California Central Valley Dairy Waste and Nutrient Management
Nutrient 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 Nutrient Management Plan (NMP) module, a component of a larger internet based dairy compliance software application specific to California's Central Valley. The NMP is intended to provide a detailed assessment of a dairy facility resulting in the creation and implementation of a sampling and analysis plan and nutrient budget protective of water resources related to the collection, transport and application of solid and liquid manure and other nutrients. Computations utilized in the NMP module are approximations from process based assessment approaches to facility specific nutrient generation as manure and subsequent land application, import, export and management practices in a relatively open biological system. Completion of a NMP 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 NMP will require review and signature by a specialist who is certified in developing nutrient management plans. A certified specialist is a Professional Soil Scientist, Professional Agronomist, or Crop Advisor certified by the American Society of Agronomy or a Technical Service Provider certified in nutrient management in California by the Natural Resources Conservation Service (NRCS). The Central Valley Regional Water Quality Control Board Executive Officer may approve alternative proposed specialists. Computational methods utilized are typically conservative (high) values. 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 nutrient excretion daily subtotals are stored, summed then multiplied by 365 days to obtain annual totals for reporting outputs regarding nitrogen, phosphorus and potassium estimates. All herd manure nutrient excretion daily subtotals are stored, summed then partitioned to dry lot storage or process waste water storage for reporting output 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. Flush manure management systems may result in higher manure collection efficiencies.

Herd Manure Nitrogen, Phosphorus, and Potassium Excretion:
Approximated nitrogen composition of manure excreted based upon March 2005, American Society of Agricultural and Biological Engineers (ASABE, formerly ASAE) 384.2, Section 5.3.7, Equation 16, page 8 for milk cows, and Table1.b, Section 3, page 2 table values for dry cows, heifers, and calves. Approximated phosphorus composition of manure excreted based upon March 2005, American Society of Agricultural and Biological Engineers (ASABE, formerly ASAE) 384.2, Section 5.3.10, Equation 22, page 8 for milk cows, and Table1.b, Section 3, page 2 table values for dry cows, heifers, and calves. Approximated potassium composition of manure excreted based upon March 2005, American Society of Agricultural and Biological Engineers (ASABE, formerly ASAE) 384.2, Section 5.3.13, Equation 26, page 8 for milk cows, and Table1.b, Section 3, page 2 table values for dry cows. Potassium excretion estimates for heifers, and calves are excluded at this time. Table value nutrient excretion rates from ASABE 384.2 are displayed in this document as constants in the Field Name Suffixes, Constants and Conversion Factors appendix. Waste is either partitioned to dry lot storage or to process waste water storage ponds based upon hours on flush and solids separation processes.

It is important to note that much like manure solids excretion, nutrient 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 collection efficiencies, separation processes, liquid manure 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, volumes, and nutrient composition affecting nutrient budget/balance estimates.

Nitrogen excreted per day per maturity in pounds.
milk = AvgMilkProduction * KG_PER_LB

HerdNPerDayMilkCow = MaxMilkCowCount * ((milk * 4.204) + 283.3) * KG_PER_G * LBS_PER_KG
HerdNPerDayDryCow = MaxDryCowCount * NITROGEN_EXCRETION.DRY_COW
HerdNPerDayHeifer15To24 = MaxHeifer15To24Count * NITROGEN_EXCRETION.HEIFER
HerdNPerDayHeifer7To14 = MaxHeifer7To14Count * NITROGEN_EXCRETION.HEIFER
HerdNPerDayCalf4To6 = MaxCalf4To6Count * NITROGEN_EXCRETION.CALF
HerdNPerDayCalfTo3 = MaxCalfTo3Count * NITROGEN_EXCRETION.CALF

Phosphorus excreted per day per maturity in pounds.

HerdPPerDayMilkCow = MaxMilkCowCount * ((milk * 0.773) + 46.015) * KG_PER_G * LBS_PER_KG
HerdPPerDayDryCow = MaxDryCowCount * PHOSPHORUS_EXCRETION.DRY_COW
HerdPPerDayHeifer15To24 = MaxHeifer15To24Count * PHOSPHORUS_EXCRETION.HEIFER
HerdPPerDayHeifer7To14 = MaxHeifer7To14Count * PHOSPHORUS_EXCRETION.HEIFER
HerdPPerDayCalf4To6 = MaxCalf4To6Count * PHOSPHORUS_EXCRETION.CALF
HerdPPerDayCalfTo3 = MaxCalfTo3Count * PHOSPHORUS_EXCRETION.CALF

Potassium excreted per day per maturity in pounds (heifers and calves excluded at this time).
HerdKPerDayMilkCow = MaxMilkCowCount * ((milk * 1.800) + 31.154) * KG_PER_G * LBS_PER_KG
HerdKPerDayDryCow = MaxMilkCowCount * POTASSIUM_EXCRETION.DRY_COW

