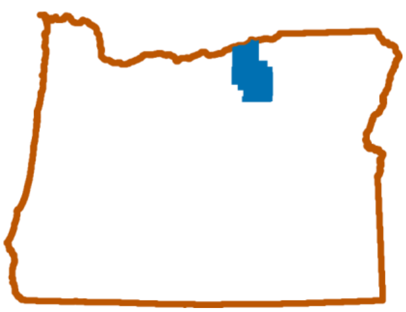
Morrow County

MULTI-JURISDICTIONAL NATURAL HAZARDS MITIGATION PLAN

VOLUME I: THE BASIC PLAN



- Morrow County
- City of Boardman
- City of Heppner
- City of Ione
- City of Irrigon
- City of Lexington

FEMA

Effective September 19, 2024, through September 18, 2029

Cover photo credits: Morrow County Natural Hazards webpage (top left), Heppner Flood of 1903, county Natural Hazards webpage (bottom left); KFLD News Talk radio 870 AM|98.7 FM [8 Close Fires Contained in Southern Morrow County, OR (newstalk870.am)] (right)

Acknowledgements

Morrow County Multi-Jurisdictional Natural Hazards Mitigation Plan Update Steering Committee

Plan Holders:

Morrow County

Former Emergency Manager, H. Paul Gray,
Current Emergency Manager, Steve Freeland
Planning Director, Tamra Mabbot,
Associate Planner and GIS Technician, Stephen Wrecsics.
Public Works/Airport Manager, Sandi Pointer

City of Boardman

Former City Manager, Karen Pettigrew
Planning Official, Carla McLane
Special Projects Coordinator, Rolf Prag

City of Heppner

Former City Manager, Kraig Cutsforth
Interim City Manager, Tommy Wolf

City of Ione

City Manager, Elizabeth Peterson

City of Irrigon

City Manager, Aaron Palmquist

City of Lexington

Former Town Recorder, Veronica Hess
Town Councilor, Katie Imes

Interested Parties and Partners:

Columbia Basin Electric Cooperative

General Manager, Andy Fletcher
Represented by Jake Calvert and Brian Kollman

Confederated Tribes of Umatilla Indian Reservation

Emergency Management Coordinator, Bob Fossek

Heppner Rural Fire Protection District

Fire Chief, Steven Rhea

Morrow County Health District:

CEO, Emily Roberts
Health and Safety Coordinator, Danielle Hoeft
Pioneer Memorial Hospital, Dwayne Marsh

Morrow County Soil and Water Conservation District

District Manager, Kevin Payne
Also represented by Jared Huddleston

State and Federal Agencies

Federal Emergency Management Agency, Region X

Erin Cooper, Hazard Mitigation Planning Program Lead

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Marian Lahav, Natural Hazard Program Coordinator
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Morrow County

H. Paul Gray, former Emergency Manager
Tamra Mabbott, Planning Director
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Funding for the Morrow County Multi-Jurisdictional Natural Hazards Mitigation Plan Update was provided in part by grant DR-4519-02, from the Federal Emergency Management Agency.

Cover photos: Morrow County Natural Hazards webpage (top left), Heppner Flood of 1903, county Natural Hazards webpage (bottom left); KFLD News Talk radio 870 AM|98.7 FM 8 Close Fires Contained in Southern Morrow County, OR (newstalk870.am) (right)

U.S. Department of Homeland Security
FEMA Region 10
130 228th Street, SW
Bothell, WA 98021-8627

FEMA

September 19, 2024

David Sykes, Chair
Morrow County
110 N. Court St.
Heppner, Oregon 97836

Reference: Approval of the Morrow County Multi-jurisdictional Hazard Mitigation Plan

Dear Chair Sykes:

In accordance with applicable[1] laws, regulations, and policy, the United States Department of Homeland Security's Federal Emergency Management Agency (FEMA) Region 10 has approved the Morrow County multi-jurisdictional hazard mitigation plan for the following jurisdictions:

Morrow County		

The approval period for this plan is from September 19, 2024 through September 18, 2029.

An approved hazard mitigation plan is one of the conditions for applying for and receiving FEMA mitigation grants from the following programs:

- Hazard Mitigation Grant Program (HMGP)
- Hazard Mitigation Grant Program Post-Fire (HMGP-PF)
- Building Resilient Infrastructure and Communities (BRIC)
- Flood Mitigation Assistance (FMA)
- High Hazard Potential Dams Grants Program (HHPD)

Based on FEMA's review, the plan did not include all dam risk. Thus, the participating jurisdictions are not eligible for assistance from the HHPD Grant Program. If any participating jurisdictions with HHPDs are interested in this assistance, they should contact the FEMA Region 10 Hazard Mitigation Planning Team at FEMA-R10-MT_Planning@fema.dhs.gov, to learn more about how to include all dam risks in the plan.

Having an approved hazard mitigation plan does not mean that mitigation grant funding will be awarded. Specific application and eligibility requirements for the programs listed above can be found in each FEMA grant program's respective policies and annual Notice of Funding Opportunities, as applicable.

[1] Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended; the National Flood Insurance Act of 1968, as amended; and National Dam Safety Program Act, as amended; Title 44 Code of Federal Regulations (CFR) Part 201, Mitigation Planning; and Local Mitigation Planning Policy Guide (FP-206-21-0002).

To avoid a lapsed plan, the next plan update must be approved before the end of the approval period, including adoption by the participating jurisdiction(s). Before the end of the approval period, please allow sufficient time to secure funding for the update, including the review and approval process. Please include time for any revisions, if needed, and for participating jurisdictions to formally adopt the plan after the review, if not adopted prior to submission. This will enable each jurisdiction to remain eligible to apply for and receive funding from FEMA's mitigation grant programs with a hazard mitigation plan requirement. Local governments, including special districts, with a plan status of "Approvable Pending Adoption" are not eligible for FEMA's mitigation grant programs with a hazard mitigation plan requirement.

If you have questions regarding your plan's approval or FEMA's mitigation program, please contact Stephen Richardson, State Hazard Mitigation Officer, Oregon Department of Emergency Management at (971) 332-0005 or stephen.richardson@oem.oregon.gov, who coordinates these efforts for local entities.

Sincerely,

WENDY L SHAW Digitally signed by WENDY L SHAW
Date: 2024.09.23 13:42:47 -07'00'

Wendy Shaw, P.E.
Risk Analysis Branch Chief
Mitigation Division

Enclosures

cc: Stephen Richardson, Oregon Department of Emergency Management
Joseph Murray, Oregon Department of Emergency Management

JF:JG:WS

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I. INTRODUCTION

> *"On Sunday, June 14, 1903, at about 5:00 p.m., a cloudburst broke over the hills south of the small farming community of Heppner. Overloaded creeks rushed toward the town, picking up debris from the farms through which they passed. At the south end of Heppner, a steam laundry crossed the path of the water. Debris built up behind the laundry, effectively damming the water until the building could not withstand the pressure. When the water broke free, it hit Heppner with a force unmatched in the history of the state.*
>
> *"After the floodwaters subsided, the task of finding and burying the dead began. Bodies were dug out of the debris and, in some cases, brought back to town from several miles downstream. A temporary morgue was set up in the stone Roberts Building, one of the few structures left relatively unscathed on Main Street. Fatality counts varied; some people simply disappeared and were never accounted for, some bodies were never identified. The final count was 'approximately 250 dead.'"*

(Reprinted from the website: : www.rootsweb.com/morrow/HeppnerFlood.htm; citation not located during 2024 update.)

A. What is Natural Hazard Mitigation?

What is natural hazard mitigation? Natural hazard mitigation is defined as permanently reducing or alleviating the losses of life, property, and injuries resulting from natural hazard events through both long term and short-term strategies. Example strategies include policy changes (e.g., updated development codes), capital improvement projects (e.g. seismically retrofitting critical facilities such as bridges), and education opportunities to targeted audiences (e.g., non-English speaking community members or the elderly).

Hazard mitigation aims to reduce damage to communities and increase community safety, economic stability, and overall resilience. Natural hazard mitigation cannot be accomplished by one entity alone but is rather the responsibility of the "Whole Community": individuals, private businesses and industries, state and local governments and the federal government.

Engaging in mitigation activities benefits jurisdictions in many ways. including increasing community resilience and capacity. Through natural hazard mitigation, the loss of life, property, essential services and critical facilities due to natural hazards are decreased. and cooperation and communication within the community is increased through the planning process. The plan is also essential to gain eligibility for FEMA recovery and reconstruction grants.

B. Why Develop a Mitigation Plan?

The Heppner Flood was the worst flood, in terms of loss of life, ever to occur in Oregon. Morrow County developed this Natural Hazards Mitigation Plan in an effort to reduce future loss of life and property resulting from natural disasters such as the flood event mentioned above. It is impossible to predict exactly when these disasters will occur, or the extent to which they will affect the County. However, with careful planning and collaboration among public agencies, private sector organizations, and citizens within the community, it is possible to minimize the losses that can result from natural disasters.

A natural disaster occurs when a natural hazard impacts people or property and creates adverse conditions within a community. This plan focuses on the primary natural hazards that could affect Morrow County, Oregon, which include drought, wildfire, flooding, windstorms, winter storm, and to a lesser extent, landslides, seismic and volcanic events. The dramatic increase of the costs associated with recovery from natural disasters over past decades has fostered interest in identifying and implementing effective means of reducing vulnerability. This Natural Hazards Mitigation Plan is intended to assist Morrow County in reducing its risk from natural hazards by identifying resources, information, and strategies for risk reduction.

In addition to establishing a comprehensive community-level mitigation strategy, the Disaster Mitigation Act of 2000 (DMA2K) and the regulations contained in Title 44 CFR Part 201, require that jurisdictions maintain an approved NHMP to receive federal funds for mitigation projects. Local adoption and federal approval of this NHMP ensures that the County and listed cities will remain eligible for pre- and post-disaster mitigation project grants.

The Disaster Mitigation Act of 2000 (DMA 2000) reinforces the importance of mitigation planning and emphasizes planning for disasters before they occur. As such, this Act established a pre-disaster hazard mitigation program and new requirements for the national post-disaster Hazard Mitigation Grant Program (HMGP). Section 322 of the Act specifically addresses mitigation planning at the state and local levels. States and local communities must have approved mitigation plans in place in order to be eligible to apply for both pre-disaster and post-disaster FEMA hazard mitigation funds. Mitigation plans must demonstrate that their proposed mitigation measures are based on a sound planning process that accounts for the risk to the individual and their capabilities.

Title 44 Code of Federal Regulations (CFR), section 201.6, also requires a local government to have an approved NHMP in order to receive HMGP project grants. Pursuant to Title 44 CFR, the NHMP planning processes shall include opportunity for the public to comment on the NHMP during review and the updated NHMP shall include documentation of the public planning process used to develop the NHMP.[7] The NHMP update must also contain a risk assessment, mitigation strategy and a NHMP maintenance process that has been formally adopted by the governing body of the jurisdiction. Lastly, the NHMP must be submitted to the Oregon Department of Emergency Management (ODEM) for initial review and then sent to FEMA for federal approval. Additionally, the way ODEM administers the Emergency Management Performance Grant (EMPG), which helps fund local emergency management programs, also requires a FEMA-approved NHMP.

C. Policy Framework for Natural Hazards in Oregon

Planning for natural hazards is an integral element of Oregon's Statewide Land Use Planning program, which began in 1973. All Oregon cities and counties have comprehensive plans and implementing ordinances that are required to comply with the statewide planning goals. The challenge faced by state and local governments is to keep this network of local plans coordinated in response to the changing conditions and needs of Oregon communities.

Statewide Land Use Planning Goal 7: Areas Subject to Natural Hazards calls for local plans to include inventories, policies, and ordinances to guide development in hazard areas. Goal 7, along with other land use planning goals, has helped to reduce losses from natural hazards. Through risk identification and the recommendation of risk-reduction actions, this plan aligns with the goals of the Morrow County's Comprehensive Plan and helps Morrow County meet the requirements of Statewide Land Use Planning Goal 7.

The primary responsibility for the development and implementation of risk reduction strategies and policies lies with local jurisdictions. However, resources to assist local jurisdictions exist at the state and federal levels. Some of the key agencies in this area include Oregon Department, of Emergency Management (OEM), Oregon Building Codes Division (BCD), Oregon Department of Forestry (ODF), Oregon Department of Geology and Mineral Industries (DOGAMI), and the Department of Land Conservation and Development (DLCD).

D. How was the Plan Developed and Updated?

The plan is non-regulatory in nature, meaning that it does not set forth any new policy. The mitigation plan works in conjunction with regulatory and policy documents. The NHMP includes a factual basis to be incorporated into policy documents such as a comprehensive plan or regulatory code such as the development code. The current suite of county, city and state plans and programs that are connected to the Natural Hazard Mitigation Plan are:

- The Natural Hazards Element of the Morrow County Comprehensive Plan;
- Flood Hazard Overlay Zone of the Morrow County Zoning Ordinance;
- City Flood Ordinances;
- Morrow County Community Wildfire Protection Plan;
- Mutual Aid Agreements for fire and emergency services between Morrow and Umatilla Counties; and
- State of Oregon Natural Hazards Mitigation Plan.

The Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan (NHMP) both analyzes natural hazard risks and identifies mitigation strategies to reduce risk. The NHMP provides a set of actions to prepare for and reduce the risks posed by natural hazards through education and outreach programs, the development of partnerships, and implementation of preventative activities such as land use or watershed management programs. The resources and information within the mitigation plan establish a foundation for coordination and collaboration among agencies and the public in Morrow County, identify and prioritize future mitigation projects, and assist in meeting qualifications for federal assistance programs. The actions described in the plan are intended to be implemented through existing codes, plans and programs within the County.

The first Morrow County Natural Hazards Mitigation Plan was developed and approved in 2006. The plan was updated in 2016 and the current 2023/24 plan update marks the second update of the Morrow County Multi-Jurisdictional Natural Hazards Mitigation (NHMP). This updated NHMP will consolidate and replace the prior version of the Plan when it is approved by FEMA and adopted by the participating jurisdictions.

This plan update was supported by Hazard Mitigation Grant Program (HMGP) grant funds through HMGP DR-4519.

The Plan Update Process: In the fall of 2022 a Natural Hazard Mitigation Planner from the Oregon Department of Land Conservation and Development worked with county staff to convene meetings with Morrow County and representatives from Morrow County incorporated cities and other interested parties to begin the process of updating this plan. The convener from the Morrow County, the County Emergency Manager, worked with the DLCD planner to develop a roster of participants that would include representatives from all the cities and representatives of neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development as well as businesses, academia, and other private and non-profit interests.

The representatives of interested parties to the NHMP update included those representing the Morrow County Health District, the Heppner Rural Fire Protection District, the Columbia Basin Electric Cooperative, the Morrow Soil and Water Conservation District and the Confederated Tribes of the Umatilla Indian Reservation.

The DLCD planner working to manage this NHMP update project changed three times during the course of this update. Pam Reber filled this role from the beginning of the project until December 2022. At that time Susan Millhauser assumed the role of project manager and completed the steering committee meetings, data gathering and mitigation strategy assessment. Katherine Daniel and Gianna Alessi took up the project in late 2023 to complete the drafting of the plan update.

The Steering Committee evaluated how the plan should change to address current community priorities. The major changes to the Plan are:

- Section 1, Introduction was updated in that new steering committee members were introduced and all meetings held during the process of updating the plan were documented. Plan organization was improved, and this was also documented.
- Section 2, Community Profile was updated with the latest demographic information from 2020 US Census and the American Community Survey along with other sources of data on the people and property within Morrow County. Housing and development trends were updated with information obtained through internet research and information provided by the county.
- The city annexes were incorporated into Volume I rather than presented separately. This change was made because there is much information in common among the cities and the county. This change creates a more wholistic plan document describing a plan within which all jurisdictions can support mitigation efforts.

- Section 3. The Natural Hazard Annexes were incorporated into this section and updated information was added.
- Section 4. The mission and goals were confirmed as written in 2016 and Action Items were updated through Steering Committee review and through small group meetings with city representatives. All current action items completed action items, and action items that were deleted from the plan are included in the tables within this section.
- Section 5. The Plan Implementation and Maintenance section was reviewed and updated by the Steering Committee. The Convener for the Morrow County MJNHMP was identified as the County Emergency Manager. Plan maintenance meetings will be held on a semi-annual basis.

D. Who was Involved in the Update Process?

The Morrow County Natural Hazard Mitigation Plan is the result of a collaborative effort between the county, cities, special districts, citizens, public agencies, non-profit organizations, the private sector, and regional organizations. The convener of the plan for the county, the Emergency Manager, Paul Gray, and the DLCD project manager developed a roster of participants that included both existing members from the original Morrow County NHMP development and new partners to ensure that all community interests participated actively in the process.

The Emergency Manager and the DLCD Project Manager sent emails and information about the NHMP update process to a wide range of potential participants. Participation in the NHMP update process was solicited from all of the county's rural fire protection districts, the State Fire Marshal's office, the Umatilla National Forest, Heppner Ranger District, representatives of the Fire Defense Board, the Morrow County Soil and Water Conservation District, representatives of the local electric cooperative, and the Confederated Tribes of the Umatilla Indian Reservation. Some of those invited to participate attended meetings and provided input to the plan update.

Participants in the Steering Committee and the group of Interested Parties are listed below.

1. Steering Committee

Morrow County Plan Holders	Name	Position
Morrow County	H. Paul Gray,	Former Emergency Manager
Morrow County	Steve Freeland	Current Emergency Manager
Morrow County	Tamra Mabbot	Planning Director
Morrow County	Stephen Wrecsics	Associate Planner and GIS Technician
Morrow County	Sandi Pointer	Public Works/Airport Manager
City of Boardman	Karen Pettigrew	City Manager
City of Boardman	Carla McLane	Planning Official
City of Boardman	Rolf Prag	Special Projects Coordinator
City of Heppner	Kraig Cutsforth	Former City Manager
City of Heppner	Tommy Wolf	Interim City Manager
City of Ione	Elizabeth Peterson	City Manager
City of Irrigon	Aaron Palmquist	City Manager
City of Lexington	Veronica Hess	Town Recorder
City of Lexington	Katie Imes	Town Councilor
Interested Parties and Partners		
Columbia Basin Electric Cooperative	Andy Fletcher	General Manager
Columbia Basin Electric Coop.	Jake Calvert, Brian Kollman	
Confederated Tribes of Umatilla Indian Reservation	Bob Fossek	Emergency Management Coordinator
Heppner Rural Fire Protection District	Steven Rhea	Fire Chief
Morrow County Health District	Emily Roberts	CEO
Morrow County Health District	Danielle Hoeft	Health and Safety Coordinator
Morrow County Health District	Dwayne Marsh	Pioneer Memorial Hospital
Morrow County Soil and Water Conservation District	Kevin Payne	District Manager
Morrow County SWCD	Jared Huddleston	

The Steering Committee and Interested Parties met eight times between November 2022 and July 2023. Also, during the update process, each incorporated community in Morrow County held a meeting to review the risk assessment and to update their respective hazard mitigation actions for the NHMP's annexes. Documentation of these meetings is provided in Appendix B.

2. Meetings

November 2, 2022: Project introduction and establishment of project practices, the need to conduct public outreach activities during the development of the plan and a proposed schedule for completion of the project.

November 15, 2022: Prior plan mitigation strategy actions were the primary topic of this meeting as well as the content of updated city annexes. The Steering Committee decided to conduct separate risk assessments for the northern and southern portions of the county. The use of Box and completion of cost share forms were also discussed.

January 17, 2023: The Steering Committee identified the natural hazards that will be addressed by the NHMP update. The group identified two new hazards, Extreme Temperatures and Air Quality. Tornado was recategorized under Thunderstorms. Other natural hazards that carry over from the 2016 plan include Drought, Earthquake (Cascadia), Earthquake (Crustal), Flood, Landslide, Thunderstorm, Windstorm, Winter Storm, Wildfire, and Volcanic Event. A total of twelve natural hazards are addressed by this NHMP update. The meeting also included an OEM methodology Hazard Vulnerability Assessment (HVA) for the North County and individual updates from the cities about meetings held locally to discuss mitigation strategies.

February 21, 2023: Susan Millhauser joins the project as a Natural Hazard Planner and Project Manager to replace Pam Reber. The agenda included confirmation of the natural hazards identified at the previous meeting were relevant for both north and south county areas. Susan informed the group that Dam Safety is to be addressed in the plan update per FEMA guidance issued in April 2023.

March 21, 2023: The project timeline was adjusted to better reflect the time for outreach efforts on risk assessment and also on mitigation strategies. New FEMA requirements for addressing High Hazard Potential Dam risk and how to message that to the public as well as mitigation strategy requirements with a focus on equitable outcomes.

April 18, 2023: Matt Williams, Geohazard Analyst for the Department of Geology and Mineral Industries, presented the results of the multi-hazard risk analysis he completed for Morrow County with respect to landslide, earthquake, flood, channel migration, and wildfire. The Steering Committee discussed the ranking of the hazards using the OEM methodology HVA with the DOGAMI analysis in mind. The north and south county rankings were finalized.

May 16, 2023: Erica Fleishman, Director of the Oregon Climate Change Research Institute provided an overview of the Future Climate Projections report prepared for Morrow County regarding the projected impact of a warming climate on the natural hazards addressed in the Morrow County Multi-

Jurisdictional NHMP update. The development of maps for the plan and progress reports were the other topics covered at this meeting.

July 18, 2023: The meeting purpose was to provide updates to the OCCRI Future Climate Projections report (Erica Fleishman) and to summarize the findings of the draft DOGAMI report so that the Steering Committee could discuss any updates needed to the OEM Methodology HVA. This was postponed. Public outreach and feedback to incorporate into the NHMP were also considered in light of the departure of the convener from county employment.

Small group meetings: DLCD project managers met in small groups with all the city representatives and the county and health district participants to focused discussion on the mitigation strategies for each jurisdiction.

3. Public Review and Comment

Public outreach began in the Spring of 2024 when the county held two open houses to inform the public and gather feedback on the plan. One was held in the City of Boardman in conjunction with a Preparedness Fair. The second event was held in the southern part of the county, in Heppner, in conjunction with a Board of County Commissioners meeting.

The county developed a flyer for the Open House in Heppner that was posted online and in physical locations. The flyer was also published in the local newspaper, the Heppner Gazette Times, on Tuesday April 17th. The Gazette is a county-wide publication and is available for free at locations throughout Morrow County, the Planning Department office being one. Both events were free and open to the public. The events were well advertised to encourage members of the public to visit, learn about the NHMP update and provide their thoughts and comments.

The feedback provided by one attendee was focused on the impact of overhead high tension electric wires on the susceptibility of dry land wheat to ignite and become a wildfire. The attendee voiced concern that the role of overhead electric lines be more prominently identified in the NHNMP update as a factor in wildfire susceptibility in rural Morrow County. The plan was revised to make note of this input.

E. How is the Plan Organized?

Volume I: The Plan

The 2024 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan update is more consolidated than previous plan updates. It still consists of the following five sections:

<u>Section I: Introduction</u>

The Introduction briefly describes the purpose of and basis for the county's mitigation planning efforts and the methodology used to develop the plan. It also includes information about the Steering Committee's role and how other stakeholders provided input.

Section II: Community Profile

The Community Profile briefly describes the county and each of the cities in terms of demographic, economic, and development trends as well as geography and environment, housing, social vulnerability, and transportation. This section is more substantial than previously due to inclusion of the Community Profile appendix into the principal plan document.

Section III: Hazard Risk Assessment

This section contains Hazard Profiles that describe the thirteen natural hazards that affect Morrow County. The subsection includes additional resources and documentation that was previously in a separate section of the plan. Each natural hazard is characterized with respect to location and extent as well as the probability of future occurrence and vulnerability of people and property in Morrow County. The impact of future climate conditions on relevant natural hazards is discussed in this section based on the work of the Oregon Climate Change Research Institute. The full report is included as an appendix.

The second subsection also contains a Vulnerability Assessment based on the OEM-FEMA Hazard Vulnerability Analysis Methodology conducted with the Steering Committee participants at meetings documented elsewhere in this plan. This method asks participants to rank severity of four factors that comprise risk to natural hazards: Historic Frequency, Future Probability, Vulnerability and Maximum Threat. Scores are weighted and result in a Total Risk score that informs the risk assessment phase of the planning process.

The final subsection, Risk Analysis, contains the exposure and loss estimates developed by the Department of Geology and Mineral Industries for the unincorporated county and for each of the incorporated cities within Morrow County. The complete report is included in Appendix E

Section IV: Mitigation Plan Goals and Action Items

This section describes the vision of the plan and the goals established to implement the vision statement. The bulk of this section includes mitigation actions that are intended to implement the identified mitigation goals.

Section V: Plan Implementation and Maintenance

This section provides information on the implementation and maintenance of the plan. It describes the process for prioritizing projects and includes a suggested list of tasks for updating the plan to be completed at the semi-annual and 5-Year review meetings.

Volume II: Resource Appendices

The resource appendices are designed to provide users of the Morrow County Natural Hazards Mitigation Plan with additional information to assist them in understanding the contents of the mitigation plan and provide them with potential resources to assist with Plan implementation.

Several of the appendices from the 2016 NHMP update were folded into the Basic Plan. These include the Existing Plans, Policies, and Programs and the Mitigation Activities and Resource Directory. This information forms part of Section V of Volume I. The Action Items is also incorporated into Volume I within Section IV: Mitigation Plan Goals and Action Items. Maps are incorporated into Volume I within Section III: Hazard Risk Assessment; A. Hazard Identification

New appendices were added. The FEMA Approval Letter, the resolutions of adoption and the FEMA Local Plan Review Tool are compiled separately in Appendix A. The analyses performed by the Department of Geology and Mineral Industries and the Oregon Climate Change Research Institute are included as new appendices in Volume II.

Appendix A: Resolutions, FEMA Letter of Approval and Review Tool

This appendix includes the signed local resolutions of approval from each jurisdiction that is adopting the plan. This is followed by the official FEMA letter of approval and the accompanying Local Review Tool.

Appendix B: Planning and Public Process

This appendix includes evidence of the public process involved in the development of this Plan. Steering Committee attendance, meeting minutes, agendas are included.

Appendix C: Economic Analysis of Natural Hazard Mitigation Project

This appendix describes FEMA requirements for benefit/cost analysis in natural hazards mitigation, as well as various approaches for conducting economic analysis of proposed mitigation activities.

Appendix D: Grant Programs and Resources

This appendix lists state and federal resources and programs by hazard.

Appendix E: DOGAMI Multi-Hazard Risk Report for Morrow County, OR

A multi-hazard analysis of losses and exposure to earthquake, landslide, flood, and channel migration was conducted using a model developed by FEMA (Hazus) and local assessors' data regarding building construction type and first floor elevations.

Appendix F: OCCRI Future Conditions Report Morrow County, Oregon

Analysis performed by the Oregon Climate Change Research Institute assesses the potential localized effects of a warming climate on the intensity and frequency of a wide range of natural hazards.

II. COMMUNITY PROFILE

The following section describes Morrow County from several perspectives to help define and understand the County's sensitivity and resilience to natural hazards. Sensitivity and resilience indicators are identified through the examination of community capitals which include natural environment, social/demographic capacity, economic, physical infrastructure, and political capital. These community capitals can be defined as resources or assets that represent many aspects of community life. When paired together, community capitals can influence the decision-making process to ensure that the needs of the community are being adequately met.

Sensitivity factors can be defined as those community assets and characteristics that may be impacted by natural hazards, (e.g., special populations, economic factors, and historic and cultural resources). Community resilience factors can be defined as the community's ability to manage risk and adapt to hazard event impacts (e.g., governmental structure, agency missions and directives, and plans, policies, and programs). To help define and understand the County's sensitivity and resilience to natural hazards, the following capacities must be examined:

- Natural Environment Profile
- Social/Demographic Profile
- Economic and Employment Profile
- Built Environment Profile
- Transportation Infrastructure Profile
- Cultural Resources and Historical Places Profile
- Political Capacity Profile

The Community Profile describes the sensitivity and resilience to natural hazards of Morrow County, and its incorporated cities, as they relate to each capacity. It provides a snapshot of the time when the plan was developed and will assist in preparation for a more resilient County.

A. Natural Environment Profile

Natural environment capacity is recognized as the geography, climate, and land cover of the area such as, urban, water and forested lands that maintain clean water, air and a stable climate.[2] Natural resources such as wetlands and forested hill slopes play significant roles in protecting communities and the environment from weather-related hazards, such as flooding and landslides. However, natural systems are often impacted or depleted by human activities adversely affecting community resilience.

1. Geography

Morrow County is located in the eastern portion of Oregon and covers an area of 2,031 square miles bordered by Gilliam county to the west, Wheeler and Grant counties to the south, and Umatilla county to the east. The county's northern border is bounded by the Columbia River, with 35 miles of shoreline.

The major city in Morrow County is Boardman where 36.2 % of the population live. The nearest large urban area is Hermiston located just over 20 miles east.

While most of the county is dry and flat, south county has a section of the Blue Mountains Range, making it fairly mountainous. The highest point in Morrow County reaches upwards of 6,000 feet at Black Mountain in the Umatilla National Forest (5,923 feet). Elevation dips as low as 260 feet above sea level at the Columbia River to the north.

