TOWN OF WEST YELLOWSTONE

WASTEWATER TREATMENT PLANT PRELIMINARY ENGINEERING REPORT

Prepared By: FORSGREN Associates Inc.

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THIS PLAN IS STAMPED AND SIGNED BY
KEVIN HARRIS, P.E.

FORSGREN PROJECT NO. 01-19-0046

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A. PROBLEM EVALUATION AND EXISTING FACILITY REVIEW

A.1. Introduction

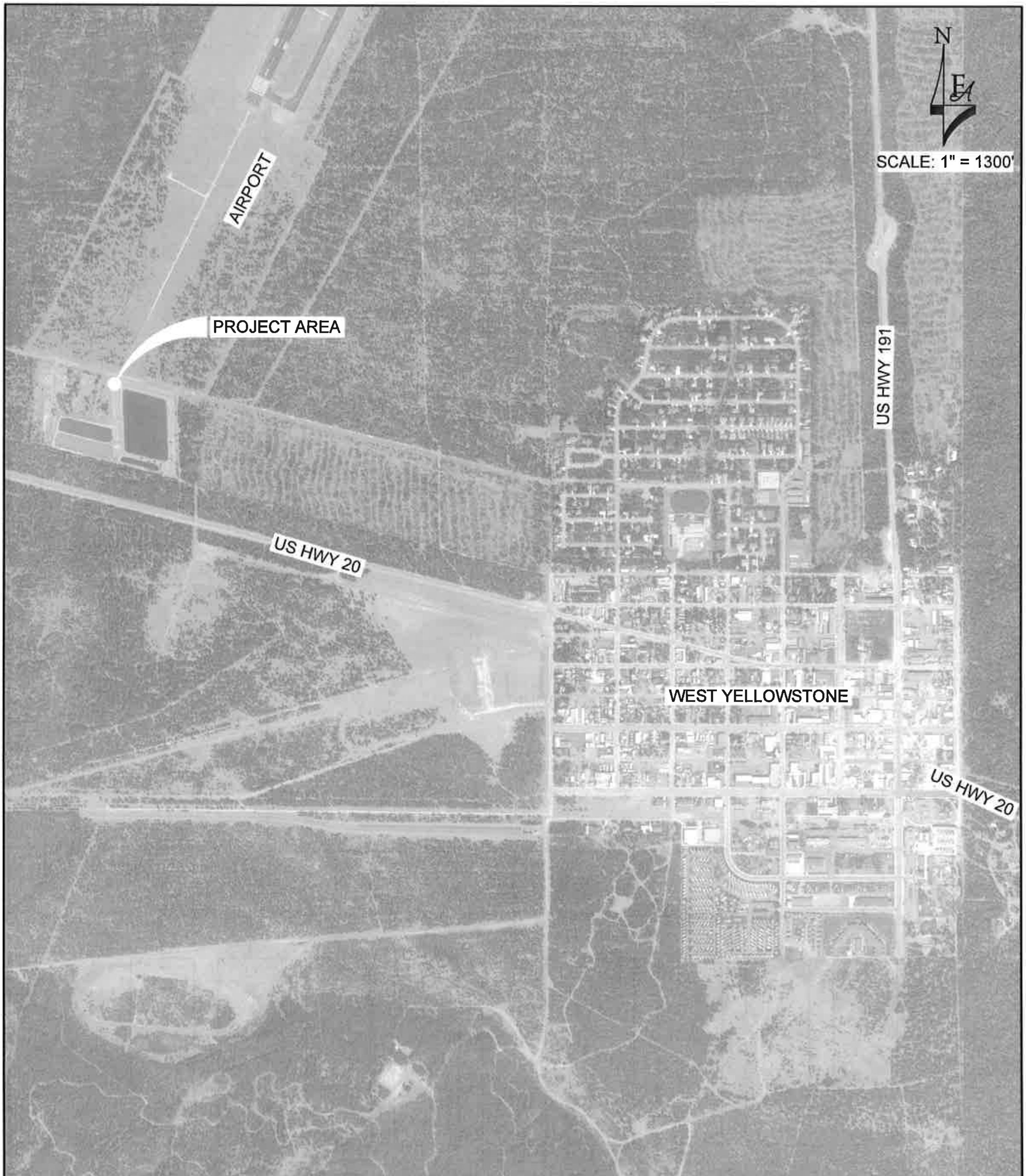
The Town of West Yellowstone has elected to complete a Facility Planning Study (FPS) for their wastewater treatment plant (WWTP) as part of a continued effort to maintain aging infrastructure and keep pace with future growth. This FPS was expanded upon to also meet Preliminary Engineering Report design guidelines and criteria as set forth by the State. This study is intended to evaluate alternatives for improving the wastewater treatment system to correct existing deficiencies and prepare the system to provide reliable and adequate wastewater treatment for current and future residents. This study includes a final project selection and discussion of design parameters for the future facilities. This study is written in accordance with Montana Department of Environmental Quality (DEQ) guidance as set forth in Circular DEQ-2 Design Standard for Public Sewage Systems 2018 and is intended to satisfy requirements set forth in Chapter 10. Upon approval of this document by DEQ, the Town intends to continue with final design and submission of project plans and specifications.

A.2. Existing Treatment System Components

The existing West Yellowstone WWTP is located approximately one mile west of Town along Targhee Pass Highway and is situated just north of the road. Please see Figure A-1 for reference to the vicinity map for the site. The WWTP was designed and constructed in 1993. In 1997, the WWTP was modified to a partial mixed aerated lagoon system. No further modifications have been made to the treatment process. However, in 2018, two new infiltration-percolation (IP) beds were added to increase discharge capacity. Furthermore, three mechanical evaporators were added in the Summer of 2019 to further increase discharge capacity. With the evaporators, an ultrasonic algae controller was also installed to minimize the growth of algae thus minimizing organic loading to the IP beds. Note that the evaporators and algae controller were approved by DEQ for short term increases to capacity and are scheduled to be removed from service upon completion of a new WWTP by 2023. Plans from the 1993, 1997, 2018 and 2019 improvements are included in Appendix A for reference. The designated point of discharge is local groundwater. The following is a list of processes and equipment included as part of the WWTP.

- Influent
  - Influent Flow Meter
- Secondary Treatment (Aerated Lagoons Cells A & B)
  - Aeration Blowers
  - Fine Bubble Diffusers
  - Coarse Bubble Diffusers
- Tertiary Treatment (Polishing Pond Cell C)
  - Ultrasonic Algae Controller
- Discharge
  - Mechanical Evaporators
  - IP Beds

The layout of the plant is illustrated in a flow schematic shown in Figure A-2.



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WEST YELLOWSTONE WWTP

FIGURE A-1

VICINITY MAP

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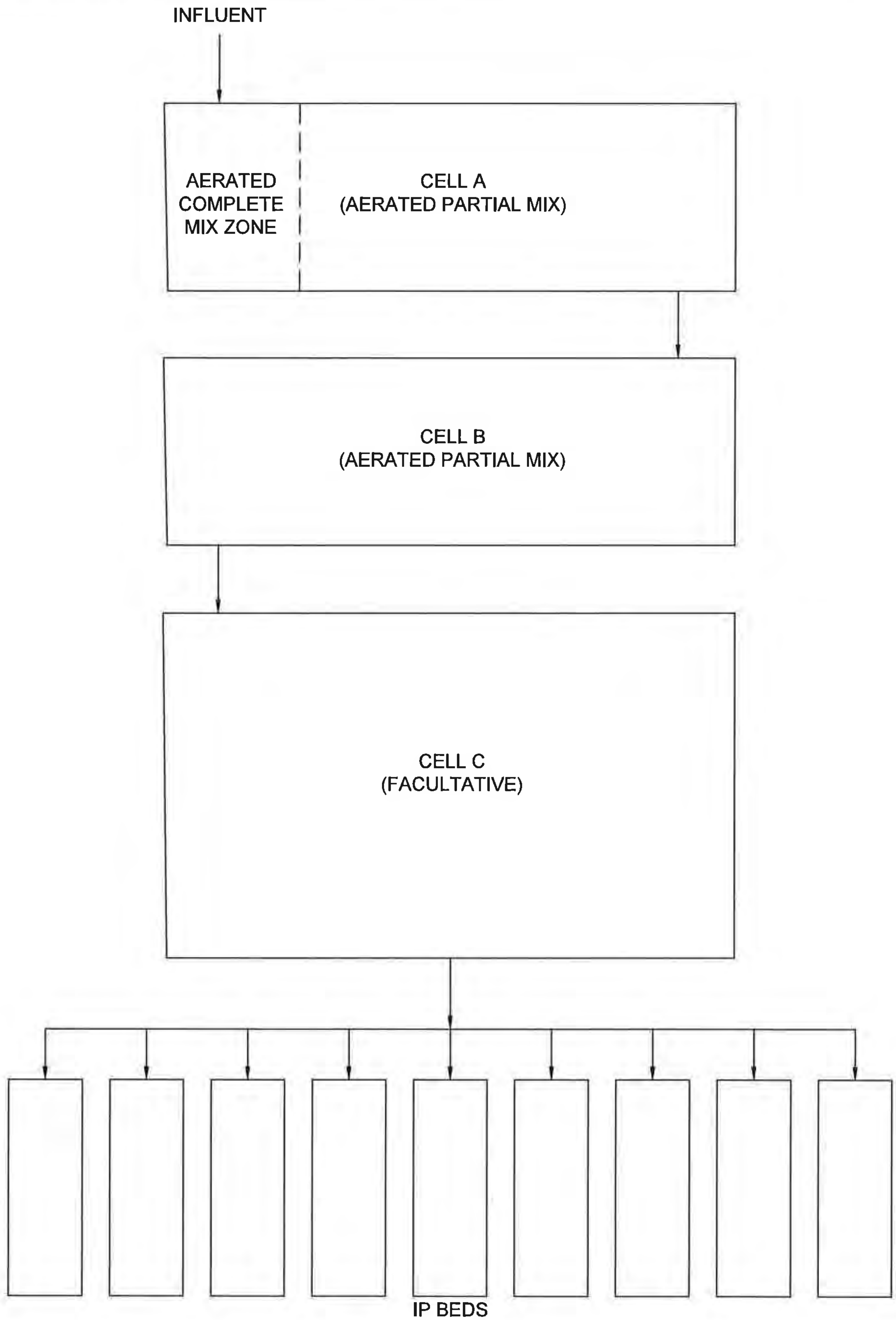

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WEST YELLOWSTONE WWTP

FIGURE A-2

FLOW SCHEMATIC

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A.2.a. Influent

The majority of the current flow to the West Yellowstone WWTP is domestic waste. There are no significant industrial waste dischargers to the Town's wastewater collection system. The influent enters the plant from two separate lift stations, the Main Lift Station and the Madison Addition Pump Station. The combined influent flows through a flow meter prior to entering the treatment plant. See Figure A-3 for reference to a site map.

A.2.b. Primary Treatment

The existing WWTP does not have a headworks building. As part of the original design, a screen was installed; however, the screen was damaged and removed several years ago. Therefore, there is currently no primary treatment at the WWTP.

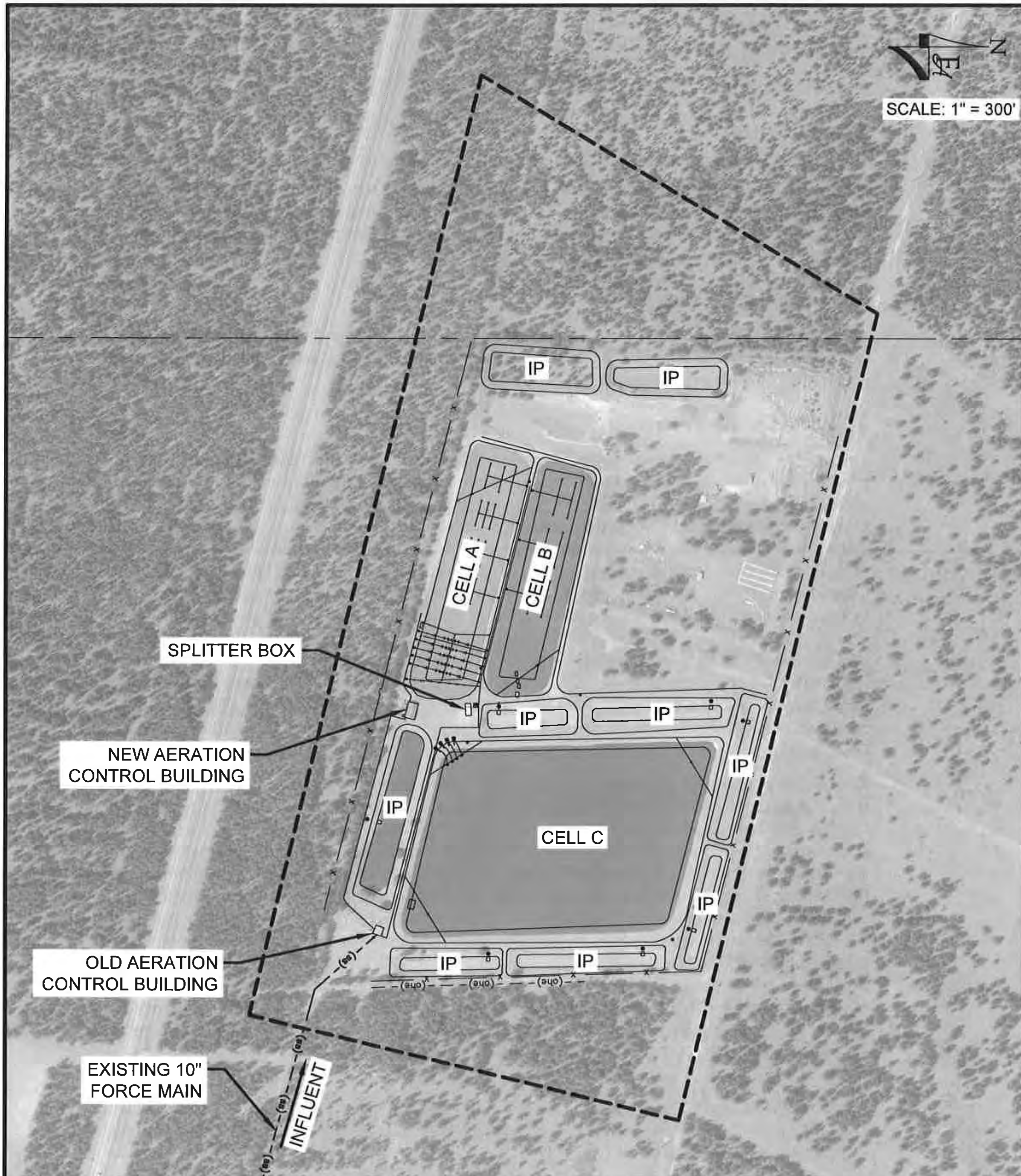
A.2.c. Secondary Treatment

The sewage lagoons are used as the secondary treatment to treat the domestic wastewater by breaking down the raw sewage into gas and sludge. The decomposition of the raw sewage is accomplished via aerated lagoons which do not depend on algae and sunlight to supply the necessary DO for bacteria, but instead depend on diffusers to supply the oxygen and suspend the solids via a mixing action in the wastewater. Cell A is an aerated lagoon comprised of both a complete mix zone and a partial mix zone. Cell B is a partially mixed aerated lagoon. The air utilized to aerate the lagoons is generated via blowers located inside the blower building. The existing blowers function but have exceeded their design life. Cell A utilizes both fine bubble aeration and coarse bubble aeration, while Cell B utilized only coarse bubble aeration. Fine bubble aeration introduces very small bubbles into the wastewater treatment process. The main principle behind fine bubble aeration versus course bubble aeration is the smaller bubbles result in more bubble surface area per unit volume and thus greater oxygen transfer exchange. The fine bubble aeration in Cell A is working properly; however, the coarse bubble aeration in both cells is not functioning.

Overall, the lagoon system is comprised of a series of three lagoons. The influent wastewater travels from one lagoon to the next until it has passed through all three lagoons, as shown in Figure A-2. Cells A and B are approximately 18' deep from top of berm to lagoon floor with 3:1 side slopes. A freeboard of 3-feet was utilized in design, making the design water depth of the lagoons 15-feet. The design plans do not provide sludge storage depth in the bottom of the lagoons and utilize the full 15-foot depth for process capacity. Cell C is approximately 5-feet deep. Table A.3-1 summarizes the design volume of each lagoon. From the influent, flow enters a splitter box and is directed to the aeration basins, first the complete mix zone and then the partial mix zone of Cell A followed by Cell B. Flow then enters the Polishing Pond (Cell C) for tertiary treatment. Influent flows can be diverted from the splitter box directly to Cell B in the case that Cell A is full, not functioning properly, or during maintenance activities. Likewise, flow from Cell A can be diverted directly into Cell C in the case that Cell B is full, not functioning properly, or during maintenance activities. Both Cells A and B are currently experiencing an excess of built-up biosolids due to overloading and lack of maintenance.

Lastly, Cells A and B are lined with a 30 mil Hypalon liner, which is a chlorosulfonated polyethylene synthetic rubber material. The liners on both cells are significantly damaged and have exceeded their design life.

The basis of design for the system established in 1993 is an aeration system capable of removing a minimum of 85 percent of the average design BOD loading of 800 lbs/day at an annual average flow rate of 0.439 mgd.



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WEST YELLOWSTONE WWTP

FIGURE A-3

SITE MAP

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A.2.d. Tertiary Treatment

Tertiary treatment is the final stage before the wastewater can be discharged to the natural water source. In West Yellowstone, tertiary treatment is accomplished via the polishing pond (Cell C) and the recently installed ultrasonic algae controller. Per Figure A-2, flow from the partial mix aerations basins (Cells A and B) enter Cell C, where additional suspended solids and BOD are removed prior to discharge. Cell C appears to be in good repair except for a broken gate in the outlet structure from Cell C.

A.2.e. Discharge

Flow exits via an outlet structure near the southwest corner of Cell C and is dispersed into one of nine (9) IP Beds situated around Cell C. Treated water from the IP Beds is allowed to percolate and discharge into the existing groundwater. Mechanical evaporators at Cell C are also utilized for discharge. Both the IP Beds and the mechanical evaporators are in good repair.

A.2.f. Equipment Summary

Table A.2-1 below summarizes the existing condition of each of the main components of the system.

Table A.2-1: Condition of Existing Equipment and Processes

Equipment	Condition
Influent Flow Meter	Inoperable
Aeration Blowers	Exceeded Design Life
Splitter Box	Operable
Cell A	Operable Fine Bubble Aeration
Cell A & B	Damaged Liners
	Excessive Biosolids
	Inoperable Course Bubble Aeration
	Leaking Air Lines
Cell C	Operable
Outlet Structure	Damaged Gate

Equipment	Condition
IP Beds	Operable
Mechanical Evaporators	Operable
Ultrasonic Algae Controller	Operable

A.3. Design and Operating Parameters

As mentioned, the existing West Yellowstone Wastewater Treatment Plant was designed and constructed in 1993. At that time, the average daily flow was estimated to be 323,000 GPD and the system was designed for a future design flow based on a 20-year projection. The 1993 design was not governed by any regulatory compliance measures, including no discharge permit, no discharge limits, no monitoring requirements, and no reporting requirements. Approval of the design was based solely on operating the plant within the design parameters. Table A.3-1 below summarizes the original design characteristics of the existing WWTP.

Table A.3-1: Existing West Yellowstone WWTP Design Characteristics

<table>
<tr><th colspan="2">Parameter</th><th>1993 Value</th><th>Design Value</th></tr>
<tr><td rowspan="2">Population</td><td>Peak Summer (persons)</td><td>7,436</td><td>10,076</td></tr>
<tr><td>Average Annual (persons)</td><td>5,853</td><td>7,950</td></tr>
<tr><td rowspan="2">Flow</td><td>Average Daily Flow (gpd)</td><td>323,000</td><td>439,000</td></tr>
<tr><td>Peak Hour Flow (gpm)</td><td>675</td><td>920</td></tr>
<tr><td rowspan="3">Lagoon Process Volume</td><td>Cell A (MG)</td><td>NA</td><td>5.71</td></tr>
<tr><td>Cell B (MG)</td><td>NA</td><td>5.36</td></tr>
<tr><td>Cell C (MG)</td><td>NA</td><td>11</td></tr>
<tr><td rowspan="2">Influent Characteristics</td><td>BOD (lb/day)</td><td>590</td><td>800</td></tr>
<tr><td>TSS (lb/day)</td><td>400</td><td>545</td></tr>
<tr><td rowspan="4">Design Effluent Characteristics</td><td>BOD Removal (%)</td><td>NA</td><td>85</td></tr>
<tr><td>TSS Removal (%)</td><td>NA</td><td>85</td></tr>
<tr><td>Ammonia Removal (%)</td><td>NA</td><td>None</td></tr>
<tr><td>Total Nitrogen Removal (%)</td><td>NA</td><td>None</td></tr>
</table>

In 2017, based on coordination with DEQ, the Town of West Yellowstone submitted an application for a discharge permit, the first in the plant's history. In 2018, DEQ issued the Town a discharge permit

(Permit No. MTX000244) to discharge from the WWTP thru IP Beds to Class I groundwater. The permit was issued on July 1, 2018 and expires on June 30, 2023. See Appendix B for a copy of that permit. The only discharge limit listed on the permit is a Total Nitrogen limit. However, in the permit fact sheet from DEQ (also included in Appendix B), additional requirements were set forth including effluent monitoring, quarterly reporting, and flow limits. The discharge and flow limits are summarized in Table A.3-2 below.

