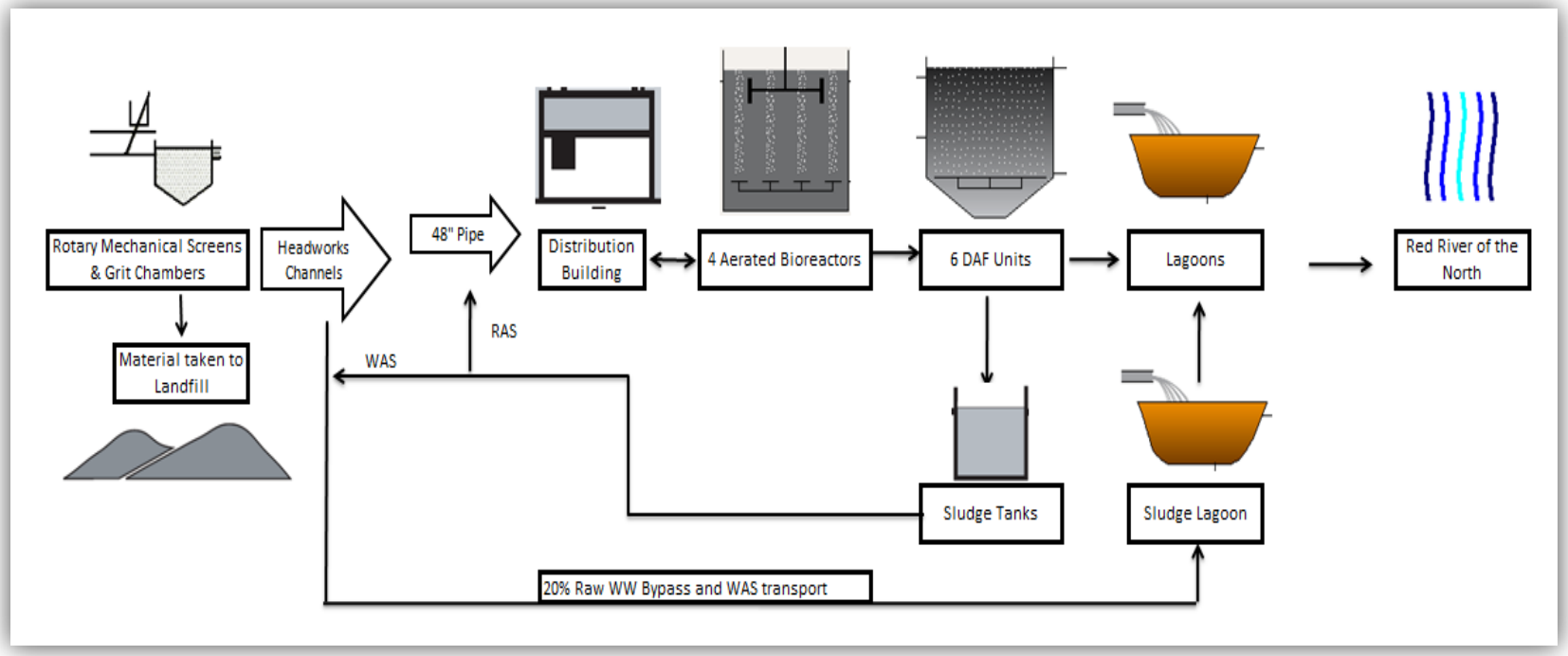
Pretreatment of Waste Activated Sludge for Aerobic Digestion

