Chapter 9. Airport

Oakland International Airport (OAK) is located in the ART project area approximately 6.5 miles southeast of downtown Oakland on Bay Farm Island (Figure 1). It first opened to commercial aviation in 1927, and is currently one of three airports in the San Francisco Bay Area operating international passenger service; the other two are San Francisco International Airport (SFO) and Norman Y. Mineta San Jose International Airport (SJC).

OAK is owned and operated by the Port of Oakland (Port), which is an autonomous department of the City of Oakland that receives no tax money from the city and funds its own operations. The Port is governed by a Board of Port Commissioners, nominated by the mayor of Oakland and appointed by a vote of the Oakland City Council. The Port manages property stretching along 20 miles of the eastern shore of San Francisco Bay and is divided into three operating units: Aviation, which owns and operates Oakland International Airport; Maritime, which owns and operates the Port of Oakland; and Commercial Real Estate, which owns development property along the shoreline, including the Jack London Square District.

Figure 1. Oakland International Airport area map. (Source: Google 2012)

OAK encompasses 2,600 acres and borders the San Francisco Bay on its northern, western, and southern sides. Its longest commercial runway, 11/29, is located on the airport's western end and was constructed on bay fill in the 1960s. The airport property is organized into two distinct facility areas: South Field and North Field. South Field, the airport area south of Ron Cowan Parkway, is used by commercial airline service and air cargo. North Field, north of Ron Cowan Parkway, is used for general aviation. Land along the northwestern end of the airport consists of the Chuck Corica Golf Complex and an array of low-density residential development, while land along the eastern end of the airport contains industrial land uses and a golf course, the Metropolitan Golf Links. Some natural areas exist around the airport, such as the tidal flats along the western edge of Runway 11/29 and the mud flats adjoining the southern end of the airport adjacent to the terminal buildings.

Runways constitute the largest aviation land use at OAK at approximately 1,078 acres (Port of Oakland 2006). South Field contains 208 acres of passenger facilities, including Terminals 1 and 2. Runway 11/29 is the South Field's primary runway that provides service to large commercial aircraft. Additionally, South Field has 104 acres of air cargo facilities, the largest of which is the FedEx Metroplex, the largest west coast hub operation for the shipping company. On the other side of the airport, North Field has a variety of land uses, the largest of which is general aviation (approximately 85 acres), including aircraft hangars, ramps, and two fixed base operators,

KaiserAir and Business Jet Center. North Field also accommodates some air cargo facilities (approximately 30 acres), including Ameriflight, a small package carrier. North Field's three runways (Runway 9R-27L, Runway 9L-27R, and Runway 15-33) provide service to smaller aircraft, including general aviation and air cargo.

Exposure

Exposure is the extent to which an asset, such as a facility at OAK, experiences a specific climate impact such as storm event flooding, tidal inundation, or elevated groundwater. The exposure of selected facilities at OAK to two sea level rise projections and three Bay water levels was evaluated. The two sea level rise projections, 16 inches (40 cm), and 55 inches (140 cm), correlate approximately to mid- and end-of-century. These two sea level rise projections were coupled with three Bay water levels: the new daily high tide, measured as mean higher high water (MHHW), the new 100-year extreme water level, also known as the 100-year stillwater elevation, and the 100-year extreme water level coupled with wind waves, hereafter "storm event with wind waves," or "wind waves." These water levels were selected because they represent a reasonable range of potential Bay conditions that will affect flooding and inundation along the shoreline. For each exposed facility, the average depth of inundation from the daily high tide and storm events was calculated. Whether a facility is exposed to wind waves was evaluated as a simple binary – yes or no. For more information about sea level rise projections and Bay water levels evaluated see Chapters 1 and 2.

The extent of the facility footprint exposed to each sea level rise projection and Bay water level was determined for each airport asset evaluated. Facility footprints were identified using aerial imagery in combination with the Alameda County Assessor parcel information, and are therefore an approximation rather than an exact facility boundary (see Appendix C).

