CITY OF BAINBRIDGE ISLAND
ENVIRONMENTAL TECHNICAL ADVISORY COMMITTEE

MEMORANDUM

TO: Planning Commission and City Council

FROM: ETAC

DATE: September 29, 2011

RE: **Technical Framework: Riparian Protection Zones and Buffers Addendum**

ADDENDUM TO RIPARIAN PROTECTION ZONES AND BUFFERS MEMORANDUM

The Bainbridge Island Environmental Technical Advisory Committee (ETAC) would like to offer the following information and recommendations to the Planning Commission and City Council for consideration in determining riparian buffers and protective standards for marine shorelines in the SMP update. We understand that the topic of protective buffers and shoreline vegetation management is somewhat controversial, and believe that some of the controversy and confusion stems from a lack of understanding of what the available scientific and technical information tells us about riparian areas and the use of buffers as a management tool. Therefore, we offer the following additional notes regarding the ecological functions of marine riparian areas (MRAs) and science available to guide their management, as well as a set of conclusions and recommendations which we hope will be helpful in your deliberations regarding the use of buffers and other shoreline vegetation management tools. This document is an addendum to the previously submitted memo to Council and Planning Commission in consideration of additional deliberations by ETAC and to clarify the discussion of riparian science, with the following primary goals:

1. Clarify and add additional details to the explanation of riparian functions
2. Expand the discussion on the needs for and science behind riparian buffers
3. Add general conclusions based on the objective review of scientific documents
4. Provide Recommendations from ETAC to the City Council, Planning Commission and staff regarding the use of riparian science for the management of shoreline under the SMP, including buffers.

PART I: GENERAL MARINE RIPARIAN VEGETATION ISSUES

The Importance of Marine Riparian Areas

Puget Sound's marine shorelines and riparian areas have been altered over the last 160 years by human activities including agriculture, forestry and development. Nearly all of the merchantable timber along the marine shorelines of Puget Sound was harvested or burned by 1884 (Chasan, 1981). Although natural regeneration of riparian vegetation occurred in the years that followed, human manipulation of vegetation continues to influence marine shorelines today (*e.g.,* clearing and grading for development). Although the level of alteration and loss has not been well-documented, some data indicate continuing loss and degradation.

For example, in an evaluation of 11 major deltas in Puget Sound, Levings and Thom (1994) determined that there was at least a 76 percent loss of tidal marshes and riparian habitats. Ongoing degradation and loss of nearshore habitats have been generally quantified and highlighted as a critical component of Puget Sound restoration and salmon recovery by the Puget Sound Partnership (PSP), the Puget Sound Nearshore Ecosystem Restoration Program (PSNERP), and the National Marine Fisheries Service.

Riparian areas are integral parts of marine nearshore ecosystems, and a critical component of shoreline management strategy. Since the passage of the SMA, there have been significant advancements in our knowledge and understanding of these adjacent lands (*i.e.*, riparian areas), and their importance for maintaining the resource values of both aquatic and terrestrial systems. Riparian areas provide important ecological functions that are not only critical for maintaining ecosystem health and integrity, but also for providing valued ecosystem services for mankind (e.g., socioeconomic, biophysical, recreational, aesthetic).

Riparian Functions

In discussions within ETAC, we felt that the riparian functions table in the original memorandum (also Table 1) could use additional clarification of data gaps and uncertainties, and a stronger focus on describing the specific ecological functions that can be provided by MRAs. Table 1 below provides these clarifications and a specific focus on the roles of the MRA in providing ecological functions in the shoreline environment. In addition to the functions outlined in Table 1, MRAs also provide separation from human activity for sensitive aquatic and upland species, and provide for human values, such as protection from coastal hazards, aesthetic values, improved air and water quality, and recreational values.

