WATER QUALITY IN THE DISTRIBUTION SYSTEM

BEST PRACTICES

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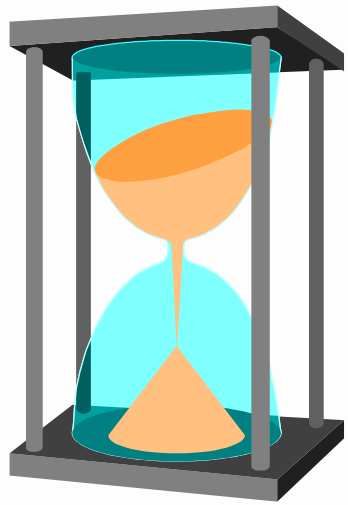
R.V. Anderson Associates Limited

March 25, 2003

OUTLINE

- National Guide to Sustainable Municipal Infrastructure (NGSMI)
- Common water quality problems
- 21 Best practices



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NGSMI - OVERVIEW

- ***National Guide to Sustainable Municipal Infrastructure: Innovations and Best Practices***
- Federation of Canadian Municipalities (FCM) & National Research Council (NRC)
- Funded by Infrastructure Canada, NRC & in-kind contributions
- Part A – decision-making & investment planning
- Part B – technical best practices
- www.infraguide.ca

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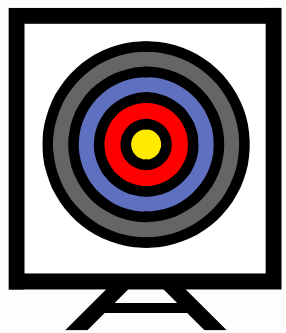
NGSMI – TARGET AREAS

- Potable water systems
- Storm & wastewater systems
- Municipal roads & sidewalks
- Environmental protocols
- Decision-making & investment planning



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BEST PRACTICE - DEFINITION

- *"State of the art methodologies & technologies for municipal infrastructure planning, design, construction, management, assessment, maintenance & rehabilitation that take into consideration local economic, environmental & social factors."*

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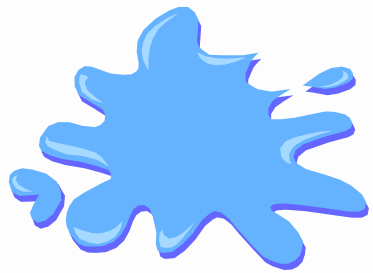
BEST PRACTICES - WATER

- **PW-1** – Evaluation of Water Loss in the Water Distribution System
- **PW-2** – Deterioration & Inspection of Water Distribution Systems
- **PW-3/SWW-4/MR-4** – Condition Assessment & Evaluation of Municipal Infrastructure
- **PW-4** – Available Technologies for the Rehabilitation or Reconstruction of Water Distribution Systems
- **PW-5 – Water Quality in the Distribution System**
- **PW-6** – Developing a Water Distribution System Renewal Plan

BEST PRACTICES - WATER

Upcoming Best Practices

- **PW7** – Establishing Service Levels
- **PW8** – Establishing a Metering Plan to Account for Water Use & Loss
- **PW9** – Criteria for the Selection of Technologies for the Renewal of Water Distribution System Components



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WORKING GROUP

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- Kelly Kjartanson, City of Winnipeg, Manitoba
- Larry Gangur, City of Gatineau, Quebec
- Wayne Miller, City of Windsor, Ontario
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- Brian Pett, 5 Square Consulting Inc., Caledonia, Ontario
- Graham Gagnon, Dalhousie University, Halifax, Nova Scotia
- Susan Clift, City of Vancouver, British Columbia
- Gord Lefort, IPEX Inc., Toronto, Ontario
- Michael Tobalt, National Guide, Ottawa, Ontario

