Stormwater Treatment Systems Independent Verification

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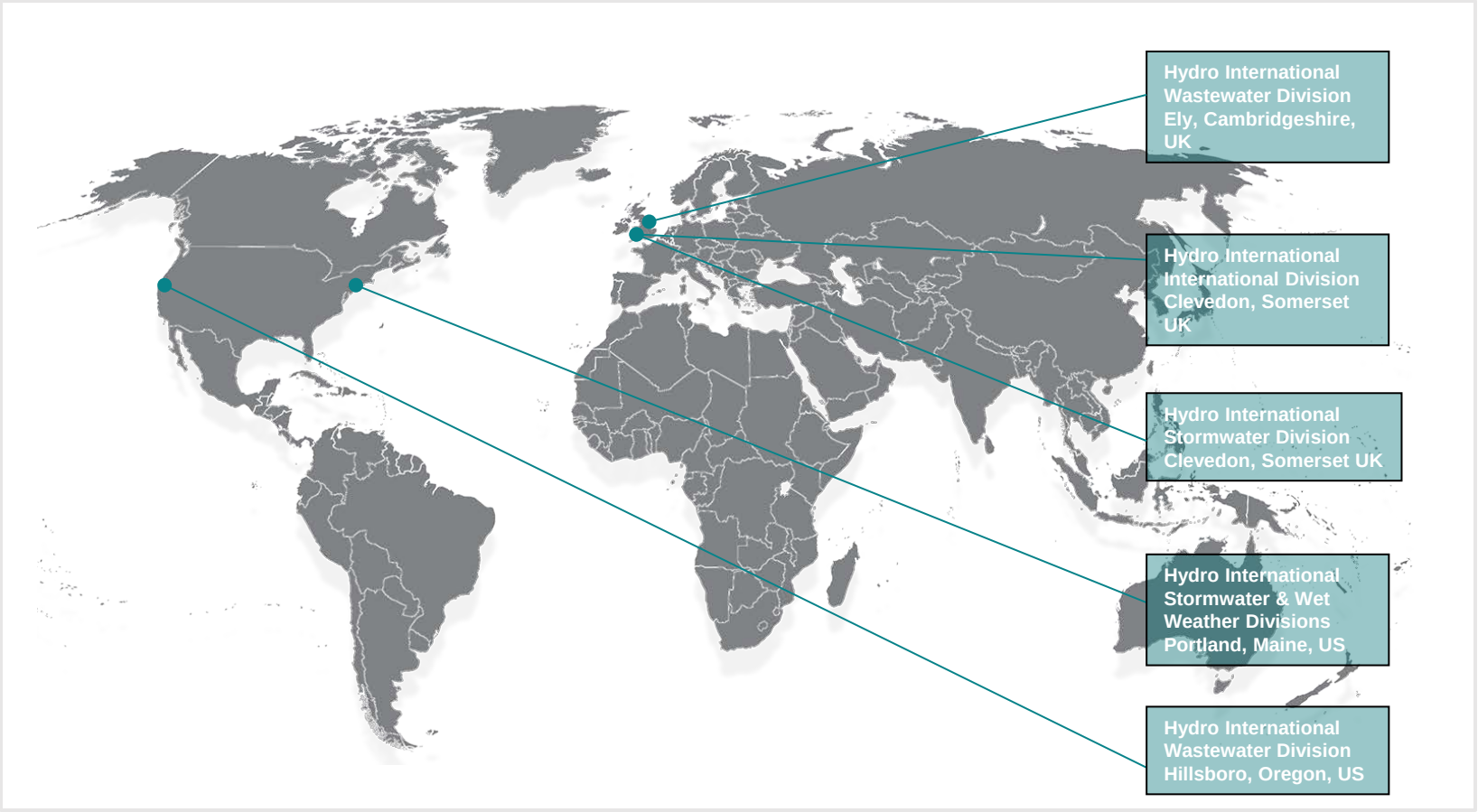
Hydro International – Office Locations



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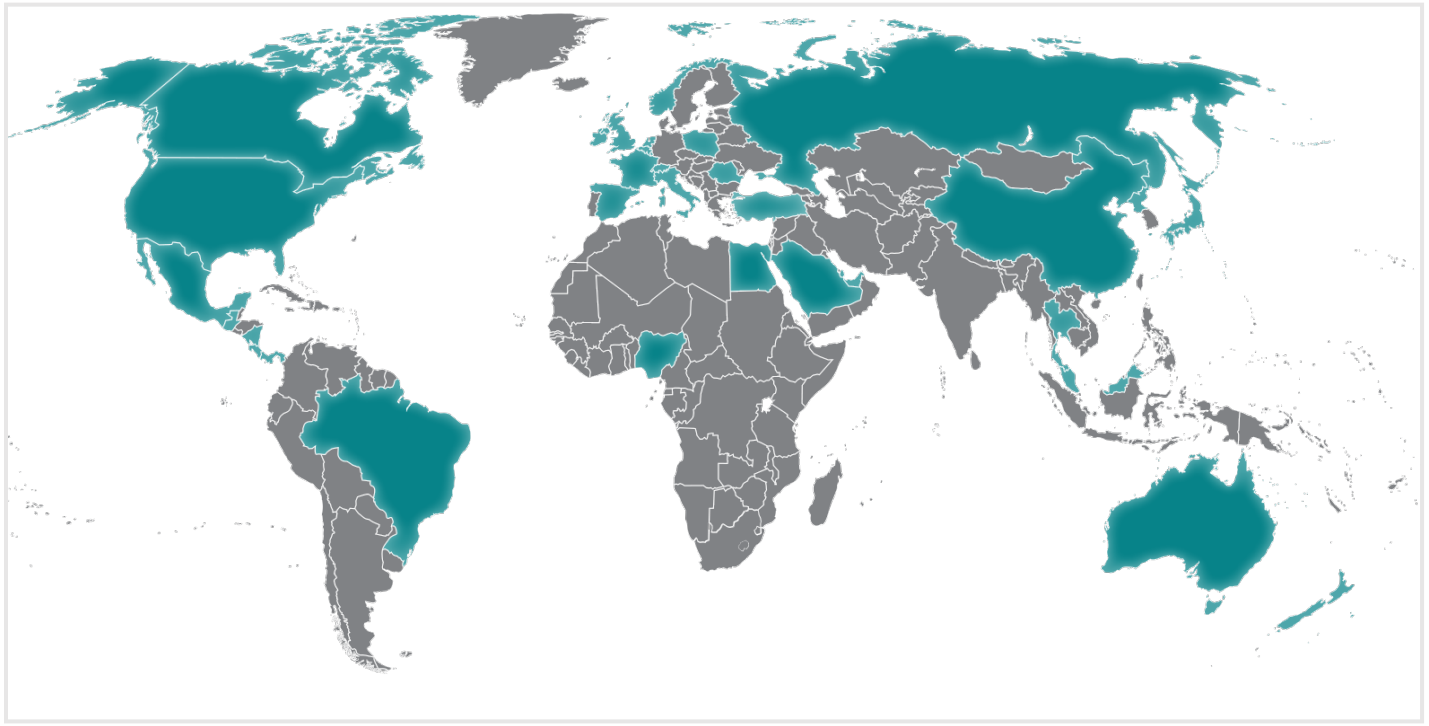
Hydro International – Operations World Wide

