6.14 PHASE II DESIGN CALCULATIONS

Headworks:

The existing headworks utilizes two mechanical fine screens with a combined capacity of 6.8 MGD. Flooding out the screens provides by-pass capability.

The upgrade to the headworks includes expansion of the wet well and construction of two additional channels for mechanical fine screens. The proposed screens will be sized to treat in excess of 50% of Phase V peak hourly flow, which equates to 9.0 MGD each. Phase II will include installation of one mechanical fine screen and the second channel will be utilized for by-pass requirements. The second will be installed in Phase III. The existing screens will be replaced in Phase IV with a third 9.6 MGD screen.

Number of channels	3
Phase II Peak Hourly Flow, MGD	7.5
Capacity existing screens, MGD	6.8
Capacity Phase II screen, MGD	9.6
Capacity by-pass channel, MGD	9.6
Gravity Influent	30"
Opening Space	¼"

Raw Sewage Pump Station:

The raw sewage pump station will be upgraded with two new immersible pumps controlled by VFD's. The pump station operation shall be capable of flow pacing between 580 and 5,500 gpm utilizing a three-pump system. The existing 12" force main will be replaced to provide lower head conditions at high flows.

Oxidation Ditch:

The existing two-ring oxidation ditch was constructed in 1998 with provision for the addition of a third ring. The oxidation ditch design will allow for each of the channels to be operated in series or parallel.

Below are the calculations associated with the process design for the oxidation ditches.

Hydraulic Detention Time =24 hours

2,300,000 gallons / 7.48 cuft/gal = 307,487 cuft of treatment volume required.
Volume of each oxidation ditch:

Long Straight sections:
- Length of straight section = 70.0'
- Width of channels = 20'
- Depth of water = 14
- Number of straight sections = 6
- 70 x 20 x 14 x 6 = 117,600 cuft

End Straight sections:
- Length of straight section = 4.0'
- Width of channels = 20'
- Depth of water = 14
- Number of straight sections = 6
- 4 x 20 x 14 x 6 = 6,720 cuft

End sections

Channel #1 - Outer Ring
- Radius outer wall = 67.33'
- Radius inner wall = 47.33'
- Outer area = 14,242 sqft
- Inner area = 7,038 sqft
- Depth of water = 14
- (14,242 – 7,038) x 14 = 100,856 cuft

Channel #2 - Middle Ring
- Radius outer wall = 46.16'
- Radius inner wall = 26.16'
- Outer area = 6,694 sqft
- Inner area = 2,150 sqft
- Depth of water = 14'
- (6,694 – 2,150) x 14 = 63,616 cuft

Channel #3 - Inner Ring
- Radius outer wall = 25.0'
- Radius inner wall = 5.0'
- Outer area = 1,963.0 sqft
- Inner area = 78.5 sqft
- Depth of water = 14'
- (1,963 - 78.5) x 14' = 26,383 cuft

Total = (117,600 + 6,720 + 100,856 + 63,616 + 26,383) = 315,175 cuft
Volume = 315,175 cuft x 7.48 gallons/cuft = 2,357,509 gallons

Oxygen requirements

Influent BOD_5 = 5,505 lbs/day
Influent NH_3 = 875 lbs/day

1.4 lbs of O_2 required per lb of BOD_5 applied
4.6 lbs of O_2 required per lb of NH_3 applied

O_2 required for BOD_5 = 5,505 lb/day x 1.4 lb O_2/lb BOD_5 = 7,707 lb of O_2
O_2 required for NH_3 = 875 lb/day x 4.6 lb O_2/ lb NH_3 = 4,205 lb of O_2
Denitrification recovery of 50% = 0.5 x 4,205 lb of O_2 = 2,102 lb of O_2

Total pounds of O_2 required = 7,707 + 4,205 – 2,102 = 9,810 lb of O_2 / day

The following calculations and logic are taken from the Envirex-Orbal design guide

D.O. levels and volume split for each channel

Channel #	D.O. level	Volume	% of Volume
Channel #1	0 mg/l	142,296 cuft	45.2 %
Channel #2	1 mg/l	105,056 cuft	33.3 %
Channel #3	2 mg/l	67,823 cuft	21.5 %

Calculate Oxygen Delivery:
Use a Combined Correction Factor for a, b temperature and elevation = 0.93
Use a D.O. Correction Factor = (9.02 - D.O.) / 9.02 (@ 20 degrees C.)
O_2 required for channel = (total O_2 required x % volume) / (CCF x D.O. CF)
Total O_2 Required = 9,810 lb of O_2 / day

Correction Factors and lb O_2 required for each channel

Channel #	% Volume	CCF	D.O.	D.O. C.F.	O_2 required
Channel #1	45.2%	0.93	0 mg/l	1.0	4,768 lb/day
Channel #2	33.3%	0.93	1 mg/l	0.89	3,947 lb/day
Channel #3	21.5%	0.93	2 mg/l	0.79	2,871 lb/day
					11,586 lb/day

Calculate number of discs required
Pounds of Oxygen supplied = 11,600 lb/day = 483 lb/hour

