MARIN COUNTY
LOCAL COASTAL PROGRAM UPDATE

Coastal Cliff and Bluff Erosion Technical Background Report

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"Establishing Development Setbacks from Coastal Bluffs" (Johnsson, *in press*)

"Sample Policies for Planners Developing, Amending or Reviewing LCP Policies on Shoreline Protective Structures, Hazards, and Beach Erosion" (California Coastal Commission)

I. EXECUTIVE SUMMARY

The following report provides an analysis of the state of bluff erosion in the communities of Bolinas, Dillon Beach and Muir Beach. Review of published and unpublished reports, erosion rates, community plans and existing policies was performed to assess the severity of bluff erosion, the current policies in addressing this coastal hazard and to provide guidance in development of future policies regarding bluff erosion. Bluff erosion has impacted each community to varying degrees and, thus, the amount of data and the existing policies are different for each of the communities.

Bluff erosion is a continual dynamic geologic process that must be dealt with. It is hoped that this report provides enough information for creating uniform policies that are applicable to all the coastal communities within Marin County. In general, the bluff erosion hazard is relatively consistent throughout the west side of the County and new policies should be broad enough to address the issues of bluff erosion for all the affected coastal communities.

In recent years, the ability to analyze data with computers and GIS has led to great advances in analysis of coastline changes. New mapping methodologies are beginning to be utilized in addressing coastal hazards throughout the United States. The increased awareness of the severe impacts of coastal erosion has come to the forefront of major issues recognized by federal, state, and local governing agencies as something that needs to be dealt with. These new methods of analysis are being applied in other coastal regions, are applicable to Marin County, and should be pursued for enhancing the amount and quality of data on bluff erosion, which can be used for developing new policies for the Local Coastal Program (LCP) update.

Appended to this report are two documents, a report on policy development previously published by the California Coastal Commission and a report on determining bluff setbacks recently prepared by their staff geologist (Johnsson, *in press*). These documents will be useful for developing new policies addressing the hazard of coastal bluff erosion and updating the LCP.

II. INTRODUCTION

Bluff erosion is a continuous, dynamic geologic process that is a natural part of the evolving Marin County coastline. For the purpose of further description in this report, the term “bluff erosion” encompasses all the mass wasting processes involved in eroding the bluffs (gullying, sloughing, landsliding, etc.) It is one of the most active and readily observable (within the span of a winter storm) geologic processes affecting Marin County. The hazards and effects of bluff erosion have been known for some time and they pose a serious threat to development located near bluff

crests. Many structures located in hazardous areas were constructed prior to establishment of bluff/cliff erosion policies in the early 1980's. Coastal bluff erosion analysis has matured to a level that can provide relatively accurate erosion rates and adequate safety setback zones.

The increased level of understanding of the significant effects of bluff erosion on the California coastline has led to improvements in the analysis and evaluation of bluff erosion rates and bluff erosion setbacks (Johnsson*, in press*). This understanding has evolved with the increasing knowledge and awareness of the significant hazards and impacts that coastline erosion is having across the coastlines of the United States (Heinz, 2000; National Research Council, 1990). The purpose of this report is to provide background information on bluff erosion in the communities of Bolinas, Dillon Beach and Muir Beach; and, to provide recommendations regarding policy updates and mapping methodologies that can be implemented by the County for mitigating bluff erosion hazards and for updating the LCP.

A. BLUFF EROSION ANALYSIS

The following provides descriptions of the bluff erosion hazard in the three primary coastal communities in Marin County. Portions of each community are developed at the edge of the continent and some areas will eventually be removed by bluff erosion. This discussion will begin with a brief general description of bluff erosion and bluff erosion analysis followed by the bluff erosion hazards specific to each community.

Bluff erosion is a complex erosional process involving many aspects that can vary greatly along the coast (Hampton and Dingler, 1998). The primary component of this process, and the greatest single factor in the erosion rate of a bluff as compared to another, involves the physical characteristics of the bluff materials (Benumof and Griggs, 1999). Different soil and rock materials are susceptible to erosion to varying degrees. Benumof and Griggs (1999) label these physical characteristics of eroding materials as the intrinsic variables involved in bluff erosion, and include the strength of the material, the severity of joints and fractures, and the susceptibility of a material to weathering. Therefore, given the same external influences, a bluff composed of strong, weather resistant rock with no fractures will erode at a slower rate than a weak rock with extensive fracturing that is highly susceptible to weathering. The secondary component of the bluff erosion process involves the extrinsic variables that impact the intrinsic variables. These include wave erosion, amount of precipitation, surface runoff, groundwater seepage, and seismic shaking. The bluffs of Marin County are susceptible, in varying degrees, to all of these intrinsic and extrinsic variables.

The degree of erosion varies over time and significant erosion appears to be episodic in nature when greater than normal storm events cause the greatest erosion. This was observed and well documented during the 1982-83 and 1997-98

El Niño winter storms (Storlazzi and Griggs, 1998; Cannon et al., 1998). These greater than normal storm events result in larger wave heights, higher sea surface elevations, and increased precipitation relative to average storm events. As expected, these greater than normal extrinsic variables have a greater impact on the intrinsic variables; thereby, increasing the erosion rates for a limited period. This is an important point when considering the length of time that is evaluated for determining setback lines from eroding bluffs. This leads to the next part of the discussion: bluff erosion analysis and determination of setback lines.

A portion of Section 30253 of the California Coastal Act states:

> "*New development shall:*
>
> 1) *Minimize risks to life and property in areas of high geologic, flood, and fire hazard.*
>
> 2) *Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.*"

In order to satisfy these laws, new development must be sited far enough away from a bluff so that it is not at risk during its expected economic lifetime and that measures are employed during development to prevent any adverse impacts to the bluffs or adjacent properties. The following two setback methodologies are used by the staff of the California Coastal Commission in evaluating setbacks for bluff top development (Johnsson, *in press*). The first method that can be use is based on determining the stability of a bluff; if a bluff is not stable then a setback line can be determined with a slope stability analysis. This setback line, derived from slope stability analysis, is the line that meets the minimum factor of safety deemed appropriate. For residential and commercial structures, this is typically a factor-of-safety of 1.5 (ratio of driving force to resisting force). This type of analysis is very effective for a site-specific study and should include evaluation of the subsurface conditions and the potential for landsliding along planes of weakness. The bluffs in the coastal communities evaluated for this study are unstable and will continue to erode and fail over time.

