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memorandum

date May 6th, 2011 (revised May 24, 2011)

to Surfrider Foundation

from David Revell, PhD., Bob Battalio, P.E., Sara Townsend

subject Malibu Lagoon Restoration - Effects on surfing and beach conditions

Project scope
The purpose of this project was to review the available technical information on the proposed Malibu Lagoon restoration plan and evaluate the potential effects of the lagoon restoration on beach and surfing conditions.

The purpose of the lagoon restoration is to improve circulation and water quality by grading a more natural tidal channel morphology which should promote scour of sediments and avoid pools of stagnant water that have impaired water quality. We note that we were not asked to specifically examine any water or sediment quality related issues.

Background
Concerns about the lagoon project have been raised by local surfers regarding the potential impacts of the proposed restoration on the surf conditions. These concerns focus on several issues associated with the quality of the surf as it relates to the timing of lagoon breaching and the location of the opening itself. Some additional concerns were raised about the possible affect of the 1983 restoration on the inlet location (personal communication Andy Lyons – May 3/2011). We address some of these concerns in the discussion of the dynamics associated with the lagoon and coastal processes, and include more specific responses at the end of this memorandum.

We understand that the armoring of the Adamson house recently occurred due to the creek mouth migration to the northeast. The armoring was accomplished under an emergency permit and is a renovation of armoring previously installed. Historic documents and geomorphic analysis indicate that the Adamson House is in the range of natural mouth migration (Ambrose and Orme 2000). Also, the natural creek mouth estuary lagoons are highly dynamic, and these types of obstructions inhibit the natural reworking and passage of sediments. Observations show that the creek mouth tends to migrate eastward as it closes following natural or mechanical breaches near Third Point.

Setting
Malibu Lagoon is the downstream coastal end where the Malibu Creek watershed, which drains 110 sq. miles of the Santa Monica Mountains, meets the Pacific Ocean. This site is characterized by a Mediterranean climate with cool wet winters and hot dry summers. Malibu Lagoon is a 31 acre seasonally tidal lagoon (M&N, 2005) meaning that during certain times of year (generally in the winter and spring) the lagoon mouth is open to the ocean, discharging fresh water and sediment into the surf zone. When the lagoon is open, it experiences tidal fluctuations. During other times of year (generally summer and fall), the sand bar closes off the tidal inlet. When the inlet is closed, creek flow increases the lagoon water level. When the lagoon level rises close to the top of the

beach, a breach occurs. The breach typically forms where there is a low or narrow crest, or will break “straight out” (towards Third Point) when the river flow rates are high and impinge on the sand barrier with sufficient velocity to overtop and scour it.

Malibu is part of the Santa Monica Bay Littoral cell (or beach sand compartment) with sediment delivered from the steep coastal watersheds and seacliff erosion to the coast, then transported along the beaches by waves until the sediment is eventually lost into the Redondo submarine Canyon (Patsch and Griggs 2006). The barrier beach along Malibu is underlain by two bedrocks outcrops that are a function of tectonic activity associated with the Malibu fault. The bedrock outcrops are separated by an incision shaped by river flow during lower stands of sea level. The eastern most outcrop forms Malibu Point and serves to anchor the beach in a relatively stable position (Ambrose and Orme 2000). The shoreline at Malibu faces south with the primary wave exposure to long period southerly swells in the summer time. More energetic northwest swells in the winter are greatly reduced in size due to this shoreline orientation. Tidal range is about 6 feet. This wave exposure and shoreline orientation sets up wave driven longshore transport of sand which is from west to east at approximately 30,000 cubic yards per year (cy/yr) (Patsch and Griggs 2006).

Precipitation and stream discharge are episodic with the majority of total annual rainfall occurring in several days over the winter. This climate also supports terrestrial chapparal communities susceptible to large wildfires which can dramatically increase sedimentation rates into the watersheds.

