Future Trends in Filtration/Separation Research (particles, molecules and water)

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Overview

Separations research at the University of Melbourne:

•Particulates in water (mining, waste water)
Aggregates, molecules and thickening

•Ions and organics in water (water production, recycle)
RO, forward osmosis, membrane fouling and nanofiltration

•Water removal from particulate networks (energy, waste minimisation)
Lignite dewatering

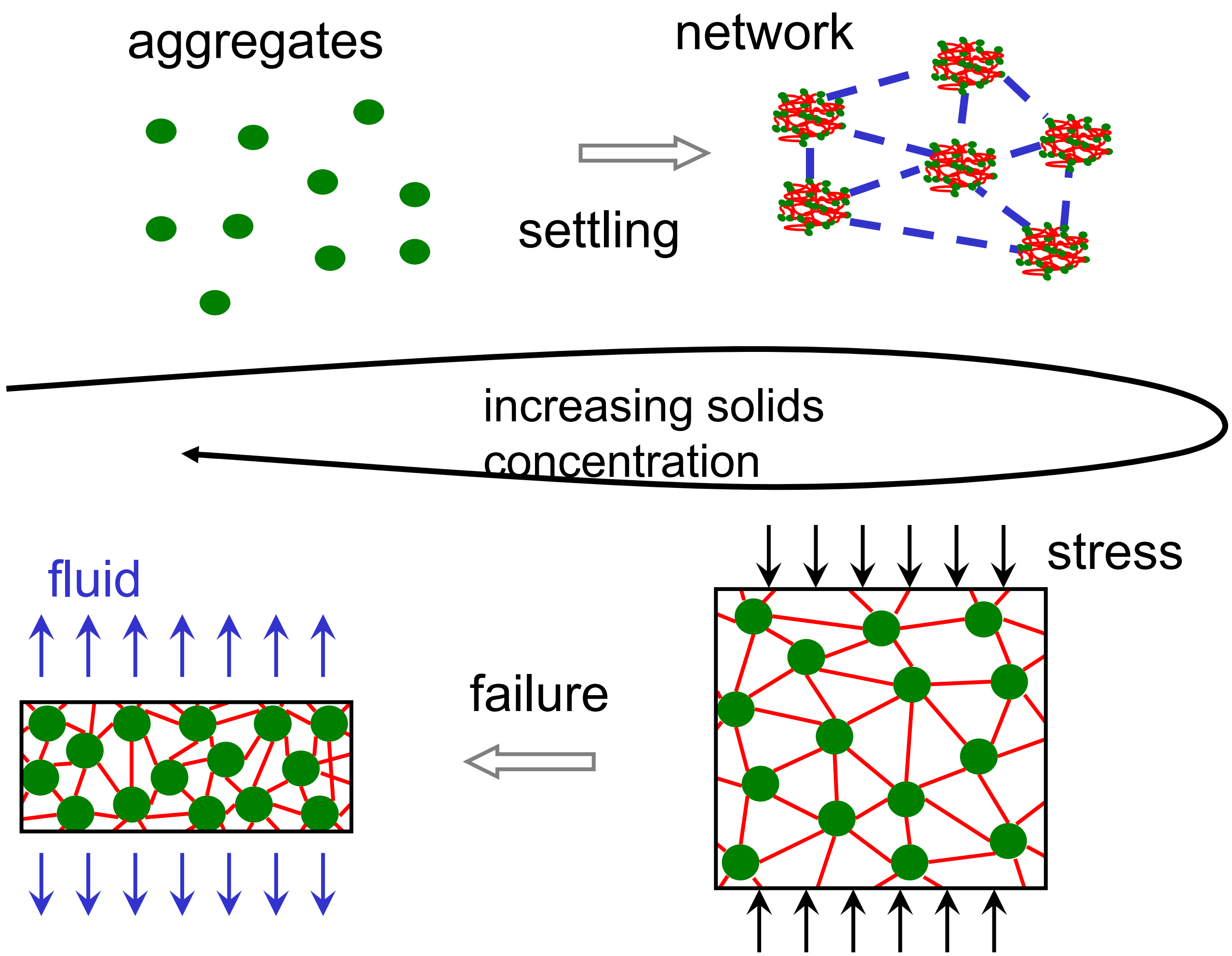
•Modelling of sedimentation, filtration and centrifugation
3D rheology – shear and compression

Some Definitions

- **Shear rheology of suspensions**
  - The study of the flow of suspensions in shear
    - Important to mixing, pipe start-up and flow, free channel flow, pumping
    - Characterised by parameters such as the shear yield stress and shear viscosity

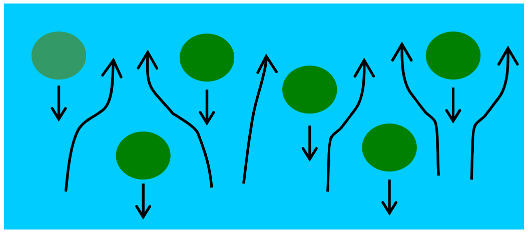
- **Compressional rheology of suspensions**
  - The study of the separation of a liquid from a particulate suspension through the use of compressional forces
    - Important to sedimentation, thickening, filtration, centrifugation
    - Characterised by parameters such as the compressive yield stress and the hindered settling function