With 16 inches of sea level rise, the General Aviation facilities and the North Field runways are likely to be inundated by the new daily high tide to depths of approximately 3 to 4 feet (Table 1). During a storm event, potential inundation depth increase by approximately 2 feet, and new facilities are exposed, including the commercial runway at South Field. The inundation depths at these sites range from less than 1 foot at the Maintenance Hangar to nearly 7 feet at the commercial runways and taxiways.

With 55 inches of sea level rise, the entirety of the airport would be exposed to the daily high tide (Table 1). Inundation depths range from a low of approximately 1 foot at the Maintenance Hangar facility near Airport Drive to a high of over 7 feet at the commercial airfield runways and taxiways. During a storm events, inundation levels become significantly higher. Some of the airport's facilities are located at a lower elevation than adjacent areas currently within the daily tidal range, and are therefore more vulnerable to wind waves; these include assets such as the jet fuel storage tanks, commercial runways, and air cargo facilities. Currently, these assets are not exposed to flooding due to protective structures such as tide gates and levees, but when subjected to storm event flooding, it is possible that wind waves will overtop these protective structures, causing even greater amounts of inundation. In storm events, every facility at the airport may be flooded up to several feet. More specifically, the runways and taxiways at the general aviation airfield at North Field and the commercial and cargo airfield at South Field may be inundated by as much as 10 feet.

Table 1. Exposure of select assets at Oakland International Airport to the daily high tide and storm events with 16 and 55 inches of sea level rise. All assets exposed to storm event flooding are also within the wind wave zone and could experience deeper inundation than estimated because Bay water levels increase when there are wind waves.

	16" SLR		55" SLR	
	Daily High Tide	Storm Event Flooding and wind waves	Daily High Tide	Storm Event Flooding and wind waves
Airport Asset Name	Average depth (ft)	Average depth (ft)	Average depth (ft)	Average depth (ft)
Jet Fuel Storage		5	5	8
General Aviation	3	5	6	8
North Airfield Runways & Taxiways	4	6	7	9
South Airfield Runway & Taxiways		7	7	10
Air Cargo		3	4	6
Maintenance Hangar			1	4
Passenger Terminals		3	4	6

OAK is dependent not only on its own facilities, but also on the connecting transportation infrastructure that enables workers and passengers to access the airport and allows goods to be transported to and from the airport air cargo facilities. This means that the airport is sensitive not only to climate impacts within its own property, but also to impacts on surrounding areas, such as those that provide access to the airport. Vulnerability of ground transportation assets that provide access to airport will affect the airport's sea level rise vulnerability and risk (see Chapter 11 for an assessment of Ground Transportation assets in the ART project area).

OAK depends on three major access roads for the transit of goods and people to and from Interstate 880 (the nearest major Interstate highway) and major East Bay public transit hubs: Hegenberger Road, 98th Avenue, and CA-61. Table 2 summarizes the exposure of the access routes to the Oakland International Airport.

With 16 inches of sea level rise, all sections of Hegenberger Road south of Interstate 880 could experience up to 2 feet of inundation during storm events. Airport Road, the only link between all three major access roads and the airport's terminal facilities will be impassable because it is an underpass, and therefore could be inundated by up to 26 feet.

With 55 inches of sea level rise, most of the Airport's major services that lie along Hegenberger Road, 98th Avenue, and Doolittle Drive, such as hotels, gas stations, and restaurants, will be inundated by the daily high tide. Hegenberger Road, where most of OAK's hotels are located, will be inundated by up to 3 feet from airport property to Interstate 880 and the Oakland Coliseum station complex. The other routes, 98th Avenue and CA-61/Doolittle Road, will be

exposed to flooding during storm events. CA-61 on Oakland's North Field is crucial to the airport's services as it is home to most of the airport's major "on-property" rental car facilities, including a 15,000-square-foot rental car center.

Ron Cowan Parkway, an alternate route to the airport from Alameda and Bay Farm Island, could be vulnerable to inundation under all sea level rise scenarios. With 16 inches of sea level rise, Ron Cowan Parkway may face 15 feet of inundation at high tide.

