Assessment of Best Management Practices For Equestrian Facilities in the Tomales Bay Watershed

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ABSTRACT

The Tomales Bay and its tributaries have been listed as impaired by pathogens. The San Francisco Bay Water Quality Control Board, (SFWQCB) has initiated a total maximum daily load (TMDL) planning process for pathogen reduction. Confined animal facilities (including equestrian facilities) have been identified by the SFWQCB as potential sources of pathogens. The Marin County Stormwater Pollution Prevention Program (MCSTOPPP) conducted a Best Management Practices (BMP) assessment of 18 equestrian facilities within the Tomales Bay Watershed. This voluntary assessment program was designed to detect the level of actual or potential pollutant sources discharged from these facilities. MCSTOPPP staff and a private equestrian consultant conducted the assessments. Facility BMPs that prevent manure and/or sediment from entering nearby creeks were evaluated. The BMPs were evaluated qualitatively for effectiveness in keeping rainwater runoff from carrying animal excrement into nearby creeks that flow into Tomales Bay. Overall, 16 of 18 facilities exhibited minimal to no discharge potential. There were 13 of 18 facilities effectively using BMPs to eliminate discharge. Of the remaining facilities that had partially effective or non-effective BMPs, 3 of 5 had minimal potential for discharge due to efficient manure management practices and/or small amounts of manure. Professional advice was provided to improve the 5-facilities' BMP implementation and/or management.

INTRODUCTION

The San Francisco Bay Regional Water Quality Control Board, (SFWQCB) has developed a list of impaired waterbodies and pollutants in accordance with Section 303(d) of the Clean Water Act (CWA). Based on numerous coliform monitoring studies, Tomales Bay and its tributaries have been identified as impaired by pathogens (3).

As a part of the Total Maximum Daily Load (TMDL) protocol development, the SFWQCB has identified agricultural runoff from grazed lands and confined animal facilities (i.e., cattle operations, dairies, sheep farms, equestrian facilities, etc.) as one of the significant pathogen-loading sources based on source assessment studies on Tomales Bay. The pathogens of primary concern identified by the SFWQCB include: *Cryptosporidium parvum, Giardia duodenalis, Campylobacter spp., Salmonella ssp*., and pathogenic strains of *E. coli*.

Based on a prior pathogen study on Marin County horses for *E. coli* and *Salmonella*, trace amounts of pathogenic *E. coli* were detected and no *Salmonella* was detected (2). Also, results from another study on manure samples from 91 horses detected no amounts of *Cryptosporidium* and *Giardia spp.* (5). Although these studies show the absence and/or significantly low levels of these pathogens in horse manure, they will remain on the SFWQCB list as potential pathogens from confined animal facilities. There are no known studies on *Campylobacter spp.* in horses.

Tomales Bay is also listed as being impaired by nutrients and sediment. Grazed lands and confined animal facilities may be potential sources of these pollutants.

Regardless of the type of pollutant, the most efficient and cost effective method known to reduce or eliminate pollutant discharges from equestrian facilities are effective Best Management Practices (BMPs). Appropriate BMPs, when implemented properly, may reduce or eliminate upper watershed-borne pollutants.

The focus of this study was to assess types of BMPs used at horse facilities within the Tomales Bay watershed and to determine qualitatively how effective they are at reducing or eliminating pollutant discharges into adjacent creeks. The initial intent was to determine the effectiveness of BMPs employed and then to recommend improvements whenever necessary.

SCOPE AND AREA OF STUDY

The study was conducted by the Marin County Stormwater Pollution Prevention Program, (MCSTOPPP). An equestrian facility consultant was hired by MCSTOPPP to aid in conducting the study. Individuals conducting the study were Dave Nicholson of MCSTOPPP, and Michael Murphy, equestrian consultant.

The goal was to assess approximately 80-100% of the equine facilities within the Tomales Bay Watershed. It was initially determined that 20 facilities would offer enough data for the study (estimated to be at least 80% of the equine facilities in Tomales Bay). Therefore, a list of 20 horse facilities within the Tomales Bay watershed was compiled. The list of equine facilities was compiled from several sources: a prior Marin County equine facility study (6), the Marin Horse Council, and personal references from sites visited. From that list, site visits were arranged on a voluntary basis. Dave Nicholson and Michael Murphy conducted all site visits. Due to time constraints or refusals, only 18 of the 20 facilities were visited.

The area of study included San Geronimo Creek, Lagunitas Creek, Olema Creek, and the Walker Creek sub-watersheds (Appendix-A).

METHODS & MATERIALS

A checklist used for gathering consistent information from each facility was formulated and approved by the SFWQCB, the Marin Horse Council (MHC) and MCSTOPPP (Appendix-B). The checklist was set up to collect data on general facility information, building condition, stormwater conveyance, manure and paddock management, and nearby creek/watershed information.

BMP effectiveness was based on qualitative measurement rather than quantitative. For example, some grassy swales were observed to have fresh sediment accumulation from the prior rainy season. Another example observed was a soil-constructed berm that had clearly diverted stormwater away from confined animals. Note that there were no water quality analyses conducted to test BMP effectiveness, but such quantitative measurements may be implemented in future studies.

General facility information included location, ownership, facility size, animal density, and general proximity to nearby creek(s).

With respect to rooftops as an impervious surface, stormwater runoff conveyance via roof rain gutters and downspouts were observed. To prevent roof runoff from carrying pollutants to a nearby waterbody, all roof runoff should be channeled away from confined animal areas. This is best accomplished with the use of rain gutters and downspouts. The presence, condition, and maintenance status were noted for all rain gutters and downspouts. Also, the conveyance and destination of roof runoff was observed as well as the methods used to channel roof runoff away from animal pens and pastures.

Conveyance of stormwater runoff from the facility to a nearby creek was observed and the type, condition, discharge potential and BMPs used were noted. Once the type or method of stormwater runoff management was observed, its path and destination were evaluated. During this process, BMP efficiency and use were noted. Finally, it was determined whether any pollutant discharge or potential for discharge was present.

For manure management, collection frequency, storage conditions and composting information were observed. Noting the frequency of manure collection in stalls, paddocks and pastures was useful in determining the overall cleanliness of the site. The manure is easier to manage from a centralized storage location. If manure was being stored on site, the volume was estimated and manure containment was evaluated.

Manure volumes for each site were estimated based on the approximate volume observed. This estimation was labeled as “actual” volume and typically represented approximately a 30-day accumulation period. The volume estimates were grouped into the following ranges:

- <5cy
- 5 to 10cy
- 10 to 25cy
- 25 to 50cy
- 50 to 100cy
- >100cy

The on-site “actual” volume of manure was compared to the “expected” average daily volume (calculated from known standards).

Stall bedding materials are typically expected to add 50 to 75% of the total manure-pile volume. This was confirmed by field observation throughout the study and from prior studies (6). For this reason, the field actual volumes were assumed to be half manure and half bedding material (50% bedding).

Although Marin County Code (Section 7.08.090) prohibits accumulation of manure for more than 3-days, many of the facility managers reported that a maximum 30-day accumulation period is manageable. Marin County Environmental Health Services (EHS) enforces the 3-day maximum on a complaint basis, as EHS does not conduct routine inspections of equestrian facilities (4). Consequently, provided the stored manure is well contained, completely covered, does not have any liquids leaking or draining from it, has an impervious bottom, does not generate odor complaints, and does not attract or harbor vermin or vectors (such as flies or rats), storage of manure in excess of 3-days typically does not result in compliance issues with EHS. As stated above, the majority of the property owners/managers surveyed have found that, on the average, manure storage accumulation is manageable for up to 30-days. Therefore, as long as the manure storage is managed in a way that prevents any discharge to nearby water bodies, a 30-day (or less) storage period was determined reasonable.

