MEASUREMENT METHODS FOR WASTEWATER CHARACTERIZATION

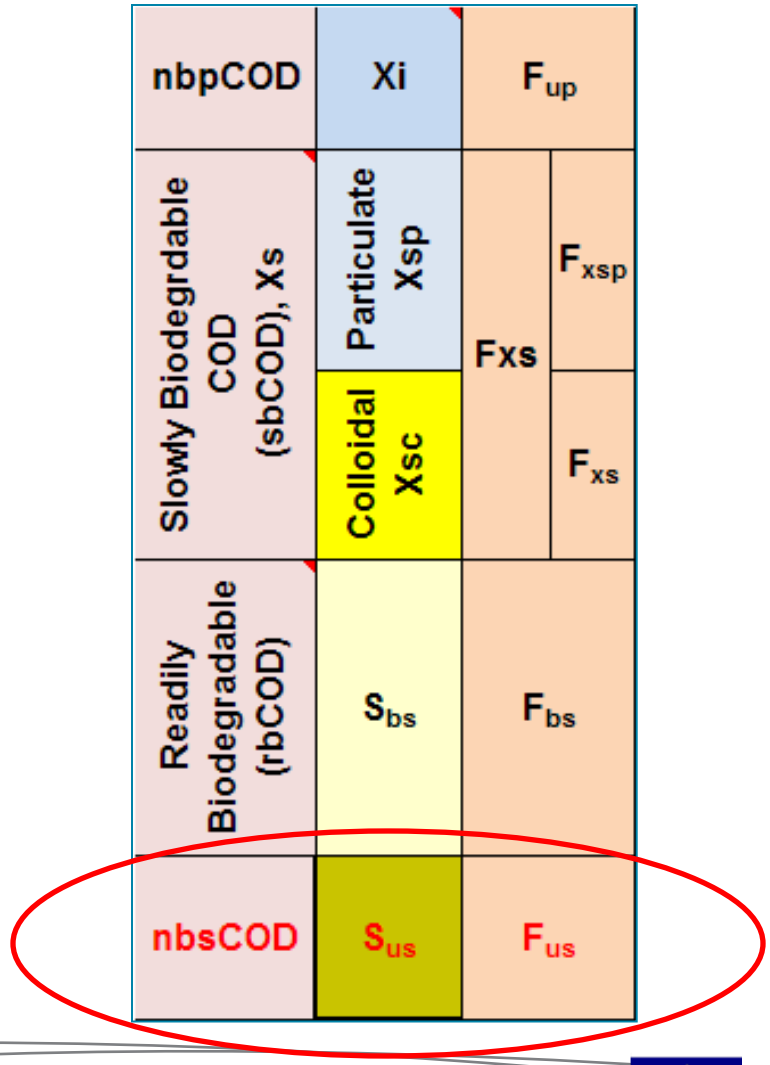
COD FRACTIONS

COD FRACTIONS CRYPTIC VARIABLES NAMES FOR BIOWIN & GPS-X

		BioWin			GPS-X Library-1		GPS-X Library-2	
Particulate	Nonbiodegradable	X_I	F_{up}		xi	frxi	xi	frxi
	Slowly Biodegrdable	X_{SP}	F_{Xs}	F_{xsp}	xs		xs	
Colloidal		Xsc		F_{xc}	scol	frxcol	ss	frss
Soluble	Readily Biodegradable	S_{bs}	F_{bs}		ss	frss		
	Nonbiodegradable	S_{us}	F_{us}		si	frsi	si	frsi

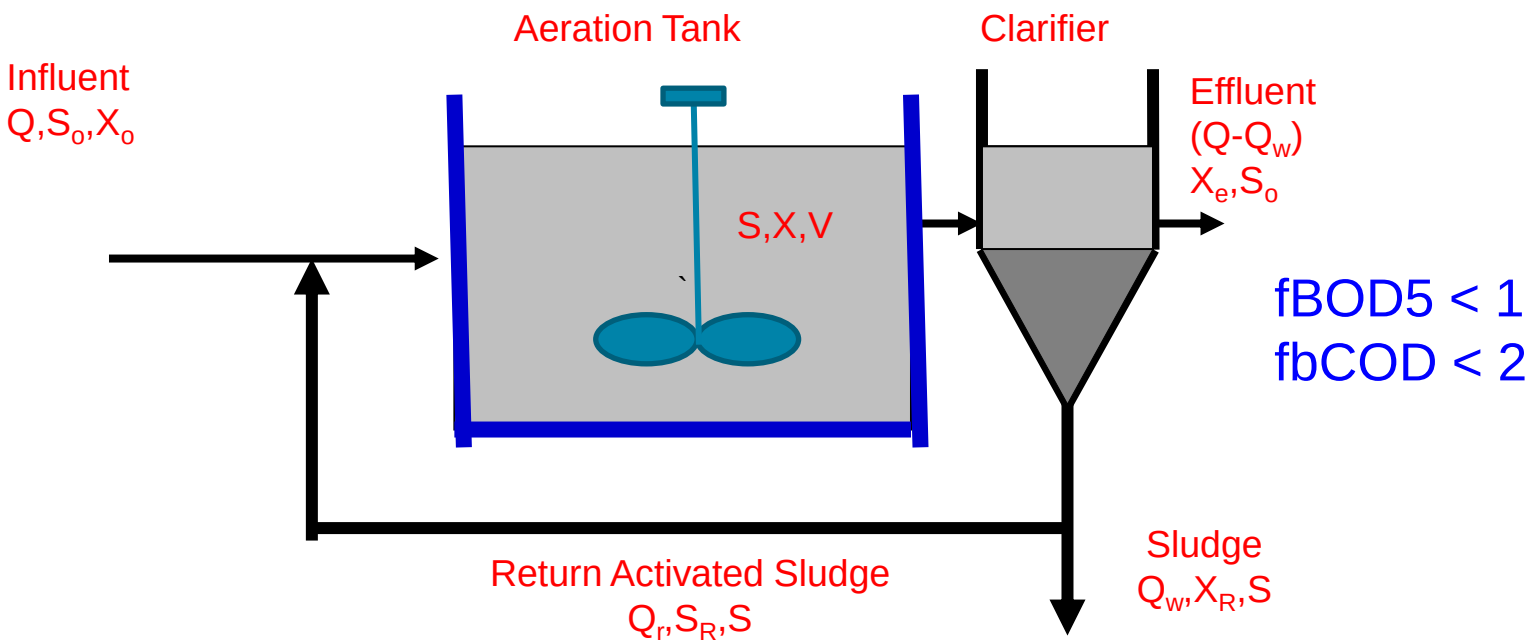
NON-BIODEGRADABLE SOLUBLE COD(nbsCOD,S_{us})

- The concentration of non-biodegradable soluble COD in the influent is determined by assuming that all soluble biodegradable COD is degraded within the process and the soluble COD in the effluent is exclusively non-biodegradable. Therefore the influent soluble non-biodegradable COD equals effluent soluble COD.
- Should measurable effluent soluble BOD exists then the non-biodegradable effluent COD equals the total effluent COD minus the effluent soluble biodegradable COD.



