

A photograph of a water treatment plant with large white pipes and machinery. The image is overlaid with a green semi-transparent banner at the top and white text.

**WANDA**

Deltares



**WANDA user conference  
4 March 2010**

**WELCOME**

A photograph of an industrial facility, likely a water treatment plant, featuring large white pipes, machinery, and red structures. The scene is brightly lit, and the equipment is arranged in a complex, organized manner.

**WANDA**

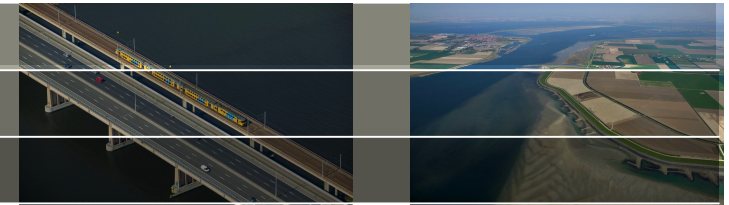
Deltares



# Wanda 4 Liquid

Kees Kooij

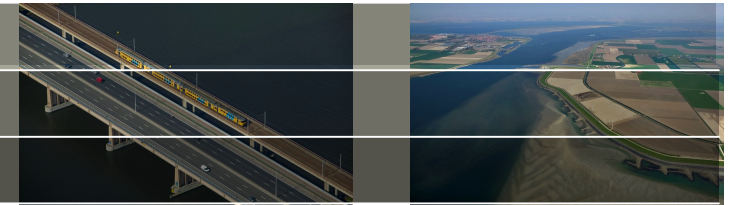
# Wanda 4 Liquid



- What is new
- What has been changed
- What has been left unchanged



# Wanda 4 Liquid - GUI

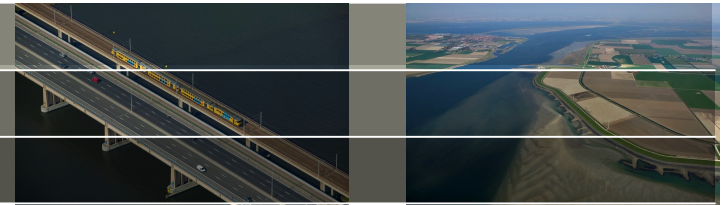


**Find the three differences**

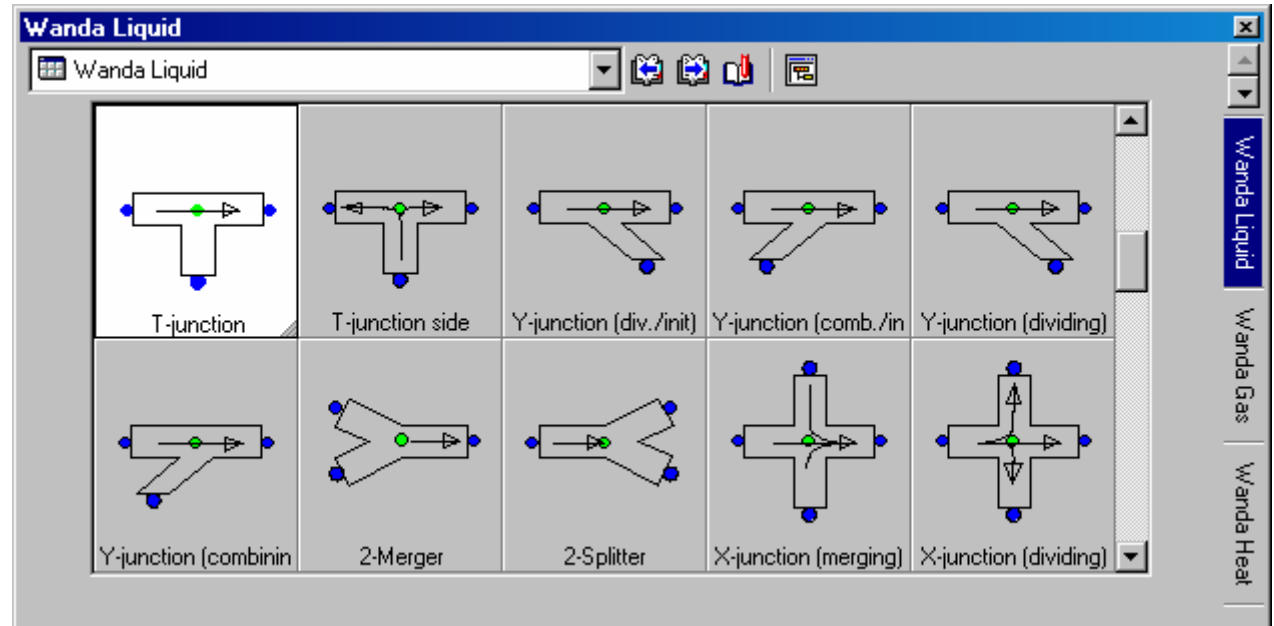
**User interface (almost) unaltered**

PUMP P1 (1/1)	
Name	P1
Comment	
Keywords	
User name	wanda
Modified	2010 Mar 3 20:33
Type	Pump
Model name	
Sequence number	
Disuse	NO
Reference id	
Characteristic type	QHE
QHE_table	...
Rated speed	(rpm)
Initial setting	Speed
Initial speed	(rpm)
Messages	...
Discharge 1	(m3/h)
Head 1	(m)
Pressure 1	(barg)
Discharge 2	(m3/h)
Head 2	(m)
Pressure 2	(barg)
Discharge drop	(m3/h)
Head drop	(m)
Pressure drop	(barg)
Pump speed	(rpm)
Fluid torque	(kNm)
Motor torque	(kNm)
ON/OFF	(-)
Efficiency	(%)
power	(kW)

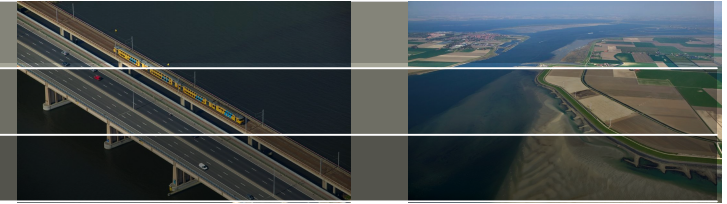
# Wanda 4 Liquid - new



3 and 4 node  
components



# Wanda 4 Liquid - new



3 en 4 node components

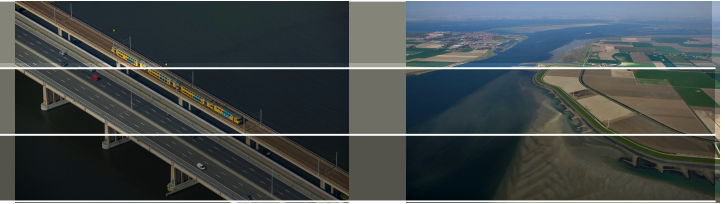
- Complex resistance model
- Local losses depend on ratio of areas and ratio of discharges
- Formulas en tables in handbooks (Idelchik, Miller)

In WANDA 3 essentially not possible to calculate correctly  
(determine iteratively)

