WASTE MANAGEMENT PLAN

for

HAWAIʻI DAIRY FARMS

MAHAʻULEPU, KAUAʻI, HAWAIʻI

TMK: (4) 2-9-003: 001 por and 006 por
(4) 2-9-001: 001 por

Prepared for:
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July 23, 2014

Farm Name:	HAWAIʻI DAIRY FARMS
Facility Location:	Mahaʻulepu Road Mahaʻulepu, Kauaʻi, Hawaiʻi TMK: (4) 2-9-003: 001 por and 006 por (4) 2-9-001: 001 por
Land Owner:	Mahaʻulepu Farms, LLC 3-1850 Kaumualiʻi Hwy Lihuʻe, Hawaiʻi 96766
Dairy Owner/Operator:	Hawaiʻi Dairy Farms, LLC
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Operated by:	James Garmatz (Farm Manager)
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As the Owner/Operator of Hawaiʻi Dairy Farms, LLC, I agree to manage the dairy operation in accordance with this waste management plan and maintain those practices described in the plan.

Signature: _____ Date: _____

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1.0 Project Overview

Hawai'i Dairy Farms LLC (HDF) intends to ultimately develop a 2,000-cow dairy in the Maha'ulepu Valley at Grove Farm on the island of Kaua'i. The entire project will be a pastoral-based rotational pasture system, and has been designed by U.S. and New Zealand dairy experts to be zero-point source discharge. At full production the dairy will double current milk production to provide more fresh, local milk to Hawaii's families. To demonstrate the environmental sustainability of the dairy, HDF will develop the project in two phases: Phase 1 will have no more than 699 cows, and Phase 2 will have up to 2,000 cows. THIS APPLICATION IS SOLELY FOR PHASE 1 OF THE HDF PROJECT.

All the facilities and infrastructure presented in this application are sized for the Phase 2 full-scale production. The Waste Management Plan calculations presented reflect Phase 1 stocking rates of ~1.3 animals per acre or 699 milking cows (grazing on ~517 acres). The animals will be managed in small groups (of 115-150 cow mobs) and are milked twice a day (1 hour per milking). Only one mob can be held in the dairy at any one time. The effluent pond calculations demonstrate that the Phase I margin for safety would exceed regulatory compliance requirements and contain roughly 100 days of storage capacity. Similarly, the pasture stocking rate is consistent with temperate zone dairies and the more productive Hawai'i ranching pastures, even though the carrying capacity of the pasture is far greater due to consistent fertilization and irrigation. The grazing pasture will be primarily Kikuyu, which HDF grass trials have shown to be highly productive and nutritious forage. The cows spend 22 hours in the paddock and only 2 hours in the milking area each day.

HDF is submitting this Waste Management Plan for its Animal Feeding Operation (AFO) to the Hawai'i State Department of Health for approval, in accordance with the "Guidelines for Livestock Waste Management", prepared by the University of Hawai'i-Mānoa Cooperative Extension Service, College of Tropical Agriculture and Human Resources (CTAHR), and applicable state and county regulations.

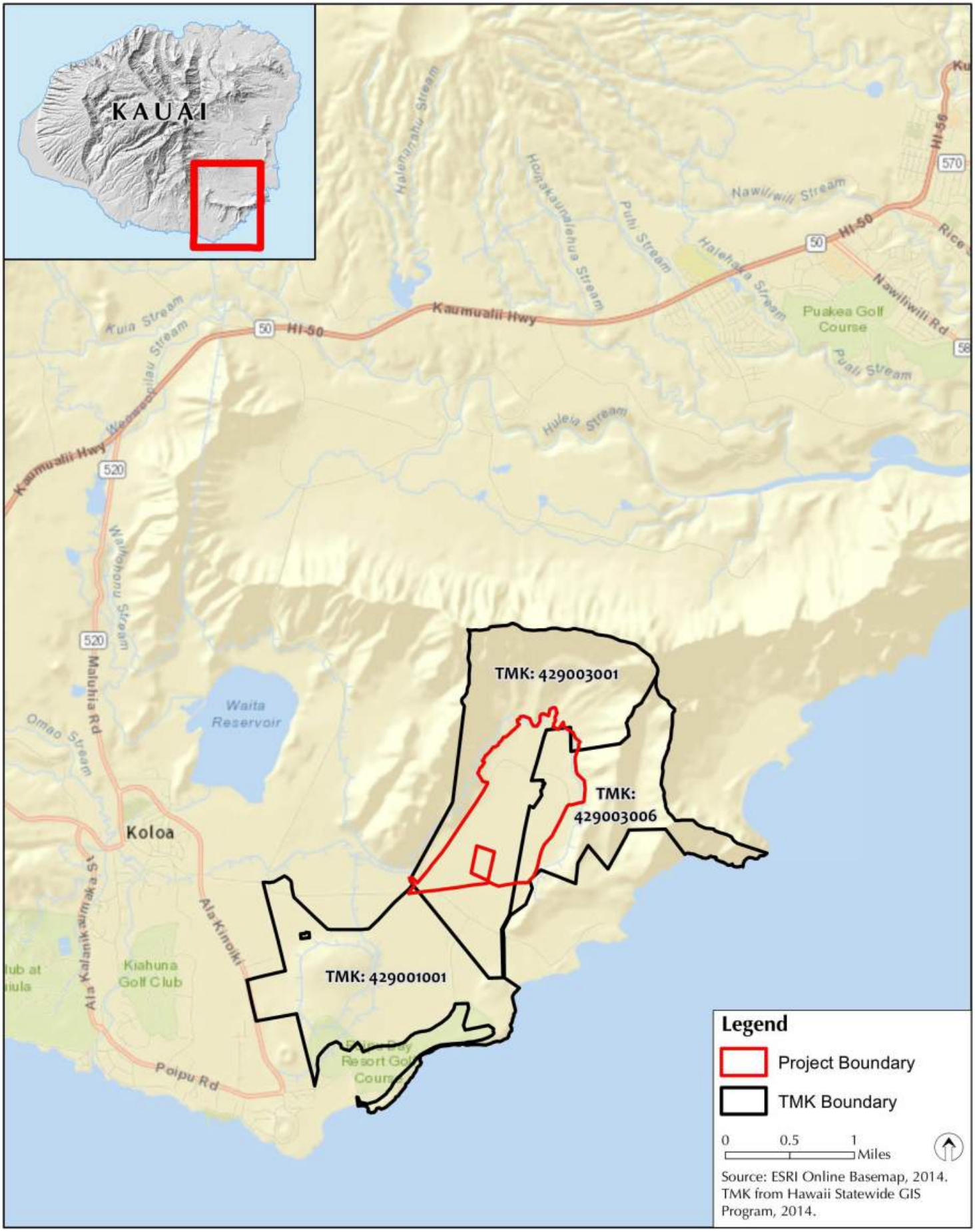


Figure 1 – Vicinity Map

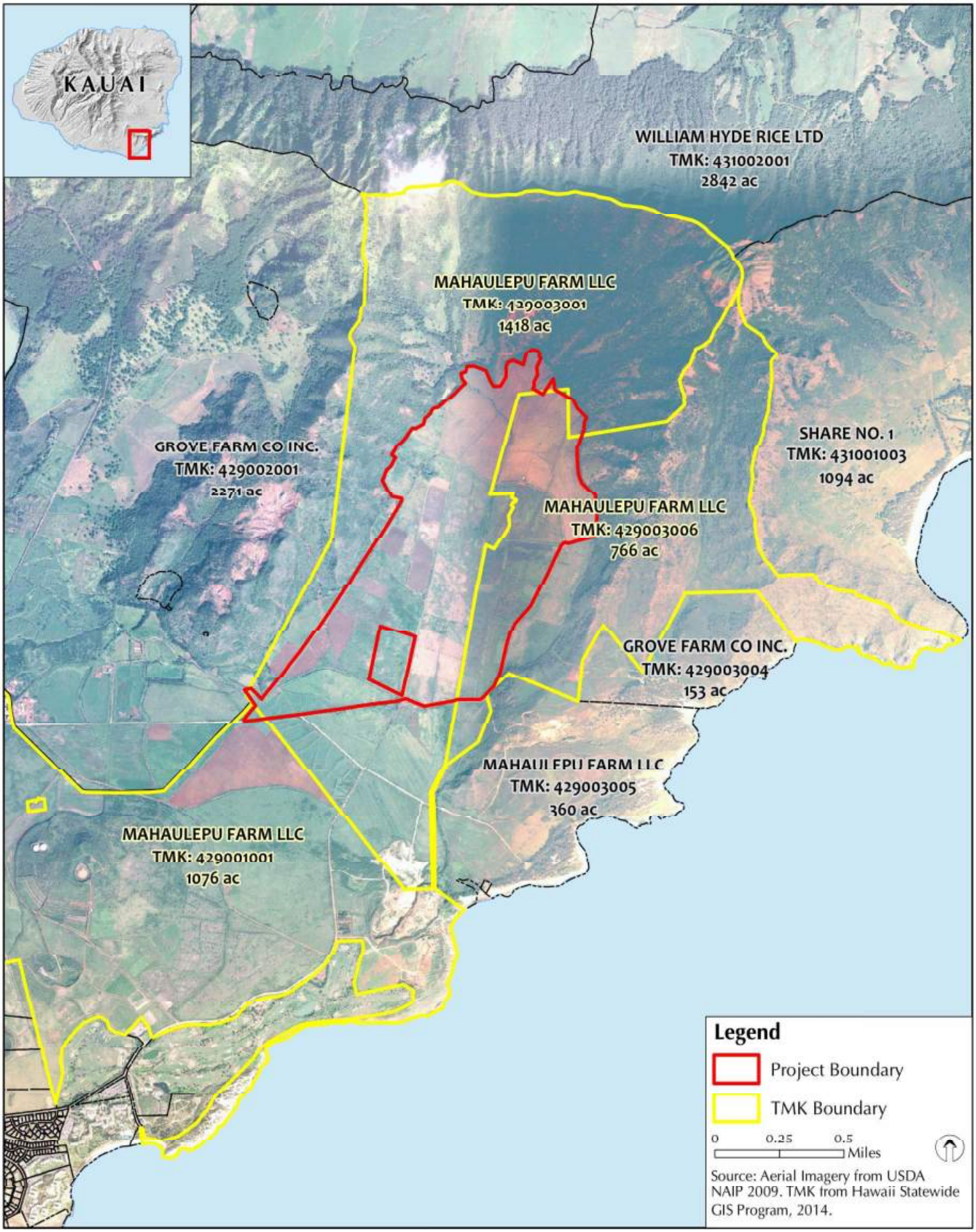


Figure 2 – Project Location Map

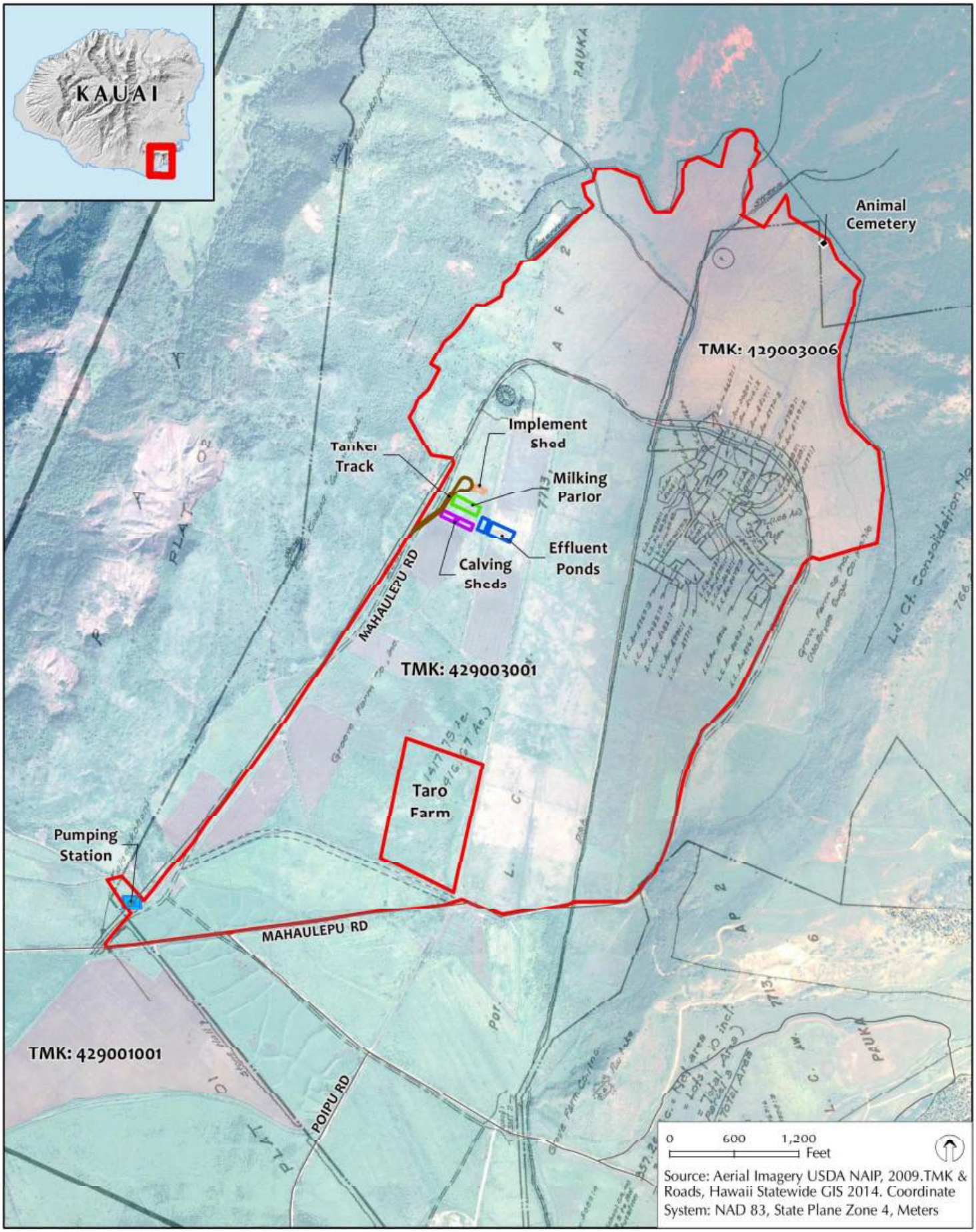


Figure 3 – TMK Map

2.0 Existing Conditions

The project area has historically been used for sugar cane production as part of the Koloa Plantation until the late 1990s when the Koloa Mill closed. Since the mill closed, the project area has been leased to various tenants for ranching and diversified agricultural operations. A small plot of land in the lower center of the valley is currently used for taro lo'i and will continue to be leased and farmed after the dairy and related pastures are in full operation. See Figure 3 – TMK Map.

The original agricultural infrastructure from the sugar plantation is largely still in place and continues to be used for on-going agricultural activities. Much of this existing infrastructure will also be used for the dairy, but with a significant amount of upgrades and improvements. The existing infrastructure in the project area includes: gravel access roads, field roads, water wells, reservoirs, pipelines, pumps, irrigation ditches, drainage ways and culverts.

2.1 Topography

The project site is situated in the Maha'ulepu Valley on the island of Kaua'i. The valley is on the leeward side of the Ha'upu mountain ridge, which runs in the east-west direction, and the valley is also flanked by ridge lines on both sides. Mt. Ha'upu is the highest point on the ridge line at the back of the valley with an elevation of 2,297 feet. From this point, the ground drops very quickly down to the bottom of the valley to about an elevation of 150 feet. The base of the valley itself is somewhat gradually sloped from an elevation of 150 feet to an elevation of 60 feet along Maha'ulepu Road on the makai side of the project site near the taro farm. See Figure 4, USGS Map.

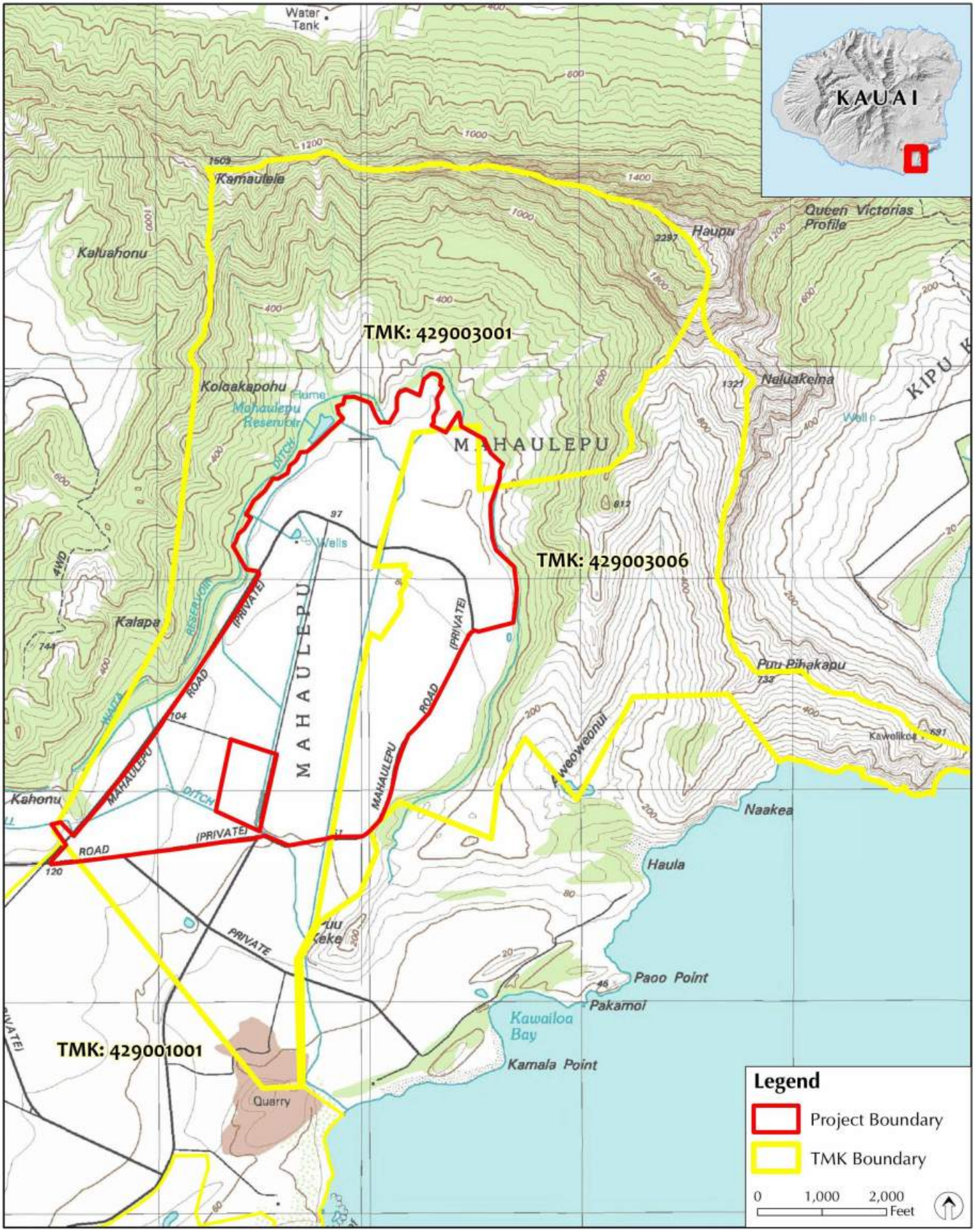


Figure 4 – USGS Map

2.2 Water Resources

The Maha'ulepu Valley has been in agricultural use for a very long time and much of the water resources and infrastructure in the valley are man-made and were constructed to provide irrigation water to the sugar cane lands throughout the valley. Systems of ditches, reservoirs and irrigation pipes and pumps are still in place and are still used to irrigate fields and pasture. Much of this infrastructure is shown on the USGS maps and in other datasets. See Figure 5, Water Resources. Water resources shown in Figure 5 include: canals, ditches, streams and ponds as identified in the National Hydrography Dataset (NHD), water wells from the State of Hawai'i, Department of Land and Natural Resources (DLNR), and wetlands from the National Wetlands Inventory (NWI).

2.2.1 Receiving Water Body State Water Quality

The drainage ways within Maha'ulepu Valley and within the project site are classified by the DOH Clean Water Branch (CWB) to be Class 2 inland waters as defined in Hawai'i Administrative Rules (HAR) Title 11, Chapter 54 (§11-54). These canals and ditches flow in the makai direction beyond the project site across Maha'ulepu Road and into the agricultural lands on the opposite side of the road. The unnamed drainage ways from the valley all converge near Pu'u Keke and are discharged into Class A marine waters along the Maha'ulepu coastline between Kamala Point and Punahoa Point. The Maha'ulepu coastline is classified as Class 1 critical habitat by the State.

2.2.2 Wetlands

According to the United States Fish and Wildlife Service (FWS), the agricultural canals, ditches and ponds within the valley are listed in the National Wetlands Inventory (NWI). There is also a freshwater wetland on the makai side of Maha'ulepu Road outside the project site. FWS classifies the wetlands as follows:

Table 1 – NWI Wetlands Classification

Location (Wetland Code)	System	Sub-System	Class	Sub-Class	Modifiers
R4SBCx	Riverine	Intermittent	Streambed		• Seasonally Flooded • Excavated
PUBHh	Palustrine		Unconsolidated Bottom		• Permanently Flooded • Diked/Impounded
PEM1Hh	Palustrine		Emergent	Persistent	• Permanently Flooded • Diked/Impounded
PEM1Kx	Palustrine		Emergent	Persistent	• Artificially Flooded • Excavated

2.2.3 Water Wells

The State Department of Land and Natural Resources (DLNR) Commission on Water Resource Management (CWRM) manages and tracks water resources in the State including groundwater wells. The State database identifies two primary well sites in the Maha'ulepu Valley. The Koloa F Well is a public drinking water source used by the County of Kaua'i Department of Water Supply. The Maha'ulepu Well site includes up to 14 irrigation wells drilled by the sugar cane plantations. The water wells are shown on Figure 5, Water Resources. The Koloa F well is located over ½ mile away from the dairy facility site.

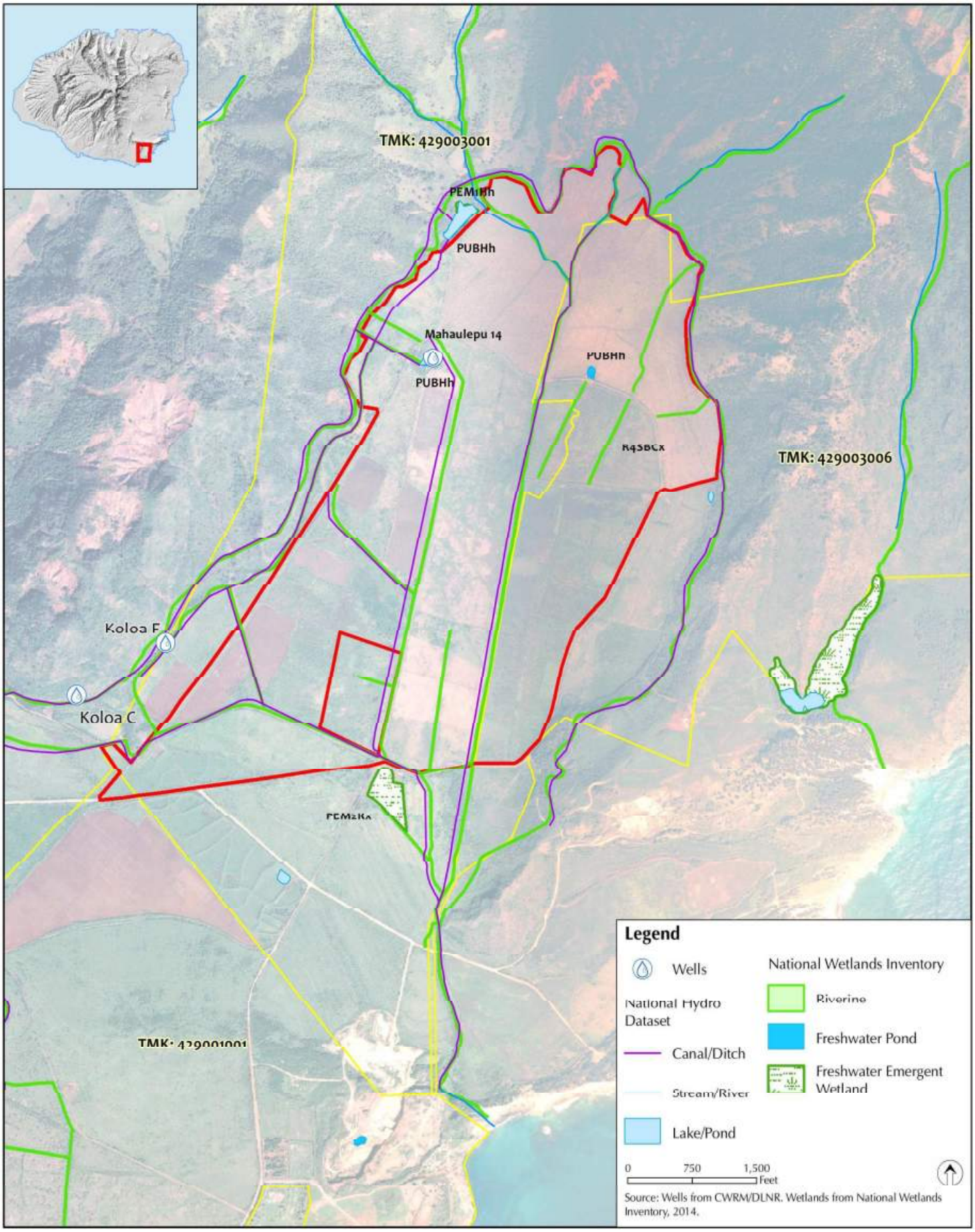


Figure 5 – Water Resources

2.3 Rainfall Data

The data sources used for sizing of the waste management systems and irrigation scheduling of the dairy facility site are described in this section.

2.3.1 Normal Precipitation

Normal monthly precipitation depths were obtained from the University of Hawai'i Rainfall Atlas of Hawai'i (2011). The average monthly precipitation depths will be used for sizing of the waste management systems and irrigation scheduling as required by the standards.

Table 2 – Average Monthly Precipitation Data

Month	Mean Monthly Rainfall (in)
January	4.88
February	4.20
March	5.04
April	3.66
May	3.05
June	2.86
July	3.13
August	3.20
September	3.25
October	4.96
November	6.01
December	5.71
Annual	49.95

2.3.2 NOAA 24-Hour Rainfall

Precipitation depths for various durations and recurrence intervals were obtained from NOAA Atlas 14, Volume 4, Version 3. The 25-year 24-hour precipitation data will be used for sizing of waste management systems as required by the standards.

Table 3 – NOAA 24-Hour Rainfall Data

Storm Event (Recurrence Interval)	Storm Duration	
	1-hour	24-hour
1-year	1.18"	3.47"
2-year	1.55"	4.78"
10-year	2.54"	8.18"
25-year	3.17″	**10.4″**
50-year	3.70"	12.2"
100-year	4.25"	14.1"

2.3.3 NOAA Rain Gauge Data

Rain gauge data was obtained from NOAA National Climatic Data Center for the Maha'ulepu 941.1 rain gauge located on the farm off of Maha'ulepu Road (GHCND:USC00515710 - MAHA'ULEPU 941.1 HI US). The rain gauge is located at: Elevation = 24.4, Latitude = 21.90194, Longitude = -159.42111. The data record analyzed included daily precipitation records from 1/1/1984 to 12/31/2013 for a total of approximately 10,957 days (30 years). The rainfall events were ranked based on days of consecutive rainfall (DAPR) and the corresponding multiday precipitation total (MDPR). The data suggests that having more than a week of consecutive rain is very unusual for Maha'ulepu Valley with this only having occurred 5 times in the last 30 years.

Table 4 – NOAA Rain Gauge Data

GHCND:USC00515710 - MAHA'ULEPU 941.1 HI US			
DATE	**MDPR, in**	**DAPR**	**Occurrence**
19960108	1.90	17	1
19920922	2.60	12	1
19930104	3.70	7	3
19960930	0.20	7	3
19980105	1.48	7	3
19920928	0.02	6	5
19940105	0.03	6	5
19960923	0.03	6	5
19970106	0.05	6	5
20031229	0.20	6	5
19861229	0.04	5	21

MDPR – Multiday precipitation total

DAPR – Number of days included in the multiday precipitation total (MDPR)

Occurrence – number of occurrences in 10,957 day record between 1/1/1984 to 12/31/2013

2.4 Flood Hazards

The entire project area is located within Federal Emergency Management Agency (FEMA) Zone X based on FEMA Flood Insurance Rate Map (FIRM) panels 1500020316E and 1500020318F. Zone X includes areas determined to be outside the 0.2% annual chance floodplain.

2.5 Soils

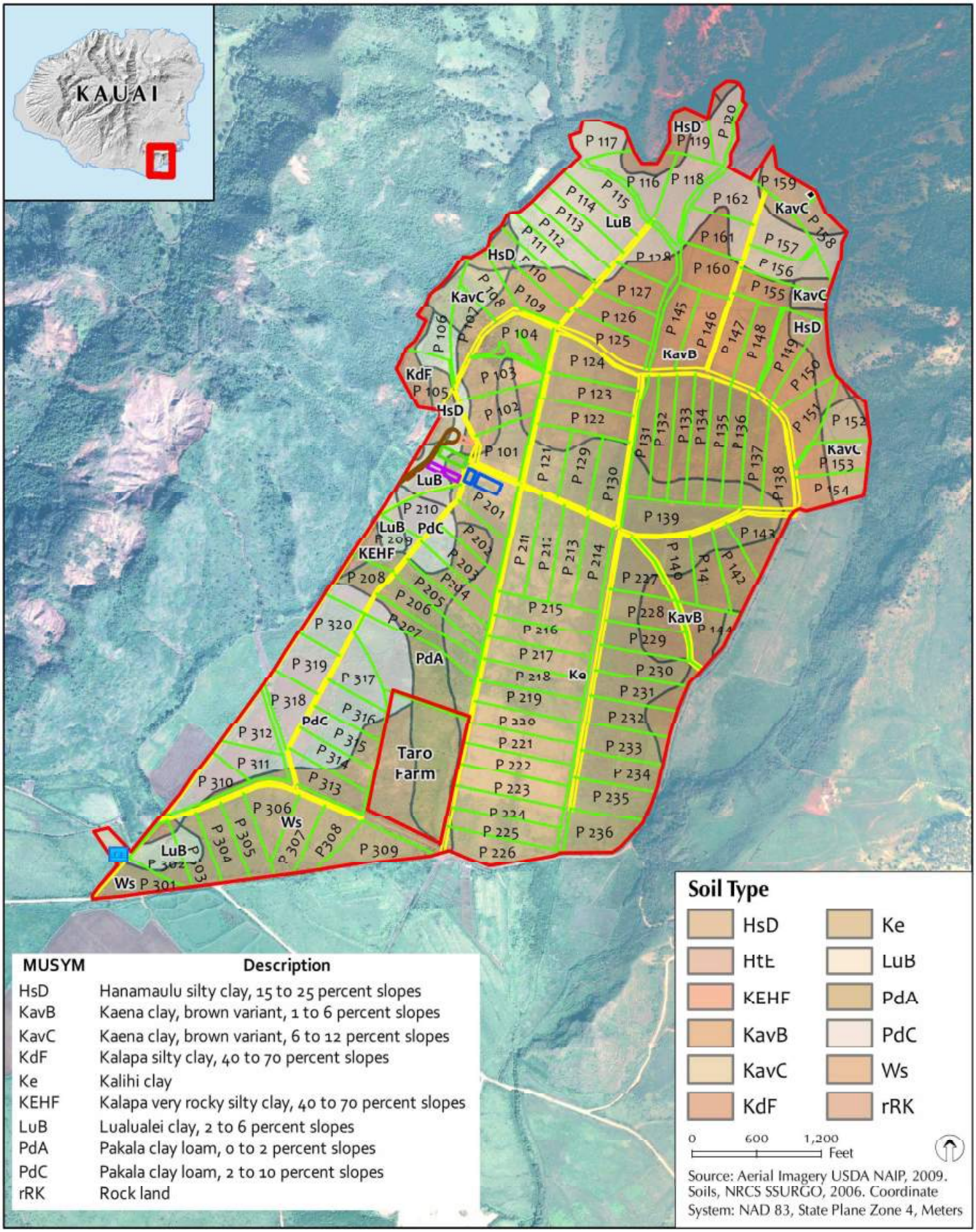
According to the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) survey data, the project area consists of a variety of soils. Soil characteristics are summarized in the table below. See Figure 6, Soil Map.

Table 5 – Soil Characteristics Summary

Soil Classification	Soil Classification	Slope Range (%)	Hydrologic Soils Group	Drainage Class	Depth to Water Table (inches)	Capacity to transmit water – Ksat (in/hr)	Typical Soil Profile - Layer 1 (depth from surface)	Typical Soil Profile - Layer 2 (depth from surface)	Typical Soil Profile - Layer 3 (depth from surface)
Hanamaulu Silty Clay	HsD	15 to 20%	B	Well Drained	> 80″	0.14 to 1.98	0 to 11″ Silty Clay	11 to 36″ Silty Clay	36 to 72″ Silty Clay Loam
Hanamaulu Stony Silty Clay	HtE	10 to 35%	B	Well Drained	> 80″	0.20 to 2.00	0 to 11″ Stony Silty Clay	11 to 36″ Silty Clay	36 to 72″ Silty Clay Loam
Ka'ena Clay, Brown Variant	KavB	1 to 6%	D	Poorly Drained	24 to 60″	0.00 to 0.20	0 to 10″ Clay	10 to 37″ Stony Clay	37 to 54″ Stony Clay
Ka'ena Clay, Brown Variant	KavC	6 to 12%	D	Poorly Drained	24 to 60″	0.00 to 0.20	0 to 10″ Clay	10 to 37″ Stony Clay	37 to 54″ Stony Clay
Kalapa Silty Clay	KdF	40 to 70%	B	Well Drained	> 80″	0.00 to 0.20	0 to 10″ Silty Clay	10 to 60″ Clay	
Kalihi Clay	Ke	n/a	D	Poorly Drained	24 to 60″	0.06 to 0.60	0 to 16″ Clay	16 to 70″ Clay	
Kalapa Very Rocky Silty Clay (Very Rocky)	KEHF	40 to 70%	B	Well Drained	> 80″	0.00 to 0.20	0 to 10″ Silty Clay	10 to 60″ Clay	
Kalapa Very Rocky Silty Clay (Rock Outcrop)	KEHF	40 to 70%	D			0.00 to 0.06	0 to 60″ Bedrock		
Lualualei Clay	LuB	2 to 6%	D	Well Drained	> 80″	0.00 to 0.20	0 to 10″ Clay	10 to 60″ Clay	

Table 5 – Soil Characteristics Summary (continued)

Soil Classification	Soil Classification	Slope Range (%)	Hydrologic Soils Group	Drainage Class	Depth to Water Table (inches)	Capacity to transmit water – Ksat (in/hr)	Typical Soil Profile - Layer 1 (depth from surface)	Typical Soil Profile - Layer 2 (depth from surface)	Typical Soil Profile - Layer 3 (depth from surface)
Pakala Clay Loam	PdA	0 to 2%	B	Well Drained	> 80"	0.60 to 1.98	0 to 16″ Clay Loam	16 to 60″ Silty Clay Loam	
Pakala Clay Loam	PdC	2 to 10%	B	Well Drained	> 80"	0.60 to 1.98	0 to 16″ Clay Loam	16 to 60″ Silty Clay Loam	
Rock Land	rRK	n/a	D	Well Drained	> 80"	0.00 to 0.06	0 to 4″ Silty Clay	4 to 8″ Silty Clay	8 to 20″ Bedrock
Rock Land (Rock Outcrop)	rRK	n/a	D			0.00 to 0.06	0 to 60″ Bedrock		
Waikomo Stony Silty Clay	Ws	n/a	D	Well Drained	> 80"	0.00 to 0.06	0 to 14″ Stony Silty Clay	14 to 20″ Stony Silty Clay Loam	20 to 30″ Bedrock



MUSYM	Description
HsD	Hanamaulu silty clay, 15 to 25 percent slopes
KavB	Kaena clay, brown variant, 1 to 6 percent slopes
KavC	Kaena clay, brown variant, 6 to 12 percent slopes
KdF	Kalapa silty clay, 40 to 70 percent slopes
Ke	Kalihi clay
KEHF	Kalapa very rocky silty clay, 40 to 70 percent slopes
LuB	Lualualei clay, 2 to 6 percent slopes
PdA	Pakala clay loam, 0 to 2 percent slopes
PdC	Pakala clay loam, 2 to 10 percent slopes
rRK	Rock land

Figure 6 – Soils Map

3.0 Land Use Summary

The total dairy farm area inclusive of pasture and dairy facility, but excluding the existing taro farm, is 577.9 acres. The dairy project site has been divided into two land use areas as described in Table 6 (below): Field 1, 563.4 acres of pasture; and Field 2, 14.5 acres for the dairy facility. See Figure 7, Field Map.

Table 6 – Land Use Summary

Land Use	Acres
Field 1	
Paddocks	517.3
Cow Races, Farm Roads, Drainage Ways	46.1
Subtotal	**563.4**
Field 2	
Dairy Facility, Yard, Sheds, Road	4.6
Open Space	9.9
Subtotal	**14.5**
TOTAL	**577.9**

Field 1 is broken up into a total of 118 paddocks which are approximately 4 to 5 acres in size. See Figure 8, Paddock Map and Table 7, Paddock Area Summary. Other land uses within Field 1 include the cow races, walkways, farm roads, drainage ways, animal cemetery, and effluent ponds. The animal cemetery is located on paddock 159, and the effluent ponds are located on paddock 201. Both uses are included in the total paddock area.

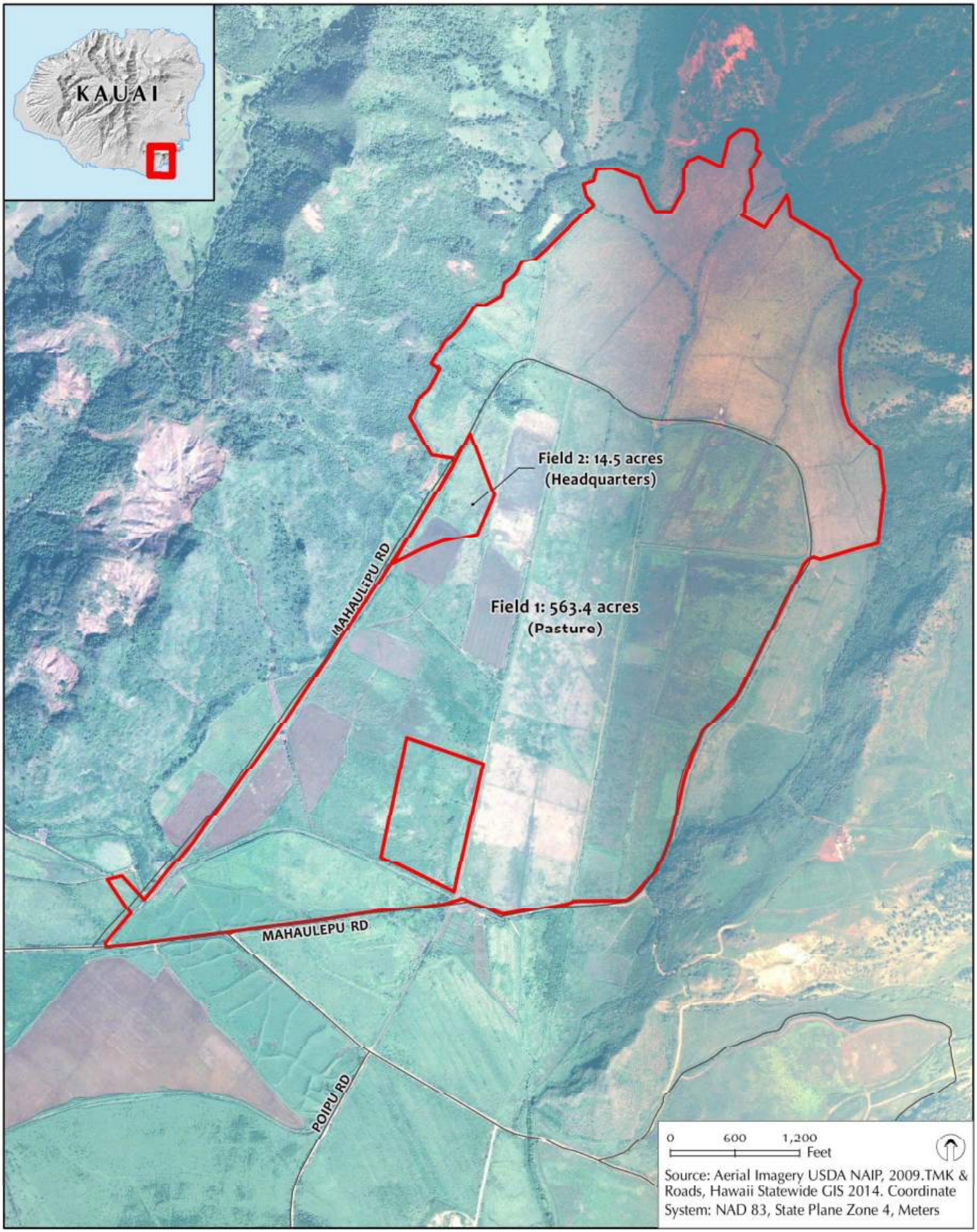


Figure 7 – Field Map

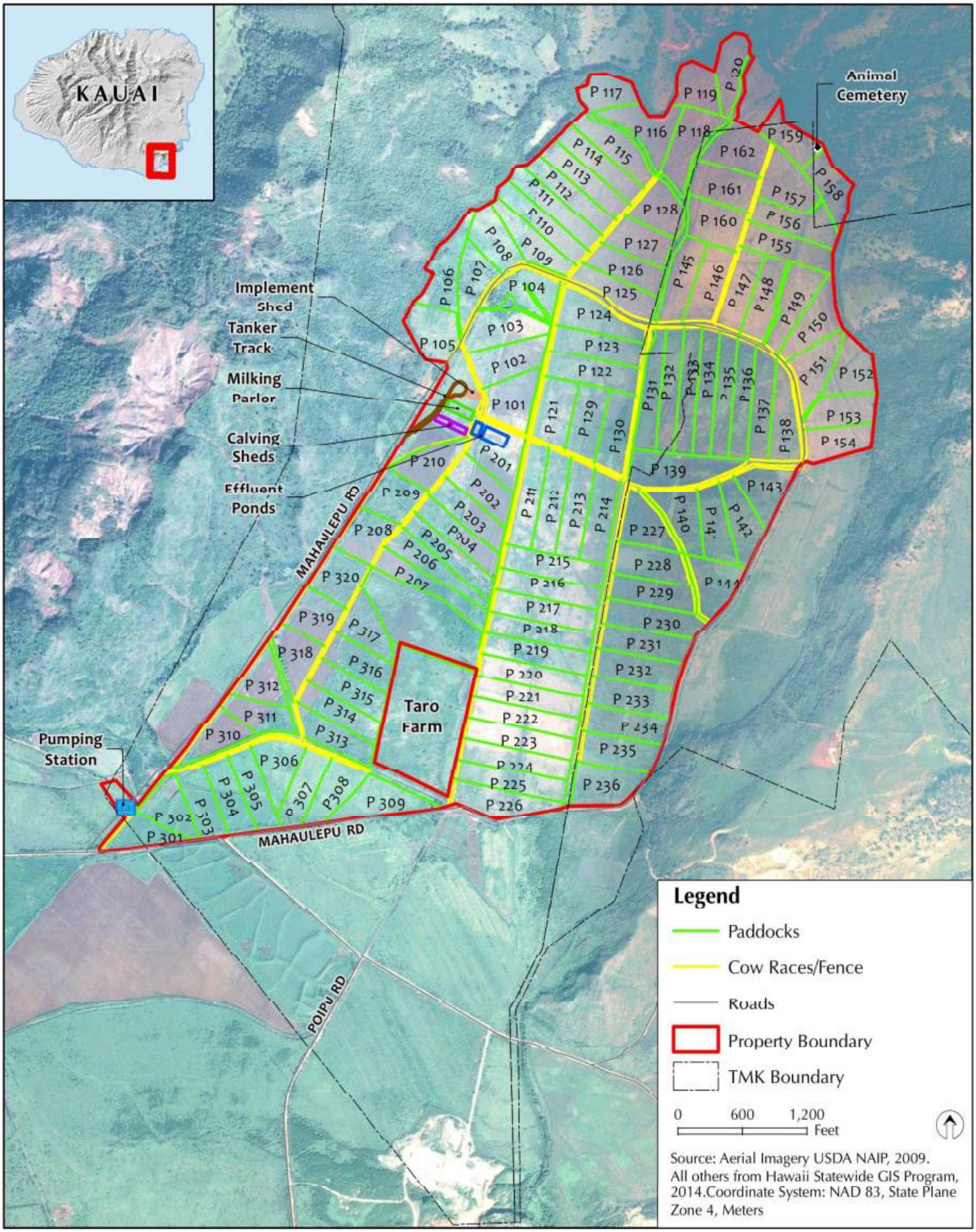


Figure 8 Paddock Map

Table 7 – Paddock Area Summary

Field	Acres	Field	Acres	Field	Acres	Field	Acres
P 101	4.82	P 131	4.35	P 161	4.67	P 229	4.59
P 102	4.82	P 132	4.35	P 162	4.67	P 230	4.59
P 103	4.82	P 133	4.35	P 201	4.94	P 231	4.59
P 104	4.82	P 134	4.35	P 202	4.27	P 232	4.59
P 105	4.69	P 135	4.35	P 203	4.27	P 233	4.59
P 106	4.69	P 136	4.35	P 204	4.27	P 234	4.59
P 107	4.27	P 137	4.45	P 205	4.27	P 235	4.59
P 108	4.27	P 138	4.50	P 206	4.27	P 236	4.94
P 109	4.27	P 139	5.63	P 207	4.27	P 301	3.04
P 110	4.27	P 140	4.30	P 208	3.95	P 302	3.95
P 111	4.27	P 141	4.30	P 209	3.95	P 303	4.20
P 112	4.27	P 142	4.30	P 210	3.95	P 304	4.30
P 113	4.27	P 143	4.30	P 211	4.62	P 305	4.05
P 114	4.27	P 144	4.30	P 212	4.62	P 306	4.30
P 115	4.27	P 145	4.67	P 213	4.62	P 307	4.30
P 116	5.06	P 146	4.67	P 214	4.62	P 308	4.20
P 117	3.24	P 147	4.67	P 215	4.59	P 309	4.94
P 118	5.06	P 148	4.67	P 216	4.54	P 310	3.85
P 119	3.58	P 149	4.67	P 217	4.54	P 311	3.85
P 120	3.58	P 150	4.67	P 218	4.54	P 312	3.85
P 121	4.67	P 151	4.67	P 219	4.54	P 313	4.03
P 122	4.67	P 152	4.08	P 220	4.54	P 314	4.03
P 123	4.67	P 153	4.08	P 221	4.54	P 315	4.27
P 124	4.67	P 154	4.08	P 222	4.54	P 316	4.12
P 125	4.05	P 155	4.67	P 223	4.54	P 317	4.03
P 126	4.05	P 156	4.67	P 224	4.54	P 318	4.03
P 127	4.05	P 157	4.67	P 225	4.54	P 319	4.03
P 128	4.05	P 158	3.58	P 226	4.59	P 320	4.03
P 129	4.67	P 159	3.58	P 227	4.64		
P 130	4.67	P 160	4.67	P 228	4.59	***Total***	***517.29***

4.0 Farm Description

HDF is located on 577.9 acres of agricultural lands leased from Maha'ulepu Farms, LLC (a wholly-owned subsidiary of Grove Farm). HDF is a pasture-based dairy that will be developed in two phases. Phase 1 will include up to 699 cows and Phase 2 will include up to 2,000 cows (total). The facilities will be built out during Phase 1 to support full operation at 2,000 cows.