Assume NWL = 749 therefore immersion is 15".
At 15" immersion the reserve is 33%
483 lb O_2 /hr x 1.37 = 662 lb O_2 /hr @ 21" immersion
Design speed in Channel #1 is up to 55 RPM and Channels #2 & 3 are 43 rpm
Lb O_2 /hr/disc @ 55 RPM = 1.88 @ 15" immersion
Lb O_2 /hr/disc @ 55 RPM = 1.88 @ 15" immersion

Number of Discs Required per Channel at 15" submersion

Channel #	O_2 required	O_2 required	lbs. O_2/hr/disc	# Discs	#Discs Prop.
CHANNEL #1	**4,768 LB/DAY**	**199 LBS./HR**	**1.88**	**105**	**120**
Channel #2	3,947 lb/day	165 lbs./hr	1.88	88	120
Channel #3	2,871 lb/day	120 lbs./hr	1.88	64	120

Calculate Percent O_2 Reserve @ 21" immersion @ 55 RPM
21" @ 55 RPM = 2.5 lbs O_2/hr/disc

Channel #	#Discs Prop.	O_2 Produced	O_2 Required	% Reserve
CHANNEL #1	**120**	**300 LBS/HR**	**199 LBS./HR**	**51%**
CHANNEL #2	**120**	**300 LBS/HR**	**165 LBS./HR**	**82%**
CHANNEL #3	**120**	**300 LBS/HR**	**120 LBS./HR**	**250%**

Calculate Volume of Return Activated Sludge
Assume RAS concentration is 7,500 mg/l
$(Q_{RAS} \times mg/l_{RAS}) + (Q_{In\ BOD} \times mg/l_{In\ BOD}) = (Q_{In\ BOD} + Q_{RAS}) \times mg/l_{MLSS}$
$(Q_{RAS} \times 7{,}500\ mg/l) + (3.0 \times 220\ mg/l) = (3.0 + Q_{RAS}) \times 4{,}000\ mg/l$
$7500\ Q_{RAS} + 660 = 12{,}000 + 4{,}000\ Q_{RAS}$
$3{,}500\ Q_{RAS} = 11{,}340$
$Q_{RAS} = 3.24$ MGD

Calculate Volume of Waste Activated Sludge

MOP 8 for Phosphorus removal estimates 1.0 sludge production factor
WAS = 1.0 x influent BOD_5
WAS = 1.0 x 5,505 = 5,505 lb/day

Sludge age may be calculated by either two ways:
Sludge Age = total lb solids under aeration / influent lb BOD_5/day
or, Sludge Age = total lb solids under aeration / lb TSS Wasted
In this particular case it is the same answer

Sludge Age based on BOD_5

Influent BOD_5 = 5,505 lb
MLSS 4,000 mg/l
Total Volume = 315,175 cuft = 2,357,509 gallons
Total lb solids under aeration:
2.36 MGD x 4,000 mg/l x 8.34 lb/gal = 78,730 lbs
Sludge Age = 78,730 lbs solids / 5,505 lb BOD_5/day = 14.3 days

Sludge Age based on WAS
MLSS 4,000 mg/l
Total Volume = 315,175 cuft = 2,357,509 gallons
Total lb solids under aeration:
2.36 MGD x 4,000 mg/l x 8.34 lb/gal = 78,730 lbs
Sludge Age = 78,730 lbs solids / 5,505 lb WAS/day = 14.3 days

Calculate F/M ratio = influent lb BOD_5/day / total lb solids under aeration

Influent BOD_5 = 5,505 lb
MLSS 4,000 mg/l
Total Volume = 315,175 cuft = 2,357,509 gallons
Total lb solids under aeration:
2.36 MGD x 4,000 mg/l x 8.34 lb/gal = 78,730 lbs
F/M ratio = 5,505 lb BOD_5/day / 78,396 lbs solids = 0.07

Mixed Liquor Diversion Structure

The mixed liquor diversion structure splits the flow from the oxidation ditch to the two existing clarifiers.

Final Clarifier

There are two existing 85' diameter center feed final clarifiers of the Tobro design with suction sludge removal and scum removal. The Peak Hourly Flow to the clarifiers is 7.5 MGD, which is split evenly in the diversion structure. Fiberglass domes cover the clarifiers in order to prevent icing which could be the result of extremely long detention times in the oxidation ditch. The process design calculations are shown below.

