



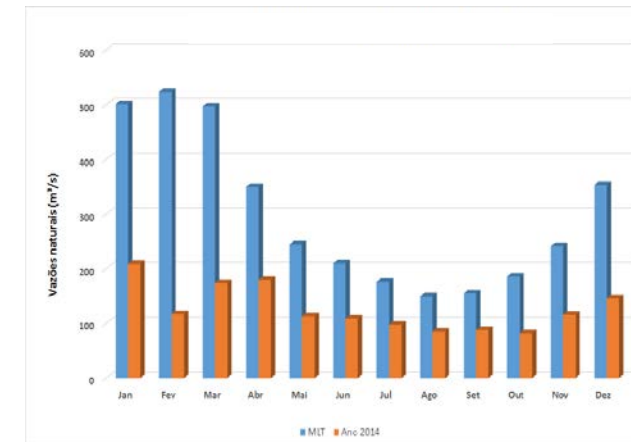
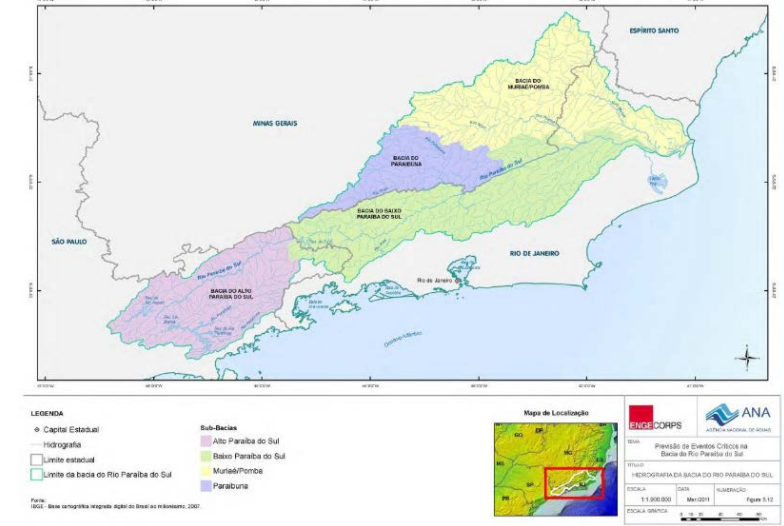
# Flood Control and Drought Management Services Provided by Hydropower Plants in the Paraíba do Sul River Basin, Brazil.

J.M. Damazio, F.S. Costa, P. Diniz

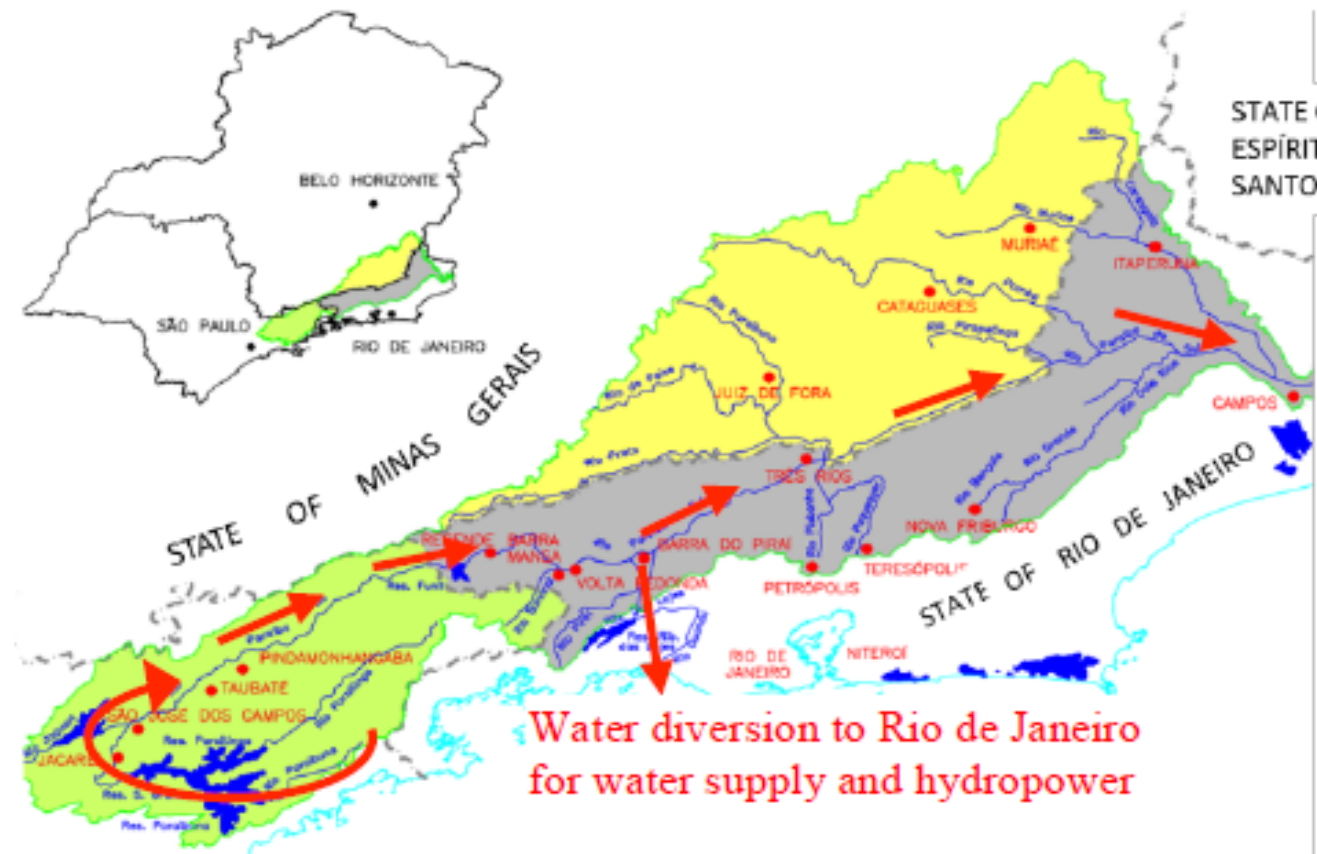


# The Paraíba do Sul River Basin

- Drainage Areas: 56,500 km<sup>2</sup>
- Total head: 1,800 m
- Length: ~ 1,150km
- Length/(maximum width) ~3
- Average long-term flows :
  - high stretch: 150m<sup>3</sup>/s;
  - medium stretch: 280m<sup>3</sup>/s;
  - low stretch: 810m<sup>3</sup>/s.

