Flooding Vulnerability Assessment for the City of Kingston, NY

- *For 10-year and 100- year Storm Events*
- *With High and Low Sea Level Rise Scenarios*
- *For the Years 2013, 2060 and 2100*
- *Including Predictions for All Cumulative Expected Monetary Damage to Buildings and Improvements using the COAST tool*

Catalysis
Adaptation Partners LLC

Jonathan T. Lockman AICP
Vice President of Environmental Planning
jtlockman@catalysisadaptation.com
12 March 2013

Catalysis Adaptation Partners, LLC

In the Spring of 2012,
Dr. Sam Merrill, Director of the New England EFC at the Muskie School, created **Catalysis Adaptation Partners**, to spread the use of the Coast Approach beyond Maine and New England.

Samuel Merrill, PhD
President
COAST developer

J.T. Lockman, AICP
Vice President
Environmental Planning

Peter Slovinsky
Vice President
Geological Sciences

Paul Kirshen, PhD
Senior Technical Consultant
Climate Science

Ellen Douglas, PE, PhD
Senior Technical Consultant
Engineering

Jack Kartez, PhD
Senior Technical Consultant
Citizen Engagement

http://www.catalysisadaptation.com

What is “COAST?”

COastal

Adaptation to

Sea level rise

Tool

The COAST approach and software tool were developed at the Muskie School of Public Service.

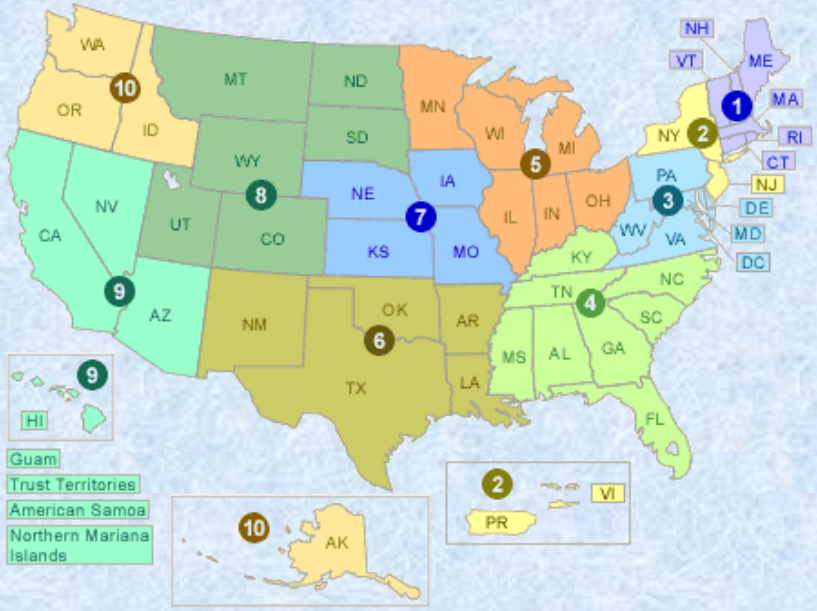
University of Southern Maine
Portland, Maine

USM is part ot the Environmental Finance Center Network

The EFCN is a university-based organization creating innovative solutions to managing costs of environmental protection and improvement. It consists of ten EFCs serving states in EPA's ten regions. By sharing information, tools and techniques, the EFCs help address difficult how-to-pay issues of providing environmental services.

http://www.epa.gov/efinpage/efcn.htm.

EFCN
environmental finance center network



Why did we name the company "Catalysis?"

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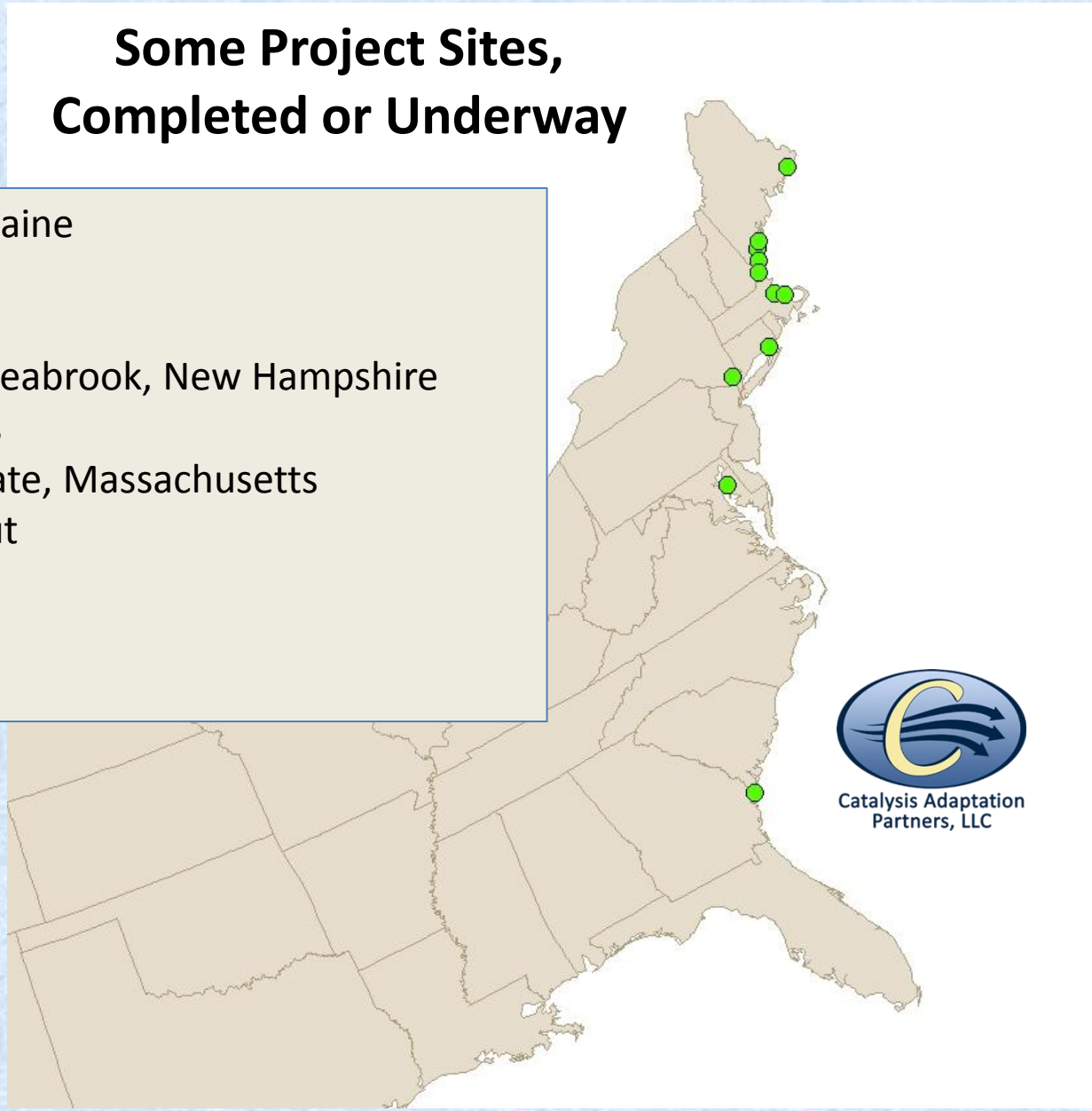
The word ***catalysis*** comes from chemistry. To catalyze means to create a reaction by bringing things together; we are experts in catalyzing local adaptation to sea level rise and storm surge, by bringing together innovative technology with tailored community engagement processes.

Some Project Sites, Completed or Underway

- East Machias/Falmouth, Maine
- Old Orchard Beach, Maine
- Portland, Maine
- Hampton/Hampton Falls/Seabrook, New Hampshire
- Cambridge, Massachusetts
- Duxbury/Marshfield/Scituate, Massachusetts
- Groton/Mystic, Connecticut
- Kingston, New York
- Oxford, Maryland
- Tybee Island, Georgia



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Helping Communities Decide on Sea Level and Storm Surge Adaptation Strategies with the COAST software tool

- COAST is flexible; it can provide cost-benefit analysis for many candidate adaptation actions to protect a diversity of vulnerable assets, staged over time.
- Different scenarios for sea level rise and storm surge can be inputted in to the model, after stakeholder engagement. Stakeholder engagement delivers buy-in.
- Vulnerabilities to damage are mapped and quantified based on the scenarios.
- Costs of adaptation strategies are estimated. The software will generate prediction of cumulative expected damages avoided over time, with different strategies providing a cost benefit analysis.

There are only four options:

1) Do nothing (usually = remain in denial)
2) Fortify assets
3) Accommodate higher water levels
4) Relocate assets

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COAST is a tool and approach to help evaluate costs and benefits of these options. Step 1 is a vulnerability assessment, to help decide which of these options to pursue.

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City of Kingston - Modeled Water Levels and Vulnerability Assessment Results

Year	Sea Level Rise Scenario	Storm Intensity (return period in years)	Elevation of Storm Surge from FEMA Flood Insurance Study plus Mean Higher High Water NAVD88 (ft.)	Sea Level Rise Since 2013 Selected by Kingston (inches/ft)		Modeled Total Flood Height NAVD 88 (ft.)	COAST Model Expected Damage to the Value of All Buildings & Improvements From This Single Storm Incident in the Scenario Year ($ Million)	COAST Model Expected Damage to the Value of Waste Water Treatment Plant Only From This Single Storm Incident in the Scenario Year ($ Million)	COAST Model Cumulative Expected Damage to the Value of All Buildings & Improvements From All Storms, 2013 to Scenario Year ($ Million)**	COAST Model Percent of Cumulative Expected Damage to the Value of All Buildings & Improvements From 2013 to Scenario Year Attributable to Sea Level Rise Only (Percent)**
2013	1 No SLR	10 yr	9.00	0	0	9.00	**22.0**	**16.8**	**n/a**	**n/a**
2013	1 No SLR	100 yr	11.20	0	0	11.20	**29.5**	**22.2**	**n/a**	**n/a**
2060	3 Lo SLR	10 yr	9.00	20	1.67	10.67	**27.2**	**20.6**	**102**	**18.1%**
2060	4 Lo SLR	100 yr	11.20	20	1.67	12.87	**32.4**	**23.6**	**102**	**18.1%**
2060	5 Hi SLR	10 yr	9.00	36	3	12	**30.2**	**22.2**	**106**	**22.0%**
2060	6 Hi SLR	100 yr	11.20	36	3	14.2	**36.0**	**25.9**	**106**	**22.0%**
2100	7 Lo SLR	10 yr	9.00	33	1.75	11.75	**29.7**	**22.2**	**121**	**19.6%**
2100	8 Lo SLR	100 yr	11.20	33	1.75	13.95	**34.7**	**24.8**	**121**	**19.6%**
2100	9 Hi SLR	10 yr	9.00	68	5.67	14.67	**36.3**	**25.9**	**126**	**24.4%**
2100	10 Hi SLR	100 yr	11.20	68	5.67	16.87	**39.9**	**27.6**	**126**	**24.4%**

