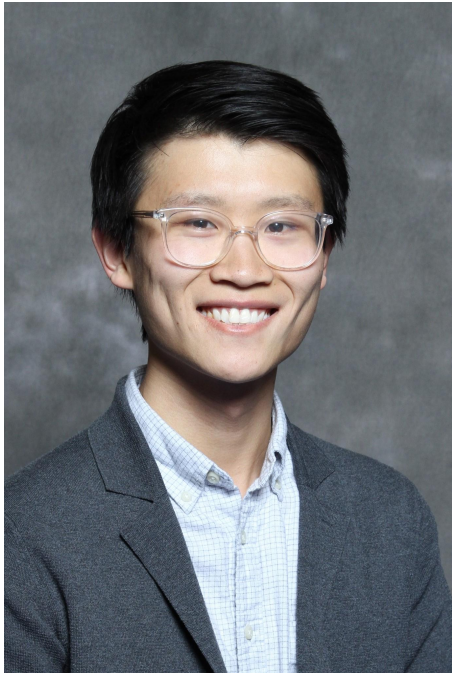
# Derek Ouyang

- B.S. Architectural Design
- B.S. Civil Engineering
- M.S. Structural Engineering
- Lecturer at Stanford University
  Sustainable Urban Systems Initiative
  http://sus.stanford.edu
- Co-founder of non-profit City Systems
- douyang1@stanford.edu



Stanford | ENGINEERING
Sustainable Urban Systems Initiative

NOTE: ALL RESULTS IN THIS PRESENTATION ARE PRELIMINARY

# Key Takeaways

1. NFO is not at significant direct risk of coastal flooding, but may face significant indirect risks through network effects such as transportation and socioeconomic vulnerability.

# Key Takeaways

1. NFO is not at significant direct risk of coastal flooding, but may face significant indirect risks through network effects such as transportation and socioeconomic vulnerability.

2. The Stanford Sustainable Urban Systems graduate project course seeks to partner with NFO stakeholders to make progress on sea level rise risk mitigation and other urban problem solving.

# Key Takeaways

1. NFO is not at significant direct risk of coastal flooding, but may face significant indirect risks through network effects such as transportation and socioeconomic vulnerability.

2. The Stanford Sustainable Urban Systems graduate project course seeks to partner with NFO stakeholders to make progress on sea level rise risk mitigation and other urban problem solving.

3. El Concilio, Siena Youth Center, NFO Community Council, and Stanford SUS submitted a proposal for SMC Communities Resilience grant, seeking $90,000 for 2019. We expect to hear about finalists in October.

