



Univerzitet u Beogradu
Građevinski fakultet
Odsek za hidrotehniku i vodno ekološko inženjerstvo

Mehanika fluida – napredni kurs

MODELIRANJE TEČENJA U KANALU SA SUŽENJEM
PRIMENOM SOFTVERA IRIC NAYSCUBE

Mentori:

Prof. dr Dušan Prodanović

Docent dr Damjan Ivetić

Student:

Dušan Marjanović 903/21

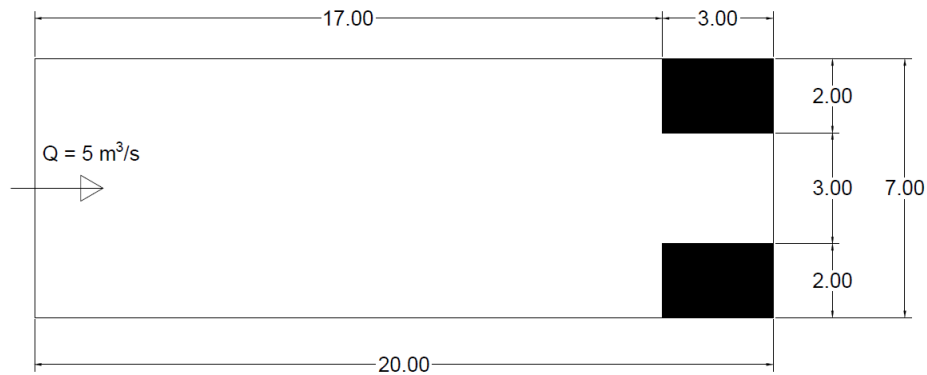
Beograd, 2022.

Opis problema

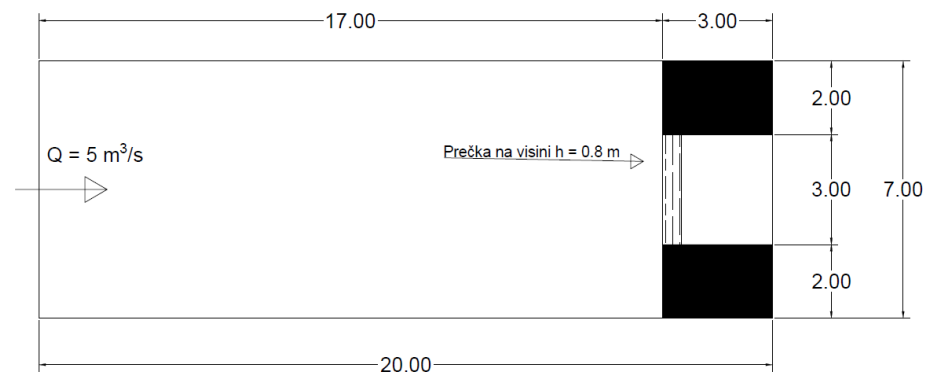
Analiza strujanja u kanalu sa suženjem

Kritična dubina u suženju iznosi: 0.656 m i ona se koristi kao granični uslov.

Varijanta 1:



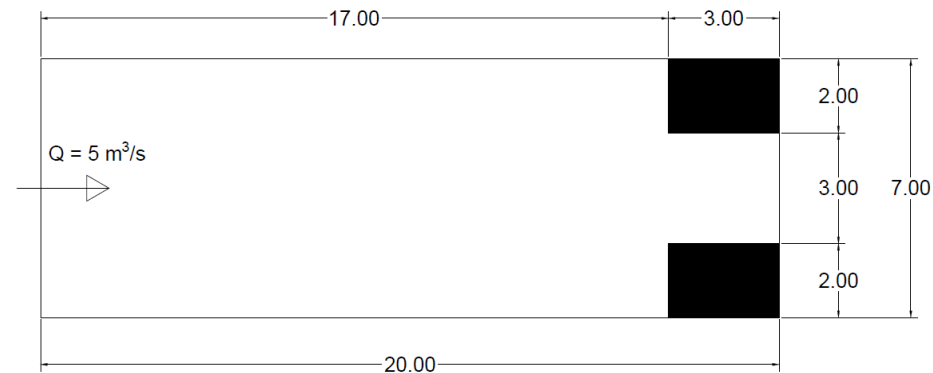
Varijanta 2:



Opis problema

Rezultati analize varijante 1 (u okviru NaysCUBE paketa) će biti upoređeni sa istim slučajem analiziranim u okviru TELEMAC-MASCARET softverskog paketa.

Varijanta 1:



IRIC

iRIC – International River Interface Cooperative

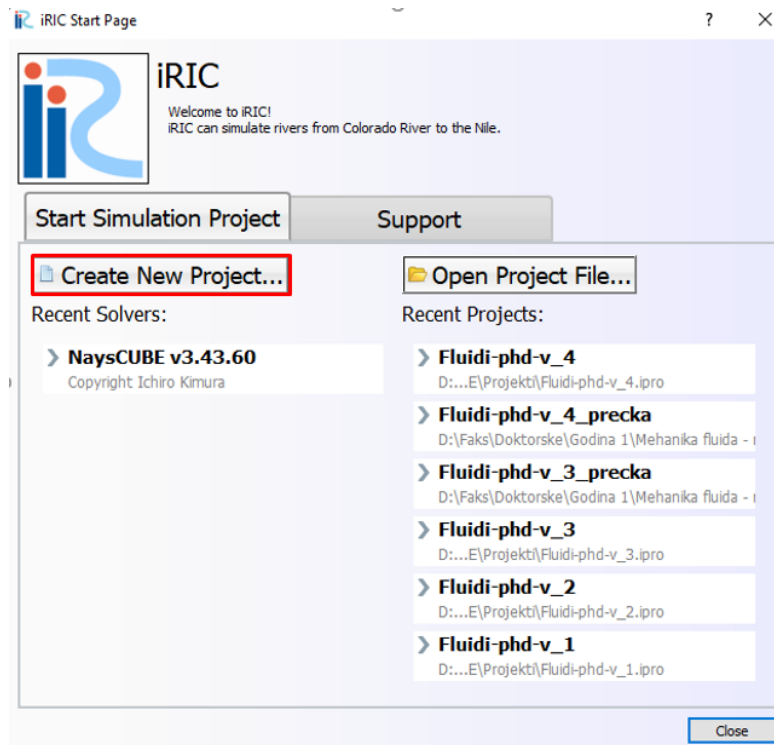
iRIC softver podrazumeva besplatnu platformu koja podržava veliki broj „solver“-a za probleme iz vodnog inženjeringa.

iRIC softver je pogodan za upotrebu zbog jednostavnog korisničkog interfejsa.

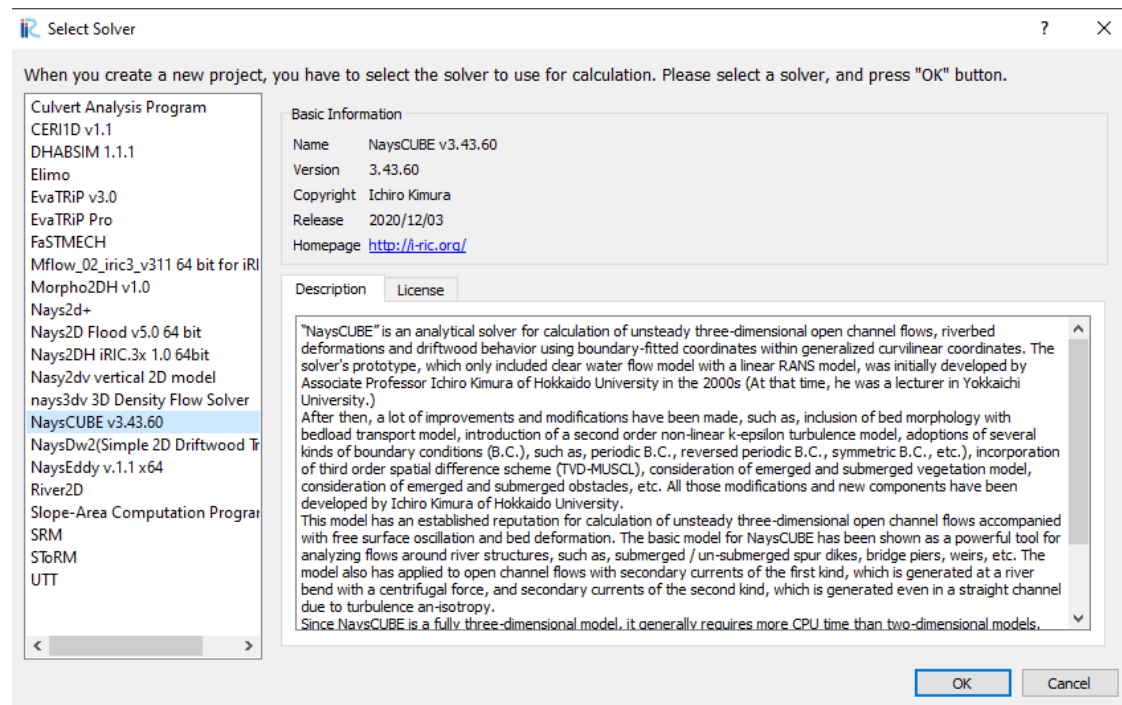
U okviru iRIC softvera, koristiće se NaysCUBE solver.

