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WTS5

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(FORMERLY WTS 5-8)

# GUIDANCE DOCUMENT FOR DESIGN OF WASTEWATER TREATMENT PONDS

Information from the items listed below shall be presented as a minimum in an engineering plans submittal for a wastewater treatment pond. The Bureau of Water Pollution Control reserves the right to require further information as needed. Any applicant needs to confer with the Permits Branch to determine the discharge permit requirements.

The primary goals of a wastewater treatment pond design shall focus on simplicity and flexibility of operation, and protection of the environment and public health.

The Nevada Division of Water Resources (775) 684-2800 **must** be notified of the proposed pond to offer their review. Any pond with a berm height greater than 20 feet or containing more than 20 Acre Feet of water will require a dam permit. (NRS 535.010 2a -2b)

**KEY WORDS:**

| | |
|---|---|
| NDEP: | Nevada Division of Environmental Protection |
| ASTM: | American Society for Testing and Materials |
| WTS: | Wastewater Technical Services (Document) |
| $BOD_5$: | Biochemical Oxygen Demand exerted by waste over 5 days |
| TSS: | Total Suspended Solids |
| GEOMEMBRANE: | Synthetic liner comprised of polymer resins, plasticizers, and various additives. |
| FACULTATIVE POND: (OXIDATION) (STABILIZATION) | Treatment pond, around 4 to 10 feet deep, with aerobic layer overlying an anaerobic layer. Principal oxygenation is via algae photosynthesis and surface (non-mechanical) reaeration. |
| PARTIAL MIX POND: | Treatment pond, generally 6 to 20 feet deep, with mechanical or diffused aeration to meet BOD. |
| COMPLETE MIX POND: | Treatment pond, generally 6 to 20 feet deep, with supplied aeration to meet BOD and mixing requirements. |

## I. SITE CHARACTERIZATION DATA REQUIRED

A. A topographical map of the site with 2-foot contour intervals. On this map, please provide identification of the following features within a one mile of the proposed pond:

1) Creeks and Rivers;
2) Dwelling units;
3) Earthquake fault lines;
4) Drinking water wells;
5) Wellhead Protection Zone Area delineation (if available)

B. The depth to the groundwater table shall be provided along with a description of the underlying strata (confining layers, soil types, etc.). The groundwater gradient and direction, depth to groundwater, and groundwater quality shall be provided.

If this information is not available from available data, the applicant will have to drill borings to the water table and have the strata categorized by a licensed professional with expertise in this discipline

C. Drainage map of the site which depicts the 100 year flood plain.

D. Direction of the prevailing winds at the site.

## II. DESIGN REPORT ITEMS REQUIREMENTS

A. Influent wastewater characteristics (BOD, TSS, pH, TKN, alkalinity, flow). List any industrial wastewater sources and non-domestic sources. Include an estimate of the maximum monthly flow rate to the ponds (factoring in potential I/I, population dynamics, etc.).

B. A water balance demonstrating storage capacity of the pond within the required freeboard. This balance shall incorporate local figures for pond evaporation, direct precipitation, and pond seepage (see page 8 and 9 for seepage limits).

C. Design rationale for the selected treatment pond system. Acceptable design parameters for three common pond types are provided in the tables on the following two pages. The items presented in the tables are from several design references that have proven acceptable in the design of ponds in Nevada. The engineer may present alternatives to these for consideration.

Treatment efficiency is enhanced the more ponds are placed in series. A <u>minimum</u> of two ponds should be placed in series to enhance treatment and allow for taking a pond off-line for servicing. Baffling in ponds should also be evaluated.

