

4.0 HYDROLOGY AND HYDRODYNAMICS

4.1 BACKGROUND AND SETTING

“Hydrology” is a term that means “the study of water.” Water is perhaps the central element that unites the ecology of Humboldt Bay, its watershed, and the nearshore Pacific Ocean. A thorough characterization of the hydrological relationships affecting Humboldt Bay is beyond the scope of this EIR; moreover, a thorough characterization of the Bay region’s hydrology is not currently possible. The Draft Plan summarizes the general setting as follows:

As a whole, Humboldt Bay is approximately 14 miles (22.7 km) long, with a width between about 0.5 mile (0.8 km) in Entrance Bay and about 4.3 miles (6.9 km) across the widest part of Arcata Bay. The water surface area at low tide is about 7000 acres (2750 ha), or about 10.9 square miles (28 square km); the water surface area at high tide, when all of the tidelands subject to District jurisdiction are flooded, is about 15,600 acres (6140 ha), or about 24.4 square miles (62.4 square km).¹

The Bay, under current conditions, essentially represents two shallow, broad tidal flat expanses at the ends of a deeper but smaller embayment, with the tidal flat expanses being of different sizes. The tidal flats are drained by tidal channels, which are shallow at their upper ends but deepen substantially as they enter the inner embayment. Tidewater enters and leaves the Bay through a narrow inlet located at the southern end of the smaller embayment, yielding variations in flood and ebb patterns that cause the two shallow arms to differ from one another in some ways.

The Bay occurs in a small coastal watershed, which is only about 223 square miles (570.9 square km) in area. A small number of significant streams enter the Bay, including (from north to south) Jacoby Creek, Freshwater/Ryan Creek, Elk River, and Salmon Creek; a number of smaller streams also enter the Bay. On the whole, the freshwater inflow to the Bay is hydrologically dominated by the tidal exchange with the Pacific Ocean, and the Bay has been generally characterized as a “marine embayment” for much of the year (see subsection 4.3 below). However, there is sufficient freshwater inflow and terrestrial ecosystem inputs to the Bay’s aquatic environment, even during the summer, that ecological conditions within Humboldt Bay differ from conditions in the adjacent Pacific Ocean.

The following subsections summarize selected hydrological elements and relationships that are germane for characterizing potential hydrological effects resulting from the Draft Plan’s implementation.

¹ The physical data describing Humboldt Bay included in this Plan are generally agreed upon as approximations; specific descriptive data describing Humboldt Bay differ among the existing background studies for the Bay. For the purposes of this Plan, the differences in specific data values do not represent significant variations in the physical characteristics of Humboldt Bay.

4.1.1 Watershed Hydrology and the Relationship Between the Bay and its Watershed

Water moves from the land surface to the atmosphere or into the ground, then back to the surface again, including passage through organisms and flow in surface watercourses or through a porous soil; these water movements are part of the *hydrological cycle*. The volume and rate at which water drains from a given land area depends on a number of factors, including the rainfall potentially occurring at the site, the land slope, the degree to which the flows will infiltrate into the ground, and the characteristics of the channels through which the water flows. Some of these factors are influenced, in turn, by the kind and intensity of land use in the area. In addition, hydrological changes resulting from development and other human land uses are associated with changes in water quality (see Chapter 6.0).

It is not possible to summarize the science of hydrology in a few paragraphs; interested readers should consult one or more of the various texts available (e.g., Dunne and Leopold 1978, Maidment 1993). As a general statement about the relationships among basin hydrology and a variety of environmental resources of concern for the Humboldt Bay Management Plan, readers should consider that Humboldt Bay is the “receiving water” for any drop of rain that falls within the basin made up of all the surface watercourses that end at the bay’s margin.² Through ecological and geological time the bay’s watershed has “adjusted” itself to the long-term physical and biological dynamics of rainfall, erosion, vegetation, fire, and other changes (including pre-European human-induced changes) in the watershed. It is simply not possible to describe with precision or a high level of certainty the pre-European hydrological conditions of the bay’s watershed, even by analogy to currently less-developed regions on the Pacific Coast (since the hydrological relationships of currently undeveloped regions are unlikely to duplicate the pre-settlement relationships in the Humboldt Bay region).

The current hydrological context of the Humboldt Bay watershed is generally that of a landscape that has been subjected to human alteration over virtually 100 percent of its surface during the past 150 years. Some of the land use changes have had relatively minor long-term hydrological effects (e.g., replacing old-growth forests with younger forests); other land use changes clearly have been associated with substantial changes in runoff characteristics and in the resulting basin hydrology. The most

² Humboldt Bay is also the “receiving water” for substantial volumes of water diverted from the Mad River by the Humboldt Bay Municipal Water District, which is delivered by that district to municipal water supply agencies serving most of the developed areas in the bay’s basin. The vast majority of this imported water is ultimately discharged to the bay by the publicly-owned treatment works (POTWs) of the cities of Eureka or Arcata, although some of the imported water reaches the bay as overland or subsurface flow after being used for landscape irrigation and other purposes in the developed areas. The POTW effluent has a potential for affecting water quality (see Chapter 6.0), and a potential for altering the ecological processes in Humboldt Bay as a consequence of altered salinity. However, the potential effects of the POTW effluent is beyond the scope of this EIR except in a very indirect sense (the District has no direct, and very little indirect, authority to regulate these POTWs), and this topic is not addressed in the EIR.

significant changes resulted from the type of land use generally called “urbanization.” As summarized in the Draft Plan (page 88):

A variety of research sources (e.g., Pitt 1995) have documented the hydrological and water quality effects of the kind of land development generally recognized as “urbanization” on receiving waters, including estuaries such as Humboldt Bay. Hydrologically, runoff patterns associated with developed areas show shifts toward greater storm peaks and shorter delivery periods, usually associated with reduced summertime base flows. The water quality effects of development usually include significant delivery of a large variety of pollutants to the receiving waters, including sediment, various metals, transportation-related hydrocarbons, fertilizers and growth stimulators hormones, biocidal chemicals, and various organic materials that increase demand for oxygen in the receiving waters.

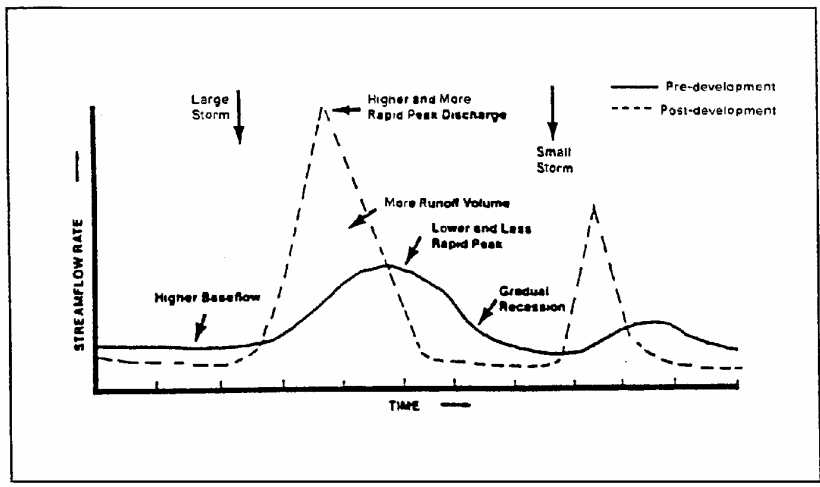
The potential water quality effects of this change are summarized briefly below and considered in more detail in Chapter 6.0. The hydrological changes resulting from development also have a direct effect on ecological systems.