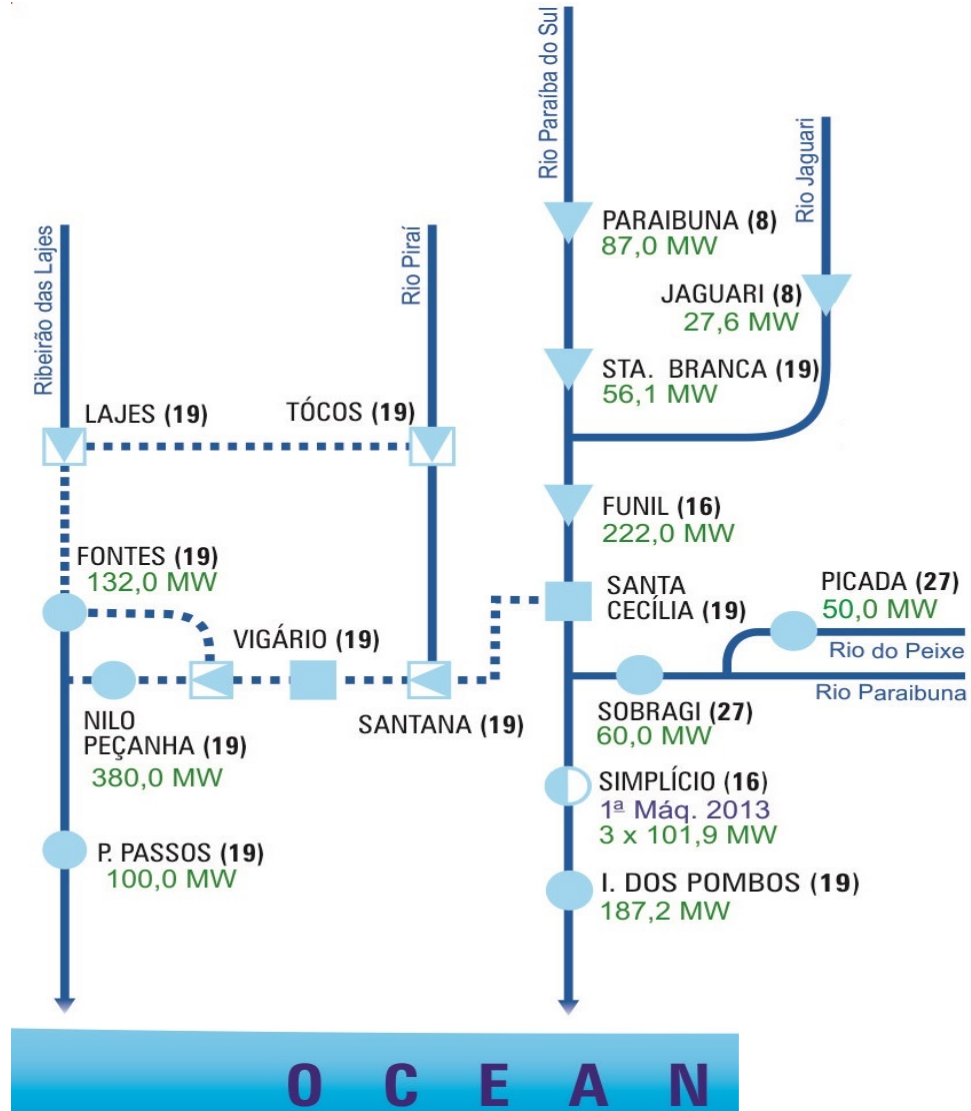


# Main Water Uses



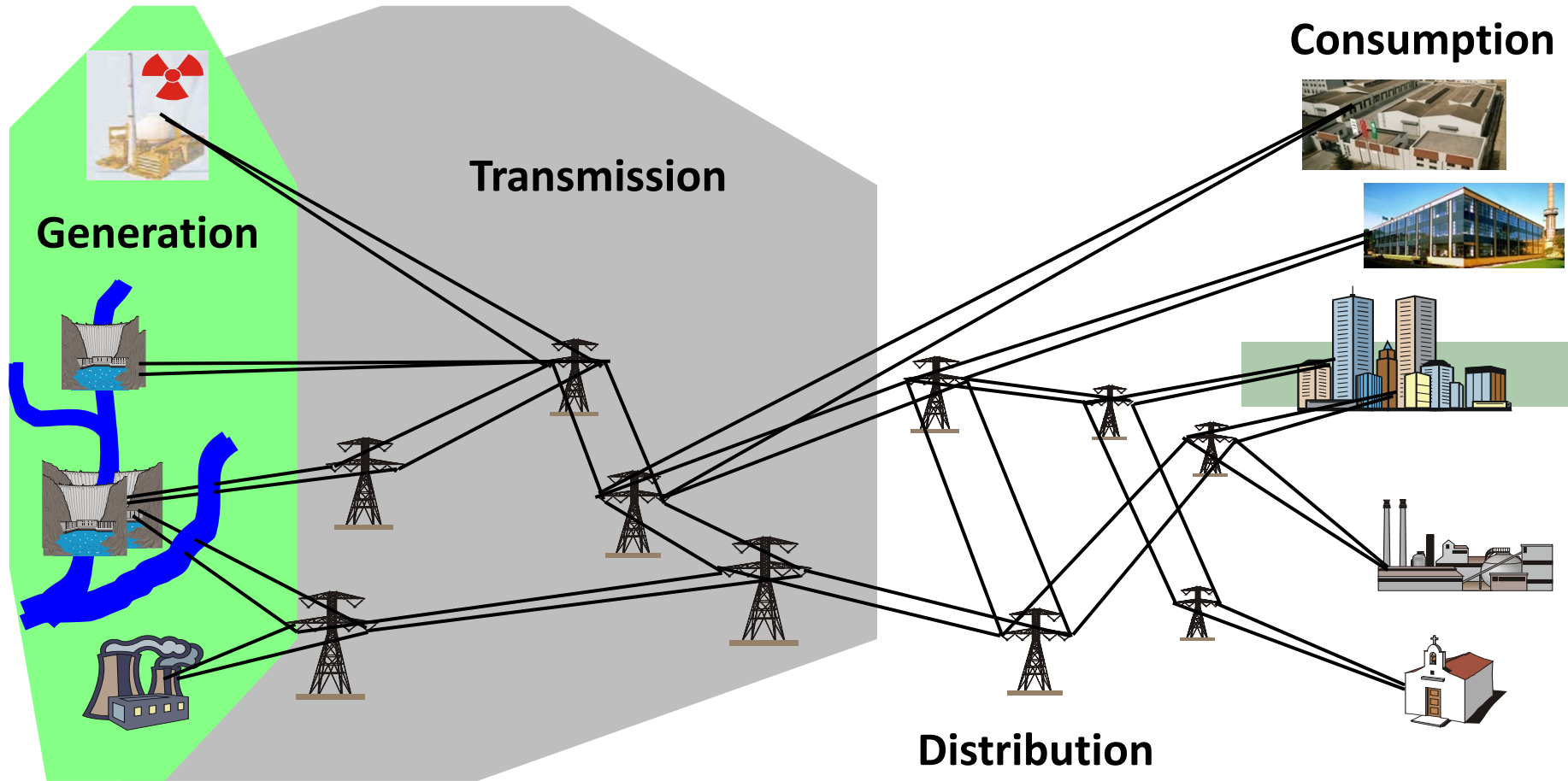
- Water Supply : 16 millions inhabitants (including 8.7 millions of Rio de Janeiro)
- Irrigation for sugar cane production in the low stretch.
- Electric energy supply
- Sewage dilution
- Flood Control

# Hydropower System



- The development started in 1908
- Now in operation:
  - four upstream regulation reservoirs,
  - 11 powerhouses and
  - one pump station,
- Total generation capacity  
1607.6 MW
- Operation integrated in the  
Brazilian Interconnected Power  
System

# Brazilian Interconnected Power System - BIPS



# BIPS Hydroelectric Generation



## Diagrama Esquemático das Usinas Hidroelétricas do SIN

Usinas Hidroelétricas Despachadas pelo ONS na Otimização da Operação Eletroenergética do Sistema Interligado Nacional

