

# Modeliranje uređaja za pročišćavanje otpadnih voda – znanstvena fantastika ili skora realnost?

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- Što je to model?
- Kratka povijest modeliranja
- Uporaba modela

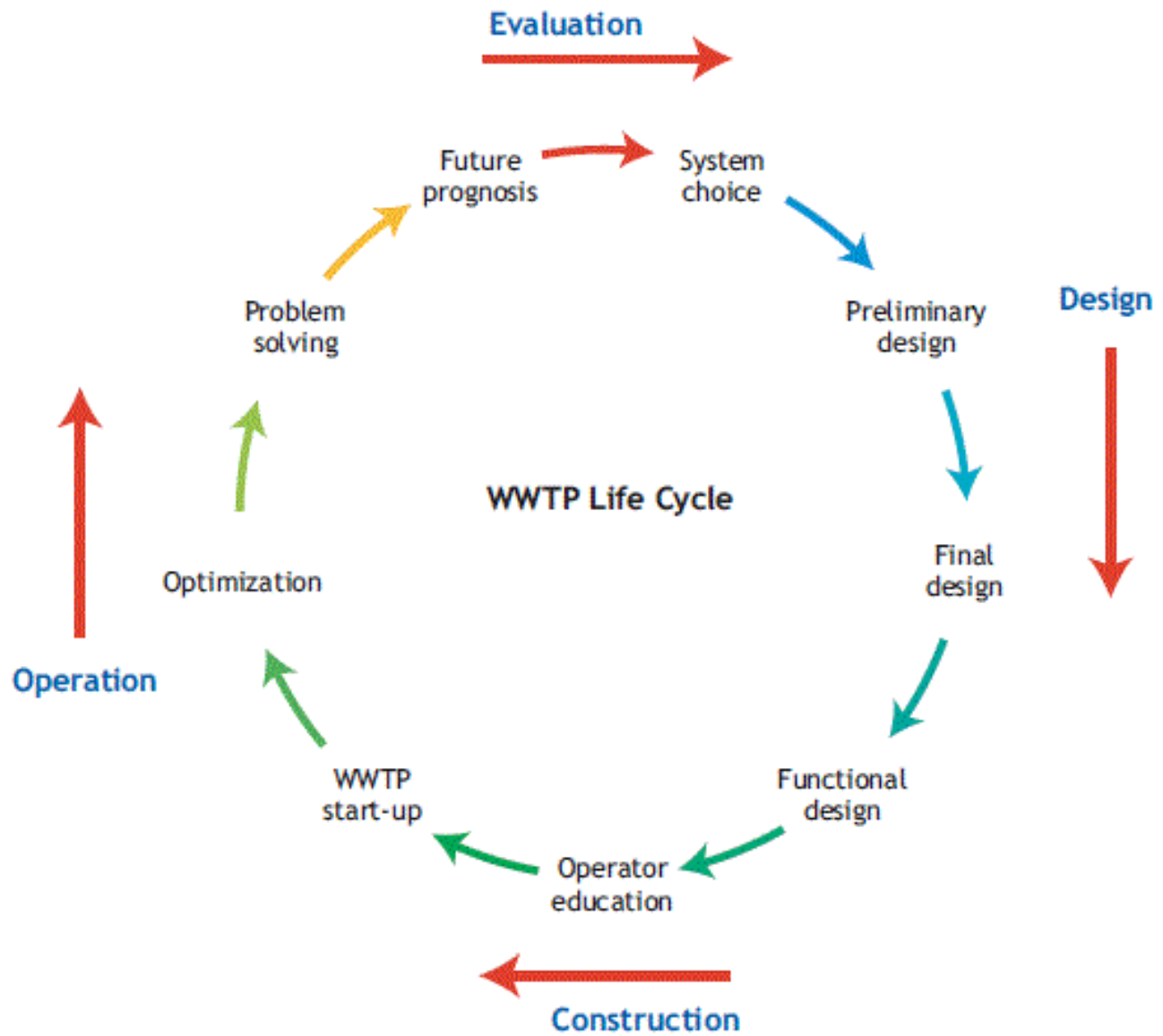


Figure 2.1 Wastewater treatment plant lifecycle

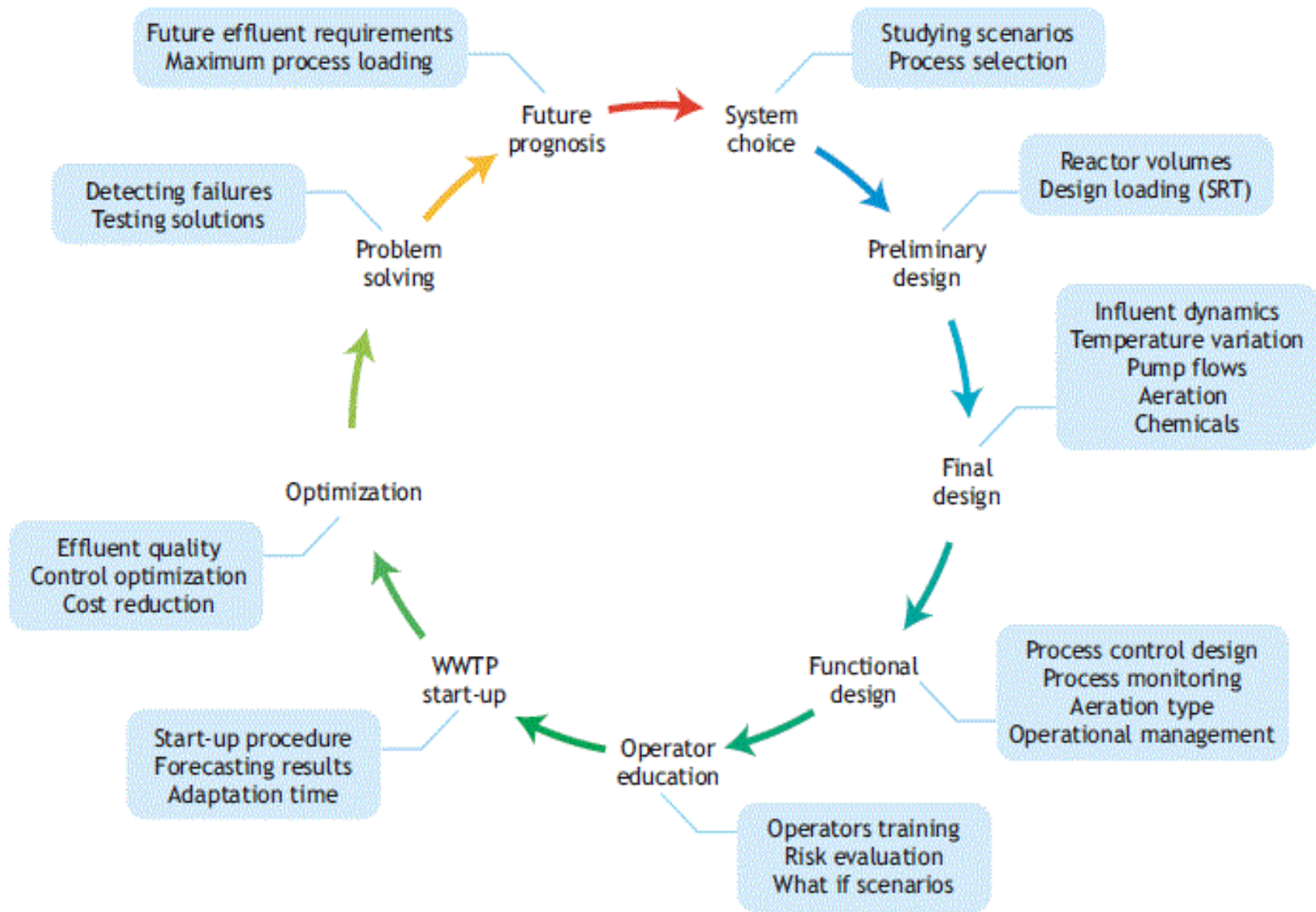
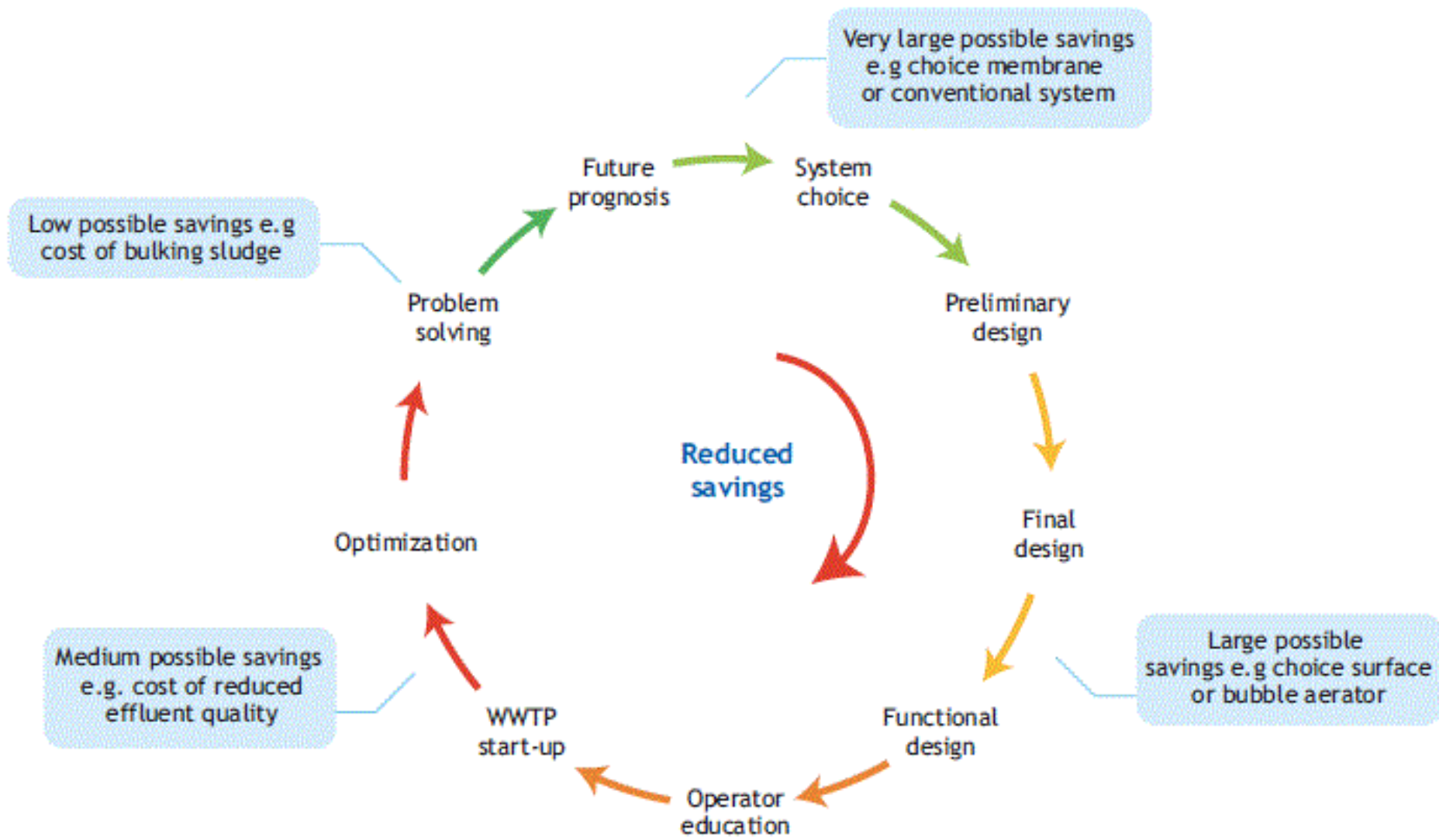


Figure 2.2 Modeling application at different stages of the plant lifecycle



**Figure 2.3 Possibility for costs saving during the WWTP lifecycle**

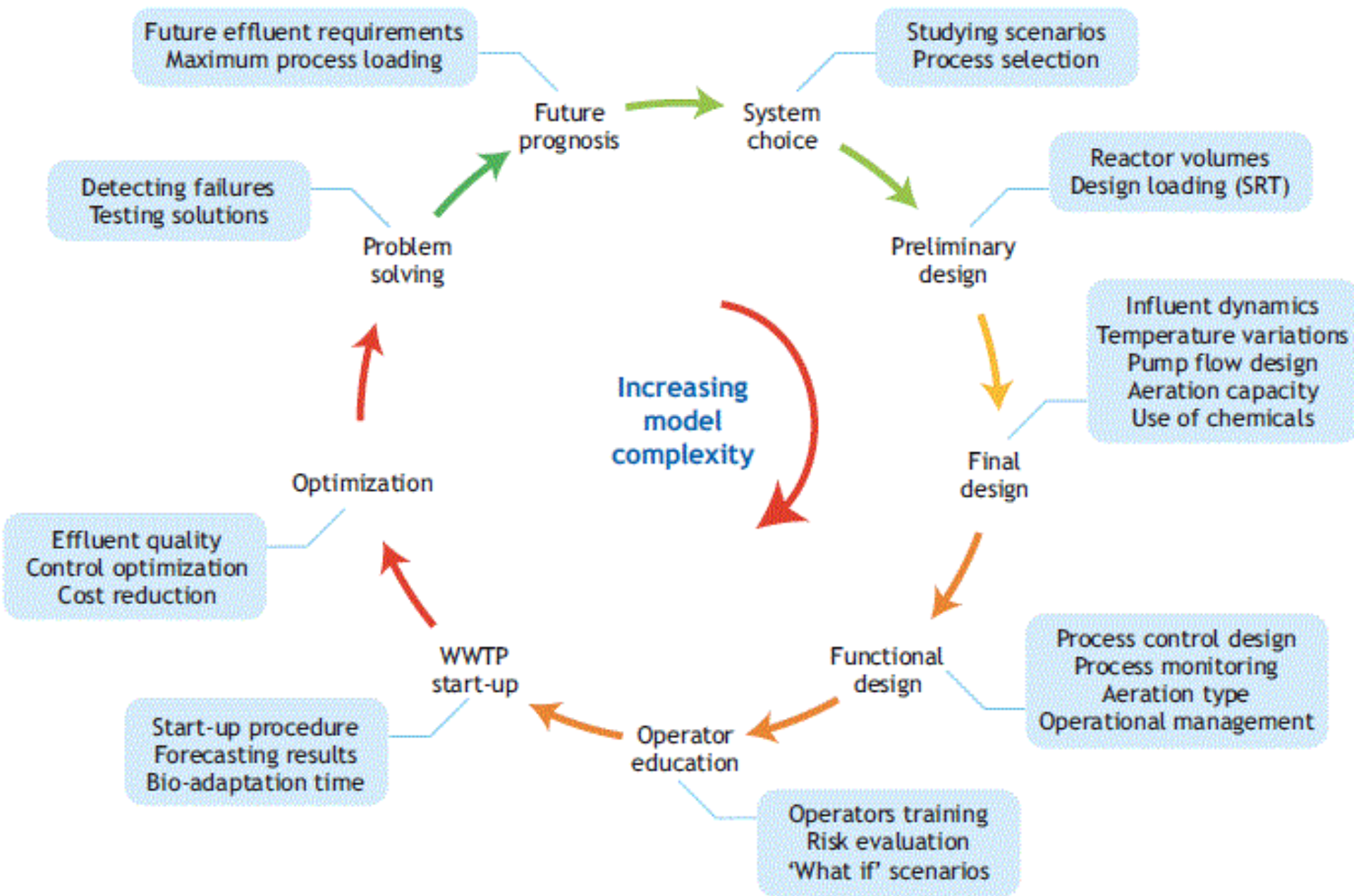
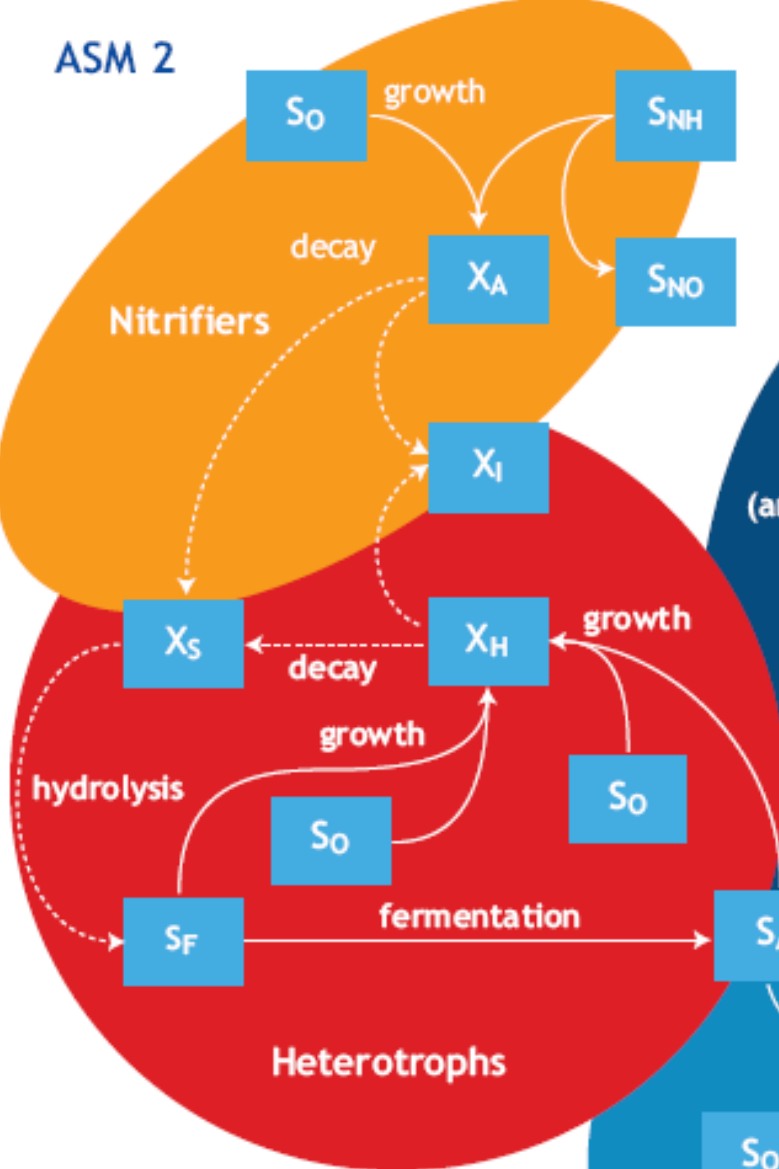


Figure 2.4 Model complexity and increasing operational risks during the plant lifecycle

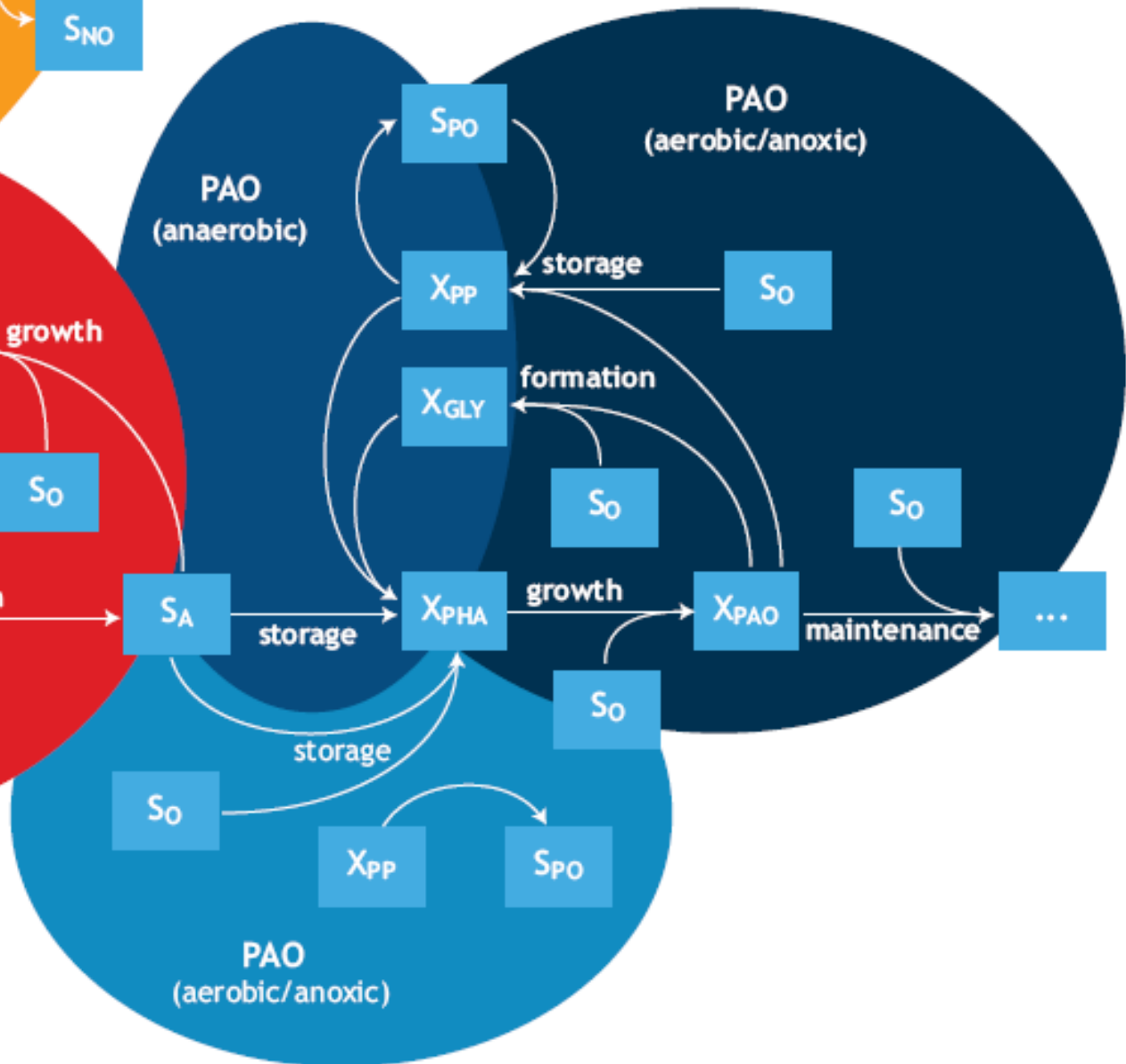
# MATRICA

Components i	1: S <sub>O</sub>	2: S <sub>S</sub>	3: X <sub>H</sub>	Process rate equation ρ <sub>j</sub>
List of processes j				
Aerobic growth	$-\frac{1}{Y_H} + 1$	$-\frac{1}{Y_H}$	+1	$\mu_H^{\max} \cdot \frac{S_S}{K_S + S_S} \cdot X_H$
Lysis		+1	-1	$b_H \cdot X_H$
Observed transformation rate r <sub>i</sub>	$r_i = \sum_j v_{j,i} \cdot \rho_j \quad [M_i L^{-3} T^{-1}]$			
Definition of stoichiometric parameters:				Definition of kinetic parameters:
Y <sub>H</sub> Heterotrophic yield coefficient [M <sub>H</sub> M <sub>S</sub> <sup>-1</sup> ]	Dissolved oxygen (O <sub>2</sub> )	Dissolved organic substrate (COD)	Heterotrophic biomass (COD)	μ <sub>H</sub> <sup>max</sup> Maximum specific growth rate [T <sup>-1</sup> ] K <sub>S</sub> Saturation coefficient for substrate [M <sub>COD</sub> L <sup>-3</sup> ] b <sub>H</sub> rate constant for decay [T <sup>-1</sup> ]

