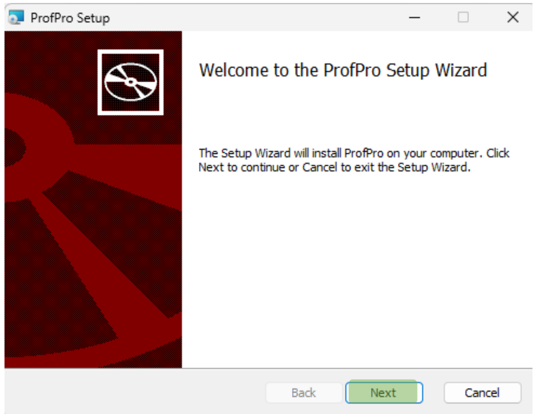
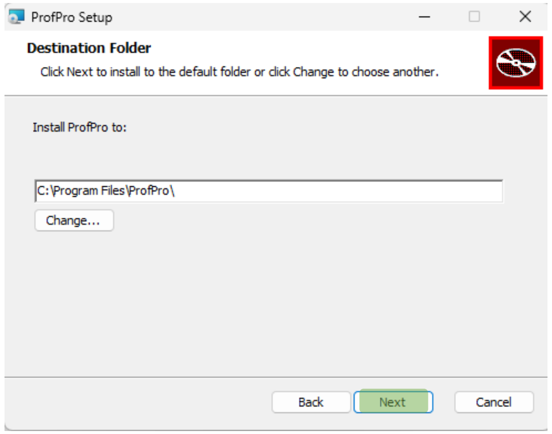
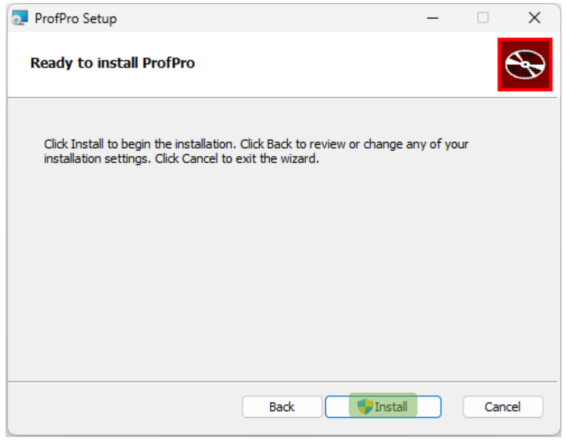
ProfPRO Manual

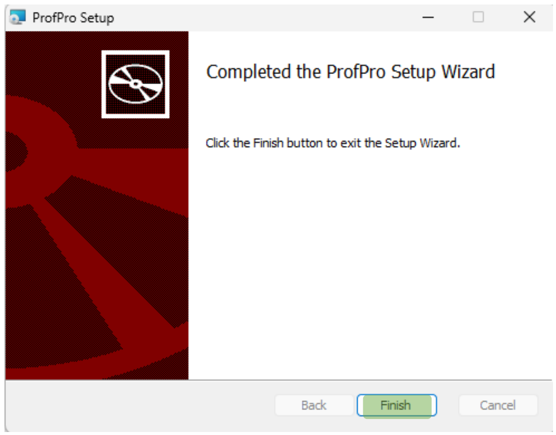
Installation of Software:

The software is supplied in a dongle USB in which the installation file exists. When the executive file “ProfPro-1.0.0” is double clicked, Installer Screen will appear. You might be asked to give privileged permissions to move on. The screenshots will guide the user for further steps.









Now your Installation is complete.

Warning: Make sure that the dongle is plugged to the computer as long as the software is being used.

CONTENTS

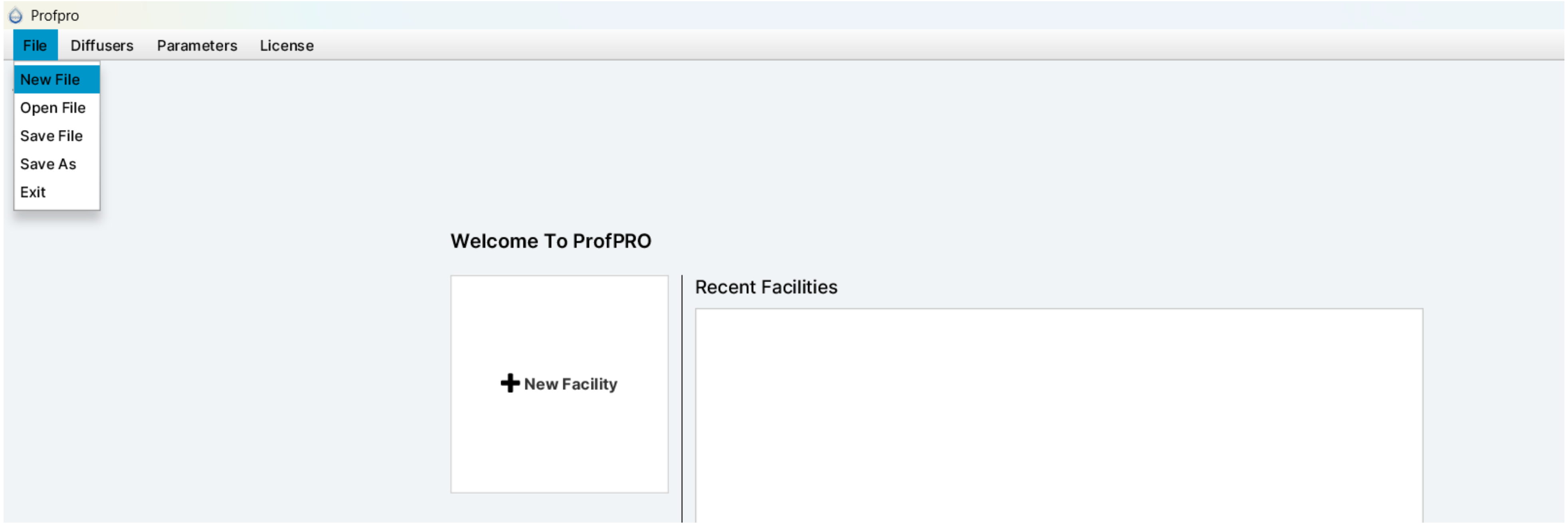
1- Installation of Software:

Hardware Requirements:

ProfPRO runs on all operating systems.

Java 21 SE must be installed

2-Main Screen and its Components



From this tab, you can form a new file and open an existing one. You can also save your work or exit from the ProfPRO software.

Diffusers:

Before starting up the software, at least one diffuser SOTE graph should be introduced. In order to do this task, SOTE graph equation estimation has to be accomplished as precise as possible.

The steps of uploading a diffuser brand are explained below;

1) SSOTE or SSTOR graph is obtained from the manufacturers. Generally, manufacturers supply the SSOTE or SSTOR data of their products in terms of gO2/Nm3/m - %1/m (Y-axis) against Air Flow Rate per diffuser (Nm3/h) (X-axis) . If the graph is not in that form, you should convert that curve in one of either form.

2) The common general formula of diffusers matched the parabolic equation:

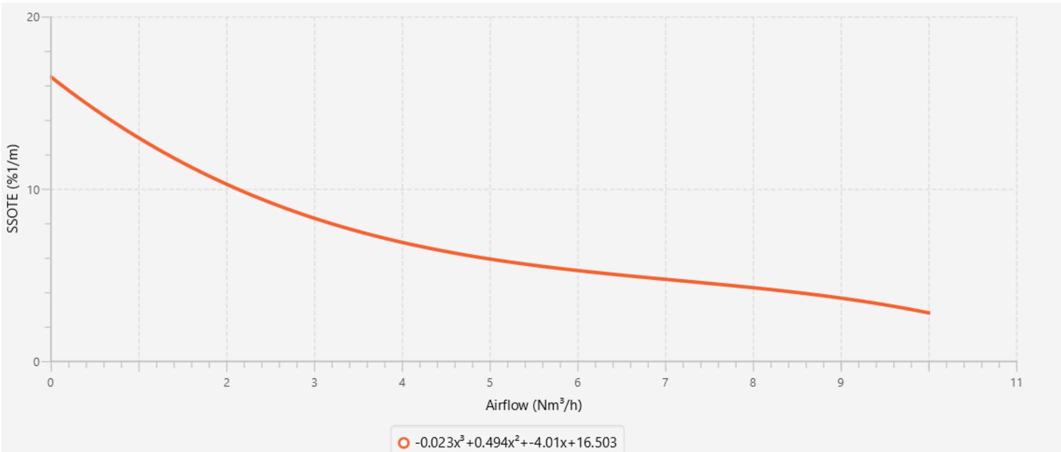
SSTOR-SSOTE ($gO_2/Nm^3/m$ or %1/m) = Y-axis

Diffuser Air Flow per diffuser (Nm^3/h)= X-axis

$Y = A*x^3+B*x^2+C*X+D$

For example;

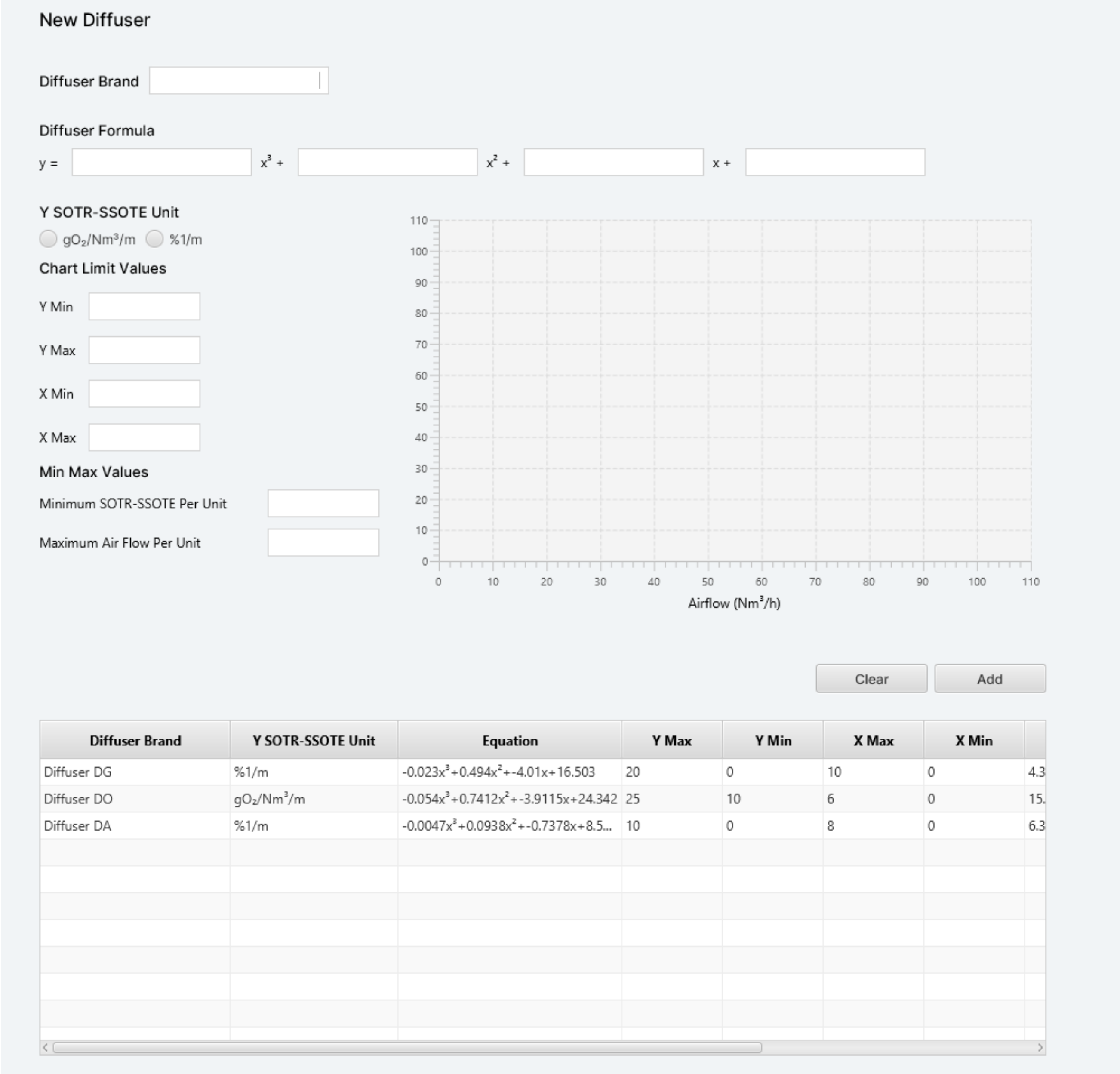
The SSOTE of the following graph is;



Once you get the original curves of any manufacturer, you can form the parabolic curve equation by using relevant software like Excel or etc.

You can upload as many curves as you like. This feature of the software allows the user flexibility in choosing the most economic diffusers and comparing them with each other.

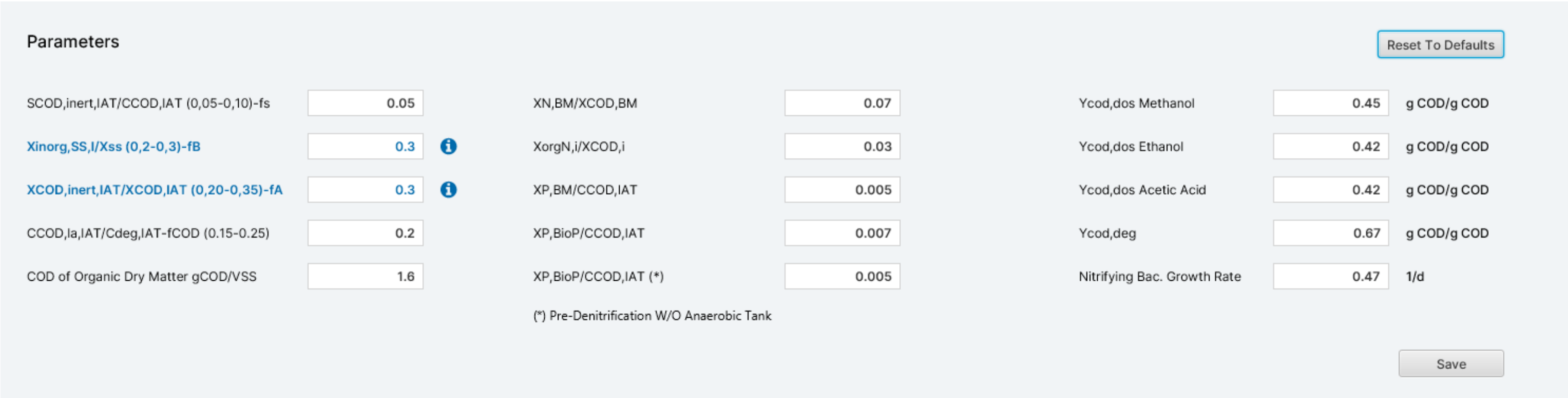
To add a new diffuser brand, select “New Diffuser” from the Diffuser tab and fill the following page;


New Diffuser
Diffuser Brand
Diffuser Formula
y =
x³ +
x² +
x +
Y SOTR-SSOTE Unit
gO₂/Nm³/m
%1/m
Chart Limit Values
Y Min
Y Max
X Min
X Max
Min Max Values
Minimum SOTR-SSOTE Per Unit
Maximum Air Flow Per Unit
110
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100 110
Airflow (Nm³/h)
Clear
Add
Diffuser Brand
Y SOTR-SSOTE Unit
Equation
Y Max
Y Min
X Max
X Min
Diffuser DG
%1/m
-0.023x³+0.494x²+-4.01x+16.503
20
0
10
0
4.3
Diffuser DO
gO₂/Nm³/m
-0.054x³+0.7412x²+-3.9115x+24.342
25
10
6
0
15.
Diffuser DA
%1/m
-0.0047x³+0.0938x²+-0.7378x+8.5...
10
0
8
0
6.3

After filling all the required fields click add and it will appear in the diffuser list.

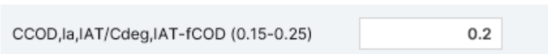
Parameters:

The parameters section is very important for process calculation. For every **"New Project"**, it is advised to check these parameters before diving into calculations. It contains the fractions of raw wastewater characterization which directly effects the sizing of volumes, oxygen requirements and sludge productions.



__Among them, the extremely important ones are;__

__These fractions above directly affect the sludge quantity and consequently the biological reactor volume and the sizes of sludge treatment units .__ Both fractions should be determined very carefully according to the real measurements in the raw wastewater or after primary sedimentation if it is a part of design.



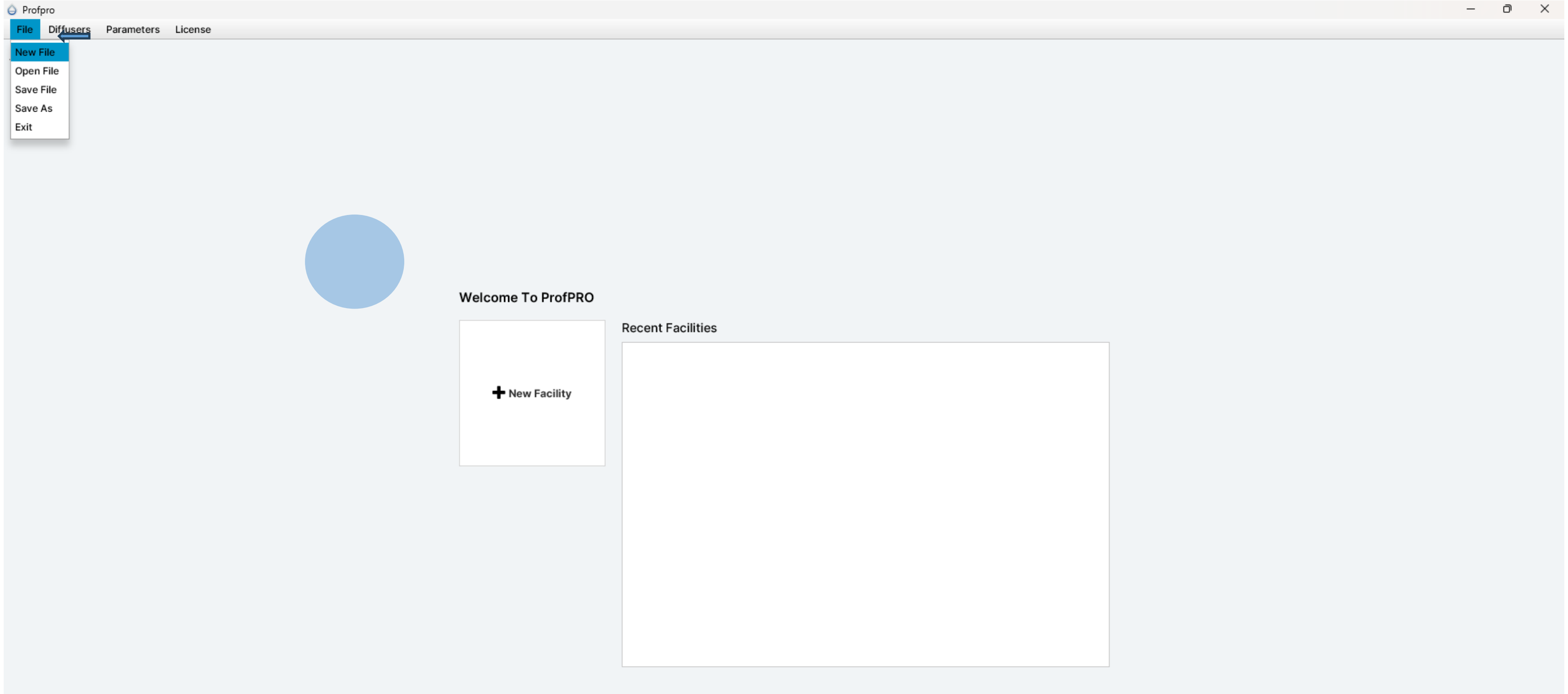
This fraction is important for biological phosphorus removal and denitrification.

This fraction of COD is not affected by biological processes and remains the same in the influent and effluent.

__The other parameters are relevant in ATV 131 E (2016)__

3-How To Form a New File:

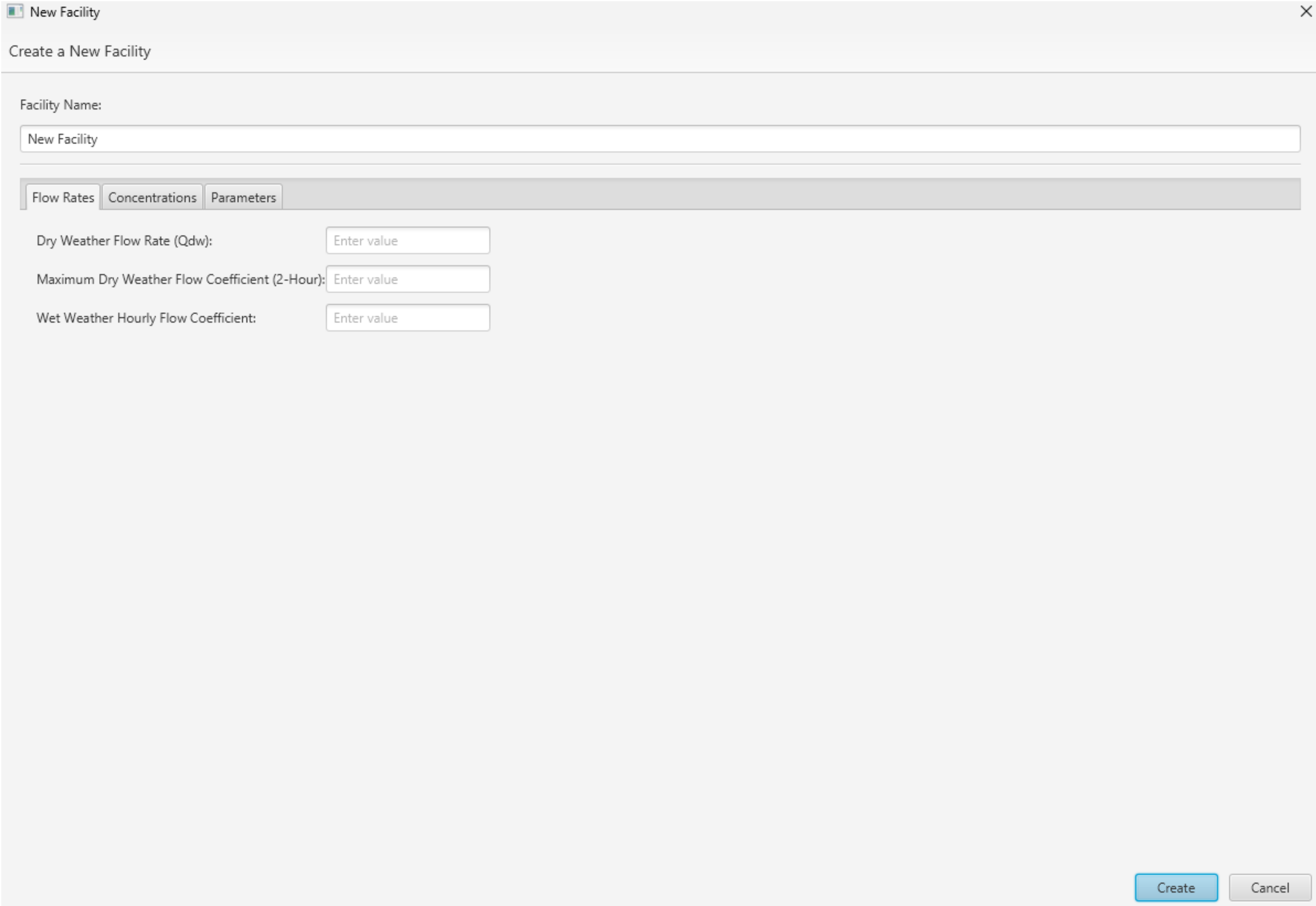
Create New Project File:



This is the welcome screen of ProfPRO, you can either select **"+New Facility"** or **"New File"** from the File tab to create a new project.

After you create or open a project, it will appear in the Recent Facilities section in the welcome screen for quick access.

Once you choose new file the following screen appears;



There are 3 tabs in the new project creation screen to be filled by user. The facility name is the name of the project, flow rates and corresponding coefficients are determined by user.

<u>ATV 198 – E (Standardization and Derivation of Dimensioning Values for Wastewater Facilities)</u> can be used for determining the “Maximum Dry Weather Coefficient” and “Wet Weather Hourly Flow Coefficient”.

In general approach, $Q_{DW,d}$ (m^3/day) = $Q_{dom,d}$ + $Q_{ind,d}$ + $Q_{inf,d}$

$Q_{DW,d}$ (m^3/day) = Average daily dry weather flow rate.

$Q_{dom,d}$ (m^3/day) = Average daily domestic flow rate.

$Q_{ind,d}$ (m^3/day) = Average daily industrial flow rate.

$Q_{inf,d}$ (m^3/day) = Average daily constant infiltration flow rate.

$Q_{DW,24hAve}$ (m^3/h) = 24 hour average hourly flowrate.

In order to calculate maximum 2 hourly flow rate “$Q_{DW,h}$”, the following graph can be used according to ATV 198 -E.

$$Q_{DW,max}, Q_{DW,h,max} \text{ resp. } Q_{DW,2h,max} = \frac{24 \cdot Q_{WW,aM}}{x_{Qmax}} + Q_{Inf,aM} \quad \text{[l/s]} \quad (11)$$

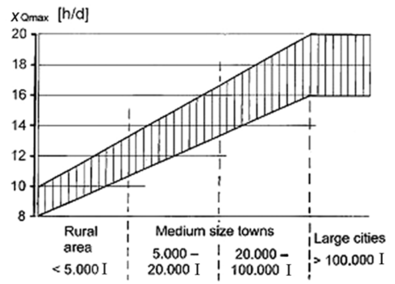


Fig. 2: Divisor x_{Qmax} dependent on the size [number of residents] of the [catchment] area *[Authors' afternotes]*

In other word, $Q_{DW,h} = Q_{DW,d} / x$ and it is totally dependent of the size of the treatment plant. In the past advisory documents, x values change as in the following table;

Treatment Plant Capacity (PE)	Corresponding x-factor
>200.000	20
>50.000	18
>20.000	16
>5.000	14
<5.000	12

The maximum 2 hourly flow rate “$Q_{DW,h}$” (m^3/hour), is the design flowrates of the following units;

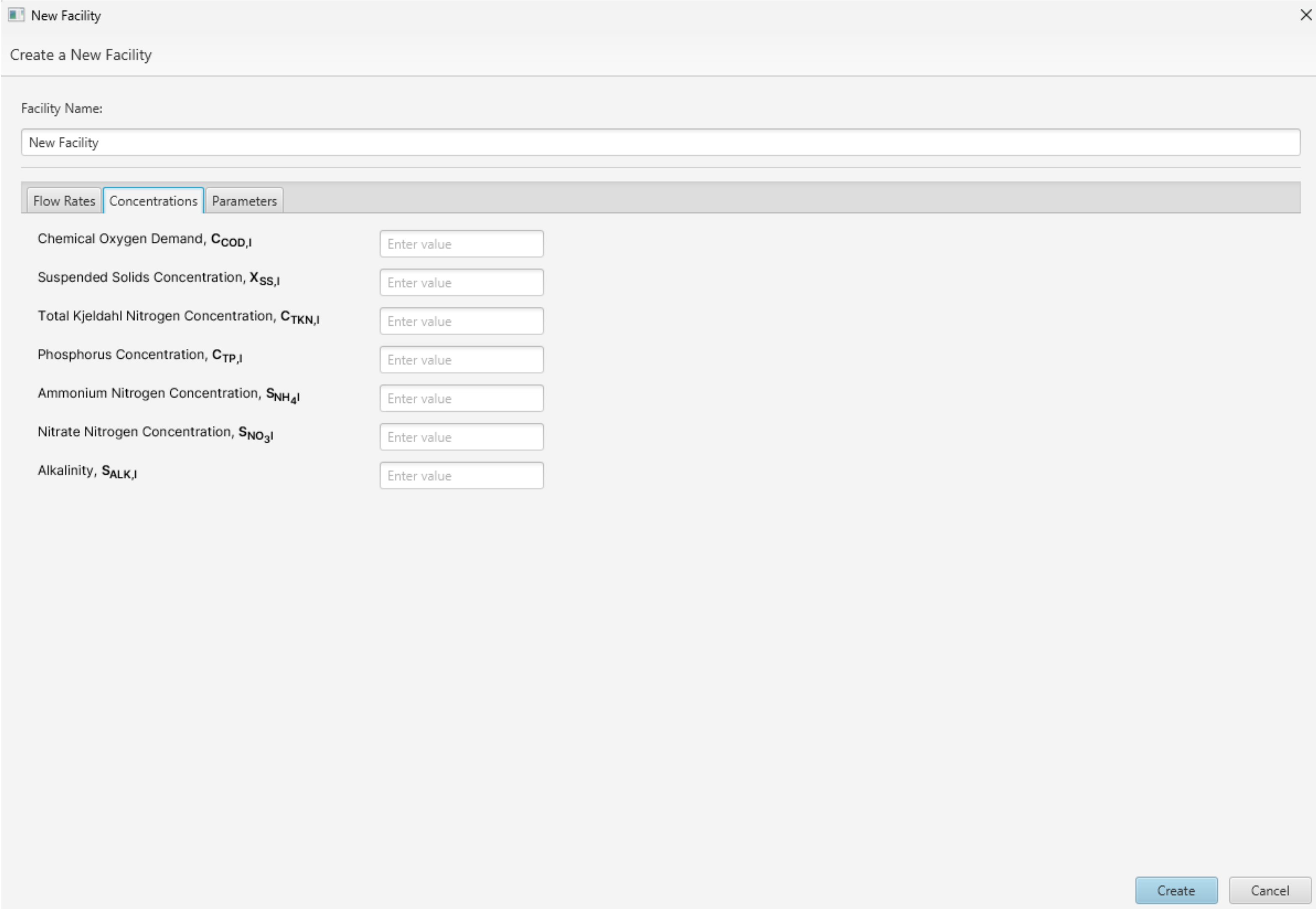
1- Primary Sedimentation Tank Volume (m^3)
2- Grit and Grease Chamber design check for grease loading. (qA) (m/h)
3- Anaerobic Biological Phosphorus Removal Tank Volume (m^3)
4- Internal Recirculation Pump Capacity (m^3 / h)
5- Return Sludge Pump Staging. (m^3 / h)

Wet Weather Flow (Maximum Hourly Flow) $Q_{WW,h}$ (m^3/h) is totally dependent on the sewerage collection network which can be either separated or collective system. Wastewater treatment plants cannot be designed to treat the whole stormwater flow. In many countries, $Q_{WW,h}$ is equal to maximum 2 - 2.5 x $Q_{DW,24hAve}$.

