Grit Collection & Classification Case Studies

OWEA

2010 Specialty Biosolids Specialty Workshop

Brian F. McNamara, HRSD

Definition of Grit

Metcalf & Eddy 2nd Edition 1979

"…grit, consisting of sand, gravel, cinders, or other heavy solid materials that have subsiding velocities or specific gravities substantially greater than those of the organic putrescible solids,… Grit also includes eggshells, bone chips, seeds, coffee grounds, and large organic particles, such as food waste."

Grit Design Parameters

Grit Removal Equipment is designed for 2.65 SG and 1 fps horizontal velocities**

Collection systems design velocities for 2 fps peak diurnal flow.

Velocity for grit re-suspension is ~ 5.0 fps

** Metcalf & Eddy 2nd Edition 1979

Notes that if the native grit specific gravity is less than 2.65, then grit removal equipment designs should be adjusted accordingly or less than 1 ft/sec horizontal velocity.

Operator View of Grit

No test to monitor grit in RWI

Measurement parameter is grit removed

Impact of Grit

- Takes up volume in down stream tanks
  - Primaries, aeration tanks, digesters, incinerators…
  - Manual labor to remove and dispose ($$$ & Time)
- Accelerates wear on equipment
  - Primary biosolids pumps
  - Centrifuge feed pumps
  - Centrifuges
  - Collectors and screws
  - Maintenance operator time and parts ($$$ & Time)

Evaluate Entire *System*

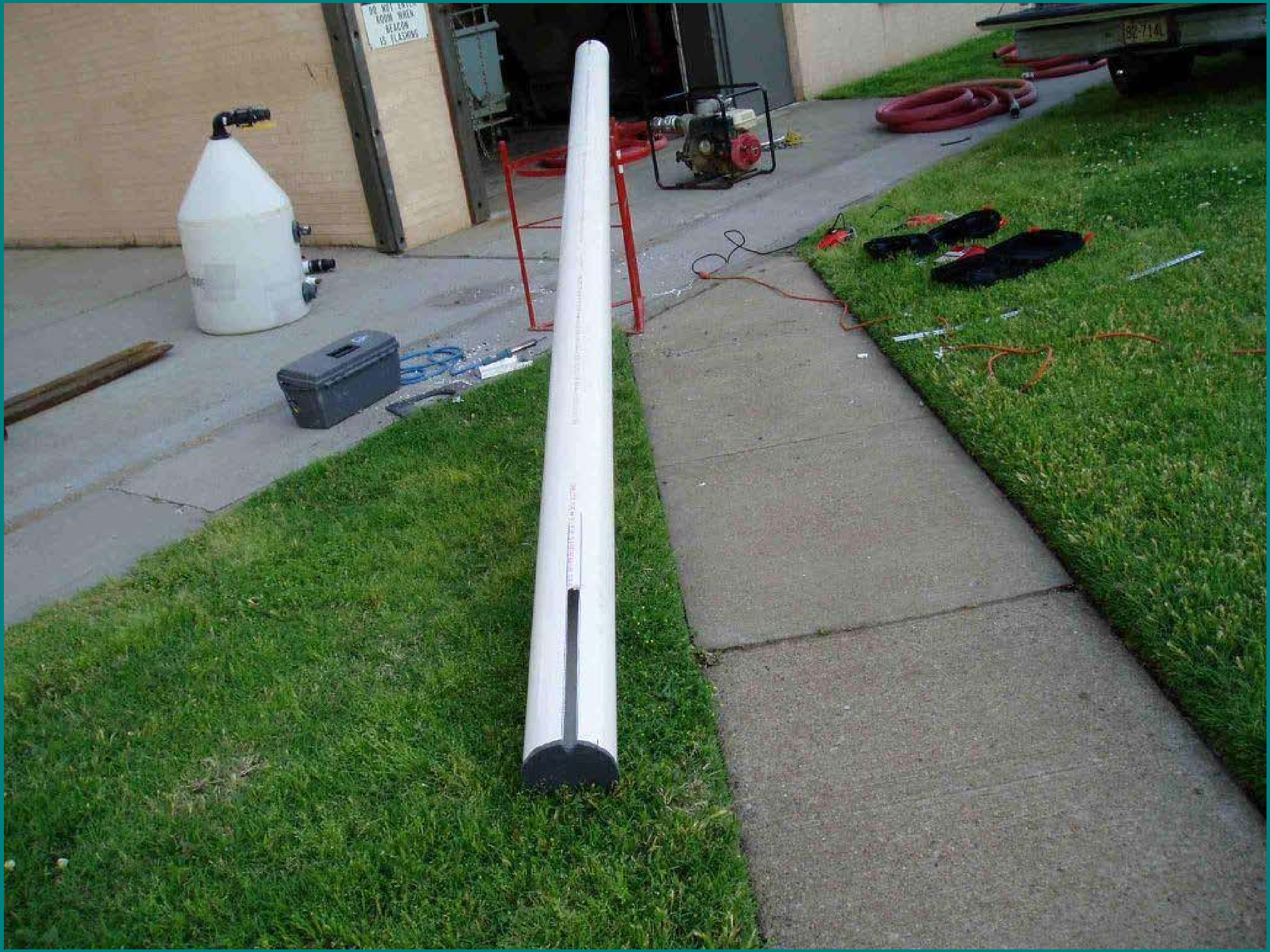
- Influent collection system parameters
  - Gravity, force main
- Pipe sizes, pump stations, vertical runs,…
- Industrial loads
- Diurnal flow rates, velocities
- Infiltration influences
- Volume of grit loads
- Historical impact on treatment plant
- Type of grit removal equipment
- Number of grit removal units are available
- Operation of grit removal equipment

How to…?

- How to sample grit?
- How to analyze grit?
- How to quantify?
- How to conduct a process review?
- How to conduct an equipment review?
- How to find historical effect of grit on treatment processes?

Obtaining a Representative Sample

Vertical Sampler



Vertical Sampler

Typical pump rate approximately 120 gpm

Vertical Sampler

Gathers a representative sample from the entire vertical water column

Slot width function of stream velocity, channel depth, pump velocity, & cross sectional area of pump suction

50-micron Grit Settler

Sampling begins as diurnal flows raise up and continue thru the peak of the afternoon. Continuous composit for 6 hours.

Post-Sampling Activities

- Decant sample from settler
- Rinse loose floatable organics from sample
- Drain off liquid
- Volume & Weight of total sample recorded
- Wet-sieve

Wet-sieve System

Stirred ! Not Shaken.

