SALINITY IN THE COLORADO RIVER BASIN: CAUSES, EFFECTS, AND IMPLICATIONS

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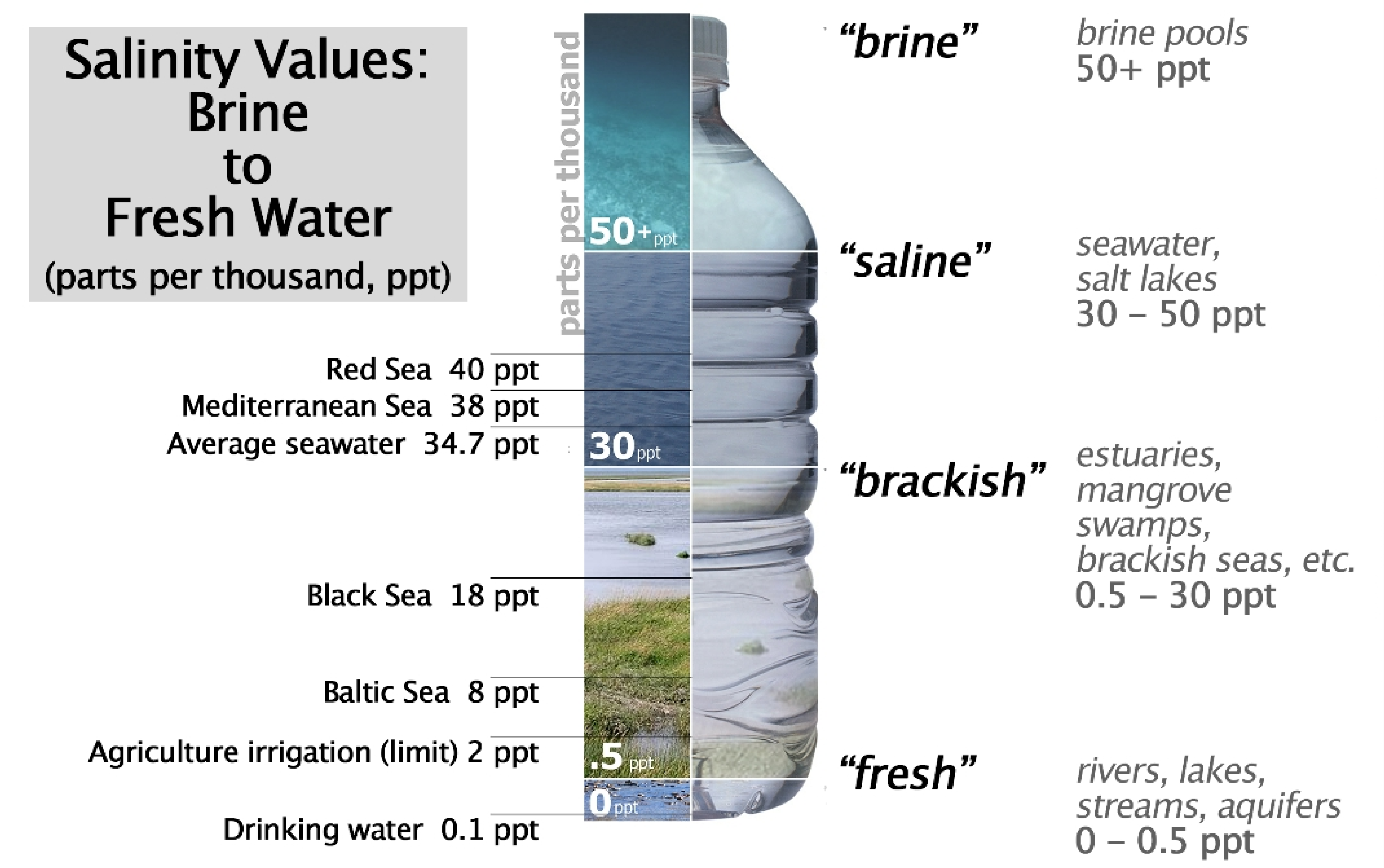