Nitrogen herd totals per day in pounds.
HerdNPerDayTotal = HerdNPerDayMilkCow + HerdNPerDayDryCow + HerdNPerDayHeifer15To24 + HerdNPerDayHeifer7To14 + HerdNPerDayCalf4To6 + HerdNPerDayCalfTo3

Nitrogen herd total per year in pounds.
HerdNPerYearTotal = HerdNPerDayTotal * AVG_DAYS_PER_YEAR

Phosphorus herd totals per day in pounds.
HerdPPerDayTotal = HerdPPerDayMilkCow + HerdPPerDayDryCow + HerdPPerDayHeifer15To24 + HerdPPerDayHeifer7To14 + HerdPPerDayCalf4To6 + HerdPPerDayCalfTo3

Phosphorus herd total per year in pounds.
HerdPPerYearTotal = HerdPPerDayTotal * AVG_DAYS_PER_YEAR

Potassium herd totals per day in pounds.
HerdKPerDayTotal = HerdKPerDayMilkCow + HerdKPerDayDryCow

Potassium herd total per year in pounds.
HerdKPerYearTotal = HerdKPerDayTotal * AVG_DAYS_PER_YEAR

Nitrogen to flush system herd total per day in pounds.
dailyNToFlush = HerdNPerDayMilkCow * MilkCowFlushHours / 24 + HerdNPerDayDryCow * DryCowFlushHours / 24 + HerdNPerDayHeifer15To24 * Heifer15To24FlushHours / 24 + HerdNPerDayHeifer7To14 * Heifer7To14FlushHours / 24 + HerdNPerDayCalf4To6 * Calf4To6FlushHours / 24 + HerdNPerDayCalfTo3 * CalfTo3FlushHours/ 24

Nitrogen to dry lot herd total per day in pounds.

dailyNToDrylot = HerdNPerDayMilkCow * (24 - MilkCowFlushHours) / 24 + HerdNPerDayDryCow * (24 - DryCowFlushHours) / 24 + HerdNPerDayHeifer15To24 * (24 - Heifer15To24FlushHours) / 24 + HerdNPerDayHeifer7To14 * (24 - Heifer7To14FlushHours) / 24 + HerdNPerDayCalf4To6 * (24 - Calf4To6FlushHours) / 24 +HerdNPerDayCalfTo3 * (24 - CalfTo3FlushHours) / 24

Apply loss to atmosphere and convert to an annual value.
HerdNPerYearToFlush = dailyNToFlush * RESIDUAL_N_AFTER_LOSS * AVG_DAYS_PER_YEAR
HerdNPerYearToDrylot = dailyNToDrylot * RESIDUAL_N_AFTER_LOSS * AVG_DAYS_PER_YEAR
HerdNPerYearInStorage = HerdNPerYearToFlush + HerdNPerYearToDrylot

Phosphorus to flush system herd total per day in pounds.
dailyPToFlush = HerdPPerDayMilkCow * MilkCowFlushHours / 24 + HerdPPerDayDryCow * DryCowFlushHours / 24 + HerdPPerDayHeifer15To24 * Heifer15To24FlushHours / 24 + HerdPPerDayHeifer7To14 * Heifer7To14FlushHours / 24 + HerdPPerDayCalf4To6 * Calf4To6FlushHours / 24 + HerdPPerDayCalfTo3 * CalfTo3FlushHours/ 24

Phosphorus to dry lot herd total per day in pounds.
dailyPToDrylot = HerdPPerDayMilkCow * (24 - MilkCowFlushHours) / 24 + HerdPPerDayDryCow * (24 -.DryCowFlushHours) / 24 + HerdPPerDayHeifer15To24 * (24 - Heifer15To24FlushHours) / 24 + HerdPPerDayHeifer7To14 * (24 - Heifer7To14FlushHours) / 24 + HerdPPerDayCalf4To6 * (24 - Calf4To6FlushHours) / 24 + HerdPPerDayCalfTo3 * (24 - CalfTo3FlushHours) / 24

Convert to an annual Phosphorus value.
HerdPPerYearToFlush = dailyPToFlush * AVG_DAYS_PER_YEAR
HerdPPerYearToDrylot = dailyPToDrylot * AVG_DAYS_PER_YEAR
HerdPPerYearInStorage = HerdPPerYearToFlush + HerdPPerYearToDrylot

Potassium to flush system herd total per day in pounds.
dailyKToFlush = HerdKPerDayMilkCow * MilkCowFlushHours / 24 + HerdKPerDayDryCow * MilkCowFlushHours / 24

Potassium to dry lot herd total per day in pounds.
dailyKToDrylot = HerdKPerDayMilkCow * (24 - MilkCowFlushHours) / 24 + HerdKPerDayDryCow * (24 - DryCowFlushHours) / 24