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NGSMI REVIEW PROCESS

- Working Group
- Technical Committee
- Stakeholder Group
- Peer Review Group

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MULTI-BARRIER APPROACH

1. Source water protection
2. Treatment
3. **Disinfection**
4. **Proper O&M of distribution system**
5. **Water quality monitoring**

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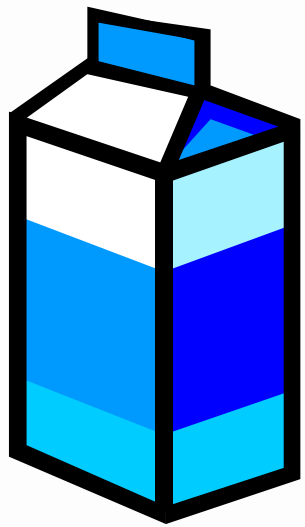
BEST BEFORE…

- Water – perishable product
- Shelf life – detention time
- Preservative – chlorine/chloramine
- Packaging – pipes & reservoirs



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WEB SITES

- Health Canada
- Canadian Council of Ministers of the Environment (CCME)
- American Water Works Association (AWWA)
- Canadian Water and Wastewater Association (CWWA)
- US Environmental Protection Agency (USEPA)
  - 9 white papers on potential health effects of changes to water quality in distribution systems

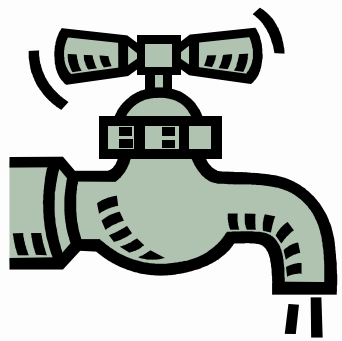
AWWA MANUALS

- M7 – Problem Organisms in Water: Identification & Treatment
- M14 – Recommended Practice for Backflow Prevention & Cross-Connection Control
- M19 – Emergency Planning for Water Utility Management
- M20 – Water Chlorination Principles & Practices
- M25 – Flexible-Membrane Covers & Linings for Potable Water Reservoirs
- M28 – Rehabilitation of Water Mains
- M48 – Waterborne Pathogens

WATER QUALITY CHANGES

- Internal reaction (within the water itself)
- Reaction between the water & pipe wall

- **Primary factors**
  - Water quality leaving treatment plant / well
  - Pipe material & condition
  - Hydraulic detention time
  - Water temperature
  - O&M practices
  - Pressure & flow control
  - Disinfectant residual



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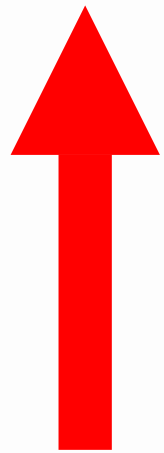
SEASONAL INFLUENCES

As water temperature increases, all of these conditions/ parameters increase:

- Disinfectant demand
- Disinfection by-product formation
- Nitrification (if chloramine is used)
- Microbial activity
- Algal growth
- Taste & odour episodes
- Lead & copper solubility
- Scaling / $CACO_3$ precipitation



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WATER QUALITY PROBLEMS

- Biological
- Chemical / physical
- Aesthetic

Fig. 5.5. Tuberculation in a cast iron pipe.

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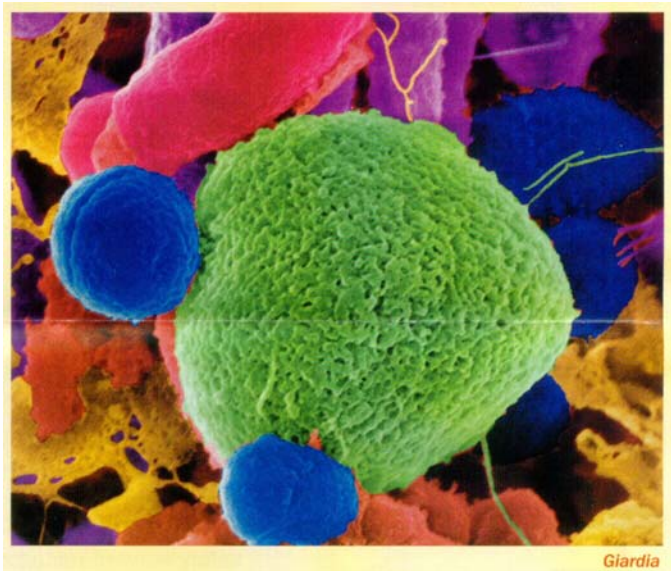
BIOLOGICAL

