NRCE® Natural Resources Consulting Engineers, Inc.
131 Lincoln Ave, Suite 300
Fort Collins, CO 80524
Phone: (970) 224-1851, Fax: (970) 224-1885

TECHNICAL MEMORANDUM

Date: May 15, 2010

To: Janet Goldsmith, Esq. and Mark Blum, Esq.

From: L. Niel Allen, Ph.D., P.E. and Brett Bovee, M.Eng., P.E.

RE: Soil and Erosion Information for El Sur Ranch Irrigated Pastures Water Rights Application Number 30166

This memorandum describes the soil properties and the potential for erosion due to irrigation of the El Sur Ranch pasture. It provides information to complete the Final Environmental Impact Review (EIR) being prepared by PBS&J for the El Sur Ranch water right application. The memorandum sections include (1), Soil Descriptions, (2) Soil Properties, (3) Water Movement in Soils, and (4) Erosion Potential. In summary, the erosion potential on the El Sur Ranch irrigated pasture has been reduced from conditions prior to irrigation development by the soil conservation practices implemented by El Sur Ranch. Furthermore, during the irrigation season when there is dry buffer between the end of the field and the ocean bluff, the lateral flow of water to the bluff face is minimal, if any.

Soil Descriptions

The soils on the El Sur Ranch irrigated pastures are described in the 1978 Soil Survey of Monterey County prepared by the USDA Soil Conservation Service (USDA-SCS, 1978). A description of the soils was also provided in Chapter 4 of the March 2007 NRCE report (NRCE, 2007). Copies of relevant pages from the 1978 Soil Survey are included in Appendix A. Figure 1 is a copy of Figure 4-1 from the 2007 NRCE report, showing the aerial extent of different soil series on the El Sur Ranch property.

Most (86%) of the irrigated pasture soils are Santa Ynez Fine Sandy Loam, with the next most prevalent soils being Lockwood Shaly Loam (8%) and Pfeiffer Fine Sandy Loam (6%). The soil survey includes a description of the top five feet of the soil profile. Figures 2 to 4 diagram the soil profiles for these three soil types. In addition to the three soil types the irrigated pastures have some Badland soils along the coastline and Swiss Canyon. The badland soils in the irrigated portion of the pasture have been reclaimed.