**The Vermeer Rahmstorf Curve is at 4 inches, present day (2013).*

***Discount Rate of 3.3 percent applied.*

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Key Points from the Analysis

- The Wastewater Treatment Plant arises as the most expensive improved land needing protection.
- The model is over-predicting the expected dollar damage to the plant, as such a facility is more resilient to flooding than a normal commercial building. Further modeling of the expected damage to the wastewater treatment plant should be undertaken with a specialized depth-damage function. In a 10 year storm, current day, the existing berm protecting the WWTP should prevent inundation.
- Flooding from the Esopus Creek and other localized stormwater flows were not included in the analysis. Only Rondout Creek and Hudson River water level flooding was modeled.
- Stillwater flooding was modeled (like rising water in a bathtub). Wind, wave or erosion effects were not included.
- The Ulster County/City of Kingston Tax Assessment data from 2012 were used to assign values to the improvements to land at each parcel location.
- LiDAR data provided by Scenic Hudson was used to compute the land elevation.
- A Depth-Damage Function from the U.S. Army Corps of Engineers was utilized, to estimate the dollar damage to each building from each foot of flood water. (Analysis of Nonresidential Content Value and Depth-Damage Data for Flood Damage Reduction Studies, IWR Report 96-R-12, May 1996, Figure V-2)

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Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #1**, Flood Height: **9.00 ft.** (NAVD 88)
Year **2013**, With **No Sea Level Rise** and a **10-year Storm**
10% Probability of Occurrence in Any Given Year

Total Damage for this Event: **$22.0 Million**
Damage to Wastewater Treatment Plant: **$16.8 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge

Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #2**, Flood Height: **11.20 ft.** (NAVD 88)
Year **2013**, With **No Sea Level Rise** and a **100-year Storm**
1% Probability of Occurrence in Any Given Year

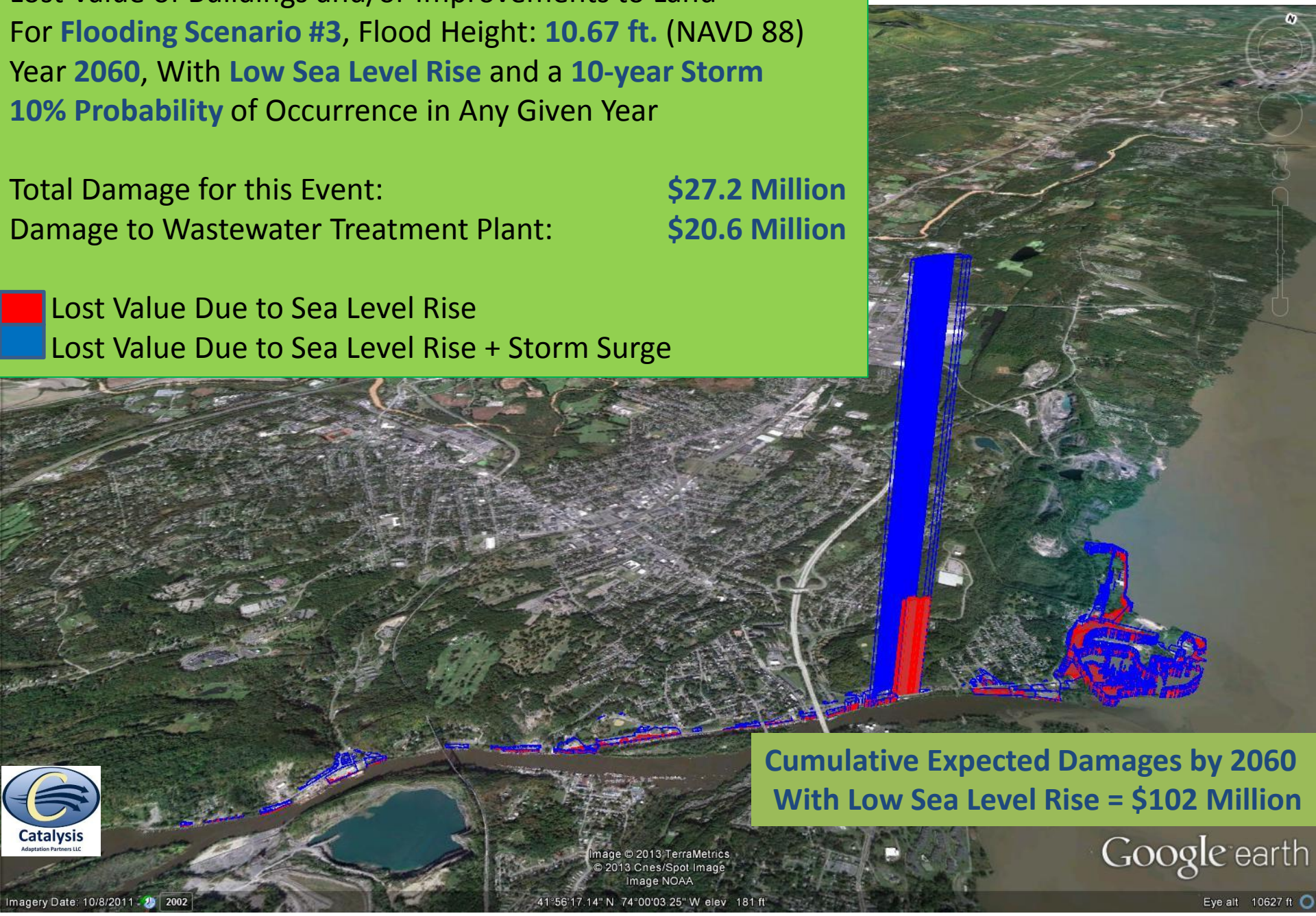
Total Damage for this Event: **$29.5 Million**
Damage to Wastewater Treatment Plant: **$22.2 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge

Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #3**, Flood Height: **10.67 ft.** (NAVD 88)
Year **2060**, With **Low Sea Level Rise** and a **10-year Storm**
10% Probability of Occurrence in Any Given Year

Total Damage for this Event: **$27.2 Million**
Damage to Wastewater Treatment Plant: **$20.6 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge



Cumulative Expected Damages by 2060
With Low Sea Level Rise = $102 Million

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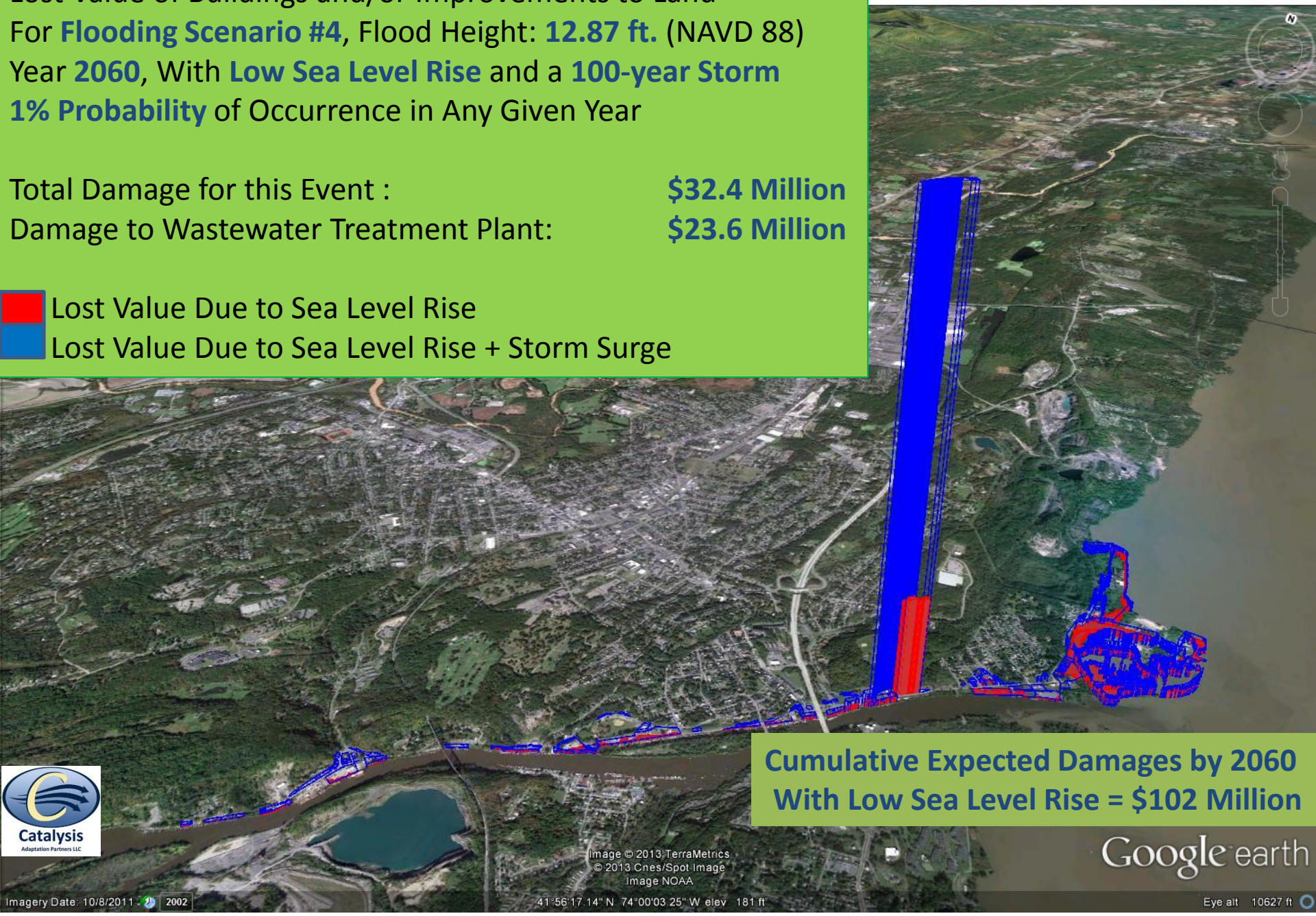
Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #4**, Flood Height: **12.87 ft.** (NAVD 88)
Year **2060**, With **Low Sea Level Rise** and a **100-year Storm**
1% Probability of Occurrence in Any Given Year

Total Damage for this Event : **$32.4 Million**
Damage to Wastewater Treatment Plant: **$23.6 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge



Cumulative Expected Damages by 2060
With Low Sea Level Rise = $102 Million

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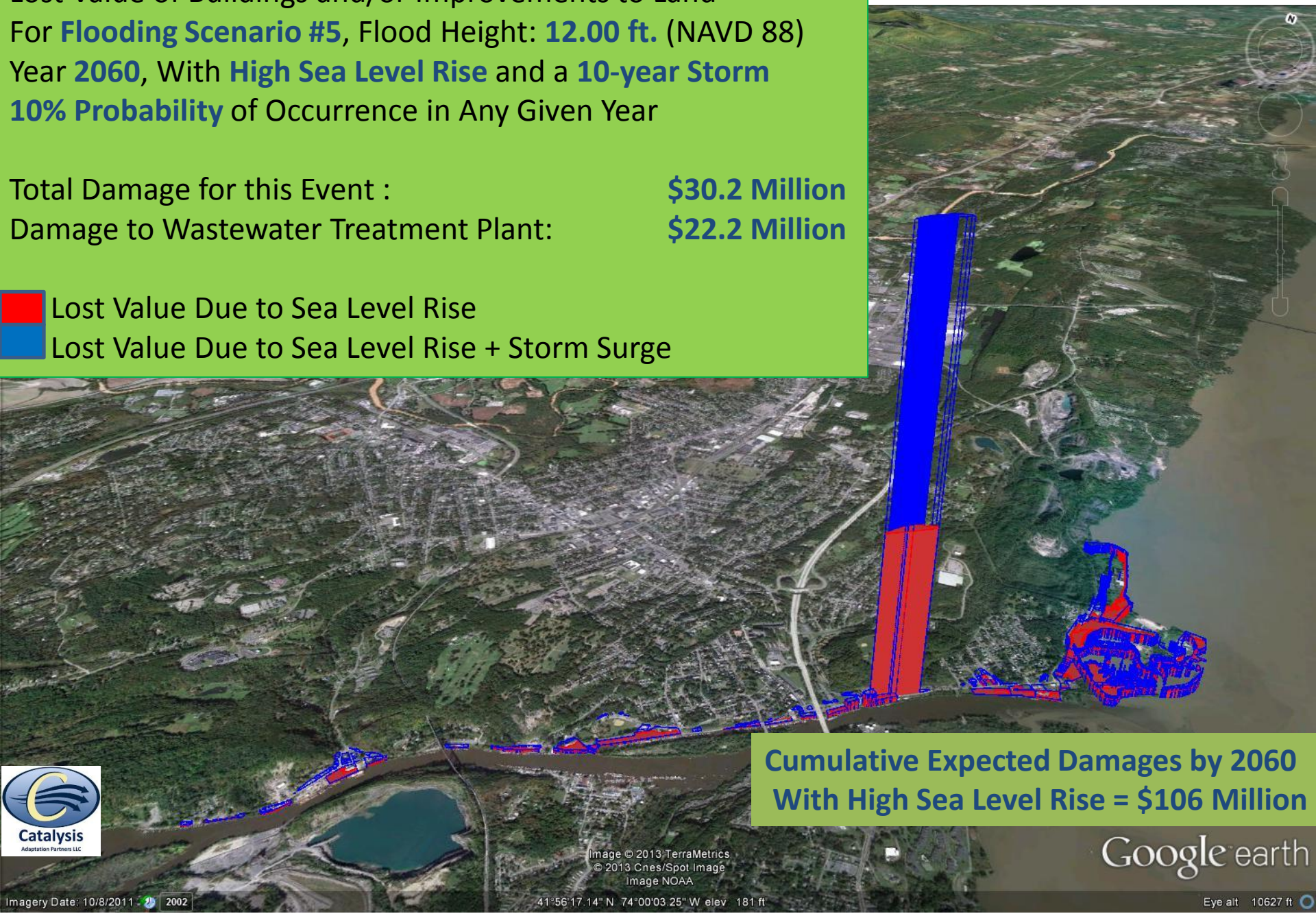
Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #5**, Flood Height: **12.00 ft.** (NAVD 88)
Year **2060**, With **High Sea Level Rise** and a **10-year Storm**
10% Probability of Occurrence in Any Given Year

Total Damage for this Event : **$30.2 Million**
Damage to Wastewater Treatment Plant: **$22.2 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge



Cumulative Expected Damages by 2060
With High Sea Level Rise = $106 Million

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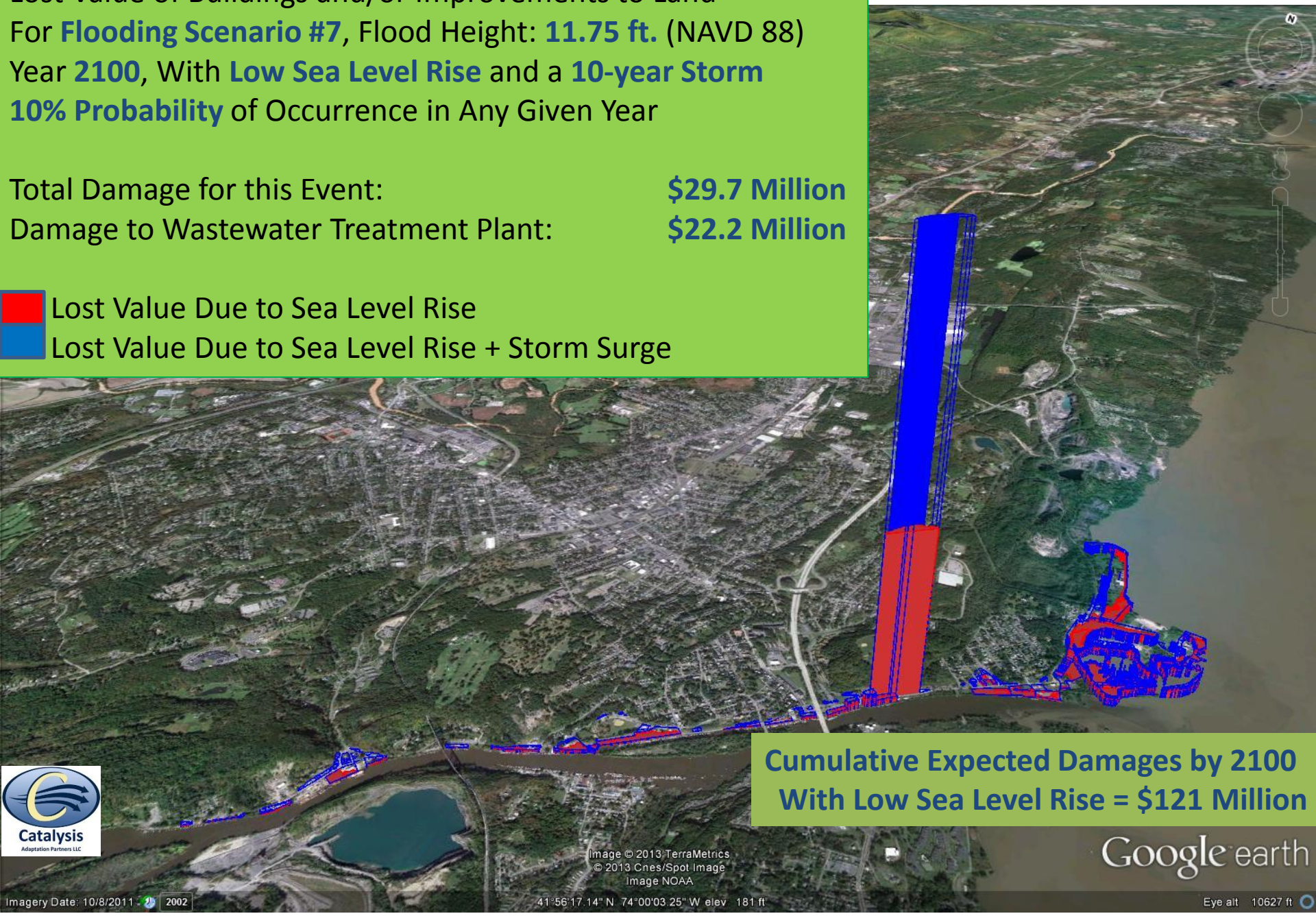
Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #7**, Flood Height: **11.75 ft.** (NAVD 88)
Year **2100**, With **Low Sea Level Rise** and a **10-year Storm**
10% Probability of Occurrence in Any Given Year

Total Damage for this Event: **$29.7 Million**
Damage to Wastewater Treatment Plant: **$22.2 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge



Cumulative Expected Damages by 2100
With Low Sea Level Rise = $121 Million

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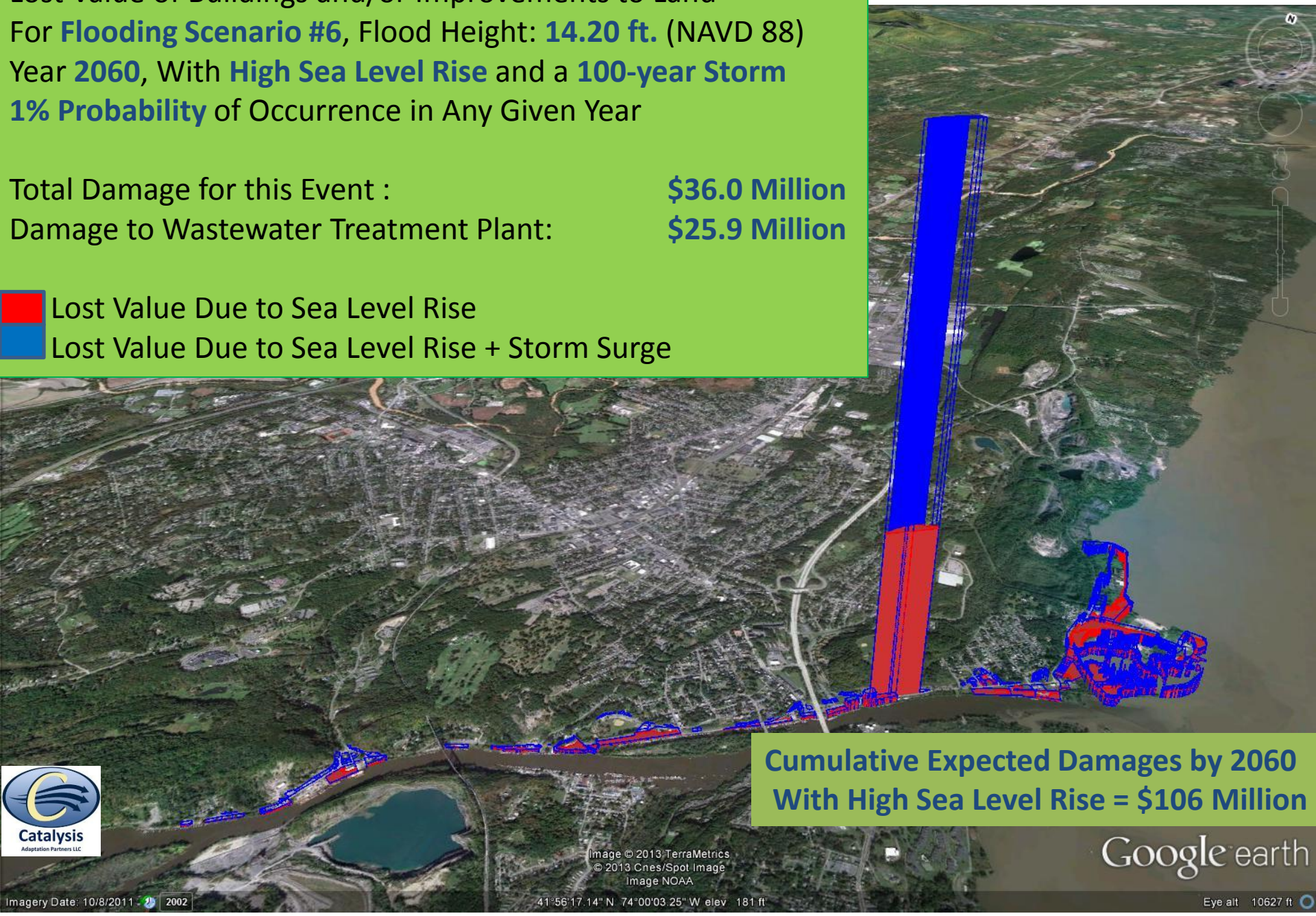
Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #6**, Flood Height: **14.20 ft.** (NAVD 88)
Year **2060**, With **High Sea Level Rise** and a **100-year Storm**
1% Probability of Occurrence in Any Given Year