Based on the above observations and guidelines for manure storage, it was determined that 30-day accumulation calculations for expected manure production would allow for a comparison between the volumes observed in the field, and volumes expected.

Equation-A was used to calculate the expected manure volume. It is based on the expected daily volume of 0.75 cubic feet (ft^3) per day of excrement per an average 1,000 lb horse (8, 9).

$$\mathbf{n[0.75\ ft^3/day\text{-}horse]d = V_e} \qquad (A)$$

The number of horses per facility, n, multiplied by expected manure volume per horse, per day, multiplied by the number of accumulation days, d, yields an expected volume (ft^3) of manure, V_e. The field volume estimations were based on cubic yards, so V_e was converted to cubic yards (B). A sample calculation appears in Appendix-C.

$$\mathbf{V_e/[27\ ft^3/yd^3]} \qquad (B)$$

If composting operations were being conducted, the irrigation frequency, runoff containment and runoff destination was noted. Efficient and effective composting operations that utilized appropriate irrigation, turning, and compost duration were considered successful. Effective composting includes irrigation and turning at least 2 to 3 times a week, and composting for at least a 90-day duration. Just storing a pile of manure does not constitute composting.

The final survey category was Observation of Nearby Creek and Watershed Conditions. Parameters noted were as follows: creek classification, animal access, riparian zone condition, mud management, proximity of manure storage to the creek, potential impacts from the manure pile on water quality, and BMP effectiveness. General creek classifications used were as follows: perennial, intermittent, ephemeral, and natural swale. For the riparian zone, the type of vegetation was noted. Percentage of tree cover, presence of underlying brush, and percent of native vegetation were estimated.

Each site was visited during the daytime and the checklist was filled out during the site visit. Also, during each site visit, landowners and/or managers were advised on BMP improvement where it was determined that the BMPs employed were not effective. Improvements consisted of repairing failed BMPs, upgrading outdated systems and/or installing new BMPs. The checklist was also used to indicate the type of BMPs used and/or recommended. Examples of the BMPs that were expected or suggested for use include berms, grassy swales, detention ponds, and/or as per the Horse Keeping Manuel of the Natural Resource Conservation Service (8).

Finally, the datasheets from all eighteen facilities visited were numbered to allow anonymity for the property owners, and the data was compiled and evaluated (Appendix-C). This study will be made available for viewing on the MCSTOPPP website (*www.mcstoppp.org*).

RESULTS

The majority of the facility managers surveyed expressed an interest in protecting the watershed by reducing and/or eliminating any manure discharges. Most were fully aware of both the environmental and legal consequences for pollutant discharges.

Among the 18 facilities, 272 horses were observed over 380 acres. There was an average of 15 horses per facility on sites that averaged 21 acres in size. The average number of horses per acre was 1.48. The largest and smallest sites were 100 acres and 1.0 acre respectively and the highest and lowest density was 4.2 horses/acre and 0.10 horses/acre respectively (Table-1). *Note that 15 of the 18 sites had 2 or fewer horses per acre* (Appendix C).

Table-1. *Facility Animal and Area Totals with Animal Density Totals.*

Parameter	High	Low	Totals	Average
No. of Horses	100	2	272	15
Facility Area (acres)	100	1	380	21
Horses/acre	4.20	0.10	26.7	1.48

BUILDINGS

Of the 18 facilities visited, 3 of them had no buildings. Of the 15 facilities observed with buildings, 12 of them had rain gutters and downspouts. All of the rain gutters and downspouts observed were in good operating condition. With respect to the rain gutter maintenance, 11 were well maintained and unobstructed. All the downspouts were well maintained and unobstructed. Note that one site with multiple buildings had some without rain gutters and downspouts (Table-2).

Table-2. *Rain Gutter and Downspouts Condition and Maintenance at 15 of the 18 Facilities.*

Parameter	Rain Gutters	Down spouts
Rain Gutters Present	12	12
None[1]	4	4
Condition		
Good/Functional	12	12
Bad/Needs repair	0	0
Maintenance		
Clean/Unobstructed	11	12
Needs Maintenance	1	0

1. One facility had some buildings with and some without downspouts.

Gutter Water Diversion. For each facility, gutter water diversion from paddocks, manure storage, and natural waters and waterways were observed. Generally, 9 (out of 12) of the facilities had roof runoff diverted away from paddocks, 8 sites made sure that roof runoff was diverted from manure piles, 7 from natural ponds, and 4 of the facilities had no BMPs installed to divert roof runoff from animal or storage areas (Table-3).

Table-3. *Roof Runoff Water Diversion from Animal, Manure Storage, and Pond Areas at 12 Sites.*

Water Diversion	No. of Sites
Away from Paddocks	9
Away from Manure Storage	8
Away from Ponds	7
Not diverted	4

Where roof runoff was not diverted from critical areas, most of the facilities had natural or other BMPs installed to reduce or prevent any pollutant discharge, such as grassy swales and french drains. There were 3 facilities (one with 2 areas) that did not divert roof runoff water from paddocks. Among them, 2 facilities had roof runoff water channeled to natural grassy swales located 100 to 150-yards from any watercourse. The facility that had 2 areas where water was not diverted appeared to significantly reduce discharge potential into a watercourse with grassy swales 20 to 40-yards long, small retention ponds, french drains, silt fences, straw wattles, and straw-bale dikes.

STORMWATER RUNOFF MANAGEMENT

Water conveyance BMPs were inspected and non-point sources were identified. The intent of observing stormwater runoff management was to insure that runoff is not flowing through areas where pollutants (sediment and manure) could be picked up and carried into a nearby watercourse. Generally the desired outcome is to keep clean runoff clean, and to channel sediment and/or manure laden water to a separate area that will retain them rather than wash into the any nearby watercourse.

BMP Methods, Water Runoff Destination and Water Runoff Systems Condition. BMP methods were analyzed qualitatively for effectiveness. First, the method of water conveyance for stormwater runoff was noted to identify potential pollutants. Then the type of BMP was noted and weather or not it was effectively retaining pollutants by noting pollutant/sediment accumulation within the BMP.

Some sites had more than one of the listed methods installed. There were 10 facilities that employed open ditches. Although the open ditch is not the preferred method, most of them conveyed runoff to a grassy swale before entering a watercourse.

The least effective stormwater management method is culverts that may transport polluted water from the facility directly into a watercourse. There were 4 sites that had culverts installed, and of those 4, there were 3 that had the culverts outfall to a grassy swale or grassy field before entering any natural watercourse. Only 1 had culverted flow directly to the nearby creek. The property owner at that site was advised to re-rout the culvert to a nearby grassy field.

There were 6 sites that used BMPs not listed on the evaluation form. Effective ones included; sheet-flow over grassy pastures, detention ponds, horses penned away from pastures near creeks in winter, and french drains (other-A). The only non-effective one was a rock-lined ditch leading to a nearby creek (other-B). These were commonly used in conjunction with the other BMPs listed (Table-4). Note that some sites had a combination of runoff system-types with varying destinations.

Table-4. *Stormwater Runoff Management BMPs Systems, Their Potential Effectiveness and Water Flow Destination.*

Type/Destination[2]	Effective BMP? *Yes*	Effective BMP? *No*	Systems
Open Ditch to grassy swale	✓		10
Culvert to grassy swale	✓		3
Culvert to creek		✓	1
Grassy Swale	✓		10
Other-A[2a]	✓		5
Other- B		✓	1
Flows To:			
Sheet flow into grass	✓		20
Sheet flow into exposed soil		✓	5
Flows directly to watercourse		✓	1

2. Several sites had more than one conveyance method flowing to grass, exposed soil, a watercourse or other type of BMP.
2a. "Other" BMPs deemed effective eliminated or significantly reduced pollutants.

