WTBURDEN

drainage&civils landscape street furniture

Surface Water Drainage Seminar 2019

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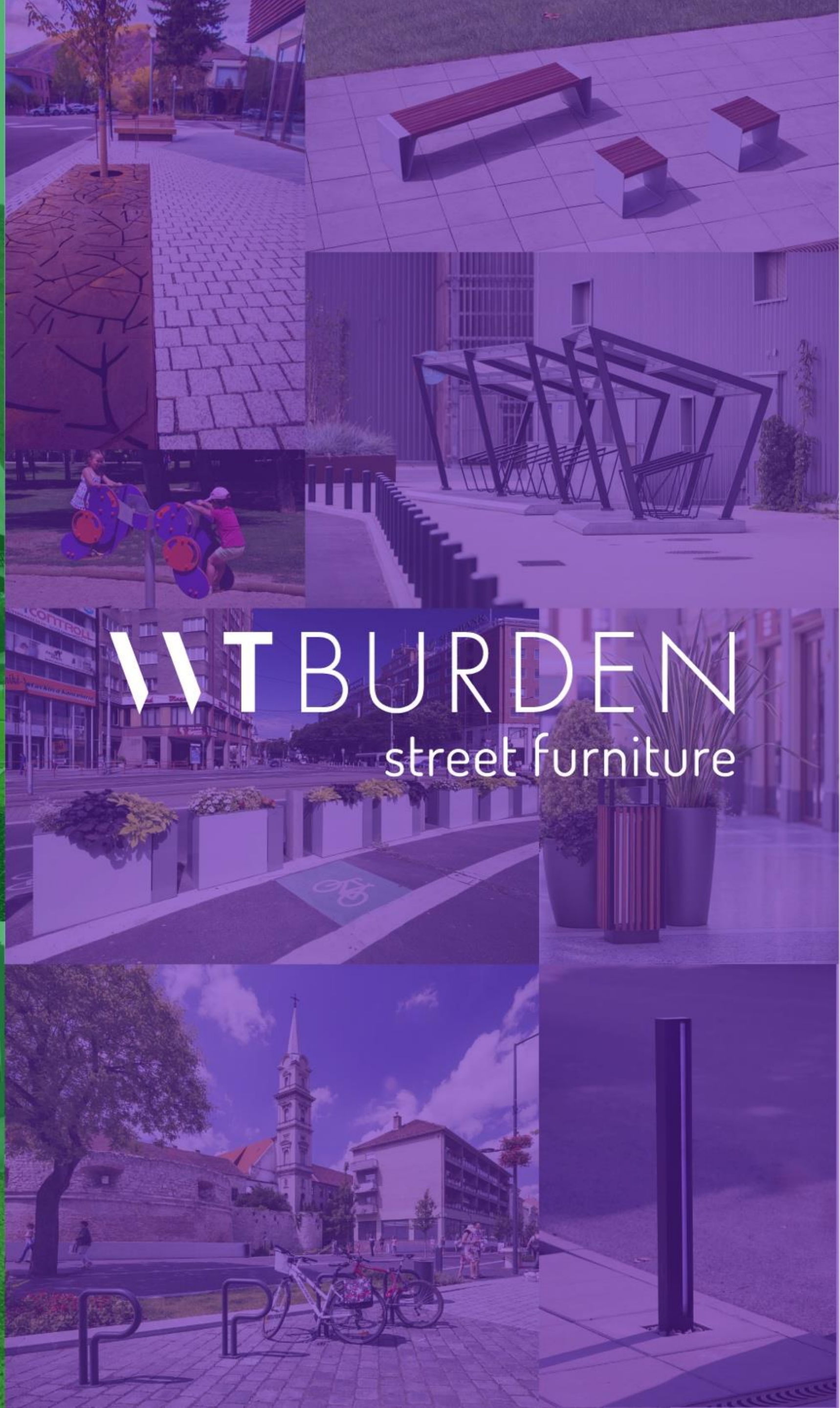
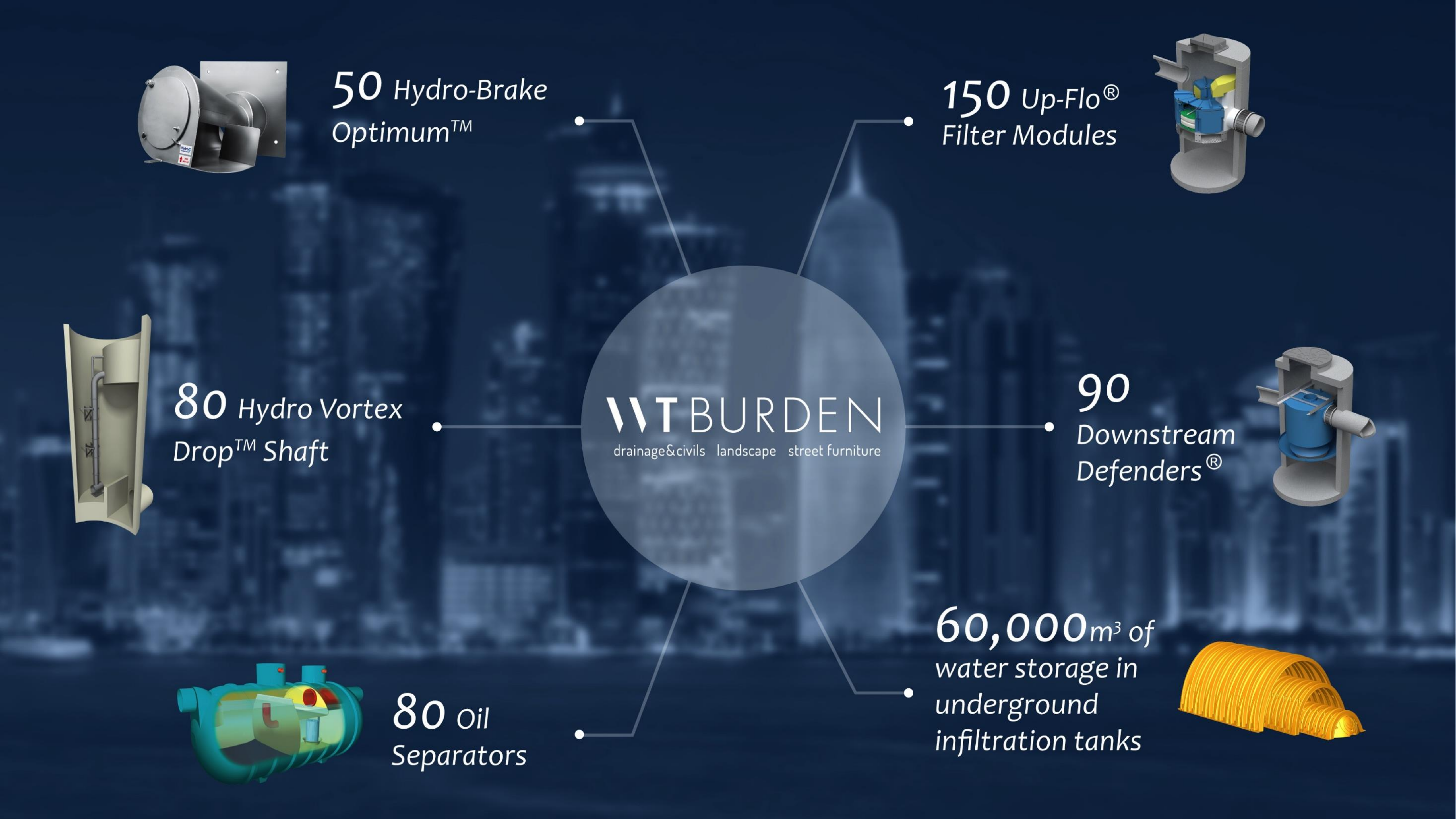
1. Introduction to WTBurden


WTBURDEN
drainage&civils


WTBURDEN
landscape


WTBURDEN
street furniture


What brings us all together?


50 Hydro-Brake Optimum™
150 Up-Flo® Filter Modules
80 Hydro Vortex Drop™ Shaft
WTBURDEN
drainage&civils landscape street furniture
90 Downstream Defenders®
60,000m³ of water storage in underground infiltration tanks
80 Oil Separators

Why are we all here today?

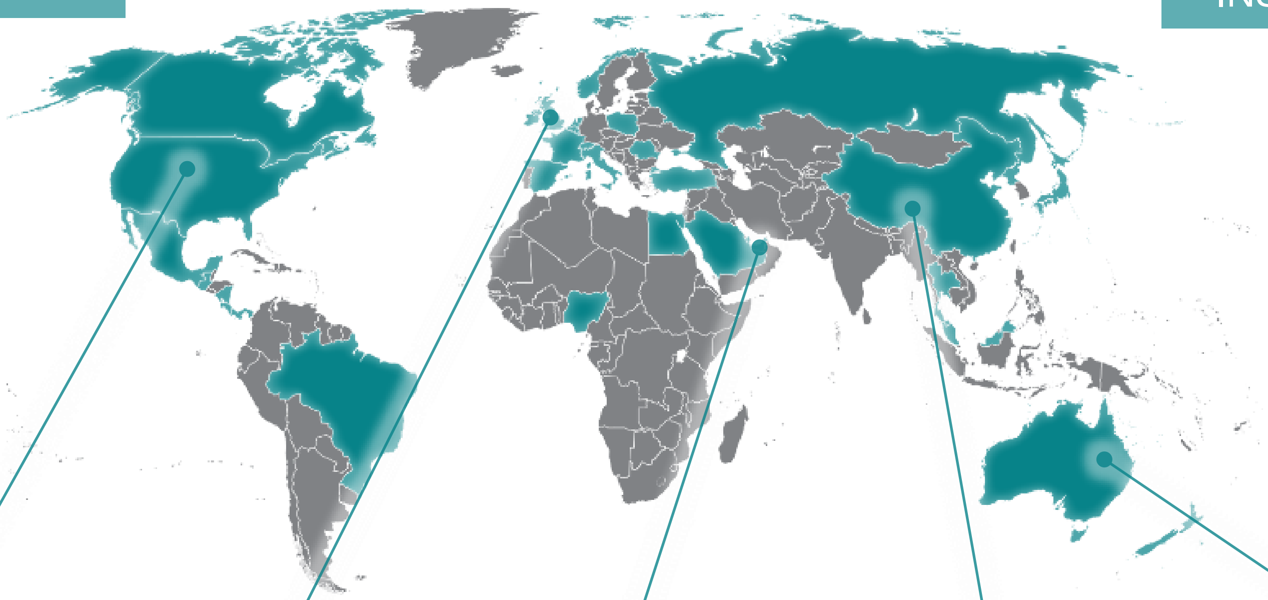
Maintenance

1. Introduction to Hydro International

Hydro International: Who are we?

40
COUNTRIES

+37,000
INSTALLATIONS



Offices

USA (2)

UK - HQ (7)

Middle East

China

Australia

Hydro International

Water Quantity

Manage the rate that water travels through a catchment.

Water Quality

Removal of unwanted pollutants and particles from water collected from the catchment.

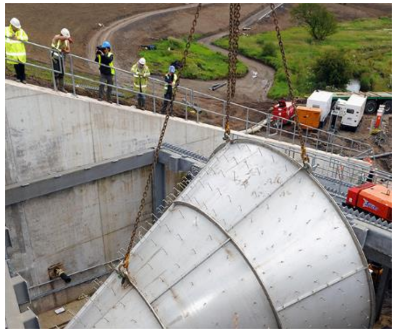
Water Behaviour

Collect and analyse water quality and quantity data as the water travels through the catchment.

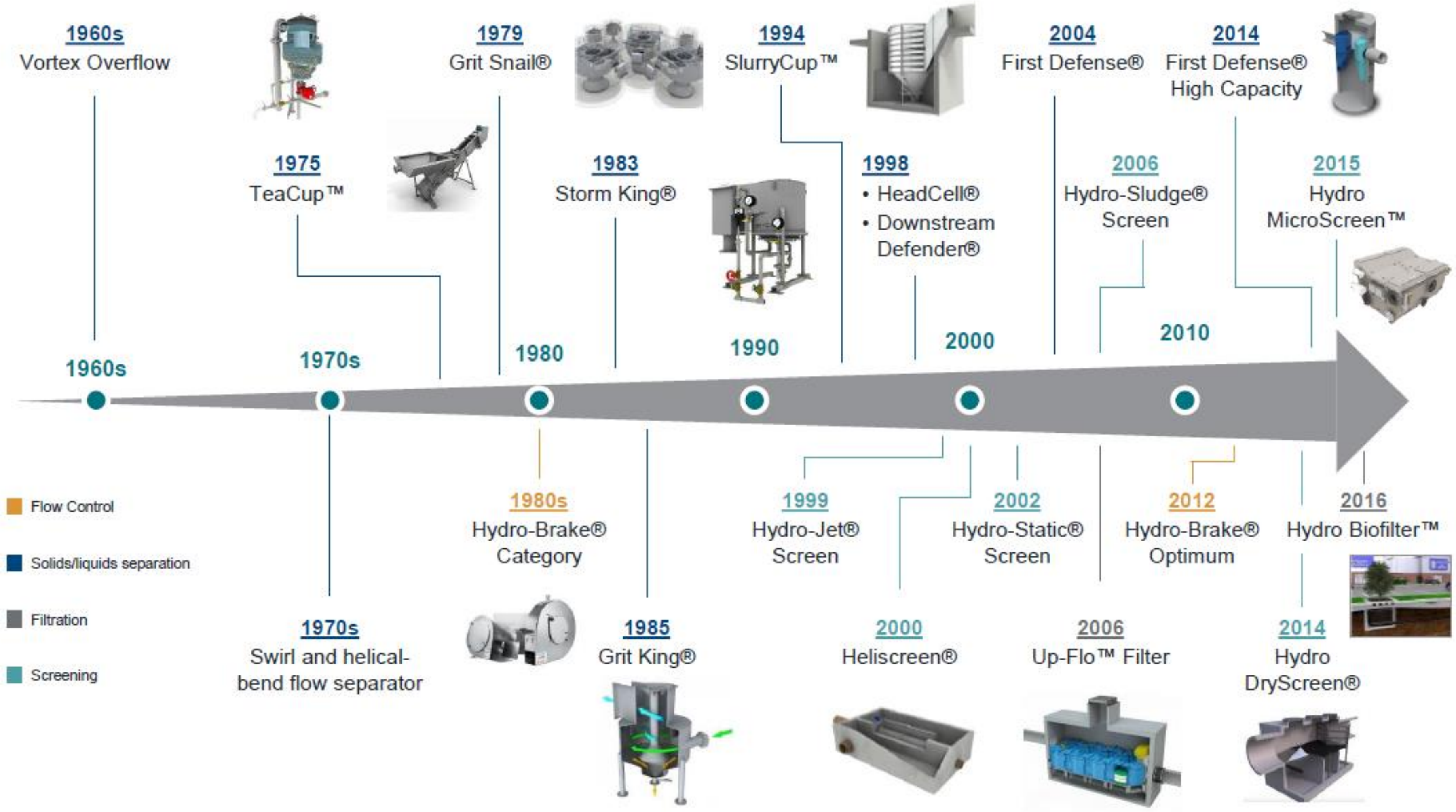
Hydro International Product Philosophy

- Hydro International product goals
  - No moving parts / minimal moving parts
  - No power / minimal power
  - Simple to install
  - Highly effective
  - Low maintenance

....Technologies that have low ecological footprint



A Foundation of Good Science



Testing and Validation

Comprehensive facilities for full-scale tests



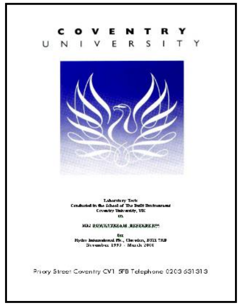

Our Collaborations

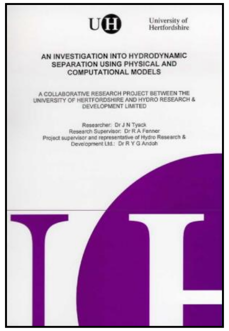
Hydro International

liverpool JMU

University of New Hampshire

PennState 1855




AN INVESTIGATION INTO HYDRODYNAMIC SEPARATION USING PHYSICAL AND COMPUTATIONAL MODELS

A COLLABORATIVE RESEARCH PROJECT BETWEEN THE UNIVERSITY OF HERTFORDSHIRE AND HYDRO RESEARCH & DEVELOPMENT LIMITED

Researcher: Dr J N Tyack
Research Supervisor: Dr R A Fenner
Project supervisor and representative of Hydro Research & Development Ltd.: Dr R Y G Andoh

University of Bradford — Making Knowledge Work

Cardiff University — Prifysgol Caerdydd

University of Massachusetts Amherst

University of Bristol

The University of Alabama

UF University of Florida

The University Of Sheffield.

University of Minnesota — Driven to Discover

University of Exeter

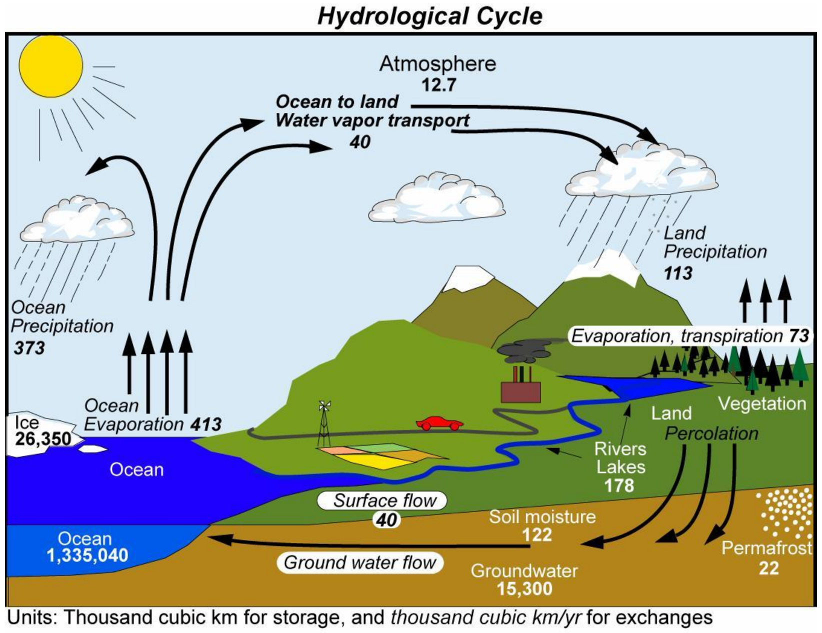
stream — The Industrial Doctorate Centre for the Water Sector

Trinity College Dublin — Coláiste na Tríonóide, Baile Átha Cliath — The University of Dublin

Certifications

2. Urban Water Management

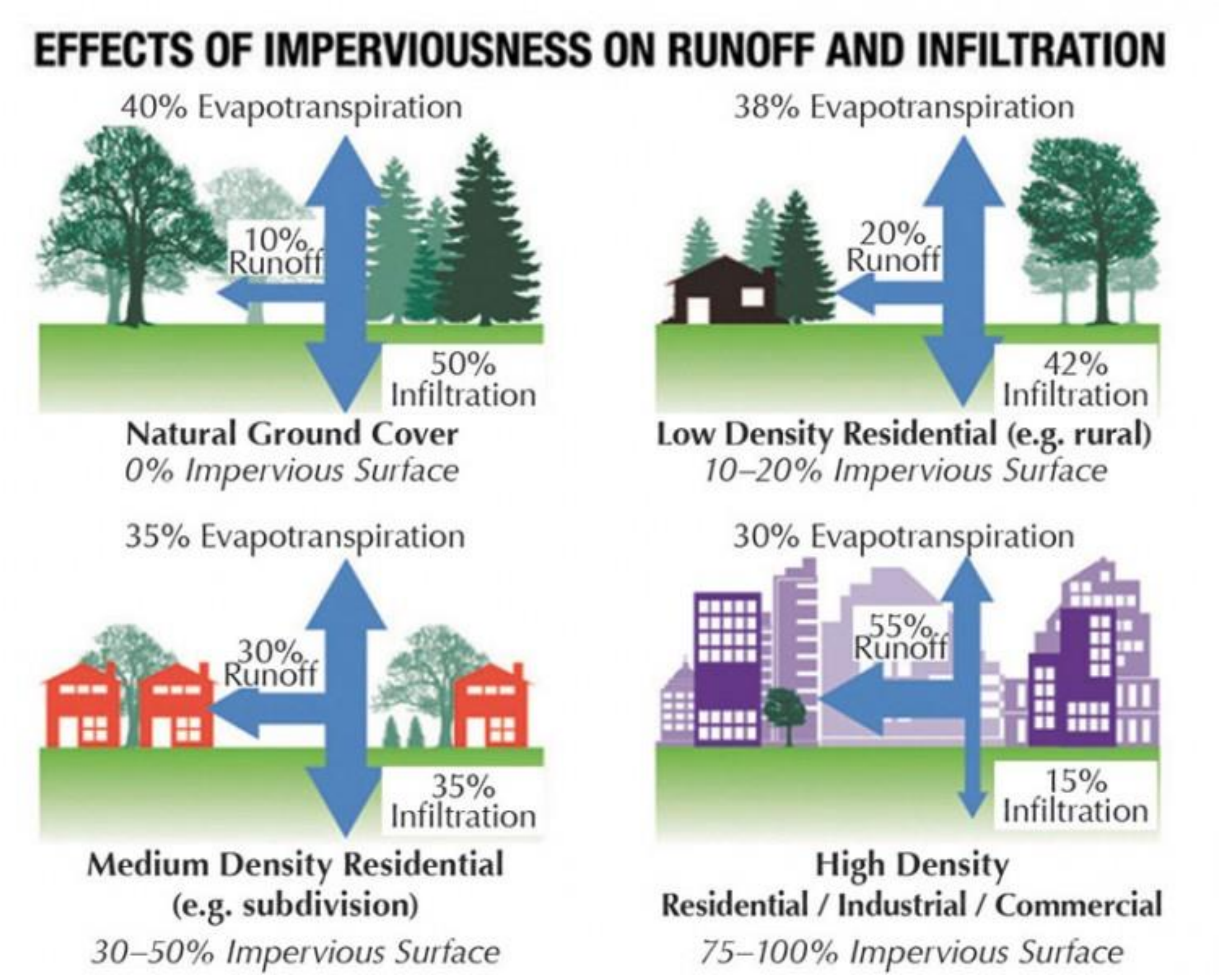
The Water Cycle



Nature has evolved balanced hydrological / hydro-geological cycles over the millennia

