Climate Change-Sea L#CE864D.doc
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Flood Control Districts provide flood protection services to the communities within their service area. Most Flood Control Districts or similar agencies providing flood protection are organized at the county level. Flood Control Districts distinguish between regional drainage and local drainage. Regional drainage facilities are often planned, designed, built and maintained by Flood Control Districts. These would include the "backbone" main channel improvements in urbanized areas and often include the lower reaches of creeks, streams and rivers as they enter into the Bay. Local drainage facilities are at a neighborhood or community scale that direct flows from neighborhoods into regional drainage facilities maintained by a Flood Control District.

As we look forward to the impacts of climate change and sea level rise on the low lying communities that we provide flood protection services, there are many issues that will manifest themselves. It is thought that climate change will result in warmer storms which will produce a reduced snow pack and higher spring runoff volumes. It is also thought that storm rainfall intensities will increase as the ocean water temperatures rise, resulting in more flash flooding especially in urbanized areas. With the advent of increased temperatures and expansion of sea water and melting of glacial ice, sea levels will also rise.

The impacts that Flood Control Districts will face are described below. Although these impacts of climate change and sea level rise are discussed separately, they are all intertwined.

Impacts Travel Upstream

The impacts of sea level rise are not confined to the Bay shoreline with future waves lapping further and further inland. The impacts of sea level rise will also travel up the lower reach of every stream, creek and river that drains into the Bay. Most communities along the Bay also have a creek flowing through them. Water in the tidally-influenced portion of creeks will become higher in elevation similar to the rising waters in the Bay. The influence of sea level rise will extend further up the creek to the new head of tide. During storm events, the higher bay water levels will result in increased flooding as the flow capacity of our creeks is reduced. Although restricted to the lower reaches of creeks, sea level rise will have a big impact on communities located on these lower channel reaches.

Local Drainage Backwater Flooding

With increased intensity in storms, there will be an increase in local flooding. Local drainage in low areas typically travels along ditches or pipes to a culvert draining into a regional drainage facility with a "flap gate". Flap gates are a backflow prevention device. They are installed at the end of pipes in channels that drain properties lower in elevation than the channel flood waters to prevent the flood waters from the channel flowing back to the lower properties. These flap gates will be closed for a longer period of time due to

the increased flows in the regional facility. This will result in a larger ponding and backup of water into the local drainage facilities and flooding onto property and structures. In the community of Pinole for example, the local drainage from the lower Tennent Avenue neighborhood drains into Pinole Creek through culverts controlled by flap gates. With an estimated increase in sea level rise of 10-17 inches by 2050, the water surface elevation in the channel at this location will also rise by the same amount as it is close to the creek mouth. (See Note 1)

Regional Drainage Channel Flooding

With increased intensity of storms, the watersheds draining into regional drainage facilities will produce higher runoff flows. In addition, sea level rise at the mouth of the regional drainage facilities will result in a higher starting water surface. This will impact the capacity of the regional facility up to the new head of tide. This combination of increased flows and higher starting water surface will result in more levees and flood walls along the lower reaches of regional drainage facilities. Pinole Creek flood control channel in the community of Pinole and Hercules was recently restored in the lower reaches to increase habitat value and flood capacity. Flood walls were added to provide the necessary capacity to meet the Corps requirements to contain the design flow. An additional increase of 10–17 inches by 2050 or 31-69 inches by 2100 would require a commensurate increase in flood wall height, making the surrounding community further below the top of the flood wall. For example, at Orleans Drive in Pinole the road is currently 4.5 feet below the recently installed flood wall.

Changing Hydrology

Our current design requirements and tools, such as isohyets, are based upon 40 to 80 years of past rainfall data. As the impacts of climate change manifests themselves at a more accelerated rate than any changes in the past, our design criteria and tools will have to be adjusted. We have experienced 7 inches of sea level rise during the past century yet we expect a 10-17 inch rise in the next 40 years. If we use sea level rise as an indicator of the rate of change of Climate Change, then we won't be able to look to the past to predict the future as we have done up till now. Over time our isohyets will become more and more obsolete. More intense storms will produce a higher volume runoff in our paved urbanized areas. Higher intensity storms producing higher peak flows may increase erosion potential throughout our watersheds. Regional flood control channels tend to recover between high flow events with sediment filling in scoured banks and washed out vegetation re-establishing itself. Increased high flow events in a channel would not allow for that historic recovery time and could result in more in-channel erosion. This would require additional armoring or other means to prevent the erosion. This would also have impacts on the environmental and habitat quality of the channel. The dynamic equilibrium of our channels will be changing as climate change progresses. Additional resources will be required for data collection and analysis to predict flash flooding and develop flood protection strategies that protect habitat while protecting the

public. An example is the need to fill in the rainfall radar coverage gap in the North Bay through the addition of an additional radar station as proposed by the National Weather Service in cooperation with BAFPAA. This real time data could be used by Flood Control Agencies to improve the real-time flash flood forecasting system for local communities to predict flooding and protect the public.

Changing hydrology also may have two additional impacts on flood control systems:

Increased Landslides. The higher intensity of local storms (well documented in the 1982 storm event) also leads to increased landslides and sediment erosion into the lower gradient flood control channels. These large scale "episodic" events have overwhelmed channel capacities in the past and resulted in large scale damage and maintenance costs. Most of the hills around the Bay are geologically young features and are geomorphically very active due to uplift and erosional and tectonic activity (i.e. faults). This results in high erosion rates in some areas that may be increased under Climate Change conditions.

