G. Operation and Maintenance

1. Reviews and Plan Modifications

- Dates of Review, including person performing the review and recommendations that resulted from the review
- Suggested modifications
- A revision may be necessary because of a change in objectives, size of the unit, livestock numbers, economics, weather conditions, etc.
- Based on the results of implementation, there also may be a need to look at additional alternatives if the results of plan implementation are not solving the identified problems or meeting the landowner's/operator's objectives.

2. Operation and Maintenance Procedures

- List of maintenance items to be done periodically to maintain system.

G. OPERATION AND MAINTENANCE - Cottonwood Springs Dairy

1. Manure and Wastewater Handling Summary

Follow safety and emergency action plan and operation and maintenance included in individual practice jobsheets in this CNMP, in addition to the following general items.

a. Manure

Manure produced at the dairy will be removed from the pens at least twice annually (more frequently if dust is a problem) and either applied onsite or hauled offsite by a custom manure hauler. Records of manure removal will be maintained in the CNMP. Manure will be sampled annually to determine the nutrient content of the material. This information will remain on-site and be provided to the manure hauler to determine appropriate application rates for off-site fields. Solids will be removed from milkhouse trap area and handled in a similar manner.

Sludge will be removed from the retention pond when the volume of sludge reduces the 60-day storage volume in the retention pond. Sludge that is removed will be stockpiled until it can be utilized in one of the ways described above. Rainfall runoff associated with the manure stockpile will be contained.

b. Wastewater

The wastewater storage system at the dairy will consist of the utilization of a pond. A permanent marker will be installed with a mark identifying the required 25-year, 24-hour storm volume in the pond. The level of the pond should be recorded on a weekly basis, after each precipitation event and before and after pumping occurs.

The wastewater disposal system consists of a combination of evaporation and irrigation. Wastewater is allowed to evaporate within the pond or pumped for land application according to the Nutrient Management Jobsheet. Annual wastewater and soil sampling will be used to determine the appropriate application rates for each field for the crops grown. Records will include the date of application, amount of wastewater applied, soil nutrient data, and wastewater nutrient data from annual sampling. Wastewater will not be land applied when the ground is frozen or saturated.

Inspections and maintenance are required to obtain intended function of the waste storage facility. Items to inspect and maintain during the 20-year design life of the waste storage facility are:

- Do not dispose of dead animals, greases, syringes, or other wastes in the facility.
- A thorough inspection of clay or geosynthetic liners, and concrete sumps, pits, walls, ramps and floors for separations and/or cracks, which would indicate potential failure. This should be done each time the pond is emptied. Repairs should be made immediately.
- Inspect haul roads and approaches to and from the waste storage facility frequently to determine the need for stone or other stabilizing materials. Repair roads as needed.
- All pipes, pumps, valves, gates, should be inspected a minimum of twice a year. Inspect for functional and structural soundness. Repair as needed.
- Mow the embankments twice a year. Good vegetative cover should be maintained on earth embankments. If the vegetative cover is damaged, embankments should be revegetated as soon as possible. Banks should be planted and mulched as soon as the pond is complete. Weeds should be controlled.
- Check frequently for burrowing animals. When found, remove the burrowing animals, replace embankment materials and reseed.
- The livestock facility, including the embankments, should be fenced. All fences and gates should be inspected at least twice a year. Damaged fences and gates should be repaired or replaced.
- Maintain appropriate warning signs.
- Safety stations should be inspected at least twice a year. Safety items should be replaced as necessary.
- Immediately repair any vandalism, vehicular or livestock damage to any earthfills, spillways, outlets or other appurtenances.
- Immediately remove any foreign debris in or adjacent to the waste storage facility.

2. Land Application of Wastewater

a. The discharge or drainage of irrigated wastewater is prohibited where it will result in an unauthorized discharge of pollutants into or adjacent to waters in the state.

b. When irrigation of wastewater occurs, application rates shall not exceed the recommended fertilizer rate of the crop planned. Land application rates of wastewaters will be based on the available nitrogen content; however, where local water quality is threatened by phosphorus, the producer shall limit the application rate to the recommended rates based on the Phosphorus Index and Nutrient Management Jobsheet.

c. Wastewater shall not be irrigated when the ground is frozen or saturated or during rainfall events.

d. Irrigation practices shall be managed so as to reduce or minimize ponding or puddling of wastewater on the site, pollution of waters in the state, and prevent the occurrence of nuisance conditions.

e. **If a CAFO surface water discharge permit is in place,** It shall be considered "Proper Operation and Maintenance" for a facility which has been properly operated, and that is in danger of imminent overflow due to catastrophic rainfall, to discharge wastewaters to land application sites for filtering prior to discharging to waters in the state. Only that portion of the total retention facility wastewater volume necessary to prevent overflow due to catastrophic rainfall shall be land applied for filtering prior to discharging to waters in the state. Any such discharges shall be documented.

f. Facilities including ponds, pipes, ditches, pumps, diversion and irrigation equipment shall be maintained to ensure ability to fully function as represented in the plan. Pipelines are inspected daily and the ditches, drains, sump, storage facility, separator, meters, and berms are inspected weekly.

g. Adequate equipment and/or land application area shall be available for removal of wastewater as required to maintain the retention capacity of the facility.

3. Pond Solids Removal and Handling

a. Solids shall be removed when encroaching on the volume reserved for the 25-year, 24-hour storm event and the 60 day storage volume. At no time shall emissions from cleaning activities create a nuisance.

b. Storage and land application of pond solids shall not cause a discharge of pollutants to waters in the state, cause a water quality violation in waters in the state or cause a nuisance condition. At all times, sufficient volume shall maintained within the control facility to accommodate manure, other solids, wastewaters and contaminated storm waters (rain water runoff) from the concentrated animal feeding areas.

4. Manure Handling and Land Application

a. At all times, sufficient volume will be maintained within the control facility to accommodate manure, other solids, wastewaters and contaminated storm waters from the concentrated animal feeding areas.

b. Storage and/or surface disposal of manure in the 100-year flood plain, near water courses or recharge zone/feature is prohibited unless protected by adequate berms or other structures; berms or other structures must be certified by a licensed professional engineer to be adequate and properly constructed.

c. When manure is stockpiled, it will be stored in a well-drained area with no ponding of water, and the top and sides of stockpiles will be adequately sloped to ensure proper drainage. Stockpiles should be located away from watercourses, above the 100-year flood plain, at least 150 feet downstream of wells. Runoff from manure storage pile must be retained on-site.

d. Manure will not be applied to land when the ground is frozen or saturated, or during rainfall events. Do not apply to land within 150 ft. of surface water or wells.

e. Manure will be applied to suitable land at appropriate times and rates according to the nutrient management plan. Discharge (run-off) from the application site is prohibited. Timing and rate of applications will be in response to crop needs, assuming usual nutrient losses, and expected precipitation and soil conditions. Use management (e.g. handling, application method, tillage, irrigation regime, cropping pattern, grazing pattern) and site factors (soil texture, slope, aspect) to modify manure application rates.

f. No land application will cause or contribute to a violation of surface water quality standards, contaminate ground water or create a nuisance condition.

g. Earthen pens will be designed and maintained to ensure good drainage and to prevent ponding. As the herd grows in number, pen regrading will be done to insure that runoff flows toward the circle (cropland).

5. Erosion

a. Should water or wind erosion become a problem, fields shall be protected with conservation practices within the standards of the NRCS. The following methods will be used to control/prevent erosion of exposed soils at the dairy site:

- Seeding of exposed areas. Circle corners should have a cover crop of small grain or permanent grass planted.
- Reduced tillage (residue management) practices. See the Residue Mgt Jobsheet. It has the required amount of residue at seeding time of all crops in the rotation.
- Construction of terraces and berms. Runoff from the feeding area must be contained on the dairy property.
- Covering erosive areas with road surfacing materials
- Use of solid manure on exposed soil surfaces
- Maintenance of existing vegetation in areas between management units and off-site areas

6. Dust and Odor Control

a. Other resource concerns, such as fly control, odor, dust and other soil, water, animal, plant, air or human, must also be addressed in the CNMP as part of a Resource Management System. The NRCS Field Office Technical Guide, Section IV, Conservation Practices (http://www.nm.usda.gov), provides conservation practices for addressing all of these concerns. Several practices follow to address odor and dust concerns:

- Scrape pens frequently to remove manure.
- Use windbreaks to reduce dust and odor problems.
- Communicate with neighbors to ensure they understand the dairy operation and are not harboring complaints.

Review and Plan Modifications

Facility inspections must be conducted quarterly and annually by the facility operator or other authorized personnel. Every 5 years, a Licensed Professional Engineer must perform a facility inspection. Inspection checklists are provided in the recordkeeping section of the CNMP. Reports must be maintained in the CNMP for three years. Nutrient Management Plans must be reviewed at least annually to update yield, soil test, and wastewater analysis information. If either a facility inspection or review results in modifications to the CNMP, document the date and the specific changes made to the plan in the table below.

Date	Modification

H. Recordkeeping

- If a producer is to safely manage and assess his/her CNMP, it is critical he/she maintain a record of activities and the functionality of the system. A recordkeeping plan should be implemented that addresses key elements of the CNMP to aid in the proper application and provide for assessment documentation.
- Where the CNMP is part of a permitting or other regulatory program, it is the responsibility of the producer to maintain any required documentation, including plans and implementation records, and make them available to the regulatory organization, if required.
- Land application records – dates, methods, rates; observations on weather conditions during and immediately following nutrient application; crops planted, planting and harvesting dates, yields; nutrient application equipment calibration. (If CNMP, use 590 Jobsheet Records; if not CNMP, use LADS report – NMED-GWB)
- Soil test results, by field
- Manure and lagoon sampling results
- Procedures for sampling and testing records - soil, manure, water, plants
- Livestock information
- Off-site use of manure (Jobsheet 633)
- Available maps, sketches, and designs resulting from the planning process that will be useful to the producer in implementing the plan
- Environmental evaluations
- Monitoring well results
- Changes made in CNMP
- Records of maintenance performed associated with operation and maintenance plans

[redacted]

Schedule of Events

The following schedule of events is an example of typical recordkeeping to be kept by an animal feeding operation, depending on whether they have a CNMP, CAFO Permit and/or Groundwater Permit. The specific permit may require additional recordkeeping. This is an example and the producer is responsible for compliance with permit requirements. A CNMP for an animal feeding operation must include all recordkeeping requirements for the Groundwater and/or CAFO permit, depending on which permits the operation is required to have. If an operation has both permits, the most frequent recordkeeping must be carried out for the CNMP.

