# Experience with Fire- and Weather-Induced Changes in Water Quality

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# Presentation Objectives

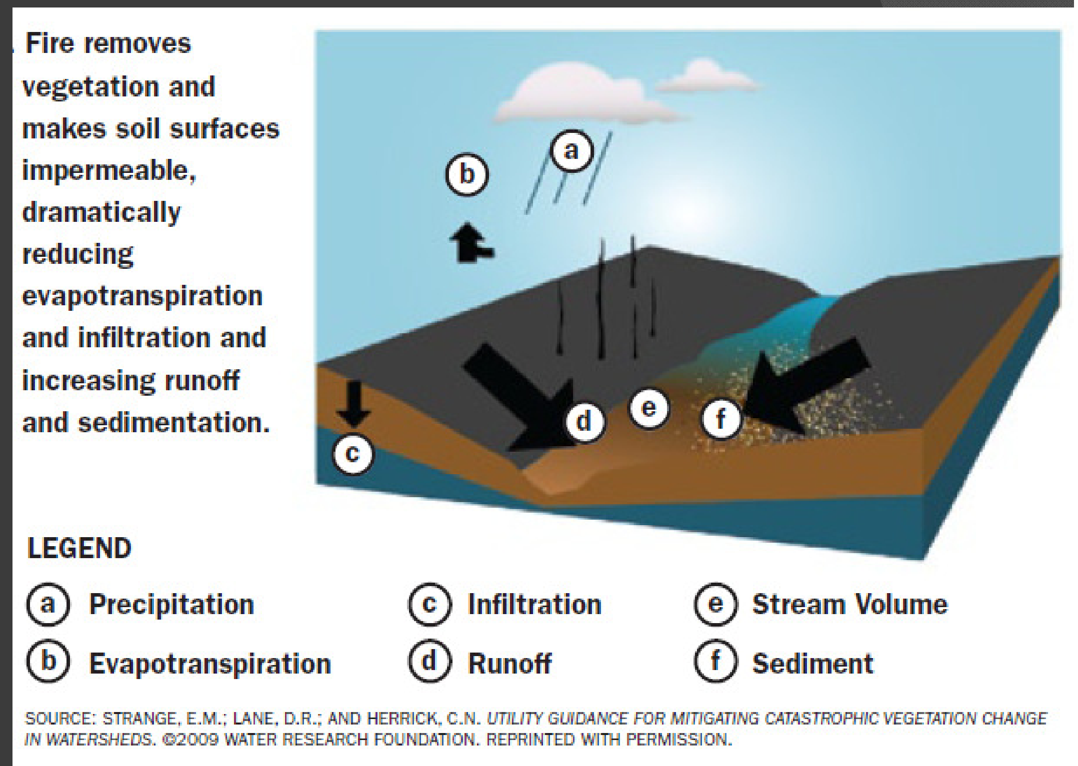
- Potential Water Quality Changing Events
- Remembering Rodeo-Chediski
  - Immediate Water Quality Impacts
  - Phoenix Metro-Area Utilities' Response
- Broader View of Climate Change Issues
- Utility Response Options

# Potential Water Quality Changing Events

- Wildfire
- Heavy runoff events
- Prolonged drought
- Floods and extreme storm events
- Extreme temperature events

# Wildfire

- Arid states vulnerable to wildfire events
- Changes characteristics of watershed
  - Absorbance of water
- Immediate impacts, as well as long term changes to the watershed
  - Ash runoff
  - Decreased vegetative productivity
- Fire suppression chemicals
- Changes in vegetation types
  - Evergreen to deciduous
  - Repopulation with grasses

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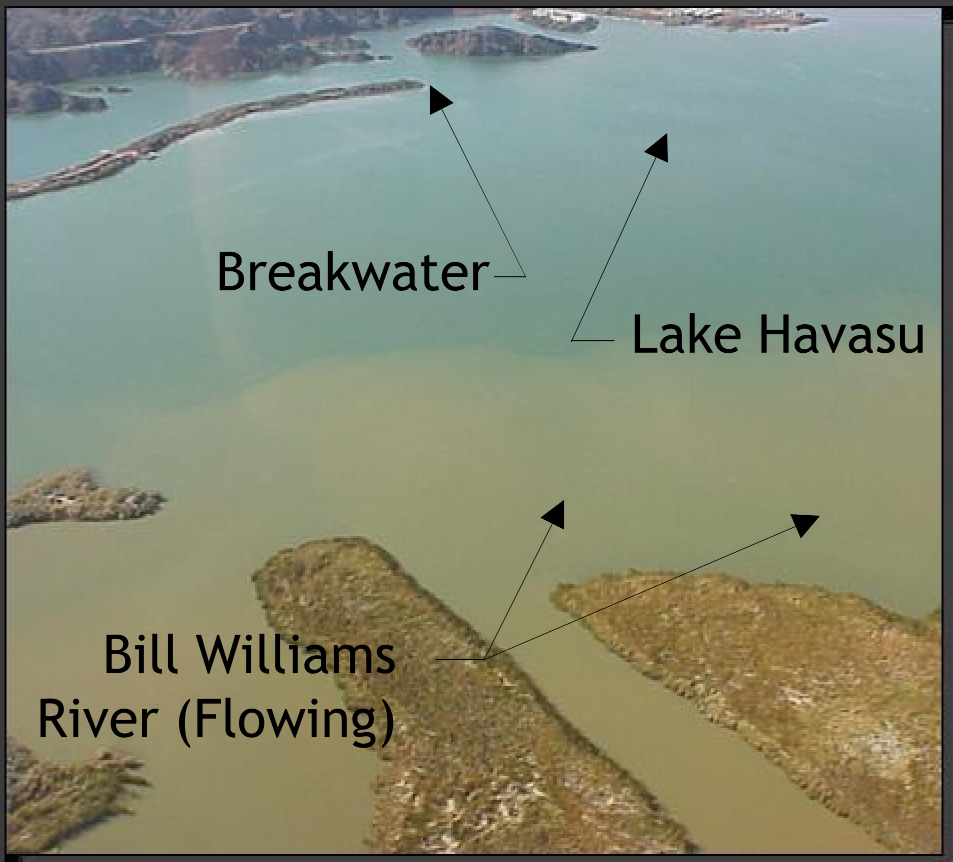
# Heavy runoff events




