651.1050 Appendix 10A—Blank worksheets

Worksheet 10A-1—Waste storage structure capacity design

Decisionmaker: | Date:

Site:

Animal units

1. Animal type _____ _____ _____

2. Animal weight, lbs (W) _____ _____ _____

3. Number of animals (N) _____ _____ _____

4. Animal units, $AU = \frac{W \times N}{1000}$ = _____ _____ _____ _____

Manure volume

5. Daily volume of daily manure production per AU, ft^3/AU/day (DVM)= _____ _____ _____

6. Storage period, days (D) = _____

7. Total volume of manure production for animal type for storage period, ft^3
VMD = AU x DVM x D = _____ _____ _____

8. Total manure production for storage period, ft^3 (TVM) _____

Wastewater volume

9. Daily wastewater volume per AU, ft^3/AU/day (DWW) = _____ _____ _____

10. Total wastewater volume for animal description for storage period, ft^3
WWD = DWW x AU x D = _____ _____ _____

11. Total wastewater volume for storage period, ft^3 (TWW) _____

Bedding volume

12. Amount of bedding used daily for animal type, lbs/AU/day (WB) = _____ _____ _____

13. Bedding unit weight, lbs/fb^3 (BUW) = _____

14. Bedding volume for animal type for storage period, ft^3 BV = _____ _____ _____

$$VBD = \frac{0.5 \times WB \times AU \times D}{BUW}$$

15. Total bedding volume for storage period, ft^3 (TBV) = _____

Minimum waste storage volume requirement

16. Waste storage volume, ft^3 (WV) = TVM + TWW + TBV = _____ + _____ + _____ = _____

Waste stacking structure sizing

17. Structure length, ft $L = \frac{WV}{WI \times H}$ = _____

18. Structure width, ft $WI = \frac{WV}{L \times H}$ = _____

19. Structure height, ft $H = \frac{WV}{L \times WI}$ = _____

Notes for waste stacking structure:

1. The volume determined (WV) does not include any volume for freeboard. It is recommended that a minimum of 1 foot of freeboard be provided for a waste stacking structure.

2. The equations for L, WI, and H assume manure is stacked to average height equal to the sidewall height. Available storage volume must be adjusted to account for these types of variations.

Tank sizing

20. Effective depth, ft. (EH)

Total height (or depth) of tank desired, ft (H) _____

Less precipitation for storage period, ft. (uncovered tanks only) – _____

Less depth allowance for accumulated solids, ft – (0.5 ft. minimum) _____

Less depth for freeboard (0.5 ft. recommended), ft – _____

Effective depth, ft (EH) = _____

21. Surface area required, ft^2 $SA = \frac{WV}{EH}$ = _____

22. Rectangular tank dimensions

Total height, ft (H) = _____ Selected width, ft (WI) = _____

Length, ft $L = \frac{SA}{WI}$ = _____

23. Circular tank dimensions

Total height, ft H = _____

Diameter, ft $DIA = (1.273 \times SA)0.5$ = _____

Notes for waste storage tank structure:
1. Final dimensions may be rounded up to whole numbers or to use increments on standard drawings.
2. Trial and error may be required to establish appropriate dimensions.

Worksheet 10A-2—Waste storage pond design

Decisionmaker: | Date:

Site:

Animal units

1. Animal type _____ _____ _____

2. Animal weight, lbs (W) _____ _____ _____

3. Number of animals (N) _____ _____ _____ _____

4. Animal units, $AU = \frac{W \times N}{1000}$ = _____ _____ _____ _____

Manure volume

5. Daily volume of manure production per AU, ft^3/AU/day (DVM)= _____ _____ _____

6. Storage period, days (D) = _____

7. Total volume of manure production for animal type for storage period, ft^3 VMD = AU x DVM x D = _____ _____ _____

8. Total manure production for storage period, ft^3 (TVM) _____ _____

Wastewater volume

9. Daily wastewater volume per AU, ft^3/AU/day (DWW) = _____ _____ _____

10. Total wastewater volume for animal description for storage period, ft^3 WWD = DWW x AU x D = _____ _____ _____

11. Total wastewater volume for storage period, ft^3 (TWW) _____ _____

Clean water volume

12. Clean water added during storage period, ft^3 (CW) _____

Solids accumulation

14. Volume of solids accumulation, ft^3 (VSA) _____ _____

Runoff volume

13. Runoff volume, ft^3 (ROV) (attach documentation) _____ _____
Includes the volume of runoff from the drainage area due to normal runoff for the storage period and the runoff volume from the 25-year, 24-hour storm.

