Water Quality and Horse Keeping Facilities

Fact Sheet | Equine Facilities Assistance Program | June 2003

Protection of water resources is directly linked to the quality of our life. Contaminated water can compromise drinking water supplies for humans and livestock, degrade our recreational water resources, and impair wildlife habitat. Runoff from horse paddocks and/or manure piles can pick up contaminants, such as nutrients, organic matter, and microbial pathogens, and transport them to the nearest water body (lake, pond, wetland, stream, or river). Certain site conditions, such as steep slopes, lack of vegetative cover, and proximity of horse manure to ditches, swales, or natural waterways can increase the potential for contamination of surface water resources. Nonpoint source (NPS) pollution is defined as the accumulation of small pollution sources (like manure piles or paddocks) and single pollution events that as a whole cause significant degradation to water quality. Runoff from stables and ranches may be considered as nonpoint source pollution.

An average 1,000 pound horse produces between 12 to 15 cubic yards (0.75 cubic feet/day) of manure a year. Manure contains inorganic plant nutrients, soluble and insoluble organic compounds, as well as microorganisms. Additionally, at an average use of 1 cubic foot per horse per day, bedding will add another 13.5 cubic yard per year of waste materials that must be properly handled, recycled, or disposed. Manure must be managed to ensure that constituents such as phosphorus, salts, ammonia, nitrate and microbial pathogens are not carried by runoff into waterways or downward through the soil into groundwater.

Horse keepers and stable owners have become increasingly aware of the need to manage wastes generated from horses so as not to negatively impact water quality and the environment they cherish for equestrian activities. Implementing appropriate collection, storage, and management practices on the ranch and in the stable has shown that horses need not contribute to environmental problems. This fact sheet addresses the protection of water quality around horse facilities, water quality parameters of concern, and what you can do to monitor water quality on your ranch or stable.¤

Water Quality Issues of Concern to Horse Keepers

Surface Water

Safeguarding our surface waters is an important part of horse keeping. Aquatic life is highly susceptible to pollutants from human activities. When manure is deposited near surface water bodies, it can negatively impact the quality of water resources if the nutrients contained in manure are carried by runoff to ponds, streams, creeks, or lakes. Nutrients can fertilize aquatic plants, including microalgae, and accelerate growth in water bodies. This accelerated growth can deplete oxygen levels, reducing the amount of oxygen available for aquatic species such as fish and the benthic organisms that fish feed on. When the microalgae or plants die, additional oxygen is required for decomposition, further reducing oxygen levels and water clarity, which impacts aquatic life, and can generate unpleasant odors and/or tastes. This process is called eutrophication. Surface water contamination is a primary concern for Bay Area horse keepers.¤

Watersheds

A watershed is an area of land that drains into a creek or river. Most conservation practices and stewardship programs are implemented on a watershed basis. Landowners need to know what watershed their property is located in to be aware of where water goes and who it potentially impacts. Understanding the connection between the land, water, and human activities in a watershed is a key to preventing problems. A

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healthy watershed will have clean water in creeks, an abundance of fish and wildlife habitat, and a well vegetated and stable riparian zone with little erosion. Horse keepers need to understand the many processes involved in healthy watersheds so that they can help to minimize non-point source impacts to watersheds from their horses and equestrian activities.¤

Groundwater

Ground water and surface water are interconnected. Water in soils both percolates downward and flows horizontally beneath the surface seeking a discharge area such as springs, creeks, wells, and other surface waters. Rainwater may also percolate through and out of large manure piles, leaching nutrients into the ground, and under certain circumstances, these nutrients may reach and contaminate groundwater. Groundwater quality can also be impacted by leached salts or forms of nitrogen contained in manure. Because of the naturally dry nature of horse manure compared to manure from other animals, groundwater contamination is of less concern to Bay Area horse keepers than the potential for surface water contamination. However, if your paddocks or manure piles are on porous soils, like sand and/or in an area with a high water table, special consideration may need to be given to groundwater protection.¤