Postupak izrade modela

Prozor pri pokretanju programa



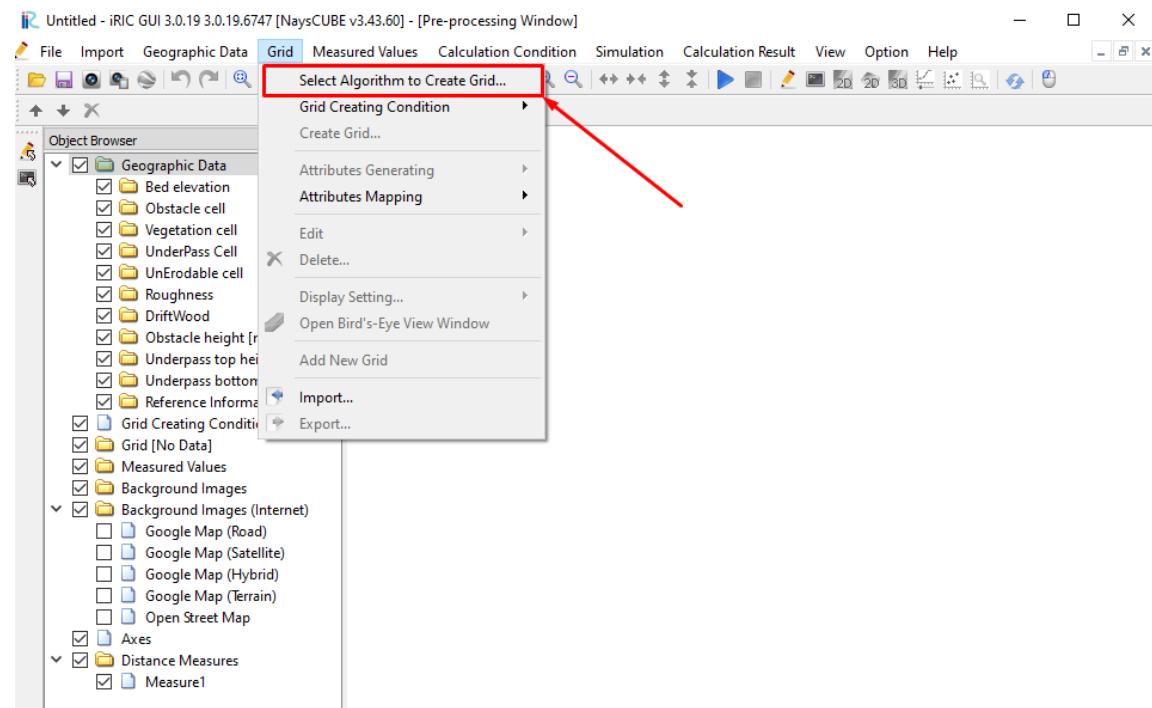
Odabir solvera



Postupak izrade modela

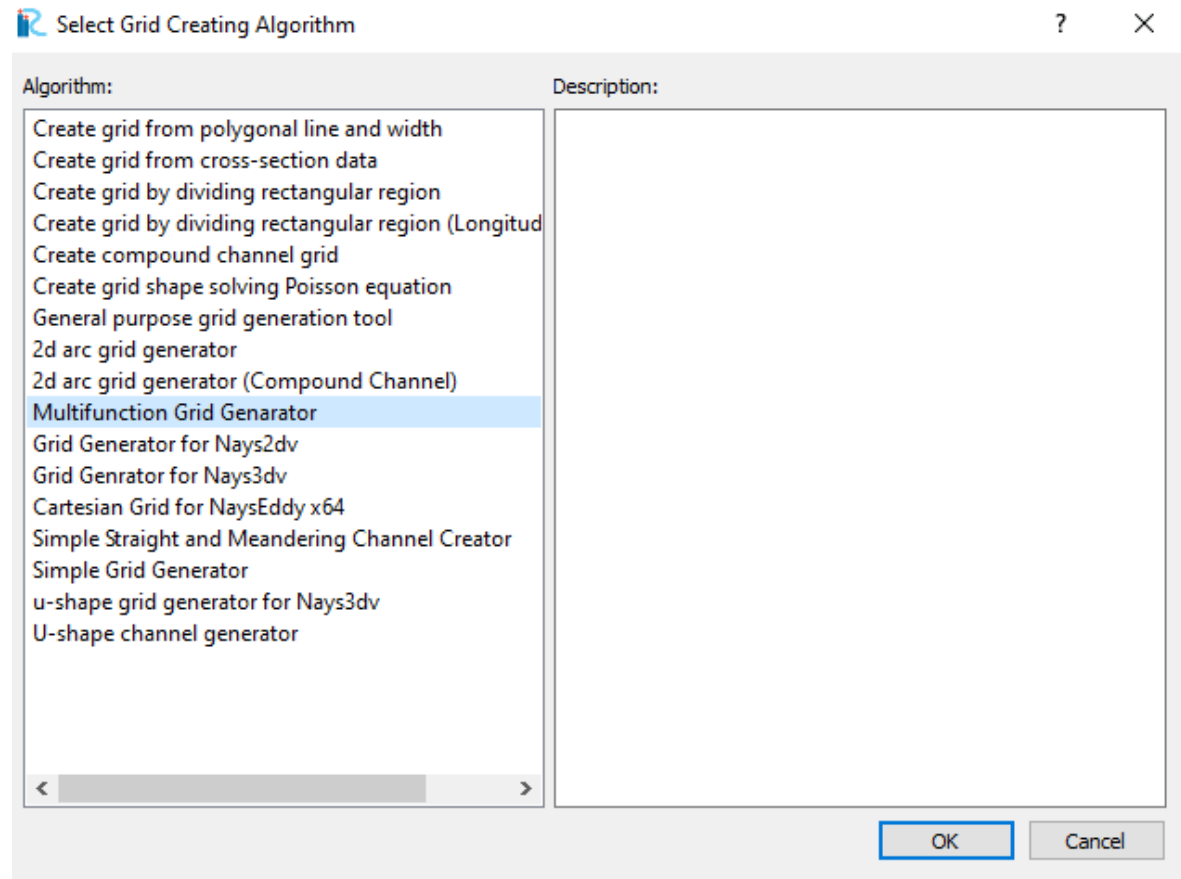
NaysCUBE solver diskretizuje prostor korišćenjem kvadratnih ćelija, dimenzije tih ćelija je moguće podešavati.

Prvo se bira algoritam kreiranja mreže.



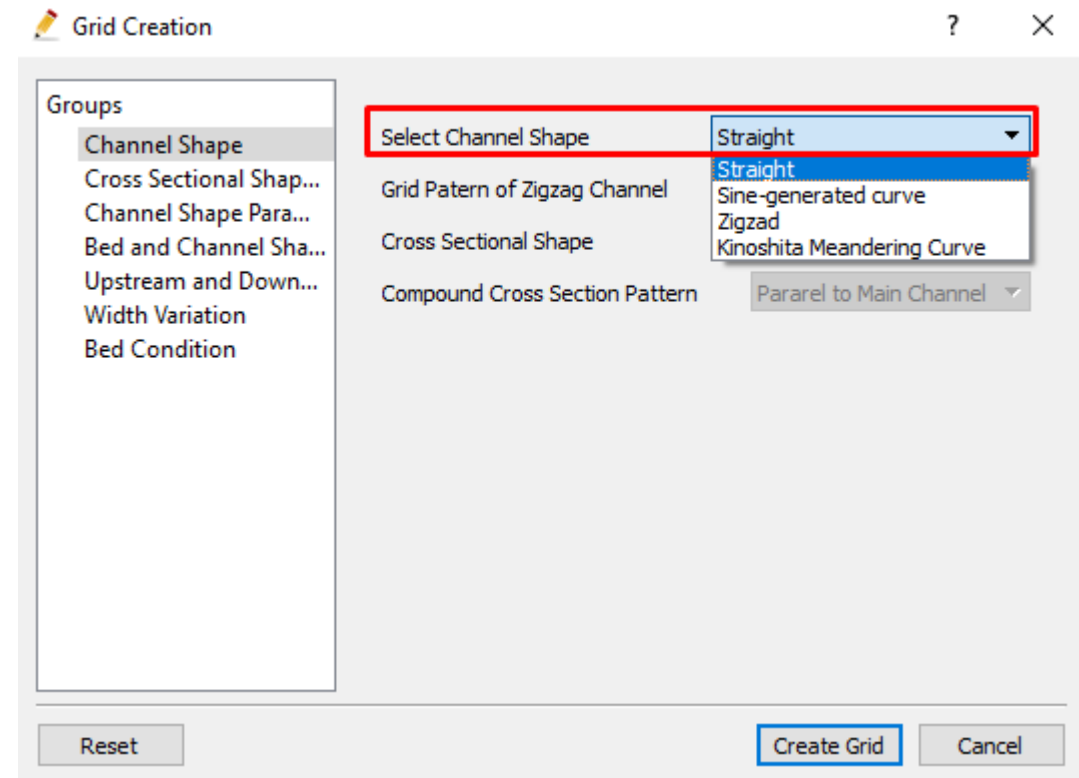
Postupak izrade modela

Iako je formalno moguće koristiti više algoritama za rešavanje zadatog problema, „Multifunction grid generator“ daje najviše slobode u podešavanju mreže korisniku.



Postupak izrade modela

Channel Shape „Straight“
podrazumeva prizmatičan kanal.



Postupak izrade modela

Grid Creation

Ovom dispozicijom se dobija kanal sa diskretizacijom $\Delta y = 0.2$ m

Groups

- Channel Shape
- Cross Sectional Shape Parameters
- Channel Shape Parameters
- Bed and Channel Shape
- Upstream and Downstream ...
- Width Variation
- Bed Condition

Single Cross Section

Width(m)

Number of Grid in Lateral Direction

Compound Channel

Numbers of Grids

Left Floodplain

Low Water Channel

Right Floodplain

Low Water Channel Depth(m)

Bank Slope Ratio of Low Water Channel

Numbers of Grids in Low Water Channel Bank

Simple Compound Channel

Channel Width

Left Flood Channel Width(m)

Low Water Channel Width(m)

Right Flood Channel Width(m)

With Straight or Meandering Levees

Total Width(m)

Low Water Channel Width(m)

Left Levee Distance from Channel Center(m)

Right Levee Distance from Channel Center(m)

Reset Create Grid Cancel

Grid Creation

Ovom dispozicijom se dobija kanal sa diskretizacijom $\Delta x = 0.2$ m

Groups

- Channel Shape
- Cross Sectional Shape Parameters
- Channel Shape Parameters
- Bed and Channel Shape
- Upstream and Downstream ...
- Width Variation
- Bed Condition

Wave Length of Meander(m)

Wave Number

Meander Angle(degree)

Number of Grids in One Wave Length

Levee Meander Parameters

Meander Angle(degree)

Meander Wave Length(m)

Phase Lag from LWC(m)

Kinoshita Meander Parameters

Additional Meander Angle(degree)

n1(Wave Number of the second term)

Reset Create Grid Cancel

Grid Creation

Initial Bed Shape

Bar Height or Amplitude of Parabolic Shape(m)

Lag Between Bar and Plane Geometry(m)

Channel Slope

Da bi program mogao da obavi proračun, neophodno je zadati nagib različit od nule!

Reset Create Grid Cancel

Diskretizacija kvadratnim ćelijama sa stranicama dužine 0.2 m je izabrana radi usaglašavanja sa TELEMAC simulacijom.

Postupak izrade modela

Grid Creation

Groups

- Channel Shape
- Cross Sectional Shap...
- Channel Shape Para...
- Bed and Channel Sha...
- Upstream and Down...
- Width Variation
- Bed Condition

Add straight channel in upstream and downstream

Number of Adding Sections in Upstream End

Number of Adding Sections in Downstream End

U ovoj kartici se ne zadaje nijedan parametar!

Grid Creation

Groups

- Channel Shape
- Cross Sectional Shape Paramet...
- Channel Shape Parameters
- Bed and Channel Shape
- Upstream and Downstream Co...
- Width Variation
- Bed Condition

Width Variation

Width Variation Type

Width Deviation(m)

Kanal konstantne širine!

