It’s A Gritty Situation: Tackling Grit at Village Creek Water Reclamation Facility

January 29, 2021 TACWA Meeting

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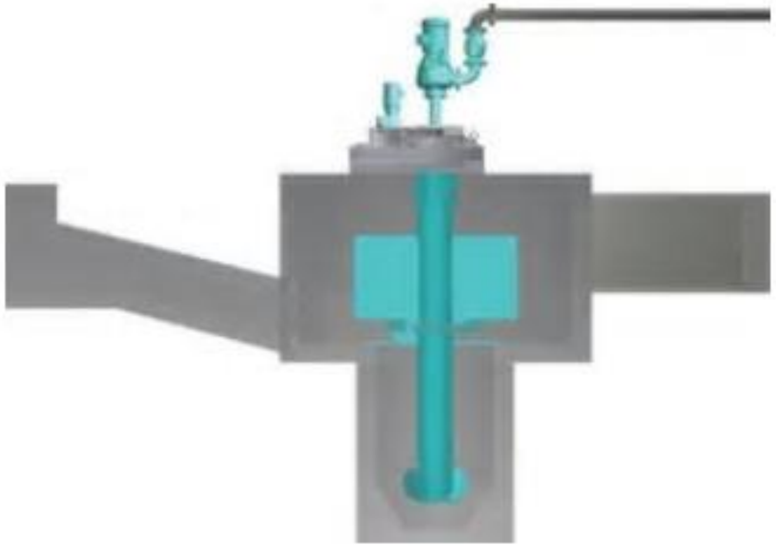
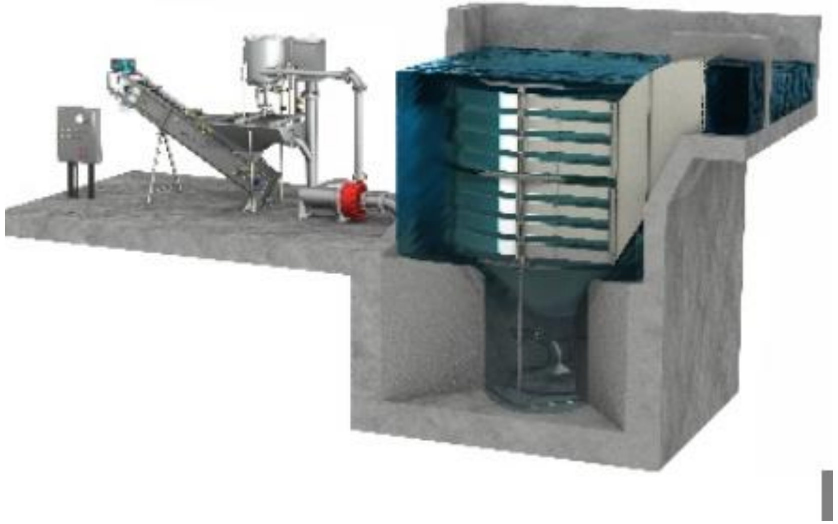
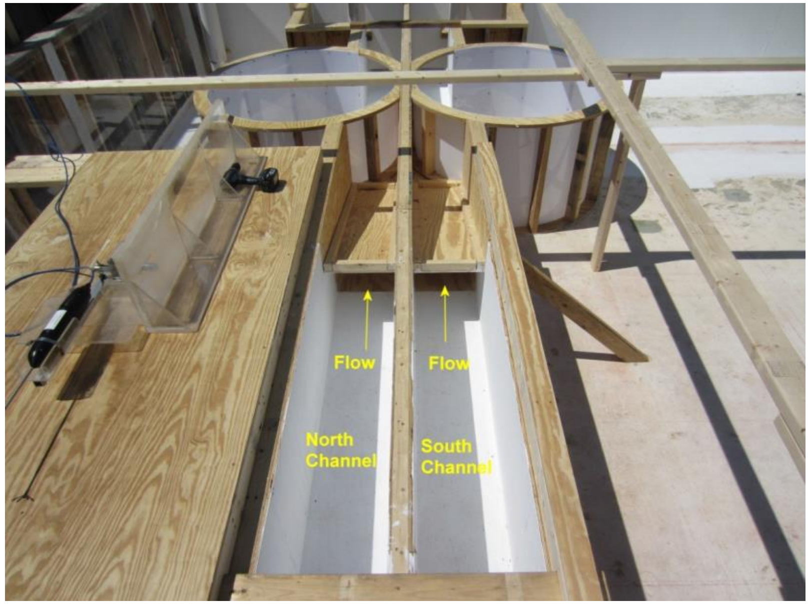






Presentation Overview

- Village Creek Water Reclamation Facility (VCWRF)
- Grit Characterization and Profiling
- Grit Facility Location Strategy
- Grit Technology Evaluation
- Physical Modeling
- Design 3D Model

Village Creek 1958

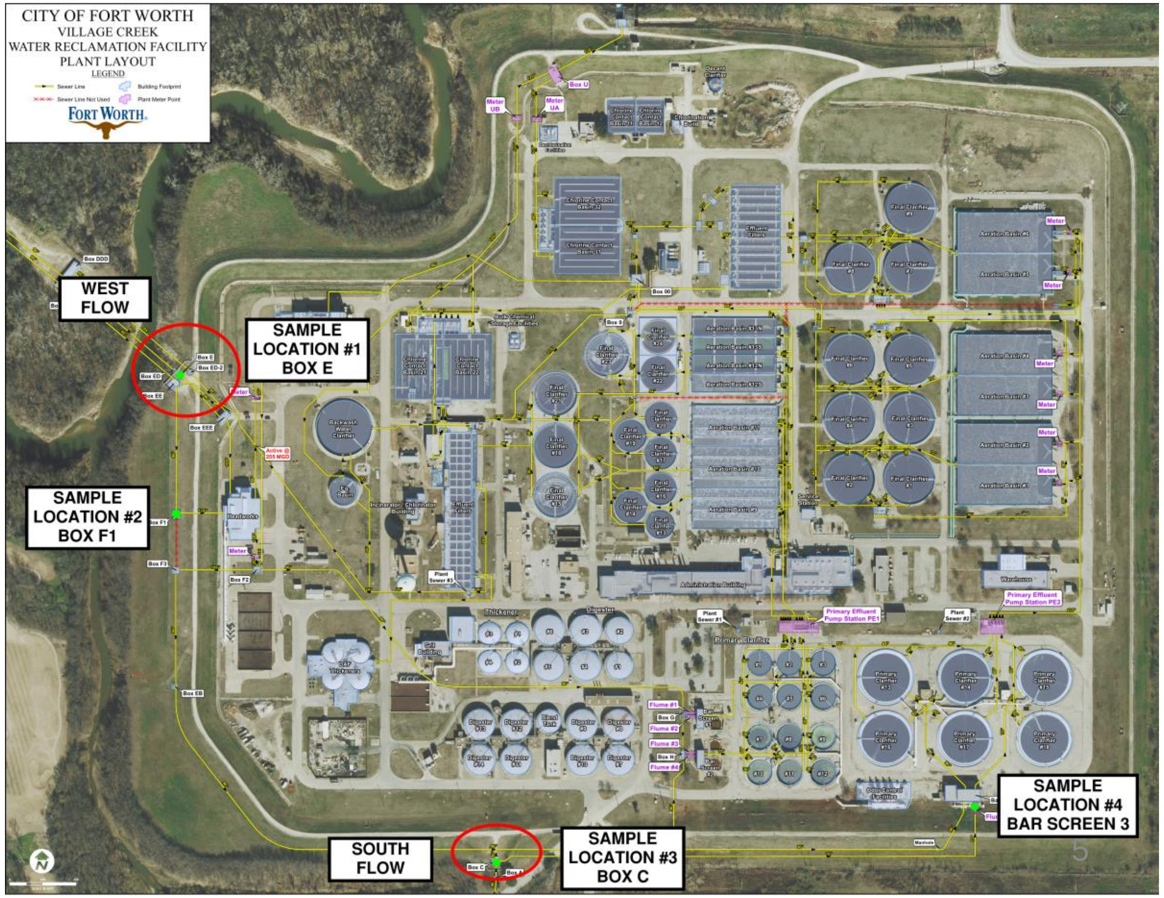
- “In the middle of no-where”
- Initial Capacity 5 MGD to serve East Fort Worth
- Built to replace Riverside WWTP
- Population of Fort Worth 350,000

Village Creek WRF Now

- Now serves around 1.2 million people including 880,000 Fort Worth residents, 23 communities in Tarrant and Johnson Counties
- Permitted for 166 mgd AADF and 369 mgd 2-hr peak
- Conventional WWTP
- No influent grit removal process
- Primary sludge de-gritting system

Grit Sampling & Characterization Studies

- September 2012 - influent & primary sludge
- June 2013 – influent & Salsnes Filter
- October 2015 – Digesters
- April-June 2016 existing primary sludge de-gritting system and slurry cup pilot
- April 2017 – Aeration Basin 6
- May 2017 – Sludge Holding Tank at Solids Dewatering Facility
- September 2017 – influent and primary sludge



Grit Characterization and Profiling

	Average Grit Particle Distribution		
Particle Size	≤105µm	≤150µm	≤297µm
Influent Box E	5.3%	13.5%	34.4%
Influent Box F1	9.3%	21.3%	50.0%
Influent Box C/Bar Screen 3	9.1%	23.0%	53.9%
Average	**7.9%**	**19.3%**	**46.1%**

