

California Central Valley Dairy Waste and Nutrient Management Waste Management Plan Computations Documentation

Information and Computations

Software format, computation methods, and content are a reflection of Central California regulatory compliance goals (California Regional Water Quality Control Board Central Valley Region, Order No. R5-2007-0035, Waste Discharge Requirements General Order For Existing Milk Cow Dairies). This document contains support materials for the Waste Management Plan (WMP) module, a component of a larger internet based dairy compliance software application specific to California's Central Valley. The WMP is intended to provide a detailed assessment of a dairy facility's ability to collect, store and manage solid wastes and wastewater generated. Computations utilized in the WMP module are approximations from process based assessment approaches to facility specific wastewater, manure, bedding solids, rainfall collection and management practices in a relatively open biological system. Completion of a WMP will provide owners and operators with a more detailed perspective of individual dairy facility compliance for potential infrastructure improvements and management modifications in accordance with regulatory requirements. Components of the WMP will require review and signature by appropriately registered or trained professionals (civil engineer, backflow specialist, surveyor, etc.) Computational methods utilized are typically conservative (high) values. Several automated calculations can be over-riden with manual entries by the user for greater accuracy on a site specific basis. This software relies on user entered information and employs computational methods in accordance with generally accepted principals and practices at the time of release and is subject to change. See Release Notes for up to date information on software modifications. This software was developed with a grant from the California State Water Resources Control Board, Agreement Number 05-095-550-0.

Herd Computations

All manure volume excretion daily subtotals are stored, summed then multiplied by 365 days to obtain annual totals or multiplied by the user selected storage period to obtain storage period totals for reporting outputs regarding storage capacity estimates. All manure volume herd excretion daily subtotals are stored, summed then partitioned to dry lot storage, solids removed by separation or process waste water storage for reporting outputs regarding process waste water storage pond capacity estimates. Partitioning to dry lot storage, solids removed by separation or process waste water storage ponds are controlled by hours on flush (water used to remove manure that is sent to the process waste water storage ponds) in this software application, a user entered value not exceeding 24 hours per day and solids separation processes. Flushed free-stall, flushed feed lane, and flushed milk barn style settings must be considered collectively to more accurately estimate manure partitioning. Recent studies (Air Emissions Mitigation Techniques and Technologies for Californian Dairies – Final Report, University of California at Davis, April 10, 2007, Frank Mitloehner, Ph.D) which measured behaviors of confined bovine stock suggest that elimination processes occur more frequently after resting, and during or after eating. During these periods significant quantities of manure (feces and urine) may, therefore, be subject to partitioning to the process waste water storage ponds where animal housing includes flushed free-stall and flushed feed lane settings. Consideration of appropriate selections by the user as hours on flush is

imperative to properly estimate realistic partitioning of manure to process waste water, solids remaining or dry lot storage. The absence of large volumes of manure accumulating in corrals (for example) is the first indication suggesting high rates of partitioning to process waste water storage ponds. Flush manure management systems may result in higher manure collection efficiencies.

Herd Manure, Manure Solids and Separation:

Approximated volume of manure and manure solids excreted based upon March 2005, American Society of Agricultural and Biological Engineers (ASABE, formerly ASAE) 384.2, Section 5.3.1, Equation 3, page 6 for milk cows, Section 5.3.2, Equation 4, dry cows and Section 5.3.3, Equation 6, heifers, Section 1, Table 1.b, Section 3, page 2. Total Manure (ft³/d-a) table values for calves. Manure solids, Table 1.b, Section 3, page 2. Waste is either partitioned to dry lot storage, solids removed or to process waste water storage ponds based upon hours on flush and solids separation processes. ASABE 393.3, Section 5.2.3, "Consideration should be given to treating the holding pond influent with solid/liquid separation to minimize problems associated with solids".

Contemporary solids separation equipment removal and process efficiencies are based upon material dry weight and volume. To estimate manure solids removal as a result of separation both manure volume and manure solids weight quantifications are compiled. The process based assessment concept applied includes quantification of manure volume and manure solids content for the herd where the separation process removes manure solids and fluids returning a fraction of the fluids to the pond requiring close attention to moisture content and density of the materials handled. Example for a single milk cow producing 88 pounds of milk per day excreting 150 pounds or 2.4 cubic feet of manure; Manure material excreted in a flush manure management system approaches the separation device (inclined screen) with large volumes of water, of 150 pounds approximately 20 pounds may be manure solids. If the combined removal/separation efficiency for manure solids is 30% approximately 6 pounds of manure solids may be removed. With the 6 pounds of dry material are fluids, some of these fluids are retained in the separated manure solids piles, some are returned to the process wastewater storage ponds. An estimated factor of 1.33 is applied indicating that for every pound of manure solids removed an estimated additional 1.33 pounds of fluids (mainly water) are also removed. Summing the manure solids removed and the moisture factor applied approximately 14 pounds of material may have been removed and is subtracted from the 150 pounds of manure resulting in approximately 136 pounds of manure to the ponds. The estimated density for manure solids alone is a default value of 50 pounds per cubic foot. The density of the non-separated manure to the pond is estimated at a default value of 62.4 pounds per cubic foot due to its high moisture content particularly in a flush manure management system. Separated solids found in most piles near separation processes are likely to have moisture contents from 60 to 85%. Moisture content of separated solids through various forms of phase separation processes can be considerably lower. As liquid removal efficiencies (solids presses, augers etc.) increase, additional fine solids may pass through along with moisture/fluids removed and returned to the ponds with various effects on storage capacity and nutrient content (potentially higher organic nitrogen content). Software distinguishes separated manure solids from manure partitioned to dry lots.

It is important to note that much like nutrient excretion, solids excretion is directly related to feed composition, quality and quantity. Expected changes in diets and environmental conditions among other factors can create variable manure quantity and component content further complicating solids collection efficiencies, separation processes and solids accumulation estimates in storage systems (ie-particle buoyancy, suspension and precipitation). As manure and bedding solids move and cycle through the dairy facility and manure management systems, particle sizes may change along with resultant relative densities and volumes affecting storage capacity estimates. Storage Period solids volume accumulation is estimated by applying a 0.50 manure and bedding solids particle size volume reduction factor (ASABE 393.3).



Manure excretion estimates.