The majority of the dairy farm area (i.e. ~90%) is dedicated to pasture. The dairy facility including effluent ponds is contained within a 4.6-acre area in Field 2, which represents less than 1% of the entire dairy farm area. The corresponding building areas are under 0.1% of the total farm area. The dairy building and infrastructure are summarized as follows and are shown on Figure 9, Farm Map:

- Paved Access Road and Truck Turnaround
- Cow Walkways/Races and Farm Roads
- Concrete Holding Yards and Gravel Farm Races
- Milking Parlor
- Implement Shed
- Calf Sheds
- Waste Settling Pond and Storage Pond
- Effluent and Sludge Pumps and Distribution System
- Irrigation Water Storage and Distribution System
- Potable Well and Transmission Main to Milking Parlor
- Potable Water Tank for Milking Parlor and Livestock Consumption
- Livestock Water Distribution System
- Feed Silos
- Milking Parlor - Individual Wastewater System (IWS)
- Animal Cemetery

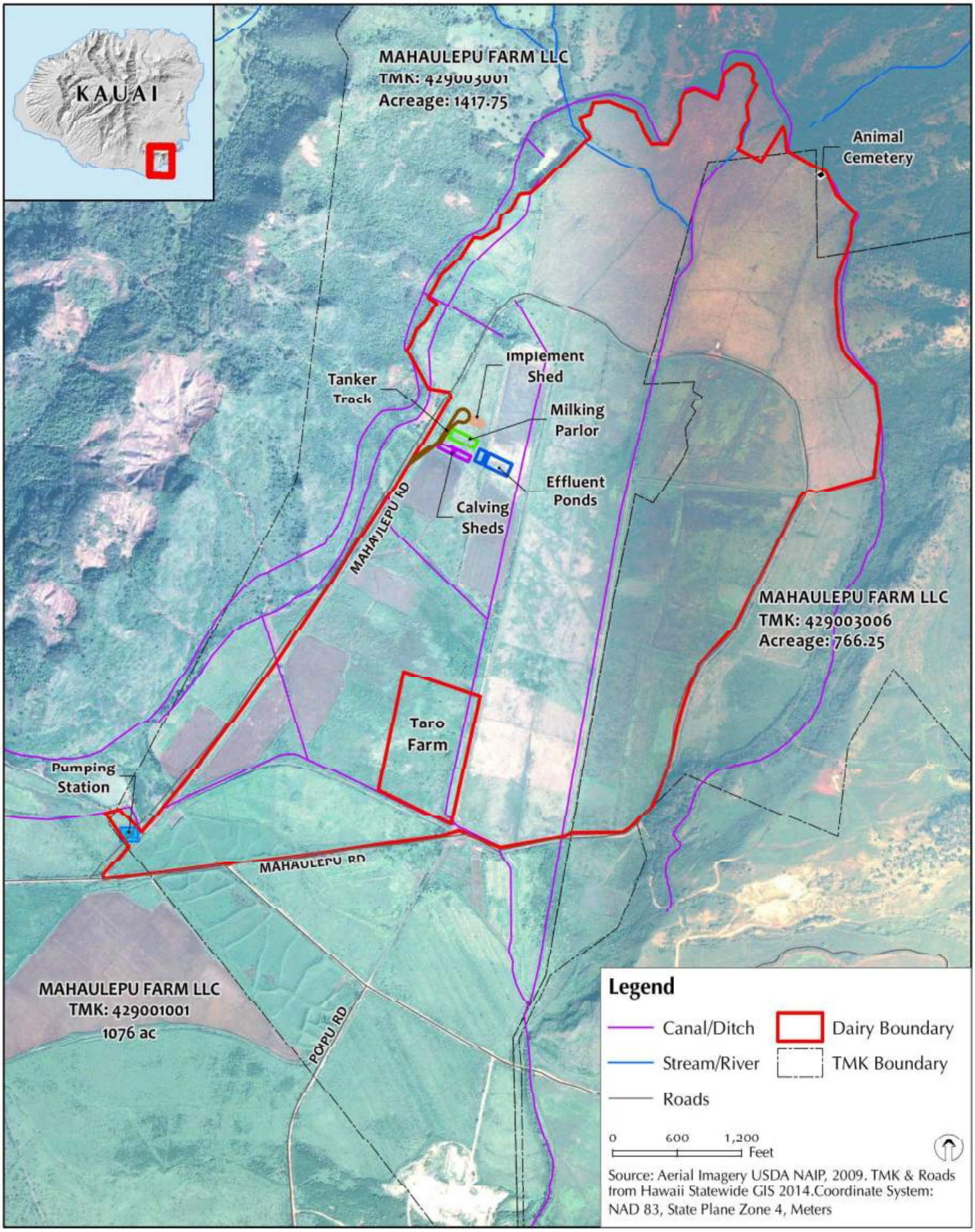


Figure 9 – Farm Map

4.1 Cows Walkways and Races

The dairy farm pasture areas are divided into 4- to 5-acre paddocks as shown on Figure 8, Paddock Map. A network of walkways and races connect the paddocks together and provide access to and from the dairy facility. The walkways and races are generally aligned with existing farm roads where possible, but additional walkways and races will be constructed through the existing fields. See Figure 10, Cow Walkways/Races

The walkways and races are compacted crushed rock access ways that are approximately 16 to 20 feet in width. The cow races allow twice daily movement of the cows from the paddocks to the Milking Parlor. The cow races are not irrigated and are frequently maintained to maximize efficient and rapid movement to and from the dairy with minimal injury to livestock. The races are bordered by 3 wire electrical fencing.

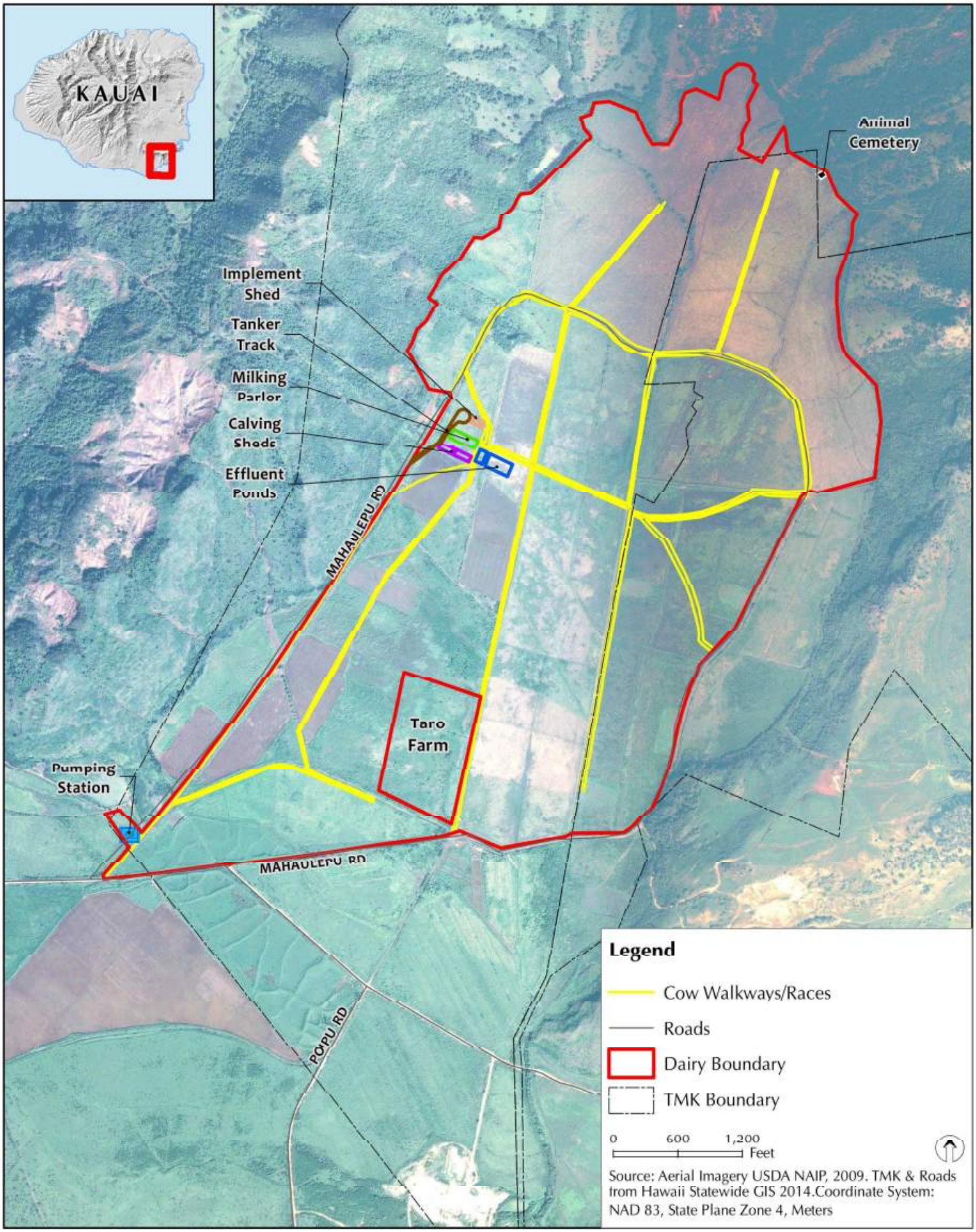


Figure 10 – Cows Walkways/Races

4.2 Dairy Facility

4.2.1 Calf Sheds

Calf sheds will be constructed to provide safe housing to newly born calves. There are two open bay calf sheds, which will be steel structures with metal roofs on concrete slabs. Each shed will be approximately 81 ft. long by 26 ft. wide by 15 ft. tall for a total area of 2,106 sq. ft. each. A minimum 21.52 sq. ft. area is allocated for each calf and 20 calves are kept in one pen (26 ft. x 16 ft.). Each pen is divided in two areas (feeding area and bedding area). The feeding area is washed daily and wastewater is transferred to the effluent ponds. Calf bedding will be constructed of non-skid interlocking plastic tiles. Calves are moved into open paddocks after 3-4 weeks. See Figure 11, Site Plan.

4.2.2 Implement Shed

An implement shed will be constructed for storage of equipment and tools and farm machinery parking. The implement shed will be an open bay steel structure with metal roofs on a concrete slab, similar to the calving sheds. The implement shed will be approximately 65 ft. long by 26 ft. wide by 15 ft. tall for a total area of 1,690 sq. ft. See Figure 11, Site Plan.

4.2.3 Milking Parlor

The Milking Parlor is the single largest structure on the dairy farm with dimensions of approximately 256 ft. long by 88.5 ft. wide by 33 ft. tall. The Milking Parlor contains a highly-automated 60-stall rotary, which completes one rotation of 60 cows in approximately 8-10 minutes. It will operate 365 days a year.

In Phase 1, the 699 cows are managed in small mobs of 105-115 cows. The mobs are brought into the holding yard and Milking Parlor twice a day. Per milking, an individual cow's maximum milking time is 10 minutes and the maximum time off pasture is 1 hour. In Phase 2, the cows are managed in larger groups (300-330 cows per mob) according to their calving, lactation and health status. Similar to Phase 1, the mobs are brought into the holding yard and Milking Parlor twice a day for milking. The individual milking time is the same in both phases, the total time for the mob is less, corresponding to the smaller size of the mob.

The Milking Parlor building includes the following components:

- Covered Loading Area
- Milking Area
- Holding Pens
- Mechanical Room and Pump Room
- Office Space
- Veterinary Space and Storage
- Staff Restrooms
- Milk Storage

4.2.4 Milking Parlor Feeding System

In-parlor feeding is offered to the cows to provide additional nutrients, which improve animal health and milk production. Cows are eager to enter into the parlor to be milked so milking time is typically improved. A small portion of feed (6.6 lbs.) is offered to cows during the milking time (8-10 min), which will be stored in two 44-ton – 60-degree cone silos.

4.2.5 Holding Yard

The holding yard is designed to hold a single 330-cow mob at any one time, and is approximately 150 ft. long by 82 ft. wide for a total area of 12,300 sq. ft. Yard area is heavily used by livestock and needs to be cleaned frequently. Manure/contaminated water is transferred to the effluent pond through underground pipes. No feed is offered in the holding yard and each mob spends less than one hour in the yard before entering into the Milking Parlor.

4.2.6 Access Road and Tanker Truck Turnaround

A new 20-foot wide paved access road will be constructed off of Maha'ulepu Road down to the dairy facility. The access road will serve as the primary access to the dairy and will be used by milk tanker trucks for transport of milk off site. A paved truck turnaround is located at the end of the access road and leads up to a covered loading area where milk is pumped directly into the trucks.

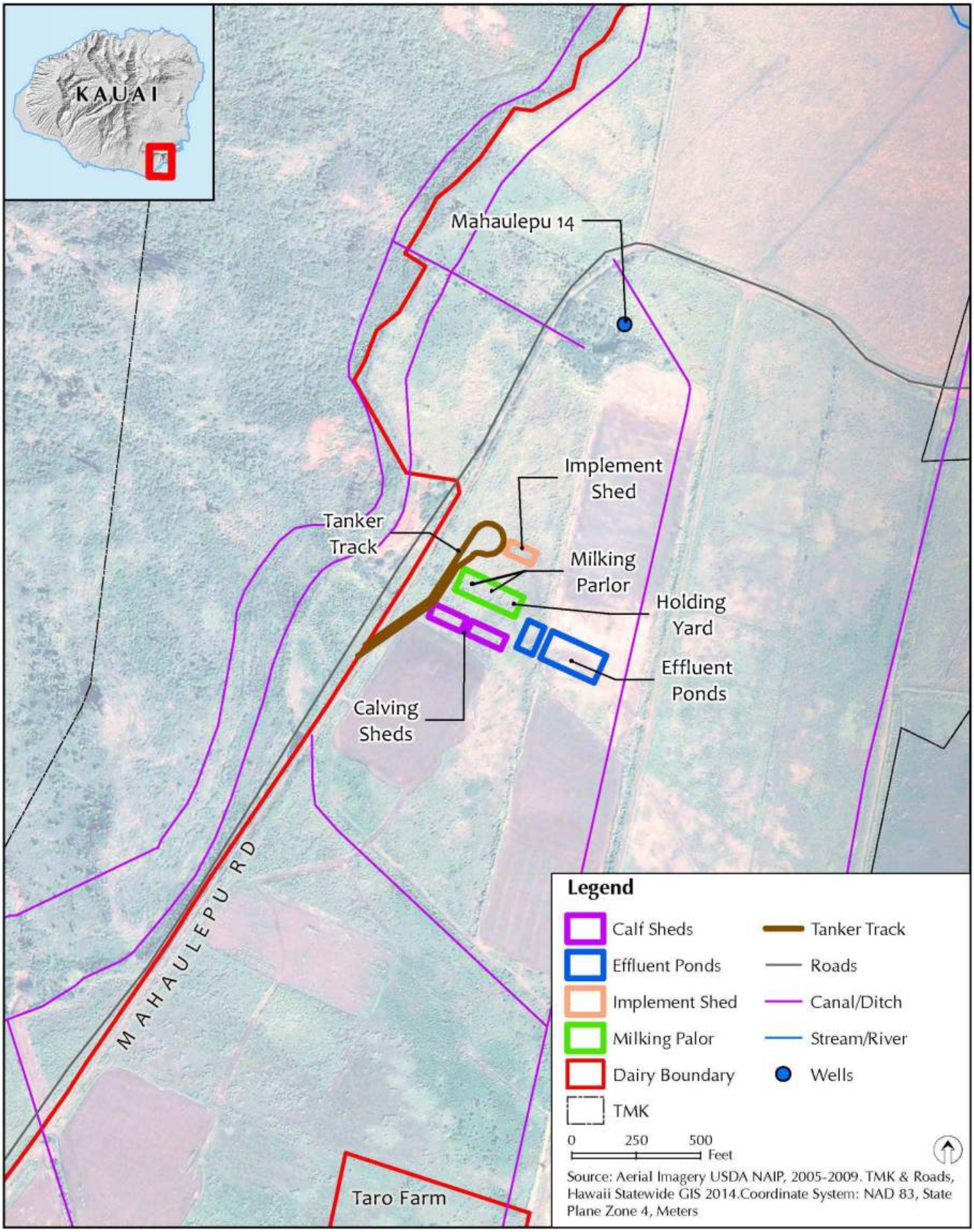


Figure 11 – Site Plan

5.0 Potable Water Systems

Potable water is required for: washing down the Milking Parlor and yards, milk cooling, livestock consumption, and potable consumption within the dairy facility. Total potable water demand for the dairy facility (primarily for wash water) is approximately 0.03 millions of gallons per day (MGD). Total potable water demand for livestock is 0.02 MGD for Phase 1 and 0.05 MGD at full operation of 2,000 cows (i.e. approximately 25 gallons per day/head).

5.1 Water Source and Quality

Potable water for the dairy facility and livestock consumption must be of acceptable quality. Water will either be sourced from the Maha'ulepu Well located within the project site or from a packaged water treatment plant capable of bringing water from the Waita Reservoir up to potable standards. The well site contains up to 14 wells, which were drilled by the sugar plantation. The water source has been tested and is of an acceptable quality. See test results below.

Table 8 – Maha'ulepu Well Water Quality

Sample Type: Aqueous					
Sample Name:		Mahaulepu Palama Well 16-May-2013 2:00 pm		Guideline Value	Maximum Acceptable Values (MAV)
Lab Number:		1140368.1			
Routine Water Profile					
pH	pH Units	7.6	-	7.0 - 8.5	-
Total Alkalinity	g/m³ as $CaCO_3$	171	-	-	-
Free Carbon Dioxide	g/m³ at 25°C	7.8	-	-	-
Total Hardness	g/m³ as $CaCO_3$	250	-	< 200	-
Electrical Conductivity (EC)	mS/m	92.6	-	-	-
Electrical Conductivity (EC)	µS/cm	926	-	-	-
Approx Total Dissolved Salts	g/m³	620	-	< 1000	-
Total Boron	g/m³	0.120	-	-	1.4
Total Calcium	g/m³	55	-	-	-
Total Copper	g/m³	0.00073	-	< 1	2
Total Iron	g/m³	< 0.021	-	< 0.2	-
Total Magnesium	g/m³	27	-	-	-
Total Manganese	g/m³	< 0.00053	-	< 0.04 (Staining) < 0.10 (Taste)	0.4
Total Potassium	g/m³	3.4	-	-	-
Total Sodium	g/m³	101	-	< 200	-
Total Zinc	g/m³	0.041	-	< 1.5	-
Chloride	g/m³	165	-	< 250	-
Nitrate-N	g/m³	1.55	-	-	11.3
Sulphate	g/m³	30	-	< 250	-

The well site has a total capacity of 2 MGD, with redundancy in the form of multiple well heads and potential additional backup source and interconnection with the Waita Reservoir water supply.

The irrigation water supply is an alternative source for potable water. If the well water is not utilized, a water treatment system will be installed to treat the available irrigation water to an acceptable quality for potable consumption in the dairy facility and for livestock.

5.2 Livestock Water Distribution System

Availability of drinking water has an impact on animal health and milk production. The livestock water distribution system has been designed to supply a large volume of water to meet the seasonal high daily water demand of 25 gpd per cow. The total livestock drinking water demand is estimated to be 17,475 gpd for Phase 1 (699 cows) and 50,000 gpd for Phase 2 (2,000 cows). Two large covered and lined water storage tanks totaling 39,682 gallons are located at the Milking Parlor (i.e. providing total storage of nearly 80,000 gallons).

Water from the storage tanks will be distributed into the Milking Parlor and to adjacent buildings for dairy use. Water will also be distributed throughout the paddocks for livestock consumption. Small booster pumps will be used to ensure the required flow is delivered throughout the farm.

Small diameter water mains 2 to 3 inches in size deliver water to the paddocks. Two concrete troughs will be installed in each paddock to give animals free access to drinking water at all times. Troughs are raised and placed on a crushed rock base to provide a firm and stable surface for animal movement around the trough. The trough is high enough for the animal to reach over and in, but will discourage the animal from stepping into the trough. The troughs are also fitted with valves to stop the flow of water into the trough when the trough is full and refill the trough as the water is consumed.

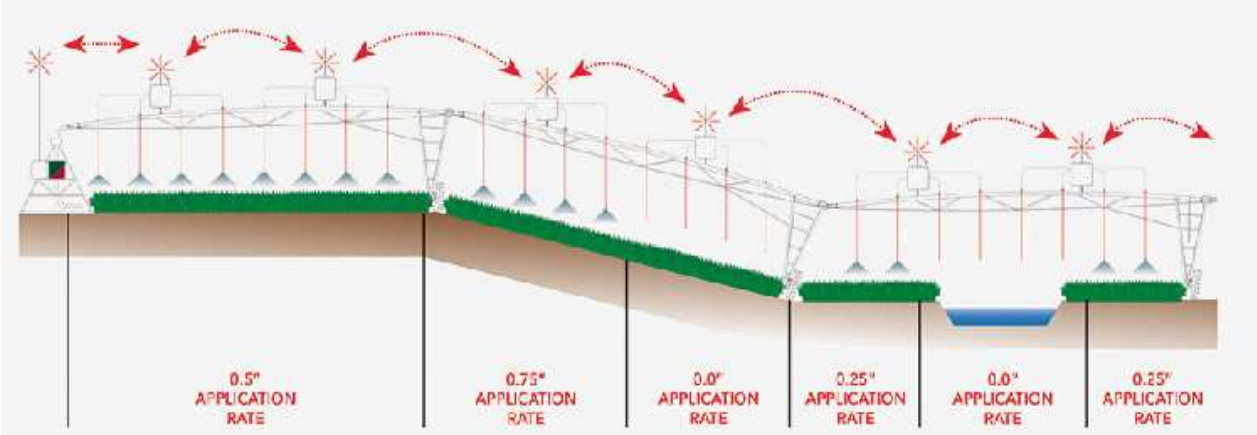
6.0 Irrigation

The total pasture area of the farm is 517.3 acres. The majority of the pastures will be irrigated through either spray or drip irrigation systems. See Figure 12, Irrigation Map.

6.1 Spray Irrigation System

The spray irrigation system will consist of two central pivot irrigation systems. A central pivot irrigation system is an overhead irrigation system, which includes irrigation pipes supported on trusses mounted on wheeled towers that rotate around a central water supply point. The farm will have two pivots; irrigation pivot #1 will be a full circle (FC) pivot and irrigation pivot #2 will be a partial circle (PC) pivot. See Figure 13, Center Pivots. The irrigation system including irrigation application rates and emitters is controlled using computer software and GPS receivers to allow very precise application of irrigation on the pasture.

The various components of a typical spray irrigation control system are described below:



Precision VRI Controller
Controls the irrigator ground speed and the water outlets including individual sprinklers and the end gun (as an optional extra).

- The Precision VRI controller reads the irrigation plan and uses data from other inputs (such as GPS coordinates) to calculate which valves need to be actuated at any one time.
- Communication within the system is via wireless links from the Precision VRI controller to the wireless nodes. Node control signals are packet-based, thus any form of information desirable for control of the irrigator can be transmitted to the wireless nodes.
- The Precision VRI controller is placed next to the irrigator's main controller (generally

situated at or near the center of the irrigator), operating on 12V DC.

- The Precision VRI controller contains a Windows-based touchscreen panel PC. A large number of plans that can be loaded into the Precision VRI controller if desired.

Wireless Nodes

The wireless nodes consist of a watertight enclosure and a Printed Circuit Board (PCB) containing the wireless transceiver, processor and drivers to individually control four latching relays.

- Each wireless node provides both power and control signals via wired connections to four (or less) valves. The wireless node will either turn the sprinklers on, off or pulse at a duty cycle determined by the Precision VRI controller.
- Each wireless node is powered by a common 24V DC power line.
- Each wireless node also acts as a wireless repeater to send signals further up and down the length of the irrigator.

Wiring Loom

- The looms consist of a power cable that runs between wireless nodes and four wires from the wireless node to control each valve.
- Each loom is pre-wired into the wireless nodes at the factory.

Power Source

- 1 x 90~264VAC input, 24VDC output, 225W switch mode power supply with constant current limiting.
- The system converts power from the high voltage line and provides 24V DC to the power line.
- Three phase power option, 340~550VAC Input, 24VDC 10A Output, 240W fully self-protected switch mode power supply

GPS

The GPS system consists of an industrial grade GPS unit with high receiver sensitivity (waterproof -22°F to +176°F operating temperature range).

- A GPS unit at the end of the pivot (or one GPS unit at each end of a lateral-move) sends a signal back through the wireless node network to notify the Precision VRI controller the position of the irrigator. The Precision VRI controller uses this position to calculate the valve control signals at this point.

PC Software

- Irrigation plans are created in the Field Map farm mapping software.

- The Field Map software takes in to account both source and field information to optimize water application for each irrigation plan.
- Irrigation plans are loaded into the controller either manually via a USB stick or through a wireless connection.

6.2 Drip Irrigation System

The drip irrigation system is a subsurface irrigation system using either drip tubing or tape installed in the ground. Irrigation water will be filtered and pumped at low pressures into the subsurface irrigation system. See Figure 14, Drip Irrigation.

6.3 Non-Irrigated Pasture

Approximately 11% of the pasture area is not irrigated as shown on Figure 15, Non Irrigated Pasture.

6.4 Irrigation Setbacks

Setback distances have been established to limit activity and irrigation within non-irrigated areas within the irrigation pivot areas. The spray irrigation systems are configured with GPS controlled emitters that will turn off so that water is not directly applied to the ditches, cow races and any agricultural or natural water resources. The following setbacks are incorporated into the design and are indicated on Figure 16, Irrigation Setbacks:

- Streams, agricultural water, and natural water resource - 50 feet on both sides.
- Cow walkways and races - 6 feet on both sides
- Existing taro farm - 20 feet on each side

The setback areas will also be re-vegetated with native plants. See example below of a restored setback area along a stream for the AgResearch Tokanui Farm in New Zealand.

6.5 Irrigation Demand

The irrigation areas are summarized in the table below. Irrigation water demand is based on a rate of 6 mm/0.24 inches per day over the irrigated area. The total irrigation demand to irrigate all areas is 2.93 MGD.

Table 9 – Irrigation Demand Summary

Irrigation Area	Acres	Demand, MGD
Irrigation Pivot #1 (FC)	216	1.36
Irrigation Pivot #2 (PC)	162	1.04
Drip Irrigation Area	82	0.53
Subtotal	460	2.93
Non Irrigated Area	57	0
TOTAL	**517**	**2.93**

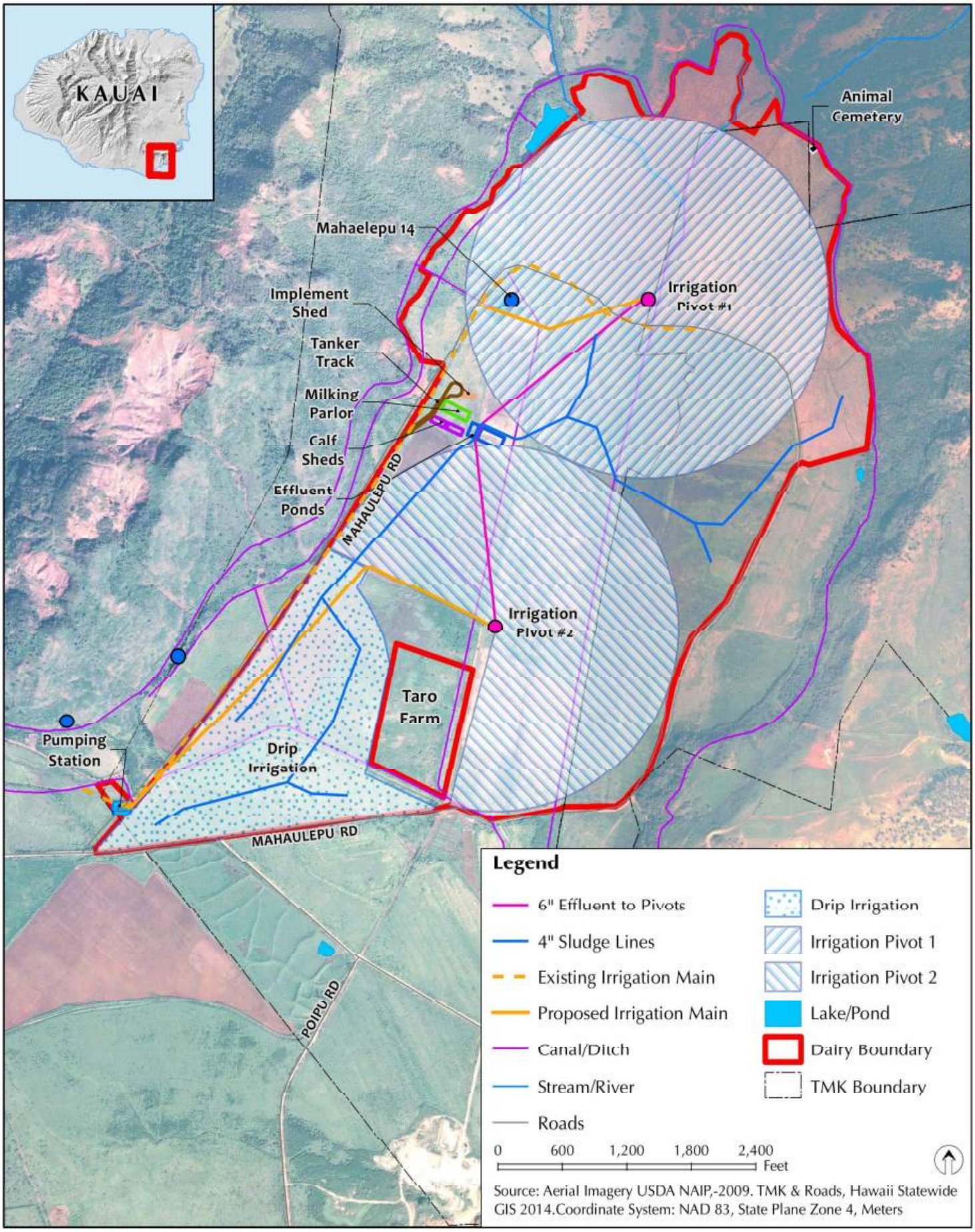


Figure 12 – Irrigation Map

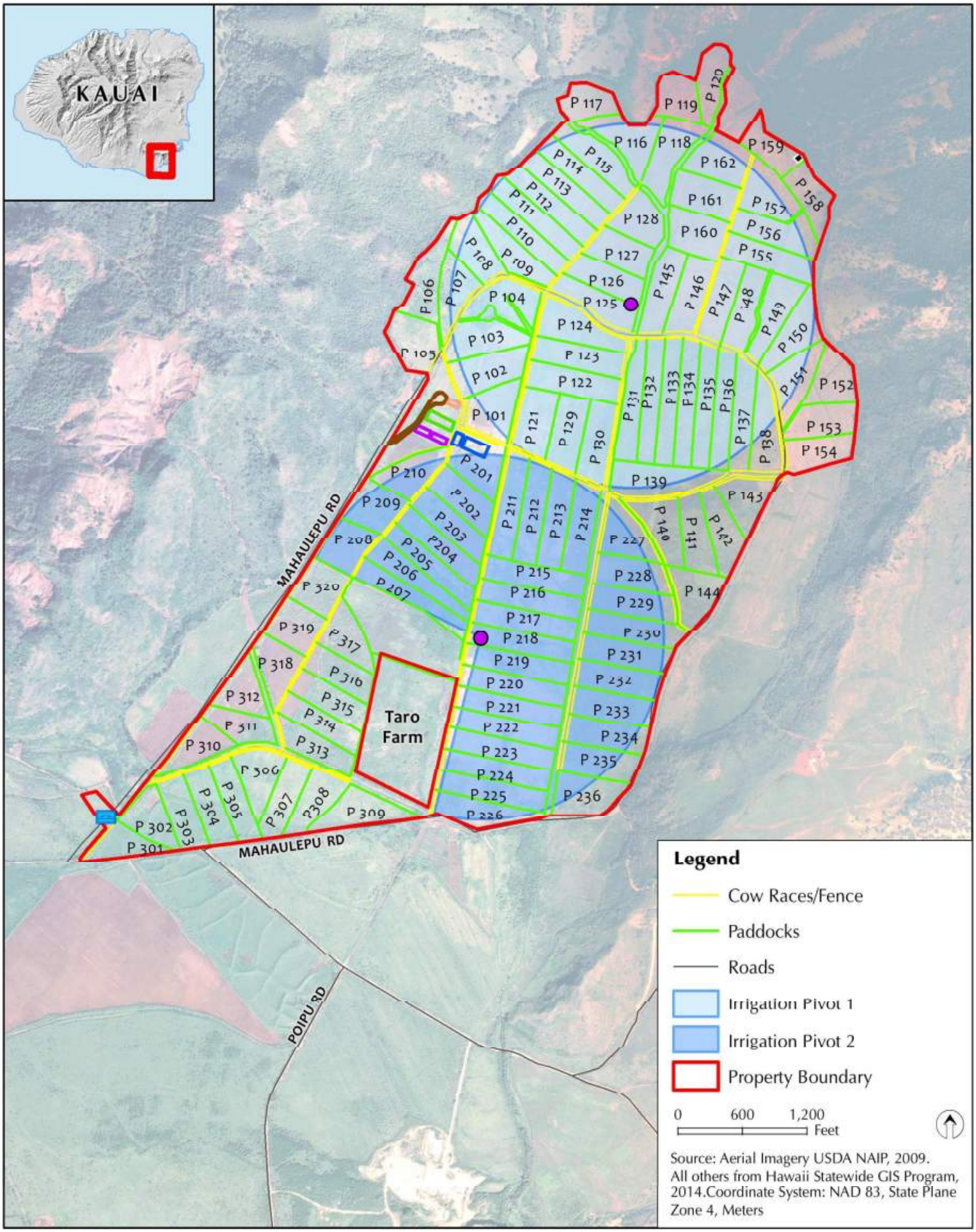


Figure 13 – Center Pivots

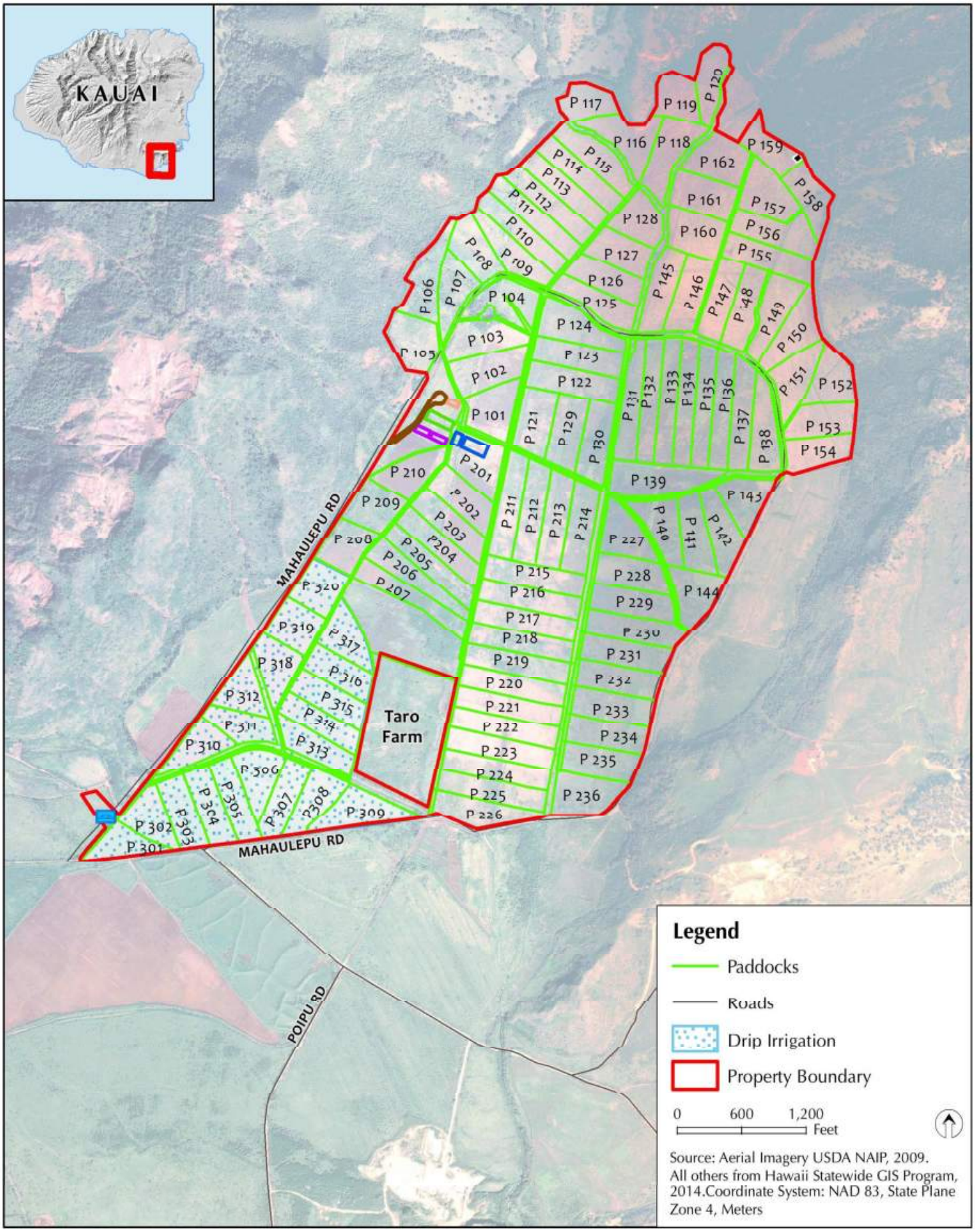


Figure 14 – Drip Irrigation

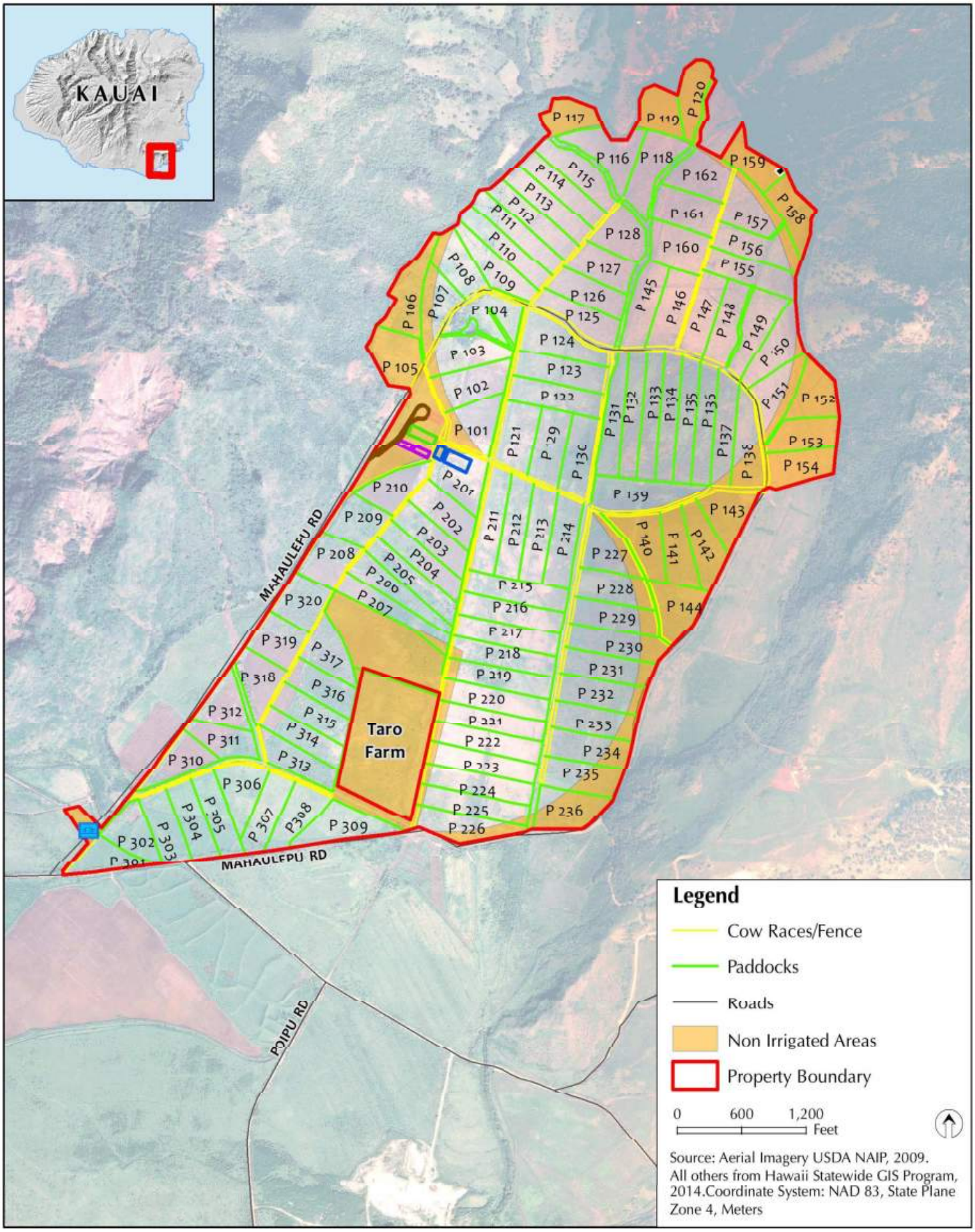


Figure 15 – Non-Irrigated Pasture

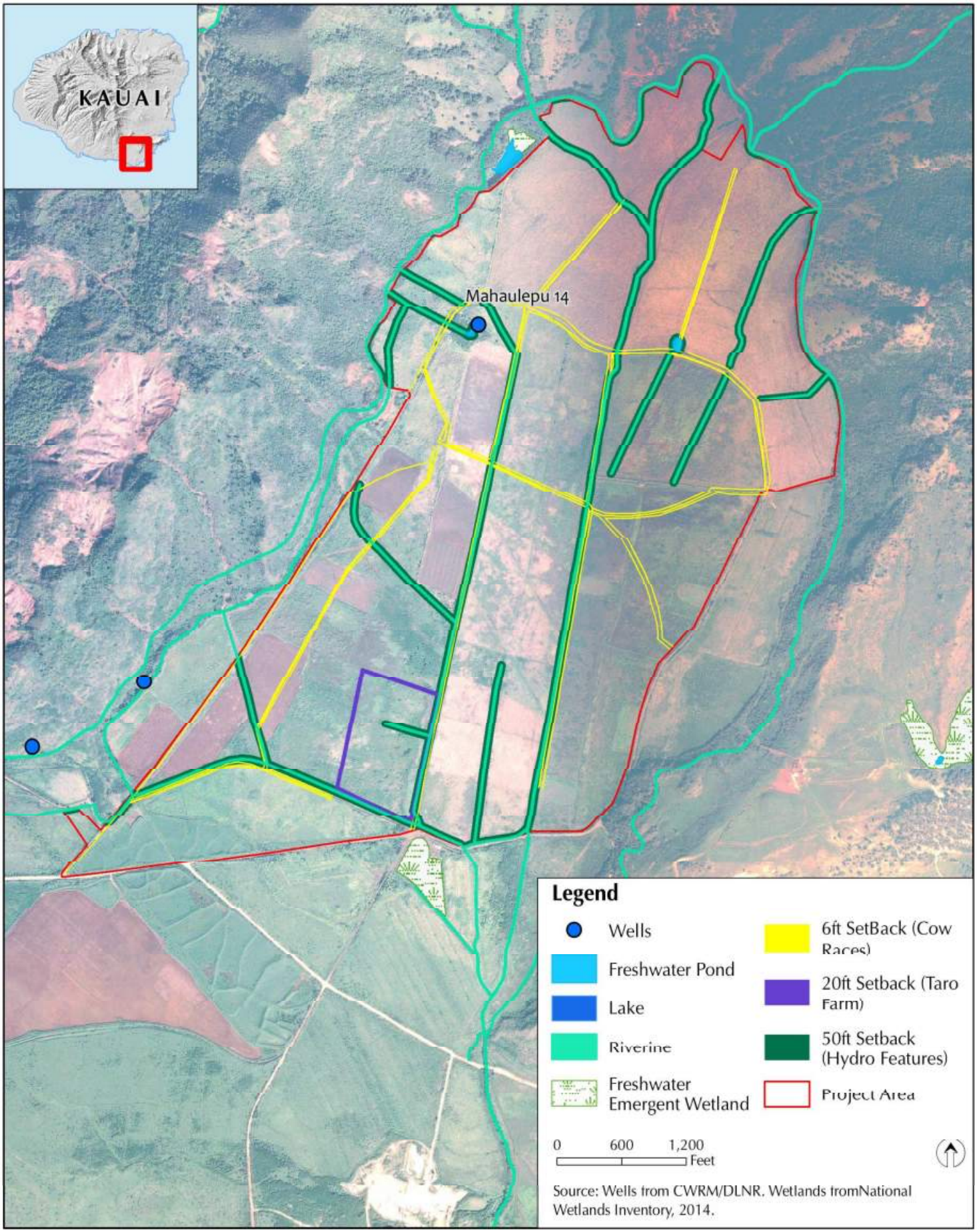


Figure 16 - Irrigation Setback

6.1 Irrigation Schedule

At full irrigation, the pasture will require 2.93 MGD of water per day, to achieve an average application of 6 mm/0.24 inches per acre (over the irrigated area, which includes the areas previously described in Table 9). The actual schedule of irrigation days will depend on the days that it rains. The following discussion and associated tables provide the methodology for determining seasonal irrigation demand and associated number of irrigation days per month.

