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Optimisation of Sedimentation Basins' Return Water

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Content

Return Water Quality (RWQ) Challenge

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- Hydraulic dredgers can economically pump soil over several to dozens of kilometres ashore
- Water acts as the transport medium for solid particles using large volumes of water
- Large reclamation areas and even larger sedimentation basins are required to receive soil-water mixtures
- Typically, reclamation basins cannot store all the transport water
  Return water should thus be released into the environment on a daily or even hourly basis
- Releasing return water into pristine water systems can be challenging and requires predictive models and real-time monitoring

Hydraulic Transport System Analysis

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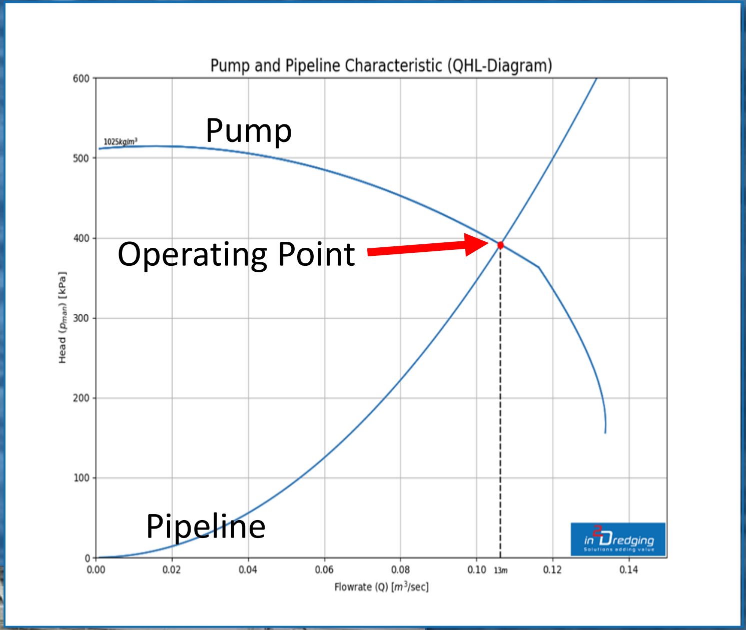
- Used to estimate production rates by considering:
  - ◊ Pump specifications
  - ◊ Pipeline properties
  - ◊ Soil-water mixture properties
- Includes:
  - ◊ Slurrification assessment of cohesive material
  - ◊ Particle degradation assessment of granular material
- Employed to estimate:
  - ◊ Operational production
  - ◊ Realistic mixture density
  - ◊ Transport water volume



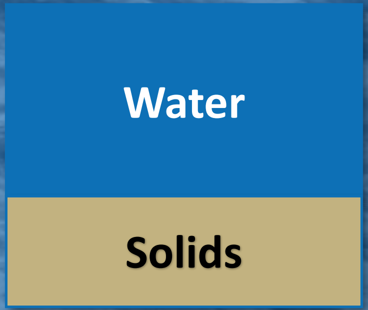
RWQ Requirements and Management

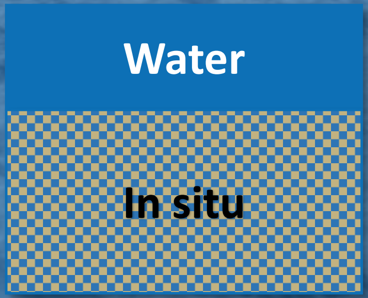
- Return water quality requirements often form part of permit conditions
- Sedimentation basins should have enough capacity to allow continuous dredging under normal wind conditions
- RWQ Management:
  - ◊ Relies on turbidity action response plans that are based on turbidity levels
  - ◊ During monitoring periods, turbidity levels are continuously measured in NTU (Nephelometric Turbidity Unit)
  - ◊ Bottle samples are taken to determine sediment concentration
  - ◊ Correlations between NTU and mg/l need to be developed, which are site specific