University of North Dakota
WEFTEC Design Project

Background - GFWWTP

- Current Treatment Scheme



Aerial View of GFWWTP

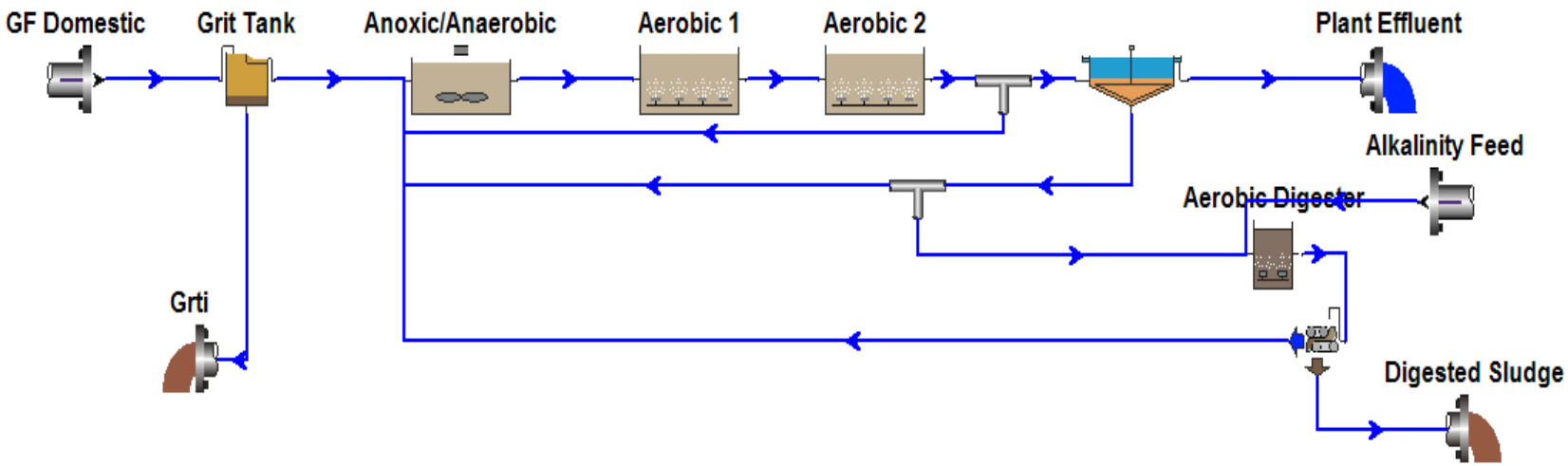
Plant Loadings

- Design
  - 10 MGD, peaking factor of 3
    - Expandable to 15 MGD
  - TSS: 1,040 mg/l
  - BOD_5: 480 mg/l
- Average
  - 5-8 MGD
  - TSS: 537 mg/l
  - BOD_5: 252 mg/l

Need for a solution

- Extended Aeration Activated Sludge Plant
  - Lacking Primary Clarifier.
- Produces ~65,000 gallons of WAS per day.
- Currently treating WAS in lagoons with 20% raw wastewater.
- Looking to produce Class B biosolids.
- BioWin models show ~35% Destruction

Biowin Model



Regulations

40 CFR Part 503

- The relevant biosolids section in the Code of Federal Regulations
- Handles the use or disposal of sewage sludge
- Differentiates between Class A and Class B biosolids
- Sets the standards for contaminates of concern and pathogens

Class A Biosolids

- Implicit goal of reducing pathogens below the detectable limits
- Meeting limits for "Exceptional Quality" and "Annual Pollutant Loading Rate" or "Pollutant Concentration"

Pollutant	**Pollutant Concentration Limits for EQ and PC Biosolids (mg/kg)**	**Cumulative Pollutant Loading Rate Limits for CPLR Biosolids (kg/ha)**	**Annual Pollutant Loading Rate Limits for APLR Biosolids (kg/ha/yr)**
Arsenic	41	41	2.0
Cadmium	39	39	1.9
Chromium	1,200	3,000	150
Copper	1,500	1,500	75
Lead	300	300	15
Mercury	17	17	0.85
Molybdenum	--	--	--
Nickel	420	420	21
Selenium	36	100	5.0
Zinc	2,800	2,800	140
Applies to:	Bulk and bagged biosolids	Bulk biosolids	Biosolids that are Bagged
From Part 503	Table 3	Table 2	Table 4

Class B Biosolids

- Goal of reducing the pathogens to a level which is unlikely to pose a threat to human life
- Can meet PC or CPLR limits
- Have restrictions placed on land use after application
- Can not be sold or given away in other containers
- Fecal coliform levels must be below 2 million CFU or MPN.