Table A.3-2: West Yellowstone WWTP Permit Requirements

Parameter	Limit
Total Nitrogen Limit (lb/day)	314
Average Daily Design Flow (gpd)	439,000
Daily Maximum Design Flow (gpd)	650,000

Note that the Average Daily Design Flow designated by the permit is equivalent to the design flow projected for the original 1993 design. Based on recent flow data collected by the Town, the average daily flow rate for 2019 is approximately 600,000 GPD, which is almost 40% higher than the design flow. Therefore, the existing system is operating above its design capacity, outside of the permit limits, and beyond its design life. Note that the plant is, however, operating within the current Total Nitrogen Limit as set forth in the permit. See future sections for additional discussion.

A.4. Summary of Existing Condition Deficiencies

Based on evaluation of the existing system, the following items are deficient and causing permitting violations. These items are categorized into two categories: operational deficiencies and design deficiencies. The operational deficiencies can be mitigated for with appropriate operation and maintenance measures. The design deficiencies are inherent in the original basis of design and mitigation will require increase in treatment capacity and addition of processes specific to the permitted constituents. The deficiencies are as follows:

Operational Deficiencies:

- Non-functional Influent Flow Meter
- Damaged Pond Liners
- Excess Biosolids Build-up
- Non-functional Course Bubble Aeration
- Transfer Structure Damage

Design Deficiencies:

- Insufficient Average Day Capacity
- Insufficient Maximum Day Capacity
- Insufficient Nitrogen Removal

A.5. Summary of Previous Planning Documents

The Town of West Yellowstone has not completed a Facility Planning Study since the early 90's, prior to construction of the current WWTP. The Town has a current Capital Improvement Plan for Fiscal Years 2020 thru 2024 that identifies prioritized sewer system improvements. A copy of the *2019-2020 Capital Improvement Plan* is included in Appendix C for reference. No other relevant wastewater studies have been performed for the Town.

B. PLANNING AND SERVICE AREA

B.1. Existing Planning Area

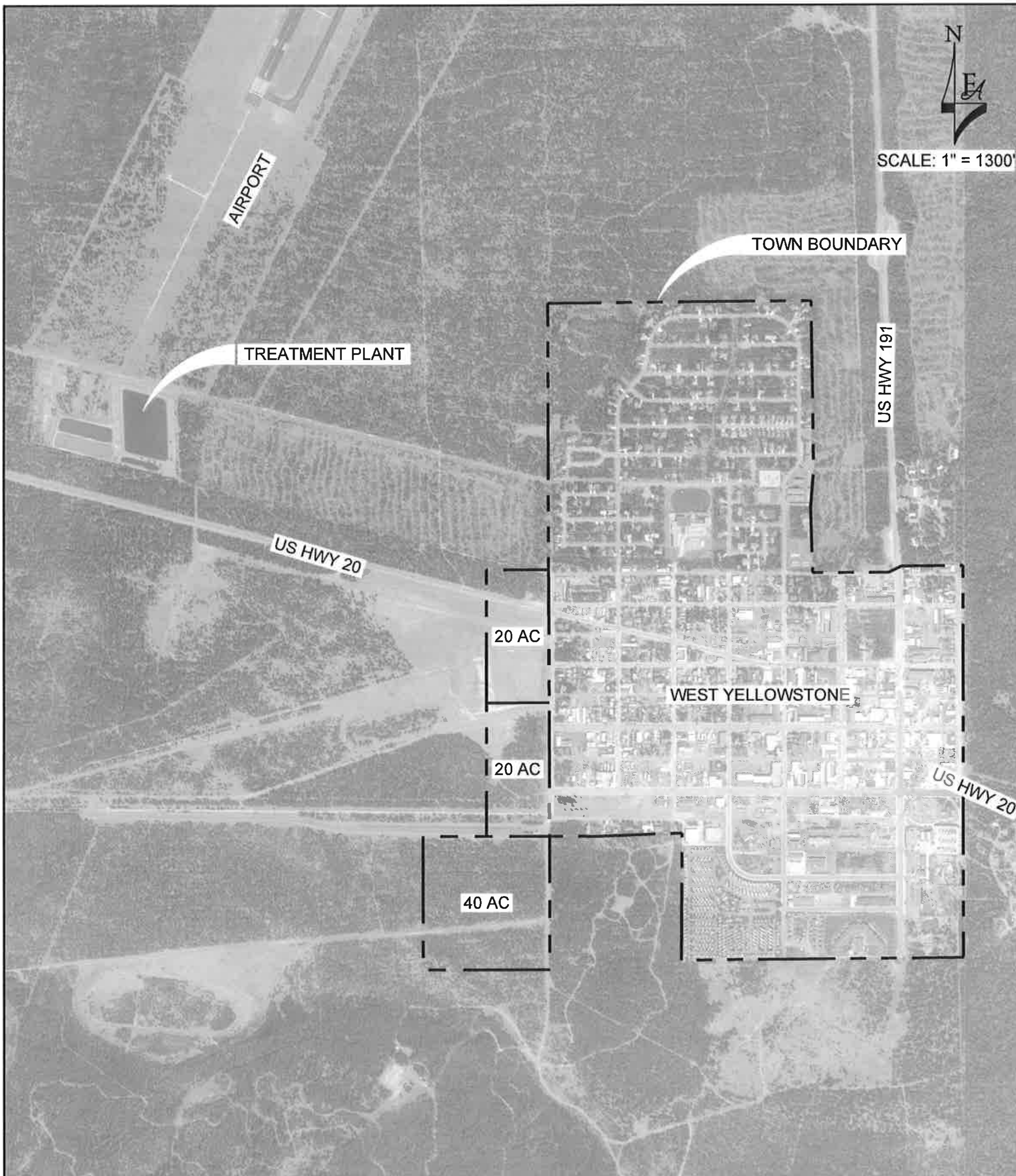
The West Yellowstone WWTP services the area within the Town limits, including the Madison Addition. Note that the Town is bordered by Federal Lands, including National Park and Forest Service land, in all directions. However, there are three parcels to the east totaling 80-acres that have recently been deeded to the Town of West Yellowstone by the Forest Service and there is the potential for future growth there. See Figure B-1 for reference to the planning boundary including the additional parcels.

B.1.a. Unserved Developed Areas

Outside of the West Yellowstone boundary, sewer service is provided by onsite septic systems. There are not any areas immediately adjacent to the community with sufficient concentration of homes or businesses to make extending sewer service feasible at this time.

B.2. Future Planning Area

As mentioned, the majority of land bordering the West Yellowstone town boundary is Federally owned. However, the opportunity exists for the Town of West Yellowstone to get deeded portions of the ground. However, due to the unpredictability of that land transfer taking place, and for the purposes of this study, the future planning area is not anticipated to extend outside of the planning boundary identified on Figure B-1.



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WEST YELLOWSTONE WWTP

FIGURE B-1

PLANNING BOUNDARY

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C. POPULATION PROJECTION AND PLANNING PERIOD

C.1. Planning Period

The planning period for projects of this scale is typically 20 years, an interval based on the terms of the financing arrangements for municipal infrastructure projects and the approximate design life of major equipment components. In accordance with DEQ standards, a 20-year planning period has been used for the design of this project and projections have been made to the year 2039.

C.2. Population Projection

The 2010 U.S. Census reports a population for the Town of West Yellowstone of 1,271 people with an average household size of 2.06 persons/household. Note that this census data is 10 years old and we are currently in a census year. Therefore, the population data is somewhat obsolete as significant growth has likely occurred in the past 10 years. Therefore, the projections utilized in the study are based on flow data collected by the Town over the past several years. These projections are reported in the following section of this report.

D. HYDRAULIC CAPACITY

D.1. Flow Definitions and Identification

Flows for the design year (2039) have been projected and will be used for the basis for design for the future WWTP. Projections are based on actual flow data collected by the Town over the past several years, as well as known pending growth and typical growth rates. Note that due to the WWTP currently operating beyond its design capacity, the Town has been hesitant to approve new development. In fact, the Town currently has applications for developments within the planning boundary; however, they have had to put a moratorium on approval of additional sewer service agreements until an evaluation of the treatment system is complete and the Town is better equipped with the data needed to allow for responsible growth.

Several flow scenarios must be evaluated to determine the worst-case scenario and ensure the design is adequate for the future flows. DEQ has outlined the design flows that must be identified as part of a new design. The design flows are summarized below and have been evaluated as follows:

D.1.a. Design Average Flow

The design average flow is the average of the daily volumes to be received for a continuous 12-month period expressed as a volume per unit time. However, the design average flow for facilities having critical seasonal high hydraulic loading periods must be based on the daily average flow during each distinct seasonal period with the largest value used for design purposes, as stated in Circular DEQ-2 Section 11.241.a. West Yellowstone is a tourist town, with a large population and flow influx happening during the summer months, specifically in the 3rd quarter. Therefore, the design average flow has been determined based on the daily average flow during the 3rd quarter.

In order to project the design average flow out 20 years, historical growth rates were evaluated from 1993 to 2019. The historical growth rate for that period was approximately 1.1%. However, it must be considered that additional growth, especially within the last several years, has likely been stunted based on the fact that the WWTF has been functioning at or above capacity and a moratorium was placed on development. Therefore, we also looked at a typical growth rate of 2% projected out 20 years. What neither of these analyses takes into consideration is the growth spurt that will likely occur over the next 5 years when the moratorium on development is lifted. The Town currently has several known developments requesting permits; however, the Town is postponing granting permits until improvements are in place to accommodate additional wastewater flows. However, when additional capacity becomes available and permits are granted, it is likely that there will be a spike in growth in the next 5 years, and then it is assumed that growth will continue at the average 2% growth rate until 2039. See Figure D-1 for an illustration of the growth projection determination. Flow values are presented in Table D.1-1.

D.1.b. Design Maximum Day Flow

The design maximum day flow is the largest volume of flow to be received during a continuous 24-hour period expressed as a volume per unit time. The Maximum Day Flow for the last 4 years was determined using data collected. An average of the maximum day flow for each of the last 4 years was determined as the current Design Maximum Day Flow. The projected Design Maximum Day Flow was determined using the same growth factor used in the Design Average Flow. See Figure D-2 for an illustration of Design Maximum Day Flow. Flow values are presented in Table D.1-1.

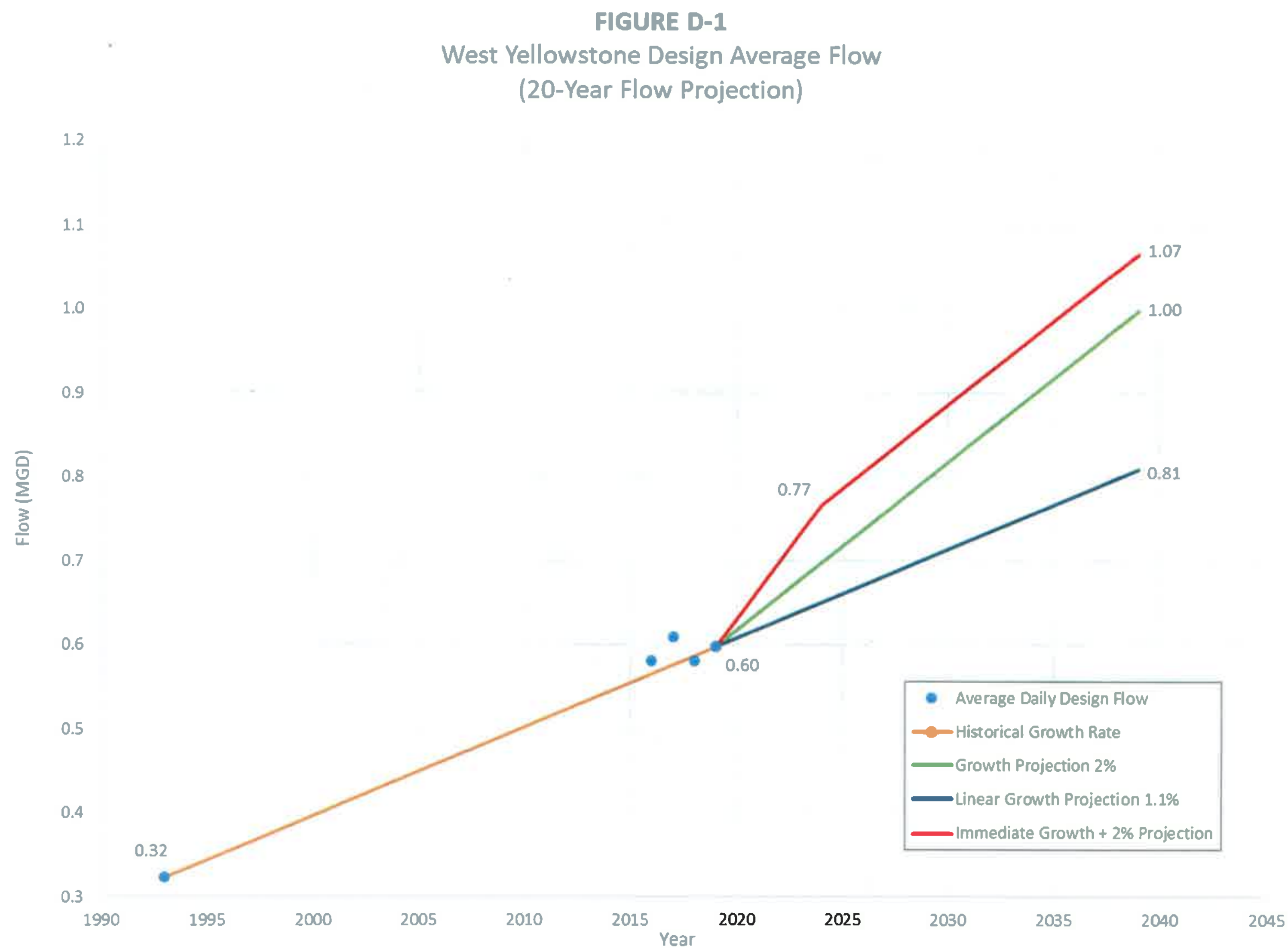

Figure D-1: West Yellowstone Design Average Flow (20-Year Flow Projection)

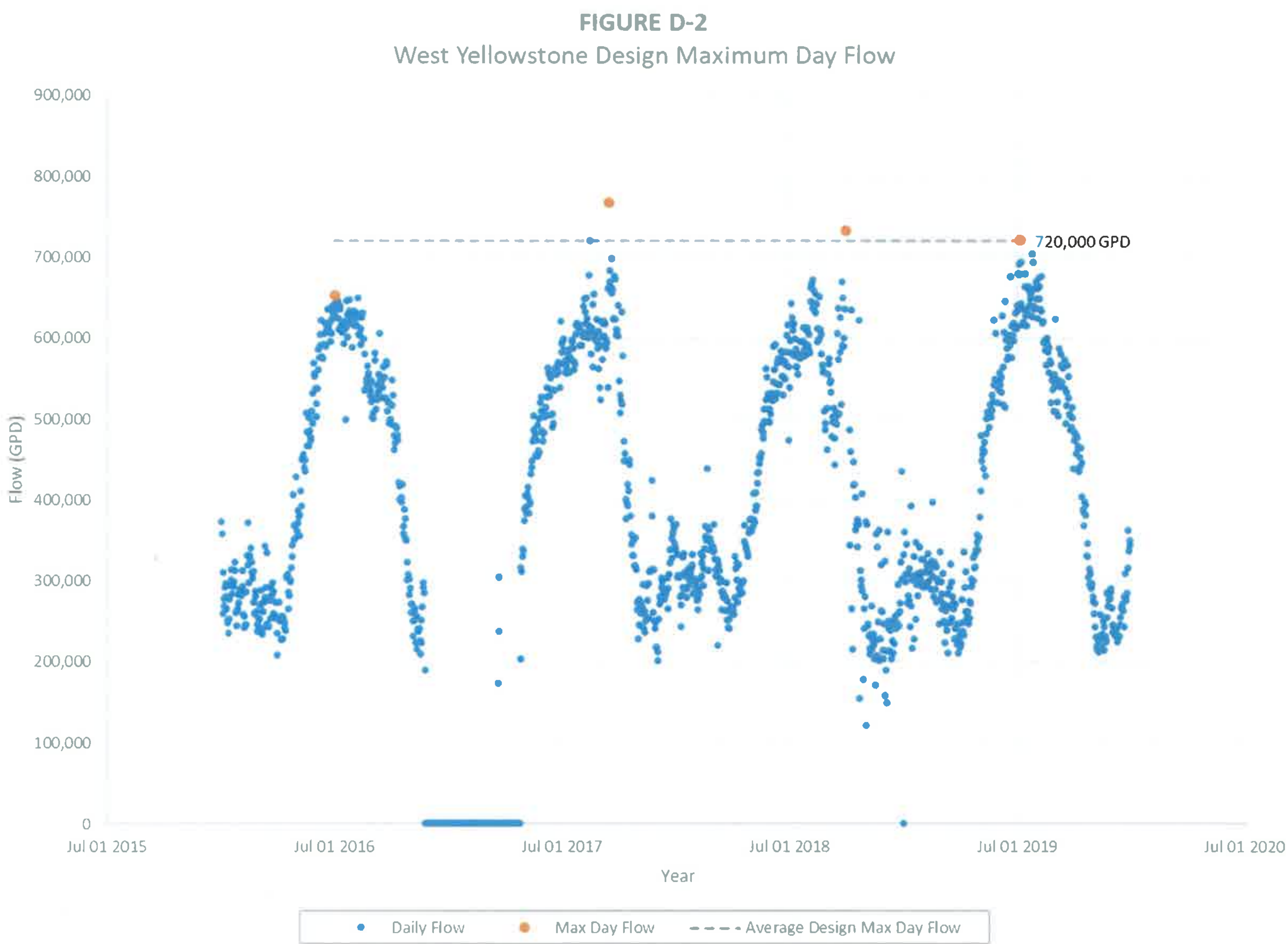

Figure D-2: West Yellowstone Design Maximum Day Flow

D.1.c. Design Peak Hourly Flow

The design peak hourly flow is the largest volume of flow to be received during a one-hour period expressed as a volume per unit time. This value was determined based on guidance set forth in the Recommended Standards for Wastewater Facilities, 2014 Edition, commonly referred to as the 10-States Standards. See Appendix D for reference to Figure 1 used to estimate the Peak Hourly Flow for the 2019, the projected 2039, and the future design flows. Note that this calculation is based off of population that was back-calculated utilizing the average flow per household determined using data collected by Forsgren throughout Summer 2019, as well as U.S. Census Bureau data outlining the average household size for the Town of West Yellowstone. This referenced data is also included in Appendix D. Flow values are presented in Table D.1-1.

D.1.d. Design Peak Instantaneous Flow

The design peak instantaneous flow is the highest recorded flow rate occurring for a period consistent with the recording equipment. Due to the larger volumes being treated, the instantaneous flow is not as critical as total volume since total volume governs the WWTP design. However, the influent lift stations that pump flow to the WWTP must be adequately sized to convey the peak flows. Therefore, the combined capacity of the influent lift stations has been indicated on the design peak instantaneous flow row in Table D.1-1 below. Note that the current lift stations can convey the current flows. However, future upgrades to the lift stations will be required to convey future increases in flow.

D.1.e. Design Maximum Month Flow

The design maximum month flow is the average daily flow received during the maximum calendar month, or 30 consecutive days, (whichever is greater) expressed as a volume per unit time. The maximum month flow for the last 4 years was determined using data collected. An average of the maximum month flow for each of the last 4 years was determined as the current Design Maximum Month Flow. The projected Design Maximum Month Flow was determined using the same growth factor used in the Design Average Flow. See Figure D-3 for an illustration of Design Maximum Month Flow. Flow values are presented in Table D.1-1.

