BIOMATH
Department of Applied Mathematics,
Biometrics and Process Control

Secondary Clarifier Monitoring: some new tools

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Monitoring tools

flow

→ *weirs*
electromagnetic sensors

solids concentration profiles & solids blanket

→ *optical (intrusive)*
acoustic (non-intrusive)

settling properties

→ *SVI*
settling velocity: hindered *vs.* discrete
manual *vs.* automatic

Monitoring tools (cont'd)

floc properties

→ *ex situ*
image analysis, laser diffraction,
electrical resistance, time of transition

→ *in situ*
acoustic & electroacoustic spectroscopy,
laser reflection

Internal hydraulics

→ *lab-scale*
hydrogen bubble wire
Laser Doppler Velocimetry (LDV)

→ *full-scale*
floats, flow turbines, pitot tubes,
electromagnetic & acoustic Doppler velocity meters

acoustic Doppler current profiler → laser reflection ↓

- reveal clarifier physics
- clarifier evaluation - fault detection
- can be used for model calibration / validation

1. Acoustic doppler current profiler (ADCP)

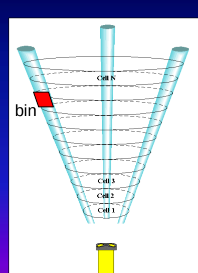
- origin in oceanography
- based on doppler effect
- measures particle velocity !

$$u = \frac{u_3 - u_4}{2\sin\theta}$$

$$v = \frac{u_1 - u_2}{2\sin\theta}$$

$$w(1) = \frac{u_1 - u_2}{2\cos\theta}$$

$$w(2) = \frac{u_3 - u_4}{2\cos\theta}$$



1. Acoustic doppler current profiler (cont'd)

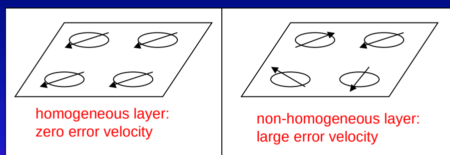
Advantages of ADCP

- profile of 3D-velocity
- high measurement frequency (~ 1 Hz)
- measurement of shear rates and stresses

1. Acoustic doppler current profiler (cont'd)

Disadvantages of ADCP

- measures particle and not fluid velocity
- assumption of homogeneous flow

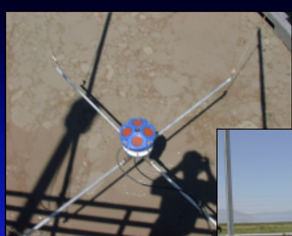


1.1. Experimental layout

Central Davies County Sewer District, Utah, USA

- spiral scraper mechanism to remove settled solids
- sloped bottom floor

1.1. Experimental layout (cont'd)



upward deployment

downward deployment

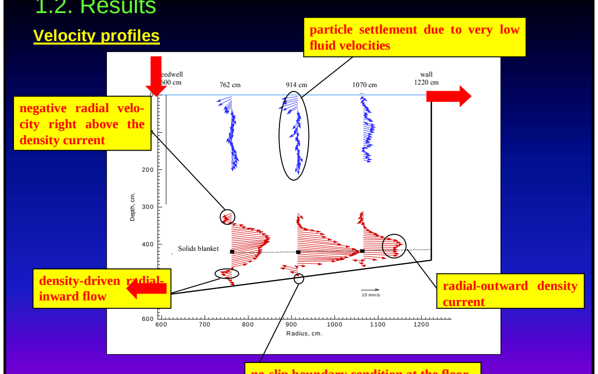
1.1. Experimental layout (cont'd)

experimental conditions:

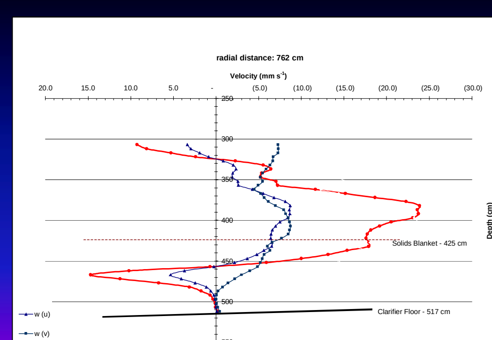
- Workhorse Monitor ADCP Direct-Reading 1200 kHz (RD Instruments)
- measurement resolution: 80 bins of 5 cm each!
- sampling frequency: 1 Hz
- velocity resolution: 1 $mm.s^{-1}$
- 2-minute time averaging
- profiling at three radial locations

1.2. Results

Velocity profiles



1.2. Results (cont'd)



1.3. Conclusions

- pros & cons of ADCP are demonstrated
- for model validation use the beam velocities!
- turbulence and error estimation definitely require more future work!

