Is Smaller Simpler?

Engineering and Operating Considerations for Remote WWTPs

May 2, 2024

HDR

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01 Common themes/constraints for remote sites

Common considerations for large WWTPs

- Treatment requirements
- Flow swings
- Maintaining operations during construction
- Land availability
- Receiving body water quality
- Biosolids management
- Power availability
- Site accessibility
- Provisions for future expansion
- Operability
- Maintenance
- Public Perception

small

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small

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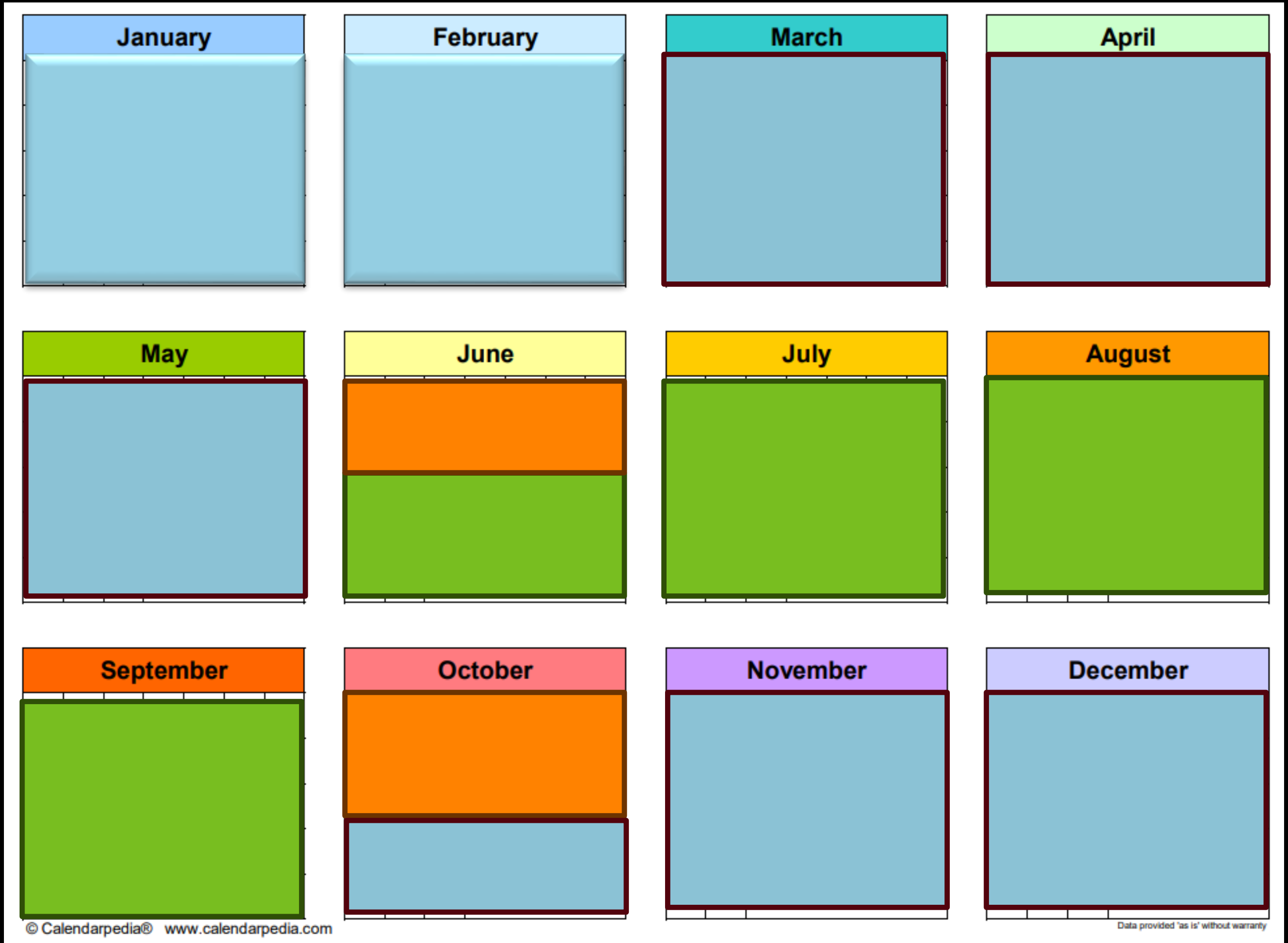
But with a twist!

02 Stevens Pass WWTP

Stevens Pass, WA

- Fantastic Snow
  - 460” per season
- Avalanches
- Access?
  - Snow machines
  - Foot (ski, snowshoe, etc)
- Amenities
  - Lodge/Restaurant
  - Ski mountain
- Very few full-time residents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Stevens Pass WWTP

- Owned and operated by Stevens Pass Sewer District
  - Small dedicated staff
  - Restart biology every fall
  - 0.1 mgd MBR treatment system.
  - Upper mountain lift station
  - Pre-treatment and equalization
  - Nason Creek effluent disposal
- Disinfection components no longer available and upgrade needed.
- Frequent power losses

Existing Disinfection

- No parts available from suppliers
- Manufacturer no longer in business
- Suitable alternatives
- Class A production
- Two reactor trains

UV Disinfection Design Criteria

Design Criterion	Unit	Design Value	Notes
Number of reactors (trains)	N/A	2	One duty + one standby
Peak flow	mgd/gpm	0.125/87 0.15/105	Current peak flow ~ 0.1 mgd Evaluate peak flow over range noted
UVT (min)[a]	Percent	65	Field sampling to confirm spring/summer 2020
TSS (max)[a]	mg/L	5	
Turbidity (avg./peak)[a]	NTU	0.2/0.5	
UV dose (min)[a]	mJ/cm^2	80	Delivered dose at peak flow and min UVT
EOLL (min/max)[b]	N/A	0.5/0.9	End-of-lamp-life factor
FF (min/max)[b]	N/A	0.8/0.9	Fouling factor
Inlet temperature (min/max)	°C	5/25	
NWRI validation	N/A	Yes	All reactors validated through 2003 or 2012 NWRI standards

[a] Based on Class A reclaimed water standards for filtered effluent.