Schedule of Events

SCHEDULE	FREQUENCY	FORM	REQUIRED FOR
Precipitation	As-Needed	Precipitation Log	CAFO Permit
Wastewater Application	As-Needed	Nutrient Management Records Jobsheet/ LADS	CAFO Permit, Groundwater Permit, and CNMP
Manure and Chemical Fertilizer Application	As-Needed	Nutrient Management Records Jobsheet/ LADS/ Nutrient Application Equipment Calibration	CAFO Permit, Groundwater Permit, and CNMP
Off-site Manure Removal	As-Needed	Waste Utilization Jobsheet	CAFO Permit, Groundwater Permit, CNMP
Discharge Report	As-Needed	Discharge Report	CAFO Permit, Groundwater Permit
Spills	As-Needed	Spills Log	CNMP, CAFO Permit, Groundwater Permit
Log of Liner Disturbance	As-Needed	Liner Maintenance Log	CAFO Permit, Groundwater Permit, CNMP
Pond Water Levels	Weekly and As-Needed	Pond Water Levels Log	CAFO Permit, CNMP
Structural Controls Inspection	Quarterly, Weekly, Daily – CAFO Permit Monthly – Groundwater Permit	Inspection Report (Structural)	CAFO Permit, Groundwater Permit, CNMP

Soil Analysis	**Yearly or more frequently if required**	**Soil Sampling Form and Lab Report**	**CAFO Permit, Groundwater Permit, CNMP**
Manure Analysis	**Yearly or more frequently if required**	**Manure Analysis Form and Lab Report**	**CAFO Permit**
Wastewater Analysis	**Quarterly or as required**	**Wastewater Analysis Form and Lab Report**	**Groundwater Permit**
Nutrient Management Plan	**Annually**	**Nutrient Management 590 Jobsheet**	**CNMP, Groundwater Permit, CAFO Permit**
Preventative Maintenance	**As Needed**	**Preventative Maintenance Checklist (Non-Structural)**	**CNMP**
Site Inspection	**Yearly**	**Annual Inspection Form**	**CAFO Permit**
Status Review	**Yearly**	**Annual Status Review Form**	**CNMP**
Employee Training	**Yearly**	**Employee Training Log**	**CAFO Permit**
Mortalities Management	**As-Needed**	**Inventory Form for Planned Practices**	**CAFO Permit, NRCS**
Environmental Evaluations	**As-Needed**	**ENV-1 Form or equivalent**	**CNMP, CAFO Permit**
Feed Management	**As-Needed**	**Inventory Form for Planned Practices**	**CNMP**
Soils, Geologic Documentation	**When completed**	**Reports**	**CNMP, Groundwater Permit**
As-built Documentation	**When completed**	**Submit copies to NMED-GWQB and NRCS/Keep on-site**	**CNMP, Groundwater Permit**
Operation and Maintenance	**As-Needed**	**Operation and Maintenance Section of CNMP**	**CNMP**
Monitoring Well Analyses	**Quarterly or as required**	**Lab Reports**	**Groundwater Permit**

Precipitation Log

This log will be used to record all measurable precipitation events at the facility. A rain gauge shall be maintained in good working condition at all times.

Date	Amount	Date	Amount	Date	Amount	Date	Amount

Nutrient Application Equipment Calibration:

Calibrate application equipment to ensure uniform distribution and accurate application rates.

Commercial Fertilizer Application Equipment Calibration:
The nitrogen applicator, the commercial broadcast spreaders, and corn planter will be set per the manufacturers recommendations then filled with a known amount and checked over known acreage. Adjustments will be made to achieve the planned rates.

Manure Spreader Calibration
There are several methods that can be used to calibrate the application rate of a manure spreader. The two best methods are the load-area method and the plastic sheet method. It is desirable to repeat the calibration procedure 2 to 3 times and average the results to establish a more accurate calibration.

Before calibrating a manure spreader, the spreader settings such as splash plates should be adjusted so that the spread is uniform. Most spreaders tend to deposit more manure near the spreader than at the edge of the spread pattern. Overlapping can make the overall application more uniform. Calibration of application rates when overlapping requires measuring the width of two spreads and dividing by two to get the effective spread width.

Calibration should take place annually or whenever manure is being applied from a different source or consistency.

Load-Area Method
The load-area method is the most accurate and can be used for most types of manure handling. This method consists of determining the amount (volume or weight) of manure in a spreader and the total area over which it is applied. The most accurate method to determine the amount of manure in a spreader is to weigh the spreader when it is full of manure and again when it is empty (portable pad scales work well for this). The difference is the quantity of manure applied over the area covered. Spreader capacities listed by the manufacturers can be used to determine the amount of manure in the spreader. However care must be taken when using manufactures spreader capacities. Heaped loads, loading methods and manure type may vary considerably from what is listed by manufacturers of box and side delivery manure spreaders. Spreader capacities for liquid tankers are accurate provided the tanker is filled to the manufactures recommended levels, and no foam is present in the tank.

The area of spread is determined from measuring the length and width of the spread pattern. Measuring can be done with a measuring wheel, measuring tape or by pacing.

The application rate is calculated using the following formula:

$$\frac{\text{Spreader capacity (tons or gallons) X 43560 sq. ft/acre}}{\text{Distance traveled X Spreading width}} = \text{Application Rate tons or Gallons/Acre}$$

Plastic Sheet Method
The plastic sheet method can only be used with solid or semi-solid manure. This method of calibrating spreader application rates involves **1)** cutting a plastic sheet to the specified dimensions (56 inches X 56 inches), **2)** weighing the clean plastic sheet, **3)** laying out the plastic sheet on the ground and driving the manure spreader (applying manure at a recorded speed and spreader setting) over the sheet, **4)** weighing the plastic sheet with the manure on it, and **4)** determine the net weight of the manure on the sheet (weight of manure and sheet - weight of the clean sheet), and **5)** the net pounds of manure equals tons per acre applied.

When calibrating manure spreaders, all details regarding tractor speed and manure spreader settings and date(s) of each calibration should be recorded with manure application information, and directly on the equipment. Mark equipment to ensure a known application rate is applied each time the referenced tractor speed and spreader settings are used. Manure spreader settings can include such things as: fast and slow settings on some box spreaders, gate position on side delivery spreaders and splash plate position and fill levels on liquid tankers.

Irrigation System Calibration:
Place 3-5 buckets throughout the irrigation spray pattern and collect samples while operating the pump at a given rpm and pressure (for a traveling gun record the ground speed also). At the end of the planned sample period measure the amount of liquid collected in inches (average the samples). The following chart shows how many gallons per acre applied per inch applied.

Gallons applied per inch of liquid manure applied.

Inches Liquid Manure Applied via Irrigation	Gallons per Acre
.20	5,430
.30	8,146
.40	10,860
.50	13,577
.75	20,365
1.0	27,154
1.25	33,942
1.5	40,731

Soft Hose Injection System with Irrigation Hose:
Alternative 1. Use a flow meter mounted on the injector system and calculate the distance and width to determine amount applied over a measured area. Example the flow meter measures 1000 gallons over a distance of 600 feet and 10 feet wide.

Formula:

$$\frac{\text{Gallons Applied (1000 gal) X 43560 sq. ft/acre}}{\text{Distance traveled (600 ft) X Application width (10 ft)}} = \text{Application Rate (7260 gallons/acre)}$$

Alternative 2. (Requires a 10-20 gallon graduated measuring container)
Step 1) In the field, measure the flow out of one injector for 5 seconds into the graduated measuring container and record gallons, repeat three (3) times and average the results. **Step 2)** Multiply the average amount collected from one injector by the number of injectors (equals amount applied for the whole system for 5 seconds). **Step 3)** Multiply the results of Step 2 times

12 to get gallons per minute. **Step 4)** Place the injector in the soil at the planned depth and operating speed and record the distance traveled in 1 minute (average 3 different measurements). **Step 5)** Determine the effective application width (number of injectors X injector spacing in feet). **Step 6)** Multiply the effective width times the distance traveled in 1 minute (this gives the square feet covered in 1 minute). **Step 7)** Divide the result of Step 6 by 43,560 (this gives the acres covered in 1 minute). **Step 8)** Divide the results of Step 3 (gallons per minute) by the results of Step 7 (acres covered in 1 minute) - (this gives the gallons applied per acre. Example:

Step 1) Collected an average of 6 gallons from one injector for 5 seconds.
Step 2) Applicator has 8 injectors (8 injectors X 6 gallons per injector = 48 gallons for 5 seconds)
Step 3) 48 gallons in 5 seconds X 12 = 576 gallons/minute applied
Step 4) Average distance covered in 1 minute was 250 feet.
Step 5) Average width of the applicator is 12 feet.
Step 6) 12 feet wide X 250 feet long = 3000 square feet
Step 7) 3000 square feet divided by 43,560 square feet/acre = .0688 acres covered in 1 minute
Step 8) 576 gallons/minute divided by .0688 acres/minute = 8,372 gallons/acre.

Field No.	**Type of Equipment**	**Calibration Date**	**Name of Person Calibrating**	**Calibration Data and Units**	**Comments/Changes Made**

Discharge Report

The animal feeding operation will document the following information to these records and shall contact the NMED immediately:

Cause of discharge:

____
____
____
____

Flow path description to the body of water discharged into:

____
____
____

Volume and flow estimates of discharge:

____
____
____

Discharge Starting date: ________________________ **Time:**________________
Discharge Ending date: ________________________ **Time:**________________

Steps being taken to reduce, eliminate, and prevent future discharge:

____
____
____

Were samples taken? _______**Yes** ________**No**

If yes, where were the samples sent?

____

Attach chain of custody report and analysis

If the discharge is caused by precipitation, fill out the following:

Date	Time Started	Time Ending	Rainfall Measurement

Was NMED notified of the discharge? ______**Yes** _____**No**
Date written notification was sent to NMED: __________________________

Spills

List any significant spills of pollutants at the facility since date of operation:

Date	Item Spilled	Quantity Spilled	Clean-up Completed

Liner Maintenance

Where a liner is installed to prevent hydrologic connection, the operator must maintain the liner to inhibit infiltration of wastewaters to the underlying soils and groundwater. Liners shall be protected from animals by fences or other protective devices. No trees shall be allowed to grow within the potential distance of the root zone. Documentation of liner maintenance shall be kept in the CNMP.

Description of Disturbance:

____
____
____

Action Taken:

____
____
____

Inspector: __________________________________ **Date:**__________________

Description of Disturbance:

____
____
____

Action Taken:

____
____
____

Inspector: __________________________________ **Date:**__________________

- **If inspection confirms that the liner has mechanical or structural damage, the operator shall have a Professional Engineer evaluate the liner.**

Pond Water Levels

The water level of ponds shall be measured weekly and documented in these records. The water level of each pond should also be documented when a precipitation event occurs or when pumping wastewater to the application area.

Date	Water Level	Inspector		Date	Water Level	Inspector

Note: Routine operation volume must be maintained at _________ level.

Pond Type:

- ❑ **Effluent Only**
- ❑ **Storm water Only**
- ❑ **Effluent and Storm water**

Structural Controls Inspection

The form shall be filled out with the indicated frequency for your permit. A checklist is provided to allow the user to answer questions about the condition of each cell of the pond and to document preventative maintenance activities as necessary.

Date: ______________ Description (Name or Location):_____________________

Yes	No	N/A	
___	___	___	**Embankment of manure or wastewater impoundment free of visible seepage**
___	___	___	**Embankment of manure or wastewater impoundment showing no signs of cracking**
___	___	___	**Vegetation maintained on embankment following plan**
___	___	___	**Riprap or erosion controls in place (if required)**
___	___	___	**Erosion of exterior slope**
___	___	___	**Erosion of interior slope**
___	___	___	**Irrigation system functional**
___	___	___	**Livestock entry prohibited (fenced)**
___	___	___	**Minimum freeboard (2')**
___	___	___	**Trees excluded within root zone distance**
___	___	___	**Liquid level measuring device in place and functional**
___	___	___	**Rain gauge in place and functional**
___	___	___	**Irrigation system functional**
___	___	___	**Storm water diversion devices free of seepage, cracking**
___	___	___	**Runoff diversion structures free of seepage, cracking**
___	___	___	**Devices that channel storm water to an impoundment free of seepage, cracking**
___	___	___	**Water lines functional (including drinking or cooling water)**
___	___	___	**Other ________________________________**

Comments:

Signature: ______________________________ Title: ____________________

PREVENTATIVE MAINTENANCE CHECKLIST (NON-STRUCTURAL)

Maintenance Description				Maintenance Date/Comments
Motors/Engines of Dewatering Equipment	Yes	No	N/A	
Check oil level				
Change oil/lubricate bearings				
Electrical control panel enclosed and free from trash				
All components are free of rodent nests				
Operational				
Valves	Yes	No	N/A	
Operational				
Flow Line	Yes	No	N/A	
Operational				
Drain before freezing temperatures				
Back Flow Prevention Device	Yes	No	N/A	
Operational				
Center Pivot Sprinklers	Yes	No	N/A	
Check oil in wheel gearboxes				
Change oil in wheel gearboxes				
Grease/pack gearbox bearings				
Properly secure system for winter				
Properly drain system for winter				
Leaky joints and worn nozzles				
Operational				
Manure Application Equipment	Yes	No	N/A	
Operational				

Signature

Date

Soil Sampling

A soil sample will be collected and analyzed annually or as required from the application fields. Refer to this section for sampling and testing procedures. Make copy of blank log prior to use.