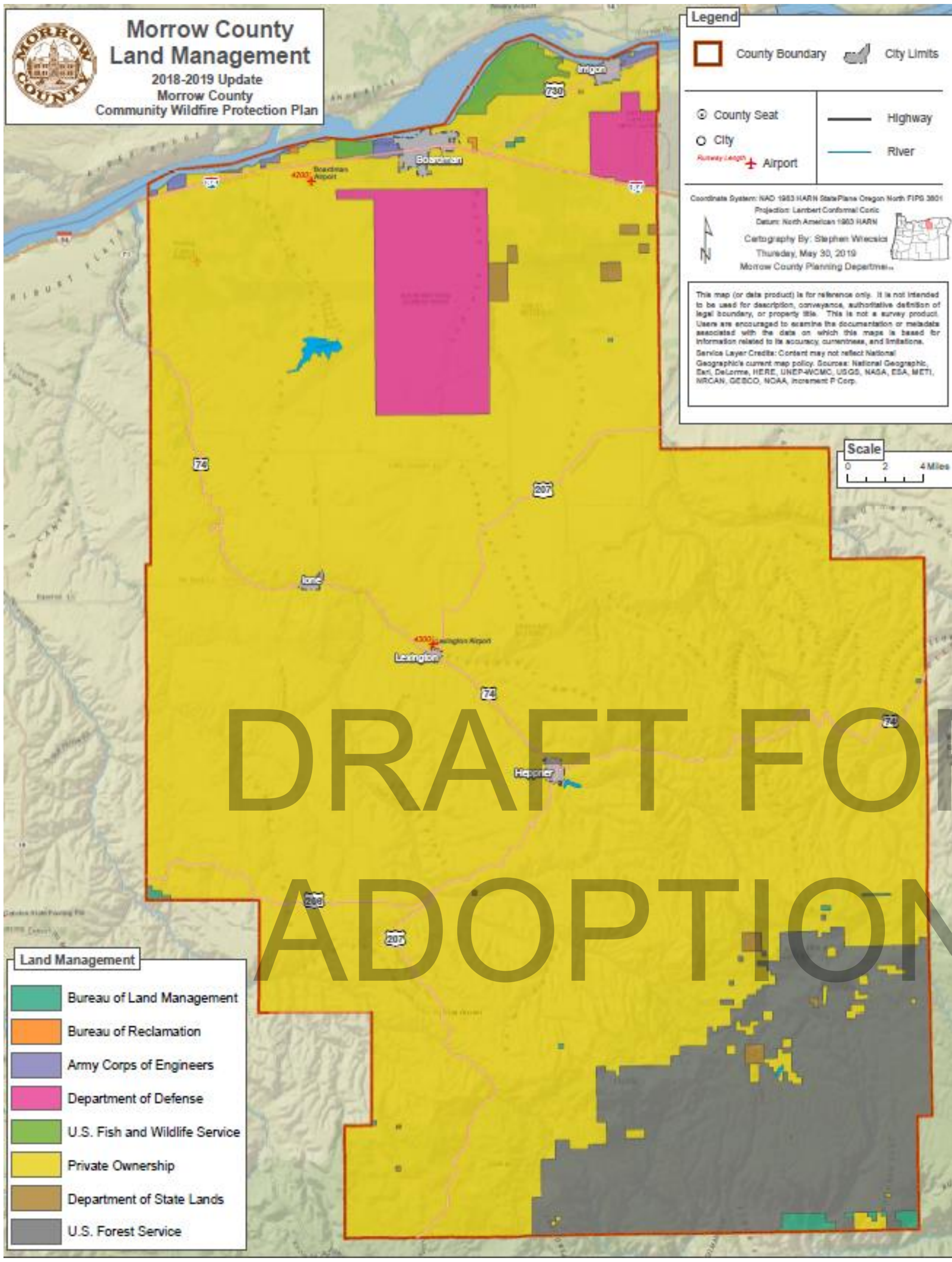
Table 1. Morrow County Land Management Inventory

Management Type	Acres (Approximately)	Percentage of Land
Private Lands (Residential, Ranches, Timber Companies, etc.)	**1,085,129**	**82.8%**
Public Land	**225,333**	**17.2%**
Federal Government	216,741	16.5%
State Government	2,182	0.2%
Local Government	6,410	0.5%
Total	**1,310,462**	**100.0%**

Source: Morrow County Community Wildfire Protection Plan, 2019

The County is comprised of approximately 1,321,462 acres of land. As broken down in Table 1 and Figure 1, the vast majority of the land is privately owned (82.8 %). The remaining lands comprises approximately one fifth of the land (17.2 %) in Morrow County is publicly owned (16.5 % Federal Government, 0.2 % State Government, 0.5 % Local Government).

Figure 1. Morrow County Land Management



Source: Morrow County Community Wildfire Protection Plan, 2019

1. *Geological Provinces*

Morrow County is comprised of two geologic provinces or ecoregions located within its boundaries: Columbia Plateau and Blue Mountains.[1] These provinces are characterized by complex and rugged topography, unique soils groups, deep and narrow valleys, which impact all activities of residents of the County (see Figure 2). The physical setting of the County plays an important role in the hazard analysis

[1] EPA Ecoregions III in Oregon Map. Accessed April 10, 2022.

process. Most of Morrow County is in the treeless high plains of the Columbia Plateau. The Plateau rises gently to the south into the forested Blue Mountains and is cut by many steep-walled, flat-bottomed canyons carrying streams.

Figure 2. Morrow County Geologic Provinces

Source: Oregon Department of Land Conservation and Development, 2024

The Columbia Plateau province is an arid, sagebrush steppe and grassland that is flanked by moister, predominantly forested, mountainous ecoregions. The Columbia Plateau (10) is underlain by basalt up to two miles thick and partially covered by thick loess deposits. Where precipitation amounts are sufficient, its deep loess soils have been extensively cultivated for wheat. The Columbia River bisects Ecoregion 10; its water is subject to resource allocation debates involving fisheries, navigation, power production, recreation, and irrigation.

The Blue Mountains province is a complex of mountain ranges that are lower and more open than the neighboring Cascades (4) and Northern Rockies (15). Like the Cascades (4), but unlike the Northern Rockies (15), the Blue Mountains (11) are mostly volcanic in origin. However, the core of the Blue Mountains and the highest ranges, the Wallowa and Elkhorn Mountains, are composed of granitic intrusives, deep sea sediments, and metamorphosed rocks. Much of Ecoregion 11 is grazed by cattle.

2. Water Resources

The County lays within two river drainage basins: The Umatilla River Basin and the John Day River Basin, where the Umatilla River Basin covers the majority of the County. There are five river systems that run throughout the county, four of which are tributaries of the Umatilla River: the Willow-Rhea Creek, Butter Creek, Rock Creek, and the Columbia, and a John Day River basin tributary. These provide the county with water for fish and wildfire, domestic needs, recreational uses, agriculture, industrial transportation, general vegetation growth, and contains streams that were historically viable for salmonid population, which are slowly returning.

2. Umatilla River Basin

The Umatilla River Basin lays within the majority of both Umatilla County and Morrow County and comprises a total of 4,694.75 square miles. This basin helps the County maintain its water supply and economic health, such as agriculture, power generation, and environmental and pollution abatement.

The Umatilla River Basin is part of the Umatilla River, which flows approximately 89 mi. (143 km) from where it branches into the north and south forks of the Umatilla River to the mouth at the confluence with the Columbia River. The Umatilla River originates in the conifer forests of the Blue Mountains at over 6,000 feet elevation and flows west and then northwest through the semi-arid shrub steppe of the Deschutes-Umatilla plateau, entering the Columbia River at an elevation of 270 feet above sea level. This confluence occurs at the town of Umatilla, Oregon, about 300 miles upstream from the Pacific Ocean.

Major tributaries include Meacham Creek, Birch Creek, McKay Creek, Butter Creek, and Wildhorse Creek. As part of the Umatilla Drainage Basin, these tributaries that run throughout Morrow County includes Butter Creek, which flows into the Columbia River. It also includes Willow Creek, whose headwaters are in the mountains above Heppner, and flows through the communities of Heppner, Lexington and Ione, eventually joining the Columbia River just outside of Morrow County to the west. There are other minor drainages, which flow into Willow Creek, which have been locally renowned for periodic flash flooding such as Balm Fork, Hinton Creek, Rhea Creek, and Shobe Creek.

3. Nitrate in Morrow County[2]

Morrow County's groundwater, the primary source of drinking water for the county, has been measured in some areas to have approximately five times the federal safe drinking water limit of nitrates, a naturally occurring chemical commonly found in fertilizer. While nitrates can provide beneficial nutrients that help crops grow, when in excess can cause serious health issues, such as respiratory infections, thyroid dysfunctions, and bladder cancer. As large-scale agricultural operations or other entities, such as

[2] Morrow County water contamination could prompt EPA to intervene

Port of Morrow, have played a big role in the County's economy for decade, the widespread groundwater contamination has steadily increased over the past 30 years, according to data collected by the Oregon Department of Environmental Quality (DEQ). According to a report conducted by the Lower Umatilla Basin committee, there has been a 55 % increase in nitrates contaminating groundwater since 1997.[3]

Nitrate contamination and extent of exposure can be exacerbated through natural disasters. For example, flooding can cause more nitrates to enter soil near private wells or increase the extent to which nitrate impacts the local groundwater. Furthermore, in the aftermath of a wildfire, burned watersheds are prone to increased risks of flooding and erosion, which can negatively impact water-supply reservoirs, water quality, and drinking-water treatment processes.

3. Climate - Temperature

The climate is relatively dry because the Cascade Mountains serve as an effective moisture barrier causing storms to dump much of their moisture west of the peaks leaving areas to the east, including Morrow County, in a "rain shadow." This region has a definite winter rainfall climate.

According to the Oregon Climate Change Research Institute (OCCRI), the annual average temperature in Morrow County increased at a rate of 2.3°F per century from 1895 through 2022[4]. During the twenty-first century, average temperature in the county is projected to warm at a rate similar to that of Oregon as a whole.

The National Weather Service (NWS) has several weather stations located in Morrow County – one in Boardman located in the north and one in Heppner located in the south. These are summarized in Table 2 and Table 3

According to the Boardman station, between the years 1991-2020, the annual temperature average recorded was 54.0°F, while the average in July was 75.7°F and the average in December was 35.4°F. The NWS station located in Heppner recorded the annual average temperature between 1991-2020, for Morrow County was recorded as 51.7°F, while the average in July was 71.0°F and the average in December was 34.9°F.

[3] State publishes Nitrate Reduction Plan for LUBGWMA | Local News | hermistonherald.com
[4] *Climate at a glance: county time series*. NOAA National Centers for Environmental Information (NCEI).

Table 2. Average Annual and Monthly Temperatures for North County

Boardman (North)			
	Mean Avg Temperature Normal (°F)	Mean Max Temperature Normal (°F)	Mean Min Temperature Normal (°F)
Annual Average	54.0	65.9	42.1
July Average	75.7	91.3	60.0
December Average	35.4	41.6	29.1

Source: NOAA Online Weather Data, 2024

Table 3. Average Annual and Monthly Temperatures for South County

Heppner (South)			
	Mean Avg Temperature Normal (°F)	Mean Max Temperature Normal (°F)	Mean Min Temperature Normal (°F)
Annual Average	51.7	63.3	39.9
July Average	71.0	86.8	55.1
December Average	34.9	42.5	27.2

Source NOAA Online Weather Data, 2024

4. Climate - Precipitation

The months of November through February generally receive the most precipitation due to winter storms, which bring rain to lower elevations and snow to higher areas characteristic to the southern portion of the County. Between the years 1991-2020. the overall annual level of precipitation is 12.5". However, annual totals vary and are proportional to elevation, with the average annual rainfall for Boardman in the northern and lower portion of the County is 8.6 inches while Heppner, which is a part of the higher areas, receives 13.1 inches annually. Occasional summer thunderstorms bring localized, occasionally heavy rain, but the highest total precipitation levels are mostly seen during the winter months. Tables 3 and 4 illustrate annual precipitation averages for Morrow County.

Table 4. Annual and Monthly Total Precipitation in Northern and Southern Morrow County (1991-2020)

Total Precipitation Levels (inches)		
	Boardman (North)	Heppner (South)
Annual Total	8.6	13.1
July Total	0.1	0.3
December Total	1.4	1.3

Minerals Source: NOAA Online Weather Data, 2024

5. Minerals

The County's mineral sources include small deposits of gem opal in the southern part of the County, minor coal deposits on Willow Creek (south of Heppner), and aggregate resources are found throughout the County. Only the aggregate resources have been mined and provide economic benefits to the County, and can be used as gravel, or use stone or sand to create concrete.

The County has sedimentary deposits generally less than 100 feet thick, some of which are wind-deposited loessal soil which support extensive wheat farming. Where the deposits are thin or discontinuous, they provide grazing for cattle and sheep. In the northern portion of the county are deposits left during the glacial melt water transport of the Missoula Floods. They are the primary type of sedimentary deposits present there and are generally less than 100 feet thick and support the extensive irrigated agriculture present in the northern portion of the County.[5]

6. Soils

The soils in Morrow County have formed in a variety of parent materials. In the northern part of the County, soil has developed from a mixture of aeolian, and water deposited sands and gravel over basalt bedrock. In the central part of Morrow County, soils have developed from loess deposits that range from a few inches to more than 15 feet in thickness and are generally deeper and have coarser texture than in the northern part of the County. In the southern part of the County, deposits have become finer textured and thinner, which have developed from a mixture of fine sediment and volcanic ash deposits.[6]

Potential soil related hazards include landslides and liquefaction. Landslides can occur when areas featuring steep slopes and shallow soils are saturated with water, causing the mass movement of rock,

[5] Morrow County Comprehensive Plan, 2013
[6] Morrow County Comprehensive Plan, 2013

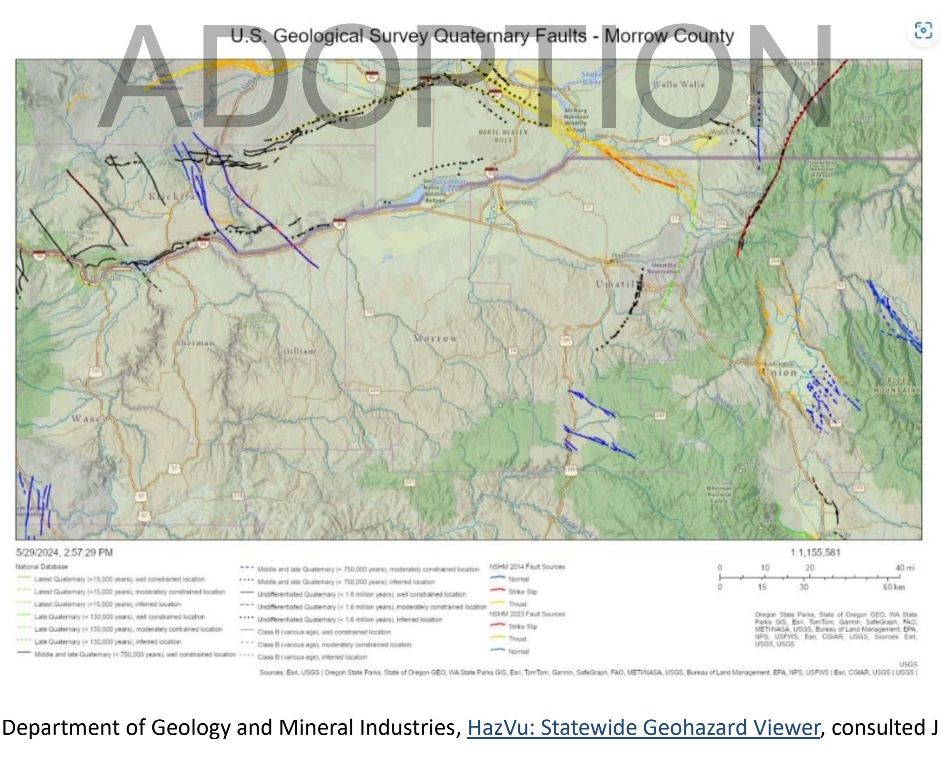
debris, or earth. The southern part of the county has many steep canyons that are comprised of basalt flows within a thing cover of soil and colluvium. These steep slopes, when paired with intense rainfall, can trigger debris flows which can leave deposits at the mouths of side canyons. In more populated areas, such as around Boardman on the Columbia Plateau, there are little to no landslides due to the terrain being very flat. However, for cities in the south, such as Heppner, which are located in canyons, debris flow is common, leaving large debris deposits along the sides of the canyon at the mouths of side streams and gullies.[7]

Additionally, liquefaction can occur when loose, water-logged sediment loses its structural integrity because of ground shaking during an earthquake, causing the ground to behave like a liquid. Major structural damage can occur where liquefaction occurs near or beneath buildings or other structures.

7. Fault Lines and Seismic Threats

Although Morrow County may not experience the impact of a Cascadia Subduction Zone (CSZ) earthquake where the North American crustal plate overrides the Juan de Fuca plate off the coast of Oregon, a local earthquake may cause damage in Morrow County. Other local, crustal fault lines lie near Morrow County that can cause significant localized damage to Morrow County communities. As seen in Figure 3, there are fault lines to the west in Gilliam County as well as in the Horse Heaven Hills in Washington north of Morrow County.

Figure 3. Fault Lines near Morrow County



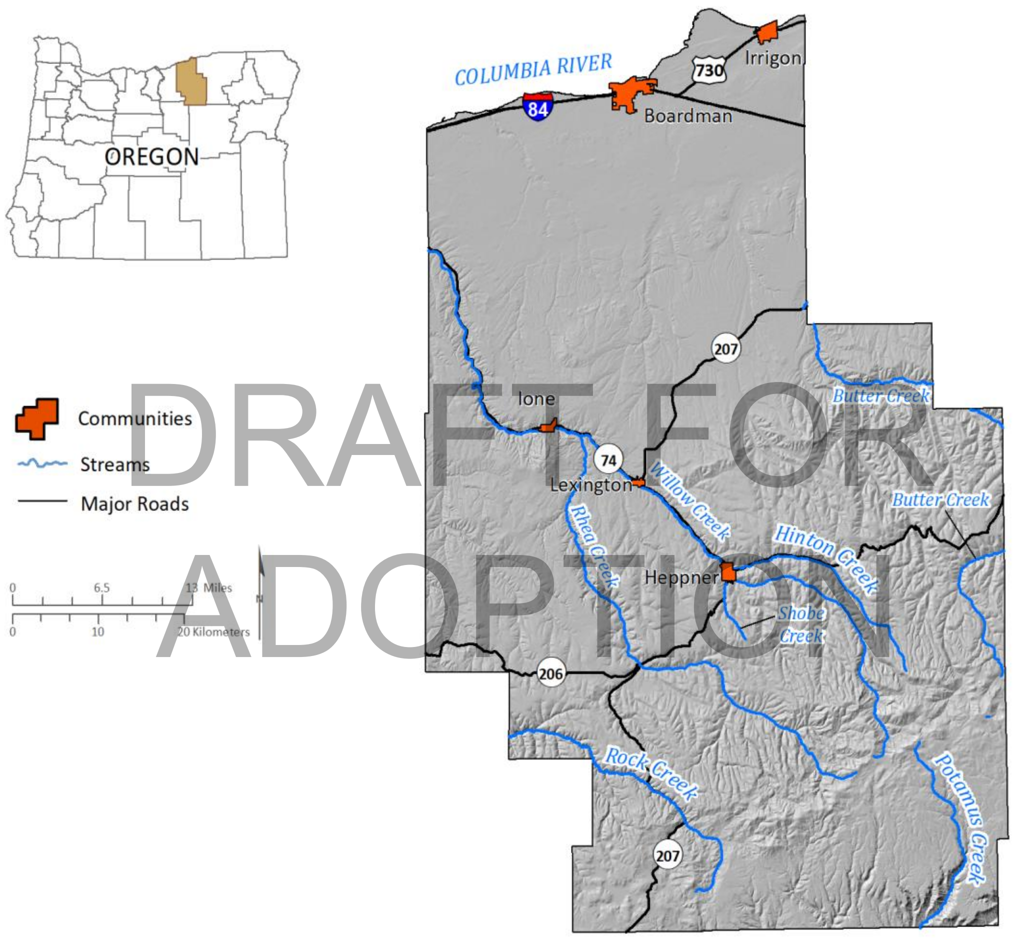
Source: Oregon Department of Geology and Mineral Industries, [HazVu: Statewide Geohazard Viewer](), consulted June 2024.

[7] [Open-File Report O-21-14](), DOGAMI

B. Social/Demographic Profile

Social/demographic capacity is a significant indicator of community hazard resilience. The characteristics and qualities of the community population such as language, race and ethnicity, age, income, educational attainment, and health are significant factors that can influence the community's ability to cope, adapt to and recover from natural disasters. Population vulnerabilities can be reduced or eliminated with proper outreach and community mitigation planning.

Figure 4. Morrow County Communities



Source: DOGAMI Morrow County Risk Assessment, 2024

1. Morrow County Communities

Morrow County has a variety of community types: incorporated cities, unincorporated urban areas, rural communities, and rural service centers, which are listed in Table 5.

Table 5. Morrow County Communities

Morrow County	
Incorporated	**Unincorporated**
Boardman	Castle Rock (historic)
Heppner	Cecil
Ione	Clarke
Irrigon	Eightmile
Lexington	Ella
-	Gooseberry
	Hardman (ghost town)
-	Lena
-	Morgan
-	Pine City
-	Ruggs
-	Valby

Source: Morrow County NHMP Steering Committee; Castle Rock, Morrow County, Oregon - Wikipedia

2. History

The land that is now established as Morrow County lays on land historically inhabited by the Umatilla, Cayuse, and Walla Walla people.[8] Prior to European contact, tribal people numbered 8,000 members strong, The Umatilla, Cayuse, and Walla Walla people have lived in the Columbia River region, fishing, hunting, and gathering food for more than 10,000 years. They would move in a large circle from the lowlands along the Columbia River to the highlands in the Blue Mountains. The three tribes spent most of their time in the area that is now northeastern Oregon and southeastern Washington. Today, these three tribes have united as the Confederated Tribes of the Umatilla Indian Reservation, which encompass about 172,000 acres (approximately 273 square miles) and has over 3,100 tribal members.[9]

European contact was made in the 1800's in what would be known as Morrow County, when permanent settlements were established in the canyons of Willow and Butter Creek before 1870. In August of 1872 Henry Heppner and Jackson Lee Morrow opened a store on Stansbury Flat near the forks of Willow Creek to serve the needs of the stockmen settled on Willow Creek, Balm Fork, and Rhea Creek. These stockmen were tired of hauling goods themselves from the Columbia River at Umatilla Landing or Castle Rock. Sheep were the chief product of the Morrow County rangelands which eventually changed to a grain-based economy after the establishment of National Forest lands, grazing restrictions and the spread of sagebrush onto the grasslands. The population slowly grew through the twentieth century despite economic hard times in the 1930s and the need for young people to look for work outside of the County if they weren't interested in the farming profession. During the 1950s and 1960s Heppner's population grew due to the post WWII baby boom and employment opportunities at the sawmill. The next two decades saw the introduction of irrigated agriculture and the formation of the Port of Morrow in the northern portion of the County. Portland Gas and Electric developed a coal fired power plant in

[8] Native-Land.ca | Our home on native land
[9] CTUIR - History & Culture CTUIR - History & Culture

the Boardman area and the population in the northern part of the County began to rise due to the need for agricultural and industrial workers.[10]

3. Population

As of 2023, Morrow County has a population of 12,402 in an area of 2,031 square miles. The population of Morrow County has steadily increased over the past decade, and population growth is projected to continue (as shown in Table 6), according to the Coordinated Population Forecast 2023 – 2073 for Morrow County produced by the Population Research Center at Portland State University.[11]

Table 6. Projected Morrow County Population

	2023	2048	2073
Morrow County Population Projections	12,402	13,600	15,223

Source: PSU Population Research Center, Annual Population Report., 2023

Most of Morrow County's population resides in northern Morrow County, along the Columbia River. The largest cities in the County are Boardman and Irrigon, with populations of 4,496 and 2,311, respectively, which comprise approximately 45 % of the total County's population.

The cities of Heppner, Ione and the Town of Lexington are situated in the southern portion of the County along Willow Creek and contain 16.5 % of the County's population. This points to the fact that most of the population of Morrow County lives in the northern third of the County.

Table 7 and Figure 5 below shows the forecast average annual growth rate for Morrow County and each of its five incorporated cities. Please note, that the population for each city is different than that of the 2010 and 2020 census, since this population data includes the number of people in each of the city's urban growth boundaries as well as the city limits. It is anticipated that most of the cities will experience some level of growth within the next 20 years, though the city of Heppner is projected to decrease in population.

Morrow County will experience an average annual growth rate of approximately 0.5 %. Urban and rural growth patterns can impact how agencies, cities and counties prepare for emergencies, because changes in development can increase risk associated with hazards. The table and figure below show population trends in Morrow County.

Table 7. Morrow County & Cities – Projected Population (2023 to 2073)

Total Population						
Area/Year	**2023**	**2033**	**2043**	**2053**	**2063**	**2073**
Morrow County	12,402	13,007	13,430	13,833	14,460	15,223
Boardman	4,496	4,962	5,358	5,732	6,182	6,673

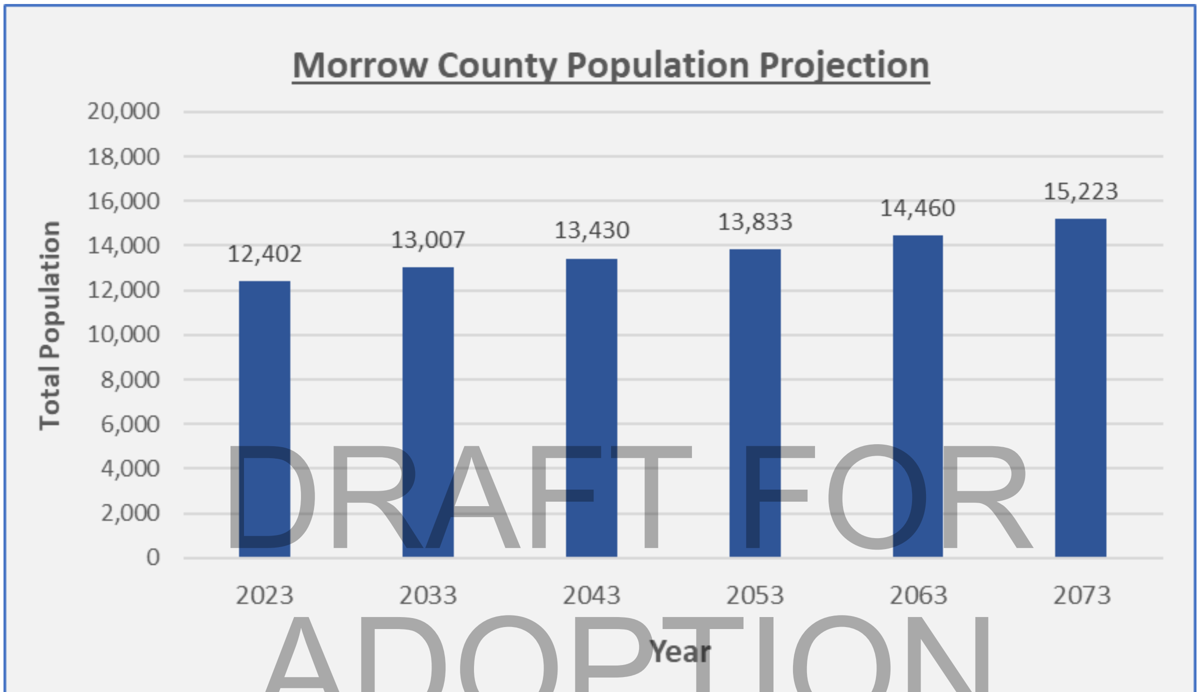
[10] Columbia River Heritage Trail | Morrow County Oregon

[11] .2022 Annual Population Report Tables, Portland State University Population Research Center

Heppner	1,266	1,217	1,147	1,073	1,015	963
Ione	347	366	377	386	397	409
Irrigon	2,311	2,433	2,531	2,641	2,813	3,034
Lexington	251	260	262	261	262	262
Unincorporated	3,732	3,770	3,755	3,740	3,792	3,883

Source: PSU Population Research Center, Annual Population Report., 2023

Figure 5. Projected Total Population Growth (2023 to 2073)



Source: PSU Population Research Center, Annual Population Report., 2023

The five incorporated communities within the County comprise about 69.9 % of the County population. The remaining 30.1 % of the population resides in unincorporated areas.

4. Social Vulnerability in Morrow County[12]

On its own, population size is not an indicator of vulnerability. Other characteristics are more indicative of vulnerability, including location, community composition and demographics, socio-economic statuses, community and individual health and well-being, community connectivity, and overall community adaptive capacity. Each of these characteristics can play a significant role in a community's and individuals' ability to prepare for, respond to, and recover from a natural hazard.

Social vulnerability is the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood. Natural hazards disproportionately impact socially vulnerable individuals due to a variety of characteristics, such as age,

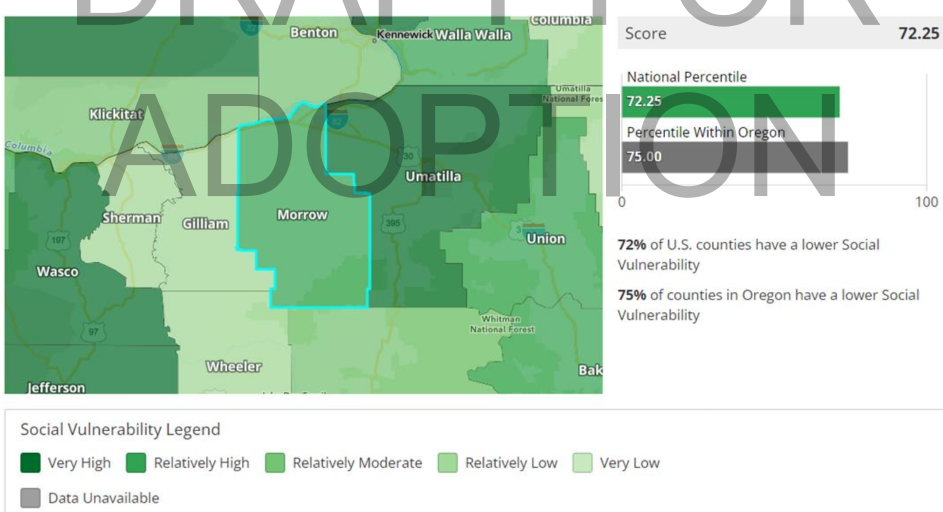
[12] Social Vulnerability | National Risk Index (fema.gov)

gender, race and ethnicity, disability, language spoken, access to Internet or devices, household size, housing tenure, and household composition. Equally important is recognizing seasonal, outdoor workforces and transient populations affecting the total number of people physically present within the County's political boundaries, including tourists and visitors. People experiencing homelessness also face a disproportionate level of public health and exposure risk to natural hazards.

Socially vulnerable populations experience the impacts of natural hazards and disasters more acutely, requiring mitigation actions that targets the specific needs of vulnerable groups in manners that have the potential to greatly reduce their vulnerability. FEMA's Office of Equal Rights by encouraging agencies and organizations planning for natural hazards to identify special needs populations, make recovery centers more accessible, and review practices and procedures to remedy any discrimination in relief application or assistance.

Social vulnerability can be broadly assessed using the FEMA National Risk Index (NRI), an online risk analysis tool that illustrates a community's risk and vulnerability for 18 different natural hazards using various data sources, such as the US Census, federal agencies, state provided data, and more. According to NRI (seen in Figure 6), Morrow County has a Relatively Moderate social vulnerability rating. This rating captures the vulnerability to the adverse impacts of natural hazards when compared to the rest of the U.S. and other Oregon counties. This means that due to certain characteristics, residents of Morrow County may experience the impacts of natural hazards and disasters more accurately, and suffer more deaths, injuries, losses, and disruptions of livelihoods in proportion to the larger population.