Water and Soils

Soils vary in their ability to hold water, their ability to percolate water and the types of vegetation they can support. This affects the rate at which nutrients and pollutants are carried by water and go down through the soil layers impacting the land's ability to absorb runoff. Clay soils are the least permeable and absorb water slowly whereas sand is highly permeable allowing water to penetrate quickly downward. One of the greatest non-point pollution sources in the Bay Area is from sedimentation caused by the erosion of soil particles that are then carried by water into streams. Areas with bare soil at horse facilities such as turnouts, corrals and paddocks are subject to erosion. Horses can also contribute to sedimentation through grazing on wet soils that can cause soil compaction. Soil particles pressed together from the pressure caused by the weight of a horse reduces the space between the soil particles resulting in soil compaction. Compaction decreases infiltration of rain water and thus increases runoff and the potential for soil erosion further down the slope or drainageway. Adopting proper management practices can minimize erosion , and thereby sedimentation from horse keeping facilities. ¤

Water Quality Parameters of Concern to Horse Keepers

Nutrients

Horse manure composition varies depending on the type and quantity of bedding used, age and function of the animal, kind of feed, and how the manure is stored. Table 1 gives an average nitrogen, phosphorus, and potassium (NPK) content of horse manure alone and with bedding.

Table 1. *Average nitrogen, phosphorus, and potassium content of horse manure and manure with bedding (dry weight basis)*

	Manure alone	**w/bedding**
Nutrient	*(%)*	*---- lbs/ton ----*
Nitrogen (N)	*0.95*	*19*	*11*
Phosphorus (P)	*0.3*	*6*	*2.2*
Potassium (K)	*1.5*	*30*	*13*

Well vegetated riparian zone.

Water quality parameters of concern to horse keepers include: Ammonia-Nitrogen, Nitrate-Nitrogen, Phosphorus, Organic Matter, Salts, Microbial pathogens, Dissolved Oxygen, Temperature, pH, and Sedimentation.

Ammonia Nitrogen

Ammonia is found in fresh manure. It is also formed during the decomposition of manure and bedding. It easily dissolves in water and can be either a direct "fertilizer" in water or at higher concentrations directly toxic to aquatic organisms including fish. Ammonia-nitrogen is an inorganic form of nitrogen that results from decomposition of organic materials by microbes. Total ammonia is composed of ion-

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ized (NH_4^+) and unionized ammonia (NH_3) with the latter form being the most toxic to aquatic animals. The percentage of the unionized form or NH_3 increases with increasing temperature and increasing pH. It can be lethal at concentrations of 0.025 parts per million (ppm which is the same as milligrams per liter or mg/l). Ammonia is typically found at very low concentrations (<0.5 ppm) in pristine water bodies. Horse keepers should strive to keep total ammonia below 1 ppm and unionized ammonia less than 0.025 ppm in any runoff.¤

Well vegetated riparian zone.

Nitrate-Nitrogen

Nitrate (NO_3^-) is another inorganic form of nitrogen that is formed by microbial activity during the decomposition of manure. In simple terms, bacteria oxidize ammonia to nitrate. Nitrification is most rapid at pH of 7 to 8 and temperatures of ~65 to 95 degrees Fahrenheit. Nitrate in drinking water is of great concern to babies and children due to the ability to interfere with oxygen absorption (blue-baby syndrome). Livestock are also at risk from drinking nitrate contaminated water. The acceptable limit for humans is currently 10ppm nitrate-N and for livestock it is 100 ppm.¤

Phosphorus

Phosphorus, primarily in the phosphate form, is of increasing concern and is becoming a key indicator in determining pollution of waters. The growth and development of aquatic microorganisms, microalgae and higher plants are most limited by the low concentrations of phosphorus in natural water bodies. Therefore they will respond quite rapidly when phosphorus is added to the aquatic environment. While the total phosphorus in manure is lower than that of nitrogen, it can have a greater environmental impact. Typically natural waters may have concentrations of 0.1 to 0.2 ppm phosphate-phosphorus (PO_4-P). Phosphorus can be leached directly from manure, but more importantly, it can also attach to soil particles and may enter water bodies if soil erodes from the vicinity of manure piles or manure-fertilized pastures. Phosphorus is only present in livestock urine in trace amounts. ¤