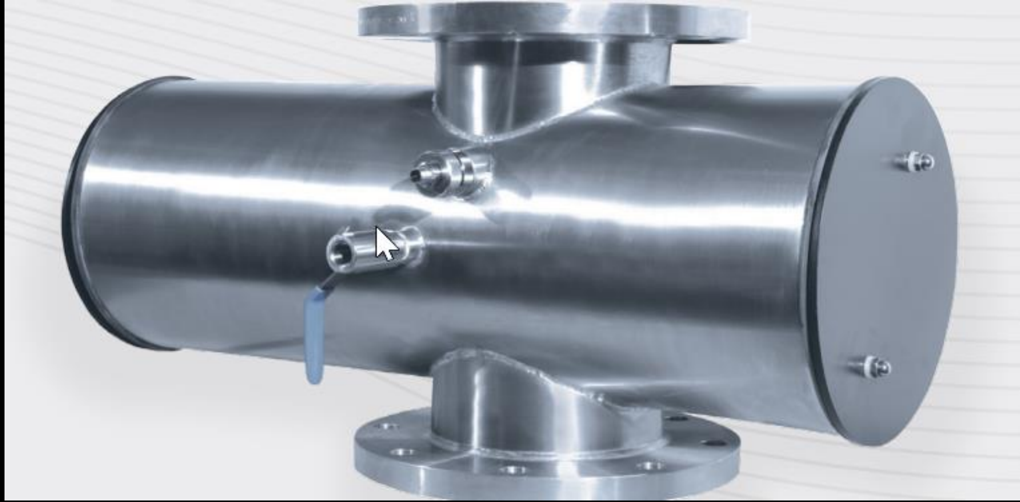
[b] Minimum will be used unless manufacturer can provide independent confirmation of higher value, up to max.

Reactor Type Comparison

Open Channel	Closed Vessel
Algae growth in channel; potential algae growth is greater if not covered	Algae growth in closed vessel
Gravity flow through the system	Pressurized flow full
Concrete (or stainless steel) channel configuration	Pipe flanged reactors
Need to lift lamps/modules/banks out of channel for periodic channel cleaning	**Cleaning in place**
Automated wiper system; easy visual observation and manual cleaning	Automated wiper system; difficult manual cleaning
Potential of short circuiting: the movement of effluent through open channels is not particularly turbulent, so some sections of the effluent may not pass close enough to the UV lamps to receive minimum required dose	Low potential of short circuiting: the movement of effluent through the treatment chamber is more turbulent than in the open channels, ensuring that all the effluent receives the minimum required UV dose by passing close to the lamps.
Horizontal lamp systems need lifting devices for lamp replacement	**No lifting devices required for lamp replacement; lamp replacement in place**

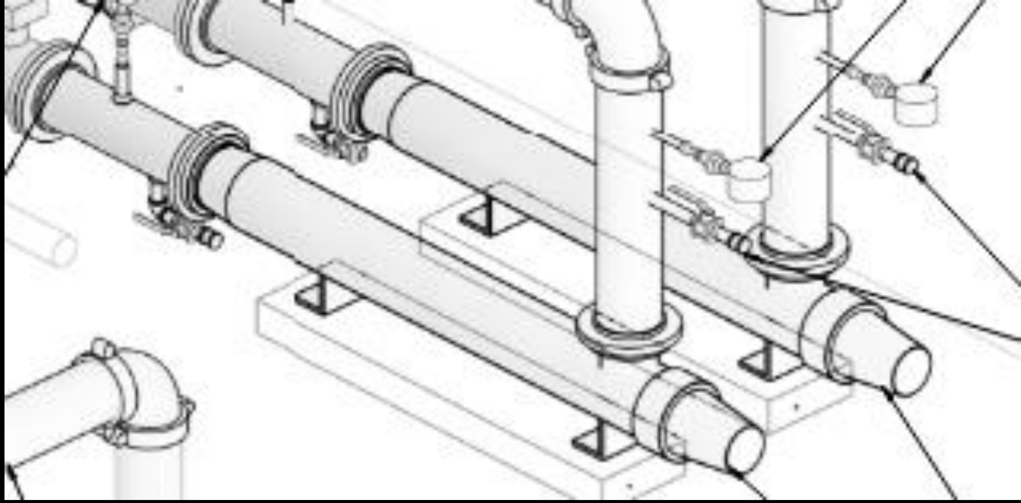
Reactor Option 1

- Aquionics
- MPHO
  - Smaller footprint
  - Side lamp access
  - Less bulb lifespan
- Minimum cooling flow… 44gpm
- Recommended straight pipe lengths:
  - Upstream – 10
  - Downstream – 5
- Lamp cost - $500/lamp
- Life cycle cost - $$



