Clean Water State Revolving Fund Green Project Reserve

- Preliminary -

City of Nampa Phase II: WWTP Upgrade Project

FY20 Amendment #1 SRF Loan #WW1903: $24,000,000

Preliminary Green Project Reserve Justification[1]

Categorical Energy Efficient GPR Documentation

1. Premium Energy Efficient Motors and VFDs (Energy Efficiency). Premium energy efficient motors and VFDs will be installed as part of the Wastewater System Upgrade project. GPR Categorical Case per Section 3.2-2: *Use of premium efficiency motors and VFD pumps in a new project to achieve 20% reduction in energy consumption.* ($xxxxx).
2. Installs Tertiary Filter to reduce UV disinfection energy output requirements (Energy Efficiency). Categorically GPR-eligible per Section 3.2-2: *greater than 20% reduction in energy use*; also GPR-eligible per Section 3.4-1: *cost effective as cost is recovered over the useful life of the process* ($xxxxxx).
3. Install Anaerobic Digestion in lieu of Aerobic Digestion (Energy Efficiency). *Categorical per GPR 3.2-2: "projects that achieve a 20% reduction in energy consumption."* ($xxxxxxx).
4. Low Pressure High Intensity UV Disinfection System (Energy Efficiency). Categorically GPR-eligible per Section 3.2-2: *projects that achieve a 20% reduction in energy consumption; and* 4.5-5a: *Projects that significantly reduce or eliminate the use of chemicals in wastewater treatment* ($yyyyyyy).

Environmentally Innovative GPR

5. Innovative Multi-stage Activated Biological Process For Biological Nutrient Removal (Innovative). Environmentally Innovative GPR-eligible per Section 4.5-5a: *Projects that significantly reduce or eliminate the use of chemicals in wastewater treatment; 4.5-5b: …approaches that significantly reduce the volume of residuals, or lower the amount of chemicals in the residuals*. ($yyyyy).
6. Side Stream Phosphorus Treatment (Innovative): Environmentally Innovative GPR-eligible per Section 4.5-5a: *Projects that significantly reduce or eliminate the use of chemicals in wastewater treatment; 4.5-5b: …approaches that significantly reduce the volume of residuals, or lower the amount of chemicals in the residuals*. ($yyyyy).

[1] All costs/analyses and text in red font will be updated in the GPR Technical Memorandum submitted by the loan recipient at completion of design.

1. PREMIUM EFFICIENCY MOTORS & VFDS

Summary

The City of Nampa has obtained a FY20 Loan Amendment 1 ($24M) to supplement their FY19 SRF loan ($37M) to implement Phase II of their wastewater treatment plant (WWTP) upgrade and expansion project. GPR-eligible components of Phase II include premium pumps and VFDs, an additional BPR aeration basin, tertiary filtration, ultraviolet disinfection, side-stream phosphorus removal, and a fifth anaerobic digester.

- Amend 1 amount = $24,000,000 (Total Loan = $61M)
- GPR-eligible = Pumps/VFDs = $xxxxx (preliminary cost estimate);   Estimated portion of loan = y%

Description

- Energy efficient items installed in the Nampa WWTP Phase II upgrade include:
    - Primary effluent vertical turbine, solids handling, premium efficient pump + VFD
    - WAS Pumps + VFDs
    - Filter Pump Station pumps + VFDs
    - Effluent Pump Station pumps + VFDs

GPR Justification[2]

VFDs:
- The Baseline Standard Practice for comparison is a standard EPAct motor not controlled by a VFD[2].
- VFD efficiency data were calculated using the Baldor Adjustable Speed Drive Energy Savings Calculator[3] (for pump applications).
- The combined annual energy savings for utilizing VFDs is estimated to be xxxxx kWh per year per pump/VFD system (xx% reduction in energy compared to motors without VFDs). This corresponds to a cost savings of $yyyyy per year (at an energy cost of $0.05 per kWh) per VFD system when compared to the Baseline Standard Practice, with a total cost savings of $zzzzz per year (two VFD systems in operation continuously).
- With an estimated incremental cost increase of $xxxxx per unit, the simple payback is approximately yy years for the systems.

Motors:
- Premium motor energy savings over the EPAct motor is $yyy per year per motor or $yyy per year total (two motors in operation continuously).[4]
- With an estimated incremental cost increase of $yyyy per unit, the simple payback is yy years per motor.