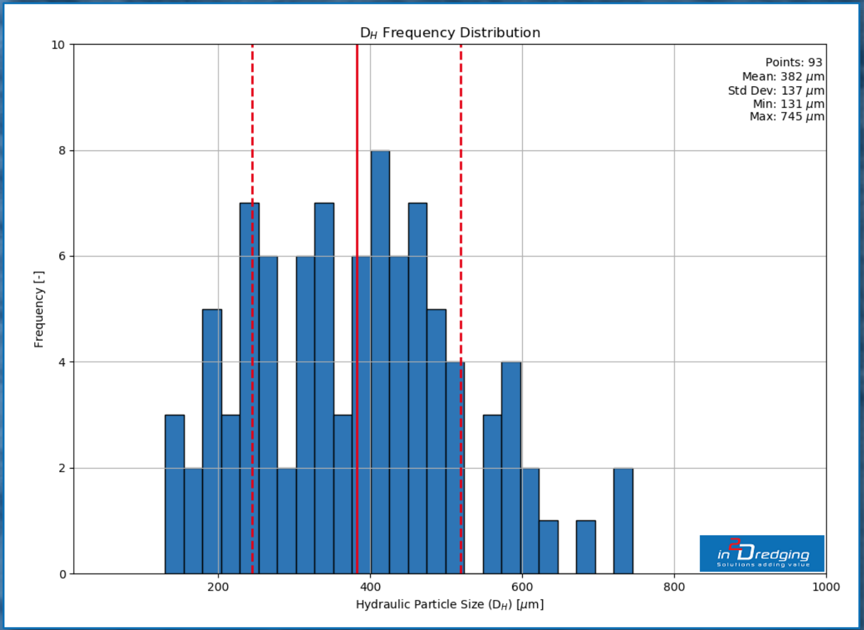
	P80	P95	P99
Turbidity [NTU]	40	80	200

Hydraulic Mixture Properties

- Mixture flow
- Particle size
  - ◊ Fines, clay and fine silt are key
  - ◊ Effect of natural flocculation
- Densities
  1. In situ
  2. Mixture
  3. Bulked
  4. Gel
  5. Consolidated, consisting of:
     - ◊ Water
     - ◊ Solids
- Atterberg limits
- Shear strength
- Yield stress
- Particle shape
- Temperature