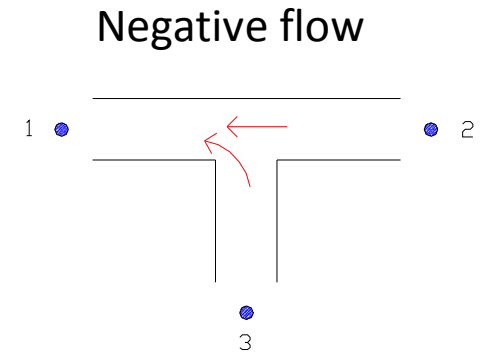
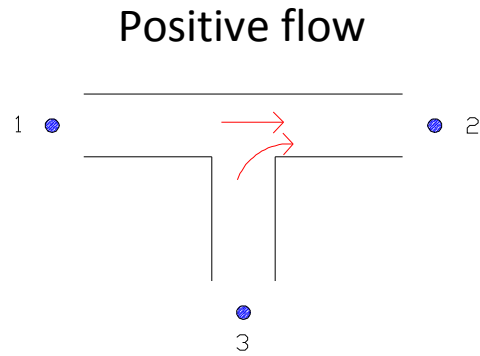
In WANDA 4 correct calculation of resistances

- Fast
- In time simulation continual recalculation of coefficients with actual Q

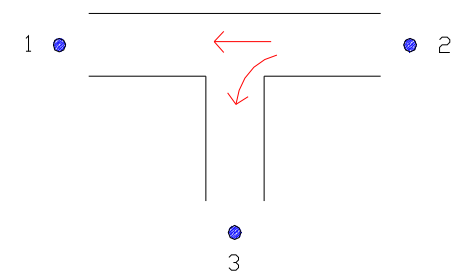
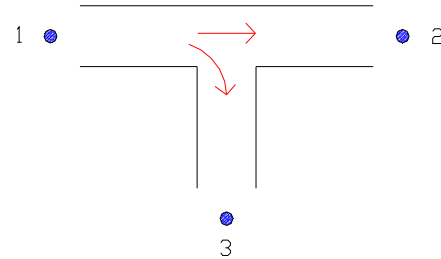
# T – Junction



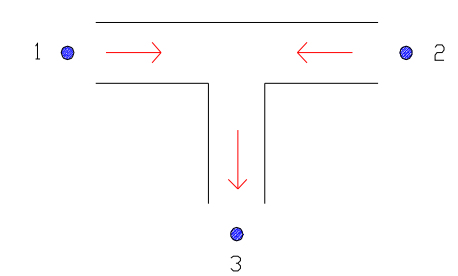
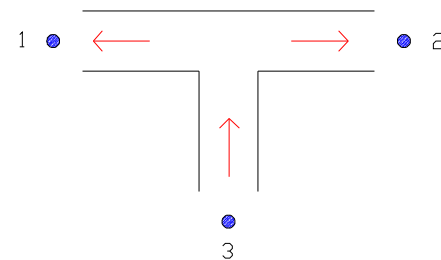
1) *COMBINING*



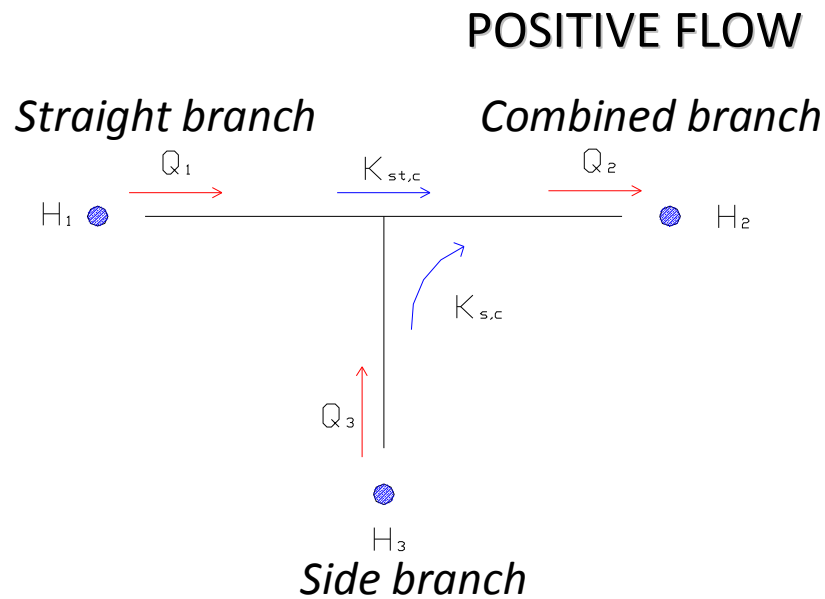
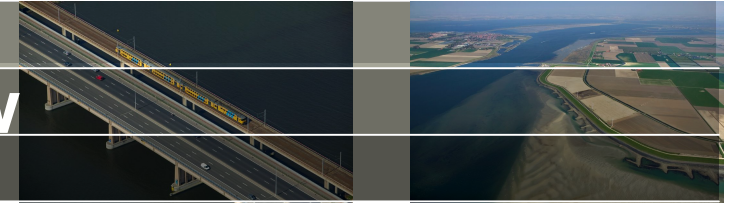
2) *DIVIDING*



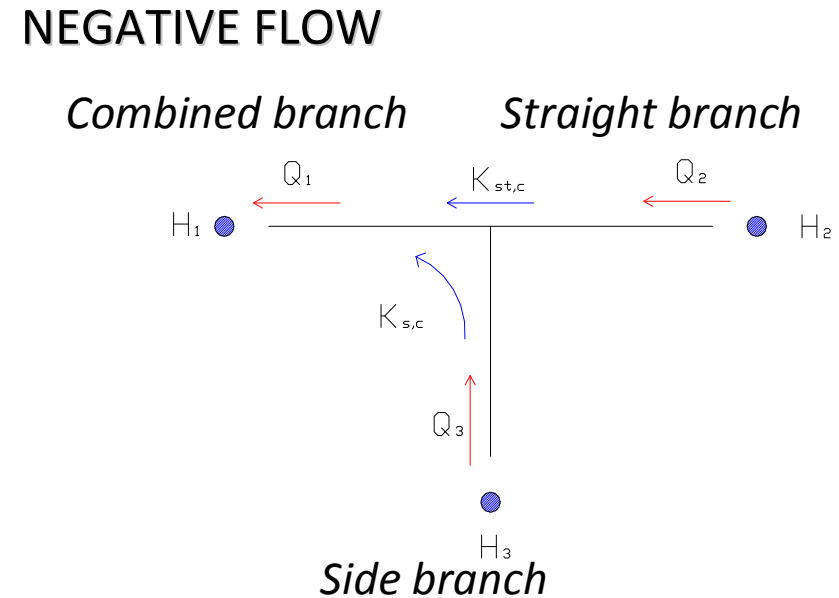
3) *UNKNOWN*



# T – Junction – combining flow



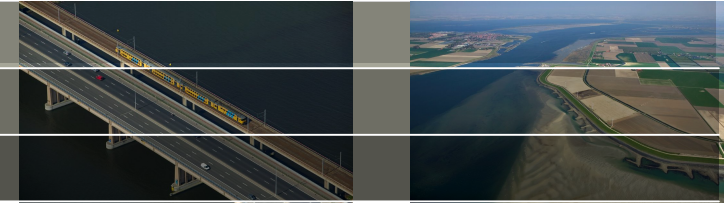
- Continuity equation:
- $Q_1 + Q_3 = Q_2$
- Head loss:
- $H_1 - H_2 = K_{st} (w_2^2/2g)$
  - $H_3 - H_2 = K_s (w_2^2/2g)$