Table 10 provides the average monthly rainfall and pan evaporation rates which demonstrate a clear deficit in water supply during the spring, summer and fall seasons with only a modest demand for irrigation during the winter season.

Table 10 – Monthly Average Rainfall and Evaporation

Month	Days	Mean Monthly Rainfall (in) UH Rainfall Atlas of Hawai'i 2011 (30 years data)	Evaporation rates per month (in) Weather Station 941-00
January	31	4.88	5.14
February	28	4.2	5.65
March	31	5.04	6.93
April	30	3.66	7.43
May	31	3.05	7.82
June	30	2.86	8.05
July	31	3.13	9.10
August	31	3.2	9.37
September	30	3.25	8.23
October	31	4.96	7.33
November	30	6.01	6.17
December	31	5.71	5.40
Total	365	49.95	86.62

During the wet winter months of November, December and January, the frequency and need of use of the irrigators is significantly lower than other times of the year, but irrigation is still required as there are a number of dry days in those months.

The winter rain pattern is typified by episodic storms followed by several days of no/zero rainfall. Since the fields will need to be irrigated after five days of mostly dry weather, the number of dry days in the winter months was evaluated to gauge irrigation demand. The table below shows the number of days with less than 0.12 inches of rainfall in January, November, and December from 1989-2012.

Table 11 - Dry Days Data
(including 0.12 inch (3mm) or less rainfall)

Year/Month	Jan	Nov	Dec
1989	15	18	25
1990	17	16	16
1991	27	14	14
1992	23	18	11
1993	22	14	16
1994	16	21	16
1995	29	16	14
1996	14	9	17
1997	20	19	16
1998	23	16	21
1999	15	17	18
2000	17	14	23
2001	24	20	19
2002	22	18	17
2003	21	16	16
2004	19	17	17
2005	18	18	28
2006	16	16	21
2007	20	21	14
2008	20	19	21
2009	17	14	27
2010	16	17	18
2011	8	21	13
2012	18	14	9
Average Dry Days	19	17	18

We assume irrigation is required approximately every 5 dry days. Therefore, we assume the irrigators will run on average 3 times per month during the wet season (December to February), plus the average difference between rainfall and evaporation. (eg. 4 irrigation days for

November, December and January shown on Table 12). For the other months, we calculate the irrigation days as the differential between the evaporation rate and the mean monthly rainfall divided by the daily demand of 0.24 inches per acre.

Table 12 – Irrigation Days per Month

Month	Number of Irrigation days required at 0.24 inches per day
January	4
February	9
March	8
April	16
May	20
June	22
July	25
August	26
September	21
October	10
November	4
December	4
Total	154

A weather station is already installed on-site, capable of measuring temperature, humidity, rain, wind direction and speed, irradiance and evaporation. Soil moisture meters will also be added to determine the ideal moisture bandwidth for grass growth and support irrigation decisions. It will be sensible to load the soil towards its maximum moisture level before July and August, as little rainfall in these months is possible and during that time the soil could enter into a deficit greater than the rate of available irrigation. It will also be sensible to dry the soil towards its minimum moisture level before November, December and January, as significant rainfall in these months is probable and could cause the soil to exceed capacity from rainfall alone. However, we have modelled the days where it has not rained in these wet months since the irrigators are likely to be needed to run in these dry spells. Furthermore, the evaporation rate will dry the soils if it doesn't rain regularly and affect pasture growth rates after several days without rain.

In addition to the need for irrigation during the dry spell days, the irrigators can run in November, December and January (if no dry spells occur) to distribute only effluent water. In the case of a continuously wet period that keeps soil at capacity, (the longest on 30-year record is 17 days) the irrigators can be programmed to drop effluent water only and at a rate as low as 0.04 inches, and the placement of the effluent water can be targeted to the freest draining soils on the farm. A target zone for an exceptionally wet season application is paddocks 111 - 115, where the Lualualei Clay soil is classified as "well drained" and a raceway (acting as a berm) separates the paddocks from any water ways. The irrigation system will track and plot any such exception placement of effluent and its corresponding nutrient loading. Other "well drained" soil type options are Hanamaulu Silty Clay, Hanamaulu Stony Silty and Pakala Clay Loam.

The upper pivot, irrigation pivot #1 (FC), will irrigate 216 acres under one rotation. It is expected that the upper pivot will do a rotation every 40 hours, applying 0.39 inches/10 mm of water onto 47 paddocks during normal operation.

The bottom pivot, irrigation pivot #2 (PC), will irrigate 162 acres in a similar time period to the upper pivot, but with the addition of a 'fast cycle' for the end of each pass of the pivot. This fast cycle is done at maximum machine speed so that a minimum of water is applied at the end of the run, which reduces the wetness of the ground when the machine reverses direction and then applies a 'normal' amount onto this same area. The whole cycle takes about 40 hours applying 0.39 inches/10 mm water onto 36 paddocks.

Drip Irrigation system will be installed to irrigate 82 acres.

7.0 Wastewater Treatment

The dairy is a pasture-based operation, and livestock spend a limited time in the holding yard and Milking Parlor. Livestock waste and wastewater generated from the dairy facility, including any runoff, will be collected, treated and reused on the farm. Fundamentally, the water treatment system recycles 100% of all wastes with zero point source discharge into State waters. The objectives of the design are:

i. To capture all of the effluent that is produced at the dairy facility
ii. To spread the effluent on the grazing land to meet nutrient demand of the plants/pasture
iii. To control the effluent application rate and spread effluent only on the desired areas within boundaries
iv. To keep effluent completely separate from potable water to prevent contamination
v. To comply with all regulatory requirements under the state and federal laws

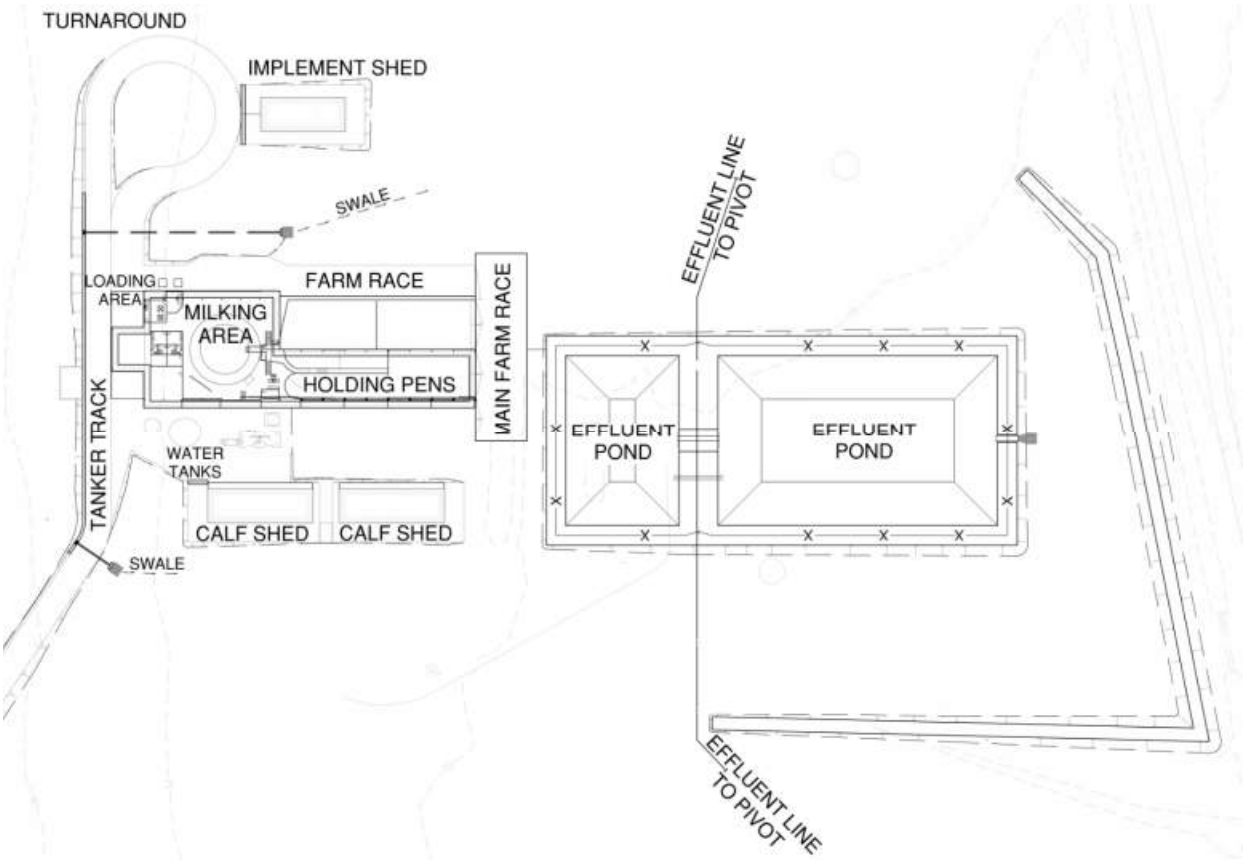


Figure 17 – Dairy Facility Site Plan

The dairy facility including the wastewater treatment ponds and other infrastructure will be sized and constructed for the Phase 2 capacity of 2,000 cows. However, the calculations in this report are based on the Phase 1 capacity of 699 cows. A future amendment to the Waste Management Plan will be submitted for review and approval for Phase 2. Refer to NRCS Practice Code Standard 633 Waste Utilization.

7.1 Effluent/Manure Volume

HDF is a pasture-based dairy farm that is being designed for kiwi-cross animals. A mature kiwi-cross cow's weight is about 1,210 lbs. and it produces an average of 143 lbs. of manure per day or 8.8 lbs. (1.05 gallons) average per waking hour. The 699 cows in Phase 1 will be maintained in mobs of 105-115 animals, on a 54-acre block, that is subdivided into 18 paddocks. The cows graze for one day per paddock, so once every 18 days the entire mob (all 105-115 animals) will produce the majority of its effluent on that one paddock as it grazes.

Grass-fed cattle produce significantly more liquid manure than cattle fed on concentrate and Kikuyu is also a relatively wet grass (87% water). The total amount of manure produced in the milking platform each day will be 1,477 gpd [699 cows x (1hr x 2 milkings per day) x manure of 1.05 gallon per hour = 1,477 gpd].

The holding yard and Milking Parlor are washed twice a day after each milking. All of the manure produced in the Milking Parlor and yards is washed out and the contaminated water is transferred to the settling pond. The milk storage tanks located within the Milking Parlor are also washed out after milk is pumped to tanker trucks for delivery. Wash water from the milk tanks is also transferred to the settling pond. The total wastewater volume for 699 cows from the machine wash, yard wash, and other milking activity is 10,667 gpd. See Figure 18, Water Flow Schematic.

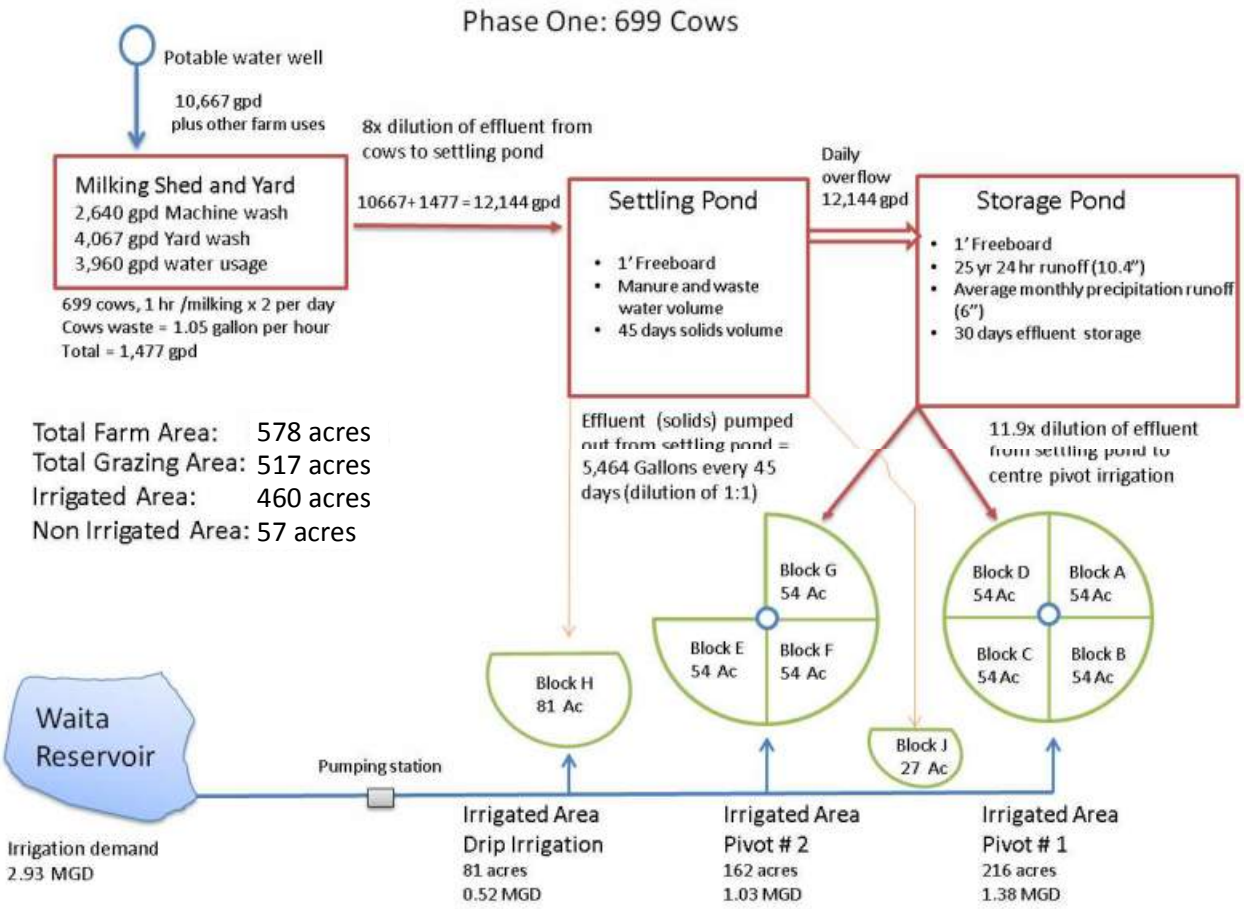


Figure 18 - Water Flow Schematic

All of the manure that is collected from the Milking Parlor and yards is transferred to the settling pond. The settling pond remains full in normal steady state, and any excess liquid overflows into the storage pond through screened overflow pipes. The clear screens are fitted into the overflow pipes and do not allow solids to enter into the storage pond. A stirrer pump is operated two hours per day to break up the solids in the settling pond. The accumulated sludge in the settling pond will be pumped out every 45 days. The minimum settling pond volume will include 45 days of sludge storage plus an appropriate mixing volume of liquid required for stirring and pumping for application to the pastures.

Liquid effluent from the settling pond overflows into the storage pond which is then applied from the storage pond onto the pastures aftering being diluted and injected into the irrigation water through the center pivots. The level of the storage pond will rise gently during each

milking washdown and fall on irrigation days. The total amount of effluent from the storage pond (0.012 MGD) is only a small fraction of the total daily irrigation demand of 2.93 MGD. As a result, effluent pumped to the center pivots is diluted approximately 12x and applied to the grazing land at an application rate significantly less than the nutrient requirement of the grass and at a rate significantly less than the daily draining capacity of the soil.

The storage pond will be emptied according to a 4-day application schedule (i.e. every 4 days). The effluent will be applied only when there has been no heavy rain in the last two days and no rain is forecasted for the next two days. Any single nutrient application (i.e. from a 4-day block of storage pond effluent) is enough to supply approximately 20% of the nutrient needs of the grass for the 54 acres the effluent is applied to.

The minimum required effluent storage volume in the pond shall include the 4 days of effluent required for the typical application schedule and also the additional storage required during periods of rainfall when irrigation application of effluent is not possible. The design effluent storage period includes allowance for the following volumes:

- Effluent volume for 4-day storage period between scheduled irrigation of effluent
- Effluent volume for maximum 17 consecutive rain days based on NOAA rain gauge data, See Table 4 – NOAA Rain Gauge Data
- Effluent volume for 2 days minimum of pasture dry time

Based on the above volumes, the minimum effluent storage should include 23 days of effluent volume. The design storage volume required will be set to 30 days of effluent, which will provide an additional storage buffer.

The storage pond will be sized and constructed for the ultimate Phase 2 capacity of 2,000 cows. The minimum storage requirement for Phase 2 full operation is estimated to be approximately 30,360 gpd for a 30-day storage period. Phase 1 has a lower effluent volume of 12,144 gpd; therefore, the storage pond effectively has excess storage and could hold approximately 100 days of effluent storage capacity (for 699 cows).

7.2 Effluent Ponds

The effluent ponds will be constructed for effluent collection, management and proper utilization of nutrients available from livestock waste. The pond design is based on a two-step system, which includes a settling pond and storage pond. The settling pond allows for the settlement and accumulation of wastewater sludge with the overflow of liquid effluent entering the storage pond. The ponds will be located outside of wetlands and at a minimum distance of 1,000 feet from public drinking water resources and 50 feet from surface water resources. See Figure 11, Site Plan.

Ponds will have minimal potential impacts from breach of embankment, accidental release, and liner failure. Ponds have been designed to be protected from inundation or damage from a 25-year flood event.

The ponds have the capacity for storage of the following volumes:

- Volume of accumulated sludge for the storage period between sludge removal events
- Volume of manure, wastewater, and other wastes accumulated during the storage period between irrigation application
- Depth of average precipitation for the storage period
- Depth of the 25-year, 24-hour storm precipitation

The pond volume calculations are based on the following assumptions:

Table 13 – Effluent Pond Sizing Criteria

Design Criteria/Assumption	**Phase 1 699 Cows**	**Phase 2 2,000 Cows**
Daily Wastewater Generation	12,144 gpd	30,360 gpd
Percentage of Solids	1%	1%
Minimum Volume of Accumulated Sludge	5,464 gal – 45 days	13,662 gal – 45 days
Daily Overflow to Storage Pond	12,144 gpd	30,360 gpd
Minimum Volume of Effluent Storage	0.36 MG – 30 days	0.91 MG – 30 days
Depth of 25-Year, 24 Hour Storm	10.4 inches	
Depth of normal precipitation for storage period	6 inches	

The effluent ponds and concrete holding areas are not covered. All rainfall in these areas, and from any area that could generate contaminated runoff is collected and conveyed to the ponds. Approximately 1.76 acres of area drain to the ponds and are accommodated in the pond sizing

and minimum volume requirements. The areas included are; the calf sheds and concrete gutter, the uncovered holding pens and yards, the uncovered loading areas, and the settling and storage pond areas. The rainfall onto the roofs of the Milking Parlor and implement shed is discharged directly to the pasture areas adjacent to the buildings, and does not enter the effluent system.

7.2.1 Settling Pond

Wastewater from the dairy is discharged into the settling pond first. Solids are accumulated in this pond and liquid effluent overflows to the adjacent storage pond. The volume of accumulated solids is sized to allow 45 days of sludge storage based on the solids application schedule. The minimum required sludge volume for each phase is shown in Table 13 above. The pond is oversized in Phase 1 to allow for Phase 2 sludge volume requirements.

In addition to the sludge volume, a mixing volume will be provided to allow for stirring and suspension of solids during de-sludging and application of sludge to the pastures. The minimum mixing volume is dependent on type of equipment, operational needs and operator preferences. For the settling pond, the mixing volume will be set to a nominal volume of 0.5 MG.

The top of the settling pond is 87′ x 133′ with a total depth of 12′ from invert to overflow spillway. The settling pond minimum required Phase 1 volumes and total available volumes are shown in the figure below.

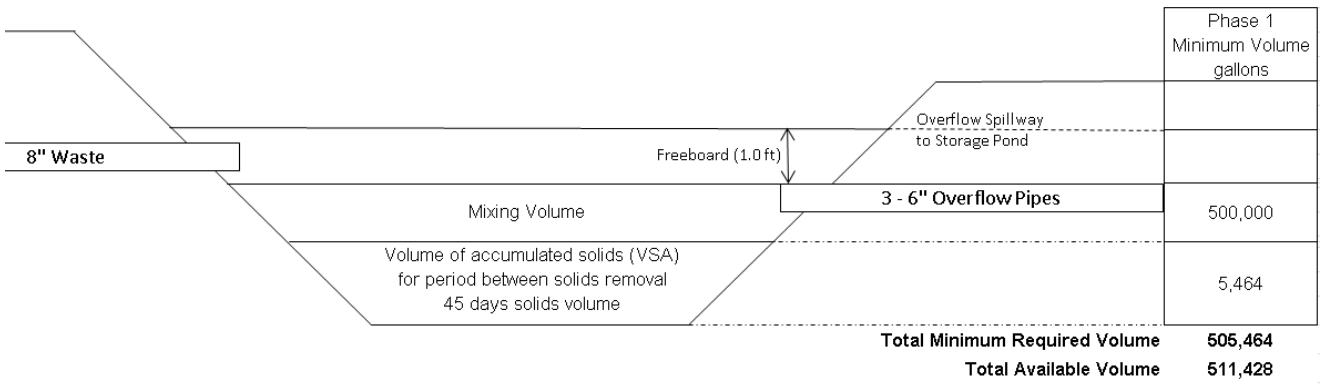


Figure 19 - Settling Pond Typical Section & Volumes

7.2.2 Storage Pond

Effluent from the settling pond overflows through three 6-inch screened overflow pipes. The volume of effluent storage is sized to allow a minimum of 30 days effluent storage based on the irrigation schedule. The top of the storage pond is 215′ x 133′ with a total depth of 15.5′. The pond is oversized to allow for Phase 2 effluent volume requirements. The storage pond minimum required Phase 1 volumes and total available volumes are shown in the figure below.

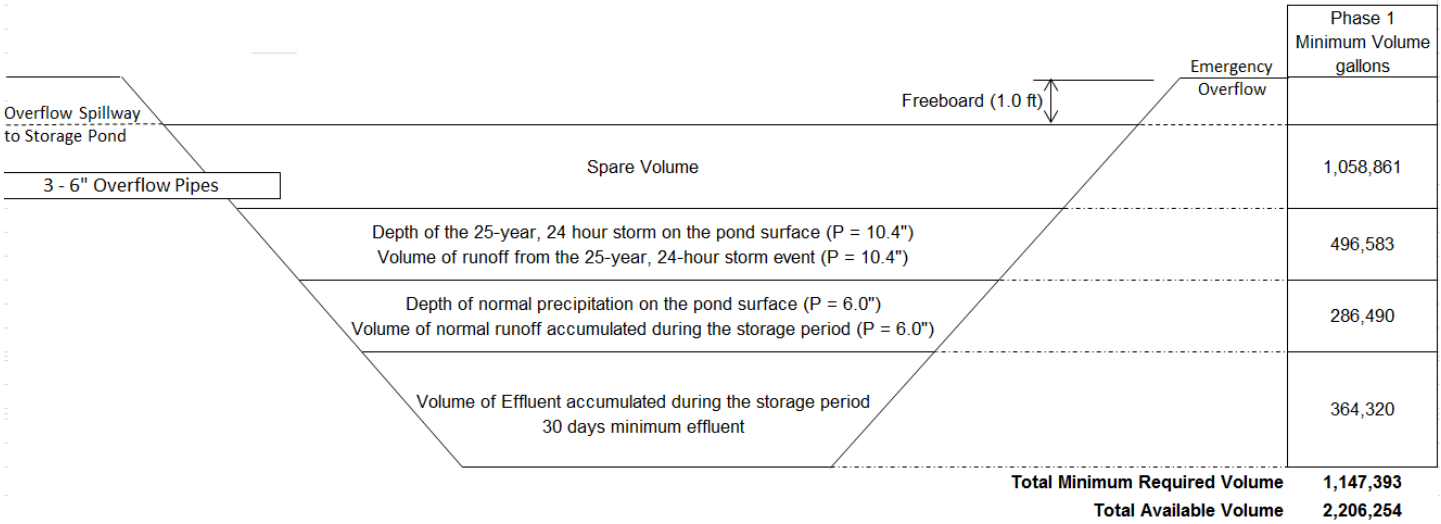


Figure 20 - Storage Pond Typical Section and Volumes

7.2.3 Effluent Pond Design

Ponds will have a minimum of 2-feet bottom elevation above the seasonal high water table. Excavated side slopes will not be steeper than 2 horizontal to 1 vertical. The inlet pipe at the effluent pond will be a concrete pipe with a minimum of 6 inches diameter. A pipe with a minimum diameter of 8 inches will be used for Milking Parlor waste. The pipe terminates a sufficient distance from the shoreline of the pond to ensure good distribution. A cleanout is also provided for removing obstructions. Irrigation intake pipes from the required volume are designed to resist corrosion and plugging. The irrigation system will not automatically pump from the required volume of the pond based on water level. The irrigation system is on a predetermined schedule which can also be manually controlled.

The minimum elevation of the top of the settled embankment shall be 1 foot above the pond's required volume. The combined side slopes of the settled embankment shall not be less than 5

horizontal to 1 vertical, and neither slope shall be steeper than 2 horizontal to 1 vertical unless provisions are made to provide stability.

Safe drawdown of the liquid level in the pond is provided. Embankments and disturbed areas surrounding the pond are treated to control erosion. This includes the inside slopes of the pond as needed to protect the integrity of the liner.

The pond perimeter will be fenced and warning signs posted to prevent children and others from using it for other than its intended purpose. A marker or water level measuring device will be installed in the pond to measure the stored volume and/or storage capacity remaining.

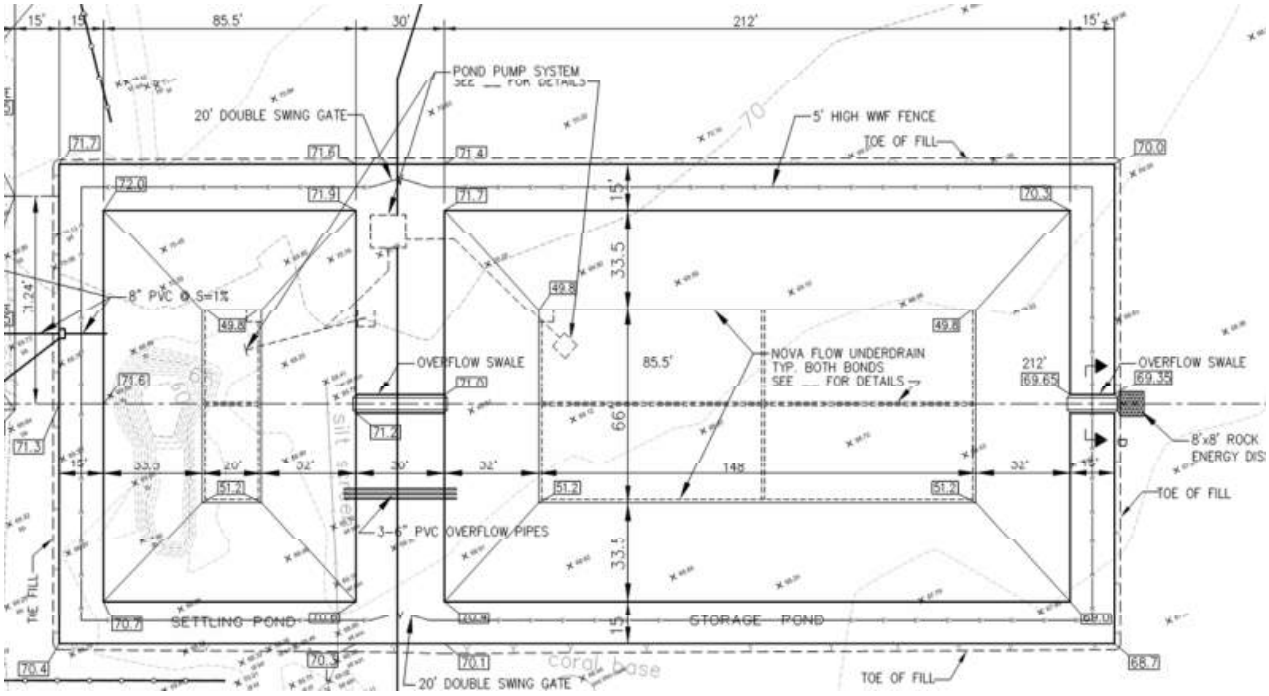


Figure 21 - Effluent Pond Plan

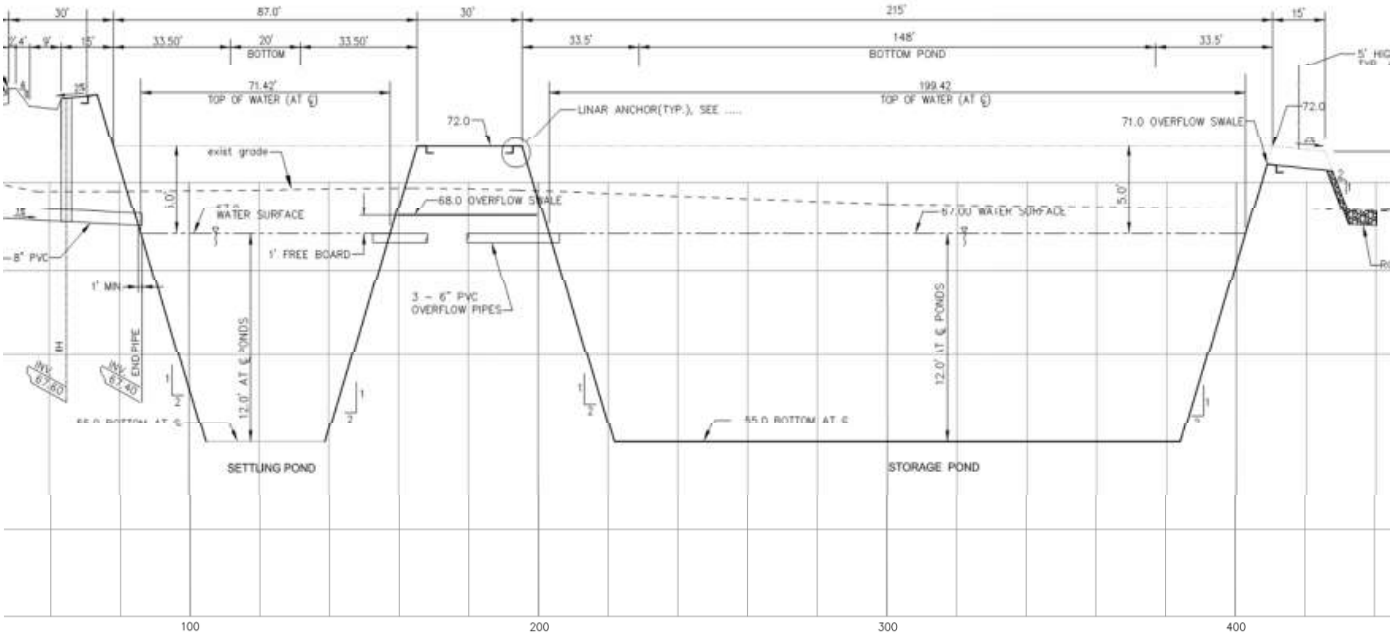


Figure 22 - Effluent Ponds Section

7.2.4 Emergency Spillway

The storage pond will have an emergency spillway that will allow discharge from the pond in the event of a cataclysmic emergency such as a rainfall event greater than the 25-year, 24-hour storm or other natural disaster. A secondary berm will also be constructed downhill of the effluent ponds at the edge of the paddock before the existing drainage way and farm road. Although not required by the guidelines, this secondary containment area will provide a large overflow volume in case of an emergency. The total available volume within the secondary containment area will be roughly equivalent to the total effluent volume over the 30-day storage period.

7.2.5 Effluent Ponds Construction Specifications

The entire pond area will be cleared of all trees, stumps, roots, brush, boulders, sod and debris. Topsoil containing more than 10% organic matter will be removed. All material cleared from the area will be disposed of at sites away from the work area, in accordance to state and county laws.

To establish vegetation, the topsoil and sod will be stockpiled and spread on the completed pond. Foundation surfaces will be sloped no steeper than 1:1. The foundation area will be stripped of all loose material, and thoroughly scarified before placement of the first layer of fill material.

The foundation surface will have moisture added and be compacted prior to fill placement. Required excavations will be cut to the lines and grades shown on the drawings.

Excavated materials could be used to construct the embankment. The material placed in the fill should be free of sod, roots, and stones over 3 inches in diameter. All fill material is obtained from required excavations and designated borrow areas.

Fill will be placed once required excavation and foundation preparation have been completed and the foundation has been inspected and approved. The foundation surface should be scarified and loosened to a depth of not less than 2 inches (51 mm) before placement of the first layer of fill. If the surface of any layer becomes too hard and smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth of not less than 2 inches (51 mm) before the next layer is placed.

The placing and spreading of fill material is started at the lowest point of the foundation. The fill should be brought up in horizontal layers of a maximum thickness as shown in the Compaction section below.

The fill will be constructed in continuous horizontal layers except where openings or sectionalized fills are required. The bonding surface will be treated the same as that specified for the foundation so as to insure a good bond with the new fill.

Embankments shall be constructed in continuous horizontal layers. The distribution and gradation of materials shall be such that no lenses, pockets, streaks, or layers of material differ substantially in texture or gradation from the surrounding material. The complete work will conform to the lines, grades and elevations shown on the drawings or as staked in the field.

Selected backfill material is placed around structures and pipe conduits at about the same rate on all sides of prevent damage from unequal loading. Fill placed around structures will be brought up at approximately uniform height, not to exceed a difference in elevation of 8 inches, on all sides of the structure.

The moisture content of the foundation and fill material should be such that the required compaction can be obtained. The moisture content is as uniform as feasible throughout each

layer. The proper moisture content for compaction will be determined by inspection during the placement operation.

The material should maintain a ball shape when squeezed in the hand.

Construction equipment is operated over the areas of each layer of fill to ensure the required compaction. Fill, adjacent to structures and pipe conduits, shall be compacted to a density equivalent to that of the surrounding fill by means of hand tamping, manually directed power tampers, or plate vibrators. Heavy equipment should not be operated within two feet of any structure.

Hand directed tampers or compactors are used on areas not accessible to heavy compaction equipment, and within 2 feet of any structure. Fills compacted in this manner will be placed in layers not greater than 4 inches in thickness before compaction, and shall meet the same density requirement as for the adjacent area.

Fill not meeting the specified requirements should be reworked or removed and replaced with acceptable fill. Compacting of fill adjacent to structures should not be started until 7 days have elapsed since the placement of the concrete. Once the backfill operations have been completed, the surface area shall be graded to convey any surface runoff away from the structure.

A hazard warning sign will be posted and fence will be constructed around the facility to prevent unwanted entry. Refer to NRCS Waste Storage Structure Practice Code 319 and Practice Code 359 Waste Treatment Lagoon.

7.2.5.1 Pond Sealing, Lining and Flexible Membrane

Pond lining will be installed to control seepage of contamination from waste impoundment structure for water conservation and environmental protection. All inlets, outlets, ramps, and other appurtenances will be installed in a manner that does not damage or impair the proper operation of the liner. To ensure human and livestock safety, warning signs, fences and ladders/ropes will be installed. Manufacturer recommendations will be followed with regard to protection from weather and exposure.

Lining material for ponds will be High Density Polyethylene (HDPE) geomembrane that has 6.5 mm thickness cover (1.5 mm HDPE + 5 mm Bidim). The maximum size of soil cover material will be 3/8-in unless the liner is cushioned by an 8-ounce or greater needle punched, non-woven geotextile padding material. Cover materials will be stable against slippage down the slope under all operational and exposure conditions.

The subgrade will be smooth with no sharp corners or angular stones to avoid damaging the liner or adversely affecting its function. No sharp objects shall protrude through subgrade material. Subgrade material shall be formed with no loose material on or around embankments or floor. Pond construction should have a good Maximum Dry Density (MDD). All surfaces will be of smooth finish.

The area to be lined will be drained and allowed to dry until the surface is firm and will support the workers and equipment that must travel over it during installation of the lining. The foundation area for flexible membrane linings shall be smooth and free of projections that might damage the lining. Stumps and roots will be removed. Rocks, hard clods, and other such material will be removed, or rolled so as to provide a smooth surface. No sharp or hard objects larger than 3/8 inches in diameter will allowed in the top 1-inch of the surface to be covered. The surface should provide a firm, unyielding foundation for the membrane. If the subgrade is coarse-textured and open after preparing and compacting, or in rocky soils, geotextile or a 2-inch cushion layer of sand or fine grained soil such as silty clay or silt will be applied.

All lining material should be free of damage or defect. Membranes will be carefully spread over the subgrade so they lie in a relaxed state. Polyethylene film requires about 5% slack for satisfactory results. Backfill in anchor trench will be compacted to a density equivalent to that of the surrounding area. All field splices will be made in accordance with the manufacturer's recommended technique, using materials furnished for the purpose. The joints will be watertight and maintain their integrity through the expected life of the lining.

The maximum particle size of soil cover material will be 3/8-inch unless the liner is cushioned by an 8-ounce or greater needle punched, non-woven geotextile padding material. The cover shall be placed to the specified depth without damage to the membrane.

The liner installation will be complete with product panel placement, seam placement and test results. As the liner is fabricated on site the information is documented post install.

A standard Quality Assurance (QA) is completed post installation. This QA includes:

- Material type/size/date deployed and roll number
- Technician details
- Subgrade material acceptance
- Trial weld log including shear/peel testing and machine settings
- Panel placement log including pipe boots/attachments/appurtenances
- Non-destructive testing reports (seam tested welds)
- Repair report logged in diagram also in panel log
- Completion certificate
- Warranty certificate, refer to NRCS Practice Code 521 A Pond Sealing or Lining, Flexible Membrane

7.3 Effluent Application

Effluent water will be applied through either center pivot, providing a total application area of 378 acres (this area excludes the cow lanes and a 50-ft. setback from drains/watercourses). Although it is possible to apply effluent through both machines at the same time, it is much simpler from a management and control perspective to only apply through one machine at a time – the other machine will either be applying straight irrigation water or not operating. The best time to apply the effluent water is just after the cows have finished grazing, allowing 17 days for the grass to utilize the nutrients before the cows next enter the paddock.

The design allows both pivots to do a rotation every 40 hours. The maximum flow rate from the pump injecting the effluent from the storage pond is 320 gallons per minute (gpm), which is 30% of the total flow capacity of the nozzle package fitted to either centre pivot. Based on the 40-hour cycle mentioned above, this calculates as 0.3x10 mm = 3 mm or 0.12 in. of effluent in an application. There is room to cut back the amount of effluent applied, however 0.12 in. is considered a low figure and even twice this amount at 0.25 in. won't be excessive if the soil moisture levels allow.

Soil moisture will determine the total amount of water and effluent to be applied in an application, with the deficit below field capacity determining the amount that can be applied

(provided that there isn't any rain forecast for the application period). The worst draining soil types will have soil moisture tapes installed to allow real-time monitoring of soil moisture.

As stated in Section 7.2, the effluent ponds are designed to withstand a 25-year, 24-hour storm event at the full 2,000 cow (Phase 2) effluent output. In Phase 1, the excess capacity of approximately 1MG provides a considerable factor of safety well above the minimum required by standards.

Nonetheless, if a cataclysmic storm was forecast, the time to completely empty the storage pond, if it were full, is around 96 hours. If warranted due to potential impact from the approaching storm event, the settling pond could also be pumped empty within an additional 40 hours. If the forecasted storm is forecast six days prior, then virtually no effluent would remain in storage when the storm arrives. Refer to NRCS Practice Code Standards 430 Irrigation Pipeline, 442 Irrigation System, Sprinkler, 449 Irrigation Water Management.

7.4 De-sludging

The first of the effluent ponds is for the settling of solids. It will normally be full of effluent with the solids content having settled to the bottom, and the liquid component will then flow from the top of this pond into the second pond which is for storage (i.e. the storage pond).

Solids (mostly soft organic matter, but also some sand and mud, etc.) will be applied on a designated area after every 5 weeks (within 45 days), and it will be applied through a 'gun type' application system to areas outside the liquid effluent application.

The solids in the pond are brought into suspension through stirring the pond and then this liquid, along with the suspended solids, is pumped through a 4-inch underground pipe to a number of hydrants which have a 'gun sprinkler' with a 5/8-inch nozzle attached via a length of flexible hose. The guns (and their 65 foot radius of spray area) will be moved around the paddocks after a period of running (2 hours) so that the solids become evenly spread. The application rate is 9mm/hr. Each time solids are applied, the guns will be run for 3 hours. The nutrients within this 3 hour application will be absorbed by the pasture within approximately 3.3 days. Refer to Section 8.0 – Nutrient Management.

The flow from the solids pump will depend on how many guns are being run at the same time. However, in normal circumstances there will be two guns running and the pump will be pumping 158 gpm. At this rate it will take a total of 40 to 50 hours to nearly empty the settling pond depending on the amount of mixing volume.

8.0 Nutrient Management

HDF will be developed in two phases. Phase 1 is a 699 milking cow operation, which will utilize HDF's initial herd purchase and fit into the Animal Feeding Operation (AFO) regulatory framework. Phase 2 is an expansion to 2,000 milking cows (total). This expansion will require a Concentrated Animal Feeding Operation (CAFO) permit to be issued prior to the animal population exceeding 700 mature dairy cows. The Phase 1 HDF nutrient management plan utilizes soil fertility recommendations provided by a certified US laboratory to support all nutrient applications. Fertilizer applications will be optimized and balanced to insure proper timing, placement, and nutrient utilization. Planned nutrient application rates were also compared to the Hawai'i NRCS 590 Nutrient Management Standard. This standard insures that the total amount of nutrients applied is not at a risk for nitrogen leaching or phosphorus indexing.

8.1 Historical Background

The historical use of the land has been for sugar cane production, terminated in the late 1980s, and after that time, for a beef cattle operation. The historical uses of the farm have left the soils depleted of the essential nutrients required for crop growth. A well-managed pasture-based dairy focused on the application of nutrients will be a benefit to the existing soil structure and composition.

