

Appendix F
Guidance for Estimating Percent Damage for Non-Residential Structures

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Basic Flooding Model Assumptions:

1) Medium height freshwater flooding - limited duration. Some high-velocity action; possible wave action.

This guidance represents a starting point for inspectors to perform assessments on non-residential buildings. Because of the wide range of structure types, this guidance should be used as a rough estimation for a typical 1-story convenience store. Any variation from that should take into consideration the potential differences in each element.

2) The damage evaluation guidance in this should be taken as possible or likely indicators of the respective level of damage, but is not a definite representation of damage to a structure after a flood and wind event. Not all threshold markers may need to be met to achieve the level of damage indicated.

Foundation		Damage Threshold			
		0- 25%	25-50%	50-75%	Over 75%
Description	Continuous perimeter foundations, footings, and piers for internal beams and floor loads. Materials include masonry or concrete masonry units (CMUs) or piles.	<p>Water level rises just above first floor level.</p> <p>No scouring around foundation.</p> <p>Some undermining but no visible cracking at concrete slab.</p>	<p>Water level is 4-7 feet against the outside of the building.</p> <p>Limited scouring around foundation.</p> <p>Soils are saturated.</p> <p>Undermining of the foundation, especially at corners - hairline cracks only.</p>	<p>Water level is 7-10 feet against the outside of the building.</p> <p>Limited scouring around foundation.</p> <p>Soils are saturated and unstable.</p> <p>Cracks noted on or along the foundation walls.</p> <p>Significant undermining of the foundation - significant cracking is visible.</p>	<p>Water level is more than 10 feet against the outside of the building.</p> <p>Limited scouring around foundation.</p> <p>Foundation is notably cracked and/or displaced. Structure has been knocked off its foundation.</p> <p>Portions of the foundation are damaged or missing.</p> <p>Significant undermining of the foundation - major cracking and separation of the foundation.</p>
		<p>Short-term inundation to limited heights. Limited scouring and erosion - low-flow and low velocity floodwaters. No noticeable cracking of the masonry or displacement of the foundation walls.</p>	<p>Short-term inundation - foundation is inundated with flood waters but for a limited duration. Limited scouring or undermining of the foundation or footings is found. Minor cracking from some settlement but no displacement, heaving, or discontinuities of the structural support systems.</p>	<p>Floodwaters extend over the top of the foundation system - significant inundation for over 12 hours. Some cracking of the masonry/concrete foundation walls. Some damage to the foundation wall from debris or settlement noted.</p>	<p>Settlement noted at the footings due to erosion or unstable soils. Foundation wall damage - sections of the walls cracking, displaced, and missing, causing an inherent instability to the support for the building. Use caution when approaching or entering the building.</p>
	<p>Special Considerations for Coastal/High Velocity Floods</p>	<p>Coastal floods may have more evidence of scouring at the supports - the foundation system may be better designed to resist this scouring action.</p> <p>High-velocity floodwaters may create erosion/scouring that the building has not been designed to resist.</p>			