Impact of Bill Williams River on CAP Intake

- Flash flooding can result in significant soil runoff
- Agricultural runoff
- Erosion of soils and plant material
- Increased turbidity
- Change in character of TOC
- Addition of debris

# Prolonged drought

**Right:** Bathtub ring at Lake Mead
Photo courtesy of Neil McIntosh completetosh.com

- Increased variability of rainfall
- Short, intense events
- Storage volume reduction
- Increased agricultural demand

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# Example Water Quality Impacts

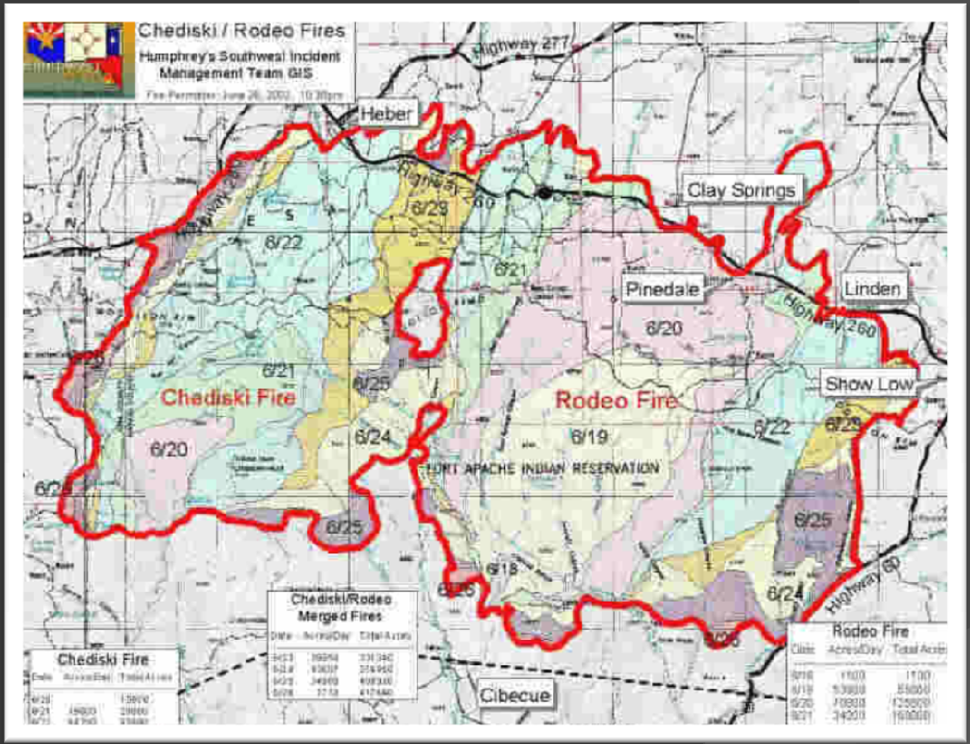
| Weather event | Algae | Alkalinity | Inorganics | Organics | pH | Salinity | Temperature | Turbidity |
|---|---|---|---|---|---|---|---|---|
| | Water quality impact (source water or finished water) | | | | | | | |
| Extreme runoff | X | X | X | X | X | X | | X |
| Prolonged drought | | | X | X | X | X | X | X |
| Storms | | | X | X | | X | | X |
| Temperature | X | | | X | | X | X | |

| Water quality variable | Relevant extreme events | Coagulation | Settling | Filtration | Disinfection | Distribution/ finished water | Solids handling |
|---|---|---|---|---|---|---|---|
| | | Degree of impact on water treatment process | | | | | |
| Algae | Extreme heat, nutrient rich runoff | ++ | ++ | + | +++ | + | - |
| Alkalinity | Runoff events | +++ | - | - | + | +++ | - |
| Inorganics | Runoff events, drought | ++ | + | - | + | + | - |
| Natural organic matter (NOM) | Runoff events, drought | ++ | - | - | +++ | ++ | - |
| Organic contaminants (natural and anthropogenic) | Runoff events, drought | - | + | + | +++ | +++ | - |
| pH | Runoff events | ++ | - | - | ++ | +++ | - |
| Salinity | Runoff events, drought, storms, and low temperature associated with road deicing | - | + | + | - | + | + |
| Temperature | Storms, temperature events | - | + | + | + | +++ | + |
| Turbidity | Runoff events, drought | +++ | +++ | +++ | ++ | ++ | +++ |

Notes:
"-" = minimal or no impact.
"+" = potential impact.
"++" = moderate impact.
"+++" = significant impact.
Source: Information in this table modified from "Water Quality and Treatment" (Letterman, 2010).