8.2 Pasture-Based Dairy

The pasture-based system enables the dairy cows to spend 22 hours in the paddocks, where a corresponding proportion of their excreted manure will be discharged directly onto the paddocks. The dominant grass is Kikuyu; (Pennisetum clandestinum) a high yielding C4, that (when properly fertilized) will yield more than 20 tons (U.S.) per acre. The perennial grasses can be classified as either C3 or C4 plants. These terms refer to the different pathways that plants use to capture carbon dioxide during photosynthesis. All species have the more primitive C3 pathway, but the additional C4 pathway evolved in species in the wet and dry

tropics. These differences are important because the two pathways are also associated with different growth requirements. C3 plants are adapted to cool season establishment and growth in either wet or dry environments. On the other hand, C4 plants are more adapted to warm or hot seasonal conditions under moist or dry environments. Some C4 grasses are known to produce more than 35 tons of dry matter per acre per year.

This 20 ton Kikuyu yield goal for mature pasture grass is the basis for all nutrient application rates. In Phase 1, the grass will need significant additional nutrient application with conventional fertilizers as the excreted manure will supply less than 20% of the nutrient needs of the grass. Nutrients applied to the soil will be in balance with the grass' nutrient needs, and therefore, not result in an over application of nitrogen (N) or phosphorus (P). A managed soil sampling schedule will allow refinement and adjustments to nutrient applications as the soil heath continues to improve. Application rates of sludge and liquid manure will be constantly monitored and adjusted accordingly, as nutrients are applied to Blocks A through J as shown on Figure 23 – Nutrient Management Map.

The effluent ponds have been designed to allow for flexibility in nutrient application. The effluent will not be applied when it is raining, or when the soil is completely saturated. The water holding capacity of each soil type has been taken into consideration for all effluent application rates. The current design allows for a minimum of 30 days effluent storage in both Phase 1 and Phase 2. The effluent is highly diluted, to the extent that it will have next to no odor in the storage pond and certainly no odor at the farm boundary. The settling pond will also be aerated to help mitigate odor. To help further mitigate any odors arising from the facility a Windbreak / Shelterbelt (i.e. a multiple row planting of trees) will be established along the prevailing wind pattern of the pond. This design will follow the guidance of NRCS Conservation Plan Standard 380 Windbreak / Shelterbelt Establishment.

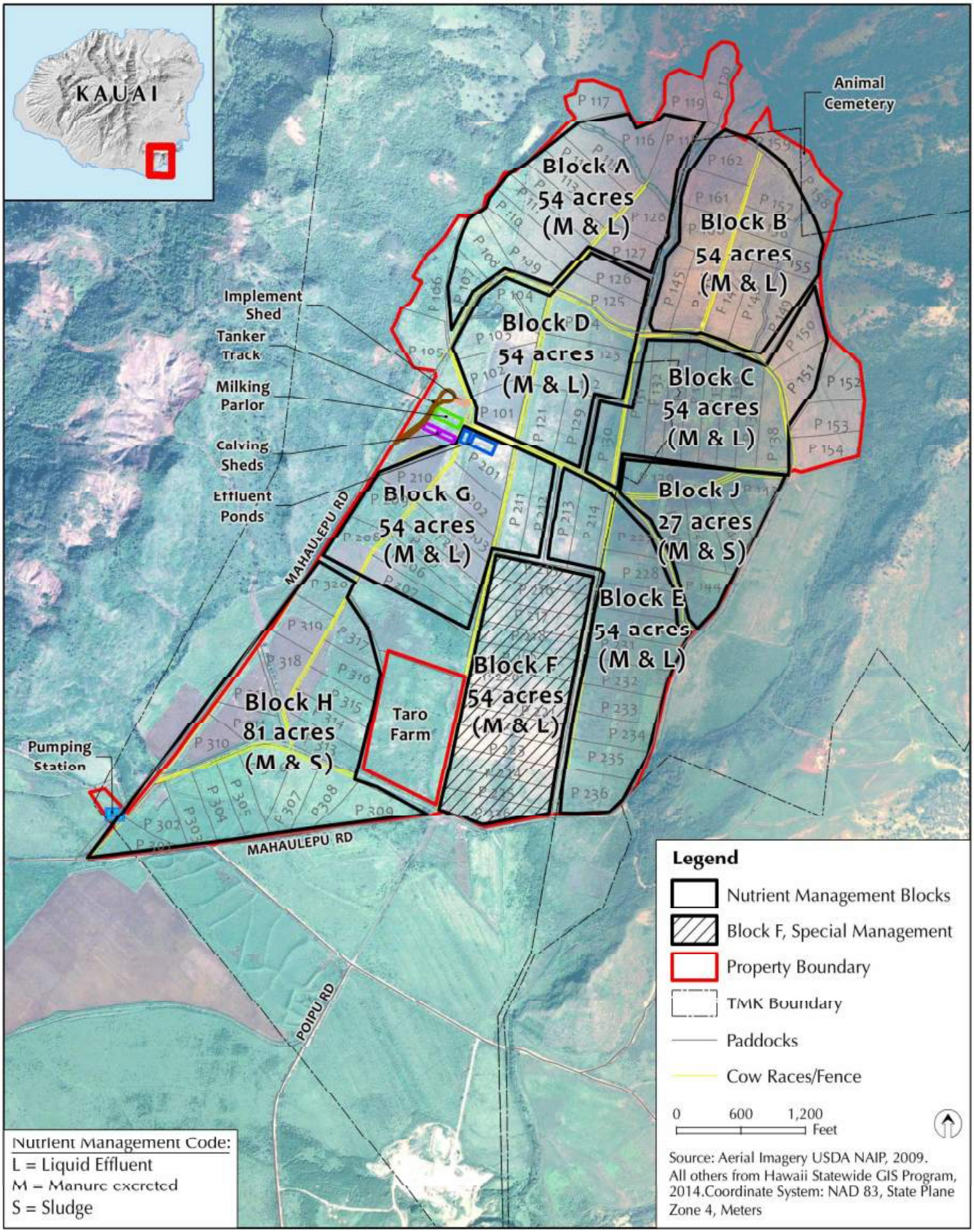


Figure 23 – Nutrient Management Map

Site specific soil moisture will be monitored, in real time, to ensure irrigation water, liquid effluent and cattle are not applied to soils when conditions are suboptimal. HDF will ensure that soils conditions can support Kikuyu growth and are not wet enough to potentially cause pugging (penetration of cow hoofs into the soil), even through the thatch.

The Kikuyu is extremely effective in the tropics and adds significant protection to soils in terms of creating a tight organic thatch, which also reduces hoof compaction via the thatch. Some of the current issues with soil compaction are related directly to the disturbance in the soil structure caused by machine cultivation. Once the Kikuyu thatch is established, the soil itself is not disturbed by cultivation; the thatch will be exposed to grazing pressure and annual mulch.

As the cattle excrete on the Kikuyu thatch, it is incorporated into what is effectively an organic net. Due to the high moisture and moderate temperatures, the microbial activity in the thatch is very high and the effluent will be largely broken down by microbial activity within 24 hours. The effluent is less than 20% of the daily nutrient needs, and therefore readily absorbed in Kikuyu.

The project has budgeted 20 tons (U.S.) of dry matter production of Kikuyu per acre. The average local temperature is in the ideal 60 and 104°F range for Kikuyu. Kikuyu yield ranges between 4 tons unfertilized and 20 tons of dry matter (DM)/acre/year depending on levels of N fertilization. Kikuyu's response to fertilization is very good and linear combined with irrigation, anticipated growth rates in Maha'ulepu are estimated be some of the best in the world.

The current key hubs of Kikuyu-based dairy farms are Northland of New Zealand, Australia's Hunter Valley and in the Eastern Cape of South Africa (George and Knysnal) where current

farmers consistently achieve greater than 20 metric tons (mt) of dry matter production of Kikuyu per acre in the temperature ranges that best match those available in Hawai'i all year round.

Author	**Quoted Metric Tons of Dry Matter per Acre per Year**	**Notes**
Taylor et al (1976)	36.204	Irrigated Kaitaia NZ
Rojas (1999)	20.240	Costa Rica
Murtagh (1988)	34.580	CSIRO Australia

Local Hawai'i data is available for Kikuyu and similar C4 grasses:

Author	**Quoted Metric Tons of Dry Matter per Acre per Year**	**Notes**
Fukumoto, Lee (2003)	13.450	Unfertilized
Roche (2010)	20.100	Peak Fertilized

The farm will be equipped with state-of-the-art technology, called Ag Hub, to ensure management systems and operational uses achieve optimal growth and environmental sustainability. Ag Hub technology will be deployed at HDF to ensure proper application rates and timing of all irrigation events. Ag Hub is a modular online farm management system that collects and displays automated irrigation data. Ag Hub data capture devices and soil tapes will provide electronic and GIS mapped proof of placement of nutrients and real time monitoring.

Figure 24 - Example Nutrient Placement Map (Not HDF)

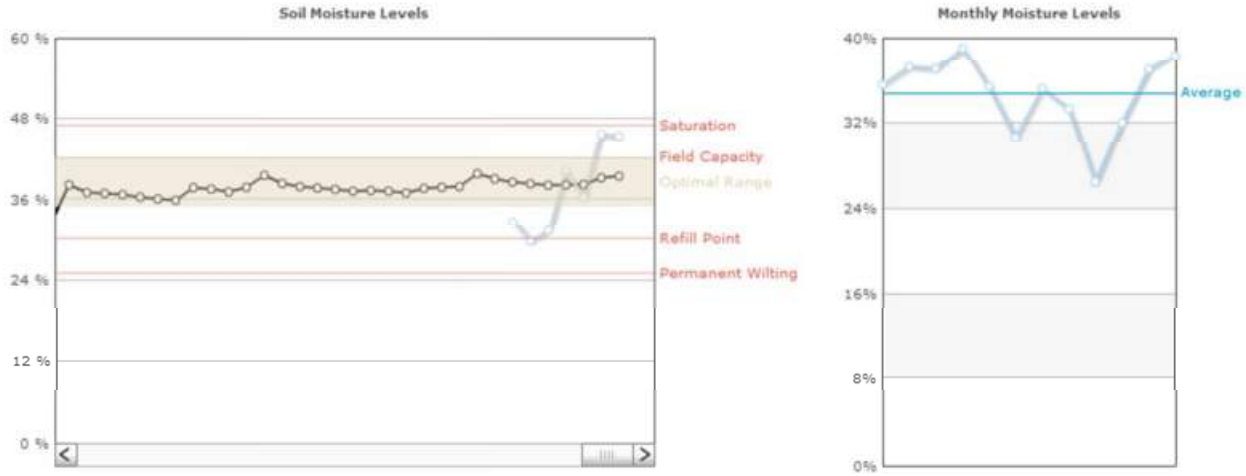


Figure 25 - Example of Field Capacity Monitoring

Animal waste (manure) is applied to the pastures that have a significant deficit from the total grass nutrient requirement. The deficit between grass nutrient requirements and nutrients from cattle effluent, produced either in the paddock or the recovered from the milking platform, will be balanced with supplemental fertilizer. To simplify the management of the recovered cattle effluent, solids from de-sludging the settling pond are only applied to areas outside the pivots in Block H & J. See Figure 23 - Nutrient Management Map. Blocks A through G, under the pivot, will technically be able to receive water and effluent water in different application rates to reflect how the soil is responding and grass is growing, i.e. using or not using the water and or nutrients. The nutrient residue or deficit is reflected in the on-going individual soil test data

from those blocks, which will be used to refine applications over time to identify where the nutrients are imported and/or recovered. Given the current degraded state of the soils, HDF should add more nutrients and rebuild the soils to normal levels over the coming years.

Manure will be utilized in a manner to avoid any contamination of surface and ground water supplies and records of the use of wastes will be kept for a minimum of five years. The manure will be sampled and analyzed at least once each year to identify nutrient and specification concentrations. Manure application rates will be consistent with legal requirements. The application rate will not exceed the infiltration rate of the soil, and the amount of waste applied will not exceed the moisture holding capacity of the soil profile at the time of application.

8.3 Soils Analysis

The NRCS soils classifications and descriptions provide a good base layer of information to use for nutrient budgeting. However, additional soil testing is required to determine soil nutrient levels to be used in the nutrient budget analysis. Soil samples have been analyzed for pH, phosphorus, nitrogen, potassium, calcium, magnesium, organic matter, salinity, micronutrients and other constituents.

The farm has approximately 517 acres in pasture, which is divided up into 118 total paddocks of about 4- to 5-acres in size. Soil sample grabs were taken at 5 to 10 locations within each paddock and combined into one representative sample per paddock. Soil samples from approximately 5 paddocks were aggregated into Conservation Management Units (CMUs) based on the underlying NRCS soils classification. See Figure 26 – Conservation Map Units. The baseline test results will be used for design and subsequent sampling will occur during operation to monitor nutrient levels so the nutrient budgets can be adjusted during operation. Samples have been tested by Spectrum Analytical and soil fertility recommendations are shown in Table 15.

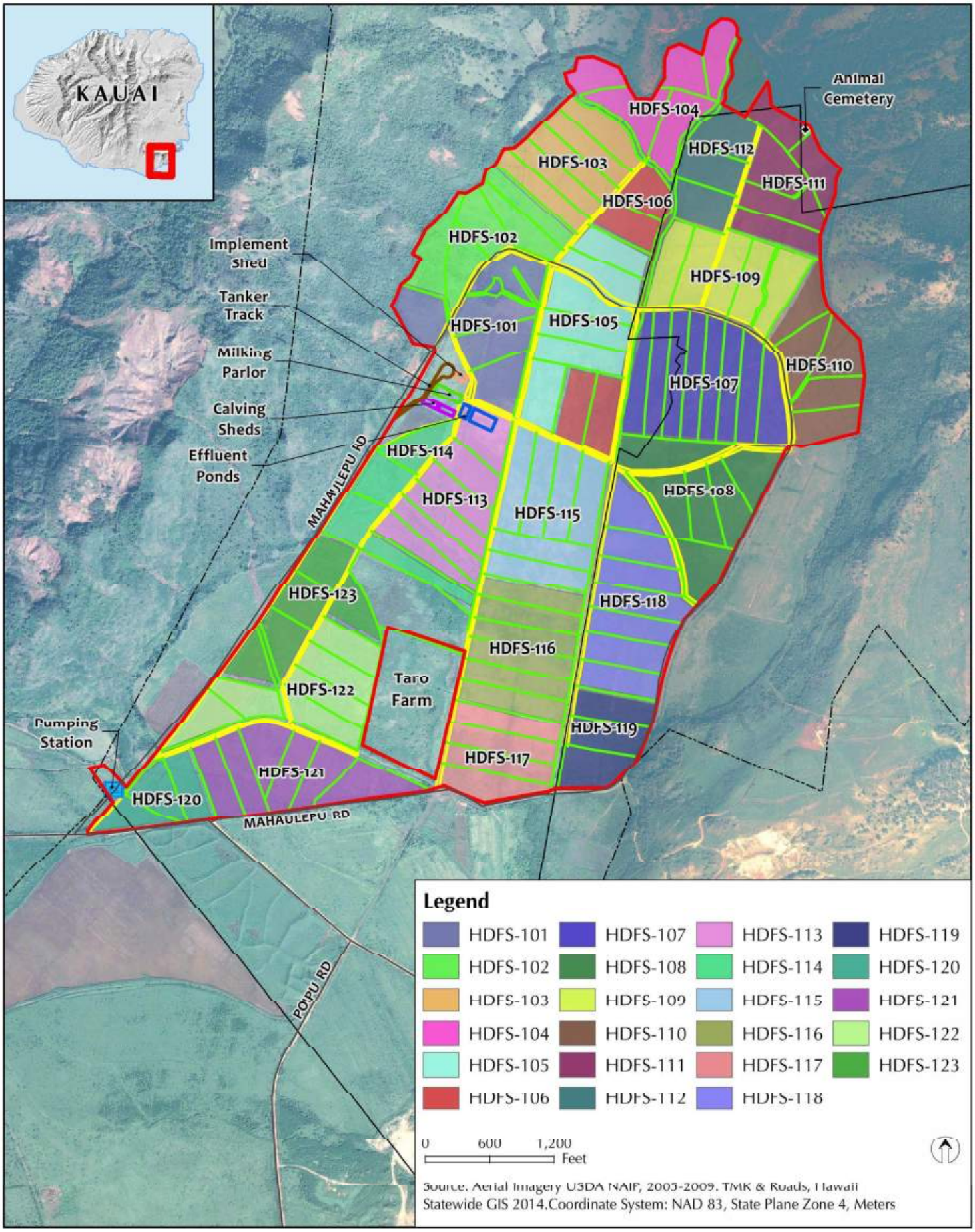


Figure 26 – Conservation Management Unit Map

The Conservation Management Units (CMUs) and related paddocks and NRCS soil types are summarized in the table below.

Table 14 – Conservation Management Units (CMUs)

Paddock Number	Conservation Management Units (CMU)	NRCS Soil Type
101	HDFS-101	KavB, Ke
102		KavB, Ke
103		KavB, Ke
104		KavB
105		KdF, HsD
106	HDFS-102	KavC, KdF
107		LuB, KavC, KavB
108		HsD, KavC , KavB
109		HsD, KavC , KavB
110		HsD, KavC , KavB
111	HDFS-103	KavB, LuB
112		LuB
113		LuB
114		LuB
115		Lub
116	HDFS-104	LuB, HsD
117		LuB, HsD
118		LuB, HsD
119		LuB, HsD
120		LuB, HsD
121	HDFS-105	Ke, KavB
122		KavB
123		KavB
124		KavB
125		KavB
126		KavB
127	HDFS-106	KavB, LuB
128		KavB, LuB
129		KavB, Ke
130		KavB, Ke
131	HDFS-107	KavB, Ke
132		KavB, Ke
133		KavB, Ke
134		KavB, Ke
135		KavB, Ke
136		KavB, Ke
137		KavB, Ke
138		KavB, Ke
139	HDFS-108	KavB
140		KavB
141		KavB
142		KavB
143		KavB
144		KavB
145	HDFS-109	KavB
146		KavB
147		KavB
148		KavB
149		KavB
150	HDFS-110	KavB, Hsd
151		KavB, KavC, Hsd
152		KavC
153		KavB, KavC
154		KavB, KavC
155	HDFS-111	LuB
156		LuB
157		LuB, KavC
158		KavC
159		Kavc

Table 14 – Conservation Management Units (CMUs) (continued)

Paddock Number	Conservation Management Units (CMU)	NRCS Soil Type
160	HDFS-112	KavB
161		KavB, LuB
162		KavB, LuB
201	HDFS-113	Ke
202		Ke, PdA
203		Ke, PdA, PdC
204		Ke, PdA, PdC
205		Ke, PdA
206		Ke, PdA
207	HDFS-114	Ke, PdA, PdC
208		PdA, PdC, KefH
209		PdA, PdC, KefH,
210		PdC
211	HDFS-115	Ke
212		Ke
213		Ke
214		Ke
215		Ke
216		Ke
217	HDFS-116	Ke
218		Ke
219		Ke
220		Ke
221		Ke
222		Ke
223	HDFS-117	Ke
224		Ke
225		Ke
226		Ke
227	HDFS-118	Ke, KavB
228		Ke, KavB
229		Ke, KavB
230		Ke, KavB
231		Ke, KavB
232		Ke, KavB
233		Ke, KavB
234	HDFS-119	Ke
235		Ke
236		Ke
301	HDFS-120	LuB, Ws
302		Lub, Ws
303		Lub, Ws
304	HDFS-121	Ws
305		Ws
306		Ws
307		Ws
308		Ws
309		Ws
310	HDFS-122	PdC, PdA
311		Pdc, Pda
313		Pdc, Pda
314		Pdc, Pda
315		Pdc, Pda
316		Pdc, Pda
312	HDFS-123	Pdc
317		Pdc
318		Pdc
319		Pdc
320		Pdc

Table 15 - Spectrum Analytic – Soil Fertility Recommendations

Spectrum Analytic
1087 Jamison Road NW
Washington Court House, OH 43160-8748
www.spectrumanalytic.com

Report To	Prepared For		
HAWAII DAIRY FARM LLC 3083 AKAHI ST STE 301 LIHUE, HI 96766	HAWAII DAIRY FARM LLC	Sampled Tested	04-04-2014 04-09-2014

Sample Number	Lab Number	pH		Organic	Analysis Result* and Rating				CEC	Base Saturation			Mehlich-3 PPM and Rating						
		Soil pH	Buffer pH	Matter %	Phosphorus P	Potassium K	Magnesium Mg	Calcium Ca		K %	Mg %	Ca %	Sulfur S	Boron B	Zinc Zn	Iron Fe	Copper Cu	Mang. Mn	Alum. Al
HDFS 101	D21097	6.1	6.6	5.2	19 L	108 M	1127 V	1459 M	18.8	1.2	44.0	29.2	16 M	0.6L	5.5 G	152 V	5.5 G	155 H	
HDFS 102	D21098	6.3	6.6	6.3	7 L	128 M	920 V	1466 M	17.3	1.6	39.0	31.7	8 L	0.5L	2.7 M	124 V	5.1 G	139 G	
HDFS 103	D21099	6.1	6.5	5.1	16 L	132 M	975 V	1259 M	18.2	1.6	39.4	26.0	6 L	0.4L	3.3 M	129 V	4.9 G	85 G	
HDFS 104	D21100	5.6	6.4	6.4	5 L	118 M	568 V	718 L	14.3	1.8	29.1	18.8	22 G	0.4L	1.8 M	95 H	3.9 G	142 H	
HDFS 105	D21101	6.4	6.7	6.9	10 L	215 G	962 V	1128 M	15.3	3.0	46.0	27.6	10 M	0.5L	5.8 G	126 V	5.0 G	182 H	
HDFS 106	D21102	6.9	6.9	6.2	9 L	162 M	1016 V	2338 M	19.4	1.8	38.4	45.2	9 L	0.7L	3.0 M	143 V	5.8 G	110 G	
HDFS 107	D21103	6.6	6.9	5.1	6 L	110 M	797 V	3186 G	22.5	1.1	25.9	53.0	28 G	0.6L	3.6 M	104 V	7.0 G	125 G	
HDFS 108	D21104	7.4		5.1	6 L	113 M	988 V	6078 V	22.5	1.1	32.2	66.7	16 M	0.9M	3.1 M	89 H	5.4 G	131 G	
HDFS 109	D21105	5.8	6.3	6.2	5 L	91 L	836 V	1964 M	22.1	0.9	27.8	33.3	9 L	0.4L	4.7 G	112 V	5.8 G	133 H	
HDFS 110	D21106	6.5	6.6	4.6	14 L	147 M	1332 V	1426 M	19.8	1.6	49.5	27.1	8 L	0.5L	3.7 M	156 V	4.5 G	108 G	

* P, K, Mg and Ca are extracted by Mehlich-3 (ICP) and are reported in ppm

Sample Number	Lab Number	Year	Crop	Yield Goal	Acres	Nutrient recommendations expressed in broadcast rates of lbs/A except where noted.									
						CaCO3** Lime	N	P2O5	K2O	Mg	S	B	Cu	Fe Foliar	Mn Row	Zn
HDFS 101	D21097	14	Kikuyugrass (Forage)	20		1652 C	748	296	1138	0	9	0.25	0	0	0	0
HDFS 102	D21098	14	Kikuyugrass (Forage)	20		0	737	310	1113	0	11	0.50	0	0	0	2
HDFS 103	D21099	14	Kikuyugrass (Forage)	20		1936 C	749	301	1112	0	13	0.50	0	0	0	2
HDFS 104	D21100	14	Kikuyugrass (Forage)	20		4887 C	736	310	1113	0	7	0.50	0	0	0	3
HDFS 105	D21101	14	Kikuyugrass (Forage)	20		0	731	310	1014	0	10	0.50	0	0	0	0
HDFS 106	D21102	14	Kikuyugrass (Forage)	20		0	738	310	1086	0	11	0.25	0	0	0	2
HDFS 107	D21103	14	Kikuyugrass (Forage)	20		0	749	310	1143	0	6	0.25	0	0	0	2
HDFS 108	D21104	14	Kikuyugrass (Forage)	20		0	749	310	1140	0	10	0.50	0	0	0	3
HDFS 109	D21105	14	Kikuyugrass (Forage)	20		4571 C	738	310	1160	0	11	0.50	0	0	0	0
HDFS 110	D21106	14	Kikuyugrass (Forage)	20		0	754	303	1102	0	14	0.50	0	0	0	2

**Lime expressed in 100% pure CaCO3. Adjust accordingly. D = Dolomitic Lime. C = Calcitic Lime.

Kikuyugrass (Forage): Split apply fertilizer to best match grass growth and nutrient demand. Monitor and adjust nutrient program with annual plant analysis.
D21102 (Kikuyugrass (Forage)): Apply 40 lbs/A Calcium from gypsum and/or fertilizer sources.
D21106 (Kikuyugrass (Forage)): Apply 226 lbs/A Calcium from gypsum and/or fertilizer sources.

Analyzed by Spectrum Analytic Inc.
www.spectrumanalytic.com

HID:4985-0137-3801-0013

Table 15 - Spectrum Analytic – Soil Fertility Recommendations (continued)

Spectrum Analytic
1087 Jamison Road NW
Washington Court House, OH 43160-8748
www.spectrumanalytic.com

Report To	Prepared For	
HAWAII DAIRY FARM LLC 3083 AKAHI ST STE 301 LIHUE, HI 96766	HAWAII DAIRY FARM LLC	Sampled 04-04-2014 Tested 04-09-2014

Sample Number	Lab Number	pH		Organic	Analysis Result* and Rating				CEC	Base Saturation			Mehlich-3 PPM and Rating						
		Soil pH	Buffer pH	Matter %	Phosphorus P	Potassium K	Magnesium Mg	Calcium Ca		K %	Mg %	Ca %	Sulfur S	Boron B	Zinc Zn	Iron Fe	Copper Cu	Mang. Mn	Alum. Al
HDFS 111	D21107	6.2	6.6	5.0	5 L	84 L	942 V	1121 M	16.1	1.1	42.9	26.1	5 L	0.4L	2.3 M	135 V	4.3 G	84 G	
HDFS 112	D21108	6.4	6.6	6.6	4 L	84 L	880 V	1027 M	15.3	1.2	42.2	25.2	6 L	0.4L	2.6 M	137 V	4.6 G	130 G	
HDFS 113	D21109	7.3		3.3	9 L	322 H	699 V	4128 H	20.8	3.3	24.6	72.0	18 M	0.8M	1.5 L	119 V	3.1 G	113 G	
HDFS 114	D21110	6.6	7.0	4.3	13 L	265 G	727 V	3586 G	24.2	2.4	22.0	55.6	41 H	0.6L	1.9 M	113 V	3.0 G	97 G	
HDFS 115	D21111	7.9		5.0	21 M	144 M	1070 V	5960 V	23.2	1.3	33.9	64.8	24 G	1.1M	3.1 M	111 V	4.5 G	96 M	
HDFS 116	D21112	7.6		4.2	9 L	114 M	1219 V	4370 G	24.2	1.0	37.0	62.0	18 M	0.9M	1.9 M	143 V	3.8 G	105 G	
HDFS 117	D21113	6.3	6.8	4.3	4 L	51 L	409 V	657 M	8.0	1.4	37.6	30.9	10 M	0.5L	1.2 L	145 V	2.2 G	67 G	
HDFS 118	D21114	8.0		3.6	13 L	114 M	875 V	7138 V	21.7	1.1	29.6	69.2	25 G	1.1M	2.3 M	77 H	3.6 M	107 G	
HDFS 119	D21115	8.0		4.2	42 G	210 M	1137 V	7951 V	23.8	1.9	35.0	63.1	32 G	1.6M	2.6 M	84 H	3.6 L	82 M	
HDFS 120	D21116	6.4	6.6	7.6	6 L	380 V	368 H	734 M	11.1	7.4	24.4	24.9	9 L	0.5L	1.9 M	99 H	4.3 G	52 G	

*P, K, Mg and Ca are extracted by Mehlich-3 (ICP) and are reported in ppm

Sample Number	Lab Number	Year	Crop	Yield Goal	Acres	Nutrient recommendations expressed in broadcast rates of lbs/A except where noted.										
						CaCO3** Lime	N	P2O5	K2O	Mg	S	B	Cu	Fe Foliar	Mn Row	Zn
HDFS 111	D21107	14	Kikuyugrass (Forage)	20		862 C	750	310	1158	0	14	0.50	0	0	0	3
HDFS 112	D21108	14	Kikuyugrass (Forage)	20		0	734	310	1156	0	11	0.50	0	0	0	2
HDFS 113	D21109	14	Kikuyugrass (Forage)	20		0	767	310	485	0	11	0.25	0	0	0	5
HDFS 114	D21110	14	Kikuyugrass (Forage)	20		0	757	302	1012	0	3	0.25	0	0	0	4
HDFS 115	D21111	14	Kikuyugrass (Forage)	20		0	750	290	1114	0	7	0.50	2	0	2	4
HDFS 116	D21112	14	Kikuyugrass (Forage)	20		0	758	309	1143	0	10	0.75	0	0	0	6
HDFS 117	D21113	14	Kikuyugrass (Forage)	20		0	757	310	1174	0	13	0.25	0	0	0	5
HDFS 118	D21114	14	Kikuyugrass (Forage)	20		0	764	304	1138	0	9	0.50	2	0	0	6
HDFS 119	D21115	14	Kikuyugrass (Forage)	20		0	758	251	1058	0	6	0.25	2	0	2	5
HDFS 120	D21116	14	Kikuyugrass (Forage)	20		0	724	310	0	0	9	0.50	0	0	0	3

**Lime expressed in 100% pure CaCO3. Adjust accordingly. D = Dolomitic Lime. C = Calcitic Lime.

Kikuyugrass (Forage): Split apply fertilizer to best match grass growth and nutrient demand. Monitor and adjust nutrient program with annual plant analysis.

Analyzed by Spectrum Analytic Inc.
www.spectrumanalytic.com

HID:4985-0137-3801-0013

Table 15 - Spectrum Analytic – Soil Fertility Recommendations (continued)

Spectrum Analytic
1087 Jamison Road NW
Washington Court House, OH 43160-8748
www.spectrumanalytic.com

Report To	Prepared For		
HAWAII DAIRY FARM LLC 3083 AKAHI ST STE 301 LIHUE, HI 96766	HAWAII DAIRY FARM LLC	Sampled Tested	04-04-2014 04-09-2014

Sample Number	Lab Number	pH		Organic	Analysis Result* and Rating				CEC	Base Saturation			Mehlich-3 PPM and Rating						
		Soil pH	Buffer pH	Matter %	Phosphorus P	Potassium K	Magnesium Mg	Calcium Ca		K %	Mg %	Ca %	Sulfur S	Boron B	Zinc Zn	Iron Fe	Copper Cu	Mang. Mn	Alum. Al
HDFS 121	D21117	6.5	6.6	7.4	8 L	270 H	632 V	1257 M	12.7	4.6	36.5	37.1	8 L	0.4L	2.0 M	114 V	3.6 G	49 G	
HDFS 122	D21118	6.1	6.7	3.7	5 L	279 H	847 V	1079 M	14.5	4.2	43.0	28.0	14 M	0.4L	1.4 L	111 V	2.9 G	72 G	
HDFS 123	D21119	6.4	6.9	3.6	4 L	368 V	680 V	1440 M	12.4	6.4	40.3	43.6	43 H	0.4L	1.4 L	100 H	2.0 G	71 G	

** P, K, Mg and Ca are extracted by Mehlich-3 (ICP) and are reported in ppm*

Sample Number	Lab Number	Year	Crop	Yield Goal	Acres	Nutrient recommendations expressed in broadcast rates of lbs/A except where noted.										
						CaCO3** Lime	N	P2O5	K2O	Mg	S	B	Cu	Fe Foliar	Mn Row	Zn
HDFS 121	D21117	14	Kikuyugrass (Forage)	20		0	726	310	352	0	10	0.50	0	0	0	3
HDFS 122	D21118	14	Kikuyugrass (Forage)	20		1368 C	763	310	416	0	13	0.50	0	0	0	5
HDFS 123	D21119	14	Kikuyugrass (Forage)	20		0	764	310	0	0	3	0.50	0	0	0	5

***Lime expressed in 100% pure CaCO3. Adjust accordingly. D = Dolomitic Lime. C = Calcitic Lime.*

Kikuyugrass (Forage): Split apply fertilizer to best match grass growth and nutrient demand. Monitor and adjust nutrient program with annual plant analysis.
D21117 (Kikuyugrass (Forage)): Apply 81 lbs/A Calcium from gypsum and/or fertilizer sources.

Analyzed by Spectrum Analytic Inc.
www.spectrumanalytic.com

HID:4985-0137-3801-0013

8.4 NMP

Managing the amount, source, placement, and timing of plant nutrients and soil amendments is the purpose of the nutrient management plan. This type of planning minimizes the agricultural nonpoint sources of pollution of surface and groundwater by properly utilizing manure and commercial fertilizers in balance with plant nutrient requirements. All nutrient applications, including manure and commercial fertilizer, will be applied to the Kikuyu grass utilizing the most current soil fertility recommendations from a certified laboratory. Spectrum Analytic Labs has provided fertility recommendations for Kikuyu based upon a 20 ton yield goal. Yield goals will be adjusted higher or lower based upon measured outputs and site specific data.

The Hawai'i NRCS Nutrient Management Practice standard 590 excel worksheets were utilized to insure that each Crop Management Unit (CMU) met the specific risk assessment profile as defined by NRCS. There are three risk assessment areas that were completed for each CMU. Each risk assessment identified and scored erosion rates, nitrogen leaching index, and phosphorus index.

8.4.1 Risk Assessment Classification

The planned CMUs are meeting all soil loss tolerance (T) in accordance with the approved Conservation Plan. Soil Loss T is attainable since the planned system is pasture-based and there is not a significant amount of annual tillage planned.

Nitrogen Leaching Index per Hawai'i NRCS 590 Standard:

Annual Rainfall	Soil Hydrologic Group			
	A	B	C	D
>100"	H	H	M	M
50-100"	H	M	M	L
<50"	M	M	L	L

Low – No additional mitigation required
Mod – Timing of nitrogen applications must be applied to coincide with crop growing season
High – Timing of nitrogen applications must coincide with crop growing season and be split applied to prevent leaching

The nitrogen leaching index was run on each CMU. Below are the results by CMU:

CMU	Predominent Soil Type	Soil Hydrolic Group	Annual Rainfall	Nitrogen Leaching Potential
HDFS 101	KavB	D	<50"	Low
HDFS 102	KavB	D	<50"	Low
HDFS 103	LuB	D	<50"	Low
HDFS 104	LuB	D	<50"	Low
HDFS 105	KavB	D	<50"	Low
HDFS 106	KavB	D	<50"	Low
HDFS 107	KavB	D	<50"	Low
HDFS 108	KavB	D	<50"	Low
HDFS 109	KavB	D	<50"	Low
HDFS 110	KavB	D	<50"	Low
HDFS 111	LuB	D	<50"	Low
HDFS 112	KavB	D	<50"	Low
HDFS 113	Ke	D	<50"	Low
HDFS 114	PdC	B	<50"	Medium
HDFS 115	Ke	D	<50"	Low
HDFS 116	Ke	D	<50"	Low
HDFS 117	Ke	D	<50"	Low
HDFS 118	Ke	D	<50"	Low
HDFS 119	Ke	D	<50"	Low
HDFS 120	LuB	D	<50"	Low
HDFS 121	Ws	D	<50"	Low
HDFS 122	PdC	B	<50"	Medium
HDFS 123	PdC	B	<50"	Medium

Phosphorus Index Interpretation per Hawai'i NRCS 590 Standard:

Risk Assessment	Phosphorus Index Value
Low	<30
Mod	30-90
High	>90

Low - phosphorus can be applied at rates greater than crop requirement not to exceed the nitrogen requirement for the succeeding crop if manure or other organic materials are used to supply nutrients

Mod - phosphorus can be applied not to exceed the crop requirement rate

High - phosphorus can be applied not to exceed the crop removal rate if the following requirements are met: A soil phosphorus drawdown strategy has been implemented, and a site assessment for nutrients and soil loss has been conducted to determine if mitigation practices are required to protect water quality. Any deviation from these high risk requirements must have the approval of the Chief of the NRCS.

The phosphorus index interpretation was run on each CMU. Below are the results by CMU:

CMU	Risk Assessment	Phosphorus Index Value
HDFS 101	Low	18
HDFS 102	Low	18
HDFS 103	Low	12
HDFS 104	Low	18
HDFS 105	Low	18
HDFS 106	Low	18
HDFS 107	Low	18
HDFS 108	Low	18
HDFS 109	Low	10
HDFS 110	Low	18
HDFS 111	Low	18
HDFS 112	Low	18
HDFS 113	Low	10
HDFS 114	Low	10
HDFS 115	Low	10
HDFS 116	Low	10
HDFS 117	Low	10
HDFS 118	Low	10
HDFS 119	Low	10
HDFS 120	Low	10
HDFS 121	Low	10
HDFS 122	Low	10
HDFS 123	Low	10

8.4.2 Nutrient Mass Balance

The annual net nutrient (nitrogen, phosphorus and potassium) demand for 20 Ton Kikuyu is summarized in the following table. The crop nutrient needs will be satisfied by the application of manure and supplemental commercial fertilizer.

Hawai'i Dairy Farms - Nutrient Mass Balance
Plant Nutrient Demand by CMU - Kikuyu Grass Yield Goal of 20 Ton/ac

CMU Sample #	CMU Ac	N lbs/Ac	P_2O_5 / Ac	K_2O / Ac	Total N lbs / CMU	Total P_2O_5/CMU	Total K_2O/CMU
HDFS 101	24.0	748	296	1138	17,952.0	7,104.0	27,312.0
HDFS 102	21.8	737	310	1113	16,066.6	6,758.0	24,263.4
HDFS 103	21.4	749	301	1112	16,028.6	6,441.4	23,796.8
HDFS 104	20.5	736	310	1113	15,088.0	6,355.0	22,816.5
HDFS 105	26.8	731	310	1014	19,590.8	8,308.0	27,175.2
HDFS 106	17.4	738	310	1086	12,841.2	5,394.0	18,896.4
HDFS 107	35.0	749	310	1143	26,215.0	10,850.0	40,005.0
HDFS 108	27.1	749	310	1140	20,297.9	8,401.0	30,894.0
HDFS 109	23.3	738	310	1160	17,195.4	7,223.0	27,028.0
HDFS 110	21.6	754	303	1102	16,286.4	6,544.8	23,803.2
HDFS 111	21.2	750	310	1158	15,900.0	6,572.0	24,549.6
HDFS 112	17.6	734	310	1156	12,918.4	5,456.0	20,345.6
HDFS 113	26.3	767	310	485	20,172.1	8,153.0	12,755.5
HDFS 114	16.1	757	302	1012	12,187.7	4,862.2	16,293.2
HDFS 115	27.6	750	290	1114	20,700.0	8,004.0	30,746.4
HDFS 116	27.3	758	309	1143	20,693.4	8,435.7	31,203.9
HDFS 117	18.2	757	310	1174	13,777.4	5,642.0	21,366.8
HDFS 118	32.2	764	304	1138	24,600.8	9,788.8	36,643.6
HDFS 119	14.1	758	251	1058	10,687.8	3,539.1	14,917.8
HDFS 120	11.2	724	310	0	8,108.8	3,472.0	0.0
HDFS 121	26.1	726	310	352	18,948.6	8,091.0	9,187.2
HDFS 122	24.2	763	310	416	18,464.6	7,502.0	10,067.2
HDFS 123	20.0	764	310	0	15,280.0	6,200.0	0.0
Total	521.0				390,001.5	159,097.0	494,067.3

There are three types of organic manure nutrients that will be applied to the Kikuyu grass: liquid effluent, solid sludge, and the manure that is excreted directly onto the pasture by the dairy animals. Crop growth will be achieved by the application of supplemental fertilizer. Total annual nutrients applied is summarized in the following table:

Hawai'i Dairy Farms - Nutrient Mass Balance
Total Nutrients Applied

Nutrient Application	Area, ac	N Applied/ac/yr	$P_2 0_5$ Applied/ac/yr	$K_2 0$ Applied/ac/yr
Liquid Effluent	378	24.0	16.0	35.0
	Subtotal	9,072.0	6,048.0	13,230.0
De-sludging	108	50.6	30.0	73.0
	Subtotal	5,464.8	3,240.0	7,884.0
Manure Excreted on Pasture	521	128.0	102.0	134.0
	Subtotal	66,688.0	53,142.0	69,814.0
Total Nutrients Applied from Animals		81,224.8	62,430.0	90,928.0
Plant Nutrient Demand		390,001.5	159,097.0	494,067.3
Percentage Demand from Animals		20.8%	39.2%	18.4%
Required Chemical Fertilizer		308,776.7	96,667.0	403,139.3
Percentage Demand from Fertilizer		79.2%	60.8%	81.6%

8.4.3 Block F – Special Management

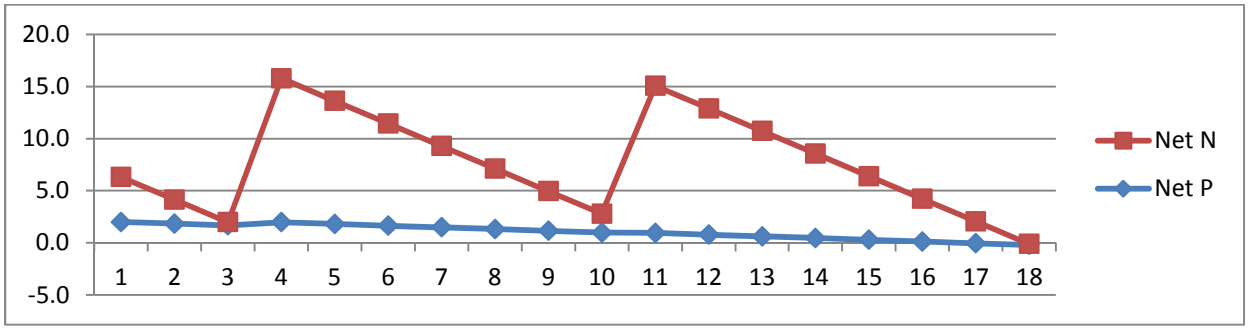
The Maha'ulepu soils, particularly in the south-central portion of the farm (Block F, See Figure 23 – Nutrient Management Map), are perceived as heavy, flood frequently and difficult to crop. Much of the water from the northern part of the farm runs through Block F. The dominant soils on the lower farm are Ka'ena Clay, Kalapa Silty Clay and Kalihi Clay, which are prone to compaction and are characteristically poor draining. However, less than two days after heavy rain, with rapid removal of the surface water during and after a significant rain event, they are observed as being dry enough to graze, even without a Kikuyu thatch.

The Kikuyu itself doesn't grow as effectively in wet conditions, so the farm is highly motivated to make sure the drainage system is as effective as it can be in the lower farm, particularly Block F. Winter weather may dictate if Block F will receive nutrients at all.

8.5 Application Schedule

The 18-day rotation for Blocks A to G assume the cattle enter the paddock on day 1, and all of the manure is excreted in the paddock on the first day. This essentially supplies enough N for three days pasture growth. On day 4, half of the chemical fertilizer is applied and is consumed by the grass over the next 7 days, the second application of chemical fertilizer is applied on day 11, and is consumed by the grass just before the cattle enter the paddock to graze again. The impact of the irrigated liquid effluent is negligible and can be done at any stage in the rotation without materially affecting the nutrient loading as it is less than a half of the daily N requirement of the grass.

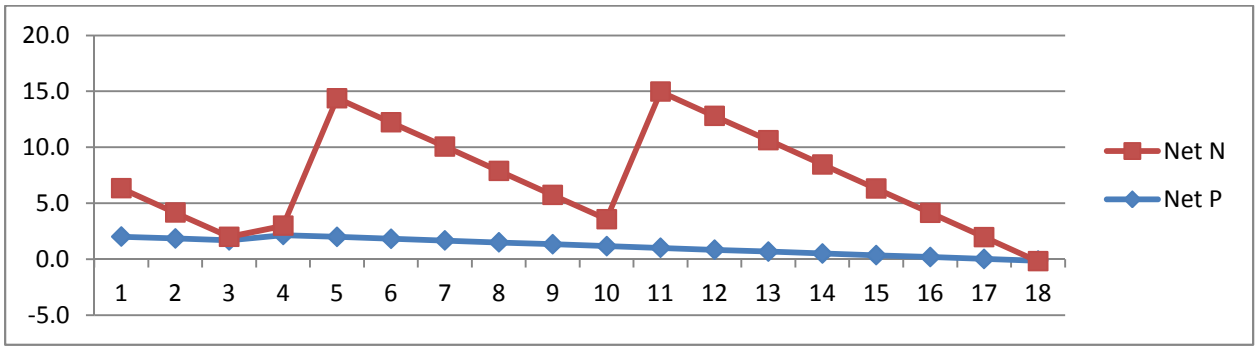
																		annualized
Chemical Fertilizers P				0.12							0.12							5
Chemical Fertilizers N				14.3							14.3							580
Dairy Manure Effluent - irrigated P - Liquids				0.35														7
Dairy Manure Effluent - irrigated N - Liquids				1.18														24
Cattle Manure as excreted P	2.17																	44
Cattle Manure as excreted N	6.31																	128
Daily P demand for Grass	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	60
Daily N demand for Grass	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	730
Net P	2.0	1.8	1.7	2.0	1.8	1.7	1.5	1.3	1.2	1.0	1.0	0.8	0.6	0.5	0.3	0.1	0.0	-0.2
Net N	4.3	2.3	0.3	13.8	11.8	9.8	7.8	5.8	3.8	1.8	14.1	12.1	10.1	8.1	6.1	4.1	2.1	0.1
DAY IN ROTATION	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**



The 18-day rotation for Blocks H and J assume the cattle enter the paddock on day 1, and all of the manure is excreted in the paddock on the first day. This essentially supplies enough N for three days pasture growth. On day 4, the solids are applied, supplying enough N for further days pasture growth. Half the chemical fertilizer is applied on day 5 and is consumed by the grass over the next 6 days, the second application of chemical fertilizer is applied on day 11, and is consumed by the grass just before the cattle enter the paddock to graze again. The impact of the irrigated solids effluent is negligible and can be done at any stage in the rotation without

materially affecting the nutrient loading as it is a little more than a day's N requirement of the grass.

																		annualized
Chemical Fertilizers P					0						0							0
Chemical Fertilizers N					13.6						13.6							550
Dairy Manure Effluent - irrigated P - Solids				0.64														13
Dairy Manure Effluent - irrigated N - Solids				2.52														51
Cattle Manure as excreted P	2.17																	44
Cattle Manure as excreted N	6.31																	128
Daily P demand for Grass	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	60
Daily N demand for Grass	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	730
Net P	2.0	1.8	1.7	2.2	2.0	1.8	1.7	1.5	1.3	1.2	1.0	0.8	0.7	0.5	0.3	0.2	0.0	-0.1
Net N	4.3	2.3	0.3	0.8	12.4	10.4	8.4	6.4	4.4	2.4	14.0	12.0	10.0	8.0	6.0	4.0	2.0	0.0
DAY IN ROTATION	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**



8.6 Effluent Application Schedule

Manure is applied in liquid form with irrigation equipment, and application conditions are documented in the nutrient management plan. All materials will be handled in a manner to minimize the generation of particulate matter, odors and greenhouse gases.

