



Effluent Dominated Rivers

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Watershed Management – Prof. V. Novotny

Introduction

- Effluent dominated rivers are quite common in areas of high population density
- More common in arid areas
- Each river is unique
 - Magnitude of effluent flows
 - Water quality issues
 - Effects



Introduction

- Selected effluent dominated rivers
 - Lower Des Plaines, Illinois
 - Ipswich River*, Massachusetts
 - Santa Ana, California
 - South Platte, CO
 - Trinity River, Texas

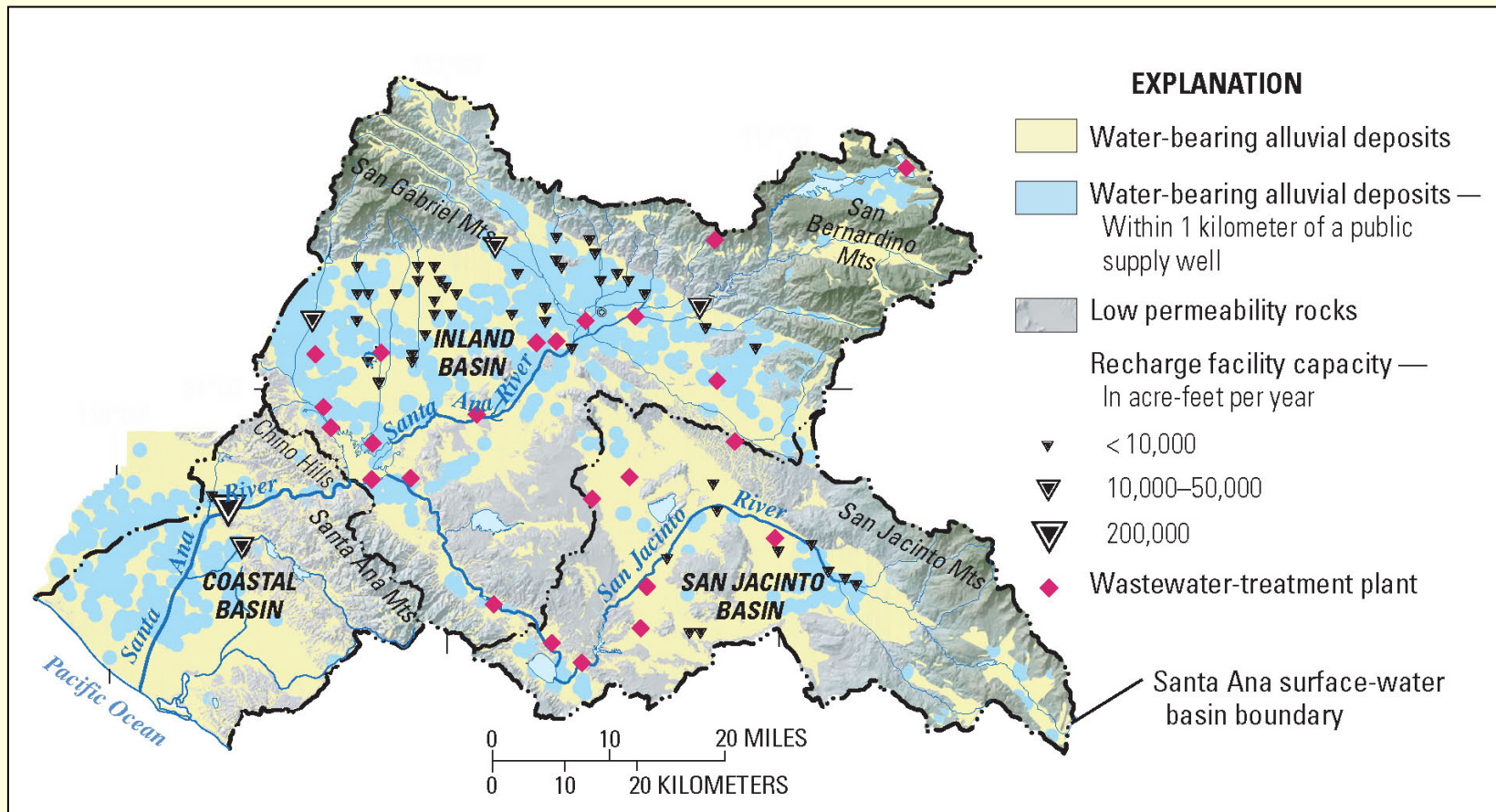


Santa Ana River, CA — Physical Setting

- Southern California's largest river
- Catchment of 2,700 sq-miles
- Highly urbanized throughout
- Population ~5.5 million,
 - 1,500 people/sq-mile

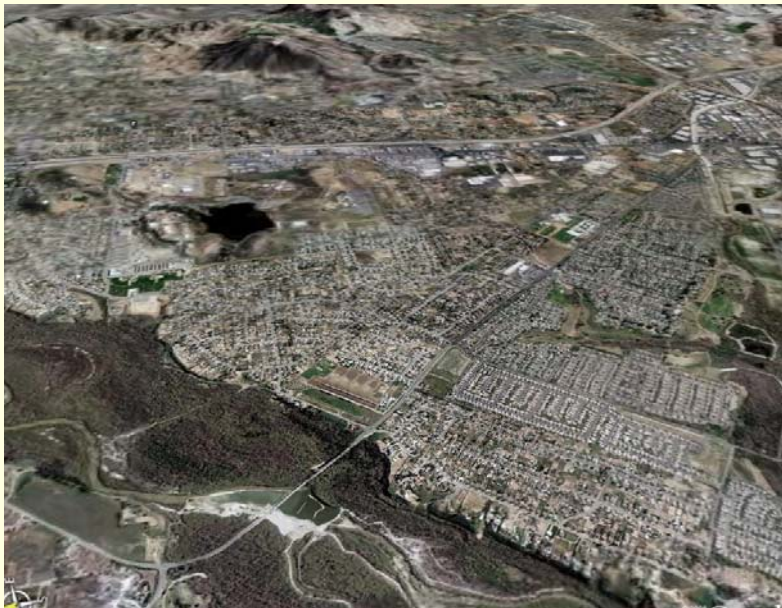


Santa Ana River, CA — Physical Setting



Santa Ana River, CA — Physical Setting

- Inland Basin
 - Source of flow for Santa Ana, Orange County
 - Least densely populated, yet highly urban
 - Prado Dam located at downstream end



Santa Ana River, CA — Physical Setting

- Coastal Basin / Orange County
 - Four major segments
 - Natural channel, ~11 miles
 - Groundwater recharge ponds
 - Concrete lining, ~11 miles
 - Modified, unlined channel, ~5 miles
- Discharge to the Pacific Ocean

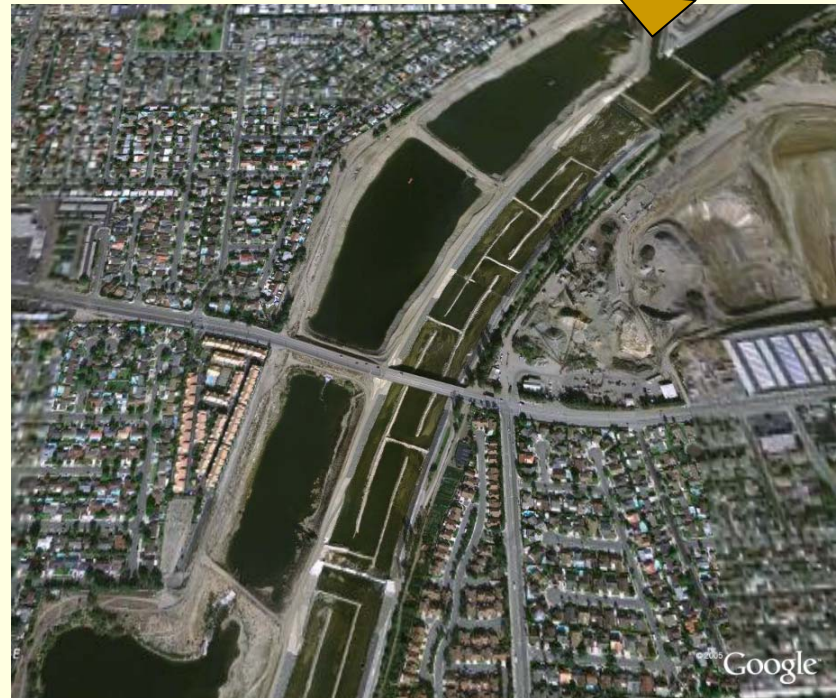
Santa Ana River, CA — Physical Setting



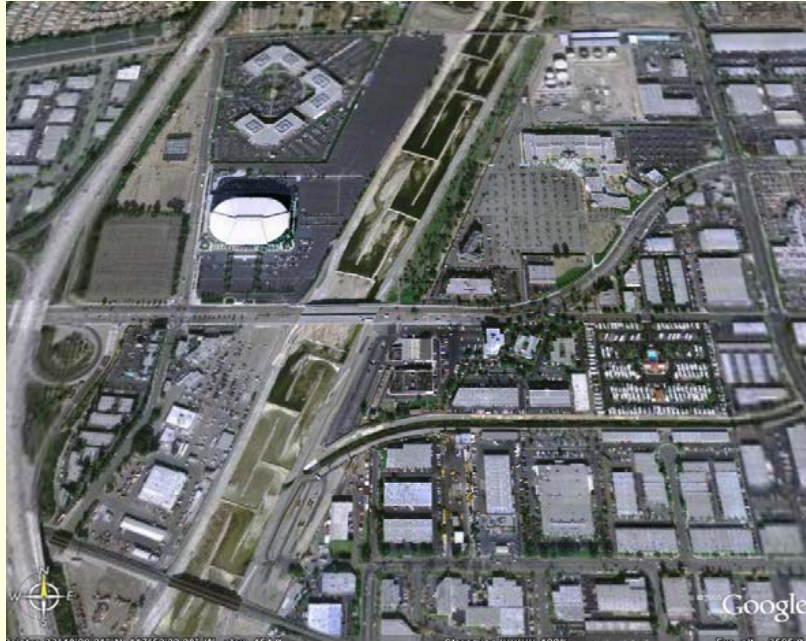
Natural Channel
below Prado Dam

Prado Dam

Groundwater
recharge

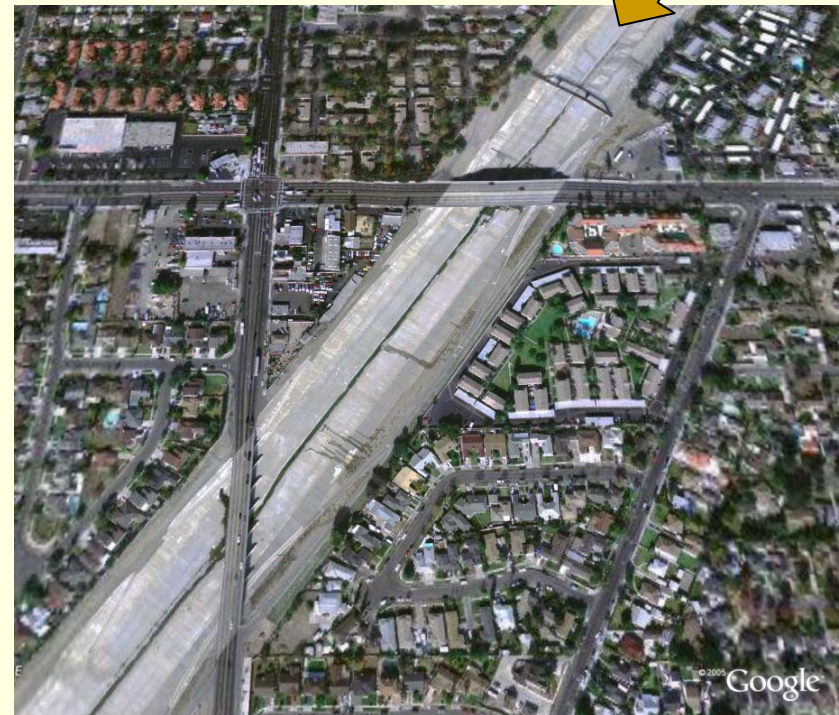


Santa Ana River, CA — Physical Setting



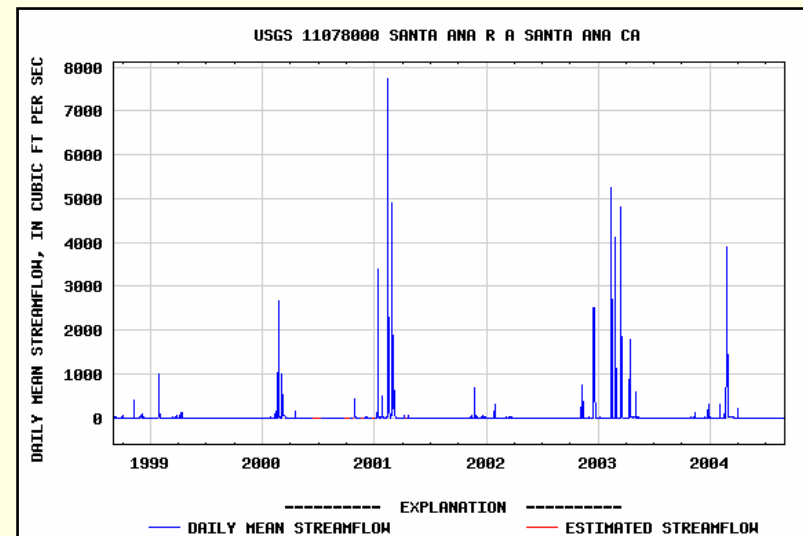
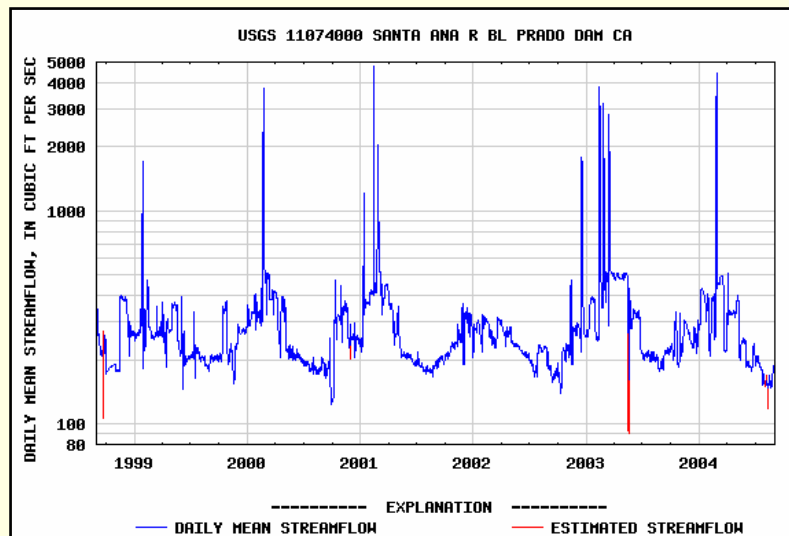
Groundwater
recharge

