General Approaches and Recent Developments in Handling Wet Weather Flows in WWTPs

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Improving Wet Weather Flow Management at WWTPs

- Flows resulting from unaddressed I/I
- Often exceed plant’s treatment capacity
- Established dry weather approaches are not applicable
- Driven by increased public and regulatory pressures
Navigating Through Unsettled Regulatory Seas

- Initial years of CWA focused attention on dry weather discharges as long as all discharges complied with NPDES program
- EPA’s CSO Policy (1994) regulated combined systems
- We don’t have something equivalent for SSOs
  - 2003 – Blending Policy “Draft”
  - 2005 – Peak Flow Policy “Draft”
  - 2009 – “Draft” PFP Implementation Guidelines
  - 2010 – Initiation of rulemaking on SSO and wet weather issues – Public input
Defining Design Influent Flows… That Change All the Time!

- In dry weather, flows and loads are predictable and somewhat “static”
- Wet weather flows and loads: unpredictable and “dynamic” - Hydrograph
Design Pollutographs: Loads Are also Variable and Unpredictable…. 

- Concentrations/ loadings change during a storm…as well as between storms!
- First flush issues: How big? When it occurs? For how long? Where does it go?
Optimizing Operations: An Ongoing Learning Adventure

- Quasi “steady-state” nature of dry weather operations allows establishment of “proven and reliable” operational practices
- In a wet weather event things are always changing…and every event could be a new adventure!

Wet-Weather Impacts WWTPs

- Flows: hydraulic surge
- Loads: First-flush then dilute waste
- Trash and grit
- Other toxics
- Heavy metals
- Effluent impacts
  - Effluent loads
  - Biomass washout
Wet Weather Management Options

1. Reduce I/I
2. Store
3. More treatment
4. Combination
Storage and Equalization

- Always consider first (at/off plant site)
- Process issues
  - Tank size/treatment Capacity
  - Odor control
  - Mixing
  - Post-event cleaning
Wet-Weather Treatment Improvement Approaches

- Sequential Treatment (upgrade/expand)
- Parallel Treatment (new)

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Sequential Treatment (upgrade/expand)
Parallel Treatment (new)
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Screening
Grit Rem.

Primary
Treatmt.

Secondary
Treatmt.

Filtration

Disinfect.

Storage

Addtn’l
Facilities

“Blending” Concept
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Impacts on Preliminary Treatment

Potentially significant impacts even if flow can be managed “hydraulically”…

- Blinding of screens (higher velocities)
- Reduced performance of grit removal
  - Increased loads (first flush)
  - Reduced detention times
Impacts on Preliminary Treatment

Potential issues even if flow can be "hydraulically" managed:

- Blinding of screens (higher velocities)
- Reduced performance of grit removal
  - Increased loads (first flush)
  - Reduced detention times
Primary Treatment of Wet-Weather

- Conventional Primary Clarification
  - Low SORs (<< 5 m/h at $Q_p$)
  - Low removal efficiencies (< 50% TSS)
  - Lower performance at higher flows

- Chemically Enhanced Clarification (CEC)
  - The use of coagulants and or flocculants to improve the performance of a gravity solids settling process.
  - Improved performance:
    - Increased hydraulic capacity
    - Increased effluent quality
Conventional Primary Clarification

WW Flow → Aerated Grit → Primary Clarifier → To Solids Processing

Conventional PC SOR: 1 gpm/ft² (1500 gpd/ft²)

50% TSS Removal
Chemically Enhanced Primary Treatment (CEPT)

Conventional PC SOR: 1 gpm/ft$^2$ (1500 gpd/ft$^2$)
CEPT SOR: 2 gpm/ft$^2$ (3000 gpd/ft$^2$)
Chemically Enhanced Primary Treatment (CEPT)

Recent evolution of a proven concept…

- **Coagulants**
  - Alum (30-70 ppm)
  - Fe salts (15-50 ppm; eliminates H₂S; affects UV disinfection)

- **Flocculation aid**
  - 0.3 - 2.0 ppm polymer
High Rate Clarification (HRC)

- Water treatment origin (Europe); successful “cross-over” to wet-weather applications
- Chemically assisted tube/plates clarification
- Extremely compact
  - SOR: 30 – 60 gpm/sf (30-60 x’s conventional PC)
  - HRT: 8 - 10 min
- Dosages
  - FeCl₃ (50 - 100 mg/l); Alum (70 -150 mg/l)
  - Polymer: 0.5 - 2.0 mg/l
Actiflo (Kruger)

To Sludge Processing

Polymer

Coagulant

WW Flow

Coagulation/ Flocculation

Micro-Sand

Plate Clarifier

95% TSS Removal

Conventional PC SOR: 1 gpm/ft$^2$ (1,500 gpd/ft$^2$)
CEPT SOR: 2 gpm/ft$^2$ (3,000 gpd/ft$^2$)
Lamella SOR: 5 gpm/ft$^2$ (7,000 gpd/ft$^2$)
Actiflo SOR: 50 gpm/ft$^2$ (72,000 gpd/ft$^2$)
RapiSand™ Flow Diagram

RapiSand (Westech)
CoMag (Siemens)

Conventional chemical coagulation/flocculation plus ballasted flocculation
DensaDeg (IDI)