# Stanford Urban Risk Framework

Hazard

Coastal Flood Maps

+

Exposure

Structure Value and Use

+

Vulnerability

Depth-Damage Curves

=

Risk

Aggregate For Regional Damage

# Components of the Urban Risk Framework

Hazard

Coastal Flood Maps

+

Exposure

Structure Value and Use

+

Vulnerability

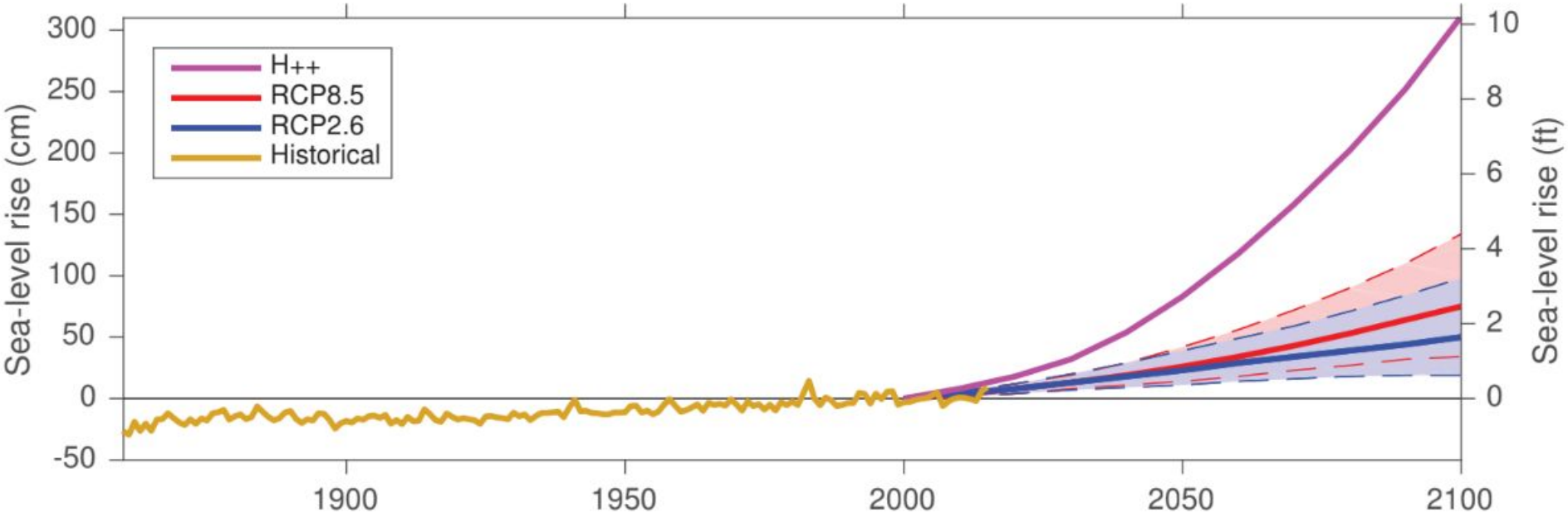
Depth-Damage Curves

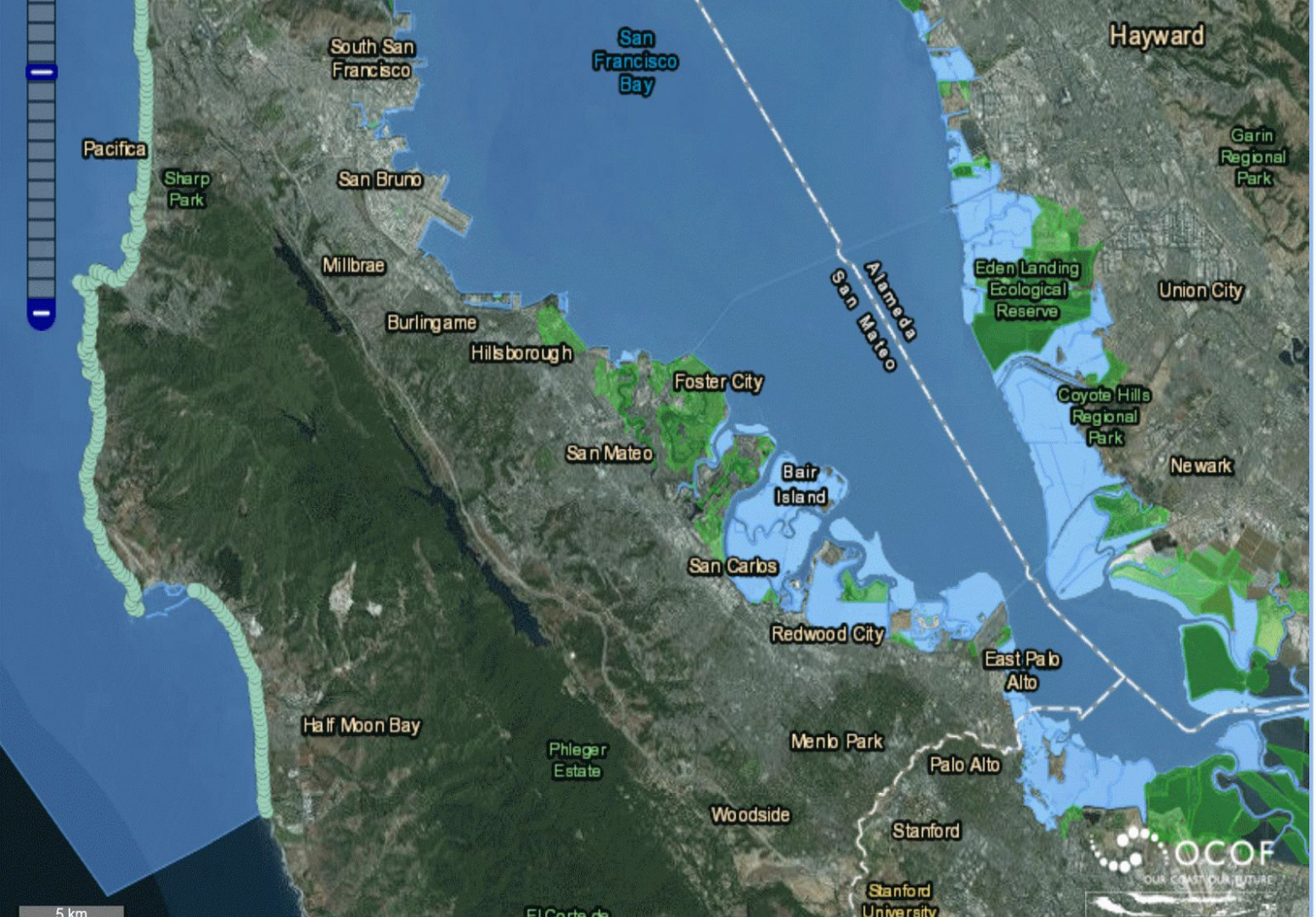
=

Risk

Aggregate For Regional Damage

## (b) Relative sea level in San Francisco, California






Flood Hazard 000cm SLR + Wave 001

Flood Depth 000cm SLR + Wave 001

No Data

0 cm

250 cm

500 cm

750 cm

# Components of the Urban Risk Framework

Hazard

Coastal Flood Maps

+

Exposure

Structure Value and Use

+

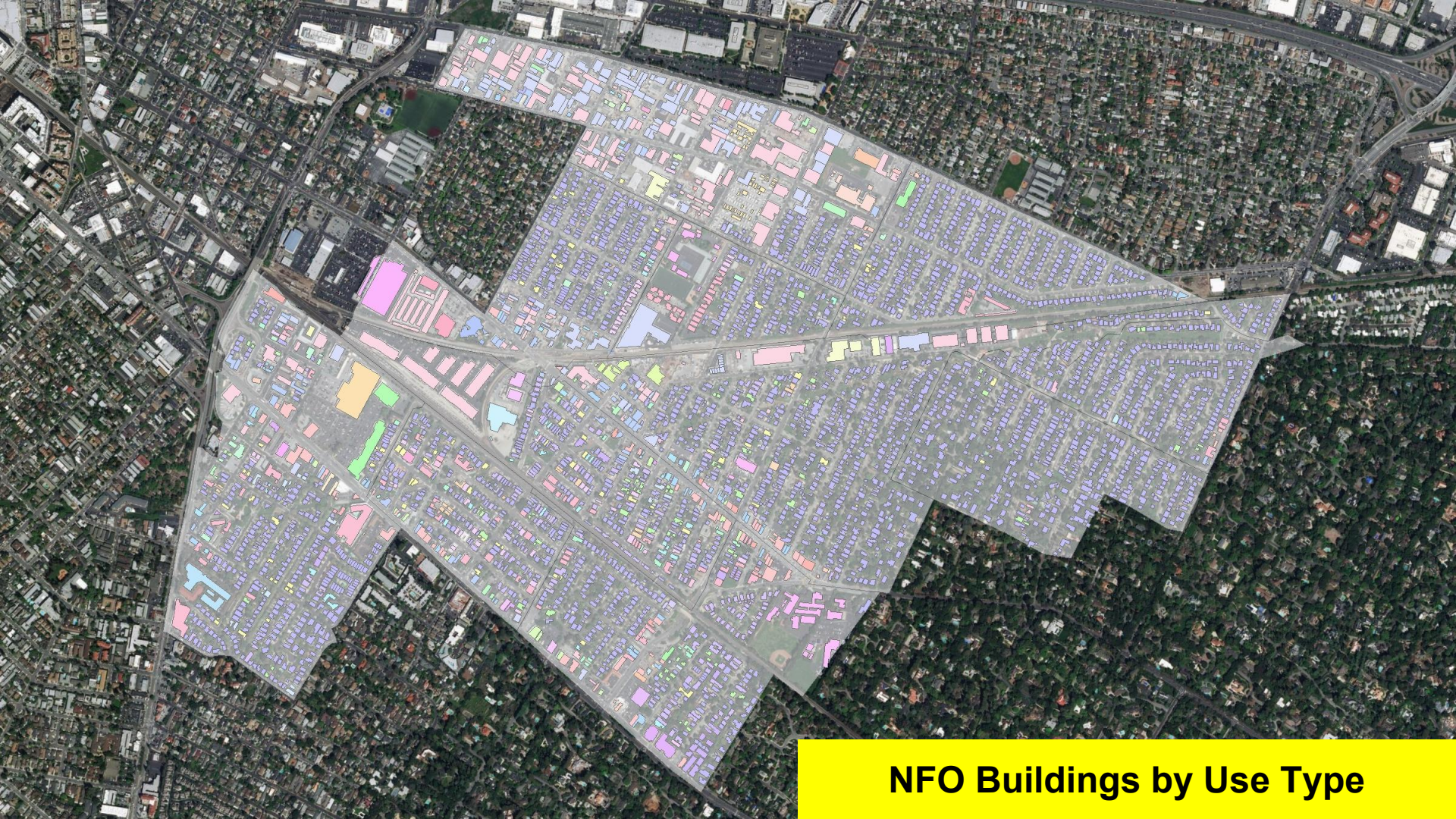
Vulnerability

Depth-Damage Curves

=

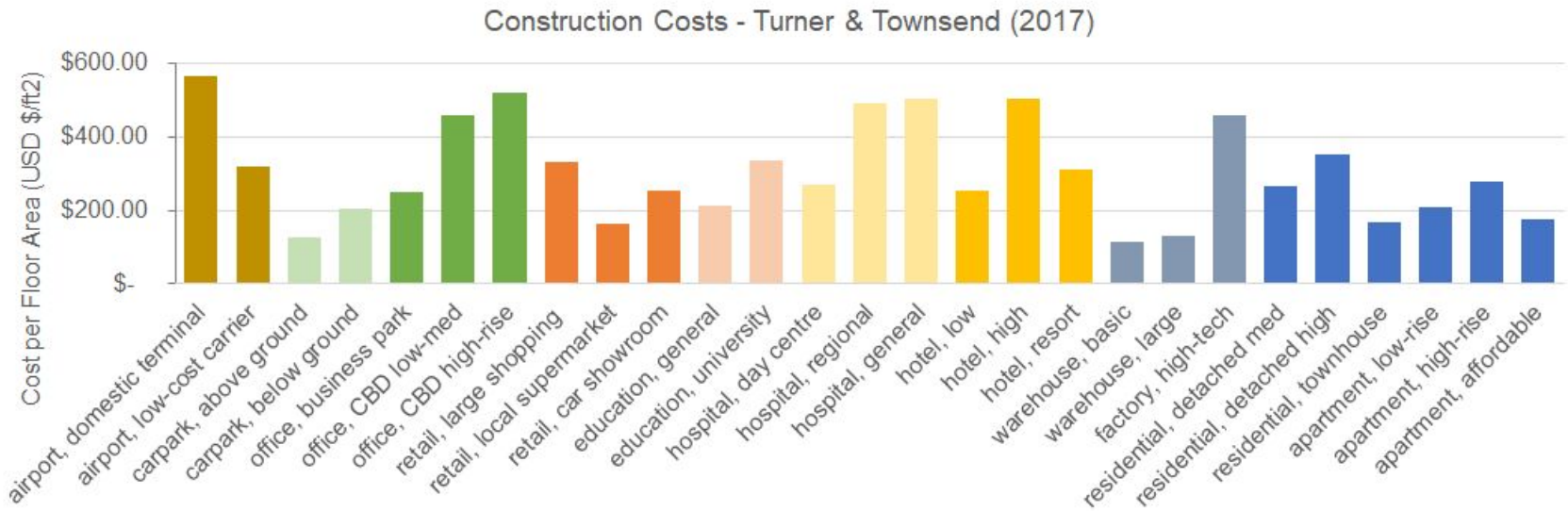
Risk

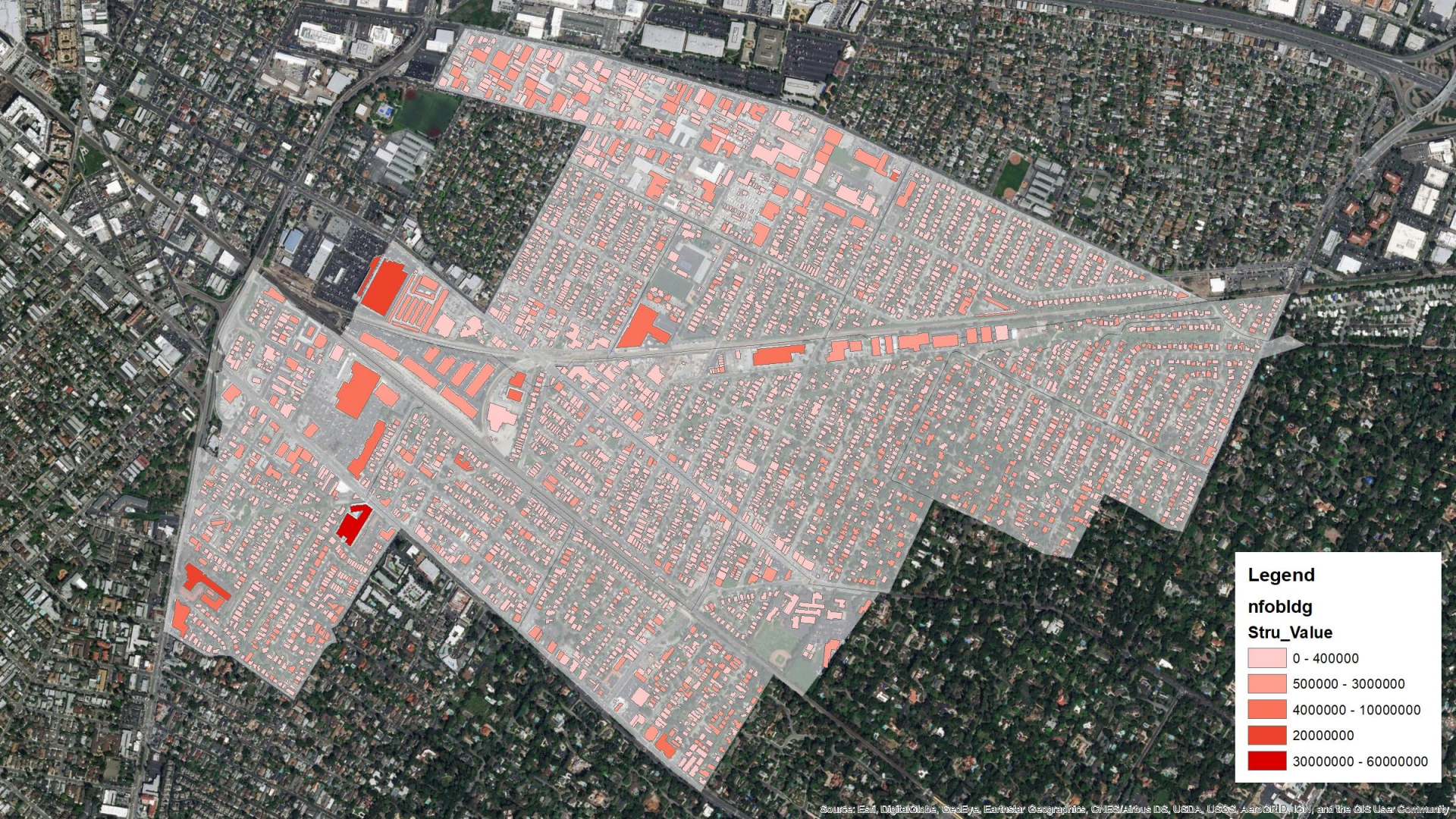
Aggregate For Regional Damage



NFO Buildings by Use Type

# Structure Value and Use




Legend
nfobldg
Stru_Value
0 - 400000
500000 - 3000000
4000000 - 10000000
20000000
30000000 - 60000000
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

# Components of the Urban Risk Framework

Hazard

Coastal Flood Maps

+

Exposure

Structure Value and Use

+

Vulnerability

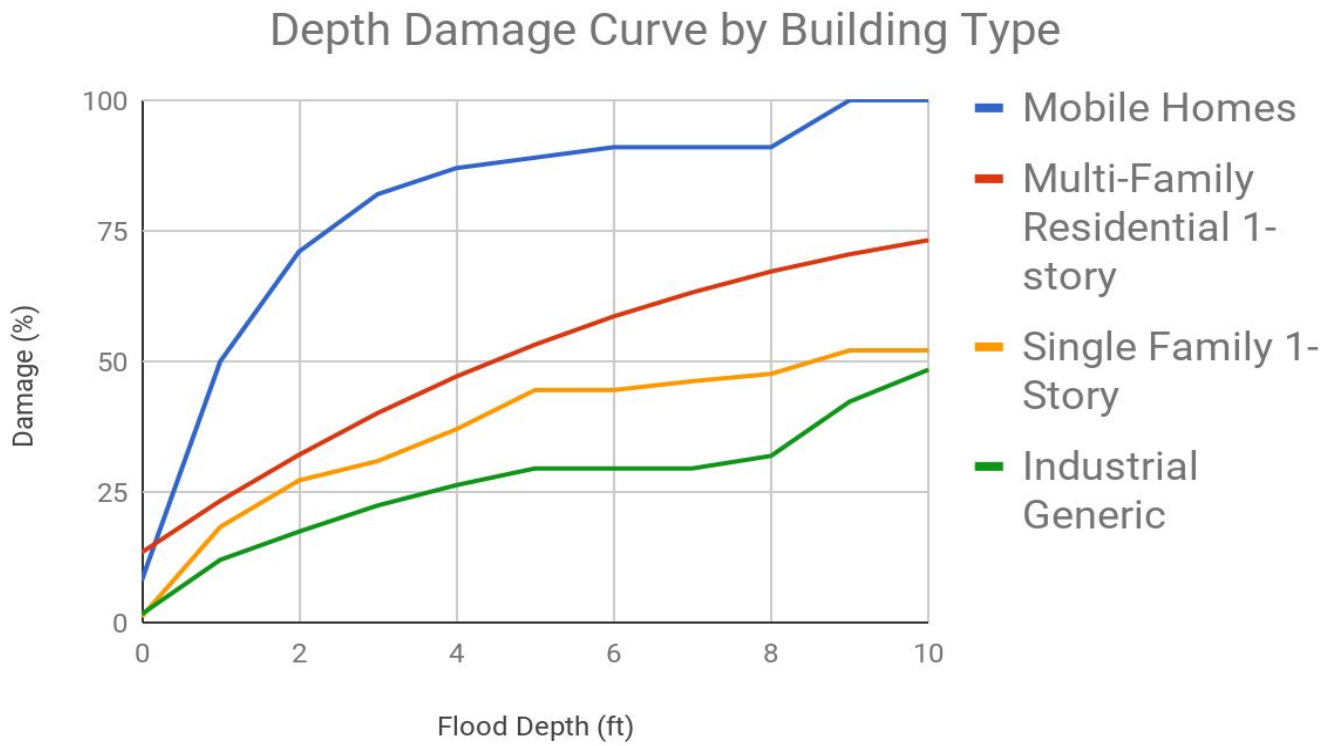
Depth-Damage Curves

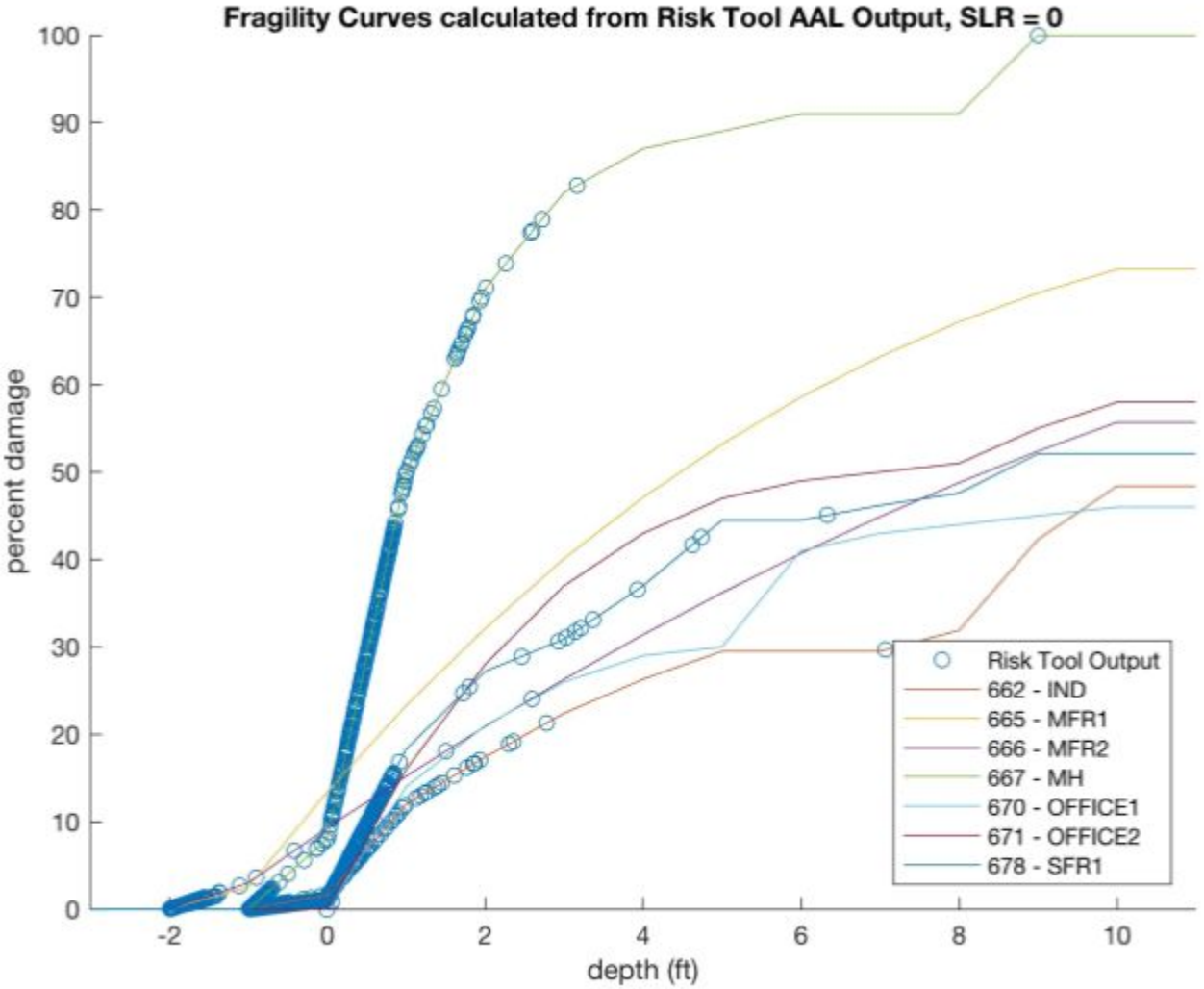
=

Risk

Aggregate For Regional Damage

# USACE Depth-Damage Curves




Fragility Curves calculated from Risk Tool AAL Output, SLR = 0
percent damage
depth (ft)
0
10
20
30
40
50
60
70
80
90
100
-2
0
2
4
6
8
10
Risk Tool Output
662 - IND
665 - MFR1
666 - MFR2
667 - MH
670 - OFFICE1
671 - OFFICE2
678 - SFR1

# Components of the Urban Risk Framework

Hazard

Coastal Flood Maps

+

Exposure

Structure Value and Use

+

Vulnerability

Depth-Damage Curves

=

Risk

Aggregate For Regional Damage

# How likely is a 100-year flood in the next 100 years?

A 100-year flood has a 1% annual exceedance rate. There is a 1% chance in any given year that a flood of this intensity or greater will occur.

# How likely is a 100-year flood in the next 100 years?

A 100-year flood has a 1% annual exceedance rate. There is a 1% chance in any given year that a flood of this intensity or greater will occur.

- What is the likelihood that **NO** 100-year flood happens in one year? **99%**

# How likely is a 100-year flood in the next 100 years?

A 100-year flood has a 1% annual exceedance rate. There is a 1% chance in any given year that a flood of this intensity or greater will occur.

- What is the likelihood that **NO** 100-year flood happens in one year? **99%**