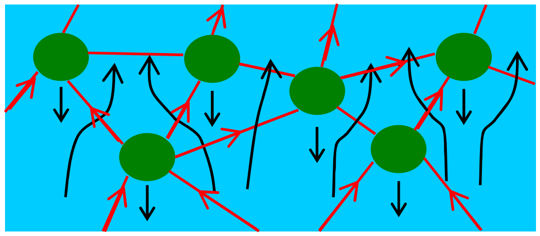
Compressional Rheology

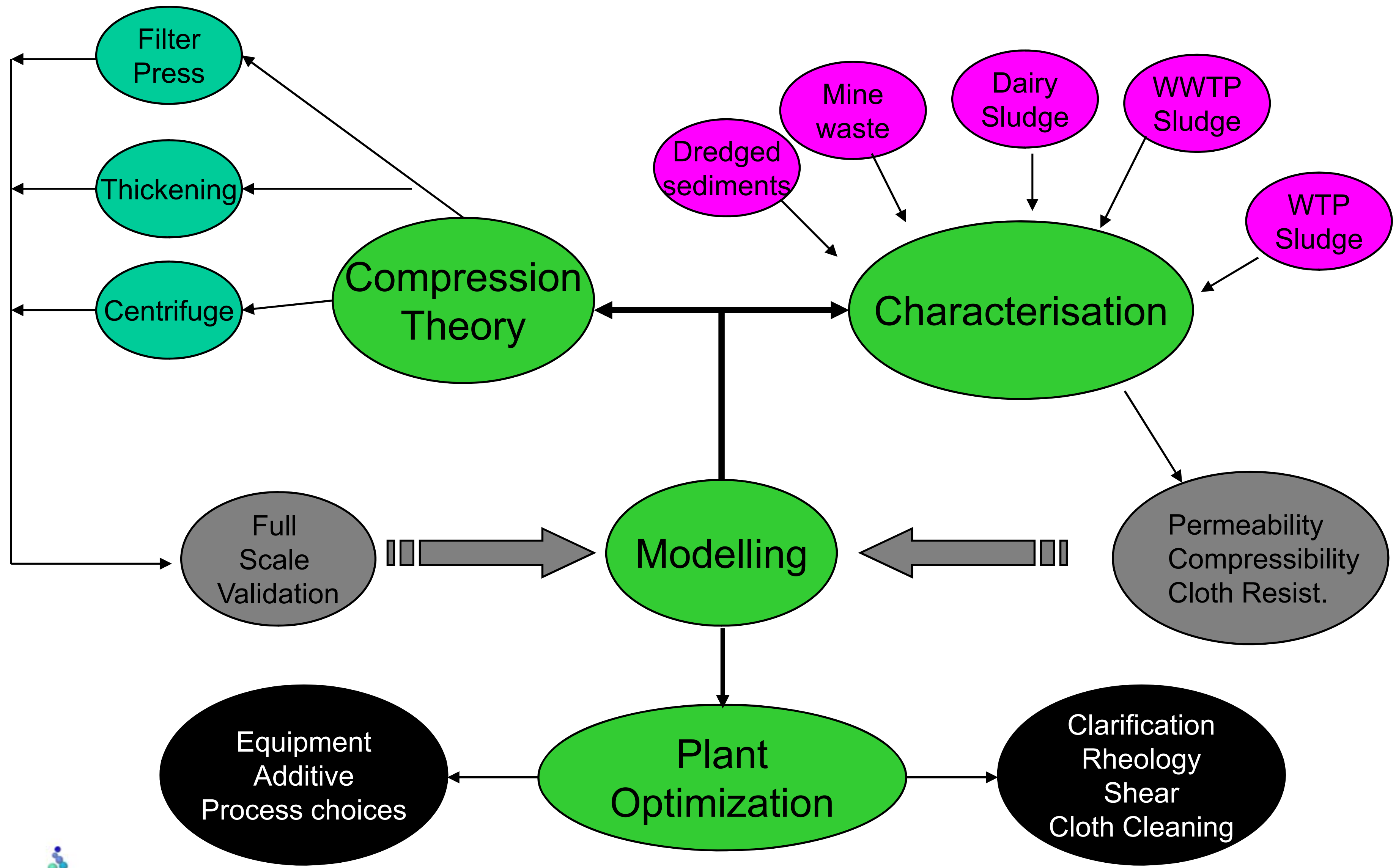


Solid-liquid separation characterisation

- Buscall and White (1987) established that the failure of a suspension in compression can be characterised by:
  - Gel point, ϕ_g
    - Network percolation concentration
  - Compressive yield stress, $P_y(\phi)$
    - *Network strength*
  - Hindered Settling function, $R(\phi)$
    - *-Rate of liquid escape*

