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memorandum

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to Bonny O'Connor, AICP

cc Tina Wehrmeister

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subject Methodology for Economic Analysis of Sea Level Rise Hazards for Pacifica Sea Level Rise LCP Update

Executive Summary

- The economic analysis for this project will provide the City of Pacifica with the best available data/analysis for public and private property at-risk due to coastal hazards.

- The economic analysis will evaluate the market value of land and the replacement costs of residential, commercial and public structures in order to provide an aggregate estimate of the value of property at risk due to coastal hazards—for planning purposes.

- The engineering consulting firm, ESA, will provide estimates of the cost of replacement or modification of key infrastructure such as roads and wastewater facilities as well as engineering cost estimates for each adaptation strategy.

- For each adaptation strategy, the economic benefit/cost analysis will compare the engineering costs of each adaptation strategy with the benefits (in terms of protecting private and public property) of each strategy.

- This memo provides more detail on methods and data sources.

Purpose of the Analysis

The economic analysis prepared for this project is designed to provide the City of Pacifica, its residents, and other stakeholders with the best available information on the aggregate economic value of property and activities at-risk due to hazards associated with sea-level rise. The economic analysis will use the best available data on property values and coastal recreation. The economic analysis will also estimate the economic activity and tax revenues associated with businesses in these hazard zones (e.g., hotels).

Although the economic analysis will include a benefit-cost analysis, it should be emphasized at the outset that this analysis is *not* designed to proscribe any specific policies, but rather to inform local decision-makers and stakeholders about the economic considerations associated with various sea-level rise scenarios and adaptation options available to the City.

It should be emphasized that the, economic analysis is only one indicator for adaptation scenarios. Any economic analysis is subject to numerous limitations, which are discussed in this memo. The memo will detail the methodology employed in the economic analysis, specifically: 1) The use of geospatial data; 2) The valuation of economic assets including land, buildings and other infrastructure (e.g. wastewater utilities including pump stations); 3) Non-market valuation including the valuation of coastal recreation (beach recreation, hiking, golfing) and other ecological functions goods and services (EFGS) in the hazard zone; 4) Economic Impact analysis; 5) How to apply the economic methods to adaptation.

Geospatial Data

The impacts of coastal erosion, flooding, and other coastal hazards all have spatial components (e.g. extent of flooding and erosion) that are best modeled in a geospatial framework (i.e., using maps). The engineering consulting firm associated with this project, ESA, will provide modeling of flooding, erosion and other coastal hazards with geospatial references. The modeling will include specific geospatial coordinates, which define the specific locations of expected future erosion and flooding from 1% or other storm event (also referred to as a 100-year storm or flood, though they may occur more frequently). The flooding data will also include depth of flooding either as a specific measure of the depth (i.e., in feet or meters) or as a category (e.g., high, medium, low). The hazard maps will be overlain on the map of assets (e.g. homes, streets, etc.) to identify assets that would be impacted by the hazard.

The economic analysis will begin with (San Mateo) County Assessor's parcel data and City land use data, to identify property boundaries, location and size of the parcel along with other information obtained from the City of Pacifica such as zoning and current use. In the case of taxable property, the parcel data also provides the current assessed value of the land and "improvements" (structures).

The use of geospatial analysis also allows one to incorporate the length and width of beaches, coastal trails, parking, access points and other pertinent information about coastal recreation. One can also incorporate geospatial data on environmentally sensitive habitat (ESHA).

Valuing Land and Structures

Erosion Losses

This study will use 2018 market prices (per parcel, per acre) to value land. If land is lost due to erosion, the loss is assumed to be equal to the loss of the land at current market value. For small (mostly) residential parcels (< ¼ acre) this analysis will assume that the land value and structure value is lost as soon as any part of the parcel is eroded. For larger parcels (> ¼ acre) the loss of land will be pro-rated—the percentage loss in land will be equivalent to the percentage loss in value (i.e., if 50% of a $1,000,000 parcel is lost, $500,000 in market value is lost).

