Primary treatment

Cranfield UNIVERSITY

Peter Jarvis

www.cranfield.ac.uk

Aims

Cranfield UNIVERSITY

Aim: To learn about the main principles of primary processes used in sewage treatment

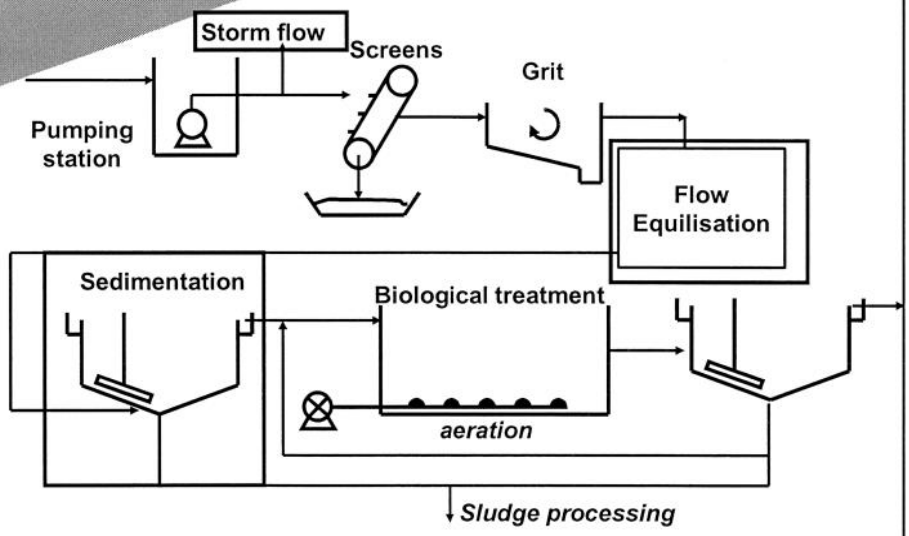
At the end of this session you should:

- understand the purpose of primary processes
- understand the main options available
- understand the issues

www.cranfield.ac.uk

Primary treatment

Cranfield UNIVERSITY



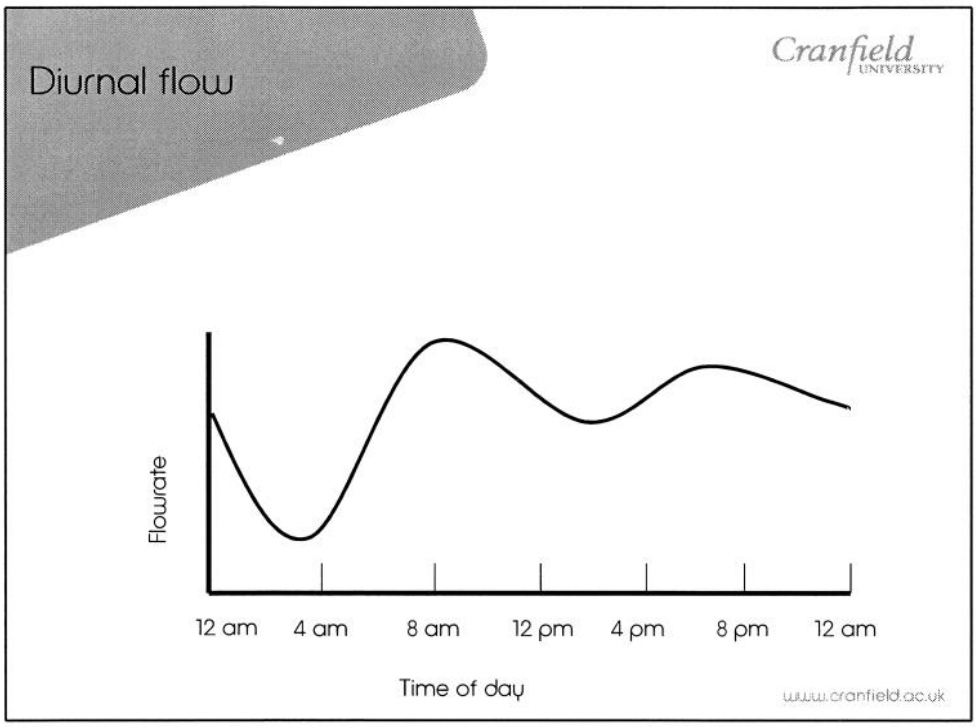
www.cranfield.ac.uk

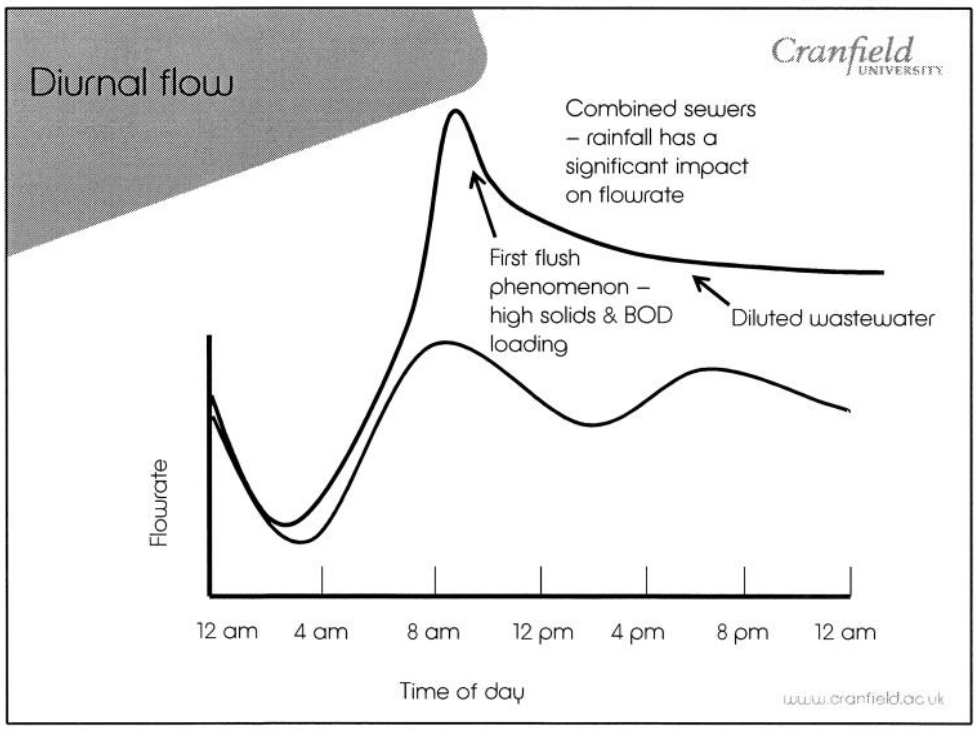
Contents

Cranfield UNIVERSITY

- Flow equilisation
- Primary sedimentation
- Septic tanks
- Combined sewer overflows

www.cranfield.ac.uk


Diurnal flow
Cranfield UNIVERSITY
Flowrate
12 am
4 am
8 am
12 pm
4 pm
8 pm
12 am
Time of day
www.cranfield.ac.uk