# Remembering Rodeo-Chediski

- June-July 2002
- Nearly 500,000 acres burned
- Located on Salt River Watershed
  - Approximately 8% of watershed burned
- Drought conditions
  - Ongoing conditions
- Reservoir levels near historic lows



# Immediate Water Quality Impacts

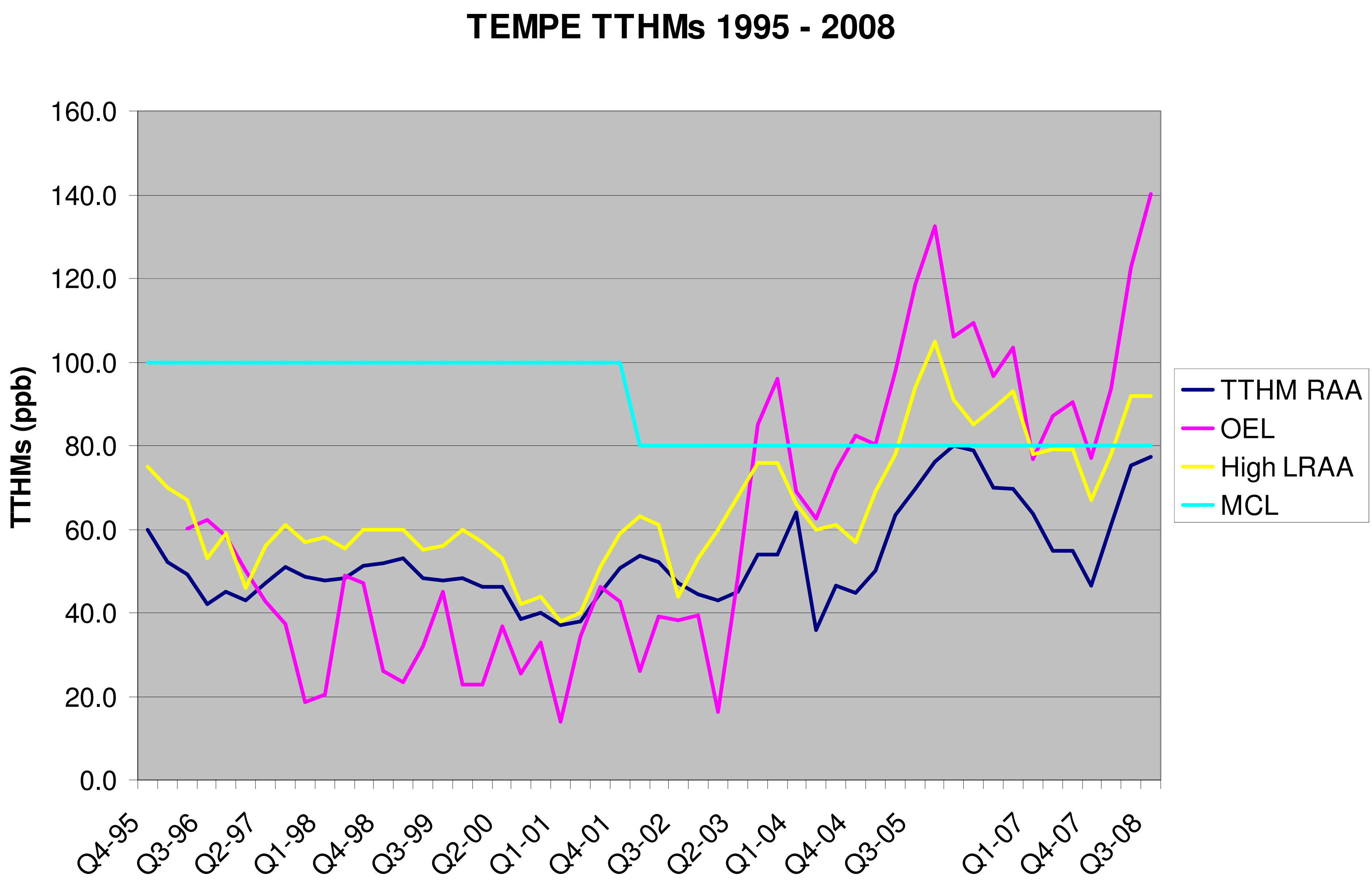
| Constituent | Time Period | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) | Average Concentration (mg/L) |
|---|---|---|---|---|
| **Ammonia** | Pre-fire | 0.01 (MRL) | 0.06 | 0.02 |
| | Post-fire | 0.004 | 1.09 | 0.18 |
| **Total Nitrogen** | Pre-fire | 0.02 | 3.8 | 0.74 |
| | Post-fire | 0.84 | 220 | 52.8 |
| **Nitrate+Nitrite** | Pre-fire | 0.01 (MRL) | 0.62 | 0.081 |
| | Post-fire | 0.013 | 2 | 0.42 |
| **Dissolved Organic Carbon** | Pre-fire | 0.9 | 4.9 | 2.16 |
| | Post-fire | 0.703 | 56.6 | 7.66 |
| **Total Organic Carbon** | Pre-fire | 0.9 | 33 | 5.42 |
| | Post-fire | 4.8 | 1140 | 228 |
| **Dissolved Phosphorus** | Pre-fire | 0.01 (MRL) | 0.08 | 0.019 |
| | Post-fire | 0.0035 | 0.57 | 0.12 |
| **Total Phosphorus** | Pre-fire | 0.01 (MRL) | 4 | 0.12 |
| | Post-fire | 0.006 | 39 | 3.89 |
| **Suspended Sediment** | Pre-fire | 1 | 11700 | 293 |
| | Post-fire | 1.6 | 42500 | 4050 |

Pre-Fire: 1980-2002

Post-Fire: 2002-2005

Source: THE IMPACTS OF FOREST FIRES ON DRINKING WATER QUALITY, Darla Deane Gill, ASU

# City of Tempe, AZ DBP History



# City of Tempe Efforts

- Understand whether the current operations can comply with the Stage 2 DDBP Rule
- Identify the factors (WQ and operational changes) that influence DBP formation
- Evaluate potential solutions
- Use ongoing surveillance and reactive “tweaks” to contribute potentially significant returns
- WTP Improvements:
  - Coagulation with optimized coagulant and PAC dose
  - Blending with GW