Table 1. Ecological Functions, role of the MRA in providing the function, and data gaps/uncertainties

Ecological Functions	Roles of the MRA in providing the function	Data Gaps and Uncertainties
Water quality	• Moderating surface erosion and filtering sediment from surface runoff and flood flows. • Removing and transforming nutrients and harmful substances from surface runoff and flood flows. • Infiltrating and storing surface runoff and flood flows into groundwater for later release to water bodies. • Removing and transforming nutrients and harmful substances from groundwater passing through root zones.	• Most pollution control functions are derived from the freshwater literature. The basic processes of pollutant attenuation via slowing of runoff and uptake by vegetation are expected to be similar regardless of the salinity of the adjacent water body. • More Island-specific information is needed about shoreline runoff and nearshore water quality to evaluate the importance of shoreline areas in providing water quality functions, and to evaluate baseline and ongoing conditions • The extent to which fine sediment acts as a "pollutant" in terms of adverse effects on aquatic life is mainly drawn from stream literature.
Fish and Wildlife habitat	• Providing fish with cover from predators. • Providing spawning and feeding substrate. • Contributing in-water organic matter to support fish prey (insects and invertebrates), and other aquatic life. • Screening or dampening noise, glare, and human activity from the water. • Contributing large woody debris and other organic matter needed for amphibian, small mammal, bird, and insect habitat within the MRA. • Providing wildlife habitat areas (for feeding, reproducing, resting, dispersal, migration, etc.) for riparian species, and for upland species that use riparian areas.	• Wildlife functions of MRAs are generally not well documented • Need better understanding of wildlife interactions on Bainbridge Island shorelines

Ecological Functions	Roles of the MRA in providing the function	Data Gaps and Uncertainties
Bank/Slope Stabilization and Regulation of Sediment Supply	1. Supporting slope stability and inhibiting erosion through a variety of processes, such as soil anchoring or binding, intercepting rainfall, evapotranspiration, and decreasing soil water saturation. 2. Contributing to a normative rate of coarse sediment supply by moderating but not eliminating bluff erosion, which provides critical habitat and substrate to important biota (e.g. forage fish and eel grass). Erosion of marine riparian bluffs is the dominant source of coarse sediment to most Bainbridge beaches. 3. Fine sediment control: Excessive fine sediment on beaches may inhibit important ecological functions. 4. Contributing woody debris to beaches which can reduce and slows erosive water forces through barriers and increased roughness.	1. The net ecological impacts of changes are not established. For example, a decrease in slope stability may have both negative (accelerated loss of MRA, excessive fine sediment on beaches) and positive (increased supply of coarse sediment and LWD to beaches) effects. 2. The net effects of changes in sediment supply resulting from alterations to the MRA are likely to be site specific and even depend on ecological characteristics of inland areas.
Shading and microclimate moderation	• Riparian vegetation provides thermal and structural refuge for wildlife, vegetation, fishes, and invertebrate species by moderating solar radiation and moisture in the upper beach as well as throughout the riparian area (e.g., moderating ambient temperature and moisture for temperature-sensitive species. • Influencing the microclimate (e.g., shade, temperature, moisture) near the water to be more suitable for aquatic and riparian organisms, particularly for climate-sensitive species or life stages • Protects riparian species by sheltering from wind, moderating temperature and moisture	• The importance of vegetation shading is variable and dependent on shoreform and orientation; e.g., a steep bank may be more likely to have overhanging vegetation compared to a gradual shoreform such as a barrier beach. • Specific functions and species assemblages are site-specific and variable across shoreforms
Nutrient exchange	• Generating and providing organic plant matter (e.g., leaf litter) needed for food web. • Providing primary and secondary productivity for food web functions to support fishes and wildlife (e.g., plants, insects).	• Differences between native and non-native vegetation in providing these resources needs further study

Ecological Functions	Roles of the MRA in providing the function	Data Gaps and Uncertainties
Large Woody Debris (LWD) function(s)	Provision of LWD to beaches which in turn provides: 1. Beach stabilization and erosion control by trapping sediments and providing a barrier to wave energy 2. Nutrients and moisture for plants and animals 3. Habitat structure for fishes and wildlife (see habitat functions), and enhances development of shore vegetation	5. Uncertain how sea level rise will effect presence and movement of LWD and related ecosystem functions 6. Differences in LWD functions between wood from different sources needs additional evaluation; we do know that cut logs are more transient 4. Additional information is needed to understand the importance and variability of LWD in providing some of these functions including provisioning of substrate for plant and invertebrate communities in the backshore

Conceptual Model of Marine Riparian Functions

Figure 1 illustrates many of these functions, along with delineations of conceptual management buffers.