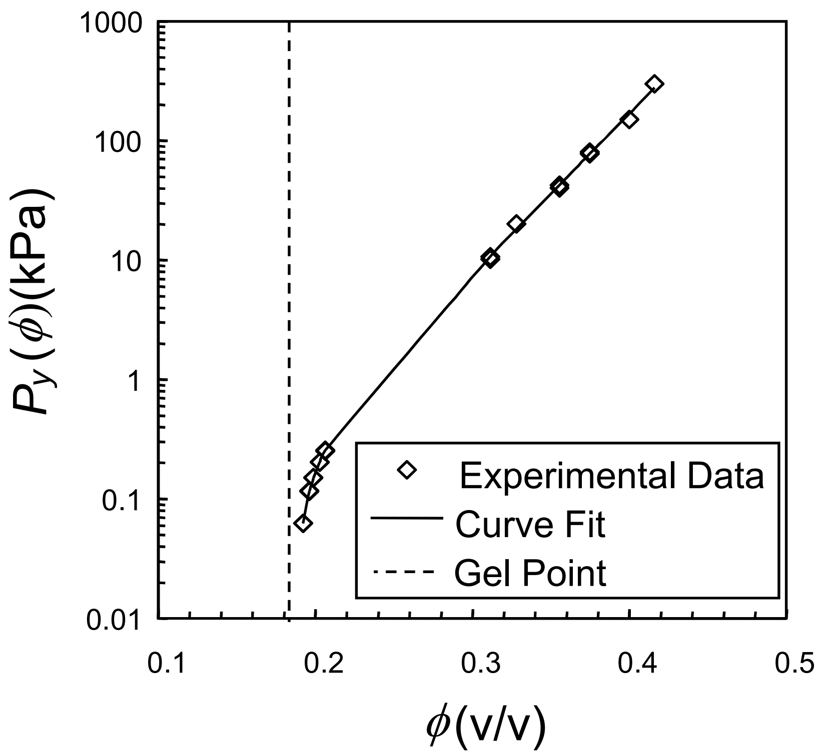




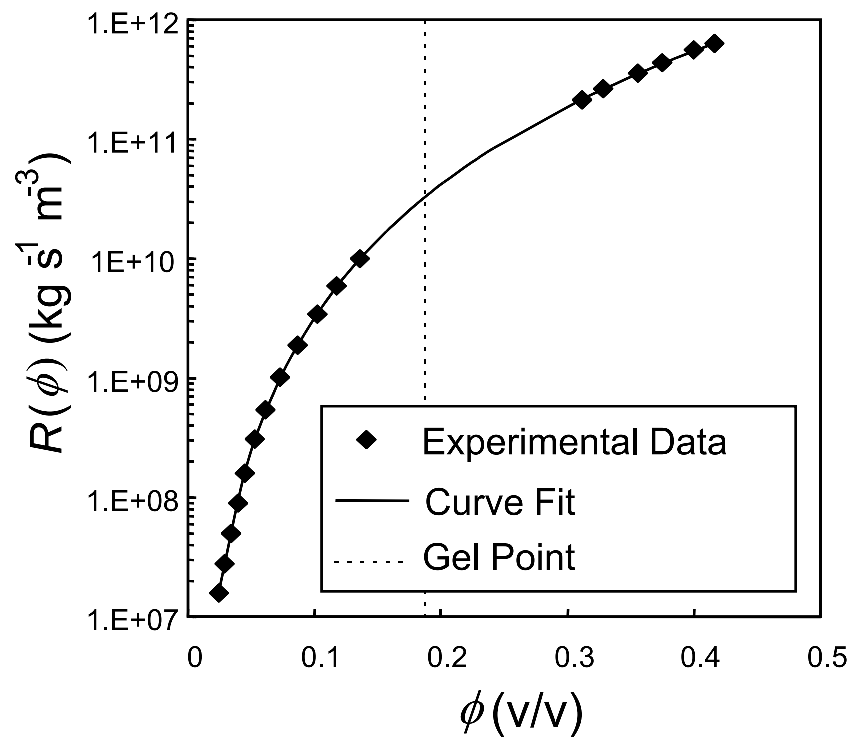

Filter Press
Thickening
Centrifuge
Compression Theory
Dredged sediments
Mine waste
Dairy Sludge
WWTP Sludge
WTP Sludge
Characterisation
Full Scale Validation
Modelling
Permeability
Compressibility
Cloth Resist.
Equipment
Additive
Process choices
Plant Optimization
Clarification
Rheology
Shear
Cloth Cleaning