There were 20 water runoff systems among the facilities that directed runoff into a grassy area before discharging into a watercourse. There were 5 systems that directed runoff into exposed soil. This was not considered effective if there was no filtering process, as with a grassy area, before entering a creek. Of the 5, there were 4 systems that directed any soil-laden runoff into a grassy swale before entering a watercourse. The remaining 1 of the 5 had no creek nearby. There was 1 runoff system with a direct discharge into a creek. The property owner/manager of that site was advised to direct all runoff to the 100-ft grass buffer between the facility and the nearby creek (Table-4).

The condition and maintenance status of the water runoff systems were evaluated. The majority of the systems were in good operating condition and 11 of the 18 were well maintained (clean and unobstructed). Of all the sites visited, 6 did no maintenance on water runoff systems because they were self maintaining. Nearly all of the water runoff systems exhibited little to no erosion or erosion potential while only 1 site required some repair to erosion conditions.

Pollution Discharge Status/Potential. The presence or potential for a discharge into a creek or watercourse was noted for each site. A discharge consists of any pollutant entering a watercourse under stormwater or non-stormwater runoff conditions. If a discharge to a watercourse existed, the source of the discharge was noted and guidance for correction was given.

Discharge levels were estimated as minimal, moderate and high potential. A minimal-potential discharge constitutes little or no adverse water quality effect. A moderate-potential discharge constitutes a water quality effect that may have an adverse impact on aquatic organisms, or may approach water quality standards set by the SFWQCB. High-potential discharges constitute an exceedance of SFWQCB water quality standards and thereby potentially contributing to an impaired waterbody.

Among the 18 sites visited, 13 had neither a discharge present nor potential to discharge. The BMPs employed at those sites were types known from prior studies to be effective at retaining the target pollutants, such as grassy swales. On the other hand, the remaining 5 sites had either a discharge present, or a potential discharge due to BMP ineffectiveness or lack of BMP use. Of those 5 sites, 1 had minimal-potential for discharge, 2 had a moderate-potential, and the remaining 2 had a high-potential. This potential was qualitatively assessed according to the type and condition of the BMPs used. The site deemed to have minimal potential had an extensive array of BMPs installed, such as berms, grassy swales, holding ponds, etc. The minimum-potential may be attributed to two conditions. First, horses were allowed to cross the creek at one point during the summer. Any manure inadvertently allowed to remain within the ordinary high water mark would result in a pollutant discharge. Second, there are three creeks that converge at this particular site; as a result, more BMPs are needed which require more time, cost and maintenance.

Of the 2 sites with moderate-potential, one site only needed to collect manure more frequently from the paddocks to eliminate 99% of any potential discharge. The property owner was advised to collect manure more often. The other of the 2 sites could improve BMP conditions by installing a fence and planting grass to establish a 50-foot buffer between the paddock and the creek.

The final 2 sites had a high-potential for discharge due to improperly installed BMPs, or no BMPs at all. One site had a paddock located within a natural watercourse and some open ditches that drain directly to the nearby creek. They were advised to abandon the paddock in the watercourse, and to convert the open ditch to a grassy swale. The other site had a culvert that collected water from paddocks routed directly into the creek. They were advised to re-route the culvert into a 100-foot grassy buffer between the facility and the creek.

Categories of discharge sources or potential sources that were observed for each site included erosion/sediment control, storage containment, animal pens, open pasture, and compost bins/piles. An erosion/sediment source constitutes soil exposed to rain and/or runoff and may be washed into a creek or watercourse. A source from storage containment may constitute poor manure containment resulting in rainfall exposure or by runoff flowing through the manure pile. Animal pens and open pastures exposed to rain or runoff where manure is not collected could result in a potential pollutant discharge. And lastly, as with storage containment, poorly managed compost bins/piles where water may carry manure constitutes a discharge potential. These categories were observed for each of the 5 sites that had a potential for discharge (Table-5).

Table-5. *Discharge Sources Attributed to Improper or No BMP Implementation at 5 sites.*

Source	No. of Sites
Erosion/Sediment	4
Manure Storage	2
Animal Pens	5
Open Pastures	4
Compost bins/piles	0

Reasons for No BMP Use. There were 4 sites that had no BMPs implemented. A list of reasons was anticipated and noted on the checklist to include the following:

- No Time
- No Money
- No Expertise
- No Interest
- Natural Conditions don't Warrant BMPs

Of the 4 sites, 2 had natural conditions (large naturally occurring grassy swales) that did not warrant BMP implementation. There was 1 site that had no expertise and 1 site that listed no money as the reason for its lack of BMP use (Table-6). These two were advised that BMP consultation is available from the MCSTOPPP at no cost to the landowner. There are no funds available from MCSTOPPP for materials and labor at this time.

Table-6. *Reasons for no BMP Use on 4 of 18 sites.*

Reason	No. of Sites
No Time	0
No Money	1
No Expertise	1
No Interest	0
Natural Conditions don't Warrant BMPs	2

MANURE MANAGEMENT

Appropriate manure management is the most important BMP a facility employs. Water quality may be significantly impaired with manure mismanagement especially in areas exposed to rain and subsequent run-off. Proper management, on the other hand, can significantly reduce or eliminate discharges.

Adequate manure management is comprised of two general BMPs: regular collection and storage management. Collection should be conducted daily at a minimum. Storage should meet the standards set forth by EHS (depicted in Methods and Materials). It should be contained well enough to eliminate any stored material from being washed into a nearby creek and it should be covered. Manure piles exceeding a volume where it becomes difficult to manage may result in a discharge.

Manure Collection. The survey found that 10 of 18 facilities collected manure at least daily. There were 4 sites that collected 2 to 3 times a week, and the remainder of the sites either collected monthly, or not at all. Some of the sites varied in collection frequency. The two sites that did not collect at all had a combination of exclusively open pastures and/or a relatively low animal density (Table-7).

Manure collection in open pastures varied significantly from paddock and stall collection. It was found that 13 of the sites did not collect manure in their pastures. 1 site collected daily, 1 site collected 2 to 3 times a week, 1 site collected monthly, and 2 sites didn't have any pastures (Table-8).

Table-7. *Manure Collection Frequency in* ***Stalls*** *and Paddocks Exposed to Rain or Runoff and the Average Animal Density Among Them.*

Collection Frequency	No. of Sites	Ave. Density
		horses/acre
Daily	10	1.90
2 to 3 times a week	4	1.73
Weekly	2	0.24
Biweekly	0	-
Monthly	2	1.56
Not Collected	2	1.22

Table-8. *Manure Collection Frequency in* ***Pastures*** *and the Average Animal Density Among Them.*

Collection Frequency	No. of Sites	Ave. Density
		horses/acre
Daily	1	3.50
2 to 3 times a week	1	2.00
Weekly	0	-
Monthly	1	3.70
Not Collected	13	0.90
No Pastures	2	-

Regular *pasture* manure collection was generally not necessary unless the animal density was high enough to result in excessive manure accumulation, which was found at 2 sites. Between those 2 sites, pasture manure was collected daily and/or at least 2 to 3 times a week. If any horses were kept in areas with steep slopes near a creek, it could be argued that manure dropped in those areas could wash into the creek. No facilities appeared to have horses kept on steep slopes near creeks.

Manure Storage & Containment Management. The concerns with stored manure are volume, containment and storage time. The volume of onsite-stored manure should not be significantly higher than expected for the number of animals boarded (within a 30-day manure accumulation time) and should not exceed any EHS standards.

Field-calculated volume estimates for the facilities that stored manure (12 facilities) were compared to the expected calculated volumes of manure. The field estimates were based on volume ranges, so the volume value is approximate. Due to bedding materials typically adding 50% volume to storage piles, the field –calculated estimates were 50% of the "actual volume". The expected manure volume calculation was based on an industry standard of 0.75 ft^3/day-horse over 30-days. An average animal size of 1,000-lbs was assumed, so field estimates of expected volume may vary for horses of various size. Also, not all manure produced is collected and placed into a storage area. The majority of the manure collected is from stalls and paddocks, not the pastures.

