3.2 Flood

Flooding is a common hazard in the Pacific Northwest due to numerous watercourses that carry runoff and snowmelt in a wet climate. Historically, significant floods occurred in the northern Willamette Valley approximately every seven to fifteen years. All participating jurisdictions and districts in this plan face impacts from river and lake flooding and/or urban stormwater runoff. All participating entities in this plan also have flood hazards mapped through FEMA's National Flood Insurance Program (NFIP), which identifies zones with required mitigation requirements in participating communities.

Despite the significant history of flooding in Multnomah County, widespread vulnerability is not severe due to flood safety infrastructure and limited development in most of the county's highest risk areas, especially outside the City of Portland[37]. Vulnerability becomes much more significant in failure of flood safety infrastructure or catastrophic events beyond regulated probabilities. The risk of landslides during high-precipitation events may also be among the most dangerous local risks from flood. However, impacts from climate change (discussed later in this chapter) are increasing the possibility of extreme flooding and require continuing awareness of catastrophic flood event scenarios.

Flood risk from localized rain events in Multnomah County is highest between October and April. During this period, heavy winter or early spring rains may cause sudden snow and ice melt or fall on saturated or frozen ground. Atmospheric rivers are often the driver of sudden warming and unusually heavy rainfall amounts over several days. Historically, rain-on-snow events between December and February have caused the majority of the most severe flooding.

Figure 45 - Map showing the drainage basins of the Willamette (darker blue) and Columbia Rivers. Map from Portland Bureau of Environmental Services

The Columbia River faces its highest annual risk of floods between May and July due to rain-on-snow thawing events that may occur in other parts of the river's massive drainage basin and continuously raise river levels as the system moves west through Oregon. These flood events can be massive because of the size of the drainage area, although these floods will usually have days of notice based on forecasts from upstream gauges and dam holding levels.

Large portions of the planning area are protected by a 45-mile levee system along the Columbia River – 27 of those miles are maintained through the Columbia Corridor Drainage Districts included in this

[37] The City of Portland has significant risk from flooding along the Willamette River and Johnson Creek.

plan. Before the construction of flood control infrastructure, flooding was common in low-lying areas across the Columbia River floodplain. Since their construction, flood risk from the Columbia River has been reduced. However, due to the amount of development built behind this flood safety infrastructure in the years that followed levee construction, vulnerability to levee breach or overtopping due to high water is Multnomah County's most severe flood risk to life safety and property. A breach during high water on the Columbia River during the Flood of 1948 destroyed the City of Vanport and killed at least 15 people, making it the deadliest flood in Multnomah County in at least the last century.

Dams regulate water flows, but can also be a source of flooding when they fail or when large flow releases are required when exceeding safe storage levels.

Urban stormwater flooding occurs when natural drainage systems are altered and modified impervious landscapes such as parking lots, roads, and roofs speed up the movement of rain runoff. As development increases, these effects can become cumulative and more difficult to manage. These effects are mitigated through engineered stormwater systems and restoration of natural hydrological systems. Urban stormwater flooding can be more difficult to predict because of the complexity of interconnected management systems and new development patterns constantly being built or rebuilt. Stormwater flooding is also less likely to be mapped as an identified hazard area through the FEMA Flood Insurance Rate Map program, which may reduce risk awareness and decrease resilience provided by flood insurance.

Flooding is also a primary driver of landslides in Multnomah County. Flooding and debris flows are also worsened in wildfire burn areas, where vegetation has been removed and soil chemistry has been altered, reducing the ability of the soils to infiltrate stormwater and altering the movement of water below the ground's surface[38].

Multnomah County's largest rivers also have a tidal influence from the Pacific Ocean, which can add to flood conditions if other flood factors occur at the same time as high tides. Coastal tsunamis can also travel the 60 miles from the mouth of the Columbia River and cause minor impacts in Multnomah County.

Channel Migration

Channel migration is a natural process where streams and rivers move over time. This is a natural gradual process and can take years for significant movement to happen, but a significant flood event can result in a rapid change. This process also results in an erosion hazard created by the movement of river channels. This dynamic change to rivers can threaten structures near rivers with undercutting or flood damage, even when they are located outside of mapped high-risk flood zones. The Sandy River is one of the rivers most subject to channel migration in Oregon because of its high velocity during high precipitation events due to runoff from Mount Hood and its banks and deltas made up of soft volcanic silt that erodes quickly.

5-Year Report, 2017-2022

Hazard Events

[38] The Portland District of the US Army Corps of Engineers has developed materials on post-fire flooding.

Several flooding events occurred since the last version of this plan, beginning in the winter of 2017. February 5, 2017 saw 2.19 inches of rain at the Portland Airport, breaking the single day February record set in 1996. An atmospheric river arrived mid-month and brought additional heavy rain, causing street flooding and ponding in low-lying areas. February ended with 10.36 inches of precipitation to become the wettest February on record, again topping a previous high set in 1996. Despite the record rain, flooding in the communities and districts participating in this plan was minor.

However, high water continued through March and heavy rains continued to raise water levels on the Columbia River. On March 22, an encampment on the Columbia Slough had to be evacuated. The Columbia River peaked on March 31 at 22.7 feet, damaging the levees and again causing minor flooding in some low-lying areas. The Columbia Corridor Drainage Districts activated their Incident Management Team twice in 2017 to respond to the Columbia being at Minor Flood Stage. The April 2017 event lasted multiple weeks, causing concern for oversaturated levees.

Figure 46 - Levee sloughing damage near NE Bridgeton Rd., in Portland caused by high water during the Spring 2017 flood event. Photo Multnomah County Drainage District.

High water on the Columbia River occurred in spring of both 2018 and 2019. In both seasons, minor erosion and sinkholes damaged levees, requiring repairs. Another atmospheric river event in December 2020 led to road flooding and inundation of ponding areas. This was a short duration event with the most significant impacts occurring in streams, such as Johnson Creek in Portland, where a footbridge was washed away. The winter flood season continued into 2021. Heavy rains in January led to a fatal landslide in Dodson in unincorporated Multnomah County, an incident described in the Landslide chapter.

In mid-November 2021, an early-season atmospheric river deluged the region with around three inches of rain over two days. The most significant impact was at Fairview Lake, where difficulty accessing a pump station led to a water rise that flooded yards and caused some damage to neighborhood homes.

In June 2022, an atmospheric river from June 9th to 12th brought a succession of rainstorms throughout the region resulting in high water levels on the Columbia River and triggering elevated water levels in the Slough and at Fairview Lake.

New Study Data

- A *Flood Risk Assessment for the Columbia Corridor Drainage Districts* was published by DOGAMI in 2018 to better understand the significance of the levee system in protecting people and development from high-water events. The findings of this report are summarized in this chapter, providing detail of the vulnerability in levee-protected areas from breach or overtopping.

  The study bolstered the work of the Columbia Corridor Drainage Districts, which completed a 3-year New Start Feasibility Study with the United States Army Corps of Engineers (USACE) as a part of the Portland Metropolitan Levee System (PMLS) Project. In the project's Final Report & Environmental Assessment, it was determined that there would be substantial benefit to federal investment in improvements to the levee system and a proposal was created for Congress to invest in the Districts' levee system, including: creating a new setback levee, raising and widening sections of the levee, and providing backup power connections to pump stations. This will result in a more resilient system and provide a higher level of flood protection. If approved, construction could start as early as 2025.

- Most of Multnomah County uses flood study data from 2009 or earlier to analyze the hydrology and hydraulics of streams and rivers. However, a significant flood study revision was initiated by FEMA for the Lower Columbia-Sandy Watershed, and was published on February 1, 2019. Portions of Troutdale, Gresham and Unincorporated Multnomah County are in the Multnomah County portion of the revised watershed.

  This study used new engineering analysis, including more detailed ground elevation data, to revise flood scenarios on Burlingame Creek, Kelly Creek, and portions of the Sandy River and Beaver Creek. New approximate (less detailed) modeling was used to refine flood risk for some portions of Beaver Creek and the Sandy River. Flood risk boundaries were made more detailed with improved ground elevation data (without any revised engineering analysis) in other portions of Beaver Creek and a portion of the Columbia River.

  This revision updated 23 of the county's flood map panels under the National Flood Insurance Program. The remainder of Multnomah County's effective flood map panels continue to be last published on December 18, 2009. The 2009 publishing date reflects when the entire county received digitized maps—flood studies used in those areas may be from dates earlier than 2009. Another update – a revised study for Sauvie Island in unincorporated Multnomah County – is also underway and is expected to be completed in 2023.

- Five Letters of Map Revision (LOMRs) were completed between 2017 and 2022 in Multnomah County. These letters are locally initiated studies that upgrade flood studies based on revised engineering and ground surveys. They are published in real time to the online National Flood Hazard Layer and incorporated into paper maps when those are republished. These revisions were identified due to flood control work along Crystal Springs Creek (two) and Fanno Creek in Portland, on Beaver Creek in the City of Troutdale where a new culvert was installed at Cochran Road, and on Fairview Creek in Fairview and Gresham to reflect previous culvert improvements at NE Halsey Street and NE Fairview Ave/NE 223rd Ave.

- Vulnerability in river and lake flood risk areas outside of levee protection continues to use data applied in the 2017 version of this plan, except in the location of the new flood study. DOGAMI also published a *Natural Hazard Risk Report for the Lower Columbia-Sandy Watershed*, which ran an updated vulnerability analysis for the entire watershed, and included a vulnerability assessment for channel migration threat.

Climate Change Impacts

A warmer climate is expected to make large rain events more intense. Warmer air can hold more water, which is released as precipitation. Atmospheric rivers—long narrow corridors that transport huge amounts of water vapor from tropical regions—are a common source of flooding in Oregon. These weather phenomena[39] cause flooding because of the duration and intensity of rainfall they bring, along with much warmer temperatures that cause rapid melting of snow. Approximately 25-30% of autumn and winter rains in Oregon and the majority of extreme precipitation events in autumn and winter are caused by atmospheric rivers.

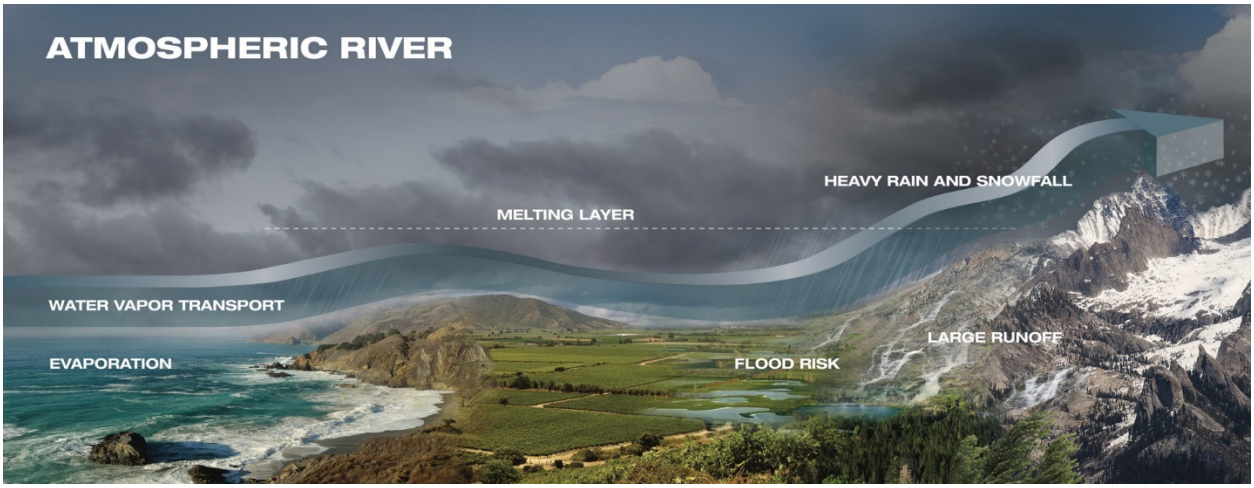

Figure 47 - Graphic showing the impact of atmospheric rivers on land. Image from NASA/JPL - CalTech

Under the high-emission scenario used in the Fifth Oregon Climate Report, days with atmospheric rivers are projected to increase 5-10% in Western Oregon by the end of the century. Because floods caused by rain have higher flood peaks than those driven by snowmelt, warmer winters could lead to increased flash flooding on creeks and tributaries.