4.1.1.1 Runoff Intensification and Related Effects

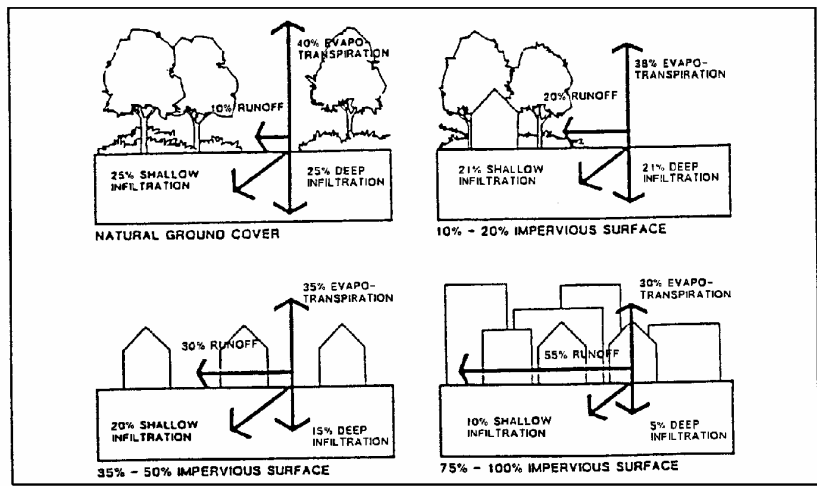
Subsection 4.3.2, in Chapter 4.0 of Section II of the Draft Plan, summarizes several important factors in understanding changes in the Humboldt Bay watershed’s hydrology as a consequence of “intensified” land use. The changes are all derived from a related intensification in the runoff of incident rainfall and the resulting surface runoff into the bay or watercourses tributary to the bay.

Development and other land use changes in the watershed have both changed the runoff patterns and altered the quality of the runoff that reaches the Bay. Many authors have addressed this subject (see, for example, Dunne and Leopold 1978, Pitt 1995, Rhoads 1995, and USEPA 1993). In general, development has well-known effects on the hydrology of small stream basins (EIR Figure 4-1).

The upper panel in EIR Figure 4-1 summarizes the basic hydrological relationship between a rainfall event and the runoff from that event in watercourses draining the affected area. After a rainfall event begins there is typically a delay in increased streamflow, caused by the arrival of runoff at surface watercourses only after it flows across some length of the watershed’s surface. Natural ground cover retards overland flow compared with runoff rates in areas that have been paved or otherwise developed (see below). When the surface (or subsurface) flow reaches the stream course, the stream’s discharge (the volume of water passing a particular point in a fixed time interval) increases to a peak flow that depends on the intensity of the storm event, the size and steepness of the basin, and the runoff characteristics of the basin. Storm events usually have only a limited amount of rainfall, and runoff events therefore also have a limit to the elevated discharge and the time of increased runoff (of course, the arrival of another storm during the period of increased runoff could result in additional runoff added on top of an already-elevated discharge). Additional information may be obtained from many hydrology textbooks (e.g., Dunne and Leopold 1978, particularly chapter 9).



Changes in stream hydrology as a result of urbanization (Schueler, 1992).



Changes in runoff flow resulting from increased impervious area (NC Dept. of Nat. Res. and Community Dev., in Livingston and McCarron, 1992).

EIR Figure 4-1. Effects of Site Development on Hydrology.
 Increasing impervious surface decreases infiltration, increases total runoff, increases peak discharge, reduces time-of-concentration, and decreases base flow. (Source: USEPA 1993)

The hydrological alterations that result from development and other land uses changes are modulated in most basins by *impervious surfaces*, a term that refers to concrete, asphalt, wood, and other surfaces that prevent rainfall from contacting and infiltrating soil.

Increased impervious surfaces in the Humboldt Bay basin are presumed to have created the kinds of adverse aquatic ecosystem effects that are summarized in EIR Table 4-1 (see USEPA 1993 for a more complete explanation of these relationships).

EIR Table 4-1. Effects of Intensified Runoff Resulting from Development on Aquatic Ecosystem Elements.

Effect	Description
Increased Peak Flows	A primary effect of development on the localized runoff hydrology within a localized stream basin is a marked increase in peak stream flow resulting from a given storm event. Increased peak flows are associated with an increased likelihood for out-of-channel flows (i.e., flooding, with both biological and economic implications) and an increased likelihood that stream channel and/or basin morphology will be altered.
Reduced Time-of-Concentration	Development creates increased peak flows by accelerating the delivery of runoff to stream channels. The increased peak flow and reduced time-of-concentration are associated with: (i) increased velocities, causing the loss of instream refuges for fish and invertebrates; (ii) changed substrate sizes and composition, favoring coarser materials because the increased flows remove finer materials, resulting in bed armoring; (iii) lost pools because finer, more mobile sediment materials increase in abundance; and (iv) increased likelihood of channel and streambank erosion, bank failure, and loss of riparian vegetation.
Increased Total Runoff	Development in small drainage basins changes the distribution of incident rainfall between runoff and infiltration. Development causes an increase in the fraction of a given rainfall event that runs off the land surface. The primary cause of this increase in runoff from a given storm event is the increased <i>impervious surface</i> (pavement for streets, sidewalks, and driveways; roofs; and similar impenetrable surfaces) resulting from development.
Reduced Infiltration	The increased fraction of a given rainfall event that leaves a developed catchment is equal to less infiltration into the soil. The primary cause of the reduced infiltration is the impervious surface resulting from development. An additional reason for the increased runoff and reduced infiltration is the development of drainage systems that shorten the distance the runoff must travel, smooth the surfaces over which it flows, accelerate the delivery of rainfall/runoff to natural watercourses, and preclude contact with permeable soil materials.
Increased Stream Power	Stream power refers to the ability of flowing water to move sediment and produce changes in the stream's channel. Stream power increases are directly related to the percentages of tributary watersheds covered by impervious surfaces. The potential for the runoff to change the stream channel is disproportionately concentrated in discharges that recur on average about once every two years in most stream basins (Dunne and Leopold 1978); storms with this recurrence interval have a disproportionate ability to modify channels in the Humboldt Bay basin (Rhoads 1995).
Reduced Base Flow	The greatest ecological effect of development on basin hydrology is reduced base flow because of decreased infiltration. The total volume of rain falling within a stream basin will not change because of development. If more of the rainfall leaves the basin because the land is covered by

Effect	Description
	impervious surfaces, less water will infiltrate into the ground, and less groundwater will be available for discharge to the stream during the summer (<i>base flow</i>). Reduced base flow is associated with increased stream temperatures, reduced oxygen saturation, and a decrease in the total volume of aquatic habitats in the basin.