Malibu is a world-renown surfing location, a right hand cobble point break important in the early development of surf culture. Malibu was recently identified as the first World Surfing Reserve site in the United States (figure 1; Save The Waves, 2010[1]). The surf spot known as Malibu is composed of three separate takeoff spots. From west to east the spots are known as Third Point, Second Point and First Point. The surf conditions at Malibu are related to coarse sediment delivery from Malibu Creek and reworking by wave action. The foundation of the Malibu surf break is the creek delta which results from the underlying geology and fluvial discharge, including coarse sediments (cobbles, boulders) remnant from thousands of years of creek discharge at lower sea levels. The best surf conditions follow large rainfall events when the creek mouth tends to break through the beach near Third Point, with coarse sediment then worked by waves through Second Point to First Point. This mouth configuration results in bottom contours that are exceptionally well formed to induce good surfing conditions. The bottom contours together with southern swell create a breaking wave form that “peels” (i.e. translates) laterally along the wave crest as it propagates along the point, producing one of the world’s best surfing waves.

The variability in river discharge and location of lagoon breaching largely controls the sediment discharge ultimately affecting the quality of the surf (Figure 2). For example, a 1963 Surfing Guide to Southern California describes Third Point as a “…right slide so fast as to be ridable only rarely…" (Stern and Cleary 1963). However following the 1969 flood event of record, 33,800 cubic feet per second (cfs), sediment built out the delta and waves were ridden from Third Point through First Point, as documented in numerous surfing accounts. The following decade is often considered the glory days of Malibu as the wave shape was both hollow (plunging) and long connecting from Third Point to First Point. In general, when the creek discharges near First Point, the sediment delivery to Second and Third Point is reduced resulting in bottom contours and surfing conditions not conducive to quality surfing.

Historic changes

Historically, Malibu Creek would change its course in response to the episodic fluvial flood events with the lagoon inlet breaching more to the west (Ambrose and Orme 2000). Analyses of historic maps and imagery show that the historic lagoon was much larger, extending parallel to the shore for at least a half a mile and potentially up to 0.8 mile (Ambrose and Orme 2000) (Figure 3). Human alterations throughout the watershed in the form of

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[1] *See* http://www.savethewaves.org/malibu. Save the Waves Coalition. Malibu World Surfing Reserve. (last visited May 6, 2011).

dam construction, infilling, road construction, urbanization, flood control and wastewater treatment have influenced the size, shape and functionality of Malibu Lagoon.

In 1926, construction of the 100-ft high Rindge Dam was completed. The dam controls nearly one-third of the watershed and began to quickly accumulate sediment. Today, Malibu Creek contributes only about 24,000 c.y/yr of sand annually on average. This is a reduction of 55% from the natural sand discharge of approximately 41,000 c.y/yr due to the damming and control of Malibu Creek (Knur and Kim, 1999; Willis and Griggs 2003). Sediment impoundment took only 34 years to fill the entire Rindge dam capacity. The dam currently traps 1.2 million c. y of sediment (Slagel and Griggs 2006). The U.S. Army Corps of Engineers and California State Parks have undertaken a feasibility study on the removal of Rindge Dam to help restore Malibu Creek's natural sediment supply. Cost estimates for the removal of Rindge Dam range between $4 million and $18 million, depending on the strategy of sediment removal (Patsch and Griggs 2006).

Development along the barrier beach and spit to the west and east of the current lagoon have constrained breaching locations and reduced flushing capacity. From about 1940 until 1983, Malibu Lagoon was first used as a disposal site for excess dirt by the California Department of Transportation during construction of the Pacific Coast Highway (PCH, aka Highway 1), and then subsequently hosted two baseball fields.[2] By the early 1980s, in recognition of the degradation of the ecosystem, Malibu Lagoon underwent its first restoration process coinciding with one of the largest El Nino events of record. However, the restoration is generally not considered successful because it did not properly restore the tidal flow and water circulation within the lagoon. This was likely caused by the lack of natural geomorphic form of the tidal channel (three artificial circular channels were created instead of a natural geometry) and the fact that the channel entrances to the main lagoon were set perpendicular to the main channel, potentially deflecting flows especially on ebb (dropping) tides. These channels have silted in and contributed to impaired water quality as a result of lack of tidal scour and water circulation. In 1996 the Los Angeles Regional Water Quality Control Board placed Malibu Lagoon on the 303(d) list of impaired water bodies.[3] Addressing the degraded water quality of Malibu Lagoon, by improving the tidal flow and circulation within the lagoon, is the focus of the newly permitted restoration project slated to begin June 1, 2011[4].