"However, in the relatively recent emergence of the human race on planet earth; the *human being* has become such a *force of change and influence* that we are now impacting and interfering with these cycles on an unprecedented global scale"

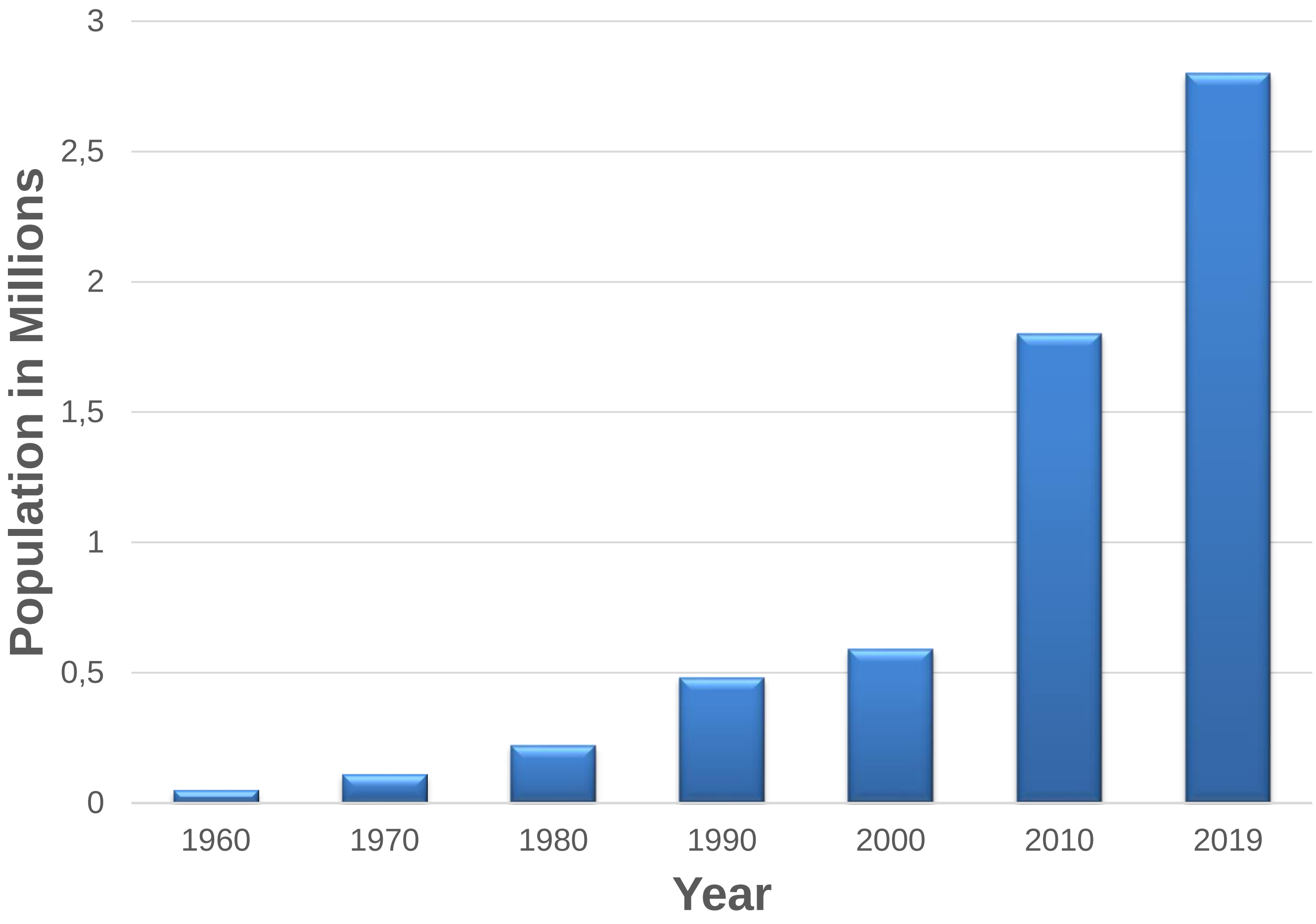
Effects of Imperviousness



Source: Arnold and Gibbons (1996)

Water Quality and Quantity Impacts

Population of Qatar

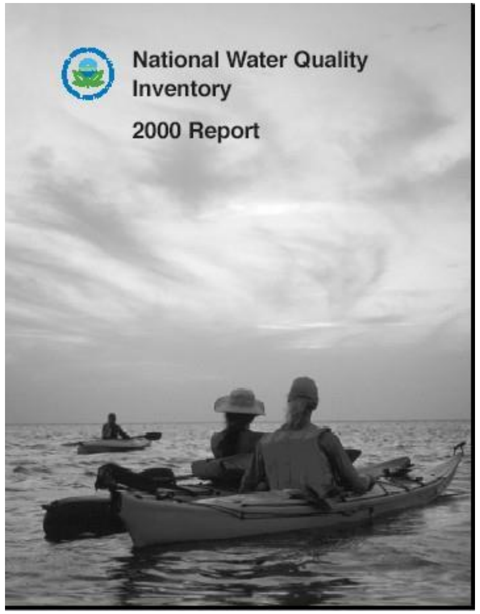


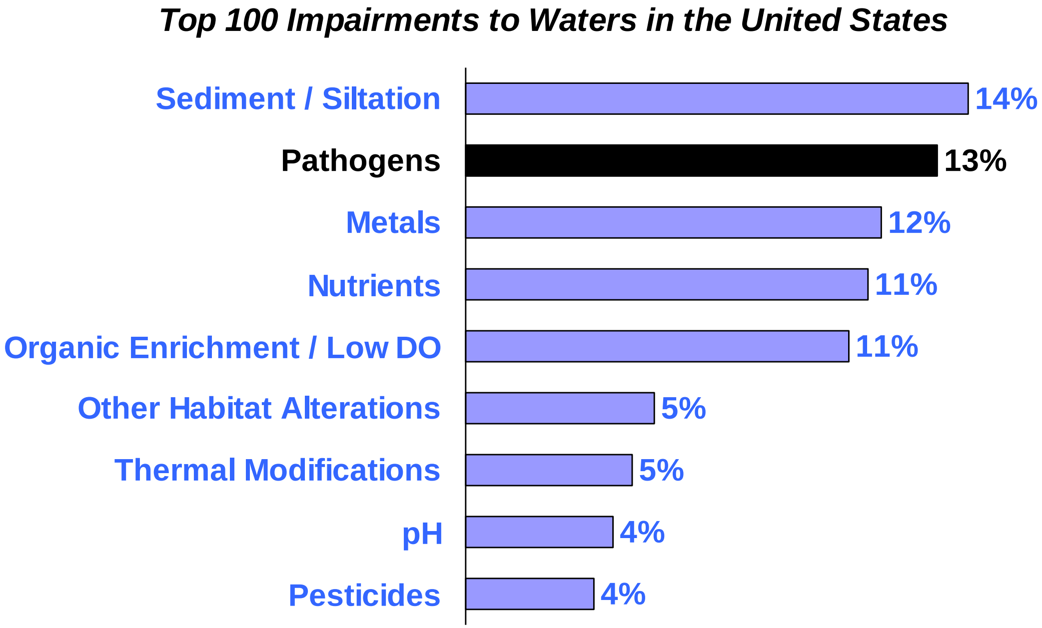
Population growth increases water management challenges

3. Controlling your water Quality – Innovative and cost effective treatment train

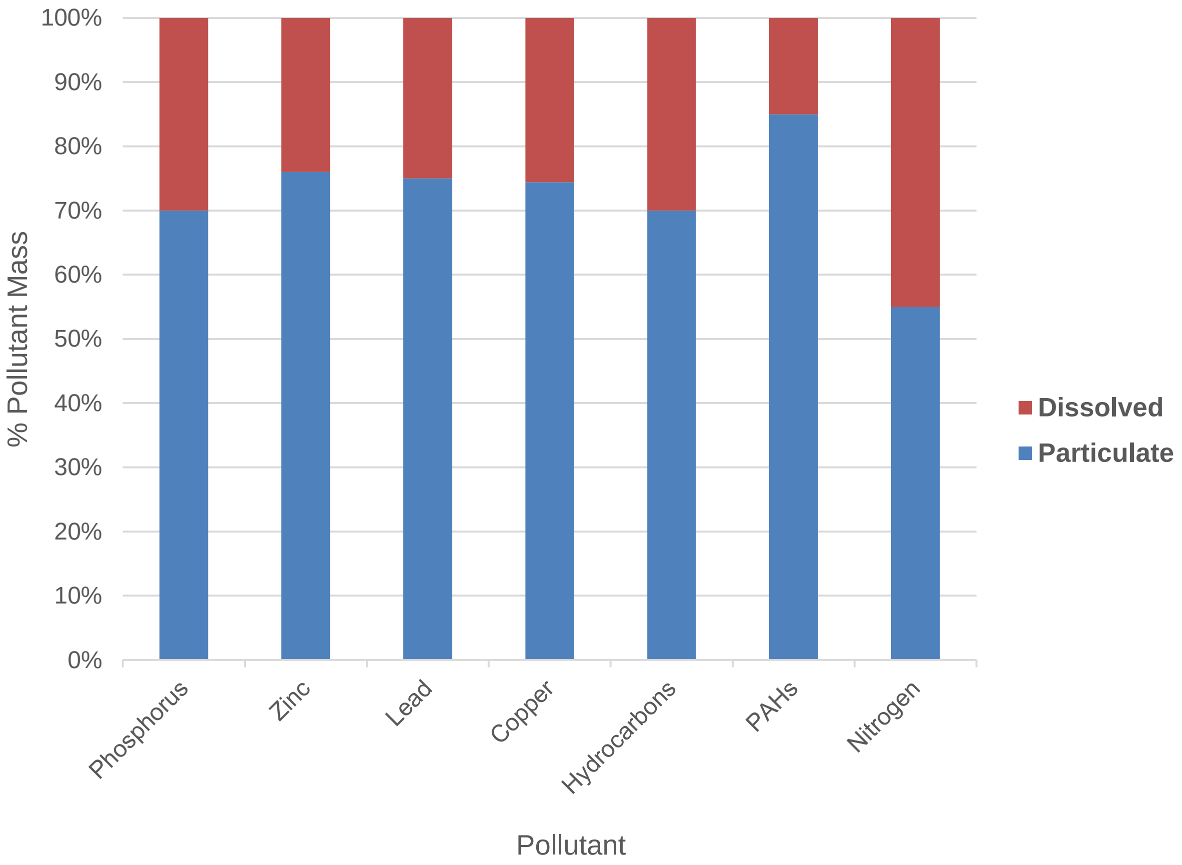
What should we prioritise?

- According to USEPA, sediment is the leading cause of water-quality impairment in the US.





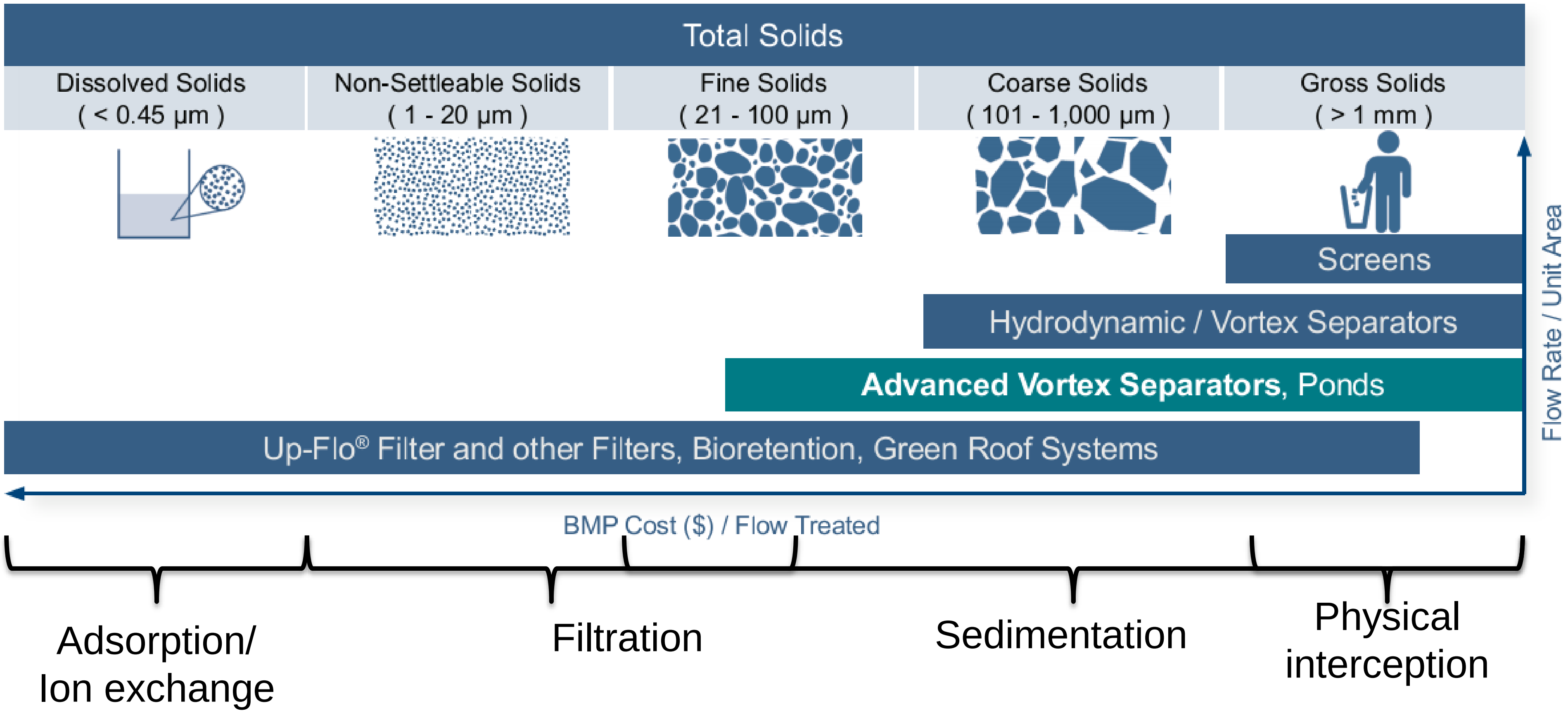
Dissolved or solids?



Typically 2/3rds of pollutants or greater are associated with sediments…

The Treatment Spectrum

- Screening
- Sedimentation & floatation
- Filtration
- Sorption
- Soil processes



a. Downstream Defender® Hydrodynamic Vortex Separator

Traditional vs. Vortex Separation

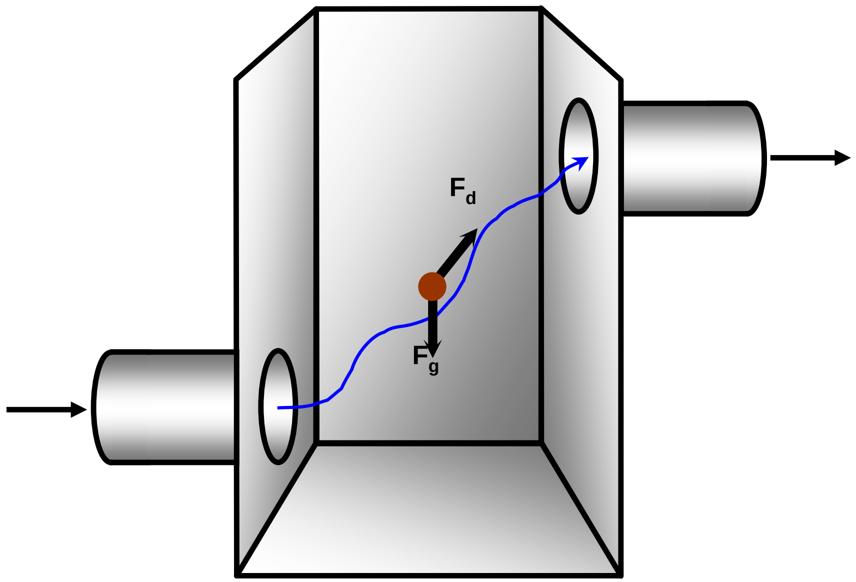
How do you differentiate?

- Conventional Approach
  - Gravitational sedimentation
  - Quiescent conditions
  - Linear tanks and catch pits
  - Particle reaches base before flow exits chamber

- Particle Forces
  - Gravity (Fg)
  - Drag (Fd)

Sizing criteria

- Particle settling velocity
- Settling distance
- Tank length
- Flow-rate



Forces Acting on a Particle in a Simple Linear Sedimentation Chamber

Stoke's Law:

$$V_m = \frac{\delta\rho\,\gamma d^2}{18\mu}$$

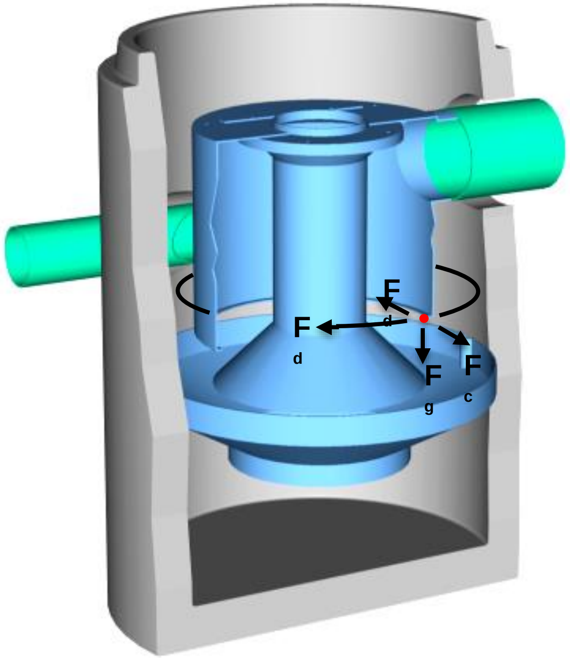
Where,

V_m = migration velocity
$\delta\rho$ = density difference between the particle and fluid
γ = the intensity of the acceleration field
d = effective diameter of the particle
μ = the viscosity of the fluid

Traditional vs. Vortex Separation

How do you differentiate?