Horizonte: 2020 - 2024

Existents

161 Hydropower Plants

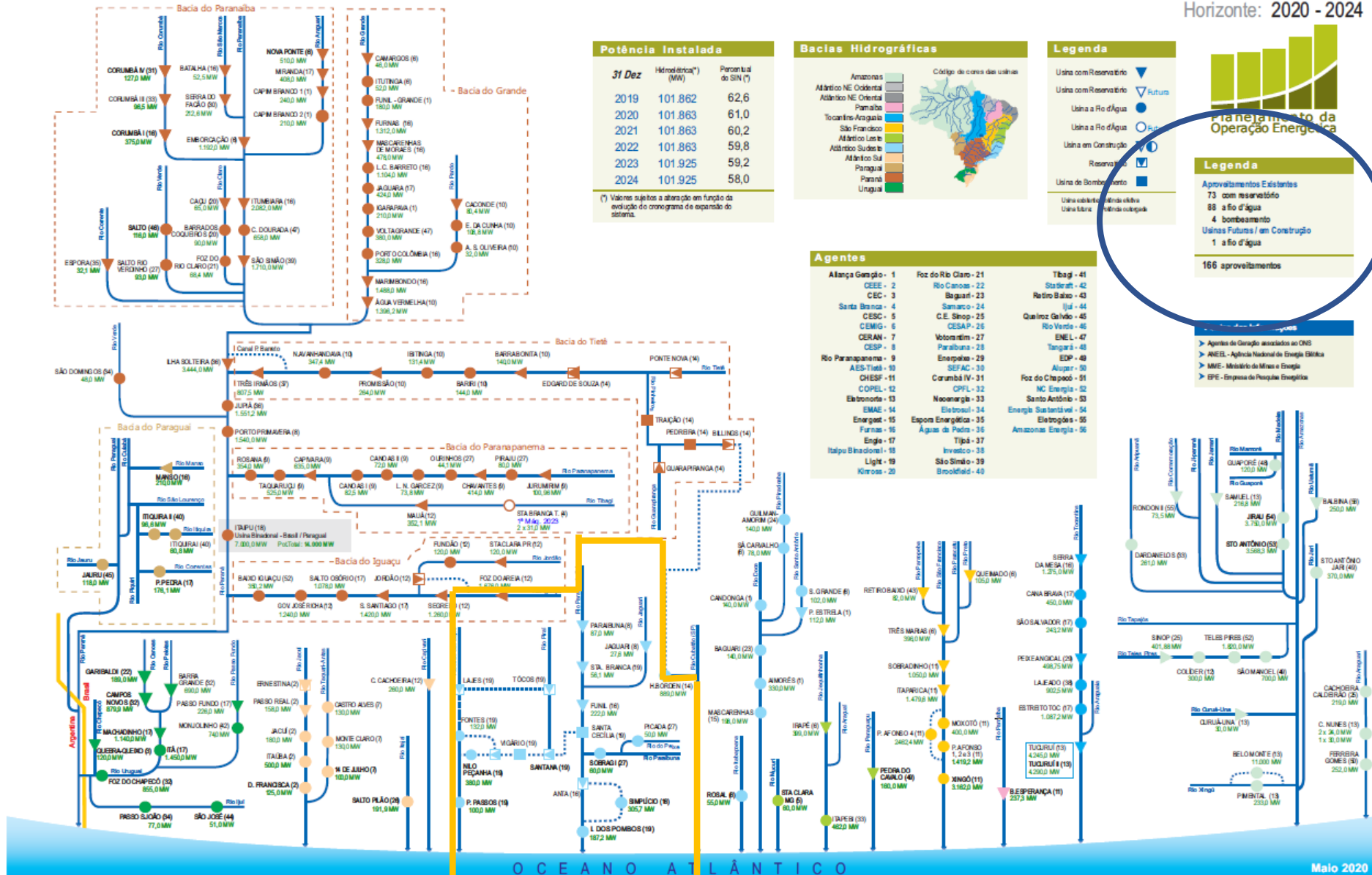
73 Storage

88 run-of-river

4 pump station

Under Construction

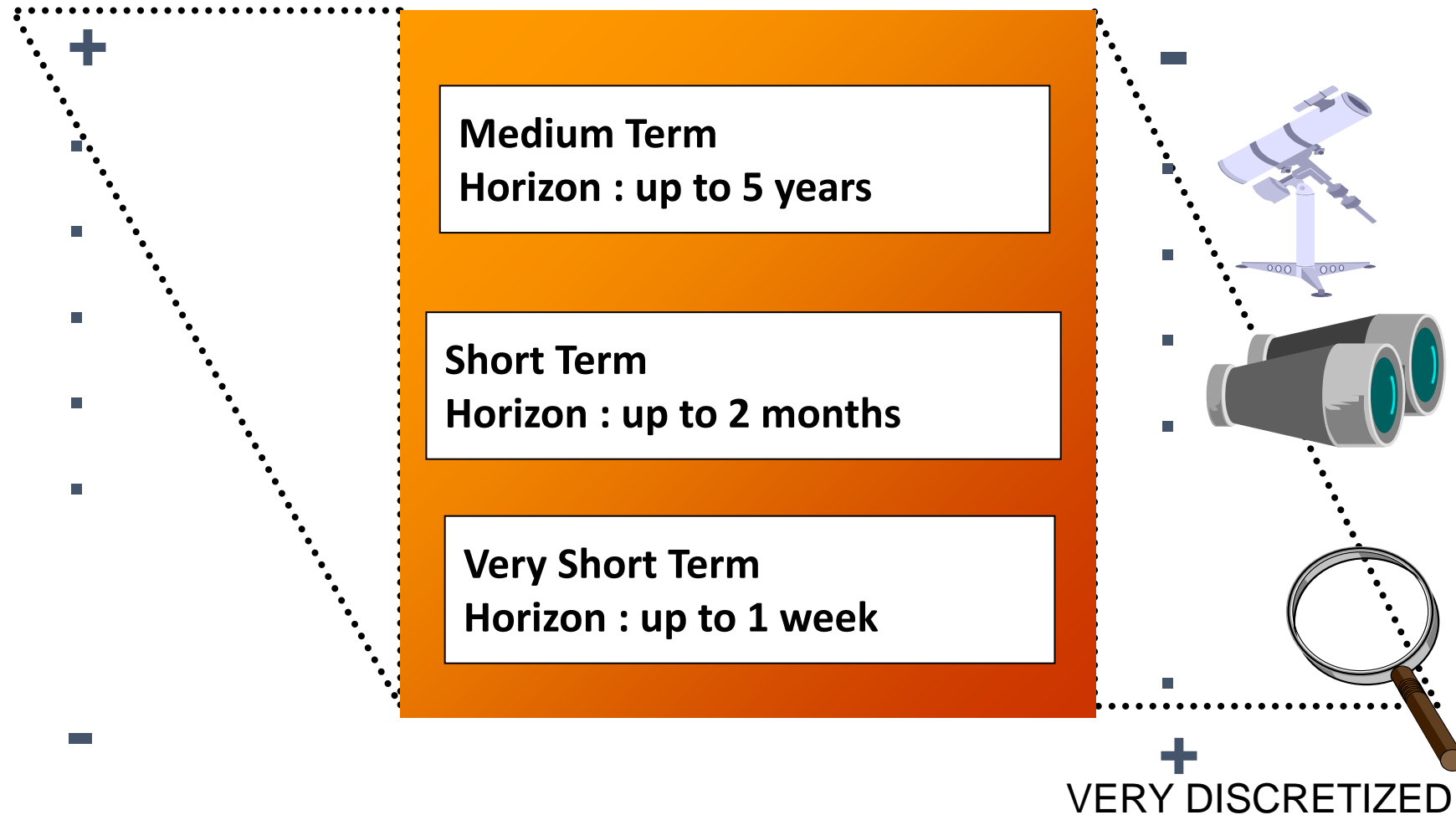
1 run-of-river



