# Natural radionuclides in sediments from Poços de Caldas Plateau - Brazil

N. C da Silva, H. L. C. Alberti, E. T. Z. Guerrero, M. R. L. Nascimento, R. L. Bonifácio, H. A. Franco do Nascimento, R. A. S. Villegas

Brazilian Commission for Nuclear Energy - CNEN
Laboratory of Poços de Caldas - LAPOC

# Outline

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2. Why Poços de Caldas Plateau?
3. Acid Mine Drainage at Caldas site (former uranium mine)
4. Sampling strategy
5. Analytical procedures
6. Results
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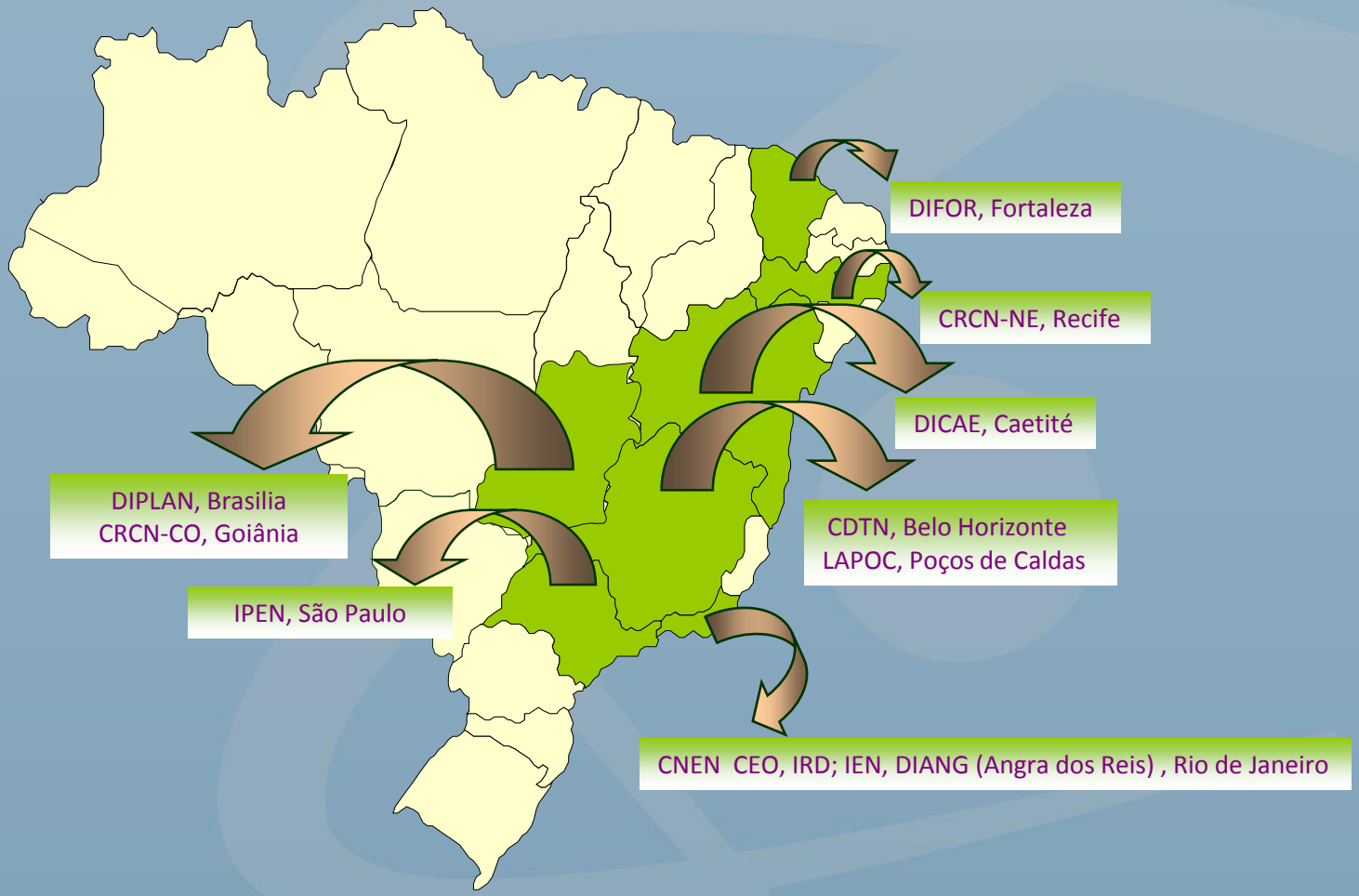
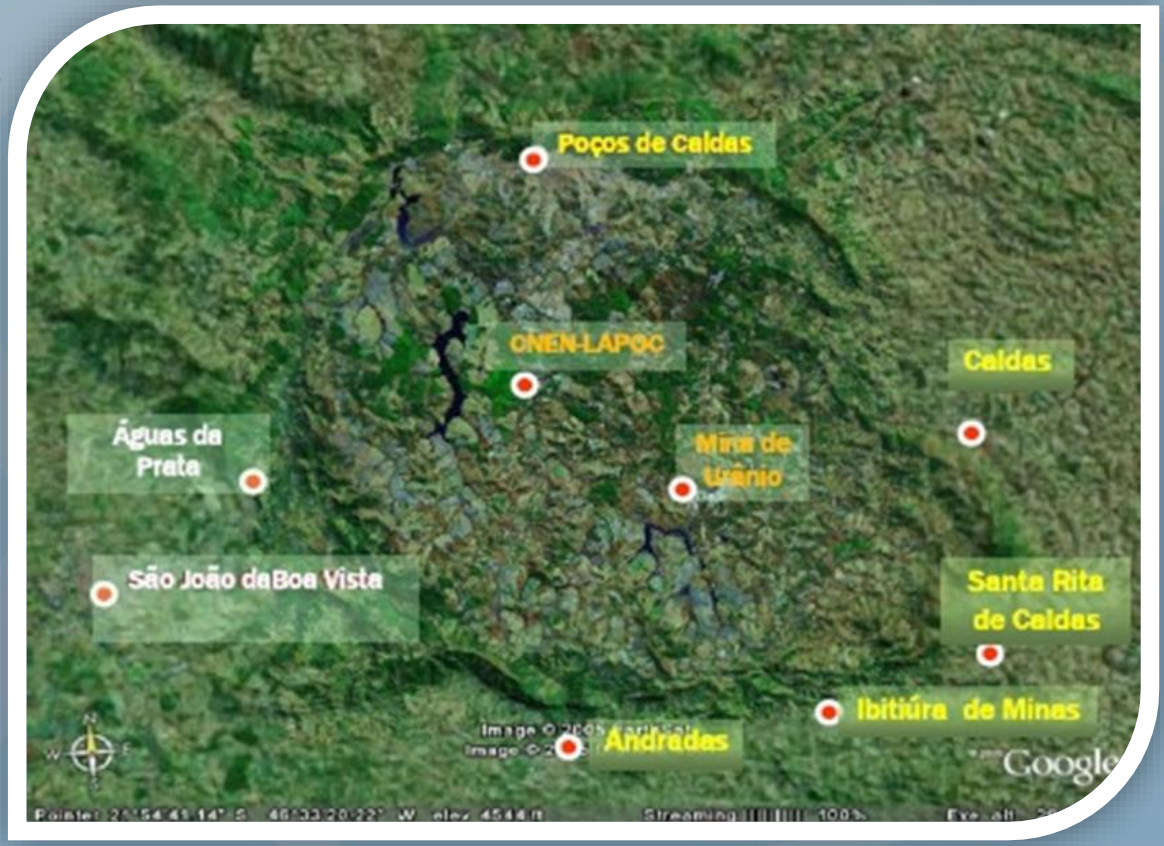
# Brazilian Commission for Nuclear Energy- CNEN