Superstructure (Wood Frame/Masonry)		0-25%	25-50%	50-75%	Over 75%
Description	<p>The wall support systems that extend from the foundation wall to the roof structure. Superstructures include the exterior wall sheathing panels, shear panels, or braced wall panels. This section also includes structural members that support the roof, but does not include roof sheathing.</p> <p>Wood frame construction: Lightweight lumber or metal studs Interior wall framing (without sheathing) Typical exterior structural panel wall sheathing is plywood or hardboard</p> <p>Masonry construction: Typically concrete or CMUs, with steel reinforcement. Typical exterior covers are stucco, siding (aluminum, vinyl, or wood), and masonry veneer</p>	<p>Water level does not rise to the level of the bottom of the first floor of the structure.</p> <p>No damage to the roof framing.</p> <p>No wind damage to the superstructure.</p>	<p>Water level rises just above first floor level.</p> <p>Damage to the exterior walls is limited.</p> <p>Damage to the roof framing is limited.</p>	<p>Water level is up to 3 feet high on the first floor level.</p> <p>Some damage to exterior walls.</p> <p>Some damage to sections of the roof framing.</p>	<p>Water is over 3 feet high on the first floor level of the building.</p> <p>Significant damage to exterior walls.</p> <p>Significant damage to the main portion or multiple sections of the roof framing. Pressurization and failure of framing connections.</p>
	<p>Special Considerations for Coastal/High Velocity Floods</p>	<p>Coastal areas have higher wind conditions requiring additional exterior wall structural panels, shear walls, and braced wall panels.</p> <p>Damage to these wall structural systems would indicate a higher percent of damage, because they are already designed to resist higher wind conditions.</p>			
		<p>Minor damage to portions of the wall structure. Wall studs and sheathing suffered minor damage by contact with debris or from floodwater pressures against the structure. Minor missing or damaged sections of the roof structure. No deformation or distortion of the structural frame is evident.</p>	<p>Some missing sections or open damage to portions of the wall structure. Wall studs and sheathing suffered some damage by contact with debris or from floodwater pressures against the structure. Some missing or damaged sections of the roof structure. No deformation or distortion of the structural frame is evident.</p>	<p>Missing sections or open damage to some portions of the wall structure. Wall studs and sheathing damaged by contact, collision, or piercing with debris or from floodwater pressures against the structure. Some missing or damaged sections of the roof structure. Some deformation or distortion of the structural frame is evident.</p>	<p>Missing exterior wall(s) or open damage to large portions of the wall structure. Wall studs and sheathing damaged by contact, collision, or piercing with debris or from floodwater pressures against the structure. Large missing or damaged sections of the roof structure. Significant deformation or distortion of the structural frame is evident.</p>

Roof Covering		0-25%	25-50%	50-75%	Over 75%
Description	<p>Roofing includes a lightweight composition shingle, tile roofs, metal roofs, or a built-up roof with gravel or rock cover material. Roofing does not include structural framing members such as rafters or prefabricated trusses that support the roof deck. The roof sheathing and flashing is included in this section.</p>	<p>Minor wind damage to the roof coverings.</p>	<p>Some damaged areas of the roof from high winds or damage from debris.</p>	<p>Significant damaged areas of the roof from high winds or damage from debris.</p>	<p>Large damaged areas of the roof from high winds or damage from debris.</p>
		<p>Main surface areas are unaffected.</p> <p>Flashings are intact.</p> <p>No damage to the roof sheathing.</p>	<p>Some sections of the roof covering are missing or loose.</p> <p>Some damage to the flashings.</p> <p>Minimal damage to the roof sheathing.</p>	<p>Significant sections of the roof covering are missing or loose.</p> <p>Damage to the flashings allows some water infiltration at joints and roof penetrations.</p> <p>Significant damage to the roof sheathing - some areas of the sheathing will need replacement.</p>	<p>Major sections of the roof covering are missing or loose.</p> <p>Damage to the flashings allows significant water infiltration at joints and roof penetrations.</p> <p>Major damage to the roof sheathing - most of the roof sheathing will need replacement.</p>
	<p>Roof covering mostly intact. Some minor damage - some torn or loose parts of covering in limited areas.</p>	<p>Some areas where the roof was damaged by high winds. Several small areas of exposed roof sheathing as a result of missing/damaged covering.</p>	<p>Some areas where the roof was damaged by high winds. Several small areas of exposed roof sheathing as a result of damaged covering. Some damage to the roof covering and sheathing due to debris falling or penetrating the roof assembly.</p>	<p>Major areas of the roof where the shingles/tile are missing, allowing rainwater to freely enter the building below. Significant damage to roof covering and roof sheathing from strong winds or windborne debris penetrating the roof assembly.</p>	
<p>Special Considerations for Coastal/High Velocity Floods</p>	<p>Coastal areas have higher wind conditions requiring additional roof covering requirements.</p> <p>Damage to these roof coverings would indicate a higher percent of damage, because they are designed to resist higher wind conditions.</p> <p>Damage to the roofing is more likely during high-wind conditions due to the loss of protection from missing roof coverings. This will increase the percent of damage.</p> <p>It is also possible that the local building code will require that the entire roof covering be removed and replaced.</p>				