Table D.1-1: West Yellowstone WWTP Design Flows

Parameter	Current Design	2019 Data	2039 Projected	Future Design
Design Average Flow (gpd)	439,000	600,000	1,070,000	1,250,000
Design Maximum Day Flow (gpd)	650,000	720,000	1,284,000	1,500,000
Design Peak Hour Flow (gpd)	920,000	1,800,000	3,100,000	3,400,000
Design Peak Instantaneous Flow (gpd)	NA	2,250,000	3,100,000	3,400,000
Design Maximum Month Flow (gpd)	NA	640,000	1,141,000	1,333,000

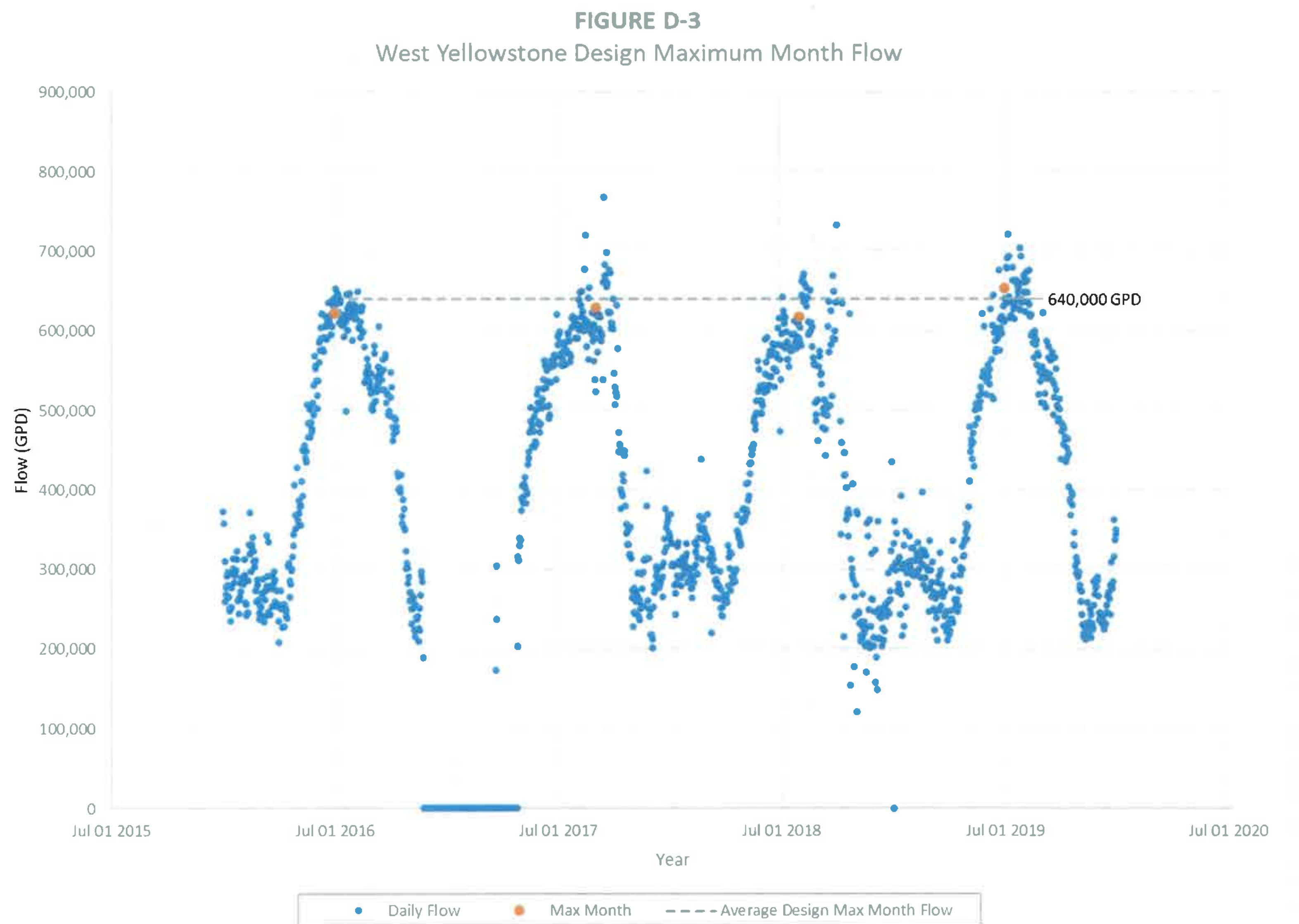

Figure D-3: West Yellowstone Design Maximum Month Flow

D.1.a. Future Design

Note that Table D.1-1 shows a column of future design values. It is reasonable to assume a factor of safety in the projected design values to account for possible fluctuations in projected populations and/or to allow for a window for additional study and design time after the 20-year design life has been met. Therefore, the Town has elected to design for a design average flow of 1.25 MGD and has adjusted the other design flow values accordingly as represented in the "Future Design" column of Table D.1-1.

D.2. Hydraulic Capacity for WWTP to Serve Existing Collection System

The existing WWTP has insufficient capacity to meet the design flows established herein. The system is currently operating outside the design parameters and is in violation of the flow requirements set forth in the DEQ permit.

D.3. Hydraulic Capacity for WWTP to Serve New Collection Systems

Since the WWTP has insufficient hydraulic capacity to serve the existing collection system, there is no capacity for the system to serve new service. This is furthered evidenced by the present moratorium on development.

D.4. Combined Sewer Interceptors

Inasmuch as the Town is aware, there are not storm drains connected into the municipal wastewater collection system.

E. ORGANIC/NUTRIENT CAPACITY

E.1. Organic Load Definitions and Identification

The organic influent characteristics for the design year (2039) have been projected and will be used for the basis for design for the future WWTP. Projections are based on actual influent flow data collected by the Town over the past several years, as well as known pending growth and typical growth rates. See Appendix E for influent flow data.

E.1.a. Biochemical Oxygen Demand

The 5-day Biochemical Oxygen Demand (BOD5) is defined as the amount of oxygen required to stabilize biodegradable organic matter under aerobic conditions within a five-day period in accordance with "Standard Methods for the Examination of Water and Wastewater", latest edition. Total 5-day Biochemical Oxygen Demand (TBOD5) is equivalent to BOD5 and is sometimes used in order to differentiate carbonaceous plus nitrogenous oxygen demand from strictly carbonaceous oxygen demand. The carbonaceous 5-day Biochemical Oxygen Demand (CBOD5) is defined as BOD5 less the nitrogenous oxygen demand of the wastewater. Note that the BOD information presented herein is the BOD5 and will be referred to as BOD from this point forward.

E.1.a.i. Design Average BOD

The design average BOD is generally the average of the organic load received for a continuous 12-month period for the design year expressed as weight per day. However, the design average BOD for facilities having critical seasonal high loading periods must be based on the daily average BOD during the seasonal period. Therefore, due to the high rates of tourism and the influx of flow in the summer months, the design average BOD is based off the loadings in the 3rd quarter.

The design peak hourly BOD is the largest amount of organic load to be received during a one-hour period expressed as weight per day. Figure E-1 shows influent BOD concentrations for West Yellowstone WWTP wastewater from May 2018 to February 2020. Note that data collection on the influent has been very sporadic up to this point. Influent data collection and testing will continue monthly from now until design completion in order to properly characterize the influent wastewater and in turn, adequately design the selected treatment alternative. This information comes from composite sampling conducted on the influent prior to entering the treatment system. The data appears to show a recent low of 180 mg/L and highs in Summer 2018 exceeding 300 mg/L. The design average influent BOD concentration is calculated for the 3rd quarter in 2018, the only quarter in the collection period to have 3 consecutive months of data. See Appendix E for a summary of the data. Utilizing the current 2019 and the future design average flows summarized in Table D.1-1 above, the design average BOD load is calculated in pounds per day. See Table E.1-1 below for a summary of the BOD design values.

E.1.a.ii. Design Maximum BOD

The design maximum BOD is the largest amount of organic load to be received during a continuous 24-hour period expressed as weight per day. Utilizing the maximum BOD concentration of 325 mg/L from the influent sample collected in June 2018 and the current 2019 and the future design maximum flows summarized in Table D.1-1 above, the design maximum BOD load is calculated in pounds per day. See Table E.1-1 below for a summary of the BOD design values.

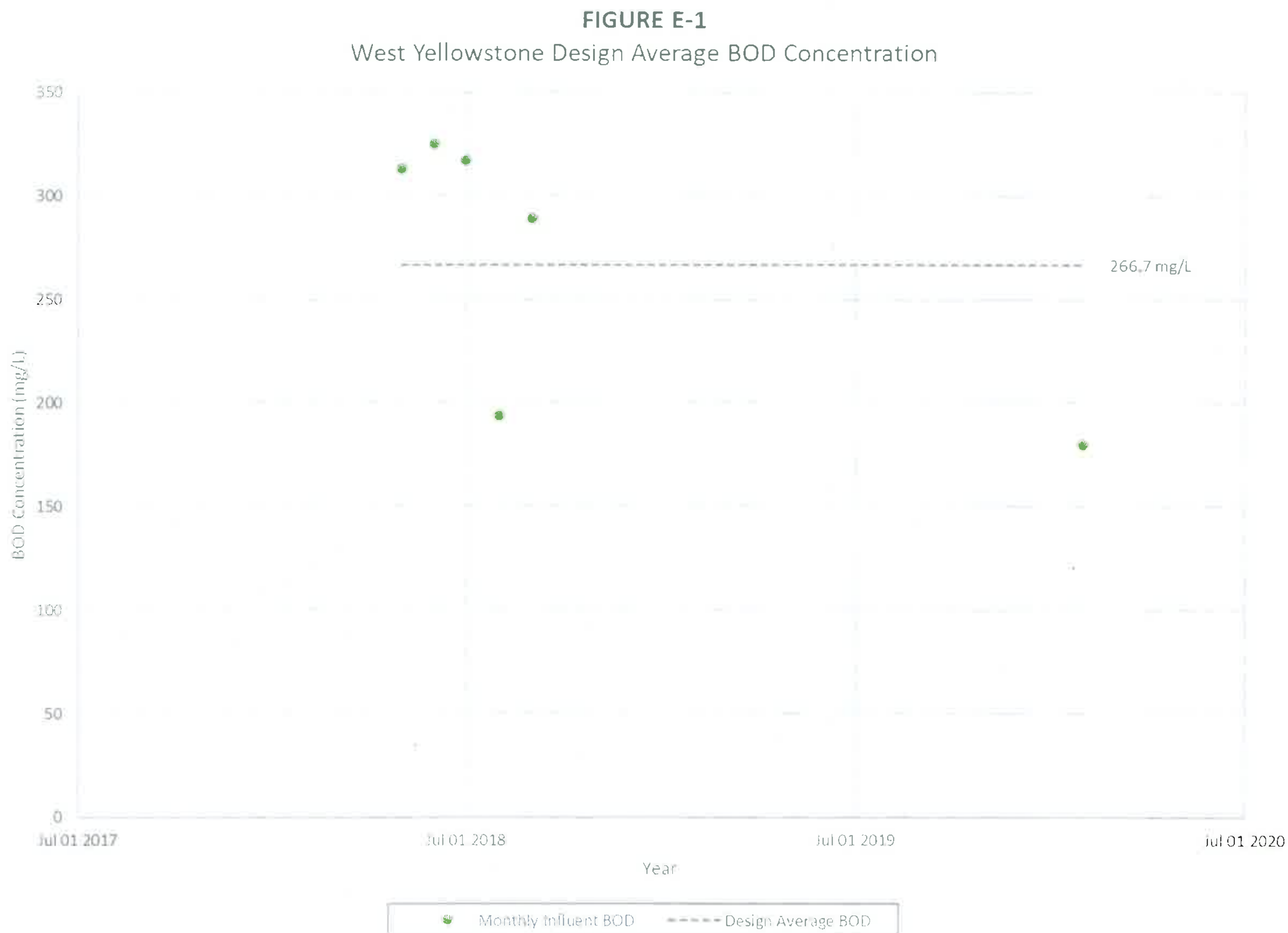

Figure E-1: Design Average BOD Concentration

E.1.a.iii. Design Peak Hourly BOD

The design peak hourly BOD is the largest amount of organic load to be received during a one-hour period expressed as weight per day. Utilizing the maximum BOD concentration of 325 mg/L from the influent sample collected in June 2018 and the current 2019 and the future design peak hour flows summarized in Table D.1-1 above, the design peak hourly BOD load is calculated in pounds per day. See Table E.1-1 below for a summary of the BOD design values.

Table E.1-1: West Yellowstone Design BOD

Parameter	Current Design	2019 Data	Future Design
Design Average BOD (lb/day)	800	1,334	2,780
Design Maximum BOD (lb/day)	1,762	1,952	4,065
Design Peak Hourly BOD (lb/day)	2,494	4,879	9,216

E.1.b. Total Nitrogen

Total nitrogen is the sum of organic nitrogen, ammonia, nitrite and nitrate (all expressed as N). Analytically, organic nitrogen and ammonia are typically reported as Total Kjeldahl Nitrogen (TKN). See Table E.1-2 below for a summary of the design total nitrogen determined with this study.

E.1.b.i. Design Average Total Nitrogen

The design average total nitrogen loading is generally the average of the influent nitrogen load received for a continuous 12-month period for the design year expressed as weight per day. However, the design total nitrogen value for facilities having critical seasonal high loading periods must be based on the daily average influent total nitrogen load during the seasonal period. Therefore, due to the high rates of tourism and the influx of flow in the summer months, the design average total nitrogen load is based off the influent concentrations in the 3rd quarter.

Figure E-2 shows influent Total N concentrations for West Yellowstone WWTP wastewater from May 2018 to February 2020. Note that data collection on the influent has been very sporadic up to this point. Influent data collection and testing will continue monthly from now until design completion in order to properly characterize the influent wastewater and in turn, adequately design the selected treatment alternative. This information comes from grab sampling conducted on the influent prior to entering the treatment system. The data appears to show recent lows of 20-30 mg/L and highs in Summer 2018 exceeding 100 mg/L. The design average influent Total N concentration is calculated for the 3rd quarter in 2018, the only quarter in the collection period to have 3 consecutive months of data. The design average Total N concentration is determined to be 77.4 mg/L. Utilizing the current 2019 and the future design average flows summarized in Table D.1-1 above, the design average Total N load is calculated in pounds per day. See Table E.1-2 below for a summary of the Total N design values.

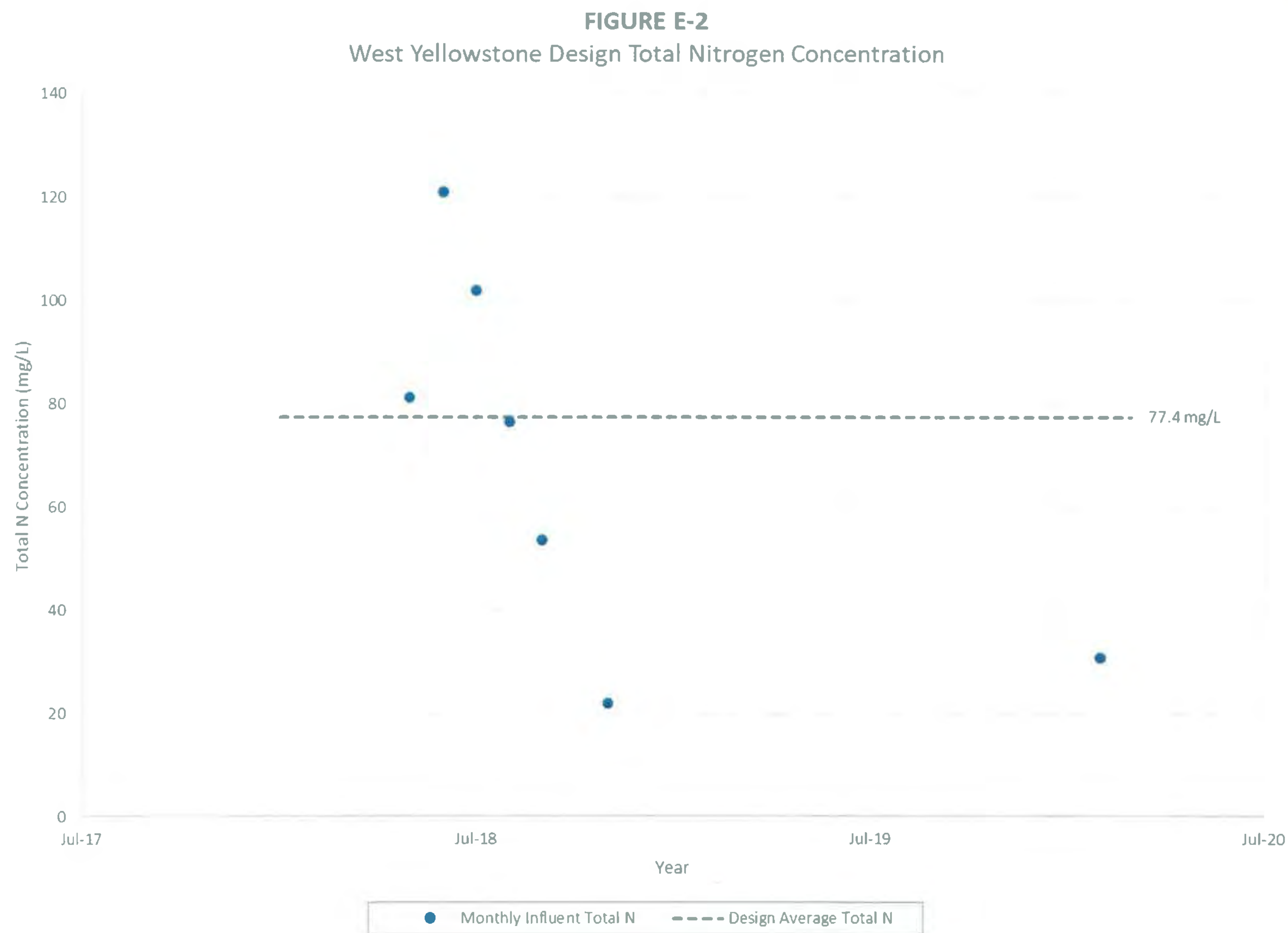

Figure E-2: Design Average Total Nitrogen Concentration

E.1.b.ii. Design Diurnal Peak TKN

The design diurnal peak TKN is the largest amount of TKN load to be received during a continuous 24-hour period expressed as weight per day. Since data concerning TKN variation is not available, a diurnal peak TKN load (lbs/day) of 2.0 times the average load will be assumed per guidance set forth by DEQ. Note that TKN is not currently regulated by the Town's discharge permit and the likelihood of it becoming a discharge limit is low.

Table E.1-2: West Yellowstone Design Total Nitrogen

Parameter	Current Design	2019 Data	Future Design
Design Average Total Nitrogen (lb/day)	NA	387	807
Design Diurnal Peak TKN (lb/day)	NA	774	1,614

E.1.c. Total Phosphorus

Total phosphorus includes all orthophosphates and condensed phosphates, dissolved and particulate, organic and inorganic.

E.1.c.i. Design Average Total Phosphorus

The design average total phosphorus loading is generally the average of the phosphorus load received for a continuous 12-month period for the design year expressed as weight per day. Note that the current permit does not have phosphorus limits. Furthermore, based on review of similar permits in the State that discharge to Class I groundwater, it is highly unlikely that a phosphorus limit will be issued. However, the design average total phosphorus has been reported in Table E.1-3 for informational purposes.

Figure E-3 shows influent Total P concentrations for West Yellowstone WWTP wastewater from May 2018 to February 2020. Note that data collection on the influent has been very sporadic up to this point. Influent data collection and testing will continue monthly from now until design completion in order to properly characterize the influent wastewater and in turn, adequately design the selected treatment alternative. This information comes from composite sampling conducted on the influent prior to entering the treatment system. The data appears to show recent lows of 3-5 mg/L and highs in Summer 2018 exceeding 10 mg/L. The design average influent Total P concentration is calculated for the 3rd quarter in 2018, the only quarter in the collection period to have 3 consecutive months of data. The design average Total P concentration is determined to be 6.0 mg/L. Utilizing the current 2019 and future design average flows summarized in Table D.1-1 above, the design average Total P load is calculated in pounds per day. See Table E.1-3 below for a summary of the Total P design values.

