Flood Resilience Study Findings

Presentation to
San Francisco Public Utilities Commissioners

May 24, 2016
Stefani Harrison, Project Manager
1. Flooding Background
2. Combined Collection System Background
3. Flood Resilience Study Process
4. Flood Protection Policy Options
   a) Is the current LOS (5-yr storm) appropriate?
   b) How would a revised LOS impact SFPUC’s capital plan and rates?
5. Next Steps
Flood Resilience Study Findings

FLOODING BACKGROUND
Flooding Terminology

- **Stormwater:**
  Overland runoff generated by rainfall.

- **Sanitary Sewage:**
  Residential, commercial, and (mostly pre-treated) industrial wastewater carried away from homes and businesses; main contributor to the collection system when it is not raining.

- **Combined Water:**
  Combination of stormwater and sanitary sewage in the combined collection system. Our pipe sizes are much larger in a combined system because of the flow capacity needed to manage stormwater. Flow in SF pipes in heavy rain events is mostly stormwater.
Flooding Terminology

- Flooding:
  - Generally in San Francisco, flooding is stormwater that can’t get into the collection system and ponds on the surface.
  - In certain low-lying areas of the City, combined water can exit the collection system in large storms and mix with stormwater on the surface.
How Flooding Can Occur

- Large storm (beyond collection system capacity)
- High tides
- Natural topography
  - Historic waterways
  - Drainage basin size and features
- Land settlement
- System blockage (e.g. O&M Issue)
San Francisco’s Historic Waterways
Modeled flooding in large storm event that exceeds capacity of collection system.
Example Watershed - Folsom

17th and Folsom

Drainage Map
- Division St Outfall
- Contributing Area
- Immediately Upstream of 17th & Folsom
Example Watershed – Sewer main profile along 17th Street
Flood Resilience Study Findings

COMBINED COLLECTION SYSTEM BACKGROUND
History of Our Collection System

• The City’s collection system was built over time, starting in the 1840s.
History of Our Collection System

1840s
Construction of City’s collection system begins

1908

1936
IDF curve for 5-yr storm refined; remains in use today

1941

1952 & 1982
Subdivision Regulations affirm 5-yr design storm (for new development only)

Commission endorses 5-yr | 3-hr storm as Level of Service, further specifying design storm

PIPE SIZING GUIDELINES EVOLVED

5-YR STORM PIPE SIZING REQUIREMENT DOCUMENTED

Estimated Collection System Improvement Costs to Meet Different Levels of Service
Collection System Level of Service

Wastewater Enterprise Goal

Integrate Green and Grey Infrastructure to Manage Stormwater and Minimize Flooding

Wastewater Enterprise Level of Service

Control and manage flows from a storm of a 3 hour duration that delivers 1.3 inches of rain
National Context for Flood Protection

New York City + Chicago + Philadelphia + Seattle + Kansas City, MO

- Some major urban cities that also use 5-yr storm design criteria for their combined systems

Sacramento

- Small portion of city (12 sq miles) with combined system has:
  - Interim goal to minimize flooding in 5-year storm
  - Final goal to minimize flooding in 10-year storm
- Topography is bowl-shaped; greater risk of widespread flooding

San Francisco

- Steep and hilly terrain presents unique challenges.
- Flooding occurs in localized low lying areas (historical waterways).
Managing Stormwater

- Stormwater runoff from large impermeable areas is the primary culprit when it comes to flooding

- City adopted Stormwater Management Ordinance in 2010:
  - Requires new, large developments to manage stormwater onsite
  - To date: has resulted in 250 projects spanning 430 acres citywide

- City is looking at incentivizing stormwater management financially, through our rate structure
Despite the City’s growing population over the past 30 yrs, water consumption and resulting dry weather sewer flow have decreased (7% to 8% per decade).
What is San Francisco’s plan for flood minimization projects?

- **Multiple critical priorities**
  - Aging Infrastructure
  - Seismic Reliability
  - Combined Sewer Discharges
  - Climate Change
  - Odors, Noise & Visual
  - Environmental Stewardship
  - **Stormwater Management & Flood Minimization**

- **SSIP** includes **flood resilience projects**
  - Folsom, Cayuga, Wawona, Victoria/Urbano, Joost/Foerster, etc.