Hydro Offer Solutions to the Stormwater, Wastewater, and Wet Weather Industries

- Headquartered in the UK and in business for over 40 yrs
- Operations in America, United Kingdom, Europe, Africa, Middle and Far East, and Australasia, through a network of licensees and distributors



Stormwater, Wastewater, Combined Sewer

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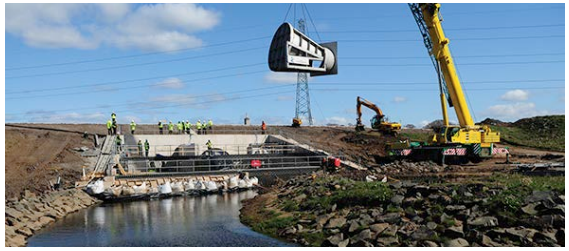

Stormwater

Wastewater

Combined Sewer Overflows

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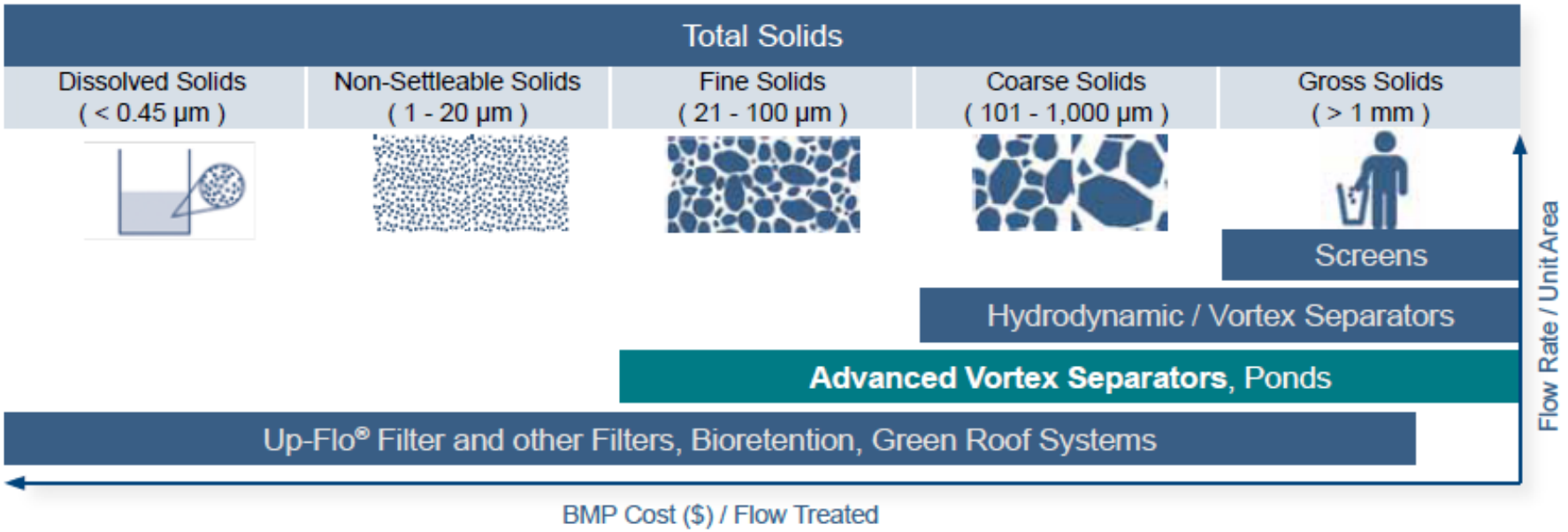
TSS Control Limits



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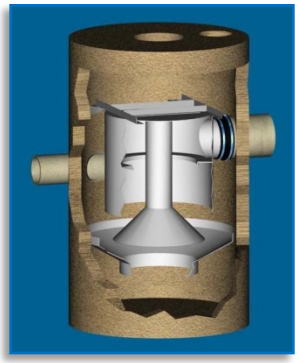
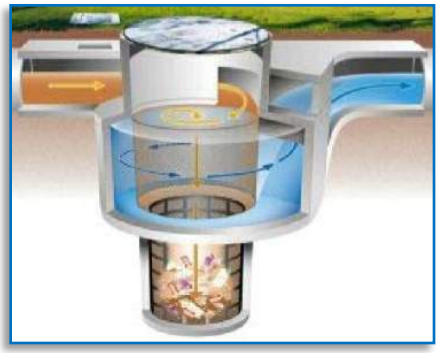
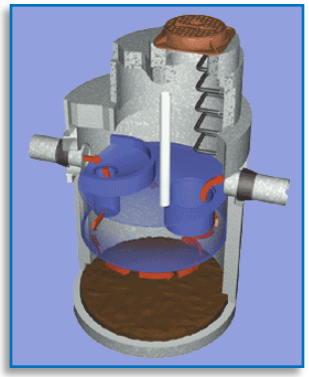
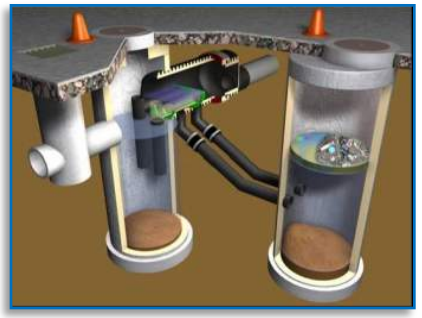
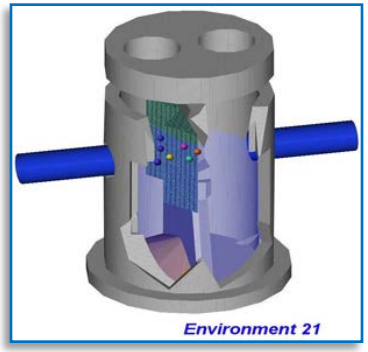
So Many Options?

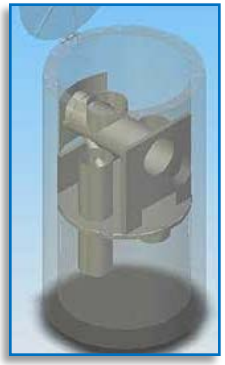


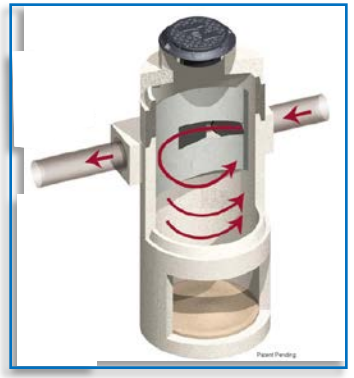


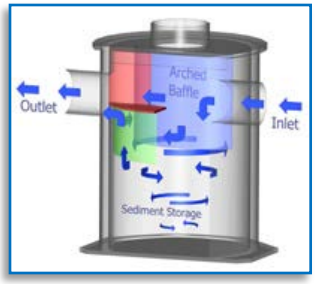


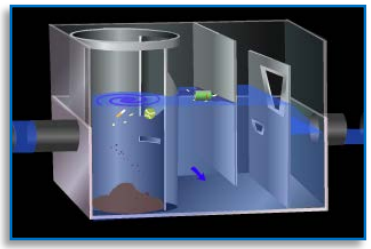


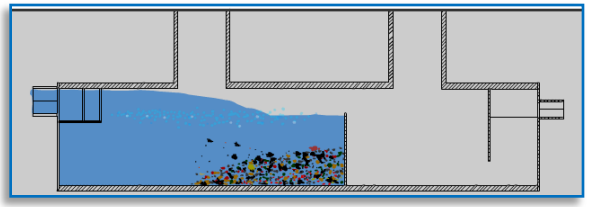












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How To Employ HDS Systems

- Equipment meets water quality guidelines
- Enables engineers and reviewers to work with assurance
- Simple to check a sizing
- Allows for competitive bidding
- Allows for fair and direct assessment of alternates

Testing Validates & Benchmarks

- Allows new technology development
- Verifies vendor’s performance claims
- Meets local water quality standards

Water Quality Standards, Not Standard

- TMDL – Total Maximum Daily Loads
- TSS – Sediment
- Effluent Control – Limit on Effluent Concentration
- TP – Total Phosphorous
- Oil
- Trash

Total Suspended Solids Reduction

- 70% to 95% TSS reduction is typical
- 80% TSS is most commonly required

80% Of What?

