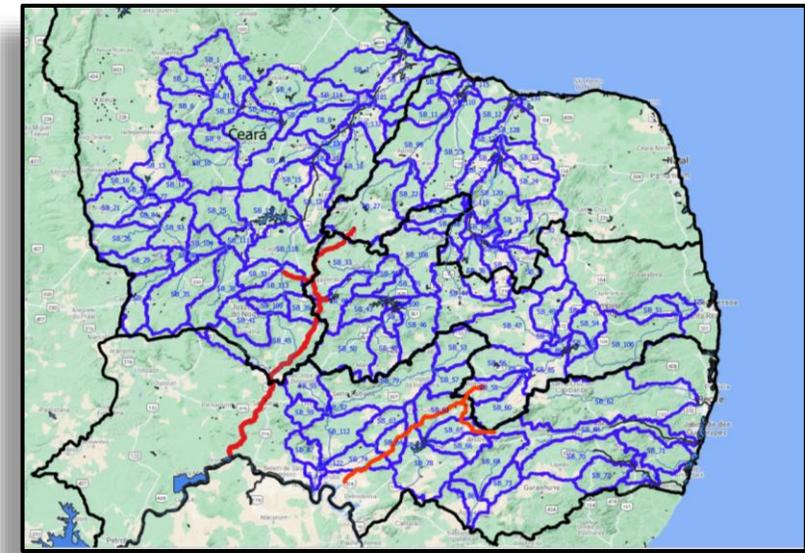


# PISF HEC-ResSim Modelo

PISF Eixo Leste HEC-ResSim

PISF Eixo Norte HEC-ResSim

Nordeste Modelo de escoamento de chuva HEC-HMS



May 5, 2022



US Army Corps  
of Engineers®



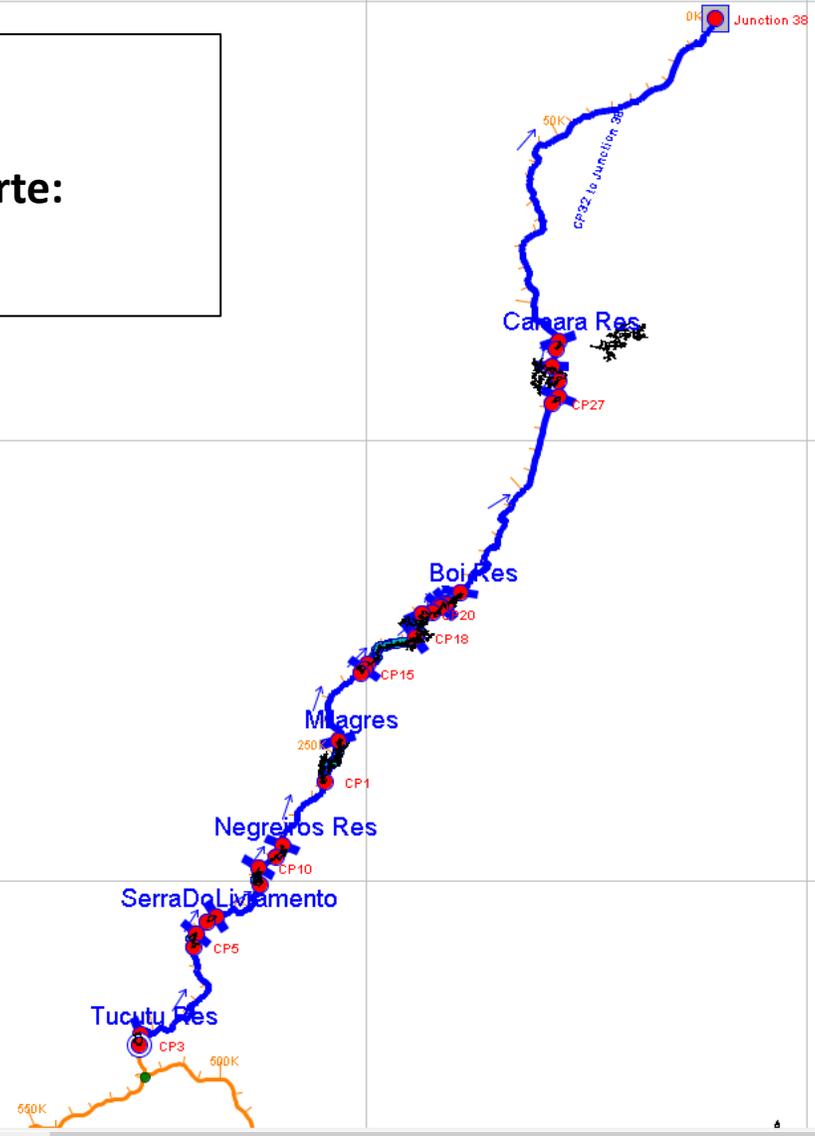
# HEC-ResSim Model

- Developed by U.S. Army Corps of Engineers – Hydrologic Engineering Center
- Used to Model Reservoir Operations for One Reservoir or System of Multiple Reservoirs
- Model: Flood Management, Water Supply, Hydropower Generation
- Model Reservoir Systems (Multiple Reservoirs) through: Reservoirs, Routing Reaches, Junctions, Diversions
- Used For Long-Term Reservoir Studies and Real-Time Operations
  
- Current Status:
  - East Axis Complete
  - North Axis 80% Complete
  - Integrate into HEC-Real Time System (RTS) Operational Model
  - Integrating HEC-HMS Rainfall-Runoff Model



- 
- Desenvolvido pelo Corpo de Engenheiros do Exército dos EUA – Centro de Engenharia Hidrológica
  - Usado para modelar operações de reservatório para um reservatório ou sistema de vários reservatórios
  - Modelo: Gestão de Inundações, Abastecimento de Água, Geração de Energia Hidrelétrica
  - Sistemas de Reservatórios Modelo (Reservatórios Múltiplos) através de: Reservatórios, Alcances de Roteamento, Junções, Desvios
  - Usado para estudos de reservatórios de longo prazo e operações em tempo real
  
  - Status atual:
    - Eixo Leste Completo
    - Eixo Norte 80% concluído
    - Integrar no modelo operacional HEC-Real Time System (RTS)
    - Integrando o Modelo de Escoamento de Chuvas HEC-HMS