- How about **NO** 100-year flood **two years in a row**? **99% * 99% = 98.01%**

# How likely is a 100-year flood in the next 100 years?

A 100-year flood has a 1% annual exceedance rate. There is a 1% chance in any given year that a flood of this intensity or greater will occur.

- What is the likelihood that **NO** 100-year flood happens in one year? **99%**
- How about **NO** 100-year flood **two years in a row**? **99% * 99% = 98.01%**
- How about **NO** 100-year flood **100 years in a row**? **$(99\%)^{100}$ = 36.66%**

# How likely is a 100-year flood in the next 100 years?

A 100-year flood has a 1% annual exceedance rate. There is a 1% chance in any given year that a flood of this intensity or greater will occur.

- What is the likelihood that **NO** 100-year flood happens in one year? **99%**
- How about **NO** 100-year flood **two years in a row**? **99% * 99% = 98.01%**
- How about **NO** 100-year flood **100 years in a row**? **$(99\%)^{100}$ = 36.66%**
- The alternative is at least one 100-year flood: **1 - 36.66% = 63.4%**

San Mateo County's Vulnerability Assessment (http://seachangesmc.org) was finalized in March 2018 and includes minimal details about NFO-specific risk.

In the baseline scenario (1% annual chance storm in current sea level rise conditions), the assessment shows no exposure at all to NFO assets. **But with 3.3ft of sea level rise, a 100-yr storm would cause damage.**

## North Fair Oaks (Unincorporated)

*Map: Zone 6*

In the unincorporated area of North Fair Oaks, no land is inundated in the baseline scenario, 8 acres are inundated in the mid-level scenario, and 50 acres are inundated in the high-end scenario. In the baseline scenario, 35 parcels are inundated, and portions of Bay Road are affected. One underground chemical storage site is vulnerable in the mid-level scenario. Roads and storm drains (~2% and ~4%, respectively) are also vulnerable in the mid-level scenario. In the high-end scenario, the extent of inundation includes parts of the Spring Street area. Less than 1% of the neighborhood's population is vulnerable under the mid-level scenario.

**GENERAL INFORMATION**

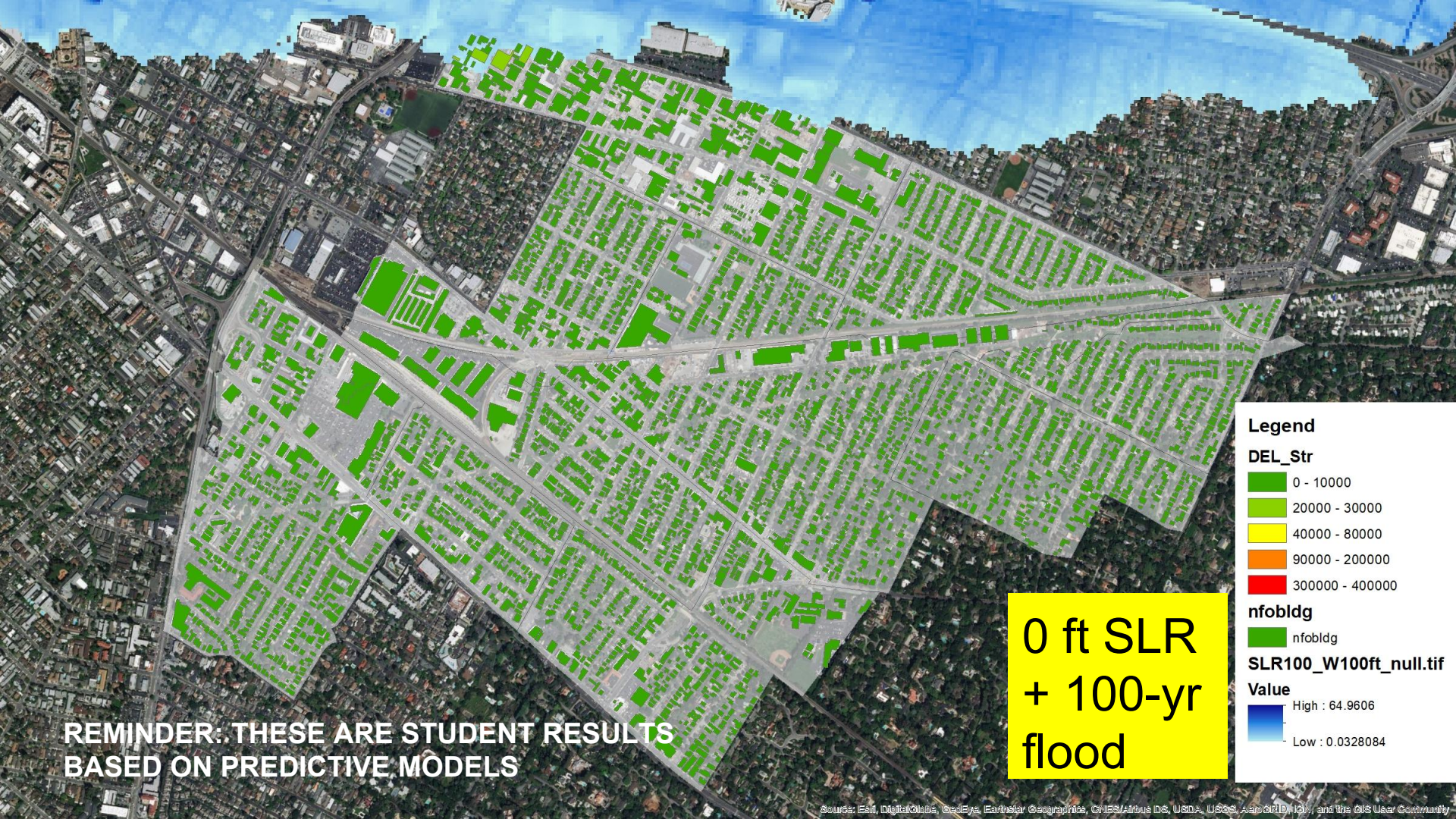
| LAND USE, POPULATION, AND PARCELS | TOTAL | EROSION SCENARIO | BASELINE SCENARIO | MID-LEVEL SCENARIO | HIGH-END SCENARIO |
|---|---|---|---|---|---|
| Land Area (acres) | 766 | 0 | 0 | 8 | 50 |
| Population | 14,500 | 0 | 0 | <100 | 300 |
| Population in Vulnerable Communities[1] | 13,000 | 0 | 0 | <100 | 300 |
| Urban Land (acres) | 766 | 0 | 0 | 8 | 50 |
| Agricultural Land (acres) | 0 | 0 | 0 | 0 | 0 |
| Industrial Land (acres) | 0 | 0 | 0 | 0 | 0 |
| Natural Land (acres) | 0 | 0 | 0 | 0 | 0 |