Channelized
with concrete



Santa Ana River, CA – Streamflow

- USGS stations of interest
 - Below Prado Dam
 - Below groundwater recharge ponds



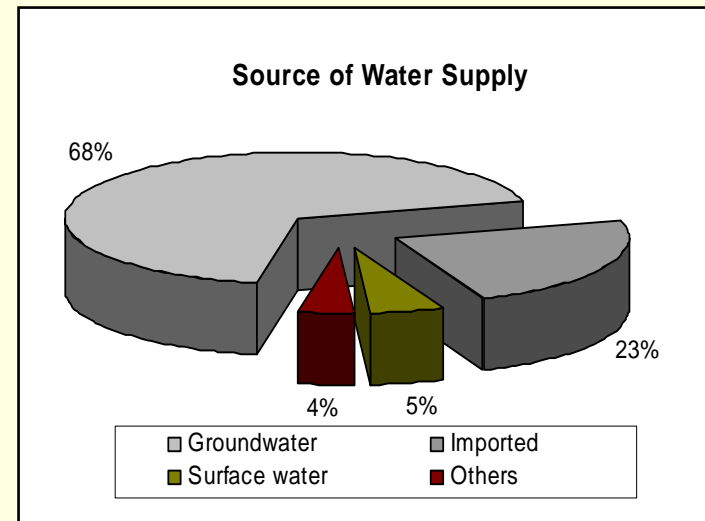
Santa Ana River, CA – Water supply

Water supply

- Water supply in Santa Ana Basin from multiple sources
- Most water for domestic use

Effluent issues

- Large quantities of effluent
- Prado flow ~75% effluent
- Effluent → groundwater recharge



Santa Ana River, CA

- NAWQA study by USGS, 1998-2001
 - Nutrients, dissolved solids, effects of urbanization, etc..
- Regional Water Districts
- State & federal agencies
- Local water / wastewater treatment providers
- Non-government & stakeholder organizations

Santa Ana River, CA

- Non-point sources of pollution
 - atmospheric deposition
 - land application of animal waste
 - use of fertilizers
 - agricultural runoff
 - urban storm water runoff
- Point sources
 - Conventional WWTP effluent
 - Industrial discharges
 - Leaky underground storage tanks
 - concentrated animal operations
 - Storm sewer outfalls
 - Construction sites

Santa Ana River, CA

- Water quality issues
 - Elevated levels of TDS (600 – 620 mg/L)
 - High levels of nitrates (6 – 7.5 mg N/L)
 - Phosphorus (1 mg/L)
 - Pesticides (92% samples)
 - SVOCs, Organochlorides
 - Trace metals

Santa Ana River, CA

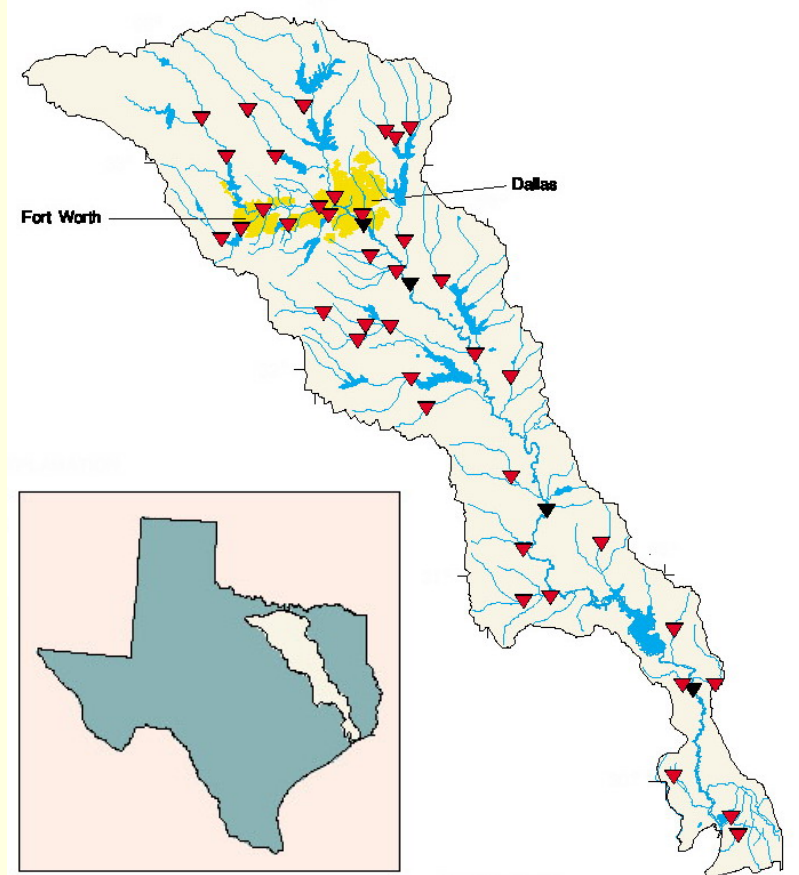
- Biological Impacts
 - Prado Dam allows year long flows
 - Basin studies indicate channel type, water quality and flow reliability key variables
 - Responses to effluent mixed
 - Little information for birds, amphibians, reptiles, insects or plants
 - People (GW impacts)

Santa Ana River, CA – Summary

- Highly urbanized & modified basin
- Effluent dominated conditions common throughout basin, especially Orange County
- Surface water generally of good condition
- Today's surface water is tomorrow's groundwater

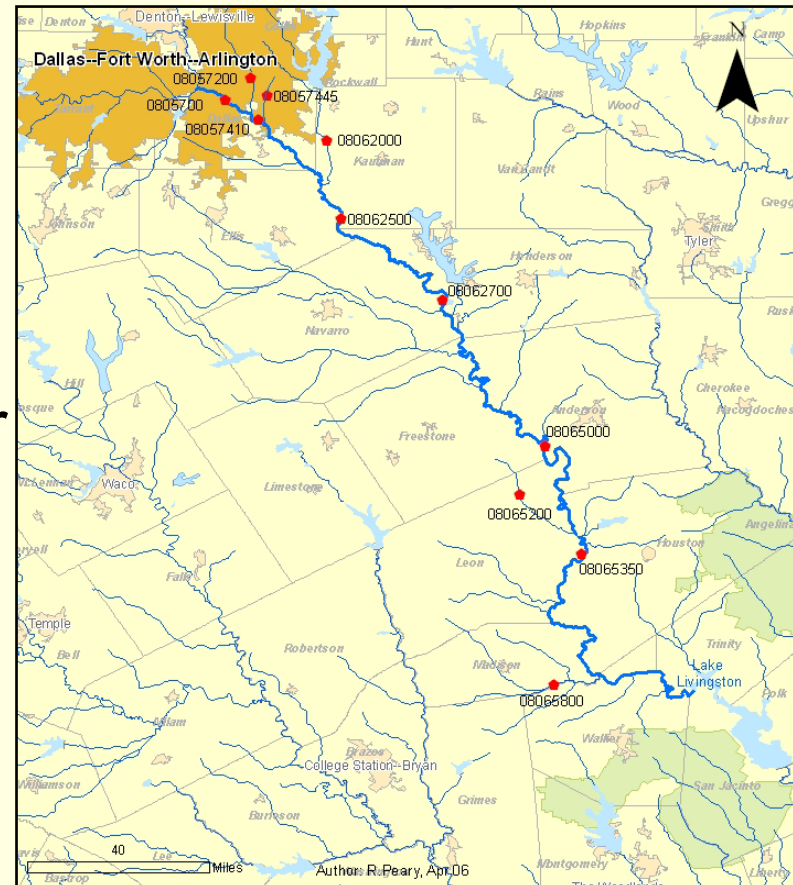
Trinity River, TX — Physical Setting

- Catchment of 18,000 sq-miles
- 5-10% urban, Dallas-Fort Worth metro area
- Population
 - Total ~4.5 million
 - 3.5 million in Dallas – Fort Worth area



Trinity River, TX — Physical Setting

- Effluent dominated “Main Stem”
 - Between Dallas and Livingston Lake
 - Effluent dominated for much of the year
 - ~250 miles in length
 - “River of Death”



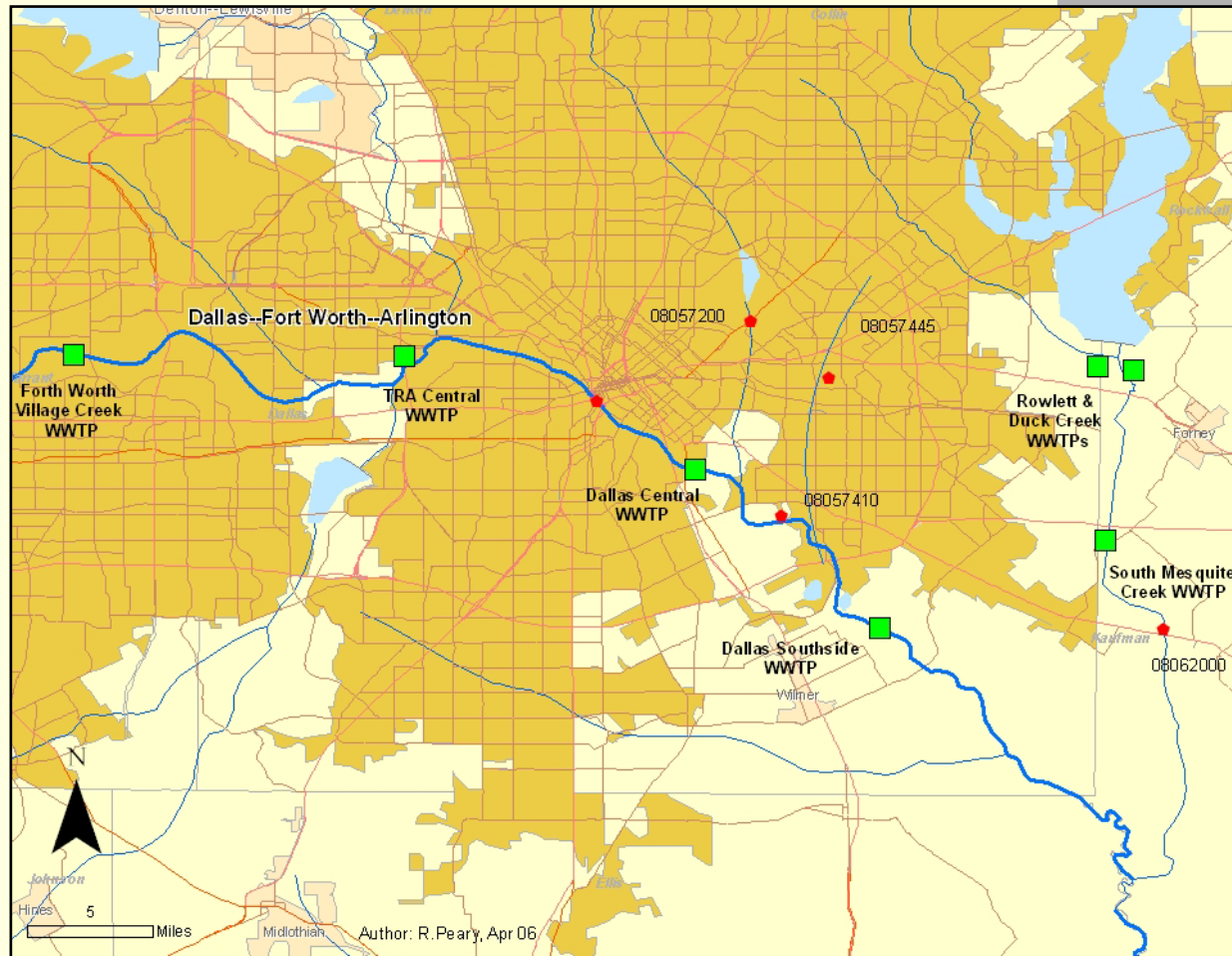
Trinity River, TX

- NAWQA study by USGS, start 1991
 - Nutrients, dissolved solids, effects of urbanization, etc..
- Regional Water Districts
- State & federal agencies
- Local water / wastewater treatment providers
- Non-government & stakeholder organizations