Waste will be applied at a rate significantly less than the crop (Kikuyu) nutrient requirements. Residue management practices will be used for maintenance of soil structure. Manure will be applied on recently grazed paddocks and before pasture re-growth starts.

The whole area of 378 acres where liquid manure will be applied has been divided into 7 blocks of 54 acres each. See Figure 23 – Nutrient Management Map.

Block A:	54 Acres
Block B:	54 Acres
Block C:	54 Acres
Block D:	54 Acres
Block E:	54 Acres
Block F:	54 Acres
Block G:	54 Acres

8.6.1 Effluent Volume:

All of the manure and contaminated water from the Milking Parlor and yard is washed out and transferred to the effluent ponds (manure from cows to the effluent pond is diluted about 12x). In Phase 1, an estimated 12,144 gallons effluent will be produced daily, which will enter into the settling pond. Only 1% of incoming wastewater is solids, which will remain in the settling pond. The remaining volume of wastewater overflows into the storage pond. For water and nutrient calculations, it is assumed that 100% of the volume is transferred to the storage pond.

8.6.2 Liquid Effluent Application Schedule:

Effluent is applied on 54 acres at any one time every 4th day. Total effluent volume after four days in the storage pond would be 48,576 gallons, which will be diluted (12x) with irrigation water. If it is raining on the scheduled application day, then the volume from that day will be carried over until the next scheduled day. If there are 17 contiguous rain days (longest on record), the worst case is the A, B, C and D are all delivered on E. The critical issue is not the lump of nutrients, but the day's effluent that can be stored in the pond. The day's storage as designed far exceeds the 17 days of rain, at 100 days storage for Phase 1 (699 cows).

During the wet months of November, December and January, the frequency and need for use of the irrigators is significantly lower than other times of the year. During the wet season, the effluent will be applied 4 times a month instead of 7 times a month, as it will be in the dry season. In these 4 wet season applications, the effluent water will be spread over twice the area of the dryer months, hence no change to the concentration of the effluent, just the frequency.

Effluent is applied only when conditions are favorable; and the application day can be selected based upon weather and soil conditions to avoid any nutrient overloading or risk of flushing through excess rain.

Table 16 – Liquid Effluent Application Schedule

Month/Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
January								A & B								C & D								E & F				G			
February	A				B				C				D				E				F				G						
March	A				B				C				D				E				F				G				A		
April		B				C				D				E				F				G				A				B	
May				C				D				E				F				G				A				B			
June	C				D				E				F				G				A				B				C		
July			D				E				F				G				A				B				C				D
August				E				F				G				A				B				C				D			
September	E				F				G				A				B				C				D				E		
October			F				G				A				B				C				D				E				F
November								G & A								B & C								D & E				F			
December						G & A								B & C								D & E								F & G	

Month/Day	1	4	8	12	16	20	24	28	31
January			**A, B**		**C, D**		**E & F**	**G**	
Area (acres)			108		108		108	54	
Plant irrigation requirement (gal) on the application day @ 0.39 inch			1153852		1153852		1153852	576926.1	
Effluent volume in storage pond on application day (gal)			97152		97152		97152	48576	
Irrigation water mixed with effluent (gal)			1056700		1056700		1056700	528350.1	
Diluation rate			11.9		11.9		11.9	11.9	
Nitrogen (lbs) applied on 54 acres block/s (0.025%)			203		203		203	101	
P (lbs) applied on 54 acres block/s (0.006%)			49		49		49	24	
K (lbs) applied on 54 acres block/s (0.03%)			243		243		243	122	
N application per Acre (lbs)			1.88		1.88		1.88	1.88	
P application per Acre (lbs)			0.45		0.45		0.45	0.45	
K application per Acre (lbs)			2.25		2.25		2.25	2.25	

Month/Day	1	5	9	13	17	21	25	28
February	**A**	**B**	**C**	**D**	**E**	**F**	**G**	
Area (acres)	54	54	54	54	54	54	54	
Plant irrigation requirement (gal) on the application day @ 0.39 inch	576926	576926.1	576926.1	576926.064	576926.1	576926.1	576926.1	
Effluent volume in storage pond at day 5 (gal)	48576	48576	48576	48576	48576	48576	48576	
Irrigation water mixed with effluent (gal)	528350	528350.1	528350.1	528350.064	528350.1	528350.1	528350.1	
Diluation rate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	
Nitrogen (lbs) applied on 54 acres block (0.025%)	101	101	101	101	101	101	101	
P (lbs) applied on 54 acres block (0.006%)	24	24	24	24	24	24	24	
K (lbs) applied on 54 acres block (0.03%)	122	122	122	122	122	122	122	
N application per Acre (lbs)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	
P application per Acre (lbs)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
K application per Acre (lbs)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	

Table 16 – Liquid Effluent Application Schedule (continued)

Month/Day	1	5	9	13	17	21	25	29	31
March	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**A**	
Area (acres)	54	54	54	54	54	54	54	54	
Plant irrigation requirement (gal) on the application day @ 0.39 inch	576926	576926.1	576926.1	576926.064	576926.1	576926.1	576926.1	576926.1	
Effluent volume in storage pond at day 5 (gal)	48576	48576	48576	48576	48576	48576	48576	48576	
Irrigation water mixed with effluent (gal)	528350	528350.1	528350.1	528350.064	528350.1	528350.1	528350.1	528350.1	
Diluation rate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	
Nitrogen (lbs) applied on 54 acres block (0.025%)	101	101	101	101	101	101	101	101	
P (lbs) applied on 54 acres block (0.006%)	24	24	24	24	24	24	24	24	
K (lbs) applied on 54 acres block (0.03%)	122	122	122	122	122	122	122	122	
N application per Acre (lbs)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	
P application per Acre (lbs)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
K application per Acre (lbs)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	

Month/Day	2	6	10	14	18	22	26	30
April	**B**	**C**	**D**	**E**	**F**	**G**	**A**	**B**
Area (acres)	54	54	54	54	54	54	54	54
Plant irrigation requirement (gal) on the application day @ 0.39 inch	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	576926.064
Effluent volume in storage pond at day 5 (gal)	48576	48576	48576	48576	48576	48576	48576	48576
Irrigation water mixed with effluent (gal)	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	528350.064
Diluation rate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
Nitrogen (lbs) applied on 54 acres block (0.025%)	101	101	101	101	101	101	101	101
P (lbs) applied on 54 acres block (0.006%)	24	24	24	24	24	24	24	24
K (lbs) applied on 54 acres block (0.03%)	122	122	122	122	122	122	122	122
N application per Acre (lbs)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88
P application per Acre (lbs)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
K application per Acre (lbs)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25

Month/Day	4	8	12	16	20	24	28	31
May	**C**	**D**	**E**	**F**	**G**	**A**	**B**	
Area (acres)	54	54	54	54	54	54	54	
Plant irrigation requirement (gal) on the application day @ 0.39 inch	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	
Effluent volume in storage pond at day 5 (gal)	48576	48576	48576	48576	48576	48576	48576	
Irrigation water mixed with effluent (gal)	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	
Diluation rate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	
Nitrogen (lbs) applied on 54 acres block (0.025%)	101	101	101	101	101	101	101	
P (lbs) applied on 54 acres block (0.006%)	24	24	24	24	24	24	24	
K (lbs) applied on 54 acres block (0.03%)	122	122	122	122	122	122	122	
N application per Acre (lbs)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	
P application per Acre (lbs)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
K application per Acre (lbs)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	

Month/Day	1	5	9	13	17	21	25	29	30
June	**C**	**D**	**E**	**F**	**G**	**A**	**B**	**C**	
Area (acres)	54	54	54	54	54	54	54	54	
Plant irrigation requirement (gal) on the application day @ 0.39 inch	576926	576926.1	576926.1	576926.064	576926.1	576926.1	576926.1	576926.1	
Effluent volume in storage pond at day 5 (gal)	48576	48576	48576	48576	48576	48576	48576	48576	
Irrigation water mixed with effluent (gal)	528350	528350.1	528350.1	528350.064	528350.1	528350.1	528350.1	528350.1	
Diluation rate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	
Nitrogen (lbs) applied on 54 acres block (0.025%)	101	101	101	101	101	101	101	101	
P (lbs) applied on 54 acres block (0.006%)	24	24	24	24	24	24	24	24	
K (lbs) applied on 54 acres block (0.03%)	122	122	122	122	122	122	122	122	
N application per Acre (lbs)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	
P application per Acre (lbs)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
K application per Acre (lbs)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	

Table 16 – Liquid Effluent Application Schedule (continued)

Month/Day	3	7	11	15	19	23	27	31
July	**D**	**E**	**F**	**G**	**A**	**B**	**C**	**D**
Area (acres)	54	54	54	54	54	54	54	54
Plant irrigation requirement (gal) on the application day @ 0.39 inch	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	576926
Effluent volume in storage pond at day 5 (gal)	48576	48576	48576	48576	48576	48576	48576	48576
Irrigation water mixed with effluent (gal)	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	528350
Diluation rate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
Nitrogen (lbs) applied on 54 acres block (0.025%)	101	101	101	101	101	101	101	101
P (lbs) applied on 54 acres block (0.006%)	24	24	24	24	24	24	24	24
K (lbs) applied on 54 acres block (0.03%)	122	122	122	122	122	122	122	122
N application per Acre (lbs)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88
P application per Acre (lbs)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
K application per Acre (lbs)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25

Month/Day	4	8	12	16	20	24	28	31
August	**E**	**F**	**G**	**A**	**B**	**C**	**D**	
Area (acres)	54	54	54	54	54	54	54	
Plant irrigation requirement (gal) on the application day @ 0.39 inch	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	
Effluent volume in storage pond at day 5 (gal)	48576	48576	48576	48576	48576	48576	48576	
Irrigation water mixed with effluent (gal)	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	
Diluation rate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	
Nitrogen (lbs) applied on 54 acres block (0.025%)	101	101	101	101	101	101	101	
P (lbs) applied on 54 acres block (0.006%)	24	24	24	24	24	24	24	
K (lbs) applied on 54 acres block (0.03%)	122	122	122	122	122	122	122	
N application per Acre (lbs)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	
P application per Acre (lbs)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
K application per Acre (lbs)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	

Month/Day	1	5	9	13	17	21	25	29	30
September	**E**	**F**	**G**	**A**	**B**	**C**	**D**	**E**	
Area (acres)	54	54	54	54	54	54	54	54	
Plant irrigation requirement (gal) on the application day @ 0.39 inch	576926	576926.1	576926.1	576926.064	576926.1	576926.1	576926.1	576926.1	
Effluent volume in storage pond at day 5 (gal)	48576	48576	48576	48576	48576	48576	48576	48576	
Irrigation water mixed with effluent (gal)	528350	528350.1	528350.1	528350.064	528350.1	528350.1	528350.1	528350.1	
Diluation rate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	
Nitrogen (lbs) applied on 54 acres block (0.025%)	101	101	101	101	101	101	101	101	
P (lbs) applied on 54 acres block (0.006%)	24	24	24	24	24	24	24	24	
K (lbs) applied on 54 acres block (0.03%)	122	122	122	122	122	122	122	122	
N application per Acre (lbs)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	
P application per Acre (lbs)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
K application per Acre (lbs)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	

Month/Day	3	7	11	15	19	23	27	31
October	**F**	**G**	**A**	**B**	**C**	**D**	**E**	**F**
Area (acres)	54	54	54	54	54	54	54	54
Plant irrigation requirement (gal) on the application day @ 0.39 inch	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	576926.1	576926
Effluent volume in storage pond at day 5 (gal)	48576	48576	48576	48576	48576	48576	48576	48576
Irrigation water mixed with effluent (gal)	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	528350.1	528350
Diluation rate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
Nitrogen (lbs) applied on 54 acres block (0.025%)	101	101	101	101	101	101	101	101
P (lbs) applied on 54 acres block (0.006%)	24	24	24	24	24	24	24	24
K (lbs) applied on 54 acres block (0.03%)	122	122	122	122	122	122	122	122
N application per Acre (lbs)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88
P application per Acre (lbs)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
K application per Acre (lbs)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25

Month/Day	1	4	8	12	16	20	24	28	29	30
November			**G, A**		**B, C**		**D, E**	**F**		
Area (acres)			108		108		108	54		
Plant irrigation requirement (gal) on the application day @ 0.39 inch			1153852		1153852		1153852	576926.1		
Effluent volume in storage pond on application day (gal)			97152		97152		97152	48576		
Irrigation water mixed with effluent (gal)			1056700		1056700		1056700	528350.1		
Diluation rate			11.9		11.9		11.9	11.9		
Nitrogen (lbs) applied on 54 acres block/s (0.025%)			203		203		203	101		
P (lbs) applied on 54 acres block/s (0.006%)			49		49		49	24		
K (lbs) applied on 54 acres block/s (0.03%)			243		243		243	122		
N application per Acre (lbs)			1.88		1.88		1.88	1.88		
P application per Acre (lbs)			0.45		0.45		0.45	0.45		
K application per Acre (lbs)			2.25		2.25		2.25	2.25		

Table 16 – Liquid Effluent Application Schedule (continued)

Month/Day	1	2	6	10	14	18	22	26	30	31
December			**G & A**		**B & C**		**D & E**		**F & G**	
Area (acres)			108		108		108		108	
Plant irrigation requirement (gal) on the application day @ 0.39 inch			1153852		1153852		1153852		1153852	
Effluent volume in storage pond on application day (gal)			97152		97152		97152		97152	
Irrigation water mixed with effluent (gal)			1056700		1056700		1056700		1056700	
Diluation rate			11.9		11.9		11.9		11.9	
Nitrogen (lbs) applied on 54 acres block/s (0.025%)			203		203		203		203	
P (lbs) applied on 54 acres block/s (0.006%)			49		49		49		49	
K (lbs) applied on 54 acres block/s (0.03%)			243		243		243		243	
N application per Acre (lbs)			1.88		1.88		1.88		1.88	
P application per Acre (lbs)			0.45		0.45		0.45		0.45	
K application per Acre (lbs)			2.25		2.25		2.25		2.25	

Nitrogen applied (lbs) on each block

Effluent Block	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Acres	**54**	**54**	**54**	**54**	**54**	**54**	**54**
January	101	101	101	101	101	101	101
February	101	101	101	101	101	101	101
March	203	101	101	101	101	101	101
April	101	203	101	101	101	101	101
May	101	101	101	101	101	101	101
June	101	101	203	101	101	101	101
July	101	101	101	203	101	101	101
August	101	101	101	101	101	101	101
September	101	101	101	101	203	101	101
October	101	101	101	101	101	203	101
November	101	101	101	101	101	101	101
December	101	101	101	101	101	101	203
Total Nitrogen application per year (lbs)	**1317**	**1317**	**1317**	**1317**	**1317**	**1317**	**1317**
Nitrogen application on each acre per annum (lbs)	**24.4**	**24.4**	**24.4**	**24.4**	**24.4**	**24.4**	**24.4**

Note: Since effluent application occurs every 4th day and days in each month vary, each block receives two applications in certain months as reflected in the table above. The total application per year is the same for all blocks.

Table 16 – Liquid Effluent Application Schedule (continued)

Phosphorous applied (lbs) on each block

Effluent Block	A	B	C	D	E	F	G
Acres	**54**	**54**	**54**	**54**	**54**	**54**	**54**
January	24	24	24	24	24	24	24
February	24	24	24	24	24	24	24
March	49	24	24	24	24	24	24
April	24	49	24	24	24	24	24
May	24	24	24	24	24	24	24
June	24	24	49	24	24	24	24
July	24	24	24	49	24	24	24
August	24	24	24	24	24	24	24
September	24	24	24	24	49	24	24
October	24	24	24	24	24	49	24
November	24	24	24	24	24	24	24
December	24	24	24	24	24	24	49
Total Phosphorous application per year (lbs)	**316**	**316**	**316**	**316**	**316**	**316**	**316**
Phosphorous application on each acre per annum (lbs)	**5.9**	**5.9**	**5.9**	**5.9**	**5.9**	**5.9**	**5.9**

Note: Since effluent application occurs every 4th day and days in each month vary, each block receives two applications in certain months as reflected in the table above. The total application per year is the same for all blocks.

Table 16 – Liquid Effluent Application Schedule (continued)

Potassium applied (lbs) on each block

Effluent Block	A	B	C	D	E	F	G
Acres	**54**	**54**	**54**	**54**	**54**	**54**	**54**
January	122	122	122	122	122	122	122
February	122	122	122	122	122	122	122
March	243	122	122	122	122	122	122
April	122	243	122	122	122	122	122
May	122	122	122	122	122	122	122
June	122	122	243	122	122	122	122
July	122	122	122	243	122	122	122
August	122	122	122	122	122	122	122
September	122	122	122	122	243	122	122
October	122	122	122	122	122	243	122
November	122	122	122	122	122	122	122
December	122	122	122	122	122	122	243
Total Potassium application per year (lbs)	**1581**	**1581**	**1581**	**1581**	**1581**	**1581**	**1581**
Potassium application on each acre per annum (lbs)	**29.3**	**29.3**	**29.3**	**29.3**	**29.3**	**29.3**	**29.3**

Note: Since effluent application occurs every 4th day and days in each month vary, each block receives two applications in certain months as reflected in the table above. The total application per year is the same for all blocks.

At Phase 1 steady state:

Daily effluent enters into storage pond	12,144 gal
Effluent volume in 4 days:	12,144 gal x 4 days = 48,576 gal
Effluent volume to be applied at any one time:	48,576 gal
Nitrogen percentage in effluent volume:	0.025%
Application area:	54 Acres
Nitrogen applied on day of application:	1.87 lbs/acre

Nutrient requirement of the Plant:

Kikuyu growth rate:	120.5 lbs DM/ac/day
Crude protein level:	22-23%
Crude protein lbs:	30 lbs CP/ ac/day
Nitrogen required per day for growth:	4.4 lbs N/ac/day
Nitrogen required on day 5:	4.4 x 4 = 17.7 lbs

At the application rate of 1.87 lb/acre (typically 1x per month per block), the nitrogen will minimally reach the soil surface, and instead will be absorbed through the plant leaves directly into the pasture/grass. The calculation for the nitrogen requirement is based on plant protein containing 16% N. Therefore if pasture is growing at 120.5 lbs. DM/ac/day and contains 23% Crude Protein, then the N requirement will be 4.4 lbs [120.5 X 0.23 X 0.16 = 4.4 lbs].

8.7 De-sludging Application Schedule

Table 17 – De-sludging Application Schedule

Wet solids applictaion schedule		Month/Day	6	7	8	9	10	11	12	13	14	15	21	22	23	24	25	26	27	28	29	30	31
H, J Block 108 acres		January																					
	1st application	February																					
	2nd application	March																					
		April																					
	3rd application	May																					
	4th application	June																					
		July																					
	5th application	August																					
	6th application	September																					
		October																					
	7th application	November																					
	8th application	December																					

Table 17 – De-sludging Application Schedule (continued)

Wet solids applictaion schedule		Month/Day	6	7	8	9	10	11	12	13	14	15	21	22	23	24	25	26	27	28	29	30	31
H, J Block 108 acres		January																					
	1st application	February				18	18	18	18	18	18												
						7590	7590	7590	7590	7590	7590												
						114	114	114	114	114	114												
						29	29	29	29	29	29												
						137	137	137	137	137	137												
						6.3	6.3	6.3	6.3	6.3	6.3												
						1.6	1.6	1.6	1.6	1.6	1.6												
						7.6	7.6	7.6	7.6	7.6	7.6												
	2nd application	March																18	18	18	18	18	18
																		7590	7590	7590	7590	7590	7590
																		114	114	114	114	114	114
																		29	29	29	29	29	29
																		137	137	137	137	137	137
																		6.3	6.3	6.3	6.3	6.3	6.3
																		1.6	1.6	1.6	1.6	1.6	1.6
																		7.6	7.6	7.6	7.6	7.6	7.6
		April																					
	3rd application	May					18	18	18	18	18	18											
							7590	7590	7590	7590	7590	7590											
							114	114	114	114	114	114											
							29	29	29	29	29	29											
							137	137	137	137	137	137											
							6.3	6.3	6.3	6.3	6.3	6.3											
							1.6	1.6	1.6	1.6	1.6	1.6											
							7.6	7.6	7.6	7.6	7.6	7.6											
	4th application	June														18	18	18	18	18	18		
																7590	7590	7590	7590	7590	7590		
																114	114	114	114	114	114		
																29	29	29	29	29	29		
																137	137	137	137	137	137		
																6.3	6.3	6.3	6.3	6.3	6.3		
																1.6	1.6	1.6	1.6	1.6	1.6		
																7.6	7.6	7.6	7.6	7.6	7.6		
		July																					
	5th application	August			18	18	18	18	18	18													
					7590	7590	7590	7590	7590	7590													
					114	114	114	114	114	114													
					29	29	29	29	29	29													
					137	137	137	137	137	137													
					6.3	6.3	6.3	6.3	6.3	6.3													
					1.6	1.6	1.6	1.6	1.6	1.6													
					7.6	7.6	7.6	7.6	7.6	7.6													
	6th application	September												18	18	18	18	18	18				
														7590	7590	7590	7590	7590	7590				
														114	114	114	114	114	114				
														29	29	29	29	29	29				
														137	137	137	137	137	137				
														6.3	6.3	6.3	6.3	6.3	6.3				
														1.6	1.6	1.6	1.6	1.6	1.6				
														7.6	7.6	7.6	7.6	7.6	7.6				
		October																					
	7th application	November	18	18	18	18	18	18															
			7590	7590	7590	7590	7590	7590															
			114	114	114	114	114	114															
			29	29	29	29	29	29															
			137	137	137	137	137	137															
			6.3	6.3	6.3	6.3	6.3	6.3															
			1.6	1.6	1.6	1.6	1.6	1.6															
			7.6	7.6	7.6	7.6	7.6	7.6															
	8th application	December											18	18	18	18	18	18					
													7590	7590	7590	7590	7590	7590					
													114	114	114	114	114	114					
													29	29	29	29	29	29					
													137	137	137	137	137	137					
													6.3	6.3	6.3	6.3	6.3	6.3					
													1.6	1.6	1.6	1.6	1.6	1.6					
													7.6	7.6	7.6	7.6	7.6	7.6					

Table 17 – De-sludging Application Schedule (continued)

Nitrogen applied (lbs) on each block

Effluent Block	H, J
Acres	**108**
January	0
February	683
March	683
April	0
May	683
June	683
July	0
August	683
September	683
October	0
November	683
December	683
Total Nitrogen application per year (lbs)	**5465**
Nitrogen application on each acre per annum (lbs)	**50.6**

Phosphorous applied (lbs) on each block

Effluent Block	H, J
Acres	**108**
January	0
February	173
March	173
April	0
May	173
June	173
July	0
August	173
September	173
October	0
November	173
December	173
Total Phosphorous application per year (lbs)	**1384**
Phosphorous application on each acre per annum (lbs)	**12.8**

Table 17 – De-sludging Application Schedule (continued)

Potassium applied (lbs) on each block

Effluent Block	H, J
Acres	**108**
January	0
February	820
March	820
April	0
May	820
June	820
July	0
August	820
September	820
October	0
November	820
December	820
Total Potassium application per year (lbs)	**6558**
Potassium application on each acre per annum (lbs)	**60.7**

8.8 Soil Sampling Procedures

8.8.1 Soil Testing Frequency

Soils samples and testing will be performed at least every three years. Soil samples will be collected from each field receiving manure as described in the University of Hawai'i CTAHR Cooperative Extension Service publication (SCM-9).

Soil samples will be submitted for analysis to the University of Hawai'i ADSC laboratory or another laboratory accepted in state-certified programs, the North American Proficiency Testing Program (Soil Science Society of America), or laboratories whose tests are accepted by the University of Hawai'i CTAHR Cooperative Extension Service. All soil analyses will be conducted by methods approved by the University of Hawai'i CTAHR.

Soil samples will be analyzed for pH and phosphorus, nitrogen, potassium, calcium, magnesium, organic matter, salinity, micronutrients, and other constituents pertinent to monitoring or amending the annual nutrient budget.

Refer to Table 15 - Spectrum Analytic – Soil Fertility Recommendations, for the initial soil testing and fertility recommendations at HDF.

8.9 Manure Analysis

Assumptions for manure volume and nutrient levels used in the nutrient budget analysis have been made based on available industry standards. Manure volume assumptions are based on a grazing system by NZ Genetics, which produces manure at a rate of 17.2 gal per cow per day (Vanderholm, Dale H., 1984). See reference below.

Table 1. Comparing estimated manure production.

	ASAE (1999)	ASAE (2005)	Nennich *et al.* (2005)	Vanderholm (1984)	Victoria [d]	Victoria [d]
Relevance	USA	USA	USA	NZ (pasture)	Victoria (pasture + grain)	Victoria (pasture + protein)
Milk yield ($kg \cdot day^{-1}$)		*16.5*	*16.5*			
Body weight (kg)	*600*	*600*		*600*		
Total manure (faeces + urine) ($kg \cdot day^{-1}$)	52	54	56	65		

The industry standard document "DairyNZ Facts and Figures Guide Book" is created by AgResearch and DairyNZ. This document has provided the basis of all effluent estimates and is the best fit to HDF's system being implemented on Kaua'i. It is based on 10 gal of wash down water per cow. HDF is using 17.4 gal of wash down water per cow. Therefore, the nitrogen concentration in effluent will be 0.025% (10/17.4 x 0.045 = 0.025).

Page 80 extract:

Some measured nutrient concentrations (%) in various effluents compared to farm dairy effluent

Source	%DM	%N	%P	%K
Farm dairy effluent	0.8	0.045	0.006	0.035

Page 81 extract:

Dairy shed and feed pad effluent volumes produced

	Dairy shed (litres) (Includes wash down water)		Feed pad (litres) (Raw manure only, no wash down water) Time on pad			
Herd size	Per cow/day	Herd size x per cow/day	0.5 hr	1.0 hr	1.5 hr	2.0 hr
1	50	50	1.7	3.4	5.1	6.8
150	50	7,500	255	510	765	1,020
250	48	12,000	425	850	1,275	1,700
500	43	21,500	850	1,700	2,550	3,400
750	38	28,500	1,275	2,550	3,825	5,100
1,000	34	34,000	1,700	3,400	5,100	6,800
2,000	23	46,000	3,400	6,800	10,200	13,600

The full DairyNZ Facts and Figures Guide Book is downloadable from the DairyNZ website: http://www.dairynz.co.nz/page/pageid/2145866931/Facts_and_Figures

8.9.1 Manure Sampling Frequency

Manure samples will be collected annually from both (liquid and solid) effluent ponds and the result of manure analyses will be used in determining land application rates of manure.

8.9.2 Liquid (Effluent) Manure Sampling

Effluent samples will be taken at the same depth from five sites around the pond.

Sub-samples will be mixed in a large, clean plastic container and analyzed while the contents are still swirling.

One pint of material will be collected in an unbreakable container that is no more than three quarters full and sent to the laboratory for analysis.

Samples will be transported in a cooler with ice packs, if necessary. Any stored samples will be refrigerated or frozen before being sent for analysis.

8.9.3 Solid Manure Sampling

Samples from five locations from around the settling pond will be taken at the same depth from which the sludge will be removed for application.

Sub-samples will be combined in a clean plastic container and mixed thoroughly.

At least one pint of material will be collected in an unbreakable container, that is no more than three quarters full (a quart-sized freezer bag will be used).

Samples will be transported in a cooler with ice packs. Any stored samples will be refrigerated or frozen before being sent for analysis.

8.10 Feed Management

A feed management plan will be developed and implemented utilizing the USDA NRCS Feed Management 592 Standard. This standard specifies certain criteria that must be followed and will become an essential component of the CNMP. Feed management uses an assortment of tools, including regular analysis of feeds, milk, and manure, to more frequently review nutritional diet formulas and reduce the uncertainties of feed delivery. This process enables maintenance efficiency, improvement in milk production, and/or the improved health of livestock. Decreasing or stabilizing nitrogen and phosphorus nutrient levels in the manure are also key objectives of HDF.

The feed management plan will contain the following information and be developed by a certified animal nutritionist:

- Diets and feed management strategies based upon a benchmark manure sample
- A laboratory analysis completed for the feedstuffs used to formulate the diet to determine nutrient content for the ration
- Feed analysis conducted by an accepted accredited laboratory
- Adjustments to nutritional levels to improve or sustain livestock productivity
- Diet adjustments to reduce (or not exceed) N and P levels in as excreted manure

- Feed management records will be kept on site and reviewed annually along with manure analysis results

8.10.1 Nutritional Requirements

The nutritional requirements are based on an approximately 1,000 lb animal producing 5.3 gal of milk per day. Total intake of 39.7 lbs. DM intake/day is about 4% of body weight. (This will be the maximum and not achievable under average management). The limiting factor for dairy cows is metabolic energy (ME). The example shown below is illustrated in metric units.

ME for maintenance:	60 MJ ME/Day = 60
ME for milk production:	6 MJ ME/Litre x 20 l = 120
ME for Pregnancy:	10 MJ ME/Day = 10
ME for activity:	8 MJ ME/Day = 8
	198 MJ ME/cow/day

Kikuyu @ 10 MJ ME / kg dm x 14 kg dm intake = 140 MJ ME/cow/day
Grain @ 11.5 MJ ME / kg dm x 5.4 kg dm intake = 59.4 MJ ME/cow/day
Total 199.4 MJ ME/cow/day

Protein
Daily requirement. (18 % of 18 kg intake) = 3240 gms
Kikuyu will be 14 kg dm @ 20 % protein so protein intake at +/- 2800 gms/cow/day.
6 kg grain at 90% dm = 5.4 kg dm @ 9% protein = protein intake of +/- 486 gms/cow/day.
Total 3286 gms/cow/day

Starch
Daily requirement. (30 %)
Kikuyu @ 4 % x 14kg = 560
Grain @ 75 % x 6 kg = 4500
Total. 5060 gms/cow/day
Fibre NDF about 35 % of diet
Kikuyu 14 x 40% NDF =5600
Maize Grain 6 x 11% NDF = 660
Total 6260 = +/- 35 % of diet

9.0 Operations and Maintenance

An effective operations and maintenance (O&M) plan is essential for HDF. The O&M Plan for HDF includes the following components:

1) Wastewater System O&M Requirements
    a) Accidental Entry of Waste Storage Emergency
    b) Effluent Storage Ponds
    c) Effluent Sludge Management
2) Manure Sampling Protocol
3) Soil Testing Protocol
4) Animal Mortality Management Plan
5) Water Quality Monitoring Plan
6) Emergency Action Plan Storage Facility Spill, Leak, or Failure
7) Nutrient Management Record Keeping

9.1 Water Quality Monitoring

HDF will implement a plan for water quality monitoring to assess baseline water quality and monitor water quality during operation, as well as assess the effectiveness and adjust HDF irrigation, nutrient management and conservation practices.

Monitoring Goals

- Determine baseline water quality
- Monitor water quality during operation of the dairy
- Evaluate and adjust the frequency and timing of nutrient application and irrigation schedule
- Evaluate and adjust conservation practices
- Detect any potential problems early to allow adjustment of practices before the impacts are significant

9.1.1 Monitoring Stations

Water quality monitoring will be done at several stations located throughout the farm. At a minimum, monitoring points will located upstream of the farm, at multiple drainage ways and water bodies in the farm and at locations downstream of the farm. The initial baseline sampling may be more intensive and evaluate and test water quality from locations further away from the farm both upstream and downstream and possibly near the coastline.

9.1.1.1 Sampling Plan and Procedures

A detailed sampling plan will be developed after baseline test results are available. However, it is anticipated that the sampling plan will include the following components and requirements:

- Regular samples will be taken at a 1- to 3-month intervals
- Specific samples will be taken during and after storm events
- Sampling will also document weather conditions, flow measurement
- Sampling will follow Quality Control and Quality Assurance protocols established in the Sampling Plan

9.1.1.2 Sampling Parameters

Parameters for measurement may include the following:

- Temperature
- Flow
- pH
- Dissolved oxygen
- Turbidity
- Total Suspended Solids
- Bacteria
- Pesticides
- N, P, K

9.1.2 Response Planning

A detailed response plan will be prepared that outlines actions to be taken for problems that arise during farm operation. The response plan will include:

- Contact person
- Discussion of concern
- Outline of action to be taken

- Documentation of action taken and follow-up testing

A variety of actions could be taken to mitigate water quality issues that arise at the site. It is likely that one or more of the following actions would be considered and taken to address typical water quality concerns for this type of agricultural operation:

- Addition/modification to erosion and sediment controls
- Addition/modification to conservation measures
- Adjustment to irrigation application schedules
- Adjustment to effluent and sludge application schedules
- Adjustment to nutrient application
- Adjustment to pasture rotation
- Changes to sampling routines, procedure or scheduling

9.1.3 Record Keeping and Evaluation

The Water Quality Plan and records will be maintained by the Farm Manager onsite, including the following items:

- Emergency contact info
- Laboratory contact info
- Sampling Plan and Procedures
- Baseline sample test results
- Regular sample test results
- Specific sample details and test results
- Graphical depiction of test results and trends
- Response Plan and Actions Taken

Hawai'i Dairy Farm LLC
Operation and Maintenance Worksheet
Accidental Entry of Waste Storage Emergency

For:	Lessor/Operator:	Hawai'i Dairy Farm LLC
	Job Location:	Koloa, Hawai'i
	County:	Kaua'i
	SWCD:	West Kaua'i Soil & Conservation District
	Tax Map Key(s):	(4) 2-9-003:001 (4) 2-9-003:006 (4) 2-9-001:001
Prepared By:	James Garmatz	Date: 4-16-14

Operations and Maintenance Items

Entry into the waste storage area is strictly prohibited by untrained personnel and should never be attempted by management or his employees.

The facility shall be surrounded by a woven wire fence to deter any animals or untrained personal from accidently falling in the waste storage facility. Gates will be located at each end to allow trained and supervised individuals access for maintenance and repairs.

Contact Person	**Phone Number**
Fire/Rescue	**911**
Primary Emergency Coordinator James Garmatz (Koloa, Hawai'i)	**808-212-5985**
Secondary Emergency Coordinator Adam Killerman (Koloa, Hawai'i)	**808-639-4311**

Action Plan

- Call for Help.
- Locate Emergency Rescue Equipment and attempt to reach the victim. (Grab Pole, Ladder, Flotation Device, Rope)
- Initiate CPR if Necessary.

Hawai'i Dairy Farms LLC
Operation and Maintenance Worksheet
Effluent Storage Ponds

For:	Lessor/Operator:	Hawai'i Dairy Farm LLC
	Job Location:	Koloa, Hawai'i
	County:	Kaua'i
	SWCD:	West Kaua'i Soil & Conservation District
	Tax Map Key(s):	(4) 2-9-003:001 (4) 2-9-003:006 (4) 2-9-001:001
Prepared By:	James Garmatz	Date: 4-16-14

Operation and Maintenance Items

An Effluent Storage Structure is used for temporary storage of liquid effluent. It will be designed, installed, and contain a plastic liner that will meet the supplier's specifications.

At any time this structure is out of service, the Hawai'i Department of Agriculture will be contacted for guidance in decommissioning the structure to avoid environmental concerns.

The estimated life span of a structure is 20 years. This can be assured by developing and executing a suitable "Operation and Maintenance Program". A properly operated/maintained effluent storage structure is an asset to our farm.

This practice will require you to perform periodic operation and maintenance to maintain satisfactory performance. A valuable "Operation and Maintenance Program" will include:

_____ Do not allow equipment that exceeds design loading to operate within 30 feet of the structure.

_____ Continually maintain all pumps, agitators, piping valves and all other electrical and mechanical equipment in good operating condition by following the manufacturer's recommendations.

_____ Continually maintain grounding rods and wiring for all electrical equipment in good condition.

_____ Maintain all fences, gates, railings and/or warning signs to prevent of any humans or animals entrance to the facility.

_____ Repair, immediately all livestock, vehicle and vandalism damage.

_____ Remove all foreign debris within the structure that may cause damage to pumps, agitators and earthen structures.

_____ On a monthly basis inspect all spillways and control gates for proper functioning for their ability to maintain the water level to design elevations. Remove any blockage or obstruction in spillways and maintain a minimum of 1 foot of freeboard from the top of the structure to the maximum water for earthen storage structure.

_____ Maintain a vigorous growth of vegetative covering on earthen structures. This may include the seeding, fertilization, and mowing of this grass. Maintain any weeds that occur and keep eliminated.

_____ Monitor all drains and screens on drains to make sure soil is not being transported thru the drainage system. Maintain screens and rodent guards.

_____ Eradicate all rodents and repair any damage caused by them.

_____ Facility should be low as possible prior to wet weather season.

_____ Immediately empty storage facility if damage to the structure may cause failure and immediately seek a qualified engineer to assess the situation. During de-watering of the structure, ensure that the effluent is spread at minimum rates on permanent pastures. Spread the effluent no closer than 50 feet from open water sources when applying liquid effluent with an effluent gun traveler. Do not reduce the effluent level in the structure more than 1 foot per day when emptying the structure.

_____ Protect the structures liner from erosive forces of filing operation, operating agitators at least 3 feet from the liner. Protect liner by keeping a layer of manure over the liner or keeping the liner moist.

Hawai'i Dairy Farms LLC
Operation and Maintenance Worksheet
Effluent Sludge Management

For:	Lessor/Operator:	Hawai'i Dairy Farm LLC
	Job Location:	Koloa, Hawai'i
	County:	Kaua'i
	SWCD:	West Kaua'i Soil & Conservation District
	Tax Map Key(s):	(4) 2-9-003:001 (4) 2-9-003:006 (4) 2-9-001:001

Prepared By: James Garmatz Date: 4-16-14

Operation and Maintenance Items

Ponds will have sludge buildup and will require dredging or pumping regularly. Proper maintenance of a pond, such as quarterly agitating and pumping to remove many of the solids will keep it functioning effectively for many years.

- Sludge cannot be measured or sampled from the edge of the pond, it must be done from a boat.
- For safety reasons, at least 3 people should be present: two in boat and one on pond bank.
- A long, lightweight, rigid pole with measurements should be used.
- Pole is slowly lowered into the pond until the liquid seems to become thicker and denser.
    - The depth on the pole is then recorded.
- The pole is then pushed deeper into the sludge until the bottom of the pond is reached.
    - That depth is recorded also.
- The difference between the two markings is the depth of the sludge.
- Sludge removal can be accomplished by:
    1) Agitating the pond and irrigating/land applying;
    2) Dewatering the pond, agitating the sludge and land applying the sludge;
- When using agitators, care should be taken to prevent damage to liners that are in place.
- More than one agitator may be required for large ponds
- The liquid can then be applied through large-bore irrigation equipment.

Proper maintenance of the pond also protects the environment, complies with regulations and demonstrates an ethics of civil responsibility.

Hawai'i Dairy Farms LLC
Operations and Management Worksheet
Manure Sampling Protocol

For:	Lessor/Operator:	Hawai'i Dairy Farm LLC
	Job Location:	Koloa, Hawai'i
	County:	Kaua'i
	SWCD:	West Kaua'i Soil & Conservation District
	Tax Map Key(s):	(4) 2-9-003:001 (4) 2-9-003:006 (4) 2-9-001:001
Prepared By:	James Garmatz	Date: 4-16-14

Operation and Maintenance Items

Manure Sampling Frequency
Manure samples will be collected annually from both (liquid and solid) effluent ponds and the result of manure analysis will be used in determining land application rates of manure.

Liquid (Effluent) Manure Sampling

- Effluent samples from five sites around the pond will be taken at the depth and from the portion of the pond from which effluent sample is taken.
- Sub samples will be mixed in a large clean plastic container and analyzed while the contents is still swirling.
- One pint of material will be collected in an unbreakable container, no more than three quarters full and send to the lab laboratory for analysis.
- Samples will be transported in a cooler with ice packs, if necessary; any stored samples will be refrigerated or frozen before being sent for analysis.

Solid Manure Sampling

- Samples from five locations around the settling pond will be taken at the same depth from which the sludge will be removed for application.
- Sub samples will be combined in a clean plastic container and mixed thoroughly.
- At least one pint of material will be collected in an unbreakable container, no more than three quarters full (A quart freezer bag will be used)
- Samples will be transported in a cooler with ice packs. Any stored samples will be refrigerated or frozen before being sent for analysis.

Hawai'i Dairy Farms LLC
Operation and Maintenance Worksheet
Soil Testing Protocol

For:	Lessor/Operator:	Hawai'i Dairy Farm LLC
	Job Location:	Koloa, Hawai'i
	County:	Kaua'i
	SWCD:	West Kaua'i Soil & Conservation District
	Tax Map Key(s):	(4) 2-9-003:001 (4) 2-9-003:006 (4) 2-9-001:001
Prepared By:	James Garmatz	Date: 4-16-14

General Information

HDF has a total of 517 acres in pasture. These pastures are divided up into 118 total paddocks that have an average area of 4 to 5 acres per paddock.

The spray irrigation that will apply effluent along with fresh water will only cover approximately 378 acres. 82 acres will have drip irrigation and no effluent will be applied here. The remaining 57 acres will not be irrigated and will only receive precipitation.

Each of the 118 paddocks will have a soil sample taken from 5-10 locations. Five paddock samples will be combined into one sample and mixed together. These composite sample combinations will be linked to the farm map, which is attached, taking into consideration each distinct sub-area found throughout the farm.

The use of clean tools, containers and clean bags to store the samples, is required. The sample will be gathered from the top 8 inches of the soil.

The method of sampling is as follows:

1. Clean surface of any litter or plant growth. Dig a hole about as wide as your spade and as deep as 8 inches.
2. One inch outside the edge of the hole, cut down to remove a slice of one side of the hole wall.
3. Keeping that slice on the blade of the spade, use a trowel to cut away the sides of the slice leaving a center section about 1 inch wide. A 1 x 1 inch vertical section of this soil is your sub-sample.

4. Place the sub-samples in a plastic container, mix them well and remove about 2 cups of this mixture. This is your composite sample, to send to the lab for analysis.
5. Retain equal parts of all samples for retained material in the event further testing is required.

Soil samples should be submitted for analysis to the University of Hawai'i, The Agricultural Diagnostic Service Center (ADSC) Laboratory or another laboratory accepted in state - certified programs, the North American Proficiency Testing Program (Soil Science of America), or laboratories whose test are accepted by University of Hawai'i, College of Tropical Agriculture and Human Resources (CTAHR) Cooperative Extension Services.

Soil samples should be analyzed for pH, Phosphorus, Nitrogen, Potassium, Calcium, Magnesium, Organic Matter, Salinity, Micronutrients and other constituents pertinent to monitoring or amending the annual nutrient budget.

All soil analyses should be conducted using methods approved by CTAHR. If a laboratory other than ADSC Laboratory is used, the laboratory and analytical methods used by that laboratory must be identified in the nutrient management plan.

The fertilizer recommendations associated with these samples should be based upon Kikuyu as the planned crop.

Laboratory choices are as follows:

1. The Agricultural Diagnostic Service Center (ADSC)
   College of Tropical Agriculture and Human Resources
   University of Hawai'i – Manoa
   1910 East-West Road
   Room 134
   Honolulu, Hawai'i 96822
   Raymond Uchida, Lab Director
   808.956.6706

2. Spectrum Analytical Inc.
   1087 Jamison Road NW
   Washington Court House, Ohio 43160-8748
   1.800.321.1562

Hawai'i Dairy Farms LLC
Operations and Management Worksheet
Animal Mortality Management Plan

For:	Lessor/Operator:	Hawai'i Dairy Farm LLC
	Job Location:	Koloa, Hawai'i
	County:	Kaua'i
	SWCD:	West Kaua'i Soil & Conservation District
	Tax Map Key(s):	(4) 2-9-003:001 (4) 2-9-003:006 (4) 2-9-001:001
Prepared By:	James Garmatz	Date: 4-16-14

Operation and Maintenance Items

If on-farm storage or handling of animal mortality is done, NRCS Standard 316, Animal Mortality, will be followed for proper management of dead animals. By following NRCS Standard 316, Animal Mortality, we decrease non-point source pollution of surface and ground water resources, reduce the impact of odors that result from improperly handled animal mortality, and decrease the likelihood of the spread of disease or other pathogens. An approved process shall be implemented in the handling of normal mortality losses.