The second method of determining a setback line is by measuring the long-term bluff retreat rates from historical data and creating setbacks based on the expected economic lifetime of proposed new development. This is a method that has already been implemented for The Bolinas Gridded Mesa (Edaw, Inc. and The Mesa Plan Resource Group, 1985). This approach requires determining the maximum erosion rate for a bluff and plugging it into the following formula:

Setback = (expected economic life of structure) x (rate of retreat)

Because of the uncertainty involved in the actual analysis of bluff erosion, it is common for an additional distance to be added to the setback as a safety factor. This can been done using various methods, which are outlined in Johnsson (*in press*). As an example, the Bolinas Gridded Mesa Plan incorporates an additional safety factor of 45 feet to the above formula:

Setback = (expected economic life of structure) x (rate of retreat) + (safety factor 45 feet)

Even though uncertainties do exist, some of them can be reduced somewhat by accurate computer mapping techniques, including the use of GIS (Moore, 2000; Crowell, et al., 1993; Anders and Brynes, 1991). Moore (2000) provides an overview of the various shoreline-mapping techniques that can be applied to the Marin County coastline. The more recent techniques use recent advances in cartography and photogrammetry that provide less error and "higher resolution" measurements of erosion. An explanation of the mapping techniques available is beyond the scope of this report; however, Moore (2000) provides an excellent overview of the techniques available. Table 2 in Moore (2000) provides an overview of the shoreline mapping techniques that have been developed and as indicated, all vary in approach, accuracy, expense, and training/time requirements.

Other uncertainties that are beyond control and difficult to determine, include the effects of sea level rise, the number and severity of future large storm events and the number and severity of future earthquake events.

A method useful for addressing some uncertainty and for refining a setback line over time is the use of a rolling setback. A rolling setback is based on the use of updated coastline change information. The Bolinas Gridded Mesa Plan proposed this technique in Policy LU-1.1 that states, "*this* [bluff] *edge shall be reexamined and adjusted as necessary every five years.*" This ensures that the location of new development evolves with the ever-changing coastline.

This is a brief description of the methods employed for determining setback distances. For a more detailed discussion of these methodologies, refer to Johnsson (*in press*), which is appended to this report.

B. BOLINAS

1. General Geology and Bluff Erosion Hazards

Bolinas was developed, like many coastal communities in California, on relatively level marine terrace terrain (Cleveland, 1975). Marine terraces are emerged wave-cut platforms that were cut by the ocean at a time when the sea level was relatively

higher relative to the land surface. Typically, these wave-cut platforms were covered with surficial deposits as the elevation of the platform rose higher than sea level. Most of Bolinas Peninsula is a broad, relatively flat, gently sloping terrace, with steep bluffs about 140 to 200 feet high. This terrace is known as “The Mesa.” Two flat-topped hills east of the Mesa are known as “Little Mesa” and “Francisco Mesa.” Little Mesa is located west of the entrance to Bolinas Lagoon and Francisco Mesa is located north of Little Mesa. An important geologic note regarding Bolinas is the presence of the San Andreas Fault Zone at the eastern portion of the Peninsula. A trace of the 1906 fault rupture is located east of Little and Francisco Mesas, in Bolinas Lagoon (CDMG, 1974).

The bluffs of Bolinas are composed of three different types of materials. The east end of the Bolinas Peninsula, east of the western boundary of the San Andreas Fault Zone, is underlain by the Merced Formation. The Merced Formation is reported to consist of poorly consolidated, massive yellow sandstone with interbeds of massive gray, blue, and orange silty clay and minor amounts of pebble gravel. This material exposed on the steep slopes is very susceptible to erosion and landsliding (Wagner, 1977). West of the western boundary of the State Earthquake Fault Zone for the San Andreas Fault Zone, the bluffs are underlain by the Monterey Shale. The Monterey Shale is reported to consist of light tan to white, siliceous shale, dark brown to gray, massive siltstone with rare interbeds of sandstone (Wagner, 1977). The stability of the Monterey Shale is variable and dependent on the degree of fracturing and weathering. The bedding of the shale generally dips to the west and southwest at angles of 45 to 72 degrees (Clark and Brabb, 2000); thereby, providing a potential plane of weakness for landslides in westerly facing slopes. Landslides and erosion are prevalent in the bluffs composed of Monterey Shale. Some upper portions of the bluff faces expose terrace deposits overlying the bedrock units. Terrace deposits are reported to consist of silt, sand and gravel and rest on top of the wave-cut terrace (Wagner, 1977).

In general, most of the bluff faces are mapped as landslides (Wagner, 1977; Wentworth and Frizzell, 1975). Landslides have destroyed homes and portions of Ocean Parkway during relatively recent storm events. Significant damage to property occurred during the 1982-1983 winter storms. The Monterey Shale, between Duxbury Point and Terrace Avenue, is very susceptible to landsliding and bluff erosion because of deep weathering and extensive fracturing and shearing, especially near the west edge of the San Andreas Fault Zone (Griggs and Savoy, 1985). The sandstone and siltstones of the Merced Formation are highly susceptible to erosion and failure, especially when they become saturated from heavy rains (Wagner, 1977). Review of aerial photographs suggests active erosion and landsliding along the entire bluff coastline of Bolinas.

Springs are quite common in the bluff faces and are part of the erosion process. Development on the Mesa, including the use of septic systems, has increased the

presence of subsurface water resulting in an increase in water migration into the joint and fractures of the Monterey Shale and increasing the moisture levels in the Merced Formation and surficial terrace deposits.