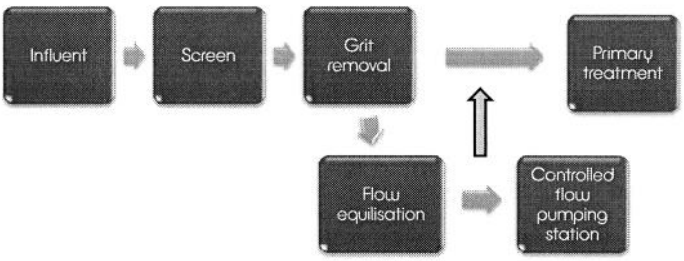

Diurnal flow
Cranfield UNIVERSITY
Combined sewers – rainfall has a significant impact on flowrate
First flush phenomenon – high solids & BOD loading
Diluted wastewater
Flowrate
12 am
4 am
8 am
12 pm
4 pm
8 pm
12 am
Time of day
www.cranfield.ac.uk

Flow equilisation

Cranfield UNIVERSITY

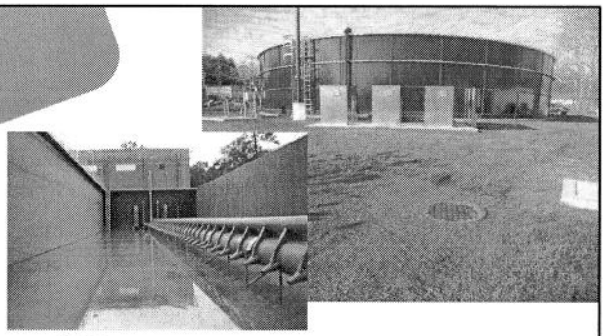
In-line flow equilisation

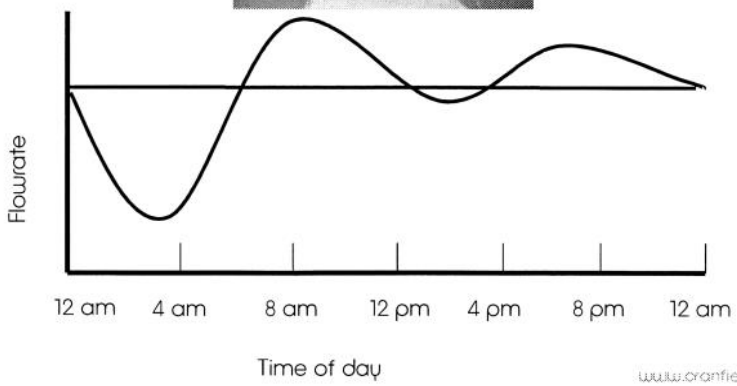
Off-line flow equilisation



www.cranfield.ac.uk

Diurnal flow

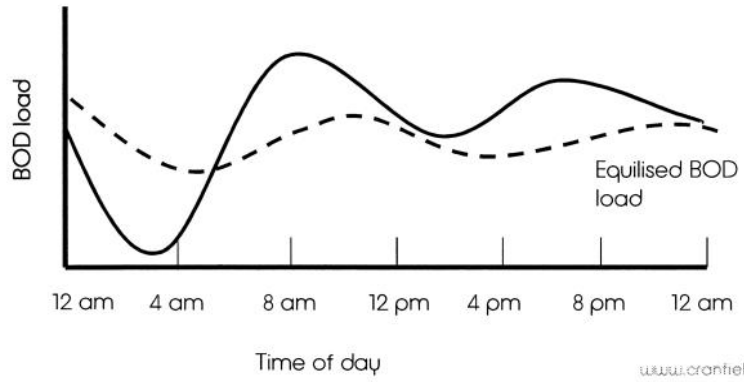




www.cranfield.ac.uk

Diurnal flow

Cranfield UNIVERSITY



www.cranfield.ac.uk

Primary processes

Cranfield UNIVERSITY

Sedimentation

- Removal of readily settleable solids and floating material to reduce the solids content
- Removal of particulate material under the force of gravity
  - •Chemically assisted
  - •Mechanically assisted

More Screens!

Fine screens

www.cranfield.ac.uk

European Environment Agency definition

Cranfield UNIVERSITY

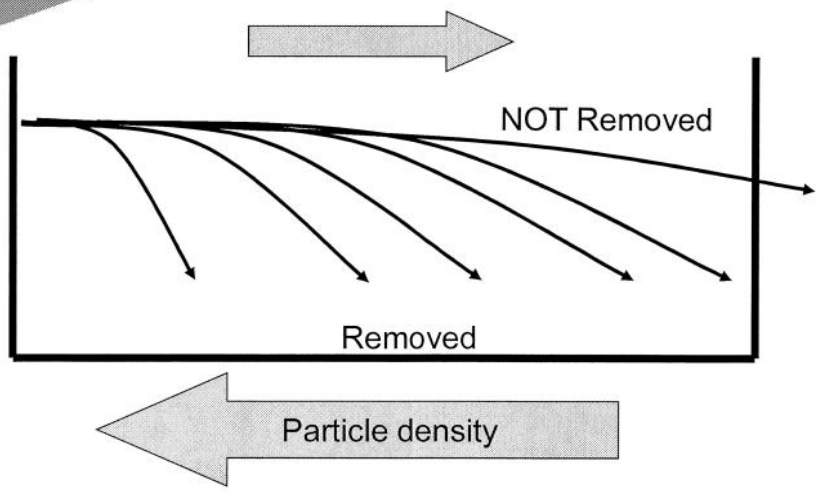
(1) Removal of floating solids and suspended solids, both fine and coarse, from raw sewage.