Predicted Removal Efficiency of System Designed for Particular SES[1]		
105µm	150µm	297µm
96%	78%	31%

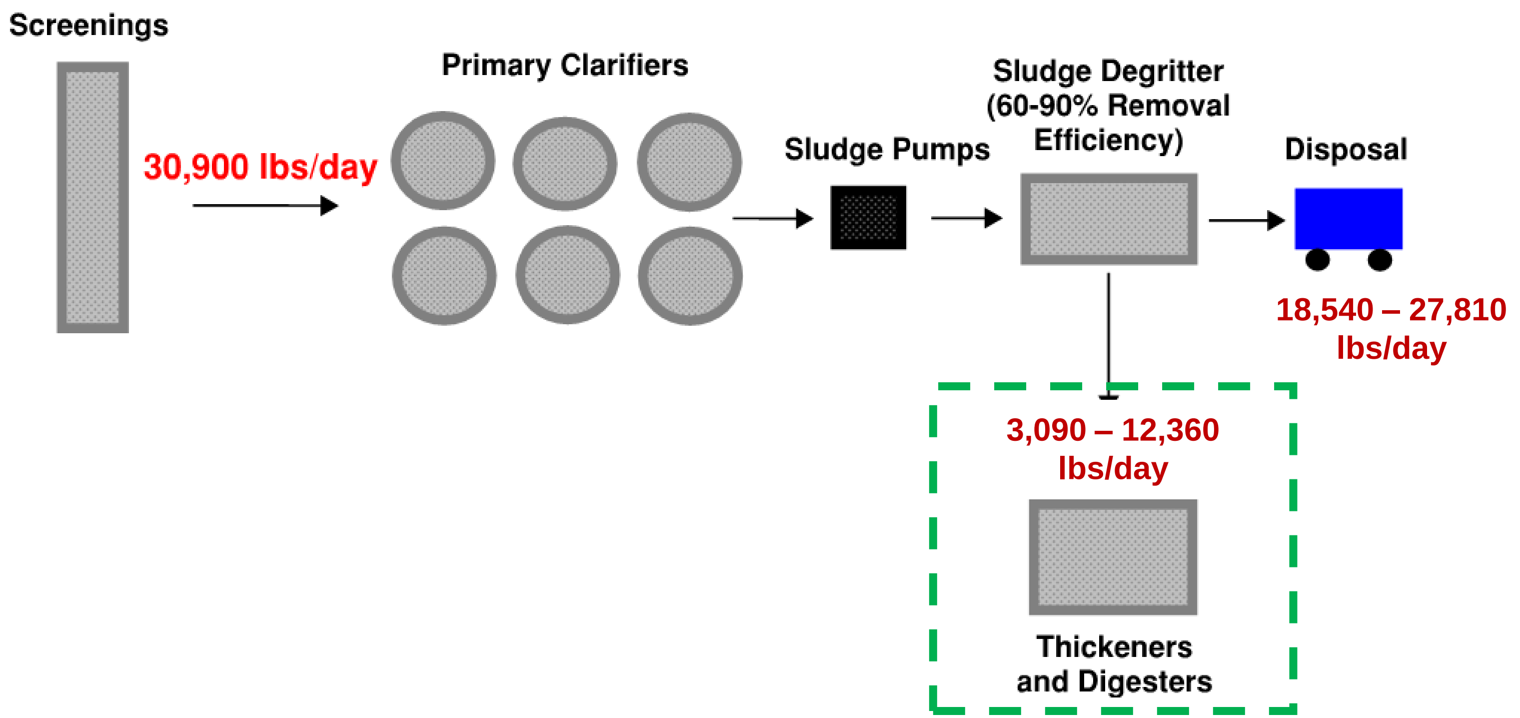
1. SES is Sand Equivalent Size – sand particle size (microns) having same settling velocity as the selected grit particle

Grit Characterization and Profiling

Location	Average Grit Concentration	
	lb/MG	mg/L
Influent Box C	67	8
Bar Screen 3	38	5
Influent Box F1	396	48
Influent Box E	115	14
Average	186	22