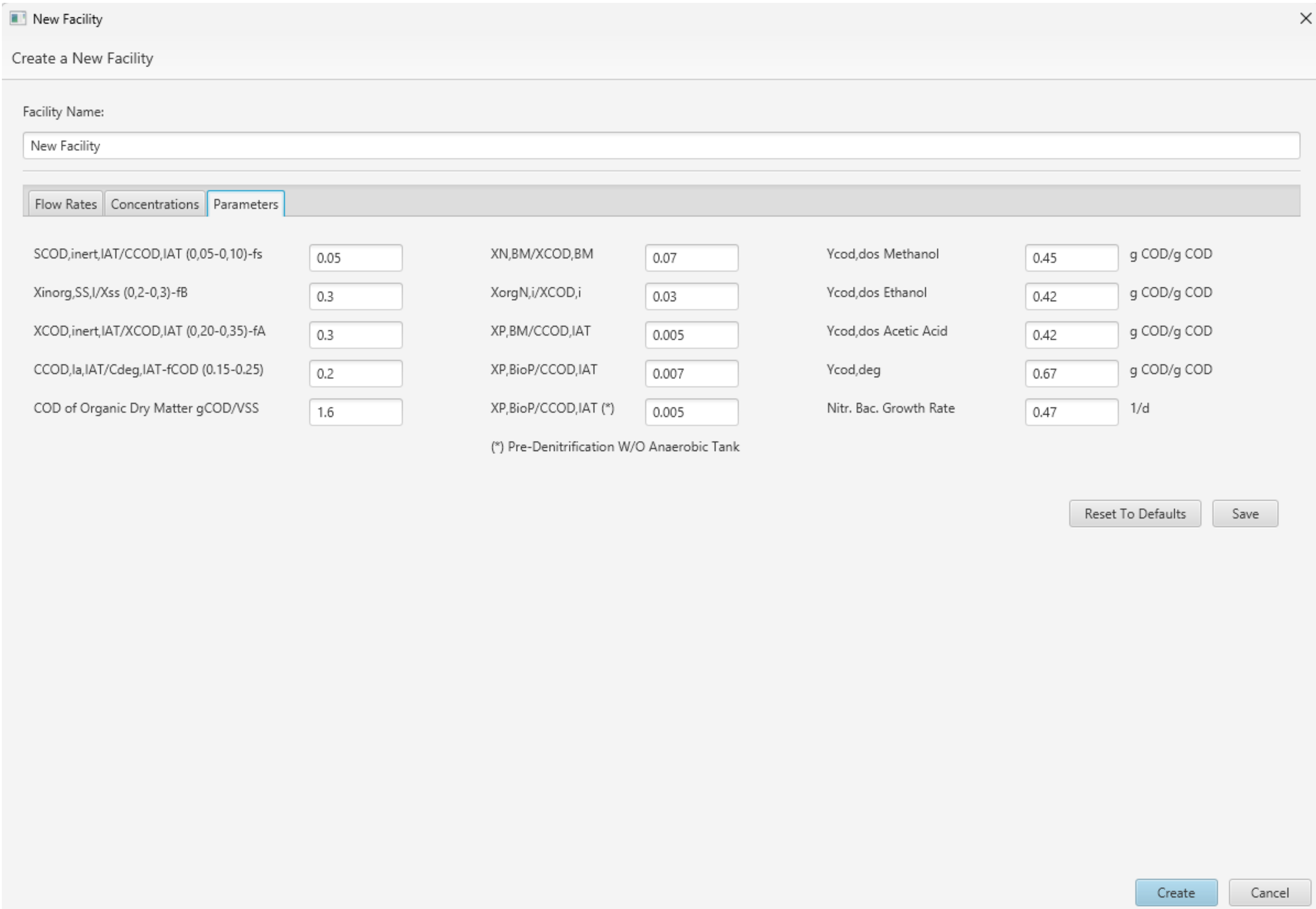
The wet weather flow rate “$Q_{WW,h}$” (m^3/h), is the design flowrates of the following units;

1- Coarse and fine screens
2- Inlet pumping stations
3- Grit and grease chamber
4- Return sludge pumping stations
5- Open channels
6- Secondary sedimentation tanks

$Q_{DW,d}$ (m^3/day) = Average daily dry weather flow rate is the design flowrate for calculation of pollutant loads and therefore for sizing the biological reactor volume.

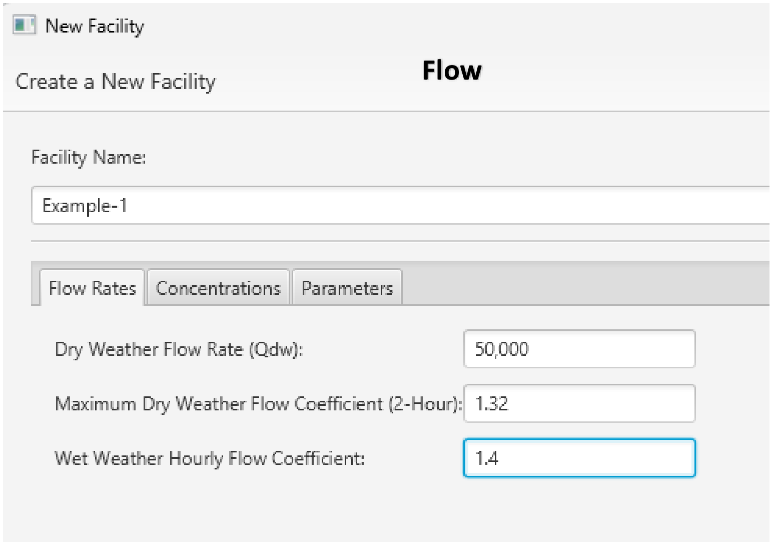


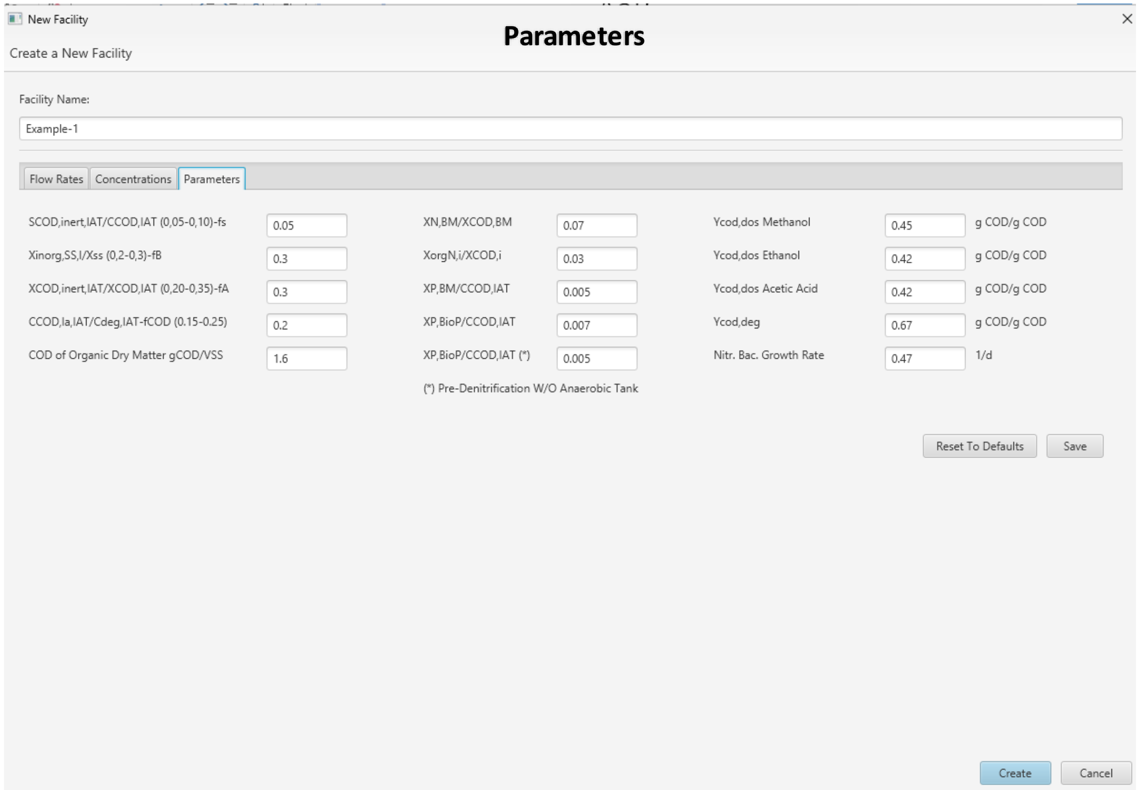
On the Concentrations Tab, you identify **THE CONCENTRATIONS OF INFLUENT IN THE RAW WASTEWATER AFTER GRIT AND GREASE CHAMBER AND BEFORE PRIMARY SEDIMENTATION TANK.**

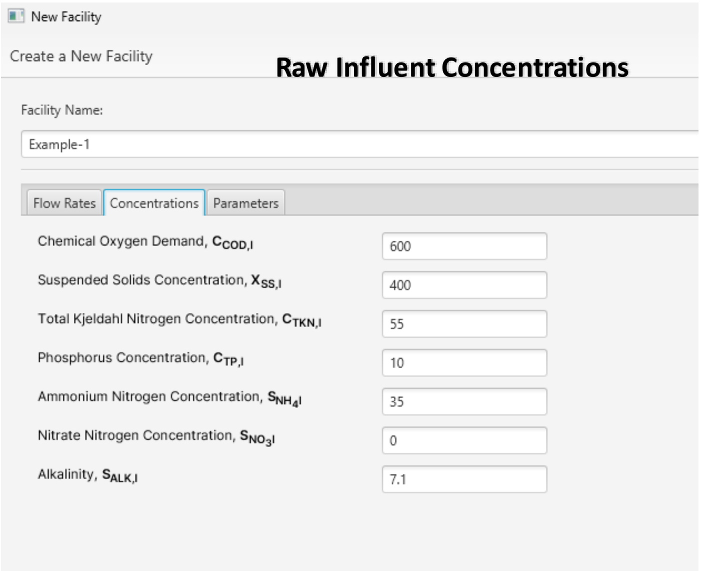


Before starting the WWTP design calculations, you are able to change the parameters, or you can just accept the default values.

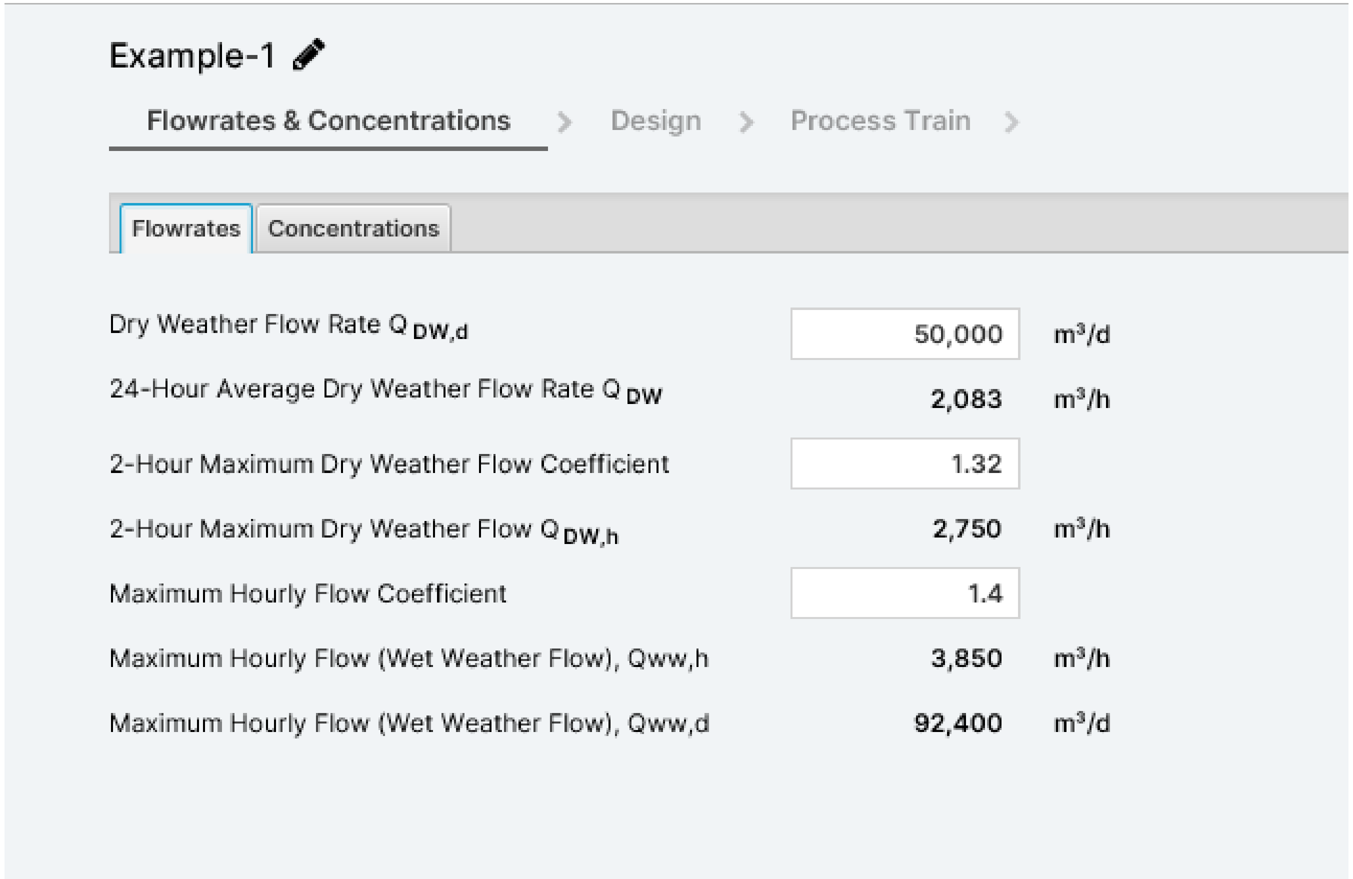
Here is an example of a treatment plant which has flowrates of; $Q_{DW,d}$ = 50.000 m^3/day, $Q_{DW,h}$ = 2.750 m^3/h, $Q_{WW,h}$ = 3.850 m^3/h





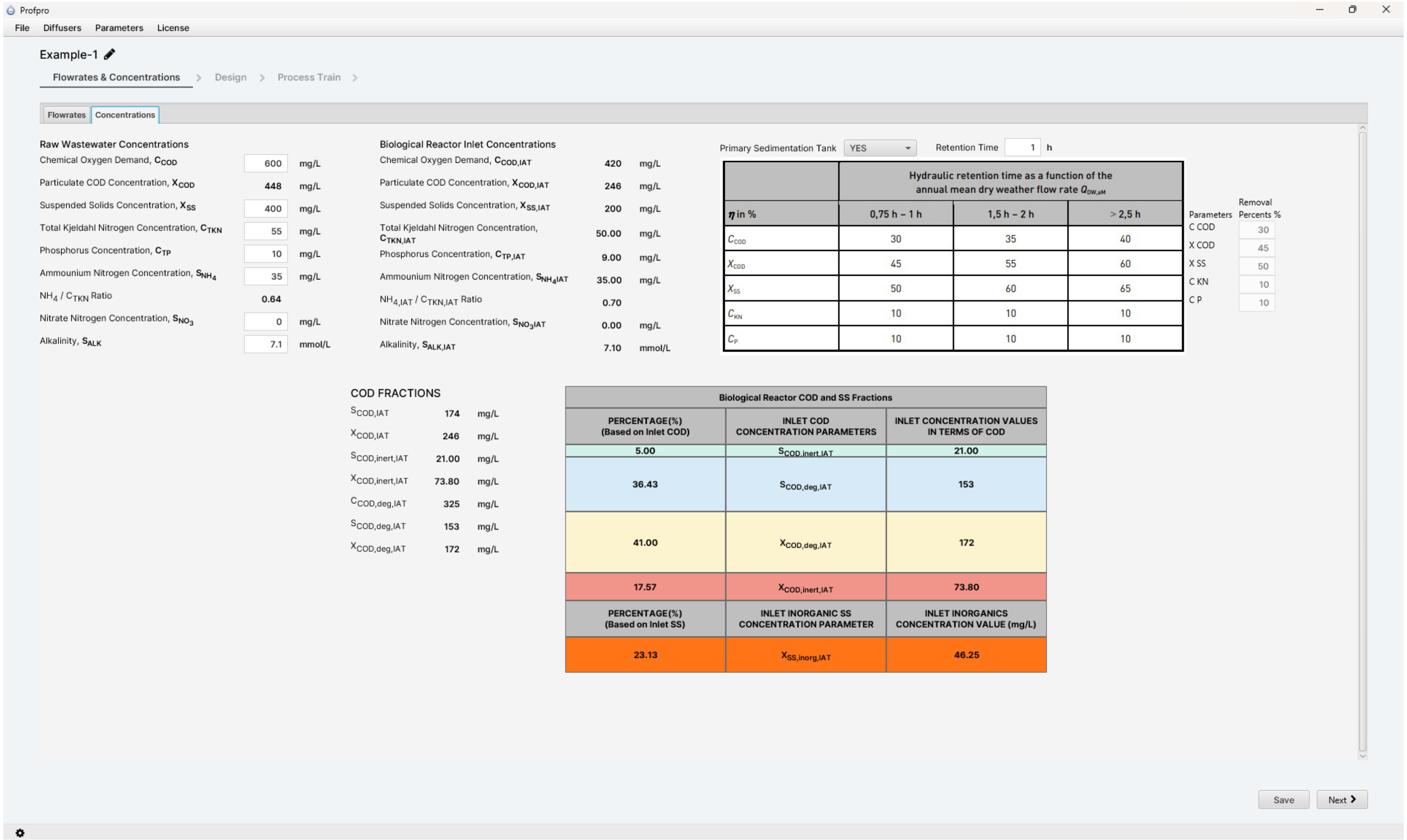


Once filled all empty fields, press **“Create”** button then the project file is formed for further calculations, and **“Flowrates”** and “**Concentrations”** tabs screen appears;



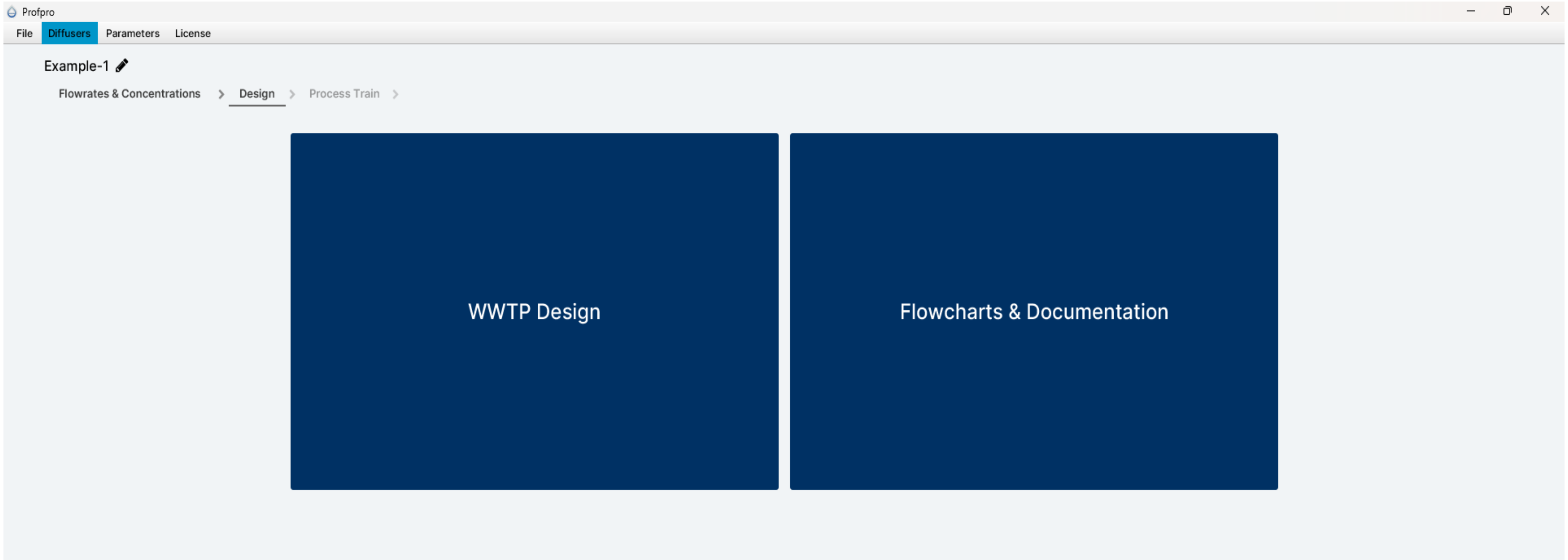
Daily and hourly flow rates, which will be the reference data for relevant units in WWTP, is shown in the **“Flowrates”** tab.

"Concentrations" tab is the second section in this page.

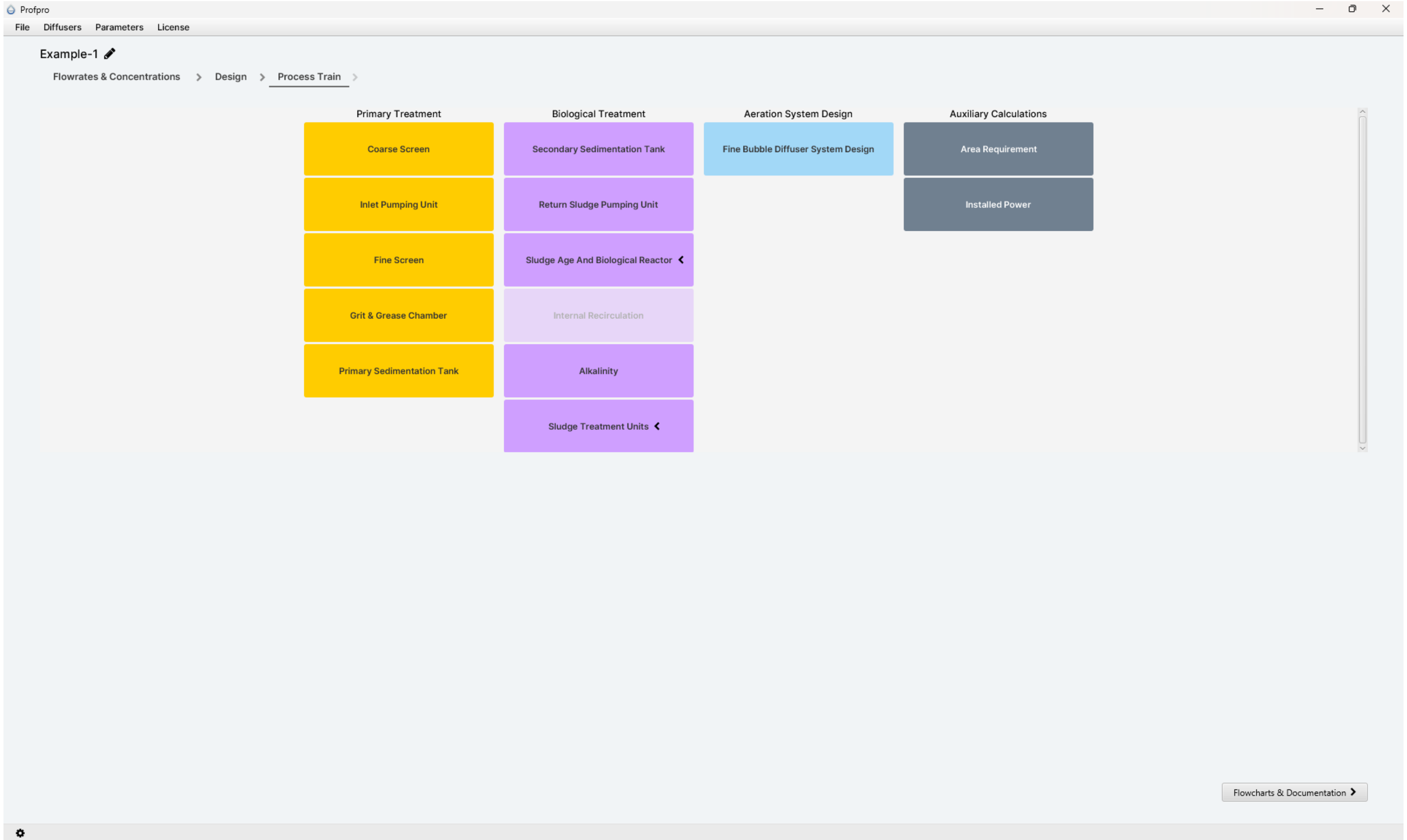


Here the concentrations are *calculated based on the choice of primary sedimentation tank and its retention time according to ATV 131-E (2016) Table 2.* There are 3 options for primary sedimentation tank (“YES”, “NO” and “CUSTOM”). *In the custom selection, removal percentages can be determined by the user, which allow the user to choose his/her own measured percentages.*
The COD fractions are calculated according to the fractions already identified in the **“Parameters”** section.