- Test Sediment
  - What the protocol used
- Design Sediment
  - What in the local design manual
- What's coming off the site
  - Highly variable

80% Calculated How?

- Water Quality Flow
  - Single event design
  - 2 yr 24 hr runoff event, 0.5” runoff depth, or similar

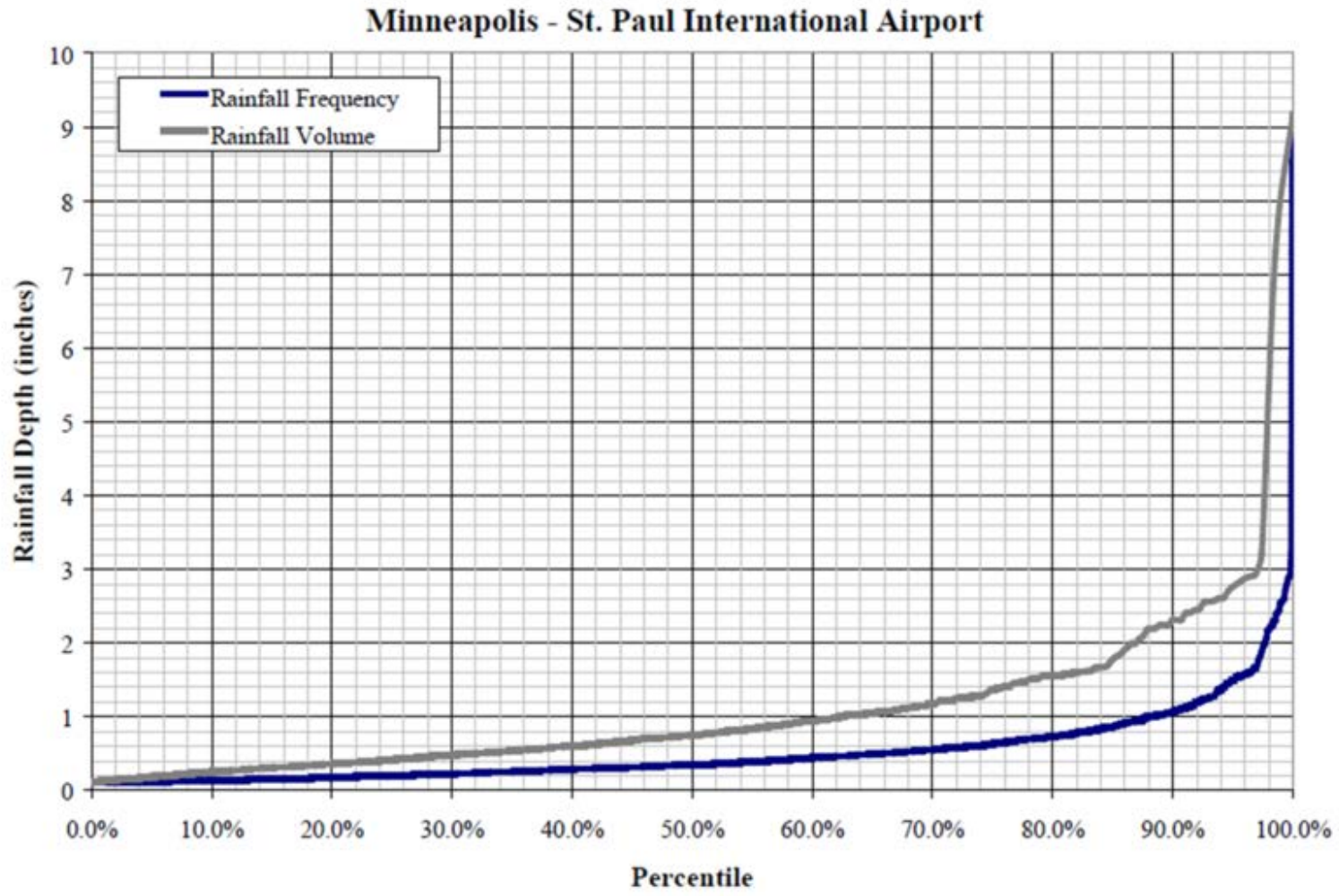
- Net Annual Flow
  - Long term
  - Flow * Fraction of long term rainfall record * % Removal of device

Net or Average Annual Calculation

- Removal is weighted towards the high percentage of low flow events

I (in./hr)	Rational Method (cfs)	Annual Frequency (%)	Device Efficiency for TSS (%/100)	Total TSS Reduction (%)
0.010	0.004	30.030	0.990	29.730
0.020	0.007	17.250	0.990	17.078
0.030	0.011	9.140	0.980	8.957
0.040	0.014	7.380	0.980	7.232
0.050	0.018	5.190	0.980	5.086
0.060	0.021	4.570	0.980	4.479
0.070	0.025	2.670	0.980	2.617
0.080	0.029	2.980	0.970	2.891
0.090	0.032	1.770	0.970	1.717
0.100	0.036	2.160	0.970	2.095
0.110	0.039	1.270	0.970	1.232
0.120	0.043	1.320	0.970	1.280
0.130	0.046	1.020	0.970	0.989
0.140	0.050	1.190	0.970	1.154
0.150	0.054	0.900	0.970	0.873
			Net Annual (%):	**87.4**

Sizing Method Influence



Source: http://stormwater.pca.state.mn.us/index.php/File:Minneapolis_St._Paul_rainfall_frequencies.png

Validate Based On?