Total Damage for this Event : **$36.0 Million**
Damage to Wastewater Treatment Plant: **$25.9 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge



Cumulative Expected Damages by 2060
With High Sea Level Rise = $106 Million

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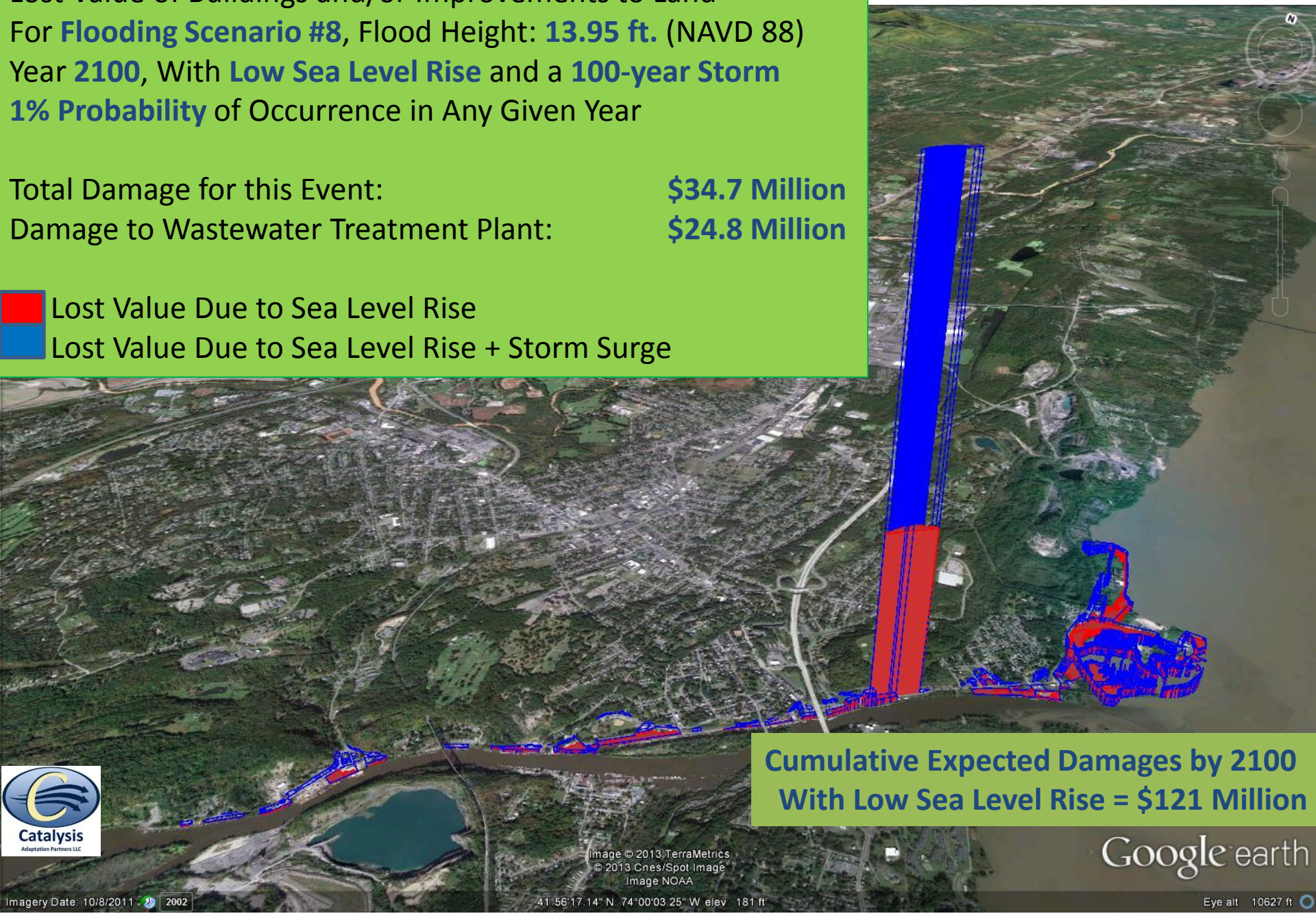
Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #8**, Flood Height: **13.95 ft.** (NAVD 88)
Year **2100**, With **Low Sea Level Rise** and a **100-year Storm**
1% Probability of Occurrence in Any Given Year

Total Damage for this Event: **$34.7 Million**
Damage to Wastewater Treatment Plant: **$24.8 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge



Cumulative Expected Damages by 2100
With Low Sea Level Rise = $121 Million

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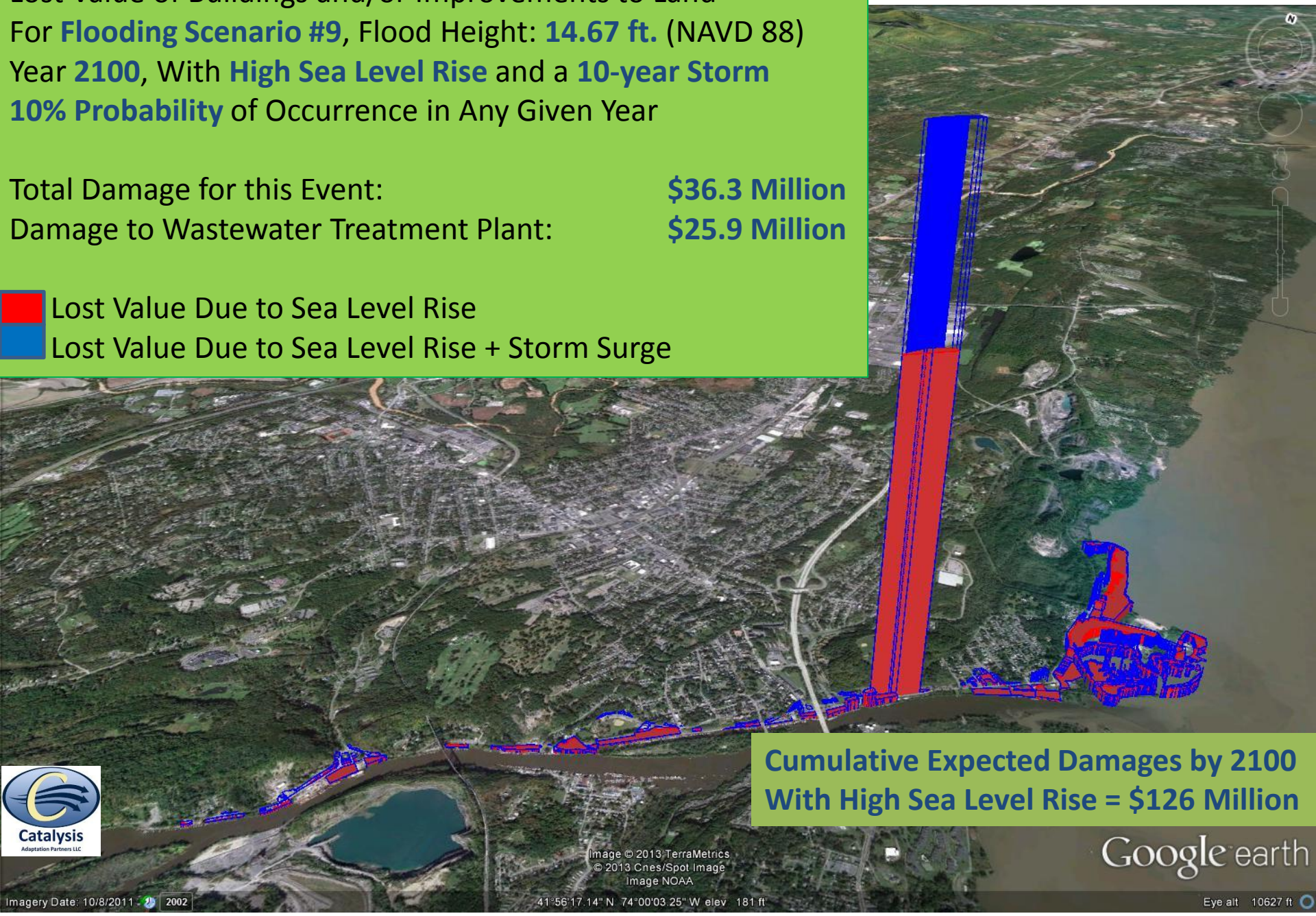
Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #9**, Flood Height: **14.67 ft.** (NAVD 88)
Year **2100**, With **High Sea Level Rise** and a **10-year Storm**
10% Probability of Occurrence in Any Given Year

Total Damage for this Event: **$36.3 Million**
Damage to Wastewater Treatment Plant: **$25.9 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge



