Resource Conservation District of Monterey County

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TECHNICAL PAPER

STORMWATER EROSION AND RUNOFF ON SALINAS AND PAJARO VALLEY FARMS

PURPOSE

The purpose of this document is to characterize the typical rates of stormwater runoff and soil erosion under different cropping patterns for Salinas and Pajaro valley farms.

METHODS

Peak and total runoff rates were calculated using the hydrology model presented in the Natural Resources Conservation Service Engineering Field Manual, Chapter 2, which was calibrated using limited field data collected locally during storms. Erosion estimates were made based on field measurements made by the Natural Resources Conservation Service, the Resource Conservation Districts of Monterey County and Santa Cruz County, and the California State University at Monterey Bay in addition to calculations using the Unified Soil Loss Equation modified to include concentrated channel erosion. Input parameters were selected based on historic rainfall data, typical soil types and farm sizes.

LIMITS OF THIS ANALYSIS

This paper is intended for general educational purposes and not for design. Farm facilities including ditches, sediment basins and pipes should be designed on an individual basis. Using the values presented here for design may result in massive erosion, flooding, dam failure, injury and death. Each farm should be evaluated by a professional engineer prior to the design and installation of structures to control water or sediment. The Resource Conservation District of Monterey County and the Natural Resources Conservation Service offer this service free of charge, and capable local engineering businesses are available as well.

The analysis presented here is based on specific hypothetical examples. We discourage extrapolating this information beyond these examples. Each farm is unique and should be evaluated on an individual basis. The combination of soil management, soil type and cropping pattern can increase or decrease runoff and erosion rates substantially. Two farms that appear similar to the untrained observer can vary in their runoff and erosion rates by several hundred percent.

This analysis is based on mathematical models that, while calibrated to observed conditions on Central Coast farms, contain numerous assumptions and simplifications. As such, the full range of conditions is not examined here. Typical values are provided as a general indication of how much runoff and erosion can be expected from different types of land management.

This document is intended to be informational purposes and not intended to promote or guide any regulation on land use restriction. The variability between farms is an important reason why this data should not be used for such purposes.

EXAMPLE FARM BLOCK

The farm block considered for this analysis was 10 acres, square and sloped at four percent. For the case of a strawberry field with full bed plastic mulch, 50 percent of the soil surface was assumed to be covered with plastic. A strawberry field without plastic mulch will behave similarly to the vegetable crop case. For the hoop houses, 80 percent of the soil surface was assumed to be covered with plastic. In all cases it was assumed that runoff flows off the farm down roads or through ditches. Spreading runoff water over large flat areas reduces peak runoff and erosion rates. (Such areas are typically unavailable as they are used for production.)

With respect to runoff rates, it is assumed that no practices have been used to increase infiltration, such as incorporating organic material into the soil, chiseling, or planting cover crops in furrows, on farm roads or in other areas. These practices may reduce runoff rates significantly.

RESULTS: RUNOFF RATES

Table 1 presents approximate stormwater runoff rates, reported as cubic feet per second (cfs), resulting from different agricultural operations. There is a wide spectrum of runoff rates for different types of crop cover. Undisturbed soil with perennial pasture cover infiltrates large quantities of water, resulting in very low runoff rates. Both soil covered with plastic and bare soil are effectively sealed to infiltration, resulting in substantial increases to runoff rates. (Rain impact on bare soil rapidly clogs soil pores.)

The increase factor presented in table 1 relates the cropping situation to pasture. An increase factor of five indicates that the peak runoff rate of the cropping situation is five times that of pasture. The increase factor is the highest for frequent storms because most of the rain associated with these smaller storms will infiltrate in a pasture setting while some runoff will be generated on cropland.

While the percent increase in runoff between certain types of irrigated agriculture and pasture is high, whether that amount of runoff poses a problem depends largely on the capacity and erodibility of downstream ditches, culverts and channels. If those channels have sufficient capacity, the excess runoff may not be a problem. If the channels lack sufficient capacity, flooding or downstream erosion will result. Downstream erosion is discussed in the following section. Water that infiltrates into the soil leaches salts, is available to plants and can recharge groundwater if geologic conditions permit. Runoff is less available for groundwater recharge unless it is captured and detained for infiltration.

Many parts of these two valleys have heavier soils such as clays and clay loams. These soils will yield more runoff under all conditions, including pasture. The runoff increase factor for these soils will be less than for sandy soils.

To help interpret these results, table 2 shows the capacity of culverts of different sizes. In order to estimate the cumulative impacts of more than one farm block, additional analysis is required. Generally, as the total acreage increases the peak runoff per acre decreases.