Overall these watershed changes have probably affected the surfing conditions by altering sediment transport, stream discharge and lowering the peak velocities responsible for moving coarse grain sized material (cobbles and boulders) through the lagoon and resupplying the Malibu creek delta with sediment.

Current inlet dynamics

A generalized conceptual model of inlet dynamics is shown in Figure 4. During a closed system, the lagoon fills with inputs from upland watershed sources, groundwater flow, treated discharges from the wastewater treatment plant, and wave overtopping. As the lagoon fills, the volumes in the lagoon vary as a semilogarithmic function of lagoon stage (water level), a volume of water of approximately 65,000 cy is held below the 3.5 foot stage, ~200,000 cy held at the 6.5 foot stage, and ~290,000 cy at the 7 foot stage (Ambrose and Orme 2000). The maximum water level held in the lagoon is largely controlled by the elevation of the beach berm crest. In a "closed" condition, sand drift dynamics and tidal action have built up the barrier beach to approximately elevation 10 NAVD88, and the lagoon stays flooded to approximately elevation 9 NAVD88 (Jones and Stokes 2009). The differences can largely be attributed to seepage through the beach as well as evaporation.

A natural breaching of the lagoon can be caused when lagoon water levels exceed the beach crest at which point, the lagoon rapidly drains scouring sand from the beach and lagoon at the new inlet. Soon after the barrier beach is initially breached, the lagoon can drain to elevation 0.0 (NAVD88) and match the lowest daily tide (Jones and Stokes 2009). In general terms, the larger the volume in the lagoon, and the higher the coincidental fluvial

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[2] *Malibu Lagoon Restoration Project: Technical Information.* Santa Monica Bay Restoration Commission. September 2010.

[3] Water bodies placed on the 303(d) list are in violation of Section 303(d) of the Clean Water Act.

[4] The project is delayed until October, 2011 by an injunction on May 20, 2011 (personal communication, Surfrider Foundation).

discharge upon breaching, the larger the scour and the farther offshore the sediment is transported. This sediment, scoured from the beach and lagoon or discharged directly from the Creek, nourishes the nearshore sea bed. Once the discharge abates, waves move the sediment onshore, to construct a beach, and along shore to create a sandy shoal. The interactions of the waves and sediments result in a long, uniform wave form conducive to surfing. The location of the breach is also a key consideration affecting surfing conditions. When the lagoon breaches straight out along the west side of the lagoon, the sediment is deposited at Third Point initially and then carried along the rest of the point in the longshore transport: This is the favored condition. Discharge at First Point is not favored.

Artificial breaching has occurred throughout much of the modern human dominated era both permitted (Ambrose and Orme 2000) and unpermitted (personal communication Andy Lyons 5/3/2011). The permitted mechanical breaching has usually been done to alleviate flooding and prevent septic system failures in the Malibu Colony and Civic Center with ancillary benefits to lagoon water quality, mosquito abatement and shorebird habitats. This permitted breaching was historically done (1984-1996), between Second and Third Points, in consideration of surfing conditions (Ambrose and Orme, 2000). The unpermitted breaching has usually been done by surfers along the west site of the lagoon in an effort to enhance surfing conditions (personal communications Andy Lyons 5/3/2011).

The effect of artificial breaching is not well studied, however it can be detrimental to lagoon habitat and have unintended effects on sediment supply patterns. A breach is usually caused when the water volume in a full lagoon is joined by a rainfall, creek discharge event and serves to maximize the scour through the barrier beach thus setting the initial inlet location for subsequent creek flows to discharge sediment. A premature breach may not scour as much sand and result in a more rapid migration of the lagoon entrance to the east through which subsequent large flows may scour and “train” the entrance into a new location. This increases the tendency for multiple mechanical breaches in a given water year. Geomorphically this makes sense, but more research is needed to determine the relative importance of initial breach conditions such as timing and location.

The effect of breach location on ecology is not as obvious. In general, the location of the breach affects the initial and subsequent breach geometry (e.g. cross section), hydraulics (e.g. tide range), rate and extent of subsequent migration, salinity and water quality and sediment transport. Therefore, since these parameters affect the lagoon (i.e. suitable habitat for species), breach morphology is generally considered to have an indirect effect on lagoon ecology. This is of course why mechanical breaches have been discouraged – depending upon a species life history traits, adverse effects may occur if it is conducted during a critical time period. However we note that the Malibu system is highly degraded and a “hands off” approach is not necessarily more natural or preferred. We recognize that mechanical breaching is controversial and that competing objectives can be difficult to satisfy. This problem is being addressed in many of California’s coastal lagoons and river mouths with varying levels of success.