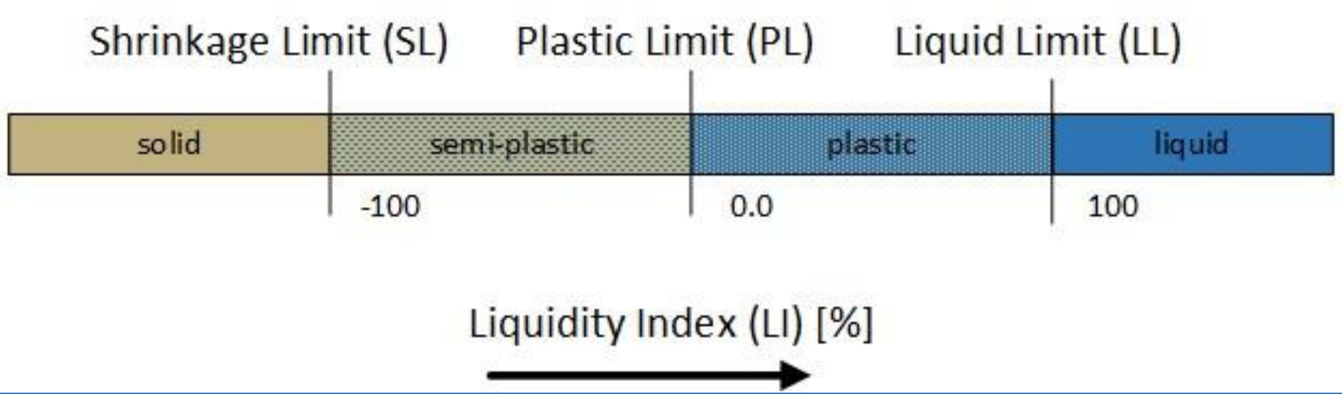




Clay Slurrification

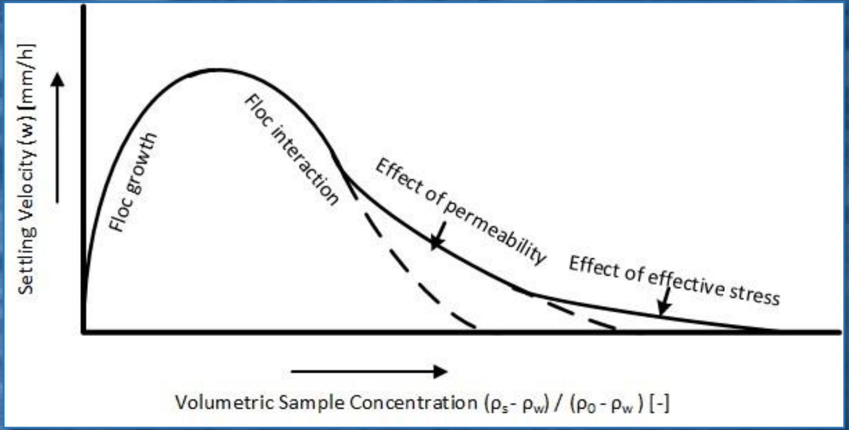
- Criteria used include:
  - ◊ Clay state and properties
  - ◊ Dredging method
  - ◊ Number of pumps
  - ◊ Pump distance
- A field of study in which further research is required
- Reclamation areas may receive clay balls
- Sedimentation basins receive slurrified clay

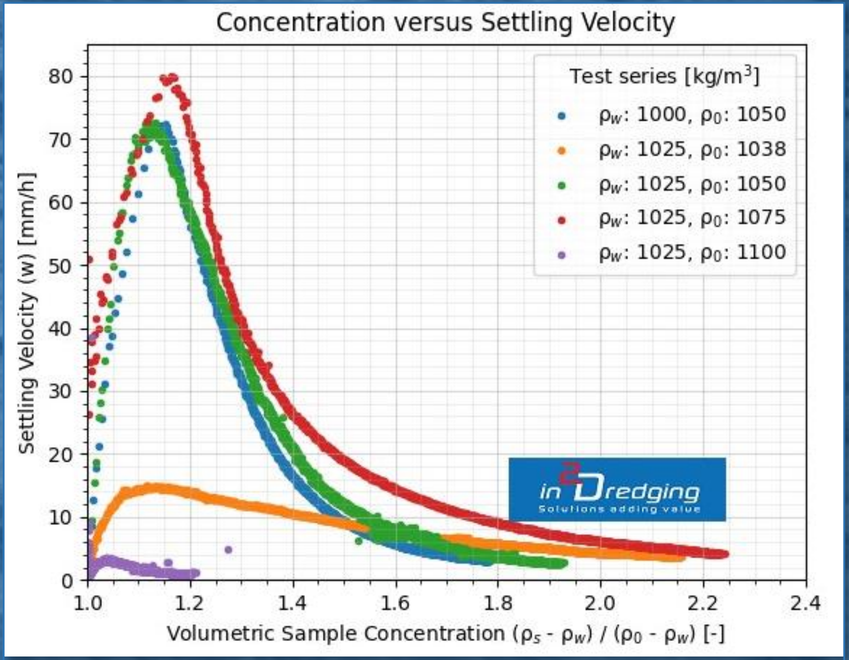
Key Suspects
Clay content
Shear strength
In situ density
Atterberg limits
Exposure time



Natural Flocculation

- Clay and very fine silt flocculate in salt water
- Flocculation is a process that binds small particles together to form flocs
- Settlement tests
  - ◊ Exhibit significantly higher settling velocities due to floc growth, which leads to the formation of larger particles that settle more rapidly
  - ◊ Result in more accurate RWQ modelling, making models less pessimistic
- Turbulence breaks up flocs