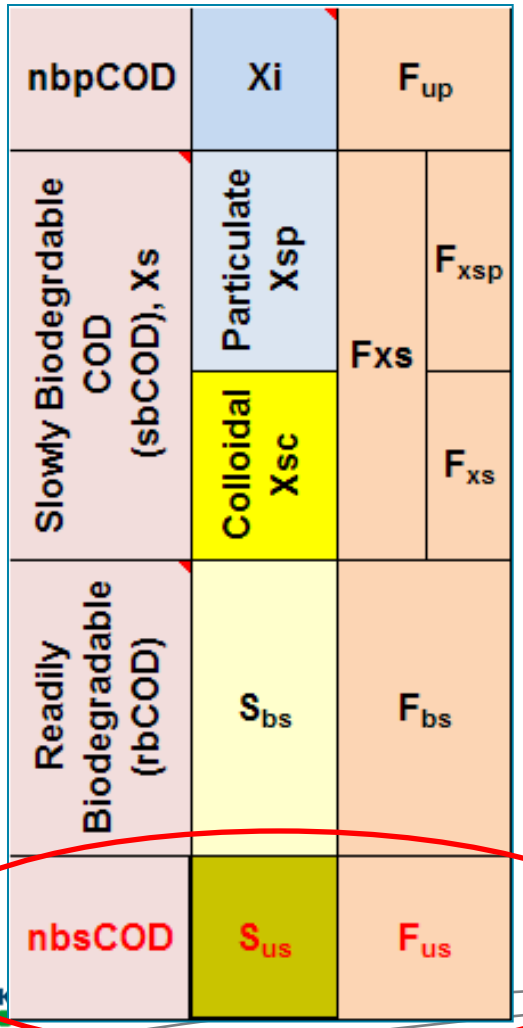
ACTIVATED SLUDGE SYSTEM
EFFLUENT SOLUBLE SUBSTRATE

SRT> 3 days



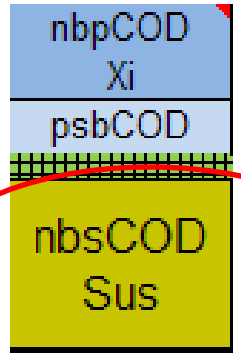
NON-BIODEGRADABLE SOLUBLE COD(nbsCOD,S_{us}) LOW EFFLUENT BOD

Influent



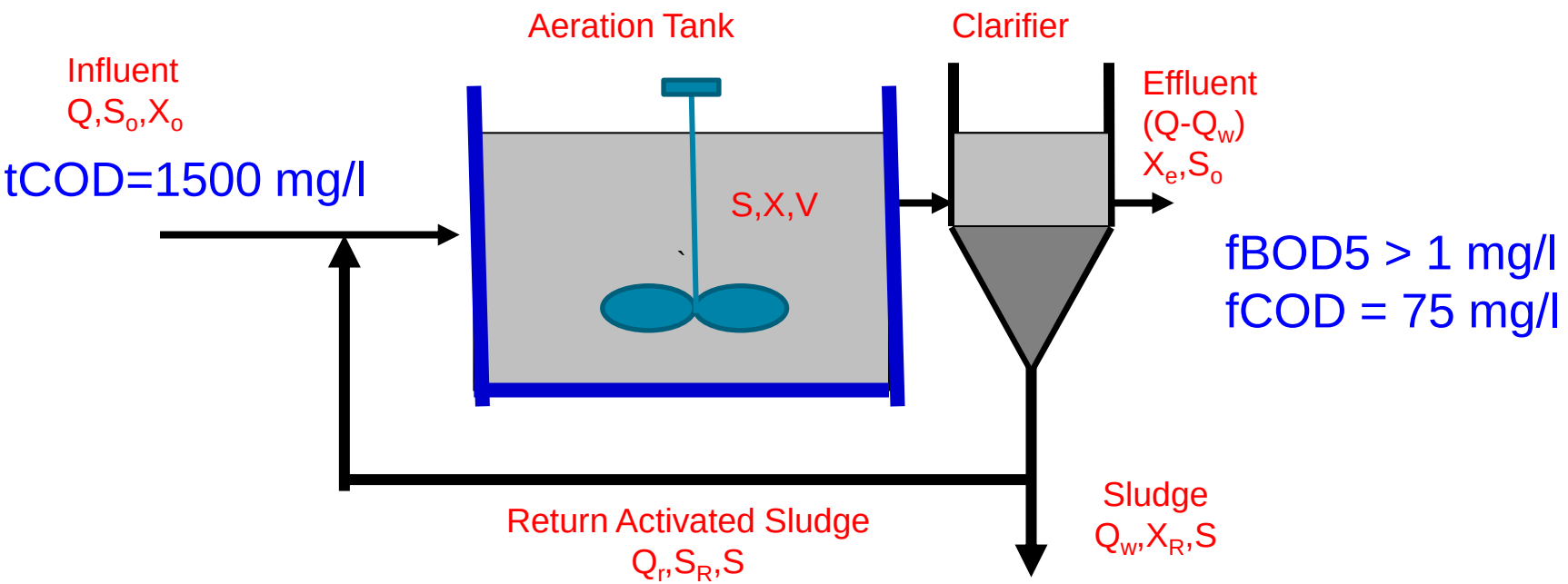
nbsCOD=sCOD in the effluent

Effluent



Valid for very low soluble BOD in the effluent(1.5 mg/l)

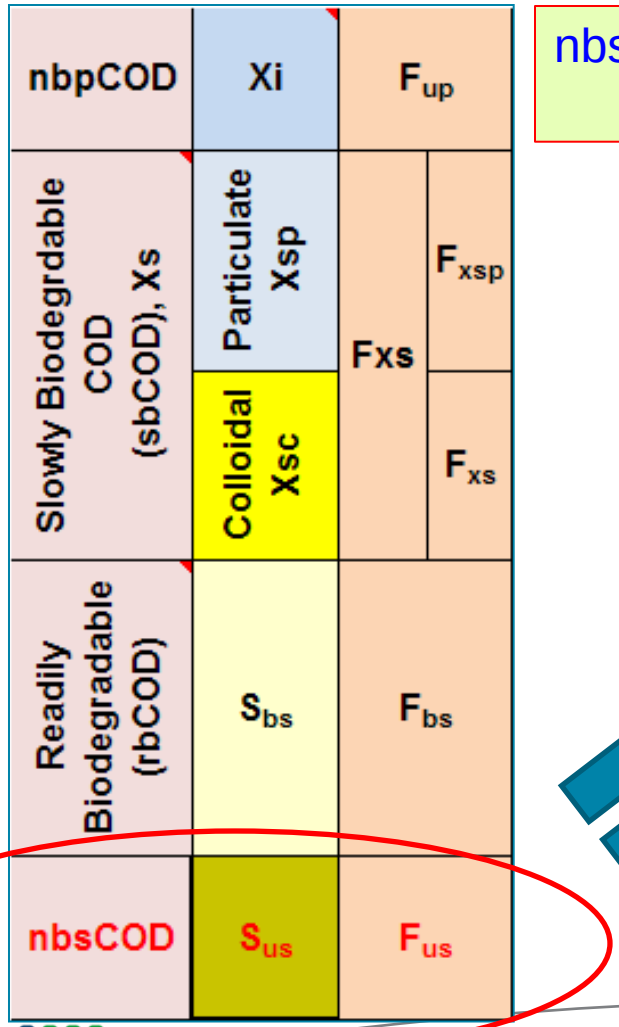
EXAMPLE
nbsCOD LOW FILTERED EFFLUENT BOD