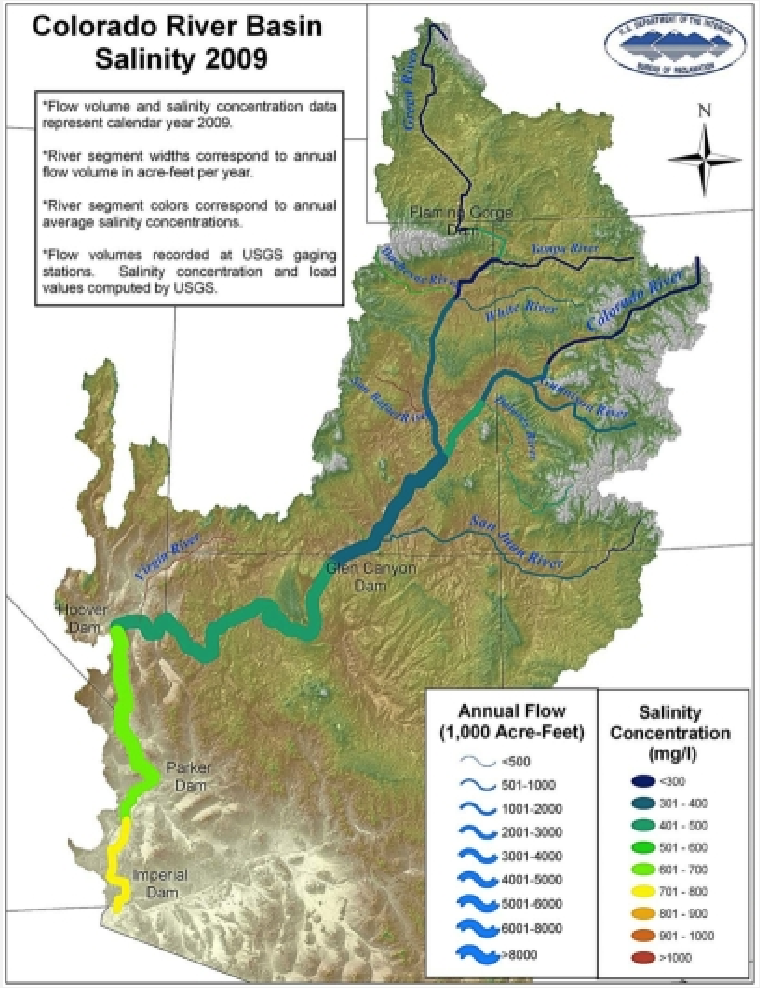
(Ocean Observatories Education)

Note: 1 ppt = 1000 mg/L

SALINITY OF THE COLORADO RIVER

- Salinity increases downstream from headwaters (BoR 2013)
  - 600 mg/L at Glen Canyon Dam
  - 723 mg/L at Hoover Dam
  - 879 mg/L at Imperial Dam
- Colorado River salt loads -
  - 1940-1980 – 9.3 million tons per year
  - 2005- present – 7.7 million tons per year
- Estimated salinity damages ~$382 million annually

  (BoR 2017)