- Ongoing **R&R** projects offer opportunities for **incremental capacity improvements**

- **Flood Resilience Study** informs policy discussions. Policy decision will drive future project prioritization, development, and implementation
Flood Resilience Study Findings

FLOOD RESILIENCE STUDY PROCESS
Risk-Based Planning for Flood Resilience

What is Flood Resilience?
The capacity to anticipate risk, limit impact, and recover quickly when damage occurs from flooding events.
Flood Resilience Study Components

• Infrastructure:
  • Risk-based framework to assess flood risk and identify/prioritize capital investments
    • Costs for infrastructure (representative project sets for comparing policy options)
    • Benefits of infrastructure (using economic impact)
  • Provide this information to review the current LOS
    • Guides decisions for what to do and what not to do

• Other flood risk reduction measures:
  • Programmatic measures to build citywide flood resilience
  • Provide a “safety net” for larger storms
  • Strengthen partnership between SFPUC, residents, businesses, other City Departments.
Flood Resilience Approach

1. **CONDUCT ANALYSIS**
   - **Risk**
     - Likelihood
     - Economic Consequence
   - **Project Cost**
     - Structural
     - O&M

2. **GRAPH COST-BENEFIT CURVES**

3. **CONSIDER POLICY CHANGES**

4. **DEVELOP PROJECTS TO IMPLEMENT**

**FLOOD RESILIENCE STUDY**

In Parallel: Develop Programmatic and Operational Strategies

**FUTURE Capital Investments**
## Flood Risk Analysis: Design Storms

<table>
<thead>
<tr>
<th>Frequency (years)</th>
<th>Duration (hours)</th>
<th>Rainfall (in)</th>
<th>Annual Probability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>3</td>
<td>1.3</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>1.5</td>
<td>10</td>
</tr>
<tr>
<td>25</td>
<td>3</td>
<td>1.8</td>
<td>4</td>
</tr>
<tr>
<td>50</td>
<td>3</td>
<td>2.0</td>
<td>2</td>
</tr>
<tr>
<td>100</td>
<td>3</td>
<td>2.3</td>
<td>1</td>
</tr>
</tbody>
</table>

### Flood Protection Policy Options for Consideration

- 5-year/3-hour storm citywide, with 10-year/3-hour flood risk protection along major historic waterways

### Sensitivity Analyses and Evaluations

<table>
<thead>
<tr>
<th>Frequency (years)</th>
<th>Duration (hours)</th>
<th>Rainfall (in)</th>
<th>Annual Probability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>24</td>
<td>3.2</td>
<td>20</td>
</tr>
</tbody>
</table>

- **Geographic Hybrid:** 5-year/3-hour storm citywide, with 10-year/3-hour flood risk protection along major historic waterways

- **Sea Level Rise:**
  - 2050 most likely SLR of 11” with 2-year storm surge (default)
  - 2100 most likely SLR of 36” with 2-year storm surge
  - 2100 worst case SLR of 66” and 100-year storm surge
Flood Resilience Analysis: Basic Process

- Storm
- System Infrastructure
- Property & Asset Data
- Assumptions + Rules for Assigning Cost

H+H MODEL → Flooding on the Surface → GIS MODELS → Assets Potentially Impacted → ECONOMIC MODELS

OUTPUTS
- Flood Risk
- Economic Impact* of Flooding

*Societal cost of water on the urban landscape
Flood Resilience Analysis: Stepwise Process

1. For each design storm, identify:
   a) **Baseline economic impact** (with today’s infrastructure)
   b) **Representative infrastructure project set/costs** to minimize flooding

2. Develop baseline economic impact over 100-year timespan

3. For each project set, estimate:
   a) **Residual economic impact** over 100-year timespan
   b) **Total benefit** for the project set = avoided economic impact = 
      (baseline economic impact) – (residual economic impact)
## Economic Impact: Issue Areas