- Bacterial regrowth & biofilms
- Nitrification (chloraminated water)
- Waterborne diseases
- Worms & insects



Giardia

WATERBORNE PATHOGENS

AWWA Manual M48

- Bacterial pathogenic agents – 17 including E.coli
- Parasitic pathogenic agents – 18 including Giardia & Crypto
- Viral pathogenic agents – 8 including Hepatitis A

Bacteria

- Heterotrophic plate count (HPC) bacteria – bacteria that generate energy through the oxidation of organic carbon.
- Coliform bacteria – a group of bacteria inhabiting the intestines of humans & animals; presence of coliform bacteria in water is used an indication of fecal contamination.
- E.coli - a bacteria of the coliform group that indicates fecal contamination & poses a serious threat to public health.

CHEMICAL / PHYSICAL

- Disinfection byproducts (THMs & HAAs)
- Corrosion (lead & copper)
- pH stability & scale formation
- Byproducts of linings & coatings
- Disinfectant residual
- Sediment

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AESTHETIC

- Taste & odour
- Colour & appearance

Note: Aesthetic problems are usually related to chemical/physical problems

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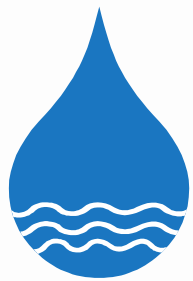
BP1 – Produce high quality water

- Stabilize pH
- Optimize coagulation
- Provide corrosion control treatment
- Use UV for primary disinfection
- Reduce turbidity & natural organic matter using well adjusted chemically adjusted chemically assisted filtration/coagulation



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BP2 – Maintain Adequate Disinfectant Residual

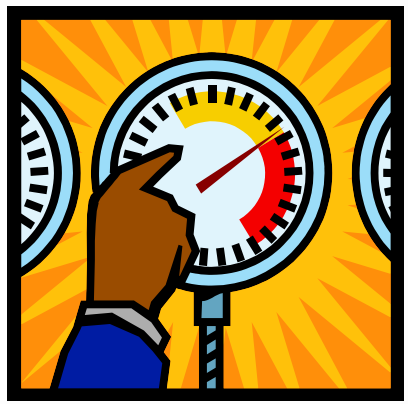
- **Chlorination**
  - Maintain free chlorine residual > 0.2 mg/L
  - Use chlorine booster stations in large systems
  - Can react with naturally occurring organic matter to produce disinfection by-products (DBPs)
- **Control DBPs**
  - Reduce the amount of chlorine used
  - Shift the point of chlorine application
  - Adjust chlorination pH
  - Remove naturally occurring organic matter
  - Use a different type of chlorine

BP2 – Maintain Adequate Disinfectant Residual

- **Chloramination**
  - Add ammonia to chlorinated water
  - More stable & persistent disinfectant
  - Fewer chlorination by-products
  - Less taste & odour complaints
  - Potential for nitrification (ammonia is oxidized to nitrite)
  - Maintain chloramine residual > 1 mg/L

BP3 – Maintain Positive Water Pressure

- **Prevent contaminant intrusion**
  - Maintain pressure > 140 kPa (20 psi)
  - Mitigate pressure transients