The following outline describes how normal mortality will be managed in a manner that protects surface and ground water quality:

- Pits will be sized to accommodate appropriate weight to volume conversions.
    - Capacity will be in accordance with state and local regulatory agencies' guidelines.
- The burial pit will be a minimum of 2 feet wide with length necessary to accomplish mortality.
- The maximum size of the burial excavation will be 0.10 acre (about 4,400 sq. ft.)
- Pit bottoms will be level.
- Lengths will be limited to soil suitability and slope.
- Multiple pits must be separated by a minimum of three feet of undisturbed or compacted soil.
- Each carcass will be placed in a one-carcass-thick layer, covered with a minimum of 2 feet of soil.
    - Pits will never go deeper than 8 feet.

- Site consideration will include the following:
    - prevailing winds to neighbors
    - at least a 100 feet from any drainage way
    - at least 200 feet from any natural water course
    - at least 300 feet from any well
    - at least 20 feet from any building to prevent spontaneous combustion
    - as far from a fuel source as practical.
- Uncontaminated runoff must be diverted away from animal mortality facility.
- In soils with a permeability of more than 2 in/hr. a liner must be installed in accordance with NRCS standards
- Vehicular traffic will not be allowed within four feet of the pit edge.
- If the pit is four feet deep, a step or bench 18-inches wide and one foot deep will be dug around the perimeter of the main pit so the remaining vertical wall will not exceed four feet.

Hawai'i Dairy Farm LLC
Operation and Maintenance Worksheet
Emergency Action Plan Storage Facility Spill, Leak or Failure

For:	Lessor/Operator:	Hawai'i Dairy Farm LLC
	Job Location:	Koloa, Hawai'i
	County:	Kaua'i
	SWCD:	West Kaua'i Soil & Conservation District
	Tax Map Key(s):	(4) 2-9-003:001 (4) 2-9-003:006 (4) 2-9-001:001
Prepared By:	James Garmatz	Date: 4-16-14

Operation and Maintenance Items

In Case of an Emergency Storage Facility Spill, Leak or Failure

Implement the following first containment steps:

a. Stop all other activities to address the spill.
b. Stop the flow. For example, use skid loader or tractor with blade to contain or divert spill or leak.
c. Call for help and excavator, if needed.
d. Complete the cleanup and repair the necessary components.
e. Assess the extent of the emergency and request additional help, if needed.

In Case of an Emergency Spill, Leak or Failure during Transport or Land Application

Implement the following first containment steps:

a. Stop all other activities to address the spill and stop the flow.
b. Call for help if needed.
c. If the spill posed a hazard to local traffic, call for local traffic control assistance and clear the road and roadside of spilled material.
d. Contain the spill or runoff from entering surface waters using straw bales, saw dust, soil or other appropriate materials.
e. If flow is coming from a tile, plug the tile with a tile plug immediately.
f. Assess the extent of the emergency and request additional help, if needed.

Emergency Contacts

Department / Agency	Phone Number
Fire	911
Rescue services	911
State veterinarian	Dr. Jason D. Moniz, D.V.M 808-960-8409
Sheriff or local police	911

Nearest available excavation equipment/supplies for responding to emergency

Equipment Type	Contact Person	Phone Number
Waalani Bros	Ryan Waalani	808-645-1683
AJAR Inc	Adam Killerman	808-639-4311
George Kawamura Construction	George Kawamura	808-635-5894

Contacts to be made by the owner or operator within 24 hours

Organization	Phone Number
EPA Emergency Spill Hotline	1-888-ASK-USGS
County Health Department	1-808-586-4400
Other State Emergency Agency	1-888-246-2675

Be prepared to provide the following information:

a. Your name and contact information.
b. Farm location (driving directions) and other pertinent information.
c. Description of emergency.
d. Estimate of the amounts, area covered, and distance traveled.
e. Damage: employee injury, fish kill, or property damage.
f. Current status of containment efforts.

Hawai'i Dairy Farms LLC
Operations and Maintenance Worksheet
Nutrient Management Record Keeping

For:	Lessor/Operator:	Hawai'i Dairy Farm LLC
	Job Location:	Koloa, Hawai'i
	County:	Kaua'i
	SWCD:	West Kaua'i Soil & Conservation District
	Tax Map Key(s):	(4) 2-9-003:001 (4) 2-9-003:006 (4) 2-9-001:001
Prepared By:	James Garmatz	Date: 4-16-14

Operation and Maintenance Items

Nutrient Management record keeping is an essential task that needs to be completed on a daily basis. All applications of Nitrogen, Phosphorus and Potassium is required. The dates and application rates are also required in the record keeping. It also includes the different crops planted and the dates they are planted. The task involves the following methodology:

- Must include farm name on top line identified as Name.
- The field number is required on the second line identified as Field Number.
- Every field will have its own page and must be kept in a binder for easy access.
- When a particular crop is planted, log the crop name and the date planted.
- As fertilizer is applied, log each application with the date applied, application rate, and fertilizer formulation, for each crop.
- It is critical that anytime an activity is completed, the records are updated.
- All lime applications must also be entered.

Appendix A
NRCS Practice Codes

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

CONSERVATION PRACTICE STANDARD

WASTE STORAGE FACILITY

(No.)

CODE 313

DEFINITION

A waste storage impoundment made by constructing an embankment and/or excavating a pit or dugout, or by fabricating a structure.

PURPOSE

To temporarily store wastes such as manure, wastewater, and contaminated runoff as a storage function component of an agricultural waste management system.

CONDITIONS WHERE PRACTICE APPLIES

- Where the storage facility is a component of a planned agricultural waste management system
- Where temporary storage is needed for organic wastes generated by agricultural production or processing
- Where the storage facility can be constructed, operated and maintained without polluting air or water resources
- Where site conditions are suitable for construction of the facility
- To facilities utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads.
- To fabricated structures including tanks, stacking facilities, and pond appurtenances.

CRITERIA

General Criteria Applicable to All Waste Storage Facilities.

Laws and Regulations. Waste storage facilities must be planned, designed, and constructed to meet all federal, state, and local laws and regulations.

Location. To minimize the potential for contamination of streams, waste storage facilities should be located outside of floodplains. However, if site restrictions require location within a floodplain, they shall be protected from inundation or damage from a 25-year flood event, or larger if required by laws, rules, and regulations. Waste storage facilities shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized; and separation distances are such that prevailing winds and landscape elements such as building arrangement, landforms, and vegetation minimize odors and protect aesthetic values.

Various localities may have specific requirements which must be followed. For instance, the State of Hawaii, Department of Health, requires waste facilities be located a buffer distance of 1,000 feet from public drinking water resources and 50 feet from surface water resources. Waste storage facilities shall not be located in wetlands.

Storage Period. The storage period is the maximum length of time anticipated between emptying events. The minimum storage period shall be based on the timing required for environmentally safe waste utilization considering the climate, crops, soil, equipment, and local, state, and federal regulations.

Design Storage Volume. The design storage volume equal to the required storage volume shall consist of the total of the following as appropriate:

(a) Manure, wastewater, and other wastes accumulated during the storage period

(b) Normal precipitation less evaporation on the surface area (at the design storage volume level) of the facility during the storage period

(c) Normal runoff from the facility's drainage area during the storage period

(d) 25-year, 24-hour precipitation on the surface (at the required design storage volume level) of the facility

(e) 25-year, 24-hour runoff from the facility's drainage area

(f) Residual solids after liquids have been removed. A minimum of 6 inches shall be provided for tanks

(g) Additional storage as may be required to meet management goals or regulatory requirements

Inlet. Inlets shall be of any permanent type designed to resist corrosion, plugging, and ultraviolet ray deterioration while incorporating erosion protection as necessary.

The inlet pipe should have a minimum diameter of 6 inches. An inlet pipe shall terminate a sufficient distance from the shoreline to insure good distribution. A plumbing cleanout must be provided, as needed, to allow access to the pipe for removing blockage.

Emptying Component. Some type of component shall be provided for emptying storage facilities. It may be a facility such as a gate, pipe, dock, wet well, floating pump, pumping platform, retaining wall, or ramp. Features to protect against erosion, tampering, and accidental release shall be incorporated as necessary.

Accumulated Solids Removal. Provision shall be made for periodic removal of accumulated solids to preserve storage capacity. The anticipated method for doing this must be considered in planning, particularly in determining the configuration of ponds and type of seal, if any.

Safety. Design shall include appropriate safety features to minimize the hazards of the facility. Ramps used to empty liquids shall have a slope of 4 horizontal to 1 vertical or flatter. Those used to empty slurry, semi-solid, or solid waste shall have a slope of 10 horizontal to 1 vertical or flatter unless special traction surfaces are provided. Warning signs, fences, ladders, ropes, bars, rails, and other devices shall be provided, as appropriate, to ensure the safety of humans and livestock. Ventilation and warning signs must be provided for covered waste holding structures, as necessary, to prevent explosion, poisoning, or asphyxiation. Pipelines shall be provided with a water-sealed trap and vent, or similar device, if there is a potential, based on design configuration, for gases to enter buildings or other confined spaces. Ponds and uncovered fabricated structures for liquid or slurry waste with walls less than 5 feet above ground surface shall be fenced and warning signs posted to prevent children and others from using them for other than their intended purpose.

Erosion Protection. Embankments and disturbed areas surrounding the facility shall be treated to control erosion.

Liners. Liners shall meet or exceed the criteria in Pond Sealing or Lining, Compacted Clay Treatment (521D); or Pond Sealing or Lining, Flexible Membrane (521A).

Additional Criteria for Waste Storage Ponds

Soil and foundation. The pond shall be located in soils with an acceptable permeability that meets all applicable regulation, or the pond shall be lined. Information and guidance on controlling seepage from waste impoundments can be found in the Agricultural Waste Management Field Handbook (AWMFH), Appendix 10D.

The pond shall have a bottom elevation that is a minimum of 2 feet above the seasonal high water table unless features of special design are incorporated that address buoyant forces, pond seepage rate and non-encroachment of the water table by contaminants. The water table may be lowered by use of perimeter drains, if feasible, to meet this requirement.

Maximum Operating Level. The maximum operating level for waste storage ponds shall be the pond level that provides for the required

volume less the volume contribution of precipitation and runoff from the 25-year, 24-hour storm event plus the volume allowance for residual solids after liquids have been removed. A permanent marker or recorder shall be installed at this maximum operating level to indicate when drawdown should begin. The marker or recorder shall be referenced and explained in the O&M plan.

Outlet. No outlet shall automatically release storage from the required design volume. Manually operated outlets shall be of permanent type designed to resist corrosion and plugging.

Embankments. The minimum elevation of the top of the settled embankment shall be 1 foot above the waste storage pond's required volume. This height shall be increased by the amount needed to ensure that the top elevation will be maintained after settlement. This increase shall be not less than 5 percent. The minimum top widths are shown in Table 1. The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical, and neither slope shall be steeper than 2 horizontal to 1 vertical unless provisions are made to provide stability.

Table 1 – Minimum Top Widths

Total embankment Height, ft.	Top Width, ft.
15 or less	8
15 – 20	10
20 – 25	12
25 – 30	14
30 – 35	15

Excavations. Unless supported by a soil investigation, excavated side slopes shall be no steeper than 2 horizontal to 1 vertical.

Additional Criteria for Fabricated Structures

Foundation. The foundations of fabricated waste storage structures shall be proportioned to safely support all superimposed loads without excessive movement or settlement.

Where a non-uniform foundation cannot be avoided or applied loads may create highly variable foundation loads, settlement should be calculated from site-specific soil test data. Index tests of site soil may allow correlation with similar soils for which test data is available. If no test data is available, presumptive bearing strength values for assessing actual bearing pressures may be obtained from Table 2 or another nationally recognized building code. In using presumptive bearing values, adequate detailing and articulation shall be provided to avoid distressing movements in the structure.

Foundations consisting of bedrock with joints, fractures, or solution channels shall be treated or a separation distance provided consisting of a minimum of 1 foot of impermeable soil between the floor slab and the bedrock or an alternative that will achieve equal protection.

Table 2 - Presumptive Allowable Bearing Stress Values[1]

Foundation Description	Allowable Stress
Crystalline Bedrock	12000 psf
Sedimentary Rock	6000 psf
Sandy Gravel or Gravel	5000 psf
Sand, Silty Sand, Clayey Sand, Silty Gravel, Clayey Gravel	3000 psf
Clay, Sandy Clay, Silty Clay, Clayey Silt	2000 psf

[1] Basic Building Code, 12th Edition, 1993, Building Officials and Code Administrators, Inc. (BOCA)

Liquid Tightness. Applications such as tanks, that require liquid tightness shall be designed and constructed in accordance with standard engineering and industry practice appropriate for the construction materials used to achieve this objective.

Structural Loadings. Waste storage structures shall be designed to withstand all anticipated loads including internal and external loads, hydrostatic uplift pressure, concentrated surface and impact loads, water pressure due to seasonal high water table in compliance with this standard and applicable local building codes.

The lateral earth pressures should be calculated from soil strength values determined from the results of appropriate soil tests. Lateral earth pressures can be calculated using the procedures in TR-74. If soil strength tests are not available, the presumptive lateral earth pressure values indicated in Table 3 shall be used.

TABLE 3 - LATERAL EARTH PRESSURE VALUES[1]

Soil		Equivalent fluid pressure (lb/ft^2/ft of depth)			
		Above seasonal high water table[2]		Below seasonal high water table[3]	
Description[4]	Unified Classification[4]	Free-standing walls	Frame tanks	Free-standing walls	Frame tanks
Clean gravel, sand or sand-gravel mixtures (maximum 5% fines)[5]	GP, GW, SP, SW	30	50	80	90
Gravel, sand, silt and clay mixtures (less than 50% fines) Coarse sands with silt and and/or clay (less than 50% fines)	All gravel sand dual symbol classifications and GM, GC, SC, SM, SC-SM	35	60	80	100
Low-plasticity silts and clays with some sand and/or gravel (50% or more fines) Fine sands with silt and/or clay (less than 50% fines)	CL, ML, CL-ML SC, SM, SC-SM	45	75	90	105
Low to medium plasticity silts and clays with little sand and/or gravel (50% or more fines)	CL, ML, CL-ML	65	85	95	110
High plasticity silts and clays (liquid limit more than 50)[6]	CH, MH	-	-	-	-

[1] For lightly-compacted soils (85% to 90% maximum standard density.) Includes compaction by use of typical farm equipment.
[2] Also below seasonal high water table if adequate drainage is provided.
[3] Includes hydrostatic pressure.
[4] All definitions and procedures in accordance with ASTM D 2488 and D 653.
[5] Generally, only washed materials are in this category
[6] Not recommended. Requires special design if used.

Lateral earth pressures based upon equivalent fluid assumptions shall be assigned according to the following conditions:

- **Rigid frame or restrained wall.** Use the values shown in Table 3 under the column "Frame tanks," which gives pressures comparable to the at-rest condition.
- **Flexible or yielding wall.** Use the values shown in Table 3 under the column "Free-standing walls," which gives pressures comparable to the active condition.

Walls in this category are designed on the basis of gravity for stability or are designed as a cantilever having a base wall thickness to height of backfill ratio not more than 0.085.

Internal lateral pressure used for design shall be 65 lb/ft^2 where the stored waste is not protected from precipitation. A value of 60 lb/ft^2 may be used where the stored waste is protected from precipitation and will not become saturated. Lesser values may be used if supported by measurement of actual pressures of the waste to be stored. If heavy equipment will be operated near the wall, an additional two feet of soil surcharge shall be considered in the wall analysis.

Tank covers shall be designed to withstand both dead and live loads. The live load values for covers contained in ASAE EP378.3, Floor and Suspended Loads on Agricultural Structures Due to Use, and in ASAE EP 393.2, Manure Storages, shall be the minimum used. The actual axle load for tank wagons having more than a 2,000 gallon capacity shall be used.

If the facility is to have a roof, wind loads shall be as specified in ASAE EP288.5, Agricultural Building Snow and Wind Loads. If the facility is to serve as part of a foundation or support for a building, the total load shall be considered in the structural design.

Structural Design. The structural design shall consider all items that will influence the performance of the structure, including loading assumptions, material properties and construction quality. Design assumptions and construction requirements shall be indicated on standard plans.

Tanks may be designed with or without covers. Covers, beams, or braces that are integral to structural performance must be indicated on the construction drawings. The openings in covered tanks shall be designed to accommodate equipment for loading, agitating, and emptying. These openings shall be equipped with grills or secure covers for safety, and for odor and vector control.

All structures shall be underlain by free draining material or shall have a footing located below the anticipated frost depth. Fabricated structures shall be designed according to the criteria in the following references as appropriate:

- Steel: "Manual of Steel Construction", American Institute of Steel Construction.
- Timber: "National Design Specifications for Wood Construction", American Forest and Paper Association.
- Concrete: "Building Code Requirements for Reinforced Concrete, ACI 318", American Concrete Institute.
- Masonry: "Building Code Requirements for Masonry Structures, ACI 530", American Concrete Institute.

Slabs on Grade. Slab design shall consider the required performance and the critical applied loads along with both the subgrade material and material resistance of the concrete slab. Where applied point loads are minimal and liquid-tightness is not required, such as barnyard and feedlot slabs subject only to precipitation, and the subgrade is uniform and dense, the minimum slab thickness shall be 4 inches with a maximum joint spacing of 10 feet. Joint spacing can be increased if steel reinforcing is added based on subgrade drag theory.

For applications where liquid-tightness is required such as floor slabs of storage tanks, the minimum thickness for uniform foundations shall be 5 inches and shall contain distributed reinforcing steel. The required area of such reinforcing steel shall be based on subgrade drag theory as discussed in industry guidelines such as American Concrete Institute, ACI 360, "Design of Slabs-on-Grade".

When heavy equipment loads are to be resisted and/or where a non-uniform foundation cannot be avoided, an appropriate design procedure incorporating a subgrade resistance parameter(s) such as ACI 360 shall be used.

CONSIDERATIONS

Waste storage facilities should be located as close to the source of waste and polluted runoff as practicable.

Non-polluted runoff should be excluded from the structure to the fullest extent possible except where its storage is advantageous to the operation of the agricultural waste management system.

Freeboard for waste storage tanks should be considered.

Solid/liquid separation of runoff or wastewater entering pond facilities should be considered to minimize the frequency of accumulated solids removal and to facilitate pumping and application of the stored waste.

Due consideration should be given to environmental concerns, economics, the overall waste management system plan, and safety and health factors.

Considerations for Minimizing the Potential for and Impacts of Sudden Breach of Embankment or Accidental Release from the Required Volume.

Features, safeguards, and/or management measures to minimize the risk of failure or accidental release, or to minimize or mitigate impact of this type of failure should be considered when any of the categories listed in Table 4 might be significantly affected.

The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments when one or more of the potential impact categories listed in Table 4 may be significantly affected:

1. An auxiliary (emergency) spillway
2. Additional freeboard
3. Storage for wet year rather than normal year precipitation
4. Reinforced embankment -- such as, additional top width, flattened and/or armored downstream side slopes
5. Secondary containment

Table 4 - Potential Impact Categories from Breach of Embankment or Accidental Release

1. Surface water bodies -- perennial streams, lakes, wetlands, and estuaries
2. Critical habitat for threatened and endangered species.
3. Riparian areas
4. Farmstead, or other areas of habitation
5. Off-farm property
6. Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places.

The following options should be considered to minimize the potential for accidental release from the required volume through gravity outlets when one or more of the potential impact categories listed in Table 4 may be significantly affected:

1. Outlet gate locks or locked gate housing
2. Secondary containment
3. Alarm system
4. Another means of emptying the required volume

Considerations for Minimizing the Potential of Waste Storage Pond Liner Failure.

Sites with categories listed in Table 5 should be avoided unless no reasonable alternative exists. Under those circumstances, consideration should be given to providing an additional measure of safety from pond seepage when any of the potential impact categories listed in Table 5 may be significantly affected.

Table 5 - Potential Impact Categories for Liner Failure

1. Any underlying aquifer is at a shallow depth and not confined
2. The vadose zone is rock
3. The aquifer is a domestic water supply or ecologically vital water supply
4. The site is located in an area of solutionized bedrock such as limestone or gypsum.

Should any of the potential impact categories listed in Table 5 be affected, consideration should be given to the following:

1. A clay liner designed in accordance with procedures of AWMFH Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than 1 x 10^{-6} cm/sec
2. A flexible membrane liner over a clay liner
3. A geosynthetic clay liner (GCL) flexible membrane liner
4. A concrete liner designed in accordance with slabs on grade criteria for fabricated structures requiring water tightness

Considerations for Improving Air Quality

To reduce emissions of greenhouse gases, ammonia, volatile organic compounds, and odor, other practices such as Anaerobic Digester – Ambient Temperature (365), Anaerobic Digester – Controlled Temperature (366), Waste Facility Cover (367), and Composting Facility (317) can be added to the waste management system.

Adjusting pH below 7 may reduce ammonia emissions from the waste storage facility but may increase odor when waste is surface applied (see Waste Utilization, 633).

Some fabric and organic covers have been shown to be effective in reducing odors.

PLANS AND SPECIFICATIONS

Designs (drawings and specifications) shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use.

The design will include quantities of materials required such as:

- Earth cuts and fills
- Volume of concrete,
- Steel reinforcement, and
- Length of pipe.

Ponds. Drawings shall include:

- A plan layout of the embankment and pond with topographic contours,
- Profile of the embankment,
- Cross section of the embankment,
- Profile and cross section of the auxiliary spillway, and
- Inlet and outlet pipe details and material requirements.

For ponds that require a lining, the lining requirements shall be incorporated into the drawings.

Structures. Drawings for structures shall include:

- The location,
- Capacity,
- Dimensions,
- Material requirements,
- Structural details, and
- Foundation requirements.

Construction drawings shall show sufficient detail so that the structures will be built as designed.

The Pacific Islands Area specification for Waste Storage Facility (313) shall be provided as a construction specification.

The drawings and operating instructions for the waste storage facility will be incorporated into the comprehensive nutrient management plan.

The design shall specify the recommended species, planting method, and fertilizer for protective vegetation on the embankment and other exposed areas.

OPERATION AND MAINTENANCE

The Pacific Islands Area operation and maintenance plan for this practice shall be developed for and reviewed with the client that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design.

The plan shall contain the operational requirements for emptying the storage facility. This shall include the requirement that waste shall be removed from storage and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan.

In addition, for ponds, the plan shall include an explanation of the permanent marker or recorder installed to indicate the maximum operating level.

The plan shall include a strategy for removal and disposition of waste with the least environmental damage during the normal storage period to the extent necessary to insure the pond's safe operation. This strategy is for the removal of the contribution of unusual storm events that may cause the pond to fill to capacity prematurely with subsequent design inflow and usual precipitation prior to the end of the normal storage period.

Development of an emergency action plan should be considered for waste storage facilities where there is a potential for significant impact from breach or accidental release. The plan shall include site-specific provisions for emergency actions that will minimize these impacts.

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

CONSERVATION PRACTICE STANDARD

WINDBREAK/SHELTERBELT ESTABLISHMENT

(Ft.)

CODE 380

DEFINITION

Windbreaks or shelterbelts are single or multiple rows of trees or shrubs in linear configurations.

PURPOSE

- Reduce soil erosion from wind.
- Protect plants from wind related damage.
- Alter the microenvironment for enhancing plant growth.
- Provide shelter for structures, animals, and people.
- Enhance wildlife habitat.
- Improve air quality by reducing and intercepting air borne particulate matter, chemicals and odors.
- Improve irrigation efficiency.
- Increase carbon storage in biomass and soils.
- Reduce energy use

CONDITIONS WHERE PRACTICE APPLIES

Apply this practice on any areas where linear plantings of woody plants are desired and suited for controlling wind, noise, and visual resources. Use other tree/shrub practices when wind, noise and visual problems are not concerns.

CRITERIA

General Criteria Applicable to All Purposes

The location, layout and density of the planting will accomplish the purpose and function intended within a 20-year period.

Composition of species will be adapted to site conditions and suitable for the planned purpose(s). Select from species listed in the PI Plant Materials Technical Note 7, Pacific Islands Area (PIA) Vegetative Guide, Table N.

A precondition for windbreak/shelterbelt establishment is appropriately prepared sites. Should any type or amount of site preparation be required, only conservation practice Tree/Shrub Site Preparation Standard (490) shall be planned and applied prior to planting. Conservation practices: Forest Stand Improvement (666), Brush Management (314) and/or Herbaceous Weed Control (315) shall not be planned or applied in conjunction with, or in sequence with Tree/Shrub Site Preparation (490) for the purposes of preparing a site for tree/shrub planting.

The maximum design height (H) for the windbreak or shelterbelt shall be the expected height of the tallest row of trees or shrubs at age 20 for the given site.

No plants on the Federal or state noxious weeds list shall be planted.

Spacing between individual plants shall be based on the needed growing space for plant type and species, the accommodation of maintenance equipment, and the desired characteristics of the stem(s), branches and canopy as required for a specific purpose.

The windbreak will be oriented as close to perpendicular to the troublesome wind as possible.

The length of the windbreak will be sufficient to protect the site including consideration for the “end effect” and changes in wind direction.

Avoid planting trees or shrubs where stems, branches, roots, debris and/or leaf litter will interfere with infrastructure, above or below ground utilities, or natural features.

Moisture conservation or supplemental watering shall be provided for plant establishment and growth where natural precipitation is too low for the selected species.

The planting and care of selected tree and shrub species will comply with all General Criteria detailed in the Tree/Shrub Establishment Standard (612).

Additional Criteria to Reduce Wind Erosion and Protect Growing Plants

The interval between windbreaks shall be determined using current, approved, wind erosion technology. Interval widths shall not exceed that permitted by the soil loss tolerance (T), or other planned soil loss objective. Calculations shall account for the effects of other practices in the conservation management system.

For wind erosion control, temporary measures will be installed to supplement the windbreak until it is fully functional.

Sites, fields, and plants are protected within an area 10 times the design height (H) on the leeward side and two times the design height (H) on the windward side of the windbreak.

Select species that are taller than the crops being protected.

Additional Criteria to Provide Shelter for Structures, Livestock and People

For wind protection, the minimum barrier density will be 65 percent during the months of most troublesome wind.

The area to be protected will fall within a leeward distance of 10H.

Drainage of livestock waste from the livestock area shall not flow into the windbreak.

Additional Criteria to Improve Air Quality by Reducing and Intercepting Airborne Particulate Matter, Chemicals and Odors

The windbreak interval shall be less than or equal to 10h depending on site conditions and related supporting conservation practices.

Windbreak density on the windward side of the problem source, (i.e. particulate, chemical or odor) shall be greater than 50% to reduce the airflow into the source area.

Windbreak density on the leeward side of the problem source, and windward of the area to be protected, shall be greater than 65%.

Select and maintain tree and shrub species with foliar and structural characteristics to optimize interception, adsorption and absorption of airborne chemicals or odors.

Additional Criteria for Increasing Carbon Storage in Biomass and Soils

Maximize width and length of the windbreak to fit the site.

For optimal carbon sequestration, select plants that have higher rates of sequestration in biomass and soils.

Plant and manage the appropriate plant spacing for the site that will maximize above and below ground biomass production

Minimize soil disturbance during establishment and maintenance of the windbreak/shelterbelt.

Additional Criteria for Enhancing Wildlife Habitat

Plant species selection shall benefit targeted wildlife species including pollinators.

Design dimensions of the planting shall be adequate for targeted wildlife species.

Additional Criteria for Improving Irrigation Efficiency

For sprinkler irrigation systems, the windbreak shall be taller than the spray height.

The windbreak shall not interfere with the operation of the irrigation system.

Additional Criteria to Reduce Energy Use

Orient the windbreak as close to perpendicular to the troublesome wind as possible

Use proper plant density to meet energy reduction needs.

Use plants with a potential height growth that will be taller than the structure or facility being protected.

CONSIDERATIONS

Consider enhancing aesthetics by using evergreen species or species with features such as showy flowers, brilliant foliage, or persistent colorful fruits.

When designing and locating a windbreak or shelterbelt, consider the impact upon the landowner's or public's view of the landscape.

Selection of plants for use in windbreaks should favor species or varieties tolerant to herbicides used in the area.

Plants that may be alternate hosts to undesirable pests should be avoided.

All plantings should complement natural features.

Tree or shrub rows should be oriented on or near the contour where water erosion is a concern.

Wildlife and pollinator needs should be considered when selecting or siting tree or shrub species. Species diversity, including use of native species, should be considered.

Species diversity, including use of native species, should be considered to avoid loss of function due to species-specific pests.

Consider the invasive potential when selecting plant species.

Windbreaks for odor and chemical control increase in effectiveness as the amount of foliage available for intercept increases. Multiple-row, wide plantings offer greater interception potential than do smaller plantings.

When using trees and shrubs for greenhouse gas reductions, prediction of carbon sequestration rates should be made using current, approved carbon sequestration modeling technology.

A shelterbelt can be used as a travel corridor to connect existing patches of wildlife habitat.

In cropping systems select windbreak and shelterbelt species that minimize adverse affects to crop growth (e.g. shade, allelopathy, competing root systems or root sprouts).

Locate windbreaks as near as possible to property boundaries to delineate ownership and minimize the amount of land removed from other productive uses where appropriate.

Windbreaks that also serve as noise screens should be:

- At least 65 percent dense.
- As tall as, and as close to the noise source as practicable.
- Twice as long as the distance from the noise source to the receiver.
- Not less than 65 feet wide for high-speed traffic noise.
- Not less than 20 feet wide for moderate speed traffic noise.
- Select species that are tolerant to noxious emissions.

Windbreaks that also serve as visual screens should be located as close to the observer as possible with a density, height and width to sufficiently block the view between the area of concern and the sensitive area.

PLANS AND SPECIFICATIONS

Plans and specifications for applying this practice shall be prepared for each site and recorded using the Pacific Islands Area Windbreak/Shelterbelt Establishment (380) Jobsheet.

OPERATION AND MAINTENANCE

All of the following actions shall be carried out to insure that this practice functions as intended throughout the practice lifespan. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance).

Replacement of dead trees or shrubs will be continued until the windbreak/shelterbelt is functional.

Supplemental water will be provided as needed.

Thin or prune the windbreak/shelterbelt to maintain its function.

Inspect trees and shrubs periodically and protect from adverse impacts including insects, diseases or competing vegetation. Refer to the standards for Integrated Pest Management (595) if pesticides will be employed and Herbaceous Weed Control (315) for weeds. The trees or shrubs will also be protected from fire and damage from livestock and wildlife.

Periodic applications of nutrients may be needed to maintain plant vigor.

REFERENCES

Bentrup, Gary 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station.

Brandle, J.R. etal. 1988. Windbreak technology. Agric. Ecosyst. Environ. Vol. 22-23.

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

STATEMENT OF WORK

WINDBREAK/SHELTERBELT ESTABLISHMENT (380)

These deliverables apply to this individual practice. For other planned practice deliverables refer to those specific Statements of Work.

DESIGN

All design documents shall be developed in accordance with the requirements of the NRCS Pacific Islands Area Field Office Technical Guide (FOTG) Section IV, Conservation Practice Standard.

Deliverables:

1. Design documents that demonstrate criteria in NRCS practice standard have been met and are compatible with planned and applied practices.
    a. Practice purpose(s) as identified in the conservation plan.
    b. List of required permits to be obtained by the client.
    c. Practice standard criteria-related computations and analyses to develop plans and specifications including but not limited to:
        i. Determination of adapted species of trees and shrubs, extent and position in row(s), and desired density for intended purpose(s).
        ii. The maximum design height (H) for the windbreak or shelterbelt shall be the expected height of the tallest row of trees or shrubs at age 20 for the given site.
        iii. Orientation of windbreaks/shelterbelts and, as applicable, spacing between windbreaks, to achieve intended purpose(s).
        iv. Protective measures for plants to provide desired function including access control.
        v. Additional provisions, as required, wind erosion control, shelter of structures and livestock, noise abatement, improvement of air quality, increasing carbon storage in plants and soil, providing wildlife habitat and travel corridors, and improving irrigation efficiency.
2. Written plans and specifications including sketches and drawings shall be provided to the client that adequately describes the requirements to install the practice and obtain necessary permits. The Pacific Islands Area Conservation Practice Jobsheet for this practice shall be used to provide the client with the requirements to install the practice on the treatment unit. The Jobsheet is available in Section IV of the Pacific Islands Area FOTG.
3. Documentation of needed operation and maintenance. The Pacific Islands Area Conservation Practice Jobsheet for this practice shall be used to provide the client with the requirements for the operation and maintenance of the practice on the treatment unit. The Jobsheet is available in Section IV of the Pacific Islands Area FOTG.
4. Certification that the design meets practice standard criteria and comply with applicable laws and regulations.
5. Design modifications during installation as required.

INSTALLATION

Deliverables

1. Pre-application conference with client.
2. Verification that client has obtained required permits.
3. Staking and layout according to plans and specifications including applicable layout notes.
4. Application guidance as needed.

5. Facilitate and implement required design modifications with client and original designer.
6. Advise client/NRCS on compliance issues with all federal, state, tribal, and local laws, regulations and NRCS policies during installation.
7. Certification that the application process and materials meet design and permit requirements.

CHECK OUT

Deliverables

1. Records of application.
    a. Extent of practice units applied.
    b. Actual plant materials used and applied.
2. Certification that the application meets NRCS standards and specifications and is in compliance with permits.
3. Progress reporting.

REFERENCES

- NRCS Pacific Islands Area Field Office Technical Guide (FOTG), Section IV, Pacific Islands Area Windbreak/Shelterbelt Establishment (380) – Conservation Practice Standard, and Conservation Practice Jobsheet.
- NRCS National Forestry Handbook (NFH), Part 636.4
- NRCS National Environmental Compliance Handbook
- NRCS Cultural Resources Procedures Handbook

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

CONSERVATION PRACTICE STANDARD

WASTE TREATMENT LAGOON

(No.)

CODE 359

DEFINITION

A waste treatment impoundment made by constructing an embankment and/or excavating a pit or dugout.

PURPOSE

To biologically treat waste, such as manure and wastewater, and thereby reduce pollution potential by serving as a treatment component of a waste management system.

CONDITIONS WHERE PRACTICE APPLIES

- Where the lagoon is a component of a planned agricultural waste management system.
- Where treatment is needed for organic wastes generated by agricultural production or processing.
- On any site where the lagoon can be constructed, operated and maintained without polluting air or water resources.
- To lagoons utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads.

CRITERIA

General Criteria for All Lagoons

Laws and Regulations. All Federal, state, and local laws, rules, and regulations governing the construction and use of waste treatment lagoons must be followed.

Location. To minimize the potential for contamination of streams, lagoons should be located outside of floodplains. However, if site restrictions require location within a floodplain, they shall be protected from inundation or damage from a 25-year flood event, or larger if required by laws, rules, and regulations. Lagoons shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized; and separation distances are such that prevailing winds and landscape elements such as building arrangement, landforms, and vegetation minimize odors and protect aesthetic values.

Lagoons should be located so they have as little drainage area as possible. If a lagoon has a drainage area, the volume of normal runoff during the treatment period and 25-year, 24-hour storm event runoff shall be included in the required volume of the lagoon.

The State of Hawaii, Department of Health requires waste facilities be located a distance of 1,000 feet from public drinking water resources and 50 feet from surface water resources. Lagoons shall not be located in wetlands. Other jurisdictions may have similar requirements.

Soils and Foundation. The lagoon shall be located in soils with an acceptable permeability that meets all applicable regulations, or the lagoon shall be lined. Information and guidance on controlling seepage from waste impoundments can be found in the Agricultural Waste Management Field Handbook (AWMFH), Appendix 10D.

The lagoon shall have a bottom elevation that is a minimum of 2 feet above the seasonal high water table unless special design features are incorporated that address buoyant forces, lagoon seepage rates,

and non-encroachment of the water table by contaminants. The water table may be lowered by use of perimeter drains to meet this requirement.

Flexible Membranes. Flexible membrane liners shall meet or exceed the requirements of flexible membrane linings specified in Pond Sealing or Lining, Flexible Membrane (521A).

Required Volume. The lagoon shall have the capability of storing the following volumes:

- Volume of accumulated sludge for the period between sludge removal events;
- Minimum treatment volume (anaerobic lagoons only);
- Volume of manure, wastewater, and other wastes accumulated during the treatment period;
- Depth of normal precipitation less evaporation on the surface area (at the required volume level) of the lagoon during the treatment period;
- Depth of the 25-year, 24-hour storm precipitation on the surface area (at the required volume level) of the lagoon.

Treatment Period. The treatment period is the detention time between drawdown events. It shall be the greater of either 60 days; or the time required to provide the storage that allows environmentally safe utilization of waste considering the climate, crops, soil, and equipment requirements; or as required by local, state, and Federal regulations.

Waste Loading. Daily waste loading shall be based on the maximum daily loading considering all waste sources that will be treated by the lagoon. Reliable local information or laboratory test data should be used if available. If local information is not available Chapter 4 of the AWMFH may be used for estimating waste loading.

Embankments. The minimum elevation of the top of the settled embankment shall be 1 foot above the lagoon's required volume. This height shall be increased by the amount needed to ensure that the top elevation will be maintained after settlement. This increase shall be not less than 5 percent. The minimum top widths are shown in Table 1. The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical, and neither slope shall be steeper than 2 horizontal to 1 vertical unless provisions are made to provide stability.

Table 1 – Minimum Top Widths

Total embankment Height, ft.	Top Width, ft.
15 or less	8
15 – 20	10
20 – 25	12
25 – 30	14
30 – 35	15

Excavations. Unless supported by a soil investigation, excavated side slopes shall be no steeper than 2 horizontal to 1 vertical.

Inlet. Inlets shall be of any permanent type designed to resist corrosion, plugging, and ultraviolet ray deterioration, while incorporating erosion protection as necessary. Inlets shall be provided with a water-sealed trap and vent, or similar device if there is a potential, based on design configuration, for gases to enter buildings or other confined spaces.

The inlet pipe should have a minimum diameter of 6 inches except that a minimum diameter of 4 inches may be used for milking center waste. The pipe should terminate a sufficient distance from the shoreline to insure good distribution. A cleanout shall be provided for removing obstructions.

Outlet. Outlets from the required volume shall be designed to resist corrosion and plugging. No outlet shall automatically discharge from the required volume of the lagoon.

Facility for Drawdown. Measures that facilitate safe drawdown of the liquid level in the lagoon shall be provided. Access areas and ramps used to withdraw waste shall have slopes that facilitate a safe operating environment. Docks, wells, pumping platforms, retaining walls, etc. shall permit drawdown without causing erosion or damage to liners.

Sludge Removal. Provision shall be made for periodic removal of accumulated sludge to preserve the treatment capacity of the lagoon.

A solids separator may be installed between the waste sources and the lagoon. This may be a concrete or earth structure that can be

emptied periodically. A minimum of two cells should be planned so that one can be dried and cleaned while the other is functioning.

Erosion Protection. Embankments and disturbed areas surrounding the lagoon shall be treated to control erosion. This includes the inside slopes of the lagoon as needed to protect the integrity of the liner.

Safety. Design shall include appropriate safety features to minimize the hazards of the lagoon. The lagoon shall be fenced around the perimeter and warning signs posted to prevent children and others from using it for other than its intended purpose.

Additional Criteria for Anaerobic Lagoons

Loading Rate. Anaerobic lagoons shall be designed to have a minimum treatment volume based on Volatile Solids (VS) loading per unit of volume. The maximum loading rate shall be 12 pounds of VS per 1,000 cubic feet per day.

Operating Levels. The maximum operating level shall be the lagoon level that provides the required volume less the 25-year, 24-hour storm event precipitation on the surface of the lagoon. The maximum drawdown level shall be the lagoon level that provides volume for the required minimum treatment volume plus the volume of accumulated sludge between sludge removal events. Permanent markers shall be installed at these elevations. The proper operating range of the lagoon is above the maximum drawdown level and below the maximum operating level. These markers shall be referenced and described in the O&M plan.

Depth Requirements. The minimum depth at maximum drawdown shall be 6 feet. If subsurface conditions prevent practicable construction to accommodate the minimum depth at maximum drawdown, a lesser depth may be used, if the volume requirements are met.

Additional Criteria for Naturally Aerobic Lagoons

Loading Rate. Naturally aerobic lagoons shall be designed to have a minimum treatment surface area as determined on the basis of daily BOD_5 loading per unit of lagoon surface. The required minimum treatment surface area shall be the surface area at maximum drawdown. The maximum loading rate shall be 50 pounds of BOD5 per acre per day.

Operating Levels. The maximum operating level shall be the lagoon level that provides the required volume less the 25-year, 24-hour storm event on the lagoon surface. The maximum drawdown level shall be the lagoon level that provides volume for the volume of manure, wastewater, and clean water accumulated during the treatment period plus the volume of accumulated sludge between sludge removal events. Permanent markers shall be installed at these elevations. The proper operating range of the lagoon is above the maximum drawdown level and below the maximum operating level. These markers shall be referenced and described in the Operation and Maintenance Guide.

Depth Requirements. The minimum depth at maximum drawdown shall be 2 feet. The maximum liquid level shall be 5 feet.

Additional Criteria for Mechanically Aerated Lagoons

Loading Rate. Mechanically aerated waste treatment lagoons' treatment function shall be designed on the basis of daily BOD_5 loading and aeration equipment manufacturer's performance data for oxygen transfer and mixing. Aeration equipment shall provide a minimum of 1 pound of oxygen for each pound of daily BOD_5 loading.

Operating Levels. The maximum operating level shall be the lagoon level that provides the required lagoon volume less the 25-year, 24-hour storm event precipitation and shall not exceed the site and aeration equipment limitations. A permanent marker or recorder shall be installed at this elevation. The proper operating range of the lagoon is below this elevation and above the minimum treatment elevation established by the manufacturer of the aeration equipment. This marker shall be referenced and described in the O&M plan.

CONSIDERATIONS

General

Lagoons should be located as close to the source of waste as possible.

Table 2- Potential Impact Categories from Breach of Embankment or Accidental Release

1. Surface water bodies -- perennial streams, lakes, wetlands, and estuaries
2. Critical habitat for threatened and endangered species
3. Riparian areas
4. Farmstead, or other areas of habitation
5. Off-farm property
6. Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places

Solid/liquid separation treatment should be considered between the waste source and the lagoon to reduce loading.

The configuration of the lagoon should be based on the method of sludge removal and method of sealing.

Due consideration should be given to economics, the overall waste management system plan, and safety and health factors.

Considerations for Minimizing the Potential for and Impacts of Sudden Breach of Embankment or Accidental Release from the Required Volume

Features, safeguards, and/or management measures to minimize the risk of embankment failure or accidental release, or to minimize or mitigate impact of this type of failure should be considered when any of the categories listed in Table 2 might be significantly affected.

The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments when one or more of the potential impact categories listed in Table 2 may be significantly affected:

- An auxiliary spillway
- Additional freeboard
- Storage volume for the wet year rather than normal year precipitation
- Reinforced embankment -- such as, additional top width, flattened and/or armored downstream side slopes
- Secondary containment
- Water level indicators or recorders

The following should be considered to minimize the potential for accidental release from the required volume through gravity outlets when one or more of the potential impact categories listed in Table 2 may be significantly affected:

- Outlet gate locks or locked gate housing
- Secondary containment
- Alarm system
- Another means of emptying the required volume

Considerations for Minimizing the Potential of Lagoon Liner Seepage

Consideration should be given to providing an additional measure of safety from lagoon seepage when any of the potential impact categories listed in Table 3 may be affected.

Table 3 - Potential Impact Categories for Liner Seepage

1. Any underlying aquifer is at a shallow depth and not confined
2. The vadose zone is rock
3. The aquifer is a domestic water supply or ecologically vital water supply
4. The site is located in an area of carbonate rock (limestone or dolomite)

Should any of the potential impact categories listed in Table 3 be affected, consideration should be given to the following:

- A clay liner designed in accordance with procedures of AWMFH, Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than 1 x 10^{-6} cm/sec (12.4 inches per year).
- A flexible membrane liner
- A geosynthetic clay liner (GCL) flexible membrane liner
- A concrete liner designed in accordance with slabs on grade criteria, Waste Storage Facility (313), for fabricated structures requiring water tightness.

Considerations for Improving Air Quality

To reduce emissions of greenhouse gases, ammonia, volatile organic compounds, and odor:

- Reduce the recommended loading rate for anaerobic lagoons to one-half the values given in AWMFH Figure 10-22.
- Use additional practices such as Anaerobic Digester (366), Roofs and Covers (367) and Composting Facility (317) in the waste management system.
- Liquid/solid separation prior to discharge to lagoon will reduce volatile solids (VS) loading resulting in reduced gaseous emissions and odors. Composting of solids will further reduce emissions.
- Design lagoons to be naturally aerobic or to allow mechanical aeration.