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milk = .AvgMilkProduction * .KG_PER_LB
.ManureMilkCowPpd = ((milk * 0.647) + 43.212) * .LBS_PER_KG *
.ManureMilkCowCount
.ManureDryCowPpd = (((.DryCowAvgWeight / .LBS_PER_KG) * 0.022) + 21.844) *
.LBS_PER_KG * .MaxDryCowCount
.ManureHeifer15To24Ppd = (((.Heifer15To24AvgWeight / .LBS_PER_KG) * 0.018) +
17.817) * .LBS_PER_KG * .MaxHeifer15To24Count
.ManureHeifer7To14Ppd = (((.Heifer7To14AvgWeight / .LBS_PER_KG) * 0.018) +
17.817) * .LBS_PER_KG * .MaxHeifer7To14Count
.ManureCalf4To6Ppd = .MaxCalf4To6Count
* .MANURE_EXCRETION_WEIGHT.CALF
.ManureCalfTo3Ppd = .MaxCalfTo3Count * .MANURE_EXCRETION_WEIGHT.CALF
.ManureTotalPpd = .ManureMilkCowPpd + .ManureDryCowPpd +
.ManureHeifer15To24Ppd + .ManureHeifer7To14Ppd + .ManureCalf4To6Ppd +
.ManureCalfTo3Ppd
.ManureTotalCfpd = .ManureMilkCowPpd / .MANURE_DENSITY.MILK_COW +
.ManureDryCowPpd / .MANURE_DENSITY.DRY_COW + .ManureHeifer15To24Ppd /
.MANURE_DENSITY.HEIFER + .ManureHeifer7To14Ppd /
.MANURE_DENSITY.HEIFER + .ManureCalf4To6Ppd / .MANURE_DENSITY.CALF
+ .ManureCalfTo3Ppd / .MANURE_DENSITY.CALF
.ManureTotalCfpp = .ManureTotalCfpd * .StoragePeriodDays

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$.ManureTotalGpd = .ManureTotalCfpd * .GALLONS_PER_CUBIC_FOOT$
 $.ManureTotalGpp = .ManureTotalGpd * .StoragePeriodDays$
 $.ManureSolidsMilkCowPpd = ((milk * 0.096) + 5.073) * .LBS_PER_KG *$
 $.MaxMilkCowCount$
 $.ManureSolidsDryCowPpd = (((.DryCowAvgWeight / .LBS_PER_KG) * 0.004) + 1.863)$
 $* .LBS_PER_KG * .MaxDryCowCount$
 $.ManureSolidsHeifer15To24Ppd = .SOLID_EXCRETION.HEIFER *$
 $.MaxHeifer15To24Count$
 $.ManureSolidsHeifer7To14Ppd = .SOLID_EXCRETION.HEIFER *$
 $.MaxHeifer7To14Count$
 $.ManureSolidsCalf4To6Ppd = .SOLID_EXCRETION.CALF * .MaxCalf4To6Count$
 $.ManureSolidsCalfTo3Ppd = .SOLID_EXCRETION.CALF * .MaxCalfTo3Count$

Manure volumes to flush and to dry lot based on flush hours

$.ManureToDryLotCfpd = (.ManureMilkCowPpd / .MANURE_DENSITY.MILK_COW)$
 $* ((24 - .MilkCowFlushHours) / 24) + (.ManureDryCowPpd /$
 $.MANURE_DENSITY.DRY_COW) * ((24 - .DryCowFlushHours) / 24) +$
 $(.ManureHeifer15To24Ppd / .MANURE_DENSITY.HEIFER) * ((24 -$
 $.Heifer15To24FlushHours) / 24) + (.ManureHeifer7To14Ppd /$
 $.MANURE_DENSITY.HEIFER) * ((24 - .Heifer7To14FlushHours) / 24) +$
 $(.ManureCalf4To6Ppd / .MANURE_DENSITY.CALF) * ((24 - .Calf4To6FlushHours) /$
 $24) + (.ManureCalfTo3Ppd / .MANURE_DENSITY.CALF) * ((24 -$
 $.CalfTo3FlushHours) / 24)$

$.ManureToDryLotCfpp = .ManureToDryLotCfpd * .StoragePeriodDays$
 $.ManureToDryLotGpd = .ManureToDryLotCfpd * .GALLONS_PER_CUBIC_FOOT$
 $.ManureToDryLotGpp = .ManureToDryLotGpd * .StoragePeriodDays$

$.ManureToFlushPpd = .ManureMilkCowPpd * (.MilkCowFlushHours / 24) +$
 $.ManureDryCowPpd * (.DryCowFlushHours / 24) + .ManureHeifer15To24Ppd *$
 $(.Heifer15To24FlushHours / 24) + .ManureHeifer7To14Ppd * (.Heifer7To14FlushHours$
 $/ 24) + .ManureCalf4To6Ppd * (.Calf4To6FlushHours / 24) + .ManureCalfTo3Ppd *$
 $(.CalfTo3FlushHours / 24)$

$.ManureToFlushCfpd = (.ManureMilkCowPpd * (.MilkCowFlushHours / 24) /$
 $.MANURE_DENSITY.MILK_COW) + (.ManureDryCowPpd *$
 $(Wmp.DryCowFlushHours / 24) / .MANURE_DENSITY.DRY_COW) +$
 $(.ManureHeifer15To24Ppd * (.Heifer15To24FlushHours / 24) /$
 $.MANURE_DENSITY.HEIFER) + (.ManureHeifer7To14Ppd *$
 $(Wmp.Heifer7To14FlushHours / 24) / .MANURE_DENSITY.HEIFER) +$
 $(.ManureCalf4To6Ppd * (Wmp.Calf4To6FlushHours / 24) /$
 $.MANURE_DENSITY.CALF) + (.ManureCalfTo3Ppd * (.CalfTo3FlushHours / 24) /$
 $.MANURE_DENSITY.CALF)$

Total solids sent to flush before separation

$.ManureSolidsToFlushPpd = .ManureSolidsMilkCowPpd * (.MilkCowFlushHours/24) +$
 $.ManureSolidsDryCowPpd * (.DryCowFlushHours/24) +$
 $.ManureSolidsHeifer15To24Ppd * (.Heifer15To24FlushHours/24) +$

.ManureSolidsHeifer7To14Ppd * (.Heifer7To14FlushHours/24) +
 .ManureSolidsCalf4To6Ppd * (.Calf4To6FlushHours/24) + .ManureSolidsCalfTo3Ppd *
 (.CalfTo3FlushHours/24)

Total manure solids removed by separation

.ManureSolidsRemovedPpd = .ManureSolidsToFlushPpd * .RemovalEquipEff

Total manure solids (and contact water) removed by the separation processes in cf/day,
 cf/period, gallons/day, gallons/period

.ManureRemovedCfpd = (.ManureSolidsRemovedPpd /
 Common.MANURE_SOLIDS_DENSITY) +

(.LiquidRemovedPpd / .WATER_DENSITY)

.ManureRemovedCfpp = .ManureRemovedCfpd * .StoragePeriodDays

.ManureRemovedGpd = .ManureRemovedCfpd * .GALLONS_PER_CUBIC_FOOT

.ManureRemovedGpp = .ManureRemovedGpd * .StoragePeriodDays

Convert manure solids removed from lbs/day to cf/day, cf/period, gallons/day, and
 gallons/period

.ManureSolidsRemovedCfpd =

.ManureSolidsRemovedPpd/.MANURE_SOLIDS_DENSITY

.ManureSolidsRemovedCfpp = .ManureSolidsRemovedCfpd * .StoragePeriodDays

.ManureSolidsRemovedGpd =

.ManureSolidsRemovedCfpd * .GALLONS_PER_CUBIC_FOOT

.ManureSolidsRemovedGpp = .ManureSolidsRemovedGpd * .StoragePeriodDays

Total liquids removed by separation

.LiquidRemovedPpd =

.ManureSolidsRemovedPpd * .SEPARATION_PARTICLE_MOISTURE

Convert the total liquids removed by separation from lbs/day to cf/day, cf/period,
 gallons/day, and gallons/period