Convert to an annual Potassium value.
HerdKPerYearToFlush = dailyKToFlush * AVG_DAYS_PER_YEAR
HerdKPerYearToDrylot = dailyKToDrylot * AVG_DAYS_PER_YEAR
HerdKPerYearInStorage = HerdKPerYearToFlush + HerdKPerYearToDrylot

Application Area Parcels, Fields, and Anticipated Harvest Content:

All land application areas receiving manure/nutrients during the reporting year must have planted crops. Users enter all planned land application area Assessor Parcel Numbers with owner/operator information, associate field names or reference codes, assign a cropable acreage value, crop types (rotation for the reporting year), acres planted and anticipated harvest content. Anticipated harvest content is estimated by user entries for acres planted (acres), harvest yield (tons/acre), Nitrogen (lbs/ton of yield), Phosphorus (lbs/ton of yield), and Potassium (lbs/ton of yield). Nutrient content information for common harvested crops in tabular form is available to the user as a help screen link. Anticipated harvest yields must be realistic and should rely on historical harvest yields under varying conditions. Anticipated harvest content is estimated using standard agronomic computational methods below.

Potential anticipated harvest or crop uptake (as N, P or K) in lbs/acre.
.NitrogenUptake = HarvestYield * NitrogenContent
.PhosphorusUptake = HarvestYield * PhosphorusContent
.PotassiumUptake = HarvestYield * PotassiumContent

Irrigation Sources:

Users enter and describe all irrigation water supplies applied to all land application areas to estimate potential nutrient contributions to land application areas from these fresh water sources. Entries and selections include a name or code for the fresh water irrigation supply source, the type of source (groundwater or surface water), nutrient concentrations (nitrate as nitrogen, phosphorus, and potassium), and the discharge rate (cubic feet per second or gallons per minute). Irrigation source nutrient contributions to land application areas are estimated using standard computational methods listed below. Software code “xDensity” is utilized as a surrogate for nutrient content from milligrams per liter (mg/L) converted to and expressed as pounds per gallon [nitrogen (n), phosphorus (p), or potassium (k)] delivered to land application areas at a user specified rate and run time for any specified fresh water irrigation event. Use laboratory analytical data for nutrient content of irrigation sources.

Nutrient contributions from an irrigation source event in lbs/gal.
nDensity = .NitrogenContent * MGL_TO_LBSGAL
pDensity = .PhosphorusContent * .MGL_TO_LBSGAL
kDensity = .PotassiumContent * .MGL_TO_LBSGAL

Irrigation source rate of discharge in gal/min.
rate = .DischargeRate

Convert from cfs to gpm. If IrrigationEvent.UnitAbbr = "cfs"
rate *= .CFS_TO_GPM

Duration of discharge in minutes (RunTime, user entry in hours).
runtime = .RunTime * .MINS_PER_HOUR

Size of the field in acres.
acres = .PlantedAcres

Irrigation applied nutrients in lbs/acre.
IrrigationNitrogen = (nDensity * rate * runtime) / acres
IrrigationPhosphorus = (pDensity * rate * runtime) / acres
IrrigationPotassium = (kDensity * rate * runtime) / acres

Total fresh water applied in gallons.
FreshWaterAppliedGallons = runtime * rate

Nutrient Applications and Budgets:

The user can develop a nutrient budget for subsequent implementation which includes planned rates of nutrient applications for each crop and field based on soil test results, manure and process wastewater analyses, irrigation water analyses, crop nutrient requirements and patterns, seasonal and climatic conditions, the use and timing of irrigation water and nutrient application restrictions listed in Attachment C, Technical Standards Section V., A-D of the Waste Discharge Requirements General Order Number R5-2007-0035 (General Order) on a single page/screen. Total nitrogen applications and crop uptake are focal points of the General Order. Except under very specific conditions, application rates shall not result in total nitrogen applied to land application areas exceeding 1.4 times the nitrogen that will be removed from the field in the harvested portion of the crop. See Attachment C, Technical Standards Section V., A-D. of the General Order for detailed information on nutrient budgets related to nitrogen, phosphorus, and potassium. The user must enter all planned nutrient (manure, commercial fertilizers, etc.) applications considering the anticipated harvest yield for all crop rotations during the reporting year. The user first selects a field and crop previously entered to further associate a series of planned nutrient or irrigation applications in accordance with the General Order. The following sections describe the user selected screen options for a wide variety of nutrient and/or irrigation events that may occur on any land application area and crop type. All planned nutrient application events added to any single nutrient budget selected require a nutrient contribution in pounds per acre. Nutrient applications/fertilization recommendations may vary significantly among analytical laboratories and nutrient specialists because of different analytical methods, yield response models, yield predictions, expected/planned precipitation/irrigation, and nutrient use efficiency. In accordance with the General Order all nutrient budgets must be developed and approved by a qualified nutrient specialist and include a method and basis for nutrient applications.