- Vortex approach:
  - Enhanced gravitational sedimentation
  - Harness rotational behaviour
  - Extends particle path and chance to settle
  - Reduced footprint and cost
  - Low headloss separation
  - Base flow sweeps sediment into sump
- Particle Forces:
  - Gravity (Fg)
  - Drag (Fd)
  - Centrifugal force (Fc)
- Sizing criteria
  - Particle settling velocity
  - Balance centrifugal and drag forces
  - Flow-rate



Forces Acting on a Particle in a Vortex Separation Chamber

Centrifugal Force:

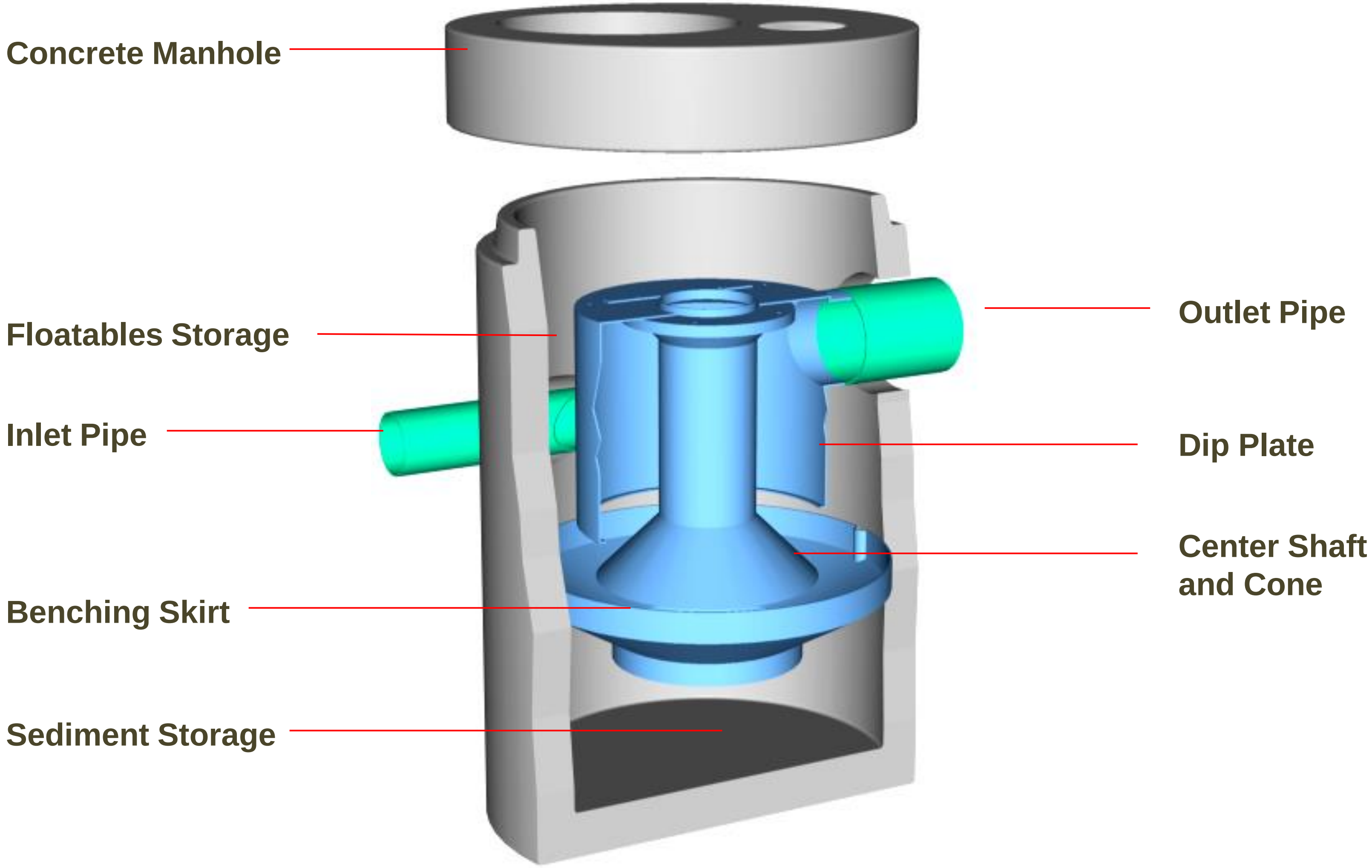
$$F = \frac{mv^2}{r}$$

Where,

F = Force
m = mass of particle
v = velocity
r = radius of the flow path

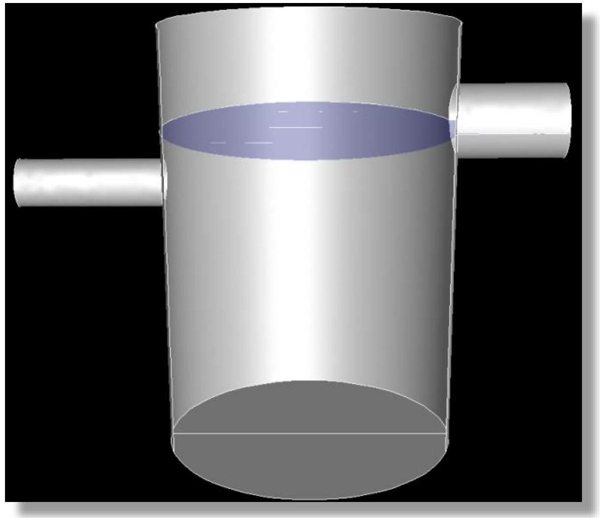
Downstream Defender Components

- Swirl enhancing system internals:

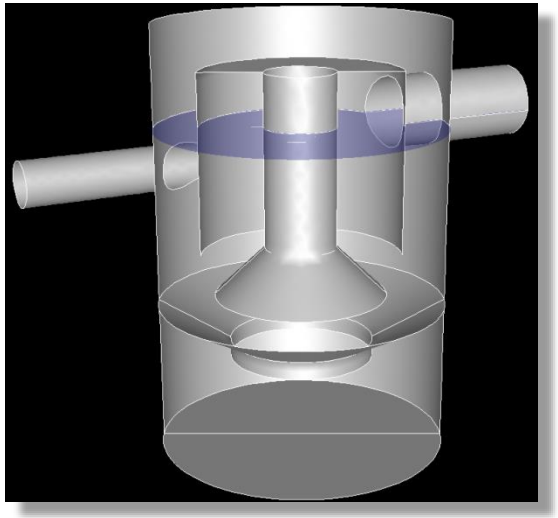


Comparison of Chamber Performance

- Comparisons made using CFD and physical testing
  - Particle capture efficiency
  - Particle retention efficiency
- Geometries for comparison:

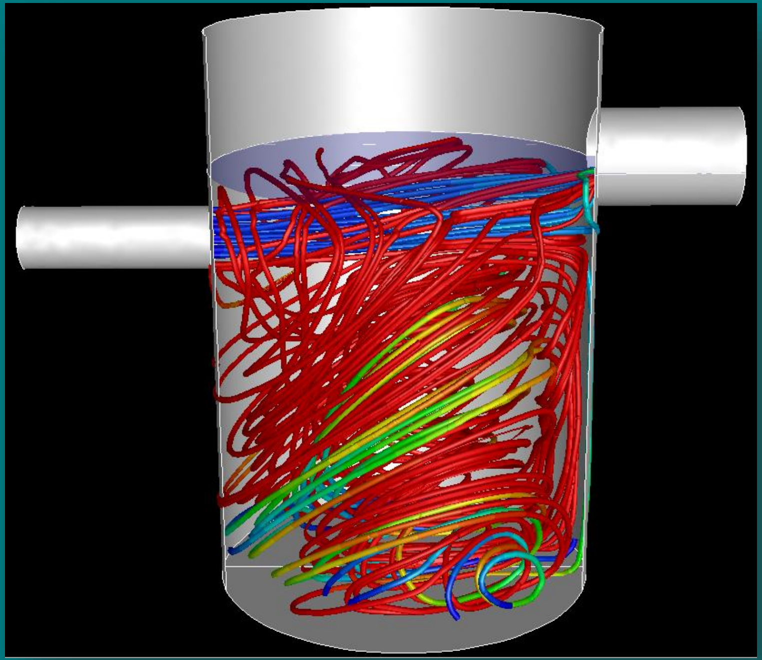


Gravitational Separation Device
(GSD)
No internals
(catch pit)

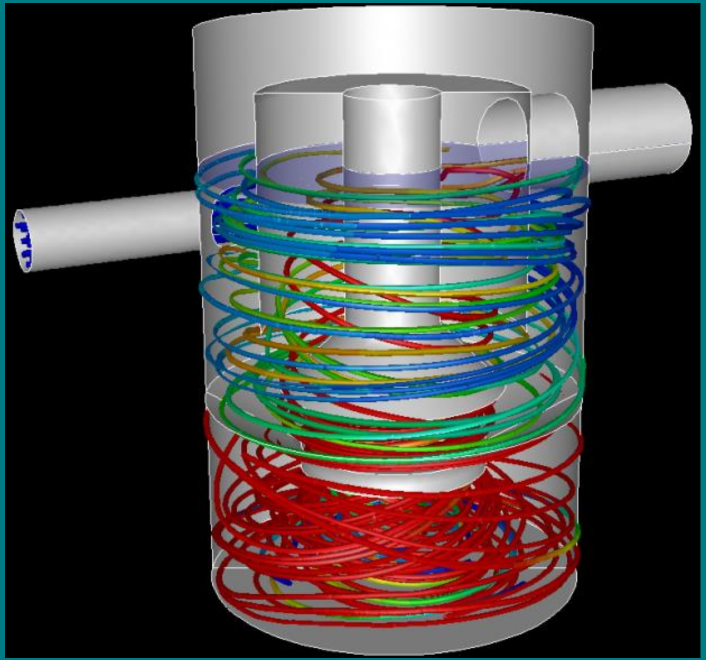


Downstream Defender®
Advanced Vortex Separator
(AVS)
Rotational flow with proprietary components

Fluid Path Lines Coloured by Age

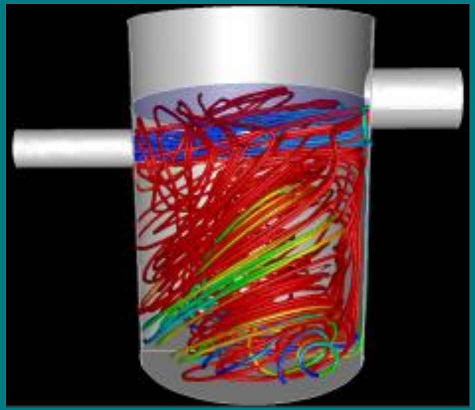


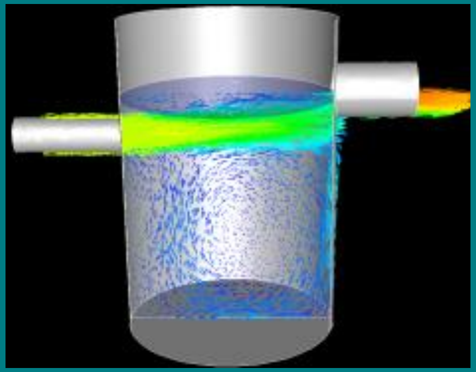
Simple Chamber (GSD)

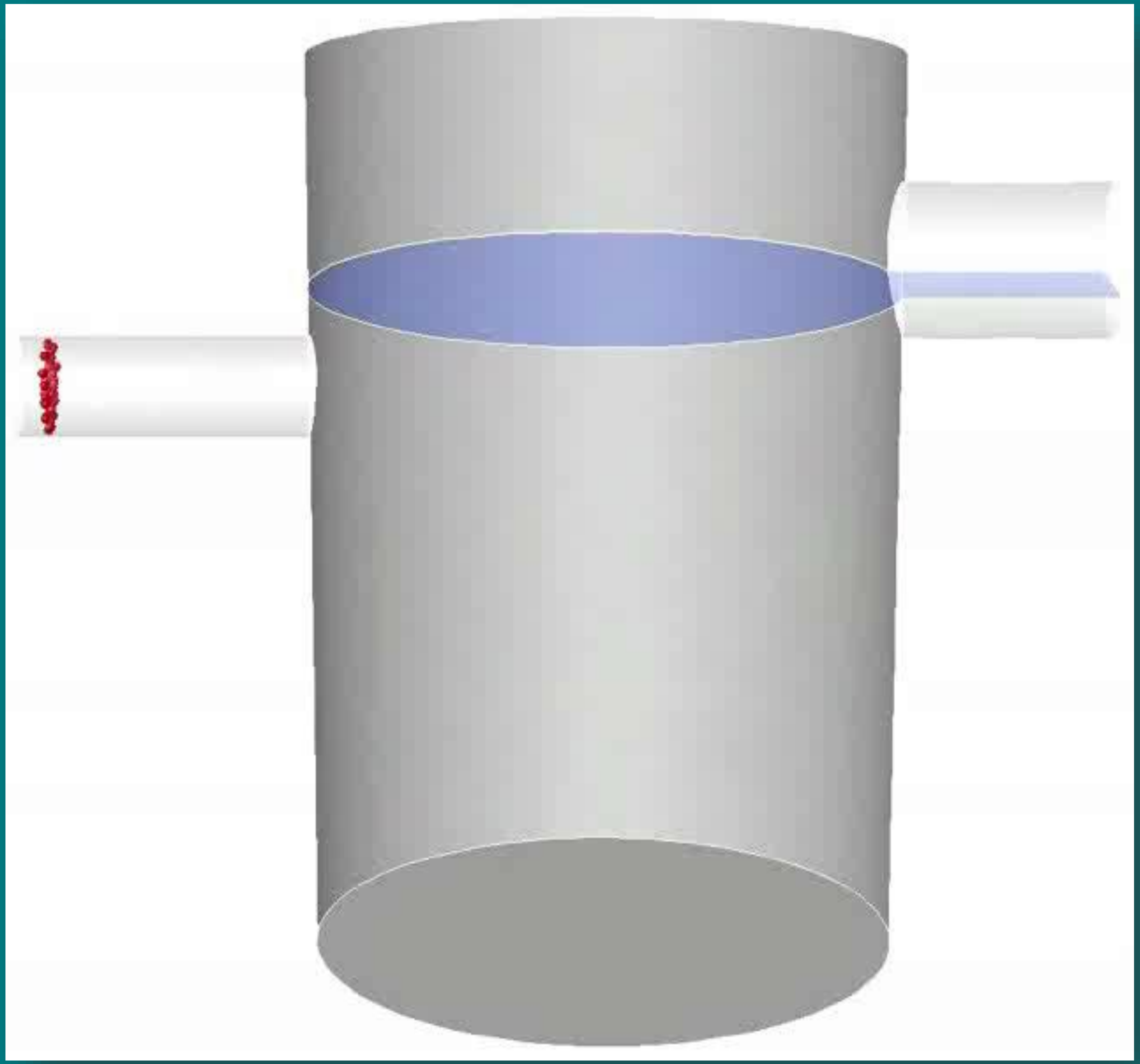


Advanced Vortex Chamber (AVS)

GSD – Capture Efficiency

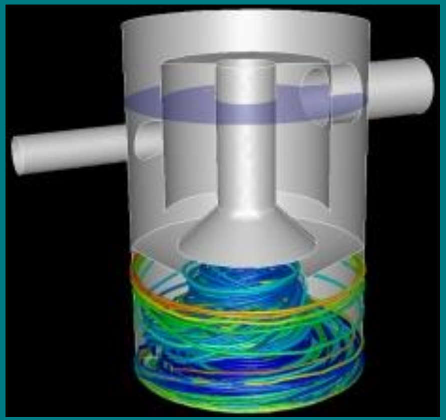


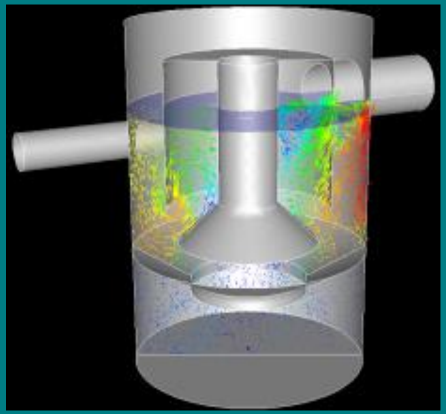


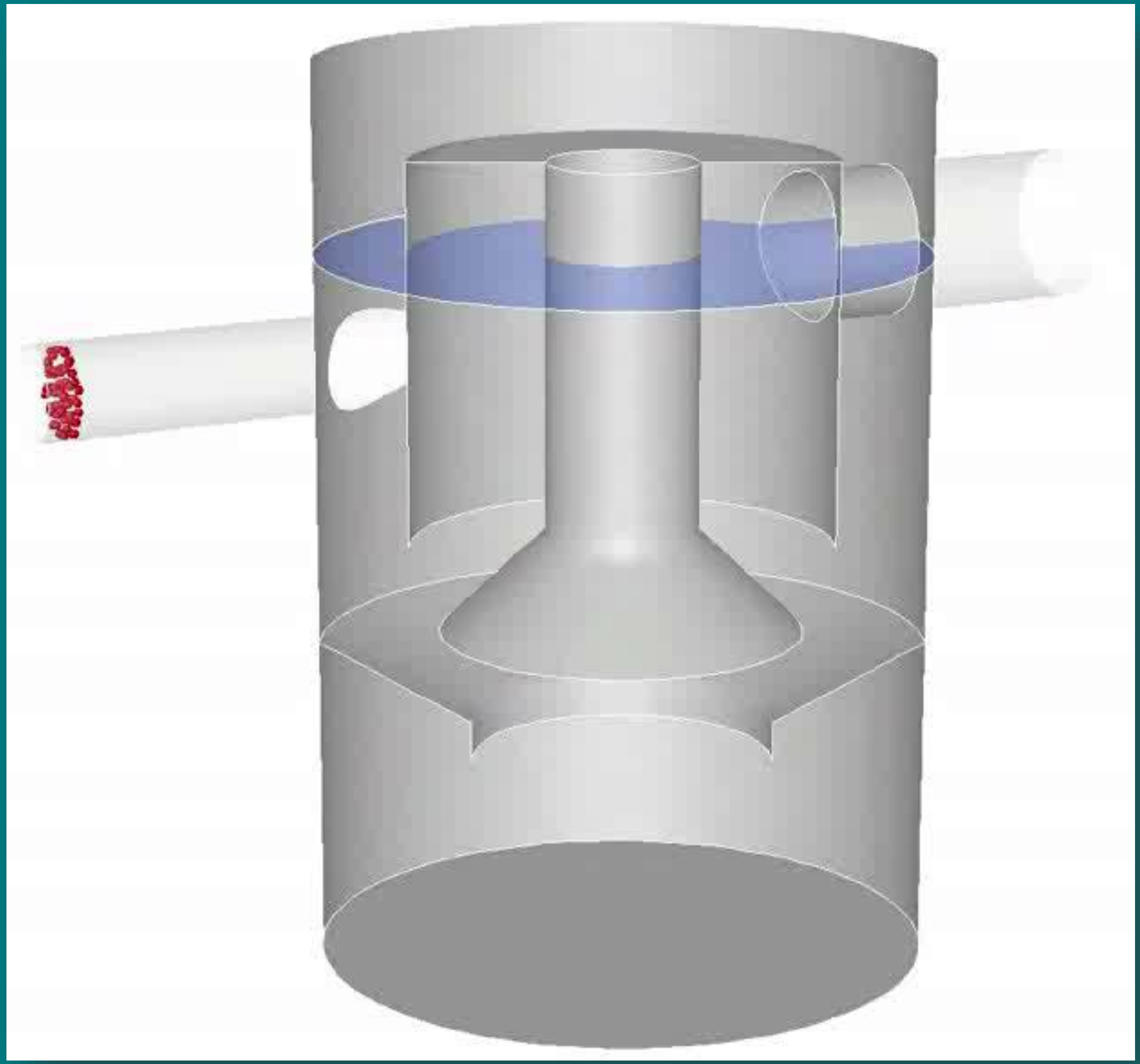


Downstream Defender – Capture Efficiency

Hydro International®

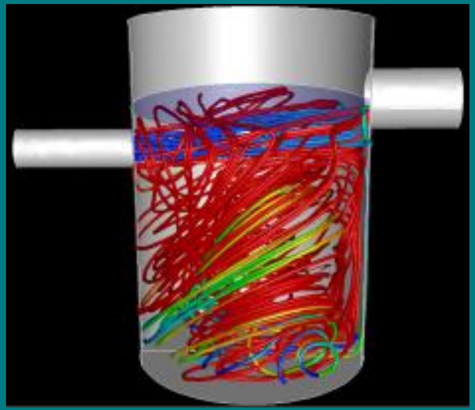


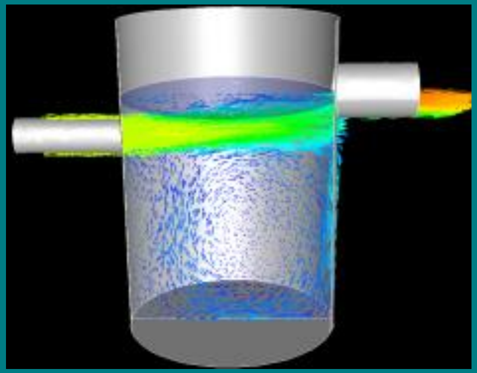




GSD – Retention Efficiency at Peak Flow

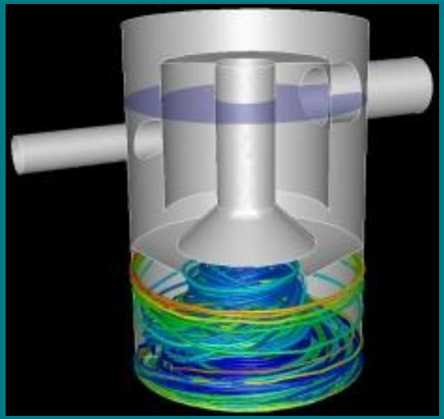
Sump initially loaded with fine sediment to test for washout