Sites 2 through 5 had 2 horses boarded, as well as less than 2.5-cy of stored manure. Those sites appeared to have about the expected amount of manure accumulation over a 30-day period. Sites-8, 12, 13, and 15 had more accumulated manure than expected over 30-days (Table-9).

Site-8 had only a few more cubic yards on site than expected, but there was a natural grassy swale about 100-ft long between any manure piles and the nearest watercourse. Site-12 had significantly more manure accumulated than expected. This site also had about 100-ft of vegetated buffer between the manure storage and the nearest watercourse. Site-13 had about 20% more accumulated manure on site than expected. This site had several BMPs employed than appeared to significantly reduce a potential discharge. There were some manure piles fairly close to the nearest watercourse, so the facility manager/owner was advised to move them farther away (at least 50-ft).

Table-9. *Actual*[3] *Manure Volume Compared to a 30-Day Expected*[3a] *Manure Volume for a Given Number of Horses at the 12 Facilities that Stored Manure.*

Site No.	No. of Horses	Expected	Actual
		cubic yards	
2-5	2 ea.	1.7	2.5
8	4	3.3	5-12
9	10	8.3	5-12
11	8	6.7	2.5-5
12	11	9.2	25-50
13	100	83	100
15	30	25	25-50
16	35	29	5-12
17	20	17	5-12

3. The actual manure volume observed in the field was reduced by 50% to account for typical bedding material volume.
3a. Expected volume of manure based on industry standard derived by equations (A) & (B).

Site-15 had about 28% more manure on-site than expected. Between the manure storage and the nearest watercourse at this site were french drains, grassy swales and a 100-ft vegetated buffer. The remainder of the sites had either close to the expected volume or less than the expected volume of manure. Note that the median of the field-estimated manure volume ranges was used for the chart values (Figure-1).

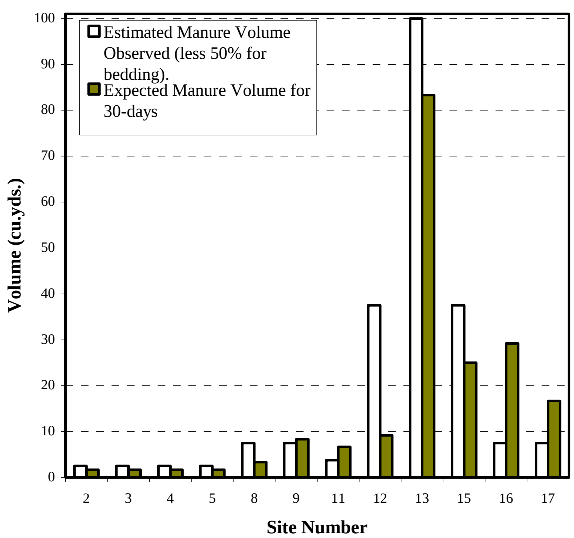

Figure-1. *Estimated vs. Expected Manure Volume at 12 Sites.*

Containment methods for stored manure varied and the site visits focused on containment effectiveness, pervious or impervious bottoms, and proper storage cover. To qualify as a well-contained 30-day storage facility, all EHS criteria for manure storage and containment should be met.

Of the 12 facilities that stored manure onsite (one facility had two storage locations totaling 13 storage piles evaluated), 7 had effectively contained manure piles and 6 of them made no attempt to contain the piles. Although these sites varied in storage volume, the majority of them had adequate run-off BMPs implemented to reduce discharge potential (Table-10).

Table-10. *Manure Storage Containment Practices versus BMPs Implemented per Site.*

Parameter	No. of Sites	Effective BMPs per Site
Effectively-contained	5	4
Not contained	6	6
Pervious bottom	8	5
Impervious bottom	3	2
Covered	3	2

Those that did not have adequate run-off BMPs installed (i.e. culverts directly routed to a water body) were advised on more effective BMPs (i.e. grassy swales).

The majority of the facilities claimed to have their manure hauled away within 30-days. 6 of the facilities had manure hauled away about every 1 or 2-days. Generally, those facilities that did not meet all of the storage containment requirements were advised to do so even if other BMPs were in use.

Manure Storage Proximity and Animal Access to Waterbodies. The proximity of manure storage areas to a watercourse was important to note because of the increased potential for discharge for manure storage within 50-ft of a waterbody. General distances from the watercourse observed in the field were as follows:

- >100-ft
- >50-ft
- Within 50
- Within the creek

Facilities that allow animal access to a creek posed a higher potential for discharge and increased the potential for riparian-zone degradation. *Note that some facilities had more that one creek flowing through it. All site surveys accounted for all creeks within or adjacent to each facility. This accounts for totals higher than the 18 facilities evaluated.*

There were 7 facilities that stored manure for 3-days or greater, and located their storage areas at least 100-ft from any creek. There was 1 facility that stored manure between 50 and 100-ft. There were 4 facilities that stored manure within 50-ft of a creek. These facilities were asked to relocate their piles. There were no facilities storing manure within a creek. The other facilities either had no creek nearby, or did not store manure onsite (Table-11).

Of the 15 facilities located near a creek, 12 had animals fenced out. There were 4 facilities that allowed animal access to the creek either by trail crossing, or within a pasture. Discharge potential and/or riparian zone impairment was assessed for the facilities that allowed animal access to the creek. Of these 4 facilities there was 1 facility that exhibited potential discharge and riparian zone impairment (Table-11). That one facility was advised to move all animals out of the creek and riparian zone.

Table-11. *Proximity of Manure Storage and Animal Access to a Creek of Riparian Zone.*

Parameter	No. of Sites
Storage >100-ft	7
Storage <100-ft, but >50-ft	1
Storage <50-ft	4
Within creek	0
Not applicable[4]	6
Animals fenced away from creek	12
Animals have access to creek	6
Creek/Riparian zone impaired by animals	1

4. Facilities not applicable included those with no nearby creek or no onsite storage.

Composting Operations. Only 3 of the 18 sites visited conducted composting operations. The sites were evaluated based on how the piles were contained, and the destination of water runoff (if any).

Only 1 of the sites irrigated regularly. The composting site at this facility was >100-feet from any watercourse so any non-stormwater pollutant discharge from the composting site would most likely be naturally filtered or settle out before entering any watercourse. The other 2 sites irrigated infrequently or not at all. Irrigation water runoff destination for all 3 sites appeared not to pose any water quality impairment potential. This was due to runoff flowing into grassy areas before entering any watercourse. Of the 2 sites that irrigated, 1 had kept irrigation water contained, and the other site directed irrigation runoff to a grassy swale before flowing into a watercourse.

NEARBY CREEK/WATERSHED ASSESSMENT

Facilities with nearby creeks were inspected using the following criteria: creek classification, proximity to creek, animal access, water quality impairment potential, and riparian zone condition.

Creek Classification. Creeks adjacent to a facility were classified based on their perennial, intermittent, or ephemeral status. Perennial creeks within or adjacent to the facility were given a higher priority for BMP effectiveness than intermittent or ephemeral creeks. This is due to perennial creeks having a higher potential for carrying pollutants via year-around flow, as well as higher consequences for impairment to year-around aquatic life and/or its habitat. *Note that all perennial creeks within the Tomales Bay watershed have been deemed impaired for pathogens, sediments and nutrients and are salmon bearing* (3).

Most of the creeks observed in the study were intermittent. Only 3 of the facilities visited had no nearby creek or watercourse. Some of the facilities had more than one class of creek flowing near or through the property (Table-12).