There are numerous ways to apply current market prices to estimate the value of lost property; however, the current assessed value of land often does not provide an accurate estimate, since California's Proposition 13 limits increases in assessed value to 2% per year from the last date of sale. For property that has not changed hands for many years, this 2% limit can result in undervaluing the current market price. For example, for residential housing, according to the Case-Shiller housing Index, housing prices in San Francisco in January 2018 are 4.91 times higher than in January 1988, 30 years ago.[1] However, even if housing prices were adjusted every year by 2%, the increase would only be equal to 1.81 times January 1988 prices[2] which is less than half of the market increase in value.

To adjust for the inherent bias in assessed data, this analysis will incorporate the best available housing price data to construct a housing priced index (HPI) for the City of Pacifica, which converts the original sale price into current market prices. The HPI will use the best available data on housing price changes, still to be determined.

Since there are fewer commercial properties in Pacifica than residential properties, this analysis will use available recent sales prices, and interviews with local commercial real estate experts to estimate the value of commercial property. Similarly, the analysis will examine the small number of government buildings and estimate the replacement cost. Public land will be valued using recent sales data from sales/purchases of public land, trusts, and conservation easements.

One limitation of using parcel data is that some parcels, mostly owned by local, State or Federal agencies are not subject to property tax. For these properties, we will rely on data provided by the City and County on recent acquisitions of land by government and non-government agencies. Since some of these transactions may be below market value, it's possible that the estimates provided for the estimates of the value of property owned by various governmental and non-governmental agencies may be too low—they should be considered to have a conservatively low estimated value. In addition, these un-assessed parcels typically do not have any information about the structures on them (if any) so it is difficult to estimate these structure damages.

Structures

All buildings will be valued at replacement cost using the best available data. Residential buildings/structures will be valued using a cost construction index based on the size of the structure (in square feet) and the prevailing

[1] Federal Reserve of St. Louis Database (2018).
[2] The value is adjusted by 2% a year for 30 years which is equivalent to $(1.02)^{30}=1.81$.

type of construction.[3] Since there are a large number of residential structures, one must make some generalizations about size/materials and cost. For larger structures every effort will be made to estimate the replacement cost with reasonable accuracy.

Commercial property will also be valued by standard metrics (e.g., square footage of building, # rooms, etc.) using the best available data, in conjunction with local experts. Government and other buildings will also be estimated type of structure.

Roads and Other Infrastructure

Roads, wastewater infrastructure will be valued at replacement cost using estimates prepared by ESA. If modifications to existing infrastructure is warranted, then these costs will be incorporated into the analysis.

Flood Damages

Flood damages to structures will be estimated by applying the U.S. Army Corps of Engineers depth damage curves (USACE, 2003) which estimates damages as a percent of the total value of the structure. The Corps' method also allows one to estimate the average damage to the contents of the structure (e.g., furniture, appliances, etc.). These curves translate flood depth into a percentage loss as a function of the total value of the structure. The percentage loss also varies with the number of stories, type of construction, and other factors.

Non-Market Valuation

In addition to using market prices/values, economists use techniques referred to as non-market valuation to evaluate property and ecosystems that cannot be adequately valued by market prices. For coastal communities such as Pacifica, beaches (below the mean high tide line) are always considered public property and there is no market price. Consequently, economists value beaches, and other coastal ecosystems using non-market valuation techniques. While we recognize these values, estimating them is beyond the scope of work of this study. The appendix to this memo contains a more detailed description of non-market valuation.

Beach Recreation

This study will estimate the recreational value of Pacifica's beaches and coastal trails and golf course, using non-market valuation techniques. For beach recreation, this study will follow California Coastal Commission guidance and apply a day use value of $40 — that is a day at the beach is worth $40.[4] The study will use the best available attendance data. For Pacifica State (Linda Mar) Beach, this study will use the City of Pacifica's attendance estimates, which it has supplied to the California Coastal Commission. For other beaches, we will use the best available data including data from a recent San Mateo County Coastal Access Study (2015) as well as the Draft Coastal Regional Sediment Master Plan (CRSMP) prepared for the San Francisco littoral cell, which contains estimates of attendance at all of Pacifica's beaches.