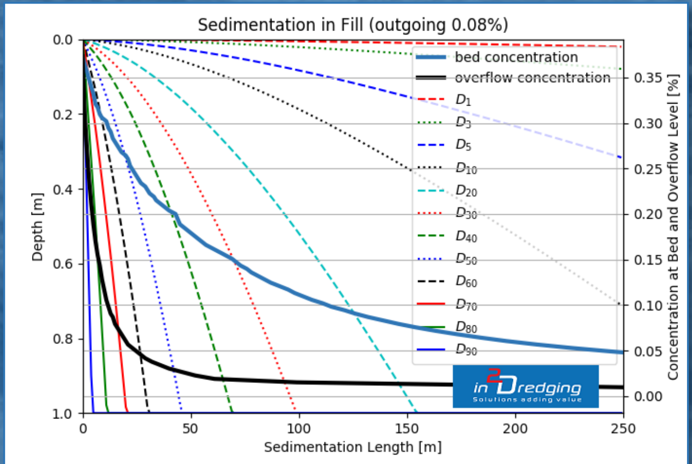


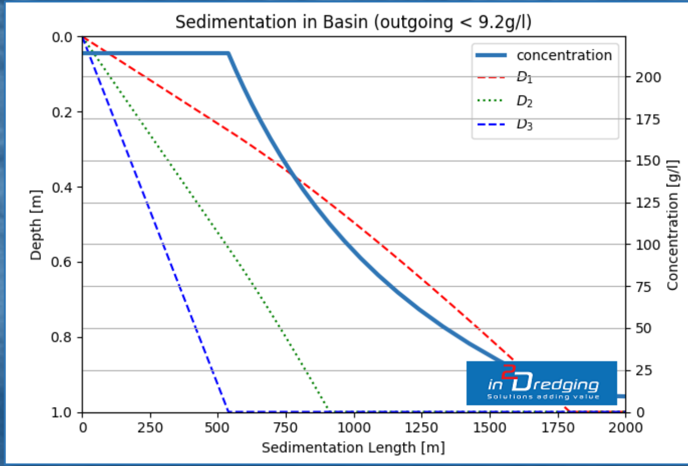


Continuous Settlement Test over 48 Hours

Predictive Modelling - Return Water Quality (RWQ) Tool

- Predicts the quality of return water leaving soil placement areas
- Assists with designing reclamation areas and sedimentation basins
- Analyses particle segregation in reclamation areas
- Determines ideal discharge rates, mixture density and weir box configuration to improve sedimentation rates





Reclamation Areas and Sedimentation Basins

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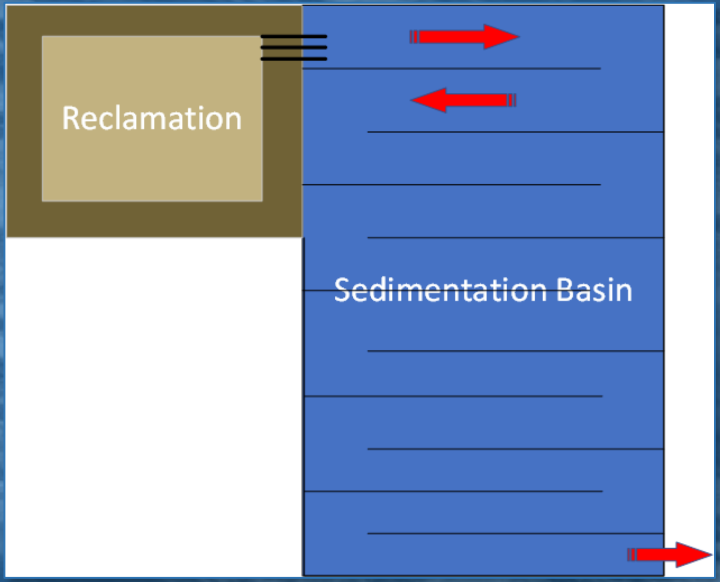
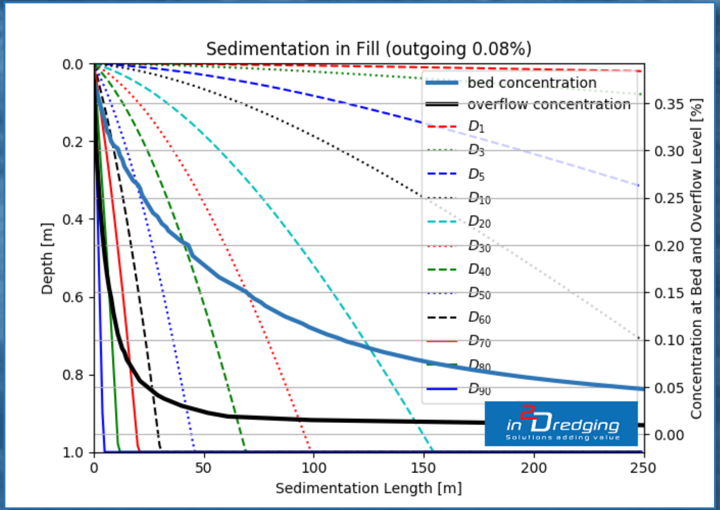
- Reclamation areas
  - ◊ Should be sufficiently large to hold the total bulked in situ volume present at the project's conclusion
  - ◊ Bunds must be high enough to hold the fill, including water and freeboard
- Sedimentation basins
  - ◊ Hold the bulked fine fraction
  - ◊ Should maintain minimum flow velocity and maximise sedimentation length to meet required turbidity levels at the project's end
  - ◊ Are significantly larger than reclamation areas and often require hectares of space