**North Axis Integrated Reservoir System:**  
**Sistema Integrado de Reservatório Eixo Norte:**

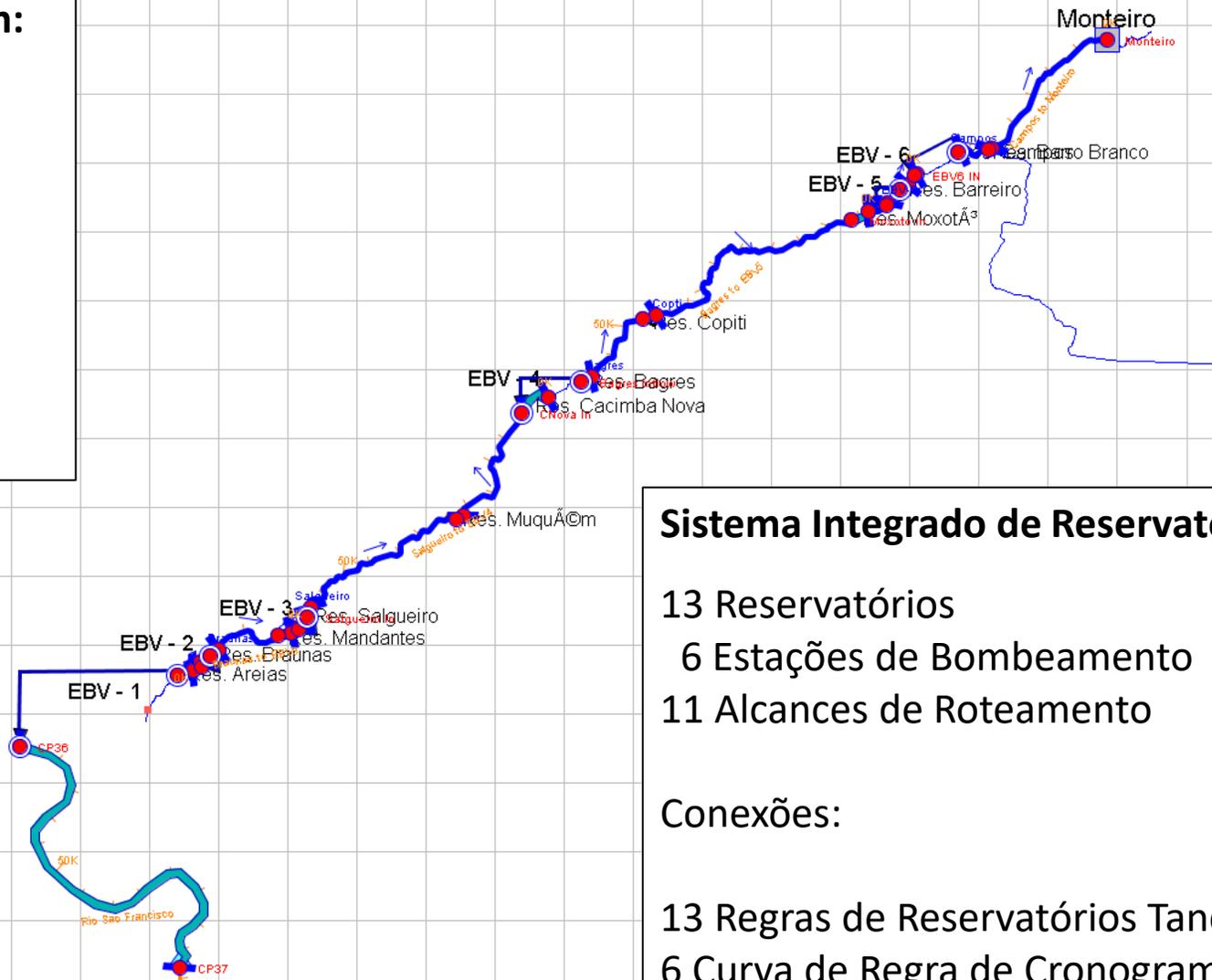


### East Axis Integrated Reservoir System:

- 13 Reservoirs
- 6 Pumping Stations
- 11 Routing Reaches

#### Connections:

- 13 Tandem Reservoirs Rules
- 6 Pump Schedule Rule Curve



### Sistema Integrado de Reservatório do Eixo Leste:

- 13 Reservatórios
- 6 Estações de Bombeamento
- 11 Alcances de Roteamento

#### Conexões:

- 13 Regras de Reservatórios Tandem
- 6 Curva de Regra de Cronograma de Bombas

#### Simulation Control

Simulation: 01 Oct 2021, 0100  
 Lookback: 01 Oct 2021, 0000  
 End: 10 Oct 2021, 1200

- 01Oct-Simulation
- Workshop1

# Capacidade da Área do Reservatório

Reservoir Editor - Network: Workshop1

Reservoir: Salgueiro Description: [ ] 11 of 17

Physical Operations Observed Data

Salgueiro-Pool

Linear Interpolation  Conic Interpolation Initial Conic Depth (m): [ ]

Elevation (m)	Storage (m3)	Area (ha)
443.90	0.00	0.00
444.00	811.00	0.00
444.50	2424.00	0.00
445.00	4980.00	1.00
445.50	10268.00	2.00
446.00	19242.00	3.00
446.50	35371.00	4.00
447.00	55460.00	5.00
447.50	83729.00	6.00
448.00	114378.00	7.00
448.50	151688.00	8.00
449.00	196354.00	10.00
449.50	244697.00	12.00
450.00	307862.00	14.00
450.50	392143.00	16.00
451.00	474339.00	17.00
451.50	566487.00	20.00
452.00	667136.00	23.00
452.50	777640.00	26.00
453.00	920767.00	29.00
453.50	1064858.00	32.00
454.00	1248805.00	36.00
454.50	1421976.00	39.00
455.00	1651601.00	43.00
455.50	1865936.00	47.00
456.00	2114702.00	52.00
456.50	2417473.00	56.00
457.00	2689428.00	60.00
457.50	2972453.00	65.00
458.00	3298882.00	70.00
458.50	3645304.00	75.00
459.00	4499291.00	80.00