(2) Primary treatment means treatment of urban wastewater by a physical and/or chemical process involving settlement of suspended solids, or other processes in which the BOD_5 of the incoming wastewater is reduced by at least 20 % before discharge and the total suspended solids of the incoming wastewater are reduced by at least 50 %.

www.cranfield.ac.uk

Sedimentation

Cranfield UNIVERSITY



www.cranfield.ac.uk

Technology options

Cranfield UNIVERSITY

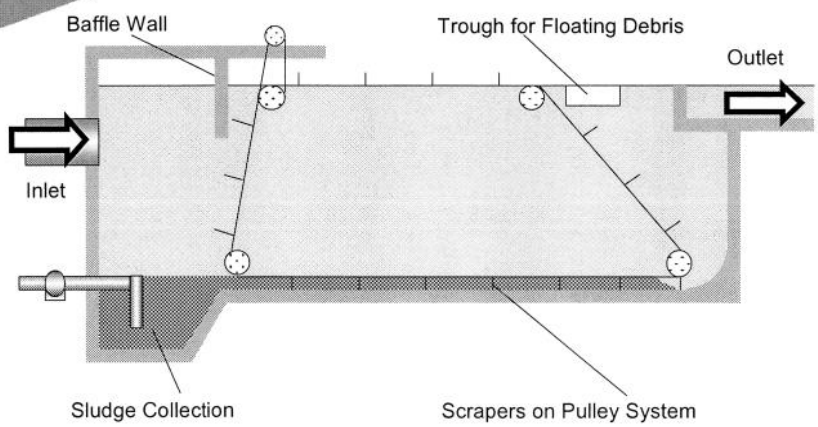
- Rectangular
- Circular
- Upflow

- Each systems contains:
  - A tank
  - A scrapper system
  - An overflow system (weir)

www.cranfield.ac.uk

Rectangular

Cranfield UNIVERSITY



www.cranfield.ac.uk

Rectangular tanks

Cranfield UNIVERSITY

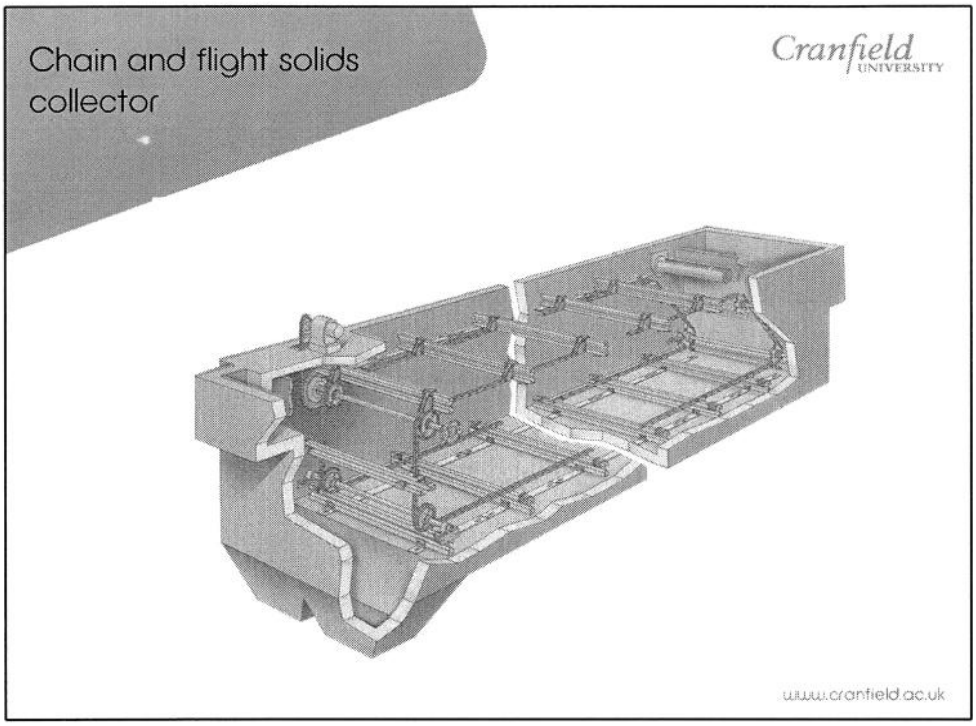
- Flow distribution is crucial
  - Full width inlet channels
  - Inlet channels with submerged ports/orifices
  - Inlet channels with baffles/gates
- Re-suspending solids can be an issue
- Good for large plants where multiple tanks required

