DOCKETED

Docket Number:	15-AFC-01
Project Title:	Puente Power Project
TN #:	204942
Document Title:	City of Oxnard CPUC Proceeding Testimony
Description:	Testimony of Dr. David Revell on behalf of the City of Oxnard on Sea Level Rise Submitted to CPUC Case A14-11-016
Filer:	Jon Hilliard
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	6/8/2015 3:54:21 PM
Docketed Date:	6/8/2015

BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Application of Southern California Edison Company (U338E) for Approval of the Results of Its 2013 Local Capacity Requirements Request for Offers for the Moorpark Sub-Area. Assigned Commissioner: Michel P. Florio Assigned ALJ: Regina M. DeAngelis	Application 14-11-016 (Filed November 26, 2014)

TESTIMONY OF DR. DAVID REVELL ON BEHALF OF THE CITY OF OXNARD

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Date: April 8, 2015

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TESTIMONY OF DR. DAVID REVELL ON BEHALF OF THE CITY OF OXNARD

Please state your name, place of employment, and business address.

My name is Dr. David Revell. I am a Principal at Revell Coastal, which is located at 125 Pearl Street, Santa Cruz, CA 95060.

What is the purpose of this testimony?

This testimony assesses the vulnerability of the Proposed Mandalay Generating Station ("Generating Station") to existing and future coastal hazards and climate change impacts. It identifies the potential inundation and hazard impacts to the Generating Station under a variety of current and future sea level scenarios. It also considers the regional coastal processes which could further exacerbate the identified hazards. Any evaluation of the Generating Station's safe and reliable operations must consider potential coastal hazards that could result from siting critical power infrastructure along the Oxnard coast.

Please describe your qualifications for providing this testimony.

I am a coastal geomorphologist who studies marine, coastal, and estuarine processes, with a particular focus on the science and management of coastal processes and climate change. I received my doctorate from UC Santa Cruz and have over 15 years of experience in the field. I have included a copy of my CV and Firm Qualifications as Exhibit CO-3.

Please describe your technical evaluation and findings.

I have prepared a report that draws upon recent sea level rise studies, local mapping efforts, regulatory guidance, and academic papers to evaluate coastal hazards in the coastal area surrounding and including the Generating Station. This report elaborates upon work that I prepared with ESA PWA in 2013. I've included this report as part of this testimony (Exhibit CO-4).

The report finds that portions of the Generating Station's site are exposed to coastal flooding hazards under existing conditions. The report also finds that the site's flood risk will increase with expected sea level rise, so that much of the Generating Station site will be exposed to coastal hazards by 2030, and almost the entire site will face hazard exposure by 2060. Finally, the report notes that the coastal hazard risk to the Generating Station will increase substantially if the current dredging operations at Ventura Harbor cease.

Aside from the information contained in Exhibit CO-4, does this conclude your opening testimony?

Yes.

Attachments

Exhibit CO-3: Resume of Dr. David Revell and Firm Qualifications

Exhibit CO-4: Vulnerabilities of the Proposed Mandalay Generating Station to Existing and Future Coastal Hazards and Sea Level Rise

672051.1

Exhibit CO-3

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DAVID L. REVELL, Ph.D.

Principal / Chief Coastal Scientist

Dr. David Revell is a coastal geomorphologist with 15 years experience studying marine, coastal and estuarine processes, in particular in the science and management of coastal processes and climate change. He has been involved in a wide variety of community stakeholder processes ranging from evaluating erosion hazard alternatives to climate change vulnerability impacts to fisheries management, water quality, and marine spatial planning. Much of his work has involved using Geographical Information Systems (GIS) to facilitate communication of science to inform decision making. He received his M.S. in 2000 from Oregon State University in Marine Resource Management with an Emphasis on Earth Science Information and Technology. He received his Ph.D. in Coastal Geology in 2007 from UC Santa Cruz with his research focusing on climate change, shoreline evolution, storm response, and coastal monitoring in Santa Barbara and Ventura Counties. He has served as a science advisor on a range of topics related to ocean and coastal management especially at the intersection of how physical processes and alterations affect habitats, sensitive species, and human use. David served as a technical advisor to the Oregon Coastal Management Program on regional coastal hazards assessments and GIS. David currently advises multiple local jurisdictions on climate change, beach, dune and coastal sediment management, and lagoon processes and inlet management.

Education

Ph.D., Earth Sciences, University of California, Santa Cruz

M.S., Marine Resource Management, Oregon State University

B.A.s, Geography and Environmental Studies, University of California, Santa Barbara

Selected Work Experience

Principal and Chief Scientist, Revell Coastal, LLC ***July 2014 - Present***
Founded company to provide scientific and technical consulting services to coastal management agencies, local jurisdictions and non-profit organizations. Communicates the best available science to inform better coastal management decisions. Specific project work includes climate change vulnerability and adaptation planning, regional sediment management, and coastal lagoon management and restoration.

Senior Coastal Geomorphologist, Environmental Science Associates (formerly Philip Williams & Associates), ***Jan. 2008 –July 2014***
Managed projects and lead technical analyses on projects related to climate change, coastal lagoons, coastal restoration, sea level rise vulnerabilities, adaptation planning and coastal regional sediment management .

Adjunct Professor, Monterey Institute of International Studies, ***Aug. 2013 to May 2014***
Co-instructed graduate level courses on International Marine Science and Policy and Sustainable Coastal Management. Assist with framing the strategic planning for the Center for the Blue Economy with specific emphasis on climate change opportunities.

Project Scientist, Marine Science Institute, UC Santa Barbara – ***June 2009 – Present***
Coastal research scientist collaborating on a Seagrant investigation of changes to the sandy beach ecosystems in Southern California. Responsible for physical process field data collection, evaluation of historic trends in shoreline and sand volume changes to integrate with ecological changes. Managed graduate student researcher summer 2009 and 2010.

Coastal Scientist, CoastalCOMs & Business Development, Coastal Watch USA, *Jan. 2008 – May 2012*
International business development of coastal monitoring systems for integrated coastal observation. Identification and development of coastal management data products. Applications of video imagery to nearshore processes, coastal engineering, and marine protected areas with an emphasis on integrating ocean and coastal observations. Focus on coastal processes, ports and harbors, socio-economic data collection. Supported USGS data collection efforts for projects in TRNERR, Goleta Beach, and Surfers' Point.

Postdoctoral Scholar/Research Associate – Institute of Marine Sciences, UCSC *Apr. 2007 – April 2008*
Researched historic shoreline changez along Santa Barbara and Ventura County coasts using a variety of GIS, remote sensing and field collection techniques. Collaborated with USGS, USACE, and BEACON to assess coastal hazards and model sediment transport along the Santa Barbara coast.

Surf 2 Sea Consulting, GIS, Marine and Coastal Processes Consultant – ***Aug. 2002 – Dec. 2007***
Sole proprietor consultant. Contracted with Ecoshore International to develop a beach and groundwater monitoring plan for a passive beach dewatering system in Hillsboro FL (2007). Subconsulted with Moffat and Nichols on Coastal Processes Section of Goleta Beach Environmental Impact Report (2006). Collaborated with PWA on historic shoreline changes to Goleta Beach County Park in Santa Barbara, and helped identify alternative solutions to park protection (2004-05). Worked for oceanfront property owners to assess coastal erosion alternatives and processes affecting property boundaries (2005). Created GIS and planning databases for the City of Bandon in Oregon (2000-03). ---Completed an inventory for the Council for Environmental Cooperation on whale watch operators and guidelines (2002). --- Coordinated the Port Orford Ocean Resources Team GIS project, a community based management effort that interviewed 33 local fishermen and recreational users regarding ocean use, harvest practices, and marine conservation. Digitized interviews into GIS and facilitated socio-economic analyses with Ecotrust (2002-03).

NOAA Coastal Management Fellowship – *Aug. 2000 – Aug. 2002*
Received a NOAA Fellowship through an extended application process working as a technical advisor to the Oregon Coastal Management Program on littoral cell management planning. Developed coastal hazard GIS inventories for five jurisdictions - Coos, Curry, Lincoln, and Tillamook Counties and City of Bandon. Conducted a hazard assessment for the Bandon Littoral cell. Worked on the Oregon Coastal Atlas project as a member of the Project Development Team. This project collects pertinent GIS and database information for ocean areas, rocky shores, sandy shores, and estuaries, and facilitates various spatial analyses such as hazard assessment through a regional Internet Map Server.

Graduate Research Assistant – **Oregon State University - *July 1998 – July 2000***
Constructed the Netarts Littoral Cell Coastal Hazard GIS inventory for Oregon Sea Grant, Oregon Parks and Recreation Department, Oregon Coastal Management Program, and Tillamook County. This involved survey fieldwork, data processing, map making, and project management. Conducted local stakeholder workshops to educate, facilitate and receive feedback on GIS design and hazard avoidance strategies. Recommended mitigation alternatives to State Parks regarding the Cape Lookout Dune Restoration Project - Section 227 – Army Corp of Engineers.

Selected Project Experience

City of Goleta, Local Coastal Program Climate Change Update. *Project Director*
Revell Coastal worked for the City of Goleta to incorporate climate change and coastal hazards into the Local Coastal Program. This work was focused on the City's Safety and Conservation Elements from their General Plan and included additional technical fieldwork and review of existing scientific literature.