The hydrological alterations summarized in EIR Table 4-1 are associated with changes in habitat availability and habitat quality in Pacific coastal watersheds for a variety of aquatic species, including salmonids that are listed pursuant to state and federal laws. Applied research in the Puget lowlands in Washington state has indicated that watershed-altering development may have significant effects on salmonids when as little as ten percent (10%) of a basin is under impervious surfaces (Cooper and others 1997, Johnson and Caldwell 1995).

The above Plan excerpt synthesizes the process by which “urbanization” alters basin hydrology. A variety of other land use practices (e.g., agriculture) also produce impervious surfaces, and thus contribute to the hydrological changes that lead to intensified runoff. As described further in EPA (1993),³ these hydrological alterations are the primary hydrological impact that urbanization creates in coastal watersheds.

4.1.1.2 Water Quality Effects

Subsection 4.3.3 of Chapter 4, Section II, Volume I, of the Draft HBMP, summarizes the effect of urbanization on water quality:

More significant water quality concerns arise as a consequence of surface runoff from the lands surrounding the Bay. Surface streams draining developed areas deliver a variety of toxic and nontoxic nonpoint source pollutants to Humboldt Bay (see Chapter 6.0).

The rapidity with which runoff is delivered to the bay is inversely related to the potential for adverse water quality impacts, because natural hydrological processes include filtration and sequestration of suspended materials, biological activities that can detoxify many harmful compounds and “digest” organic pollutants, and the trapping and removal of physical objects (e.g., trash). Intensified runoff resulting from urbanization reduces this potential self-cleaning process. In contrast, under pre-development conditions, the runoff delivered to Humboldt Bay from its watershed was likely to be essentially unimpaired (subsection 4.3.2, Chapter 4.0 of Section II of the Draft Plan):

The water quality in Humboldt Bay ... and the biota in the Bay are affected by runoff from the surrounding seasonal wetlands and the uplands in the basin. It is likely that under pre-settlement conditions rainfall in the basin was delivered to the Bay relatively slowly, and that the quality of the runoff when it reached the Bay was close to that of the rain itself.

³ This document is available online at URL: <http://www.epa.gov/owow/nps/MMGI/> (viewed January 2006), although the highly useful graphics are not included.

The above Plan excerpts indicate very generally the interrelationships that exist between hydrology and water quality, a subject that is covered, from a regulatory context, in Chapter 6.0.

4.1.2 Humboldt Bay Hydrodynamics and Surface Elevations

The surface elevation of the Pacific Ocean at any location along the western U.S. coastline is regularly modified by a host of factors, including atmospheric pressure, wave energy delivered from distant sources, the effects of wind moving water onto or off the coastline, El Niño – Southern Oscillation (ENSO) events, and tides.⁴ The effects of any of these agents on the ocean’s surface elevation may be significant, and in combination they may raise or depress the “average sea level” elevation at any particular location by several feet for short time periods. A detailed explanation of how these factors, separately and cumulatively, affect water surface elevation in the bay is largely beyond the necessary scope of this EIR; however, a basic consideration of water movements and surface elevations in the bay is required in order to address a number of factors affected by the Draft Management Plan.

4.1.2.1 Tidal Dynamics

The most significant of the factors listed above with respect to Humboldt Bay is the regular change in water surface elevation that is called “the tide” in everyday usage. The existence of tides is the result of gravitational attraction between the water on the earth’s surface and the mass of the moon (the mass of the sun has a similar, though weaker, effect on the ocean waters), combined with effects that result from the rotation of the planet. In the most direct sense, the gravitational attractions of the sun and moon combine when they are aligned with the earth (“new moons” and “full moons,” producing more extreme elevations for both high tides and low tides); when the moon is at a “right angle” to the axis connecting the earth and the sun (“quarter moons”) the surface elevations caused by tidal forces are reduced.

The regular changes in water surface elevation along the Pacific Coast that are charted in tidebooks as surface elevations are descriptions at specific coastal locations of a “wave” that rotates around the northern Pacific Ocean. The period of rotation of the wave is determined by planetary physics, a combination of the gravitational attraction noted in the previous paragraph with effects caused by planetary rotation. The period of the wave’s rotation around the Pacific Basin is slightly longer than one solar day, causing the timing of similar tidal stages to shift by about 50 minutes each day. Along the northern Pacific coast of North America the effects of these factors results in a “mixed semidiurnal tide,” as described in subsection 4.3.1, Chapter 4.0, Section II of the Draft Plan:

Tidal elevations in Humboldt Bay have been well documented as having a “mixed semidiurnal” pattern, with two daily high tides and two low tides; the averages of the two highs typically differ substantially, as do the averages of the two lows.⁵

4 See URL: <http://www.biosbcc.net/ocean/marinesci/02ocean/swmovement.htm> (viewed December 2005) for a brief overview of ocean water movements.

5 The District’s jurisdiction in Humboldt Bay is defined by the average elevation of the higher of the two high tides, known as “mean higher high water.”

Tidal elevations inside Humboldt Bay are complex. Consider the following example: the tidal “wave” passes the bay entrance, resulting in a locally higher water surface than inside the bay, and tidewater flows into the bay through the entrance. This flow continues so long as the water surface outside the bay is higher than the surface inside the bay; when the sea surface elevation is lower than the bay surface elevation, the flow reverses and water flows out of the bay.

Tidewater flows inside the bay are not instantaneous, so there is generally a lag between a given tidal stage at the entrance and a comparable stage at any location inside the bay, and the extent of the lag is proportional to the distance between the bay entrance and the site considered (for example, high tide at the Eureka Slough Bridge typically is delayed by about half an hour compared to the bay entrance, and the high tide at the north end of Arcata Bay is typically delayed by about three-quarters of an hour compared to the bay entrance; the times of low tides are similarly delayed compared to the times of those events at the bay entrance). Similarly, the surface elevations reached by tides inside the bay do not precisely correspond to the elevations at the entrance, and the tidal range is greater at the extremes of the bay compared to the range at the entrance (see Shapiro and Associates 1980 for a relatively thorough description).

The “theoretical” relationships among tidal circulation and many of the ecological resources in Humboldt Bay indicate that tidal circulation is an important process for managing the bay’s ecosystem. However, the extent of understanding about this dynamic relationship is limited. As summarized in the Draft Plan, subsection 4.3.1, Chapter 4.0, Section II:

The dynamics of tidewater flows have been evaluated by only a few studies in the past, and while there is general agreement about the pattern of tidewater movement (compare, e.g., Shapiro and Associates 1980 and Barnhart and others 1992), there are substantial uncertainties regarding the detailed patterns of tidewater movements that occur in Humboldt Bay.