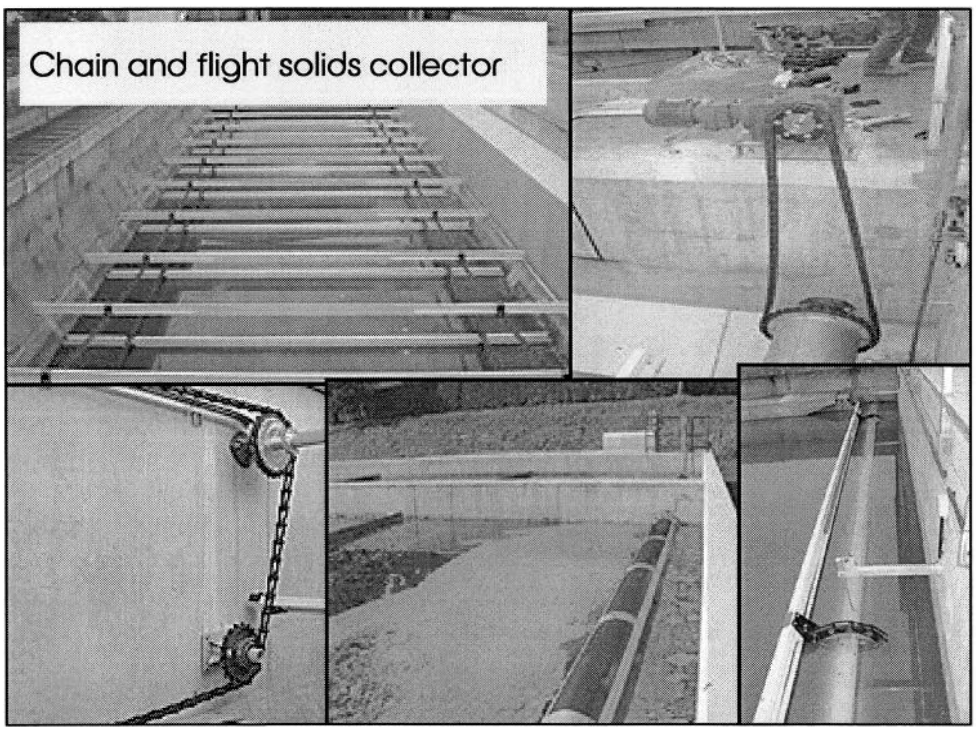
www.cranfield.ac.uk

Rectangular tanks

Cranfield UNIVERSITY

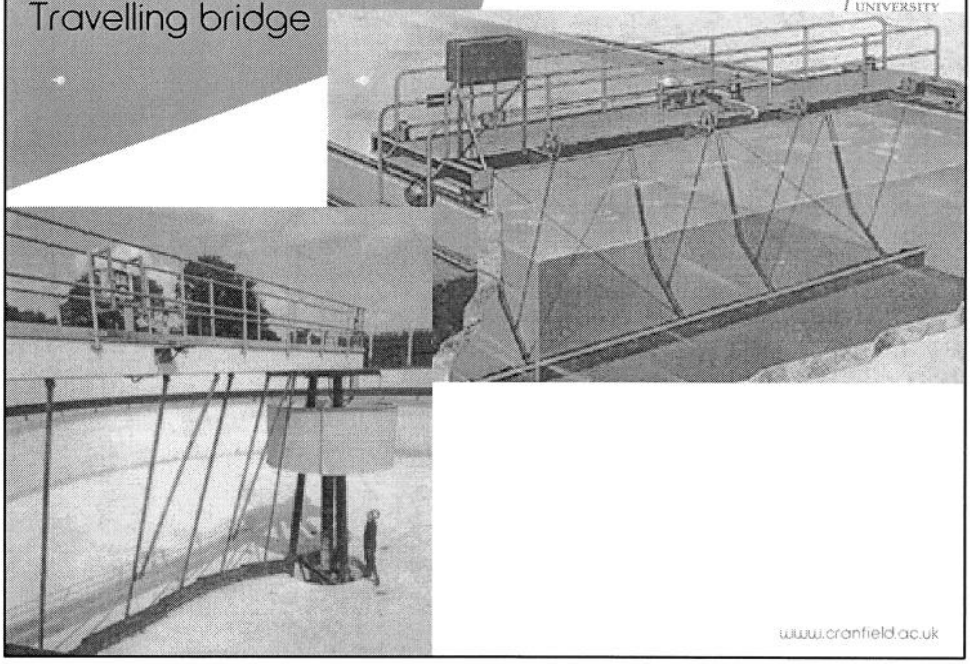
www.cranfield.ac.uk


Chain and flight solids collector
Cranfield UNIVERSITY
www.cranfield.ac.uk


Chain and flight solids collector

Travelling bridge

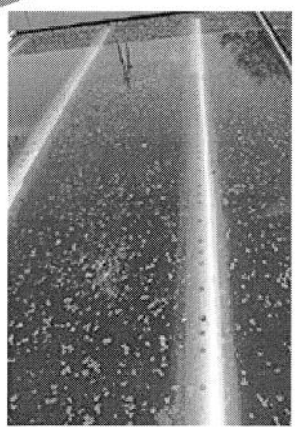
Cranfield UNIVERSITY

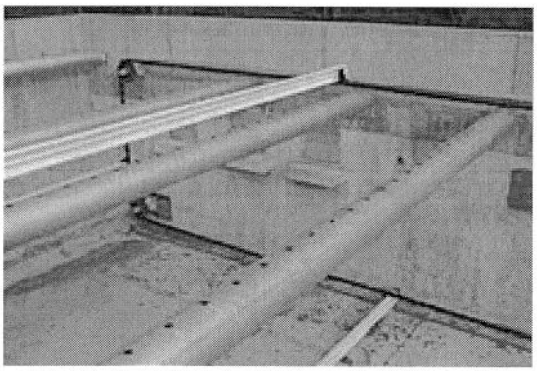


www.cranfield.ac.uk

Outlet systems

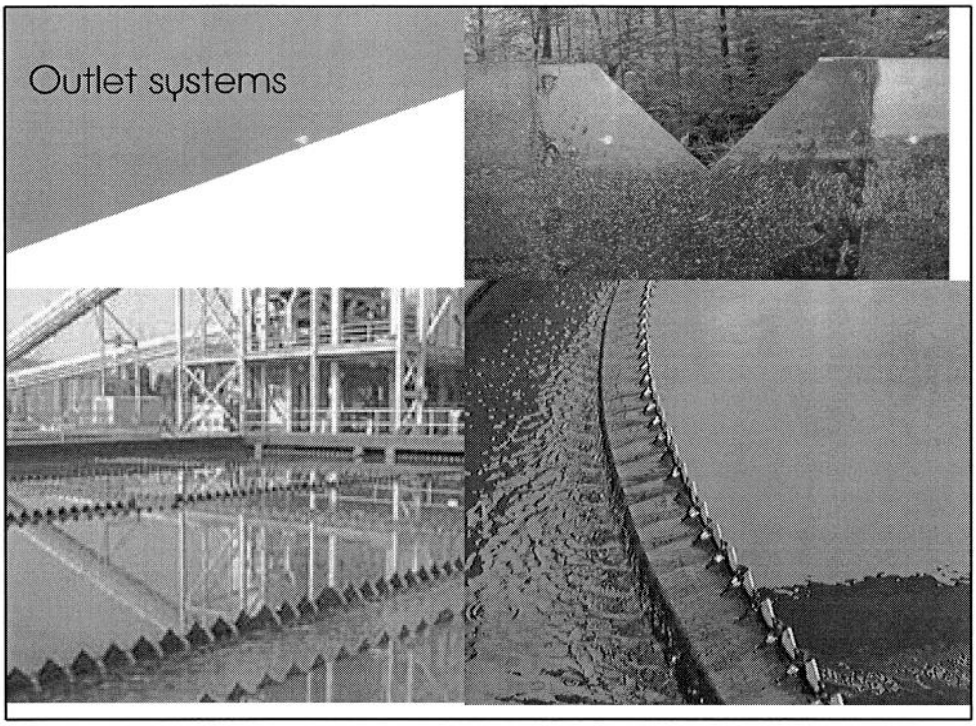
Cranfield UNIVERSITY





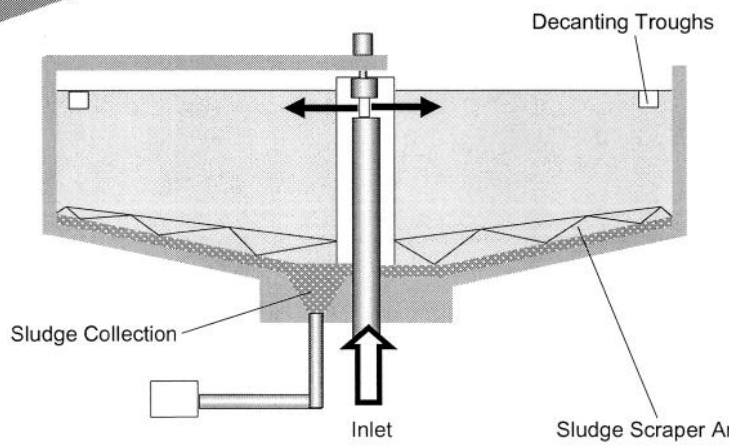
www.cranfield.ac.uk

Outlet systems



Circular

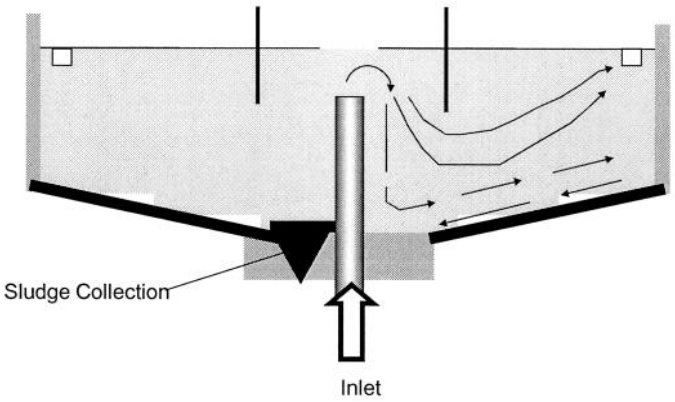
Cranfield UNIVERSITY



www.cranfield.ac.uk

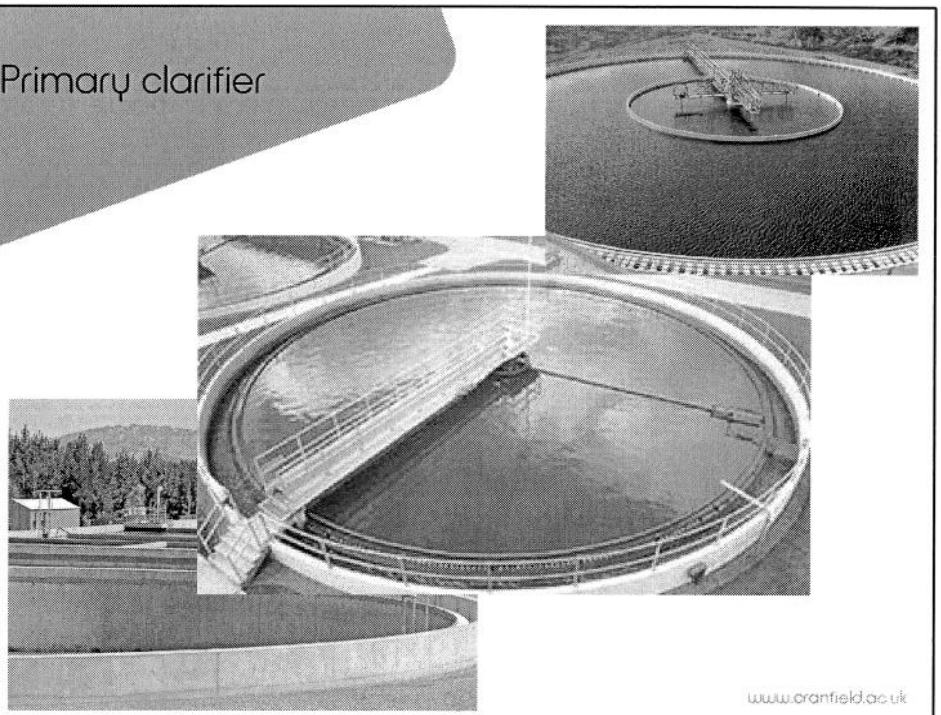
Circular tanks

Cranfield UNIVERSITY



www.cranfield.ac.uk

Primary clarifier



www.cranfield.ac.uk

Primary tanks

Cranfield UNIVERSITY

	Dimensions	Residence time	Overflow rate
Rectangular	15-90m long 3-24 m wide	2h	30-50 $m.d^{-1}$
Circular	3-40 m diameter	2h	24-32 $m.d^{-1}$