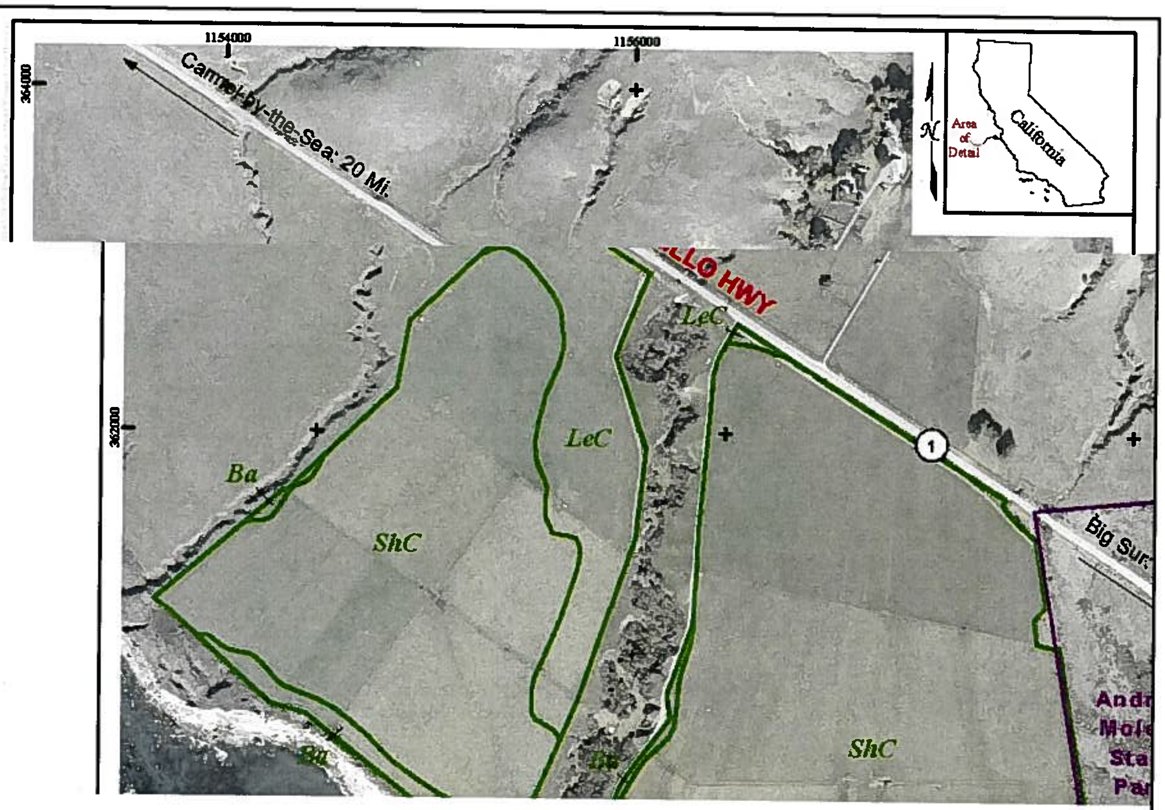

Figure 1: Soil Map of El Sur Ranch

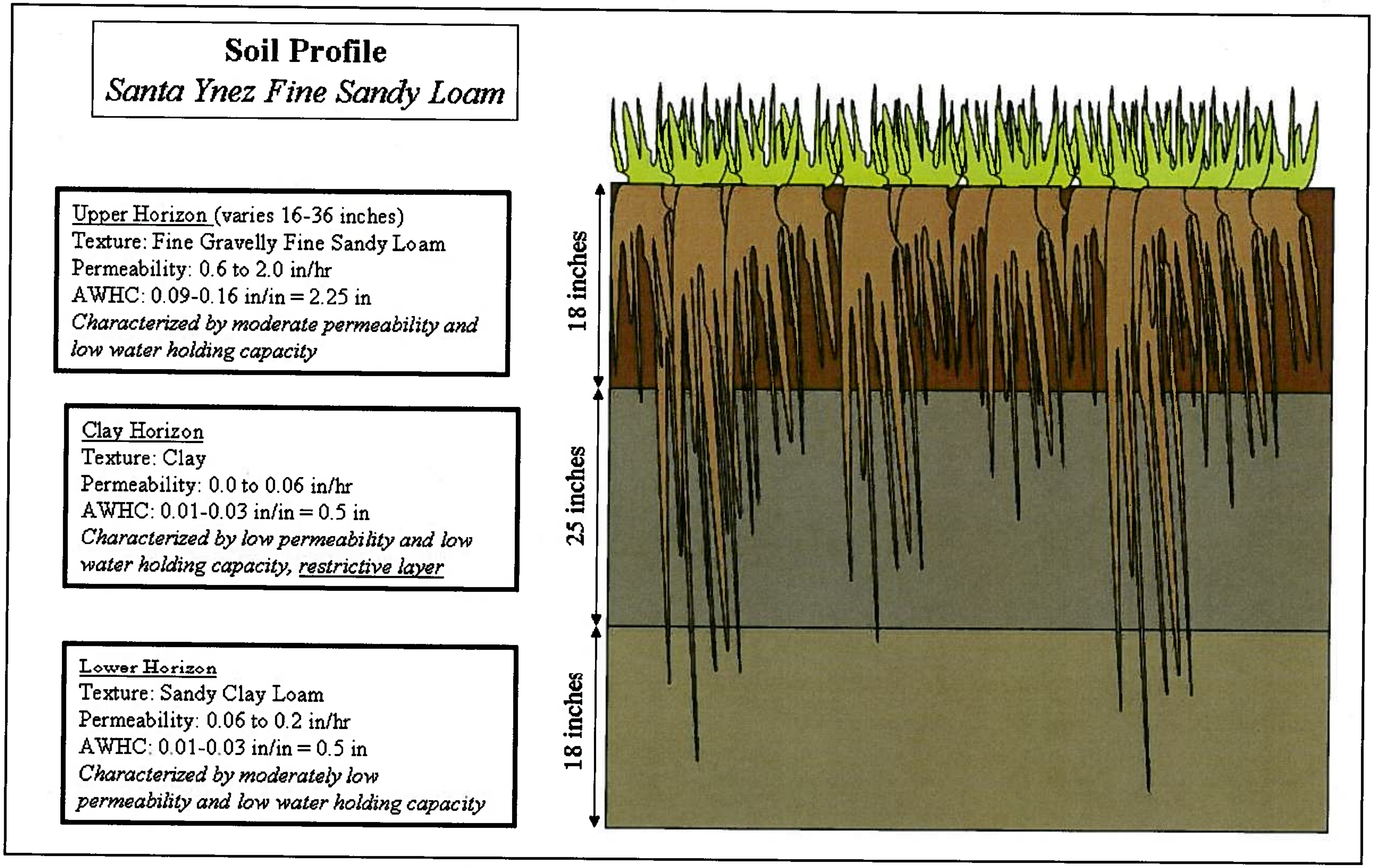

Figure 2: Soil Profile of Santa Ynez Fine Sandy Loam

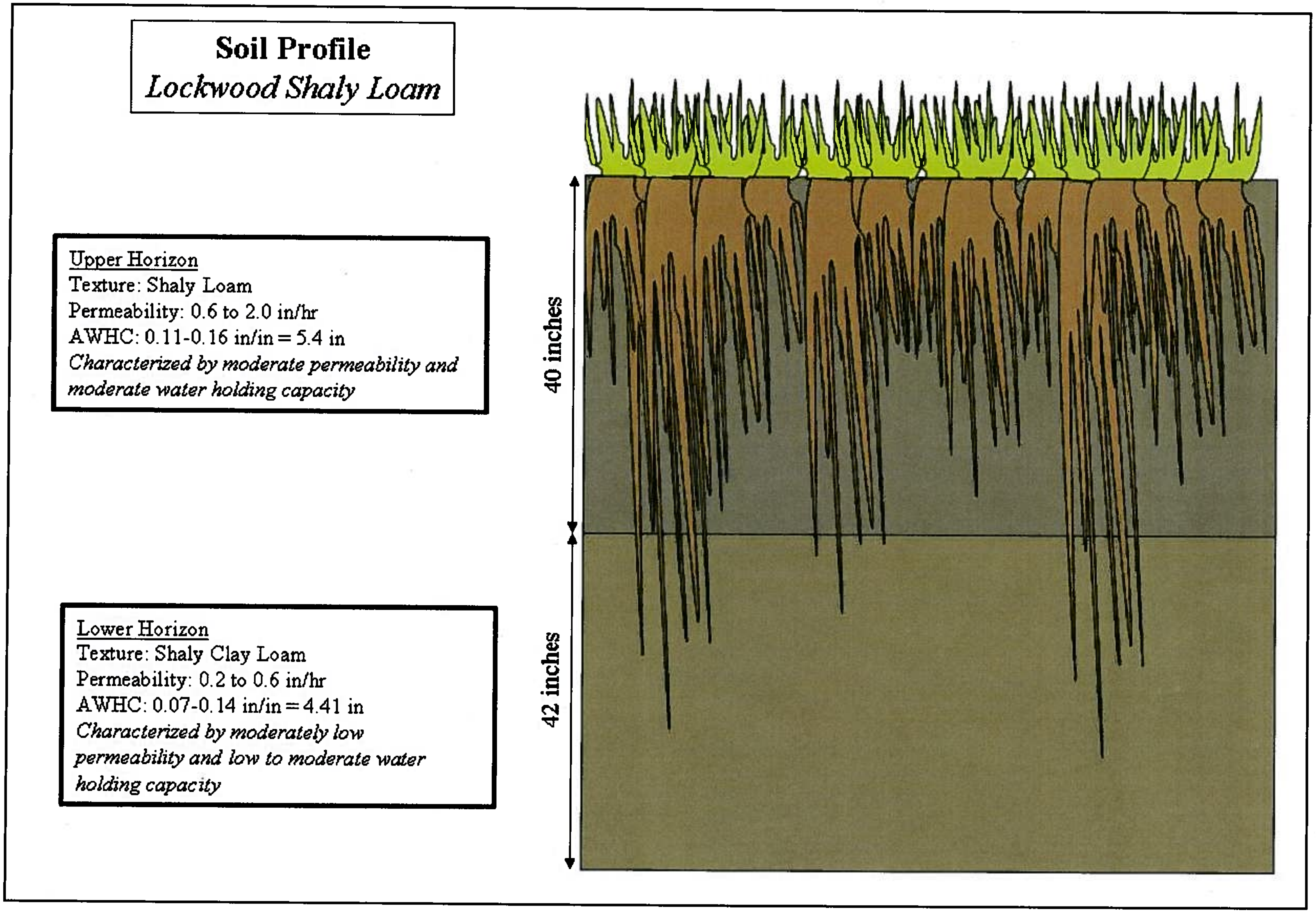

Figure 3: Soil Profile of Lockwood Shaly Loam

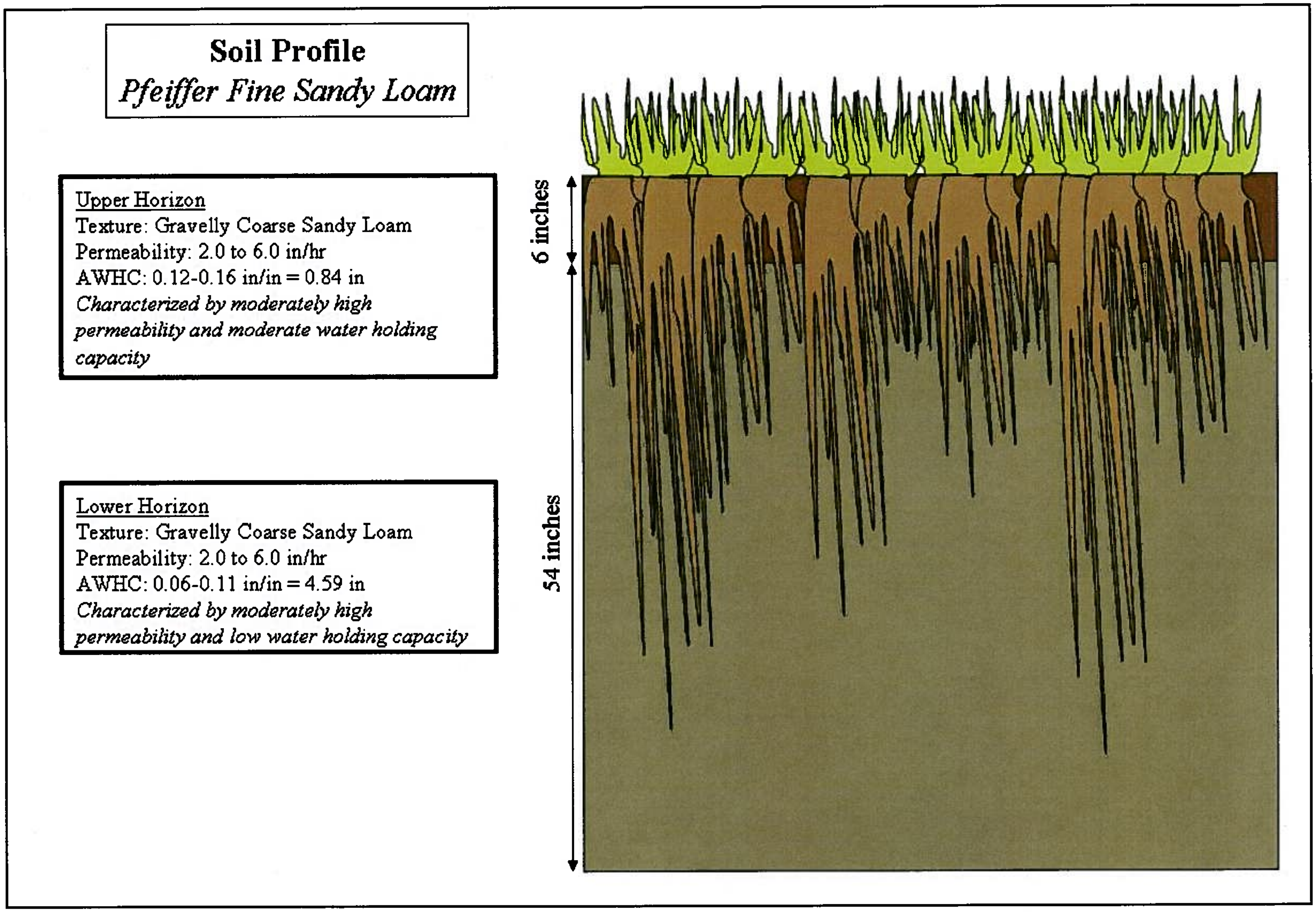

Figure 4: Soil Profile of Pfeiffer Fine Sandy Loam

The 1978 Soil Survey describes soil types and properties in the upper five feet. Two wells that were drilled in the Pump House pasture field on Santa Ynez soils, near the southern edge of the El Sur Ranch property boundary provide soil information at deeper depths. These wells are identified as ESR-11 and ESR-12 in the May 20, 2005 water right application by The Source Group, Inc. (TSG, 2005). The drill log for ESR-11 indicates medium to coarse sandy clay from a depth of about 5 to 20 feet. The groundwater table was reached at a depth of 42 feet and bedrock appears to have been reached at a depth of 90 feet. There were no perched water tables noted in the well drill logs.

Soil Properties

This section defines some of the soil properties that enter into the discussion of water movement through soils. Definitions were largely taken from Maidment (1993).

Saturated Hydraulic Conductivity (K_{sat})

Hydraulic conductivity (K) is a measure of the ability of the soil to transmit water and depends upon both the properties of the soil and the fluid. Hydraulic conductivity is reported in units of length per time (for example, inches per hour of water movement through the soil). Porosity, pore-size distribution, and pore connectivity are important soil characteristics affecting hydraulic conductivity. The saturated hydraulic conductivity (K_{sat}) is measured when the soil is at saturation.

Permeability

Permeability is also a measure of the ability of the soil to transmit water, but depends only upon the properties of the soil. Permeability is reported in units of length squared (for example, square inches). Permeability can be related to hydraulic conductivity by properties of the fluid. The 1978 Soil Survey defines permeability as "the quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil." This definition indicates that permeability reported in the 1978 Soil Survey is actually describing the saturated hydraulic conductivity of the soil.

Porosity

Porosity is the volume of void space per unit volume of porous medium; it is a measure of how much empty space exists in a given amount of soil. Porosity is reported as a fraction or percentage. For example, a soil with 40% porosity means that 40% of the soil consists of voids and 60% consists of solid soil particles. The porosity or void space in a given soil provides a measure of the volume of water than can enter into the soil profile. Various terms are used to describe the degree to which the total porosity (void space) is filled with water, such as saturation, field capacity, and wilting point.

Saturation
Saturation is the condition when the soil voids are filled with water.