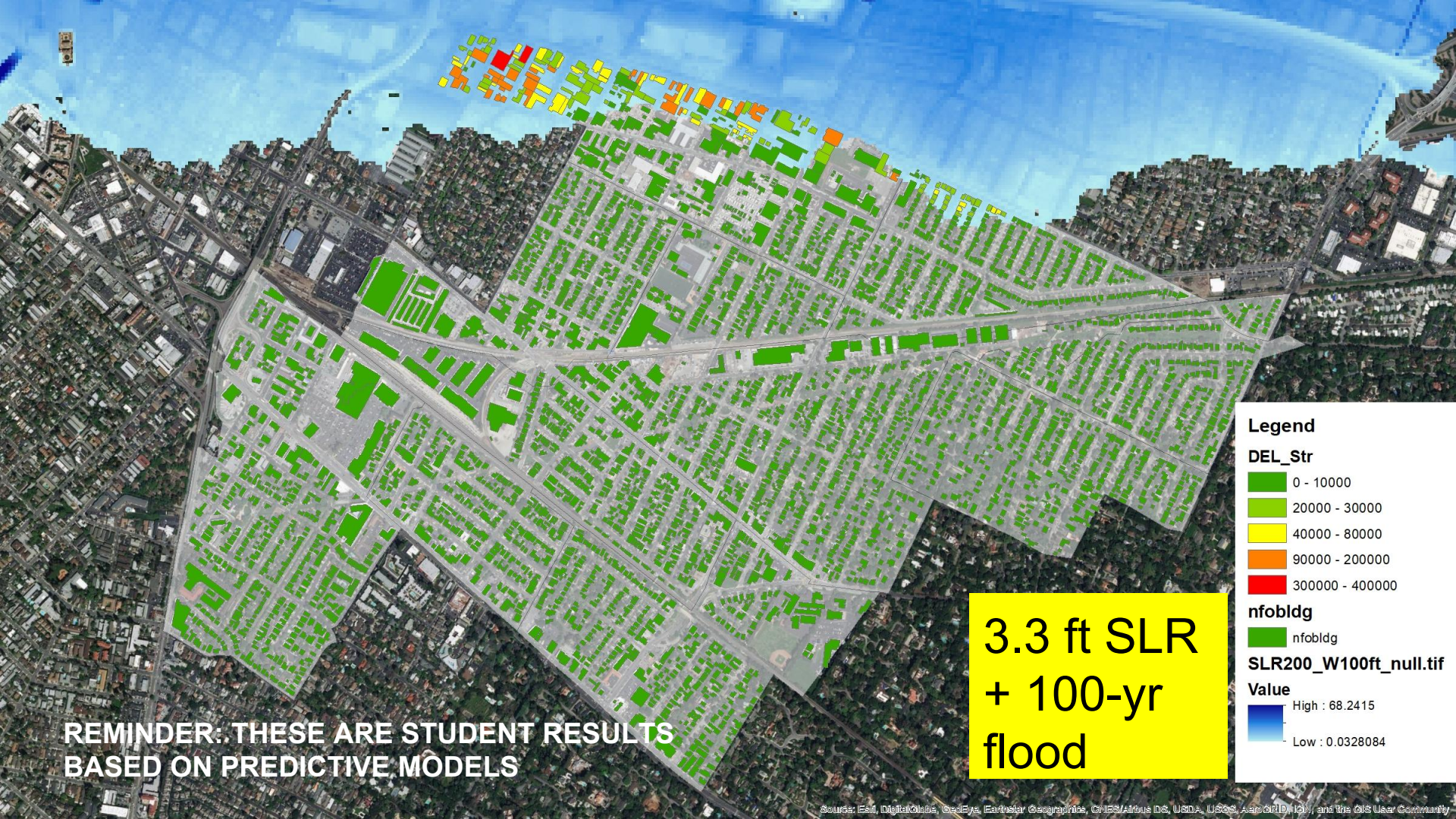


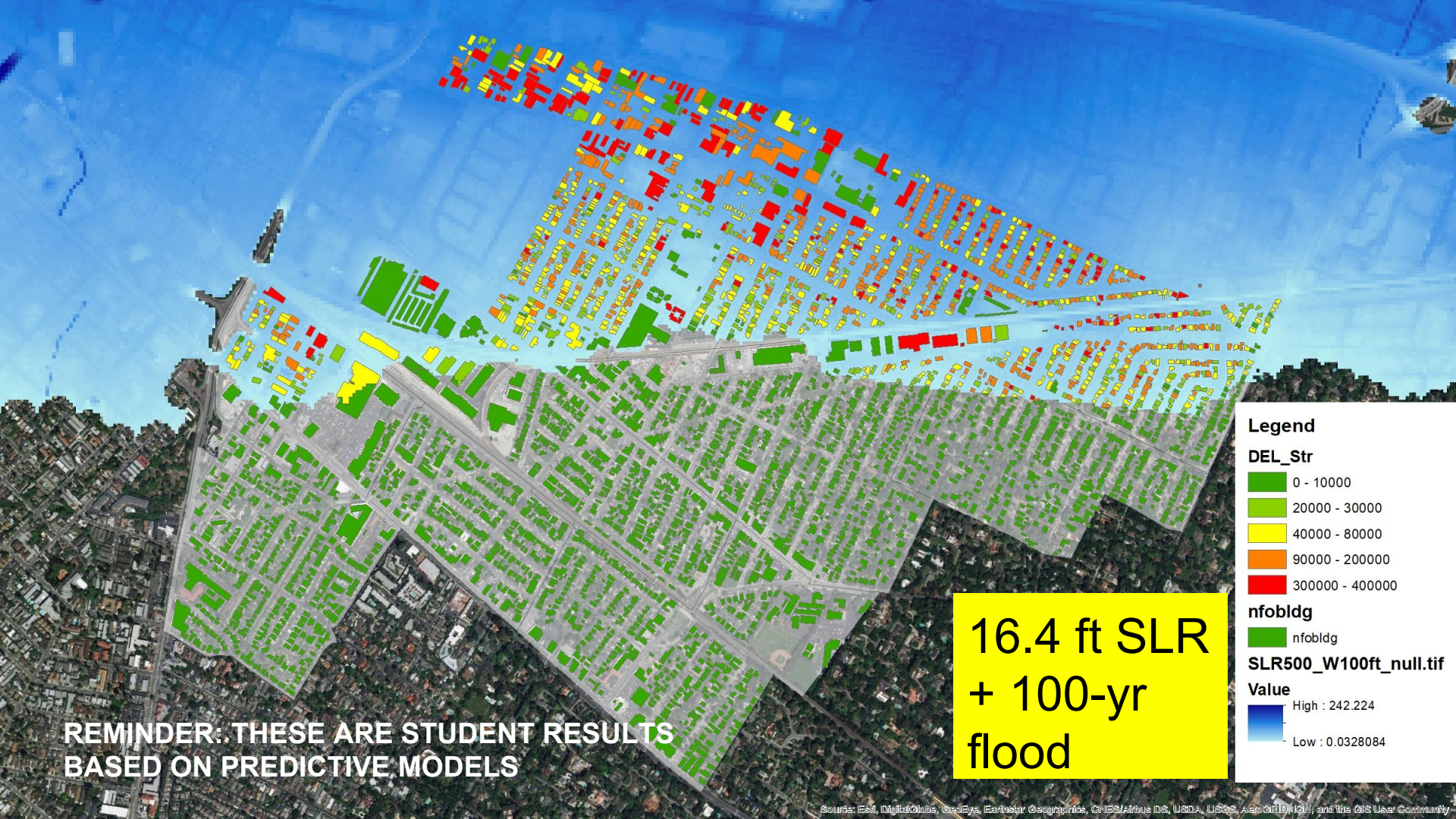


| | | | | | |
|---|---|---|---|---|---|
| Residential Parcels[2] | -- | 0 | 0 | 0 | 56 |
| Commercial Parcels[2] | -- | 0 | 0 | 33 | 102 |
| Other Parcels[2] | -- | 0 | 0 | 2 | 5 |
| Parcels with No Data Available[2] | -- | 0 | 0 | 0 | 0 |
| Assessed Value of All Parcels at Risk ($ in Millions) | $1,586 | $0 | $0 | $19 | $100 |

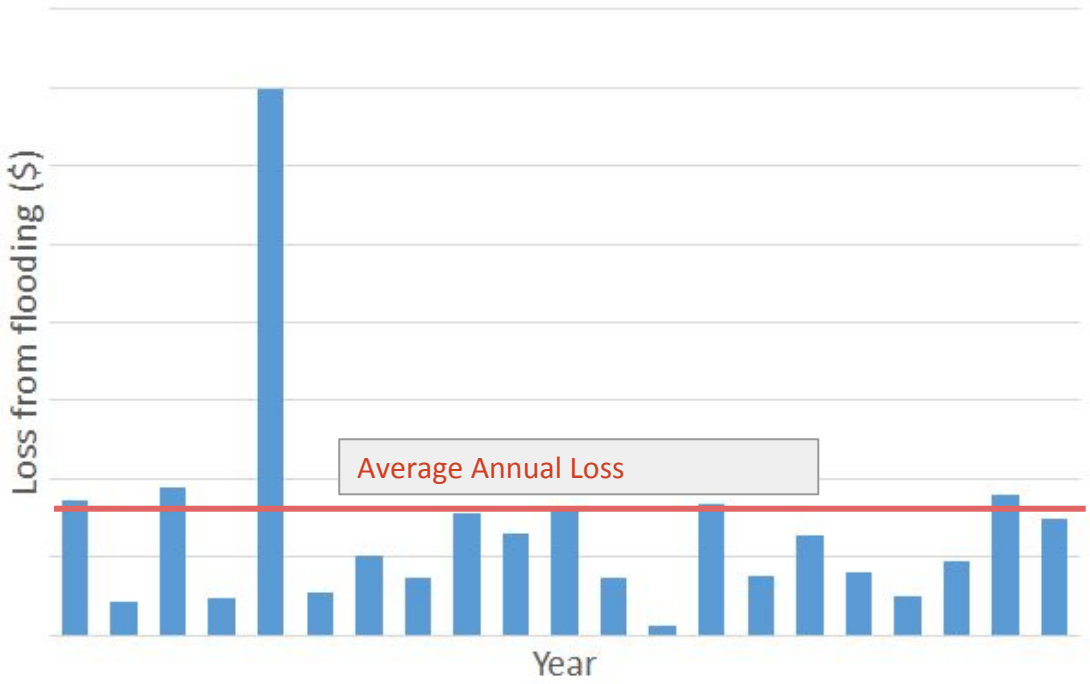
[1]Individuals with characteristics that make them more vulnerable to flooding and other natural disasters; measured at the census block level.
[2]Parcel counts were only inventoried in the hazard zone.


Legend
DEL_Str
0 - 10000
20000 - 30000
40000 - 80000
90000 - 200000
300000 - 400000
nfobldg
nfobldg
SLR100_W100ft_null.tif
Value
High : 64.9606
Low : 0.0328084
0 ft SLR + 100-yr flood
REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

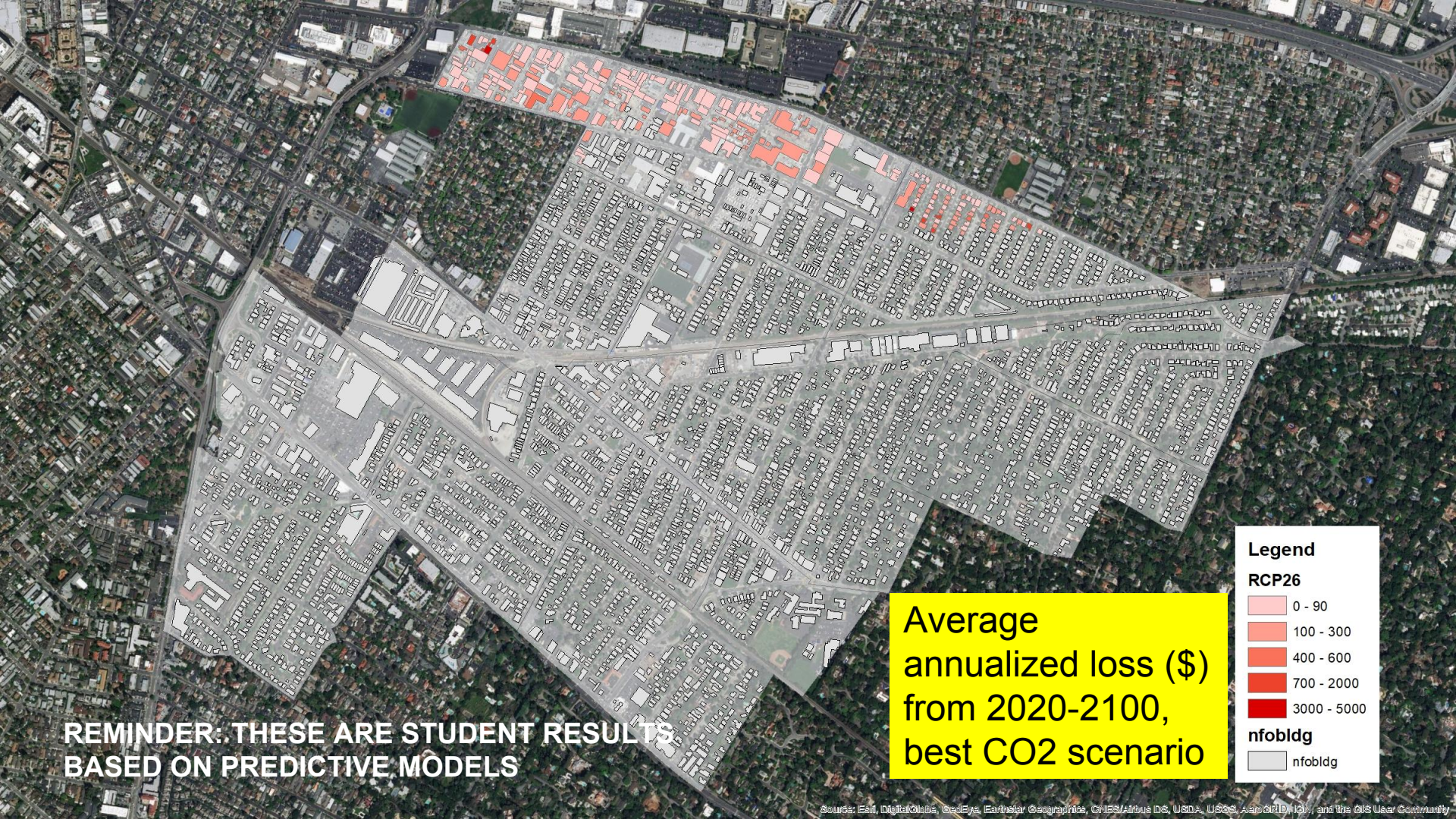

Legend
DEL_Str
0 - 10000
20000 - 30000
40000 - 80000
90000 - 200000
300000 - 400000
nfobldg
nfobldg
SLR200_W100ft_null.tif
Value
High : 68.2415
Low : 0.0328084
3.3 ft SLR + 100-yr flood
REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Legend
DEL_Str
0 - 10000
20000 - 30000
40000 - 80000
90000 - 200000
300000 - 400000
nfobldg
nfobldg
SLR500_W100ft_null.tif
Value
High : 242.224
Low : 0.0328084
16.4 ft SLR + 100-yr flood
REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