Table E.1-3: West Yellowstone Design Total Phosphorus

Parameter	Current Design	2019 Data	2039 Design
Design Average Total Phosphorus (lb/day)	NA	30	63

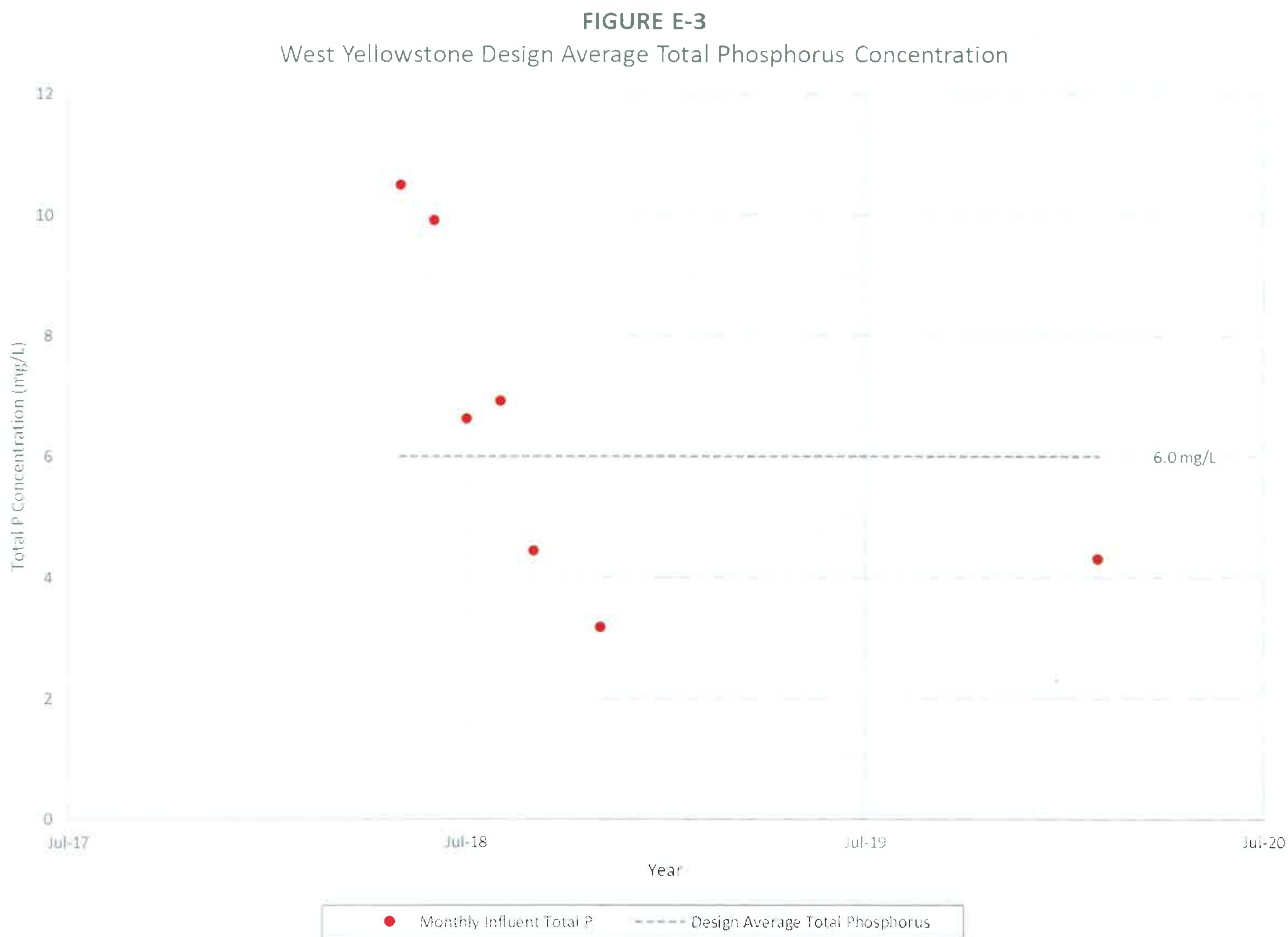

Figure E-3: Design Average Total Phosphorus Concentration

E.2. Design of Organic Capacity of WWTP to Serve Existing Collection System

The existing WWTP is operating outside the original average design flow and therefore, accepting higher levels of BOD than the plant was originally designed for. Effluent BOD data is available and has been summarized in Figure E-4. We can see that the current system is not adequately removing BOD to the industry standard of 30 mg/L in the effluent stream.

Furthermore, the existing WWTP does not have the specific unit processes to remove Total Nitrogen. However, due to the inefficiencies of a partial mix aerated lagoon system, some nitrogen removal does occur. Reliable nitrogen removal for an aerated lagoon system is difficult to predict, but an anecdotal estimate of 20% reduction generally provides a reasonable estimate and is consistent with the EPA's publication entitled Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers, and Managers. Although the original design did not anticipate the need for Total Nitrogen removal, an evaluation of the performance of the existing lagoon shows approximately 20% removal of nitrogen. The recent permit limit from DEQ of 314 lb/day of Total Nitrogen requires less than the 20% removal rate. Therefore, the existing facility is meeting the current limit. See Figure E-5 for reference.

E.3. Design of Organic Capacity of WWTP to Serve New Collection Systems

The existing WWTP is operating beyond its limit for handling BOD and is therefore inadequate to serve additional future connections.

Furthermore, as demonstrated in Figure E-6, the existing WWTP will only be able to handle the growing Total Nitrogen loadings for approximately 5-7 years, at which time the increased flow and increased loading will required an nitrogen removal rate greater than the 20% capability of an aerated lagoon system. At such time that the flow and loading increase, specific unit processes for efficient nitrogen removal must be incorporated. Mechanical treatment process provide the necessary nitrogen removal and therefore should be considered.

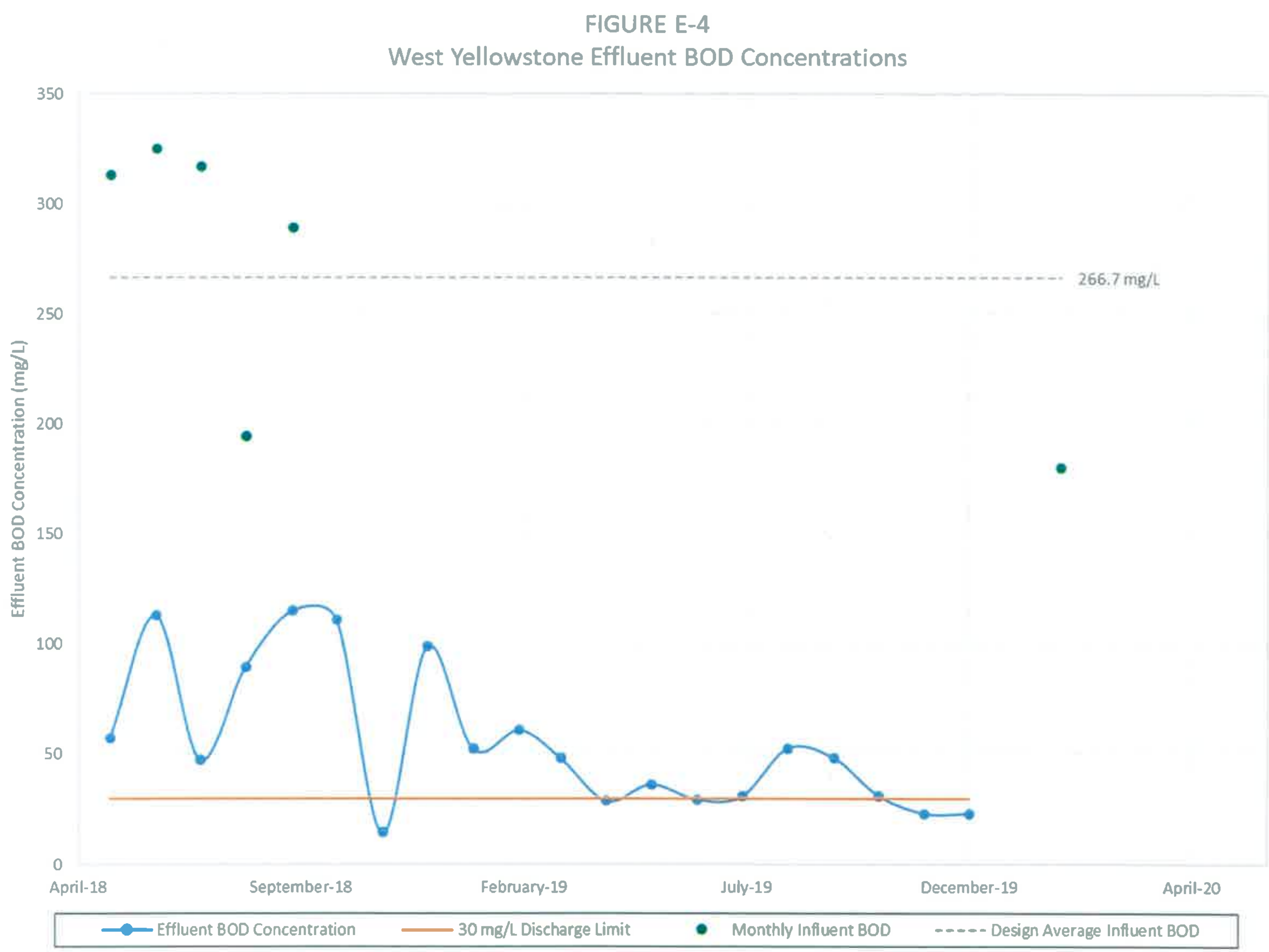

Figure E-4: West Yellowstone Effluent BOD

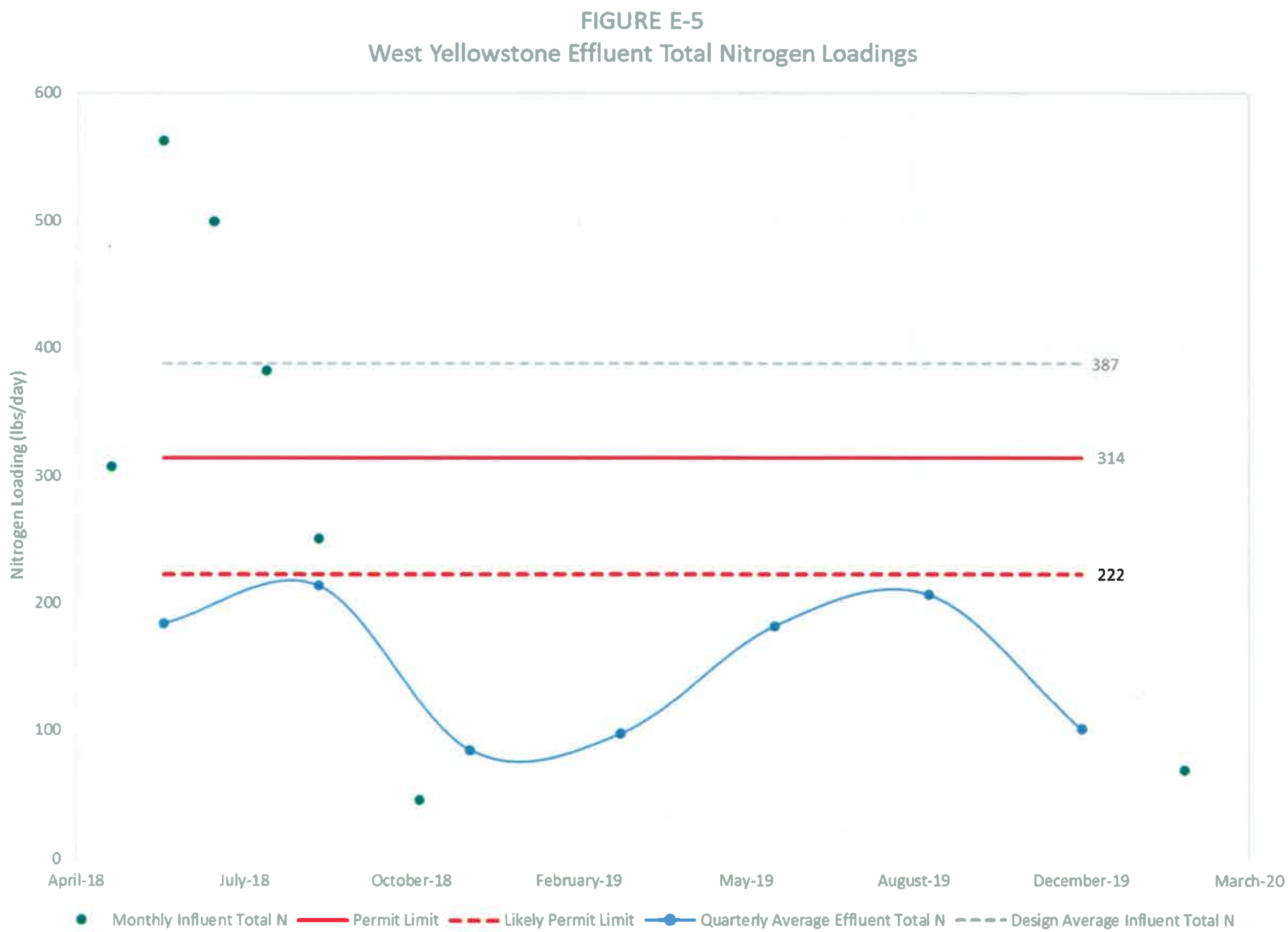

Figure E-5: West Yellowstone Effluent Total Nitrogen

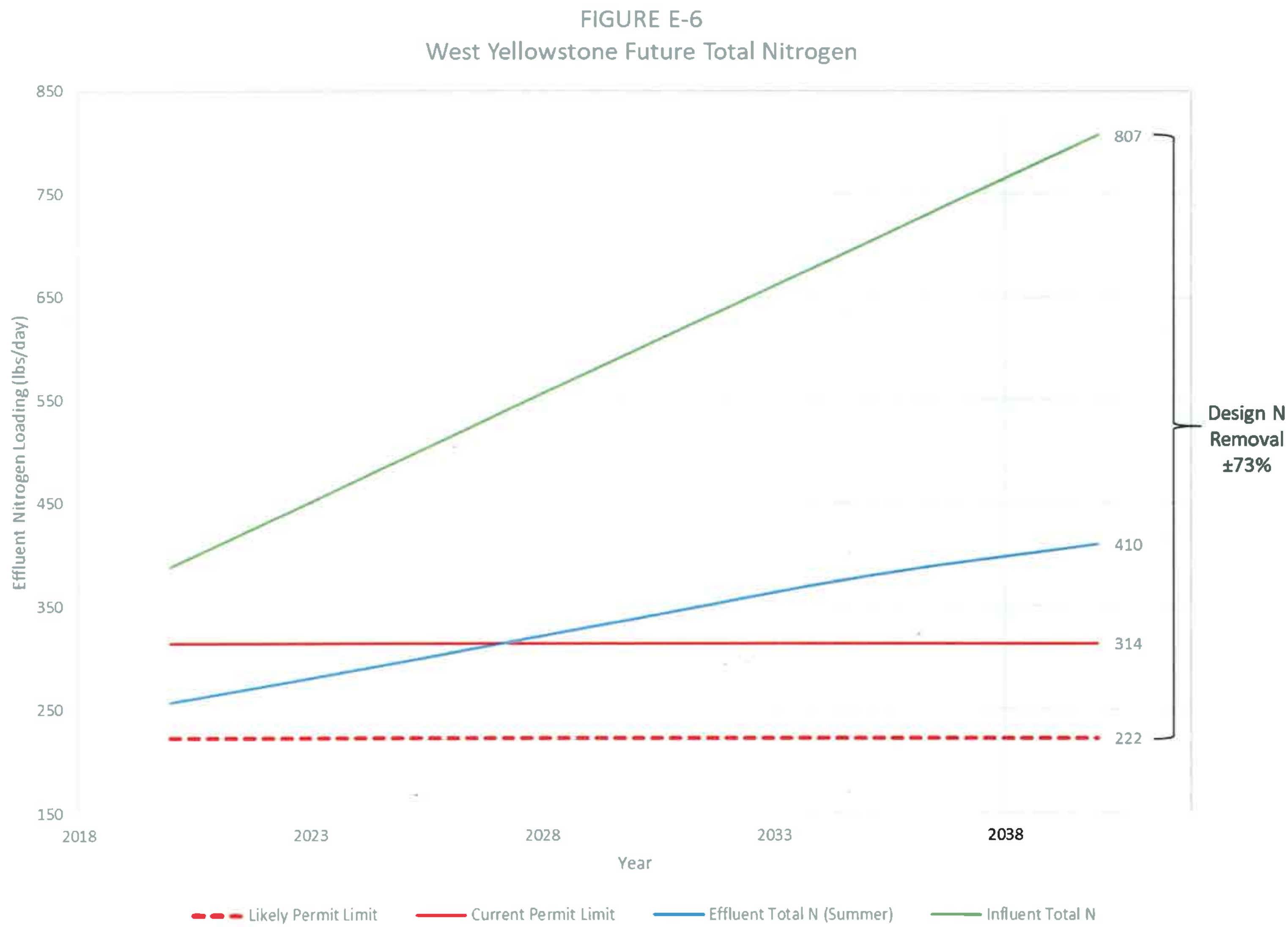

Figure E-6: West Yellowstone Future Total Nitrogen

F. WASTEWATER TREATMENT FACILITY DESIGN CAPACITY

The wastewater treatment facility design capacity for the proposed facility is defined by DEQ as the design average flow at the design average BOD for the most restrictive unit process. The design capacity is summarized in Table E.3-1 below. Note that additional design values will be required for detailed design of unit processes. See Table J.5-1 for additional design criteria for the selected alternative.

Table E.3-1: West Yellowstone WWTP Summary of Design Capacity

Parameter	Year 2019	Future Design
Design Average Flow (MGD)	0.60	1.25
Design Average BOD (lb/day)	1,334	2,780
Design Average Total Nitrogen (lb/day)	387	807

G. STATE AND FEDERAL TREATMENT STANDARDS

As discussed, the Town of West Yellowstone recently received their first DEQ permit for wastewater discharge. The 1993 design had no DEQ Permit, no discharge limits, no monitoring requirements, and no reporting requirements. The approval for that design was based on criteria in accordance with DEQ standards. Compliance with approval was simply based on operation of the facility within the design parameters. However, in 2018, the Town was issued their first DEQ discharge permit, effective July 1, 2018 to June 30, 2023. The permit identifies that the discharge will be to Class I ground water and set forth a regulated Total Nitrogen limit. It also set forth requirements for effluent monitoring, quarterly reporting, and placed limits on flow based on the 1993 design flows. Since the planning period for this document and future design is 20-years, it is judicious to evaluate what the future permit limits may likely be. Although it is impossible to definitively say what DEQ will decide, there are three possible scenarios: less stringent permit limits, permit limits stay the same, or more stringent permit limits.

G.1. Less Stringent Permit Limits

The wastewater discharge from the Town of West Yellowstone is subject to the State Nondegradation Policy which reads, "Existing uses of state waters and the level of water quality necessary to protect those uses must be maintained and protected." Simply put, DEQ cannot permit a facility that will decrease the current level of water quality in the Class I receiving waters it is discharging to. Therefore, based on State law, as well as on currents trends for water quality and permitting, it is highly unlikely that the permit limits will become less stringent than they currently are.

G.2. Permit Limits Stay the Same

As mentioned, the current permit is effective until June 30, 2023. See Table A.3-2 above for a detailed summary of the permit limits. Note that if the permit limits stay the same, the Total Nitrogen will exceed the limit in 2026 (see Figure E-6).

G.3. More Stringent Permit Limits

Although it cannot be definitively determined if permit limits will become more stringent, per discussions and interactions with DEQ staff, it is likely. For the purpose of example, DEQ sent over a sample permit from Anaconda-Deer Lodge County, which is an indicator of what the Town of West Yellowstone might expect to see on future permits. The facility is similar to West Yellowstone in that they have a treatment facility with lagoons and IP beds. However, Anaconda-Dear Lodge County also has polishing ponds with 90 days of winter storage and they also have an offsite land application component. The sample permit requires influent and effluent monitoring and sets a Total Nitrogen Limit of approximately 10 mg/L. See Appendix G for reference to the sample permit.

Further discussion with DEQ staff have revealed that DEQ has a Nondegradation Policy regarding groundwater quality. Additionally, DEQ staff has indicated that a likely interpretation of this policy specific to the West Yellowstone WWTP could be as follows:

- Previously approved design flows with associated discharge loadings to remain unchanged for Total Nitrogen.
- Future approved design flows above and beyond the previously approved design flows with associated discharge loadings limited to 10 mg/L Total Nitrogen.

Based on this likely scenario, an estimated permit limit of 222 lb/day of Nitrogen has been used for evaluation in this report. See Figure E-5 for reference. When we examine the impacts of a more stringent permit, we find that if the permit limit is decreased, the Town will be in immediate violation at the beginning of the new permit cycle. See Figure E-6 for reference.

H. INITIAL ALTERNATIVE DEVELOPMENT

Based on the information presented in the previous section, the goal of this study is to develop alternatives for addressing the system deficiencies and recommending a preferred alternative or set of alternatives. First, existing system deficiencies were identified and summarized. Then the preferred alternatives were developed to address the deficiencies. System deficiencies were evaluated to determine if they could be addressed without changes to infrastructure, but through cooperation with operation. This evaluation included the No Action Alternative. An initial screening of preliminary alternatives was then performed for each of the deficiencies identified based on screening criteria that was determined most relevant. The chosen preliminary alternative was then advance to the Final Screening of Alternatives consisting of Chapter I.

H.1. Problems and Deficiencies with the Existing Wastewater System

The principal focus regarding wastewater treatment system for West Yellowstone can be categorized into the three following components:

- Treatment Capacity: As discussed previously, the current treatment capacity is 439,000 GPD. The plant currently accepts a design average flow of approximately 600,000 GPD. Therefore, the plant has far surpassed its capacity and the Town is having to delay impending growth by placing moratoriums on approval of development plans.
- Nitrogen Removal: Based on the current wastewater flows and the current permit, the Nitrogen loading is meeting regulatory limits. However, within the next 5-7 years, the Nitrogen limit will exceed the current permit based on the approximated growth. Furthermore, if the permit limit becomes more stringent, exceedance may occur at the time of the reissuance, or in Summer 2023.
- Equipment Upgrades: Equipment in need of replacement in order to keep operating the plant, see Section A.4 Summary of Existing Condition Deficiencies for condition of the Existing System.