Calculate Surface Loading Rate 85 foot Clarifier

Surface loading rate shall not exceed 600 gpm/ sqft/day at Peak Hourly Flow for tertiary treatment

$(85' / 2)^2 \times \Pi \times 2$ units = 11,349 square feet

7,500,000 gal/day / 11,349 sqft = 660 gpd/ day /sqft

Calculate Solids Loading Rate

Solids loading shall not exceed 50 lb/day/sqft

Total MLSS lb/day = 4,000 mg/l x 7.5 MGD x 8.34 lb/gal = 250,200 lbs/day

250,200 lbs/day / 11,349 sqft = 22 lb/day/ sqft

Calculate Weir Length

Weir overflow rate shall not exceed 30,000 gal/day/ft at Peak Hourly Flow

85' Clarifier Weir radius = 39'-4" or 39.33 feet

Weir length per clarifier = 2 x 39.33 x Π = 247 lineal feet

Total weir length = 247 feet x 2 units = 497 lineal feet

Overflow rate = 7,500,000 gal/day / 497 feet = 15,090 gal/day/ft

Chlorine Contact Tank

Calculate Volume:

Number of Tanks	2
Channel width	12'
Channel Length	56'
Side water Depth	8.5'

2 tanks x 12 ft x 56 ft x 8.5ft = 11,425 cuft
11,425 x 7.48 gallons/cuft = 85,460 gallons

Calculate Detention time @ Peak Hourly Flow of 7.5 MGD

85,460 gal. / 7,500,000 gpd = 0.0114 days or 16.4 minutes

RAS/WAS Pump Station

The existing RAS/ WAS Pump Station is a duplex design with a relatively small wet well. The return rate from the pump station is limited 1,400 gpm. The Phase II required return rate is 3.24 MGD or 2,250.

Calculate Volume of Return Activated Sludge Phase II

Assume RAS concentration is 7,500 mg/l

$(Q_{RAS} \text{ x mg/l}_{RAS}) + (Q_{In\ BOD} \text{ x mg/l}_{In\ BOD}) = (Q_{In\ BOD} + Q_{RAS}) \text{ x mg/l}_{MLSS}$

$(Q_{RAS} \text{ x } 7{,}500 \text{ mg/l}) + (3.0 \text{ x } 220 \text{ mg/l}) = (3.0 + Q_{RAS}) \text{ x } 4{,}000 \text{ mg/l}$

$7500\ Q_{RAS} + 660 = 12{,}000 + 4{,}000\ Q_{RAS}$

$3{,}500\ Q_{RAS} = 11{,}340$

$Q_{RAS} = 3.24$ MGD

It is recommended that a new pump station be constructed as part of the Phase II Design. The design of the pump station should accommodate future phases. Based on simply doubling the plant capacity in Phase III requires a return rate of 6.5 MGD. The addition of primaries in Phase IV will lower the raw to return ratio and should be closer to 9.0 MGD or below. The existing RAS Force main is limited to a 14" diameter pipe. The RAS Force Main will be increased to an 18" diameter main.

RAS Pumps

Discharge elev. = 749
Centerline of pump = 726.0
Static Head = 23
Phase III Q_{ras} = 4,513 GPM
8" riser pipe @ 1,500 gpm = (45)/ 1000' x 150' of pipe = 7'
14" main @ 4,500 gpm = 22/ 1000' x 150' of pipe = 3'
TDH = 23 + 7 + 3 = 33 ft
Number of pumps = 3 @ 1,500 gpm @ 33 ft

The waste activated sludge from the biological process is expected to be equal to the incoming Biological Oxygen Demand. As a result, Phase II will require wasting of roughly 5,505 lbs/day

Calculate Volume of Waste Activated Sludge for Phase III

MOP 8 for Phosphorus removal estimates 1.0 sludge production factor
WAS = 1.0 x influent BOD_5
WAS = 1.0 x 5,505 = 5,505 lb/day
5,505 lbs/day / (8.34 lbs/gal x 7,500 ppm) = 88,000 gallons per day

The volumes in Phase III will increase to 11,010 lbs per day or 172,000 gallons per day. But in Phase IV if primary clarifiers and chemical phosphorus removal is included this figure should drop to 6,977 lbs per day or 112,000 gallons per day.

WAS Pumps

Discharge elev. = 749
Centerline of pump = 726.0
Static Head = 23
Phase IV Q_{was} = 250 GPM
6" riser pipe @ 250 gpm = (6.6)/ 1000' x 60' of pipe = 0.5'
6" main @ 250 gpm = 6.6/ 1000' x 500' of pipe = 3'
TDH = 23 + 0.5 + 3 = 26.5 ft
Number of pumps = 2 @ 250 gpm @ 26.5 ft

Biosolids Handling

The existing aerobic digesters are converted package contact stabilization plants. Only the annular space is currently in use. The interior clarifiers have been abandoned. The interior walls were constructed of steel and are at the end of their service life and are in need of replacement. The exterior walls of the tanks are constructed of concrete and are 78' feet in diameter.

Calculate the total digestion volume available:

$(78 / 2)^2 \times \Pi = 4{,}780$ square feet
4,780 sqft x 14 ft swd = 66900 cuft per tank
66900 cuft x 2 = 133,800 cuft of digester capacity
133,800 cuft / 4.5 cuft/ P.E. = 29,733 P.E.

The Illinois EPA requires sufficient digester capacity to provide 4.5 cuft / P.E. when operating single stage nitrification when provided in conjunction with separate thickening facilities. If separate thickening is not provided the volume should be increased by 25%. Additionally, the values are based on retaining the temperature in the digester at 60 degrees and a detention time of 27 days.

Options include

- a gravity thickener, which will increase the solids to 2.5 to 3%

OR

- membrane thickening unit which will increase the solids concentration to 3 – 3.5%.