Air Mixing in Coagulation

Axial Turbine in Flocculation

Sludge Recycled as Ballasting Agent
Handling Wet Weather Flows Through Biological Secondary Processes

• Hydraulic surges increase mass loading to secondary clarifiers in activated sludge
  – Disruptive currents
  – High sludge blankets
  – TSS lost over effluent weir
  – Potential for biomass washout

• Process Impacts
  – P removal
  – Nitrification
  – Denitrification
  – Disinfection
Maximize Use of Existing Facilities for Treatment

• Treatment modifications
  – ‘Hiding’ the bugs: Aeration tank settling; Step feed; Contact stabilization
  – ‘Anchoring’ the bugs: IFAS, BAF
  – Final clarifier enhancements

• Operational modifications (Modified SOPs)
  – Dry weather-wet weather transition
  – Residuals
  – Chemicals, if used
  – Monitoring & reporting

Tools
• Clarifier stress testing
• CFD analysis
• Process and hydraulic modeling
Conventional Activated Sludge

Q

RAS 75% Q

To Clarifier

MLSS

3,000 mg/L

Distance Along Basin

RAS Solids: 7000 mg/L

Clarifier Sees 3,000 mg/L
Aeration Tank Settling

RAS
Q
To Clarifier
Air off - Sludge settling

P
Convert to Step Feed

RAS (50%)
Q/4

Q/4

To Clarifier

2,172

MLSS

RAS

Q/4

Q/4

Q/4

Q/4

4,500 mg/L

3,316

2,625

Avg. 3,153 mg/L

RAS Solids: 7000 mg/L

Clarifier Sees
2,172 mg/L

Distance
Potential Secondary Treatment Improvements: “Anchor” the Bugs...

IFAS

MBR

Biological Aerated Filter
A Newer Concept: Biologically Enhanced High Rate Clarification

- Primary Effluent
- Aeration Basin
- Secondary Clarifier
- Disinfection
  - Effluent
  - Excess Wet Weather Flow
  - Biological Contact Tank
  - Coagulant
  - Polymer
  - RAS
  - Sludge
  - Actiflo or CEC
  - Air
Biologically Enhanced High Rate Clarification

Incorporating Chemically Enhanced Biomass Separation in Activated Sludge

• Provide short (15-30 min) biomass (WAS/RAS) contact (contact/stab?)

• Several benefits over primary treatment “blending”:
  – Soluble BOD uptake
  – Bioadsorption of colloidal and particulate matter
  – Lower foaming potential
  – Higher UV Transmittance
  – P removal
BioActiflo (Kruger)

Actiflo ~60 gpm/sf
BioActiflo ~ 30 gpm/sf

WW Flow

WAS/RAS (from Activated Sludge process)

Aerated Contact Tank

Coagulant

Polymer

To Sludge Processing and/or AS

Micro-Sand

Coagulation/Flocculation

Plate Clarifier

~60 gpm/sf
Milwaukee MSD BioCEC Tests Confirmed Process Capabilities

Testing Conditions
• 25 ppm alum; 50 ppm Fe$_2$Cl$_3$
• 2 ppm anionic polymer
• 5 minute biol. contact time
• 2,000 – 2,500 ppm MLSS

Results
• Significant Soluble BOD$_5$ removal
• Lower turbidity
• Higher UVT
Recent BioActiflo Projects

Sycamore Creek WWTP
BioActiflo - Enabled

Wilson Creek RWWTP
BioActiflo

Cox Creek WRP
BioActiflo
Reconfiguring Actiflo for Tertiary and Wet Weather Applications

Screens

Q

Prelim. Treatment

Prim. Clarifier

Aeration Basin

Sec. Clarifier

Filters

Disinfection

< 0.1 ppm P

Tertiary Actiflo

PS

RAS

WAS

0.5Q

3Q

Prelim. Treatment

Prim. Clarifier

Aeration Basin

Sec. Clarifier

Filters

Disinfection

< 20/20

BioActiflo

PS

RAS

WAS
Filters with High Hydraulic Loading Capabilities

- Upflow Continuous Backwash
- Cloth Media (Disk)
- Compressible Fiber (Fuzzy)
Wet Weather Flow Disinfection

**Options**

- Hypochlorite/bisulfite
- Peracetic acid
- Ozone
- UV light
- Hybrid system
  - UV for dry weather flow
  - Chemical for excess flows

**Challenges**

- Storage, handling & shelf life (chemical)
- Power quality & emergency power (UV)
- Variable effluent quality: Ammonia-Nitrogen; TSS; UVT
- Process control strategy
Additional Wet-Weather Management Components

- Advance warning systems
- Real-time control
  - Collection system/storage/pumping coordination
  - Placing facilities on-line
  - Chemical feed
- Automation
Wet Weather Flow Management Operations Requirements

- Start-up & shut-down
- Winterization & freeze protection
- Chemical feed optimization
- Additional labor: sampling, lab, process control, clean-up
- Staffing and level of process automation
- Residuals management – quantity & quality
- Aesthetics: odor control; foam control; traffic
Take Away Points

• Effective wet-weather flow management requires a “paradigm shift” from dry weather treatment.

• Existing plants can be modified to improve operation at high flows.

• Successful wet weather management strategies also include advanced warning systems, real-time controls, and automation.

• Wet-weather management will increase O&M requirements
Muchas Gracias!!!!
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