Cumulative Expected Damages by 2100
With High Sea Level Rise = $126 Million

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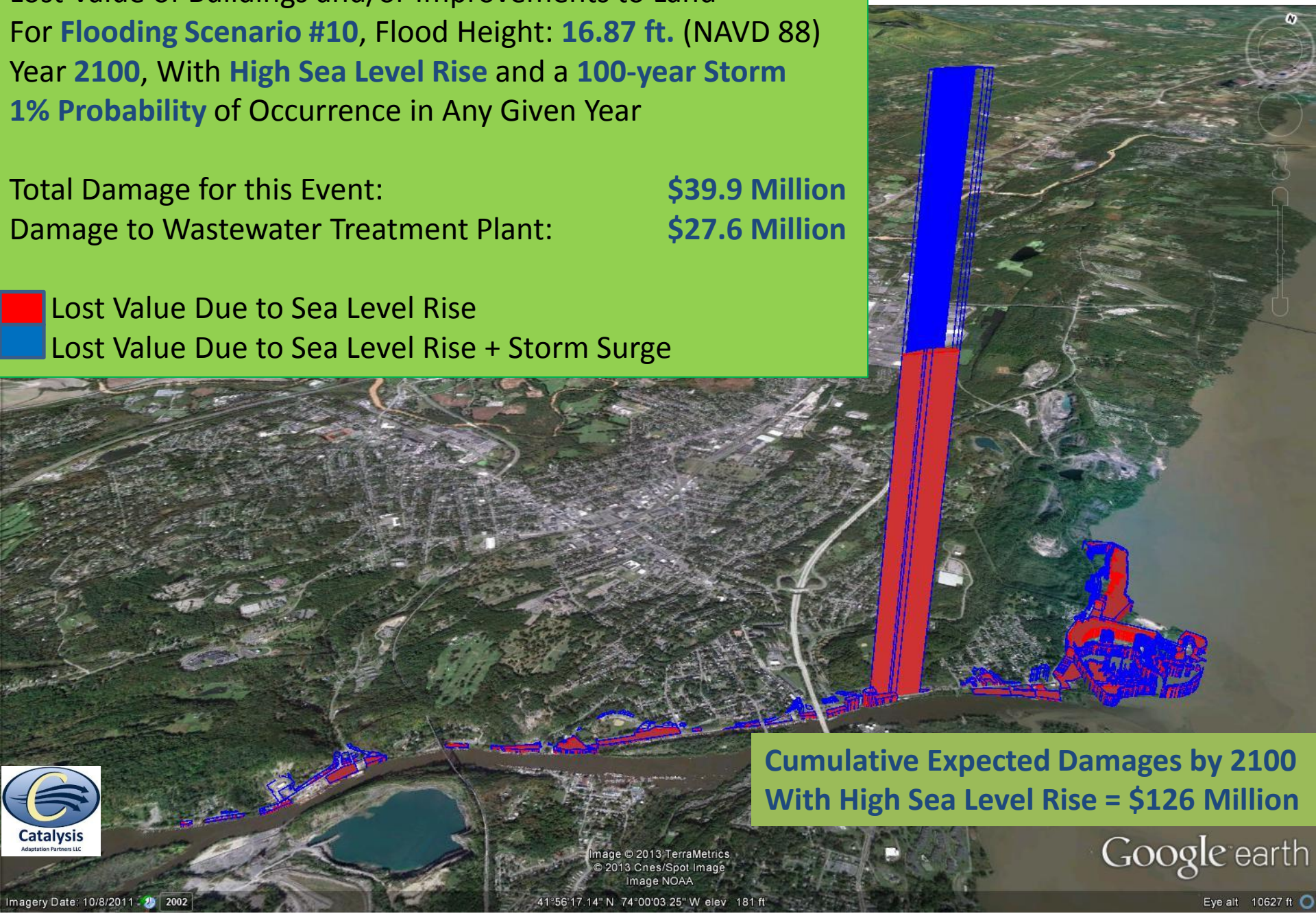
Lost Value of Buildings and/or Improvements to Land
For **Flooding Scenario #10**, Flood Height: **16.87 ft.** (NAVD 88)
Year **2100**, With **High Sea Level Rise** and a **100-year Storm**
1% Probability of Occurrence in Any Given Year

Total Damage for this Event: **$39.9 Million**
Damage to Wastewater Treatment Plant: **$27.6 Million**

Lost Value Due to Sea Level Rise
Lost Value Due to Sea Level Rise + Storm Surge



Cumulative Expected Damages by 2100
With High Sea Level Rise = $126 Million

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A Close-up Look at the COAST Model Output…

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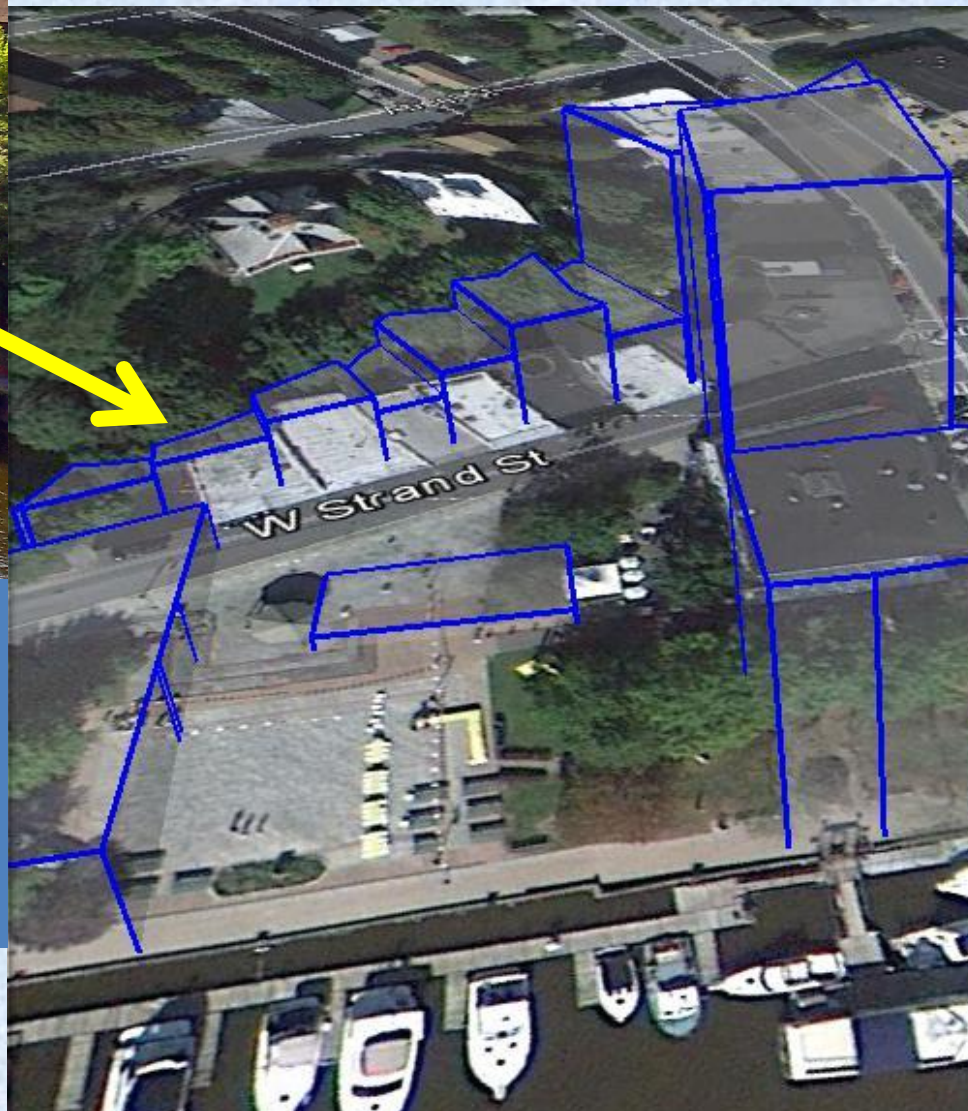

West Strand Street
Rondout Landing Area
COAST Output
Relative Height of
Blue Boxes Indicates Predicted Dollar
Damages to Buildings and Improvements

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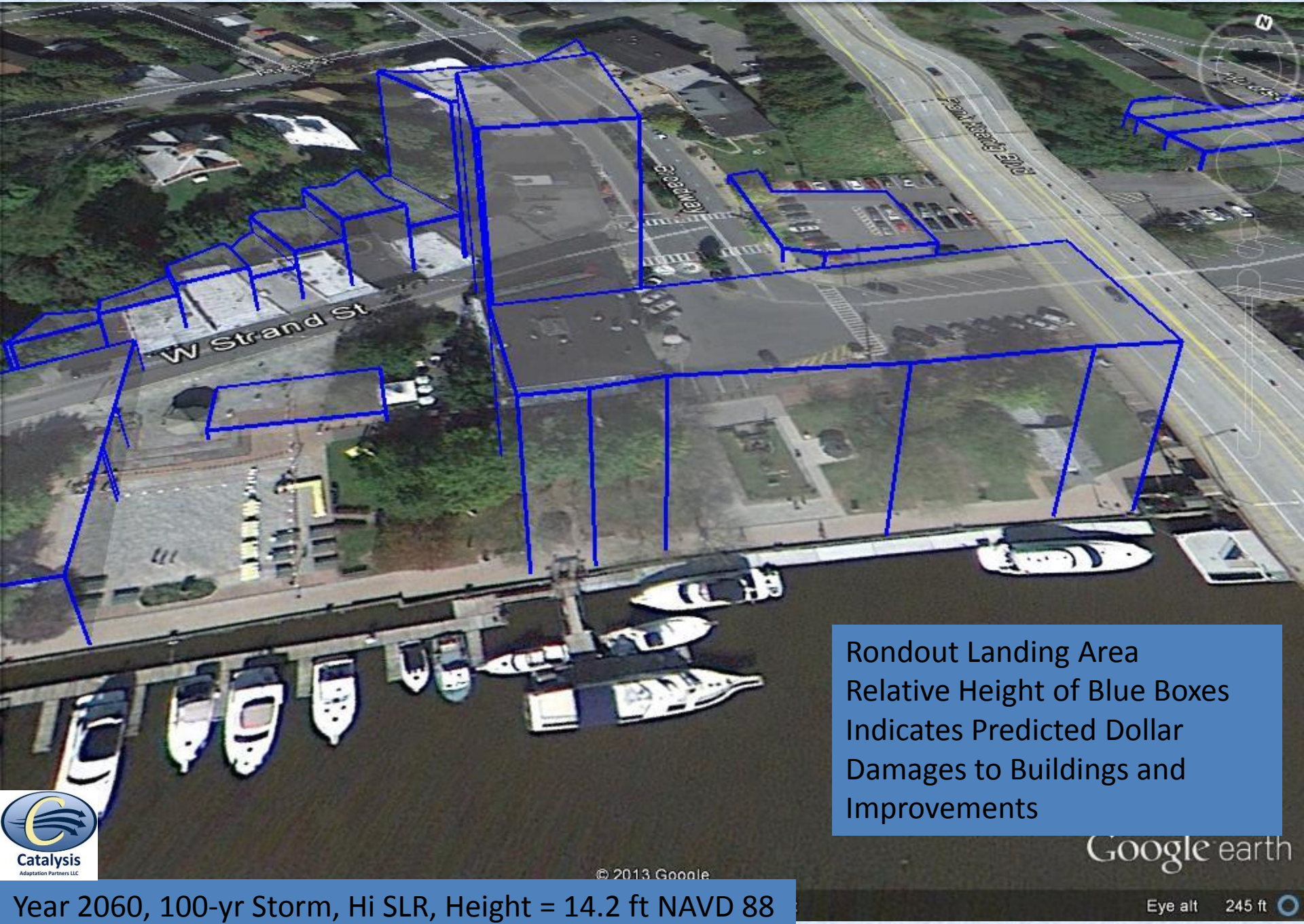