Pathogens and Vector Attraction

- Process to Significantly Reduce Pathogens
  - Aerobic digestion is one of them
    - Must have SRT of 40 days at 20°C and 60 Days at 15°C
- Vector Attraction Reduction
  - **38%** VSS destruction

Pretreatment

Pretreatment Options

- Ultrasound "Sonic"
- Electrochemical Pretreatment
- Ozone Pretreatment
- Thermal Pretreatment
- Alkaline/ Sodium Hydroxide Pretreatment

Ultrasonic

- Acoustic Cavitation
  - Ultrasonic pressure waves propagate through water as gas and vapor bubbles form
  - Waves grow and collapse at high velocities breaking down extracellular polymeric substances
- Improved sludge dewaterability
- Increases temperature for improved aerobic digestability
- Easy retrofit for GFWWTP

- High energy consumption

Electrochemical

- Pair of plate electrodes, with constant, stable power source which disintegrates large flocs into more easily destructible flocs
- Most efficient during first 30 minutes
- Removal efficiency is a function of energy supplied and pH extremity

Ozone

- Powerful oxidant which acts as a catalyst for breaking down higher molecular weight organics

- Costly retrofit (cost of equipment)
  - Ozone Generator
  - Ozone Analyzer
  - Oxygen Cylinder
  - Contact Column
  - Ozone Destructor
- Costly to run apparatus

Thermal

- High temperatures break down gel structure of cells within sludge
- Destruction of cells is a function of system temperature
- Cost is a function of temperature

Sodium Hydroxide

- Destroys floc structures by creating high pH
- Simple process, highly efficient
- Easy retrofit
- Relatively inexpensive product
- Decreases amount of alkalinity required at aerobic digester

Recommendations for Design

Reactor Tank 1

- Recommend to turn into an conventional aerobic sludge digester using sodium hydroxide as pretreatment.
- Operating temperature of the full-scale ASD will be higher than that of the model.
  - Compressed air supply temperature is about 100°C.
  - On-off cycling will reduce the likelihood of elevating reactor temperatures above 30°C and impeding nitrification in the full scale ASD.
- On-off cycling would also allow supernatant liquid to be pumped from the top of the tank to lower the water level in the tank to provide more room for feeding