Minimum waste storage volume requirement

15. Waste storage volume, ft^3 (WSV) = TVM + TWW + CW + ROV + VSA

= _____ + _____ + _____ + _____ + _____ = _____

Pond sizing

16. Sizing by trial and error

Side slope ratio, (Z) = _____ V must be equal to or greater than WSV = _____ ft^3

Rectangular pond,

$$V = \left(\frac{4 \times Z^2 \times d^3}{3}\right) + \left(Z \times BL \times d^2\right) + \left(Z \times BW \times d^2\right) + \left(BW \times BL \times d\right)$$

Circular pond,

$$V = (1.05 \times Z^2 \times d^3) + (1.57 \times W \times Z \times d^2) + (0.79 \times W^2 \times d)$$

Trial no.	Bottom width ft (BW)	Bottom length ft (BL)	Depth* ft (d)	Volume ft^3 (V)

Trial no.	Bottom diameter (DIA)	Depth* ft (d)	Volume ft^3 (V)

* *Depth must be adjusted in Step 17.*

Depth adjustment

17. Depth adjustment

Depth, ft (d) _____

Add depth of precipitation less evaporation + _____ (For the storage period)

Add depth of 25-year, 24-hour storm + _____

Add for freeboard (1.0 foot minimum) + _____

Final depth _____

Worksheet 10A-3—Anaerobic lagoon design

Decisionmaker: | Date:

Site:

Animal units

1. Animal type _____ _____ _____

2. Animal weight, lbs (W) _____ _____ _____

3. Number of animals (N) _____ _____ _____

4. Animal units, AU = $\frac{W \times N}{1000}$ = _____ _____ _____

Manure volume

5. Daily volume of daily manure production per AU, ft^3/AU/day (DVM)= _____ _____ _____

6. Treatment period, days (D) = _____

7. Total volume of manure production for animal type for treatment period, ft^3
VMD = AU x DVM x D = _____ _____ _____

8. Total manure production for treatment period, ft^3 (TVM) = _____

Wastewater volume

9. Daily wastewater volume per AU, ft^3/AU/day (DWW) = _____ _____ _____

10. Total wastewater volume for animal description for treatment period, ft^3
WWD = DWW x AU x D = _____ _____ _____

11. Total wastewater volume for treatment period, ft^3 (TWW) _____

Clean water volume

12. Clean water added during treatment period, ft^3 (CW) _____

Waste volume

13. Waste volume for treatment period, ft^3 WV = TVM + TWW + CW = _____ + _____ + _____ = _____

Manure total solids

14. Daily manure total solids production, lbs/AU/day (MTS) = _____ _____ _____

15. Daily manure total solids production for animal type, lbs/day
MTSD = MTS x AU = _____ _____ _____

16. Total manure total solids production, lbs/day (TMTS) = _____

Manure volatile solids

17. Daily manure volatile solids production per AU, lbs/AU/day (MVS) = _____ _____ _____

18. Daily manure volatile solids production for animal type per day, lbs/day MVSD = AU x MVS = _____ _____ _____

19. Total manure volatile solids production, lbs/day (TMVS) _____

Wastewater volatile solids

20. Daily wastewater volatile solids production, lbs/1000 gal (DWVS) = _____ _____ _____

21. Total wastewater volatile solids production for animal type, lbs/day

$$WVSD = \frac{DWVS \times DWW \times 7.48}{D \times 1{,}000}$$ = _____ _____ _____

22. Total wastewater volatile solids production, lbs/day (TWVS) = _____

Total volatile solids (manure and wastewater)

23. Total daily volatile solids production, lbs/day TVS = TMVS + TWVS = _____ + _____ = _____

Minimum treatment volume

24. Selected lagoon VS loading rate, lbs VS/1,000 ft^3 (VSLR) = _____

25. Minimum treatment volume, ft^3

$$MTV = \frac{TVS \times 1000}{VSLR} = \frac{(\quad) \times 1000}{(\quad)} =$$ _____