# Brazilian Interconnected Power System - BIPS

## BIPS - Operation Planning

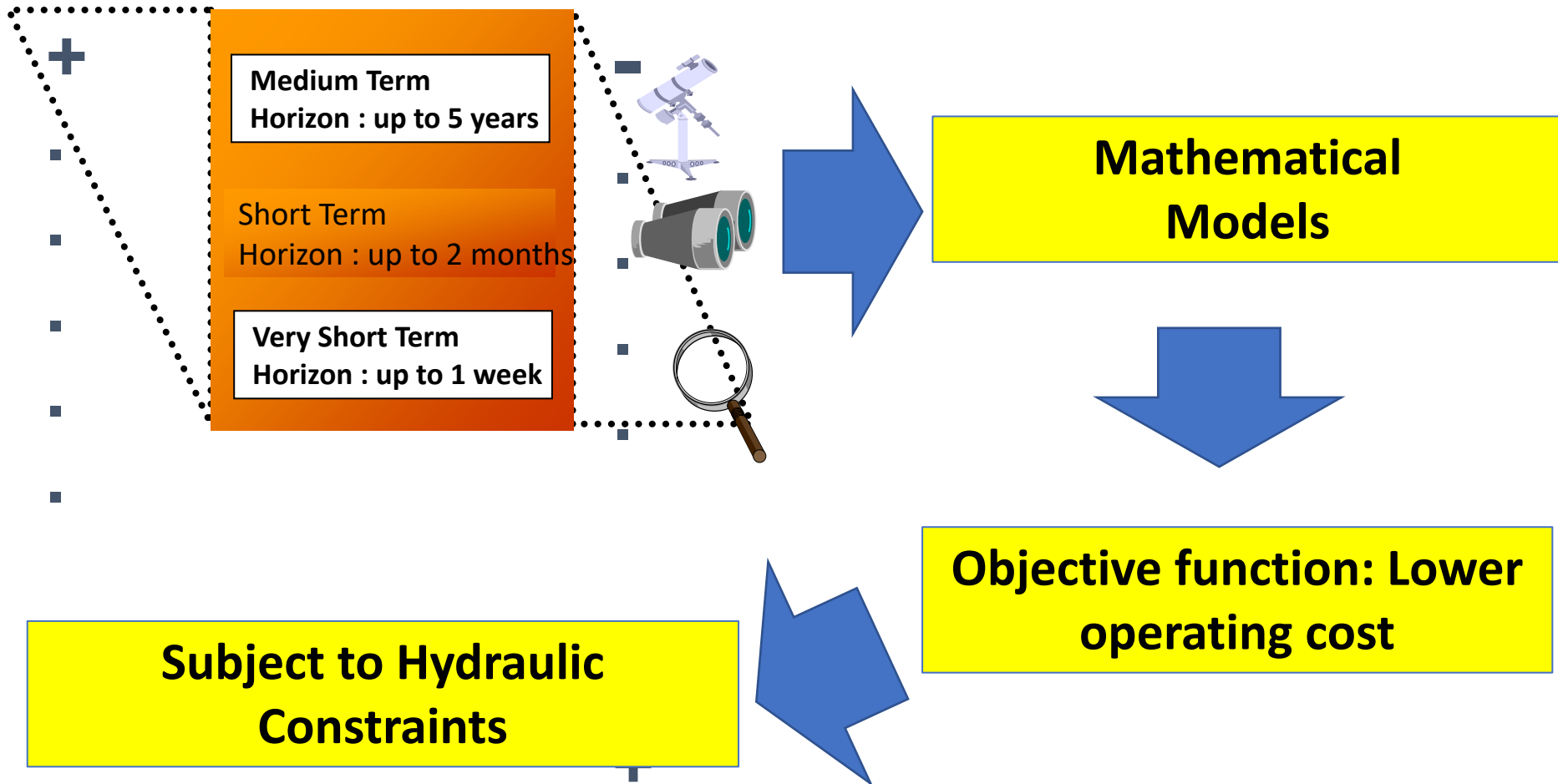
UNCERTAINTY IN RESOURCES





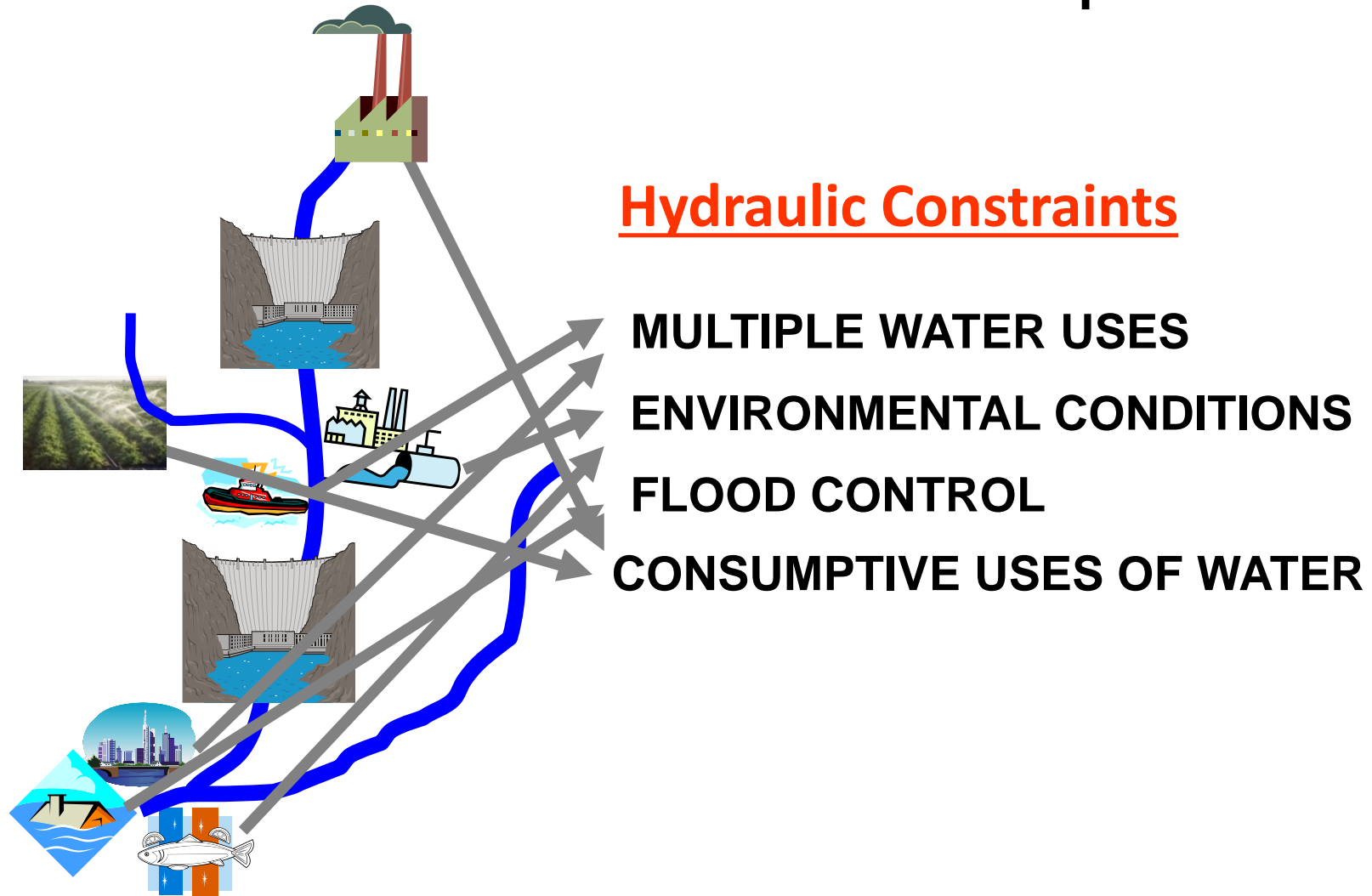
# Brazilian Interconnected Power System - BIPS