Date Sampled	Lab	Field	Sample Depth	Sampler

Place lab analysis and map showing fields and sampling location within fields behind this page.

Manure Analysis

A manure sample will be collected and analyzed annually or as required. Refer to this section for sampling and testing procedures. Make copy of blank log prior to use.

Date Sampled	Lab	Sample Location	Sampler

Place lab analysis behind this page.

Wastewater Analysis

A wastewater sample will be collected and analyzed quarterly or as required. Results from the soil, manure and wastewater samples will be used to determine the application rate of wastewater on the wastewater application areas. Refer to this section for sampling and testing procedures. Make copy of blank log prior to use.

Date Sampled	Lab	Sample Location	Sampler

Place lab analysis behind this page.

Annual Inspection

A complete inspection of the facility shall be done and a report documenting the findings of the inspection made at least once per year. The inspection shall be conducted by authorized persons, to verify that the description of potential pollutant sources is accurate; the site plan has been updated or otherwise modified to reflect current conditions; and the controls outlined in the plan to reduce pollutants and avoid nuisance conditions are being implemented and are adequate. Records documenting significant observations made during the site inspection shall be retained as part of the CAFO Permit Nutrient Management Plan for a period of three years.

Year_____________ ANNUAL INSPECTION CHECKLIST

Documentation has been inspected:

Inspection Description	Yes	No	N/A	Comments
Facility Maps				
Potential pollutant sources				
Spills of potential pollutant sources				
Retention facility inspection reports				
Weekly measurement of retention facility level				
Log of rainfall reports				
Log of liner maintenance reports				
Wastewater application rate calculations				
Manure and pond solids application rate calculation				
Manure removal documentation				
Preventive maintenance log				
Employee training documentation				
Discharge report forms				
Visual inspection forms				
Site inspection forms				

ANNUAL INSPECTION CHECKLIST (continued)

The following equipment and facility areas have been visually inspected:

Inspection Description	Yes	No	N/A	Comments
Potential pollutant sources are properly stored				
All significant spills of potential pollutant materials have been properly cleaned up				
Structural controls (dams, dikes, terraces)				
Non-structural controls (irrigation system, mechanical separator)				
Permanent marker in wastewater retention facility				
Rain gauge				
Manure application areas meet requirements				
Wastewater application areas meet requirements				
Employees are properly trained				
Discharge sampling equipment is available				
The description of potential pollutant sources is accurate				
Drainage map reflects current conditions				
Controls outlined to reduce pollutants are being implemented and are accurate				

____

Signature

____

Date

<u>Employee Training</u>

Employee training is conducted, check the appropriate category(ies). Some employees may not need any training and some employee may not need training in all of these categories, based on employee job responsibilities. Check all that apply.

Year____________________

Date	Employee	Land Application of Wastes	Proper Operation and Maintenance of Control Facilities	Good Housekeeping & Potential Pollutant Material Handling	Record Keeping Requirements	Spill Response and Clean Up

CNMP Annual Plan Review

1. **Have any changes been made in the number of livestock (more or less) that will affect the amount of manure and nutrients produced?**

2. **Is the manure/effluent storage sufficient to manage manure/effluent for land application?**

3. **Is water/runoff adequately controlled around the facilities to control runoff and keep excess water off feedlots and out of the manure?**

4. **Are records being kept of livestock numbers, average sizes, amount of manure produced, amount of manure applied on land, and/or the amount of manure transported off site, rainfall, and irrigation applied?**

5. **Has the manure been analyzed for nutrient content from each type of storage this year?**

6. **Are soil tests current (1 year old or less)?**

7. **Have fields been redefined or improved that may effect yield goals and nutrient applications?**

8. **Are the rotations and crops maintained as planned or do they need to be modified?**

9. **Have any changes occurred on neighboring properties that may require a change in the plan?**

10. **Is the present or planned method(s) of application appropriate or are changes needed?**

11. **Are records of fertilizer and manure applications maintained for each field and nutrients balanced per the plan and crop needs?**

12. **Has manure and fertilizer application equipment been calibrated?**

13. **Are Operation and Maintenance actions being carried out?**

14. **Are practice jobsheet actions being implemented?**

Name of Operation Reviewed: ______________________ **Reviewed by:** ____________________
Date Review Completed: ____________________

Cottonwood Springs Dairy

Darryl Bollema, *Partner*
Home (505) 365-2729
Mobile (505) 308-1008
Fax (505) 365-2473

491 West Funk Road
Lake Arthur, New Mexico 88253
(505) 365-2741

Phil Troost, *Partner*
Home (505) 365-2793
Mobile (505) 365-7605
Fax (505) 365-2794

FACSIMILE TRANSMISSION SHEET

REDDY

DATE 3-17-05

TO Jay

FAX # 983 6482

NUMBER OF SHEETS INCLUDING COVER SHEET 3

FROM Phil Troost

FAX #

PHONE #

REGARDING Soil Samples for Cottonwood Springs Dairy - Farm Land

Disregard Sample 7 & 8 They were taken for someone else

SOIL ANALYSIS REPORT

CLIENT:		LAB NO:	17946-17949
1290	AGRILIANCE 103 E MILL RD P O BOX 38 ARTESIA, NM 88210-0038	INVOICE NO:	D41926
		DATE RECEIVED:	12-21-04
		DATE REPORTED:	12-30-04

Servi-Tech Laboratories
1816 E. Wyatt Earp, PO Box 1397
Dodge City, KS 67801
Phone 620-227-7123
FAX 620-227-2047

SOIL ANALYSIS RESULTS FOR: CWS **FIELD IDENTIFICATION:** CWS

METHODS USED:

			1:1	SMP	1:1		Mod. W.B.	Cd Reduction		Bicarb	Ammonium Acetate						DTPA			
Lab Number	Sample ID	Sample Depth*	Soil pH	Buffer pH	Sol. Salts mmho/cm	Excess Lime	%Organic Matter	Nitrate-Nitrogen ppm	lb. N/A	Phosphorus ppm P	Potassium ppm K	Sulfur ppm	lb. S/A	Calcium ppm Ca	Magnesium ppm Mg	Sodium ppm Na	Zinc ppm Zn	Iron ppm Fe	Manganese ppm Mn	Copper ppm Cu
17946	6 WEST	0- 6	7.8		0.50	Hi	3.4	24	43	246	541	44	79	5185	459	27	7.9	8.3	9.8	2.5
17947	6 EAST	0- 6	7.8		0.67	Hi	2.3	49	88	143	588	46	83	5082	404	21	5.5	20.8	7.1	4.2
17948	8	0- 6	7.7		1.60	Hi	2.6	10	18	143	600	1641	2954	7062	374	32	6.4	9.8	5.5	20.2
17949	9	0- 6	7.7		1.51	Hi	3.0	13	23	169	599	758	1364	6304	405	27	3.7	6.8	6.8	3.3

FERTILIZER RECOMMENDATIONS: POUNDS ACTUAL NUTRIENT PER ACRE

Lab Number	Sample ID	Crop To Be Grown	Yield Goal	Lime, ECC Tons/A	Nitrogen N	Phosphorus P_2O_5	Potassium K_2O	Zinc Zn	Sulfur S	MgO	Cu	Mn
17946	6 WEST	ALFALFA - NEW	9 T		0		0	0	0	0	0	0
17947	6 EAST	WHEAT HAY	2 T		0	0	0	0	0	0	0	0
17948	8	CORN SILAGE	28 T		260	0	0	0	0	0	0	0
17949	9	WHEAT HAY	2 T		30	0	0	0	0	0	0	0

CATION EXCHANGE CAPACITY

CEC	%H	%K	%Ca	%Mg	%Na
31	0	4	83	12	0
30	0	5	84	11	0
40	0	4	80	8	0
37	0	4	86	9	0

SPECIAL COMMENTS AND SUGGESTIONS:

SAMPLE(S): 6 WEST, 6 EAST, 8, 9
CEC calculated by cation summation may overestimate true CEC and underestimate exchangeable sodium percentage (ESP) in soils containing excess lime.

SAMPLE(S): 6 WEST
FORAGE LEGUMES (alfalfa or clover), NEW SEEDING: Applying 15 to 20 lb. of nitrogen can aid in establishing legumes, if soil nitrate is low. Do not apply excess nitrogen or it may stimulate competition from grassy weeds.

SAMPLE(S): 6 EAST, 8, 9
Subsoil nitrate samples to 24 or 36 inches can improve the accuracy of nitrogen recommendations. Contact the laboratory for further details.

SAMPLE(S): 8, 9
WARNING: Soluble salts level indicates potential salinity problems. Please call if you wish us to run a soil salinity test or for additional information.

SOIL ANALYSIS REPORT

CLIENT:	
1290	AGRILIANCE 103 E MILL RD P O BOX 38 ARTESIA, NM 88210-0038

Servi-Tech Laboratories
1816 E. Wyatt Earp, PO Box 1397
Dodge City, KS 67801
Phone 620-227-7123
FAX 620-227-2047

LAB NO:	17942-17945
INVOICE NO:	D41926
DATE RECEIVED:	12-21-04
DATE REPORTED:	12-30-04

SOIL ANALYSIS RESULTS FOR: CWS **FIELD IDENTIFICATION:** CWS

METHODS USED:

Lab Number	Sample ID	Sample Depth"	Soil pH (1:1)	Buffer pH (SMP)	Sol. Salts mmho/cm (1:1)	Excess Lime	%Organic Matter (Mod. W.B.)	Nitrate-Nitrogen ppm (Cd Reduction)	Nitrate-Nitrogen lb N/A (Cd Reduction)	Phosphorus ppm P (Bicarb)	Potassium ppm K (Ammonium Acetate)	Sulfur ppm	Sulfur lb S/A	Calcium ppm Ca (Ammonium Acetate)	Magnesium ppm Mg (Ammonium Acetate)	Sodium ppm Na (Ammonium Acetate)	Zinc ppm Zn (DTPA)	Iron ppm Fe (DTPA)	Manganese ppm Mn (DTPA)	Copper ppm Cu (DTPA)
17942	1	0- 6	7.9		0.56	Hi	2.9	16	29	113	763	126	227	5531	461	22	5.7	22.4	7.8	62.2
17943	4	0- 6	8.1		0.49	Hi	2.8	8	14	120	521	75	135	5349	465	35	9.4	8.4	6.5	3.1
17944	5	0- 6	8.1		0.56	Hi	4.5	14	25	495	1158	46	83	4778	642	67	9.9	11.8	10.3	6.4
17945	7	0- 6	8.1		0.51	Hi	1.6	12	22	56	307	48	86	5313	444	51	23.5	6.8	7.8	3.0

