Delay and loss of production water along the Orkla river

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Two problems

- Loss of water to aquifer in glacial deposits
- Water delay in serial waterway, vary with time

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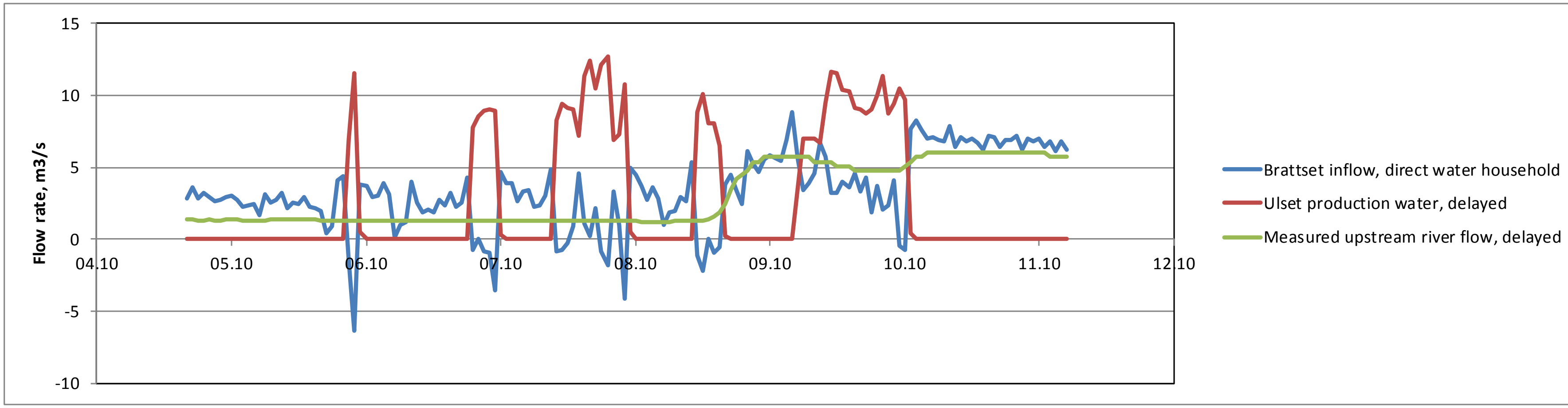
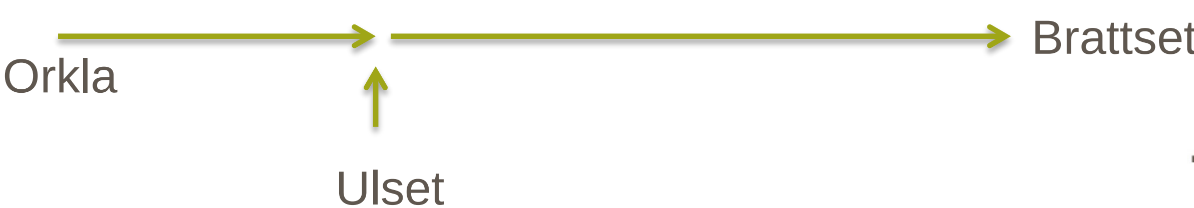
Problem 1: Water loss



- Negative, jumpy water household inflow
- Jumps correlate with upstream production



