Water Quality Impacts of Extreme Weather Events

Jan 19, 1996
14,090 mgd

Jan 27, 1996
6,720 mgd

Turbidity (NTU) or Flow (mgd)

Reservoir Turbidity (NTU)
Reservoir Inflow (mgd)

Two Projects

Just Finishing
Funded by Water Research Foundation (USA) and WSAA 2011-2013
Benjamin Stanford (Hazen Sawyer)
Ben Wright (Hazen Sawyer)
Jan Routt (J Routt & Associates)
Jean Debroux (Kennedy/Jenks)
Stuart Khan (UNSW)

Just Beginning
Funded by WQRA 2013-2015
Stuart Khan (UNSW)
Dan Deere (Water Futures)
Frederic Leusch (Griffith University)
Andrew Humpage (SA Water)
David Cunliffe (SA Health)
Madeline Jenkins (CAT)
Water Quality Impacts of Extreme Weather-Related Events

- **Aim**: to identify and characterise water quality impacts from extreme weather-related events

- **Project Stages**:
  - Preliminary Data Collection
  - Supplementary Data Collection
  - Analysis and Assimilation
  - Extreme Weather Event Case Studies

- Total of 46 detailed case studies collected
- Eleven Australian case studies from ACT, NSW, QLD, SA, VIC
46 US and Australian case studies

Weather Event (or scenario)
- Recognition, characterisation

Raw and Finished Water Quality Impact
- Actual, potential

Responses before during and after
- Innovations, adaptations, costs

Key insights, applications
- Lessons learned, priorities forward

Adaptations—long term
- Future planning, costs

Some case study findings

Weather Events
- Droughts, floods, heavy rainfall, changes in rainfall patterns, bushfires and high winds

Water Quality Impacts
- Included increased turbidity and organic matter, hypoxia, eutrophication leading to algal and cyanobacterial growth, taste and odour problems, increased presence or risk of pathogens and changes to conductivity, pH and alkalinity

Infrastructure Impacts
- Water, power and communications infrastructure damaged and destroyed through fire and inundation

Responsive Measures
- Implementation of incident management plans including changes to operations and staffing. Communication with key stakeholders.
Water Quality Impacts of Extreme Weather Events

Extreme Rainfall Events

Physical impacts
- Erosion → ↑sediment and ↑TOC
- Power and communications loss
- Damaged pumps
- Submerged WWTPs

Impacts to source waters
- ↑turbidity and colour (organic and inorganic)
- Pathogens, nutrients, DOC.

All 11 Australian case studies detail the impacts of heavy rainfall. Two case studies show the impacts of heavy rainfall that occurred in isolation.

Water Quality Impacts of Extreme Weather Events

Heavy Rainfall and Flooding

Raw Water Quality
- Increased colour 3.3x, conductivity 1.5x and turbidity 2.3x and 40x normal concentrations.

Finished Water Quality
- Increased turbidity, taste and odour compounds

Infrastructure Damage
- WTP inundated, repairs to electrical works, cleaning of clear water tanks.

Treatment and Distribution
- WTP offline, Boil Water Advisory. Raw Water extraction from river ceased.
Water Quality Impacts of Extreme Weather Events

Drought

El Niño conditions caused a prolonged drought across much of Eastern Australia from 2001 – 2010

Impacts of drought include:
- Decreased flows
- Dry soils → decreased run off and mains breakages
- Decreased water storage volume → ↑salinity, ↑DOC, ↑turbidity
- Increased temperature, nutrients → algae
  - Increased animal and bird activity around reservoirs → erosion, pathogens

Seven Australian case studies detail the combined impacts of drought and heavy rainfall

Water Quality Impacts of Extreme Weather Events

Rainfall preceded by Drought

- Raw Water Quality
  - Increased nutrients, DOC >15mg/L, turbidity up to 1200 NTU. Decreased DO <6mg/L.
  - Cyanobacterial bloom, Microcystis sp., E. Coli, Cryptosporidium and Giardia.
- Finished Water Quality
  - Cryptosporidium detected, alternate water supplies sourced
- Infrastructure Damage
  - Inundation of WTPs, extremely high turbidity threatened treatment systems.
- Treatment and Distribution
  - Decrease filter run times, increase coagulant and disinfectant dosing, Boil Water Advisories issued, WTPs taken offline
Water Quality Impacts of Extreme Weather Events

Bushfire

From 2001-2011 Australia experienced 20 major bushfires including some within the main drinking water catchments for Sydney, Canberra and Melbourne.

Impacts of bushfire include:

- Infrastructure damage → loss of power and communications
- Loss of vegetation in catchment → erosion → sediment, OC and nutrient (P) mobilisation
- Damage to soils → slow recovery of vegetation
- Ash and silt → ↑DOC, colour, turbidity, nutrients, metals in waterways
- ↑ aerobic metabolic activity → ↓DO
- Pathogens from dead animals

Three Australian case studies detail the impacts of bushfires.
All of these bushfires occurred in combination with rainfall events.