## Nuclear regulatory authority and research & development

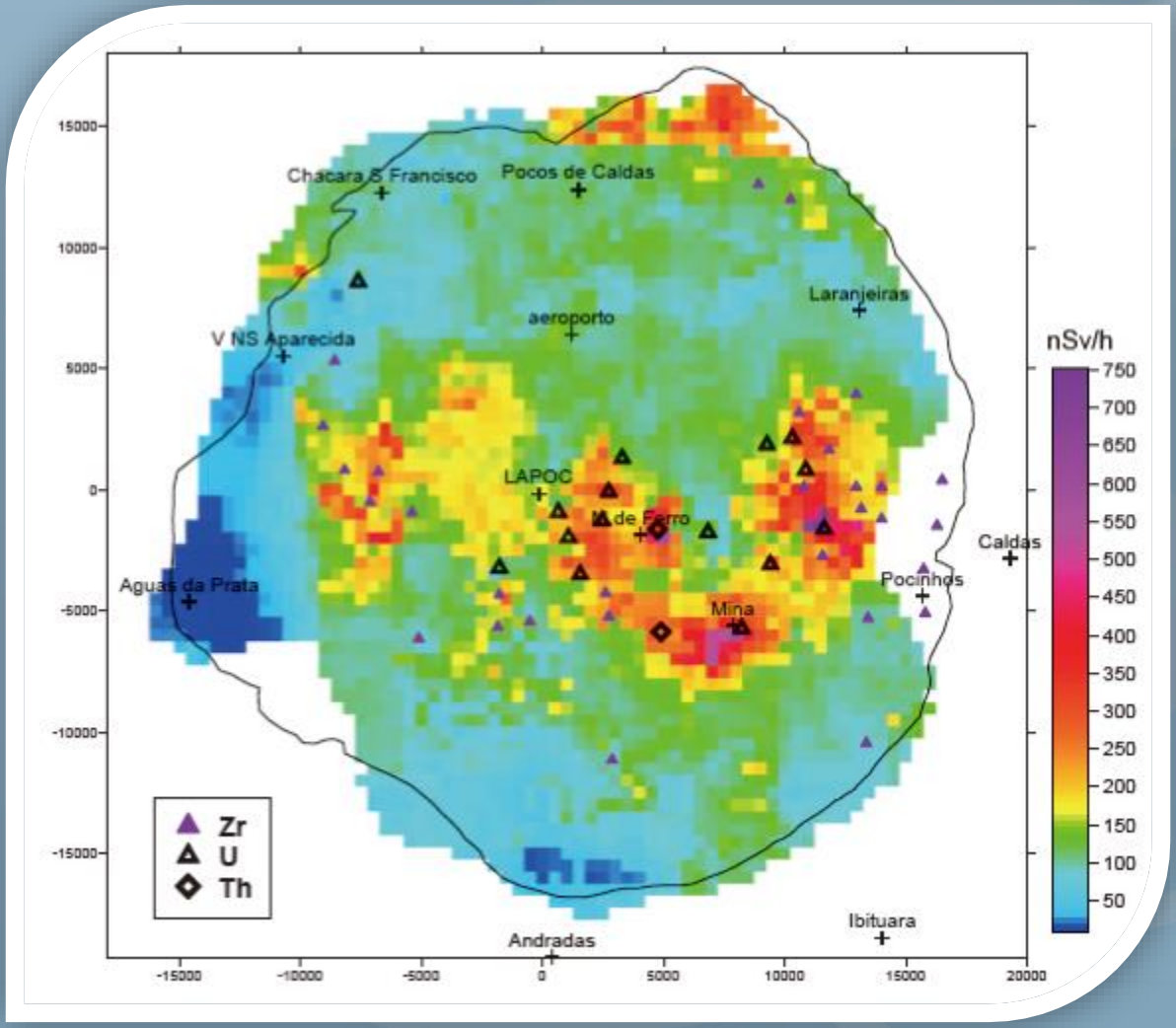
# Area Location (Poços de Caldas Plateau)