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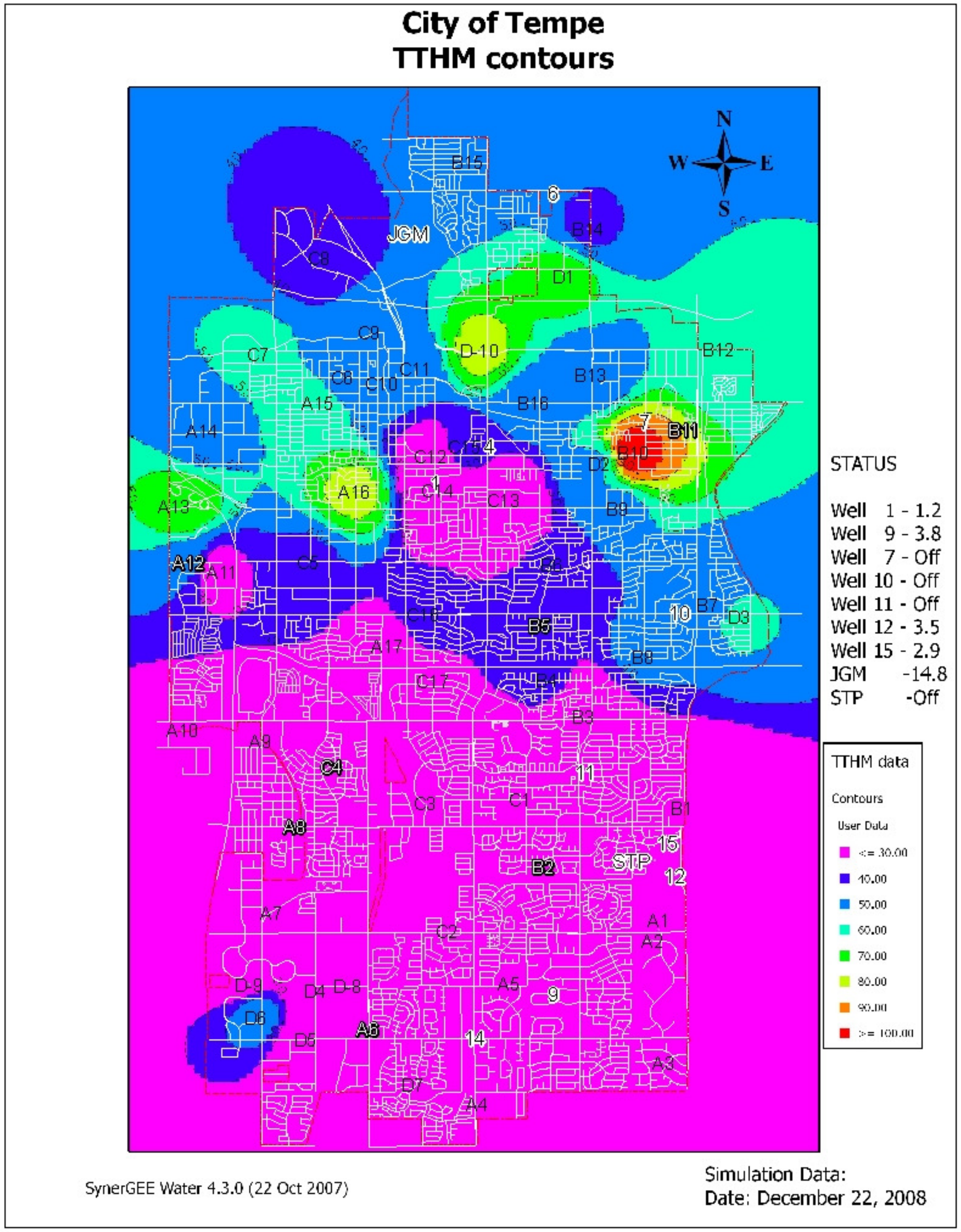


TTHM (ppb)