RESULTS: EROSION

Field erosion is affected by many factors, including the amount of soil protected from rainfall by plants, mulch or other covers, and the amount of runoff, which is largely determined by soil texture and management related to permeability. Steeper slopes, longer runs and areas of more intense rainfall will generally also have more erosion. This analysis is limited to sandy loam soils. Heavier soils are generally less erosive. While fields partially covered with plastic have less area exposed to rainfall, the runoff rate is much higher than for fields without plastic and this generally causes the overall erosion rate to be higher.

The Soil Surveys of the US Department of Agriculture, Soil Conservation Service lists rates of erosion that are tolerable from the perspective of maintaining long term crop production. Those rates typically range from two to five tons per acre per year. Erosion at these rates is nearly invisible. Field erosion averaging $1/16^{th}$ of an inch in depth amounts to 11 tons per acre. Tolerable rates of erosion with respect to maintaining channel capacity and other beneficial uses of receiving waters have not been determined for our area. Similarly, site specific assessments are required to determine the amount of increased runoff that can be accommodated by existing channels and ditches without excessive erosion.

Table 1. Peak runoff rates for a 10 acre block of Pajaro and Salinas valley cropland on sandy loam soil at four percent slope. One cubic foot per second (cfs) is equal to 7.3 gallons per second.

Farm Site: Pajaro Valley, East of Watsonville, West of foothills.

Storm Size	Rainfall	Pasture	Row Crops		Strawberries		Hoop Houses	
Frequency (years)	24 hours (inches)	Peak Flow (cfs)	Peak Flow (cfs)	Increase Factor	Peak Flow (cfs)	Increase Factor	Peak Flow (cfs)	Increase Factor
2	3.5	0.3	7	22	15	47	19	60
10	4.6	1.5	12	8	21	14	26	17
25	6.0	4.3	18	4	29	7	35	8
100	8.0	10	28	3	41	4	48	5

Farm Site: Castroville to Greenfield, Salinas Valley

Storm Size	Rainfall	Pasture	Row Crops		Strawberries		Hoop Houses	
Frequency (years)	24 hours (inches)	Peak Flow (cfs)	Peak Flow (cfs)	Increase Factor	Peak Flow (cfs)	Increase Factor	Peak Flow (cfs)	Increase Factor
2	1.6	0.0001	0.7	5,400	4.3	35,000	7.1	57,000
10	2.5	0.06	3.2	51	9.2	150	13	200
25	3.0	0.15	5.0	34	12	80	16	110
100	3.8	0.5	8.2	16	17	32	21	41

Table 2. This table is intended to illustrate how runoff affects downstream drainage facilities. This table is not intended for design purposes. The culvert size required to pass a certain flow rate is presented. Assumptions: The top of the culvert at the inlet is submerged by 2 feet. The culvert outlet is free flowing. The culvert is sloped at two percent, is made of corrugated steel, and is kept free from debris and sediment.

Culvert diameter (inches)	Flow capacity (cfs)
12	5
24	22
36	53

Downstream erosion frequently occurs in natural areas, ditches and creeks that were built or formed by natural processes to handle less runoff than they currently receive. Gully erosion is a common form of downstream erosion. Ditches and creeks typically adjust to increased runoff by eroding to achieve a lower gradient or slope. This causes the channel to become deeper and wider as bank failure occurs. (Channels subject to increased runoff that become shallower over time are often filling with sediment faster than they erode.) Typically, moderately sized storms such as the two-year storm cause the most erosion over the long term because they are both erosive and relatively frequent.

Downstream erosion is largely determined by the runoff rate and the position of the farm on the landscape. A farm high on a terrace or alluvial fan may contribute significantly to downstream erosion, while a farm that is level with a wide flat area or a lake or slough will probably contribute little to downstream erosion. A low rainfall area will have lower peak runoff rates, but it is also likely to have smaller or less developed channels that are less able to handle additional runoff without erosion.

The potential for downstream erosion is a description of the probability of erosion if the downstream areas area vulnerable. A moderate potential for downstream erosion indicates that erosion is unlikely in dry years but is likely in heavy rain years if downstream areas are vulnerable. The severity of that erosion is affected by a number of factors including the geometry and geology of the downstream area in addition to peak runoff rates.

Table 3. Approximate annual erosion rates resulting from different types of agricultural operations.

Farm Site: Pajaro Valley, East of Watsonville, West of foothills.

Crop Type	Without soil conservation practices* or runoff water detention		With soil conservation practices*, but without runoff water detention	
	Annual Field Erosion (tons/acre)	Potential Downstream Erosion due to runoff	Annual Field Erosion (tons/acre)	Potential Downstream Erosion due to runoff
Fallow	16	Moderate	1.5	Very Low
Row Crops	5.5	High	2.2	Moderate
Strawberries	16	Extreme	4.5	High
Hoop Houses	11	Extreme	4.4	High

* Practices such as row arrangement, cover crops, broad waterways lined with rock or perennial grass, and grassed roads

Farm Site: Castroville to Greenfield, Salinas Valley.