Field Capacity
Field capacity refers to the condition wherein soils at saturation have been allowed to drain (typically for 24 to 48 hours). A portion of water remaining in the soil is available for plant use. The water remaining in the soil is held in the soil voids by negative capillary pressure.

Capillary Pressure
The force by which water is drawn around soil particles because there is a stronger attraction between the soil particles and the water molecules themselves. The movement of water within the soil due to the forces of adhesion, cohesion, and surface tension acting in a liquid that is in contact with soil particles. The capillary pressures move water from wet soils to adjacent drier soils. The movement of water in soils due to capillary pressure is generally only a couple of feet. The capillary pressures also hold water in soils against the force of gravity.

Wilting Point
Wilting point refers to the condition where water remains in soil voids and cannot be utilized by plants because the negative pressures holding water in the soil pores are greater than the pressure created by the plant to extract water from the soil voids. Figure 5 shows the differences between these conditions.

Available Water Holding Capacity
The available water holding capacity represents the amount of water that can be held in the soil and is available for uptake by plants. The available water holding capacity is measured as the difference between Field Capacity and Wilting Point, and is reported as depth of water per depth of soil (for example, 2 inches of water available per 12 inches of soil depth).

Drainable Water
Drainable water represents the amount of water that drains out of the soil voids under the influence of gravity. It is calculated as the difference between the volume of water under saturated conditions and the volume of water at field capacity.

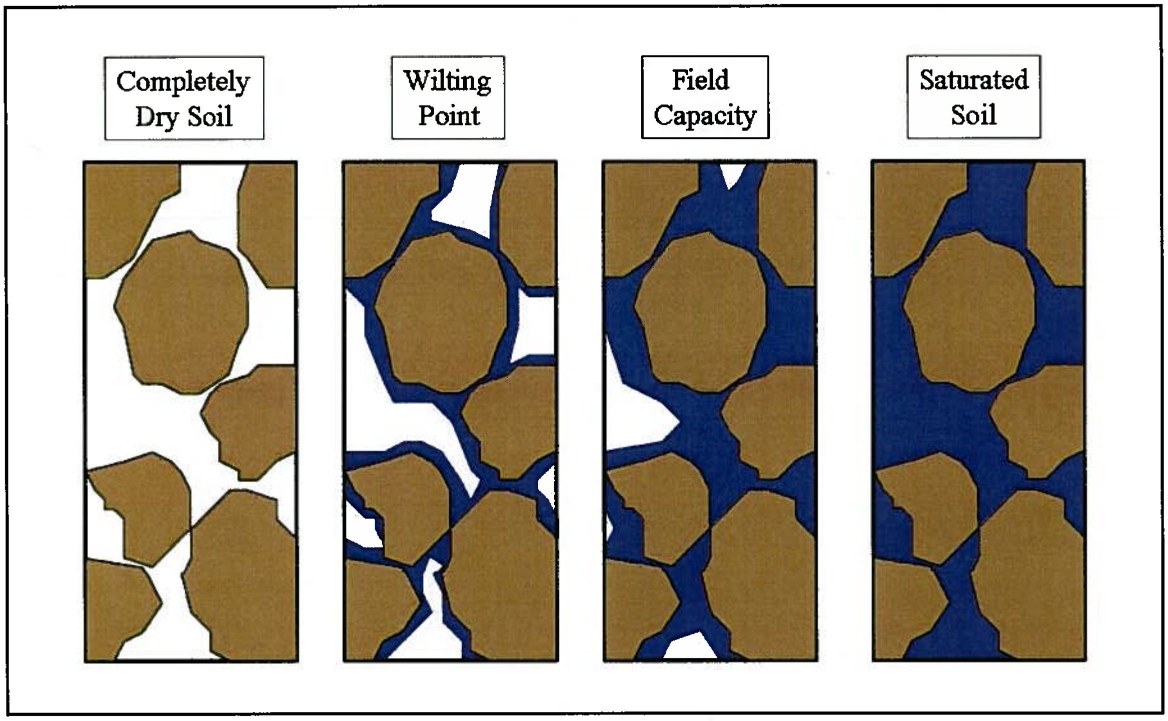

Figure 5: Diagram of Saturation, Field Capacity, and Wilting Point

Infiltration

Infiltration is the process of water entry into a soil from rainfall, snowmelt, or irrigation. Infiltration is influenced by movement of water within the soil as infiltrated water moves vertically downward by gravity and is distributed through the soil profile. Infiltration is dependant upon many factors; including soil type, land cover condition, rainfall or irrigation rate, and degree of saturation of the soil profile. For most soils, as the soil becomes wetter over the course of a rainfall or irrigation event, the infiltration rate decreases. The soil saturated hydraulic conductivity is almost always less than the initial infiltration rate. Runoff occurs when application rate (precipitation or irrigation) is greater than infiltration or when the soil becomes saturated and water movement through the soil is limited either by a restrictive layer or a water table.

Water Movement

This section describes the various pathways that water moves on El Sur Ranch irrigated pasture. An understanding of the soil types and properties provided in the preceding sections is helpful to understand water movement. Water movement is described for two different situations, a peak rainfall event and an irrigation event, because the dominant processes and magnitude of different water pathways differs for each situation.

Irrigation Event

Irrigation begins with water being applied at the head end of a pasture field. Irrigation water is discharged from the supply pipeline at valve locations and immediately starts to pond near the valve. The applied water that does not infiltrate into the soil moves laterally away and down gradient from the valve. Water moves much more readily on the soil surface than in the soil. For surface irrigation the application rate is greater than the water infiltration rate. Thus a portion of the water advances towards the tail end (lower portion of the field) and a portion infiltrates into the soil under the influence of gravity. The advance of the water is a function of the land slope, the surface cover conditions (density of grass, etc.), and the infiltration rate into the soil. The water generally advances down gradient, but also extends laterally a short distance due to the depth of water flow. The lateral movement of surface water is controlled by dikes between the field borders.

As the water advances, water infiltrates into the soil and fills unsaturated voids in the soil. Once the soil is saturated, water moves downward through the soil profile under the influence of gravity at a rate equal to the hydraulic conductivity (or Soil Survey permeability). For Santa Ynez soils, water moves through the upper soil horizon faster than it can move through the restrictive clay layer. With time the upper soil layer becomes saturated. When the upper soil horizon becomes completely saturated, the water infiltration rate decreases to the infiltration rate of the lower clay soil layer. Water that moves downward through the restrictive clay layer will continue to drain through the more permeable layer below the clay layer and eventually to the water table.

As an example, the following discussions refer to a specific pasture on the El Sur Ranch, and for reference purposes Figure 6 shows the El Sur Ranch pasture layout. The various water movement pathways associated with an irrigation event are shown in Figure 7. This condition produces the peak irrigation runoff and would likely only occur for a few hours near the end of the irrigation. Some irrigation events have minimal runoff. The water application rate for an irrigation event was estimated from the 2004 pumping data, which was approximately 2.92 cubic feet per second (cfs) applied to Pasture 7 (18 acres) on June 18-19, 2004. This irrigation application rate is consistent for Pasture 7, because of the pumps and irrigation system capacities. The water movement rates shown in Figure 7 assume that water movement rates are governed by the permeability provided in the 1978 Soil Survey. As previously stated the initial infiltration rate is generally higher than saturated permeability.

Rainfall Event

Rainfall occurs uniformly across the entire ranch area. As raindrops land on the soil surface, water will begin to pond and infiltrate into the soil. Similar to irrigation, the infiltrating water begins to fill unsaturated voids in the soil matrix. Water continues to move downward through the soil profile under the influence of gravity at a rate equal to the hydraulic conductivity (or Soil Survey permeability). For Santa Ynez soils, water will drain through the upper soil horizon faster than it can drain through the restrictive clay layer. The result is that soil water will start to pond on the clay layer and begin to fully saturate the upper soil horizon. When the upper soil horizon becomes fully saturated, water which has ponded on the surface will not be able to infiltrate into the soil as fast as the rainfall rate. This generates overland runoff as water continues to pond to the point where it starts to flow down-gradient under the influence of gravity.

The dense stand of pasture grass would help to control the velocity of runoff on the pasture fields. An important difference from irrigation is that rainfall occurs everywhere at once on the ranch property. Thus, overland runoff is not limited to a single pasture field, but instead runoff would be occurring from all fields. As runoff generated from rainfall flows down-gradient, it will tend to accumulate into rills and gullies in the natural land surface. Field borders and road embankments formed as part of the pasture land management, as well as the dense pasture, help to reduce the formation of rills and gullies in the pasture fields. In general, if the El Sur Ranch property were not managed for irrigated pasture, the formation of natural rills and gullies from rainfall runoff would be much more likely. A good example of this is the erosion in Pastures 5, 6, and Pump House Field which can be observed in the 1929 and 1942 aerial photos, prior to development of irrigation.

Irrigations occur when the soils are relatively dry, because of high evapotranspiration (ET) rates during the summer and the lack of rainfall. As a result, the initial infiltration of water during irrigation is stored in unsaturated soil. Contrary to this, winter rainfall events often occur when the soil is partially saturated as a result of consistent rainfall and low ET rates during winter. Initial infiltration during a winter rainfall event may encounter partially or fully saturated soils, resulting in rapid runoff. The various water movement pathways associated with a peak rainfall event are shown in Figure 8.

For example, a peak rainfall event recorded by the El Sur Ranch pasture automated weather station occurred December 7, 2004. On this day the total precipitation was 3.07 inches, with 2.76 inches occurring during a 6-hour period. During this 6-hour period, the peak measured rainfall rate of 0.55 inches per hour occurred for 4 hours. The water movement rates shown in Figure 8 assume that no preferential flow pathways exist in the soil matrix, and water movement rates are governed by the permeability provided in the 1978 Soil Survey.