City of Santa Cruz, San Lorenzo Lagoon Outlet Channel. ***Project Director***
During emergency lagoon flooding conditions amidst a regulatory stalemate, Revell Coastal provided on site guidance to construct a temporary outlet channel and reduce lagoon water levels to alleviate flooding while avoiding a rapid dewatering to the lagoon which could have resulted in take of multiple listed species.

Goleta Slough Management Committee. Goleta Slough Ecosystem Management Plan Update and Sea Level Rise Study, Santa Barbara, California. *Project Manager.* Dr. Revell working with ESA PWA conducted a sea level rise vulnerability and adaptation study for the Goleta Slough. This sea level rise study is being incorporated into the Ecosystem Management Plan Update. The work consisted of evaluation of climate related impacts including identification of vulnerabilities to both infrastructure and habitats. Following a series of focus groups, a series of appropriate adaptation strategies were identified including proposed revisions to relevant policies. The entire processes included substantial outreach and education of technical information to planners, elected officials and regulatory agencies.

The Nature Conservancy, Ventura Climate Change Ecological Vulnerability Assessment, Ventura, CA. *Project Manager.* Dr. Revell working with ESA PWA conducted climate change modeling that examines changes to coastal hazards of flooding and erosion from sea level rise and increased storminess on the Ventura coast. This included modeling changes to sediment yield and fluvial flooding using HEC-RAS by examining changes to precipitation. The coastal and fluvial changes were used as inputs to drive an ecological vulnerability assessment using SLAMM (Sea Level affecting Marsh Model). The technical modeling supports community adaptation planning as well as The Nature Conservancy conservation acquisition program along the Ventura County coast and Santa Clara River Parkway.

Santa Barbara County Land Trust and UCSB. Ocean Meadows Golf Course – Upper Devereux Slough Restoration, UC Santa Barbara, California. *Project Manager.* Dr. Revell working for ESA PWA conducted three phases of conceptual design work to inform the restoration of the Upper Devereux Slough which had been filled in the 1960s to construct a golf course. These first three phases of work improved upon a 2000 Bren School report on the restoration. The first phase evaluated the historic ecology and provided geomorphic interpretation to support restoration of an upland mesa adjacent to the golf course and to ascertain whether the volume of material estimated in the Bren report to be excavated from the golf course could be accommodated on the upland mesa site. The second phase included geomorphic interpretation and initial engineering including conceptual design and cost estimates of an initial grading plan for the upper slough restoration based on the findings that the volume of material required for excavation from the golf course were about half of that calculated in the Bren School report. The third phase focused on hydraulic analyses to specifically examine the potential impacts of the restoration both from the potential to cause scour and damages to the primary access bridge and to also model future water levels and likely functioning of the slough. This work also provided input and guidance on necessary technical studies and recommendations on consideration for future engineering and design.

Monterey Bay Sanctuary Foundation, Monterey Bay Sea Level Rise Vulnerability Assessment, Monterey County, CA. *Project Manager.* With funding from the California Coastal Conservancy, the Natural Capital Project, and the City of Capitola, Dr. Revell working with ESA PWA modeled projected climate change impacts to the coast of Monterey Bay at a scale suitable for planning purposes. Projected future coastal hazards were mapped which represented an integrated approach of stepping through time eroding the coast and flooding newly eroded areas through hydraulic connectivity. The project was advised by a Monterey Bay region wide technical advisory group comprised of research institutions (UCSC, Naval Postgraduate School, Moss Landing, CSUMB and USGS), local planning agencies (Santa Cruz, Monterey Counties, Cities of Monterey, Santa Cruz, Seaside, Sand City, Capitola), and other technical experts. The is study provided estimates of future erosion rates, flood elevations and depths of flooding at various planning horizons into the future. Uncertainty in the projections was addressed by developing a variety of projected impacts then overlapping them and developing an uncertainty index that shows relative risk of impact.

Mission Creek Lagoon and Laguna Channel Restoration. Santa Barbara, CA. ***Technical Advisor***
Dr. Revell working with ESA PWA summarized the relevant regional and local site conditions to inform the conceptual level restoration design. This work included review and analysis of relevant historic, existing and future coastal processes along the Santa Barbara Waterfront. Restoration designs are still under consideration by the City of Santa Barbara.

Audubon California, the California State Coastal Conservancy and the Department of Fish and Game, Lower Santa Ynez River Estuary Restoration, Santa Barbara, CA. ***Project Manager.*** Dr. Revell working with PWA documented historic changes in land uses, hydrology and lagoon functioning to identify potential restoration opportunities to improve the ecological health of the Lower Santa Ynez River Estuary. This assessment summarized the functioning and evolution of habitats based on existing available information and field data. The goal of this project was to identify restoration opportunities to enhance the ecologic value and ensure sustainability of native habitats in the lower Santa Ynez River corridor and estuary (approx. four river miles). One of these restoration actions was funded for design and permitting to improve southern Steelhead habitat. Funding for preliminary design was acquired from California Dept of Fish and Wildlife and design completed before Vandenberg Air Force Base decided to remove support for the project.

Scott & Waddell Creeks Bridge Realignment, Santa Cruz County, CA. ***Caltrans Project Manager.***
Currently, Highway 1 crosses Scott Creek and Waddell Creek at the interface between the ocean and the creeks' lagoons in Santa Cruz County. Dr. Revell working with ESA PWA evaluated the impact of the existing bridges and various alternative bridge designs and alignments to provide recommendations to Caltrans on design criteria to reduce long term maintenance and impacts to the coastal lagoon habitats of the planned replacement of two bridges located on Highway 1.

Surfrider Foundation, Malibu Lagoon Restoration – Impact Assessment to Surfing Resources, Malibu, CA. ***Project Manager.*** Dr. Revell reviewed technical studies related to the 2012 Malibu Lagoon restoration to assess the potential impacts of the restoration on surfing and beach conditions. Assessment included review of sediment transport, coastal processes and lagoon breaching dynamics and provided recommendations to alter the project slightly to improve benefits to surfing conditions without disrupting the project permitting and schedule.

Santa Barbara County Parks and Recreation, Goleta Beach Erosion Mitigation, Goleta, CA. ***Project Manager.*** Studied coastal processes responsible for erosion hotspot at Goleta Beach County Park. Presented research results to stakeholder groups, and participated in technical discussions evaluating erosion mitigation alternatives. Reviewed and commented on Environmental Impact Report. Developed a reconfiguration alternative to avoid erosion hazards through appropriate setbacks, and reviewed technical modeling.

The Association of Monterey Bay Area Governments and the Monterey Bay National Marine Sanctuary, Coastal Regional Sediment Management Plan for Southern Monterey Bay, CA. ***Project Manager.*** Development of a coastal regional sediment management (RSM) plan for southern Monterey Bay and evaluation of a range of erosion mitigation strategies. RSM plans take a system wide approach to identifying sources of sediment and implementation of strategies to ensure that sediment delivery to the beaches continues.

Neskowin Shoreline Assessment, Neskowin, OR. Tillamook County, ***Project Manager***. In response to a high rate of erosion that has diminished the beaches and now threatens homes and roads in Neskowin, OR, ESA analyzed the viability of various coastal erosion mitigation strategies to an eroding shore, utilizing existing information from local academics (Oregon State University) and agencies (including the Geology and Mineral Industries Department), as well as applying our experience completing assessments for similar high-energy wave-exposed coastal areas. The community is striving to find a balance of private property protection with maintenance of a sandy beach to support the tourist economy.

Santa Barbara and Ventura County Coastal Processes Study, CA. *Project Manager*. UC Santa Cruz project manager for collaborative USGS study, involving field data collection to determine historic and seasonal changes to beaches in SB and Ventura Counties.

BEACON Regional Sediment Management Plan. Dr. Revell summarized long term trends, erosion hotspots, quantified the sediment budget, recommended changes to the monitoring program and identified opportunistic project locations.

Ocean Protection Council. Coastal Infrastructure and Vulnerability Impacts Assessment. *Project Manager.* Mapped coastal erosion hazards resulting from sea level rise scenarios, evaluated geomorphic response of various backshore types by applying a total water level methodology, collaborated with climate change researchers at Scripps, organized and engaged peer review team on methods and results, collaborated with Pacific Institute to vulnerability assessment associated with coastal hazards.

Selected Publications

Weaver, C.P., C. Brown, J.A. Hall, R. Lempert, **D. L. Revell**, D. Sarewitz, and J. Shukla, 2013. Climate Modeling Needs for Supporting Robust Decision Frameworks. *WIRE's Climate Change*

Revell, D.L., R.Battalio, B. Spear, P. Ruggiero, and J. Vandever, 2011. A Methodology for Predicting Future Coastal Hazards due to Sea-Level Rise on the California Coast. *Climatic Change* 109:S251-S276. DOI 10.1007/s10584-011-0315-2.

Orme, A.R., Griggs, G.B., **Revell, D.L.**, Zoulas, J.G., Chenault, C., Koo, H. 2011. Beach changes along the southern California coast during the twentieth century: A comparison of natural and human forcing factors. *Shore and Beach*

Revell, D.L., Dugan, J.E., and Hubbard, D.M. 2011. Physical and ecological responses of sandy beaches to the 1997-98 ENSO. *Journal of Coastal Research*. 27(4)718-730

Barnard, P.L., **Revell, D.L.**, Hoover, D., Warrick, J., Brocatus, J., Draut, A.E., Dartnell, P., Elias, E., Mustain, N., Hart, P.E., and Ryan, H.F., 2009, Coastal processes study of Santa Barbara and Ventura Counties, CA: U.S. Geological Survey Open-File Report 2009-1029, http://pubs.usgs.gov/of/2009/1029/

Revell, D.L., Barnard, P. and Mustain, N. 2008. Influence of Harbor Construction on Downcoast Morphological Evolution: Santa Barbara, California. Published in Coastal Disasters '08 Conference, April 2008 North Shore, HI.