H.2. General Wastewater Treatment Principles

Contaminants in wastewater are removed by physical, chemical and/or biological processes. The individual methods usually are classified as physical unit, chemical unit and biological unit processes. The most cost-effective process or combination of processes for treatment can be selected only after specific treatment objectives have been established and unique conditions have been identified.

H.2.a. Physical Unit Processes

Treatment processes in which physical forces predominate are known as physical unit operations. These processes were the first to be used for wastewater treatment. Screening, mixing, flocculation, sedimentation, flotation, filtration, and gas transfer are typical physical unit operations.

H.2.b. Chemical Unit Processes

Treatment processes in which the removal or conversion of contaminants is brought about by the addition of chemicals or by fostering chemical reactions are known as chemical unit processes. Precipitation, absorption, and disinfection are the most common examples used in wastewater treatment. In chemical precipitation, treatment is accomplished by producing a chemical precipitate, which settles out of the wastewater. In most cases, the settled precipitate will contain both the constituents that may have reacted with the added chemicals and the constituents that were swept out of the wastewater as the precipitate settled. Absorption involves the removal of specific compounds from the wastewater on solid surfaces using the forces of attraction between bodies. Disinfection kills or inactivates organisms common in wastewater.

H.2.c. Biological Unit Processes

Treatment processes in which the removal of contaminants is brought about by biological activity are known as biological unit processes. Biological treatment is used primarily to remove the biodegradable organic substances (colloidal or dissolved) in wastewater. Basically, these substances are converted to gases that can escape to the atmosphere and into biological cell tissue that can be removed by settling. Biological treatment is also used to remove nutrients (nitrogen and phosphorus) in wastewater. With proper environmental control, in most cases, wastewater can be treated biologically to meet TMDL guidelines and/or discharge permit limits.

H.3. Wastewater Treatment Plant Design – Liquid Stream

The principal methods or unit operations now used in the wastewater industry for the treatment of wastewater and sludge use any one or a combination of physical, chemical, and biological processes. Typically, at a wastewater treatment facility wastewater progressively flows through a series of unit operations each designed to perform a specific treatment function resulting in properly treated effluent leaving the facility. Wastewater progressively improves in quality due to contaminant reduction as it flows through the series of operations. Any one operation by itself is not sufficient to completely treat the wastewater.

Unit operations are grouped together to provide various levels of treatment. Historically, unit operations included the term "preliminary" and/or "primary", which referred to physical unit operations; "secondary" referred to chemical and biological unit operations; and "advanced" or "tertiary' referred to combinations of all three. Additional present-day unit operations are available which may use a combination of all three processes and are titled "nutrient removal or control", "advanced wastewater treatment/wastewater reclamation", "toxic waste treatment/specific containment removal", and "sludge processing and disposal".

Table H.3-1 summarizes in general the options available of various unit operations, processes, or treatment systems that are required to treat various types of contaminants. Specific unit operations are described in the following paragraphs.

Table H.3-1: Contaminant Removal Operations, Processes and Treatment Systems

Contaminant	Unit Operation, Unit Process or Treatment System
Suspended Solids	Screening and Comminution Grit Removal Sedimentation Filtration Flotation Chemical Polymer Addition

	Coagulation/Sedimentation Natural Systems (Land Treatment)
Biodegradable Organics	Activated-Sludge Variations Fixed-Film Reactor: Trickling Filters Fixed-Film Reactor: Rotation Biological Contractors Lagoon Variations Intermittent Sand Filtration Physical-Chemical Systems Natural Systems
Volatile Organics	Air Stripping Carbon Absorption
Pathogens	Chlorination Hypochlorination Bromine Chloride Ozonation UV Radiation Natural Systems
Nitrogen	Suspended Growth Nitrification and Denitrification Variations Fixed-Film Nitrification and Denitrification Variations Ammonia Stripping Ion Exchange Breakpoint Chlorination Natural Systems
Phosphorus	Metal-Salt Addition Lime Coagulation/Sedimentation Biological Phosphorus Removal Biological-Chemical Phosphorus Removal Natural Systems
Refractory Organics	Carbon Absorption Tertiary Ozonation Natural Systems

Heavy Metals	Chemical Precipitation Ion Exchange Natural Systems
Dissolved Organic Solids	Ion Exchange Reverse Osmosis Electrodialysis

H.3.a. Preliminary Wastewater Treatment

Preliminary wastewater treatment is defined as the removal of wastewater constituents that may cause maintenance or operational problems with the treatment operations, processes and ancillary systems. Examples of preliminary operations are screening and comminution for the removal of debris and rags, grit removal for the elimination of coarse suspended matter that may cause wear or clogging of equipment, and flotation for the removal of larger quantities of oil and grease. Preliminary treatment is distinguished from industrial pretreatment, where constituents are treated at their source before discharge to the sewer system.

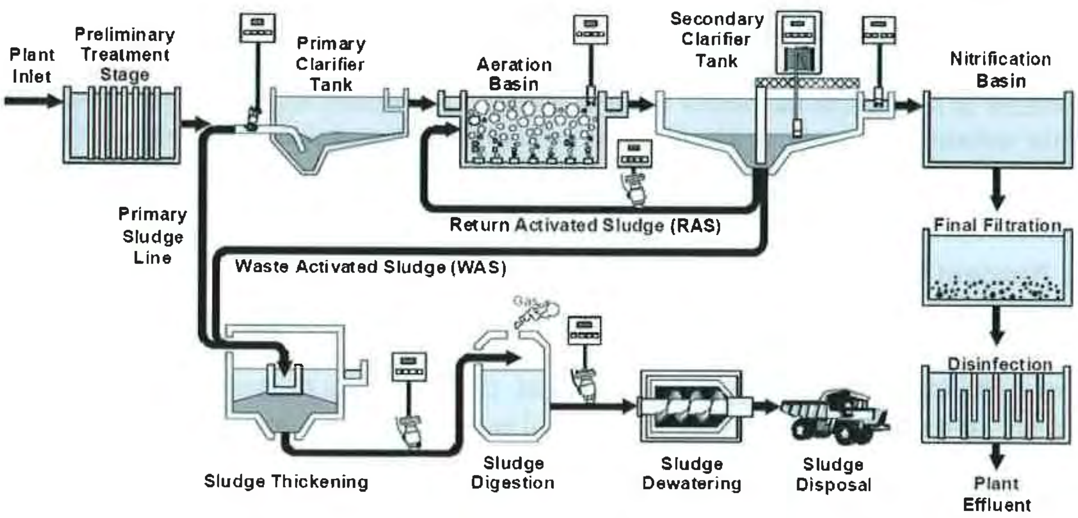

Figure H-1: Typical Wastewater Treatment Process Flow Diagram

H.3.b. Primary Wastewater Treatment

In primary treatment, a portion of the suspended solids and organic matter is removed from the wastewater. This removal is usually accomplished with physical operations such as screening, sedimentation, and flotation of solids that will settle or float, leaving only suspended solids. BOD reduction through primary treatment typically averages 40%. Therefore, the effluent from primary treatment will ordinarily contain considerable organic matter and will still have a relatively high BOD in the form of suspended and dissolved solids. The principal function of primary treatment is to be as a precursor to secondary treatment. Solids removed during primary treatment, called primary sludge, must be treated in digesters prior to disposal.

Present day technology has developed treatment methods that are a combination of secondary, nutrient removal, and advanced treatment systems, which allow bypassing altogether of the primary treatment unit operation. These methods can represent a significant cost savings by deleting the need for primary sedimentation ahead of the secondary treatment process.

H.3.c. Secondary Wastewater Treatment

Secondary treatment is directed principally toward the removal of biodegradable organics and suspended solids. Disinfection is included frequently in the definition of secondary treatment. Secondary treatment is defined as the combination of processes customarily used for the removal of these constituents and includes biological treatment by activated sludge and/or fixed-film reactors such as trickling filters and sedimentation, or lagoon systems. Secondary treatment is biological and provides bacteria and other organisms which consume suspended and dissolved organic contaminants, thereby converting contaminants into gas that is released to the atmosphere and bacteria cell tissue that is collected through sedimentation. Settled material or sludge produced from secondary treatment may be digested or disposed without digestion depending upon the methods allowed under state regulations and preferred by the system owner.

Most systems are compared to a conventional activated sludge treatment system. In conventional treatment, bacteria and other organisms, collectively called activated sludge, are mixed with raw wastewater and agitated and aerated in a basin generally termed a reactor. After sufficient detention time, the mixture of activated sludge and wastewater, called mixed liquor, flows to a separate basin where the activated sludge is subsequently separated from the treated wastewater by sedimentation and is wasted or returned to the reactor basin as needed. The treated wastewater flows over the weir of the sedimentation basin, in which separation from the activated sludge takes place. Wasting a portion of the activated sludge is necessary because the activated sludge population continually grows as a result of continuous feeding on organic contaminants inherent in the raw wastewater.

H.3.d. Nutrient Removal or Control

The removal or control of nutrients in wastewater treatment is important for several reasons. Nutrient removal or control is generally required for: (1) discharges to confined bodies of water where eutrophication may be caused or accelerated, (2) discharges to flowing streams where nitrification can tax oxygen resources or where rotted aquatic plants can flourish, and (3) recharge of groundwater that may be used indirectly for public water supplies. The nutrients of principal concern are nitrogen and phosphorus, and may be removed by biological, chemical or a combination of processes. In many cases, the nutrient removal processes are coupled with secondary treatment. For example, metal salts may be added to the aeration tank mixed liquor for the precipitation of phosphorus in the final sedimentation tanks, or biological denitrification may follow an activated sludge process that produces a nitrified effluent.

Nitrogen is removed in an activated sludge plant through a series of unit processes. BOD and ammonia are oxidized by microorganisms in the aerobic zone, a favorable location since a high level of dissolved oxygen is present from aerators. Nitrification occurs, which uses large amounts of dissolved oxygen and alkalinity, converting ammonia (NH4) to gas and nitrogen to the form of nitrates (NO3). Following nitrification, the mixed liquor, or a portion thereof, enters the anoxic basin. In the anoxic basin, preliminary treated raw wastewater and recycled activated sludge are mixed with nitrified mixed liquor. Bacteria then feed on the carbon-rich influent, using molecular oxygen from the abundant nitrate to drive metabolic reactions. Nitrate is reduced first to nitrite

(NO2), and then to nitrogen gas, which is stripped in subsequent aeration. In the process, portions of the alkalinity and oxygen consumed during nitrification are restored.

Enhanced biological phosphorus removal is achievable in an activated sludge plant with the addition of an anaerobic stage ahead of the aeration tank. The anaerobic stage promotes the growth of phosphorus removing bacteria.

H.3.e. Advanced Wastewater Treatment/Wastewater Reclamation

Advanced wastewater treatment is defined as the level of treatment required beyond conventional secondary treatment to remove constituents of concern including nutrients, toxic compounds, and small amounts of organic material and suspended solids still left in the wastewater after secondary treatment. In addition to the nutrient removal process, unit operations or processes frequently employed in advanced wastewater treatment are chemical coagulation, flocculation, and sedimentation followed by filtration and activated carbon. Less used processes include ion exchange and reverse osmosis for specific ion removal or for the reduction in dissolved solids. Advanced wastewater treatment is also used in a variety of reuse applications where a high quality of water is required such as for industrial cooling water and groundwater recharge. Some forms of natural treatment such as creating wetlands (formerly termed land treatment) may also be equivalent to advanced wastewater treatment in terms of effluent quality.

H.3.f. Toxic Waste Treatment/Specific Contaminant Removal

For industrial waste discharges to municipal collection and treatment systems, the concentrations of toxic pollutants are usually controlled by pre-treatment prior to discharge to the municipal system. In some cases, removal of toxic substances is done at the municipal treatment facilities. Many toxic substances such as heavy metals are reduced by some form of chemical-physical treatment such as chemical coagulation, flocculation, sedimentation, and filtration. Some degree of removal is also accomplished by conventional secondary treatment. Wastewater containing volatile organic constituents may be treated by air stripping or by carbon absorption. Small concentrations of specific contaminants may be removed by ion exchange.

Each entity operating a treatment facility should implement an industrial pretreatment program to assure industrial waste is treated to a minimum standard prior to discharging into the municipal collection system. This would reduce the potential of toxic pollutants disrupting the treatment processes at the municipal treatment plant. This would also force each individual industry to pay its fair share for treatment as opposed to the whole responsibility for treatment of each specific industry's waste to fall on the owner of the municipal treatment plant.

A pretreatment program should be viewed as adaptable and should be changed as needed to protect the treatment plant from changing industrial discharge. The pretreatment program should be in place before starting final design of a new wastewater treatment plant or revised before final design of a treatment plant expansion ensuring that anticipated contaminant levels can be incorporated into the final design.

In conjunction with the industrial pretreatment program the sewer use ordinance should provide for surcharges to residential and commercial users who discharge higher flows and/or higher strength wastewater (measured by BOD and Suspended Solids) than the average residential unit as a baseline. This again is a means to equitably distribute the cost of wastewater treatment to those who use the system and could be a significant income generating mechanism in the rate structure.

H.4. Wastewater Treatment Plant Design – Solids Stream

For the most part, the methods and systems reported in Table V-1 are used to treat the liquid portion of the wastewater. Of equal, if not of more importance in the overall design of treatment facilities, are the corresponding unit operations and processes or systems used to process the sludge removed from the liquid portion of the wastewater. The principal methods now in use are reported in following table.

Table H.4-1: Biosolids Processing and Disposal Methods

Processing or Disposal Function	Unit Operation, Unit Process or Treatment System
Preliminary Operations	Sludge Pumping Sludge Grinding Sludge Blending and Storage Sludge Degritting
Thickening	Gravity Thickening Flotation Thickening Centrifugation Gravity Belt Thickening Rotary Drum Thickening
Stabilization	Lime Stabilization Heat Treatment Anaerobic Digestion Aerobic Digestion Composting
Conditioning	Chemical Conditioning Heat Treatment
Disinfection	Pasteurization Long-Term Storage
Dewatering	Vacuum Filter Centrifuge Belt Press Filter Filter Press Sludge Drying Beds Lagoons

Heat Drying	Dryer Variations Multiple Effect Evaporator
Thermal Reduction	Multiple Hearth Incineration Fluidized Bed Incineration Co-Incineration with Solid Wastes Wet Air Oxidation Vertical Deep Well Reactor
Ultimate Disposal	Land Application Distribution and Marketing Landfill Lagoon Chemical Fixation

H.4.a. Ultimate Disposal - Landfill Sludge

It is likely most economical and feasible for the sludge generated from the West Yellowstone WWTP to be hauled offsite to the landfill. It is likely that a dewatering mechanism would be used to dry the sludge. Some dewatering mechanisms include a screw press, belt press, centrifuge, or dewatering can or bag. Screw press, belt press, and centrifuge all use a motor to get rid of the water, whereas a dewatering can or bag uses gravity. The power operated mechanisms are normally used for large amounts of wastewater flow and sludge, whereas a dewatering can or bag is used for smaller amounts. The amount of sludge varies on the selected treatment option but is usually around 60% of the lbs/day of BOD. The addition of a digester ahead of wasting can reduce the sludge volume by 30 to 50%. The Town will have to coordinate with the landfill to determine any specific requirements or regulations that may apply to dumping the waste; however, it is likely that once the sludge is dewatered it can be taken to the landfill.

H.5. Initial Alternatives Analysis

An initial round of alternatives were developed to outline scenarios for the Town to consider. The initial alternatives are described below.

H.5.a. "No Action" Alternative

For West Yellowstone, the no action alternative is described by continuing to operate the current lagoon system as is, making no capital improvements and no significant operational changes. As discussed previously, the current system exceeds its design flow capacity, is soon to exceed the Total Nitrogen permit limit for discharge, and has several items that are in need of repair and/or replacement. It is currently violating the DEQ permit. The No Action future condition is assumed to represent no action in terms of infrastructure improvements. Many deficiencies identified require upgrades to the infrastructure. Such improvements cannot be accomplished through modified operations. The No-Action Alternative is not recommended and will not be carried forward for detailed evaluation for all other deficiencies.

H.5.b. "Status Quo" Alternative

It is convenient to discuss improvements to the system in two categories, the first being capital improvements necessary to correct failing assets that expose the Owner to significant operation and maintenance costs or violate regulatory and or contractual obligations. For the purposes of this report these will be referred to as capital improvement projects. The second is to discuss improvements based on an asset management approach where system components are replaced or rehabilitated over time as system components surpass their useful life. For the purposes of this report these will be referred to as maintenance improvement projects.

The primary consideration for maintenance improvement projects is to provide an ongoing effort to replace or rehabilitate equipment within the system that have been determined to be in poor condition. The implementation of maintenance improvement projects is referred to as the status quo alternative. The maintenance improvement projects for this alternative include upgrading any existing equipment discussed in section B.3.i of this report that is in need of replacement in order to keep operating the facility. This includes repairing the current lagoon system, including pond liners, course bubble aeration, and removing and disposing of excess biosolids build-up. See Figure H-2 for reference to this alternative. Note that this alternative does not address the deficiencies in capacity or volume, and therefore, does not address the insufficient Total Nitrogen removal within the system.

H.5.c. Expand Lagoons

The primary considerations for the recommended capital improvement projects for the treatment system are evaluated on a need to meet the current and future DEQ discharge permit. The capital improvement project for this alternative includes expanding the existing lagoon system so that it can meet the requirements set forth in the likely DEQ discharge permit. This alternative also includes the maintenance improvements suggested in the Status Quo alternative. The proposal to expand the existing lagoon system will keep the same lagoon treatment process currently at the site but will add at least two additional lagoons to treat the projected flow. This will include adding a new aeration system to the lagoons with new blowers while using the existing blower building to house the new blowers. Due to the proximity of the lagoons to the airport, and to detour wildlife, a ball-type floating cover will be utilized. Additional unit processes will be necessary to provide reliable nitrogen removal for the increased flow and loading. See Figure H-3 for reference to this alternative.

H.5.d. Mechanical Treatment

This alternative addresses the deficiencies identified for treatment by proposing construction of a mechanical treatment plant on the existing FAA leased property. A mechanical treatment plant would allow the Town to consistently meet stringent DEQ discharge permit limitations with technology that is reliable and has a history of producing quality effluent. The treatment plant will need to be housed in a building in order to prevent freezing. The building is a large component of the cost to construct a new mechanical treatment facility. See Figure H-4 for reference to this alternative.

FORSGREN Associates Inc.

350 NORTH 2ND EAST, REXBURG, ID 83440
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WEST YELLOWSTONE WWTP

FIGURE H-2

STATUS QUO

PROJECT NO: 01-19-0046-200

DATE: MARCH 2020

FORSGREN Associates Inc.

350 NORTH 2ND EAST, REXBURG, ID 83440
PH: 208.356.9201
FAX: 208.356.0206

WEST YELLOWSTONE WWTP

FIGURE H-3

EXPAND LAGOONS

PROJECT NO:
01-19-0046-200

DATE:
MARCH 2020

FORSGREN Associates Inc.
350 NORTH 2ND EAST, REXBURG, ID 83440
PH: 208.356.9201 FAX: 208.356.0206

WEST YELLOWSTONE WWTP

FIGURE H-4

MECHANICAL TREATMENT

PROJECT NO: 01-19-0046-200

DATE: MARCH 2020

H.6. Initial Screening of Alternatives

Initial Screening Criteria

1. Owner Preference
2. Cost
3. Schedule
4. Regulatory Compliance
5. Process Flexibility/Expandability
6. Environmental Clearance
7. Land Acquisition

Treatment plant design will be one of the most critical steps in developing the wastewater system for West Yellowstone WWTP. Both theoretical knowledge and practical experience are necessary in the selection and analysis of the treatment processes and unit operations that the wastewater will flow through. Practical experience and convenient operations and maintenance are especially important in the design and layout of the physical facilities and their appurtenances and in the preparation of plans and specifications.

Major elements involved in the selection of the type of treatment and specific design of process flow are: (1) Owner preference, (2) cost considerations, (3) schedule considerations, (4) regulatory compliance, (5) process flexibility and expandability to accommodate variable loading and possible change in permit limits, (6) need for environmental clearance, and (7) need to acquire additional land. Much of the input to evaluate these issues comes from the Town staff as well as from tours of existing treatment works and interviews with manufacturers and operators of plants similar to those proposed.

H.6.a. Owner Preference

A factor of highest priority in the selection of a treatment process is the needs and desires of West Yellowstone. It is recognized that limitations of cost and the ability to pay for the project are essential concerns for the project to be viable. These factors will therefore be forefront in the planning process. It is likely that current staff will be required to operate a new wastewater treatment plant and training for the new equipment should be expected. Process preferences are expected to be technologically advanced yet reliable. Only proven processes or equipment are recommended, and specification of unproved equipment and experimenting will be avoided.