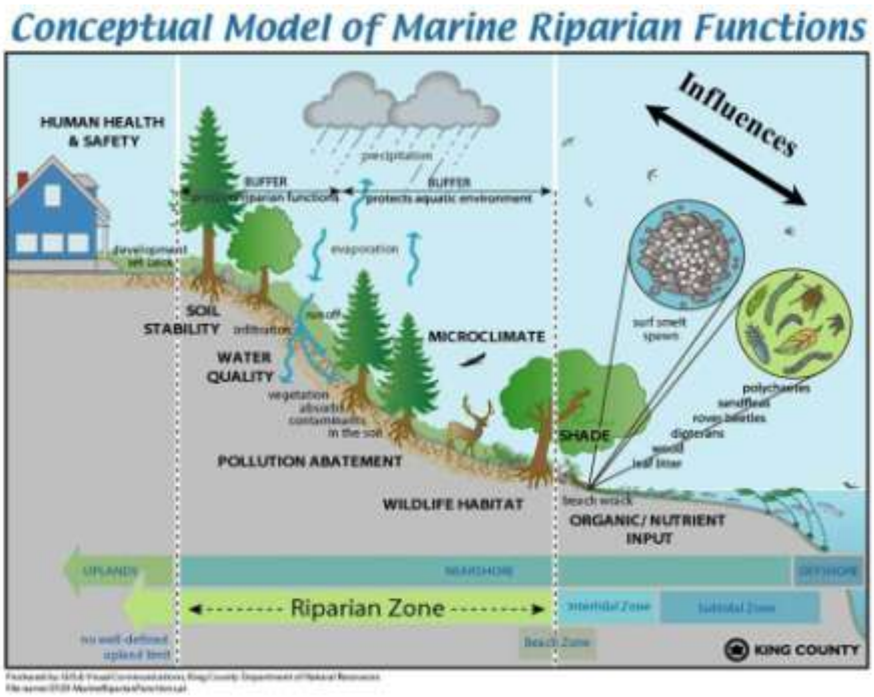

Figure 1. Conceptual model of marine riparian functions, used to illustrate various riparian functions and the use of buffers to protect both aquatic systems and riparian functions. Illustration also shows a development setback from the riparian area (Source: Brennan and Culverwell 2004[1]).

Native vs. Non-Native Vegetation

Native plants are generally understood to be the best choice for maintaining riparian functions, as they are adapted to local climatic, hydrologic, and trophic conditions. Associated species have evolved and adapted along with native vegetation, and are often dependent upon the native vegetation communities found in this region. The scientific and technical literature recommends maintenance of and replacement with native vegetation for prudent management, enhancement, and restoration of shorelines (Menashe 1993; WDNR 2010; WDOE 2011). Such recommendations are made in part because studies have established the relationships between native vegetation and associated biota, or biogeophysical and/or biogeochemical processes. In addition, the use of native vegetation offers a higher level of certainty in protection and restoration efforts, and typically requires less maintenance (e.g., watering, use of herbicides, pesticides, fertilizers) because native plant communities are adapted to local conditions. Also, funding entities require the use of native plants appropriate for local conditions (e.g., climate, soils, etc) in restoration activities.

---

[1] **Note that the authors have recommended some changes to this early illustration, such as changing "riparian zone" to "riparian area" and including beach vegetation in the transition area to account for a more well-developed understanding of riparian area processes, structure, and functions.**

We know of no literature that offers equivalency in ecological functions offered by non-native vegetation. It is important to note that there are currently extensive (and costly) efforts to remove a number of non-native species which can outcompete native species, offer low ecological value, provide little (if any) or negative habitat and food web value, mask or contribute to slope instability, may be harmful to humans or wildlife (eg, giant hogweed, tansy ragwort), or have become a nuisance (e.g., impede drainage, have rapid growth to outcompete or overtop native vegetation, may be a threat to livestock and/or wildlife) (e.g., scotch broom, pepperweed, Himalayan blackberry, English Ivy, knotweed, tansy ragwort). Until equivalency can be determined, the use of native plant species is the most prudent management approach.