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[3] Specifically, this report will use data from RSMeans, Square Foot Costs, 2015.

[4] California Coastal Commission (2015).

Other Coastal Recreation

In addition to numerous beaches, the City of Pacifica also has a number of coastal trails, which are quite popular. As with beaches, these coastal trails are free and open to the public. The non-market value of hiking on trails has also been studied by economists. As with beaches, this study will apply a non-market value for coastal trails based on estimated attendance and day use value. Unfortunately, data on Pacifica's coastal trail usage is limited.

Pacifica also has a golf course in the coastal hazard zone. Coastal flooding has already impacted the golf course and future erosion may have larger impacts. The golf course is currently owned and operated by the City of San Francisco. Since everyone who uses the golf course must pay a fee, the City of San Francisco's Parks and Recreation department has records of golf course use and fees paid. Consequently, the value of the golf course can be approximated in terms of fees generated per year. However, the community of Pacifica may place a higher value on the course.

The challenge with estimating the potential impact of coastal erosion on the golf course is that erosion does not impact all of the holes. However, since golf is an 18- hole game, even the loss of one hole can seriously diminish the value of the golf course.

Summary of Methods/Data Sources

Table 1 below briefly summarizes the general methods and sources to be used in this study. In some cases (e.g., beach attendance at Pacifica State Beach) this study has identified a specific source; in other cases (e.g., commercial real estate data) a specific source has yet to be identified though a general methodology has been identified.

Table 1: Summary of Methods and Sources

Estimate	Valuation	Method	Source
Residential Land	Market	Update Parcel Data	Housing Price Data
Commercial Land	Market	Update Parcel Data	Commercial Land Data
Publicly Owned Land	Market	Update Parcel Data	Best Available Estimates
Land Trusts, Other Unassessed Land	Market	Update Parcel Data	Recent Sale Prices
Residential Buildings	Replacement Cost	Apply sq. ft. metric	RSMeans
Other Buildings	Replacement Cost	Apply sq. ft. metric	Best Available
Linda Mar Beach	Non-Market Valuation	Day Use Value *Attendance	City of Pacifica
Other Beaches	Non-Market Valuation	Day Use Value *Attendance	City of Pacifica
Trails	Non-Market Valuation	Day Use Value *Attendance	City of Pacifica
Golf Course	Market/Non-market	Day Use Value *Attendance	City of San Francisco
Roads	Replacement Unit Cost	Engineering Cost	ESA
Water/Sewer/Stormwater Infrastructure	Replacement Unit Cost	Engineering Cost	ESA
Adaptation Measures	Unit Costs	Engineering Cost	ESA

ESA has compiled a list of preliminary engineering unit costs for infrastructure replacement and adaptation measures, shown in Table 2 below. These costs were developed for prior studies in other areas with different shore geometries and wave exposures, and have not yet been tailored for Pacifica. ESA will work with the City to refine the engineering cost estimates as needed to reflect the geographic location and setting in Pacifica and ensure the costs are consistent with the City's recent experiences. The costs below were developed for projects including the Ocean Beach Master Plan (ESA PWA and SPUR, 2015), Southern Monterey Bay Climate Ready Study (Leo et al., 2017), San Francisco Coastal Regional Sediment Management Plan (ESA, 2016), and Economic Analysis of Nature-Based Adaptation to Climate Change in Ventura County (Environ and ESA PWA, 2013). Some costs have been adjusted based on input from Pacifica Department of Public Works.