## BIPS - Operation Planning

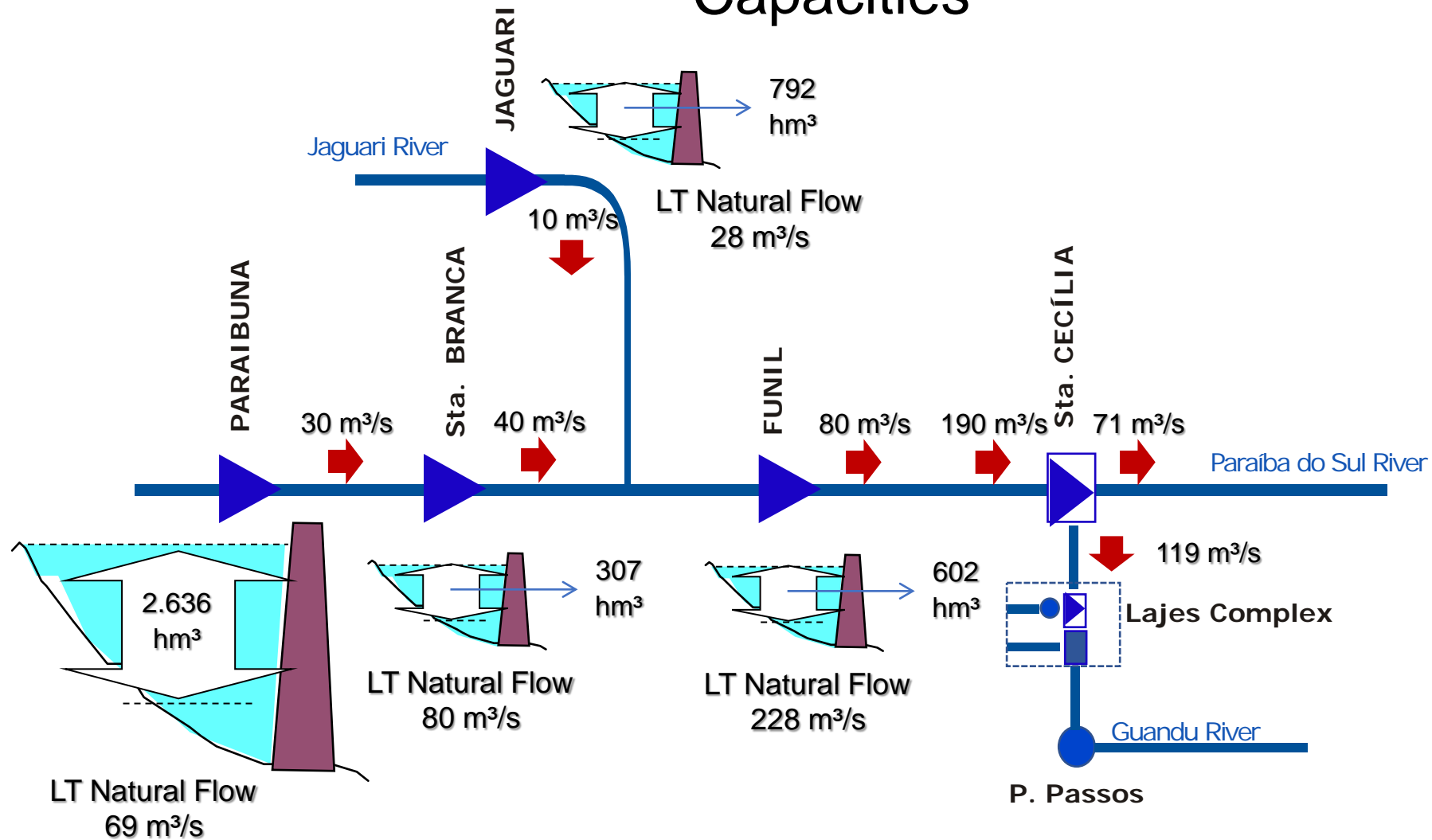


# Brazilian Interconnected Power System - BIPS

## BIPS - Operation Planning



# Upstream Paraíba do Sul – Minimum Outflows (2013) and Storage Capacities



## Recent drought episodes:

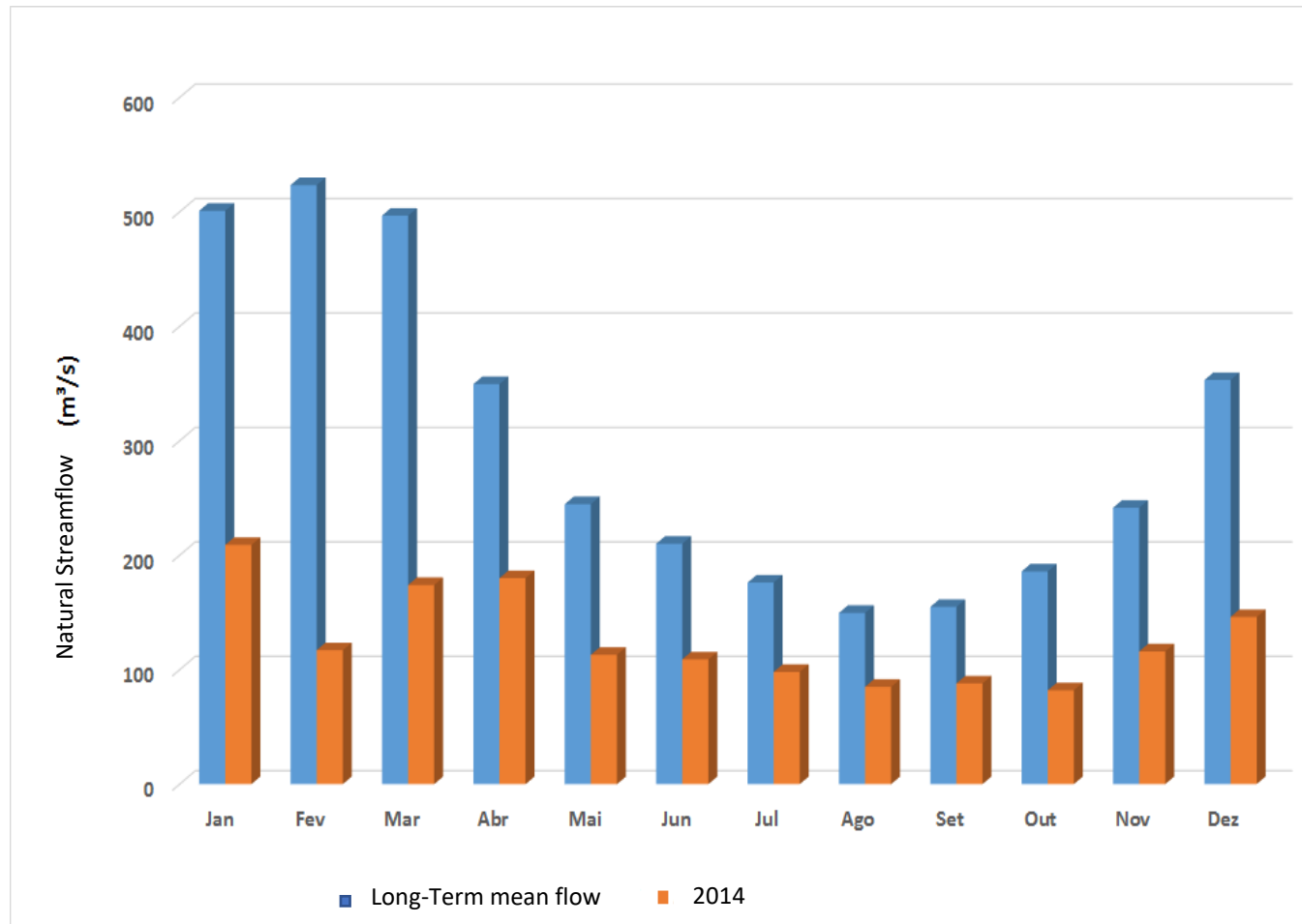
- **2003** severe drought - total water storage dropped to 14.2%,
- **2014 to 2018** extremely severe drought - emptied total water storage

## Effect:

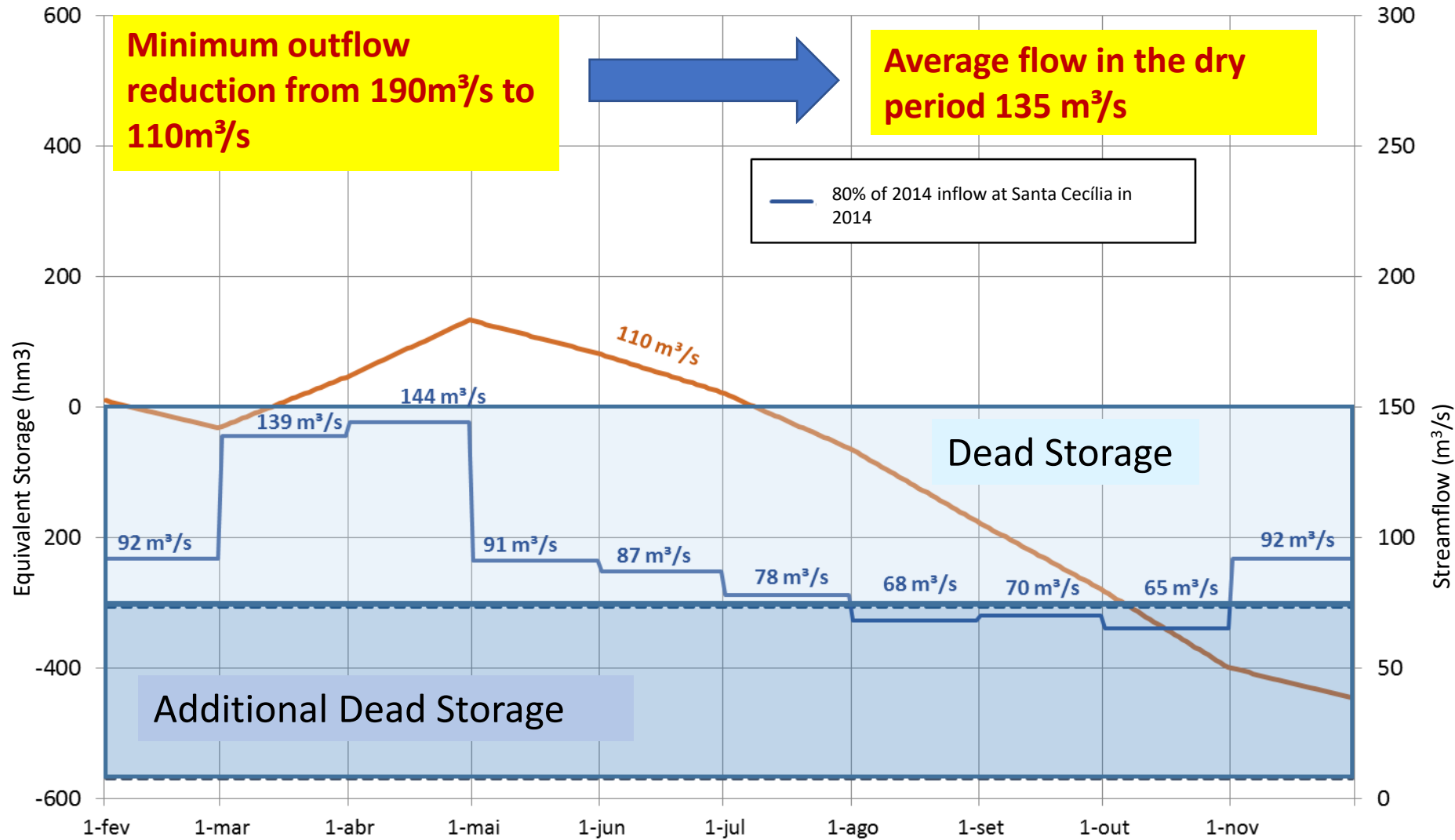
Successive improvements of the operation rules aiming at preserving the multiple use and expanding the re-filling capacity of the reservoirs