Recreational Activities

The current literature on riparian management recommends minimizing recreational disturbances by limiting alterations and managing access in the riparian area by allowing for low-impact trails, or other "designated" access that helps define areas of limited disturbance and leave other areas protected in the MRA.

General Data Gaps and Uncertainties

As noted in the original document, the science on marine riparian areas is incomplete. However, there is a lot of research regarding riparian functions across a diverse range of shore types, vegetation community types, shoreline alterations and other disturbances or disruptors to riparian condition, and functional effectiveness of buffers. Riparian science is emerging, and our understanding of marine riparian areas in Puget Sound stems from the substantial amount of work that has been conducted in freshwater systems and marine systems in other areas. Although the marine riparian research and data available from this region are limited, the available data support the hypothesis that there are functional linkages between marine aquatic and riparian areas. The relationship between marine aquatic and associated riparian areas is not simply theory, but has been recognized by the broader scientific, management, and restoration communities as critical to management of marine shorelines for marine ecosystem health and integrity.

In an effort to reduce uncertainty, and to provide guidance for managers and policy makers on marine riparian management and the use of buffers as a management tool, the State conducted a workshop in 2008, comprised of a multidisciplinary team of scientists, to review the science on buffers and determine conceptually appropriate functional effectiveness curves. This, in addition to a literature review and analysis (collectively published in Brennan et al 2009), provides guidance similar to that developed for understanding the ecology and the establishment of buffer recommendations in freshwater riparian systems. The results of this work, among other publications, make it clear that, while uncertainties remain, there is little uncertainty that riparian areas are an important component of marine nearshore ecosystems, that they have been degraded by human activities, and that their protection and restoration is critical to meeting the goals of the SMA, GMA, Endangered Species Act, Clean Water Act, Puget Sound recovery, and other societal and regulatory goals.

Ultimately, the only way to reduce uncertainty is to conduct research to address the list of data gaps. However, designing, implementing, and analyzing robust studies to investigate these relationships are time and resource-intensive. Funding for research is limited, particularly at the spatial scale and time frame required to fill many of these data gaps. Therefore, one approach that the City may take in allowing some flexibility to proscriptive buffers is to require site evaluations and development of mitigation appropriate for disturbance to riparian areas, such as utilization of an appropriate habitat management plan. Such an approach may not only allow for some flexibility to proscriptive buffers, but may also contribute to the base of knowledge regarding riparian functions and establishment of appropriate buffers under specified site conditions.

PART II: MARINE RIPARIAN AREAS AND BUFFERS

Additional Comments

Riparian buffers are a management tool typically used to protect a water body from the adverse impacts of development and other activities. Buffers are generally recognized as a "separation zone" between a water body and a land use activity (e.g., timber harvest, commercial or residential development) for the purposes of protecting ecological processes, structure, and functions, and/or mitigating the threat of a coastal hazard on human infrastructure. Buffers are intended to be relatively undisturbed by human activities, and thus represent mature vegetation (over time) consistent with the potential of the site (National Wildlife Federation 2007; Brennan et al. 2009).

Buffers are distinguished from setbacks. On shorelines and sensitive areas, setbacks provide a working area outside the buffer, reducing impacts to the buffer from machinery, soil compaction, and human disturbance in the buffer during construction. Setbacks may also be used in terms of a horizontal distance established to protect development from a coastal hazard (e.g., landslide, storm surge). Setbacks typically do not account for ecological values. As the level of understanding that riparian areas are also ecologically sensitive and important habitat, buffers are now also being used to protect not just the water bodies that they border, but the riparian areas themselves.