- Located at the border of States of Minas Gerais and São Paulo (230 km far from São Paulo), Southeast Brazil;
- Volcanic caldera: ∅ ~35 km ~250.000 inhabitants



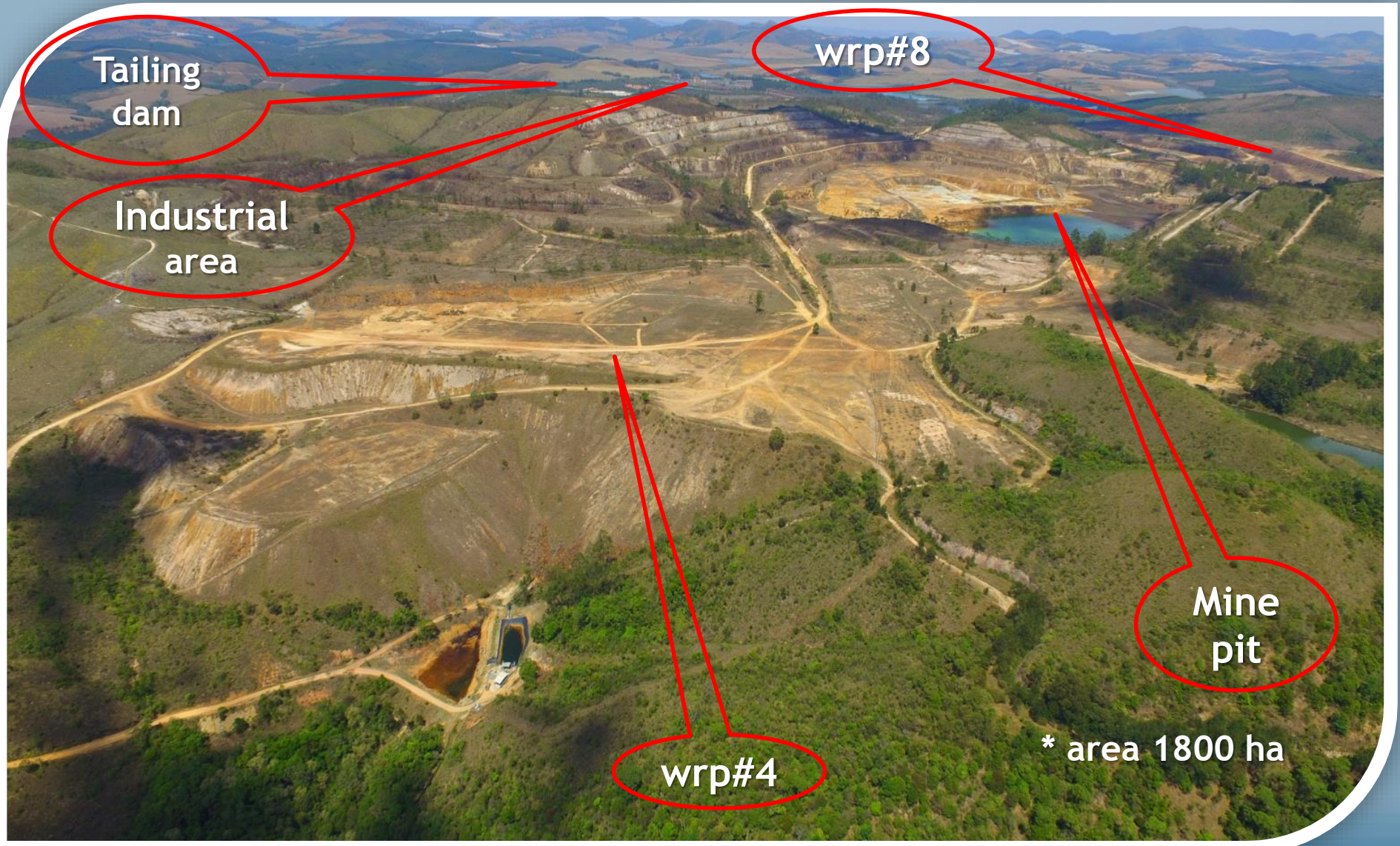

Average altitude 1200 – 1600 m

# Why Poços de Caldas Plateau?




- Elevated altitude compared to the surrounding area
- Some radioactive anomalies (e.g. Morro do Ferro)