.LiquidRemovedCfpd = .LiquidRemovedPpd / .WATER_DENSITY

.LiquidRemovedCfpp = .LiquidRemovedCfpd * .StoragePeriodDays

.LiquidRemovedGpd = .LiquidRemovedCfpd * .GALLONS_PER_CUBIC_FOOT

.LiquidRemovedGpp = .LiquidRemovedGpd * .StoragePeriodDays

Total manure sent to the pond after separation in lbs/day and cf/day

.ManureToPondPpd = .ManureToFlushPpd - (.ManureSolidsRemovedPpd +
 .LiquidRemovedPpd)

.ManureToPondCfpd = .ManureToFlushCfpd - .ManureRemovedCfpd

Total manure solids sent to the pond after separation

.ManureSolidsToPondPpd = .ManureSolidsToFlushPpd - .ManureSolidsRemovedPpd

.ManureSolidsToPondCfpd = .ManureSolidsToPondPpd

/.MANURE_SOLIDS_DENSITY

.ManureSolidsToPondCfpy = (.ManureSolidsToPondPpd /.WATER_DENSITY) *

.AVG_DAYS_PER_YEAR

.ManureSolidsToPondGpy = .ManureSolidsToPondGpy *
.GALLONS_PER_CUBIC_FOOT

Total flushed waste sent to the pond after separation

.FlushToPondCfpd = .ManureToPondCfpd + .BeddingSolidsToPondCfpd
+.GeneratedBeddingSolidsToPondCfpd
.FlushToPondCfpp = .FlushToPondCfpd *.StoragePeriodDays
.FlushToPondGpd = .FlushToPondCfpd *.GALLONS_PER_CUBIC_FOOT
.FlushToPondGpp = .FlushToPondGpd *.StoragePeriodDays
.FlushToPondCfpy = .FlushToPondCfpd *.AVG_DAYS_PER_YEAR

Residual Manure and Bedding Solids volume sent to pond

.ResidualSolidsToPondCfpd = (.ManureSolidsToPondCfpd +
.TotalBeddingSolidsToPondCfpd) * SOLIDS_VOLUME_REDUCTION_FACTOR
.ResidualSolidsToPondCfpp = (.ResidualSolidsToPondCfpd * .StoragePeriodDays)
.ResidualSolidsToPondCfpy = (.ResidualSolidsToPondCfpd
*.AVG_DAYS_PER_YEAR)
.ResidualSolidsToPondGpd = (.ManureSolidsToPondGpd +
.TotalBeddingSolidsToPondGpd)
.ResidualSolidsToPondGpp = .ResidualSolidsToPondGpd *
.StoragePeriodDays.
.ResidualSolidsToPondGpy = .ResidualSolidsToPondGpd *
.AVG_DAYS_PER_YEAR

Bedding Solids

A variety of bedding materials may be used for animal resting, maternity and other animal housing settings that are generated by the facility as manure or imported that may ultimately affect pond storage capacity. Users select the appropriate bedding type and enter a weight in tons used during the storage period. If the facility operates solids separation equipment/processes the software applies a default removal efficiency as a percentage and density in pounds per cubic feet, then converts from tons of solid material removed to volume as cubic feet and gallons for daily and storage period totals. Bedding solids are summed and partitioned to separated solids removed or pond storage in accordance with hours on a flushed manure management system. For facilities lacking solids separation equipment/processes zero solids removal efficiency is applied.



Default bedding values

Bedding Type	Density (cu.ft.)	Potential Removal Efficiency %
Almond Shells	20	0.85
Manure	40	0.50
Sand	110	0.65
Wood Products	12	0.85
Straw (Chopped)	7	0.75
Rice Hulls	9	0.85

Total bedding imported sent to the pond after separation

```
.BeddingSolidsPpd = (.ImportedAmount *.LBS_PER_TON)/
.StoragePeriodDays (lbs/day)
.BeddingSolidsToPondPpd = .BeddingSolidsPpd * (1.0D - .BeddingTypeRemovalEff)
.BeddingSolidsToPondCfpd = .BeddingSolidsToPondPpd / .BeddingTypeDensity
.BeddingSolidsToPondCfpp = .BeddingSolidsToPondCfpd * .StoragePeriodDays
.BeddingSolidsPpd += .BeddingSolidsPpd.BeddingSolidsToPondPpd +=
.BeddingSolidsToPondPpd
.BeddingSolidsToPondCfpd += .BeddingSolidsToPondCfpd
.BeddingSolidsToPondCfpp += .BeddingSolidsToPondCfpp
.BeddingSolidsToPondGpp += (.BeddingSolidsToPondCfpp *
.GALLONS_PER_CUBIC FOOT)
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Total bedding generated by the herd sent to the pond after separation