2. Erosion Rates

The bluff erosion rates for the Bolinas Peninsula vary and published rates indicate a range of values. Galloway (1977) reports an average rate of erosion of about 30 inches per year for the west facing cliffs from Duxbury Point to the north. In the vicinity of Little Mesa, the Merced Formation is reported to be eroding at a rate of 18 inches per year. Wagner (1977) cites bluff erosion rates from Galloway (1977) of 30 inches per year for the west facing cliffs and 20 inches per year for the cliffs above the Bolinas Lagoon channel. Wahrhaftig (1970a) is cited as reporting rates of 12 to 24 inches per year between Bolinas Point and Duxbury Point. The Bolinas Community Plan, reports the Bolinas Bay facing cliffs (Little Mesa to Duxbury Reef) to be eroding 18 to 24 inches per year and the Pacific Ocean facing cliffs (Duxbury Reef to Point Reyes National Seashore) as eroding 36 inches per year. The Bolinas Gridded Mesa Plan reports a rate range of 12 to 24 inches per year between Overlook Drive and Duxbury Point and 30 inches per year between Duxbury Point and Poplar Road. The Community Plan and Gridded Mesa Plan use the rates cited in the Wagner (1977) publication.

All of the engineering reports from the Bolinas area, reviewed for this study, report or discuss erosion rates for different properties, in the range of 12 to 24 inches per year; however, a source is never cited. These rates correspond with the rates reported in Galloway (1977) and Wahrhaftig (1970). It appears that independent bluff erosion rate studies were not conducted for any of the site-specific investigations reviewed. These investigations date from 1968 to 2001 and only one report issued in 2001 reported that they could "*document a retreat rate of approximately 16 inches per year*" for a specific property, but do not provide the method of analysis nor the source of this rate and, instead, use the 24 inches per year rate from the Bolinas Community Plan (Salem Howes Associates, Inc., 2001).

Another analysis of historical bluff erosion rates in Bolinas, by Griggs and Savoy (1985), reports rates at specific locations from Duxbury Point to the north at specific locations. Six points of measurement are shown on the map and range from 4.7 to 35 inches per year. For the northern portion of the west facing coast, it is reported that a few sections of the less weathered Monterey Shale that has more vegetation coverage receded at a rate of 0.4 to 7 inches per year, while areas to the south, where the shale is significantly fractured, has rates over 36 inches per year. Four points shown on the map, between Duxbury Point and Little Mesa, have rates between 11 and 20 inches per year. In addition, the study reports that, between Bolinas Point and Duxbury Point, the range of erosion rates varies from 6 to 24 inches per year.

Bergquist (1979) reports that photos from 1907 and 1976 "*show apparent recession and a decrease in slope of the cliffs at Duxbury Point. Topographic surveys described by Swainson (1929) indicate that Duxbury Point receded 60 m (0.8 m/yr* [32 inches/year]*) during the 1854-1929 period, and the cliffs between Duxbury Point and the Bolinas Lagoon inlet receded 30 m (0.4 m/yr* [16 inches/year]*) for the same time period.*"

Based on review of all the reported bluff erosion rates discussed above, the maximum rates reported thus far are 24 inches per year for the bluffs between Duxbury Point and Bolinas Lagoon, 32 inches per year for the bluffs between Duxbury Point and Poplar Road (including Duxbury Point); and, 36 inches per year for bluffs north of Poplar Road.

C. DILLON BEACH

1. General Geology and Bluff Erosion Hazards

The coastal bluffs, north of the planning subarea called the "Village," are located in or next to the Ocean Marina subarea. They are relatively steep and up to 100 feet high near the developed areas. These bluffs are underlain by the Franciscan mélange. Beach sand and terrace deposits overlie portions of the Franciscan mélange at the south end of the Oceana Marin subarea (Marin County Planning Department, 1989; Blake et al, 1971). Specific bluff property engineering investigations, report that the Franciscan mélange consists of large blocks of sandstone and shale within the mélange matrix at (Harding-Lawson Associates, 1973; Beattie, 1979). Beattie (1979) reports the lack of any consistent bedding structure within the mélange sandstone and shale, but that it is sheared and contorted. The following excerpt from Wahrhaftig (1970b) provides an overview of the bluff hazards present and the potential hazards from development:

> "*The coast of Marin County north of Dillon Beach is underlain largely by unstable masses of relatively impermeable crushed sandstone and shale, and is subject to very active landsliding. Retreat of the bluff top at the head of the landslides may average a foot or more a year, and cannot practically be controlled by riprapping at the base of the bluff. Soils formed from this material have a high content of swelling clays and will present serious foundation problems aside from the landslides. A perennially high water table in this impermeable material is suggested by numerous seeps, springs, and patches of tules on the upland above the bluff, and would seriously interfere with underground sewage disposal such as by septic tanks and drain fields. In addition, the effluent water from such sewage-disposal procedures would probably intensify landslide activity.*"

The Franciscan mélange is essentially an ancient fault zone of Cretaceous and Jurassic-age bedrock, which has been broken and sheared by tectonic forces as the continental crustal plate overrode the thinner subducting Pacific plate. The result is a disrupted mass of hard rock types embedded in a fine-grained matrix, which has been sheared and crushed. This assemblage or "mélange" unit is found throughout Marin County.

In the mélange, the comparatively low strength of the fine-grained matrix generally exerts a noticeable effect on slope stability and is a major influence on landsliding. Varying slope stabilities throughout Marin County result from differential inherent strengths of the various components of the assemblage. Rice, Smith, and Strand (1976) state:

> "*The mélange matrix weathers to clay-rich, highly expansive soils, which swell upon wetting and shrink upon drying. As a result, downslope creep occurs by the alternating seasonal wetting and drying.*"

Therefore, this mélange presents inherent problems both in slope stability and through the shrink-swell process of expansive soils.

2. Erosion Rates

The Dillon Beach Community Plan (1989) reports "*the long-range average rate of sea level cliff retreat in the Dillon Beach area is not known. However, the average rate of one to three feet per year found in Pt. Reyes Peninsula can be applied to this area.*" It does not state why the rates found in Pt. Reyes Peninsula can be applied to the bluffs in the Dillon Beach area. This is a very broad generalization and likely incorrect, since the geology of the Dillon Beach bluffs are different from the geology of bluffs at Pt. Reyes Peninsula. Due to the complex and variable characteristics of the Franciscan mélange, bluff erosion rates are likely quite variable along the bluffs north of Dillon Beach.