Sludge volume requirement

26. Sludge accumulation ratio, ft^3/lb TS (SAR) = _____

27 Sludge accumulation period, years (T) = _____

28. Sludge volume requirement, ft^3
SV = 365 x TMTS x T x SAR
= 365 x ( )( )( ) = _____

Minimum lagoon volume requirement

29. Minimum lagoon volume requirements, ft^3
(MLVR) = MTV + SV + WV = _____ + _____ + _____ = _____

Lagoon sizing

30. Sizing by trial and error $V = \frac{(4 \times Z^2 \times d^3)}{3} + (Z \times BL \times d^2) + (Z \times BW \times d^2) + (BW \times BL \times d)$

Side slope ratio, (Z) = _____

V must be equal to or greater than MLVR = _____ ft^3

Trial no.	Bottom width ft (BW)	Bottom length ft (BL)	Depth* ft (d)	Volume ft^3 (V)

* *Depth must be adjusted in Step 31.*

Depth adjustment

31. Depth adjustment

Depth, ft (d) ---------- _____

Add depth of precipitation less evaporation on lagoon surface ---------+ _____
(for the treatment period)

Add depth of 25-year, 24-hour storm ---------- + _____

Add for freeboard (1.0 foot minimum) ----------+ _____

Final depth ---------- _____

32. Compute total volume using final depth, ft^3 (use equation in step 30) ---------- _____

Worksheet 10A-4—Aerobic lagoon design

Decisionmaker: | Date:

Site:

Animal units

1. Animal type _____ _____ _____

2. Animal weight, lbs (W) _____ _____ _____

3. Number of animals (N) _____ _____ _____

4. Animal units, AU = $\frac{W \times N}{1000}$ = _____ _____ _____ _____

Manure volume

5. Daily volume of daily manure production per AU, ft^3/AU/day (DVM) = _____ _____ _____

6. Treatment period, days (D) = _____

7. Total volume of manure production for animal type for treatment period, ft^3
VMD = AU x DVM x D = _____ _____ _____

8. Total manure production for treatment period, ft^3 (TVM) _____ _____

Wastewater volume

9. Daily wastewater volume per AU, ft^3/AU/day (DWW) = _____ _____ _____

10. Total wastewater volume for animal description for treatment period, ft^3
WWD = DWW x AU x D = _____ _____ _____

11. Total wastewater volume for treatment period, ft^3 (TWW) _____ _____

Clean water volume

12. Clean water added during treatment period, ft^3 (CW) _____ _____

Waste volume

13. Waste volume for treatment period, ft^3 WV = TVM + TWW + CW = _____ + _____ + _____ = _____

Manure total solids

14. Daily manure total solids production, lbs/AU/day (MTS) = _____ _____ _____

15. Daily manure total solids production for animal type, lb/day
MTSD = MTS x AU = _____ _____ _____

16. Total manure total solids production, lbs/day (TMTS) = _____

Manure 5-day biochemical oxygen demand

17. Daily manure BOD_5 production per AU, lbs/AU/day (MBOD) = _____ _____ _____ _____

18. Daily manure BOD_5 production for animal type per day, lbs/day MBOD = AU x BOD = _____ _____ _____

19. Total manure production, lbs/day (TMBOD) _____ _____

Wastewater 5-day biochemical oxygen demand

20. Daily wastewater BOD_5 production, lbs/1000 gal (DWBOD) _____ = _____ _____ _____

21. Total wastewater BOD_5 production for animal type, lbs/day

$$WBOD = \frac{(DWBOD \times TWW \times 7.48)}{D \times 1{,}000}$$

_____ = _____ _____ _____

22. Total wastewater BOD_5 production, lbs/day (TWBOD) _____ = _____

TOTAL BOD_5 (manure and wastewater)

23. Total daily production, lbs/day TBOD = TMBOD + TWBOD = _____ _____ + _____ = _____

Minimum treatment surface area

24. Selected lagoon BOD_5 loading rate, lbs BOD_5/acre (BODLR) = _____

25. Minimum treatment surface area, acres

$$MTA = \frac{TBOD}{BODLR} = \frac{(\quad\quad)}{(\quad\quad)} =$$ _____

Sludge volume requirement

26. Sludge accumulation ratio, ft^3/lb TS (SAR) = _____

27 Sludge accumulation period, years (T) = _____

28. Sludge volume requirement, ft^3
SV = 365 x TMTS x T x SAR
= 365 ( )( )( ) = _____

Minimum lagoon volume requirement

29. Minimum lagoon volume requirements, ft^3
MLVR = SV + WV = _____ _____ + _____ = _____

Lagoon sizing

30. Sizing by trial and error:

Side slope ratio, (Z) = _____

V must be equal to or greater than MLVR = _____ ft^3

SA must be equal to or greater than MTA = _____ acres

Rectangular lagoon:

d must be less than 5 feet

$$SA = \frac{(BL + 2Zd)(BW + 2Zd)}{43{,}560}$$

$$V = \left(\frac{4 \times Z^2 \times d^3}{3}\right) + \left(Z \times BL \times d^2\right) + \left(Z \times BW \times d^2\right) + \left(BW \times BL \times d\right)$$