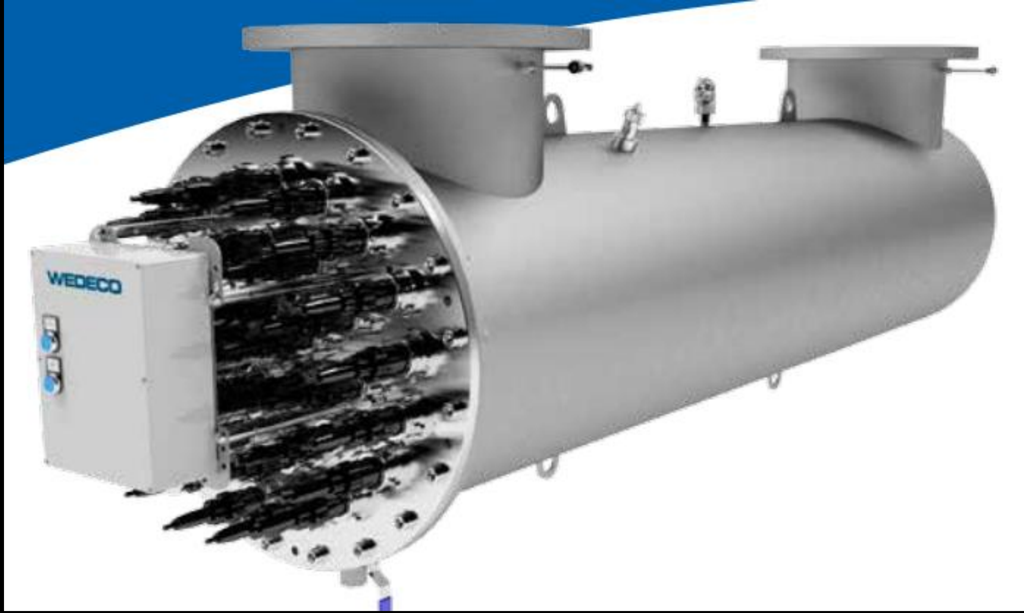
Reactor Option 2

- Trojan
- LPHO
  - Lamp access on the end
  - Normal bulb lifespan
- Minimum cooling flow… 22gpm
- Reactors – 1 + 1
- Recommended straight pipe lengths:
  - Upstream – 3 to 5
  - Downstream – 0
- Lamp cost - $377/lamp
- Life cycle cost - $$



Reactor Option 3

- Xylem/Wedeco
- LPHO
  - Lamp access on the end
  - Normal bulb lifespan
- Minimum cooling flow… 4.4 gpm
- Reactors – 2 + 1
- Recommended straight pipe lengths:
  - Upstream – 5
  - Downstream – 0
- Lamp cost - $159/lamp
- Life cycle cost - $$



Reactor Option 4

- Evoqua
- LPHO
  - Lamp access on the end
  - Normal bulb lifespan
- Minimum cooling flow… 10 gpm
- Reactors – 1 + 1
- Recommended straight pipe lengths:
  - Upstream – 2
  - Downstream – 0
- Lamp cost - $395
- Life cycle cost - $

Initial Comparison

- Closed vessel due to lamp access and piping arrangement
- Xylem/Wedeco – only one to need 3 reactors
- Xylem had lowest flow turndown, Aquionics the highest, Evoqua and Trojan in the middle
- Warm up times similar
- Most efficient – Xylem/Wedeco
- Highest output – Aquionics (MPHO)
- Capital Costs – similar for all but Xylem/Wedeco (additional unit)
- Head loss in all very minor (1” WC)

General Comparison of LPHO Manufacturers

Manufacturer	Pro	Con
Trojan	• Competitive total price • Good hydraulic range • Modest power requirements and turndown • Lowest wattage per lamp	• Large reactor (higher O&M costs) • High number of lamps • Higher cooling flow
Xylem/Wedeco	• Excellent hydraulic and power turndown • Lowest total lamp power requirements • Modest reactor size • Low wattage per lamp	• Higher total price (equipment capital and life cycle) • More reactor trains (complexity) with additional cost for valves/piping that are not shown
Evoqua-ETS	• Competitive total price • Modest power requirements and excellent turndown • Modest reactor size • Minimal hydraulic restrictions (straight pipe in/out)	• Relatively high lamp wattage