Dugan, J.E., Hubbard, D.M., Rodil, I., and **Revell, D.L**. 2008. Ecological Effects of Coastal Armoring on Sandy Beaches. *Marine Ecology*.

Revell, D.L., Marra, J.J., and Griggs, G.B. 2007. Sandshed Management. Special issue of Journal of Coastal Research - Proceedings from International Coastal Symposium 2007, Gold Coast, Australia.

Revell, D. L and Griggs, G.B. 2006. Beach Width and Climate Oscillations along Isla Vista, Santa Barbara, California. *Shore and Beach*. 74(3)8-16.

Revell, D.L., Komar, P.D., Sallenger, A.H. Fall 2002. *An Application of LIDAR to Analyses of El Niño Erosion in the Netarts Littoral Cell, Oregon*. *Journal of Coastal Research*, ACEC Vol. 18 4:702-801.

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FIRM PROFILE AND QUALIFICATIONS

Revell Coastal, LLC is a coastal management firm that specializes in coastal geomorphology, coastal lagoon dynamics, beach and dune sediment management, and climate change vulnerability and adaptation planning with expertise along the entire U.S. West Coast. Revell Coastal approaches projects by applying the best available science on climate change to interpret the potential hazards and vulnerabilities, and provides recommendations on adaptation strategies tailored to fit local jurisdictions needs and political realities across multiple planning horizons. The firm focuses on improving the use of science in coastal management decisions and provides scientific facilitation, expert witness, technical analysis, field surveying and planning services. Revell Coastal, LLC was founded in 2014 by Dr. David Revell in Santa Cruz, California.

Dr. Revell has been involved in coastal management and coastal process assessments for over 20years. He has been pioneering climate related work beginning in 2008 with the initial technical hazard analysis and vulnerability assessment for the Pacific Institute study "*The Impacts of Sea Level Rise to the Coast of California*." Dr. Revell has also completed hazard modeling for the *Coastal Resilience Ventura* project for the Nature Conservancy (2013), and the *Monterey Bay Sea Level Rise Vulnerability Assessment (2014)*, for the California Coastal Conservancy. Dr. Revell has led an interdisciplinary team of economists, legal scholars, and engineers to evaluate potential erosion mitigation (adaptation strategies) strategies in Southern Monterey Bay (2012).

SELECT FIRM EXPERIENCE

City of Imperial Beach Sea Level Rise Study: "Adaptive" Vulnerability and Adaptation Planning

Lead: Revell Coastal, LLC
Firm Project Manager: Dr. David Revell
Client Project Manager: Jim Nakagawa, Principal Planner, City of Imperial Beach, 619-628-1355, jnakagawa@imperialbeachca.gov
Award Date: September 2014
Completion Date: December 2015 (anticipated)
Project Description: Revell Coastal, LLC teamed with USC Seagrant is conducting a Sea Level Rise Vulnerability and Adaptation Study in Imperial Beach, San Diego, CA. With funding from the State Coastal Conservancy, Revell Coastal, is leading the City through a facilitated sprocess to characterize existing and future vulnerabilities, identify potential adaptation strategies, and then help educate the local community to garner support for implementing of prioritized actions. Part of the project is to build technical capacity within the City to support future incorporation of new relevant data. The vulnerability assessment will utilize CoSMoS 3.0 for the final analysis of vulnerabilities (CoSMoS 2.0 = Our Coast Our Future). Key partners in the initiative include the Tijuana River National Estuarine Research Reserve, the Port of San Diego, and the U.S. Navy.

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City of Goleta: Incorporating Climate Change into the Local Coastal Program
Lead: Revell Coastal, LLC
Firm Project Manager: Dr. David Revell
Client Project Manager: Chandra Slaven (formerly Krout), Senior Planner, City of Goleta 805-961-7544, cslaven@cityofgoleta.org
Award Date: July 2014
Completion Date: April 2015 (anticipated)
Project Description: Revell Coastal is working for the City of Goleta to update and draft their LCP to include climate change impacts and be consistent with the California Coastal Commission DRAFT Guidance on Sea Level Rise. This includes reviewing technical background materials, conducting a high reconnaissance level vulnerability assessment, identifying adaptation strategies and policy recommendations and drafting sections of the Local Coastal Program related to coastal hazards, specifically in the open space, safety and conservation elements. Revell Coastal will be developing a summary report for use in internal City capacity building and externally as outreach and educational materials. Funding for this work was acquired from the California Coastal Commission through their climate granting program.

Goleta Slough Sea Level Rise Vulnerability and Adaptation Study and Ecosystem Management Plan Update
Lead: ESA (former employer of Dr. Revell)
Firm Project Manager: Dr. David Revell
Client Project Manager: Rachel Couch, California Coastal Conservancy for the Goleta Slough Management Committee, 805-845-8853 rcouch@scc.ca.gov
Award Date: October 2012
Completion Date: October 2014 (scheduled)
Project Description: The Goleta Slough Ecosystem Management Plan was prepared by the Goleta Slough Management Committee and adopted by the City of Santa Barbara in 1997. As part of an update to the Management Plan, the Coastal Conservancy is funding a vulnerability and adaptation study to re-evaluate the study area based on projected sea level rise. Through a facilitated stakeholder process and technical analyses, the study is assessing vulnerability and risk to both natural and human resources and infrastructure. Based on results of the vulnerability assessment a series of adaptation strategies are being recommended that include both capital improvements and policy recommendations. Dr. Revell has managed the project, the stakeholder process, led the technical analyses and provided guidance and direction to the subcontractors.

Monterey Bay Sea Level Rise Vulnerability Assessment, Monterey and Santa Cruz Counties
Lead: ESA (former employer of Dr. Revell)
Firm Project Manager: Dr. David Revell
Client Project Manager: Dennis Long, Executive Director, Monterey Bay Sanctuary Foundation (831) 647-4209, dennis@mbnmsf.org
Award Date: June 2012
Completion Date: June 2014
Project Description: With funding from the California Coastal Conservancy, the Natural Capital Project, and the City of Capitola, ESA PWA (former employer of Dr. Revell) modeled projected climate change

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impacts to the coast of Monterey Bay at a scale suitable for planning purposes. Deliverables included projected future coastal hazards which include a new integrated approach of stepping through time eroding the coast and flooding newly eroded areas through hydraulic connectivity. The project was being advised by a Monterey Bay region wide technical advisory group comprised of research institutions (UCSC, Naval Postgraduate School, Moss Landing, CSUMB and USGS), local planning agencies (Santa Cruz, Monterey Counties, Cities of Monterey, Santa Cruz, Seaside, Sand City, Capitola), and other technical experts. Uncertainty in the sea level rise projections were represented by projection a variety of projected impacts then overlapping them and developing an uncertainty index that showed relative risk of coastal hazard impacts. Dr. Revell managed the project and led the technical work for ESA.

The Nature Conservancy's Coastal Resilience Program

Lead: ESA (former employer of Dr. Revell)
Firm Project Manager: Dr. David Revell
Client Project Manager: Sarah Newkirk, J.D., Coastal Programs Director, (415) 730-7437, snewkirk@tnc.org
Award Date: September 2012
Completion Date: July 2014
Project Description: The Coastal Resilience Ventura (www.coastalresilience.org) project encompasses the entire Ventura County coastline, including Mugu Wetlands, the Santa Clara River, and the Ventura River. Working through an interactive stakeholder process with multiple agencies, local government representatives, and several non-profit organizations, Dr. Revell led a technical team which modeled current and potential future coastal and fluvial hazards for a variety of climate change scenarios, including sea level rise and changes to rainfall and sediment delivery. We applied a habitat evolution model (Sea Level Affecting Marsh Migration - SLAMM) to predict long-term wetland conversion with sea level rise, as well as to identify areas of ecological vulnerability based on potential adaptation strategies. SLAMM model results were then used to calculate the greenhouse gas emissions related to multiple adaptation strategies. The results are being used by local communities and the Department of Defense to evaluate vulnerabilities and consider adaptation strategies. Dr. Revell was the project manager, led the technical modeling, and worked with the client on a project development team and as a co-facilitator for the stakeholder process.

Goleta Beach Erosion Projects for the County of Santa Barbara

Lead: PWA, ESA, UCSC (former employers of Dr. Revell)
Firm Project Manager: Dr. David Revell
Client Project Manager: (multiple) Current project manager is Alex Tuttle, Planner, Development Review County of Santa Barbara, 805-884-6844, atuttle@countyofsb.org
Award Date: September 2003
Completion Date: April 2014
Project Description: The 1997-98 El Niño catalyst an erosion wave which caused substantial erosion to Goleta Beach County Park in Santa Barbara County. Dr. Revell has been involved in multiple stakeholder processes and technical studies over the last 11 years working primarily for the County of Santa Barbara. These studies have included peer reviewed scientific research, technical studies on various adaptation strategies with several alternative park reconfigurations and managed retreat options. Dr. Revell also peer reviewed other technical modeling and led a technical team to conduct wave run-up and climate change

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modeling to support the Environmental Impact Report on a managed retreat strategy. Throughout the process, Dr. Revell has presented research results to stakeholder group.