Increased Wildfire Erosion. The predictions of future hydrology also indicate more dry periods with a higher risk of wildfires due to early grass growth and die-off. More wildfires will result in more erosion and a much higher inflow of fine-grained sediments that clog up channels and gravel beds important to fish), reduce hydraulic capacity and increase dredging and maintenance costs.

Increased Pumping and Maintenance Costs

The communities fronting along creeks and rivers adjacent to the shoreline will drop deeper and deeper below levees and flood walls that are growing in height. Local drainage will pond higher requiring new pumping systems to be installed and existing pumping systems to pump waters over a longer duration for a given storm season. All of these new pumps and longer pumping cycles of existing pumps will result in higher maintenance and energy costs, and result in impacts to the local economy. In addition, much of the materials used in standard piping and pumping systems are not designed for Bay salinity conditions (costs for salt-water resistant types of materials are much higher), therefore, infrastructure maintenance and replacement costs may be much higher in the future.

Higher and More Saline Ground Water Levels

Ground water levels will rise up to the new head of tide and the impacted area of the modified ground water flow-net as sea levels rise. This will lead to higher water levels in basements for residents living in lower elevations adjacent to the Bay. If ground water becomes high enough and is above the flow line of drainage ditches, then additional pumping will be required to maintain localized drainage in the dry season. These communities along creeks and rivers adjacent to the Bay shoreline will become more and more like a Delta island. For communities on septic systems, higher ground water levels may also reduce the effectiveness of septic leach fields and may result in biological health impacts from sewage overflows into local drainage facilities.

Salt water will be migrating upstream, which will create corrosion problems for infrastructure. The service life for reinforced concrete flood control structures is about 75 years. Service life can be shortened by environmental factors on the structure like excessive bed load (gravel) in the stormwater, freeze/thaw cycles and presence of salt water. This also impacts piping materials for drainage facilities.

Higher Likelihood for Catastrophic Events and Failures

As levees become higher and floodwalls are raised to accommodate the impacts of climate change and sea level rise, adjacent communities will become lower and lower below the tops of the flood protection infrastructure. What would be a modest disaster event for a community today if infrastructure is overwhelmed would be a catastrophic disaster event in the future when infrastructure is overwhelmed. This is similar to a subsiding Delta island with its land and structures becoming lower and lower below the water surface and flood protection infrastructure over time.

Legacy Pollutant Migration

There are many legacy industrial chemicals in the soils near the shoreline and creeks that circle the bay as a result of historic industrial uses. Increasing heights of ground water can mobilize more pollutants over time as the head of tide marches inland.

Compounding Impacts

There are several other ongoing changes to our hydrology and hydraulics in flood control channels that will compound the impacts of climate change and sea level rise. These impacts included storm surge from drainage of the San Joaquin/Sacramento River basins, atmospheric rivers in the weather patterns, low air pressure areas during storm events that raise water surface elevations, and the Army Corps of Engineers tendency when designing flood control channels in the past of assuming a channel invert elevation that was not sustainable under local water and sediment conditions at the channel mouth.

Increased storm surge from the Delta due to warmer storms will result in a higher water surface in the Carquinez Straits and San Pablo Bay during flood stage backing up water in the creeks and reducing flood capacity at the channel mouth. Atmospheric rivers is a recently discovered phenomenon that explains the “pineapple express” type storms that tend to bring the wettest and most deadly and costly flooding events into the Bay Area. If these become more commonplace with increased sea water temperatures and other results of climate change, our hydrology will be changed dramatically. Low air pressure during a storm event can also raise water surface elevations similar to a tide at certain locations impeding the drainage of watersheds. The Army Corps of Engineers historically built some flood control channels at the outlet that did not consider local sedimentation patterns and were often lower in elevation than the outboard bay ground elevation and would therefore require constant dredging to maintain the lowered flow line. This allowed the channel to have a steeper grade at the outlet resulting in reduced channel

width and cheaper right of way costs. Today, however, it is virtually impossible to get permits to dredge these lowered Corps channels. Flood Control Districts today often must modify their channel outlets to accommodate an "elevated" flow line which approximates the original flow line. For example, the Pinole Creek flood control channel in the cities of Pinole and Hercules was recently restored with a flow line at a dynamic stable equilibrium that is two feet higher than the original Crops design. The channel floodplains were widened to the maximum width possible to provide the necessary capacity to pass the design flow, but now leaves us less flexibility to address sea level rise in the future. In addition, outdated Corps Operations and Maintenance manual requirements to contain flood flows within the active channel rather than being able to access the floodplain result in floodwall designs that may lead to catastrophic failures as discussed above.

Increased System Maintenance Costs

Levees along the creek channels in the lower reaches will have to be increased in height or flood walls constructed. These will increase maintenance costs for the flood protection system. There always seems to be community support to fund system improvements, such as for sea level rise, but rarely is the attendant ongoing maintenance costs included. Flood control districts are also concerned about being saddled with the maintenance of a community's sea walls along the shoreline because they are similar to the community's flood protection facilities along the creek. Wind-wave energy increases as a non-linear function of water depth, and increased Bay water levels will result in much higher erosional forces on sea walls due to this increased wave power along our shoreline. This will result in increased costs and need for right of way to build structures to combat wind-wave erosion. This would also be a new operational concern for flood control districts.

Opportunity for New Community Design

Low-lying communities need to understand and acknowledge the full impacts of sea level rise on their community. This is also an opportunity to redesign the community to accommodate sea level rise and provide the width needed in the flood control channels for adequate flood capacity and habitat value.

Notes

The estimates for sea level rise are taken from the California Climate Change Handbook which is based on work by the California Ocean Protection Council.

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A Flood Control District Perspective
Bay Area Flood Protection Agencies Association
January 2013

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