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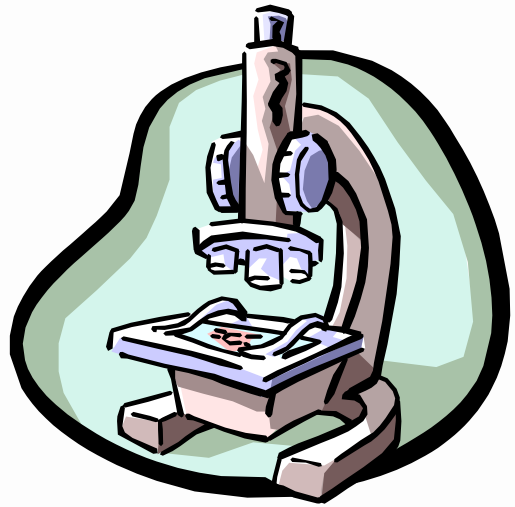
BP3 – Maintain Positive Water Pressure

Best Practices

- Maintain distribution system in good condition
- Maintain clearance between sewers & water mains
- Provide elevated storage
- Install surge control equipment
- Provide drains in air valve chambers
- Interconnect pressure zones
- Provide standby power for pumps
- Open & close valves & hydrants slowly
- Ensure dry barrel hydrants are adequately plugged

BP4 – Monitor Water Quality

- **Routine monitoring** to anticipate, detect & solve water quality problems
  - Sampling sites
  - Dedicated sampling stations
  - Test parameters
  - Sampling frequencies
  - LIMS, GIS, SCADA



- **Non-routine monitoring** to respond to complaints & monitor construction & maintenance activities

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BP5 – Implement Backflow Prevention Program

Contamination through cross connections resulting from backflow (back siphonage or back pressure)

- Maintain clearance between sewers & water mains
- Install backflow prevention devices
- Implement cross-connection control program
- Maintain adequate disinfectant residual
- Maintain positive pressures
- Maintain the system in good condition

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BP6 – Flush / Swab Water Mains

- Conventional flushing
- Uni-directional flushing
- Swabbing (main should be disinfected afterwards)

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BP7 – Control Valve & Hydrant Operations

- Regular inspection to be prepared for emergencies (e.g. main breaks, contamination)
- Maintain positive pressures
- Mitigate pressure transients

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BP8 – Implement Biofilm Control Program

- Nutrient control – through biological treatment
- Prevent contamination
- Control pressures
- Flushing & swabbing
- Prevent backflow
- Maintain disinfectant residual
- Provide internal corrosion control
- Maintain distribution system & storage facilities

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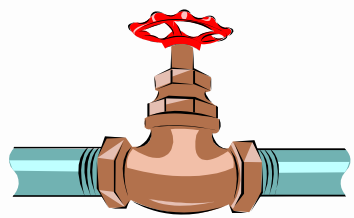
BP9 – Control Blending of Water Sources

- Oxidation/reduction reaction in unlined cast iron mains
- Precipitation of iron & manganese
- Change pH / alkalinity
- Flow changes can cause turbidity and/or red water
- Detailed blending analysis
  - Chemical compatibility
  - Predict blended water quality characteristics
  - Assess impact on pipe materials



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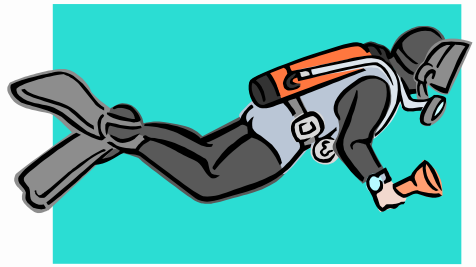
BP10 – Properly Design & Operate Storage Facilities

- Long detention time (e.g. standpipes)
- Uncovered reservoirs should not be used
- Floating covers should be designed per AWWA M25
- Coatings should comply with NSF/ANSI Std. 61
- Vents & hatches
- Promote complete mixing of water
- Operate system to promote turnover of water
- Provide security systems