| PARAMETER | FACULTATIVE PONDS | PARTIAL MIX (AERATED-FACULTATIVE) PONDS | COMPLETE MIX PONDS |
|---|---|---|---|
| AREAL LOADING: LBS $BOD_5$/ACRE-DAY | 35 for elevation over 3000 feet.<br><br>50 for elevation below 3000 feet | NOT APPLICABLE | NOT APPLICABLE |
| BOD TREATMENT MODELS<br><br>KINETIC MODELS FROM: <u>NATURAL SYSTEM FOR WASTE MANAGEMENT AND TREATMENT</u> 1995 Crites, Reed, & Middlebrooks<br><br>NOTE 1: OTHER MODELS MAY BE ACCEPTABLE<br><br>NOTE 2: MANY SYSTEMS WILL BE COMBO OF DIFFERENT TYPES, THUS USE EQUATIONS TO DETERMINE INPUT TO NEXT POND (CELL). | **Plug Flow Model**<br>(More fully met when ponds are in series)<br><br>$Ce/Co = e^{-Kpt}$<br><br>Ce=effluent $BOD_5$ (mg/l)<br>Co=influent $BOD_5$ (mg/l)<br>Kp=reaction rate, $day^{-1}$<br>t = hydraulic detention time (days)<br><br>Variation of Kp with loading<br><u>Loading(lbs/ac-d) Kp(20°C)</u><br>19.6 0.045<br>40.15 0.071<br>59.8 0.083<br>80.3 0.096<br><br>Variation of Kp with Temp.<br><br>$Kp(temp) = Kp20°C(1.09)^{T-20}$<br><br>T= temperature in Celsius | **Partial Mix Model**<br>(This is for equal sized ponds in series. See references for solution to un-equal sized ponds in series)<br><br>$Cn/Co = \left[\frac{1}{[1+(K_{pm}t/n)]^n}\right]$<br><br>Kpm = Partial Mix reaction rate (0.276 $day^{-1}$ at $20^0C$.)<br>t = detention time in each pond (days)<br><br>n = number of **equal** sized ponds in series<br><br>Variation of Kpm w\ Temp.<br><br>$Kpm(temp) = KpM20°C(1.036)^{T-20}$<br><br>T= temperature in Celsius<br><br>NOTE: Use Kpm20°C(0.276 $d^{-1}$) as a cold temp design maximum. | **Complete Mix Model:**<br><br>$Cn/Co = \left[\frac{1}{[1+(K_{cm}t/n)]^n}\right]$<br><br>Kcm = Complete Mix reaction rate of 2.5 $day^{-1}$ at $20^0C$.<br><br>t = detention time in each pond (days)<br><br>n = number of **equal** sized ponds in series<br><br>Variation of Kcm w\ Temp.<br><br>$Kcm(temp) = Kcm20°C(1.085)^{T-20}$<br>T= temperature in Celsius<br><br>NOTE: Use Kcm20°C (2.5 $day^{-1}$)as a cold temp design maximum. |

| PARAMETER | FACULTATIVE PONDS | PARTIAL MIX (AERATED-FACULTATIVE) PONDS | COMPLETE MIX PONDS |
|---|---|---|---|
| OXYGEN REQUIREMENTS FOR TREATMENT | Not Applicable | 1.5 pounds Oxygen per pound of $BOD_5$. (Also include needs for COD and anaerobic decomposition of solids) | 1.5 pounds Oxygen per pound of $BOD_5$ |
| MIXING DEMANDS | NOT APPICABLE | NOT APPLICABLE | Aerator/Mixer Power requirement necessary to keep solids suspended.<br><br>Consult the manufacturers charts and tables. (Ranges often between 15 to 30 HP per million gallons) |
| SETTLING CELLS | Optional | Recommended | Required |
| NITROGEN REMOVAL (if applicable) | Estimate based upon acceptable design models[1] | Estimate based upon acceptable design models[1] | Estimate based upon acceptable design models[1] |
| OPERATING DEPTH RANGES (FEET) | 6 TO 10 | 6 TO 20 | 6 TO 20 |

REFERENCE LIST:

1. Natural Systems for Waste Management and Treatment (1995) Reed, S., Middlebrooks, J., Crites, R.
2. Municipal Wastewater Stabilization Ponds (1983) US EPA - 625/1-83-015
3. Wastewater Engineering Treatment, Disposal, and Reuse (1991) Tchobanoglous, G., Burton, F.
4. Upgrading Lagoons (1973) US EPA Technology Transfer Seminar
5. Lagoon Information Source Book (1979) Middlebrooks, Jones, Reynolds,Torpy, Bishop

NOTE: The above tables are provided only for guidance to the design engineer. It is not a requirement that only these models be used in the pond(s) design. NDEP may accept other design alternatives to those presented above.