[39] Informally known as 'rivers in the sky'

A study by the United States Geologic Survey and United States Army Corps of Engineers (USACE) found that potential warmer, wetter conditions in the region could lead to more wintertime rain-on-snow events, potentially increasing the flow of the Columbia River by 40%. Additionally, impact from sea-level rise during a large storm surge event (which could happen at the same time as a high water event flowing downstream) was shown by the same study to impact areas along the Willamette River (up to Willamette Falls) and Columbia River (up to the Bonneville Dam). The study estimated a 1.4 meter increase in water surface elevations along the Columbia Corridor Drainage District levee protection areas.

3.2.1 Flooding Location and Extent

Flooding can happen anywhere, but locations near identified flooding sources are the areas that are most likely to flood. FEMA-produced Flood Insurance Rate Maps (FIRMs) show the extent of floods expected in a 1% annual chance flood (also known as a 100-year flood[40]), and development in these areas is regulated by local Flood Management Ordinances in each Multnomah County city or county jurisdiction. Flood scenarios outside of the 1% annual chance, both smaller but more frequent events and larger, less frequent floods, are also provided by FEMA and other sources. This additional flood data can be used to inform risk and create optional local development standards.

The area of regulated flood hazard zone (1% annual chance) is called the *Special Flood Hazard Area* (SFHA). In these areas, homes are statistically more likely to be damaged by flood over the period of a 30-year mortgage than by house fire. Part of the SFHA in detailed flood maps is reserved for the *floodway*, an area with the highest velocity of water in a flood. In floodways, development is typically not allowed, but structures may be located in floodways when they were built before they were mapped, and infrastructure may still be built in floodways when it is built in a way that does not increase the flooding risk to others.

Not every potential source of flood is mapped under the Flood Insurance Rate Map program. Priorities for mapping are developed based on the size of the flood source and the likelihood of impact to development. Local communities can also initiate mapping studies when information is not available or is considered out of date, or when local stream restoration or infrastructure projects alter data.

FEMA produces a Flood Insurance Study (FIS)[41] for Multnomah County, which includes all of the flood analysis that has been performed to date. Different flood sources, and even different stretches of the same source will have different analysis dates, depending on when studies were performed. The most recent Flood Insurance Study for Multnomah County was published on February 1, 2019, to incorporate the revised study for the Lower Columbia-Sandy Watershed.

Current flood sources in Multnomah County with detailed studies are listed below. Some portions of these flood sources may have less detailed approximate studies.

[40] FEMA prefers the use of the term 1%-annual chance flood, because a '100-year flood' may happen many times or not at all over the course of a century.

[41] FEMA's Map Service Center has all documents regarding to the Flood Insurance Study. The National Flood Hazard Layer (NFHL) is an online mapping tool with real-time FEMA flood mapping that can be used to look up identified risk at any address.

- Beaver Creek
- Brick Creek
- Burlingame Creek
- Columbia River
- Fairview Creek
- Hogan Creek
- Johnson Creek
- Kelly Creek
- MacDonald Creek
- Multnomah Channel
- North Fork Johnson Creek
- Sandy River
- Sunshine Creek
- Unnamed Tributary to Rock Creek
- Willamette River

Additional flood sources with only approximate studies include Arata Creek, Brigman Creek, Butler Creek, McNutt Creek, Mitchell Creek, and a number of unnamed tributaries to already named sources. Additional approximate mapping exists for some drainage areas and lakes around Fairview Lake, Blue Lake and Smith and Bybee Lakes.

An interactive version of this map can be found at this link (Flood Hazard – Effective FEMA Flood Data)

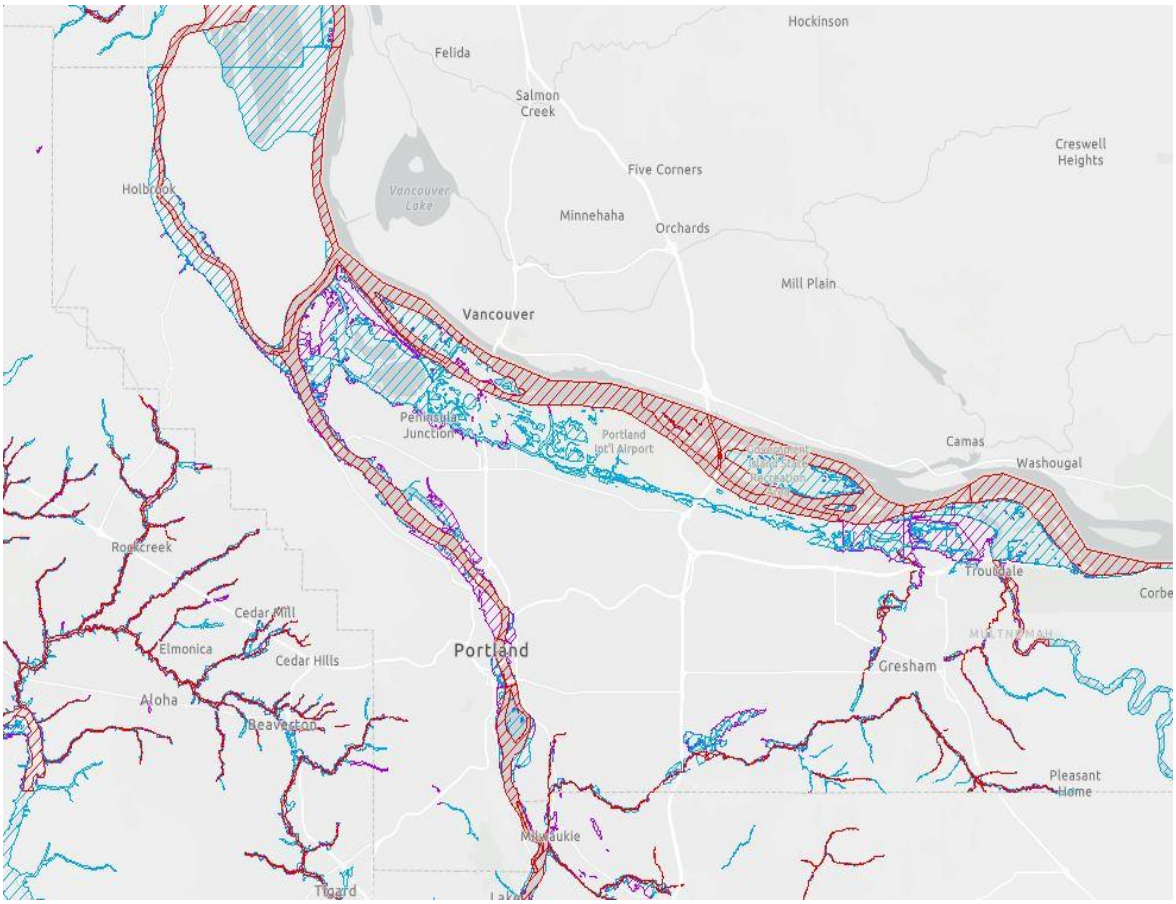

Figure 48 – DOGAMI Map showing FEMA identified flood risk zones in the western and central portions of Multnomah County. The areas hatched in red are floodways, the blue hatched areas are the Special Flood Hazard Area, and the purple areas are the 0.2% annual chance flood areas where regulation is optional. FEMA's National Flood Hazard Layer is the most up to date source for property-specific flood hazard designations.

An interactive version of this map can be found at this link (Flood Hazard – Effective FEMA Flood Data)

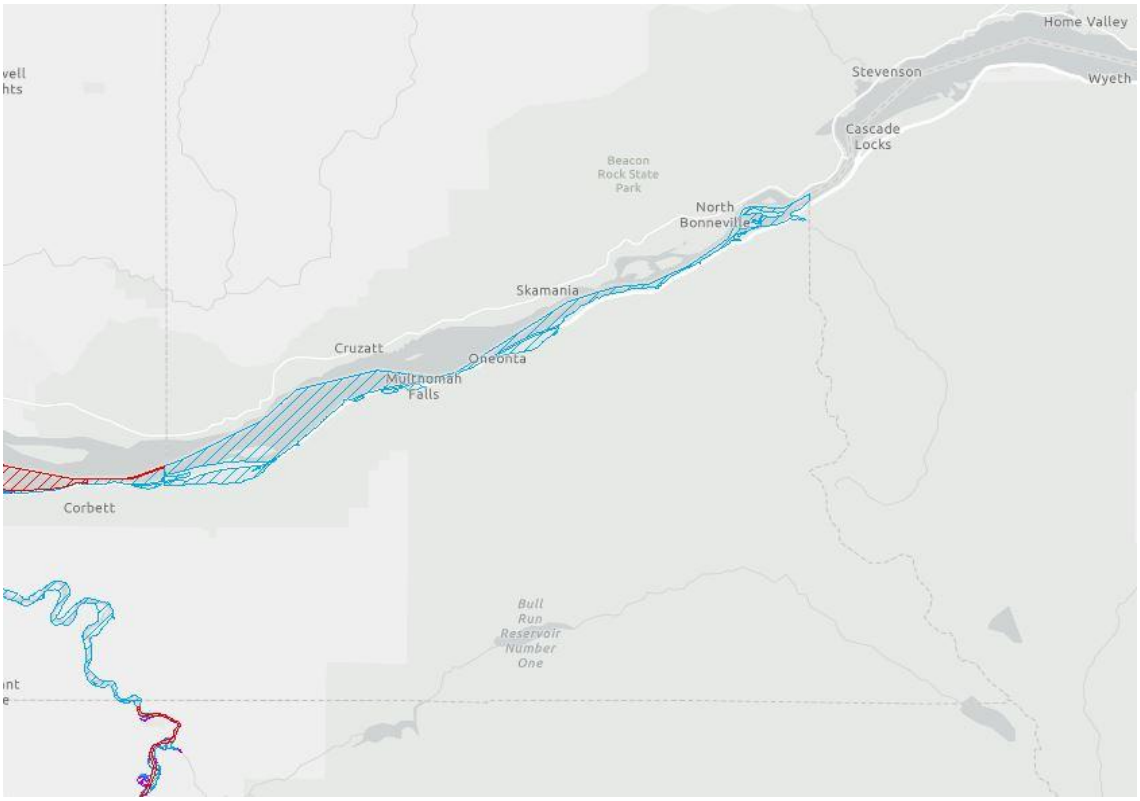

Figure 49 – DOGAMI Map showing FEMA identified flood risk zones in the eastern portion of Multnomah County. The areas hatched in red are floodways, the blue hatched areas are the Special Flood Hazard Area, and the purple areas are the 0.2% annual chance flood areas where regulation is optional. FEMA's National Flood Hazard Layer is the most up to date source for property-specific flood hazard designations.

Leveed Areas

Areas protected from flood by FEMA-accredited levee systems are typically not shown on FEMA maps as part of the SFHA because levee certification studies require them to be able to withstand a 1% annual chance flood. They may be indicated as lower risk zones or have printed language on the maps alerting people that the area is protected by a levee.

There are two levee areas located in low-lying areas along the Columbia River and Willamette Rivers in Multnomah County with five special districts dedicated to levee and drainage management:

- The four Columbia Corridor Drainage Districts along the Columbia River and Columbia Slough (included as participating districts to this plan), with 27 miles of levee (this area is identical to the managed floodplain area of the Urban Flood Safety & Water Quality District). The four districts are Peninsula Drainage District #1 (PEN1), Peninsula

Drainage District #2 (PEN2), Multnomah County Drainage District (MCDD) and Sandy Drainage Improvement Company (SDIC);

Figure 50 - Map showing the boundaries of the four current Columbia Corridor Levee Districts, along with the locations of the levees themselves and pump stations. Map from the Multnomah County Drainage District.

- Sauvie Island Drainage Improvement Company (SIDIC), which manages an 18-mile levee system along the Columbia and Willamette Rivers and Multnomah Channel on roughly the southern half of Sauvie Island. SIDIC is not a participating district to this plan, but a portion of unincorporated Multnomah County is protected by the district.