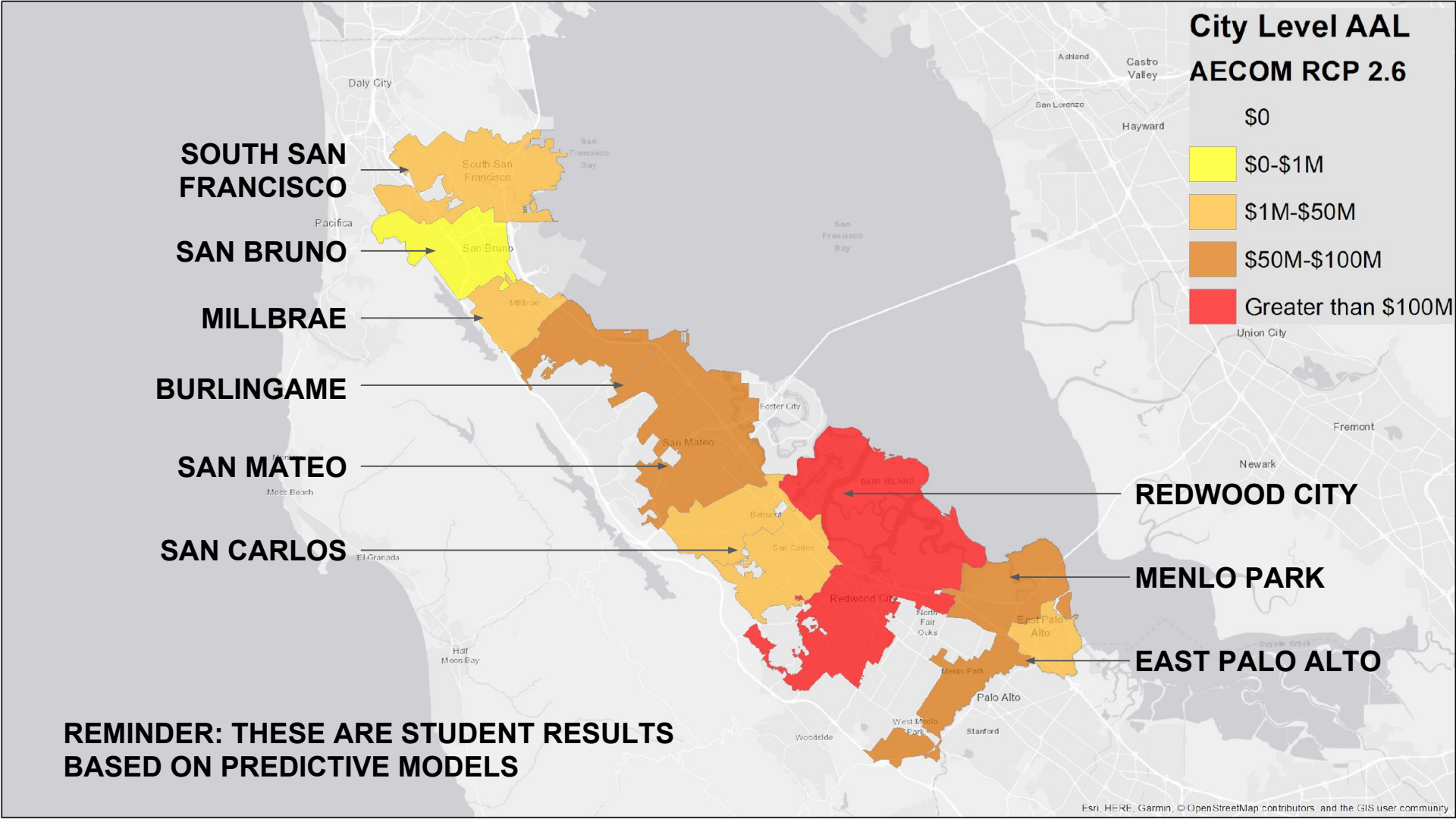
# Calculating Risk: Average Annual Loss



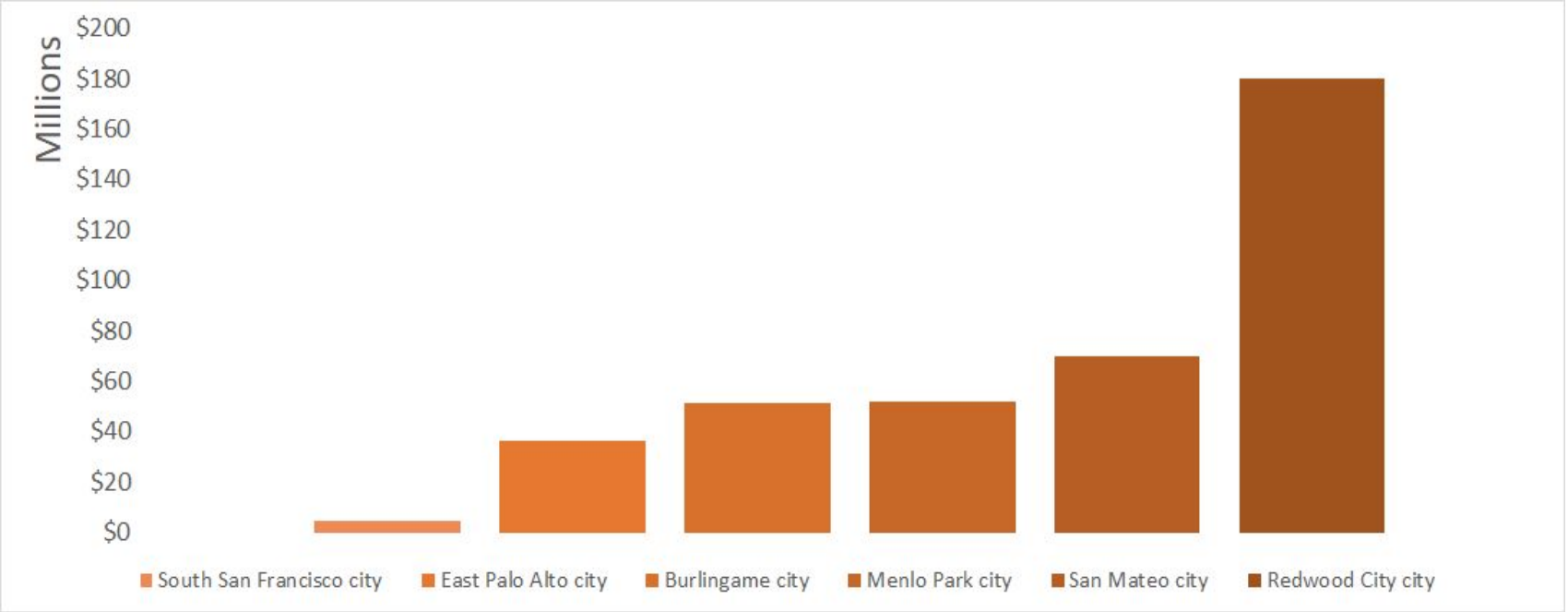

Average Annual Loss for a *single* Sea Level Rise depth


Legend
RCP26
0 - 90
100 - 300
400 - 600
700 - 2000
3000 - 5000
nfobldg
nfobldg
Average annualized loss ($) from 2020-2100, best CO2 scenario
REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend
RCP26
0 - 90
100 - 300
400 - 600
700 - 2000
3000 - 5000
REMINDER: THESE ARE STUDENT RESULTS
BASED ON PREDICTIVE MODELS
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

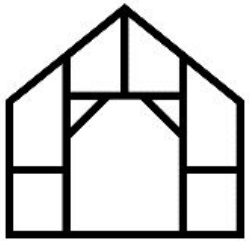

City Level AAL
AECOM RCP 2.6
$0
$0-$1M
$1M-$50M
$50M-$100M
Greater than $100M
SOUTH SAN FRANCISCO
SAN BRUNO
MILLBRAE
BURLINGAME
SAN MATEO
SAN CARLOS
REDWOOD CITY
MENLO PARK
EAST PALO ALTO
REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