The design includes construction of a membrane thickener unit and rehabilitation of the existing digesters.

At Design Average Flow it is estimated that the biological process will produce 5,505 lb/day at 0.75% solids or 88,000 gal/day of Waste Activated Sludge. The WAS from the RAS/WAS pump station will be tributary to the two anoxic tanks of the proposed membrane thickening complex. The anoxic tanks have capacity for 25,000 gallons each.

The aerobic digestion process will consist of eleven basins including; anoxic/ alkalinity recovery basin, membrane thickening basin, and each existing digester (#1 and #2) will be divided into four compartments (A-D). The digesters #1 & #2 will operate in parallel while the cells within the digesters (A-D) will operate in series. The process will incorporate continuous recycle from digesters #1A and #2A to the anoxic and thickening basin. Cells B – D of each digester will isolate the digesting sludge to prevent recontamination.

WAS Sludge Storage

The dimensions of anoxic / alkalinity recovery basins will be 30 x 30 x 15

Calculate volume

30 x 30 x 15 SWD x 2 tanks = 27,000 cu.ft. or 201,000 gallons

WAS lbs = 1.0 lb solids/ lb. BOD_5 influent x 5,505 lb. BOD_5 /day = 5,505 lb/day
WAS volume = (1,000,000 x 5,505 lb./day) / 8.34 lb./gal x 7,500 mg/l = 88,000 gal/day
Detention time = 200,000 gallons / 88,000 gal/day = 2.27 days

Membrane Thickening Tank

The dimensions of the membrane-thickening tank will be 30 x 30 x 15

Calculate volume

30 x 30 x 15 SWD = 13,500 cu.ft. or 100,000 gallons

Calculate water to be removed
Water to be removed = 88,000 gpd x (1- 0.75/ 3.0) gpd = 66,000
Recycle = 4.0 x WAS Flow = 352,000 gpd

Flux = 5.1 gpd/sf *(based on Kabota operational data @ 3% solids)*
Membrane Area / Plate = 8.6 sf/ unit
Calculate number of plates
66,000gpd / (5.1gpd/sf x 8.6 sf/plate) = 1,505 plates use 1,600
Air Scour = 0.53 scfm/plate x 1,600 plates = 848 scfm

Digester Performance @ 20 ^{0}C

Volatile Fraction = 75%
Volatile Solids = 5,505 lbs. TSS/ day x 75% = 4,129 lbs. VSS/ day
Fixed Solids = 5,505 lbs. TSS/ day – 4,129 lbs. VSS/ day = 1,376 lbs. FSS / day
Volatile Solids Reduction = 2,057 lbs. VSS/ day x 42.9% = 882 lbs. VSS destroyed
Volatile Solids Remaining =2,057 lbs. VSS/ day - 882 lbs. VSS = 1,175 lbs. VSS/ day
Solids Production = 686 lbs. FSS / day + 1,175 lbs. VSS/ day = 1,861 lbs. TSS/ day

First Stage Digester

Digester #1A & #2A Volume = 2 units x ¼ tank x 39^2 x Π x 15' SWD= 35,837 cuft
Anoxic Mixing Basin Volume = 2 x 30 ft by 30 ft by 15 ft deep = 27,000 cu.ft.
Membrane Thickening Basin Volume = 30 ft by 30 ft by 15 ft deep = 13,500 cu.ft.

Volume of First Stage = 35,837 + 27,000 + 13,500 = 76,338 cu.ft. or 571,006 gallons

Digester #1 Target Concentration = 3%
Volume Loading @ 3% = {11,764 cuft./day x (0.75%/3%)}= 2,941 cuft/ day
Estimated Detention time 76,338 cuft / 2,941 cuft/day = 29 days
Est. VSS Reduction 26 days @ 20 °C = 540 days- °C
Est. VSS Reduction 540 °C = 38% *(based on White Paper)*
Daily VSS Reduction in First Stage = 4,129 lbs. VSS/ day x 0.38 = 1,569 lbs. VSS/day
Water from VSS reduction = 1,569 lbs/day / (8.34 x 3.0%) = 6,270 gpd or 838 cuft/day
Revised Detention Time @ 3 % = 76,338/ (2,941 cuft/day – 838 cuft/day) = 36 days
Water to be removed to maintain 3% solids = 66,000 gpd + 6,270 gpd = 72,270 gpd

Digester #1A & #2A Air Requirements @ 20 °C

VSS Reduction in First Stage = 4,129 lbs. VSS/ day x 0.38 = 1,569 lbs. VSS/day

Process Oxygen Required
AOR = 1,569 lbs. VSS/ day x 2.0 lbs. O_2/ lb. VSS destroyed = 3,138 lbs. O_2/ day
AOR/SOR = 0.64
SOR = 3,138 lbs. O_2/ day / 0.64= 4,903 lbs. O_2/ day or 3.4 lbs. O_2/ min.
Diffuser Submergence = 13 ft
OTE = 8%
Calculate Air Flow Rate
3.4 lbs. O_2/ min. / (0.075 lbs./cuft x 23.2% O_2 x 8% OTE) = 2,442 scfm