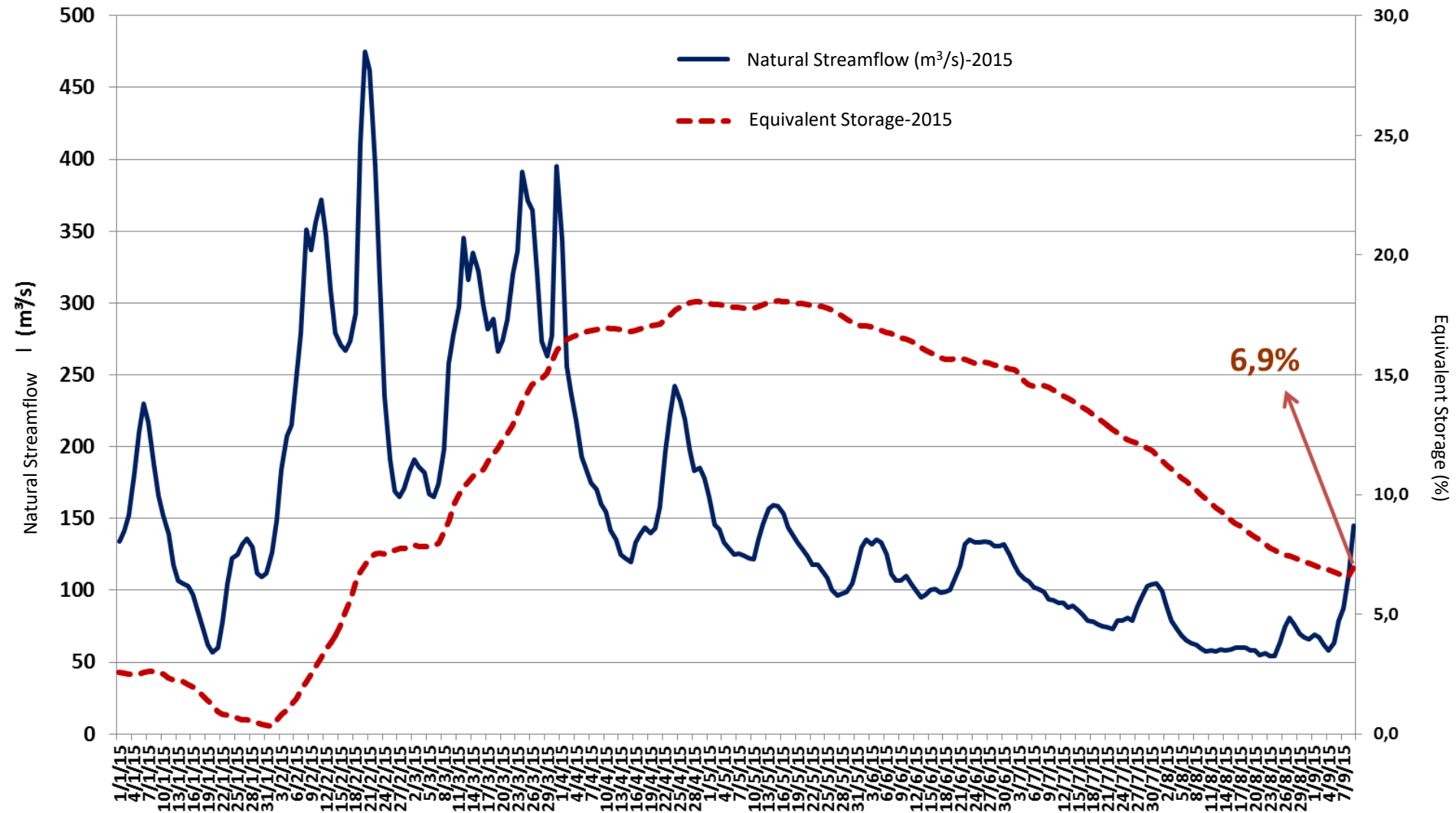
## 2014 Drought at Santa-Cecília



# Outflow minima at Santa Cecília in 2015

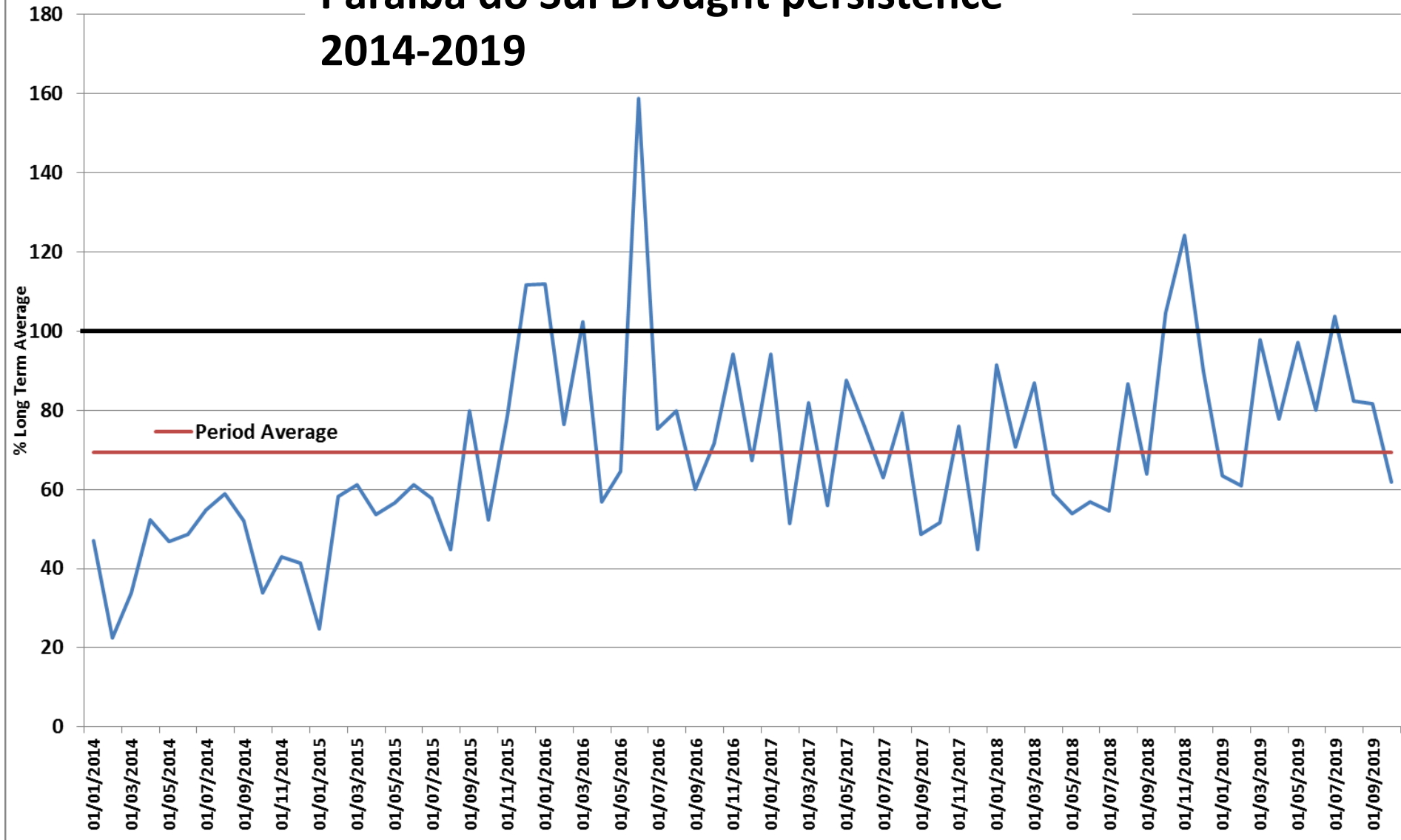