```
.GeneratedBeddingSolidsToPondPpd = (.GeneratedBeddingSolidsAmount *
.LBS_PER_TON * (1.0D -
.MANURE_BEDDING_REMOVAL_EFF)/.StoragePeriodDays
.GeneratedBeddingSolidsToPondCfpd =
.GeneratedBeddingSolidsToPondPpd/.MANURE_DENSITY.BEDDING
.GeneratedBeddingSolidsToPondCfpp = .GeneratedBeddingSolidsToPondCfpd *
.StoragePeriodDays
.TotalBeddingSolidsToPondCfpd = .BeddingSolidsToPondCfpd +
.GeneratedBeddingSolidsToPondCfpd
.TotalBeddingSolidsToPondCfpp = .TotalBeddingSolidsToPondCfpd *
.StoragePeriodDays
.TotalBeddingSolidsToPondGpd = .TotalBeddingSolidsToPondCfpd *
.GALLONS_PER_CUBIC FOOT
.TotalBeddingSolidsToPondGpp = .TotalBeddingSolidsToPondGpd *
.StoragePeriodDays
```

Milkbarn Equipment and Computations

All daily process waste water subtotals are stored, summed then multiplied by the storage period selected by the user (120 – 240 days). A systematic, detailed assessment of milkbarn equipment and waste water generation is critical to estimating process waste water storage pond capacity. Reliance on automated/default computation values is not recommended as significant variability is expected on a site specific basis. Before making changes to water use patterns in the milk barn consider the potential end effect. Less fresh water to process waste water storage ponds may create undesirable results (flush water high in solids content, high concentrations of nutrients, etc.) and conversely, more fresh water to process waste water storage ponds may create other problems.

Bulk Tank Wash and Sanitizing:

Approximated volume of waste water based upon an automatic or manual valve user selection and entry, each time the milk tank is emptied (MilkTankCleaningsPerDay, a regulatory requirement to wash the milk bulk tank each time it is emptied) and user entries for bulk tank vat volume in gallons of water/cleaning agent for each cycle, most operations use a two to four vat cycle process (rinse, detergent wash, rinse, acidification/sanitizer) also user entered. Milk tank cleanings per day are multiplied by the number of bulk milk tank vat cycles and bulk tank vat volume gallons for each cycle. No user override. Waste water sent to waste water storage ponds directly. See automatic tank wash switch panel below. See photo of pumped cleaning agent system used to meter in cleaning agents into vat, and see photo of a vat below Pipeline Wash and Sanitizing section, page 5.

.BulkTankWashVol = .MilkTankCleaningsPerDay *.BulkTankWashCycles
*.BulkTankVatVolume



Pipeline Wash and Sanitizing:

Approximated volume of waste water based upon automatic or manual valve use each time a milking event is complete (MilkingPerDay) with user entries for pipeline vat volume in gallons of water/cleaning agent for each cycle, most operations use a two to four vat cycle process (rinse, detergent wash, rinse, acidification/sanitizer) also user entered. Milking per day are multiplied by the number of vat cycles multiplied by the user entry for pipeline vat volume gallons for each cycle (considering pipeline lengths and diameters, air injector performance, numerous milking stations, heat exchange equipment, etc., which often require significant water/cleaning agent volumes per vat cycle particularly for larger dairy operations). No user over-ride. Waste water sent to waste water storage ponds directly. See photos of vat (1st photo) below and stainless steel

pipelines/flexible hose connections from carousel milking platform (2nd photo) to vat through wall.

.PipelineWashVol = .MilkingsPerDay * .PipelineWashCycles * .PipelineVatVolume



Miscellaneous Equipment/Processes:

Approximated volume of waste water based upon throughput (gallons per day) multiplied by the storage period selected by the user. For those using miscellaneous water/equipment systems user may name the equipment/practice, select the source of water (fresh or from reuse), enter the appropriate throughput (gallons per day), and select the final destination for discharge (recycled, returned to pond, leaves system). No photos.

MiscEquipWash (many) = throughput (gpd)

Traditional Automatic Parlor Floor Flush:

Approximated volume of waste water based upon automatic flush mounted/grated deck flush valve use with average flows at approximately 1000 gpm running 2 minutes each cycle averaging 2.5 times per milking. User must select floor wash water source (fresh or from reuse). For those using hoses operated by hand or other modern spray/manure removal systems for parlor deck (floor) washing rather than a large diameter flush mounted/grated deck (floor) flush as pictured below, user may over-ride the automated computation by a manual entry as gallons per day.. Waste water sent to waste water storage ponds directly. Similar process in photo below Traditional Manual Parlor Floor Wash section.

$$\text{MilkingPerDay} * 1000 \text{ gallons} * 2 * 2.5 = \text{gallons per day}$$

Traditional Manual Parlor Floor Wash:

Approximated volume of waste water based upon manual floor flush at 1000 gallons multiplied by the number of strings entering the barn per day multiplied by the number of milkings per day. User must select floor wash water source (fresh or from reuse). Waste water sent to waste water storage ponds directly. For those using hoses operated by hand or other modern spray/manure removal systems for parlor deck (floor) washing rather than a large diameter flush mounted/grated deck (floor) flush as pictured below, user may over-ride the automated computation by a manual entry as gallons per day. See photo below of gravity fed floor wash in progress (recycled water source).

$$\text{MilkCowCount/CowsPerString} = \text{Strings sent to milkhouse per milking, so;} \\ \text{Strings} * 1000 \text{ gallons per string} * \text{MilkingPerDay} = \text{gallons per day}$$



Fresh Water Use in Flush System:

Approximated volume of additional fresh water use facility wide for flush systems is based upon user entries of gallons per day. Flush gallons are multiplied by the storage period. Waste water sent to waste water storage ponds directly.

$$.\text{FreshWaterInFlushLnsPd} = .\text{StoragePeriodDays} * .\text{FlushLaneWaterVolume}$$

Continuous Rotary / Carousel Deck Wash:

Approximated volume of waste water based upon 20 gallons per minute discharge to rotary deck multiplied by 60 minutes per hour multiplied by the number of hours spent milking each day. User must select deck wash water source (fresh or from reuse). For operations utilizing known (higher or lower) nozzle discharge rates user may over-ride the automated computation by a manual entry as gallons per day. Waste water sent to waste water storage ponds directly. See photo below of typical Continuous Rotary/Carousel Deck Wash (red nozzle and yellow valve handle half open).

HoursMilkingPerDay * 20 * 60 = gallons per day



Plate Coolers:

Air/mechanically cooled plate coolers (heat exchangers) have zero water discharge volume to reuse or to process waste water storage ponds in this software application. Approximated volume of waste water generated by water cooled plate coolers based upon pounds of milk per cow per day converted to gallons cooled by 4 gallons of well water per gallon of milk processed. Waste water (in this case as non-contact) may be recycled or sent to waste water storage ponds directly, user selected. Average lbs of Milk produced per cow per day divided by 8.6 lbs/gallon conversion, product is gallons of milk multiplied by number of milk cows multiplied by 4 gallons of well water to cool 1 gallon of milk. User may over-ride the automated computation by a manual entry as gallons per day. See photo of typical plate cooler below (white pipes are inlet and outlet for cooling fluid, stainless steel piping for milk flow into and out of heat exchanger, non-contact plate/press/heat exchanger in center of photo. Tan colored valve handle in closed position.).

$$(AvgMilkProduction (lbs) / 8.6) * MilkCowCount * 4 = \text{gallons per day}$$



Water cooled pumps / compressors / chillers combined:

Approximated volume of waste water based upon the hours spent milking per day multiplied by 25 gallons per minute water flow rate multiplied by 60 minutes per hour. The software logic combines pump, compressor and chiller flows/throughputs for the automated/default computation. Approximated value can be over-riden with a manual entry (ie-more or less efficient water use, compressor only, etc...) as gallons per day. Non-contact waste water may be recycled or sent to waste water storage ponds directly, user selected. No photo of water cooled pumps, compressors or chillers. Mechanical cooling equipment (condensers) on the roof of, or near the milkbarn indicates the producer is likely not using water cooled equipment solely (see photo below).

HoursMilkingPerDay * 25 * 60 = gallons per day



Herd Drinking Water:

Approximated volume of herd drinking water from recycle/reuse sources are estimated by multiplying the gallons of water used per head per day by total number of animals of a specific maturity stage for the storage period, then sums all drinking water consumed. User selects source of drinking water (fresh or from reuse). Drinking water volume from recycled sources leaves system and does not enter process waste water storage pond(s).

$$\text{RecycledDrinkingWaterPerDay} = (.MilkCowReusedCount * .MilkCowReusedRate) + (.DryCowReusedCount * .DryCowReusedRate) + (.Heifer15To24ReusedCount * .Heifer15To24ReusedRate) + (.Heifer7To14ReusedCount * .Heifer7To14ReusedRate) + (.Calf4To6ReusedCount * .Calf4To6ReusedRate) + (.CalfTo3ReusedCount * .CalfTo3ReusedRate)$$



Sprinkler Pen:

Approximated volume of waste water used to wash milk cows based upon number of sprinklers, multiplied by sprinkler run time, multiplied by number of sprinkler cycles per string, multiplied by sprinkler head flow rate, multiplied by number of strings (MaxMilkCowCount/CowsPerString) entering barn per day, the product (SprinklerPenWastewaterGen) is multiplied by the number of milkings per day. Source of sprinkler water can be user selected as recycled from other equipment, if not from recycled source software assumes it is from fresh water source (ie-well). Waste water sent to waste water storage ponds directly. See photo below of typical sprinkler pen on sloped floor surface draining to flush lane prior to milking parlor.

$.SprinklerPenWastewaterGen = .SprinklerCount * .SprinklerCycleLength * .SprinklerCyclesPerMilking * .SprinklerFlowRate * MilkCowStringCount$

$.SprinklerPenWastewaterVol = .SprinklerPenWastewaterGen * .MilkingsPerDay$



Milkbarn Water Use/Reuse:

Approximated volume of milkbarn water used, recycled, and sent to process waste water storage ponds is based upon a reuse water balance. Balance value, when displayed, is a positive number indicating some water may be available yet undesignated for reuse, negative values displayed as a zero balance assuming fresh water sources are filling the required flow deficit (logic in software controls user entry scenarios that would otherwise allow the balance/recycle tank to become oversupplied or undersupplied for user designated equipment throughputs). Water intended for recycling is typically stored in large tanks. The water in these tanks can be from equipment reuse and often fresh water is added to maintain sufficient head (pressure) for gravity flow floor/deck washing, operating sprinkler pens, animal drinking water, and other miscellaneous activities. Some forms of reuse storage tanks are referred to as cisterns. Excess volume (not reused) flows directly to process waste water storage ponds. See photo below of reuse water storage tank outside milking barn. Second photo below shows large diameter safety overflow outlet pipe from reuse storage tank to padded milk cow return lane near head of sprinkler pen.

$$\text{ReuseWaterBalance} = \text{WaterAvailableForReuse} - \text{ReuseWaterUsed}$$



Rainfall, Runoff and Tailwater

The user must enter information related to rainfall onto process waste water storage pond surface(s), rainfall onto roofed, impervious and earthen areas that runs off, and tailwater that runs off into the process waste water storage ponds to estimate the volume of rainfall retained in the process wastewater storage ponds during the storage period. Scaled site plans and maps can dramatically improve user data entry efficiency in the following rainfall, tailwater and pond sections.

Rainfall Into and Onto Ponds:

Approximated volume of rainfall onto and draining (diverted) into ponds is estimated by user entries describing the physical dimensions of ponds, surface areas and associated runoff coefficients where appropriate including roofed, impervious, and earthen areas that receive rainfall draining to the process waste water storage and storm water pond(s). Total rainfall is estimated by a required user selection of nearest rainfall station for Storage Period precipitation (table driven precipitation data from California Department of Water Resources selected Central Valley locations) and the 25-year/24-hour storm event (from the National Oceanic and Atmospheric Administration, NOAA Atlas 2, Isopluvials chart). User over-rides available for climate values, see California Department of Water Resources, California State Climatologist, State Climate Data and Information, and National Oceanic and Atmospheric Administration resources available online. For users selecting an assessment of storage capacity for normal rainfall multiplied by a factor of 1.5, storage period rainfall includes the 1.5 factor. The 25-year/24-hour storm and storage period rainfall are summed to derive total rainfall. Amount of rainfall onto and into pond(s) for the storage period is estimated by dividing rainfall inches by 12 to obtain feet of rainfall, multiplied by surface areas and the designated runoff coefficients and then multiplied by 7.48051945 gallons per cubic foot to obtain gallons of rainfall in the pond(s) for the selected storage period. Evaporation loss can be applied, overridden or set to zero.

Rain onto pond(s)

$.NormalRainfallOnToPondPd = (.PondSurfaceAreaTotal * (.StoragePeriodRainfall/ INCHES_PER_FOOT)) * GALLONS_PER_CUBIC_FOOT$

$.NormalRainfallOnToPondPdFactored = (.PondSurfaceAreaTotal * (.StoragePeriodRainfallFactored/ INCHES_PER_FOOT)) * GALLONS_PER_CUBIC_FOOT$