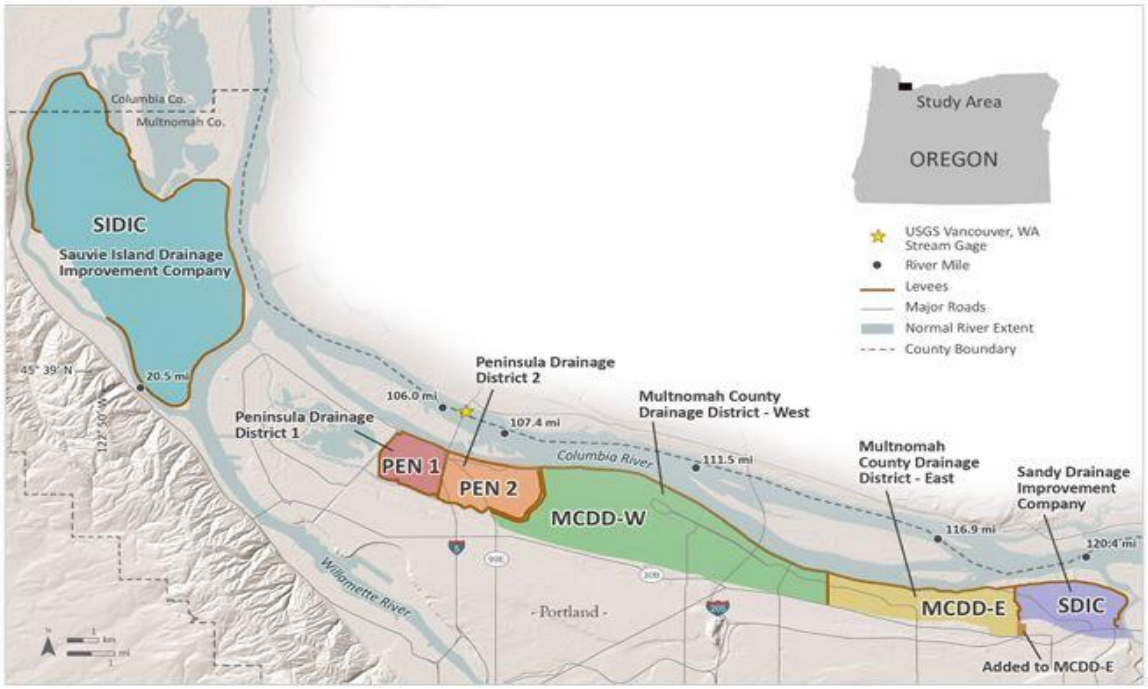

Figure 51 - Map showing the Sauvie Island Drainage Improvement Company (SIDIC) in relation to the Columbia Corridor Levee Districts

The four participating Drainage Districts and the combined Urban Flood Safety & Water Quality District make up a contiguous levee system with 27 total miles of levee. The levee system stretches from Smith Lake on the west to the Sandy River on the east, with the Columbia River as the northern boundary and the Columbia Slough/Columbia Boulevard as the approximate border on the south. It also includes four cross-levees that run adjacent to the Columbia River and Columbia Slough, providing extra protection between basins within the Districts.

The minimum standard used by FEMA for accreditation (44 CFR 65.10) is to reduce flood risk from a 1% annual chance flood. Some cities in the United States have opted to build protection to a less common and more severe flood such as a 0.5% annual chance (200-year) or 0.2% annual chance (500-year) flood elevation. Because river systems vary widely, the US Army Corps of Engineers selects a unique design standard for each levee's inclusion and rating in its Rehabilitation and Inspection Program.

For the Columbia Corridor levee system, the PEN 1 system was designed to withstand the magnitude of the local 1876 flood and is authorized at that level. The PEN 2 system is also authorized for the 1876 flood, but some modifications make certain portions of the system authorized for the design surface flood elevation of the 1894 flood, accounting for additional floodwater storage since dam construction in the 1950s. MCDD and SDIC levees are both authorized for this design water surface elevation. The design water surface elevation is a higher standard than the 1% annual chance flood used as a regulatory standard on FEMA Flood Insurance Rate Maps and increases the levee elevations from west to east, with the levees on the eastern end of the system at higher elevations.

All district levees are currently accredited by FEMA, but require reaccreditation by engineers, and that work is currently being undertaken. By the time this plan reaches its next renewal in

five years, the Districts will be dissolved and consolidated under a new District, currently called the Urban Flood Safety & Water Quality District (UFSWQD).

The Sauvie Island levee system is approximately 18 miles in length and is divided into four segments and managed by the Sauvie Island Drainage Improvement Company (SIDIC). The levee protects 11,200 acres of Sauvie Island from flooding. Construction began in the late 1930s from material dredged from the Columbia River and pits and canals dug on the island. The main Pump House was constructed in 1941 and holds four pumps capable of evacuating 125,000 gallons-per-minute of water at varying river levels. The interior of the drainage system consists of over 30 miles of canals and ditches to convey rain, seepage and spring water from the interior of the levee to the Multnomah Channel. This levee system has also been accredited by FEMA.

Dam Protection

Large dams provide flood protection by storing and systematically releasing water during high-water events. Smaller dams may serve just to hold water in reservoirs, and operate more as levees. In each case, areas that could be flooded by a dam failure are not mapped on FIRMs, which may decrease the awareness of risk in those areas.

Multnomah County has 26 dams identified by the Oregon Water Resources Department[42]. Eight are classified as being of high-risk, with five of those located in the City of Portland. The three high-hazard dams outside of Portland are located on the Columbia River (Bonneville Dam), in the protected Bull Run Watershed (Bull Run Reservoir) and on Rock Creek in western Multnomah County (Van Raden Dam). Failure of any dam could cause localized flood risk. The failure of the Lewis River dam in Washington could also cause minor effects to areas on the Columbia River in Western Multnomah County.

Urban Stormwater

Full extents of urban stormwater flooding are not typically mapped on FIRMs, although some low-lying urban areas may be captured in flood studies as ponding areas. The extent of where stormwater will overwhelm storm sewer systems is not captured in this plan, except for descriptions of areas that have required response to repeated street and yard flooding.

Jurisdictions in this plan all have Stormwater Management Programs to maintain and improve storm sewer systems. Mitigation actions in this plan may support work to improve these programs and reduce local flooding.

Channel Migration

Areas subject to channel migration are also not typically shown on FIRMs, but maps have been modeled by the Oregon Department of Geology and Mineral Industries (DOGAMI) to show potential channel movements on the Sandy River.

Different sections of the Sandy River in Multnomah County have different ways in which the channel may move. Upland areas with highly constrained channels will suddenly erode soft streambanks when water velocities increase in high water events. In the Sandy River Delta, at

[42] A full dam inventory is provided in the section on flood vulnerability.

the confluence with the Columbia River, slow flow and the continual depositing of sediments allows the river to meander and create secondary channels.
Areas with lahar deposits from volcanic eruptions are more prone to channel migration, because of the deposit of fine volcanic silt. The lahar risk zones and channel migration zones in Multnomah County are therefore very similar.

The four types of channel migration zones identified through local risk mapping are:

- Historical channels, which can be identified through historical records and LIDAR imaging and are considered likely to become channels again at some point in the future. Sandy River mapping shows historical channels that have existed between 1955 and 2009
- Disconnected migration areas, where erosion control or other development has prevented future migration
- Erosion zones, where there is a likelihood of erosion occurring in the next 100 years (as of 2009)
- Avulsion zones, where the catastrophic development of new channels or the reoccupation of abandoned channels is considered a risk

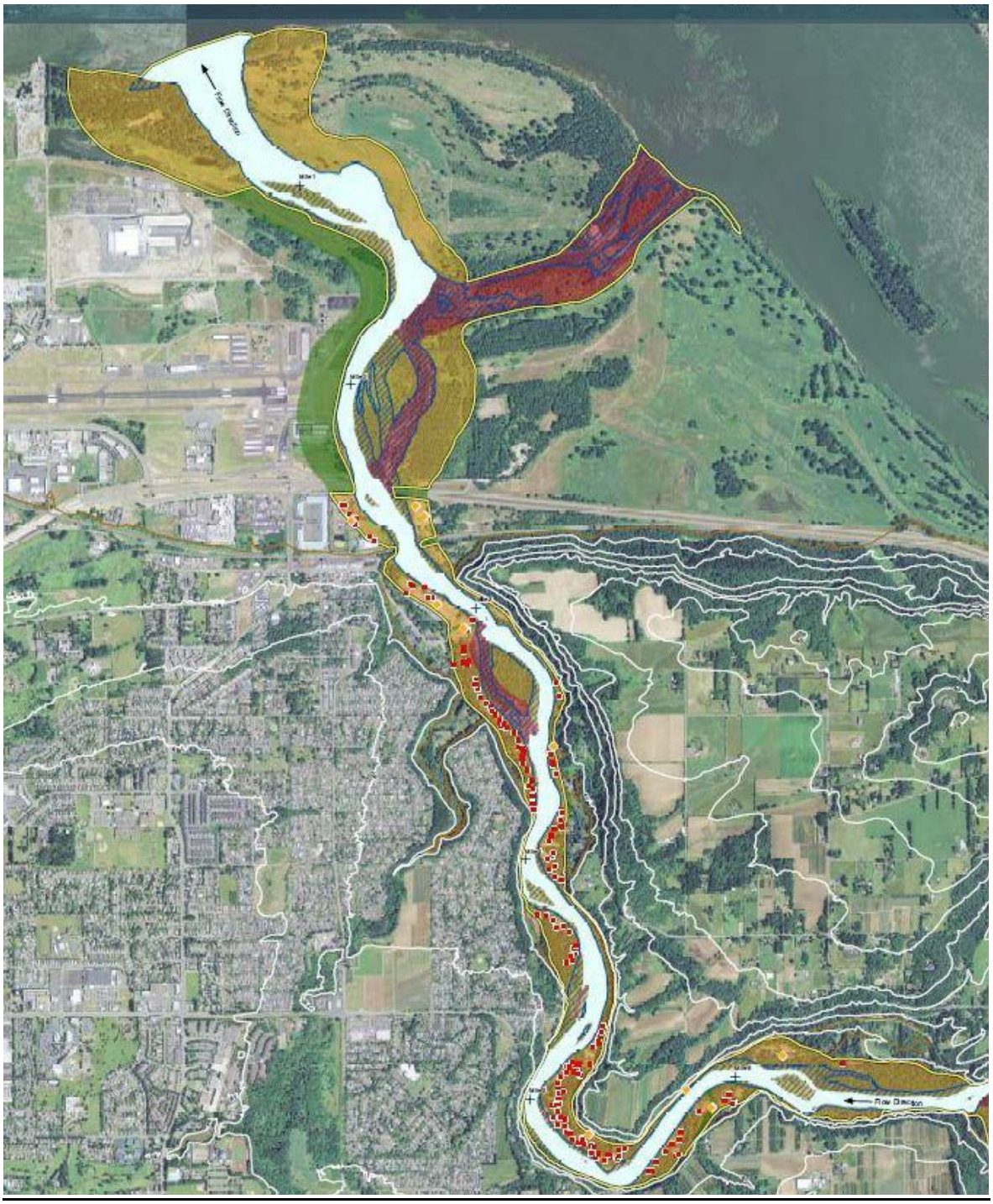

Figure 52 - DOGAMI map showing channel migration threat at the lower Sandy River and confluence with the Columbia River. Yellow areas are at risk from erosion, red areas are areas at risk of new river channels forming, blue hatched areas are former channels, and green areas are areas that were once channels but have become disconnected from the channel movement process. The small red squares are locations of structures.