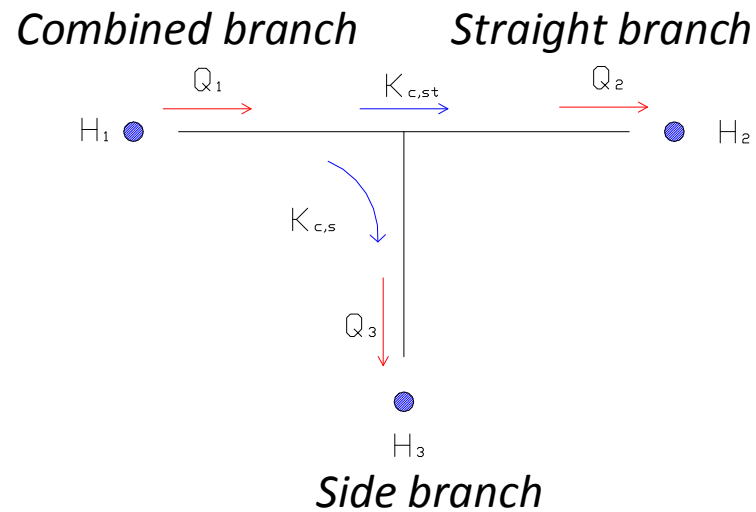
- Continuity equation:
- $Q_2 + Q_3 = Q_1$
- Head loss:
- $H_2 - H_1 = K_{st} (w_1^2/2g)$
  - $H_3 - H_1 = K_s (w_1^2/2g)$



# T – Junction – dividing flow



## POSITIVE FLOW



Continuity equation:

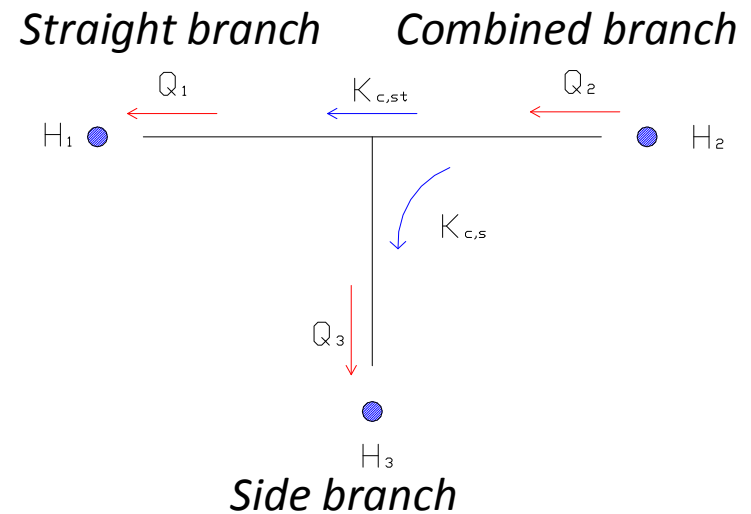
- $Q_2 + Q_3 = Q_1$

Head loss:

- $H_1 - H_2 = K_{st} (w_1^2/2g)$

- $H_1 - H_3 = K_s (w_1^2/2g)$

## NEGATIVE FLOW



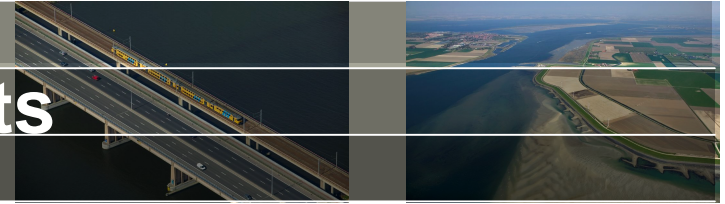
Continuity equation:

- $Q_1 + Q_3 = Q_2$

- $H_2 - H_1 = K_{st} (w_2^2/2g)$

- $H_2 - H_3 = K_s (w_2^2/2g)$

# T – Junction – loss coefficients

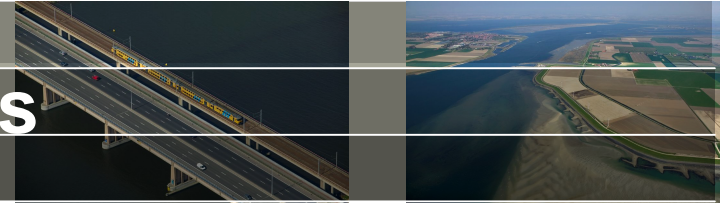


## IDELCHIK HANDBOOK

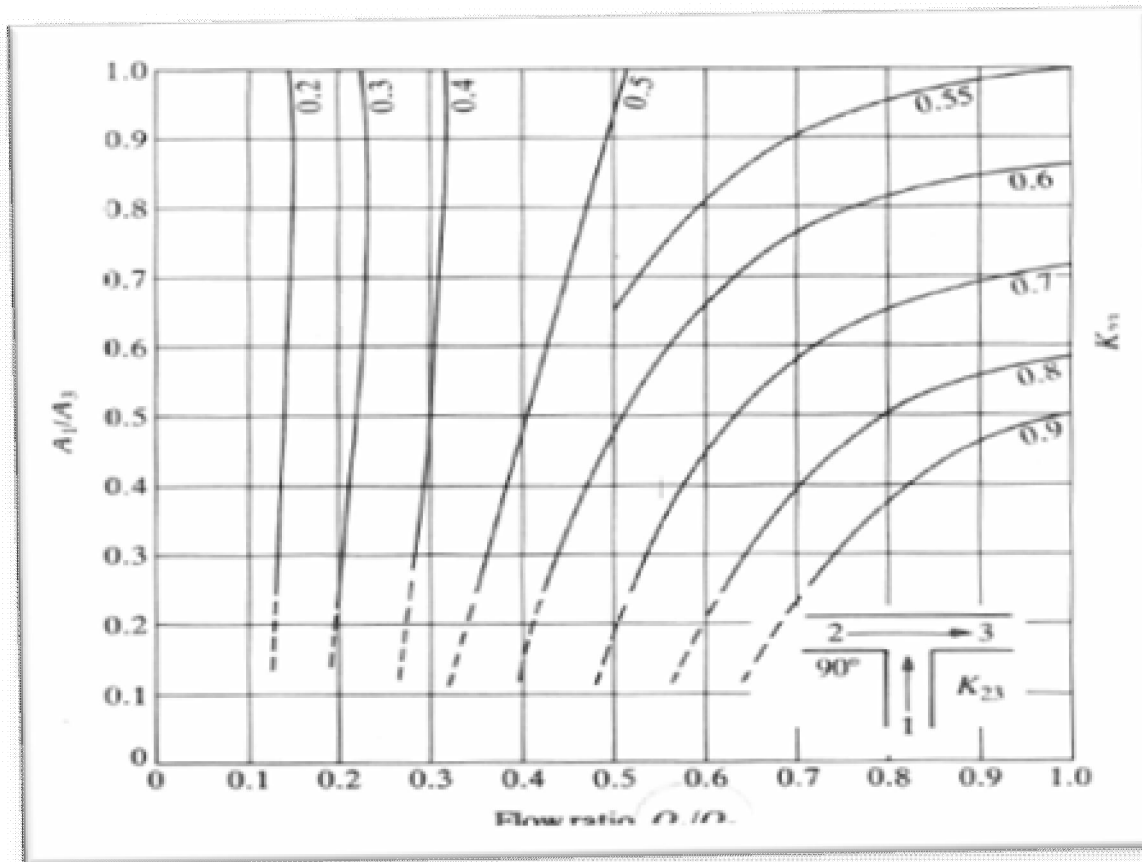
1. COMBINING	{	<i>Straight passage:</i>	$K_{st} \approx 1.55 \frac{Q_s}{Q_c} - \left(\frac{Q_s}{Q_c}\right)^2$
		<i>Side passage:</i>	$K_s = A \left[ 1 + \left(\frac{Q_s A_c}{Q_c A_s}\right)^4 - 2 \left(1 - \frac{Q_s}{Q_c}\right)^4 \right]$
2. DIVIDING	{	<i>Straight passage:</i>	$K_{st} = \tau_{st} \cdot \frac{Q_s}{Q_c}$
		<i>Side passage:</i>	$K_s = A' \left[ 1 + \left(\frac{Q_s A_c}{Q_c A_s}\right)^2 \right]$