Click **“Next”** for further steps. After clicking **“Next”**, the user will see the following screen;



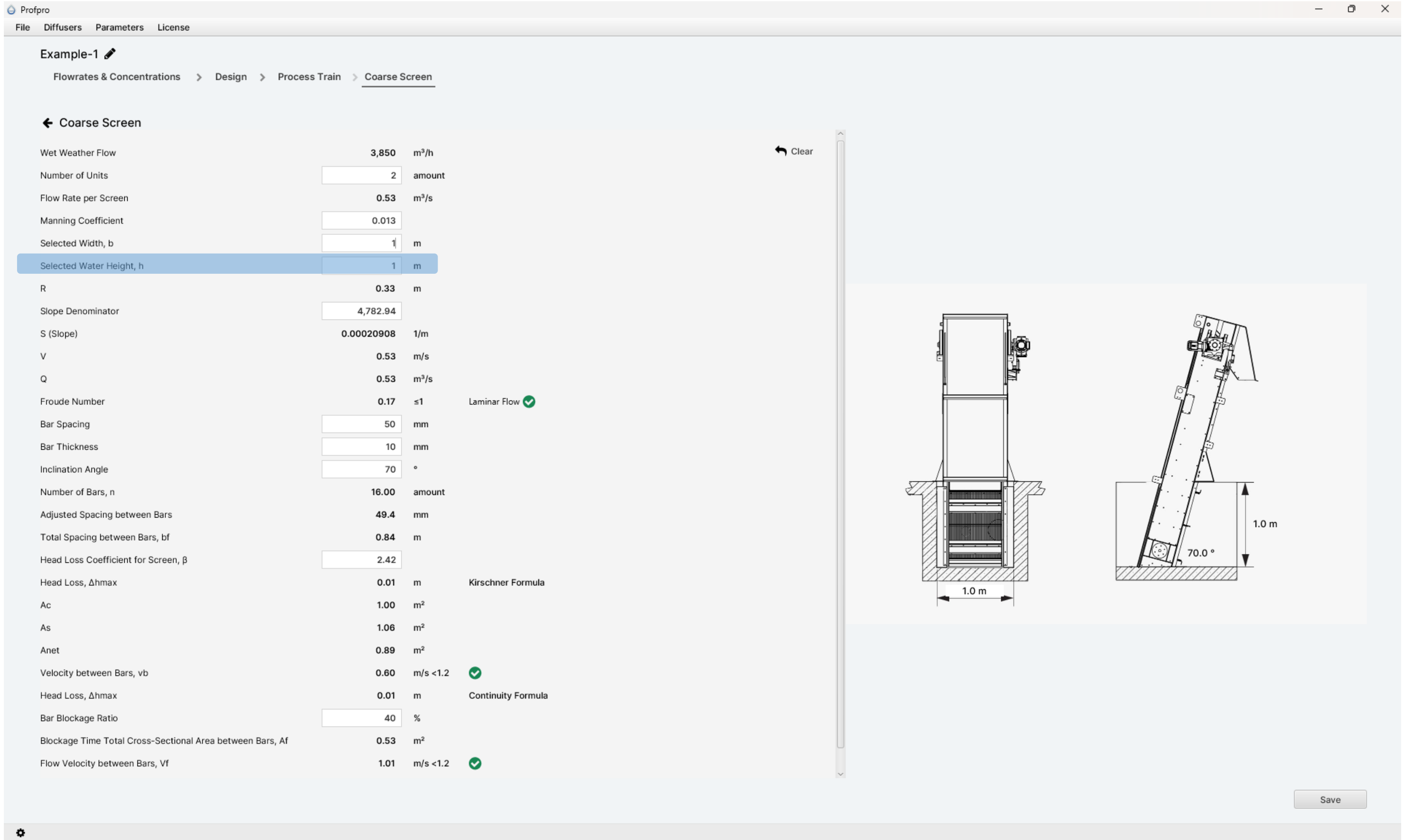
Now, the user should press on **“WWTP Design”** button to design the units one by one. After clicking **“WWTP Design”** button following page appears;



This is the main design module of all units. Designing all units in each line (Primary Treatment-Biological Treatment-Aeration System Design-Auxiliary Calculations) is explained one by one in the sections below;

Primary Treatment Line:

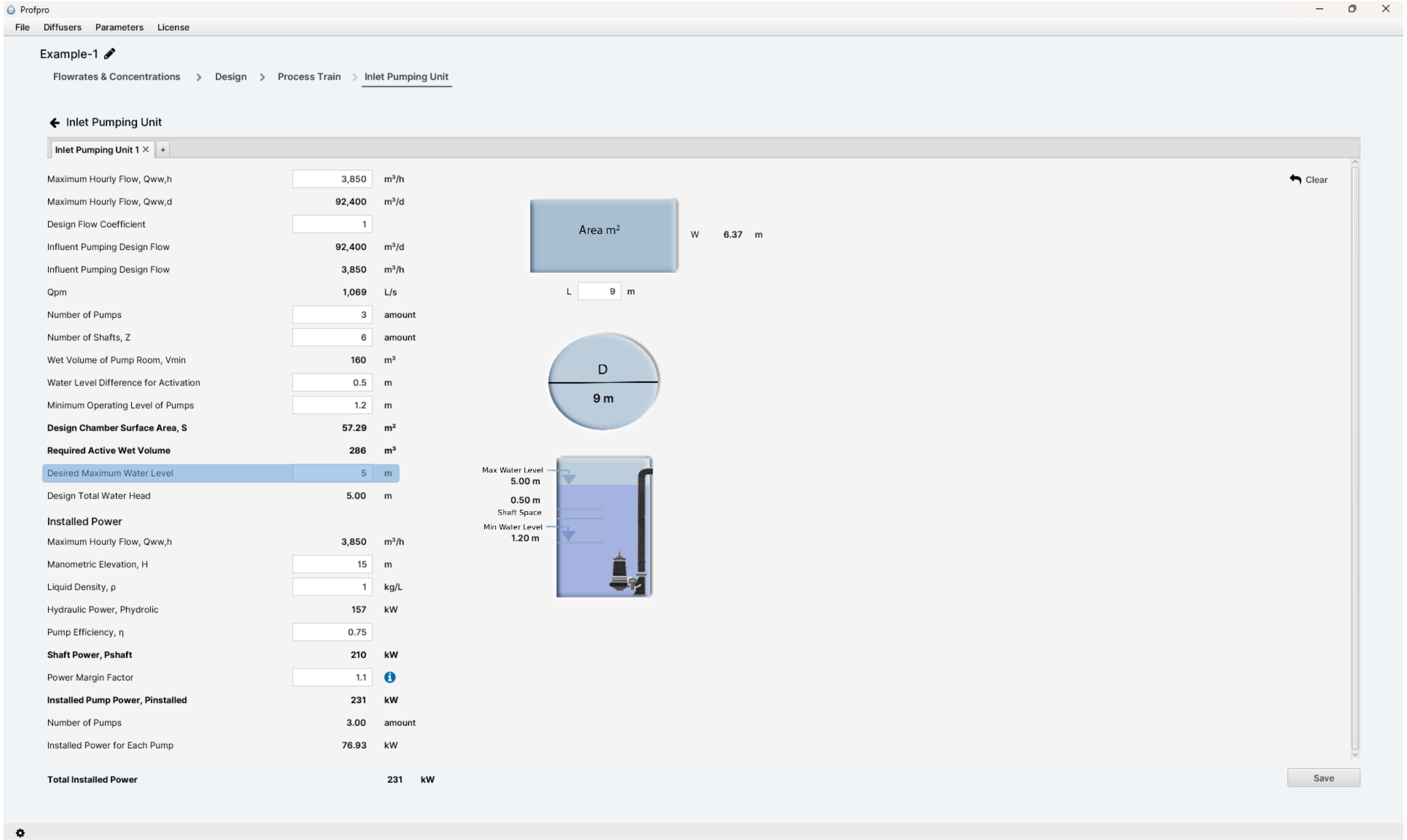
Coarse Screen:



Once filled the empty fields, coarse screen design is completed. The selected water height is determined based on the hydraulic profile of downstream weir height.

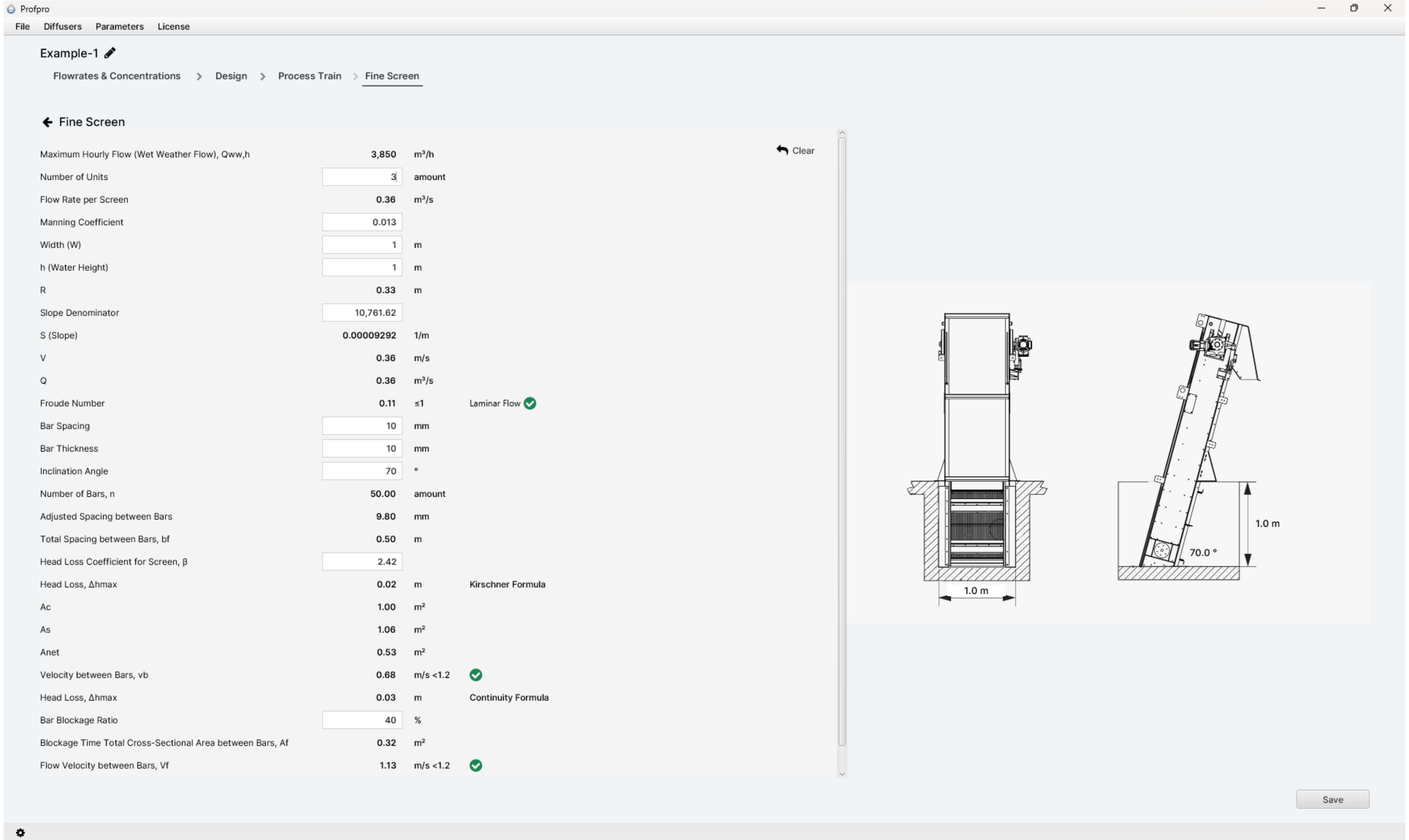
DIN EN12255-3 Preliminary treatment is the reference document.

Inlet Pumping Unit:



<u>*Suction line and pressure line head losses, which might be estimated or calculated properly*</u>, can be added to the Manometric Head value to calculate the power more precisely. *ATV 134 E "Planning and Construction of Wastewater Pumping Stations" (2000) is the reference document.*

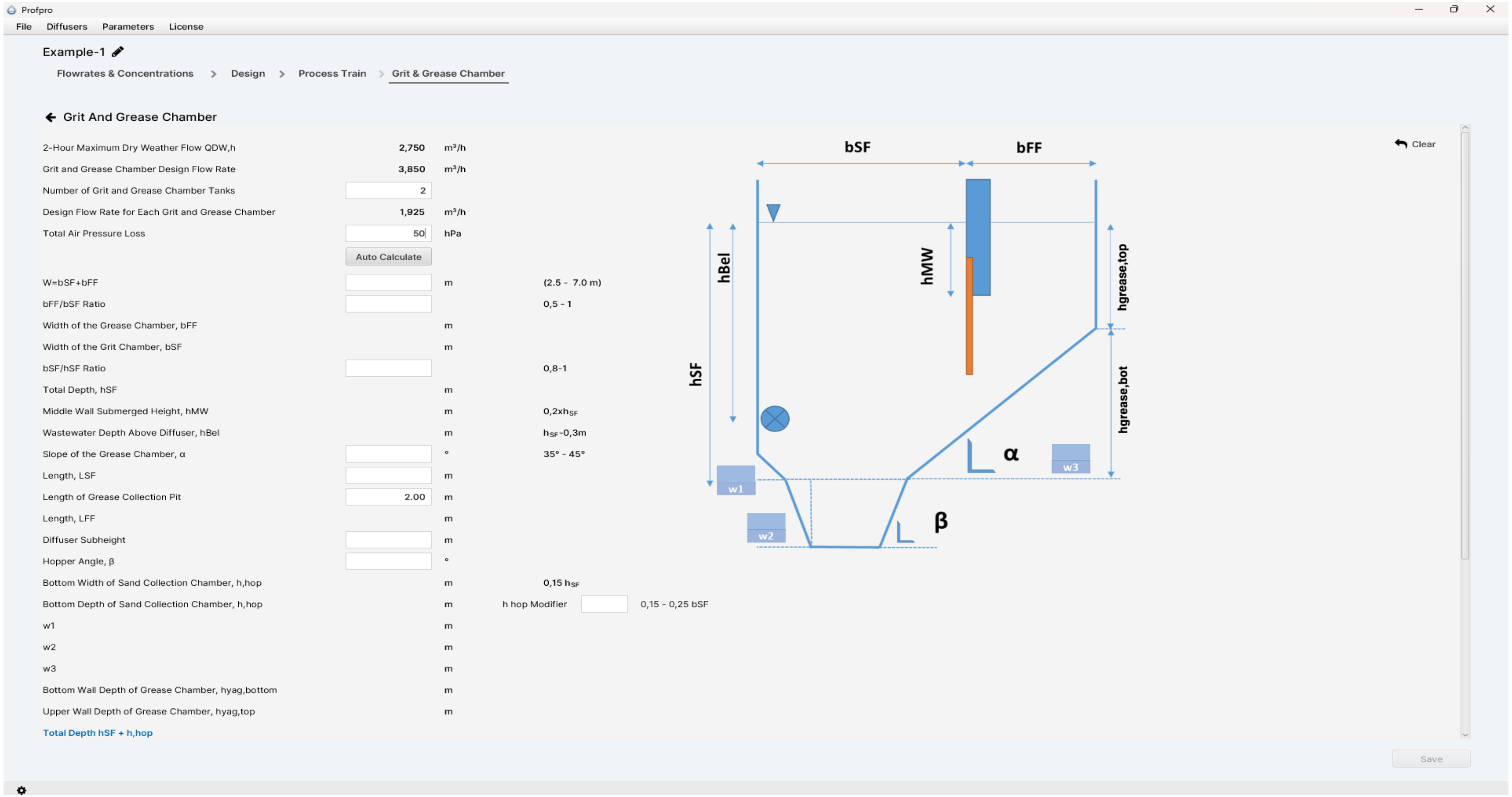
Fine Screen:

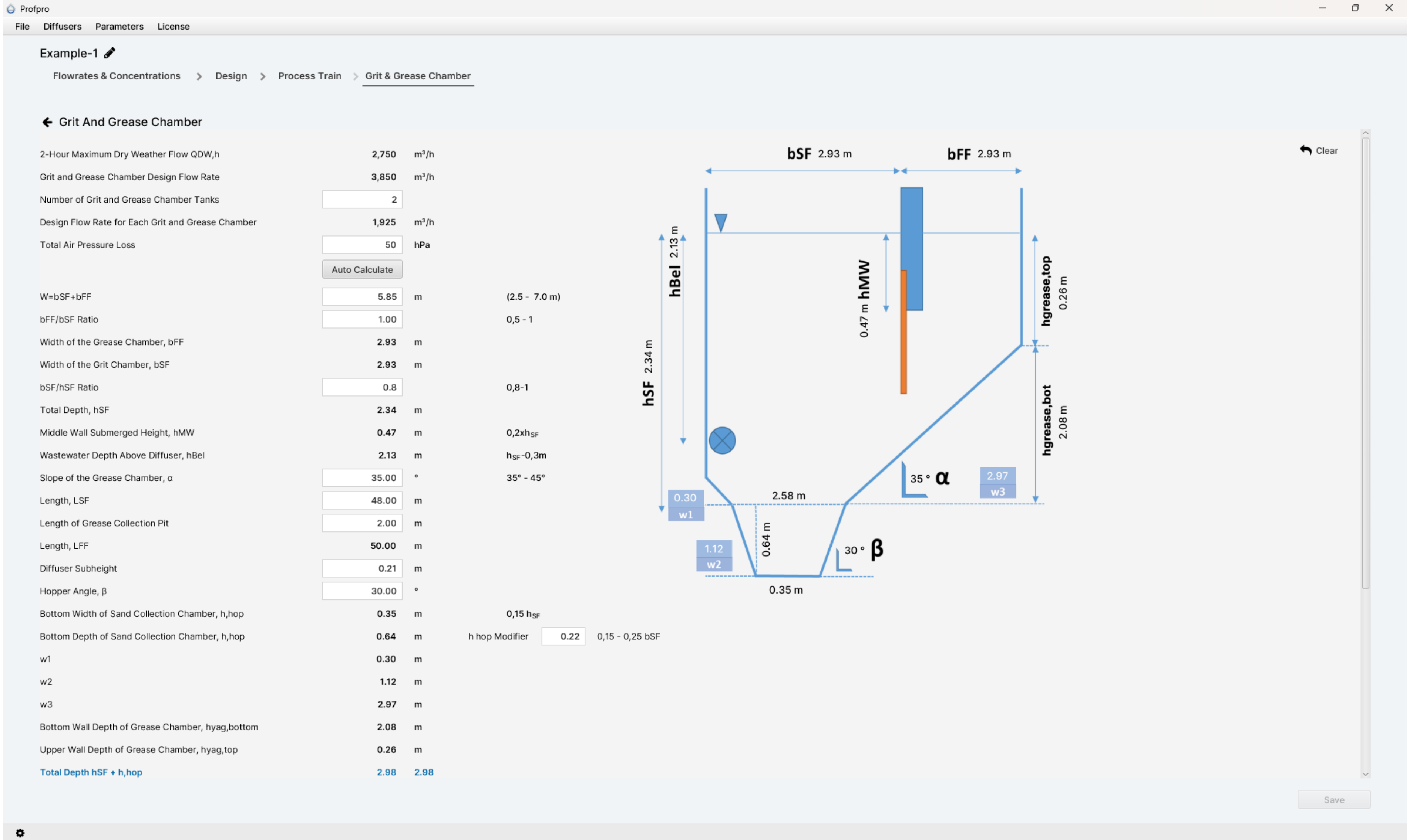


The methodology is the same as Coarse Screen Unit. The selected water height is determined based on the hydraulic profile of downstream weir which is located generally after grit-grease chamber unit. *DIN EN12255-3 Preliminary treatment is the reference document.*

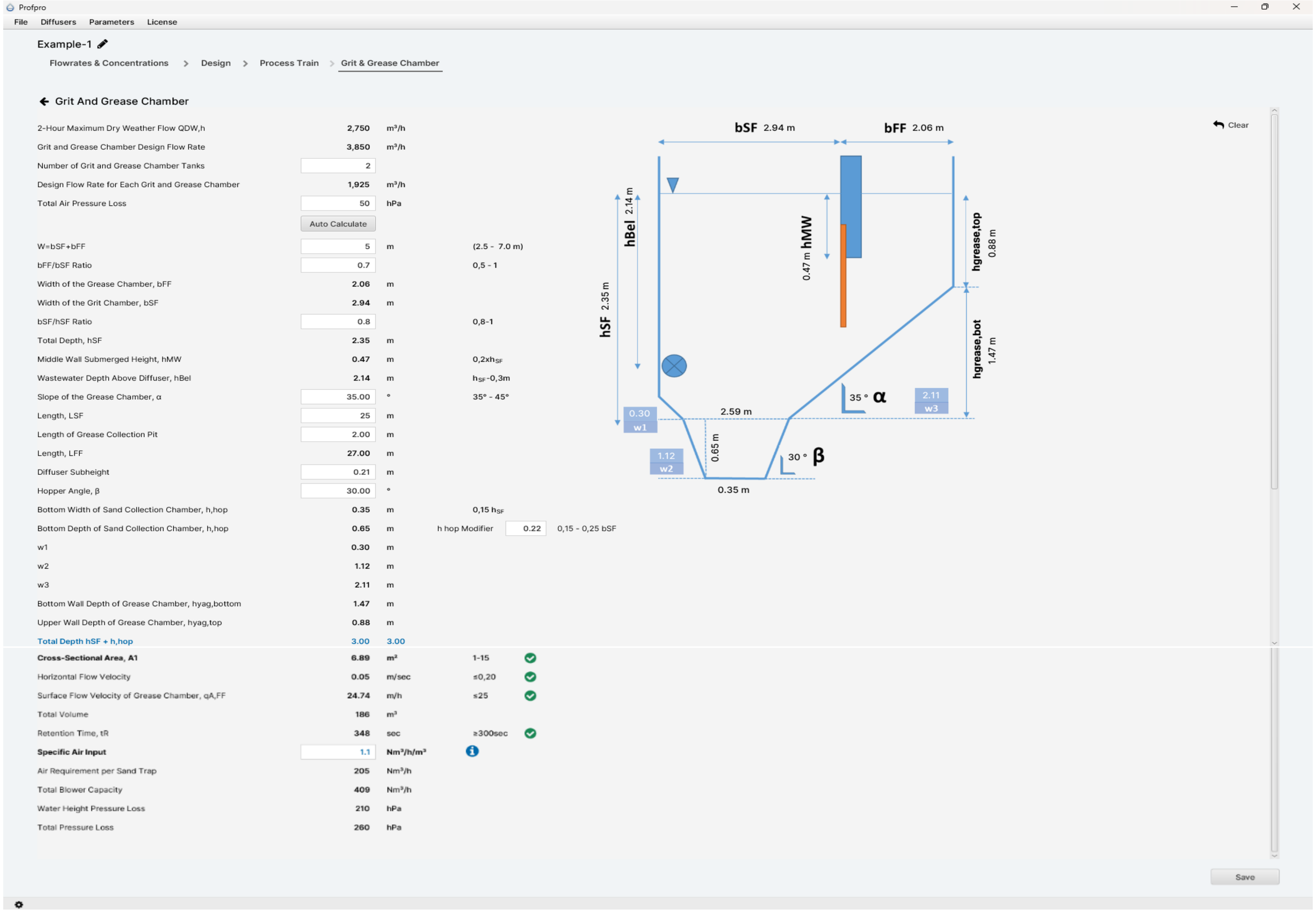
Grit & Grease Chamber:

ProfPRO automatically calculates the sizing of the Grit and Grease Chamber Unit by **“Auto Calculate”** button.





Total Air pressure loss is the total head loss except for water height pressure loss. Once Pressed **"Auto Calculate"**, ProfPRO automatically calculates the grit chamber design. Now you can adjust your own design choices by changing the values already calculated by the software.

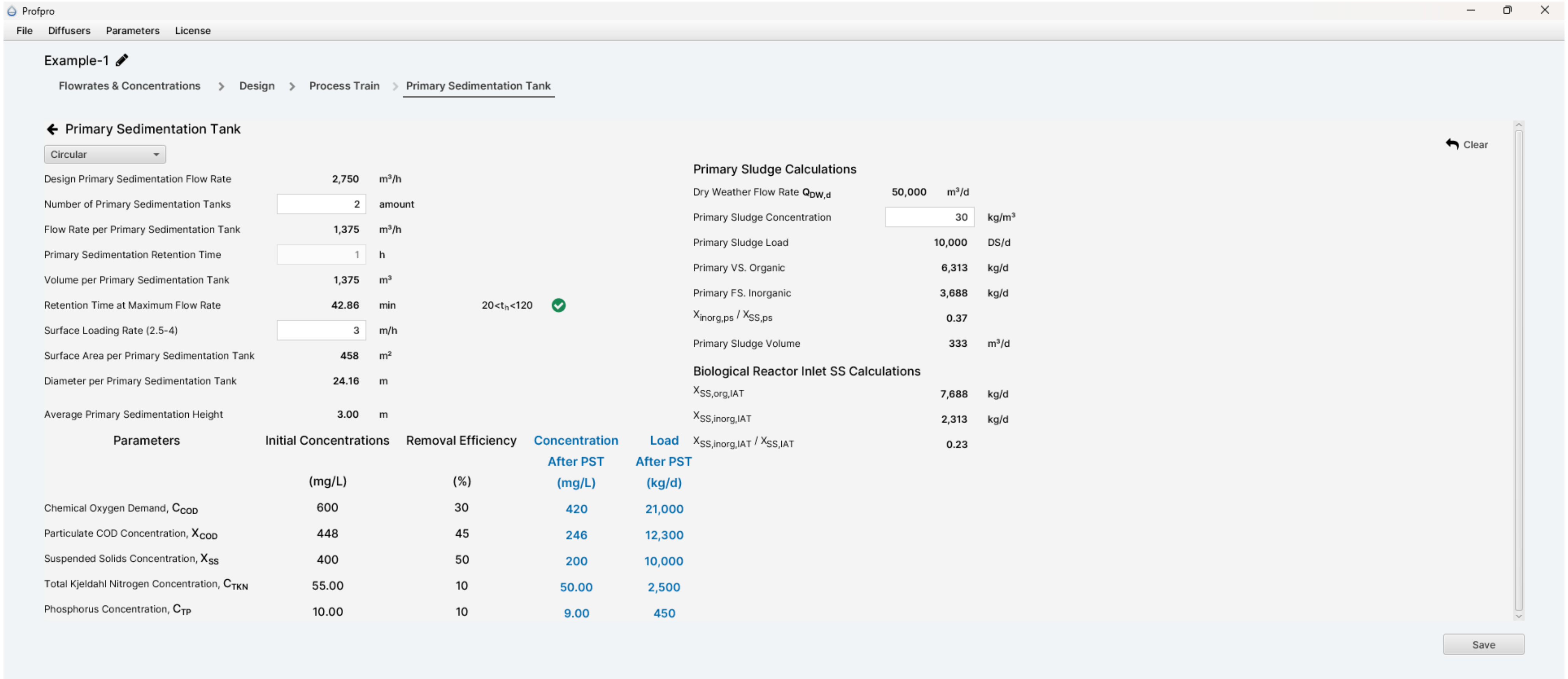


Profpro
File Diffusers Parameters License
Example-1
Flowrates & Concentrations > Design > Process Train > Grit & Grease Chamber
Grit And Grease Chamber
2-Hour Maximum Dry Weather Flow QDW,h 2,750 m³/h
Grit and Grease Chamber Design Flow Rate 3,850 m³/h
Number of Grit and Grease Chamber Tanks 2
Design Flow Rate for Each Grit and Grease Chamber 1,925 m³/h
Total Air Pressure Loss 50 hPa
Auto Calculate
W=bSF+bFF 5 m (2.5 - 7.0 m)
bFF/bSF Ratio 0.7 0,5 - 1
Width of the Grease Chamber, bFF 2.06 m
Width of the Grit Chamber, bSF 2.94 m
bSF/hSF Ratio 0.8 0,8-1
Total Depth, hSF 2.35 m
Middle Wall Submerged Height, hMW 0.47 m 0,2xhSF
Wastewater Depth Above Diffuser, hBel 2.14 m hSF-0,3m
Slope of the Grease Chamber, α 35.00 ° 35° - 45°
Length, LSF 25 m
Length of Grease Collection Pit 2.00 m
Length, LFF 27.00 m
Diffuser Subheight 0.21 m
Hopper Angle, β 30.00 °
Bottom Width of Sand Collection Chamber, h,hop 0.35 m 0,15 hSF
Bottom Depth of Sand Collection Chamber, h,hop 0.65 m h hop Modifier 0.22 0,15 - 0,25 bSF
w1 0.30 m
w2 1.12 m
w3 2.11 m
Bottom Wall Depth of Grease Chamber, hyag,bottom 1.47 m
Upper Wall Depth of Grease Chamber, hyag,top 0.88 m
Total Depth hSF + h,hop 3.00 3.00
Cross-Sectional Area, A1 6.89 m² 1-15
Horizontal Flow Velocity 0.05 m/sec ≤0,20
Surface Flow Velocity of Grease Chamber, qA,FF 24.74 m/h ≤25
Total Volume 186 m³
Retention Time, tR 348 sec ≥300sec
Specific Air Input 1.1 Nm³/h/m³
Air Requirement per Sand Trap 205 Nm³/h
Total Blower Capacity 409 Nm³/h
Water Height Pressure Loss 210 hPa
Total Pressure Loss 260 hPa
Clear
bSF 2.94 m
bFF 2.06 m
hBel 2.14 m
hSF 2.35 m
0.47 m hMW
hgrease,top 0.88 m
hgrease,bot 1.47 m
2.59 m
35 ° α
0.30 w1
1.12 w2
2.11 w3
0.65 m
30 ° β
0.35 m
Save

Parameter	Recommended Range of Values
Horizontal flow velocity	≤ 0.20 m/s
Width/depth ratio b_{SF}/h_{SF}	0.8–1.0
Cross-sectional area A⊥ (without grease trap)	1 m² – 15 m²
Detention time tR	≥ 300 s
Tank length L_{SF}	> 10 × bSF < 50 m
Submergence depth h_{Bel}	h_{SF} – 0.3 m
Specific air input (related to tank volume, without grease trap chamber)	0.5–1.3 m³/(m³ × h)
Immersion depth of the middle wall (without installations) h_{MW}	approx. 0.2 × h_{SF}
Bottom cross slope of grease trap chamber α	35°–45°
Width of grease trap chamber b_{FF}	0.50 to 1.00 × b_{SF}
Surface load of the grease trap chamber $q_{A,FF}=Qt/A_{FF}$	≤ 25 m/h (for dry weather inflow)
Grit channel: depth	approx. 0.15 × h_{SF}
Grit channel: top width	0.15 to 0.25 × b_{SF}

The table above is included in the document of *Grit Chambers – Requirements, Systems and Dimensioning Work Report of DWA Technical Committee (2008)* as constraints and recommendations in the grit & grease chamber design.