Interiors		0-25%	25-50%	50-75%	Over 75%	
Description	<p>Interiors include the partitions, interior doors, and surface finishes (for walls, floors, and ceilings).</p> <p>Materials include low-grade wood/plastic composites, soft woods, and hard woods. Finishes include paint, stain, or varnish.</p> <p>This item also covers any exterior and interior painted surfaces. This includes all interior painted surfaces, but not the building or repairs of the underlying surfaces. This also includes those exterior siding materials (and trim work) that need to be painted, but not those that have inherent coloring within the materials themselves (brick, stucco, EIFS).</p> <p>NOTE: Non-residential structures with multiple stories will receive less damage to this element than single-story structures, as the majority of interior finish for multi-story structures will likely not be on the ground floor.</p>	Threshold Markers	<p>Water level does not rise to the level of the first floor structure.</p> <p>The duration of the floodwaters is limited - less than 12 hours.</p>	<p>Water level rises just above the first floor level.</p> <p>The duration of the floodwaters is limited - less than 12 hours.</p>	<p>Water level is up to 3 feet above the first floor level.</p> <p>The duration of the floodwaters is more than 12 hours.</p>	<p>Water is more than 3 feet above the first floor level of the building.</p> <p>The duration of the floodwaters is more than 12 hours.</p>
		Common Damage	<p>Wicking of the water and high moisture conditions into the finished materials at the subflooring and at the bottom of the walls. Water staining and damage possible at baseboard and the casings at the bottoms of door openings. Some adjustment/repair/replacement may be necessary. No damage anticipated on door, cabinet, and window hardware. The baseboards and the bottom of the door casings may need to be cleaned and painted.</p>	<p>Water staining and damage likely at the baseboard and the casings at the bottoms of door openings. Some adjustment/repair/replacement may be necessary. Water damage at the lowest levels of the wall assembly - lower wall and trim may need to be removed and replaced. Minor damage anticipated on door, cabinet, and window hardware. After repairs to surfaces, the lower wall finishes, baseboards, and door casings will need to be primed and repainted. The bottoms of cabinet bases in bathrooms may require repainting.</p>	<p>Water staining and damage at the baseboards and the casings at door openings need to be replaced. Water damage at the lowest levels of the wall assembly - wall and trim, window sills and window aprons, wall paneling, wainscoting, and chair rails require removal and replacement. Wall surfaces should be removed to a height of 4 feet. Some damage anticipated on door, cabinet, and window hardware. Some replacement needed. After repairs to surfaces, the entire wall finishes, baseboards, and door and window casings will need to be primed and repainted, along with the vanity cabinets in the bathrooms. Both upper and lower paint-grade cabinets should be repainted where lower cabinets were repaired or replaced.</p>	<p>Water staining and damage at the baseboards, running trim, and casings at door and window openings need to be replaced. Water damage at all the levels of the wall assembly - wall and trim, window sills and window aprons, wall paneling, wainscoting, and chair rails require removal and replacement. Wall surfaces should be removed to a height of 8 feet. Significant damage anticipated on door, cabinet, and window hardware. Some replacement needed. After repairs to surfaces, the entire wall finishes, baseboards and door and window casings, and window sashes will need to be primed and repainted along with the vanity cabinets in the bathrooms. Repaint both upper and lower cabinets, where these are paint-grade cabinets.</p>
	Special Considerations for Coastal/High Velocity Floods		<p>Damage to the interior finishes are more likely during high-wind conditions due to the loss of protection from missing roof coverings and exterior finishes, and from subsequent water infiltration. The salt, erosion, and winds in coastal areas will have a damaging effect on the quality of exterior hardware. This will significantly increase the percent of damages.</p>			