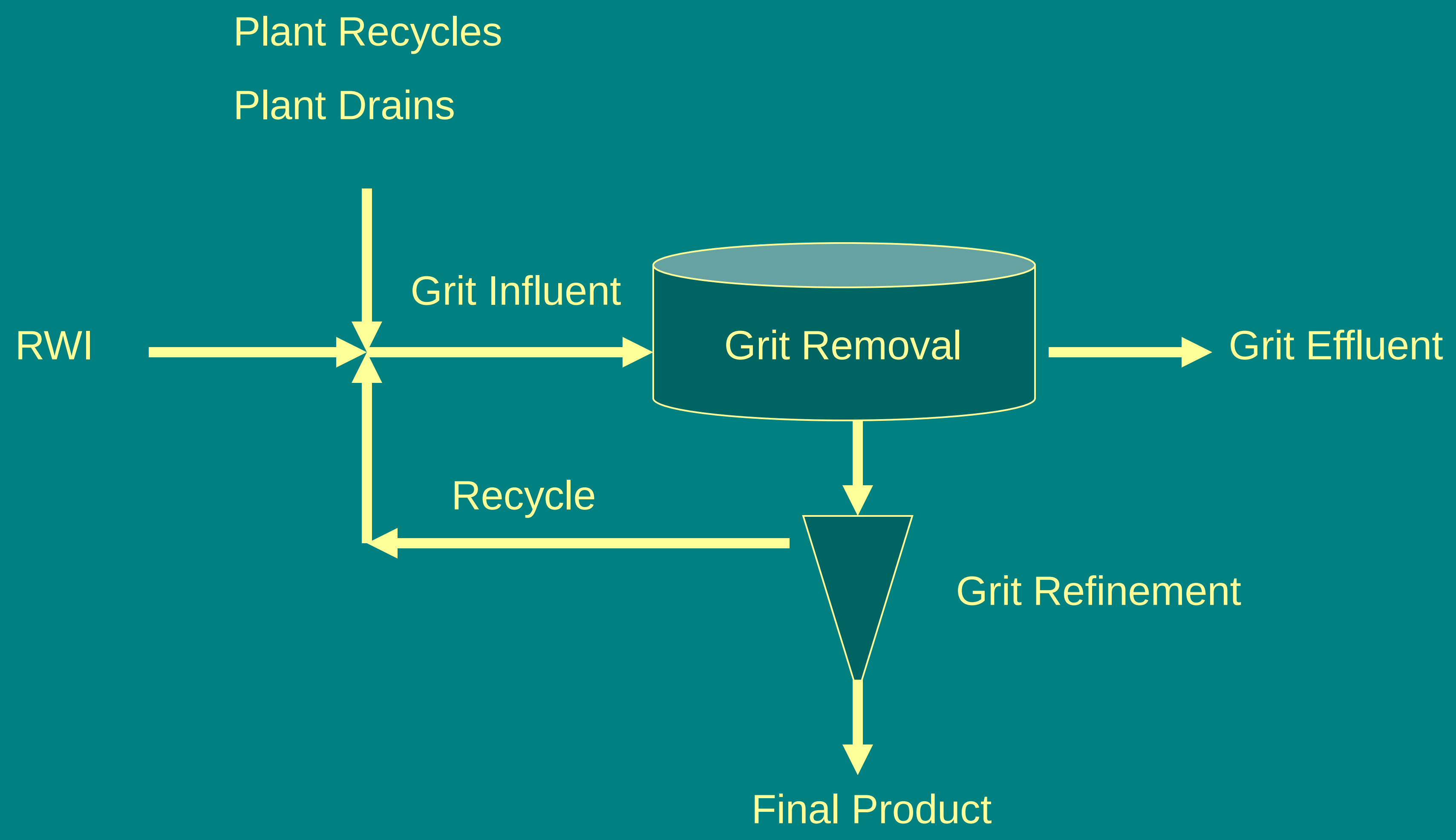
Remove Classified Grit

Laboratory Analysis & Calculations

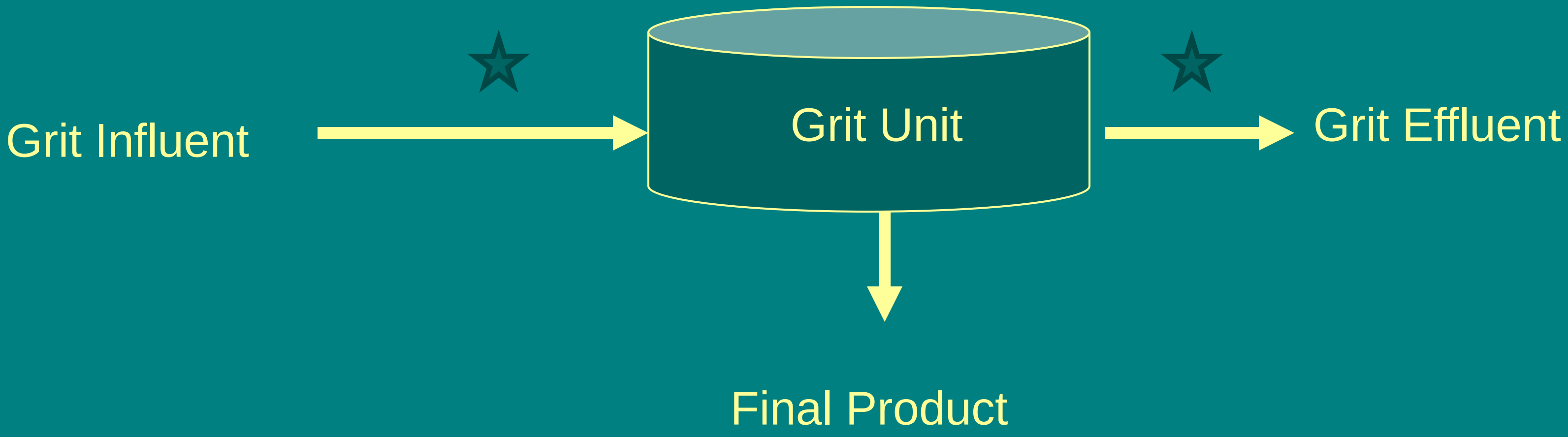
Fixed Solids Determination

Flow weighted calculations for quantity of grit per MGD

Generic Process Model



Grit Removal Efficiency



$$\%\text{Grit Efficiency} = \frac{\text{Grit Inf} - \text{Grit Eff}}{\text{Grit Inf}} \times 100$$

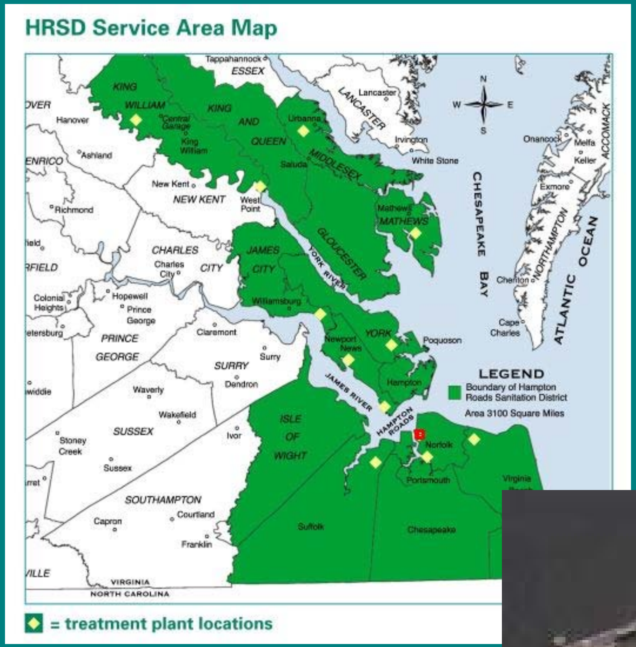
★ Sample Location

Grit vs. Grit

Pilot Evaluation Comparing Two Grit Removal Technologies

Brian F. McNamara, Thomas Kochaba, Jimmie Griffiths, David Book

HRSD Army Base WWTP



- Began 1947
- 18 MGD (68 ML/d)
- Secondary WWTP
- Converted High Purity Oxygen to Surface Aeration
- Chemical P Removal
- Multiple Hearth Incinerator

Army Base WWTP Grit Channels

Plastic chain and buckets

Army Base WWTP

- Present: Grit Channels
  - Inefficient system, cannot handle slug loads
- Consequences
  - Increased wear on primary biosolids pumps
  - Grit removed from aeration tanks
  - Grit removed from holding tank

Army Base WWTP Grit Experience

2010 Plant Improvement

- 18 MGD (68 ML/d)
- Five Stage Bardenpho
  - Methanol Addition
- Distributive Control System
- Nitrification Enhancement Facility
- New Pretreatment Headworks
  - Ban Screens
  - Self Cleaning Wetwell
  - Grit Removal???

Grit Removal Technologies

- Gravity Settling
- Free Vortex (Tea Cup)
- Aerated Grit
- Forced Vortex

Grit Removal Technologies

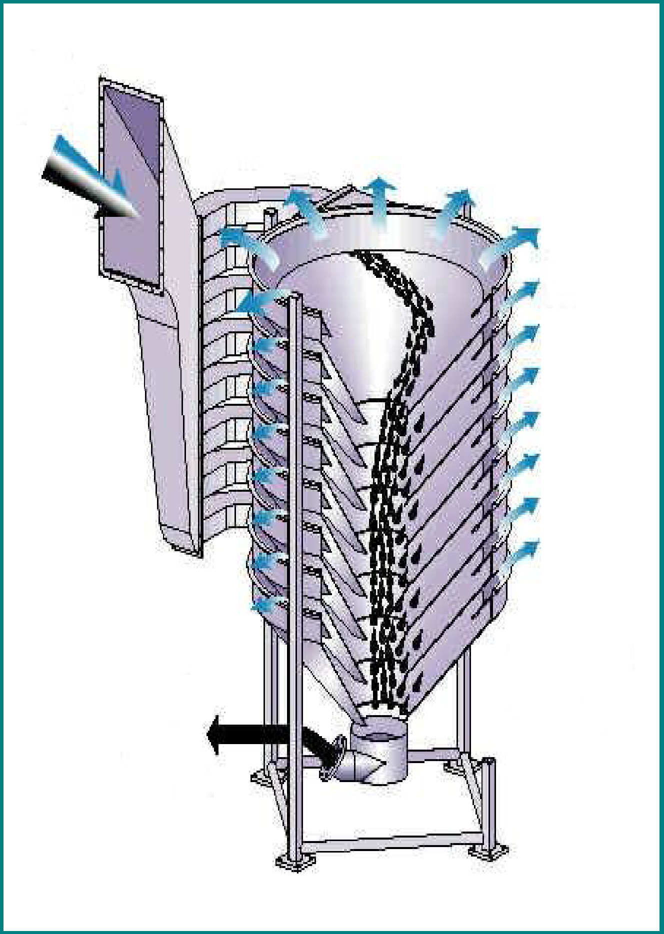
- Gravity Settling
- ~~Free Vortex (Tea Cup)~~ High Energy
- ~~Aerated Grit~~ Poor Success
- Forced Vortex

Site Constraints

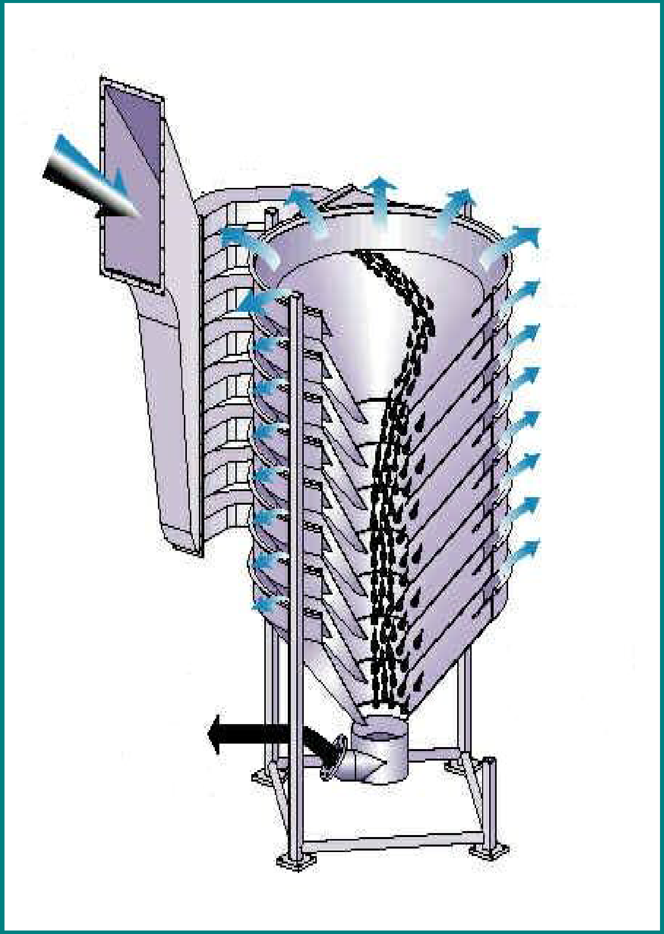
Available Technologies

- Gravity Settling
- Forced Vortex

Gravity Settling Technology



Gravity Settler Features



- Full Scale
- Two Units
- 18 MGD each (68 ML/d)
- 9 Trays
  - 12 foot dia (3.66 m)
  - 1062 ft^2 (98.7 m^2)
- Plastic & Stainless Steel
- Two foot head loss (60 cm)
- Cut Point 100 µm @ 2.65 sg