## ASM 2



## Metabolic P model





# MATRIČNI PRIKAZ JEDNOG SLOŽENOG ASM MODELA

Component →			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
			S <sub>O</sub>	S <sub>F</sub>	S <sub>A</sub>	S <sub>NH</sub>	S <sub>NO</sub>	S <sub>NI2</sub>	S <sub>PO</sub>	S <sub>I</sub>	S <sub>HCO</sub>	X <sub>I</sub>	X <sub>S</sub>	X <sub>H</sub>	X <sub>PAO</sub>	X <sub>PP</sub>	X <sub>PHA</sub>	X <sub>GLY</sub>	X <sub>A</sub>	X <sub>TSS</sub>	
Process ↓			gO <sub>2</sub> /m <sup>3</sup>	gCOD/m <sup>3</sup>	gCOD/m <sup>3</sup>	gN/m <sup>3</sup>	gN/m <sup>3</sup>	gN/m <sup>3</sup>	gP/m <sup>3</sup>	gCOD/m <sup>3</sup>	mole/m <sup>3</sup>	gCOD/m <sup>3</sup>	gCOD/m <sup>3</sup>	gCOD/m <sup>3</sup>	gP/m <sup>3</sup>	gCOD/m <sup>3</sup>	gCOD/m <sup>3</sup>	gCOD/m <sup>3</sup>	gCOD/m <sup>3</sup>	g/m <sup>3</sup>	
	1	r <sub>H</sub> <sup>O</sup>	Aerobic Hydrolysis	gCOD <sub>XH</sub> /d	1-f <sub>SI</sub>		C <sub>N,1</sub>			c <sub>P,1</sub>	f <sub>SI</sub>	c <sub>e,1</sub>			-1						C <sub>TSS,1</sub>
2	r <sub>H</sub> <sup>NO</sup>	Anoxic Hydrolysis	gCOD <sub>XH</sub> /d	1-f <sub>SI</sub>		C <sub>N,1</sub>			c <sub>P,1</sub>	f <sub>SI</sub>	c <sub>e,1</sub>			-1						C <sub>TSS,1</sub>	
3	r <sub>H</sub> <sup>AO</sup>	Anaerobic Hydrolysis	gCOD <sub>XH</sub> /d	1-f <sub>SI</sub>		C <sub>N,1</sub>			c <sub>P,1</sub>	f <sub>SI</sub>	c <sub>e,1</sub>			-1						C <sub>TSS,1</sub>	
Regular Heterotrophic Organisms X <sub>H</sub>																					
4	r <sub>SF</sub> <sup>O</sup>	Aerobic Growth on S <sub>F</sub>	gCOD <sub>XH</sub> /d	-(1/Y <sub>H</sub> - 1)	-1/Y <sub>H</sub>		C <sub>N,4</sub>			c <sub>P,4</sub>	-1/Y <sub>H</sub>	c <sub>e,4</sub>			1					C <sub>TSS,4</sub>	
5	r <sub>SA</sub> <sup>O</sup>	Aerobic Growth on S <sub>A</sub>	gCOD <sub>XH</sub> /d	-(1/Y <sub>H</sub> - 1)		-1/Y <sub>H</sub>	C <sub>N,5</sub>			c <sub>P,5</sub>		c <sub>e,5</sub>			1					C <sub>TSS,5</sub>	
6	r <sub>SF</sub> <sup>NO</sup>	Anoxic Growth on S <sub>F</sub>	gCOD <sub>XH</sub> /d		-1/Y <sub>H</sub>		C <sub>N,6</sub>	$-\frac{(1/Y_H - 1)}{2.86}$	$\frac{(1/Y_H - 1)}{2.86}$			c <sub>e,6</sub>			1					C <sub>TSS,6</sub>	
7	r <sub>SA</sub> <sup>NO</sup>	Anoxic Growth on S <sub>A</sub>	gCOD <sub>XH</sub> /d		-1/Y <sub>H</sub>		C <sub>N,7</sub>	$-\frac{(1/Y_H - 1)}{2.86}$	$\frac{(1/Y_H - 1)}{2.86}$			c <sub>e,7</sub>			1					C <sub>TSS,7</sub>	
8	r <sub>H</sub> <sup>AN</sup>	Fermentation	gCOD <sub>SF</sub> /d		-1	1	C <sub>N,8</sub>			c <sub>P,8</sub>		c <sub>e,8</sub>								C <sub>TSS,8</sub>	
9	r <sub>HL</sub>	Heterotrophic Lysis	gCOD <sub>XH</sub> /d				C <sub>N,9</sub>			c <sub>P,9</sub>		c <sub>e,9</sub>	f <sub>XLH</sub>	1 - f <sub>XLH</sub>	-1					C <sub>TSS,9</sub>	
Phosphorus Accumulating Organisms X <sub>PAO</sub>																					
10	r <sub>SA</sub> <sup>AN</sup>	Anaerobic Storage of S <sub>A</sub>	gCOD <sub>SA</sub> /d			-1				Y <sub>PO</sub> <sup>AN</sup>		c <sub>e,10</sub>					-Y <sub>SA</sub> <sup>AN</sup>	Y <sub>SA</sub> <sup>AN</sup>	1 - Y <sub>SA</sub> <sup>AN</sup>	C <sub>TSS,10</sub>	
11	r <sub>M</sub> <sup>AN</sup>	Anaerobic Maintenance	gP/d							1		c <sub>e,11</sub>					-1			C <sub>TSS,11</sub>	
12	r <sub>SA</sub> <sup>NO</sup>	Anoxic Storage of S <sub>A</sub>	gCOD <sub>SA</sub> /d			-1				Y <sub>PO</sub> <sup>NO</sup>		c <sub>e,12</sub>					-Y <sub>PO</sub> <sup>NO</sup>	Y <sub>SA</sub> <sup>NO</sup>		C <sub>TSS,12</sub>	
13	r <sub>PHA</sub> <sup>NO</sup>	Anoxic PHA Consumption	gCOD <sub>PHA</sub> /d				C <sub>N,13</sub>	$-\frac{(1 - Y_{SA}^{NO})}{2.86}$	$\frac{(1 - Y_{SA}^{NO})}{2.86}$			c <sub>e,13</sub>			1/Y <sub>PHA</sub> <sup>NO</sup>			-1		C <sub>TSS,13</sub>	
14	r <sub>PP</sub> <sup>NO</sup>	Anoxic Storage of polyP	gP/d				C <sub>N,14</sub>	$-\frac{(1/Y_{PP}^{NO})}{2.86}$	$\frac{(1/Y_{PP}^{NO})}{2.86}$			c <sub>e,14</sub>			-1/Y <sub>PP</sub> <sup>NO</sup>	1				C <sub>TSS,14</sub>	
15	r <sub>GLY</sub> <sup>NO</sup>	Anoxic Glycogen Formation	gCOD <sub>GLY</sub> /d				C <sub>N,15</sub>	$-\frac{(1/Y_{GLY}^{NO} - 1)}{2.86}$	$\frac{(1/Y_{GLY}^{NO} - 1)}{2.86}$			c <sub>e,15</sub>			-1/Y <sub>GLY</sub> <sup>NO</sup>			1		C <sub>TSS,15</sub>	
16	r <sub>M</sub> <sup>NO</sup>	Anoxic Maintenance	gCOD <sub>PAO</sub> /d				C <sub>N,16</sub>	-1/2.86	1/2.86			c <sub>e,16</sub>				-1				C <sub>TSS,16</sub>	
17	r <sub>PHA</sub> <sup>O</sup>	Aerobic PHA Consumption	gCOD <sub>PHA</sub> /d	1/Y <sub>PHA</sub> <sup>O</sup> - 1			C <sub>N,17</sub>					c <sub>e,17</sub>				1/Y <sub>PHA</sub> <sup>O</sup>			-1	C <sub>TSS,17</sub>	
18	r <sub>PP</sub> <sup>O</sup>	Aerobic Storage of polyP	gP/d	-1/Y <sub>PP</sub> <sup>O</sup>			C <sub>N,18</sub>					c <sub>e,18</sub>				-1/Y <sub>PP</sub> <sup>O</sup>	1			C <sub>TSS,18</sub>	
19	r <sub>GLY</sub> <sup>O</sup>	Aerobic Glycogen Formation	gCOD <sub>GLY</sub> /d	1 - 1/Y <sub>GLY</sub> <sup>O</sup>			C <sub>N,19</sub>					c <sub>e,19</sub>				-1/Y <sub>GLY</sub> <sup>O</sup>			1	C <sub>TSS,19</sub>	
20	r <sub>M</sub> <sup>O</sup>	Aerobic Maintenance	gCOD <sub>PAO</sub> /d	-1			C <sub>N,20</sub>					c <sub>e,20</sub>				-1				C <sub>TSS,20</sub>	
Autotrophic Nitrifying Organisms X <sub>A</sub>																					
21	r <sub>A</sub> <sup>O</sup>	Autotrophic Growth	gCOD <sub>XA</sub> /d	1 - 4.57/Y <sub>A</sub>			C <sub>N,21</sub>	1/Y <sub>A</sub>				c <sub>e,21</sub>								1	C <sub>TSS,21</sub>
22	r <sub>AL</sub>	Autotrophic Lysis	gCOD <sub>XA</sub> /d				C <sub>N,22</sub>					c <sub>e,22</sub>	f <sub>XLA</sub>	1 - f <sub>XLA</sub>						-1	C <sub>TSS,22</sub>
Component →			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
			S <sub>O</sub>	S <sub>F</sub>	S <sub>A</sub>	S <sub>NH</sub>	S <sub>NO</sub>	S <sub>NI2</sub>	S <sub>PO</sub>	S <sub>I</sub>	S <sub>HCO</sub>	X <sub>I</sub>	X <sub>S</sub>	X <sub>H</sub>	X <sub>PAO</sub>	X <sub>PP</sub>	X <sub>PHA</sub>	X <sub>GLY</sub>	X <sub>A</sub>	X <sub>TSS</sub>	
↓ Composition		gO <sub>2</sub>	gCOD	gCOD	gN	gN	gN	gP	gCOD	mole	gCOD	gCOD	gCOD	gCOD	gP	gCOD	gCOD	gCOD	gCOD	g	
1	COD	gCOD	-1	1	1			-2.86	...			1	1	1	1						
2	TOC/COD	gC/gCOD		...	0.4							...	...	...		0.334 (α)	0.334	0.375	...		
3	Nitrogen	gN		i <sub>N,SF</sub>	i <sub>N,SA</sub>	1	1	1			i <sub>N,SI</sub>	i <sub>N,XI</sub>	i <sub>N,XS</sub>	i <sub>N,XH</sub>	i <sub>N,BM</sub>					i <sub>N,BM</sub>	
4	Phosphorus	gP		i <sub>P,SF</sub>	i <sub>P,SA</sub>						1	i <sub>P,SI</sub>	i <sub>P,XI</sub>	i <sub>P,XS</sub>	i <sub>P,XH</sub>	i <sub>P,BM</sub>	1			i <sub>P,BM</sub>	
5	Ionic charge	mole			-1/64	+1/14	-1/14				-1.5/31		-1				-1/31				
6	TSS	g										i <sub>TSS,XI</sub>	i <sub>TSS,XS</sub>	i <sub>TSS,BM</sub>	i <sub>TSS,BM</sub>	i <sub>TSS,PP</sub>	i <sub>TSS,PHA</sub>	i <sub>TSS,GLY</sub>	i <sub>TSS,BM</sub>	1	

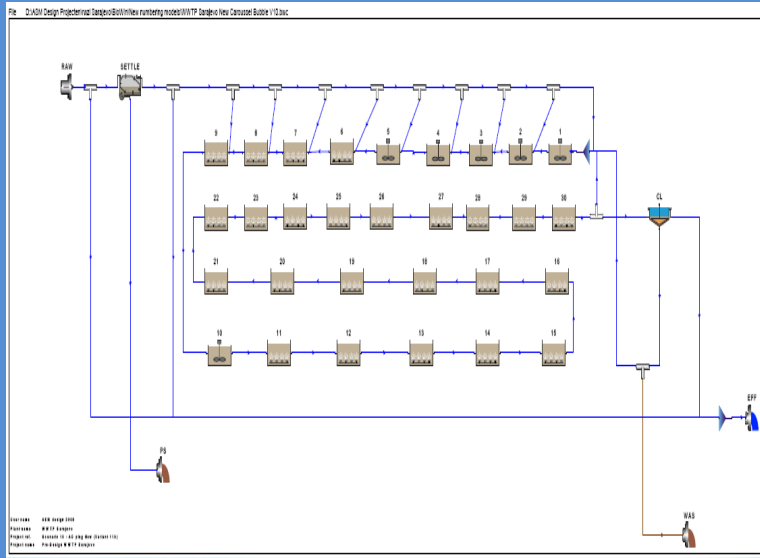
# Primjer 1: Sarajevo, Bosna i Hercegovina

**Publication:**

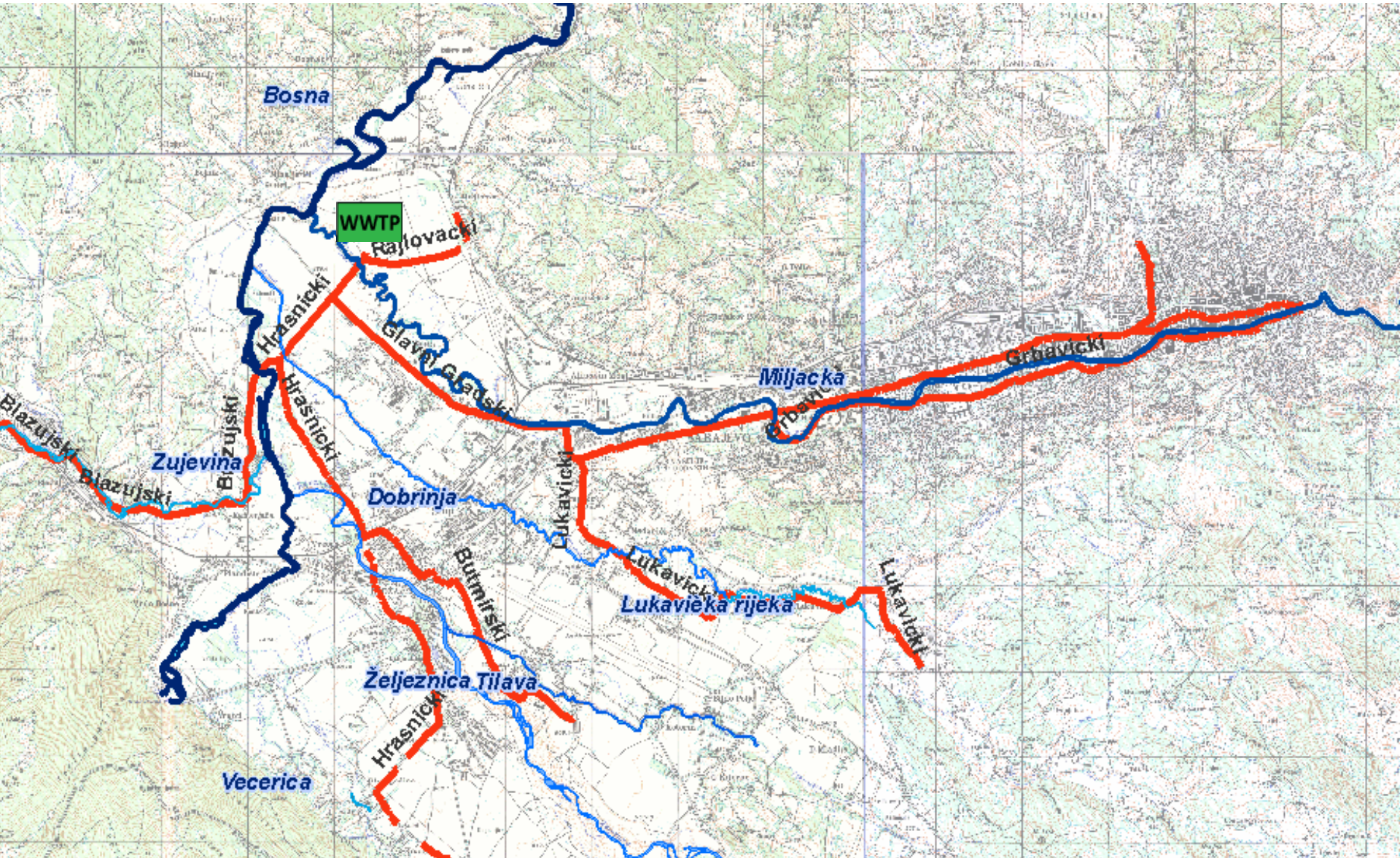
B. Meijer and D. Brdjanovic,

**USE OF MODELLING IN A DECISION-MAKING PROCESS FOR UPGRADE OF A WWTPs**

*IWA Conference Wastewater Treatment Plants of the XXI Century, Moscow 2010*



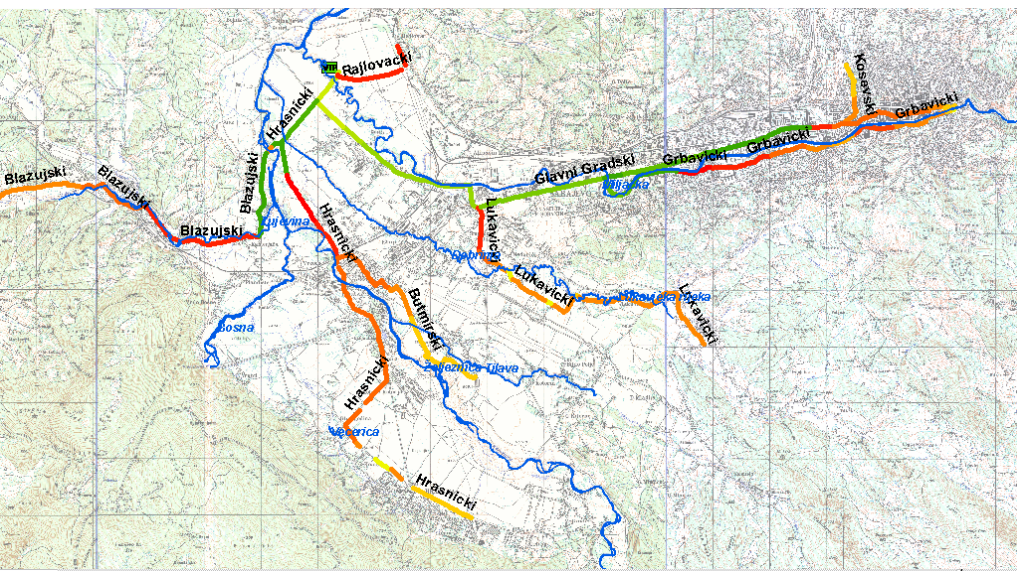
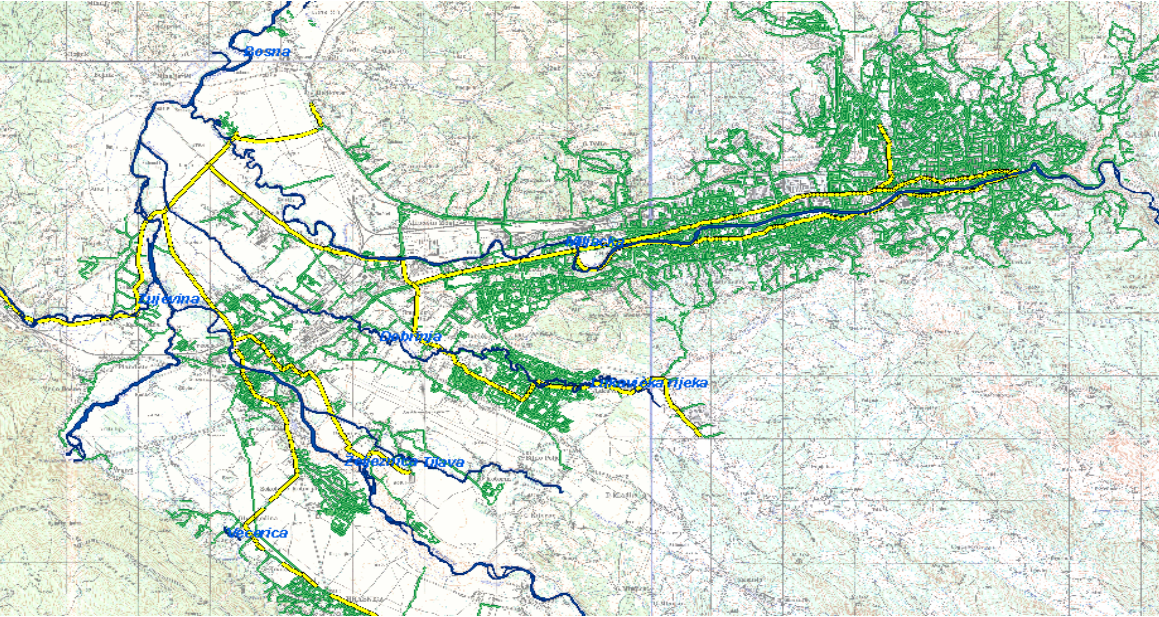
# Područje studije





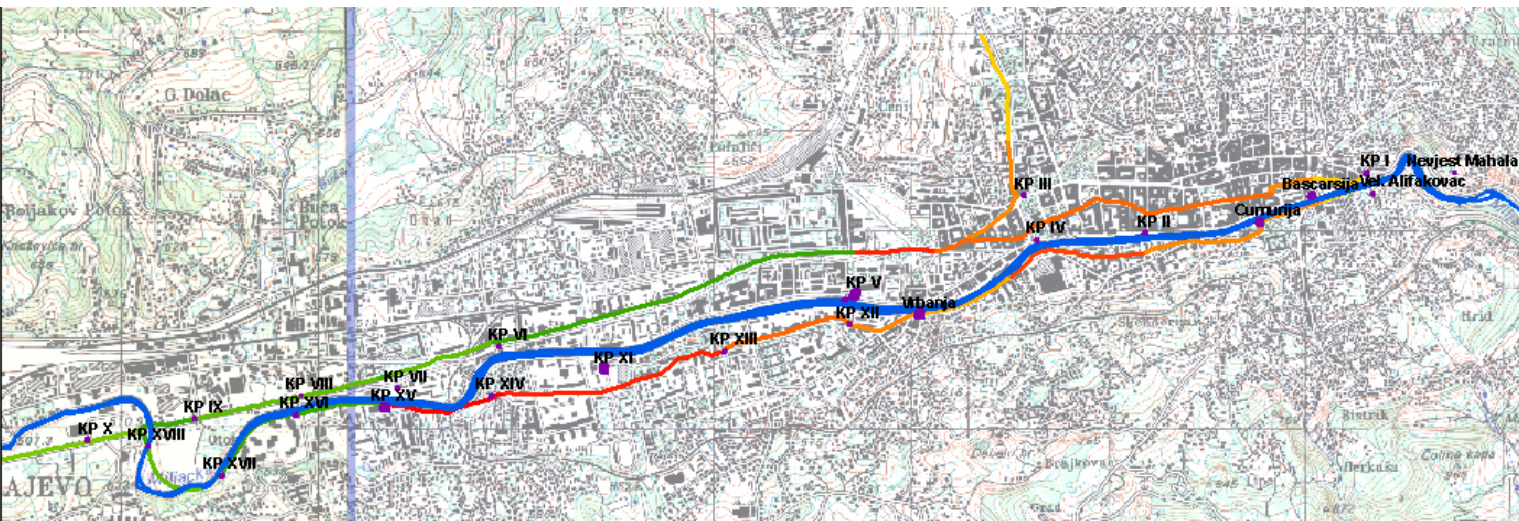
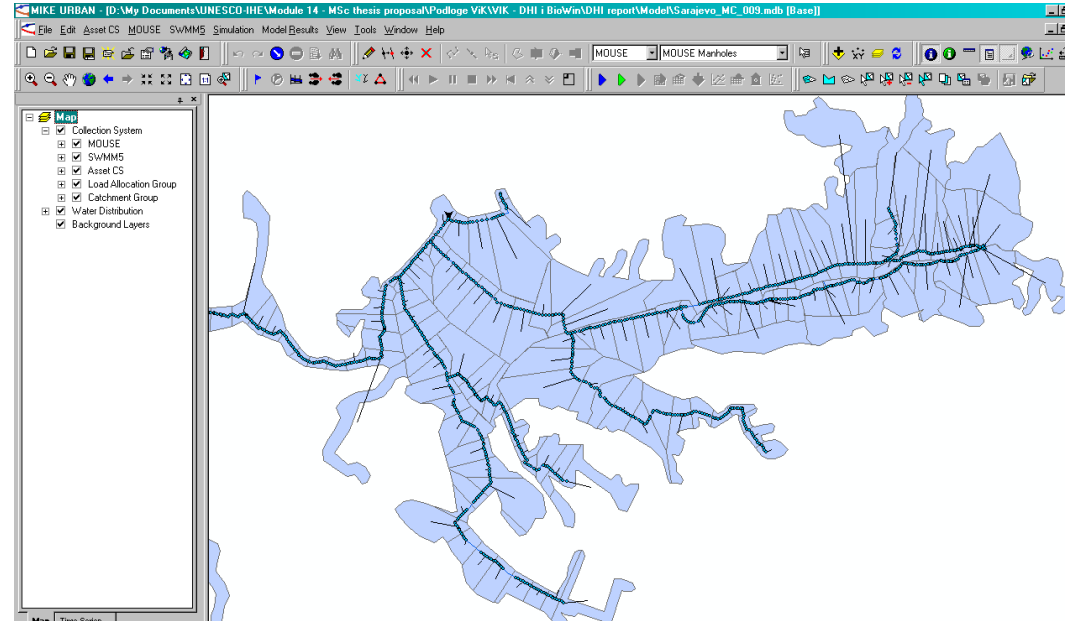