Plumbing		0-25%	25-50%	50-75%	Over 75%
Description	<p>The plumbing system includes the incoming water service (municipal water supply or well service), the water heater, water distribution piping, fire protection system, and the wastewater system. Wastewater will be conveyed away from the structure by either a connection to the municipal sewer system or a septic system.</p> <p>When floodwaters saturate the soils, septic systems may be unable to discharge their waste, causing a back-up of the septic systems. If floodwaters raise above the level of the municipal sewer manhole covers, the sewage can back-up into the building through the sewer lines. Verify the condition of the potable water supply to determine if it can provide a safe water supply.</p>	<p>Water level is less than 6 inches above the lowest floor level.</p>	<p>Water level is between 6 inches and 18 inches above the lowest floor level.</p> <p>Flood duration is short - no prolonged exposure to water or contaminants.</p>	<p>Water level is between 18 inches and 3 feet above the lowest floor level.</p> <p>Flood duration is longer than 12 hours - prolonged exposure to water and contaminants.</p>	<p>Water level is more than 3 feet above the lowest floor level.</p> <p>Flood duration is longer than 12 hours - prolonged exposure to water and contaminants.</p>
		Common Damage	<p>Floor drains can backflow into the building. Under floor (or under slab) plumbing systems should be purged, cleaned, and sanitized. Any materials that might contain remnants of waste materials or other contaminants in the floodwaters will require replacement.</p>	<p>Floor drains, shower drains, bathtubs, and toilets can backflow into the building. Septic contamination is likely. Water heaters may need to be replaced.</p>	<p>Floor drains, shower drains, bathtubs, toilets, bathroom sinks, utility sinks, and toilets will backflow into the building. Septic contamination will occur. Water heaters will need to be replaced.</p>
	Special Considerations	<p>The plumbing systems in place in the buildings may vary significantly, and damage thresholds should account for the situation of the building being assessed.</p>			

Electrical		0-25%	25-50%	50-75%	Over 75%
Description	<p>Consists of all electrical components on the property site, such as electrical wiring, communications, conveyance, lighting, and security.</p> <p>A minimum number of outlets and lighting fixtures, sometimes quantified by local building code, begin to increase in number and application as the quality level of the structure increases. Structure type will also affect the amount of fixtures, wiring, and electrical equipment in the building, and therefore will significantly affect the percent damage to this element. For this example, equipment is assumed to be on the first floor. In multi-story buildings where equipment is on floors higher than where the flooding is occurring, these percent damage estimates would be significantly lower.</p>	<p>Water level is less than 12 inches above the finished floor level.</p> <p>Minor electrical components and limited wiring are inundated but remain below normal receptacle height.</p>	<p>Water level is between 12 inches and 18 inches above the finished floor level.</p> <p>A significant number of wiring components and limited wiring are inundated, and floodwaters are above the normal receptacle height.</p>	<p>Water level is between 18 inches and 3 feet above the lowest floor level.</p> <p>A significant number of wiring components and a significant amount of wiring is inundated - floodwaters are above normal wall switch height.</p>	<p>Water level is more than 3 feet above the lowest floor level.</p> <p>Most of the wiring components and a significant amount of wiring are inundated - floodwaters are above normal wall switch height.</p>
	Common Damage Details	<p>If the main electrical power source is located in the basement, the panel will need to be replaced. All outlets (receptacles, switches and lights) located below grade should be replaced. All receptacles, switches, and outlets located above the flood water high mark can be left in place and reused.</p>	<p>Modern Romex wiring that is inundated only for short durations (without wetting the ends/joints/terminations) can be dried and reused. Older nonmetallic cable (with impregnated braided sheathings) should be replaced when wetted. When chemical contaminants are suspected in the floodwaters, all inundated electrical wiring and components will require replacement.</p>	<p>Modern Romex wiring that is inundated only for short durations while wetting the ends/joints/terminations should be replaced. Older non-metallic cable (with impregnated braided sheathings) should be replaced when wetted. When chemical contaminants are suspected in the floodwaters, all inundated electrical wiring and components will require replacement.</p>	<p>Modern Romex wiring that is inundated only for long durations should be replaced. Older nonmetallic cable (with impregnated braided sheathings) should be replaced when wetted. When chemical contaminants are suspected in the floodwaters, all inundated electrical wiring and components will require replacement.</p>
Special Considerations	<p>The electrical system in place and its location with respect to the building may vary significantly, and damage thresholds should account for the situation of the building being assessed.</p>				