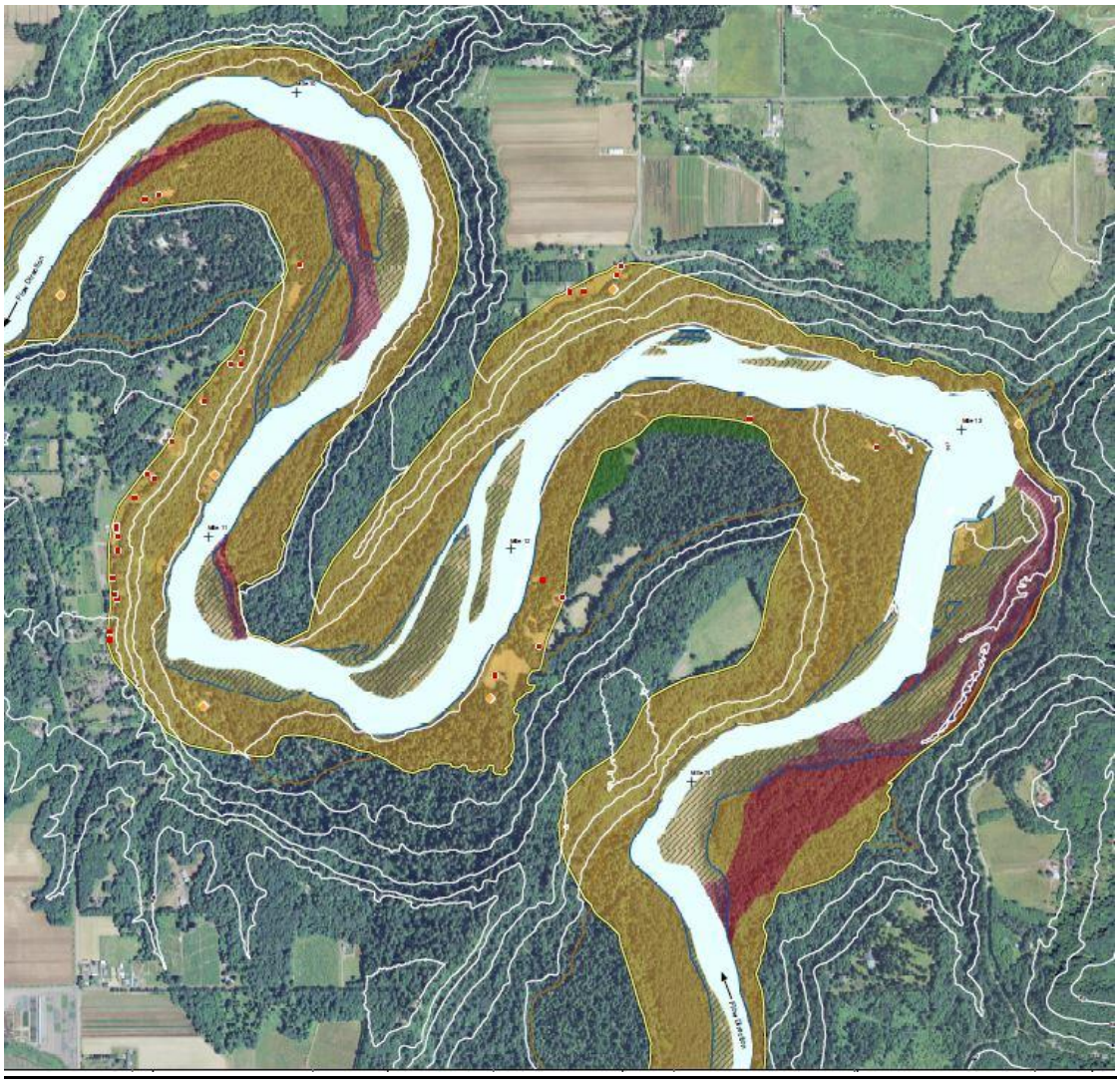

Figure 53 - DOGAMI map showing channel migration threat in the upstream portion of the Sandy River in Multnomah County. Yellow areas are at risk from erosion, red areas are areas at risk of new river channels forming, blue hatched areas are former channels, and green areas are areas that were once channels but have become disconnected from the channel movement process. The small red squares are locations of structures.

3.2.2 Flood Probability and History

The accepted standard for measuring probability of flood comes from Flood Insurance Studies published by FEMA as part of the National Flood Insurance Program. Participation in the program, which allows local residents to purchase Federal flood insurance, requires regulation of development within areas considered to have a 1% chance of flooding each year (100-year flood). Because of this regulatory tie-in, these mapped areas are generally used as a baseline for flood risk and protection strategies.

Other predicted flood frequencies are included in Flood Insurance Studies when a flood study has been detailed enough to provide that data. Many of the rivers and streams in Multnomah County also have flood heights provided for 5% annual chance (20-year), 2% annual chance (50-year), and 0.2% annual chance (500-year) events. Communities can use these other

probabilities to apply higher standards of flood protection regulation. The 0.2% annual chance area is printed on Flood Insurance Rate Maps (FIRMs) to provide additional risk information and guidance for protection against larger events, although any flood protection regulation in these areas is determined locally.

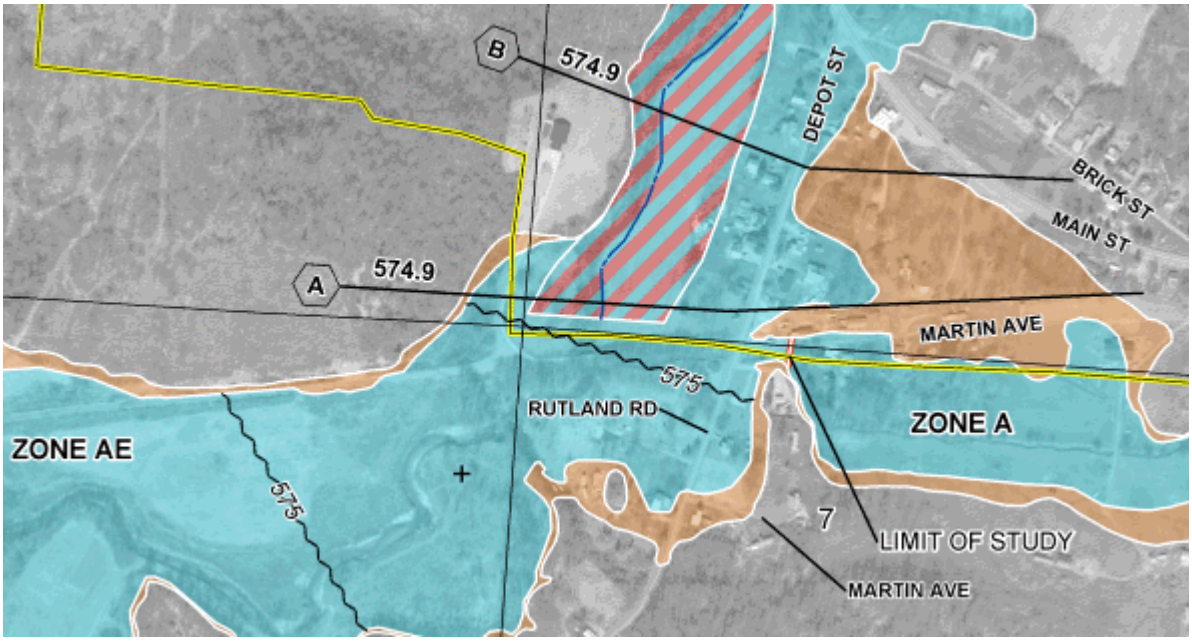

Figure 54 - An example of a Flood Insurance Rate Map. The Zones in blue labelled A or AE are the Special Flood Hazard Area (1% annual chance flood) and the red and blue hatched area is the Floodway, the area with the highest risk. The orange is the 0.2% annual chance flood, typically used as an advisory risk zone. The cross-sections (hexagons marked A and B) are where a flood study has been conducted and a flood elevation has been calculated. This elevation is used to determine how high above the ground new construction should be raised when inside the blue zones. These map elements are all shown on FEMA's National Flood Hazard Layer (NFHL), which can be used to look up individual properties.

Not every potential flood probability is mapped by Flood Insurance Studies. Priorities for mapping are developed based on the size of the flood drainage area and the likelihood of flood impact to population and development. Therefore flood probabilities in this plan are generally limited to areas studied by FEMA.

Some alternate flood modeling has theorized that actual flood probabilities are more frequent and of larger extents than those mapped by FEMA. This analysis may be bolstered by climate change effects, discussed above, which are usually not accounted for in FEMA flood studies[43]. FEMA has found that over 25% of flood damage claims[44] come from locations not shown as hazard areas on FIRMs.

Probabilities of unmapped urban stormwater events are most likely to be identified in local Stormwater Management Plans, and areas of highest concern may be included in specific Jurisdictional and District Chapters of this plan.

Probabilities of future channel migration may be linked to that of flooding events, although erosion patterns may occur more slowly over time in some areas. The maps used in the

[43] Communities may choose to regulate to a higher standard and develop maps showing additional flood risk zones.

[44] Fact Sheet: Myths and Facts About Flood Insurance, FEMA, June, 2019

previous section show potential extent of channel migration over set periods of time, but the probability of when, where or how quickly that movement will occur is difficult to calculate because of the complexity and dynamism of the process. For this reason, channel migration risk maps show all of the potential directions of movement over a set time period.

Dam Failure

Unlike other forms of flooding discussed in this chapter, dam failure is not usually linked to storm events. Most failures are caused by

- structural failure (30%), which may be linked to earthquakes or foundation defects.
- mechanical failure (36%), when failing gates, conduits of valves cause dams to fail to open or close when needed.
- hydraulic failure (34%), or overtopping of a dam most commonly because of poor spillway design, debris blockage of spillways, or settlement of dam crests.

Because these failures are frequently not related to flood events, probability of failure can only be established by maintenance and evaluation. Inspection dates for county dams are included in the section on Flood Vulnerability.

Flood History

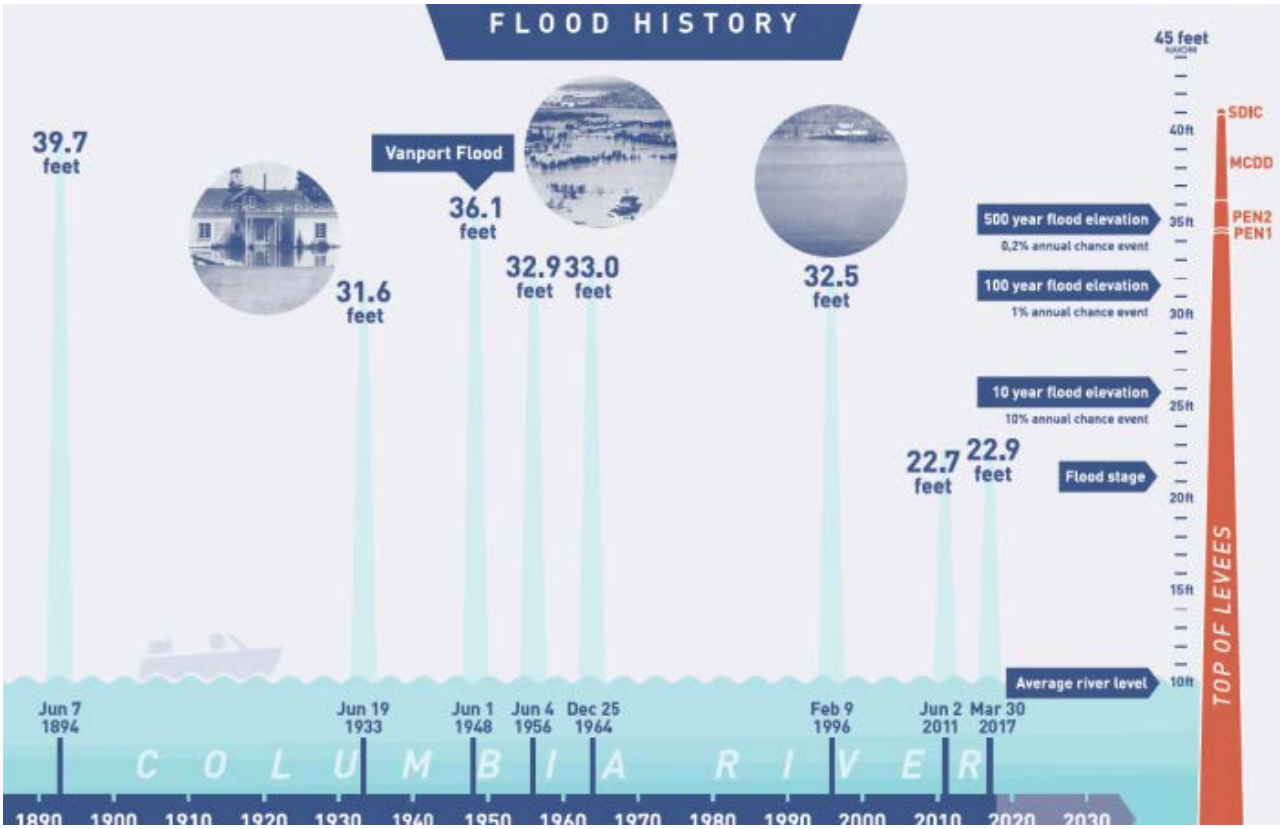

Figure 55 - Graphic showing historical high-water marks along the Columbia River. Graphic from the Multnomah County Drainage District.