FERTILIZER RECOMMENDATIONS: POUNDS ACTUAL NUTRIENT PER ACRE

Lab Number	Sample ID	Crop To Be Grown	Yield Goal	Lime, ECC Tons/A	Nitrogen N	Phosphorus P_2O_5	Potassium K_2O	Zinc Zn	Sulfur S	MgO	Cu	Mn
17942	1	ALFALFA - NEW	9 T		10	0	0	0	0	0	0	0
17943	4	WHEAT HAY	2 T		45	0	0	0	0	0	0	0
17944	5	ALFALFA - NEW	9 T		10		0	0	0	0	0	0
17945	7	CORN SILAGE	28 T		260	0	0	0	0	0	0	0

CATION EXCHANGE CAPACITY

CEC	%H	%K	%Ca	%Mg	%Na
34	0	6	82	11	0
32	0	4	83	12	0
33	0	9	74	16	1
31	0	3	84	12	1

SPECIAL COMMENTS AND SUGGESTIONS:

SAMPLE(S): 1, 4, 5, 7
CBC calculated by cation summation may overestimate true CEC and underestimate exchangeable sodium percentage (ESP) in soils containing excess lime.
SAMPLE(S): 1, 5
FORAGE LEGUMES (alfalfa or clover), NEW SEEDING: Applying 15 to 20 lb. of nitrogen can aid in establishing legumes, if soil nitrate is low. Do not apply excess nitrogen or it may stimulate competition from grassey weeds.
SAMPLE(S): 4, 7
Subsoil nitrate samples to 24 or 36 inches can improve the accuracy of nitrogen recommendations. Contact the laboratory for further details.

CHAPTER 16. MONITORING AND SAMPLING

1. GENERAL

Monitoring and sampling have been practiced for centuries. Early forms of monitoring probably were frequent observations of crops for success or failure. In their travels, the pioneers of this country sampled the soil and the surrounding wildlife and vegetation to determine whether an area was habitable. This checking of segments of the environment was a form of monitoring.

Today, various facets of the environment are being monitored to meet a particular need. These monitoring systems are concerned with basic resources, population, economy, health, and the like. They are complex systems and use an enormous amount of public funds, but they are essential to the well-being of the Nation.

This chapter discusses an approach to sampling and monitoring for two different purposes and is divided accordingly. The first part discusses sampling and monitoring of streams for evaluating surface water quality. The second part discusses monitoring and sampling of various animal waste treatment and disposal systems.

2. MONITORING AND SAMPLING TO DETERMINE SURFACE WATER QUALITY

Previous chapters of this manual define water-quality requirements for various uses of surface water and discuss sources of pollution and methods of waste treatment and disposal. This chapter discusses various methods of monitoring the water quality of streams and lakes. It provides guidance in collecting and analyzing water-quality data. Analytical results of water-quality surveys are helpful in describing some aspects of water quality, but such surveys do not provide a complete description of a water resource.

For evaluating water quality, monitoring and sampling are defined as follows:

1. Sampling is the physical act of collecting a volume of water for the sole purpose of analysis or analyses for various water-quality parameters.
2. Monitoring is frequent or routine systematic collection of samples over a period of time and analyzing them for an understanding of the variances in the water-quality parameters for a body of water. Monitoring as used in this section is not a continuous, unending process.

Analysis of a sample of water shows the water quality at a definite time at one sample collection station. To understand the fluctuation and variances expected in a body of water, a series of samples under varying circumstances is necessary.

MONITORING

Before an effective monitoring system can be initiated the following questions should be answered:

1. What is the monitoring objective?
2. What are the critical water-quality parameters for this monitoring objective?
3. What is the availability of water-quality data that relate to the project under investigation?
4. What visible factors in the drainage area influence water quality?
5. In what type of streams is the sampling to be conducted--ephemeral, intermittent, perennial?
6. What is the necessary frequency and duration of sampling?

1. What is the monitoring objective?

The objective of a monitoring system should be the first determination. The proposed use of the water determines which water-quality parameters are the most important to monitor.

Monitoring water quality in the past has been mostly for multipurpose reservoirs that store water for contact sports or public raw-water supply, or both. Comments in response to environmental impact statements now suggest that water-quality analyses should also be conducted on projects related to altering or regulating waterflow. Reviewers of impact statements are concerned about the changes in a stream's water quality, e.g., in temperature, dissolved oxygen, reaeration rate, suspended solids, turbidity, and the like, that may occur after a watershed project is completed. The purpose of water-quality monitoring therefore governs many of the decisions that should be made before establishing a monitoring system.

2. What are the critical water-quality parameters for this monitoring objective?

a. Recreation use - water contact sports

The crucial water-quality parameter for water contact sports usually is the fecal coliform bacteria count. Because a participant can ingest water during swimming or water skiing, the allowable bacteria count in lakes and streams used for contact sports usually is limited to 200 fecal coliform/100 ml as a maximum monthly geometric mean. No more than 10 percent of the samples shall exceed 400 fecal coliform/100 ml. Fecal streptococci are also frequently analyzed to determine the source of fecal material.

The chemical and physical quality of water may be a critical factor in the use of water for sports in certain regions of the country. While local water-quality experts may be able to estimate chemical and physical qualities of water, enough analyses should be made to verify these estimates.

b. Public raw-water supply

As in water for recreation, the bacterial limit is a crucial parameter for a public raw-water supply. But raw water for public use is usually allowed a higher concentration of fecal coliform bacteria than recreation water since all surface water has some treatment and disinfection before it is distributed to consumers. The source of the fecal coliform bacteria is important in determining the suitability of a water supply for public use.

The chemical and physical analyses of water for public use are as critical as the bacterial analysis. The list of allowable concentrations of various constituents is lengthy, but the water should be analyzed for each constituent if there is any question about existing concentration. The analysis is necessary to prepare designs and estimate costs for water treatment plants and to determine possible hazards to consumers' health.

c. Agricultural water use

The parameters for monitoring and sampling water for agriculture depends on the intended use of the water. For example, if the water is for irrigation, it should be analyzed for constituents that influence crop yields. If the water is for animal consumption, it should be analyzed for constituents that affect animal health.

d. Watershed projects

Small watershed projects present complicated circumstances in water-quality analysis, particularly in projecting any changes in the water quality of perennial streams. Water quality should be described in the present environmental conditions. Forecasting changes in water quality after project installation requires experience and judgment. For example, a watershed project may be planned for floodwater-retarding structures and alterations of the stream's configuration. Response to the environmental impact statement may be:

(1) For floodwater-retarding structures on perennial streams:
- (a) Will the impounded water change the base flow or the low flow $7Q_{10}$ of the stream? ($7Q_{10}$ is the symbol for the minimum unregulated streamflow that occurs for 7 consecutive days on a 10-year frequency.)
- (b) Will discharges from the impounded surface water elevate the stream's temperature? If so, how much?
- (c) If a submerged low-flow orifice is used to maintain the stream's temperature, at which depth should it be located and what will be the dissolved-oxygen level of the discharge? (If the orifice is near the bottom of a deep lake, the dissolved-oxygen level may be depressed and the plant-nutrient level may be high.)

(2) For channel improvement on perennial streams:
  (a) What change will occur in the stream's reaeration rate?
  (b) Will the modifications speed up the transfer of pollutants in the channel system and increase the waste load downstream?
  (c) How much temperature change can be expected if the stream's banks are cleared for construction?
  (d) Will the stream's water quality be reduced below the water-quality standards for fish and wildlife?

A review of these comments makes it obvious that projections of stream quality are needed but difficult to develop. Some states make descriptive statements about water quality based on data for present conditions but without specific figures on possible changes in water quality after the watershed project is installed. Descriptions of water quality should include data on dissolved oxygen, pH, suspended solids, temperature, turbidity, $7Q_{10}$, nitrogen, and phosphorus. Other parameters may be necessary, depending on conditions in the watershed.

3. <u>What is the availability of water-quality data that relate to the project under investigation?</u>

Although water-quality data are practically nonexistent for many streams, there are useful data on some selected streams. It is advisable to contact any agency that may have such information before beginning a water-quality study.

Almost every state has begun to study water quality by river basins within the state and to relate this information to discharges of treated and untreated waste water. These studies are required by EPA and are coordinated by the state water pollution control agency. If the needed water-quality data are not available, the regulatory agency may conduct the monitoring program or assist in analyzing the data. The regulatory agency may also assist SCS through consultation and review of water-quality data.

The U.S. Geological Survey (USGS) has a limited program for analyzing various water-quality parameters in some states. Most of the analyses are for major streams, but some USGS offices conduct extensive monitoring programs on a reimbursable basis with other agencies. USGS is also best qualified to provide data on $7Q_{10}$ flow rates.

Other sources, such as universities, river basin districts, Corps of Engineers, military installations, etc., may have some water-quality data.

4. <u>What visible factors in the drainage area influence water quality?</u>

A thorough field reconnaissance of the contributing drainage area is probably the most important step in developing a monitoring system. Knowledge of the physical characteristics of a drainage area provides guidance in determining sample points, water-quality parameters to analyze, major sources and types of pollution, stream conditions, and the like. The quality of water in a stream or lake depends on the chemical, biological, and physical features of the drainage area.

Noting the features of a drainage area on a map helps in locating the most advantageous sampling points of a stream. Sampling points should be located both upstream and downstream from possible waste sources to identify the source's input. Figure 16-1 shows sampling point locations for a segment of a stream.

5. In what type of stream is the sampling to be conducted--ephemeral, intermittent, or perennial?

To monitor a stream properly, several samples should be collected from both base flow and flow resulting from surface runoff. Since Indian Creek is a perennial stream, base flow samples can be collected, but there is no base flow in Frog Branch except that from the potential waste source (subdivision). Therefore, sampling stations 1 and 4 will yield data for a base-flow analysis. During runoff events all stations should be sampled and flows measured to get an idea of possible waste loads from the potential waste source. This is illustrated further at the end of this section.