- 30
- 40
- 50
- 60
- 70
- 80
- 90
- ≥100

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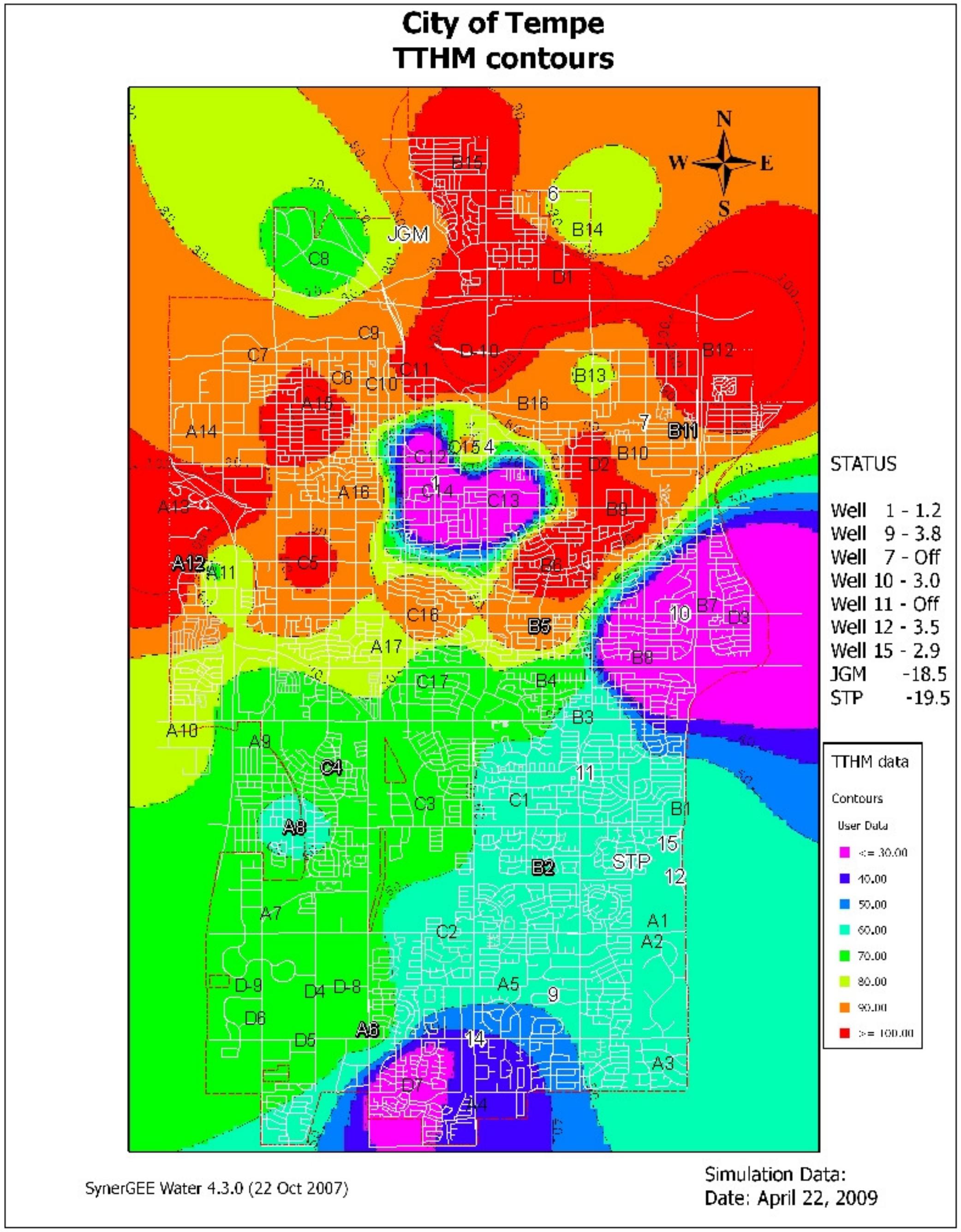


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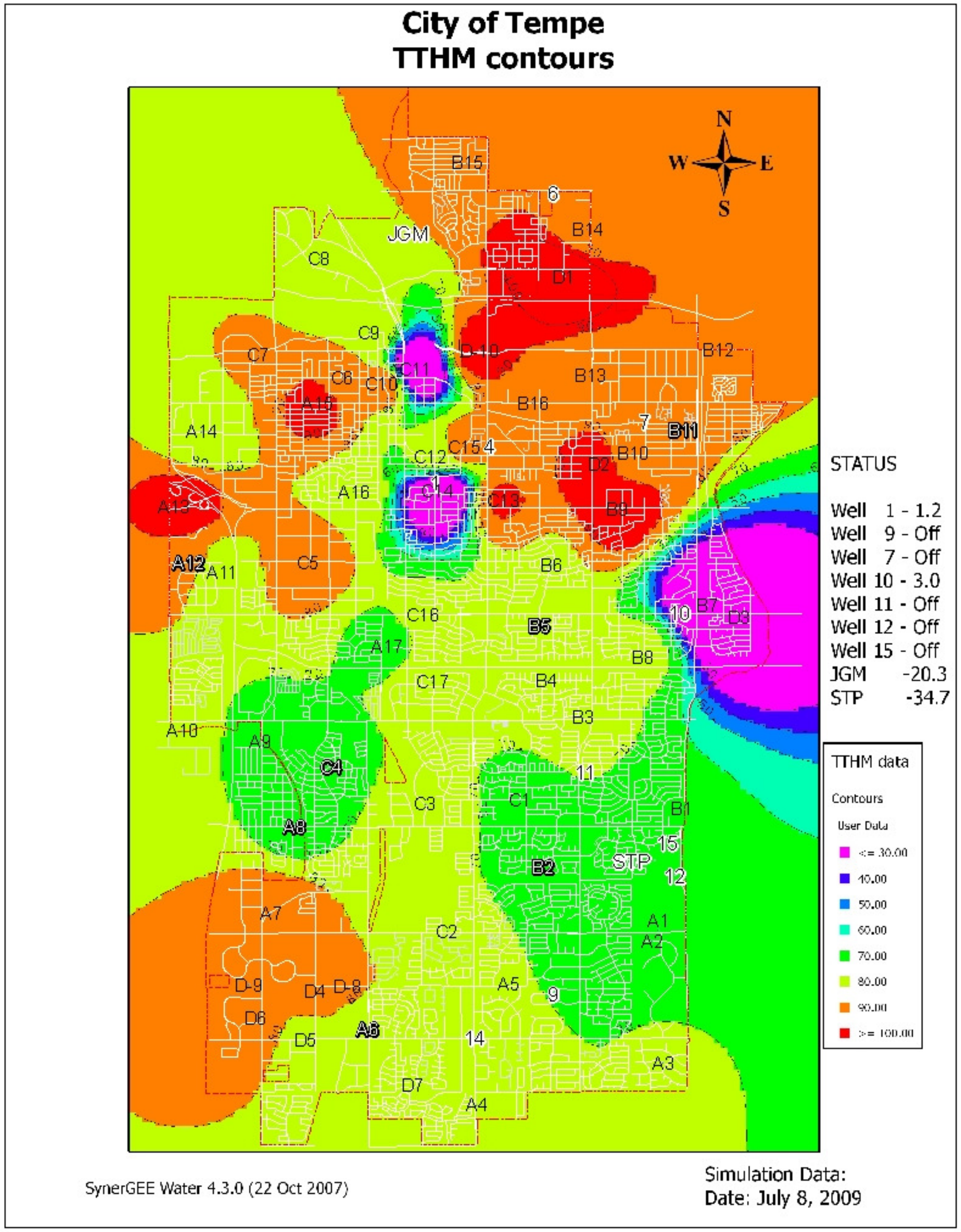