Aquionics not selected for final evaluation

Final Selection

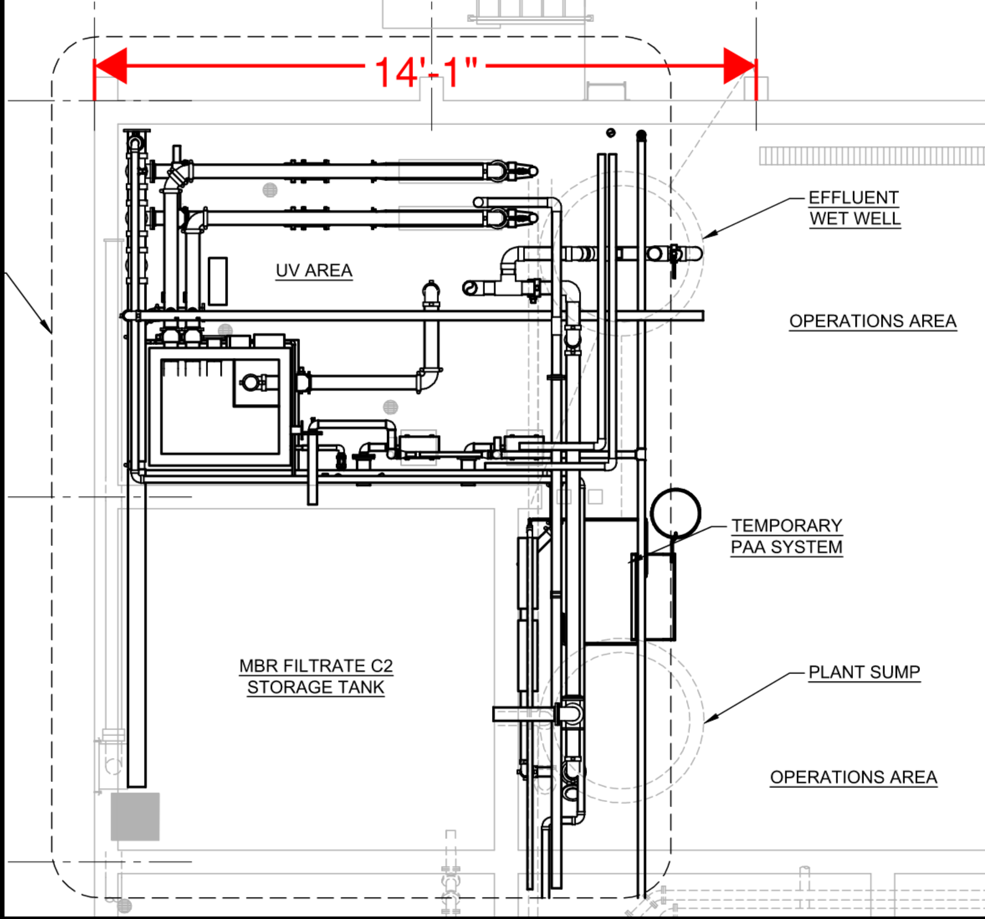
- Moved to peak flow of 0.125 mgd

- Trojan, 18-lamp to 8-lamp model
  - Significant reduction in life cycle cost
  - Cooling flow down to 10 gpm
  - Maintains 25% peak flow buffer
  - Future expansion

- Xylem/Wedeco, 6-lamp not NWRI validated, so had to stick with 16-lamp
- Evoqua-ETS, no changes with new peak flow

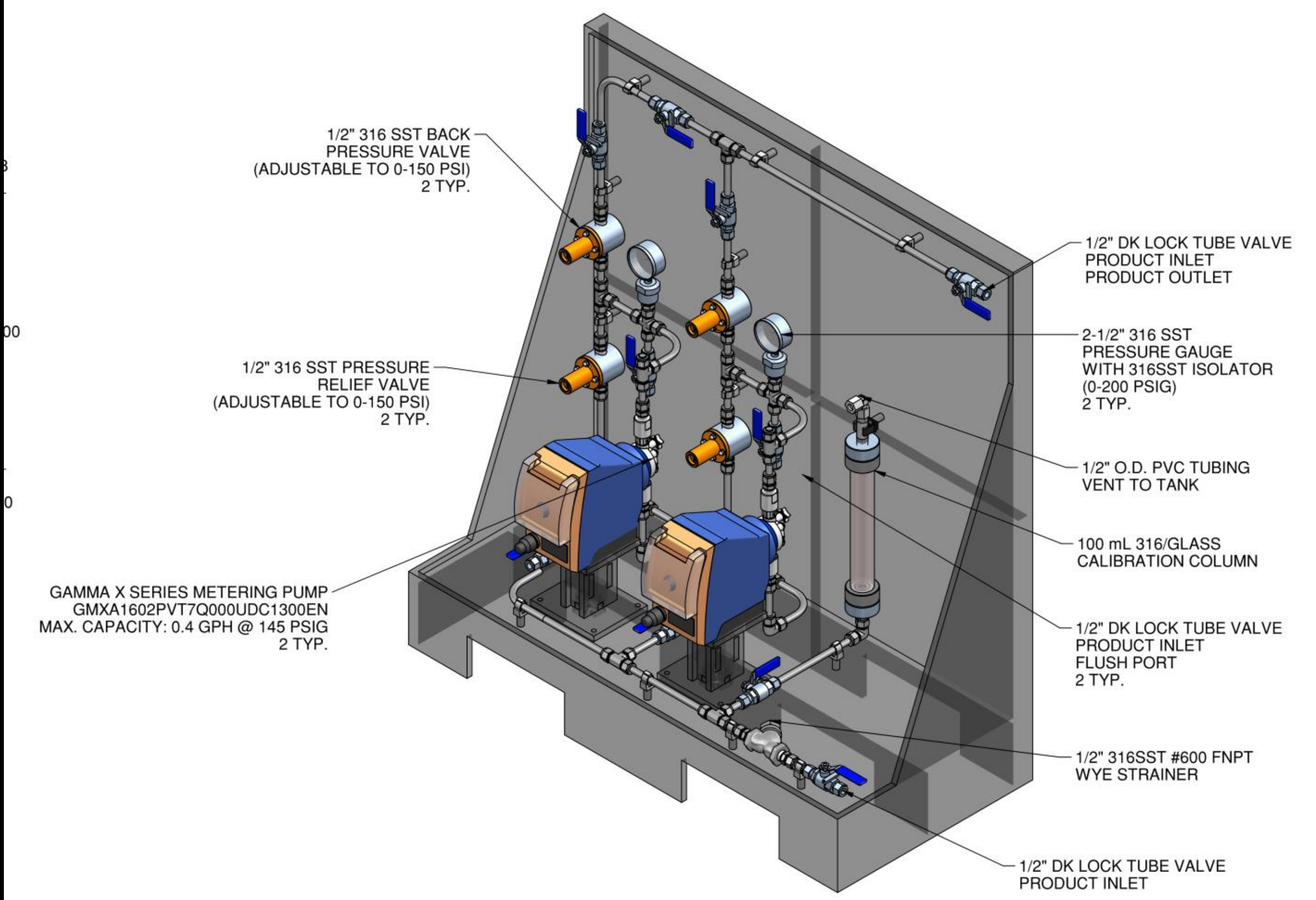
Construction 1

- Laydown
  - Building is a 50’x40’ concrete box accessible from one side
- Shuffling vehicles for deliveries
- Animals
  - Birds, bears, cats, etc
- Security
  - Surprisingly frequent issues
- Construction Window
  - Closes very fast



Construction 2

- Temporary Disinfection
  - PAA
  - No Chlorine
  - Safe residuals
  - Challenges with small scale
  - Had to remove nearly all equipment downstream of the pumps
  - Took up valuable space
  - Temporary piping