6. What is the necessary frequency and duration of sampling?

The frequency and duration of sampling depends on the size and complexity of the drainage area, climatic conditions, streamflow

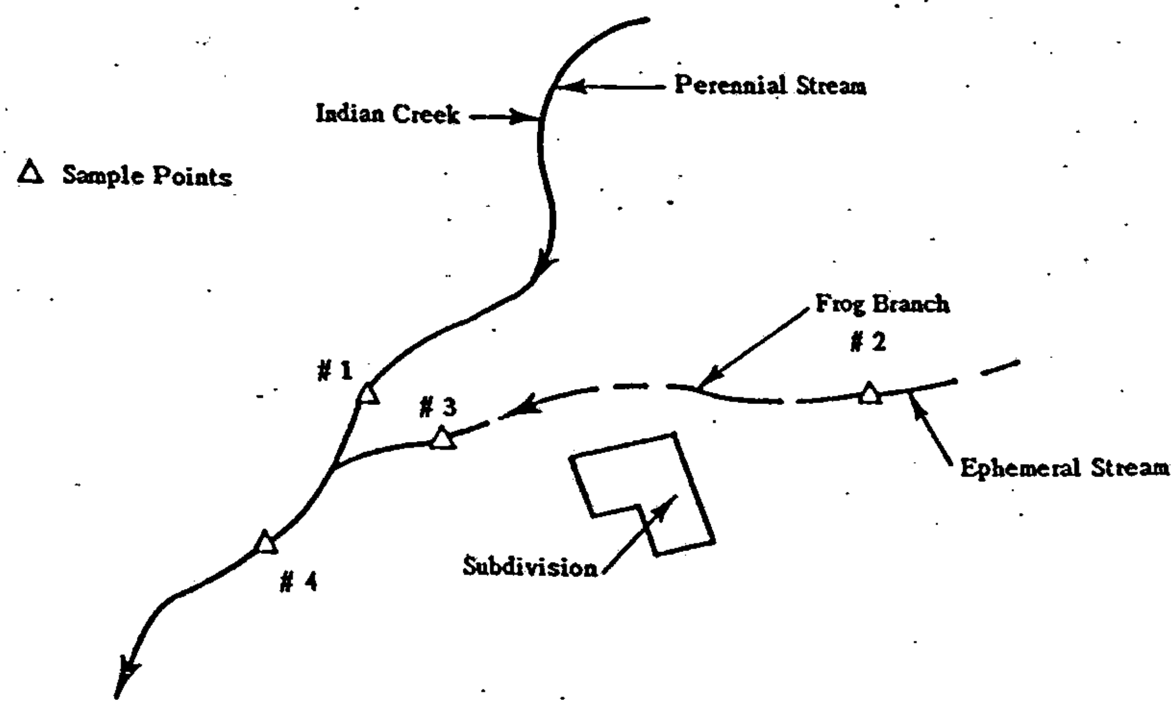

Figure 16-1.--Sampling stations on a stream segment.

characteristics, and the objective of the monitoring program. This is a judgment factor. Enough samples must be collected to estimate existing water quality for both base flow and flow resulting from runoff events. It may be possible to make such estimates with as few as four or five series of samples over a period of 1 or 2 months, or as many as 20 or more series of samples over a period of a year or longer may be needed. If the drainage area is small and covered with forest, four or five samples may be enough. If the drainage area is large with a wide variance in land use, a more extensive sampling and monitoring program is necessary.

METHOD OF COLLECTING SAMPLES

The results of any investigation that requires sampling are only as good as the method of sampling and analysis. If either the sampling or analysis is not done properly, the final report will be inaccurate and misleading. The samples collected should represent the actual field conditions. They should not be contaminated through mishandling.

A 1/2-gal plastic container, thoroughly clean, is usually satisfactory for collecting water for chemical and physical analyses. Most laboratories furnish containers that have been cleaned with a weak acid solution and thoroughly rinsed with demineralized water. The sample should be taken near the center of a stream or at least in the main flow. Some collectors use a rigid, light rod approximately 3 to 10 feet long for collecting samples. The container can be fastened to the rod, and the collector can extend his reach without extensive wading. For sampling lakes, a boat is probably necessary.

Water for bacterial analysis should be collected in a sterilized glass bottle (approximately 100 ml or larger) from a laboratory. Most laboratories have bottles especially for such samples. The collector must be extremely careful not to contaminate the inside of the bottle. It is best not to remove the cap of the bottle until just before the sample is collected. The mouth or opening of the bottle should not be touched when the cap is removed. The same care must be exercised when collecting the sample. The bottle should be submerged in the water and moved upstream in one motion to avoid floating particles and to prevent washing contamination from the hands into the bottle. As soon as the sample is collected, the cap should be replaced and tightened firmly. Samples should be protected by using recommended packaging and transportation procedures.

A tag should be attached to all sample bottles giving the station location and time of collection. Other vital information such as stream temperature, pH, and dissolved oxygen can be recorded in a log book or on the tag attached to the bottle. For accurate comparison of water quality from one sample point to another, the stream's discharge rate at each sample point should be measured. Available rainfall data should be recorded for determining the relationship of runoff to possible fluctuations in the various parameters.

ANALYZING THE WATER QUALITY DATA

The quality of water is not accurately described by measurements of a series of parameters. The complications and interactions of the parameters must also be considered. Persons without necessary experience or training should seek qualified assistance. Such assistance will help in getting a better understanding of water quality under normal conditions and the fluctuations in water quality under varying conditions.

This section does not attempt to discuss all the various aspects of interpreting water-quality data. Each region, state, or watershed has characteristics peculiar to the area. Only a brief summary of the parameters is given. It must be remembered that an onsite survey of the drainage area is necessary to get an accurate picture of water quality.

Dissolved Oxygen (DO)

The dissolved-oxygen content of pure water varies with the temperature of the water. The curve in figure 16-2 portrays the dissolved-oxygen saturation point in pure water at different temperatures at mean sea level (msl). Unpolluted surface water may have near-saturation values for the corresponding temperature and elevation. The dissolved-oxygen level can be depressed by:

1. Introduction of biodegradable wastes that increase the activity of aerobic bacteria,
2. Aquatic plant growth resulting from an increase in available nutrients such as carbon, nitrogen, and phosphorus (algae may raise the dissolved-oxygen level above the saturation point during favorable light intensity but depress it during the night, and
3. Injection of organic or inorganic compounds that require oxygen to complete their chemical reaction.

Turbidity

Turbidity is a measurement of the interference to light penetration in water caused by suspended matter that ranges in size from colloidal and fine materials to coarse grains, depending on the degree of turbulence. Turbidity in relatively quiescent lakes and streams is due mostly to colloidal particles, suspended clay, and silt. Turbidity in a body of water may be caused by substances that range from nearly all inorganic to nearly all organic. Turbidity is commonly expressed in Jackson turbidity units (JTU).

Turbidity affects the amount and depth of sunlight penetration into water, cost of water filtration for domestic consumption, effectiveness of disinfectant, and general appearance of the body of water. The amount of turbidity is usually related to the amount of soil eroded and its clay content, the amount of sewage solids, and various inorganic and organic substances that enter the water from the drainage area. Turbidity can also be generated within the stream by degradation of the channel.

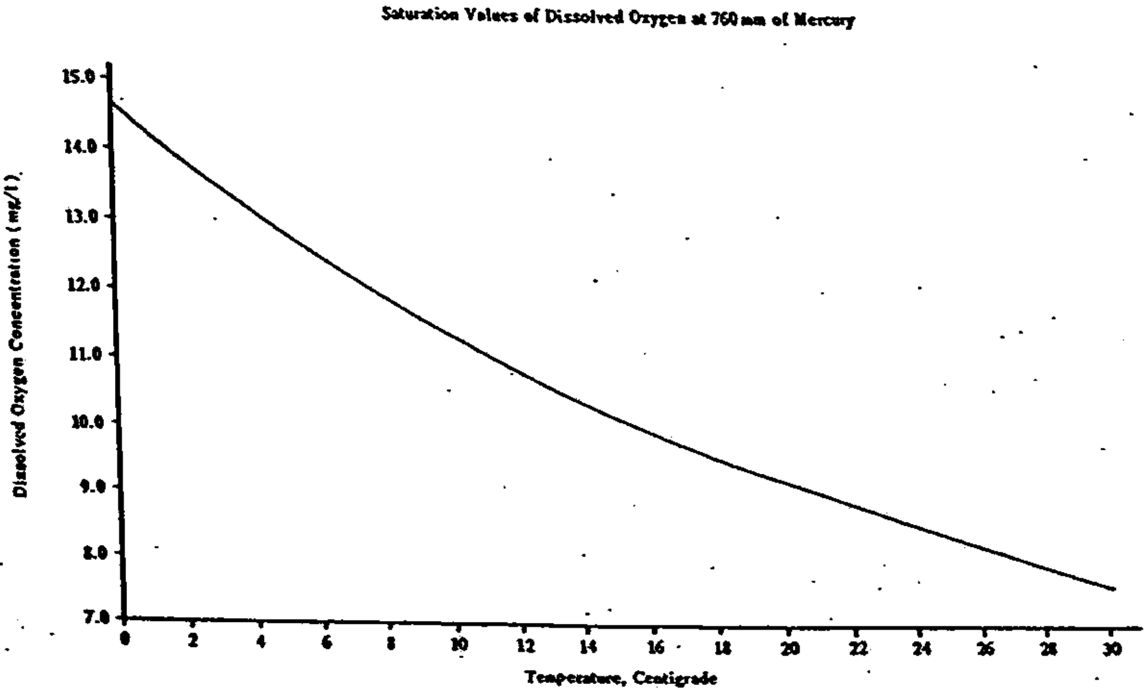

Figure 16-2.—Dissolved oxygen saturation in water vs. water temperature.

Color

Surface waters are often colored, especially those draining from swampy areas. The coloring is a result of contact of the water with organic debris such as leaves, wood, and the like in various stages of decomposition. The color comes from a variety of vegetable extracts. The principal color sources are tannins, humic acid, and humates from the decomposition of lignin. Also, color may be caused by industrial discharge such as that from dyeing or pulping. Color caused by suspended matter such as red clay particles is called apparent color. It is differentiated from color due to colloidal vegetable or organic extracts, which is called true color.

Apparent color is usually determined directly from the sample. To measure true color, a sample is usually contrifuged to separate any suspended solids and the measurements are made on the clarified liquor.

Measuring the color of a stream can give an idea of the origin of the water and its esthetic acceptability for human consumption and contact sports. If the color units are high, a thorough onsite field investigation should be conducted to identify the source.

The color in water from swampy areas is not harmful or toxic, but the water is generally not acceptable to the public as a source of drinking water without extensive treatment. Water intended for human consumption should not have a color measurement exceeding 20 platinum-cobalt standard units. For detailed information concerning units of color measurement and procedures for determination, contact someone with experience or training in this field. The natural color of water can usually be removed by coagulation with a salt having a trivalent metallic ion.

pH

The pH of water is a measure of its hydrogen ion concentration and expresses its acidity or alkalinity. The pH value is an important factor in practically all phases of sanitary engineering and biology (aquatic and microscopic). On a pH scale of 0 to 14, a pH of 7.0 (neutral) is best for water treatment, body contact sports, wildlife, aquatic life, etc. Values below 7.0 indicate acid solutions; values above 7.0 indicate alkaline solutions.

1. Acidity

The pH and the carbon dioxide (CO_2) content of water should be measured in the field, since some of the CO_2 escapes to the atmosphere enroute to a laboratory for testing. Carbon dioxide depresses the pH but not lower than 4.5. A pH lower than 4.5 indicates the presence of a strong mineral acid in natural water or that an industrial waste is influencing the acidity. A stream that has numerous springs may have a high CO_2 concentration and subsequently a low pH. If a significant amount of organic matter is present in water, the pH may be influenced by the CO_2 produced as an end product of decomposition of the organic matter by bacteria.

2. Alkalinity

The alkalinity of natural waters is due primarily to bicarbonates from the action of CO_2 on basic minerals in the soil. If algae flourish in surface waters, carbonate and hydroxide alkalinity may occur and the pH may be as high as 9 to 10. Industrial discharges may also influence the alkalinity.

Biochemical Oxygen Demand (BOD)

The BOD parameter is used primarily to measure the organic strength of waste water, not to describe stream characteristics. Normally, a BOD determination is necessary only when an oxygen-consuming waste discharge is influencing the stream. The BOD of a natural stream is usually so low that a test is not accurate nor the results significant.

Nitrogen (N)

The primary importance of nitrogen in monitoring surface waters is that (1) the form of nitrogen tells how recently a stream has been polluted, (2) the amount of nitrate can be related to a possible health problem, and (3) the nitrogen concentration may indicate the possibility of nuisance algal blooms.

In streams freshly polluted by untreated sewage, nitrogen is in the form of organic (protein) N and ammonia. In time the organic N is converted to ammonia N, and later, if aerobic conditions exist, ammonia is oxidized to nitrites and then to nitrates. Thus the form of nitrogen in a stream indicates how recently the stream was polluted.