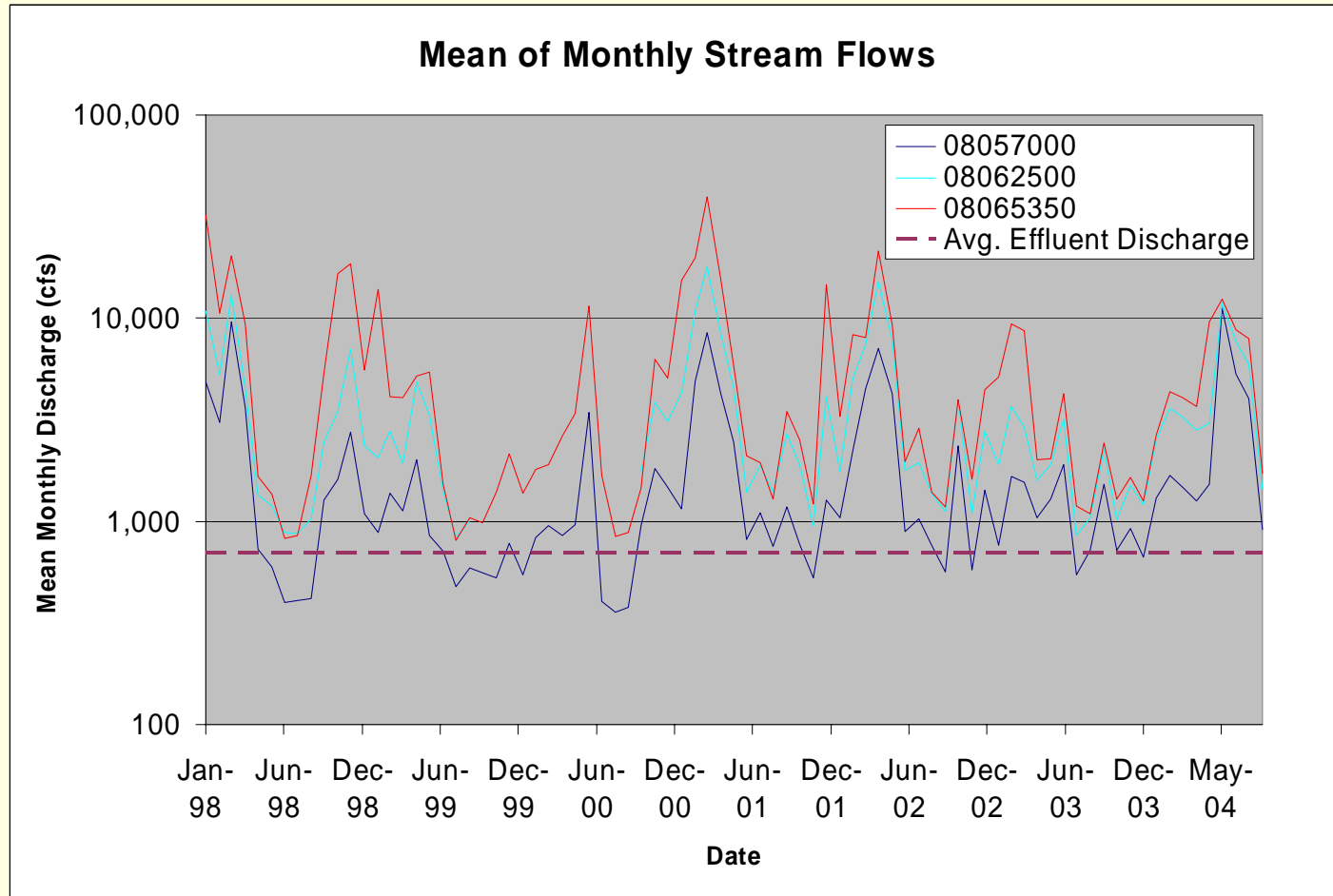
Trinity River, TX

- Reasons for effluent dominated condition
 - Seasonality of rainfall
 - Large wastewater treatment plants in Dallas
 - 7 major plants
 - Total permitted discharge 761 MGD
 - Actual average discharge 450 MGD (~700 cfs)

Trinity River, TX



Trinity River, TX



Trinity River, TX

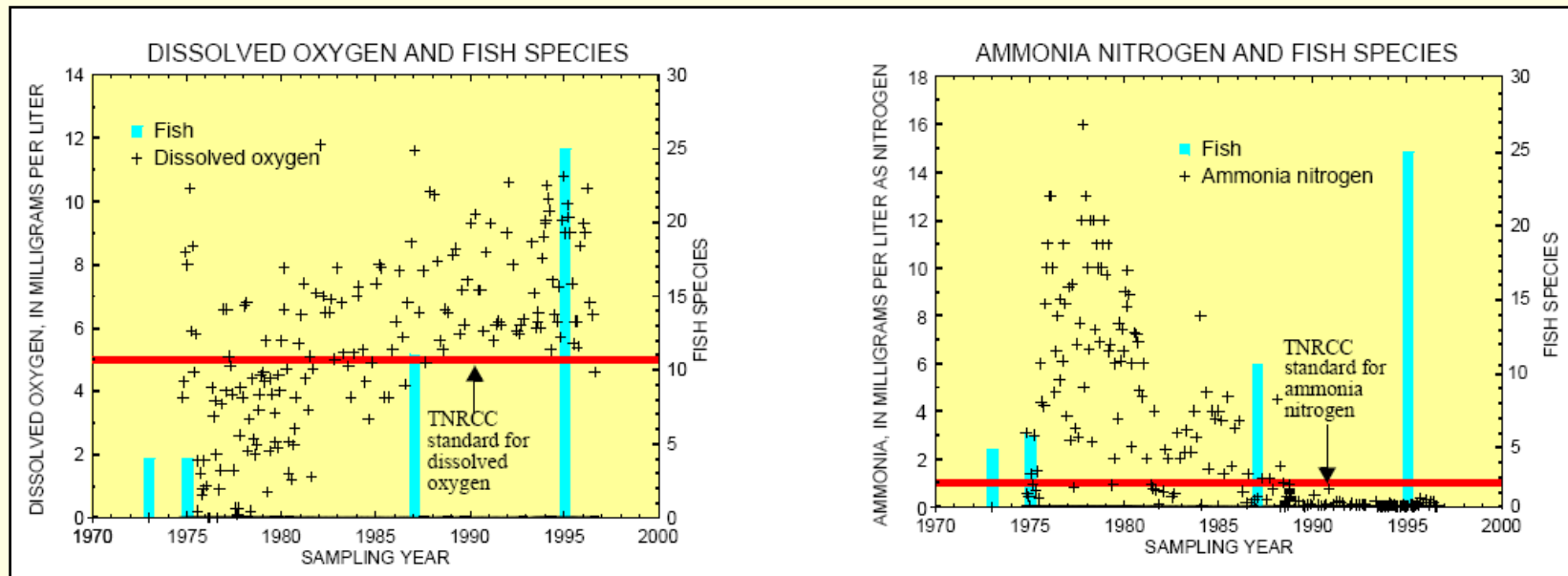
- Non-point sources of pollution
 - Land application of animal waste
 - Use of fertilizers
 - Agricultural runoff
 - Urban storm water runoff
- Point sources
 - Conventional WWTP effluent*
 - Industrial discharges
 - Leaky underground storage tanks
 - Storm sewer outfalls

Trinity River, TX

- Water quality issues
 - Nutrients
 - Top 75%
 - Pesticides
 - Top 75%
 - Trace elements (in sediments)
 - Between median and top 75%
 - SVOCs (in sediments)
 - Top 75%

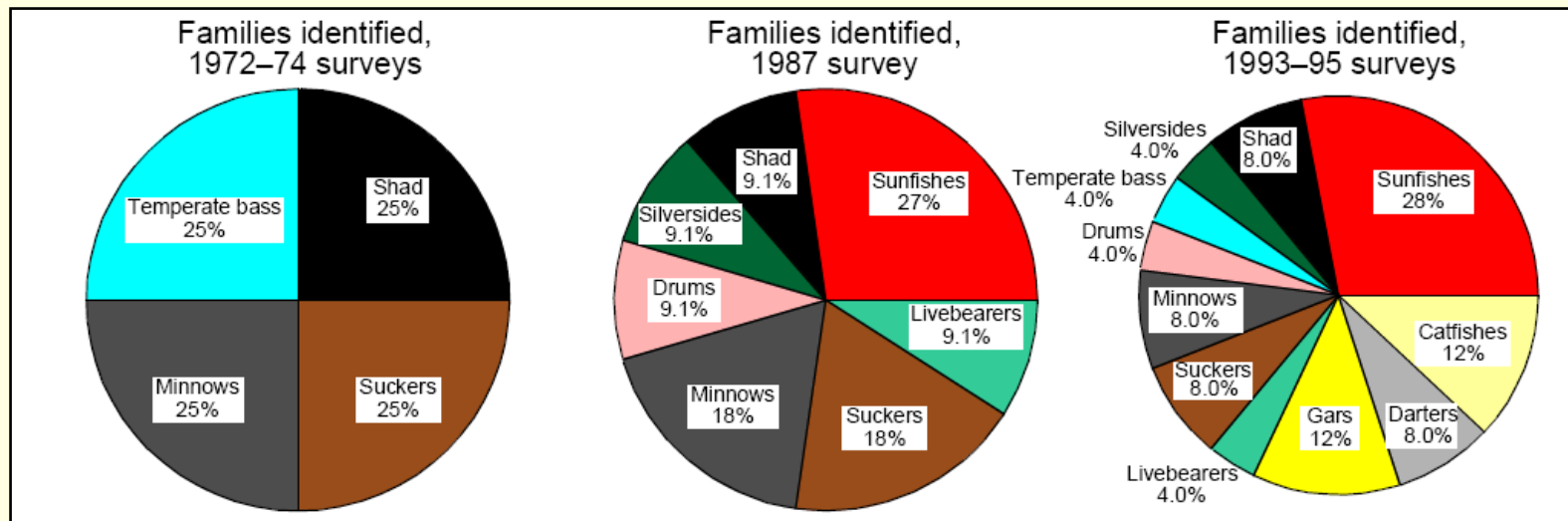
Trinity River, TX

Biological Impacts



Trinity River, TX

■ Biological Impacts

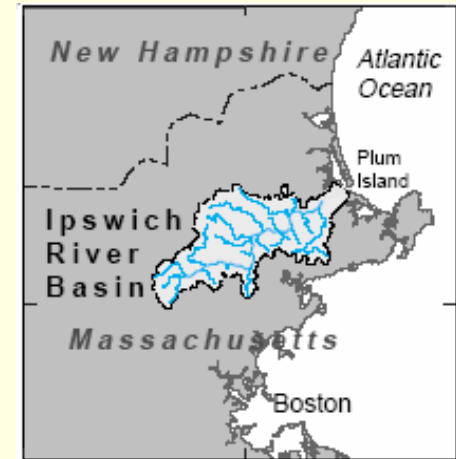


Trinity River, TX – Summary

- Prior to 1970's Trinity River was severely polluted
- Many pollution sources have been addressed
- Primary issues are now:
 - Effluent quality
 - Polluted sediments
- Flow to Lake Livingston → Houston water supply

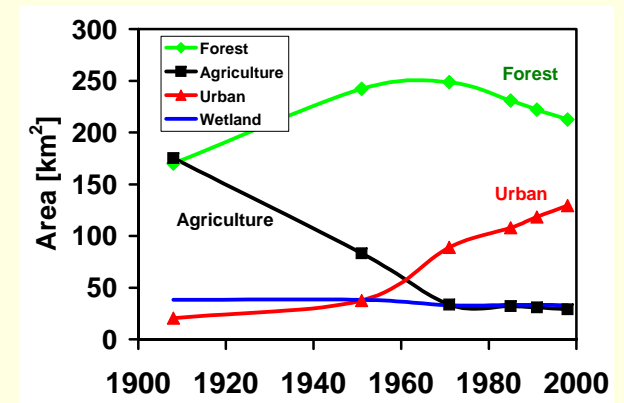
Ipswich River, MA — Physical Setting

- Located on the coastal plain of northeastern Massachusetts.
- 155-square-mile watershed
- The most flow-stressed river in the Northeast
- In 2003 declared third endangered rivers in the US.