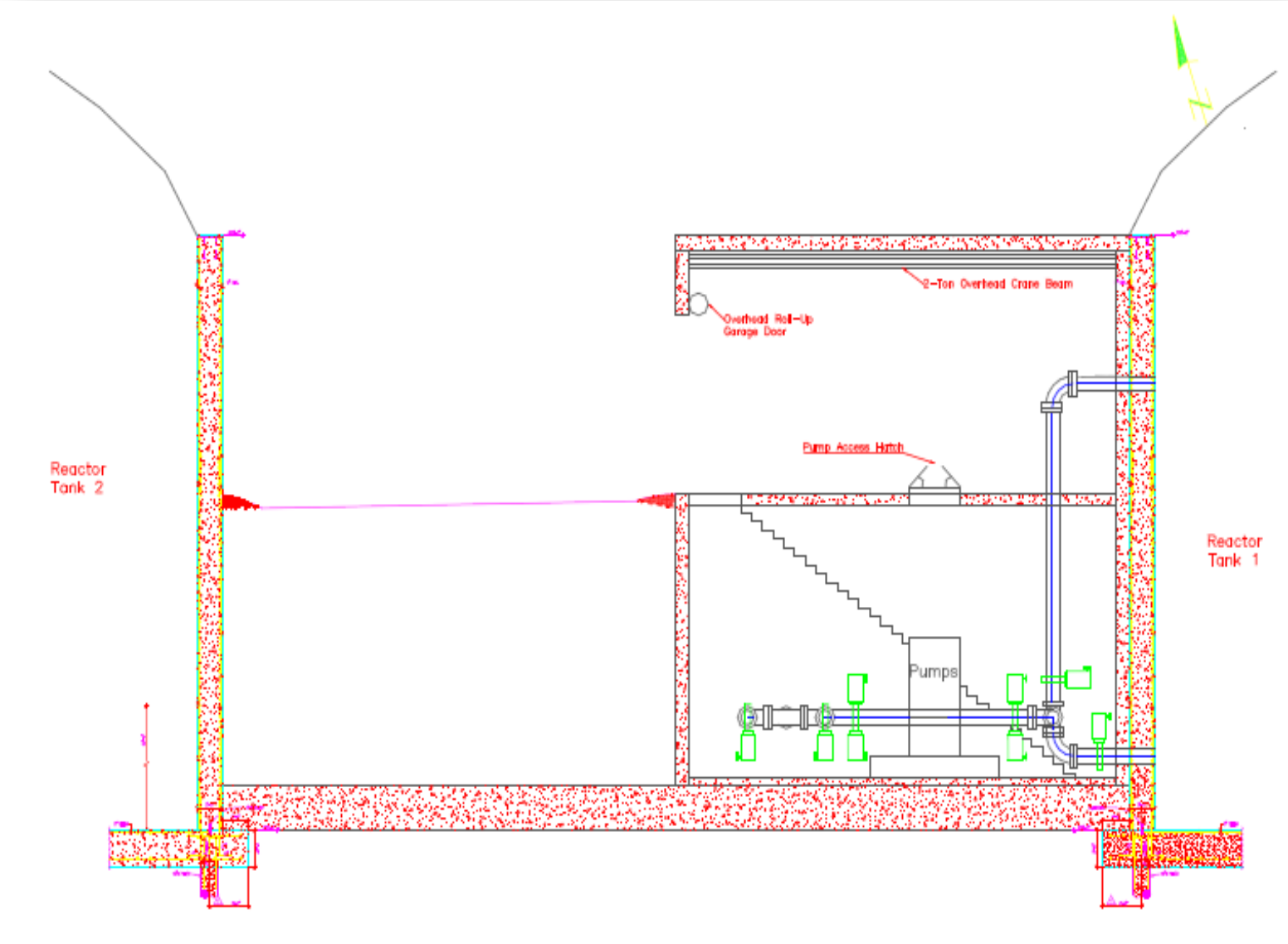
Sodium Hydroxide

- Relative low cost
- Ability to decrease amount of lime feed needed
- Propose to house the pretreatment system in a pump house
- Will have a heater in the system to obtain
- Adding 0.04 mol/L of sodium hydroxide at a contact time of 30 minutes resulted in a demand of sodium hydroxide of approximately 1600 lb/d.

Pump House

- A building would be constructed adjacent to Reactor Tank 1 and between Reactor Tanks 1 and 2.
  - House the pumps, valves, piping, and NaOH feed system
- Have a concrete beam running from the piles of Reactor Tanks 1 and 2 to support the building

