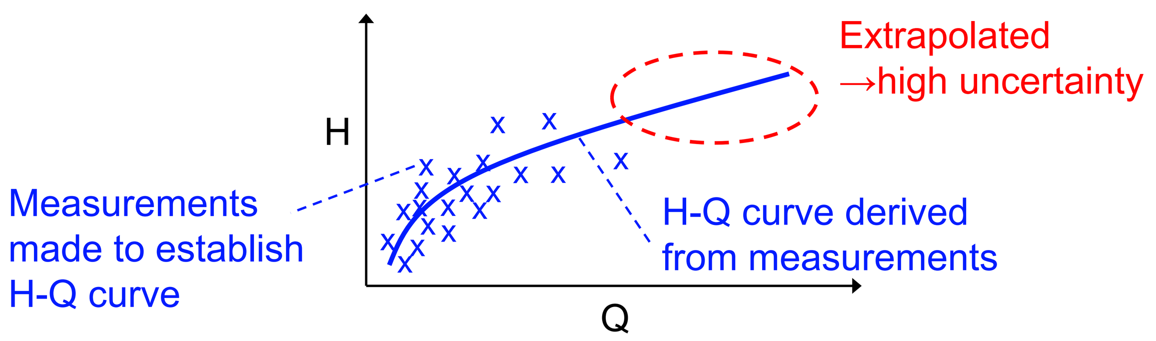
- A H-Q curve shows the relationship between flow stage (*H*) and flow rate (*Q*)
- It is used to convert flow stage to discharge
- Quality of H-Q curve directly affects quality of hydrological model
  - hydrological model is calibrated using discharge, which is converted from water level
- Generally, it is expressed in the following form:

$Q = a(H+b)^2$ or $H = \sqrt{Q/a} - b$ — *a* and *b*: constants, derived by the fitting