Three stand alone detailed nutrient application planning tools associated with the NMP module are available as a link (see "Links", "Tools"). These tools are provided to assist producers with event specific planning for dry manure, liquid manure (water-run/irrigation), and manure liquid/sludge (not water-run) applications at agronomic rates and times. It is important to note that manure and process waste water nutrient content is highly variable and rarely in proportions that match crop needs (nitrogen uptake often less than potassium and phosphorus uptake, etc…). For this reason, actual laboratory data should be entered for nitrogen, phosphorus, and potassium content to better understand, and minimize the potential over application of one or more specific nutrient. The three nutrient application planning tools allow for empirical and metric unit entry and are designed to rapidly convert targeted applications to a nitrogen, phosphorus, or potassium basis displaying total and available nutrients on a pounds per acre basis. Nutrient availability (%) should include mineralization expectations. Liquid nutrient application tools estimate volumetric discharges in gallons, gallons per minute (for flow meters), and acre-inches. Dry manure nutrient application tools estimate broadcast rates as tons or yards per acre. For nutrients applied by truck or trailer loads, a scale weight is advised to reduce errors often associated with volumes as cubic yards. These tools should be used to refine nutrient content entries found in the Nutrient Application screens.

Existing Soil Nutrient Content:
The starting point for most land application area nutrient budgeting is soil nutrient content needed for germination through harvest. Soil analyses reports are critical to set reasonable application targets for manure and fertilizer application rates. Nutrient planning specialists may recommend soil sampling after pre-irrigation where appropriate. Most soil analyses reports express nutrients in elemental form (Potassium/K, Phosphorus/P) rather than oxide form (K_2O/Potash, P_2O_5/Ortho-phosphate). Soil phosphorus analytical results are most often reported as extracted phosphorus. Evaluating soil nutrient analytical results often requires extrapolation to nutrient content into soil acre-slice equivalents (averaging 2 million pounds of soil per acre in a 6 2/3 inch thickness). A conversion utility is available to assist in converting soil nutrient analytical data from parts per million (ppm or mg/Kg) into pounds per acre, and to/from elemental and oxide forms as a link. Users must select a nutrient contribution data source (laboratory or estimated), enter soil nutrient content as pounds per acre (lbs/acre) and nutrient availability (%). Estimating or attempting to predict soil nutrient content is difficult and often unreliable, laboratory analyses are advised. Soil nutrient contents as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Plow-down Credit:
Legumes (alfalfa, etc.) and other crop residues can contribute nutrients to subsequent crops. Users select or enter a plow-down source and an application method, then enter plow down/legume nutrient credit from the previous crop (not normal crop residue) in pounds per acre and availability. Plow-down credit contents as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Dry Manure Applications:
Users select or enter a nutrient source and application method, then enter nutrient contribution content, availability, and number of similar events planned for dry manure applications. Laboratory data should be used. Nutrient content should not be estimated. Nutrient availability (%) should include mineralization expectations. A conversion utility is available to assist in converting manure nutrient analytical data from parts per million (ppm or mg/Kg) into percent (%), and to/from elemental and oxide forms as a link. Dry manure applications as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Non-Irrigation Liquid Nutrient Applications:
Non-irrigation (not water run) liquid nutrient source application examples may include liquid manure, sludge, commercial fertilizers, and process waste water from dairy storage ponds and treatment lagoons. Application methods may include aerial, towed tank or hose applications among others. Users select or enter a nutrient source and application method, then enter nutrient contribution content, availability, and number of similar events planned for non-irrigation liquid nutrient applications. Laboratory data should be used. Nutrient content should not be estimated. Nutrient availability (%) should include mineralization expectations. A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm or mg/L) into percent (%), and to/from elemental and oxide forms. Liquid nutrient applications as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Commercial Fertilizer Pre-Plant before Pre-Irrigation:
Commercial fertilizers are at times applied prior to any pre-irrigation. Users select or enter an application method, then enter nutrient contribution content and availability planned for pre-plant commercial fertilizer applications. Commercial fertilizer nutrient compositions are found on product labels. A label posted on a 50 pound bag of granular commercial fertilizer as 15-15-15 can be interpreted as 15% nitrogen (N), 15% phosphorus (P), and 15% potassium (K) indicating the bag contains 7.5 pounds of nitrogen, 7.5 pounds of phosphorus, and 7.5 pounds of potassium or 22.5 pounds of nutrients as N, P, and K combined (15% of 50 is 7.5). Phosphorus content is often

expressed as ortho-phosphate (P_2O_5) and potassium content as potash (K_2O). Read, understand, and carefully follow fertilizer labels. A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms as a link. Commercial fertilizer applications as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Commercial Fertilizer Pre-Plant after Pre-Irrigation:
Commercial fertilizers are often applied after pre-irrigation. Users select or enter an application method, then enter nutrient contribution content and availability planned for pre-plant commercial fertilizer applications. A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms. Commercial fertilizer applications as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Starter Fertilizer At Planting:
Starter fertilizers are commonly applied at the time crops are planted. Users select or enter an application method, then enter nutrient contribution content and availability for planned starter commercial fertilizer applications at planting. A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms. Commercial fertilizer applications as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