<table>
<thead>
<tr>
<th>Category</th>
<th>Issue Area</th>
<th>Economic Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damages</td>
<td>Damage to Property Structure</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Property Cleanup</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Damage to Vehicles and Content Loss</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Damage to Area Infrastructure</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Population Disruption/Relocation</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Emergency Response</td>
<td>Medium</td>
</tr>
<tr>
<td>Indirect Effects</td>
<td>Business Effects</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Transit + Traffic Disruption</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Interruption to Public Services</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Temporary Loss of Community Amenities</td>
<td>Low</td>
</tr>
<tr>
<td>First Order Losses</td>
<td>Property Value</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Public Health</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Office Staff</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Economic Models: Methods & Inputs

Methods used **standard federal approaches:**
- 9 issue areas based on FEMA approaches
- Remaining 4 derive from USDOT, USEPA, and USACE

**Local data** used to customize models to SF where possible:
- Local replacement cost estimates
- Inputs from 11 City agencies
  - Data on assets, activities, and costs
  - Guidance from staff about thresholds for flood damage to assets and likely extent of impacts
- Field survey conducted to:
  - Supplement data gaps in city GIS data
  - Identify likelihood of flood-related characteristics (e.g. downsloping driveway)
Flood Resilience Study Findings

FLOOD PROTECTION POLICY OPTIONS
Flood Protection Policy Options

• Each option is an assessment of what it would take to address flooding in a design storm.
  • Investments prioritized to eliminate high/very high flood risk

• Each option is characterized by:
  • A representation of infrastructure needs
  • Cost, benefit, and benefit–cost ratio
  • Ratepayer impacts
Representative Infrastructure Project Sets

• Representative group of projects to manage flooding in select storms
• Developed at a high level
• Purpose: to provide comparative information and inform policy discussions

• Once policy is decided, specific projects need to be identified and developed for implementation.
Representative Infrastructure Project Sets: “Minimize Flooding”

Flood volume for a given storm event

Remnant flood volume once high + very high risk is addressed
<table>
<thead>
<tr>
<th>Flood Protection Policy Option:</th>
<th>5-yr storm</th>
<th>10-yr storm</th>
<th>25-yr storm</th>
<th>50-yr storm</th>
<th>100-yr storm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Set Components¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe, new/upsized (miles)</td>
<td>61</td>
<td>72</td>
<td>128</td>
<td>175</td>
<td>226</td>
</tr>
<tr>
<td>Detention (MG)</td>
<td>9</td>
<td>30</td>
<td>102</td>
<td>163</td>
<td>221</td>
</tr>
<tr>
<td>Pump Stations, new/improved (MGD)</td>
<td>34</td>
<td>109</td>
<td>165</td>
<td>405</td>
<td>715</td>
</tr>
<tr>
<td>Outfall Expansion (number)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Surface Detention (acres)</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Modified Street Grade (LF)</td>
<td>1,610</td>
<td>1,830</td>
<td>10,180</td>
<td>18,890</td>
<td>23,260</td>
</tr>
</tbody>
</table>

¹Representative Project Sets also include smaller projects not listed above, such as flow control, weirs, surface inlet features, and sealed manholes

| Project Cost ($B, escalated to 2030) | $2.0 | $2.9 | $5.6 | $8.3 | $11.1 |
### Flood Protection Policy Options: Representative Costs

<table>
<thead>
<tr>
<th>Flood Protection Policy Option:</th>
<th>5-yr storm</th>
<th>10-yr storm</th>
<th>25-yr storm</th>
<th>50-yr storm</th>
<th>100-yr storm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Cost ($B, escalated to 2030)¹</td>
<td>$2.0</td>
<td>$2.9</td>
<td>$5.6</td>
<td>$8.3</td>
<td>$11.1</td>
</tr>
<tr>
<td>Planned Expenditures ($B)</td>
<td>$0.7</td>
<td>$0.7</td>
<td>$0.7</td>
<td>$0.7</td>
<td>$0.7</td>
</tr>
<tr>
<td>New Funds ($B)</td>
<td>$1.3</td>
<td>$2.2</td>
<td>$4.9</td>
<td>$7.5</td>
<td>$10.3</td>
</tr>
</tbody>
</table>

| Project Life Cycle Cost ($B, NPV in 2016) | $2.3 | $3.7 | $6.9 | $10.5 | $14.8 |
| Project Cost ($B, NPV in 2016)            | $1.0 | $1.5 | $2.9 | $4.2 | $5.6 |
| O&M/Replacement ($B, NPV in 2016)          | $1.3 | $2.2 | $4.0 | $6.3 | $9.2 |
Total Life Cycle Costs for Project Sets, Net Present Value