Engineering reports for bluff properties in Dillon Beach from County files were reviewed, but they did not provide any adequate historical retreat rates or setback analysis for bluff retreat. In general, comments in these reports, regarding bluff erosion and its impact on a specific development, are qualitative. Most of the properties that are threatened by bluff erosion are on the west side of Kailua Way. Review of aerial photographs suggests the presence of active landslides and erosion of the bluffs west of these properties.

Historical long-term bluff erosion rates are reported in a geotechnical investigation performed on a large parcel of land, the Marin Coast Ranch, north of the river Estero de San Antonio (Miller Pacific Engineering Group, 1996). The geology of the bluffs within this project site is very similar to that of Dillon Beach. The bluffs are generally

underlain by Franciscan mélange and at some locations are overlain by terrace deposits and the Wilson Grove Formation. Bluff erosion rates were obtained across several transects through the bluffs. The report groups the bluffs into two main areas by prevalent modes of landsliding. The "north segment" of the coastline is reportedly "*dominated by seated block type landsliding which occurs episodically with long recurrence interval. By comparison, retreat of the southern coastal segment was by progressive shallow landsliding and gully erosion.*" The rates of bluff erosion for the north segment are given as 1 to 4 feet per year and the south segment as 0.3 to 5.5 feet per year (Miller Pacific Engineering Group, 1996). Reportedly, additional information from coastal retreat studies that were carried out in Marin, San Francisco and San Mateo counties were evaluated by Miller Pacific Engineering Group, resulting in modification of the above mentioned erosion rates in a supplemental letter by Miller Pacific Engineering Group (1997), which states:

> "*These studies carefully evaluated systematic "errors" associated with maps and air photo sources. The data from our December 1996 report has been re-evaluated in the context of those studies and our findings have been modified as follows:*

North Segment	*range 1.4 to 1.9 feet/year*
South Segment	*range 0.8 to 4.4 feet/year"*

Based on all the information reviewed for the Dillon Beach area, erosion rates do not appear to have been established for the bluff areas. The bluff retreat rates from the geotechnical investigation in similar geologic terrain, north of Dillon Beach (Marin Coast Ranch), indicates bluff erosion rates are up to 4.4 feet per year at specific sections of the coastline. The rates determined in that study are likely relatively approximate estimates of bluff erosion rates for this type of geologic terrain. However, Franciscan mélange geology is complex and variable and the rates even for the Marin Coast Ranch are quite variable and may not be applicable to the Dillon Beach area bluffs. These rates are for bluffs in an undeveloped area that is not affected by the various impact issues that development can impose: concentrated surface runoff, excessive irrigation and associated increase in subsurface water, sewage disposal (effluent dispersal), development induced seeps and springs, introduction of inappropriate vegetation and increased surface erosion and gullying.

D. MUIR BEACH

1. General Geology and Bluff Erosion Hazards

The bluffs of Muir Beach are steep and generally range from 50 to over 275 feet in height. The bluffs are mapped as being underlain by Franciscan Complex mélange (Blake et al., 2000). Mélange characteristics are relatively consistent throughout the County and it is inherently weak and pervasively sheared. It is the source of highly

expansive soils and the reason for pervasive landsliding. Landslides are mapped in the vicinity of the Muir Beach bluffs; and, numerous landslides are mapped in the mélange of the coastline, north and south of Muir Beach (Blake et al., 2000; Wentworth and Frizzell, 1975). Review of aerial photographs suggests active erosion and landsliding along the entire bluff coastline of Muir Beach.

2. Erosion Rates

Rates of bluff erosion in the vicinity of Muir Beach are not available. The Muir Beach Community Plan and County records do not have information with regards to bluff erosion, and erosion rates were not found in the published literature for this area.

III. POLICY EVALUATION AND RECOMMENDATIONS

The following sections of the report list the existing LCP policies specifically related to bluff erosion issues, followed by an evaluation and recommendations for change. The recommendations are based on the evaluation of the information collected during this study and on the current state-of-understanding regarding bluff erosion hazards. Policies not related to bluff erosion issues are not listed in this report; therefore, in some cases the policy numbers skip significantly. This report only addresses those policies directly pertaining to bluff erosion.

A. LOCAL COASTAL PROGRAM, UNIT I POLICIES

Policy III-1 (page 40 – 41)

III, Shoreline Protection and Hazard Areas

1. New structures shall be set back from the Bolinas and Muir Beach bluffs a sufficient distance to ensure with reasonable certainty that they are not threatened from cliff retreat within their economic life expectancies. Adequate setback distances will be determined from information contained in required geologic reports and the setback formula established below. These setbacks will be of sufficient distance to eliminate the need for shoreline protective works. In view of the fact that the retreat rate varies markedly along the cliffs, and that the life expectancy of different kinds of structures varies greatly, the following formula will be used to determine setbacks from the bluff for new structures:

Setback (meters) = structure life (yrs.) X retreat rate (meters/yr.) In areas where vigorous sliding is taking place, an additional 15 [approximately 50 feet] meters should be added as a safety factor.

The retreat rate will be determined by a complete geotechnical investigation which will be required if one or both of the following conditions are met: The building or proposed development site is within 150 feet of the blufftop, or the site is located in

stability zones 2, 3 or 4 as indicated on the Slope Stability of the Bolinas Peninsula Study Area map which accompanies Wagner's 1977 report, "Geology for Planning, Western Marin County". This report and accompanying maps is incorporated by reference as part of the LCP.

Evaluation of Policy III-1

The value of 150 feet from the bluff top is inadequate based on the estimated rates of retreat that are known. Based on the maximum erosion rate so far reported for the bluffs from Duxbury Point to Poplar Road (32 inches per year), the bluff edges would reach this 150-foot setback line in about 56 years. This is well within the design life of most structures. Investigation of properties with structures within stability zones 2, 3, and 4 is still applicable and should be enforced. However, in order to determine an appropriate setback distance, a detailed analysis of historical bluff erosion rates and a geologic/geotechnical investigation of the bluffs is required.