In Season Fertilizer Side-Dress:
Fertilizers as a side-dress application may be applied to crops during the growing season. Users select or enter an application method, then enter nutrient contribution content and availability for in season commercial fertilizer applications as a first or second side-dress. A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms. Commercial fertilizer applications as total nitrogen, phosphorus and

potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Nutrient Sources Other Than Manure or Process Waste Water:

Nutrients other than manure or process wastewater may be applied to crop land at any time. Users enter a nutrient source and application method, nutrient contribution content, availability, and number of similar events planned for nutrient sources other than manure or process wastewater applications. Laboratory data should be used. Nutrient content should not be estimated. A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms. Nutrient availability (%) should include mineralization expectations. Non-manure/other fertilizer applications as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Pre-Irrigation Prior to Planting (No-Fertilizer):

Pre-irrigation as fresh water without fertilization is commonly applied prior to planting. Inefficiencies including distribution uniformity in irrigation methods are a significant source of nutrient transport to groundwater, conservative use of fresh water and process waste water is advised. Users select or enter an application method. Surface application methods for fresh water sources include flood, sprinklers, drip and other above surface grade methods. Subsurface application methods for fresh water sources include buried drip tapes and other below surface grade methods. Users enter the typical runtime expected for the appropriate fresh water irrigation source(s) for this field and crop event. If a fresh water source is not shown go to the Irrigation Sources page and enter the water source, discharge rate and nutrient contribution content then return to complete this entry. Nutrient contributions will be estimated based upon concentration, runtime, discharge rate, and planted field size. Fresh water irrigation applications with nutrient content as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Pre-Irrigation Prior to Planting (With-Fertilizer):
Fresh water pre-irrigation prior to planting with fertilizers are, in some cases, applied prior to planting. Inefficiencies including distribution uniformity in irrigation methods are a significant source of nutrient transport to groundwater, conservative use of fresh water and process waste water is advised. Users select or enter a nutrient source and application method, nutrient contribution content and availability for pre-irrigations prior to planting. A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms. Laboratory data should be used. Nutrient content should not be estimated. Users enter the typical runtime expected for the appropriate fresh water irrigation source(s) for this field and crop event. If any needed fresh water sources are not shown, users must go to the Irrigation Sources page and enter the water source, discharge rate and nutrient contribution content then return to complete the entry. Fresh water irrigation nutrient content contributions will be estimated based upon concentration, runtime, discharge rate, and planted field size. Collectively, fresh water irrigation applications, the respective fresh water nutrient content contribution and fertilizer nutrient content as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

In Season Irrigation (No-Fertilizer):
Fresh water in season irrigations without fertilizer may occur frequently during the crop growing season. Inefficiencies including distribution uniformity in irrigation methods are a significant source of nutrient transport to groundwater, conservative use of fresh water and process waste water is advised. Users select or enter an application method and number of similar planned events (must use the same fresh water sources and runtimes). Surface application methods include flood, sprinklers, drip and other above surface grade methods. Subsurface application methods include buried drip tapes and other below surface grade methods. Enter the typical runtime expected for the appropriate fresh water irrigation source(s) for this field and crop event. If the fresh water source is not shown go to the Irrigation Sources page and enter the water source, discharge rate and nutrient contribution content then return to complete this entry. Nutrient contributions will be estimated based upon concentration, runtime, discharge rate, and planted field size. Fresh water irrigation applications with nutrient content as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

In Season Irrigation (With-Fertilizer):
Fresh water in season irrigations with fertilizer are commonly applied. Inefficiencies including distribution uniformity in irrigation methods are a significant source of nutrient transport to groundwater, conservative use of fresh water and process waste water is advised. Users select or enter a nutrient source, application method, nutrient contribution content, availability and number of similar planned events (must use the same fresh water sources and runtimes). Surface application methods include flood, sprinklers, drip and other above surface grade methods. Subsurface application methods include buried drip tapes and other below surface grade methods. Enter the typical runtime expected for the appropriate fresh water irrigation source(s) for this field and crop event. If the fresh water source is not shown go to the Irrigation Sources page and enter the water source,

discharge rate and nutrient contribution content then return to complete this entry. A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms. Laboratory data should be used. Nutrient content should not be estimated. Nutrient contributions will be estimated based upon concentration, runtime, discharge rate, and planted field size. Collectively, fresh water irrigation applications, the respective fresh water nutrient content contribution and fertilizer nutrient content as total nitrogen, phosphorus and potassium are summed for each field and crops in the rotation on a pounds per acre basis. Percent availability is displayed.