$.TwentyFiveYrOnToPond = (.PondSurfaceAreaTotal * .TwentyFiveYrStormAdded/ INCHES_PER_FOOT) * GALLONS_PER_CUBIC_FOOT$

$.TotalRainOnToPond = .NormalRainfallOnToPondPd + .TwentyFiveYrOnToPond$

$.TotalRainOnToPondFactored = .NormalRainfallOnToPondPdFactored + .TwentyFiveYrOnToPond$

$.StoragePeriodRainfallFactored = .StoragePeriodRainfall * 1.5$

$.TotalStoragePeriodRainfallFactored = .StoragePeriodRainfallFactored + .TwentyFiveYrStormAmtAdded$

Rainfall runoff into ponds

$.NormalRainfallRunoffPd = .ConcreteNormalRunoff + .RoofNormalRunoff + .UnpavedNormalRunoff$

$$\begin{aligned}
& .NormalRainfallRunoffPdFactored = .ConcreteNormalRunoffFactored + \\
& RoofNormalRunoffFactored + .UnpavedNormalRunoffFactored \\
& .TwentyFiveYrRunoff = .ConcreteTwentyFiveYrRunoff + .RoofTwentyFiveYrRunoff + \\
& .UnpavedTwentyFiveYrRunoff \\
& .TotalRunoff = .NormalRainfallRunoffPd + .TwentyFiveYrRunoff \\
& .TotalRunoffFactored = .NormalRainfallRunoffPdFactored + .TwentyFiveYrRunoff \\
& .ConcreteTotalRunoff = .ConcreteNormalRunoff + .ConcreteTwentyFiveYrRunoff \\
& .ConcreteTotalRunoffFactored = .ConcreteNormalRunoffFactored + \\
& .ConcreteTwentyFiveYrRunoff \\
& .RoofTotalRunoff = .RoofNormalRunoff + .RoofTwentyFiveYrRunoff \\
& .RoofTotalRunoffFactored = .RoofNormalRunoffFactored + .RoofTwentyFiveYrRunoff \\
& .UnpavedTotalRunoff = .UnpavedNormalRunoff + .UnpavedTwentyFiveYrRunoff \\
& .UnpavedTotalRunoffFactored = .UnpavedNormalRunoffFactored + \\
& .UnpavedTwentyFiveYrRunoff
\end{aligned}$$

Total rainwater onto and drained into the process waste water pond for the storage period is estimated by summing the rainfall onto ponds and rainfall draining into ponds.

$$TotRainDrainedToWastePondsPd = RainfallOntoPondForPd + RainfallDrainToPond$$

Impervious Areas:

The user must enter the name of the impervious area, typically a concrete, asphalt or other water infiltration resistant surface/composition where rainfall may collect, partially infiltrate and run-off, the width and length if rectangular, if not rectangular the surface area in square feet, the number of similar areas, select if diverted into a pond, and if not describe the destination, enter a 25 year/24 hour (TF) storm and storage period (SP) run-off coefficient. No user over-rides. The software allows each precipitation type and quantity (TF and SP) to collect on each surface, converts rainfall inches to feet of rain, converts feet of rain to gallons then applies the appropriate run-off coefficient and sums the volumes to the designated destinations. For users selecting an assessment of storage capacity for normal rainfall multiplied by a factor of 1.5, storage period rainfall includes the 1.5 factor. Rainfall values for both TF and SP events are derived from user selection/entries on the Rainfall Estimates page. For rainfall areas not diverted to ponds the corresponding cumulative surface areas are displayed. The coding uses the field name “ConcreteArea” as a surrogate for “Impervious Areas”.



ConcreteAreaCalc.PhysicalSurfaceArea = PhysicalLength * PhysicalWidth (or Physical Surface Area)

ConcreteAreaCalc.TotalSquareFeet = concreteAreaCalc.PhysicalSurfaceArea * NumberOfAreas

Diverted to Ponds

ConcreteNormalRunoff += concreteAreaCalc.TotalSquareFeet * (StoragePeriodRainfall/.INCHES_PER_FOOT) * .GALLONS_PER_CUBIC_FOOT) * .StoragePeriodRunoffCoefficient

ConcreteTwentyFiveYrRunoff += concreteAreaCalc.TotalSquareFeet * (TwentyFiveYrStorm/.INCHES_PER_FOOT) * .GALLONS_PER_CUBIC_FOOT) * .TwentyFiveYrStormCoefficient

ConcreteNormalRunoffFactored += concreteAreaCalc.TotalSquareFeet * (StoragePeriodRainfallFactored/.INCHES_PER_FOOT) * .GALLONS_PER_CUBIC_FOOT) * .StoragePeriodRunoffCoefficient

Not Diverted To Ponds

ConcreteNonRunoffArea += concreteAreaCalc.TotalSquareFeet

Roof Areas:

The user must enter the name of the roofed area where rainfall may collect, the width and length if rectangular, if not rectangular the surface area in square feet, the number of similar areas, select if diverted into a pond, and if not describe the destination, and determination of rainfall collection system type. No run-off coefficient is applied to roofed areas. No user over-rides. The software allows each precipitation type and quantity (TF and SP) to collect on each surface, converts rainfall inches to feet of rain, converts feet of rain to gallons and sums the volumes to the designated destinations. For users selecting an assessment of storage capacity for normal rainfall multiplied by a factor of 1.5, storage period rainfall includes the 1.5 factor. The software sums the volumes to the designated destinations. For users selecting an assessment of storage capacity for normal rainfall multiplied by a factor of 1.5, storage period rainfall includes the 1.5 factor. Rainfall values for both TF and SP events are derived from user selection/entries on the Rainfall Estimates page. For rainfall not diverted to ponds the corresponding cumulative surface areas are displayed.



roofAreaCalc.PhysicalSurfaceArea = .PhysicalLength * .PhysicalWidth (or Physical Surface Area)
roofAreaCalc.TotalSquareFeet = roofAreaCalc.PhysicalSurfaceArea * .NumberOfAreas

Diverted to Ponds

RoofNormalRunoff += roofAreaCalc.TotalSquareFeet * (StoragePeriodRainfall/ .INCHES_PER_FOOT) * .GALLONS_PER_CUBIC_FOOT
RoofTwentyFiveYrRunoff += (roofAreaCalc.TotalSquareFeet * (TwentyFiveYrStorm/ .INCHES_PER_FOOT) * .GALLONS_PER_CUBIC_FOOT
RoofNormalRunoffFactored += (roofAreaCalc.TotalSquareFeet * StoragePeriodRainfallFactored/ .INCHES_PER_FOOT) * .GALLONS_PER_CUBIC_FOOT
Not Diverted To Pond
RoofNonRunoffArea += roofAreaCalc.TotalSquareFeet

Earthen Areas:

The user must enter the name of the earthen area, typically a soil surface (corral, roads, alleys) lacking water infiltration resistant surfaces/compositions where rainfall may collect, partially infiltrate and run-off, the width and length if rectangular, if not rectangular the surface area in square feet, the number of similar areas, select if diverted into a pond, and if not describe the destination, enter a 25 year/24 hour (TF) storm and storage period (SP) run-off coefficient. No user over-rides. The software allows each precipitation type and quantity (TF and SP) to collect on each surface, converts rainfall inches to feet of rain, converts feet of rain to gallons then applies the appropriate run-off coefficient and sums the volumes to the designated destinations. For users selecting an assessment of storage capacity for normal rainfall multiplied by a factor of 1.5, storage period rainfall includes the 1.5 factor. Rainfall values for both TF and SP events are derived from user selection/entries on the Rainfall Estimates page. For rainfall areas not diverted to ponds the corresponding cumulative surface areas are displayed. The coding uses the field name “UnpavedAreas” as a surrogate for “Earthen Areas”.



`unpavedAreaCalc.PhysicalSurfaceArea = PhysicalLength * .PhysicalWidth (or Physical Surface Area)`

`unpavedAreaCalc.TotalSquareFeet = unpavedAreaCalc.PhysicalSurfaceArea * .NumberOfAreas`