BoR, 2013 Progress Report

PROCESSES OF SALINIZATION

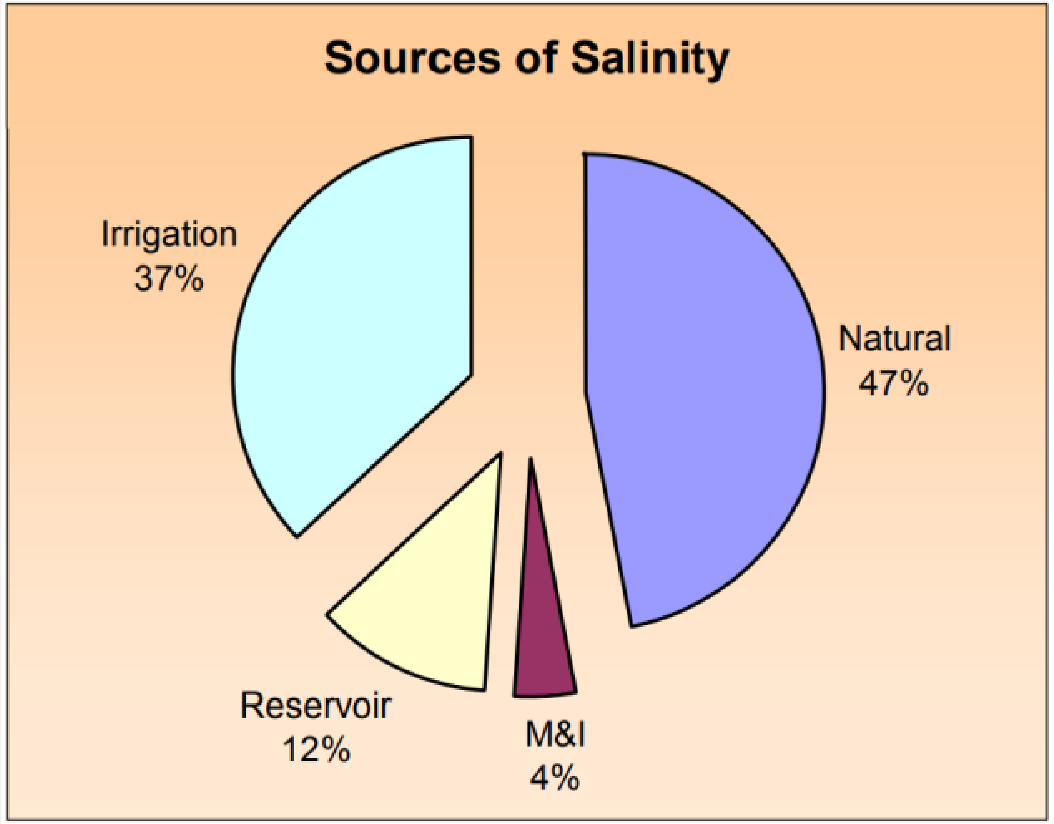
- Salt Loading
  - Dissolution and leaching of salt
  - Main Contributors:
    - Inefficient irrigation/runoff
    - Dissolution of geologic materials
- Salt Concentration
  - Direct: Concentrated through evaporation and transpiration
  - Indirect: Diversion of high-quality water

WHY IS SALINITY A PROBLEM?

- Agricultural Damages (El-Ashry et al. 1974, Rhoades 1984)
  - Decreases in yield
  - Legacy Salt Accumulation
  - Negative agricultural effects begin at TDS (total dissolved solids) of 700-850 mg/L
- Infrastructure Damages
  - Corrosion
  - Precipitation → blocking of pipes
- Drinking Water Standards
  - 500 mg/L set by EPA as a Secondary Drinking Water Standard

CAUSES OF SALINITY

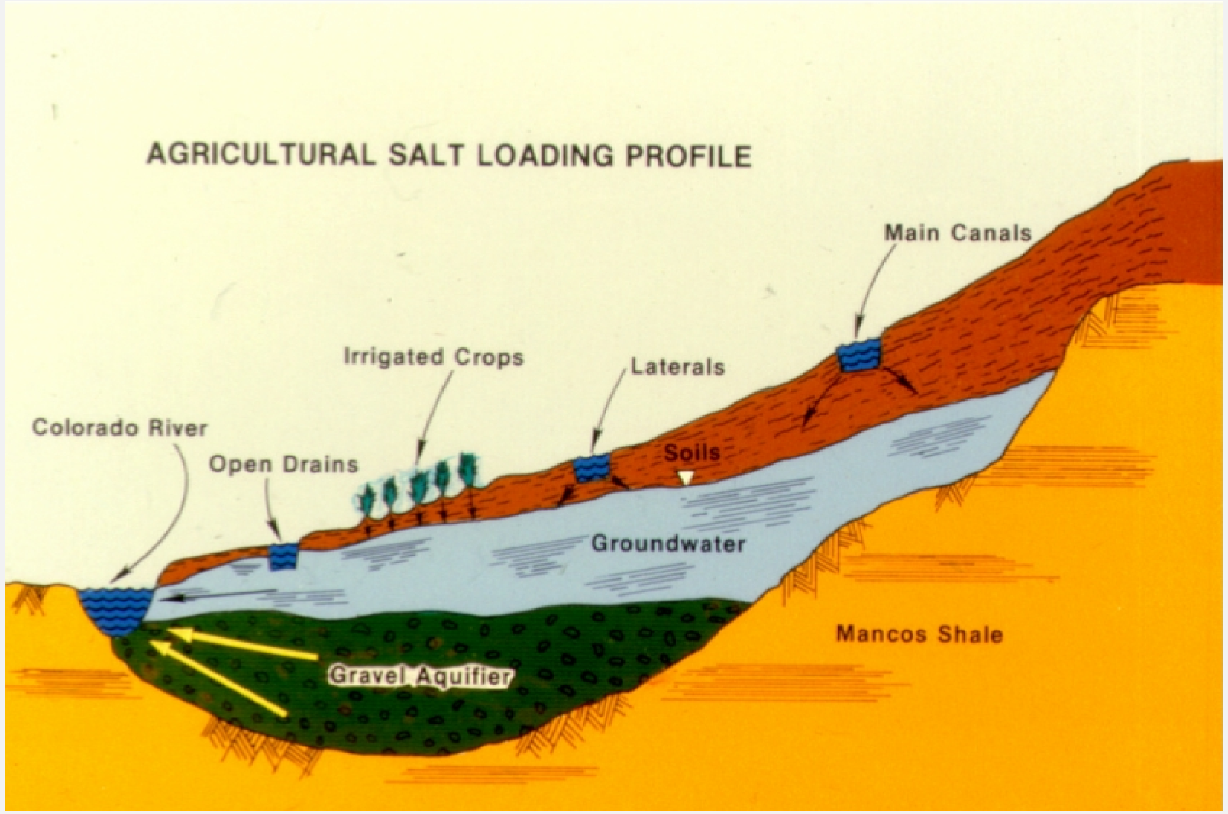
- Irrigation (Agricultural)
- Natural
- Municipal and Industrial
- Reservoir Storage