Adjusting pH below 7 may reduce ammonia emissions from the lagoon but may increase odor when waste is surface applied (See Waste Utilization, code 633).

PLANS AND SPECIFICATIONS

Designs (drawings and specifications) shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use.

Drawings shall include:

- A plan layout of the pond, embankment, and adjacent area with topographic contours,
- Profile and cross section of the embankment and auxiliary spillway,
- Inlet and outlet pipeline details such as dimensions and material requirements,
- Quantities of materials required, such as: earth cut and fill yardage; yardage of concrete, pounds of steel reinforcement; and length of pipes, etc.

For ponds that require a lining, the lining requirements shall be incorporated into the drawing.

The drawings shall specify the recommended species, planting method, and fertilizer for protective vegetation on the embankment and other exposed areas.

OPERATION AND MAINTENANCE

The Pacific Islands Area operation and maintenance plan for this practice shall be developed for and reviewed with the client that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for design. The plan shall contain the operational requirements for drawdown and the role of permanent markers. This shall include the requirement that waste be removed from the lagoon and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan. In addition, the plan shall include a strategy for removal and disposition of waste with least environmental damage during the normal treatment period to the extent necessary to insure the lagoon's safe operation. This strategy shall also include the removal of unusual storm events.

Development of an emergency action plan should be considered for lagoons where there is a potential for significant impact from breach or accidental release. The plan shall include site-specific provisions for emergency actions that will minimize these impacts.

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

CONSERVATION PRACTICE SPECIFICATION

IRRIGATION PIPELINE (430)
(PLASTIC PIPE)

SCOPE

The work shall consist of furnishing and installing thermoplastic pipe and necessary appurtenances to the alignment, grades, and dimensions as shown on the drawings and/or staked in the field. The work also includes site preparation, earth fill, excavation, and any other applicable practice necessary for installation as shown on the drawings. This specification only applies to pipelines used as part of an irrigation system. Unless otherwise specified, the pipe shall conform to the requirements listed in this specification, NRCS-PI Irrigation Pipeline (430) Standard, and the requirements shown on the drawings.

SAFETY

Landowners or operators, sponsoring organizations, and contractors shall be liable for damage to utilities and damage resulting from disruption of service caused by construction activities. The Natural Resources Conservation Service makes no representation on the existence or non-existence of any utilities. Absence of utilities on the drawings is not assurance that no utilities are present at the site.

It is the responsibility of the landowner or operator to determine if there are buried or overhead utilities in the vicinity of the proposed work. They should take proper procedures to ensure that the utilities shall not be jeopardized and that equipment operators and others will not be injured during construction operations.

MATERIALS

This section covers the quality and requirements of Polyvinyl Chloride (PVC), corrugated Polyethylene (PE), High Density Polyethylene (HDPE), and Acrylonitrile-Butadiene-Styrene (ABS) plastic pipe, fittings, and joint materials.

Material/Polymer requirements. Pipe and fittings materials shall meet the minimum cell classification and material designation as stated in **Table 1.**

Pipe requirements. Manufactured pipe shall meet the applicable ASTM/AWWA standards listed in **Table 2.** Except for corrugated PE, all pipes shall be pressure-rated for water. ABS pipe shall be of solid wall construction.

Pipe shall be as uniform as commercially practicable in color, opaqueness, density, and other specified properties. It shall be free of visible cracks, holes, foreign inclusions, sunburn, bleaching, or other defects. The dimensions of the pipe shall be measured as prescribed in ASTM Standard D2122.

Wall thickness. The wall thickness for all pipe installed under this standard, regardless of pressure rating or type, shall not be less than 0.060 inches.

Pipe joints and fittings. All fittings shall meet or exceed the same strength, pressure, and dimension requirements as those of the pipe and shall be made of material that is recommended for use with the pipe. Joints and fittings shall meet the applicable ASTM specification and shall be used and installed according to the recommendations of the manufacturer.

Solvent for solvent cement joints shall conform to ASTM specifications D-2564 for PVC pipe and fittings and D-2235 for ABS pipe and fittings.

Fittings or belled ends for solvent cement joints shall have tapered sockets with socket lengths as per ASTM D2672. Sleeves for clamp-type joints shall provide a minimum of 4 inches overlap between the sleeve and the pipe or fitting.

Table 1 - Material Requirements

Material	Cell Class	Allowable Material Designation	Applicable Material Specification
Polyvinyl Chloride	12454	PVC1120	ASTM D1784
		PVC1220	
	14333	PVC2120	
Polyethylene	345464C or greater	PE3408 or greater	ASTM D3350 ASTM F2306 (corrugated PE)
Acrylonitrile-Butadiene-Styrene	20643 or greater	ABS1210 or greater	ASTM D3965

Table 2 - Applicable Pipe Standards

Material	PVC	PE	Corrugated PE	ABS
Applicable Specification	ASTM D1785 ASTM D2241 ASTM D2672 AWWA C900 AWWA C905	ASTM D2239 ASTM D3035 ASTM F714 ASTM F771 AWWA 906	ASTM F2306 AWWA 906	ASTM D1527

Rubber gasket joints. Rubber gasket joints shall conform to ASTM Specification D3139 for pressure pipe or D3212 for corrugated PE pipe. All rubber gaskets shall conform to ASTM F477. Gasket lubricant shall be suitable for use in water transmission applications. The gasket shall be the sole element depended upon to make the joint flexible and water tight. All surfaces of the joint upon or against which the gasket may bear, shall be smooth, free of cracks, fractures, or imperfections that could adversely affect the integrity of the joint.

Markings. Fitting markings shall include, as a minimum, the following information:

- Manufacturer's name or trademark
- Nominal size
- Pipe Schedule/pressure class/rating for water at 73 degrees F
- Materials name and designation (PVC1120, PE3408, etc)
- Recognized standard to which fitting is designed and manufactured

Pipe markings shall be repeated at a minimum interval of 5 ft along the pipe and shall include, in addition to fitting marking requirements, the following information:

- Specific production code including month and year
- Outside diameter base/system (IPS, PIP, etc)

INSTALLATION

Construction activities shall follow all OSHA standards and regulations. All work shall be neat and of a professional quality, as determined by the engineer.

Site preparation. Site preparation (mobilization and demobilization, clearing and grubbing, structure removal, pollution control, and water for construction) shall follow NRCS PI Supplemental Construction Specifications or others as appropriate.

Pipe storage. If pipe is stored outside for more than 15 days, it shall be covered by a durable, light-colored, opaque material, and vented to prevent heat buildup. Avoid awkward placement of pipe that could affect pipe integrity and strength.

HDPE pipe installed on the surface. Polyethylene plastic pipe, PE-3408 or better, up to 4-inch diameter, may be laid on the ground surface at locations where minimal hazards are imposed by fire, farm operations, traffic, vandalism, or theft. Snaking the pipe is necessary for surface pipes and an additional minimum 4% must be added to the length to accommodate the expansion and contraction. Surface pipe laid on steep slopes shall be anchored to control creep and resulting added stresses at intervals of no less than 200 feet. At vehicle crossings, burial, encasement of pipe, or other approved methods shall be used.

Depth of cover. Pipe shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by traffic crossings, farming operations, freezing temperatures, or soil cracking. The minimum depth of cover for pipe susceptible to any of these hazards shall be according to **Table 3.**

In areas where the pipe will not be susceptible to freezing and vehicular or cultivation hazards, and the soils do not crack appreciably when dry, the minimum depth of cover may be reduced to the values in **Table 4.**

Table 3 - Normal Minimum Cover Depth

Pipe diameter (in)	Depth of cover (in.)
½ through 2-1/2	18
3 through 5	24
6-18	30
More than 18	36

Table 4 - Non-Hazardous Minimum Cover Depth

Pipe diameter (in)	Depth of cover (in.)
½ through 1-1/2	6
2 through 3	12
4 through 6	18
More than 6	24

At locations where extra protection is needed such as vehicle crossings, encasement pipe or other approved methods shall be used.

In areas where burning is very likely, such as in sugarcane fields, the pipe shall be buried a minimum of 18 inches. Where peat or muck exists in their normal layered pattern, solvent-welded joints shall be used at all connections of PVC pipe. Where coarse sand or cement layers exist, rubber gasket joints may be used following normal bedding procedures.

In shallow trenches, extra fill may be placed over the pipeline to provide the minimum depth of cover. The top width of the fill shall be no less than 2 feet wider than the trench and the side slopes no steeper than 6H:1V. If extra protection is needed at vehicle crossings, encasement pipe or other approved methods may be used.

Minimum cover for corrugated PE is 12 inches. The maximum depth of cover for all plastic pipe sizes shall be 4 feet.

Trench construction. Provisions shall be made to insure safe working conditions where unstable soil, trench depth, or other conditions can be hazardous to personnel working in the trench.

The minimum width of the trench shall be wide enough to permit the pipe to be easily placed and joined and to allow the initial backfill material to be uniformly placed and compacted under the haunches and along the side of the pipe. The trench width shall depend upon the type of compaction of the backfill, and the width shall be the pipe diameter plus:

a. For water saturation - not less than 12 inches or more than 15 inches.
b. For mechanical compaction - not less than 24 inches or more than 36 inches.

If the trench is precision excavated and has a semicircular bottom that fits the pipe, the width shall not exceed the outside diameter of the pipe by more than 10 percent.

The trench bottom shall be uniform so that the pipe lies on the bottom without bridging. Clods, rocks, and uneven spots that provide non-uniform support or can damage the pipe or shall be removed.

If rocks or any other materials that can damage the pipe are encountered, the trench bottom shall be undercut a minimum of 4 inches below final grade and filled with bedding material consisting of sand or compacted fine-grained soils no greater than ½" diameter.

Pipelines having a diameter of ½ through 2-1/2 inches that are placed in areas not subject to vehicular loads and in soils that do not crack appreciably when dry, may be placed by using "plow-in" equipment instead of conventional trenching.

Pipe Placement. Care shall be taken to prevent permanent distortion and damage when handling the pipe. The pipe shall assume near-soil temperature before placing backfill. The pipe shall be uniformly and continuously supported over its entire length on firm stable material. Blocking or mounding shall not be used to bring the pipe to final grade.

If the pipe is assembled above ground, it should be lowered into the trench, taking care to not drop it or damage it against the trench walls.

Joints and connections. All joints and connections shall be installed to withstand the design maximum pressure for the pipeline without leakage. The inside of the pipe shall be free of any obstruction that may reduce its capacity below the design requirements.

For pipe with bell joints, bell holes shall be excavated in the bedding material, as needed, to allow for unobstructed assembly of the joint and to permit the body of the pipe to be in contact with the bedding material throughout its length.

The maximum bell joint deflection shall follow the manufacturer's recommendation. In curved sections, where joint deflection is greater than recommended, deflection couplings or elbows shall be used. A pipe section shall never be bent, deformed, blocked, or braced to hold a curve.

Allow heat fused and solvent-cemented joints to cool or cure for the minimum prescribed time before moving the pipe.

Fittings made of steel or other metals susceptible to corrosion shall be adequately protected by being wrapped with plastic tape or by being coated with a substance that has high corrosion-preventative qualities. If plastic tape is used, all surfaces shall be thoroughly cleaned and coated with a primer compatible with the tape before wrapping.

Thrust blocks. Thrust blocks shall be used at all major changes in alignment, under valves, intersections, and dead ends. Thrust blocks must be formed against a solid hand-excavated trench wall undamaged by mechanical equipment. They shall be constructed of concrete with a compressive strength of no less than 2000-psi and framed with wood or soil to restrain the freshly placed concrete. The space between the pipe and trench wall shall be filled with concrete to the height of the outside diameter of the pipe or as specified by the manufacturer. Allow sufficient time for concrete to cure before burying the thrust block or pressurizing the pipe.

Tracer wire. Where pipes are located close to utilities, roads, right-of-ways, in locations where development is anticipated, or as indicated in the drawings, tracing wire shall be installed. At a minimum, 14 gauge braided copper tracer wire shall be secured to the top of the pipes and shall surface at all ends and air vents. Wire shall be continuous or have an approved splice. Tracer tape is acceptable.

Water testing. The pipeline shall be tested for pressure strength, leakage, and proper functioning. The tests may be performed before backfilling or anytime after the pipeline is ready for service. Partial backfills needed to hold the pipe in place during testing shall be placed as specified in the **Initial backfill** section.

The line shall be slowly filled with water. Adequate provisions shall be made for air release during filling operations, taking care to bleed all entrapped air. The pressure shall be slowly built up to the maximum design working pressure of the system. While this pressure is maintained, all exposed pipe fittings, valves, hydrants, joints, appurtenances, and covered parts of the line shall be examined for leaks. Any leaks shall be repaired and the system retested.

The pipeline shall be tested to insure that it functions properly at design capacity. At or below design capacity, there shall be no objectionable flow conditions.

Initial backfill. Normally, hand, mechanical, or water packing methods may be used; however, all special backfilling recommendations of the pipe manufacturer shall be met.

The initial backfill material shall be soil or sand that is free from rocks or stones larger than 1 inch in diameter and earth clods greater than about 2 inches in diameter. Initial backfill shall extend 6 inches above the top of the pipe.

At the time of placement, the moisture content of the material shall be such that the required degree of compaction can be obtained with the backfill method to be used. The material shall be placed so that the pipe will not be displaced, deformed, or damaged.

If backfilling is done by hand or mechanical means, the initial fill shall be compacted firmly around and above the pipe as required to provide adequate lateral support to the pipe.

If the water packing method is used, to prevent floating the pipe, the pipeline first shall be filled with water and remain full until after the final backfill is complete. The initial backfill before saturation shall be of sufficient depth to insure complete coverage of the pipe after consolidation. Water packing is accomplished by adding enough water to diked reaches of the trench to thoroughly saturate the initial backfill without excessive pooling. The wetted fill shall be allowed to dry until firm before beginning the final backfill.

Final backfill. All special backfilling requirements of the pipe manufacturer shall be met.

The final backfill material shall be free of large rocks and other debris greater than 3 inches in diameter. The material shall be placed and spread in approximately uniform layers so that there will be no unfilled spaces in the backfill and the backfill will be level or slightly mounded with the natural ground or at the design grade required to provide the minimum depth of cover after settlement. Rolling equipment shall not be used to consolidate the final backfill until the specified minimum depth of cover has been placed.

Exposed PVC. Exposed PVC shall be specifically manufactured for use in above ground applications or shall be coated with a heavily pigmented latex or acrylic paint, chemically compatible with PVC. While color is not particularly important for UV protection, the use of light paint colors will reduce pipe temperature.

Above-ground pipe installation. Saddles and supports shall be installed and constructed as designed by the engineer and shall be approved prior to commencement of construction.

Vegetative cover. Permanent vegetation will be established following Conservation Practice Standard 342, Critical Area Planting.

CONSTRUCITON OPERATIONS AND WORKMANSHIP

Construction operations shall be carried out in such a manner and sequence that air and water pollution and erosion are minimized and held within legal limits.

The owner, operator, contractor, or other persons will conduct work and operations will conduct all work and operations in accordance with proper safety codes for the type of construction being performed with due regards to the safety of all persons and property.

All construction shall be performed in a workmanlike manner, and the job site shall have a neat appearance when finished.

QUALITY ASSURANCE AND GUARANTEE

The contractor shall contact the local NRCS office at least 24 hours in advance of any pipe that will be buried for quality assurance checks relating to pipe grade and appurtenances, bedding conditions, trench width and depth, and suitability of backfill material. Pipe and appurtenances that are of questionable quality (sun burnt PVC, gouged pipe, etc.) shall be subject to rejection at NRCS discretion.

The manufacturer or supplier of pipe materials shall supply a statement certifying that all pipe and materials have met the standards and specifications as described in this specification, as applicable.

The installing contractor shall certify that the installation complies with the requirements of this specification and NRCS Conservation Practice Standard 430. They shall furnish a written guarantee that protects the owner against defective workmanship and materials for not less than 1 year and that identifies the manufacturer and markings of the pipes used.

If requested by the engineer, a qualified testing laboratory shall certify with supporting test results that the pipe meets the requirements in this specification.

MEASUREMENT

The quantity of each size, type, and class of pipe shall be determined to the nearest foot by measurement of the laid length of pipe along the crown centerline of the conduit.

BASIS OF ACCEPTANCE

The acceptability of this practice shall be determined by inspections to insure compliance with all provision of this specification and to the drawings.

REFERENCE DOCUMENTS

American Society for Testing and Materials (ASTM)

ASTM D1527	Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe, Schedules 40 and 80
ASTM D1784	Standard Specification for Rigid PVC Compounds and Chlorinated PVC Compounds
ASTM D1785	Standard Specification for PVC Plastic Pipe, Schedules 40, 80, and 120
ASTM D2122	Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
ASTM D2235	Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
ASTM D2239	Standard Specification for Polyethylene Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM D2241	Standard Specification for PVC Pressure-Rated Pipe (SDR Series)
ASTM D2466	Standard Specification for PVC Plastic Pipe Fittings, Schedule 40
ASTM D2467	Standard Specification for PVC Plastic Pipe Fittings, Schedule 80
ASTM D2564	Standard Specification for Solvent Cements for PVC Plastic Piping Systems
ASTM D2609	Standard Specification for Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe
ASTM D2672	Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement
ASTM D2683	Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D3035	Standard Specification for Polyethylene Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3139	Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3261	Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM D3965	Standard Specification for Rigid Acrylonitrile-Butadiene-Styrene (ABS) Materials for Pipe and Fittings
ASTM F477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F714	Standard Specification for Polyethylene Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F771	Standard Specification for Polyethylene (PE) Thermoplastic High-Pressure Irrigation Pipeline Systems
ASTM F2306	Standard Specification for 12-in to 60-in Annular Corrugated Profile-Wall Polyethylene Pipe and Fittings for Gravity-Flow Storm Sewer and Subsurface Drainage Applications

American Water Works Association (AWWA)

AWWA C900	Standard for PVC Pressure Pipe and Fabricated Fittings for Water Transmission and Distribution, 4-in though 12-in
AWWA C905	Standard for PVC Pressure Pipe and Fabricated Fittings for Water Transmission and Distribution, 14-in through 48-in
AWWA C906	Standard for PE Pressure Pipe and Fittings for Water Distribution and Transmission, 4-in through 63-in

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

CONSERVATION PRACTICE STANDARD

IRRIGATION SYSTEM, SPRINKLER

(Ac.)

CODE 442

DEFINITION

An irrigation system in which all necessary equipment and facilities are installed for efficiently applying water by means of nozzles operated under pressure.

PURPOSE

This practice may be applied as part of a resource management system to achieve one or more of the following purposes:

- Efficiently and uniformly apply irrigation water to maintain adequate soil water for the desired level of plant growth and production without causing excessive water loss, erosion, or water quality impairment.
- Climate control and/or modification.
- Applying chemicals, nutrients, and/or waste water.
- Leaching for control or reclamation of saline or sodic soils.
- Reduction in particulate matter emissions to improve air quality.
- Reduce energy use.

CONDITIONS WHERE PRACTICE APPLIES

The sprinkler method of water application is suited to most crops, irrigable lands, and climatic conditions where irrigated agriculture is feasible. Areas must be suitable for irrigation or sprinkler water application and have an adequate supply of suitable quality water available for the intended purpose(s).

This standard applies to the planning and design of the overall water application through sprinkler discharge systems. This standard pertains to the planning and functional design of all sprinkler components except for special structures, such as permanently installed main and lateral pipelines or pumping plants. Other components shall meet appropriate NRCS Conservation Practice Standards.

This standard does not include criteria for mini- or micro-sprinkler systems, which are covered by NRCS Conservation Practice Standard, Irrigation System, Microirrigation (441).

CRITERIA

General Criteria Applicable to All Purposes

The criteria for the design of components not addressed in NRCS practice standards shall be consistent with sound engineering principles.

Each sprinkler discharge system must be designed as an integral part of an overall plan of conservation land use and treatment for the intended purpose(s) based on the capabilities of the land and the needs of the operator. The selected system shall be based on a site evaluation, expected operating conditions, and verification that soils, topography, *and water quantity and quality* are suitable for the intended purpose(s).

***Water Meter**. All systems installed under this practice, shall have an approved water meter, such as from the local utility, as an integral part of the system.*

Depth of Application. Net depth of application shall meet criteria for the intended purpose, not exceeding the available soil water holding capacity *of the active root zone plus the leaching fraction,* and meeting the land user's management plan for the intended purpose.

Capacity. The sprinkler irrigation system shall be designed with adequate capacity to accomplish the primary purpose(s) of the system.

Design Application Rate. Rates shall be selected such that runoff, translocation, and unplanned deep percolation are minimized.

Additional conservation measures, such as furrow diking, dammer diking, in-furrow chiseling, conservation tillage or residue management shall be applied as needed and appropriate.

Distribution Patterns, Nozzle Spacing and Height. A combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution shall be selected.

Coefficient of Uniformity (CU) data or distribution uniformity (DU) shall be used in selecting sprinkler spacing, nozzle size, and operating pressure. Definitions of each of these uniformity values can be found in the NRCS National Engineering Handbook, Part 652, Irrigation Guide.

Pipelines. The design of main lines, submains, and supply lines shall insure that required water quantities can be conveyed to all operating lateral lines at required pressures. For detailed criteria, see NRCS Conservation Practice Standard, Irrigation Pipeline (430).

Pump and Power Unit. Where required, pump and power units shall be adequate to efficiently operate the sprinkler system at design capacity and total dynamic head. For detailed criteria, see NRCS Conservation Practice Standard, Pumping Plant (533). *Certain systems may benefit from the use of variable frequency drives.*

Management Plan. An Irrigation Water Management plan, meeting NRCS Conservation Practice Standard, Irrigation Water Management (449), shall be developed for this practice, unless the purpose of the practice is waste water application. Where implemented for waste application, as a component of a Comprehensive Nutrient Management Plan (CNMP), a waste utilization plan and/or nutrient management plan shall be developed that meets the requirements of NRCS Conservation Practice Standards, Waste Utilization (633) and Nutrient Management (590), as appropriate.

Additional Criteria Applicable to Center Pivot or Linear-Move Sprinkler Systems

Design Capacity. Sprinkler systems shall be designed to have the capacity to meet the primary purpose. For the purpose of crop irrigation, sprinkler irrigation systems shall have either (1) a design capacity adequate to meet peak water demands of all irrigated crops in the design area, or (2) adequate capacity to meet requirements of selected irrigations during critical crop growth periods when less than full irrigation is planned.

In computing capacity requirements, allowance must be made for reasonable application water losses.

Distribution Patterns, Nozzle Spacing and Height. Pivot system (Heermann-Hein) or Linear (Christensen) CU shall not be less than 85% (76% DU), except as noted in criteria for a Low Energy Precision Application (LEPA) system. In lieu of the manufacturer's CU information, simulation modeling shall use Agricultural Research Service model Center Pivot Evaluation and Design (CPED) or similar modeling software. Manufacturer's information on nozzle packaging, allowing exclusion of the end gun and the first 12 percent of pivot length, not to exceed 250 feet, shall be considered acceptable documentation of system CU.

In the absence of CU data, sprinkler performance tables provided by the manufacturer shall be used in selecting nozzle size, operating pressure, and wetted diameter for the required sprinkler discharge. To the extent possible, low pressure spray nozzles shall be at uniform heights along the length of the lateral, with the exception of height adjustment to increase wetted diameter for runoff control. From a point midway between the first and second tower to the distal end of a center pivot, spray nozzle spacing along lateral lines shall not exceed 25% of the effective wetted diameter and impact sprinkler spacing shall not exceed 50 percent of the effective wetted diameter. The effective wetted diameter shall be determined from manufacturer's information for the nozzle height.

Lower elevation nozzle application systems, typically less than 7 feet from ground surface, that discharge water in the crop canopy for a considerable length of time during the growing season shall also meet the criteria of a Low Pressure in Canopy (LPIC) system as defined in this standard.

Additional Criteria Applicable to LEPA and Low Elevation Spray Application (LESA) Center Pivot or Linear-Move Sprinkler Systems

Distribution Patterns. For center pivot systems, nozzle discharge CU using the Heermann-Hein weighted area method shall be used in selecting sprinkler spacing, nozzle size, and operating pressure. Nozzle discharge CU shall not be less

than 94% of the calculated design flow rate needed at the discharge point. For linear systems, discharge shall be based on equivalent unit areas.

Nozzle Spacing. Nozzle spacing shall not be greater than two times the row spacing of the crop, not to exceed 80 inches.

Specific Additional Criteria for LEPA

Discharge Height. Water shall discharge through a drag sock or hose on the ground surface, or through a nozzle equipped with a bubble shield or pad at a uniform height not to exceed 18 inches.

Row Arrangement and Storage. LEPA systems are only applicable on crops planted with furrows or beds. LEPA systems shall have row patterns that match the lateral line movement (i.e., circular for center pivots). Water shall not be applied in the tower wheel track of a LEPA system. Runoff and translocation under LEPA systems shall be eliminated by providing surface basin storage such as furrow dikes, dammer dikes, or implanted reservoirs.

Slope. The slope for a LEPA system shall not exceed 1.0 percent on more than 50 percent of the field.

Systems that utilize bubble pads or shields, or drag hoses for a portion of the crop year and then spray nozzles at uniform height not exceeding 18 inches for a portion of the crop year shall meet LESA criteria.

Specific Additional Criteria for LESA

Discharge Height. LESA Systems shall discharge water through a spray nozzle at uniform heights not to exceed 18 inches.

Row Arrangement and Storage. LESA Systems are applicable on crops flat planted, drilled, or planted with furrows or beds. LESA Systems should employ some method of providing surface basin storage such as furrow dikes, dammer dikes, or implanted reservoirs, or farming practices such as conservation tillage, in-furrow chiseling, and/or residue management to prevent runoff.

Land Slope. The slope for LESA systems shall not exceed 3.0 percent on more than 50 percent of the field.

Additional Criteria Applicable to LPIC and Mid Elevation Spray Application (MESA) Center Pivot or Linear-Move Sprinkler Systems

Systems that utilize bubble pads or shields or drag hoses for a portion of the crop year and spray nozzles for a portion of the crop year not meeting all of the LEPA or LESA criteria shall meet LPIC criteria.

Distribution Patterns, Nozzle Spacing and Height. For row crops, when nozzles operate in canopy for 50 percent or more of the growing season, nozzle spacing shall not exceed every other crop row. In-canopy heights shall be such that areas of high leaf concentration are avoided (i.e., corn near the ear height (approximately 4 feet)). Local research and Extension Service information with applicable crops may serve as a guide for establishing appropriate nozzle spacing, height, and row arrangement.

CU (Heermann–Hein CU for center pivots) shall not be less than 90% for all LPIC and MESA Systems with nozzle heights less than 7 feet.

CU shall not be less than 85% (76% DU) for MESA Systems with nozzle heights 7 feet or greater.

Land Slope. The slope for LPIC and MESA systems shall not exceed 3.0 percent on more than 50 percent of the field for fine textured soils and not exceed 5 percent on more than 50 percent of the field on coarse textured soils.

Additional Criteria Applicable to Fixed-Solid-set, Big Gun and Periodic Move Sprinkler Systems

Design Capacity. Sprinkler irrigation systems shall have either (1) a design capacity adequate to meet peak water demands of all crops to be irrigated in the design area, or (2) adequate capacity to meet requirements of selected water applications during critical crop growth periods when less than full irrigation is planned. In computing capacity requirements, allowance must be made for reasonable application water losses.

Design Application Rate. The design application rate shall be within a range established by the minimum practical application rate under local climatic conditions, and the maximum application rate consistent with soil intake rate, slope, and conservation practices used on the land. If two or more sets of conditions exist in the design area, the lowest maximum application rate for areas of significant size shall apply.

Lateral Lines. Unless pressure reducers or regulators are installed at each outlet, or other pressure compensating or flow control devices are used, lateral lines shall be designed so that the pressure variation or flow variation at any sprinkler, resulting from friction head and elevation differential, does not exceed 20 percent of the design operating pressure or 10 percent of the design flow of the sprinklers, respectively.

Distribution Patterns and Spacing. A combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution shall be selected.

If available, CU (or DU) data shall be used in selecting sprinkler spacing, nozzle size, and operating pressure. CU shall not be less than the following:

- 75 % (60% DU) for deep-rooted (4 feet or more) field and forage crops where fertilizers and pesticides are not applied through the system.
- 85 % (76% DU) for high-value or shallow-rooted crops and for any crop where fertilizer or pesticides are applied through the system.

In the absence of CU data, maximum lateral and nozzle spacing shall comply with the following criteria:

1. For low (2-35 pounds/square inch (psi))-, moderate (36-50 psi)-, and medium (51-75 psi)-pressure sprinkler nozzles, the spacing along lateral lines shall not exceed 50 percent of the wetted diameter, as given in the manufacturer's performance tables, when the sprinkler is operating at design pressure. The spacing of laterals along the main line shall not exceed 65 percent of this wetted diameter.

If winds that can affect the distribution pattern are likely during critical crop growth periods, spacing should be reduced to 60 percent for average velocities of 1 to 5 miles per hour (mph), to 50 percent for average velocities of 6 to 10 mph, and to 45 percent for average velocities greater than 10 mph.

2. For high-pressure and big gun type sprinklers (>75 psi), the maximum distance (diagonal) between two sprinklers on adjacent lateral lines shall not exceed two-thirds of the wetted diameter under favorable operating conditions

If winds that can affect the distribution pattern are likely during critical crop growth periods, the diagonal spacing should be reduced to 50 percent of the wetted diameter for average velocities of 5 to 10 mph and to 30 percent for average velocities greater than 10 mph. Guidance for towpath spacing of travelers in NRCS National Engineering Handbook (NEH), Part 623, Chapter 11, Sprinkler Irrigation, Table 11-31.

3. Sprinkler spacing requirements for orchards, including subtropical fruits:

a) Triangular pattern. The spacing along lateral lines shall not exceed 65 percent of the effective wetted diameter. The spacing of laterals along the main line shall not exceed 70 percent of the effective wetted diameter.

b) Square or rectangular pattern. The nozzle spacing along the lateral and the lateral spacing along the main line shall not exceed 65 percent of the effective wetted diameter at the design operating pressure.

c) Spacing between sprinklers and lateral lines shall be reduced by 2.5 percent for each mph over 3 mph average wind velocity normally occurring during planned hours of operation.

Risers. Except for under-tree operation, riser pipes used on lateral lines shall be high enough to prevent interference with the distribution pattern when the tallest crop is irrigated. Riser heights shall not be less than shown below:

Sprinkler discharge *(gallons/minute)*	Riser length *(inches)*
Less than 10	6
10-25	9
25-50	12
50-120	18
More than 120	36

Risers over 3 feet in height shall be anchored and stabilized.

Additional Criteria Applicable to Traveling Sprinkler Irrigation Systems

The towpath spacing shall follow the recommendations in NEH, Part 623, Chapter 11, Sprinkler Irrigation, Table 11-31.

Additional Criteria Applicable to Climate Control and/or Modification

Design Capacity. For temperature control, the sprinkler irrigation system shall have sufficient capacity to satisfy the evaporative demand on a minute-by-minute basis throughout the peak use period. NEH, Part 623, Chapter 2, Irrigation

Water Requirements, contains guidance on using sprinkler irrigation systems for temperature control.

For frost protection, the system shall be capable of applying the necessary rate, based on the minimum temperature, maximum anticipated wind speed, and relative humidity, in a uniform manner. The capacity shall be sufficient to supply the demand for the entire crop being protected. NEH, Part 623, Chapter 2, Irrigation Water Requirements, contains guidance on using sprinkler irrigation systems for frost protection.

Additional Criteria Applicable to Chemical, Nutrient and/or Waste Water Application

The installation and operation of a sprinkler irrigation system for the purpose of chemical or nutrient application (chemigation) shall comply with all federal, state and local laws, rules and regulations. This includes backflow and anti-siphon prevention measures. Additionally, surface waters shall also be protected from direct application.

Injectors (chemical, fertilizer or pesticides) and other automatic operating equipment shall be located adjacent to the pump and power unit and installed in accordance with state regulations, or lacking the same, in accordance with manufacturer's recommendation. The chemical injection device shall be within 1 percent of maximum injection rates and easily calibrated and adjustable for all chemicals at the required injection rate.

A reduced pressure principle backflow prevention assembly valve will be installed upstream of chemical injectors in accordance with the standard for the Conservation Practice Standard, Irrigation Pipeline (430).

Sprinkler irrigation systems used to apply waste shall be designed with sprinkler nozzles of sufficient size to prevent clogging. Treatment of the wastewater using solid separators, two stage lagoons, two-stage waste holding ponds, etc., may be needed to reduce percent solids.

Design Application Rate and Timing. Application rates shall meet the levels specified in General Criteria. Timing of chemical applications shall be the minimum length of time it takes to deliver the chemicals and flush the pipelines at rates specified by the label.

Coefficient of Uniformity. If available, CU (or DU) data shall be used in selecting sprinkler spacing, nozzle size, and operating pressure. The CU shall not be less than 70% for wastewater and not less than 85% (76% DU) for chemigation or fertigation. If CU data is not available, distribution patterns and spacing requirements shall be in keeping with the appropriate specific criteria of this standard.

Nutrient and Pest Management. Chemicals, fertilizers and liquid manure shall be applied in accordance with appropriate NRCS Conservation Practice Standards, Nutrient Management (590), Pest Management (595), Waste Utilization (633), and Manure Transfer (634). Chemical or nutrient application amounts shall not exceed these standards.

NEH, Part 623, Chapter 2, Irrigation Water Requirements, contains guidance on using sprinkler irrigation systems for chemigation.

Additional Criteria Applicable to Leaching

Design Application Rate and Depth. Application rates shall meet the levels specified in General Criteria. Design depth shall be determined as defined in NEH, Part 623, Chapter 2, Irrigation Water Requirements.

Management or Reclamation Plan. A plan shall be developed conforming to the requirements contained in NRCS Conservation Practice Standard, Salinity and Sodic Soil Management (610).

Additional Criteria Applicable to Reduction in Particulate Matter Emissions to Improve Air Quality

These criteria pertains to sprinkler systems used to improve air quality by controlling dust emissions from confined animal pen areas and other critical areas such as unpaved roads, staging areas, and equipment storage yards.

Installation of fixed solid set sprinklers or periodic move sprinkler systems for dust control shall conform to the criteria stated above, unless described by criteria in this section. The installation and operation of Sprinkler Systems for dust control on confined animal pen areas shall provide application coverage on the majority of pen areas occupied by livestock, except for feed bunk aprons. The quality of discharge water shall be pathogen free and fit for animal consumption.

Capacity and Application Rate. For dust control, the sprinkler irrigation system shall have sufficient capacity and operational flexibility to apply the design application depth every three days or less. When determining capacity

requirements, allowance shall be made for reasonable water losses during application.

The minimum design application rate shall meet the maximum total daily wet soil evaporation rate, with allowances for moisture input to pen areas from animal manure and urine.

Open-lot management practices shall be applied that include scraping and removal of manure in pens between occupations, and shaping of the holding areas to prevent water ponding and chronic wet areas.

Over-application and excessive sprinkler overlap shall be avoided to minimize runoff and reduce odor and fly problems.

Water Amendments. Appropriately labeled chemicals for pest control or dust suppression may be applied through the sprinkler system when designed, installed and operated with appropriate backflow prevention and anti-siphon devices. When chemicals are applied through the sprinkler system, surface waters and livestock watering facilities shall be protected from direct application unless chemical labels indicate that direct application will not negatively impact animal health or water quality.

Distribution Patterns and Spacing. A combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution pattern shall be selected.

Maximum spacing of sprinklers along laterals shall not be greater than 75 percent, and no closer than 50 percent of wetted diameter listed in manufacturer's performance tables. Spacing between lateral shall comply with the following criteria:

1. For medium (51-75 psi)-pressure sprinkler nozzles, the spacing of laterals along the main line shall be no more than 90 percent, and no closer than 70 percent of wetted diameter.

2. For high-pressure sprinklers (>75 psi), the maximum distance between two sprinklers on adjacent lateral lines shall not exceed 100% of wetted diameter.

If winds impact distribution patterns during critical dust emission periods, the system shall be equipped with timer overrides and have the flexibility to be operated manually during periods of lesser wind, such as late evening and early morning.

Risers. Riser pipes used in lateral lines shall be high enough to minimize interference with the distribution pattern. The risers shall be constructed in a manner that provides protection from corrosive soils, equipment damage, and livestock damage. Riser heights shall place the discharge sprinkler not less than 6 feet above ground surface. Risers shall be anchored and stabilized.

System Valves and Controllers. Due to high application rates inherent with large sprinkler nozzle diameters, an automatic irrigation control system shall be utilized for all nozzles greater than 0.5 inch diameter. The automated control system shall utilize electro-hydraulic valves facilitating automatic operation. The valves shall be of a size and quality consistent with standard engineering practice. The operating system shall provide the flexibility to change sprinkling duration in one-minute increments and have a minimum of six start times per-day to provide for adjustment for climate conditions.

Systems shall be equipped with a rain sensor connected to the control valve network set to prohibit system operation during rainfall events.

Manual zone isolation valves shall be incorporated to isolate laterals allowing partial system operation during periods of maintenance and repair.

In areas of uneven or sloping terrain a control valve or low-head drainage device shall be incorporated at each sprinkler to ensure that line drainage to the lowest sprinkler is minimized.

Additional Criteria Applicable to Reduce Energy Use

Provide analysis to demonstrate reduction of energy use from practice implementation.

Reduction of energy use is calculated as average annual or seasonal energy reduction compared to previous operating conditions.

CONSIDERATIONS

When planning this practice the following items should be considered, where applicable:

Application rates near the end of a center pivot may exceed soil intake rate. Light, frequent applications can reduce runoff problems, but may increase soil surface evaporation. Nozzle offsets or booms can be used to reduce peak application rates.

For low suspended nozzle application systems, row arrangement, nozzle spacing, discharge nozzle type and configuration, along with height all impact CU. System design and field management should complement each other to yield the highest CU. In general, circular rows for center pivot systems and straight rows for linear move systems provide higher CU's.

Some aspects of non-uniformity tend to average out throughout the irrigation season while others tend to accumulate. Factors that tend to average out during the irrigation season are climatic conditions and uneven travel speed for systems that start and stop. Factors that tend to accumulate during the irrigation season are nozzle discharge variances due to pressure or elevation differences, surface movement of water, and poor water distribution around field boundaries.

Consider the effects of a center pivot end gun operation on CU. A large end gun may reduce the average CU by 1 percent for each 1 percent of the area covered past the main system hardware.

Consider the on and off effects of center pivot corner arm units and end guns on overall sprinkler performance. Discharges reduce flow in the main tower, significantly lowering the CU.

Beneficial effects of conservation practices applied to limit surface redistribution of water and runoff may diminish over the irrigation season.

The velocity of prevailing winds and the timing of occurrence should be considered when planning a sprinkler system. Systems designed to operate in varied time increments aid in balancing the effects of day and night wind patterns.

Consider filtering or screening the irrigation water before it enters the system if it contains particulate matter, algae, or other material that could plug the sprinkler nozzles.

Drop tubes should be installed alternately on both sides of the mainline and when used in-crop they should have a flexible joint between the gooseneck pipes and the application device. Drops should be weighted or secured in windy areas.

Consider different sprinkler application depths and application rates with hand move and center pivot systems. With hand move systems, the application rates more nearly match the soil infiltration rate so that large irrigations can be applied and the number of hand moves reduced. With an automated system, such as a center pivot, hand labor is not a major consideration and small applications at high rates are normal.

Fertilizer and chemical application amounts may vary from prior application methods and rates, due to precise applications possible with some sprinkler irrigation systems.

Management of sprinkler irrigation systems normally include utilizing soil water stored in the root zone, especially during critical crop growth stages.

Deflection of spans on center pivots and linear-move systems is common when the lateral is loaded (filled with water). This should be considered when determining nozzle heights. Wheel track depth will also affect nozzle height.

Water distribution is greatly affected by nozzle spacing and height for LPIC and MESA systems. In general, smaller, more closely spaced nozzles will yield a higher uniformity than larger, more widely spaced nozzles.

On center pivot or linear move systems, nozzles should be diverted away from wheel tracks to avoid rutting.

Low pressure systems (35 psi or less) are sensitive to small changes in nozzle pressure. Consider using pressure regulators on all low pressure systems where elevation differences, pumping depth variations, and end gun or corner arm operation can significantly change nozzle discharge and sprinkler uniformity. Also consider installing a pressure gauge at both ends of the sprinkler system to monitor system pressure.

Consider system effects on the water budget, especially the volume and rate of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

Consider system effects on erosion and movement of sediment, and soluble and sediment-attached substances carried by runoff.

Consider system effects on soil salinity, soil water or downstream water quality including subsurface drains. Crops may be more sensitive to salts applied to plant foliage during sprinkling than to similar water salinities applied by surface irrigation, subirrigation, and microirrigation. Information on foliar injury from saline water applied by sprinkler irrigation is contained in NEH, Part 623, Chapter 2, Irrigation Water Requirements. If the salt content of the irrigation

water is high, other irrigation methods should be considered.

Where wastewater is used for irrigation, timing of irrigation based on prevailing winds should be considered to reduce odor. In areas of high visibility, irrigating at night should be considered. The use of wastewater may reduce the life of the system due to corrosion or abrasion.

When utilized for particulate matter reduction, check to assure adequate animal feeding operation water supplies are available to meet other operating needs, during sprinkler system operation.

Irregularly shaped pen areas that are impractical to treat with a sprinkler system and where potential dust sources may occur should be treated for dust control with tanker water trucks equipped with hoses, or nozzles designed to apply water at rates similar to an equivalent sprinkler system.

Open-feedlot management practices that minimize thickness of loose manure will reduce water demands for dust control, as well as, reduce wet areas and ponding that could increase ammonia emissions.

Water Quality*. Water quality will affect production and must be appropriate for the crop to be grown.*

Elevated levels of electrical conductivity (ECw) will effect production and is specific for each crop.

Elevated levels of Sodium (Na+) or Chloride (Cl-) can cause foliar injury as well.

Test irrigation water to ensure compatibility to the selected crops.

Suspended solids can cause accelerated wear of system components, resulting in decreased irrigation efficiency, and added maintenance expense.

PLANS AND SPECIFICATIONS

Designs (drawings and specifications) for constructing irrigation sprinkler systems shall be in keeping with this standard and shall describe the requirements for properly installing *and operating* the practice to achieve its intended purpose. *As a minimum, the design must include the following:*

- *A location map, showing the scale, north arrow, field number and size, water meter, and crop(s) to be grown.*
- *Depth of active root zone, soil water holding capacity at time of irrigation.*
- *Irrigation application time and rate and soil infiltration rate.*
- *Sprinkler type, nozzle size, operating pressure, flow rate, wetted diameter, and spacing along lateral line.*
- *Instruction on number of sprinklers to operate at one time.*
- *Lateral line diameter and spacing along the main line.*
- *Number and lengths of laterals lines;*
- *Pipe material, pressure rating, and system operating pressure.*
- *Pressure regulator(s) and pressure setting(s) (if needed).*
- *Back-flow prevention valves.*
- *An Irrigation Water Management plan, meeting the NRCS Conservation Practice Standard, Irrigation Water Management (449).*

Designs (drawings and specifications) for permanently installed main lines (Irrigation Pipeline, Code 430) may be incorporated into the sprinkler system design.

OPERATION AND MAINTENANCE

The Pacific Islands Area operation and maintenance plan *shall be prepared for and reviewed with the client, and* must provide specific instructions for operating and maintaining the system to insure that it functions properly. It should also provide information regarding periodic inspections and prompt repair or replacement of damaged components. The plan, at minimum, shall include provisions to address the following:

- Periodic checks and removal of debris and sediment as necessary from nozzles to assure proper operation.
- Inspection or testing of all pipeline and pumping plant components and appurtenances, as applicable.
- Regular testing of pressures and flow rates to assure proper operation.
- Periodic checks of all nozzles and spray heads for proper operation and wear.
- Routine maintenance of all mechanical components in accordance with the manufacturer's recommendations.
- Prior to retrofitting any electrically powered irrigation equipment, electrical service must be disconnected and the absence of stray electrical current verified.

REFERENCES

USDA-NRCS, National Engineering Handbook, Part 623, Chapter 2, Irrigation Water Requirements

USDA-NRCS, National Engineering Handbook, Part 623, Chapter 11, Sprinkler Irrigation

Sprinkle and Trickle Irrigation, Keller and Bliesner, 2000

Agricultural Salinity Assessment and Management, ASCE, 1990

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION WATER MANAGEMENT

(Ac.)
CODE 449

DEFINITION

The process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner.

PURPOSE

- Manage soil moisture to promote desired crop response
- Optimize use of available water supplies
- Minimize irrigation induced soil erosion
- Decrease non-point source pollution of surface and groundwater resources
- Manage salts in the crop root zone
- Manage air, soil, or plant micro-climate
- Proper and safe chemigation or fertigation
- Improve air quality by managing soil moisture to reduce particulate matter movement

CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable to all irrigated lands.

An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, air quality, etc.) must be available and capable of efficiently applying water to meet the intended purpose(s).

CRITERIA

General Criteria Applicable to All Purposes

Irrigation water shall be applied in accordance with federal, state, and local rules, laws, and regulations. Water shall not be applied in excess of the needs to meet the intended purpose.

Measurement and determination of flow rate is a critical component of irrigation water management and shall be a part of all irrigation water management purposes.