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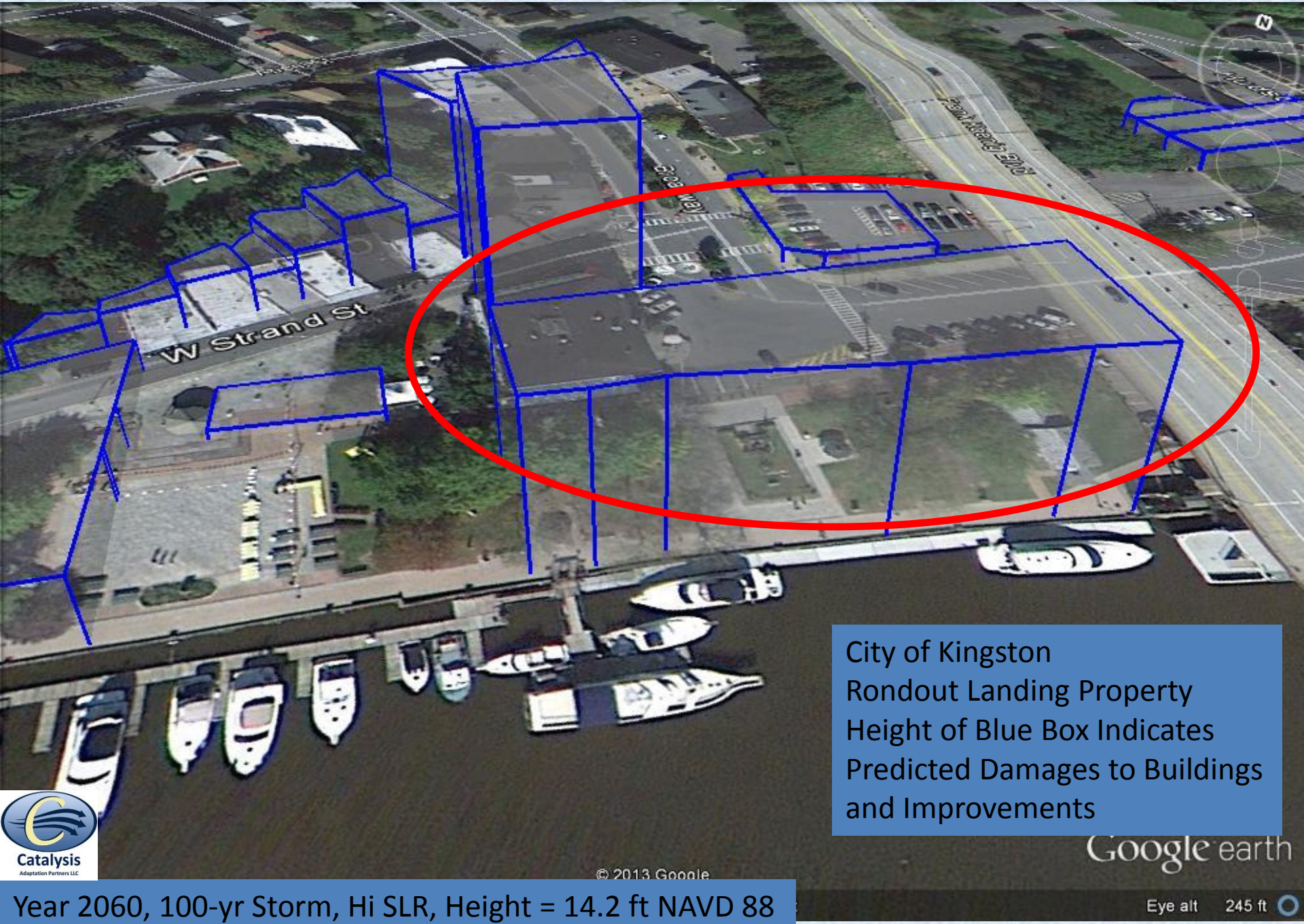

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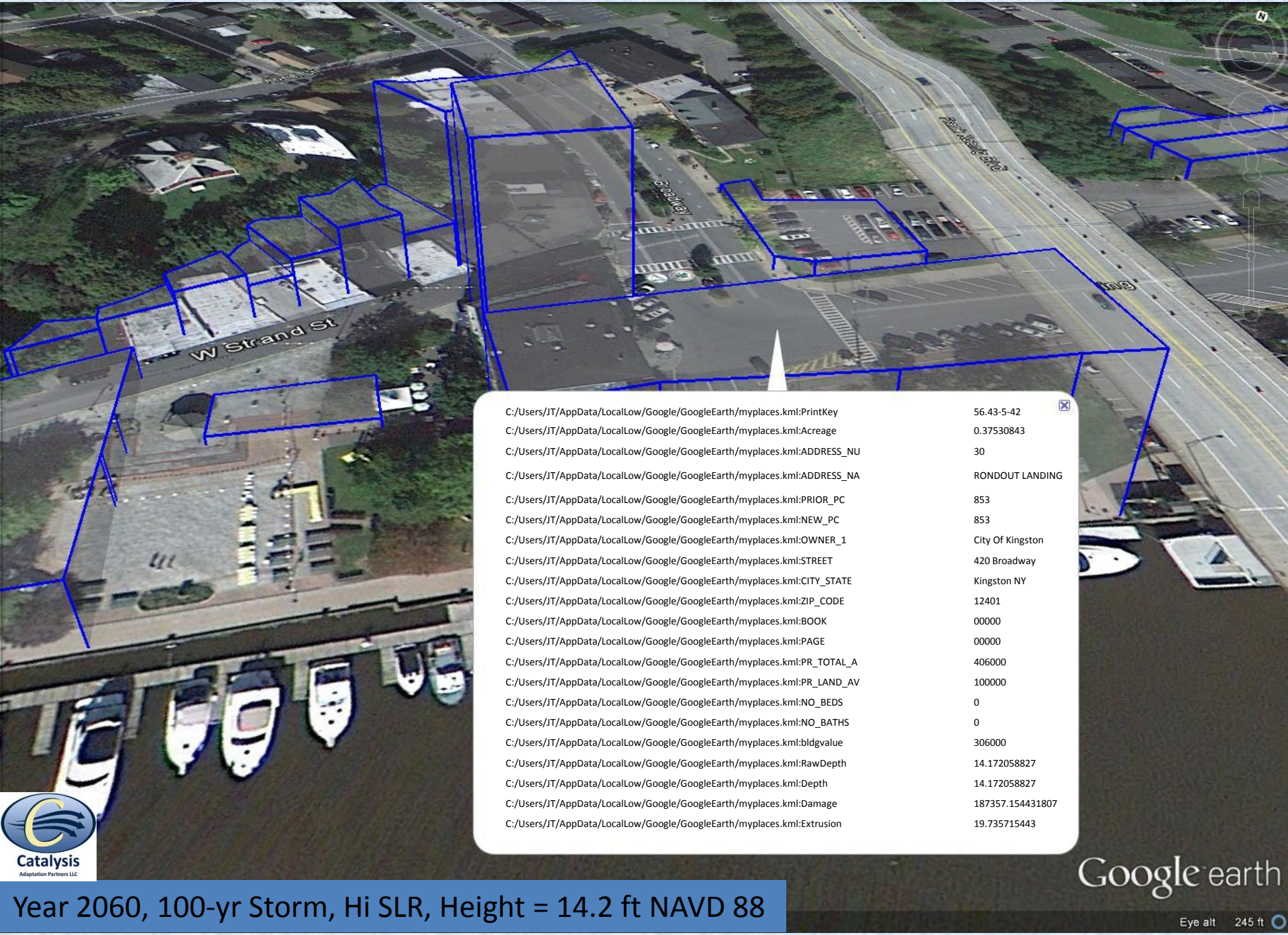

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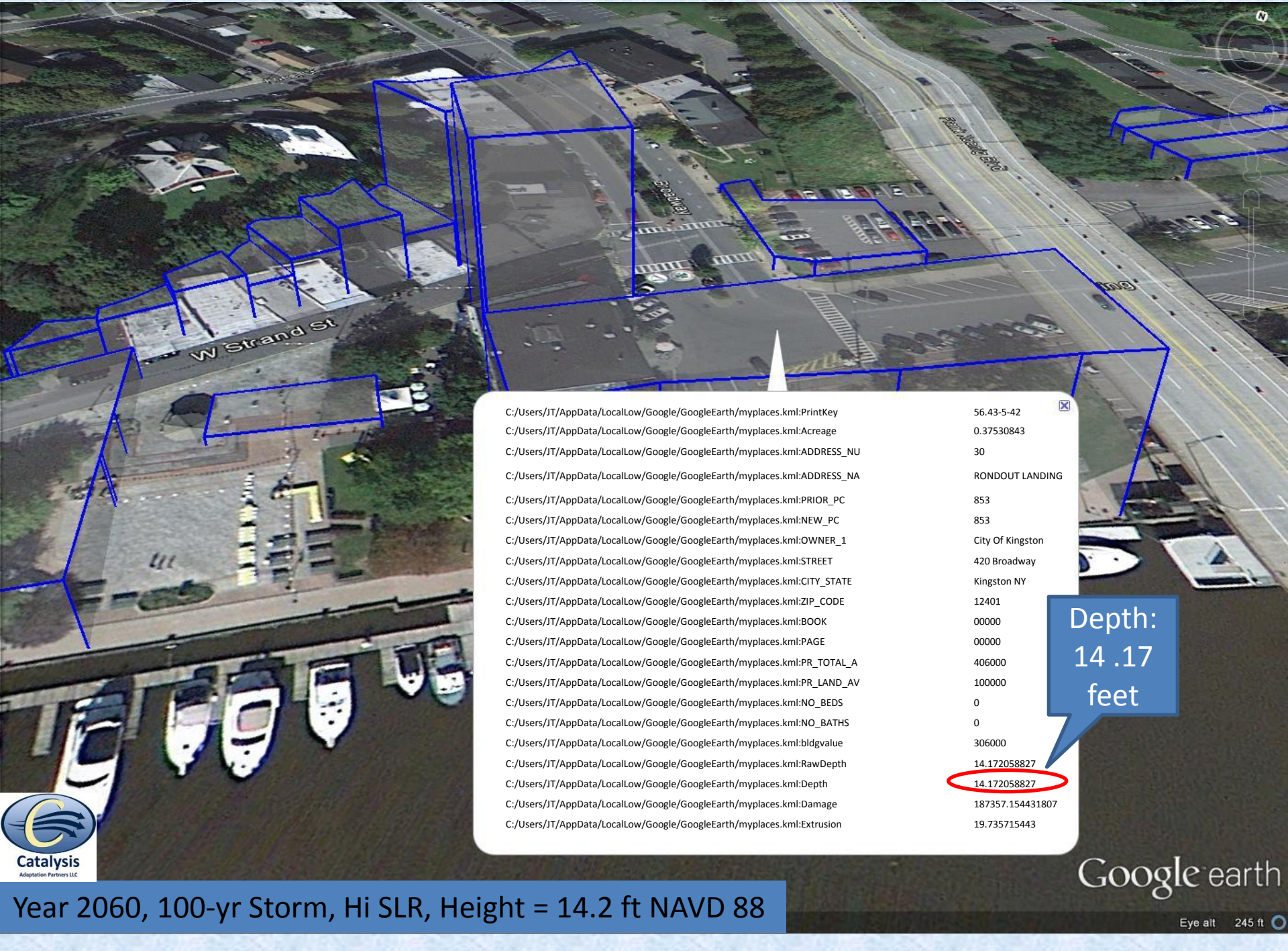
Year 2060, 100-yr Storm, Hi SLR, Height = 14.2 ft NAVD 88