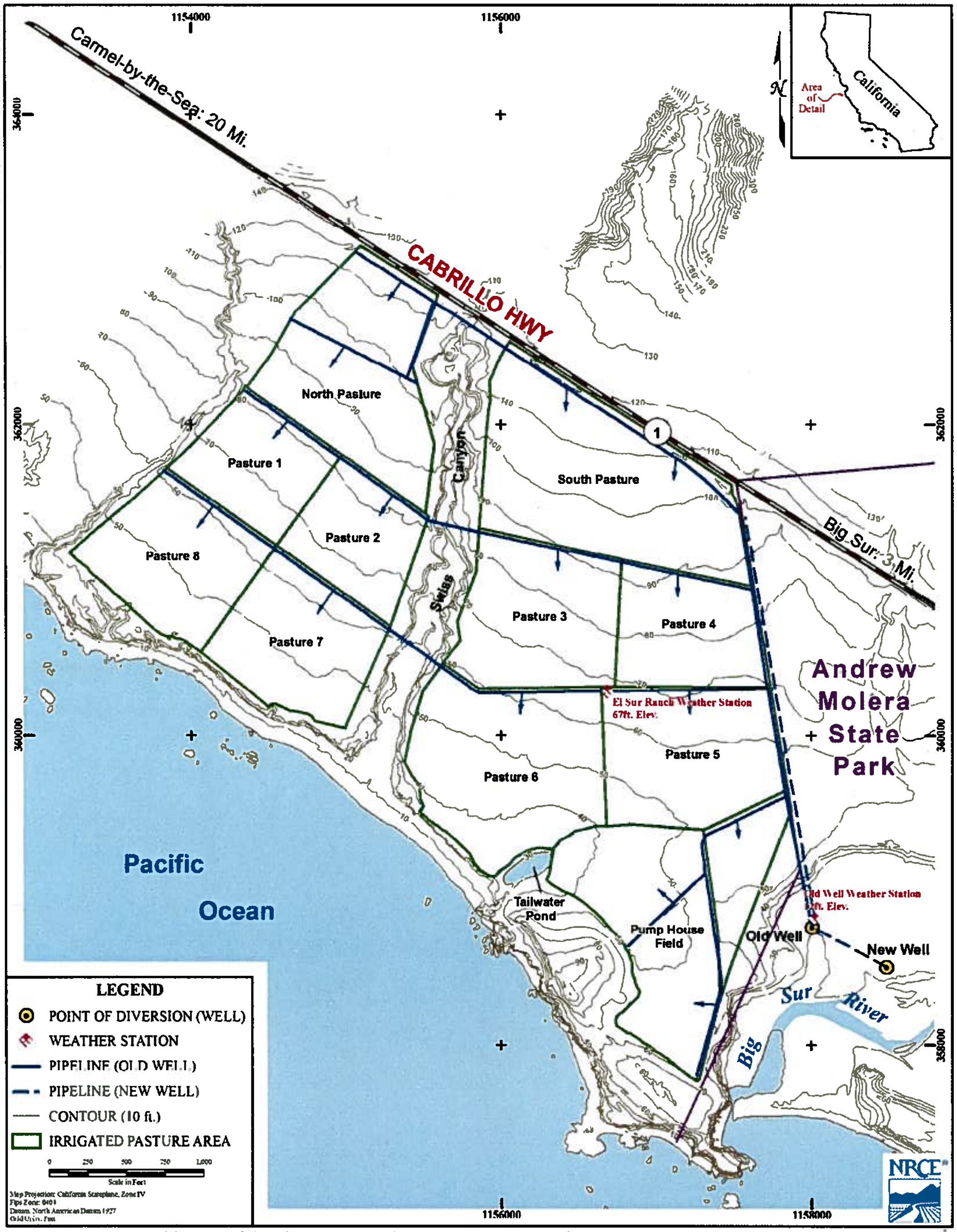

Figure 2-5: Topographic Map of the El Sur Ranch Irrigated Pasture and its Infrastructures. March 2007

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Figure 6: El Sur Ranch Irrigated Pasture Layout and Topography.