## 2015 - Implementation of the Target Inflow to Santa -Cecilia

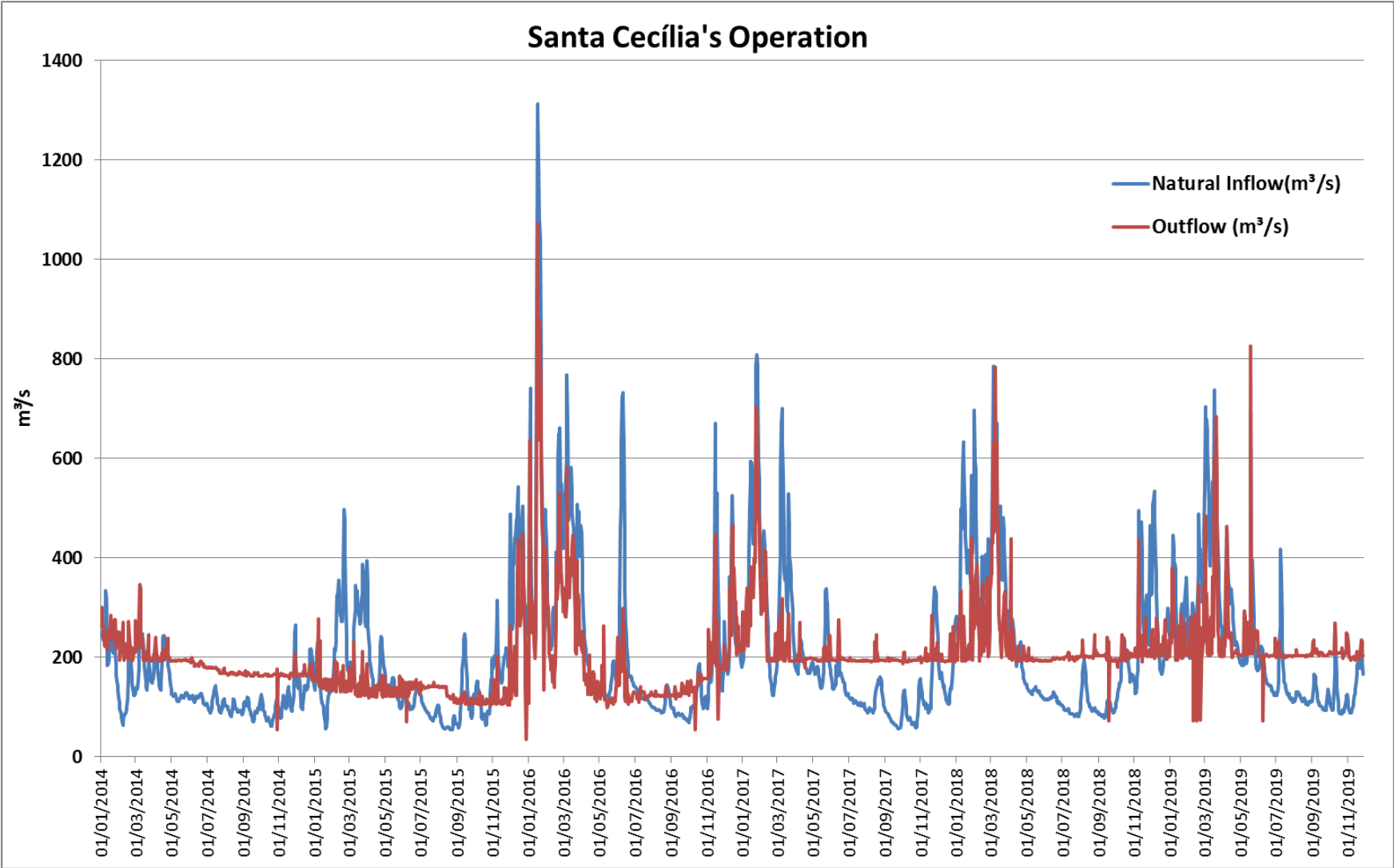




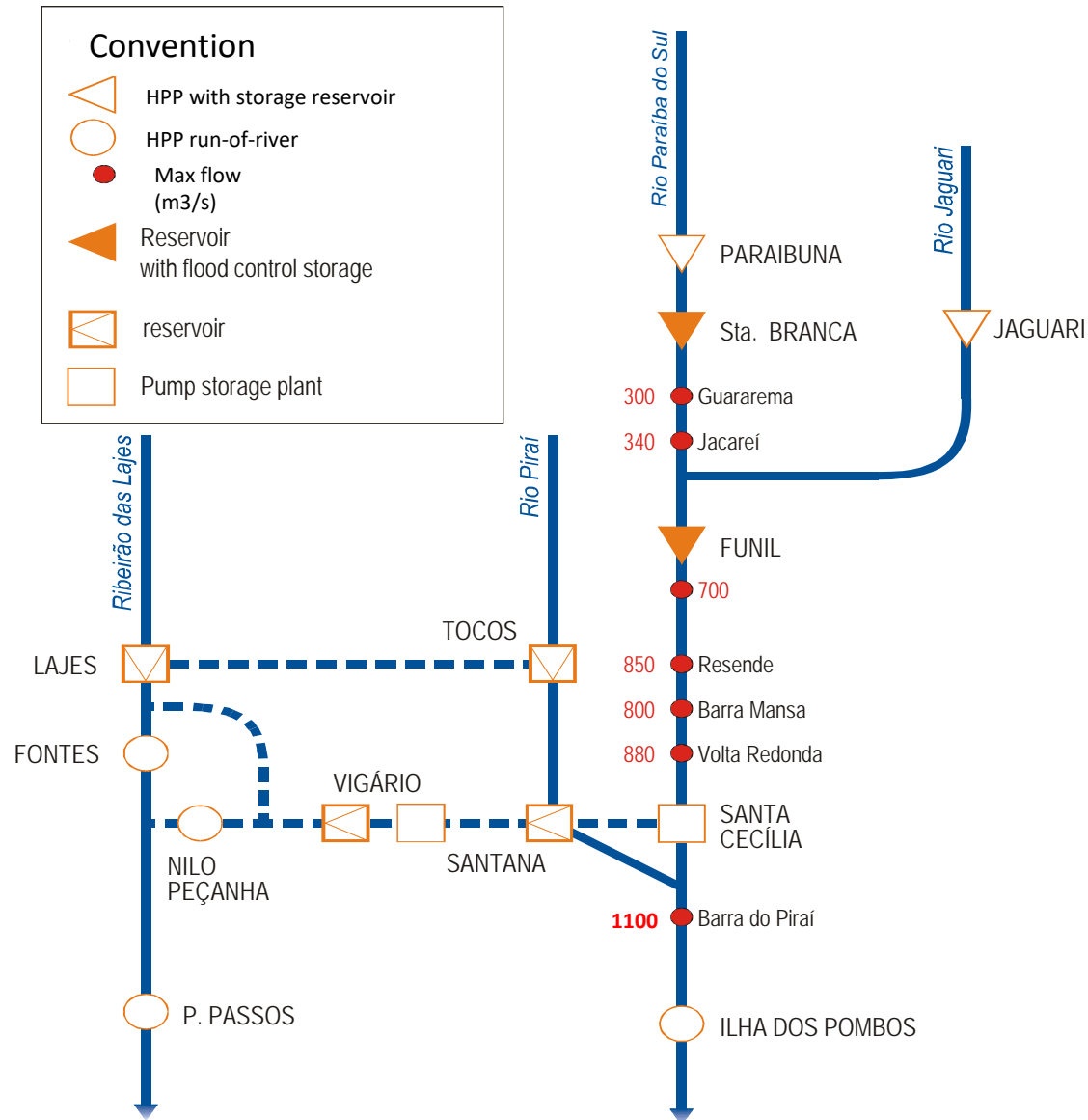
# Paraíba do Sul Drought persistence 2014-2019



