Appendix A

POTENTIAL MITIGATION MEASURES THAT ARE PRE-DETERMINED TO BE COST EFFECTIVE

The following potential mitigation measures (reference: paragraph VII.B.2) are determined to be cost-effective if they:

- do not exceed 100% of project cost,
- are appropriate to the disaster damage,
- will prevent future similar damage,
- are directly related to the eligible damaged elements,
- do not increase risks or cause adverse effects to the property or elsewhere,
- are technically feasible for the hazard and location, and
- otherwise meet requirements stipulated in this policy, including environmental, historic, and mitigation planning considerations.

This list will continue to be evaluated and will evolve over time as new information becomes available.

I. General:

A. Drainage/crossings and bridges

1. Drainage structures - When drainage structures are destroyed, replacing the structure with multiple structures or a larger structure. Sizing of replacement culverts can be made using in-place state/local drainage criteria (nomographs). However, structures need to be considered with regard to a total drainage system and should not be upgraded without a watershed hydrology study with an emphasis on downstream effects and NFIP regulations.

2. Culverts – Where the alignment of culverts is inconsistent with streams flowing through them (because it has been blown-out), realign or relocate the culverts to improve hydraulics and minimize erosion. However, realignment of structures must be considered in regard to a total drainage system and shall not be replaced without a hydrology study with an emphasis on downstream erosion effects.

3. Headwalls and wing walls - Installation to control erosion.

4. Low-water crossings – When bridges are destroyed and where traffic counts are low, replacing bridges with carefully placed low-water crossings.

5. Gabion baskets, riprap, sheet-piling, and geotextile fabric installation - Installation to control erosion.

6. Roadways – Where roadways shoulders are damaged by overflow from adjacent water courses, stabilize shoulders and embankments with geotextile fabric.

7. Restraining cables on bridges - Installation of cables to restrain a bridge from being knocked off piers or abutments during floods or earthquakes. Also, where bridges have been damaged or destroyed when girders, beams and decking system are displaced by storm surges or earthquakes, install girder and deck uplift tie-downs to prevent their displacement from the substructure.

B. Sanitary and storm sewer systems

1. Access covers - When feasible, access covers can be elevated to the hydraulic grade line. There are a number of devices that prevent infiltration into access holes.

2. Sewer lines – Repair, lining or encasement of damaged sections to prevent infiltration or structural collapse.

3. Pump stations –

a. Equipment or controls in a pump station that are subject to damage from the 100- year flood can be elevated. Pump station buildings can be dry flood-proofed.

b. Installation of camlocks, transfer switches, and electrical panels to facilitate the connection of portable emergency generators.

c. Pump stations – If pumps and their attached motors are damaged by storm water inundation, replace them with submersible or inline pumps as appropriate.

d. Pump stations – If pump station equipment is damaged as a result of inundation resulting from power failure, install switches, circuit isolation and/quick connect capability to facilitate rapid connection of backup power.

C. Wastewater treatment plants

1. Elevation of equipment and controls that can be elevated easily.

2. Dry or wet flood-proofing of buildings.

D. Potable water

1. Well systems –

a. Reduction of infiltration and subsequent contamination of the aquifer. Methods include casing the well or raising the elevation of the well head.

b. Elevation of controls, mechanical equipment, or electrical service associated with use of the well to protect them from flood damage.

2. Raw water intakes - Buttressing to prevent damage from erosion, scour and flood debris.

3. Water treatment plants –

a. Elevation of equipment and controls that can be elevated easily.

b. Dry flood-proofing.

E. Electric power distribution

1. Pad-mounted transformers - elevating above the base flood elevation.

2. Using multiple poles to support transformers.

3. Anchoring or otherwise protecting fuel tanks from movement in a disaster.

4. Replacing damaged poles with higher-rated poles, of the same or different material such as replacing wood poles with precast concrete or steel.

5. Adding guy wire or additional support to power lines.

6. Removing large diameter lines from poles.

7. Providing looped distribution service or other redundancies in the electrical service to critical facilities.

F. Above ground storage tanks

1. Strengthening or stiffening base connections.

2. Installation of self-initiating disconnects and shut-off values between tanks and distribution lines to minimize damage and leaks.