Water Quality Impacts of Extreme Weather Events

Rainfall preceded by Bushfire

Raw Water Quality

- Increased nutrients, turbidity, iron and manganese. Cyanobacterial bloom

Finished Water Quality

- Taste and odour compounds

Infrastructure Damage

- Water, power and communications infrastructure burnt.

Treatment and Distribution

- WTPs and pumping stations offline. Boil Water Advisories.
Water Quality Impacts of Extreme Weather Events

Combinations of Extreme Events

Case studies give examples of exacerbated impacts of combinations of weather events
e.g. Drought + Rainfall $\Rightarrow$ increased nutrients, DOC, turbidity; decreased DO;
increased risk and presence of pathogens
Rainfall + bushfire $\Rightarrow$ increased nutrients and turbidity leading to
cyanobacterial bloom

These impacts appear to be worse than had these weather events occurred in isolation
- Isolated rainfall events did not lead to significant algae and pathogen problems as seen in combined events

Water Quality Impacts of Extreme Weather Events

Combinations of Extreme Events

The timing of combinations of extreme weather events is an important factor in the magnitude of the outcomes
e.g. Bushfire + Heavy Rainfall $>1$ year later
Bushfire + Heavy Rainfall $<1$ year later

It is likely that an increased frequency of extreme weather events will prevent full recovery of catchments from preceding weather events therefore resulting in worse outcomes on source water quality and drinking water supply.
Water Quality Impacts of Extreme Weather Events

Combinations of Extreme Events

Increased frequency → ‘synergistic’ outcomes
What water quality impacts have occurred during a specific extreme weather event?
Executive Summary
1. Introduction and Project Overview
2. Project Approach
3. Preliminary Data on Extreme Weather-Water Quality Impacts
4. Water Quality Impacts on Extreme Weather-Related Events
5. Infrastructure, Staff and Customer Impacts of Extreme Weather-Related Events
6. Preparation and Recommendations for Future Extreme Weather-Related Events
7. Concluding Remarks
Appendices
What gaps did the WRF project leave?

• Collected a lot of excellent data
• Provided a good understanding of what could happen
• Australian water industry has different risk management philosophy to USA.

Two extreme event simulations

• Diverse range of personnel from water utilities and other relevant agencies will be selected
• Participants will prepare by studying previously prepared literature and case studies.
• Larger invited audience will participate by asking questions and contributing key insights as appropriate.
• Participants may be confronted with unanticipated developments as the simulated scenario proceeds.
• Outcomes will be reported in a format that their findings may be generally applicable to a wide range of water utilities and risk managers.
• At the conclusion a facilitated discussion will be used to identify new insights, key learning’s, vulnerabilities and areas for improvement.
‘Short term exposure’ drinking water guideline values

Most guideline values for chemical contaminants in ADWG are based on assumption of lifetime chronic exposure.

The fact that significantly higher concentrations of some chemicals can be tolerated for short periods of time without significant increase to human health risk is not well described or understood.

We will calculate and will provide transparent details of short-term safe exposure levels for a range of chemical substances. These levels will be based on consideration of both acute and chronic toxicity data as available.

Will be undertaken for all DBPs in ADWG and other chemicals that have occasionally been reported as having exceeded ADWG values for short periods.

Identify management approaches to ensure supply of safe drinking water during and immediately following extreme events

These include operational approaches that may not involve strict adherence to the ADWG, but may ensure water quality by other means.

For example, after major floods, normal turbidity standards may not be achievable, but alternative measures may be used to demonstrate microbial quality.

Similarly, in times of very high raw water NOM, normal disinfection residuals may not be achievable, but alternative practices and monitoring may enhance risk management.

Will involve significant consultation with water utilities and state-based health regulators. This is crucial to enhance the likelihood of the broad acceptance and endorsement of the final product.
Guideline document on managing drinking water quality in preparation for and during extreme events.

It is anticipated that this document could be considered as a formal (pending endorsement) or informal appendix to the ADWG.

It would include key learning's from the literature review, case studies and the extreme event simulations.

Furthermore, these guidelines will introduce the topic of ‘short term exposure’ drinking water quality guidelines.

Close consultation with water utilities and health regulators will be maintained throughout the development of this document.

A budgetary allowance has been made to cover the consultancy fees of a professional technical writer to review the final draft of the document.

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**Project Plan**

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<th>Project Objectives</th>
<th>Year 1</th>
<th>Year 2</th>
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<tbody>
<tr>
<td>1. Project team workshop to refine project methodology</td>
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<td>2. Literature review</td>
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<td>3. Case Study review and supplementation</td>
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<td>4. Extreme Event Simulation #1 (eg. Bushfire)</td>
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<td>5. Extreme Event Simulation #2 (eg. Flood)</td>
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<td>6. Calculate safe ‘short term exposure’ drinking water guideline values</td>
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<td>8. Identification of suitable management approaches</td>
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<td>9. Development of extreme weather events management guidelines</td>
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**Start Date: July 2013.**