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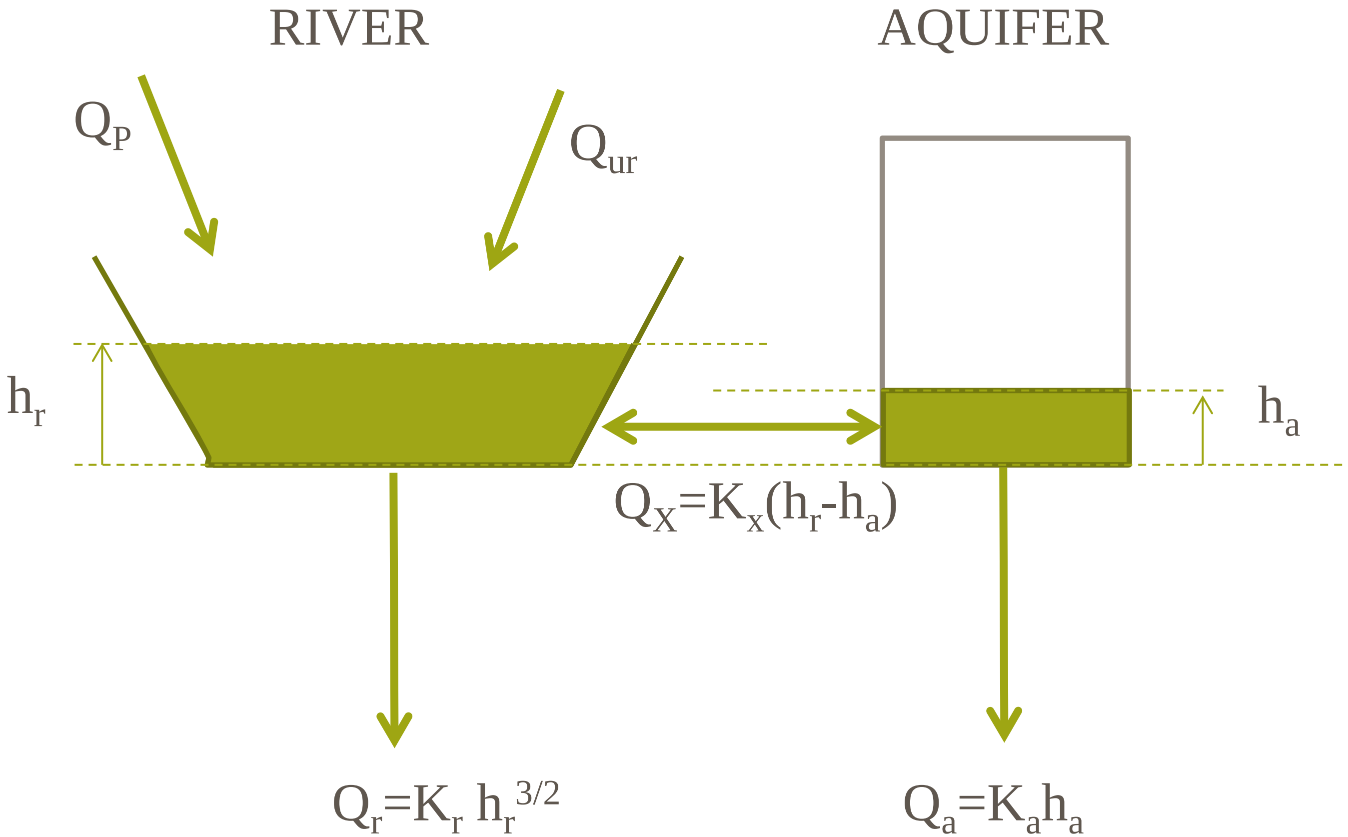
Proposed tank model