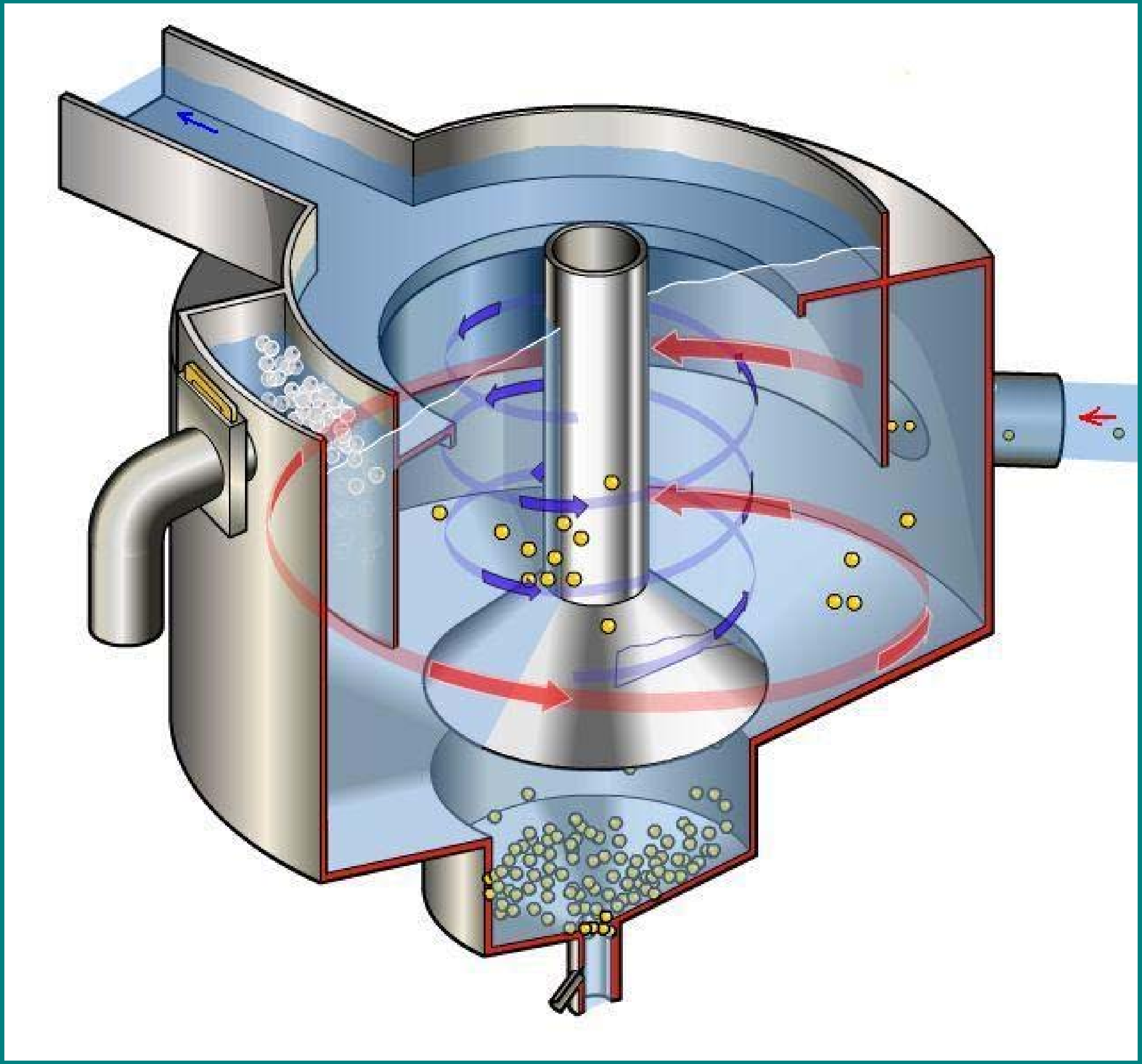
Gravity Technology Pilot Unit

Two Trays 4 ft diameter (1.22 m)

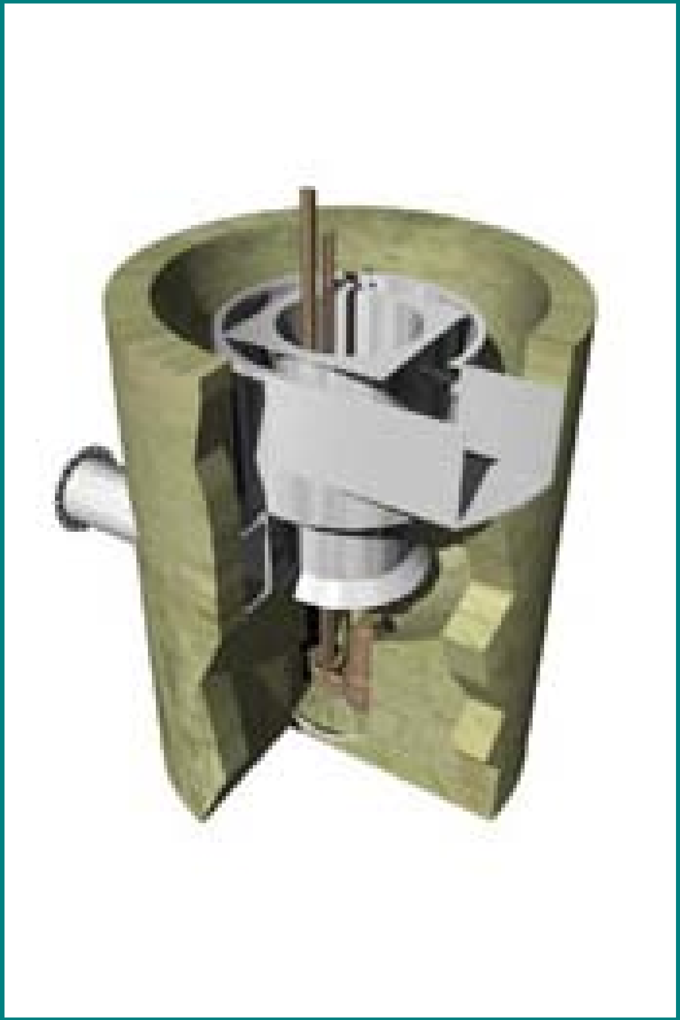
Optimum Performance: Feed Rate170 gpm

Cut point : 75 µm @ 2.65 sg

Forced Vortex Technology



Forced Vortex Features



- Full Scale
- Two Units
- 18 MGD each (68 ML/d)
- 22 foot diameter (6.7 m)
- Concrete & Stainless Steel
- Less than one foot head loss (30.5 cm)
- Cut point 150 µm @ 2.6 sg

Vortex Pilot Unit

4 ft dia (1.22m)

Optimum Performance: Feed Rate180 gpm

Cut point : 106 µm @ 2.65 sg

Test Protocol

- Simultaneous Parallel testing
- Same day testing
- Use native grit from plant RWI
- Comparable flow rates
- Applicable full scale flow rates
- Same test procedures
- Same analysis
- One laboratory

Scale Up Test Protocol

Gravity Settler

Full to Pilot ratio based on SOR

Feed Rate gpm (Lpm)	Cut Point	SOR L/m^2-day	Comparable Plant MGD (ML/d)		Full Scale No. of 12 ft (3.6m) dia trays
170 (643)	75µm	402,837	10	(40)	9
247 (935)	100µm	575,453	15	(57)	9

Forced Vortex

(Diameter Full Scale/Diameter Pilot)$^{2.2}$ x Pilot Flow Rate = Full Scale Flow Rate

Feed Rate gpm (Lpm)	Cut Point	Comparable Plant MGD (ML/d)		Diameter Full Scale
180 (681)	106µm	11	(42)	22 ft (6.7m)
247 (935)	150µm	15	(57)	22 ft (6.7m)

Pilot Testing

Dual Vertical Samplers at RWI

Pilots with Sampling Equipment

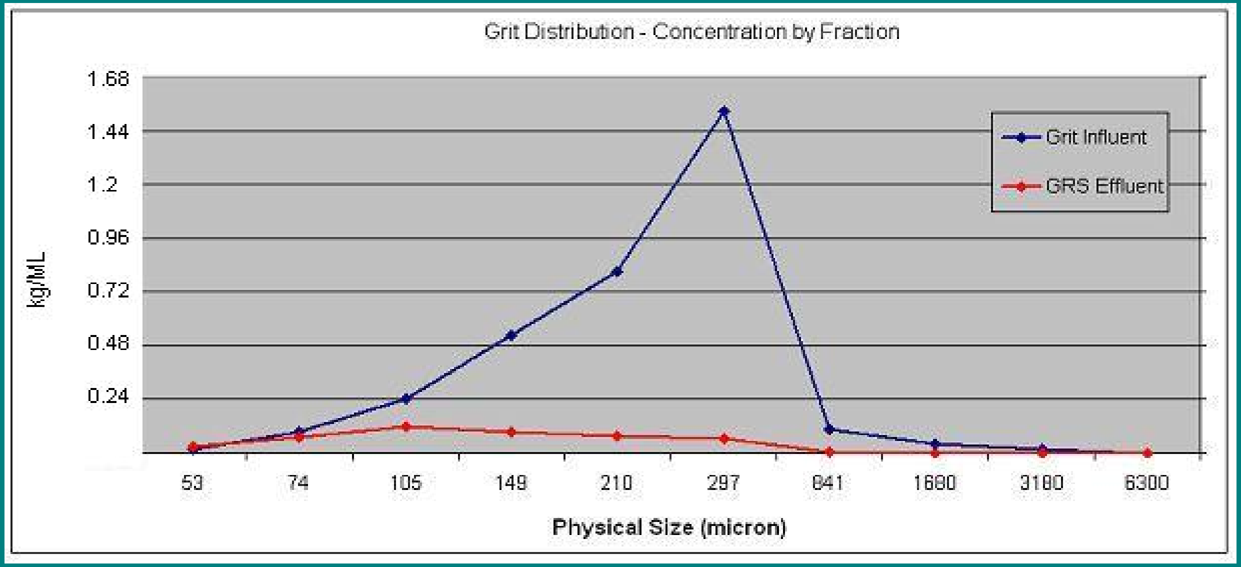
Testing Problems

- Ultrasonic Flow Meters could not perform
  - Feed rates determined by fill test and adjusting throttle on pump motor