# Paraíba do Sul Drought persistence 2014-2019

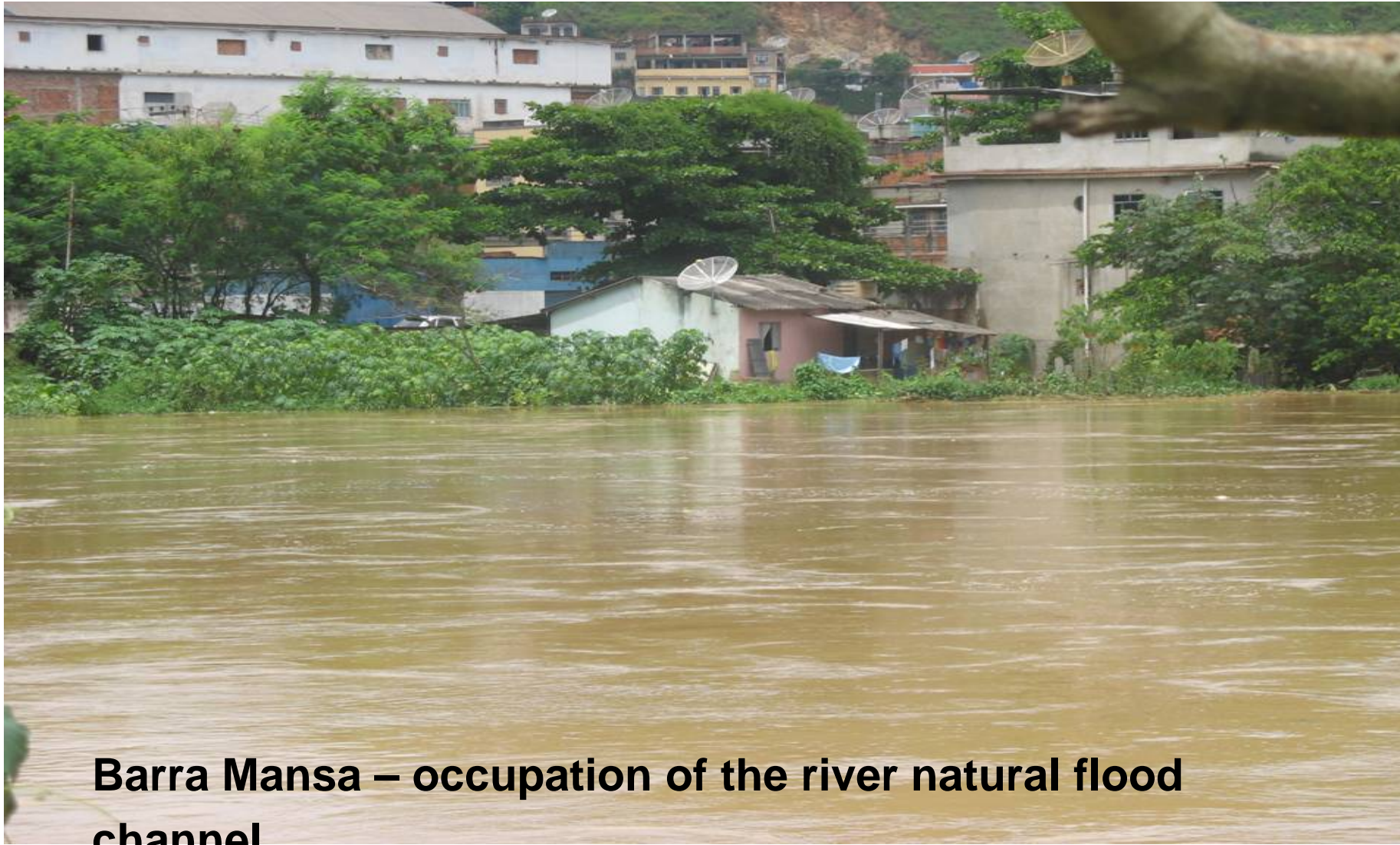


# Flood Control



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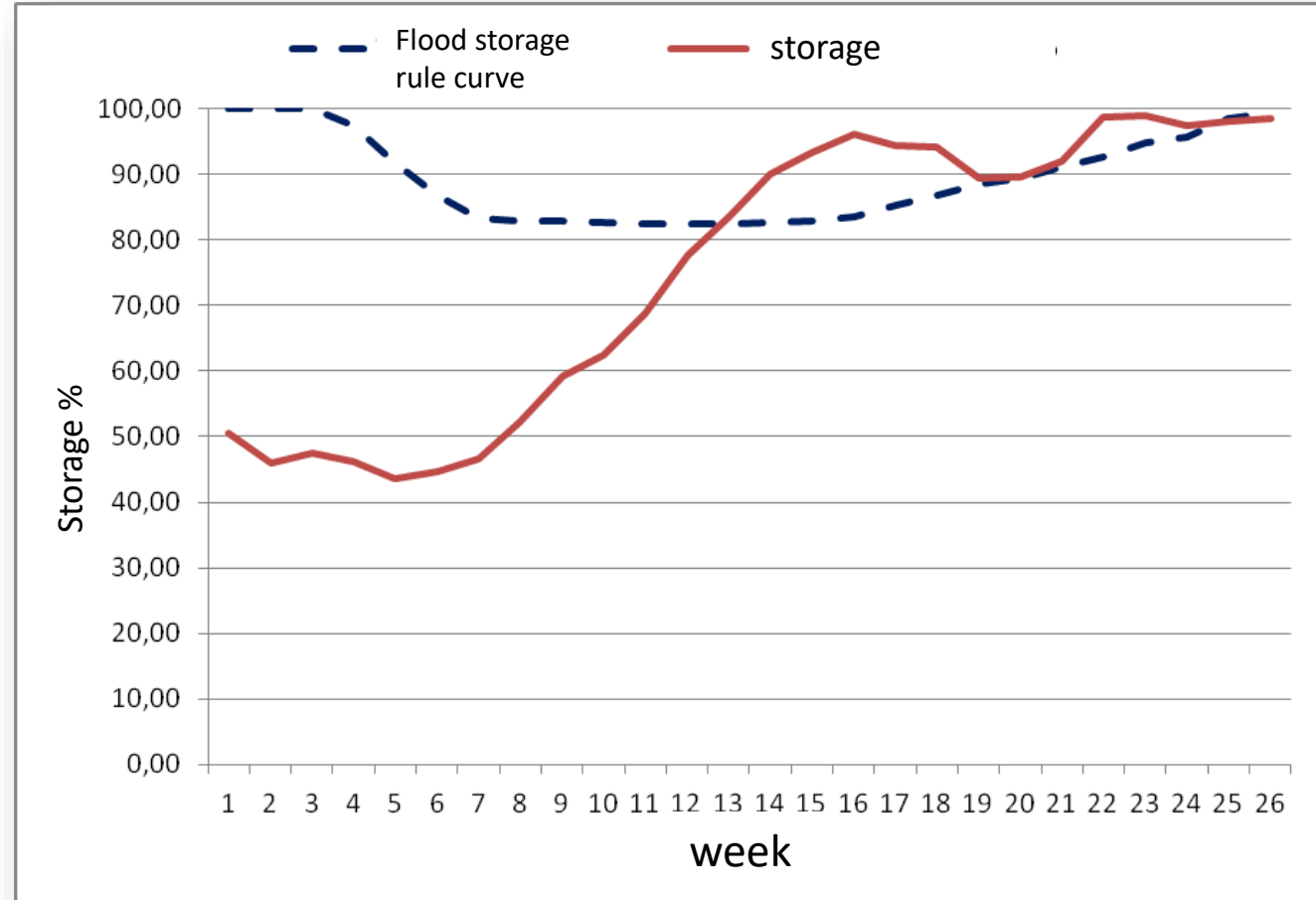
# Flood Control



**Barra Mansa – occupation of the river natural flood channel**

# Operation for flood control

week	Storage %	76
		Risco
13	6,48	2
14	42,28	4
15	61,19	4
16	76,12	5
17	62,05	4
18	56,39	4
19	7,24	1
20	0,89	1
21	11,38	1
22	82,52	5
23	77,91	5
24	39,03	3
25	0,00	0
26	0,00	0



# Conclusions

- The Paraíba do Sul river basin, an important industrial Brazilian region, responsible for 10% of Brazilian GNP, encompass numerous municipalities which depends on its water resources.
- Decades of multipurpose operation of upstream hydropower regulation reservoirs had proved to be valuable in increasing basin water resources availability and reducing vulnerability against droughts in the basin and in the two metropolitan nearby regions (Rio de Janeiro and São Paulo).
- Valley vulnerability against floods had also been enhanced by proper allocation of flood control storage in the hydropower regulation reservoirs.