Grid Creation

Groups

- Channel Shape
- Cross Sectional Shape Parameters
- Channel Shape Parameters
- Bed and Channel Shape
- Upstream and Downstream Condit...
- Width Variation
- Bed Condition

Low Water Channel

Bed Condition

Roughness Definition

Roughness Value

Floodplain

Bed Condition

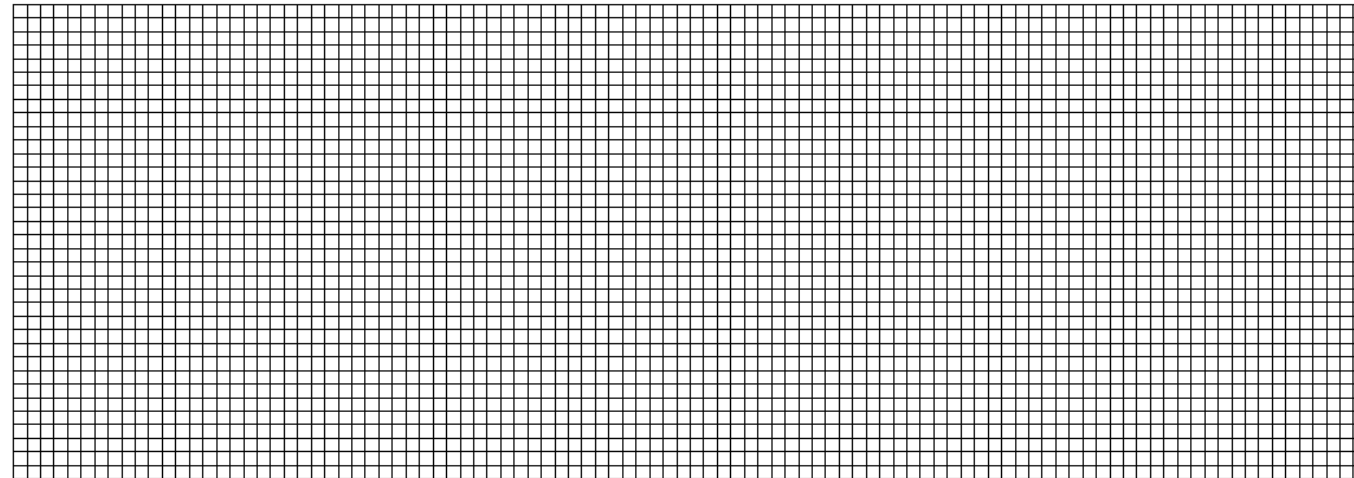
Roughness Definition

Roughness Value

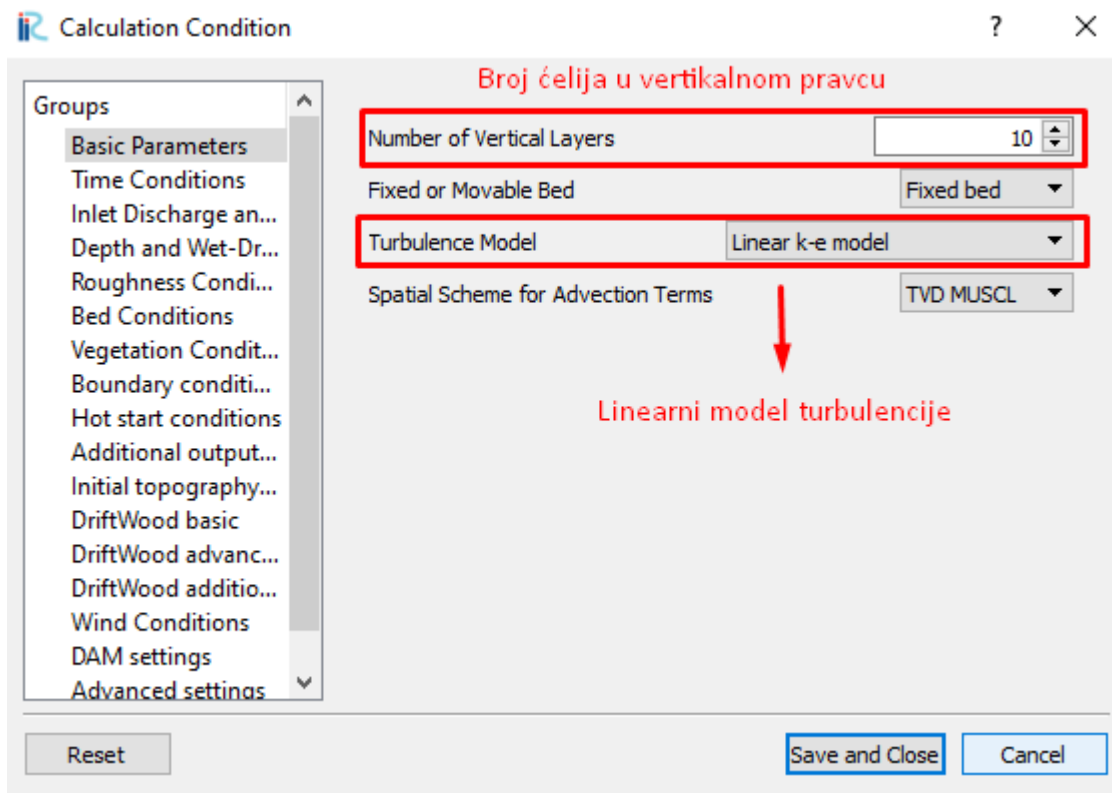
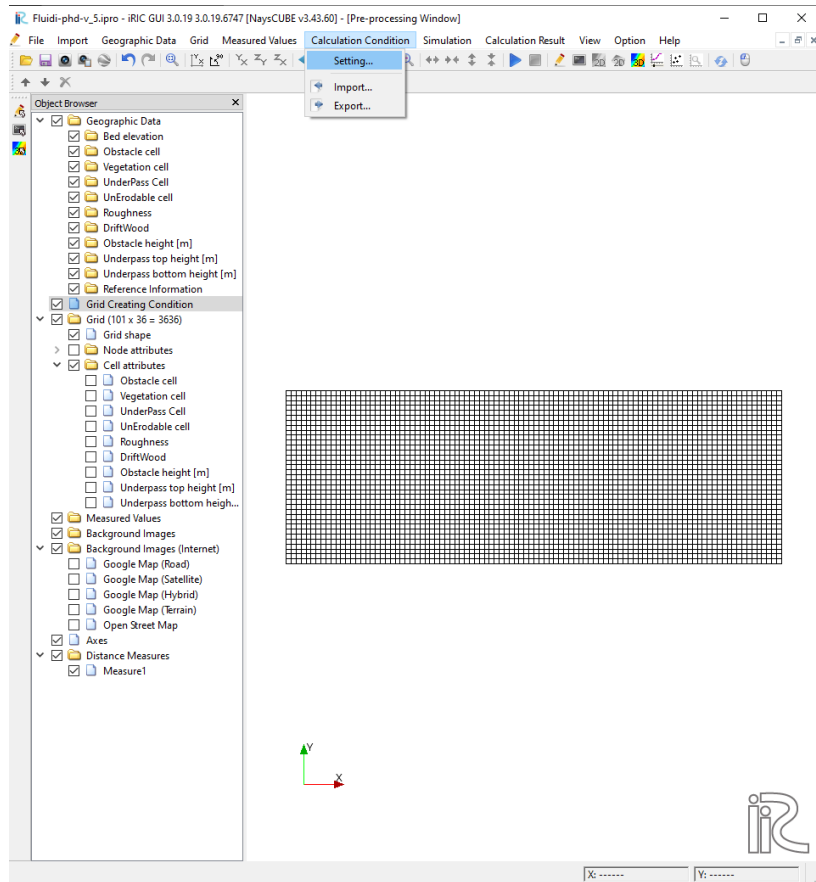
Neophodno je odabrati "Fixed Bed", odnosno "Nepokretno dno"!

Postupak izrade modela

Zaključno sa prethodnim korakom, pritiskom na dugme „Create Grid“, dobija se sledeća mreža:



Zadavanje proračunskih parametara



Zadavanje proračunskih parametara

Calculation Condition

Groups

- Basic Parameters
- Time Conditions
- Inlet Discharge and Outlet Wa...
- Depth and Wet-Dry Conditions
- Roughness Conditions
- Bed Conditions
- Vegetation Conditions
- Boundary conditions
- Hot start conditions
- Additional output files
- Initial topography correction
- DriftWood basic
- DriftWood advanced
- DriftWood additional
- Wind Conditions
- DAM settings
- Advanced settings

Start Time[s] 0

End Time[s] 60

File Output Time[s] 0.1

Start time of surface move[s] 0.5

Start time of bed move[s] 2

Variable DT with CFL condition Fixed DT

Coefficient for CFL condition 0.13

Time Step[s] 0.01

Display output interval 1

Vrlo bitno!
Može izazvati numeričku nestabilnost
ako se loše zada

Reset Save and Close Cancel

Calculation Condition

Zadato zadatkom

Groups

- Basic Parameters
- Time Conditions
- Inlet Discharge and Outl...
- Depth and Wet-Dry Con...
- Roughness Conditions
- Bed Conditions
- Vegetation Conditions
- Boundary conditions
- Hot start conditions
- Additional output files
- Initial topography correc...
- DriftWood basic
- DriftWood advanced
- DriftWood additional
- Wind Conditions
- DAM settings
- Advanced settings

Hydrograph Data Type Constant discharge

Constant Discharge[m3/s] 5

Outlet water level for fixed Q given as a constant

Outlet water level for variable Q set from uniform flow

Constant outlet water level[m] 0.656

Unit of time for Q Kritična dubina! second

Time series of Q at inlet Edit

Time series of Q at inlet and WL at outlet Edit

Q gradual increase Q given directly

Initial Q rate 0.1

Time for Q slope[s] 10

Nema promene proticaja u vremenu

Reset Save and Close Cancel

Zadavanje proračunskih parametara

Calculation Condition

Minimalna dubina kanala je 0

Groups

- Basic Parameters
- Time Conditions
- Inlet Discharge and O...
- Depth and Wet-Dry C...
- Roughness Conditions
- Bed Conditions
- Vegetation Conditions
- Boundary conditions
- Hot start conditions
- Additional output files
- Initial topography cor...
- DriftWood basic
- DriftWood advanced
- DriftWood additional
- Wind Conditions
- DAM settings
- Advanced settings

Wet and Dry Cells: Fixed wet and dry cells

Minimum Depth[m]: 0

How to give initial surface slope?: Given by parabolic curve fit

Initial surface slope: 0.0001

Relaxation coefficient: 0.3

Reset Save and Close Cancel

Calculation Condition

Groups

- Basic Parameters
- Time Conditions
- Inlet Discharge and Outlet WaterL...
- Depth and Wet-Dry Conditions
- Roughness Conditions
- Bed Conditions
- Vegetation Conditions
- Boundary conditions
- Hot start conditions
- Additional output files
- Initial topography correction
- DriftWood basic
- DriftWood advanced
- DriftWood additional
- Wind Conditions
- DAM settings
- Advanced settings

How to evaluate u^* at BED?: Manning Law

Manning n for zone A: 0.012

Manning n for zone B: 0.012

Manning n for zone C: 0.012

Manning n for zone D: 0.012

Manning n for zone E: 0.012

How to calculate u^* at WALL?: Manning Law

Manning n for WALL: 0.012

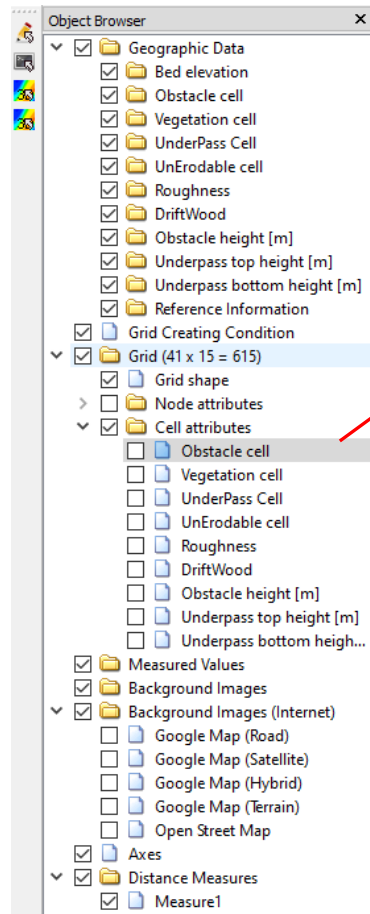
Manning n for obstade: 0.012

Maningova hrapavost uniformna za svaki deo ispitivane deonice!