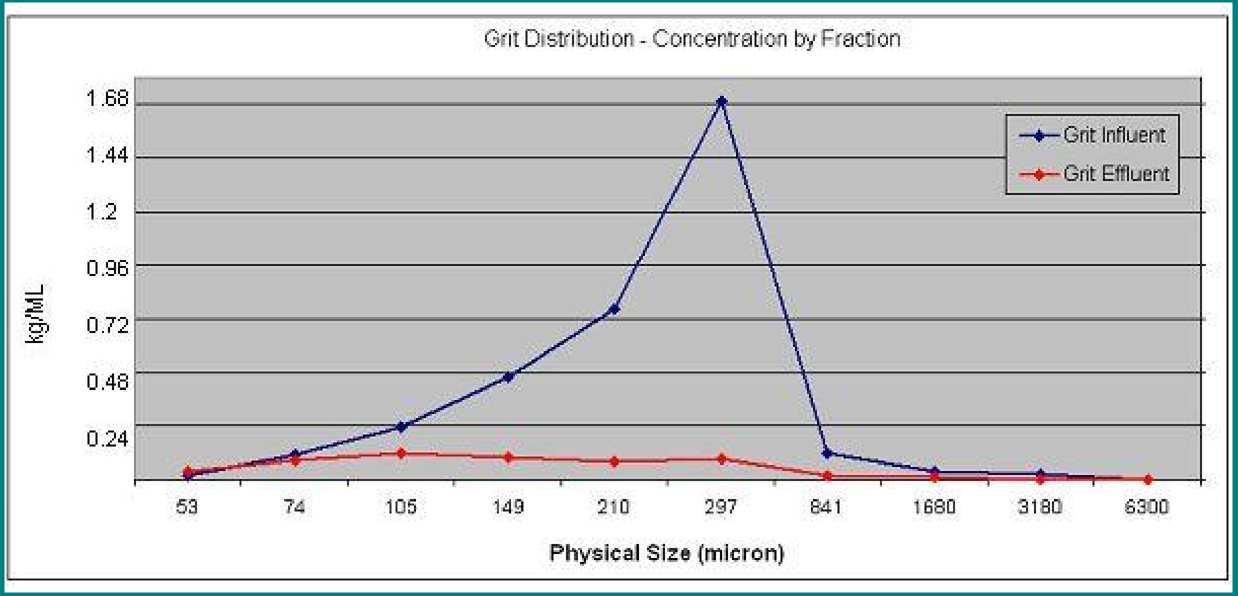
- Rags fouled pump suctions
  - Bar screens placed in hand

- Could not achieve pump rates of 300 gpm (1136 Lpm) or the full scale equivalent of 18 MGD (68 LPD)
  - RWI channel 22 ft deep
  - Trash pumps too small
  - Rented pumps unable to perform

10 MGD Results

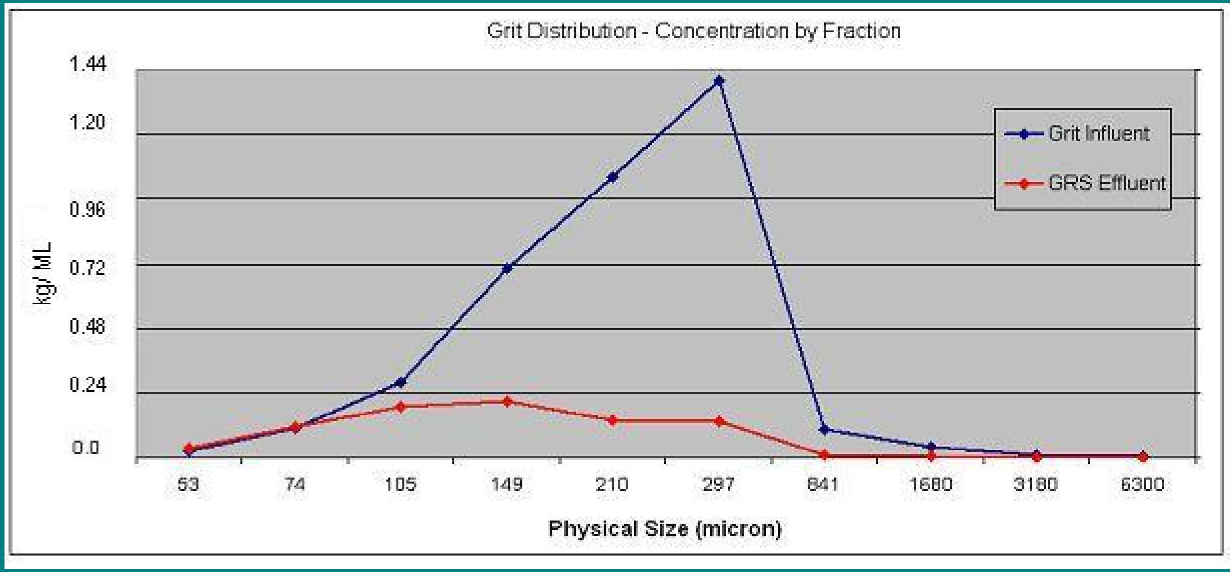


Gravity Settler
39 ML/d
(10.4 MGD)
December 17, 2007

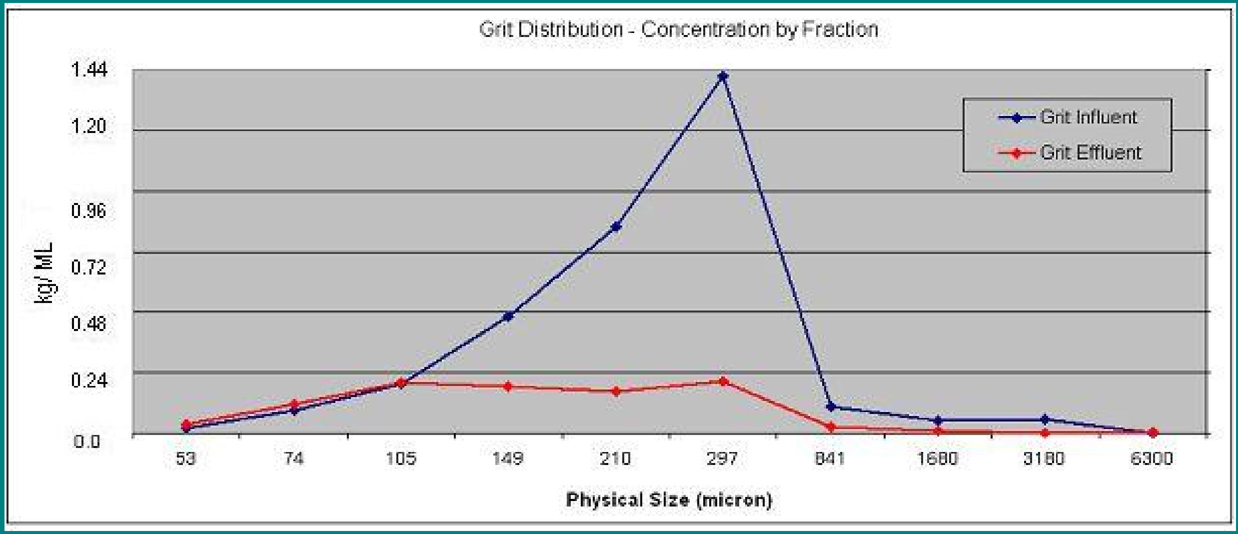


Vortex
40 ML/d
(10.5 MGD)
December 17, 2007

15 MGD Results



Gravity Settler
57 ML/d
(15.1 MGD)
December 18, 2007



Vortex
56 ML/d
(14.8 MGD)
December 18, 2007

Pilot Unit Removal Efficiencies

			%Removal Efficiency				
Pilot Name and Date	Scale Up Flow Rate MGD (ML/d)	Pilot Flow Rate Lpm (gpm)	#50 Mesh (>297-microns)	#70 Mesh (<297-microns >210-microns)	#100 Mesh (<210-microns >149-microns)	#140 Mesh (<149-microns >105-microns)	Total % Removal 105 μm & up
Gravity							
17-Dec-07	10.4 (39)	643 (170)	95.8	90.4	81.5	50.8	88.8
18-Dec-07	15.1 (57)	939 (248)	90.3	86.8	70.0	32.0	80.8
Vortex							
17-Dec-07	10.5 (40)	651 (172)	93.6	89.4	78.7	50.3	87.5
18-Dec-07	14.8 (56)	916 (242)	84.9	79.5	59.7	0.0	74.2

Conclusion

- Foot Print Equal
- Price Comparable
  - $1.3 Million for 2 Gravity Units
  - $1.2 Million for 2 Vortex Units
- Head loss greater for gravity unit
- Gravity settler exhibited higher removal rates at higher flows

True Grit

Full-Scale Performance Assessment of Three Common Grit Removal Technologies

Brian F. McNamara, HRSD

Jimmie Griffiths

Dave Book

Evaluated Grit Removal Processes

Plant	Equipment	Design Removal Paramters
VIP	Forced Vortex 20 ft dia	150 ***µm*** 65% removal 26.7 MGD
CETP	Forced Vortex 24 ft dia	150 ***µm*** 95% removal 30 MGD 270 ***µm*** 95% removal 70 MGD
NTP	Forced Vortex 24 ft dia	150 ***µm*** 95% removal 50 MGD *
JRTP	Detritor 28 ft	150 *µm*** ?? Removal 6.5 MGD
YRTP	Aerated Grit 0.278 MG	150 *µm*** ?? Removal 15 MGD