OK Cancel Apply

# Routing Reaches

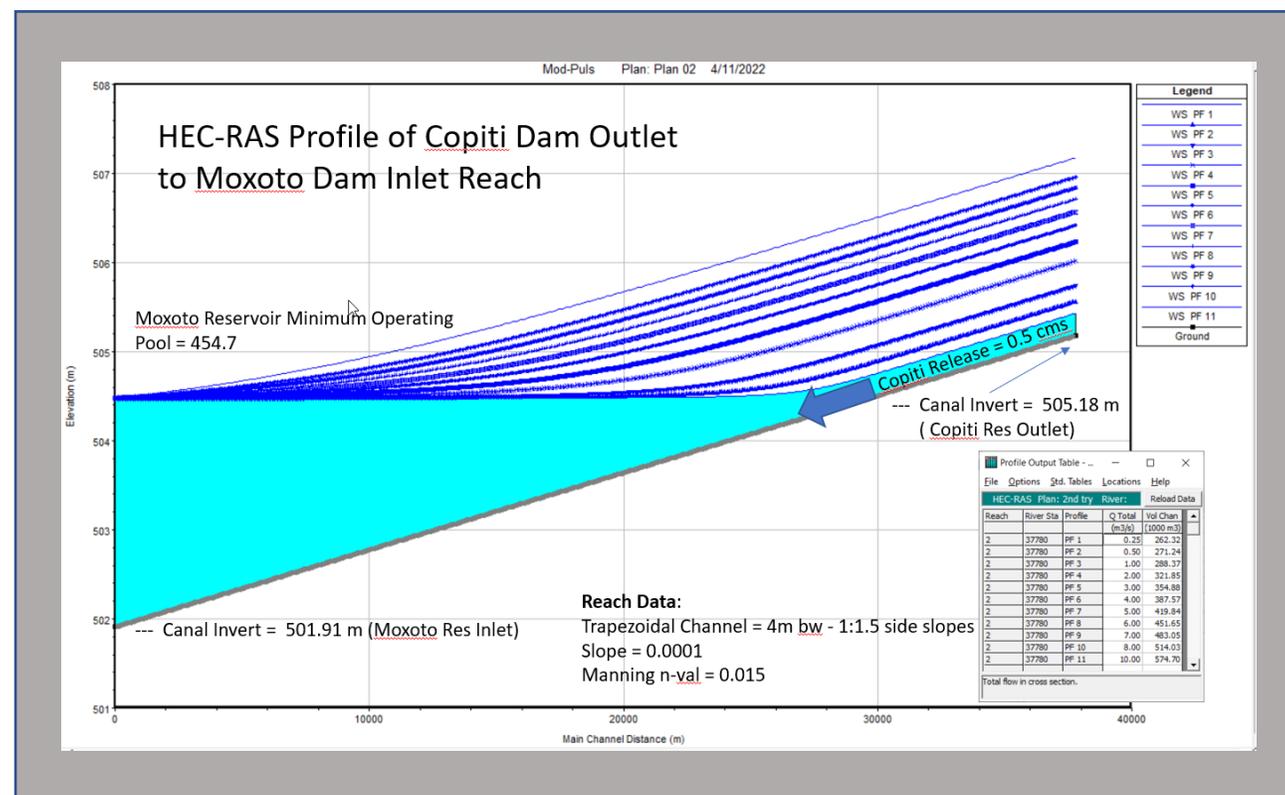
## Alcance de roteamento

Modified Puls Routing Method:

Can model backwater effects that slow the flow of water

Método de roteamento de pulso modificado:

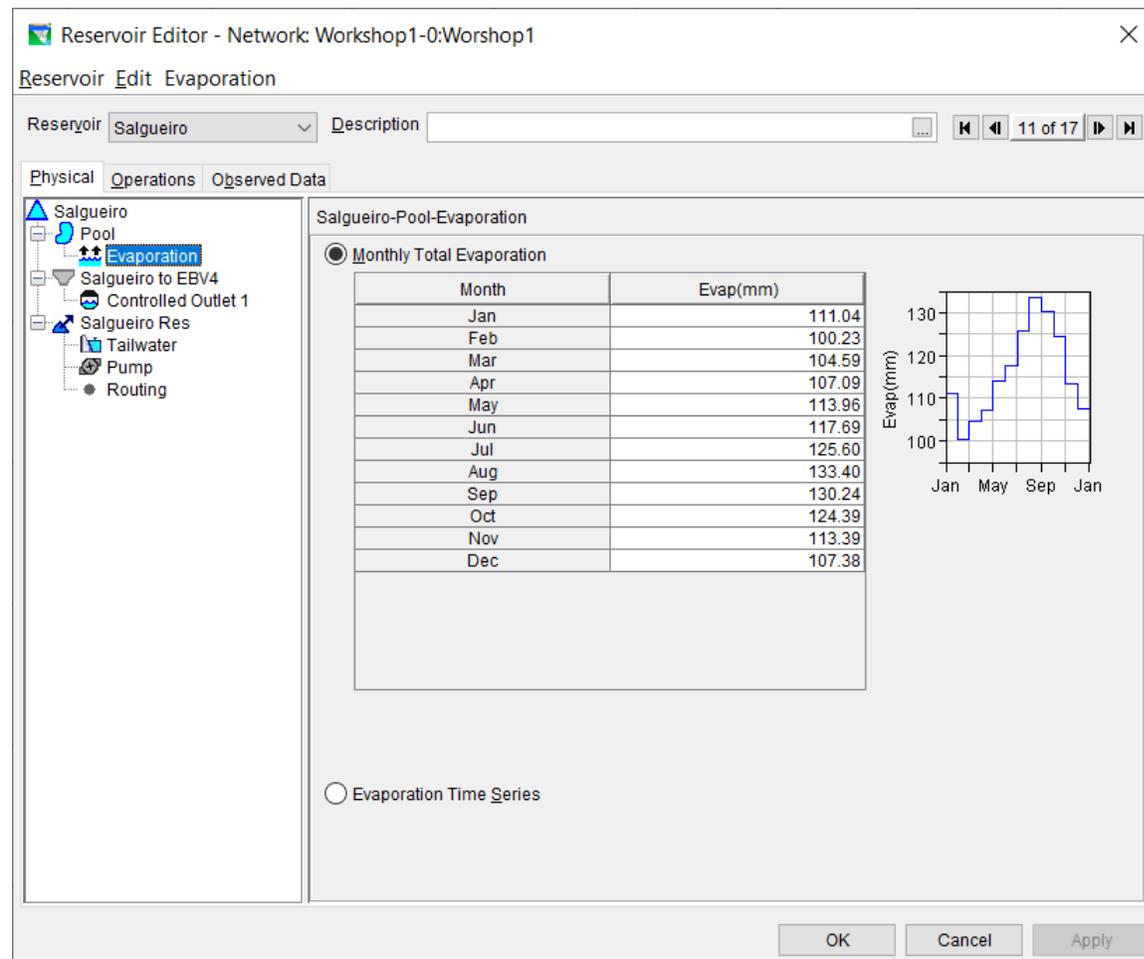
Pode modelar efeitos de remanso que retardam o fluxo de água