Table-12. *Creek Classifications Found in the Study*[5].

Classification	No. of Creeks
Perennial	5
Intermittent	7
Ephemeral	4
Natural swale	1
No creek near enough to affect	3

5. Some facilities had more than one watercourse flowing near or through it.

Potential Effect on Water Quality. The majority of the facility visits were conducted during the dry season. As a result, only a potential adverse discharge could be noted. A potential adverse discharge was noted if manure was observed within or near a watercourse, such that it could be washed down into a stream during an average rain event. Although the degree of impairment varied from site to site, any potential impairment was assessed, large or small.

There was no pollutant discharge potential observed at 13 of the 18 facilities. Of the 5 facilities that exhibited a discharge potential, 1 had minimal-potential for discharge, 2 had a moderate-potential, and the remaining 2 had a high-potential. (Table-13). All facilities with a discharge potential were advised on more effective BMPs.

Table-13. *Discharge Potential from 18 Equine Facilities.*

Discharge Potential	Facilities	% of 18
None	13	72%
Potential	5	28%

Riparian Zone Condition. A diverse native flora with a complex under-story is generally an indicator of a healthy riparian buffer (7). The creek needs shade from trees to keep the water temperature down during the day. What's more, based on prior studies, a healthy, dense riparian buffer may aid in filtering out the pollutants of concern from horse facilities.

Although a riparian zone in good condition is not an indicator for a manure, sediment or nutrient discharge, it may be an indicator for the general health of the creek. On the other hand, a degraded riparian zone due to animal access depicts poor creek-side management. A degraded riparian zone in turn significantly degrades the water quality in the form of increased water temperature as well as potential sediment and nutrient discharges. As a result, the riparian zone condition was assessed to gauge the general health of the watercourse.

Percent of riparian cover values were estimated among 15 facilities. Riparian cover was not estimated at 3 facilities because they had no watercourse nearby. The average creek had 70% of canopy coverage, 45% of low-lying vegetation, 82% of native vegetation and 15% with minimal to no vegetation. These numbers generally depict a high average of healthy riparian zones among the facilities evaluated for riparian zone percent coverage (Table-14). Those facilities with minimal to no vegetation were advised to at least seed with native grasses and ideally plant native trees and shrubs.

Table-14. *Riparian Vegetation Condition for the 15 Facilities Observed.*

Condition	Average %
Shaded with Trees and Shrubs	70%
Low-Lying Vegetation	45%
Minimal to no Vegetation	15%
Native Vegetation	82%

BMP Effectiveness. The effectiveness of BMPs is more important than the BMPs themselves. If installed improperly or inefficiently, the BMPs do not succeed in significantly or completely retaining pollutants. The BMP method as well as its implementation was assessed. Any deficiencies noted were communicated to the property owner/land-manager along with ideas for improving them.

There were some sites that had multiple BMPs installed. Every BMP on each site was observed and evaluated. There were 10 of 15 facilities that had effective BMPs with only 1 facility that had ineffective BMPs installed (Figure-2).

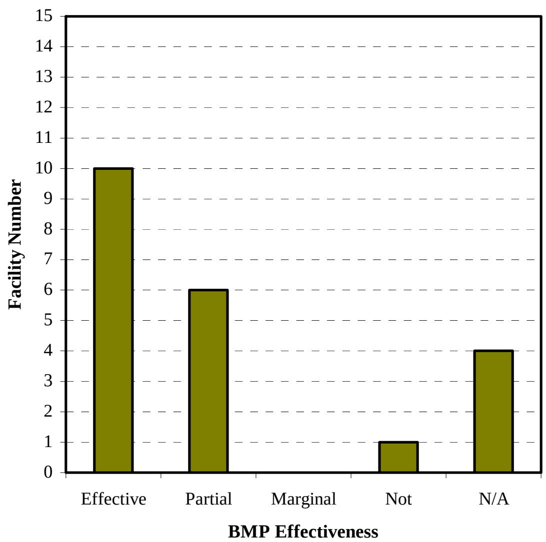

Figure-2. *BMP Effectiveness per Site*.

The sites that were not applicable did not have a creek nearby, or natural conditions —such as natural grassy swales or large open grassy fields— warranted no need to implement BMPs.

Mud Management. Reduction and/or elimination of muddy conditions during winter operations will reduce the potential for sediment to discharge into a water body. It was found that 7 of the sites had no potential to discharge due to mud. This was due to BMPs that insured drier conditions during winter months. One of these BMPs included using gravel in the paddocks to reduce ponding. There were 8 sites that had a potential to discharge sediment. (Table-15).

Table-15. *Muddy Conditions Affect or Potential Affect on Nearby Water Bodies.*

Impact on Water Quality	No. of Facilities
No Impact	7
Potential Impact	8
Impending Impact	3

The majority of the sites visited had BMPs installed that would significantly reduce or eliminate a sediment discharge. There was 1 site that needed to improve BMPs to insure that no discharge would occur during a rain event. That site was advised on how to improve their BMPs.

DISCUSSION & CONCLUSIONS

Recent studies on Marin County horses performed by veterinary researchers at UC Davis have shown that their manure contains negligible amounts of *E. coli* strains, and no *Salmonella*. (2). Other studies have detected no *Cryptosporidium parvum* or *Giardia* in horse manure (5).

A scientific study of the transport of *Cryptosporidium parvum* oocytes through vegetated buffer strips and an estimate on their filtration efficiency was published in *Applied and Environmental Microbiology*, in November 2002. The general results of the study concluded that vegetated buffer strips located in an appropriate soil texture (silty clay and/or loam) with < 20% slope and a length of ≥ 3-meters (or >10-feet) removed ≥99.9% of the oocytes under mild to moderate rain events (1). This study may support the claim that vegetated buffer strips are effective at retaining similar pollutants under normal rain and soil conditions (typical 2-year-event rainfall). There were no known studies on BMP effectiveness noted in this report for significant or catastrophic rain events such as a 100-year event.

Excess pathogens, sediment and nutrients continually pose a potential contribution to waterbody impairment from confined animal facilities. This study demonstrates that the majority of the equestrian facilities visited have implemented BMPs effective at eliminating or significantly reducing pathogen, nutrient and sediment discharges.

Although 24% of the facilities had no runoff diversion from paddocks and pastures, nearly all of those facilities had water runoff flowing to a natural grassy swale before entering a nearby creek. It should be noted that 83% of the facilities have implemented grassy swales and/or other effective BMPs (Table-16). Furthermore, it appears that 83% of the facilities maintain their onsite water conveyance systems and BMPs in working order.

The potential for runoff pollutants in the form of manure and/or sediment was noted at 27% of the sites. There were 5 sites (site-9, and sites-12 through 15) that showed a potential for discharge during a moderate or severe rain event.

Table-16. *Water Runoff Diversion and/or Effective BMP use that Effectively Treats Runoff.*

Runoff Diversion	% of Facilities
Runoff Diverted	76%
Runoff not Diverted	24%
Grassy Swales and/or Other Effective BMP	83%
Diversion Systems/BMPs well Maintained	83%

The property owners/managers were notified of the potential for discharge and given advice regarding regular BMP maintenance as well as how to remedy and/or implement BMPs to reduce or eliminate any discharge potential.

At site-9, there was a discharge potential from contained corrals that drained into an open ditch along the driveway. From there, the stormwater runoff drained directly into a tributary of a major perennial creek. It was suggested that the driveway side-ditch could be seeded with native grasses to filter the runoff. At this same site, there was one corral that had an intermittent tributary flowing through it. It was suggested to the owners that the creek be fenced off at least 50-ft from the top of bank to allow natural vegetation to grow within that 50-ft buffer. Another suggestion was to not allow animals in the corral at all.