nbsCOD=75 mg/l
Sus=75/1500=5%

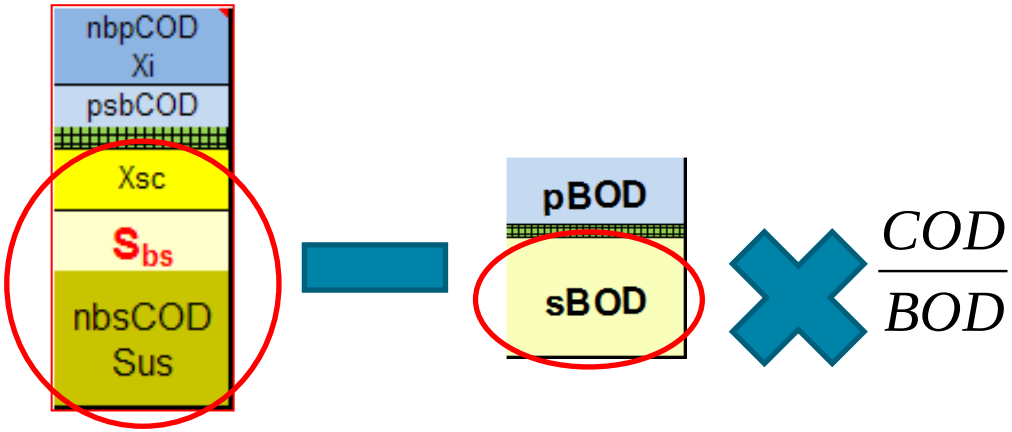
NON-BIODEGRADABLE SOLUBLE COD(nbsCOD,S_{us}) HIGH EFFLUENT BOD

Influent



nbsCOD=sCOD in the effluent-COD equivalent of the sBOD in th effluent(COD/BOD*sBODe)

Effluent

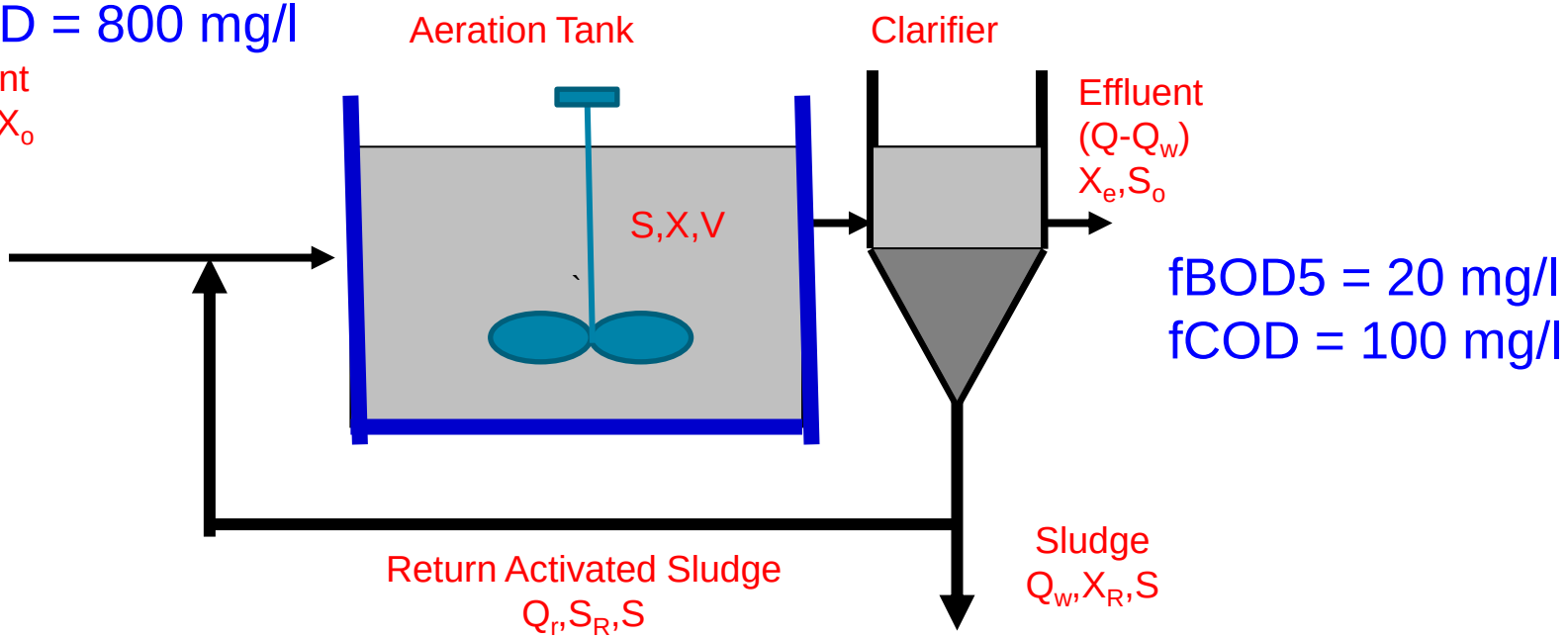


fCOD

Valid for very lhigh soluble BOD in the effluent(>1.5 mg/l)