Primary Sedimentation Tank:



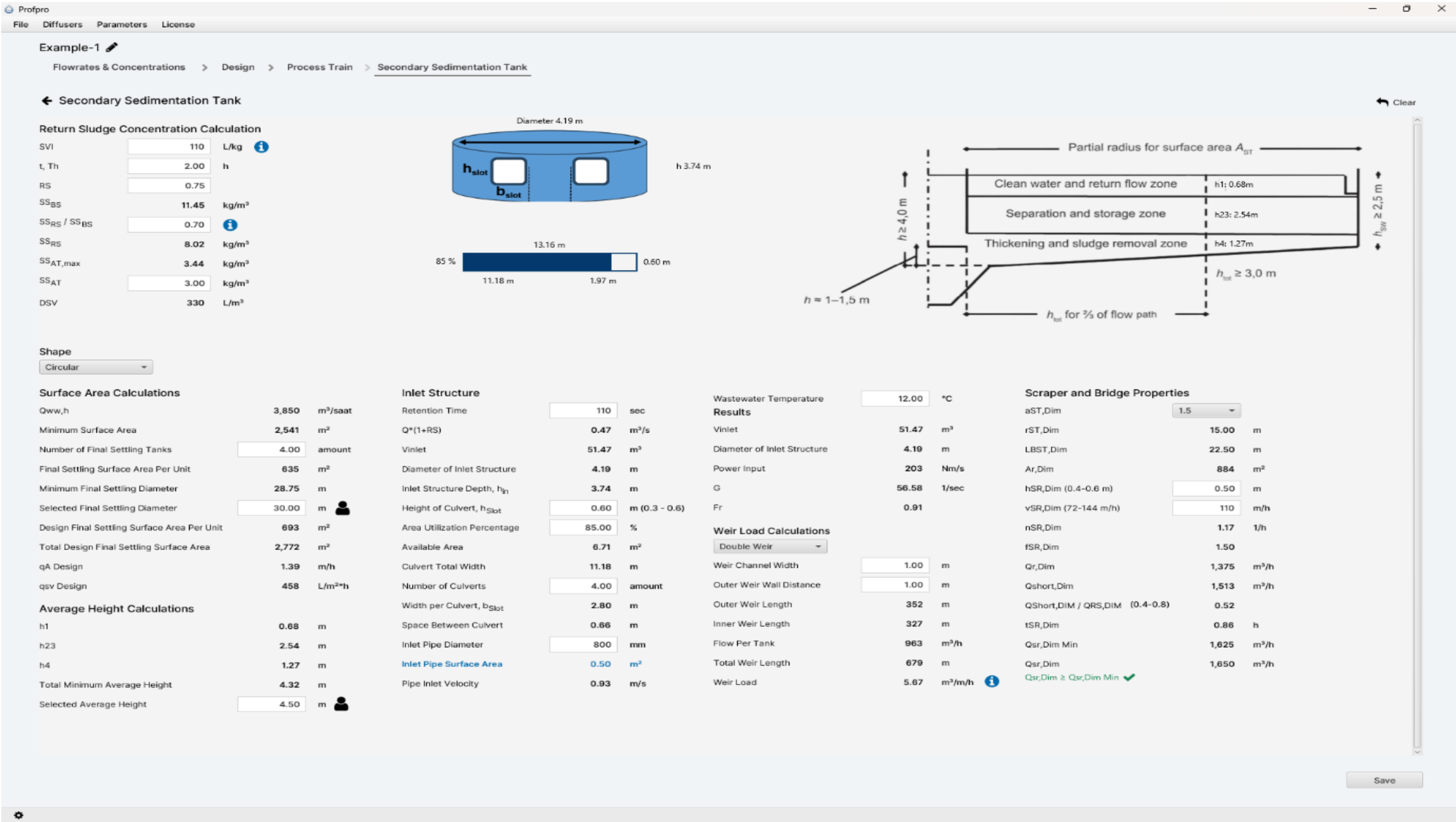
In **“Primary Sedimentation Tank”** the user first chooses the shape (“Circular” or “Rectangular”). Once the user fills all the empty fields, pollutant loads after primary sedimentation tank and the primary sludge calculations is made by ProfPRO.

ATV 131 E (2016) and DWA Topics – Design of wastewater treatment plants in hot and cold climates (May 2019) are the reference documents.

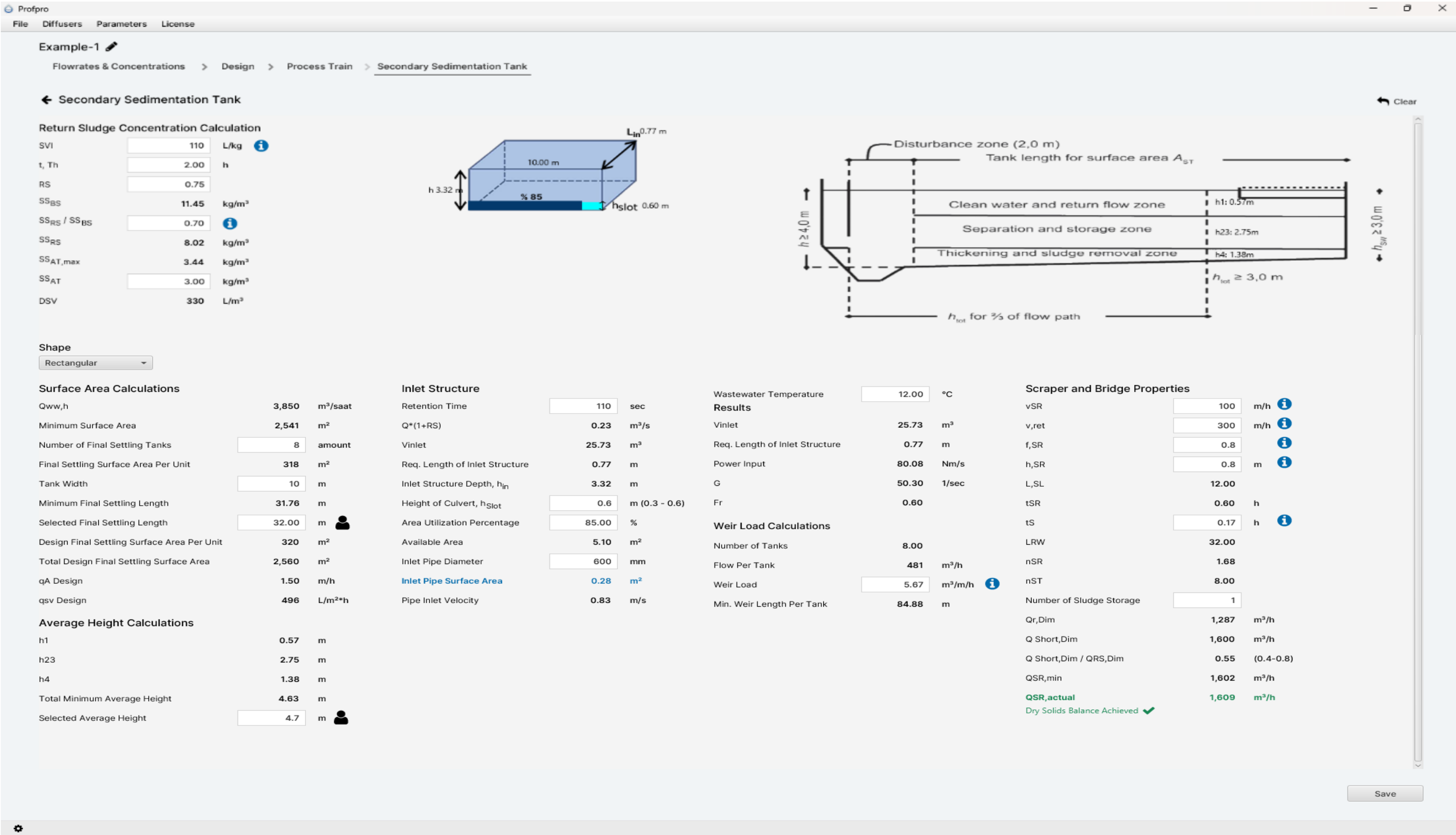
Biological Treatment Line:

Secondary Sedimentation Tank:

Circular Sedimentation Tank Design Example;



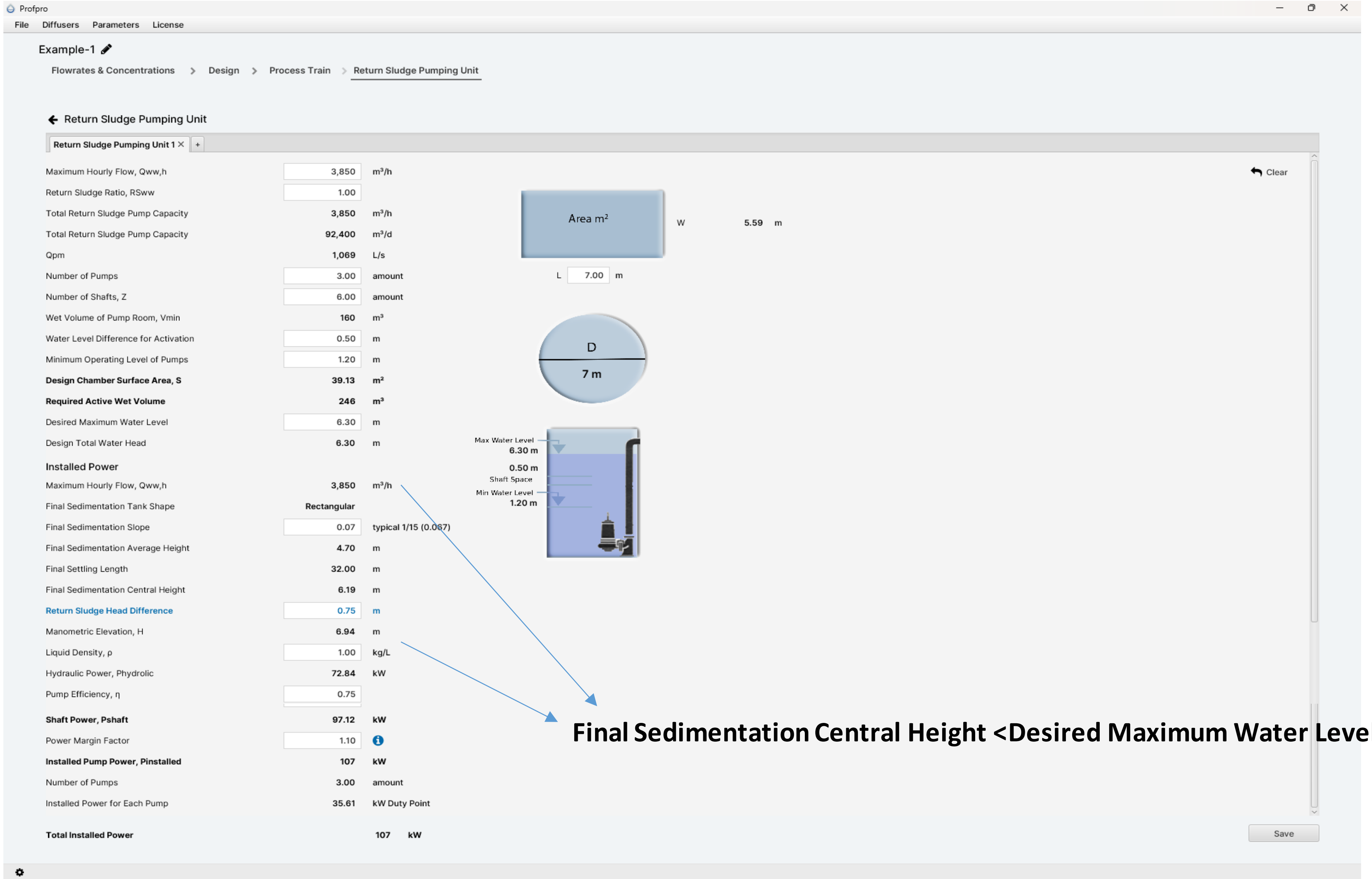
Rectangular Sedimentation Tank Design Example;



Design calculations of the secondary sedimentation tanks is made according to equations and constraints published in the documents of *ATV 131-E (2016) and Working Report of the ATV Special Committee Sedimentation Processes*.

Return Sludge Pumping Unit:

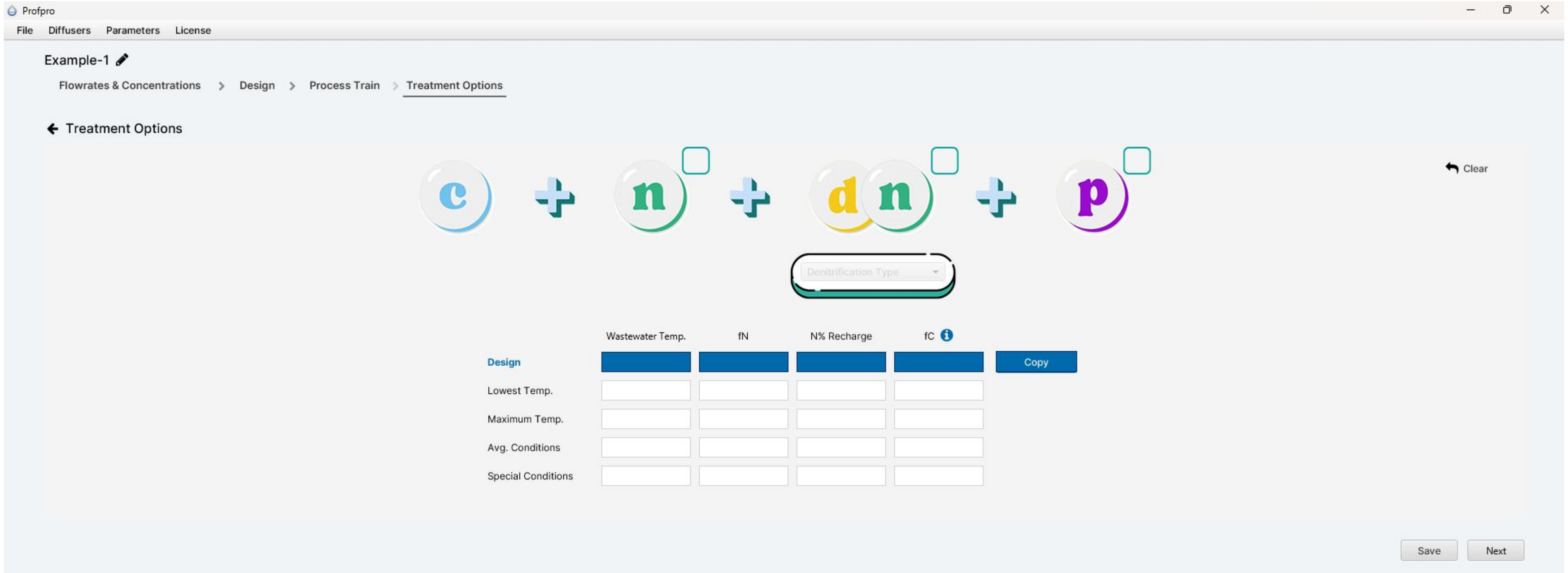
ATV 134 E



"Planning and Construction of Wastewater Pumping Stations" (2000) is the reference document.

Sludge Age and Biological Reactor:

Treatment Options:



User selects treatment objectives by marking relevant process options shown above. The options are;

1- Carbon Only (No marking in the tick box)
2- C + N (Carbon + Nitrification)
3- C + P (Carbon + Phosphorous Removal)
4- C + N + P (Carbon + Nitrification + Phosphorus Removal)
5- C + N + dN + P (Carbon + Nitrification + Denitrification + Phosphorus Removal)

Phosphorous Removal can be biological, chemical or both.

If denitrification process is chosen, 6 types of denitrification process can be selected from the dropdown menu. Among them, pre-anoxic, step feed 2 and step feed 3 denitrification processes have internal recirculation unit. In this section the user must identify wastewater temperature, fN, N recharge from the backflows and fC values. These values are determined with the procedures of ATV 198-E or default values can be taken from the table. (ATV 131E)

Table 7: Peak factors for oxygen demand

	Required sludge retention time SRT_{dim} in d					
	4	6	8	10	15	25
f_C	1,3	1,25	1,2	1,2	1,15	1,1
f_N *) for $L_{d,COD,I}$ ≤ 2.400 kg/d				2,4	2,0	1,5
f_N *) for $L_{d,COD,I}$ > 12.000 kg/d			2,0	1,8	1,5	

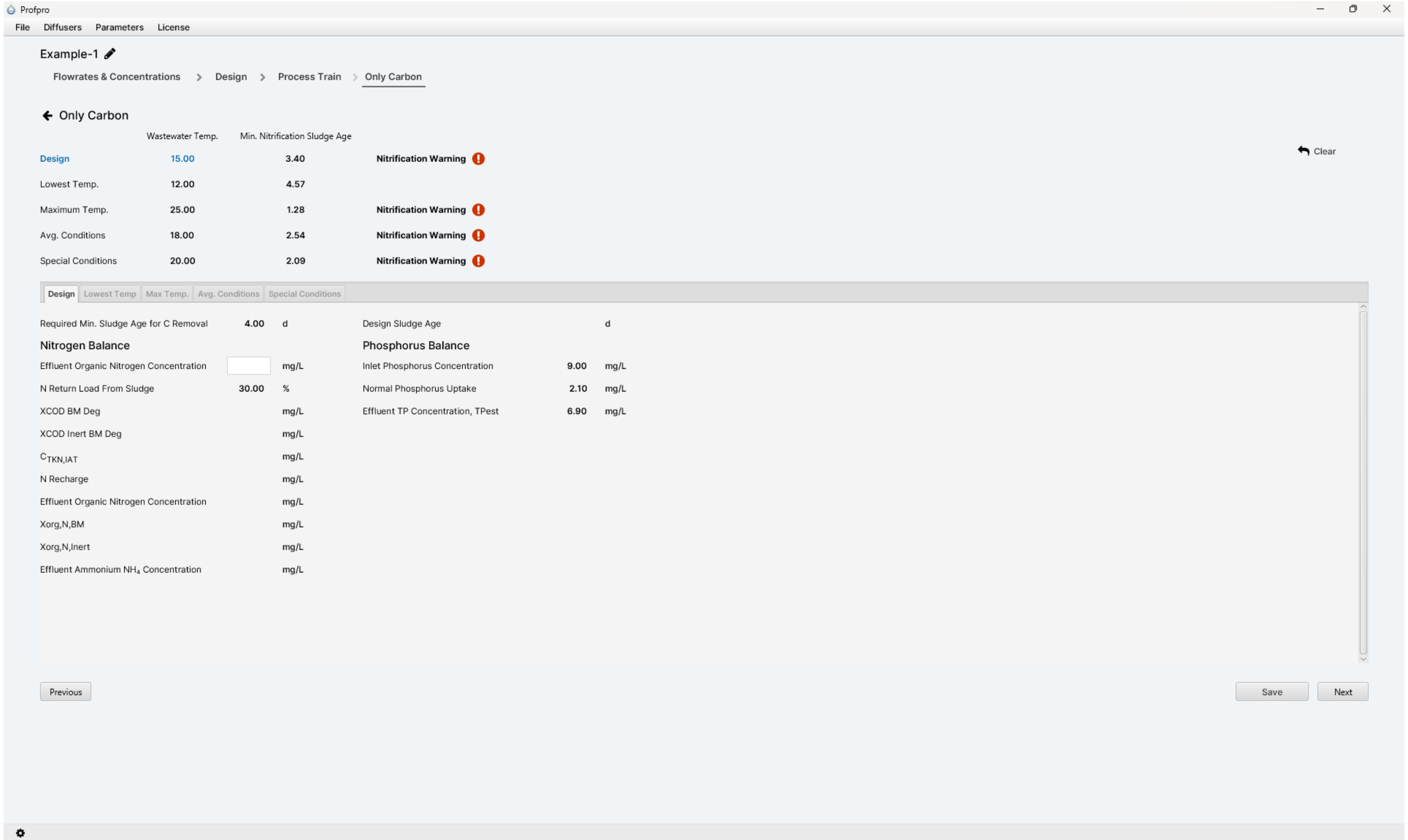
NOTE
f_N *) as a substitute when no measurements of f_N are available **Parameter**.

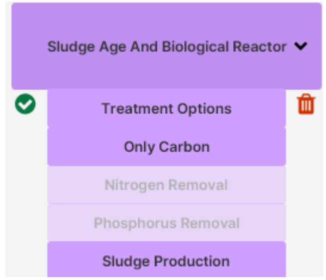
Example Calculation:

Table C-4: Example for the determination of the peak factor for the nitrogen load

Date	Parameter	Unit	10 - 12 h	12 - 14 h	14 - 16 h	24-h mean	Maximum 2-h load	Max. 2-h load/ 24-h mean
1	2	3	4	5	6	7	8	9
10.2. Wed	$Q_{DW,2h}$ ($Q_{DW,d}$)	m³/h	789	957	896	623		
	C_{TKN}	mg/l	67	58	61	54		
	$B_{2h,TKN}$ ($B_{d,TKN}$)	kg/h	52.9	55.5	54.7	33.6	55.5	1.65
4.3. Thur	$Q_{T,2h}$ ($Q_{T,d}$)	m³/h	870	1023	977	678		
	C_{TKN}	mg/l	65	61	58	51		
	$B_{2h,TKN}$ ($B_{d,TKN}$)	kg/h	56.6	62.4	56.7	34.6	62.4	1.80
	$Q_{T,2h}$ ($Q_{T,d}$)	m³/h						
	C_{TKN}	mg/l						
	$B_{2h,TKN}$ ($B_{d,TKN}$)	kg/h						
						Mean	59.3	1.77

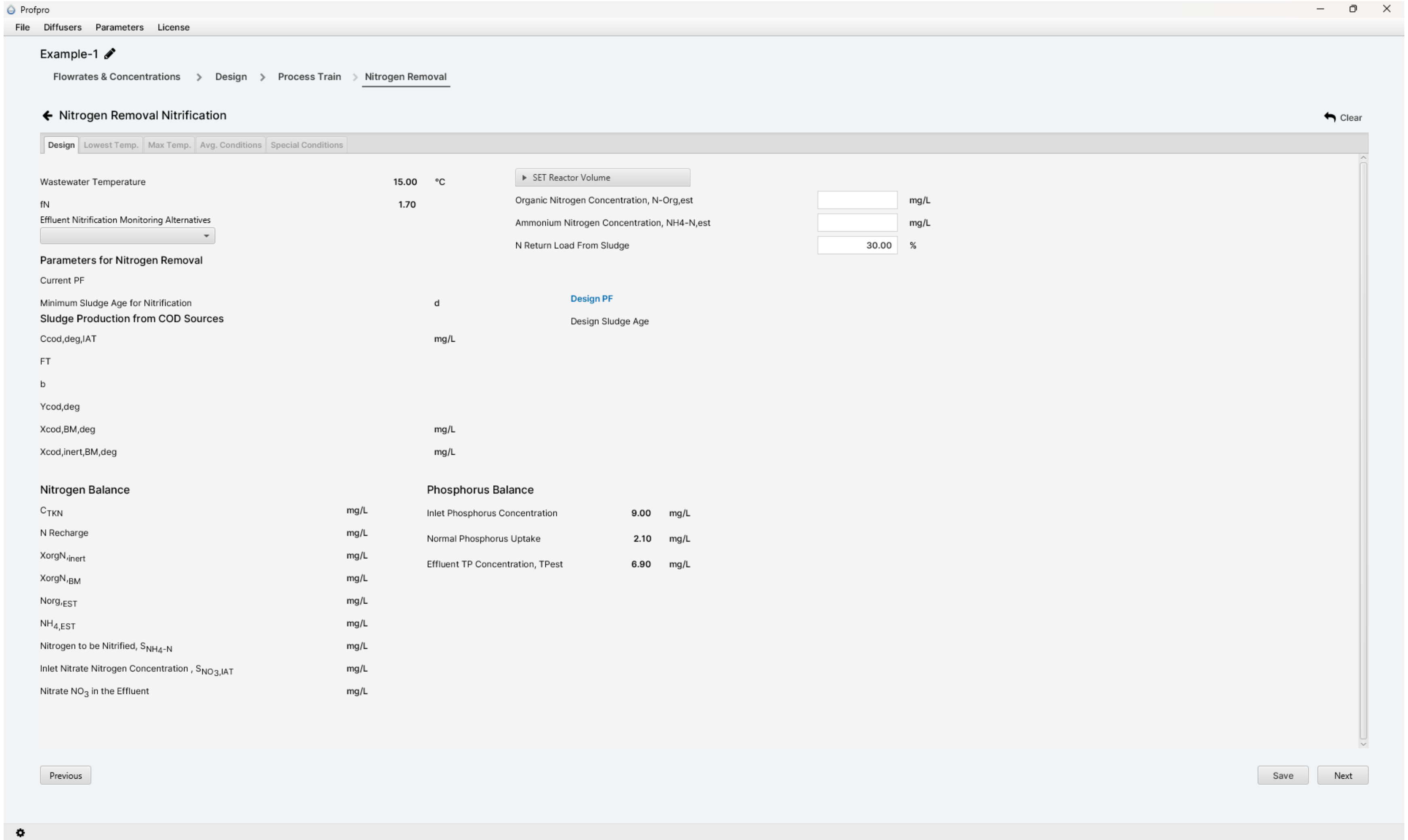
If “**Only Carbon**” Removal is selected, the screen below appears.

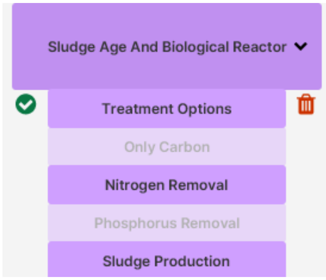




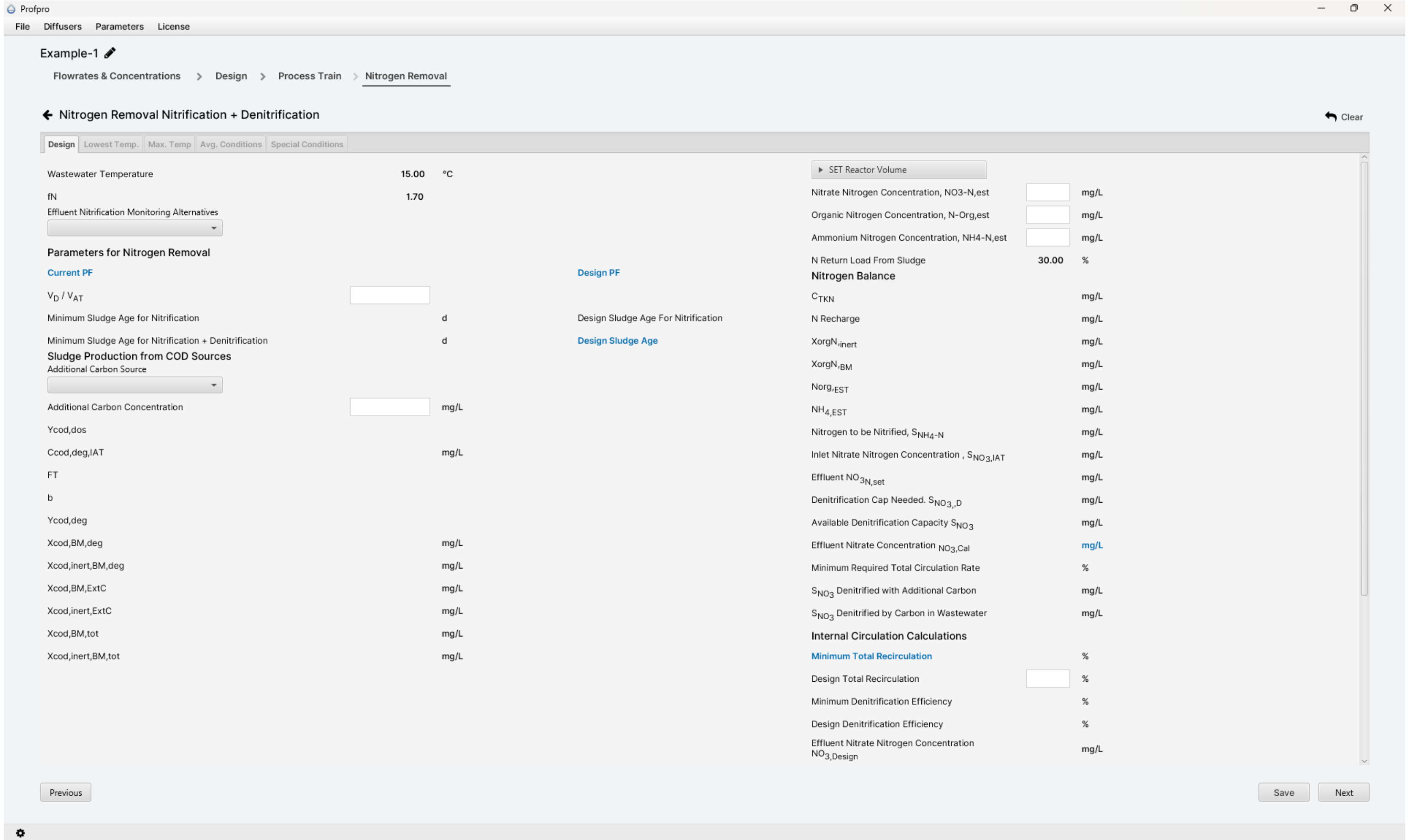
As seen from the page shown above, according to the wastewater temperatures defined in “Treatment Options”, the software warns the user for the possible nitrification occurrences. In those circumstances, it is advised that the aeration design should be made as if nitrification takes place.

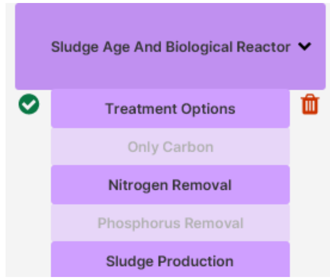
If **"Carbon Removal + Nitrification"** process is selected, the screen below appears.