Marine riparian buffers are designated areas of limited disturbance, which are used to protect the marine nearshore and corresponding ecosystem functions from the effects of land use activities, such as clearing and grading; the discharge of pollutants; and other activities. Marine shoreline buffers may have fixed or variable widths, depending upon the management goals and riparian conditions.

Buffer Widths

Functional effectiveness increases with increasing buffer widths. However, as noted in the original document, there is a broad range of buffer width recommendations in the literature to achieve reasonable levels of effectiveness. The wide range of recommended buffers must reflect, at least in part, the different site characteristics, including slope, soil type, and the specific vegetative community present.

A state-sponsored literature review and data synthesis (Brennan *et al,* 2009) provides a summary of buffer widths recommendations (Table 2) that includes a range of buffer width recommendations from the scientific literature to achieve ≥ 80% effectiveness in protecting the function (Column 2); and buffer widths based on FEMAT[2] curves (Column 3). In addition

Function	Range of Buffer Recommendations in Literature to 2009	Buffer Recommendations from FEMAT curves
Water Quality	5 - 600 m (16 – 1,968 ft)	25 m (82 ft): sediment 60 m (197 ft): TSS[b] 60 m (197 ft): nitrogen 85 m (279 ft): phosphorous
Fine Sediment Control	25-91 m (82-299 ft)	25 m (82 ft)
Shade/Temperature moderation	17-38 m (56-125 ft)	37 m (121 ft)
Large Woody Debris (LWD	10-100 m (33-328 ft)	40 m (131 ft)
Organic inputs		24 m (79 ft)
Wildlife	73-275 m (240-902 ft)	
[b] TSS is Total Suspended Solids		

Table 2. Summary of Buffer Width Recommendations from Brennan et al. 2009

In addition, Brennan et al. 2009 provides a range of functional effectiveness values associated with different buffer widths adapted from FEMAT curves; these are summarized in Figures 2 and 3.

A more recent literature review and analysis (Zhang et at., 2010) concluded that for water quality issues, a buffer width of 10m (33 ft) would be >80% effective in removing nitrogen, phosphorous, pesticides, and sediment when the buffer vegetation was primarily trees. Similarly sized buffers comprised of grass or mixed trees and grass were less effective: typically 70% effective in removing these compounds. The City's proposed set of complete (Zone 1 and Zone 2) buffer recommendations combine an understanding of the purpose of buffers in protecting and maintaining nearshore ecological functions with information about existing conditions.

---

[1] [a]FEMAT: the Forest Ecosystem Management Assessment Team, formed in the mid-1990s to evaluate forest management within the range of the northern Spotted Owl; FEMAT curves were created to represent the relationship between buffer width and ecosystem function.

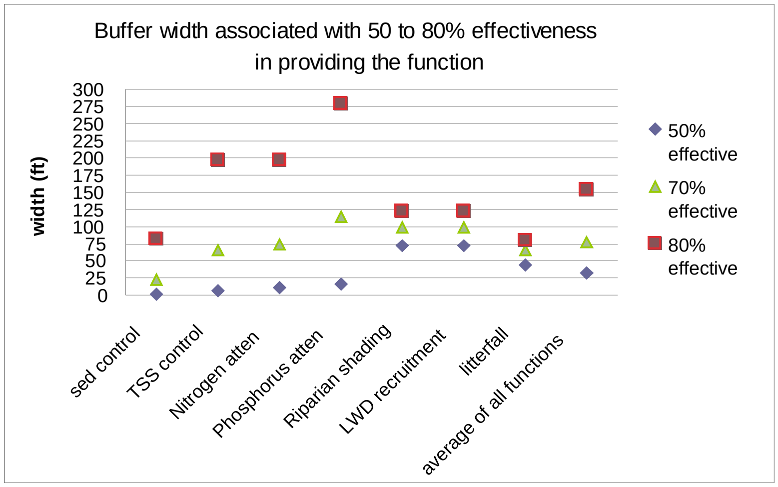

Figure 2. Buffer widths associated with levels of effectiveness from 50 to 80% in provisioning of various riparian ecological functions (adapted from Brennan et al. 2009)