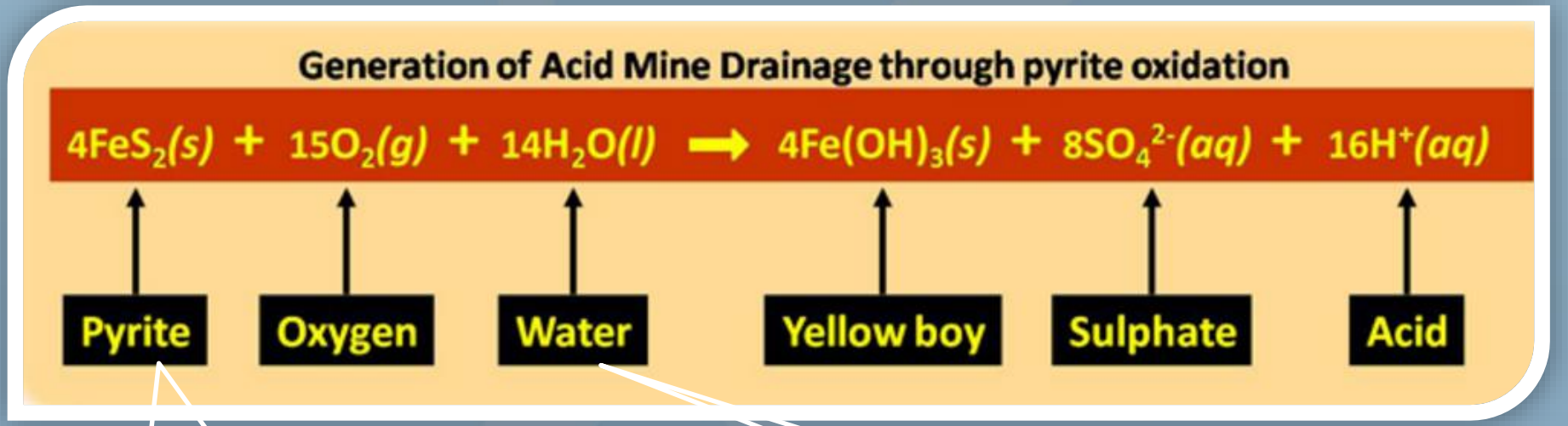
# Why Poços de Caldas Plateau?




- First Brazilian uranium mining and milling

# Acid Mine Drainage

Source: https://www.dwa.gov.za/projects/amdfslts/default.aspx




**Waste rock ~ 28.4 Million $m^3$**
**$FeS_2$ up to 2%**
**Cutoff grade (U < 170 mg/kg)**

**Annual Precipitation**
**~1800 mm/year**

# Acid water treatment and sludge management

Annual lime consumption ~ 3500 tons

Thickener overflow high pH >11

Energy consumption 3.5 – 4.3 TW-h/year

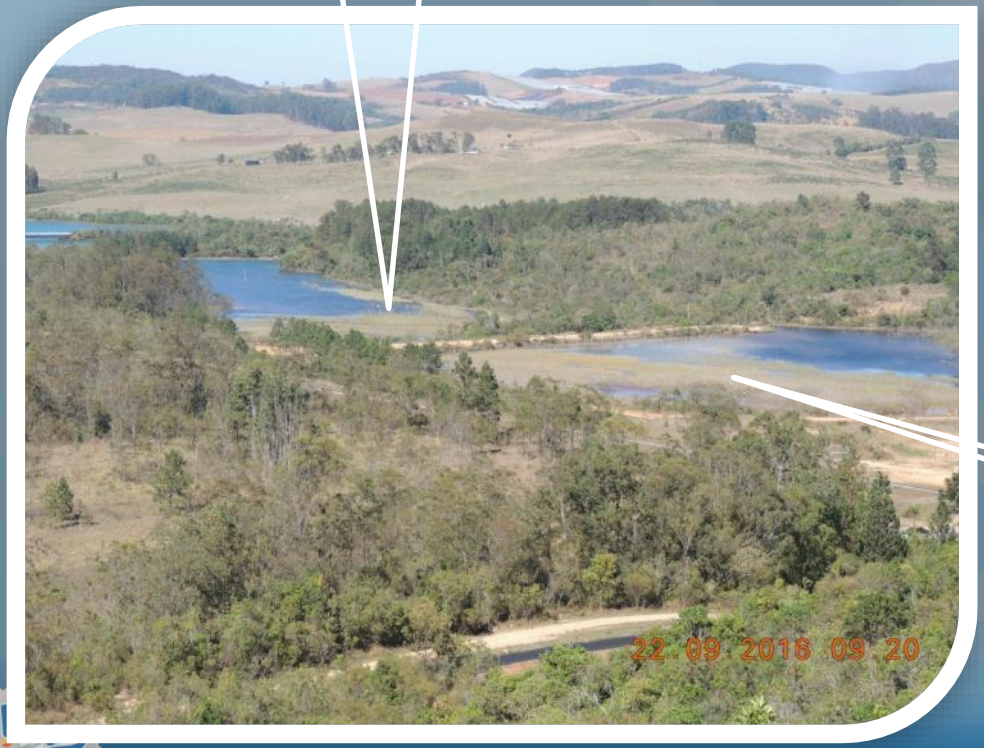
Annual acid water treated ~ 2.5 million $m^3$ (~ 1.4 lime kg/m3 treated water)

* Operating since 1982

- Flow rate to mine pit 45 $m^3/h$
- Sludge density ~1.04 $g/cm^3$
- Dried mass 16 g /L