If **“Carbon Removal + Nitrification + Denitrification”** process is selected, the screen below appears.

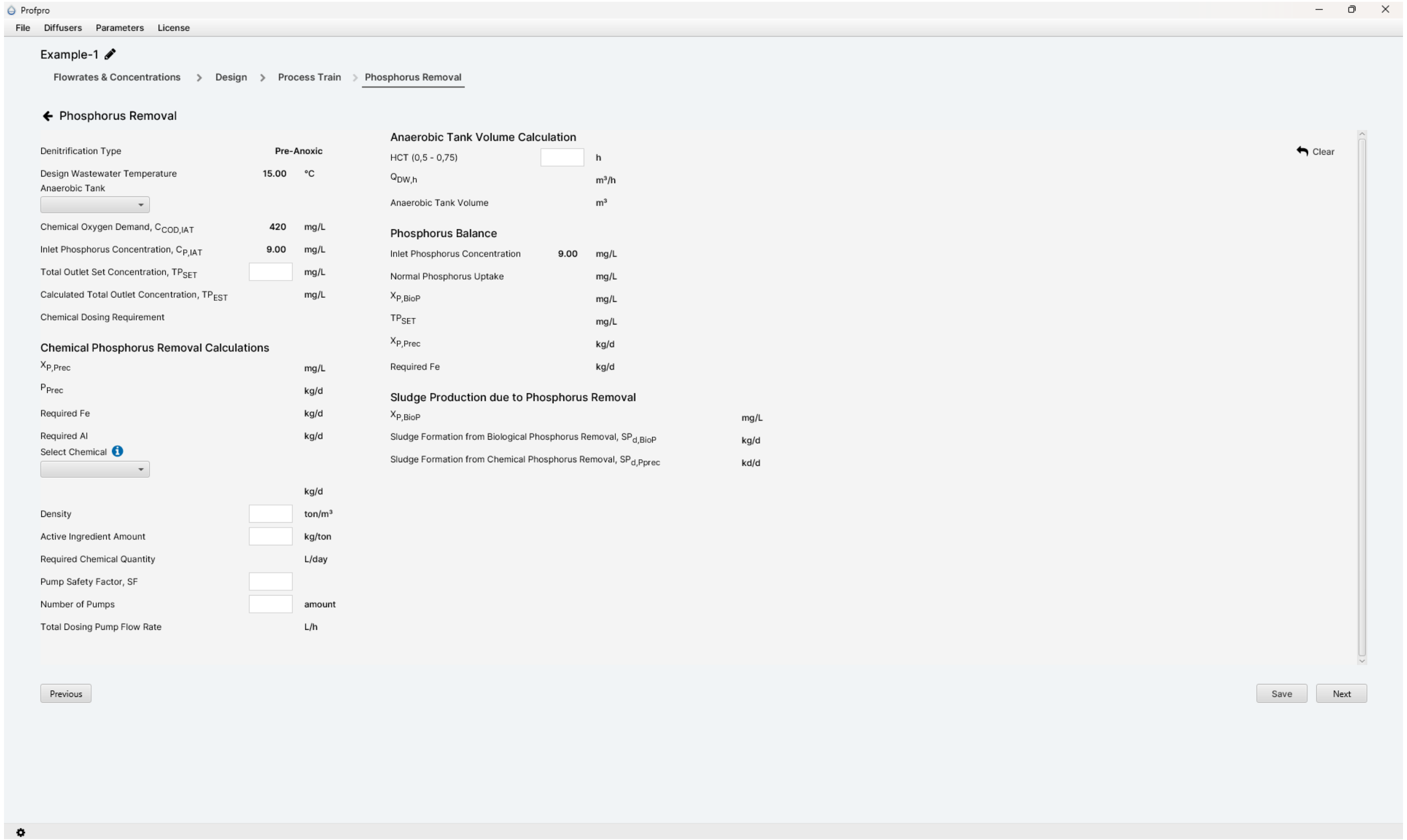




Whether **“C”, “C + N” or “C + N + dN”** processes are selected, the relevant pages of these processes are to be calculated in **two steps**. **Firstly**, the user must fill the blanks and proceed to the **“Sludge Production**” page. **Secondly**, after biological tank volume is selected in the **“Sludge Production” page**, further calculations are proceeded by returning to the **“Only Carbon”** or **“Nitrogen Removal”** pages.

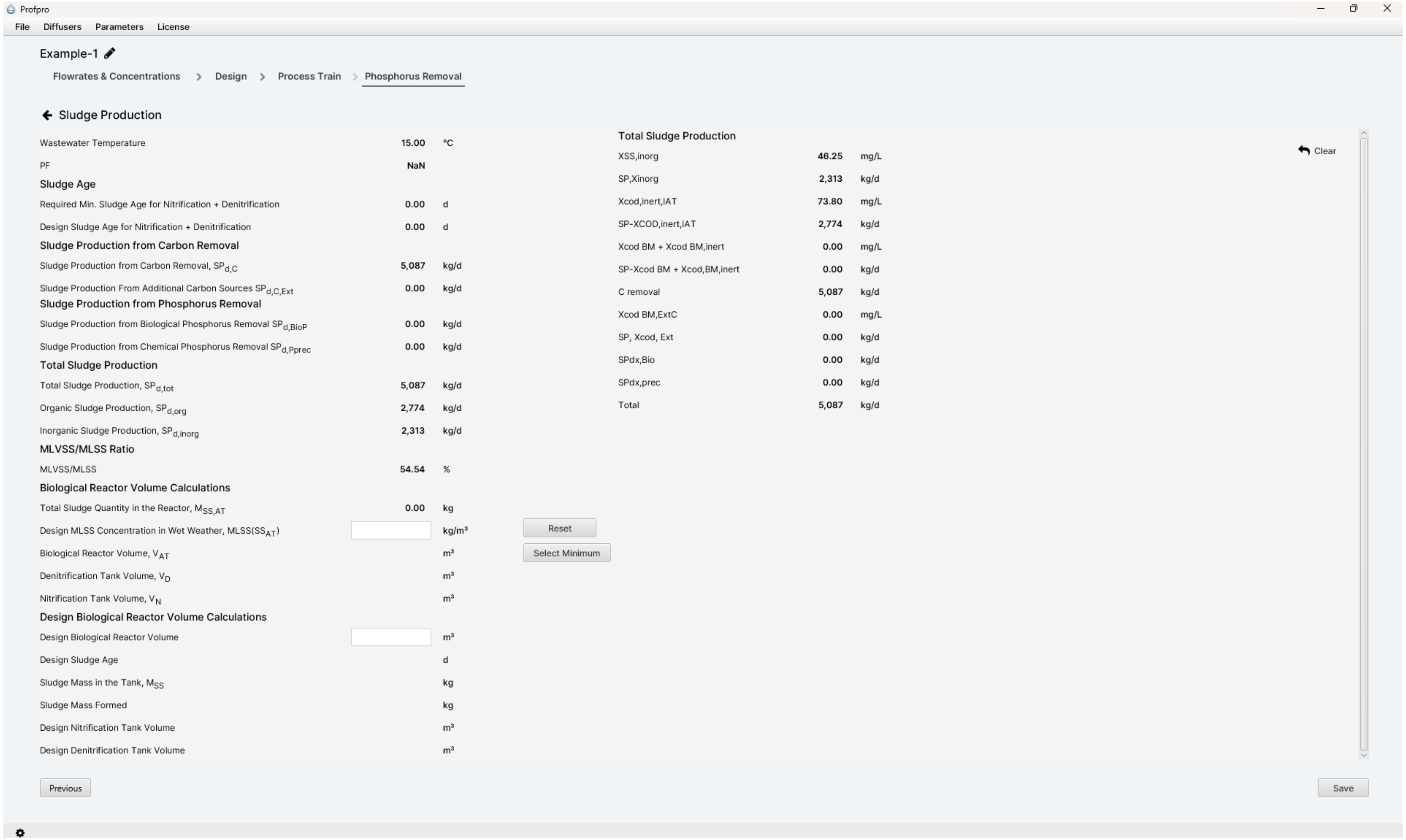
__The summary of the steps explained below;__

1- Treatment Objective is identified in the **“Treatment Options”** page.
2- Design and other wastewater temperatures, fN, N-Recharge, fC values are typed.
3- Depending on the choice of treatment objective **“Only Carbon”** or **“Nitrogen Removal”** pages filled in **“Design Temperature”** tab.
4- If “**Phosphorus Removal”** option is selected and marked, the following page should be filled.



5- Depending on biological, chemical or both process choices, the software calculates the relevant process calculations.

6- The next step is to go into the **“Sludge Production”** page. Once moved to this page, the following screen appears:



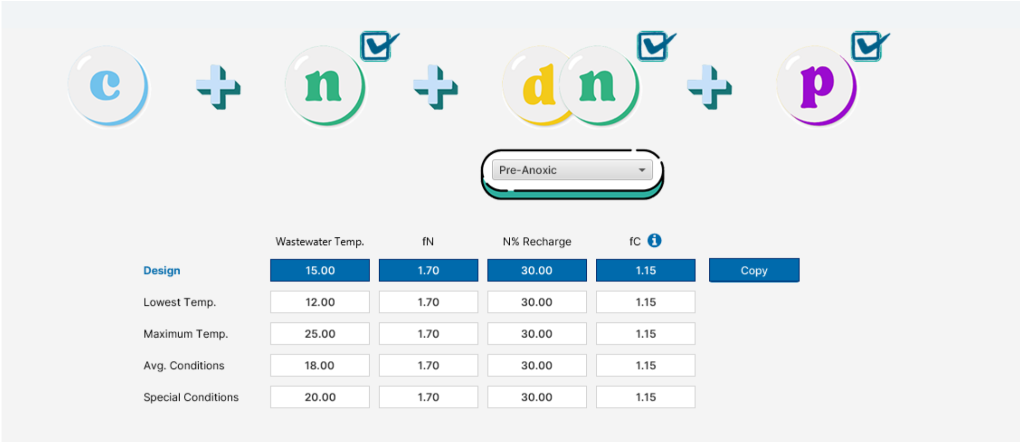
7- In this page, **design temperature MLSS concentration** and design **Biological Tank Volume** is determined and the page is saved.

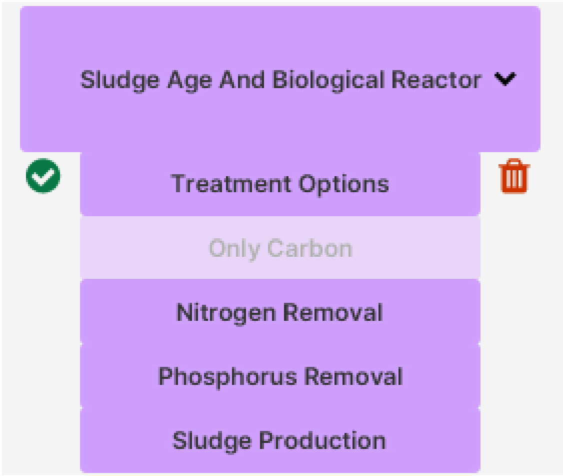
8- After this step is completed, the user should go back to the **“Only Carbon”** or **“Nitrogen Removal”** pages.

9- Process calculations in different temperature cases and internal recirculation flow rate calculations are completed step by step.

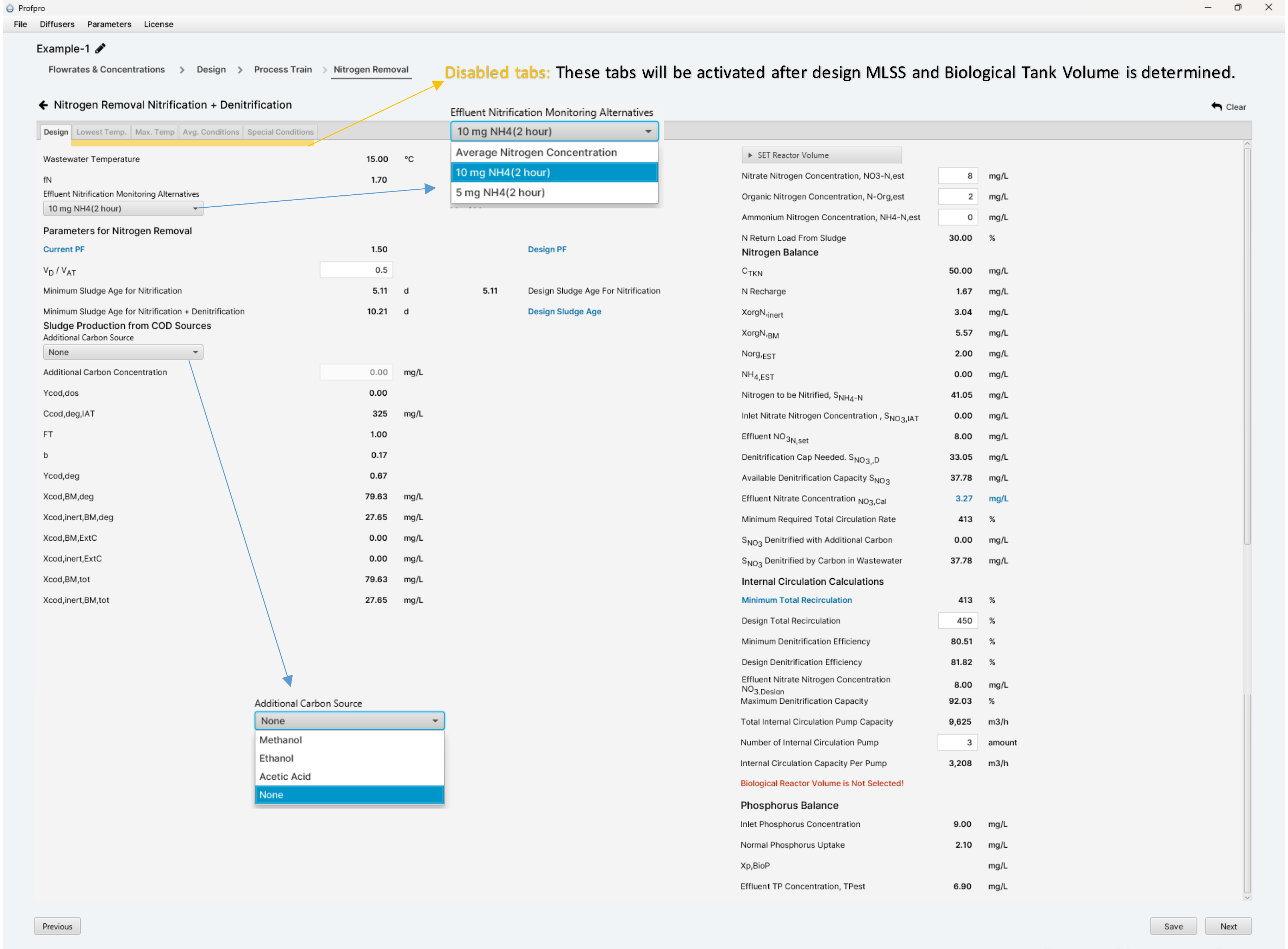
Step 1 - 2

Here is an example of a pre-anoxic denitrification + phosphorous (chemical+biological) removal enabled treatment plant is shown:





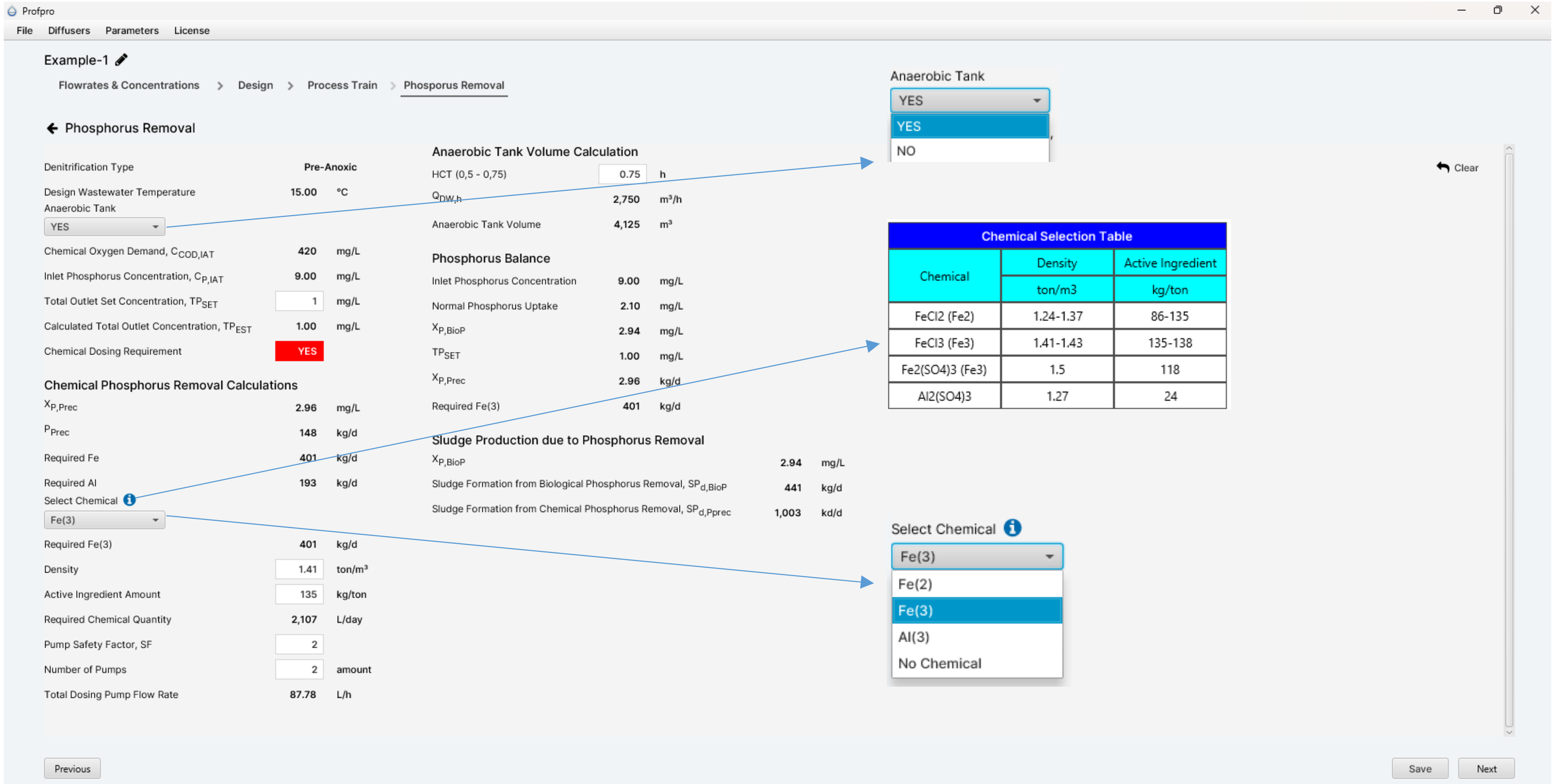
Step 3



Press **Next** or **Save**

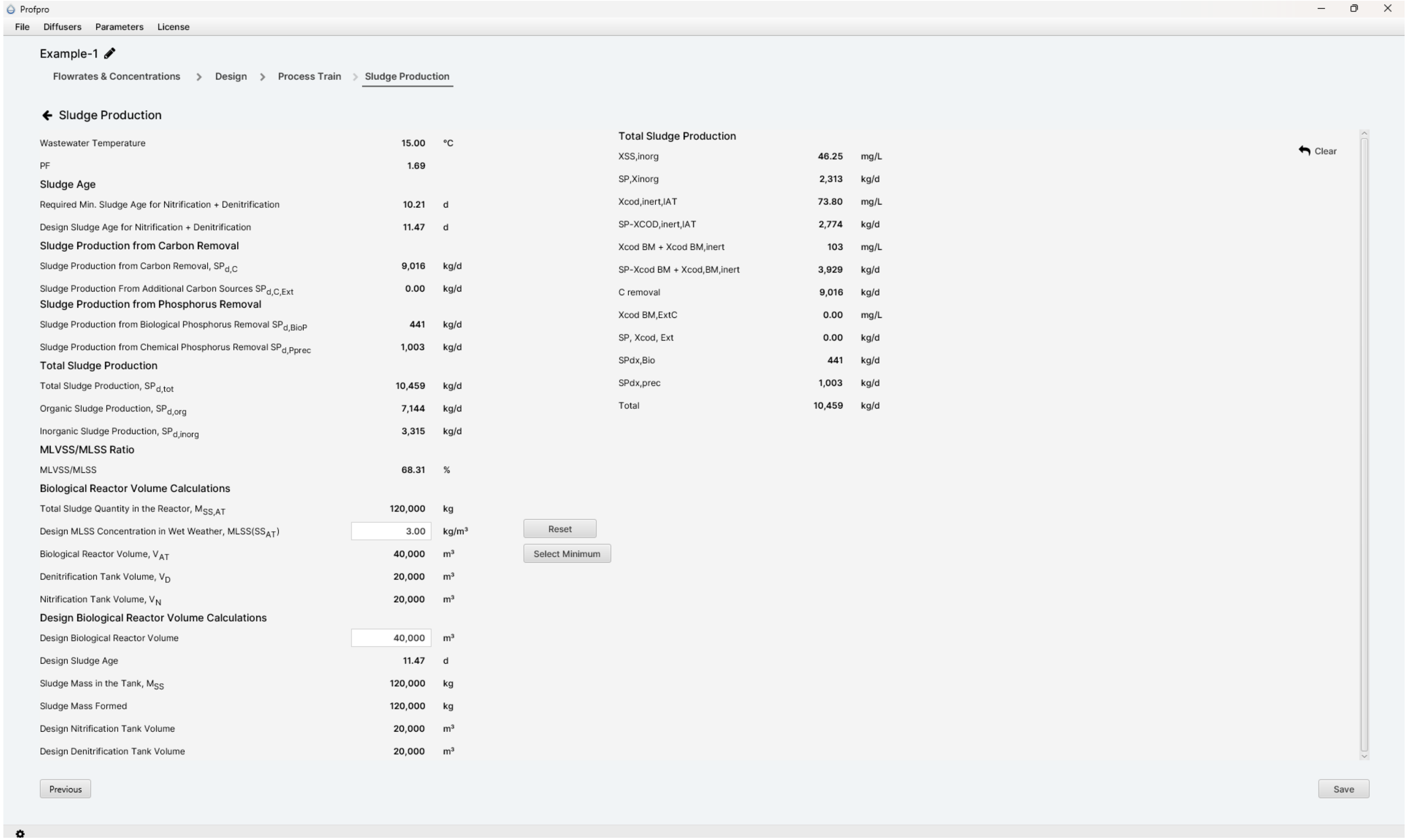
Step 4 - 5

ATV 202E "Chemical-Physical Methods for the Removal of Phosphorous from Wastewater" (2004) and ATV 131 E (2016) standards are the reference documents.



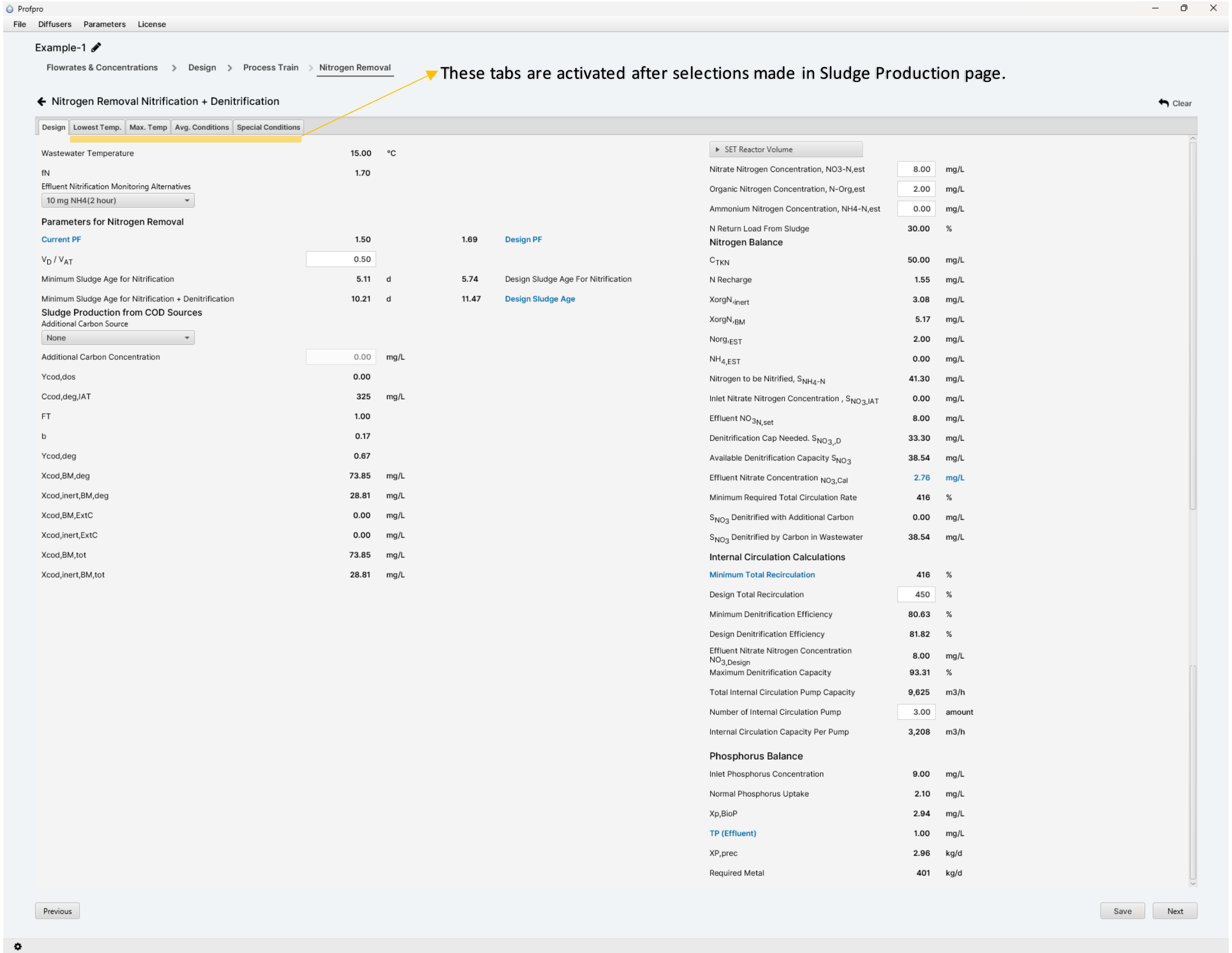
Press **Next** or **Save**

Step 6 - 7

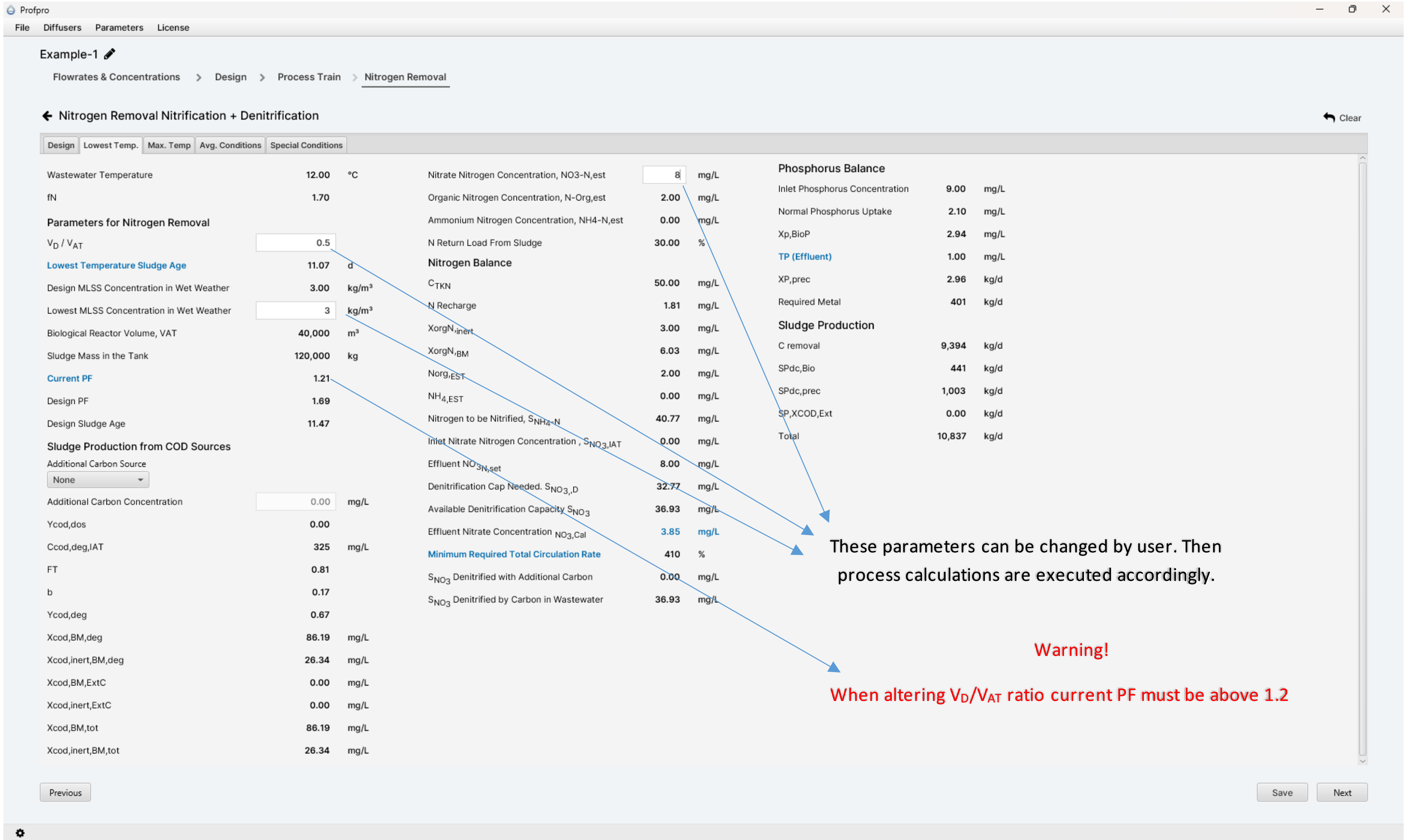

Profpro
File Diffusers Parameters License
Example-1
Flowrates & Concentrations > Design > Process Train > Sludge Production
Sludge Production
Wastewater Temperature 15.00 °C
PF 1.69
Sludge Age
Required Min. Sludge Age for Nitrification + Denitrification 10.21 d
Design Sludge Age for Nitrification + Denitrification 11.47 d
Sludge Production from Carbon Removal
Sludge Production from Carbon Removal, $SP_{d,C}$ 9,016 kg/d
Sludge Production From Additional Carbon Sources $SP_{d,C,Ext}$ 0.00 kg/d
Sludge Production from Phosphorus Removal
Sludge Production from Biological Phosphorus Removal $SP_{d,BioP}$ 441 kg/d
Sludge Production from Chemical Phosphorus Removal $SP_{d,Pprec}$ 1,003 kg/d
Total Sludge Production
Total Sludge Production, $SP_{d,tot}$ 10,459 kg/d
Organic Sludge Production, $SP_{d,org}$ 7,144 kg/d
Inorganic Sludge Production, $SP_{d,inorg}$ 3,315 kg/d
MLVSS/MLSS Ratio
MLVSS/MLSS 68.31 %
Biological Reactor Volume Calculations
Total Sludge Quantity in the Reactor, $M_{SS,AT}$ 120,000 kg
Design MLSS Concentration in Wet Weather, MLSS(SS_{AT}) 3.00 kg/m³
Reset
Select Minimum
Biological Reactor Volume, V_{AT} 40,000 m³
Denitrification Tank Volume, V_D 20,000 m³
Nitrification Tank Volume, V_N 20,000 m³
Design Biological Reactor Volume Calculations
Design Biological Reactor Volume 40,000 m³
Design Sludge Age 11.47 d
Sludge Mass in the Tank, M_{SS} 120,000 kg
Sludge Mass Formed 120,000 kg
Design Nitrification Tank Volume 20,000 m³
Design Denitrification Tank Volume 20,000 m³
Total Sludge Production
XSS,inorg 46.25 mg/L
SP,Xinorg 2,313 kg/d
Xcod,inert,IAT 73.80 mg/L
SP-XCOD,inert,IAT 2,774 kg/d
Xcod BM + Xcod BM,inert 103 mg/L
SP-Xcod BM + Xcod,BM,inert 3,929 kg/d
C removal 9,016 kg/d
Xcod BM,ExtC 0.00 mg/L
SP, Xcod, Ext 0.00 kg/d
SPdx,Bio 441 kg/d
SPdx,prec 1,003 kg/d
Total 10,459 kg/d
Clear
Previous
Save

Step 8 - 9

These tabs are activated after selections made in Sludge Production page.