Salts

Collectively, nutrients such as nitrogen, calcium, potassium, sulfur, etc, can be found as inorganic salts in manure. Fresh manure contains these soluble salts in varying amounts. Salts make water "hard" and thus reduce drinking water and aquatic habitat quality. Composting of manure reduces the quantity of salts available. High salt content in soils interferes with plant water uptake resulting in reduced plant growth and germination. Currently the limit for salts in drinking water is 1,000 ppm total soluble salts. Salts or salinity are measured by electrical conductivity with a meter that records micromhos per centimeter or µmhos/cm. For reference, 1,000 µmhos equals 1 millimole and 1mmhos/cm = 640 ppm total soluble salts. Horse keepers should strive to keep conductivity below that of safe drinking water standards. ¤

Organic Matter

Manure contains a high percentage of organic matter. This organic matter is made up of complex and simple compounds containing carbon and may include uneaten feed, grains, hay, and bedding. A variable percentage of the organic matter in manure and bedding is soluble in water. One can see the effects of this around the edges of saturated manure piles where the water is tea-colored. These soluble organic compounds are often preferred food or energy sources for aquatic microorganisms. These compounds may increase the Biological Oxygen Demand (BOD) in a water body. The term BOD simply refers to the amount of oxygen used by microorganisms during the use or decomposition of these organic compounds. BOD is an important water quality parameter and in chemical terms is a measurement of the ability of bacteria to grow and reproduce in animal waste over a 5 day period. It is not typically measured by horse keepers. However, BOD may be measured when a facility is regulated under a discharge permit. As with phosphorus, the variable, yet low amount of dissolved organic matter typically found in coastal streams limits BOD .Substantial increases in dissolved organic matter levels can lead to oxygen depletion and the potential for fish kills. Dissolved organic matter can also increase the cost of drinking water treatment and can impart an off-taste to water. Additionally, woody bedding may contain slowly soluble compounds

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important to the aquatic food chain. A desirable management practice for horse keepers is to keep BOD in runoff below 10 ppm¤

pH

Water pH is a measure of the hydrogen ion concentration and ranges in value from 0 to 14. A reading of 7 is neutral while a value below 7 is termed acidic and above 7 termed basic or alkaline. The pH directly affects the amount of unionized ammonia in water. An increase in pH and/or temperature increases the quantity of unionized ammonia and that can be deadly to aquatic organisms including fish. Water pH can be measured with litmus paper or a more sophisticated meter. A good pH range for water is between 6.5 to 8.5.¤

Dissolved Oxygen and Temperature

Neither dissolved oxygen (DO) nor temperature are considered pollutants, but both are important water quality parameters of concern as they help describe the relative health of a water body. DO is the concentration of oxygen molecules dissolved in water and is critical to the health of aquatic organisms, especially fish. As organic materials, such as animal wastes, enter surface waters, micro-organisms in the water use the organic materials for food (as a carbon source) consuming DO in the process. If the DO drops sufficiently, larger aquatic organisms, like fish, cannot effectively compete with the resulting micro-organisms and plants and can become stressed and die. DO decreases as water temperatures increases. Trout and salmonids are cold water fish, meaning they thrive in colder, highly oxygenated waters. Both DO and temperature in water bodies fluctuate over the course of a day. If DO is extremely high (greater than 15 ppm) in the late afternoon, then it typically indicates a high concentration of aquatic plants and/or microalgae that will consume this oxygen at night (through respiration), dropping the DO to low levels that may endanger fish. Water bodies should maintain DO concentrations at 5 ppm or higher in order to support healthy fish populations. Good coastal streams typically have DO concentrations in the 7-10 ppm range from natural shading and riparian habitat that help keep waters cool. ¤