Table 2. Exposure of selected road assets at Oakland International Airport to the daily high tide and storm event flooding with 16 inches and 55 inches of sea level rise. All assets exposed to storm event flooding are also within the wind wave zone and could experience deeper inundation than estimated because Bay water levels increase when there are wind waves.

	16" SLR			55" SLR	
	Daily High Tide	Storm Event Flooding		Daily High Tide	Storm Event Flooding and wind waves
Selected road asset name	Average depth (ft)	Average depth (ft)	Exposed to wind waves only	Average depth (ft)	Average depth (ft)
Hegenberger Rd. (San Leandro St. to Coliseum Way)			Yes	3	5
Hegenberger Rd. (SB I-880 Off-Ramp to Coliseum Way)		2		3	5
Hegenberger Rd. (Edgewater Dr. to Pardee Dr. / Airport Access Rd.)		2		3	5
Hegenberger Rd. (Pardee Dr. / Airport Access Rd. to Doolittle Dr.)		2		3	5
Airport Dr. (Entire Facility)		26		27	29
Ron Cowan Parkway (Entire Facility)	15	19		19	22

Sensitivity and Adaptive Capacity

The sensitivity and adaptive capacity of the Airport was assessed for three potential climate impacts that could occur due to sea level rise and storm events. The three climate impacts considered are:

- More frequent floods or floods that last longer due to storm events
- Permanent or frequent inundation by the daily high tide
- Elevated groundwater levels and saltwater intrusion

Sensitivity is the degree to which an asset or entire system would be physically or functionally impaired if exposed to a climate impact. Adaptive capacity is the ability for an asset or system to accommodate or adjust to a climate impact and maintain or quickly resume its primary function. The sensitivity and adaptive capacity of the Airport was evaluated, considering not just physical and functional sensitivity of airport facilities, but also the sensitivity of the access roads transportation and key support services and facilities the airport relies upon.

OAK requires un-flooded runways and facilities in order to move people and goods. The combination of the airport's low-lying elevation and its physical sensitivity to flooding make the airport's function vulnerable to multiple sea level rise scenarios. The airport is particularly sensitive to storm events when water may overtop protective levees. As discussed in the exposure analysis, every facility at the airport could be inundated up to several feet when subjected to storm event flooding with 55 inches of sea level rise.

In addition to flooding, the airport sits on bay fill. This makes OAK more physically vulnerable to inundation or liquefaction than areas farther inland. Most of the original airfield was constructed through reclamation in the late 1950s and consists of hydraulically placed sand fill. The perimeter dike, with a width of 18 to 28 feet and situated 9 to 17.5 feet above the Bay, is underlain by silty clay and young Bay mud, which has a high liquefaction potential. During a seismic event OAK is vulnerable to liquefaction which could magnify the impacts of flooding and other natural events on its physical structures, especially runways that rely on flat, even terrain for departures. The risk of liquefaction is particularly high for the levee that protects the airport. To address this issue, the Port's Environmental Programs and Planning Division has focused on industry-leading project designs that enable runoff from roadways, parking lots and buildings to divert to grassy swales, detention basins, and landscape areas to allow for increased infiltration and treatment prior to discharging water off-site.

Consequences

Consequences are the magnitude of the effects on the economy, society, environment, and governance if an impact occurs. Factors that inform the magnitude of the potential consequences include the severity of the impact on O&M or capital improvement costs, the size and demographics of the population, and the type of natural resources affected. The potential consequences of daily tidal inundation, storm event flooding, or elevated groundwater on Oakland International Airport are considered as a whole, which expands the coverage of this report to include communities served by OAK.

<u>Economy</u>
OAK is near a number of highways, roads, and public transit routes, and provides a convenient way for air travelers throughout the ART project area and the greater Bay Area to fly across the state, across the nation, or around the world. The airport's low-lying runways are at risk of inundation and it is likely that in a storm event with 16 inches of sea level rise, OAK will have to reduce or redirect aviation activity to other Bay Area airports such as San Francisco

International Airport and San Jose Mineta International Airport. Any form of inundation affecting OAK's ability to handle flights could have a significant impact on the entire regional and national network of air traffic.