- Highly urbanized throughout

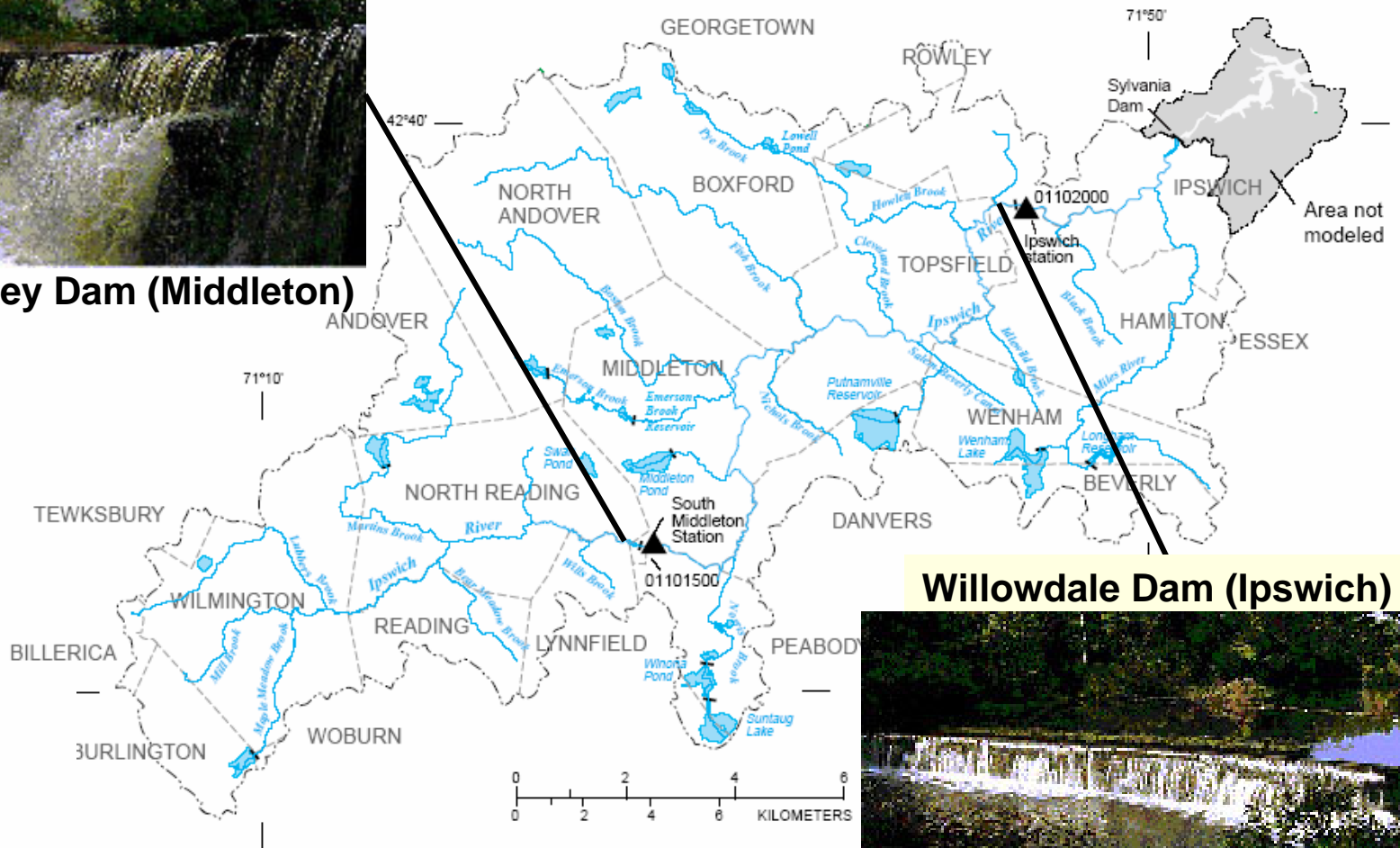
- 22 municipalities
- 330,000 residents



Ipswich River, MA — Physical Setting








Bostik-Findley Dam (Middleton)

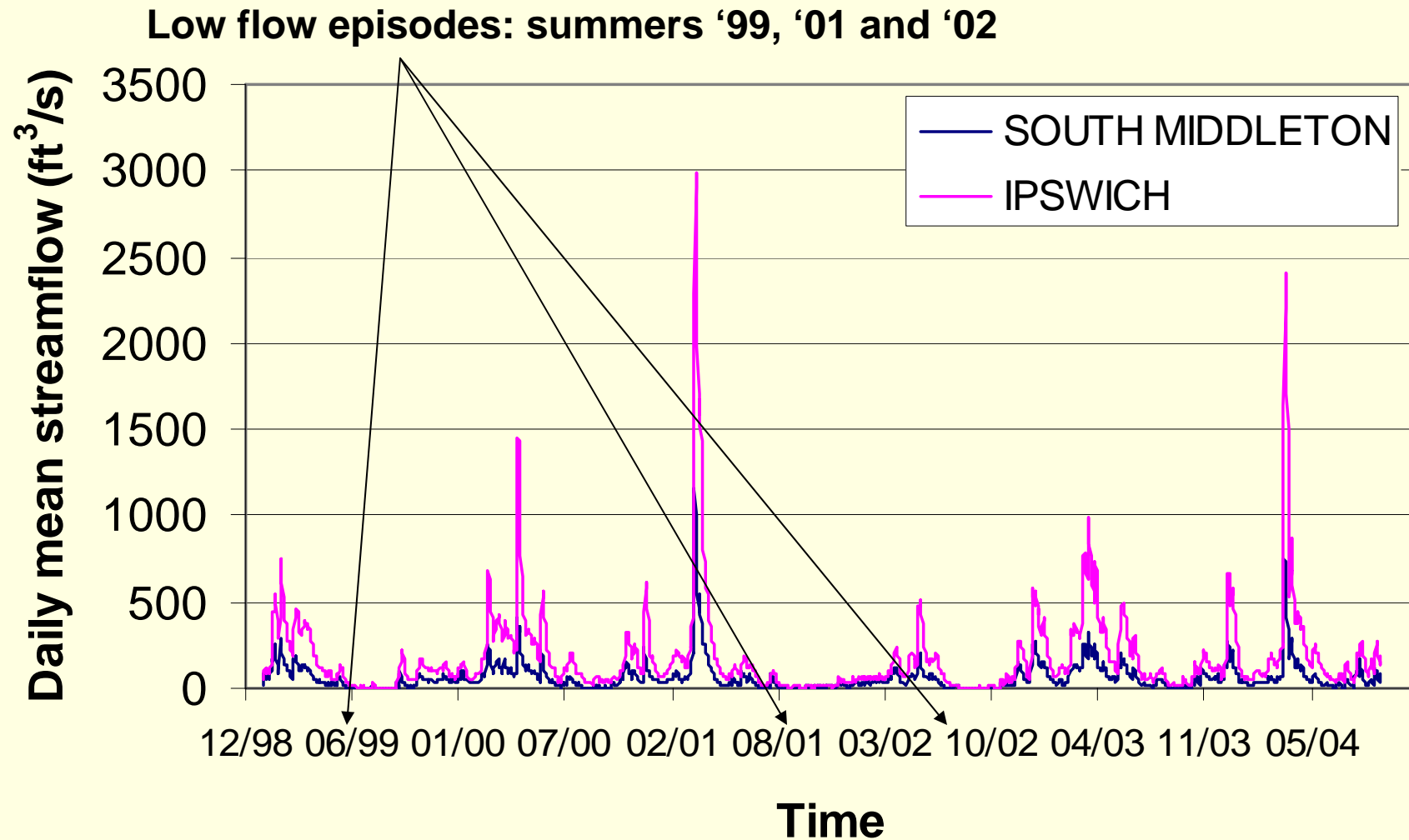


Willowdale Dam (Ipswich)



- EXPLANATION**
-  OPEN WATER
 -  BASIN BOUNDARY
 -  TOWN BOUNDARY
 - 01101500  STREAM-GAGING STATION AND NUMBER
 -  DAM

Ipswich River, MA – Streamflow



Ipswich River, MA — Streamflow



Summer '99



Summer '01

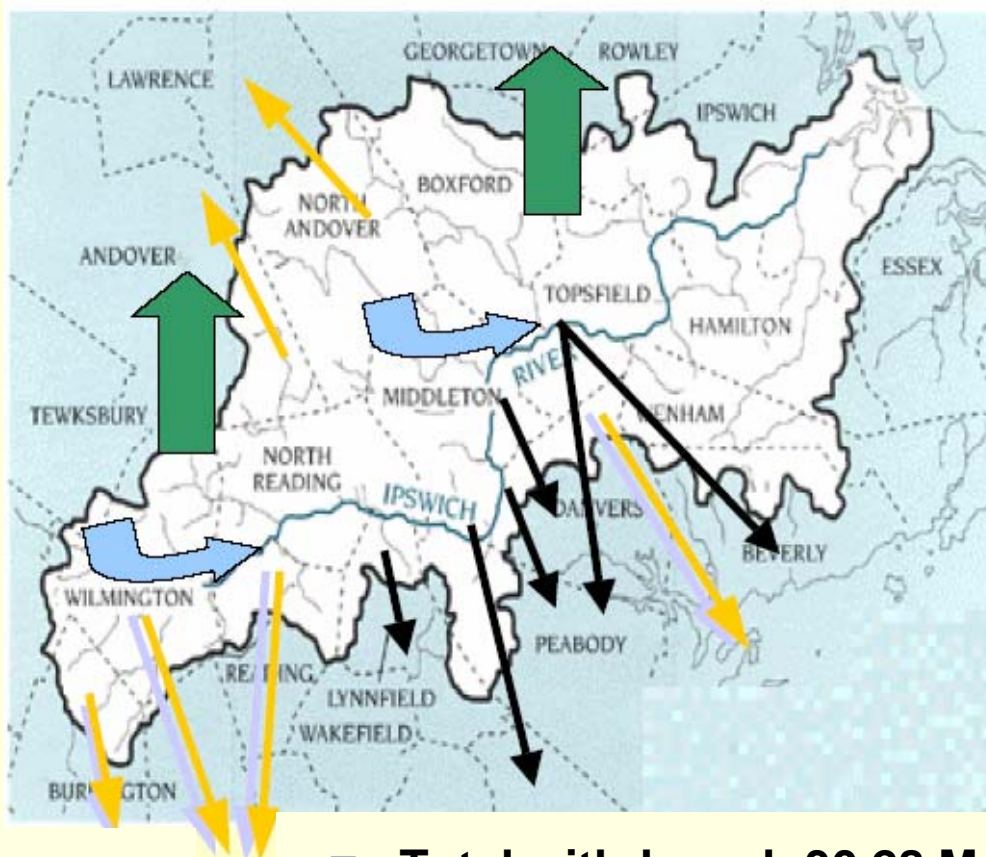


Summer '02



Summer '05

Ipswich River, MA



- Export of water for water supply
- Export of wastewater
- Inflow and Infiltration
- Increased loss to runoff
- Loss to lawn irrigation

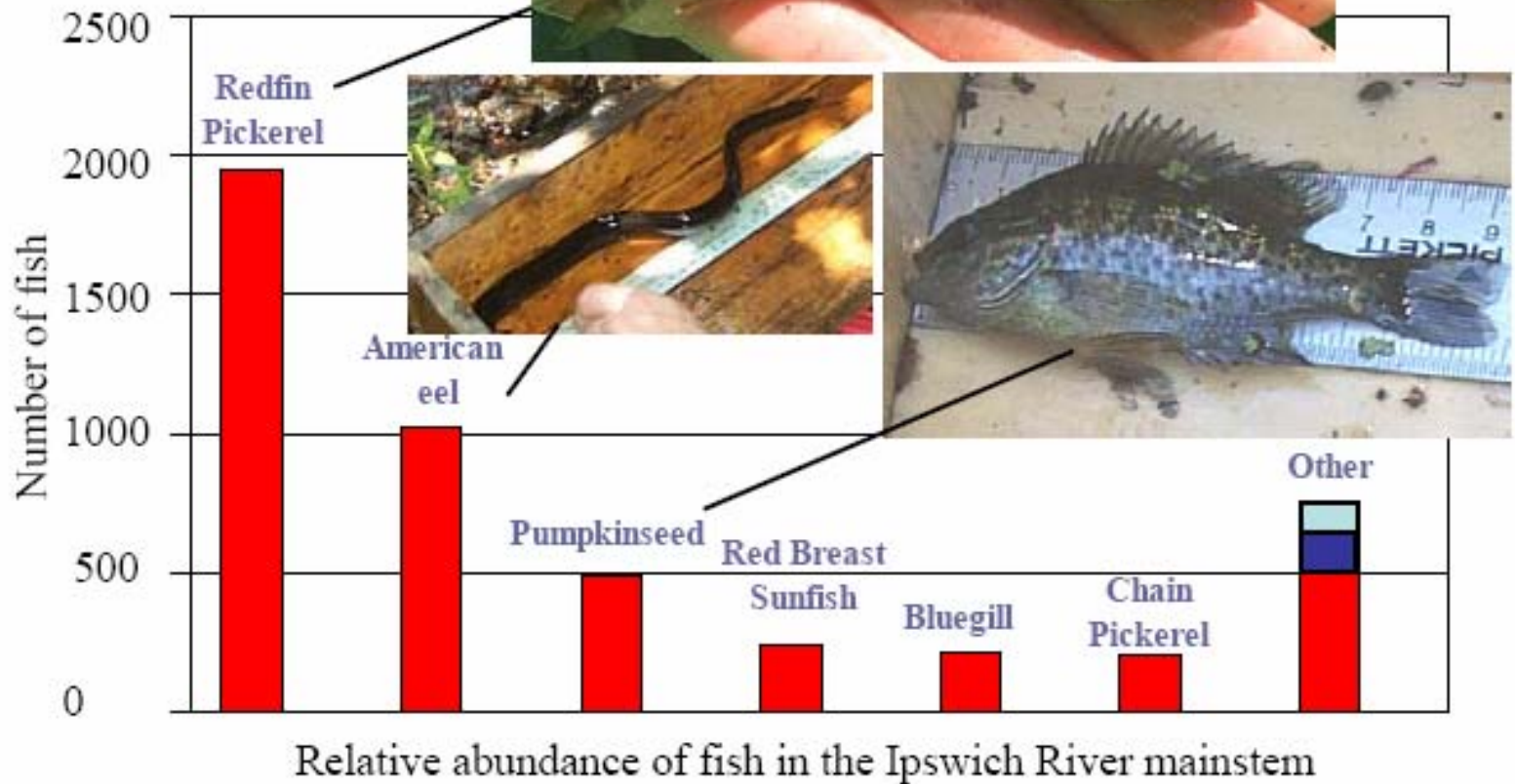
- Total withdrawal: 30.28 Mgd
- Groundwater withdrawal 9.08 Mgd
- Average transfer outside the watershed of 23.54 Mgd

Ipswich River, MA – Water Quality

- Water quality issues
 - Low DO level
 - Fecal coliform contamination – SSO, WWTP (closure of all of the shellfishing areas)
 - Nutrients
 - High mercury concentration in sediment ($0.5 \mu\text{g/g}$)