BP11 – Regularly Monitor, Inspect & Maintain Storage Facilities

- Inspections
  - Routine
  - Periodic
  - Comprehensive



- Cleaning (based on water quality monitoring, biofilm monitoring & sediment sampling)
  - Drain, disinfect & flush
  - Commercial divers or remote operated vehicles
- Maintenance (prepare an outage plan)

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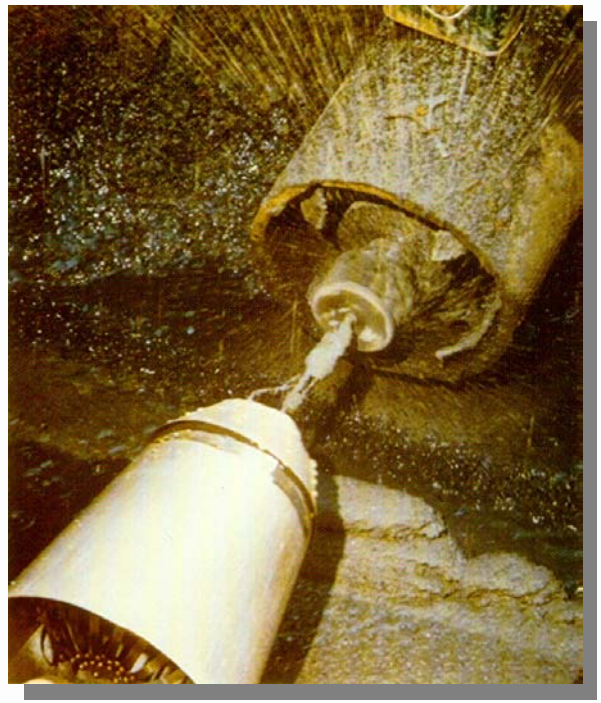
BP12 – Properly Design & Operate Distribution Systems

- Eliminate dead ended mains
  - Extended detention time
  - Reduction in disinfectant residual
  - Increase in microbial counts
  - Accumulation of sediment
  - Taste & odour complaints
- Loop water mains wherever possible
- Install hydrants, blow-offs or automatic flushing devices

BP13 – Rehabilitate / Replace Water Mains

- Non-structural rehabilitation
  - Cement mortar lining
  - Epoxy lining
- Structural rehabilitation
  - Slip lining
  - Cured in place lining
- Replacement
  - Open trench
  - Trenchless



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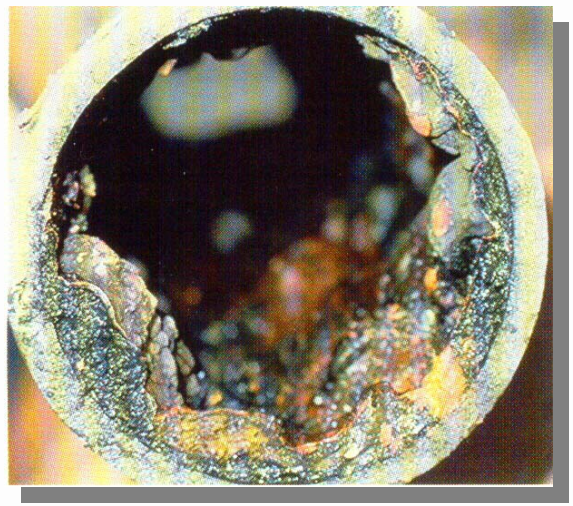
BP14 – Control Internal Corrosion

Lead

- Public education
- Corrosion control treatment
- Replace lead services



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BP15 – Use Approved Materials

- Leaching of pipe linings & coatings
- Permeation through pipe wall
- Excessive use of pipe lubricants
- NSF/ANSI Standards 60 & 61

BP16 – Utilize Appropriate Disinfection Procedures

AWWA Standard 651-99

- New mains
- Temporary water supplies
- Connections
- Repairs

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BP17 – Conduct Vulnerability Assessment