During a majority of the “open” season the barrier beach is naturally maintained at an average elevation of three feet. Tidal influences enter the lagoon twice a day and flood the project area to an average elevation of six feet, with the extreme high tides serving to backup fluvial discharge causing lagoon elevations to reach an elevation of approximately 8 feet (NAVD). If the lagoon is “open” the approximate maximum tidal flow could be as high as 1000 cfs during a short period on the incoming tide. The average flow over the six hours from low tide to high tide would be approximately 250 cfs (Jones and Stokes 2009).

As the “open” lagoon season continues, the barrier beach begins to rebuild. Due to wave and wind driven longshore transport from west to east the inlet mouth would tend to get pushed to the east. The elevation of the beach at the inlet determines the tidal influence, generally the more tidal volume into the lagoon (tidal prism), the greater the scouring potential on a falling tide and the longer the inlet mouth tends to remain open. As spring wind conditions and long period south swells take control in the summer, the beach begins its seasonal recovery and the lagoon becomes more of a stream flow dominated lagoon with less tidal and salinity influences until gradually the lagoon closes, generally during a neap tide series and a period of extended calm wave energy.

Findings and Discussion

The proposed restoration involves the recontouring of lagoon channels to create a single meandering tidal channel and involves excavation of 51,200 c.y. and the placement of 37,500 c.y. to improve the function of the lagoon ecosystem. Upon review of the existing technical information, staff reports and permits, we find that the technical work available to us does not analyze the effects of the lagoon restoration on the lagoon breaching and inlet dynamics to a level sufficient to address the purpose of our study – namely determine the effect of the restoration on surfing and beach conditions. We have not found any analysis of the potential impacts of the restoration specifically on the sediment transport to the nearshore and the subsequent impact on surfing conditions.

Based on review of the limited available technical information, we do not expect the lagoon restoration project to adversely impact inlet dynamics or surfing, except possibly to reinforce the existing mouth location until the system is "re-set" by a large fluvial event or other action[5]. The volume of water contained in the restored area is relatively small compared to the size of river discharges during relatively frequent (e.g. annual) events. The existing mouth location is problematic, in that increased tidal prism resulting from restoration may reinforce this location temporarily (see below).

Future restorations which would improve sediment delivery to the coast, restore a more natural hydrograph or expand the tidal prism in a more substantial way would likely increase sand and coarser sediment delivery to the nearshore delta thus improving surfing conditions.

Recommendations

It is important to note that we have not conducted our own analysis or fully digested all of the work done over the decades at Malibu Lagoon. Therefore, these recommendations can be considered provisional pending review by others who are more familiar with historic conditions and prior work. It may be possible to address some of these recommendations with the final design and construction while others are potentially important next steps to restoring the Malibu Creek watershed.

A. Recommendations for the existing projects (Lagoon Restoration and Adamson House)

We recommend that the following actions be included in the existing projects, to the extent that these can be accomplished within the project parameters. The intent is to identify actions that can be accomplished without delaying the approved projects and that are generally practical (e.g. consistent with the existing projects).

- **Facilitate breach near Third Point:** Change the angle that the new tidal channel enters the lagoon in order to facilitate breaching near Third Point. Ideally it would be oriented more parallel to the mainstem of the creek and angled toward the beach and west end of the inlet.

- **Facilitate breach near Third Point:** Revise the rewatering portion of the construction so that the final breach of the temporary earthen berm can train the creek channel along the west side of the inlet to the maximum extent practicable.

- **Impede inlet at existing location (First Point):** Following appropriate sediment testing for grain size and contaminants, reuse excess coarse grained size material and place it in front of the Adamson house to reduce the erosion and scour of the eastern lagoon inlet. We expect that State Parks would place additional material to provide adequate volume to discourage the existing inlet location.