# Wastewater collection system of Sarajevo (main collectors) - System 1



# Sewage network – Mike Urban

- 5 year return period 2 hour duration rain
- wastewater loads has diurnal flow variation pattern
- locations of 24 CSO's



# Design Degremont 1984

## Design 1981-1984 - 600000 PE

PE Design Capacity	600000	60g BOD/PE/day
Population	411000	60g BOD/PE/day
Industry	189000	60g BOD/PE/day
BOD Design Capacity	36000	kgBOD/d
Population	24660	kgBOD/d
Industry	11340	kgBOD/d
Mixed Influent Flow	2.15	m3/s
Mixed Influent Flow	310	Liter/PE
Concentration	194	mgBOD/l

## Extention - 900000 PE

PE Design Capacity	900000	60g BOD/PE/day
Population	616500	60g BOD/PE/day
Industry	283500	60g BOD/PE/day
BOD Design Capacity	54000	kgBOD/d
Population	36990	kgBOD/d
Industry	17010	kgBOD/d
Mixed Influent Flow	3.23	m3/s
Mixed Influent Flow	310	Liter/PE
Concentration	194	mgBOD/l



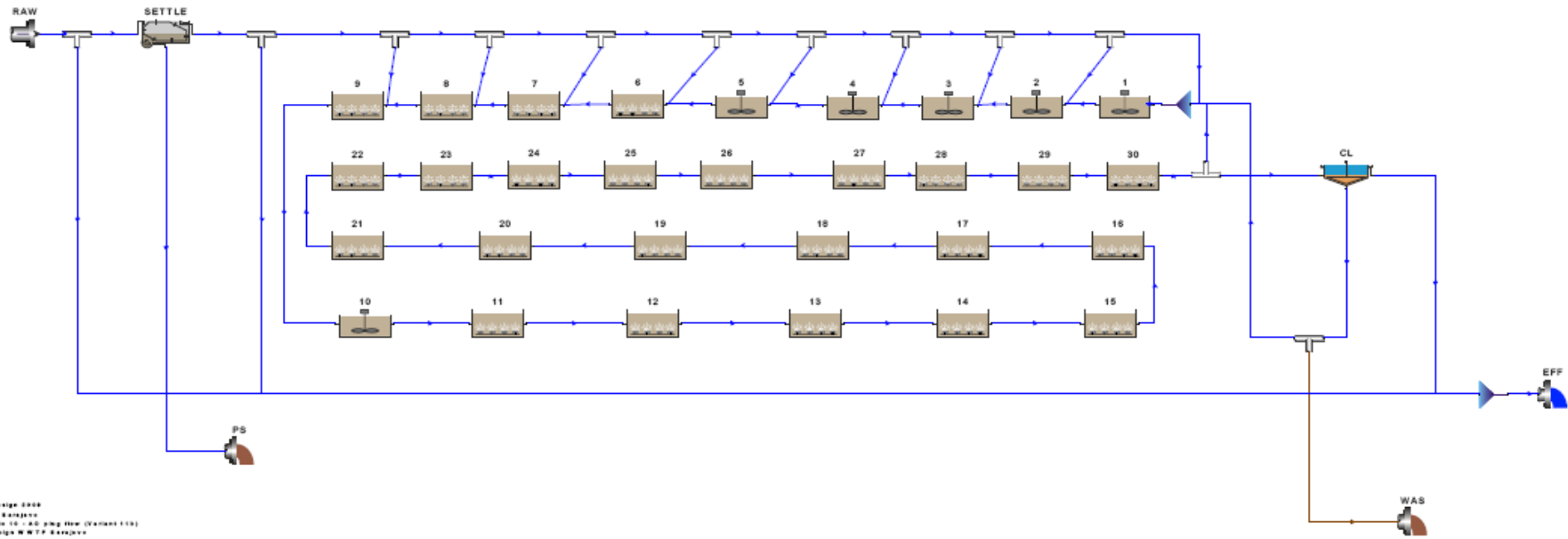


# Scenariji

## Simulation Scenario Overview

No.	Description	Influent pre-treatment	Biological Tanks	Configuration	Aeration Type	Removal performance
0	Existing reactors for BOD removal - installed surface aerator capacity, settled influent	Settled	Existing	Plug-flow	Turbines	BOD
1	Existing reactors for BOD removal - new surface aerator capacity, settled influent	Settled	Existing	Plug-flow	Turbines	BOD
2	Existing reactors for BOD removal - bubble aerators, settled influent	Settled	Existing	Plug-flow	Bubble	BOD
3	Existing reactors for BOD removal - bubble aerators, raw influent	Raw	Existing	Plug-flow	Bubble	BOD
4	Nitrifying Extended Volume Plug flow - bubble aerators, settled influent	Settled	Extended	Plug-flow	Bubble	BOD/Nitrifying
5	Nitrifying Extended volume Plug flow - turbines + bubble aeration, settled influent	Settled	Extended	Plug-flow	Turbines/Bubble	BOD/Nitrifying
6	<b>Denitrification, Extended Volume Plug flow - bubble aerators, settled influent</b>	<b>Settled</b>	<b>Extended</b>	<b>Plug-flow</b>	<b>Bubble</b>	<b>BOD/NIT/Denitrification</b>
7	Extended Volume Plug Flow for BOD removal - bubble aeration, raw influent	Raw	Extended	Plug-flow	Bubble	BOD
7a	Extended Volume Plug Flow for BOD removal - bubble aeration, raw influent	Raw	Extended	Plug Flow	Bubble	BOD
7b	Extended Volume Plug Flow for BOD removal - bubble aeration, raw influent	Raw	Extended	MLSS recirculation	Bubble	BOD
7c	Extended Volume Carrousel for BOD removal - bubble aeration, raw influent	Raw	Extended	Carrousel	Bubble	BOD
8	Nitrifying Carrousel type activated sludge system - bubble aeration, raw influent	Raw	Extended	Carrousel	Bubble	BOD/Nitrifying
9	Denitrifying Carrousel AO process - raw influent, bubble aeration	Raw	Extended	Carrousel/AO	Bubble	BOD/NIT/Denitrification
10	<b>Denitrifying Plug flow AO process - raw influent, bubble aeration (EU standard)</b>	<b>Raw</b>	<b>Extended</b>	<b>Plug Flow/AO</b>	<b>Bubble</b>	<b>BOD/NIT/Denitrification</b>
11	A2O Plug flow process - raw influent, bubble aeration (EU standard)	Raw	Extended	Plug flow/A2O	Bubble	BOD/NIT/DEN/Bio-P
12	A2O Carrousel process - raw influent, bubble aeration (EU standard)	Raw	Extended	Carrousel/A2O	Bubble	BOD/NIT/DEN/Bio-P

Highlighted scenarios are best performing for settled and raw influent



Client name: ADM Sarajevo  
Project name: WWTP Sarajevo  
Project ref.: Kanton 10 - AD plavina (Varianta 11a)  
Project owner: ProjeKcija WWTP Sarajevo



### Scenario performance on Effluent

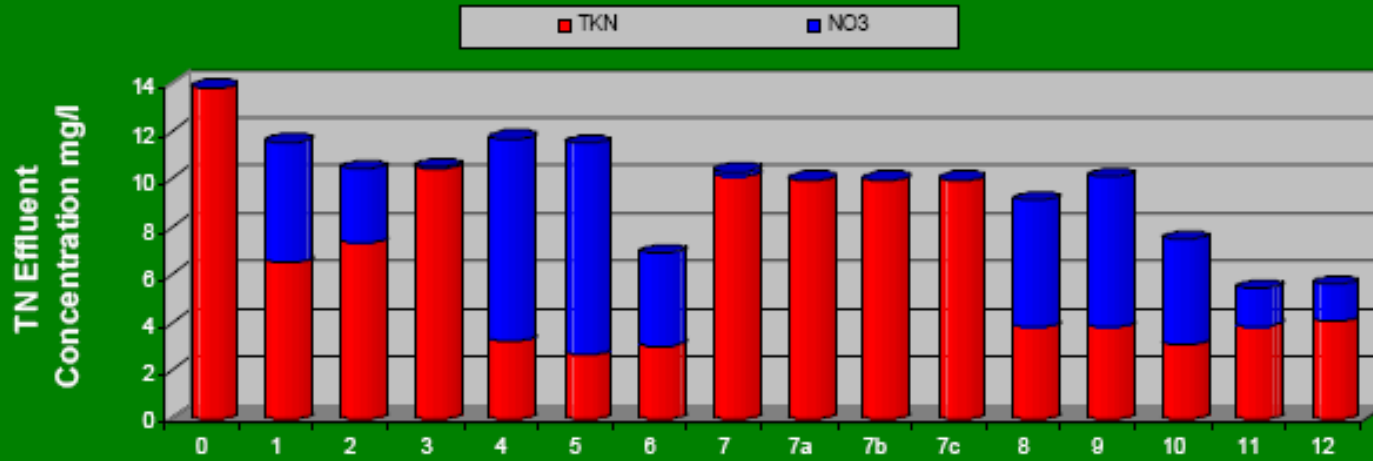


Figure 8. Scenario performance on Effluent; TKN and Nitrate

### Scenario performance on Reactor Volume

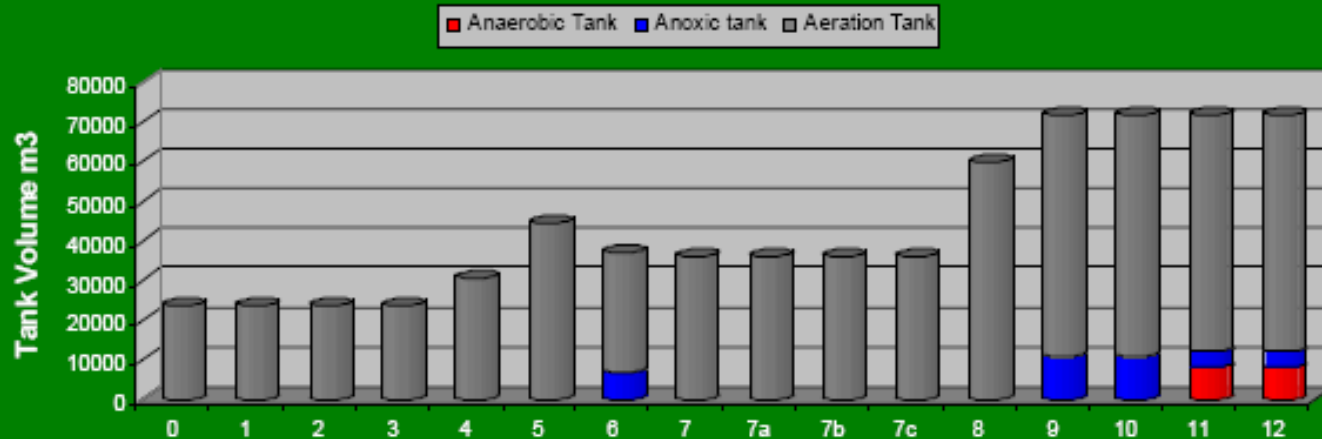
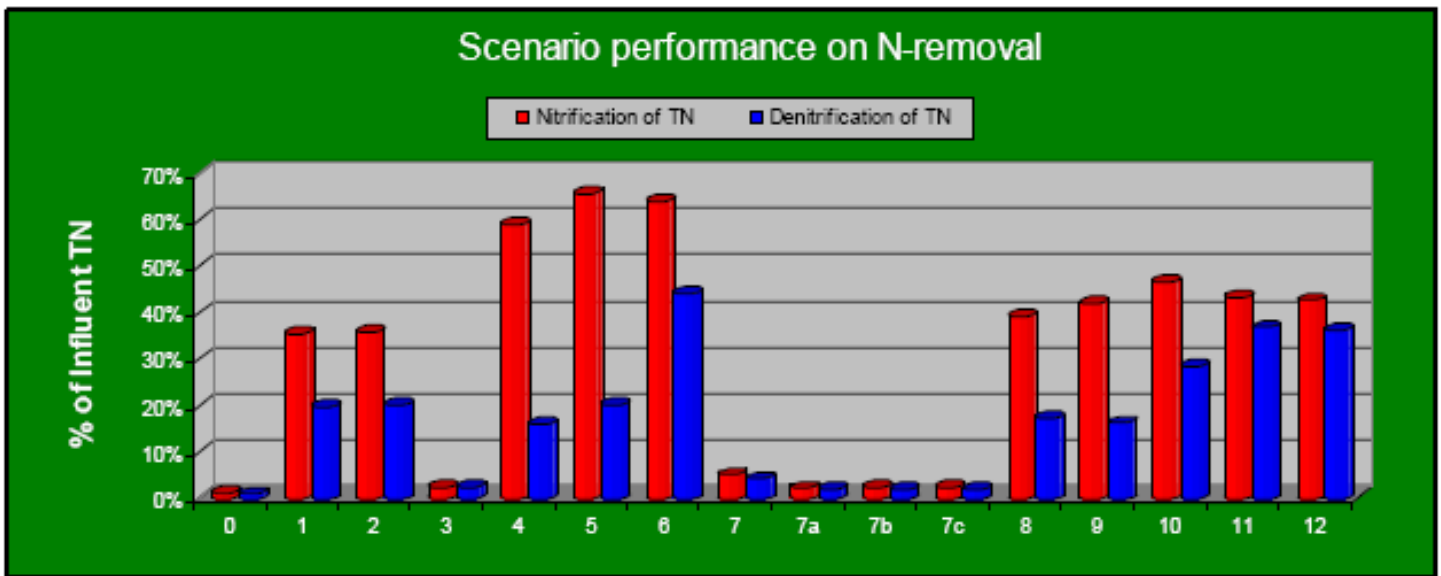
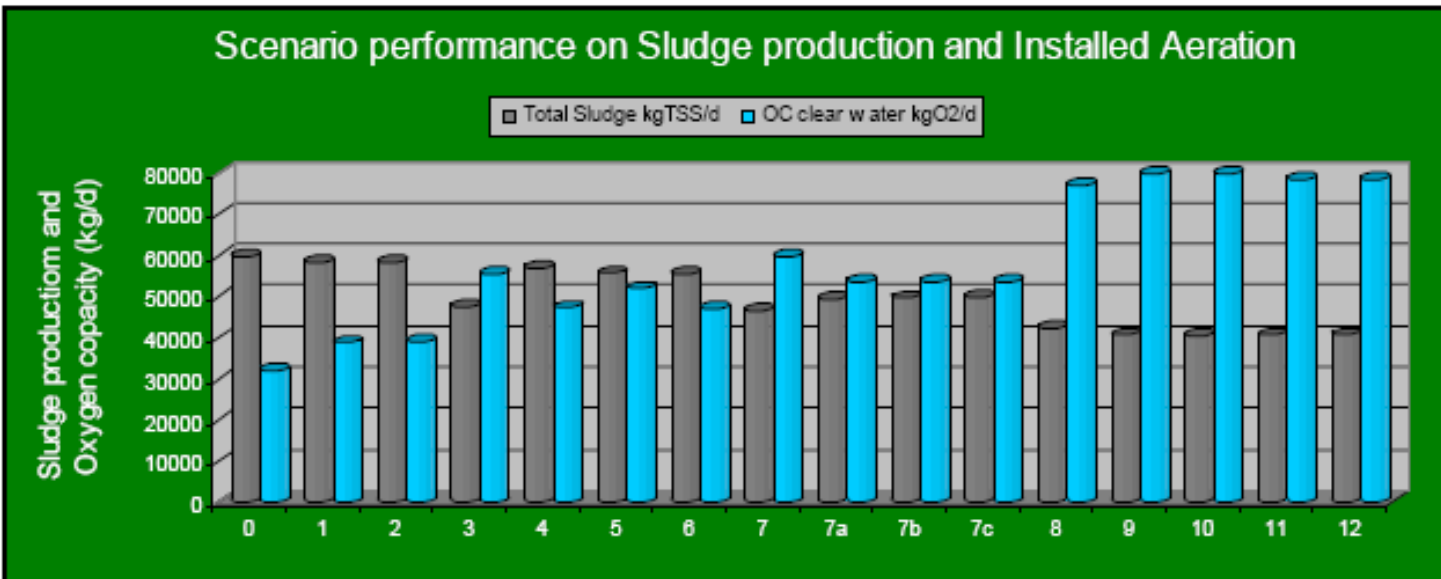


Figure 9. Scenario performance on reactor volume



**Figure 11.** Scenario performance on N-removal; nitrification and denitrification efficiency



**Figure 14.** Scenario performance on Sludge production (WAS + Primary) and Installed oxygen

## Overview Clarifier Design Results

	unit	Empirical	Flux	WRCm	ATV (1976)	STOWA
Area	m <sup>2</sup>	12197	11000	9683	12200	10600
Extra tanks	units	1.74	1.18	0.56	1.74	0.99
<b>At ADWF</b>	<b>unit</b>	<b>Empirical</b>	<b>Flux</b>	<b>WRCm</b>	<b>ATV (1976)</b>	<b>STOWA</b>
Overflow, QADWF	m <sup>3</sup> /h	7560	7560	7560	7560	7560
Overflow rate	m/h	0.6	0.7	0.8	0.6	0.7
Recycle flow	m <sup>3</sup> /h	10735	3000	12000	4200	4200
Recycle rate	m/h	0.9	0.3	1.2	0.3	0.4
Recycle ratio	-	1.4	0.4	1.6	0.6	0.6
RAS concentration	kg/m <sup>3</sup>	6.8	14.1	6.5	11.2	11.2
Solids loading rate	kg/m <sup>2</sup> /h	6.0	3.8	8.1	3.9	4.4
<b>At PDWF</b>	<b>unit</b>	<b>Empirical</b>	<b>Flux</b>	<b>WRCm</b>	<b>ATV (1976)</b>	<b>STOWA</b>
Overflow, QPDWF	m <sup>3</sup> /h	10735	10735	10735	10735	10735
Overflow rate	m/h	0.9	1.0	1.1	0.9	1.0
Recycle flow	m <sup>3</sup> /h	10735	3000	12000	4200	4200
Recycle rate	m/h	0.9	0.3	1.2	0.3	0.4
Recycle ratio	-	1.0	0.3	1.1	0.4	0.4
RAS concentration	kg/m <sup>3</sup>	8.0	18.3	7.6	14.2	14.2
Solids loading rate	kg/m <sup>2</sup> /h	7.0	5.0	9.4	4.9	5.6
<b>At PWWF</b>	<b>unit</b>	<b>Empirical</b>	<b>Flux</b>	<b>WRCm</b>	<b>ATV (1976)</b>	<b>STOWA</b>
Overflow, QPDWF	m <sup>3</sup> /h	18900	18900	18900	18900	18900
Overflow rate	m/h	1.5	1.7	2.0	1.5	1.8
Recycle flow	m <sup>3</sup> /h	9450	12000	12000	4200	4200
Recycle rate	m/h	0.8	1.1	1.2	0.3	0.4
Recycle ratio	-	0.5	0.6	0.6	0.2	0.2
RAS concentration	kg/m <sup>3</sup>	12.0	10.3	10.3	22.0	22.0
Solids loading rate	kg/m <sup>2</sup> /h	9.3	11.2	12.8	7.6	8.7

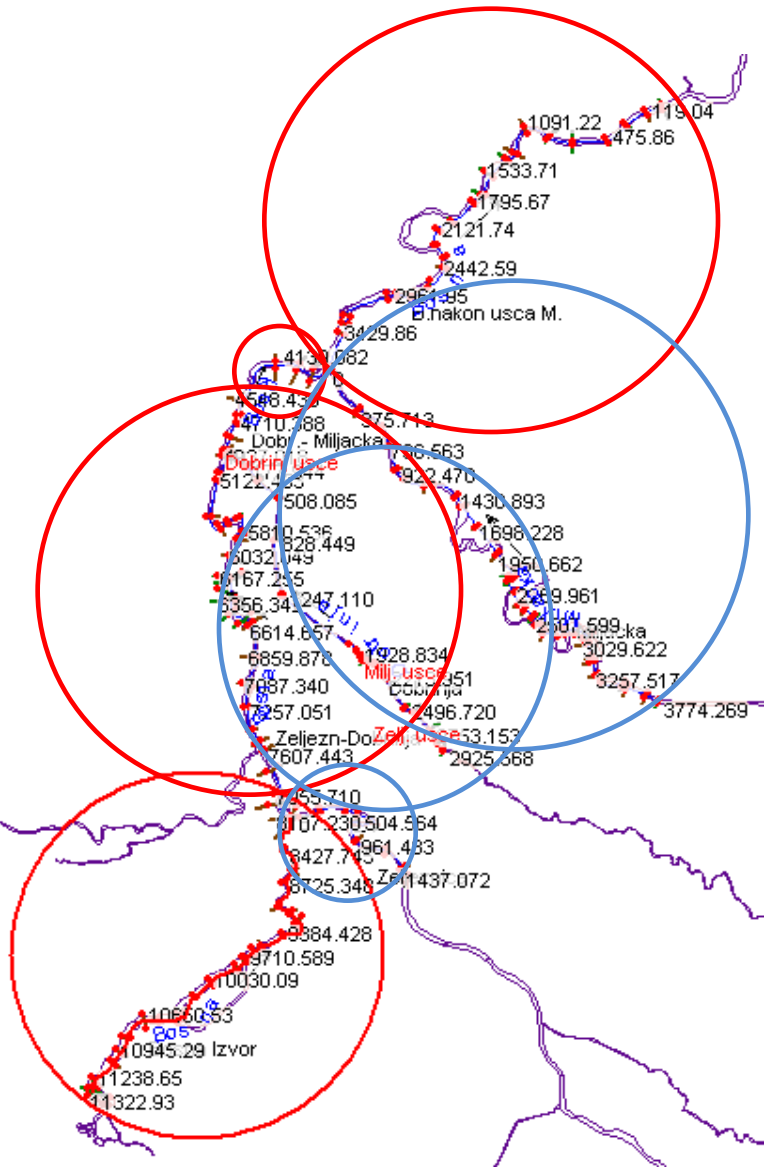


**UNIONINVEST d.d.**  
SARAJEVO, BOSNA I HERCEGOVINA

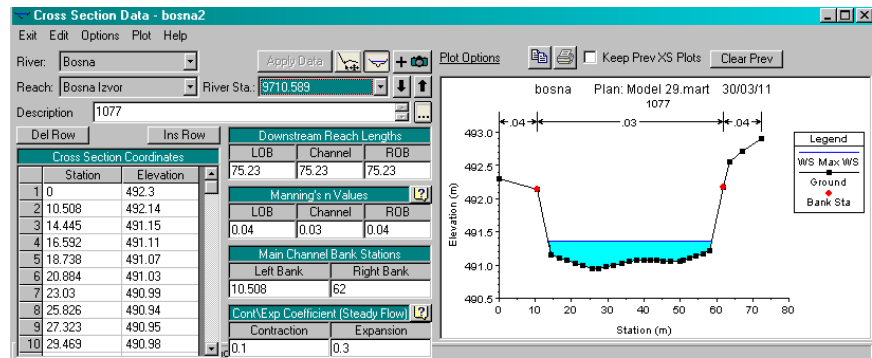
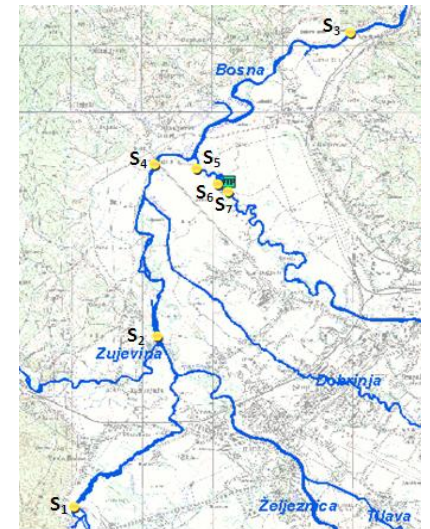
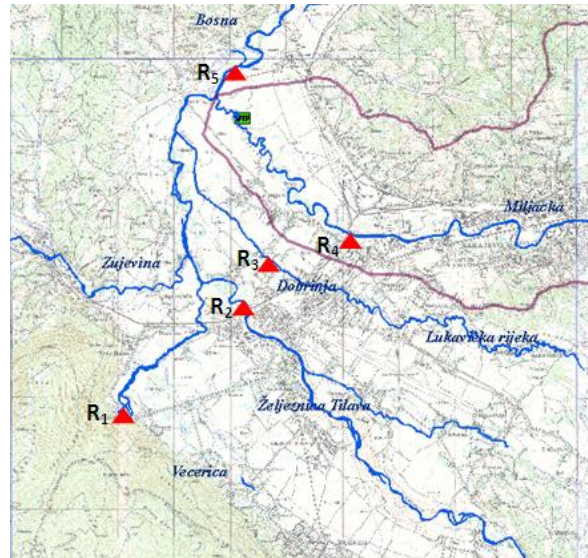