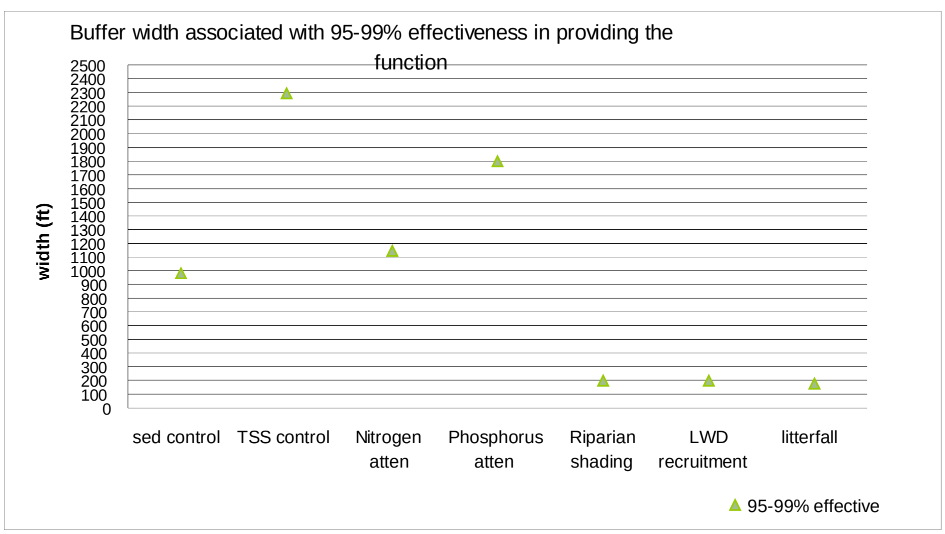

Figure 3. Buffer widths associated with high (95 to 99%) levels of effectiveness in provisioning of various riparian ecological functions (adapted from Brennan et al. 2009).

As the Herrera memo outlines, buffer recommendations take into account information about the current status of the shoreline buffer across the environmental designations by evaluating existing width of the buffer to a primary structure and using that information to define a buffer width that seeks to maintain intact buffers where they exist (eg, median distance to primary structure in areas designated shoreline residential is 60 ft, proposed buffer width is 50 ft; median distance to primary structure in shoreline conservancy is 83 ft, proposed buffer width is 75 ft). These are coarse proxies for actual conditions on a site-specific basis, but to the extent that they recognize that intact riparian buffers may be larger in some residential and undeveloped areas in the shoreline, they provide an approach that accounts for baseline conditions and maintaining those conditions, consistent with the No Net Loss framework and consistent with our understanding that larger buffers have a better chance of maintaining a fuller suite of ecological functions. Therefore, it is appropriate to consider multiple designations and variable buffer widths that are larger where consistent with existing conditions to maintain the functionality of shoreline riparian systems.

Existing and proposed Bainbridge Island buffer widths for urban and shoreline residential designations are at the low end of the literature range for provision of multiple shoreline functions. This approach does not appear consistent with the 'precautionary principle' (WAC 173-26-201(3)(g)), which holds that the greater the uncertainty, the more protective provisions should be. It is possible that currently proposed buffers are adequate for water quality; however the scientific literature supports that other marine riparian functions including shading of the upper beach, temperature moderation, and LWD provision may not be fully functional. Currently proposed buffers are below the ranges that the scientific literature suggests is relevant for the provision of wildlife habitat. Consequently, full MRA functionality may not be achieved in residential and urban areas with proposed buffers.

Increasing our understanding of marine riparian functions and quantification of the functional effectiveness of buffers for various functions under site-specific conditions will require more extensive research. Therefore, at this point in time, we cannot recommend more specific fixed or variable buffers for Bainbridge Island than is offered by the preponderance of evidence and recommendations for buffer widths found in the literature, and in syntheses such as those provided by Desbonnet et al. (1994), Brennan et al. (2009), and Zhang et al (2010). Reducing uncertainty requires site and reach-specific analysis, which may be achieved through the use of habitat management plans, or other evaluation tools, which could be implemented at the time of a development permit review

PART III CONCLUSIONS AND RECOMMENDATONS

The following summarizes our conclusions and recommendations, based upon our review of the scientific and technical literature on marine riparian areas and buffers.