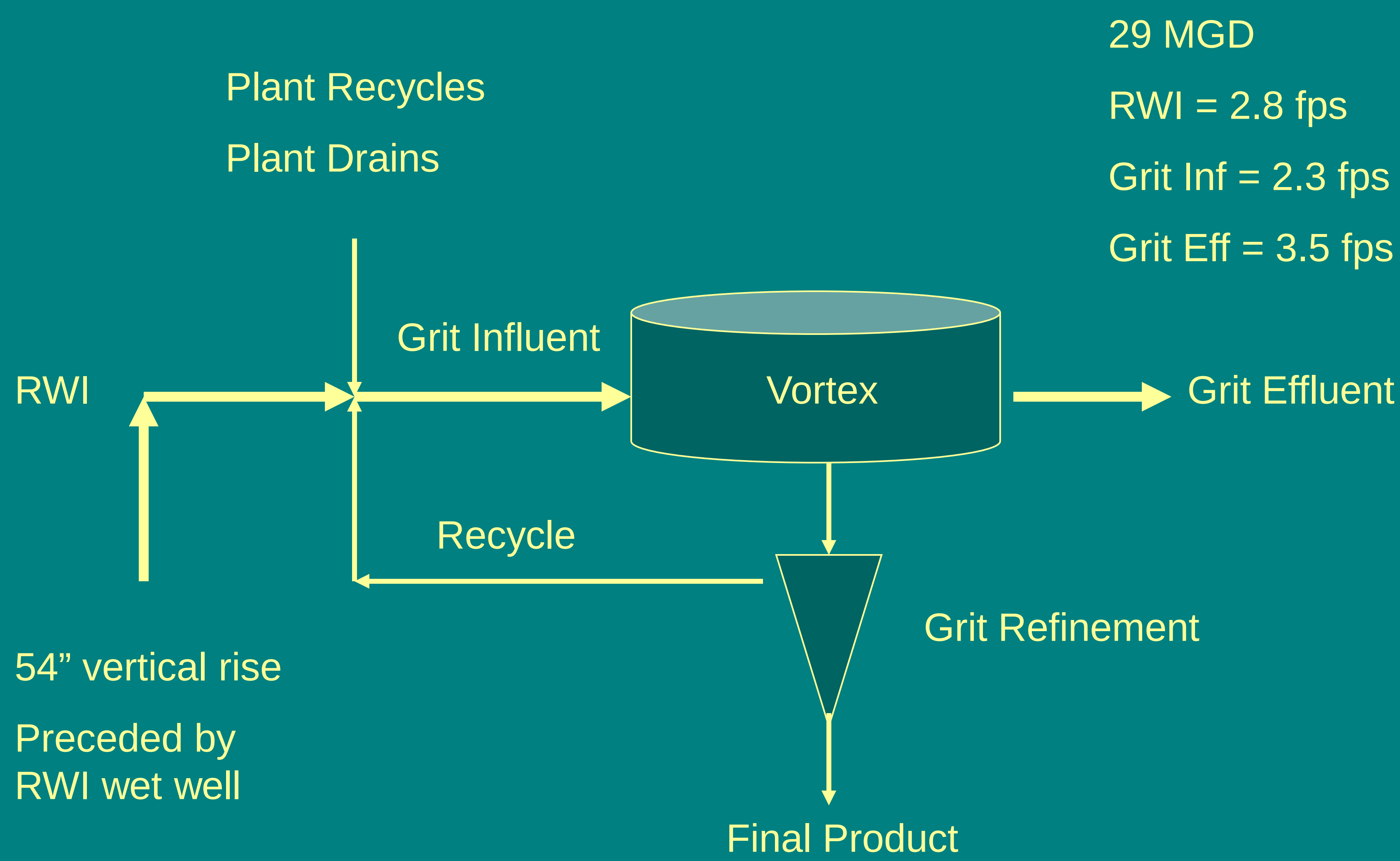
*Specs indicate both 30 MGD and 50 MGD
**Detritors & Aerated Grit derived from design literature.
**All systems reference grit at 2.65 SG

Note: All removal processes refined the grit using cyclones & classifiers

VIP Forced Vortex 20 ft dia

Plant Design 40 MGD with Collection system composed of both gravity and force mains

VIP Forced Vortex 20 ft dia



VIP RWI Forced Vortex 20 ft dia

VIP Forced Vortex 20 ft dia

Grit Influent
and
Grit Effluent

Plant History

VIP Forced Vortex 20 ft dia

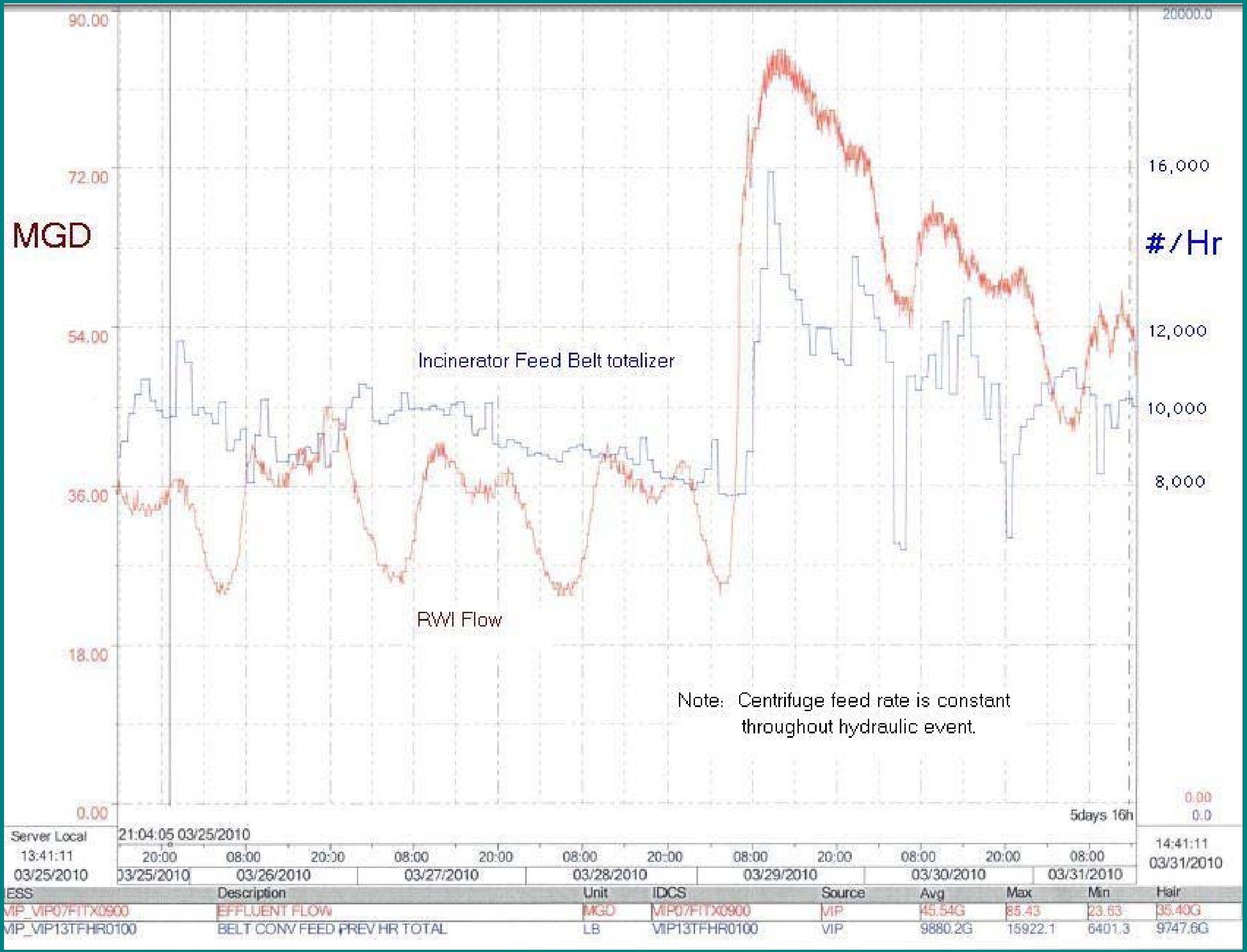
Grit in primary biosolids

Premature wear on centrifuges

Grit volume taking up valuable incinerator space

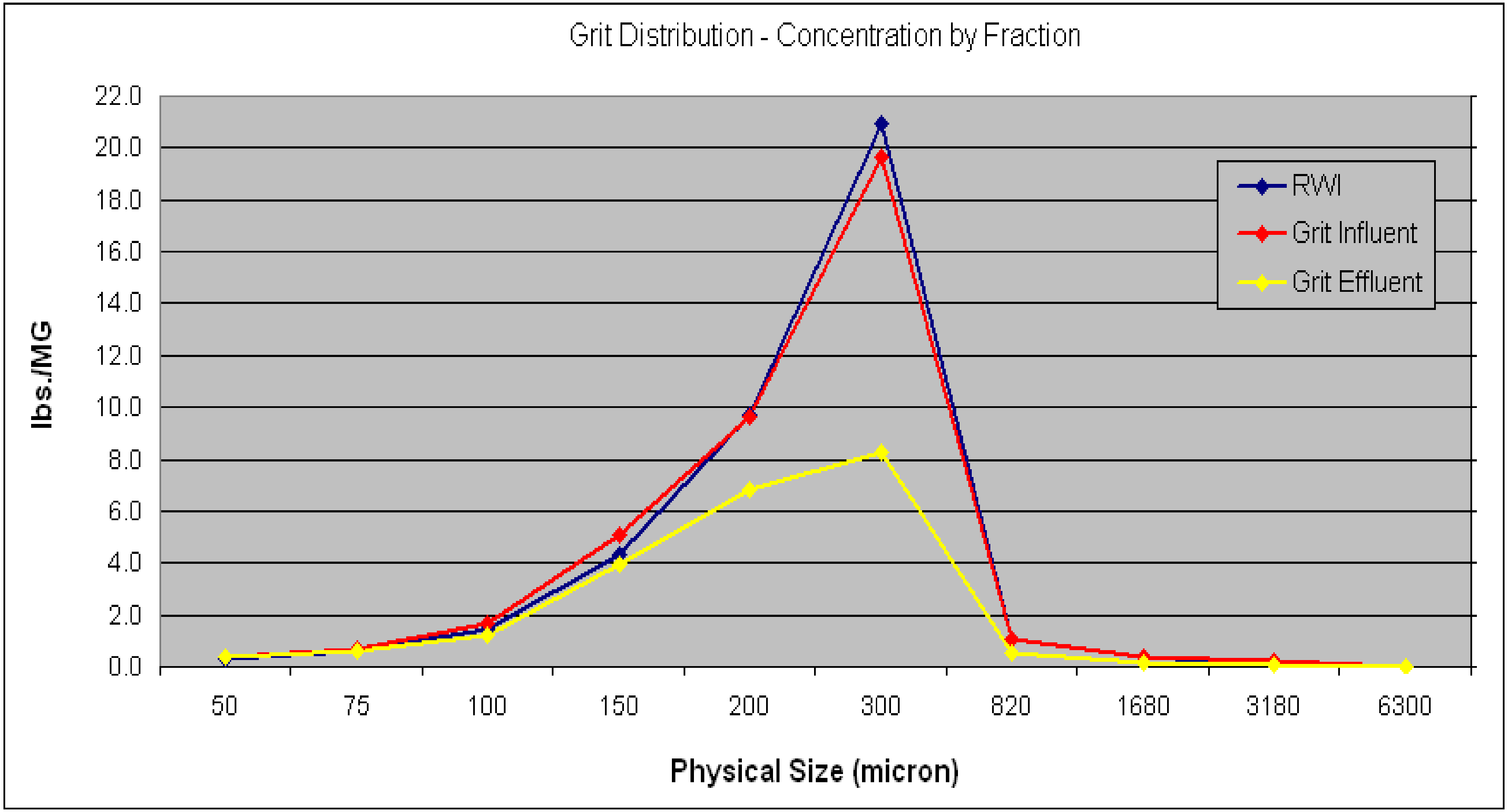
Plant History

VIP Forced Vortex 20 ft dia



RWI flow and Incinerator feed belt totalizer during a hydraulic event.