- $A_s$  = Area of the side branch;
- $A_c$  = Area of the combined branch;
- $Q_s$  = discharge in the side branch;
- $Q_c$  = discharge in the combined branch;
- $A, A'$  and  $\tau_{st}$  functions of  $Q_s, Q_c, A_s, A_c$

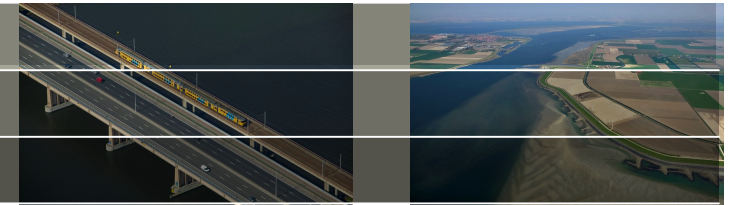
# T – Junction - loss coefficients



## MILLER HANDBOOK



# T – Junction



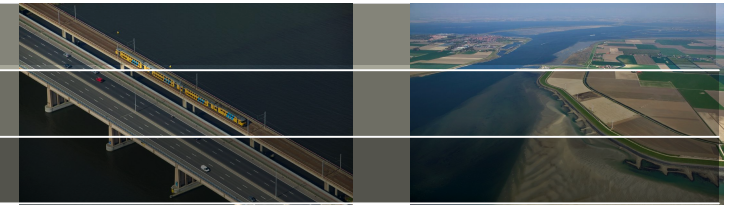
Input parameter: formula / table (Idelchik, Miller or other)

Type	T-junction (prototype)
Model name	
Sequence number	
Disuse	NO
Reference id	
Diameter straight branch	500.0 (mm)
Diameter side branch	250.0 (mm)
Xi method	Formula

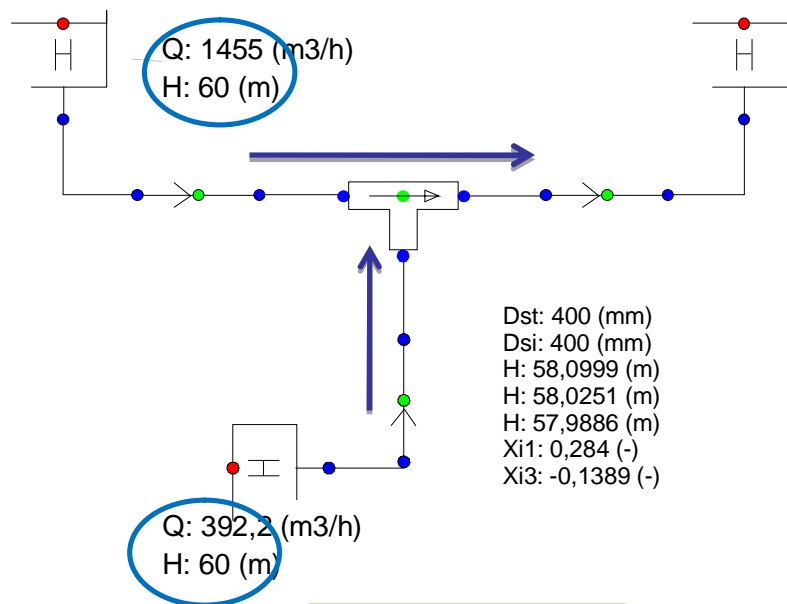
Type	T-junction (prototype)
Model name	
Sequence number	
Disuse	NO
Reference id	
Diameter straight branch	500.0 (mm)
Diameter side branch	250.0 (mm)
Xi method	Table
Xi tables valid for	Both
Xi combining straight	...
Xi combining side	...
Xi dividing straight	...
Xi dividing side	...

Table: Combining / Dividing / Both

# T – Junction - test results



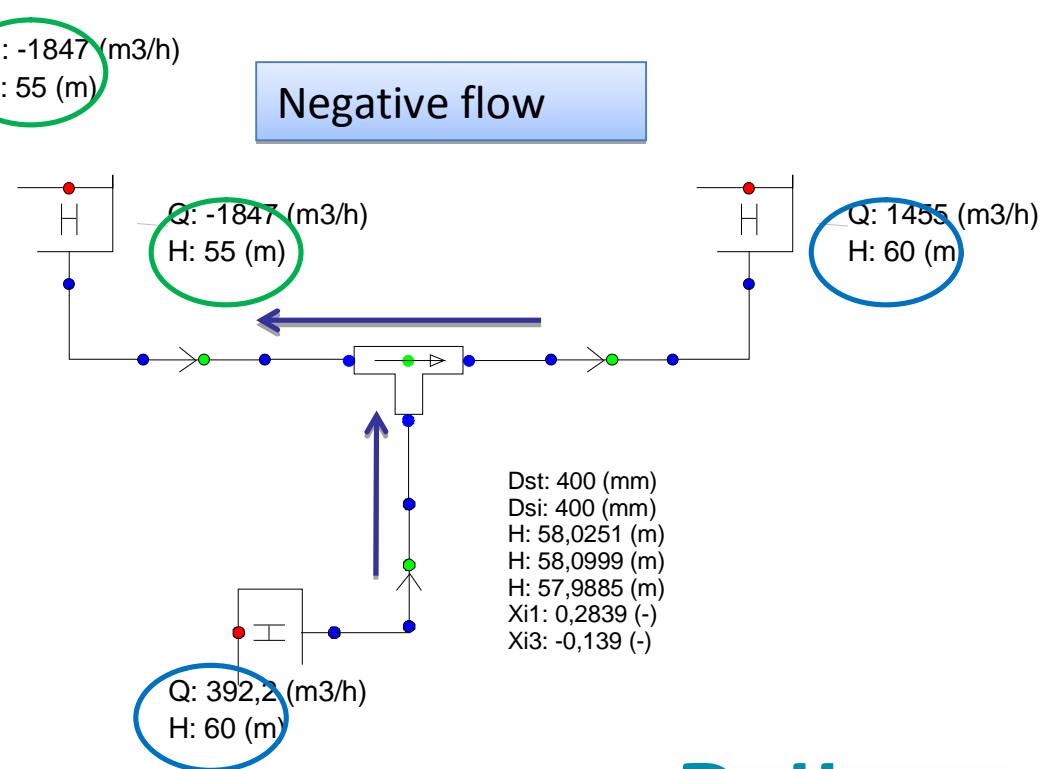
Positive flow



Dst: 400 (mm)  
Dsi: 400 (mm)  
H: 58,0999 (m)  
H: 58,0251 (m)  
H: 57,9886 (m)  
Xi1: 0,284 (-)  
Xi3: -0,1389 (-)