8:01 / 10:04

# Rivers – HEC-RAS



ID	River	Reach	River Station	Boundary conditions
R <sub>1</sub>	Bosna	Bosna spring	11322.93	Flow Hydrograph
R <sub>2</sub>	Željeznica	Željeznica	1437.072	Flow Hydrograph
R <sub>3</sub>	Dobrinja	Dobrinja	2925.568	Flow Hydrograph
R <sub>4</sub>	Miljacka	Miljacka	3774.269	Flow Hydrograph
R <sub>5</sub>	Bosna	Reljevo	0	Rating curve



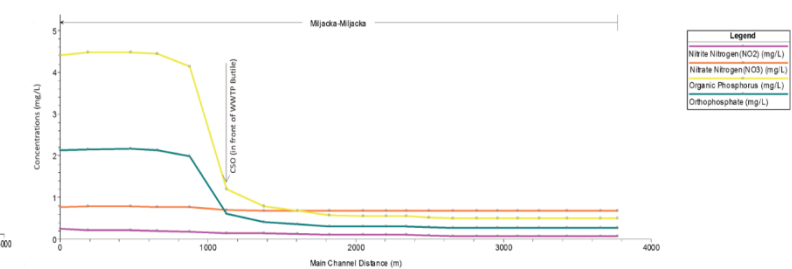
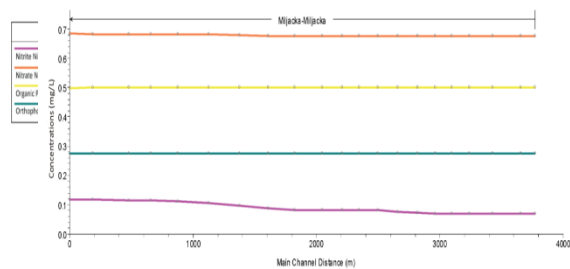
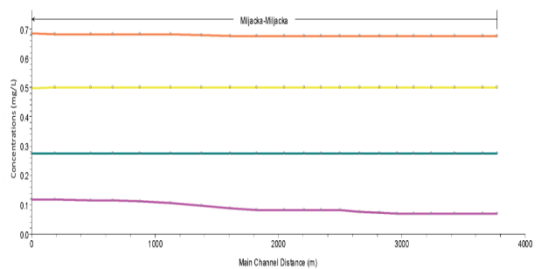
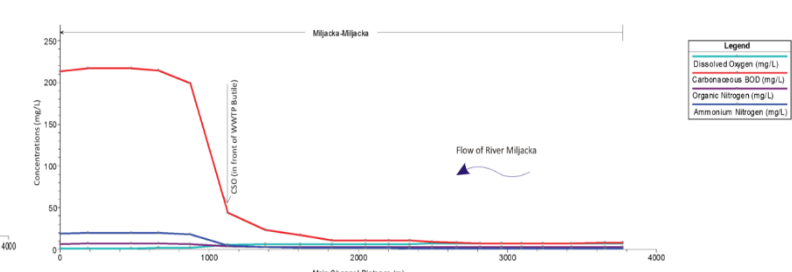
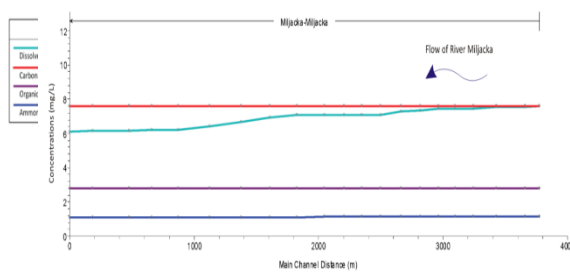
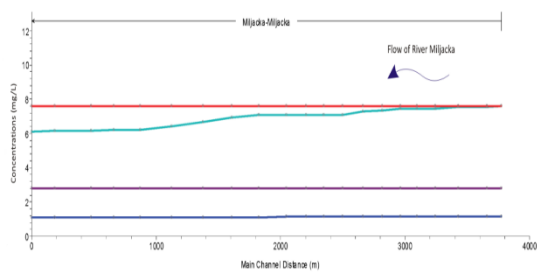
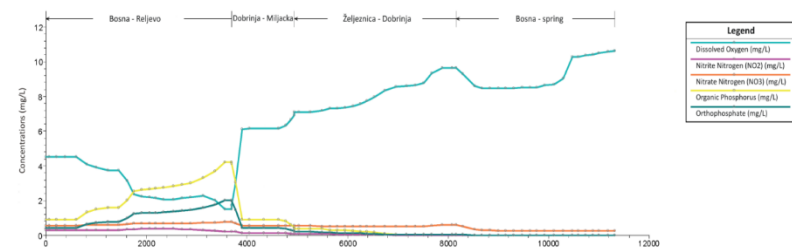
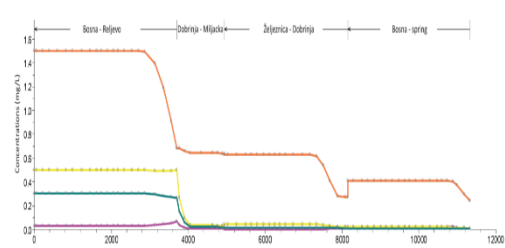
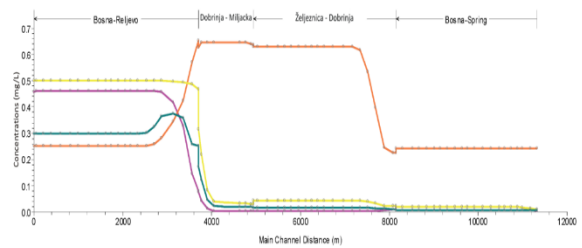
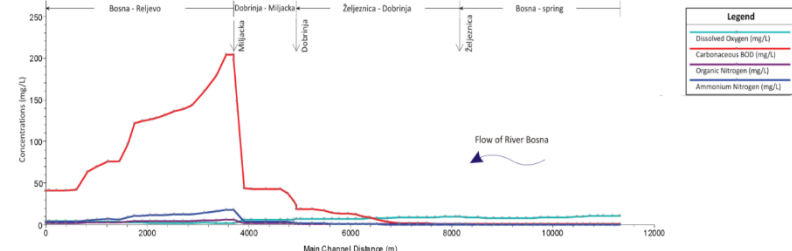
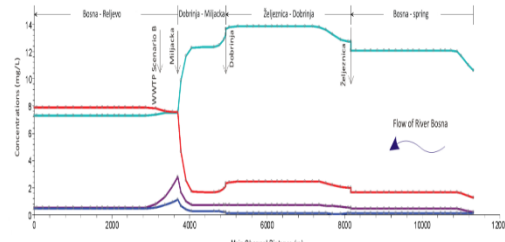
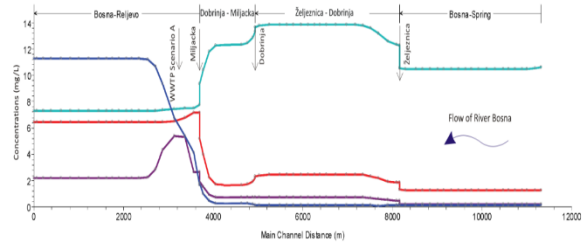
# Results

## Rivers – HEC-RAS

### A. Original design scenario

### B. New design scenario

### C. Treatment plant out of operation



Legend	
Disolved Oxygen (mg/L)	Blue line
Carbonaceous BOD (mg/L)	Red line
Organic Nitrogen (mg/L)	Purple line
Ammonium Nitrogen (mg/L)	Dark blue line

Legend	
Disolved Oxygen (mg/L)	Blue line
Nitrite Nitrogen (NO2) (mg/L)	Pink line
Nitrate Nitrogen (NO3) (mg/L)	Light blue line
Organic Phosphorus (mg/L)	Yellow line
Orthophosphate (mg/L)	Light green line

Legend	
Disolved Oxygen (mg/L)	Blue line
Carbonaceous BOD (mg/L)	Red line
Organic Nitrogen (mg/L)	Purple line
Ammonium Nitrogen (mg/L)	Dark blue line

Legend	
Nitrite Nitrogen(NO2) (mg/L)	Pink line
Nitrate Nitrogen(NO3) (mg/L)	Light blue line
Organic Phosphorus (mg/L)	Yellow line
Orthophosphate (mg/L)	Light green line



# Primjer 2: Hrvatska



- |                       |                   |
|-----------------------|-------------------|
| 1. Beli Manastir      | 14. Kutina        |
| 2. Belišće            | 15. Našice        |
| 3. Bjelovar           | 16. Pakrac-Lipik  |
| 4. Čakovec            | 17. Pitomača      |
| 5. Daruvar            | 18. Požega        |
| 6. Donji Miholjac     | 19. Samobor       |
| 7. Đurđevac           | 20. Topusko       |
| 8. Garešnica          | 21. Varaždin      |
| 9. Ivanič Grad        | 22. Velika Gorica |
| 10. Koprivnica        | 23. Vinkovci      |
| 11. Krapinske Toplice | 24. Virovitica    |
| 12. Križevci          | 25. Zagreb        |
| 13. Kumrovec          | 26. Zaprešić      |

● UPOV-i posjećeni od strane konzorcija

Belišće

Bjelovar

Čakovec

Daruvar

Koprivnica

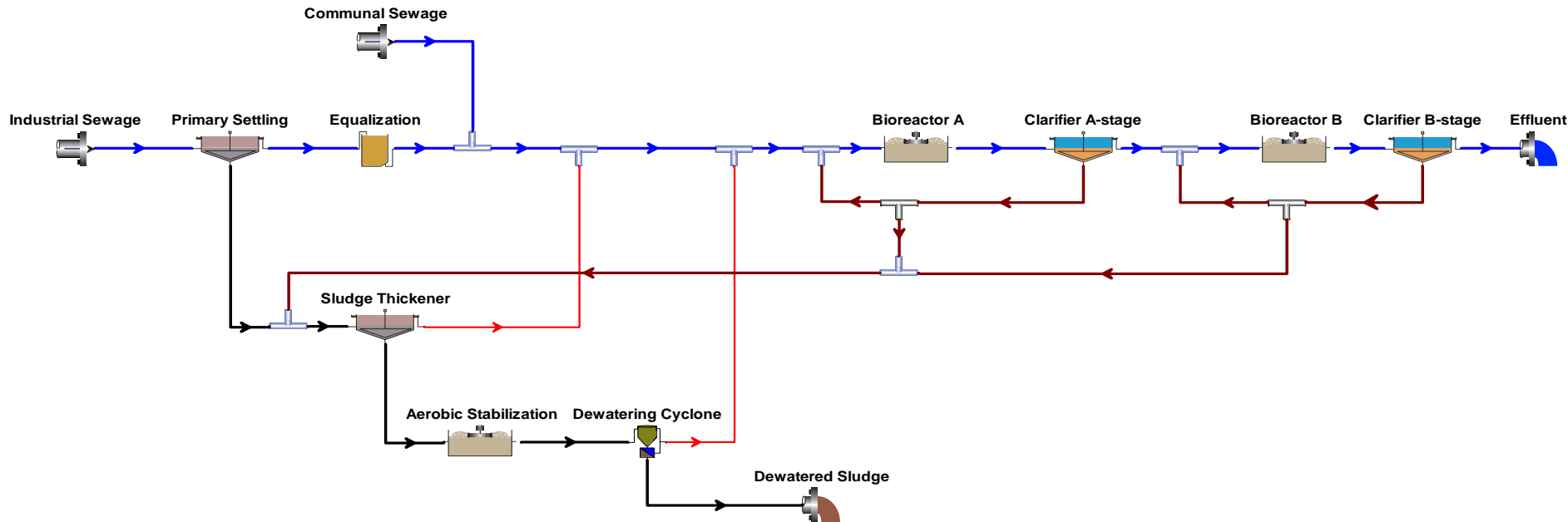
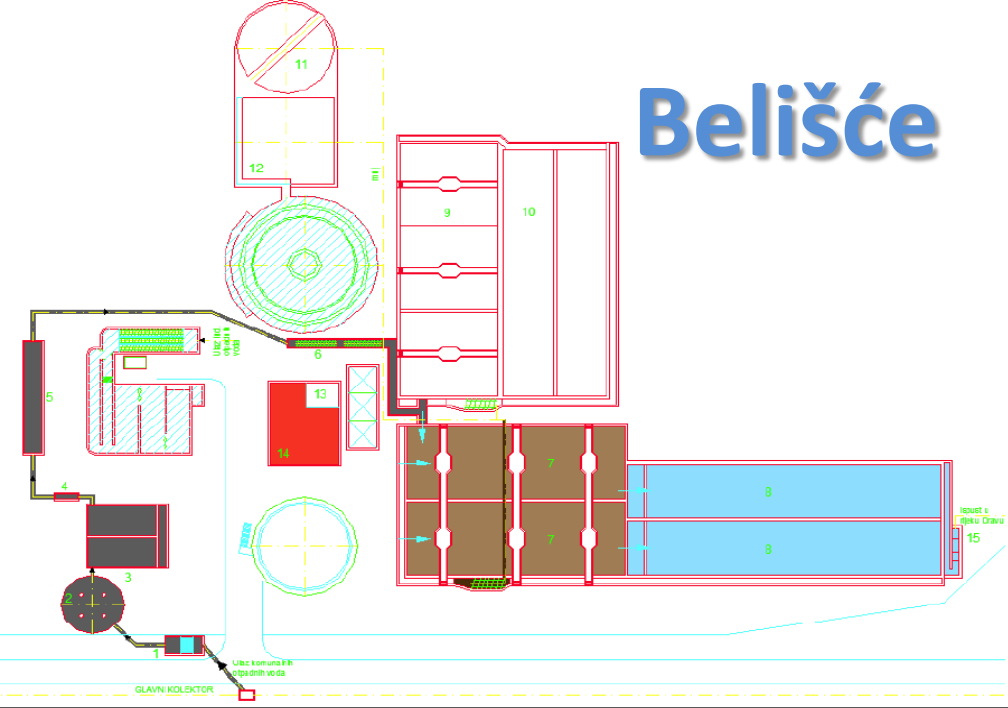
Varaždin

Velika Gorica

Vinkovci

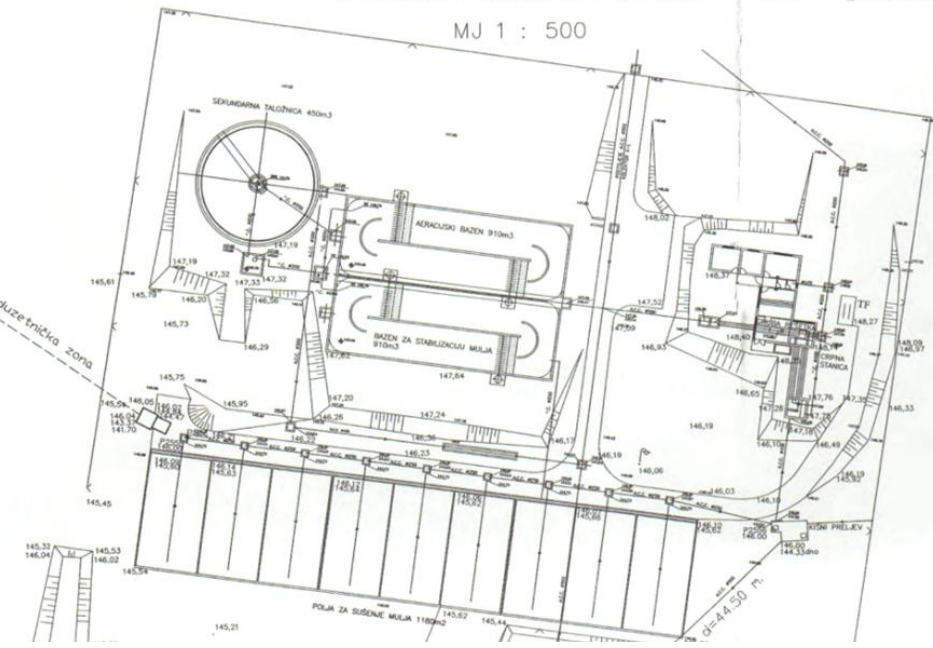
Zagreb

# Belišće



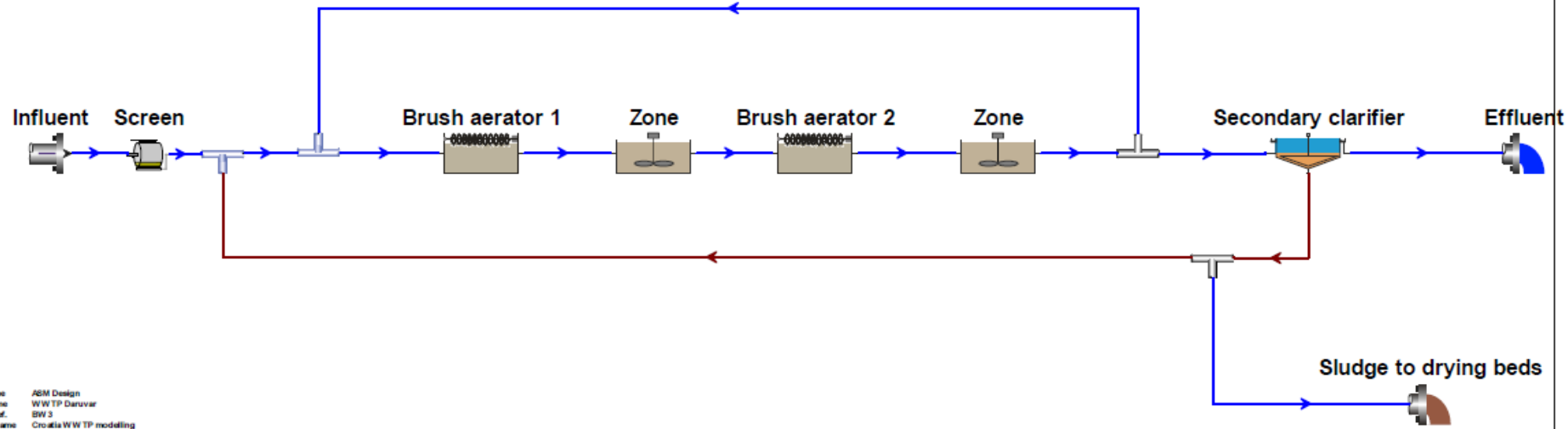
SITUACIJA POSTOJEĆEG STANJA UPOV DARUVAR

MJ 1 : 500

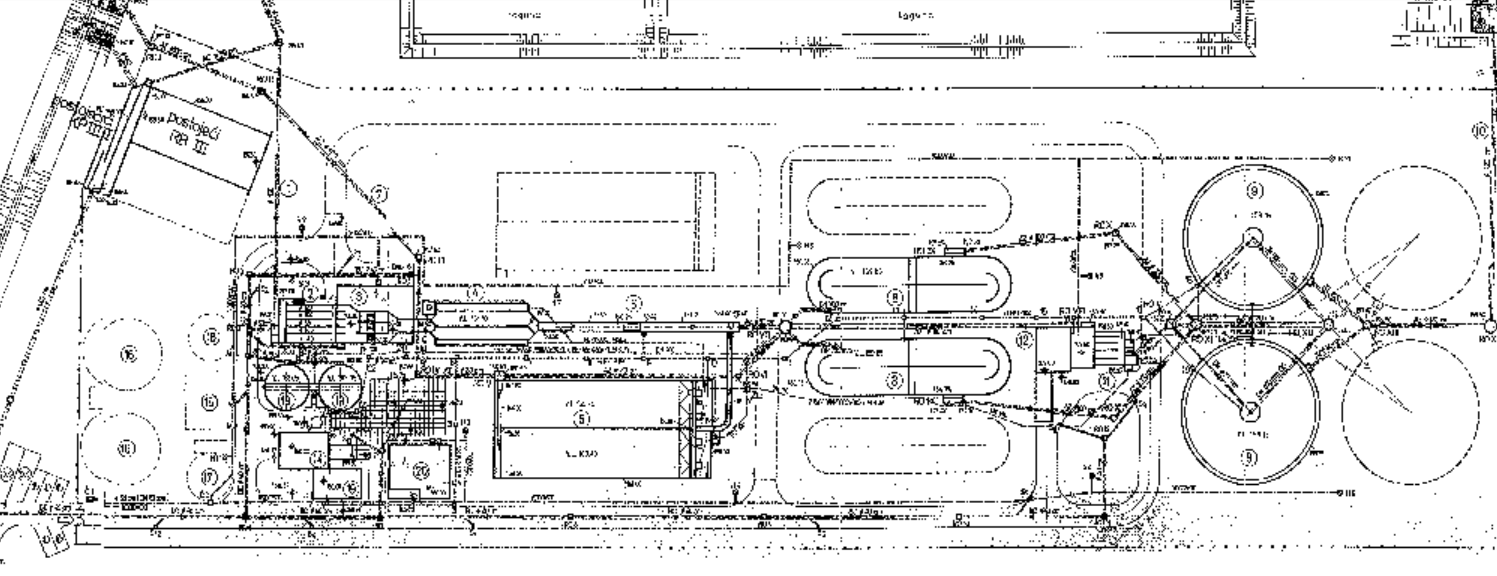


File C:\Program Files (x86)\EnviroSim\BioWin 3.1\Data\7 WWTP Daruvar.BWC

# Daruvar

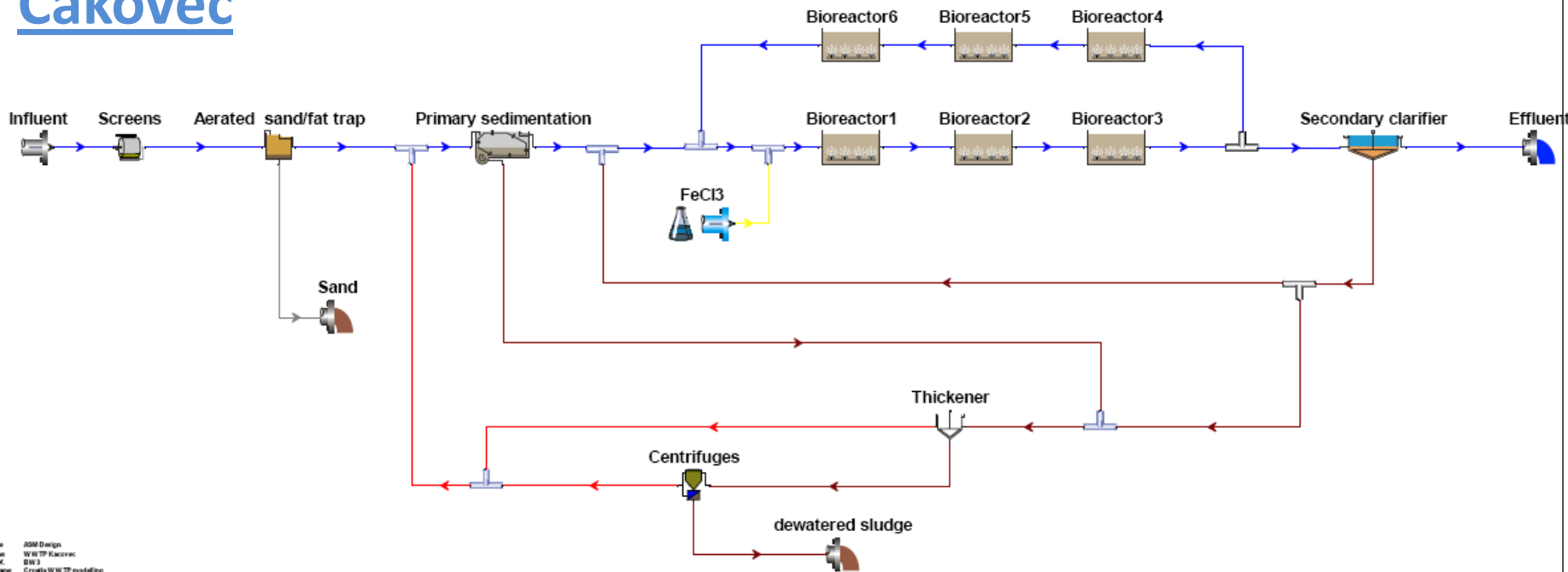


User name AGM Design  
 Plant name WWTP Daruvar  
 Project ref. BW 3  
 Project name Croatia WWTP modelling