Nutrient Application Copy Tool:

This tool is provided to rapidly copy fertilization and irrigation events from a field crop to other field crops. After copying to another appropriate crop field, users can readily modify/edit portions of a nutrient budget as needed. Users select the crop to copy using the pull-downs, then select crop fields to copy to by checking the boxes in the table, then click Copy. Crops with existing fertilization and/or irrigation events cannot be selected in the table as a copy destination.

Nutrient Contributions and Crop Uptake Summary:

All nutrients applied to land application areas as existing soil nutrient content, plow-down legume and/or crop residue credit, dry manure, non-irrigation (not water run) liquid nutrients, commercial fertilizer pre-plant before and after pre-irrigations (includes fresh water nutrient contributions if any), starter fertilizers at planting, in-season fertilizer side dress (limited to 1st and 2nd in-season side dress), nutrient sources other than manure or process waste water, pre-irrigations prior to planting (includes fresh water nutrient contributions if any, with or without commercial fertilizer or process waste water applications), in-season irrigations (includes fresh water nutrient contributions only, if any), in-season irrigations (includes fresh water nutrient contributions if any, with or without commercial fertilizer or process waste water applications), and atmospheric nitrogen deposition (14 pounds per planted crop acre) are summed as total nitrogen, phosphorus and potassium. Anticipated crop harvest nutrient removal (uptake) as total nitrogen, phosphorus, and potassium is estimated for all crops included in the nutrient budget on a pound per acre basis. A balance estimate is calculated for total nutrients applied and removed from each land application area (field) based upon anticipated crop harvest yields and nutrient content for all crops in a rotation on that field for the reporting year on a pound per acre basis. An estimate is also calculated regarding nutrients applied to crop removal uptake ratio for individual fields and a facility wide basis on a pound per acre basis.

Estimate nutrients applied to all crops in the NMP.
Accumulate irrigation applied nutrients applied in lbs.
.IrrigationNitrogen += .IrrigationNitrogen * acres
.IrrigationPhosphorus += .IrrigationPhosphorus * acres
.IrrigationPotassium += .IrrigationPotassium * acres

Accumulate atmospheric nitrogen deposition in lbs (a constant at 14 lbs/acre).
.AtmosphericDeposition +=.AtmosphericDeposition * acres

Accumulate total nitrogen applied in lbs.
.AppliedNitrogen += .TotalNitrogen * acres
.AppliedPhosphorus += .TotalPhosphorus * acres
.AppliedPotassium += .TotalPotassium * acres

Accumulate total crop nitrogen uptake in lbs.
.NitrogenUptake += .NitrogenUptake * acres
.PhosphorusUptake += .PhosphorusUptake * acres
.PotassiumUptake += .PotassiumUptake * acres

Accumulate fresh water applied in gal.
.FreshWaterAppliedGallons += FreshWaterAppliedGallons

Accumulate irrigation applied nutrients in lbs/acre (.Quantity as "events").
.IrrigationNitrogen += .IrrigationNitrogen * .Quantity
.IrrigationPhosphorus += .IrrigationPhosphorus * .Quantity
.IrrigationPotassium += .IrrigationPotassium * .Quantity

Accumulate total applied nutrients in lbs/acre.
.TotalNitrogen += .TotalNitrogen * .Quantity
.TotalPhosphorus += .TotalPhosphorus * .Quantity
.TotalPotassium += .TotalPotassium * .Quantity

Accumulate fresh water applied in gallons.
.FreshWaterAppliedGallons += .FreshWaterAppliedGallons * .Quantity

Estimate fresh water applied in feet (acre-feet/acre = feet).
.FreshWaterAppliedFeet = (.FreshWaterAppliedGallons / .GALS_PER_ACREFOOT) / .PlantedAcres

Atmospheric nitrogen deposition added to crop nitrogen total (referred to as .AND).
.AtmosphericDeposition = .AND_RATE
.TotalNitrogen += .AtmosphericDeposition

Estimate the potential crop uptakes in lbs/acre.
.NitrogenUptake = .HarvestYield * .NitrogenContent
.PhosphorusUptake = .HarvestYield * .PhosphorusContent
.PotassiumUptake = .HarvestYield * .PotassiumContent

Estimate applied versus crop uptake balances in lbs/acre.
.NitrogenBalance = .TotalNitrogen - .NitrogenUptake
.PhosphorusBalance = .TotalPhosphorus - .PhosphorusUptake
.PotassiumBalance = .TotalPotassium - .PotassiumUptake

Accumulate the nutrient values into the matching source group in lbs/acre.
.TotalNitrogenPerAcre += .NitrogenContent * .Quantity
.TotalPhosphorusPerAcre += .PhosphorusContent * .Quantity
.TotalPotassiumPerAcre += .PotassiumContent * .Quantity

.TotalNitrogen = .TotalNitrogenPerAcre * .PlantedAcres
.TotalPhosphorus = .TotalPhosphorusPerAcre * .PlantedAcres
.TotalPotassium = .TotalPotassiumPerAcre * .PlantedAcres