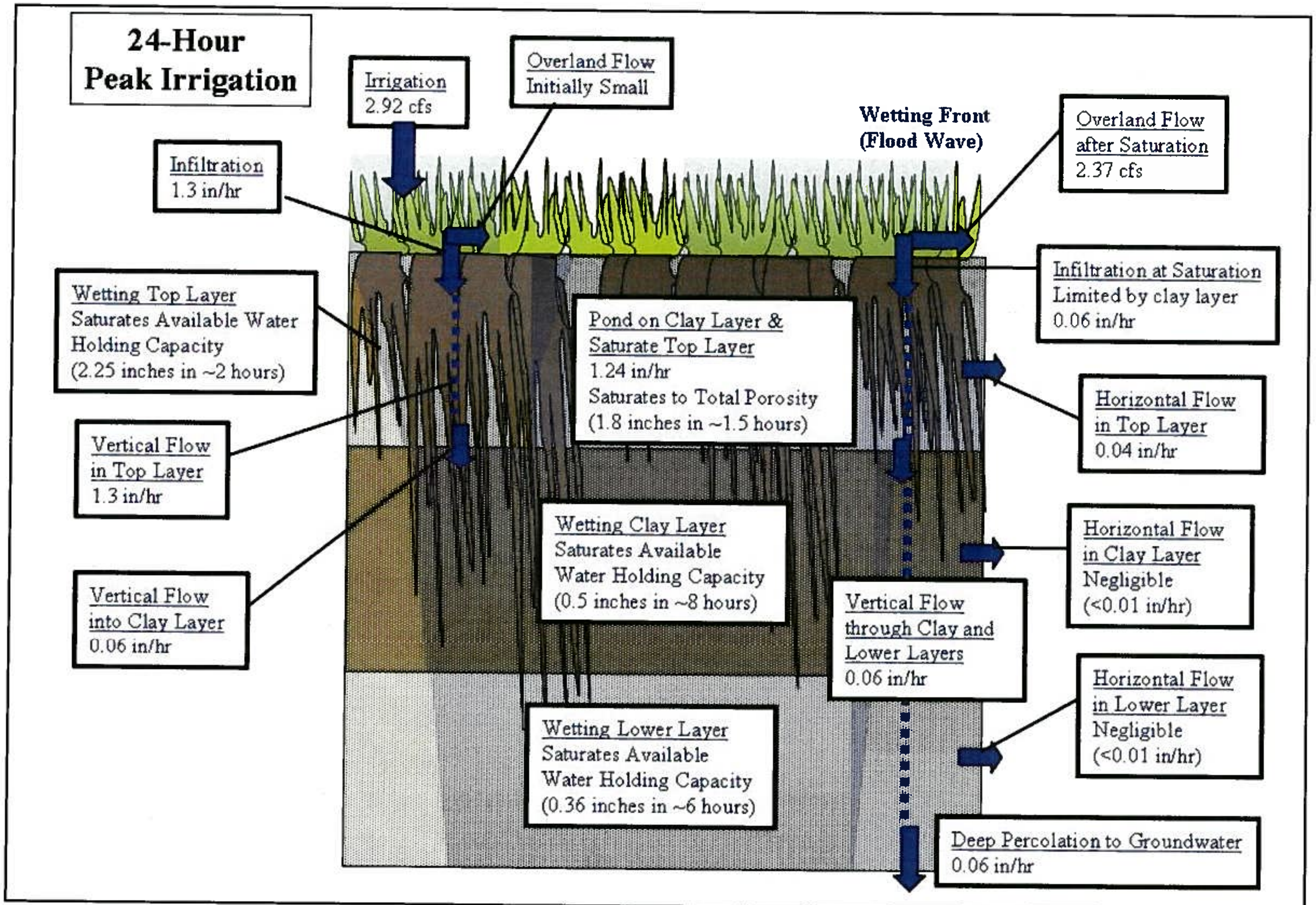


Figure 7: Irrigation Event Water Movement

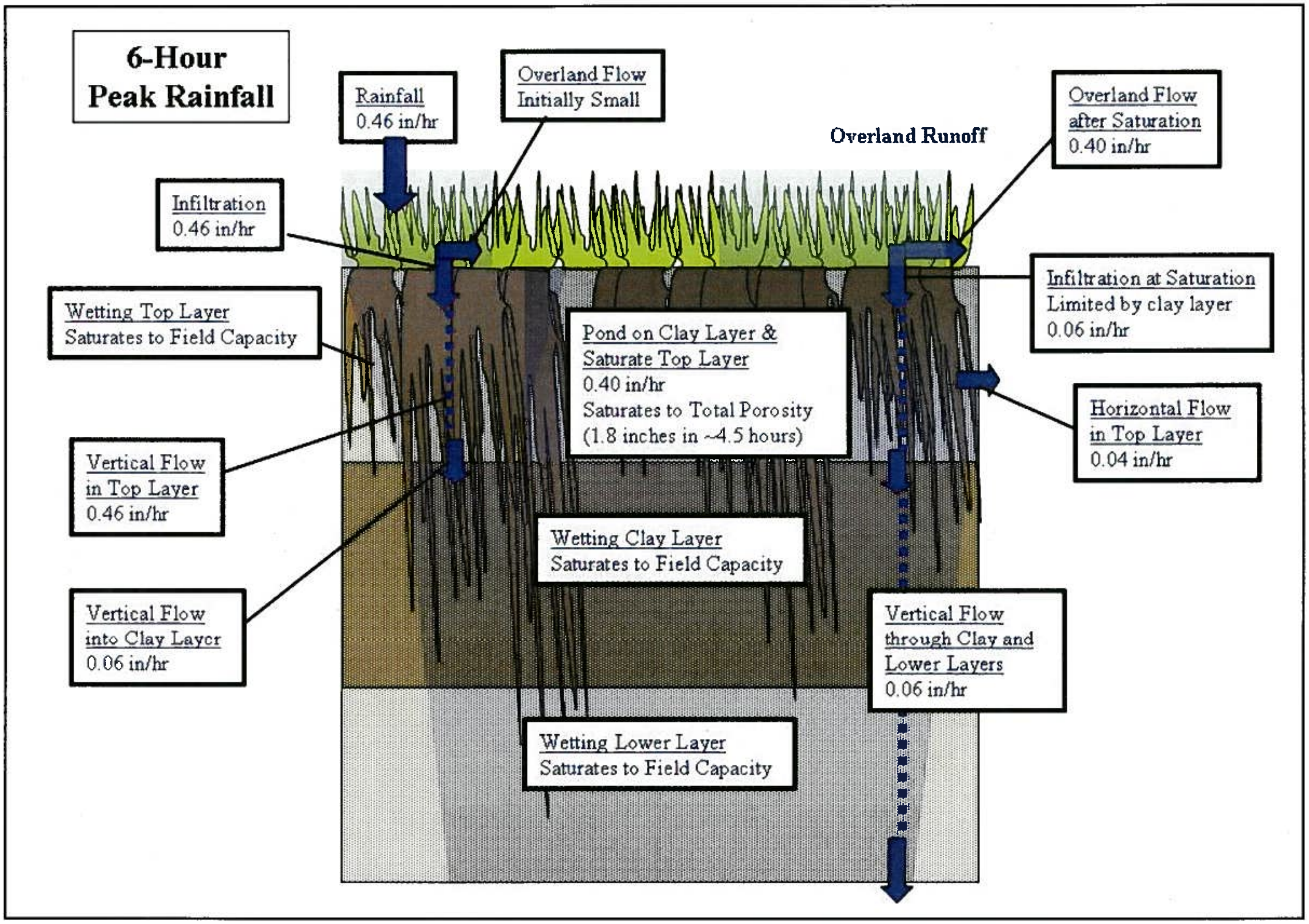


Figure 8: Rainfall Event Water Movement

The calculated runoff rates assume that the upper soil layer is near saturation prior to the storm. It is also assumes that natural rainfall does not cause sealing of the soil surface due to raindrop impact and movement of the surface soil particles. This process acts to reduce the infiltration rate into the soil and increase the magnitude of overland runoff. The presence of the dense stand of pasture grass would reduce the likelihood of surface sealing, because the grass canopy absorbs the energy of the raindrop impact.

Spatial Analysis of Runoff

Figures 7 and 8 look at water movement in a profile, two-dimensional frame, which is useful in looking at the generation of overland runoff. The movement of water across the land surface and the accumulation of water into channels can be seen as a third dimension of water movement on the ranch. On the El Sur Ranch property, overland runoff is limited in its ability to accumulate into rills and gullies by the field borders and road embankments, and by the dense stand of pasture grass which acts to slow overland flows and keep water uniformly spread across the surface. Also, at the downstream ends of the pasture fields, irrigation tailwater is managed and directed to specific outlet discharge areas. In comparison, a natural landscape that did not contain field borders, dense pasture grasses, and other water management practices would likely contain rills and gullies as overland runoff accumulates in topographic depressions. This erosion occurred in Pastures 5, 6, and the Pump House Field prior to development of irrigation.

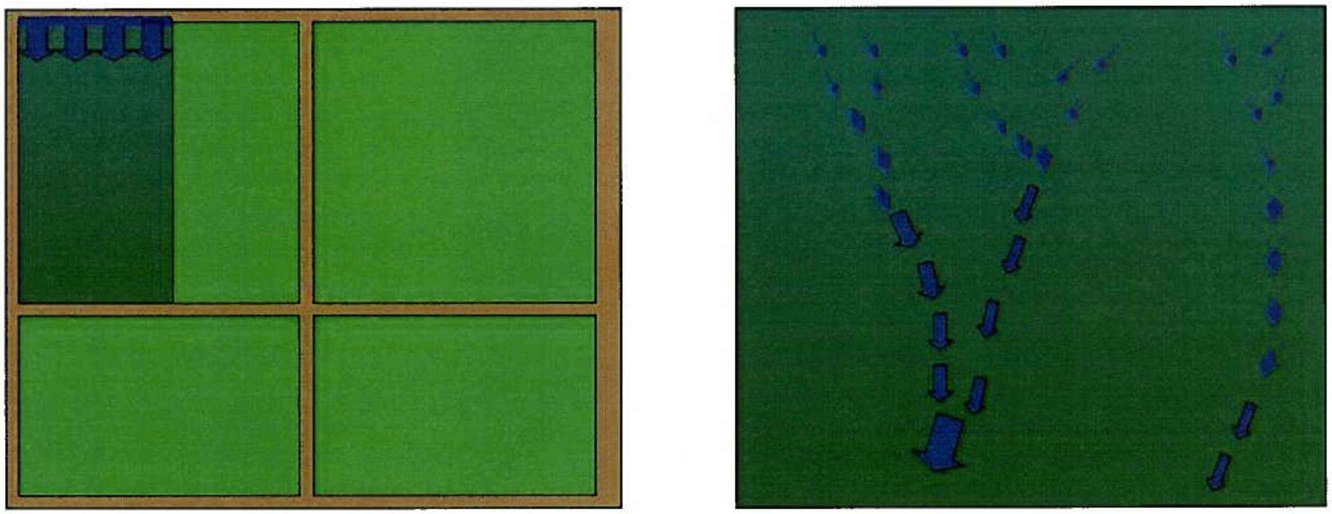
Rainfall events would produce more overland runoff over the entire irrigated pasture area, whereas irrigation events are limited to specific fields. The total overland runoff is much greater under rainfall events. For comparison, using the water movement rates provided in Figures 7, irrigation at peak rates might be expected to produce a maximum of 2.37 cfs of overland runoff for a limited time. This runoff is managed by field borders and road embankments. For comparison, during the 6-hour precipitation event on December 7, 2004 the average rainfall rate was 0.46 in/hr with a saturated infiltration rate of 0.06 in/hr for the Santa Ynez soils (Figure 8) for a runoff rate of 0.4 inches per hour. This results in a calculated runoff of 84 cfs (0.4 in/hr runoff times 208 acres (Santa Ynez soils) times 43,560 ft^2/acre divided by 12 in/ft divided by 3,600 sec/hr). The total runoff volume to the ocean from the rainfall event is estimated to be 35 to 55 times greater than the runoff from the irrigation. Under natural conditions this runoff would likely accumulate into rills and gullies. Under the existing irrigated pasture conditions, rills and gullies less likely to occur and discharge from the pasture would occur at the outlet to the tailwater pond and other pasture outlet locations. Figure 9 illustrates the difference between irrigation runoff and rainfall runoff.

Irrigation on Pasture

Peak Application Rate:
0.324 in/hr = 0.324 cfs/acre
2.92 cfs for 9 acre half-field

Rainfall on Natural Landscape

Peak Rainfall Rate:
0.46 in/hr = 0.46 cfs/acre
134 cfs for 292 acre ranch



Irrigation on Pasture

Runoff Rate:
0.264 in/hr = 0.264 cfs/acre
2.37 cfs for 9 acre half-field

Runoff Conditions:
Runoff distributed across bottom edge of field
Runoff managed by field borders and road embankments

Rainfall on Natural Landscape

Runoff Rate:
0.40 in/hr = 0.40 cfs/acre
117 cfs for 292 acre ranch

Runoff Conditions:
Runoff accumulates into rills and gullies
Runoff flow is distributed across number of gullies

Figure 9: Plan View of Runoff Water Movement

Lateral water movement towards the ocean also occurs in the irrigated pasture area within the soil profile, but to a much lesser extent than surface water movement. Lateral water movement in the soil is restricted by soil particles and is dependant upon the type of soil. The hydraulic conductivity (Soil Survey permeability) provides the estimated rate of water movement in the vertical direction under the influence of gravity. At a land slope of 3%, the force of gravity pulling soil water in the lateral direction down gradient to the ocean is small.

Lateral Water Movement in Soil

The following calculations show that water within the soil at saturation moves down through the restrictive clay layer more rapidly than towards the coastal bluff. The movement of water in soil is described by Darcy's Law, which states that the flow of water in a porous media (such as soil) is related to the hydraulic conductivity within the media and the pressure gradient acting on the water. One form of Darcy's Law can be described by the following equation:

$$V = K\frac{\Delta H}{L}$$

Where: V = velocity of water flow in soil (ft/s), K = hydraulic conductivity (ft/s), ΔH = head or elevation difference along flow path (ft), L = length of flow path (ft).

For vertical flow within the soil, the term $\Delta H/L$ is equal to one, and so the velocity of water flow is equal to the hydraulic conductivity. For lateral flow within the soil, the term $\Delta H/L$ is equal to the slope of the land surface or less permeable layer, which varies but can be estimated at 3% or 0.03. Applying the above equation and assuming that the hydraulic conductivity of the soil is the same in all directions, the lateral flow velocity is equal to only 3% of the hydraulic conductivity. The velocity of the wetting front of the water in the soil is 2 to 3 times greater than the Darcy's Law velocity because the water is only moving through the pores.