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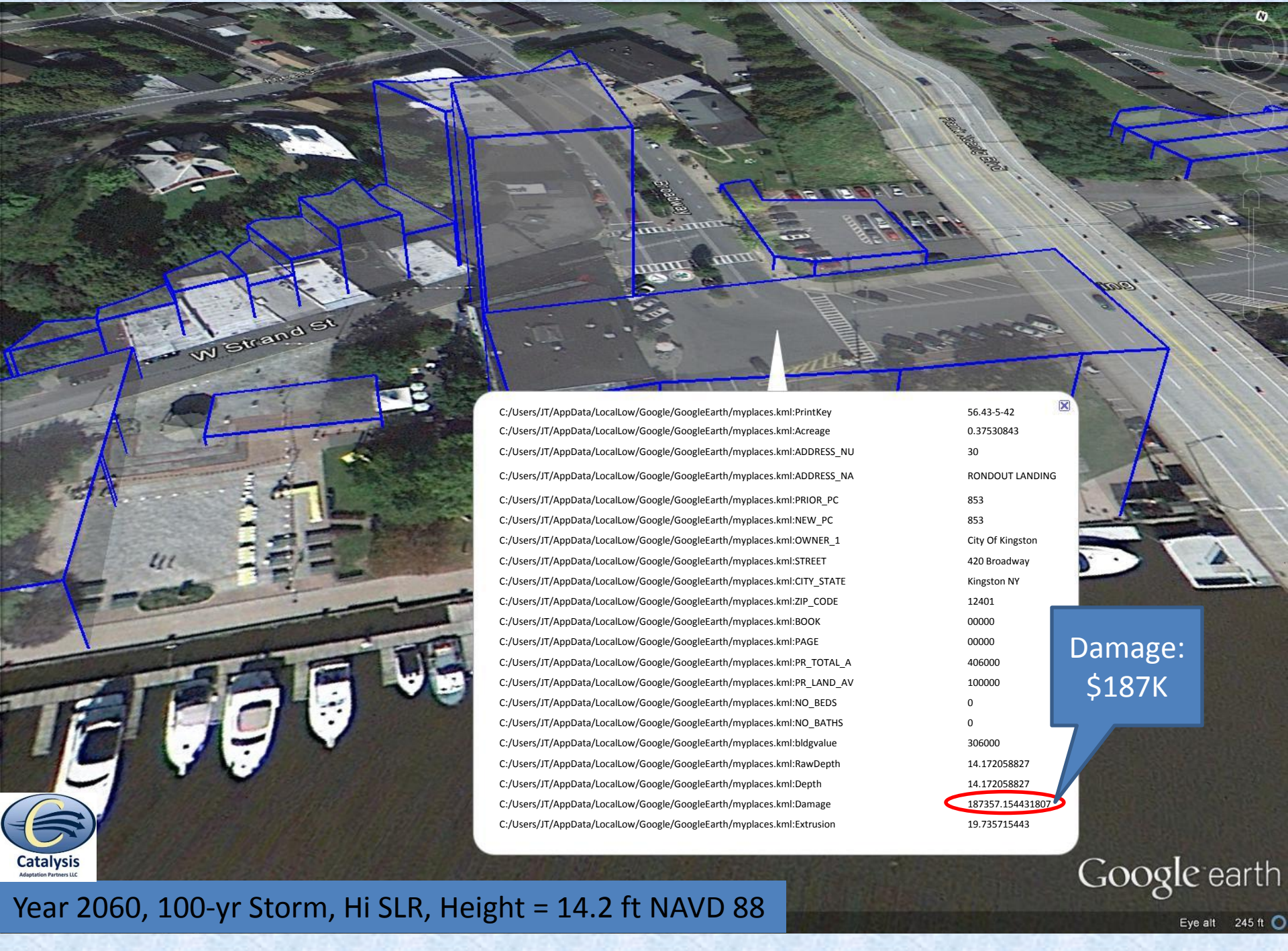

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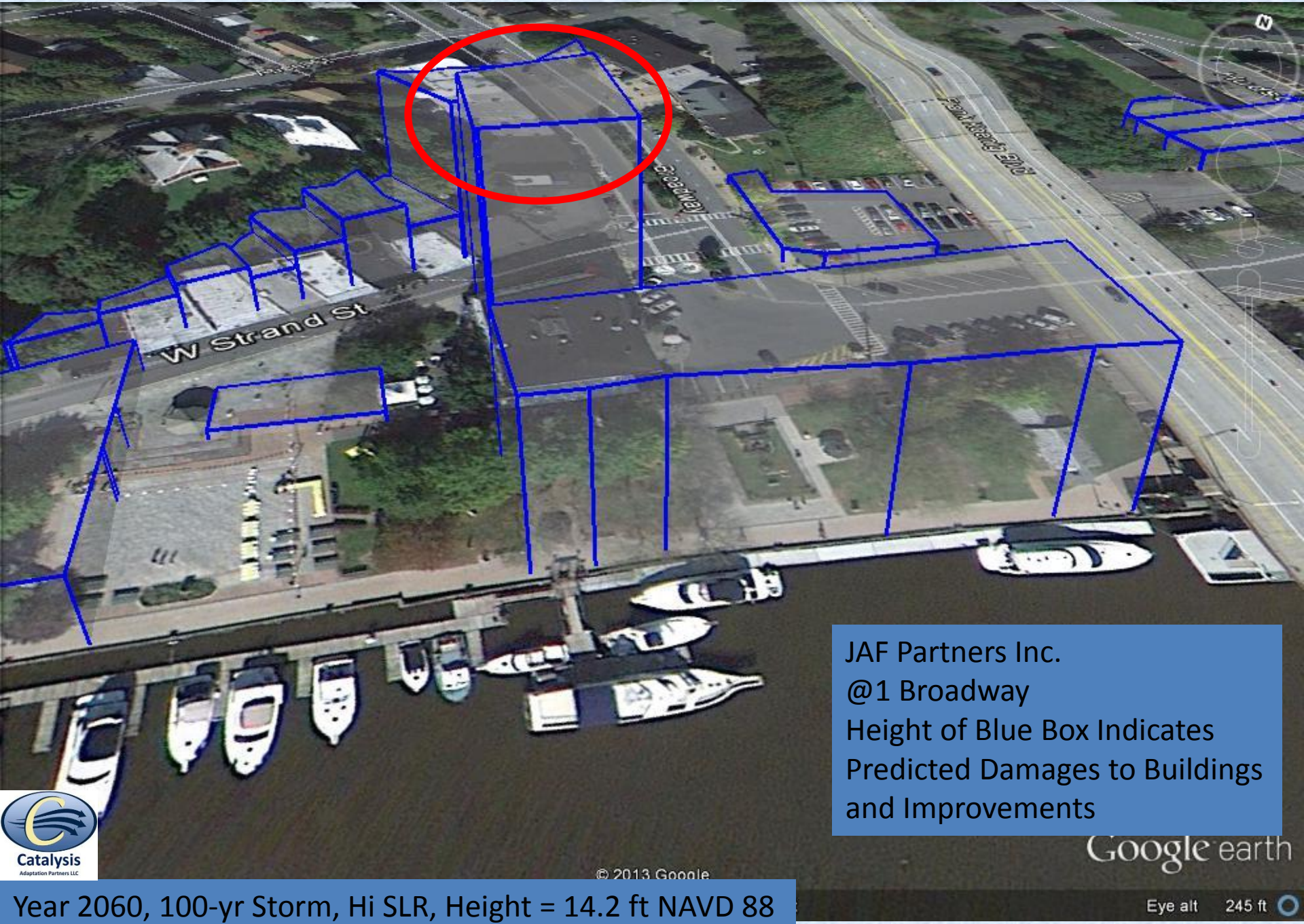
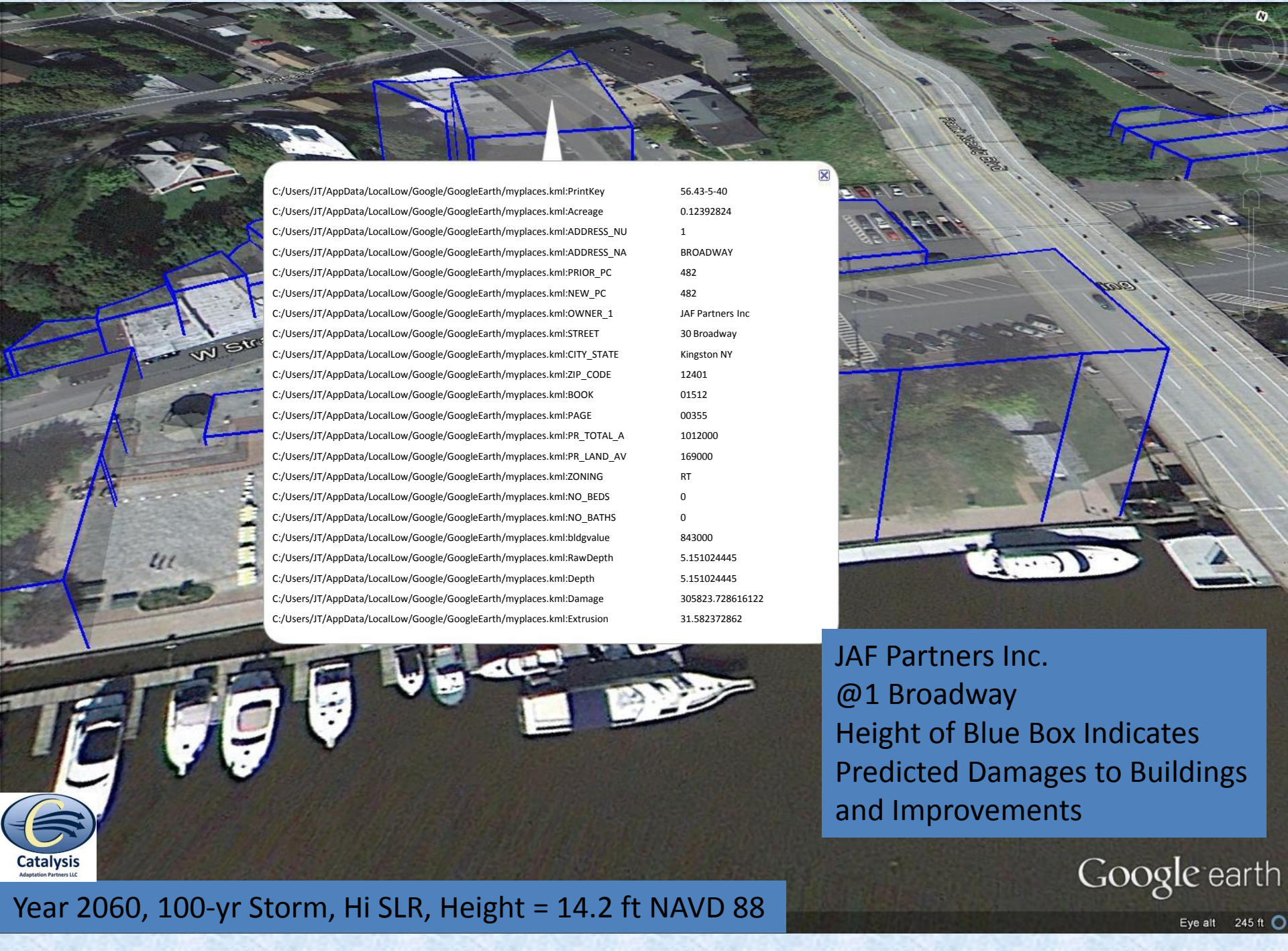
Year 2060, 100-yr Storm, Hi SLR, Height = 14.2 ft NAVD 88



