

California Central Valley Dairy Waste and Nutrient Management

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 Preliminary Dairy Facility Assessment (PDFa) module, a component of a larger internet based California dairy compliance software application. The Preliminary Dairy Facility Assessment is only intended to provide a preliminary assessment of your dairy facility's ability to store wastewater generated at your dairy and the ability of your cropland to utilize the nutrients generated at your dairy. PDFa calculations are preliminary and approximate only. Completion of your Waste Management Plan and Nutrient Management Plan will provide you with more detailed and precise calculations upon which to make important decisions. Computational methods provided below 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 was developed with a grant from the California State Water Resources Control Board, Agreement Number 05-095-550-0.

Herd Computations

All manure volumes, nitrogen and phosphorus excretion daily subtotals are stored, summed then multiplied by 365 days to obtain annual totals for reporting outputs regarding nutrient balance estimates. All manure volumes, nitrogen and phosphorus excretion daily subtotals are stored, summed then multiplied by the storage period selected by the user (120 – 240 days) and partitioned to dry lot storage or process waste water storage for reporting outputs regarding process waste water storage pond capacity estimates. Partitioning to dry lot storage 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. 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 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.

Herd Manure (Volume) Excretion:

Approximated volume of manure 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, page 2. Total Manure (ft³/d-a) table values for calves. Calf excretion computations utilize an ASABE Table value of 0.30 cu. ft. Manure/head/day. Terminal position divisor (ie - 62.5) is the moisture content (% w.b.)-density based value of manure for the particular maturity stage listed. Waste is either partitioned to dry lot storage or to waste water storage ponds based upon hours on flush.

milk = AvgMilkProduction (lbs) / 2.2 (Converts lbs of milk to kg of milk)

ManureExcEquMilkcows = (((milk * 0.647) + 43.212) * 2.2) / 62.5

ManureExcEquDrycows = (((DryCowAvgWeight / 2.2) * 0.022) + 21.844) * 2.2 / 63.8

ManureExcEquHef15to24 = (((Heifer15To24AvgWeight / 2.2) * 0.018) + 17.817) * 2.2 / 61.5

ManureExcEquHef7to14 = (((Heifer7To14AvgWeight / 2.2) * 0.018) + 17.817) * 2.2 / 61.5

ManureExcTb1Cav3to6 = 0.30

ManureExcTb1Cav0to3 = 0.30

ManureExcMilkcows = MilkCowCount * ManureExcEquMilkcows

ManureExcDrycows = DryCowCount * ManureExcEquDrycows

$\text{ManureExcHef15to24} = \text{Heifer15To24Count} * \text{ManureExcEquHef15to24}$
 $\text{ManureExcHef7to14} = \text{Heifer7To14Count} * \text{ManureExcEquHef7to14}$
 $\text{ManureExcCav3to6} = \text{Calf4To6Count} * \text{ManureExcTblCav3to6}$
 $\text{ManureExcCav0to3} = \text{CalfTo3Count} * \text{ManureExcTblCav0to3}$

$\text{ManureExcCompTotal} = \text{ManureExcMilkcows} + \text{ManureExcDrycows} + \text{ManureExcHef15to24} +$
 $\text{ManureExcHef7to14} + \text{ManureExcCav3to6} + \text{ManureExcCav0to3}$

$\text{ManureToPondsMilkcows} = \text{ManureExcMilkcows} * \text{storagePeriodDays} * (\text{MilkCowFlushHours}/24)$
 $\text{ManureToPondsDrycows} = \text{ManureExcDrycows} * \text{storagePeriodDays} * (\text{DryCowFlushHours}/24)$
 $\text{ManureToPondsHef15to24} = \text{ManureExcHef15to24} * \text{storagePeriodDays} * (\text{Heifer15To24FlushHours}/24)$
 $\text{ManureToPondsHef7to14} = \text{ManureExcHef7to14} * \text{storagePeriodDays} * (\text{Heifer7To14FlushHours}/24)$
 $\text{ManureToPondsCav3to6} = \text{ManureExcCav3to6} * \text{storagePeriodDays} * (\text{Calf4To6FlushHours}/24)$
 $\text{ManureToPondsCav0to3} = \text{ManureExcCav0to3} * \text{storagePeriodDays} * (\text{CalfTo3FlushHours} / 24)$