- $2.3 B (20 years)
- $3.7 B (50 years)
- $6.9 B (100 years)
- $10.5 B (150 years)
- $14.8 B (200 years)
Benefit – Cost Analysis

Representative Project Set

- 5-Year Storm: $2.3
- 10-Year Storm: $3.7
- 25-Year Storm: $6.9
- 50-Year Storm: $10.5
- 100-Year Storm: $14.8

Representative Project Set LCA Cost (NPV)
Benefit – Cost Analysis

Baseline
Economic Impact of Flooding

$4.7

5-Year Storm
$1.0
$3.7
$4.1

10-Year Storm
$0.6
$4.1
$4.5

25-Year Storm
$0.2
$4.5
$4.6

50-Year Storm
$0.1
$4.6
$4.7

100-Year Storm
$0.1
$4.7

Representative Project Set

Residual Economic Impact
Economic Benefit
Benefit – Cost Analysis

- Baseline Economic Impact of Flooding: $4.7
- 5-Year Storm: $2.3, $3.7, $4.1
- 10-Year Storm: $3.7, $4.1, $4.5
- 25-Year Storm: $6.9, $4.5, $4.9
- 50-Year Storm: $10.5, $4.6, $0.1
- 100-Year Storm: $14.8, $0.1, $4.7

Legend:
- Representative Project Set LCA Cost (NPV)
- Residual Economic Impact
- Economic Benefit
Benefit – Cost Analysis

Baseline Economic Impact of Flooding

- 5-Year Storm
- 10-Year Storm
- 25-Year Storm
- 50-Year Storm
- 100-Year Storm

**Benefit-Cost Ratio** = 1.0

**Representative Project Set**

- **Baseline Economic Impact of Flooding**
  - $4.7

- **5-Year Storm**
  - $1.0
  - $3.7

- **10-Year Storm**
  - $4.1
  - $3.7

- **25-Year Storm**
  - $6.9
  - $0.6
  - $0.2

- **50-Year Storm**
  - $10.5
  - $0.1
  - $4.6

- **100-Year Storm**
  - $14.8
  - $0.1
  - $4.7

Legend:

- **Blue**: Representative Project Set LCA Cost (NPV)
- **Red**: Residual Economic Impact
- **Green**: Economic Benefit
- **Orange**: Benefit-Cost Ratio
Areas Impacted by Flooding

TOTAL FLOODED AREA

- **10 Year Storm Baseline** 0.8% of San Francisco
- **5 Year Storm Baseline** 0.5% of San Francisco
- **Remnant Flooded Area with Project Set** 0.1% of San Francisco

- 1 acre
- 10 acre

[Map showing areas impacted by flooding in San Francisco]
Ratepayer Impact Analysis

<table>
<thead>
<tr>
<th>Event</th>
<th>Flood Resilience Cost to Ratepayer</th>
<th>Projected Rate Increase</th>
<th>SSIP Treatment</th>
<th>SSIP Collection</th>
<th>Non-SSIP Capital</th>
<th>O&amp;M</th>
<th>Current Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-Year Storm</td>
<td>$221</td>
<td>$15</td>
<td>$57</td>
<td>$38</td>
<td>$37</td>
<td>$23</td>
<td>$51</td>
</tr>
<tr>
<td>10-Year Storm</td>
<td>$232</td>
<td>$26</td>
<td>$58</td>
<td>$38</td>
<td>$37</td>
<td>$23</td>
<td>$51</td>
</tr>
<tr>
<td>25-Year Storm</td>
<td>$264</td>
<td>$58</td>
<td>$58</td>
<td>$38</td>
<td>$37</td>
<td>$23</td>
<td>$51</td>
</tr>
<tr>
<td>50-Year Storm</td>
<td>$295</td>
<td>$89</td>
<td>$58</td>
<td>$38</td>
<td>$37</td>
<td>$23</td>
<td>$51</td>
</tr>
<tr>
<td>100-Year Storm</td>
<td>$328</td>
<td>$122</td>
<td>$58</td>
<td>$38</td>
<td>$37</td>
<td>$23</td>
<td>$51</td>
</tr>
</tbody>
</table>