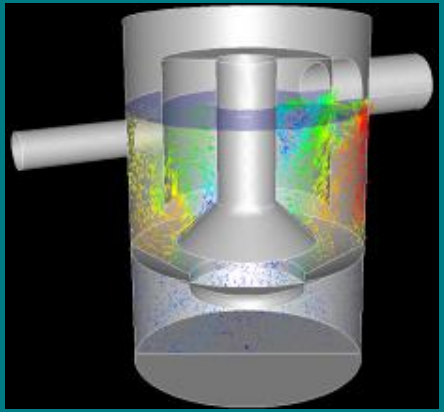




Downstream Defender – Retention Efficiency at Peak Flow

Sump initially loaded with fine sediment to test for washout





What Gets Captured

Hydro International

Dirt,
Debris,
Organics

Oil,
Gasoline

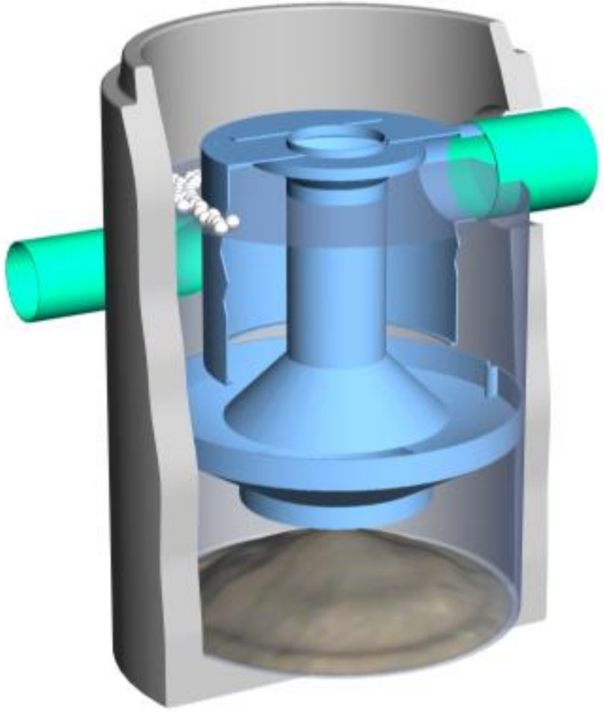
Trash,
Plastics
Wrappers

Maintenance

Downstream Defender

- Optimised Internal Geometry
- Advantages:
  - Control of sediment, floatable trash and petroleum products.
  - Smaller footprint than traditional methods
  - Independently verified performance
  - Low head loss
  - Easy maintenance access

  - **Proven to prevent washout**



b. Up-Flo Filter®, Media filtration

Multi-Stage Treatment Flow Path

Chamber – Floatables and trash

Angled Screens – Neutrally buoyant material

Sump – Coarse grit and gross debris

Filter media:

- Fine sediment
- Hydrocarbons
- Metals
- Organics
- Nutrients

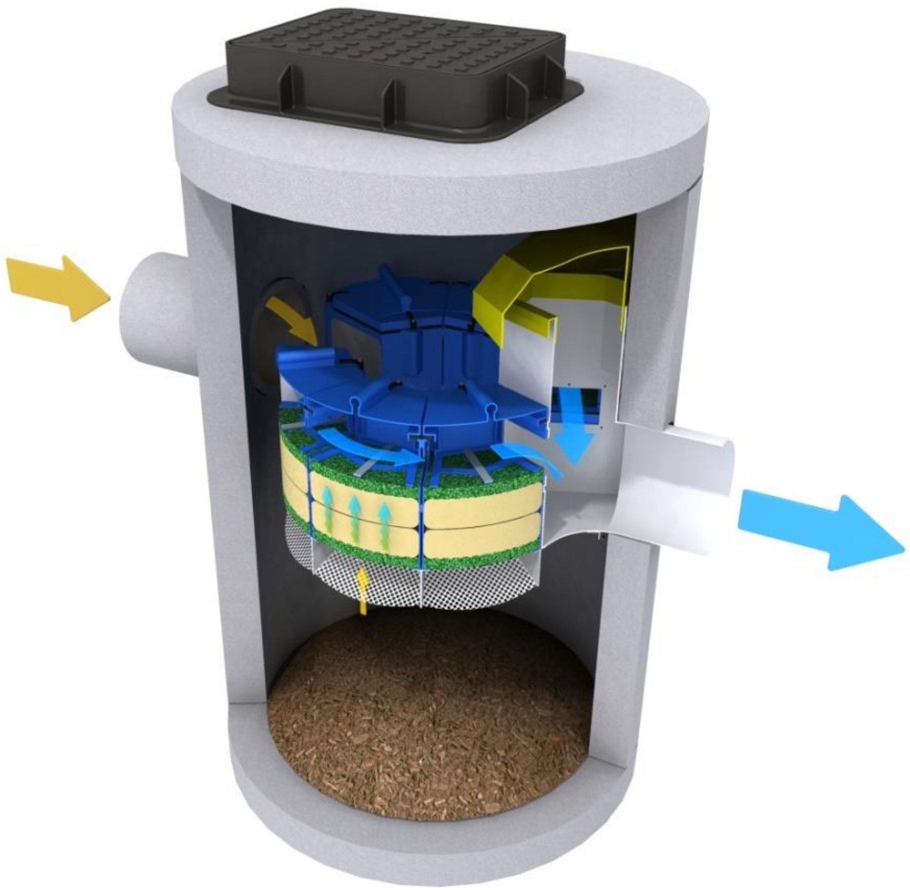
Up flow filtration advantages

- High throughput
- Clogging resistant
- Drain-down

  Prevents anaerobic conditions

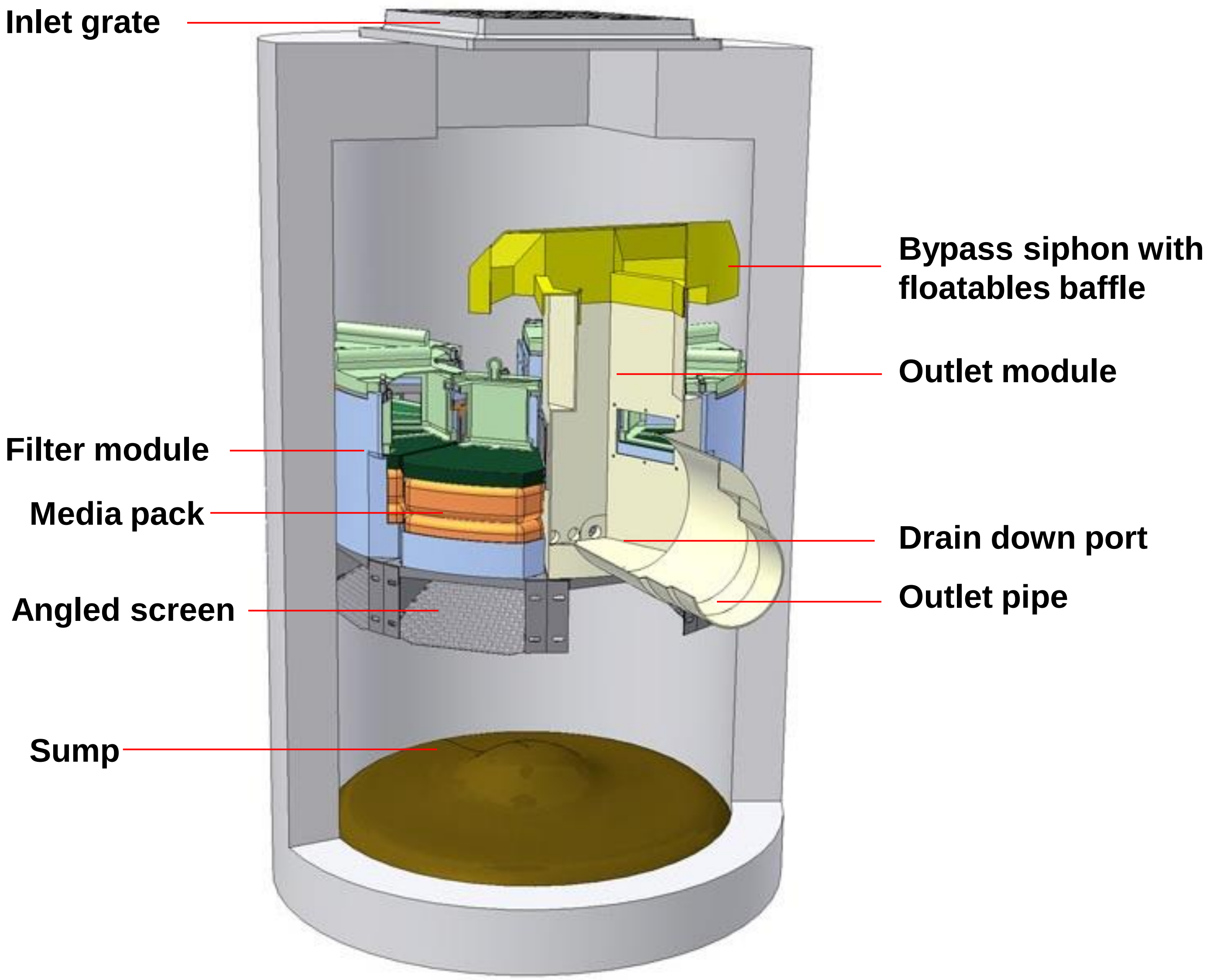
  Prevents pollutant leaching

  Back washes filter media

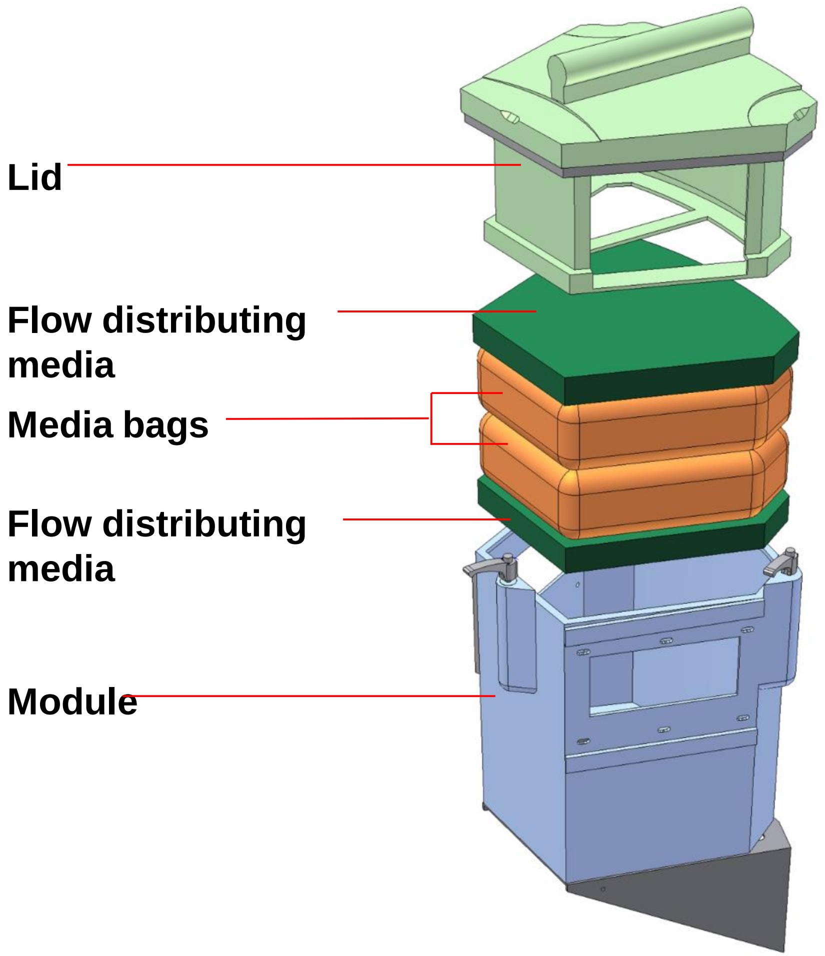


Up-Flo® Filter System Components

Hydro International®



Filter Module Components

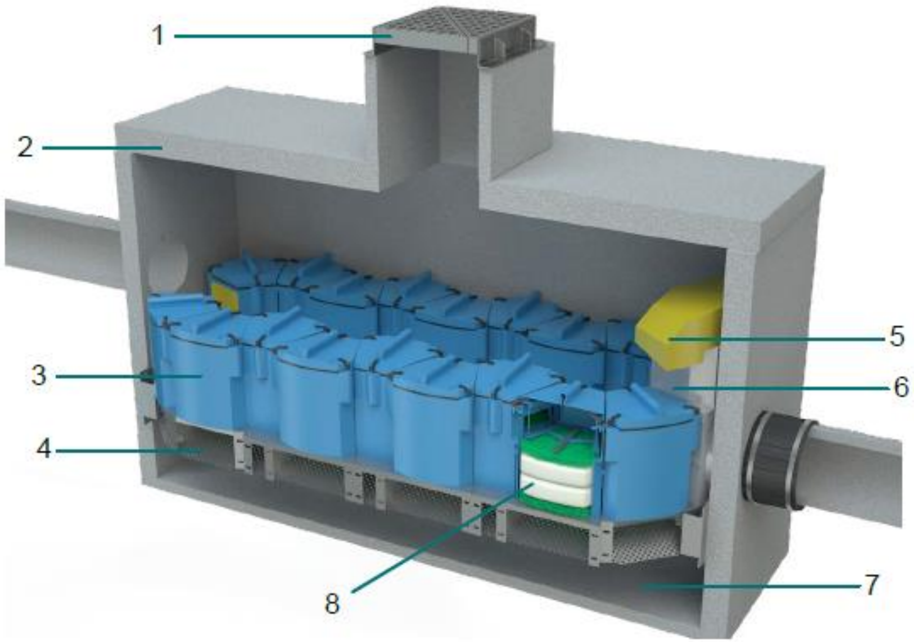


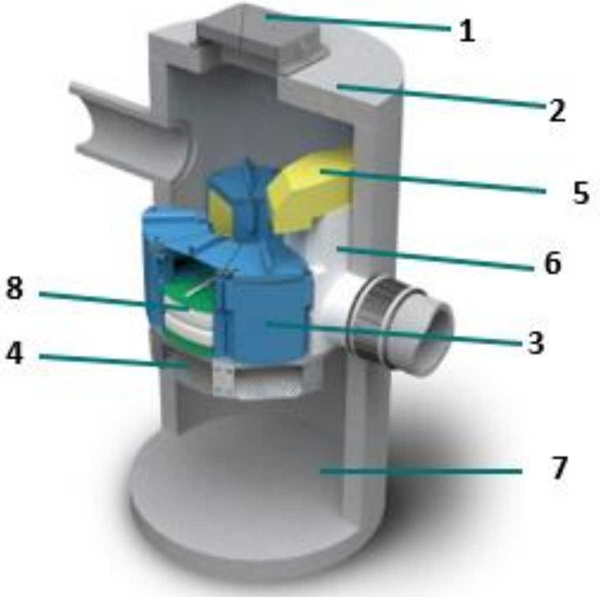
Up to 1.5l/s per Module

Configurations

System Components

1. Inlet grate (pictured) or Inlet Pipe (not shown)
2. Precast Filtration Chamber
3. Filter Module
4. 4mm Screening
5. Bypass Hood/Siphon
6. Outlet Module with Drain Down Filter
7. Pollutant Storage Sump
8. Media bags





Third Party Verification & Field Testing

The University of Alabama:

- Controlled field tests by sediment dosing
- 20 storms monitored for solids and a suite of pollutants
- Protocols follow US regulatory standards
- Third party verification with industry expert

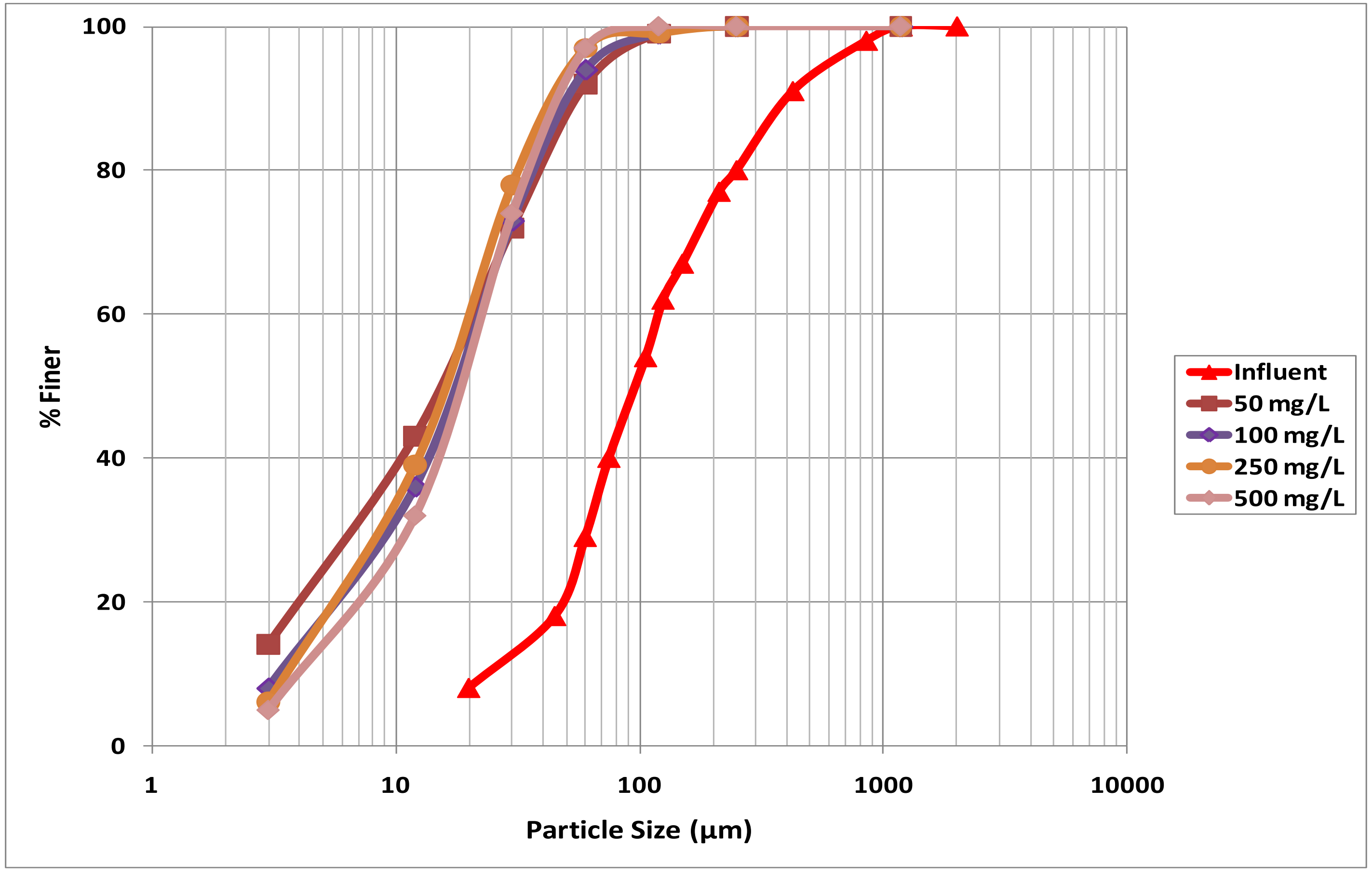
Sampling Methodology

River flow pumped to flow control chamber

Seeding of influent with mixed sediment

Grab sampling in outlet chamber

Particle Capture Results (Particle Seeding)



✓**Effluent PSDs are significantly finer (**d_{50} **< 20µm) when compared with the influent gradation (**d_{50} **~ 100µm)**

Particle Capture Results (Particle Seeding)

Particle Size (µm)	Average Influent Concentration (mg/L)	Average Effluent Concentration (mg/L)	Solids Reduction (%)
<0.45	165	123	26
0.45-3	20	3	84
3-12	74	15	79
12-30	93	21	78
30-60	50	11	77
60-120	6	2	73
120-250	3	0	94
250-1180	31	0	100
>1180	14	0	100
Total	**292**	**53**	**82**