Compressional Rheology Characterisation

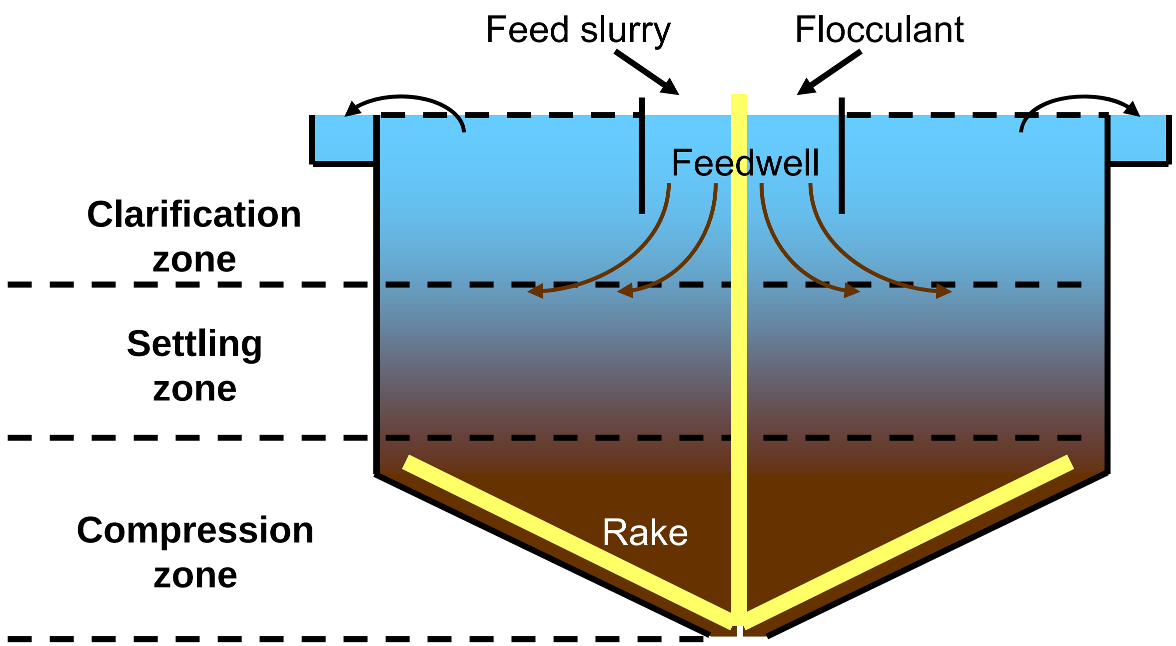
Compressive Yield Stress, $P_y(\phi)$



Hindered Settling Function , $R(\phi)$

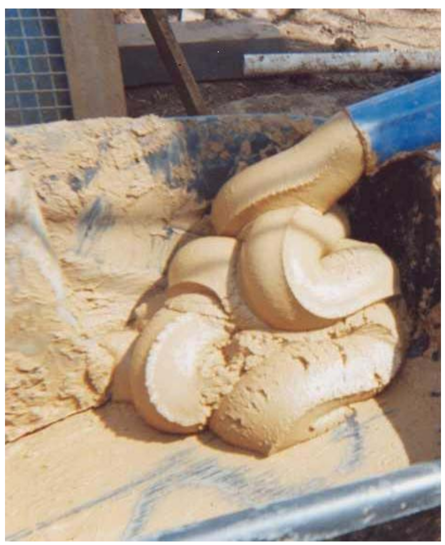


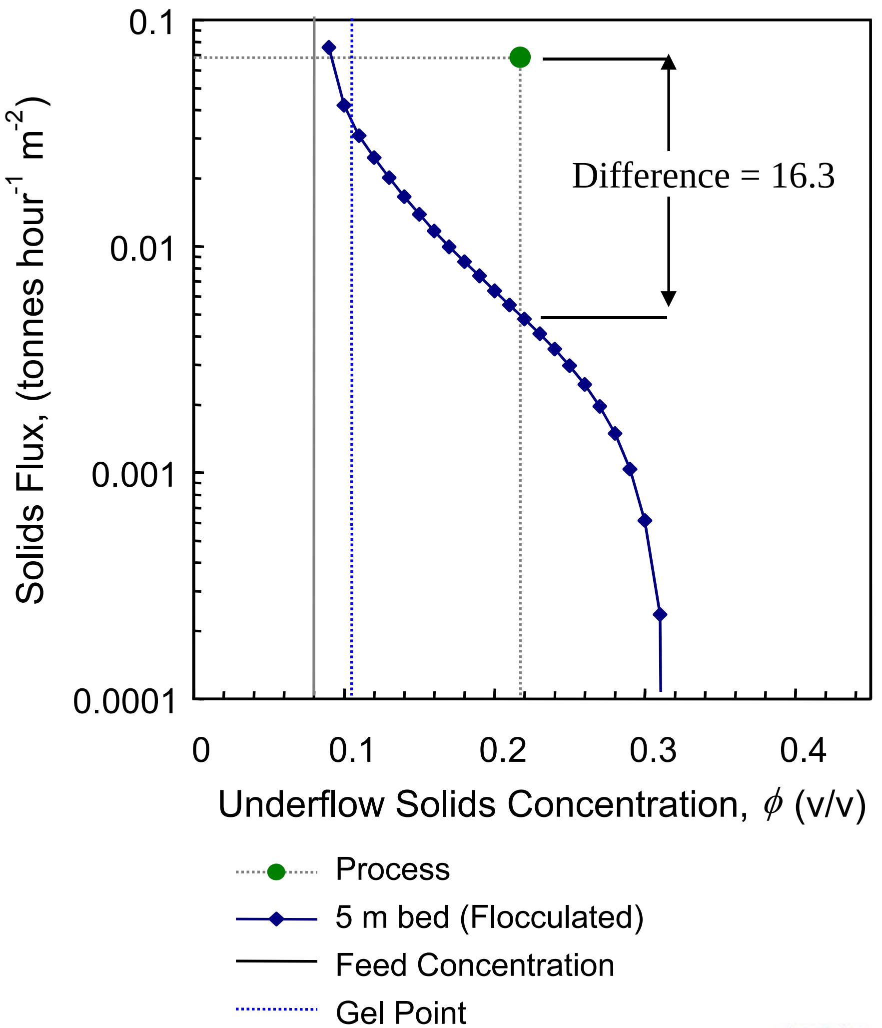
Theme 1: Particulates in water



Thickener Model Validation

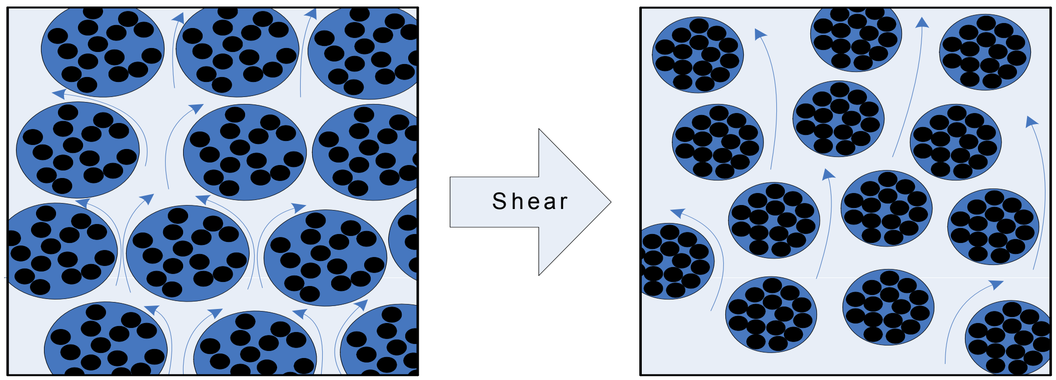
TYPE	Real/predicted flux
Conventional	1-5
High rate	5-15
Deep cone	10-50





Shear Forces & Densification

Aggregate densification and pressure driven densification at walls and rake/rod surfaces is a major effect in thickening



TREND: Understanding the dynamics of aggregates in shear and compression and developing methods to quantify the behaviour in terms of useful parameters for model input.