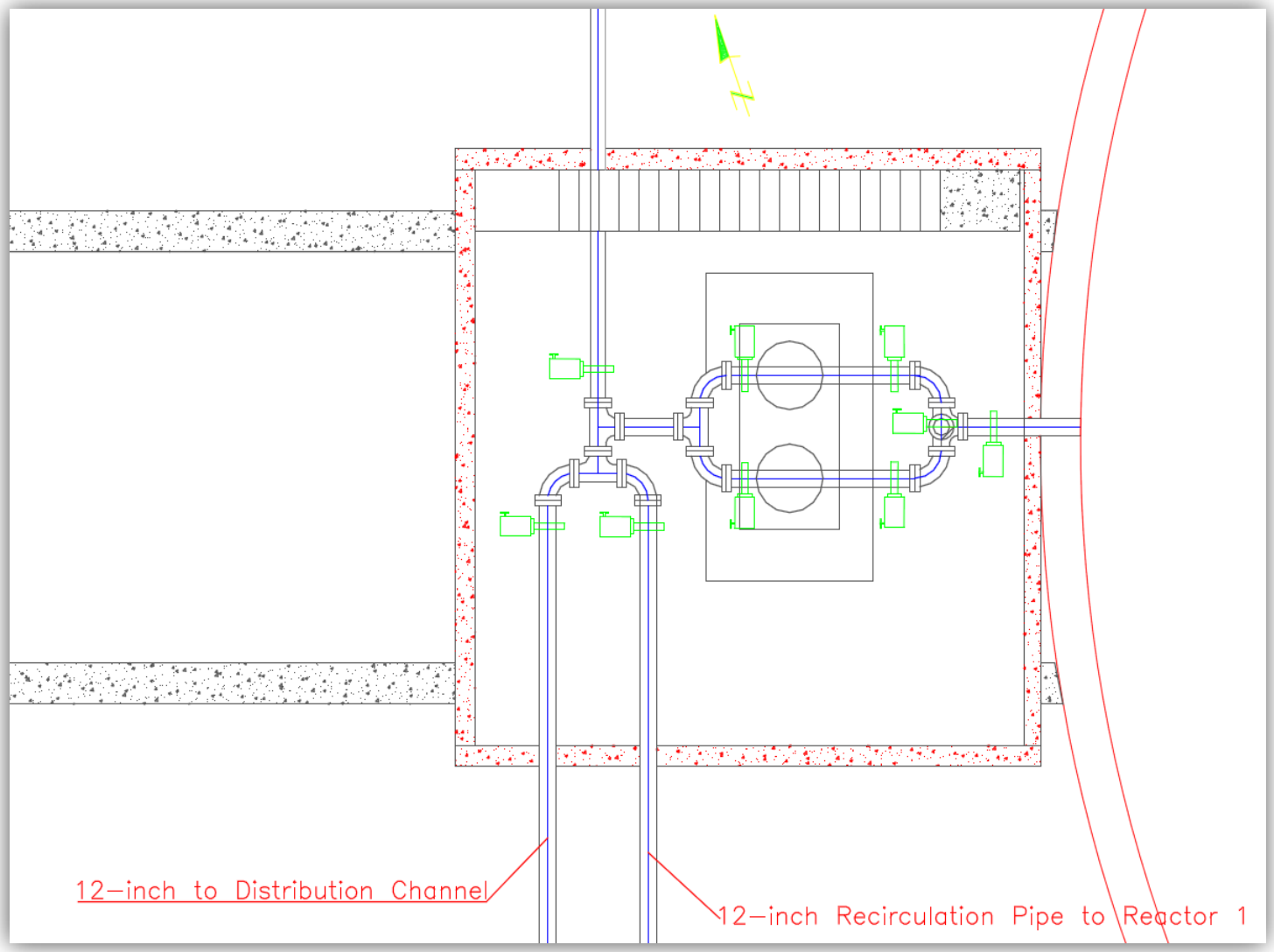
Side View


2-Ton Overhead Crane Beam
Overhead Roll-Up Garage Door
Pump Access Hatch
Reactor Tank 2
Reactor Tank 1
Pumps