Reclamation Areas

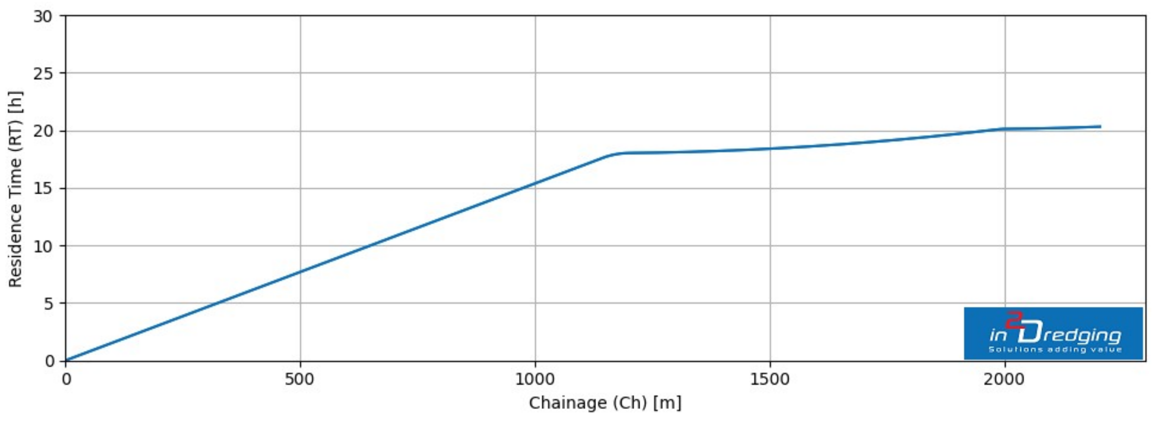
- Are relatively small areas in which to spread the mixture flow, which is conducted with the assistance of a bulldozer
- Larger particles settle fast and accumulate near the pipeline outlet
- Majority of dredged material typically remains in the reclamation area and can be reused as construction material, if the fines are managed
- Only clay and silt leave the reclamation area and are of interest in return water quality assessments

Sedimentation Basins

- Consist of large areas
- Ideally require:
  - ◊ Optimised flow lengths between the inlet and outlet
  - ◊ A constant effective flow width
  - ◊ Extremely low mixture velocities
  - ◊ Prevention of "dead pockets"
    - i.e. Areas without any mixture flow
- Clay and silt can be ripened and reused for agricultural purposes