Conclusions

- Puget Sound's marine shorelines and riparian areas have been altered over the last 160 years by human activities including agriculture, forestry and development.

- There is consensus in the scientific community that marine riparian areas (MRAs) are an integral part of the marine nearshore ecosystem and that MRAs are critical to formation, maintenance, and provision of a number of nearshore ecological functions. Protecting MRAs and their functions will help meet the requirements of the SMA, GMA, CWA, ESA, Puget Sound recovery and other management goals.
- Riparian areas provide both ecological functions as well as benefits to humans (such as socio-economic, biophysical, recreational, and aesthetic benefits), and are a critical component of any shoreline management strategy.
- Native vegetation is well adapted in terms of climate, nutrient requirements, and soil conditions and provides ecological functions including provision and timing of food resources and habitat to which native wildlife are adapted. We know of no literature that offers information on whether non-native vegetation can provide functional equivalency to native vegetation.
- Riparian buffers are an important management tool for the protection and restoration of nearshore marine ecosystems. Guidance on buffer widths is available in the scientific and technical literature; however there is a broad range in recommended values. The determination of appropriate buffer widths depends upon a number of factors, but should ideally be sized to account for a high level of functional effectiveness for multiple functions.
- Some of the shoreline buffers suggested by the city are at the lower end of the wide range of values recommended for protection of ecological functions in the scientific literature Therefore, they do not appear consistent with the WAC precautionary principle, and they may not provide for full MRA ecological functionality. It is appropriate to consider multiple designations and variable buffer widths that are larger where consistent with existing conditions to maintain the functionality of shoreline riparian systems.

Recommendations

- The City should include riparian buffers, which offer a high level of functional effectiveness for multiple functions, in their SMP update.
- Make a clear distinction between buffers and setbacks. Buffers, by definition, are relatively undisturbed separation areas, where native vegetation is protected, retained, and/or enhanced to provide a suite of ecological functions.
- The two-zone approach to the buffer that has been suggested appears reasonable in that it recognizes that several functions may be most critical in the area most adjacent to the shoreline. Therefore, focusing on an inner zone for directly protecting the aquatic nearshore, and prioritizing restoration and maintenance of an intact riparian community, while committing to making that zone wider as practicable consistent with our understanding that many ecological functions need large buffers to achieve even moderate levels of effectiveness, is a technically sound approach.
  For regulatory purposes, a habitat management plan, or similar assessment and

mitigation tool, may be used to allow flexibility and increase certainty in buffer requirements and/or alterations in fixed buffers resulting from development proposals.

- Given that there is substantive evidence that human activities can impact ecological functions of riparian and marine nearshore ecosystems, and the importance of the Precautionary Principle in dealing with uncertainty in ecological science and in the regulatory language of Washington State, a strong scientific argument can be made for going beyond absolute minimum buffers to protect ecological functions. Indeed, it can be argued that from the goal of protecting marine nearshore and riparian functions, a larger burden of proof should be placed on justifying lower buffer ranges.
- Given the uncertainties associated with buffers at the site scale, the City should support a monitoring program to evaluate activities and changes within riparian areas. Hypothesis-driven scientific research will be needed if the City is interested in evaluating cause-and-effect relationships. ETAC believes monitoring is critical to any long-term management of shorelines and marine riparian areas. However, it is important not to wait until we have more data to take prudent management actions now, or we run the risk of ecosystem decline that may be irreversible. An adaptive management approach could begin with more precautionary buffers now and provide for monitoring and regulatory change in review as new information becomes available. Whether these buffers will ultimately be protective of the ecosystem functions along the Bainbridge Island nearshore will likely remain unknown unless we can narrow the data gaps and the range of uncertainty through monitoring of both nearshore stressors and resources.

