Sea Level Rise in the Canal District: Effects of Climate Change on Underserved Coastal Communities

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Abstract

Sea level rise is one of the most telling signs of global climate change and one that has already begun to affect people. The issue of sea level rise is especially relevant to the lives and livelihoods of individuals in the San Francisco Bay Area. The focus of this project was to research the effects of rising waters on the Canal District of San Rafael, California and to build a physical model of these changes as they will affect Bahia Vista Elementary School. The Canal is an underrepresented, low-income coastal community disproportionately likely to be affected by sea level rise. Though the physical modeling is not yet complete, computer modeling from Our Coast, Our Future shows that further sea level rise of only a foot and a half (which will likely happen by 2100, if not sooner) will put most of this neighborhood underwater, with other, slightly more protected areas solidly in the floodplain. There are many adaptation strategies to prevent damage from sea level rise that could work in the Canal, such as retrofitting, tidal gates and horizontal levees, though a dearth of capital may prevent such changes from being achieved in the Canal.

Introduction

Sea level rise has been one of the most telling signs of global climate change and one that has already begun to affect people. Given that we live in a low lying coastal community, the issue of sea level rise is relevant to our lives and livelihoods and those of the people in our region. We can see what future flooding, induced by climate change, might look like through King Tides in combination with the excessive amount of rain the Bay Area has gotten this year (1). But which areas, and which groups of individuals, will be predominantly affected? In this project, we will show that the Canal, a low-lying area with relatively high poverty and racial diversity, is exceptionally at risk to experience devastating flooding as a result of rising seas and future king tide floods and possible storm surges.

The canal district is located within San Rafael and is one of the most threatened areas in marin in regard to sea level rise. The canal is home to many low-income, Latin American families, and this area has become slightly crowded, especially because of the increase of immigrants. Also, because of the high rent rates in Marin, these families are paying more than one third of their earnings on rent alone. The residents of the canal also face poor, dense living conditions. The area's population increased by one half from the early 1990s to 2013, yet there was little to no development of new living spaces for the new residents. The canal is an area in which generations cycle through and little progress is made. Most people in the canal only have a high school degree or less. When living with three to four other houses in one unit, sharing one room with your whole family, thriving in school would be near impossible (2). Also, because the canal is so close to the coast, these families could be kicked out of their homes if the sea level were to rise.

When growing up in the canal, your education begins at Bahia Vista elementary school. This is an essential part of growing up in the United States and anything that takes away this opportunity would be devastating. One way in which Bahia Vista could be taken out is through sea level rise. If the water increases by just fifty centimeters, then the school would no longer be high, dry and ready for learning. Majority of scientist predict that sea level rise would rise to fifty centimeters between 2050 and 2060. (3) In just 35 years, there is a chance these children will have no place to obtain basic knowledge, or they will be forced to go to other school like Vanesia Valley school with extremely crowded classrooms(point blue). Overall, there must be a counter method to sea level rise in order to maintain not only education for canal residents, but also living spaces.