Multnomah County has experiened significant floods throughout the last 125 years, including six events where the Columbia River met or exceeded the current 1% annual chance flood elevation. Although flooding on some level occurs nearly every year, the last widespread

flooding throughout the county occurred in 1996, an event with flooding throughout major river systems in Central and Northwestern Oregon that is maintained as a modern benchmark for local catastrophic flooding. The 1996 flood was the first time in over 30 years that the 1% annual chance flood level was exceeded on major rivers, and it has now been 27 years since that flood, making public risk perception of major flood an ongoing challenge. A public survey conducted for this plan update showed much lower concern from respondents about flood compared to earthquakes and more recently experienced climate-driven hazards.

The Flood of 1948 (Vanport)

Risk from levee failure was realized on May 30, 1948, with the destruction of the Vanport community in what is now Delta Park in North Portland. At least 15 people died in this disaster, making it the most catastrophic flood and largest hazard-caused population dislocation in Multnomah County in at least a century.

The Columbia and Willamette rivers were cresting at eight feet above flood stage when a breach occurred in a railroad embankment that served as a levee separating the City of Vanport from Smith Lake. Subsequent breaches occurred along the Columbia Slough, resulting in flooding in three of the four Columbia Corridor Drainage Districts.

The breach became a 500-foot gap that allowed flood waters to pour into the city within 10 minutes. Earlier in the day, residents had received flyers on their doors from the Portland Housing Authority telling them to remain calm and that warning would be given in time for them to evacuate if flooding occurred[45].

Vanport had been developed for wartime shipyard workers, peaking with a population of over 40,000 people in 1944, making it the largest public housing development in the nation and the second largest city in Oregon. The development had been designed to be temporary, but housing for non-white workers was limited in existing neighborhoods because of racially exclusionary housing policies. After the war, 18,500 people remained, of whom about a third were African-American. The city maintained commercial and cultural institutions and became the site of Vanport College and housed many returning war veterans attending the university on GI Bills.

The flood displaced the entire population and the town was not rebuilt[46]. Residents received no compensation for the total loss of their homes and belongings. Vanport College was re-formed in downtown Portland and became Portland State University, and the displacement of black residents into segregated neighborhoods in Northeast Portland began a cycle of disinvestment followed by gentrification and further displacement from those neighborhoods[47].

The Vanport Mosaic, a local non-profit organization, has collected stories from those who lived in Vanport and were affected by the Vanport Flood.

---

[45] The Life and Death of Vanport, 70 years after the flood, *Street Roots*, Patricia Kullberg, April 20, 2018

[46] "Dikes are Safe at Present": The 1948 Columbia River Flood and Destruction of Vanport, Portland State University Library Digital Exhibit

[47] The Time Nature and Racism Teamed Up to Wipe Out A Whole Town, NPR Code Switch, Kenya Downs, March 2, 2015

Figure 56 - Vanport before (left) and after (right) the Flood of 1948. Photos Portland City Archives.

The US Army Corps of Engineers (USACE) and the Columbia Corridor Drainage Districts reinvested in the levee system and pump stations following the Vanport Flood, making improvements and re-establishing the levees where they had failed. Nonetheless, there remains risks of levee failure along the same railroad embankment where the Vanport Flood breach occurred. Levee Ready Columbia, the UFSWQD, and the Drainage Districts are working in partnership with the USACE on shoring up the levee system to protect against similar size floods in the future, including plans for creating a setback levee behind the railroad embankment.

Other Historic Flood Events

The historic 1996 statewide flood occurred from February 5th-9th. The cause of the flood was a wet and snowy winter that had left soils saturated and deep snowpack, followed by a freezing snap that made soils even less able to absorb water. The sudden arrival of an unusually long-lasting atmospheric river brought heavy rains and warm temperatures, combining extreme storm runoff with rapid snowmelt.

An interactive version of this map can be found at this link (Additional Regulatory Layers – Flood 1996 Inundation Zone)

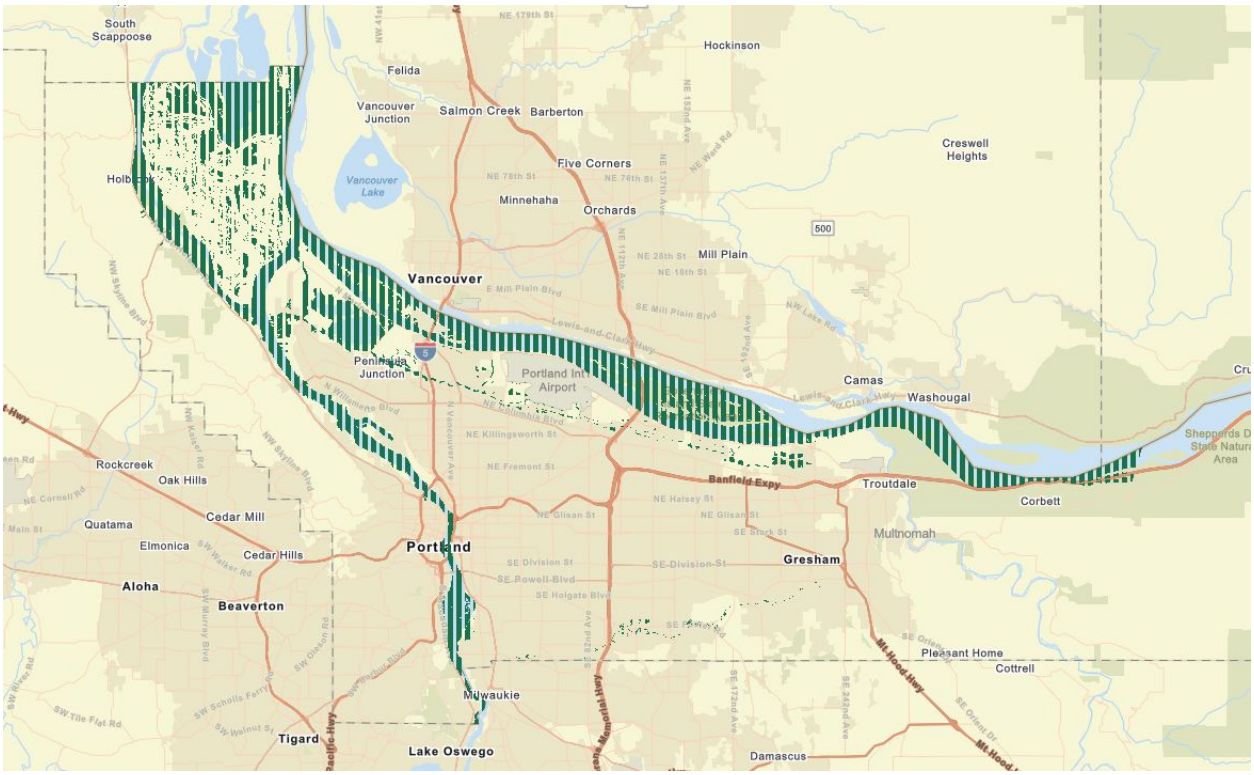

Figure 57 - Map showing Multnomah County areas flooded during the 1996 Flood event. Map from Multnomah County Land Use Planning.

The flooding closed major highways and roads, disrupted airport operations over fears of levee failure, and significantly impacted water supplies because of sedimentation. Eight deaths occurred across the state[48], including one near Troutdale, when a home was swept into the Sandy River[49]. Most Oregon deaths were people in vehicles that were carried away by floodwaters or fell into sinkholes.

The 1964 Christmas Flood was the first major non-levee related flood in Multnomah County after the creation of the extensive flood control works beginning in the 1930s. The Christmas Flood was also a rain on snow event that impacted almost the entire State of Oregon causing over $1 billion in damage.

The Flood of 1894 is considered a flood of record for Multnomah County, although larger floods have almost certainly occurred during its period of human settlement. The 1894 flood had the highest recorded flood levels on both the Willamette and Columbia Rivers. This was a spring flood, occurring in June as heavy rains and melting mountain snow combined to inundate the region. The floodwaters killed livestock, damaged railroad tracks and bridges and left central city locations covered in water for three weeks[50].

[48] Remembering Oregon's epic 1996 flood, *The Oregonian*, Joseph Rose, February 5, 2020

[49] Flood of '96: A high water mark in Oregon's weather history, KATU, February 8, 2016

[50] Willamette River flood of 1894, Oregon Encyclopedia, Oregon Historical Society

Figure 58 - Photo from downtown Portland during the Flood of 1894. Photo from City of Portland Archives.

While upriver flood-control dams and levees constructed since this event may make a flood of this magnitude less likely, it is still of note that the high water elevation on the Columbia River in 1894 was a full seven feet higher than in the catastrophic 1996 flooding event. Given the increased probability of climate-driven weather extremes, including more winter days with atmospheric rivers, analysis of current vulnerability to a repeated event of this magnitude may be warranted.

Table 20 – Flood History of Multnomah County (Federally Declared Disasters Shaded)

Date	Location	Type of Flood	Description
Dec. 1861	Willamette River	Rain on snow	Probably the most immense flood in the valley in recorded history, the “Great Flood” devastated the valley’s economy and resulted in the deaths of several people.
Dec. 1862	Willamette Basin	Rain on snow	Widespread flooding throughout western Oregon.
Feb. 1890	Willamette Basin	Rain on snow	Second largest flood of known magnitude; water levels in Portland: 22.3 ft.
June 1894	Columbia River	Snowmelt	Largest recorded flood on Columbia. Estimated to have covered everything below 36 feet along the Columbia River from the Sandy to the Willamette; only a few knolls were above water on Sauvie and Hayden islands.
Jan. 1923	Willamette & Columbia River	Rain on snow	Widespread damage to roads and railroads
Dec. 1937	Willamette Basin	Rain on snow	Considerable flooding; landslides

Date	Location	Type of Flood	Description
Dec. 1945	Willamette Basin/ NW Oregon	Rain on snow	Very warm temperatures; considerable flood damage
May–Jun. 1948	Columbia River	Rain, flooding, snowmelt	Memorial Day flood on the Columbia River. Levee breaches destroyed the City of Vanport (18,000 people); 15 fatalities recorded. Subsequent levee breaches followed, flooding Portland; flooding also occurred along Columbia River Highway and the Sandy River Delta. Snowmelt event in June and contributed impacts. Willamette River crested at 31.6 feet.
Dec. 1955	Statewide	Rain on snow	DR-49. Event occurred on December 29, 1955. Flooding and strong winds; five fatalities.
Jul. 1956	Statewide	Storms, flooding	DR-60. Event occurred on July 20, 1956. Storms and flooding.
Mar. 1957	Statewide	Flooding	DR-69. Event occurred on March 1, 1957.
Oct. 1962	Statewide	Storms	DR-136. Event occurred on October 16, 1962.
Feb. 1963	Statewide	Flooding	DR-144. Event occurred on February 25, 1963.Flooding.
Dec. 1964	Statewide	Heavy rains, flooding, rain on snow	DR-184.Event occurred on December 24, 1964. Record-breaking rainfall; damaged or destroyed about 750 homes along the Sandy River. In Multnomah County, the Columbia River Highway was washed out at the east end of the Beaver Creek Bridge. Statewide damage totaled $157 million and 17 deaths.
Jan. 1972	Willamette & Sandy Rivers	Storms, flooding, rain on snow	DR-319.Event occurred on January 21, 1972. Widespread damage; five fatalities.
1974	Western Oregon	Rain on snow, flooding	DR-413. Flooding resulted from rain-on-snow events. Willamette River at Portland crested at 25.7 feet. Nine counties declared disasters.
Jan. 1978	Willamette River	Rain on snow	Intense rain/snowmelt; widespread flooding
Feb. 1986	Statewide	Snowmelt, flooding	Intense rain, melting snow, and flooding. Some homes evacuated.
1990	Western Oregon	Rain on snow, flooding	DR-853 Ten rivers in eight counties were flooding in a rain-on-snow weather event. Many bridges were washed away.
Feb. 1996	Statewide	Storms, flooding, rain on snow	DR-1099 Winter storms with rain, snow, ice, floods and landslides. Power outages, road closures and property damage. Warm temperatures, record breaking rains; extensive flooding in Multnomah County; widespread closures of major highways and secondary roads; eight fatalities. Multnomah County was one of 27 counties covered by the disaster declaration.