HVAC		0-25%	25-50%	50-75%	Over 75%	
Description	Threshold Markers	<p>The base HVAC system is a forced-air heating system (furnace) with ductwork. The air handler system is located inside the thermal barrier of the building.</p> <p>The percent damaged will be less for a boiler. A boiler system has a sealed piping system to distribute the heat while the furnace uses a duct system. Ducts with water infiltration will need to be cleaned, repaired, and re-insulated. By contrast, a boiler piping system only needs to have the distribution piping clean and re-insulated. Note: Old duct and HVAC insulation may contain asbestos - use appropriate caution and adjust the costs for removal, if found.</p> <p>A gas-fired or oil-fired furnace located in a basement or crawlspace will require replacement of the furnace assembly as soon as 12 inches of floodwaters are present. This will require an adjustment of the percent damaged to 75%, as soon as the water reaches the firebox level of this heating equipment. A central air conditioner or heat pump will have a ducted air distribution system. The outside condenser unit(s) will require reconditioning after any flooding conditions.</p>	<p>Water level is less than 6 inches above the lowest floor level.</p> <p>Water level is in the lower ducts but not into the air handler or equipment operating system.</p> <p>The condenser unit may be reconditioned if the water level is less than 6 inches from the bottom of the appliance. If the condenser unit is located below the flood level, it needs to be replaced.</p> <p>Minor to no damage to exterior HVAC components.</p>	<p>Water level is between 6 inches and 12 inches above the finished floor level.</p> <p>Water level is into the lower ducts and the air handler, but not into the equipment operating system.</p> <p>The condenser unit may be reconditioned if the water level is up to 12 inches from the bottom of the appliance. If the condenser unit is located below the flood level, it needs to be replaced.</p> <p>Minor to some damage to exterior HVAC components.</p>	<p>Water level is between 12 inches and 3 feet above the finished floor level.</p> <p>Water level is into the lower ducts, air handler, and the equipment operating system.</p> <p>The fuel-fired equipment (burners/controls) is inundated.</p> <p>The condenser unit needs to be replaced.</p> <p>Some damage to some exterior HVAC components. Some components may have connection failures and some became windborne debris.</p>	<p>Water level is more than 3 feet above the lowest floor level.</p> <p>Water level is into the duct distribution system, air handler, and the equipment operating system.</p> <p>The fuel-fired equipment (burners/controls) is inundated.</p> <p>The condenser unit needs to be replaced.</p> <p>Significant damage to multiple exterior HVAC components. Components may have connection failures and components became windborne debris.</p>
		Common Damage	<p>If HVAC equipment (furnace, air handler, heat pump) are located in the basement or the under floor areas, the equipment should be reconditioned or replaced. Water-inundated duct insulation should be removed and replaced. If the duct insulation is integral to the ducts (duct board or secured interior duct liners), the ducts should be replaced. All ducts that are being reused will require cleaning.</p>	<p>If portions of the HVAC equipment (furnace, air handler, heat pump) are located in the basement or the under floor areas, the equipment should be reconditioned or replaced. Water-inundated duct insulation should be removed and replaced. If the duct insulation is integral to the ducts (duct board or secured interior duct liners), the ducts should be replaced. All ducts that are being reused will require cleaning.</p>	<p>Portions of the HVAC equipment (furnace, air handler, heat pump) should be replaced. Water-inundated duct insulation should be removed and replaced. If the duct insulation is integral to the ducts (duct board or secured interior duct liners), the ducts should be replaced. All ducts that are being reused will require cleaning.</p>	<p>All HVAC equipment (furnace, air handler, heat pump) should be replaced. Water-inundated duct insulation should be removed and replaced. If the duct insulation is integral to the ducts (duct board or secured interior duct liners), the ducts should be replaced. All ducts that are being reused will require cleaning.</p>

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