OAK hosts flights departing from various points throughout California, the United States, and Mexico, and is a focus city for Southwest Airlines and Allegiant Air. In 2010, OAK carried 9,857,845 passengers, making it the 33rd busiest airport in the U.S. in terms of total passengers (Airports Council International 2009), and 34th busiest in the U.S. in terms of total aircraft movements, at 219,652 landings and takeoffs. OAK's air cargo traffic was also among the highest in the U.S. in 2010, ranking 10th with 510,947 metric tons handled. The airport is the North American West Coast hub for FedEx, the largest air cargo operator at OAK which sorts and distributes freight and overnight packages from around the world. In 2010, FedEx averaged 15 flights a day, handling 907 million pounds of cargo (Port of Oakland 2011).

Any inundation-related impacts to OAK's runways could mean that all of these flights and networks will be affected in the form of significant delays or re-routings, meaning lost time or lost money for both passengers and air carriers. Additionally, the airport would have to pay for costly repairs to any dikes, pavements, and structures that flood. OAK has paid for such incidents in the past. During strong winter storms in 1983, a historically active winter rain season, parts of OAK's main dike were overtopped. The Port of Oakland made emergency repairs to the damage by filling the Bay side of the overtopped sections of the levee with up to 15 feet of concrete rubble, and filling the landside dike with gravel fills. The cost of these initial repairs totaled $429,743, while a complete reconstruction of the dike was later carried out at a cost of $975,020 (Port of Oakland 1984). With the exception of the overtopping in 1983, the perimeter dike has performed well in protecting the airport's facilities from flooding and storm events.

OAK's location on top of bay fill makes it particularly susceptible to liquefaction during a seismic event. The 1989 Loma Prieta earthquake affected airport operations even though the airport was over 40 miles from the epicenter. The airport's main 10,000-foot runway (South Field's Runway 11-29), built on hydraulic fill over Bay mud, was severely damaged by liquefaction; 3,000 feet of the runway sustained cracks, some of which were up to one foot wide and one foot deep (USGS 1998). Spreading of the adjacent unpaved ground resulted in cracks up to 3 feet wide. Large sand boils, some as wide as 40 feet, appeared on the runway and adjacent taxiway. As a result, OAK was immediately shut down to evaluate runway damage.

North Field's 6,212-foot general aviation runway (Runway 9R-27L) was used to accommodate diverted air traffic for several hours before the main runway was reopened with a usable length of only 7,000 feet. This shorter runway length affected cargo loads during takeoff. Over the thirty days following the earthquake, 1,500 feet of the 3,000-foot damaged section of the runway was repaired using an emergency repair order for resurfacing and local crews. An adjacent taxiway was also damaged by liquefaction. Repairs of this taxiway segment and the final 1,500 feet of the main runway were completed six months later, with repair costs totaling approximately $6.8 million. This total included $3.5 million for runway repairs, $2.2 million for taxiway repairs, and $1.1 million for repair of other (non-liquefaction related) damage, including a below-grade tramway used to transport baggage under terminal buildings, which was filled with sand and water up to six and a half feet deep. FAA funded approximately $5.5 million of the repairs, with the remainder funded by OAK. Sea level rise and coincident groundwater rise will increase the risk of liquefaction at OAK and surrounding areas.

Society

As a major link in northern California's transportation network, OAK supports thousands of jobs directly through its operations and indirectly via the industries that require a functioning

airport. Any event resulting in major inundation would temporarily interrupt the road and public transport links that many people rely on to get to and from the airport, especially those that are dependent on public transportation. AC Transit, the third-largest bus system in California, operates bus service to and from OAK and nearby Alameda County, with connections to surrounding Contra Costa County. Many airport employees rely on these services to transport them from their homes to the terminal areas.

Line 73 of AC Transit is a local service operating between OAK and the Eastmont Transit Center in Oakland. Line 73 passes through BART Coliseum/Oakland Airport Station, but continues east and provides access for employees in Oakland who do not have convenient access to BART. This route traverses Airport Drive, which could be inundated in storm events with 16 inches of sea level rise.