Year 2060, 100-yr Storm, Hi SLR, Height = 14.2 ft NAVD 88



JAF Partners Inc.
@1 Broadway
Height of Blue Box Indicates
Predicted Damages to Buildings
and Improvements

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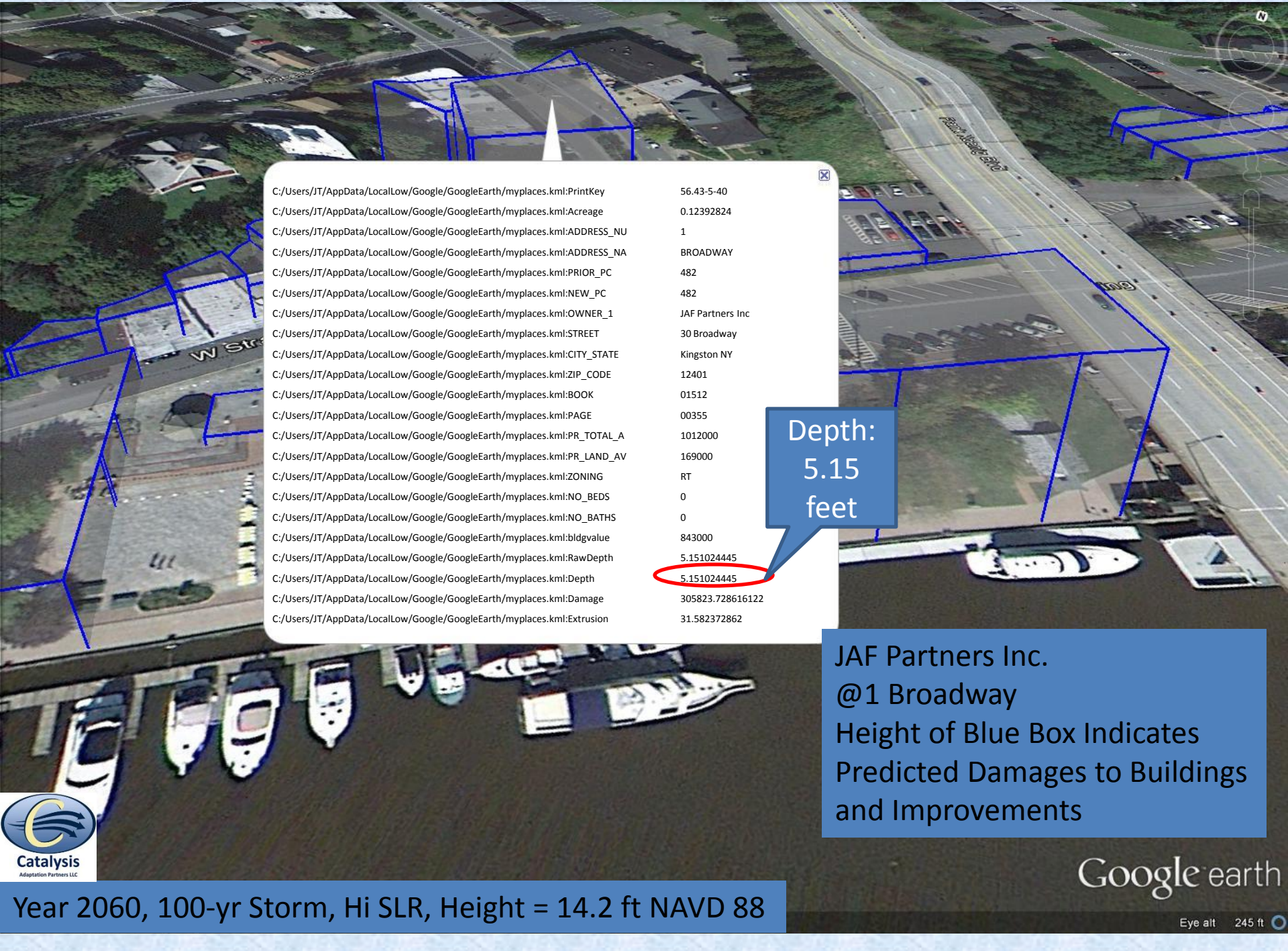
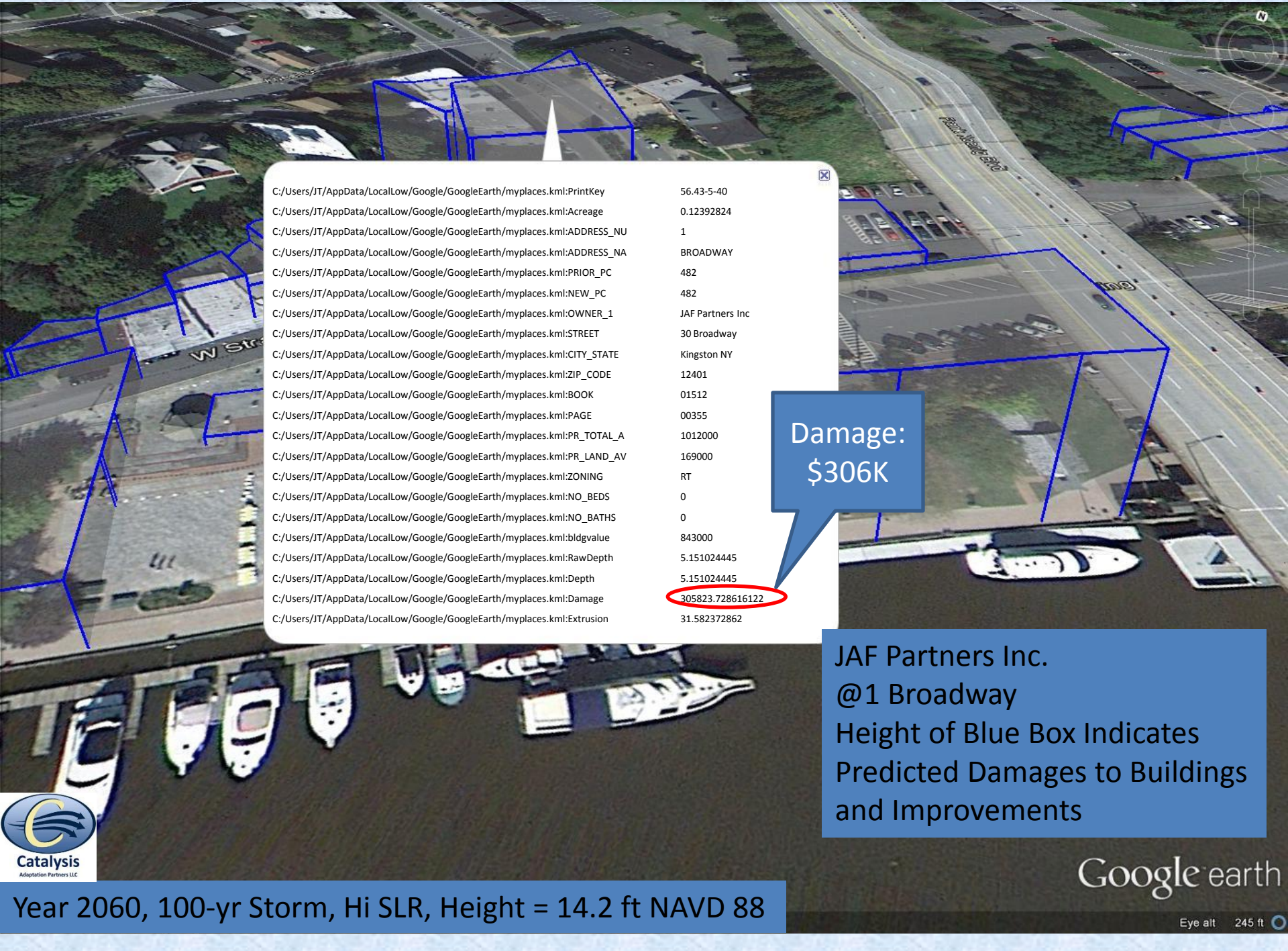
Year 2060, 100-yr Storm, Hi SLR, Height = 14.2 ft NAVD 88

Google earth

Eye alt 245 ft



Year 2060, 100-yr Storm, Hi SLR, Height = 14.2 ft NAVD 88



Year 2060, 100-yr Storm, Hi SLR, Height = 14.2 ft NAVD 88

COAST Model Output Can Be Easily Used by the Community

- All output files are in Google Earth format, and can be easily distributed.
- Google Earth is available as a free download usable on a variety of operating systems.
- Users can “fly through” the community to any location and look up potential flood depths and damages.
- Fly-through demonstration, selecting sites chosen by participants, showing predicted flood depths and damages.

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Part II: Selecting Possible Adaptation Actions:

Hard

- Revetments
- Sea walls
- Jetties
- Dry Flood-proofing
- Increasing Freeboard Now – Grants for Elevating Structures
- Automatic Floodgates
- Levees/Berms
- Road Elevations

Soft

- Geotextile tubes
- Dune Restoration
- Tidal Marsh Restoration
- Wet Flood-proofing
- Zoning changes
- Requiring Increased Freeboard Over Time– Elevating Structures
- Buyouts
- Rolling Easements

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Kingston waterfront
Simulation: elevated sea level (low tide), armored protection

Kristin Marcell, Jan. 2012

Kingston waterfront
Simulation: elevated sea level (low tide), vegetated revetment, floodproofed buildings

Kristin Marcell, HREP, Jan. 2012

Kingston waterfront
Simulation: elevated sea level (low tide), strategic retreat

Kristin Marcell, HREP, Jan. 2012

Flooding Vulnerability Assessment for the City of Kingston, NY

- *For 10-year and 100- year Storm Events*
- *With High and Low Sea Level Rise Scenarios*
- *For the Years 2013, 2060 and 2100*
- *Including Predictions for All Cumulative Expected Monetary Damage to Buildings and Improvements using the COAST tool*

Catalysis
Adaptation Partners LLC

Jonathan T. Lockman AICP
Vice President of Environmental Planning
jtlockman@catalysisadaptation.com
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