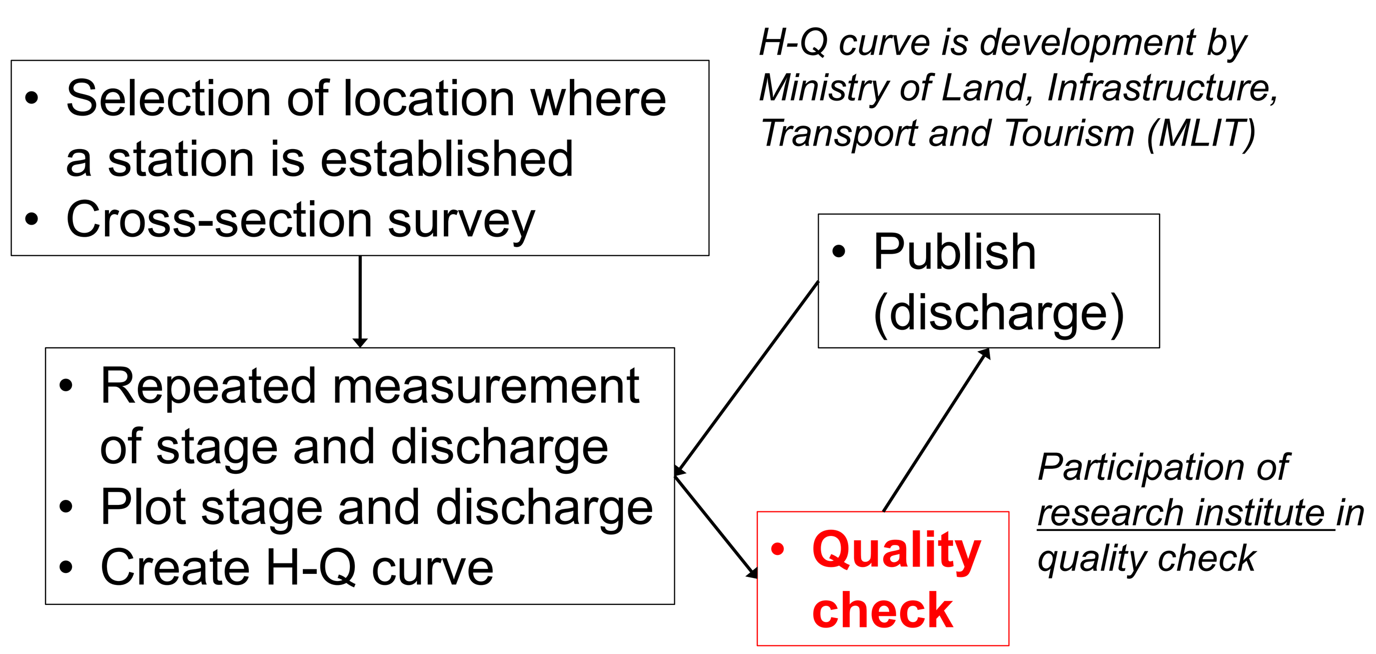


CHALLENGES IN H-Q CURVE OPERATIOM (IN THE PHILIPPINES)

- Developing H-Q curve requires repeated observation
- Limited human resources for H-Q maintenance
- Manuals do not explain how to assess deviations from the curve
- Measurement is limited particularly at high stages
  → extrapolation is used

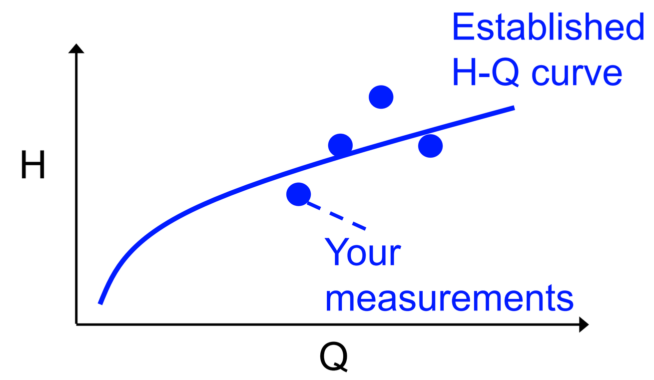


HOW H-Q CURVE IS OPERATED IN JAPAN?



HOW DYNAMIC CAN H-Q CURVE BE?

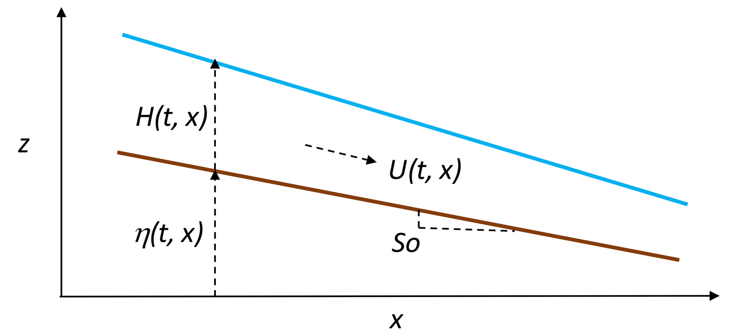
- Your measurement often deviates from established H-Q curve
- Deviation can be due to
  1) hydraulic dynamics,
  2) formation of bedforms such as dunes,
  3) channel incision / deposition, etc.



1) Effect of hydraulic dunamics

Momentum equation for 1D shallow water

$$\frac{\partial U}{\partial t} + U\frac{\partial U}{\partial x} = g\frac{\partial H}{\partial x} - g\frac{\partial \eta}{\partial x} - \frac{\tau_b}{\rho H} \quad + g\,(So - Sf)$$



Friction slope *Sf*:

$$S_f = S_o - \frac{\partial H}{\partial x} - \frac{U}{g}\frac{\partial U}{\partial x} - \frac{1}{g}\frac{\partial U}{\partial t}$$

(Assuming friction is only source of energy loss)