# Average Annual Loss by City

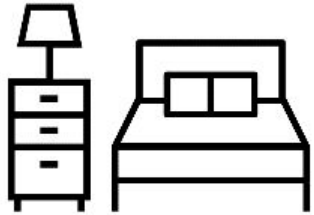



**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

# Calculating Direct Loss for San Mateo County



+



=

$270M

$140M

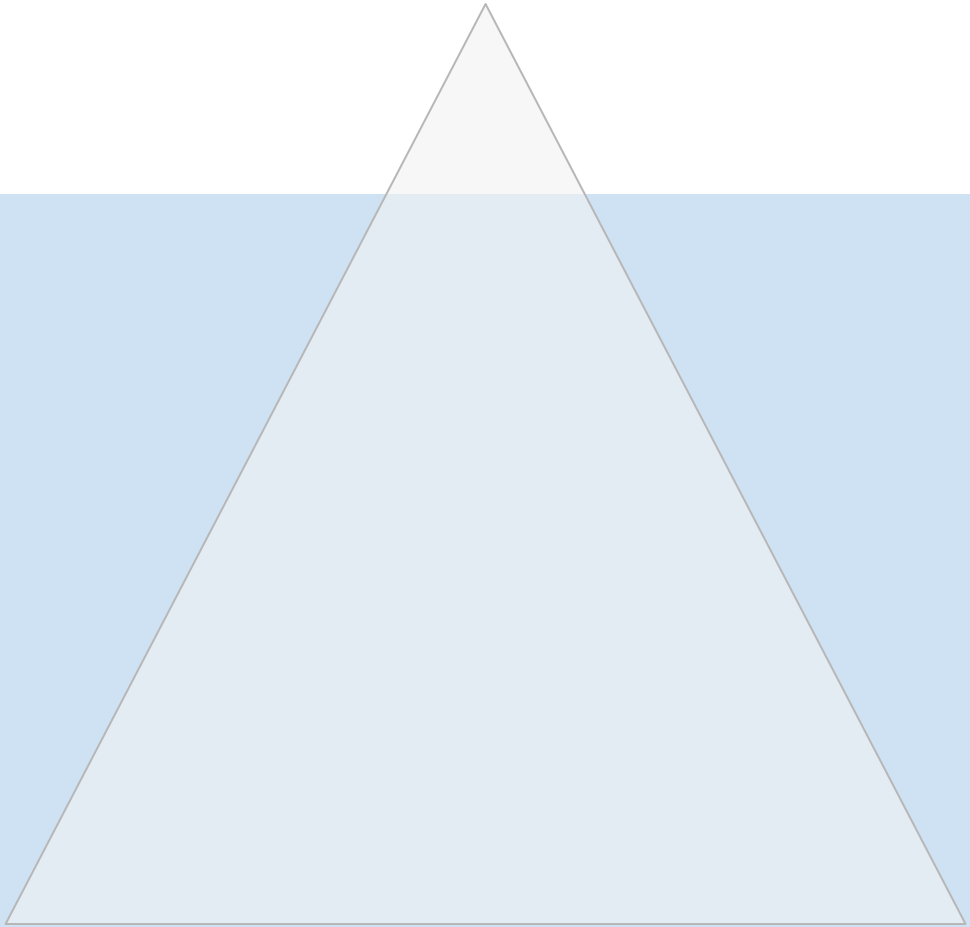
$410M

Structure

Contents

Total

**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**



## THE TIP OF THE ICEBERG

Direct damage to structures and contents

## THE BIGGER PROBLEM

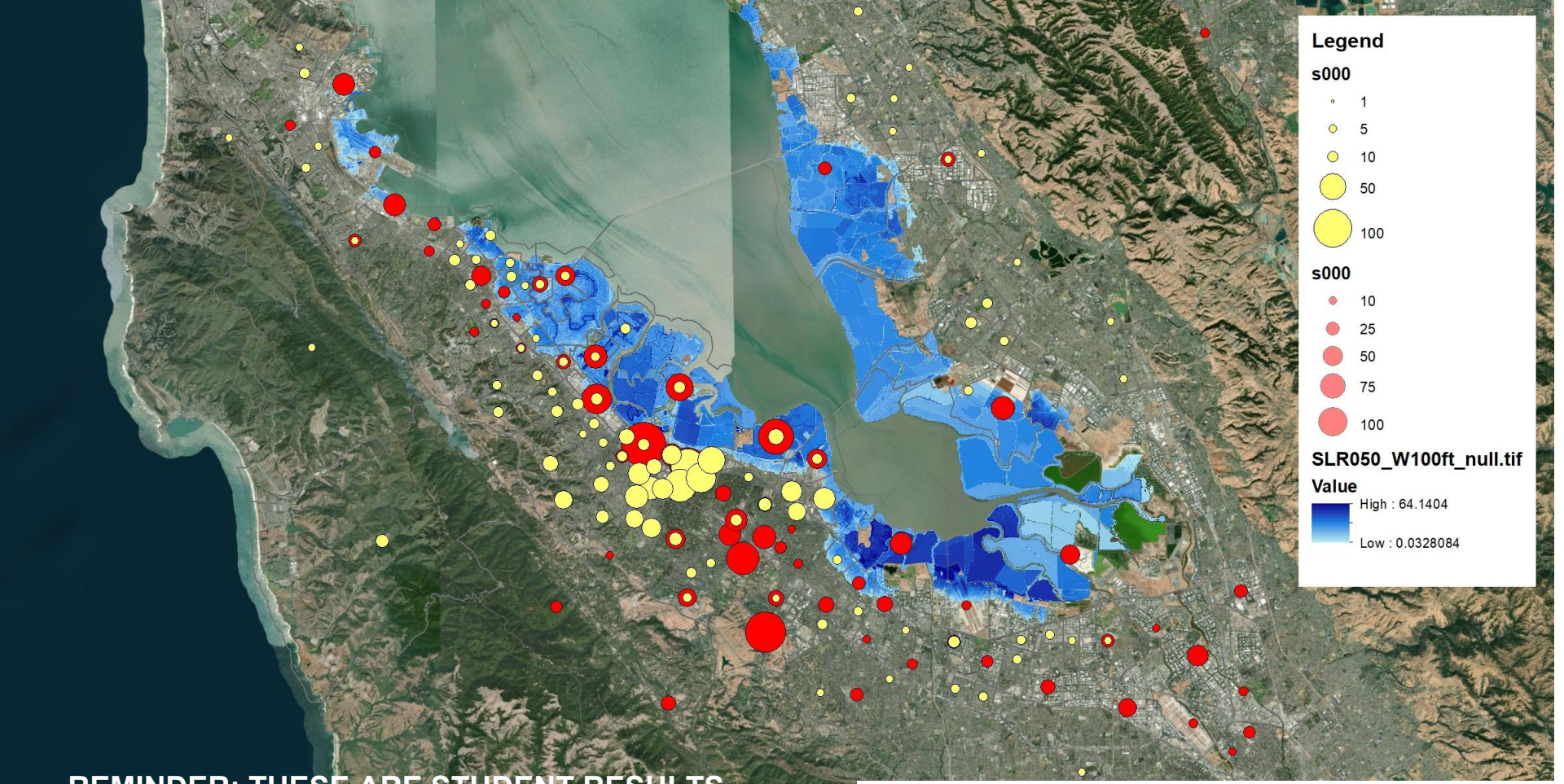
**Utility Disruption**

**Commute Disruption**

**Business disruption**

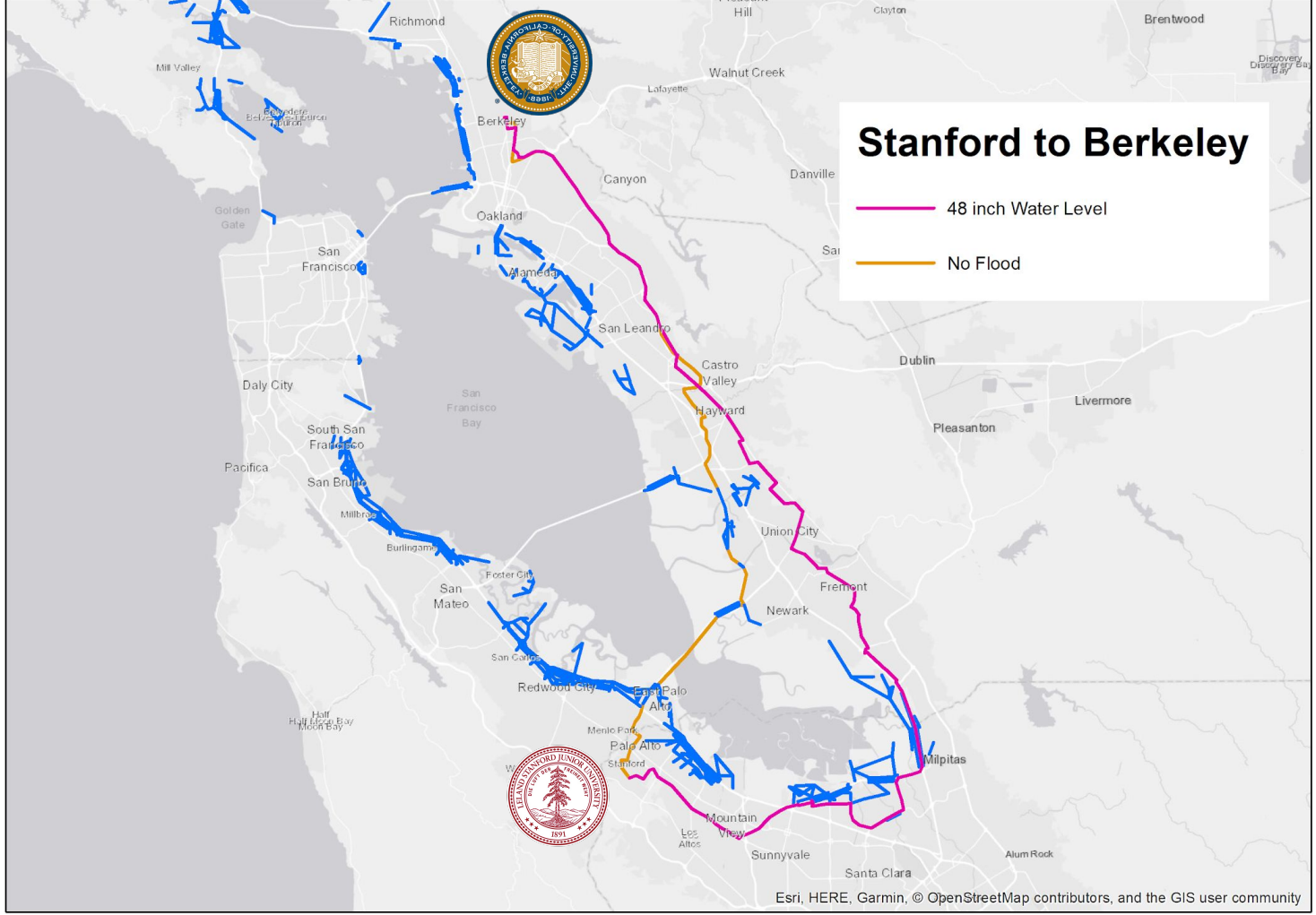
**Exacerbation of poverty**

Etc.