$\text{ManureToDrylotMilkcows} = \text{ManureExcMilkcows} * \text{storagePeriodDays} * ((24 - \text{MilkCowFlushHours})/24)$
 $\text{ManureToDrylotDrycows} = \text{ManureExcDrycows} * \text{storagePeriodDays} * ((24 - \text{DryCowFlushHours})/24)$
 $\text{ManureToDrylotHef15to24} = \text{ManureExcHef15to24} * \text{storagePeriodDays} * ((24 -$
 $\text{Heifer15To24FlushHours})/24)$
 $\text{ManuretoDrylotHef7to14} = \text{ManureExcHef7to14} * \text{storagePeriodDays} * ((24 -$
 $\text{Heifer7To14FlushHours})/24)$
 $\text{ManureToDrylotCav3to6} = \text{ManureExcCav3to6} * \text{storagePeriodDays} * ((24 - \text{Calf4To6FlushHours})/24)$
 $\text{ManureToDrylotCav0to3} = \text{ManureExcCav0to3} * \text{storagePeriodDays} * ((24 - \text{CalfTo3FlushHours})/24)$

$\text{TotManureProdForPeriod} = \text{ManureExcCompTotal} * \text{storagePeriodDays}$

$\text{TotManureForPeriodPonds} = (\text{ManureToPondsMilkcows} + \text{ManureToPondsDrycows} +$
 $\text{ManureToPondsHef15to24} +$
 $\text{ManureToPondsHef7to14} + \text{ManureToPondsCav3to6} + \text{ManureToPondsCav0to3})$

$\text{TotManureForPeriodDrylot} = \text{TotManureProdForPeriod} - \text{TotManureForPeriodPonds}$

Herd Nitrogen Excretion:

Approximated nitrogen excretions based upon March 2005, ASABE 384.2, Section 5.3.7, Equation 16, page 8 for milk cows, Section 1, Table 1.b, page 2 values for dry cows (0.50) heifers (0.26), and calves (0.14) lbs Nitrogen/head/day with a 30% (mid point of 20 – 40% range) atmospheric nitrogen loss [per Managing Dairy Manure in the Central Valley of California (University of California, Division of Agriculture and Natural Resources, Committee of Experts on Dairy Manure Management, June 2005)]. Waste is either partitioned to dry lot storage or to process waste water storage ponds based upon hours on flush utilizing the same computational methodology listed in manure volumes to dry lot storage or process waste water pond storage above.

$\text{milk} = \text{AvgMilkProduction} \text{ (lbs)} / 2.2 \text{ (Converts lbs of milk to kg of milk)}$

$\text{NitrogenExcTblMilkcows} = ((\text{milk} * 4.204) + 283.3) / 454$
 $\text{NitrogenExcTotMilkcows} = \text{MilkCowCount} * \text{NitrogenExcTblMilkcows}$
 $\text{NitrogenExcTotDrycows} = \text{DryCowCount} * \text{NitrogenExcTblDrycows} (0.50)$
 $\text{NitrogenExcTotHef15to24} = \text{Heifer15To24Count} * \text{NitrogenExcTblHef15to24} (0.26)$
 $\text{NitrogenExcTotHef7to14} = \text{Heifer7To14Count} * \text{NitrogenExcTblHef7to14} (0.26)$
 $\text{NitrogenExcTotCav3to6} = \text{Calf4To6Count} * \text{NitrogenExcTblCav3to6} (0.14)$
 $\text{NitrogenExcTotCav0to3} = \text{CalfTo3Count} * \text{NitrogenExcTblCav0to3} (0.14)$

$\text{NitrogenExcCompTotal} = \text{NitrogenExcTotMilkcows} + \text{NitrogenExcTotDrycows} +$
 $\text{NitrogenExcTotHef15to24} + \text{NitrogenExcTotHef7to14} + \text{NitrogenExcTotCav3to6} +$
 $\text{NitrogenExcTotCav0to3}$

$\text{AnnualNitrogenToPond} = (\text{ExcretedPerDay} * 365) * (\text{FlushHours} / 24) * 0.7$
 $\text{HoursOnDrylot} = 24 - \text{FlushHours}$

$$\text{AnnualNitrogenToDrylot} = (\text{ExcretedPerDay} * 365) * (\text{hoursOnDrylot} / 24) * 0.7$$

Herd Phosphorus Excretion:

Approximated phosphorus excretions based upon March 2005, ASABE 384.2, Section 5.3.10, Equation 22, page 8, excretion equations for milk cows, Section 1, Table 1.b, page 2., values for dry cows (0.066), heifers (0.0440), and calves as dairy veal (0.0099) lbs Phosphorus/head/day in the absence of calf values. Waste is either partitioned to dry lot storage or to process waste water storage ponds based upon hours on flush utilizing the same computational methodology listed in manure volumes to dry lot storage or process waste water pond storage above.

$$\text{milk} = \text{AvgMilkProduction} / 2.2 \text{ (Converts lbs of milk to kg of milk)}$$

$$\text{PhosExcTblMilkcows} = (((\text{milk} * 0.773) + 46.015) * 2.2) / 1000$$

$$\text{PhosExcTotMilkcows} = \text{MilkCowCount} * \text{PhosExcTblMilkcows}$$

$$\text{PhosExcTotDrycows} = \text{DryCowCount} * \text{PhosExcTblDrycows} (0.066)$$

$$\text{PhosExcTotHef15to24} = \text{Heifer15To24Count} * \text{PhosExcTblHef15to24} (0.0440)$$

$$\text{PhosExcTotHef7to14} = \text{Heifer7To14Count} * \text{PhosExcTblHef7to14} (0.0440)$$

$$\text{PhosExcTotCav3to6} = \text{Calf4To6Count} * \text{PhosExcTblCav3to6} (0.0099)$$

$$\text{PhosExcTotCav0to3} = \text{CalfTo3Count} * \text{PhosExcTblCav0to3} (0.0099)$$

$$\text{PhosExcCompTotal} = \text{PhosExcTotMilkcows} + \text{PhosExcTotDrycows} + \text{PhosExcTotHef15to24} + \text{PhosExcTotHef7to14} + \text{PhosExcTotCav3to6} + \text{PhosExcTotCav0to3}$$

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 automatic or manual valve use each time the milk tank is emptied (MilkTankCleaningsPerDay) using approximately 75 gallons of water/cleaning agent for each cycle, most operations use a two to four vat cycle process (rinse, detergent wash, rinse, acidification/sanitizer) which is user entered. Milk tank cleanings per day are multiplied by the number of bulk milk tank vat cycles entered multiplied by 75 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.

$$\text{BulkTankWashVol} = \text{MilkTankCleaningsPerDay} * \text{BulkTankWashCycles} * 75$$



Pipeline Wash and Sanitizing:

Approximated volume of waste water based upon automatic or manual valve use each time a milking event is complete (MilkingsPerDay) using approximately 200 gallons of water/cleaning agent for each cycle, most operations use a two to four vat cycle process (rinse, detergent wash, rinse, acidification/sanitizer) which is user entered. Milkings per day are multiplied by the number of vat cycles multiplied by 200 gallons for each cycle (assumes moderate pipeline lengths, adequate air injector performance, numerous milking stations, heat exchange equipment, etc., which 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.

$$\text{PipelineWashVol} = \text{MilkingsPerDay} * \text{PipelineWashCycles} * 200$$



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 Deck (Floor) Flush Valve:

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) and 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 Deck (Floor) Flush section.

MilkingsPerDay * 1000 gallons * 2 * 2.5 = gallons per day

Traditional Manual Parlor Deck (Floor) Flush:

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).

MilkCowCount/CowsPerString = Strings sent to milkhous per milking, so;
Strings * 1000 gallons per string * MilkingsPerDay = gallons per day



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). 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 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. 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.).

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



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 PDFFA combines pump, compressor and chiller flows/throughputs for the automated/default computation. Approximated value can be over-riden with a manual entry (ie-more efficient water use, compressor only, etc...) as gallons per day. 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 is estimated by multiplying the gallons of water used per head per day by total number of animals in herd. User selects source of drinking water (fresh or from reuse). Drinking water volume from recycled sources leave system, does not enter process waste water storage pond(s).

$$\text{DrinkingWaterAmount} = \text{GallonsHeadDay} * \text{TotalAnimals}$$

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 (MilkCowCount/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.

$$\text{SprinklerPenWastewaterGen} = (\text{SprinklerCount} * \text{SprinklerCycleLength} * \text{SprinklerCyclesPerString} * \text{SprinklerFlowRate}) * (\text{MilkCowCount}/\text{CowsPerString})$$

$$\text{PenWastewaterVol} = (\text{SprinklerPenWastewaterGen} * \text{MilkingsPerDay})$$



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. 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 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.