Discharge Q (Manning's formula):

$$Q = UA = \frac{1}{n}BH^{\frac{5}{3}}S_f^{\frac{1}{2}}$$

$$\Rightarrow Q = \frac{1}{n}BH^{\frac{5}{3}}\sqrt{S_o - \frac{\partial H}{\partial x} - \frac{U}{g}\frac{\partial U}{\partial x} - \frac{1}{g}\frac{\partial U}{\partial t}}$$

(1) (2) (3)

(1) hydrostatic pressure
(2) convective acceleration
(3) local acceleration

Steady uniform flow (*So* = *Sf*)

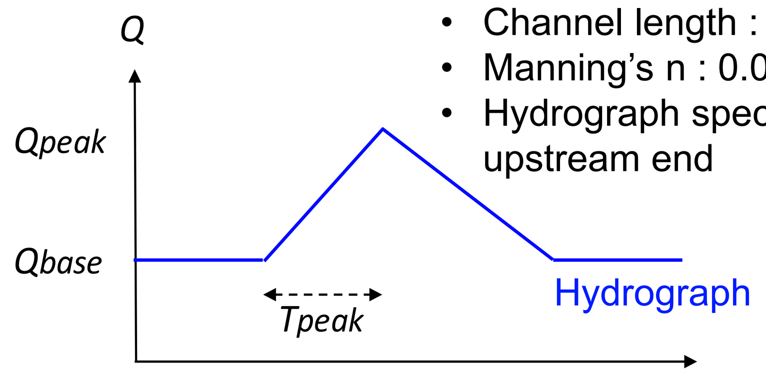
$$Q = \frac{1}{n}BH^{\frac{5}{3}}S_o^{\frac{1}{2}}$$

Relative difference between bed slope *So* and (1)~(3) determines degree of deviation

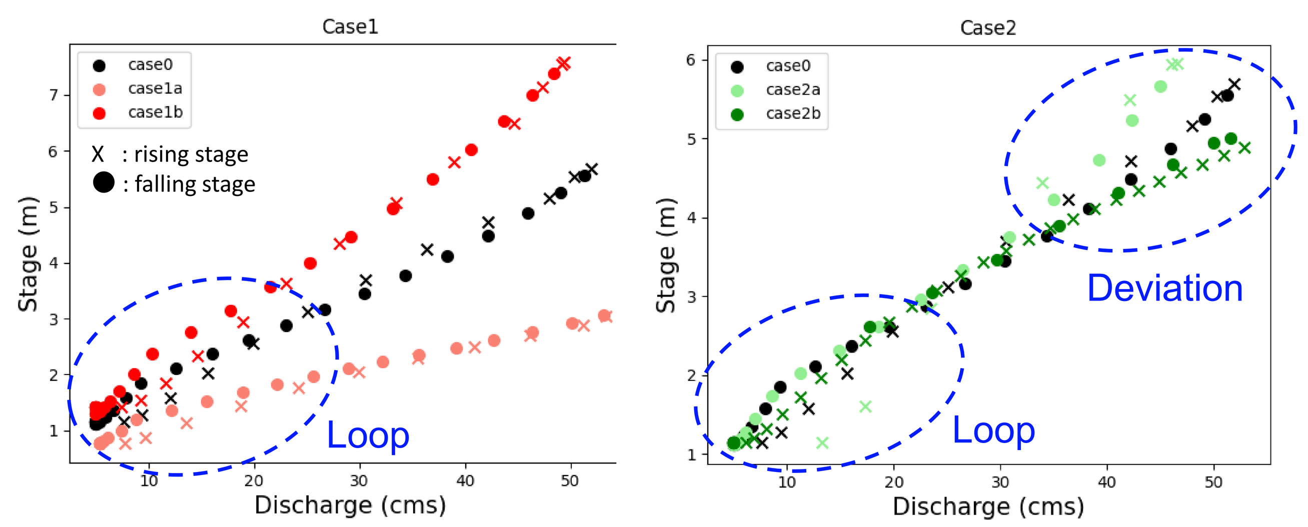
Simple 1D simulations to examine effect of (1)~(3)