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[5] The mouth opened farther west on May 18th (personal communication, Surfrider Foundation)

- **Breach near Third Point:** Consideration should be given to breaching near Third Point as part of the proposed restoration and/or the erosion management at the Adamson House. The existing mouth location appears to be incongruent with the wetland restoration project (specifically the new channel location), preservation of the Adamson property, and surf conditions[6]. This may require amending the State Park emergency permit, or some refinements to the engineering design and construction of the wetland restoration project.

- **Expand Final Hydrologic Monitoring Plan (Special Condition 5):** The restoration monitoring plan could be expanded to include the creek mouth / inlet and neashore. The objectives would generally be to identify changes in conditions, address whether restoration effects the surf, and provide a baseline for future actions. Monitoring elements could include surf conditions, coastal processes, beach profiles, beach grain sizes, nearshore bathymetry and mouth morphology. The observations should be distilled to address linkages with the restoration project and mouth management, and support future work (see below). Specifics of an expanded plan can be completed upon request.

B. Recommendations for the future work

We recommend that the following actions be taken in order to accomplish protection and enhancement of the Malibu Creek mouth, shore and lagoon system. For context, we believe our recommendations to be consistent with the Lower Malibu Creek and Lagoon Resource Enhancement and Management study (Ambrose and Orme, 2000). We note that a conceptual version of the lagoon restoration project nearing construction was recommended by this prior report, along with investigation of modified inlet management.

- **Develop a Malibu Creek Mouth and Lagoon Resource Management Plan.** A management plan would update the 2000 study for lower Malibu Creek and Lagoon, and expand to address the shore and near shore, and provide more detailed analysis of breaching and inlet morphology. Individual projects, such as additional wetland restoration, modification to the lower creek and lagoon, and breach location management are possible components of the plan. We recommend that a conceptual model of creek mouth and lagoon inlet function be developed. The Conceptual model would articulate the linkages between the nearshore, including surf conditions, and the lagoon, wetlands and creek processes. A key consideration of this Plan would be an evaluation of mechanical breaching to affect the initial fall breaching location.

- **Ecosystem Based Management –** A broader, long-term plan to enhance the ecosystem will help guide future actions, and assess the implications of dam removal and climate change. This plan would consider the entire watershed ecosystem and develop a range of conservation, restoration / enhancement and management actions.

Local concerns

The concern we are addressing is whether the restoration project may adversely affect surfing conditions. Based on personal communications, we believe the primary concerns are as follows, along with our initial assessment:

- *The lack of mechanical breaching (mouth management) at the west end has adversely affected the surf.* This concern is consistent with the limited information available to us, although the occurrence (or lack of occurrence) of large creek discharges (e.g. February 1998) is considered the controlling factor and the

[6] The mouth opened farther west on May 18th (personal communication, Surfrider Foundation).

breaching timing and methods could also have a detrimental effect. We note also that such interventions need to consider multiple objectives and the historic breaching protocols may not be feasible;

- *The lagoon restoration in 1983 has increased the tendency for the mouth to locate near First Point.* There is insufficient information to assess this concern. We note that there are multiple potential causes of the existing mouth location, some of which are natural and others related to actions by man. Lagoon volume and configuration can affect mouth morphology. However, the volume of water in the restoration area (existing and proposed) is small relative to the river discharge and the volume in the open lagoon, indicating that the restoration project is not a controlling factor in mouth morphology or surfing conditions. There may be an effect on mouth location or rate of migration when the lagoon is tidally dominant (low river discharge), due to the trajectory of ebb flows which are reportedly from the restoration area toward the east (personal communication, Andrew Lyon) ;

- *The proposed restoration will have a similar but greater effect as the 1983 restoration, and further entrench the mouth at First Point.* There is insufficient information to assess this concern. However, the consolidation of the tidal channels to one channel connecting with the open lagoon, and its location near the third Point could reduce whatever effect the 1983 restoration had on mouth location. However, we do not think the restoration project in itself can "re-set" the mouth from its present, problematic location;

- *Future restoration will further expand the wetlands and adversely affect the surf.* There is insufficient information to address this concern, but the information we have indicates this concern is dubious except for the potential for short term effects following construction and influenced by other factors, such as antecedent conditions (the existing mouth location and timing of breach). Typically, restoration is considered neutral to positive to surfing because the surf conditions are often a characteristic of a healthy creek mouth ecosystem. We speculate that this is one reason the effect on surfing was not previously a concern for project proponents;