Theme 2: Ions and organics in water

IWA report on the City of the Future

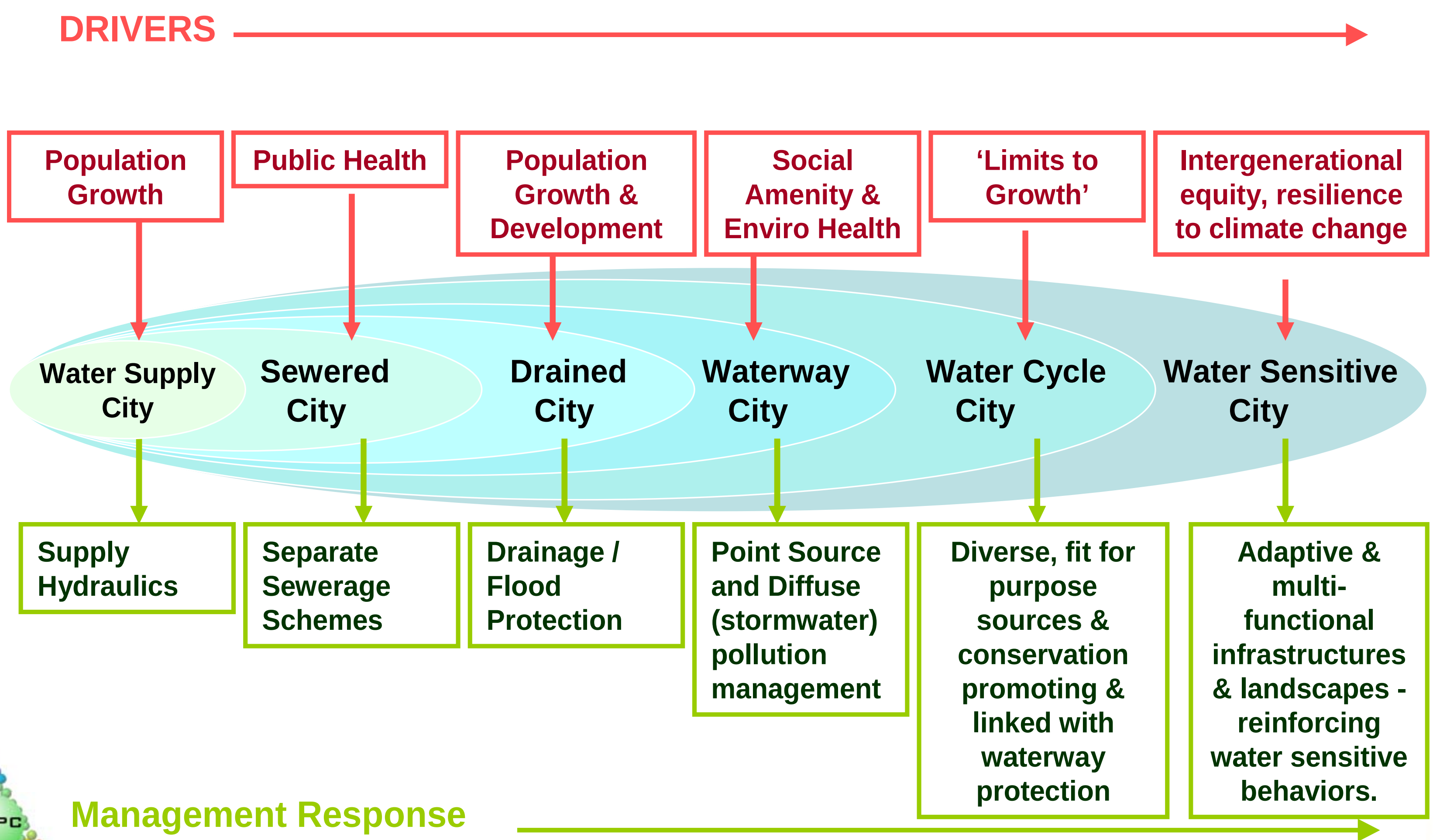
Many values for Water

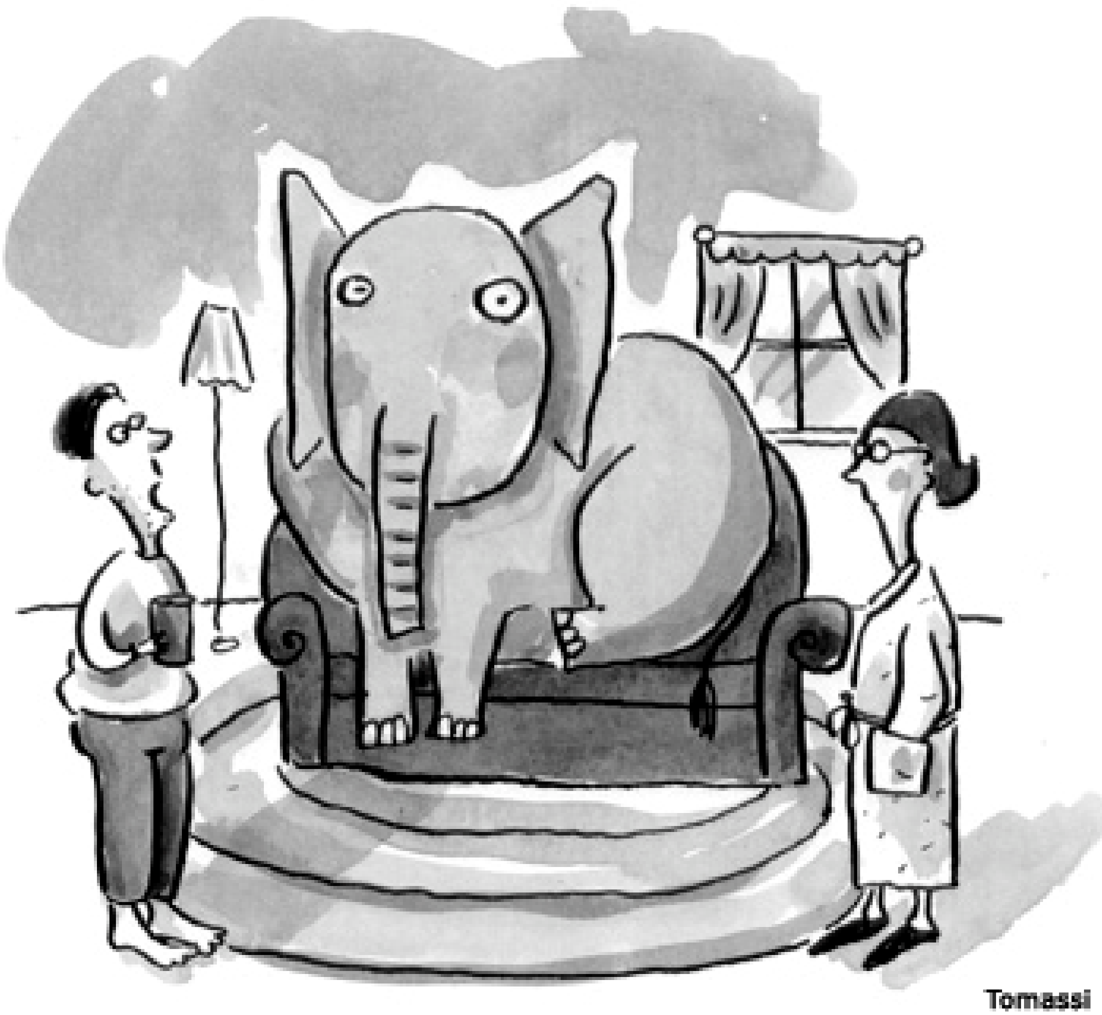
-Well managed water cycle

-All water is good water – fit for purpose

Principle 5: Sustainable cities will be served by a well-managed water cycle that – in addition to public health and water security – provides for healthy waterways, open spaces and a green city.

Principle 6: Sustainable cities will recognise that all water is good water – based on the concept of 'fit-for-purpose' use.