## II. Design Report Items Requirements Continued:

D. The design should provide enough volume for sludge storage.

E. Provisions of future expansion should be evaluated in the design.

F. Provisions for chemical and nutrient addition should be developed. Dosing methods for these items should be established.

G. Effluent disinfection (if required) plans need to be presented. (This may require pH adjustment).

H. The specification for the aeration (if applicable) equipment must be presented. This should include the calculations for determining the required horsepower to meet the oxygen and mixing requirements in the ponds. Special consideration should be given to:

1. Providing some method for varying the submergence of the rotors on fixed mounted units.

2. If submerged bubble diffusers are used, the design must provide for ease of maintenance of the diffusers. A back-up blower must be on-line.

3. Proper placement of surface aerators to enhance mixing and limit short-circuiting. The anchoring system should allow for easy movement of the aerators.

4. Consideration should be given to the need for back-up power.

I. Intrapond recirculation and/or interpond recirculation should be evaluated **if** necessary given the pond organic loadings. If a recirculation method is proposed, there should be redundancy in the pumping system.

J. Pond Effluent Disposal Plans need to be presented in detail. Some acceptable disposal options include:

Rapid infiltration basins (RIB's)
Surface discharge, requiring federal permit (NPDES)
Land application

K. Monitoring wells(if required) plan. Please use the guidance document on monitoring wells WTS-4.

L. The treatment and disposal facility shall be fenced and appropriate permanent signs shall be provided along the fence to designate the nature of the facility and warn against trespass. Signs shall be posted on each side of the fenced facility. Posting shall be every 500 feet or less;

M. Controls for algae and other floatable solids should be evaluated.

## III. TREATMENT BASIN CONSTRUCTION DETAILS

A. Interior slopes shall be 3:1 (horizontal to vertical).

B. Pond bottom shall be level

C. Top of dike shall be a minimum of 10 feet wide (wide enough for vehicle travel) and be covered with gravel.

D. Pond geometry should preferably be either square or rectangular. If rectangular, the side lengths shall be no longer than 3 times the side width. Islands, peninsulas or coves shall not be permitted. There shall be no isolated areas where circulation of flow might be impeded. The corners of the ponds should be rounded to limit solids accumulation.

E. A freeboard of 3 feet is required for all large ponds (greater than 1 acre) unless an engineering wave analysis is provided indicating that pond overtopping is not a concern in high wind conditions with a lower 2 feet freeboard and the Division of Water Resources approves of the reduced freeboard. A freeboard of 2 feet may be acceptable for smaller ponds (1 acre or less).

F. The pond must contain, without release, the 24-hour storm event with a 25-year recurrence interval

The pond must be designed to withstand, without release (i.e., from structural damage of the outside berms, etc.), the run-off generated from the 24-hour storm event with a 100 year recurrence interval.

The designer shall attempt to **not** locate any ponds within the 100 year flood plain (NAC 445A.285). If located in this plain, the ponds must be protected from this flood.

G. Plans for protection from floodwater must be presented. Some effective options for protection include diversion of run-on away from the pond exterior berms and gravel covering of the pond exterior.

H. A staff gage or other water depth measurement device must be present in each pond. Length intervals shall be demarked in units of tenths of a foot or in inches.

## IV. POND HYDRAULICS

A. Influent and effluent flow measuring and recording devices may be required for all facilities. Some examples of acceptable measuring devices include Parshall and Palmer Bowlus flumes. Screening units (if required) shall be located so as not to interfere with the accurate recording of flow rate.

B. A location for collecting an effluent sample shall be given.

C. Multiple inlet locations are recommended. However, if a single inlet is chosen, it should be located the furthest distance possible from the pond outlet(s) to minimize short-circuiting effect. Additionally, it is recommended that the inlet outfall(s) be baffled, equipped with a diffuser or some other mechanism to disperse the influent sewage into the pond.