The total amount of water that moves through the soil after an irrigation or rainfall event is equal to the drainable water, which is the difference between water held at saturation and water held at field capacity. Porosity and field capacity for the upper soil layer (sandy clay loam) are estimated to be 0.4 and 0.27, respectively (Risinger and Carver, 1987), resulting in drainable water amount of 0.13 inches per inch of soil depth, or 2.34 inches for the upper soil layer. Water in the upper 18 inches of soil would drain downward at a rate of 0.06 in/hr which is the Soil Survey permeability of the restrictive clay layer, or 1.44 inches per day. Water would travel laterally at a rate of 0.039 in/hr, which is 3% of the average Soil Survey permeability for this upper layer, or 0.94 inches

per day (movement of water in pores would be 2-3 inches per day). These rates indicate that drainable water would move into the restrictive clay layer in about 39 hours, over which time the drainable water would have moved less than a foot in the lateral direction. Thus during the irrigation season when there is dry buffer between the end of the field and the ocean bluff, the lateral flow of water to the bluff face is minimal, if any. However, during the winter when the entire pasture is saturated, there can be lateral water flowing to the bluff face through the saturated upper layer of soil.
As an illustration, consider a sponge saturated with water that is 10 inches long. If one end was elevated by 0.3 inches, there would be little if any water flow out of the lower edge. If additional water was poured on the sponge nearly all the drainage would be out of the bottom of the sponge.

As previously stated negative capillary pressures move water from wetter to drier soil. These pressures can move water laterally, but the capillary pressures are also the pressures that hold water in the soil against gravity.

Erosion Potential

This section describes the erosion potential for the El Sur Ranch irrigated pasture. A general discussion of common types of erosion and factors influencing erosion is followed by a discussion of erosion specifically for El Sur Ranch.

Types of Erosion

Erosion occurs when the forces acting to displace soil particles are greater than the forces holding the soil particles in their original state. More specifically, erosion occurs when the actual shear stress on soil particles (in this case, from water) exceeds the critical shear stress needed to dislodge and suspend the soil particles (Mays, 2005). Erosion of the land surface due to surface runoff can be classified into several types, depending on the severity and type of water flow, such as sheet, rill, and gully. These types of erosion are illustrated in Figure 10 and described below:

- *Sheet Erosion* occurs as overland runoff flows across the soil surface. Sheet erosion can occur as the overland flow picks up soil particles dislodged by rainfall impact, or by the uniform removal of a thin film of soil from the land surface. Sheet erosion is not associated with recognizable water channels.
- *Rill Erosion* begins to occur as overland runoff flow begins to form small concentrated channels. Erosion rates often increase under rill erosion, due to the larger, higher velocity flows in the rills.

- *Gully Erosion* forms as the water flowing in rills accumulates into larger incised channels. Gullies are usually defined as water channels that cannot be remedied by tilling or discing the soil surface. Gully erosion can result in more significant damage to ranch equipment and field borders.

Erosion can also occur along the coastline as a result of ocean waves, tidal or other fluctuations in sea level, surface water runoff over the top of the bluff, and groundwater seepage at the bluff face (Hampton and Griggs, 2004). These processes differ from those shown in Figure 10 and described above.

Factors Influencing Erosion Potential

Factors that would increase the potential for erosion include: increasing flow/application rate and duration (either from rainfall or irrigation), and increasing slope angle. Factors that would decrease the potential for erosion include: density of plant cover (roots to anchor soil), the presence of ground cover, and increasing organic matter in the soil. These factors are incorporated into the Universal Soil Loss Equation (USLE) published by the U.S. Department of Agriculture in 1965. The factors included in the USLE help describe the factors that influence erosion. These factors are provided in Table 1.

Erosion is often a topic of interest on grazing lands because grazing has the potential to increase erosion. Compaction of the soil surface by cattle can reduce the infiltration of water into the soil profile and increases the overland sheet flow of water. This is most problematic when the surface soil is wet, such as when cattle are allowed to graze on a field while it is being irrigated or during the rainy season. Loss of plant cover from grazing can cause increased overland flow rates and reduce beneficial soil anchoring by plant roots. Also, ground cover (duff) can be reduced which exposes the bare soil to rainfall impact and overland sheet flow. Understanding that these erosion concerns exist, the importance of land and water management in grazing operations is seen as the over-riding factor in determining erosion from grazing lands. Several studies provide that well-managed grazing lands will likely reduce the potential for erosion, whereas poorly-managed grazing lands will usually experience an increased potential for erosion (Huss, 1996; Smiens, 1975; CCWD, 2005; Patric and Helvey, 1986).

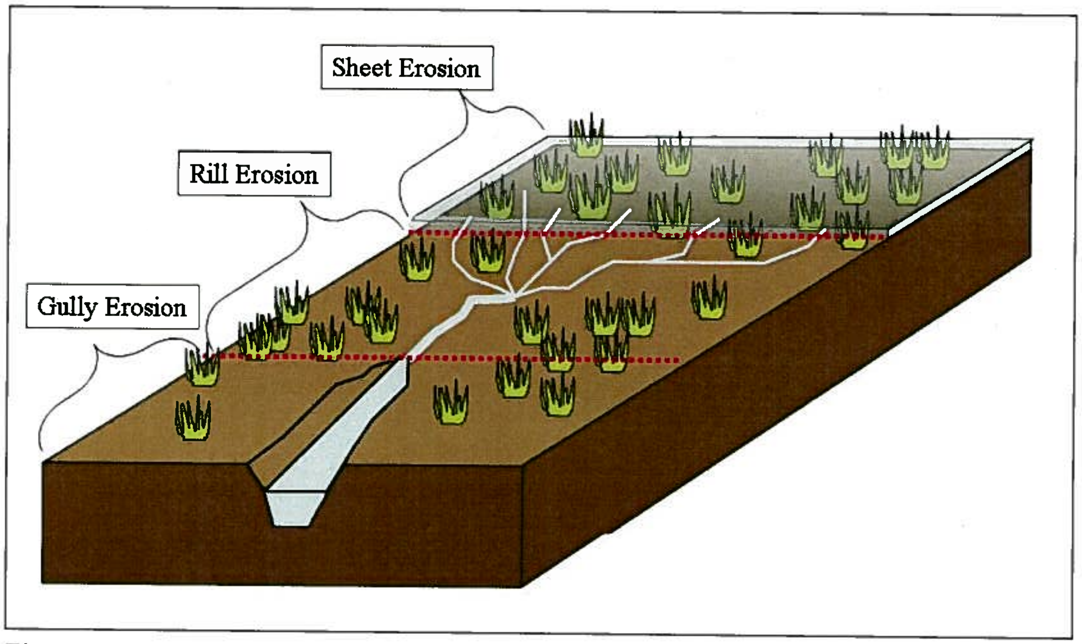


Figure 10: Illustration of Erosion Types

Table 1: Factors Influencing Erosion Potential

Factor	Discussion
Rainfall-Runoff Factor (R)	The intensity (rate) of rainfall is important because it provides the energy to displace surface soil particles and determines the magnitude of overland runoff flow that might cause erosion.
Soil Erodibility Factor (K)	The type of soil is important because soils differ in their infiltration rates, adhesion properties, and overall erodibility. The El Sur Ranch irrigated pasture soils have a slight to moderate Soil Erodibility Factor.
Slope Length (L) and Steepness (S) Factors	Slope length is important because it provides the distance or time over which runoff and erosion may occur. Longer slopes provide a longer opportunity time for erosion to develop. Slope steepness or angle is important because it determines how the force of gravity acts upon the lateral movement of soil and water. Steeper slopes have a greater tendency to erode. El Sur Ranch irrigated pasture slopes are low.
Cover Management Factor (C)	Cover management involves many individual factors. Land use determines what kind of land surface impacts have taken place and what kind of disturbance the topsoil has experienced. The percent of canopy cover determines how much protected the soil surface is from direct raindrop impact. The percent of surface cover determines the degree to which the soil surface is anchored in place by plant roots and to what extent overland runoff is in direct contact with bare soil. The surface roughness determines how fast overland runoff moves across the land surface, which influences the erosive potential of the runoff. Previous soil moisture influences how much water infiltrates into the soil profile instead of becoming overland runoff flow. El Sur Ranch irrigated pastures have good canopy and plant stands
Support Practice Factor (P)	There are several practices that can be implemented to help reduce erosion. Some examples include terracing cultivated fields, installing vegetation buffer strips, and installing subsurface drainage. El Sur Ranch irrigated pastures have good erosion control practices and management.

For the El Sur Ranch, several land and water management practices help to reduce the potential for erosion on the ranch. The erosion control factors in place or in practice on El Sur Ranch include:

(1) Tailwater Pond. A tailwater pond collects irrigation runoff from those fields located south of Swiss Canyon (except the Pump House field, which is about 6.6 acres). The tailwater pond acts as a collection pond so that tailwater from irrigating the fields does not just runoff the coastal bluff, which could be highly erosive. The pond allows the irrigation tailwater to be discharge in a controlled, non-erosive, manner.

(2) Controlled Discharge to Ocean. There are two controlled discharges locations to the Pacific Ocean, one of the northern side of Swiss Canyon and one on the southern side. In the absence of these controlled discharge structures, tailwater runoff from the fields would simply spill over the coastal bluff, likely leading to erosion problems over time. The controlled discharge structures ensure that water is discharged from the El Sur Ranch irrigated pastures in manner that minimizes erosion.

(3) Field Borders and Road Embankments. The pasture fields on El Sur Ranch are irrigated using borders that limit the lateral extent to which flood irrigation water can travel. These field borders ensure that irrigation water does not flow off of the intended pasture and through unintended areas where the potential for erosion is higher. Road embankments and/or tailwater ditches along Swiss Canyon and at the lower edge of the ranch ensure that tailwater runoff and precipitation runoff do not flow off the pasture lands and onto natural landscapes in an uncontrolled fashion. The field borders, road embankments and tailwater ditches basically help El Sur Ranch control the flow of water when irrigating and during rainfall events, which can prevent erosion from occurring.