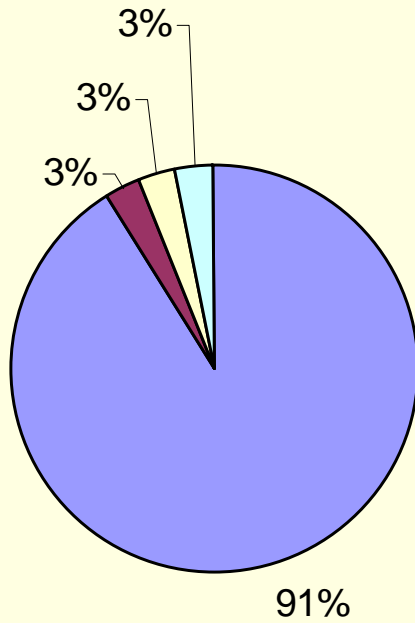


Ipswich River, MA – Biota data

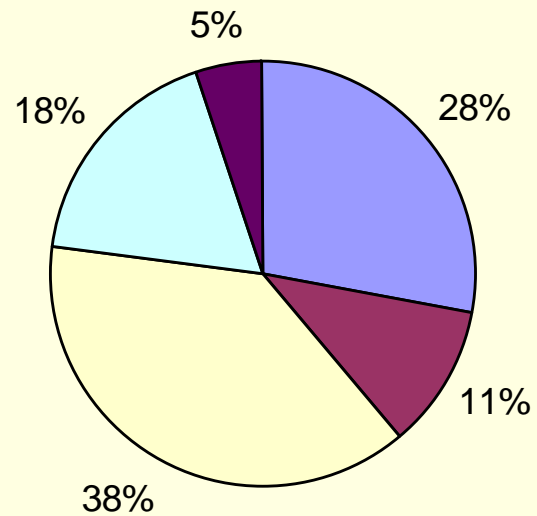


Ipswich River, MA — Biota data

Existing Ipswich River Fish Community



Ipswich River Target Fish Community



- Macrohabitat Generalists
- Fluvial Specialists
- Regional Fluvial Specialists
- Fluvial Dependent
- Other

Ipswich River, MA — Management Plan

- **Selected Elements of Management Strategy:**

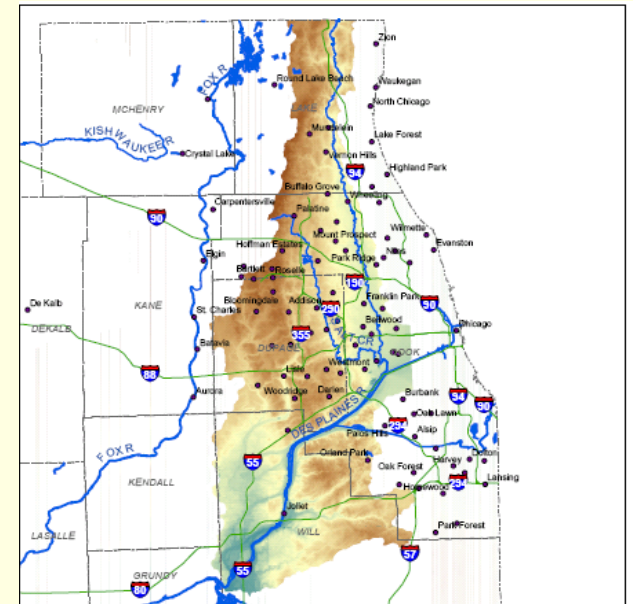
- **Water Conservation**
- **Stormwater Management**
- **Alternative Sources of Water Supply**
- **Wastewater Management**
- **Land Use Planning**
- **Education/outreach**

Ipswich River, MA — Streamflow restoration

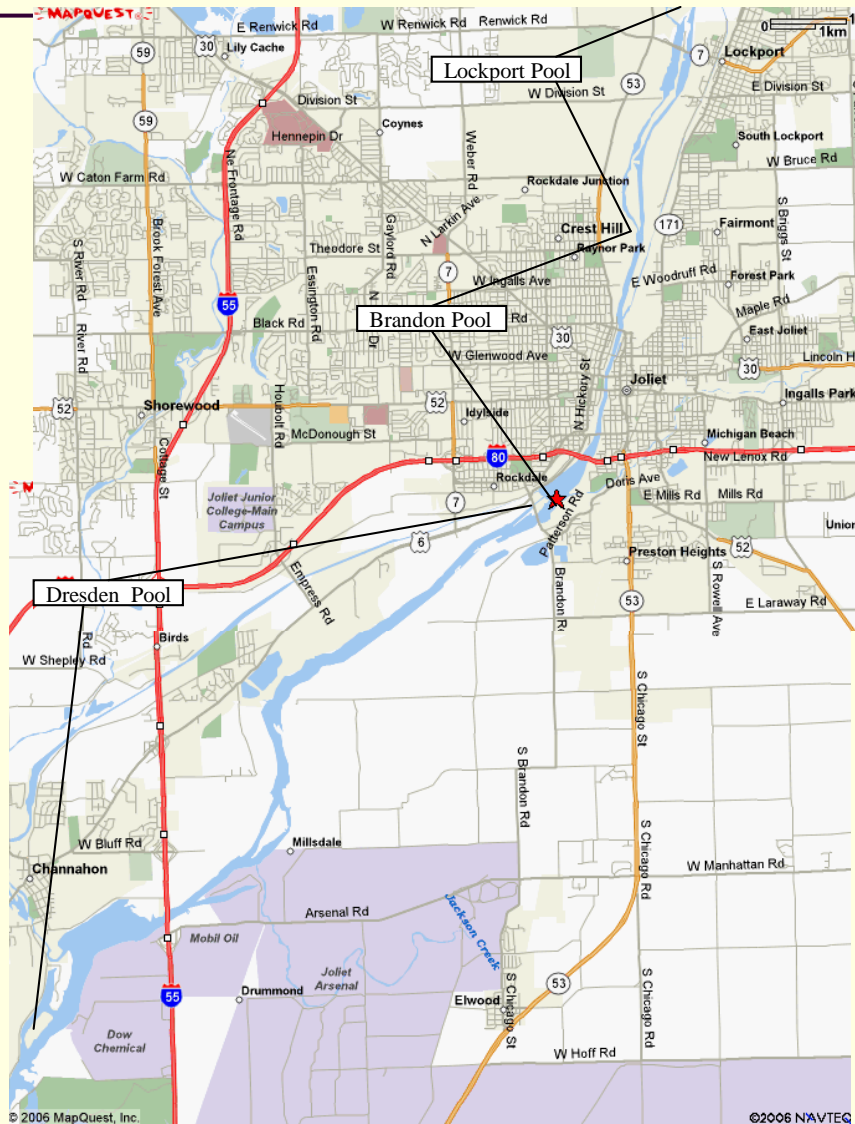


Lower Des Plaines River, IL — Physical Setting

- Des Plaines River runs 95 miles through four Illinois counties, it "*changes from prairie creek to a suburban stream, to a large urbanized river, to a major industrial waterway.*"
- The Lower Des Plaines is use as a conduit for sanitary and industrial discharges from CSSC
- The Des Plaines river is the largest effluent dominated stream in the world
- 1 million residents in the basin



Lower Des Plaines River, IL — Physical Setting



Lockport Lock and Dam



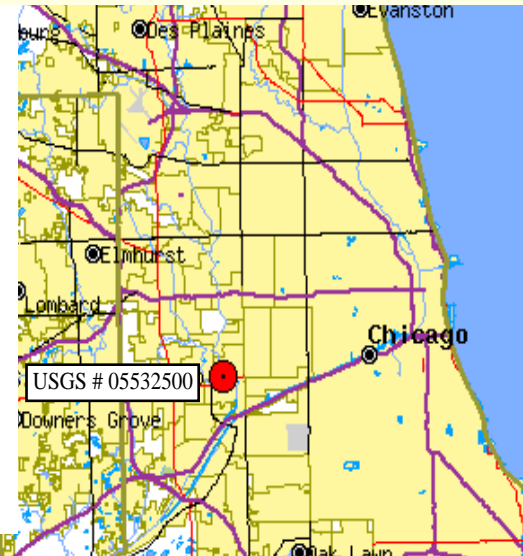
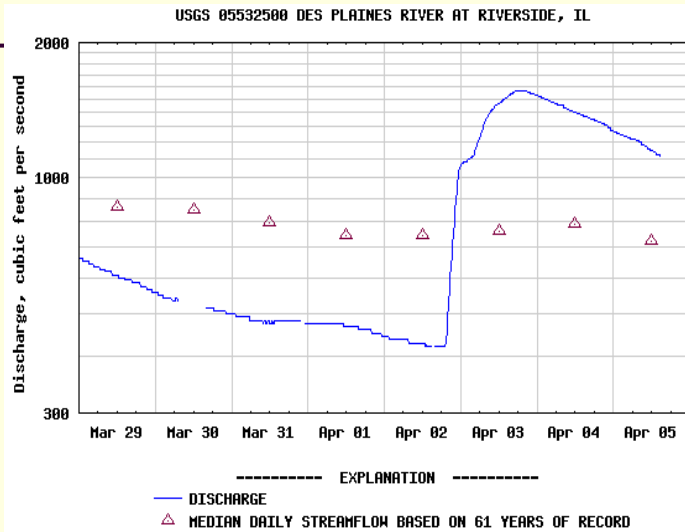
Brandon Pool in downtown Joliet



Dresden Lock at the confluence with the Illinois River

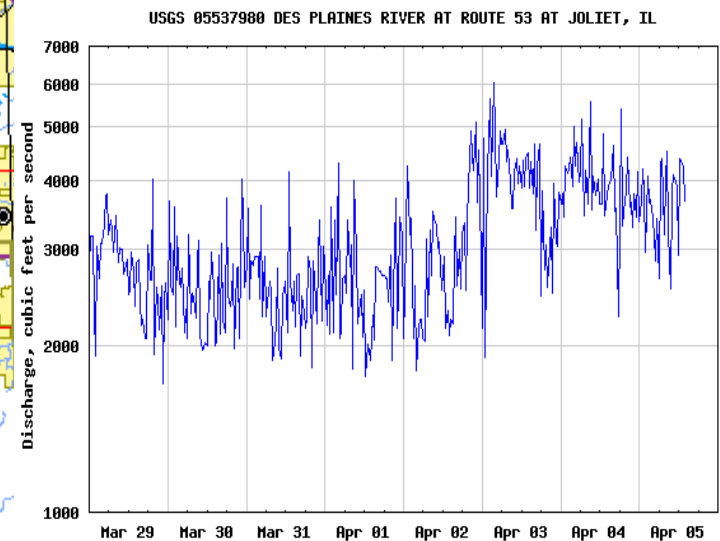
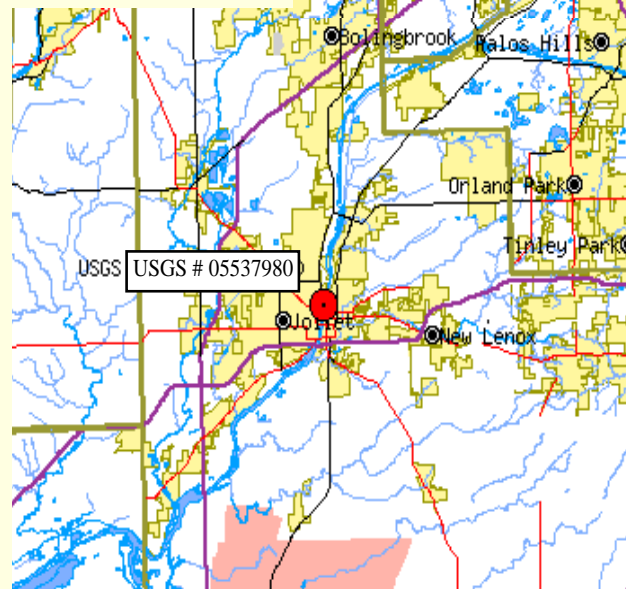