Diverted to Ponds

`UnpavedNormalRunoff += unpavedAreaCalc.TotalSquareFeet * (StoragePeriodRainfall / .INCHES_PER_FOOT) * .GALLONS_PER_CUBIC_FOOT) * .StoragePeriodRunoffCoefficient`

`UnpavedTwentyFiveYrRunoff += unpavedAreaCalc.TotalSquareFeet * (TwentyFiveYrStorm/ .INCHES_PER_FOOT) * .GALLONS_PER_CUBIC_FOOT) * .TwentyFiveYrStormCoefficient`

`UnpavedNormalRunoffFactored += unpavedAreaCalc.TotalSquareFeet * (StoragePeriodRainfallFactored/ .INCHES_PER_FOOT) * .GALLONS_PER_CUBIC_FOOT * .StoragePeriodRunoffCoefficient`

`Not Diverted To Ponds`

`UnpavedNonRunoffArea += unpavedAreaCalc.TotalSquareFeet`

Tailwater Management Areas:

The user must enter the name of each area generating tailwater, typically a soil surface (land application areas) returning wastewater into process waste water storage ponds and the volume of water in gallons for the selected storage period. Tailwater can include irrigation return and rainfall. No user over-rides. The software uses the field name “TailWater.TailWaterVolume” for each entry/field source and sums all tailwater volumes to process waste water storage ponds as “TailWaterTotalGallons” for the selected storage period. No photos.

TailWaterTotalGallons += TailWater.TailWaterVolume

Pond Capacity Computations

Storage Period:

The user must select a Storage Period from 120 to 240 days to estimate process waste water storage pond capacity. The Storage Period must be related to several factors. These factors include but are not limited to nutrient applications to crops from process waste water storage ponds on an annual basis at agronomic rates and times, process waste water accumulation on a daily basis including manure and other solids, rainfall onto process waste water storage pond surface(s), and rainfall onto roofed, impervious and earthen areas that drain into the process waste water storage ponds and evaporation losses. Controlled nutrient applications to crops from the process waste water storage pond(s) occur at different rates and times affecting process waste water storage pond capacity. A 240 day Storage Period may be appropriate for single crop systems, 180 day Storage Period may be appropriate for a double crop system, and a 120 day Storage Period may be appropriate for a triple crop system, expect variability. Many conditions can adversely extend or shorten these storage periods. It is important to plan for adequate accumulation of nutrients over time, after 120 days of nutrient accumulation only one-third of the potential nutrients generated by the herd may be available to apply to crops assuming none are applied or exported during this time period (the remainder of the year may produce an additional two thirds of the potential annual nutrient accumulation). Regulations in Central California will require the owner/operator of dairy facility process waste water storage ponds to accommodate normal runoff due to normal precipitation (minus evaporation) times a factor of one and one-half (a factor of 1.5) or include a contingency plan that addresses how excess precipitation will be managed. Conservative estimating processes should be utilized when evaluating storage capacity. Estimations of storage capacity assume all storage ponds (including settling basins) are at the minimum operating level at the beginning of the selected storage period. After completing a detailed integrated Waste and Nutrient Management Plan a more reliable estimate of Storage Period can be derived.

Storage Pond Capacity:

Approximated storage capacity is based upon standard engineering computational methods for rectangular waste water storage ponds. Note: For non-rectangular waste water storage ponds, contact a qualified professional (engineer) for assistance to certify storage capacity as sidewall slopes and pond inverts are often irregular with unpredictable bottom elevations resulting from natural topographical variation and solids accumulations near outfall points. The user must enter a pond name/description, select if the pond is

rectangular, enter the earthen length, width and depth, side slope, freeboard and dead storage loss (minimum operating level/elevation from pond invert) in feet (0.1 ft increments). If not rectangular the user must enter the pond surface area (subject to rainfall), storage volume, storage volume adjusted for dead storage loss, pond marker elevation, evaporation volume and freeboard from a qualified professional assessment, attach calculation methods to the WMP report as needed. The software estimates liquid length and width, surface area, storage volume, adjusted storage volume, evaporation volume, and pond marker elevations for rectangular ponds. Software validation controls dimensional data entry errors related to pond capacity estimates by ensuring width and length are individually greater than two times the depth multiplied by the slope to exclude any pond with less than zero bottom width. Software validation also controls dimensional data entry errors related to pond capacity estimates by evaluating dead storage loss and freeboard relationships to earthen depth ensuring that earthen depth cannot be equal to or less than zero.

SideSlope = Horizontal component of Horizontal to (:) 1 Vertical aspect

LiquidWidth = Earthen Width - (2 * SideSlope * FreeBoard)

LiquidLength = Earthen Length - (2 * SideSlope * FreeBoard)

LiquidDepth = Earthen Depth - FreeBoard

PondSurfaceArea = Earthen Width * Earthen Length

Volume 1 = LiquidWidth * LiquidLength * LiquidDepth

Volume 2 = SideSlope * (LiquidDepth ^ 2) * (LiquidWidth + LiquidLength)

Volume 3 = (4 * (SideSlope ^ 2) * (LiquidDepth ^ 3)) / 3

Pond StorageVol = (volume1 - volume 2 + volume 3)

Adjustment of storage volume for dead storage loss is an important consideration. Dead storage loss is the minimum operating level (elevation in ft. from pond invert) often dictated by equipment such as floating flush pumps which require several feet of clearance from pond liquid level to bottom of pond for reliable operation. A floating pump intake on the bottom of the process waste water storage pond may become inoperable as it comes in contact with sludge. Dead storage loss entries may also be utilized to compensate for incomplete solids removal allowance (ASABE 393.3, Section 5.2.3, page 776, at least 2 feet), treatment lagoons or other process wastewater storage ponds requiring a minimum solids or sludge volume. After correcting for dead storage losses all ponds adjusted volumes are summed in gallons then converted and displayed in cubic feet and gallons.

Volume 1 = LiquidWidth * LiquidLength * (LiquidDepth - DeadStorage)

Volume 2 = (SideSlope * ((LiquidDepth - DeadStorage) ^ 2) * (LiquidWidth + LiquidLength))

Volume 3 = (4 * (SideSlope ^ 2) * ((LiquidDepth - DeadStorage) ^ 3)) / 3

StorageVolAdjusted = (volume 1 - volume 2 + volume 3)

PondSurfaceAreaTotal += pondCalc.PondSurfaceArea

PondStorageVolTotal += pondCalc.StorageVol

PondStorageVolTotalGal += (pondCalc.StorageVol *
 .GALLONS_PER_CUBIC_FOOT)
 PondStorageVolAdjTotal += pondCalc.StorageVolAdjusted
 PondStorageVolAdjTotalGal += (pondCalc.StorageVolAdjusted *