Microbial Pathogens

Coliform bacteria can be a microbial pathogen of concern for horse keepers. The State Water Resources Control Board has identified coliform bacteria as a major source of non-point source water quality problems in many streams throughout the Bay Area. There are many species of coilform bacteria, some are pathogens and many are not pathogenic. Coliforms in streams may be contributed from many sources including runoff from leaking aged septic systems, paved surfaces and roads, warm blooded animals and birds including both domestic and wildlife species. A number of microorganisms can be found in horses and horse manure, however, the majority are beneficial and necessary for digestion. Some, however, can become pathogenic. Although little is understood about what causes organisms to become virulent, it is best to keep coliform bacteria out of water. The best way to avoid coliform problems with your horses is through sound manure *management practices. Coliform tests cover a wide variety of species with E.* coli *being the most common used organism test. The test is complicated and typically only performed by private and government laboratories. Coliforms are counted and reported as Most Probable Numbers. Runoff waters should be below 200 MPN with readings below 100 MPN being desirable.¤*

Retention pond.

Water Quality Monitoring

The decision to measure water quality may result from any number of reasons including, personal interest of the landowner, as part of a ranch or stable conservation plan, or due to a regulation, permit or potential violation. Advice should ***always*** *be sought from your local RCD, NRCS, Farm Advisor, or other professional consultant prior to undertaking your own water quality monitoring program. A horse keeper can learn to monitor water quality with simple test kits (see below) if their desire is to gain a better understanding or snapshot of water quality on their ranch or property. A horse keeper should use a certified laboratory if a regulatory issue exists or legal action may be pending. Most commercial laboratories are quality assured meaning that their work will*

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withstand legal scrutiny. Readers should understand that water quality monitoring and interpretation of data requires attention to detail along with proper training and experience. This publication focuses on test kits and their use in understanding water quality on the ranch or stable. For information on water quality standards and the State Water Resources Control Board's Surface Water Ambient Monitoring Program or SWAMP, go to: www.swrsb.ca.gov/swamp. ¤

Why Test?

State and federal laws both require urban and rural landowners to prevent water pollution. You may have a need to test if you operate a large stable, live adjacent to a stream that has water quality concerns, are seeking permits, or have had your horses indicated (correctly or incorrectly) as a source of pollution. Reasons to monitor your water quality include helping maintain a healthy environment for your horses, prevent spread of pathogens to your horses, help maintain clean water for human use, and to prove you are a good land steward thus avoiding any potential violations, fines or legal actions from your neighbors and/or regulatory agencies. It is better to become proactive, than to try to play catch-up after a spurious neighbor complaint!¤

What to Test

The most important water quality tests for horse keepers include ammonia, temperature, pH, dissolved oxygen, conductivity, sediment and water flow (if you live along a creek). Coliforms may be important to be tested for certain regulatory issues. Coliform tests on water samples should be undertaken by a qualified laboratory.¤

When to Test

Water quality testing might be done monthly or quarterly throughout the year if water is flowing in the stream during dry summer months. Testing may be done following runoff from early rains that might contain the highest amount of animal waste that has accumulated throughout the summer. Testing may also be undertaken during a significant storm event defined as an inch or more during a 24 hour period. Testing should not be undertaken during low stream flows.¤

Where to Test

If your site is along a perennial stream, then you should test both upstream and downstream of your property boundaries. This will tell you how clean the water is entering your property and whether or not conditions on your property are contributing to any water quality problems as the water flows out. As a general rule of thumb, you want the water leaving your property to be as good or better than the water entering your property. If water leaving your property shows problems, then work your way back upstream testing as frequently as necessary until you find the source(s) of your problems. You might also want to test runoff from stable areas, feeding areas, watering areas, manure storage areas, and manure application areas.¤

How to Test

Testing water quality can be relatively simple and inexpensive using commercially available test kits, or complex using a professional company employing more sophisticated equipment and quality control procedures. If you test water quality yourself, make sure you first determine where you are going to test (stations) and how you are going to record the data collected. Once a sampling "station" has been chosen, you should ALWAYS return to that location. Also it is important to realize that multiple tests either on a single collected water sample or tests on more than one water sample collected at the same time can be important to confirm your result. It will also help you to understand how much fluctuation there is in your sampling or test procedure. ***Read the instructions for your test kit carefully!***

Temperature can be easily measured with a thermometer, however, you should use use a different thermometer than that used for a compost pile. Water pH can be easily measured with inexpensive litmus paper. Dissolved oxygen and ammonia can be measured with inexpensive colorimetric test kits. Stream flow may be determined using an object floating through an area of known volume. Low, medium and high flows can be visually estimated.