Neskowin Shoreline Assessment, Neskowin, Tillamook County, Oregon
Lead: ESA (former employer of Dr. Revell)
Firm Project Manager: Dr. David Revell
Client Project Manager: Patrick Corcoran, Oregon Seagrant Coastal Hazard Specialist, 503-325-8573, patrick.corcoran@oregonstate.edu
Award Date: August 2012
Completion Date: May 2013
Project Description: In response to high rates of erosion and sea level rise that have diminished the beaches and now threatens homes and roads in Neskowin, OR, ESA analyzed the viability of various coastal erosion mitigation strategies on an eroding shore, utilizing existing information from local academics (Oregon State University) and agencies (including the Department of Geology and Mineral Industries), as well as applying our experience completing assessments for similar high-energy wave-exposed coastal areas. We applied modeling to evaluate physical changes from various adaptation strategies and provided conceptual level engineering cost estimates for each strategy to inform community decision making. The community was striving to find a balance of private property protection with maintenance of a sandy beach to support the tourist economy. Dr. Revell managed the project, led the technical analyses and co-facilitated the community process.

Technical Evaluation of Erosion Mitigation Alternatives and Regional Sediment Management Plan for Southern Monterey Bay
Lead: PWA (former employer of Dr. Revell)
Firm Project Manager: Dr. David Revell
Client Project Manager: Brad Damitz, Natural Resource Specialist, 415-250-8406
brad.damitz@noaa.gov
Award Date: October 2010
Completion Date: May 2012
Project Description: The Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay (Alternatives Study - http://montereybay.noaa.gov/research/techreports/esapwa2012.pdf) provided an assessment of various erosion mitigation measures (adaptation strategies) to support development of a regional strategy to address coastal hazards. In this study, 22 different erosion mitigation measures including land use planning tools, soft engineering solutions and hard engineering solutions. The measures were compared using a variety of criteria including an innovative effectiveness criteria which compared each measures merit at protecting upland property and beach widths (a highly valued community resource). The Study then compared the costs and benefits of each measure over multiple time horizons by tracking the physical impacts of each measure on the beach and upland through time. The holistic cost/benefit analysis included accounting for beach recreation and ecosystem services in addition to traditional storm damages. While this initial study did not include climate impacts directly, it began to

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inform adaptation strategies across the region and was the basis for a recently kicked off project called Adapt Monterey Bay funded by the California Coastal Conservancy Climate Ready Grant Program. Dr. Revell managed the project for ESA and led the technical work as well as contributed to the successful Climate Ready grant proposal.

Coastal Infrastructure and Vulnerability Impacts Assessment for the Pacific Institute
Lead: Pacific Institute
Firm Project Manager: Dr. David Revell (working for Philip Williams and Associates)
Client Project Manager: Matt Heberger, P.E., Water Resource Associate/Climate Program Coordinator, Pacific Institute, 510-251-1600, mheberger@pacinst.org
Award Date: June 2008
Completion Date: January 2009
Project Description: With funding from the Ocean Protection Council as part of the 2008 California Climate Impacts Assessment through the California Energy Commission, PWA conducted the first California statewide coastal hazard assessment resulting from sea level rise. This groundbreaking project, the first of its kind on the U.S. West Coast, mapped projected future coastal erosion and coastal flooding hazards. (http://www.energy.ca.gov/2009publications/PWAOPC-1000-2009-013/PWAOPC-1000-2009-013.PDF) To complete this project, PWA (led by Dr. Revell) developed a new methodology which evaluated geomorphic response of various backshore types by applying a total water level methodology (Revell *et al* 2011); collaborated with climate change researchers at Scripps, USGS, and Oregon State; organized and engaged a technical and regulatory peer review team on methods and results; then collaborated with Pacific Institute to vulnerability assessment associated with coastal hazards which were published in the Pacific Institute Report: *The Impacts of Sea Level Rise to the California Coast.* Dr. Revell managed the project and led the technical work for PWA.

USGS-UCSC Coastal Processes Study for Santa Barbara and Ventura Counties
Lead: USGS
Firm Project Manager: Dr. David Revell (for University of California Santa Cruz)
Client Project Manager: Dr. Patrick Barnard, Coastal Hazards Scientist, USGS 831-460-7556, pbarnard@usgs.gov
Award Date: October 2005
Completion Date: December 2007
Project Description: The USGS and UCSC collaborated on a large scale coastal process study of the Santa Barbara littoral cell. http://pubs.usgs.gov/of/2009/1029/ .Building on research by Dr. Revell (formerly at UCSC) assessing the long term changes to beaches from climate change and human impacts, the study examined seasonal changes through extensive field data collection campaigns and conducted numerical modeling to further inform observations of short term and seasonal changes and provide insights into long term shoreline evolution. Dr. Revell, conducted research and managed the UCSC research team led by Dr. Gary Griggs.

Exhibit CO-4

Vulnerabilities of the Proposed Mandalay Generating Station to Existing and Future Coastal Hazards and Sea Level Rise

By

David Revell, PhD.

4/6/2015

Photo Courtesy of California Coastal Records Project

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Vulnerabilities Of The Proposed Mandalay Generating Station To Existing And Future Coastal Hazards And Sea Level Rise

1.0 ENVIRONMENTAL SETTING AND BACKGROUND

The City of Oxnard is located about 60 miles northwest of Los Angeles along the Pacific Ocean coastline (Figure 1). Oxnard lies at the western edge of Ventura County with a 10.5 mile Pacific Ocean coastline between the Santa Clara River on the north and the Ormond Beach wetlands on the south.

The coast of Oxnard lies within the Santa Barbara Channel and is part of the larger Santa Barbara littoral cell that extends from at least Point Conception to Point Mugu Submarine Canyon southeast of the study sites. The presence of the Channel Islands to the South and Point Conception to the west create a narrow swell window through which waves must pass. This wave direction sets up a dominant sand transport from NW to SE along the Oxnard coast.

Beach and dune sand for this site is derived from upcoast watershed inputs which provides a natural defense from waves and coastal erosion. Sand on the beaches and in the dunes fronting the site come from a combination of upcoast beaches watershed delivery from the Ventura and Santa Clara Rivers, and cliff erosion. This sand moves south with littoral (wave driven) currents and is trapped on the north side of the Ventura Harbor by the harbor jetties and breakwater. Currently the U.S. Army Corps of Engineers operates a maintenance dredging program to bypass sand from one side of the harbors to the other. The width and buffering capacity of the beaches are dependent on the continuous bypass of sand across each of the federal navigation channels (Figure 1).

The State of California is directing local coastal governments to take more proactive steps to address sea-level rise due to the significant impacts sea level rise may have on the economy, natural systems, the built environment, and human health. In 2012, the National Research Council published a scientific report on expected sea level rise along the coasts of California, Oregon, and Washington (NRC 2012). In October, 2013, the California Coastal Commission building on the National Research Council science report, issued a DRAFT Sea Level Rise Policy Guidance (Guidance) document that provides a step-by-step guidance on how to address Sea level rise in new and updated Local Coastal Programs and Coastal Development Permits (CCC 2013). Several aspects of the Coastal Commission guidance document are relevant to this vulnerability assessment. First, there is specific guidance for critical public infrastructure to consider the worst case scenario of sea level rise. Second, the Guidance document outlines an analysis of future potential hazards to the development and future impacts to coastal resources, along with identification of potential adaptation strategies. Much of this analysis is dependent on identification of an economic life expectancy of this structure. This report is intended to meet the guidance document criteria for vulnerability assessment for a coastal development permit.

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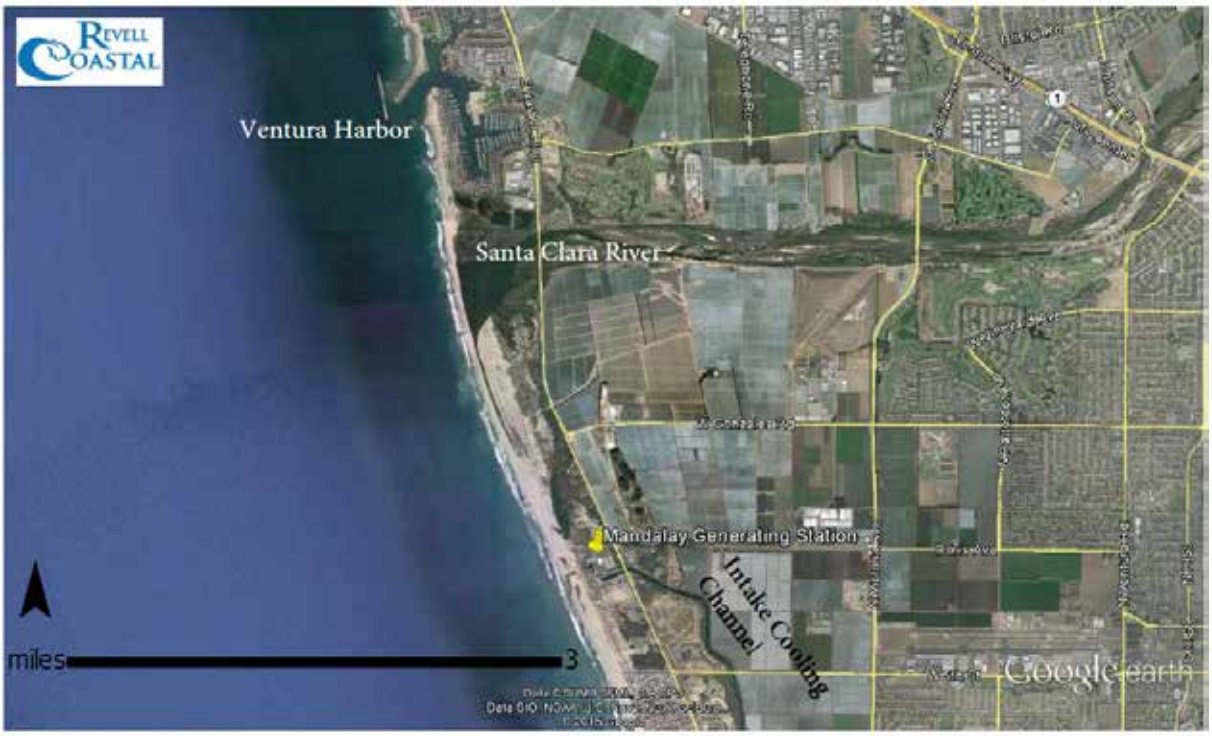
Figure 1. Mandalay Generating Station Regional Setting