Date	Location	Type of Flood	Description
Dec. 1996-Jan. 1997	Statewide	Winter storm, flooding	DR-1160. Severe snow and ice. Up to four to five inches of ice in the Columbia Gorge. Interstate 84 closed for four days. Hundreds of downed trees and power lines. Widespread power outages in the greater Portland area, including Multnomah County.
Jan.-Feb. 1999	NW Oregon	Rain, flooding, landslides, mudslides	Widespread flooding on smaller rivers and streams;. numerous landslides and mudslides. Historic Columbia River Highway east of the Sandy River Bridge covered with slides coming from the cliffs above. Mudslide pushed a house into the Sandy River, resulting in a fatality.
Winter 2001	Wood Village	Flooding	Arata Creek overflowed its banks at the point where it crosses NW 244th Avenue. One building east of that point was damaged.
Jan. 2003	Portland area	Heavy rain	Johnson Creek crested at two feet above flood stage, the highest Johnson Creek had risen in years. No damages were reported, but the rising river prompted the evacuation of approximately 25 nearby houses. Heavy rain resulted in standing water on many streets in the Portland metro area, resulting in some road closures. A small slide resulted in the temporary closure of a ramp leading to the St Johns Bridge.
Dec. 2007–Jan. 2008	NW Oregon	Winter storms, heavy rain, flooding	DR-1824. Severe winter storm, flooding, winds, record and near-record snow, landslides and mudslides. Gresham received 26 inches of snow . Many roads closed. Significant damages to public infrastructure, homes and businesses.
Jan. 2009	Portland area	Rain, flooding, rain on snow	The Portland area received 3.04 inches of rain from a warm tropical storm (“Pineapple Express”) which combined with extensive snowmelt from heavy snowfall in December. Flood elevations in Johnson Creek were the second highest recorded, and flooding also occurred on other streams in Multnomah County.
Jan. 2011	Statewide	Winter storm	DR-1956. Severe winter storm, flooding, mudslides, landslides and debris flows.
Jan. 2012	Multnomah County	Rain, rain on snow	Heavy rain combined with snowmelt runoff caused the Johnson Creek at Sycamore to overflow its banks and flood low-lying areas. Johnson Creek crested at 13.2 feet on January 19 at 4 pm PST, 2.2 feet above flood stage.
Sep. 2013	Portland Metro Area	Heavy rain, flooding	KPTV-KPDX Broadcasting reported that heavy rain resulted in flooding and damage to the Legacy Good Samaritan Medical Center and several businesses in Northwest Portland. Besides damage to the hospital's emergency and operating rooms, some elective surgeries were canceled.

Date	Location	Type of Flood	Description
Dec. 2015	Western Oregon	Winter storm, heavy rain	DR-4258. Severe winter storms, straight-line winds, flooding, landslides and mudslides. Pump failed and had to be replaced at Sandy Pump Station.
Mar. 2017	Western Oregon	Winter storm, heavy rain	High water duration lasted over one month, some minor erosion occurred at levees requiring repair.
May 2018	Multnomah County	Regional rains	15 days of elevated water on the Columbia River, requiring some repairs for minor erosion.
April 2019	Statewide	Severe storm, flooding, landslide	DR-4452; Limited impacts in Multnomah County. Columbia River elevated for 2 days, with some minor erosion and sinkholes in the levee system.
Dec. 2020-Jan. 2021	Multnomah County	Heavy rain, landslide	Heavy rains caused minor damage on Johnson Creek in Portland. Continuing rain caused a fatal landslide in a burned over area in Dodson, in Unincorporated Multnomah County.
Nov. 2021	Multnomah County	Heavy rain	Internal flood event in MCDD East caused by heavy rains and pump station inaccessibility. Impacted communities in Fairview and Interlachen community in Unincorporated Multnomah County
June 2022	Multnomah County	Heavy rain	High water levels on the Columbia River, Columbia River Slough, and Fairview Lake.

3.2.3 Flood Vulnerability

Riverine and Lake Flooding

Because of the protective levee system and limitations on development in high-hazard areas, the participating jurisdictions in this plan face mostly localized impacts from stream and lake flooding. If event intensity increases because of climate change, additional risk should be considered.

A 2016 HAZUS model estimated damages caused by a 1% annual chance flood of all mapped flooding sources in the county. This study did not contemplate a failure of the levee system–the vulnerability to that event is covered later in this chapter.

In the table below, it is shown that only twelve residences in communities participating in this plan would be substantially damaged by the mapped event, with another 203 homes suffering moderate damage. Substantial damage means that the cost of repairs is 50% or more of the structure's market value before the event, while moderate damage means less than 50% of pre-disaster value. No commercial or industrial structures were identified as being damaged. The combined losses for all locations, considering building loss, contents loss and relocation costs, were calculated at over $72 million. Johnson Creek in the City of Portland is not included in this data, but has been a recent source of flood losses in Multnomah County.

Table 21 – 2016 Estimation of Flood Damage Across Multnomah County Jurisdictions (HAZUS Model)

Community*	# of Homes Substantially Damaged (>50% of Value)	# of Homes with <50% damage	Building Loss	Contents Loss and Relocation Cost
Participating Communities Total	12	203	$44,247,000	$28,383,000
Total for Unincorporated Multnomah County	10	62	$19,462,000	$12,898,000
East of Sandy River	2	10	$4,809,000	$3,980,000
Interlachen	0	0	$109,000	$69,000
Pleasant Valley	0	1	$292,000	$182,000
Riverdale Area	3	2	$1,282,000	$723,000
Sauvie Island Area	5	47	$10,910,000	$6,631,000
West of Sandy River	0	2	$2,060,000	$1,322,000
City of Fairview	0	36	$4,882,000	$3,013,000
City of Gresham	0	78	$13,371,000	$8,482,000
City of Troutdale	2	27	$6,532,000	$3,985,000
City of Wood Village	0	0	0	0

In the Lower-Columbia Sandy Watershed where flood maps were recently revised, another vulnerability assessment was conducted shortly after the 2019 map update was published. This analysis used HAZUS as well, along with updated hydrology and improved ground mapping and building inventories. This study overlaps, and provides more detailed analysis, for the parts of Troutdale, Gresham, and Unincorporated Multnomah County located within the watershed.

Note that this study uses different criteria to explain vulnerability than the above table, including analyzing scenarios for different flood frequency events. This study indicates slightly more exposure for Troutdale, which is primarily located in this watershed, than was shown in the 2016 analysis. That increase is most likely reflective of increases in predicted flood heights or changes to the flood extent from improved ground elevation mapping. Additional development may have occurred in the area, but would have been required to be constructed to withstand the 1% annual chance flood with little damage.

It is worth noting that damage projection continue to roughly double once the study looks at a larger event than the 1% annual chance flood. Those additional areas are outside the mapped regulatory floodplain and therefore much less likely to restrict development or require higher construction standards to limit flood loss. Residents may not be aware of this flood risk and would not be subject to mandatory flood insurance purchase requirements, which could further decrease resilience.

Table 22 – 2020 Estimation of Flood Damage in the Lower-Columbia Sandy Watershed (DOGAMI O-20-06, Natural Hazard Risk Report for the Lower Columbia-Sandy Watershed)

	10% annual chance (10-year) flood – buildings damaged	10% annual chance (10-year) flood – damage costs	2% annual chance (50-year) flood – buildings damaged	2% annual chance (50-year) flood – damage costs	1% annual chance (100-year) flood – buildings damaged	1% annual chance (100-year) flood – damage costs	0.2% annual chance (500-year) flood – buildings damaged	0.2% annual chance (500-year) flood – damage costs
Watershed Total (Multnomah County portion only)	4	$54,000	20	$286,000	48	$967,000	106	$4,956,000
Gresham	1	$16,000	5	$94,000	6	$119,000	10	$380,000
Troutdale	1	$10,000	8	$87,000	33	$640,000	67	$3,262,000
Unincorporated Multnomah County	2	$28,000	7	$105,000	9	$218,000	29	$1,314,000

National Flood Insurance Program

Participation in the National Flood Insurance Program (NFIP) is a way to both evaluate vulnerability and identify resilience, as flood insurance is a key way to make communities more able to recover from flood. Participation also requires standards for new buildings in flood-prone areas to meet standards identified in local Floodplain Management Ordinances. All communities in Multnomah County participate in the plan except for the City of Maywood Park. Special districts do not join the NFIP–their eligibility is included in the city or county jurisdictions where their structures or served communities are located.

Homes built before areas were mapped under the NFIP may have grandfathered 'pre-FIRM' status and be the structures most at risk from flood. Minus-rated policies are those pre-FIRM policies where the lowest floor is at least one foot below the 1%-annual chance flood elevation.

Table 23 – NFIP Policies by Type and Coverage Amount in Participating Jurisdictions (FEMA)

Community	Policies In Force	Pre-FIRM Policies	Minus Rated Policies	Insurance Coverage ($)
Participating Communities Total	345	187	6	100,231,000
Unincorporated Multnomah County	177	112	2	49,917,000
Fairview	41	10	0	13,634,100
Gresham	83	45	1	23,214,600
Troutdale	44	20	3	13,465,300
Wood Village	0	0	0	0

Between 1978 and 2015, 105 NFIP claims were made by property owners in communities that are part of this plan. In that time period, $1.2 million in insurance payments were received to cover flood losses.

Table 24 – NFIP Flood Damage Claims in Participating Jurisdictions (FEMA)

Community	Total Losses Submitted	Losses Paid	Closed Without Payment	Total Payments ($)
Participating Communities Total	105	72	33	1,206,915.96
Unincorporated Multnomah County	86	61	25	1,148,575.44
Fairview	3	2	1	13,276.26
Gresham	6	2	4	7,862.87
Troutdale	10	7	3	37,201.39
Wood Village	0	0	0	0

Repetitive loss and severe repetitive loss properties are an indication of development in extremely high-hazard areas. These properties are considered of the highest vulnerability and best candidates for property mitigation, such as voluntary buyouts that return the properties to open space.

FEMA defines repetitive loss properties as those that have had at least two paid flood losses of more than $1,000 apiece in any 10-year period. There are four repetitive loss structures in jurisdictions included in this plan.

- Unincorporated Multnomah County
  - 2 single-family residences
  - 1 non-residential structure
- City of Troutdale
  - 1 single-family residence

Severe repetitive loss properties are those that have:

- Four or more separate paid claims, each more than $5,000; or
- Two paid claims where the total amount paid exceeds the market value of the structure before each flood loss.

There are no severe repetitive loss properties in the jurisdictions participating in this plan.

The Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced

flood risk resulting from the community actions. CRS ratings range from 1-10, with lower scores indicating a higher level of flood reduction programs and improved flood insurance discounts.

The City of Troutdale is the only jurisdiction in this plan that participates as a CRS community. Troutdale entered the program in 2008 and has a rating of 7, meaning city residents receive a 15% discount on Federal flood insurance. The City of Portland has been a CRS participant since 2001 and has a rating of 5 (25% discount).