U.S. Dept. of Interior, 2003

AGRICULTURAL IRRIGATION

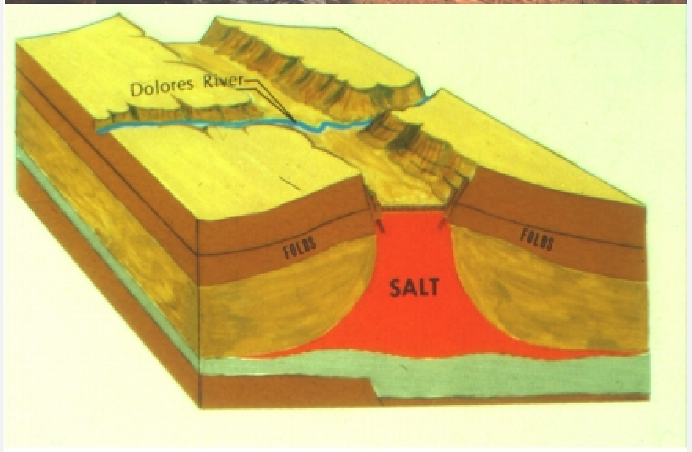
- Inefficient irrigation practices leads to leaching of salts from the root zone (upper 1-2m)
- Leaky water conveyance infrastructure also a contributor



U.S. Dept. of Interior, 2003

NATURAL

- Point and non-point sources
  - Non-point: Diffuse contributions of low-conc. sources (non-agricultural soil and geologic formation contributions)
    - Saline aquifers overlying Mancos Shale unit (Gardner and Young, 1988)
  - Point Sources: high-conc. sources (springs, salt domes) (BoR, 2017)
      - Examples: Glenwood-Dotsero Springs Unit, Paradox Valley Unit