www.cranfield.ac.uk

Chemically assisted sedimentation

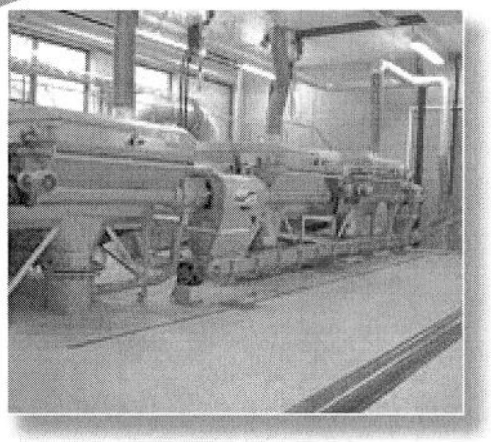
Cranfield UNIVERSITY

- Include a coagulation stage prior to sedimentation.
- Dose directly into the inlet well or a proper rapid mix/flocculator
- Removal to:
  - BOD: 70 $mg.L^{-1}$
  - SS: 70 $mg.L^{-1}$
  - P: 0.9 $mg.L^{-1}$
  - H_2S control

www.cranfield.ac.uk

Screens (Salsnes)

Cranfield UNIVERSITY



- Mesh size 0.1-1.0 mm
  - 350 μm
- Wire mesh
- Removal:
  - SS: 40-80%
  - BOD: 40-60%

www.cranfield.ac.uk

Septic tank

Cranfield UNIVERSITY

- IF not connected to sewer

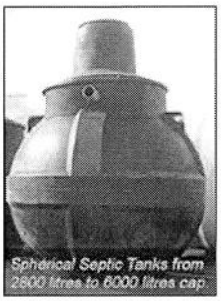
25 % of US rely on septic tanks

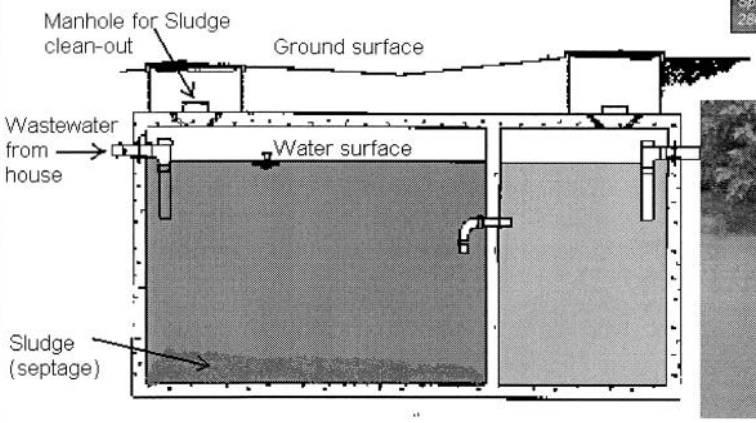
Europe – rural locations

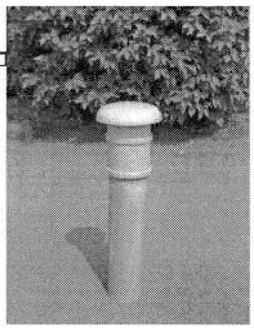
- Cesspool: a storage tank from which sewage is regularly collected
- Septic tank: continuous flow tank in which sludge is retained long enough for anaerobic treatment
  - When de-sludged some left as a seed.
  - 2 tanks in series