Reset Save and Close Cancel

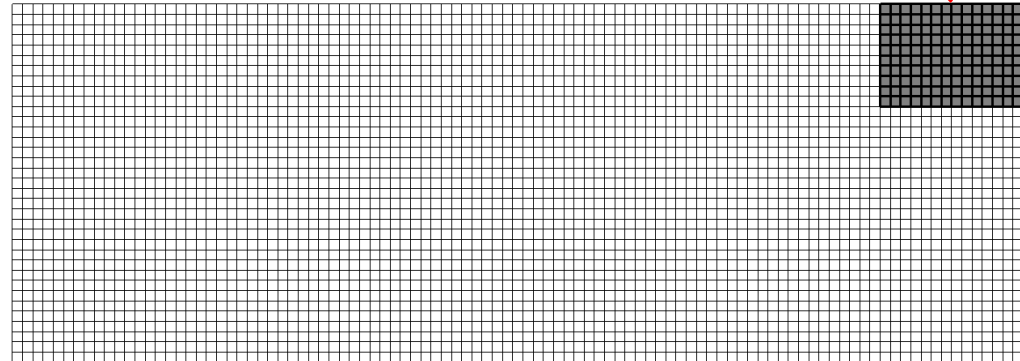
Kako ostale kartice nisu od interesa za ovaj problem, preskaču se.

Postavljanje prepreka

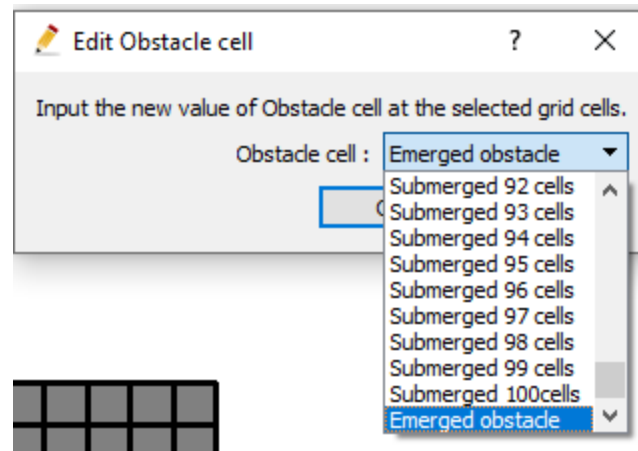
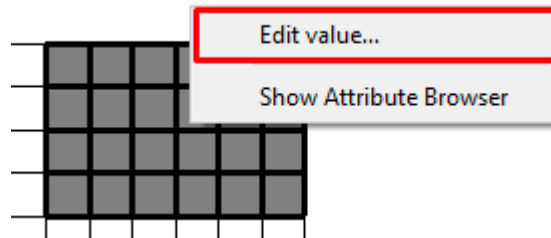


Klikne se na atribut „Obstacle cell“

Obeleži se površina na kojoj se nalazi prepreka

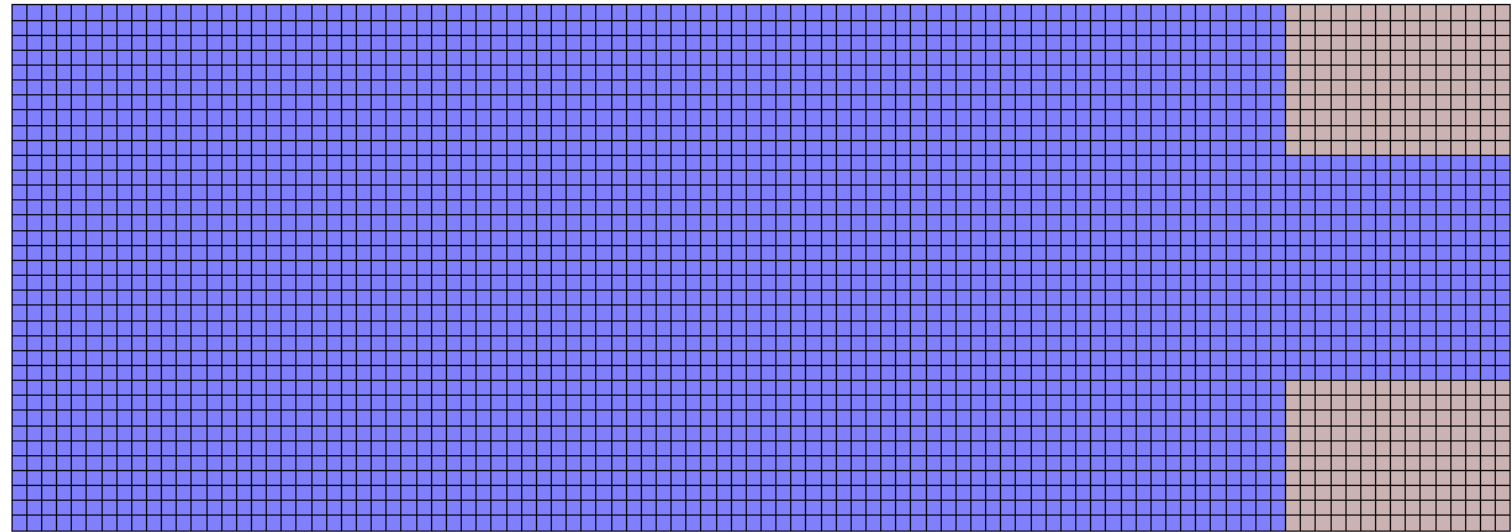
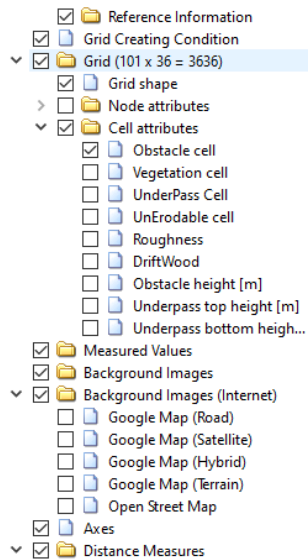


Postavljanje prepreka



Pojam „Emerged obstacle“ podrazumeva prepreku čija je visina uvek jednaka dubini vode u ćeliji u kojoj se prepreka nalazi

Postavljanje prepreka



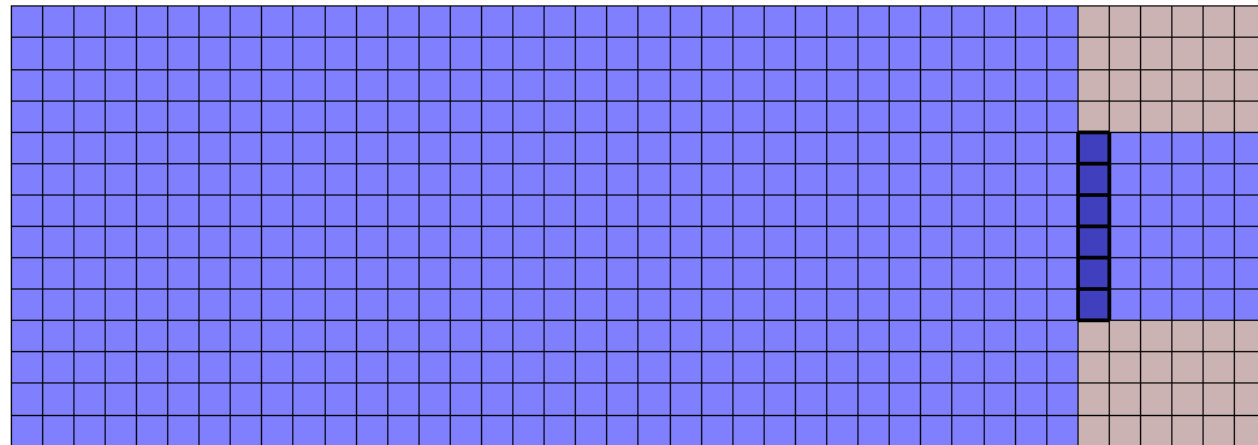
Štikliranjem ćelije „Obstacle cell“ možemo videti koje ćelije u mreži sadrže prepreke.

Sa time, završena je dispozicije varijante 1

Postavljanje prepreka – Varijanta 2

Druga varijanta koja se razmatra ima isto suženje na kraju kanala, sa prečkom debljine 10 cm, koja se nalazi na početku suženja, na visini 80 cm

- Grid (41 x 15 = 615)
- Grid shape
- Node attributes
- Cell attributes
 - Obstacle cell
 - Vegetation cell
 - UnderPass Cell
 - UnErodable cell
 - Roughness
 - DriftWood
 - Obstacle height [m]
 - Underpass top height [m]
 - Underpass bottom heigh...
- Measured Values
- Background Images
- Background Images (Internet)
 - Google Map (Road)
 - Google Map (Satellite)
 - Google Map (Hybrid)
 - Google Map (Terrain)
 - Open Street Map

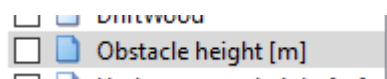


Prvo se obeleže ćelije gde se nalazi prepreka, radi lakše orijentacije, ostala je štiklirana kartica „Obstacle cell“, imajući na umu da se prepreka nalazi u samom suženju.