DRIVERS
Population Growth
Public Health
Population Growth & Development
Social Amenity & Enviro Health
'Limits to Growth'
Intergenerational equity, resilience to climate change
Water Supply City
Sewered City
Drained City
Waterway City
Water Cycle City
Water Sensitive City
Supply Hydraulics
Separate Sewerage Schemes
Drainage / Flood Protection
Point Source and Diffuse (stormwater) pollution management
Diverse, fit for purpose sources & conservation promoting & linked with waterway protection
Adaptive & multi-functional infrastructures & landscapes - reinforcing water sensitive behaviors.
Management Response



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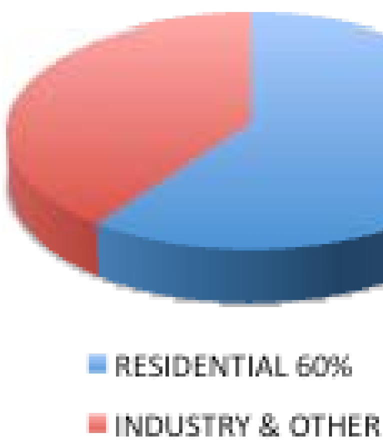


≈70% of our needs are for potable water and we are a one use society

Research

Robust membrane systems (ceramics)

Nanobubbles and use of ozone to replace chlorine (energy)

Understanding the permeability of RO membranes

Fouling of membranes (coatings)

Guaranteeing water is safe to drink – instantaneously

Low energy water recycle

TREND: Molecular interfacial structures and on-line molecular detection (at <ppm)

Theme 3: Water removal from networks

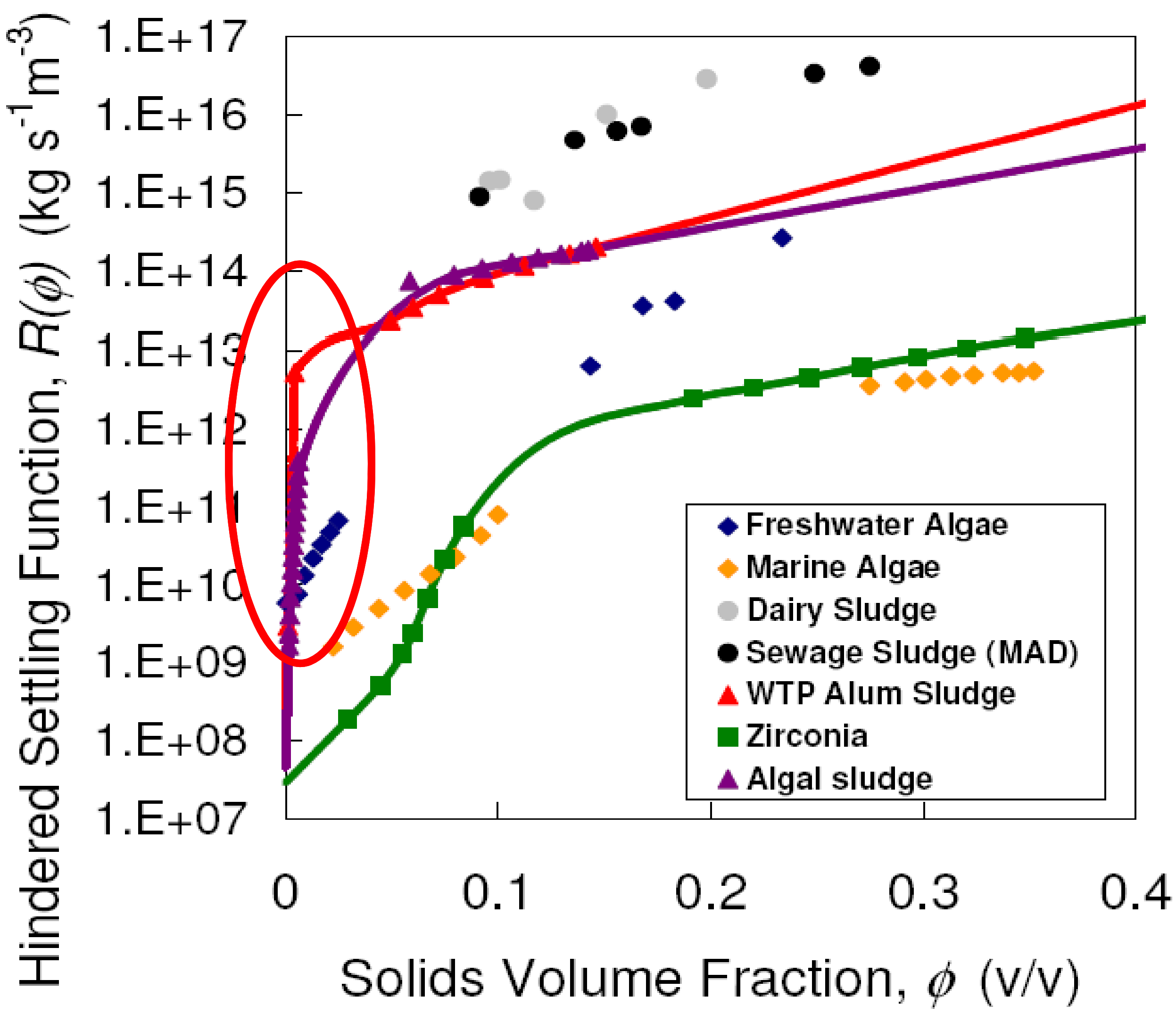
Force removes water from all networks but sometimes the time scale is prohibitive

Problem systems:

- fine particulate systems (<0.1 microns)
- starches
- cells
- ECP’s
- biomass
- lignites

Filtration

Why are they difficult to dewater?