Over the course of the planning period, the consulting team met with the staff of West Yellowstone on multiple occasions, often discussing the unique needs of the Town with staff well-qualified to offer opinions regarding advantages and drawbacks of various treatment systems. The current Wastewater Supervisor, Greg Johnson, is a certified Class 1B, Class 2E, Class 3A and Class 3C wastewater treatment operator and has a long-standing relationship with the Town.

The findings and recommendations of the consultant team suggest a preference for West Yellowstone to upgrade to a mechanical treatment plant to accommodate the fluctuations in wastewater flows and strengths. It is presumed that upgrading to a mechanical plant will better allow for growth within the sewer service area. Appellate to this opinion is the stance that constructing a mechanical treatment plant must be cost competitive to that of upgrading the current lagoon system, evaluated on a net present value basis over the life the facility. If a mechanical plant is established as cost competitive, construction of a mechanical treatment plant will be the preferred alternative.

H.6.b. Cost

The selected treatment system must be affordable in comparison to expanding the current lagoon system. West Yellowstone has a fixed and limited budget for design and construction of the wastewater system. Without expanding the budget beyond what is affordable for the residents, it is likely the Town may have some preferences that cannot be constructed and some compromises in materials and appearance of the facility are probable. If a process alternative initially appears too expensive, it will be eliminated from further consideration. This applies not only to the alternative of constructing a mechanical plant, but to continuing to utilize the current system.

H.6.c. Schedule

Due to the pending permit renewal happening in Summer 2023, and the likelihood that the permit will become more stringent placing the treatment plant out of compliance, the selected treatment system must be able to be designed and constructed by Summer of 2023. Based on this criteria, only processes that can be designed and constructed within this time frame will be considered for further evaluation. See Figure H-5 for a diagram of the anticipated schedule.

H.6.d. Regulatory Compliance

In Montana, DEQ establishes the permit requirements for wastewater discharges into natural water bodies, including groundwater. DEQ has also published design guidelines for specific treatment processes. The requirements of the DEQ, including those for public health, air quality, and solid waste management, will be carefully followed. The consulting team will consider anticipated future permit limits. While specific future limits are not published or advertised by DEQ, the trend is toward more stringent discharge limits. Based on the foregoing, only processes that can consistently meet the anticipated effluent limits and can be adapted for higher nutrient removal will be considered for further evaluation.

H.6.e. Process Flexibility / Expandability

The potential for the community to double or triple in size during the planning period contributes to the uncertainty associated with sizing a wastewater treatment plant. Generally, a wastewater facility operates at an acceptable efficiency when it exceeds 60-70% of its design capacity and planning for expansion is prudent when a plant reaches 80-85% of its design capacity. However, this model is appropriate under consistent and moderate growth rates wherein the time interval between startup for a new plant and construction for system expansion is on the order of 20 years. The population projections for West Yellowstone do not necessarily fit that traditional model. Compounding the treatment plant sizing problem for the Town is the variability in flows and strength, which are predicted due to the seasonal influences due to tourism in the area. Given the anticipated variability in flow quantity and quality, the ability for a treatment process to operate reliably with flow and strength fluctuations, a flexible process that is conducive to rapid expansion, is of paramount importance.

H.6.f. Environmental Clearance

Due to the proximity to the airport and the fact that we are on FAA lands, expanding the treatment plant to previously undisturbed property will likely trigger an environmental clearance. The extent of that clearance is unknown; however, discussion with regulatory staff have indicated that a full environmental study could take up to two years to get approved. This would push the Town well past the Summer 2023 schedule they have targeted. Therefore, only processes that do not require a full environmental study will be considered for further evaluation.

H.6.g. Land Acquisition

As discussed in earlier sections of this report, the current WWTP site is leased from the FFA and the Town has no intention of moving the WWTP location. Therefore, more consideration will be afforded to processes that fit within the current leased property and do not require additional land acquisition.

H.7. Cost Analysis for Initial Alternatives

An opinion of probable cost was developed for each of the viable preliminary alternatives. Note that the "no action" alternative has already been dismissed. The costs evaluated include the capital cost and the operation & maintenance costs. Note that the best way to compare various alternatives with differing capital costs and cash flows is done by comparing the net present value of each alternative. The net present value converts all cash flows to an equivalent value at time zero using appropriate discount rates, inflation, and interest. The net present value for each of the three alternatives is presented in the following table. Detailed cost estimates can be found in Appendix H.

Table H.7-1: Initial Screening Net Present Value Analysis

DESCRIPTION	STATUS QUO ALTERNATIVE	EXPAND LAGOONS ALTERNATIVE	MECHANICAL TREATMENT ALTERNATIVE
CAPITAL COST - CONSTRUCTION	$2,805,200	$19,912,500	$13,384,400
CAPITAL COST - SUPPORT	$685,500	$4,635,000	$2,962,672
OPERATION & MAINTENANCE COSTS	$3,736,000	$15,212,000	$4,310,000
NET PRESENT VALUE	**$7,227,000**	**$39,760,000**	**$20,657,072**

H.8. Evaluation of Initial Alternatives

The various alternatives considered in this document are examined below for their compatibility with the stated objectives of the project as expressed in the discussion regarding initial screening criteria.

Table H.8-1: Initial Screening of Alternatives

Town of West Yellowstone
Evaluation Matrix
Wastewater Treatment Alternatives

	Owner Preference	Cost	Schedule	Regulatory Compliance	Process Flexibility/Expandability	Environmental Clearance	Land Acquisition	TOTAL
Status Quo	1	3	3	1	1	3	3	**15**
Expand Lagoons	2	1	1	2	2	1	1	**10**
Mechanical Treatment	3	2	2	3	3	2	2	**17**

Rank each alternative 1 to 3 in each Category
1 = Worst in Category
3 = Best in Category

Based on the preliminary screening and evaluation matrix, the status quo alternative gets eliminated due to the fact that it doesn't bring the system into compliance with the discharge permit. The lagoon expansion alternative also gets eliminated based on high cost, extensive environmental study requirements that will negatively impact schedule, and the incapacity of a lagoon system to meet future nitrogen limits. Therefore, the mechanical treatment plant is the preferred alternative for both the Engineer and the Town based largely on cost, schedule, and the ability of the WWTP to handle fluctuations in wastewater flow and strength. The final screening process considers what type of mechanical treatment facility is most suited for the conditions presented in the Town.

H.9. Town Input and Participation

A Town Council meeting was held on Tuesday, January 21, 2020 where these initial alternatives were presented. In the subsequent meeting, held Wednesday, February 5, 2020, the Council agreed that moving forward with a mechanical treatment alternative was the most viable option. Meeting minutes from that meeting are included in Appendix I.

I. DETAILED ALTERNATIVE EVALUATION

The goal of this chapter is to evaluate the general mechanical treatment alternative advanced from initial screening for addressing the system deficiencies and then to recommend a preferred specific mechanical treatment alternative. To accomplish this purpose, we have first addressed some of the site conditions and general information to show that the West Yellowstone site is adequate for a mechanical treatment plant. We then evaluated all of the mechanical treatment alternatives considered and narrowed it down to three probable alternatives. Those three alternatives were evaluated in further detail, including a cost analysis for each. Then an evaluation matrix was be completed to rank each alternative. The alternative with the highest numerical rating was selected as the preferred alternative.

I.1. Sewer System Revisions

All of the mechanical treatment alternatives evaluated herein include a total replacement of the existing lagoon system. Staged construction will not be needed for the West Yellowstone WWTP because they currently have a fully operating lagoon system that can treat and dispose of the wastewater until a new facility is built. Note that West Yellowstone is a relatively small municipality and has limited resources to expend on untried and experimental technologies or those that consume considerable research and operator attention. Therefore, treatment choices are limited to those that are recognized in the industry as ubiquitous, accepted, and reliable and other technologies are not considered further.

I.2. Wet Weather Flows

The West Yellowstone operations staff have not identified inflow during wet weather conditions. Furthermore, if inflow does occur, it is during the off-peak season and will not increase worst-case flow conditions identified in this report.

I.3. Site Evaluation

The following items have been addressed with respect to the site in accordance with Chapter 10 of Circular DEQ-2:

1. The existing WWTP site will be used to construct the new mechanical WWTP. The current and future land use will remain the same. The current WWTP has several blowers housed in a blower building that do create some noise pollution that has received some negative feedback from residents. This consideration will be accounted for in the future design by specifying less noisy blowers, soundproofing, or a combination of the two. Adequate aeration and ventilation will be utilized in design to address odor and air quality. Sludge processing was discussed in the previous section, but is it anticipated that a dewatering mechanism will be specified and the dried sludge will be hauled to and disposed of at either the Fremont County, Idaho or Gallatin County, Montana landfill. The preferred dewatering method is gravity using dewatering bags.
2. As discussed, the site is currently being utilized to treat wastewater, so no changes to zoning are proposed. However, the site is owned by the FAA and is being leased by the Town. Therefore, close coordination with the FAA must be maintained for the life of the project. It is likely they will require environmental clearances and have input on building heights and other design aspects. However, they are aware of the current use and have been cooperative with the Town thus far.
3. A maintained road provides accessibility to the site. Please see the existing plans from 1993 located in Appendix A for current site topography and accessibility.

4. The footprint for a mechanical plant will be much smaller than the current footprint of the WWTP. Therefore, as shown on Figure A-3, the site has several locations on the site that the new mechanical WWTP could be constructed, along with several locations it could be expanded. The ultimate location of the plant will be determined upon collection of survey data and upon coordination with the FAA and Town staff. For now, it is anticipated that the main treatment building will be situated between the existing newer blower building and the IP beds.
5. The direction of the prevailing wind was determined during design of the mechanical evaporators and is from southwest to northeast across the site.
6. Flood considerations have been made. It is determined that the 25-year flood level is 2.2 inches and the 100-year flood level is 2.8 inches. The treatment works will be protected and will remain fully functional during the 100-year flood in accordance with Section 51.2 of DEQ Circular 2.
7. The site is located on Pleistocene obsidian sand deposits washed out of Yellowstone Park. Sand deposits in this area range between 80 and 100 feet thick.
8. See Figure I-1 for groundwater well locations in relation to the WWTP site. Note that all wells are further than 1000-feet away. Also note that there are several monitoring wells located onsite and in the immediate vicinity of the site. See DEQ Fact Sheet (page 14 of 29) located in Appendix B for reference to the monitoring well locations.
9. The local aquifer is unconfined and is hydraulically connected to the downgradient Madison River and Hebgen Lake. Groundwater near the WWTP is Class I groundwater. The static groundwater elevation is relatively shallow and on average is approximately 40 feet BGS. See Figure I-1 for static water surface information for the groundwater wells in the site vicinity.
10. No known field tiles discharge in the immediate area of the site.
11. As discussed, the site currently houses the Town's WWTP and will continue to be available for such use.
12. Present and future effluent quality requirements have been discussed in detail in previous sections of this report.
13. The WWTP currently discharges to Class I groundwater and will continue to do so.
14. The majority of the site has been previously disturbed by construction activities. There are no known historical, archeological, or paleontological resources in the immediate area. However, additional environmental assessments may be required by the FFA prior to construction. Furthermore, the construction specifications included with the design will include instructions to contractors concerning discovery of such items during construction.
15. Based on information taken from the Fish and Wildlife Service National Wetlands Inventory, no natural wetlands exist within the proposed project boundary. The aeration basins have been identified on the wetlands map as freshwater ponds. See Appendix I for reference to a wetland map.
16. The FAA has already determined the site to be sufficient for use as a WWTP.
17. A list of federally listed threatened and endangered species is included in Appendix I for reference.

18. The site is located on an FAA property that is leased by the Town of West Yellowstone. It is highly unlikely that the FAA will lease additional property for land application, and the surrounding area is Forest Service with very limited, if any, agricultural land. Furthermore, the limited growing season in the area due to snow and freezing temperatures significantly hinders the viability of land application. Therefore, land application was not evaluated as a viable alternative for the Town of West Yellowstone. All effluent will be discharge to Class I groundwater.

I.4. Mechanical Treatment Plant Alternatives

Mechanical treatment has proven to produce high effluent qualities and is feasible to communities the size of West Yellowstone and larger. The processes have been used for years in water pollution control and are fully proven and reliable. The typical mechanical plant includes an aeration basin where environmental conditions are controlled to produce an active population of bacteria. The bacteria feed upon the pollutants in the sewage and the oxygen necessary to sustain microbial life is provided by introducing air into the basin through some mechanical means. To maintain a heavy inventory of bacteria, effluent from the aeration basin is conveyed to a clarifier and bacterial flock, which settles in the clarifier, is returned to the aeration basin as a return activated sludge (RAS). Filtration of final effluent may be necessary to ensure that plant effluent complies with discharge requirements at all times.

Mechanical plants that treat the type of wastewater produced by the Town of West Yellowstone are typically categorized according to the predominant type of bacterial growth and the reactor type. The bacterial growth may be suspended growth, attached growth, or a combination of the two. The most common reactor types are batch reactors and plug flow reactors.

Mechanical treatment plant alternatives will be discussed in general to determine which bacterial growth and reactor types would be best suited for the Town of West Yellowstone.

I.4.a. Suspended Growth

In general, suspended growth systems achieve relatively high concentrations of bacteria in the aerobic treatment basins through recycling solids from downstream separation processes. Suspended growth processes are often labeled as activated sludge systems. The activated sludge process was initially developed in Manchester, England in 1914. Early system design relied on anecdotal observations which were replaced by empirical relationships as designer's knowledge grew. Finally, mass balances and kinetic growth equations were developed for use in sizing treatment facilities.

The activated sludge process wastewater is first mixed and aerated in a reactor; the resulting mixture, termed mixed liquor (MLSS) contains bacteria endemic to the raw wastewater which are suspended in the liquid. After allowing sufficient time for the bacteria to feed on the organic matter carried into the process with the raw wastewater, the mixed liquor is transferred to a separate basin where the liquid portion and solid portion can separate, typically using gravity as the driving force.

Over the past 100 years, numerous configurations of suspended growth have been developed. Some operate in continuous flow while others utilize a fixed volume concept and treat only a specified volume. Various methods have been designed to introduce air to the basins for use by the bacteria in respiration and mixing. Some systems use mechanical means to achieve mixing. It is anticipated that the West Yellowstone WWTP will need to be housed inside of a building due to snow and freezing temperatures. Therefore, the following suspended growth systems have been evaluated in detail due to their relatively small footprints.

- Membrane Bioreactor (MBR): A Kubota MBR system incorporates a standardized, continuous feed, plug flow arrangement with the addition of a proprietary membrane to separate the liquids and the solids and has been further evaluated.
- Extended Aeration: An Aero-mod extended aeration system incorporates a continuous feed, plug flow arrangement in a proprietary configuration and has been further evaluated.

I.4.b. Attached Growth

Attached growth systems utilize bacteria that grow on surfaces immersed in the wastewater. Essentially, unit processes are designed to promote bacterial growth and to maximize the surface area for bacterial growth. The bacteria are alternatively exposed to the influent wastewater to provide nutrients and to the atmosphere for oxygen. However, attached growth systems generally require low BOD loading rates in order to achieve secondary treatment effluent quality. Low BOD loading rates require very large WWTP footprints. Therefore, no attached growth processes on their own have been further evaluated.

I.4.c. Combined Systems

Combined systems use both suspended and attached growth with the intent to capture the advantages inherent in each of those systems. Combining suspended growth and attached growth within the same volume allows for an even smaller footprint than an independent suspended growth system. The following combined growth system was evaluated in detail:

- Integrated Fixed Film Activated Sludge (IFAS): An STM Aerotor IFAS system incorporates a standardized, continuous feed, plug flow arrangement with a proprietary fixed film component permanently mounted in the aeration basins and has been further evaluated.

I.5. Detailed Treatment Process Evaluation

As discussed, three mechanical treatment alternatives have been advanced for further evaluation in the West Yellowstone WWTP design. These alternatives are discussed in detail below.

I.5.a. Membrane Bioreactor (MBR)

The MBR is a variation of the activated sludge process wherein the clarification and filtration unit processes that traditionally occur in separate basins are replaced with a polypropylene or polyethylene membrane installed within the activated sludge. Effluent is drawn through the membrane by creating a hydraulic gradient across the membrane, either through mechanical means by using a pump to create a vacuum on the downstream side of the membrane or through physical means by creating a hydraulic head condition on the upstream side of the membrane. The resulting flow through the membrane is known as the flux rate. The flux rate is the principal factor in determining the quantity, or surface area, of membrane material required to meet the design flow conditions.

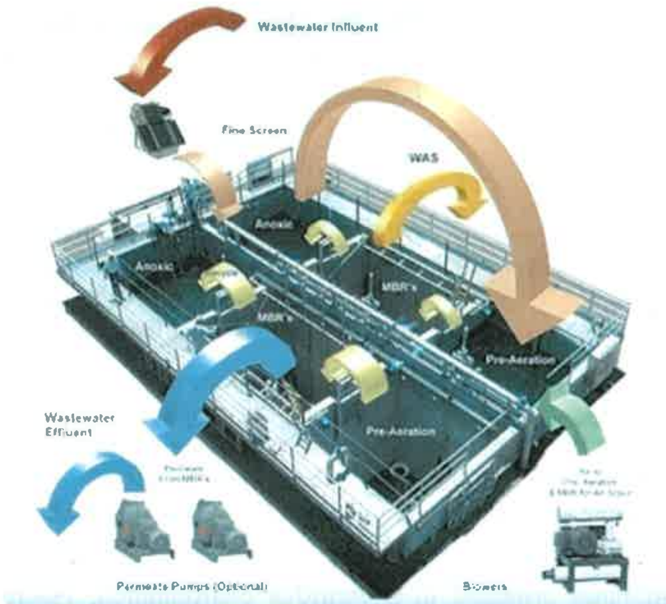


Figure I-2: MBR Process (Enviroquip)

The membrane pore size is carefully controlled during the manufacturing process to limit the diameter of the opening, thereby providing a physical barrier to the conveyance of solids in the effluent. The solids left behind increase the mixed liquor suspended solids (MLSS) concentration, a parameter used to describe the quantity of microorganisms in the treatment basin. In comparison to other activated sludge treatment processes, the MLSS in an MBR is maintained at a much higher concentration, typically on the order of 2 to 5 times that of an oxidation ditch.

The high MLSS concentrations are achieved with high Return Activated Sludge (RAS) rates. The RAS flow recycles mixed liquor from the terminal end of the reactor basin to the front of the reactor basin. The RAS flow is typically 4 times the influent flow rate and may be achieved by pumping or by gravity flow depending upon the design specific to the treatment plant.

Membranes used in MBR facilities are manufactured in two configurations, 1.) a hollow fiber that resembles floating line used for fly fishing, and 2.) flat plates where the membrane is supported on the exterior of a plastic framework. The hollow fiber was introduced into the U.S. market first with installations approaching the ten year mark. The flat plate followed the hollow fiber by approximately five years. Both configurations have been used for longer periods of time in other countries.

The hollow fiber configuration typically uses a pump to draw water from the outside of the fiber into the hollow center. Generally, multiple fibers are arranged in a bundle and potted in an epoxy on one or both ends. A watertight fitting envelops the potted ends and connects to a header pipe for conveyance of the extracted water to a collection point.

Figure I-3: MBR Hollow Fiber

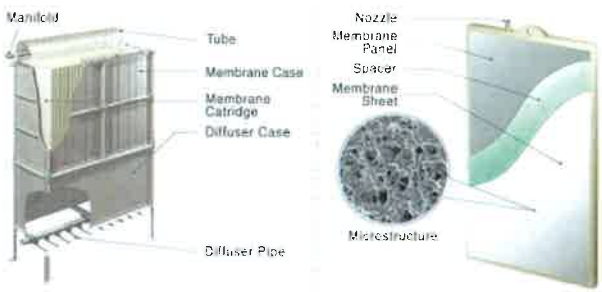


Figure I-4: MBR Flat Plate

The flat plate configuration has a similar functional design and operates similar to the hollow fiber. A primary difference is the material used for the membrane. It is possible to use a static hydraulic head to drive water through the flat plate membrane. At least one flat plate manufacturer relies on the formation of a biofilm on the surface of the membrane to provide a consistent filtered product.

Periodically, water, and sometimes a mild disinfectant, is backpulsed through the fibers to open the pores and to maintain the flux rate through the membrane. Less frequently, the pumps return a disinfectant solution to accomplish a lengthier clean-in-place. If operating conditions are heavier than normal, some systems may require removal of the membrane cassettes for submerging in an acid solution for cleaning.

Both configurations employ membranes arranged in a cartridge configuration, reactor tanks constructed of concrete or steel, an aeration system complete with blowers and diffusers, a means of mixing the biomass, a recycle system for the RAS, effluent pumps to remove the water and discharge to the disinfection process, and process controls including valves, meters, and instruments.

Membrane bioreactors require more effort in the preliminary treatment processes typically accomplished through installation of finer mesh screens (1 mm to 3 mm openings) and grit removal. Fine screening for a membrane bioreactor system is an essential pretreatment step to prevent unwanted solids in the waste stream from entering the membrane tank. This prudent design measure minimizes solids accumulation and protects the membranes from damaging debris and particles, resulting in extended membrane life, reduced operating costs, higher quality sludge and trouble-free operation. Screen configurations acceptable to most manufacturers of MBR equipment are the band screen and rotary drum screen, both of which use a perforated plate for the screening surface.