Table 2: Engineering Unit Cost Estimates for Infrastructure Replacement and Adaptation Measures

Infrastructure Category	Cost	Unit	Asset
Water	$ 270 to 468	per LF	Main
Communications	$ 100	per LF	Comcast Conduit
Wastewater	$ 1,000,000	per mi	Wastewater Collection Main
Wastewater	$ 2,000,000	per mi	Wastewater Force Main
Transportation	$ 400	per LF	Roads (typical width)
Adaptation Measure	**Cost**	**Unit**	**Description**
Elevate Buildings	$ 150	per SF	In Flood Zone
Elevate Buildings	$ 250	per SF	In Wave Zone
Elevate Road	$ 800	per SF	Elevate on bridge/trestles
Rock Revetment	$ 40,000,000	per mi	i.e. Quarry stone
Seawall	$ 97,000,000	per mi	Reinforced Concrete
Breakwaters	$ 76,000,000	per mi	i.e. Quarry stone
Offshore Reef	$ 76,000,000	per mi	i.e. Quarry stone
Horizontal Levee	$ 2,000	per LF	Flat wide levee
Traditional Levee	$ 54	per CY	Clay Levee
Bulkhead/Floodwall	$ 5,000	per LF	Floodwall for Linda Mar/San Pedro Crk
Beach Nourishment	$ 22	per CY	Imported sand
Dune Restoration	$ 220,000	per acre	Vegetated sand dune with buried cobble
Pump Station (Sewer)	$ 11,000,000	per Pump	Sewer Pump Station

SF=square foot; mi=mile; LF=linear foot; CY=cubic yard

Economic Impacts

When making decisions about proposed coastal land uses, local decision-makers and stakeholders often are interested in the amount of spending and taxes generated for various activities. For example, beach tourists will spend money locally on food, gas, hotels (if staying overnight) and other items as a part of their beach activities. This spending generates economic activity and taxes for the City of Pacifica. This study will use the best available data on spending to estimate the local share of sales taxes and transient occupancy taxes generated by beach tourism.

In addition, a number of businesses (e.g., the Best Western hotel) are located within the coastal zone. This study will make every effort to estimate the share of Pacifica's taxes generated by businesses in the coastal zone. However, since this type of information is proprietary, the study will need to rely on the cooperation of local businesses.

The Future

The economic analysis in this study projects the impacts of sea-level out to 2100. However, our current understanding of the impacts of climate change is limited and evolving. In addition, our understanding of future economic conditions and market prices/replacement costs is similarly limited, particularly for longer time horizons.

The economic analysis for this study estimates all prices and replacement cost in (real) 2018 dollars. Effectively this assumption implies that the relative prices/costs of various decisions/options will remain the same over time—that is, the inflation rate for all goods and services will be the same. However, it is likely that some costs/prices will rise faster than others while new technologies or techniques may lower the relative prices of other goods and services.

As is standard in any economic benefit/cost analysis, future costs and benefits must be discounted — future benefits/costs are worth less than the same benefit/cost today. The choice of discount rate is critical in any benefit/cost analysis. Currently there is no consensus among economists as to what the proper discount rate should be.[5] When considering capital investments (e.g., financing a seawall) one should consider the cost of capital — what it actually costs to borrow the necessary funds to finance a project. Currently, short and long term interest rates are historically low, and the cost of financing a project through State or local municipal bonds is in the 4% to 5% range. However, even a relatively low discount rate can imply that benefits and costs for future generations are valued far less than current benefits and many economists have argued that the social discount rate should be lower than the market cost of capital.[6] Table 3 below shows the discounted value of a $100 benefit in future time horizons. When projecting out to 2100, even a relatively low discount rate, such as 3%, implies that a $100 benefit is worth less than one-tenth of today's valuation — $8.86. A 5% discount rate implies that by 2100 the benefit or cost is worth less than one-fiftieth of today's value ($1.86).

