RECOMMENDED BNR/ENR DESIGN CRITERIA

BNR TYPICAL DESIGN CRITERIA:

Usually two-stage reactor (anoxic/aerobic) would be sufficient to achieve BNR level of 8 mg/l TN.

Typical Design Criteria for Two-Stage BNR:

Parameter	Recommended
MLSS (mg/l)	3000-4000
Total HRT (hr)	12-16
Anoxic	2-4
Aerobic	8-12
MCRT (d)	15-40
F/M (g BOD/g MLVSS/d)	0.05-0.2
RAS (%Q)	50-100
Internal Recycle (%Q)	100-400
Anoxic Mix Power (hp/MG)	40-70

Typical Design Criteria For SBR BNR System:

Parameter	Recommended
BOD Load (Lbs/d/ft^3)	0.005-0.015
Cycle time (hr):	
Fill	1-3
Settle	0.75-1
Draw	0.5-1.5
MLSS (mg/l)	3000-5000
MLVSS (mg/l)	---
HRT (hr)	~6 per cycle per reactor
MCRT (d)	20-40
FM (g BOD/g MLVSS/d)	0.05-0.2

Additional Criteria:
A flow equalization basin with a storage capacity adequately for two decants should be provided for flows of 2.0 mgd or less, or when the total SBR system less than four (4) units.

BIOLAC Wave Oxidation Reactor BNR System:

- Nominal Hydraulic Detention Time = 36 hours
- Side-Water-Depth = 8 feet
- Free Board = 2 feet
- Aeration system and automatic control air valves shall be capable of achieving BNR.
- The reactors are earth structure lined with high quality of liners.

Typical Design Parameters for BNR Orbal/Oxidation Ditch:

Flow (mgd)	**BOD Load (Lbs/d/ft^3)**	**MLSS (mg/l)**	**MCRT (d)**	**HRT (hr)**	**Side-Water Depth (ft)**
<0.2	0.012	4000-5000	31-38	24	8-13
0.2 to 0.499	0.015	4000-5000	26-32	20	8-13
0.5 to 0.999	0.015-0.018	4000-5000	20-32	16.6-20	8-13
1.0 to 2.0	0.018	4000-5000	21-27	16.6	8-13
>2.0	0.02	5000-6000	24-29	15	8-13

ENR TYPICAL DESIGN CRITERIA:

To achieve ENR, in general four-stage reactor, or two-stage with denitrification filter would be needed.

Four-Stage Badenpho Process for ENR:

- The proposed four-stage Bardenpho process is intended to meet 3 mg/l TN. However, facilities for supplemental carbon and/or a conventional filtration process for polishing may be required to meet the nutrient goals of 3 mg/l TN and 0.3 mg/l TP.
- The width to length ratio of the reactor: 1:5
- Side-water-depth = 18 feet
- Free Board = 2 feet

Parameter	Recommended
MLSS (mg/l)	3000-5000
Total HRT (hr)	16-23 (~23 is used when high BOD with no primary)
1st Anoxic	2-4
Aerobic	8-12
2nd Anoxic	2-5
Re-aeration	0.5-1
MCRT (d)	10-40
F/M (g BOD/g MLVSS/d)	0.1-0.2
RAS (%Q)	100
Internal Recycle (%Q)	400-600
Anoxic Mix Power (hp/MG)	40-70

Carrousel Process for ENR:

- Nominal Hydraulic Detention Time = 21 hours
  1st Anoxic Zone = 3 hours
  Aerobic Zone = 15.5 hours
  2nd Anoxic Zone = 2 hours
  Re-aeration Zone = 0.5 hour
- Reactors are reinforced concrete structures.
- Side-Water-Depth = 14 feet
- MLSS = 4,000 mg/l

Secondary Sedimentation Tanks for BNR/ENR Process

- Hydraulic Surface Overflow Rate = 400 gpd/sq. ft.
- Solids Loading Rate = 25 pounds/sq. ft. /day
- Influent MLSS = 4,000 mg/l
- Side-Water-Depth = 12 feet (minimum 9 feet)

Facilities for Supplemental Carbon Source

- BNR Effluent: TN = 8 mg/l; Dissolved Oxygen = 2.0 mg/l
- Methanol Dosage = 13 mg/l
- Capacity of Feed Facilities = 3 times of Average Daily Demands
- Methanol Storage Capacity = 30 days
- Methanol Commercial Grade (99.90%) = 6.59 pounds/gallon
- Dilution of methanol with water at 5:1 liquid ratio using an eductor when transferring from shipping container or shipping tank to storage tank.

Conventional Filters

- The conventional filtration process is designed for polishing purpose.
- Filter Media Depth = 4 feet
- Hydraulic Loading Rate: 2.5 gpm/sq. ft. at average daily flow
- Hydraulic Loading Rate: 4.0 gpm/ sq. ft. at sustained daily peak
- A conventional filtration process following the four-stage Bardenpho process may be required to achieve the level of 3 mg/l of TN and 0.3 mg/l of TP.