- *Restoration is misguided because the natural condition did not include the wetlands.* We disagree with this concern. Based on the historical interpretation in Ambrose and Orme (2000), there were much larger extents of wetlands which were mostly damaged or destroyed by the 1930s due to development. The restoration appears to be generally consistent with historical conditions except that it is limited in size;

- *The proposed projects (wetland restoration and protection of the Adamson House) are not addressing the key issue of mouth management.* We agree that a more holistic consideration of the lower lagoon and lower creek, essentially a follow on the 2000 study with improved monitoring data, and inclusion of nearshore coastal processes, would be beneficial if not necessary to evaluate the performance of the restoration and armoring projects and inform future projects.

References

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Source: courtesy of Save the Waves 2010

figure ***1***

Malibu Lagoon Restoration – Surfing Assessment

Malibu World Surfing Reserve Site Map

PWA Ref# D211385.00

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Source: California Coastal Records Project

figure **2**

Malibu Lagoon Restoration – Surfing Assessment

Variability of Lagoon Breaching Locations

PWA Ref# D211385.00

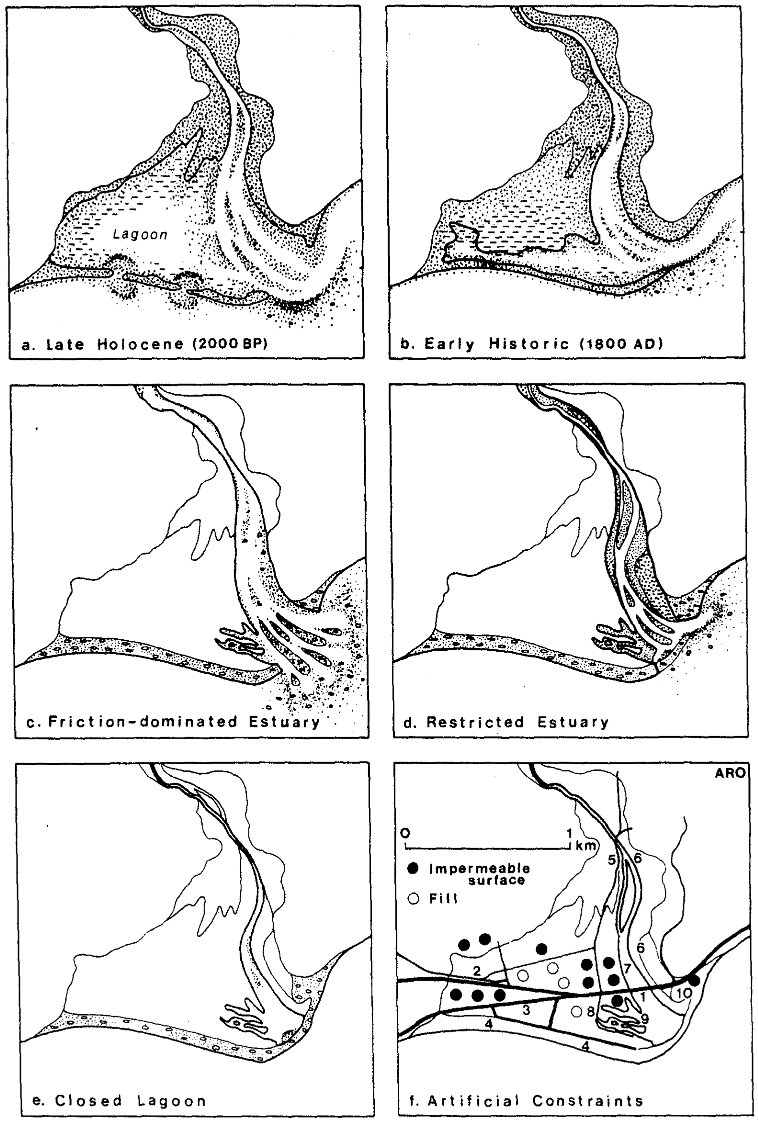

Figure 2-1 Malibu estuarine lagoon system: late Holocene and early historic stages, present morphodynamic options, and artificial constraints

2-3

Source: Ambrose and Orme 2000.