Figure 6. Social Vulnerability in Morrow County



Source: FEMA National Risk Index, 2023

Hunger and Food Insecurity[13]

The level of participation in federal assistance programs, such as a community's utilization of monthly food benefit programs for both families and children, are another indicator of poverty or lack of

[13] County Fact Sheets – Oregon Hunger Task Force, 2023

resource access. In 2023, 10 % of Morrow County's total population identified as food insecure, with over 25 % of children being food insecure.

Statewide social assistance programs include Supplemental Security Income (SSI), Supplemental Nutritional Assistance Program (SNAP), Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), or Free/Reduced Priced School Lunches, and all of which can provide aid to economically vulnerable families and individuals.

In 2022, Morrow County had 210 individuals receiving SSI, with most participants being either blind or disabled, and 58 % of all pregnant people were served by WIC. For SNAP benefit participation, in 2022 Morrow County had an average of 2,220 individuals per month using SNAP benefits, which totaled to an average monthly dollar amount of approximately $1.5 million. These numbers have changed since 2019, with the average number of individuals per month using SNAP changing marginally (2019 estimate of 2,204 users). The annual value of SNAP participation was significantly reduced between 2019 and 2022, with approximately $2.8 million being the estimated annual value, showing a 52 % decrease of available SNAP funds between 2019 and 2022.

Amongst students in 2022, approximately half of the student population participated in school breakfast (41 %) and school lunch (62 %). These percentages were substantially higher than the State of Oregon's rate of student participation in school breakfast (24 %) and school lunch (45 %, highlighting the higher-than-average rates of food insecurity for students in Morrow County.

These income support programs provide critical financial assistance to local vulnerable and distressed populations and provide vital assistance to these communities during times of increased financial stress and burden, such as during the COVID Pandemic and large-scale wildfire disasters.

5. *Race and Ethnicity*

Studies have shown that racial and ethnic minorities can be more vulnerable to natural disaster events due to historic patterns of inequality associated with race and ethnicity. Minority communities are more likely to live in inferior building stock, with degraded infrastructure, or having less access to public services.

Table 8 displays Morrow County's population by race and Hispanic or Latino/a ethnicity.

Table 8. Race and Ethnicity in Morrow County

Morrow County, Oregon		
	Number	**Percentage**
Total Population (2020)	12,186	
Hispanic or Latino	4,988	40.93%
Not Hispanic or Latino:	7,198	59.07%
Population of one race:	6,797	55.78%
White alone	6,600	54.16%
Black or African American alone	37	0.30%
American Indian and Alaska Native alone	82	0.67%
Asian alone	29	0.24%
Native Hawaiian and Other Pacific Islander alone	5	0.04%
Some Other Race alone	44	0.36%
Population of two or more races:	401	3.29%

Source: Decennial Census, 2020; P9: HISPANIC OR LATINO, AND NOT ... - Census Bureau Table

The overall population in Morrow County is primarily white, though over 40% of the people in the county identify as ethnically Hispanic or Latino/a. Of those who do not identify as Hispanic or Latino/a over 54% identify as White alone.

It is important to identify specific ways to support all portions of the community through hazard mitigation, preparedness, and response. Culturally appropriate, and effective outreach can include both methods and messaging targeted to diverse audiences. For example, connecting to historically disenfranchised populations through pre-established trusted sources or providing preparedness handouts and presentations in the languages spoken by the population can significantly contribute overall community resilience.

Hispanic or Latino/a Population

The U.S. Census Bureau relies on self-reporting to enumerate persons as Hispanic, Latino or Spanish origin: Mexican, Mexican American or Chicano, Puerto Rican, Cuban, or a descendent from other countries (e.g., Dominican).

Many Latino people face unique and substantial challenges, and their circumstances can vary widely depending on their education levels, English-speaking proficiency, income, and access to resources. Due to these, Latino communities, especially who are low-income, are often hit the hardest during natural disasters.

As Latino youth, families, taxpayers, and consumers are a critical part of the future economic, social, and political prosperity of Morrow County, as the Latino population continues to grow, it is increasingly important to ensure that all Latino Oregonians have access to the education, economic and the health care opportunities the community needs to thrive. Morrow County has the highest percentage of Hispanic/Latino persons per total population in the state. For the State of Oregon, 14.4 % of the overall population identify as Hispanic or Latino, while approximately 40 % of Morrow County residents identify as Hispanic or Latino.

6. Age

The age profile of an area has a direct impact on what actions are prioritized for mitigation and how response to hazard incidents is carried out. Older populations often have special needs prior to, during and after a natural disaster. Older populations may require assistance in evacuation due to limited mobility or health issues and may require special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, older people may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to all ages and abilities.

Table 9. Age Structure of the Population

Area	Younger than 14 years old	Ages 15 to 64 years old	Older than 65 years old
Morrow County	22.3%	61.7%	16.1%
Boardman	26.9%	65.8%	7.3%
Heppner	21.2%	56.4%	22.3%
Ione	18.9%	57.0%	24.0%
Irrigon	22.7%	64.1%	13.0%
Lexington	17.8%	52.9%	29.3%
Average	21.6%	59.7%	18.7%

Source: Social Explorer, 2022

Morrow County's population is aging, like many areas in Oregon. Table 9 shows that Morrow County has a population that is 16.1 % 65 or older, which increased from 12.3 % in 2012. This growth highlights the increasing risk that natural hazards pose to these vulnerable populations. Further evidence of Morrow County's aging population can be seen by the slight increase of the median age of individuals from 36.6 in 2012 to 37.0 in 2022.

Youth and Education[14]

Children, people aged under 18, also represent a vulnerable segment of the population. Special considerations should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation options, and require assistance to access medical facilities. In addition, parents might lose time and money when their children's childcare facilities and schools are impacted by disasters.

Morrow County has two school districts: Morrow School District 1, which has 9 total schools, and Ione School District 2, which has 1 school. According to the Oregon Department of Education, in total, the student count in both school districts was 2,417 students during the 2022-2023 school year.

[14] At-A-Glance School and District Profiles and Accountability Details - Oregon Department of Education

In the Morrow School District 1, there are many students that identify as having at least one social vulnerability: Over 95 % of students receive free or reduced-price lunches, 58 % of students identified as Hispanic/Latino (compared to the 39 % students who identified as white), and 17 % of students identified as having a disability. Furthermore, between both districts one indicator, 360 total students are classified as Special Education students (358 in Morrow SD1, 22 in Ione SD2). Special Education Students are defined under the guidelines of the Federal Individuals with Disabilities Education Act (IDEA) and are considered disabled.

Hispanic/Latino Youth and Education[15]

Many Latino children face unique and substantial challenges, and their circumstances can vary widely depending on their parents' countries of origin, education levels and English-speaking proficiency. High-quality early childhood education is a critical steppingstone in helping children succeed in school and become productive adults later in life. However, Latino children are underrepresented in early childhood education programs in the state. Teenagers who drop out of high school are at a severe disadvantage in terms of future employment opportunities and potential earnings, and Latino youth in Oregon are among the least likely to graduate from high school.

According to the Oregon Department of Education, the school districts in Morrow County have among the highest percentage of students who identify as Hispanic/Latino in the state, with Morrow School District 1 having over 58 % of students identifying as Hispanic/Latino and Ione School District 2 having over 32 % of students identifying as Hispanic/Latino. Additionally, a large proportion of these students are identified as English Language Learners, meaning that their first language is not English and who has limited proficiency in the English language. Approximately 43 % of students at Morrow SD1 identified as English Language Learners, while 19 % of students at Ione SD2 identified as such.

7. Language[16]

For people who are not native English speakers, communication about hazards before, during, and after a disaster may be daunting, increasing their vulnerability. Culturally appropriate outreach and informative materials in the languages spoken in the County would reduce that vulnerability. Almost 35 % of Morrow County's people speak a language other than English at home as compared to the approximately 15 % of people in the state of Oregon speak a language other than English at home. Additionally, over 15 % of Morrow County residents speak English less than "very well", indicating that a large proportion of the County are unable to access emergency and disaster management resources that are only available in English.

Of those, most speak Spanish or Spanish Creole, and most live in the unincorporated areas of the County.

[15] At-A-Glance School and District Profiles and Accountability Details - Oregon Department of Education

[16] U.S. Census Bureau, 2023

8. Income

Household income and poverty status are indicators of socio-economic demographic capacity, and the stability and overall resilience of the local economy. Household income can be used to compare economic areas as a whole but does not reflect how the income is divided among the area residents. Based on data provided by the US Census Bureau, through the American Community Survey, the 2022 median household income across Morrow County was estimated at $64,975, which is significantly lower than the State of Oregon median household income for 2022, which is $76,632.

Table 10 shows the distribution of household incomes in Morrow County in 2022. Most households in Morrow County are making under $100,000 dollars, yet the household income category with the highest percentage is $100,000 - $199,999 (22.7%).

Table 10. Household Income

Household Income	Households	Percent
Less than $15,000	246	5.9%
$15,000 - $34,999	690	16.4%
$35,000 - $49,999	712	16.9%
$50,000 - 74,999	767	18.3%
$75,000 - $99,999	592	14.1%
$100,000 - $199,999	952	22.7%
$200,000 or more	242	5.8%

Source: U.S. Census Bureau, 2021

Poverty Levels

Poverty levels are another indicator of community resilience. People in poverty are generally not able to adequately prepare for and/or respond to natural hazards. Table 11 below identifies the percentage of individuals that were below the poverty level. Research suggests that lack of wealth contributes to social vulnerability because individual and community resources are not as readily available. Affluent and white communities are more likely to have both the collective and individual capacity to rebound from a hazard event more quickly, while financially insecure populations and communities of color may not have this capacity –leading to increased vulnerability.

Table 11. Poverty Levels

Area	Number	Percent
Oregon	503,935	12.1%
Morrow County	2,020	16.7%
Boardman	799	20.9%
Heppner	216	16.5%
Ione	38	9.6%
Irrigon	303	16.2%
Lexington	5	3.6%

Source: U.S. Census Bureau, 2021

Wealth can help those affected by hazard incidents to absorb the impacts of a disaster more easily, which can either help them maintain or even grow their overall wealth. Conversely, poverty, at both an individual and community level, can drastically alter recovery time and quality, often putting them further into poverty, leading to an even greater wealth gap. Research suggests that in the aftermath of disaster, white affluent communities and individuals are more likely to not only recovery quicker, but also might gain wealth as result of more ease of access to and knowledge of post-disaster recovery funds and possess funds saved pre-disaster. In contrast, more socio-economically vulnerable communities tend to lose wealth, as they often lack saved funds and do not have the knowledge to navigate and receive post-disaster recovery funds – leading to greater social vulnerability.

Understanding the economic makeup of a community can help assessing community needs regarding their ability and capacity to prepare for and recover from natural disasters, the proportion of the population who will be adversely affected because of natural disasters, and the potential for an increase in poverty rates following a natural disaster. More socially vulnerable communities will likely need greater assistance prior to and in the aftermath of a natural disaster, particularly with preparing for a natural hazard and navigating the process to obtain post-disaster recovery funds.

9. *Health*

Individual and community health play an integral role in community resiliency. Indicators such as health insurance, people with disabilities, dependencies, and homelessness paint an overall picture of a community's well-being and resilience. These factors contribute to community risk and vulnerability, and reflect a community's ability to prepare, respond to, and cope with the impacts of a disaster. Community members who have health-related vulnerabilities will likely require additional community support and resources, both prior to and following a natural hazard.

Table 12 shows percentage of the population in Morrow County without health insurance (8.2%) is higher than that of the State (6.5%), as well as three out of the five cities in Morrow County have higher rates of uninsured individuals than Oregon and the overall County (Irrigon – 12.4%, Boardman – 11.4%, Heppner – 10.6%). The ability to provide services to the uninsured populations may burden local providers, as well as local health services following a natural disaster. Many Oregonians are enrolled in health care coverage under the Oregon Health Plan, which was established under the Affordable Care Act (ACA) coverage expansion, and the rate of uninsured has significantly decreased over the past decade.

Table 12. Health Insurance Coverage

Area	Population	Number of Uninsured	Percentage of Uninsured
Oregon	4,161,550	272,563	6.5%
Morrow County	12,132	996	8.2%
Boardman	3,830	436	11.4%
Heppner	1,310	139	10.6%
Ione	397	23	5.8%
Irrigon	1,869	232	12.4%
Lexington	140	0	0.0%

Source: U.S. Census Bureau, 2021

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations are disproportionately affected during disasters and can be difficult to identify and measure (Cutter, Boruff, & Shirley, 2003). Research recognizes that those who are impaired with sensory, mental, or physical disabilities have higher vulnerability to hazards and will likely require additional community support and resources.

Table 13 below describes the disability status of people in Morrow County.

Table 13. Total Population with a Disability

Area	Population	Number of Disabled	Percentage of Disabled
Oregon	4,161,550	503,935	12.1%
Morrow County	12,132	2,023	16.7%
Boardman	3,830	387	10.1%
Heppner	1,310	410	31.3%
Ione	397	170	42.8%
Irrigon	1,869	291	15.6%
Lexington	140	49	35.0%

Source: U.S. Census Bureau, 2021

Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events. Planning professionals might take a number of steps to mitigate risk for disabled community members. Inaccessible shelter facilities can pose challenges in a disaster event. Local officials should also strengthen partnerships with the disability community, and work with local media organizations to ensure emergency preparedness and response communications are accessible for all.

Health Service Area Description

Direct health care services are limited to being available in Boardman, Irrigon, and Heppner, and a school-based/community health center in Ione.

Local medical providers also support some level of health care and social services to three of the surrounding frontier counties. Morrow County is designated as a Health Professional Shortage Area for primary medical, dental and mental health care, either geographically or service to the low-come or migrant seasonal farmworker populations. The counties surrounding Morrow have population or geographic shortage designations for primary medical, dental and mental health care as well.

Pioneer Memorial Hospital is located in Heppner, which is also the location of the Morrow County Health District's Emergency Medical Services. The Morrow County Emergency Medical Services include six ambulance vehicles located at four separate dispatch sites. Two vehicles are located in Heppner, two in Boardman, and one each in Irrigon and Lexington. The community of Ione has a First Response Vehicle. In a medical emergency, south Morrow County residents are transported to Pioneer Memorial Hospital in Heppner where Trauma Level IV services are available. If necessary, patients can be flown via helicopter or fixed-wing aircraft to higher levels of trauma care in: Bend, Oregon; Portland, Oregon; or Walla Walla, Washington. Patients in the north end of the county can be transported to Trauma Level III services in Hermiston, or to higher level care centers if needed.

The Heppner and Ione communities are a forty-eight-mile drive over a two-lane state highway to the nearest larger health service area – Hermiston and seventy miles to Pendleton. Boardman, located in the north end of the county, is twenty-three miles away from Hermiston. Depending on your location within the county, Hermiston and Pendleton are the nearest access to obstetrical/prenatal care.

10. Unhoused Population[17]

The Oregon Housing and Community Services (OHCS) provide homelessness counts across the state, which is used to identify the number of homeless, their age and their family type[18]. The OHCS data shows that that as of 2023, 1 individuals and persons in families in Morrow County identify as unhoused. This individual was identified as being sheltered, meaning they were residing in an emergency shelter or transitional or temporary housing, as compared to being unsheltered, meaning they resided in a place not meant for human habitation, such as cars, parks, abandoned buildings, or on the streets.

The unhoused often have limited personal resources to rely on, especially during an emergency. The County, cities, and local non-profit entities provide services such as shelter, food and medical assistance following natural hazard events. Assistance is available through agencies and organizations in the community, such as the American Red Cross and homeless shelters. Additionally, it is necessary to determine the most effective means to communicate with these populations, as traditional means of communication may not be feasible or accessible to them.

People experiencing homelessness are typically more physically and psychologically vulnerable compared to the general population and natural hazard events exacerbate their vulnerability. Local emergency management professionals should take a trauma-informed approach to providing services and include people with expertise in providing support to people experiencing homelessness in planning for natural hazard events (U.S. Department of Housing and Urban Development, 2016). Additionally, it is important to plan for episodic natural hazards as well as chronic events. For example, year-around access to shelter is becoming increasingly important as wildfire smoke becomes more common across the state.

[17] Profile – Oregon Housing and Community Services | Tableau Public
[18] County Profiles 2023 - Oregon Housing | Tableau Public

C. Economic and Employment Profile

Economic capacity refers to the financial resources present, and revenue generated in the community to achieve a higher quality of life through income equality, housing affordability, economic diversification, and diversification of employment and industry opportunities. These indicators can represent strong community economic resilience. Economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how items like employment sectors, workforce, resources and infrastructure are interconnected in the existing economic picture. Identifying systematic strengths and vulnerabilities allows public and private entities to address needs and increase the resilience of the local economy.

1. *History of Morrow County Economy*

The first entrepreneurs in Morrow County were the sheep herders who used the grasslands in the area as open pastureland in the early 1870s. Not long afterward, Henry Heppner and Jackson Lee Morrow opened a store, and an economy was born. The portion of Morrow County first settled were the areas around the Oregon Trail and Willow Creek. The Oregon Trail came almost straight west from Pendleton through what would later become north central Morrow County. Commercial and financial establishments proliferated in Heppner during the decade of the 1870s and the census-taker counted 318 citizens in the city in 1880. The Oregon-Washington Railroad & Navigation Company, which would eventually become the Union Pacific Railroad, completed their The Dalles to Wallula line in April of 1881 and a branch to Heppner was put in by 1889. When Morrow County was established in 1885 Heppner won the contest with Lexington for County seat. The economic basis of the Heppner area continued to be sheep production with the addition of logging from the 1880's until the Depression in the 1930s when all but the largest grazing operators went away. By 1939 Highway 74, the Heppner Highway, from Lexington and Heppner along Willow Creek through Lena east towards Pendleton had been built. The rail spur going north from Heppner to the Willow Junction at the Columbia River helped to encourage wheat farming and the farmers began to look to the north for more land, but the northern portion of the County was, in the early years, relatively unpopulated.

The economics of the County began to change when irrigated agriculture was developed in the northern portion of the County and the Port of Morrow opened for business in 1957. The Cities of Boardman and Irrigon started to expand as the demand for workers at the Port and on the farms began to grow.

2. *Current Economic Base*

Northern Morrow County is dependent on large-scale corporate agri-business, which can be traced to 1963 when the Boeing Company leased 100,000 acres of land south of Boardman and pioneered circle irrigation in this region. This property continues to be in agricultural production, which includes the production of wheat, potatoes, alfalfa and milk. The Port of Morrow also hosts many large agri-businesses including those for the production of French fries, dried onion production and dairy products.

Other significant contributors to the County's tax base are the regional solid waste landfill located in north Morrow County and the PG&E coal fired electrical plant south of Boardman and co-generation plant at the Port of Morrow.

3. Economic Diversity

Economic diversity is a general indicator of an area's fitness for weathering difficult financial times. One tool for measuring economic diversity is the Hachman Index, which uses measures such as gross domestic product (GDP) or employment to measure the mix of industries present in a particular region relative to a (well-diversified) reference region (in this case, all 36 of Oregon's Counties). The Hachman Index scores from 0 to 1.00, with a higher score indicating more similarity with the reference region, while a lower score indicates less similarity. For example, a diversity ranking of one would indicate that the County enjoys the most diverse economic activity compared to other counties in Oregon, while a ranking of 36 would signify the least diverse economy. The table below describes the Hachman Index Scores for Morrow County and neighboring counties.

Table 14 shows that Morrow County has an economic diversity rank of 32 as of 2021, as compared to Umatilla County which has a diversity rank of 18 and Wheeler County which has a diversity rank of 30. The County's ranking has remained the same since 1999, indicating that economic diversity in Morrow County has remained steady over the past two decades.

Table 14. Morrow County Economic Diversity (1999 and 2021)

	1999		2021	
	Value	Rank	Value	Rank
Morrow County	0.152	32	0.092	32
Gilliam County	0.040	36	0.138	35
Wheeler County	0.157	31	0.141	30
Grant County	0.144	33	0.080	33
Umatilla County	0.483	12	0.387	18

Source: U.S. Census Bureau, 2021

While illustrative, economic diversity is not a guarantor of economic vitality or resilience. Morrow County, as of September 2023, is listed as an economically distressed community as prescribed by ORS 285A.020(5). The economic distress measure is based on indicators of decreasing new jobs, average wages, and income, and is associated with an increase in unemployment.[19]

4. Employment

Employment status and salary level may impact the resilience of individuals and families in the face of disasters as well as their ability to mitigate natural hazards. The possibility of additional unemployment

[19] Business Oregon: Distressed Areas in Oregon : Reports, Publications, and Plans : State of Oregon

following a disaster compounds the number of unemployed people within the community, making post recovery efforts from a disaster an even slower process.

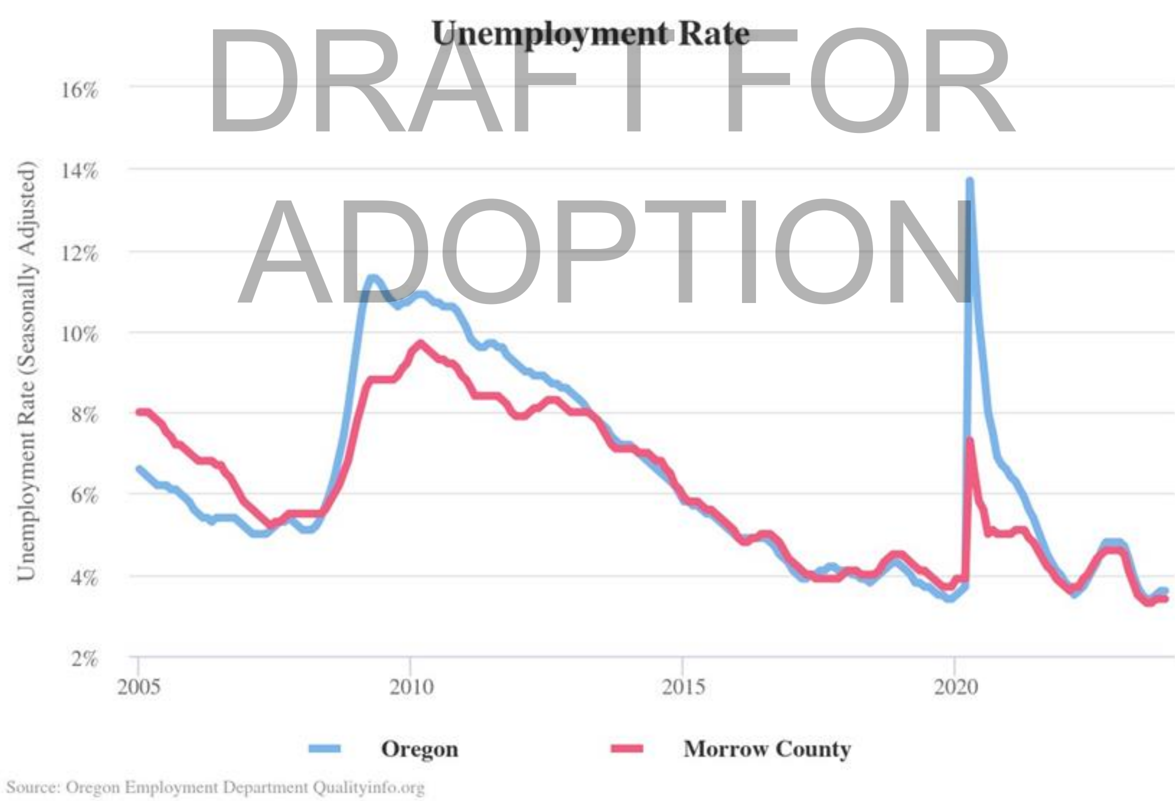
Table 15 and Figure 7 shows that the rate of unemployment in both Oregon and Morrow County has been mostly declining since 2010. While the rate of unemployment in Morrow County lagged behind the state's average up until 2005, the County has mostly had a lower rate of unemployment after the year 2005. While unemployment increased for the state during 2020, due in part to the 2019 Novel Corona Virus (Covid-19) pandemic, Morrow County slightly decreased (5.6 % in 2015 to 5.2 % in 2020). Unemployment eventually fell to over a two-decade low by 2022 (3.9 %). For Morrow County, the rates reflected a similar pattern, with unemployment rates decreasing to 3.7 % in 2023.

Table 15. Unemployment Rate in Morrow County and the State of Oregon (2000-2023)

	2000	2005	2010	2015	2020	2023	Change (2000-2023)
Oregon	5.2%	6.2%	10.7%	5.5%	7.6%	3.9%	-1.3%
Morrow County	7.8%	7.6%	9.4%	5.6%	5.2%	3.7%	-4.1%

Source: Oregon Employment Department, 2022

Figure 7. Unemployment Rate from 2000 to 2023



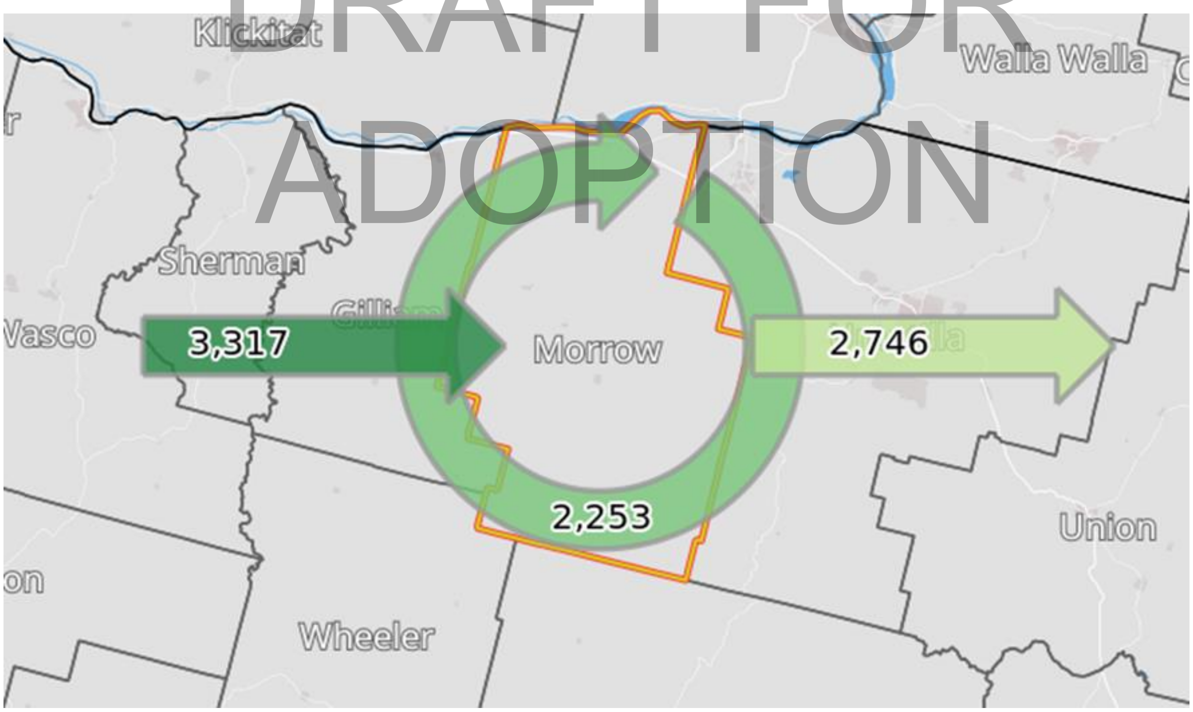
Source: Oregon Employment Department, 2022

5. Labor and Commute Trends

Most hazards can happen at any time during the day or night. It may be possible to give advance warning to residents and first responders who can take immediate preparedness and protect measures, but the variability of hazards is one part of why they can have such varied impact. A snowstorm during the workday will have different impacts than one that comes during the night. During the day, a hazard has the potential to segregate the population by age or type of employment (e.g., school children at school, office workers in downtown areas). This may complicate some aspects of initial response such as transportation or the identification of wounded or missing. Conversely, a hazard at midnight may occur when most people are asleep and unable to receive an advance warning through typical communication channels. The following labor shed, and commute shed analysis is intended to document where County residents work and where people who work in Morrow County reside.

The Morrow County economy is a cornerstone of regional economic vitality. Morrow County employers draw in more than 3,300 workers from outside the County. Figure 8 shows the County's laborshed (i.e., the area or region from which an employer draws their commuting workers). The map shows that about 45.1 % of workers (all jobs) live and work in the County. Roughly 59.5 % of workers reside outside of the County and work in the County, and about 40.4 % of residents work outside of the County.

Figure 8. Morrow County Laborshed



Source: U.S Census OnTheMap, 2021

Table 16 shows the areas and regions that workers employed in Morrow County commute live (i.e., home destination). Of the 5,570 jobs that employ workers in Morrow County, less than half (40.4 %) of employed Morrow County residents live in the County. The remainder of the employed residents live in various other Oregon counties, including Umatilla County (33.2 %) and Multnomah County (5.6 %). Some residents must commute much further from as far as Multnomah and Washington Counties in northwest Oregon.

Table 16. Home Destination Report, 2021

Jurisdiction	Number of Jobs	Share
All Counties	5,570	100%
Morrow County, OR	2,253	40.4%
Umatilla County, OR	1,851	33.2%
Benton County, WA	356	6.4%
Franklin County, WA	117	2.1%
Yakima County, WA	65	1.2%
Multnomah County, OR	59	1.1%
Gilliam County, OR	57	1.0%
Wasco County, OR	55	1.0%
Washington County, OR	47	0.8%
Clackamas County, OR	46	0.8%
All Other Locations	664	11.9%

Source: U.S Census OnTheMap, 2020

Table 17 shows the areas and regions that residents of Morrow County commute for work (i.e., work destination). Of the 4,999 jobs employing Morrow County residents, roughly half (45.1 %) of employed Morrow County residents work in the County. The remainder of the employed residents are employed in various other Oregon counties, including Umatilla County (22.0 %) and Multnomah County (5.6 %). Some residents must commute much further to work, going as far as Marion and Deschutes Counties in central Oregon.