EXAMPLE
nbsCOD HIGH FILTERED EFFLUENT BOD

tCOD=1500 mg/l
tBOD = 800 mg/l

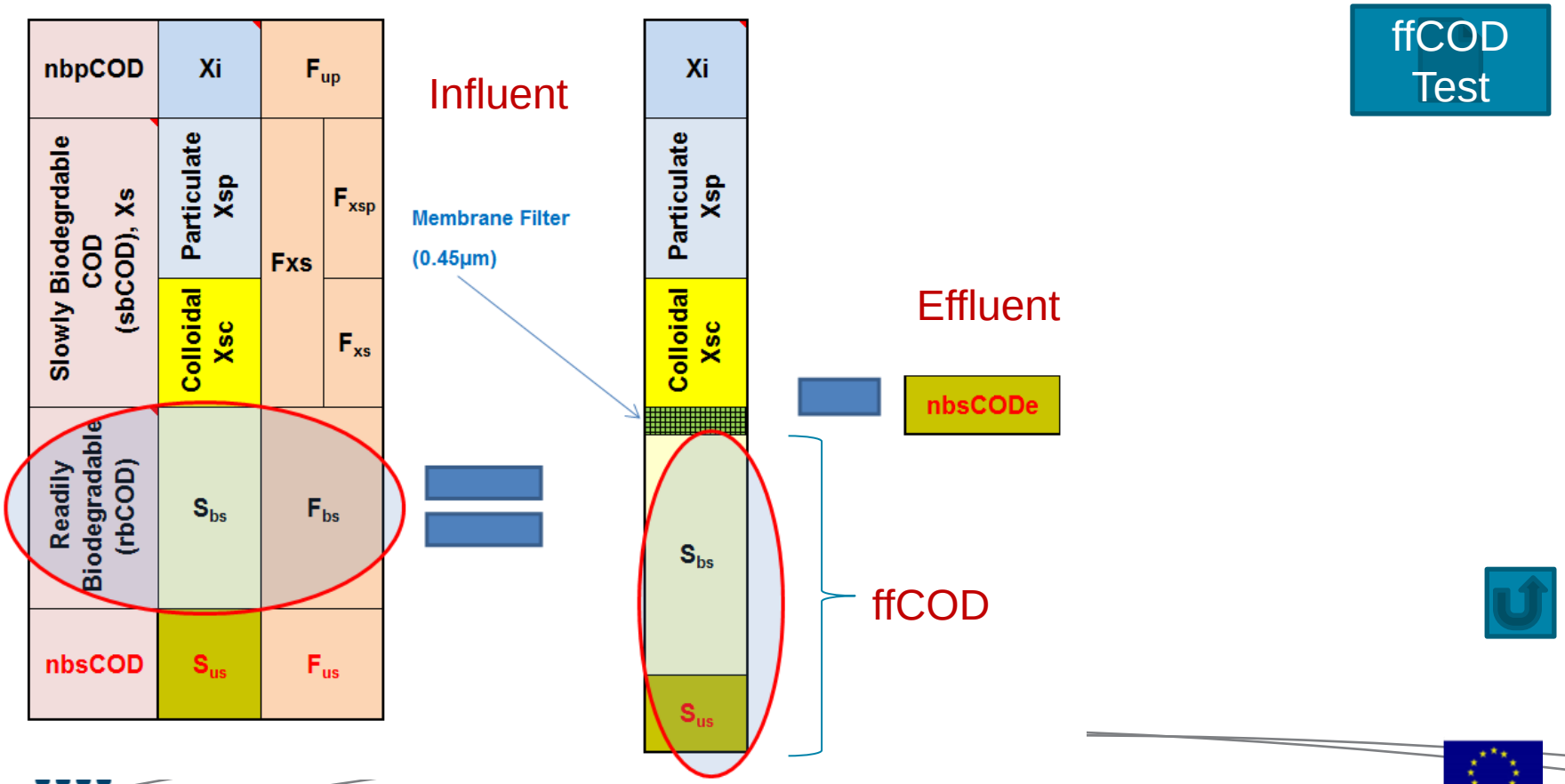


nbsCOD=100-20*(1500/800)=100-37.5=62.5 mg/l
Sus=62.5/1500=4.1%

READILY BIODEGRADABLE rbCOD(S_{bs})

Readily Biodegradable COD rbCOD is measured by the Flocculated & Filtered COD test in the influent and filtered COD in the effluent.

rbCOD=ffCOD influent-nbsCOD effluent



PARTICULATE XCOD/VSS RATIO(F_{cv})

$$F_{cv} = \frac{Particulate\_COD}{VSS} = \frac{tCOD - fCOD}{VSS}$$

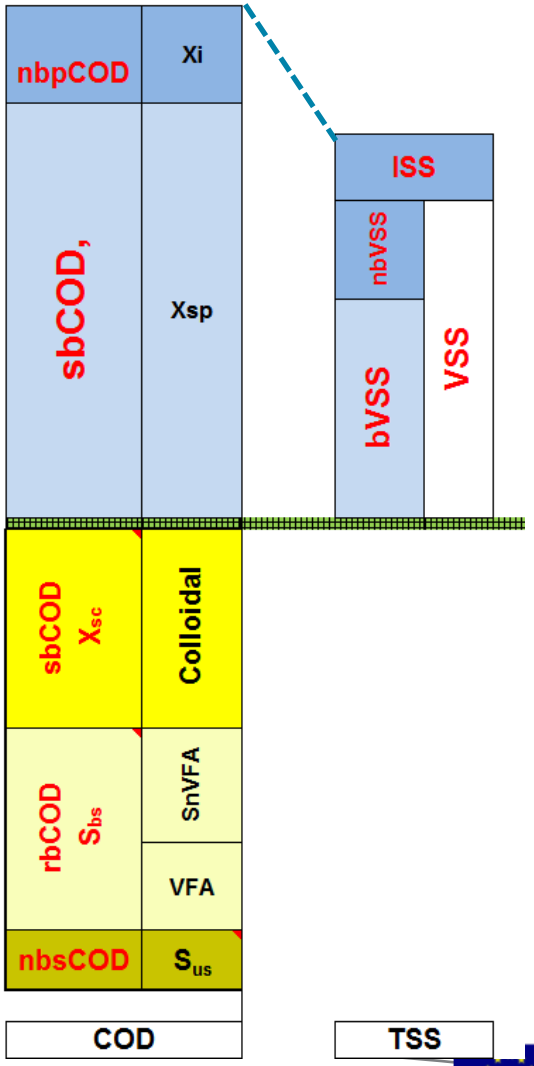
This is valid for particulate substrate and particulate inert material.