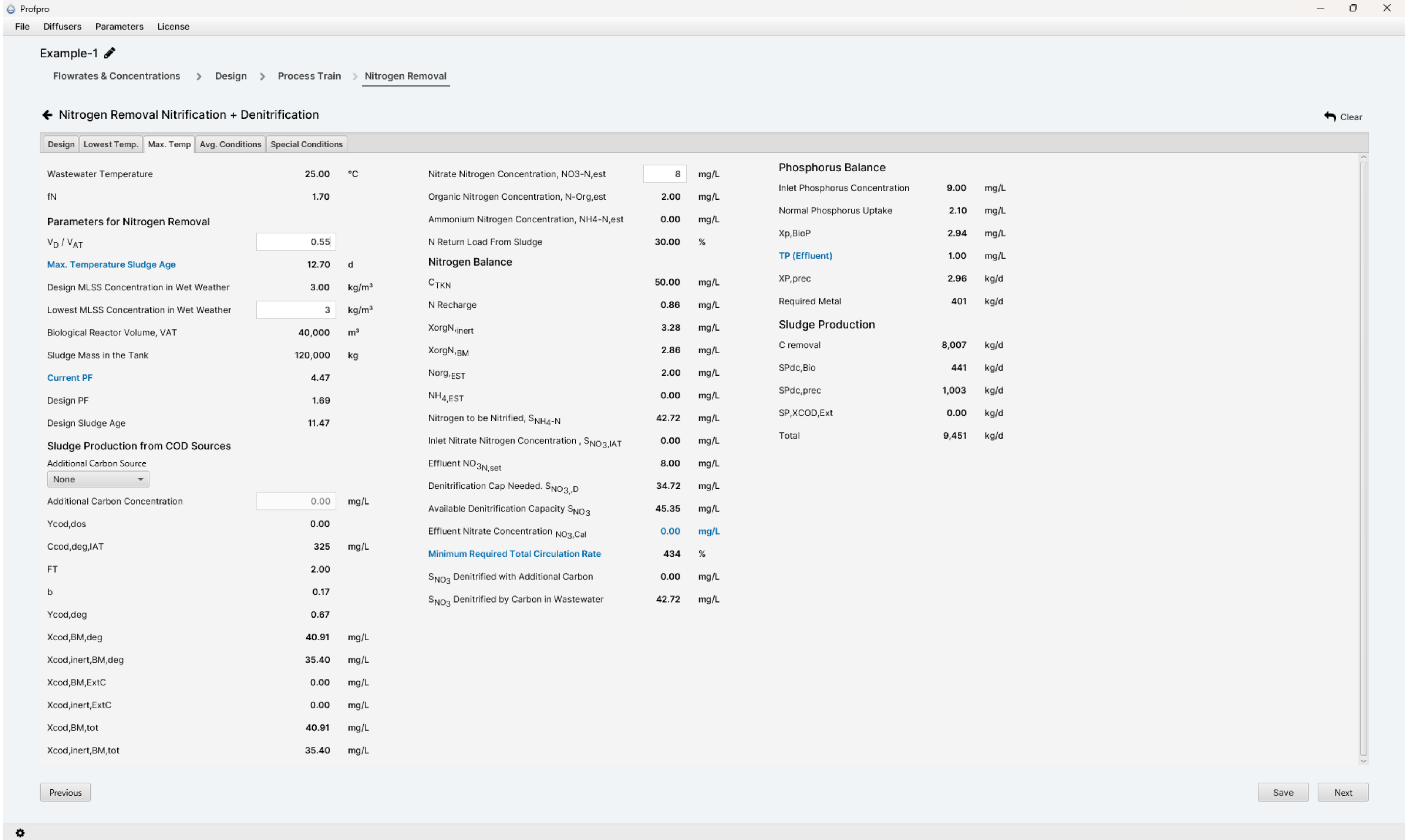


Step 8 - 9



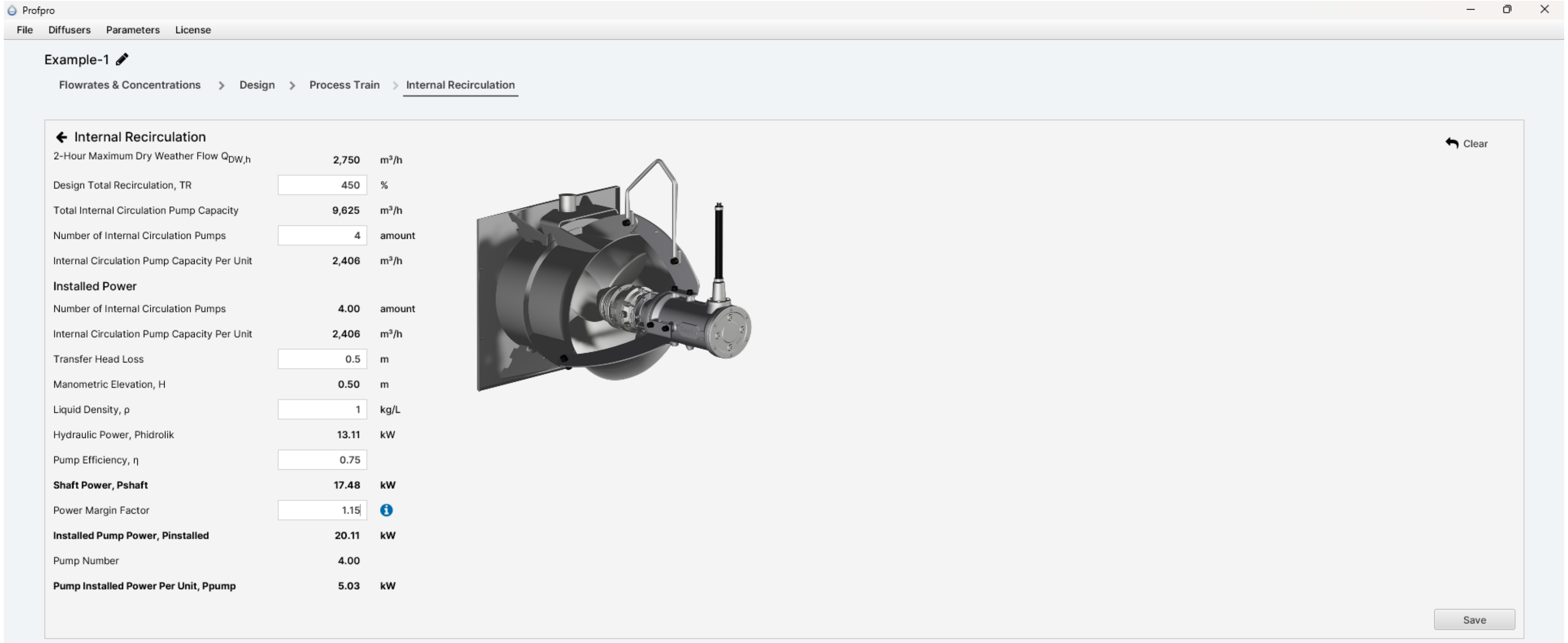
PF (Process Factor) is a safety coefficient for growth of nitrification bacteria and it is used for calculation of the minimum sludge age for different temperatures. *ATV 131 – E (2016) strongly advices that this coefficient must be at least 1.2.*

Step 8 - 9



User can evaluate 5 different scenarios with different temperatures, V_D/V_{AT} *ratios and MLSS concentrations*.

Internal Recirculation



This page is enabled in only “Pre-Anoxic”, “Step 2” and “Step 3” denitrification types.

The important point is that maximum 2 hourly dry weather flow is used in determining design capacities of the pumps.

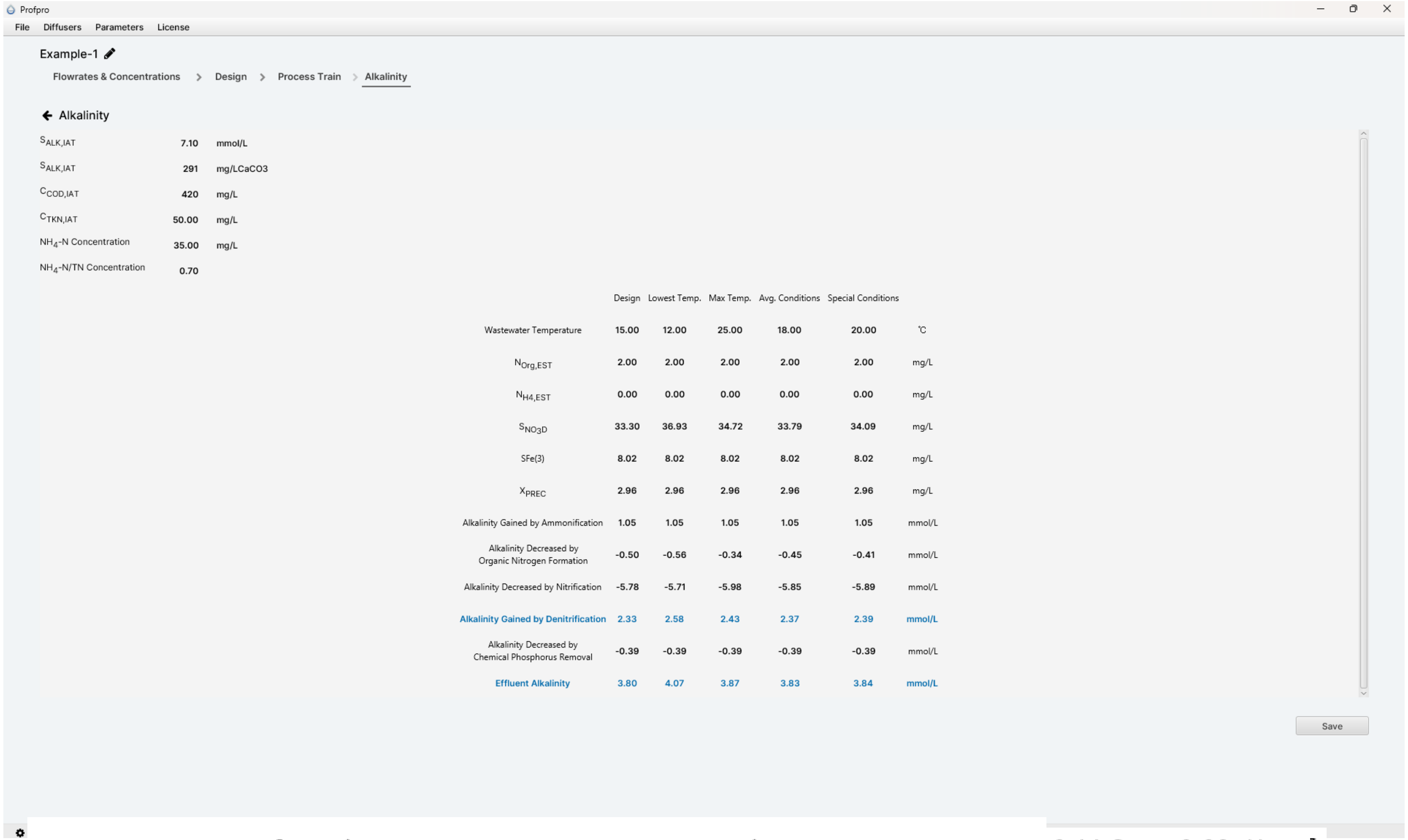
TR (Total Circulation Ratio) = RS + IR

RS = 100% (Dry weather return sludge ratio)

IR = Internal circulation ratio.

ATV-131E (2016) standard is the reference document.

Alkalinity



Profpro

File Diffusers Parameters License

Example-1

Flowrates & Concentrations > Design > Process Train > Alkalinity

Alkalinity

$S_{ALK,IAT}$	7.10	mmol/L
$S_{ALK,IAT}$	291	mg/LCaCO3
$C_{COD,IAT}$	420	mg/L
$C_{TKN,IAT}$	50.00	mg/L
NH_4-N Concentration	35.00	mg/L
NH_4-N/TN Concentration	0.70	

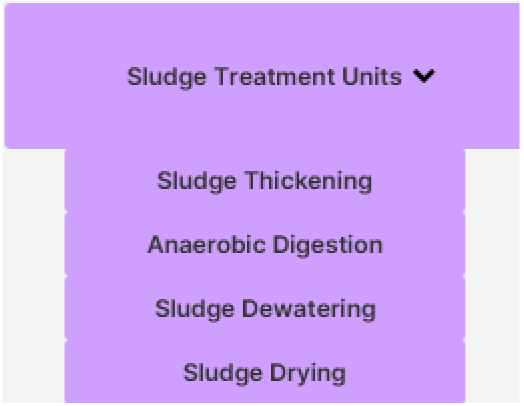
	Design	Lowest Temp.	Max Temp.	Avg. Conditions	Special Conditions	
Wastewater Temperature	15.00	12.00	25.00	18.00	20.00	℃
$N_{Org,EST}$	2.00	2.00	2.00	2.00	2.00	mg/L
$N_{H4,EST}$	0.00	0.00	0.00	0.00	0.00	mg/L
S_{NO3D}	33.30	36.93	34.72	33.79	34.09	mg/L
SFe(3)	8.02	8.02	8.02	8.02	8.02	mg/L
X_{PREC}	2.96	2.96	2.96	2.96	2.96	mg/L
Alkalinity Gained by Ammonification	1.05	1.05	1.05	1.05	1.05	mmol/L
Alkalinity Decreased by Organic Nitrogen Formation	-0.50	-0.56	-0.34	-0.45	-0.41	mmol/L
Alkalinity Decreased by Nitrification	-5.78	-5.71	-5.98	-5.85	-5.89	mmol/L
Alkalinity Gained by Denitrification	2.33	2.58	2.43	2.37	2.39	mmol/L
Alkalinity Decreased by Chemical Phosphorus Removal	-0.39	-0.39	-0.39	-0.39	-0.39	mmol/L
Effluent Alkalinity	3.80	4.07	3.87	3.83	3.84	mmol/L

Save

$$S_{ALK,EAT} = S_{ALK,IAT} - [0,07\cdot(S_{NH4,IAT} - S_{NH4,EST} + S_{NO3,EST} - S_{NO3,IAT}) + 0,06\cdot S_{Fe3} + 0,04\cdot S_{Fe2} + 0,11\cdot S_{Al3} - 0,03\cdot X_{P,Prec}]$$

Alkalinity changes are calculated according to *ATV-131E (2016) standard.* $S_{ALK,EAT}$*(mmol/L) is the alkalinity value at the effluent of the aeration tank.*

Sludge Treatment Units



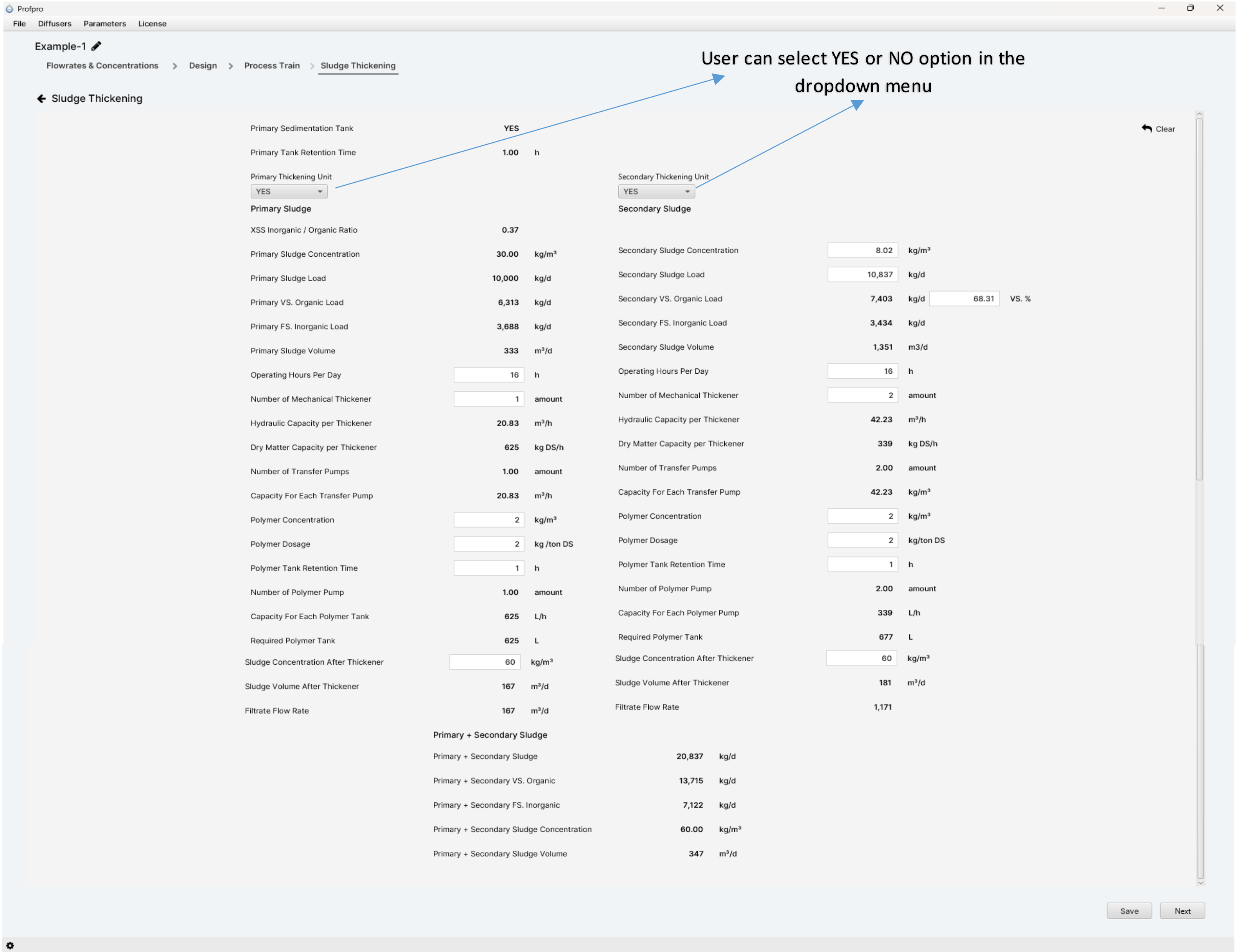
There are four types of sludge treatment units which are most commonly found in any WWTP.

Sludge Thickening and Sludge Dewatering calculations are based on centrifugal mechanical thickeners. In these sections of the software, the user can also design polymer pump capacities and polymer preparation tank volumes properly.

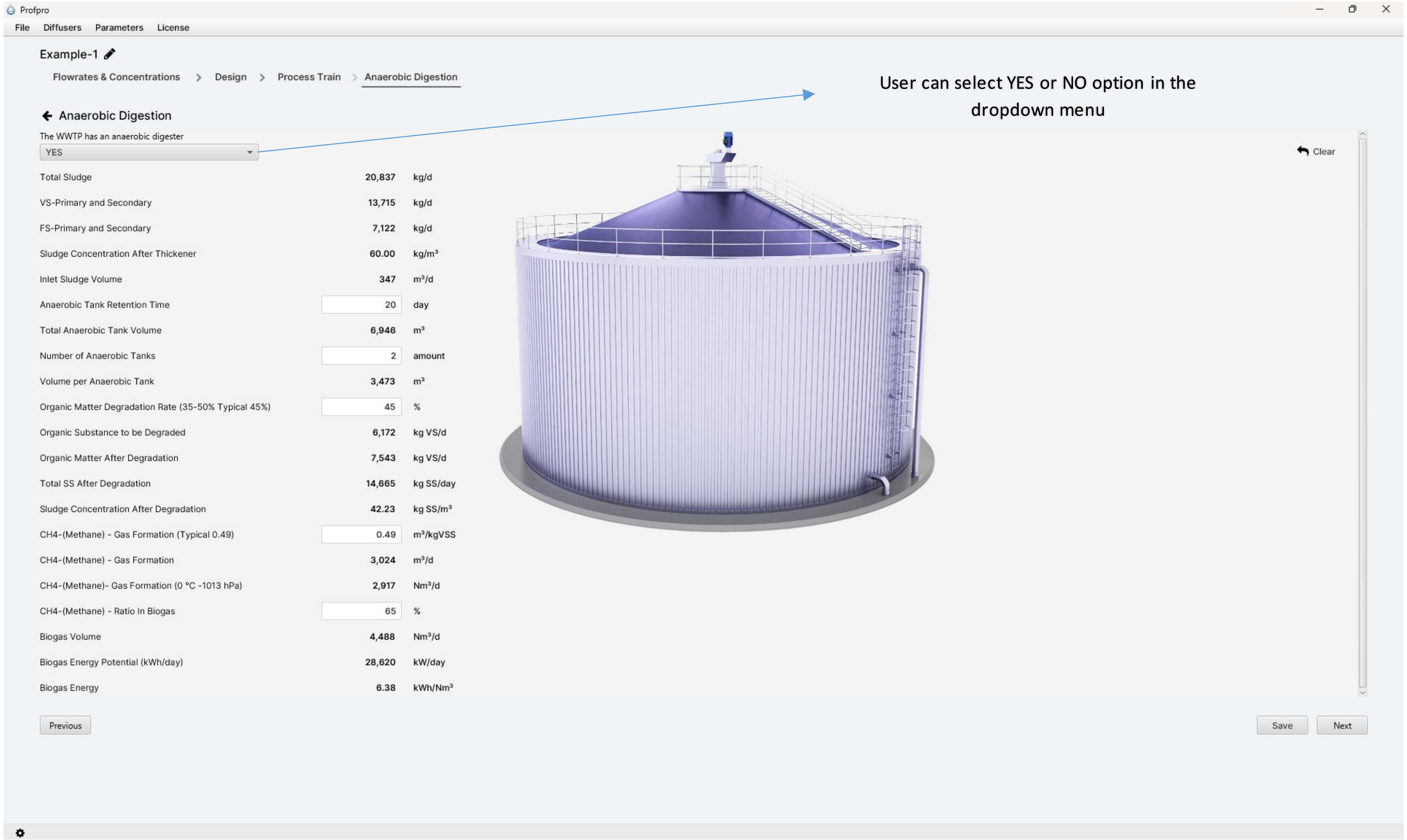
Anaerobic Digestion is another important unit for dimensioning. When primary sedimentation tank unit exists in the design, it is strongly advised that anaerobic digestion should be a part of it.

Thermal type of drier design section is included in the software.