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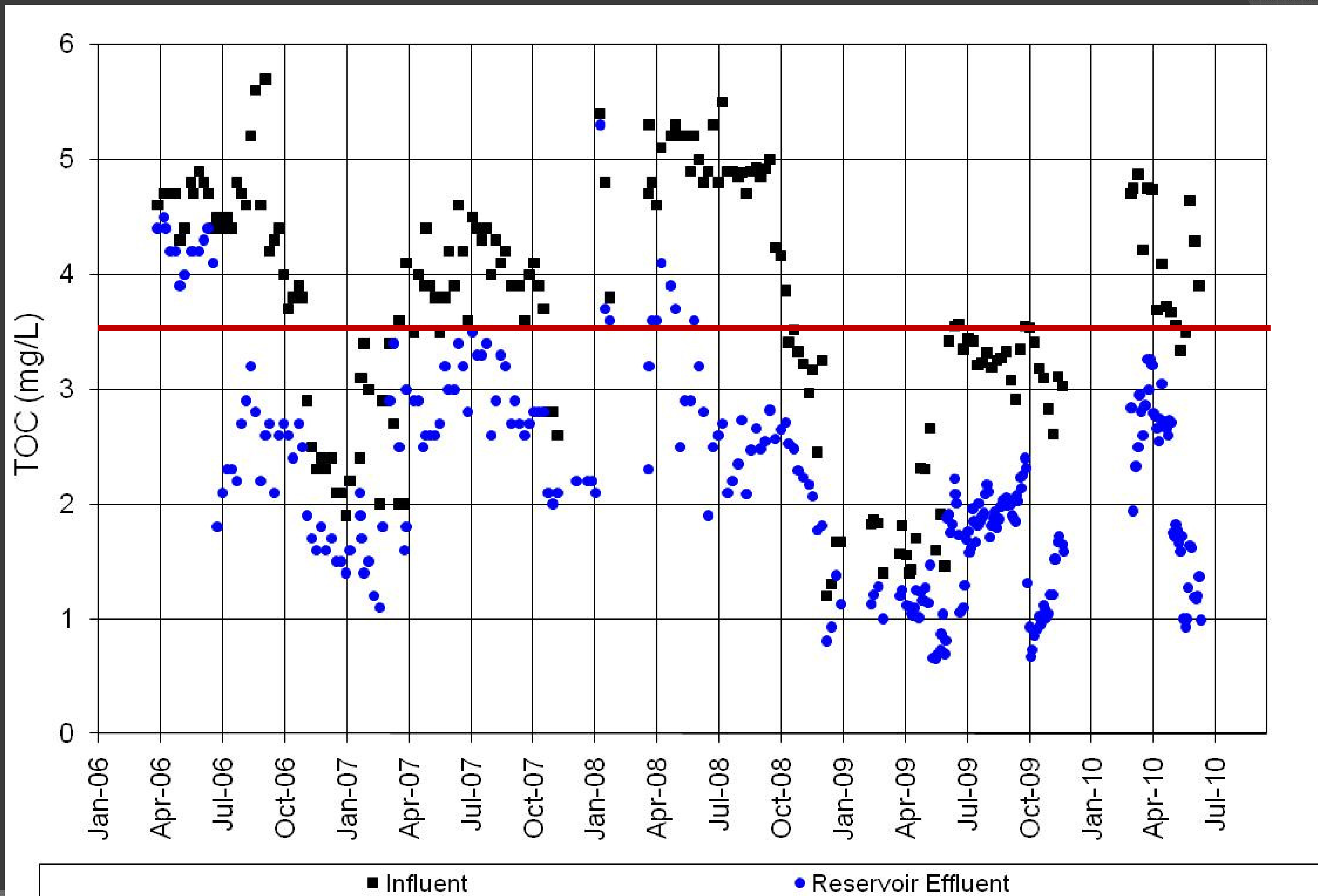
# Scottsdale Chaparral WTP TOC History