Typical pCOD/VSS ratio is 1.6 g COD/g VSS

$$\frac{XCOD}{VSS} = 1.6$$

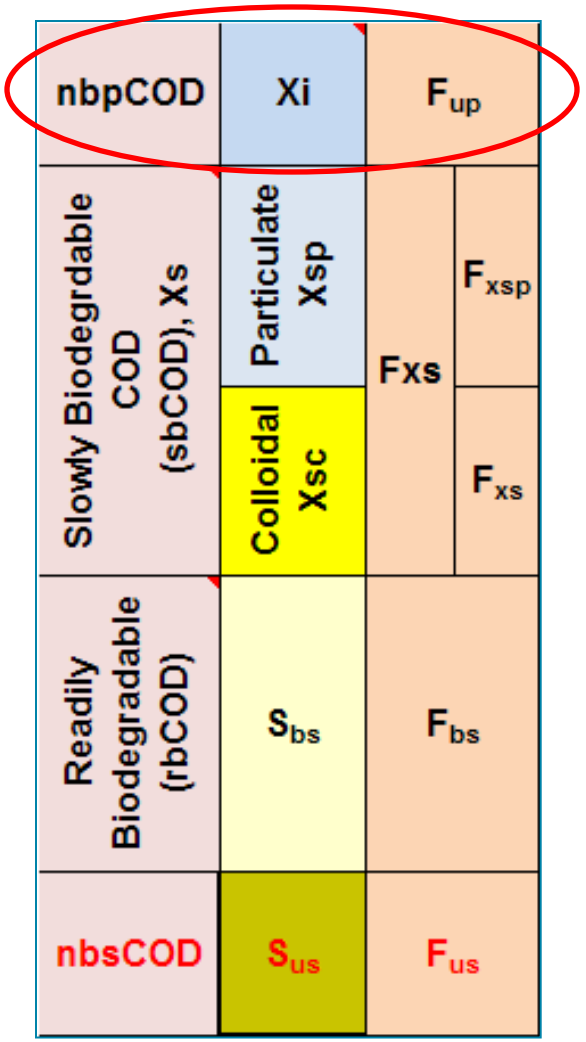
$$VSS = \frac{X_I + X_{sp}}{F_{cv}}$$

$$TSS = VSS + ISS_{measured}$$



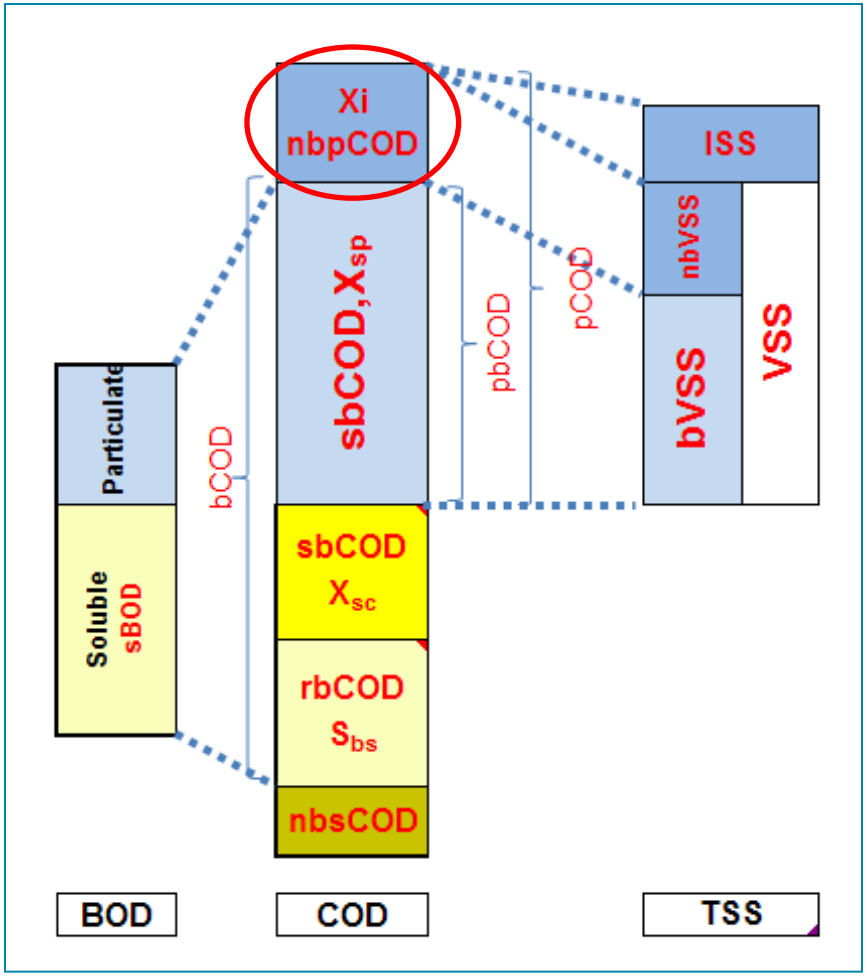
PARTICULATE NON-BIODEGRADABLE(INERT) COD

- Particulate non-biodegradable COD(X_i) is the portion of particulate COD unaffected by biological reactions at the plant and accumulates in the system and collected in sludge mass.
- The magnitude of this fraction is important in the description of activated sludge system behavior, particularly with respect to volatile solids production and oxygen demand.
- The mass of X_i in the system will equal the influent mass per day multiplied by the system sludge age.
- It is important to note that X_i doesn't register as BOD in the influent. Therefore as a result an increasing proportion of X_i will increase the COD/BOD ratio in the influent.

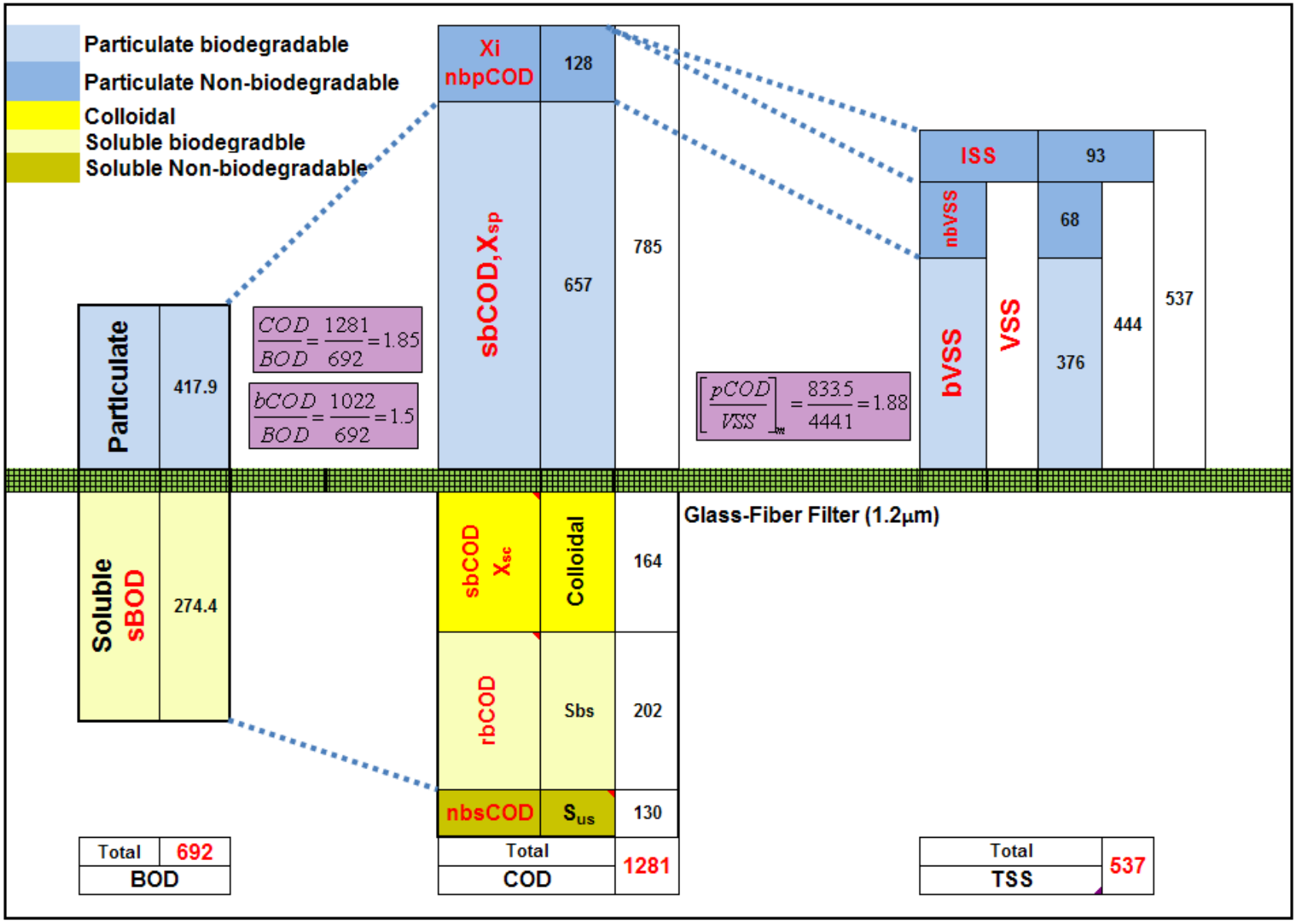


PARTICULATE NON-BIODEGRADABLE(INERT) COD ESTIMATION FROM COD,BOD5 and VSS

The nbpCOD can be estimated by matching the measured and the calculated COD fractions based on the previously calculated fractions of F_{bs} and F_{us} and the assumed fractions for F_{up} and F_{xsp}.