Case	Qbase (m3/s)	Qpeak (m3/s)	Tpeak (s)	So (%)
0	5	50	1,500	0.01
1a	5	50	1,500	0.05
1b	5	50	1,500	0.005
2a	5	50	1,000	0.01
2b	5	50	2,000	0.01

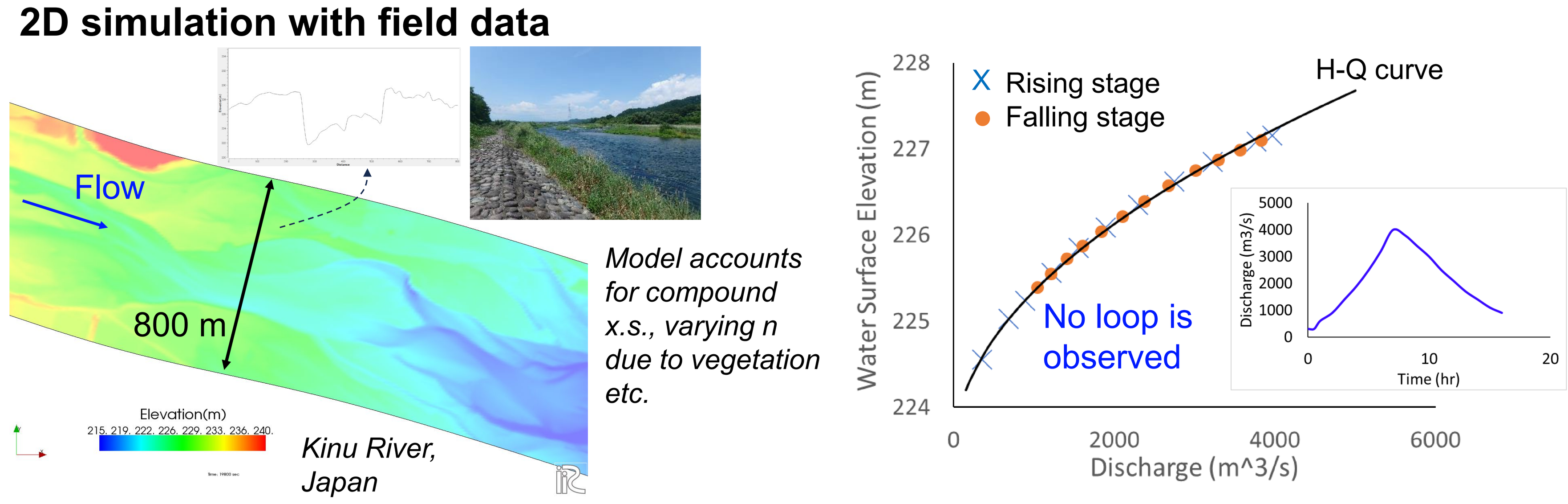
- Channel width : 10 m
- Channel length : 200 m
- Manning's n : 0.03
- Hydrograph specified at upstream end



- Loop (hysteresis)
  Rising stage:
  Sf > *So*
  Falling stage:
  Sf < *So*
- High deviation at high discharge when *Tpeak* is changed