Line 21 of AC Transit is a local service operating between the Dimond District in Oakland and OAK. Between these two points, the bus travels through the Fruitvale BART Station, Alameda Island, and Bay Farm Island with selected trips to the Alameda Harbor Bay Ferry Terminal (southernmost ferry service to San Francisco), allowing public transit access for employees who live west and north of OAK. This route traverses Ron Cowan Parkway, which is highly susceptible to inundation and liquefaction; therefore, interruption of service is highly probable, even during the daily high tide with 16 inches of sea level rise.

Public transport and road closures to OAK will cause problems for large numbers of employees who work on or near the airport's premises. In the Bay Area in 2010, aviation activity from OAK generated 7,680 direct, 5,578 induced, and 1,408 indirect jobs, for a total of 14,466 jobs (Table 3).

The direct jobs supported by the airport include a range of public and private sector employment, from air traffic controllers working for the FAA to bus drivers operating private airport shuttles. These jobs generated $4.2 billion in business revenue and $1.9 billion in personal income. OAK also generated $197 million in state and local taxes and provided a direct payment of $3.2 million to the City of Oakland. A reduction in convenient access to OAK for airport and airport-related employees could translate into significant economic losses to the City of Oakland, the Port of Oakland, and the entire State of California.

Table 3. Direct and indirect jobs dependent on aviation activity at OAK (Source: Port of Oakland)

Impact Category	Impact Sub-Category	Number of Direct Jobs by Category
Surface Transportation	Rail	174
	Truck	3,708
	Subtotal	*3,882*
Maritime Services Sector	Terminal Employees	210
	ILWU	1,701
	Towing	78
	Pilots	47
	Steamship Lines / Agents	168
	Maritime Services	559
	Freight Forwarders	1,616
	Warehouse / Distribution Centers	1,955
	Government	416
	Marine Construction / Ship Repair	145
	Subtotal	*6,894*
Dependent Shippers/Consignees		88
Port of Oakland		63
	Grand Total	**10,927**

For air travelers, the regional access roads of OAK serve an integral role in shuttling passengers in and out of the terminal facilities. Many of these roads will be inundated with 16 inches of sea level rise. Ron Cowan Parkway, a secondary travel route for OAK passengers traveling from Alameda communities, has high seismic liquefaction potential and will be inundated up to 15 feet under the new daily high tide with 16 inches of sea level rise. Airport Drive, the primary access road to OAK, will be inundated up to 26 feet during storm events with 16 inches of sea level rise. Rental car and hotel facilities are located along these major access roads, meaning that even if the airport is not exposed, it could face major difficulties connecting arriving and departing passengers to these services. This may translate into lost revenue for OAK's service industry as well as economic losses for the 24,428 employees in the hospitality industry along these corridors.

BART's Coliseum/Oakland Airport Station is the primary gateway for regional rail commuters and air travelers to OAK from other parts of the East Bay and the greater Bay Area. In FY2010, it served 20,785 Amtrak passengers yearly[1] and 6,191 BART passengers daily[2]. The station opened as part of BART's initial service in 1972, and today, for an additional fee, passengers connect to the airport through a private shuttle bus service known as AirBART. In October 2010, construction began on a new $500 million Automated Guideway Transit (AGT) system to OAK, known as the Oakland Airport Connector and slated for completion in mid-2014[3]. The future Airport Connector will be on an elevated rail line and therefore may not be directly affected by inundation. However, if flooding occurs before the rail line is completed, AirBART service to and from OAK's terminals could be suspended; eliminating another means of access to the airport.

[1] http://www.amtrak.com/pdf/factsheets/CALIFORNIA10.pdf
[2] http://www.bart.gov/docs/WeekdayExits.pdf
[3] http://www.bart.gov/about/projects/oac/

Environment

OAK's primary commercial runway, 9R-27L, is situated adjacent to a protective dike that is highly susceptible to structural failure due to high liquefaction vulnerability. During the Loma Prieta Earthquake of 1989, Runway 9R-27L experienced a dike failure and was temporarily closed to all arrivals and departures while emergency repairs were being made. During this time, commercial aircraft were temporarily re-routed to the North Field runways. While these runways are capable of serving commercial aircraft in times of emergencies, local communities and businesses experience a significant increase in noise-related impacts.