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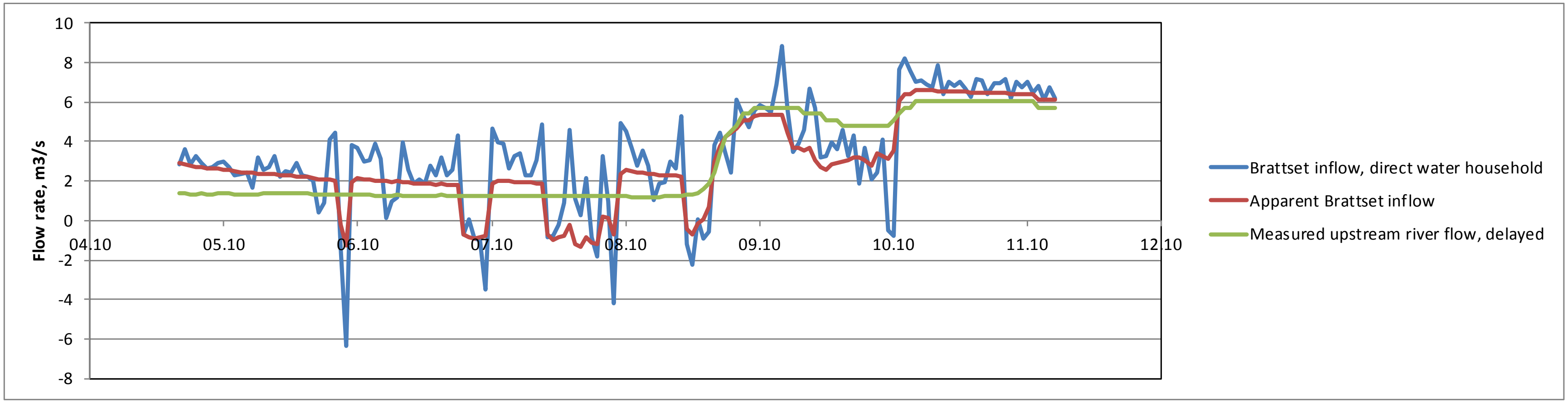
Model results



- Model explains jumpy apparent inflow
- Model predicts flow at production start/stop

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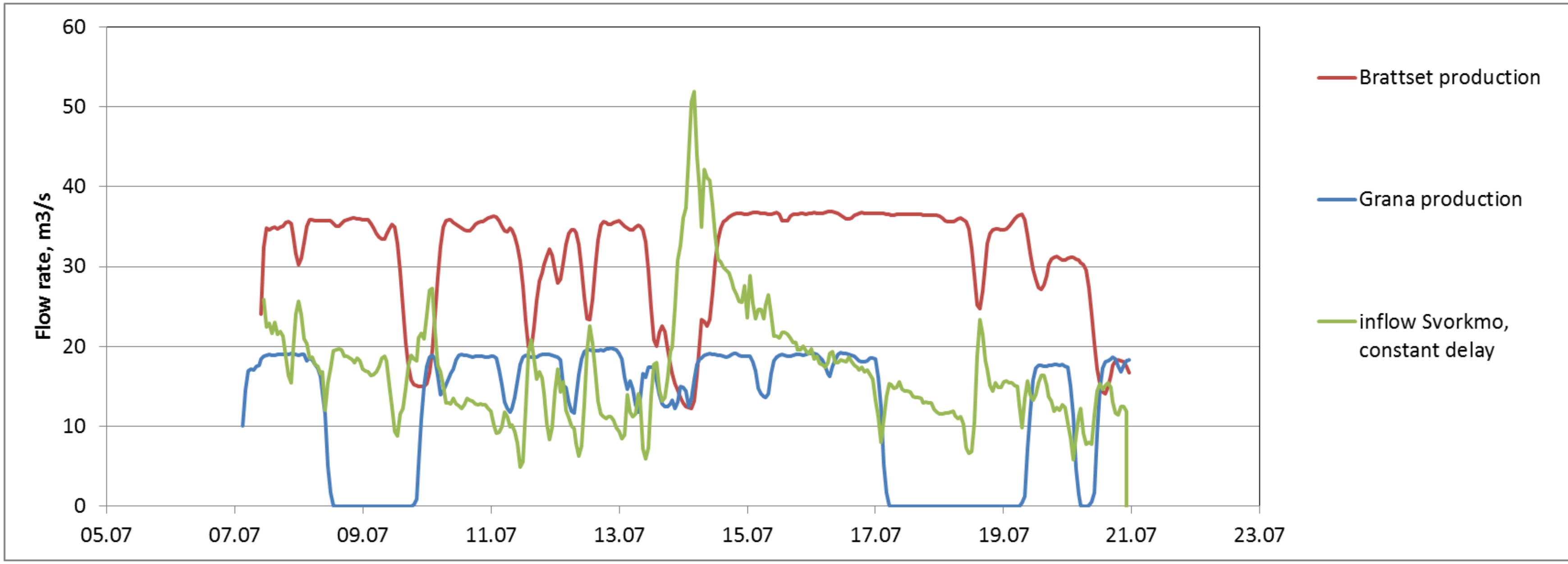
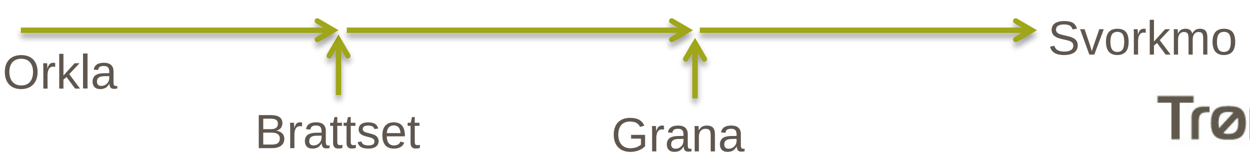
Problem 2: River delay