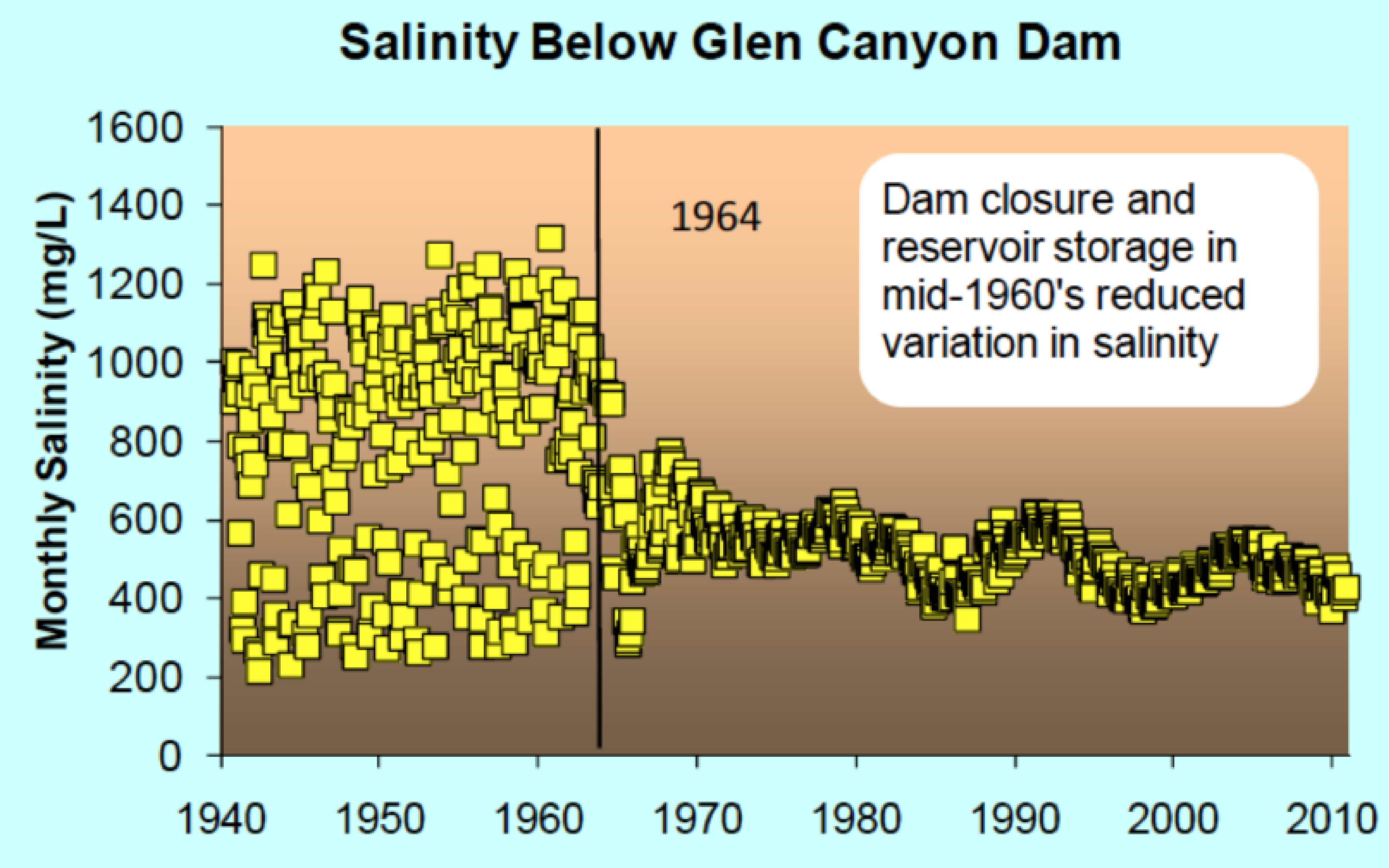
RESERVOIR STORAGE

- Increased evaporation occurs in reservoirs

- Measured examples (Paulson et al. 1983)
  - 900,000 acre-ft/yr due to evaporation from Lake Mead
  - 500,000 acre-ft/yr at Lake Powell

- Now managed to release low-saline flows during drought periods, dilute high saline flows during wet years

RESERVOIR STORAGE



POLICY

- The Water Quality Act of 1965
  - States must develop water quality criteria
  - Specific salinity requirements not established at this time
- Clean Water Act (1972)
  - Numerical standards required!
  - Annual flow-weighted TDS concentration limits set at 1972 levels:
    - 723 mg/L below Hoover Dam
    - 747 mg/L below Parker Dam
    - 879 mg/L at Imperial Dam
    - Average salinity must be maintained at or below 1972 levels
  - Success to be evaluated on 3-year intervals

POLICY

- Colorado River Basin Salinity Control Act (1974) – Passed largely to uphold treaty conditions with Mexico regarding water quality regulations
  - Title I
    - Approves budget to construct desalinization plant on border of US-Mexico
      - Will regulate salinity of water delivered to Mexico
  - Title II
    - Funding for widespread attempts to reduce salt loading into the Colorado River
      - Agencies involved include Bureau of Reclamation, Natural Resource Conservation Service (USDA), Bureau of Land Management (USDI)
- 1976 – Seven basin states, EPA and BoR implement Salinity control program for Colorado River Basin