# Evaporação do Reservatório

Based on Measured Evap Rates  
On Nearby-Similar Reservoirs (per ANA)

Com base nas taxas de evaporação medidas  
Em Reservatórios Semelhantes Próximos (por  
ANA)



# Perdas de Infiltração do Canal

Moritz Equation: (Kraatz, 1977)

Reach Editor - Network: Alt-2021--0:Model-2021

Reach Name: Junction 21 to Junction 22

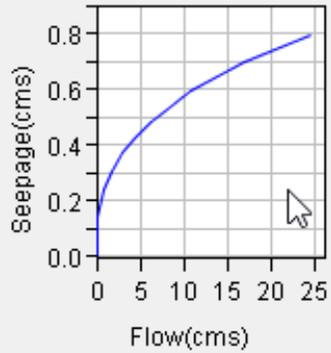
Description:

Routing Losses Observed Data

Constant Seepage (cms)

Seepage as a function of Flow

Flow(cms)	Seepage(cms)
0.87	0.2425
1.77	0.3093
2.95	0.3699
4.44	0.4275
6.24	0.4829
8.35	0.5369
10.82	0.5902
16.84	0.6943
24.41	0.7965



OK Cancel Apply



# Example of Real-Time Operations using HEC-ResSim for this Month's TUDs/Demands

## Exemplo de operações em tempo real usando HEC-ResSim para as TUDs/Demandas deste mês

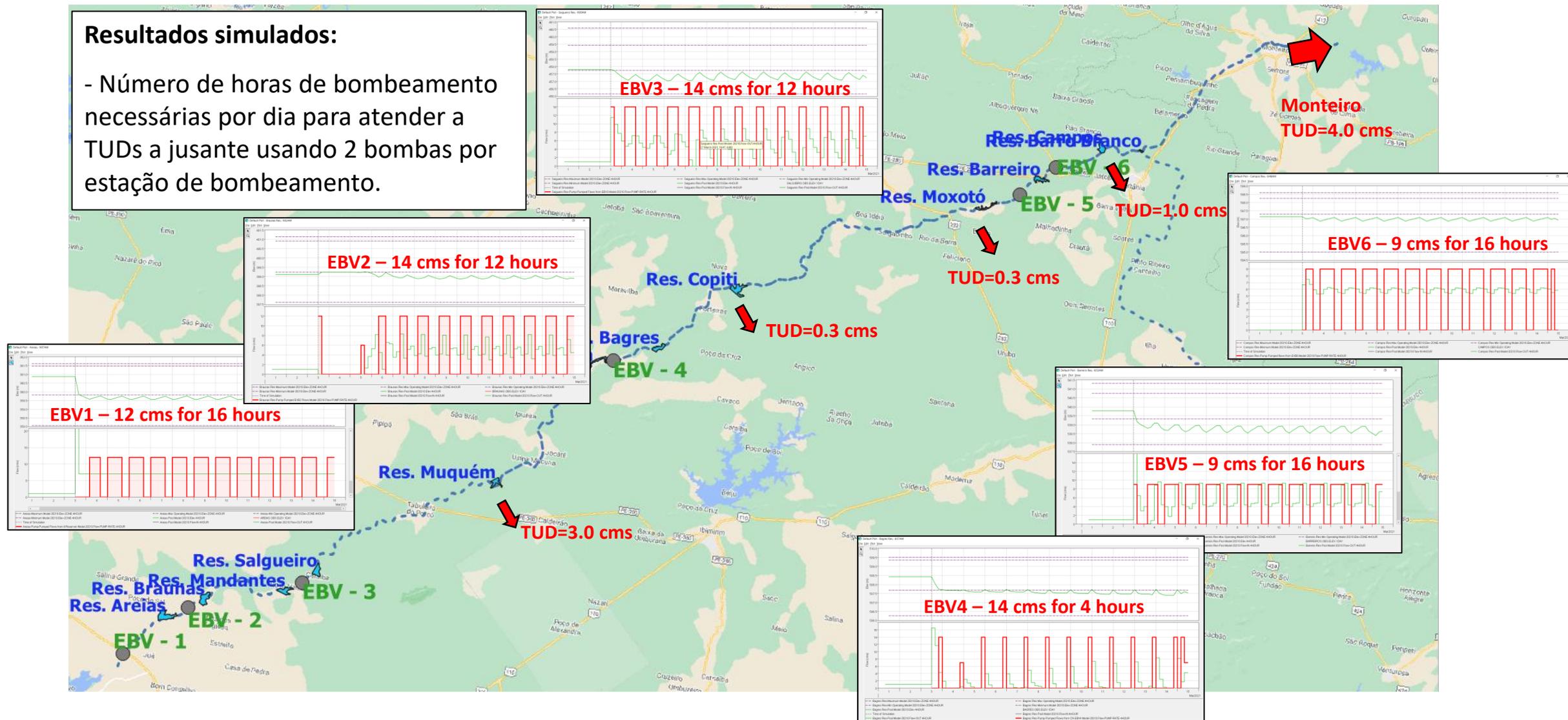


# Example of Real-Time Operations using HEC-ResSim for this Month's TUDs/Demands

## Exemplo de operações em tempo real usando HEC-ResSim para as TUDs/Demandas deste mês

### Resultados simulados:

- Número de horas de bombeamento necessárias por dia para atender a TUDs a jusante usando 2 bombas por estação de bombeamento.