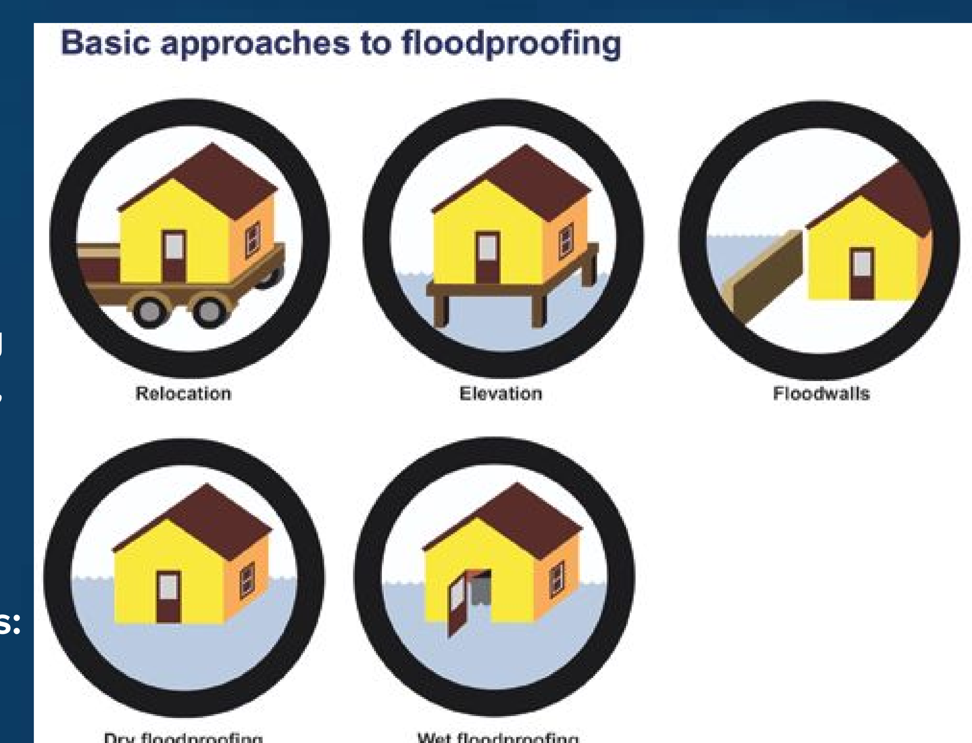
Protection Methods

Relocation: (Fig. 1) a structure is taken off of its foundation and moved to a new location with less flood hazards. **Advantages:** reduces flood risks, can easily be done, and can eliminate the need for flood insurance. **Disadvantages:** can be cost-prohibitive, a new site has to be found, the old site must be restored, and there could be more costs to readjust the building in its new location (5)

Dry Floodproofing: (Fig. 1) make houses water tight by adding special wall coatings, waterproofing compounds and impermeable sheeting and wall systems. **Advantages:** reduced flood and damage risks, can cost less than other retrofitting measures, no extra land needed, and the looks of the building remain relatively the same. **Disadvantages:** more maintenance is need, does not reduce flood insurance premiums, evacuation is still needed, exterior might be damaged, not always aesthetically pleasing, might fail in extended exposure, and could damage the inside of the building if sealants fail. (5)

Elevation: (Fig. 1) a structure is lifted off its foundation ad placed on an open foundation like piers, posts, columns and piles. **Advantages:** reduces flood risk, reduces flood insurance premiums, easy to contract people to do it, and there is no need to add additional floodwalls or levees. **Disadvantages:** can be cost-prohibitive, changes structure's appearance, changes access to structure, cannot be elevated in certain extreme conditions, and will need extra reinforcements to make sure the building can withstand the forces. Structures will most likely be protected from flooding but it will face other problems such as wind, tectonic activity, erosion, scour, debris flow, mudslides, etc. (5)

Figure 1 (6)



Wet Floodproofing: (Fig. 1) a building is modified to allow water to enter and damage as little as possible. Items like furnaces and other utilities are relocated to safer grounds so that they are not compromised. **Advantages:** reduces flood damage to a building, reduces loads on walls, may be able to get flood insurance, costs less, and no extra land is required. **Disadvantages:** does not reach NFIP requirements, needs warnings before floods, needs people to actually move the items, extensive cleanup can be required, need to evacuate when there is a flood, might take time before structure is usable again, floodable area is not as usable, maintenance, and possible additional costs in bringing the building up to code.