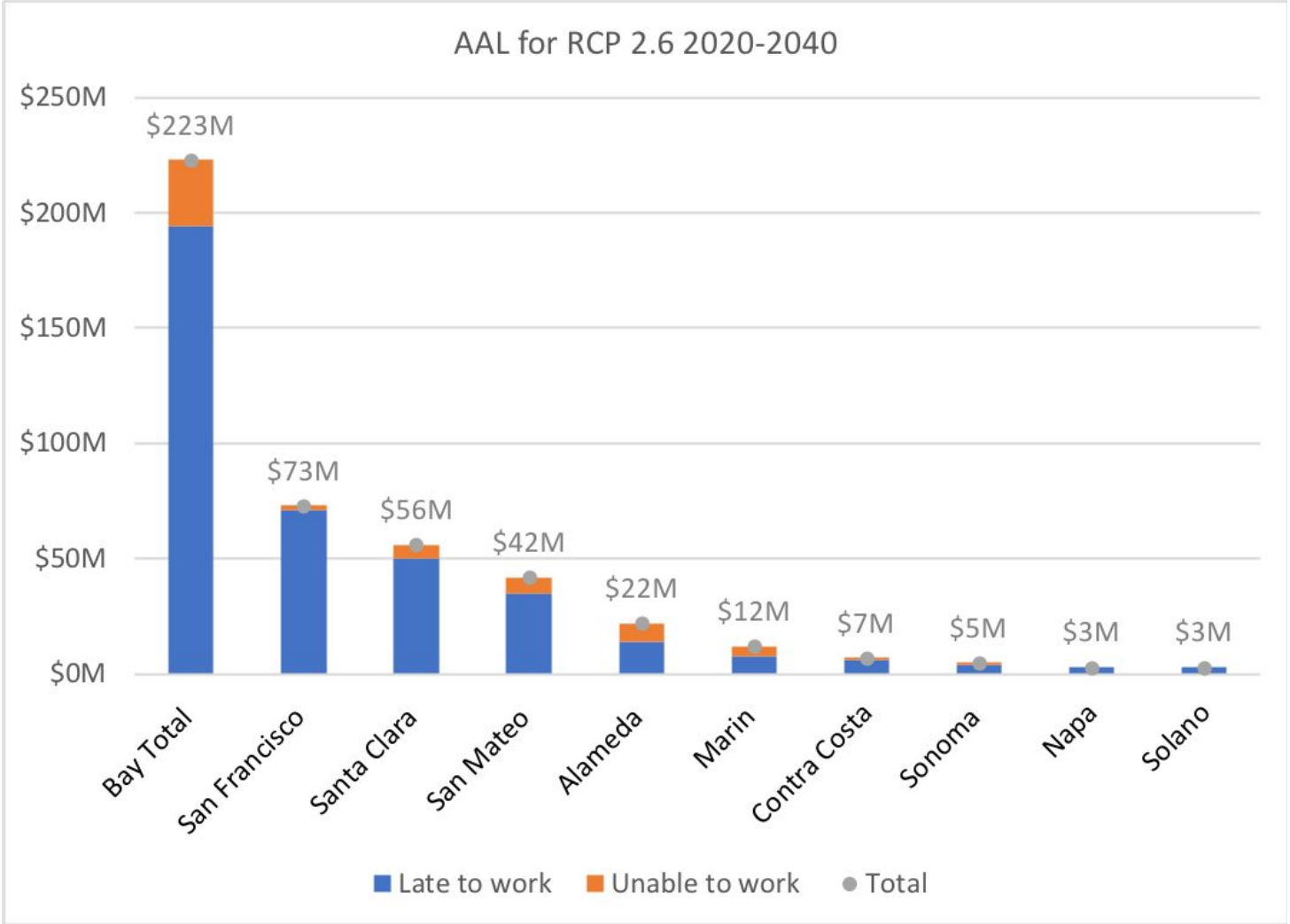



**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

**Red: Where NFO Residents Work**
**Yellow: Where NFO Workers Live**

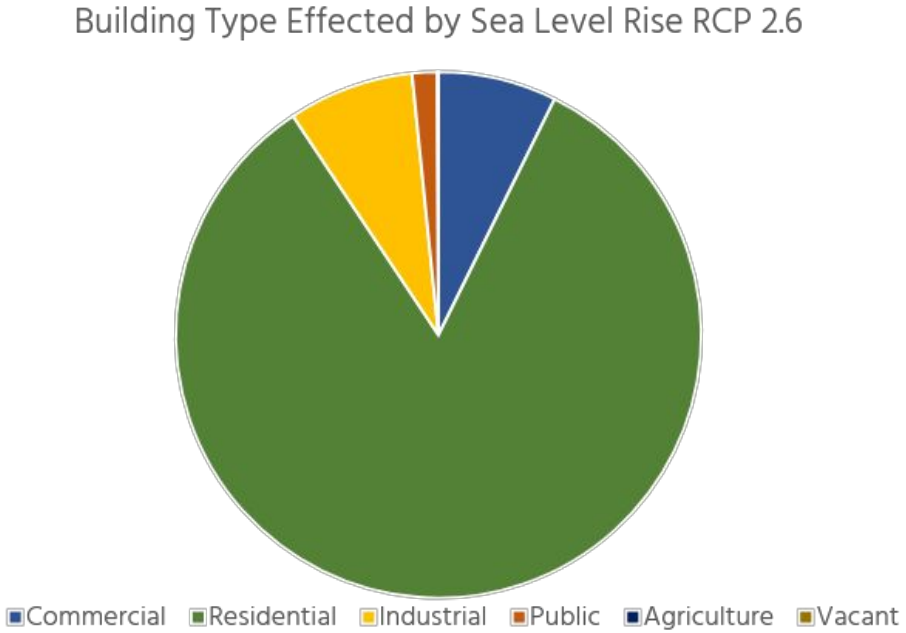


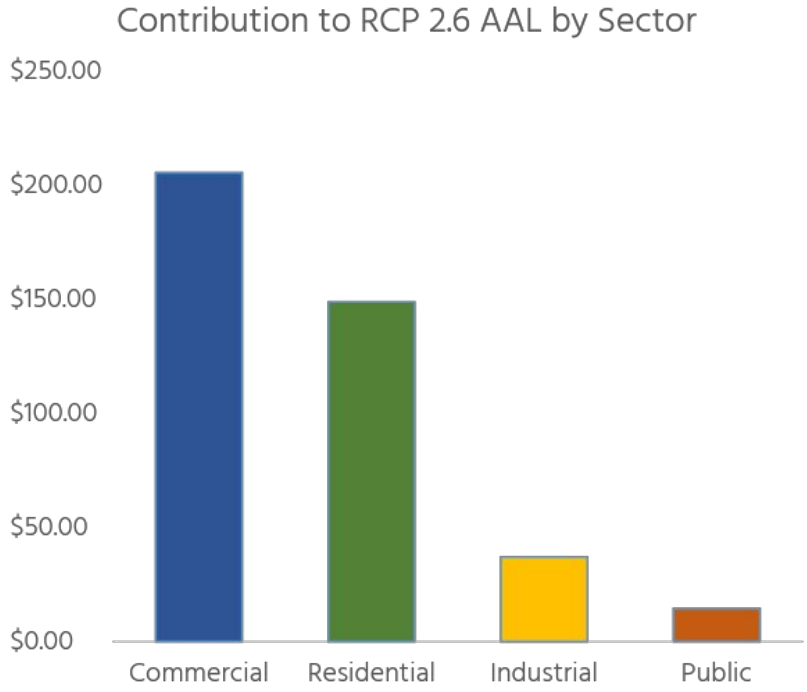

**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**




**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

# Sector Contributions to AAL



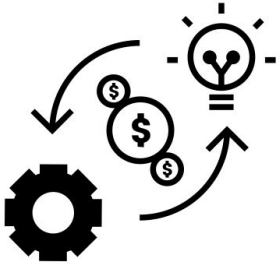



# Business Disruption Categories

## Direct Losses

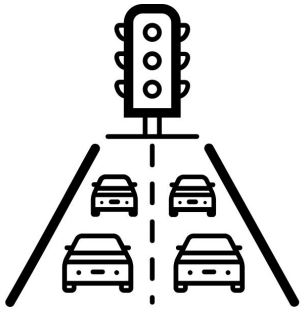
Structure/ Content
AAL Damage

## Indirect Losses

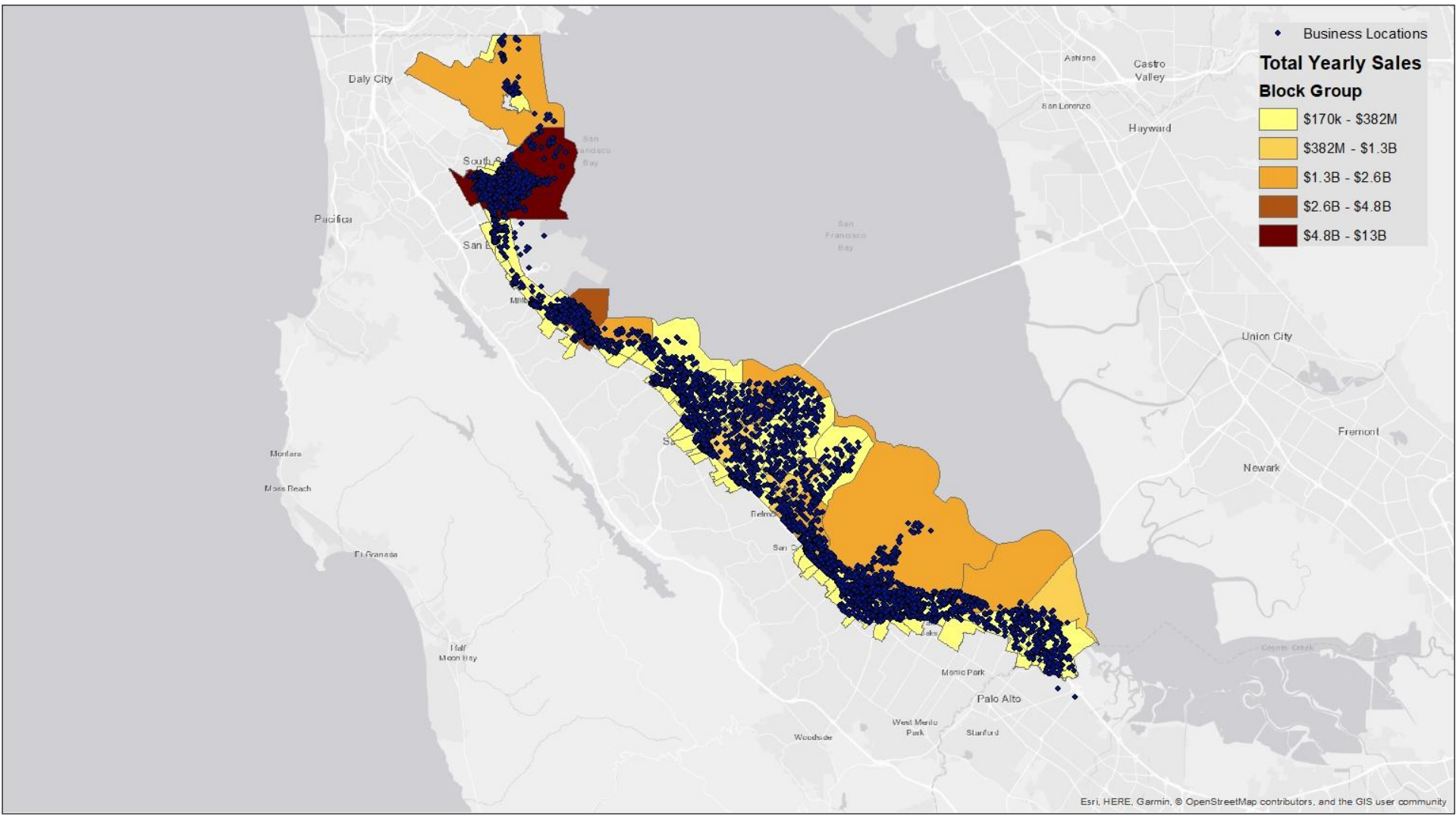


Operational
Disruption

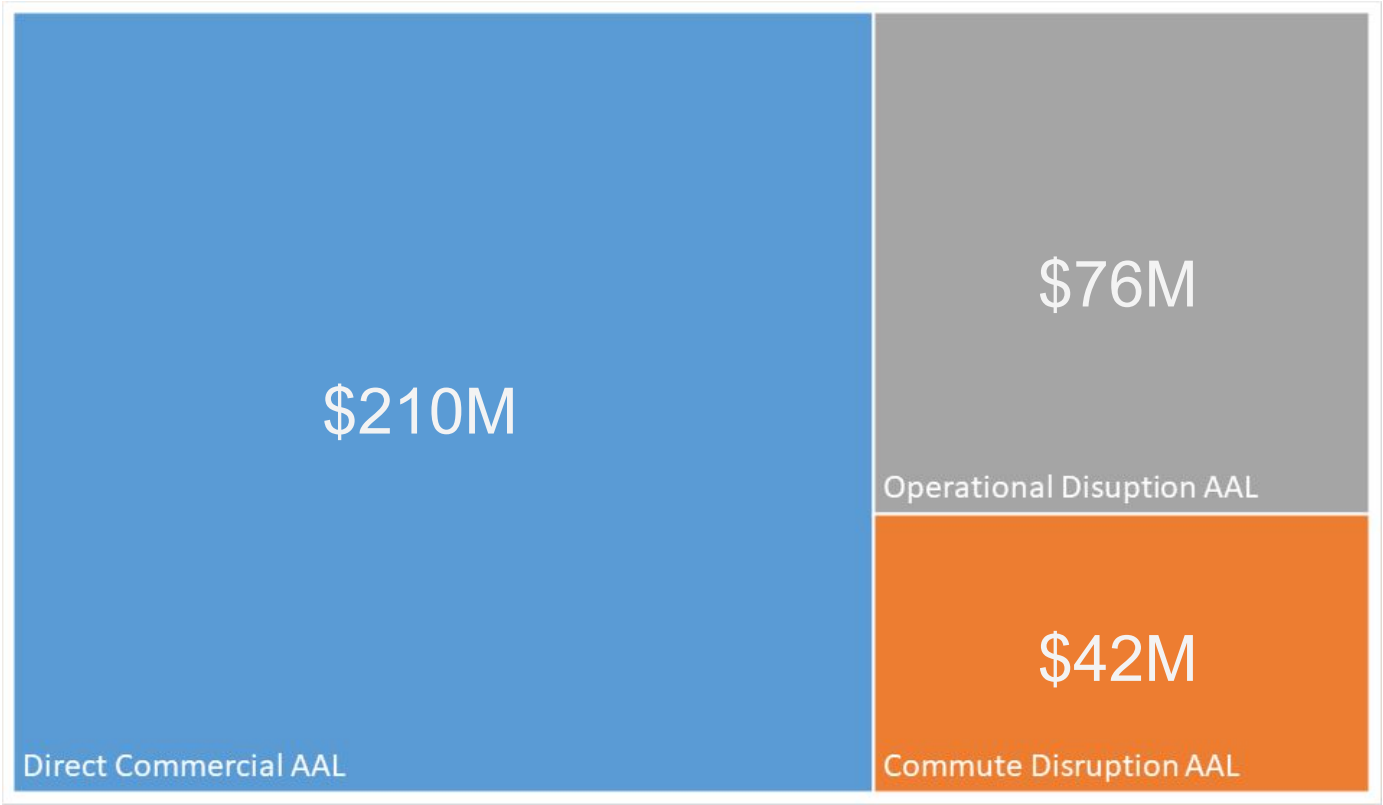
Supply Chain
Disruption



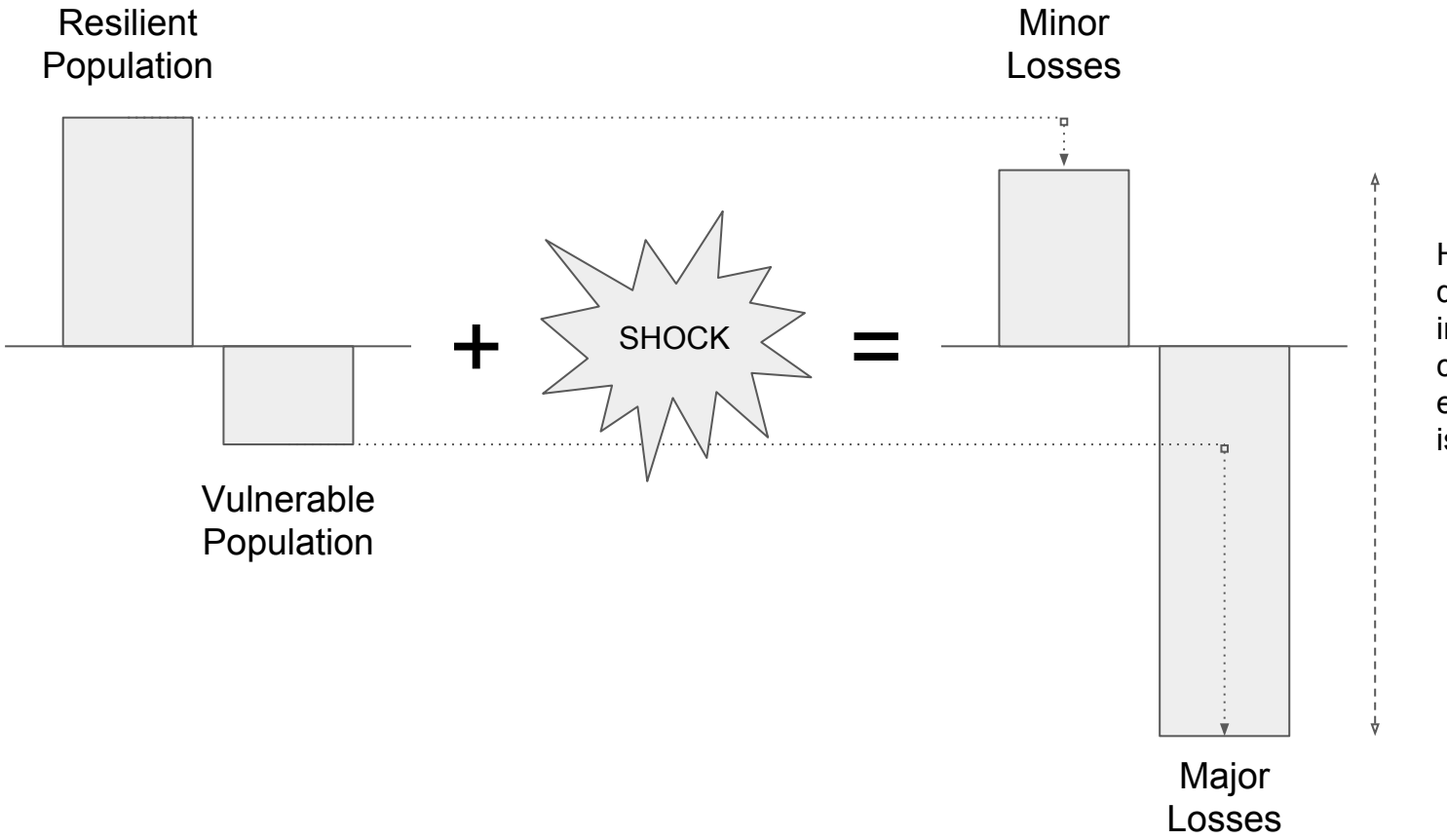
Employee Commute
Disruption


Business Locations
Total Yearly Sales
Block Group
$170k - $382M
$382M - $1.3B
$1.3B - $2.6B
$2.6B - $4.8B
$4.8B - $13B
Daly City
Pacifica
Montara
Moss Beach
El Granada
Half Moon Bay
Ashland
Castro Valley
San Lorenzo
Hayward
Union City
Fremont
Newark
Menlo Park
Palo Alto
West Menlo Park
Stanford
Woodside
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

# Total Cost to Businesses




**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

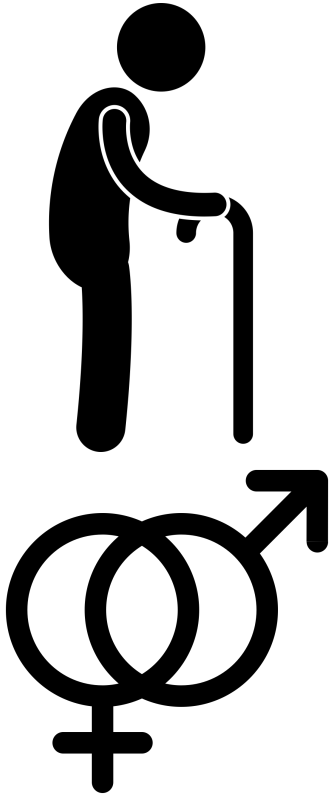


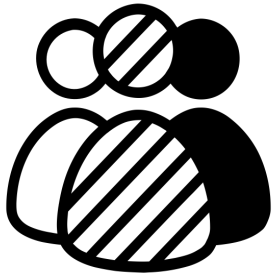

Hazards disproportionately impact vulnerable communities, thereby exacerbating equity issues.

Are flood damages distributed equitably?

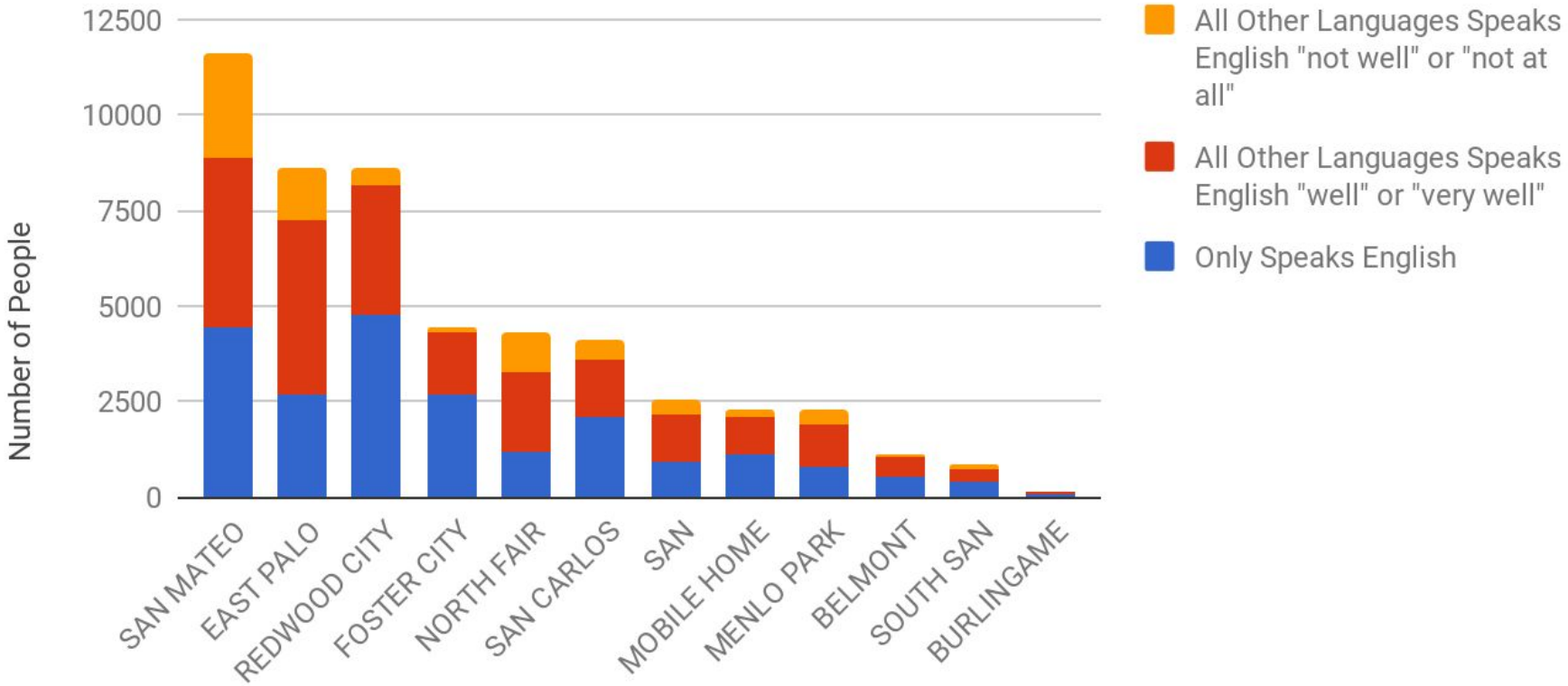
Will flood damage exacerbate inequity?

# Metrics of Interest

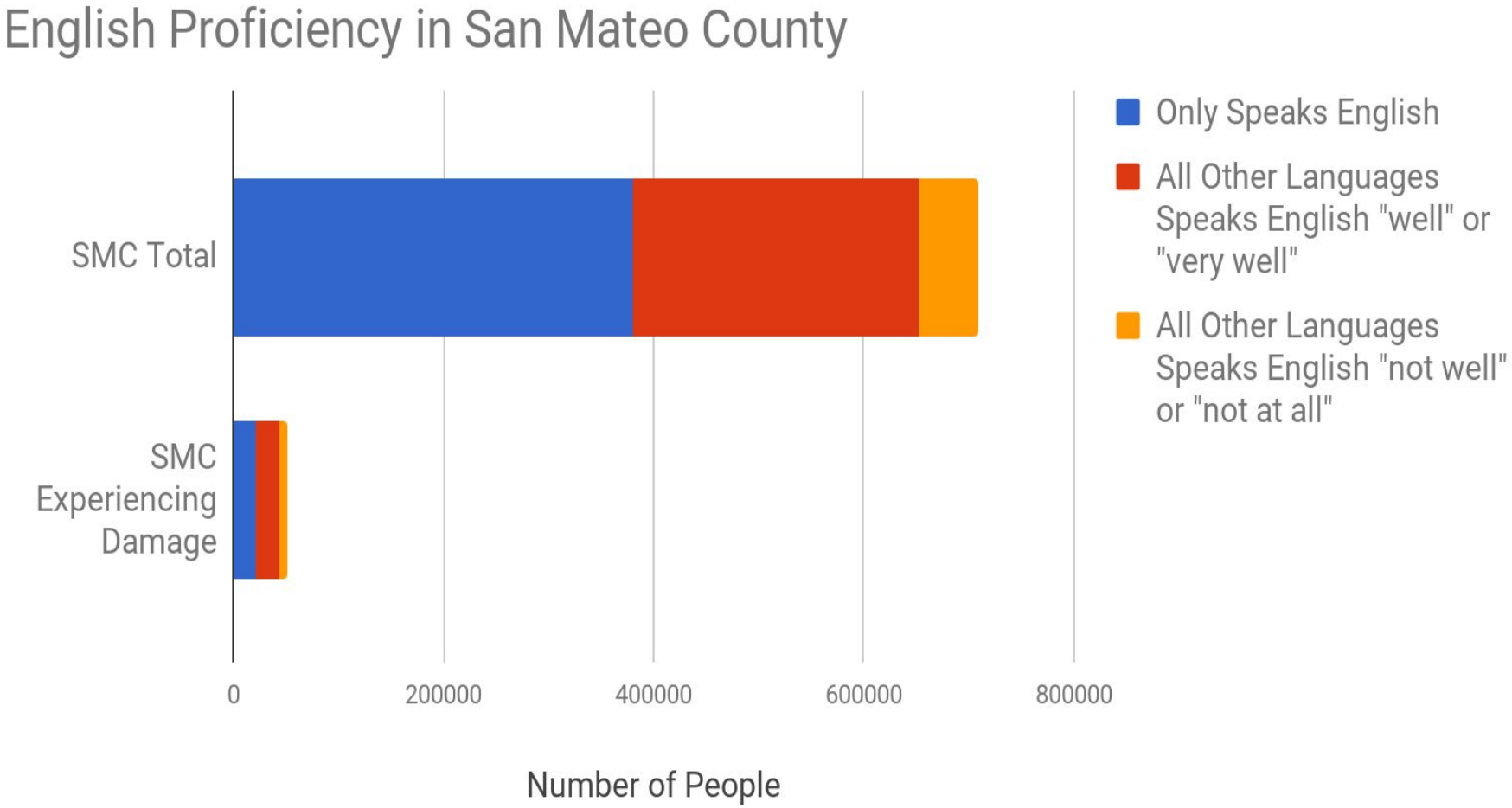




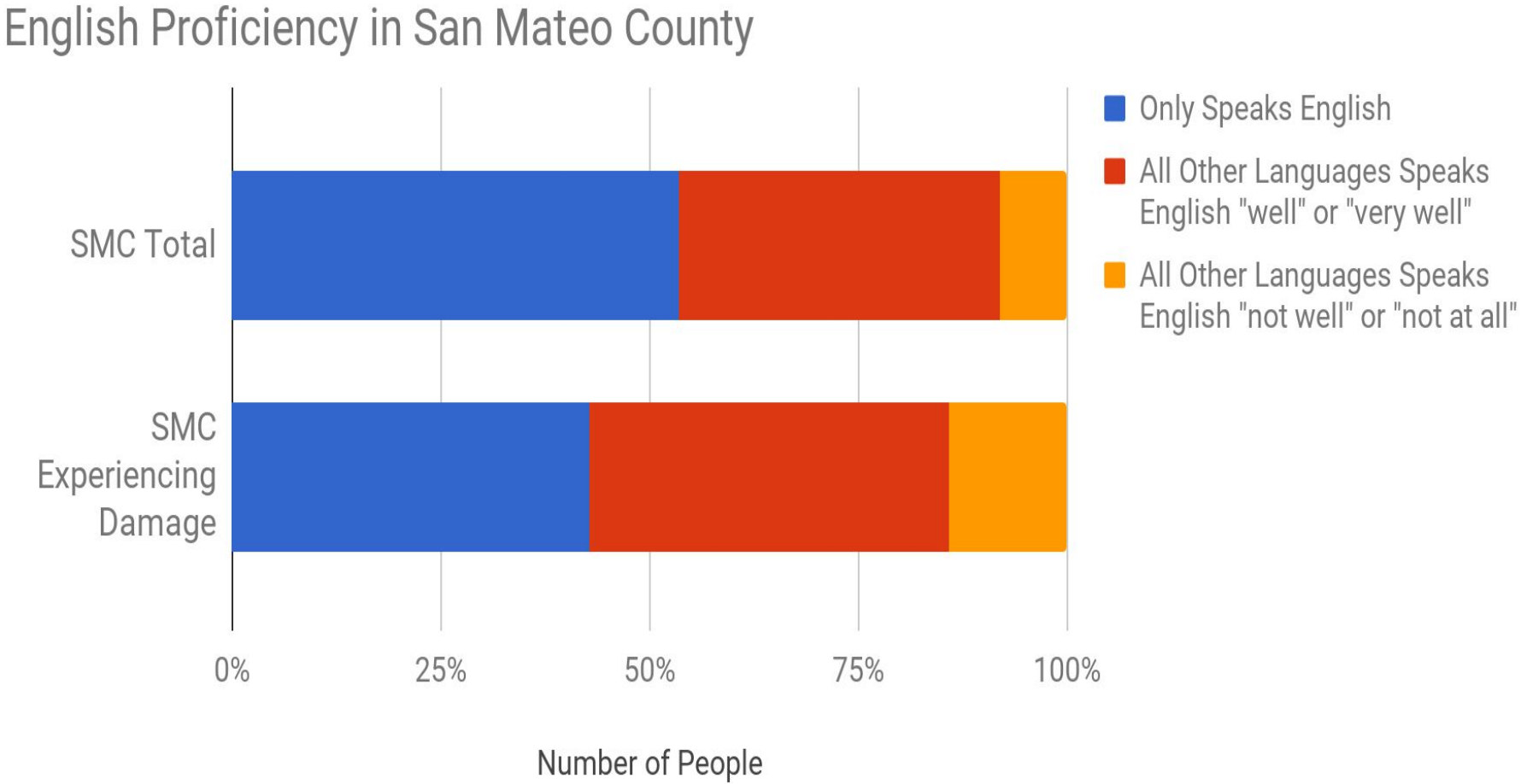
# San Mateo Cities: Population Experiencing Damage by English Proficiency