Trial no.	Bottom width ft (BW)	Bottom length ft (BL)	Depth* ft (d)	Volume ft^3 (V)	Surface area acres (SA)

** Depth must be adjusted in Step 31*

Depth adjustment

31. Depth adjustment

Depth , ft (d) ---------- _____

Add depth of precipitation less evaporation on lagoon surface + _____
(for the treatment period)

Add depth of 25-year, 24-hour storm ---------- + _____

Add for freeboard (1.0 foot minimum) ---------- + _____

Final depth ---------- _____

32. Compute total volume using final depth, ft^3
(use equation in step 30) ---------- _____

Worksheet 10A-5—Anaerobic digester design

Decisionmaker: | Date:

Site:

Animal units

1. Animal type _____ _____ _____

2. Animal weight, lbs (W) _____ _____ _____

3. Number of animals (N) _____ _____ _____

4. Animal units, $AU = \frac{W \times N}{1000}$ = _____ _____ _____

Manure volume

5. Daily volume of daily manure production per AU, ft^3/AU/day (DVM)= _____ _____ _____

6. Total volume of daily manure production for animal type, ft^3/day

$MPD = AU \times DVM$ _____ _____ _____

7. Total daily manure production volume, ft^3/day (TMP) _____

Manure total solids

8. Daily manure total solids production, lbs/AU/day (MTS) = _____ _____ _____

9. Daily manure total solids production for animal type, lb/day

$MTSD = MTS \times AU$ = _____ _____ _____

10. Total manure total solids production, lbs/day (TMTS) = _____

Manure volatile solids

11. Daily manure volatile solids production per AU, lbs/AU/day (MVS) = _____ _____ _____

12. Daily manure volatile solids production for animal type per day, lbs/day $MVSD = AU \times MVS$ _____ _____ _____

=

13. Total manure volatile solids production, lbs/day (TMVS) _____

Percent solids

14. Percent solids, % (PS)

$$PS = \frac{TMTS \times 100}{TMP \times 62.4} = \frac{(\quad) \times 100}{(\quad) \times 62.4} = \_\_\_\_$$

Digester feed solid concentration

15. Desired digester feed solids concentration, % (DDFSC) = _____

Daily manure inflow

16. Daily manure inflow, ft^3

$$DMI = \frac{TMTS \times 100}{DDFSC \times 62.4} = \frac{(\quad) \times 100}{(\quad) \times 62.4} = \_\_\_\_$$

Digester effective volume

17. Digester effective volume, ft^3

$DEV = DMI \times 20 = (\quad) \times 20$ _____

=

Digester dimensions

18. Digester depth, ft

$$H = \left(\frac{DEV}{8}\right)^{0.33} = \left[\frac{(\quad)}{8}\right]^{0.33} = \_\_\_\_$$

19. Digest width, ft $WI = 2 \times H = 2 \times (\quad)$ _____

=

20. Digest length, ft $L = 4 \times H = 4 \times (\quad)$ _____

=

Estimated energy production

21. Biogas per unit (*VS*), ft^3/lb (*BUVS*) _____

=

22. Estimated biogas production ft^3/day

EBP = $BUVS \times TMVS$ = (\quad) x (\quad) _____

=

23. Estimated energy production BTU/day

$EEP = EBP \times 600$ = (\quad) x (600) _____

=

Worksheet 10A-6—Monthly precipitation minus evaporation

Decisionmaker: | Date:

Site:

Annual FWS Evaporation (*FWS*) = _____ inches

Month	Monthly precipitation MP (inches)	Monthly portion of annual evaporation MPAE (percent)	Monthly evaporation ME (inches)*	Monthly precipitation less evaporation MPLE (inches)
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

**ME = FWS x MPAE*

Storage or treatment period, days (D) = _____

months = _____

Critical successive months

Month	Monthly precipitation less evaporation MPLE (inches)	Month	Monthly precipitation less evaporation MPLE (inches)
Total			