- Delay varies with time, depends on river state.
- Do we need a complex river model?



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No, all you need is...

Two-parameter steady-state
river description

$$Q = CV^n$$

Flow
rate

Stored volume
per river length

Volume conservation
= kinematic limit

$$\frac{\partial V}{\partial t} + \frac{\partial Q}{\partial x} = 0$$

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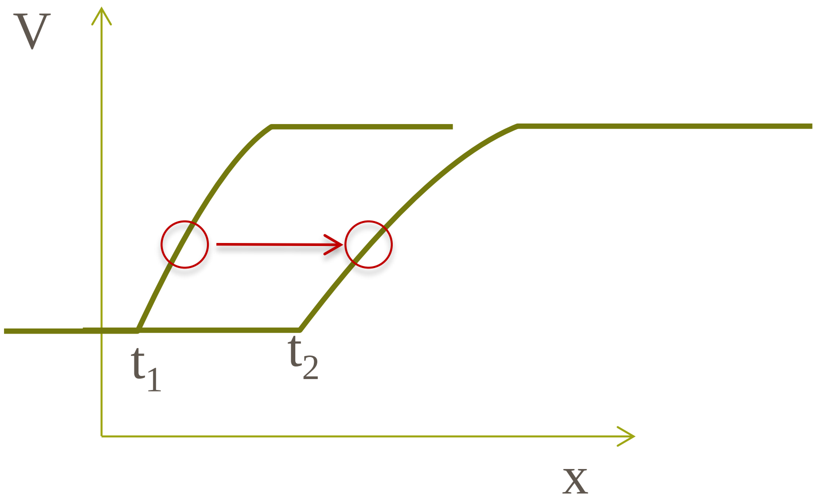
... solved with method of characteristics

Follow one V-value V=V(x,t):