Lower Des Plaines River, IL — Streamflow



**Flow from CSSC:
1880 ft³/s**

**Average flow at
Riverside:
751 ft³/s**

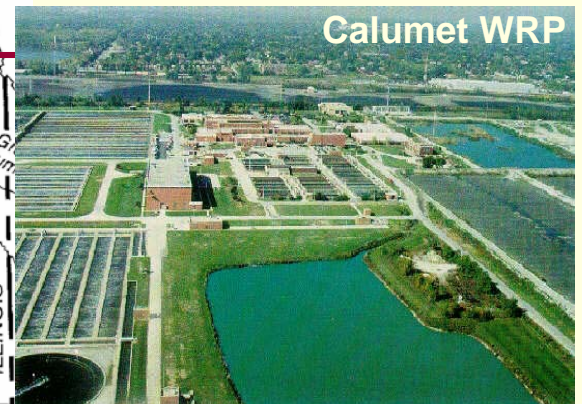
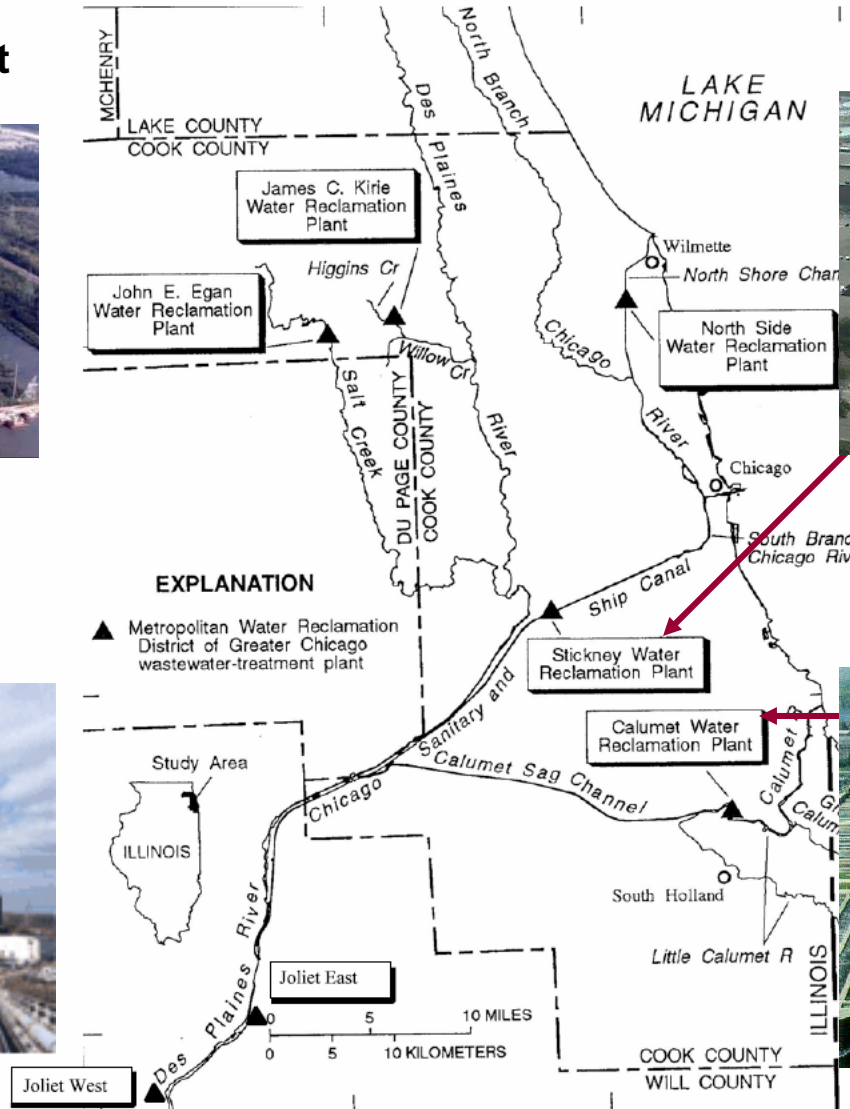


Lower Des Plaines River, IL

Will county power plant



Joliet power plant



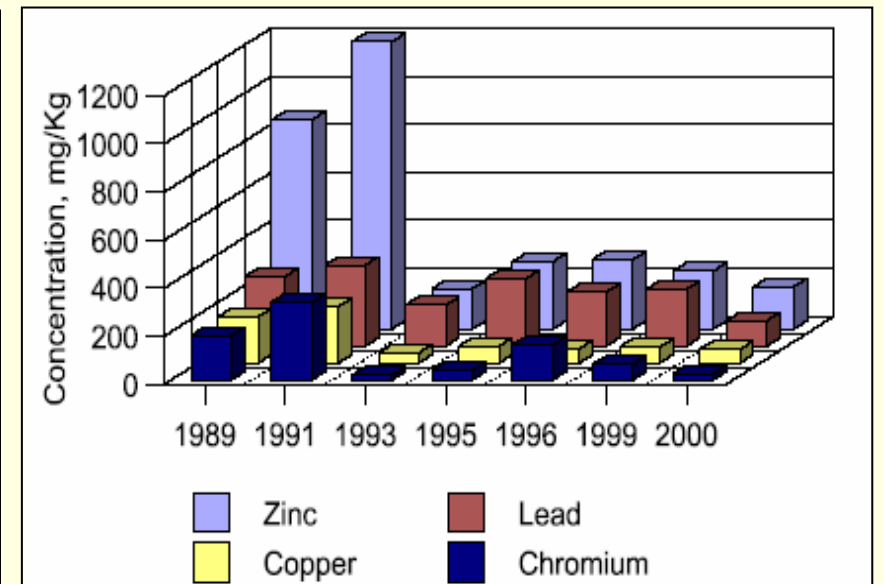
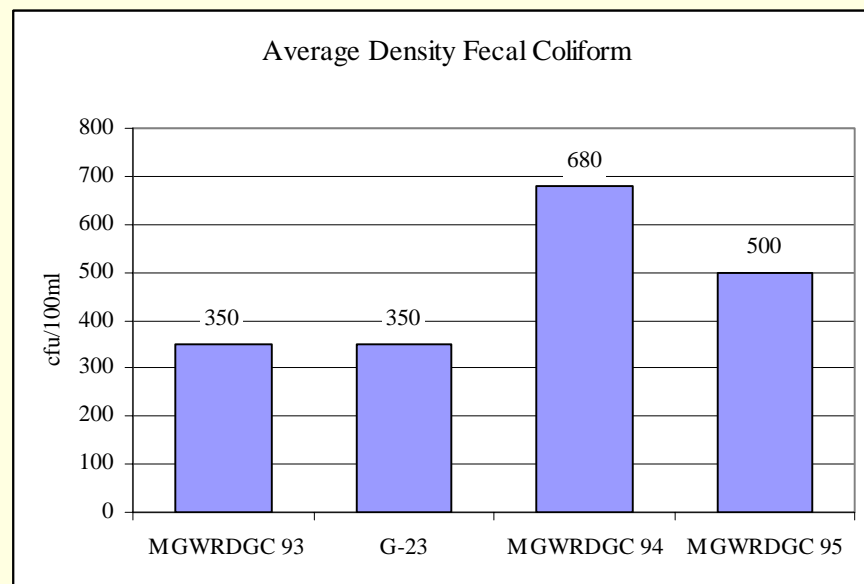
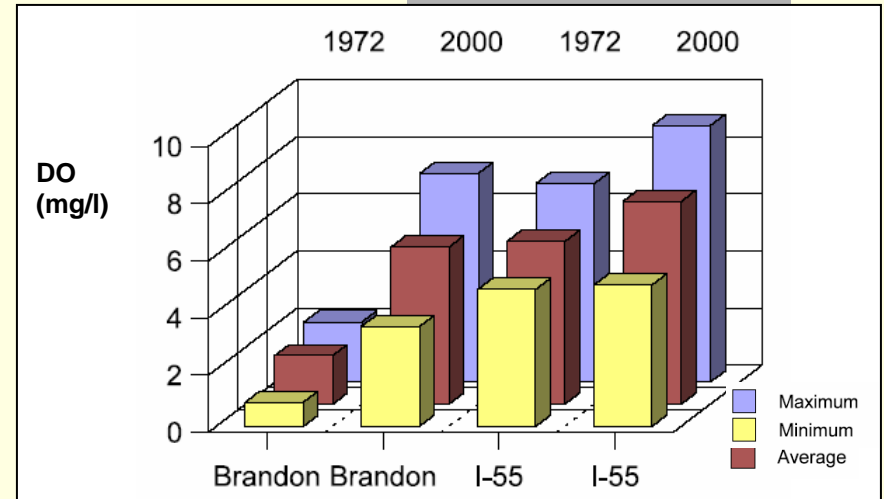
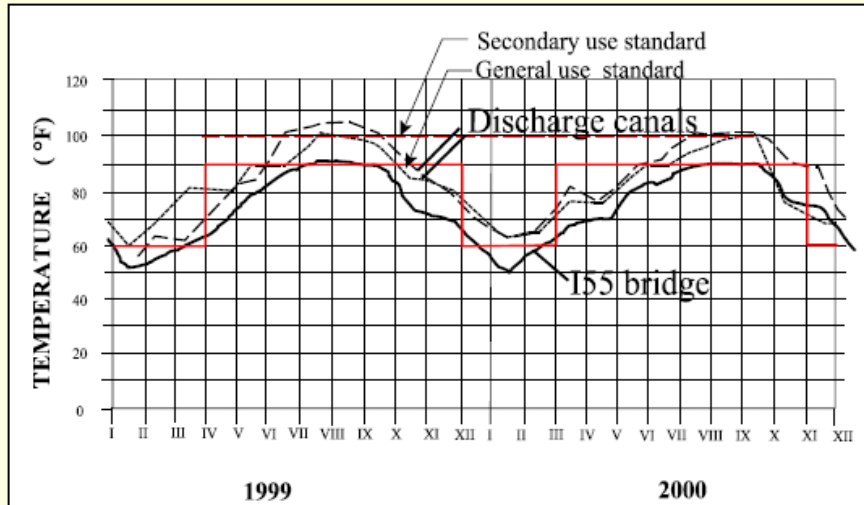
Lower Des Plaines River, IL — Water Quality

- Parameters of concern
 - priority organics
 - ammonia
 - nutrients
 - pathogens
 - metals
 - habitat alterations
 - flow alteration and
 - low dissolved oxygen/
organic enrichment
 - High temperature

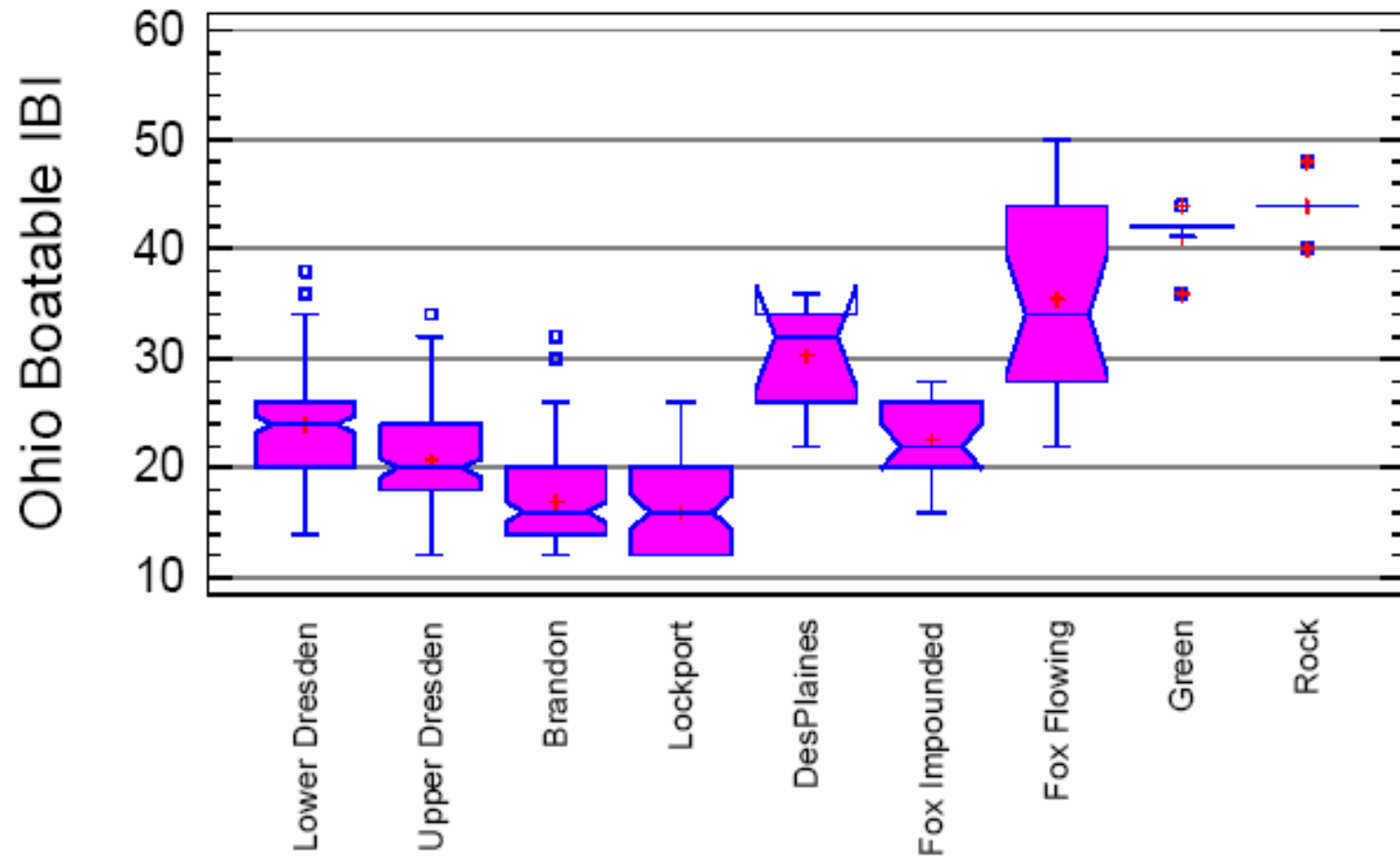
Current Designated use:
***Secondary Contact and
Indigenous Aquatic Life***