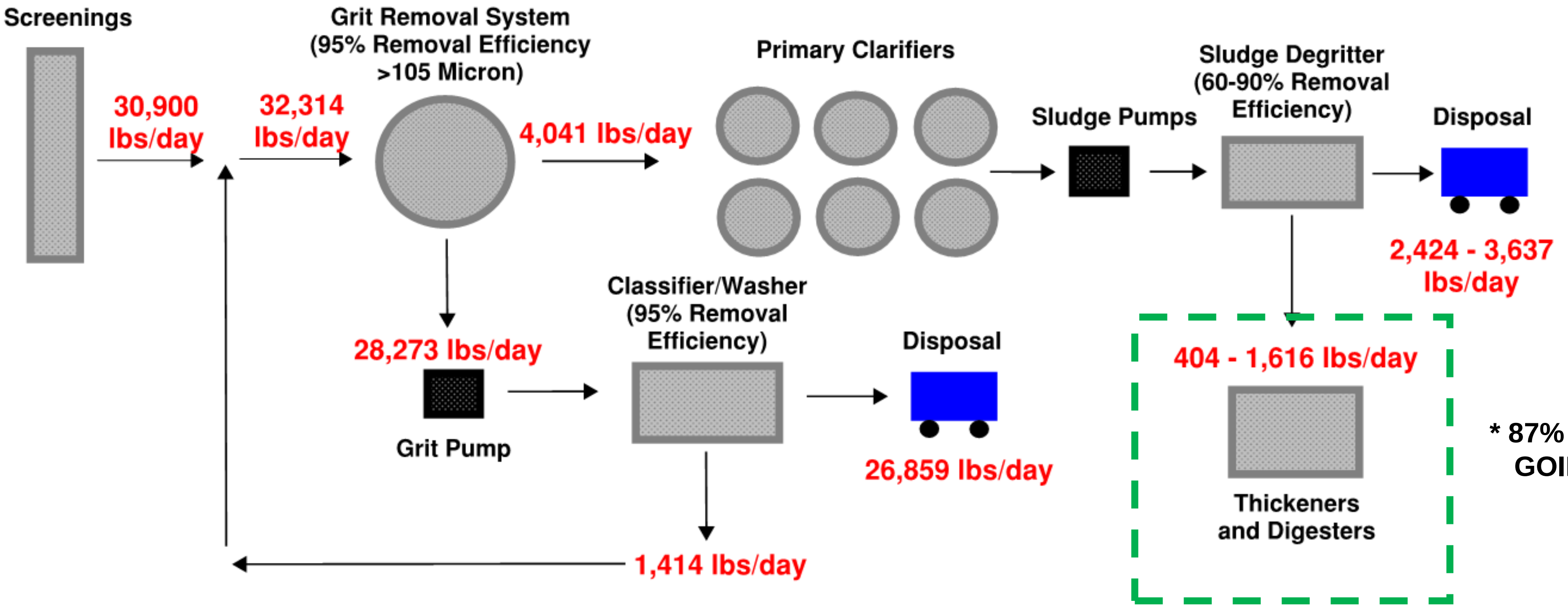
Grit Handling Mass Balance

Existing System



Grit Handling Mass Balance

System Design for 105 Micron Removal



* 87% REDUCTION IN GRIT GOING TO DIGESTERS

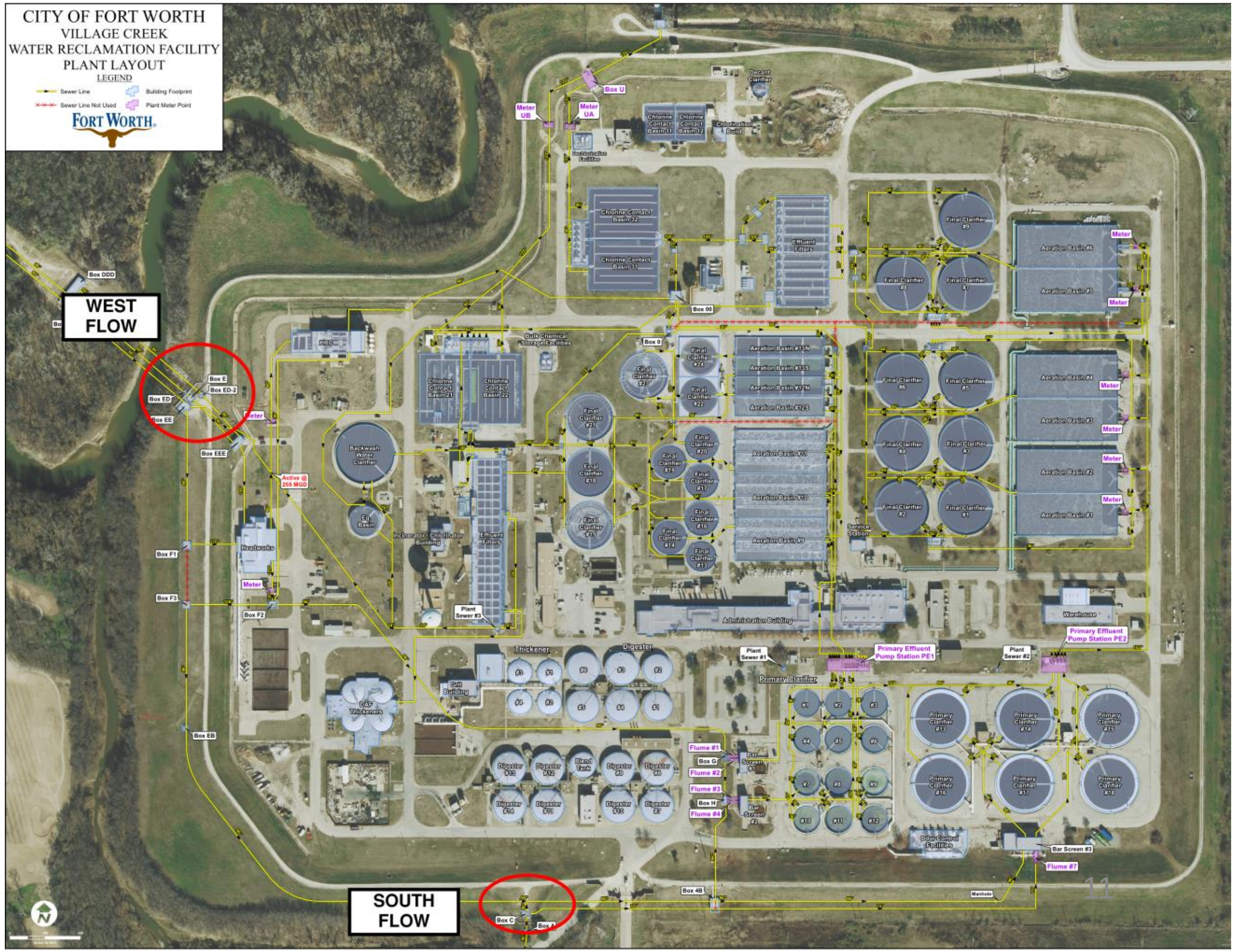
Grit Facility Design Criteria

Flow Scenario	Total Plant Flow	HRC Flow	Grit Facility Design Flow	Performance Cutpoint
Design AADF, mgd	166	0	166	≥105µm
2030 AADF, mgd	189	0	189	≥105µm
SPTC, mgd	365	110	255	≥150µm
PHF, mgd	494	110	384	≥212µm

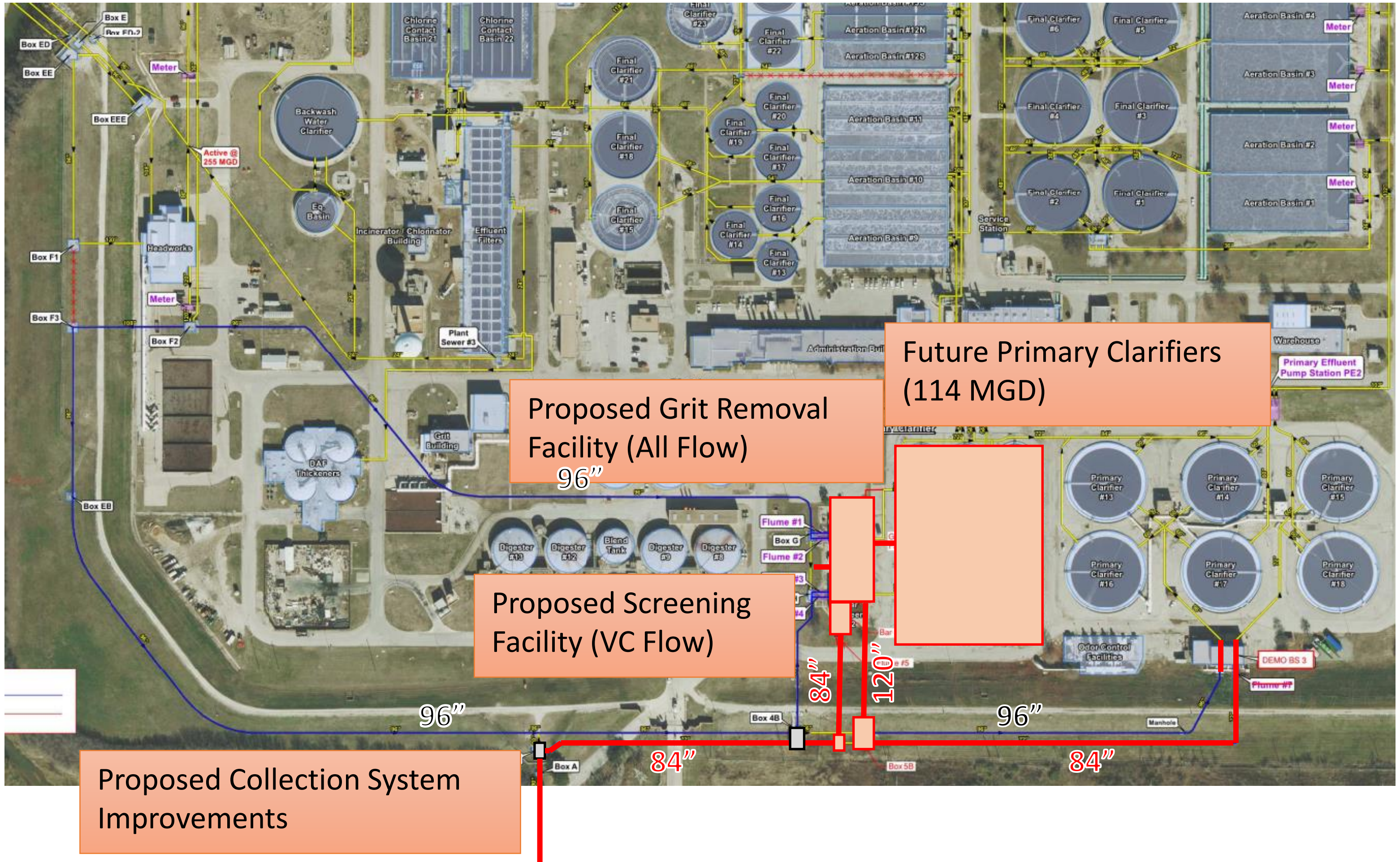
AADF – annual average daily flow; PHF – peak hour flow
SPTC - sustainable peak treatment capacity (extended 3-day peak treatment)

Grit Facility Location Strategy

- Address all flow
  - 75-80% West
  - 20-25% South
- South flow screening (BS3)
- Utilize existing Headworks screening capacity
- Collection system impacts