Table 3: Value of $100 over Time at Various Discount Rates

Discount Rate	0%	1%	3%	4%	5%
2030	$100.00	$88.74	$70.14	$62.46	$55.68
2060	$100.00	$65.84	$28.90	$19.26	$12.88
2100	$100.00	$44.22	$8.86	$4.01	$1.83

[5] For example, see Arrow et. al., 2014 and Zuang et. al. (2007).
[6] *Ibid.*

Adaptation

The economic analysis discussed above can be used to help inform adaptation decisions. Adaptation to sea level rise often involves compromise. For example, the decision to armor a portion of the coast involves a number of economic tradeoffs. First, the City of Pacifica, or private property owner or some other entity, must pay for the costs of armoring, including future maintenance or potential rebuilding. Second, armoring protects public and private property from coastal erosion and storms. Third, armoring may reduce beach width, reducing coastal recreation, and interfere with other coastal ecosystems processes.

For each adaptation strategy, the economic analysis will compare impacts of different adaptation strategies on: (1) land, structures and infrastructure, (2) recreation, (3) coastal ecosystems. Where possible, these changes will be estimated in dollar terms and comparisons can be made. However, as discussed above, our current knowledge, in terms of both the science and economics, of many ecological values is limited as is our ability to predict the future. Consequently, the benefit/cost analysis provided in this study should provide guidance to stakeholders and policy-makers, but is not designed to proscribe any particular policies.

Appendix: Non Market Valuation

This appendix will discuss how economists approach valuing various ecosystems, including beach ecosystems. The section begins with a discussion of non-market valuation, and continues with a discussion of various techniques currently in use to value these systems.

Ecologists and economists generally refer to services provided by beaches and other natural ecosystems with the term ecological functions goods and services (EFGS). Economists divide the total economic value (TEV) of these EFGS into a number of different components as shown in Figure 1 below. "Use Values" encompass EFGS that benefit humans either directly (Direct Use Value) or indirectly (Indirect Use Value). Direct use values involve uses that directly benefit human consumers, such as timber for a forest or beach visitation. Indirect use values occur when an ecosystem provides benefits that are more difficult to measure but still apparent, such as flood or storm control for a beach, or erosion control for a forest.

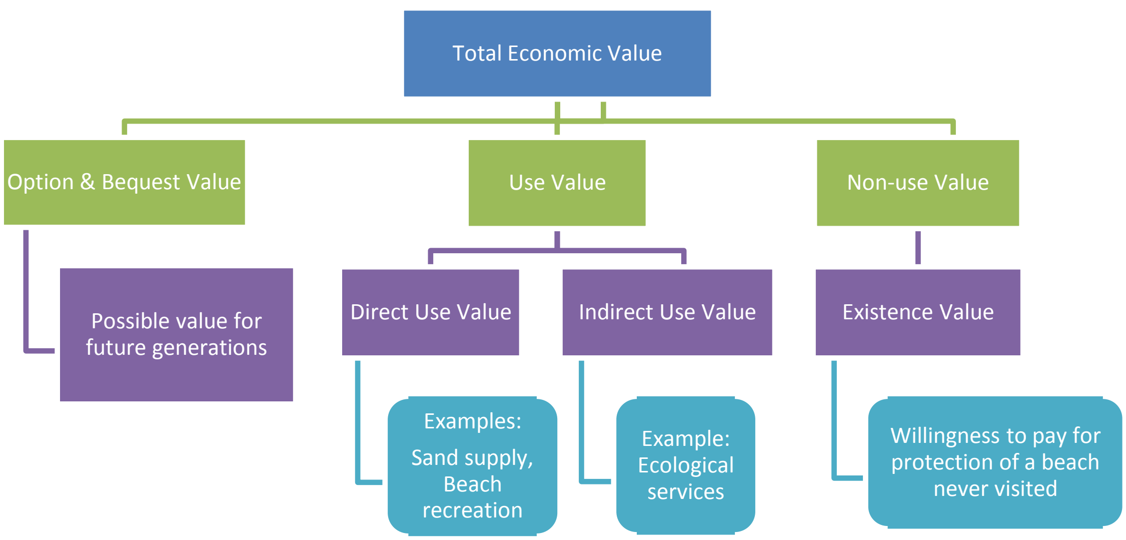

Figure 1: Schemata of Total Economic Value[7]

Direct Use Value

Visiting a beach to sunbathe, swim, surf or engage on other recreational activities is considered a direct use value. Since beaches below the mean high tide line in California allow open access, they are considered free (though parking may not be). Economists have developed techniques to estimate how much consumers would be willing to pay for a day at the beach (willingness to pay or WTP). A full discussion of these techniques is beyond the scope of this memo. Briefly, there are two widely accepted approaches to estimating WTP: revealed preference and stated preference.