Conclusion

- The use of premium energy-efficient pumps and VFDs achieve more than a 20% reduction in energy consumption and are cost effective.
- **GRP Costs Identified**:
    - Premium Efficiency Pumps + VFDs = **$zzzzz** (preliminary estimate)

[2] NYS Energy Research and Development Authority, Energy Evaluation Memorandum, Village of Greenport WWTP Upgrade 8-2009
[3] http://www.baldor.com/support/software_download.asp?type=BE$T+Energy+Savings+Tool
[4] Productive Energy Solutions Motor Slide Calculator. Energy cost at $0.05/kWh. 94.1% efficiency for premium motor vs. 92.4% for EPAct motor.

- **GPR Justification**: The Pump/VFD system is Categorically GPR eligible (Energy Efficiency) per Section 3.2-2 page 9[5]: *Use of premium efficiency motors and VFD pumps in a new project where they are cost effective and achieve a 20% reduction in energy consumption*. Section 3.5-9 also states: *Variable Frequency Drives can be justified based upon substantial energy savings*[6]; such savings are identified above.

[5] 2012 Clean Water State Revolving Fund 10% Green Project Reserve: Guidance for Determining Project Eligibility
[6] Attachment 2. April 2012 EPA Guidance for Determining Project Eligibility.

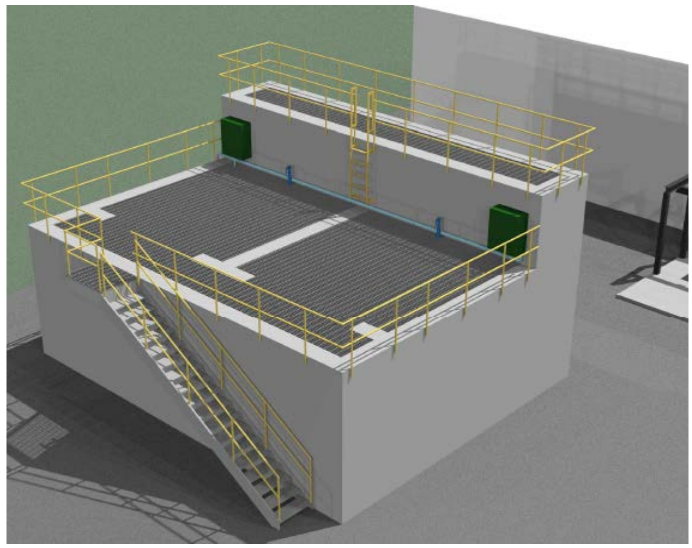
2. Tertiary Filtration

Summary

The project incorporates tertiary filtration for increased removal of suspended solids prior to UV disinfection, resulting in greater UV disinfection capacity at much lower power.

- Energy efficiency (green) portion of loan = yy% ($zzzz) [Final Installed Cost]
- Estimated annual power savings = xxxx kWh (30%) = $yyyy per year

Background



- The tertiary filter reduces the average TSS concentration flowing into the UV vessels from xx mg/L to y mg/L or less. This allows the design UV transmissivity (or the ease at which UV light can pass through the water) to increase from 60% to 70%.
- As UVT improves, more UV light would be able to reach the disinfection target; the UV sensor would read this and adjust the lamps' output down accordingly therefore decreasing the power consumption.
- The energy savings is not completely linear, but UV disinfection suppliers indicate the increase in transmissivity would significantly reduce energy consumption.
- The yyyy lamps for the UV disinfection are guaranteed for 14,000 hours; this accounts for 100% operation, all the time. Operating capacity does not have as large an effect on lamp life as number of on/off cycles.

Calculated Energy Efficiency Improvements[7]

- Without the tertiary filter the average power draw per UV chamber = 6.31 kW; annual power draw = zzzzz kWh = Annual Energy Costs (@$0.10/kWh) = $yyyyy
- With the filter the average power draw = 4.44 kW; annual power draw = yyyyy kWh = Annual Energy Costs (@$0.10/kWh) = $zzzzz
- Therefore, with the tertiary filter, the UV disinfection unit uses only 70% of the power required without the filter = 38,894 kWh /55,276 kWh = .70, resulting in an annual cost saving = $1,639.
- Thus, with the tertiary filter, the UV system is more energy-efficient resulting in an annual power savings of xxxxx kWh.