(4) Irrigation Timing and Management. In addition to controlling the tailwater runoff from irrigation using field borders and road embankments, water is also controlled by properly managing the application of irrigation water to the pasture fields. Irrigation on El Sur Ranch is well-managed and scheduled based on several factors, such as: field or irrigation system maintenance needs, soil moisture conditions, labor constraints, the soils and topography of particular fields, climate conditions, pasture condition and height, and future grazing needs. Irrigation is scheduled to provide pasture production and to limit excessive water applications. Additionally, when possible, irrigation does not occur when cows are grazing on a field, this limits damage to the pasture and the potential for erosion.

(5) Grazing Practices. The grazing practices of El Sur Ranch are intended to maintain a healthy pasture, which reduces the potential for erosion. Pertinent practices include: rotating cows from field to field so that any one field is not over-grazed exposing bare soil; moving cows off of the irrigated pasture lands during the rainy season to ensure that the cows do not compact the soil when it is saturated; and providing water for the cows in troughs as opposed to in creeks or on the pasture itself during flood irrigation.

Erosion Estimation

Equations or methods to estimate erosion are numerous for watershed-scale planning, row crop irrigation practices, and streambed or channel processes. Methods to estimate erosion for flood irrigation of pasture lands are not readily available. After contacting several NRCS field offices in the western U.S., the over-riding response was that field observation of erosion is the best method to estimate erosion potential or likelihood for pasture lands caused by flood irrigation. Based on observation, the erosion potential at El Sur Ranch would be considered low.

Irrigated pasture for grazing has been managed on the El Sur Ranch property for over 50 years. Over this length of time, signs of erosion would be prevalent if in fact erosion was caused by irrigation of the pasture lands. While there have been some instances of overland runoff spilling off of the El Sur Ranch property, and some signs of limited erosion can be found, in general serious erosion concerns are not found within El Sur Ranch. Also, the pasture on El Sur Ranch is healthy as evidenced by the variety of plant species found within the pasture; which indicates the pasture areas have been free excessive from erosion for many years.

The Universal Soil Loss Equation (USLE) is often employed when estimating erosion for large landscapes. The USLE has been extended into several forms, such as the Revised USLE (RUSLE) methods, the Water Erosion Prediction Project (WEPP) software, and the RUSLE2 software program. The USLE and its extensions are rainfall-runoff based methods (specifically the R-Factor), and are not readily applicable to a case where flood irrigation is the driving force behind any erosion.

Application of the USLE with the WEPP software for conditions on the pasture provides an estimated soil loss rate of 0.075 tons per acre per year. This is less than 1/1000th of an inch per year soil loss. These estimates are shown in Table 2. The estimate of maximum annual erosion by wind or water that can occur without affecting crop productivity for

Santa Ynez soils over a sustained period is 1 ton per acre per year (NRCE Soil Survey for Monterey County, Erosion Factor "T", Table 7 in Appendix A of this memorandum).

The soil loss estimates provided in Table 2 are very small, indicating the erosion should not be a significant concern on El Sur Ranch. Pasture lands in California have erosion rates of 0.1 to 0.2 tons per acre, per year as reported by the NRCS National Resources Inventory (1982-1997).

Table 2: Application of the USLE to El Sur Ranch Rainfall-Runoff

Method	Source	Factors	Estimated Soil Loss (tons/acre/year)
WEPP	NSERL	Monterey climate station, 700 ft. field length, 900 ft. field width, 3% slope, Santa Ynez soil, Fescue cover with grazing, 30-year simulation	0.0752
USLE	Mays, 2005	R-Factor from map (80), K-Factor for very fine sandy loam (0.41), LS-Factor from graph for 700 foot length at 3% slope (0.5), C-Factor for range cover with no appreciable canopy and 95% cover (0.003)	0.0492

Previous Investigations of Erosion

Three studies have been conducted on the El Sur Ranch to specifically address erosion on the property. The findings of these studies show: (1) that erosion of the coastal bluff is most likely due to ocean surf activity, (2) that erosion in Swiss Canyon has been reduced as a result of pasture establishment and irrigation, and (3) that overland runoff from the Pump House field that has periodically occurred has not caused erosion within or outside of the El Sur Ranch property. No studies or field investigations have been completed regarding erosion of the pasture fields, likely because it has not been a concern. In a review of the water right application and environmental impact review, Custis (2010) has raised several concerns about groundwater seepage causing coastline erosion that are also discussed below.

Rogers E. Johnson & Associates, March 2007

A study by Rogers E. Johnson & Associates, consulting engineering geologists, addressed erosion on the banks of Swiss Canyon and along the coastal bluff on the lower edge of the El Sur Ranch property. The study consisted of reviewing historical aerial photography (taken between 1929 and 2003) and field mapping. Coastal bluff erosion was found to be caused by episodic ocean conditions (high tides and sustained storms) and mostly related to the direction of ocean storm fronts. Erosion along the banks of

Swiss Canyon was found to have been reduced from that which occurred during pre-irrigation years, due to increased riparian vegetation from irrigation and the filling of drainage gullies in establishing the pasture. The study concluded that "irrigation of pasture land has had no discernable effect on rates of coastal bluff retreat within the study area", and that the investigation "did not reveal evidence of increased erosional activity during the past 50 years or so, either along the blufftop or on the banks of Swiss Canyon. In fact, subaerial gullying and slumping has diminished over this time period, primarily due to filling of gullies and control of surface runoff."

The Source Group Inc., 2005

The Source Group, Inc. conducted three separate field visits in March, June, and July of 2005 to investigate claims that overland runoff from El Sur Ranch irrigation was flowing into Andrew Molera State Park. The three field investigations concluded that irrigation of the Pump House field could cause overland runoff onto the State Park lands, but that modifications by El Sur Ranch to the road embankment and irrigation practices could alleviate future occurrence. Although signs of overland runoff were observed, there was no evidence of erosion as a result of runoff onto State Park lands.

Hanson Environmental Inc., 2006

Hanson Environmental Inc. conducted a month-long survey of erosion and seepage conditions along the coastal bluff of El Sur Ranch. Five stations were established along the western (coastal) edge of Fields 7 and 8. Stations were visited and photographed on a twice weekly interval between September 9 and October 16, 2006. This time period included a six-day irrigation of Fields 7 and 8 from October 6 -12. The study did not find any erosion resulting from irrigation or overland runoff along the bluff face during the field surveys. This study is significant because irrigation of Pastures 7 and 8 is the most likely to cause bluff face seepage and erosion.

Custis Memorandum, December 2009

Custis's comments provide a hypothesis on the instability of the coastal bluff and the causes of coastal erosion that differs from previous investigations. Custis notes two processes that might be causing erosion of the coastal bluff; processes that may be accelerated if greater than baseline irrigation applications were to be applied on the pasture field. Both of these processes are described by Hampton and Griggs (2004).

The first process consists of infiltrated groundwater flowing down-gradient (towards the coastal bluff) on top of the restrictive clay layer and accumulating into concentrated groundwater flow paths. According to Custis's hypothesis, upon reaching the bluff, the perched groundwater seeps out of the cliff face and causes gully formation and erosion in the form of scallops or theatre-headed valleys on the bluff face at the location of concentrated groundwater seepage. Custis's comments included photographs of scallops along the El Sur Ranch coastal bluff to support his claim that this process is occurring at El Sur Ranch. The 2005 and 2008 coastline photographs provided by Custis show defined scallop-shaped erosion formations along Pasture 7 near Swiss Canyon. These erosion features could be associated with groundwater flows near the soil surface. However, a few questions are worth asking: (1) Are these features caused by irrigation drainage flows and/or subsurface flows from natural rainfall events? (2) What is the erosion magnitude of these features relative to the total bluff erosion?

The first question was addressed in the investigation by Rogers E. Johnson & Associates, which did not reveal increased erosion activity along the irrigated pasture bluff or banks of Swiss Canyon during the 50 years of irrigation preceding the 2007 report. Based on aerial photos since 1929, field mapping and review of previous reports, Rogers E. Johnson & Associates concluded that "irrigation of pasture land has had no discernable effect on rates of coastal bluff retreat within the study area", and that the investigation "did not reveal evidence of increased erosional activity during the past 50 years or so, either along the blufftop or on the banks of Swiss Canyon. In fact, subaerial gullying and slumping has diminished over this time period, primarily due to filling of gullies and control of surface runoff."

Custis's comments state that. "Seepage at the cliff face and resultant sapping erosion can be expected to increase with an increase in water applied to the adjacent pastures from the baseline of approximately 3 feet to the applicant's 6 to 6.5 feet." However, the comments did not provide evidence that the seepage to the cliff face is a result of irrigation, and did not provide analysis to show that increased irrigation will increase seepage to the cliff face

Based on coastline photography, Custis has commented, "The number and density of these scalloped-shaped gullies appears to have increased significantly between 1989 and 2005." If this is correct, it does not necessarily follow that the cause was the irrigation from 1989 through 2005. The estimated average annual irrigation diversion from 1989 through 2005 was 815 acre-feet per year with a maximum diversion of 1,136 acre-feet in 2004; the estimated average annual irrigation diversion from 1975 through 1988 was 1,070 acre-feet per year with a maximum diversion of 1,737 acre-feet in 1984. In other words, irrigation levels decreased during the period when Custis has suggested that erosional activity increased. This does not support a correlation. Irrigation of the pasture began approximately 60 years ago, and irrigation pumping from 1989 through 2005 is not greater than prior pumping. On the other hand, a review of the monthly precipitation on the El Sur Ranch as correlated from the Monterey precipitation record and the precipitation measure on the El Sur Ranch shows that there were two months during the 1975 through 1988 period with over 10 inches of precipitation and that during the 1889 through 2005 period there were 12 months with over 10 inches of precipitation. While a correlation between irrigation and cliff face erosion is not apparent, there may be a correlation between the greater number of high precipitation periods from 1989 through 2005 than occurred from 1975 through 1988.