www.cranfield.ac.uk

Septic tanks







Problems of septic tanks

Cranfield UNIVERSITY

- Fats and oils
- Non-degradable items
- Chemicals down the toilet/sink
- Tree roots
- No nitrate removal

www.cranfield.ac.uk

Septic tanks

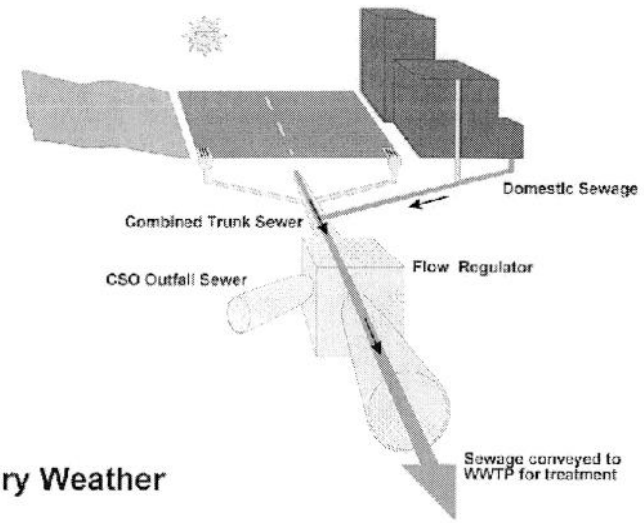
Cranfield UNIVERSITY

- Typical effluent quality
  - •BOD<150 $mg.L^{-1}$
  - •SS <90 $mg.L^{-1}$
- Effluent is percolated onto an infiltration basin
- Empty once per year
- New installations tend to be package treatment works

www.cranfield.ac.uk

Combined sewer overflows

Cranfield UNIVERSITY

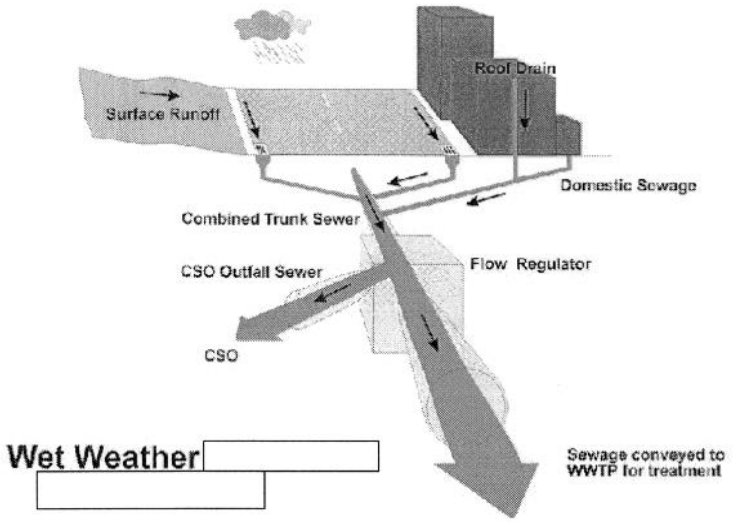


Dry Weather

www.cranfield.ac.uk

Combined sewer overflows

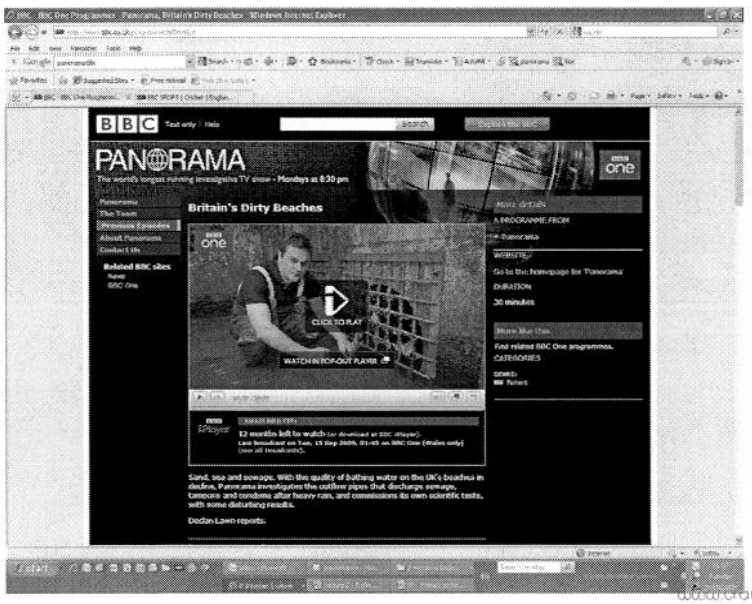
Cranfield UNIVERSITY



www.cranfield.ac.uk

Combined sewer overflows

Cranfield UNIVERSITY



www.cranfield.ac.uk

Combined sewer overflows

Cranfield UNIVERSITY


Environment

Come on in - but watch out for the sewage, tampons and cotton buds

Wet summer means more pollution pumped into sea

Almost a third of beaches breach European standard

Guardian, 23rd August 2008

www.cranfield.ac.uk

Combined sewer overflows

Cranfield UNIVERSITY

- Major source of pollution incidents relate to untreated sewage during heavy rainfall
  - STWs overwhelmed by volume of water
  - Exaggerated by concrete
- CSO's provide basic treatment of this water
  - Over 20,000 CSO's in England & Wales
- Water Framework Directive & Bathing Water Directive are driving increased treatment of this wastewater

www.cranfield.ac.uk

What quality is the water?