2.0 PURPOSE

This study conducts a vulnerability assessment of the existing and future coastal hazards and climate change impacts for the proposed Mandalay Generating Station Facility. Specifically the vulnerability assessment is intended to evaluate potential impacts to the facility. The study uses the best-available information and science that have identified various coastal processes (i.e. coastal erosion, flooding, wave impacts, tidal inundation) that create coastal process hazards to determine to what exent is the proposed coastal power plant site presently vulnerable to damage from existing coastal process hazards, and to what extent do their respective vulnerablilities change with sea level rise?

3.0 VULNERABILITY ANALYSIS SCOPE AND LIMITATIONS

This vulnerability assessment conducted by Revell Coastal utilized several primary data sources. The coastal hazards modeling analysis results (ESA PWA 2013), FEMA's effective flood maps (FEMA 2010), the spatial infrastructure and locational data available from ESRI and TNC (2015), and the proposed location of the NRG energy facility. Climate change impacts to coastal hazards and sea level rise are from Coastal Resilience Ventura: Technical Report for Coastal Hazards Mapping (ESA PWA 2013). http://maps.coastalresilience.org/ventura/methods/CRV_Hazards_Mapping_Technical_Report.pdf

The Coastal Resilience Ventura initiative was started by the Nature Conservancy in 2011 to join regional partners to plan for coastal hazards and climate change (www.coastalresilience.org/ventura). The primary goals of Coastal Resilience Ventura are to assess the vulnerabilities of human and natural

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resources, and identify solutions that help nature help people. A steering committee comprised of the cities of Oxnard and Ventura as well as Ventura County, along with state and federal agency representatives, local non-profit and non-governmental organizations, and regional technical experts, helped to guide the project[1]. In particular the steering committee identified particular planning needs and data products related to technical analysis on coastal hazards, climate change, habitat evolution, planning and adaptation strategies.

The existing and future coastal hazard modeling methods and assumptions are summarized briefly below and readers are encouraged to read the technical documentation for further technical details (ESA PWA 2013).

The modeling work in Coastal Resilience Ventura included modeling of the following coastal processes:

1. **Coastal King Tide flooding** - based on an expected monthly recurrence
2. **High tide coastal flooding** - based on the largest El Niño storm on record (January 1983) this included storm surge and large waves with sea level rise
3. **Wave impacts** - Wave impacts similar to the historic January 1983 storm with sea level rise
4. **Coastal Erosion** – loss of fronting dunes based on a 100 or 500 year wave event.

Hazard Modeling

The localized coastal hazard modeling methodology relies on a detailed parcel level backshore characterization that includes backshore type, geology, and local geomorphology (i.e., elevations, beach slopes). The backshore characterization was analyzed at each ~100 yard spacing and then statistically represented at a ~500 yard alongshore distance. Calculations of wave run-up and tides are combined into a total water level elevation which then drives coastal erosion and shoreline response models (Pacific Institute 2009, Revell et al 2011). Climate change impacts, assessed using a series of sea level rise, wave climate, and precipitation scenarios, projected potential future coastal erosion and flooding hazards (ESA PWA 2013). Projected impacts were evaluated at four planning horizons: existing (2010), 2030, 2060, and 2100. All hazards were mapped on the California Coastal LIDAR Digital Elevation model (available from NOAA Digital Coast website).

Scenarios

Scenarios for the climate change modeling considered sea level rise, wave climate, and precipitation. Scenarios were selected prior to release of the Draft Guidance document but meetings were held with the Coastal Commission staff so as to be consistent with the intent of the California Coastal Commission draft guidance on sea level rise (CCC 2013), the National Research Council (NRC 2012), and the U.S. Army Corps of Engineers guidance (USACE 2011). However, as a result some of the specific numbers used in the analysis are not the same as those listed in the draft guidance. Instead of using the subsidence south of Cape Mendocino rates (NRC 2012), the sea level rise curves were adjusted using vertical land motion reported at the Santa Monica Bay tide gage. The specific scenarios used in the modeling are shown in Table 1 and Figure 2.

[1] A complete list of the steering committee membership organizations can be found at: http://coastalresilience.org/project-areas/ventura-county-introduction/

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Figure 2. Sea Level Rise scenarios used in the coastal hazard modeling adjusted for vertical land motion relative to 2010 (ESA PWA 2013).

NRC 2012: Global SLR from table 5.2. Polynomial (order 2) fit to obtain global SLR for intermediate years. This curve was shifted by 1.5 mm/year subsidence to get local SLR (Table A.1, Santa Monica).

USACE 2011 Curve: NRC 1987 curve I, adjusted to local SLR by replacing global SLR (1.7 mm/year, IPCC 2007) with local sea level rise for Santa Monica (1.42 mm/yr, Gill/NOAA 2011).

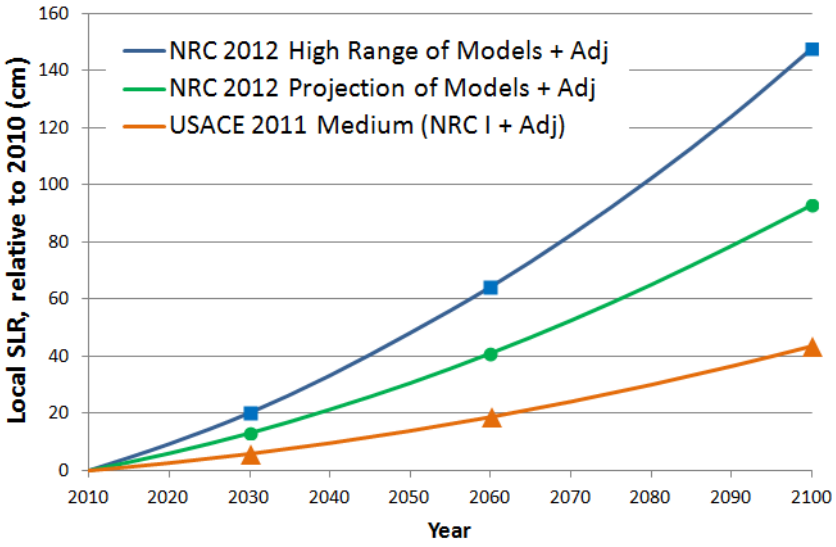

Table 1. Sea Level Rise Scenario elevations by planning horizon

Year	Low SLR	Medium SLR	High SLR*
2030	2.3 inches	5.2 inches	8. 0 inches
2060	7.4 inches	16.1 inches	25.3 inches
2100	17.1 inches	36.5 inches	58.1 inches

**The NRC 2012 High scenario for the South of Cape Mendocino is 2030- 11.8inches, 2100 – 65.5inches*

Coastal Erosion

The coastal dune erosion hazard modeling considered three components, erosion due to sea level rise, erosion due to historic trends in shoreline change (as a proxy for sediment supply), and erosion due to a large storm wave event. Three scenarios of changes to waves were modeled including: no changes in historic wave conditions, a 500 year ArkStorm event (USGS 2010), and a doubling of the El Niño storm frequency to represent some of the uncertainty associated with increasing storm intensity.

The potential inland erosion caused by sea level rise and a large storm wave event was projected using a geometric model of dune erosion originally proposed by Komar et al (1999) and applied with different slopes to make the model more applicable to sea level rise (Revell et al 2011). This method is consistent with the FEMA Pacific Coast Flood Guidelines for storm induced erosion (FEMA 2005).

Coastal Storm Flooding

The coastal storm flood modeling was consistent with FEMA's Pacific Coastal Flood Guidelines (FEMA 2005). The high tide coastal storm flood modeling was integrated with the coastal erosion hazard zones. Every 10 years, erosion projections were made and the coastal storm flood model considered areas that were eroded during this time period and thus exposed to wave flooding through enhanced hydraulic connectivity. For the coastal storm flooding, the storm of record was used; a large historic storm event that occurred during the strong El Nino winter of 1982/1983 on January 27, 1983 during which wave heights reached 25 feet at 22 seconds (ESA PWA 213, Seymour 1996).