## Next Steps:

### East Axis:

- Calibrate, Calibrate, Calibrate
- Change Routing Reach Method  
Muskingum-Cunge to Mod-Puls?
- Run in "Real-Time"

### North Axis:

- Add Pumping Stations
- Same as Above

### Regional:

- Integrate with State Reservoir Systems
- Add Rainfall-Runoff Component
- Develop "Operational" Model (HEC-RTS)

## Próximos passos?:

### Eixo Leste:

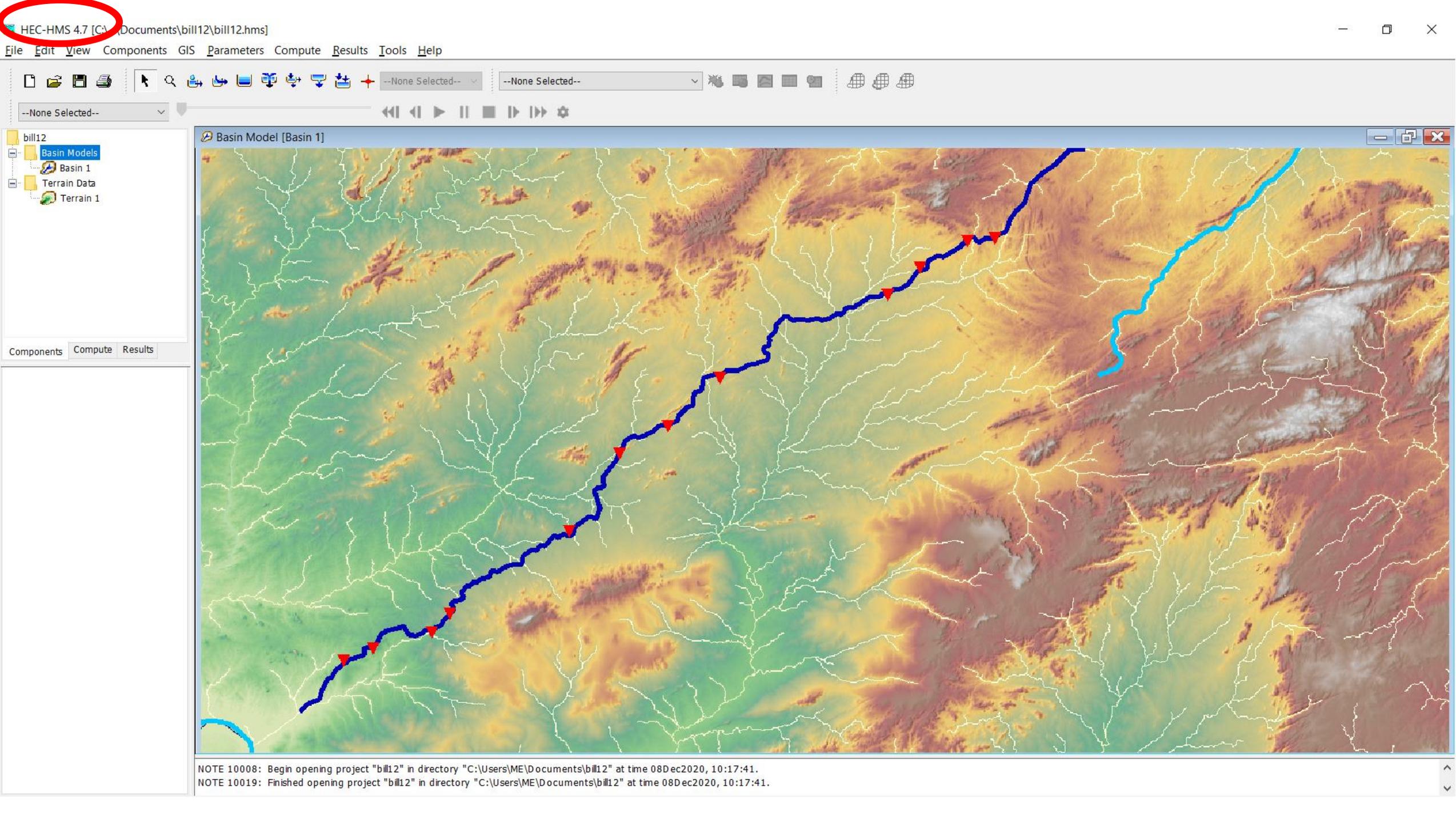
- Calibrar, calibrar, calibrar
- Alterar método de alcance de roteamento  
Muskingum-Cunge para Mod-Puls?
- Executar em "tempo real"

### Eixo Norte:

- Adicionar estações de bombeamento
- mesmo que acima

### Regional:

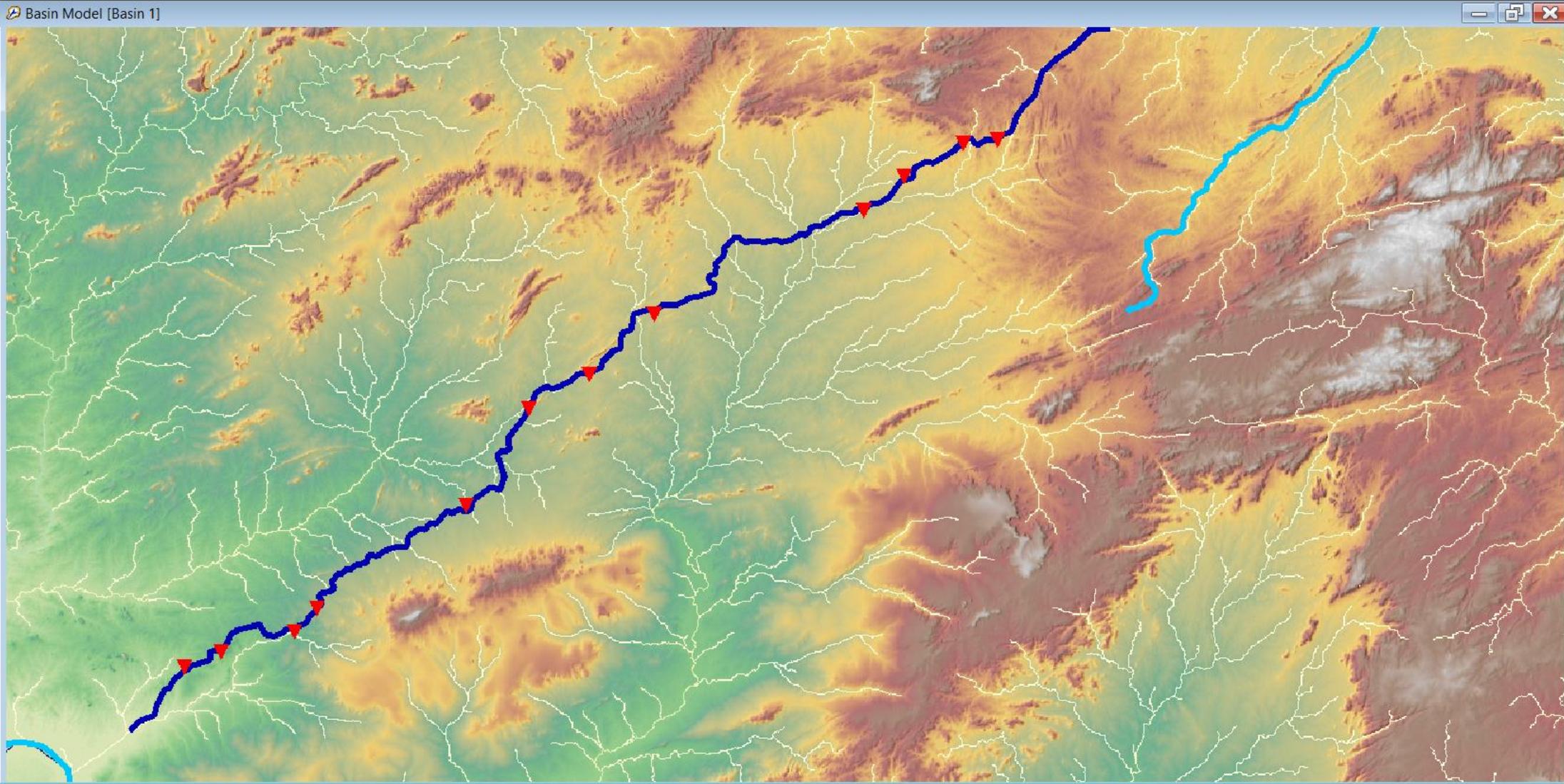
- Integrar com sistemas de reservatórios estaduais
- Adicionar componente de chuva-vazão
- Desenvolver Modelo "Operacional" (HEC-RTS)