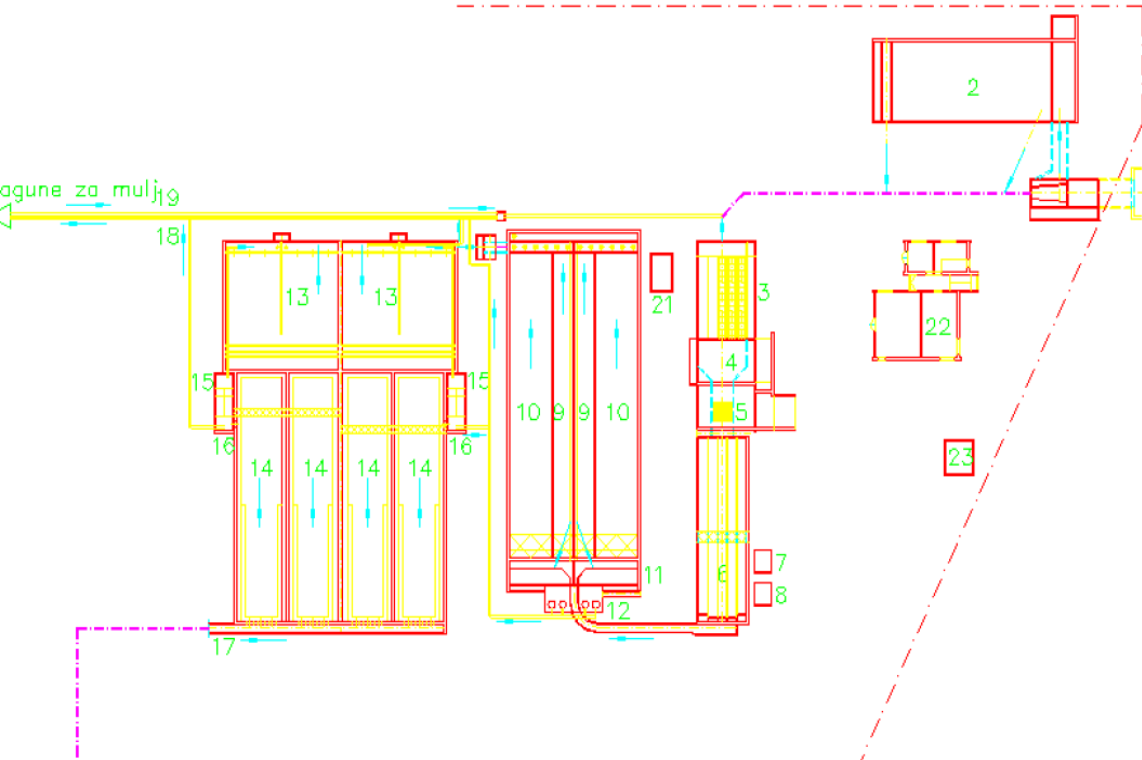


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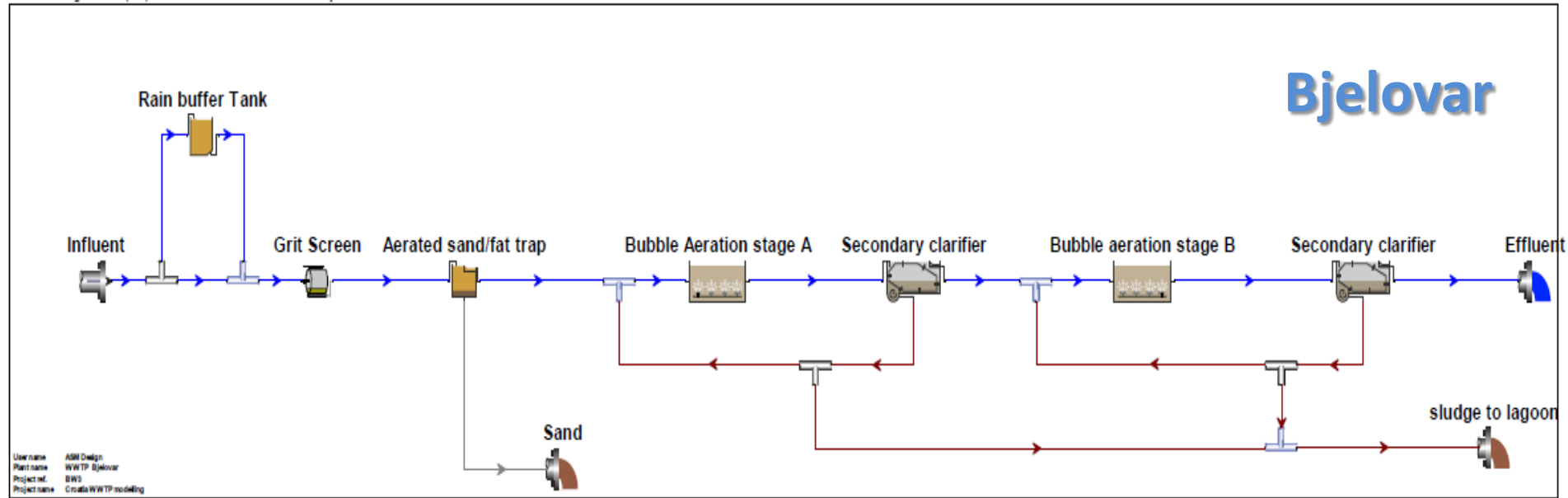
# Čakovec



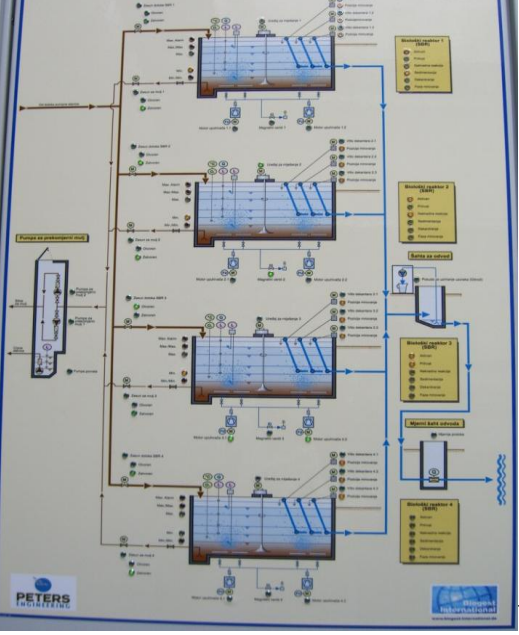
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 Plant name: WWTP Cakovec  
 Project ref.: 0103  
 Project name: Croatia WWTP modeling



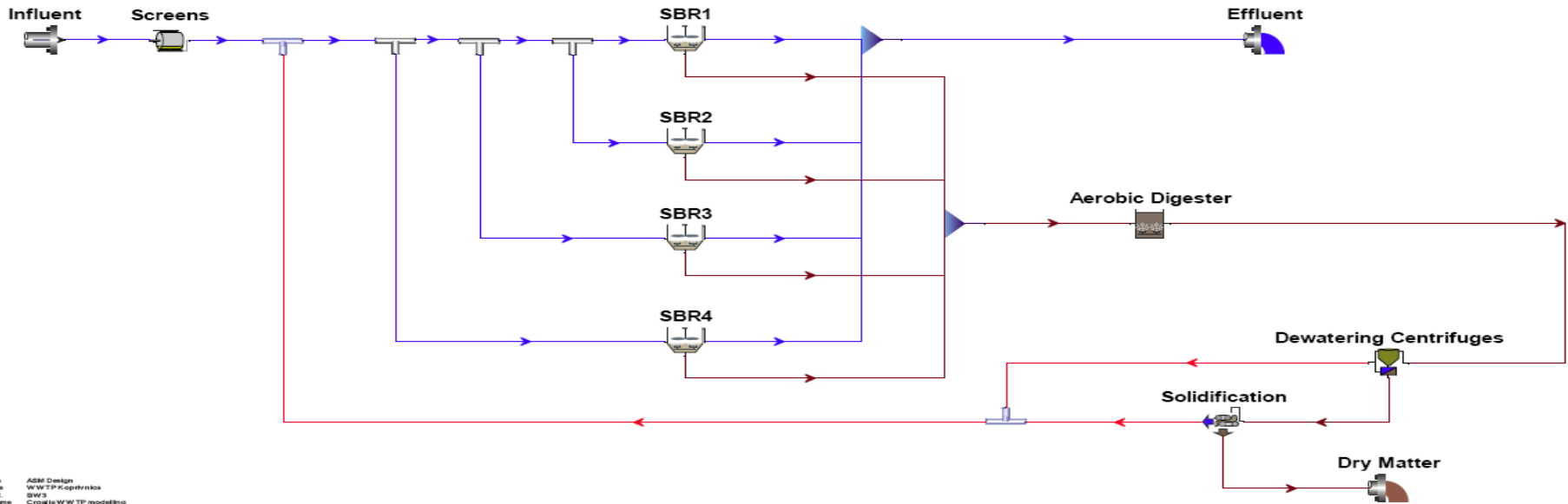
File C:\Program Files (x86)\EnviroSim\BioWin 3.1\Data\3 WWTP Bjelovar.BWC



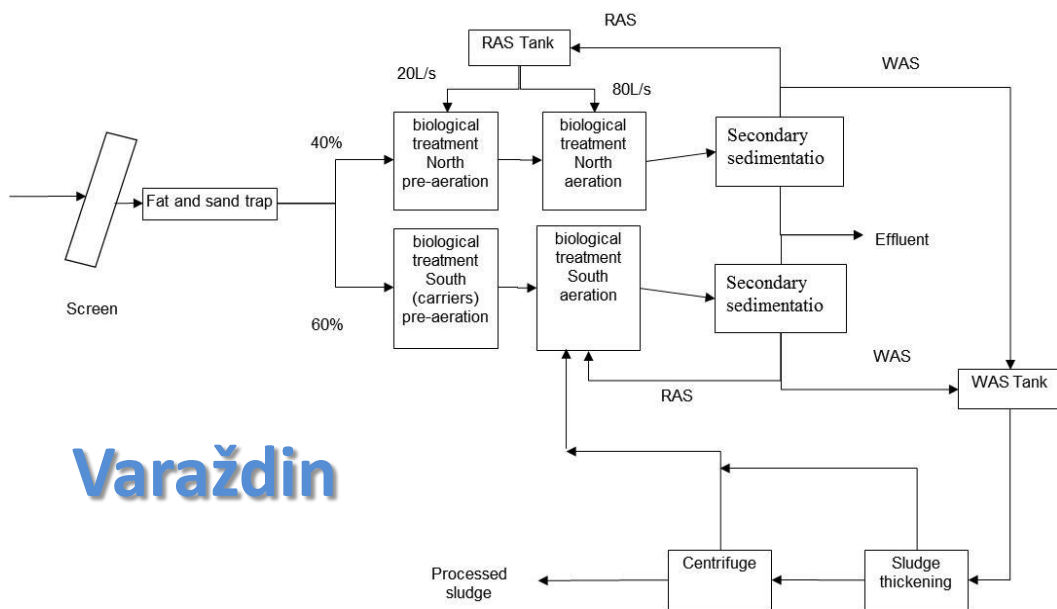
# Pročištač otpadnih voda Grada Koprivnica Biološki stupanj pročišćavanja



# Koprivnica



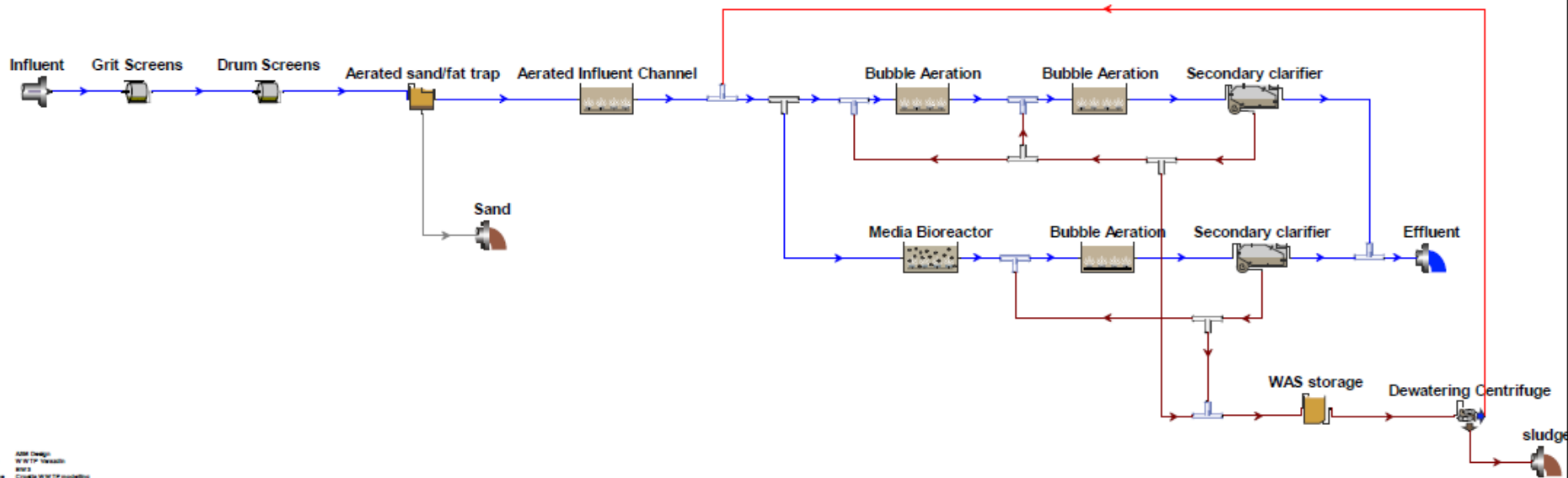
# Proces Flow Diagram (PFD)



Varaždin

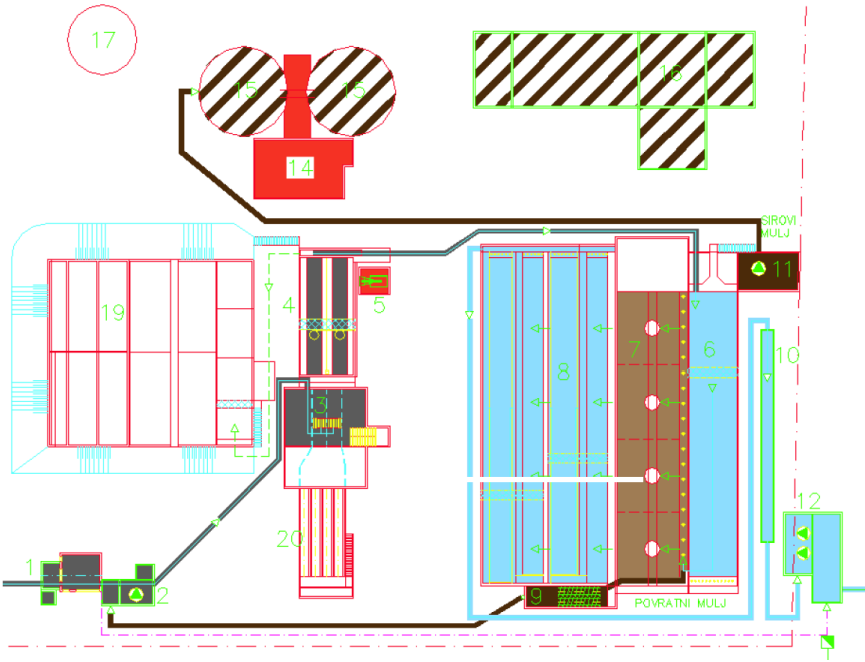


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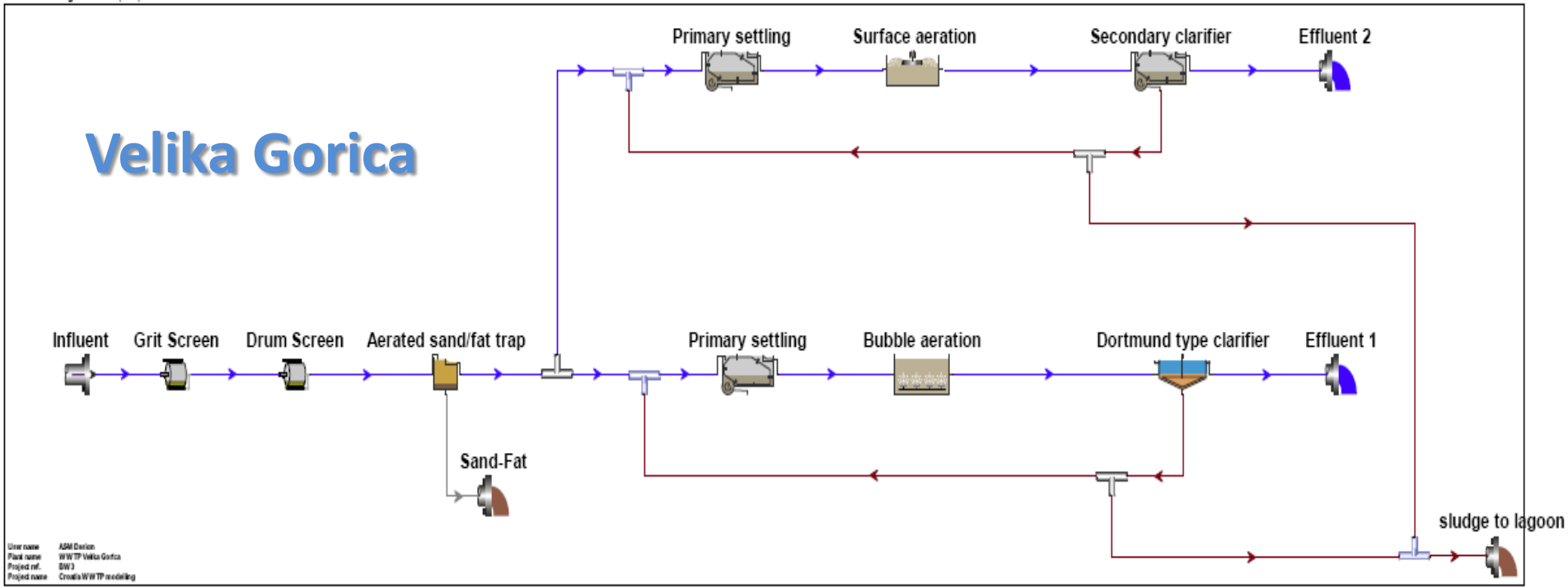


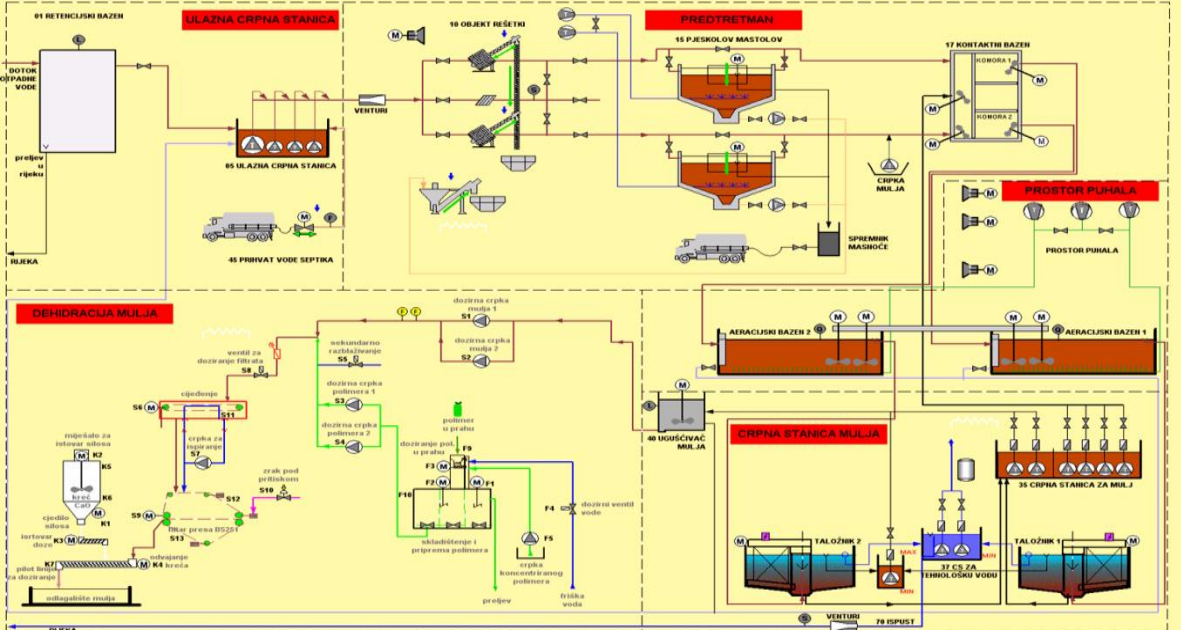
User name ADM Design  
 Plant name WWTP Varaždin  
 Project no 2013  
 Project name Crank WWTP modeling