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Coastal Wave Impact

Wave impact modeling assessed the inland extent of wave velocity and inland extents of flooding using the method of Hunt (1959) and supported in the Shore Protection Manual (USACE 1984). This method calculated the dynamic water surface profile, the nearshore depth limited wave, the wave run-up elevation and inland extent at the end of each representative profile. This hazard was requested by the steering committee who requested the modeling to identify a future FEMA velocity wave impact zone (aka V-Zone).

Coastal Inundation

Tidal inundation modeling represents the Extreme Monthly High Water level (EMHW) or what areas are projected to get wet once a month. This modeling is similar to a King Tide. This monthly elevation was averaged from the maximum monthly water level from the Rincon Island tide gauge (EMHW = 6.56ft NAVD88 or 9.3ft MSL) and it was applied to each of the sea level rise scenarios.

Combined Hazards

For each planning horizon, projected hazards were combined into a single layer using a process called "spatial aggregation" (ESA PWA 2013). This layer represents the overlap in all of the hazard zones and shows how many of the various sea level rise and wave condition scenarios impact specific areas. For example, an area mapped under three scenarios indicates that the area was hazardous during that planning horizon for all scenarios.

Critical Modeling Assumptions

As with all modeling, assumptions had to be made to complete the work. Below are some of the critical modeling assumptions made in the ESA PWA 2013 work. These assumptions are discussed in the context of the proposed power plant site on the Mandalay Generating Station parcel.

- **Coastal erosion and flood hazard projections do not consider existing coastal armoring** – the coastal hazard projections did not consider the influence of the existing water outfall structure on changes to coastal erosion and coastal flood hazard projections;

- **Modeling and hazard identification did not consider tsunamis –** this modeling was not part of the scope of work but should be considered as part of a full coastal hazards investigation. Such a consideration would include existing harbor dredging and without harbor dredging practices;

- **Projections of potential erosion do not account for uncertainties in the duration of a future storm** – the erosion projections assumes that the coast would respond to the combination of high tides and large waves inducing wave run-up. Instead of predicting future storm specific characteristics (waves, tides, and duration), the potential erosion projection assumes that the coast would erode under a maximum high tide and storm wave event with undefined duration;

- **Modeling does not consider future changes to supply of sediment from the watersheds –** while some fluvial modeling was completed for the project there remain large uncertainties in projections of future precipitation frequency and magnitude. Downscaled global climate models show

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precipitation changes between a 23% increase and a -14% decrease from existing conditions. Using USGS sediment rating curves this translates precipitation changes to the following projected changes in sediment yield (Table 2).

Table 2. Relative Change in Annual Watershed Sediment Yield from the Santa Clara over Time

	Time Horizon	A2 Scenario	B1 Scenario
% Change relative to 1980-2010 average	2030	69.5%	11.4 %
	2060	0.5 %	-20 %
	2100	-17.7 %	-31.9 %

(Adapted from ESA PWA 2013)

Given the wide variability and uncertainty in watershed land use changes ESA PWA assumed that there was no substantive changes. However a long term decline in sediment yield from the watershed would be expected to result in narrower beaches, shrinking sand dunes, and an increase in the coastal processes hazards to the proposed site. This would increase exposure to coastal hazards at the Mandalay Generating Station.

- **Modeling assumes that the existing dredge practices at all of the harbors continue** – currently the Ventura Harbor bypasses/dredges ~600,000 yards of sand annually from the sand trap on the north side of the harbor over the navigation channel to the south side, just updrift from the Mandalay Generating Station. This continuing supply of sand helps to maintain the wide beaches and dune fields fronting the Mandalay Generating Station. If this harbor bypass/dredging stops, then beaches and dunes currently fronting the facility would narrow exposing the site to an increase in coastal process hazards (see Environmental Setting section below).

4.0 MANDALAY GENERATING STATION ENVIRONMENTAL SETTING

The Mandalay Beach Generating Station (MGS) is located next to the beach at the western terminus of the Oxnard plain. It is directly south and downdrift from the Ventura Harbor and the Santa Clara River (Figure 3). The site is exposed to long period westerly swells that typically occur during the fall to spring months. In 2009, the available elevation data shows MGS is located behind a wide beach (~ 300+ feet) with some protective dunes. This wide beach though is based largely on continuous dredging and can be substantially narrower (Figure 5). In 2009, the average crest of the dunes fronting the MGS is up to 22 feet above MSL (25 feet NAVD88). The ground floor elevation of the existing power plant site is on average ~11 feet above MSL (14 feet NAVD88). The power plant receives its cooling water through the Edison canal which connects to Channel Islands Harbor, this tidally influenced channel is ~120 feet in width and terminates at the power plant. Once through cooling water is returned to the ocean from the outfall on the beach.

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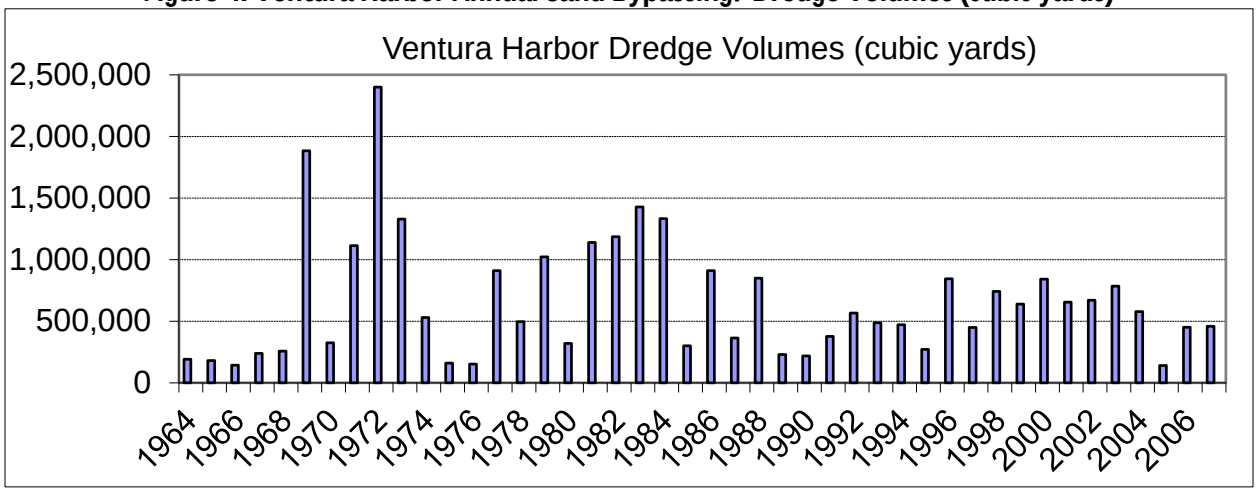
Figure 3. Proposed Site of New Energy Plant at Mandalay Generating Station
(*photo courtesy of California Coastal Records Project***)**

Harbor Dredging/Sand Bypassing

Beach and dune sand for this site is derived from upcoast watershed inputs and cliff erosion. These beaches and dunes provide a natural defense from waves and coastal erosion. Sand found on the beaches moves south with littoral (wave driven) currents and depends heavily on sand bypassed over the Ventura Harbor navigation channel. The Ventura Harbor dredges an average of ~600,000 cubic

Figure 4. Ventura Harbor Annual Sand Bypassing/ Dredge Volumes (cubic yards)



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yards of sand per year (Figure 4) to maintain the supply of sediment. Following flood events, additional sand is provided by river discharge from the Santa Clara River.

Following construction of Ventura harbor, sand moving down the coast was trapped on the north side of the harbor. The impoundment of sand updrift of the harbor caused disruption of longshore sand transport and caused an erosion wave downcoast (Adams 1976). Without dredging to bypass sand from the north to the south side of the harbor beaches in front of the Mandalay Generating Station narrowed to the minimum beach width observed since the harbor was constructed. Figure 5 shows the comparison between the 1966 beach width in front of the outfall in Figure 5A with the same beach width in 2012 Figure 5B. This shows a narrower beach by at least 200 feet without sand bypassing from Ventura Harbor. A narrower beach such as that shown in Figure 5A is not currently represented in the in the 2009 LIDAR digital elevation data. A narrower beach would likely have much more substantive erosion and coastal flooding impacts.

Figure 5. Mandalay Generating Station in 1966(A) and 2012 (B)

In recent years, the Army Corp of Engineers budget for dredging of the Ventura Harbor has been relatively flat. This level funding means that as the cost of dredge operations has risen with increasing fuel costs and environmental monitoring, the volume of sand dredged from the harbor has declined. Since 2008, the volume of sand dredged had been insufficient to remove the annual accumulation of sand. In the FY2013 budget there was no funding for any dredging of the Ventura Harbor. This story is consistent with small harbors around the country as dredge funding has declined except for the biggest commercial ports.