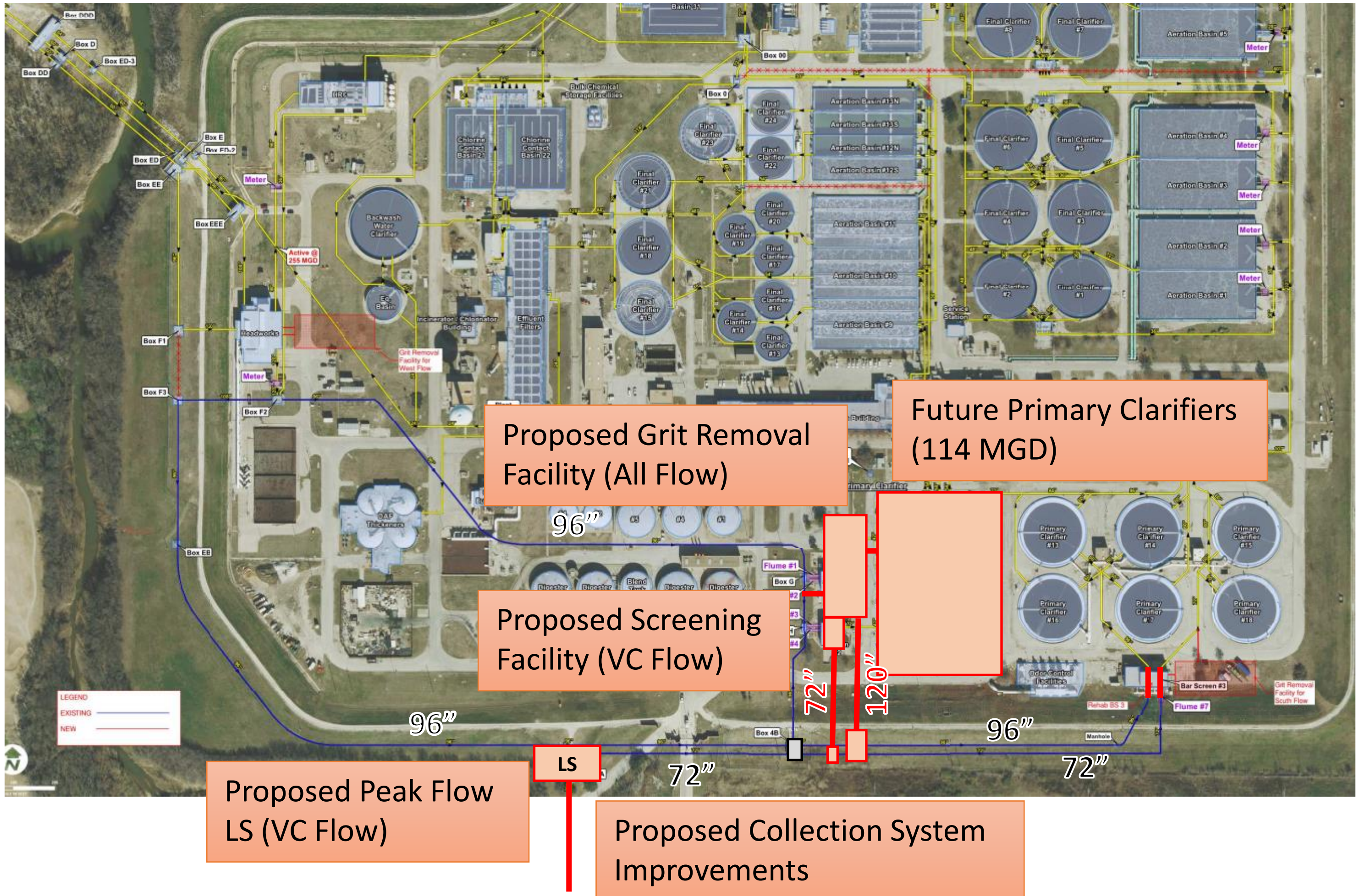


Grit Facility Location - Option 1



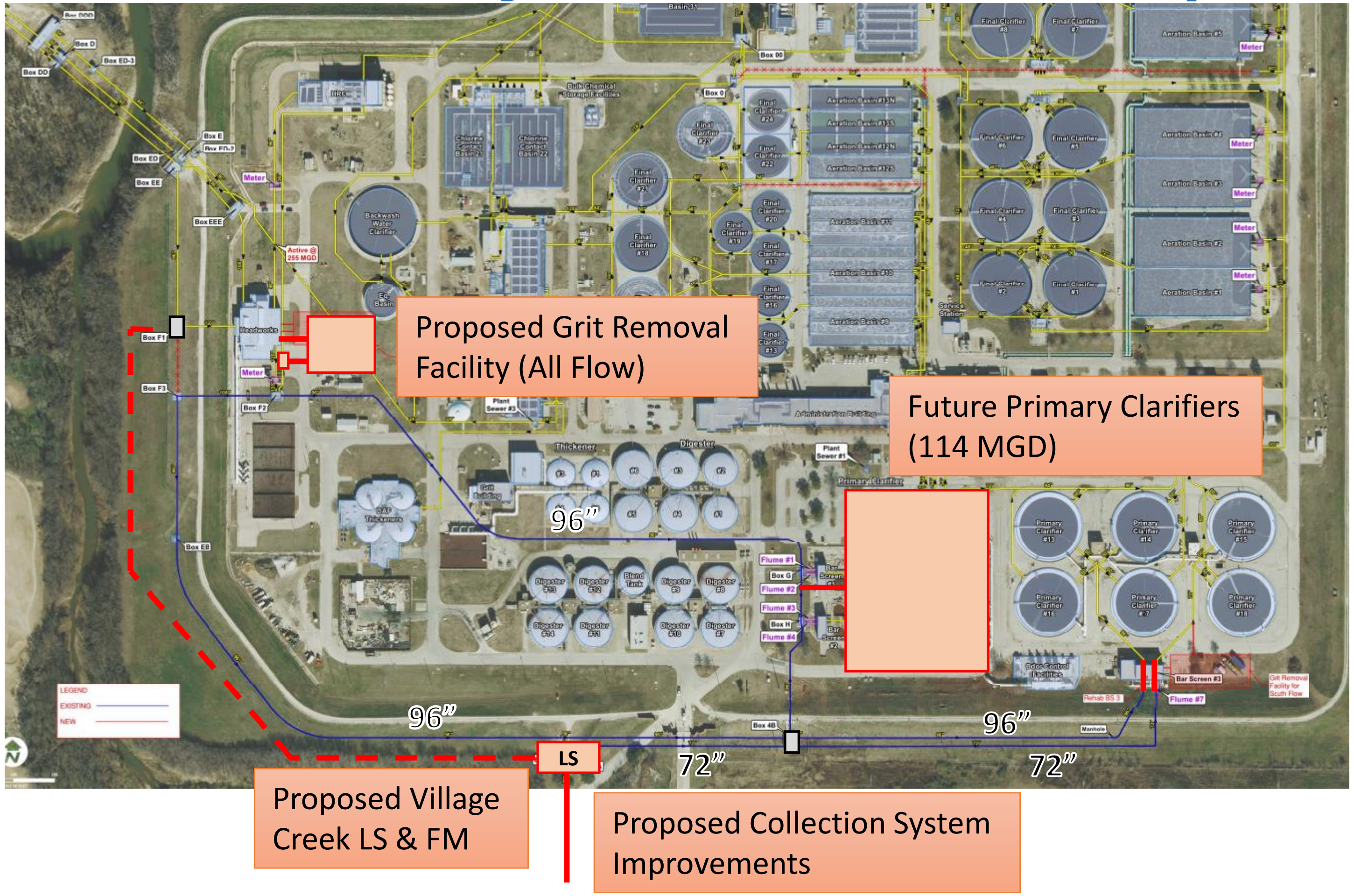
- Combined Grit Facility for West and South flow
- New Screen Facility for South flow
- Screening and grit handling in 2 locations
- Requires significant collection system improvements for south flow

Grit Facility Location - Option 2



- Combined Grit Facility for West and South flow
- New Screen Facility for South flow
- 124 MGD intermittent Peak Flow Lift Station for South flow to minimize collection system improvements

Grit Facility Location - Option 3



- Combined Grit Facility for West and South flow
- Upgrade existing Headworks Facility
- Full service 124 MGD Lift Station for South Flow

Life Cycle Cost Analysis

	Grit Facility Location 1	Grit Facility Location 2	Grit Facility Location 3
Capital Cost	$46,900,000	$44,440,000	$35,200,000
Operations and Maintenance Cost	$14,100,000	$18,300,000	$32,300,000
Total Present Worth	$61,000,000	$62,740,000	$67,500,000

- Life Cycle in years = 20
- Discount rate = 5%
- Inflation rate = 2%
- P/A factor = 14.96

Grit Technology Evaluation

- Grit Separation
- Grit Pumping
- Grit Processing

- Recommendation → Separate each component for evaluation

Grit Technology Evaluation Criteria

- Independent performance testing acceptance
- Installations for fine grit removal (105-micron)
- Operation and maintenance perspective
- Life cycle cost

Grit Separation Evaluation Summary

Criteria	Mechanically Induced Forced Vortex	Stacked Tray Forced Vortex
Performance	Average	Good
Head Loss	Similar Under Optimal Design Conditions	Similar Under Optimal Design Conditions
Footprint (single unit)	Large	Small
Screening Required	Yes	Yes
Maintenance	Medium	Low
Installations of Similar Size	Many (Fewer with V-force baffle)	Few (140 total, 3+ of similar size)
Other	Long Approach Channels	Sole Source

Stacked Tray Forced Vortex Sizing

Maximum Flow for Single 12 Tray HeadCell® (Mgal/d)				
		Cutpoint Performance		
Tray Diameter	Area ft² (m²)	106 µm	150 µm	212 µm
4' (1.2 m)	150 ft² (13.9 m²)	2.6	4.0	5.1
6' (1.8 m)	340 ft² (31.6 m²)	5.8	9.0	11.5
9' (2.7 m)	763 ft² (70.9 m²)	13.0	20.2	26.0
12' (3.7 m)	1356 ft² (125.9 m²)	23.1	36.0	46.1

Cutpoint Performance	Loading Rate	
	gpm/ft²	*L/m²*
75 µm	6.9	4.7
106 µm	11.8	8.0
125 µm	15.6	10.6
150 µm	18.4	12.5
175 µm	21.1	14.3
212 µm	23.6	16.0

166 MGD Grit Facility Flow / 23.1 MGD/ Unit Capacity → **8 Units**
255 MGD Grit Facility Flow / 23.1 MGD/ Unit Capacity = → **12 Units**

Mechanically Induced Forced Vortex Sizing

Peak Hour Flow, MGD	Diameter, ft.	Chamber Depth, ft.	Hopper Diameter, ft.	Hopper Depth, ft.	Calculated Detention Time, sec.
1	6	3.67	3	5	67
2.5	7	4.5	3	5	45
4	8	4.67	3	5	38
7	10	5	3	5.5	36
12	12	6.67	5	6.67	41
20	16	7.5	5	6.83	49
30	18	9.17	5	7	50
50	20	11.5	5	7	47
70	24	12.67	6	8	53
100	32	12.67	8	10	66

- Does not use particle settling theory
- Particle separation depends on liquid flow pattern creating forces acting in tangential, vertical, and radial directions.
  - Particle Force Balance Equation (i.e. drag, centrifugal, buoyancy)
  - Particle Diameter Equation to determine particle diameter cut-off that will separate from fluid flow
  - CFD analysis to determine grit path through unit

Mechanically Induced Forced Vortex Sizing

Manufacturer	Unit Size	No. of Units Per Manufacturer	No. of Units (1.5 SF)	No. of Units (2 SF)	No. of Units (Settling Theory)
Smith & Loveless	70.0 MGD	4	6	8	34*
John Meunier	76.8 MGD	5	8	10	34*