--None Selected--

- bill12
  - Basin Models
  - Basin 1
  - Terrain Data
  - Terrain 1

Components Compute Results

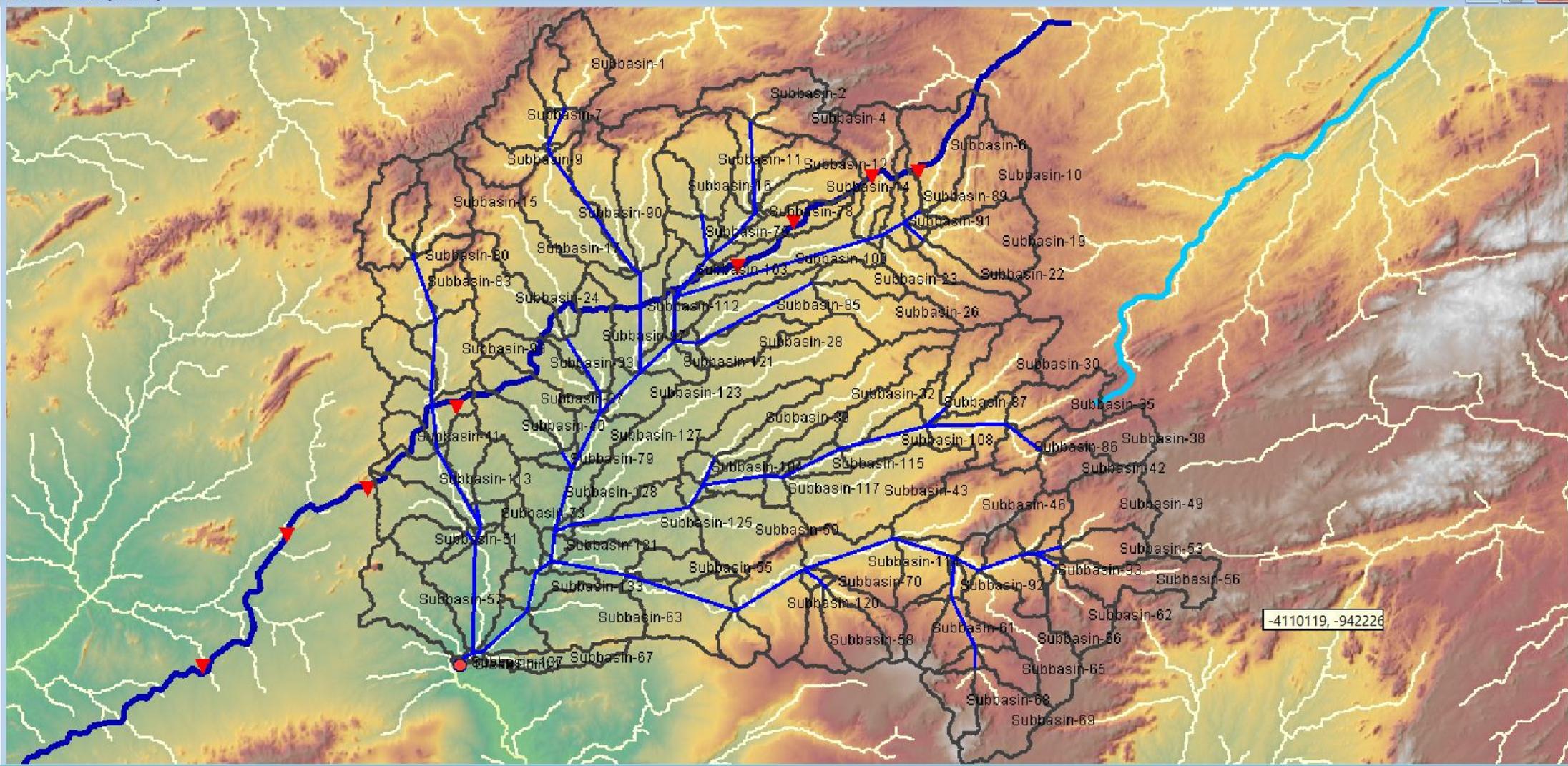


NOTE 10008: Begin opening project "bill12" in directory "C:\Users\ME\Documents\bill12" at time 08Dec2020, 10:17:41.  
NOTE 10019: Finished opening project "bill12" in directory "C:\Users\ME\Documents\bill12" at time 08Dec2020, 10:17:41.

Toolbar with icons for file operations, navigation, and GIS functions. Includes dropdown menus for selection.