Takeaway Project Challenges

- Matching install schedule with equipment arrival
- Getting all equipment to the site for the day’s work
- Pressure to accept items that show up unexpectedly
- Intermittent inspections
- Getting subs to show up on time
- Small changes in design criteria can produce

03 Stehekin WWTP

Stehekin, WA

- Gateway to the North Cascades
- Accessible by….
  - Boats,
  - Boots,
  - Planes
- Amenities
  - Lodge/Restaurant
  - Gift Shop
  - Post Office
  - Visitor Center
- 80 full time residents (mostly outside of sewered area)


WARNING
MANHOLE
SEWER


Stehekin WWTP

- Owned and operated by the National Park Service (North Cascades National Park)
  - 25,000 gallon per day "Physical Chemical" treatment system.
  - Lift station
  - Equalization tankage
  - Subsurface effluent disposal
- Treatment system components no longer available and upgrade needed.
  - Project administered by NPS Denver Service Center

Constructed 1974, Skid replaced in 1980s, Rehab'ed in 2000

LOSS

- Regulated by the Department of **HEALTH**, as a large onsite sewage system because:
  - Capacity is between 3,500 and 100,000 gallons per day
  - Effluent disposal is to a subsurface drain field.

Major Challenges

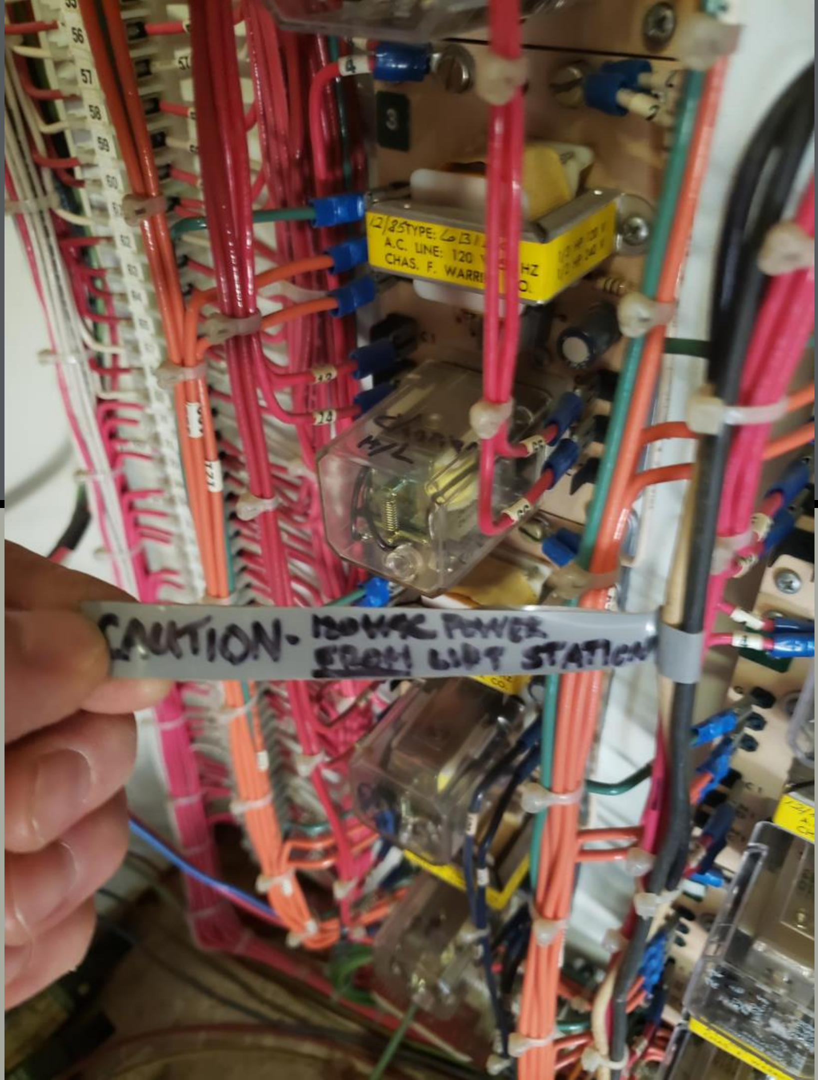
- Power Availability
- Seasonality
- Footprint

Lesser Challenges

- Accessibility
  - Increased construction costs but easily addressed.
- Connectivity
  - Initially very limited internet, no cell service, but rural internet availability changed throughout the project.

Power Availability

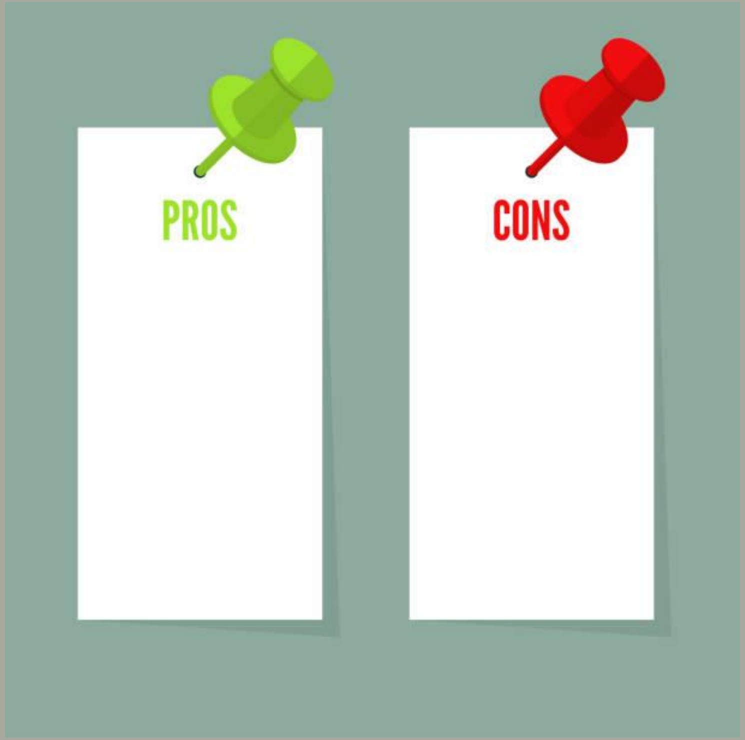
- Stehekin's power supply is generated by a hydropower turbine operated and maintained by Chelan PUD
  - This is "maxed out"
  - Only 208/120V service available
  - Power was "dirty"
- Key commitment of the project was no net increase in power demands.
  - Single largest power demand was the lift station and was excluded from the funding available.
    - About the power usage of two single family homes.