Table 17. Work Destination Report, 2021

Jurisdiction	Number of Jobs	Share
All Counties	4,999	100%
Morrow County, OR	2,253	45.1%
Umatilla County, OR	1,102	22.0%
Multnomah County, OR	282	5.6%
Benton County, WA	143	2.9%
Marion County, OR	134	2.7%
Washington County, OR	115	2.3%
Deschutes County, OR	84	1.7%
Gilliam County, OR	73	1.5%
Yakima County, WA	73	1.5%
Clackamas County, OR	72	1.4%
All Other Locations	668	13.4%

Source: U.S Census OnTheMap, 2020

The degree to which workers are impacted during a disaster can depend upon the means of transportation relied upon to reach their place of employment. Workers reliant on motorized vehicles and public transportation may be delayed or unable to travel if maintained roads, bridges, and other infrastructure are impacted during an event (for example, earthquakes or heavy winter storms). Table 18 shows that 88.6 % of Morrow County commuters utilize motorized vehicles (cars, trucks, vans, or motorcycles) and less than one percent (0.8 %) use public transportation. Only around 4% of commuters' bike or walk to work or take other means, and almost 5% work from home, a rising trend since the COVID-19 Pandemic.

Table 18. Means of Transportation to Work

Jurisdiction	Workers (16 and older)	Motorized Vehicle^ (Percent)	Public Transportation (Percent)	Bike/Walked (Percent)	Other (Percent)	Worked from Home (Percent)
Morrow County	4,900	88.6%	0.8%	4.0%	1.5%	5.0%
Incorporated	3,154	57.0%	0.8%	3.6%	1.5%	1.6%
Unincorporated	1,746	31.6%	0.1%	0.5%	0.0%	3.4%

Source: Social Explorer, 2022

Mitigation activities at the business level ensure the health and safety of workers and limit damage to industrial infrastructure. Employees are highly mobile, commuting from all over the surrounding area to industrial and business centers. As daily transit continues to stay high, there is a continual risk that a natural hazard event will disrupt the travel plans of residents across the region and seriously hinder the ability of the economy to meet the needs of Morrow County residents and businesses.

Employment by Industry

Key industries include major employers and significant revenue generators in Morrow County. Different industries face distinct vulnerabilities to natural hazards; thus, it is important to identify the key industries in the region that enable the community to target mitigation activities addressing the specific sensitivities of those industries. A natural hazard event can affect one industry and can reverberate throughout the regional economy.

This is of specific concern when the businesses belong to the basic sector industry. Basic sector industries are those that are dependent on sales outside of the local community; they bring money into a local community via employment. The farm and ranch, information, and wholesale trade industries are all examples of basic industries. Non-basic sector industries are those that are dependent on local sales for their business, such as retail trade, construction, and health services.

Economic resilience to natural disasters is particularly important for the major employment industries in the region. If these industries are negatively impacted by a natural hazard, such that employment is affected, the impact will be felt throughout the region. Thus, understanding and addressing the sensitivities of these industries is a strategic way to increase the resiliency of the entire regional economy.

The five major employment sectors in Morrow County are grouped into the following categories: (1) Manufacturing; (2) Natural Resources and Mining; (3) Government; (4) Trade, Transportation, and Utilities; and (5) Professional and Business Services. Table 19 shows the distribution of total employment across all sectors.

Table 19. Covered Employment by Industry Sector in Morrow County, 2022

Industry	Employment	Percent	Wages	Annual Average
Total All Employers	6,406	100.0%	$410,415,509	$64,067
Total Private Employers	5,381	84.0%	$350,029,942	$65,049
Natural Resources & Mining	1,061	19.7%	$60,107,379	$56,652
Construction	170	3.2%	$16,455,886	$96,799
Manufacturing	1,795	33.4%	$116,276,611	$64,778
Trade, Transportation & Utilities	602	11.2%	$38,418,552	$63,818
Information	-		-	-
Financial Activities	54	1.0%	$2,480,654	$45,938
Professional & Business Services	313	5.8%	$15,947,509	$50,951
Education & Health Services	280	5.2%	$13,357,445	$47,705
Leisure & Hospitality	251	4.7%	$5,246,145	$20,901
Other Services	-		-	-
Private Non-Classified	-		-	-
Total All Government	1,025	16.0%	$60,385,567	$58,913
Federal Government	58	5.7%	$3,998,522	$68,940
State Government	60	5.9%	$3,662,887	$61,048
Local and Tribal Government	908	88.6%	$52,724,158	$58,066

Source: Oregon Employment Department, 2022

6. *Significant Industries in Morrow County*

Port of Morrow Employment and Economic Contribution[20]

The Port of Morrow has been developing industrial facilities in Morrow County for over 40 years and continues to be the most significant entity bringing jobs to Morrow County. Today, the Port has four established industrial parks with over 5,200 acres of available land: the Boardman and East Beach Industrial Parks, the Airport Industrial Park, and the south Morrow Industrial Park

The Port of Morrow is opportunely located with the Pendleton-Hermiston Metropolitan Statistical Area (MSA) and is adjacent to the Tri-Cities area in Washington, serving as a major source of employment for these communities. Approximately 6,700 people from the surrounding region are employed at the Port of Morrow. Additional employment is found at the nearly 50 "direct port-related" businesses that operate within Port of Morrow industrial lands or are dependent upon transportation and infrastructure facilities provided by the Port.

Based on job-estimates, the largest port-related sectors include food & beverage manufacturing, wholesalers, crop and animal production, chemical manufacturing, telecommunication, etc. The Port continues to make and leverage significant infrastructure investments, including budgeting approximately $211.5 million on public infrastructure projects to be made over the next several years.

[20] Port of Morrow Economic Impact Analysis Report, 2021

The Port of Morrow further benefits the surrounding communities by providing education and meeting facilities for businesses and community groups, recreational opportunities, and establishing sustainable heat-and-wastewater recovery systems to conserve energy and utilize less water for the Port.

Renewable Energy

Throughout Morrow County, many renewable energy projects are being proposed and permitted, with a goal to harness the power of the sun and wind to implement sustainable energy practices. Such projects include the Shepherds Flat Wind Farm and Wheatridge Energy Facilities, a wind farm with over 100 wind turbines and generates 850 megawatts of clean energy.

These energy facilities must be approved by the Oregon Department of Energy's Energy Facility Siting Council before they can be developed. Within Morrow County, there are 22 of these sites, most of which are currently operating, others that are waiting to be approved, and others that are decommissioned. Table 20 lists the Renewable Energy Sites in Morrow County, some of which are also located in both Morrow and neighboring Gilliam and Umatilla counties.

Table 20. Morrow County Renewable Energy Siting Assessment Summary

Project	Energy Facility Type	Energy Capacity	Status	Location	Acres	Owner
Shepherds Flat South	Wind	290 MW	Operating/Under Construction	Gilliam, Morrow	15,928	Caithness Energy LLC
Shepherds Flat Central	Wind	290 MW	Operating/Under Construction	Gilliam, Morrow	11,769	Caithness Energy LLC
Boardman to Hemingway Trans Line RFA2 Proposed Alt	Transmission Line	500kv	Proposed	Morrow	2	Idaho Power
Columbia Ethanol Project[21]	Ethanol Production	35 million gallons/year	Operating	Morrow	25	Pacific Ethanol Inc
Coyote Springs Cogeneration	Natural Gas Plant	503 MW	Operating	Morrow	20	Portland General Electric
Wheatridge Renewable Energy Facility I	Wind	100 MW	Operating	Morrow	3,100	Wheatridge Wind Energy, LLC
Wheatridge Renewable Energy Facility II	Wind/Solar	200 MW	Operating	Morrow	7,850	Wheatridge Wind II, LLC
Wheatridge Renewable Energy Facility III	Solar	150 MW	Operating	Morrow	2,294	Wheatridge Solar Energy Center, LLC
Wagon Trail Solar Project	Solar	500 MW	Proposed	Morrow	7,450	Wagon Trail Energy Center, LLC

[21] State of Oregon: Facilities - Columbia Ethanol Project

Project	Energy Facility Type	Energy Capacity	Status	Location	Acres	Owner
Carty Generating Station	Natural Gas Plant/Solar	500 MW	Approved	Morrow	4,997	Portland General Electric
Echo Solar Project	Solar	1250 MW	Proposed	Morrow	10,992	Echo Solar, LLC
Carty Generating Station pRFA4	Natural Gas Plant/Solar	635 MW	Proposed	Morrow	0	Portland General Electric
Boardman Solar Energy Facility	Solar	75MW	Approved	Morrow, Gilliam	798	Invenergy LLC
Boardman Coal Plant	Coal Plant	550MW	Decommissioned	Morrow, Gilliam	0	Portland General Electric
Wheatridge Renewable Energy Facility East	Wind	200 MW	Approved	Umatilla, Morrow	4,582	Wheatridge Wind East, LLC
Boardman to Hemingway Trans Line RFA1 Proposed Alt	Transmission Line	500kv	Proposed		0	Idaho Power
Boardman to Hemingway Trans Line ASC Approved Alt	Transmission Line	500kv	Approved		0	Idaho Power
Boardman to Hemingway Trans Line ASC Approved Rt	Transmission Line	500kv	Approved		0	Idaho Power

Source: Facilities Under the Energy Facility Siting Council, Oregon Department of Energy, 2024

As economic growth flourishes and job opportunities bloom, Morrow County becomes more than a geographical location; it transforms into a hub of prosperity and innovation. The impact of renewable energy initiatives is felt in every job created, every investment attracted, and every family benefiting from newfound economic stability.

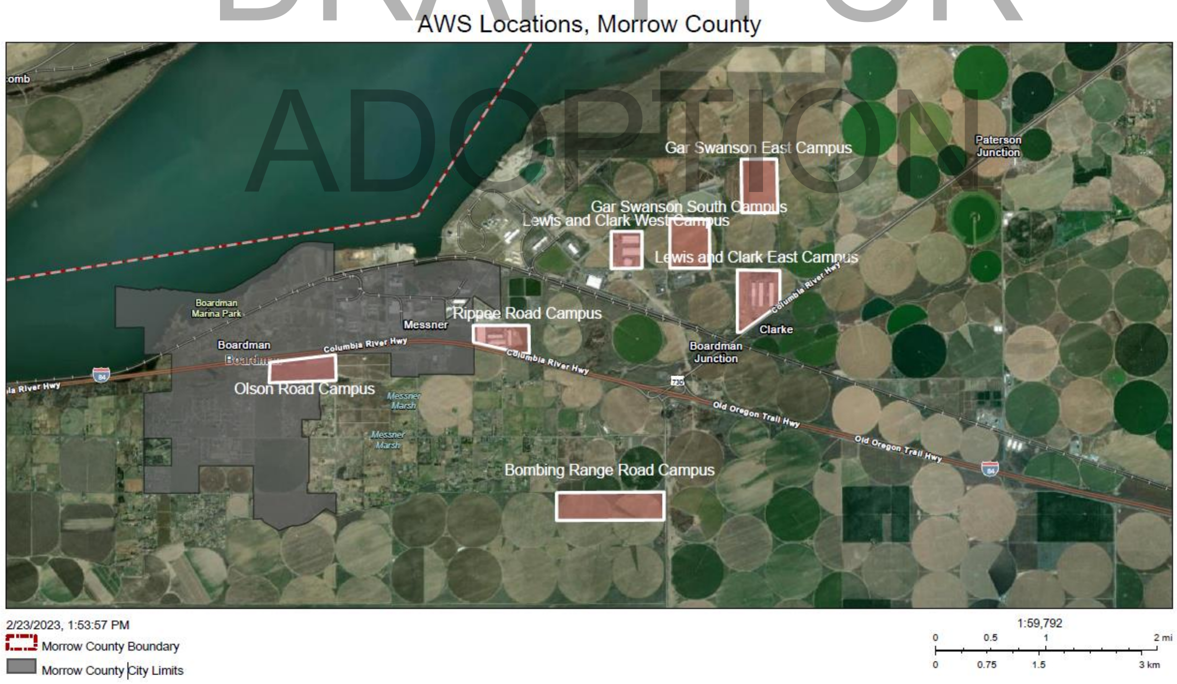
The potential for overhead electric lines to become an ignition source for the dry land vegetation beneath them was noted by a member of the public at one of the public Open House events the Steering Committee organized. A mitigation strategy about Public Safety Power Shutoffs was revised to include mention of these concerns about potential elevated risk of ignition from overhead electric wires.

Amazon Data Centers[22]

There are several data centers located in Morrow County (see Figure 9), which provide data storage services to the region. The data center campuses are located in eastern Oregon for a variety of reasons and have contributed to increased employment.

Each data center campus includes four large buildings and contain computer equipment that is kept cool with electricity and water. The data centers have become a major economic driver, supplementing traditional reliance on agriculture. Both the data centers and agriculture rely on power and water and are adapting to use less water and power and reducing vulnerability of the local water supply with more sustainable approaches to water use.

Figure 9.   Morrow County Amazon Data Centers



Source: Oregon Water Resources Department, Benton County WA, Maxar, Oregon State Parks, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA

[22] One of Oregon's smallest utilities is suddenly among the state's biggest polluters. Why? Amazon data centers - oregonlive.com

7. Tourism and Overnight Visitors

Morrow County, along with Umatilla County, makes up Oregon's Rugged Country, a tourism marketing moniker. Working through the Eastern Oregon Visitors Association (EOVA) the Boardman and Heppner Chambers work diligently to market Morrow County's variety of tourist opportunities such as the SAGE Center, Heritage Trail, parks along the Columbia River and in the Blue Mountains, various hunting and fishing opportunities, and experiences along the Historic Oregon Trail to name just few.

Tourists are not counted in population statistics; and are therefore considered separately in this analysis. The table below shows the estimated number of person nights in private homes, hotels and motels, and other types of accommodations.

Table 21 shows that, between 2020-2022, approximately 40 % of all visitors to Morrow County lodged in private homes, with approximately 40 % staying in hotels/motels, the remaining visitors stay on other suggests these visitors are staying with family and friends. For hazard preparedness and mitigation purposes, outreach to residents in Morrow County will likely be transferred to these visitors in some capacity. Visitors staying at hotel/motels are less likely to benefit from local preparedness outreach efforts aimed at residents.

Table 21. Overnight Visitors between 2020-2022

	2020 Person-Nights (1,000's)	Percent	2021 Person-Nights (1,000's)	Percent	2022 Person-Nights (1,000's)	Percent
All Overnight	78,220	100.0%	100,550	100.0%	112,930	100.0%
Hotel/Motel	28,340	36.2%	43,660	43.4%	50,180	44.4%
Private Home	33,030	42.2%	38,950	38.7%	43,850	38.8%
Other Overnight	16,850	21.5%	17,940	17.8%	18,900	16.7%

Source: The Economic Impact of Travel Oregon, Travel Oregon, 2022

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

8. Migrant and Undocumented Workers

Estimating the number of migrant and seasonal farmworkers in agricultural positions throughout Oregon is a challenge, due to the fact that these workers are often transient or on a temporary work visa, or possibly undocumented. Although it is challenging to estimate these numbers and is not accounted for in population projections by the U.S. Census or Portland State Universities Population

Research Center, it is highly important to take into account these estimates and population patterns when assessing a community's vulnerability to natural hazards.

Migrant and undocumented workers are some of the most vulnerable to natural hazards for a variety of reasons. First, these workers might have limited to no English comprehension, making it difficult for them to find and utilize hazard resources, such as handouts and reports or receive hazard evacuation announcements. However, even if these workers are aware of how to evacuate if there should be a disaster, they might not do so out of fear of detention or deportation, for both them and their families. This is further compounded by the fact that often these farmworkers lack access to transportation, making it even more difficult for them to evacuate during an emergency.

Additionally, farm workers are at risk of losing work due to hazards but also their lodging, which also has a significant impact on employers in Morrow County. Many of these farm workers live in housing provided by their employers, close to the fields and often in flood plains, residing in poorly kept trailers and sub-standard housing that are especially susceptible to damage from natural hazards.

Additionally, when a disaster strikes, recovery costs further amplify these barriers. When a natural disaster affects crops, not only is there the problem of potentially losing lodging, but also the lack of work, leading to a loss of wages. Due to the fact that this money is often the primary source of income for these workers and their families, it can negatively impact the stability and security of both workers and their families.

As a agriculture dependent economy, Morrow County has a large population of farmworkers and their families. Based on numbers of migrant and seasonal farmworker (MSFW)s provided by the Census of Agriculture, roughly 4 % of the total MSFWs in Oregon are located in Morrow County, as seen in Table 22. These workers are also often accompanied by their families, including spouses and children. The number of children who live with their migrant partners are estimated based on statewide estimates, with the total number of children of MSFW parents statewide is approximately 21,000.

Table 22. Migrant and Seasonal Farmworker (MSFW) County Estimate, 2018

	Total MSFW Workers and Non-Farmworkers	MSFW Non-Farmworkers for the state (percent)	Total MSFW Workers Estimate	MSFW Workers of Total (Percent)	Total MSFW Non-Farmworkers	MSWF Non-Farmworkers of Total (Percent)
Oregon	165,762	-	82,961	50.0%	82,801	50.0%
Morrow County	6,074	3.7%	3,040	50.0%	3,034	50.0%

Source: Estimates of Migrant and Seasonal Farmworkers in Agriculture, Oregon Health Authority, s2018

D. Built Environment Profile

Built Environment capacity refers to the built environment and infrastructure that supports the community. The various forms, quantity, and quality of built capital contribute significantly to community resilience. Physical infrastructure, including utility and transportation lifelines, are critical during a disaster and are essential for proper response. The lack or poor condition of infrastructure can negatively affect a community's ability to cope, respond and recover from a natural disaster. Following a disaster, communities may experience isolation from surrounding cities and counties due to infrastructure failure. These conditions force communities to rely on local and immediately available resources.

1. Land Use and Development Patterns

Throughout its history and to this day, the County's, as well as the state and regional economies are largely based on timber, tourism, and agriculture. This, along with the large portions of the County that are public lands, impacted the land use and development patterns in the County.

In 1973, the Oregon Legislature adopted Senate Bill 100 (SB 100), which established the statewide land use planning program. SB 100 required the development of Statewide Planning Goals, which took place over subsequent years (the last Goals were adopted in 1976). The 19 Statewide Planning Goals provide Oregon's policies related to land use, including citizen involvement (Goal 1), housing (Goal 10), and natural resources (Goal 5).

Local jurisdictions, including Counties and incorporated cities, were required to prepare and adopt comprehensive plans, zoning regulations, and land use permitting regulations. As part of the 19 Goals, Urban Growth Boundaries (UGBs) were established to separate areas planned for urban use as opposed to rural uses. UGBs must contain enough land to meet estimated 20-year development based on employment and population growth. UGBs may need to be amended periodically to accommodate growth.

2. Existing Land Use

Morrow County's topography plays a large role in how the land is used. The Columbia River borders the northern edge of the county. South of the river, lowlands gently rise to the Umatilla Forest, which occupies the southern part of the county. The road system generally follows drainage corridors in the south county and is straight and rolling in the north county.

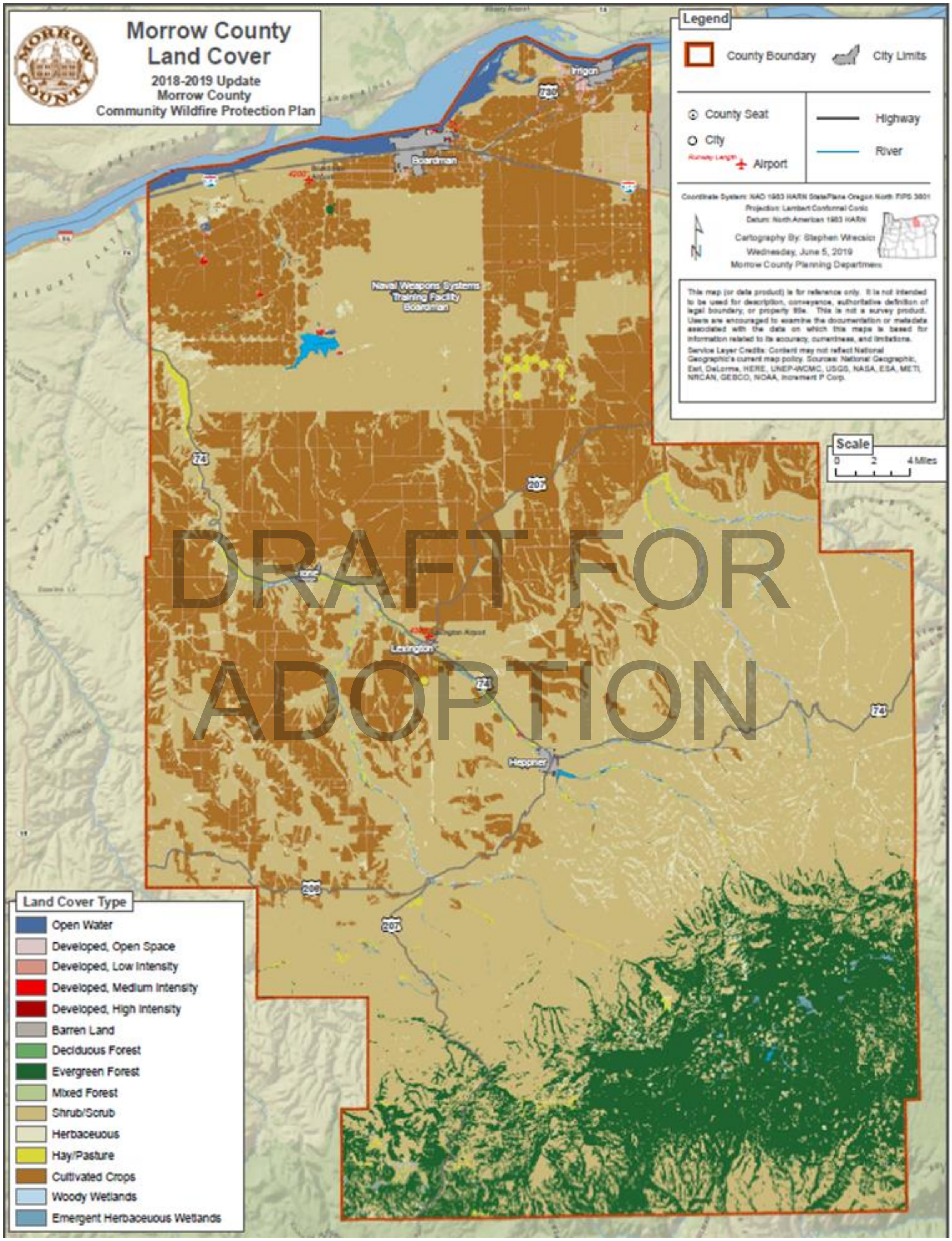
The major population center, commercial operations, and transportation facilities are primarily located in the northern part of the county, near the river, along with the port facilities, including docks and loading facilities. Interstate-84, the major east-west route across the county, parallels the river, as does the Union Pacific rail line. The lowlands south of the river are well suited to agriculture. This area is characterized by large tracts of land, including some of which is used for farming. The U.S. Navy's bombing range and the U.S. Army's Umatilla Chemical Depot also occupy a large portion of northern Morrow County and affect land use, road placement, and traffic patterns. Logging, recreation, and grazing are the major activities in the forested areas in the southern extents of the county.

Because land uses in the county are largely agricultural related, the population is sparse. Most of the population is concentrated in the Irrigon-Boardman area, which also provides most of the land available for urban development. In all, the population per square mile is 5.89 people.[23]. As seen in Figure 10, a significant portion of the County lacks significant development, with the developed area primarily located in the northern region where access to the principal transportation corridors supports economic development. Of the 1,321,600 acres of total county land, it is approximately divided into ½ rangeland, ¼ cropland, and ¼ forest land, and urban areas occupy roughly 0.2 % of the total county area is developed and populated.[24]

[23] U.S. Census Bureau QuickFacts: Morrow County, Oregon, 2023

[24] Morrow County Comprehensive Plan, 2013

Figure 10. Morrow County Land Cover Map



Source: Morrow County Community Wildfire Protection Plan, 2019

3. Development in Morrow County

Development of all types has taken place across Morrow County, including residential, commercial, and industrial development. Generally, development in the southern portion of the County has been driven by recreation activities such as hunting, and use of the off-road vehicle park operated by the county. Morrow County expects to see further interest in development with a focus on the recreation industry.

The northern portion of the county is expected to see further agro-industrial and energy related development. There is interest in expanding the dairy industry, biofuels, and wind energy development. The northern portion of the county will also see continued interest in the further use of the Boardman Bombing Range, and the redevelopment of the former Umatilla Army Depot.

Between 2017 to 2024, approximately 280 permits were applied for and issued to build new 1 and 2-family dwellings. In addition, approximately 10 permits were issued to develop new multi-family dwellings, such as apartment complexes. A significant number of these residential structures were to be constructed in Boardman, a city that has a lower wildfire risk than the southern part of the county but has a greater risk of damage from a Horse Heaven Fault earthquake.

Additionally, for residential dwellings in the County, approximately 100 permits were issued to place manufactured dwellings throughout the County. As a dwelling, manufactured homes are more susceptible to damage caused by natural hazards, such as wildfire or flooding. This is in part due to their construction, concentration of already socially vulnerable populations, ambiguous policies on land management and ownership, and often location. Much like single family housing, many of these permits were requested to place manufactured homes in Boardman, as well as Irrigon. These two cities and their surrounding areas have a higher potential damage risk from an earthquake associated with the Horse Heaven Fault (See Chapter 3 – Hazard Risk Assessment, Earthquake section), which could result in a greater loss of life and property damage in the north than in the south of the county. The county is also experiencing an increase in the number of manufactured homes being installed in the south, an area where hazard risks, such as wildfires, flooding, or landslides are higher than in the north.

There have been many permits for commercial and industrial structures to develop a variety of nonresidential structures, additions/alterations to nonresidential structures, and garages/carports/shops. In this regard, several permits were issued to construct more Amazon Data Centers in and around Boardman, valued at over $150 million in development. The establishment of these centers has been steadily occurring throughout the County over the past decade.

4. Built Structures Inventory

The countywide building inventory is an important factor in assessing risk. This inventory consists of all buildings larger than 500 square feet, as determined from building footprints or tax assessor data. Table 23 shows the distribution of building count and value within Morrow County.

Table 23. Morrow County Building Inventory

	Total Number of Buildings	Percentage of Total Buildings	Estimated Total Building Value ($)	Percentage of Total Building Value
Morrow County	8,480	100%	$4,271,375,000	100%
Boardman	1,214	14%	$823,077,000	19%
Heppner	797	9.4%	$229,967,000	5.4%
Ione	249	2.9%	$68,770,000	1.6%
Irrigon	867	10%	$217,274,000	5.1%
Lexington	212	2.5%	$55,260,000	1.3%
Unincorporated	5,141	61%	$2,877,028,000	67%

Source: Multi-Hazard Risk Report for Morrow County, Oregon, DOGAMI, 2024

5. *Potential for Rural and Urban Development*

The latest Oregon Office of Economic Analysis data estimates that the population in the County will increase by approximately 11.5 % by the year 2050. In evaluating potential development of existing land uses and population as well as its distribution, two types of development are considered.

One is growth in residential housing development. This will likely take the form of new subdivisions on currently vacant land within an Urban Growth Boundary. These vacant parcels are distributed largely south and west of Irrigon and south and west of Boardman. Additional residential development outside of the Urban Growth Boundaries will be limited because the County enforces a two-acre minimum for residential development in rural residential zones.

The other opportunity for growth is through economic development led by expansion of Port of Morrow industrial facilities throughout the County. The Port, through its 30-year history, has developed a significant inventory of developable land at its four industrial park sites: The Boardman Industrial Park, located east of Boardman and north of U.S. Highway 730; the Airport Industrial Park, located west of Tower Road; the East Beach Industrial Park, and the South Morrow County Industrial Park, located at the former Kinzua sawmill complex just outside of the City of Heppner.

6. *Natural Hazards and Development*

The natural hazards that could affect the developing areas of Morrow County are most likely to be wildfire, winter storms and drought in the southern portion of the County. It is expected that as people establish residences in the County's forested lands, there will be a significant increase in threats to life and property in these areas. During winter storms, the roads and highways of southern Morrow County can become temporarily impassible due to snow or ice accumulation.

The farmers, as well as local businesses that rely on the wellbeing of the local farming economy of north and south Morrow County, are affected by a prolonged regional drought. The farmers experience reductions on water use imposed by water right restrictions and lowered water tables. Dryland farmers without access to irrigation systems have to rely on assistance programs in order to survive prolonged drought situations. In turn, the local businesses feel the belt-tightening by the farmers as they buy fewer products and services in the local area.

Development in the northern portion of Morrow County is less affected by natural hazards. Wildfire would be within undeveloped shrub-steppe areas and in dry wheat fields. Drought would worsen a wildfire situation. Flooding in the northern portion of Morrow County is controlled by the dam systems on the Columbia River, but the road systems have not been immune to local flooding situations due to summer and spring storm events. The movement of agricultural and industrial products from Morrow County on the transportation systems leading to the west and east could be potentially affected by winter storms or other events such as a seismic or volcanic event occurring in the wider mid-Columbia region.

7. Housing

Housing tenure, which captures whether someone owns or rents their home, has long been understood as a determinant of social vulnerability. Renters generally experience more housing challenges than homeowners; natural disasters frequently exacerbate those hardships.[25]

Homeownership is correlated with greater wealth, which can increase the ability to recover following a natural disaster.[26] Renters often do not have personal financial resources or insurance to help recover post-disaster; they also frequently cannot access the same federal monies homeowners typically leverage following a disaster. They also might lack social resources, such as the ability to influence neighborhood decisions.

Renters tend to be more mobile and have fewer assets at risk, however those assets might be more difficult to replace due to insufficient income. Renters typically have fewer options in terms of temporary shelter following a disaster and are less likely to stay with a relative or friend than in a public or mass shelter.[27]

The quality of construction for multi-family housing—more often rental—tends to be lower and is therefore more vulnerable to destruction during a disaster. Moreover, renters have less ability to make improvements or alterations to their dwellings to enhance durability and structural safety. Following a disaster, rental housing—especially affordable and subsidized housing—is frequently rebuilt more slowly, if at all.[28]

Throughout Morrow County, most areas have a relatively high rate of home ownership compared to those renting their residence. One out of five residents in unincorporated Morrow County is estimated

[25] Housing Tenure and Social Vulnerability to Disasters: A Review of the Evidence – Lee & Van Zandt, 2019

[26] Social Vulnerability to Environmental Hazards, Cutter, Boruff, and Shirley

[27] Housing Tenure and Social Vulnerability to Disasters: A Review of the Evidence – Lee & Van Zandt, 2019

[28] Housing Tenure and Social Vulnerability to Disasters: A Review of the Evidence – Lee & Van Zandt, 2019

to rent compared to own their homes, as over 80 % of residents own their home. In incorporated Morrow County, the ratio of owners to renters also leans more towards homeowners, with almost 61.2% of residents living in homes they own. Table 24 provides a summary of basic estimates of the housing demographics in Morrow County.