In a general sense, flood (rising) tides enter the Bay and move through the larger channels and onto the tidal flats. However, the volume of the Bay is large enough that all of the water that is in Humboldt Bay at the peak of a high tide cannot leave the Bay or be replaced by “new” ocean water during a single tidal exchange. As a result, tidewater that is in the northern part of Arcata Bay (for example) may only reach the vicinity of the Highway 255 bridge on an ebb (falling) tide before the tide turns and a new flood tide begins. “New” seawater entering the Bay entrance at the beginning of a flood tide typically only reaches the part of Entrance Bay near the south end of Indian Island before the next ebb begins [see Shapiro and Associates (1980) and Barnhart and others (1992) for useful discussions of the Bay’s tidewater dynamics].

As a general rule, therefore, the Bay does not “turn over” with each tidal exchange; water from different parts of the Bay may remain inside the Bay for one or for a number of tidal cycles. Prior studies have suggested that Entrance Bay experiences a relatively rapid exchange of water with the Pacific Ocean, whereas achieving a nearly complete “turnover” of water in Arcata Bay may require as many as 15 tidal exchanges. There is some evidence

that water in both Arcata Bay and South Bay does not mix effectively with the more marine conditions in Entrance Bay, and that water present on the tidal flats may retreat to the deeper channels in Entrance Bay and then move back onto the tidal flats with rising tides.

A recent summary of tidewater dynamics inside Humboldt Bay concluded that they are not well characterized (Costa and Glatzel 2002). The hydrological relationships among the tributary streams and the bay itself are also not well characterized. The exchange of seawater between the bay and the Pacific Ocean has significant effects on a variety of biological and physical conditions within the bay. As noted in Chapter 8.0, a number of conditions that affect the bay's ecosystem elements vary significantly according to the degree of tidewater exchange between the bay and the ocean.

4.1.2.2 Other Factors Affecting Bay Water Surface Elevations

The effects of changes in sea-surface elevation, both short-term and long-term, constitute a concern for the bay's management. This reason for concern was illustrated by flooding that overtopped the levees along eastern margin of Arcata Bay during the New Year's Eve 2005/2006 storm. The specific causes of the extremely high water surface elevation apparently included a combination of high tidal water surface elevations, storm surge, and localized windward-shore water-surface elevation increase, although the relative contributions from various factors is unclear. Whatever the combination of causes, the surface elevation in Arcata Bay was high enough to overtop the railroad levee and partially inundate the southbound lanes of Highway 101. Erosion of the ballast material from beneath the rails locally has reduced the effective levee height by as much as a foot in some locations, potentially increasing the risk of future flooding because of increased tidal elevations.

The factors that affect water surface elevations in Humboldt Bay include the Pacific Ocean's "tidal wave" (as noted above), barometric pressure, and long-term and intermediate-term ocean dynamics. Tidal effects were largely covered in the previous subsection, but it is germane for the EIR that the astronomical relationship between the Northern Hemisphere and the sun and moon characteristically produce higher tidal elevations in the winter.

Barometric pressure is inversely related to water surface elevations; that is, lower barometric pressures are associated with higher surface elevations. Low barometric pressure is a feature associated with strong low-pressure centers, which usually occur in the centers of storms.⁶ The reduced atmospheric pressure allows the water to "bulge" under the center of low pressure, and the water surface elevation may be several feet higher than under the influence of the tide alone.

The surface elevation in the eastern Pacific Ocean may be influenced by dynamics that extend across most of the Pacific Basin. The Pacific Decadal Oscillation (PDO)⁷ and

⁶ The atmospheric pressure recorded by the NOAA weather station in Eureka on the morning of Saturday, 31 December 2005, was 29.15 inches of mercury, which is an atmospheric pressure that could be expected in a Category One hurricane in the Saffir-Simpson Scale. Wind velocities greater than 90 miles per hour were recorded near Humboldt Bay (see URL: <http://www.wrh.noaa.gov/eka/misc/windstorm.htm>; viewed January 2006); this wind speed would be consistent with a Category One hurricane.

⁷ See URL: <http://tao.atmos.washington.edu/pdo/> (viewed January 2006).

the El Niño – Southern Oscillation (ENSO)⁸ are cyclic processes that can result in increased sea level elevations (by centimeters or inches, as opposed to feet) along the California coast (for periods of months for ENSO events and periods of years for PDO events). A similar result can occur when strong storm winds blow across the northern Pacific Ocean, piling up water on the western edge of the continent, an effect that may persist for hours, days, or possibly even weeks.⁹

The Federal Emergency Management Agency uses these factors to calculate a “100-year” tidal flood elevation, shown (and mapped) as the Zone A for Humboldt Bay *per se*. Based on past events, FEMA (1986) concluded that tsunami run-up does not affect flood elevations inside the bay (however, see Chapter 3.0). The calculated 100-year “stillwater” (no waves) elevation in Humboldt Bay is 6.1 feet (NGVD; this “1929 sea-level datum” is several inches below current mean sea level). In other words, undiked areas lower than 6.1 feet in elevation, and adjacent to the bay or to tidal sloughs, should be flooded by tidewater at least once per century.

The water surface elevations within Humboldt Bay at the end of December 2005 were clearly significantly higher than 6.1 feet NGVD. Because all of the factors noted in this subsection occur essentially independently of one another, all of the factors could occur at one time, with a small but non-zero probability that water surface elevations would be increased. While it appears unlikely that ENSO or PDO dynamics were related to the December 31st events in Humboldt Bay, there is little reason to doubt that a combination of high tidewater elevation, extremely low atmospheric pressure and a resulting storm surge, and water accumulation on a windward coastline all contributed to a water surface elevation that overtopped existing levees in Arcata Bay. With respect to the purpose of this EIR, the relevant conclusion is, however, that similar events could be expected in other winters, at a small, unknown, but non-zero probability. With respect to managing the bay’s ecosystem and a variety of bay-related resources, this appears to be an important element in the Management Plan’s overall setting.

4.1.3 Sea Level Change and the Humboldt Bay Region

The elevation of the Pacific Ocean’s surface is not constant in geological terms. For example, the lowest elevation of sea level before the end of the Pleistocene Epoch (circa 11,000 years ago) was approximately 400 feet lower than sea level is at the present time, owing to the volume of water frozen into Pleistocene glacial ice. As the glaciers melted during the Holocene the ocean basins refilled and sea level rose. In addition, the removal of the ice burden caused the surface elevation of formerly glaciated land areas to “rebound” to higher elevations, which resulted in associated changes on land surface elevations elsewhere. These changes are still occurring. Sea level has been changing slowly for as long as detailed topographic data have been collected, and the changes in different locations are not always in the same directions or with the same magnitudes. Generally, sea level along the Pacific Coast of North America has been rising slowly for more than a century, although the rate of increase has been

8 See URL: <http://www.cdc.noaa.gov/ENSO/> (viewed January 2006).

9 Strong wind-generated waves within the bay could also add additional inches of surface elevation on the downwind shore, and this factor may have also been a contributor to the New Year’s Eve event.

geographically variable. The modes of change are complex; for example, much of the Oregon coastline has been rising at about the same rate as sea level has increased, and the “relative sea level” along the Oregon coast has not changed substantially in the past century.