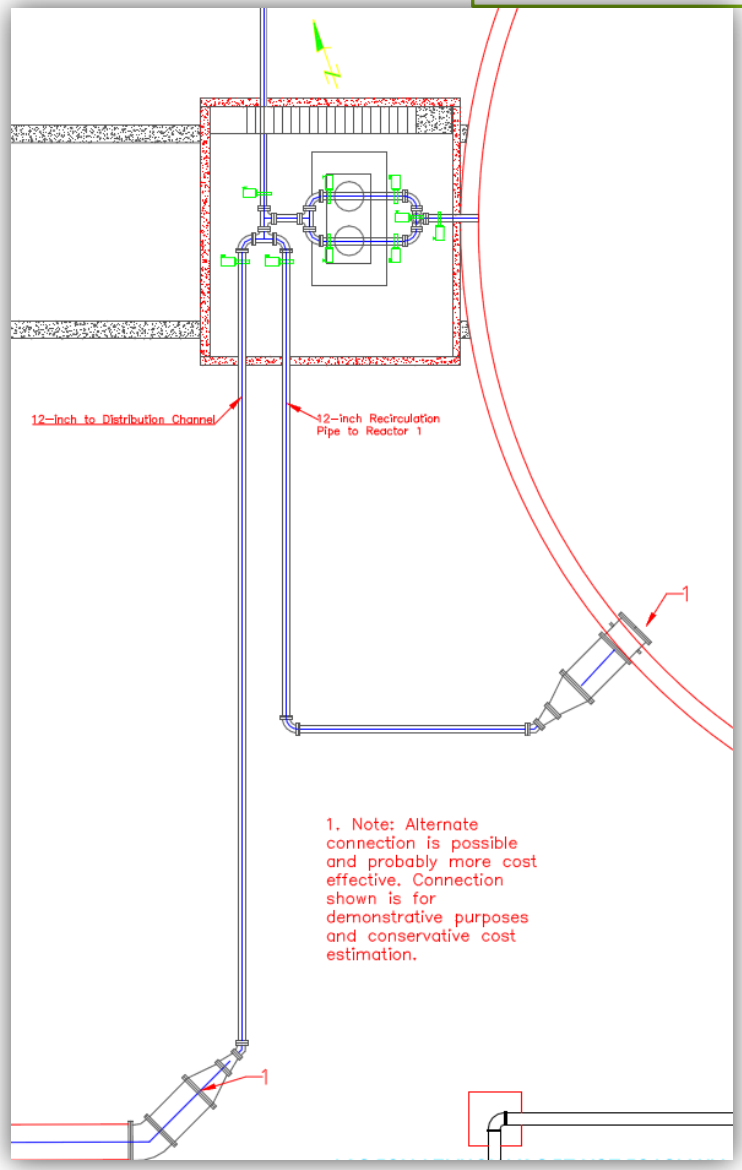
Piping

- Single 10-inch diameter pipe exiting the pump house which will be used to transport digested sludge to the maintenance garage where dewatering equipment is suggested to be located.
- Two 12-inch pipes exit the opposite (south) wall of the pump house, connected to the existing 48-inch diameter tank effluent pipe.
- One is to be used for Reactor 1 recirculation and mixing digesting sludge
- The other pipe will be connected to be able pump Reactor 1 water or sludge back into the distribution building.
- There will be about 74 ft of 48-inch diameter pipe which will be unused and could be removed or left buried in the ground.
- Nine gate valves will be installed on the pump house piping as shown to be able to control the flow of the sludge or to perform maintenance on the pumps.

Pump House Layout

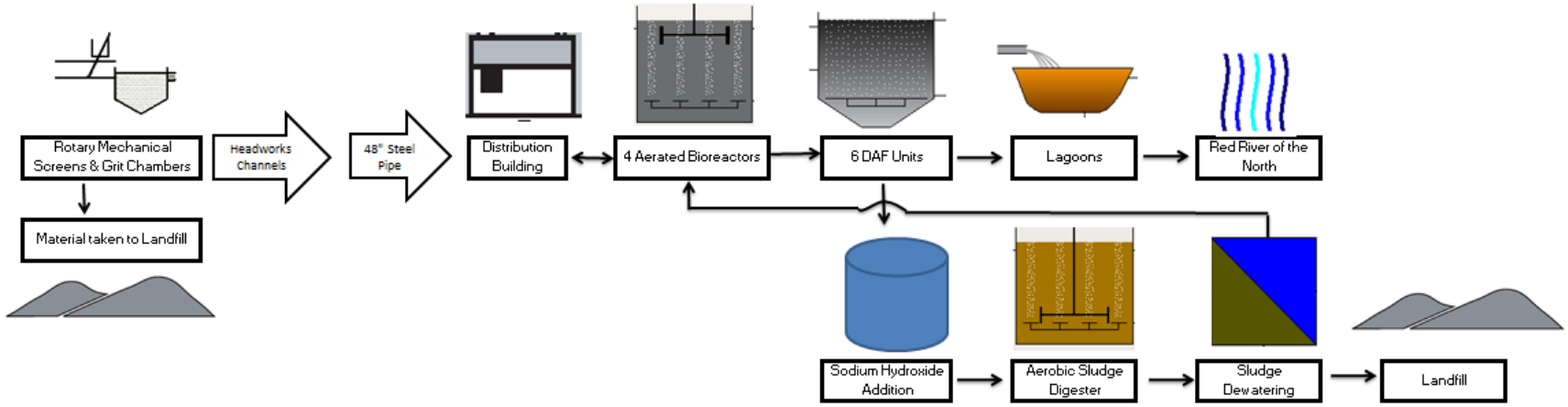


Pipe Routing



Conclusion

Proposed Treatment Scheme



Benefits

- Able to have a better solids management plan than currently is in place
- Would be able to produce Class B biosolids
- Able to land apply the biosolids, or send them to the landfill

Operating Suggestions

- It would be proposed to turn off the air in the digester to allow solids to settle and supernatant to be pumped off every other day in order to be able to feed the digester while obtaining scouring velocities in the piping

Thank You

- Thank you to everyone who has helped with this project.
  - Dr. Gullicks
  - Dr. Moretti
  - Don Tucker