Mitigations

Power Availability

- Initial screening of treatment processes based on power consumption.
- Second round used a “Choose by Advantages” method
  - Simplistic operations was the highest weighted criteria
    - Stehekin has one operator for both W and WW
- Processes Considered in CBA
  - Activated Granular Sludge Sequenced Batch Reactor
  - Integrated Fixed Film Activated Sludge (IFAS)
    - Single train IFAS
  - Recirculating Textile Filter (RTF)

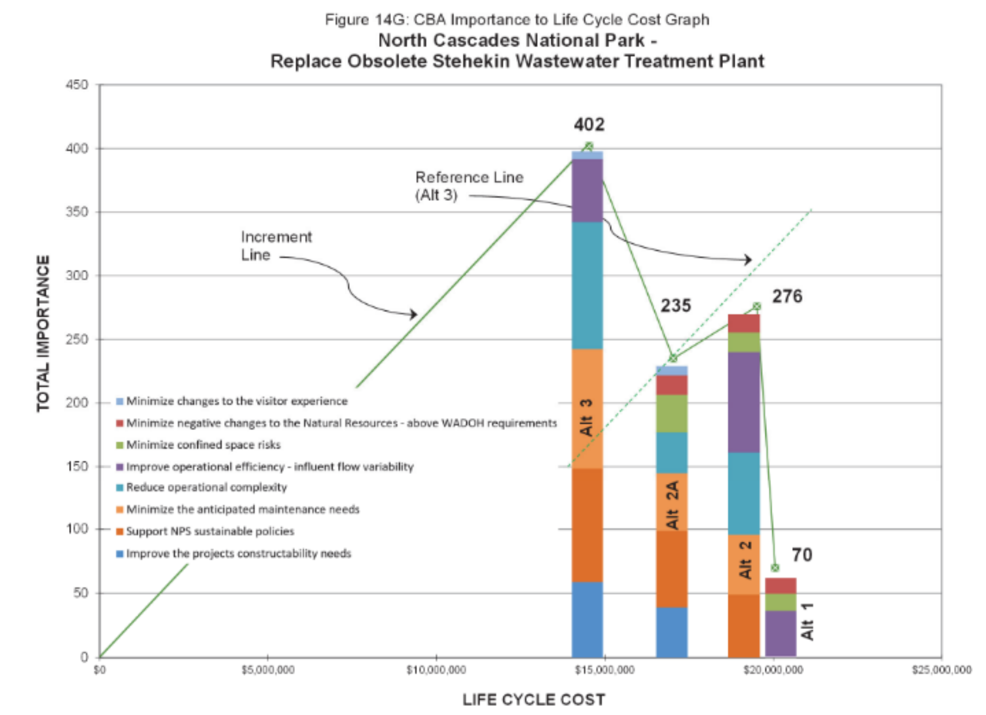


Treatment Process

RTF

- Chosen because:
  - Simplest process
  - Lowest power demands
- CBA method identified that the lowest cost alternative was also the most advantageous!

Liquid Treatment Alternative	Associated Discharge	Class C Cost Estimate	Max Month Estimated Power Use (kWh/M)
AGS	Groundwater Discharge through Drainfield	$10.8 million	3,000
IFAS	Groundwater Discharge through Drainfield	$10.6 million	2,150
Recirculating Textile Filter	Groundwater Discharge through Drainfield	$8.8 million	1,800