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



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. 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 the 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 or include a contingency plan that addresses how excess precipitation will be managed. Conservative estimating processes should be utilized when evaluating storage capacity. 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, sidewall slopes and pond inverts are often irregular with unpredictable bottom elevations resulting from natural topographical variation and solids accumulations near outfall points.

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 = LiquidWidth * LiquidLength * LiquidDepth

Value2 = SideSlope * (LiquidDepth ^ 2) * (LiquidWidth + LiquidLength)

Value3 = (4 * (SideSlope ^ 2) * (LiquidDepth ^ 3)) / 3

Pond StorageVol = (volume - value2 + value3)

Adjustment of storage volume for dead storage loss is an important consideration. Dead storage loss is the minimum operating level (ft.) 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.

Volume = LiquidWidth * LiquidLength * (LiquidDepth - DeadStorage)

Value2 = (SideSlope * ((LiquidDepth - DeadStorage) ^ 2) * (LiquidWidth + LiquidLength))

Value3 = (4 * (SideSlope ^ 2) * ((LiquidDepth - DeadStorage) ^ 3)) / 3

StorageVolAdjusted = (volume - value2 + value3)

Rainfall Into and Onto Ponds:

Approximated volume of rainfall draining into ponds is estimated by a user entry for area in acres (including roofed, impervious, and earthen areas) that receives rainfall which drains to the process waste water storage pond(s). Total runoff area acreage is multiplied by 43,560 square feet per acre to establish the total runoff area in square feet. Total rainfall is estimated by a 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), no user over-ride for these values. The 25-year/24-hour storm and storage period rainfall are summed to derive total rainfall. Amount of rainfall drained into pond(s) for the storage period is estimated by dividing the total rainfall inches by 12 to obtain feet of rainfall, multiplied by surface area (Total Runoff Area as roofed, impervious, and earthen area draining into process waste water storage ponds), then multiplied by 7.48051945 gallons per cubic foot to obtain gallons of rainfall into the pond(s) for the selected storage period. No evaporation loss or run-off coefficients are applied in the PDFFA. The companion Waste Management Plan module to this software will estimate evaporation losses and apply run-off coefficients to accurately measured surface areas entered by the user.

$$\text{TotalRunoffArea} = \text{RoofedImperviousEarthenAreaAcres} * 43,560$$

$$\text{TotalRainfall} = \text{TwentyFiveYrStormAmt} + \text{StoragePeriodRainfall}$$

$$\text{RainfallDrainToPond} = \text{TotalRunoffArea} * (\text{TotalRainfall}/12) * 7.48051945$$

Approximated volume of rainfall onto pond for the storage period is derived by summing the surface areas (earthen widths x earthen lengths) for all process waste water storage ponds to establish a pond surface area total in square feet. Divide the total rainfall by 12 to obtain feet of rainfall, multiply by pond surface area total, then multiply by 7.48051945 to obtain gallons of rainfall onto the pond for storage period.

$$\text{RainfallOntoPondForPd} = \text{PondSurfaceAreaTotal} * (\text{TotalRainfall}/12) * 7.48051945$$

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.

$$\text{TotRainDrainedToWastePondsPd} = \text{RainfallOntoPondForPd} + \text{RainfallDrainToPond}$$

Nutrient Removal, Imports and Exports

Nutrient Removal:

Approximated nutrient removal by crops (Apparent Nitrogen Recovery/ANR as one example) is based upon standard agronomic computational methods. Software utilizes a 0.16 factor for conversion of protein to nitrogen and 2000 conversion factor for pounds per ton. Moisture content (%), protein (%), phosphorus (lbs of P per unit of yield), yield (tons/acre), acres planted (acres) and crop type/name are user selected/entered. Nitrogen removal rates are sensitive to moisture content, phosphorus removal rates are not sensitive moisture content (see computations below). A crop criteria/nutrient content help table is available in the PDFFA, Nutrient Removal by Crops Estimates page. All computational nutrient uptake results are displayed in lbs.