Your RCD can help you determine how to estimate stream flow. Conductivity must be tested using a meter that can be expensive. DO and ammonia may also be tested with more expensive meters and all of the parameters may be tested using sophisticated scientific equipment and analysis. Coliform bacteria are typically measured by certified laboratories.

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Stream health can also be assessed through monitoring of aquatic organisms, specifically some macro- invertebrates. Basically, the presence or not of some of these organisms can be considered to be indicators of stream health. Attending training sessions to learn what the organisms are and which are more pollution tolerant than others may be very helpful. There are also publications available to help determine what organisms may be found in your particular area. ¤

Water Monitoring Equipment

A number of companies sell inexpensive test kits and water quality monitoring equipment. A partial list is provided below. Most have web sites and free catalogs and will gladly price and provide technical assistance on their equipment to meet your needs. Contact your extension office, RCD or NRCS for further information and assistance. RCDs or other groups may have kits for loan, and some organizations may offer training in landowner self-monitoring.

Aquafauna Biomarine	*310-973-5275*	*www.aquafauna.com*
AquaVet	*510-782-4058*	*www.novalek.com*
Aquatic EcoSystems	*800-422-3939, 407-886-3939*	*www.aquaticeco.com*
CHEMetrics	*800-356-3072*	*www.chemetrics.com*
Cole-Parmer Instrument	*800-323-4340*	
DeltaTRAK	*925-249-2250*	*www.deltatrak.com*
HACH Company	*800-227-4224*	
Hanna Instruments	*877-694-2662*	*www.hannainst.com*
LaMotte	*800-344-3100*	*www.lamotte.com*
Rosemount Analytical	*800-854-8257*	*www.raihome.com*
Yellow Springs Instruments	*800-897-4151*	*www.ysi.com* ¤

Further Reading

Available from your local RCD Office or NRCS, Petaluma CA:

Simply the Facts on Animal Waste and Water Monitoring (a simplified explanation of each water quality parameter and levels for good, caution or danger. These levels were developed by landowners, USDA Natural Resources Conservation Service, U.C. Cooperative Extension and other groups. Available from USDA NRCS Petaluma, CA.

Simply the Facts on Monitoring Sites explains where to monitor on your ranch
Water Quality Variables – good basic explanation of water quality parameters , also available from NRCS, Petaluma, CA
Water Testing for Rural Landowners –tells when where, why and how to test water. Available from NRCS, Petaluma,CA
Hoja de Hechos #1 Calidad de Agua. Como Trabaja ?

Evaluating Water Quality, miscellaneous, available from the San Mateo County RCD.

RCD Websites: 1) Marin RCD and Southern Sonoma RCD - www.sonomamarinrcd.org
2) Alameda RCD - www.baysavers.org
3) *San Mateo RCD - www.sanmateorcd.org*

The "Equine Facilities Assistance Program" is a grant funded project of the Council of Bay Area Resource Conservation Districts, and the Alameda, Marin, San Mateo and Southern Sonoma RCD's. The manure management fact sheet series was produced with the assistance of the USDA Natural Resources Conservation Service (NRCS).

Funding for this project has been provided to the Council of Bay Area RCD's in part by the U.S. Environmental Protection Agency (USEPA) pursuant to Assistance Agreement No. C9-989697-00-0 and any amendments thereto which has been awarded to the State Water Resources Control Board (SWRCB) for the implementation of California's Nonpoint Source Pollution Control Program. The contents of this document do not necessarily reflect the views and policies of the USEPA or the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.