Conclusion

- At 10 cents per kW, UV energy reductions from the tertiary filter saves up to $yyyy per year.
- **GPR Costs**: Tertiary filter = $yyyyyy
- **GPR Justification**: Categorically GPR-eligible per Section 3.2-2: *greater than 20% reduction in energy use.*

[7] 12/2/13 Correspondence with Camp Fuller, Applications Engineer for Xylem Inc.-Wedeco. See Appendix B.

3. Anaerobic Digester

Summary

- The City will install an additional anaerobic digester in lieu of aerobic digesters in order to conserve energy and increase the dewaterability of the biosolids.
- Amend 1 loan amount = F$24M; Total Loan amount = $61M
- Categorical energy efficient (green) portion of loan = xx% ($yyyyy) [Final installed cost]
- Annual Power savings = 97.9%

Background

- The solids are treated anaerobically rather than aerobically, thereby significantly reducing the required energy consumption as compared to aerobic digestion.
- The City is gravity belt thickening the waste activated sludge and clarifier sludge from approximately 1% solids to 4% solids, thereby reducing the size of the anaerobic digesters.

Energy Efficiency Improvements

- The GPR-eligibility of Anaerobic Digestion is established by a comparison of energy efficiency to a Baseline Standard Practice (BSP). The BSP in this instance is Aerobic Digestion.
- Anaerobic digestion only requires power for mixing the contents of the digester; natural gas and biogas are now used to heat the contents. Aerobic digestion has much higher energy requirements due to the larger sludge volumes (1 – 2% solids concentrations) that require treatment, and additional mixing and aeration requirements.[8]
- Anaerobically digested sludge is typically easier to dewater and results in higher cake solids with the same polymer usage. This results in a lower volume of biosolids for disposal and reduces hauling costs.[9]

Anaerobic Digester Power Estimate (Mixing)[10]

Item	Time (hr)	HP	Daily Power (kW-hr)	Annual Power Consumption (kW-hr)
Rapid Mixing	2	36.5	54	19,849
Constant Mixing	22	18.2	299	109,169
		Total	**353**	**129,018 /year**

Aerobic Digester Power Estimate (Air Supply and Mixing)

Item	Amount	Unit
% Volatile Solids Reduction	38%[11]	--
Min. SRT (winter)	60	d
Sludge Concentration (Digester)	3%	--
Diffused air mixing is used.		
Oxygen transfer efficiency	5%	--
Total Mass of VSS	5,883	kg VSS/d
Oxygen Required (Avg. of Winter & Summer)	24,026	lbs. O2 /day
Residual DO	2	mg/L
Std. Oxygen Transfer Efficiency (SOTE)	0.75	%/ft
AOR/SOR	0.438	
Standard Oxygen Required (SOR)	54,827	lb/day
Req'd Airflow for Biological Treatment	14,505	SCFM
Estimated Power	944	BHP
Estimated Daily Power Usage	16,903	kW-hrs/day
Estimated Annual Power Usage	**yyyyyyy**	**kW-hrs/year**

[8] Wastewater Engineering Treatment and Reuse, 4th Ed., Metcalf and Eddy, Pg.1533.
[9] Wastewater Engineering Treatment and Reuse, 4th Ed., Metcalf and Eddy, Pg. 1566.
[10] Aeration is not required for anaerobic digesters
[11] Approximately Class B biosolids - equivalent to anaerobic digester

Results

- The estimated power consumed by the BSP (aerobic digestion) is xxxxxxx kW-hr per year.
- The estimated power consumed by the proposed digesters is yyyyyy kW-hr per year.
- Therefore the proposed alternative saves zzzzzzz kW-hr per year.

Conclusion

- By constructing anaerobic digestion facilities, the City reduces power demand by approximately 98% as compared to the Baseline Standard Practice of installing aerobic digestion. The reduction in power is due to the elimination of the need for aeration, reduced mixing requirements, and smaller digesters that can treat thicker sludge concentrations.
- **GPR Cost:**

Equipment Name	Cost
Anaerobic Digestion Facilities	$ yyyyyyyy
∴ FY15 Total =	**$ yyyyyyyy**

- **GPR Justification:** Categorically GPR-eligible (Energy Efficiency) per Section 3.2-2: *"projects that achieve a 20% reduction in energy consumption."*