Provides information of system performance for different particle size ranges

Particle Capture Results (Storm Monitoring)

Hydro International®

Particle size range (µm)	SS influent mass (lb)	SS effluent mass (lb)	Solids Reduction (%)
0.45-3	0.3	0.2	38.8
3.0-12.0	10.7	5.1	52
12.0-30.0	35.7	12.4	65.2
30-60	81.2	12.4	84.8
60-75	24.3	1.7	92.9
75-150	43	1.3	97.1
150-250	21.9	2.8	87.1
250-425	21.4	0.4	98.3
425-850	30.1	0	100
850-1400	21.2	0	100
1400-2000	15.7	0	100
2000-4760	17.6	0	100
>4760	10.9	0	100
Sum	**333.8**	**36.3**	**85.8**

✓**Results from actual storms show good correlation with controlled test results …**

Average of 20 storms

Maintenance

Inside view of a similarly sized Up-Flo Filter vault

Power washing of Up-Flo Filter components

View of spent media removed and brought above grade

Application of fresh Up-Flo Filter media

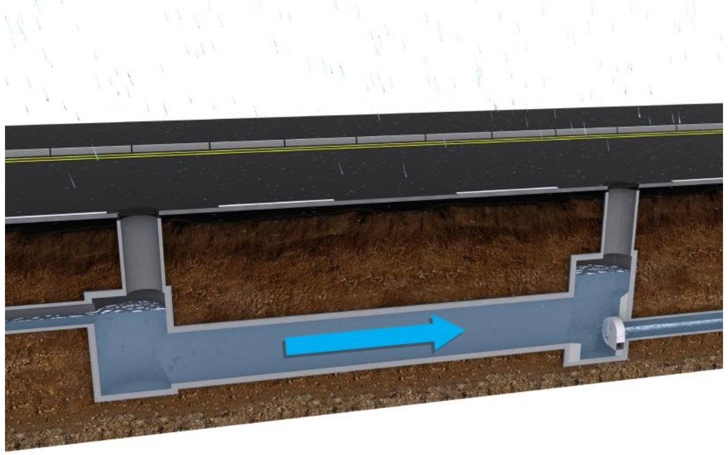
4. **Controlling your water Quantity** – Energy dissipation, Odor control and mitigation of hazards

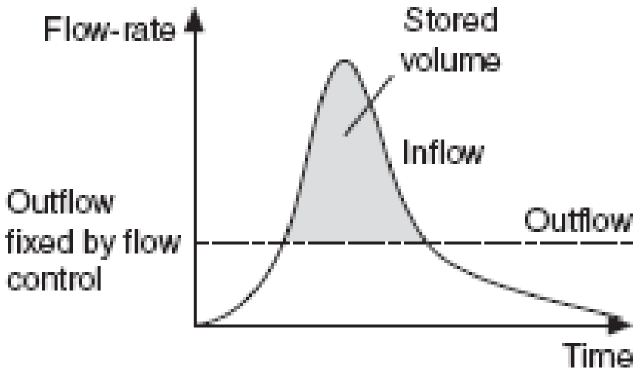
a. Hydro Brake® Optimum

Flow Attenuation Systems

- Functions
  - Minimise flood risk
  - Effectively transport pollutants

- Flow attenuation system = control + storage
  - A storage volume is required to prevent upstream flooding
  - Outflow control required to protect downstream from flow-rate/volume
    - Flow control influences the required storage volume and flood risk





$$I - O = \frac{dS}{dt}$$

I	inflow rate (m^3/s)
O	outflow rate (m^3/s)
S	stored volume (m^3)
t	time (s)

The Hydro-Brake Optimum®

S-Range

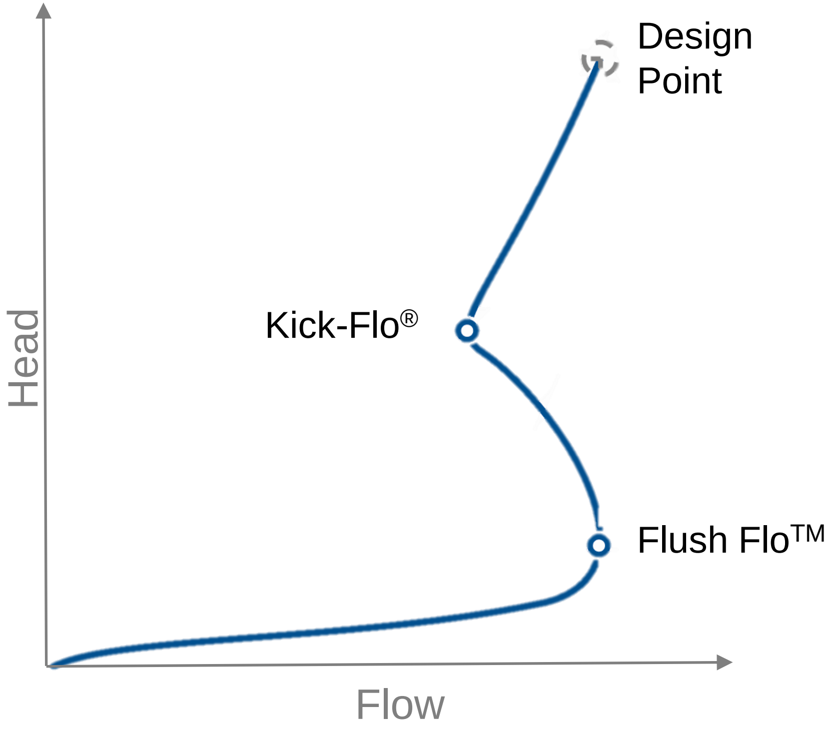
- Surface water only systems
- Requires sump

C-Range

- Foul / combined systems
- Surface water systems
- Sumpless systems

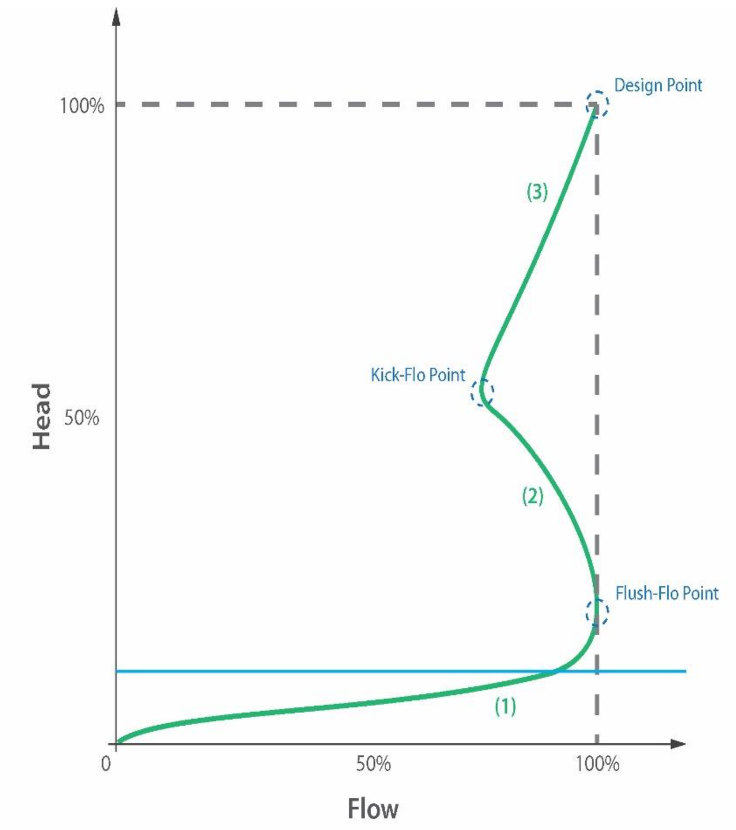
Hydro-Brake® Phases of Operation

1. Pre-initiation phase
2. Transition phase
3. Post-initiation phase



Phases of Operation

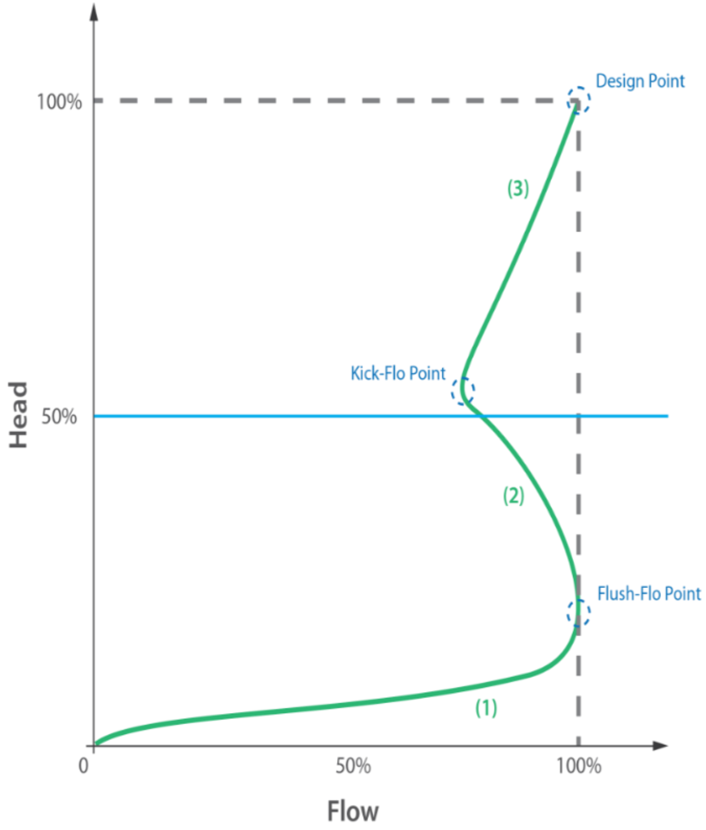
1. Pre-Initiation Phase



Essentially orifice flow $Q = C_d A\sqrt{(2gh)}$, with A being full cross sectional area of outlet orifice.

Phases of Operation

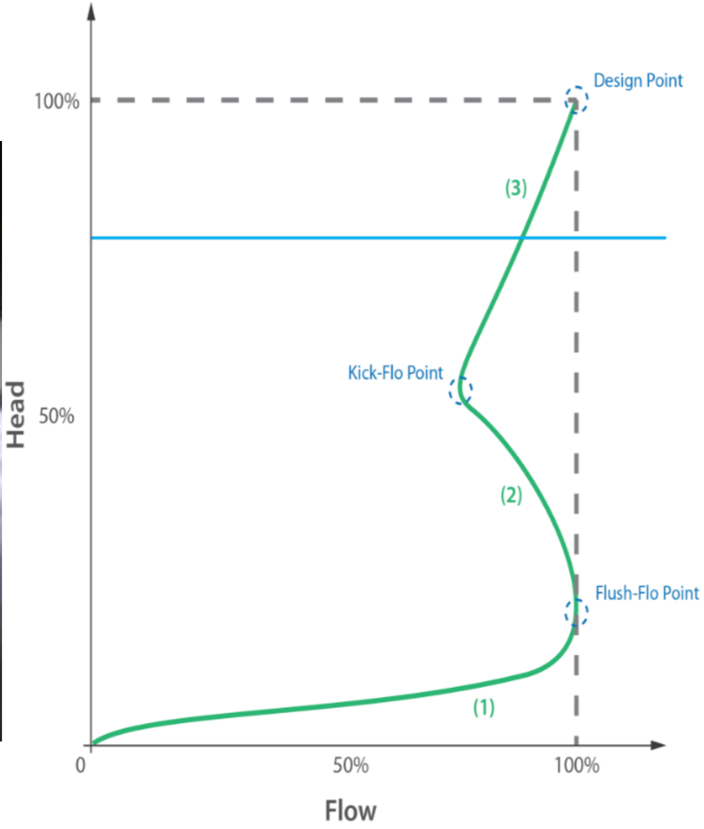
2. Transition Phase



Turbulent flow as vortex continually forms and collapses Trapped air pocket produces back pressure, which works against the flow.

Phases of Operation

3. Post Initiation Phase

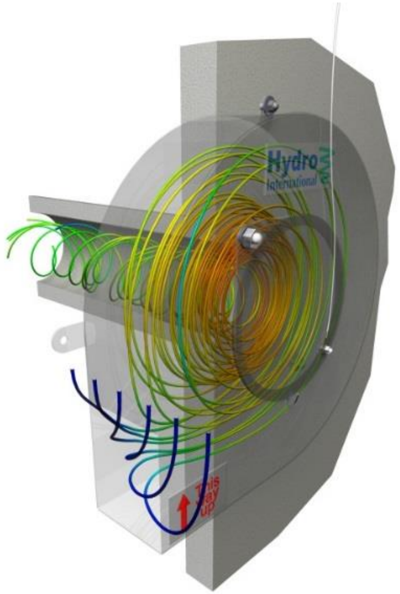


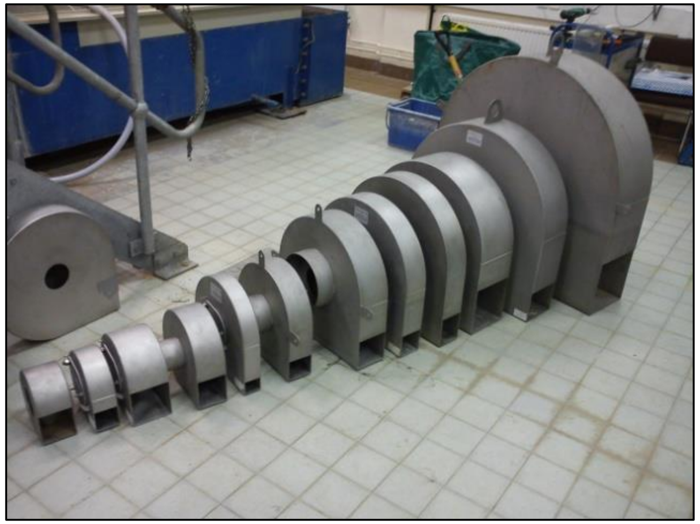
Hydraulic performance similar to orifice flow ($Q = C_d A\sqrt{(2gh)}$),with variable C_d and A being cross sectional area of outlet available for water flow (donut)

Why use the Hydro-Brake Optimum®?

Hydro International®

- The Hydro-Brake Optimum® Offers
  - Performance backed by significant R&D Investment





Why use the Hydro-Brake Optimum®?

Hydro International®

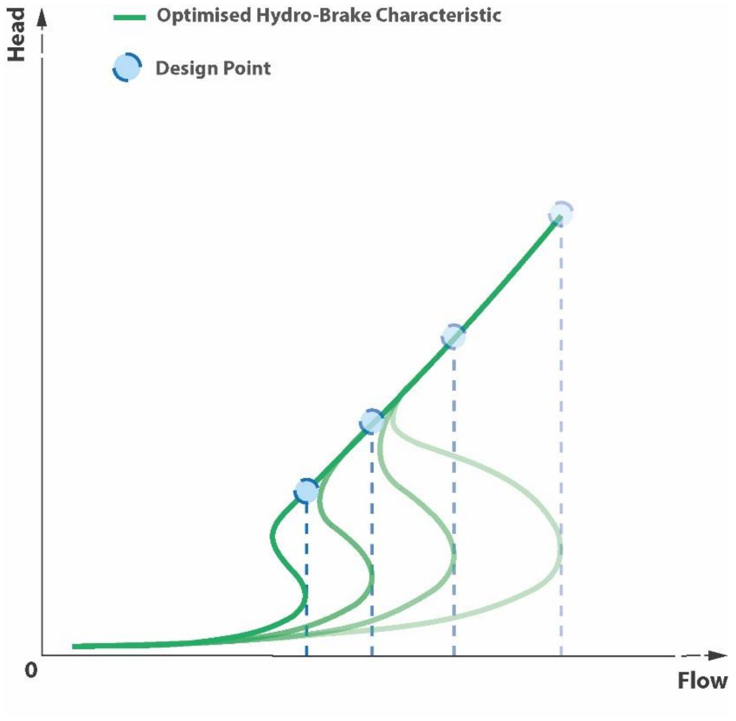
- The Hydro-Brake Optimum® Offers
    - Independent design and performance accreditation

BBA APPROVAL INSPECTION TESTING CERTIFICATION
CERTIFICATE No 08/4596

WRc APPROVED
PT/329/0412

Advantages

- The Hydro-Brake Optimum® Offers
  - Unique tailoring of full response characteristic

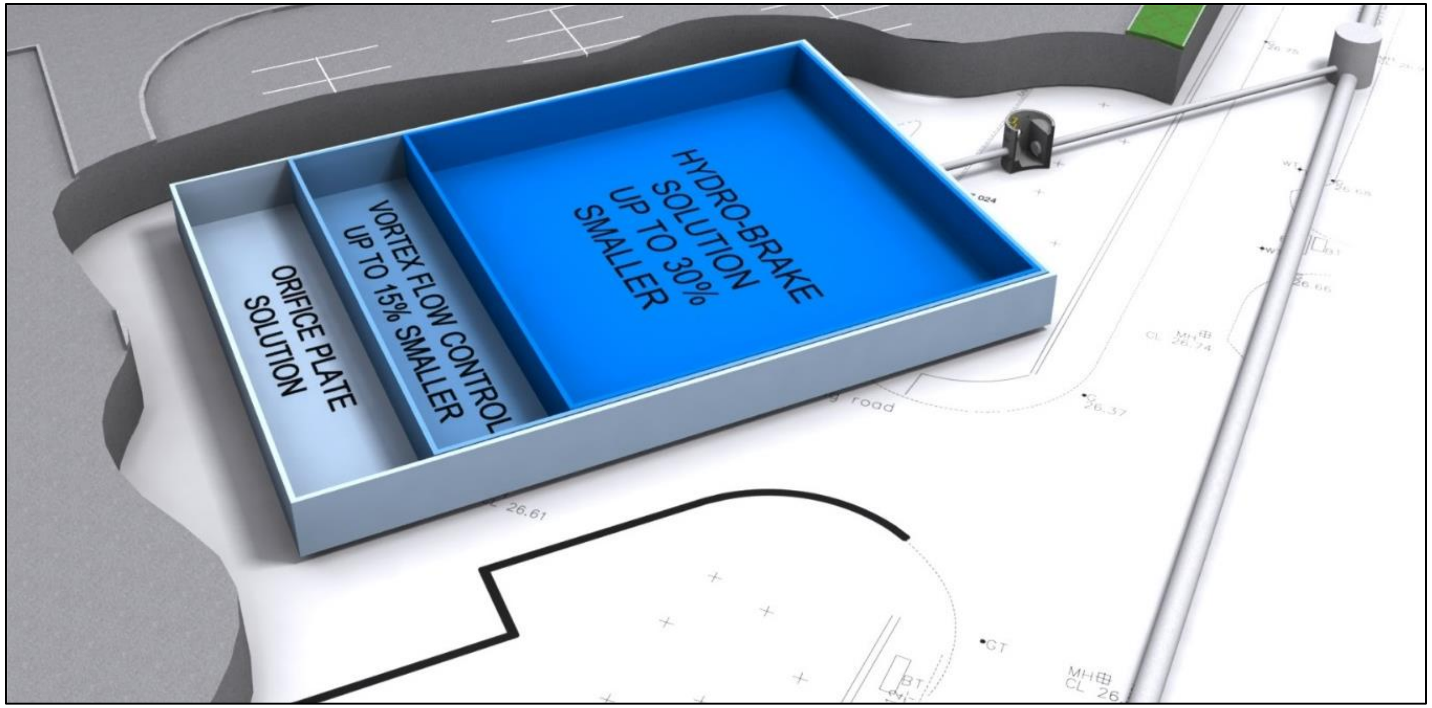


Advantages

- The Hydro-Brake Optimum® Offers
  - Unique tailoring of full response characteristic