 .GALLONS_PER_CUBIC_FOOT)

Process Wastewater, Evaporation, Pond Marker and Storage Capacity:

Process wastewater includes components entering process waste water storage ponds as manure and solids flushed to ponds, milkbarn/equipment wastewater to ponds, fresh flush water to ponds, tailwater to ponds, normal or factored rainfall onto ponds, normal or factored rainfall into ponds, 25-year/24-hour storm onto ponds and 25-year/24-hour storm into ponds. Evaporation losses are estimated by applying a default evaporation rate or over-ride to the adjusted pond surface area. Evaporation data source is California Department of Water Resources, a single value for each County in the Central Valley. Evaporation rates can be affected significantly by pond liquid surface area exposure to climatic factors and conditions including wind, periods of high humidity, prolonged fog and lack of sunlight, and solids accumulation on the surface, considering these factors, a surface area reduction factor of 75% is applied. Pond markers are required by regulation as a visual aide to operators for estimating residual capacity for a 25-year/24-hour storm to control discharges. Pond marker elevation is estimated by subtracting the 25-year/24-hour storm onto and into each pond. Pond marker elevation is displayed in tenths of one foot accuracy and is estimated by subtracting freeboard from pond earthen depth and final pond depth considering user entered pond physical dimensions.

.ProcessWastewaterPd = .FlushToPondGpp + .BarnwaterToPondPd +
 .FreshWaterInFlushLnsPd + .TailWaterTotalGallons + .NormalRainfallOnToPondPd +
 .NormalRainfallRunoffPd + .TwentyFiveYrOnToPond + .TwentyFiveYrRunoff

.ProcessWastewaterPdFactored = .FlushToPondGpp + .BarnwaterToPondPd +
 .FreshWaterInFlushLnsPd + .TailWaterTotalGallons +
 .NormalRainfallOnToPondPdFactored + .NormalRainfallRunoffPdFactored +
 .TwentyFiveYrOnToPond + .TwentyFiveYrRunoff

.BarnWaterAndOtherWasteTotal = .BarnwaterToPondPd + .FreshWaterInFlushLnsPd +
 .TailWaterTotalGallons

Average process wastewater each day

.ProcessWastewater = .ProcessWastewaterPd/.StoragePeriodDays

.ProcessWastewaterFactored = .ProcessWastewaterPdFactored/.StoragePeriodDays

Estimating Pond Evaporation

pondSurfPrct = .PondSurfaceArea /.PondSurfaceAreaTotal

pondRunoffAmt = wmpCalc.TwentyfiveYrRunoff * pondSurfPrct

Rain onto and drained into the pond for the 25 year / 24 hour storm event

.StormToPondGals = (.PondSurfaceArea * .TwentyFiveYrStorm/.INCHES_PER_FOOT)

* .GALLONS_PER_CUBIC_FOOT + pondRunoffAmt

Initial depth estimate of the pond after removing the 25year/24hour storm
.InitialPondDepthEstimate = (.StormToPondGals * .CUBIC_FEET_PER_GALLON)
/.FullPondSurfaceArea

Pond surface area considering side slope
.AdjustedPondSurfaceArea = (.LiquidLength - (.InitialPondDepthEstimate *
Pond.SideSlope)) * (.LiquidWidth - (.InitialPondDepthEstimate * Pond.SideSlope))

Adjusted pond surface area with side slope factored to the combined adjusted pond
surface area of all ponds
.AdjustedPondSurfaceAreaTot += .AdjustedPondSurfaceArea

Pond depth estimate for the adjusted pond surface area
.FinalPondDepthEstimate = (.StormToPondGals * .CUBIC_FEET_PER_GALLON) /
.AdjustedPondSurfaceArea)

Final pond liquid depth estimate estimates for all ponds
.FinalPondDepthEstimateTot += .FinalPondDepthEstimate

Estimation of pond marker elevation
.PondMarkerElevation = Pond.EarthDepth - Pond.FreeBoard - .FinalPondDepthEstimate

Estimated loss due to evaporation with surface area reduction factor (conservatively
reduced by 25%)
.PondEvaporationGals = .AdjustedPondSurfaceArea * StoragePeriodEvapRateFeet *
.GALLONS_PER_CUBIC_FOOT * .SURFACE_AREA_FACTOR

Gallons lost to evaporation any pond to the total gallons lost from evaporation for all
ponds
.TotalEvaporationGals += .PondEvaporationGals

Total gallons required for storage
.TotalStorageReqdGals = .ProcessWastewaterPd - .TotalEvaporationGals
.TotalStorageReqdGalsFactored = .ProcessWastewaterPdFactored -
.TotalEvaporationGals

Total capacity required for storage
.TotalStorageReqdFt = .TotalStorageReqdGals / .GALLONS_PER_CUBIC_FOOT
.TotalStorageReqdFtFactored = .TotalStorageReqdGalsFactored /
.GALLONS_PER_CUBIC_FOOT
.TotalStorageAvailableCfpp = .PondStorageVolAdjTotal
.TotalStorageAvailableGals = .TotalStorageAvailableCfpp *
.GALLONS_PER_CUBIC_FOOT
.TotalStorageDifferenceGals = .TotalStorageAvailableGals - .TotalStorageReqdGals

Total storage capacity meets or exceeds the total storage capacity required
.StorageExceedsReq if .TotalStorageReqdFt <= .TotalStorageAvailableCfpp
.StorageExceedsReqFactored if .TotalStorageReqdFtFactored <=
.TotalStorageAvailableCfpp

Field Name Suffixes, Constants and Conversion Factors

The following field name suffixes, constants and conversion factors are utilized in several WMP computations:

SYMBOLS and OPERATIONS

Equals : =

Sum : +

Subtract : -

Multiply : *

Divide : /

Less Than : <

Greater Than : >

Function to Sum in loops (add to previous): +=

FIELD NAMES and SUFFIXES

Pounds Per Day (lbs/day) = Ppd

Cubic Feet Per Day (cf/day) = Cfpd

Cubic Feet Per Period (cf/period) = Cfpp

Gallons Per Day (gallons/day) = Gpd

Gallons Per Period (gallons/period) = Gpp

AREA

Number of square feet in an acre

SQUARE_FEET_PER_ACRE = 43,560

Evaporation surface area reduction factor

SURFACE_AREA_FACTOR = 0.75

DENSITY

Water density in lbs/cu.ft.

WATER_DENSITY = 62.4

LENGTH

Number of inches in a foot

INCHES_PER_FOOT = 12

MANURE and BEDDING SOLIDS REMOVAL

Manure density in lbs/cu.ft. (from ASAE 384.2 tables)

MANURE_DENSITY

MILK_COW = 62.5

DRY_COW = 63.8

HEIFER = 61.5

CALF = 63.3

MANURE and BEDDING SOLIDS REMOVAL (continued)

Manure bedding density in lbs/cu.ft.

MANURE_BEDDING_DENSITY = 40

Manure solids density in lbs/cu.ft.

MANURE_SOLIDS_DENSITY = 50

Moisture factor for separated manure solids

SEPARATION_PARTICLE_MOISTURE = 1.33

Manure bedding separation efficiency percentage

MANURE_BEDDING_REMOVAL_EFF = 0.50

Pond solids volume reduction factor (ASABE 393.3)

SOLIDS_VOLUME_REDUCTION_FACTOR = 0.5

Manure excreted in lbs/head/day (from ASAE 384.2 tables)

MANURE_EXCRETION_WEIGHT

Note: Only CALF table value below is used

MILK_COW = 150

DRY_COW = 83

HEIFER = 48

CALF = 19

Manure excreted in cu.ft./head/day (from ASAE 384.2 tables)

MANURE_EXCRETION

Note: Only CALF table value below is used.

MILK_COW = 2.4

DRY_COW = 1.3

HEIFER = 0.78

CALF = 0.3

Manure Solids excreted in lbs/head/day (from ASAE 384.2 tables)

SOLID_EXCRETION

MILK_COW = 20

DRY_COW = 11

HEIFER = 8.2

CALF = 3.2

TIME

Number of minutes per hour

MINS_PER_HOUR = 60

Average number of days in a year

AVG_DAYS_PER_YEAR = 365

VOLUME

Number of cubic feet in a gallon of water

CUBIC_FEET_PER_GALLON = 0.13368055

Number of gallons in a cubic foot

GALLONS_PER_CUBIC_FOOT = 7.48051945

Number of cubic feet in a cubic yard

CUFT_PER_CUYD = 27

WEIGHT

Weight of a gallon of water in pounds

LBS_PER_GAL_WATER = 8.345

Number of pounds in a short ton

LBS_PER_TON = 2000

Number of pounds in a kilogram

LBS_PER_KG = 2.20462262

Number kilogram in a pounds

KG_PER_LB = 0.45359237