- No national clearing house
  - Lots of “local” approvals to reference
  - Many differences

- Develop a local approval?
  - Time consuming
  - Requires deep understanding of data and analysis

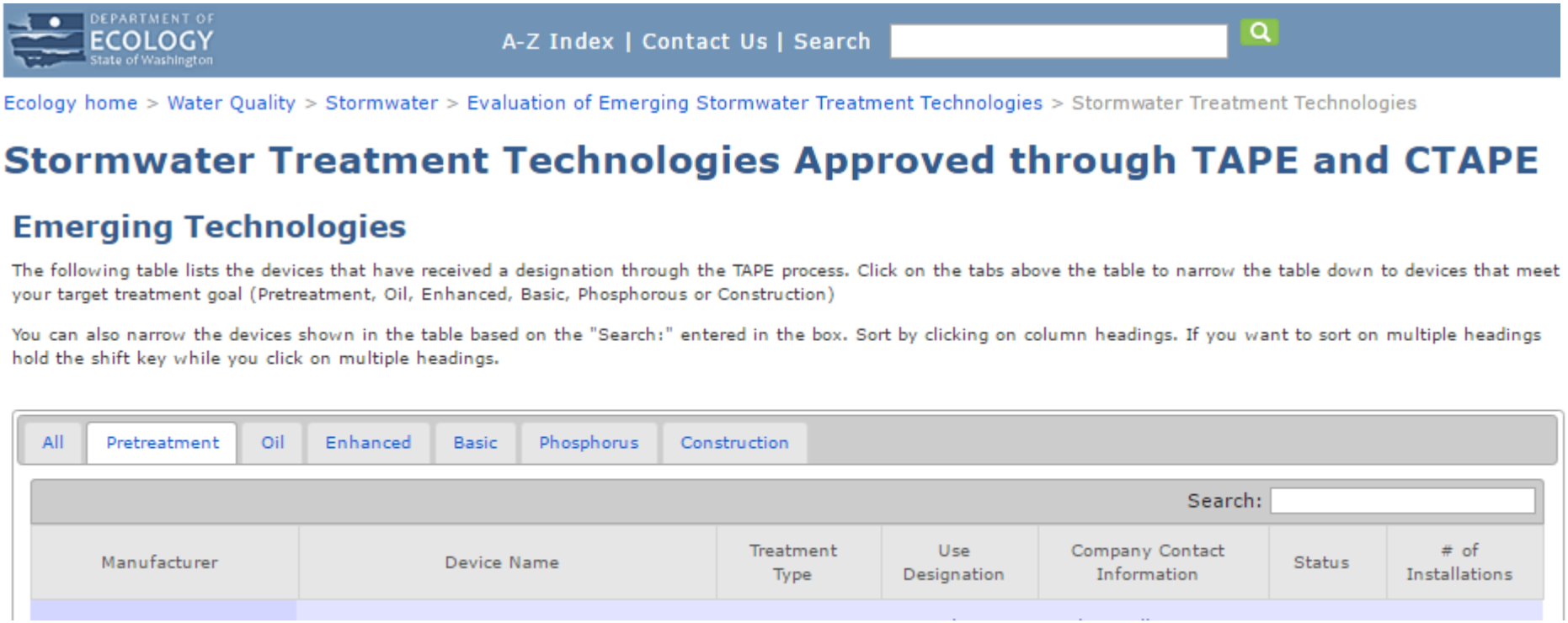
Nationally Used Validation Options

- NJDEP – TARP
- WADOE – TAPE

- Future national test standard??

WADOE

- Washington Department of Ecology (WADOE)
- Technology Assessment Protocol-Ecology (TAPE)
  - Lab and Field Test Based



Level of Use Designations

- Pilot Use Level Designation – PULD
  - Lab and field data
- Conditional Use Level Designation – CULD
  - Field test phase
- General Use Level Designation – GULD
  - Passed!

WADOE Performance Categories

- Basic Treatment (Filtration)
  - TSS
  - Dissolved Metals
  - Cu
  - Zn
- Phosphorus
- Oil
- **Pretreatment (Separators)**
  - **TSS Effluent control**

History

- 2002 first TAPE guideline published
- 2004 updated
- 2008 updated
  - Pretreatment
    - 80% of OK110 Coarse TSS
    - 50% of 50 µm Fine TSS
- 2011 most recent update
  - Pretreatment
    - Effluent limits

Pretreatment

Pretreatment is generally applied to:

- Project sites using infiltration treatment
- Treatment systems where needed to assure and extend performance of the downstream basic or enhanced treatment facility

Intended to achieve 50% removal of fine (50 micron-mean size) and 80% removal of coarse (125-micron-mean size) total suspended solids for influent concentrations greater than 100 mg/L, but less than 200 mg/L. For influent concentrations less than 100 mg/L, the facilities are intended to achieve effluent goals of 50 mg/L of fine and 20 mg/L of coarse total suspended solids.

2008 On Website

- Pretreatment
  - For influent concentrations **between 100-200 mg/L**
    - Intended to achieve a goal of 50% removal of fine (50 micron size) particles
    - or 80% removal of coarse (125 micron size)

Pretreatment

Pretreatment is generally applied to:

- Project sites using infiltration treatment
- Treatment systems where needed to assure and extend performance of the downstream basic or enhanced treatment facility

Intended to achieve 50% removal of fine (50 micron-mean size) and 80% removal of coarse (125-micron-mean size) total suspended solids for influent concentrations greater than 100 mg/L, but less than 200 mg/L. For influent concentrations less than 100 mg/L, the facilities are intended to achieve effluent goals of 50 mg/L of fine and 20 mg/L of coarse total suspended solids.

2011 GULD Pretreatment Requirement

- Influent 50 – 100 mg/L
  - Effluent <= 50 mg/L
    - Results in 0% to 50% TSS depending on influent concentration and performance

- Influent >= 100 mg/L
  - 50% TSS removal
    - If influent is 400 mg/L, 50% = 200 mg/L effluent

PLEASE NOTE: Ecology has revised the 2008 TAPE Technical Guidance Manual. Below is the current required TAPE Technical Guidance Manual.

2011 TAPE Guidance Manual (Publication #11-10-061)
Mandatory* as of January 1, 2013.

*Ecology will no longer accept the 2008 version after December 31, 2012.

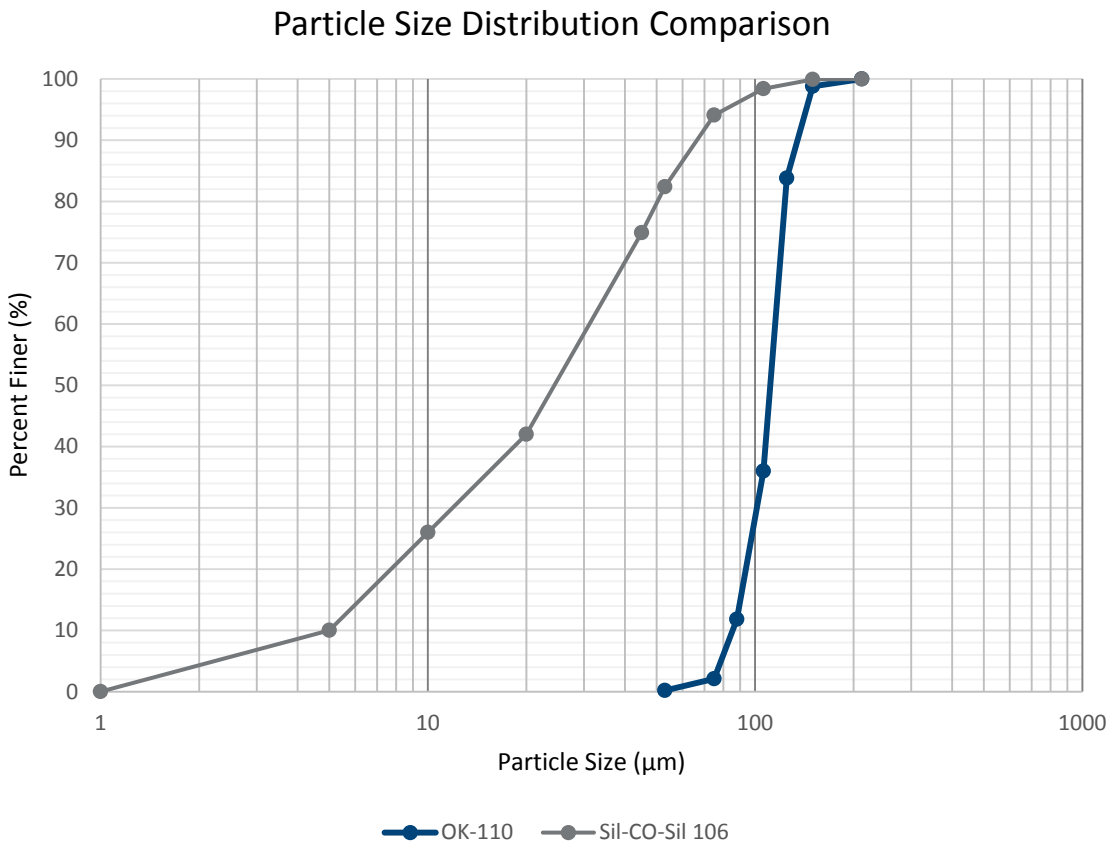
Field Test With Supplemental Lab Testing