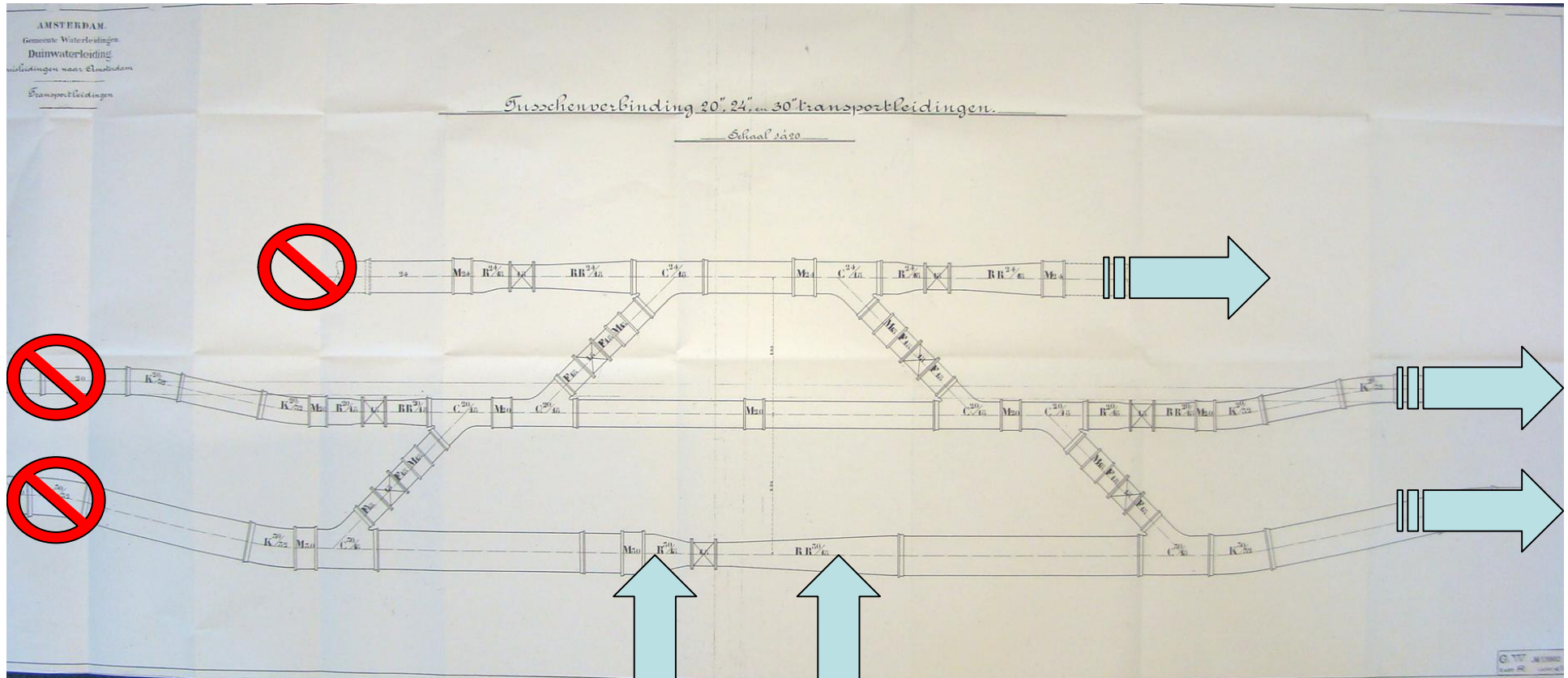
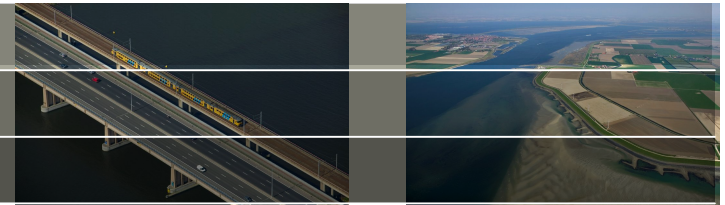
$K_{\text{straight}} = 0,28$   
 $K_{\text{side}} = 0,139$

Negative flow



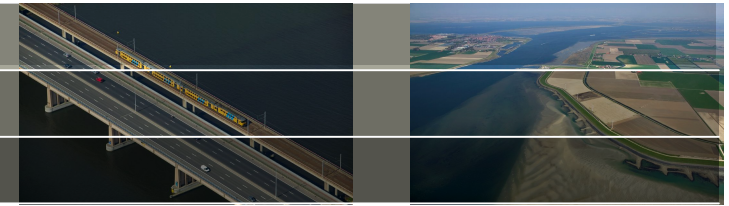
Dst: 400 (mm)  
Dsi: 400 (mm)  
H: 58,0251 (m)  
H: 58,0999 (m)  
H: 57,9885 (m)  
Xi1: 0,2839 (-)  
Xi3: -0,139 (-)