Commercial aircraft are much louder than general aviation aircraft, contributing to higher CNEL (Community Noise Equivalent Level) measurements. If commercial aircraft were to be re-routed on the North Field runways, many residents in the City of Alameda, City of Oakland and City of San Leandro could be affected by a significant increase in overall decibel levels, especially if current take-off and landing patterns were maintained. The closure of Runway 9R-27L, therefore, would not only bring significant economic impacts to the Bay Area, but could also cause health-related impacts to local residents and businesses.

Finally, while OAK has made a leading effort to improve stormwater management and treatment over the past 15 years[4], it is still possible that water from the San Francisco Bay could flow through sewage facilities and contaminate other structures on the airport property should Bay water overtop the protective dike structure. According to the Port of Oakland's Aviation Planning and Development, contamination from sewage conveyance and treatment systems is possible in the event of major inundation, which could in turn contaminate groundwater beneath the airport.

Governance

The airport's physical and regulatory structure reduces its capacity to adapt its operations, including takeoff and landing patterns, in the event of significant disruption. While the airport has maintenance personnel, heavy equipment, stockpiles of repair materials to repair an emergency dike breach, and a system of pumphouses to remove floodwaters, it would not be able to quickly or easily restore significant flood-related damage to pavements (runways, taxiways, and aprons) or critical utilities (e.g., airfield lighting and navigational aids). Because OAK's sole runway for commercial flights is also the airport's most vulnerable to flooding (Runway 11/29), it is highly possible that major operational adjustments will be needed in the event of inundation. However, these major operational adjustments will not be easy to swiftly implement due to a large number of overlapping local and federal airspace regulations.

For example, if Runway 11/29 were inundated, the only alternative stretches of pavement where commercial jets could possibly land are the rest of the airport's secondary runways on the North Field (Runways 27L/9R, 27R/9L, 19/33). These runways are shorter and narrower than Runway 11/29 and are restricted by local regulations. As a result of the Airport Development Program Settlement Agreement among the Port of Oakland, the City of San Leandro, the City of Alameda, and others, the Port agreed to prohibit the use of North Field runways by regularly scheduled large commercial aircraft, essentially making the use of these airways exclusive to general aviation and cargo flights. This agreement was made to reduce the amount of noise generated by commercial takeoffs and landings to the surrounding communities, but it also reduces the airport's adaptive capacity to relocate commercial flights on these alternate runways.

[4] http://aci-na.org/static/entransit/enviro_brochure.pdf

Moreover, federal regulations limit the airport's adaptive capacity to relocate flights on secondary runways 27L/9R, 27R/9L, and 19/33. At major airports throughout the country, FAA regulations and airport policies dictate what types of plane can land on runways, and also how they land. The FAA imposes a 24-hour noise abatement policy on OAK which prohibits turbojet and turbofan powered aircraft, turboprops over 17,000 pounds, four-engine reciprocating powered aircraft, and surplus military aircraft over 12,500 pounds from departing on runways 27L and 27R or landing on runways 9R and 9L[5].

In the event of an emergency, or whenever Runway 11/29 is closed due to maintenance, safety, high wind, or weather, the above-mentioned noise prohibitions could be waived. Local communities and businesses, however, would experience noticeable increases in noise-related impacts, because the landing patterns of louder commercial jets would shift toward residential areas instead of over the waters of the San Francisco Bay. $4.5 million has been budgeted by the Port of Oakland for environmental and community benefits, which has been concentrated on mitigating noise generated by commercial takeoffs and landings on Runway 11/29.