Table 24. Household Occupancy Profile

	Total Households	Total Housing Units	Occupancy Rate	% of Owner	% of Renter
Total Population	4,724	4,724	88.9%	69.8%	30.2%
Incorporated	2,789	2,789	91.5%	61.2%	38.8%
Unincorporated	1,935	1,648	85.2%	83.3%	16.7%

Source: Social Explorer, 2022

Table 25 identifies the types of housing most common throughout the County. Of interest are mobile homes, which account for over 35 % of the housing Countywide, posing further significant risk to the vulnerable individuals who reside in these homes.

Mobile homes are particularly vulnerable to certain natural hazards, such as windstorms, and special attention should be given to securing the structures, because they are more prone to wind damage than wood-frame construction. In other natural hazard events, such as earthquakes and floods, moveable structures like mobile homes are more likely to shift on their foundations and create hazardous conditions for occupants.

Table 25. Housing Profile Numbers

	Housing Units	Single Family	Multi-Family	Mobile Homes	Transient
	Total	Percent	Percent	Percent	Percent
Morrow County	4,724	56.1%	8.2%	35.4%	0.3%

Source: US Census Bureau, 2022

Aside from location and type of housing, the age of structures has implications on how they may be affected by certain natural hazards. Seismic building standards were codified in the Oregon building code starting in 1974; more rigorous building code standards were passed in 1993 that accounted for the Cascadia Subduction Zone earthquake. Therefore, in many cases, homes built before 1993 are more vulnerable to damage due to seismic activity.

In 1968, the federal National Flood Insurance Act instituted the National Flood Insurance Program (NFIP) through which FEMA instituted floodplain studies and mapping in order to administer the Flood Disaster Protection Act of 1973. Upon receipt of floodplain studies and maps, communities developed floodplain management ordinances to protect people and property from flood loss and damage. Table 26 illustrates the number and percent of homes built prior to 1970, 1970 to 1989, and from 1990 to the present. Regionally, approximately a third of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances and the codification of general building standards. Approximately 39.4 % of the County's housing stock was built after 1990, meaning that a large portion of the housing stock within the County are less vulnerable to flooding events due to the implementation of floodplain ordinances and codes.

Table 26. Year Structure Built

	Total Housing Units	Pre 1970		1970-1989		1990-Present	
		Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Oregon	1,818,599	592,827	32.6%	521,042	28.7%	704,730	38.7%
Morrow County	4,724	1,351	28.6%	1,515	32.1%	1,858	39.4%
Boardman	1,182	236	20.0%	440	37.2%	506	42.9%
Heppner	633	386	61.0%	194	30.7%	53	8.4%
Ione	176	109	61.9%	19	10.8%	48	27.3%
Irrigon	727	66	9.1%	285	39.2%	376	51.8%
Lexington	71	41	57.7%	21	29.6%	9	12.6%

Source: US Census Bureau, 2021

8. Critical Facilities and Infrastructure Profile

Critical facilities and infrastructure support the security, health, and economic vitality of the County, and can include structures, assets, systems, networks, and functions that maintain and provide vital services to cities, states, regions, and the nation. Disruption to these can significantly impact the overall community and accesses to the assets and services, potentially leading to further cascading effects, and result in largescale community suffering, property destruction, economic loss, and damage to public confidence and well-being.

Examples of critical facilities and infrastructure include transportation networks, systems for power transmission, and facilities essential to government response and recovery activities (e.g., hospitals, police, fire and rescue stations, school districts and higher education institutions). Due to the fundamental role that facilities and infrastructure play both pre- and post-disaster, it demands special attention in building more resilient communities.

Critical facilities are defined as those needed to maintain government functions and protect life, health, safety, and welfare of the public within Morrow County. Table 27 displays an inventory of critical facilities within Morrow County.

Table 27. Critical Facilities Inventory

Community	Fire Station	Medical Facility	Police Station	Schools	Air Transportation
Morrow County	***8***	***4***	***5***	***10***	***7***
Boardman	1	-	2	3	-
Heppner	1	1	1	2	-
Ione	1	2	-	1	-
Irrigon	1	1	1	4	-
Lexington	1	-	-	-	1
Unincorporated	3	-	1	-	6

Source: Morrow County NHMP Steering Committee; FEMA Resilience Analysis Planning Tool (RAPT), 2023

Critical infrastructure includes infrastructure essential for the safety and functionality of Morrow County and its economy. Table 28 displays a summary of critical infrastructure types within Morrow County.

Table 28. Critical Infrastructure Inventory

Community	Communication Towers	Power Plants	Government Buildings	Utilities***
Morrow County	***12***	***14***	***8***	***12***
Boardman	1	7	1	2
Heppner	2	-	3	4
Ione	3	1	1	2
Irrigon	1	-	2	1
Lexington	-	-	-	1
Unincorporated	5	6	1	2

Source: Morrow County NHMP Steering Committee; FEMA Resilience Analysis Planning Tool (RAPT), 2023

9. Dams

Dams are manmade structures built to impound water. They serve many purposes, including water storage for potable water supply, livestock water supply, irrigation, or fire suppression. Other dams are built for flood control, recreation, navigation, hydroelectric power or to contain mine tailings. Dams may also be multifunctional, serving two or more of these purposes.

The Oregon Water Resources Department is the state authority for dam safety with specific authorizing laws and implementing regulations. Oregon's dam safety laws were rewritten in 2019. This law and new regulations both became operative on July 1, 2020. OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Dam Safety Program also coordinates with the National Weather Service and the Oregon Office of Emergency Management on severe flood potential that could affect dams and other infrastructure. Oregon's statutory size threshold for dams to be regulated by OWRD is at least 10 feet high and storing at least 3 million gallons.

The National Inventory of Dams (NID) which is maintained by the United States Army Corps of Engineers, is a database of approximately 91,750 dams in the United States. The NID does not include all dams in the United States. Rather, the NID includes dams that are deemed to have a high or significant hazard potential and dams deemed to pose a low hazard if they meet inclusion criteria based on dam height and storage volume. Low hazard potential dams are included only if they meet either of the following selection criteria:

- exceed 25 feet in height and 15 acre-feet of storage, or
- exceed 6 feet in height and 50-acre feet of storage.

There are thousands of dams in Morrow County too small to meet NID selection criteria. These small dams are also generally too small to have significant impacts if they fail and thus are generally not considered for purposes of risk assessment or mitigation planning. This NID potential hazard classification is solely a measure of the probable impacts if a dam fails. Thus, a dam classified as High Hazard Potential does not mean that the dam is unsafe or likely to fail. The level of risk (probability of failure) of a given dam is not even considered in this classification scheme. Rather, the High Hazard Potential classification simply means that there are people at risk downstream from the dam in the inundation area if the dam were to fail. Table 29 summarizes the dam inventory for Morrow County.

Table 29. Morrow County Dam Inventory Summary

Dam Name	Hazard Potential Classification	Year Completed	Primary Owner Type	Max Storage Capacity (Acre-ft)	Purpose
Boardman Sewage Lagoons	Low	1984	Local Government	115	Irrigation
Carty Reservoir	Significant	1976	Public Utility	150,000	Irrigation, Other
Cutsforth Dam	Low	-	Private	21	-
John Vanden Brink Dairy	Low	-	Private	50	Other
Penland Lake Reservoir	Low	1971	Private	590	Recreation
Port of Morrow Wwt Lagoon	Low	1994	Local Government	436	Irrigation
Sand Dunes Wastewater Lagoon Dam	Significant	-	Local Government	1,264	-
Threemile Canyon Farms	Low	-	-	-	-
Willow Creek Dam	**High**	1982	Federal	14,091	Flood Risk Reduction, Other, Irrigation, Recreation

Source: National Inventory of Dams, 2024; Dam Inventory Query, Oregon Water Resources Department, 2024

Dams assigned the High Hazard Potential classification are those where structural or operational failure will probably result in the loss of human life, structures, and property. Failure of dams in the High classification will generally also result in economic, environmental or lifeline losses, but the classification is based solely on probable loss of life. Furthermore, where a dam's failure is expected to result in loss of life downstream of the dam (a High Hazard dam), an Emergency Action Plan (EAP) must be developed. The EAP contains a map showing the area that would potentially be inundated by floodwaters from the failed dam. These dams are often monitored so that conditions that pose a potential for dam failure are identified to allow for emergency evacuations. As of 2023, there is one High Hazard dam in Morrow County – The Willow Creek Dam owned and operated by the US Army Corps of Engineers - that is located in Heppner. The dam construction was completed in 1983. It was the first major dam constructed in the United States using the roller compacted concrete technique. Built to prevent the reoccurrence of the disastrous 1903 flood, it controls the flow of Willow Creek and Balm Fork above Heppner. This dam does have an EAP prepared, which was last updated in 2008.

Significant Hazard Potential dams are those where structural or operational failure results in no probable loss of human life but can cause economic loss, environmental damage, or disruption of lifeline facilities. Significant Hazard Potential dams are often located in predominantly rural or agricultural areas. There are 2 Significant Hazard dams in Morrow County – Carty Reservoir located approximately 18 miles southwest of Boardman and Penland Lake Reservoir located roughly 30 miles south of Heppner.

Low Hazard Potential dams are those where structural or operational failure results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the dam owner's property. There are five Low Hazard dams in Morrow County – Boardman Sewage Lagoons located in Boardman; John Vanden Brink Dairy located in west central Morrow County; Port of Morrow Wastewater Treatment Lagoon Dam located in northern Morrow County; Cutsforth Dam located in south Morrow County; Sand Dunes Waster Water Lagoon Dam located in northeast Morrow County; and Threemile Canyon Farms located in northwest Morrow County.

While most dams have been designated with Low Hazard Potential, there are still a significant number of dams classified as High Hazard Potential to those lives and properties within the potential inundation zone if the dam were to fail.

Dam failures can occur rapidly and with little warning. Fortunately, most failures result in minor damage and pose little or no risk to life or safety. However, the potential for severe damage still exists.

While dam failures can occur at any time in a dam's life, failures are most common when water storage for the dam is at or near design capacity. At high water levels, the water force on the dam is higher and several of the most common failure modes are more likely to occur. Correspondingly, for any dam, the probability of failure is much lower when water levels are substantially below the design capacity for the reservoir. Were dams with high storage capacity to fail, the most significant damage to the surrounding and downstream communities would result. Figure 11 shows the location of dams throughout Morrow County and the hazard potential classification of each dam.

Figure 11. Morrow County Dams and Hazard Potential Classification

Source: USGS Bureau of Land Management, EPA, NPS, USFWS

E. Transportation Infrastructure Profile

Residents and visitors to Morrow County are reliant on well-maintained and operated transportation infrastructure. Absent a functional transportation system, residents would be unable to commute to work, shipments and other economic operations would be unable to operate, and community capacity to respond and operate would greatly diminish. It is important to document and maintain an inventory of infrastructure throughout Morrow County, as well as identify critical transportation infrastructure vulnerable to natural hazards.

1. Public Highways and Roads[29]

As an agricultural area, Morrow County is especially dependent on its roadway system. The road system in Morrow County generally follows drainage corridors in the southern portion of the County and is straight and rolling in the northern portion of the County. The system is in good condition overall and currently functions generally well. Existing traffic volumes are relatively low, and existing delay is typically low. Outside of urban areas, the system is geared toward moving small numbers of vehicles over long distances. Five state highways, including 1-84, serve the county. Hundreds of miles of county roads, ranging from paved two-lane roads to narrow gravel roads, provide access between the state highways. Community transportation infrastructure is displayed in Figure 12.

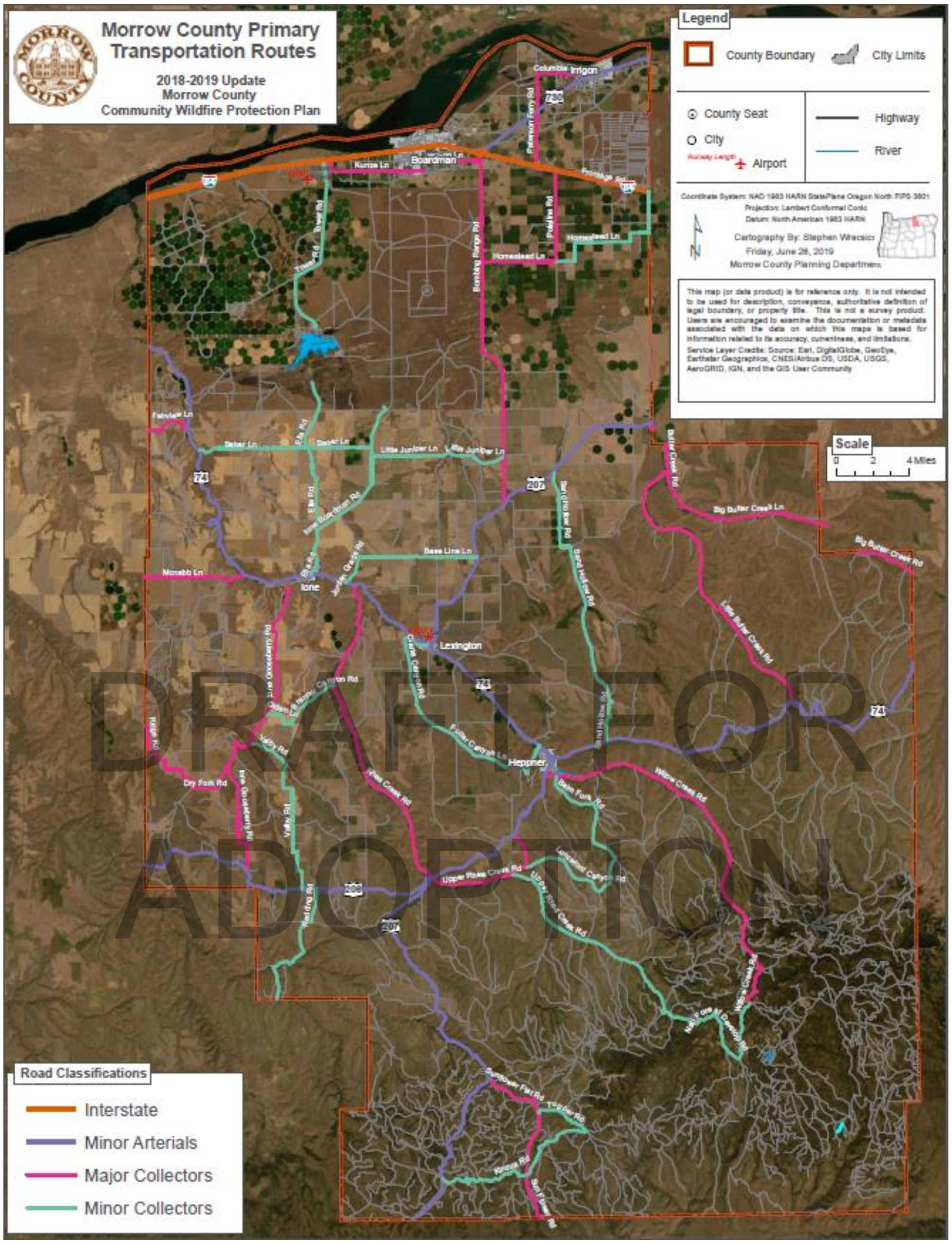
Roadways in the county fall under the jurisdiction of Morrow County, ODOT, and the cities within the county. There are also numerous private roads, with significant facilities falling under the administration of the Port of Morrow. Also, a significant portion of the Bombing Range Road is on land owned by the U.S. Navy with the county having limited authority granted via an easement.

Highways

State highways are the backbone of Morrow County's roadway system. They are used for virtually all of the through traffic in the county and connect the cities and other population centers.

[29] Transportation System Plan, Morrow County, 2022

Figure 12. Public Transportation Infrastructure



Morrow County Community Wildfire Protection Plan, 2019

Morrow County is connected to the federal interstate highway system via Interstate 84, which parallels the Columbia River in the north end of the County. Interstate 84 links the County to I-5 to the west through Portland, and to I-80 and I-15 to the south and east to Boise and Salt Lake City. Interstate 84 also links the County to I-82 north to the Tri-Cities in Washington State. State highways are summarized in Table 30:

Table 30. State Highways Service Morrow County

State Highway	Alternative Name	Location Served	Highway Category
I-84	Columbia River Highway State Highway No. 2	West of U.S. 730 through Boardman to Gilliam County, to 1-5 and Portland.	Interstate Highway
I-84	Old Oregon Trail State Highway No. 6	East of U.S. 730 to Umatilla County, to 1-80 and 1-15, Boise and Salt Lake City.	Interstate Highway
U.S. 730	Columbia River Highway State Highway No. 2	From 1-84, east through Irrigon to Umatilla County.	Regional Highway
OR 74	Heppner Highway State Highway No. 52	From 1-84, southeast through Cecil, Morgan, Ione, Lexington, Heppner, and Lena and Umatilla County.	District Highway
OR 207	Heppner Highway State Highway No. 52	From Lexington northeast to Umatilla County.	Regional Highway
OR 207	Heppner Highway State Highway No. 52	From Ruggs, south through Hardman to Wheeler Count	Regional Highway
OR 206	Wasco-Heppner Highway State Highway No. 300	East from Gilliam County through Ruggs to Heppner	District Highway

Source: Morrow County Transportation System Plan, 2022

County Roadways

Based on the most recent TSP cited below, Morrow County has 340 miles of pavement or hard-surface roads and 600 miles of gravel roadways. They connect the state highways and provide access to individual properties. The county has assigned a name, a road number, and a functional classification to each road.

Transportation Infrastructure Safety Issues[30]

The Morrow County Transportation System Plan (TSP) identifies safety issues for the transportation network in the County. The TSP states that the most overwhelming need of the Morrow County Road system is for maintenance. The county annually budgets to maintain the existing level of service and, where possible, to improve the service level. Road surface condition for paved and gravel roadways are summarized in Table 3-4 of the TSP shown below as Table 31.

[30] Transportation System Plan, Morrow County, 2022; p. 3-6.

Table 31. Surface Condition of Morrow County Paved and Gravel Roadways

Surface Type	Classification	Number of Miles	Percent of Classification
Paved	Excellent	46.72	14
	Very Good	22.01	6
	Good	119.61	35
	Fair	151.55	45
	Total	***339.89***	***100***
Gravel (farm to market roads)	Excellent	29.36	5
	Very Good	270.76	45
	Good	196.81	33
	Fair	103.58	17
	Total	***600.51***	***100***

Source: Morrow County Transportation System Plan, 2022, Table 3-4 on p. 3-12

Additionally, the TSP mentions the need for an additional north/south connection between Boardman and Ione in addition to Bombing Range Road, which is the only existing connection that wholly lies within the County. A second north/south route would provide an alternate for emergency vehicles and a fire break in the middle portion of the County where there is the potential for large losses due to a wildfire in the wheat fields and desert grasslands pushed by prevailing easterly winds.

2. Public Transportation

Transportation options available to Morrow County residents are limited. The primary public transit available is The Loop which provides regular scheduled service six days a week. The Loop aims to provide safe and reliable transportation services to all residents of Morrow County, including veterans, seniors, individuals with disabilities, or those with limited or no transportation. There is no cost to ride The Loop, but donations are accepted.

Kayak Public Transit operated by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) serves southeastern Washington and northeastern Oregon. Kayak strives to connect rural communities in the region and provide access to essential services with free, ADA-accessible public transportation. Irrigon is currently the only city in Morrow County that is served by Kayak Public Transit, providing service to Irrigon Monday through Saturday, providing two stop times daily. Morrow County funds the service to Irrigon.

3. Bridges

Because of earthquake risk, the seismic vulnerability of the County's bridges is an important issue. Non-functional or failed bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The County's bridges are part of the state and interstate highway system, which is maintained by the Oregon Department of Transportation (ODOT), or are part of regional and local systems, maintained by the region's counties and cities.[31]

Bridges in Morrow County are inventoried biennially and rated on a sufficiency scale that ranges from 0 to 100, with lower scores meaning worse conditions and higher scores indicating adequate conditions. Sufficiency scores for bridges are translated to a qualitative ranking of not deficient, structurally deficient, or functionally obsolete. Of the 116 bridges in the county, 44 are county bridges, 11 are city bridges, 60 are ODOT bridges and 1 is a railroad bridge. Table 32 lists the bridges in the county rated as structurally deficient or functionally obsolete, and identifies bridges previously listed that have been repaired or replaced."

Table 32. Existing Bridge Deficiencies

Owner	Description	Status Code
ODOT	U.S. 730/USRS Canal	
County	Spring Hollow Road/Rhea Creek	Functionally Obsolete
County	Road Canyon Road/Rhea Creek	Replaced ('08-'09)
County	Willow Creek, Oley McNab Road	Structurally Deficient
County	Willow Creek, Clarks Canyon Road	Structurally Deficient

Source: Morrow County Transportation System Plan, 2022

Table 33 shows the structural condition of bridges in the region. A *distressed* bridge is a condition rating used by ODOT indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge is a federal performance measure used for non-ODOT bridges; the ratings do not imply that a bridge is unsafe. The table shows of the 74 bridges in Morrow County 4 are distressed or deficient. The county has quite a low percentage of bridges that are distressed and/or deficient (5.4 %).

Table 33. Morrow County Distressed Bridge Inventory

Threat Potential	Distressed		Total in Morrow County	
	Number	Percent Distressed or Deficient	Number	Percent of Total
State Owned	0	0.0%	24	34.3%
County Owned	3	75.0%	32	45.7%
City Owned	1	25.0%	11	15.7%
Other Owned	0	0.0%	3	4.3%
Total Bridges per Category	4	5.4%	70	94.6%
Total Number of Bridges in Morrow County	74			

Source: Oregon Natural Hazard Mitigation Plan, 2020, data derived from Table 2-482 on page 982

[31] Transportation System Plan, Morrow County, 2022

The bridges in Morrow County require ongoing management and maintenance due to the age and types of bridges. Modern bridges, which require minimum maintenance and are designed to withstand earthquakes, consist of pre-stressed reinforced concrete structures set on deep steel piling foundations. The historic bridge is the Spring Hollow Road Bridge on Upper Rhea Creek, which was built in the early 1900s, and continues to provide a link for farmers to highways 207 and 74. It is estimated that approximately 60,000 bushels of grain and 1,000 head of cattle move over this bridge annually.

The county's public works department works in coordination with contracted engineering firms to inspect and maintain the bridges located on county roads. Bridges within Morrow County are inspected at two-year intervals or more frequently if special conditions exist. Bridges that are found to be in critical condition during an inspection are immediately prioritized for replacement.

4. Rail Transportation

Morrow County is served by one national freight rail carrier, the Union Pacific Railroad. Union Pacific provides freight rail service from Chicago west to the Pacific Ocean through the Port of Morrow on the Columbia River. The Port of Morrow operates a rail spur at their Boardman location, which is serviced by Union Pacific.

There has been no passenger rail service in Morrow County since the mid-1990s, when the Amtrak Pioneer line between Salt Lake City, Utah and Portland, Oregon stopped operating.

5. Airports

Morrow County has two public airports. The Lexington Airport is approximately one-half mile from the center of the Town of Lexington on a plateau approximately 200 feet above town. Highway 207 passes immediately east of the airport and serves as the primary surface access route to the airport. According to information contained in the 2001 Airport Layout Plan Report, the Lexington Airport site has been in aviation use since early 1945. The Lexington Airport has one paved, lighted runway (8-26), which is oriented on a 080-260 degree magnetic alignment and is approximately 4,300 feet long. The airport has been owned and operated by Morrow County since 1960.

The Boardman Airport is located approximately five miles west of Boardman and is accessed from Tower Road off of Interstate 84. The Boardman Airport has a single paved and lighted runway, which is oriented on a magnetic alignment and is approximately 4,200 feet long. Historically the Boardman Airport has served military aviation and a variety of general aviation users including agricultural aviation.

6. Water Transport

Morrow County's location on the Columbia River provides direct access to the Columbia River transportation system, one of the most modern intermodal transportation networks in the country. This commercial waterway extends from the Pacific Ocean over 465 miles into eastern Washington and Idaho and includes eight dam and lock complexes. This transportation system is accessed through the Port of Morrow in the Boardman area and the Morrow County Grain Growers access at the end of Paterson Ferry Road.

Port of Morrow System

The Port of Morrow is in the heart of the Pacific Northwest inland empire. It maintains critical transportation connections with the Columbia River barge lines, Union Pacific's main line, 1-84 with east-west access, and US 730 with access north into Washington and beyond. With the accesses indicated, the Port of Morrow offers crucial transportation links to the Pacific Ocean and the continental United States.

Beyond the current use of the Port's barge, rail, and highway system is the development of the port-owned general aviation facility for use in transportation of goods and services. The Port has four established industrial parks with over 5,200 acres of available land: the Boardman and East Beach Industrial Parks, the Airport Industrial Park, and the south Morrow Industrial Park.

F. Cultural Resources and Historic Places

The cultural and historic heritage of a community is more than just tourist charm. For families and residents that have lived in the county for generations and new resident alike, it is the unique places, stories, and annual events that make Morrow County an appealing place to live. The cultural and historic assets in the county are both intangible benefits and quality-of-life- enhancing amenities.

Mitigation actions to protect these assets span many of the other systems already discussed. Some examples of that overlap could be seismic retrofit (preserving historic buildings and ensuring safety) or expanding protection of wetlands (protect water resources and beautify the county).

Due to their critical role in defining and supporting the community, these resources must be protected from the impacts of natural disasters.

1. Historic Locations

The National Register of Historic Places lists all types of facilities and infrastructure that help define a community. Whether it is the first schoolhouse in town or simply the home of a resident who played a vital role in the success of the community, the *Register* lists all types of historic features that characterize the area.

The locations in Morrow County that are on the National Register of Historic Places are:

- Gilliam & Bisbee Building in Heppner
- Heppner Hotel in Heppner
- Morrow County Courthouse in Heppner
- Oregon Trail, Wells Springs Segment
- Hardman IOOF Lodge Hall

2. Cemeteries

Morrow County has many old cemeteries, most of which were established in the late 1800s and early 1900s by the first settlers of the County. Some of the more well-known are listed below:

- Cecil Cemetery, Cecil
- Desert Lawn Memorial Cemetery, Irrigon
- Gooseberry Cemetery, Gooseberry
- Hardman IOOF and Hardman Cemeteries, Hardman
- Highview Cemetery, Ione
- Irrigon Cemetery, historical, Paterson
- Lexington Cemetery, Lexington

- Morgan Cemetery, Cecil
- Petteys Cemetery, Ione North
- River View Cemetery, Boardman
- Valby Cemetery, at the Valby Lutheran Church 12 miles west of Ione
- Well Spring Cemetery, on the old Emigrant Road

3. *Parks and Recreational Facilities*

Parks and Recreational Facilities offer local residents and visitors alike opportunities to enjoy the local environment and recreate. Recreational activities, such as hunting and fishing, are a significant portion of Morrow County's economy, and is very important to the community. The facilities and sites serve as a major source of local economic revenue, thus playing a vital role in the health and vitality of the regional economy.

- **Morrow County Off Highway Vehicle (OHV) Park h**as over 6,200 acres in south Morrow County adjacent to Highway 207. It is approximately 28 miles south of Heppner at the edge of the Umatilla National Forest and approximately 32 miles north of Spray. This park has many miles of off-road trails and is available for winter use by snowmobile and cross-country ski enthusiasts. The OHV Park also has spaces for recreational vehicles (RVs) and small cabins. The OHV Park is owned and operated by Morrow County.
- **Cutsforth Park is** a 31.1-acre park located in the southern Morrow County 22 miles south of Heppner and bordered by the Umatilla National Forest to the south. Located along the Blue Mountain Scenic Byway, it offers horseshoe pits, a campground, the nature trails, and equestrian trails on adjacent USFS property. Cutsforth Park is owned and operated by Morrow County.
- **Anson Wright Memorial Park** is a 32.8-acre park located 26 miles southwest of Heppner on State Highway 207. It opened in 1967 on land originally owned and then donated by the Wright family. Rock Creek flows through the park and is the water source for the pond located in the northwest section of the park. The west side of the park is characterized by steep terrain and moderate vegetation. The south end of the park is on a steep slope, which has a road cut into this slope to service the campsites. Anson Wright Park is owned and operated by Morrow County.
- **Quesnel Park** is located on the Columbia River on the north side of the Threemile Canyon Exit from Interstate 84. It contains about 265 acres and offers boating and other water sport activities as well as camping and fishing opportunities. It is owned and operated by the U.S. Army Corp of Engineers.
- **City Parks in Morrow County** include the Boardman Park in Boardman, the Irrigon Skate Park and Park/Marina in Irrigon, Hager Park, City Park and the 1903 Park in Heppner. Ione has a City Park and Lexington has a dirt bike park and a small park at the Odd Fellows Hall. The parks in Boardman and Irrigon offer marine access to the Columbia River as well as picnicking and day use activities.
- **The Heritage Trail** is a concept developed by Morrow County, in cooperation with Boardman, Irrigon, The U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, the Port of Morrow and other local interests. It is a continuous trail approximately 25 miles long, for walkers, bicyclists and other non-motorized travelers and recreationists that loosely parallels the Columbia River and spans the full width of north Morrow County.
- **The Blue Mountain Scenic Byway**, designated in 1989 under the National Scenic Byway Program, allows east-west highway travelers an alternate route between the Columbia River

near Arlington and Baker City. This scenic byway covers 130 miles of paved, two-lane road, which crosses Morrow County on Highway 74 from Cecil through Ione, Lexington, and Heppner. At Heppner the byway continues on Willow Creek Road, then Forest Service Road 53 as it climbs into the Umatilla National Forest.

- **The Umatilla National Forest** is located in both Oregon and Washington and covers 1.4 million acres. Approximately 10%, or 139,000 acres, of the Umatilla National Forest lies within Morrow County. The Forest has some mountainous terrain, but most of the area consists of V-shaped valleys separated by narrow ridges or plateaus. The landscape includes heavily timbered slopes, grassland ridges and benches, and bold basalt outcroppings with elevations from 1,600 to 8,000 feet above sea level.