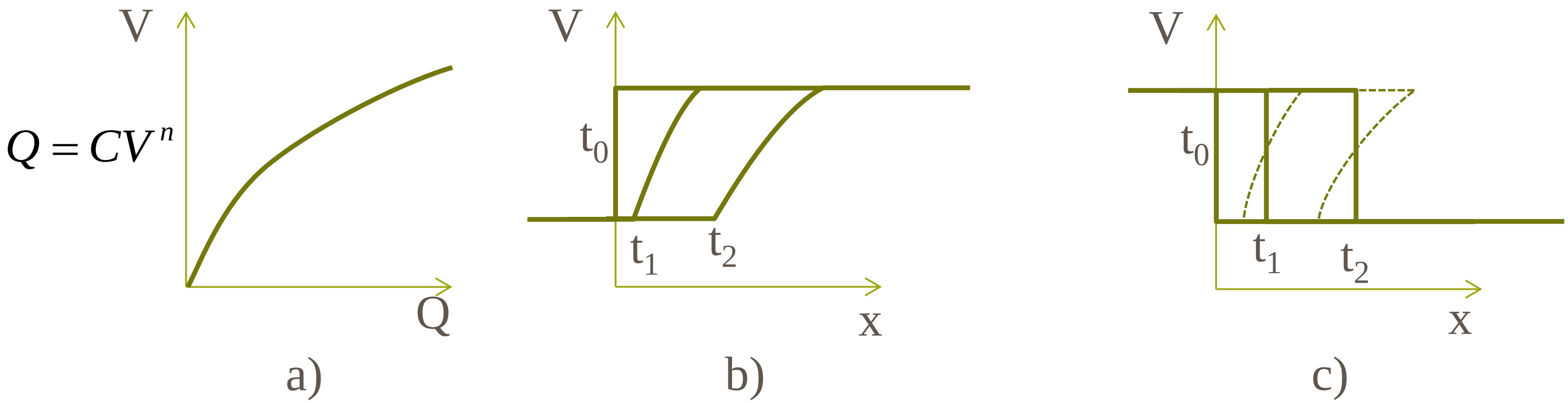
How fast does it move? $x = v_F t$



Result: speed is $v_F = \dfrac{dQ}{dV}$

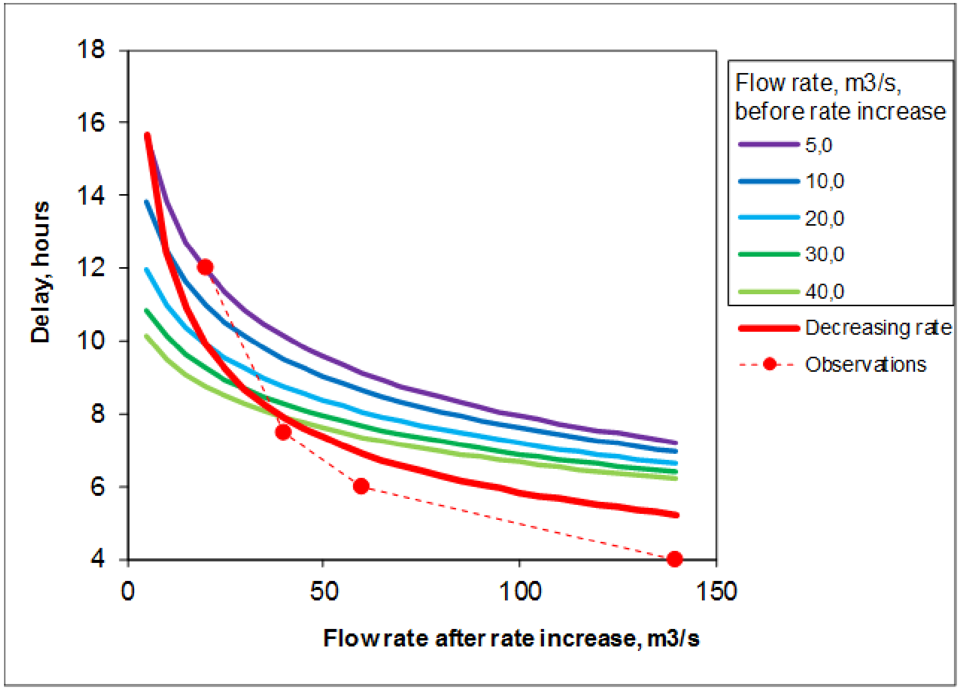
Resulting solution structure

$$v_F = \frac{dQ}{dV}$$



- High water levels move faster
- Rate reduction: Front broadening
- Rate increase: Shock formation

Is this model better?



- Yes: with only two free parameters
  - Delay varies correctly with river state.
  - Change direction dependence

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Conclusion

- There is more physics between outlet and inlet than many other places