Cranfield UNIVERSITY

Parameter	Range	Average	Typical sewage
BOD	4-700	43	190
TSS	1-4420	127	140
TP	0.1-21	0.7	7
TKN	0-82	3.6	40
FC	1-7 log	3 log	4-6 log

www.cranfield.ac.uk

Options

Cranfield UNIVERSITY

- Do nothing – flood sewage works or release to receiving water body
- Large holding tanks – treat when storm has passed
- Small scale treatment at site of CSO
- New treatment facility to cope with CSO
- Parallel treatment at existing plant

www.cranfield.ac.uk

Technology options

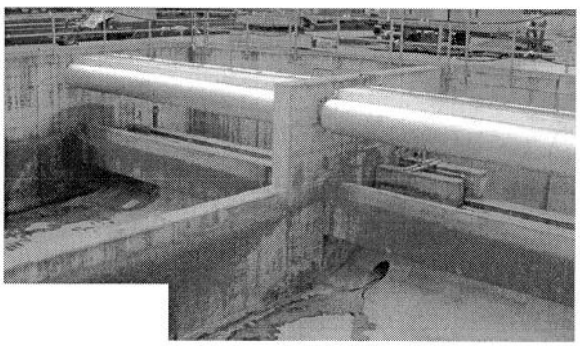
Cranfield UNIVERSITY

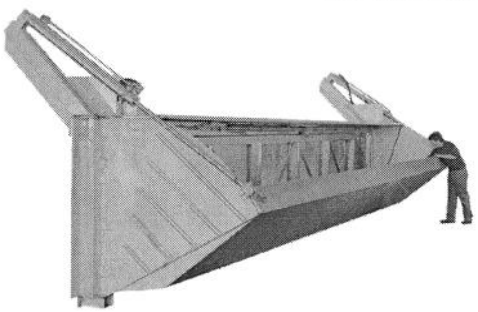
- Applicability of biological limited due to:
  - •Adverse, intense and intermittent flow
  - •Rapid change in amount and quality of pollutants
  - •Micro-organisms needs a minimum level of food to survive
- Trickling filters best equipped to cope