4. UV Disinfection System

Summary

- The Low Pressure High Intensity UV system specified for the Nampa Phase II project is 3X more efficient than medium pressure lamps and 5X higher UV-C output than conventional low pressure lamps. UV-C output is important when considering UV disinfection systems because the UV-C range is the germicidal portion of the UV radiation band. The system specified for Phase II is more expensive than conventional lamps and would be comparative in price to the medium pressure option.
- Amend 1 loan amount = F$24M; Total Loan amount = $61M
- Categorical energy efficient (green) portion of loan = xx% ($yyyyyy) [Preliminary Estimate]
- Annual Energy savings = xx%

Background

- A common alternative to low-pressure high-intensity style UV systems are medium-pressure UV systems. In comparison to medium pressure technology, low-pressure high-output technology consumes 2-4 times less power.[12] [13]
- The typical electrical to germicidal UV conversion efficiency rates of medium pressure UV systems is 10 – 20%; whereas, this efficiency for low-pressure high-intensity systems is 30 – 35%.[14]
- The specific lamp installed at the Nampa WWTP is the YYYYYYYY UV lamp which has a light yield to energy expenditure y times higher in comparison to medium pressure lamps.[15]

Results

- The maximum power consumption of the low-pressure high-intensity UV system (lamps and ballasts only) installed is 7.56 kW per UV unit. The wastewater flow at the WWTP will be constant, meaning the disinfection system is operating at all times.
- With one unit running 24 hours a day for every day of the year, the annual energy consumed by the system is 66,226 kWh/yr.

Energy Efficiency Improvements

- The approximate energy consumption by medium pressure UV system for this application = 66,226 kW-hr x 3 = 198,677 kW-hr.[12] [13]
- The energy reduction achieved by using a low-pressure high intensity system versus a medium-pressure high-intensity system = 1 - (66,226 kW-hr / 198,677 kW-hr) = 66%
- The annual energy cost savings associated with using a low-pressure high intensity system instead of a medium-pressure high-intensity system (@$0.10/kWh) = (198,677 – 66,226)kWh x $0.10/kWh = $13,245 per year

[12] Xylem Inc.-WEDECO UV products.
[13] Metcalf and Eddy-Wastewater Engineering; Tchobanoglous, Burton, & Stensel, 2003; Table 12-25
[14] Table 2.1 from the USEPA's UV Disinfection Guidance Manual (UVDGM 2006).
[15] Wedeco LBX series UV disinfection system brochure. See Appendix C.

Conclusion

- By selecting a low-pressure high-intensity UV disinfection system the power consumption will be 66% lower than the common alternative medium-pressure high-intensity disinfection system.
- The choice of UV disinfection also eliminates the use of chemical disinfection using chlorine, and eliminates toxic chlorination by-products.
- **GPR Costs:** Low-pressure high intensity UV disinfection system: $xxxx
- **GPR Justification:** Categorically GPR-eligible (Energy Efficiency) per Section 3.2-2: *projects that achieve a 20% reduction in energy consumption; also*, GPR-eligible per Section 4.5-5a: *Projects that significantly reduce or eliminate the use of chemicals in wastewater treatment*.

5. Biological Phosphorus Reduction: Aeration Tank

Summary

- Phase II will add an additional aeration basis for biological phosphorus removal.
- Amend 1 loan amount = F$24M; Total Loan amount = $61M
- Estimated green portion of loan = xx% ($xxxxx) (preliminary cost estimate)

Background[16]

- In the past, the Nampa WWTP operated using a combination of trickling filters and a nitrifying activated sludge system (aerobic only) for secondary treatment. This system was capable of biochemical oxygen demand (BOD) and ammonia-nitrogen removal. The Nampa WWTP was not able to remove phosphorus.
- Phase I of the project added innovative biological phosphorus removal (BPR) into the treatment process.

Treatment Description

- The biological activated sludge treatment system incorporates anaerobic and aerobic zones to accomplish removal of both ammonia-nitrogen and phosphorus.
- Phase II will add an additional aeration basin modified to enable the basin to contribute BPR.
- The activated sludge basins consist of a combination anaerobic selector zone followed by a flexible aerated (swing) zone that allow for process flexibility (for phosphorus removal). Anaerobic zones are used to promote the growth of phosphorus accumulating organisms which perform BPR. These initial zones are followed by two aeration passes.
- Return activated sludge is recycled from the existing secondary clarifiers to the front of the activated sludge process.
- It is estimated that biological phosphorus removal without chemical addition will be capable of lowering the phosphorus concentration to approximately 0.5 mg/L. A chemical trim system is used as needed for polishing to keep effluent phosphorus concentrations below NPDES permitted levels.