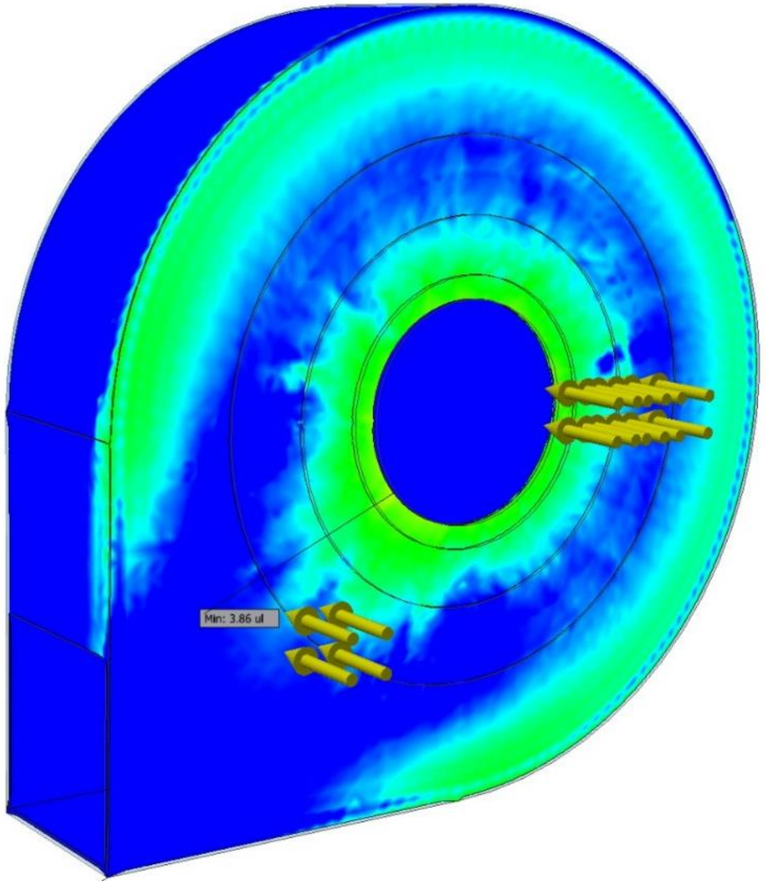
Advantages

- The Hydro-Brake Optimum® Offers
  - Up to 15% storage saving compared to other vortex flow controls



Advantages

- The Hydro-Brake Optimum® Offers
  - Verified structural fit for purpose



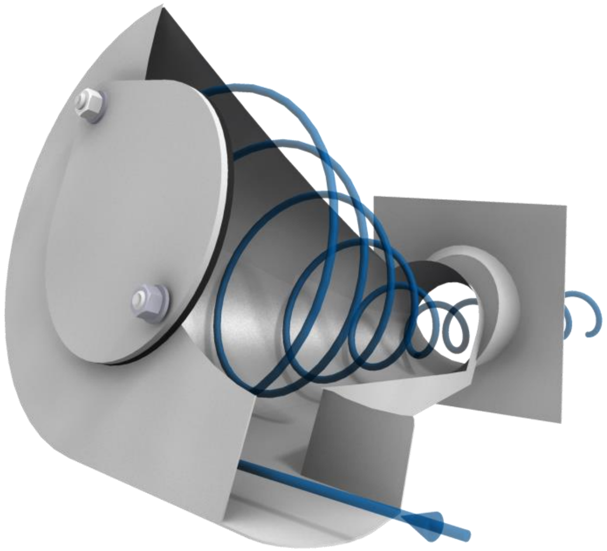
Advantages

Hydro International®

- The Hydro-Brake Optimum® Offers
  - Integral by-pass door design in line with outlet

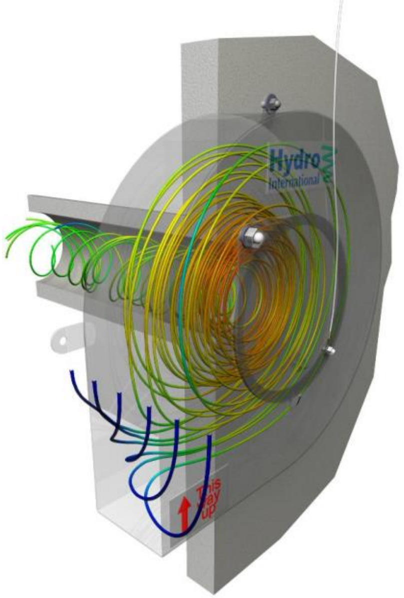
Why use the Hydro-Brake Optimum®?

- Performance
  - Out performs conventional throttle based solutions
    - Increased pass forward flows
      - Reduces frequency of flooding upstream
      - Minimise land-take
    - Optimises forward flow into downstream network
- Larger Cross Sectional Area
  - Up to 600% larger than conventional throttle devices
  - Significantly reduces the risk of blockage
- Self-Activating
  - Accurate, reliable and proven technology
  - No moving parts
  - No power requirements
  - Fail safe
- Water Quality Benefits
  - Aeration of Flows
  - Reduction of scour and erosion



BBA & WRc Certification

- Assessment Criteria:
  - Compliance with building regulations
  - Hydraulic Assessment
    - Experimental testing
    - CFD predictions
  - Structural analysis
  - Evaluation of the design and proposal process
  - QA auditing of production facility
  - Random assessment of production units
  - Assessment of installation procedures
  - Formal three-yearly review



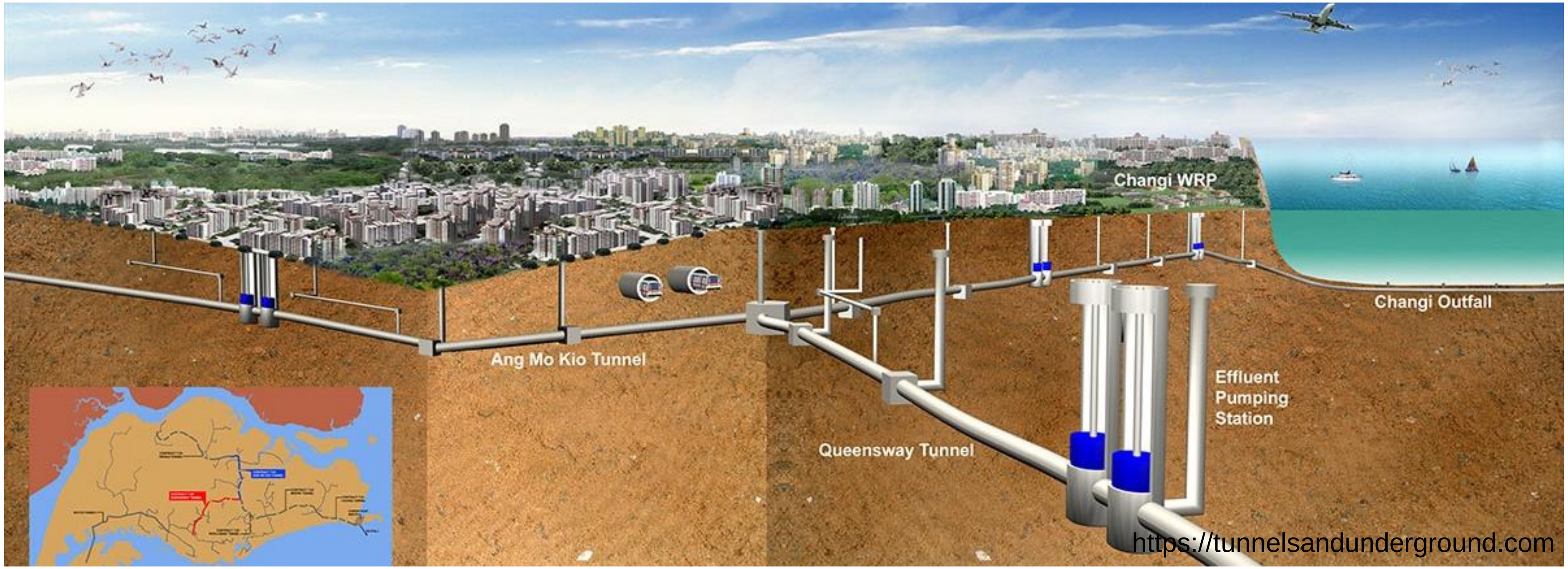
“In the opinion of the BBA, the units will have a design life in excess of the design life of typical structures in which they might be installed.”

WRc APPROVED

BBA APPROVAL INSPECTION TESTING CERTIFICATION
CERTIFICATE No 08/4596

b. Hydro Vortex Drop Shafts

The need for vortex drop shafts



Design Parameters & Requirements

- Parameters
  - Flow-rate
  - Drop height

- Other considerations
  - Hydraulic hazards
  - Pneumatics
  - Odour
  - Corrosion
  - Grit & debris

Objective

Hydro International

Safely convey a varying quantity of water from a high level to a low level along a desired path.

Typical power dissipation range: 0.01 MW – 10 MW

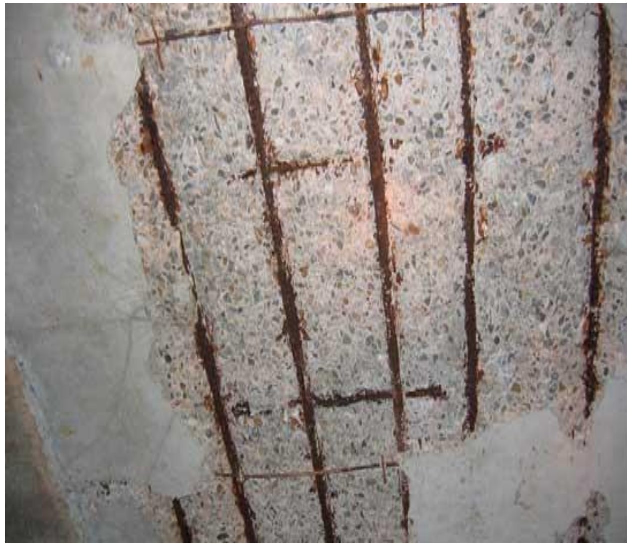
$$P = q\rho g h$$

- Hazards:

Erosion Hydraulic shocks Cavitation Vibration

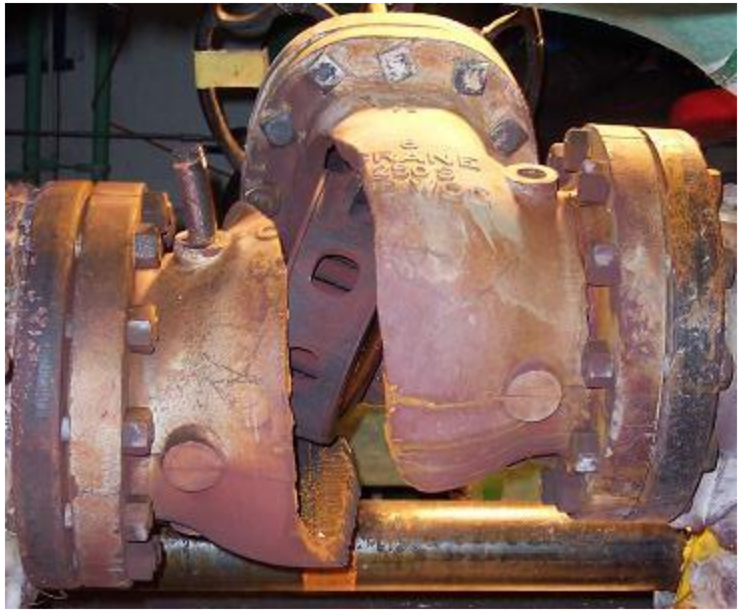
Erosion

- Thrust and shear force of water
- Impact of objects in flow



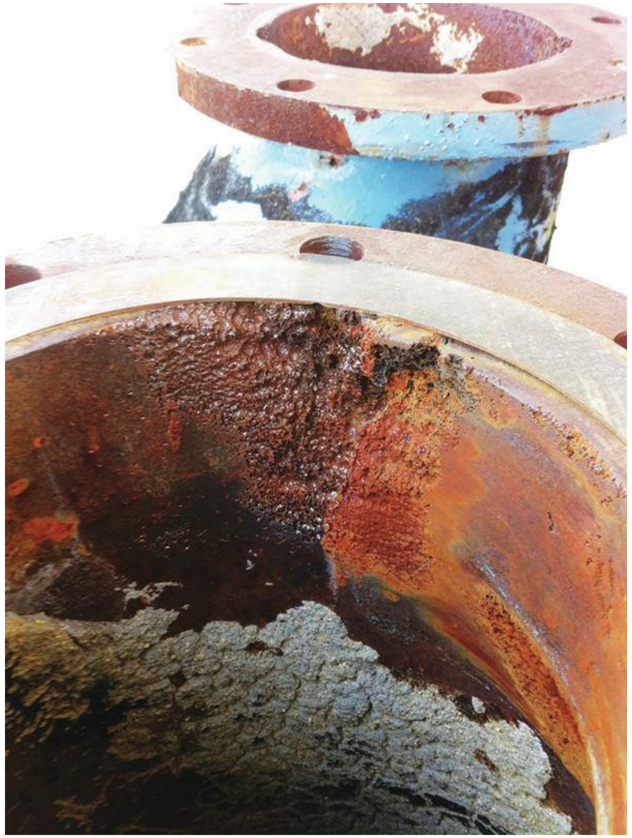
Hydraulic Shock (Water Hammer)

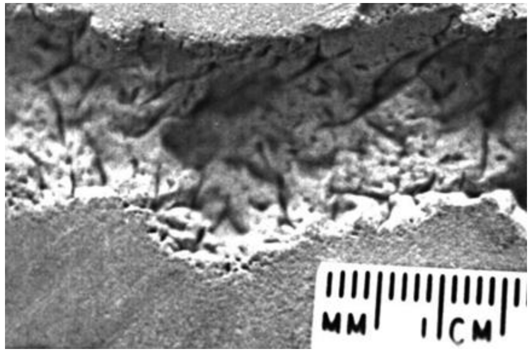
- Entrainment of air or rapid change in flow-rate

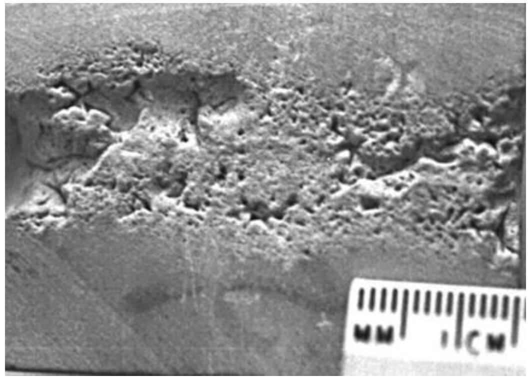


Cavitation

- Formation and collapse of water vapour bubbles

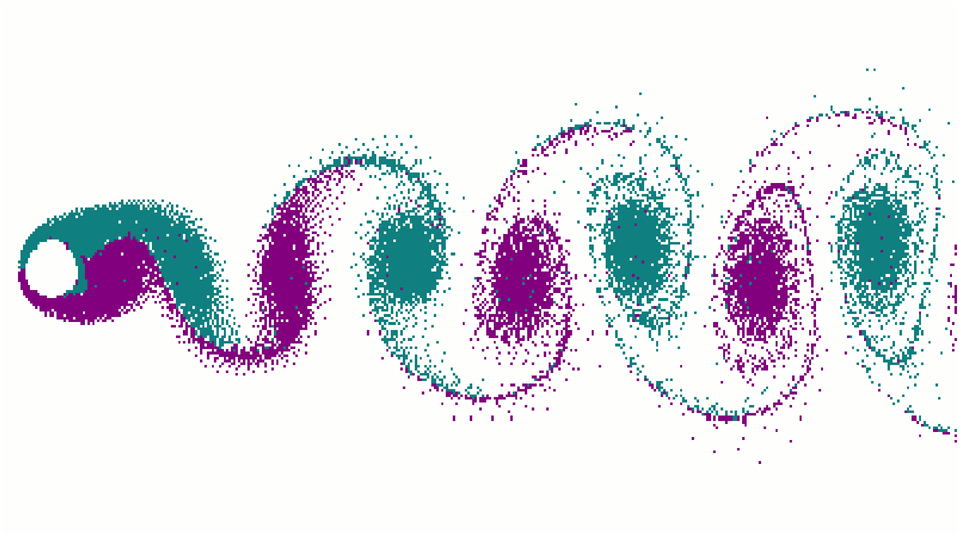






Vibration & Noise

- Vortex shedding + previous hazards



History

History of Drop Structure Design

Italy – Drioli 1940’s
UK - Ackers & Crump 1960’s
US – Jain & Kennedy 1980’s

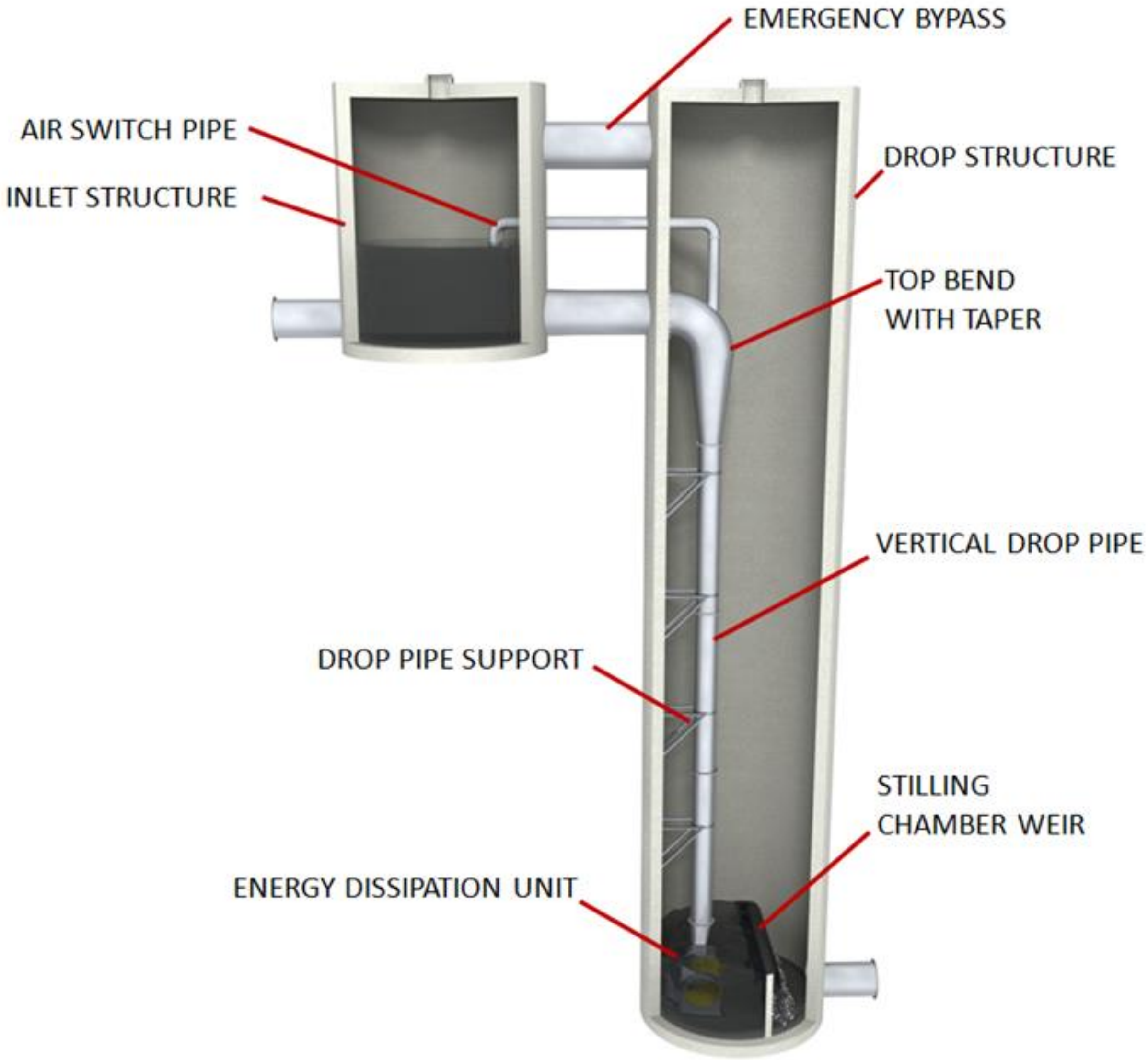
Hydro Vortex Drop Shaft

Hydro Vortex Drop Shaft

Hydro International

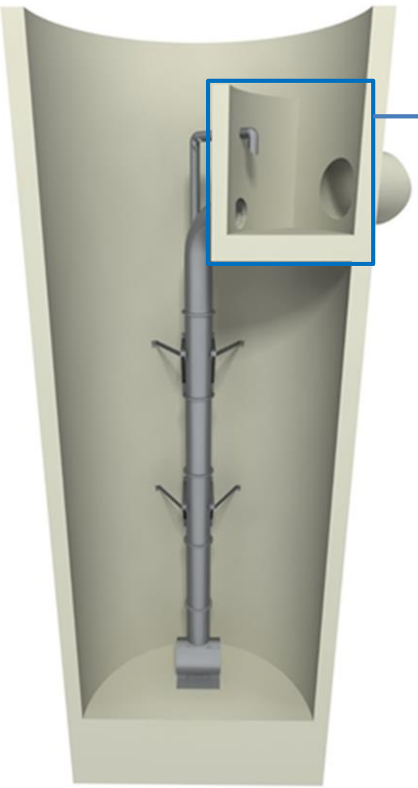
- ✓ Significant cost savings on construction
- ✓ Smaller footprint & pipe sizes
- ✓ Erosion, corrosion & odour control
- ✓ Reduction of noise and vibration at high flow rates
- ✓ No maintenance
- ✓ Versatile design with simple construction and installation