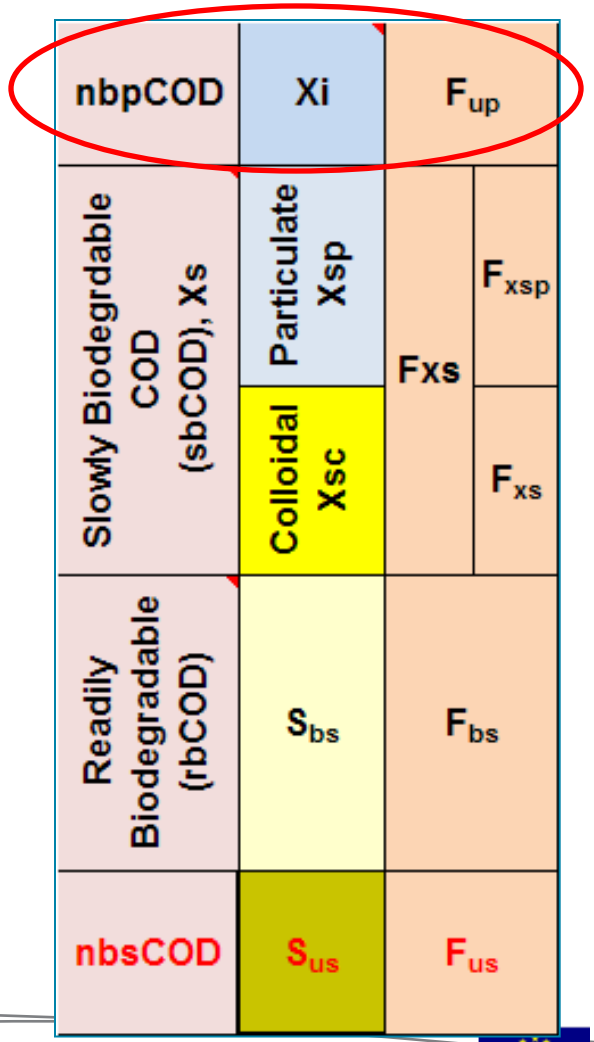


RELATIONSHIP BETWEEN BOD,COD AND TSS

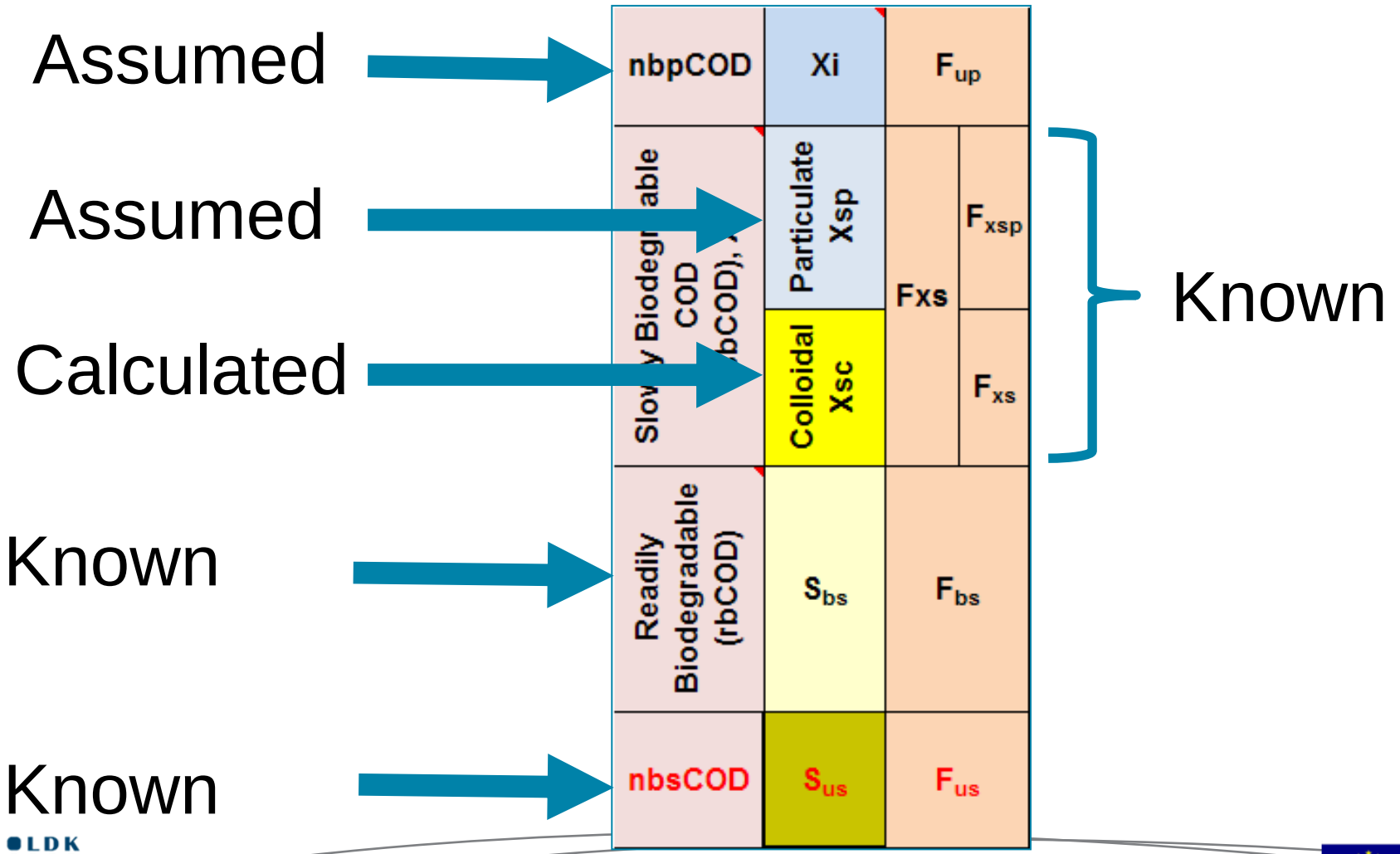


PARTICULATE NON-BIODEGRADABLE(INERT) COD

- Calculated COD Fractions
  - Assume a value for particulate non-biodegradable COD fraction. Fup(0.05-0.22)
  - Calculate the slowly biodegradable COD fraction , $F_{xs}=1-F_{up}-F_{bs}-F_{us}$.
    - $S_{us}=tCOD*F_{us}$
    - $X_I=tCOD*F_{up}$
    - $S_{bs}=tCOD*F_{bs}$
    - $Xs=tCOD*F_{xs}$
  - Assume a value for the particulate biodegradable fraction of the slowly biodegradable COD, F_{xsp} (0-1).
  - $X_{sc}=(1-F_{xsp})*Xs$
  - $X_{sp}=F_{xsp}*Xs$
  - $fCOD=S_{us}+S_{bs}+X_{sc}$
  - $ffCOD=Sus+Sbs$