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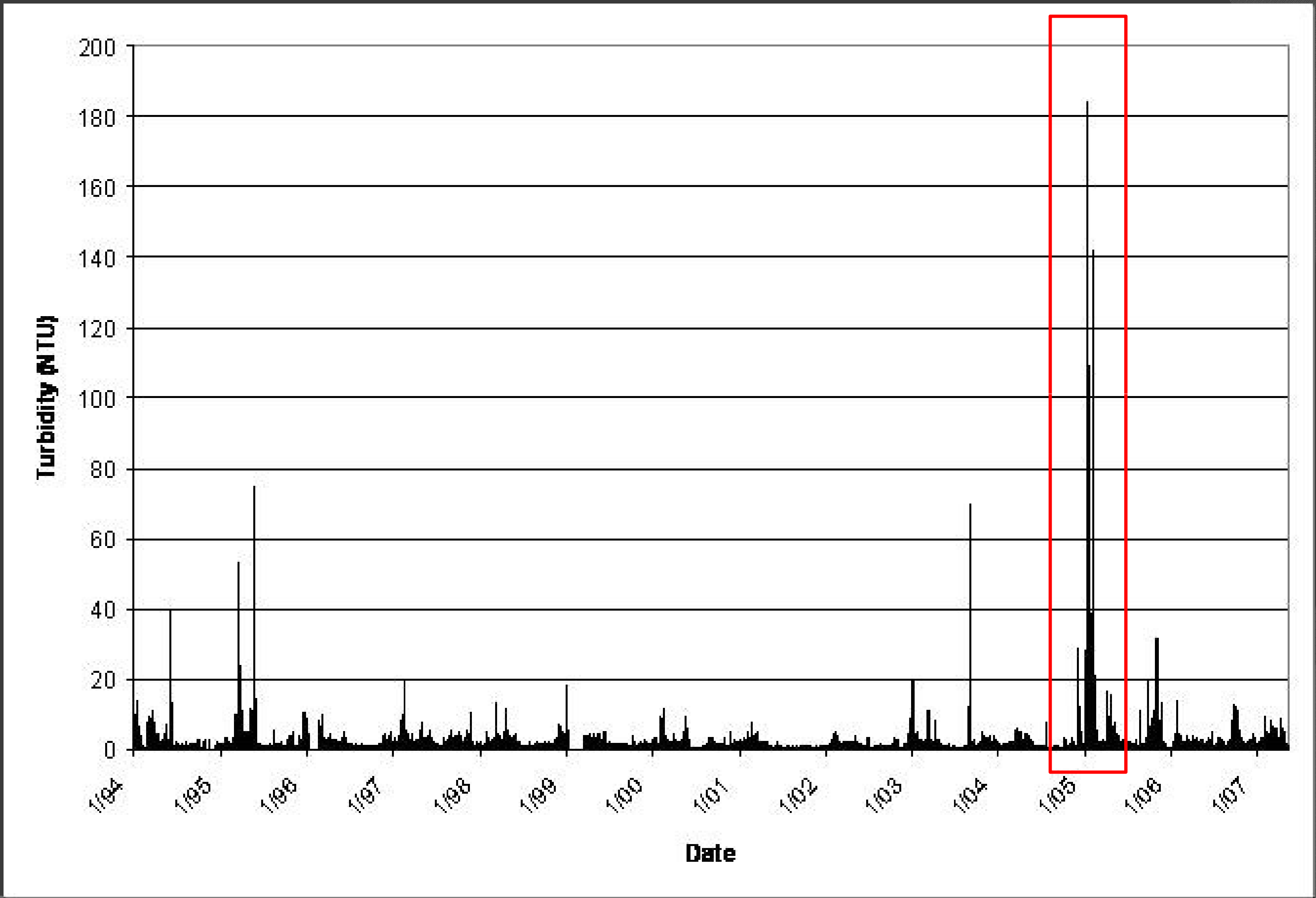
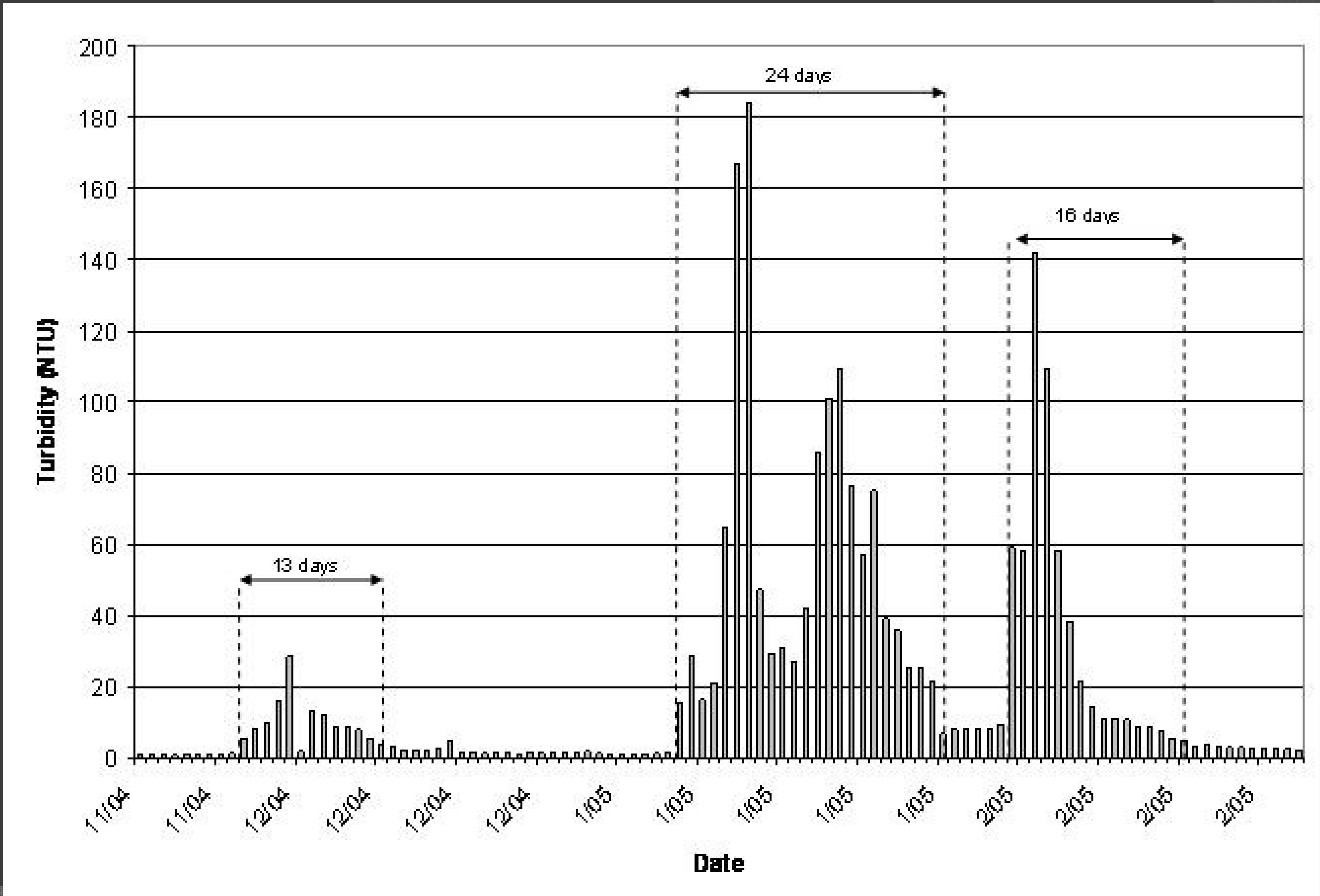
# Scottsdale Chaparral WTP Response