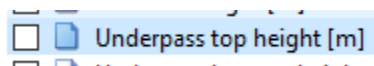
Napomena: Zbog numeričkih nestabilnosti u proračunu, diskretizacija u ovoj varijanti je promenjena na $\Delta x/\Delta y = 0.5 \text{ m}/0.5 \text{ m}$

Postavljanje prepreka – Varijanta 2

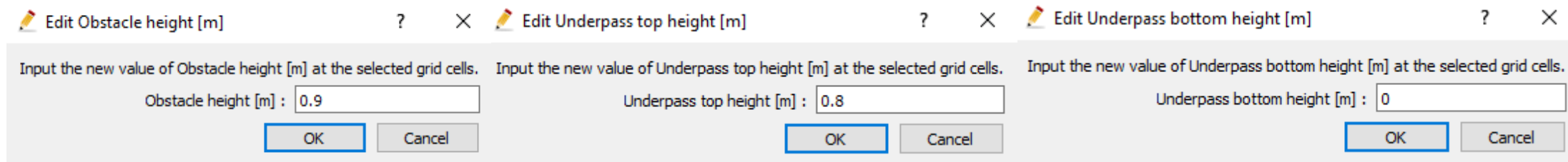
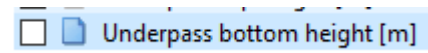
1



2

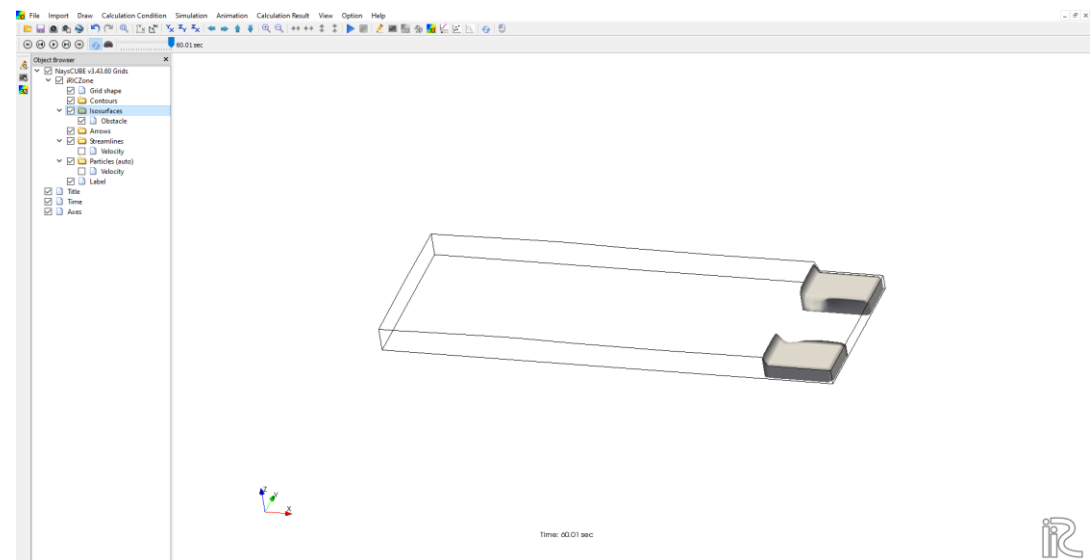
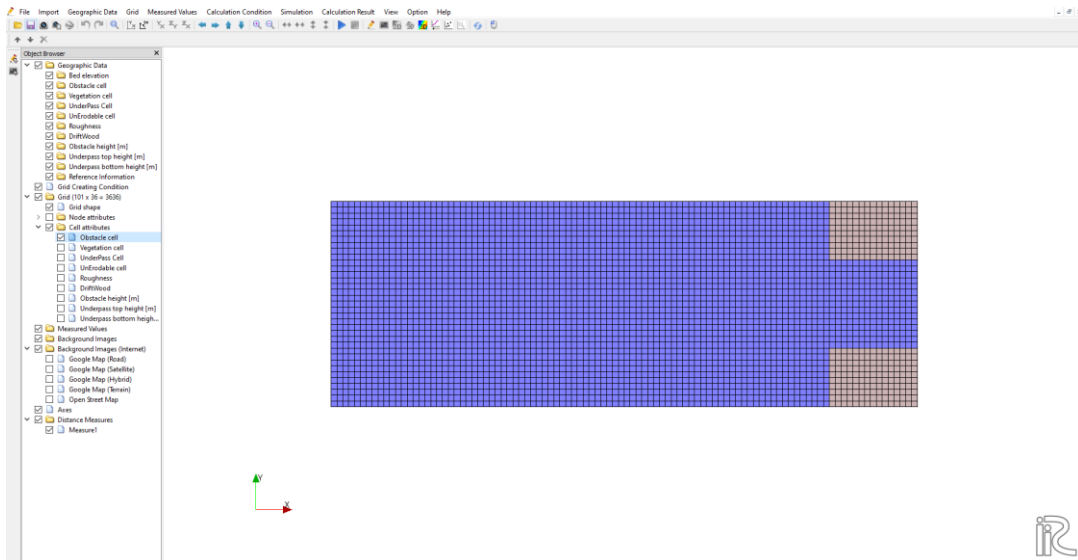