*Based on grit settling velocity of 105 micron particle size 11.8 gpm/sf

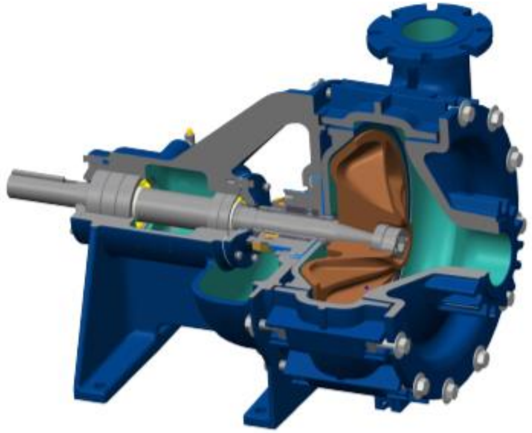
Grit Pumping

- Pump Configuration

Flooded Suction

Top-Mounted Self-Priming

- Pump Type – Recessed Impeller



Grit Pumping – Other Considerations

- Simple pipe alignment
- Minimize bends
- Long radius bends
- Proper flushing connections and cleanouts
- Pump Seals

Grit Processing Evaluation Summary

Criteria	Cyclone/Classifier	SlurryCup/GritSnail	Cone Washer
Claimed Grit Capture (best case)	95% of Grit ≥ 100µm	95% of Grit ≥ 75µm	95% of Grit ≥ 100µm
Washed Grit Water Content	≤ 25%	≤ 40%	≤ 10%
Washed Grit Organic Content	≤ 50%	≤ 15%	≤ 5%
Hydraulic Capacity	High	Medium	Medium
Manufacturers	Many	One	One (possibly two)
Maintenance	High	High	Low

Grit Removal System Direct Cost Summary

Component	Mechanically Induced Forced Vortex (8 units)	Stacked Tray Vortex (8 units) 105 micron @ 166 mgd	Stacked Tray Forced Vortex (12 units) 105 micron @ 255 mgd
Grit Separation Equipment	$680,000	$1,500,000	$2,250,000
Grit Separation Tanks (concrete)	$1,300,000	$1,100,000	$1,500,000
Grit Pumps	$480,000	$400,000	$550,000
Grit Processing	$1,200,000	$1,100,000	$1,600,000
Other Cost (gates, piping, HVAC, etc.)	$1,200,000	$1,200,000	$1,300,000
Grit Building	$460,000	$460,000	$460,000
SUBTOTAL Direct Cost	**$5,360,000**	**$5, 760,000**	**$7,660,000**
Cost per Unit	$612,500	$662,500	$600,000

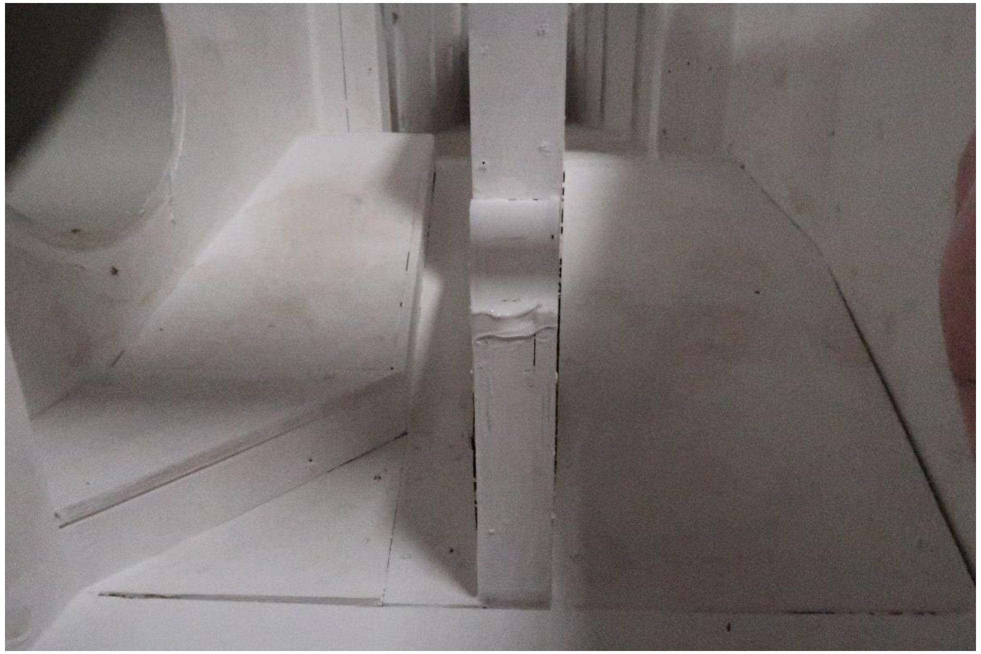
Notes:
1. Cost presented above are +/- 30% at this 15% conceptual level of estimation.
2. Cost presented are direct cost only. Bonds, insurance, and OH&P are not included.
3. Cost presented related to grit separation, pumping and processing only and does not include overall project costs such as yard piping, site work, screening, lift station cost, etc.

Design Criteria

- Grit Separation: stacked tray forced vortex units
  - 95% removal efficiency 105µm and greater
- Grit Pumping: flooded suction recessed impeller pumps
- Grit Processing: cone washer/screw conveyors
  - 95% removal efficiency
  - < 10% water content
  - < 5% organic content