Sites-12 through 15 had the potential to discharge due to improper site maintenance. Site-12 had too much manure accumulated in the paddocks. The property owner/manager was advised to increase manure collection frequency especially during the rainy season. With site-13, there were some manure storage piles too close to a perennial creek. The property owner/manager agreed to move them back at least 50-ft to allow a grassy buffer to grow between the creek and the piles. At site-14 there was a minimal discharge potential from an area next to the creek that could easily be fenced off. The property owner/manager had plans to fence off the area and plant it with native grasses. Site-15 was in the process of building some BMPs to help reduce sediment runoff from open pastures. The BMPs under construction included french drains and grassy swales. It was advised that the BMPs be finished before the rainy season. Also, they had some culverts that were carrying runoff from paddocks directly into the creek. The property owner/manager was strongly advised to decommission the culverts, and route the drainage into the large grassy swale/buffer before entering the creek (Table-17).

Table-17. *Sites with BMP Deficiencies with Accompanying Recommendations for Correction.*

Site No.	Deficiency	Recommendation
9	Runoff flows in open ditch and culverts flow to creek	Replace with grassy swale
	Corral within creek	Decommission corral
12	Excess manure accumulation in paddocks	Advised to collect manure more often
13	Manure storage too close to perennial creek	Move piles back at least 50-ft away
14	Animal access to creek	Creek fenced off at least 20 to 50-ft
15	BMPs under construction culverts routed to creek	Finish BMPs before rainy season, remove culverts and route to grassy swale

There were 16 of the 18 sites that either had effective BMPs implemented, minimal discharge potential, or natural conditions that substituted as BMPs. The partially effective BMPs were deficient as a result of the following:

- Needed maintenance
- Based on older, ineffective technology
- Installed improperly

Sites with inadequate BMPs were advised on more effective ones. The one site that had completely ineffective BMPs was almost exclusively using culverts to route water runoff into adjacent creeks. They were advised to remove and/or abandon culverts and implement grassy swales.

In closing, this study set out to evaluate BMP effectiveness at 80-100% of the equestrian facilities in the Tomales Bay watershed. The objective was to determine whether equine facilities are contributing manure, sediment and/or nutrients to Tomales Bay and its sub-watersheds. The study evaluated BMP use and maintenance that would significantly reduce and/or eliminate discharges in the form of pathogens, nutrients and/or sediment.

It was found that the majority of the equestrian facility owners and/or operators were implementing BMPs effectively. There were 89% of the sites visited that had minimal to no potential for discharge of pathogens, nutrients and/or sediments. Those few sites that were found to have discharge potential (11%) were advised on techniques and/or implementation of BMPs that would be effective at eliminating or significantly reducing a pollutant discharge potential.

Following this study, the types and effectiveness of BMPs used at the 18 equine facilities in the Tomales Bay watershed have been made known. These 18 facilities constitute an estimated 80% of the equine facilities in the watershed. After evaluating each facility with the same checklist, it may be concluded that 11% of the facilities visited may contribute to the impaired status of the Bay and/or its tributaries with, at a minimum, nutrients and sediment. This number may be significantly reduced or eliminated if the facility managers/owners employ the BMP improvement advice given during the site visits.

In order to insure that a reduction in pollutant discharge potential occurs, follow-up visits would be in order. Follow-up visits are anticipated for the winter of 2005-06.

ACKNOWLEDGMENTS

Thank you to all the property owners and/or facility managers for granting us permission to visit and evaluate their facilities for the survey. Without their cooperation, this study would not have been possible. Again, thank you!

Also, thanks to MCSTOPPP, for funding this project and to Marin County Environmental Health Services (EHS) for consultations.

Finally, thank you to Liz Lewis, Director of MCSTOPPP, and Rebecca Tuden, of EHS, for help in editing this document.

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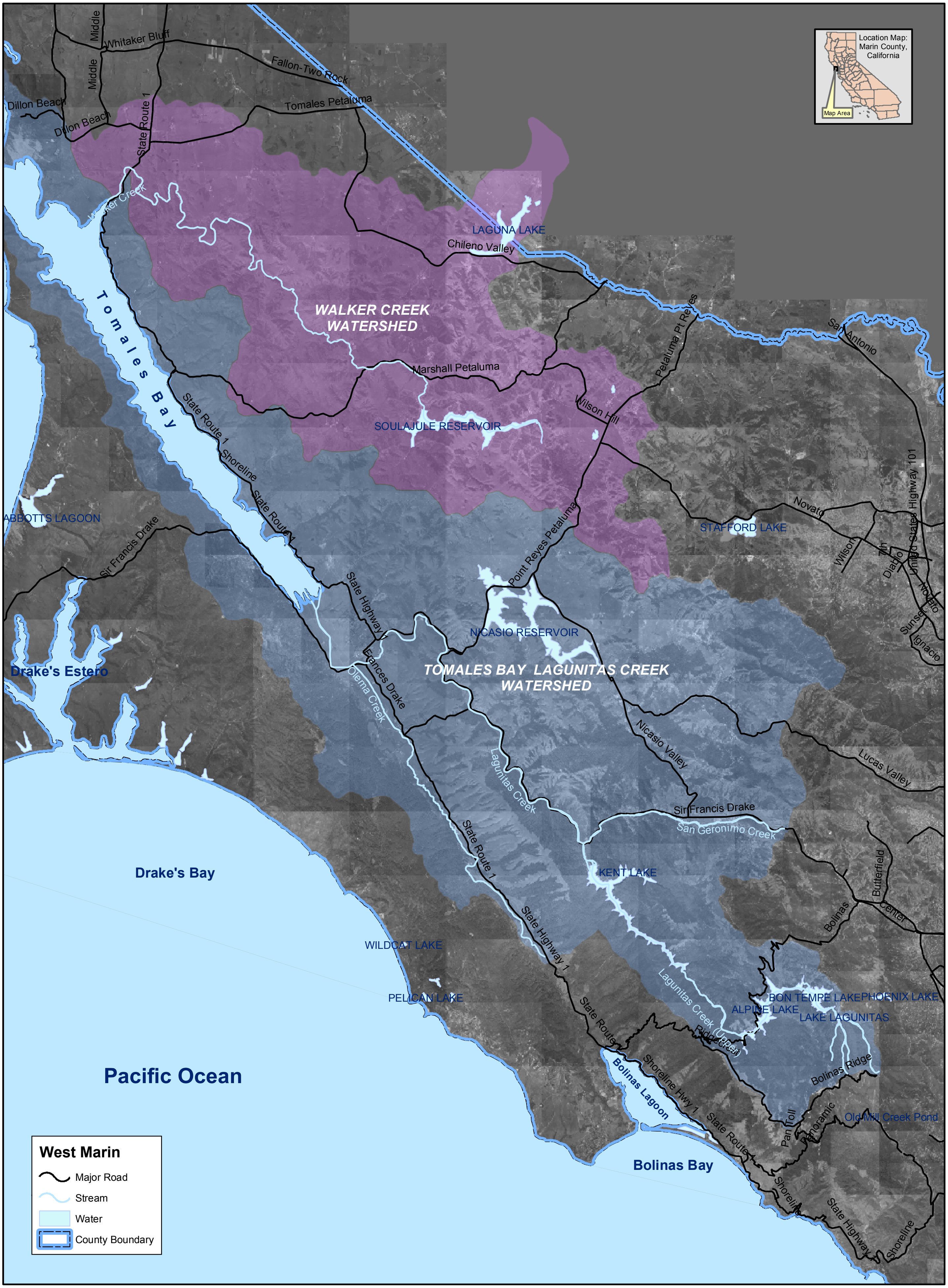
APPENDIX-A
WATERSHED MAP



Tomales Bay Watersheds
Major Stream Drainage

N

Marin County Flood Control and Water Conservation District
County of Marin
Date: May 2005
THIS MAP IS REPRESENTATIONAL ONLY. DATA ARE NOT SURVEY ACCURATE.