Denitrification Filters

- The filter depth = 6 feet media depth plus 1.5 feet support gravel depth.
- The maximum hydraulic loading rate = 4 gpm/sq. ft

Facilities for Chemical Additions for Phosphate Removal

See Chapter 12 of the State Design Guideline

Membrane Bioreactor (MBR)

Membrane Bioreactor (MBR) is a combination of suspended-growth activated sludge biological treatment and membrane filtration equipment performing the critical solid/liquid separation function that is traditionally accomplished using secondary clarifiers. To achieve ENR level of treatment, MBR needs to include a high performing nitrogen removal system such as Bardnepho, Johannesburg process, etc. MBR operates at high MLSS concentration almost double or triple the conventional activated sludge system, thereby allowing a smaller bioreactor to achieve the same level of treatment as the conventional system.

Typical MBR Design Parameters:

Parameter	Recommended
BOD Loading (Lbs/1,000 ft^3/day)	30-60
MLSS (mg/l)	8,000-15,000
F/M (g BOD/g MLVSS/day)	0.05-0.2
MCRT (day)	12-20
HRT (Hour)	6-15
Flux (gpd/ft^2)	8-15 (Temperature-Corrected at 12º C)
DO (mg/l)	Anoxic 0-.5 Aerobic 1.5-3 Membrane 2-6
Pore Size (µm)	0.1-0.4
RAS (Q)	3-6
Energy Consumption (KWh/1,000 gal)	0.1
Membrane Replacement	Every 3 to 5 years (Flux rate gradually declines overtime)
Pretreatment Requirements	1. Flow Equalization for peaking factor over 2-2.5 2. Fine Screening: 1-3 mm (0.04-0.12 in)

Reference: Metcalf & Eddie
Water Environment Federation (WEF)
Siemens
Envirep

Site Visit and Current Plant Performance Evaluation:

Before initiating the eligibility and technical discussions, MDE engineer staff must visit the treatment plant, discuss the plant performance with plant operator, and review the historical data of the plant. This is a critical step to:

- Better understand the existing process.
- Get initial ideas of possible improvements that would achieve ENR goals
- Find any feature or factor specific to the plant or its wastewater characteristics that may have an impact on the ENR upgrade.

BNR/ENR Eligibility Determination

The Department will make its best efforts to reach a resolution on eligibility determination to the satisfaction of all involved parties, while maintaining consistency with the existing laws, regulations and departmental policies. Based on the above, for a project involving both BNR and ENR upgrades, the following items would be eligible for BNR/ENR grants participation:

Process	BNR	ENR
Headwork/Grit Removal	50% Eligible only if these components are not included in the existing facility.	Not eligible
Primary Clarifier	Not eligible	Not eligible
Secondary Clarifier	100%	Not eligible
Sludge	50% if the process is changed to activated sludge due to the BNR project	Up to 20% subject to justification of increased volume of sludge due to P removal.
Phosphorus Removal	Not eligible	100%
Nitrogen Removal	Estimated cost to achieve 8 mg/l TN at the current rated capacity. Usually it is ~75% of the BNR/ENR reactor.	Estimated cost to achieve 3 mg/l TN from 8, at rated capacity approved on or before April 2003. Usually it is ~25% of BNR/ENR reactor.
Conventional or Denitrification filter	Not eligible	100% eligible
Disinfection/Post Aeration	Not eligible	Not eligible
Common items such as site work, yard piping, engineering services, etc.	Prorated based on Eligible/Total	Prorated based on Eligible/Total

If only ENR upgrade takes place, the above identified ENR items can be funded at 100%

Flow Proration (Expansion Adjustment):

BNR participation is limited to the current design capacity. ENR participation is limited to the approved design capacity as listed in the Maryland's Chesapeake Bay Tributary Strategy Statewide Implementation Plan (August 2, 2007). Initially, use the following to prorate for expansion:

% Eligible = (Allowable Capacity/Expanded Capacity)^0.62

ENR Eligibility Determination
(Upgrading from Existing BNR to ENR Process)

The Department will make its best efforts to reach a resolution on eligibility determination to the satisfaction of all involved parties, while maintaining consistency with the existing laws, regulations and departmental policies. Based on the above, for a project involving ENR upgrades from existing BNR process, the following items would be eligible for ENR grants participation:

Process	ENR
Headwork Grit Removal Equalization	Not eligible
Primary Clarifier	Not eligible
Secondary Clarifier	Not eligible
Sludge	Up to 20% subject to justification of increased volume of sludge due to P removal.
Phosphorus Removal	100%
Biological Reactor Modifications	100% of additional nitrification and denitrification improvements needed to achieve 3 mg/l annual average TN from 8 mg/l annual average.
Conventional or Denitrification filter	100% eligible
Membrane Bioreactor (MBR)	100% eligible – If determined to be more cost effective than conventional ENR process at approved design capacity, or site restricts conventional ENR upgrade at approved design capacity.
Disinfection/Post Aeration	Not eligible
Common items such as site work, yard piping, engineering services, etc.	Prorated based on Eligible/Total

Flow Proration (Expansion Adjustment):

ENR participation is limited to the approved design capacity as listed in the Maryland's Chesapeake Bay Tributary Strategy Statewide Implementation Plan (August 2, 2007). Initially, use the following to prorate for expansion:

% Eligible = (Allowable Capacity/Expanded Capacity)^0.62

Cost Effectiveness of the Upgrade:

To be allowed for funding under the BRF law (§9-1605.2(6)(ii)1), a grantee must demonstrate that the selected ENR process is cost-effective at the approved design capacity using present worth analysis or other equivalent method.