Additionally, facility operations and maintenance budgets are very complex, making it difficult for the airport to quickly arrange funding for immediate repairs. The Port of Oakland's capital planning process begins with the development of a Five-Year Capital Needs Assessment (CNA). This document is updated annually and identifies non-capacity expanding needs in order to operate and maintain existing infrastructure that is in a state of good repair. These projects are not financially committed; rather, they are a list of projects for which the Port should explore funding in order to ensure competitiveness with other maritime, aviation, and commercial real estate operations.

Once included in the CNA, the Board of Port Commissioners approves projects based on available funding and need. In its five year 2012-2016 Capital Needs Assessment, the airport has identified $423 million for aviation projects divided into six categories: Airfield Safety and Security; Airfield Pavement; Terminal Renovation and Retrofit; Parking, Roadways, and Rental Car; Environmental and/or Community Benefit; and Utility Infrastructure Maintenance. Over half of this total, or $219 million, is to come from Passenger Facility Charges (PFCs), ticket fees collected by the airlines from departing passengers to fund FAA-approved projects that enhance safety, security, capacity, noise impacts, or air carrier competition at airports throughout the country. The current maximum PFC charge is $4.50 per passenger, although there is discussion in Congress to increase this level to $7.00.

Another $108 million, or roughly one quarter of the total capital budget, is expected to come from government grants. These grants are generally in the form of FAA Airport Improvement Program funds (AIP). The AIP funds are both entitlement and discretionary and can pay for up to 80% of eligible projects, with the remaining 20% locally matched from airport-generated sources. The remaining funding for the CNA, roughly $96 million, is expected to come from aviation-generated operating revenue and debt.

Among the major projects included in the CNA are:

- $34 million budgeted for airfield pavement rehabilitation. Projects include: design and construction of two Taxiways ("Whiskey" and "Uniform") in South Field.
- $100 million budgeted for upgrades to Runway Safety Areas (RSAs) that do not meet FAA's 1,000-foot length standards.

[5] http://www.boeing.com/commercial/noise/metro_oakland.html

- $174 million budgeted for Terminal One Renovation and Retrofit Project, including seismic retrofits, ADA compliance, HVAC improvements, fire alarms/suppression, flooring and lighting, and renovation/replacement of central utility plant.

Although these projects will help improve the airport's long-term infrastructure capacity, a backlog of significant but currently unfunded projects remains. These projects include:

- $126 million in additional Terminal One improvements
- $9 million in stormwater infrastructure upgrades
- $3 million in North Field facilities improvements

These important projects will only be completed when unexpected funding sources, such as government grants or better-than-expected revenues from airport operations, become available. As such, it is difficult for the airport to plan for and execute these needed upgrades. For example, the airport's new 236-foot tall air traffic control tower and 13,000-square foot administrative base building is currently under construction and is expected to open in 2013. This long-awaited $31 million project, paid for by Federal American Recovery and Reinvestment Act funding, will replace the two existing North and South Field towers with one state-of-the-art facility. The money for this project, however, is from a one-time source. Inadequate and/or uncertain funding sources for both basic upkeep and necessary repair of critical infrastructure reduces the airport's capacity to both plan for future impacts and restore potential disruptions from climate change. Restrictions on OAK's operational and financial actions reduce the airport's adaptive capacity with regard to sea level rise.

Without proper flood protection in place, OAK will be faced with additional regulatory burdens. For example, OAK's existing perimeter dike structure does not meet FEMA 100-year flood protection standards, which means that it is no longer given accreditation under FEMA's flood programs. The lack of accreditation means that OAK must also obtain federal flood insurance on top of the private flood insurance the Port of Oakland already carries. If the airport fails to upgrade the dike to FEMA standards, not only would it become largely ineligible for federal disaster assistance in the event of a levee failure, but it would also require the Port to develop a Flood Plain Management Plan that mandates significant restrictions on the construction of new buildings or significant improvement of existing buildings. The requirements, for example, mandate that new or existing structures should be designed so that the lowest floor is elevated above the projected base flood level, or be designed so that structures below the base flood level are watertight.