G. Underground pipelines - Installation of shut-off valves so that damaged sections of pipeline can be isolated.

II. <u>Buildings:</u>

A. General effects of flood damage –

1. Buildings substantially damaged under NFIP regulations - Repair, dry flood-proofing, or elevation so they are protected to meet minimum NFIP regulations. If the building is replaced, rather than repaired, minimum NFIP requirements are generally in place as codes and standards in participating communities and are applicable in both repair and replacement situation. Section 406 mitigation should be considered in those cases where these standards either fall short or provide no protection against other hazards.

2. Buildings not substantially damaged under NFIP regulations - If technically feasible, dry flood-proofing. Electrical panels, machinery rooms, emergency generators can be elevated above the BFE or dry flood-proofed. If dry flood-proofing is not feasible, these buildings should be wet flood-proofed.

B. Roofs - Because the failure of a roof covering can lead to extensive damage to contents and operation, damaged roofing should be evaluated to determine cause of failure.

1. Low slope roofs - Replacement of the entire roof with a roof covering with a secondary membrane and a fully adhered roof covering, such as modified bitumen. Mechanically fastened insulation or membranes are not acceptable.

2. Roof-mounted equipment should be attached to a foundation that will resist expected wind forces.

3. Hurricane clips - Hurricane clips for use in high-wind areas.

4. Roofs – When roof damages are due to wind pressure beneath soffits and overhangs, strengthen the soffit and overhang material and means of attachment to prevent wind pressure adversely affecting the roofing system.

5. Roofs – When there is roof system damage or water intrusion due to damage to roof opening such as hatches and skylights strengthen the openings or the windows to avoid future damage.

6. Roofs – For gable roofs damaged by wind, replace the gable end-framing with hipped roof framing to reduce wind forces (lower edge pressure; reduced projected wind area) and strengthen the roof framing.

C. Shutters - In areas subject to hurricane winds, shutters are appropriate in the following areas:

1. All damaged windows on critical facilities such as hospitals.

2. The lower floors of buildings with damaged windows most likely to be struck by debris.

3. Damaged windows of buildings with very high value contents that can be damaged by water (such as libraries and document centers).

4. Damaged windows of buildings subject to debris from nearby ballasted roofs, metal buildings, manufactured homes or other structures likely to fail and result in debris.

D. Anchoring –

1. Anchoring of mechanical and electrical equipment in critical facilities.

2. For small ancillary buildings that have sustained damage and/or have caused damage to other facilities, anchor the buildings to foundations to prevent toppling or becoming missile hazards.

E. Flexible piping - Installation of flexible piping at pipe/conduit connections to equipment to accommodate expected movement in an earthquake.

F. Bracing –

1. Bracing of and large diameter pipes and electrical lines to meet seismic loads.

2. Bracing non structural interior walls and partitions.

3. Bracing parapets, anchoring veneer or cladding, and bracing other non-structural elements that could collapse and cause injury or block safe exit of a building during an earthquake.

G. Replacement of glass - Replacement of glass with impact-resistant material.

H. General Buildings –

1. Buildings – Where spread footings have been undercut by scour, underpin footings.

2. Siding – if siding has been damage by wind, replace with a stronger siding with stronger attachments to the wall sheathing and structure.

3. Venting – Where there has been water damage caused by water intrusion through venting systems, replace the vents with rain and water resistant vents.

I. Doors and Windows –

1. Where damage has resulted from wind and water intrusion around weather stripping on doors and/or windows, upgrade the weather stripping to prevent water infiltration.

2. Where damage has been caused by wind-induced failure of doors, replace the doors with stronger units. This applies to the door frame, door, hinges and lock hardware. Both entry and garage doors should be considered.

J. Miscellaneous Structures –

1. Marine Piers – If marine piers ramps that attach to decking have been damaged by storm-surge uplift and buoyancy, install open decking or floating decking with uplift-resistant tie-downs and fasteners.

2. Signage – If sign panels and their supports have failed, replace with a stronger type of system of supports and panels. Consider using multiple support posts and stronger panels and fasteners.

3. Gutters and Downspouts – If damaged by either wind and/or water, upgrade the gutter and downspout system to directing water away from the structure and preventing interior or basement water damage.

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