Concentration of Grit VIP Force Vortex 20 ft dia on May 20, 2007 Sunday



Virginia Initiative Plant
Vortex 20 ft Dia Efficiency Results

	%Removal Efficiency			
Plant Name and Date	#50 Mesh (>297-microns)	#70 Mesh (<297-microns >211-microns)	#100 Mesh (<211-microns >150-microns)	Total % Removal 150 µm & up
VIP Vortex				
Sun, May 20, 2007	57.7	29.8	22.7	45.3
Mon, May 21, 2007	60.5	26.8	23.2	45.1
Tue, May 22, 2007	59.3	33.2	27.9	43.3

Average hourly flow during sampling was approximately 30 MGD

Specification requires 65% of 100 mesh (150 µm) at a maximum design flow of 26.7 MGD and 2.65 sg

System Conclusions

VIP Forced Vortex 20 ft dia

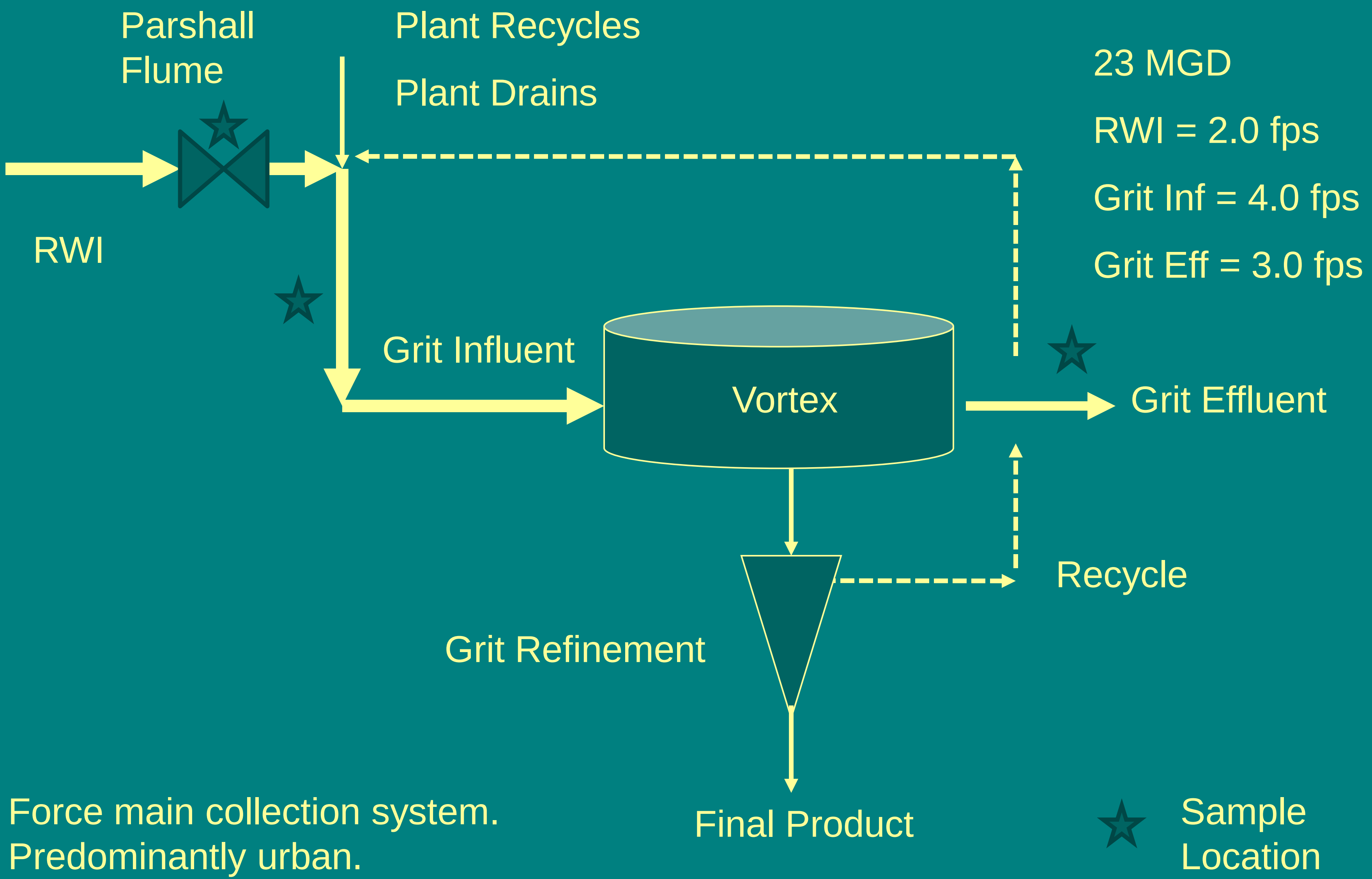
- 70% of RWI grit was over 200 microns
- > 300 micron grit shape flat, settled slowly
- Current system operation does not adequately protect downstream equipment

- Note: Plant was advised to use 2 vortexes if flows over 26 MGD

CETP Forced Vortex 24 ft dia

Plant Design 24 MGD with a collection system composed of force mains

CETP Forced Vortex 24 ft dia



Force main collection system.
Predominantly urban.

CETP Forced Vortex 24 ft dia
RWI & Grit Influent

23 MGD   RWI = 2 fps   Grit Inf = 4 fps   Grit Eff = 3 fps

CETP Forced Vortex 24 ft dia
Grit Effluent

Plant History

CETP Forced Vortex 24 ft dia

Prior to forced vortex units, plant used square grit chambers or Detritors.

2005 Detritors removed 24,570 ft^3 grit

2007 Forced vortex & hydro-cyclones removed 2,034 ft^3

Plant Grit Experience

CETP Forced Vortex 24 ft dia

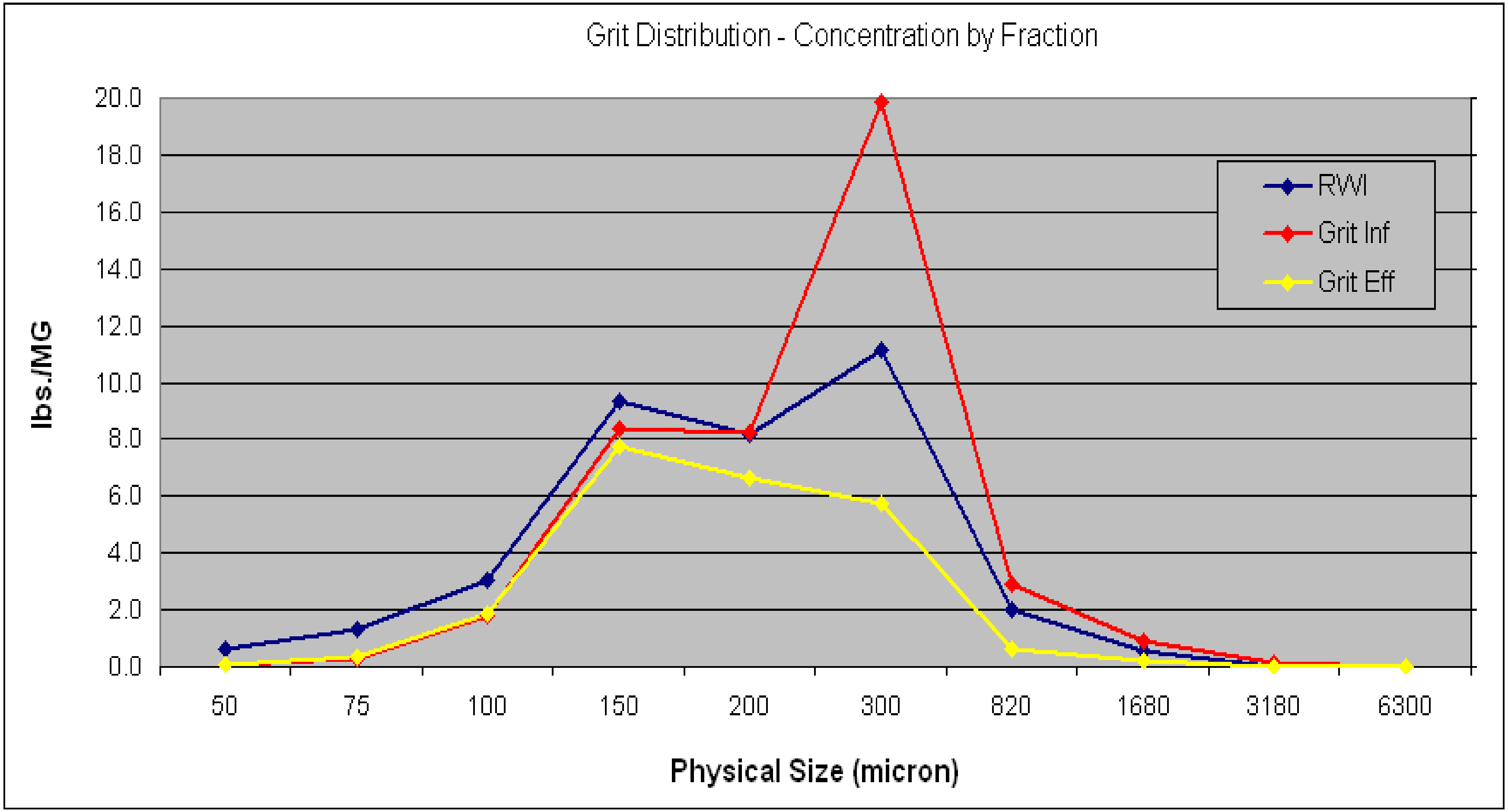
Grit Build up in the aeration tanks

Lost Secondary Clarifier due to grit build up

Removed grit from contact tanks

Removed grit in scum concentrator

Concentration of Grit
CETP Forced Vortex 24 ft dia
RWI, Grit Influent, Grit Effluent
Thursday May 17, 2007