# Settlement pond #D3 and #D4

Settlement pond D4




Thickener overflow
~300 $m^3/h$

Settlement pond D3

# Environmental impact on Águas Claras Reservoir

# Experimental - Sampling strategy

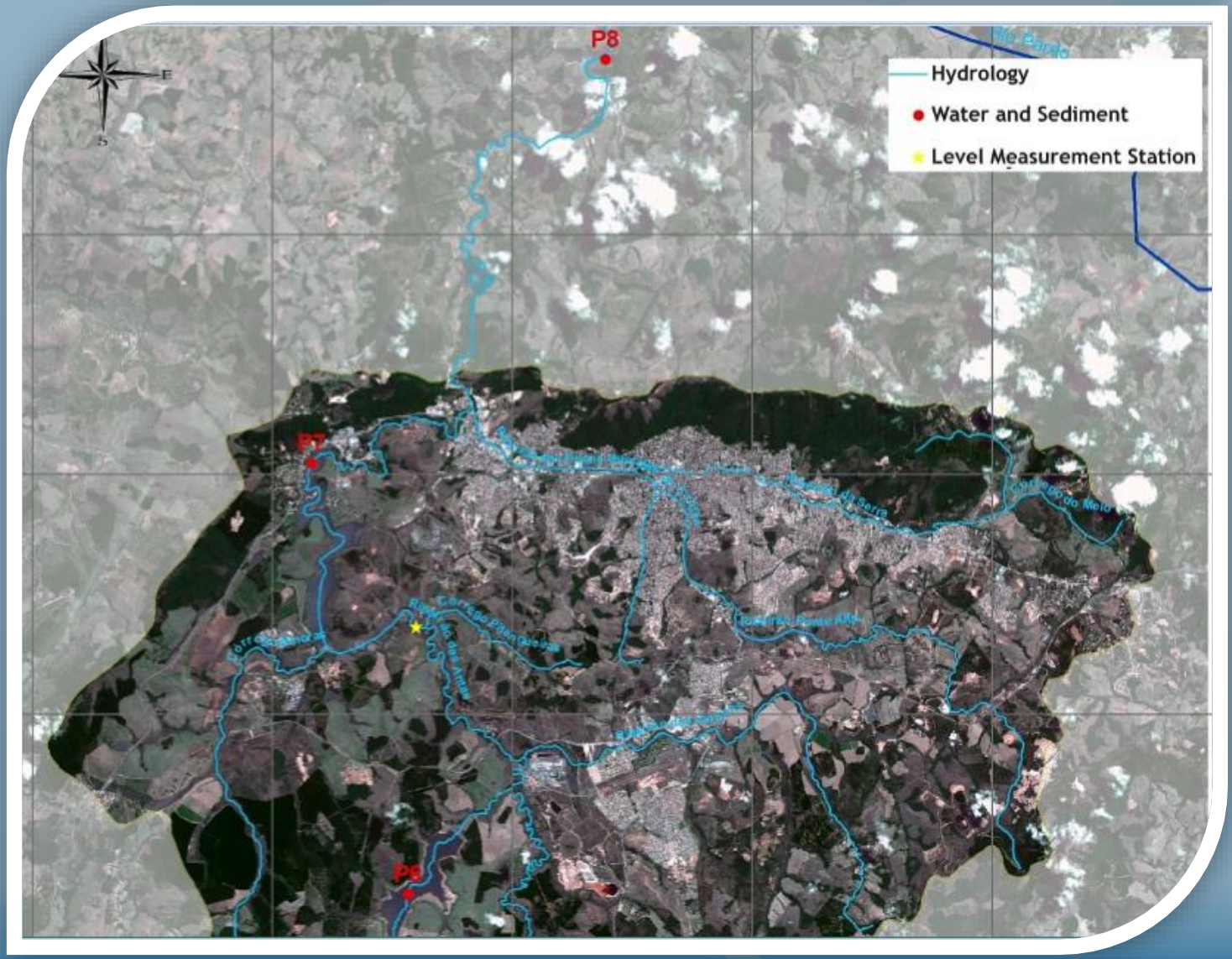
Bottom sediments were collected in 4 campaigns (held on January- 2015, March-2015, October-2015 and January- 2016) in 8 sampling stations located in reservoirs of Antas river (creek) or in its affluents.

# Experimental - Sampling strategy


- P1- Pitagueiras Creek, uranium mine upstream (background)
- P2- Águas Claras Reservoir, uranium mine upstream
- P3- Discharge point of uranium mine water treatment plant
- P4- Águas Claras Reservoir, downstream P3
- P5- Águas Claras Reservoir (near to its mouth), uranium mine downstream

# Experimental - Sampling strategy

- P6- Cipó Reservoir
- P7- Bortolan Reservoir
- P8- Rolador Reservoir



# Experimental – Sampling procedure

- A dredger drag, operated using a boat, was used to collect bottom sediment in all reservoirs.
- Samples were stored in plastic bags (20 kg maximum capacity) before being transported to laboratory.