Due to downcoast erosion impacts observed at Port Hueneme (see below), local, State and Federal elected officials lobbied effectively for additional funding for dredging. In FY2015, funding was granted

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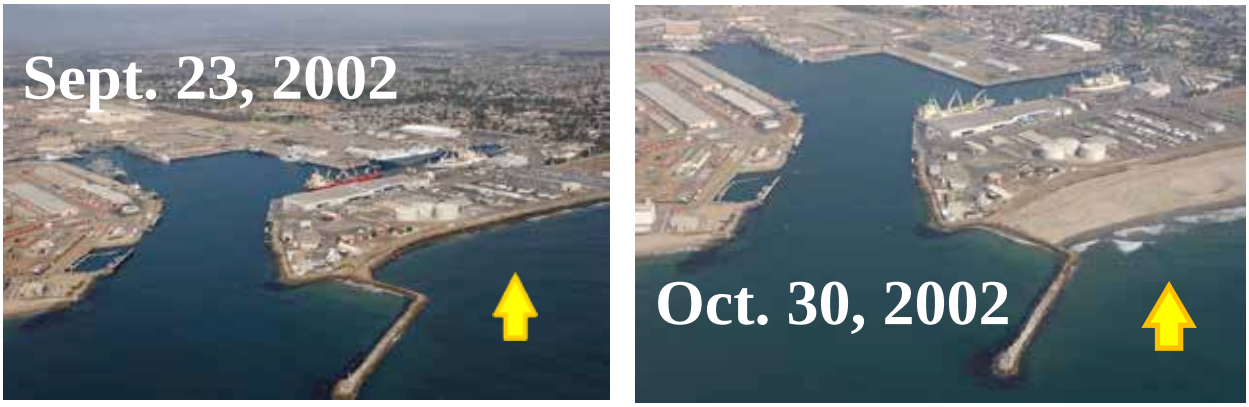
to Ventura harbor to completely clear out the sand from the north side of the Harbor entrance. However, there is no guarantee that this funding will continue.

An example just downcoast of Mandalay provides insights to what could occur at the Mandalay site should dredge practices change or cease. Port Hueneme dredges episodically around Channel Islands Harbor, which dramatically widen the beaches downcoast along the City of Port Hueneme (pre -Figure 6A, post Figure 6B).

Figure 6. Beach width pre (A: September 23, 2002) and post dredging (B: October 30, 2002) downcoast of Port Hueneme (*photos courtesy of California Coastal Records Project)*



In 2013, after several years without any dredging the city of Port Hueneme started to suffer substantial erosion which caused them to request an emergency revetment (Figure 7.)

Figure 7. Erosion at City of Port Hueneme following a multi-year gap in dredging (*photo courtesy Ventura County Star)*

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5.0 MANDALAY GENERATING STATION VULNERABILITY RESULTS

For purposes of this vulnerability assessment, it is assumed that the vacant portion of the site (shown in red) would be the site of the new power plant and that the plant would connect to the electrical transmission infrastructure (shown in yellow).

EXISTING VULNERABILITIES (2015)

The Mandalay Generating Station site is currently exposed to existing coastal flood hazards from a 500 year event (FEMA 2010). In addition, the coastal hazard modeling identified three additional coastal processes that pose hazardous conditions for the Mandalay Generating Station site – coastal erosion, wave impacts and coastal storm flooding (ESA PWA 2013; Figure 8, Table 3). A 100 year wave erosion event could remove 125+ feet of the protective dunes and leave the site vulnerable to subsequent storm events.

Figure 8. Proposed NRG Site with existing Coastal Flooding Hazards from a Large El Niño Wave Event

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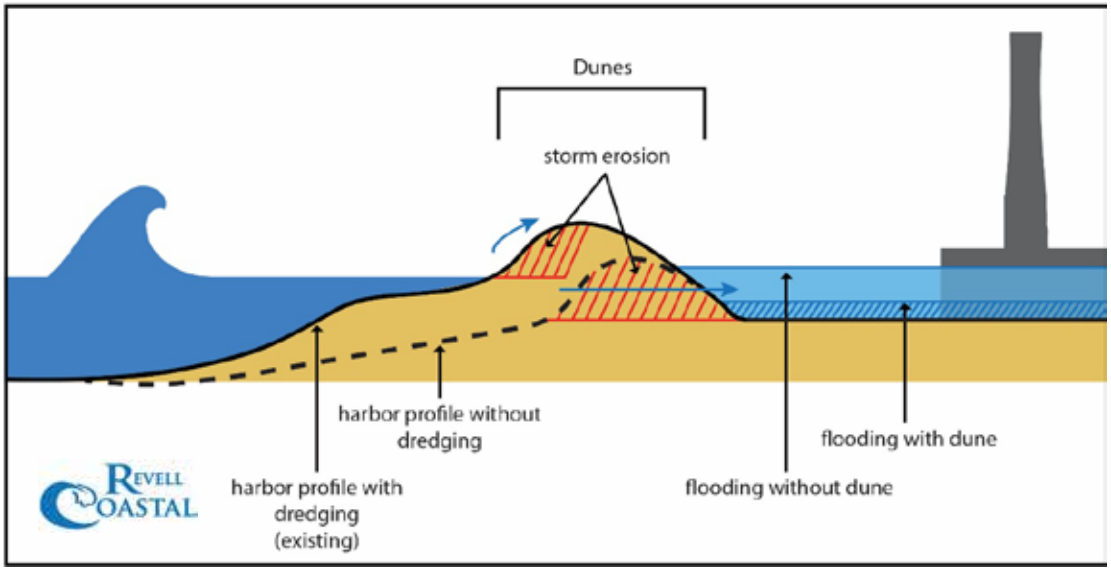
In addition, the modeling assumes that the sand bypass operations at the Ventura Harbor continue. If the dredge operations stop or shut down for several years, then the beach and dunes in front of the facility are likely to narrow and substantially increase the exposure to coastal process hazards. This would narrow the beach, lower the sand dunes and allow coastal erosion to reduce the buffering capacity of the beach and dunes which could lead to increased exposure to wave impacts, coastal erosion, and depth of coastal flooding (Figure 10, 11).

Figure 9. Conceptual differences between a beach and dune system maintained by the harbor dredging compared with a profile without sand dredging



VULNERABILITIES WITH UP TO 8 INCHES OF SEA LEVEL RISE (2030 +/-)

With sea level rise, projections of coastal processes related hazards are expected to increase. By 2030, the sea level rise is projected to increase between 2.3 and 8.0 inches. Figure 10 shows the combined hazards of coastal erosion, coastal flooding and wave impacts at 2030. While the actual footprint of the proposed new power facility is approximated presently, it should be noted that portions of this undeveloped section of the parcel are projected to experience coastal storm flooding under even the lowest sea level rise scenario. These existing and future hazards also affect the Southern California Edison grid where the new plant would tie into the transmission grid. This same hazard also extends to the connection between the proposed plant and the Southern California Edison Big Creek/Moorpark Sub-Area grid.

By 2030, the modeling does not show impact to emergency or first responder access aside from potential coastal flooding on the site itself (Figure 10; Table 4). The depth of flooding and inland extents of wave impacts are likely to increase at the Mandalay Beach Generating Station over time (Table 3; Figure 11, 12).

The extent and magnitude of these impacts would be much worse than mapped if the dredge operations which bypass sand around Ventura Harbor and maintain the fronting beach and protective dunes were reduced or ceased. A 100 year wave erosion event could remove up to 125 feet of the protective dunes and leave the site vulnerable to subsequent storm events.

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Figure 10. Combined Coastal Erosion, Flooding and Wave Impact Hazards in 2030

VULNERABILITIES WITH UP TO 25 INCHES OF SEA LEVEL RISE (2060 +/-)

By 2060, the sea level rise is projected to increase between 7.4 and 25.3 inches. Figure 11 shows the combined hazards of coastal erosion, coastal flooding and wave impacts at 2060. By 2060 almost the entire undeveloped portion of the Mandalay Beach Generating Station site is exposed to coastal process hazards under the high sea level rise scenario. Even the low sea level rise scenario shows the majority of the undeveloped portion of the site exposed to coastal process hazards (Table3). Under the approximate proposed facility location, the facility would be exposed to coastal storm flooding during both the medium and high sea level rise scenario.

Under the Year 2060 high sea level rise scenario (25.3 inches), the access road between the facility and Harbor Blvd is likely to experience flooding during coastal storm flooding events. This would impair emergency and first responder access to the facility (Table 4).

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The extent and magnitude of these impacts would be much worse than mapped if the dredge operations which bypass sand around Ventura Harbor and maintain the fronting beach and protective dunes were reduced or ceased. A 100 year wave erosion event could remove up to 125 feet of the protective dunes and leave the site vulnerable to subsequent storm events.

Figure 11. Combined coastal hazards by 2060 for all sea level rise scenarios

VULNERABILITIES WITH UP TO 58.1 INCHES OF SEA LEVEL RISE (2100 +/-)

By 2100, the sea level rise is projected to increase between 17.1 and 58.1 inches. Figure 12 shows the combined hazards of coastal erosion, coastal flooding and wave impacts at 2100. By 2100 the entire Mandalay Beach Generating Station site is exposed to coastal process hazards (Table 3).

Under the year 2100 high sea level rise scenario (58.1 inches), Harbor Boulevard is projected to experience flooding during coastal storm events. By 2100, both the access road and Harbor Boulevard would have impaired access that would impact emergency and first responder access to the facility (Figure 12, Table 4).