The elevation of the ocean’s surface bears a direct relationship to two primary factors: (1) the volume of water in the oceans, and (2) a measure of the temperature of the oceans (Cayan et al. 2005;¹⁰ IPCC 2001;¹¹ Neumann et al. 2000;¹² Field et al. 1999). Both of these factors are related to the planet’s energy balance, reflecting energy gained through solar radiation and energy lost to space. Atmospheric characteristics, particularly the relative amounts of several minor atmospheric constituents, generally termed “greenhouse gases,” affect the planet’s energy balance. There is a general scientific consensus that the atmospheric changes that have occurred over the previous century have resulted in an increased atmospheric concentration of some of these greenhouse gases, and that the planet’s energy balance has shifted to favor an increased retention of solar energy. In consequence, the planet is warming.

The increased planetary heat content affects a variety of physical processes and variables (IPCC 2001; many other references). As the planet warms, two significant changes occur that are germane for the Humboldt Bay Management Plan and for this EIR. The warmer planet will decrease the volume of glacial ice, thus increasing the relative amount of water in the planet’s oceans, and the oceans will get warmer, increasing the volume of the water. The result of these changes will be an increase in relative sea level worldwide. The increases cannot be predicted precisely. The increase predicted by the IPCC (2001, page 9) may be summarized:

“Global mean sea level is projected to rise by 0.09 to 0.88 m between the years 1990 and 2100, ... but with significant regional variations. This rise is due primarily to thermal expansion of the oceans and melting of glaciers and ice caps. For the periods 1990 to 2025 and 1990 to 2050, the projected rises are 0.03 to 0.14 m and 0.05 to 0.32 m, respectively.” (Emphasis in original)

However, recent predictions made by scientists participating in the California Climate Change Center projection (Cayan et al. 2005, page 15) are higher:

“Sea level rise projected from the models increases in proportion to the amount of global warming. By the 2070–2099 period, sea level rise projections range from 13–62 cm (5.1–24.4 in) higher than the 2000 level for simulations following the lower (B1) (greenhouse gas) emissions scenario, from 18–76 cm (7.1–29.9 in) for the medium-high (A2) emission scenario, and from 21–89 cm (8.5–35.2 in) for the higher (A1fi) scenario. It is broadly acknowledged that over the next few centuries, global sea level will likely increase by a meter or more.”

The IPCC-projected sea level increase during the next half-century, ranging between about three inches at the low end and about 13 inches in U. S. units of length at the high end, reflects an anticipated increase in the average water surface elevation

10 See URL: <http://www.energy.ca.gov/2005publications/CEC-500-2005-202/CEC-500-2005-202-SD.PDF> (viewed February 2006).

11 See URL: <http://www.ipcc.ch/> (viewed December 2005).

12 See URL: <http://www.pewclimate.org/docUploads/env%5Fsealevel%2Epdf> (viewed December 2005).

globally, and the predictions may not reflect events in California well. The higher predictions made by the California Climate Change Center appear likely to reflect a more likely future condition. Assuming the moderate prediction summarized above, the average elevation of the oceans surface may be expected to increase by somewhere between 0.18 m and 0.76 m during the next century, although the increase may be less or may be greater.

Increased sea level may be associated with many variables of concern for the Management Plan, including the following:

- Tidal times in Humboldt Bay are not likely to be affected by the “base elevation” of sea level, but the actual water surface elevations reflected by such parameters as “mean low water,” “mean tide level,” and “mean higher high water” will all likely be increased.¹³
- Sediment dynamics in Humboldt Bay are physically linked to tidal dynamics (see Chapter 5.0), and an increased sea level will likely lead to an increase in the elevations of the tidal flats in the bay.
- The elevations at which marshlands occur within the bay are associated with tidal hydrology, and increased average water levels likely will inundate and eventually eliminate the existing marshlands external to the levees in the bay.
- The levees that separate the diked former tidelands around the bay’s margin were created with an expectation of tidal variations that did not include higher future elevations, and the likely consequence of higher tidal elevations will be that levees are too low to prevent overtopping by tides and/or tides in combination with storm effects at a significantly increased frequency.
- More frequent overtopping may adversely affect the agricultural lands and the biological values of the wetlands behind the levees (see Chapter 9.0).
- More frequent overtopping may adversely affect the levees (such as by accelerated wave erosion on the levee face, or erosion because of water flow on the reverse side), or may adversely affect buildings and other human uses located in or near the diked former tidelands.

As far as the EIR’s preparers have been able to determine, no specific assessments of the potential effects of such events have been prepared for the Humboldt Bay region. In the general context of potential changes that could result from sea level increases, the northwestern coast of the United States is considered not to be at great risk of damage because much of the coastline is cliff-backed. However, areas of the Pacific coast that present lowlands, such as San Francisco Bay and Humboldt Bay, have been identified as being at “high-risk” from increasing sea level (Cayan and others 2005, Thieler and Hammer-Klose 2000).

The most significant environmental concern that is associated with the projected sea level increase for the Humboldt Bay region is the potential that climatic and/or

¹³ The dynamics of tidewater are largely a function of astronomical relationships involving the earth and other celestial bodies, which will not be affected significantly by the planet’s average temperature. Therefore the dynamics of tidal water movements in the open Pacific basin are expected to be much the same as at present. The tidal dynamics will, however, be applied to a water surface elevation increased by 3 inches or more, to as much as 28 inches.

meteorological events such as those summarized in the previous section could occur in conjunction with an elevated sea level. The clear demonstration in December 2005 that localized water surfaces in Humboldt Bay resulting from storm-related factors may reach elevations sufficient to overtop levees and cause erosion of the levees, when considered in conjunction with a high potential for sea level increases of between three and 27 inches (with a potential for an increase of more than 36 inches), indicates a real potential for risk to the integrity of the bay-margin levee system, a potential for tidal flooding of low-lying areas near the bay, and a potential for damage to a variety of cultural improvements in the bay's watershed, including highways, homes, businesses, and utilities.

4.1.4 Water Supply

Virtually all of the water provided by public agencies within the Humboldt Bay region is supplied in the ultimate sense by the Humboldt Bay Municipal Water District (HBMWD). As the Water District's website proclaims:¹⁴

"HBMWD is a wholesale water agency that serves the greater Humboldt Bay area - including the cities of Eureka, Arcata and Blue Lake, as well as Community Service Districts serving unincorporated areas such as McKinleyville, Cutten, Fairhaven, Fieldbrook and Manila. The population served via these agencies totals about 65,000 people. HBMWD's service area contains a large variety of business and industry; College of the Redwoods, a two year community college; and, Humboldt State University, a campus of the California State University System nationally-renowned for its Natural Resources, Science, and other Graduate and Undergraduate curricula."