- Lab test must show 50% of Sil-Co-Sil 106
  - Supplemental to field testing
  - Peak and higher flows may not be represented in field testing
  - Lab test may replace a portion of field testing

- Basic treatment systems must be able to remove at least 80 percent of Sil-Co-Sil 106 particles at the water quality design hydraulic loading rate, and pretreatment systems must be able to remove at least 50 percent of Sil-Co-Sil 106 particles at the water quality design hydraulic loading rate.

OK110 & Sil-Co-Sil 106 Compared

- **24 µm** = D_{50} Sil-Co-Sil 106 (medium silt)
  - 0.312 mm/s (18mm/min)
- **110 µm** = D_{50} OK110 (fine / very fine sand)
  - 6.11 mm/s (367 mm/min - 20 times faster)



WADOE Approved Devices

Hydro International

Washington Department of Ecology - Level of Use Designation for Pretreatment.									
Downstream Defender (2013)	GULD (cfs)	Stormceptor	GULD (cfs)	Vortechs (2016)	GULD (cfs)	CDS (2016)	GULD (cfs)	AquaShield (2016)	GULD (cfs)
DD4	1.3	450	0.31	1000	0.55	PMIU20-15	0.7	AS-2	0.25
DD6	4.1	900	0.64	2000	1	PMSU20-15-4	0.7	AS-3	0.43
DD8	9.4	1200	0.64	3000	1.5	PMSU20-15	0.7	AS-4	0.73
DD10	17.1	1800	0.64	4000	2.2	PMSU20-20	1.1	AS-5	1.01
		2400	1.06	5000	3	PMSU20-25	1.6	AS-6	1.45
		3600	1.06	7000	3.9	PMSU30-20	2	AS-7	1.97
		4800	1.77	9000	5	PMSU30-30	3	AS-8	2.58
		6000	1.77	11000	6.1	PMSU40-30	4.5	AS-9	3.26
		7200	2.48	16000	8.8	PMSU40-40	6	AS-10	4.03
		11000	3.54			PSWC30-20	2	AS-11	4.88
		13000	3.54			PSW30-30	3	AS-12	5.8
		16000	4.96			PSWC30-30	3		
						PSWC40-30	4.5		
						PSWC40-40	6		
						PSW50-42	9		
						PSWC56-40	9		
						PSW50-50	11		
						PSWC56-53	14		
						PSWC56-68	19		
						PSWC56-78	25		
						PSW70-70	26		
						PSW100-60	30		
						PSW100-80	50		
						PSW100-100	64		

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Scaling – Devil in the Detail

- Surface Area = Constant Load rate (gpm/ft^2)
  - *New Size Flow =* $\left(\frac{Scaled\ diamter}{Tested\ diamter}\right)^2$ *x Tested Flow*
    - *4' = 1 cfs Tested*
    - *6' = 2.25 cfs Scaled*

- Volumetric = Constant Load rate (gpm/ft^3)
  - *New Size Flow =* $\left(\frac{Scaled\ diamter}{Tested\ diamter}\right)^{2.8}$ *x Tested Flow*
    - *4' = 1 cfs Tested*
    - *6' = 3.2 cfs Scaled*

WADOE Approved Devices Scaling

Hydro International

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Downstream Defender (2013)	GULD (cfs)	Stormceptor	GULD (cfs)	Vortechs (2016)	GULD (cfs)	CDS (2016)	GULD (cfs)	AquaShield (2016)	GULD (cfs)
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DD6	4.1	900	0.64	2000	1	PMSU20-15-4	0.7	AS-3	0.43
DD8	9.4	1200	0.64	3000	1.5	PMSU20-15	0.7	AS-4	0.73
DD10	17.1	1800	0.64	4000	2.2	PMSU20-20	1.1	AS-5	1.01
		2400	1.06	5000	3	PMSU20-25	1.6	AS-6	1.45
		3600	1.06	7000	3.9	PMSU30-20	2	AS-7	1.97
		4800	1.77	9000	5	PMSU30-30	3	AS-8	2.58
		6000	1.77	11000	6.1	PMSU40-30	4.5	AS-9	3.26
		7200	2.48	16000	8.8	PMSU40-40	6	AS-10	4.03
		11000	3.54			PSWC30-20	2	AS-11	4.88
		13000	3.54			PSW30-30	3	AS-12	5.8
		16000	4.96			PSWC30-30	3		
						PSWC40-30	4.5		
						PSWC40-40	6		
						PSW50-42	9		
						PSWC56-40	9		
						PSW50-50	11		
						PSWC56-53	14		
						PSWC56-68	19		
						PSWC56-78	25		
						PSW70-70	26		
						PSW100-60	30		
						PSW100-80	50		
						PSW100-100	64		

Volumetric

Bypass

Surface Area

Bypass

Surface Area

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WADOE – Summary

- Small list – 3 vendors
- Very expensive and time consuming to gain GULD
- Now related to effluent control and not TSS reduction
- Inconsistent scaling
- Vendors ideally need an approved filter to justify HDS approval
- Slow to include new technology

NJDEP – TARP

- Technology Acceptance Reciprocity Partnership (TARP)
  - The testing protocols
- New Jersey Corporation of Advanced Technology (NJCAT)
  - Test and data validation
- New Jersey Department of Ecology (NJDEP)
  - Final certification / sizing / scaling approval

NJDEP History – Back Before 2015

- Initially lab tested (TARP 1) and field verified (TARP 2)
  - Vendors submitted some form of data
  - Usually based on 80% TSS
  - PSD similar to NJCAT PSD

- Approval for 50% TSS given
  - Scaling from test unit varied by vendor

50% TSS - Flow Weighted Calculation

Percent of Design Operating Rate	Loading Rate (gpm/ft^3)	Removal Efficiency[1] (%)	Weight Factor	Weighted Efficiency (%)
25%	(0.14 cfs) 5	96.55	.25	24.14
50%	(0.28 cfs) 10	82.72	.30	24.82
75%	(0.42 cfs) 15	57.42	.20	11.48
100%	(0.56 cfs) 20	41.17	.15	6.18
125%	(0.70 cfs) 25	35.34	.10	3.53
			Total	70.15%

Vendors Got Wise To 50% Target

- Target 50% why test to 80%?
  - Go me! – I've gone from 0.56 cfs to 1.13 cfs!