# T- Y – Junction - application



New connections

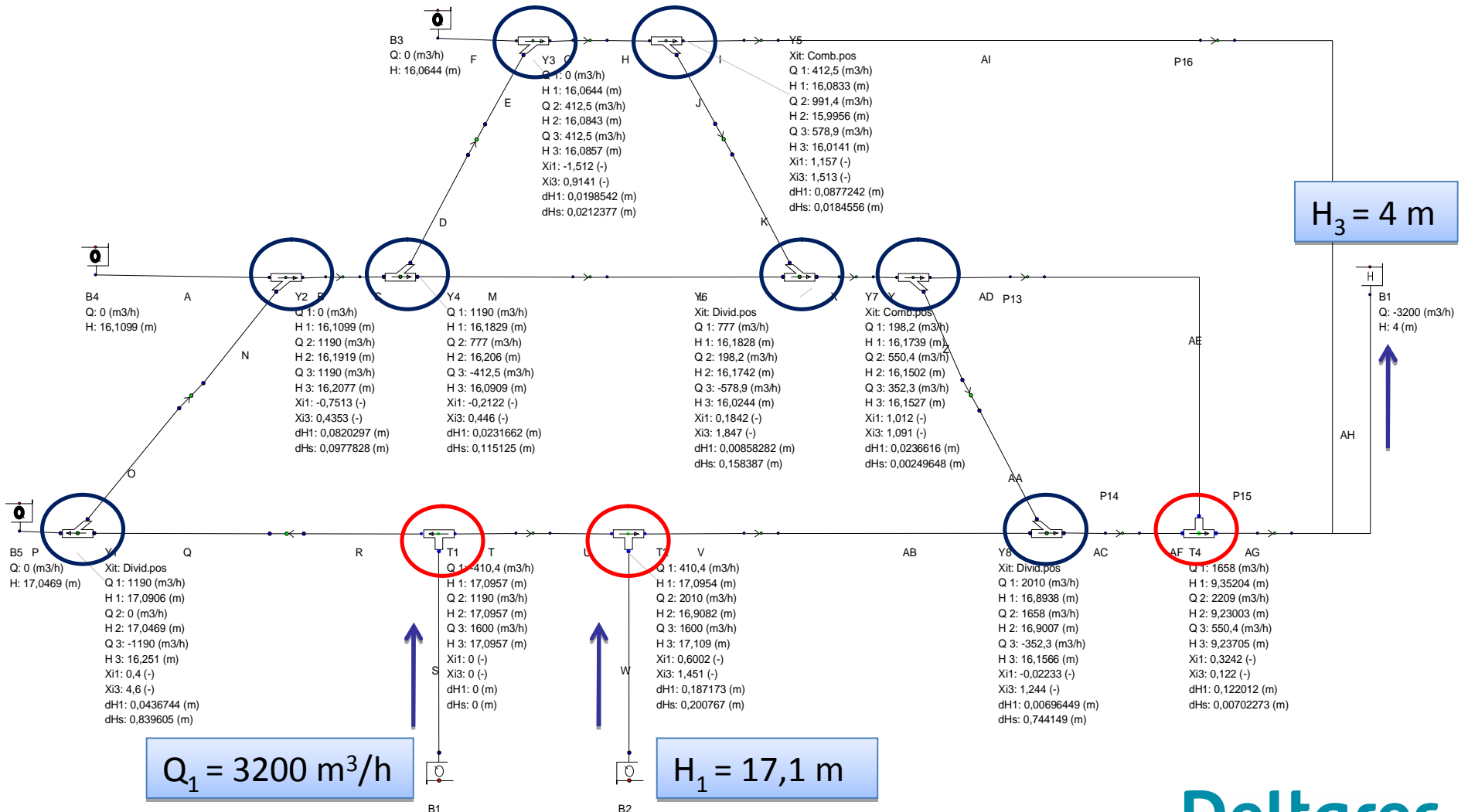
# T- Y – Junction - application



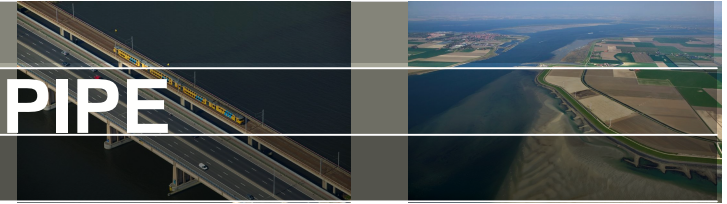
$H_2 = 16 \text{ m}$



$DH = 1,1 \text{ m}$



# Wanda 4 Liquid – “all in one” PIPE



Wanda 3 several “water hammer” PIPEs:

PIPE – rough	input: k-value
PIPE – lambda	input: lambda
PIPE – xi-losses	input: k-value + table extra losses ksi
PIPE – eq.D	input: k-value + table extra losses L_eqD

for. EPANET import

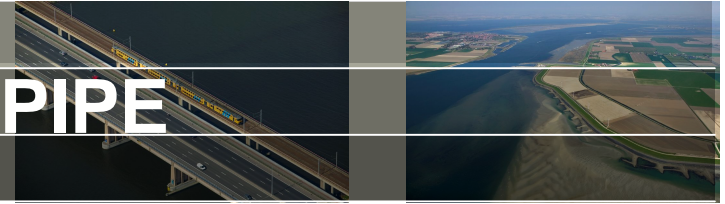
PIPE – Epanet	choice between several resistance models:
	Darcy-Weisbach (k-value)
	Chezy-Manning
	Hazen-Williams

for advise project:

PIPE met bi-directional extra local losses (ksi)

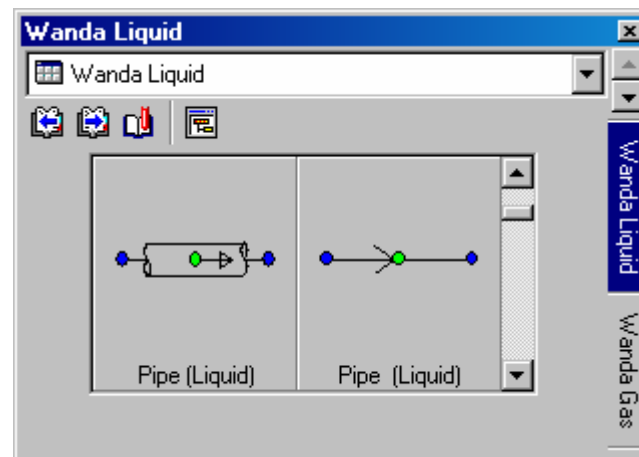


# Wanda 4 Liquid – “all in one” PIPE



All PIPEs replaced by 1 new all-comprising type

REQUEST: water hammer PIPE with rectangular cross section

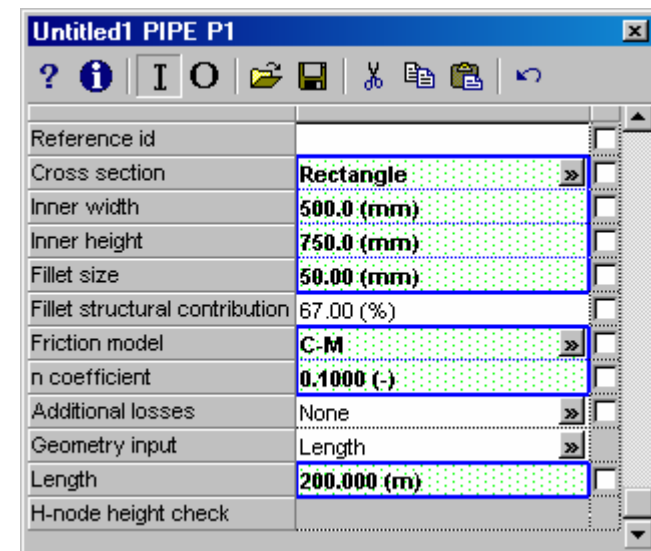
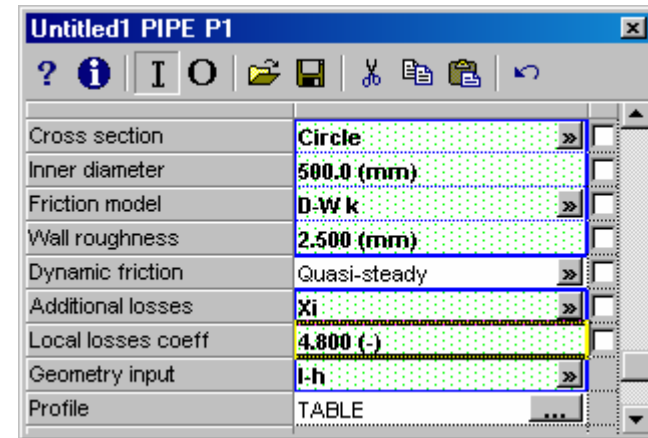


Two different (but familiar) symbols for the same model

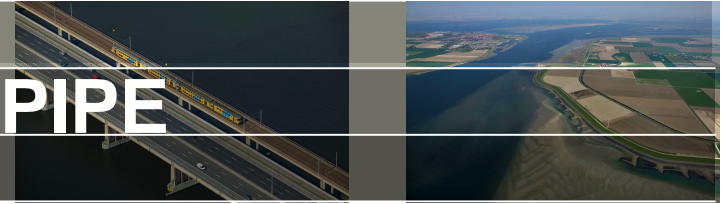
# Wanda 4 Liquid – “all in one” PIPE

Choose input by drop-down list:

- Cross section:
  - **circle**
  - rectangle
- Friction model:
  - **Darcy-Weisbach k-value**
  - Darcy-Weisbach lambda-value
  - Chezy-Manning
  - Hazen- Williams



# Wanda 4 Liquid – “all in one” PIPE



Choose input by drop-down list (2):

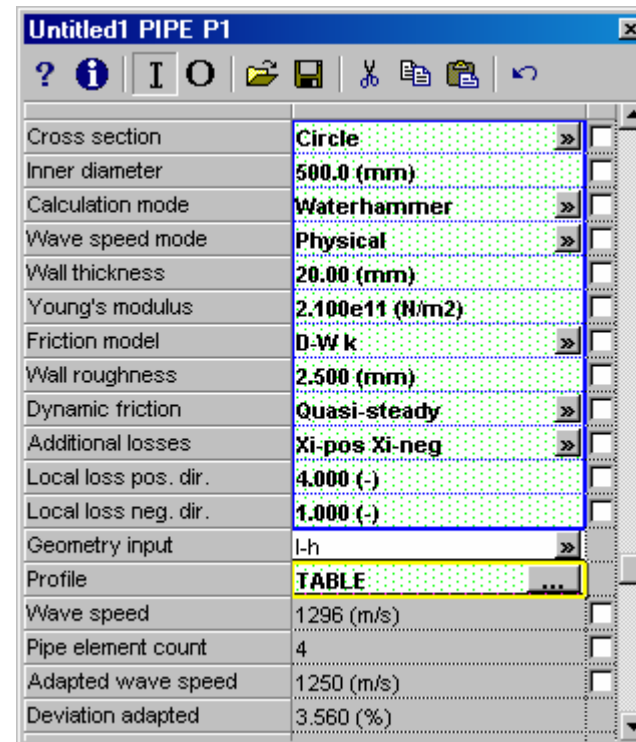
- Extra losses
  - **non**
  - Xi value (independent of flow direction)
  - Xi value Pos / Xi value Neg
  - Xi table
  - L\_equivalent #D table
- Dynamic friction
  - **Quasi steady**
  - none

# Wanda 4 Liquid – “all in one” PIPE

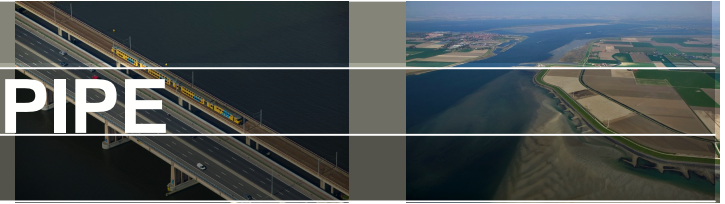
Choose input by drop-down list (3):

Solely in Transient mode

- Calculation mode
  - **Water hammer**
  - Rigid column
- Wave speed mode
  - **Physical**
  - Specified



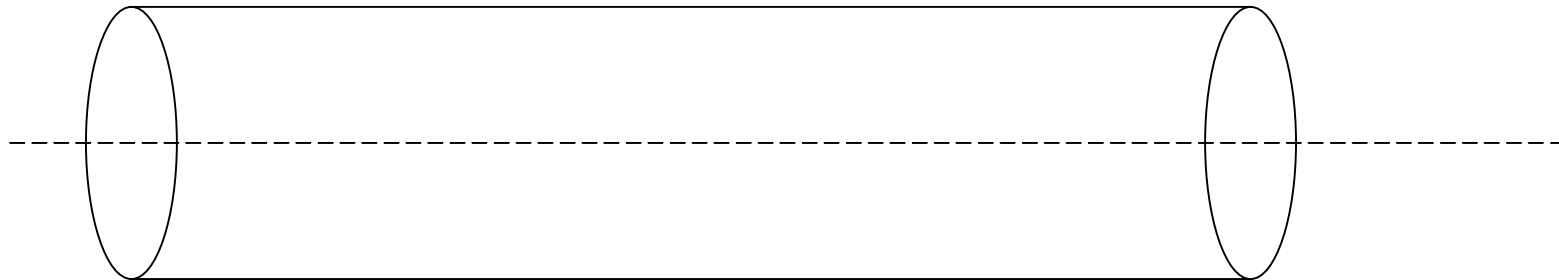
# Wanda 4 Liquid – “all in one” PIPE



Change in definition of geometry / reference plane:

Wanda 3.7      upper inner side

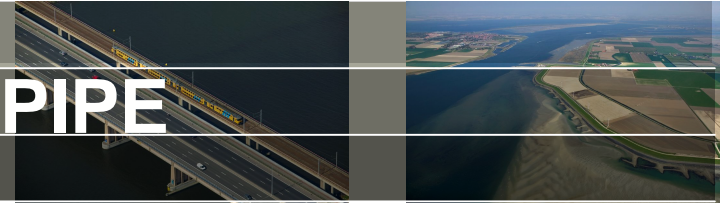
Wanda 4        center line



For cavitation model the upper inner side is determining:  
center line +  $\frac{1}{2} D$