4. Wildlife Refuges and Management Areas

- **Umatilla National Wildlife Refuge:** The Umatilla National Wildlife Refuge was established in 1969 to restore Columbia River wildlife habitat lost to construction of the John Day Dam. The Refuge is located on the Washington and Oregon sides of the river from Irrigon to Crow Butte across from Boardman, covering approximately 23,555 acres. The Refuge is managed to meet its wildlife objectives to produce Great Basin Canada geese, to provide habitat for mallards and Canada geese during spring and fall migrations, and to provide habitat for other migratory birds. Public recreation activities are also available on the Refuge. Among the many activities available are fishing, boating, and observation and photography of wildlife.
- **Umatilla Hatchery, Irrigon:** Located just west of Irrigon, the fish hatchery was authorized by the Northwest Power Planning Council with funding provided by the Bonneville Power Administration on land owned by the U.S. Army Corp of Engineers. Operated by the U.S. Fish and Wildlife Service, the hatchery began operations in 1991. The Hatchery is used for egg incubation and rearing of spring Chinook, fall Chinook, and summer steelhead. The young fish are reared for release into the Umatilla and Snake Rivers in order to contribute to the sustainability of naturally produced native fish populations and to partially mitigate for fish losses caused by hydroelectric dams on the Columbia River system.
- **Irrigon Hatchery, Irrigon:** The Oregon Fish and Wildlife Department runs a fish hatchery also on the west side of Irrigon adjacent to the Umatilla Hatchery. This hatchery rears steelhead as well as offering wildlife viewing for visitors.
- **Three Mile Canyon Conservation Area: In** 2000 the owners of the 93,000-acre Threemile Canyon Farm agreed to set aside 23,000 undeveloped acres as a conservation area. The area is located northeast of Cecil on the western side of the County. The conservation area, managed by The Nature Conservancy in conjunction with the U.S. Fish and Wildlife Service and the Oregon Department of Fish and Wildlife, protects the burrowing owl, Washington ground squirrel, the loggerhead shrike, the ferruginous hawk, the sage sparrow and the shrub-steppe environment they inhabit.

G. Political Capacity Profile

Political capacity is recognized as the government and planning structures established within the community. In terms of hazard resilience, it is essential for political capital to encompass diverse government and non-government entities in collaboration, as disaster losses stem from a predictable result of interactions between the physical environment, social and demographic characteristics and the built environment.[32] Resilient political capital seeks to involve various stakeholders in hazard planning and works towards integrating the Natural Hazard Mitigation Plan with other community plans, so that all planning approaches are consistent.

1. Government Structure

A three-member Board of Commissioners governs Morrow County. The Commissioners serve as the Executive Branch and perform legislative and quasi-judicial functions of the County. They are also responsible for the administration of all County business.

Commissioners are responsible for the planning, formation, and implementation of the annual budget. In addition, Commissioners serve on other federal, state, and local mandated governmental panels, boards and commissions with fiscal duties and authority over public monies.

Beyond Emergency Management, all departments within the County governance structure have some degree of responsibility in building overall community resilience. Each plays a role in ensuring that County functions and normal operations resume after an incident and the needs of the population are met.

County departments and divisions that are most involved with natural hazard mitigation include the following:

- **Planning**: The Morrow County Planning Department is responsible for administering state, regional, and local land use, and zoning regulations in unincorporated areas of Morrow County. This department administers both short and long-range plans that determine much of the built, physical community. Through the County Comprehensive Plan and subsequent policies, the Planning department guides decisions about growth, development, and conservation of natural resources. Beyond being the primary convener of the Morrow County NHMP, the Planning Department participates by developing, implementing, and monitoring policies that incorporate hazard mitigation principles such as ensuring homes, businesses, and other buildings are built to current seismic code and adhere to FEMA floodplain regulations. The Planning department also oversees the GIS division, which develops and maintains a Geographic Information System (GIS) for Morrow County.
- **Sheriff's Office**: The mission of the Morrow County Sheriff's Office is to provide "peace and security of the citizens and visitors to our County". The Sheriff's Office interacts with the vulnerable aspects of the community on a day-to-day basis and can help identify areas for

[32] Mileti, D. 1999. Disaster by Design: a Reassessment of Natural Hazards in the United States. Washington D.C.: Joseph Henry Press

focused mitigation. Furthermore, as first responders, they directly interact with community members, both prior to, during, and after disasters, and rely on reliable access to resources and infrastructure to assist the community.

- **Emergency Management**: The Morrow County Emergency Management division is responsible for emergency management planning and operations for the portion of the County outside the limits of the incorporated municipalities of the County. The Morrow County Emergency Operations Plan provides details on the organization and operations of emergency management, as well as preparing for, responding to, and recovering from disasters and large-scale emergencies.
- **Building**: Morrow County does not have its own Building Department; rather, the County contracts with the City of Boardman for building permits and a building inspection program. This resource enables the County to assist residents with design and construction guidelines, construction, and development requirements, as well as assist residents with permitting and building code applications. This resource also provides the County with an opportunity to connect and collaborate with county residents who own structures not constructed in compliance with modern, resilient code. Professionals from this division might even be called on to assist in surveying buildings after an incident.
- **Information Technology**: Morrow County does not have its own IT Department; rather, the County contracts with the City of Hermiston for their IT needs. This contractual relationship supports the County's ability to conduct daily business related to information systems and telecommunications technology and provide critical service to County residents. Mitigation efforts from IT would not likely involve residents but would go a long way to ensuring uninterrupted services during hazard incidents.
- **Public Works:** Morrow County Public Works provides technical assistance and information to the public for County Road access permits, County Road right of way permits, solid waste disposal at the North and South Transfer Stations, County Parks reservations, and a variety of department related programs. Public Works is made up of several departments which work together to achieve a common goal. In the County they oversee, help reporting and documenting daily operations for General Maintenance, Transfer Stations, Airport, Road Dept. and three County Parks.

2. *Civic Engagement*

Civic engagement and involvement in local, state and national politics are important indicators of community connectivity. Those who are more invested in their community may have a higher tendency to vote in political elections. The 2020 Presidential General Election resulted in 77.3% voter turnout in the county.[33] These results are relatively equal to voter participation reported across the State (82%). Other indicators such as volunteerism, participation in formal community networks and community charitable contributions are examples of other civic engagement that may increase community connectivity.

[33] Statistical Summary NOVEMBER 3, 2020, GENERAL ELECTION (oregon.gov)

3. Existing Plans and Policies

Communities often have existing plans and policies that guide and influence land use, land development and population growth. Such existing plans and policies can include comprehensive plans, zoning ordinances and technical reports or studies. Plans and policies already in existence have support from residents, businesses, and policy makers. Many land use, comprehensive, and strategic plans are updated regularly and can adapt easily to changing conditions and needs.

The Morrow County NHMP includes a range of recommended action items that, when implemented, will reduce the County's vulnerability to natural hazards. Many of these recommendations are consistent with the goals and objectives of the County's existing plans and policies. Linking existing plans and policies to the NHMP helps identify what resources already exist that can be used to implement the action items identified in the Plan. Implementing the NHMP's action items through existing plans and policies increases their likelihood of being supported and getting updated and maximizes the County's resources. In addition to the plans listed below the County and incorporated cities also have zoning ordinances (including floodplain development regulations) and building regulations. Many of the plans and policies developed and implemented by the County are also adopted by cities through motion.

Morrow County's current plans and policies (see Table 34) include the following:

Table 34. Morrow County Plans and Policies

Document Title	Communities | Year Published	Description	Relation to Natural Hazard Planning
Community Wildfire Protection Plan	Morrow County | 2019	The CWPP assists Morrow County in clarifying and refining priorities for the protection of life, property, and critical infrastructure at the wildland-urban interface on public and private lands.	The CWPP is developed as a means of identifying Morrow County's plans and goals for wildfire and prescribed fire smoke response and includes actions that the County plans to take to mitigate the negative effects of smoke.
Comprehensive Plan	Morrow County | 1986 (Sections updated periodically) Boardman | 2003 (Sections updated periodically) Irrigon | 2021	As a master plan for the community, the Comprehensive Plan helps to anticipate and plan for future land use within a community in accordance with the Statewide Land Use Planning Program, as well as provide a vision for the future of the community and the steps to achieve that vision.	The plan works in compliance with Oregon Land Use Goal 7 to remain in place through the local planning and building process, along with all local provisions for natural hazard mitigation. The plan outlines the limitations and regulations regarding natural hazards, and provides limitations, restrictions, and guidelines for developing in areas known to be at-risk of natural hazards.
Emergency Operations Plan \ Emergency Management Plan	Morrow County | 2022 Boardman | 2023 Ione | 2014 Irrigon | 2012	An Emergency Operations Plan is a multi-hazard, adaptable document that addresses a community's planned response and short-term recovery to extraordinary emergency situations related to disasters. It is developed to provide focus and direction on responding to potential large-scale disasters that can create unique and novel situations requiring unusual responses.	An EOP provides a framework for mitigation, response, and recovery activities to prevent and minimize negative impacts and damages. As mitigation takes place before and after an emergency event occurs, it seeks to implement actions that prevent an emergency from occurring, reduce the chances of an emergency happening, or minimize the damaging effects of unavoidable emergencies by working to reduce the overall response and recovery efforts and processes.

Housing Needs Analysis and Strategies Report	Morrow County | 2019	A Housing Needs Analysis analyzes and develops estimates of future housing needs and determines the number of housing units necessary to manage projected growth. This includes setting goals, policies, and objectives for housing preservation, improvement, and development.	Housing needs of the state and county are growing, which calls for the development of more housing. Thus, it may be necessary to expand into potential hazard zones, such as historical floodplains or into the Wildland Urban Interface (WUI). Identifying the location of potential housing development, along with assessing the hazard risk of these areas are necessary in order to reduce people and their homes' vulnerability to hazards.
Land Use and Development Ordinance	Morrow County |1980 (readopted in 2001) Boardman | 2003 Heppner | 2023 Irrigon | 2017	Land Use and Development Ordinances are adopted to administer development codes and zoning ordinances that regulate land uses in Morrow County.	Land use ordinances may be used or developed to direct future development away from known hazard areas, which will aid in mitigating community and structural vulnerability.
Parks Master Plan	Morrow County | 2018	A Parks Master Plan is a long-range and comprehensive strategy that guides the development, improvement, and maintenance of a community's recreational assets. The plan also identifies, prioritizes, and budgets for future park capital improvement projects.	The plan is intended to preserve and protect natural and scenic areas of importance, which includes preventing or limiting development, but also from natural hazards, such as flooding and wildfire. These at-risk areas are identified, as well as areas in need of restoration, which can contribute to the development of mitigation measures that will facilitate hazard risk reduction and the preservation and protection of the park.

Transportation System Plan	Morrow County | 2012 (Amended in 2022) Boardman | 1998 (Revised in 2001) Heppner | 2018 Ione | 1999 Irrigon | 2014 Lexington | 2003	The Transportation System Plan (TSP) addresses anticipated transportation needs. It is prepared to meet state and federal regulations that require urban areas to conduct long-range planning. The long-range planning approach is intended to serve as a guide for a community in managing its existing transportation facilities and developing future transportation facilities.	The Transportation System Plan may be a resource to identify which roads and transportation systems are most vulnerable to natural disasters. Likewise, the TSP can be utilized to implement mitigation measures aimed at protecting "transportation disadvantaged" populations in emergency situations. When updated, the TSP can also include mitigation elements in its implementation considerations.
Water Master Plan \\ Water System Management Plan \\ Water Management Conservation Plan	Boardman | 2016 Irrigon | 2006	A Water Master Plan describes the current conditions of the community's water systems and addresses projected future needs. It defines a system-wide strategy for water supply, wastewater, and capital improvement strategies.	Water Master Plans aim to assess a community's water system's current performance and determine future requirements for facilities to provide critical services, such as wastewater treatment, flood prevention, and risk reduction. This may include identifying potential improvements to or retrofitting water service stations and water storage facilities.
Main Street "Downtown" Develop Plan	Boardman | 2001 Heppner | 2003 Irrigon |2009	-	-
Wastewater Facilities Plan	Boardman | 2020 Irrigon| 2019	-	-
Water Conservation and Mitigation Plan	Irrigon | 2006	-	-

H. Morrow County City Profiles

1. City of Boardman

The City of Boardman, incorporated in 1927, is located in northeastern Oregon, along the Columbia River and Interstate 84, and 164 miles east of Portland. The city's elevation is almost 310 feet above sea level and has a total area of 4.17 square miles.

Human Population: With almost 4,500 residents as of 2023, it is the largest city in Morrow County. Boardman also has a high percentage of socially vulnerable populations, including a large Hispanic/Latino population (67.5%), and 20.9% of the population live below the poverty level.

Infrastructure and Critical Facilities: Boardman is primarily an agricultural community and is a major hub for transportation and manufactured goods. It is home to the Port of Morrow, where there are around 20 processing plants. There are also several food processing and storage plants, a gas-powered generation plant, a wood chipping mill, a dry kilns and planner mill, an alfalfa hay processing plant, an ethanol producing plant, a bio-fuels terminal for loading ethanol in barges, and a mining company that mines aggregate used for cement, asphalt and other rock uses.

2. City of Heppner

The City of Heppner, incorporated in 1887, is the southernmost city in Morrow County. As the county seat, the city's elevation is over 2,000 feet above sea level and has a total area of 1.23 square miles. It is located approximately 50 miles south of the Columbia River, nestled against the foothills of Blue Mountain Range. Highway 74, also known as the Blue Mountain Scenic Byway, runs along the city, eventually connecting to Interstate 84 along the Columbia River. It is upstream from the Town of Lexington, and the cities of Ione and Arlington (located in Gilliam County).

Human Population: There is a largely homogeneous population of over 1,250 residents in Heppner (93.8% white), which is distributed across the age categories as follows: 21.2% under the age of 15; 56.4% from ages 18 to 64, and 22.3% who are 65 years or older. Heppner has a Senior Center, an Assisted Living facility, and a 12-bed hospital.

Cultural and Historic Resource: One of the most significant cultural and historic resources in Heppner is the County Museum, which contains historical information about the County and the cities, including records of natural disasters. Heppner has three buildings listed on the National Register of Historic Places: The County Courthouse, the Gilliam & Bisbee Building, and the Heppner Hotel. Heppner has two annual celebrations: The St. Patrick's celebration In March, and the Morrow County Fair and Rodeo in August.

Infrastructure and Critical Facilities: Heppner is located in a deep canyon at the confluence of four creeks, Willow, Hinton, Balm Fork and Shobe Creeks. The dam at Willow Creek Reservoir controls the flow of Willow and Balm Fork. Since the completion of the dam in 1983 damage from flooding has been greatly reduced In the Willow Creek Valley. The dam also provides recreation opportunities and is among the most significant critical facilities in Heppner. Also listed are the local schools, the school district office, the Kinzua Mill site, the downtown area, the water and sewer system, the Heppner Fire Department, and the Hospital. The Emergency Operations Center, operated by the Morrow County Sheriff's Department is also within the Heppner City limits.

Economic Assets: Heppner hosts local and state governmental offices, which include the Morrow County government, the City of Heppner, and regional offices of the Natural Resource Conservation Service (NRCS), Oregon Department of Transportation (ODOT), Morrow County School District and the United States Forest Service (USFS). Heppner has a traditional downtown area and is also a crossroads in the southern portion of the County for agricultural products transported to market In the wider region and as such, Heppner economy reflects this agriculture/governmental identity.

3. City of Ione

The City of Ione, incorporated in 1903, is located in the southern portion of the County, along Highway 74 and within Willow Creek Valley. The city’s elevation is almost 340 feet above sea level and has a total area of 0.76 square miles.

Human Population: There is a homogeneous population in lone of the almost 350 residents (77.1% white, and 15.4% who identify as Hispanic or Latino). The age distribution is 18.9% under the age of 15; 57.0% from ages 18 to 64, and 24.0% who are 65 years or older.

Economic Assets: The following businesses are some of the businesses in Ione, including The lone Market, a combination grocery store, delicatessen and liquor store, the Wheatland Insurance, a branch of Bank of Eastern Oregon, and has been in business since 1945, and the Post Office and the lone Rural Fire Station.

Some of the largest employers in Ione are the JVB Dairy Farm and lone School District. The lone community took a large step when they opted to withdraw from the Morrow County School district and form its own district using the original district property lines. The lone district then formed a Charter School, which has allowed growth and flexibility without the threat of closure due to its size. This move brought the community even closer and has brought some growth to the community as well.

The Historic Woolery House Bed and Breakfast is located on Second Street. The West end of Main Street sees agriculture come to town; Morrow County Grain Growers operates a fertilizer-agronomy division to meet the needs of the area farmers; they also maintain a seed plant and grain storage elevator on the east end of Main Street.

Cultural & Historic Resources: One of the features that make lone unique is the buildings that make up the heart of the lone. These buildings include The Woolery House Bed and Breakfast, The lone Market, the City Hall and Library and the American Legion Hall.

Adjacent to the City Park, a large railroad warehouse houses the city shop on the East end and a beautiful stage area on the west end. The repurposing of this building has made it a great venue that serves as the centerpiece for the annual July 4th Celebration, weddings, reunions, and family picnics.

There three active churches within the city limits, Ione Community Church, St Williams Catholic Church and the Christ Alone Lutheran Church.

Over the past year a mammoth tusk was unearthed near the City of Ione. A paleontology team from University of Oregon came and removed the tusk and took it for study and will return it to the school in the future. Several Ione High School students were allowed to help alongside the university scientists.

Infrastructure & Critical Facilities: The city has two wells for domestic water but currently relies on the main well to supply water to approximately 300 users. The city also sells large quantities of water to farmers for a variety of farm uses.

Emergency Preparedness: The Ione Rural Fire Protection District volunteers are very well trained and supplied with up-to-date equipment located at the fire station within the city limits. Because it is 18 miles to the nearest medical facility, the Ione RFPD is fortunate to have EMT's, a well-equipped ambulance and several volunteer ambulance drivers.

Environmental Assets: Ione has three City parks; Mullins Park, the Horseshoe Park and a large City Park. There are picnic tables and very nice restrooms on site. There are six RV spaces with power and water available for short term stays at a nominal fee per night. There are also two private RV Parks that offer full hookups for those wishing to stay longer.

Ione residents take great pride in the city’s three parks, and the city is surrounded by farms that are a very important element to the city’s strength.

Natural Hazard Risks: Over the years, there have been improvements in the community resulting from changes made in farming practices utilized that greatly reduced the amount of damage to property caused by flash flooding. Specifically, the fields that feed into Rietmann and Lorraine Canyons became less of a threat due to a change in farm practices in this area. When the farmers use "no till" methods, the ground is more stable and less apt to move during heavy rainfall. Any water that does run down those two canyons will flow through a large culvert and into the drainage ditch. The water then flows west of town to an open area and dissipates into the ground and into Willow Creek.

The Fire District requires burning permits for all burning. This is a safeguard against uncontrolled fires. Burn bans are during the hottest, driest months to prevent fires. The danger of fire increases during wheat harvest when it is hot, and the wheat is ripe and dry. Overheated equipment can contribute to sparking a fire.

4. *City of Irrigon*

The City of Irrigon, incorporated in 1957, is also in northeastern Oregon, along the Columbia River and Interstate 84. It has an elevation of almost 300 feet above sea level and has a total area of 1.45 square miles. The city has two parks, the City Park, which fronts State Highway 730, and Marina Park, which is located along the Columbia River.

Human Population: Irrigon is a bedroom community of the larger economic region. Over the almost 2,300 residents, the demographics of the town has a large Hispanic or Latino population (36.0%). The importance of language for emergency communications is elevated in Irrigon, especially with approximately 10% of the population who are not highly proficient in English. Communication in both Spanish and English during common hazard event such as extreme heat event or a wildfire is important to reduce risk. The elderly and disabled populations are also significant, so communication methods are also an important topic in Irrigon for risk reduction through communication.

Economic Assets: Local businesses operate as essential facilities during times of actual or potential power outages. People depend on the Irrigon grocery/gas station (Huwe's) for batteries, water, ice, food, and fuel needs, as well as other essentials. There has been consensus that this local market should be identified as an essential economic asset for Irrigon. Other local restaurants and the bank were also identified as essential economic assets. The city also has various home-based businesses, a post office and local fruit stands. Irrigon has a Shell gas station and a 76 gas station as well as a Dollar General store.

Environmental Assets: Irrigon has two parks, which include the park and marina on the Columbia River and the City Park on Main Street, which fronts State Highway 730.

The Irrigon Marina Park, located along the river, is a beautiful, family-oriented park that offers boating from the public access boat ramp, Marina facilities, picnic, fishing and playground activities in a tranquil, scenic riverside setting. This park is the site of the annual Irrigon Watermelon Festival, One Plug Derby fishing tournament and co-host to summertime Music in The Park performances.

Cultural and Historic Resources: Irrigon has several cultural and historical resources that are beneficial and meaningful to the community, including the Heritage Trail, Wildlife Refuges, cemeteries, and the Oregon Trail Spur, all of which are vulnerable to wildfire. The Paterson Ferry dock and the old train docking area are also important city facilities.

Infrastructure and Critical Facilities: The city depends on a sewer system and a water system comprised of two water wells and booster stations which supply the city with drinking water. Updates have been made over the year to the potable water system, including a new storage tank south of the city on Division Street, a new water treatment facility, obtaining new sources of water and the beginning stages of replacing selected water mains, fire hydrants and residential supply piping. The wastewater treatment updates include a new, larger wastewater treatment facility that reduced the level of nitrates in the effluent; the addition of 173 new sewer services and the continuing conversion of the old style residential septic/sewer hybrid systems to conventional sewer systems.

The city schools, Irrigon Medical Clinic, Irrigon Rural Fire Protection District facilities, and City Hall are critical facilities. The churches in Irrigon may also function as essential facilities following a disaster to provide food to people in need during an emergency. The Morrow County Government Building, which is located in Irrigon, houses the Sherrif's Office, Justice Court, Veteran's Services, Public Transit (The Loop), Planning, and Administrative offices.

As part of a partnership through the Chemical Stockpile Emergency Preparedness Program (CESPP), the city has prepared for a chemical disaster, including ensuring that evacuation transportation is available for emergencies.

5. Town of Lexington

The Town of Lexington, incorporated in 1903, and is located between the Columbia River to the north and the Blue Mountains in the southeast. The town is also located along Highway 74 and is primarily an agricultural community.

Human Population: Lexington is the smallest incorporated jurisdiction in Morrow County, with a population of approximately 250 residents. School-age children attend classes in Heppner or Ione. The majority of working adults are employed out-of-town. An estimated 80% of the population is over the age of 15, with 29.3% of the population over the age of 65, making it the jurisdiction with highest proportion of this vulnerable age group in Morrow County.

Economic Base: The traditional economic base for the south Morrow County area, including Lexington, has been dry-land farming and timber. With initiation of the Conservation Reserve Program (CRP) in the 1980's and the decline in the timber industry throughout the 1980's and 1990's, the availability of living-wage jobs dropped off sharply. However, the area still supports a healthy agricultural community, and the overall economic base is bolstered to a considerable extent by jobs available in government, schools and the small hospital located in Heppner. In addition, many residents forced to seek employment elsewhere choose to commute 40 to 60 miles to jobs in the Hermiston, Boardman or Pendleton area rather than move their households.

The primary employers in Lexington include the Morrow County Grain Growers (MCGG) and the local gas station/mini mart, which is owned and operated by Hattenhauer Distributing. There are also several owner-operated shops and businesses, including a restaurant/lounge, a towing service, an auto body/ paint shop, a veterinary clinic, a welding shop, an agricultural spraying operation and loggers.

Environmental Assets: Located in the Willow Creek Valley in southern Morrow County, the area is primarily agricultural and lies approximately forty miles south of the commercial/ industrial developments situated near the Columbia River communities of Boardman and Irrigon approximately 25 miles to the east. While the surrounding topography is of the rolling-hills/ steppe-type environment, the Town lies at the convergence of Willow Creek and Blackhorse Canyon, two significant drainage areas chronically susceptible to flash-flooding.

Transportation Resources: Currently, Lexington's transportation needs are served almost exclusively by roadways. The primary north-south conduit is State Highway 207 running from Lexington north to intersect with 1-84 near Hermiston. State Highway 74 passes through Heppner and proceeds down the Willow Creek Valley to the Columbia River, connecting Heppner, Lexington, and Ione. Bombing Range Road intersects Highway 207 ten miles north of Lexington and provides the most direct route from south Morrow County to the communities of Boardman and Irrigon, as well as the Port of Morrow facilities located on the Columbia River.

Lexington is also bordered on the north by Lexington Airport, which is owned and operated by Morrow County. Although an uncontrolled field, airport facilities are adequate for use by small jets and would be available in emergency situations for the movement of supplies and personnel, including medical transport. Currently, the airport is used primarily by one agricultural spraying operator, a few private recreational pilots, several guided-hunt businesses, and the Morrow County Grain Growers.

Public Transportation: Public transportation is limited in Lexington to primarily The Loop, part of Morrow County Public Transit, and special bus services provided for senior citizens. This service regularly transports seniors to the Hermiston/Pendleton areas for shopping, entertainment, health care and social purposes.

Water System: The water system currently draws water from one source- a well located about ¼ mile south of the town limits at the edge of the town Cemetery and provides water utility to 125 local metered customers. The elevation at that site allows water to be provided by gravity flow to all but the hillside properties on the north side of Willow Creek. A booster pump is necessary to supply water to the residence near the top of the hill. The water from this well is of excellent quality and does not require daily chlorination.

Wastewater System: Lexington has no public sewer system. All homes and businesses are served by on-site septic systems.

Critical Infrastructure: In addition to the town's water system, Fire department, and town hall, the town recognizes the vital importance of its three bridges. One is located on Highway 74 and crosses the Blackhorse Canyon drainage ditch. The second also bridges Blackhorse on Arcade Street one block farther south from the State Highway. The third crosses Willow Creek on B Street, which then connects with Cemetery Hill Road. The route across the B Street Bridge is the sole means of access to the Town's water well. The other two bridges provide the only means of traversing Blackhorse Canyon in order to reach the nearest emergency medical facilities at Pioneer Memorial Hospital in Heppner.

Approximately one-half of the town's residents live on the west side of Blackhorse. If unable to reach Heppner the nearest alternative medical facilities are in Hermiston, about 45 miles north.

The towns' water mains also cross Willow Creek (in two places) and Blackhorse (in two places.) The mains are buried rather than supported on the bridge. One more important crossing should be made at the Arcade St. Bridge to loop the system for better fire flow and less water contamination from dead end pipes.

Cultural and Historical Interests: Lexington has several cultural and historical resources that are beneficial and meaningful to the community, including the Lexington Community Church, the Holly Rebekah Lodge and the worn antique that once housed the Lexington Telephone Exchange.

Holly Rebekah Lodge was Initially constructed and operated as the "Leach Mercantile Store", but currently provides its facilities for reunions, bridal showers, and club meetings, and for a time housed a popular dance hall.

The Lexington Community Church is probably best known for having been swept off its foundations during the Heppner Flood of 1903 (which, after demolishing Heppner, roared on to wreak havoc in Lexington and Ione.) Originally established in 1899 as the Methodist Episcopal Church, it rode the flood down the street and crashed into the Congregational Church- the only other church in town. Retrieved, replaced, and restored, it continues to serve the Lexington community today at its original site.

Lexington has also preserved a grist stone salvaged from its original flour mill. The stone is mounted on a concrete foundation, emphasizing the community's wheat-and-barley economic tradition. Other items of historical interest include the school bell which once called the Lexington Jackrabbits to classes, and a mammoth tusk discovered near Blackhorse Canyon on the northeastern edge of town. The three-story school, built in 1915 of brick and mortar, closed its doors to students in 1963 and to school offices in 2013. The brick-and-mortar construction is deteriorating and costly to repair, as well as dangerous should an earthquake event happen.

Government Structure and Resources: Lexington is governed by a Town Council comprised of four Council Members and a Mayor. All government officers are volunteers and unpaid, including the Chief of Lexington Volunteer Fire Department. In 2012 Town Hall and the Fire Department moved from Main Street out of the flood plain, to 425 F Street. A remodel was done for the town hall and a new fire station was built by a bond voted on by community members, along with FEMA moneys and a Wild Horse grant.

Lexington employs two people, a Clerk/Recorder and a Maintenance Technician. These two people are responsible for all the daily activities of the town and are the only people likely to be on-site at the commencement of any emergency.

Emergency Responses: Although Lexington is very proud of its fire department- the town's sole formal emergency service- the truly invaluable assets available to the town are its people. One example was demonstrated on August 6, 2006, when the well pump simply stopped pumping. The town held a 3–7-day supply of water in the reservoir. A coordinated effort by council members and neighbors willing to be pressed into service to hand deliver notices. A combined effort ranging from voluntary water use stoppage by town residents to neighborly assistance with potential livestock watering, and state resources to replace the pump return the town reservoir to ¾ full condition within a 36-hour period. [34] The cohesion of the Town of Lexington’s response shows capacity for emergency response. This may also represent the potential capacity to conduct mitigation efforts.

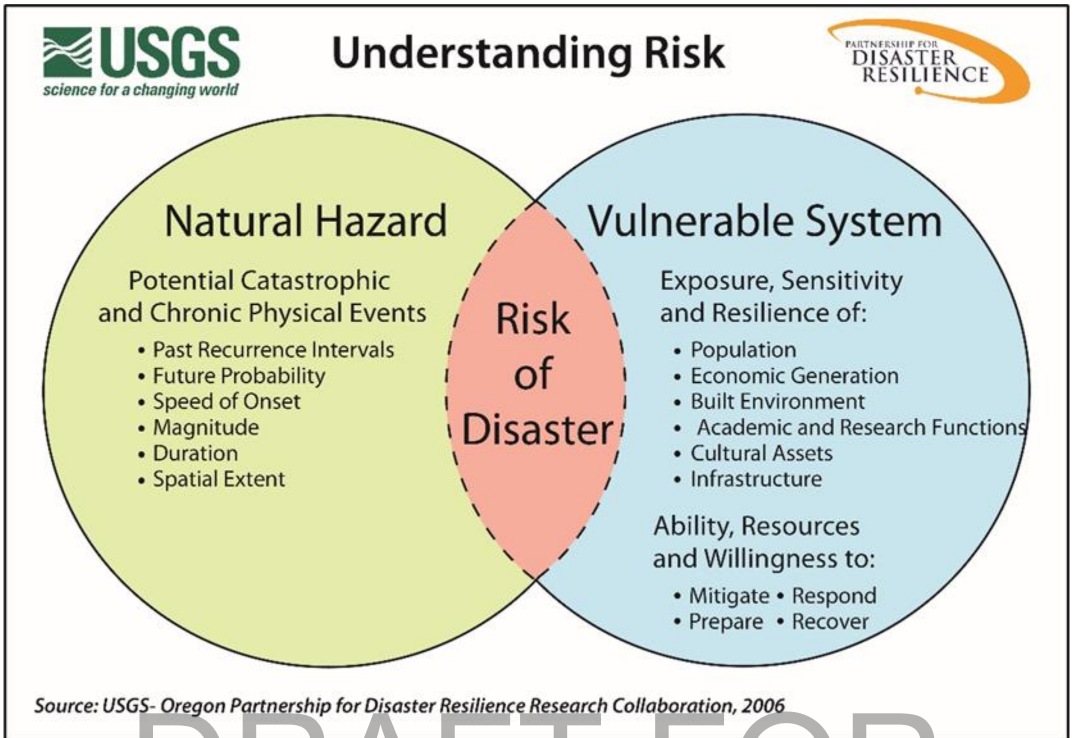
III. HAZARD RISK ASSESSMENT

This section serves as the factual basis for Morrow County and its participating jurisdictions address Oregon Statewide Planning Goal 7 – Areas Subject to Natural Hazards. The Risk Assessment applies to Morrow County and participating jurisdictions included in the NHMP. This plan addresses city specific factors to risk assessment within the City Addenda in Volume II.