Air Required for Mixing
35,837 cuft x 30 scfm/1,000 cuft = 1,075 scfm

Digester #1A & #2A Overflow Rate

88,000 gpd (WAS) – 72,270 gpd (permeate) = 15,730 gpd or 2,102 cuft/day

Digester #1B & 2B Air Requirement @ 20 °C

Digester Temperature = 20 °C
Detention Time = 38 days (1st Stage) + (35, 837cuft / 2,102 cuft/day) = 55 days
VSS Reduction Temp – Time = 55 days @ 20 °C = 1,100 days °C
VSS Reduction Percentage 1,100 days °C = 46%
VSS Reduction in 1st Stage = 1,569 lbs. VSS/day
VSS Reduction in 1st & 2nd Stage = 4,129 lbs. VSS/day x 46% = 1,899 lbs. VSS/day
VSS Reduction in 2nd Stage = 1,899 lbs. VSS/day – 1,569 lbs. VSS/day = 330 lbs. VSS/day

Process Oxygen Required
AOR = 330 lbs. VSS/ day x 2.0 lbs. O_2/ lb. VSS destroyed = 660 lbs. O_2/ day

AOR/SOR = 0.64
SOR = 660 lbs. O_2/ day / 0.64= 1,031 lbs. O_2/ day or 0.72 lbs. O_2/ min.
Diffuser Submergence = 13 ft
OTE = 8%
Calculate Air Flow Rate
0.72 lbs. O_2/ min. / (0.075 lbs./cuft x 23.2% O_2 x 8% OTE) = 514 scfm

Air Required for Mixing
35,837 cuft x 30 scfm/1,000 cuft = 1,075 scfm

Solids Concentration in 2nd Phase

Digester Volume = 35,837 cuft x 7.48 gal/ cuft = 268,060 gal
Solids @ 3% = 0.268 MG x 30,000 ppm x 8.34 lbs./gal = 67,053 lbs TSS
Solids Remaining = 67,053 lbs TSS – (330 lbs/day destroyed x 17 days) = 61,443 lbs
Solids Concentration in digester = 61,443 lbs TSS / (0.268 MG x 8.34 lbs./gal) = 2.75%

Digester #2 Overflow Rate

No Change – 15,730 gpd or 2,102 cuft/day

Digester #3 Air Requirement @ 20 °C

Digester Temperature = 20 °C
Detention Time = 55 days (1st & 2nd Stage) + (35,837 cuft / 2,102 cuft/day) = 72 days
VSS Reduction = 72 days @ 20 °C = 1,440 days °C
VSS Reduction Percentage = 1,440 days °C = 50% Reduction
VSS Reduction in 1st & 2nd Stage = 1,899 lbs. VSS/day
VSS Reduction in 1st, 2nd, 3rd Stage = 4,129 lbs. VSS/ day x 50% = 2,064 lbs. VSS/day
VSS Reduction in 3rd Stage = 2,064 lbs. VSS/day – 1,899 lbs. VSS/day = 165 lbs. VSS/day

Process Oxygen Required
AOR = 165 lbs. VSS/ day x 2.0 lbs. O_2/ lb. VSS destroyed = 330 lbs. O_2/ day
AOR/SOR = 0.64
SOR = 330 lbs. O_2/ day / 0.64=515 lbs. O_2/ day or 0.36 lbs. O_2/ min.
Diffuser Submergence = 13 ft
OTE = 8%
Calculate Air Flow Rate
0.36 lbs. O_2/ min. / (0.075 lbs./cuft x 23.2% O_2 x 8% OTE) = 259 scfm

Air Required for Mixing
35,837 cuft x 30 scfm/1,000 cuft = 1075 scfm

Solids Concentration in 3rd Phase

Digester Volume = 35,837 cuft x 7.48 gal/ cuft = 268,060 gal
Solids @ 2.75% = 0.268 MG x 27,500 ppm x 8.34 lbs./gal = 61,465 lbs TSS
Solids Remaining = 61,465 lbs TSS – (330 lbs/day destroyed x 17 days) = 55,855 lbs
Solids Concentration in digester = 55,855 lbs TSS / (0.268 MG x 8.34 lbs./gal) = 2.49%

Digester #3 Overflow Rate

No Change – 15,730 gpd or 2,102 cuft/day

Digester #4 Air Requirement @ 20 °C

Digester Temperature = 20 °C
Detention Time = 70 days (Stages 1-3) + (35,837 cuft / 2,102 cuft/ day) = 87 days
VSS Reduction Percentage = 87 days @ 20 °C = 1,740 days °C
VSS Reduction Percentage 1,740 days °C or 50% Reduction
VSS Reduction in 1st, 2nd, 3rd Stage = 2,064 lbs. VSS/day
VSS Reduction in Stage 1-4 = 4,129 lbs. VSS/ day x 50% = 2,064 lbs. VSS/day
VSS Reduction in 4th Stage = 2,064 lbs. VSS/day – 2,064 lbs. VSS/day = 0 lbs. VSS/day