3

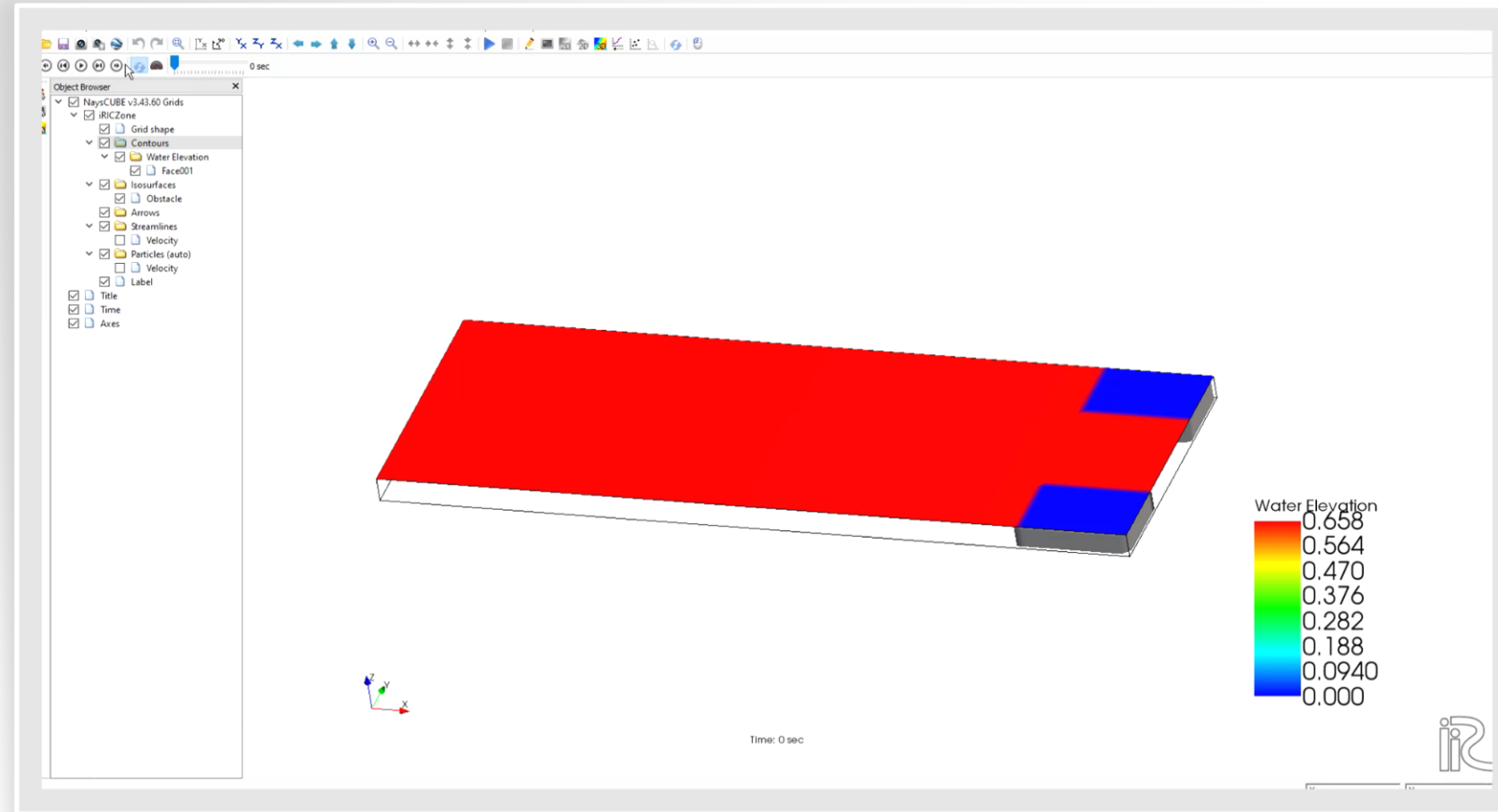


Zaključno sa ovim, postavljena je prečka iz varijante 2

Rezultati – Varijanta 1

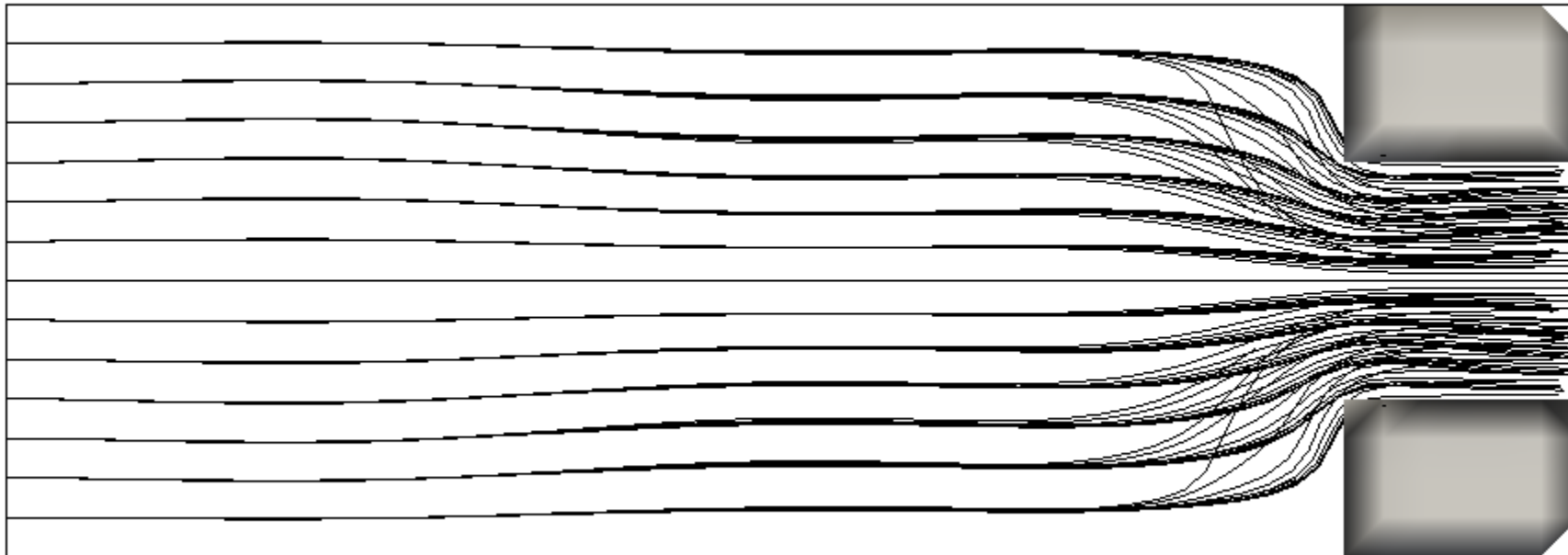


Rezultati – Varijanta 1



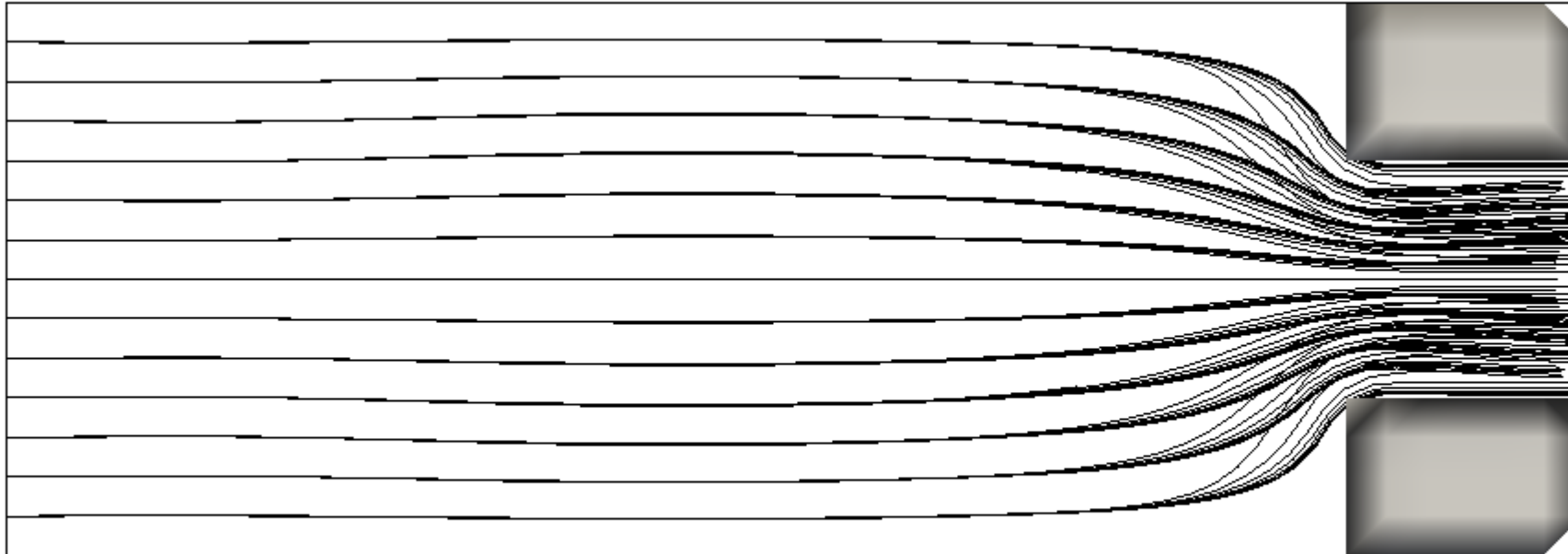
Rezultati – Varijanta 1

Strujnice u $t = 30s$



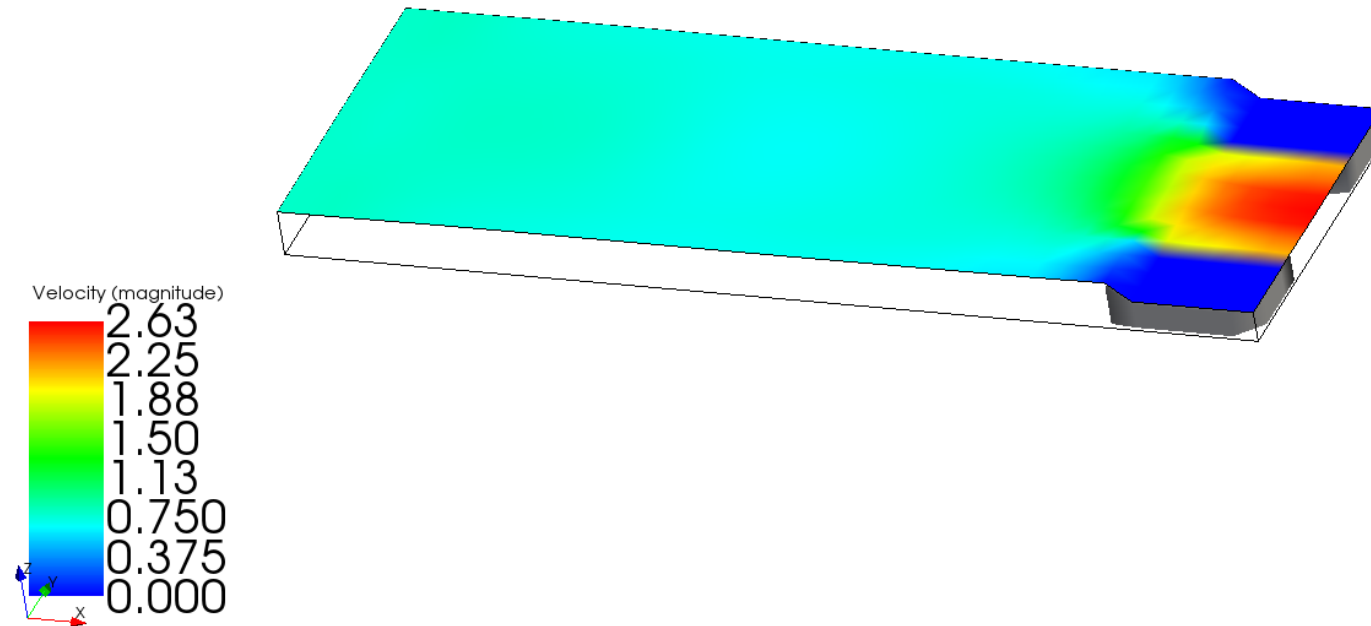
Rezultati – Varijanta 1

Strujnice na kraju simulacije od 60s



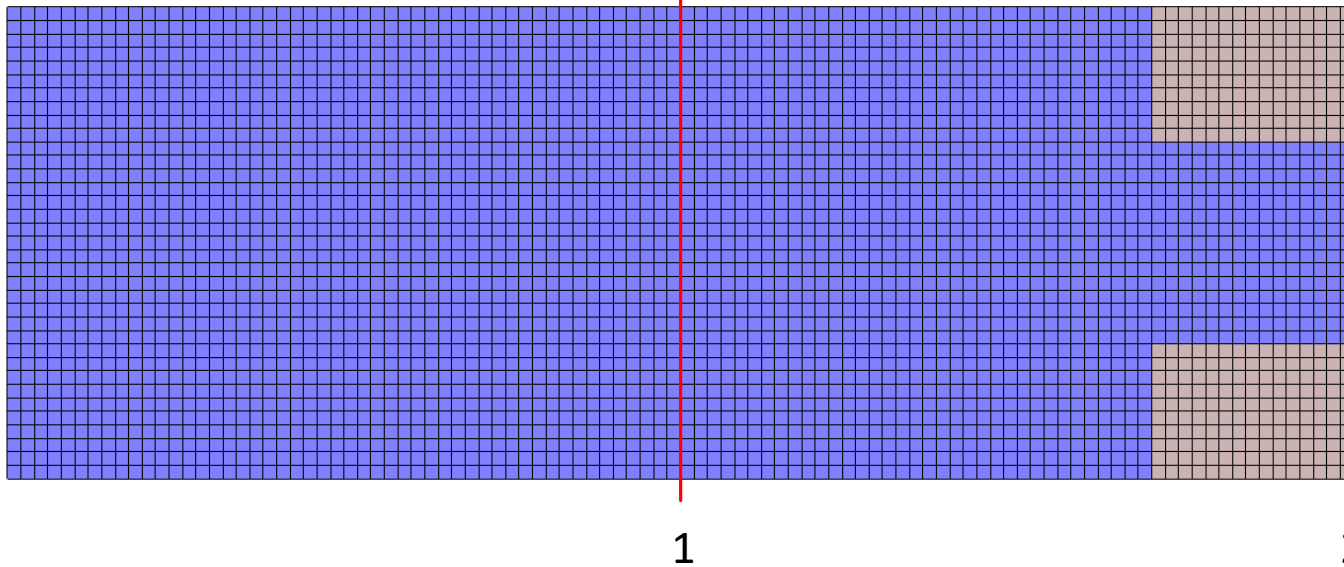
Rezultati – Varijanta 1

Colormap brzina na kraju simulacije



Rezultati – Varijanta 1

Proračun lokalnog koeficijenta gubitka



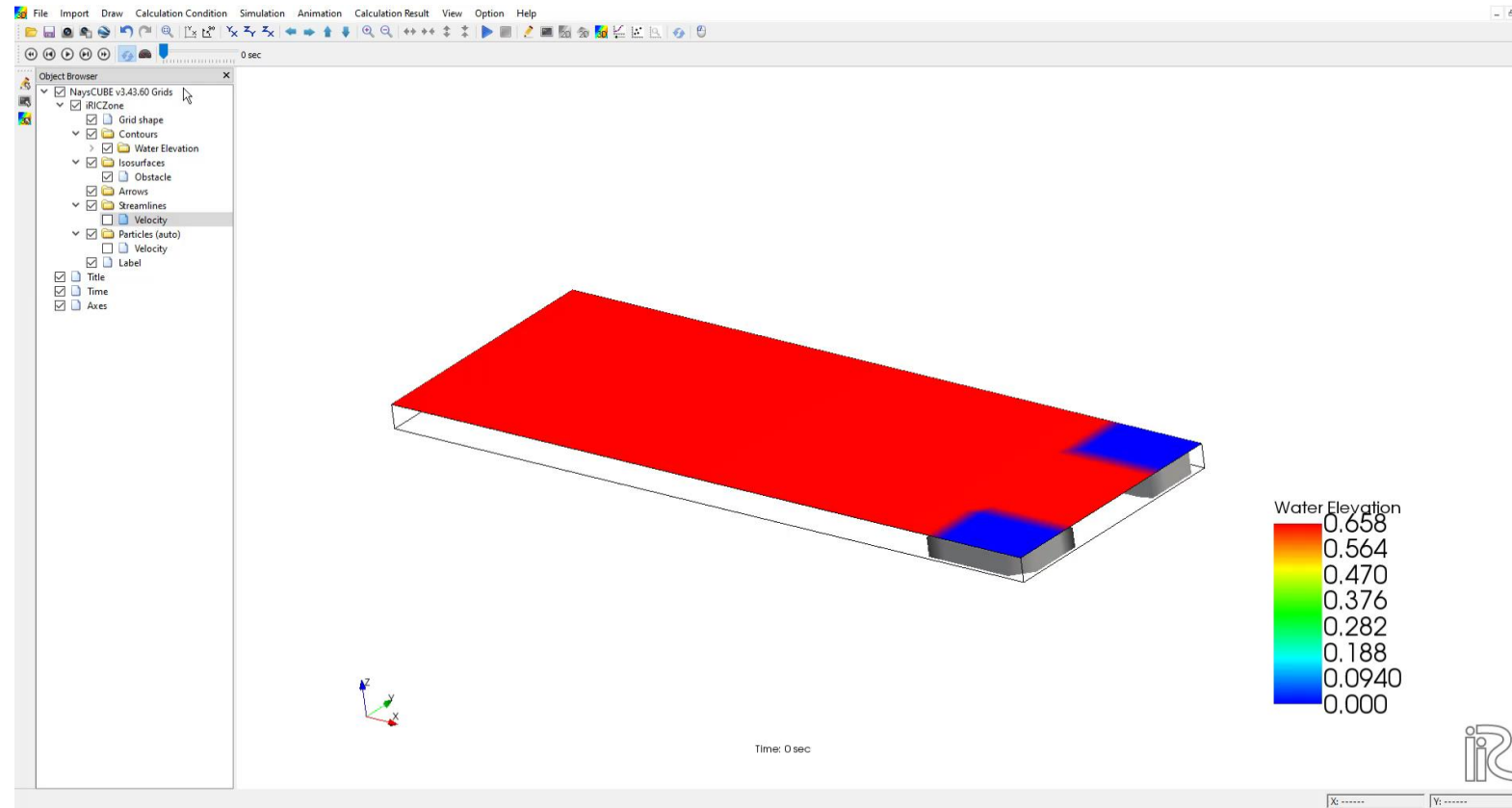
Razmatrani preseki se nalaze $x = 10$ m i $x = 20$ m