REFERENCES AND ADDITIONAL READING

Brennan, J.S., and H. Culverwell. 2004. Marine Riparian: An Assessment of Riparian Functions in Marine Ecosystems. Published by Washington Sea Grant Program. Copyright 2005, University of Washington Board of Regents Seattle, Washington. 34 p.

Brennan, Jim, Hilary Culverwell, Rachel Gregg, Pete Granger. 2009. PROTECTION OF MARINE RIPARIAN FUNCTIONS IN PUGET SOUND, WASHINGTON. Prepared by Washington Sea Grant (UW Contract: A39268) for Washington Department of Fish and Wildlife (WDFW Agreement 08-1185).

Brennan, J.S., K.F. Higgins, J.R. Cordell, and V.A. Stamatiou. 2004. Juvenile Salmon Composition, Timing, Distribution, and Diet in Marine Nearshore Waters of Central Puget Sound in 2001-2002. King County Department of Natural Resources and Parks, Seattle, WA. 164 pp.

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated buffers in the coastal zone - A summary review and bibliography. University of Rhode Island Graduate School of Oceanography.

Duffy, EJ, DA Beauchamp, RM Sweeting, RJ Beamish, and JS Brennan. 2010. Ontogenetic Diet Shifts of Juvenile Chinook Salmon in Nearshore and Offshore Habitats of Puget Sound. Transactions of the American Fisheries Society 139:803–823.

Fresh, K., C. Simenstad, J. Brennan, M. Dethier, G. Gelfenbaum, F. Goetz, M. Logsdon, D. Myers, T. Mumford, J. Newton, H. Shipman, C. Tanner. 2004. Guidance for protection and restoration of the nearshore ecosystems of Puget Sound. Puget Sound Nearshore Partnership Report No. 2004-02. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington.

Herrera. 2011a. City of Bainbridge Island Addendum to Summary of Science Report. Prepared through City of Bainbridge Island, SMA Grant Agreement No. G1000036, by Herrera Environmental Consultants, Inc.

Herrera. 2011b. Memorandum on Documentation of Marine Shoreline Buffer Recommendations. Memorandum to Ryan Ericson, Associate Planner and Libby Hudson, Division Manager City of Bainbridge Island, from Amanda Azous, José Carrasquero, and Jeff Parsons, Herrera Environmental Consultants; and Lisa Grueter, BERK. June 27, 2011

Levings, C. D., and R. M. Thom. 1994. Habitat changes in Georgia Basin: Implications for resource management and restoration. In Wilson, R., R. Beamish, F. Aitkins, and J. Bell (eds.). 1994. Review of the marine environment and biota of Strait of Georgia, Puget Sound, and Juan de Fuca Strait: Proceedings of the B.C./Washington Symposium of the Marine Environment. Canadian Technical Report of Fisheries and Aquatic Sciences. 398 p.

Menashe, E. 1993. Vegetation Management: A Guide for Puget Sound bluff property owners. Shorelands and Coastal Management Program, Washington Department of Ecology. Publication 93- 31.

National Research Council (NRC). 2002. Riparian Areas: Functions and Strategies for Management. NATIONAL ACADEMY PRESS, Washington, D.C.

Penttila, D. 2002. Effects of shading upland vegetation on egg survival for summer-spawning surf smelt on upper intertidal beaches in Puget Sound. *In* Puget Sound Research- 2001 Conference Proceedings, Puget Sound Water Quality Action Team, Olympia, Washington. 9 p.

Penttila, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Rice, C.A. 2006. Effects of shoreline modification in northern Puget Sound: beach microclimate and embryo survival in summer spawning surf smelt (*Hypomesus pretiosus*). Estuaries and Coasts 29(1):63-71.

WDOE (Washington Department of Ecology). 2011. Puget Sound Shorelines: Native Plants. http://www.ecy.wa.gov/programs/sea/pugetsound/species/native.html.

WDNR (Washington Department of Natural Resources). 2010. Aquatic Vegetation: Potential Impacts of Covered Activities and Buffer Recommendations. Olympia, WA. November 10.