Figure I-5: MBR Configuration

I.5.a.i. MBR Design Parameters

The following design parameters are common benchmarks used for designing wastewater treatment facilities and affect design performance and project costs.

Table I.5-1: Design Parameters for Membrane Bioreactor

MLSS Concentration (mg/l)	Solids Retention Time (days)	Hydraulic Detention Time Vol/Q (hours)	RAS Rate Qr/Q	Food to Mass F/M Lb BOD_5 applied/ Lb MLVSS-day
6,000 – 14,000	30-60	4-8	3-4	0.2

Where:

- MLSS is a measure of the suspended solids contained in one liter of the mixed liquor that are combustible at 550 degrees centigrade. Solids Retention Time (sludge age) is a measure of the length of time a particle of suspended solids has been undergoing aeration, expressed in day. It is usually computed by dividing the weight of the suspended solids in the aeration tank by the weight of excess activated sludge discharged from the system per day.
- Hydraulic Detention Time, also termed the mean cell residence time, is a measure of the average length of time the raw wastewater is held in the reactor basin and is calculated by dividing the reactor volume by the influent flow rate.
- RAS Rate is a measure of the activated return sludge normally returned continuously to the aeration tank. Recycling of activated sludge back to the aeration tank provides bacteria for incoming wastewater. It should be brown in color with no obnoxious odor and is often also returned in small portions to the primary settling tanks to aid sedimentation. Settled activated sludge is generally thinner than raw sludge. Some activated sludge is wasted to prevent excessive solids build up.
- Food to Mass (microorganism) Ratio is a measure defined by dividing the BOD concentration contained in the influent by the mixed liquor volatile suspended solids concentration in the reactor tank.

I.5.a.ii. MBR Performance

The following table lists the performance achievable under normal operating circumstances.

Table I.5-2: Performance Parameters for Membrane Bioreactor

Parameter	Units	Influent Strength	Effluent Performance
BOD	mg/l	266.7	<5
TSS	mg/l	166.7	<1
Total Nitrogen	mg/l	77.4	<10
Total Phosphorous	mg/l	6.0	6

I.5.a.iii. MBR Manufacturers

There are three systems with multiple installations manufactured by global companies with considerable industry experience. There are also several other systems newer to the U.S. market but with several installations in Europe and the Far East. The following table is a partial list of known manufacturers along with the parent company, the membrane configuration, and the number of U.S. installations. The flat plate membrane technology from Kubota has been evaluated for potential use for the West Yellowstone WWTP.

Table I.5-3: Manufacturer Information for Membrane Bioreactor Equipment

Parent Company	Trade Name	Model No.	Configuration	U.S. Installations
G.E. Water	Zenon	Z-MOD S UG Z-MOD S AG Z-MOD M Z-MOD L ZeeWeed™	Hollow Fiber	250/80
Siemens	U.S. Filter Memcor	Xpress™ MemJet™	Hollow Fiber	50/8
Kubota	Enviroquip	MPAC S™ MPAC B™ MPAC C™ SymBio® UNR™	Flat Plate	600/25
Toray	Kruger	NEOSEP	Flat Plate	75/1
Koch	Puron	PURON®	Hollow Fiber	50/3
Norit X-Flow	---	AquaFlex Xiga	60	45/4

I.5.a.iv. MBR Process Advantages

The advantages offered by the MBR include:

- Highest quality effluent of any activated sludge process without additional processes.
- High ability to handle variations in wastewater strength due to high MLSS concentration.
- Smallest footprint. Reactor basins are smaller due to high MLSS concentration and reduced hydraulic retention time.
- Most flexibility for incremental expansion. MBR systems can operate as at flows as low as 10% of the design capacity. This feature allows deferred cost by constructing basin capacity initially and purchasing the expensive membrane equipment incrementally as growth demands.
- Increased aesthetics. The smaller footprint often results in a configuration where the treatment plant is completely housed in a building designed to architecturally match surrounding structures. In addition, setbacks are often reduced as a result of the treatment plant housing.
- MBR systems tend to produce less sludge with a higher solids concentration from the reactor basin.

- Reduce biological operation requirements due to the physical barrier and the degree of automation inherent in the installation.
- Minimized problems with sludge settleability.

I.5.a.v. MBR Process Disadvantages

The disadvantages associated with the MBR process include:

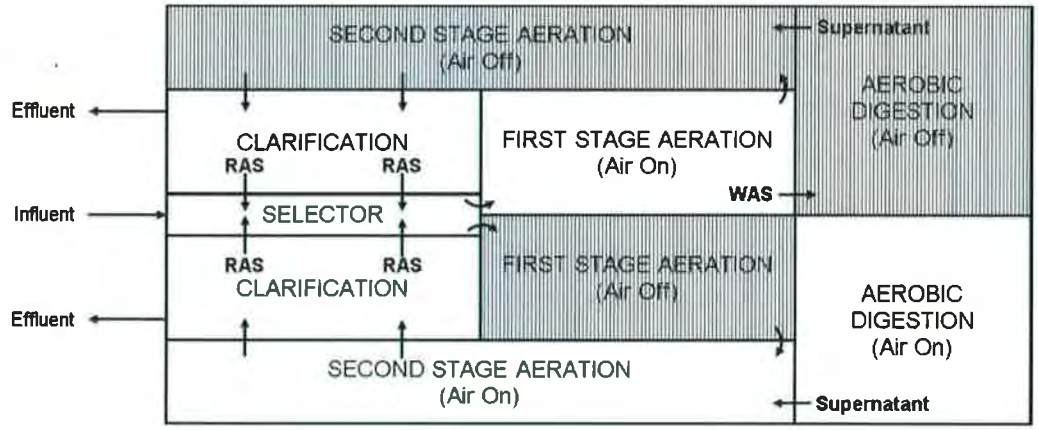
- High capital cost for the membrane equipment.
- Requires finer mesh screens to protect the membranes from deleterious materials.
- Higher operation and maintenance cost due to power requirements.
- System must be sized hydraulically for peak hour flows. This may entail equalization basins.
- Operations staff must have a higher capability for instrumentation and controls.
- Shorter history of operating installations.

Figure I-6: Aero-Mod Plant in Kansas

I.5.b. Extended Aeration Process

The extended aeration process is an activated sludge process that provides biological nutrient removal which includes suspended growth microbial reactors, solids separation equipment, and solids wasting systems. It uses diffused aeration to supply oxygen and uses alternating aerated/unaerated conditions to achieve aerobic treatment and anoxic/anaerobic treatment. This system is all inclusive. It includes aeration, digester, and clarifier. One type of process equipment evaluated is manufactured by Aero-Mod and is labeled by the manufacturer as a Sequox-Plus.

The Sequox-Plus includes individual microbial reactors that are alternately aerated and unaerated, to provide alternating aerobic and anoxic/anaerobic conditions. The Sequox-Plus Aeration is controlled to achieve desired alternating oxidation/reduction conditions in the microbial reactors. Solids in the Sequox-Plus are wasted from the microbial reactors. Sequox-Plus is designed to be mechanically and operationally simple while providing extensive operational flexibility. As shown in Figure I-7, in the Aero-Mod process, flow enters into the Selector Tank where the raw sewage is combined with returned activated sludge (RAS) from the clarifiers. The mixture then flows into the First Stage Aeration Basins where the air is sequenced on a 2-hour cycle. Flow continues into the Second Stage Aeration Tanks. The aeration is sequenced on/off on a 2-hour cycle between these two basins. The sequencing of this on/off is opposite to the 1st Stage Aeration Bains. The end result of the plug flow process with sequential reactions is excellent nitrification/denitrification without having blowers turned on and off nor have dedicated internal recycle pumps and associated mixers in separate anoxic tanks as some systems have. The flow then enters the Clarator clarifier where the biomass is settled and returned to the Selector Tank. The clarified effluent is withdrawn and discharged. At regular intervals, solids are automatically or manually wasted to an aerobic digester or aerated sludge holding tank. Supernatant is simultaneously decanted back to the aeration process over a fixed level weir.



Note: Automatic sequential aeration switches "Air On" to "Air Off" and vice versa, typically on a two-hour cycle.

Figure I-7: Aero-Mod Process Flow Diagram

I.5.b.i. Extended Aeration Design Parameters

The following design parameters are common benchmarks used for designing wastewater treatment facilities and affect design performance and project costs.

Table I.5-4: Design Parameters for Aero-Mod

MLSS Concentration (mg/l)	Solids Retention Time (days)	Hydraulic Detention Time Vol/Q (hours)	RAS Rate Qr/Q	Food to Mass F/M Lb BOD_5 applied/ Lb MLVSS-day
3,000 – 5,000	15-30	12-24	0.75-1.5	0.05-0.15

Where:

- MLSS is a measure of the suspended solids contained in one liter of the mixed liquor that are combustible at 550 degrees centigrade. Solids Retention Time (sludge age) is a measure of the length of time a particle of suspended solids has been undergoing aeration, expressed in day. It is usually computed by dividing the weight of the suspended solids in the aeration tank by the weight of excess activated sludge discharged from the system per day.
- Hydraulic Detention Time, also termed the mean cell residence time, is a measure of the average length of time the raw wastewater is held in the reactor basin and is calculated by dividing the reactor volume by the influent flow rate.
- RAS Rate is a measure of the activated return sludge normally returned continuously to the aeration tank. Recycling of activated sludge back to the aeration tank provides bacteria for incoming wastewater. It should be brown in color with no obnoxious odor

and is often also returned in small portions to the primary settling tanks to aid sedimentation. Settled activated sludge is generally thinner than raw sludge. Some activated sludge is wasted to prevent excessive solids build up.

- Food to Mass (microorganism) Ratio is a measure defined by dividing the BOD5 concentration contained in the influent by the mixed liquor volatile suspended solids concentration in the reactor tank.

I.5.b.ii. Extended Aeration Performance

The following table lists the performance achievable under normal operating circumstances.

Table I.5-5: Performance Parameters for Aero-Mod

Parameter	Units	Influent Strength	Effluent Performance
BOD	mg/l	266.7	<30
TSS	mg/l	166.7	<10
Total Nitrogen	mg/l	77.4	<10
Total Phosphorous	mg/l	6.0	6

I.5.b.iii. Extended Aeration Manufacturers

The Aero-Mod system has been evaluated for potential use for the Town of West Yellowstone. This particular process allows for the treatment components to be housed inside of a large building, and due to the extremely cold winter temperatures and large amount of snowfall, this is a necessity in West Yellowstone. Furthermore, the ability to easily expand the system and the system's capability to treat Total Nitrogen also make it a viable option. The fact that the digesters are built-in to the overall footprint is also a draw to this particular manufacturer. A photograph of a similar sized indoor Aero-Mod plant we visited in Arizona is shown in Figure I-8.

Figure I-8: Extended Aeration Process (Aero-mod)

I.5.b.iv. Process Advantages

Advantages of the Aero-Mod system include:

- Equalization, primary clarification, biological treatment, and secondary treatment can be achieved in a single reactor vessel.

- Operating flexibility and control.
- All secondary treatment in one small footprint.
- Flexible tank options.
- Small volume of waste sludge (with no chemical phosphorus removal requirements).

I.5.b.v. Process Disadvantages

Disadvantages of the Aero-Mod system include:

- Higher level of sophistication and maintenance required for automated switches and valves.
- Potential plugging of aeration devices during selected operating cycles.

I.5.c. Integrated Fixed Film Activated Sludge (IFAS) Process

The Integrated Fixed-Film Activated Sludge process, or IFAS as it is known in industry parlance, is actually a hybrid system intended to capture the benefits of both the suspended growth activated sludge process and the fixed-film process. Activated sludge is recognized for its flexibility in process control based on returning activated sludge (RAS) to the reactor basin giving the operator the ability to manage sludge age as well as sludge concentration. Fixed-film processes are known as inherently stable and resistant to organic and hydraulic shock loading.

The activated sludge process is designed around beneficial bacteria suspended in the wastewater to create a homogenous mixture or biomass and organic material. The fixed-film systems rely on the adhesion of microorganisms responsible for the conversion of organic material contained in the wastewater to gases and cell tissue of new bacteria. There are many variations promoted by various scientists and marketed by equipment manufacturers of both the activated sludge process and the fixed-film systems.

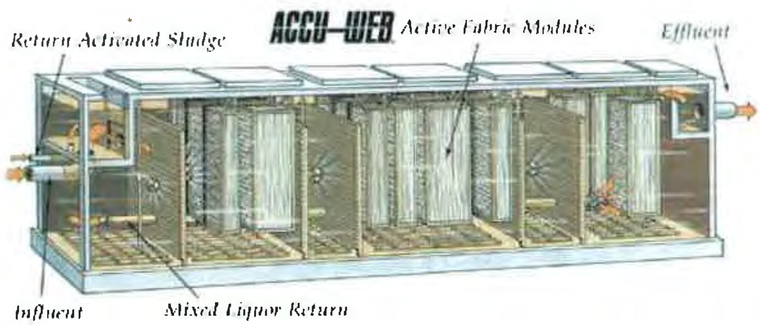


Figure I-9: IFAS Process (Brentwood Industries)

IFAS processes have been utilized in the industry since the 1930's, although without the benefit of a return sludge and a short hydraulic retention time they were not highly successful. The practice was supplanted by activated sludge systems in the U.S. until the late 1980's when new interest was generated in the integration of fixed- film and activated sludge. The systems developed in the last decade have improved the treatment effectiveness over previous efforts in IFAS designs.

The enhanced treatment provided by an IFAS system is related to the amount of biomass growth on the surface of the media and the activity of the suspended biomass in the reactor. IFAS technology has been implemented in both municipal and industrial applications using various fixed film media incorporated into many suspended growth configurations. IFAS technology has been


Figure I-10: IFAS Process (STM-Aerotor)

designed for new wastewater treatment works, in retrofitting existing plants to increase capacity, and in augmenting the treatment of existing facilities for nitrification/denitrification.

Considerable effort has been expended experimenting with different materials for the fixed film media. Currently, media can be categorized as fixed in place media which is attached in a fixed configuration in the activated sludge reactor basin and dispersed media which is allowed to move within the mixed liquor solution. Fixed in place media include synthetic fabrics, rope of natural materials, and PVC sheets. Each type of media inherently has advantages and disadvantages as outlined in Table I.5-6 below.

Table I.5-6: IFAS Media Advantages & Disadvantages

FIXED-IN-PLACE TYPES		ADVANTAGES	DRAWBACKS
	Fabric Web-type (AccuWeb)	• Simple to install • Low initial cost • No maintenance • Rapid upgrade • No material losses	• May foul if rag removal is inadequate
	Rope-type	• Rapid upgrade • No material losses	• Material breakage and entanglement • Field assembly needed • May foul if rag removal is inadequate
	PVC Sheet Media (Trickling Filter Media)	• Rapid upgrade • No material losses	• Structured media may impede mixing • May foul if rag removal is inadequate • Potential plugging from excess biomass
DISPERSED TYPES		**ADVANTAGES**	**DRAWBACKS**
	Polypropylene Finned Cylinders	• Excellent mixing • May eliminate RAS	• Media losses (washout or abrasion) • Aeration devices and screens may foul • Difficult to maintain aeration system
	Sponges		

All IFAS processes require a preliminary treatment design with fine screens to remove deleterious materials from the raw wastewater that will interfere or bind up the fixed film or result in excessive biomass build up on the fixed film. In addition, as the fixed film has the potential to interfere with the aerations system, a consistent mixing regime must be established to maintain the solids in suspension, to facilitate substrate transfer, and to ensure even oxygen transfer. Additional design considerations include sufficient oxygen capability for the additional biomass, providing a means to contain and filter dispersed media, providing the capability to remove fixed-in-place media for maintenance, and attention to the potential for solids accumulation in the media.

I.5.c.i. IFAS Design Parameters

The following design parameters are common benchmarks used for designing wastewater treatment facilities and affect design performance and project costs.

Table I.5-7: Design Parameters for IFAS

Equivalent MLSS Concentration (mg/l)	Solids Retention Time (days)	Hydraulic Detention Time Vol/Q (hours)	RAS Rate Qr/Q	Food to Mass F/M Lb BOD_5 applied/ Lb MLVSS-day
1,500 – 6,000	12-24	12-24	0.75-1.5	0.05-0.15

Where:

- MLSS is a measure of the suspended solids contained in one liter of the mixed liquor that are combustible at 550 degrees centigrade. Solids Retention Time (sludge age) is a measure of the length of time a particle of suspended solids has been undergoing aeration, expressed in day. It is usually computed by dividing the weight of the suspended solids in the aeration tank by the weight of excess activated sludge discharged from the system per day.
- Hydraulic Detention Time, also termed the mean cell residence time, is a measure of the average length of time the raw wastewater is held in the reactor basin and is calculated by dividing the reactor volume by the influent flow rate.
- RAS Rate is a measure of the activated return sludge normally returned continuously to the aeration tank. Recycling of activated sludge back to the aeration tank provides bacteria for incoming wastewater. It should be brown in color with no obnoxious odor and is often also returned in small portions to the primary settling tanks to aid sedimentation. Settled activated sludge is generally thinner than raw sludge. Some activated sludge is wasted to prevent excessive solids build up.
- Food to Mass (microorganism) Ratio is a measure defined by dividing the BOD5 concentration contained in the influent by the mixed liquor volatile suspended solids concentration in the reactor tank.

I.5.c.ii. Performance

The following table lists the performance achievable under normal operating circumstances.

Table I.5-8: Performance Parameters for IFAS

Parameter	Units	Influent Strength	Effluent Performance
BOD	mg/l	266.7	<30
TSS	mg/l	166.7	<10
Total Nitrogen	mg/l	77.4	<10
Total Phosphorous	mg/l	6.0	6

I.5.c.iii. Manufacturers

There are three systems with multiple installations manufactured by global companies with considerable industry experience. There are also several other systems newer to the U.S. market but with numerous installations in Europe and the Far East. The following table is a partial list of known manufacturers along with the parent company, the membrane configuration, and the estimated number of U.S. installations. The STM-Aerotor™ from WesTech has been evaluated for potential use for the West Yellowstone WWTP.

Table I.5-9: Manufacturer Information for IFAS

Parent Company	Trade Name	Model No.	Configuration	Installations World/U.S.
BrentWood	---	AccuWeb™	Fixed-in-place-Fabric	15/9
WesTech	---	STM-Aerotor™	Fixed-in-place Polyethylene disc	32/21
AnoxKaldnes	---	HYBAS™	Dispersed Polyethylene discs	18/7
LGV	EimCo	ClearTec®	Fixed-in-place Textile	16/4
Siemens/U.S. Filter	Envirex	AGAR®	Dispersed Polyethylene discs	11/5
Hydroxyl	AquaPoint IDI	ActiveCell™	Dispersed Polyethylene discs	22/12
Apex Mills	EnTex	BioWeb™	Fixed-in-place Rope lattice	10/10
	EnTex	BioPortz™	Dispersed Polyethylene discs	0/0

I.5.c.iv. Process Advantages

The advantages offered by the IFAS include:

Figure I-11: IFAS Process (STM-Aerotor)

- Resilience to organic and hydraulic shock loading due to inconsistent raw wastewater quality and quantity. This advantage is more pronounced in smaller systems.
- High ability to handle variations in wastewater strength due to combination of attached bacteria and suspended bacteria.
- Reduced footprint. Reactor basins may be smaller due to a higher MLSS concentration compared to conventional activated sludge and the additional treatment gained from the attached growth bacteria.
- Provides a convenient approach to increasing the capacity of an existing plant without increasing the physical size of the facility.
- Incremental expansion may be more convenient due to the ability to increase the amount of fixed film.
- IFAS systems tend to produce less sludge.
- Reduced loading on the clarifier due to a lower MLSS concentration. Less risk of upset conditions in the clarifier.
- Minimized problems with sludge settleability by reducing the food to microorganism (F/M) ratio.
- Because of reduced sludge volume index (SVI), which allows a more concentrated RAS and thus a potentially reduced return sludge flow rate (RAS) which reduces power costs and increases hydraulic retention time in the aeration basin.
- Improved nitrification due to the increased sludge age possible with attached growth bacteria.

I.5.c.v. Process Disadvantages

The disadvantages associated with the IFAS process include:

- Higher capital cost may be higher to include equipment for both suspended bacteria growth and attached bacteria growth.
- Requires finer mesh screens to protect the fixed film media from deleterious materials.

- Dispersed media systems require additional infrastructure such as screens or weirs to confine the media to the reactor basin.
- System must be sized hydraulically for peak hour flows. This may entail equalization basins.
- Some types of fixed film experience degradation and require replacement at regular intervals.
- Shorter history of operating installations when compared to conventional activated sludge.
- Solids buildup may occur in the reactor basin as a result of the fixed film interfering with flow patterns or trapping sludge in the media matrix.