Project tree view showing the hierarchy: bill12 > Basin Models > Basin 1 > Terrain Data > Terrain 1. Includes 'Components' tab with 'Compute' and 'Results' buttons.

Basin Model [Basin 1]

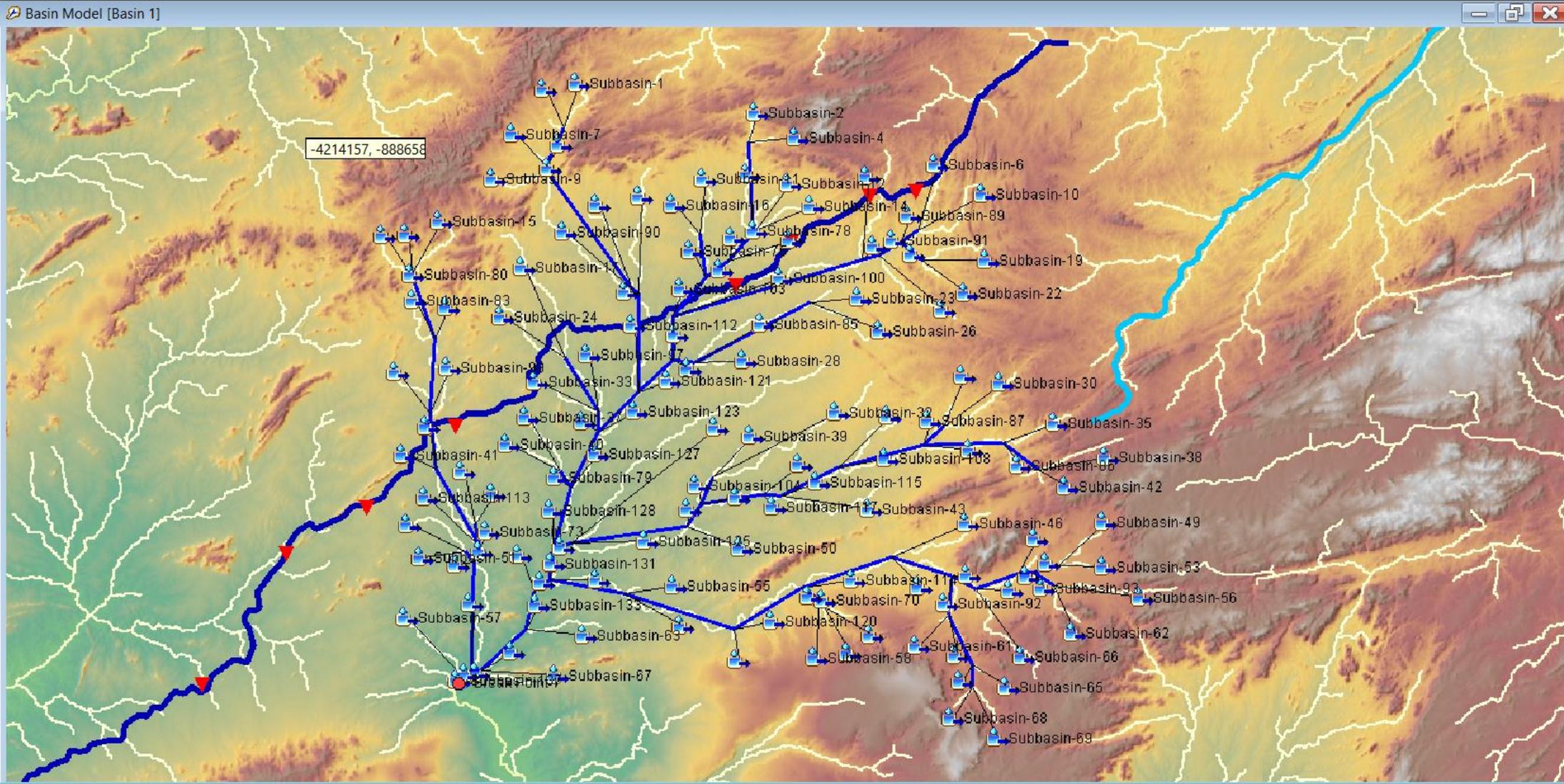


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Project Explorer showing a tree view of the project structure:

- bill12
  - Basin Models
    - Basin 1
  - Terrain Data
    - Terrain 1

Component tabs: Components | Compute | Results

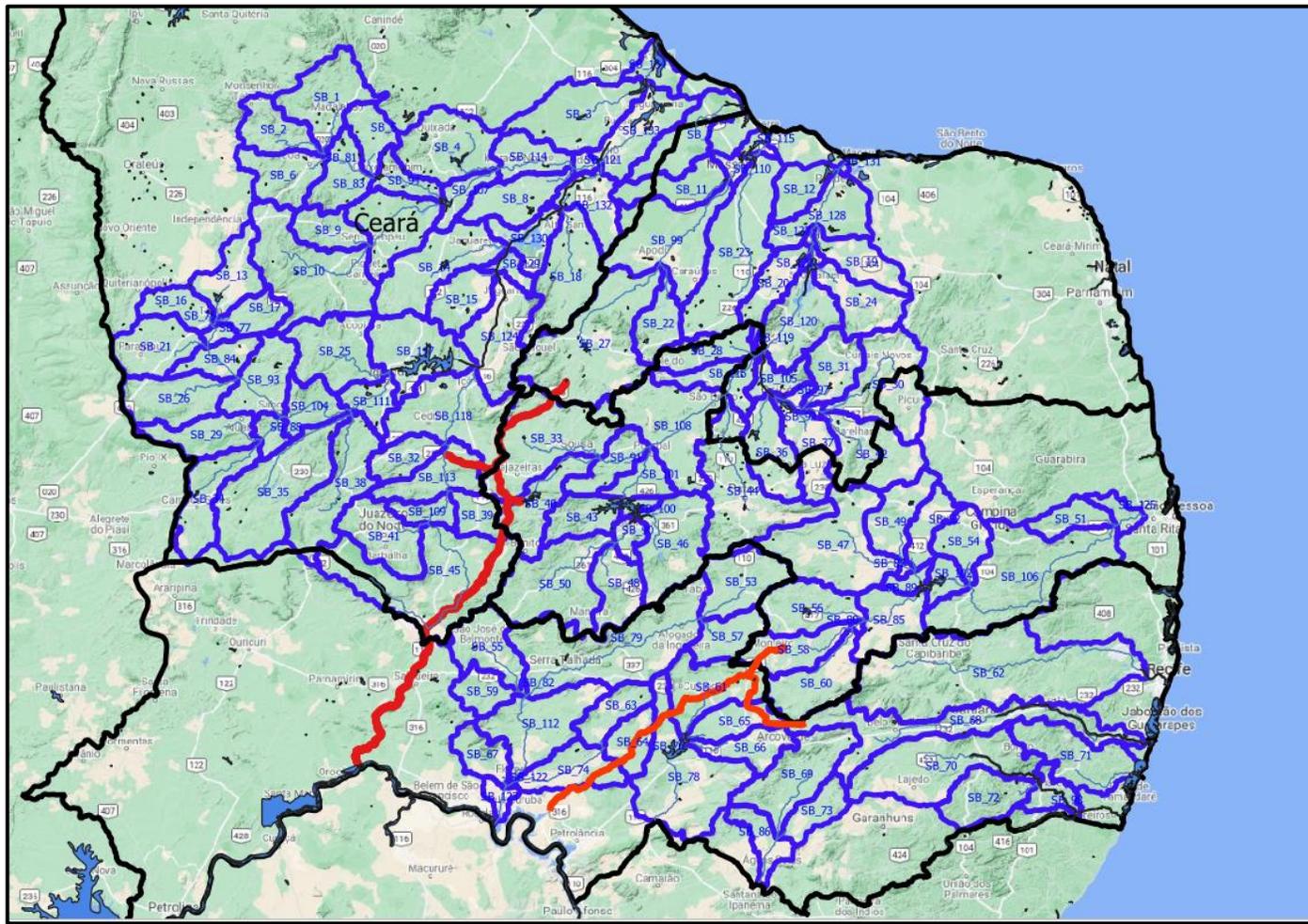


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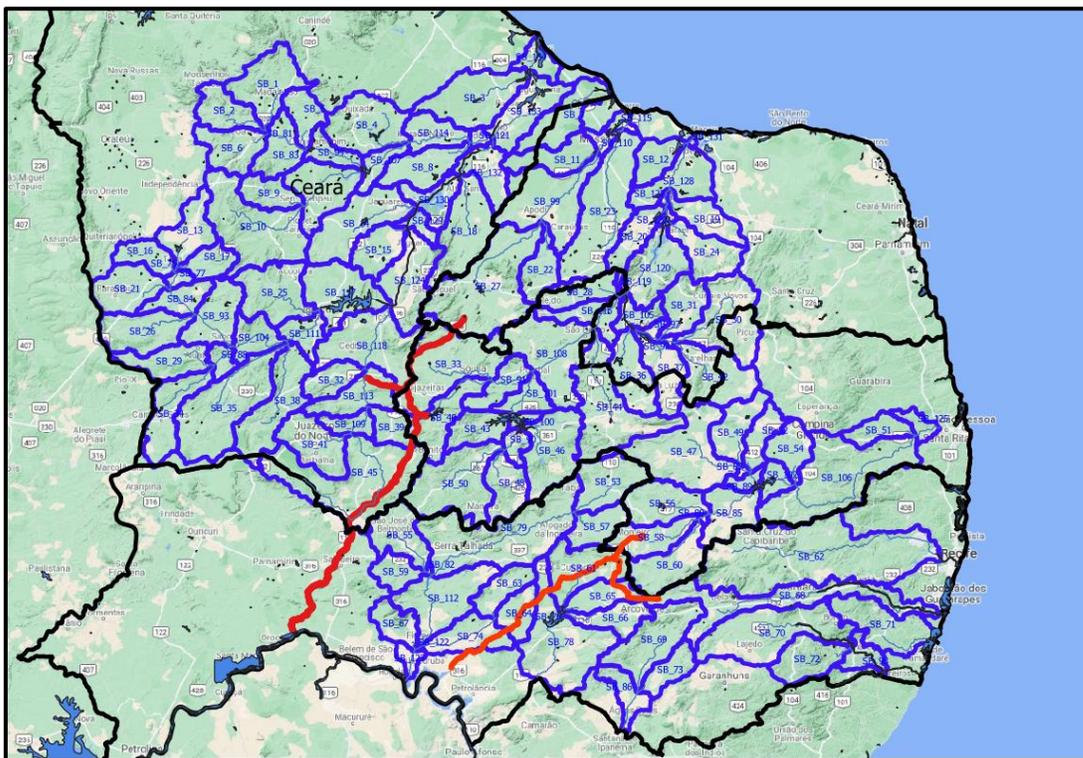
# Chuva-Escoamento / Reservatório-Simulação Integrada no Nordeste

Faça um modelo geral integrado de recursos hídricos do PISF e dos reservatórios dos Estados do Nordeste

Make a general integrated model of PISF water resources and reservoirs in the Northeastern States



# Chuva-Escoamento / Reservatório-Simulação Integrada no Nordeste



## Why an Integrated Rainfall-Runoff / Reservoir Simulation Model is Important:

### Short-Term:

- Real-time PISF Pumping-Station/Reservoir Operations.
- Water Conservation Measure - Forecast ungaged/incremental flows between release points (Reservoirs) and downstream demand-locations.
- Forecast potential flooding conditions of natural watersheds and impacts/consequences on PISF Operations (Moxoto Reservoir March 2020).
- Model and forecast State reservoir levels and associated potential for changes in State demands (TUDS).

### Long-Term:

- Long-term/persistent drought modelling and forecasting.
- Impacts of climate variability.

## Por que um Modelo Integrado de Simulação de Chuva-Esgoto / Reservatório é Importante:

### Curto prazo:

- Operações de Estação de Bombeamento/Reservatório PISF em tempo real.
- Medida de Conservação de Água - Previsão de vazão não programada/incremental entre pontos de liberação (Reservatórios) e locais de demanda a jusante.
- Prever condições potenciais de inundação de bacias hidrográficas naturais e impactos/consequências nas Operações do PISF (Reservatório de Moxoto março de 2020).
- Modelar e prever níveis de reservatórios estaduais e potencial associado para mudanças nas demandas estaduais (TUDS).

### Longo prazo:

- Modelagem e previsão de secas de longo prazo/persistentes.
- Impactos da variabilidade climática.



US Army Corps  
of Engineers.

# Conclusão

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