# Experimental – Sample treatment

- Samples were dried at 110°C until reaching constant weight, milled in a jar mill (of stainless steel balls, diameter of 1 inch, at 30 rpm) and sieved at 1,70 mm (10 mesh)

# Experimental – Ra-226, Ra-228 and Pb-210 determination

**High Resolution gamma-ray spectroscopy (Canberra HPGe of 20% relative efficiency)**

- Dried samples were kept in sealed metal boxes for 30 days (to ensure secular radioactive equilibrium between Ra-226 and its daughters Pb-214 and Bi-214)
- The photopeak 186.1 keV of Ra-226 was not considered due to high U content (and interference from photopeak 185.7 keV of U-235)
- For Ra-226 determination, the photopeaks used were 609 keV and 1020 keV of Bi-214
- The photopeak 911 keV of Ac-228 (6.12h half-life) was used for Ra-228 determination
- For determination of Pb-210, the photopeak 46.5 keV was used

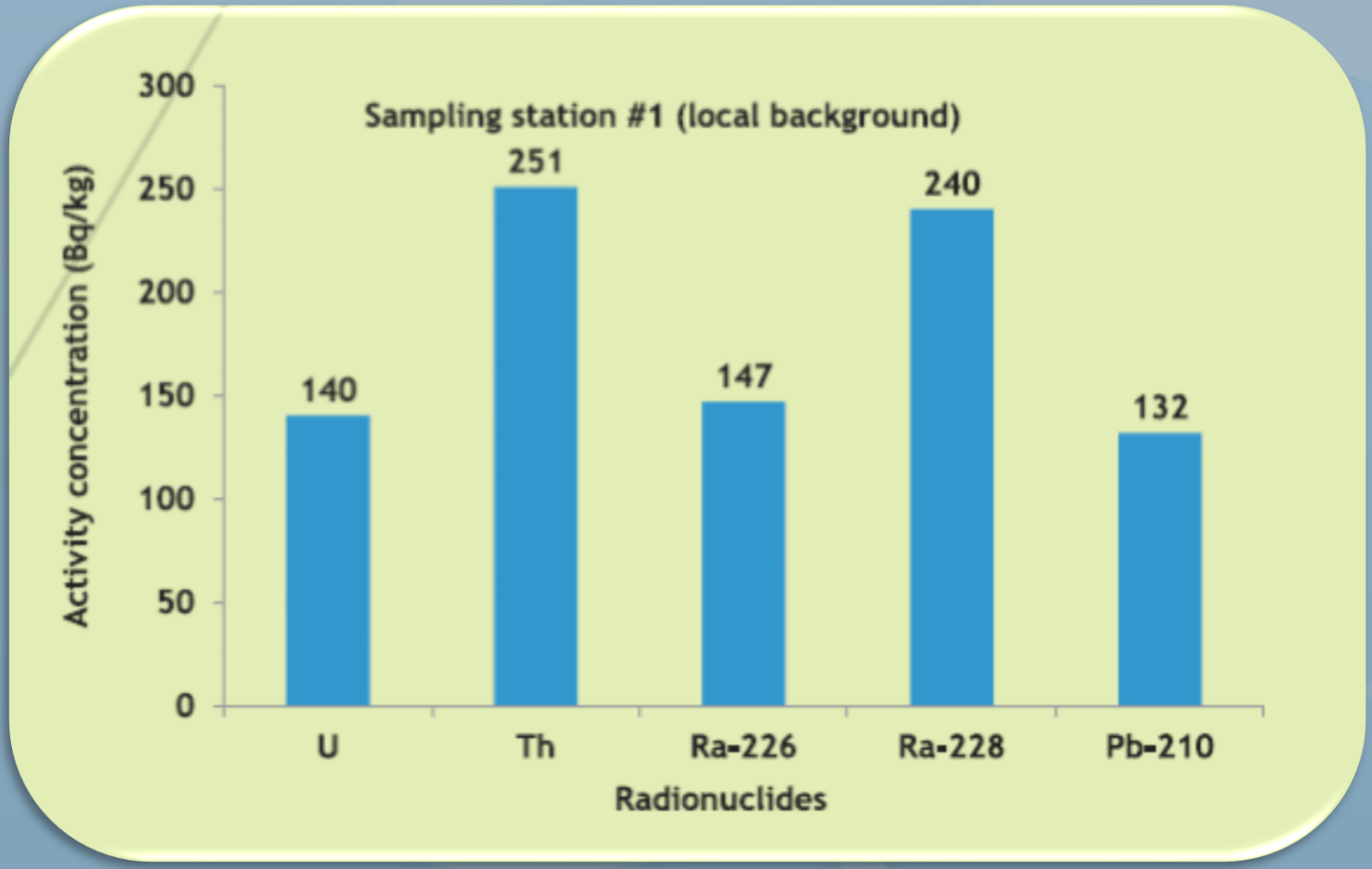
# Experimental - U and Th determination

Inductively coupled plasma mass spectrometry, ICP-MS

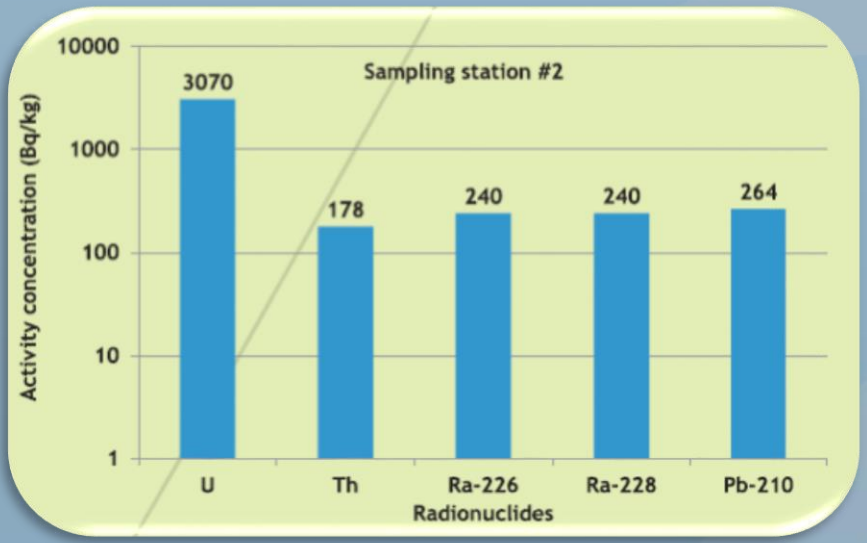
- Samples were previously solubilized using nitric digestion in closed vessel on a microwave-assisted digestion device following a procedure similar to USEPA Standard 3050B