Ideally, erosion rates should be based on high-resolution long-term historical bluff retreat rates, which can be defined as the average value of bluff retreat as measured over a sufficient time interval that increasing the time interval has negligible effect on the average value (Johnsson, *in press*). Several different mapping methods can provide high-resolution erosion rates (Moore, 2000; Cox et al., 2000; Benumof and Griggs, 1999). These methods can provide more precise erosion rate values then those that have been determined thus far.

Policy III–2 (page 41)

2. Development shall continue to be required to meet the seismic safety standards of the Alquist-Priolo Act as it has been implemented by the County. The County shall request that the State Geologist's Office review the recent study, "Depositional History and Fault-Related Studies, Bolinas Lagoon, California", by Joel R. Bergquist, U.S.G.S. Open File Report 78-802, to determine if the Alquist-Priolo Special Study Zone should be extended in the Bolinas Lagoon vicinity.

Evaluation of Policy III-2

Even though this policy does not directly address bluff erosion, it is an important component of the bluff erosion problem. The eastern portion of the Bolinas Peninsula is within the boundaries of the State of California Earthquake Fault Zone for the San Andreas Fault (CDMG, 1974). Because of the proximity to this fault zone, the likelihood of surface rupture and very strong ground shaking are highly probable. This fault zone is a likely source for causing significant coastal bluff failures, should a seismic event occur. Any development within this zone must meet the seismic safety standards of the Alquist-Priolo Earthquake Fault Zoning Act as

implemented by the County, and codified in California Public Resources Code, Division 2., Chapter 7.5. In addition, any analysis of bluff stability in Marin County should take into account the hazards associated with strong seismic shaking from this and other seismic sources in the San Francisco Bay Region. A similar policy addressing the seismic hazards present should be incorporated in the updated LCP and require that any new developments, especially near bluffs, evaluate the stability of the site with respect to strong ground shaking.

Policy III–3 (page 41)

3. The County shall seek public funds to contract with the State Division of Mines and Geology to initiate a study to identify lots and/or structures threatened with cliff retreat within their economic life expectancy. The results of this study shall be incorporated into the general restoration program for the Bolinas Mesa as described in Chapter II of the LCP.

Evaluation of Policy III-3

The County will need to determine the feasibility of implementing this policy. This policy could be implemented for this study by using the resources of the Marin County Community Development Agency in conjunction with resources and funding from federal, state, and local agencies, colleges and universities, and other sources, in addition to the California Geological Survey (new name for the State Division of Mines and Geology), if feasible. The creation of bluff setback maps based on high-resolution erosion rates would be useful for determining what existing structures are threatened by bluff erosion and what setback distances are necessary for reducing the risk to a less-than-significant level for new development.

Policy III–4 (page 41)

4. Many of the building sites in Unit I are characterized by one or more potential geologic hazards. The development of residential structures on such parcels may be subject to often sudden and destructive geologic phenomenon. The County of Marin does not encourage new residential development of such parcels and expressly states that the issuance of a coastal development permit for such property does not warrant said property's safety from geologic hazards. Further, the County of Marin will not accept liability for subsequent personal or property damage caused by geologic processes on said properties. To assure that the builder and subsequent purchasers are expressly aware of the policy, a "waiver of liability" shall be executed and recorded by said property owner prior to the issuance of a coastal development permit. Further, except for short-term, emergency food, shelter, and clothing, the County of Marin will not participate in emergency or disaster relief funding for

properties so identified and would recommend such limitations on State and/or Federal disaster/emergency grants and/or loans.

Existing geologic information indicates this geologic hazard policy shall apply to new development (excluding improvements to existing structures that would not result in an increase of 50 percent or more of internal floor area of the structure) on lots located in the following areas:

Lands located in the "Alquist-Priolo" earthquake hazard zones, as said zones may be amended.

Development within 300 feet of the mean high tide of the sea.

Development on parcels with slopes averaging over 35 percent.

All lots within the Seadrift sandspit to include the Patios, Calles and Seadrift Subdivision.

(Those lands covered by this "geologic hazards" policy are shown on the geologic hazard maps on file in the Marin County Planning Department)

Evaluation of Policy III-4

This policy should be revised to include new development and properties that are located within the limits of any established bluff erosion setback zones. The “waiver of liability” should be incorporated into any future policies and the knowledge of a property within a bluff setback zone should be part of any real estate disclosure statement.

Policy III-5 (page 42)

The following policy from Section 30235 of the Coastal Act is incorporated into the County LCP:

> Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline process shall be permitted when required to serve coastal-dependent uses or to protect existing structures (constructed before adoption of the LCP), or public beaches in danger from erosion and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply.

Evaluation of Policy III-5

This policy is law and allows property owners to protect their property from the threat of bluff erosion. However, three possibilities exist for a homeowner whose property is threatened: abandonment, relocation or protection. Evidence from other coastal communities suggest, in general, that the protection approach may work on the short term, but the long term costs can be substantial (Griggs, 1986). Studies of coastal protection structures indicate that many structures do not provide permanent protection and have required regular repair or complete reconstruction after severe winters (Griggs and Brown, 1998; Griggs, 1999). It is for these reasons that Policy III-7 should be part of the updated LCP. A protective structure is not always an effective long-term method to stop erosion, due to the potentially high costs of construction and repair, the potential impact to properties adjacent to protective structures, the potential impact on sand supply and the impact on visual enjoyment.