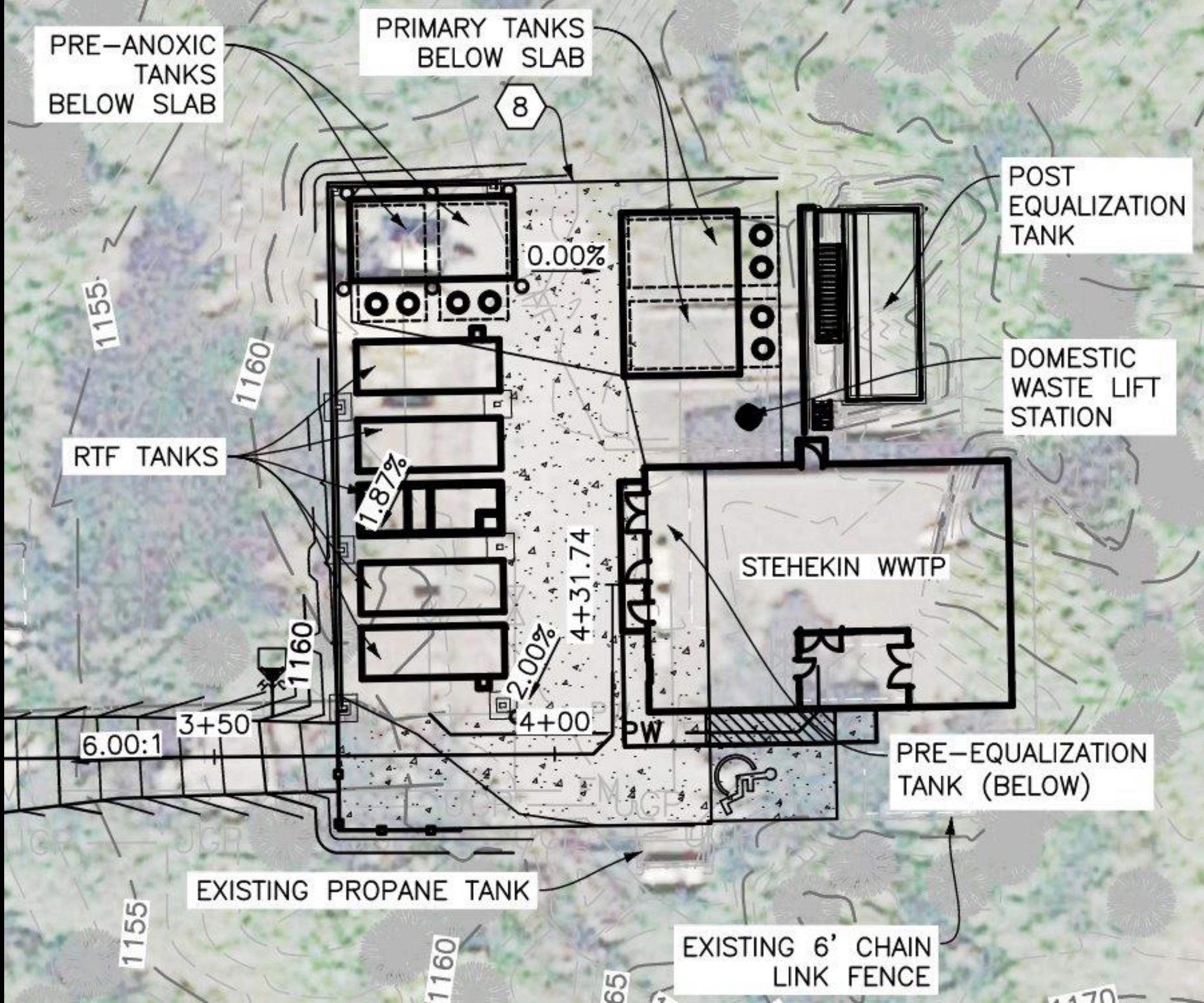
Seasonality

- Main economic driver for Stehekin is summertime tourism
- Stehekin sees a 9:1 reduction in sewer flows between summer and winter.
- Cold climate and low flows compound making maintain biology very challenging.

Mitigations

Seasonality

- Initially considered 3 large RTF tanks.
- Ultimately 5 RTF tanks were utilized.
  - Greater flexibility in site layout
  - Greater turndown to match wintertime demand
    - Lesser heating demands.
  - Enhanced constructability