D. The inlet(s) and outlet(s) axis should be aligned to reduce short-circuiting, with consideration to wind direction.

E. Inlet piping must be above the pond bottom liner and adequate erosion measures at the inlet and outletpoints must be presented (examples: include riprap beneath the inlet piping, concrete splash pads, or wear sheets for geomembrane liners).

F. Outlet structures should be designed for flexibility in operations. Provisions should be made for adjusting pond depth as necessary. Maximum withdrawal elevation should be at least one foot below the operating level of the pond to avoid floatable solids carryover. Minimum withdrawal elevation should be at least one foot off the bottom or such a depth to prevent scour and settled solids carryover.

G. The inlet and outlet structure designs should incorporate valves or gates to permit individual pond level controls and redistribution of loading. Sampling locations should be set.

H. Transfer piping should be in place to allow for pond bypassing and operation in series or parallel modes.

I. Seepage collars must be installed where piping penetrates the pond dikes.

## V. LINER REQUIREMENTS

A liner is required for each treatment pond. The allowable liner leakage shall be equivalent to 12 inches of material with an in-place hydraulic conductivity of $1 \times 10^{-7}$ cm/sec or 500 gallons per day per acre.

A plan for leak detection must be presented. Acceptable leak detection plans include double liners with leak collection sumps or down gradient monitoring wells. Other innovative plans for leak detection will be reviewed by NDEP prior to acceptance.

The necessity to provide an erosion barrier (gravel rock, concrete pad for soil lined ponds, geomembrane wear-pad for geomembrane liners) on the liner bottom under mechanical aerators to reduce pond bottom scour should be evaluated.

**1. FOR CLAY LINED PONDS, SUBMITTALS SHALL INCLUDE:**

A. A clay liner must have a minimum thickness of 12 inches and be compacted in lifts which are no more than six inches thick.

B. The liner must have a determined permeability coefficient of not more than that exhibited by 12-inches of 1 x 10-7 cm/sec material after being compacted to 90% Modified Proctor within 2% of optimum moisture.

C. The particle gradation (sieve analysis), soil density, and the Atterberg limits (liquid limit, plastic limit and shrinkage limit) of the soil liner material shall be provided to the Bureau for review and approval prior to construction.

D. Permeability testing of the compacted liner shall be in accordance with acceptable engineering practices. The number of tests and test locations must receive BWPC approval prior to implementation. The results for these tests shall be summarized in a QA/QC report submitted by the engineer.

E. The interior of the embankments shall be protected from erosion by rip-rapping or other acceptable measures.

F. A plan for protection of the liner from vegetation, desiccation, and burrowing animals must be presented. This plan shall include the resources, equipment, and chemicals necessary to control vegetation. Prevention of desiccation of the clay of the clay liner is required for facilities which experience low-flow periods or that take ponds off-line for maintenance.

**2.** FOR **GEOMEMBRANE LINED** PONDS, SUBMITTAL SHALL INCLUDE:

A. The liner should have a coefficient of permeability of at least 1 x $10^{-11}$ cm/sec and be a minimum of 60 mils in thickness.

B. The liner material specifications shall meet the standards listed in the Geosynthetic Research Institute Test Method GM13 (ex. UV Resistance, Puncture Resistance)

C. A plan for protection of the liner from ice damage, temperature extremes, wind uplift, oxidation, and sharp objects shall be presented.

D. If there is the potential for gas generation in the sub base, a plan to remove the gas beneath the liner must be presented.

E. Supporting geotechnical data on the embankment foundation and slope stability shall be submitted.

F. It is strongly recommended that the primary liner material be textured on the exposed side for slip prevention

G. A means of emergency egress shall be provided (ex. knotted hand lines, welded in ladder rungs, roped life preserver rings, etc.).

H. Provide the details on liner anchoring and all pipe penetration. It is recommended that liner penetrations be limited to the best extent possible to reduce potential for leaks.

I. Submit a quality assurance/quality control (QA/QC) report on the liner installation. This document shall include a summary of the results of all field tests conducted on the liner, including:

1.> Seam Testing - GSI Test Methods
2.> Tear Resistance - GSI Test Methods