The Draft Policy on Coastal Erosion Planning and Response, dated March 26, 2001, was issued by the California Resources Agency for "*improving how the state government plans and responds to coastal erosion along California's 1,100 coastline.*" The draft policy proposes the following criteria for construction of protection devices, which could be considered as guiding criteria for use in developing policies for the Marin County LCP (Only criteria applicable to bluff erosion are listed):

> "The first priority, if development is threatened, should be to evaluate the feasibility and desirability of re-locating the development. If re-location is not feasible or appropriate, the next step is to evaluate projects that minimize or eliminate the erosion threat. Both private parties and public agencies propose erosion response projects. Resource Agency departments should use the following principles when evaluating erosion response project applications:
>
> B. Construction of seawalls, revetments, breakwaters, groins or other artificial rigid structures for coastal erosion control should be discouraged unless each of the following conditions are met:
>
> 1. No other non-structural alternative is effective or feasible to reduce erosion risk over the useful life of the protected development;
>
> 2. The project is to serve a coastal dependent use or to protect an existing principal development or public beach in danger from erosion;
>
> 3. The project is consistent with the erosion solutions presented in the certified local coastal plan or other regional coastal management plan that identifies and comprehensively addresses regional coastal hazard issues;

4. A report by a licensed geologist demonstrates that a primary structure is at imminent risk from coastal erosion. Further, conclusive evidence should be presented in a report by a licensed engineer that a protective device is designed and can be constructed and maintained to withstand the specified design criteria that reflect the range of conditions that exist at the project site, and will successfully mitigate the effects of coastal erosion while minimizing the significant effects of the project on other sections of the shoreline;

5. There will be no net reduction in public access to, and use and enjoyment of, the natural coastal environment, and construction of a protective device will preserve, enhance or provide access to related public recreational lands or facilities;

6. The project will not have significant effects on cultural, paleontological resources, or living marine resources and habitats; and,

7. Measures are included to ensure that the protective structure can and will be maintained through its design life and removed at the expense of the project sponsor if the protective device fails or has unmitigated effect on other sections of coastline, or is no longer necessary.

D. Projects should not cause the loss or destruction of public beaches, dunes, and coastal accessways."

Similar policies to those just listed are also present in LCP, Unit II under Section III, Tomales Bay Uses, Shoreline Structures. These examples of policy for shoreline protective structures provide a template for development of new policies in the LCP update.

Policy III-7 (page 42)

7. Because revetments, seawalls or other shoreline protective works can be detrimental to maintenance of natural shoreline processes and can interfere with visual enjoyment and coastal access, such works are discouraged. The County of Marin through the LCP and other documentation has identified those coastal areas potentially subject to significant wave and run-off erosion. Because such probable risk areas are identified, sufficient opportunity for private investigation and response to such hazards is available. Therefore, the County of Marin shall not finance or construct emergency shoreline protective devices for the benefit of private developments.

Evaluation of Policy III-7

This policy should be maintained. However, setback maps based on high-resolution erosion rates would reduce the likelihood of any new development in its economic lifetime of resorting to the use of protective structures. As discussed in the evaluation of Policy III-5, a revised version of this policy could be a part of the updated LCP in order to discourage the use of protective structures and encourage the use of non-structural long-term solutions to bluff erosion.

Policy III-8 (page 42)

8. It shall be County policy to encourage property owners subject to ocean-front erosion hazards to develop responses to such hazards prior to emergency conditions. Where contiguous properties are subject to generally similar erosion hazards, joint program development should occur. The County will not finance such engineering studies (or any subsequent construction activities), but will seek aid from Federal and State agencies, colleges and universities to assist private consulting engineers in such review and recommendations. Where existing community organizations or special districts are unable to provide organizational support for such area-wide joint studies, the County, upon request, will assist in the organization and administration of such privately funded studies.

Evaluation of Policy III-8

This policy should be modified by encouraging response to emergency hazards that could arise at specific portions of the coastline. The creation of setback maps, based on high-resolution long-term bluff erosion rates is a method that can be used to reduce the impact of bluff erosion hazards. If these maps were available, they would show those properties that are at increased risk. The County could encourage property owners that are at increased risk to have a consulting civil engineer/geotechnical engineer/engineering geologist evaluate the stability of a specific bluff property with a site-specific slope stability analysis using the methods outlined in (Johnsson, *in press*). Moreover, this would provide an early warning of the inherent hazard, so that engineering measures could be performed, at the owners discretion, to protect the property before it was too late.

Policy III-9 (page 43)

9. In the absence of an overall wave hazard/shoreline erosion study, any-permit application for seawalls, riprap or other protective structures on beaches, shall be accompanied by engineering reports stating the nature and extent of wave erosion hazard along the beach area and an explanation of how the proposed protective works will mitigate the hazard, both on and off the project site. This policy shall not

apply to emergency permit applications applied for within three years of the date of adoption of the LCP. Emergency permit applications after that date shall be subject to report requirement or shall specifically establish why the need for such protective devices was not foreseen.

Evaluation of Policy III-9

This policy should be modified. This policy encompasses other coastline hazards besides bluff erosion, such as, wave runup hazards, and is intended to address beach front property. This policy could be rewritten or a new policy created, which requires that detailed site-specific engineering/geotechnical/engineering geologic investigations be performed for bluff properties.

Policy IV-40 (page 86)

40. No new development shall be permitted on the Bolinas Gridded Mesa area, except as provided below, pending resolution of the water moratorium and completion of a comprehensive restoration plan for redevelopment of the Mesa. The plan should address the issues of how the community water supply can be increased consistent with Coastal Act and LCP policies; how wastewater can be effectively disposed of consistent with Coastal Act, LCP, and Regional Water Quality Control Board policies; and how internal circulation and drainage systems can be developed to mitigate existing problems of access and ponding. In addition, a restoration plan should examine the issue of bluff erosion, including the possible elimination of endangered blufftop lots, while assuring the option of locating a bluff top access way along the perimeter of the Mesa. The plan should also address the cumulative impacts of the type and intensity of development on the capacity of Highway 1, consistent with Coastal Act priorities on the allocation of limited highway capacity for coastal dependent land uses. Finally, the restoration plan will need to examine provision of suitable areas for additional commercial uses in a manner that would protect the character of the existing community while addressing Coastal Act policies on location and priorities of development. The Coastal Commission should, to the extent feasible, provide financial and technical assistance in development of these future studies. This program will be processed as an LCP amendment.

The construction of no more than five single-family dwellings utilizing existing unused water meters shall be permitted, provided, however, that such dwellings are located on lots greater than 10,000 square feet in area and that they are located at least 150 feet from retreating bluffs.