Sludge Thickening

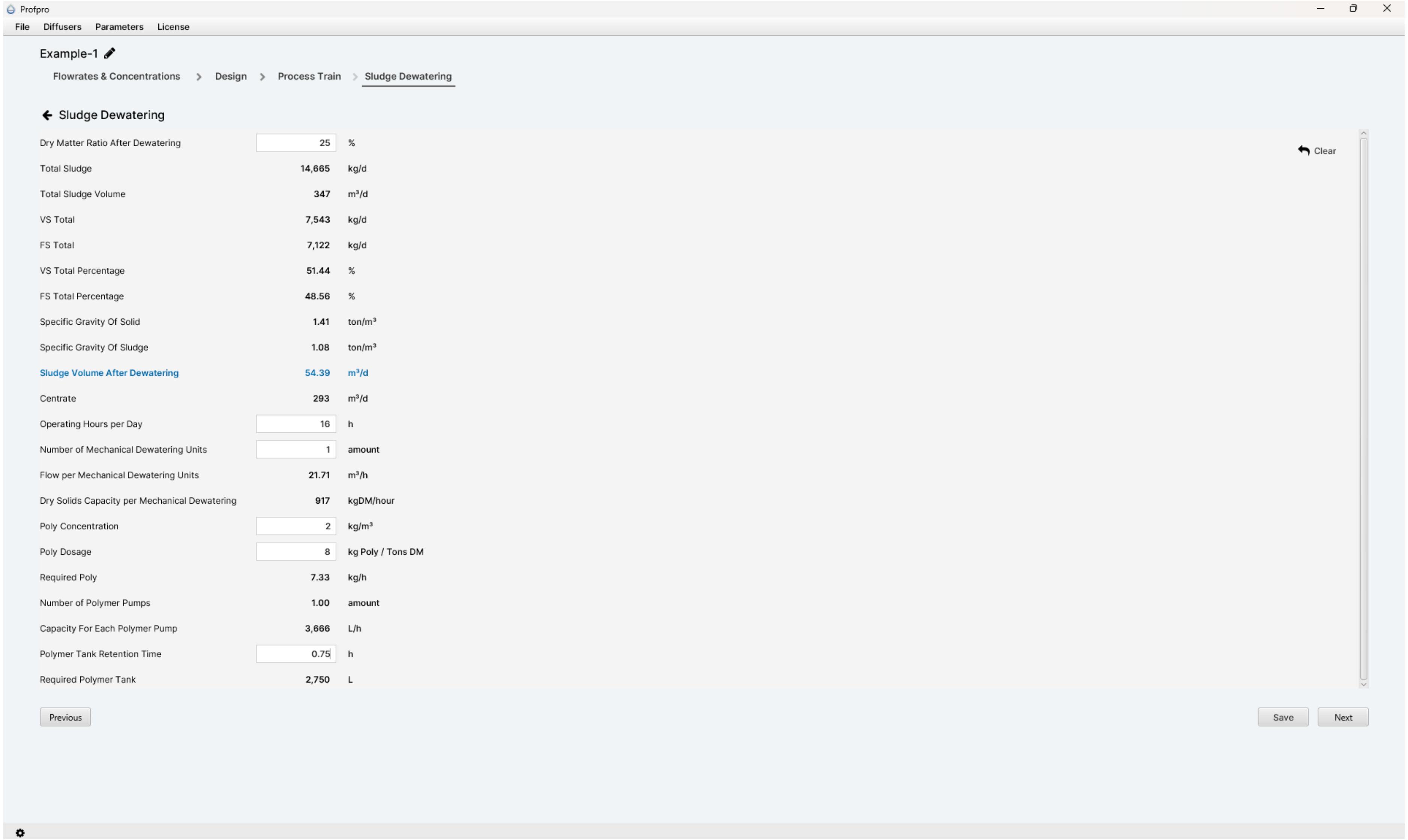


Anaerobic Digestion



In "Anaerobic Digestion" page, basic process design calculations of anaerobic digesters can be completed. *ATV-368E "Biological Stabilization of Sewage Sludge Advisory Leaflet" (2003) is the reference document.*

Sludge Dewatering



Sludge Drying (Thermal)

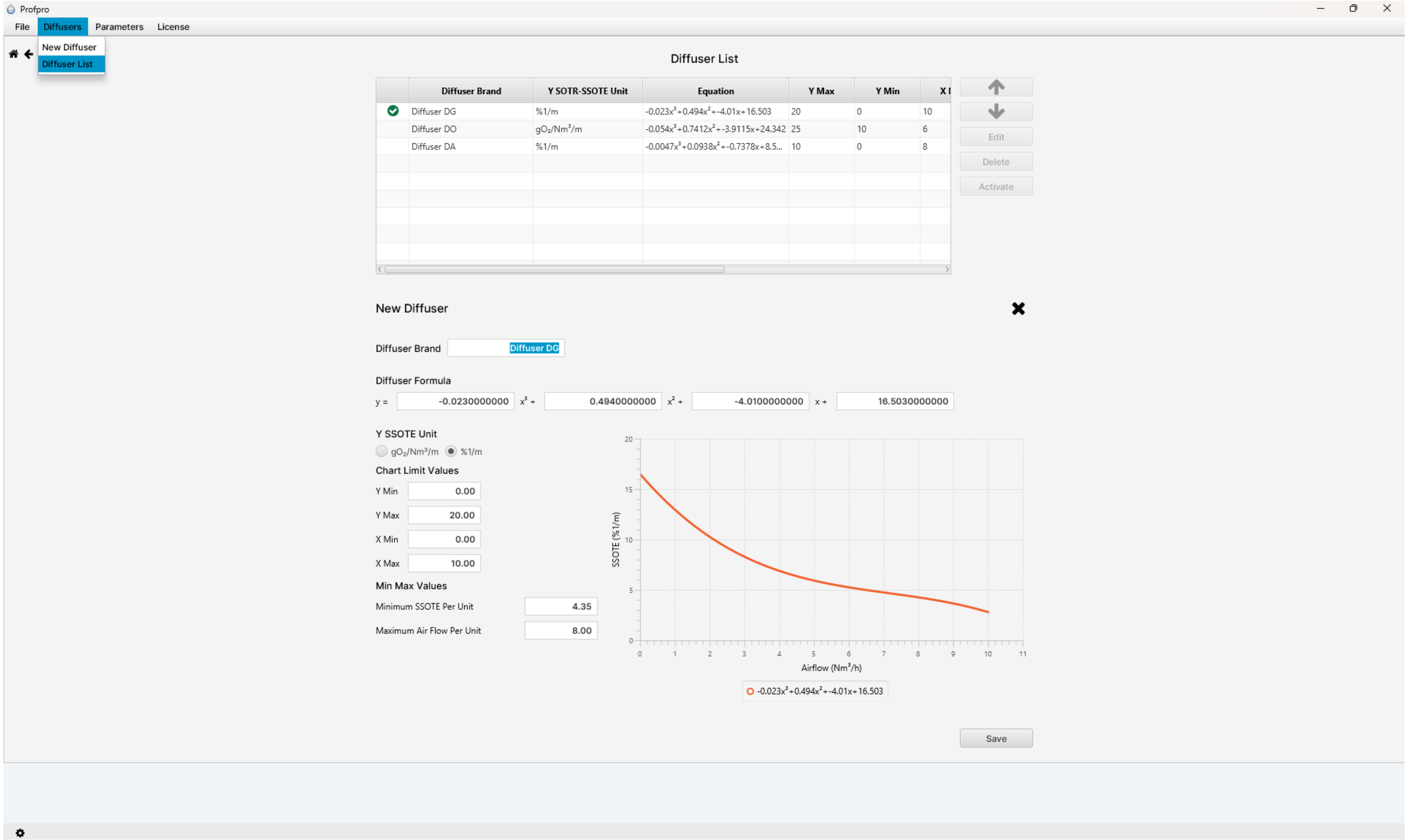
ATV 379 E "Dying of Sewage Sludge" (2004) and DIN- Fachbericht CEN/TR 15473(Characterization of Sludge-Good Practice for Sludge Drying) (2007) documents are the reference documents.

Aeration System Design

Fine Bubble Diffuser System Design

Once all the biological treatment process design is completed, aeration system design menu can be opened.

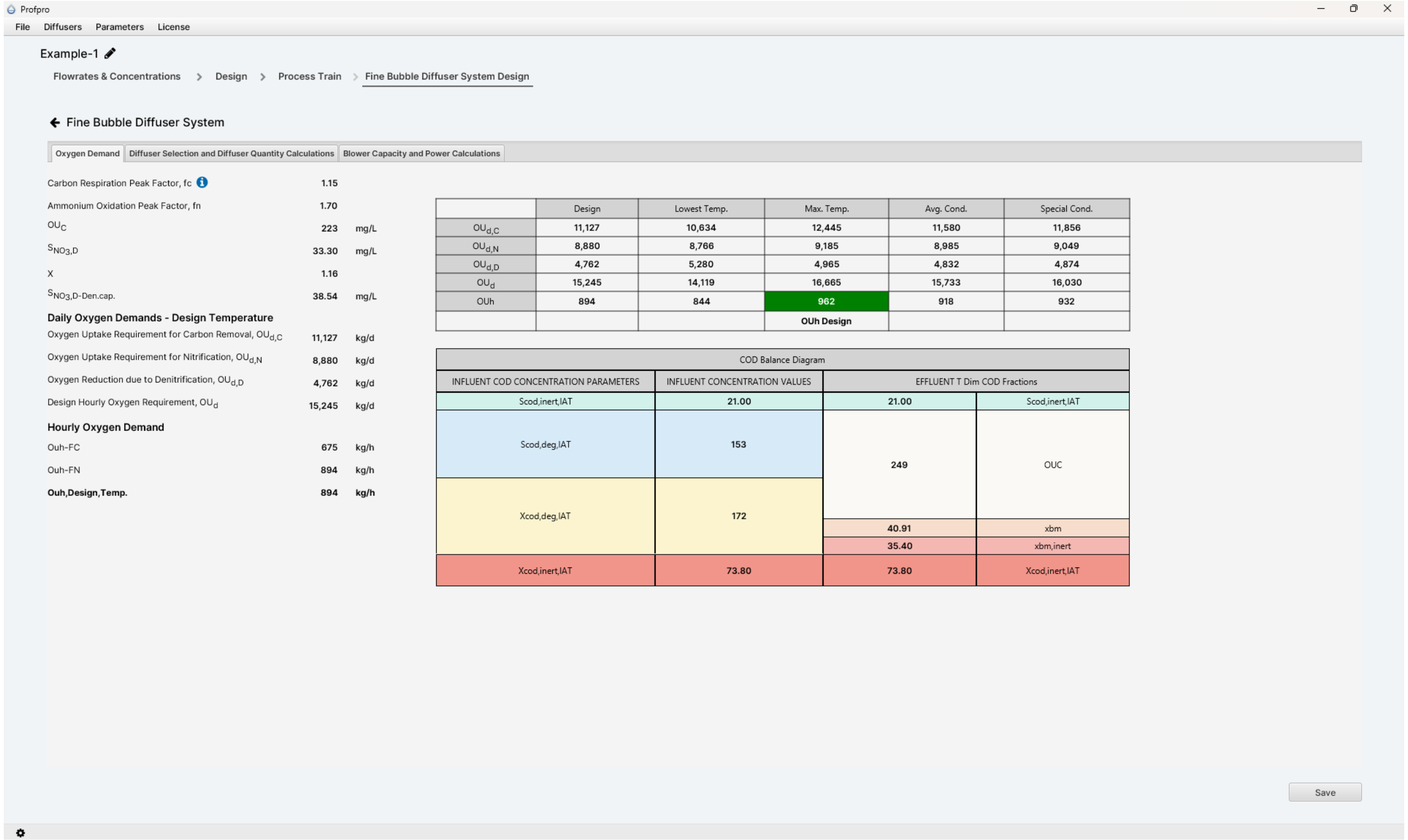
Diffuser List



It can be defined as many diffusers as that the user desire. This feature of ProfPRO allow users to select the most economical and efficient diffusers and corresponding air flow rates.

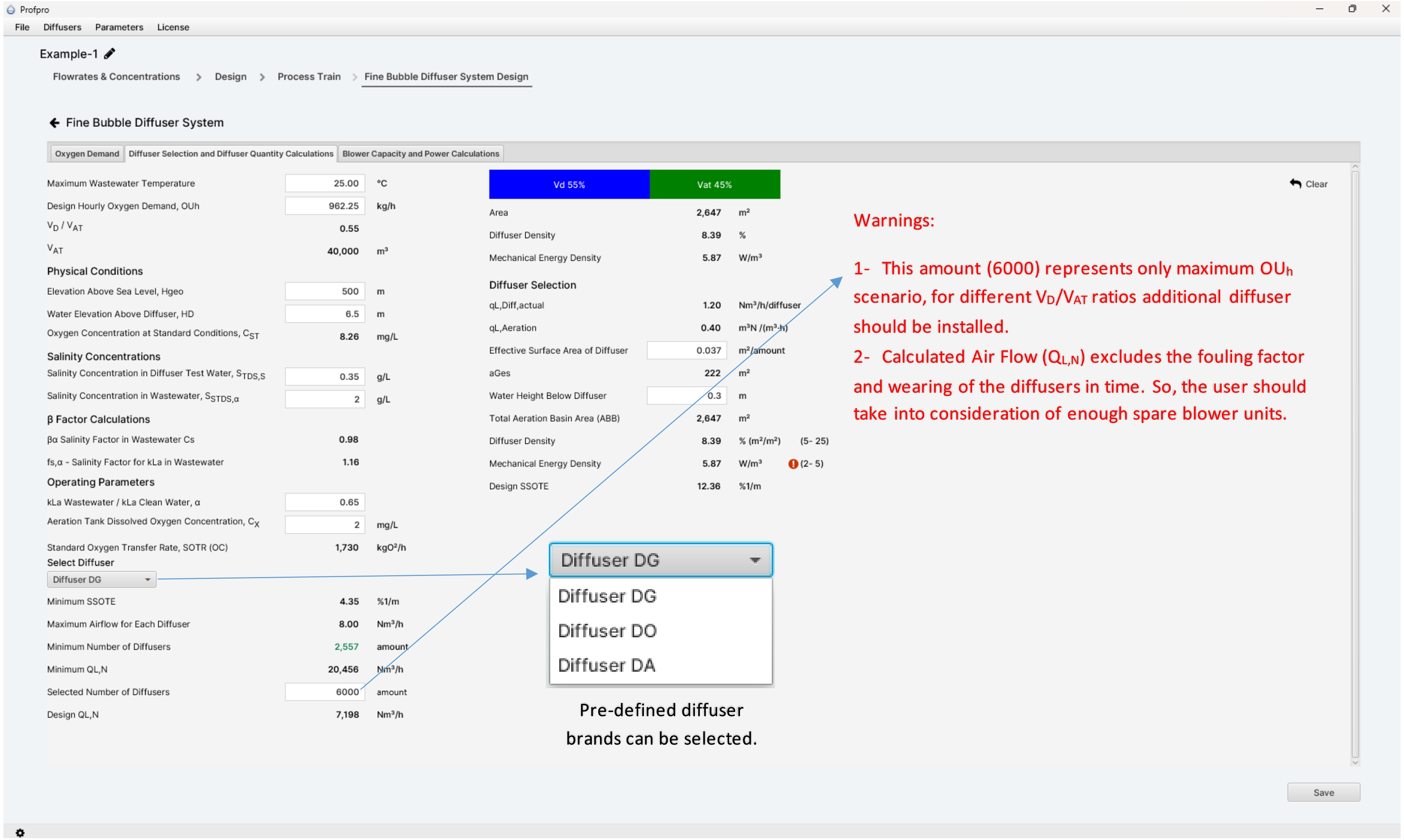
Oxygen Demand

Once **“Fine Bubble Diffuser System Design”** button is pressed, the following screen appears;



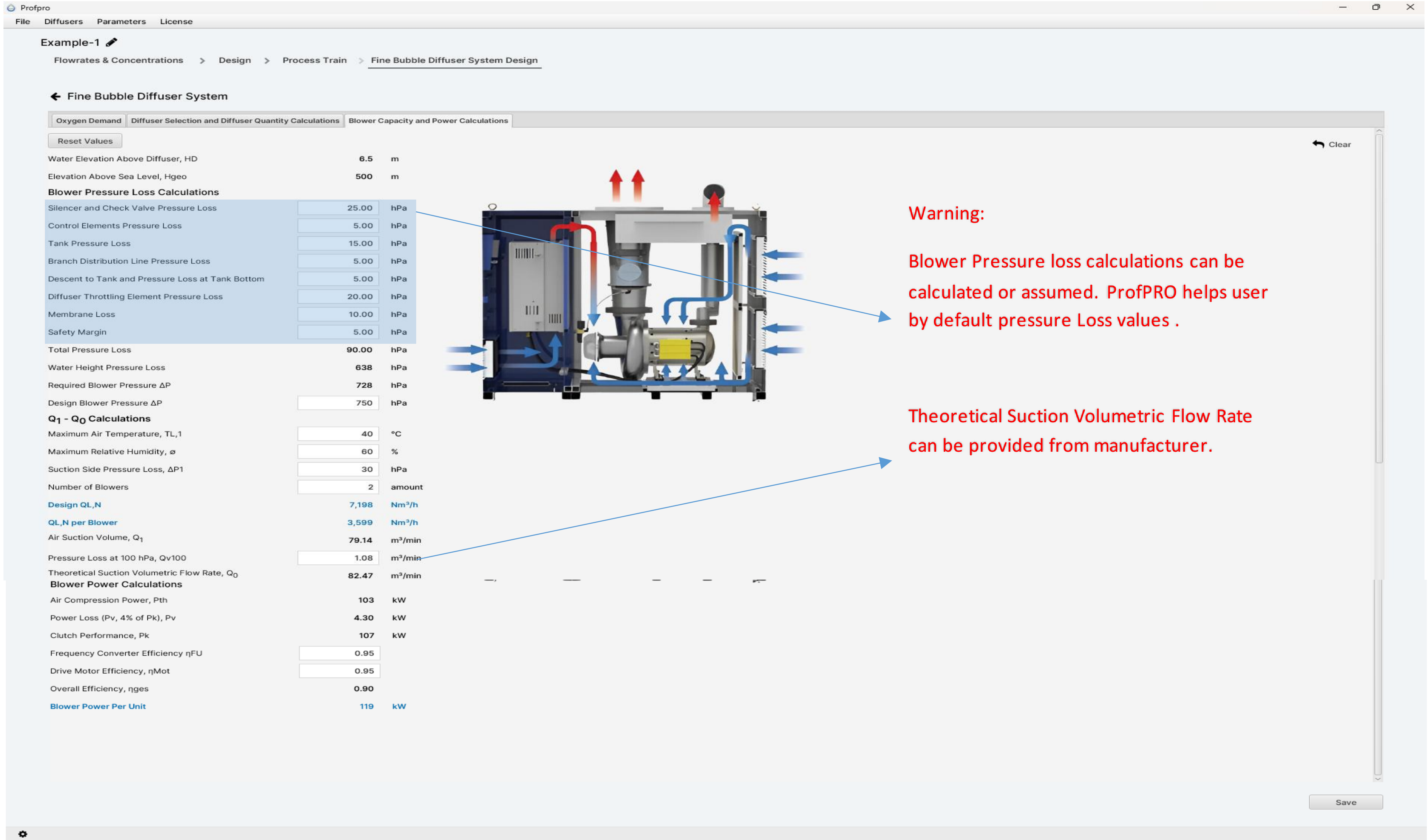
User will find automatically calculated daily and hourly oxygen demand values in a table form as shown above. In this menu there are three different steps to complete the fine bubble aeration system design. ProfPRO calculates and choses the maximum hourly oxygen demand ($OU_{h,\ design}$ kgO_2/h) by using fC and fN coefficients which has been already defined in the “Treatment Options” page. Another unique property of ProfPRO is to show COD Balance Diagram based on the design *Oxygen Utilization (OUh Design) scenario.*

Diffuser Selection and Diffuser Quantity Calculations



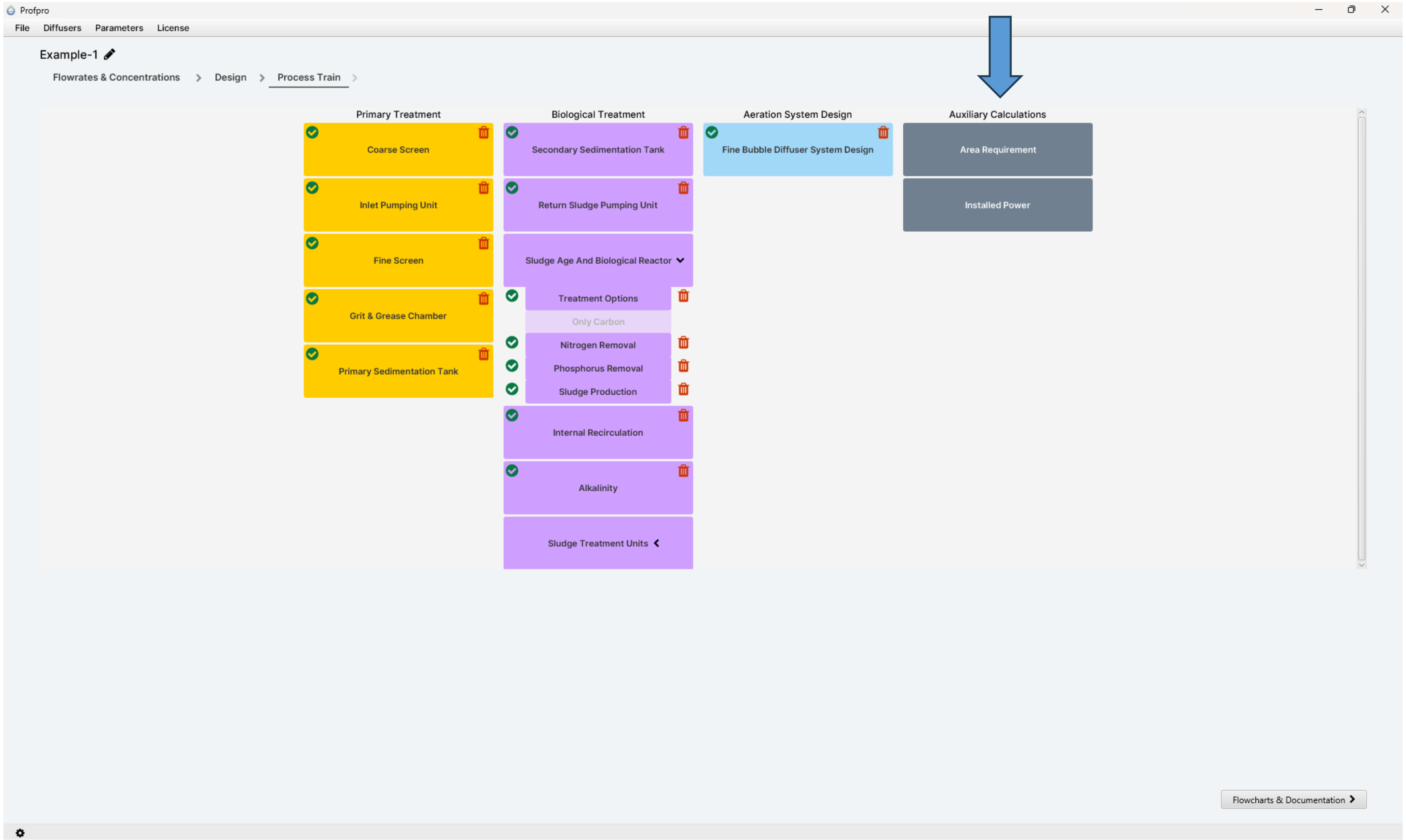
All calculations is executed according to equations and constraints published in the document of *DWA-M 229-1 Systeme zur Belüftung und Durchmischung von Belebungsanlagen. (Aeration and mixing systems for activated sludge plants) (September 2017)*

Blower Capacity and Power Calculations



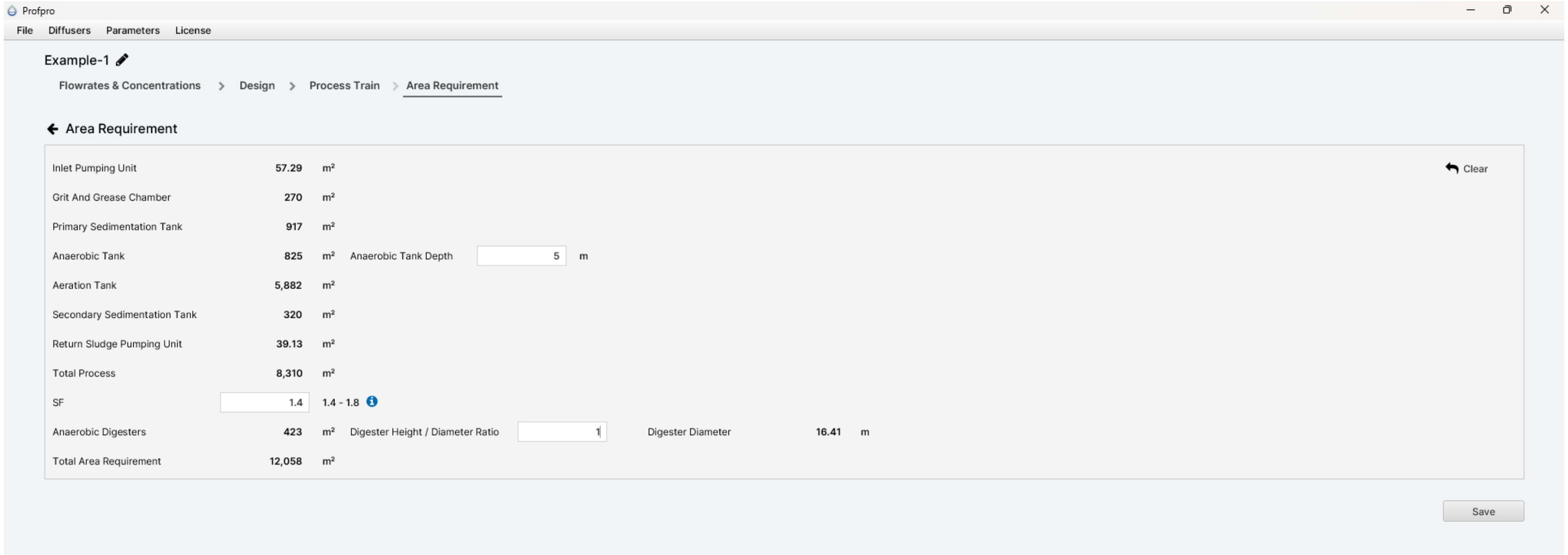
All calculations is executed according to equations and constraints published in the document of *DWA-M 229-1 Systeme zur Belüftung und Durchmischung von Belebungsanlagen. (Aeration and mixing systems for activated sludge plants) (September 2017)*

Auxilary Calculations



Area Requirement

After the whole process calculations are finished, the user can take a look at how much area (net and gross) is needed for the WWTP. This feature of the software gives an idea to the user depth selections, diameter selections in order to match available project area. In **“Area Requirement”** page ProfPRO calculates the units areas except for the areas needed for labouratories, warehouses, administritive buildings etc. The user can compesate missing areas to estimate the final area requirement with a safety factor.



Installed Power

In this section, user can estimate installed electrical power of the designed WWTP. These units listed below are the ones consuming the electricity of more than 80 percentage of total electricial power in any WWTP .The rest of the units and spare installed power calculation can be compesated by safety factor. For 100% percent accuracy, the real equipment powers has be taken into consideration. *“**Installed Power**” section is aimed to give an idea to the user about estimated total power of the designed units. This feature of ProfPRO enables the user to make energy optimisation.For example, choosing optimum water heights in aeration tanks , diffuser numbers , aeration tank volumes and secondary sedimentation tank heights as well as the deciding “YES” OR “NO” some sludge treatment units.*

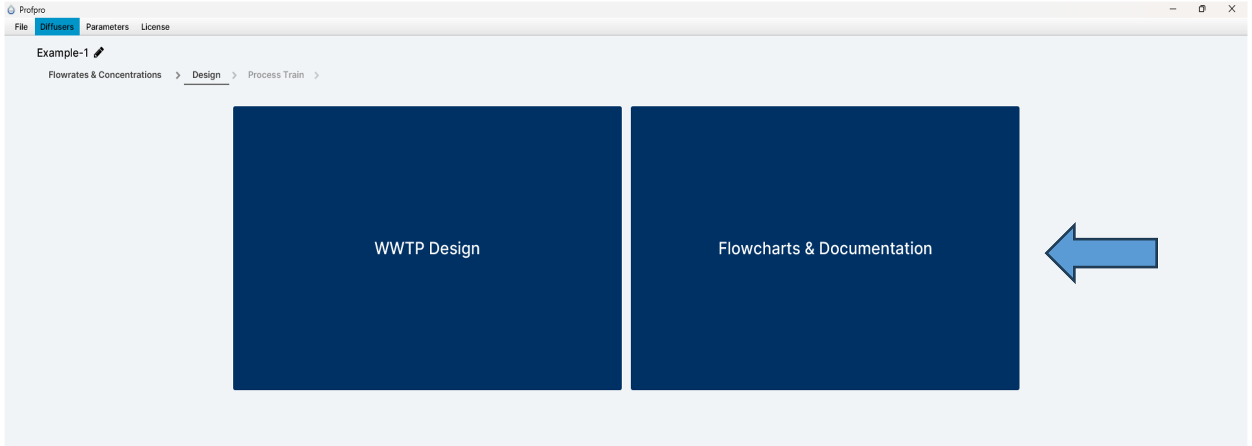
Total Approximate Installed Power

Inlet Pumping Station Installed Pump Power	231	kW
Return Sludge Installed Pump Power	107	kW
Total Mixing Installed Power	159	kW
Total Internal Recirculation Power	24.00	kW
Total Installed Blower Power	240	kW
Primary Sludge Thickening Installed Power	25.00	kW
Secondary Sludge Thickening Installed Power	90.00	kW
Sludge Dewatering Installed Power	35.00	kW
Total Dryer Installed Power	229	kW
Total	1,140	kW
SF	1.10	
Plant Installed Power	1,254	kW

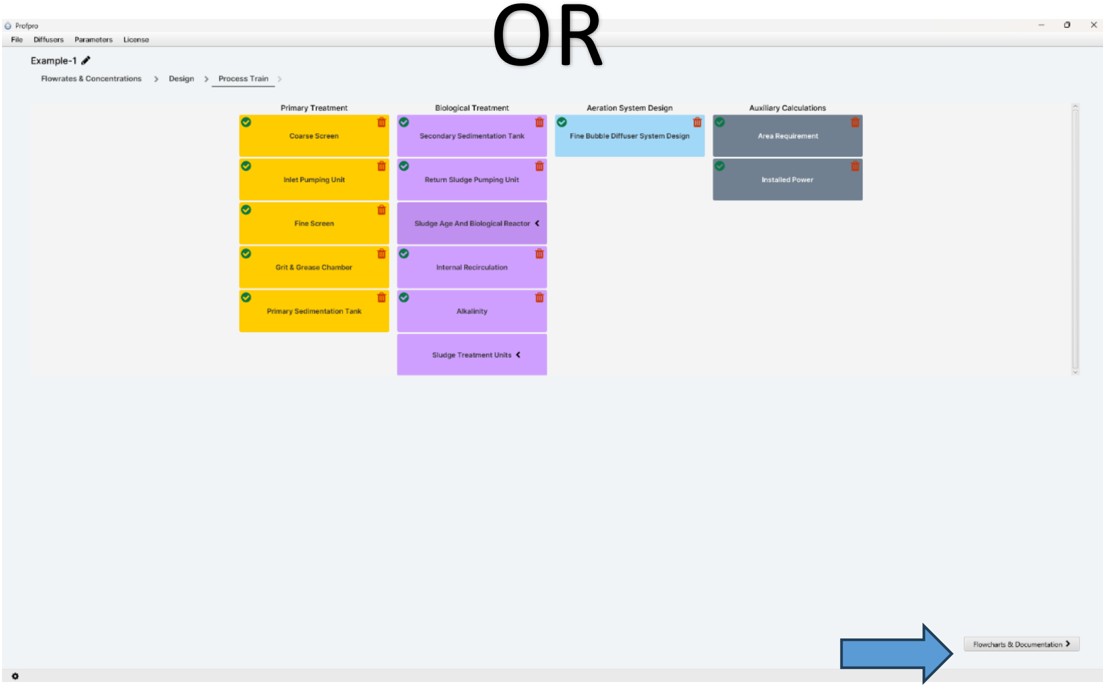
Save

Once the “WWTP Design” section is over, ProfPRO automatically prepares the process design report. The second part of the software is “Flowcharts & Documentation” section. In this section, flowchart of the designed WWTP and process report is included.