Innovative Process Justification

- The GPR-eligibility of BPR was established by comparison to a Baseline Standard Practice (BSP). The BSP for the City of Nampa is the current operating practice of treatment with trickling filters and nitrification (aerobic) basins. To meet effluent phosphorus limits using this arrangement, large quantities of chemical (metal salt) coagulant would need to be added to the treatment process in addition to tertiary filters.
- For the BSP, the WWTP expects to remove xxxx lb/day of total phosphorus (TP) at the average annual (summer) loading condition. Approximately yyyyy gallons of liquid ferrous chloride per day (or zzzzzz gallons per year) would be required to remove that TP load using the BSP. At $1.97 per gallon of liquid ferrous chloride, the WWTP would spend over $xx million annually for chemical supply. This treatment method would create a quantity of chemical sludge that would require handling and disposal. Based on

[16] Nampa Wastewater Treatment Plant 2018 Facility Plan Addendum, Brown and Caldwell

the chemical usage costs, the additional aeration tank will have a simple payback period of xx years.

Conclusion

- Compared to the BSP, BPR significantly reduces the need for chemical addition for phosphorus removal and minimizes the amount of chemical sludge to be disposed.
- **GPR Costs Identified**:
  - Modifications to existing nitrification basins = $zzzzzzzz
  - Construction of a new activated sludge basin = $yyyyyyy
  - **Total = $xxxxxx**
- **GPR Justification**: The process is GPR-eligible per Section 4.5-5a: *Projects that significantly reduce or eliminate the use of chemicals in wastewater treatment; 4.5-5b: …significantly reduce the volume of residuals, or lower the amount of chemicals in the residuals*[17].

[17] Attachment 2 of the April 2012 EPA Guidance for Determining Project Eligibility.

6. SIDE-STREAM PHOSPHORUS TREATMENT

Summary

- Phase II will add a side-stream phosphorus treatment facility to remove and recover struvite as a commercial fertilizer.
- Amend 1 loan amount = F$24M; Total Loan amount = $61M
- Estimated green portion of loan = xx% ($xxxxx) (preliminary cost estimate)

Background[18]

- In the past, the Nampa WWTP operated using a combination of trickling filters and a nitrifying activated sludge system (aerobic only) for secondary treatment. This system was capable of biochemical oxygen demand (BOD) and ammonia-nitrogen removal. The Nampa WWTP was not able to remove phosphorus.
- Phase I of the project incorporated an innovative biological phosphorus removal (BPR) system into the treatment process which results in phosphorus, ammonia and BOD removal while significantly reducing the use of chemicals. Phase II of the project will include a side-stream phosphorus recovery process to precipitate marketable phosphate as an agricultural nutrient.

Treatment Description

- Struvite formation occurs in wastewater treatment plants that have anaerobic digesters. Struvite forms when ammonia which is a byproduct of urea and urine, magnesium, and phosphate, which is a major element in the organic matter processed at the plant, come together thus precipitating struvite crystals.
- Due to struvite composition and its fertilizing properties, the control of its precipitation contributes to the reduction of phosphorus levels in effluents while simultaneously generating a valuable by-product.

Example of Struvite Harvesting Equipment

Photo courtesy of Madison Metropolitan Sewerage District

Innovative Process Justification

- The process of harvesting struvite (magnesium ammonium phosphate) to remove excess phosphorus from the anaerobic digestion process at wastewater treatment plants is simultaneously reducing operations/maintenance costs and creating small, round struvite particles suitable for reuse as a bagged fertilizer for gardens and indoor plants.

Conclusion

- Controlled struvite precipitation significantly reduces the need for chemical addition to prevent precipitates from forming in pipes and process vessels, produces valuable fertilizer, and minimizes the amount of chemical sludge to be disposed.
- **GPR Costs Identified**:
  - **Total = $xxxxxx**
- **GPR Justification**: The process is GPR-eligible per Section 4.5-5a: *Projects that significantly reduce or eliminate the use of chemicals in wastewater treatment; 4.5-5b: …significantly reduce the volume of residuals, or lower the amount of chemicals in the residuals*[19].

[18] Nampa Wastewater Treatment Plant 2018 Facility Plan Addendum, Brown and Caldwell

[19] Attachment 2 of the April 2012 EPA Guidance for Determining Project Eligibility.