Direct evidence of erosion from seepage was not provided in the Custis comments, but photographs were provided showing darkened areas and pampas grass growing along the bluff in specific areas, which Custis has suggested may have resulted from groundwater flows to the cliff face in the upper soil layers. The 2005 and 2008 coastline photographs provided in the Custis comments show vegetative growth, specifically pampas grass, below pasture 7 and 8. The Custis comments suggested that the darkened areas are indicative of seepage and that the presence of pampas grass indicate that groundwater flows are seeping out along the coastline. The comments suggested that the presence of such saturated soils along the coastline would cause instability and slumping of the surface soils. The pictures in the 2006 Hanson report show pampas grass in Pasture 8 (Stations 4 and 5).

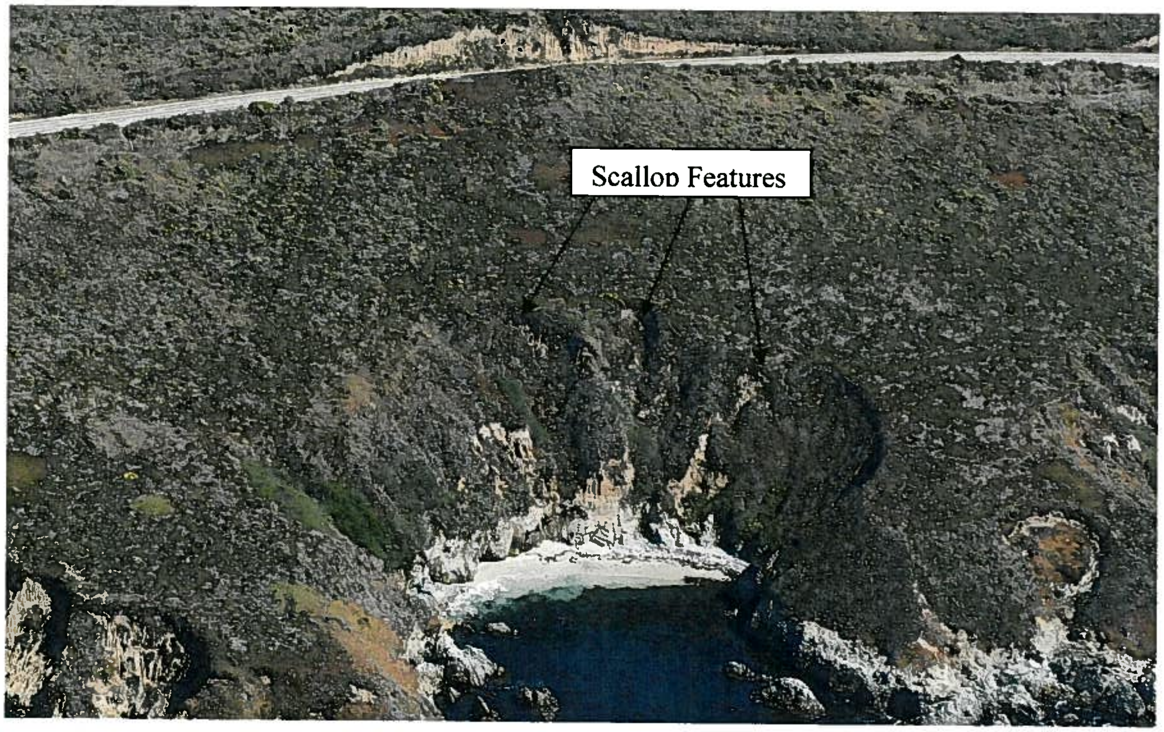
The photographs provided by Custis are not clear support for the conclusions regarding slump erosion processes. The resolution of the coastline photos is too coarse to differentiate between areas darkened by vegetative shading and bare soil faces darkened because of seepage. Supporting a contrary conclusion, the 2006 Hanson field survey of the same Pasture 7 field area found no indications of seepage along the bluff during or after irrigation of the Pasture 7. Little, if any, evidence was provided to support linking the presence of vegetation to the process of erosion by slumping of saturated soils. Further, no mention was made of the role of bluff vegetation in reducing erosion of the bluff because of anchoring by plant roots. If the presence of cliff-face vegetation were, in fact, evidence of erosion by slumping of saturated soils, the saturated soil conditions are much more likely to occur as a result of precipitation than irrigation, as previously discussed.

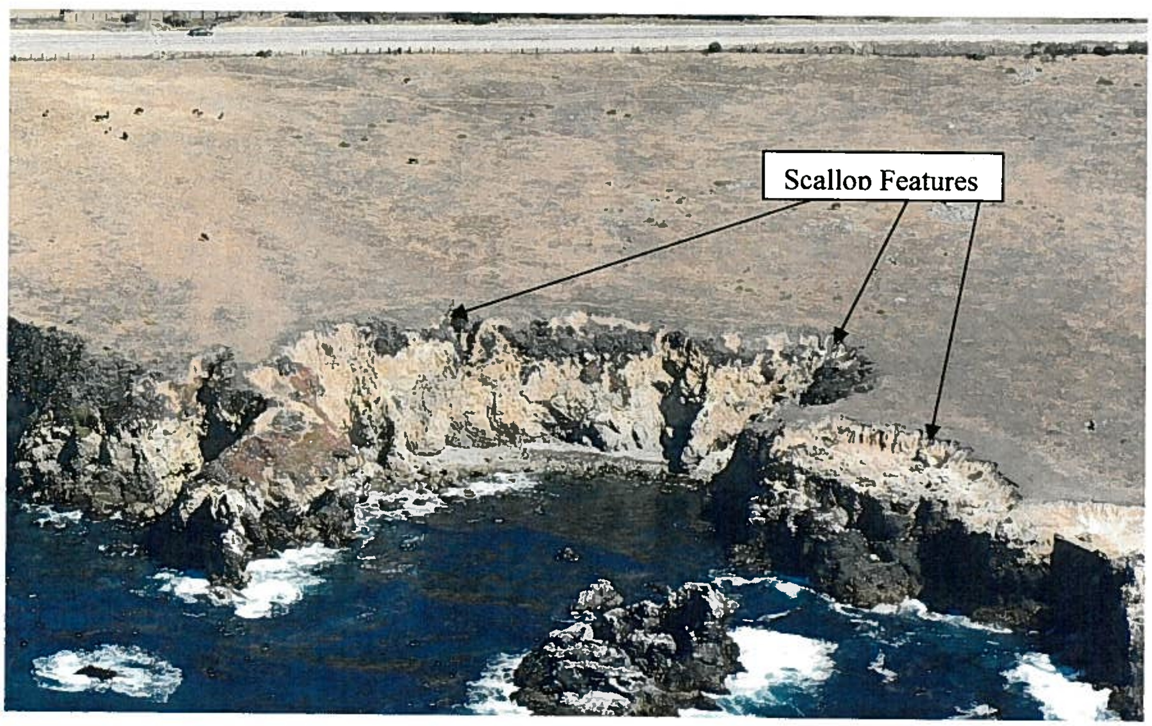
Coastline photographs archived by the California Coastal Records Project were investigated for signs of scallop formation in areas other than El Sur Ranch. Several examples of scallop-shaped erosion formations were found below natural and dry pasture landscapes, where no irrigation occurs (See Figure 11.) As can be seen from the photographs, the bluffs in the areas where the formations are seen have protection from waves and rocky formations, which reduce erosion from wave action. Most of the erosion in these locations is from groundwater seepage and surface runoff. Importantly, because these erosion formations are located outside the Ranch area, and because there is no irrigation in the land behind and up-gradient from the pictured bluffs, the formations are caused wholly by natural rainfall.

The second question related to the importance of scallop erosion features was addressed by Rogers E. Johnson & Associates.
"Surf erosion is the primary agent affecting bluff retreat; if surf erosion ceased, the coastal bluffs would soon reach a stable angle of repose regardless of whether or not the land adjacent to the bluffs is irrigated." If, as suggested in the Custis comments, infiltrated groundwater is flowing down-gradient (whether from natural rainfall or irrigation) on top of the restrictive clay layer, forming scallops or valleys on the bluff face, those processes should yield a stable angle of repose at the bluff face. The fact that the bluff face is nearly vertical -- not the process hypothesized by Custis have not resulted in a stable angle of repose -- supports Johnson's conclusion that by wave action is the primary mechanism of bluff erosion.

The second process of coastal bluff erosion described in the Custis comments consists of infiltrated groundwater flowing down-gradient above the restrictive clay layer and causing saturated soil conditions at the coastal bluff. The saturated soil conditions could result in instability because of pore water pressures and the increased weight of water. If this were to occur, unstable surface soils would then slump off the bluff face. While saturated soil conditions on the bluff face can result in erosion, the saturated soil conditions are much more likely to occur as a result of precipitation than irrigation, as previously discussed.

Figure 11: Coastline Photographs of Scallop Formations





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APPENDIX A

Excerpts form

Soils Survey of

Monterey County, California

USDA, Soil Conservation Service

April 1978