Estimate applied to crop uptake ratios.
.NitrogenRatio = .TotalNitrogen / .NitrogenUptake
.PhosphorusRatio = .TotalPhosphorus / .PhosphorusUptake
.PotassiumRatio = .TotalPotassium / .PotassiumUptake

Estimate whole farm nutrients as total N, P, and K (without crop uptake) in lbs.
nitrogenBal = .HerdNPerYearInStorage + .ImportNitrogen + .AtmosphericDeposition + .IrrigationNitrogen - .ExportNitrogen
phosphorusBal = .HerdPPerYearInStorage + .ImportPhosphorus + .IrrigationPhosphorus - .ExportPhosphorus
potassiumBal = herdKPerYearInStorage + .ImportPotassium + .IrrigationPotassium - .ExportPotassium

Estimate whole farm nutrients as N, P, and K to crop N, P, and K uptake ratios.
.NitrogenFarmRatio = nitrogenBal / .NitrogenUptake
.PhosphorusFarmRatio = phosphorusBal / .PhosphorusUptake
.PotassiumFarmRatio = potassiumBal / .PotassiumUptake

Estimate applied versus crop uptake balances in lbs.
.NitrogenAppliedBalance = .AppliedNitrogen - .NitrogenUptake
.PhosphorusAppliedBalance = .AppliedPhosphorus - .PhosphorusUptake
.PotassiumAppliedBalance = .AppliedPotassium - .PotassiumUptake

Estimate applied to crop uptake ratios.
.NitrogenAppliedRatio = .AppliedNitrogen / .NitrogenUptake
.PhosphorusAppliedRatio = .AppliedPhosphorus / .PhosphorusUptake
.PotassiumAppliedRatio = .AppliedPotassium / .PotassiumUptake

Nutrient Imports:

Nutrients imported onto the facility on an annual basis that may be placed on land application areas must be quantified. Users enter a nutrient type/name, a quantity, select gallons (for liquids) or tons (for solids), enter the moisture content (%, no moisture entry for liquids), and the nutrient contribution content for total nitrogen (%), total phosphorus as ortho-phosphate (P2O5), and total potassium as potash (K2O). Data entry for imported nutrient content allows for entries three decimal places to the right to accommodate part per million (mg/Kg or mg/L) equivalents (1% is equivalent to 10,000 ppm). The smallest ppm equivalent imported nutrient content entry allowed is 0.001% (10 ppm). A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms. Nutrient import content as total nitrogen, phosphorus and potassium are summed.

Estimate nutrient content for all nutrient imports.
.UnitAbbr for volumes as gallons ("gal")
ImportNitrogen += .NutrientAmount * .LBS_PER_GAL_WATER * .NitrogenContent
ImportPhosphorus += .NutrientAmount * .P2O5_TO_P * .LBS_PER_GAL_WATER * .PhosphorusContent
ImportPotassium += .NutrientAmount * .K2O_TO_K * .LBS_PER_GAL_WATER * .PotassiumContent

.UnitAbbr for quantities as tons ("ton")
ImportNitrogen += .NutrientAmount * .LBS_PER_TON * (1.0D - .MoistureContent) * .NitrogenContent
ImportPhosphorus += .NutrientAmount * .P2O5_TO_P *.LBS_PER_TON * (1.0D - .MoistureContent) * .PhosphorusContent
ImportPotassium += .NutrientAmount * .K2O_TO_K * .LBS_PER_TON * (1.0D - .MoistureContent) * .PotassiumContent

Nutrient Exports:
Nutrients exported from the facility on an annual basis must be quantified. Users enter a nutrient type/name, a quantity, select gallons (for liquids) or tons (for solids), enter the moisture content (%), and the nutrient contribution content for total nitrogen (%), total phosphorus as ortho-phosphate (P2O5), and total potassium as potash (K2O). Data entry for exported nutrient content allows for entries three decimal places to the right to accommodate part per million (mg/Kg or mg/L) equivalents (1% is equivalent to 10,000 ppm). The smallest ppm equivalent export nutrient content entry allowed is 0.001% (10 ppm). A conversion utility is available to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms. Nutrient export content as total nitrogen, phosphorus and potassium are summed.