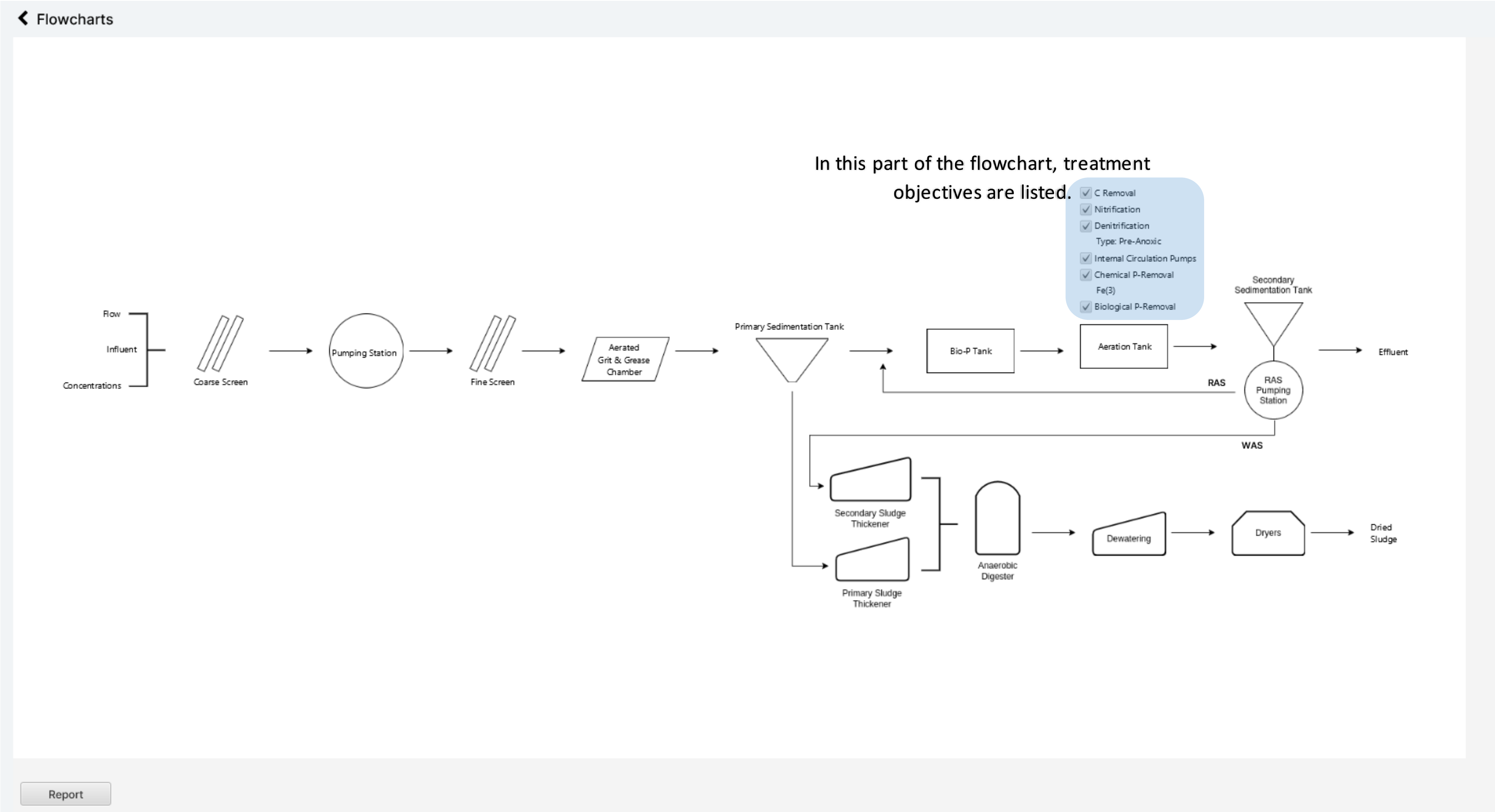
To access this section, press “Flowcharts & Documentation” buttons;



OR

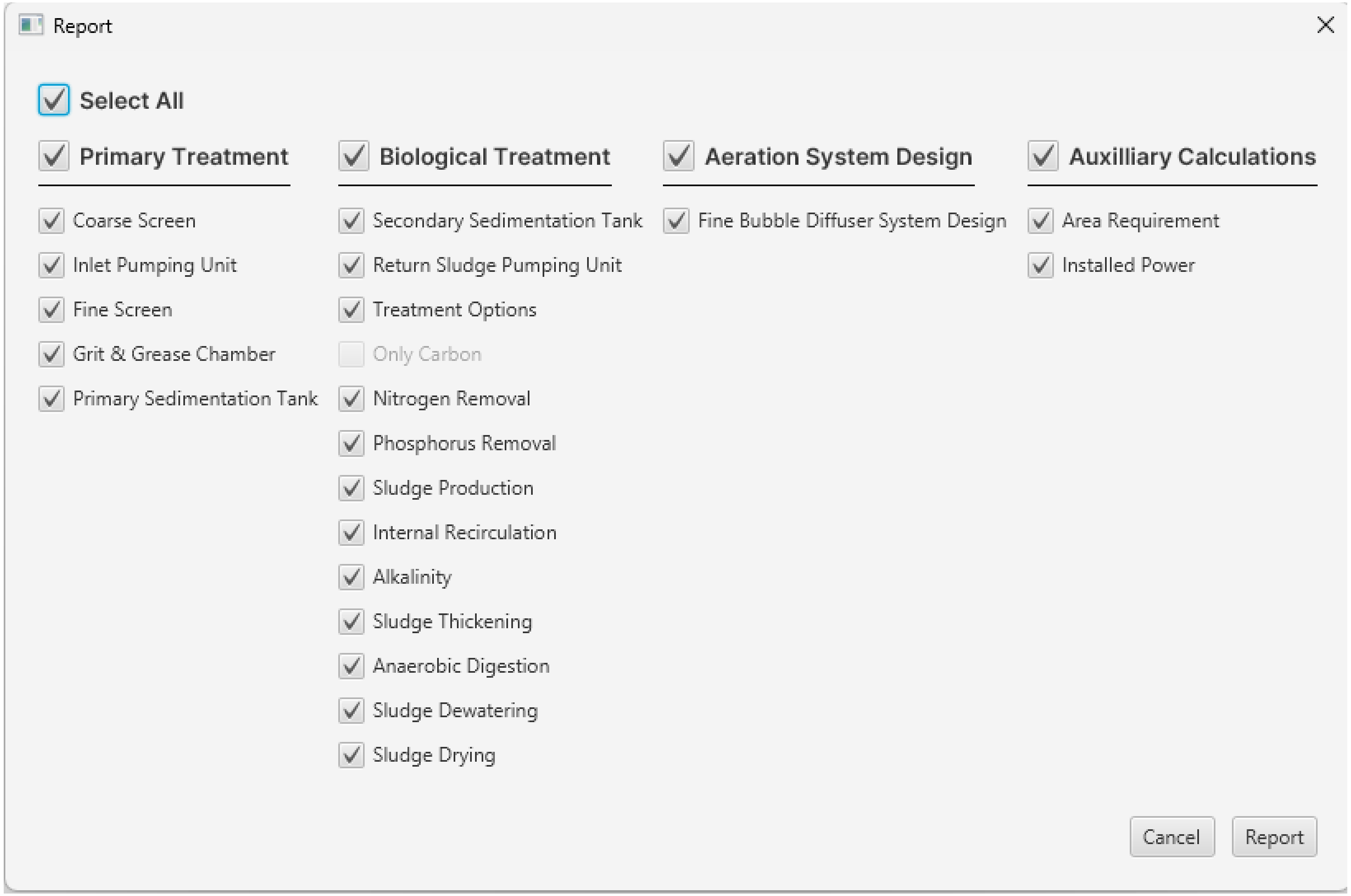


Once, the button is pressed, the user will see the screen below.



If Report button is pressed, the software generates a finalized design report of the selected units and processes.

This screen lists the summary of the units that has been already designed by user. ProfPRO allows the user to form a “Process Report “which can include all the designed units or the only units that is chosen by user.



The finalized design report can be previewed on this screen, exported to PDF or sent to printer directly. Here are the sample pages of the process report;

Flowrates & Concentrations

Dry Weather Flow Rate, $Q_{DW,d}$	50,000	m^3/d	$S_{COD,inert,IAT}$ / $C_{COD,IAT\text{-}fs}$	0.05
24-Hour Dry Weather Flow, $Q_{DW,ave}$	2,083	m^3/h	$X_{inorg,SS,I}$ / $X_{SS\text{-}fb}$	0.30
2-Hour Maximum Dry Weather Flow, $Q_{DW,h}$	2,750	m^3/h	$X_{COD,inert,IAT}$ / $X_{COD,IAT\text{-}fA}$	0.30
Maximum Hourly Flow, $Q_{WW,h}$	3,850	m^3/h	$C_{COD,la,IAT}$ / $C_{deg,IAT\text{-}fCOD}$	0.20
Maximum Hourly Flow, $Q_{WW,d}$	92,400	m^3/d		

Primary Sedimentation Tank **YES** Retention Time **1.00** h

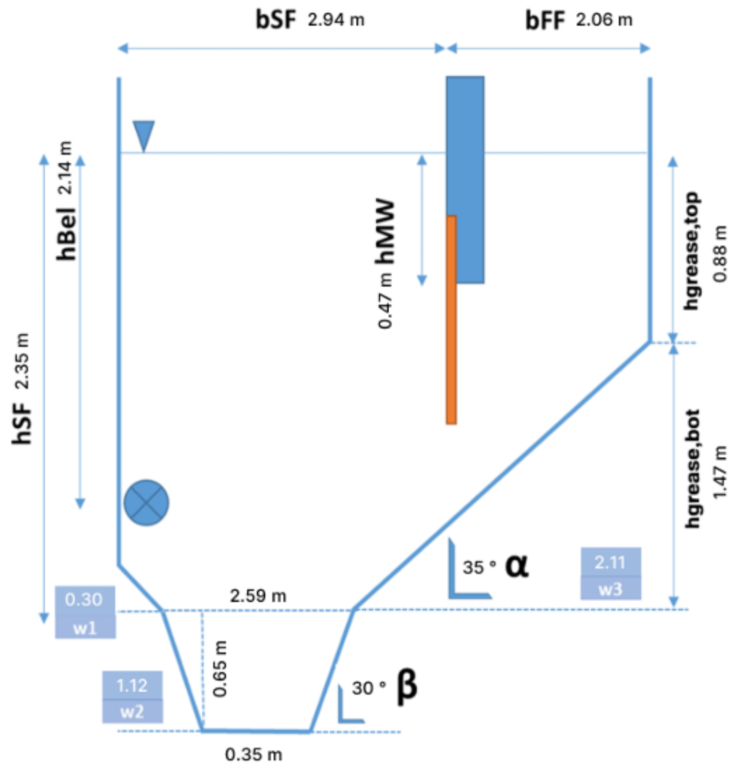
	Raw Wastewater	Biological Reactor Inlet	
Chemical Oxygen Demand, C_{COD}	600	420	mg/L
Particulate COD Concentration, X_{COD}	448	246	mg/L
Suspended Solids Concentration, X_{SS}	400	200	mg/L
Total Kjeldahl Nitrogen Concentration, C_{TKN}	55.00	50.00	mg/L
Phosphorus Concentration, C_{TP}	10.00	9.00	mg/L
Ammounium Nitrogen Concentration, S_{NH_4}	35.00	35.00	mg/L
NH_4, / C_{TKN} Ratio	0.64	0.70	
Nitrate Nitrogen Concentration, S_{NO_3}	0.00	0.00	mg/L
Alkalinity, S_{ALK}	7.10	7.10	mmol/L

COD Fractions

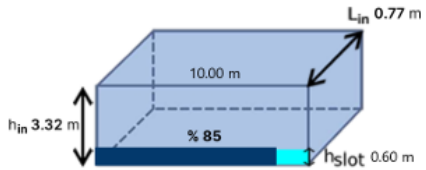
$S_{COD,IAT}$	174	mg/L	$C_{COD,deg,IAT}$	325	mg/L
$X_{COD,IAT}$	246	mg/L	$S_{COD,deg,IAT}$	153	mg/L
$S_{COD,inert,IAT}$	21.00	mg/L	$X_{COD,deg,IAT}$	172	mg/L
$X_{COD,inert,IAT}$	73.80	mg/L			

Biological Reactor COD and SS Fractions		
PERCENTAGE(%) (Based on Inlet COD)	INLET COD CONCENTRATION PARAMETERS	INLET CONCENTRATION VALUES IN TERMS OF COD
5.00	$S_{COD,inert,IAT}$	21.00
36.43	$S_{COD,deg,IAT}$	153
41.00	$X_{COD,deg,IAT}$	172
17.57	$X_{COD,inert,IAT}$	73.80
PERCENTAGE(%) (Based on Inlet SS)	INLET INORGANIC SS CONCENTRATION PARAMETER	INLET INORGANICS CONCENTRATION VALUE (mg/L)
23.13	$X_{SS,inorg,IAT}$	46.25

Grit & Grease Chamber



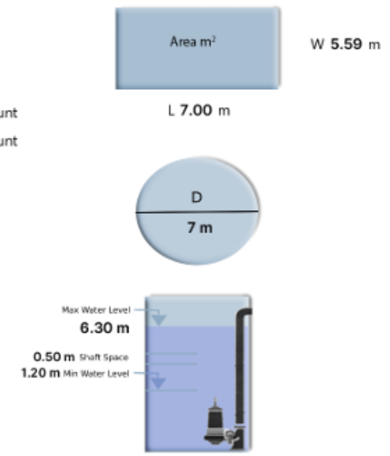
Secondary Sedimentation Tank - Inlet Structure



Retention Time	110	sec
Q*(1+RS)	0.23	m^3/s
Vinlet	25.73	m^3
Length of Inlet Structure, L_{in}	0.77	m
Inlet Structure Depth, h_{in}	3.32	m
Height of Culvert, h_{Slot}	0.60	m
Area Utilization Percentage	85.00	%
Available Area	5.10	m^2
Inlet Pipe Diameter	600	mm
Inlet Pipe Surface Area	0.28	m^2
Pipe Inlet Velocity	0.83	m/s
Wastewater Temperature	12.00	°C
Power Input	80.08	Nm/s
G	50.30	1/sec
Fr	0.60	

Return Sludge Pumping Unit 1		
Maximum Hourly Flow, Qww,h	3,850	m^3/h
Return Sludge Ratio, RSww	1.00	
Total Return Sludge Pump Capacity	3,850	m^3/h
Total Return Sludge Pump Capacity	92,400	m^3/d
Qpm	1,069	L/s
Number of Pumps	3.00	amount
Number of Shafts, Z	6.00	amount
Wet Volume of Pump Room, Vmin	160	m^3
Water Level Difference for Activation	0.50	m
Minimum Operating Level of Pumps	1.20	m
Design Chamber Surface Area, S	39.13	m^2
Required Active Wet Volume	246	m^3
Desired Maximum Water Level	6.30	m
Design Total Water Head	6.30	m
Installed Power		
Maximum Hourly Flow, Qww,h	3,850	m^3/h
Final Sedimentation Tank Shape	Rectangular	
Final Sedimentation Slope	0.07	
Final Sedimentation Average Height	4.70	m
Final Settling Diameter	32.00	m
Final Sedimentation Central Height	6.19	m
Return Sludge Head Difference	0.75	m
Manometric Elevation, H	6.94	m
Liquid Density, ρ	1.00	kg/L
Hydraulic Power, Phydrolic	72.84	kW
Pump Efficiency, η	0.75	
Shaft Power, Pshaft	97.12	kw
Power Margin Factor	1.10	
Installed Pump Power, Pinstalled	107	kW
Number of Pumps	3.00	amount
Installed Power of Each Pump, Ppump	35.61	kW

Return Sludge Pumping Unit 1 Diagram



Nitrogen Removal (Nitrification + Denitrification)

Wastewater Temperature	**15.00**	°C
fN	**1.70**	
Effluent Nitrification Monitoring Alternatives	**10 mg NH4(2 hour)**	

Parameters for Nitrogen Removal

Current PF	**1.50**		Design PF	**1.69**
V_D / V_{AT}	**0.50**			
Min. Sludge Age for Nitrification	**5.11**	d	Design Sludge Age For Nitrification	**5.74**
Min. Sludge Age for Nitrification + Denitrification	**10.21**	d	Design Sludge Age	**11.47**

Additional Carbon Source	**None**	
Additional Carbon Concentration $S_{COD,Ext}$	**0.00**	mg/L

Nitrogen Balance

C_{TKN}	**50.00**	mg/L
N Recharge	**1.55**	mg/L
$XorgN_{,inert}$	**3.08**	mg/L
$XorgN_{,BM}$	**5.17**	mg/L
$Norg_{,EST}$	**2.00**	mg/L
$NH_{4,EST}$	**0.00**	mg/L
Nitrogen to be Nitrified, $S_{NH_4\text{-}N}$	**41.30**	mg/L
Inlet Nitrate Nitrogen Concentration $S_{NO_3,IAT}$	**0.00**	mg/L
Effluent NO_3N,set	**8.00**	mg/L
Denitrification Capacity Needed $S_{NO_3,D}$	**33.30**	mg/L
Available Denitrification Capacity	**38.54**	mg/L
Effluent Nitrate Concentration,NO_3	**2.76**	mg/L
Minimum Required Total Circulation Rate	**416**	%
S_{NO_3}Denitrified with Additional Carbon	**0.00**	mg/L
S_{NO_3}Denitrified by Carbon in Wastewater	**38.54**	mg/L

Phosphorus Removal

Denitrification Type	**Pre-Anoxic**	
Design Wastewater Temperature	**15.00**	°C
Anaerobic Tank	**YES**	
$C_{COD,IAT}$	**420**	mg/L
$C_{P,IAT}$	**9.00**	mg/L
TP_{SET}	**1.00**	mg/L
TP_{EST}	**1.00**	mg/L
Chemical Dosing Requirement	**YES**	

Anaerobic Tank Volume Calculation

HCT (0.5 - 0.75)	**0.75**	h
$Q_{DW,h}$	**2,750**	m^3/h
Anaerobic Tank Volume	**4,125**	m^3

Phosphorus Balance

$C_{P,IAT}$	**9.00**	mg/L
Normal Phosphorus Uptake	**2.10**	mg/L
$X_{P,BioP}$	**2.94**	mg/L
TP_{SET}	**1.00**	mg/L
$X_{P,Prec}$	**2.96**	kg/d
Required Fe(3)	**401**	kg/d

Chemical Phosphorus Removal Calculations

$X_{P,Prec}$	**2.96**	mg/L
P_{Prec}	**148**	kg/d
Required Fe	**401**	kg/d
Required Al	**193**	kg/d
Selected Chemical	**Fe(3)**	
Fe(3)	**401**	kg/d
Density	**1.41**	ton/m^3
Active Ingredient Amount	**135**	kg/ton
Required Chemical	**2,107**	L/d
Pump Safety Factor, SF	**2.00**	
Number of Pumps	**2.00**	amount
Dosing Capacity For Each Pump	**87.78**	L/h

Sludge Production due to Phosphorus Removal

$X_{P,BioP}$	**2.94**	mg/L
Sludge Production from Biological Phosphorus Removal, $SP_{d,BioP}$	**441**	kg/d
Sludge Production from Chemical Phosphorus Removal, $SP_{d,Pprec}$	**1,003**	kg/d

Sludge Production

Wastewater Temperature	15.00	°C
PF	1.69	

Sludge Age

Required Min. Sludge Age for Nitrification + Denitrification	10.21	d
Design Sludge Age for Nitrification + Denitrification	11.47	d

Sludge Production from Carbon Removal

Sludge Production from Carbon Removal, $SP_{d,C}$	9,016	kg/d
Sludge Production From Additional Carbon Sources $SP_{d,C,Ext}$	0.00	kg/d

Sludge Production from Phosphorus Removal

Sludge Production from Biological Phosphorus Removal $SP_{d,BioP}$	441	kg/d
Sludge Production from Chemical Phosphorus Removal $SP_{d,Pprec}$	1,003	kg/d

Total Sludge Production

Total Sludge Production, SP_d	10,459	kg/d
Organic Sludge Production, $SP_{d,org}$	7,144	kg/d
Inorganic Sludge Production, $SP_{d,inorg}$	3,315	kg/d

MLVSS/MLSS Ratio

MLVSS/MLSS	68.31	%

Biological Reactor Volume Calculations

Total Sludge in the Reactor, $M_{SS,AT}$	120,000	kg
Design MLSS Concentration in Wet Weather, MLSS(SS_{AT})	3.00	kg/m³
Biological Reactor Volume, V_{AT}	40,000	m³
Denitrification Tank Volume, V_D	20,000	m³
Nitrification Tank Volume, V_N	20,000	m³

Design Biological Reactor Volume Calculations

Design Biological Reactor Volume	40,000	m³
Design Sludge Age	11.47	d
Sludge Mass in the Tank, M_{SS}	120,000	kg
Design Nitrification Tank Volume	20,000	m³
Design Denitrification Tank Volume	20,000	m³

Sludge Thickening

Primary Sedimentation Tank	YES	
Primary Tank Retention Time	1.00	h

Primary Sludge			Secondary Sludge		
Primary Thickening Unit	YES		Secondary Thickening Unit	YES	
XSS Inorganic / Organic Ratio	0.37				
Primary Sludge Concentration	30.00	kg/m³	Secondary Sludge Concentration	8.02	kg/m³
Primary Sludge Load	10,000	kg/d	Secondary Sludge Load	10,837	kg/d
Primary VS. Organic Load	6,313	kg/d	Secondary VS. Organic Load	7,403	kg/d
Primary FS. Inorganic Load	3,688	kg/d	Secondary FS. Inorganic Load	3,434	kg/d
Primary Sludge Volume	333	m³/d	Secondary Sludge Volume	1,351	m³/d
Operating Hours Per Day	16.00	h	Operating Hours Per Day	16.00	h
Number of Mechanical Thickener	1.00	amount	Number of Mechanical Thickener	1.00	amount
Hydraulic Capacity per Thickener	20.83	m³/h	Hydraulic Capacity per Thickener	42.23	m³/h
Dry Matter Capacity per Thickener	625	kg DS/h	Dry Matter Capacity per Thickener	339	m³/h
Number of Transfer Pumps	1.00	amount	Number of Transfer Pumps	2.00	amount
Capacity For Each Transfer Pump	20.83	m³/h	Capcity For Each Transfer Pump	42.23	m³/h
Polymer Concentration	2.00	kg/m³	Polymer Concentration	2.00	kg/m³
Polymer Dosage	2.00	kg/ton DS	Polymer Dosage	2.00	kg/ton DS
Polymer Tank Retention Time	1.00	h	Polymer Tank Retention Time	1.00	h
Number of Polymer Pump	1.00	amount	Number of Polymer Pump	2.00	amount
Capacity For Each Polymer Pump	625	L/h	Capacity For Each Polymer Pump	339	L/h
Required Polymer Tank	625	L	Required Polymer Tank	677	L
Sludge Concentration After Thickener	60.00	kg/m³	Sludge Concentration After Thickener	60.00	kg/m³
Sludge Volume After Thickener	167	m³/d	Sludge Volume After Thickener	181	m³/d
Filtrate Flow Rate	167	m³/d	Filtrate Flow Rate	1,171	m³/d

Primary + Secondary Sludge		
Primary + Secondary Sludge	20,837	kg/d
Primary + Secondary VS. Organic	13,715	kg/d
Primary + Secondary FS. Inorganic	7,122	kg/d
Primary + Secondary Sludge Concentration	60.00	kg/m³
Primary + Secondary Sludge Volume	347	m³/d

Anaerobic Digestion

The WWTP has an anaerobic digester	**YES**	
Total Sludge	**20,837**	kg/d
VS-Primary and Secondary	**13,715**	kg/d
FS-Primary and Secondary	**7,122**	kg/d
Sludge Concentration After Thickener	**60.00**	kg/m³
Inlet Sludge Volume	**347**	m³/d
Anaerobic Tank Retention Time	**20.00**	d
Total Anaerobic Tank Volume	**6,946**	m³
Number of Anaerobic Tanks	**2.00**	amount
Volume per Anaerobic Tank	**3,473**	m³
Organic Matter Degradation Rate	**45.00**	%
Organic Substance to be Degraded	**6,172**	kg VS/d
Organic Matter After Degradation	**7,543**	kg VS/d
Total SS After Degradation	**14,665**	kg DS/d
Sludge Concentration After Degradation	**42.23**	kg/m³
CH4-(Methane) - Gas Formation (Typical 0.49)	**0.49**	m³/kgVSS
CH4-(Methane) - Gas Formation	**3,024**	m³/d
CH4-(Methane) - Gas Formation (0 °C-1013hPa)	**2,917**	Nm³/d
CH4-(Methane) - Ratio In Biogas	**65.00**	%
Biogas Volume	**4,488**	Nm³/d
Biogas Energy Potential	**28,620**	kWh/d
Biogas Energy Content	**6.38**	kWh/Nm³

Fine Bubble Diffuser System - Oxygen Demand

Peak Factor for Carbon Load, fC	1.15	
Peak Factor for Nitrogen Load, fN	1.70	
OU_C	223	mg/L
$S_{NO3,D}$	33.30	mg/L
X	1.16	
$S_{NO3,D\text{-}Den.cap.}$	38.54	mg/L

Daily Oxygen Demands - Design Temperature

Oxygen Uptake Requirement for Carbon Removal, $OU_{d,C}$	11,127	kg/d
Oxygen Uptake Requirement for Nitrification, $OU_{d,N}$	8,880	kg/d
Oxygen Reduction due to Denitrification, $OU_{d,D}$	4,762	kg/d
Design Hourly Oxygen Requirement, OU_d	15,245	kg/d

Hourly Oxygen Demand

OUh-fC	675	kg/h
OUh-fN	894	kg/h
OUh,Tdesign	**894**	**kg/h**

	Design	Lowest Temp.	Max. Temp.	Avg. Cond.	Special Cond.
$OU_{d,C}$	11,127	10,634	12,445	11,580	11,856
$OU_{d,N}$	8,880	8,766	9,185	8,985	9,049
$OU_{d,D}$	4,762	5,280	4,965	4,832	4,874
OU_d	15,245	14,119	16,665	15,733	16,030
OUh	894	844	962	918	932
			OUh Design		

COD Balance Diagram			
INFLUENT COD CONCENTRATION	INFLUENT CONCENTRATION	EFFLUENT T Dim COD Fractions	
$S_{COD,inert,IAT}$	21.00	21.00	$S_{COD,inert,IAT}$
$S_{COD,deg,IAT}$	153	249	OU_C
$X_{COD,deg,IAT}$	172		
		40.91	X_{BM}
		35.40	$X_{BM,inert}$
$X_{COD,inert,IAT}$	73.80	73.80	$X_{COD,inert,IAT}$

Fine Bubble Diffuser System - Blower Capacity and Power Calculations

Blower Pressure Loss Calculations

Silencer and Check Valve Pressure Loss	**25.00**	hPa
Control Elements Pressure Loss	**5.00**	hPa
Tank Pressure Loss	**15.00**	hPa
Branch Distribution Line Pressure Loss	**5.00**	hPa
Descent to Tank and Pressure Loss at Tank Bottom	**5.00**	hPa
Diffuser Throttling Element Pressure Loss	**20.00**	hPa
Membrane Loss	**10.00**	hPa
Safety Margin	**5.00**	hPa
Total Pressure Loss	**90.00**	hPa
Water Height Pressure Loss	**638**	hPa
Required Blower Pressure ΔP	**728**	hPa
Design Blower Pressure ΔP	**750**	hPa

Q_1 - Q_0 Calculations

Maximum Air Temperature, TL,1	**40.00**	°C
Maximum Relative Humidity, ∅	**60.00**	%
Suction Side Pressure Loss, ΔP1	**30.00**	hPa
Number of Blowers	**2.00**	amount
Design QL,N	**7,198**	Nm^3/h
QLN Per Blower	**3,599**	Nm^3/h
Air Suction Volume, Q_1	**79.14**	m^3/min
Pressure Loss at 100 hPa, Qv100	**1.08**	m^3/min
Theoretical Suction Volumetric Flow Rate, Q_0	**82.47**	m^3/min

Blower Power Calculations

Air Compression Power, Pth	**103**	kW
Power Loss (Pv, 4% of Pk),Pv	**4.30**	kW
Clutch Performance, Pk	**107**	kW
Frequency Converter Efficiency ηFU	**0.95**	
Drive Motor Efficiency, ηMot	**0.95**	
Over Efficiency, ηges	**0.90**	
Power For Each Blower	**119**	kW