4-ft Downstream Defender Annualized Weighted TSS Removal at 1.12 cfs					
% MTFR	Mean Flow Rate Tested (cfs)	Actual % MTFR	Measured Removal Efficiency	Annual Weighting Factor	Weighted Removal Efficiency
25%	0.27	96.4%	59.4%	0.25	14.85%
50%	0.55	98.2%	53.4%	0.3	16.02%
75%	0.83	98.8%	45.4%	0.2	9.08%
100%	1.13	100.9%	42.0%	0.15	6.30%
125%	1.34	95.7%	41.0%	0.1	4.10%
			Weighted Annualized TSS Removal Efficiency		50.35%

Scaling Was Also A Problem

- Surface Area = Constant Load rate (gpm/ft^2)
  - *New Size Flow =* $\left(\frac{Scaled\ diamter}{Tested\ diamter}\right)^2$ *x Tested Flow*
    - *4' = 1 cfs Tested*
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- Volumetric = Constant Load rate (gpm/ft^3)
  - *New Size Flow =* $\left(\frac{Scaled\ diamter}{Tested\ diamter}\right)^{2.8}$ *x Tested Flow*
    - *4' = 1 cfs Tested*
    - *6' = 3.2 cfs Scaled*

NJDEP Reset 2015

All Existing Approvals Cancelled

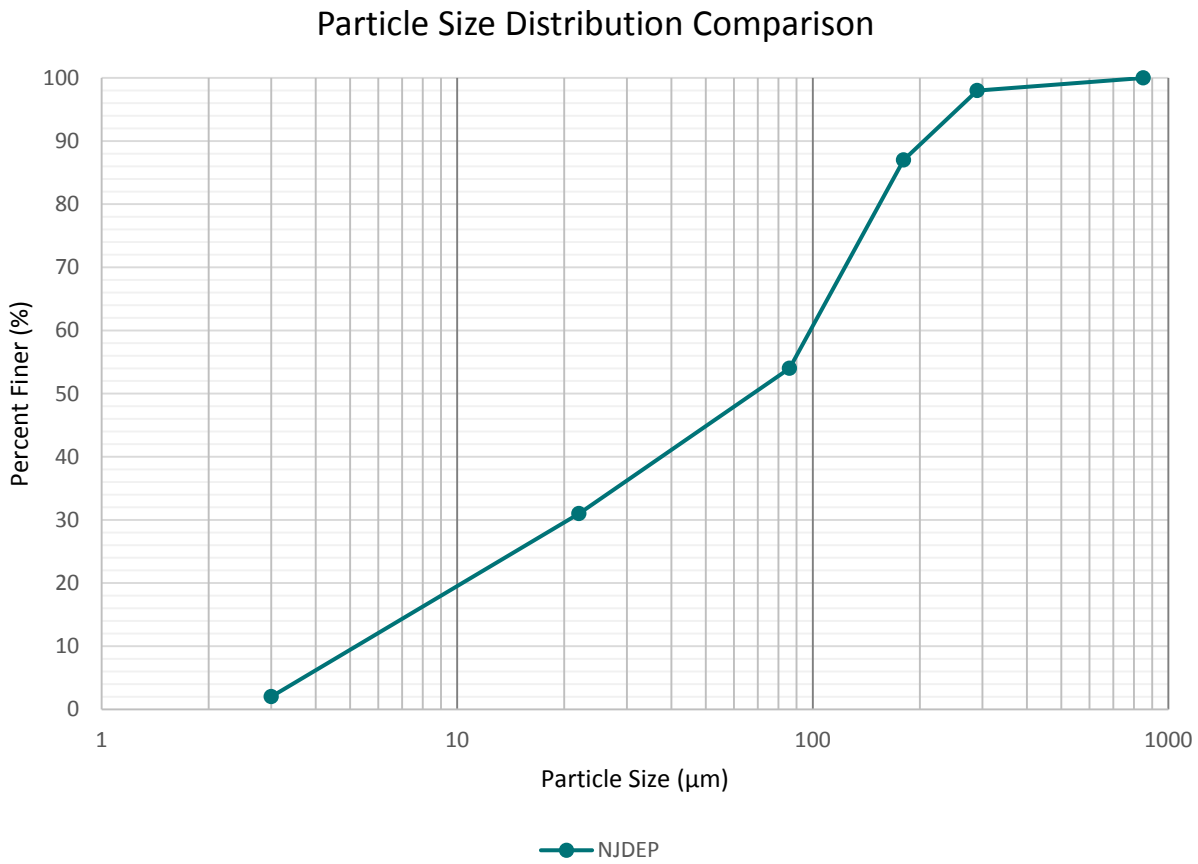
New Testing Required

- Separators
  - 50% TSS
    - Lab based
    - NJDEP PSD
    - Surface Area Scaling

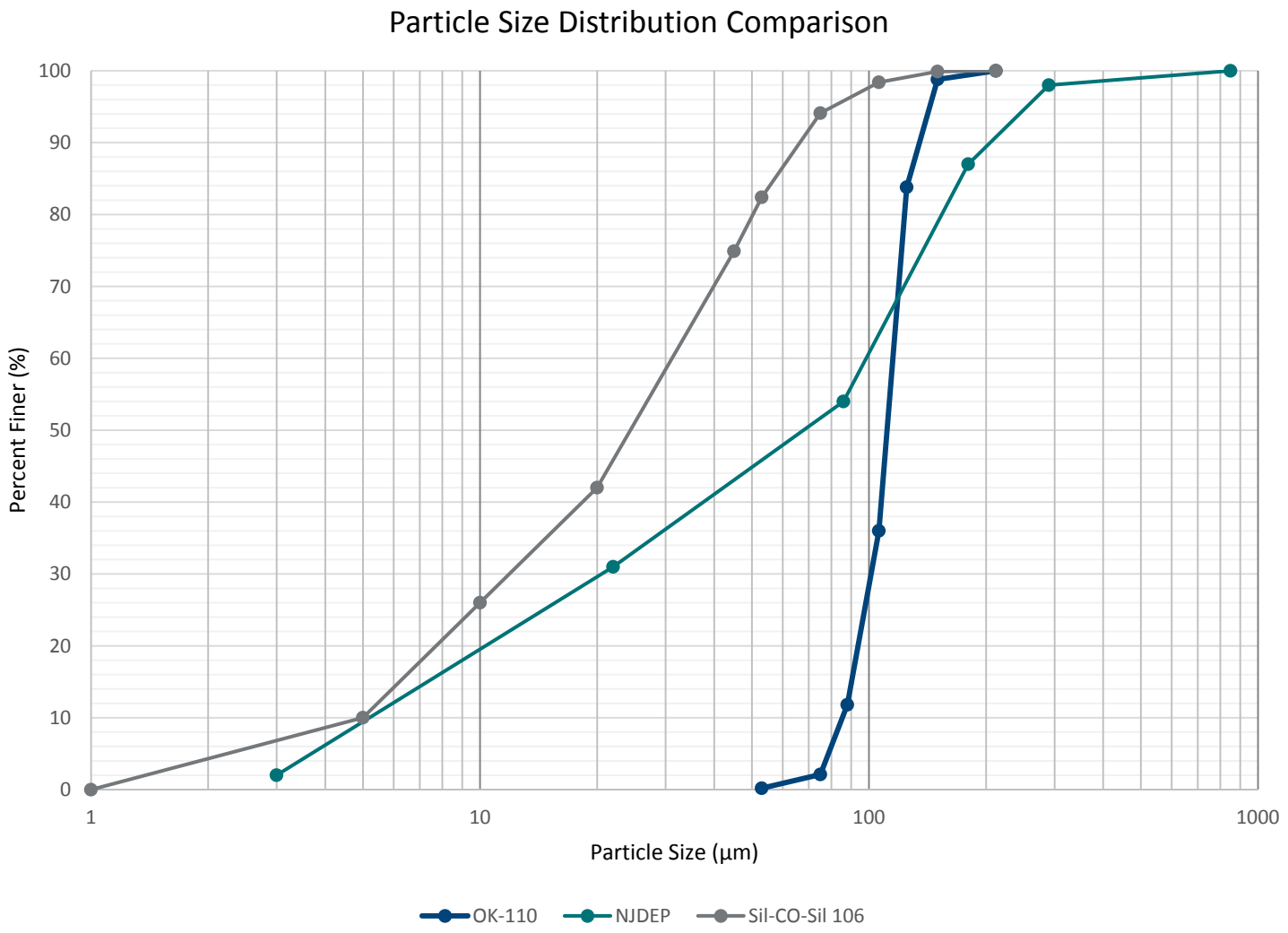
- Filters
  - 80% TSS
    - Lab based
    - Flow, exhaustion, and area limits used to calculate size