- Plant originally designed for 3.5 mg/L TOC
  - Observed TOC range 3-5 mg/L
- Novel treatment approaches
  - Coagulant change
  - Intermediate chlorination ahead of GAC
  - GAC optimization
  - TTHM aeration in clearwell

# City of Phoenix UHWTP Turbidity



# City of Phoenix UHWTP Turbidity

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# City of Phoenix UHWTP Response

- Optimization of key facilities
  - High Turbidity Events
    - Turbidity Event Operating Strategy Guide
  - Changing Water Quality
  - Reduce plant capacity, short-term
- Targeted treatment of resultant TTHMs
  - Applied aeration

# Summary of Phoenix Metro-Area Utilities' Response

- Fluctuating source water quality throughout the area
- Developed Early Warning System
  - In-stream monitoring
  - Upstream facilities alerting downstream facilities
- Focused on system optimization
  - Use what you have
- Managed impacts of increased TOC/DOC
  - WTP optimization
    - Enhanced coagulation
    - Preoxidation
    - GAC/PAC
  - DS optimization
    - Aeration
    - Flushing

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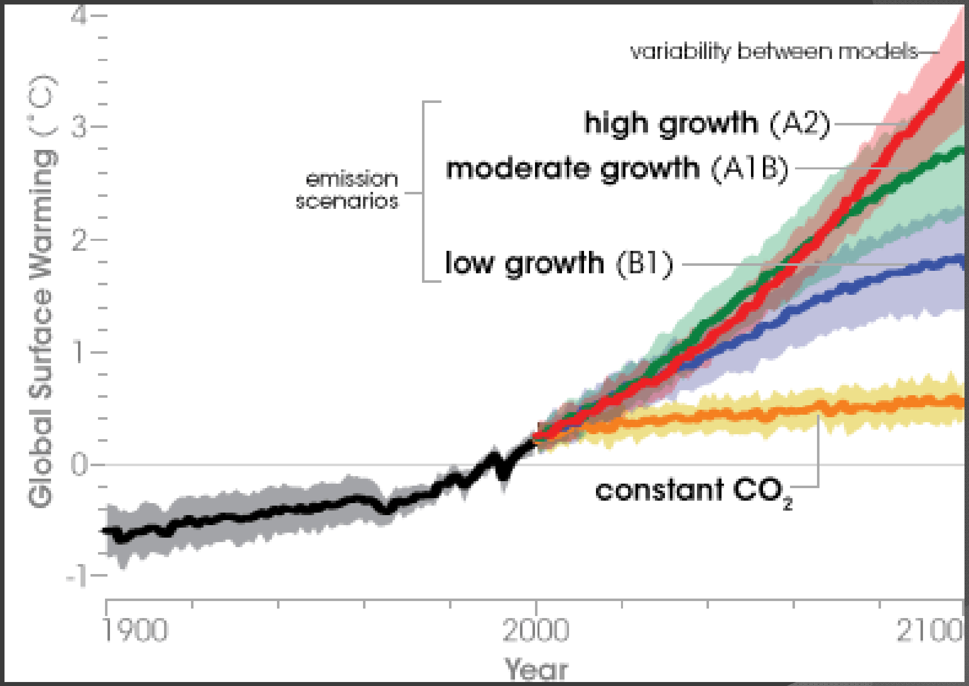
# Broader View of Climate Change Impacts

- WaterRF 4239, *Climate Change Impacts on the Regulatory Landscape*
- Objective: Study impact of climate change on the water community and related regulation
  1. Identify regulatory issues, international options and technical constraints
  2. Apply findings to our utility partners and test them through case studies
  3. Validate the case study findings through a peer review workshop

# Climate Change: An Overview

- Average surface temperature is likely to increase by 2 to 11.5 °F by the end of the 21st century, relative to 1980 – 1990, with a best estimate of 3.2 to 7.2 °F
- Warming will differ by season, with winters warming more than summers in most areas




Source: USPEA, http://www.epa.gov/climatechange/science/futuretc.html

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# Potential Impact on Western States

- Likely reduction in snowpack and seasonal shifts in runoff patterns
- Possible declines in groundwater recharge – reduced water supplies
- Increased water temperatures
  - Increased chlorine residual decay, DBP formation, and other WQ concerns
- Increased frequency of intense environmental events
  - Flash floods
  - Wildfire
- Possible salinity increase in San Francisco bay and Sacramento/San Joaquin Delta

# Case Study Highlights

- Golden, CO
  - Conservation strategies
  - Separating irrigation flows
  - Optimized operation during turbidity events
- East Bay Municipal Utility District, CA
  - Potential for high turbidity due to wildfire would be difficult to manage and costly
    - Need to address in future planning
  - Conservation strategies

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# Case Study Highlights

- Scottsdale, AZ
  - Diversified water supply
    - Surface water
    - Groundwater
    - Reclaimed water
  - Conservation strategies

# Utility Response Options

- Do nothing
  - Risk water quality impacts to drinking water
- Optimize existing facilities
  - Jar testing, chemical utilization
- Build new facilities
  - Systems that are more robust, less impacted by shifts in source waters
- Manage downstream
  - Distribution system improvements
- Reduce consumption
  - Implement conservation strategies

# Acknowledgements

- We would like to thank our teaming partners for their important contributions to this work!
  - Phoenix, AZ
  - Tempe, AZ
  - Scottsdale, AZ
  - Golden, CO
  - East Bay Municipal Utilities District
  - Arizona State University
  - USGS
  - Water Research Foundation

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# Questions

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