Evaluation of Policy IV-40

The Bolinas Gridded Mesa Plan (1985) was created to supplement Section 10 of the 1975 Bolinas Community Plan, entitled "Redevelopment of the Gridded Mesa." Therefore, The Bolinas Gridded Mesa Plan addressed the concerns raised in Section 10 and this policy. The Bolinas Gridded Mesa Plan, using available bluff erosion rates, created bluff setback zones for the Bolinas Gridded Mesa Plan. The following Land Use Policies from the Bolinas Gridded Mesa Plan were revised from the 1975 Bolinas Community Plan and are example policies from which similar policies could be developed for use in the updated LCP. Based on review of the policies in the LCP and the Community Plans, the following three programs are the most conservative and appropriate policy programs currently present in the Marin County for addressing bluff erosion hazards:

> "*Policy LU-I: There shall be no residential development or substantial construction near the bluffs. (1975 Land Use Policy 6 – revised for the Gridded Mesa Plan)*
>
> *Programs:*
>
> *LU-1.1—Establish a Bluff Erosion Zone along the Bolinas Bay side of the Mesa. The extent of this Zone shall be based on a 100-year life expectancy for a residential unit. The Zone shall extend from Overlook Drive to Duxbury Point and shall include all land from the edge of the bluff to a line 254 feet inland. This edge shall be reexamined and adjusted as necessary every five years. No new construction and no residential additions amounting to greater than 10 percent of the existing total floor area or 120 square feet (whichever is greater) shall be permitted in this zone on a one-time basis. Replacement construction will be permitted provided that it conforms to current building and environmental health codes and the waiver provisions of Program LU-1.3 below (Figure 4-1) Time Frame: Immediately.*
>
> *LU-1.2—Establish a Bluff Erosion Zone along the Pacific Ocean side of the Mesa. The extent of this Zone shall be based on a 100 year life expectancy for a residential unit. This Zone shall extend from Duxbury Point to Poplar Road and shall include all land from the edge of the bluff to a line 295 feet inland. This edge shall be reexamined and adjusted as necessary every five years. No new construction and no residential additions amounting to greater than 10 percent of the existing floor area or 120 square feet (whichever is greater) shall be permitted in this zone on a one-time basis. Replacement construction will be permitted provided that it conforms to current building and environmental health codes and the waiver provisions of Program LU-1.3 below (Figure 4-1) Time Frame: Immediately.*

LU-1.3—The restrictions imposed by LU-1.1 and 1.2 can be waived on an individual basis if a site specific engineering report prepared by a licensed engineer can show that hazardous conditions do not exist on that site or that the site-related constraints can be adequately overcome and that construction on that specific site will not contribute to cumulative negative effects, specifically groundwater mounding, nitrate accumulation and bluff erosion on the Mesa. Any construction (new construction or additions) within either bluff erosion zone will require that permit issuing agencies (e.g., the County, BCPUD) be held harmless for any loss due to erosion. Time Frame: Immediately."

B. LOCAL COASTAL PROGRAM, UNIT II POLICIES

Policy IV-5a. (page 207)

5. Hazards

An applicant for development in an area potentially subject to geologic or other hazards as mapped by the County, including Alquist Priolo earthquake hazards zones, areas subject to tsunami runup, landslides, liquefaction, beach or bluff erosion, steep slopes averaging greater than 35%, or flood hazard areas, shall be required to demonstrate that the area of construction is stable for development, the development will not create a hazard or diminish the stability of the area, and the development will not require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs. The applicant may be required to file a report by a qualified professional evaluating the geologic conditions of the site and the effect of the development. In addition, as a condition of coastal permit approval, the applicant shall be required to sign a waiver of liability exempting the County from liability for any personal or property damage caused by natural hazards on such properties.

Evaluation of Policy IV-5a.

This policy can be modified to include the following: The use of high-resolution erosion rates for determining safe setback zones and detailed site-specific slope stability analysis in civil/geotechnical/engineering geologic reports could provide property owners with the necessary information regarding feasibility of a development on a specific property affected by bluff erosion hazards. Again, the "waiver of liability" should be included in any future policy. This policy lists many of the other hazards present along the coastline. Any new policy regarding new development in a potentially hazardous area should require a geologic/engineering investigation evaluating the hazard potential at a specific site.

Policy IV-5b. (page 208)

b. In coastal bluff areas, new structures shall be set back a sufficient distance from the bluff edge to ensure with reasonable certainty that they are not threatened by bluff retreat within their expected economic lifespan (50 years). The County shall determine the required setback based on information submitted by the applicant, staff investigation, and a geologic report, which may be required. The setbacks will be of sufficient distance to eliminate the need for shoreline protective works.

Evaluation of Policy IV-5b.

This policy should be modified to change the expected economic lifespan from 50 to at least 100 years. New policies addressing this issue should require setback based on high-resolution erosion rates, as indicated in previous policy evaluations in this report. A 50-year life span for a new development is unrealistic, given the increased economic lifespan of buildings. Many of the structures in the coastal communities are more than 50 years old and it would be unwise to base setback lines on a 50-year retreat rate. A more realistic estimate of at least 100 years is recommended.

Policy IV-5c. (page 208)

c. Development of any kind beyond the required bluff-top setback shall be constructed to ensure that all surface and subsurface drainage shall not contribute to the erosion of the bluff face or the stability of the bluff itself. Surface water shall be directed away from the top of the bluff or handled in a manner which prevents damage to the bluff by surface and percolating water.

Evaluation of Policy IV-5c.

A new policy addressing these issues should be incorporated into the updated LCP, to include development within and outside of the setback zone. The contribution of surface and subsurface water could greatly increase the rates of bluff erosion. The coastal communities evaluated for this study are built on marine terrace terrain. In most cases, surface and subsurface water from community properties, upslope of the bluffs, migrates to and seeps out of the bluff faces, increasing erosion rates. Based on unpublished geotechnical investigations and previous regional studies, it is known that the wave-cut platforms generally slope toward the ocean and therefore have a predisposition for directing surface and subsurface water toward the bluffs. A new policy could include mention of reducing or eliminating significant landscape irrigation and surface water runoff and not allowing sewage disposal systems for existing development in bluff setback areas and in the development outside setback areas

built on marine terrace terrain, where subsurface water could have an effect on bluff erosion.