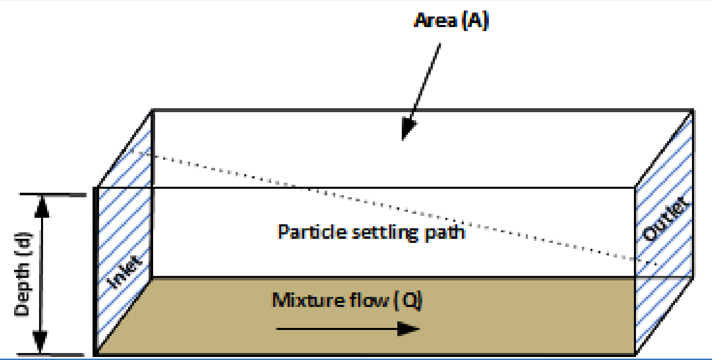
Ideal vs Actual Sedimentation Basins

- Ideal sedimentation basins
  - Have a rectangular shape
  - Flow is uniformly distributed at inlet and outlet
  - Have constant depth
  - Particles settle in a straight line
- Actual sedimentation basins
  - Have an irregular shape
  - Have pipe (point) as inlet and relatively narrow weir as outlet
  - Need to avoid obstructions to maintain uniform flow
  - Subject to obstructions and wind that resuspend particles
  - Deep and wide basins have low flow velocities
  - Typical residence times are only a few days



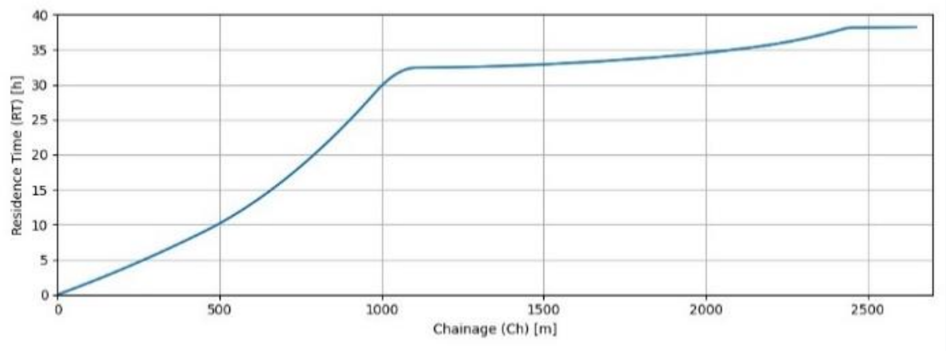
Residence Time (RT) = A x d / Q

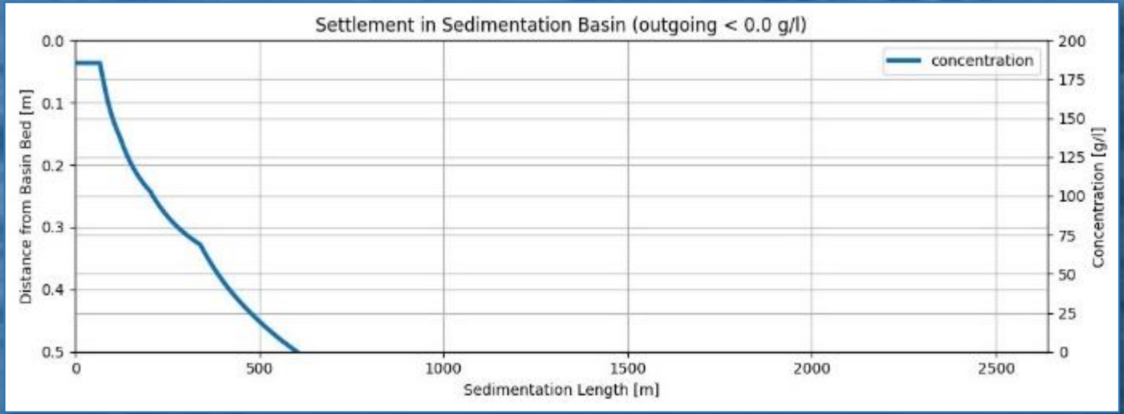
Settling Time (ST) = d / w



Conclusions

- RWQ predictive modelling ensures that settlement basins of adequate size are available to support almost continuous dredging operations
- Flocculation significantly enhances settling velocity, and incorporating flocculation in models improves the accuracy of RWQ modelling
- Large settlement basins typically enable hydraulic dredging to be environmentally feasible
- Real-time RWQ monitoring ensures compliance with permit conditions and continuity of operations





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