Various technical sources suggest general values for appraising the free ammonia content in surface waters. These values are: low concentration, 0.015 to 0.03 mg/l; moderate, 0.03 to 0.10 mg/l; and high, 0.10 mg/l or greater. One exception is the presence of ammonium sulfate of mineral origin. Nitrites, the first product of the oxidation of free ammonia, are practically nonexistent in unpolluted streams; therefore, their presence indicates pollution. Nitrates, the final product of the biochemical oxidation of ammonia, may be in streams in varying amounts and may indicate earlier pollution that has been removed through oxidation by the stream's self-purification ability. Nitrates may also be contributed by the organic material in eroded soils or by other nitrogenous sources such as commercial fertilizers. Drinking waters with a high nitrate content often cause methemoglobinemia in infants (blue babies), which is due to a lack of oxygen in the blood (see glossary and ch. 3). The maximum limit for nitrates in drinking water is 10 mg/l as N or 45 mg/l as NO_3.

Excessive plant nutrients in streams and lakes can create a nuisance aquatic plant growth such as algal bloom. A flourishing growth depends on an adequate supply of all the necessary elements, and nitrogen is only one of them. If the nitrogen source is related to organic waste, the other essential elements are usually available.

Phosphorus (P)

Phosphorus has been blamed for the abundant growth of aquatic vegetation, but phosphorus, like nitrogen, is not solely responsible. Phosphorus has been selected by some regulatory agencies as the one element from the group of elements essential to plants that can be controlled. The suggested limit for phosphorus in lakes is near 0.01 mg/l, but this limit depends on the availability of the other essential elements.

Uncontaminated streams may contain 0.01 to 0.03 mg/l total P in solution, although higher concentrations are found in streams that drain soils rich in phosphorus. Rainfall also may have a P concentration of 0.01 to 0.015 mg/l. Domestic sewage is relatively rich in phosphorus compounds. Before the development of synthetic detergents, inorganic phosphorus in domestic sewage usually ranged from 2 to 3 mg/l and organic forms from 0.5 to 1.0 mg/l. It is estimated that sewage now probably contains 3 to 5 mg/l inorganic phosphorus because of the polyphosphates in detergents.

The amount of available phosphorus in solution depends on the type and amount of sediment in the stream. Sediment with an affinity for phosphorus can remove almost all the phosphorus from solution.

Bacteria

A bacteriological study often provides the best information on the degree of pollution and the hazard to human health in a stream or lake.

But a routine analysis of water samples for all pathogenic bacteria is impossible. Therefore, indicator organisms are used to indicate fecal contamination. These are the fecal waste indicator organisms—total coliform, fecal coliform, and fecal streptococci.

1. Total coliform

Until recently the test for total coliform was used extensively for indicating the presence of fecal contamination. The test measures the concentration of total coliform bacteria in a volume of water and reports the results in number of coliform/per 100 ml. As the name indicates, the test measures all species of the coliform group and is not limited to the coliform species originating in the intestines of warm-blooded animals. Some coliform bacteria come from soil. Therefore, in stream analysis the results of this test are not always indicative of fecal contamination. The test can be applied to ground-water supplies because none of the coliform group is present in ground water unless it is contaminated.

Total coliform analysis is still conducted by many laboratories as a routine bacterial analysis. If the field reconnaissance and the water-quality surveys are thorough, a total coliform test can provide some indication of the degree of fecal contamination if the results are correlated with past water-quality studies.

2. Fecal coliform

The fecal coliform component of the coliform group can now be isolated by routine laboratory analysis. These organisms are relatively infrequent unless there is fecal pollution. The fecal coliform group survive a shorter time in natural waters than the coliform group as a whole; therefore, the presence of fecal coliform indicates relatively recent pollution. Also, the fecal coliforms do not multiply outside the intestines of warm-blooded animals.

There is no established correlation between the fecal coliform count and the total coliform count for evaluating the sanitary quality of water. In domestic sewage the fecal coliform density is usually more than 90 percent of the total coliform density, but in natural streams relatively free from recent pollution, the fecal coliform density may range from 10 to 30 percent of the total coliform density.

Most of the bacterial standards for streams are related to the allowable concentration of fecal coliform. For water contact sports, most states have a limit of 200 fecal coliform/100 ml as a maximum monthly geometric mean, and no more than 10 percent of the samples can exceed 400 fecal coliform/100 ml. These standards are based on frequent water sampling during a 30-day period.

Almost all natural waters have a fecal coliform concentration since all warm-blooded wildlife contribute. A thorough survey of the waste sources is necessary for interpreting the fecal coliform concentration. This is illustrated in the example given later.

3. Fecal streptococci

Fecal streptococci are streptococci commonly found in significant numbers in the feces of human or other warm-blooded animals. Since there are more data on fecal coliforms than on fecal streptococci and the analysis is fairly simple, the fecal coliform count is commonly used for continuous monitoring of water quality. The fecal streptococci count is used in conjunction with the fecal coliform count in sanitary surveys to get an indication of fecal sources.

Some of the merits of using fecal streptococci as indicators are that (1) they do not multiply in surface water, (2) they do not exist in pure water or virgin soil, and (3) they are not considered pathogenic.

Some limitations as indicators are that (1) their survival time versus that of pathogens is not known, (2) when waste is applied to soil, they disappear rapidly while coliforms survive for a long time, depending on the soil conditions, and (3) they grow under diverse conditions in nature, e.g., in food products or silage.

Using fecal streptococci as indicators of the sources of pollution is based on the ratio of fecal coliforms to fecal streptococci (FC/FS ratio) for bacteria excreted, as shown in table 16-1. Note that the FC/FS ratio for man is greater than 4.0 but that the FC/FS ratio for lower animals is less than 0.7. This ratio applied to field data may indicate whether the waste source is man or animal. The range from 0.7 to 4.0 is considered the "gray area," an indication of mixed waste sources. Some authorities consider the gray area to be from 1.0 to 3.0.

Interpretation of the FC/FS ratio requires extreme care. Many investigators apply this ratio only during the first 24 hours of flow in the stream from the waste source. The die-off rate of fecal coliforms and that of fecal streptococci differ; the fecal streptococci usually have a more rapid die-off rate. Also, if the bacterial population is low (less than 1,000 FC/100 ml), the ratio should be used with caution. If the pH is lower than 4.0 or higher than 9.0, the ratio should not be used.

Table 16-1.—Average density of indicators excreted in 24 hours

Animal	Fecal coliforms	Fecal streptococci	FC/FS ratio
	Million/100 ml	Million/100 ml	
Man	13.0	3.0	4.4
Duck	33.0	54.0	0.6
Sheep	16.0	38.0	0.4
Chicken	1.3	3.4	0.4
Cow	.23	1.3	0.2
Turkey	.29	2.8	0.1
Pig	3.3	84.0	0.04

3. EXAMPLE OF MONITORING AND SAMPLING

The PL-566 watershed shown of figure 16-3 is used to illustrate some of the principles that have been discussed. The following information was gathered in a field reconnaissance by the watershed planning party.

Drainage area: 10,000 acres
Average annual rainfall: 55 inches
Average annual runoff: 16 to 18 inches
Lake proposed for recreation:
- Surface area: 600 acres
- Permanent storage: 4,800 acre-feet

Present land use in drainage area:
- Woodland: 75 percent
- Pasture: 10 percent
- Row crops: 5 percent

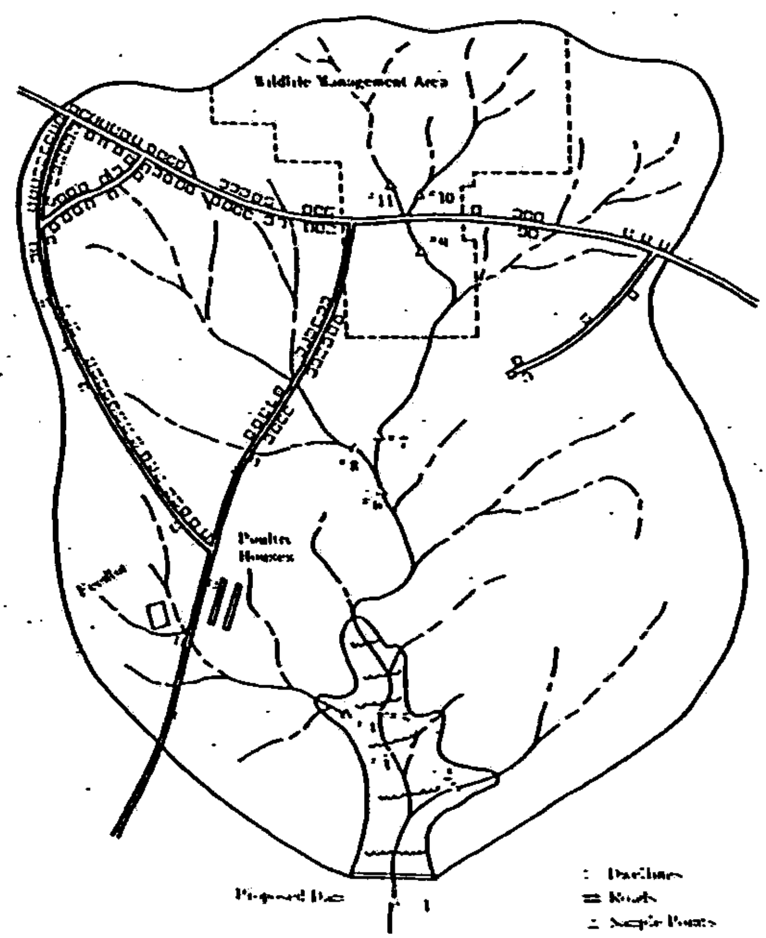

Figure 16-3.--Example of a watershed studied for water quality.

Idle: 5 percent
Miscellaneous: 5 percent
Poultry farm (broilers): one (capacity for 60,000 birds)
Feedlot: one (500 head cattle for winter feeding, November to March)
Homes in area: 150--25, modern construction; 80, 5 to 15 years old; 45, older than 15 years (information from field observation and field office data)

Since the plans include construction of a lake for recreation, the primary emphasis normally would be on a bacteriological study of the drainage area unless the water-quality records for the general area indicate that other physical and chemical factors may affect desirability for recreation. Samples should be collected at two or three stations to verify the chemical and physical water-quality characteristics. If the analyses of the first series of samples indicate a need for additional samples, these can be collected during the remainder of the monitoring period.

For adequate monitoring of the quality of water from a drainage area, more than three series of samples should be collected. Each series should be studied to determine any adjustments needed in the monitoring program. The data in table 16-2 give the analyses of the first three series of samples for this drainage area. A drastic change occurs in the third series, which were collected during a runoff event; therefore, close review of the data and correlating them to field conditions are necessary before taking any more samples.

ANALYSIS OF WATER QUALITY DATA

Bacteriological Data

As stated prviously, emphasis is on the bacterial population. The first two series of samples, taken from the base flow, did not reveal any substantial pollution. The FC/FS ratio of the first two series indicates that the waste sources are primarily lower animals. This indication can be misleading, however, since the counts are low. Many experienced investigators prefer not to use the FC/FS ratio if the fecal coliform count is below 1,000 FC/100 ml and definitely do not use the ratio if the count is below 500 FC/100 ml. Since this is a base flow with a low bacteria count, it may be wise to omit the FC/FS ratio except at station 4. The bacteria counts at station No. 4 are elevated, and the FC/FS ratio indicates that the waste source is nonhuman. The map shows that poultry and feedlot facilities drain into the tributary above station 4. If there is a base flow near these waste sources, three additional sampling stations should be used--one above both sources, one between the two sources, and one below both sources. Samples taken at these stations can identify the source of the discharge to the stream.