Property owners can diminish the impact of bluff erosion by implementing preventive measures called for in policies. These measures should include:

1. Directing all rainwater and irrigation runoff into a drainage system that directs runoff to the street.

2. Provide positive drainage away from the bluff tops.

3. A drainage plan should be prepared by a civil engineer for any new development; and, homeowners should be encouraged to improve existing properties.

4. A drainage system should be cleaned and maintained on a regular basis.

5. Ideally, minimal irrigation should be used on bluff top properties, which can be effectively done with the use of highly controlled irrigation systems and drought tolerant or water efficient plants (e.g. use of native plant species) that can live on natural rainfall alone after becoming established.

Policy IV-5d. (page 208)

d. New development shall be sited and designed so that no protective shoreline structures (e.g. seawalls, groins, breakwaters) are or will be necessary to protect the building from erosion or storm damage during its expected economic lifespan (50 years). The applicant may be required to submit a professional geologic report demonstrating that the project conforms to this policy.

Evaluation of Policy IV-5d.

This policy could be modified to include the recommendations to use high resolution bluff erosion rates. The implementation of policies using setbacks based on high-resolution bluff erosion rates and detailed site-specific slope stability analysis would greatly lower the probability that the use of protective structures would even become an issue. This concept should be incorporated into policies of the updated LCP. Again, the use of a 50-year economic lifespan should be reevaluated and a more realistic economic life span, such as 100 years, should be considered. This policy could be expanded to discuss the best approaches regarding development of shoreline protective structures. A list of criteria that can be followed in order to determine the need for construction of protection structures is discussed in the Evaluation of Policy III-5 from LCP, Unit I.

IV. GENERAL CONCLUSIONS AND RECOMMENDATIONS

Because of the limited amount of information available on bluff erosion rates for Dillon Beach and Muir Beach and the fact that the erosion rates for Bolinas have uncertainty errors, it is recommended that high-resolution erosion rates be obtained for the three coastal communities. Due to the recent advancement of technology, this can be done with the use of GIS and advanced mapping techniques. However, the County may not be able to conduct such a study due to monetary, equipment, and staffing constraints. Effective use of this technology could be accomplished by enacting LCP and Countywide Plan policies that encourage a working partnership with non-County public agencies that can help in developing setback maps using a GIS system, such as the U.S. Geological Survey or the Federal Emergency Management Agency.

The existing policies in the LCP and in The Bolinas Gridded Mesa Plan provide a foundation for development of newer, refined policies. Policies and programs similar to those in the Bolinas Gridded Mesa Plan (Policy LU-1) should be developed in order to provide a conservative and safe setback for new development near coastal bluffs in Marin County. Since the existing policies for bluff development were created, the state of knowledge on bluff erosion has greatly increased and the ability to obtain more accurate retreat rates has evolved. This should be taken into consideration and the new policies should incorporate this increased level of understanding and accuracy. The following summary of issues should be considered in development of new policies.

- The coastal bluffs of Marin County will continue to erode at varying rates and this hazard will always be an issue for the communities of Bolinas, Dillon Beach and Muir Beach.

- The erosion rates that are known from previous studies are based on methodologies that are generally never clearly explained. They are likely approximate averages that in some cases were measured over a short time span; so, the accuracy of these rates is questionable.

- The recent advancements in computer mapping techniques and GIS can greatly reduce the errors associated with determining shoreline changes and provide more precise bluff erosion rates that can be applied to creating useful setback maps. There are several techniques available for determining erosion rates and these techniques all vary in method, accuracy and cost. Ideally, it would be beneficial to use highly accurate erosion rates for determining setback distances. However, the method chosen is dependent on the resources available.

- Development related issues brought up in the evaluation of existing policies section must be addressed in new policies in order to reduce impacts from bluff-top and near-bluff development. These issues include but are not limited to surface runoff and groundwater seepage problems, the use of appropriate landscaping for bluff top and near bluff properties, and the elimination of on-site sewage disposal systems, especially in bluff setback zones. Specific drainage and landscaping policies could be established to provide long-term solutions to surface runoff and groundwater seepage problems. However, the most significant development issue that needs to be implemented in updated LCP policy is the creation of adequate setback policy. As discussed, setback zones will reduce the threat of bluff erosion and reduce the need for protective structures.

- The methodologies for determining slope stability and setbacks outlined in Johnsson (*in press*) should be incorporated into the land use and implementation policies that are developed for bluff erosion analysis (Appended to report).

- Important parameters need to be considered, established and incorporated into the bluff erosion hazard policies; and include but not limited to, determining an adequate economic lifetime of a structure, determining the best way to implement a rolling setback, and determining an adequate safety factor to the setback equation. For example, the Bolinas Grided Mesa Plan bases the bluff erosion zone on a 100-year life expectancy for a structure, recommends that the setback zone be reevaluated every five years and adds a safety factor of 45 feet to the setback. Similar parameters should be considered as part of the LCP update for bluff setbacks for all communities affected by bluff erosion.

- Development of new policies for other LCPs has taken place in other jurisdictions, incorporating the many recommendations proposed in this report. A recent example of a LCP that has incorporated policies that were adopted by the California Coastal Commission is for the City of Malibu. The City of Malibu coastline has bluff erosion hazard issues similar to those in Marin County. The recently adopted LCP for the City of Malibu (adopted September 13, 2002) can be downloaded from the California Coastal Commission web site at www.coastal.ca.gov. Example policies are also provided in the California Coastal Commission document appended to this report, titled “Sample Policies for Planners Developing, Amending or Reviewing LCP Policies on Shoreline Protective Structures, Hazards, and Beach Erosion.”

- It is conceivable that policies could be developed that pertain to all the coastal communities. In general, the impacts associated with bluff erosion

and the methods used to mitigate these impacts are the same for the three communities affected. The variables that are specific to each community; such as, erosion rates and bluff seepage rates can be addressed with non-specific policies. There does not appear to be a reason to develop specific policies for each community affected.

APPENDIX. REFERENCES

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Kristin Drumm, Planner, Marin County Community Development Agency
Mark Johnsson, Staff Geologist, California Coastal Commission
Gary Griggs, Director of the Institute of Marine Sciences, University of California Santa Cruz

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