CETP Forced Vortex 24 ft dia Removal Efficiency

	%Removal Efficiency			
Plant Name and Date	#50 Mesh (>297-microns)	#70 Mesh (<297-microns >211-microns)	#100 Mesh (<211-microns >150-microns)	Total % Removal 150 µm & up
Ches-Eliz Vortex				
Thu, May 17, 2007	72.6	19.1	7.0	48.0
Fri, May 18, 2007	77.8	28.9	14.7	52.0

Average hourly flow during sampling was approximately 20 MGD/hour

At 30 MGD, manufacturer specifies 95% removal of 100-mesh with 2.65 sg

System Conclusions
CETP Forced Vortex 24 ft dia

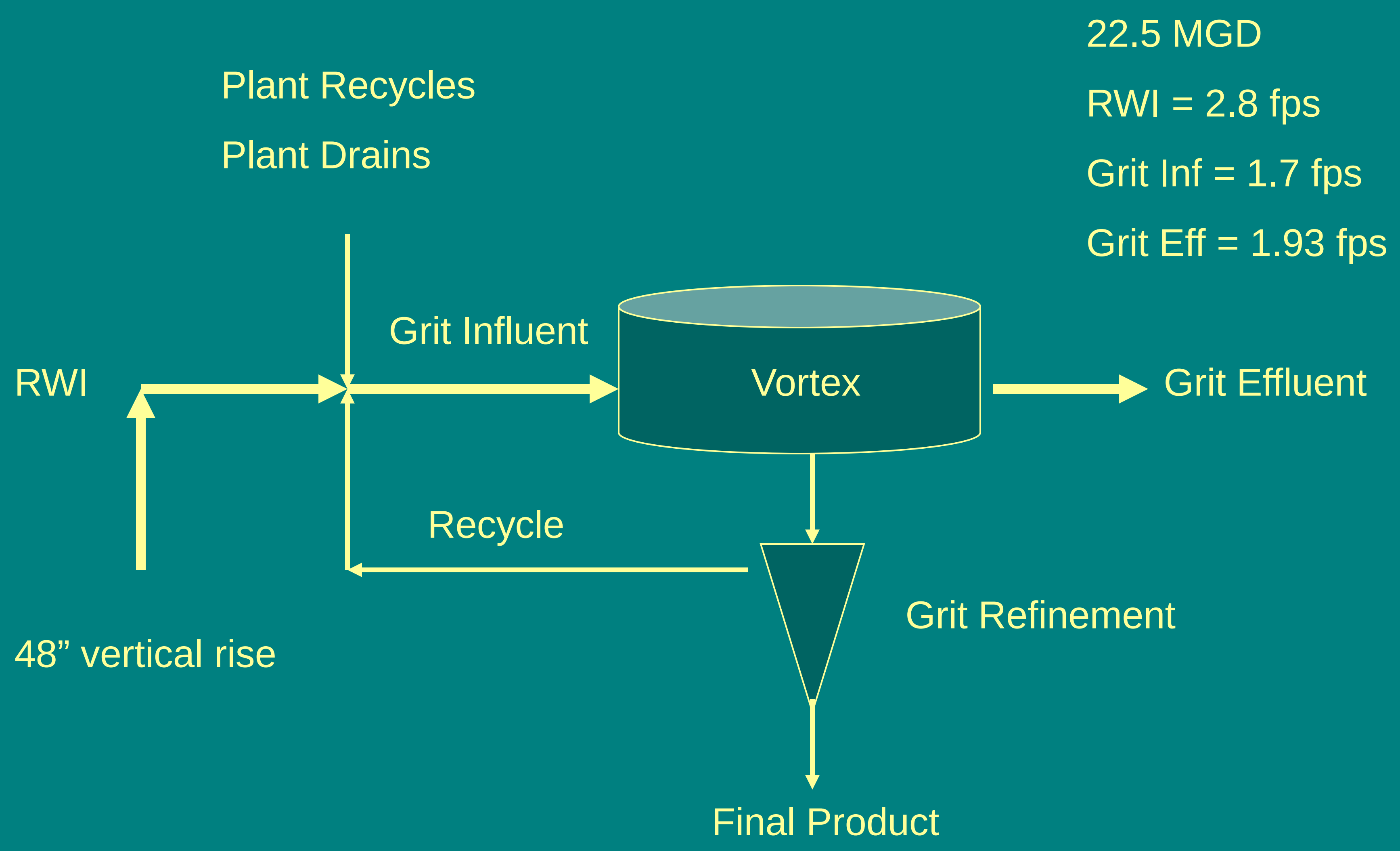
- +80% of RWI grit was over 200 microns
- > 300 micron grit shape flat, settled slowly
- System did not protect downstream equipment

Nansemond Treatment Plant
24 ft Vortex

Plant Design 30 MGD

with a collection system composed of force mains

NTP Forced Vortex 24 ft dia



Plant Grit Experience
NTP Forced Vortex 24 ft dia

1203 Wet Metric Tons Removed from Digester 2008

NTP Forced Vortex 24 ft dia
Removal Efficiency

	%Removal Efficiency			
Plant Name and Date	#50 Mesh (>297-microns)	#70 Mesh (<297-microns >211-microns)	#100 Mesh (<211-microns >150-microns)	Total % Removal 150 µm & up
Nansemond Vortex				
Tue, Mar 4, 2008	44.4	29.4	4.4	22.8
Wed, Mar 5, 2008	58.1	36.4	16.3	31.1

Average hourly flow during sampling was approximately 20 MGD/hour

At 50 MGD, manufacturer specifies 95% removal of 100-mesh with 2.65 sg *

System Conclusions

Nansemond 24 ft Vortex

- Over 80% of grit was less than 297 µm
- System does not adequately protect down stream equipment.
  - 1203 Metric tons removed from digester in 2008

JRTP 28 ft dia Detritor

Design 20 MGD, with a collection system composed of force mains

Detritor RWI and Grit Influent Sampling Setup

15 MGD

RWI = 2.5 fps

6 MGD

Grit Inf = 2 fps

Grit Eff = 2.5 fps

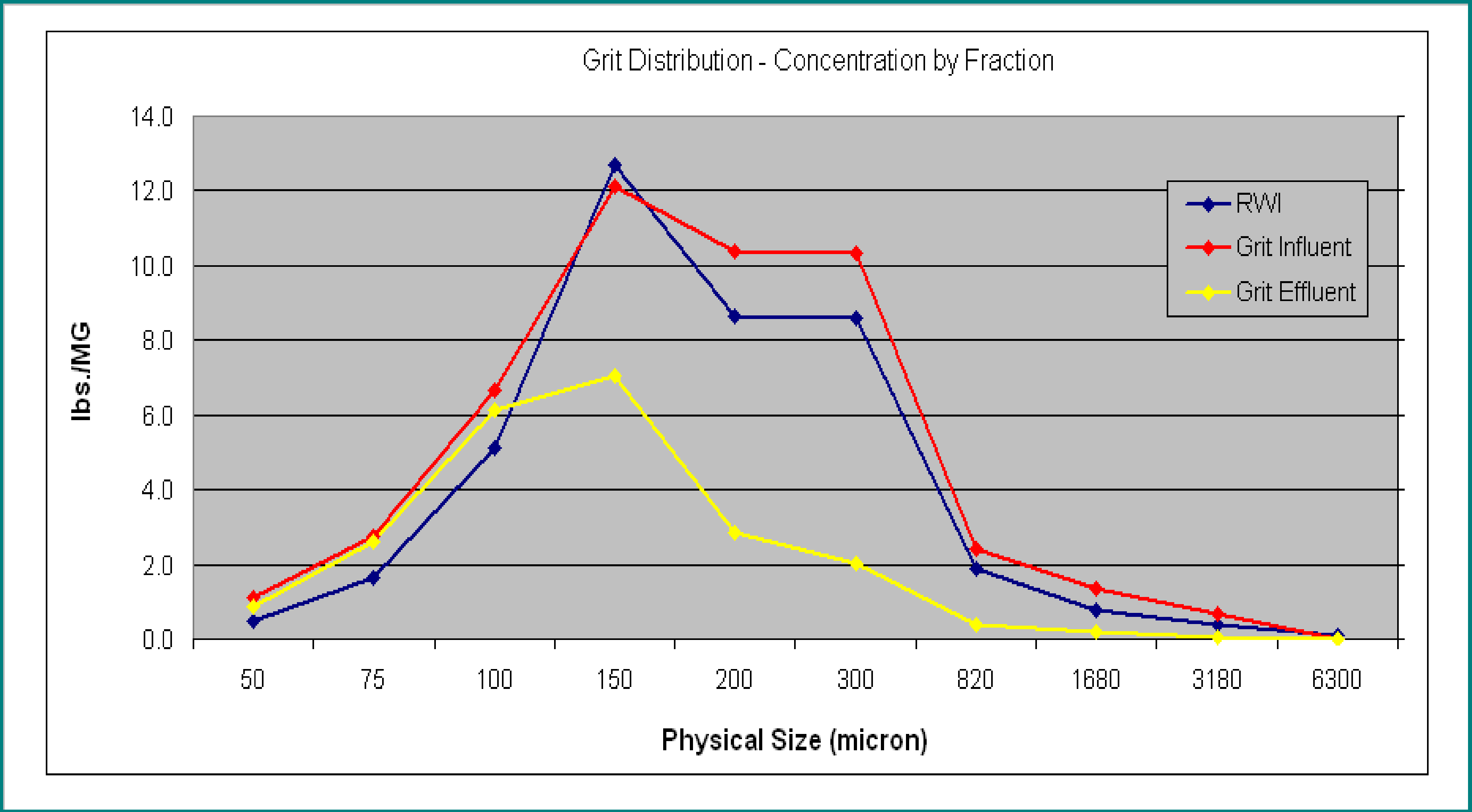
Plant Grit Experience

Detritor

No down stream grit accumulations

Digesters have not accumulated appreciable amounts of grit

Concentration of Grit Present at Plant
Detritor
June 17, 2007 Sunday



James River Detritor Treatment Plant Removal Efficiency

	%Removal Efficiency			
Plant Name and Date	#50 Mesh (>297-microns)	#70 Mesh (<297-microns >211-microns)	#100 Mesh (<211-microns >150-microns)	Total % Removal 150 µm & up
James River Detritor				
Sun, Jun 17, 2007	81.8	72.6	41.7	66.2
Mon, Jun 18, 2007	76.9	77.2	66.6	73.2
Tue, Jun 19, 2007	82.6	74.7	55.3	71.2

Average hourly flow during sampling was approximately 5 MGD

Optimum design flow 6.5 MGD for 100-mesh with 2.65 sg

System Conclusions
Detritor

- >40% of RWI grit was over 200 microns. Data suggest large grit deposits in collection system.
- System operated within design flows
- Plant operated with 3 detritors, providing adequate protection of downstream equipment

YRTP Aerated Grit

Tank Volume 0.278 MG

Design 15 MGD, with collection system composed of force mains.