The Water District generally does not purvey water directly to ultimate consumers (except for water supplied to the pulp mill on the Samoa Peninsula). Water is generally purchased by municipal agencies throughout the area and then sold to customers. The source of all water provided by HBMWD, and thus the source of most of the water consumed for domestic, industrial, commercial, and firefighting purposes in the Humboldt Bay region, is a set of Ranney collectors in the Mad River upstream from the Highway 299 bridges.¹⁵ The water produced by this process is classified for regulatory purposes as "groundwater," although the system was designed and still functions as a direct hydraulic connection with the underflow of the Mad River, which is somewhat closely linked to the river basin's surface water hydrology (see Winter et al. 1998).

The primary exception to the summary above is the Humboldt Community Services District (HCSO). The HCSO, which provides water services for residents of Humboldt County areas immediately adjacent to the eastern and southern parts of the City of Eureka, receives approximately one-third of the water for its customers directly from HBMWD through the City's Mad River Water Pipeline. The source of approximately an additional third of the HCSO supply is an existing water pipeline that is routed down the Samoa Peninsula and under Humboldt Bay. The final third of the HCSO water

14 See URL: <http://www.hbmwd.com/> (viewed December 2005).

15 The Ranney collectors operate as part of the water district's storage and diversion system. The public water supply is captured, as rainfall and surface runoff, and stored in Ruth Lake, behind Matthews Dam, in Trinity County. The stored water is released to flow down the Mad River, where it is diverted by the Ranney collectors west of Blue Lake.

supply is, at the present time, a set of District-owned wells in the Humboldt Hill region south of Eureka.

The City of Arcata also uses groundwater as a part of its domestic water supply, having a single well adjacent to Heindon Road in the northern part of the City that directly taps the Mad River groundwater aquifer some distance from the river itself.

In addition to the above municipal uses, many individual homesites in rural parts of the Humboldt Bay region utilize groundwater as a primary water supply. Many of the individual wells throughout the lower parts of the region have experienced problems with inadequate water supply or with poor water quality. Virtually none of the residential or commercial consumers within the limits of any of the municipal agencies that provide water use groundwater, owing to municipal concerns about contamination of the municipal supplies from cross-coupled systems.

Groundwater resources in the Humboldt Bay region are part of the “Eureka Plain Hydrological Unit,” and were described by Evenson (1959).¹⁶ The groundwater resources of the unit may be capable of supporting additional domestic and possibly additional municipal uses, and both the HCSD and the City of Arcata have indicated interest in additional groundwater use. Because of the poor water quality and/or the limited water supply in lowland areas around Humboldt Bay, the general trend is toward fewer individual wells and more use of public water systems.

4.2 ISSUES TO BE ADDRESSED AND THRESHOLDS OF SIGNIFICANCE

The Initial Study process identified potential hydrological impacts (see Appendix A) related to flooding-related concerns covered in Section VIII, including the following: item VIII (c), which addresses a potential alteration of drainage patterns that could result in erosion or sedimentation; item VIII (h), addressing the placement of structures within a “100-year flood hazard area,” a context that includes the waters of Humboldt Bay; and item VIII (i), which addresses risks to people or property because of flooding.

Comments received in response to the Notice of Preparation indicated that some commenters believed that the Draft Plan could affect water supply, primarily by interfering with groundwater recharge (Environmental Checklist item VIII (b)). Additional comments indicated that concerns existed regarding the Plan’s policies and the generation of additional stormwater runoff that would exceed the capability of existing drainage systems (item VIII (e)). Some commenters also stated a conclusion that the Draft HBMP represented a commitment to intensifying land uses that could be associated with increasing runoff, resulting in indirect drainage and water quality impacts that should be addressed in the EIR; “land use” is considered in Chapter 12.0; and the EIR finds that there is no evidence to support a conclusion that the District’s implementation of the Plan would lead to changes in land use near Humboldt Bay. One commenter specifically asked that the EIR evaluate the potential effect of the Management Plan on the maintenance of tidegates and drainage control structures in the bay-margin levees.

¹⁶ See URL: <http://ca.water.usgs.gov/groundwater/gwatlas/coastal/aquifers1.html> (viewed December 2005).

As noted throughout this EIR, thresholds of significance for these concerns in a programmatic environmental document crafted for a management plan are not easily drawn. This EIR adopts the “threshold of significance” convention throughout the EIR that the potential environmental effect of the plan would be significant if the proposed policies in the plan increase the potential for occurrence of a possible environmental effect (impact) beyond the degree that would exist if the policies recommended in the plan were not carried out. The assessment of the effect of the plan for each particular issue requires a judgement regarding the likelihood that the plan will lead to actions that will create or exacerbate adverse conditions that would not occur without the plan. If a reasonable argument is possible that the Plan’s policies would exacerbate a possible adverse condition, or create a new adverse condition that does not occur at the present time, then the effect of the Plan is judged to be environmentally significant

4.3 ENVIRONMENTAL EFFECTS OF PROPOSED PLAN AND PLAN ALTERNATIVES

4.3.1 “No Project” (Existing Master Plan)

The 1975 Humboldt Bay Master Plan included no specific guidance with respect to any of the topics covered in this EIR chapter, and continued reliance on the policy framework in the Master Plan would not indicate guidance to the District with respect to these issues. The District’s existing ordinances are also essentially silent regarding these concerns. The District’s operations and management activities in this circumstance would continue to be based on the requirement of existing state and federal laws and regulations. Under these existing laws and regulations the District has little or no direct involvement with any of the concerns covered in this chapter.

Were the District to continue to rely on the existing policy framework established by the Master Plan and the existing ordinances, the positive approaches to watershed-wide involvement and coordination included in the Draft Management Plan would not be implemented. Comparatively, adopting this alternative (that is, continuing to rely for policy guidance on the 1975 Master Plan) would result in an inferior level of management and District involvement when compared to the policy framework in the Draft Management Plan.

4.3.2 Proposed Management Plan

The Draft Humboldt Bay Management Plan includes a number of policies that address the hydrological relationships summarized above. The following policies directly or indirectly cover actions that could affect the District’s participation or management of activities that could affect watershed hydrological processes or the hydrodynamics of the bay itself.