Min/Max pressure: with respect to center line

# Wanda 4 Liquid – “all in one” PIPE

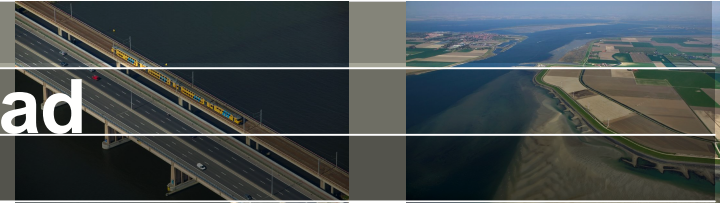


All WANDA 3.7 models (en older) will be automatically converted to the new PIPE

Input profiles will be shifted down by  $\frac{1}{2} D$



# Wanda 4 Liquid - elevation head

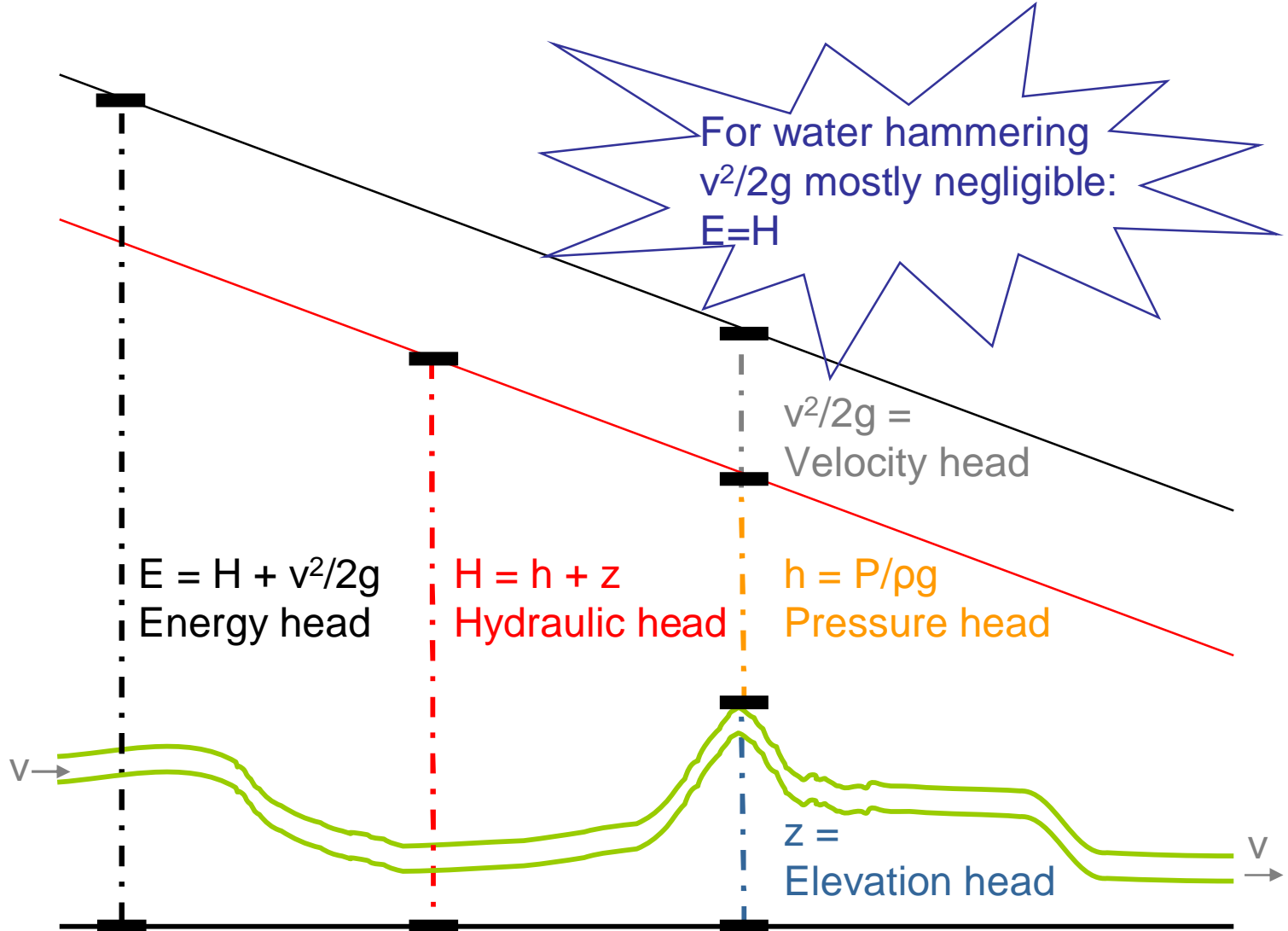


Energy Gradient

Hydraulic Gradient

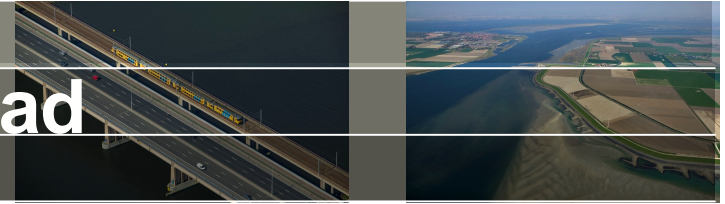
Pipeline profile

Reference level





# Wanda 4 Liquid - elevation head



In WANDA 4 velocity head term **is** incorporated

Order of magnitude:  $v = 1 \text{ m/s}$   $v^2/2g \approx 0,05 \text{ m}$

$v = 3 \text{ m/s}$   $v^2/2g \approx 0,46 \text{ m}$

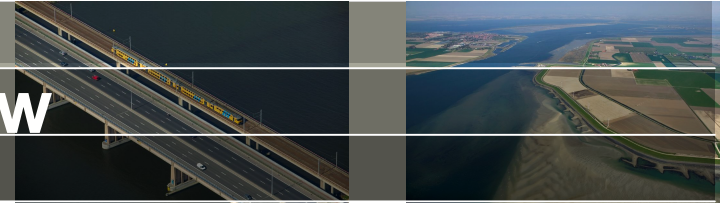
Solely for those components for which the velocity is known (which excludes e.g. the PUMP)

Consequence: Pressure in WANDA 4 is somewhat lower than in WANDA3

( 0,005 – 0,05 Bar ; 0,5 - 5 kPa)

HEAD calculation remains UNCHANGED

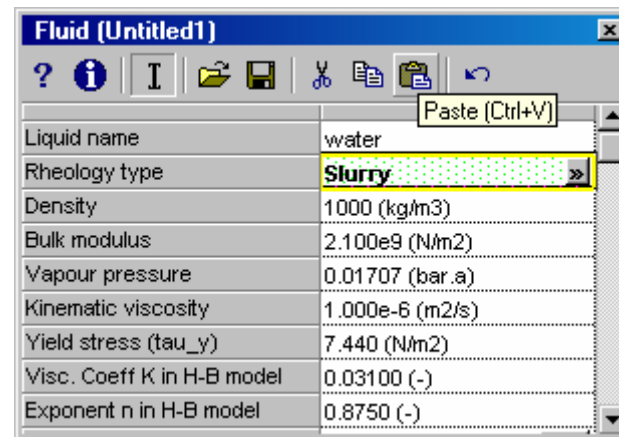
# Wanda 4 Liquid – Fluid window



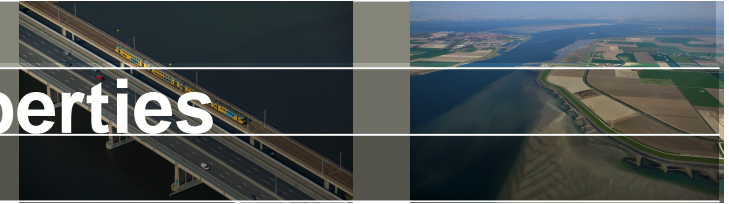
NEW (Option): resistance model for slurries  
(Non-Newtonian behavior)

Choice in Fluid window: **Newtonian** / Slurry

In case of a slurry: extra input parameters for Herschel-Bulkley model



# Wanda 4 Liquid – Output properties



Changed:

Order of output properties

Per connect node Q, H, P, v

(First: primary calculation variables,  
Next: derived calculation variables)

Property	Unit	Checkbox
Messages		<input type="checkbox"/>
Discharge 1	(m <sup>3</sup> /h)	<input type="checkbox"/>
Head 1	(m)	<input type="checkbox"/>
Pressure 1	(barg)	<input type="checkbox"/>
Velocity 1	(m/s)	<input type="checkbox"/>
Discharge 2	(m <sup>3</sup> /h)	<input type="checkbox"/>
Head 2	(m)	<input type="checkbox"/>
Pressure 2	(barg)	<input type="checkbox"/>
Velocity 2	(m/s)	<input type="checkbox"/>
Discharge 3	(m <sup>3</sup> /h)	<input type="checkbox"/>
Head 3	(m)	<input type="checkbox"/>
Pressure 3	(barg)	<input type="checkbox"/>
Velocity 3	(m/s)	<input type="checkbox"/>
Loss coeff. straight	(-)	<input type="checkbox"/>
Loss coeff. side	(-)	<input type="checkbox"/>
Head loss straight	(m)	<input type="checkbox"/>
Head loss side	(m)	<input type="checkbox"/>