Hydro Vortex Drop Shaft Components



Integrated Inlet Design

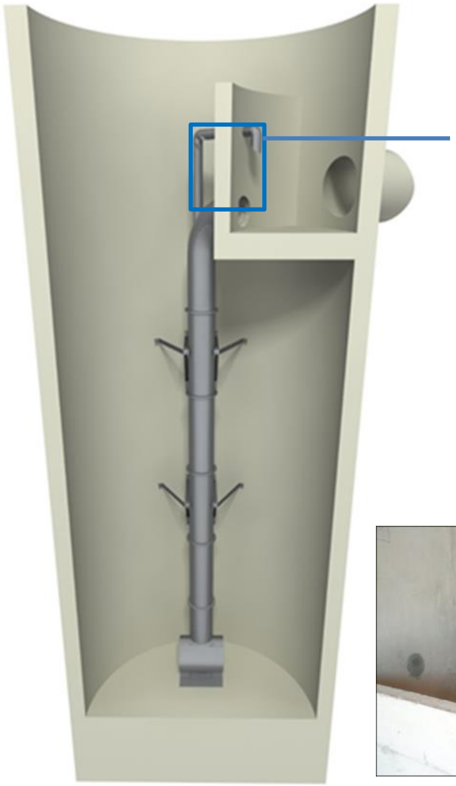
Components



Inlet Chamber

- Quiescent zone
- Minimises H_2S release
- Regulates flow-rate with air switch
- Parallel installations

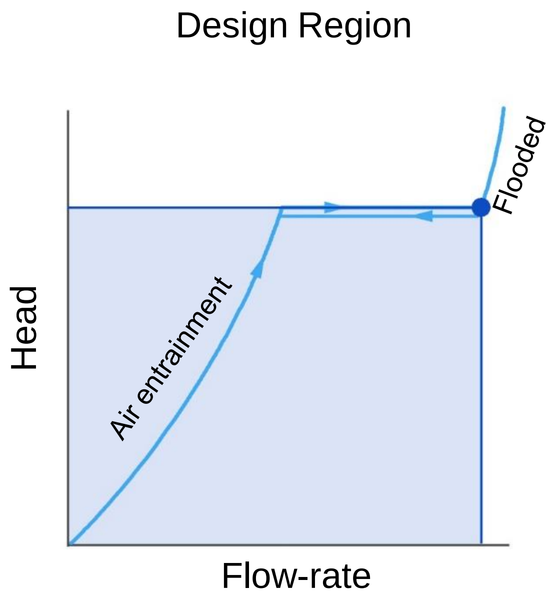
Components



Air switch

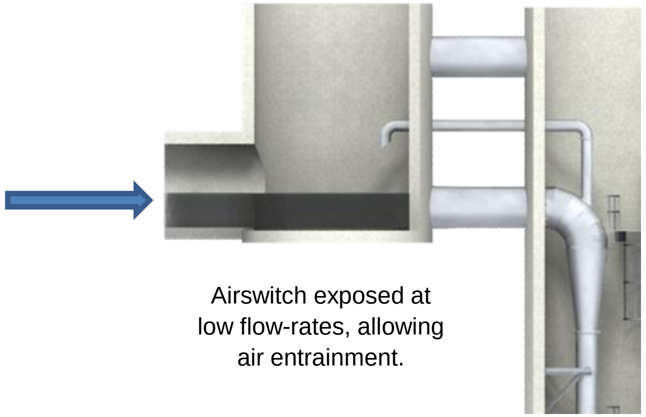
- Regulates air entrainment
- Prevents hydraulic shocks
- Minimises vibration at high flow-rates

Transition Phase



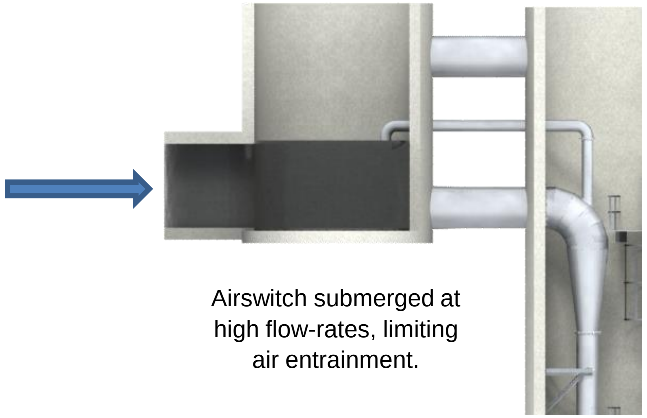
Air Switch

Low flow-rate



Airswitch exposed at
low flow-rates, allowing
air entrainment.

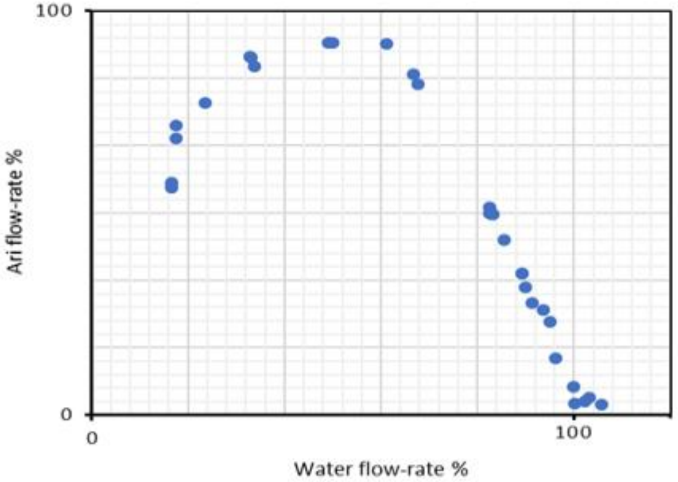
High flow-rate



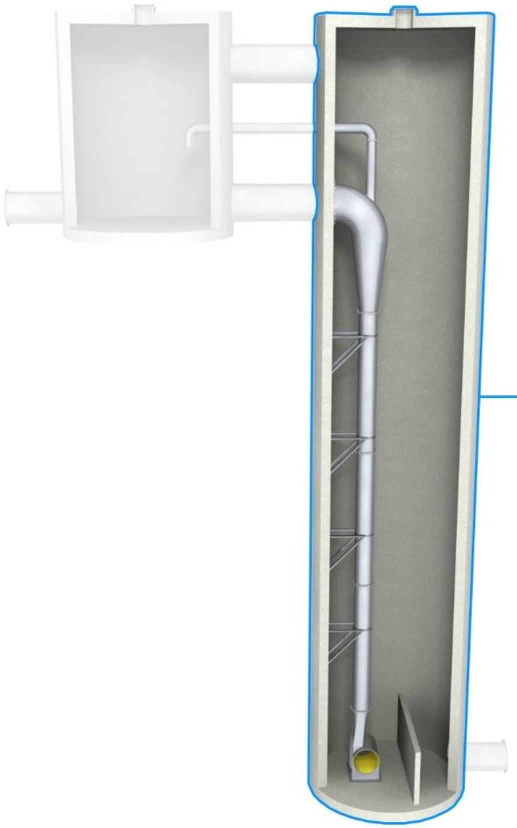
Airswitch submerged at
high flow-rates, limiting
air entrainment.

Pneumatic Control

Limits air entrainment at high flow-rates to prevent sewer pressurization

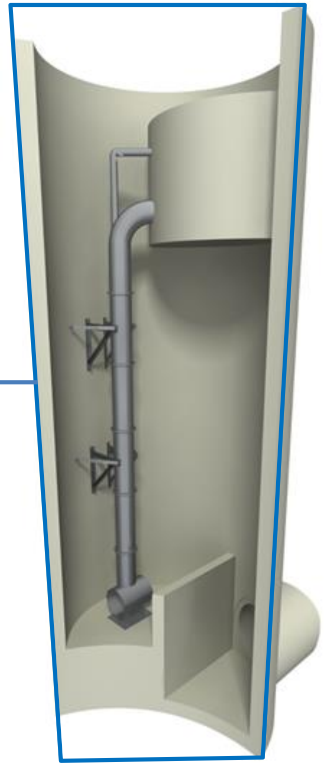


Components

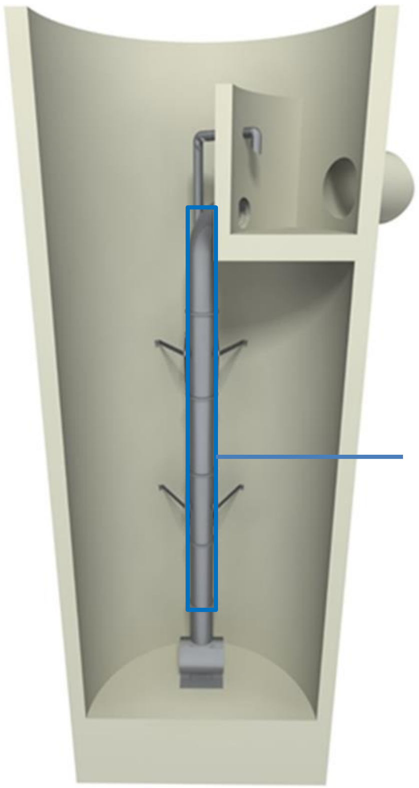


Housing Shaft

- Hybrid system
- Access & Inspection
- Ventilation
- Multiple drop pipes
- Optional bypass

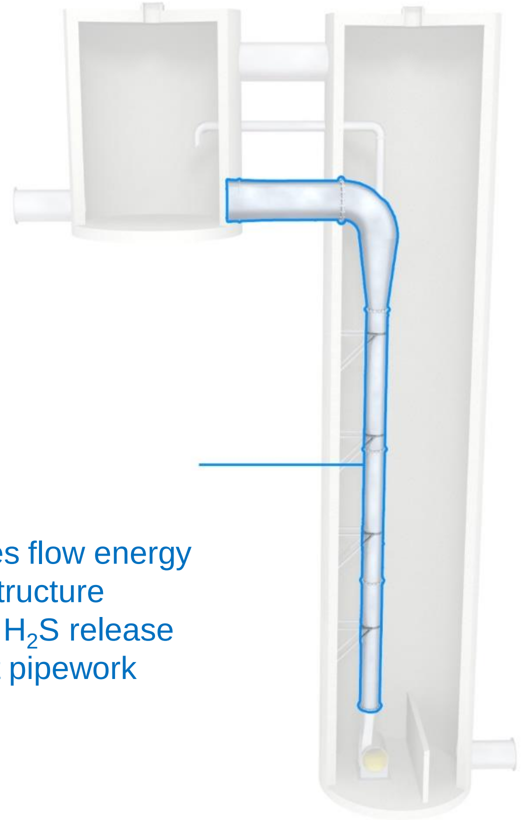


Components

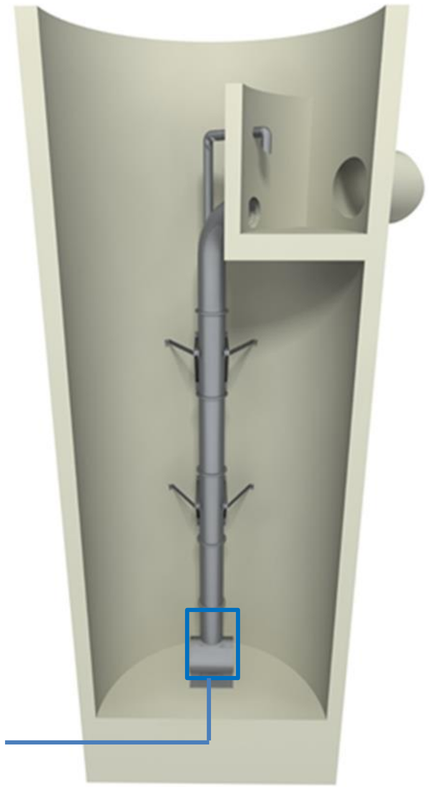


Drop Pipe

- Dissipates flow energy
- Closed structure prevents H_2S release
- Compact pipework



Components



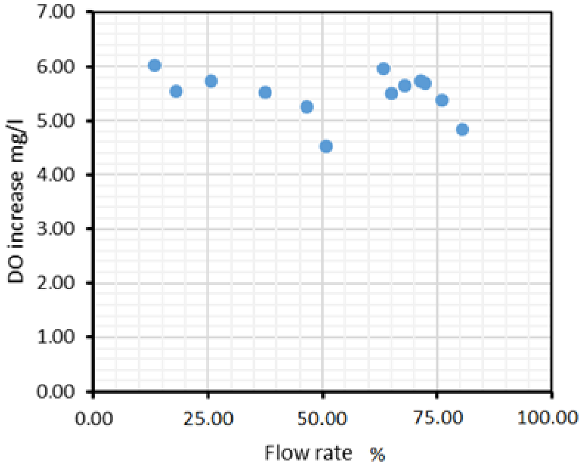
Energy Dissipation Unit

- Maximises turbulence & dissolved oxygen
- Minimises erosion

Odour Prevention

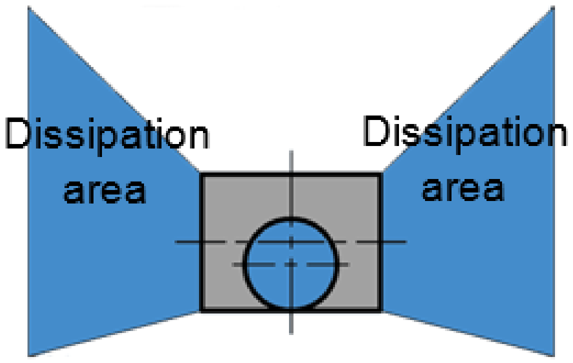
Hydro International

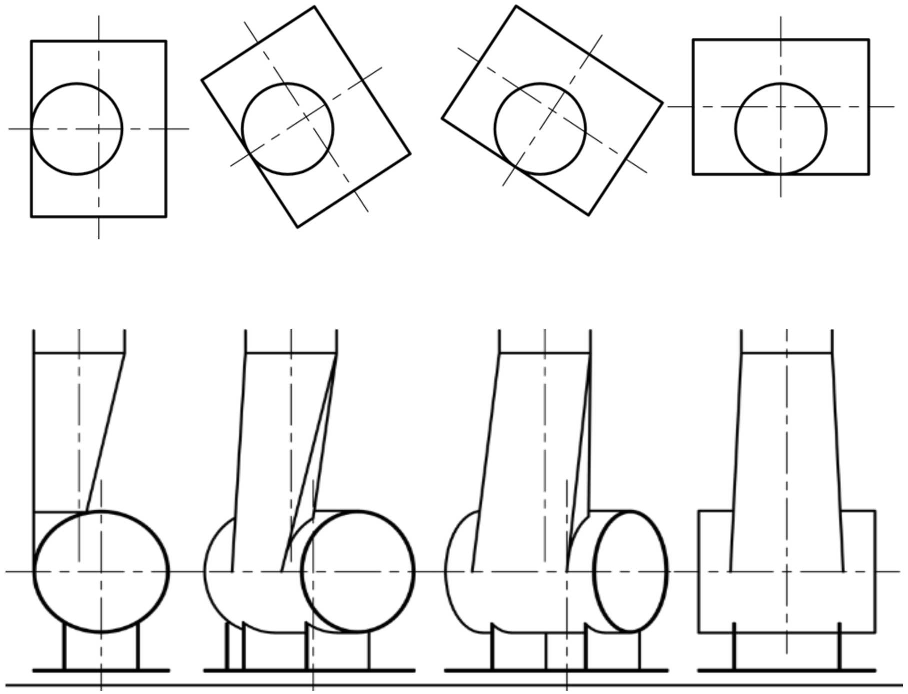
Increases DO concentrations by 600% for wastewater
Prevents H2S formation by maintaining DO concentration > 1mg/l