Key Findings

The majority of the airport assets, including both North Field (general aviation) and South Field (commercial and cargo aviation) runways, are exposed to 16 inches of sea level rise with a storm event. With 55 inches of sea level rise and a storm event, all airport assets are exposed to some amount of inundation, up to great depths in some locations. The airport's physical assets and it functional role in the region are highly sensitive to inundation and have little to no adaptive capacity.

Based on the exposure mapping, the airport assets that are exposed first are all of the roadways that serve the airport (Ron Cowan Parkway, Hegenberger Road, Airport Road, Doolittle Drive), North Field, and the airport services that are located off of Ron Cowan Parkway. This exposure begins at the daily high tide with 16 inches of sea level rise, and increases significantly with a storm event. The commercial runway which provides both cargo and passenger service is also exposed to these impacts.

The functional role that Oakland International Airport plays in the region, state, and nation as a commercial, cargo and general aviation airport cannot be met by other airports or sites in the region. Were Oakland International Airport to lose either North or South Field (or both), there is not enough capacity to meet the demand for these services at other airports or other sites within the region. Moving passenger, cargo or general aviation services to San Francisco International Airport, Norman Mineta International Airport in San Jose, and the surrounding general aviation airports would result in significant delays at those airports. The airport with the most available capacity is Norman Mineta International Airport. However, much of the commercial passenger demand would likely move to SFO, which does not have the capacity to absorb such an increase. The functional role served by OAK as a passenger, cargo, and general aviation airport does not have redundancy in the region and would result in effects on local, regional, state and national air transportation.

The airport is the site of significant numbers of jobs and provides a large economic benefit to both the subregion and the region. The airport's location in the City of Oakland results in a large number of jobs at surrounding facilities created to serve the airport, as well as those jobs that are needed to support the movement of cargo to and from the airport and the businesses and services that are located in the surrounding areas because of the close proximity to an international airport with regular, dependable service.

There are a number of potential environmental consequences from the loss of service at Oakland International Airport. If the airport operations were adapted to move passenger and cargo service from the commercial runway at South Field to the general aviation runway at North Field, it would result in significant noise increases in neighboring residential areas. The movement of general aviation service from North Field to the commercial and cargo runway at South Field would result in significant delays to South Field and have effects on both commercial and cargo transport. The movement of cargo service from Oakland to either San Jose or Sacramento would result in increased distances needed to move cargo by truck, resulting in increased air quality effects and fuel use.

The role of the Federal Aviation Administration, the airlines, and local, state, and federal regulations in the way that the Port of Oakland can operate, finance and maintain the facilities at Oakland International Airport constrain its adaptive capacity to respond quickly to the effects of sea level rise and storm events. Most airport projects take a number of years to plan, finance and implement.

Due to the airport's sensitivity to the impacts of sea level rise and its difficulty in adapting to inundation by altering operations or maintenance, it is highly likely that the adaptation response to the airport's vulnerability will primarily be to reduce exposure to sea level rise and storm event flooding. The way in which the adaptation response is developed will need to be sensitive to the significant number of other subregional assets both at the site of the airport and adjacent to it. These assets include Bay Farm Island, Martin Luther King Jr. Regional Shoreline and Arrowhead Marsh, the BART connection to the airport, the roadway access to the airport, and the infrastructure (pipelines, storm water, waste water, communications and energy, etc.) serving the airport and its surroundings. The adaptation response should be developed with these partners.

References

Airports Council International. 2010. ACI World Report.
http://www.aci.aero/aci/aci/file/World%20Report/2010/WorldReportFebruary2010.pdf.

Port of Oakland. 1984. Jan. 17, 1984 Port Commissioners' Meeting, City of Oakland.

Port of Oakland. 2006. Oakland International Master Plan.
http://www.oaklandairport.com/masterplan_oak/support_documents.shtml.

Port of Oakland. 2011. Strategic Plan, Fiscal Years 2011-2015.
http://www.portofoakland.com/pdf/2011_pbs_02.pdf.

USGS. 1998. The Loma Prieta, California, Earthquake of October 17, 1989—Liquefaction. Soil Liquefaction in the East Bay During the Earthquake. http://walrus.wr.usgs.gov/geotech/soil.