Vulnerability to Levee Failure

In 2018, DOGAMI published Special Paper 50, *Flood Risk Assessment for the Columbia Corridor Drainage Districts in Multnomah County, Oregon* to provide a comprehensive vulnerability assessment of the developed areas protected by the 45 miles of levee along the Columbia River.

The area was originally a series of sloughs, lakes, wetlands and side channels, before being initially leveed to dry the area enough for agricultural uses. After the establishment of the levees and other flood control infrastructure, the protected area grew and developed core parts of Multnomah County's urban development. Even after The Flood of 1948 (Vanport), thousands of new buildings have been built in these protected areas, which as of 2018 included around 8,000 residents, the Portland International Airport, the Portland Exposition Center, correctional facilities, and about 10% of the county's industrial employment base.

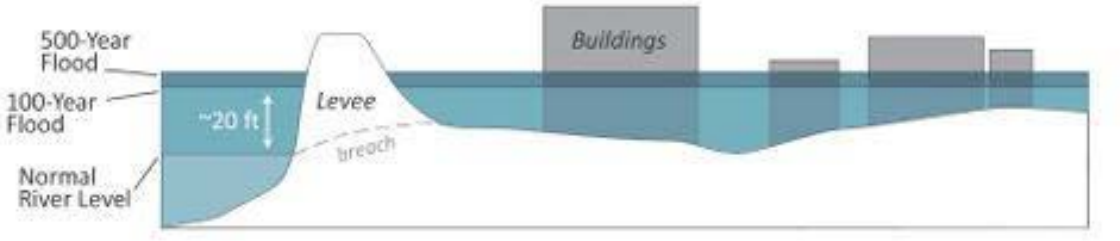

Figure 59 - Graphic showing how a levee breach impacts buildings normally protected from high water. Graphic - DOGAMI.

The study set out to quantify the loss if a breach occurred and allowed 1% annual chance (100-year) or 0.2 annual chance (500-year) flood levels to spread across the entire protected area. This analysis was conducted for each of the five current levee districts. Note that the Sauvie Island Drainage Investment Company (SIDIC) is not a participating district in this plan, but protects a large area of unincorporated Multnomah County so is included in vulnerability analyses.

Building Damage

Across the leveed areas, building exposure from 1% annual chance (100-year) flood elevations ranges from about half to nearly all of the buildings in the district, depending on the district.

Table 25 – Total Exposed Buildings and Property Damage From 100-Year Flood and 500-Year Flood without Levee Protection (DOGAMI Special Paper 50 - Flood Risk Assessment for the Columbia Corridor Drainage Districts in Multnomah County, Oregon)

District	Number of Exposed Buildings, 100-Year Flood	Number of Exposed Buildings, 500-Year Flood	Total Property Damage Assessment in 100-Year Flood after Breach (millions of dollars)	Total Property Damage Assessment in 500-Year Flood after Breach (millions of dollars)
Peninsula Drainage District #1 (PEN 1)	42	50	33.2 - 39.8	142.0 - 203.8
Peninsula Drainage District #2 (PEN 2)	1,075	1,110	672.6 - 760.2	768.7 - 826.3
Multnomah County Drainage District No. 1 (MCDD)	1,855	2,038	4,657.2 - 6,140.9	5,644.1 – 6,913
Sandy Drainage Improvement Company (SDIC)	91	131	256.4 – 345.6	383.8 – 541.2
Urban Flood Safety & Water Quality District (Total of above Districts)	3,061	3,329	5,619.4 – 7,286.5	6,938.6 – 8,484.3
Sauvie Island Drainage Improvement Company (SIDIC)	486	527	133.3 - 150	177.0 – 189.0

Displacement

Determining the extent of displacement of residents was used by applying population projections to the number of residences, adding residents of at least one established village for unhoused residents, and including those in correctional facilities.

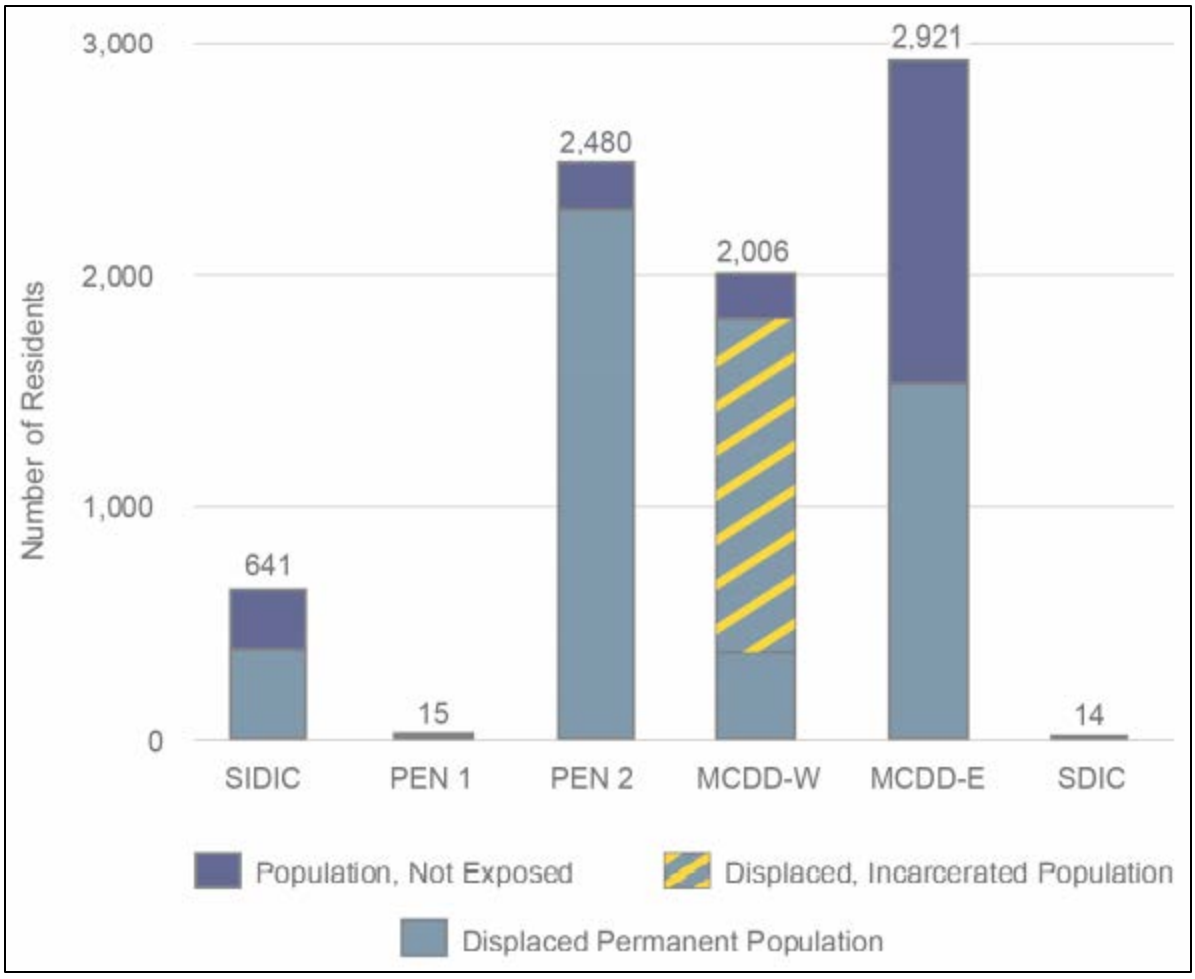

Figure 60 - Figure shows the proportion of population that would be displaced by a 1% annual chance flood without levee protection. Displacement would be especially high in the Multnomah County Drainage District and Peninsula 2 systems.

Economic Impacts

- Airport Impacts

A levee breach in a 1% annual chance (100-year) flood would expose well over $1 billion of assets at the Portland International Airport[51], damaging airport terminals and concourses, Port of Portland facilities, and long and short-term parking lots. This loss does not include damage to runways and indirect regional losses due to the interruption of regional air service.

The Troutdale Airport, a general aviation facility, would also be exposed to a 1% annual chance flood in the event of a levee breach.

- Workforce Impacts

[51] The 2018 DOGAMI study estimated the value of vulnerable PDX assets at $1 billion, but new and redeveloped facilities mean that this number is likely to be considerably higher now.

Table 26 – Impacts of Flood to Businesses and Employees in 100-Year Flood Without Levee Protection (DOGAMI Special Paper 50 - Flood Risk Assessment for the Columbia Corridor Drainage Districts in Multnomah County, Oregon)

District	Businesses Initially Closed Due to Flood, 100-Year Event	Number of Employees Initially Unable to Return to Work, 100-Year Event
Peninsula Drainage District #1	11	902
Peninsula Drainage District #2	237	4,259
Multnomah County Drainage District No. 1	1,569	42,829
Sandy Drainage Improvement Company	93	4,453
Urban Flood Safety & Water Quality District (Total of above Districts)	1,910	52,443
Sauvie Island Drainage Improvement Company	29	170

Hazardous Materials

The table below shows potential exposure of different hazardous materials in a levee breach during a 1% annual chance (100-year) or 0.2% annual chance (500-year) flood. Materials range from flammable gas, liquid, or solid; non-flammable gas; reactive and combustive materials; oxidizers; organic peroxides; poisonous materials; acute health hazards; corrosive materials; and other miscellaneous hazardous materials.

Table 27 – Hazard Materials Exposed in a 100-Year Flood without Levee Protection (DOGAMI Special Paper 50 - Flood Risk Assessment for the Columbia Corridor Drainage Districts in Multnomah County, Oregon)

District	Total Number of Buildings with Hazardous Materials Exposed in 100-Year Flood after Breach	Total Number of Hazardous Materials Exposed in 100-Year Flood after Breach
Peninsula Drainage District #1	4	40
Peninsula Drainage District #2	37	110
Multnomah County Drainage District	224	902
Sandy Drainage Improvement Company	17	65
Urban Flood Safety & Water Quality District (Total across Districts)	282	1,117
Sauvie Island Drainage Investment Company	2	2

Infrastructure Impacts

The DOGAMI study evaluated impacts to roads and four other types of critical infrastructure in their levee breach scenarios.

- *Transportation Routes*
  Assuming that road embankments hold, major road closures would likely be limited to Airport Way and Marine Drive, and one small section of Interstate 84. While limited, closures on those routes would cause substantial delays for interstate commerce and freight movement. Over three miles of light rail track and over two miles of freight/passenger rail would be inundated in a 100-year flood event.

- *Electrical Substations*
  Eight power substations are located in the inundation area, and seven would be exposed to at least six feet of flooding. Half of the substations are located in the area protected by the SDIC and were identified to suffer moderate-heavy damage, depending on full flood heights.

- *Natural Gas Facilities*
  Two natural gas facilities located in the MCDD levee area are expected to suffer extensive impacts in a 1% annual chance flood, seeing up to 10 feet of inundation.

- *Pump Stations*
  All 14 pump stations across the five levee districts would be exposed to at least seven feet of floodwater and suffer extensive impacts. All levee districts have at least one pump station, with the MCDD levee area having eight.

- *Water Facilities*
  Portions of the Columbia South Shore Well Field that provide water to parts of Fairview and Gresham would be inundated by levee breach, and would be likely to be forced to interrupt service. Two other water treatment facilities are expected to only suffer minor damage.

- *Recovery*
  Business, employment, and residential recovery would be significant. Analysis shows that many businesses would not recover or would take multiple years to reemploy staff. Debris removal post-flood totals more than 840,000 tons of debris across the Columbia Corridor Drainage Districts.

Response Plans

In addition to repairs and investments in the levee system, the Districts have a Flood Emergency Action Plan established in July 2016 and participate in flood fighting during high water events. Actions include monitoring and repairing the levee system as needed, installing flood closure structures at known low-points within the levee system, and maintaining the pump stations and internal drainage affected by rising groundwater. Additionally, the plan indicates necessary coordination between the Districts and the other overlapping jurisdictions, including traffic control.