Process Oxygen Required

AOR = 0 lbs. VSS/ day x 2.0 lbs. O_2/ lb. VSS destroyed = 0 lbs. O_2/ day
AOR/SOR = 0.64
SOR = 0 lbs. O_2/ day / 0.64= 0 lbs. O_2/ day or lbs. O_2/ min.
Diffuser Submergence = 13 ft
OTE = 8%
Calculate Air Flow Rate
0.00 lbs. O_2/ min. / (0.075 lbs./cuft x 23.2% O_2 x 8% OTE) = 0 scfm

Air Required for Mixing

35,837 cuft x 30 scfm/1,000 cuft = 1075 scfm

Solids Concentration in 4th Phase

Digester Volume = 35,837 cuft x 7.48 gal/ cuft = 268,060 gal
Solids @ 2.49% = 0.268 MG x 24,900 ppm x 8.34 lbs./gal = 55,855 lbs TSS
Solids Remaining = 55,855 lbs TSS – (0 lbs/day destroyed x 17 days) = 55,855 lbs
Solids Concentration in digester = 55,855 lbs TSS / (0.268 MG x 8.34 lbs./gal) = 2.49%

6.15 PHASE III DESIGN SUMMARY

Influent Flows:

Design Average Flow	=	4.5	MGD
Design Maximum Flow	=	9.0	MGD
Peaking Factor	=	2.3	
Peak Hourly Flow Rate	=	10.35	MGD

Design Loading:

Average BOD_5 is 202 mg/l, but use 220 mg/l for design with septage receiving

Design BOD_5 = 3.0 MGD x 220 mg/l x 8.34 lb = 8,256 lb/day

Average TSS in 2002 was 212 mg/l, but use 260 mg/l for design with septage receiving

Design TSS = 3.0 MGD x 260 mg/l x 8.34 lb = 9,757 lb/day

NH3-N = 3.0 MGD x 35 mg/l x 8.34 lb/gal = 1,317 lb / day

Phosphorus – 3.0 MGD x 13 mg/l x 8.34 lb/gal = 375 lb / day

Design Effluent Parameters:

BOD_5, 30-day avg.	=	20	mg / l
TSS, 30-day avg.	=	25	mg / l
NH_3-N, 30-day avg. (Apr - Oct)	=	1.5	mg / l
NH_3-N, 30-day avg. (Nov - Mar)	=	3.0	mg / l
pH, continuous range	=	6 - 9	

Process Description:

The Wastewater Treatment Plant process shall include preliminary screening, raw sewage pumping, extended aeration, clarification, U.V. disinfection, aerobic digestion and sludge dewatering. The following is a listing of process components and their associated sizes.

Headworks:

Number of channels	3
Peak Hourly Flow, MGD	10.35
Capacity existing screens, MGD	9.6
Capacity Phase II screen, MGD	9.6
Capacity by-pass channel, MGD	9.6
Gravity Influent	30"
Opening Space	¼"

Raw Sewage Pump Station:	
Peak Hourly Flow, gpm	7,200
Number of existing units	2
Type	Wemco Hidrostal
Existing Pump Range (Each), gpm	1,625-3,250
Number of proposed units	2
Type	Wemco Hidrostal
Phase II Pump Range (Each), gpm	1,625 -3250
Force Main Dia.	18"
Maximum Capacity of P.S.	9,750 gpmExtended Nitrification :
Design	Oxidation Ditch
Design Average Flow	4.5 MGD
Peak Hourly Flow	10.35 MGD
BOD_5	220 mg/l
BOD_5	8,256 lbs/day
TSS	260 mg/l
TSS	9,757 lbs/day
NH_3-N	35 mg/l
NH_3-N	1,317 lbs/day
Number of Oxidation Ditches	2
Number of channels	3
Side Water Depth	14 feet
Channel Width Inside	20 feet
Channel Width Middle	20 feet
Channel Width Outside	20 feet
Detention Time	25.1 hours
Total Volume	4,715,018 gal
MLSS conc.	3,000 mg/l
Solid Production	8,256 lbs/day
Solids Inventory	117,970 lbs
Sludge Age	14.3 days
F/M Ratio	0.07
Oxygen Required	723 lbs/hr
Oxygen Supplied	1,800 lbs/hr
MLSS Diversion Structure:	
Number of Units	1
Design Average Flow	7.3 MGD (DAF + RAS)
Peak Hourly Flow	13.15 MGD (PHF + RAS)
Influent MLSS	24"
Effluent MlSS	24"