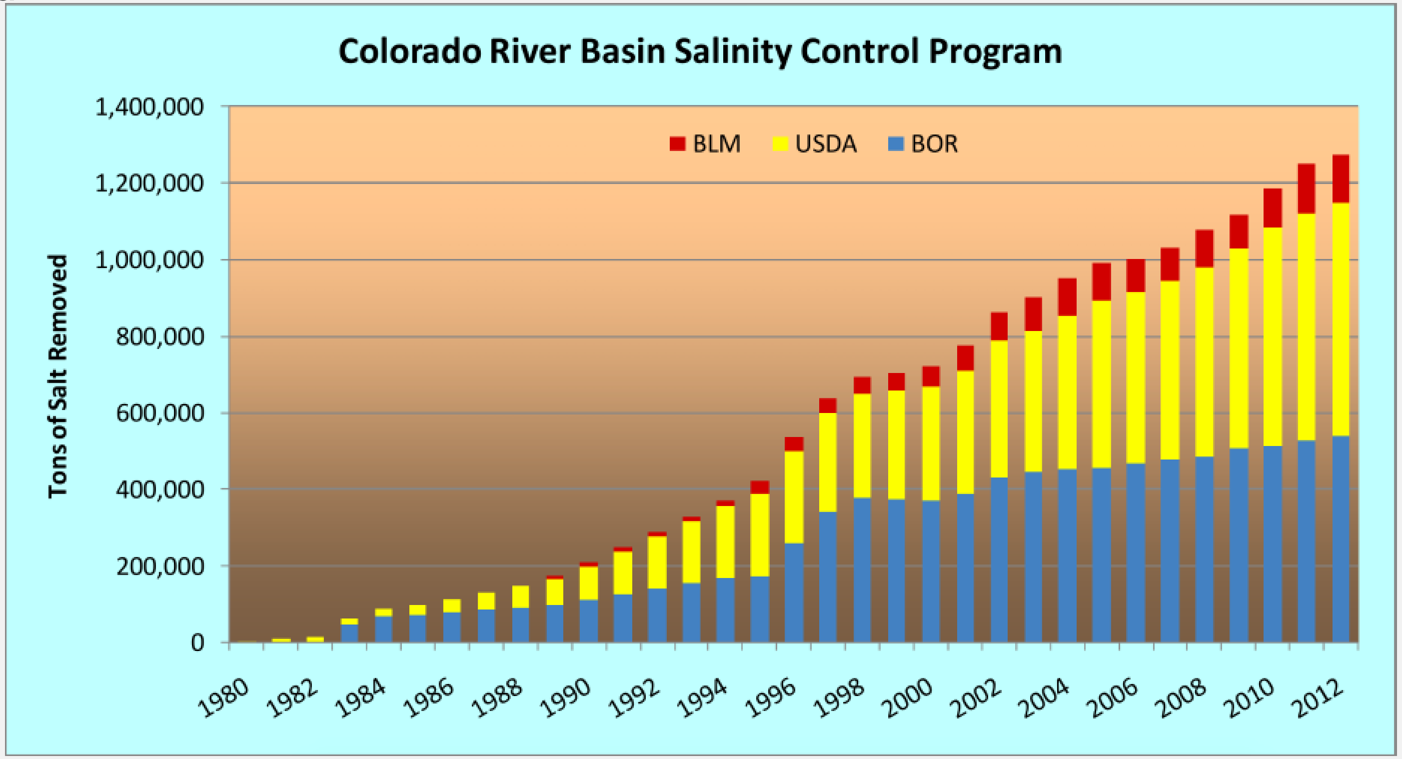
YUMA DESALTING PLANT

- World's largest reverse osmosis desalting plant
- Construction started in 1975, finished in 1992
  - $245 million project
- Rarely run since its construction
- Backstop for water quality delivery standards to Mexico

Yuma Desalting Plant - BoR

RESULTS FROM SALINITY CONTROL ACT- TITLE II

- A reported 1.295 million tons/yr of salts have been prevented from entering the Colorado River by a combination of the BOR, USDA, and BLM from point and non-point sources