Scale: 1 inch equals 3.00 miles

0 1 2 3 6 Miles

APPENDIX-B
FACILITY CHECKLIST

MARIN COUNTY DEPARTMENT OF PUBLIC WORKS
FLOOD CONTROL & WATER CONSERVATION DISTRICT

HORSE FACILITY BMP
CHECKLIST FOR TMDL PLANNING

Date of Visit: Time: Weather: Evaluated By:

Watershed: ______________________

Facility Information

Facility Name: ______________________

Address: ______________________

____

Nearest Creek: ______________________

Facility/storage distance from creek: __________ ft.

Quantity of Horses: ______ Size of Facility: ______ (acres)

Operator/Contact: ______________________

Owner (if different): ______________________

Telephone: ______________________

Fax: ______________________

Horses per Acre: ______________________

FACILITY OBSERVATIONS

Buildings

Rain Gutters ❑ Yes ❑ No

Condition (if installed)
- ❑ Good/Functional
- ❑ Bad/Needs repair

Maintenance (if installed)
- ❑ Clean/Unobstructed
- ❑ Obstructed/Needs cleaning

Downspouts ❑ Yes ❑ No

Condition (if installed)
- ❑ Good/Functional
- ❑ Bad/Needs repair

Maintenance (if installed)
- ❑ Clean/Unobstructed
- ❑ Obstructed/Needs cleaning

Gutter Water Diversion
- ❑ Away from paddocks
- ❑ Away from manure piles
- ❑ Away from ponds
- ❑ Gutter water not diverted

Comments: ______________________

Water Conveyance

Type
- ❑ Open ditch
- ❑ Culvert
- ❑ Grassy swale
- ❑ Other ______

Flows to
- ❑ Sheet flow into grass
- ❑ Sheet flow into dirt
- ❑ Flows directly into creek

Runoff through corrals/manure
- ❑ Completely diverted
- ❑ Partially diverted
- ❑ Not diverted
- ❑ Most percolates in ground

Condition
- ❑ Good/Functional
- ❑ Bad/Needs repair

Maintenance
- ❑ Clean/Unobstructed
- ❑ Obstructed/Needs Cleaning

Typical Water Velocity (if known)
- ❑ Low to normal, no erosion
- ❑ Normal to high some erosion
- ❑ High with erosion present

BMPs Employed (describe below)
- ❑ Berms
- ❑ Open ditches
- ❑ Grassy Swales
- ❑ Other: ______

Pollution Status/Potential
- ❑ **No** pollution discharge present/potential
- ❑ Pollution discharge present/potential

Non-point Pollution Source (if present)
- ❑ Erosion/Sedimentation
- ❑ Manure storage
- ❑ Horse stalls/paddock
- ❑ Horse pasture
- ❑ Compost pile/bins
- ❑ Other ______

❑ Check if no BMPs used/installed

Reasons for not using BMPs
- ❑ No time
- ❑ No money
- ❑ No expertise ❑ No interest

Comments: ______________________

Manure Management

Onsite Collection

Paddock
- ❑ Collected daily
- ❑ 2 to 3 times/week
- ❑ Weekly
- ❑ Biweekly
- ❑ Monthly
- ❑ Not collected

Pasture
- ❑ Collected daily
- ❑ 2 to 3 times/week
- ❑ Weekly
- ❑ Biweekly
- ❑ Monthly
- ❑ Not collected

Onsite Storage ❑ Manure not stored onsite/hauled away

Manure Volume
- ❑ <5 CY
- ❑ 5 to 10 CY
- ❑ 10 to 25 CY
- ❑ 25 to 50 CY
- ❑ 50 to 100 CY
- ❑ >100 CY

Containment
- ❑ Well contained
- ❑ Not well contained
- ❑ Not contained
- ❑ Pervious bottom
- ❑ Impervious bottom
- ❑ Covered

Composting Operations ❑ No onsite composting (if checked, describe reasons below*)

Irrigation
- ❑ Regularly
- ❑ Irregularly
- ❑ Sparsely
- ❑ Not irrigated
- ❑ Water unavailable

Irrigation Run-Off Containment
- ❑ Well contained
- ❑ Not well contained
- ❑ Not contained
- ❑ Pervious bottom
- ❑ Impervious bottom

Irrigation Run-Off Destination
- ❑ Completely contained
- ❑ Open dirt area
- ❑ Grassy area/swale
- ❑ Channeled to a creek
- ❑ Culverted to creek

*Reasons for not Composting
- ❑ Not interested
- ❑ No room
- ❑ No expertise
- ❑ No resources/equipment
- ❑ Interested in trying

Comments: ____________________

Nearby Creek/Watershed Information

❑ There is no creek or water body nearby

Creek Classification
- ❑ Perennial
- ❑ Intermittent
- ❑ Ephemeral
- ❑ Natural Swale

Animal Access
- ❑ Animals fenced out of creek
- ❑ Feed locations away from water
- ❑ Animals have access to creek
- ❑ Animals are within the creek area
- ❑ Creek impaired by animals

Riparian Zone Condition
- ❑ Shaded with trees & shrubs: ____ %
- ❑ Low-lying vegetation: ____ %
- ❑ Minimal to no vegetation: ____ %
- ❑ **Native** vegetation: ____ %
- ❑ **Non-native** vegetation: ____ %

Manure Storage Proximity
- ❑ Storage >100-ft away
- ❑ Storage >50-ft away
- ❑ Storage within 50-ft
- ❑ Storage next to/within watercourse

Manure Affect on Water Quality
- ❑ No impairment/potential present
- ❑ Potential impairment
- ❑ Creek is impaired
- ❑ Pollution discharge present

BMP Effectiveness
- ❑ Effective in pollution prevention
- ❑ Partially effective
- ❑ Marginally effective
- ❑ Not effective

BMPs Employed: ____________________

Comments: ____________________

Paddock Mud Management

❑ No muddy conditions occur around paddocks/pastures

- ❑ Horses are not kept in muddy paddocks or pastures
- ❑ BMPs are employed to prevent or eliminate mud
- ❑ Potential muddy conditions in winter/rain months
- ❑ Owner requests follow-up onsite winter inspection

BMPs Employed: ____________________

Comments: ____________________

APPENDIX-C
FIELD DATA

Results from Equine Facility BMP Evaluations

Facility No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Facility Info																			
No. of Horses	14	2	2	2	2	5	15	4	10	5	8	11	100	3	30	35	20	4	272
Facility Size (ac)	52.0	1.5	1.0	1.0	1.8	16.0	90.0	5.0	100.0	10.0	4.0	3.0	24.0	8.0	16.5	10.0	35.0	2.0	380.8
Horses/ac	0.3	1.3	2.0	2.0	1.1	0.3	0.2	0.8	0.1	0.5	2.0	3.7	4.2	0.4	1.8	3.5	0.6	2.0	26.72
Exp Manure Volume (cy) for 30-days	11.67	1.67	1.67	1.67	1.67	4.17	12.50	3.33	8.33	4.17	6.67	9.17	83.33	2.50	25.00	29.17	16.67	3.33	227
Buildings																			
No Buildings on Site							1			1								1	3
Rain gutters																			
Yes		1	1	1				1	1		1	1	1	1	1	1	1		12
No	1				1	1							1						4
Condition (if installed)																			
Good/Functional		1	1	1				1	1		1	1	1	1	1	1	1		12
Bad/Needs repair																			0
Maintenance (if installed)																			
Clean/Unobstructed		1	1	1				1	1		1	1	1	1	1	1			11
Obstructed/Needs cleaning																	1		1
Not Maintained																			0
Downspouts																			
Yes		1	1	1				1	1		1	1	1	1	1	1	1		12
No	1				1	1							1						4
Condition (if installed)																			
Good/Functional		1	1	1				1	1		1	1	1	1	1	1	1		12
Bad/Needs repair																			0
Maintenance (if installed)																			
Clean/Unobstructed		1	1	1				1	1		1	1	1	1	1	1	1		12
Obstructed/Needs cleaning																			0
Not Maintained																			0
Gutter Water Diversion																			
Away from paddocks		1	1								1	1	1	1	1	1	1		9
Away from manure piles		1	1								1	1	1	1	1		1		8
Away from ponds			1								1	1		1	1	1	1		7
Gutter water not diverted				1	1			1	1										4