[7] See Nelson (2012).

Revealed preference methods estimate the effort involved in a consumer decision to visit a particular beach or other natural ecosystem. The most common revealed preference technique is the travel cost model, which estimates the cost of travel to a particular site (not just gas or airfare but typically also the time it takes to get to the site). For example, one individual may be willing to pay $8000 to visit the Galapagos Islands, indicating a high WTP. For beaches with special amenities (e.g., a world class surf spot) WTP may be quite high. Economists also sometimes use "stated preference" models, which rely on surveys and ask visitors what they would be willing to pay to visit a beach or other ecosystem. Stated preference models (e.g., contingent valuation) have been criticized since visitors may misrepresent (or misunderstand) how much they would actually be willing to pay, and most estimates of beach WTP rely on revealed preference models.

Since individual's WTP for beaches and other natural ecosystems will vary from person to person, economists typically estimate a demand curve for these services and use a weighted measure (consumer surplus) of these values to derive a WTP for a beach day. For most policy applications, economists use a "day use value" to estimate the WTP for an average consumer. In May 2017, the California Coastal Commission adopted a day use value for California's beaches of $40/day8 for beach visitation in Solana Beach.

Indirect Use Value

The primary indirect use value for beaches, which will be estimated in this study, is the ability of beaches to help buffer storm damages and (inland) coastal erosion. ESA's storm analysis will model the geospatial extent (and depth) of coastal storms/erosion with varying beach widths according to agreed-upon scenarios and adaptation strategies. This analysis will estimate the differences in inland/upland private and public property loss/damage due to erosion and flooding. All things equal, a wider beach will act as a better buffer against storms/inland erosion than a narrower beach and the difference in damages can be estimated with reasonable accuracy.

Other Potential Use Values of Beach Ecosystems

Unfortunately, our knowledge of the other use values is still limited, both in terms of our knowledge of the ecology of beaches, as well as our economic valuation techniques. For now, most economic analyses of beaches, including this study, focus on recreation and storm damage prevention. Table A below, describes a number of ecosystem services provided by beaches.

[8] California Coastal Commission (2015).

Table A: Sandy Beach Ecosystem Services by Use Value Type[9]

Sandy Beach Ecosystem Services	Direct Use Value	Indirect Use Value
Sediment storage and transport;		X
Wave dissipation and associated buffering against extreme events (storms, tsunamis);		X
Dynamic response to sea-level rise (within limits);		X
Breakdown of organic materials and pollutants;		X
Water filtration and purification;		X
Nutrient mineralization and recycling;		X
Water storage in dune aquifers and seawater discharge through beaches—beaches with dunes only		X
Maintenance of biodiversity and genetic resources;	X	
Nursery areas for juvenile fishes;	X	
Nesting sites for turtles and shorebirds, and rookeries for pinnipeds;	X	
Prey resources for birds, fishes, and terrestrial wildlife;	X	
Scenic vistas and recreational opportunities;	X	
Bait and food organisms;	X	
Functional links between terrestrial and marine environments in the coastal zone.	X	

Option and Bequest Value and Other Non-Use Values

Finally, it should be noted that beaches and other natural habitats may have values beyond direct and indirect use values—that is, humans may wish to preserve an ecosystem for its existence value, e.g., we may be willing to devote resources to preserving a wilderness in Alaska even if we never go or never benefit directly and indirectly. In addition, humans may be concerned about future generations (bequest value) or the potential that these ecosystems have value we currently do not recognize (option value).

[9] See Defeo, McLachlan et al. (2009) and California Coastal Commission (2015).

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