Aerated Grit Influent

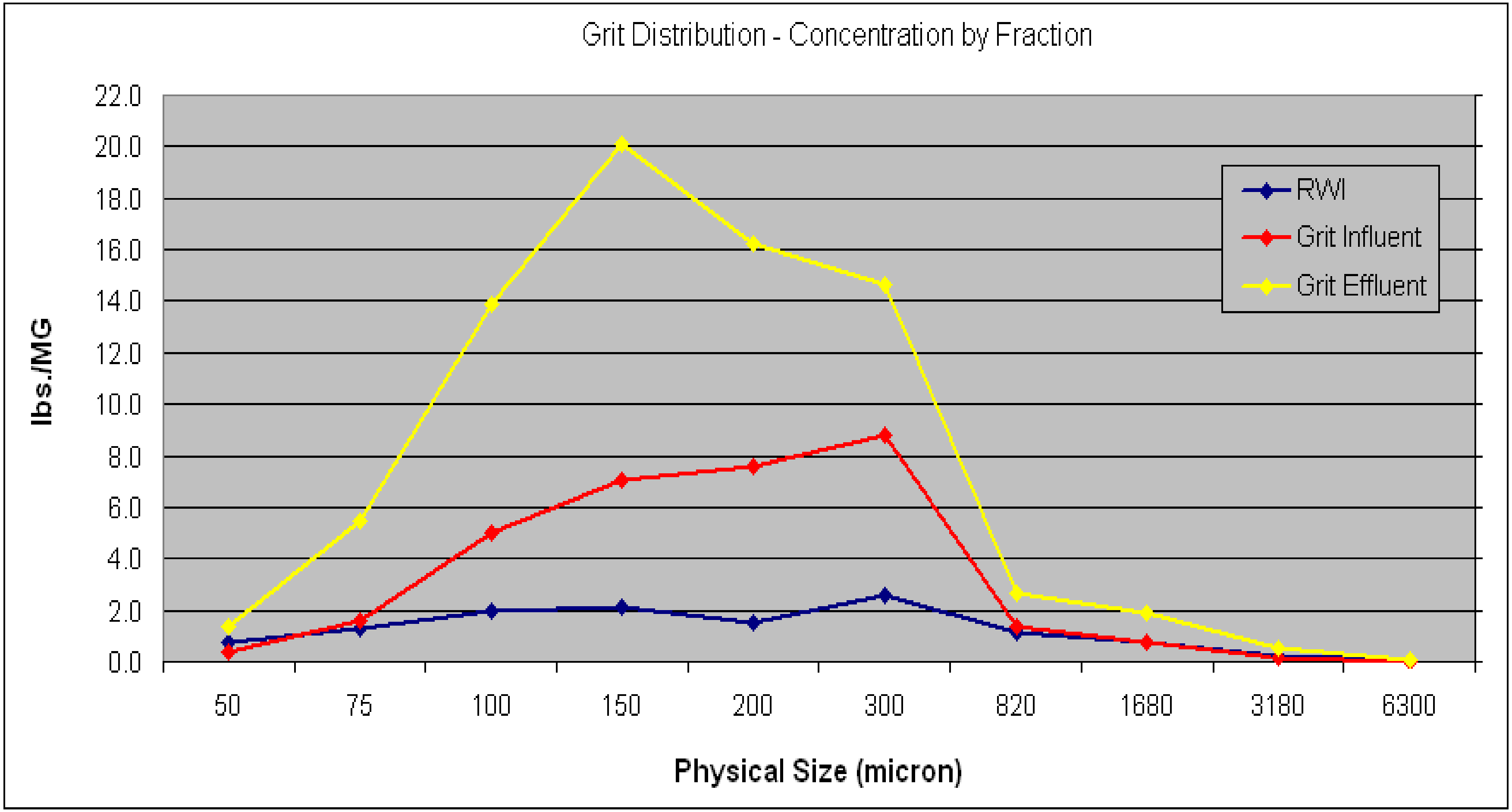
Aerated Grit Effluent

Plant History
Aerated Grit

2006 the plant processed 12.59 MGD and collected an annual total of 807 ft^3 of grit

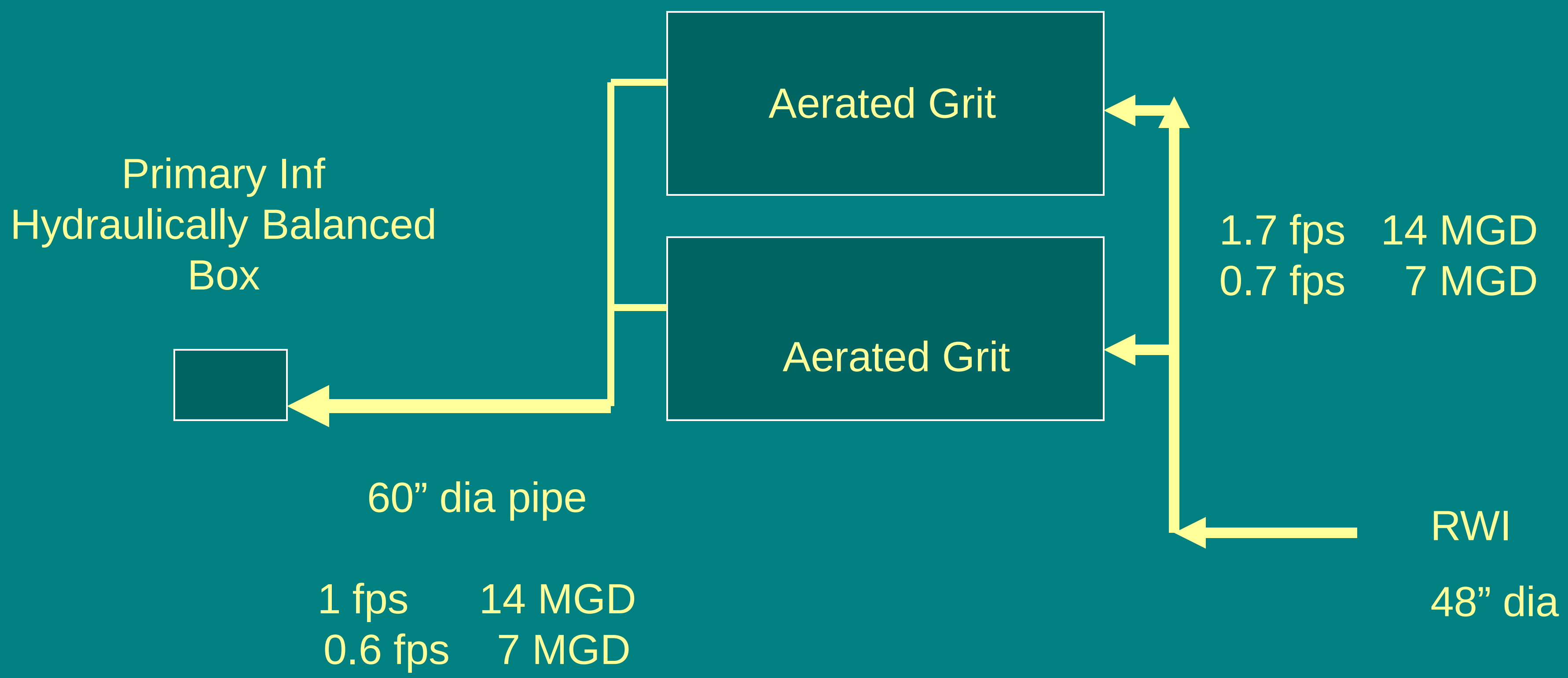
2007 Plant staff removed 14,885 ft^3 grit from digesters and sent to landfill

Concentration of Grit Present at the Plant
Aerated Grit
June 14, 2007 Thursday



Flow Velocities

Aerated Grit



System Conclusions
Aerated Grit

- Low RWI diurnal flow velocities 0.7 to 1.7 fps
- Deposition of grit in collection system
- Infiltration events achieve scouring velocities and convey slug loads into plant
- Grit system compromised during slug loads
- Primaries convey grit loads to plant digesters

Overall Conclusions

TECHNIQUE

- The grit sampling and testing methods are repeatable and meaningful
- Evaluating the overall system is necessary

EQUIPMENT (for this study)

- Detritor had the highest efficiency
- Forced vortex units had high efficiencies for large micron particles
- Forced vortex units performed better at less than design flow rates
- More testing is needed for aerated grit systems

OPERATIONAL ADVICE

- Evaluate putting more units in service to catch slug loads (first morning flows and wet weather events)

FUTURE

- More testing is desired during wet weather events
- CFD Modeling to examine how to improve performance

True Grit Summary

Plant Name and Date	%Removal Efficiency			
	#50 Mesh (>297-microns)	#70 Mesh (<297-microns >211-microns)	#100 Mesh (<211-microns >150-microns)	Total % Removal 150 µm & up
VIP Vortex				
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Tue, May 22, 2007	59.3	33.2	27.9	43.3
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Thu, May 17, 2007	72.6	19.1	7.0	48.0
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Nansemond Vortex				
Tue, Mar 4, 2008	44.4	29.4	4.4	22.8
Wed, Mar 5, 2008	58.1	36.4	16.3	31.1
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Mon, Jun 18, 2007	76.9	77.2	66.6	73.2
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Special Thanks to my Editor

Mardane McLemore

Questions?