Final Clarifier:	
Number of Units	3
Design	Hydraulic Differential
Clarifier Diameter	85ft
Design Average Flow (each)	1.5 MGD
Peak Hourly Flow (each)	3.45 MGD
Surface Loading Rate	607 gal/ day/ sq.ft.
Solids Loading Rate	15.8 lbs/ day/ sq.ft.
Weir Loading Rate	13,727 gal/ day/ ft.
U.V. Disinfection:	
Number of Channels	2
Design	Medium Pressure
Design Average Flow	4.5 MGD
Peak Hourly Flow	10.35 MGD
RAS WAS Pump Station:	
Design	Pre-Rotation
Number of Pumps	6
	4 - RAS
	2 - WAS
RAS Pump Capacity	1,500 gpm @ 33 ft (Each)
WAS Pump Capacity	250 gpm @ 26.5 ft (Each)
RAS Force Main Dia.	14"
WAS Force Main Dia.	6"
Biosolids Stabilization:	
Design	Aerobic Digestion
Waste Activated Sludge:	
WAS Production @ 0.75%	131,990 gpd
Continuous Sludge Thickening:	
Water from thickening WAS to 3%	98,993 gpd
Water from Phase 1 VSS Destruction	6,270 gpd
Total Water Removed	105,263 gpd
Membrane Flux Rate	5.1 gpd/ sq.ft.
Area per Plate	8.6 sq.ft
Number of Plates required	1,600

Phase 1 Aerobic Digestion:	
Volume of Anoxic Tank	27,000 cu.ft.
Volume of Thickener	13,500 cu.ft.
Volume of Digester #1A & #2	35,837 cu.ft.
Total Volume	76,338 cu.ft.
Detention Time @ 3%	29 days
VSS Reduction @ 20 °C	38%
Aeration Required @ 35 °C	3,000 scfm
Phase 2 Aerobic Digestion:	
Volume of Digester #2	27000 cu.ft.
Volume from Dig #1	2,102 cu.ft./day
Detention Time	17 days
VSS Reduction @ 20 °C	46%
Aeration Required @ 20 °C	1,075 scfm
Phase 3 Aerobic Digestion:	
Volume of Digester #3	2,700 cu.ft.
Volume from Dig #2	2,102 cu.ft./day
Detention Time	17 days
VSS Reduction @ 20 °C	50 %
Aeration Required @ 20 °C	1,075 scfm
Phase 4 Aerobic Digestion – Sludge Storage	
Volume of Digester #4	2,700 cu.ft.
Volume from Dig #3	2,102 cu.ft./day
Detention Time	17 days
VSS Reduction @ 20 °C	50%
Aeration Required @ 20 °C	1,075 scfm
Sludge Dewatering:	
Number of Pumps	2
Capacity	120 GPM
Number of BFP	2
Capacity	120 GPM @ 2.5%
Hours of Dewatering	7.6 hrs/ week/ unit

FINAL PHASE III COST ESTIMATE

Item No.	Description	Quantity	Unit	Unit Price	July-03
	SUMMARY				
	GENERAL CONDITIONS				$1,059,200.00
	SITE WORK				$944,794.00
	RAW SEWAGE LIFT STATION				$63,000.00
	HEADWORKS				$189,800.00
	OXIDATION DITCH				$2,176,800.00
	RAS/WAS PS & DIV STRUCTURE				$137,439.50
	CLARIFIERS				$759,540.00
	ULTRAVIOLET				$287,[illegible]
	SLUDGE DEWATERING IMPROVEMENTS				[illegible]
	EAST SLUDGE STORAGE BARN				[illegible]
	WEST SLUDGE STORAGE BARN				[illegible]
	SUB-TOTAL CONSTRUCTION				[illegible]
	CONTINGENCY 10%				[illegible]
	CONSTRUCTION TOTAL				[illegible]
	DESIGN ENGINEERING				[illegible]
	CONSTRUCTION ENGINEERING				[illegible]
	PROJECT TOTAL				[illegible]
	GENERAL CONDITIONS				
	Dumpsters		[illegible]	$400.00	[illegible]
	Job Trailer		[illegible]	$800.00	[illegible]
	Eng Trailer		[illegible]	$800.00	[illegible]
	Supervision		[illegible]	$12,000.00	[illegible]
	Surveying		[illegible]	[illegible]	[illegible]
	Rec'd Drawing		[illegible]	[illegible]	[illegible]
	Allowances				
	Bonds & Insurance		Each	$80,000.00	[illegible]
	Overhead & Profit		Each	$800,000.00	[illegible]
	TOTAL GENERAL CONDITIONS				$1,059,200.00