Research

Force chain analysis of particles in compression

Enhancement of compressional failure using shear

New technique development to understand ceramic cracking, drying cracking, shear in compression, failure dynamics of networks

Compression and removal of fouling layers in filtration

TRENDS: Dynamics of network failure in compression with the addition of shear, manipulation of molecular structure

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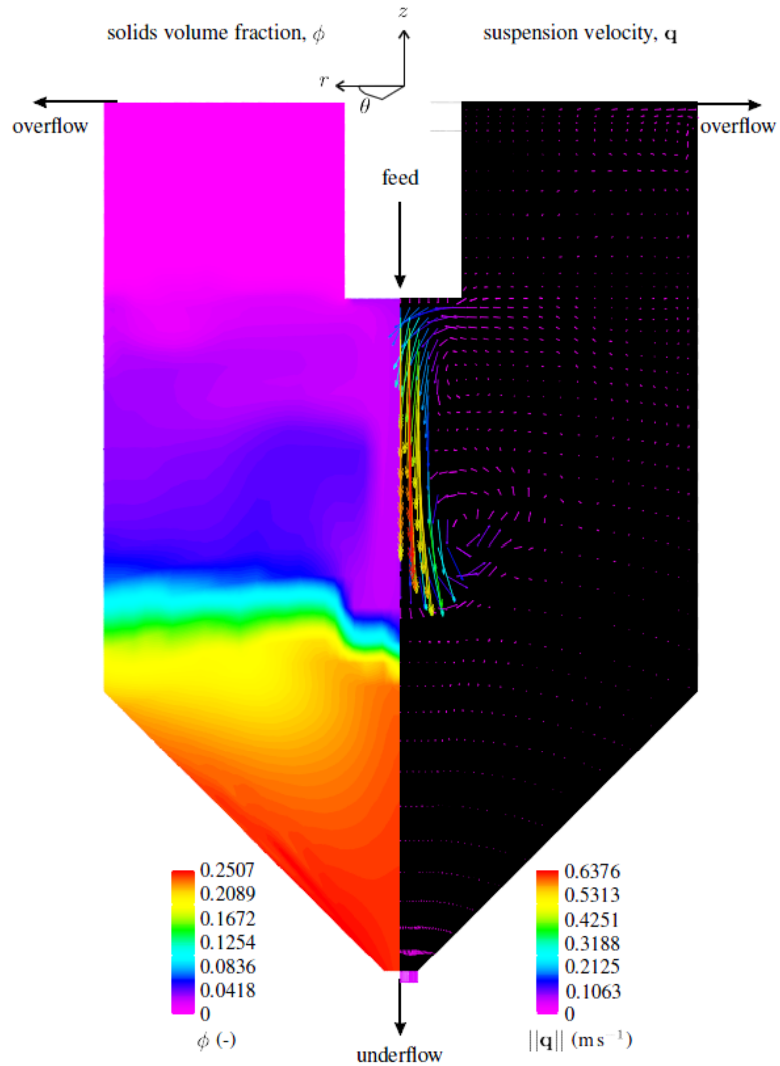
Theme 4: Separations modelling

Models developed for:

Plate and frame filtration
Dead end filtration
Vacuum filtration
Thickening
Sedimentation
Rotary drum filter
Solid bowl centrifuge
Decanter centrifuge

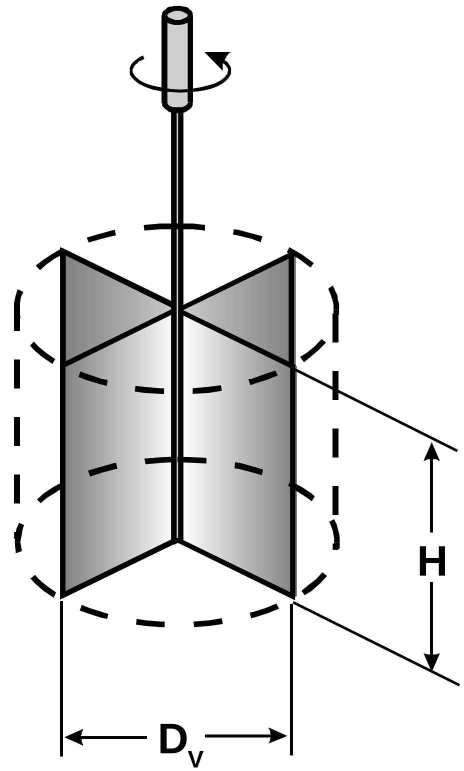
Can model shear-flow and compression separately but not together

D.R. Lester, M. Rudman, P.J. Scales, Macroscopic dynamics of flocculated colloidal suspensions, Chem. Eng. Sci., **65**/24, 16362-6378, DOI: 10.1016/j.ces.2010.09.006



Lack realistic constitutive models for

Shear + compression.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Research

Development of shear in compression measurement methodologies

Development of3D constitutive relationships for particulate network failure (inclusive of shear and compression)

TRENDS: Constitutive development to allow modelling of real filtration and separations behaviour, both transients and equilibrium

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