Evacuation planning is the responsibility of the City of Portland within PEN 1, PEN 2, and most of MCDD and of Multnomah County outside of City of Portland limits. The City of Portland has an evacuation plan for the area within the levee system, current as of October 2017. MCDD, on behalf of the Districts, coordinates with the City of Portland and Multnomah County regarding on-the-ground conditions and recommendations for evacuation considerations, but does not make final decisions on evacuation orders or other protective action orders.

Dam Failure

Dams can pose risks to people living downstream, who may not be aware of the risk of dam failure. The Oregon Water Resources Department (OWRD) uses the National Inventory of Dams (NID) threat potential methodology, and maintains an inventory of known dams in Multnomah County. The inventory currently has 26 dams listed – eight are rated as high

threat[52], four as significant threat[53] and the remaining 14 as low threat[54]. The inventory tracks the last inspection date for each dam.

Five of the eight high-threat dams are located in Portland, while Bonneville, Bull Run, and Van Raden are located in unincorporated Multnomah County. No high-threat dams exist in the jurisdictional areas of any other community, but the City of Gresham has three significant-threat dams and one low-threat dam and the City of Fairview has one low-threat dam.

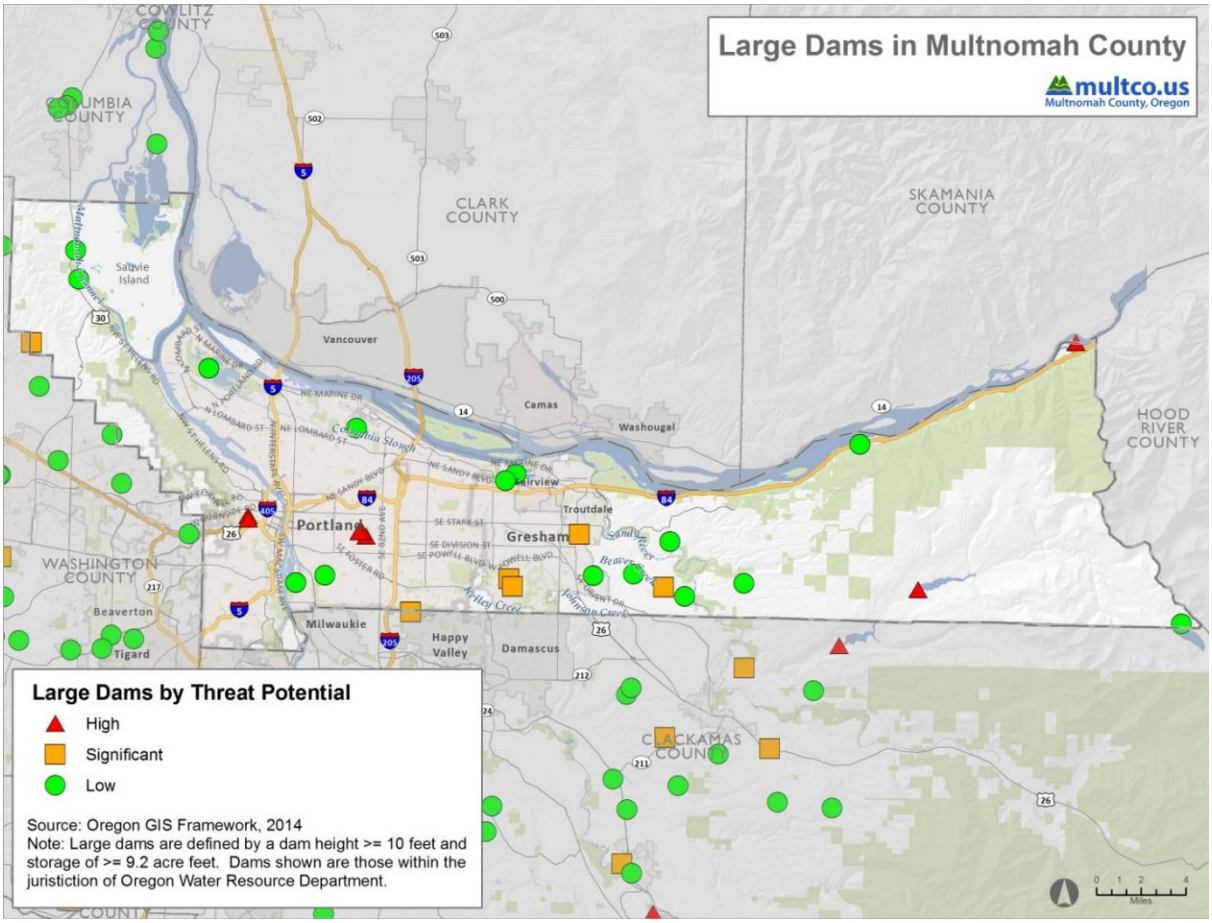

Figure 61 - Large Dams in Multnomah County, Oregon GIS Framework, 2014. Since this map was created, the Van Raden Dam has changed from significant threat to high threat. The Van Raden Dam is the farthest west orange square (on the border with Washington County) located at the Alderwood Lake Reservoir.

FEMA has a High Hazard Potential Dam (HHPD) grant program to identify and mitigate dam risks. This plan identifies all state and federally-regulated dams in Multnomah County, in accordance with 44 CFR §201 and has updated information on threat level and most recent inspection, when available.

[52] High threat means a failure is likely to cause loss of life.

[53] Significant threat means no likely loss of life in a failure, but probable economic loss and disruption of infrastructure.

[54] Low threat means no likely loss of life in a failure, and only minimal economic and environmental impact.

The *Bonneville Dam* is by far the largest dam in Multnomah County by water storage, and is a major source of regional power generation and limits Columbia River flood. The dam is operated by the US Army Corps of Engineers and power is sold by the Bonneville Power Authority – both agencies are federal, making the dam ineligible under the HHPD program. The dam is frequently inspected and has an Emergency Action Plan (EAP). Some risk exists from local earthquakes, especially a severe Mount Hood Fault Zone crustal earthquake. The dam is also at the site of a major historical landslide.

The *Bull Run Dam* is outside of the City of Portland limits, but is operated by the Portland Water Bureau, and falls under the City of Portland's vulnerability assessment. Potential inundation from this dam would be in Clackamas County, so continuing inter-jurisdictional coordination is needed. The dam was recently inspected and has an updated EAP.

The *Van Raden Dam* has moved from significant risk to high risk in the last few years. The privately-owned dam was inspected in 2020 and found to be in fair condition and an Emergency EAP was created in 2021. The Oregon Water Resources Department coordinated with Multnomah County to identify this dam as not eligible for the HHPD due to projected inundation levels and the small number of homes located below the reservoir on NW Rock Creek Road. However, it was recommended to increase coordination with the dam owner and Washington County (the dam is located right on the county line) and potentially develop an exercise for a dam failure scenario. A mitigation action is included for Multnomah County to address this risk and pursue preparation planning. The earthen dam would be subject to shaking threat from a Cascadia Subduction Zone earthquake and, especially, a major Portland Hills earthquake event.

Table 28 – Multnomah County Dam Information – (Oregon Water Resources Department and US Army Corps of Engineers)

Dam	Height (ft)	Storage (acre ft.)	Flood Source	Jurisdiction	Owner	Last Inspection	Threat Potential	Note
Bonneville	110	277,000	Columbia River	Multnomah County	US Army Corps of Engineers, Portland District	5/10/2018	High	Emer. Action Plan – 2008
Bull Run Dam 1	194	33,760	Bull Run River	City of Portland	City of Portland	9/30/20	High	Emer. Action Plan – 2021
Mount Tabor #1	30	37	Bull Run River (Offstream)	City of Portland	City of Portland	8/6/20	High	Emer. Action Plan
Washington Park #3	53	50	Bull Run River (Offstream)	City of Portland	City of Portland	8/6/20	High	Emer. Action Plan
Washington Park #4	60	54	Bull Run River (Offstream)	City of Portland	City of Portland		High	
Mount Tabor #5	55	153	Bull Run River (Offstream)	City of Portland	City of Portland	8/6/20	High	Emer. Action Plan
Mount Tabor #6	28	230	Bull Run River (Offstream)	City of Portland	City of Portland	8/6/20	High	Emer. Action Plan
Van Raden	27	115	Rock Creek	Multnomah County	Fred and Kenneth Van Raden	9/1/20	High	Fair Condition; Emer. Acton Plan 2021
Binford	25	30	Hieny Creek	City of Gresham	City of Gresham	5/1/18	Significant	

Dam	Height (ft)	Storage (acre ft.)	Flood Source	Jurisdiction	Owner	Last Inspection	Threat Potential	Note
Mt. Hood Community College	58	25	Kelly Creek	City of Gresham	Mt. Hood Community College	2/15/17	Significant	
Peyralans Reservoir	23	12	Butler Creek	City of Gresham	Marpol Ridge HOA	9/12/19	Significant	
William H. Sester	32	55	Trib. To Beaver Creek	Multnomah County	William H. Sester	10/6/16	Significant	
Belchers	28	30	Middle Fork Beaver Creek	Multnomah County	Darrold and Dan Belcher	5/24/16	Low	
Bull Run Lake	55	14,500	Bull Run River	Multnomah County	City of Portland		Low	
David Crampton	18	16		Multnomah County	David Crampton	4/7/09	Low	
Diack Reservoir	26	20	Trib. To Sandy River	Multnomah County	Samuel L. Diack	4/14/15	Low	
Fairview Lake	18	411	Columbia Slough	City of Fairview	City of Fairview	3/12/14	Low	
Kelly Creek Regional Detention Pond	20	67	Kelly Creek	City of Gresham		5/1/18	Low	
Multnomah Channel Dam #1	8.6	203	Trib. to Columbia River	Multnomah County	Metro Parks & Greenspaces		Low	
Multnomah Channel Dam #2	11.5	240	Trib. to Columbia River	Multnomah County	Metro Parks & Greenspaces	12/7/16	Low	
Oaks Bottom	9	451		City of Portland			Low	
Osburn Reservoir	34	52	Trib. to Trout Creek	Multnomah County	Tom Lehman	4/26/18	Low	
PDX De-Icing Lagoon	12	41		City of Portland	Port of Portland		Low	
Reed Lake	8	16.8	Crystal Springs Creek	City of Portland	The Reed Institute		Low	
Smith-Bybee Lakes	14	4,100	Columbia Slough	City of Portland	City of Portland	12/6/16	Low	
Wahkeena Rearing Reservoir	19	180	Wahkeena Creek	Multnomah County	Oregon Dept. of Fish and Wildlife	9/12/19	Low	

Urban Stormwater

Because urban stormwater effects are mostly local, large-scale vulnerability studies are not common. Cities included in this plan have Stormwater Management Plans to reduce impacts, and specific locations of repeated stormwater flooding are located in jurisdictional chapters.

Improvements to stormwater sewer capacity and the recovery of natural drainage systems are the primary methods for reducing vulnerability.

Channel Migration

The 2020 *Natural Hazard Risk Report for the Lower Columbia-Sandy Watershed* conducted a vulnerability assessment for channel migration risk on the Sandy River. Although channel migration undoubtedly affects other locations in Multnomah County, the Sandy River's dynamic nature and streamside location made it a clear choice for this type of study and a high-risk example of exposure.

The analysis does not include specific details for areas protected by the Sandy Drainage Improvement Company, but this movement could alter flood protection requirements or damage protective works. Totals of displaced persons and exposed buildings are for areas within the watershed boundary only.

Of the three jurisdictions in the watershed, Troutdale and Unincorporated Multnomah County are the communities with vulnerability, with a combined $55 million of potential building exposure over a 100-year view of potential erosion and new channel formation.

Table 29 – Displacement and Building Impacts from Sandy River Channel Migration Risk – (DOGAMI O-20-6 – Natural Hazard Risk Report for the Lower Columbia-Sandy Watershed)

	Number of People Potentially Displaced by Sandy River Channel Migration	Number of Buildings Exposed to Sandy River Channel Migration	Value of Buildings Exposed to Sandy River Channel Migration
Gresham	0	0	$0
Troutdale	143	66	$21,603,000
Unincorporated Multnomah County	139	114	$33,900,000