- Disruption of supply
  - Physical disruption
  - Cyber attacks on SCADA systems
- Contamination
  - Biological
  - Chemical
  - Radiological
- Physical protection systems
- Operation systems
- Consequence mitigation

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BP18 - Use Calibrated Computer Models

- Constituent analysis (chlorine decay)
- Source trace analysis (blending)
- Water age analysis (sampling & flushing)
- Tank mixing
- Vulnerability assessment
- Emergency response planning

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BP19 – Provide Operator Training & Certification

- Association of Boards of Certification
- Canadian Water and Wastewater Association

- Utility Accreditation
  - AWWA Standard G-200 (draft)
  - QualServe (AWWA)
  - ISO/RC 224

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AWWA G200 (Draft)

AWWA Standard for Distribution Systems Operation & Management

Water Quality

1. Compliance with regulatory requirements
2. Monitoring & control
3. Disinfectant residual maintenance
4. Internal corrosion monitoring & control
5. Aesthetic water quality parameters
6. Customer relations

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AWWA G200 (Draft)

Distribution System Management Programs

1. System pressure
2. Backflow prevention
3. System flushing
4. Permeation prevention
5. Unaccounted for water
6. Valve exercising & replacement
7. Fire hydrant maintenance & testing

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AWWA G200 (Draft)

Distribution System Management Programs

8. Materials in contact with potable water
9. Metering
10. Flow capacity
11. External corrosion
12. Design review for water quality
13. Energy management

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AWWA G200 (Draft)

Facility Operations & Maintenance

1. Treated water storage facility
2. Pump station operations & maintenance
3. Pipeline rehabilitation & replacement
4. Disinfection of new or repaired pipes

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BP20 – Communicate with Stakeholders

- Treatment plant operators
- Distribution system operators
- Contractors
- Fire, parks & roads department
- Provincial health department
- Large water consumers
- Neighboring municipalities
- Decision-makers (politicians)
- Public

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BP21- Customer Service

- Share water quality data
- Public education
- Standard procedure for responding to water quality complaints
- Standard procedure for dealing with potential contamination

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BENEFITS

- Reduce risks to public health
- Reduce number of non-compliant samples
- Reduce customer complaints
- Reduce corrective maintenance
- Defer costly replacement
- Reduce liability
- Increase public confidence in water supply

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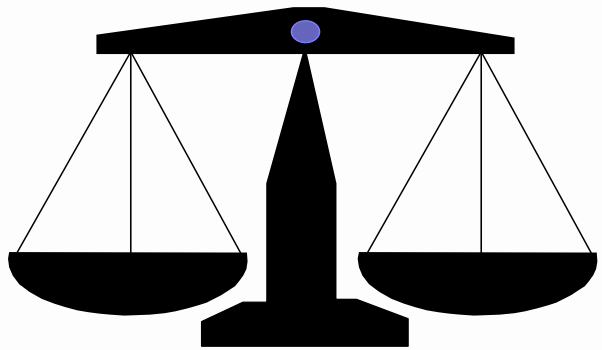
RISKS

- Higher cost for operation, maintenance & renewal
- Higher water rates
- Additional staff
- Additional training



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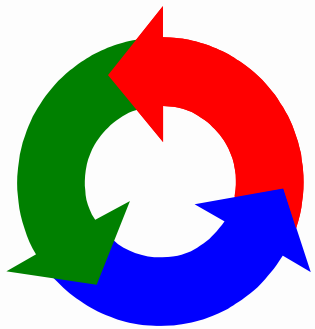
APPLICATIONS

Action plan

- Review each of the best practices
- Identify priorities (public health should be the highest priority)
- Prepare cost estimates
- Develop multi-year plan
- Implement plan
- Evaluate effectiveness



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OBJECTS IN MIRROR ARE CLOSER
THAN THEY APPEAR

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