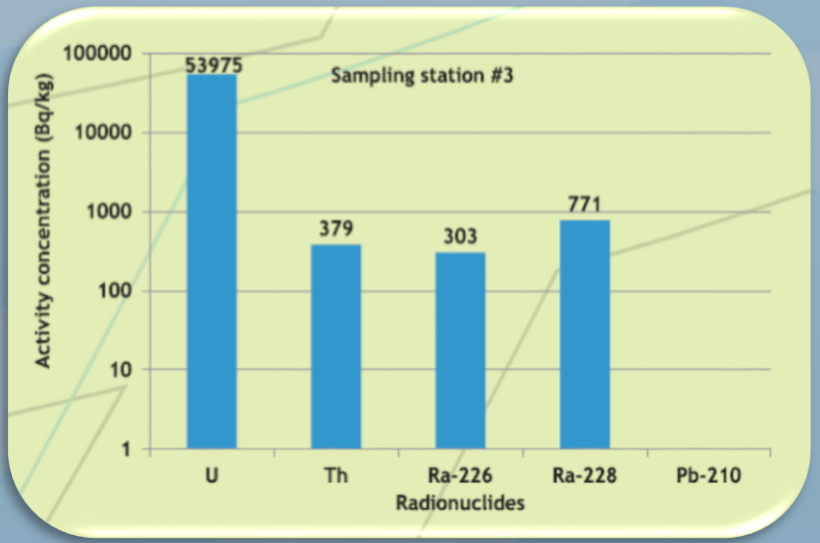
These assays (ICP-MS, HPGe) are currently under process of accreditation by the Brazilian Accreditation Authority - CGCRE/INMETRO