NJDEP PSD

- ~70 µm D_{50} = coarse silt / very fine sand



OK110, Sil-Co-Sil 106, & NJDEP



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But Wait 80% TSS???? Not 50%

- What if I want 80% TSS?
  - WADOE is effluent control around 50% TSS
  - NJDEP is 50% of NJDEP PSD
    - Flow weighted based on local WQ storm

4-ft Downstream Defender Annualized Weighted TSS Removal at 1.12 cfs					
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50%	0.55	98.2%	53.4%	0.3	16.02%
75%	0.83	98.8%	45.4%	0.2	9.08%
100%	1.13	100.9%	42.0%	0.15	6.30%
125%	1.34	95.7%	41.0%	0.1	4.10%
			Weighted Annualized TSS Removal Efficiency		50.35%

NJDEP Testing First Defense HC

- 100% MTFR Test Data

Down to 50 µm = 94.2 % TSS overall

Influent Cut Point (Micron)	% Passing	% In Band	Inf Mass (g)	Eff Mass (g)	Inf. Conc (mg/L)	Eff. Conc (mg/L)	**Removal in Particle Size Band**
1000	100.00%	0.00%	0.0	0.0	0.0	0.0	100.0%
500	96.00%	4.00%	287.1	0.0	8.2	0.0	100.0%
250	90.00%	6.00%	430.6	0.0	12.2	0.0	100.0%
150	80.00%	10.00%	717.7	0.0	20.4	0.0	100.0%
100	61.10%	18.90%	1356.4	40.3	38.5	1.1	97.0%
75	54.00%	7.10%	509.5	41.5	14.5	1.2	91.9%
50	49.30%	4.70%	337.3	128.3	9.6	3.6	62.0%
20	38.30%	11.00%	789.4	795.2	22.4	22.6	-0.7%
8	22.70%	15.60%	1119.5	1091.7	31.8	31.0	2.5%
5	15.40%	7.30%	523.9	620.1	14.9	17.6	-18.4%
2	5.80%	9.60%	688.9	716.5	19.6	20.4	-4.0%
0	0.00%	5.80%	416.2	441.8	11.8	12.6	-6.1%
		100.0%	**7176.53**	**3875.32**	**4770343.0**	**2575985.2**	**46.0%**

NJDEP Testing First Downstream Defender

Influent Cut Point (Micron)	% Passing	% In Band	Inf Mass (g)	Eff Mass (g)	Inf. Conc (mg/L)	Eff. Conc (mg/L)	**Removal in Particle Size Band**
1000	100%	0	0	0	0	0	100%
500	95%	5.0%	307.9	0.0	10.43	0.00	100%
250	90%	5.0%	307.9	12.6	10.43	0.43	96%
150	75%	15.3%	944.2	65.8	31.98	2.23	93%
100	61%	13.5%	832.8	111.8	28.21	3.79	87%
75	52%	8.8%	542.5	103.9	18.38	3.52	81%
50	47%	4.9%	302.2	239.1	10.24	8.10	21%
20	36%	11.5%	708.3	922.1	23.99	31.23	-30%
8	21%	15.3%	942.4	1024.6	31.92	34.71	-9%
5	14%	6.2%	382.7	473.6	12.96	16.04	-24%