In the third series of samples, collected during a runoff event, the fecal coliform and fecal streptococcal populations were substantially elevated. An increase in bacterial density is expected during runoff, but density depends on the particular time--early, middle, or

[illegible]—Analyses of samples collected at 11 sampling stations
[—indicates tests not run]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Dissolved oxygen	pH	Suspended solids	Total Kjeldahl nitrogen	Nitrite	Nitrate	Phosphorus
						[illegible]		[illegible]	mg/l	mg/l	mg/l	mg/l
[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	50	[illegible]	0	0.2	[illegible]
[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	100	.03	0	.3	.1
[illegible]				[illegible]	[illegible]	[illegible]	7.[illegible]	[illegible]	.2	.05	[illegible]	1.0
[illegible]				[illegible]	[illegible]	—	—	—	—	—	—	—
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[illegible]				[illegible]	[illegible]	—	—	—	—	—	—	—
[illegible]				[illegible]	[illegible]	[illegible]	6.5	35	[illegible]	0	0.1	0.3
[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	30	[illegible]	0	0.15	0.1
[illegible]				[illegible]	[illegible]	[illegible]	7.0	12,000	0.03	0	0.5	0.9
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[illegible]				[illegible]	[illegible]	—	—	—	—	—	—	—
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late—the samples were collected during the runoff event and on the degree of pollution (fig. 16-4). Although a large number of samples need to be collected and analyzed, bacterial density versus runoff curves should be developed for one runoff event whenever possible. If the waste sources are primarily wildlife, the bacterial population should not be elevated to an abnormal density unless a high percentage of the rainfall results in runoff. Because of its diluting effect, the amount of base flow in a stream also affects bacterial density.

The bacterial population at station 1 increased to an abnormal density during the runoff event, and the FC/FS ratio indicates a nonhuman source. The count at station 3 is even higher than that at station 1, indicating a possible combination of bacterial die-off between stations 3 and 1, dilution by runoff from station 2, or the different time of collection during runoff (fig. 16-4). Samples from station 4

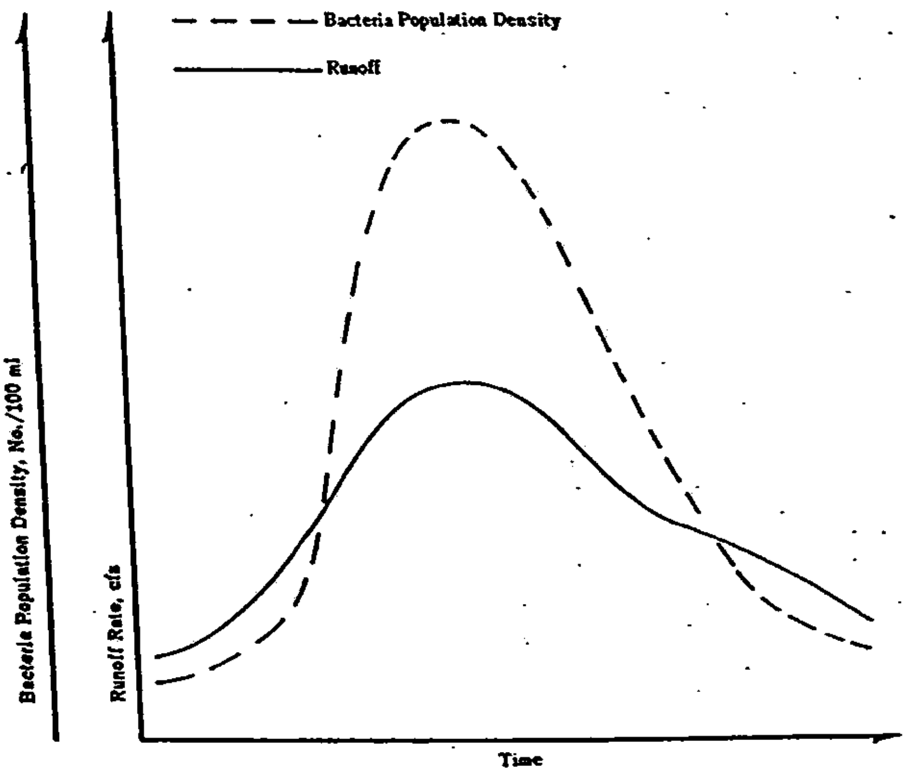

Figure 16-4.—Bacterial density and runoff curve.

give the best indication of the waste source. The FC/FS ratio indicates a nonhuman source and, from a review of figure 16-3, it is possible to conclude that the two livestock confinement units are the sources.

To verify that the livestock units are the waste sources, additional stations for sampling runoff should be installed to determine if the waste is from the confinement areas, from manure-spreading areas, or from other sources such as wildlife areas. A comparison of samples from stations 5, 6, and 8 indicates that the human population is contributing to the fecal coliform count but that the density is reduced as stream distance increases. A comparison of samples from stations 9 and 11 shows that the increased bacterial density is probably from wildlive since the area is a wildlife management area and few domestic animals are likely to be present.

Present indications are that the swimming beach should be located on the east side of the proposed recreation lake between stations 2 and 1 (see fig. 16-1). This location allows the maximum amount of dilution and bacterial die-off in the lake. Corrective action should be taken on problem waste sources before an impoundment for water is constructed. Stream monitoring should be continued after the corrective action is taken to be sure that the sources of pollution are eliminated.

Another approach is to apply a mixing equation when enough samples have been collected. The equation will give an approximation of the bacterial concentration in the lake after a runoff event. The information obtained from the mixing equation cannot be used as concrete evidence of the bacterial effect on a lake or stream because only grab samples are analyzed and uniform mixing is assumed. The information may serve as a guide.

The mixing equation is:

$$B.Q. = \frac{C_1 Q_1 + C_2 Q_2}{Q_1 + Q_2}$$

where

B.Q. = average bacterial population in a body of water after a runoff event
C_1 = mean fecal coliform density of runoff
Q_1 = acre-feet of runoff entering a lake or stream
C_2 = mean fecal coliform density in a lake or stream before the runoff event
Q_2 = acre-feet of water in the lake or stream.

This equation assumes instantaneous, complete mixing of the runoff water with the water in a lake or stream although this condition will not exist. The counts will be higher near the inlets into the lake or stream and lower the greater the distance from the waste sources.

This equation is often applied in two different ways. One approach is to calculate the average fecal coliform concentration in a lake from the mean inflow concentration. Another approach is to calculate the maximum allowable geometric mean of fecal coliform inflow from runoff.

The following example illustrates the second approach. Consider the conditions given for the watershed and assume that

Q_1 = 2,500 acre-feet
Q_2 = 4,800 acre-feet (storage in lake)
C_1 = mean fecal coliform density in runoff
C_2 = 50 FC/100 ml in the lake before runoff occurs (assumed)
B.Q. = 200 FC/100 ml maximum geometric mean/per month for water contact sports

$$200 = \frac{2{,}500\ C_1 + 50\ (4{,}800)}{2{,}500 + 4{,}800}$$

C_1 = 488 FC/100 ml (allowable fecal coliform density in the storm runoff)

As an example of the first approach, assume that the mean FC count from a rainstorm is 800 FC/100 ml. Runoff from the 10,000-acre watershed is 0.8 inches.

$$Q_1 = \frac{0.8}{12} \times 10{,}000 = 666 \text{ acre-feet}$$

C_1 = 800 FC/100 ml
Q_2 = 4,800 acre-feet
C_2 = 50 FC/100 ml (assumed)

$$B.Q. = \frac{800\ (666) + 50\ (4{,}800)}{666 + 4{,}800} = \frac{772{,}800}{5{,}466}$$

B.Q. = 141 FC/100 ml

The mean fecal coliform count should be determined from a monitoring period that covers several series of samples. It should not be used as concrete evidence for acceptance of a site but should be used with other data as an indication of the potential acceptability of a site. An analysis may indicate an average fecal coliform density in a lake of 250 FC/100 ml, but if the beach area is located away from sources of pollution, it may be reasonable to conclude that the concentration will be less than 200 FC/100 ml at the beach area because of bacterial die-off and dilution between the stream inlet and the beach.

Chemical and Physical Data

Chemical and physical analyses of samples taken at stations 1 and 6 indicate the water quality in the upper and lower reaches of the stream. If the parameters reflect an unusual condition, additional samples should be collected to determine the source of pollution. The parameters used in this example are not all inclusive; often samples should be analyzed for more parameters. Carbon dioxide, turbidity, color, chemical oxygen demand, etc., are frequently included in a water quality analysis. Figure 16-1, table 16-2, and the discussion that follows illustrate the analytical principles but do not provide a detailed analysis of each possible parameter. Only eight parameters are used.

Temperature

Knowing the fluctuation in water temperature is important in determining the concentration of dissolved oxygen at 100-percent saturation. The stream selected for this example is in the Deep South and has little overhanging cover to provide shade. The runoff water is approximately 3 to 6 degrees (°F) cooler than the base flow in the stream, which can be expected from forested areas.

If this analysis of temperature is applied to a stream for which channel improvements are planned, a record should be kept of the temperature fluctuations during the hottest weather of the year. Air and water temperatures should be taken and recorded at the same time to have a good temperature baseline for comparison after the channel improvements are made. Although these data are often lacking, they are important for future projects.

Dissolved Oxygen (DO)

For comparison of one series of samples with another, it is usually better to represent the dissolved oxygen concentration as the percentage of that at saturation. Dissolved oxygen saturation varies with water temperature and elevation above mean sea level (msl).

The data in table 16-2 indicate no substantial variance in DO concentration that would suggest a significant load of organic pollution. The increase in DO concentration in the surface runoff water is due to stream reaeration. In areas of overfalls or steep, rocky channels, the DO concentration may be higher than the 100-percent saturation level. If the DO level had dropped, it would suggest that an organic waste load had washed into the stream or that a heavy bottom deposit of organic material had gone into suspension.

pH

The pH is slightly depressed, which may be due to the carbon dioxide level in the water or to sources of acidity that can occur in spring-fed streams. It is not uncommon to find the pH fluctuating between 6.0 and 8.0, depending on the water source. The water may come from the ground into the stream with a high carbon dioxide level and a depressed pH, but as the carbon dioxide escapes to the atmosphere, the pH increases toward neutral.

Suspended Solids

The suspended solids parameter represents the concentration of soils and organic and inorganic material in suspension. The level of suspended solids for the base flow in this example is satisfactory, but it is substantially increased in the third series of samples (surface runoff).

Note that the suspended solids level is higher at station 6 than at station 1, which indicates that the upper reaches of the watershed have a source of sediment either in stream degradation or in the surrounding land area, or both. Since the concentration is lower at station 1, there may be enough reduction in stream velocity to allow some settling of suspended solids between the two stations. The lower concentration may also indicate that the bulk of suspended material had not arrived at station 1 when it was sampled. To fully explain the difference in concentration would require a series of samples taken during a runoff event.

Nitrogen (N)

Determination of the total nitrogen concentration requires three different tests. The total Kjeldahl nitrogen test measures the ammonia and organic nitrogen forms of nitrogen. The regular Kjeldahl nitrogen test measures only organic nitrogen but not ammonia. Free ammonia in surface water indicates fresh pollution. The third series of samples reflects fresh pollution, especially at station 1. The source may be the animal confinement areas.