Physical Modeling

Physical Model Overview



Influent Splitter Box

Physical Modeling

Headcell Influent Channel Isolation Gates

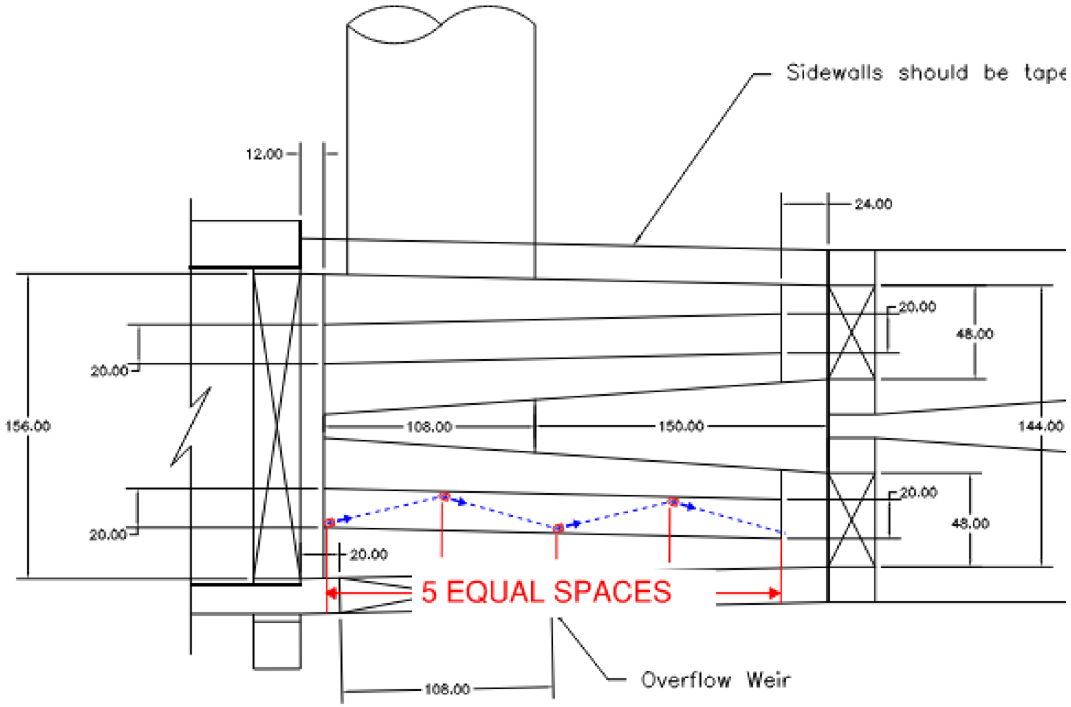
Headcell Influent Channel

Physical Modeling

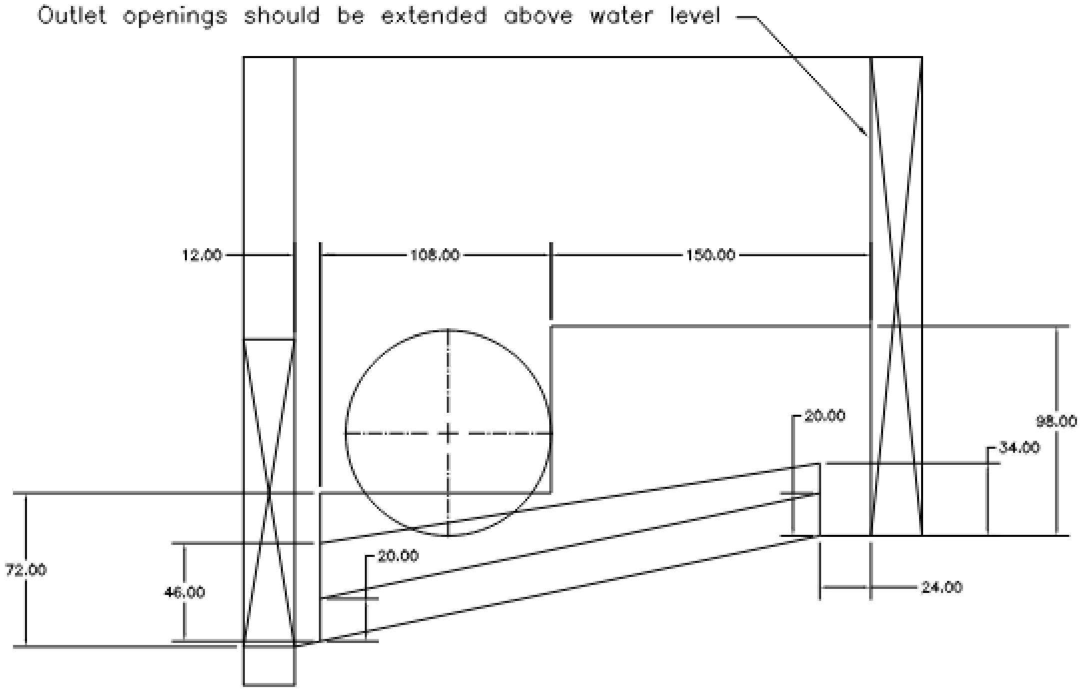
Influent Splitter Box Modification

Removed Influent Channel Gates

Influent Splitter Box Modifications

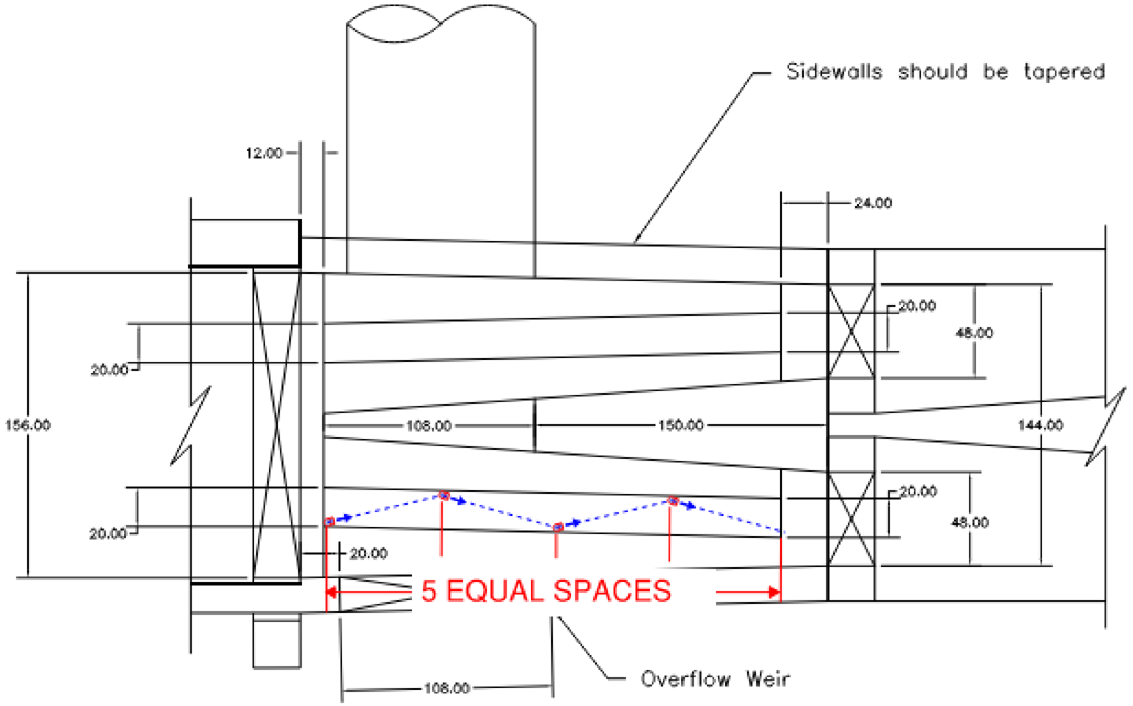


Influent Splitter Box Modification
Plan View

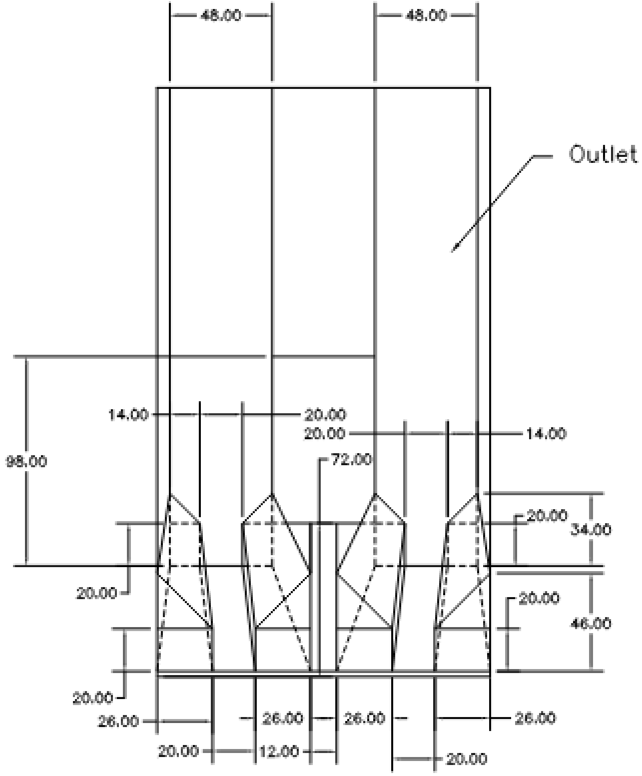


Influent Splitter Box Modification
Section View

Influent Splitter Box Modifications

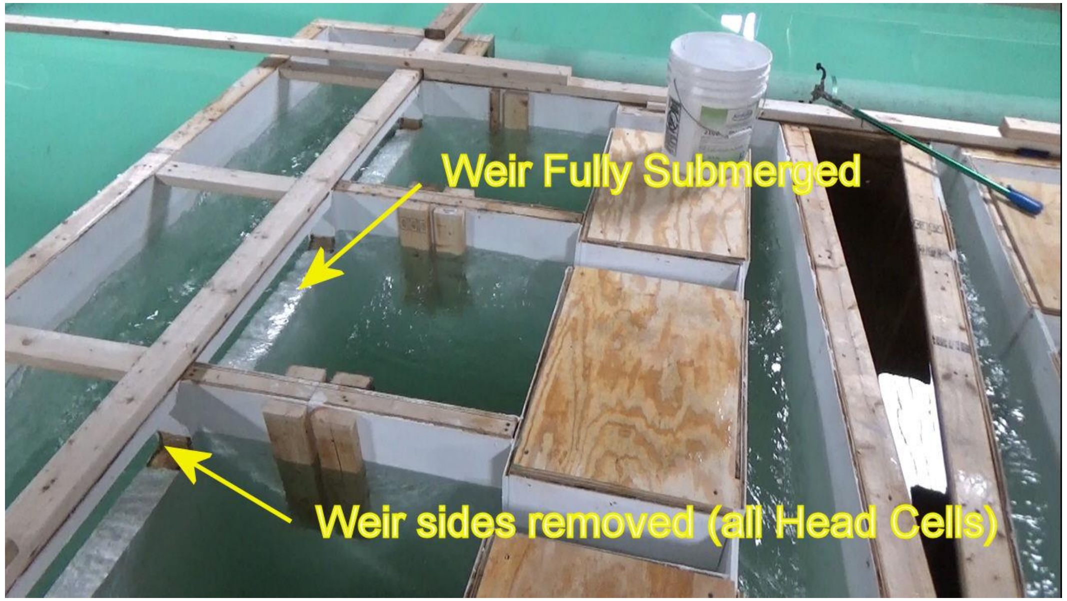


Influent Splitter Box Modification
Plan View

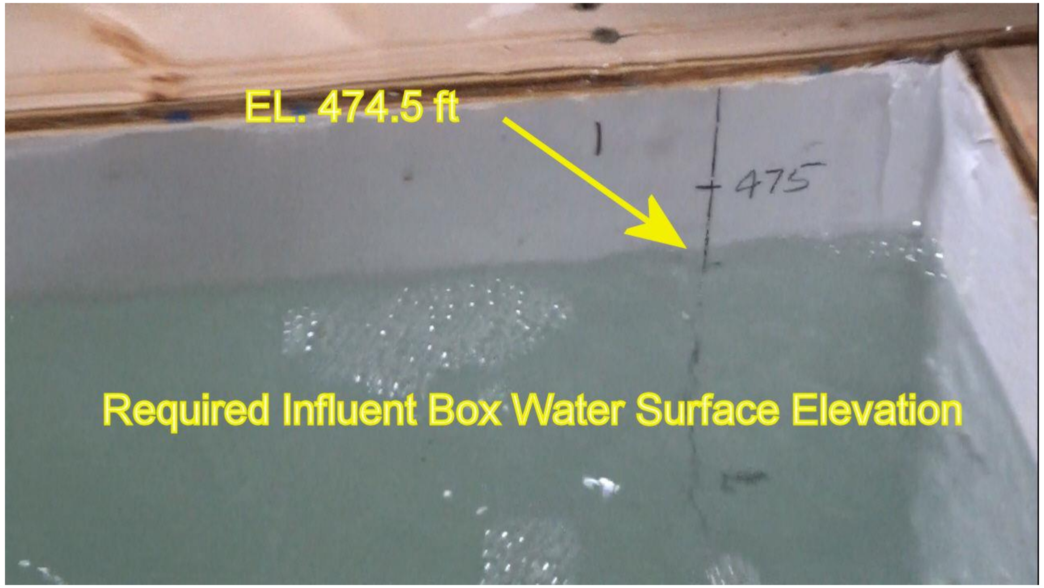


Influent Splitter Box Modification
Section View

Physical Modeling



Weir Widths Equal For All Head Cells (Submerged Flow)