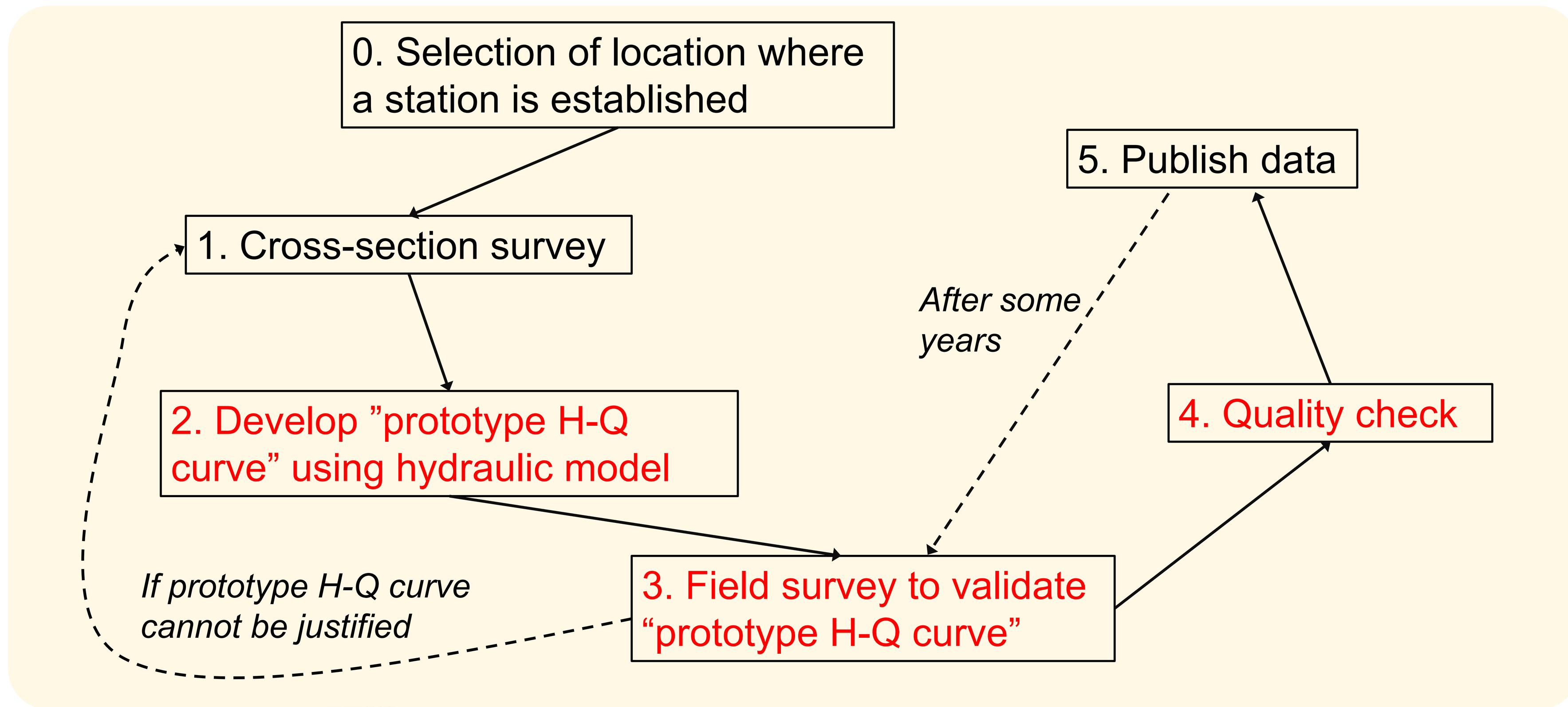
2D simulation with field data

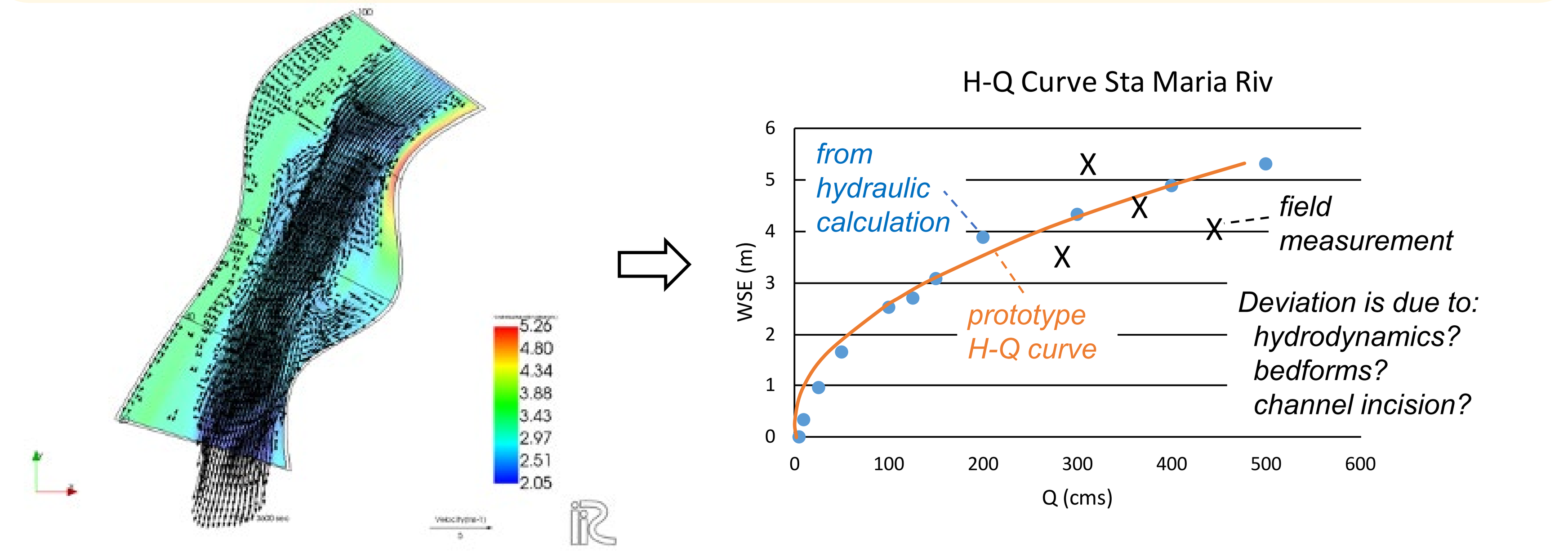


2) Effect of bedforms
3) Bed incision / erosion

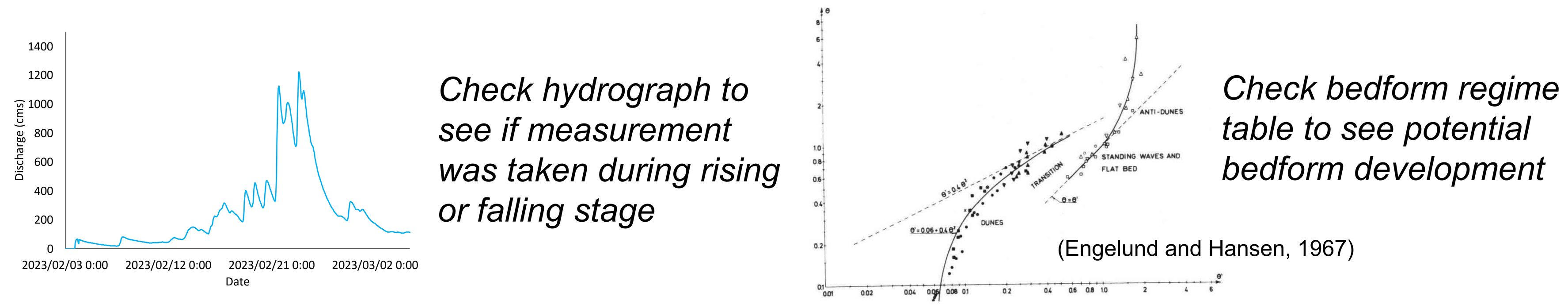
Also significantly affect flow dynamics

PROPOSED FRAMEWORK FOR H-Q CURVE DEVELOPMENT AND MAINTENANCE





2. Develop "prototype H-Q curve" using hydraulic model
   2a. Run steady state simulation for various discharge and plot H and corresponding Q
   2b. Draw the least square line to develop "prototype H-Q curve"
3. Field survey to validate "prototype H-Q curve"
   3a. Conduct field survey and plot results
   3b. Assess the degree and source of deviation from the prototype H-Q curve



Advantages:
- H-Q curve can be developed with less resources.
- Reduce uncertainty at high discharge (not rely on extrapolation)

Challenges:
- Measurements at high flows are still needed (but less number)

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