www.cranfield.ac.uk

Clarification

Cranfield UNIVERSITY

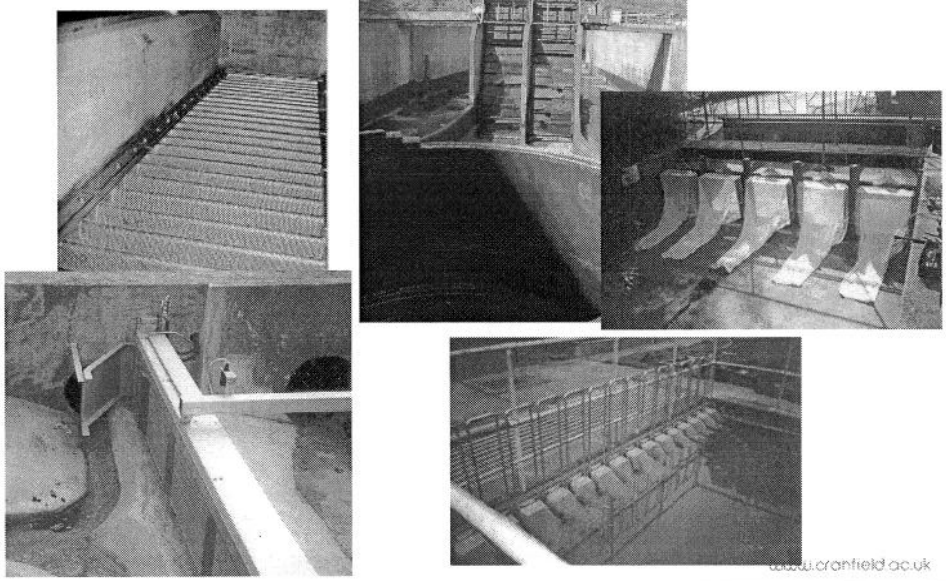




www.cranfield.ac.uk

Screens

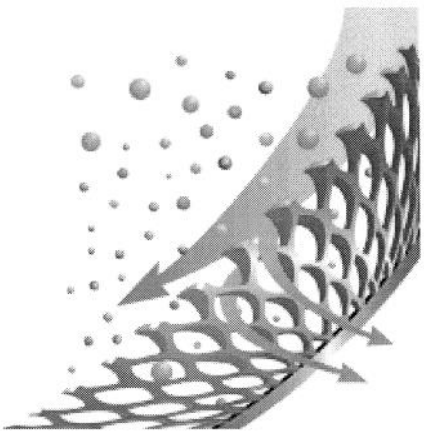
Cranfield UNIVERSITY



www.cranfield.ac.uk

Screens

Cranfield UNIVERSITY

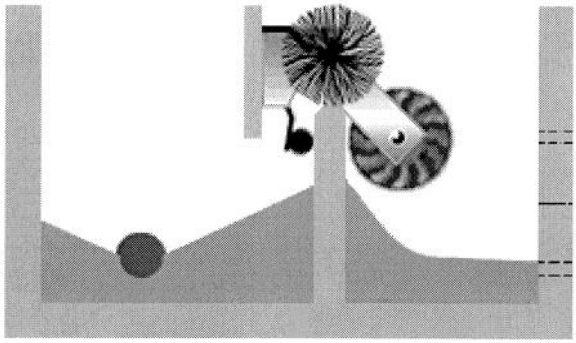


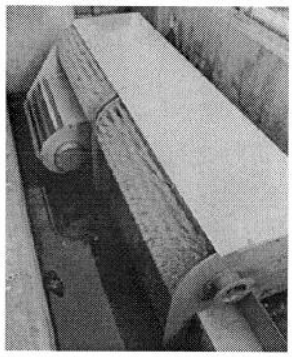
1 mm

www.cranfield.ac.uk

Screens

Cranfield UNIVERSITY



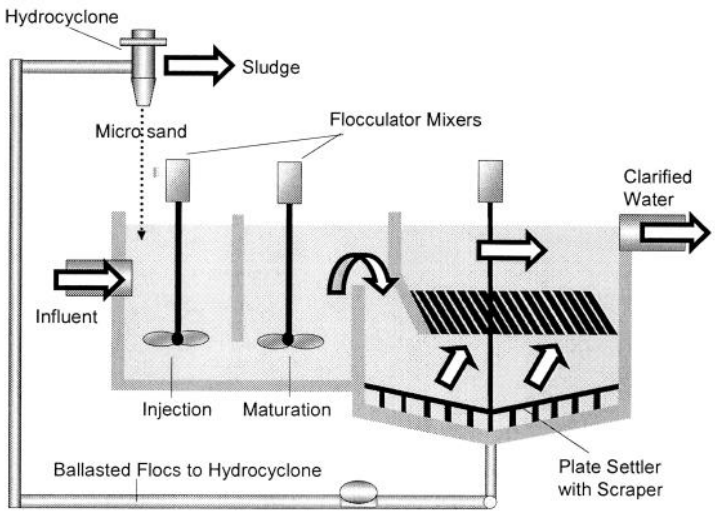


- No power required
- Self cleaning
- 4 mm solids

www.cranfield.ac.uk

Chemical treatment

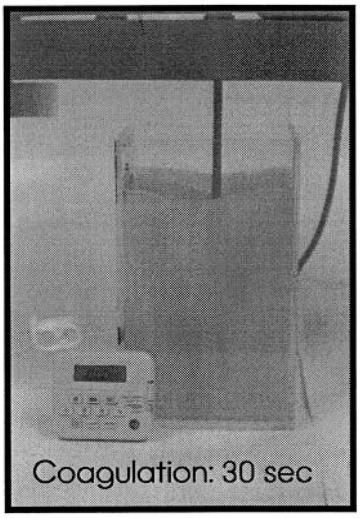
Cranfield UNIVERSITY

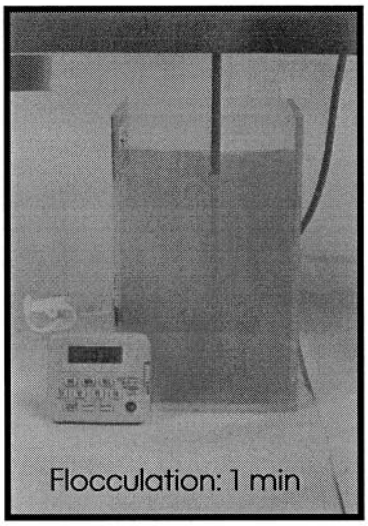


www.cranfield.ac.uk

Chemical treatment

Cranfield UNIVERSITY

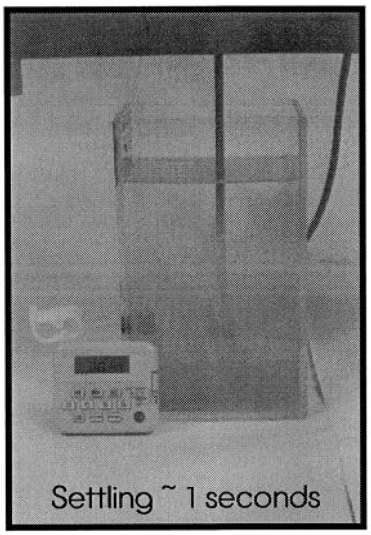


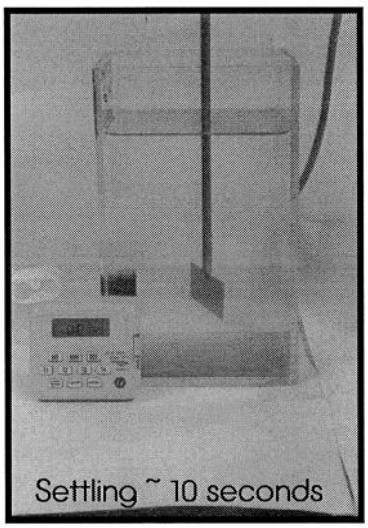


www.cranfield.ac.uk

Chemical treatment

Cranfield UNIVERSITY

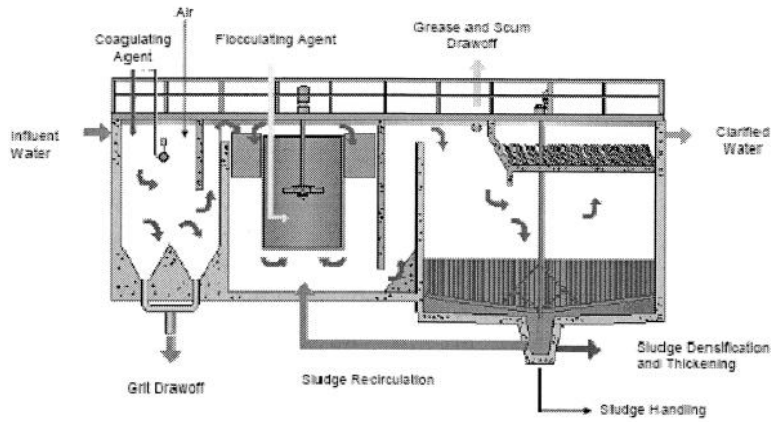




www.cranfield.ac.uk

Chemical treatment

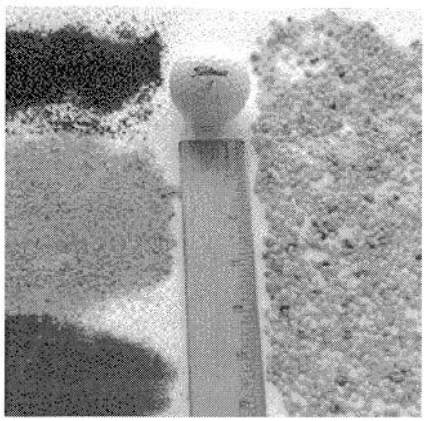
Cranfield UNIVERSITY



www.cranfield.ac.uk

Deep bed filtration

Cranfield UNIVERSITY



- Coarse deep bed (up to 3m)
- Coagulant+polymer
- High rate (up to 30 $m^3.m^{-2}.d^{-1}$)
- Removals:
  - •BOD:40%
  - •SS:70%

www.cranfield.ac.uk

CSO Comparison

Cranfield UNIVERSITY

Technology	BOD (%)	TSS
Clarification	25-40	50-70
Screens	N/A	40-70
Vortex	30	30-50
Ballasted Floc	60-75	75-90
Deep bed	65-70	55-80

www.cranfield.ac.uk

The future

Cranfield UNIVERSITY

- Sustainable urban drainage systems (SUDS)
  - Permeable surfaces,
  - Filter drains and strips,
  - Swales and infiltration devices (long depressions in ground that are allowed to flood and fill with water and vegetation)
  - Ponds, basins and artificial wetlands

www.cranfield.ac.uk

Aims

Cranfield UNIVERSITY

Aim: To learn about the main principles of primary processes used in sewage treatment

At the end of this session you should:

- understand the purpose of primary processes
- understand the main options available
- understand the issues

www.cranfield.ac.uk