Korišćenjem srednje profilske brzine, moguće je pomoću energetske jednačine izračunati lokalni koeficijent gubitka između tih preseka

Prilikom proračuna, korišćena je osrednjena dubina duž izabranog preseka

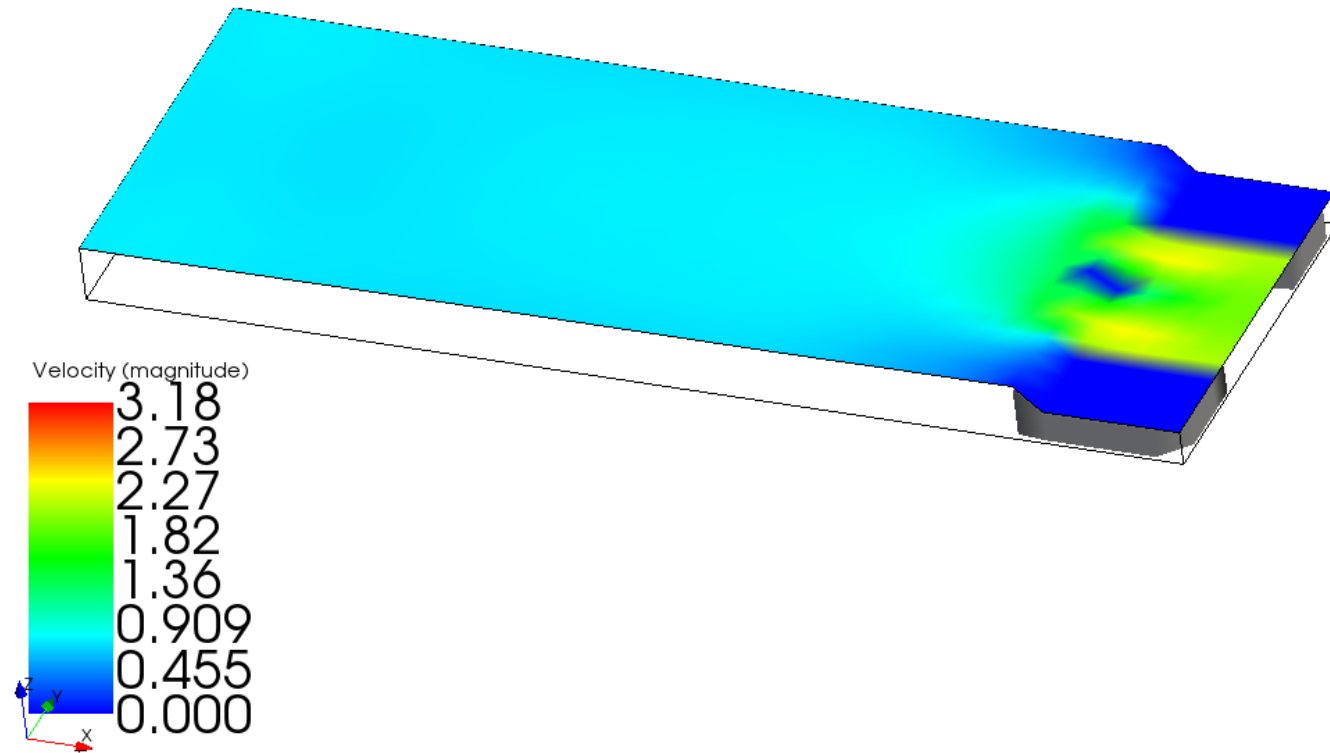
Koeficijent lokalnog gubitka za ovu varijantu iznosi: $\xi = 0.297$