Estimate nutrient content for all nutrient exports.
.UnitAbbr for volumes as gallons ("gal")
ExportNitrogen += .NutrientAmount *.LBS_PER_GAL_WATER * .NitrogenContent
ExportPhosphorus += .NutrientAmount * .P2O5_TO_P *.LBS_PER_GAL_WATER * .PhosphorusContent
ExportPotassium +=.NutrientAmount * .K2O_TO_K *.LBS_PER_GAL_WATER * .PotassiumContent

.UnitAbbr for quantities as tons ("ton")
ExportNitrogen += .NutrientAmount * .LBS_PER_TON * (1.0D - .MoistureContent) * .NitrogenContent
ExportPhosphorus += .NutrientAmount * .P2O5_TO_P *.LBS_PER_TON * (1.0D - .MoistureContent) * .PhosphorusContent
ExportPotassium += .NutrientAmount * .K2O_TO_K *.LBS_PER_TON * (1.0D - .MoistureContent) * .PotassiumContent

Sampling and Analyses Plan:
The user must select a sample type (manure, process waste water, soil, plant tissue, irrigation water, or other), if other is selected the user must enter a sample type description. The user then selects an event type (crop application, annual mineral analysis, bi-annual nutrient analysis, off-site export, or annual totals). A likely minimum set of twenty-five sample media/event type combinations (5 sample media by five event types). Sample types and event types correspond with the General Order requirements (see Monitoring and Reporting Program pages MRP-2 through MRP-4 as examples). Each time the user selects a sample type and event type the software automatically populates the frequency, sampling methods, source, field analytes, and laboratory analytes text boxes with standardized content to assist the user in meeting the minimum reporting requirements found in the General Order related to sampling and analyses plans. Users may add or delete components as needed. Text may be copied from another document directly into text boxes found in this application. In accordance with the General Order, all sampling and analysis plans must be developed and approved by a qualified nutrient specialist.

Storage Period:

The user must select a Storage Period from 120 to 240 days to estimate process waste water storage pond capacity requirements. Storage period is the maximum period of time anticipated between land applications of process wastewater from storage ponds/lagoons to croplands. A qualified nutrient specialist and civil engineer should collaborate and collectively consider predominant soil types, soil infiltration rates, maximum soil depth, available water, field capacity, permanent wilting point, allowable depletion, crop water use, evapo-transpiration, precipitation, irrigation system capacity, water delivery constraints, crop nutrient requirements, soil nutrient adsorbtion/desorption, rooting depth, nutrient accumulation/availability for current and future crop needs, process waste water accumulation on a daily basis including manure and other solids (separated solids included), 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.

Consideration must include nutrient applications to crops from process waste water storage ponds/lagoons on an annual basis at agronomic rates and times. Controlled nutrient applications to crops from the process waste water storage pond(s)/lagoons occur at different rates and times affecting process waste water storage pond capacity estimates. 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). The General Order for Central California requires the owner/operator of the dairy facility process waste water storage ponds/lagoons 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. In many cases conflicts will arise between crop water demands, crop nutrient demands and insufficient process wastewater storage capacity. Process wastewater may not be the best choice as a source of either water and/or nutrients to meet crop demands throughout the year. Groundwater and surface water vulnerability must also be considered. After completing detailed and integrated Waste and Nutrient Management Plans a more reliable estimate of Storage Period can be derived.

Nutrient Management Plan Review and Certification:

Users must select individuals and dates related to Nutrient Management Plan (NMP) development, review and certification including listing the person who created the NMP, the date the NMP was drafted, the person who approved the NMP (nutrient specialist), and the date of NMP implementation, the person who developed and certified the Sampling and Analyses Plan (SAP), owner and operator signing the SAP, any operator not an owner signing the SAP, the nutrient specialist who developed the Nutrient Budget (NB), owner and operator signing the NB, any operator not an owner signing the NB, owner and operator signing the Statements of Completion (SOC), and any operator not an owner signing the SOC. In the event an appropriate contact person does not appear as a selection, return to the NMP Contact Page to enter the appropriate contact information and return to complete this task. The selections made will be used to generate reports required in accordance with the General Order.

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

CONCENTRATION
mg/L to lbs/gal
MGL_TO_LBSGAL = 8.345e-6
mg/L to lbs/1000 gal
MGL_TO_LBS1000GAL = 8.345e-3
Kilograms in a milligram
KG_PER_MG = 1e-6

DENSITY
Water density in lbs/cu.ft.
WATER_DENSITY = 62.4
Kg/m^3 to lbs/ft^3
KGCUM_TO_LBCUFT = 0.0624279606

DISCHARGE RATE
Cubic feet per second to gallons per minute
CFS_TO_GPM = 448.831167

LENGTH
Number of inches in a foot
INCHES_PER_FOOT = 12

MANURE and BEDDING SOLIDS REMOVAL

Manure density in lbs/cu.ft. (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 = 2.33

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

NUTRIENT EQUIVALENTS (ELEMENTAL AND OXIDE FORMS)

P_2O_5 (ortho-phosphate) to Phosphorus
P2O5_TO_P = 0.437D

K_2O (potash) to Potassium
K2O_TO_K = 0.83D

TIME
Number of minutes per hour
MINS_PER_HOUR = 60
Average number of days in a year
AVG_DAYS_PER_YEAR = AVG_DAYS_PER_YEAR

VOLUME
Number of cubic feet in a gallon of water
CUBIC_FEET_PER_GALLON = 0.13368055
Number of gallons in an acre-foot
GALS_PER_ACREFOOT = 325,851
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