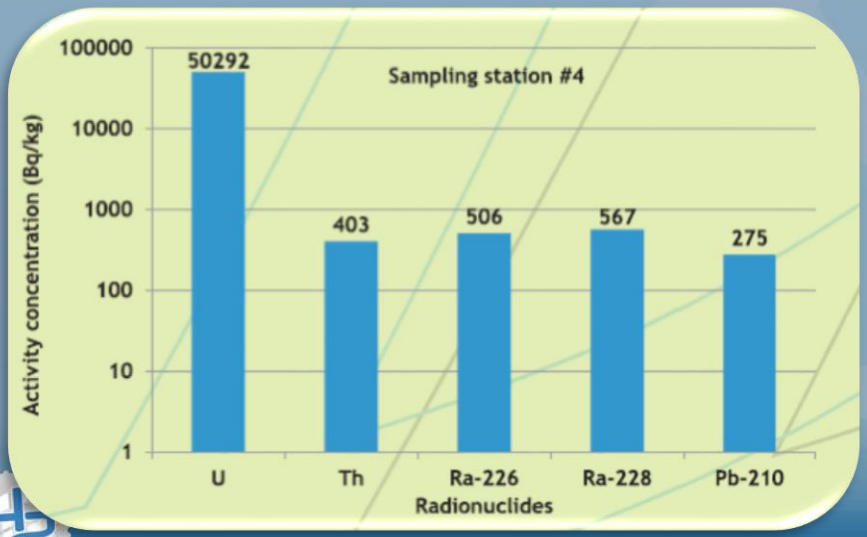
# Results- Background

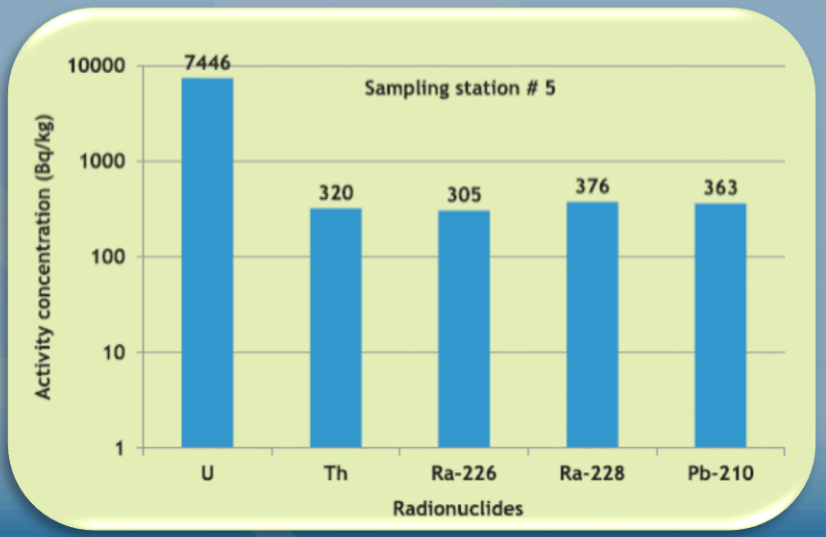


# Results- Águas Claras Reservoir

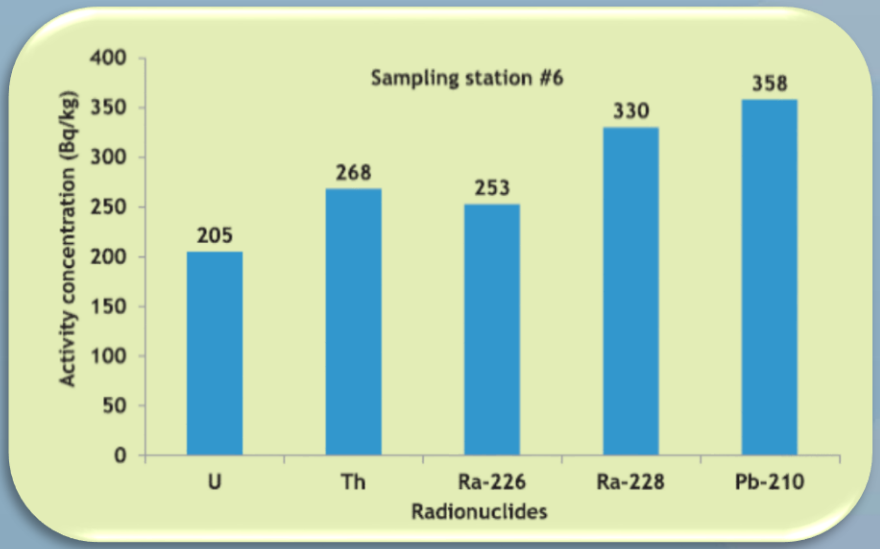


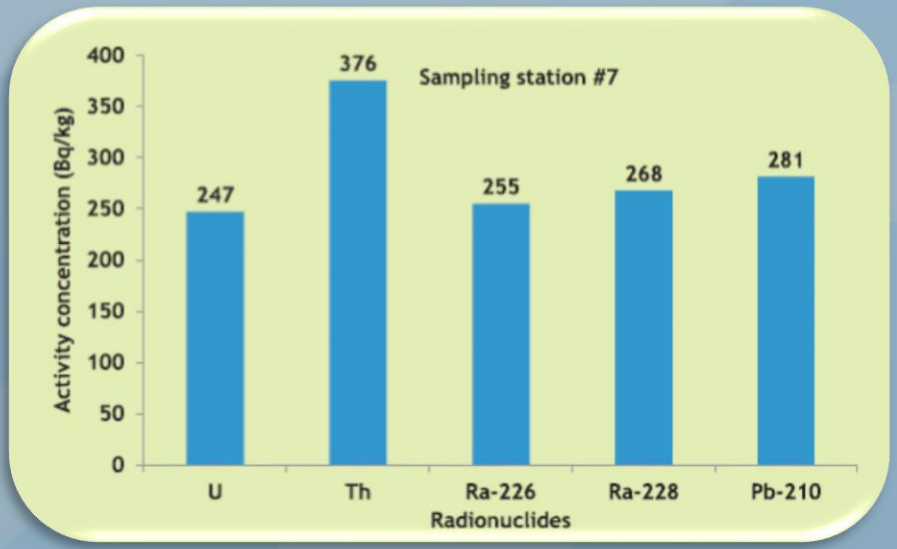



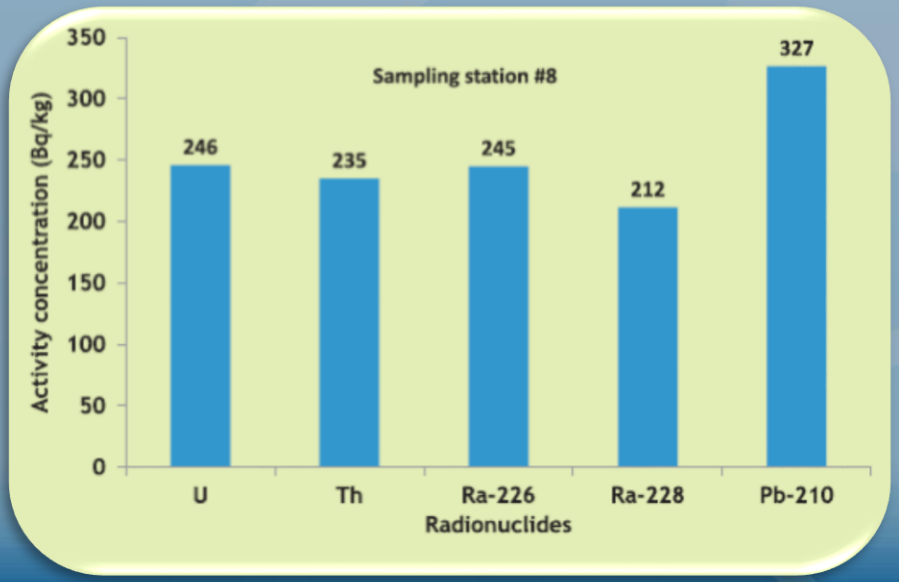



# Results- reservoirs downstream



# Conclusions

- Sampling Stations #4 and #5 (Águas Claras reservoir) present significantly high concentrations of uranium in sediments, confirming anthropogenic contribution.

- A strong dilution trend of this element is observed when comparing sampling stations #3 and #4 to the others downstream.

- A situation of environmental liability is observed and represented by these high concentrations, which come from the Acid Water Treatment System and should be environmentally remediated.

# Conclusions

• The high sulfate concentration in the acid water, which led to the precipitation of Ra-226 and Pb-210, explains the low concentration of these two radionuclides in the sediment

• The low thorium content in rocks located in the uranium mining site explains the low concentration level of this radionuclide and its daughter Ra-228 in the sediment

# Acknowledgements

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# Thank you for your attention!!!

ncsilva@cnen.gov.br