Crop Type	Without soil conservation practices* or runoff water detention		With soil conservation practices*, but without runoff water detention	
	Annual Field Erosion (tons/acre)	Potential Downstream Erosion	Annual Field Erosion (tons/acre)	Potential Downstream Erosion
Fallow	4.5	Moderate	0.3	Very Low
Row Crops	1.5	Moderate	0.6	Low to Moderate
Strawberries	4.5	High	1.5	Moderate to High
Hoop Houses	3.0	Extreme	1.2	High

* Practices such as row arrangement, cover crops, broad waterways lined with rock or perennial grass, and grassed roads

RESULTS: MITIGATION

Reducing the impacts of increased runoff and erosion can be accomplished through cultural and structural practices. These include minimizing furrow slope and plastic cover, maximizing vegetative cover, and increasing soil organic matter and tilth. In certain cases these techniques have proven to virtually eliminate increased runoff and erosion from farm fields. These are the most effective practices for reducing erosion of clay particles, which may carry fertilizers and pesticides. Waiting to apply plastic mulch until the storm season has passed will reduce runoff in strawberry fields. However, there may be unintended impacts on water quality and crop production. For example, fertilizer on the bed would be more subject to leaching or erosion.

Erosion can also be controlled using structural techniques such as underground pipes, grade control structures, energy dissipators, and lining ditches and channels with vegetation, plastic sheeting or rock. These practices may prevent downstream erosion from increased runoff along a given reach of channel, but such erosion may resume at the end of the treated reach unless those practices are extended to an area where the water will not accelerate again such as a wide level area or a slough or lake. Each of these techniques has limitations and can cause serious damage, injury or death if not properly planned, installed, or maintained. Consult with an engineer prior to installing such measures.

Where these practices are insufficient, basins that detain runoff and sediment are highly effective at capturing eroded sediment and reducing peak runoff and downstream erosion. The detention basin sizes listed below were determined based on the goal of reducing the current runoff rate to the peak rate for pasture or to 10 percent of the developed rate, whichever is greater. The capacity is listed in acre-feet and the footprint in square feet, assuming an average basin depth of 4 feet. Actual basin footprint sizes for a given capacity vary widely based on site conditions. Basins of these sizes will be only somewhat effective at retaining clay particles and associated chemicals.

Table 4. Approximate detention storage required to mitigate effects of increased runoff rates.

10 Acre Farm Site: Pajaro Valley, East of Watsonville, West of foothills.

Design Storm Size	Rainfall	Row Crops		Strawberries		Hoop Houses	
(Year)	Inches	Acre-Feet	Square Feet	Acre-Feet	Square Feet	Acre-Feet	Square Feet
2	3.5	0.7	8700	1.1	14,000	1.3	16,000
10	4.6	1.0	12,000	1.5	19,000	1.7	21,000
25	6.0	1.5	19,000	2.1	26,000	2.3	29,000

10 Acre Farm Site: Castroville, Salinas, Spreckles

Design Storm Size	Rainfall	Row Crops		Strawberries		Hoop Houses	
(Year)	Inches	Acre-Feet	Square Feet	Acre-Feet	Square Feet	Acre-Feet	Square Feet
2	1.6	0.3	3700	0.5	6200	0.6	7500
10	2.5	0.4	5000	0.8	10,000	1.0	12,000
25	3.0	0.5	6200	0.9	11,000	1.1	14,000

CONCLUSIONS

Common agricultural land uses have the potential to increase erosion and runoff rates substantially over natural levels in the Pajaro and Salinas Valleys, but common soil conservation practices have the ability to reduce these rates to levels that are sustainable over the long term. Determining acceptable levels of runoff and erosion is a complex and site specific task that is beyond the scope of this analysis. Those levels are likely to be affected more by downstream site conditions than conditions on the farm itself. Despite the potential for increased runoff associated with agricultural land uses, these runoff rates are likely to be substantially lower than urban, industrial or transportation land uses that have higher percentages of impervious surfaces. Similarly, erosion rates for the cropland situations considered here are likely to be much lower than for land uses that result in bare soil or increased runoff on land with slopes over 5 percent. Irrigation that simulates rainfall has to potential to cause erosion in a similar manner to storm events. The intensity of the irrigation is an important factor and is highly variable, therefore such analysis is beyond the scope of this paper.

More information is needed to improve these tables. Specifically, winter runoff data from adjacent fields under different management practices would be helpful to quantify the benefits of non-structural practices that reduce erosion and runoff. Interesting comparisons might include chiseled versus non-chiseled fields, or a field with runoff directed down vegetated roads versus one where runoff flows down earthen ditches, or fields with lots of incorporated organic matter versus ones with little organic matter. If you would like to participate in such a study, please contact the Resource Conservation District of Monterey County. Confidentiality is guaranteed.