Lower Des Plaines River, IL — Water Quality



Lower Des Plaines River, IL – Biota

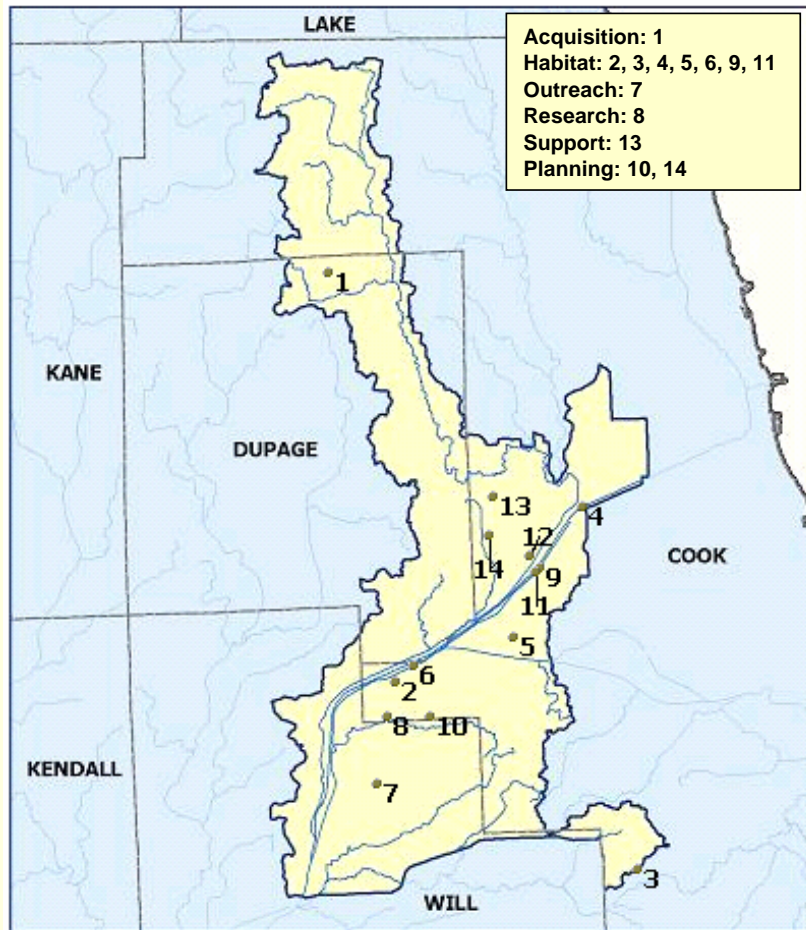


Lower Des Plaines River, IL — Conclusion

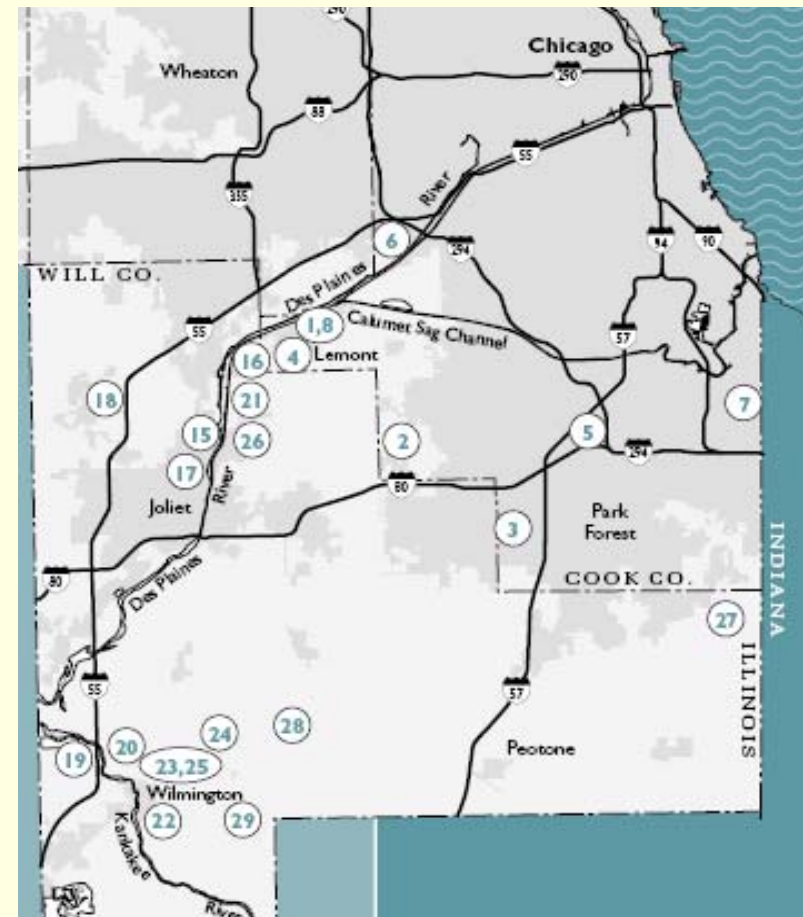
- Increasing water quality in the river;
- Physical modification and attributes are mostly irreversible (navigation);
- Action needed:
 - Change in designated use of the water body
 - Improve WWT and further reduction of CSOs
 - Temperature is an issue to be addressed
 - Establish a watershed Commission
- Something is already happening
 - Temperature criteria options study (CABB, 2005).
 - Restorations and other interventions

Lower Des Plaines River, IL

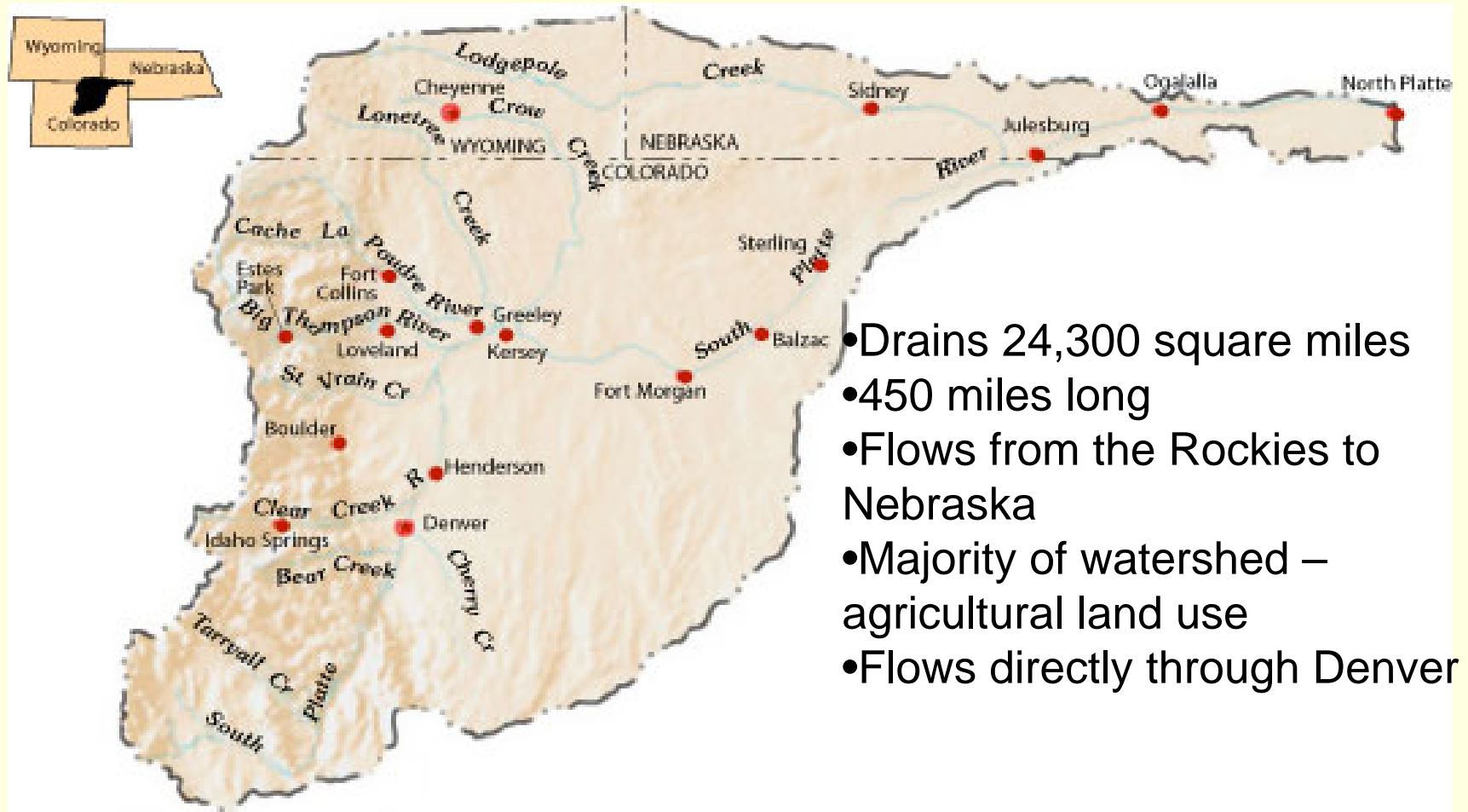
Lower Des Plaines Ecosystem partnership
Projects Receiving Funding Through C2000 grants



Open-Land
Wetland acquisition and restoration

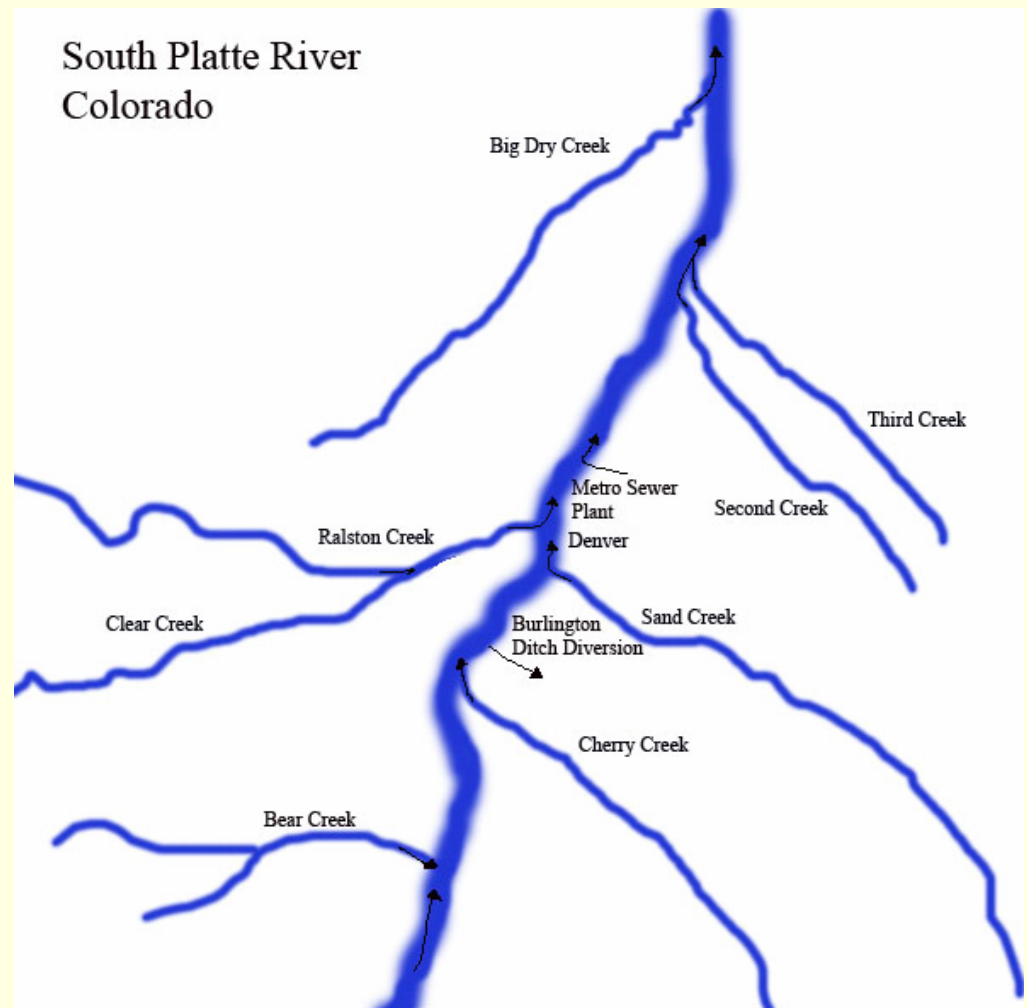


South Platte River, CO — Physical Setting



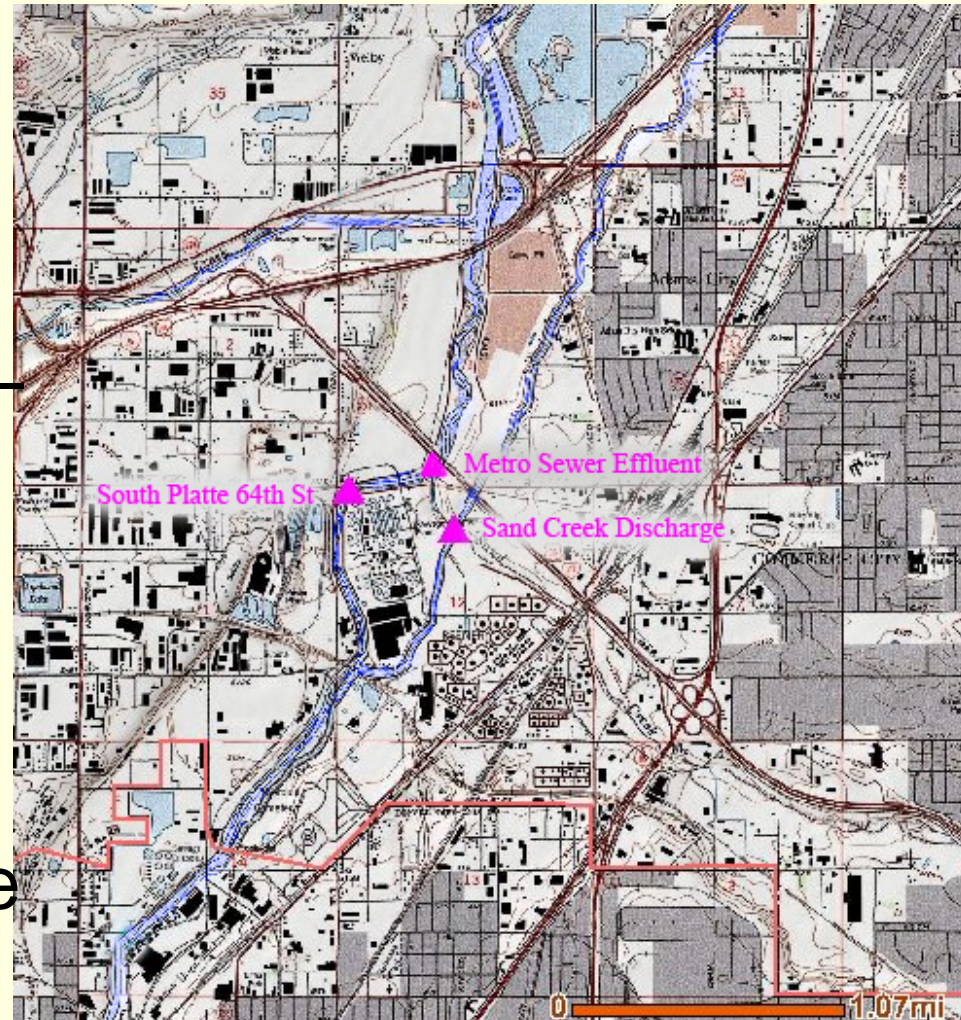
South Platte River, CO — Physical Setting