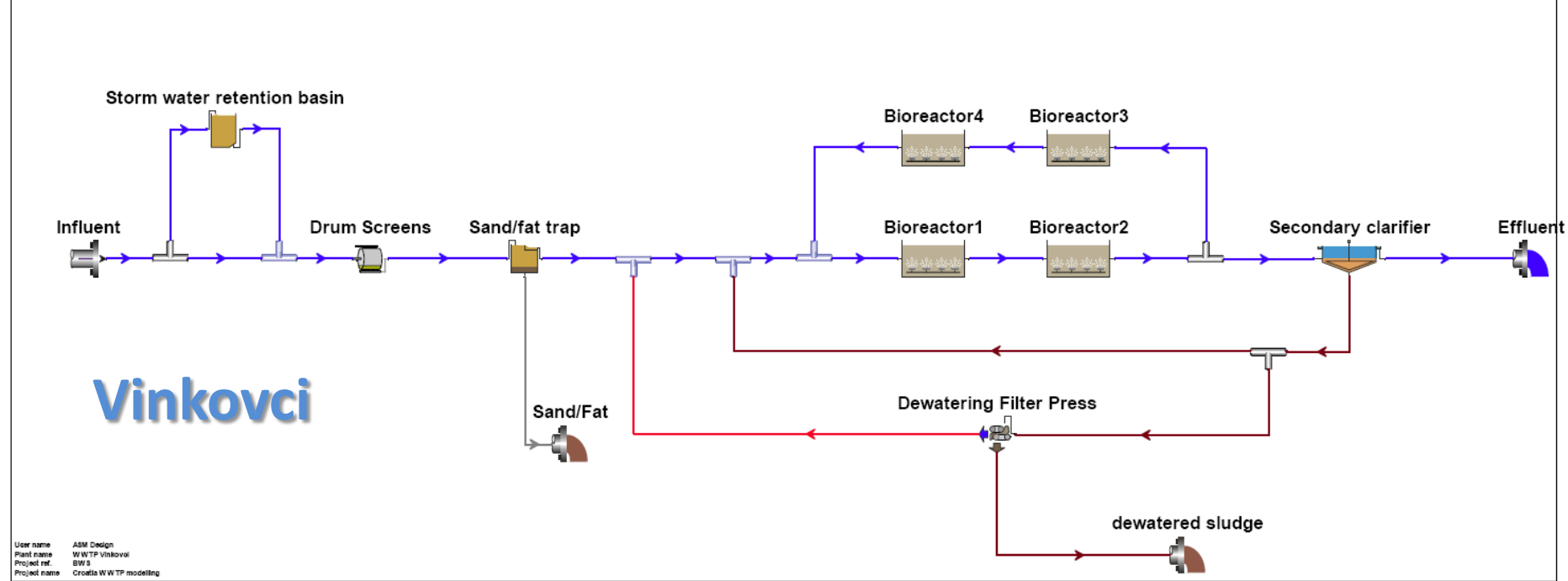


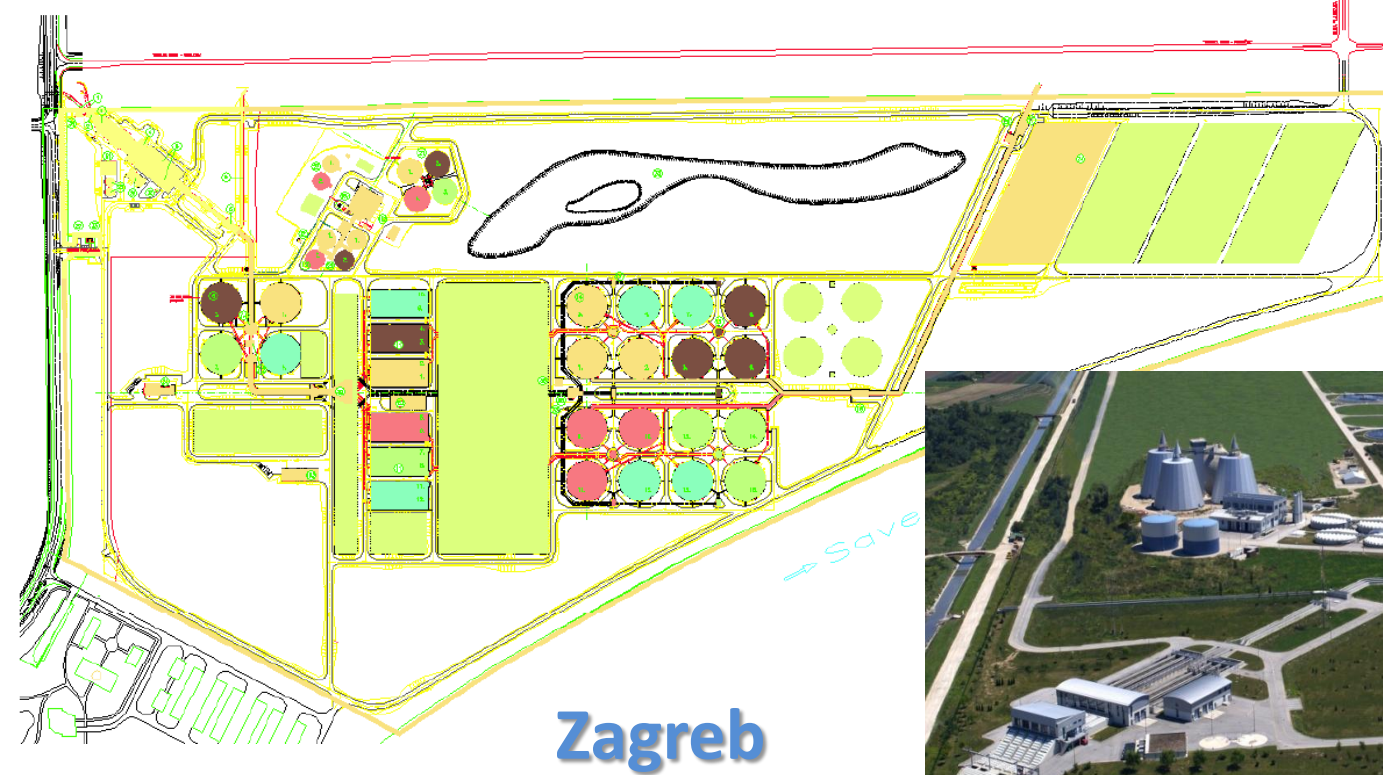
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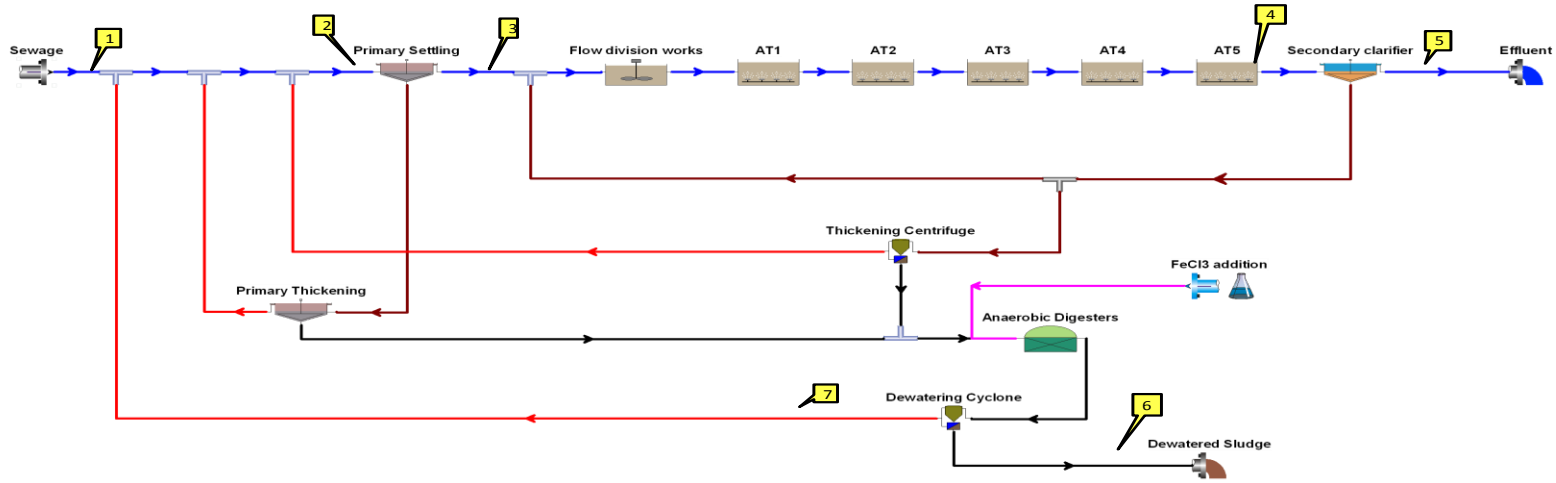


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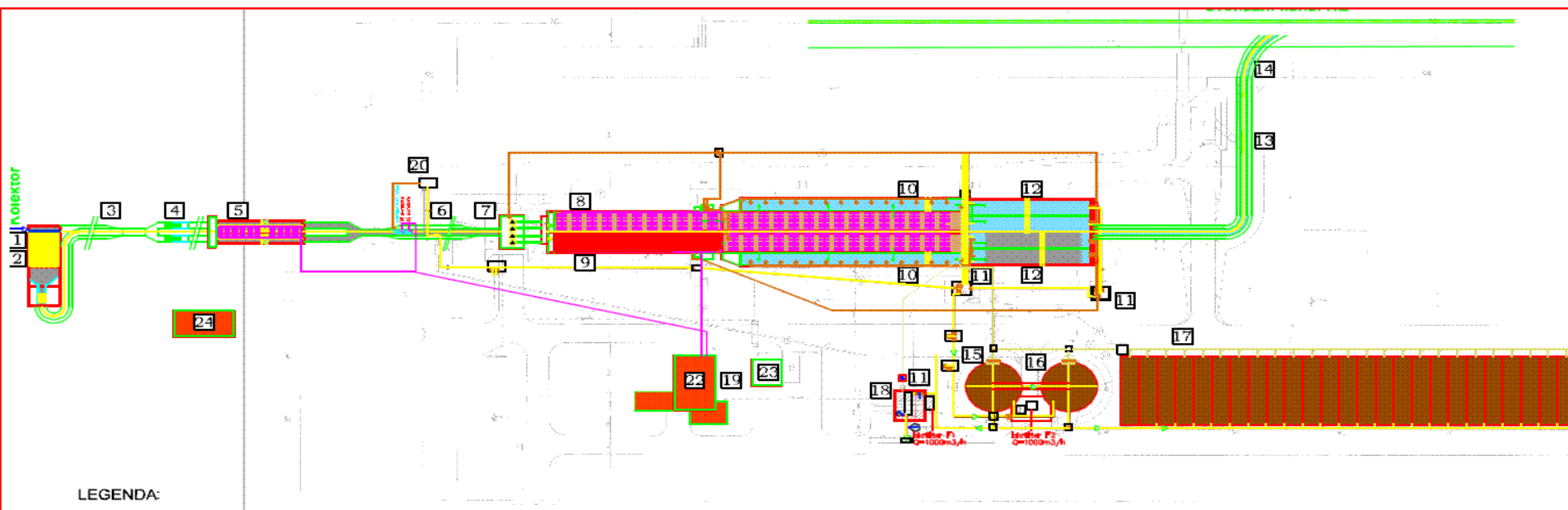
WWTP Zagreb  
BioWin model set-up



## Pregled razmatranih varijanti za nadogradnju UPOV Varazdin

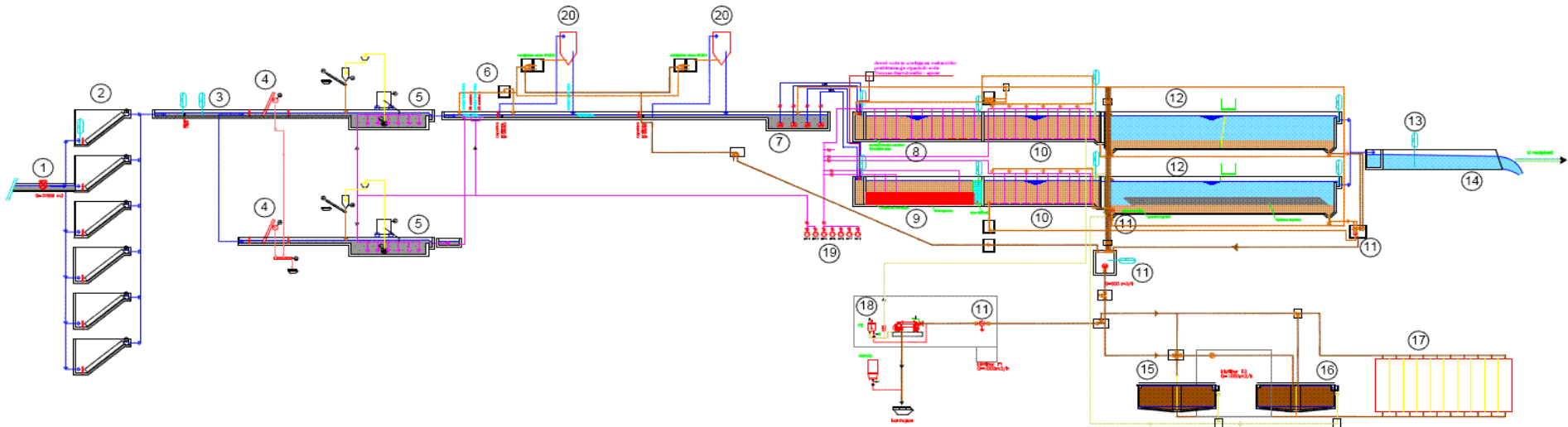
Varijanta	Kratki opis varijante	Vrsta influenta	Kakovca influenta	Bioloski spremnici	Odvajanje cvrste i tecne faze	Uguscivanje mulja	Ucinkovitost <sup>1)</sup>
S0	Postojece stanje, pre-aeracijski spremnici, aeracijski spremnici, sekundarne taloznice	Sirova otpadna voda	Visok sadrzaj inertne cvrste COD frakcije	2 linije plug flow	Opravokutne sekundarne taloznice	Uguscivanje mulja, odvajanje vode iz mulja	BOD, TSS
S1	Postojeći bioloski spremnici, postojeće sekundarne taloznice postaju bioloski spremnici sa MBR	Sirova otpadna voda	Visok sadrzaj inertne cvrste COD frakcije	2 linije plug flow + MBR	Potopljeni MBR sustav	Uguscivanje mulja, odvajanje vode iz mulja	BOD, N, TSS
S2	Postojeći bioloski spremnici, postojeće taloznice postaju bioloski spremnici sa MBR	Sirova otpadna voda	Tipican sadrzaj inertne cvrste COD frakcije	2 linije plug flow + MBR	Potopljeni MBR sustav	Uguscivanje mulja, odvajanje vode iz mulja	BOD, N, TSS
S3	Nove primarne taloznice, postojeći bioloski spremnici, postojeće sekundarne taloznice postaju bioloski spremnici sa MBR, nova trulista mulja	Istalozena otpadna voda	Visok sadrzaj inertne cvrste COD frakcije	2 linije plug flow + MBR	Potopljeni MBR sustav	Anaerobno truljenje mulja, odvajanje vode iz mulja	BOD, N, TSS
S4	Nove primarne taloznice, postojeći bioloski spremnici, postojeće sekundarne taloznice postaju bioloski spremnici sa MBR, nova trulista mulja	Istalozena otpadna voda	Tipican sadrzaj inertne cvrste COD frakcije	2 linije plug flow + MBR	Potopljeni MBR sustav	Anaerobno truljenje mulja, odvajanje vode iz mulja	BOD, N, TSS
S5	Dodatni bioloski spremnici, postojeće sekundarne taloznice postaju bioloski spremnici, nove sekundarne taloznice	Sirova otpadna voda	Visok sadrzaj inertne cvrste COD frakcije	Postojeći volumen + postojeće sekundarne taloznice+ dodatni volumen	Nove okrugle sekundarne taloznice	Uguscivanje mulja, odvajanje vode iz mulja	BOD, N, TSS
S6	Dodatni bioloski spremnici, postojeće sekundarne taloznice postaju bioloski spremnici, nove sekundarne taloznice	Sirova otpadna voda	Tipican sadrzaj inertne cvrste COD frakcije	Postojeći volumen + postojeće sekundarne taloznice+ dodatni volumen	Nove okrugle sekundarne taloznice	Uguscivanje mulja, odvajanje vode iz mulja	BOD, N, TSS
S7	Nove primarne taloznice, postojeći bioloski spremnici, postojeće sekundarne taloznice postaju bioloski spremnici, nove sekundarne taloznice, nova trulista mulja	Istalozena otpadna voda	Visok sadrzaj inertne cvrste COD frakcije	Postojeći volumen + postojeće sekundarne taloznice	Nove okrugle sekundarne taloznice	Anaerobno truljenje mulja, odvajanje vode iz mulja	BOD, N, TSS
S8	Nove primarne taloznice, postojeći bioloski spremnici, postojeće sekundarne taloznice postaju bioloski spremnici, nove sekundarne taloznice, nova trulista mulja	Istalozena otpadna voda	Tipican sadrzaj inertne cvrste COD frakcije	Postojeći volumen + postojeće sekundarne taloznice	Nove okrugle sekundarne taloznice	Anaerobno truljenje mulja, odvajanje vode iz mulja	BOD, N, TSS

1) Napomena: Fosfor je u varijantama S1-S8 uklonjen kemijskim obaranjem ispod MAC od 1 mgP/L.



**LEGENDA:**

- |   |   |  |
|---|---|--|
| <ul style="list-style-type: none"> <li>1 ULAZNA GRUBA REŠETKA</li> <li>2 CRPNA STANICA SIROVE OTPADNE VODE (6 CRPKE)</li> <li>3 OTVORENI TRAPEZNI DOVODNI KANAL</li> <li>4 FINA AUTOMATSKA REŠETKA (2 REŠETKE)</li> <li>5 RJEŠTOLOV - MASTOLOV SA CRPLIŠTEM PJEŠKA (2 OKIRKTA)</li> <li>6 OTVORENI TRAPEZNI SPJOJNI KANAL DUŽINE 1600m</li> <li>7 CRPNA STANICA BILOŠKOG DJELA (4 CRPKE)</li> <li>8 PREDAERACIJSKI SPREMNİK SA SUSTAVOM FINE DIFUZNE AERACIJE (pjevna procesna linija)</li> <li>9 PREDAERACIJSKI SPREMNİK S ISPUNOM KOJA SLUŽI KAO NOSAČ BIOPILMA S SUSTAVOM FINE DIFUZNE AERACIJE I SIFOM (južna procesna linija)</li> <li>10 BIOAERACIJSKI SPREMNICI (2 SPREMNICI, DIFUZNA AERACIJA)</li> <li>11 CRPKE ZA POVRAĆ AKTIVNOG MULJA (2 CRPKE) I CRPKE ZA VIŠAK MULJA (2 CRPKE)</li> <li>12 SEKUNĐARNE TALOŽNICE (4 TALOŽNICE)</li> <li>13 MJEŠAČ PROTOKA</li> </ul> | <ul style="list-style-type: none"> <li>14 ODVODNI KANAL S ISPUSTOM</li> <li>15 UGUŠČIVAČ MULJA</li> <li>16 SPREMNİK MULJA</li> <li>17 POLJA ZA SUŠENJE MULJA</li> <li>18 DEHIDRACIJA MULJA S CENTRIFUGOM I SUSTAVOM ZA PRIPREMU I DOZIRANJE POLIMERA</li> <li>19 KOMPRESORI I PUHALA</li> <li>20 CENTRIFUGALNI KONCENTRATOR K1, K2</li> <li>21 TOČIONSKA ZGRADA</li> <li>22 STROJARNA I LABORATORIJ</li> <li>23 TRAFI STANICA</li> <li>24 UPRAVNA ZGRADA</li> </ul> | <ul style="list-style-type: none"> <li>SIROVA OTPADNA VODA</li> <li>PROČIŠĆENA OTPADNA VODA</li> <li>AKTIVNI MULJ</li> <li>MULJ</li> <li>MBBR ISPUNA</li> <li>CIJEVNA ISPUNA</li> <li>NADMULJNA VODA</li> <li>PRATEĆI OBJEKTI</li> <li>PJEŠAK</li> <li>DOZIRANJE KEMIKALIJA</li> <li>OTPAD SA REŠETKI</li> <li>ZRAK</li> </ul> |
|---|---|--|



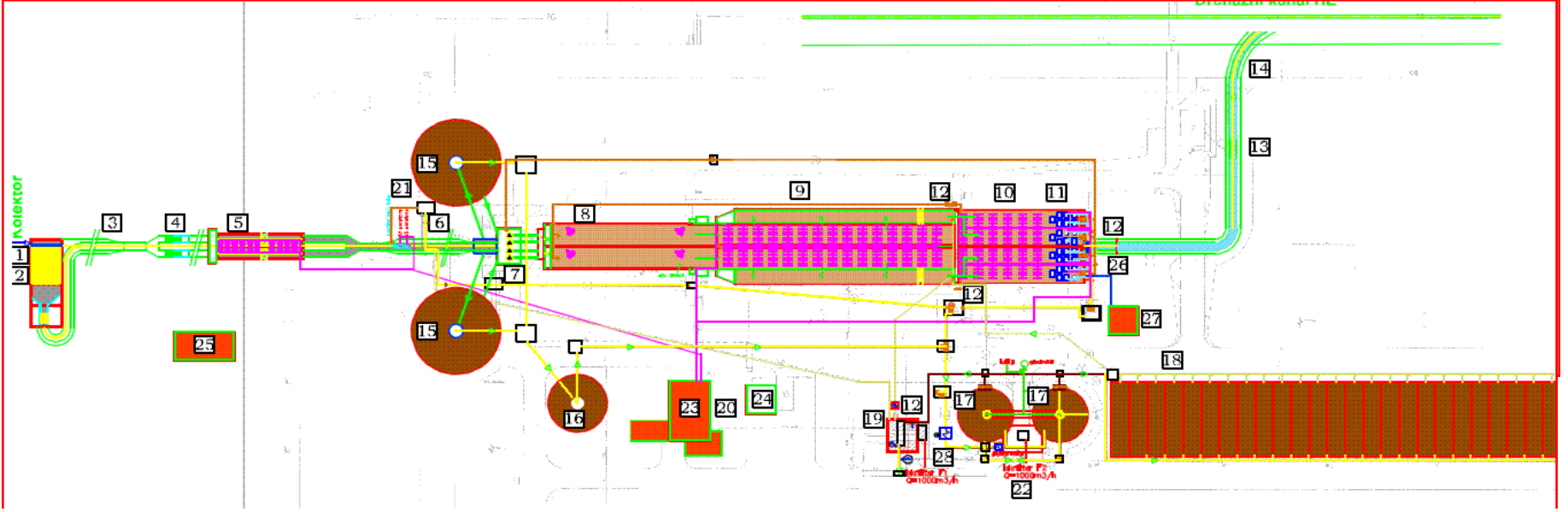
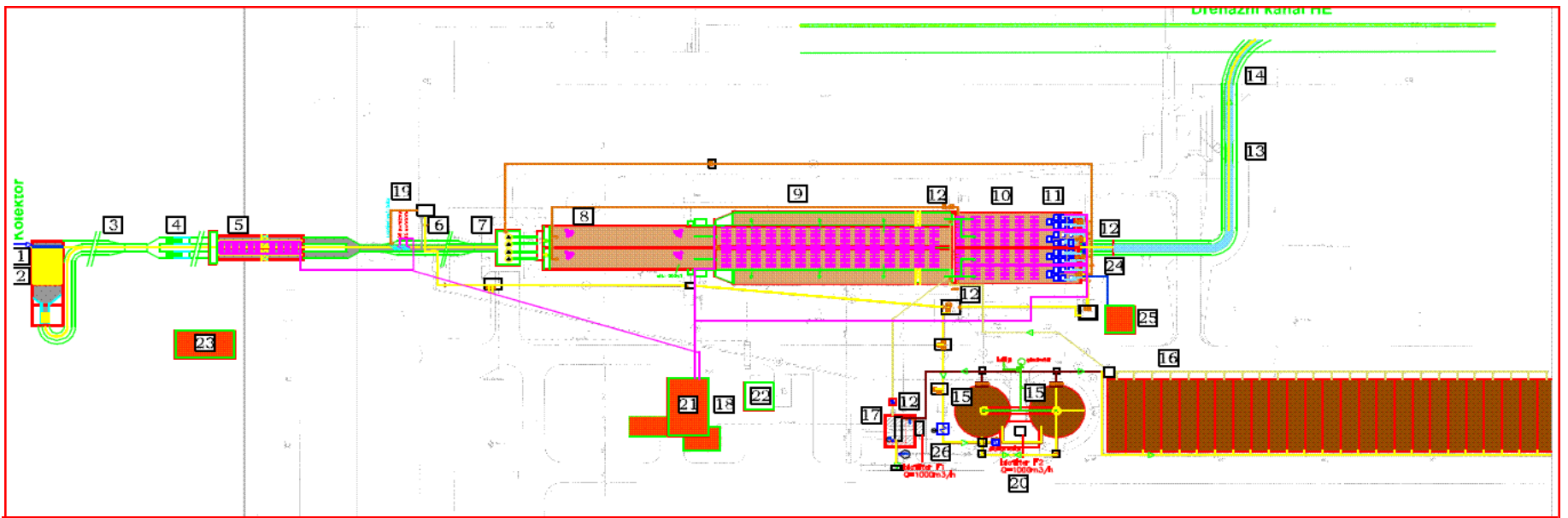
LEGENDA:

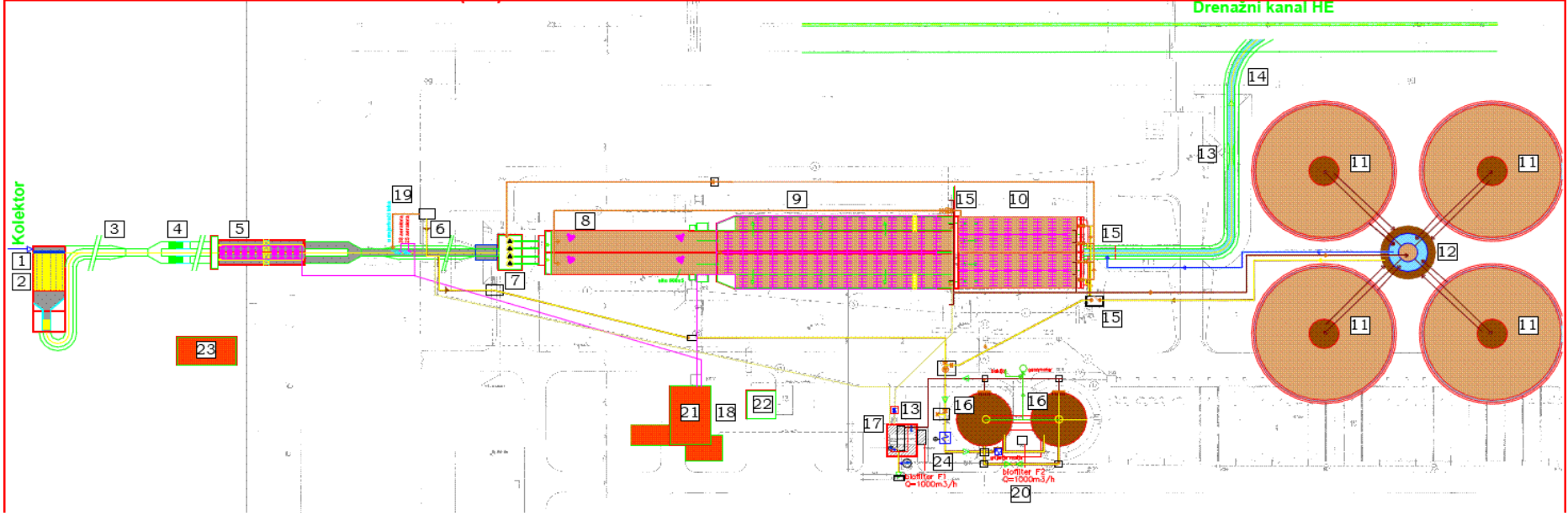
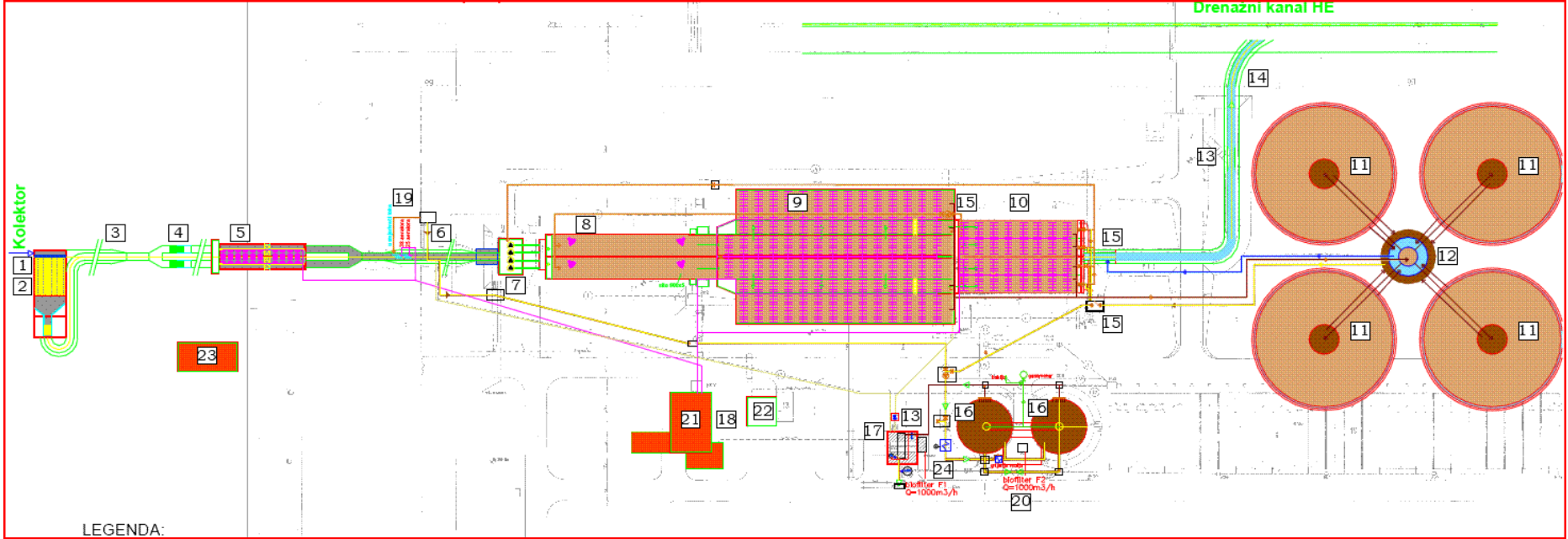
- ① ULAZNA GRUBA REŠETALA
- ② CRPNA STANICA SIROVE OTPADNE VODE (6 CRPKE)
- ③ OTVORENI TRAPEZNI DOVODNI KANAL
- ④ FINA AUTOMATSKA REŠETALA (2 REŠETALA)
- ⑤ PJSKOLOV - MASTOLOV SA CRPILIŠTEM PLSJKA (2 OBJEKTA)
- ⑥ OTVORENI TRAPEZNI SPOJNI KANAL DUŽINE 1600m
- ⑦ CRPNA STANICA BILOŠKOG DJELA (4 CRPKE)
- ⑧ PREDAERACIJSKI SPREMNİK SA SUSTAVOM FINE DIFUZNE AERACIJE (sjeverna procesna linija)
- ⑨ PREDAERACIJSKI SPREMNİK S ISPUNOM KOJA SLUŽI KAO NOSAČ BIOFILMA S SUSTAVOM FINE DIFUZNE AERACIJE I SITOM (južna procesna linija)
- ⑩ BIOAERACIJSKI SPREMNICI (2 SPREMNICA, DIFUZNA AERACIJA)
- ⑪ CRPKE ZA POVRAT AKTIVNOG MULJA (2 CRPKE) ; CRPKE ZA VIŠAK MULJA (2 CRPKE)

- ⑫ SEKUNDARNE TALOŽNICE (4 TALOŽNICE = 2+2)
- ⑬ AUTOMATSKI UZORKIVAČ PROČIŠĆENE OTPADNE VODE
- ⑭ ODVODNI KANAL S ISPUSTOM
- ⑮ UGUŠIVAČ MULJA
- ⑯ SPREMNİK MULJA
- ⑰ POLJA ZA SUŠENJE MULJA
- ⑱ DEHIDRACIJA MULJA S CENTRIFUGOM I SUSTAVOM ZA PRIPREMU I DOZIRANJE POLIMERA I VAPNA
- ⑲ KOMPRESORI I FUHALA
- ⑳ CENRIFUGALNI KONCENTRATOR K1, K2

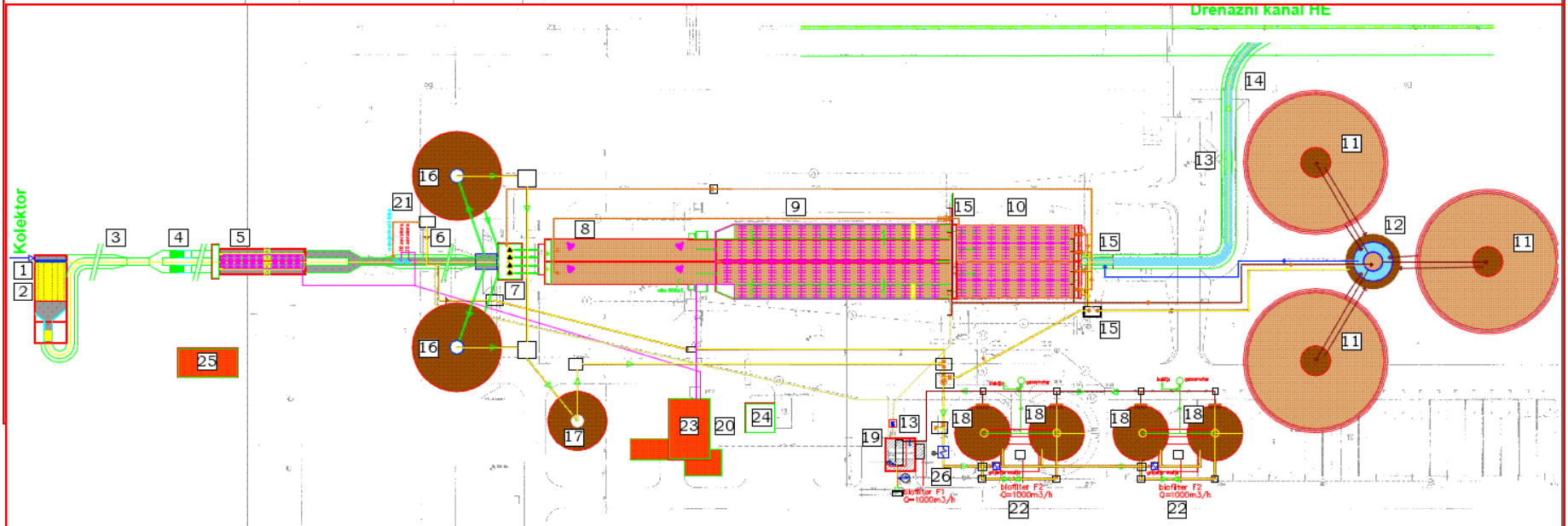
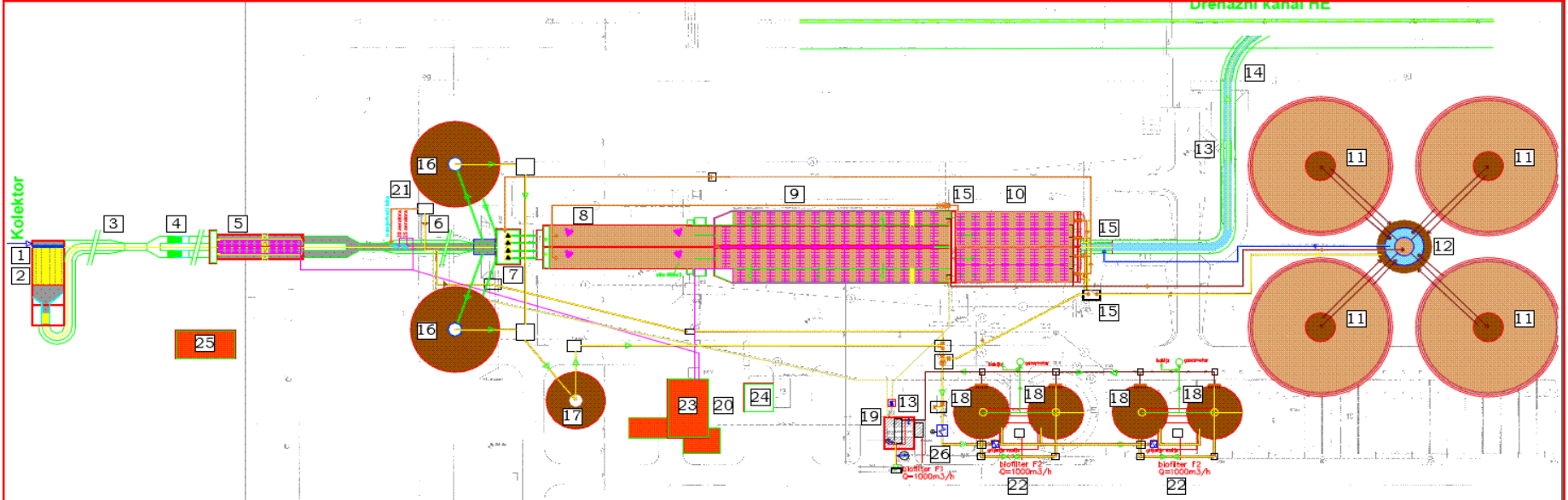
- SIROVA OTPADNA VODA
- PROČIŠĆENA OTPADNA VODA
- AKTIVNI MULJ
- MULJ
- MBBR ISPUNA
- CIJEVNA ISPUNA
- NADMULJNA VODA
- PIJESAK
- DOZIRANJE KEMIKALIJA
- OTPAD SA REŠETALA
- ZRAK

- |     |                           |      |                    |
|-----|---------------------------|------|--------------------|
| F1  | MJERAČ PROTOKA            | L1   | SENZOR ZA NIVO     |
| T1  | SENZOR TEMPERATURE        | Ls   | SONDE ZA NIVO VODE |
| Pn1 | pH-SENZOR                 | O2 I | SONDA ZA KISIK     |
| Au  | AUTOMATSKI UZORKIVAČ VODE |      |                    |









## Pregled rezultata modeliranja postojećeg stanja (S0) i 8 varijanti nadogradnje (S1 do S8) (1/6)

Faza 2B I 4

Oznaka	Opis	Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
Vrsta procesa	Aktivni mulj sa aeracijom i simultanom ND i anoksični/aerobni (AO)		Aerirani	AO	AO	AO	AO	AO	AO	AO	AO
Vrsta procesa	MBR ili konvencionalno sekundarno taloženje		SST	MBR	MBR	MBR	MBR	Novi SST	Novi SST	Novi SST	Novi SST
Tip reaktora	Carrousel ili plug flow ili mješoviti		Plug flow	Plug flow	Plug flow	Plug flow	Plug flow	Plug flow	Plug flow	Plug flow	Plug flow
Volumen	Postojeći ili nadogradjeni		Nadogradjeni	Postojeći	Postojeći	Postojeći	Postojeći	Nadogradjeni	Nadogradjeni	Nadogradjeni	Nadogradjeni
Vrsta influenta	Sirova otpadna voda ili prethodno istaložena otpadna voda		Istaložena	Sirova	Sirova	Istaložena	Istaložena	Sirova	Sirova	Istaložena	Istaložena
Vrsta aeracije	Povrsinska aeracija turbinama ili pridnena difuzorima pod tlakom		Pridnena	Pridnena	Pridnena	Pridnena	Pridnena	Pridnena	Pridnena	Pridnena	Pridnena
BOD	Dizajn za uklanjanje BOD		BOD	BOD	BOD	BOD	BOD	BOD	BOD	BOD	BOD
NIT	Dizajn za nitrifikaciju		NIT	NIT	NIT	NIT	NIT	NIT	NIT	NIT	NIT
DEN	Dizajn za denitrifikaciju (pred-denitrifikaciju)		SND	PRE-DEN	PRE-DEN	PRE-DEN	PRE-DEN	PRE-DEN	PRE-DEN	PRE-DEN	PRE-DEN
BIO-P	Dizajn za biološko uklanjanje fosfora		-	-	-	-	-	-	-	-	-
CHEM-P	Dizajn za kemijsko uklanjanje fosfora		-	CHEM-P	CHEM-P	CHEM-P	CHEM-P	CHEM-P	CHEM-P	CHEM-P	CHEM-P
<b>Projektirane zapremine</b>		<b>Jedinica</b>	<b>S0</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>S4</b>	<b>S5</b>	<b>S6</b>	<b>S7</b>	<b>S8</b>
PST	Primarna taložnica	m <sup>3</sup>	-	-	-	8000	8000	-	-	8000	8000
ANA	Anaerobni spremnik	m <sup>3</sup>	-	-	-	-	-	-	-	-	-
ANOX	Anoksični spremnik	m <sup>3</sup>	-	1239	1239	1239	1239	1239	1239	1239	1239
AT	Aerobni spremnik	m <sup>3</sup>	6131	4912	4912	4912	4912	9137	6137	6137	6137
MBR	Potopljeni Membranski Bio-Reaktor (MBR)	m <sup>3</sup>	-	1125	1125	1125	1125	-	-	-	-
SST	Sekundarna taložnica	m <sup>3</sup>	2470	-	-	-	-	11775	12480	11775	8925
PTT	Primarni ugusivač mulja	m <sup>3</sup>	-	-	-	1500	1500	-	-	1500	1500
DIG	Truliste mulja	m <sup>3</sup>	2100	2100	2100	4199	4199	2699	2100	4199	4199
V <sub>AERO</sub>	Aerobni volumen (za aerobnu starost mulja - SRT)	m <sup>3</sup>	6131	6037	6037	6037	6037	9137	6137	6137	6137
V <sub>ANOX</sub>	Anoksični volumen	m <sup>3</sup>	-	1239	1239	1239	1239	1239	1239	1239	1239
V <sub>MILSS</sub>	Ukupni volumen spremnika sa aktivnim muljem	m <sup>3</sup>	6131	7276	7276	7276	7276	10376	7376	7376	7376
V <sub>TOT</sub>	Ukupan volumen spremnika za tretman vode sa taložnicama	m <sup>3</sup>	8601	7276	7276	7276	7276	22151	19856	19151	16301
<b>Dodatni volumen u odnosu na stanje u 2011</b>		<b>Jedinica</b>	<b>S0</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>S4</b>	<b>S5</b>	<b>S6</b>	<b>S7</b>	<b>S8</b>
PST	Dodatni volumen PST	m <sup>3</sup>	-	-	-	8000	8000	-	-	8000	8000
ANOX	Dodatni volumen ANOX	m <sup>3</sup>	-	1239	1239	1239	1239	1239	1239	1239	1239
AT	Dodatni volumen AT	m <sup>3</sup>	-	-	-	-	-	3000	-	-	-
SST	Dodatni volumen SST	m <sup>3</sup>	-	-	-	-	-	11775	12480	11775	8925
PTT	Dodatni volumen PTT	m <sup>3</sup>	-	-	-	1500	1500	-	-	1500	1500
DIG	Dodatni volumen trulista mulja	m <sup>3</sup>	-	-	-	2099	2099	599	-	2099	2099

**Pregled rezultata modeliranja postojećeg stanja (S0) i 8 varijanti nadogradnje (S1 do S8) (2/6)**

Protoci i interna recirkulacija		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
Q <sub>INF</sub>	Ukupni influent	m <sup>3</sup> /d	21808	28000	28000	28000	28000	28000	28000	28000	28000
Q <sub>PS</sub>	Primarni mulj	m <sup>3</sup> /d	0	0	0	1777	1777	0	0	1777	1777
Q <sub>RET</sub>	Recirkulacijski mulj (RAS)	m <sup>3</sup> /d	9023	28000	28000	28000	28000	28000	28000	28000	28000
Q <sub>WAS</sub>	Visak mulja (WAS)	m <sup>3</sup> /d	505	448	449	448	448	642	480	450	371
Q <sub>MLSS</sub>	Anoksicna recirkulacija MLSS	m <sup>3</sup> /d	0	56000	84000	56000	84000	56000	56000	56000	56000
Q <sub>INT</sub>	Interna recirkulacija (Carousel)	m <sup>3</sup> /d	0	0	0	0	0	0	0	0	0
Q <sub>EFF</sub>	Effluent biološkog tretmana	m <sup>3</sup> /d	21778	27970	27970	27995	27995	27970	27970	27970	27995
HRT <sub>TOT</sub>	Ukupno hidrauličko vrijeme zadržavanja za cijeli uređaj	h	9,3	6,1	6,1	6,1	6,1	18,6	16,7	16,2	13,8
HRT <sub>AS</sub>	Hidrauličko vrijeme zadržavanja u biološkim spremnicima	h	6,6	6,1	6,1	6,1	6,1	8,7	6,2	6,2	6,2
Siroma otpadna voda (influent uređaja)		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
P.E. opterećenje	P.E. opterećenje (na osnovi 136 TOD/ES.d)	136 gTOD	88056	113058	113058	113058	113058	113058	113058	113058	113058
TSS	Suspendirane tvari u influentu	kg/d	3297	4233	4226	4233	4226	4233	4226	4233	4226
VSS	Isparljive tvari u influentu	kg/d	2753	3535	3525	3535	3525	3535	3525	3535	3525
ISS	Inorganske tvari u influentu	kg/d	544	698	701	698	701	698	701	698	701
BOD <sub>5</sub>	BOD opterećenje influenta	kgBOD/d	3379	4339	5894	4339	5894	4339	5894	4339	5894
TCOD	COD opterećenje influenta	kgCOD/d	8605	11049	11049	11049	11049	11049	11049	11049	11049
TKN	TKN opterećenje influenta	kgN/d	738	947	947	947	947	947	947	947	947
TP	TP opterećenje influenta	kgP/d	93	120	120	120	120	120	120	120	120
TOD	TOD opterećenje influenta	kgTOD/d	11976	15376	15376	15376	15376	15376	15376	15376	15376
VSS/TSS	Organski dio ukupne suspendirane tvari (0.75-0.85)	g/g	0,84	0,84	0,83	0,84	0,83	0,84	0,83	0,84	0,83
COD/VSS	Nerastvoreni organski dio COD (1.5-1.7)	gCOD/g	1,25	1,25	1,19	1,25	1,19	1,25	1,19	1,25	1,19
COD/BOD	Odnos COD/BOD (1.9-2.2)	gCOD/gBOD	2,55	2,55	1,87	2,55	1,87	2,55	1,87	2,55	1,87
F <sub>up</sub>	Dio biološki nerazgradivog nerastvorenog COD u ukupnom COD	gCOD/gCOD	0,39	0,39	0,13	0,39	0,13	0,39	0,13	0,39	0,13
Primarno taloženje		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
% uklanjanja TSS	Uklanjanje iz sirove vode bez internog opterećenja	%	-	-	-	49%	49%	-	-	49%	49%
% uklanjanja VSS	Uklanjanje iz sirove vode bez internog opterećenja	%	-	-	-	49%	50%	-	-	49%	50%
% uklanjanja ISS	Uklanjanje iz sirove vode bez internog opterećenja	%	-	-	-	49%	49%	-	-	49%	49%
% uklanjanja BOD <sub>5</sub>	Uklanjanje iz sirove vode bez internog opterećenja	%	-	-	-	3%	13%	-	-	3%	13%
% uklanjanja COD	Uklanjanje iz sirove vode bez internog opterećenja	%	-	-	-	21%	19%	-	-	21%	19%
% uklanjanja TKN	Uklanjanje iz sirove vode bez internog opterećenja	%	-	-	-	23%	17%	-	-	23%	17%
% uklanjanja TP	Uklanjanje iz sirove vode bez internog opterećenja	%	-	-	-	15%	15%	-	-	15%	15%