Detailed Design

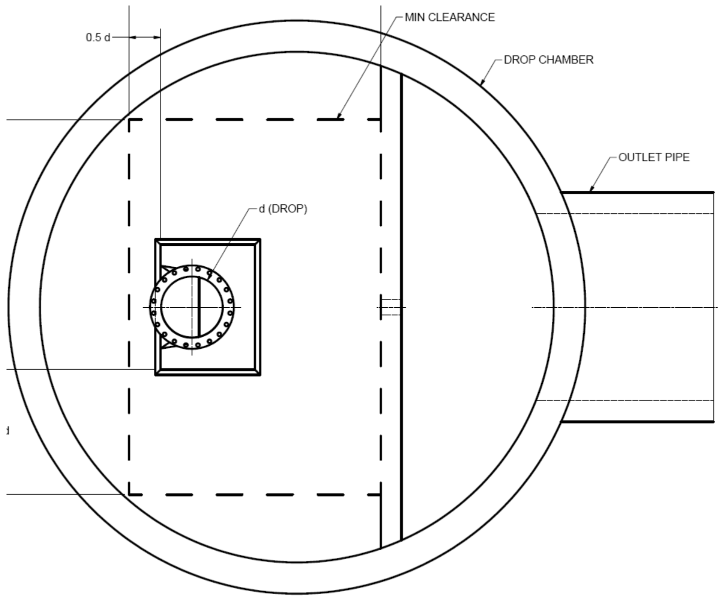
- Energy dissipation unit

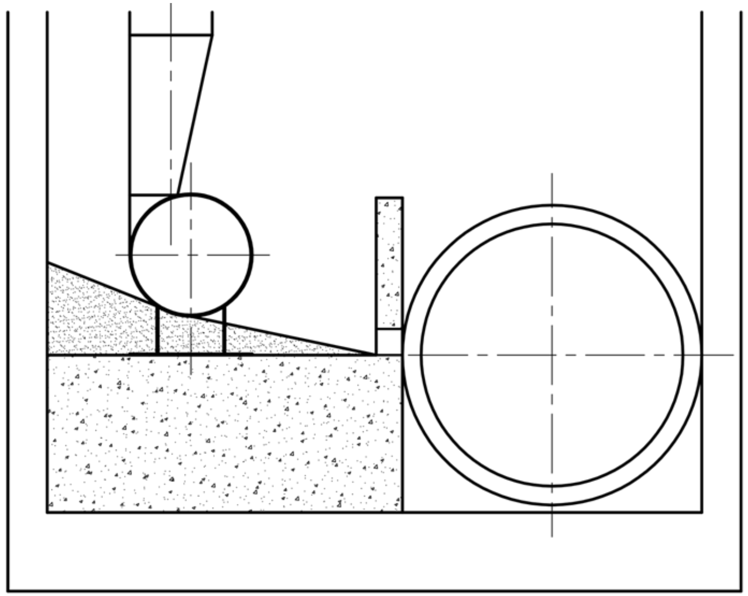




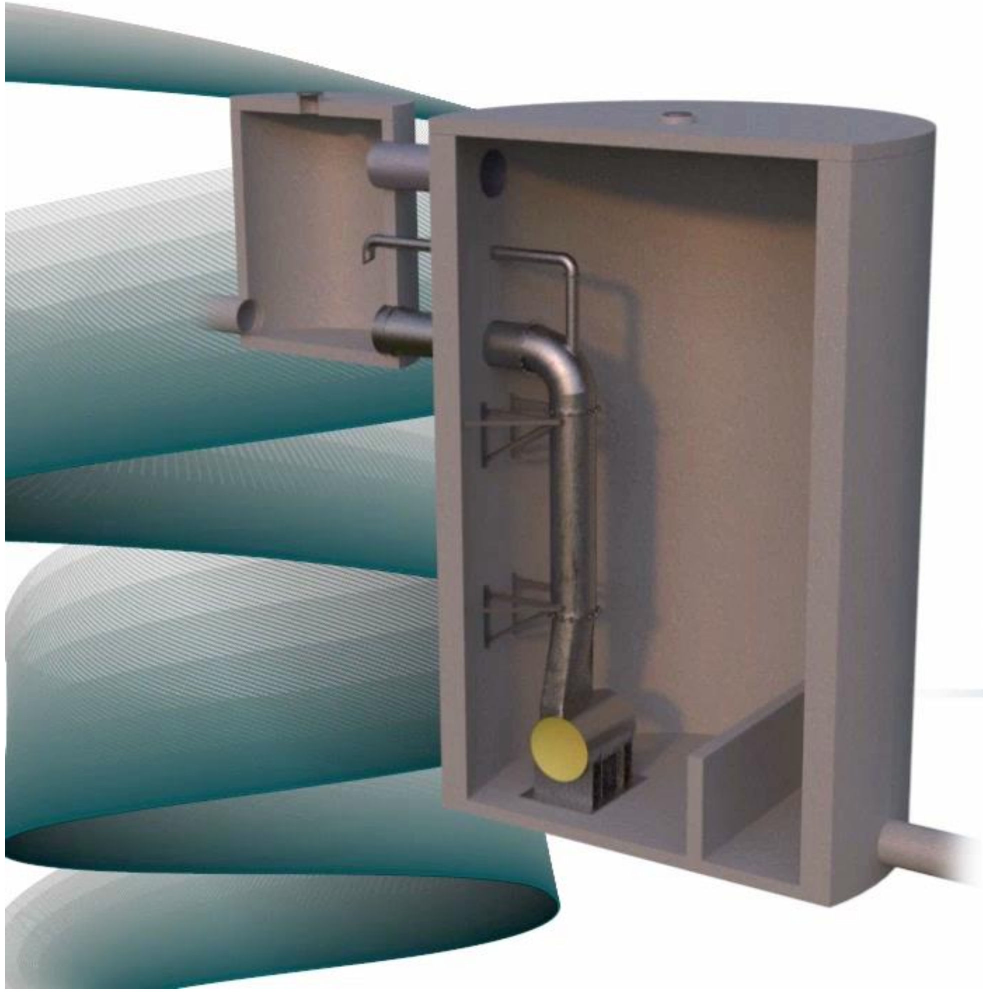
Detailed Design

- Dissipation chamber





Hydro International



Hydro-Brake® Drop

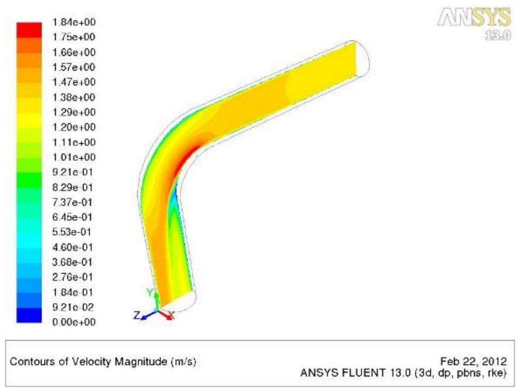
Self Activating Drop System

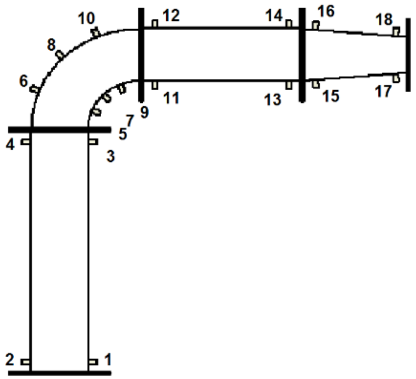
Design Flexibility

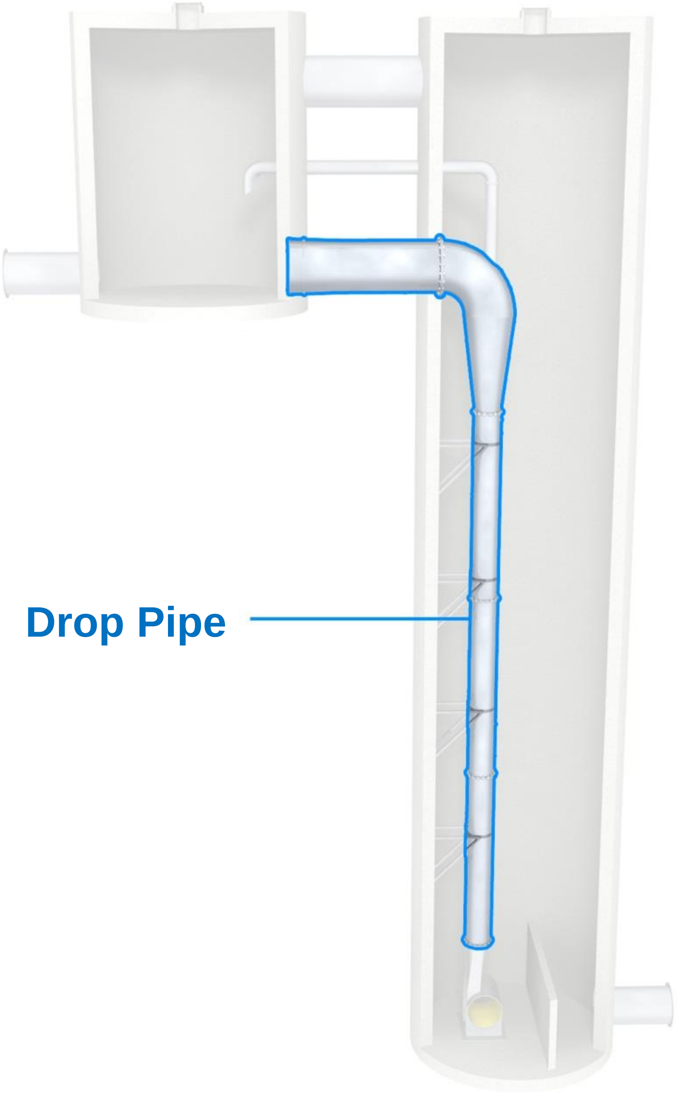
Material Selection

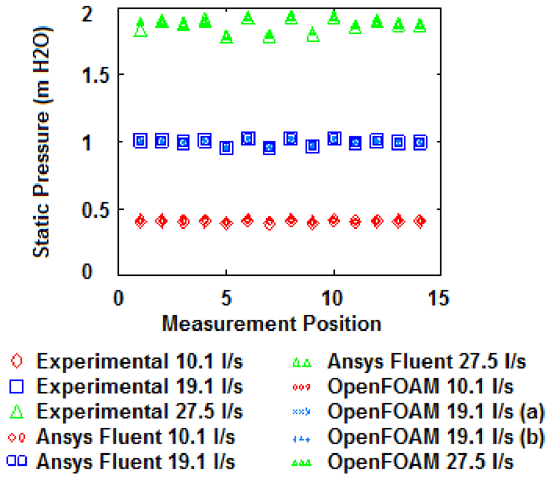
Detailed Design

Laboratory and CFD Analysis



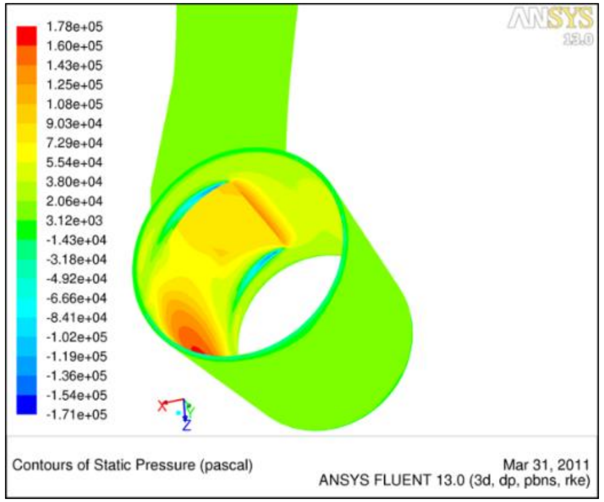


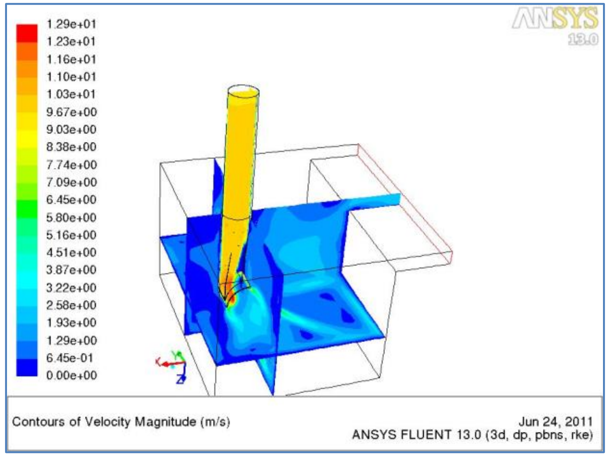




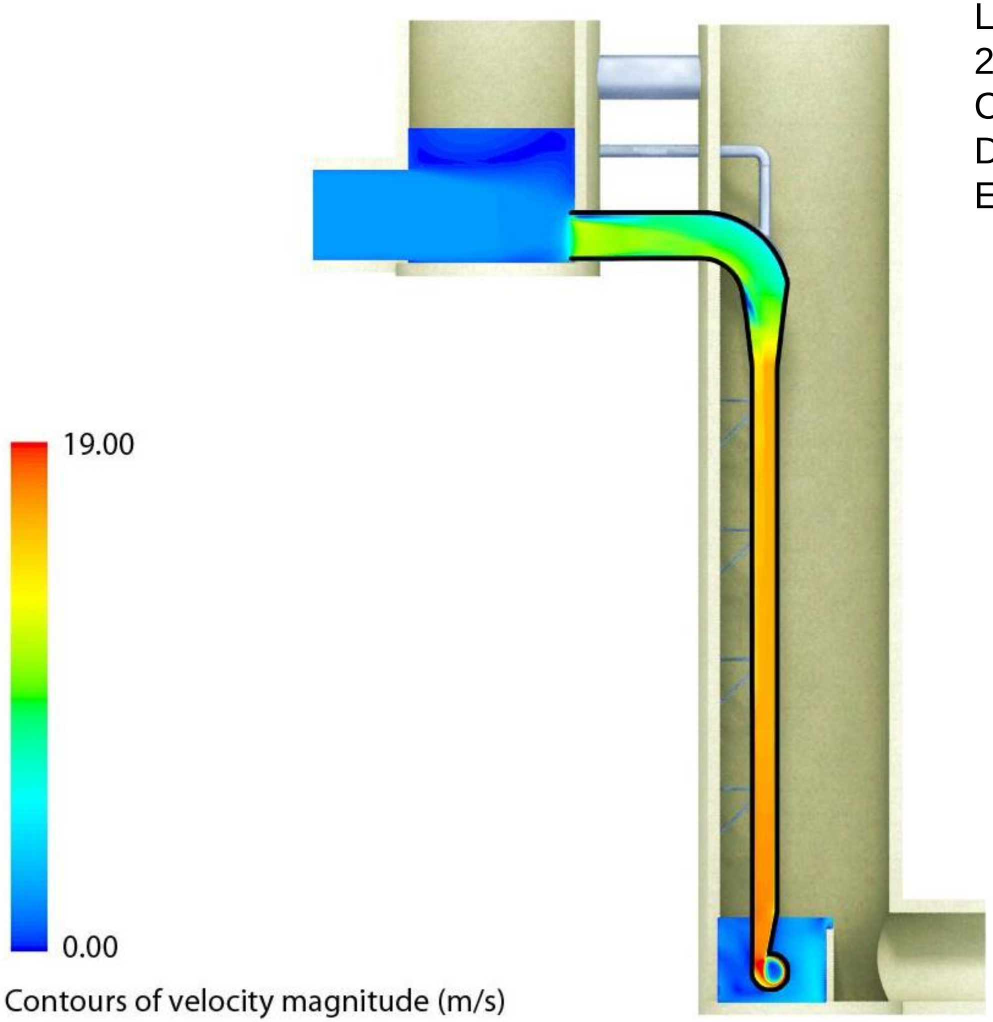
Laboratory and CFD Analysis

Energy Dissipation Unit

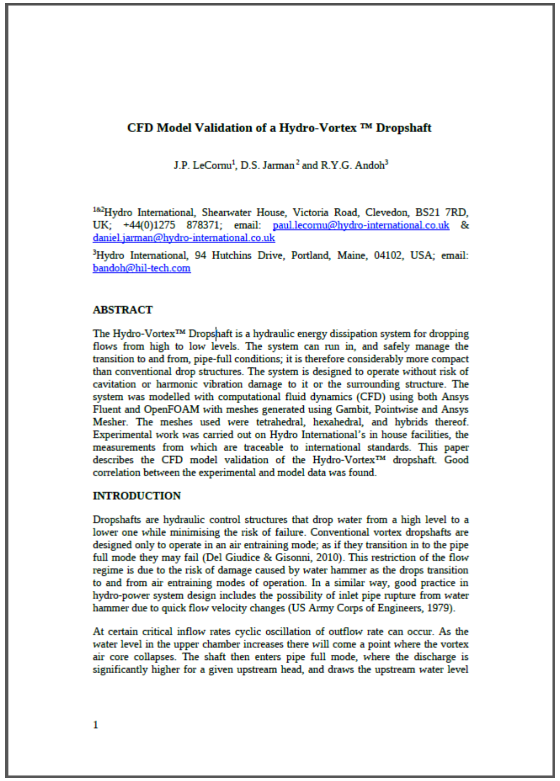




Laboratory and CFD Analysis



LeCornu JP, Jarman DS, & Andoh RYG. 2012.
CFD Model Validation of a Hydro Vortex Dropshaft.
EWRI 2012, May 2012, Albuquerque, NM



CFD Model Validation of a Hydro-Vortex ™ Dropshaft

J.P. LeCornu[1], D.S. Jarman[2] and R.Y.G. Andoh[3]

[1&2]Hydro International, Shearwater House, Victoria Road, Clevedon, BS21 7RD, UK; +44(0)1275 878371; email: paul.lecornu@hydro-international.co.uk & daniel.jarman@hydro-international.co.uk

[3]Hydro International, 94 Hutchins Drive, Portland, Maine, 04102, USA; email: bandoh@hil-tech.com

ABSTRACT

The Hydro-Vortex™ Dropshaft is a hydraulic energy dissipation system for dropping flows from high to low levels. The system can run in, and safely manage the transition to and from, pipe-full conditions; it is therefore considerably more compact than conventional drop structures. The system is designed to operate without risk of cavitation or harmonic vibration damage to it or the surrounding structure. The system was modelled with computational fluid dynamics (CFD) using both Ansys Fluent and OpenFOAM with meshes generated using Gambit, Pointwise and Ansys Mesher. The meshes used were tetrahedral, hexahedral, and hybrids thereof. Experimental work was carried out on Hydro International's in house facilities, the measurements from which are traceable to international standards. This paper describes the CFD model validation of the Hydro-Vortex™ dropshaft. Good correlation between the experimental and model data was found.

INTRODUCTION

Dropshafts are hydraulic control structures that drop water from a high level to a lower one while minimising the risk of failure. Conventional vortex dropshafts are designed only to operate in an air entraining mode; as if they transition in to the pipe full mode they may fail (Del Giudice & Gisonni, 2010). This restriction of the flow regime is due to the risk of damage caused by water hammer as the drops transition to and from air entraining modes of operation. In a similar way, good practice in hydro-power system design includes the possibility of inlet pipe rupture from water hammer due to quick flow velocity changes (US Army Corps of Engineers, 1979).

At certain critical inflow rates cyclic oscillation of outflow rate can occur. As the water level in the upper chamber increases there will come a point where the vortex air core collapses. The shaft then enters pipe full mode, where the discharge is significantly higher for a given upstream head, and draws the upstream water level

1

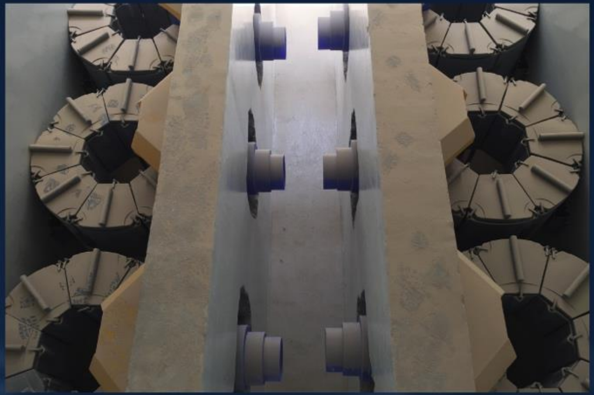
5. Local and International Projects References

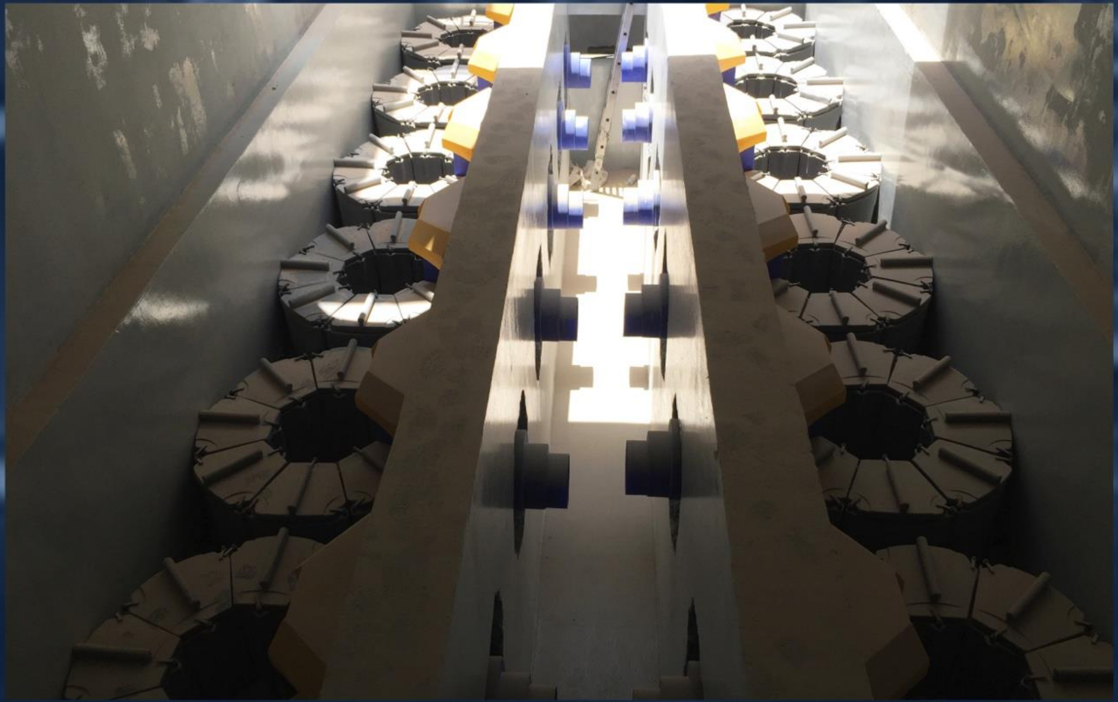
WT BURDEN drainage&civils landscape street furniture | Hydro International

Al Muntazah Street

- 43,050m^3 Water Storage Capacity
- 26 Inflitration Tanks
- 46 Downstream Defenders
- 20 Hydro Brakes
- 2 Drop Shafts

Bani Hajer





34 Up-Flo Filters

8 Downstream Defenders

7 Hydro Brakes

WT BURDEN drainage&civils landscape street furniture | Hydro International

AS-01 Shaft Pumping Station

>7000l/s Peak Treatment flow rate

10 Downstream Defenders

First Installation above ground

Al Khor Expressway

>28,500l/s Carrying Combined

16 Vortex Drop Shafts

WT BURDEN drainage&civils landscape street furniture | Hydro International

Doha Industrial Area

>20,250l/s Carrying Combined

16 Vortex Drop Shafts

One of the largest Hydro Brake in Doha at 6000lps flow rate - 14m head

WT BURDEN drainage&civils landscape street furniture | Hydro International

E-Ring Road

>10,600l/s Carrying Combined

3 Vortex Drop Shafts

WT BURDEN drainage&civils landscape street furniture | Hydro International

Qetaifan Island, Lusail City

>6,300l/s Peak Treatment flow rate

14 Downstream Defenders

Al Rayyan

Flow rate: 200 l/s
Head: 4 m

WT BURDEN
drainage&civils landscape street furniture
Hydro International

Doha Industrial Area

Flow rate: 6000 l/s
Hydraulic Head:14 m

Lusail City - Qatar 2014

Road drainage
Total flow = 4,500 l/s
8x 8.9m – 19.7m drop heights
150 kW maximum dissipation
Design criteria
Corrosion
Design life

City of Bristol - UK 1962

Relief sewer
Combined system
5,000 l/s
45m Design drop
2.2 MW dissipation
Design criteria
Safety
No cavitation

Cardiff West - UK 1996

Flood prevention scheme involved diverting flow into new deep tunnel drainage network.

Stormwater deep tunnel bypass
Drop height 28 m

Handling peak flow of 2,500 l/s
2x 450/600 mm drop pipes;

Power dissipation = 0.75 MW
Design criteria
Compact
Noise (urban area)

White Cart Flood Attenuation Scheme

Flow rate: 33,000 l/s

Hydraulic Head: 7.6 m

VDOT: Highway Application

Five Up-Flo Filter units

6. Q&A

WT BURDEN
drainage&civils landscape street furniture

Hydro International

THANK YOU