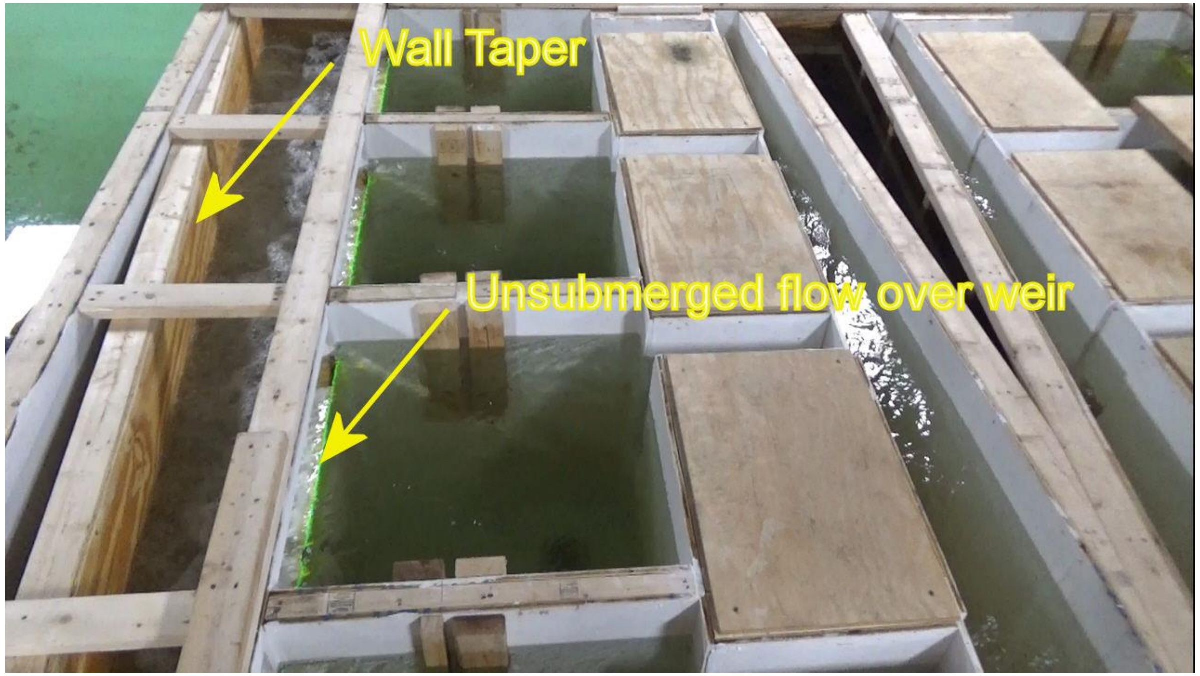


Influent Diversion Box WSE (need to add 12-in for Headcell (475.50)

Issues:
1. Submerged Weirs and Influent
2. Splitter Box WSE exceed goal of 474.25