Harbor Policies:

- HSM-2: Develop standards for new and existing Humboldt Bay shoreline protection
- HSM-3: Develop appropriate, consistent shoreline protection guidelines for commercial, industrial, and residential development around Humboldt Bay

- HSM-4: Require maintenance according to the District’s adopted shoreline protection standards
- HSM-6: Require the use of non-structural shoreline protection where feasible and appropriate
- HWM-3: Re-deposition of dredged materials within Humboldt Bay may be authorized to meet Plan purposes
- HWM-4: Placement of fill within Humboldt Bay may be authorized to meet Plan purposes

Recreation Policies:

- ROP-3: Identification of designated recreational use areas
- RFA-1: Safe and appropriate public recreational access to and use of the bay
- RFA-3: Water-oriented recreation facilities; access for fishing and shellfish harvesting
- RFA-7: Protection of recreational areas
- RSA-5: Support opportunities for recreational fishing
- RVR-1: Views of Humboldt Bay shall be protected

Conservation Policies:

- CAE-3: Work cooperatively to develop and implement a restoration and enhancement plan for Humboldt Bay’s aquatic ecosystems
- CAS-5: Fill placement may be used for habitat enhancement purposes
- CEP-3: Revetments, breakwaters, and other shoreline structures may be approved under specified conditions

The Draft Management Plan is intended to provide a “self-mitigating” programmatic management program for Humboldt Bay. In general, the goal in such an approach is to assure that policies that could result in adverse effects are accompanied by other policies that moderate or prevent possible adverse effects. For example, policies CEP-4 through CEP-11 were included in the Management Plan in order to assure that no adverse long-term impacts remain as a consequence of Plan implementation. However, as noted throughout this EIR, the Plan’s success in avoiding impacts depends entirely on the full implementation of all of the Plan’s policies.

4.3.2.1 Watershed Hydrology

The District exercises no regulatory authority over land uses or water uses in the uplands of the bay’s watershed. Nonetheless, many activities that take place in the watershed affect the District’s management concerns for Humboldt Bay. Some of those concerns are addressed in Chapter 5.0 (Erosion and Sedimentation), some are addressed in Chapter 6.0 (Water Quality), and some are addressed in Chapter 11.0 (Fish and Aquatic Organisms), although for practical purposes these several concerns are actually mutually interdependent. For example, the District’s responsibilities for helping to maintain habitat for sensitive salmonids that pass through Humboldt Bay as a migration corridor are affected by upland land and water uses that alter runoff patterns to increase rainy season flows and reduce summertime base flows, and the same upland uses are often associated with increased sedimentation into tributary streams and altered water quality (e.g., increased water temperature). The District is,

therefore, in the position of being affected adversely by impacts that arise from actions that are not within its own jurisdiction.

This EIR concludes that the Draft Humboldt Bay Management Plan does not include a policy focus that would exacerbate changes in watershed hydrology that might adversely affect the bay's aquatic ecosystems, and consequently the EIR finds that additional policy approaches are not necessary to provide mitigation for such impacts, which are legitimately the concerns of other agencies, including the County of Humboldt and the cities of Arcata and Eureka, as well as the Regional Water Quality Control Board and the Coastal Commission. Even so, the Plan includes a policy approach that commits the District to collaborative action that will assist governments and other interested persons in addressing the hydrological modifications, particularly runoff intensification, that occurs because of land use changes in the watershed. Existing Policy CAE-4 in the Draft Plan is focused on water quality, but a minor amendment in the policy may be included to incorporate hydrological modification and runoff intensification (see Section 4.4 below).

Comments received in response to the NOP suggested that the Plan's policies would lead to increased upland runoff because of increased industrial development near the bay's margin, and that this increase would adversely affect the overall hydrological pattern in the watershed. As noted elsewhere in this EIR, the District does not control land use decisions in upland areas, and the suggested relationship is conjectural at best. Assuming that the Plan's implementation did result in increased development in upland areas, the potential would exist that an increase in the area of impervious surface in the uplands near the bay would contribute to a possible cumulative runoff intensification impact, as described previously. Policy-based mitigation for this cumulative element would be the same measure noted above.

4.3.2.2 Humboldt Bay Hydrodynamics

The hydrodynamic changes in the waters of Humboldt Bay synopsised in this chapter are explicitly a part of the District's management concerns for the bay, although the District's jurisdiction ends at the Mean Higher High Water (MHHW) elevation. The Draft Management Plan includes a number of policies that relate to this subject. However, concern about changes in bay surface elevations also extends beyond the shoreline, and the District does not have authority to act in those areas.¹⁷

The Draft Management Plan includes policies directing the District to develop a shoreline maintenance approach that would protect the existing shoreline from the effects of fluctuating water surface elevations (i.e., the HSM policies in Plan Section 3.3). The elements of these policies directed at assuring adequate shoreline protection, *per se*, are not considered in this EIR to be associated with adverse effects on the bay's surface elevation, and mitigation is not necessary.

¹⁷ The District currently exercises jurisdiction over tidegates in bay-margin levees. Ordinance No. 7, the "land use" ordinance of the District, identifies in Section 3, paragraph (b), the District's jurisdictional areas as including the baylands: "2. bayward of any functional and authorized tidal gate or tidal control structure." The District interprets this clause to indicate that tidegate structures define the upstream limit of District jurisdiction on tributary waterways that pass through levees.

The Plan's policies also incorporate motivations other than shoreline protection *per se*. The compromises among meeting shoreline protection goals and meeting other goals (e.g., making the shorelines available for recreation, or using non-structural approaches to shoreline protection) are judged in this EIR to have a potential for adversely affecting the achievement of the Plan's shoreline-protection goals. That is, the potential is not qualitatively insignificant that achieving Plan goals for access to the shoreline, or goals that address non-structural approaches to shoreline protection, may adversely affect the degree to which the shoreline can be protected from surface elevation fluctuations. This EIR identifies this qualitative risk as a likely significant impact that would result from implementing the Draft Plan, and additional policies that could be crafted that would reduce this risk to a level of insignificance are not evident.

The potential incompatibility among some Plan policies, and the potential for "internal interference" that reduces the degree of shoreline protection below the level possible in a single-focus plan, is an unavoidable effect of the "balancing" approach that the District is legally obliged to adopt. No mitigation is evident for this effect.

One result of this EIR's consideration of tidewater elevations in the bay is the conclusion that existing levees surrounding Humboldt Bay may not completely protect the areas behind the levees from periodic tidal flooding. The occurrence on December 31st, 2005, of levee overtopping and inboard erosion along the eastern Arcata Bay shoreline between Bracut and the Simpson mill is an indication that existing levees are, to some unknown extent, incapable of protecting adjacent lands against high water surface elevations in the bay. It is uncertain what improvements might be required to increase the degree of protection. The EIR finds that additional policy elements should be added to the Plan to address this concern, particularly in conjunction with possible cumulative effects associated with increasing sea level (see below), in order for the Plan to address this concern adequately.

The Draft Plan includes policies that authorize the placement of shoreline structures into the bay's waters (e.g., policy CEP-3), and a number of policies that authorize the placement of fill into the bay's waters (e.g., policies HWM-3, HWM-4, and CAS-5) in order to accomplish legitimate Plan purposes. This EIR finds that the placement of fill into the bay's waters would affect the tidewater hydrodynamics of Humboldt Bay, and that the most likely effect would be a reduction in tidal prism, and potentially a decrease in the turnover rate in the bay. The EIR cannot assess the degree of tidal prism reduction quantitatively. Qualitatively, the reduced tidal exchange could be associated with adverse effects on bay water quality (e.g., warmer summertime temperatures in Arcata Bay, or reduced dissolved oxygen concentrations) or on biota within the bay. The EIR also finds, however, that existing policies included in the Conservation section of the Plan (particularly policies CEP-4 to CEP-11) are adequate for assuring that the adverse effects of any filling-related actions are identified as part of the proposal review process, and that mitigation would be identified that could reduce the adverse impacts to insignificant levels. Additional mitigation is not required for this concern.