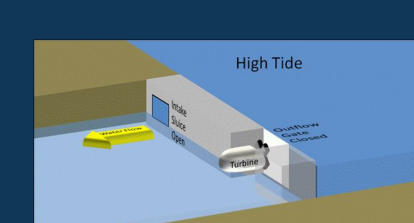


Figure 2: Tidal Gates (7)

Figure 3: Horizontal Levees (8)

Floodwalls & Levees: (Fig. 1) barriers can be placed between the house and the floodwaters. Floodwalls - maximum of 4 feet and built of bricks and other materials. Levees - maximum of 6 feet due to cost, aesthetics, access, water pressure, and space and are built out of materials such as impervious soils. **Advantages**: not very many significant structural changes, less pressure from floodwaters on the home, costs less than elevating or relocating, and, of course, reduces flood risks. **Disadvantages:** does not reach NFIP requirements, floodwaters can rise over, can be expensive, there can be maintenence, needs interior draining, does not reduce flood insurance, possible restrictions in access to structure, can require more land for levees, there is still a need to evacuate, and could violate codes. (5)

Horizontal Levees: (Fig. 3) Horizontal levees differ from traditional levees because they use green infrastructure to protect from floods, creates habitats, helps wastewater discharge and provides recreation. They are normally implemented on the coastlines along with wetlands restorations. This is one of the methods we are exploring to implement in the canal to prevent future flooding from King tides and high tides. (10)

Tidal Gates: (Fig. 2) Tidal gates help control the flow of water from tides. It is normally a hinged door that can open and close and is controlled by a timing mechanism. This is another method we are considering putting in the San Rafael creek to prevent tides from flooding upstream when there are King tides and high tides. We do have to consider the fact that the river will be flowing and that there may be a need for a pump to excess water from behind the tidal gate. (9)

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Our Methods

Initially, we used a "flood map" from Our Coast, Our Future (3), which showed areas that would be flood-prone or underwater at variable increments of projected sea level rise. It allowed us to look more specifically at how the annual, 20 year and 100 year floods plus king tides could affect our local Bay Area community and we were able to zoom in on the Canal in particular. As it stands, king tides occur every so often, king tides being an unofficial term for exceptionally high tide events that occur when the sun and moon's gravitational pulls are in alignment (4). Online, it is possible to find copious king tide photos from along Richardson Bay (Mill Valley, Sausalito, Tiburon, etc.), yet photos of king tides from the low-lying, coastal Canal District are scant to nonexistent. Judging by the elevation profile of the area (3), however, as well as what little we could find online, present day king tides and future sea level rise are a serious problem in the Canal. One day, we hope to be able to do a more detailed in-person study of King Tides in the Canal, but until then we can only model as best we can, and strategize ways for people to avert the most hazardous outcomes of sea level rise in one of Marin's most underrepresented communities.

Discussion

All of the Protection Methods are ones that could prevent damage from flooding and/or flooding in general. All of the methods vary in cost based on needs of each home or neighborhood:

- Elevation of family homes: ~$45,000 - 200,000
- Elevation of commercial buildings: ~$1-20 million
- Backflow preventers (dry floodproofing):
  - Small (e.g. laundromats); ~$3,000 - 5,000
  - Mid (e.g. office buildings): ~$7,500 - 13,000
  - Large (e.g. hospitals): ~$14,000 - 34,000
- Flood shields (dry floodproofing): ~$180-250 per square foot
- Sealants and impermeable membranes: ~$2.50-7.50 per linear foot
- Levees per linear foot:
  - 2 fee height: ~$60
  - 4 feet height: ~$106
  - 6 feet height: ~$170
- Floodwalls per linear foot:
  - 2 feet height: ~$92
  - 4 feet height: ~$140
  - 6 feet height: ~$195
- Wet floodproofing family home: ~$100,000
- Wet floodproofing commercial building: ~$1.5 million (11)
- Relocation: $12-16 per square foot (12)
- Traditional levees: $12.5 million per mile over 50 years
- Tidal Marsh levee: $6.3 million per mile over 50 years
- Brackish Marsh levee: $6.6 million per mile over 50 years (13)

All of which are subject to change depending on the house/building, the materials used, and the contractors. The most eco-friendly and helpful method of prevention would be a combination of a horizontal levee and a tidal gate, both of which could be very costly but over time would help the ecosystem and keep floodwater away from the Canal. Other methods are better for individual homes and would only really be necessary if the implementation of the tidal gate and the horizontal levee does not occur.

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