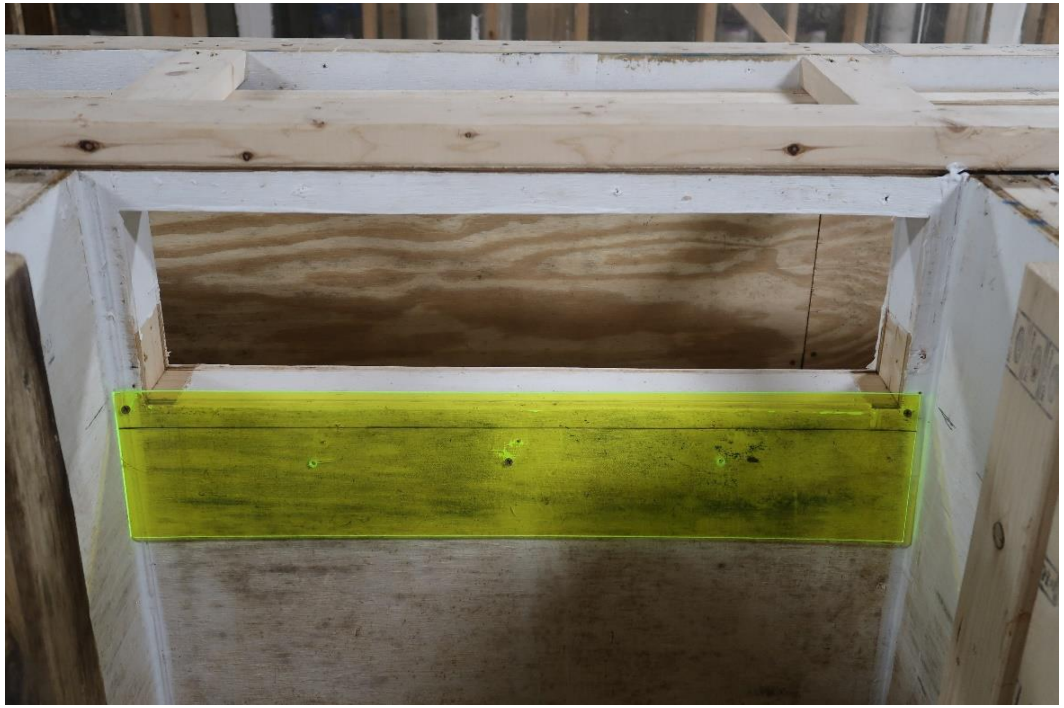
Physical Modeling

Revised S-Bend in South Channel

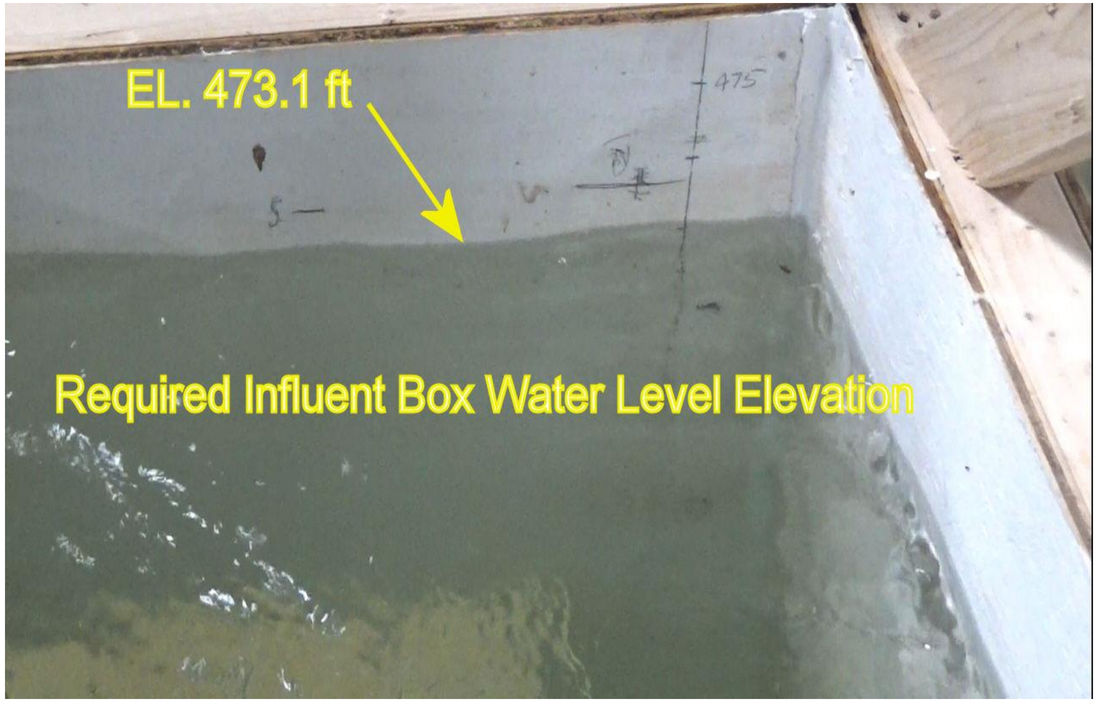


Tapered Wall in North Influent Channel

Physical Modeling

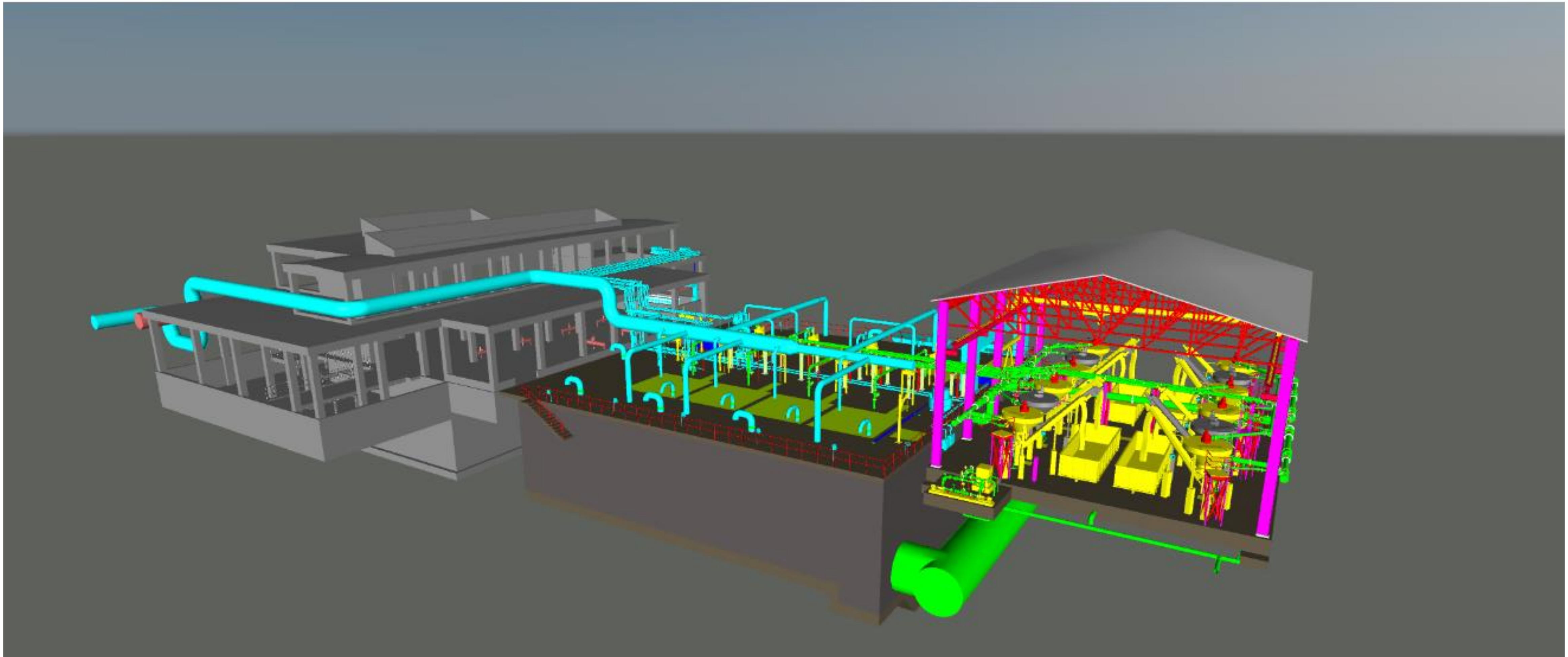


Headcell Weir Final Setting at 471.50



Tapered Wall in North Influent Channel

VC Grit Facility 3D Model



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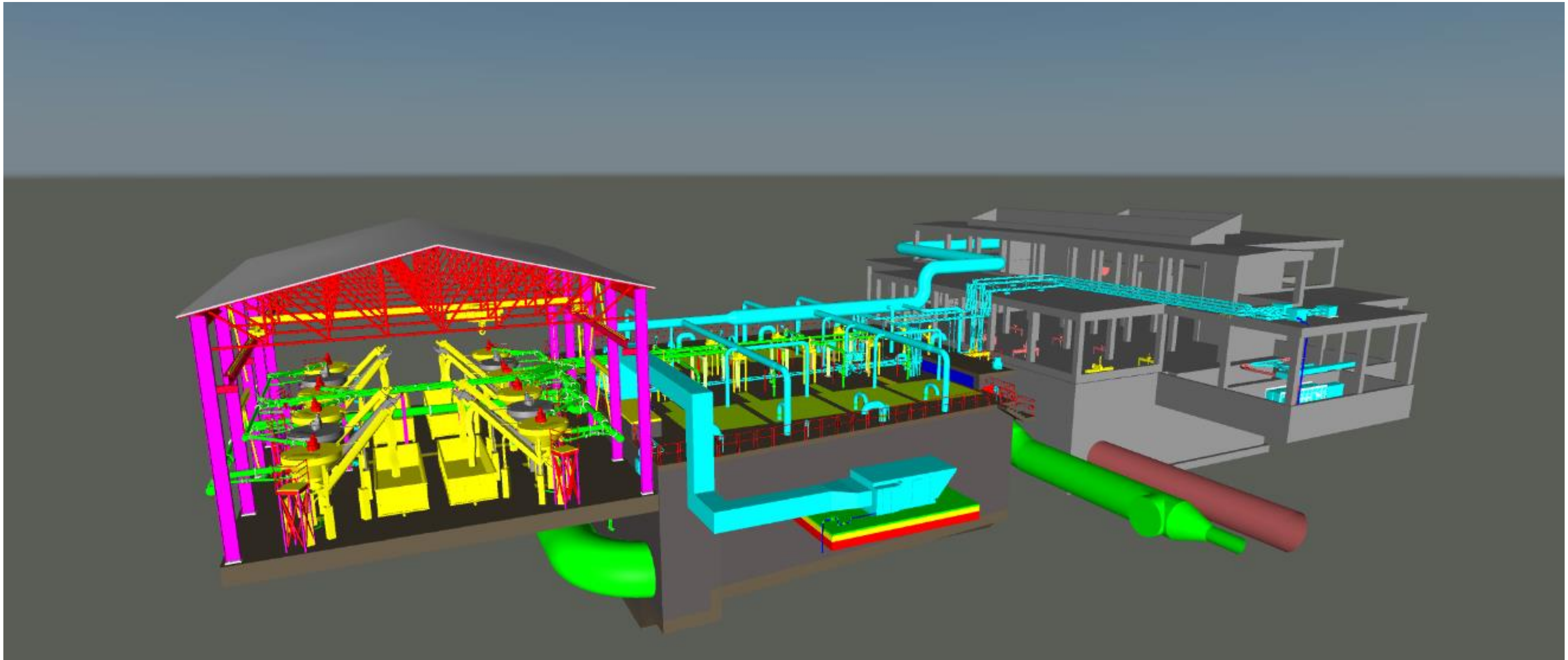
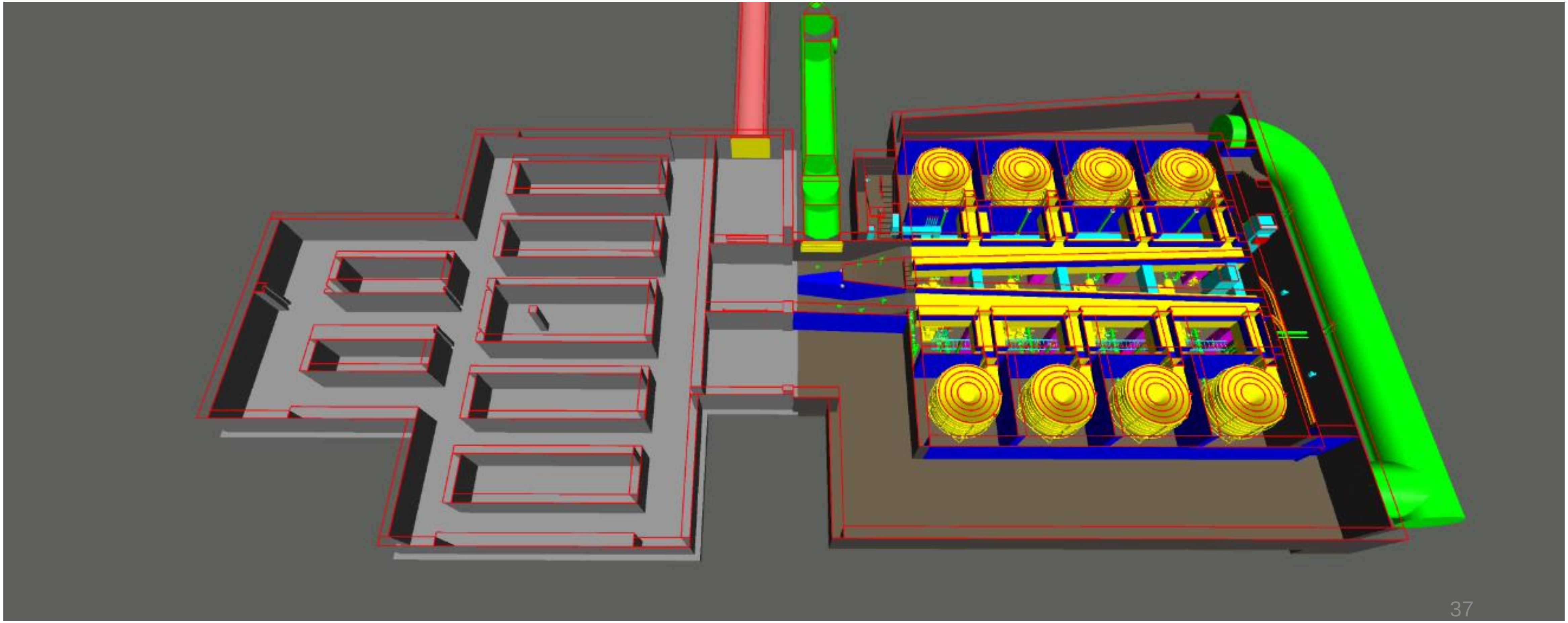


VC Lift Station 3D Model



Thank You

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