figure **3**

Malibu Lagoon Restoration – Surfing Assessment

Historic Changes to Malibu Lagoon

PWA Ref# D211385.00

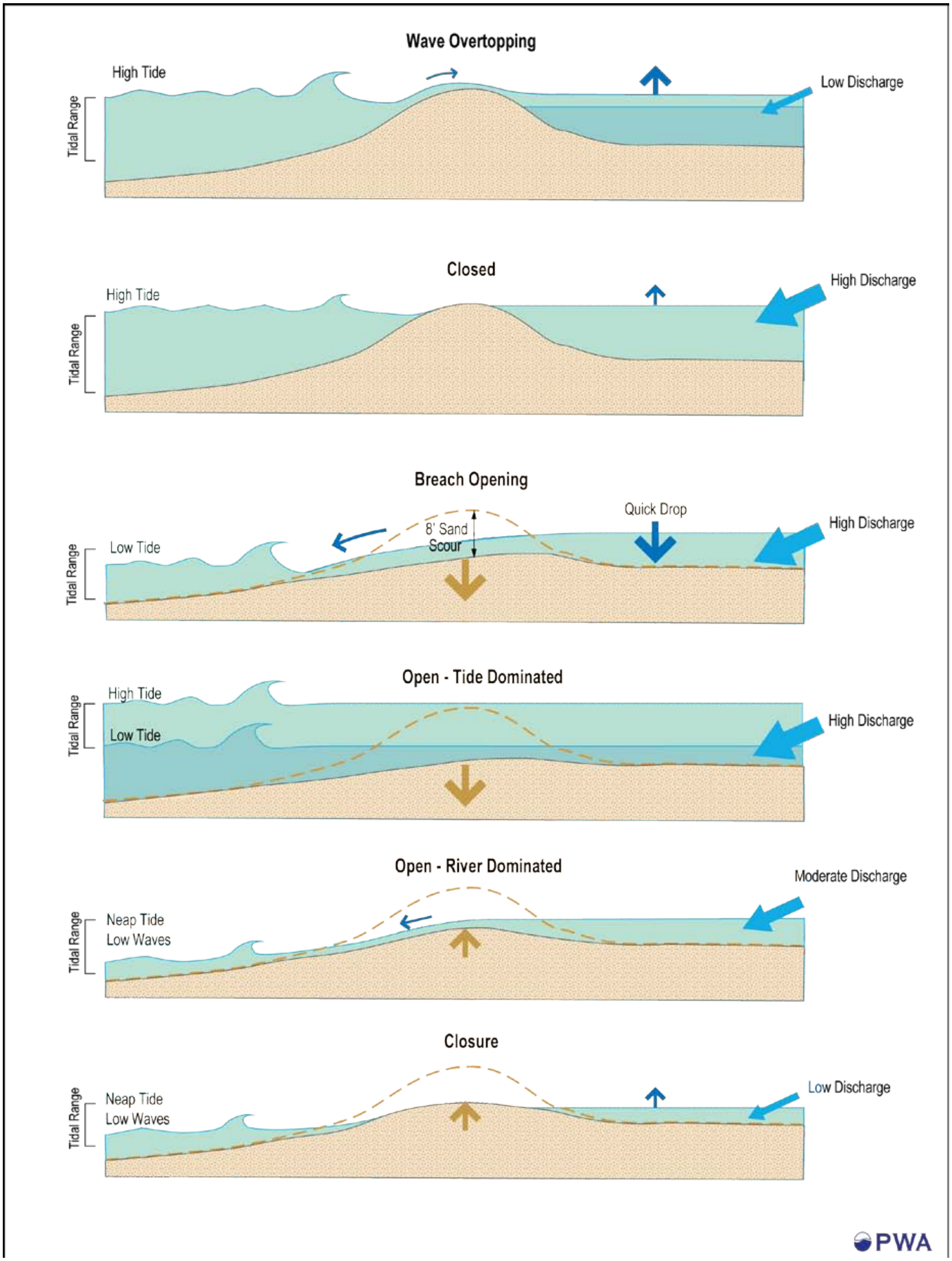

figure ***4***

Malibu Lagoon Restoration – Surfing Assessment

Conceptual model of Lagoon Breaching and Closure

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