I.6. Additional Operation and Design Considerations

In addition to the unit process specific design considerations, there are also some general considerations that must be considered in the design of the West Yellowstone WWTP as discussed below.

I.6.a. Emergency Operation

Emergency operation requirements as outlined in Section 47 and 56.1 of Circular DEQ-2 will be provided. An emergency generator will be proposed and included in the plans and specifications for the future design.

I.6.b. Technology Not Included in These Standards

Proposals to use technology and procedures for introducing and obtaining approval to use technology not included in these standards must address the requirements of Section 53.2 of Circular DEQ-2. It is understood that STM-Aerotor technology is not included as an approved technology at this time and selection of this alternative would require addition approval from DEQ.

I.6.c. Treatment During Construction

The plan for treatment during construction will be to keep the existing lagoon system up and running until the new mechanical plant is completed.

I.6.d. Plan of Operation / Start-Up Protocol

A plan of operation for the start-up of the new facility will be included in the project specifications which will provided to DEQ for approval and an approved copy will be provided to the owner and the contractor. This task is included in the Engineer's approved contract with the Town.

I.6.e. Operation and Maintenance

An Operation and Maintenance Manual will be prepared to outline complex operation or maintenance requirements for operation, industrial sampling, and/or self-monitoring. This task is included in the Engineer's approved contract with the Town.

I.7. Cost Analysis

The most significant item that will govern the selection and preliminary design of a new wastewater treatment mechanical treatment plant for West Yellowstone is the question of cost -- not only initial construction costs, but also annual operation and maintenance costs. Developing an opinion of probable cost is divided into three levels of detail: (1) Order of magnitude opinions that are used for conceptual planning and are derived from cost curves and selected publications are used primarily for general screening of alternatives to select a few alternative treatment systems for detailed investigation in this study. (2) Budget opinions (prepared during the preliminary design phase) derived from published or historical bid information, manufacturers' quotations, bid tabulation from similar projects recently constructed in the state, engineer's judgment, or limited quantity takeoffs are used to prepare opinions of probable cost for comparison of principle alternatives. The opinions of probable cost in this document are of this level. (3) Detailed opinions of probable cost derived from detailed quantity takeoffs of completed plans and specifications are developed after detail design prior to bidding for construction and are used to adjust the final budget and for comparison to ascertain if the actual contractor's bids are reasonable. The accuracy of the opinions varies according to the level of detail; therefore, a confidence factor is applied to the opinions of probable cost. In addition, the Town should consider a project contingency during construction to account for undefined items and for unforeseen conditions.

I.7.a. Capital Costs

Construction cost of the new wastewater treatment facility will be the largest cost item associated with the project. When preparing opinions of probable construction cost, the same basis of establishing cost opinions will be used to evaluate all the principal alternatives and to project future costs. See Appendix I for more detailed cost analyses of each alternative and Appendix I for manufacturers' quotations.

In this document, initial capital costs associated with implementing a new wastewater treatment facility will be projected and tabulated including: construction of the new facilities, engineering design, construction observation, inspection, and materials testing, legal, fiscal, start-up and operations training, preparation of operation and maintenance manuals, mapping, administrative, and all other miscellaneous project costs necessary to have an operating treatment plant in the Town of West Yellowstone.

Capital costs are required at the incipient stage of the project and funds necessary to cover these costs are usually obtained from reserve accounts, grant programs, or from the proceeds of bond sales by the municipality.

I.7.b. Operation & Maintenance Costs

The annual costs for operations and maintenance (O&M) are important factors in the evaluation of alternative treatment processes. The principal elements of O&M costs are labor, energy, chemicals, materials and supplies. These project costs are annual, so for the purposes of this document, once O&M costs are determined and projected, then the net present value of O&M will be calculated and added to the construction cost to provide an equitable comparison of principal alternative costs. The net present worth evaluation is a calculation of the amount of money that must be placed in an account today to pay all project costs throughout the life of the project. A summary of O&M cost analysis can be found in Appendix I.

I.7.c. Power

Concern over the rate of consumption of natural resources and energy has increased in recent years as shortages have occurred as worldwide demands have increased. Because the operation of wastewater management facilities depends on energy resources to a large extent, it is important to appraise the requirements realistically. Because energy consumption of different unit processes and operations varies greatly and because there are innumerable combinations possible, data must be available for each prospective treatment operation or process considered.

The main energy sources are electric power, either natural gas or propane, and diesel fuel or gasoline. Electric power is used mainly for running the electric motors for the process equipment and for providing lighting and power for various motors for the process equipment, and for various ancillary support systems. Natural gas or propane is used for building and digester heating and is used as a fuel source for standby engine-generators. Diesel fuel or gasoline is used similarly for standby engine-generators and for vehicle fuel.

Electrical energy charges are commonly assessed based upon energy use, power factor charges, and demand charges. Power factor charges are concerns for plants having large electric-motor driven equipment. The demand charges are assessed by utility companies when they commit sufficient power-generating capacity to meet the entire demands of the treatment system. Peak power use for as little as 15 minutes may establish a demand charge for up to 12 months. Demand charges can be reduced in some instances by providing power-generating capability at the treatment plant. All three alternatives involve providing a power supply to the treatment plant.

I.7.d. Chemicals

Chemicals have multifarious uses on a wastewater treatment site as part of the process or for ancillary purposes. Chemicals may be used for odor control, disinfection, process stabilization, constituent removal, sludge stabilization, etc. Chemical usage can contribute a significant cost to the operation and maintenance of a treatment plant.

I.7.e. Labor

Labor is a continuous cost that must be considered when evaluating treatment alternatives. Although not a perfect inverse relationship, there is a trade-off between plant automation and ongoing labor requirements for most treatment processes. The higher degree of automation implemented, the less labor cost in future years, although the skill level of the labor must account for the increased automation.

I.7.f. Salvage Value

Salvage value, while useful in many managerial accounting decisions, is not often considered in the analysis of wastewater treatment alternatives due several factors including most municipal treatment plants are a permanent construction and it is impractical to remove and relocate the infrastructure and most municipalities maintain possession of the treatment facility throughout its useful life.

I.7.g. Present Worth Analysis

A present worth analysis is presented as the only fair approach to evaluating multiple alternatives, each with differing capital costs, replacement terms, and operation and maintenance costs. The life cycle analysis uses a 20-year term and annual operation and maintenance costs for that term.

Table I.7-1: Final Screening Net Present Value Analysis

FINAL SCREENING COST ANALYSIS				
ITEM NUMBER	**DESCRIPTION**	**MBR**	**Aero-Mod**	**STM Aerotor**
1	CAPITAL COST - CONSTRUCTION	$15,507,800	$13,384,400	$19,323,000
2	CAPITAL COST - SUPPORT	$3,026,372	$2,962,672	$3,140,772
3	OPERATION & MAINTENANCE COSTS	$6,944,000	$4,310,000	$4,360,000
	NET PRESENT VALUE	**$25,478,172**	**$20,657,072**	**$26,823,772**

I.8. Staffing Requirements

The Town of West Yellowstone currently employs one certified operator who is Class 1B, Class 2E, Class 3A and Class 3C certified. It is understood that all proposed mechanical treatment alternatives will require additional certified staff and training on the specific unit processes selected will be required.

I.9. Environmental Review

An environmental assessment will be performed for the site prior to completion of design and start of construction. Environmental impacts on the physical environment and human population will be considered in accordance with Montana Environmental Policy Act (MEPA). The environmental assessment will be performed as the project progresses and a copy of the assessment will be provided to DEQ for approval prior to completion of the design.

I.10. Final Evaluation of Alternatives

The mechanical treatment alternatives are evaluated using the criteria described below, and by establishing a weighting value and rating on how the alternatives perform in each criterion. The weight values are adjusted based on importance to the Town, while the rating scale of 0-5 is used to evaluate performance in that criterion per alternative. The criteria definitions are described below.

- Capital Costs: Initial capital costs associated with implementing a new treatment facility include: construction of the new facilities; engineering design, construction observation, inspection, and materials testing; legal; fiscal; land and right of ways; start-up and operations training; preparation of operation and maintenance manuals; mapping; administrative; and all other miscellaneous project costs necessary to have an operating treatment plant. Construction cost of the new treatment facility will be the largest cost item associated with the project. When preparing opinions of probable construction cost, the same basis of establishing cost opinions is used to evaluate all the principal alternatives and to project future costs.
- O&M/Life Cycle Costs: The annual costs for operations and maintenance (O&M) are important factors in the evaluation of alternative treatment processes. The principal elements of O&M costs are energy, chemicals and equipment replacement. A present worth analysis is performed using the estimated capital construction costs and yearly O&M costs based on a 20 year life span of the equipment.

- Footprint Size: Due to the snow accumulation and cold weather in West Yellowstone, covering the WWTP with either a building and/or basin covers is necessary. Therefore, minimizing the size of the footprint is important and affects the capital cost.
- Wastewater Industry Experience: Certain processes have a longer "track record" in use with wastewater treatment, which can present an advantage in which the bugs have been worked out in the system. Newer technologies with fewer installations may experience operational difficulties when applied to a wastewater stream with different characteristics.
- Process Flexibility: Process flexibility is defined as the ability of a process to adapt to variations in wastewater strength and wastewater quantity on a daily and seasonal basis.
- Process Complexity/Operability: Process complexity addresses the effort and skill level required of the operations staff to run the treatment system and the associated time requirements. Process complexity may be partially offset by increased plant automation; however, automation may also introduce a different type of complexity, so a different skill set is required of the operations staff. Process complexity is often a compromise with effluent quality; the relationship being that additional complexity provides greater process control and thus enhances the potential to produce a higher quality effluent. The complexity of the treatment system used will result in the amount of training and experience the operator needs.
- Power Requirements: Power is typically the largest operating budget item for a treatment plant. Mechanical treatment of water requires a plethora of pumps and equipment to move the water from one process to the next and to remove the contaminants. Electricity costs were included in the overall O&M costs. Power requirements for each alternative would have an impact on the size and complexity of a back-up power supply.
- Expandability: This describes the ease at which the process can be expanded, and may be related to complexity, costs, etc. For example, a modular system (like STM Aerotor) is easier to expand than a process that uses a proprietary arrangement of unit processes where expansion would require a complete additional train (like Aero-mod).
- Reliability/Maintainability: Process reliability refers to the ability of a process to produce an effluent of consistent quality. Reliability is a factor that is both inherent in the design and dependent upon the reliability of each piece of equipment selected by the manufacturer including valves, motors, instruments, pumps etc., all comprising the total treatment system. Reliability is salient to a treatment system because the treatment plant protects the environment. The treatment facility will accept the responsibility of meeting the discharge permit, a permit that has financial penalties associated with prolonged and egregious violations. All of the processes can produce an effluent that meets the preliminary effluent limits under normal conditions, however, their ability to reliably meet the effluent limits with fluctuating conditions varies.
- Chemical Requirements: Physical treatment processes normally require varying amounts of chemicals, primarily to achieve removal of contaminants and provide cleaning of process components. Greater chemical requirements affect the work load and safety of operations staff.

Table I.10-1presents the ranking matrix for the alternatives. The rating value ranges from 1 to 3 and reflects how each selection criteria fulfills the requirement (1 being poorly and 3 being excellently). The weight value indicates how important each criteria is. Note that a higher total value is better.

Table I.10-1: Final Screening of Alternatives

Selection Criteria	Weight	MBR		Aero-Mod		STM Aerotor	
		Rating 1=Worst 3=Best	Total Value	Rating 1=Worst 3=Best	Total Value	Rating 1=Worst 3=Best	Total Value
Capital Cost	15%	2	0.30	3	0.45	1	0.15
O&M/Life Cycle Cost	15%	2	0.30	3	0.45	1	0.15
Footprint Size	15%	3	0.45	1	0.15	2	0.30
Wastewater Industry Experience	10%	2	0.20	3	0.30	2	0.20
Process Flexibility	10%	3	0.30	1	0.10	2	0.20
Process Complexity/Operability	10%	1	0.10	3	0.30	2	0.20
Power Requirements	10%	1	0.10	2	0.20	3	0.30
Expandability	6%	2	0.12	1	0.06	3	0.18
Reliability/Maintainability	6%	1	0.06	3	0.18	2	0.12
Chemical Requirements	3%	1	0.03	3	0.09	3	0.09
Totals	100%		**1.96**		**2.28**		**1.89**

J. FINAL PROJECT SELECTION

J.1. Evaluation of Final Public Input

The findings of this study were presented to the Town council and public in a public meeting held February 5, 2020 during the normally scheduled Town Council meeting. Advertisement for the public meeting was published as usual via the Town Facebook page, the Town website, the bulletin board in Town Hall, and posted at both entrances of the Post Office (where all West Yellowstone residents receive their mail). Meeting minutes are also available for viewing in Appendix I indicating that there was no public comment given. The Town Council selected the Aero-mod WWTP with a unanimous vote. Aero-mod has provided a preliminary design which is included in Appendix I for reference. Aero-mod design details are summarized below.

J.2. Selected Alternative

The selected alternative is installation of an Aero-mod wastewater treatment plant with a 1.25 MGD average daily flow capacity. The facility unit processes are intended to be housed within buildings to minimize the impact on the surrounding residential community and to prevent freezing within the system during the winter. The treatment plant components are described in the following paragraphs. See Figure H-4 for reference to the preliminary proposed site plan. Also, see Appendix J for the Process Flow Diagram and Preliminary Sizing Calculations.

J.3. Preliminary Design of the Selected Alternative

J.3.a. Primary Treatment

The primary treatment system consists of headworks building with a screen.

Another physical process anticipated for the preliminary treatment is grit removal. Removal of grit protects downstream equipment from additional wear and assists in maintaining process efficiency from reduced tank volumes due to settled grit. A grit removal system will be designed to integrate with the proprietary Aero-mod design and to remove grit prior to secondary treatment.

The new screen and grit removal system are intended for housing in a separate room within the WWTP building. The primary treatment processes are the source of many odor complaints. By containing the preliminary treatment equipment and processes, the incidences of complaints will be significantly reduced.

J.3.b. Secondary Treatment

The secondary treatment system is the heart of the facility; it epitomizes the process selection based on the screening criteria and once selected, drives the recommendations for the other unit processes that comprise the complete treatment system. A extended aeration system, and more specifically an Aero-mod system is the recommended treatment alternative. The secondary treatment is proposed to consist of two process trains with a total of nine basins; a selector, two first stage aeration basins, two second stage aeration basins, two clarifiers, and two aerobic digesters. The process air will be provided via turbo blowers with one positive displacement blower on a VFD.

J.3.c. Wastewater Discharge

After secondary treatment, effluent will be discharged to the existing IP bed system and percolated into the groundwater in accordance with the DEQ discharge permit.

J.3.d. Solids Handling

The recommended solids handling system is to build a concrete pad to house a 20-yard roll-off dumpster. Solids will be piped to the dumpster with a filter bag installed in it. The filter bag traps the solids and allows water to pass through and out of the dumpster where it can be returned to the secondary treatment process. The filter bag is designed to produce solids capable of passing a paint filter test. The filter bags are designed to fit inside a standard 20-yard roll-off dumpster which can be hauled to the landfill to be dumped. The landfill located in Logan, Montana does accept biosolids and will be the preferred dumping location for the Town of West Yellowstone.

J.4. Justification for Selected Alternative

The justification for the recommended alternative results from evaluation of various alternatives considered against the screening criteria. The principal factors are the net present value cost, the process flexibility, the comparatively low space requirements, the ability to implement incremental expansion, and public perception combined with owner preference. See the detailed evaluation matrix shown in Table I.10-1 above.

J.5. Preliminary Design Criteria

A preliminary layout of the recommended alternative depicting sizing and location is presented in Figure H-4. Please note that as influent and effluent data continue to be collected and analyzed, these design criteria may be adjusted to better depict wastewater conditions. The final design plans will contain a final design criteria summary for the final design. However, preliminary design criteria have been developed for preliminary sizing and are presented below.

J.5.a. Preliminary Wastewater Design Criteria

A summary of the design criteria suggested for both Summer and Winter operating conditions is presented below.

Table J.5-1: WWTP Design Criteria

Parameter	Design Value (Summer)	Design Value (Winter)
Design Average Flow	1.25 MGD	0.5 MGD
Peak Hourly Flow	3.1 MGD	1.5 MGD
Design Influent Temperature	55 °F	45 °F
Design Influent BOD	325 mg/L	200 mg/L
Design Influent TSS	200 mg/L	150 mg/L
Design Influent Ammonia	85 mg/L	30 mg/L
Design Influent Total Nitrogen	100 mg/L	40 mg/L

Design Effluent BOD Limit	30/45 mg/L, 85% Removal
Design Effluent TSS Limit	30/45 mg/L, 85% Removal
Design Effluent Ammonia Limit	<10 mg/L
Design Effluent Total Nitrogen Limit	222 lb/day

J.5.b. Preliminary Screen, Grit and Solids Handling Design Criteria

The preliminary design criteria for the screening, grit removal, and solids handling equipment are presented in the table below. Note that the Town has selected a propriety process for secondary treatment and the manufacturer will provide sizing and design for the process components.

Table J.5-2: Additional Treatment Design Criteria

Description	Quantity	Units
Screens		
Type	Fine	--
Number	2	--
Peak Flow Capacity	2,153	gpm
Opening Size (Fine Screen)	6	mm
Grit Removal		
Type	Vortex	
Number	1	
Flow Capacity (each unit)	2,153	gpm
Solids Handling		
Type	Filter bag	--
Number	3	--
Solids Volume (each unit)	100	lbs/day

J.6. Capability to Finance and Manage the Project

The system owner has certified they have the capability to finance and manage the building and operation of the proposed project.

J.7. Implementation

J.7.a. Operations and Maintenance

The operation and maintenance of the facility requires manpower, electrical power, chemicals, outside services, and replacement or depreciation.

J.7.b. Manpower

Manpower requirements for the operation of the West Yellowstone WWTP are anticipated for two full time employees and one on-call employee. As the plant grows, each of these functions may become a full-time position.

- Chief operator, Plant Supervisor / Responsible Charge Operator Wastewater Treatment Class 3 license
- Assistant Chief Operator / Substitute Responsible Charge Wastewater Treatment Class 3 license (this position may be filled through an on-call arrangement with personnel from another municipality who is not an employee of this facility)
- Maintenance Technician / Wastewater operator / Wastewater Treatment II license

The budget for salaries will be established based on Industry norms for like positions adjusted for the current cost of living in the area as proposed and approved by the Town of West Yellowstone.

J.7.c. Outside Services

Outside service are limited to compliance testing by a certified testing laboratory.

J.7.d. Replacement/Depreciation

The principal facility components should be designed for a life of 20 years or more including major motors, buildings, piping and concrete.

K. APPENDICES

Appendix A – Referenced Design Plans

Appendix B – Montana DEQ Permitting Information

Appendix C – Previous Planning Documents

Appendix D – Flow Projections

Appendix E – Influent Data

Appendix F – Effluent Data

Appendix G – Sample Permit

Appendix H – Initial Alternatives Screening

Appendix I – Final Alternatives Screening

Appendix A – Referenced Design Plans

- **West Yellowstone Wastewater Treatment Plant Rehabilitation (1993)**
- **West Yellowstone WWTP Aeration Improvements (1997)**
- **West Yellowstone Short Term WWTP Upgrades (2019)**

Appendix B – Montana DEQ Permitting Information

- **Montana DEQ Town of West Yellowstone Discharge Permit (MTX000244)**
- **Montana DEQ Town of West Yellowstone Permit Fact Sheet**

Appendix C – Previous Planning Documents

- **Town of West Yellowstone 2019-2020 Capital Improvement Plan**

Appendix D – Peak Flow Data

- **Peak Hourly Flow Calculations**
  - **2019 Data**
  - **2039 Projected**
  - **Future Design**
- **Average Daily Flow Data and ERUs**
- **U.S. Census Data**

Appendix E – Influent Data

- **Influent Flow Data**
- **Influent Temperature Data**

Appendix F – Effluent Data

- **Effluent Flow Data**

Appendix G – Sample Permit

- **Montana DEQ Anaconda-Deer Lodge County Discharge Permit (MTX000231)**
- **Montanan DEQ Anaconda-Deer Lodge County Permit Fact Sheet**

Appendix H – Initial Screening

- **Initial Screening Engineer's Opinion of Probably Cost**
  - **Status Quo**
  - **Expand Lagoons**
  - **Mechanical Treatment**
- **Initial Screening O&M Costs**

Appendix I – Final Screening

- **Environmental Information**
  - **Wetlands Map**
  - **Endangered Species**
  - **Rainfall Data**
- **Final Screening Engineer's Opinion of Probably Cost**
  - **MBR**
  - **Aero-mod**
  - **STM Aerotor**
- **Final Screening O&M Costs**
- **MBR Mechanical Treatment Proposal**
- **Aero-mod Mechanical Treatment Proposal**
- **STM Aerotor Mechanical Treatment Proposal**
- **Town Council Meeting Minutes (February 5, 2020)**