Since nitrites represent the first product of the oxidation of free ammonia, the presence of nitrites (0.05 mg/1) indicates organic waste that has already gone through some degree of decomposition. Thus, the pollution indicated is not necessarily fresh pollution.

The nitrate concentration varies with land use in a drainage area and with geological erosion. Nitrates can indicate possible previous pollution with the nitrogen already reduced to its final mineral form. The present nitrate concentration is not unusual except at station 1 during runoff. This unusual concentration could be due to the animal confinement area, but that is not definite since nitrates generally are present to some degree in surface water.

Phosphorus (P)

The phosphorus concentration is fairly high, which could be attributed to the P-rich soil eroded from the drainage area or to a waste discharge, but other sources should not be discounted. The high P level at both sampling stations and the increase during runoff are further indications that the source is eroded soil. Since the suspended solids level is substantially higher at station 6 than at station 1, it can be deduced that the P content would also be higher, but this depends on the affinity of the suspended solids for phosphorus. If the suspended solids have a definite affinity for phosphorus, then the solids may adsorb part of it, leaving less in solution.

SUMMARY OF EXAMPLE

This example illustrates the methodology for conducting a water-quality monitoring program. It used three series of samples, which are enough for only the beginning of a good monitoring system. At least five or six additional series are needed to further describe water quality. Additional sampling stations are also needed to evaluate the waste sources.

Although only three series of samples are used in this example, the analyses indicate that the proposed site is not satisfactory for impounding water for water contact sports. The fecal coliform concentration in the runoff from the feedlot or the poultry houses, or both, is too high. Extending the monitoring program with additional sampling stations and monitoring a few runoff events should isolate and identify the specific source of the high coliform concentration. Corrective steps should be taken to reduce the concentration and the stream monitored again to determine acceptability of the water for water contact sports.

The chemical quality is not unusual. The presence of suspended solids indicates a possible source of solids above station 6, and the total Kjeldahl nitrogen test indicates a waste source between stations 1 and 6. It is also indicated that storm runoff usually increases the concentration of most parameters.

CONCLUSION

The investigator planning a water-quality monitoring system should request suggestions and criticism from reviewing and regulatory agencies. A water-quality monitoring program requires research, vigilance, and experience. The data should be summarized and reasons given for any fluctuations. Most of these reasons can be keyed to the first field reconnaissance of the drainage area, one of the most important elements in monitoring water quality.

4. MONITORING AND SAMPLING OF ANIMAL WASTE DISPOSAL SYSTEMS

After a waste management system has been designed, approved, and constructed, it must be monitored continuously to determine effectiveness. Some guidelines for monitoring seepage from earth storage facilities and lagoons, constituents of stored wastes, constituents in soils and crops receiving waste water, and efficiency of treatment systems for animal wastes are discussed in the following pages.

For waste disposal systems, sampling and monitoring are defined as follows:

1. Sampling is the physical act of collecting water, waste water, soil, or vegetation for the purpose of analysis or analyses for various constituents.
2. Monitoring is a program of sampling and observing the analytical data to determine effectiveness of a system and fluctuations in the various constituents under surveillance. This may be a continuous process.

SEEPAGE FROM EARTH STORAGE FACILITIES AND LAGOONS

If earth storage facilities or lagoons are used to retain animal waste, seepage through the soil should be reviewed critically. Studies indicate that earth storage facilities are soon sealed with animal waste, but it may be a mistake to assume that there is no risk of pollution. It may be a few weeks or several months before the soil is adequately sealed with manure, and during this time nitrates and other undesirable constituents can enter the ground water. If a manure storage facility or waste lagoon is to be constructed in a soil with a questionable seepage stratum, approval should be obtained from the state regulatory agency and a ground-water monitoring system installed to detect possible problems.

If the direction of ground-water flow is known, monitoring a small well to ground-water level is enough. But the direction of ground-water flow is difficult to determine from surface observation. Ground-water wells should be located on all sides of the facility to be sure that one well is on the downstream side of the underground flow. Ground water does not necessarily flow parallel to the slope of the ground surface (see fig. 16-5).

When the wells are installed, several series of samples should be collected from the ground water for analysis before the facility is loaded with animal waste. The wells should be protected from contamination by surface water. Enough samples should be taken to develop a base line for constitutents of the ground water. Samples are usually analyzed for the same chemical parameters that are measured in raw-water supplies for human consumption, such as the various forms of nitrogen, phosphorus, iron, manganese, copper, etc., but they may also need to be analyzed for other constitutents.

After the ground-water base line is established, animal waste can be added to the storage facility and monitoring begun. The frequency of sampling depends on the amount of seepage expected. An analysis to determine the amount of seepage and the rate of travel is helpful in setting a sampling routine. At the beginning of the monitoring program, frequency of collecting samples can range from once every 2 or 3 days to once every 2 weeks. From the seepage analysis the travel time from the storage facility to the well on the downstream side can be calculated. If there is no pollution for a reasonable period after the calculated travel time has elapsed, frequency of sampling can be reduced. It is desirable to continue some type of monitoring program as long as

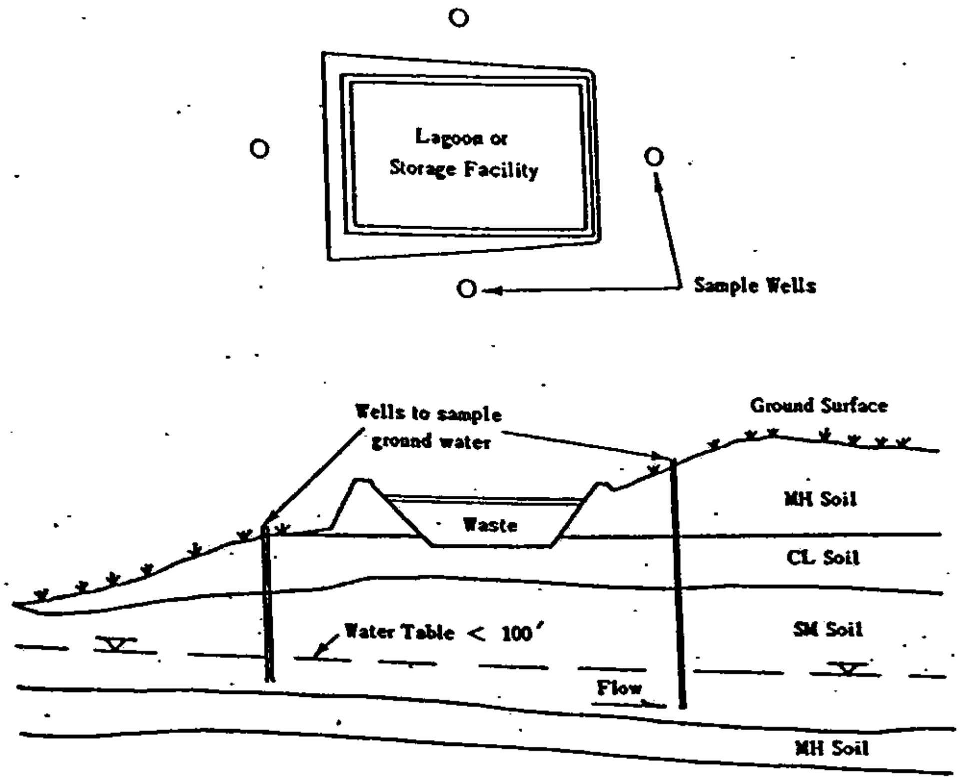

Figure 16-5.--Location of monitoring wells.

the facility is used or contains decaying organic material. Frequency of sampling eventually can be reduced to once or twice a year if there is no evidence of ground-water pollution after several years of monitoring. Fecal coliform bacteria are not usually detected in ground water because the bacteria have a high die-off rate in soils.

If the storage facility is constructed in slowly permeable or heavy clay soil, then a ground-water monitoring system may not be necessary. Seepage control is better than monitoring ground water for possible seepage. If monitoring indicates that the ground water is being polluted, the facility should not be used until the source of pollution is eliminated.

CONSTITUENTS OF STORED WASTE

The field application rate recommended for animal wastes is usually based on the nitrogen content of the wastes. If wastes are stored for only a few days, it is commonly assumed that little nitrogen is lost and the application rate is based on the nitrogen content of the manure as excreted by the animal.

If wastes are stored for longer periods, the nitrogen content may change appreciably, especially if there are aerobic and anaerobic strata in the storage facility or lagoon. The owner of a waste storage facility may wish to take several series of samples to determine the plant nutrient content of the waste before field application. If waste water is applied by sprinklers, sampling of the water to determine nitrogen loss during irrigation may be wise. This requires catching the liquid in a container as it is applied.

CONSTITUENTS IN SOILS AND CROPS RECEIVING WASTE WATER

Many waste components applied in excess can be harmful to soils or plants and may be toxic to animals consuming vegetation that has taken up excessive amounts.

It is estimated, for instance, that only half of the nitrogen in animal manure becomes available to plants during the first year and that the remainder becomes available at reduced rates in subsequent years. A high rate of annual application may be safe for the first year or so, but continued application at that rate could result in nitrogen being leached to ground water as nitrates or being taken up in excess by plants. Under certain conditions an excess of nitrates in forage causes grass tetany in animals.

Dissolved salts in waste water may be leached to ground water or, in arid areas, may build up in soils to a level that is toxic to certain plants. Too much sodium can disperse certain soils and affect plant growth adversely. Zinc, copper, and nickel can build up in soils and become toxic to vegetation. Arsenic, boron, cadmium, lead, mercury, molybdenum, and selenium in excessive amounts are toxic to both plants and animals. Elements such as lead and mercury are cumulative and over time can build up to levels toxic to animals.

Chapters 2, 5, and 6 discuss the recommended maximum concentration of the various elements in water for different uses and the effects of an excess of waste components on soils and plants. Monitoring of applied wastes, soils, and plants may be required for safe management of disposal areas that receive heavy waste applications or wastes with high concentrations of troublesome components. Assistance of soil scientists, agronomists, and geologists is necessary for establishing and evaluating such monitoring programs.

EFFICIENCY OF ANIMAL WASTE TREATMENT SYSTEMS

To monitor the efficiency of a waste-water treatment system, samples should be taken of the raw waste water, of the waste at locations between treatment units, and of the discharge. Regulatory agencies usually do not allow any discharge from animal waste treatment systems, but if discharge is allowed, the owner is usually required to have routine analyses made to be sure that the treatment unit is functioning properly. The analyses are reported to the regulatory agency. Most animal waste treatment systems provide for final disposal of the effluent on land. The effluent is treated to control odor, to reduce volume or organic content, or merely to provide inoffensive storage. Monitoring of treatment efficiency is important for determining the land application rate and for correcting possible malfunctions within the treatment system.

The constituents normally monitored are BOD, chemical oxygen demand, forms of nitrogen, phosphorus, potassium, dissolved oxygen, suspended solids, and chemicals used in animal feed that can disrupt treatment efficiency. But a monitoring system has no value if the data are not properly analyzed.

The owner of a facility is responsible for the proper functioning of the treatment or disposal system, and fulfilling this responsibility often requires a monitoring program. Monitoring benefits both the owner and the public.

Sampling water, vegetation, or soil and recording the data do not complete a monitoring system. The data must be analyzed in relation to the various effects the constituents can have upon the environment. The owner may need the assistance of engineers, agronomists, geologists, and soil scientists in establishing a monitoring program and developing a system for analyzing accumulated data.