- Segment 15 – 26 mile reach from North Denver to Fort Lupton, CO
- Effluent Dominated most of year
- Once was known as “Denver’s Sewer”



South Platte River, CO

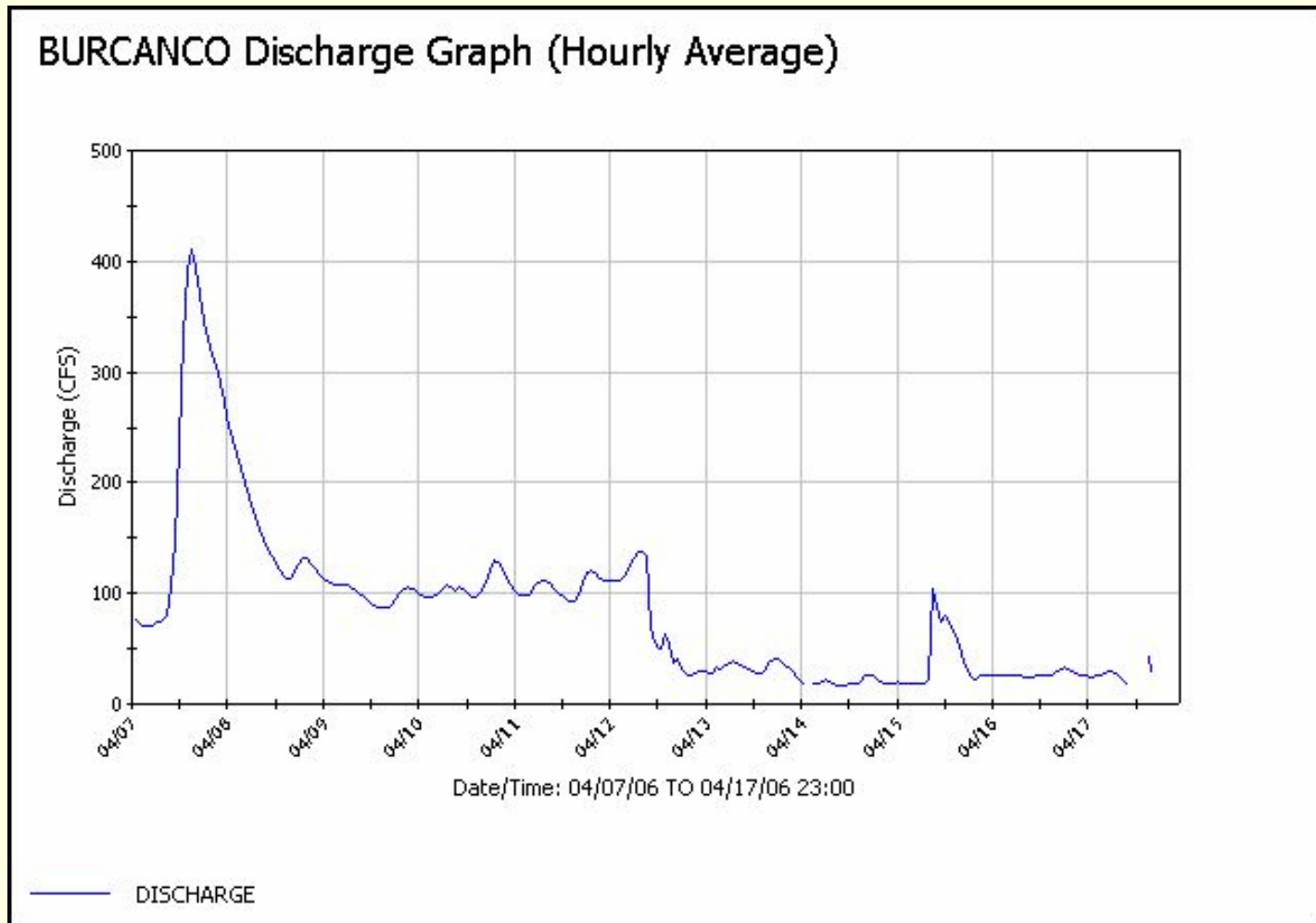
- Segment 15 – Gauging Stations
- NAWQA study 1993-1995
- 1998 303(d) list
- TMDL for low DO
- TMDL for nitrate



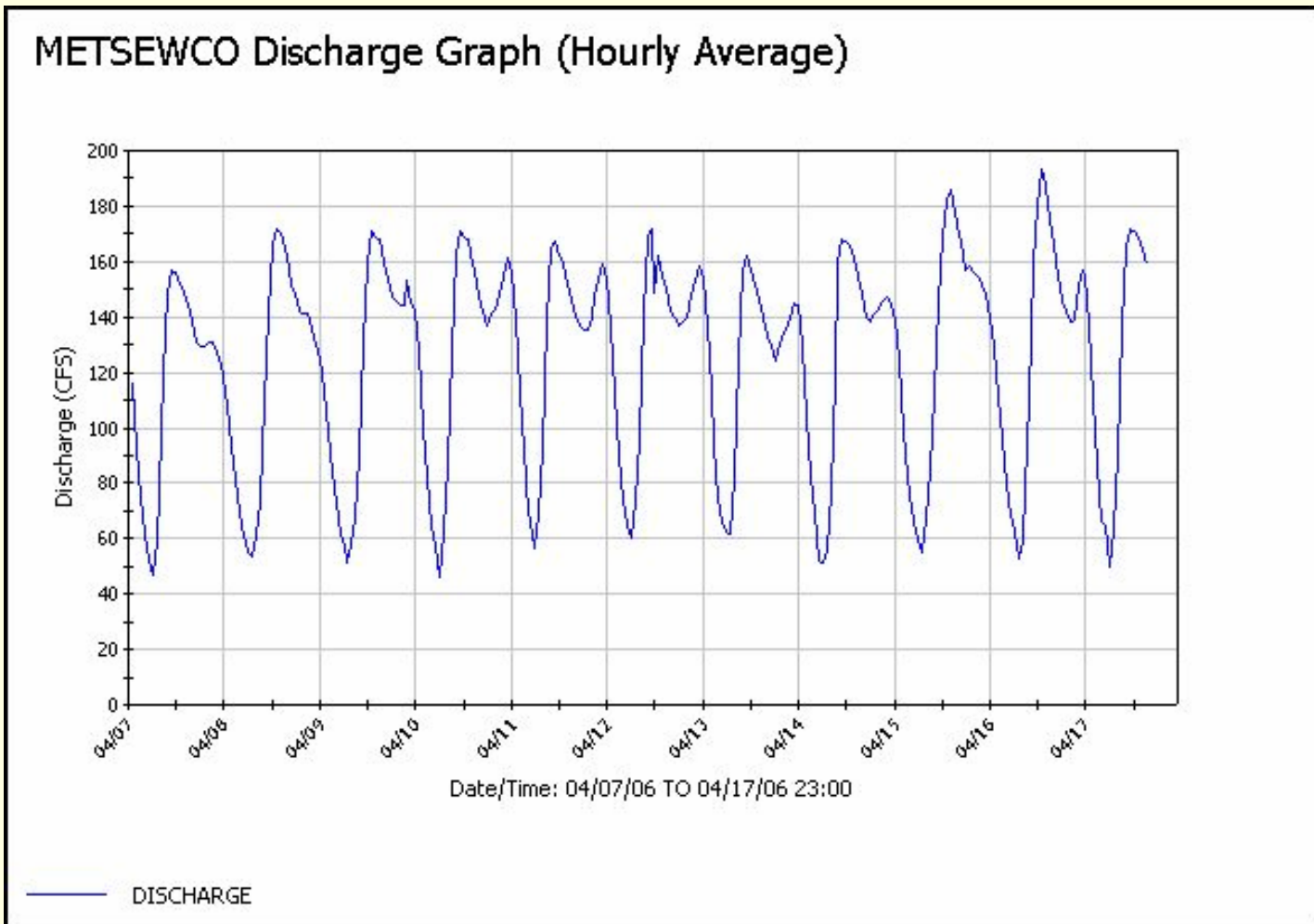
South Platte River, CO

- Upstream Diversions :
 - Burlington Ditch Structure
 - Diverts up to 100% of flow up to 9 months of the year
- Downstream Additions
 - Metro District Central Wastewater Treatment Plant

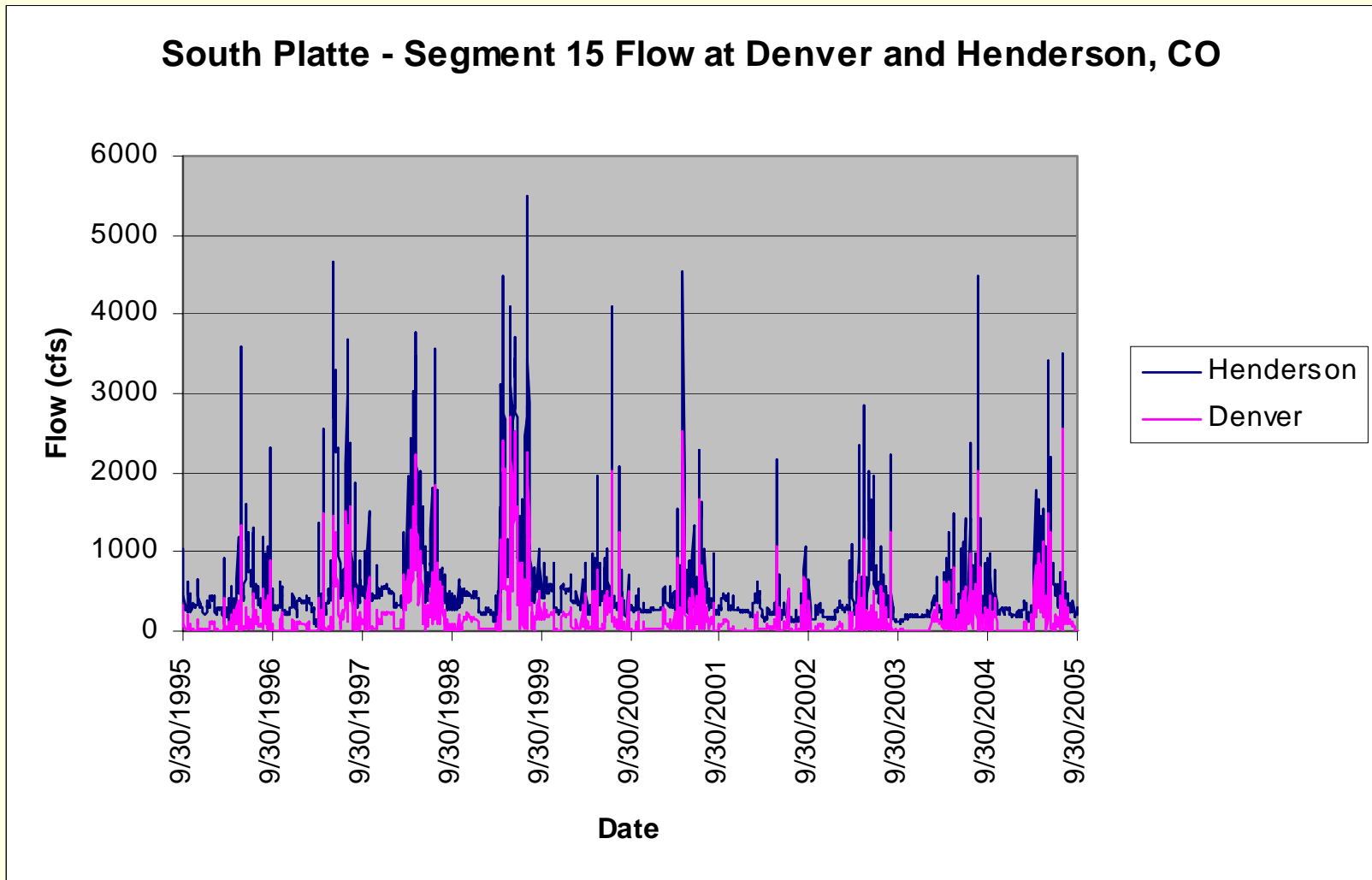
South Platte River, CO



South Platte River, CO



South Platte River, CO



South Platte River, CO

- Nonpoint pollution sources
 - Agriculture
 - Urban Runoff
- Point pollution source
 - Metro District Wastewater Treatment Plant

South Platte River, CO

- Point Source – Discharges 200 MGD
- Discharges directly to stream annually:
 - 7000 tons of nitrogen
 - 860 tons of phosphorous
- Low Dissolved Oxygen major problem
- High ammonia levels
- Half of plant has nitrification facility

South Platte River, CO — Summay

- Metro District has added Aeration Drop Structures to improve DO
- Nitrification facilities are too expensive
 - Estimated at \$112 million in 1989
- Metro District argues nutrient rich waters a “resource” for agriculture