Down to 50 µm = 83% TSS overall

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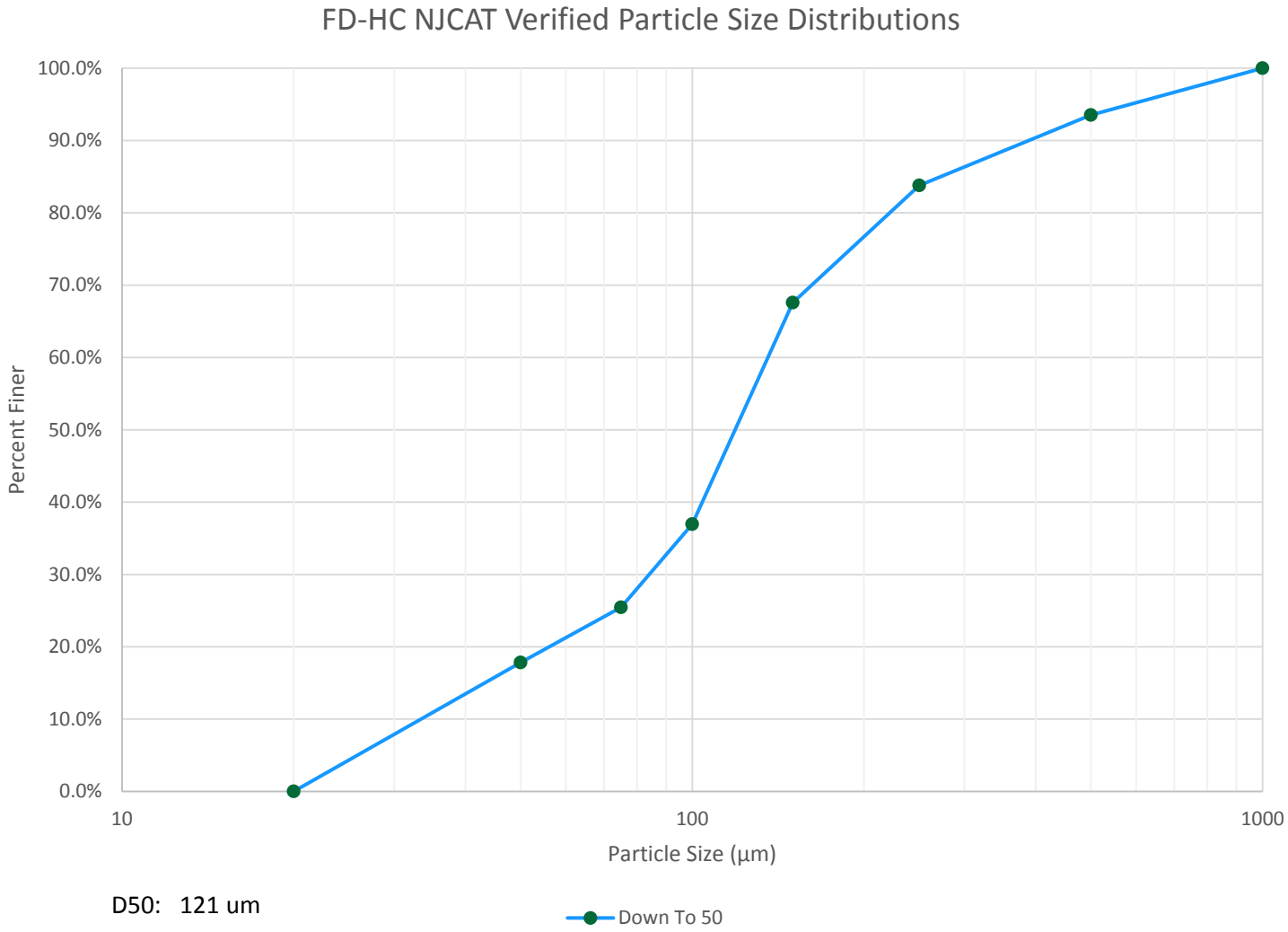
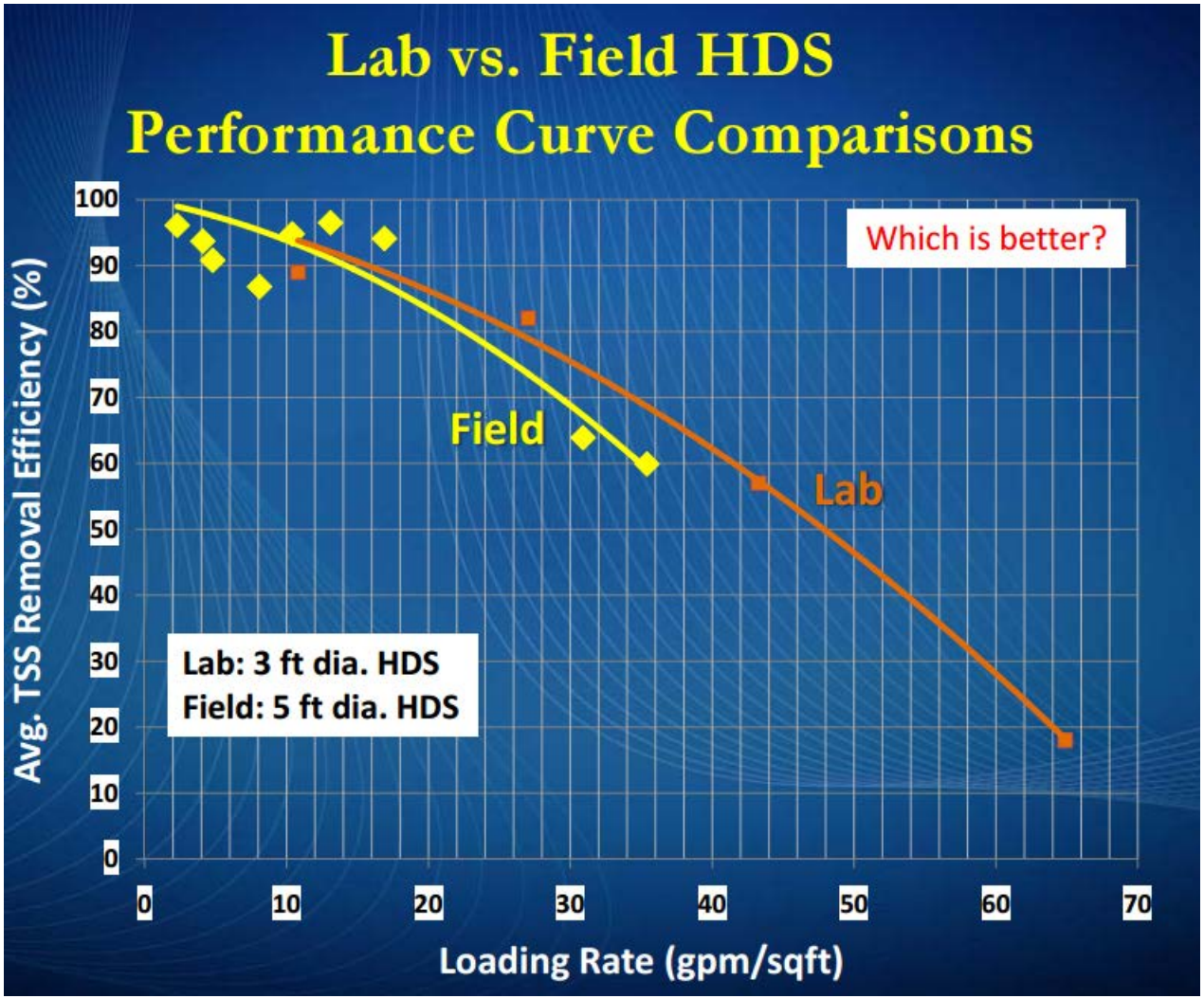
Down To 50 µm - D_{50} =121 um



D50: 121 um



http://www.tnenvironment.com/pres11/miller_m.pdf

Current NJDEP List

NJDEP 50% TSS Certification (2/24/2017)															
Hydro		Hydro		Contech		AquaShield		Environmental 21		OldCastle		Suntree		Fresh Creek Tech	
Downstream Defender	MTFR (cfs)	First Defense - HC	MTFR (cfs)	CDS	MTFR (cfs)	Aqua-Swirl	MTFR (cfs)	StormPro	MTFR (cfs)	DVS	MTFR (cfs)	NSBB	MTFR (cfs)	Site Saver	MTFR (cfs)
DD4	1.12	FD-3HC	0.85	CDS 4	0.93	AS-2	0.36	V48	1.29	DVS-36	0.56	2-4	0.62	SS4	0.67
DD6	2.52	FD-4HC	1.50	CDS 5	1.50	AS-3	0.71	V510	2.02	DVS-48	1.00	3-6	1.4	SS6	0.83
DD8	4.49	FD-5HC	2.35	CDS 6	2.10	AS-4	1.18	V612	2.91	DVS-60	1.56	3-8	1.87	SS8	1
DD10	7	FD-6HC	3.38	CDS 7	2.80	AS-5	1.46	V816	5.17	DVS-72	2.25	4-8	2.49	SS11	1.39
DD12	10.08	FD-8HC	6.00	CDS 8	3.70	AS-6	2.11	V1012	8.08	DVS-84	3.06	5-10	3.89	SS13	1.66
				CDS 10	5.80	AS-7	2.87			DVS-96	4.00	6-12	5.6	SS16	2.02
				CDS 12	8.40	AS-8	3.74			DVS-120	6.25	6-13.75	6.42	SS18	2.34
						AS-9	4.73			DVS-144	9.00	7-14	7.62	SS20	2.5
						AS-10	5.84					7-15	8.17	SS23	4.1
						AS-11	7.07					8-14	8.71	SS36	6.9
						AS-12	8.42					8-16	9.96	SS45	10.5
						AS-13	9.87					9-18	12.6	SS55	14.9
												10-17	13.22	SS65	20
												10-20	15.56		
												12-21	19.6		
												12-24	22.4		

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NJDEP Advantages

- The list is current
- Standardized testing – including washout
- Allows new technology to be tested
  - In a short time frame
  - Cost is manageable
  - Removed random variability of field testing
- Does not link the technology to use in a treatment train
  - A single product vendor can compete with a total solution vendor

Thank you

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