PARTICULATE NON-BIODEGRADABLE(INERT) COD



CALCULATE BOD FROM COD FRACTIONS

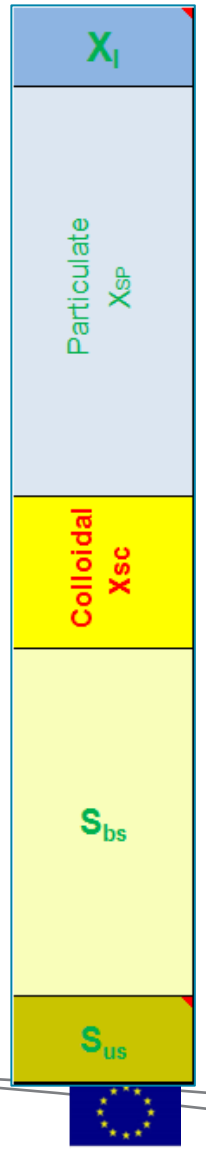
Calculate BOD fractions

$$fBOD = (1-Y)\times(S_{bs} + X_{sc}) + (1-f)\times Y \times (S_{bs} + X_{sc})\times(1-e^{-5b})$$

$$pBOD = X_{sp}\times\left[\left\{(1-Y)+\frac{(1-f)\times b\times Y}{(b-k)}\right\}\times(1-e^{-5k}) - \left\{\frac{(1-f)\times Y\times k}{(b-k)}\right\}\times(1-e^{-5b})\right]$$

$$tBOD = fBOD + pBOD$$

Parameter	Definition	Unit	Value
f	Fraction of active mass remaining as endogenous residue		0.2
b	Endogenous decay rate	1/day	0.24
Y	Yield of active organisms	mg cell COD/ mg COD	0.666
k	First order rate constant for Xsp degradation	1/day	0.4



CALCULATE VSS & TSS

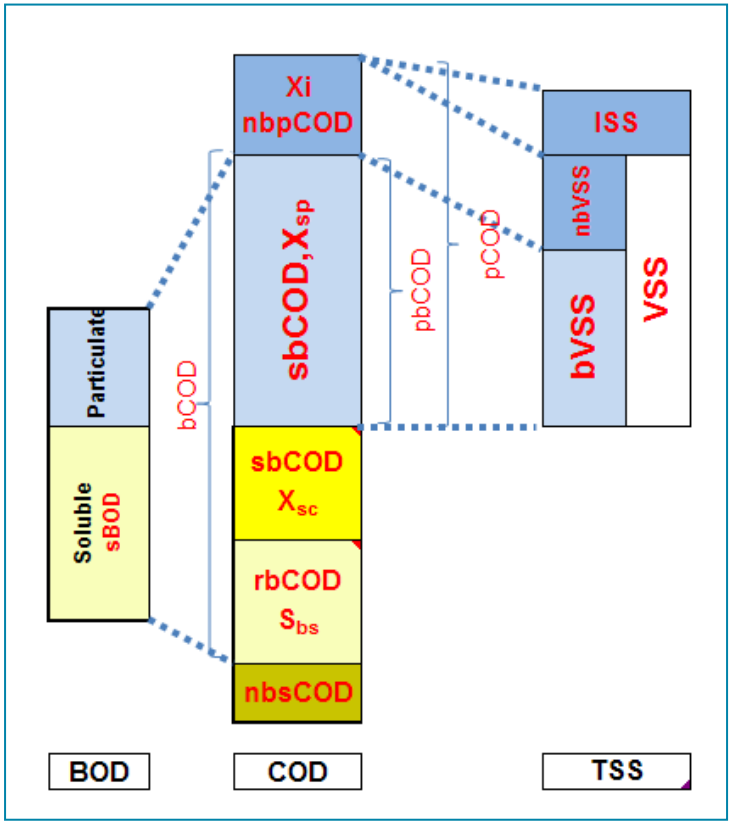
$$F_{cv} = \left[\frac{pCOD}{VSS}\right]_{measured}$$

$$VSS = \frac{pCOD_{calculated}}{F_{cv\text{-}mesured}}$$

$$VSS = \frac{X_I + X_{sp}(calculated\_by\_trial\ \&\ Error)}{F_{cv}}$$

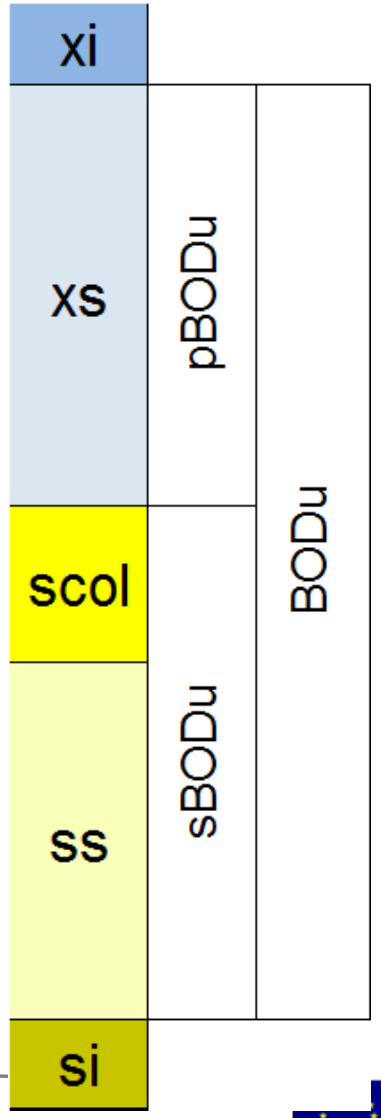
$$TSS = VSS + ISS_{measured}$$

Compare calculated BOD, TSS, and VSS with measured values and accordingly adjust assumptions and recalculate until the best matching is obtained.