**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

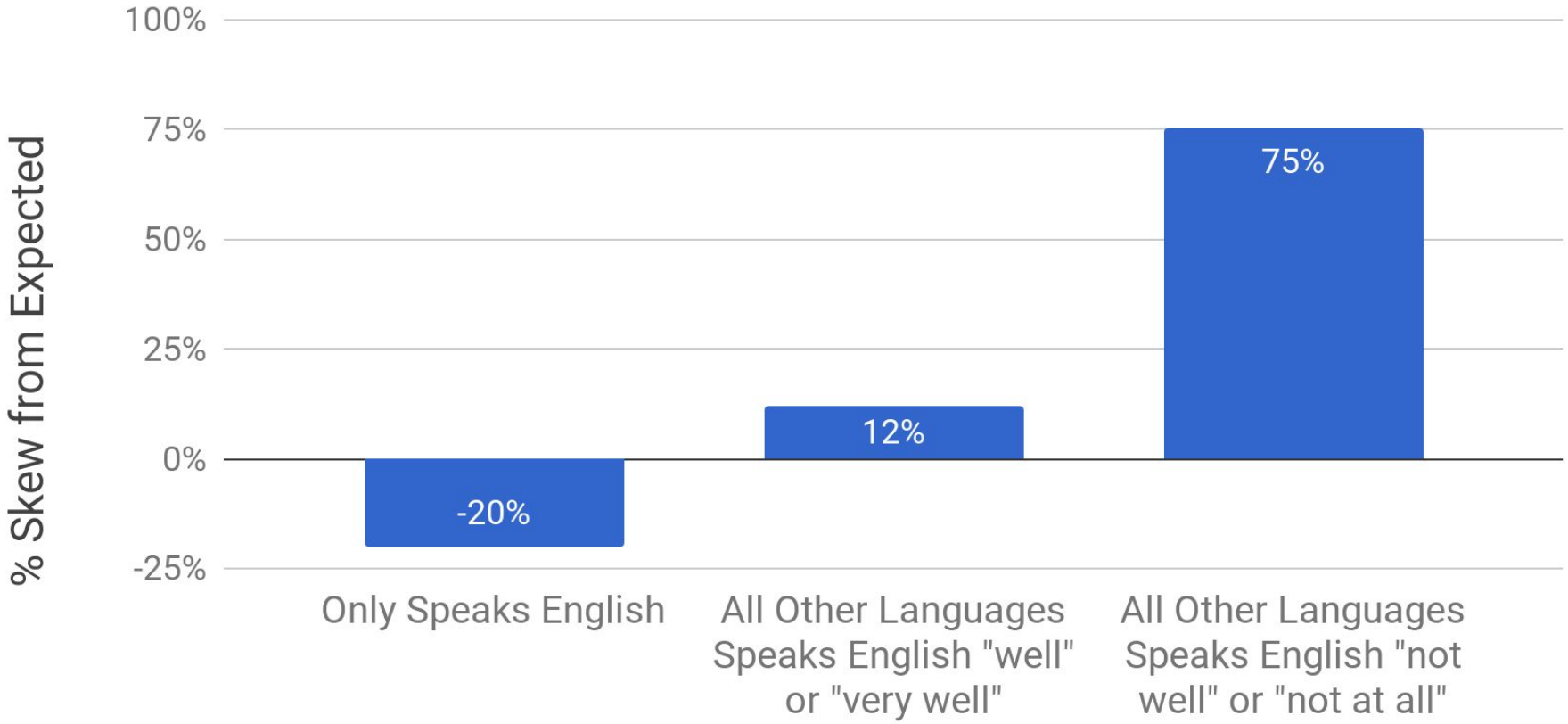



**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**



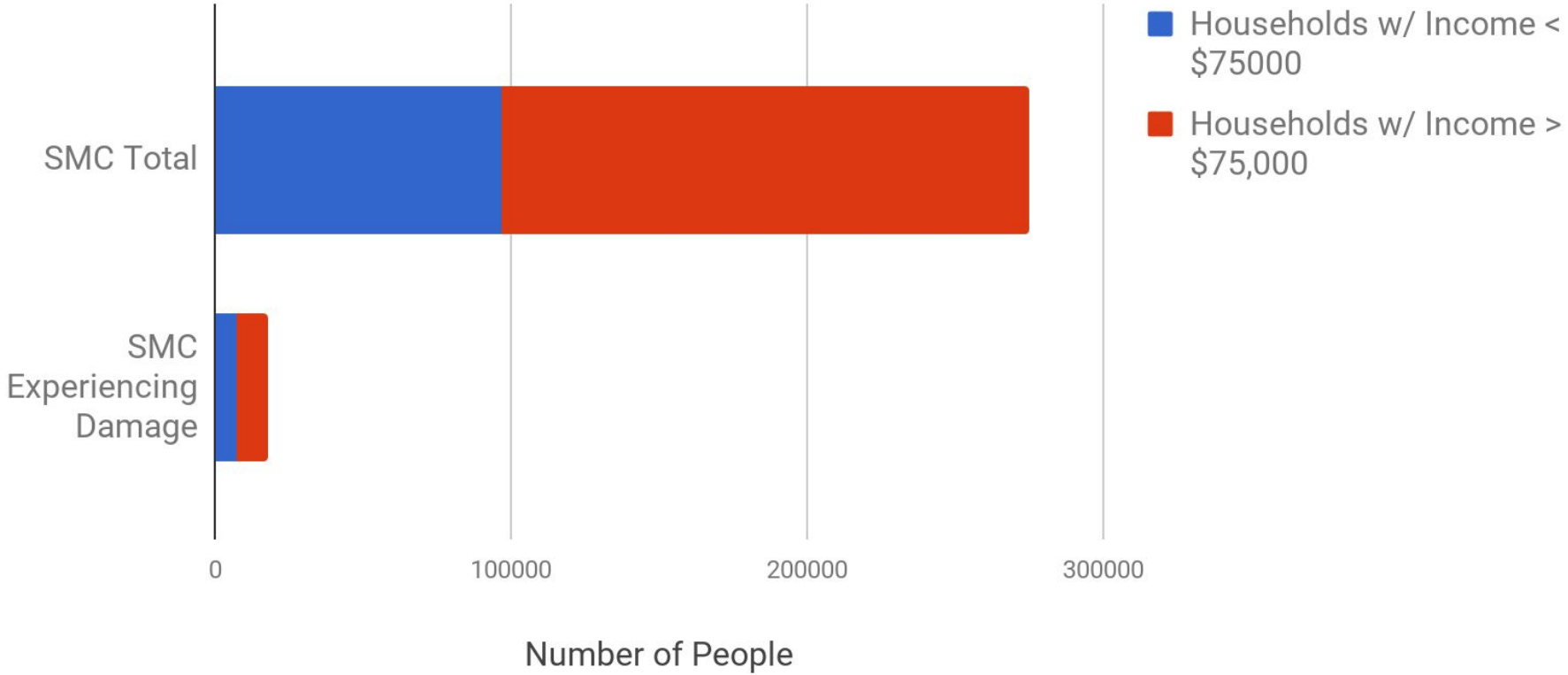

**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

# San Mateo County Proportionality of Damage



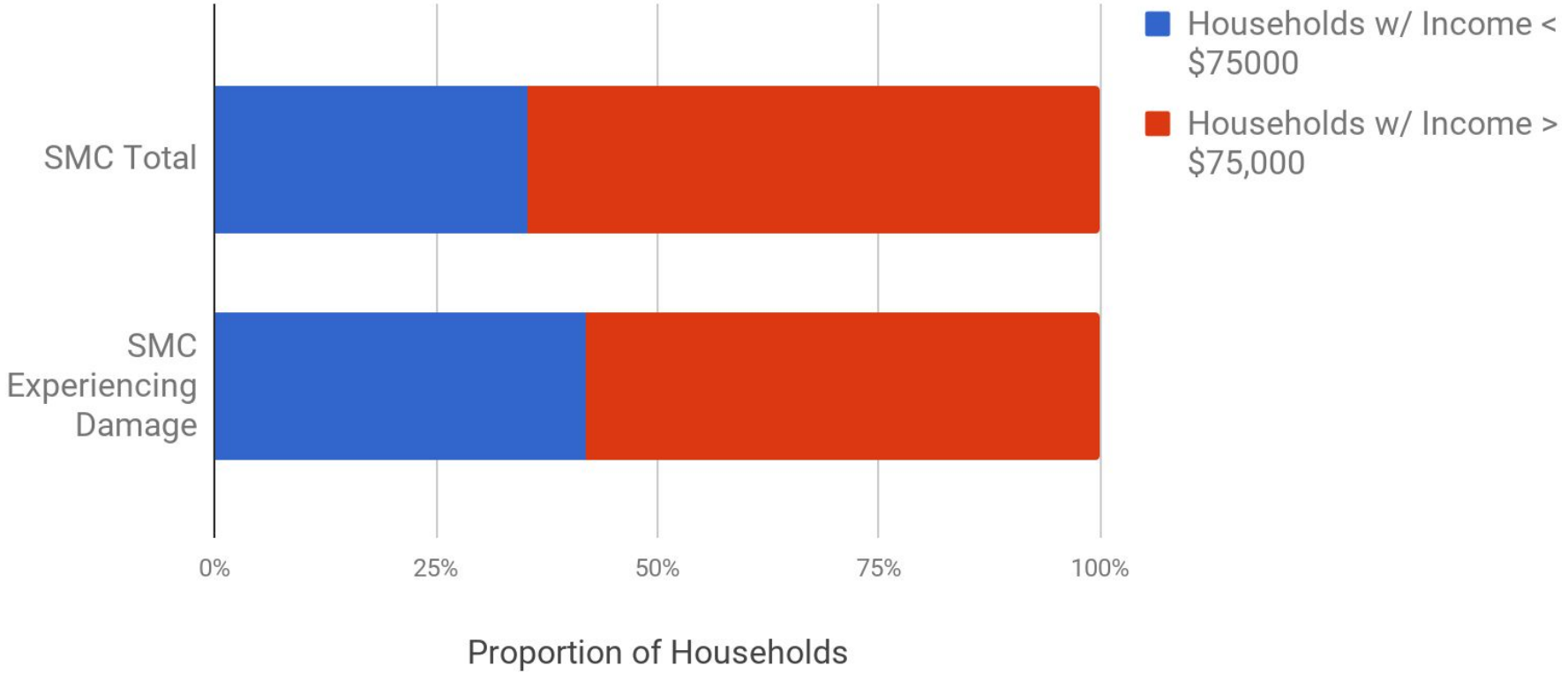

**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

# Income Levels in San Mateo County



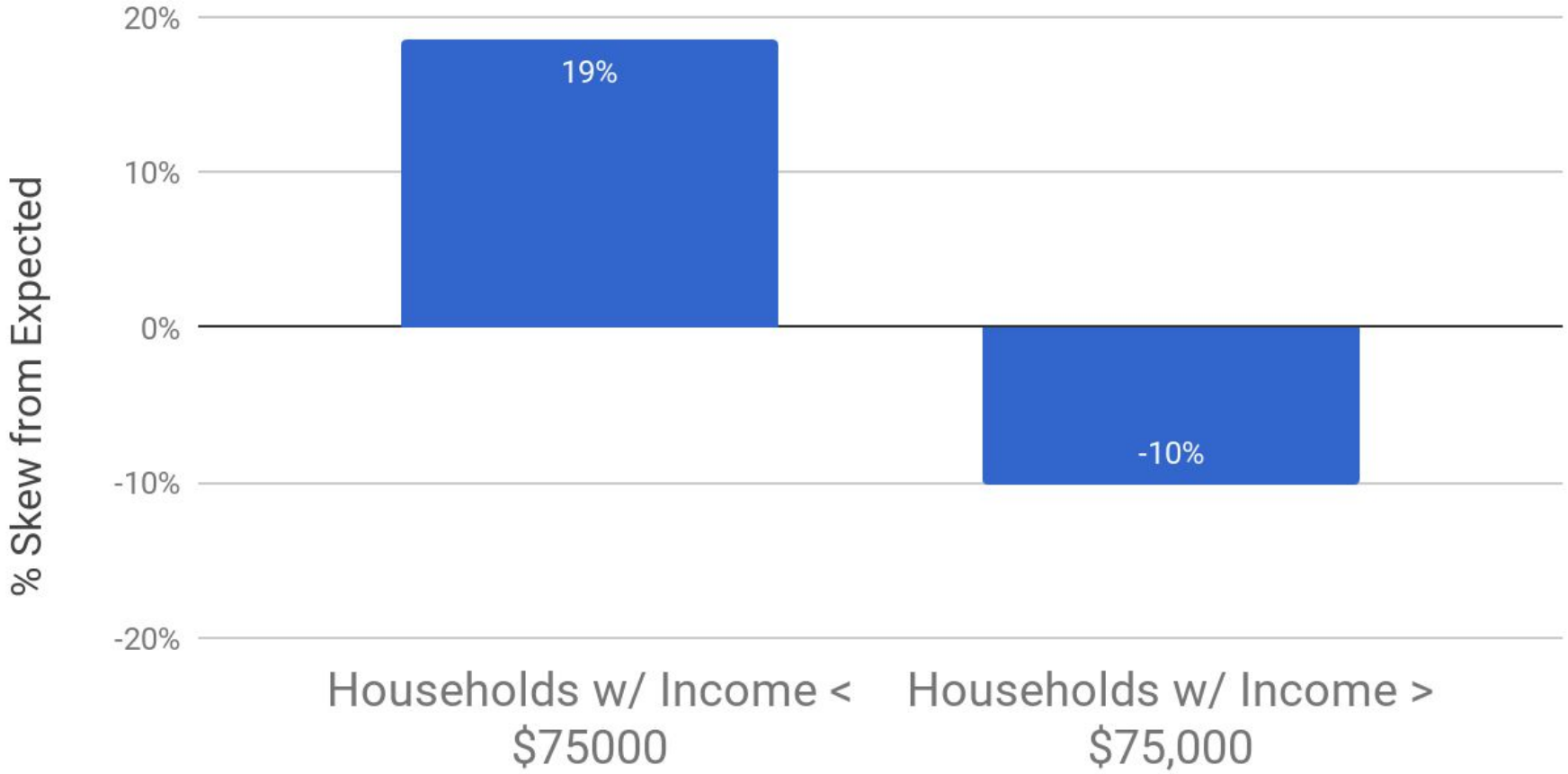

**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

# Income Levels in San Mateo County

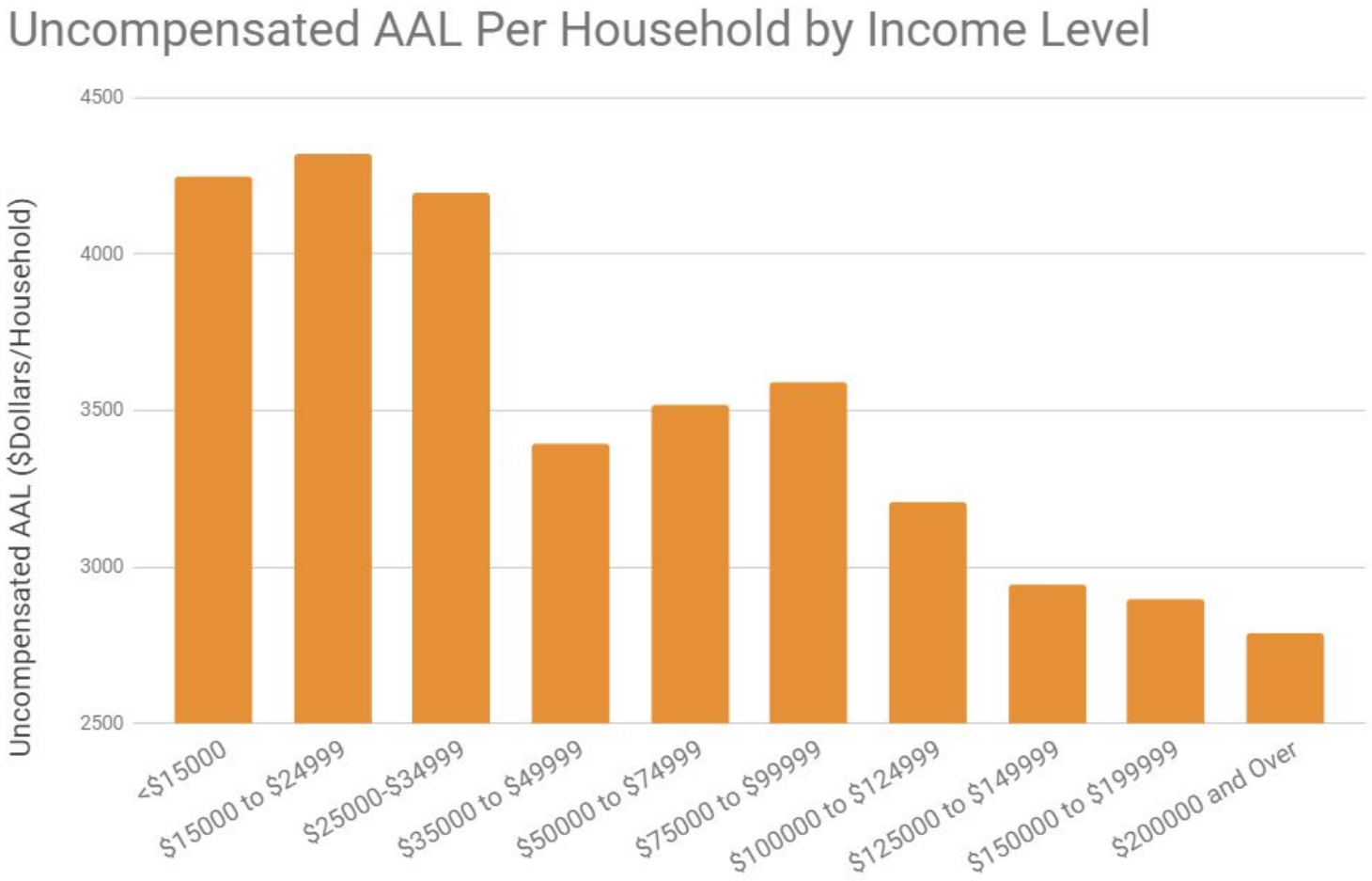



**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

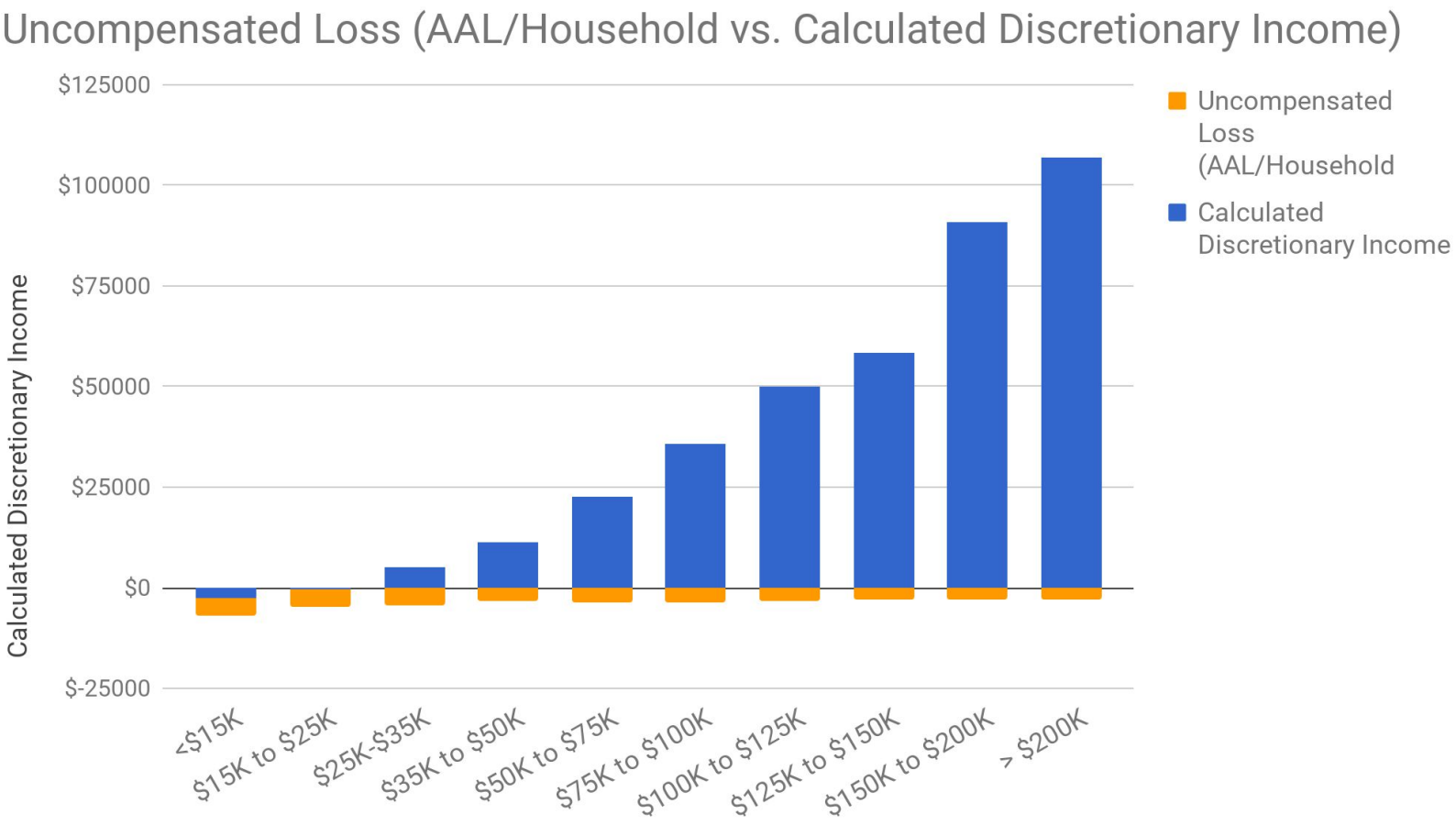
# San Mateo County Proportionality of Damage



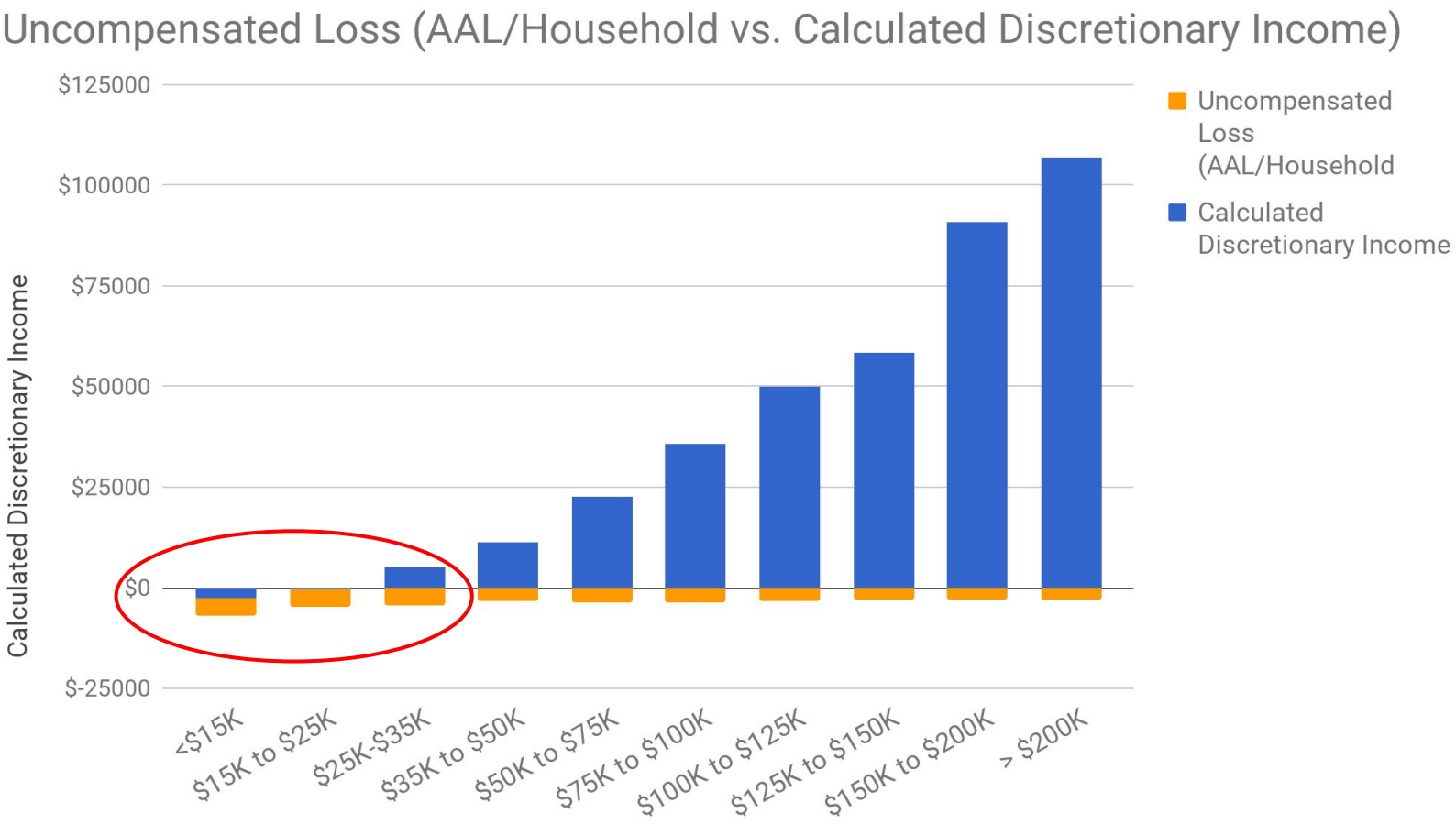

**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**




**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**




**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**




**REMINDER: THESE ARE STUDENT RESULTS BASED ON PREDICTIVE MODELS**

Students from last year's flood risk project touring a flood mitigation project at the mouth of San Francisquito Creek.

Stanford | ENGINEERING
Sustainable Urban Systems Initiative

Students from last year's flood risk project touring an area of San Jose's Coyote Creek that flooded in 2017.

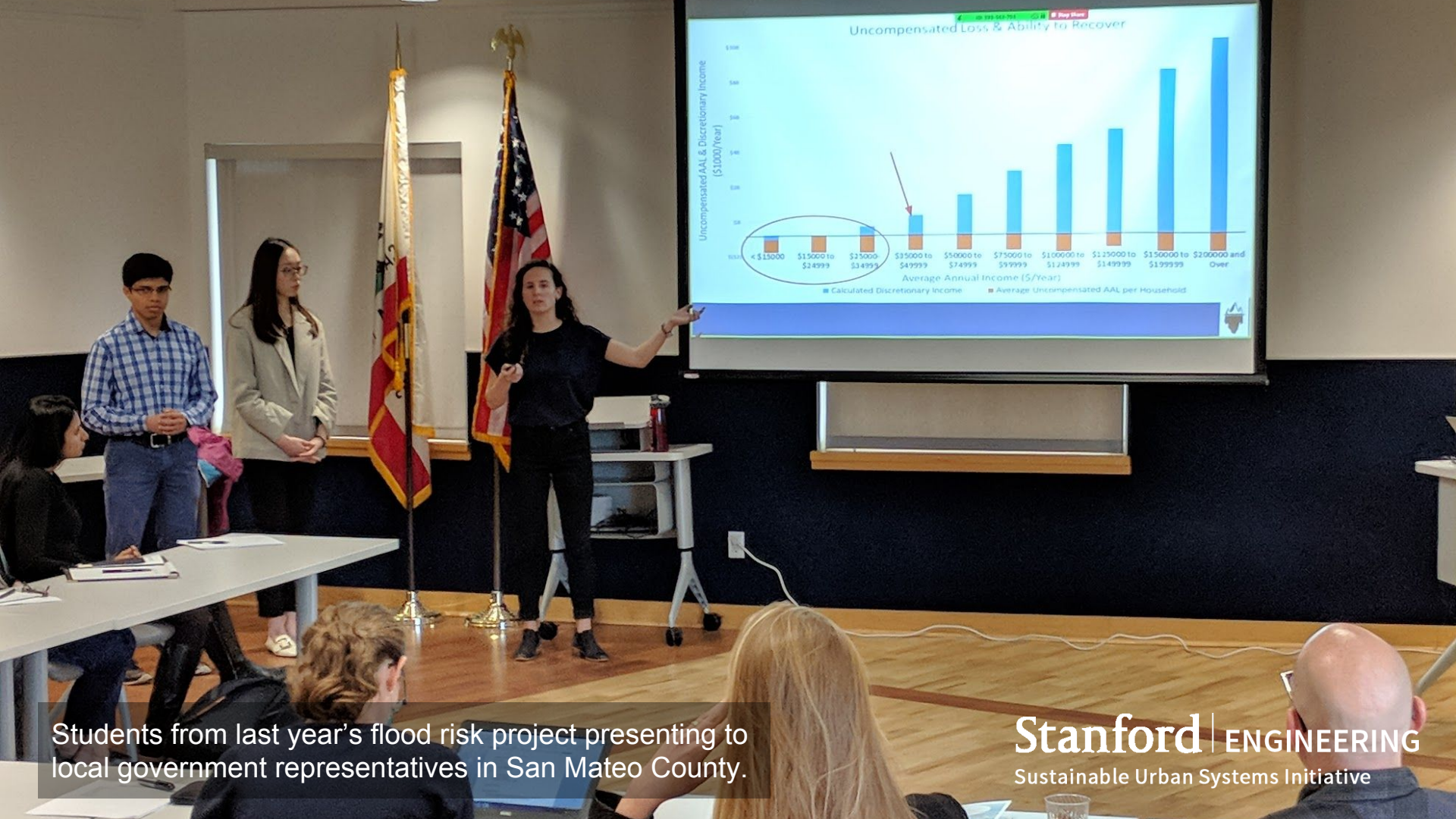
Stanford | ENGINEERING
Sustainable Urban Systems Initiative

Students from last year's flood risk project collaborating in small teams during a typical class session.

Stanford | ENGINEERING
Sustainable Urban Systems Initiative

Students from last year's flood risk project presenting their work at a public event at the Exploratorium in SF.

Stanford | ENGINEERING
Sustainable Urban Systems Initiative




Students from last year's flood risk project presenting to local government representatives in San Mateo County.

Stanford | ENGINEERING
Sustainable Urban Systems Initiative

A panel titled “Coastal Flood Risk in the Bay Area” at last year’s end-of-year SUS Symposium.

Stanford | ENGINEERING
Sustainable Urban Systems Initiative

The NFO Community Council has convened community-based organizations and a local university under the shared vision of empowering the most vulnerable youth, working-class families, and small businesses in SMC to transform into beacons of local resilience.

The **NFO Community Resilience Program** will build:

1. Awareness at the individual (youth/household/business) level
2. Preparedness at the individual level
3. Community networks similar to Community Emergency Response Teams (CERTs)
4. Civic education and participation in resilience planning and policy.

El Concilio of San Mateo County

NORTH FAIR OAKS COMMUNITY COUNCIL

Stanford | ENGINEERING
Sustainable Urban Systems Initiative

# Key Takeaways

1. NFO is not at significant direct risk of coastal flooding, but may face significant indirect risks through network effects such as transportation and socioeconomic vulnerability.

2. The Stanford Sustainable Urban Systems graduate project course seeks to partner with NFO stakeholders to make progress on sea level rise risk mitigation and other urban problem solving.

3. El Concilio, Siena Youth Center, NFO Community Council, and Stanford SUS submitted a proposal for SMC Communities Resilience grant, seeking $90,000 for 2019. We expect to hear about finalists in October.