The plan uses the information presented in this section, along with community characteristics presented in Chapter 2 to inform the risk reduction actions identified in Chapter 4. Figure 13 shows how the Steering Committee conceptualized risk in this NHMP. Ultimately, the goal of hazard mitigation is to reduce the area where hazards and vulnerable systems overlap.

[34] 2016 Morrow County NHMP-Cities, page 113-114.

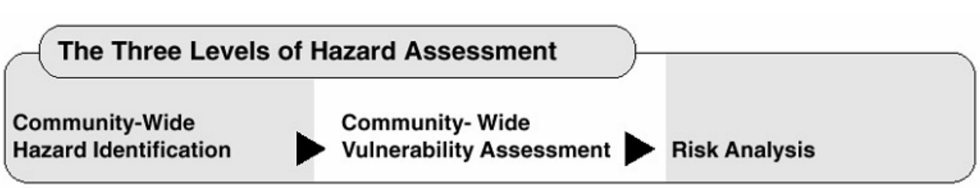
Figure 13. Understanding Risk



Evaluating the risk of natural hazards consists of three phases: hazard identification, vulnerability assessment, and risk analysis, as illustrated in the following graphic:

- **Phase 1**: Identify hazards that can impact the jurisdiction. This includes an evaluation of potential hazard impacts – type, location, extent, etc.
- **Phase 2**: Identify important community assets and system vulnerabilities. Example vulnerabilities include people, businesses, homes, roads, historic places, and drinking water sources.
- **Phase 3**: Evaluate the extent to which the identified hazards overlap with, or have an impact on, the important assets identified by the community.

Figure 14. Three Phases of a Hazard Assessment



Source: Planning for Natural Hazards: Oregon Technical Resource Guide, 1998

This three-phase approach to developing a risk assessment should be conducted sequentially because each phase builds upon data from prior phases. However, gathering data for a risk assessment need not occur sequentially.

The following risk assessment draws upon five sources: 2017 Morrow County Multi-Jurisdictional NHMP, a Hazard Vulnerability Assessment exercise conducted with Morrow County NHMP Steering Committee, the Oregon Department of Geology and Mineral Industries (DOGAMI) Multi-hazard Risk Report for Morrow County, the Oregon Climate Change Research Institute's Future Climate Projections for Morrow County, and the list of critical facilities and infrastructure compiled by the individual jurisdictions.

A. Hazard Identification

Hazard identification involves the identification of the geographic extent of a hazard, its intensity, and its probability of occurrence. This level of assessment typically involves producing a map. The outputs from this phase can also be used for land use planning, management, and regulation; public awareness; defining areas for further study; and identifying properties or structures appropriate for acquisition or relocation.[35]

A comprehensive overview of each identified hazard is provided, which includes an in-depth discussion of the characteristics and causes of each natural hazard, its previous incidences and impacts on Morrow County, and the extent to which Morrow County and its residents are vulnerable to each individual hazard based on population characteristics, infrastructure, and environment.

In the 2016 Morrow County Multi-Jurisdictional NHMP, the County identified ten major hazards that consistently affect Morrow County: Drought, Earthquake, both Crustal and Cascadia Subduction Zone, Flood, Landslides, Wildfire, Windstorm, Thunderstorm, Winter Storm, and Volcanic Event. During the NHMP update process in 2024, the Steering Committee members and the project managers identified three additional natural hazards, Dam Safety, Air Quality and Extreme Temperatures. This Plan addresses a total of thirteen natural hazards.

Another change made to the list of natural hazards addressed in the plan was the reconsideration of the impact of climate change. As part of the NHMP update process, FEMA requires that changes in the climate and future climate variability and its impact on climatic natural hazards are examined. The information discussed in these sections have been compiled from studies conducted by the Oregon Climate Change Research Institute (OCCRI), with the primary source being the Future Climate Projections, Morrow County, Oregon (2023), with additional information from the Sixth Oregon Climate Assessment (2023).

Climate change and climate resilience are important parts of this discussion. The climate is changing, and the impacts are becoming more evident through both quantitative and qualitative research and data. The NHMP Steering Committee agreed that climate change is experienced in the increased severity and frequency of natural hazard events and will be addressed throughout the NHMP. The natural hazards examined through a future climate variability lens are climate-related hazards, which include drought, extreme heat, flood, landslides, wildfire, windstorm, and winter storm as well as invasive species and air quality impacts.

[35] Burby, 1998, Cooperating with Nature: Confronting Natural Hazards with Land-Use Planning for Sustainable Communities (Natural Hazards and Disasters).

1. Federal Disaster and Emergency Declarations

Reviewing past events that have occurred in an area can provide a general sense of the hazards that have caused significant damage to the County and the cities. Where trends emerge, disaster declarations can help inform hazard mitigation project priorities.

Federally declared disasters have been approved within every state because of natural hazard related events. As of October 2023, FEMA has approved a total of 40 major disaster declarations, 101 fire management assistance declarations and four (4) emergency declarations in Oregon. [36]

When requesting a presidential declaration for a major disaster or emergency, governors provide detailed information about the amount of value of public and private property damage resulting from the event. FEMA uses these damage assessments to determine if the event meets the disaster declaration threshold. In addition, FEMA uses the information to determine the amount of federal public and private assistance being made available as well as the specific counties being included in the declaration.

Table 35. FEMA Major Disaster Declarations for Morrow County

Declaration Number	Declaration Date	Incident(s)	Incident(s) Period
Major Disaster Declarations			
DR-4499	Mar. 28, 2020	Oregon Covid-19 Pandemic	Jan. 20, 2020 - May 11, 2023
DR-1510	Feb. 29, 2004	Oregon Severe Winter Storms	Dec. 26, 2003 - Jan. 14, 2004
DR-1160	Jan. 23, 1997	Oregon Severe Winter Storms/flooding	Dec. 25, 1996 - Jan. 6, 1997
DR-1099	Feb. 9, 1996	Oregon Severe Storms/flooding	Feb. 4, 1996 - Feb. 12, 1996
DR-184	Dec. 24, 1964	Oregon Heavy Rains & Flooding	Dec. 24, 1964
Emergency Declarations			
EM-3429	Mar. 13, 2020	Oregon Covid-19	Jan. 20, 2020 - May 11, 2023
EM-3228	Sep. 7, 2005	Oregon Hurricane Katrina Evacuation	Aug. 29, 2005 - Oct. 1, 2005
EM-3039	Apr. 29, 1977	Oregon Drought	Apr. 29, 1977

Source: Federal Emergency Management Agency, consulted February 2024 Disasters and Other Declarations | FEMA.gov

Disaster declarations can help inform hazard mitigation project priorities, by demonstrating and documenting which hazards historically have caused the most significant damage to the County. Table 35 summarizes the major disasters declared for Morrow County by FEMA since 1964. The table shows that there have been five (5) major disaster declarations and three (3) emergency declarations on record for the County. The table shows that recent major disaster declarations in Morrow County have primarily been flood and weather related.

[36] Declared Disasters | FEMA.gov. Accessed October 12, 2023

2. Hazard Profiles

The following subsections describe relevant information for each hazard. For additional background on the hazards, vulnerabilities, and general risk assessment information for hazards in Southwest Oregon (Region 4), refer to the State of Oregon NHMP, Region 4, Southwest Oregon Risk Assessment (2020).

Air Quality

Air Quality Risk Ranking Summary	
Probability	**Updates Made**
North County: High **South County: High**	-New Hazard
Vulnerability	
North County: Moderate **South County: High**	

Characteristics

Communities across Oregon have begun to recognize the impacts of inversion layers trapping particulates in smoke from wood stoves, prescribed fire, wildfire, and field burning as a natural hazard. In addition, Morrow County residents have begun to recognize the impacts of reduced outdoor air quality with warmer temperatures and increase in the number and size of wildfires in the region.

The nature of air movement or stagnation in a valley causes inversion layers to form. At the valley floor daytime temperatures heat the air. In the evening, air further up the slope of the mountains cools faster than the air lower down the slope. Because cool air is slightly heavier than warm air, the cool air sinks into the valley which displaces the warm air above it to form a "lid." If the weather creates stagnant conditions this inversion "lid" may persist trapping air pollutant discharges to create poor air quality.

The Oregon Climate Change Research Institute's Future Climate Projections Morrow County, Oregon report discusses how fire seasons have increased in length, intensity and severity over the past several decades. Wildfires that have occurred in the western United States have created extensive plumes of smoke, which travel at high altitudes over long distances. This can affect air quality near and far from a wildfire site. The trend is expected to continue to grow as the effects of climate change grow, as the population density in fire-risk zones increases.

Air quality can be affected by several types of pollutants including ozone, particulate matter, air toxins (such as benzene), greenhouse gases (such as carbon dioxide), and products of combustion (such as carbon monoxide, sulfur dioxide and NOx). Among these, particulate matter with particles 2.5 microns or smaller ($PM_{2.5}$) is the pollutant of highest concern for Morrow County.

Wildfires[37] tend to provide a wide-ranging source of smoke that can blanket large areas and be detrimental to the health of all people, animals, and plants in the affected area. Diesel emissions, often from vehicles on roads, also contribute to lower air quality for people who live in areas near highly traffic roads. If a volcano were to erupt, ashfall could inundate the surrounding areas sufficiently to impact transportation and cause widespread health concerns.

Air Quality Pollutants

Oregon DEQ monitors air quality pollutants. DEQ operates the ambient monitoring network for the entire state, except Lane County, which is operated by the Lane Regional Air Protection Authority (LRAPA). These air quality monitoring networks measure ambient concentrations of the criteria pollutants – ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead.

OZONE

DEQ's Oregon Air Quality Monitoring Annual Report: 2020 (2021) describes Ozone as secondary pollutant formed when there are elevated levels of nitrogen dioxide and volatile organic compounds that undergo chemical reactions in high temperatures, and sunlight. In Oregon, elevated ozone occurs in the summer and can also be formed by human-caused pollution, such as fossil fuel combustion and by naturally caused pollution from wildfire smoke, which contains NO2 and VOCs.

Data with wildfire contributions are included because it is very difficult to determine if the ozone would have exceeded the NAAQS without the smoke from wildfires. Additionally, it is noted that the wildfire smoke in 2018 and 2020 contributed to the elevated ozone levels, which likely caused Portland and Medford to violate the NAAQS. However, it is very difficult to determine what the ozone level would have been since high levels typically occur in the summer months, which is also during wildfire season.

The 2022 Oregon Annual Ambient Criteria Pollutant Air Monitoring Network Plan describes the 10 DEQ and LRAPA monitoring sites for ozone.

$PM_{2.5}$

Fine particulate matter ($PM_{2.5}$) is a concern due to smoke impacts from woodstoves, fireplaces and other wood burning appliances besides wildfire smoke in the summer. Other sources of $PM_{2.5}$ include open burning, prescribed burning, wildfires, smoke from industrial stacks, and some road dust from vehicle travel.

The Future Climate Projections report issued by OCCRI stated that with the increasing wildfires and $PM_{2.5}$ levels, there is a greater risk of wildfire smoke exposure through increasing frequency, length, and intensity of "smoke wave" days. "Smoke wave" days are two or more consecutive days with high levels of $PM_{2.5}$ from wildfires.

There are harmful effects from breathing particles measuring less than 10 microns in diameter (PM_{10}). Fine particle matter $PM_{2.5}$ may be responsible for the most significant health effects, like

[37] See the Wildfire Hazard for more information about wildfire impacts.

hospital admission, and respiratory illness. These particles can be inhaled deeply into the lungs where they enter the bloodstream or can remain for years. The health effects of particulate matter vary with the size, concentration, and chemical composition of the particle, according to the EPA.

Numerous scientific studies, according to the EPA's Particulate Matter (PM) Pollution, have linked particle pollution exposure to problems, including premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, and increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

Morrow County has no air quality stations within its borders, and therefore depends on regional data that tracks poor air quality conditions available through three monitoring stations in Umatilla County and two stations in Grant County. Data from these sources is shown below in Figure 17 and Figure 18 for a period of over fourteen years (2010 – 2024).

CARBON MONOXIDE, SULFUR DIOXIDE, NITROGEN DIOXIDE

Carbon monoxide was above the standard in the Portland Metro area for three days during the wildfire impacts. Otherwise, for the rest of the year carbon monoxide, sulfur dioxide, and nitrogen dioxide [met] federal health standards. These pollutants, according to the *Oregon Air Quality Monitoring Annual Report: 2020* (2021)[38], have been trending mostly downward for most locations over the last ten years.

AIR TOXICS

The Oregon Air Quality Monitoring Annual Report: 2020 (2021) describes data for the toxics, or hazardous air pollutants, of concern: benzene, tetrachloroethylene, acetaldehyde, formaldehyde, naphthalene, arsenic, cadmium, chromium, lead, manganese, and nickel. According to the annual report, the values are compared to the Oregon ambient concentration health benchmarks. These benchmarks are the levels where people exposed for a lifetime have an additional one in a million risk of cancer or of experiencing non-cancer health effects. The information provided in the report is for neighborhood monitoring only and does not include monitoring next to industrial facilities. Information regarding monitoring next to industrial facilities is presented in separate reports issued by the Oregon Health Authority, specific to the monitoring project and facility.[39]

GREENHOUSE GASES

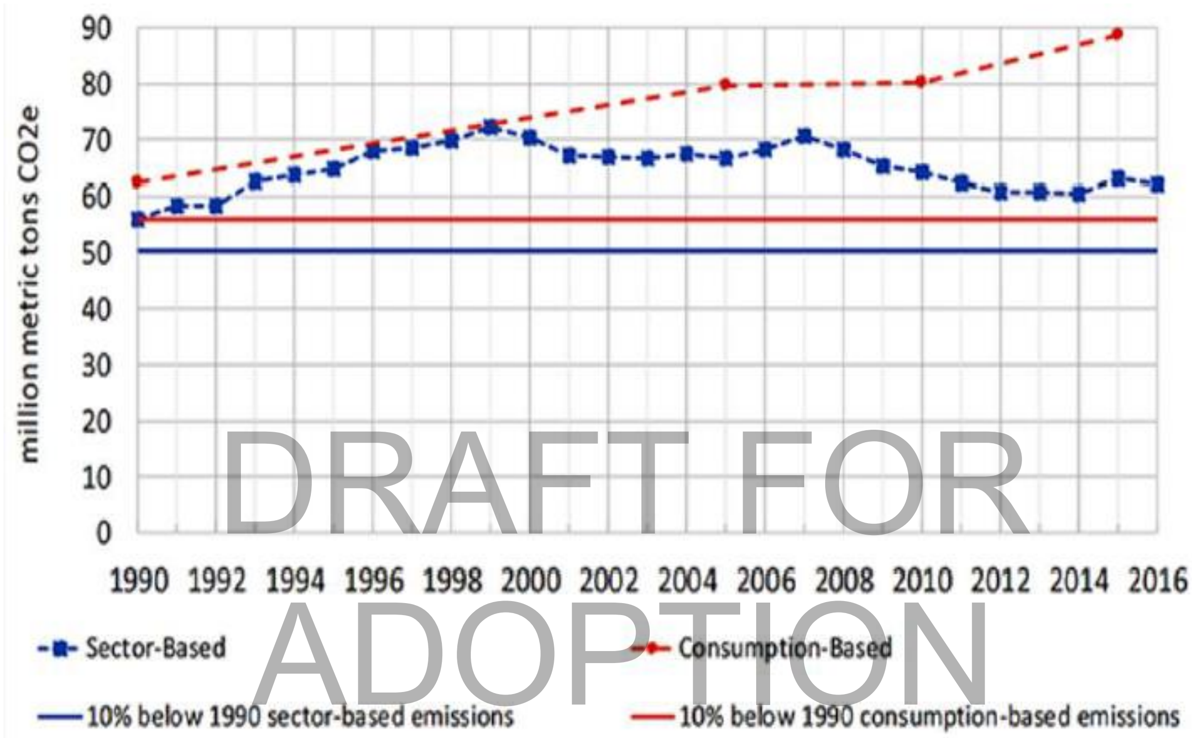
Greenhouse gas emissions are produced directly from activities such as driving cars and heating homes. Also, greenhouse gas emissions are indirectly contributed by the purchasing of goods and foods that are manufactured in other states or counties, due to the excess energy and electricity required to transport the goods. Additional information about greenhouse gas

[38] 2020 Annual Report (state.or.us)
[39] Ibid.

emissions in Oregon are presented on DEQ's website at https://www.oregon.gov/deq/ghgp/Pages/GHG.aspx.

Figure 15 is excerpted from the Oregon Air Quality Monitoring Annual Report: 2020 (2021) report and shows Oregon's greenhouse gas emissions from 1990 through 2016 by sector. Emissions from transportation and electricity use are identified as Oregon's largest sources of greenhouse gas emissions. [40]

Figure 15. Oregon Total Greenhouse Gas Emissions by Sector 1990-2016



Source: Oregon Department of Environmental Quality, 2021. 2020 Annual Report (state.or.us)

Location and Extent

Poor Air Quality has seasonality in that inversion layers tend to form from November to February. Once air temperatures warm the inversion layer conditions dissipate. During the summer months from June through August high pressure weather systems can remain in place for an extended period resulting in the accumulation of airborne particles in the lower levels of the atmosphere affecting the air quality. In addition, smoke from surrounding fires could impact Morrow County and affect the air quality prompting Air Stagnation Advisories[41]. Figure 16 shows the 2022 Ambient Air Monitoring Network sites in Oregon. In addition, the figure shows the types of air quality monitoring stations near Morrow County.

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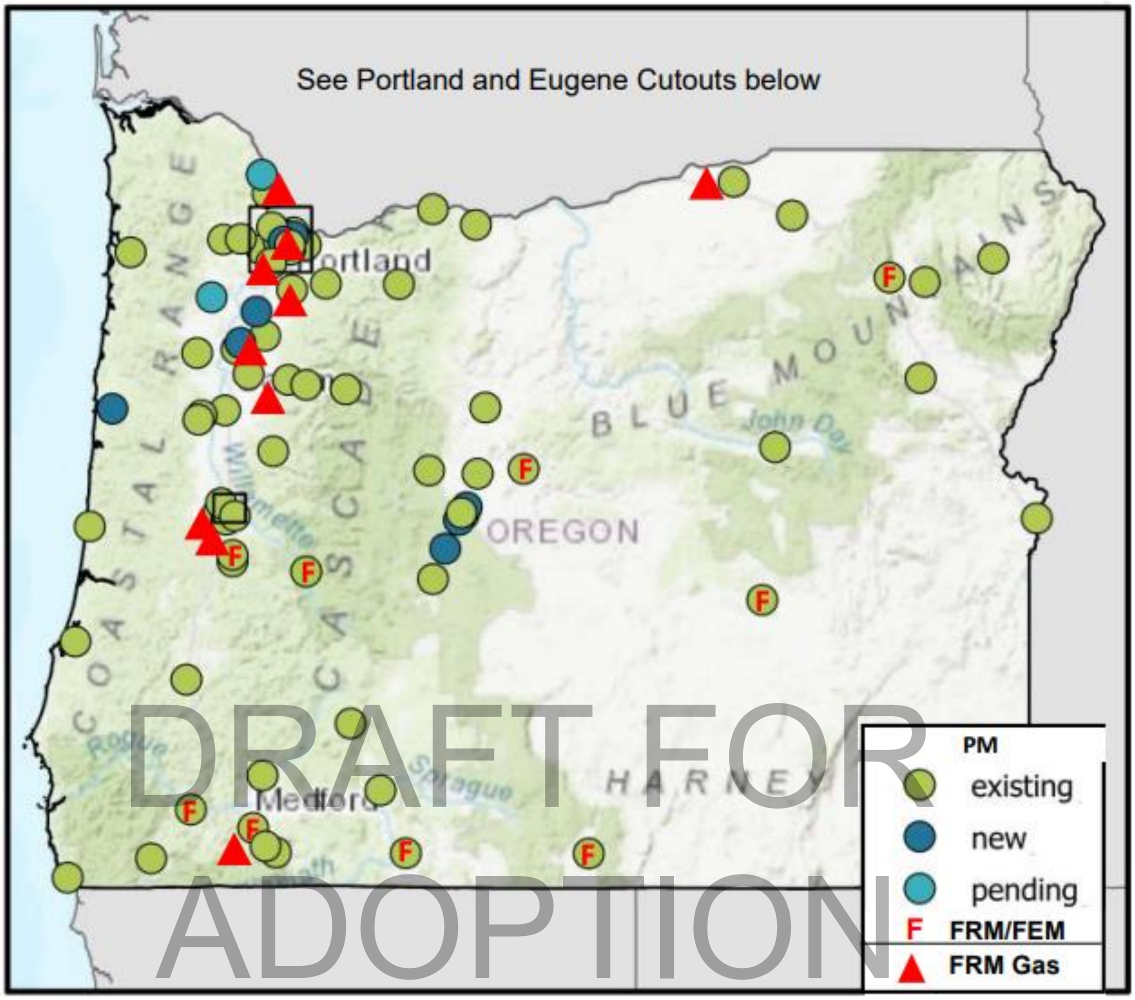
40 2020 Annual Report (state.or.us)

41 *Future Climate Projections Morrow County, Oregon*

Figure 16. Oregon Ambient Air Monitoring Network



Source: Oregon Department of Environmental Quality, 2022
Note: Portland metro and Eugene metro cutouts are not shown here.

Identifying Poor Air Quality

Air quality is determined by both measurements of specific poor air quality components (discussed above) and a general Air Quality Index (AQI).

The Air Quality Index (AQI) is a daily index of air quality that reports how clean the air is and provides information on potential health risks. Oregon's index is based on three pollutants regulated by the federal Clean Air Act: ground-level ozone, particle pollution, and nitrogen dioxide. The highest of the AQI values for the individual pollutants becomes the AQI value for that day. For example, if values are 90 for ozone and 88 for nitrogen dioxide, the AQI reported would be 90 for the pollutant ozone on that day. A rating of good, moderate, unhealthy for sensitive groups, unhealthy, very unhealthy, and hazardous are designated for the AQI providing a daily air quality rating (Table 36). The EPA provides all states with the AQI equation for national uniformity.

Table 36. Air Quality Index Ranges and Episode States for $PM_{2.5}$ and ozone

Air Quality Rating	Air Quality Index (AQI)	$PM_{2.5}$ 24-hour Average (µg/m³)	Ozone 8-hour Average (ppm)
GOOD	0 - 50	0.0 - 12.0	0.000 - 0.054
MODERATE	51 - 100	12.1 - 35.4	0.055 - 0.070
UNHEALTHY FOR SENSITIVE GROUPS	101 - 150	35.5 - 55.4	0.071 - 0.085
UNHEALTHY	151 - 200	55.5 - 150.4	0.086 - 0.105
VERY UNHEALTHY	201 - 300	150.5 - 250.4	0.106 - 0.200
HAZARDOUS	>300	>250.5	>0.200

Source: Oregon Department of Environmental Quality, 2021

According to Oregon Air Quality Monitoring Annual Report: 2020 (2021)[42], the air pollutants of greatest concern in Oregon were the following:

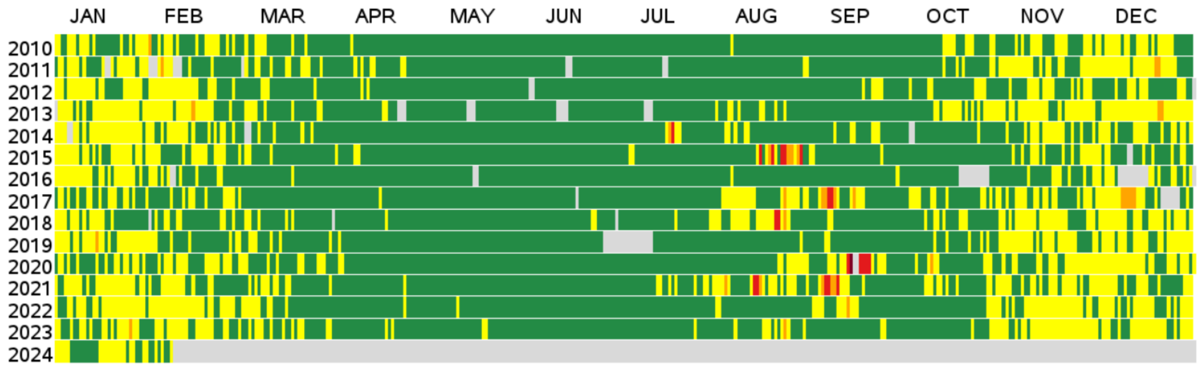
- Fine particulate matter (mostly from combustion sources) known as $PM_{2.5}$
- Air Toxics - pollutants that cause or may cause cancer or other serious health effects.
- Ground-level ozone, a component of smog.
- Greenhouse gas (GHG) emissions and global climate change. These are an overall issue across all of Oregon but of more concern in higher population density areas.

History

While Morrow County has no air quality stations within its borders, regional data that tracks poor air quality conditions is available through three monitoring stations in Umatilla County and two stations in Grant County. Figure 17 and Figure 18 below both show a pattern of periods of the year where the likelihood of high levels of particulate matter of this diameter (2.5 microns) have been present at these stations. One example that can be seen to affect both regions is during the September 2020 wildfires, which is depicted in dark red, and during which both counties experienced extremely poor air quality.

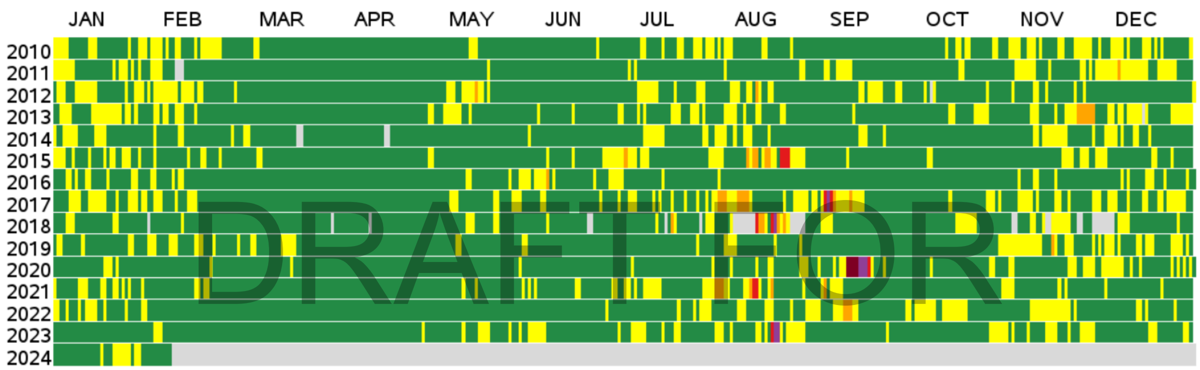
[42] *Oregon Air Quality Monitoring Annual Report: 2020* (2021)

Figure 17. Daily AQI Values, 2010 to 2024 of Umatilla County, OR



Source: U.S. Environmental Protection Agency, 2024

Figure 18. Daily AQI Values, 2010 to 2024 of Grant County, OR



Source: U.S. Environmental Protection Agency, 2024

Collecting data to demonstrate the problem and determine the severity of poor air quality may provide support for mitigation actions aimed at managing prescribed burning, reduction of the risk of high intensity wildfire, and support for mitigation actions aimed at providing relief for vulnerable people during poor air quality conditions. The EPA Ambient Monitoring Technology Information Center (AMTIC) provides information on monitoring programs and methods, quality assurance and control procedures, and federal regulations.

Poor Air Quality Risk Assessment

This hazard has been added to the 2024 Morrow County MJ NHMP.

Probability Assessment

As previously noted, communities across Oregon have begun to recognize the impacts of inversion layers trapping particulates in smoke from prescribed fire, wildfire, and field burning as a natural hazard. In addition, it is important to recognize the impacts of reduced outdoor air quality with warmer temperatures, in which warmer temperatures may increase ground-level ozone concentrations and increase in the number and size of wildfires in the region.

Depending upon climate conditions, air stagnation events can vary from infrequent to numerous in any given year. These conditions have the potential to impact air quality levels for both $PM_{2.5}$ and ozone in the area. Prevailing wind direction and strength can influence the location and extent of the air quality impacts. Air quality is based on multiple factors such as those measured for carbon monoxide, particulate matter (PM_{10} and $PM_{2.5}$), ozone, and others described above.

The sources of air pollution in the region include prescribed fire, wildfire, and field burning, industrial, and motor vehicle emissions. Concerns for air quality arise when smoke from regional wildfires either blows through the Columbia Gorge or becomes trapped during inversions. See the Wildfire Hazard for more information about wildfire impacts. In addition, climate change impacts multiple natural hazards, including wildfire, drought, flood, and extreme heat as discussed below.