Facility No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Water Conveyance																			
Type																			
Open ditch	1	1	1					1	1			1	1	1	1	1			10
Culvert													1		1	1	1		4
Grassy swale	1		1		1	1	1		1	1			1			1		1	10
Other				1			1	1			1	1						1	6
Flows to																			
Sheet flow into grass		1	2	1	1	1	2	1		1	1	1	2		1	3		2	20
Sheet flow into dirt				1								1	1		1		1		5
Flows directly into creek														1					1
Culvert or Other									1						1				2
Runoff through corrals/manure																			
Completely diverted			1								1		1		1	1	1		6
Partially diverted		1						1				1	1		1	1			6
Not diverted	1			1	1	1	1		1					1					7
Most percolates in ground	1																	1	2
Condition (if installed)																			
Good/Functional	1	1	1	1	1	-	1	1	1	1	1		1	1		1	1	1	15
Bad/Needs repair						-						1			1				2
Maintenance (if installed)																			
Clean/Unobstructed	1	1	1					1	1	1	1		1	1		1	1		11
Obstructed/Needs cleaning												1							1
Not Maintained					1				1	1		1			1			1	6
Not Applicable						1	1												2
Typical Water Velocity (if known)																			
Low to normal, no erosion	1	1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	16
Normal to high some erosion													1						1
High with erosion present																			0
BMP's Employed (describe below)																			
Berms								1			1		1		1	1	1		6
Open ditches	1		1									1	1	1	1	1			7
Grassy swale	1	1	1	1				1				1	1		1	1	1		10
Other	1		1			1	1	1	1	1	1		1					1	10
Pollution Status/Potential																			
No pollution present/potential	1	1	1	1	1	1	1	1		1	1					1	1	1	13
Pollution present/potential									1			1	1	1	1				5
Non-point Pollution Source (if present or potential)																			
Erosion/Sedimentation									1			1		1		1			4
Manure storage													1			1			2
Horse stalls/paddocks												1	1	1	1	1			5
Horse pasture									1		1	1		1					4
Compost pile/bins																			0
Other																			0
None				1	1	1	1	1		1							1	1	8
Check if no BMPS' used/installed					1					1				1				1	4
Reasons for not using BMP's																			
No time																			0
No money														1					1
No expertise					1														1
No interest																			0
Natural Conditions no need for BMPs										1								1	2

Facility No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Manure Management																			
Onsite Collection																			
Collected daily			1					1	1		1	1	1	1	1	1	1		10
2 to 3 times/week	1									1			1					1	4
Weekly						1	1												2
Biweekly																			0
Monthly				1	1														2
Not collected		1			1														2
Pasture																			
Collected daily																1			1
2 to 3 times/week																		1	1
Weekly																			0
Biweekly																			0
Monthly												1							1
Not collected	1	1	1		1	1	1	1	1	1	1			1	1		1		13
No Pastures				1									1						2
Onsite Storage																			
Manure not stored onsite	1					1	1			1				1				1	6
Manure Volume																			
<5 CY		1	1	1	1														4
5 to 10 CY											1								1
10 to 25 CY								1	1							1	1		4
25 to 50 CY																			0
50 to 100 CY												1			1				2
>100 CY													1						1
Containment																			
Well contained												1	1		1	1	1		5
Not well contained																			0
Not contained		1	1	1	1				1			1							6
Pervious bottom			1	1	1			1	1				1		1		1		8
Impervious bottom															1	1	1		3
Covered				1											1		1		3
Composting Operations																			
Composing Done Onsite				1				1	1									1	4
No onsite composting	1	1	1			1	1			1	1	1	1	1	1	1	1		13
Irrigation																			0
Regularly				1															1
Irregularly								1											1
Sparsely																			0
Not irrigated									1										1
Water unavailable																			0
Irrigation Run-off Containment																			
Well contained				1															1
Not well contained																			0
Not contained								1	1										2
Pervious bottom																			0
Impervious bottom																			0
Irrigation Run-off Destination																			
Not irrigated									1										1
Completely contained				1															1
Open dirt area																			0
Grassy area/swale								1											1
Channeled to a creek																			0
Culverted to a creek																			0
Reasons for not composting																			
Not interested					1														1
No room																			0
No expertise					1														1
No resources/equipment																			0
Interested in trying																			0

Facility No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Nearby Creek/Watershed Information																			
No creek or water body nearby			1	1	1														3
Creek Classification																			
Perennial										1		1	1		1	1			5
Intermittent		1					1				1		1	1			1	1	7
Ephemeral	1					1		1	1										4
Natural Swale	1																		1
Manure Storage Proximity																			
Storage>100-ft away										1	1	1	1		1	1	1		7
Storage>50-ft away													1						1
Storage within 50-ft								1	1				1						3
Storage next to/within watercourse							1												1
Not Applicable	1		1	1	1									1				1	6
Animal Access																			
Animals fenced out of creek	1	1						1		1	1	1	1	1	1	1	1	1	12
Feed locations away from water	1																		1
Animals have access to creek	1					1	1						1						4
Animals are within the creek area							1		1										2
Creek impaired by animals									1										1
Overall Manure Affect on Water Quality																			
Minimal/no discharge potential	1	1	1	1	1	1		1		1	1		1			1	1	1	13
Potential for discharge							1		1			1		1	1				5
Pollution discharge present																			0
Riparian Zone Condition																			
Shaded with trees & shrubs: %	0%	1%	-	-	-	90%	90%	50%	50%	99%	unk	95%	95%	70%	70%	90%	85%	90%	70%
Low-lying vegetation: %	100%	99%	-	-	-	10%	-	99%	50%	1%	unk	20%	80%	30%	30%	10%	15%	-	45%
Minimal to no vegetation: %	-	-	-	-	-	-	-	-	15%	-	unk	-	-	-	-	-	-	-	15%
Native vegetation: %	98%	98%	-	-	-	98%	90%	20%	50%	99%	unk	85%	75%	85%	85%	85%	85%	98%	82%
Non-native Vegetation: %	2%	2%	-	-	-	2%	10%	80%	50%	-	unk	15%	25%	15%	15%	15%	15%	2%	19%
BMP Effectiveness																			
Effective in Pollution Prevention	1	1				1		1			1		1		1	1	1	1	10
Partially effective							1					1	1	1	1	1			6
Marginally effective																			0
Not effective									1										1
Not Applicable			1	1	1					1									4
Paddock Mud Management																			
Muddy Conditions have no impact		1	1					1		1	1						1	1	7
WQ impairment potential	1			1	1	1	1					1	1			1			8
WQ impairment impending									1					1	1				3
																			0
																			0

SAMPLE CALCULATION

For Facility No. 8 with 4 horses over 30 days:

$n[0.75\ ft^3/day\text{-}horse]d = V_e$ = (4 horses)(0.75 ft^3 manure/day-horse)(30 days) = **90.0 ft^3 manure**

$V_e/[27\ ft^3/yd^3]$ = (90.0 ft^3 manure)/27ft^3/yd^3) = **3.33 yd^3 manure expected to accumulate over 30 days with 4 horses**