Item No.	Description	Quantity	Unit	Unit Price	Total
SITEWORK					
	Topsoil Stripping & Stockpiling	1000	Cu. Yd.	$1.50	$1,500.00
	Topsoil Re-spread	1000	Cu. Yd.	$2.50	$2,500.00
	Sidewalk	4000	Sq. Ft.	$9.00	$36,000.00
	Retaining Wall	300	Sq. Ft.	$20.00	$6,000.00
	Concrete Steps	50	Each	$25.00	$1,250.00
	Bituminous Surface 1 1/2"	300	Ton	$100.00	$30,000.00
	Bituminous Base 2 1/2"	500	Ton	$100.00	$50,000.00
	Drainage Tile	1800	Lin. Ft.	$2.00	$3,600.00
	Curb & Gutter	7000	Sq. Yd.	$9.00	$63,000.00
	Geotextile Fabric	7000	Sq. Yd.	$1.00	$7,000.00
	Pavement Removal	2000	Sq. Yd.	$3.00	$6,000.00
	Sidewalk Removal	100	Sq. Yd.	$4.00	$400.00
	Seeding	[illegible]	Acre	$[illegible]	$[illegible]
	Fence	[illegible]	Lin. Ft.	$[illegible]	$[illegible]
	[illegible]	[illegible]	Cu. Yd.	$12.00	$[illegible]
	[illegible]	[illegible]	Sq. Yd.	$[illegible]	$[illegible]
	Mailbox	[illegible]	Each	$[illegible]	$[illegible]
	[illegible]	[illegible]	Lin. Ft.	$[illegible]	$[illegible]
	[illegible]	[illegible]	Sq. Yd.	$[illegible]	$[illegible]
	[illegible]	[illegible]	Sq. Yd.	$[illegible]	$[illegible]
	[illegible] Curve and Replace	[illegible]	Lin. Ft.	$[illegible]	$[illegible]
	[illegible]	[illegible]	[illegible]	$[illegible]	$[illegible]
	[illegible] Curb & Gutter	[illegible]	Lin. Ft.	$[illegible]	$[illegible]
	[illegible] Post Sign	[illegible]	Each	$[illegible]	$[illegible]
	[illegible]	[illegible]	Each	$[illegible]	$[illegible]
	[illegible] Curb & Gutter	[illegible]	Lin. Ft.	$[illegible]	$[illegible]
	[illegible] Valve Cover Adjustment	[illegible]	Each	$[illegible]	$[illegible]
	[illegible]

Item No.	Description	Quantity	Unit	Unit Price	Amount
HEADWORKS					
	Architectural/General				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Item No.	Description	Quantity	Unit	Unit Price	Total
OXIDATION DITCH					
	Excavation	1900	Cu. Yds.	$15.00	$28,500.00
	Demolish 12" MLSS	40	Lin. Ft.	$10.00	$400.00
	Dewatering Manhole	4	Each	$1,000.00	$4,000.00
	Demolish for MLSS	10	Each	$100.00	$1,000.00
	Concrete				
	Diversion Chamber	28	Cu. Yds.	$500.00	$14,000.00
	Floor & Wall	17	Cu. Yds.	$500.00	$8,500.00
	Mat	292	Cu. Yds.	$500.00	$146,000.00
	Inner Walls	200	Cu. Yds.	$500.00	$100,000.00
	Piers	110	Cu. Yds.	$500.00	$55,000.00
	Walls	150	Cu. Yds.	$500.00	$75,000.00
	Walkways	80	Cu. Yds.	$500.00	$40,000.00
	Stairs	16	Cu. Yds.	$500.00	$8,000.00
	Expansion Joints	[illegible]	Lin. Ft.	[illegible]	[illegible]
	Quadrant Installation	[illegible]	Each	[illegible]	[illegible]
	Rebar	[illegible]	Lbs.	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]

Item No.	Description	Quantity	Unit	Unit Price	July-03
RAS/WAS PS & DIV STRUCTURE					
	Structural				
	[illegible]	880	SqFt	[illegible]	[illegible]
	[illegible]	1800	SqFt	[illegible]	[illegible]
	[illegible]				[illegible]
	[illegible]		Each	[illegible]	[illegible]
	[illegible]	120	Linear Ft	[illegible]	[illegible]
	[illegible]	14	Each	[illegible]	[illegible]
	[illegible]	10	Each	[illegible]	[illegible]
	[illegible]	10	Each	[illegible]	[illegible]
	[illegible] Release Valve	10	Each	[illegible]	[illegible]
	[illegible]	40	Linear Ft	[illegible]	[illegible]
	[illegible]	[illegible]	Lump Sum

Item No.	Description	Quantity	Unit	Unit Price	Total Price
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Item No.	Description	Quantity	Unit	Unit Price	July 05
	EAST SEDIMENT STORAGE BARN				
	Excavation	1250	Cu. Yd.	[illegible]	[illegible]
	Structural Concrete				
	Concrete Walls	[illegible]	Cu. Yd.	[illegible]	[illegible]
	Concrete Slab	470	Cu. Yd.	[illegible]	[illegible]
	Concrete Pit	140	Cu. Yd.	[illegible]	[illegible]
	Vapor Barrier	10000	Sq. Ft.	[illegible]	[illegible]
	Metal Building	1	Lump Sum	[illegible]	[illegible]
	Garage Doors	4	Each	[illegible]	[illegible]
	Entrance Doors	10	Each	[illegible]	[illegible]
	Air Handling Unit	1	Lump Sum	[illegible]	[illegible]
	[illegible]	2	Each	[illegible]	[illegible]
	[illegible]	1	Each	[illegible]	[illegible]
	[illegible]	1	Each	[illegible]	[illegible]
	[illegible]	12	Each	[illegible]	[illegible]
	[illegible]	1	Each	[illegible]	[illegible]
	[illegible]	1	Lump Sum	[illegible]	[illegible]
	[illegible]	1	Lump Sum	[illegible]	[illegible]
	TOTAL EAST BARN				
	WEST SEDIMENT STORAGE BARN				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]