**Representative Project Set**

- **Flood Resilience Cost to Ratepayer per Month**: Increase for Flood Resilience Projects by 2036
- **Projected Rate Increase per Month**: Increase by 2036 to Achieve a State of Good Repair
- **SSIP Treatment**: $57
- **SSIP Collection**: $38
- **Non-SSIP Capital**: $37
- **O&M**: $23
- **Current Bill (O&M, Non-SSIP Capital, SSIP)**: $51

San Francisco Water Power Sewer
Flood Protection Policy Options

San Francisco Water Power Sewer

Baseline Economic Impact of Flooding

- 5-Year Storm: $1.0
  - Benefit-Cost Ratio: 1.10
  - Residual Economic Impact: $3.7
  - Economic Benefit: $5.1
  - LCA Cost (NPV): $221

- 10-Year Storm: $0.6
  - Benefit-Cost Ratio: 1.60
  - Residual Economic Impact: $3.7
  - Economic Benefit: $5.1
  - LCA Cost (NPV): $232

- 25-Year Storm: $0.2
  - Benefit-Cost Ratio: 1.0
  - Residual Economic Impact: $3.7
  - Economic Benefit: $5.1
  - LCA Cost (NPV): $264

- 50-Year Storm: $0.1
  - Benefit-Cost Ratio: 1.0
  - Residual Economic Impact: $3.7
  - Economic Benefit: $5.1
  - LCA Cost (NPV): $295

- 100-Year Storm: $0.1
  - Benefit-Cost Ratio: 1.0
  - Residual Economic Impact: $3.7
  - Economic Benefit: $5.1
  - LCA Cost (NPV): $328

Representative Project Set

- Flood Resilience Cost to Ratepayer by 2036: $15 - $122
- Projected Rate Increase by 2036: $155
- SSIP Treatment: $-57
- SSIP Collection: $-38
- Non-SSIP Capital: $-37
- O&M: $-23
- Current Bill (O&M, Non-SSIP Capital, SSIP): $51

LCA Cost (NPV) represents the life-cycle assessment cost, which is the total cost of a project over its lifetime, discounted to the present value. The Benefit-Cost Ratio indicates whether the benefits of the project outweigh its costs. A ratio of 1.0 or greater is generally considered favorable. The Residual Economic Impact is the economic value that remains after the project is completed. The Economic Benefit is the additional economic value created by the project. The LCA Cost (NPV) is the discounted net present value of the life-cycle costs.
Flood Resilience Study Findings

NEXT STEPS
Opportunities for Public Input on Flooding and Future Policy Discussion

Feb 9
Commission Workshop
Present Flooding + Flood Resilience background

May 24
Commission Workshop
Present Flood Resilience Study results and policy options

2017
Commission Workshop
Staff recommendations for Flood Policy

2015
Feb 9
Commission Workshop
Present Flooding + Flood Resilience background

Mar 30
Public Open House #1 (Folsom)

Apr 2
Public Open House #2 (Cayuga)

Apr 12
CAC Wastewater Subcommittee
Present RainReadySF + Flood Resilience info

May 24
Commission Workshop
Present Flood Resilience Study results and policy options

May 11
Flood Resilience study results online

May 17
Public Workshop
at special CAC meeting to present Flood Resilience Study results and policy options

Jun - Dec
Continued Outreach
Phone survey
Presentations to stakeholders
Outreach via neighborhood events

Oct / Nov
2 Public Meetings in 17th/Folsom and Cayuga neighborhoods
Next Steps

• Continued Outreach
• Additional analysis toward policy recommendation
  • Development and prioritization of projects based on flood risk
  • Implementation/phasing approach considering:
    • SFPUC’s other critical infrastructure priorities
    • Impacts to rates and ratepayer affordability
    • Synergies with other capital programs (including SSIP, R&R, and interdepartmental projects led by other City agencies)