The irrigator or decision-maker must possess the knowledge, skills, and capabilities of management coupled with a properly designed, efficient and functioning irrigation system to reasonably achieve the purposes of irrigation water management.

An “Irrigation Water Management Plan” shall be developed to assist the irrigator or decision-maker in the proper management and application of irrigation water.

Irrigator Skills and Capabilities. Proper irrigation scheduling, in both timing and amount, control of runoff, minimizing deep percolation, and the uniform application of water are of primary concern. The irrigator or decision-maker shall possess or obtain the knowledge and capability to accomplish the purposes which include:

A. General

1. How to determine when irrigation water should be applied, based on the rate of water used by crops and on the stages of plant growth and/or soil moisture monitoring.

2. How to determine the amount of water required for each irrigation, including any leaching needs.
3. How to recognize and control erosion caused by irrigation.
4. How to measure or determine the uniformity of application of an irrigation.
5. How to perform system maintenance to assure efficient operation.
6. Knowledge of "where the water goes" after it is applied considering soil surface and subsurface conditions, soil intake rates and permeability, crop root zones, and available water holding capacity.
7. How to manage salinity and shallow water tables through water management.
8. The capability to control the irrigation delivery.

B. Surface Systems

1. The relationship between advance rate, time of opportunity, intake rate, and other aspects of distribution uniformity and the amount of water infiltrated.
2. How to determine and control the amount of irrigation runoff.
3. How to adjust stream size, adjust irrigation time, or employ techniques such as "surge irrigation" to compensate for seasonal changes in intake rate or to improve efficiency of application.

C. Subsurface Systems

1. How to balance the relationship between water tables, leaching needs, and irrigation water requirements.
2. The relationship between the location of the subsurface system to normal farming operations.
3. How to locate and space the system to achieve uniformity of water application.
4. How to accomplish crop germination in arid climates and during dry periods.

D. Pressurized Systems

1. How to adjust the application rate and/or duration to apply the required amount of water.
2. How to recognize and control runoff.
3. How to identify and improve uniformity of water application.
4. How to account for surface storage due to residue and field slope in situations where sprinkler application rate exceeds soil intake rate.
5. How to identify and manage for weather conditions that adversely impact irrigation efficiency and uniformity of application.

System Capability. The irrigation system must be capable of applying water uniformly and efficiently and must provide the irrigator with adequate control over water application.

Additional Criteria to Manage Soil Moisture to Promote Desired Crop Response

The following principles shall be applied for various crop growth stages:

- The volume of water needed for each irrigation shall be based on plant available water-holding capacity of the soil for the crop rooting depth, management allowed soil water depletion, irrigation efficiency and water table contribution.
- The irrigation frequency shall be based on the volume of irrigation water needed and/or available to the crop, the rate of crop evapotranspiration, and effective precipitation.

- The application rate shall be based on the volume of water to be applied, the frequency of irrigation applications, soil infiltration and permeability characteristics, and the capacity of the irrigation system.

Appropriate field adjustments shall be made for seasonal variations and field variability.

Additional Criteria to Optimize Use of Water Supplies

Limited irrigation water supplies shall be managed to meet critical crop growth stages.

When water supplies are estimated to be insufficient to meet even the critical crop growth stage, the irrigator or decision-maker shall modify plant populations, crop and variety selection, and/or irrigated acres to match available or anticipated water supplies.

Additional Criteria to Minimize Irrigation-Induced Soil Erosion

Application rates shall be consistent with local field conditions for long-term productivity of the soil.

Additional Criteria to Decrease Non-Point Source Pollution of Surface and Groundwater Resources

Water application shall be at rates that minimize transport of sediment, nutrients and chemicals to surface waters and that minimize transport of nutrients and chemicals to groundwater.

Additional Criteria to Manage Salts in the Crop Root Zone

The irrigation application volume shall be increased by the amount required to maintain an appropriate salt balance in the soil profile.

The requirement shall be based on the leaching procedure contained in the National Engineering Handbook (NEH) Part 623, Chapter 2 and NEH, Part 652, chapters 3 and 13.

Additional Criteria for Proper and Safe Chemigation or Fertigation

Chemigation or fertigation shall be done in accordance with all local, state and federal laws.

The scheduling of nutrient and chemical application should coincide with the irrigation cycle in a manner that will not cause excess leaching of nutrients or chemicals below the root zone to the groundwater or to cause excess runoff to surface waters.

Chemigation or fertigation should not be applied if rainfall is imminent. Application of chemicals or nutrients will be limited to the minimum length of time required to deliver them and flush the pipelines. Irrigation application amount shall be limited to the amount necessary to apply the chemicals or nutrients to the soil depth recommended by label. The timing and rate of application shall be based on the pest, herbicide, or nutrient management plan.

The irrigation and delivery system shall be equipped with properly designed and operating valves and components to prevent backflows into the water source(s) and/or contamination of groundwater, surface water, or the soil.

CONSIDERATIONS

The following items should be considered when planning irrigation water management:

- Consideration should be given to managing precipitation effectiveness, crop residues, and reducing system losses.
- Consider potential for spray drift and odors when applying agricultural and municipal waste waters. Timing of irrigation should be based on prevailing winds to reduce odor. In areas of high visibility, irrigating at night should be considered.

- Consider potential for overspray from end guns onto public roads.
- Equipment modifications and/or soil amendments such as polyacrylamides and mulches should be considered to decrease erosion.
- Consider the quality of water and the potential impact to crop quality and plant development.
- Quality of irrigation water should be considered relative to its potential effect on the soil's physical and chemical properties, such as soil crusting, pH, permeability, salinity, and structure.
- Avoid traffic on wet soils to minimize soil compaction.
- Consider the effects that irrigation water has on wetlands, water related wildlife habitats, riparian areas, cultural resources, and recreation opportunities.
- Management of nutrients and pesticides.
- Schedule salt leaching events to coincide with low residual soil nutrients and pesticides.
- Water should be managed in such a manner as to not drift or come in direct contact with surrounding electrical lines, supplies, devices, controls, or components that would cause shorts in the same or the creation of an electrical safety hazard to humans or animals.
- Consideration should be given to electrical load control/interruptible power schedules, repair and maintenance downtime, and harvest downtime.
- Consider improving the irrigation system to increase distribution uniformity or application efficiency of irrigation water applications.

PLANS AND SPECIFICATIONS

Application of this standard may include job sheets or similar documents that specify the applicable requirements, system operations, and components necessary for applying and maintaining the practice to achieve its intended purpose(s).

OPERATION AND MAINTENANCE

The operation and maintenance (O&M) aspects applicable to this standard consist of evaluating available field soil moisture, changes in crop evapotranspiration rates and changes in soil intake rates and adjusting the volume, application rate, or frequency of water application to achieve the intended purpose(s). Other necessary O&M items are addressed in the physical component standards considered companions to this standard.

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

CONSERVATION PRACTICE STANDARD

POND SEALING OR LINING, FLEXIBLE MEMBRANE

(No.)
CODE 521A

DEFINITION

A manufactured hydraulic barrier consisting of a functionally continuous layer of synthetic or partially synthetic, flexible material.

PURPOSE

To restrict, impede, and control seepage of contaminants from water and waste impoundment structures for water conservation and environmental protection.

CONDITION WHERE PRACTICE APPLIES

On ponds and water storage structures that require treatment to control seepage rates within acceptable limits.

On earthen waste storage lagoons and other waste impoundment structures that require treatment to control seepage of contaminants from the storage structure.

CRITERIA

Design. Structures to be lined shall have been constructed to meet all applicable NRCS standards. All inlets, outlets, ramps, and other appurtenances may be installed before, during, or after the liner placement, but shall be done in a manner that does not damage or impair the proper operation of the liner.

Design and installation of the flexible membrane shall be in accordance with manufacturer recommendations. All flexible membrane installations shall be certified by the installer as meeting the material and installation requirements of the plans and specifications.

Manufacturer recommendations shall be followed with regard to protection from weather and exposure.

Minimum Criteria for Membranes

Type	Limiting Parameter	
	Wastewater	Clear Water
HDPE	40 mil	30 mil
LLDPE	40 mil	20 mil
PVC	30 mil	20 mil
GCL	0.75 lb./sq ft (bentonite)	
EPDM	45 mil	
PP (Reinforced) (Un-reinforced)	 36 mil 40 mil	 24 mil 30 mil
RPE	NR	24 mil
CPSE	*30 mil*	*30 mil*

1 mil = 1/1000 of an inch
HDPE – High Density Polyethylene Geomembrane
LLDPE – Linear Low Density Polyethylene Geomembrane
PVC – Polyvinyl Chloride Geomembrane
GCL – Geosynthetic Clay Liner
EPDM – Synthetic Rubber Geomembrane *(butyl)*
PP – Polypropylene Geomembrane
RPE – Reinforced Polyethylene Geomembrane
NR – Not Recommended
CPSE – Chlorosulfonated Polyethylene (hypalon)

Cover Soil. PVC and GCL liners shall be covered with a minimum of 12 inches of soil. Cover soil may be used on other liners but is not required.

Cover soil shall be used as cover for liners when required for the proper performance,

protection and durability of the installation. Cover soils shall not contain sharp, angular stones or any objects that could damage the liner. Maximum allowable particle size of soil cover material shall be 3/8-in for geomembrane liners and ½-inch for geosynthetic clay liners, unless the liner is cushioned by an 8-ounce or greater needle punched, non-woven geotextile padding material. Cover materials shall be stable against slippage down the slope under all operational and exposure conditions.

Subgrade Preparation. Subgrade preparation shall conform to manufacturer recommendations. Subgrade materials shall not contain sharp, angular stones or any objects that could damage the liner or adversely affect its function.

Padding. A cushion or padding shall be placed beneath the liner if the subgrade particles contain sharp angular stones that could damage the liner or particles greater than 3/8-inch for geomembrane liners and ½-inch for geosynthetic clay liners. The padding or cushion may be an 8-ounce or greater non-woven geotextile or a soil meeting the particle size and shape requirements of the subgrade.

Anchorage. Liners shall be anchored to prevent uplift due to wind or slippage down the side slope.

Safety. Design shall include appropriate safety features to minimize the hazards of the structure. Warning signs, fences, ladders, ropes, bars, rails, and other devices shall be provided, as appropriate, to ensure the safety of humans and livestock. .

CONSIDERATIONS

Venting of wastewater pond liners not covered with soil is recommended unless other site conditions exist to allow dissipation of gas pressure from beneath the liner. One such condition is the presence of granular foundation soils (SW, GW or GP). A minimum vent spacing of 50 feet is recommended.

If high water tables could adversely affect the proper functioning of the structure, interceptor or relief-type drainage systems should be considered to control uplift pressures.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared for specific field sites in accordance with this standard and shall describe the requirements for applying the practice to achieve its intended uses.

As a minimum, the plans and specifications shall provide the following:

1. Layout of the containment structure, collection points, waste transfer locations or pipelines, and topography of the site
2. Required liner properties, cushion materials, and pipeline materials
3. Subgrade details, including tolerances on smoothness of the finished grade
4. Details of liner installation, seaming requirements, and requirements for attachments and appurtenances
5. Quality control testing
6. Fence and signage requirements, if required.
7. *Area of lining*
8. *Thickness of cover*
9. *Anchoring trench dimensions and details*

OPERATION AND MAINTENANCE

The Pacific Islands Area Operation and Maintenance (O&M) Plan for the liner and structure shall be *reviewed and discussed with the client*. The plan shall be consistent with the purposes of the type of liner chosen, intended life, safety requirements and design criteria. The plan shall contain requirements including but not limited to:

1. Design capacity and liquid level of the structure.
2. A description of the normal operation, safety concerns and maintenance requirements.

3. Repair procedures.
4. Periodic inspection of the following:

   - Visible portions of the liner for tears punctures, or other damage;

   - Liner interface with inlets, outlets, ramps, or other appurtenances for damage;

   - Liquid level in the structure;

   - Ballooning of the liner indicating presence of gas beneath the liner.

REFERENCES

Quality Assurance and Quality Control for Waste Containment Facilities, EPA/1600/R-93/182, September 1993.

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

CONSERVATION PRACTICE STANDARD

NUTRIENT MANAGEMENT

(Ac.)

CODE 590

DEFINITION

Managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments.

PURPOSE

- To budget, supply, and conserve nutrients for plant production.
- To minimize agricultural nonpoint source pollution of surface and groundwater resources.
- To properly utilize manure or organic by-products as a plant nutrient source.
- To protect air quality by reducing odors, nitrogen emissions (ammonia, oxides of nitrogen), and the formation of atmospheric particulates.
- To maintain or improve the physical, chemical, and biological condition of soil.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all lands where plant nutrients and soil amendments are applied. This standard does not apply to one-time nutrient applications to establish perennial crops.

CRITERIA

General Criteria Applicable to All Purposes

A nutrient budget for nitrogen, phosphorus, and potassium must be developed that considers all potential sources of nutrients including, but not limited to, green manures, legumes, crop residues, compost, animal manure, organic by-products, biosolids, waste water, organic matter, soil biological activity, commercial fertilizer, and irrigation water.

Enhanced efficiency fertilizers, used in the State must be defined by the Association of American Plant Food Control Officials (AAPFCO) and be accepted for use by the State fertilizer control official, or similar authority, with responsibility for verification of product guarantees, ingredients (by AAPFCO definition) and label claims.

To avoid salt damage, the rate and placement of applied nitrogen and potassium in starter fertilizer must be consistent with land-grant university guidelines, or industry practice recognized by the land-grant university.

For nutrient risk assessment policy and procedures see Title 190, General Manual (GM), Part 402, Nutrient Management, and Title 190, National Instruction (NI), Part 302, Nutrient Management Policy Implementation.

The following risk assessments will be completed on all Nutrient Management Plans:

1) Erosion Rates
2) Nitrogen Leaching Index
3) Phosphorus Index

The Nitrogen Leaching Index is located in Table 1. Use the guidance in the bottom of the table to plan mitigation to address leaching concerns. Planner can increase the index risk hazard based on field observations.

Table 1. Nitrogen Leaching Index

Annual Rainfall	Soil Hydrologic Group			
	A	**B**	**C**	**D**
>100”	H	H	M	M
50-100”	H	M	M	L
<50”	M	M	L	L

Low – No additional mitigation required
Mod – Timing of nitrogen applications must be applied to coincide with crop growing season
High – Timing of nitrogen applications must coincide with crop growing season and be split applied to prevent leaching

The NRCS-approved nutrient risk assessment for phosphorus must be completed on all fields. The Phosphorous Index in located in Appendix C. There is also an automated version in the Pacific Islands Area 590 jobsheet. Once soil test phosphorus exceeds 300 ppm or 600 lbs/ac no more phosphorus applications can be planned unless the land grant university is still making a recommendation for additional phosphorus.

Table 2. Phosphorus Index Interpretation

Risk Assessment	Phosphorus Index Value
Low	<30
Mod	30-90
High	>90

Low - phosphorus can be applied at rates greater than crop requirement not to exceed the nitrogen requirement for the succeeding crop if manure or other organic materials are used to supply nutrients

Mod - phosphorus can be applied not to exceed the crop requirement rate

High - phosphorus can be applied not to exceed the crop removal rate if the following requirements are met: A soil phosphorus drawdown strategy has been implemented, and a site assessment for nutrients and soil loss has been conducted to determine if mitigation practices are required to protect water quality. Any deviation from these high risk requirements must have the approval of the Chief of the NRCS.

Planners must use the current NRCS-approved soil erosion risk assessment tools to assess the risk of soil loss. Identified resource concerns must be addressed to meet current planning criteria (quality criteria).

On organic operations, the nutrient sources and management must be consistent with the USDA’s National Organic Program.

Areas contained within minimum application setbacks (e.g., sinkholes, wellheads, gullies, ditches, or surface inlets) must receive nutrients consistent with the setback restrictions.

Applications of irrigation water must minimize the risk of nutrient loss to surface and groundwater.

Soil pH must be maintained in a range that enhances an adequate level for crop nutrient availability and utilization. Refer to State land-grant university documentation for guidance.

Soil, Manure, and Tissue Sampling and Laboratory Analyses (Testing).

Nutrient planning must be based on current land-grant university soil test analysis and recommendations. Manure and (where used as supplemental information) tissue test results shall be developed in accordance with land-grant university guidance, or industry practice, if recognized by the university.

Current soil tests are those that are no older than 3 years, but may be taken on an interval recommended by the land-grant university or as required by State code. The area represented by a soil test must be that acreage recommended by the land-grant university.

Where a conservation management unit (CMU) is used as the basis for a sampling unit, all acreage in the CMU must have similar soil type, cropping history, and management practice treatment.

The soil and tissue tests must include analyses pertinent to monitoring or amending the annual nutrient budget, e.g., pH, electrical conductivity (EC) and sodicity where salts are a concern, soil organic matter, phosphorus, potassium, or other nutrients and test for nitrogen where applicable. Follow land-grant university guidelines regarding required analyses.

Soil test analyses must be performed by laboratories successfully meeting the requirements and performance standards of the North American Proficiency Testing Program-

Performance Assessment Program (NAPT-PAP) under the auspices of the Soil Science Society of America (SSSA) and NRCS, or other NRCS-approved program that considers laboratory performance and proficiency to assure accuracy of soil test results. Alternate proficiency testing programs must have solid stakeholder (e.g., water quality control entity, NRCS State staff, growers, and others) support and be regional in scope.

Nutrient values of manure, organic by-products and biosolids must be determined prior to land application.

Manure analyses must include, at minimum, total nitrogen (N), ammonium N, total phosphorus (P) or P_2O_5, total potassium (K) or K_2O, and percent solids, or follow land-grant university guidance regarding required analyses.

Manure, organic by-products, and biosolids samples must be collected and analyzed at least annually, or more frequently if needed to account for operational changes (feed management, animal type, manure handling strategy, etc.) impacting manure nutrient concentrations. If no operational changes occur, less frequent manure testing is allowable where operations can document a stable level of nutrient concentrations for the preceding three consecutive years, unless federal, State, or local regulations require more frequent testing.

Samples must be collected, prepared, stored, and shipped, following land-grant university guidance or industry practice.

When planning for new or modified livestock operations, acceptable “book values” recognized by the NRCS (e.g., NRCS Agricultural Waste Management Field Handbook) and the land-grant university, or analyses from similar operations in the geographical area, may be used if they accurately estimate nutrient output from the proposed operation.

Manure testing analyses must be performed by laboratories successfully meeting the requirements and performance standards of the Manure Testing Laboratory Certification program (MTLCP) under the auspices of the Minnesota Department of Agriculture, or other NRCS-approved program that considers laboratory performance and proficiency to assure accurate manure test results.

Nutrient Application Rates.

Planned commercial fertilizer nutrient application rates for nitrogen, phosphorus, and potassium must not exceed land-grant university guidelines or industry practice when recognized by the university.

At a minimum, determination of rate must be based on crop/cropping sequence, current soil test results, realistic yield goals, and NRCS-approved nutrient risk assessments.

If the land-grant university does not provide specific guidance that meets these criteria, application rates must be based on plans that consider realistic yield goals and associated plant nutrient uptake rates.

Realistic yield goals must be established based on historical yield data, soil productivity information, climatic conditions, nutrient test results, level of management, and local research results considering comparable production conditions.

Estimates of yield response must consider factors such as poor soil quality, drainage, pH, salinity, etc., prior to assuming that nitrogen and/or phosphorus are deficient.

For new crops or varieties, industry-demonstrated yield, and nutrient utilization information may be used until land-grant university information is available.

Lower-than-recommended nutrient application rates are permissible if the grower’s objectives are met.

Applications of biosolids, starter fertilizers, or pop-up fertilizers must be accounted for in the nutrient budget.

Nutrient Sources.

Nutrient sources utilized must be compatible with the application timing, tillage and planting system, soil properties, crop, crop rotation, soil organic content, and local climate to minimize risk to the environment.

Nutrient Application Timing and Placement.

Timing and placement of all nutrients must correspond as closely as practical with plant nutrient uptake (utilization by crops), and consider nutrient source, cropping system limitations, soil properties, weather conditions, drainage system, soil biology, and nutrient risk assessment results.

Nutrients must not be surface-applied if nutrient losses offsite are likely. This precludes spreading on:

- fields when the top 2 inches of soil are saturated from rainfall.

Additional Criteria to Minimize Agricultural Nonpoint Source Pollution of Surface and Groundwater

When there is a high risk of transport of nutrients, conservation practices must be coordinated to avoid, control, or trap manure and nutrients before they can leave the field by surface or subsurface drainage (e.g., taro loi fields). The number of applications and the application rates must also be considered to limit the transport of nutrients to discharged irrigation water. Nutrients must be applied with the right placement, in the right amount, at the right time, and from the right source to minimize nutrient losses to surface and groundwater. The following nutrient use efficiency strategies or technologies must be considered:

- slow and controlled release fertilizers
- nitrification and urease inhibitors
- enhanced efficiency fertilizers
- incorporation or injection
- timing and number of applications
- soil nitrate and organic N testing
- coordinate nutrient applications with optimum crop nutrient uptake
- Corn Stalk Nitrate Test (CSNT), Pre-Sidedress Nitrate Test (PSNT), and Pre-Plant Soil Nitrate Test (PPSN)
- tissue testing, chlorophyll meters, and spectral analysis technologies
- other land-grant university recommended technologies that improve nutrient use efficiency and minimize surface or groundwater resource concerns.

Additional Criteria Applicable to Properly Utilize Manure or Organic By-Products as a Plant Nutrient Source

When manures are applied, and soil salinity is a concern, salt concentrations must be monitored to prevent potential crop damage and/or reduced soil quality.

The total single application of liquid manure:

- must not exceed the soil's infiltration or water holding capacity
- be based on crop rooting depth
- must be adjusted to avoid runoff or loss to subsurface tile drains.

Crop production activities and nutrient use efficiency technologies must be coordinated to take advantage of mineralized plant-available nitrogen to minimize the potential for nitrogen losses due to denitrification or ammonia volatilization.

Manure or organic by-products may be applied on legumes at rates equal to the estimated removal of nitrogen in harvested plant biomass, not to exceed land grant university recommendations.

Manure may be applied at a rate equal to the recommended phosphorus application, or estimated phosphorus removal in harvested plant biomass for the crop rotation, or multiple years in the crop sequence at one time. When such applications are made, the application rate must not exceed the acceptable phosphorus risk assessment criteria, must not exceed the recommended nitrogen application rate during the year of application or harvest cycle, and no additional phosphorus must be applied in the current year and any additional years for which the single application of phosphorus is supplying nutrients.

Additional Criteria to Protect Air Quality by Reducing Odors, Nitrogen Emissions and the Formation of Atmospheric Particulates

To address air quality concerns caused by odor, nitrogen, sulfur, and/or particulate emissions; the source, timing, amount, and placement of nutrients must be adjusted to minimize the negative impact of these emissions on the environment and human health. One or more of the following may be used:

- slow or controlled release fertilizers
- nitrification inhibitors
- urease inhibitors
- nutrient enhancement technologies
- incorporation
- injection
- stabilized nitrogen fertilizers

- residue and tillage management
- no-till or strip-till
- other technologies that minimize the impact of these emissions

Do not apply poultry litter, manure, or organic by-products of similar dryness/density when there is a high probability that wind will blow the material offsite.

Additional Criteria to Improve or Maintain the Physical, Chemical, and Biological Condition of the Soil to Enhance Soil Quality for Crop Production and Environmental Protection

Time the application of nutrients to avoid periods when field activities will result in soil compaction.

In areas where salinity is a concern, select nutrient sources that minimize the buildup of soil salts.

Inoculate the soil with appropriate Rhizobia bacterial when legumes are not forming adequate nodules for nitrogen fixation or other beneficial microbes for improved nutrient cycling.

There must also be a positive trend to the Soil Condition Index score

CONSIDERATIONS

Elevated soil test phosphorus levels are detrimental to soil biota. Soil test phosphorus levels should not exceed State-approved soil test thresholds established to protect the environment.

Use no-till/strip-till in combination with cover crops to sequester nutrients, increase soil organic matter, increase aggregate stability, reduce compaction, improve infiltration, and enhance soil biological activity to improve nutrient use efficiency.

Use nutrient management strategies such as cover crops, crop rotations, and crop rotations with perennials to improve nutrient cycling and reduce energy inputs.

Use variable-rate nitrogen application based on expected crop yields, soil variability, soil nitrate or organic N supply levels, or chlorophyll concentration.

Use variable-rate nitrogen, phosphorus, and potassium application rates based on site-specific variability in crop yield, soil characteristics, soil test values, and other soil productivity factors.

Develop site-specific yield maps using a yield monitoring system. Use the data to further diagnose low- and high- yield areas, or zones, and make the necessary management changes. See Title 190, Agronomy Technical Note (TN) 190.AGR 3, Precision Nutrient Management Planning.

Use manure management conservation practices to manage manure nutrients to limit losses prior to nutrient utilization.

Apply manure at a rate that will result in an "improving" Soil Conditioning Index (SCI) without exceeding acceptable risk of nitrogen or phosphorus loss.

Use legume crops and cover crops to provide nitrogen through biological fixation and nutrient recycling.

Modify animal feed diets to reduce the nutrient content of manure following guidance contained in Conservation Practice Standard (CPS) Code 592, Feed Management.

Soil test information should be no older than 1 year when developing new plans.

Excessive levels of some nutrients can cause induced deficiencies of other nutrients, e.g., high soil test phosphorus levels can result in zinc deficiency in corn.

Use soil tests, plant tissue analyses, and field observations to check for secondary plant nutrient deficiencies or toxicity that may impact plant growth or availability of the primary nutrients.

Use the adaptive nutrient management learning process to improve nutrient use efficiency on farms as outlined in the NRCS' National Nutrient Policy in GM 190, Part 402, Nutrient Management.

Potassium should not be applied in situations where an excess (greater than soil test potassium recommendation) causes nutrient imbalances in crops or forages.

Workers should be protected from and avoid unnecessary contact with plant nutrient sources. Extra caution must be taken when handling anhydrous ammonia or when dealing with organic wastes stored in unventilated enclosures.

Material generated from cleaning nutrient application equipment should be utilized in an environmentally safe manner. Excess material should be collected and stored or field applied in an appropriate manner.

Nutrient containers should be recycled in compliance with State and local guidelines or regulations.

Considerations to Minimize Agricultural Nonpoint Source Pollution of Surface and Groundwater.

Use conservation practices that slow runoff, reduce erosion, and increase infiltration, e.g., filter strip, contour farming, or contour buffer strips. These practices can also reduce the loss of nitrates or soluble phosphorus.

Use application methods and timing strategies that reduce the risk of nutrient transport by ground and surface waters, such as:

- split applications of nitrogen to deliver nutrients during periods of maximum crop utilization,
- banded applications of nitrogen and/or phosphorus to improve nutrient availability,
- drainage water management to reduce nutrient discharge through drainage systems, and
- incorporation of surface-applied manures or organic by-products if precipitation capable of producing runoff or erosion is forecast within the time of planned application.

Use the agricultural chemical storage facility conservation practice to protect air, soil, and water quality.

Use bioreactors and multistage drainage strategies when approved by the land-grant university.

Considerations to Protect Air Quality by Reducing Nitrogen and/or Particulate Emissions to the Atmosphere.

Avoid applying manure and other by-products upwind of inhabited areas.

Use high-efficiency irrigation technologies (e.g., reduced-pressure drop nozzles for center pivots) to reduce the potential for nutrient losses.

PLANS AND SPECIFICATIONS

The following components must be included in the nutrient management plan using the Pacific Islands Area jobsheet for this practice:

- aerial site photograph(s)/imagery or site map(s), and a soil survey map of the site,
- soil information including: soil type surface texture, pH, drainage class, permeability, available water capacity, depth to water table, restrictive features, and flooding and/or ponding frequency, (Print the Map Unit Description from Soil Data Mart for this information)
- location of designated sensitive areas and the associated nutrient application restrictions and setbacks,
- for manure applications, location of nearby residences, or other locations where humans may be present on a regular basis, and any identified meteorological (e.g., prevailing winds at different times of the year), or topographical influences that may affect the transport of odors to those locations,
- results of approved risk assessment tools for nitrogen, phosphorus, and erosion losses,
- documentation establishing that the application site presents low risk for phosphorus transport to local water when phosphorus is applied in excess of crop requirement.
- current and/or planned plant production sequence or crop rotation,
- soil, water, compost, manure, organic by-product, and plant tissue sample analyses applicable to the plan,
- when soil phosphorus levels are increasing, include a discussion of the risk associated with phosphorus accumulation and a proposed phosphorus draw-down strategy,
- realistic yield goals for the crops,
- complete nutrient budget for nitrogen, phosphorus, and potassium for the plant production sequence or crop rotation,
- listing and quantification of all nutrient sources and form,
- all enhanced efficiency fertilizer products that are planned for use,

- in accordance with the nitrogen and phosphorus risk assessment tool(s), specify the recommended nutrient application source, timing, amount (except for precision/variable rate applications specify method used to determine rate), and placement of plant nutrients for each field or management unit, and
- guidance for implementation, operation and maintenance, and recordkeeping.

In addition, the following components must be included in a precision/variable rate nutrient management plan:

- Document the geo-referenced field boundary and data collected that was processed and analyzed as a GIS layer or layers to generate nutrient or soil amendment recommendations.
- Document the nutrient recommendation guidance and recommendation equations used to convert the GIS base data layer or layers to a nutrient source material recommendation GIS layer or layers.
- Document if a variable rate nutrient or soil amendment application was made.
- Provide application records per management zone or as applied map within individual field boundaries (or electronic records) documenting source, timing, method, and rate of all applications that resulted from use of the precision agriculture process for nutrient or soil amendment applications.
- Maintain the electronic records of the GIS data layers and nutrient applications for at least 5 years.

If increases in soil phosphorus levels are expected (i.e., when N-based rates are used), the nutrient management plan must document:

- the soil phosphorus levels at which it is desirable to convert to phosphorus based planning,
- the potential plan for soil test phosphorus drawdown from the production and harvesting of crops, and
- management activities or techniques used to reduce the potential for phosphorus transport and loss,
- for AFOs, a quantification of manure produced in excess of crop nutrient requirements, and
- a long-term strategy and proposed implementation timeline for reducing soil P to levels that protect water quality,

OPERATION AND MAINTENANCE

Conduct periodic plan reviews to determine if adjustments or modifications to the plan are needed. At a minimum, plans must be reviewed and revised, as needed with each soil test cycle, changes in manure volume or analysis, crops, or crop management.

Fields receiving animal manures and/or biosolids must be monitored for the accumulation of heavy metals and phosphorus in accordance with land- grant university guidance and State law.

Significant changes in animal numbers, management, and feed management will necessitate additional manure analyses to establish a revised average nutrient content.

Calibrate application equipment to ensure accurate distribution of material at planned rates.

Document the nutrient application rate. When the applied rate differs from the planned rate, provide appropriate documentation for the change.

Records must be maintained for at least 5 years to document plan implementation and maintenance. As applicable, records include:

- soil, plant tissue, water, manure, and organic by-product analyses resulting in recommendations for nutrient application,
- quantities, analyses and sources of nutrients applied,
- dates, and method(s) of nutrient applications, source of nutrients, and rates of application,
- weather conditions and soil moisture at the time of application; lapsed time to manure incorporation; rainfall or irrigation event,

- crops planted, planting and harvest dates, yields, nutrient analyses of harvested biomass, and crop residues removed,
- dates of plan review, name of reviewer, and recommended changes resulting from the review, and
- all enhanced efficiency fertilizer products used.

Additional records for precision/variable rate sites must include:

- maps identifying the variable application source, timing, amount, and placement of all plant nutrients applied, and
- GPS-based yield maps for crops where yields can be digitally collected.

The Pacific Islands Area jobsheet for this practice shall be used to record the operation and maintenance of the practice on the treatment unit, and reviewed with the client.

REFERENCES

Association of American Plant Food Control Officials (AAPFCO). 2011. AAPFCO Official Publication no. 64. AAPFCO Inc., Little Rock, AR.

Follett, R.F. 2001. Nitrogen transformation and transport processes. *In* Nitrogen in the environment; sources, problems, and solutions, (eds.) R.F. Follett and J. Hatfield, pp. 17-44. Elsevier Science Publishers. The Netherlands. 520 pp.

Schepers, J.S., and W.R. Ruan, (eds.) 2008. Nitrogen in agricultural systems. Agron. Monogr. no. 49, American Society of Agronomy (ASA), Crop Science Society of America (CSSA), Soil Science Society of America (SSSA). Madison, WI.

Sims, J.T. (ed.) 2005. Phosphorus: Agriculture and the environment. Agron. Monogr. no. 46. ASA, CSSA, and SSSA, Madison, WI.

Stevenson, F.J. (ed.) 1982. Nitrogen in agricultural soils. Agron. Series 22. ASA, CSSA, and SSSA, Madison, WI.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2010. Agronomy Technical Note, (TN) 190-AGR-3, Precision Nutrient Management Planning. Washington, DC.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2011. Title 190, General Manual, (GM), Part 402, Nutrient Management. Washington, DC.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2011, Title 190, National Instruction (NI), Part 302, Nutrient Management Policy Implementation. Washington, DC.

Appendix A. Common Nutrient Management Conversions

To convert column 1 to column 2, multiply by	Column 1	Column 2	To convert column 2 to column 1, multiply by
1.20	K	K_2O	0.83
2.29	P	P_2O_5	0.44
0.891	kg/ha	lbs/ac	1.12
8.34	gallon water	lbs	0.12
325,851	ac foot water	gallons	0.000003068
43,560	lb/ft^2	lbs/ac	0.00002295

Appendix B. Helpful Nutrient Management Websites

NPK Crop Removal Rates
Soil Data Mart
Proper Soil Sampling Procedures
University of Hawaii Soil Testing Lab
University of Guam Soil Testing Lab

Appendix C: Phosphorus Index

Phosphorus Index Risk Assessment for PIA

Client Name

Tract Number

Phosphorus Index Factors	Factor Wt	Risk Factor 0	Risk Factor 2	Risk Factor 4	Risk Factor 6	Risk Factor 8	Risk Factor x Factor wt
Soil Test Data (ppm P) Cutoff for P applications is 300 ppm P, unless the LGU is still recommending P	5	0-25	26-50	51-100	101-200	201-300	
Water Erosion Rate (tons/ac/yr)	5	1 or less	2	3	4	5 or more	
Wind Erosion Rate (tons/ac/yr)	3	1 or less	2	3	4	5 or more	
P_2O_5 Application Rate	2	None	<Recommended	=Recommended	>Recommended		
Time between P application and incorporation (days)	2	<2	2-5	6-9	10-14	>14	
Frequency of flooding (years)	2	Very Rare	Rare	Occasional	Frequent	Very Frequent	
Surface Runoff Class	1	Very Low	Low	Medium	High	Very High	
Distance to Surface Water Drainage (edge of field - feet)	-1	<50	50-150	151-300	301-500	>500	
Sediment Trapping Measures (% of field addressed)	-1	0	1-25	26-50	51-75	>75	
Sediment Trapping Practices Meeting NRCS Standards (% of field addressed)	-3	0	1-25	26-50	51-75	>75	
						Index Sum	

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

STATEMENT OF WORK

NUTRIENT MANAGEMENT (590)

These deliverables apply to this individual practice. For other planned practice deliverables refer to those specific Statements of Work.

DESIGN

All design documents shall be developed in accordance with the requirements of the NRCS Pacific Islands Area Field Office Technical Guide (FOTG) Section IV, Conservation Practice Standard.

Deliverables:

1. Design documents that demonstrate criteria in NRCS practice standard have been met and are compatible with planned and applied practices.
    a. Practice purpose(s) as identified in the conservation plan.
    b. List of required permits to be obtained by the client.
    c. List all required and/or facilitating practices.
    d. Practice standard criteria-related computations and analyses to develop plans and specifications including but not limited to:
        i. Results of applicable sampling, analyses, and tests provided by the client (e.g soil and tissue).
        ii. Realistic yield goals for the crop(s) to receive nutrient applications.
        iii. Planned nutrient and soil amendment application rates, methods, and timing of application in balance with the nutrient budget.
        iv. Site risk assessments for erosion rates, nitrogen leaching index, and phosphorus index will be completed on all nutrient management plans.
        v. Other requirements applicable to manure or organic materials, non-point source pollution, soil condition, and air quality.
2. Written plans and specifications including sketches and drawings shall be provided to the client that adequately describes the requirements to install the practice and obtain necessary permits. Plans and specifications shall be developed in accordance with the conservation practice standard Nutrient Management (Code 590). The Pacific Islands Area Conservation Practice Jobsheet for this practice shall be used to provide the client with the requirements to install the practice on the treatment unit. The Jobsheet is available in Section IV of the Pacific Islands Area FOTG.
3. Operation and maintenance plan. The Pacific Islands Area Conservation Practice Jobsheet for this practice shall be used to provide the client with the requirements for the operation and maintenance of the practice on the treatment unit. The Jobsheet is available in Section IV of the Pacific Islands Area FOTG.
4. Certification that the design meets practice standard criteria and comply with applicable laws and regulations
5. Design modifications during application as required

INSTALLATION

Deliverables

1. Pre-application conference with client.
2. Verification that client has obtained required permits.
3. Location of and communication of setback requirements for wetlands, water bodies, streams, and other nutrient-sensitive areas.

4. Application guidance as needed.
5. Facilitate and implement required design modifications with client and original designer.
6. Advise client/NRCS on compliance issues with all federal, state, tribal, and local laws, regulations and NRCS policies during application.
7. Certification that the application process and materials meets design and permit requirements.

CHECK OUT

Deliverables

1. Records of application.
    a. Extent of practice units applied.
    b. Actual materials used.
2. Guidance for record keeping (implementation records maintained by the producer or agent)
    a. Records of crops produced, planting and harvest dates, yields, residue management.
    b. Records of recurring soil tests, and other tests (e.g. manure, plant tissue, water) used to implement the plan.
    c. Records of recommended nutrient application rates.
    d. Records of nutrient applications including quantities, analyses, and sources of nutrients applied; dates and methods of application.
    e. Records of recurring review of the plan including the dates or review, individual performing the review, and recommendations that resulted from the review.
3. Certification that the application meets NRCS standards and specifications and is in compliance with permits.
4. Progress reporting.

REFERENCES

- NRCS Pacific Islands Area Field Office Technical Guide (FOTG), Section IV, Pacific Islands Area Nutrient Management (590) – Conservation Practice Standard, and Conservation Practice Jobsheet.
- NRCS General Manual Title 450, Part 401.03 (Technical Guides, Policy and Responsibilities) and Title 190, Part 402 (Ecological Sciences, Nutrient Management, Policy)
- NRCS National Planning Procedures Handbook (NPPH) (CNMP Technical Guidance)
- NRCS National Agronomy Manual (NAM) Section 503
- NRCS National Engineering Handbook (NEH), Part 651 Agricultural Waste Management Field Handbook (AWMFH), Chapter 4 – Agricultural Waste Characteristics
- NRCS National Environmental Compliance Handbook
- NRCS Cultural Resources Procedures Handbook

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC ISLANDS AREA

CONSERVATION PRACTICE STANDARD

WASTE UTILIZATION

(Ac.)
CODE 633

DEFINITION

Using agricultural wastes such as manure and wastewater or other organic residues.

PURPOSE

- Protect water quality
- Protect air quality
- Provide fertility for crop, forage, fiber production and forest products
- Improve or maintain soil structure
- Provide feedstock for livestock
- Provide a source of energy

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where agricultural wastes including animal manure and contaminated water from livestock and poultry operations; solids and wastewater from municipal treatment plants; and agricultural processing residues are generated, and/or utilized.

CRITERIA

General Criteria Applicable to All Purposes

All federal, state and local laws, rules and regulations governing waste management, pollution abatement, health and safety shall be strictly adhered to. The owner or operator shall be responsible for securing all required permits or approvals related to waste utilization, and for operating and maintaining any components in accordance with applicable laws and regulations.

Use of agricultural wastes shall be based on at least one analysis of the material during the time it is to be used. In the case of daily spreading, the waste shall be sampled and analyzed at least once each year. As a minimum, the waste analysis should identify nutrient and specific ion concentrations. Where the metal content of municipal wastewater, sludge, septage and other agricultural waste is of a concern, the analysis shall also include determining the concentration of metals in the material.

When agricultural wastes are land applied, application rates shall be consistent with the requirements of the NRCS conservation practice standard for Nutrient Management (590).

Where manure is to be spread on land not owned or controlled by the producer, *record keeping*, as a minimum, shall document the amount of manure to be transferred, *the nutrient content of the manure, the date of transfer,* and who will be responsible for the environmentally acceptable use of the waste. *Minimum quantities to document are three cubic yards of wet solids and 5,000 gallons of liquid waste.*

Records of the use of wastes shall be kept a minimum of five years as discussed in OPERATION AND MAINTENANCE, below.

Additional Criteria to Protect Water Quality

All agricultural waste shall be utilized in a manner that minimizes the opportunity for contamination of surface and ground water supplies.

Agricultural waste shall not be land-applied on soils that are frequently flooded, as defined by the National Cooperative Soil

Survey, during the period when flooding is expected.

When liquid wastes are applied, the application rate shall not exceed the infiltration rate of the soil, and the amount of waste applied shall not exceed the moisture holding capacity of the soil profile at the time of application. Wastes shall not be applied to saturated soil if the potential risk for runoff exists. The basis for the decision to apply waste under these conditions shall be documented in the *comprehensive nutrient* management plan.

Additional Criteria to Protect Air Quality

Incorporate surface applications of solid forms of manure or other organic by-products into the soil within 24 hours of application to minimize emissions and to reduce odors**.**

When applying liquid forms of manure with irrigation equipment select application conditions where there is high humidity, little/no wind blowing, a forthcoming rainfall event and/or other conditions that will minimize volatilization losses into the atmosphere. The basis for applying manure under these conditions shall be documented in the nutrient management plan.

Handle and apply poultry litter or other dry types of animal manure or other organic by-products when weather conditions are calm and there is less potential for blowing and emission of particulates in the atmosphere. The basis for applying manure under these conditions shall be documented in the nutrient management plan.

When sub-surface applied using an injection system, waste shall be placed at a depth and applied at a rate that minimizes leaks onto the soil surface, while minimizing disturbance to the soil surface and plant community.

All materials shall be handled in a manner to minimize the generation of particulate matter, odors and greenhouse gases.

Additional Criteria for Providing Fertility for Crop, Forage and Fiber Production and Forest Products

Where agricultural wastes are utilized to provide fertility for crop, forage, fiber production and forest products, the practice standard Nutrient Management (590) shall be followed.

Where municipal wastewater and solids are applied to agricultural lands as a nutrient source, the single application or lifetime limits of heavy metals shall not be exceeded. The concentration of salts shall not exceed the level that will impair seed germination or plant growth.

Additional Criteria for Improving or Maintaining Soil Structure

Wastes shall be applied at rates not to exceed the crop nutrient requirements or salt concentrations as stated above.

Residue management practices shall be used for maintenance of soil structure.

Additional Criteria for Providing Feedstock for Livestock

Agricultural wastes to be used for feedstock shall be handled in a manner to minimize contamination and preserve its feed value. Chicken litter stored for this purpose shall be covered. A qualified animal nutritionist shall develop rations that utilize wastes.

Additional Criteria for Providing a Source of Energy

Use of agricultural waste for energy production shall be an integral part of the overall waste management system.

All energy producing components of the system shall be included in the waste management plan and provisions for utilization of residues of energy production identified.

Where the residues of energy production are to be land-applied for crop nutrient use or soil conditioning, the criteria listed above shall apply.

CONSIDERATIONS

The effect of Waste Utilization on the water budget should be considered, particularly where a shallow ground water table is present or in areas prone to runoff. Limit waste application to the volume of liquid that can be stored in the root zone.

Agricultural wastes contain pathogens and other disease-causing organisms. Wastes should be utilized in a manner that minimizes their disease potential.

Priority areas for land application of wastes should be on gentle slopes located as far as possible from waterways. When wastes are applied on more sloping land or land adjacent to waterways, other conservation practices should be installed to reduce the potential for offsite transport of waste.

It is preferable to apply wastes on pastures and hayland soon after cutting or grazing before re-growth has occurred.

Minimize environmental impact of land-applied waste by limiting the quantity of waste applied to the rates determined using the practice standard Nutrient Management (590) for all waste utilization.

Consider the net effect of waste utilization on greenhouse gas emissions and carbon sequestration.

PLANS AND SPECIFICATIONS

Plans and specifications for Waste Utilization shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The *comprehensive nutrient management plan* is to account for the utilization or other disposal of all animal wastes produced, and all waste application areas shall be clearly indicated on a plan map.

OPERATION AND MAINTENANCE

Records shall be kept for a period of five years or longer, and include when appropriate:

- Quantity of manure and other agricultural waste produced and their nutrient content.
- Soil test results.
- Dates and amounts of waste application where land applied, and the dates and amounts of waste removed from the system due to feeding, energy production or export from the operation.
- Describe climatic conditions during waste application such as: time of day, temperature, humidity, wind speed, wind direction and other factors as necessary.
- Waste application methods.
- Crops grown and yields (both yield goals and measured yield).
- Other tests, such as determining the nutrient content of the harvested product.
- Calibration of application equipment.

The operation and maintenance plan shall include the dates of periodic inspections and maintenance of equipment and facilities used in waste utilization. The plan should include what is to be inspected or maintained, and a general time frame for making necessary repairs.