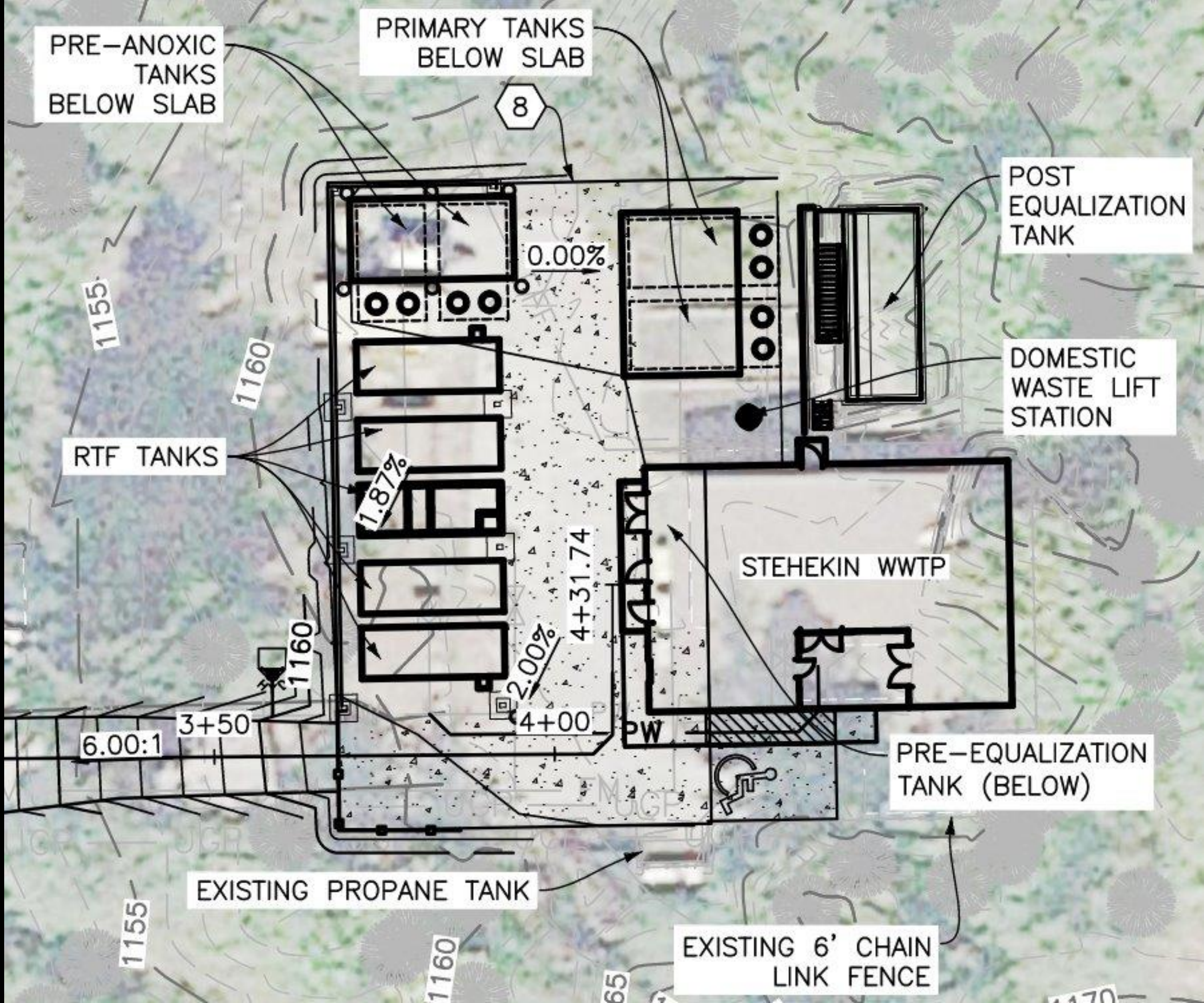
Footprint

- Lake Chelan is in a deep gorge with very little flat land.
- No above grade work allowed outside the existing WWTP fenceline.
  - Existing WWTP site was <9,500 SF
- Only available land for a drainfield was utilized for long term parking.
  - Limited to <16,000 SF

Mitigations

Footprint

- WWTP
  - Smaller RTF tank sizes offered greater flexibility.
  - Four phases of construction (over 2 years) to allow for continued operations of existing system.



Mitigations

Footprint

- Drainfield
  - Per WAC without accounting for treatment

25,000 GPD – 1 GPD/SF INFILTRATION BEDS

Mitigations

Footprint

- Drainfield
  - Repurposed previous aerobic digester as an effluent equalization tank.
    - Reduce design capacity by >45%

Mitigations

Footprint

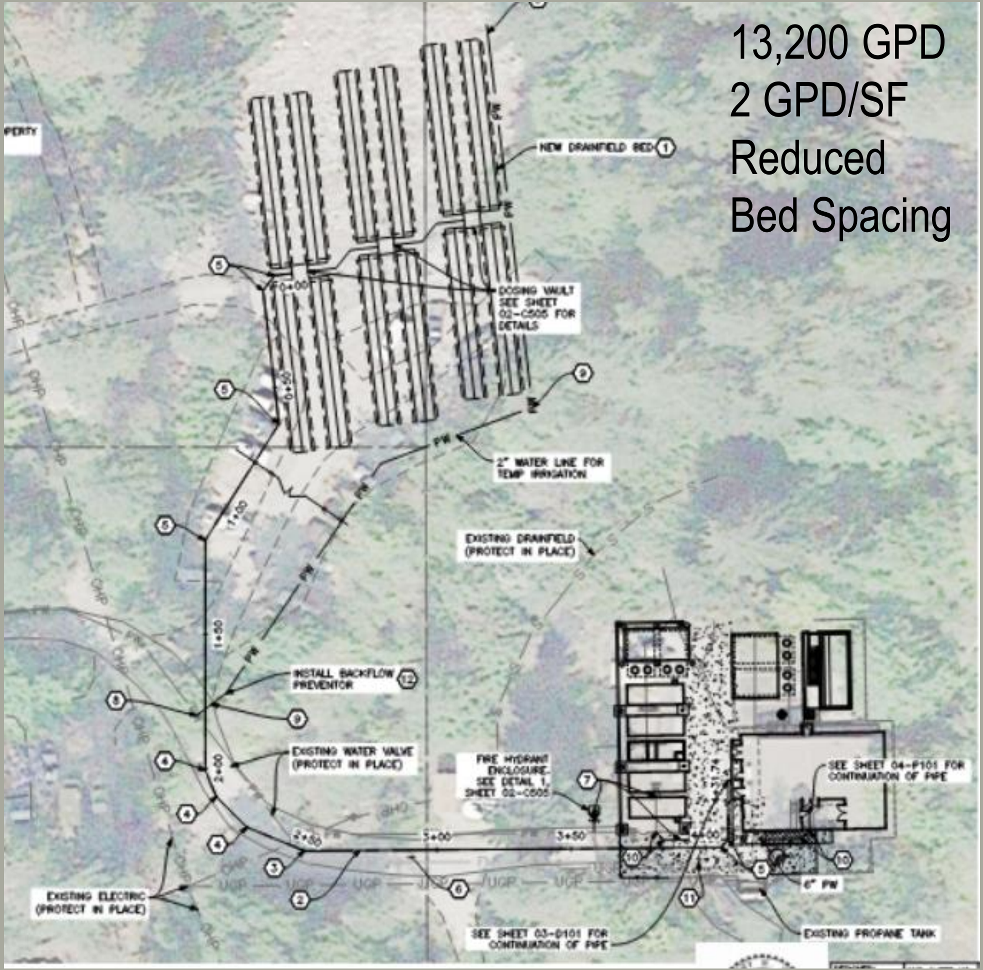
- Drainfield
  - Utilized available reduction in WAC of constructing drainfield for 100% of design capacity versus 150%
  - Coordinated with DOH on additional waivers
    - This was considered a repair/replacement of an existing drainfield
      - Increased loading rate from 1 to 2 gpd/sf
      - Reduced spacing between infiltration beds

13,200 GPD – 1 GPD/SF INFILTRATION BEDS

Mitigations

Footprint

- Drainfield
  - Waivers were backed up by:
    - Providing high degree of treatment
    - Groundwater monitoring downgradient of existing drainfield
    - New drainfield vast improvement over existing.



The NEW Stehekin WWTP

- Phase B in progress!
- Coming Fall of 2025

04 Closing

Closing

- All treatment plants regardless of size are complex.
- Considerations are often the same but with their own twist.
  - Let people know what they are!!

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Questions?

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