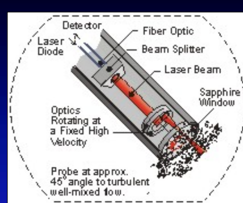
2. Characterization of particle size distributions

Available in situ techniques

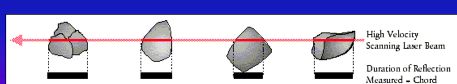
- transportable laser diffraction device, e.g. Malvern
- acoustic doppler techniques
- focused beam reflectance method or FBRM (Lasentec)

2. Focused Beam Reflectance Method (FBRM)

a) Principle of FBRM



(from Lasentec)

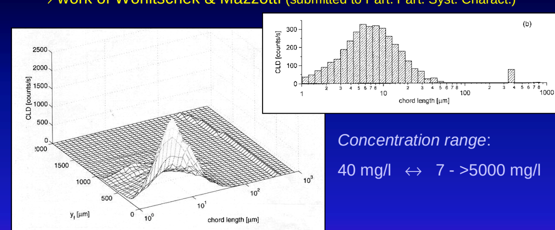


(from Lasentec)

2. Focused Beam Reflectance Method (cont'd)

b) Good positioning of focal point is crucial!

→ work of Worlitschek & Mazzotti (submitted to Part. Part. Syst. Charact.)



Concentration range:

40 mg/l ↔ 7 - >5000 mg/l

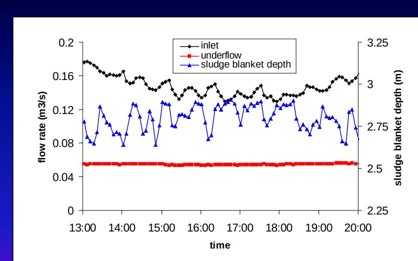
retain short focal point distance

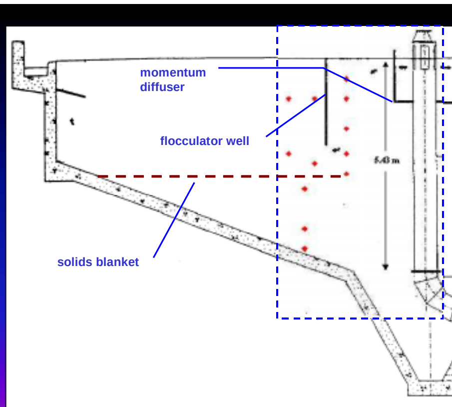
2.1. Experimental setup

(circular) secondary clarifier at Oxley Creek WWTP (Queensland, Australia)

2.2. Steady-state & dynamic PSD profiling

a) Steady-state profiling





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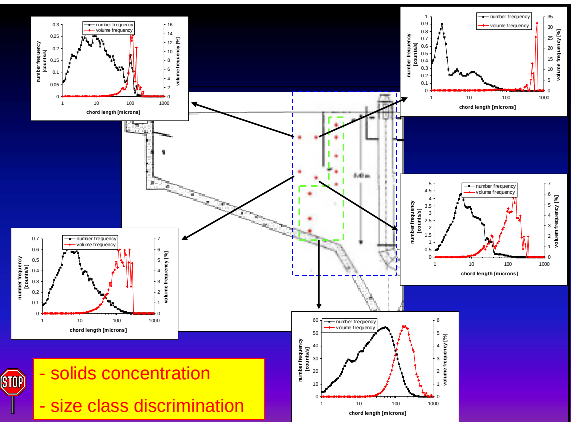

- solids concentration
- size class discrimination

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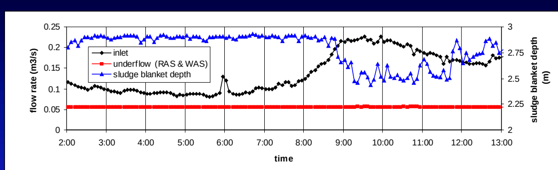
b) Dynamic profiling



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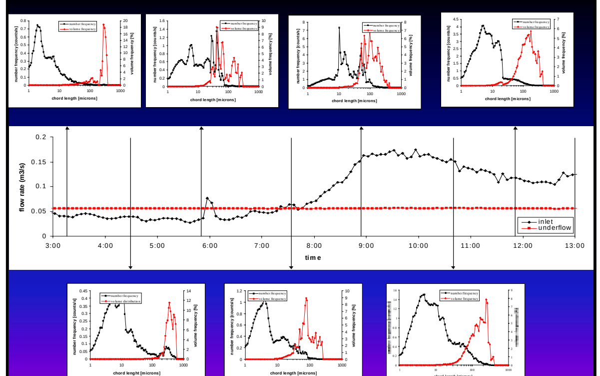

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2.3. Conclusions

- demonstrated the potential of FBRM in WWT
- crucial to consider issues such as:
  - low fluid/particle velocities
  - solids concentration
  - probe location
  - focal point position

- future work

  continue the work but with experimental improvements

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General conclusions

• Two (relatively) new tools for clarifier monitoring have been presented that can be used for:
  - clarifier evaluation
  - model calibration / validation

• More research is needed to use and interpret them properly

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