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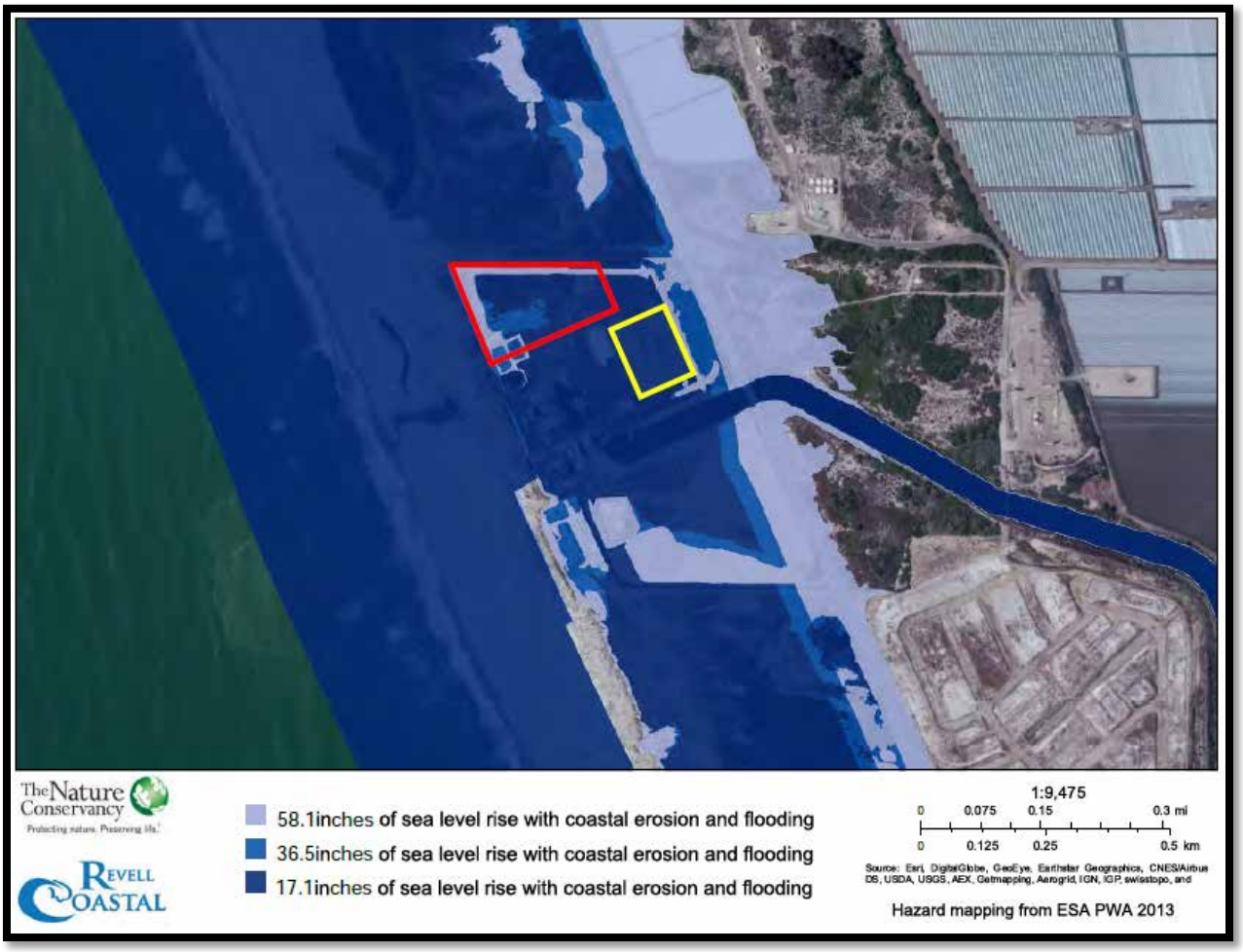
The extent and magnitude of these impacts would be much worse than mapped if the dredge operations which bypass sand around Ventura Harbor and maintain the fronting beach and protective dunes were reduced or ceased. A 100 year wave erosion event could remove up to 125 feet of the protective dunes and leave the site vulnerable to subsequent storm events.

Figure 12. Combined coastal hazards by 2100 for all sea level rise scenarios



SUMMARY OF VULNERABILITIES: PROPOSED MANDALAY BEACH GENERATING STATION EXPANSION

Table 4 summarizes the timing of the exposure to various coastal process hazards at furure time horizons. All of the coastal process hazards except for monthly tidal inundation currently threaten portions of the facility. Over time the extent and magnitude of the exposure increases which would increase the likelihood of damages to the facility interrupting energy supply and impacting the environment.

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Table 3. Timing of Exposure to Coastal Hazards for the Proposed Mandalay Generating Station Expansion

Coastal Process Hazards	Existing conditions	2030	2060	2100
Coastal erosion	-*	-*	-*	-*
Coastal storm flooding	H	H,M	H,M,L	H,M,L
Tidal inundation	-	-	-	-
Wave impact	H	H,M	H,M,L	H,M,L

(H = High sea level rise scenario, M = Medium sea level rise scenario, L = Low sea level rise scenario)
*based on assumption that current dredge practices continue

Table 4 shows the timing of potential impacts of the coastal process hazards impairing emergency and other access to the facility.

Table 4. Timing of impacts on emergency access to the proposed Mandalay Generating Station

Coastal Process Hazards	Existing conditions	2030	2060	2100
Coastal erosion	-	-	-	-
Coastal storm flooding	-	-	H	M,H
Tidal inundation	-	-	-	-
Wave impact	-	-	H	H

(H = High sea level rise scenario, M = Medium sea level rise scenario, L = Low sea level rise scenario)

6.0 SUMMARY

- Any future development should consider the existing climate change modeling information and complete additional engineering level vulnerability analysis as necessary to be consistent with the California policies for incorporating climate change into coastal permitting.
- A large storm wave erosion event is capable of removing 125 feet of dunes.
- Currently the entire site is mapped in the 500 year Coastal Flood Hazard zone by FEMA.
- By 2030, portions of the site are exposed to additional coastal storm flooding including portions of the proposed facility expansion.

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- Model projections show that by 2060 the entire proposed expansion site may be affected by coastal flood hazards during storm events. By 2100, the entire proposed site would likely be further impacted by additional frequency of storms and depths of flooding.

- By 2060, the access road to the facility for emergency response begins to be affected. By 2100 not only the access road to the site, but also Harbor Blvd is subject to coastal flooding that could impair access and emergency response to the site during storm events.

- It is recommended that future development avoid future hazards to minimize the likelihood of impacts to the facility and the related impacts to energy supply and the environment.

- The beach and dunes in front of the proposed Mandalay Generating Station expansion require continuation of the harbor dredge/sand bypassing to maintain the existing widths and dune crest elevations. If the dredging ceases, the beaches should be expected to narrow and dunes reduce in height similar to the immediate post construction of the Ventura Harbor, which would magnify the possibility of coastal hazards impacting the expansion site.

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Appendix A

Mandalay Generation Station

Coastal Hazard Vulnerabilities

REVELL COASTAL

Surf. Sand. Sustainability

Mandalay Existing Wave Impact Hazards

The Nature Conservancy
Protecting nature. Preserving life.

Revell Coastal

Wave Conditions:
25 feet at 22 seconds from 279 degrees

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

Hazard mapping from ESA PWA 2013

Mandalay Existing Coastal Flooding

The Nature Conservancy
Protecting nature. Preserving life.

Revell Coastal

Wave Conditions:
25 feet at 22 seconds from 279 degrees

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

Hazard mapping from ESA PWA 2013

Mandalay Combined Hazards 2030

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REVELL COASTAL

- 8.0inches of sea level rise with coastal erosion and flooding
- 5.2inches of sea level rise with coastal erosion and flooding
- 2.3inches of sea level rise with coastal erosion and flooding

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

Hazard mapping from ESA PWA 2013

Mandalay Combined Hazards 2060

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Revell Coastal

25.3inches of sea level rise with coastal erosion and flooding

16.1inches of sea level rise with coastal erosion and flooding

7.4inches of sea level rise with coastal erosion and flooding

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

Hazard mapping from ESA PWA 2013

Mandalay Combined Hazards 2100

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Revell Coastal

58.1inches of sea level rise with coastal erosion and flooding

36.5inches of sea level rise with coastal erosion and flooding

17.1inches of sea level rise with coastal erosion and flooding

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

Hazard mapping from ESA PWA 2013

Mandalay Coastal Flooding 2030 High SLR

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Flood Inundation (large storm)__2030__High

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

REVELL COASTAL

Hazard mapping from ESA PWA 2013

Mandalay Coastal Flooding 2060 High SLR

The Nature Conservancy
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Revell Coastal

Flood Inundation (large storm)__2060__High

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

Hazard mapping from ESA PWA 2013

Mandalay Coastal Flooding 2100 High SLR

The Nature Conservancy
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Flood Inundation (large storm)__2100__High

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

REVELL COASTAL

Hazard mapping from ESA PWA 2013

Mandalay Wave Impacts 2030 High SLR

The Nature Conservancy
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Revell Coastal

Wave Conditions:
25 feet at 22 seconds from 279 degrees
Sea Level Rise - 8 inches

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

Hazard mapping from ESA PWA 2013

Mandalay Wave Impacts 2060 High SLR

The Nature Conservancy
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Revell Coastal

Wave Conditions:
25 feet at 22 seconds from 279 degrees
Sea Level Rise - 25.3 inches

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

Hazard mapping from ESA PWA 2013

Mandalay Wave Impacts 2100 High SLR

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Revell Coastal

Wave Conditions:
25 feet at 22 seconds from 279 degrees
Sea Level Rise - 58.1 inches

1:9,475

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and

Hazard mapping from ESA PWA 2013