4.3.2.3 Sea Level Change

The existing Draft Plan elements do not address potential effects on the bay or its surroundings from increased sea level. The current IPCC and California state projections indicate that sea level can be expected to increase in the region that includes Humboldt Bay by between three and 27 inches by the latter part of this century, with at least a realistic potential that sea level will increase by more than three feet in elevation by the end of the century. This increase would be in addition to water surface elevations that resulted from tidal forces, storms, and other meteorological factors, some of which may also be exacerbated by global climate change (Cayan and others 2005). This EIR finds that an increased sea level would be associated with a potential that the higher water surface elevation would result in an increased frequency of levee overtopping, including the possible erosion of the levee crest that increases the potential for future overtopping, or possible erosion on the exterior or (particularly the less-shielded) interior levee surface.

Calculating the quantitative probability that such events may occur is beyond the scope of this EIR. The qualitative potential that these events may occur is judged to be positive and high enough to constitute a significant environmental impact pursuant to CEQA. These events, should they occur, are judged to be associated with an increased possibility of levee failure. Levee failure would likely be associated with loss of or damage to improvements (including homes, businesses, and major infrastructure elements, including Highway 101) or agricultural resources (animals, croplands); the risk that these effects will occur is also considered to be an environmentally significant effect pursuant to CEQA.

The District bears no direct responsibility for the land uses carried out behind the levees, but the District bears a responsibility for planning for expected tidewater elevations within the bay, and for addressing shoreline maintenance around the bay's margin. The District shares this responsibility with local land use agencies (the County and the cities of Arcata and Eureka), and the responsibility is likely shared by the State of California.¹⁸ This EIR recommends that an additional policy be added to the Humboldt Bay Management Plan (see below) that establishes a District responsibility for coordinated planning with the responsible agencies and with other affected parties for the increased flooding risk associated with the projected increase in sea level. Incorporating this policy into the Plan will constitute suitable plan-level mitigation for this impact. In addition, this additional policy will address the significant cumulative effects of a sea-level increase in combination with "normal" water surface elevation fluctuations in Humboldt Bay (see previous subsection).

4.3.2.4 Water Supply

This EIR finds that credible evidence does not exist to support a conclusion that implementing the Draft Plan would create a significant impact to groundwater or

¹⁸ A California Appeals Court ruling in 2003, in the case *Paterno v. State of California* (C040553; see URL: <http://caselaw.lp.findlaw.com/data2/californiastatecases/c040553.pdf>; viewed January 2006) established a state responsibility for levees along major California rivers. It is unknown whether, but likely that, this legal responsibility also applies for levees such as those adjacent to Humboldt Bay, particularly given the residual public trust responsibility owed by the state in such circumstances.

surface water supplies near the bay. The known wells in the bay's vicinity are hydraulically up-gradient from the bay and would not be affected by the bay's management pursuant to the Draft Plan.

Comments received regarding the NOP suggested that implementing the Plan would result in increased upland industrial development that could interfere with groundwater recharge, which could adversely affect groundwater used as a water supply in the project area. As noted above, the District lacks legal authority to regulate upland land uses, and this EIR finds that the Plan's implementation will not adversely affect groundwater recharge near the bay. In addition, the bay's margin is hydraulically down-gradient from all known water wells in the Humboldt Bay region, and no adverse effect on these wells is expected to result from land uses occurring along the bay's margin.

4.4 POLICY CONSIDERATIONS FOR MITIGATING POTENTIALLY SIGNIFICANT EFFECTS

The policies recommended in the Draft Management Plan already largely address the potential environmental consequences of the Plan. However, this EIR finds that a modification in the proposed Plan policy that directs the District to develop cooperative water-quality management plans with affected agencies and other interested to include concerns related to runoff intensification will address the potential Plan-related effects on the Humboldt Bay watershed. (It should be noted that the policy proposed in Section 4.4.2 is also proposed in Section 5.4.1 to address concerns identified in Chapter 5.0.)

4.4.1 Watershed Processes

This EIR recommends that Policy CAE-4 be amended to read as follows (added text underlined):

CAE-4: Work cooperatively to develop and implement a water-quality maintenance plan for Humboldt Bay

Policy: The District shall consult with the North Coast Regional Water Quality Control Board, Humboldt County, the City of Arcata, the City of Eureka, and other appropriate local, state, and federal agencies, to develop and implement a plan improving and maintaining water quality in Humboldt Bay at a level that will support and promote the beneficial uses identified for Humboldt Bay in the North Coast Regional Water Quality Control Board's Water Quality Control Plan for the North Coast Region. The resulting Humboldt Bay Water Quality Management Plan shall consider the potential effects of all management actions carried out by the District, the potential effects of all actions approved by the District, the potential effects of actions carried out or approved by other jurisdictions and parties within the Humboldt Bay watershed, the effects of land use in the watershed on runoff processes affecting Humboldt Bay, and the potential contribution of existing pollutants to water quality maintenance and the achievement of beneficial uses in Humboldt Bay. The District shall adopt findings with respect to the requirements of this plan when approving District operational programs or when approving any application for project approval submitted to the District.

The incorporation of additional text addressing watershed processes into this measure is sufficient to reduce the potential Plan-related consequences below a threshold of CEQA significance (Note: additional text added to this measure addresses water-quality concerns; see Chapter 6.0).

4.4.2 Bay Surface Elevations

The Draft Plan currently lacks a policy that addresses the District's role, which is shared with other agencies and affected parties, in crafting a coherent response to water level fluctuations in the bay, including both meteorological and climatically related changes. This lack is a significant environmental effect of the Draft Plan, but it can be addressed through the incorporation of an additional policy into the Shoreline Management section in the Draft Plan (new measure: added text underlined):

HSM-7: Identify needs for potential shoreline improvements necessary to accommodate bay water surface elevation changes, including potential effects of climate change

Policy: The District shall consult with the County of Humboldt, the City of Arcata, the City of Eureka, other affected local agencies, relevant state and federal agencies, and affected local parties to identify the potential effects on the Humboldt Bay shoreline and nearby areas that may occur because of meteorological or climate-related water surface-level fluctuations in the bay prior to the year 2050. Based upon these consultations, the District and other affected parties shall develop a plan that identifies any necessary shoreline alterations or maintenance programs needed to accommodate the water-level fluctuations. The District shall adopt findings with respect to the contents and recommendations of this plan when approving District operational programs or when approving any application for project approval submitted to the District.

The incorporation of this additional policy into the Plan will reduce the potential Plan-related consequences below a threshold of CEQA significance.

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