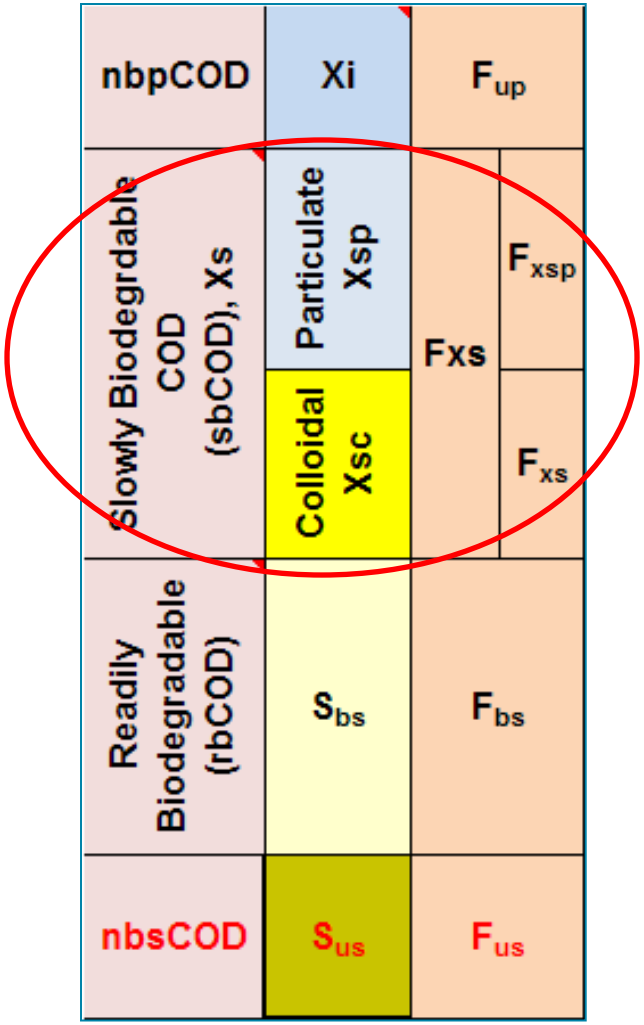
BOD ESTIMATION FROM COD FRACTIONS
GPS-X METHOD

sBODu = rbCOD
pBODu = bpCOD
BODu = sBODu+pBODu
Estimated BOD = (BOD/BODu)*BODu



SLOWLY BIODEGRADABLE sbCOD

- Slowly biodegradable COD includes both particulate and colloidal COD.
- When colloidal slowly biodegradable material is combined with activated sludge, the colloidal matter is likely adsorbed onto the floc rapidly, and removed from the liquid phase with the sludge. Therefore particulate and colloidal matters are grouped in one category(Slowly biodegradable) which is considered as particulate in separators(secondary clarifiers) downstream of bioreactors.
- The division of sbCOD between particulate and colloidal portions is particularly significant for modeling separation processes prior to activated sludge bioreactors.
- Model predictions of organics removal in a primary settling tank is directly impacted by the colloidal/particulate sbCOD fractionation because the colloidal material is not settleable.



SPREADSHEET FOR FRACTIONS ESTIMATION

Measurements	Value	Unit
Main influent concentrations		
Flow	0.0	mgd or m3/d
Total COD	500.0	mgCOD/L
Total Kjeldahl Nitrogen	40.0	mgN/L
Total P	10.0	mgP/L
Other influent concentrations		
Nitrate N	0.0	mgN/L
pH	7.3	
Alkalinity (CaCO3 equivalent)	300.0	mgCaCO3/L
Calcium	80.0	mg/L
Magnesium	15.0	mg/L
Dissolved oxygen	0.0	mgO2/L
Other measurements		
Effluent filtered COD	26.5	mgCOD/L
Influent filtered COD (GFC)	187.5	mgCOD/L
Influent FF COD	105.0	mgCOD/L
Influent acetate	12.0	mgCOD/L
Influent ammonia	26.4	mgN/L
Influent ortho-phosphate	5.0	mgP/L
Influent carbonaceous BOD5	245.6	mgO2/L
Influent filtered cBOD5 (GFC)	114.7	mgO2/L
Influent VSS	195.4	mgVSS/L
Influent TSS	240.4	mgTSS/L

GUIDE

- Enter measured lab data in column on left (**BOLD**)
  (If data is missing, estimate. May need to repeat after Step 2)
- Check resulting fractions **(BOLD)**

	Parameter	Value	Unit	Typical range
→	**Alkalinity (molar)**	**6.0**	**meq/L**	**2 - 6**
→	**Fus**	**0.05**	**-**	**0.03 - 0.08**
→	**CODp**	**312.5**	**mgCOD/L**	
→	**Fbs**	**0.16**		**0.12 - 0.25**
→	**Fac**			**0.0 - 0.3**
→	**Fna**			**0.5 - 0.8**
→	**Fpo4**	**0.50**	**-**	**0.3 - 0.6**
→	**COD/BOD5**	**2.04**	**-**	**1.9 - 2.2**
→	**Fcv**	**1.60**	**mgCODp/mgVSS**	**1.5 - 1.7**
→	**ISS**	**45.0**	**mgISS/L**	**15 - 45**

Acetate fraction of readily biodegradable COD (Sbs)

Envirosim Sheet

NON-BIODEGRADABLE VOLATILE SUSPENDED SOLIDS (nbVSS)

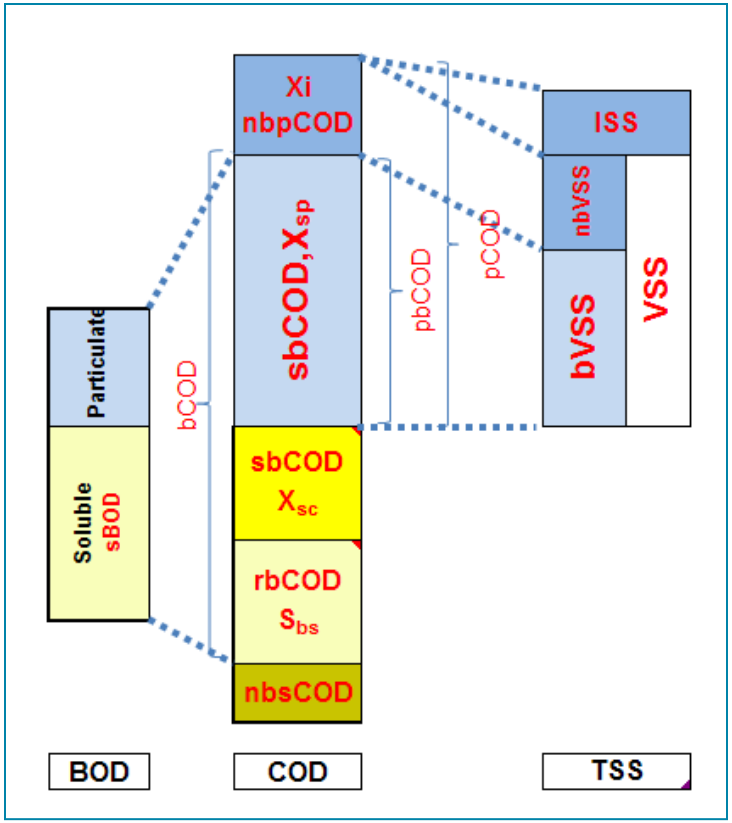
- Estimated from analysis of COD, sCOD, BOD, sBOD and VSS

$$\frac{nbVSS}{VSS} = \frac{nbpCOD}{pCOD}$$

$$nbVSS = \left[\left(\frac{nbpCOD}{pCOD}\right)\right] \times VSS$$

$$nbVSS = \left[1 - \left(\frac{bpCOD}{pCOD}\right)\right] \times VSS$$

$$\frac{bpCOD}{pCOD} = \frac{\left[\frac{bCOD}{BOD}\right] \times (BOD - sBOD)}{COD - sCOD}$$



bpCOD = Biodegradable particulate COD
pCOD = Particulate COD
sCOD = Soluble COD

Source :M&E Chapter 8 page 672