POINT SOURCE REMEDIATION METHOD

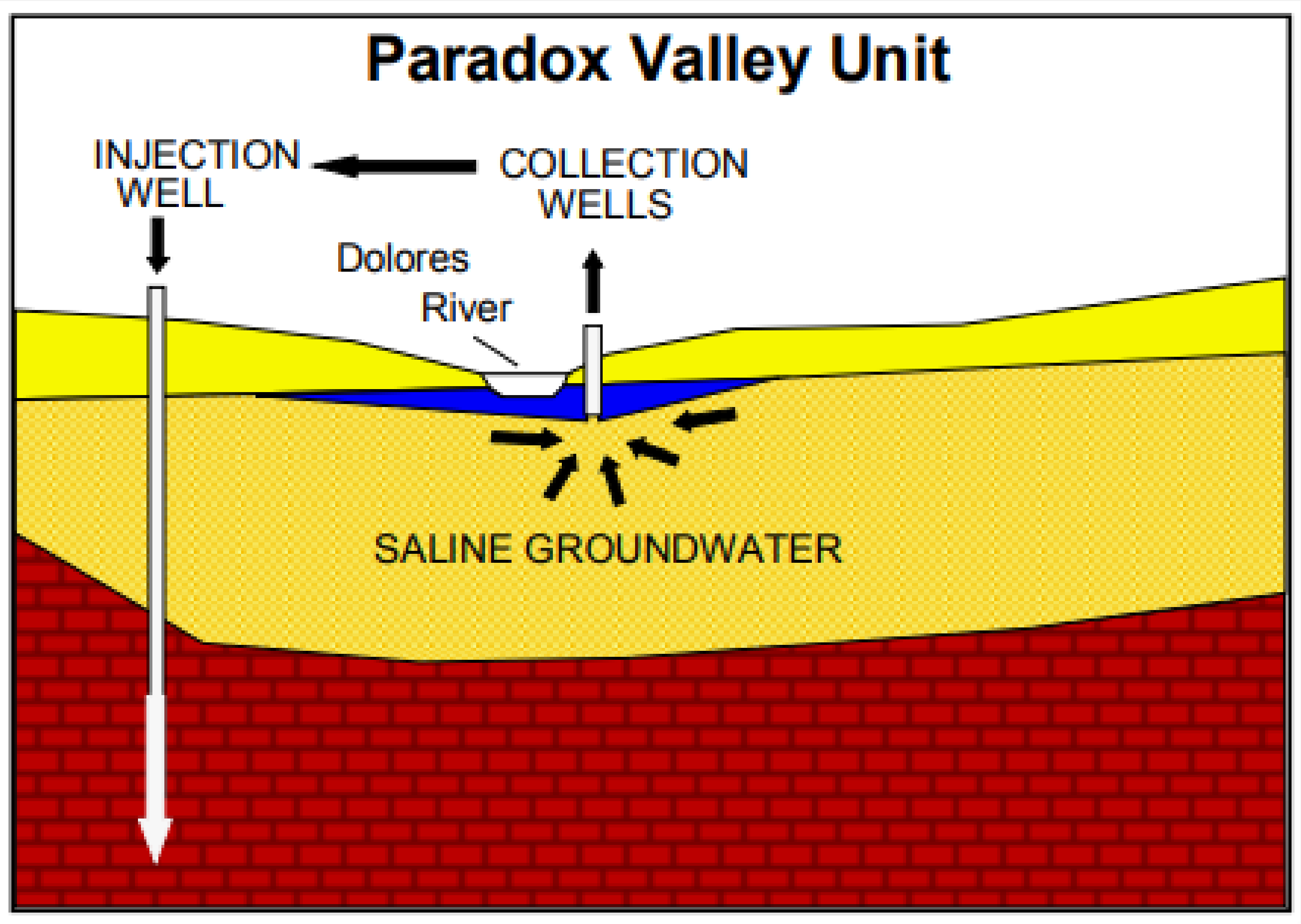
- Collapsed salt dome contributing to increased salinity of Dolores River (tributary of Colorado River)

- Groundwater salinities of 250,000 mg/L have been measured

- Groundwater pumping and injection used to sever connection to Dolores River

- An earthquake in January 2013 caused the Bureau of Reclamation to reduce injection rates

- Without pumping, salinity is projected to increase by 9-10 mg/L across the Colorado River.



(BoR, 2005)

FUTURE POLICY CONSIDERATIONS

- Continued expansion and implementation of non-point and point source management practices to reduce salinity from natural and agricultural sources
  - Projections hypothesize that by 2035, an additional 372,000 thousand tons/yr will need to be removed in order to meet regulations (BoR, 2017).
- Best management practices for disposal of point source interception flows
- Integrated modelling to predict changes in precipitation, runoff, groundwater contributions to baseflow (all variables that control salinity) will contribute towards policy decisions
  - (Venkatesan et al. 2011, Christensen et al. 2004, Lee et al. 1993)

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