Pregled rezultata modeliranja postojećeg stanja (S0) i 8 varijanti nadogradnje (S1 do S8) (3/6)

Primarni mulj		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
P.E. opterećenje	Primarni mulj nakon ugvscivanja	136 gTOD	-	-	-	23773	19705	-	-	23773	19706
Primary - TSS	Primarni mulj nakon ugvscivanja	kg/d	-	-	-	2120	1742	-	-	2120	1742
VSS	Primarni mulj nakon ugvscivanja	kg/d	-	-	-	1760	1393	-	-	1760	1393
ISS	Primarni mulj nakon ugvscivanja	kg/d	-	-	-	533	535	-	-	533	535
BOD <sub>5</sub>	Primarni mulj nakon ugvscivanja	kgBOD/d	-	-	-	61	689	-	-	61	689
TCOD	Primarni mulj nakon ugvscivanja	kgCOD/d	-	-	-	2235	1930	-	-	2235	1930
TKN	Primarni mulj nakon ugvscivanja	kgN/d	-	-	-	218	164	-	-	218	164
TP	Primarni mulj nakon ugvscivanja	kgP/d	-	-	-	18	18	-	-	18	18
TOD	Primarni mulj nakon ugvscivanja	kgTOD/d	-	-	-	3233	2680	-	-	3233	2680
VSS/TSS	Organski dio ukupne suspendirane tvari (0.75-0.85)	g/g	-	-	-	0,83	0,80	-	-	0,83	0,80
COD/VSS	Nerastvoreni organski dio COD (1.5-1.7)	gCOD/g	-	-	-	1,25	1,20	-	-	1,25	1,20
COD/BOD	Odnos COD/BOD (1.9-2.2)	gCOD/gBOD	-	-	-	36,50	2,80	-	-	36,50	2,80
Opterećenje sustava sa aktivnim muljem		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
P.E. opterećenje	P.E. opterećenje (na osnovi 136 TOD/ES.d)	136 gTOD	88056	113058	113058	88912	91901	113058	113058	88912	91901
TSS	Suspendirane tvari u influentu sustava sa aktivnim muljem	kg/d	3297	4233	4226	2174	2135	4233	4226	2174	2135
VSS	Isparljive tvari u influentu sustava sa aktivnim muljem	kg/d	2753	3535	3525	1819	1778	3535	3525	1819	1778
ISS	Neorganaske tvari u influentu sustava sa aktivnim muljem	kg/d	544	698	701	355	357	698	701	355	357
BOD <sub>5</sub>	Organska tvar (BOD) u influentu sustava sa aktivnim muljem	kgBOD/d	3379	4339	5894	4226	5133	4339	5894	4226	5133
TCOD	Organska tvar (COD) u influentu sustava sa aktivnim muljem	kgCOD/d	8605	11049	11049	8764	8922	11049	11049	8764	8922
TKN	TKN u influentu sustava sa aktivnim muljem	kgN/d	738	947	947	728	783	947	947	728	783
TP	TP u influentu sustava sa aktivnim muljem	kgP/d	93	120	120	101	102	120	120	101	102
TOD	TOD u influentu sustava sa aktivnim muljem	kgTOD/d	11976	15376	15376	12092	12499	15376	15376	12092	12499
VSS/TSS	Organski dio ukupne suspendirane tvari	g/g	0,84	0,84	0,83	0,84	0,83	0,84	0,83	0,84	0,83
COD/VSS	Nerastvoreni dio organskog COD	gCOD/g	1,25	1,25	1,19	1,25	1,19	1,25	1,19	1,25	1,19
TCOD/BOD	Odnos COD/BOD	gCOD/gBOD	2,55	2,55	1,87	2,07	1,74	2,55	1,87	2,07	1,74
BOD <sub>5</sub> /N	Odnos BOD <sub>5</sub> /N u influentu sustava sa aktivnim muljem	kgBOD/kgTKN	4,58	4,58	6,22	5,80	6,56	4,58	6,22	5,80	6,56
TCOD/N	Odnos COD/N u influentu sustava sa aktivnim muljem	kgCOD/kgTKN	12	12	12	12	11	12	12	12	11
TCOD/P	Odnos COD/P u influentu sustava sa aktivnim muljem	kgCOD/kgTP	92	92	92	86	88	92	92	86	88
Sludge Loading	Opterećenje mulja na osnovu BOD <sub>5</sub>	kgBOD <sub>5</sub> /kgTSS/d	0,18	0,08	0,16	0,12	0,19	0	0,16	0,11	0,15
Sludge Loading	Opterećenje mulja na osnovu COD	kgCOD/kgTSS/d	0,46	0,21	0,29	0,25	0,33	0	0,29	0,24	0,27
Sludge Loading	Opterećenje mulja sa TKN	kgTKN/kgTSS/d	0,04	0,02	0,03	0,02	0,03	0	0,02	0,02	0,02

### Pregled rezultata modeliranja postojećeg stanja (S0) i 8 varijanti nadogradnje (S1 do S8) (4/6)

Tretman mulja		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
Temperatura	Temperatura influenta	°C	15,2	9,5	9,5	9,5	9,5	9,5	9,5	9,5	9,5
MLSS	Activni mulj u spremnicima	gTSS/m <sup>3</sup>	3081	7144	5178	4847	3734	4926	5153	5023	4495
RAS	Povratni mulj	gTSS/m <sup>3</sup>	4512	14267	10322	9680	7446	9829	10246	10022	8971
SRT	Ukupna starost mulja (anoksicna i aerobna)	d	3,3	9,4	9,4	9,4	9,4	8,0	7,6	8,1	9,7
SRT aerobna	Stvarna starost mulja	d	3,3	8,0	8,0	8,0	8,0	7,0	6,3	6,7	8,0
SRT aerobna	Maksimalna starost mulja uključujući aeraciju anoksicne zone	d	3,3	8,0	8,0	8,0	8,0	7,0	7,6	8,1	8,0
Mulj u efluentu	Nerastvoreni COD <sub>x</sub> u efluentu	kgCOD/d	416	0	0	0	0	89	73	85	109
WAS	Visak mulja (WAS)	kgCOD/d	5858	7056	4838	4920	3670	6970	4761	4791	3347
Ukupni WAS	Ukupna produkcija mulja (WAS+Efluent)	kgCOD/d	6274	7056	4838	4920	3670	7058	4834	4876	3456
Mulj u efluentu	TSS u efluentu	kgTSS/d	375	0	0	0	0	80	76	80	109
WAS	Visak mulja (WAS)	kgTSS/d	5279	6392	4630	4336	3339	6307	4918	4513	3324
Ukupni WAS	Ukupna produkcija mulja (WAS+Efluent)	kgTSS/d	5654	6392	4630	4336	3339	6387	4994	4593	3433
Ukupni WAS + Primarni m	Ukupna produkcija mulja prije truljenja	kgTSS/d	5279	6392	4630	6456	5081	6307	4918	6632	5066
Trulista mulja		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
Temperatura	Temperatura u trulistu mulja	°C	15,2	35,0	35,0	35,0	35,0	35	35	35	35
Volumen	Volumen trulista mulja	m <sup>3</sup>	2100	2100	2100	4199	4199	2699	2100	4199	4199
HRT	Ukupno hidrauličko vrijeme zadržavanja mulja u trulistu	d	4,2	23,4	23,4	20,5	20,5	21,0	21,8	20,5	21,3
CH <sub>4</sub>	Proizvodnja metana	kgCOD/d	105	1000	1490	1052	2227	964	1293	903	1984
VSS-razgradnja	Smanjenje (organskog dijel) mulja	kgTSS/d	220	721	1033	741	1475	700	923	646	1321
VSS-razgradnja	Smanjenje (organskog dijel) mulja	% VSS	15%	15%	32%	14%	37%	14%	29%	12%	35%
Ukupan mulj	Proizvodnja mulja nakon truljenja	kgCOD/d	4528	5238	2801	5247	2847	5192	2905	5262	2778
Ukupan mulj	Proizvodnja mulja nakon truljenja	kgTSS/d	4021	4866	2980	4882	3028	4809	3309	5074	3122
Konverzija na uređaju na osnovu balansa mase		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
COD to CO <sub>2</sub>	Ukupni oksidirani COD	kgCOD/d	3027	4214	6156	4152	5375	4207	6081	4142	5523
COD to Sludge	COD uklonjen s muljem	kgCOD/d	5874	5238	2801	5247	2847	5192	2905	5262	2778
COD oxidized	Oksidirani COD	kgCOD/d	2450	3187	4727	3084	3892	3130	4730	3113	4054
COD denitrified	COD utrosen za denitrifikaciju	kgCOD/d	577	1027	1429	1068	1482	1077	1351	1028	1469
Nitrified N Load	Ukupni nitrificirani amonijum	kgN/d	206	489	648	506	673	474	597	452	652
Denitrified N load	Ukupni denitrificirani nitrat	kgN/d	201	358	498	372	516	375	471	358	512
Nitrogen uklanjanja in Slud	Organski vezani dusik	kgN/d	411	385	226	371	204	374	233	389	203
OC <sub>NIT</sub>	TOD za nitrifikaciju	kgO <sub>2</sub> /d	943	2233	2960	2314	3077	2165	2727	2063	2979
OC <sub>DEN</sub>	COD konverzija za denitrifikaciju	kgO <sub>2</sub> /d	577	1027	1429	1068	1482	1077	1351	1028	1469
OC <sub>COD</sub>	COD konverzija za kisik	kgO <sub>2</sub> /d	2450	3187	4727	3084	3892	3130	4730	3113	4054
OC <sub>TOT</sub>	Ukupna (stoihiometrijska) potreba za kisikom	kgO <sub>2</sub> /d	3388	5560	7827	5538	7109	5291	7430	5163	7007

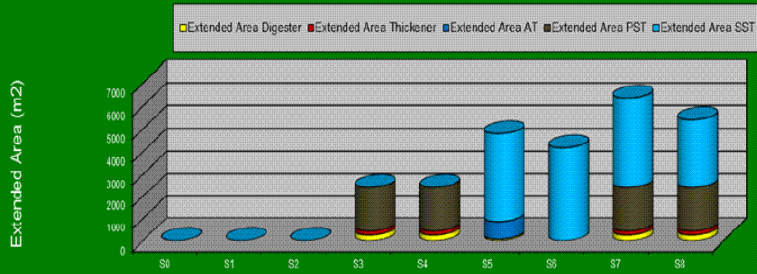
## Pregled rezultata modeliranja postojećeg stanja (S0) i 8 varijanti nadogradnje (S1 do S8) (5/6)

Dizajn aeracije		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
Tip	Povrsinska aeracija turbinama ili pridnena difuzorima pod tlakom	-	Pridnena	Pridnena	Pridnena	Pridnena	Pridnena	Pridnena	Pridnena	Pridnena	Pridnena
sp_O2	Srednja koncentracija kisika u aeracijskim spremnicima	gO <sub>2</sub> /m <sup>3</sup>	1,2	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0
Deficit kisika	Cs/(Cs-Cact) korektivni faktor za deficit kisika	-	1,1	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2
OC prijave vode	Ukupni kapacitet za unos kisika u prijavu vodu	kgO <sub>2</sub> /d	3845	6735	9482	6709	8612	6410	9001	6255	8488
Alpha faktor	Korekcija za transfer kisika u prijavi vodi	-	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
OC ciste vode	Ukupni kapacitet za unos kisika u cistu vodu	kgO <sub>2</sub> /d	7691	13470	18963	13418	17224	12819	18002	12509	16976
Potrosnja zraka	Ukupan kapacitet duvaljki zraka	Nm <sup>3</sup> /d	126720	365041	530283	359610	468867	188953	263738	172698	258937
Potrosnja zraka	Ukupna potrebna snaga za duvaljke zraka	kW	-	-	-	-	-	-	-	-	-
Dubina aeracije	Visina dizanja mjehurica zraka	m	3,8	3,8	3,8	3,8	3,8	3,8	3,8	3,8	3,8
Ucinkovitost aeracije	Ucinkovitost transfera kisika	gO <sub>2</sub> /Nm <sup>3</sup> /m	16,0	9,7	9,4	9,8	9,7	17,9	18,0	19,1	17,3
Koncentracije u efuentu		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
NO <sub>3</sub>	Nitrati	mgN-NO <sub>3</sub> /L	0,8	5,3	6,0	5,4	6,2	4,1	5,1	3,9	5,6
NH <sub>4</sub>	Amonium	mgN-NH <sub>4</sub> /L	6,4	0,6	0,5	0,6	0,5	1,2	1,9	1,7	1,0
TKN	Ukuni dusik po Kjeldahl-u	mgN/L	9,9	2,6	2,6	2,5	2,5	3,5	4,2	3,8	3,3
TN	Ukupni dusik	mgN/L	10,7	7,9	8,6	7,9	8,7	7,6	9,3	7,7	8,9
PO <sub>4</sub>	Ukupni orto-fosfat	mgP-PO <sub>4</sub> /L	1,6	2,3	2,4	2,5	2,8	2,4	0,1	1,0	1,7
TP	Ukupni fosfor	mgP/L	1,9	2,3	2,4	2,5	2,8	2,5	0,2	1,1	1,9
COD <sub>MF</sub>	Rastvoreni COD	mgCOD/L	21,7	21,3	21,5	21,4	21,4	21,4	24,9	23,5	23,4
BOD <sub>5</sub>	Bio-razgradivi COD	mgCOD/L	4,0	0,5	0,7	0,5	0,6	1,0	1,5	1,1	1,8
TSS	Suspendirane tvari	mgCOD/L	17,2	0,0	0,0	0,0	0,0	2,9	2,7	2,9	3,9
TOD	Teoretska potreba za kisikom	mgTOD/L	86,0	33,4	33,5	32,6	32,8	40,6	46,7	43,9	42,3
TCOD	Ukupni COD	mgCOD/L	40,8	21,3	21,5	21,4	21,4	24,5	27,5	26,5	27,3
Ukupna ucinkovitost uredjaja		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
Uklanjanje TSS	Odnos TSS u efuentu i influentu	%	97%	100%	100%	100%	100%	98%	98%	98%	97%
Uklanjanje COD	Odnos COD u efuentu i influentu	%	93%	95%	95%	95%	95%	94%	93%	93%	93%
Uklanjanje TN	Odnos TN u efuentu i influentu	%	44%	77%	75%	77%	74%	77%	73%	77%	74%
Uklanjanje TKN	Odnos TKN u efuentu i influentu	%	45%	92%	92%	93%	93%	90%	88%	89%	90%
Uklanjanje TP	Odnos u efuentu i influentu (bez kemijskog obaranja sa FeCl <sub>3</sub> )	%	94%	45%	43%	41%	34%	42%	96%	75%	56%
Ucinkovitost uredjaja		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
Aerobni dio mulja	Odnos aerobne mase mulja i ukupne mase mulja u sustavu	%	100%	83%	83%	83%	83%	88%	83%	83%	83%
Anoksidni dio mulja	Odnos anoksidne mase mulja i ukupne mase mulja u sustavu	%	0%	17%	17%	17%	17%	12%	17%	17%	17%
Anaerobni dio mulja	Odnos anaerobne mase mulja i ukupne mase mulja u sustavu	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Anoksidni utrosak COD	U odnosu na COD <sub>BD</sub>	%	19%	24%	23%	26%	28%	26%	22%	25%	27%
Aerobni utrosak COD	U odnosu na COD <sub>BD</sub>	%	81%	76%	77%	74%	72%	74%	78%	75%	73%
% nitrifikacija TN	Nitrifikacija influent TKN opterećenja	%	25%	52%	68%	53%	71%	50%	63%	48%	69%
% N uklanjanja sa muljem	% N uklanjanja putem viska mulja	%	49%	41%	24%	39%	22%	40%	25%	41%	21%
Efluent TN	% N uklanjanja putem efluenta	%	28%	23%	25%	22%	24%	23%	27%	21%	25%
Denitrifikacija TN	Denitrifikacija TN u influentu	%	24%	38%	53%	39%	55%	40%	50%	38%	54%

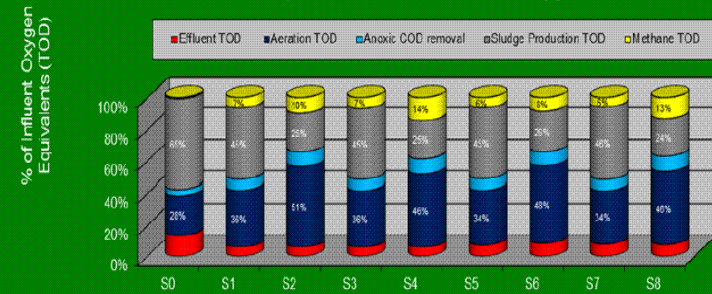
**Pregled rezultata modeliranja postojećeg stanja (S0) i 8 varijanti nadogradnje (S1 do S8) (6/6)**

Balans kisika na uređaju		Jedinica	S0	S1	S2	S3	S4	S5	S6	S7	S8
Sirovi influent TOD	Ukupna teorijska potreba za kisikom	kgTOD/d	11976	15376	15376	15376	15376	15376	15376	15376	15376
Efluent TOD	Ukupna teorijska potreba za kisikom	kgTOD/d	1876	934	937	914	917	1137	1308	1229	1184
Aeracijski TOD	Ukupna teorijska potreba za kisikom	kgTOD/d	3388	5560	7827	5538	7109	5291	7430	5163	7007
Anoksično uklonjeni COD	Ukupna teorijska potreba za kisikom	kgTOD/d	577	1027	1429	1068	1482	1077	1351	1028	1469
TOD metana	Ukupna teorijska potreba za kisikom	kgTOD/d	105	1000	1490	1052	2227	964	1293	903	1984
TOD nastalog mulja	Ukupna teorijska potreba za kisikom	kgTOD/d	7738	6995	3834	6945	3780	6903	3968	7041	3706
TOD primarnog mulja	Ukupna teorijska potreba za kisikom	kgTOD/d	0	0	0	3233	2680	0	0	3233	2680
TOD viska mulja	Ukupna teorijska potreba za kisikom	kgTOD/d	7754	9308	6393	6496	4854	9204	6300	6330	4426
Sirovi influent	% od ukupnog TOD u influentu	%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Efluent TOD	% od ukupnog TOD u influentu to EFF	%	16%	6%	6%	6%	6%	7%	9%	8%	8%
Aeracijski TOD	% od ukupnog TOD oksidiranog	%	28%	36%	51%	36%	46%	34%	48%	34%	46%
Anoksično uklonjeni COD	% od ukupnog TOD u influentu denitrificiranog	%	5%	7%	9%	7%	10%	7%	9%	7%	10%
TOD metana	% od ukupnog TOD u influentu u CH <sub>4</sub>	%	1%	7%	10%	7%	14%	6%	8%	6%	13%
TOD nastalog mulja	% od ukupnog TOD u influentu u finalnom mulju	%	65%	45%	25%	45%	25%	45%	26%	46%	24%
TOD primarnog mulja	% od ukupnog TOD u influentu u primarnom mulju	%	0%	0%	0%	21%	17%	0%	0%	21%	17%
TOD viska mulja	% od ukupnog TOD u influentu u visku mulja	%	65%	61%	42%	42%	32%	60%	41%	41%	29%

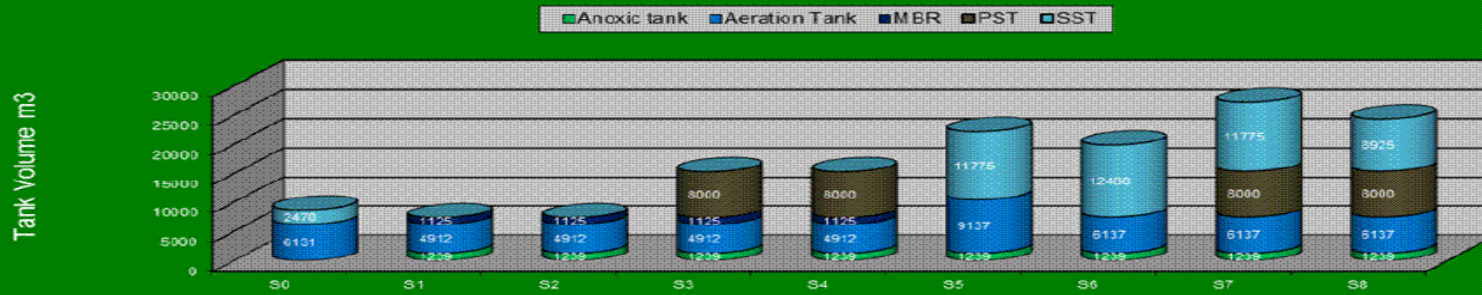
### Scenario performance on Area extension



### Scenario performance on Theoretical Oxygen Demand



### Scenario performance on total volume



### Scenario performance on Area extension





Kriterij	Relativna vrijednost	Varijanta								
		Scenario 1: Visoki sadržaj inertne čvrste COD frakcije				Scenario 2: Tipičan sadržaj inertne čvrste COD frakcije				
		S1	S3	S5	S7	S2	S4	S6	S8	
1	Efekti pročišćavanja <sup>A)</sup>	0,20	5,00	5,00	4,50	4,50	5,00	5,00	4,50	4,50
2	Investicijska ulaganja <sup>B)</sup>	0,20	5,00	3,00	4,00	3,50	5,00	3,00	4,50	3,50
3	Troškovi pogona i održavanja <sup>C)</sup>	0,20	4,50	4,25	5,00	4,75	4,25	4,25	5,00	4,50
4	Tehnološka složenost	0,05	4,50	4,25	5,00	4,75	4,50	4,25	5,00	4,75
5	Pogonska stabilnost i robustnost	0,10	4,50	5,00	4,25	4,75	4,50	5,00	4,25	4,75
6	Potreba za prostorom	0,05	5,00	5,00	4,50	4,50	5,00	5,00	4,50	4,50
7	Složenost i način implementacije <sup>D)</sup>	0,10	4,50	4,50	5,00	5,00	4,50	4,50	5,00	5,00
8	Količina mulja <sup>E)</sup>	0,10	5,00	5,00	4,50	4,50	5,00	5,00	4,50	4,50
	Ukupno	1,00	4,78	4,36	4,55	4,44	4,73	4,36	4,65	4,39

<sup>A)</sup> Treći stupanj pročišćavanja koji zadovoljava vrijednosti zakonom propisanih MDK na izlazu iz UPOV-a Varaždin

<sup>B)</sup> Kapitalni troškovi glede izgradnje dodatnih jedinica, hidro-tehnološke opreme i preinake postojećih dijelova UPOV-a Varaždin (Tablica 3)

<sup>C)</sup> Godišnji troškovi (Tablica 4)

<sup>D)</sup> Glede opsega i karaktera neophodnih radova u odnosu na postojeće stanje, kao i ometanja kontinuiranog rada uređaja tijekom nadgradnje

<sup>E)</sup> Glede ukupne produkcije obrađenog mulja, kao i produkcije bioplina

Ocjena 1 do 5 gdje je varijanta sa najvećom ukupnom ocjenom najbolje rješenje

# Advantages of use of models

- Getting insight in plant performance
- Evaluating possible scenarios for upgrading
- Evaluating new plant design
- Supporting decision making
- Developing new control schemes
- Shortening of decision time
- Cost-saving
- Teaching
- Communication

## Modelling WWTP Haarlem Waarderpolder

# Time Distribution