Rezultati – Varijanta 2



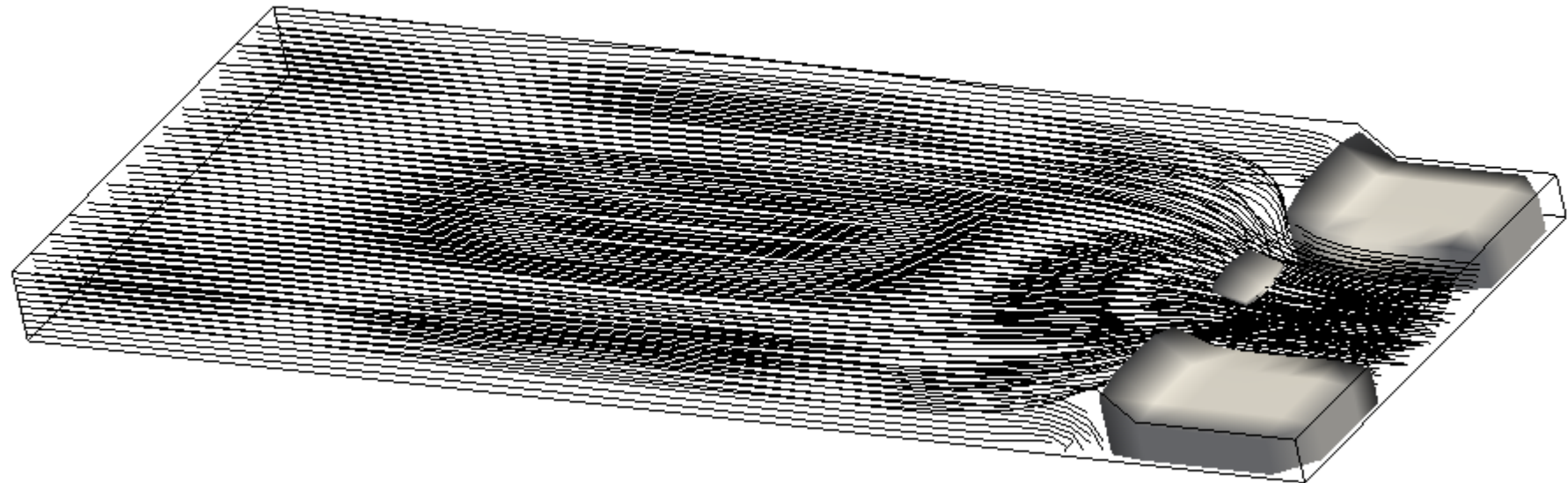
Rezultati – Varijanta 2

Colormap brzina na kraju simulacije



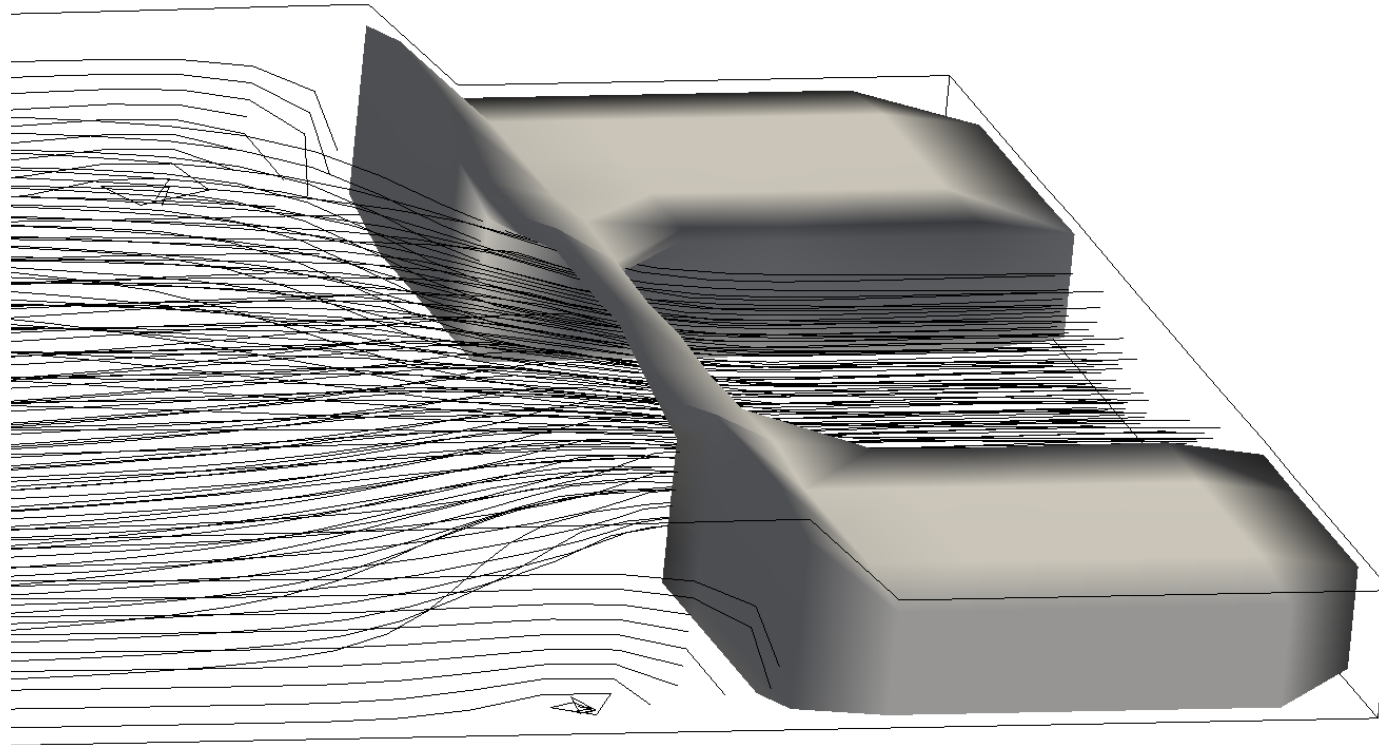
Rezultati – Varijanta 2

Strujnice na kraju simulacije od 60s



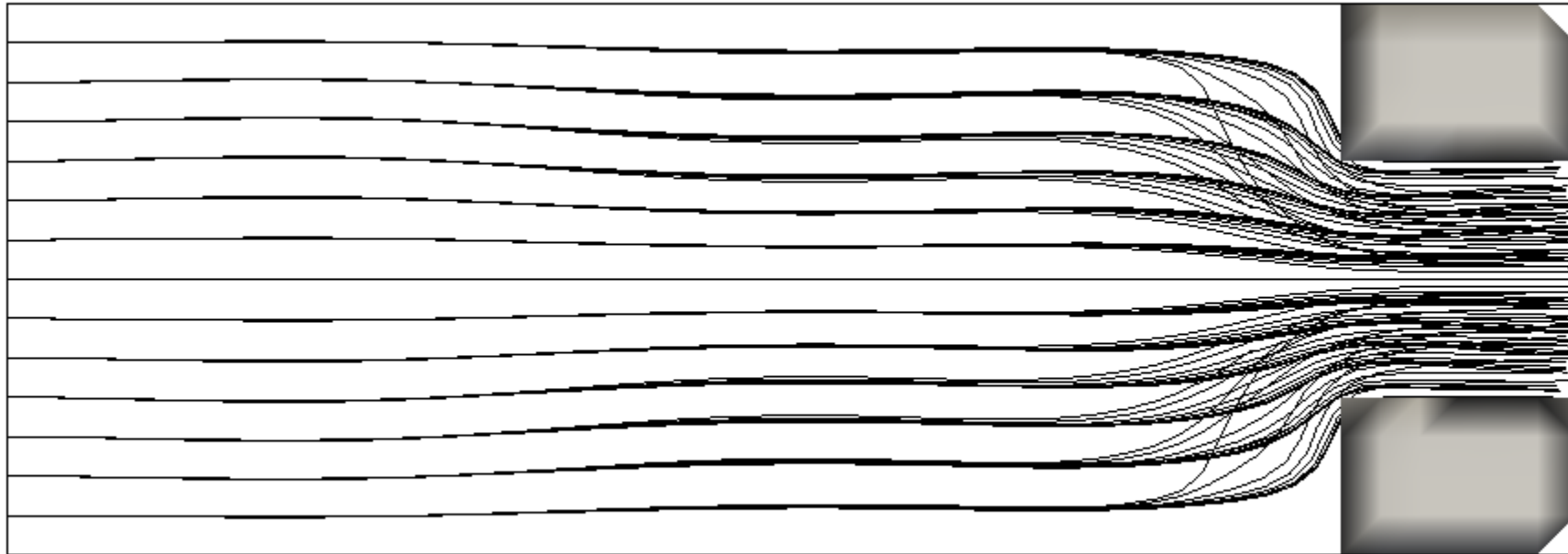
Rezultati – Varijanta 2

Detalj strujnica kod prečke



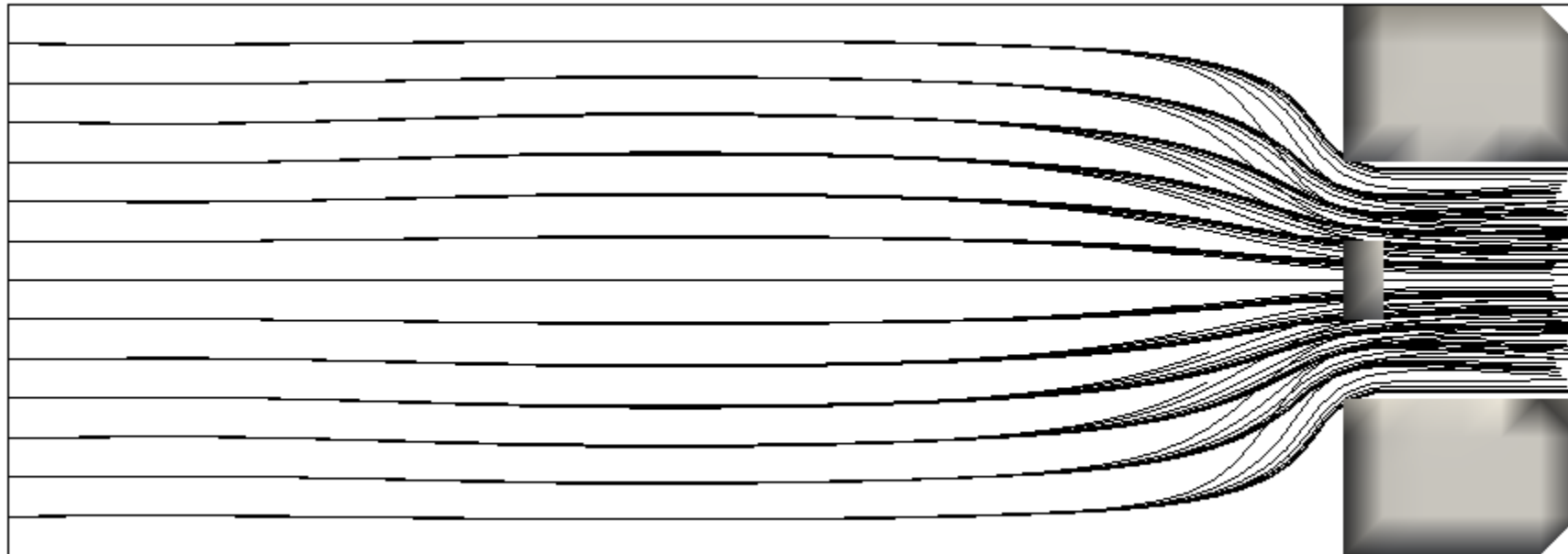
Rezultati – Varijanta 2

Strujnice u $t = 30s$



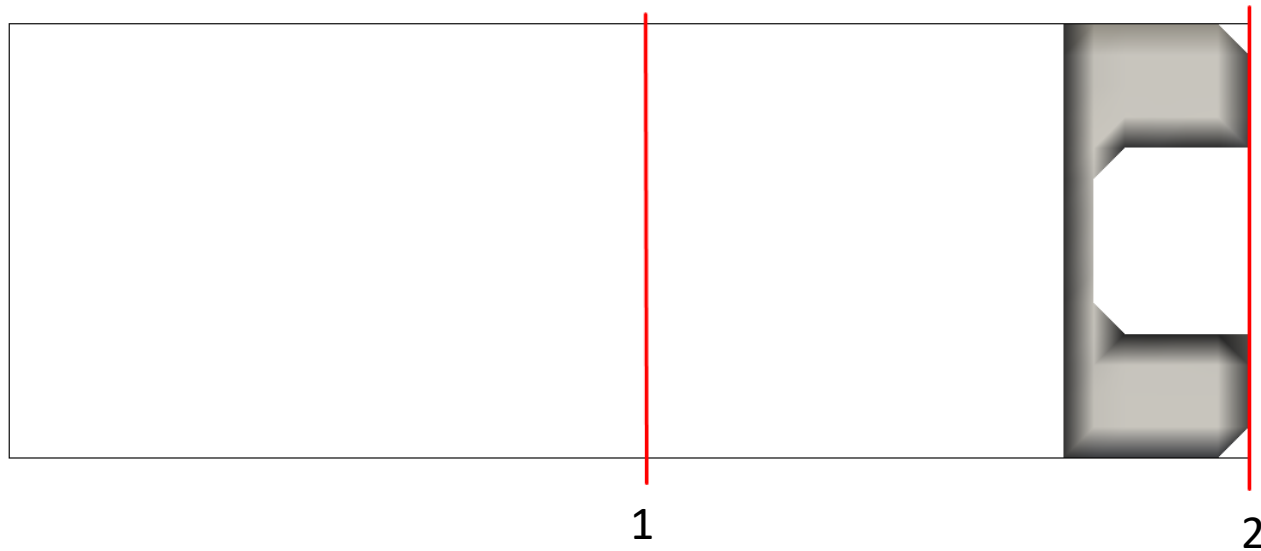
Rezultati – Varijanta 2

Strujnice na kraju simulacije od 60s



Rezultati – Varijanta 2

Proračun lokalnog koeficijenta gubitka

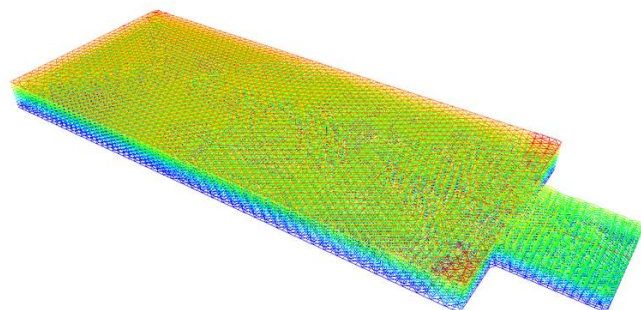


Kao i u prethodnom slučaju,
razmatrani preseki se nalaze na $x = 10$ m i $x = 20$ m

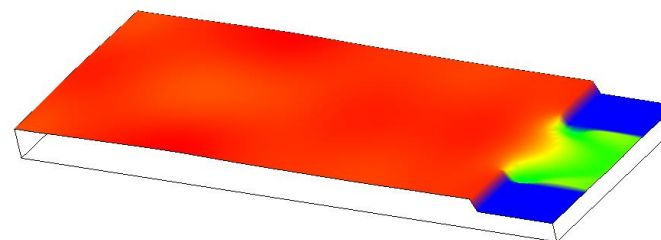
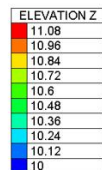
Kao posledica promene nivoa u okolini suženja, odnosno porasta nivoa, vrednost koeficijenta lokalnog gubitka je za ovaj slučaj: $\xi = 0.356$

Rezultati – poređenje sa Telemac-om

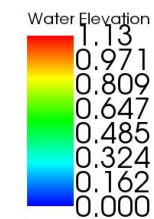
- Nivoi vode u kanalu na kraju simulacije



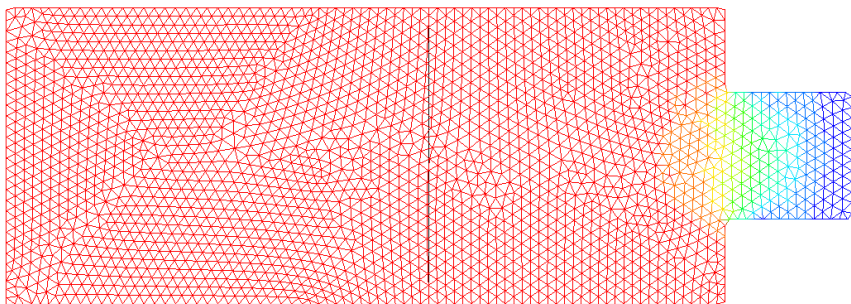
Telemac



NaysCUBE



Rezultati – poređenje sa Telemac-om



Telemac

$$\xi = 0.318$$



NaysCUBE

$$\xi = 0.297$$

Razlika u koeficijentima lokalnog gubitka može biti posledica različite prostorne diskretizacije softvera, gde Telemac diskretizuje prostor korišćenjem „trouglova“, dok NaysCUBE diskretizuje prostor kvadratnim ćelijama, takođe može biti posledica različitih vremenskih koraka koji su odabrani. Uzrok te razlike može biti tema nekog narednog rada.

HVALA NA PAŽNJI!