Nitrogen removal.

$$\text{NitrogenRemoval} = (1 - \text{moisture} (\%)) * \text{protein} (\%) * 0.16 * 2000 * \text{yield} (\text{tons}) * \text{planted} (\text{acres})$$

Phosphorus removal.

$$\text{PhosphorusRemoval} = \text{yield} (\text{tons}) * \text{phosphorus} (\text{lbs P per unit of yield}) * \text{planted} (\text{acres})$$

Nutrient Imports:

Approximated nutrient imports based upon standard agronomic annualized computational methods. Nitrogen (lbs), phosphorus (lbs) as P₂O₅, and Potassium (lbs) as K₂O are user selected/entered considering all sources of nutrients brought onto the dairy (commercial fertilizers, manure, bedding, etc...). Software utilizes 0.437 for P₂O₅ to Phosphorus and 0.83 for K₂O to Potassium conversion. All computational results are displayed in lbs.

Nitrogen Imported in lbs = Nitrogen Imported in lbs, no change in displayed or user selected/entered value.

Phosphorus Imported.

PhosImportedAsP205 (corrected to P) = PhosphorusImported (lbs) * 0.437

Potassium Imported.

PotasImportedAsK20 (corrected to K) = PotassiumImported (lbs) * 0.83

Annual Nitrogen Deposition

Annual Nitrogen Deposition Rate from atmosphere is estimated at 14 lbs Nitrogen/acre/year (Managing Dairy Manure in the Central Valley of California, University of California, Division of Agriculture and Natural Resources, Committee of Experts on Dairy Manure Management, June 2005, page 37] multiplied by the number of crop acres entered by the user. No user over-ride.

ANDNPerYear = ManuredCropAcres * 14

Nutrient Exports:

Approximated nutrient exports based upon standard agronomic computational methods. Software utilizes a 2000 conversion factor for pounds per ton, 8.34 conversion factor for pounds per gallon, and 1 million for mg/L conversions. Solids are expressed as tons, liquids as gallons, moisture content (%), nitrogen (% for solids, mg/L for liquids), and phosphorus (%) content are user selected/entered. Component composition varies widely (temporal and spatial), use of actual/laboratory derived values are recommended for moisture, nitrogen, and phosphorus content, no default or recommended values are provided. Weights and volumes of exported nutrients must be accurate. All computational nutrient uptake results are displayed in lbs.

SeparatorSolidsNitroCalc = (1 - SeparatorSolidsMoisture (%)) * SeparatorSolidsNitrogen (%) * 2000 * SeparatorSolidsExported (Tons)

SeparatorSolidsPhosCalc = (1 - SeparatorSolidsMoisture (%)) * SeparatorSolidsPhosphorus (%) * 2000 * SeparatorSolidsExported (Tons)

CorralSolidsNitroCalc = (1 - CorralSolidsMoisture (%)) * CorralSolidsNitrogen (%) * 2000 * CorralSolidsExported (Tons)

CorralSolidsPhosCalc = (1 - CorralSolidsMoisture (%)) * CorralSolidsPhosphorus (%) * 2000 * CorralSolidsExported (Tons)

LiquidManureNitroCalc = (LiquidManureExported (gallons) * 8.34 * LiquidManureNitrogen (mg/L) / 1000000

CalcsRow.LiquidManurePhosCalc = (LiquidManureExported (gallons) * 8.34 * LiquidManurePhosphorus (mg/L) / 1000000

Whole Farm Nitrogen Balance

Approximated nitrogen balance computation estimates the sum of total nitrogen in storage minus total nitrogen exported plus nitrogen imported plus irrigation nitrogen plus atmospheric nitrogen divided by nitrogen removal by crops. If the Whole Farm Nitrogen Balance is greater than 1.65, the proposed cropping rotation(s) may not be capable of removing the nitrogen applied on an annual basis, (based upon California Regional Water Quality Control Board Central Valley Region, Order No. R5-2007-0035, Waste Discharge Requirements General Order For Existing Milk Cow Dairies, page 22). No user over-ride. Irrigation nitrogen contribution values are not assessed in the PDFA (would require major data collection effort for each dairy before December 31, 2007 PDFA due date), however, the calculation for Whole Farm Nitrogen Balance without irrigation nitrogen contribution can only be conservatively low. The Nutrient Management Plan companion software module includes all five forms of nitrogen for a more comprehensive balance estimate.

Whole Farm Nitrogen Balance = (Totalnitrogeninstorage - Totalnitrogenexported + Nitrogenimported + Irrigation nitrogen + Atmospheric nitrogen (ANDN)) / nitrogen removal by crops