The OCCRI Future Climate Projections Morrow County, Oregon report states that outdoor air quality will continue to deteriorate, in part due to the growing number of wildfires and increased amounts of fine particulate matter from wildfire smoke. Increased ozone concentration along with longer and more intense pollen seasons will contribute to this deterioration in air quality. Diminished air quality will significantly impact human health, exacerbating allergy and asthma conditions, as well as increasing incidences of respiratory and cardiovascular illnesses and conditions. Air quality will significantly impact more vulnerable and marginalized populations of the region, including children, the elderly, economically disadvantaged communities and outdoor workers. When comparing the time periods of 2004–2009 to 2046–2051, the number of days per year with poor air quality due to elevated concentrations of wildfire derived fine particulate matter is projected to increase by over 150%. Furthermore, the concentration of fine particulate matter on those days is projected to increase by almost 60%.[43]

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed the probability of both regions **experiencing locally poor air quality as "High", meaning one incident is likely within a 10-to-35-year period.**

Vulnerability Assessment

Air Quality is a climate-related driver of health. Causes may include wildfire smoke, smog, and ozone, and potentially pollen. Poor air quality puts the health of all people at risk. However, people experience the impacts differently. According to OCCRI's Sixth Oregon Climate Assessment (2023) inequities and unequal investments in social determinants of health are contributing stress factors and include housing, education, income, race, gender, wealth, transportation access, food security, income security, access to health care. The effects of poor air quality are long-term, chronic, and often difficult to trace.

People most at risk tend to be the elderly, very young children, and people with pre-existing respiratory problems. Furthermore, people of color, people with low incomes, unhoused populations, agricultural workers, first responders, and rescue workers are those most susceptible to wildfire smoke exposure. It has been shown that hospitalizations in Oregon due to asthma attacks disproportionately affect Black, Pacific Islander, and Indigenous people as compared to other racial or ethnic groups, according to Oregon Health Authority. Exposure to smoke compounds this existing disparity.

Additionally, as Morrow County has a large population of outdoor migrant workers, these individuals have greater exposure to poor air, resulting in greater risk of developing poor-air quality related health issues. Air quality mitigation action that reduces this vulnerable population risk is essential, including ensuring these actions are conducted in both English and Spanish.

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[43] OCCRI, Future Climate Projections Morrow County, 2023

Small particles less than 10 micrometers in diameter pose the greatest problems, because they can get deep into lungs and the bloodstream. Exposure to such particles can affect both the lungs and heart. Particulate matter, also known as particulate pollution, is a complex mixture of extremely small particles and liquid droplets that get into the air. Once inhaled, these particles can affect the heart and lungs. The range of air quality pollutants is discussed in the section on Characteristics.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed the **vulnerability of both regions to poor air quality:**

- **North County region vulnerability is "Moderate",** meaning between 1-10% of the region's population and property would be affected by a major air quality emergency or disaster; and
- **South County region vulnerability is "High",** meaning more than 10% of the region's population and property would be affected by a major air quality emergency or disaster.

*This is a **new natural hazard** to the 2024 Morrow County NHMP update.*

Drought

Drought Risk Ranking Summary	
Probability	**Updates Made**
North County: High **South County: Moderate**	-2016 NHMP rated Probability as High -2016 NHMP rated Vulnerability as High -Drought History has been updated to included recent Drought Declarations
Vulnerability	
North County: Moderate **South County: Moderate**	

Drought is a normal, recurrent feature of the climate in Eastern Oregon. The environment and economy of Morrow County is vulnerable to the impact drought can have when there is a deficiency of precipitation for an extended period, usually a season or more. Also, the impacts of drought are often exacerbated by the demand placed on the water supply in the region's aquifers, high temperatures, high winds, and low humidity. These are all conditions that exist in Morrow County during the summer months. Drought in Morrow County has a serious effect on the local agricultural economy and the associated businesses that depend on the success of the local economy. During times of low regional snowpack in the mountains the resulting restriction on water for irrigation can cause losses to farmers who cannot irrigate their crops as usual, as well for dryland wheat farmers who are coping with lack of local rainfall.

Characteristics

A drought is a period of drier than normal conditions. As a temporary condition, it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate. Furthermore, drought is frequently an "incremental" hazard, meaning the onset and end is often difficult to determine, and its effects may accumulate slowly over a considerable period and may linger for years after the termination of the event. As such, potential impacts vary among communities.

The growing occurrence and severity of other climate-related hazards are exacerbating the severity and probability of drought. Such hazards as extreme heat and wildfires can increase the probability for Morrow County to experience more severe and chronic droughts in the future. Additionally, the diminishing annual snowpack in the Cascades, which is relied upon to replenish water tables throughout the entire County, is also exacerbating the occurrence of drought. Even in a year where precipitation exists within average historical levels, snowpack can still be lower than historical averages due to increases in global temperatures and climate trends, producing what is called a "snow drought".

Another climate-event that can increase the frequency and severity of drought is El Niño Southern Oscillation (ENSO) weather patterns, which El Niño is the warm phase of the ENSO and El Niña is the cooling phase. During their respective time, El Niño conditions lead to wetter, snowier conditions, and cooler maximum temperatures during the winter. La Niña conditions lead to drier and warmer temperatures overall, with notable extreme cold spells. During stronger El Niño or La Niña episodes, these trends are even more pronounced.

Location and Extent

Drought occurs in virtually every climatic zone, impacting many communities and regions, but its characteristics, extent, and impact can vary significantly across the county.

South County

The conifer forests of southern Morrow County suffer in drought conditions and become more vulnerable to pests and wildfire. Drought affects the recreation economy in that summertime visitors who come to the Off-Road Vehicle Park and other recreation facilities are restricted from full use of the facility due to fire bans.

North County

Drought in this region of Morrow County has a clearly detrimental effect on agriculture, which must adjust to low water tables and irrigation restrictions or rely on government support programs and crop insurance. Ranges and pastures become stressed and often over grazed in drought conditions. The usual watering areas may disappear or be negatively affected. Wildfire risks are elevated, and reservoir levels and aquifers diminish. During drought conditions the wildfire risk becomes elevated in the agricultural lands set aside as conservation reserve areas, extensive pastures and ranges, undeveloped shrub-steppe, the Boardman Bombing Range and on the former Army Depot location.

History

The 2024 Morrow County NHMP reports that to assess the severity of the drought, tree ring data from a 275-year tree ring reconstruction (1705-1979) of water year precipitation was consulted. The most significant feature in the last 100 years is a severe and extended drought in the 1930s. The precipitation was below normal for 10 years in a row (1928-1937). The 1999-2005 drought is similar to the 1930s drought in terms of duration and severity. The worst drought years of 2001 and 1977 were probably exceeded in severity by only a few years in the two preceding centuries.

Morrow County has had a State of Drought Emergency declared eleven times, which is shown in Table 37 and Morrow County was declared a Disaster Area by the U.S. Department of Agriculture in September 2001. The 60-month period ending September 2005 was among the driest such October-September month periods in the 111 years. There was no recorded precipitation in the region in August and September 2005, which was unprecedented in 100 years of record.

Drought is typically measured in terms of water availability in a defined geographical area. It is common to express drought with a numerical index that ranks severity. Most federal agencies use the Palmer Method which incorporates precipitation, runoff, evaporation, and soil moisture. However, the Palmer Method does not incorporate snowpack as a variable. Therefore, it is not believed to provide a very accurate indication of drought conditions in Oregon and the Pacific Northwest.

Table 37. State of Emergency Drought Declarations

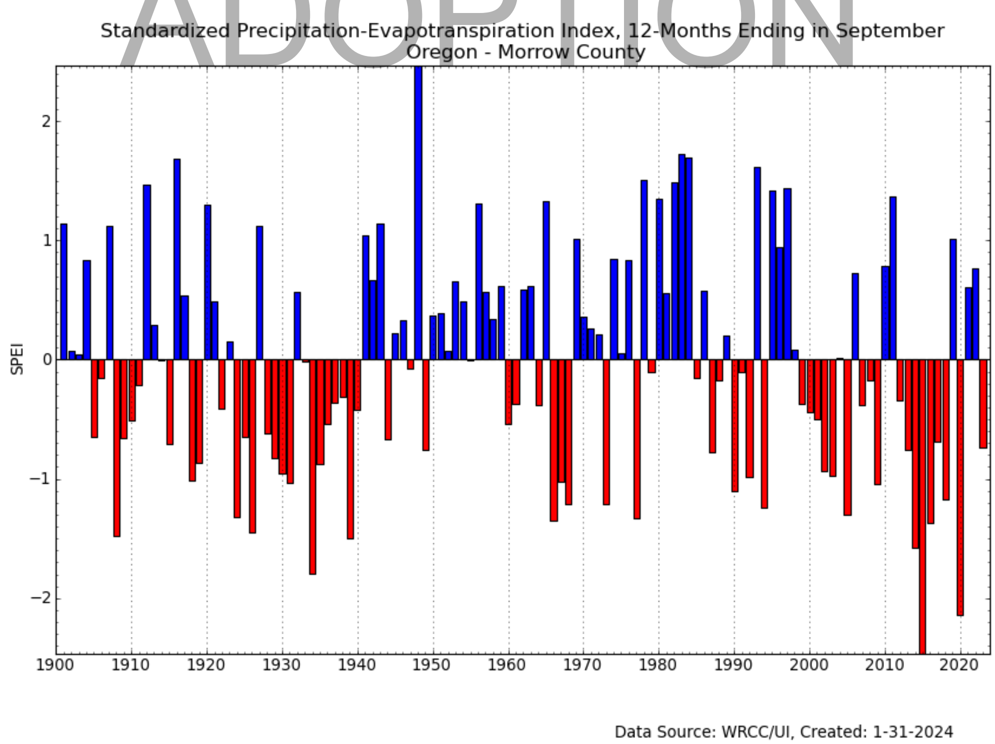
Executive Order Number	Date
Executive Order 92-21	September 3, 1992
Executive Order 01-23	September 17, 2001
Executive Order 03-07	July 16, 2003
Executive Order 04-03	March 31, 2004
Executive Order 05-05	April 7, 2005
Executive Order13-10	August 31, 2013
Executive Order 15-05	May 1, 2015
Executive Order 20-32	July 21, 2020
Executive Order 21-11	May 10, 2021
Executive Order 22-04	March 21, 2022
Executive Order 23-25	November 6, 2023

Source: [Governor of Oregon : Executive Orders : State of Oregon]

Instead, the Standardized Precipitation-Evapotranspiration Index (SPEI) is used, which provides an index of water conditions throughout the state. The index is designed to account for precipitation and evapotranspiration to determine drought. The lowest SPEI values, below -2.0, indicate extreme drought conditions. Severe drought occurs at SPEI values between -2.0 and -1.5, moderate drought occurs between -1.5 and -1.0, and mild drought occurs between -1.0 and 0.

Figure 19 shows the water year (October 1 – September 30) history of SPEI from 1901-2023 for Morrow County.

Figure 19. Standardized Precipitation-Evapotranspiration Index, 12-Months Ending in September, Morrow County, OR (1901-2023)



Source: West Wide Drought Tracker, *Bulletin of the American Meteorological Society*

As seen in Table 38, the SPEI record indicates that the County has experienced only two periods of extreme drought (water years 2015 and 2020) and three years of severe drought, 16 years of moderate drought and 43 years of mild drought. Over the past 30 years, Morrow County was declared to be under drought emergency by the Governor a total of 12 times. [44]

Table 38. Drought Determination Status (1901-2023)

Drought Determination	Total Determination	Determination Years
Extreme	2	2015, 2020
Severe	3	1934, 1939, 2014
Moderate	16	1908, 1918, 1924, 1926, 1931, 1966, 1967, 1968, 1973, 1977, 1990, 1994, 2005, 2009, 2016, 2018
Mild	43	-
No Drought	59	-

Source: West Wide Drought Tracker, *Bulletin of the American Meteorological Society*

Drought Risk Assessment

Probability Assessment

The Oregon Climate Change Research Institute assessed the projected likelihood of drought occurring more frequently in the future due to increasing global temperatures. The report is provided in its entirety as Appendix F.

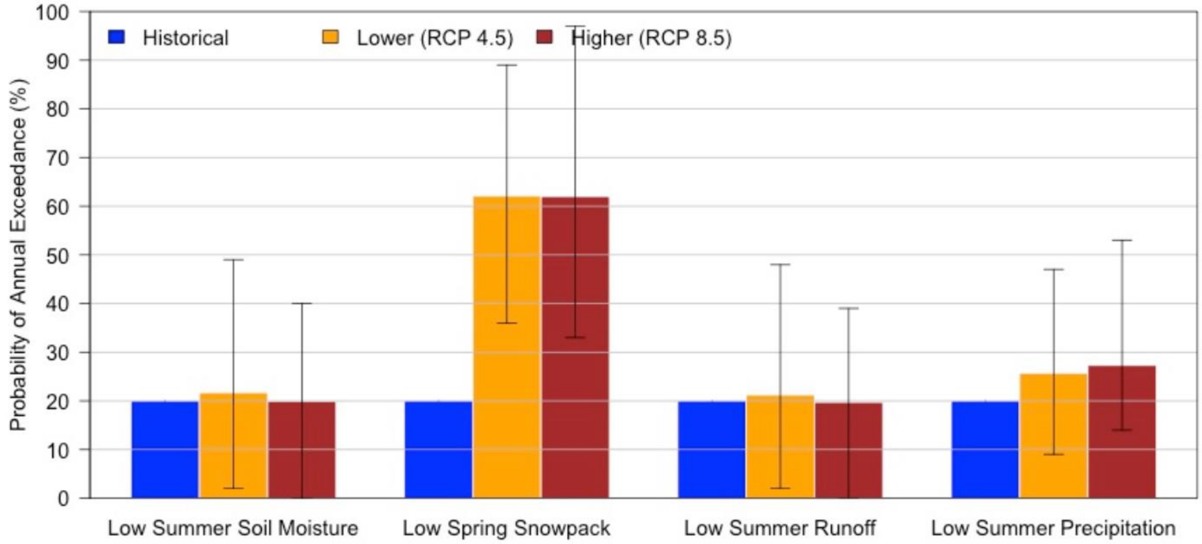
The study estimated that by the year 2100, annual mean precipitation in Oregon will increase by 5-10% (See Figure 20). However, summers will become increasingly drier and warmer, while winters will become warmer. As a result of warmer winters, snowpack across Oregon is projected to decline an estimated 25% by 2050, contributing to reduced summer soil moisture in the mountains and subsequent reduction in summer streamflow. As mountain snowpack declines, seasonal drought will become less predictable and snow droughts will increase the likelihood of hydrological and agricultural drought during the following spring and summer.

The study presents projected changes in four variables indicative of drought: low spring (April 1) snowpack (snow drought), low summer (June–August) soil moisture from the surface to 55 inches below the surface (agricultural drought), low summer runoff (hydrological drought), and low summer precipitation (meteorological drought). The report presents drought in terms of a change in the probability during a 5-year period. (Figure 20).

The research showed that summer precipitation and spring snowpack in Morrow County is projected to decline, but summer soil moisture and runoff are projected to increase. By the 2050s under the higher emissions scenario, the annual probabilities of snow and meteorological drought are projected to increase to approximately 62% (1.6-year return period) and 27% (3.6-year return period), respectively. The annual probabilities of agricultural and hydrological drought are not projected to change substantially.

[44] Oregon Water Resources Department Public Declaration Status Report

Figure 20. Projected Future Drought in Morrow County



Source: OCCRI (2023) Future Climate Projections, Morrow County, Oregon

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **both the North and South regions of the County have a probability of experiencing a severe drought as "High", meaning one incident is likely within a 10-to-35-year period.**

*This **rating has not changed** since the previous NHMP.*

Vulnerability Assessment

The environment and economy of Morrow County is vulnerable to the impact drought can have when there is a deficiency of precipitation over an extended period of time, usually a season or more. Also, the impacts of drought are often exacerbated by the demand placed on the water supply in the region's aquifers, high temperatures, high winds, and low humidity. These are all conditions that exist in Morrow County during the summer months.

Drought in Morrow County has a serious effect on the local agricultural economy and the associated businesses that depend on the success of the local economy. During times of low regional snowpack in the mountains the resulting restrictions on water wells for irrigation cause losses to farmers who cannot irrigate their crops as usual, as well as for dryland wheat farmers who are coping with lack of local rainfall. As the Morrow County economy is significantly reliant on agriculture, drought poses a significant risk to the county, resulting in people, natural resources, and development being vulnerable.

Also, domestic water-users may be subject to stringent conservation measures (e.g., rationing) as per the County's water management plan in times of severe drought. Potential impacts to county water sources that supply the agriculture industry are the greatest threat, as well as the threat posed to forest conditions, which can set the stage for potentially destructive wildfires.

The incidence of related negative physical and mental health outcomes is likely to increase in response, especially among low income, tribal, rural, and agricultural communities.[45] Other issues expected to be exacerbated due to drought include increased food scarcity and increased incidences of infectious, chronic, and vector-borne diseases that are exacerbated in drought conditions.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **the vulnerability of both the North and South regions of the County to a severe drought hazard as "Moderate", meaning 1 to 10% of the regions' population and property would be affected by a major drought emergency or disaster**.

This ***rating has changed for the entire County*** *since the previous NHMP.*

[45] York et al., 2020; Ho et al., 2021

Earthquake

Earthquake - Cascadia Risk Ranking Summary	
Probability	**Updates Made**
North County: Low **South County: Low**	-2016 NHMP rated Probability as Low -2016 NHMP rated Vulnerability as Medium
Vulnerability	
North County: High **South County: Low**	

Earthquake - Crustal Risk Ranking Summary	
Probability	**Updates Made**
North County: Low **South County: Low**	-2016 NHMP rated Probability as Low -2016 NHMP rated Vulnerability as Medium - DOGAMI *Risk Report for Morrow County* for the Horse Heaven Fault
Vulnerability	
North County: High **South County: Low**	

Characteristics

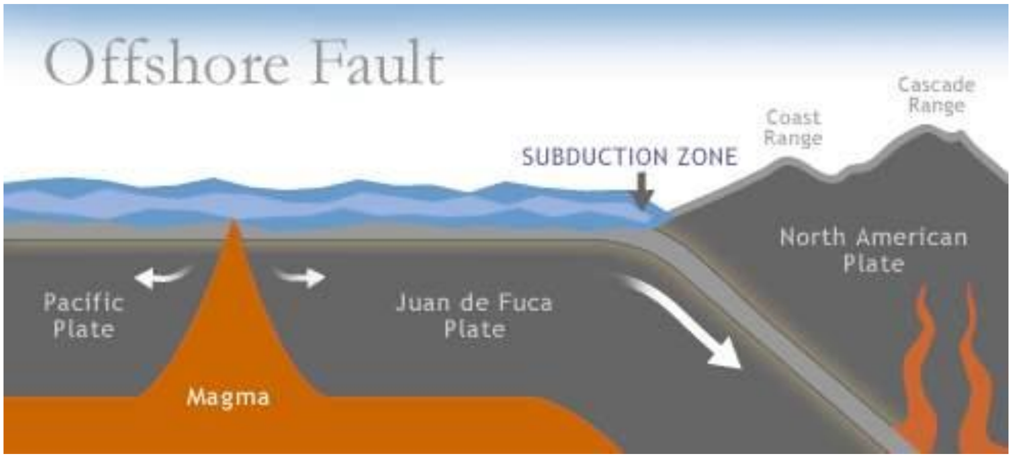
An earthquake is a shaking of the earth's surface by energy waves emitted by movement under the earth's surface, such as the slipping tectonic plates suddenly overcoming friction with one another underneath the earth's surface or from the rupture of fault lines.

Due to the geographic position of Morrow County and Oregon, it is susceptible to earthquakes from four primary sources: (a) the off-shore Cascadia Subduction Zone (CSZ), (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) shallow crustal events within the North America Plate, and (d) earthquakes associated with renewed volcanic activity.

Cascadia Subduction Earthquake

The coastal Pacific Northwest is located at a convergent plate boundary, where the Juan De Fuca and North American tectonic plates meet, creating what is known as the CSZ, which extends from British Columbia to northern California. As the Juan de Fuca plate moves, it is shoved underneath the North American plate, as can be seen in Figure 21. As the two plates converge, currently at a rate of about 1 – 2 inches per year, pressure is built up, and once the fault's frictional strength is exceeded, the plates slip past each other along the fault in a "megathrust" earthquake, which causes a CSZ earthquake. Subduction zones like the CSZ have produced earthquakes with magnitudes of 8 or larger. Historic subduction zone earthquakes include the 1960 Chile (magnitude 9.5), the 1964 southern Alaska (magnitude 9.2), and the 2011 Japan (magnitude 9.0) earthquakes.[46]

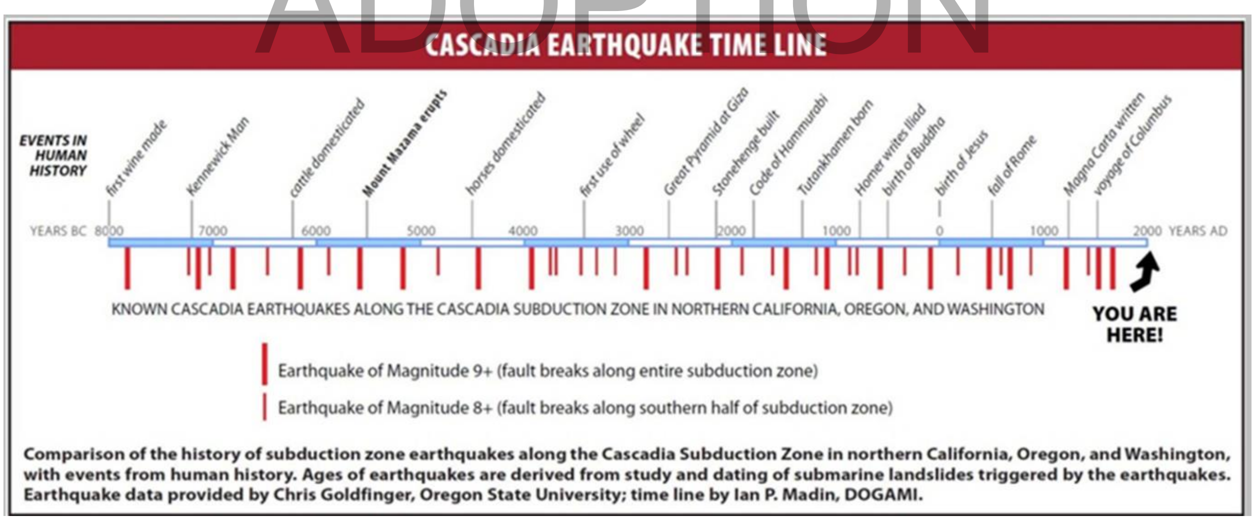
Figure 21. Cascadia Subduction Zone Diagram



Source: Washington State Department of Ecology http://www.ecy.wa.gov/programs/sea/coast/waves/fault.html

Geologic evidence shows that the CSZ has generated significant earthquakes, most recently about 300 years ago. It is generally accepted to have been a magnitude 9 or greater. The average recurrence interval of a CSZ event is approximately 500 years, with gaps between events as small as 200 years and as large as 1,000 years, which can be seen in Figure 22. Such earthquakes cause significant damage to the coastal area of Oregon as well as inland areas in western Oregon. Shaking from a large CSZ earthquake could last up to five minutes.

Figure 22. Cascadia Earthquake Occurrence Time Line



Source: [Overview of the Oregon Resilience Plan for next Cascadia Earthquake and Tsunami](), Yu et al., 2014

While an earthquake produced by the CSZ is expected to be very large (Mw-9.0) and will cause wide-ranging impacts in western Oregon, Morrow County would likely see very minor shaking causing a small amount of damage. The Oregon Seismic Hazard Database (OSHD, Madin and others 2021) calculate that

[46] Cascadia Subduction Zone | Pacific Northwest Seismic Network (pnsn.org)

ground shaking (PGA) (measured in units of g-force (g)) produced from a CSZ Mw-9.0 in Morrow County would range from 0.06 g to 0.18 g. According to the Mercalli scale, ground motion values in this range correspond to potential damage ranging from None to Very light.[47]

Deep Intraplate Earthquake

Occurring at depths from 25 to 40 miles below the earth's surface in the subducting oceanic crust, deep intraplate earthquakes can reach up to magnitude 7.5. The February 28, 2001, earthquake in Washington State was a deep intraplate earthquake. It produced a rolling motion that was felt from Vancouver, British Columbia to Coos Bay, Oregon and east to Salt Lake City, Utah. In 1965, a magnitude 6.5 intraplate earthquake centered south of Seattle-Tacoma International Airport caused seven deaths.[48]

Crustal Fault Earthquake – Horse Heaven Fault

Crustal fault earthquakes occur at relatively shallow depths of 6 – 12 miles below the surface. While most crustal fault earthquakes are smaller than magnitude 4 and generally create little or no damage, they can produce earthquakes of magnitudes up to 7, which cause extensive damage. DOGAMI's HazVu: Statewide Geohazards Viewer shows a crustal fault, the Horse Heaven Fault, approximately 20 miles north of the City of Irrigon.[49]

Volcanic Activity Earthquake

Some earthquakes are related to volcanoes. Such earthquakes most often occur along the edges of tectonic plates, where volcanoes also occur. Volcanic activity earthquakes are caused by the movement of magma. Magma exerts pressure on the rocks until it cracks the rock, then squirts into the crack, and starts building pressure again. Every time the rock cracks, it makes a small earthquake. These earthquakes are usually too weak to be felt but can be detected and recorded by instrumentation.[50]

Location and Extent

The effects of earthquakes span a large geographic area, and an earthquake occurring in or affecting Morrow County would probably be felt throughout the County. However, the degree to which the earthquakes are felt, and the damages associated with them may vary, with the northern part of the County most likely to feel the effects of an earthquake and experience the most damage, both structurally and to the people.

Earthquake damage is largely controlled by the strength of shaking at a given site. The strength of shaking at any point is a complex function of many factors, but magnitude of the earthquake (which defines the amount of energy released) and distance from the epicenter or fault rupture, are the most important. The ripples in a pond that form around a dropped pebble spread out and get smaller as they move away from the source. Earthquake shaking behaves in the same way: you can experience the same strength of shaking 10 miles from a magnitude 6 earthquake as you would feel 100 miles from a magnitude 9 earthquake.

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[47] DOGAMI (2024) Multi-hazard Risk Report for Morrow County, Oregon
[48] Deep Earthquakes | Pacific Northwest Seismic Network (pnsn.org)
[49] Crustal Faults | Pacific Northwest Seismic Network (pnsn.org)
[50] Volcanic Earthquakes | Pacific Northwest Seismic Network (pnsn.org)

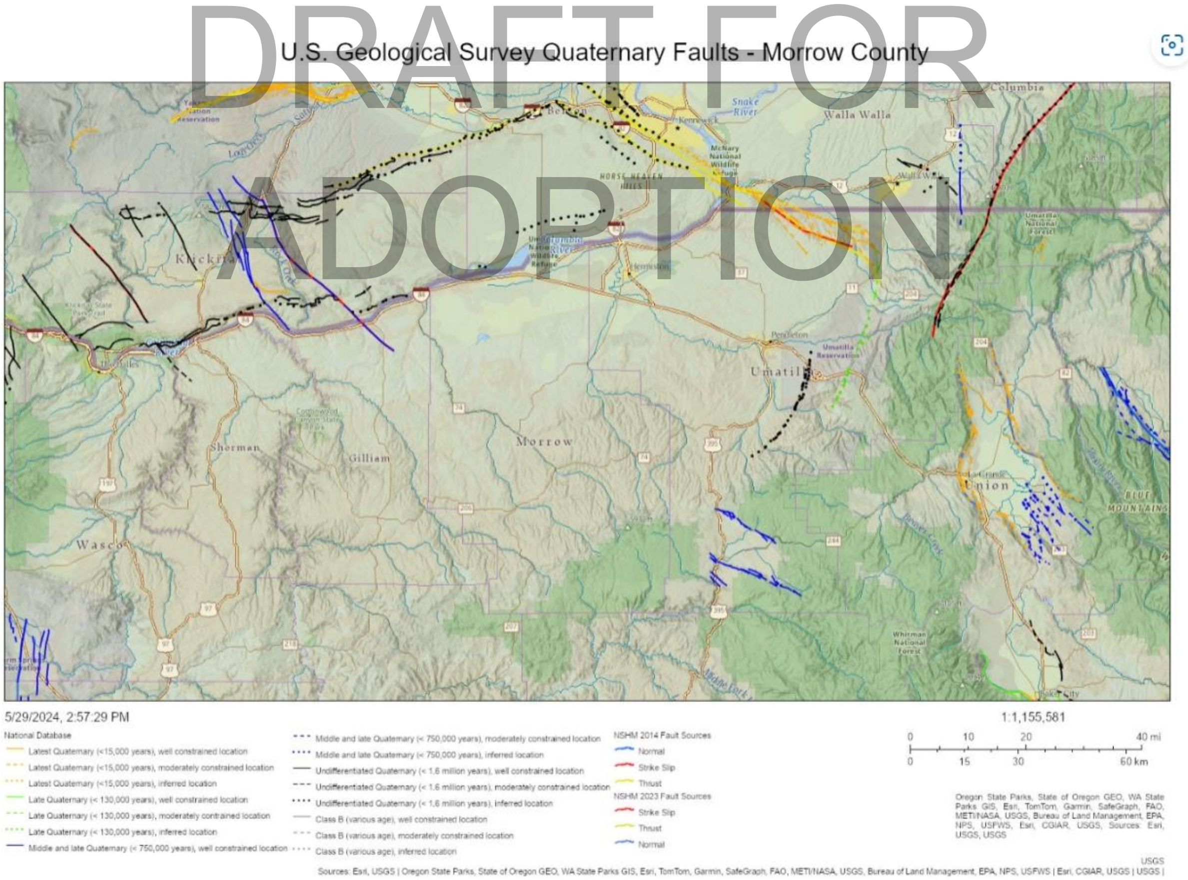
Two measurement scales are used to describe the magnitude and intensity of earthquakes. To measure the magnitude, the "moment magnitude" (Mw, or M) scale uses the Arabic numbering scale. It provides clues to the physical size of an earthquake (http://www.actforlibraries.org/understanding-the-richter-scale-and-moment-magnitude-scale/) and is more accurate than the previously used Richter scale for larger earthquakes. The moment magnitude scale is based on the total moment release of the earthquake and is a product of the distance a fault moved, and the force required to move it.

The second scale, the "modified Mercalli," measures shaking intensity and is based on felt observations; it is therefore more subjective than the mathematically derived moment magnitude. It uses Roman numerals to indicate the severity of shaking. It is important to understand the relationship between the intensity of shaking and the amount of damage expected from a given earthquake scenario.

The other important factor in controlling earthquake damage is the contribution of local geology, which can lead to several specific hazards related to earthquakes occur. These include ground shaking, landslides, liquefaction, and amplification. The severity of these hazards depends on several factors, including soil and slope conditions, proximity to the fault, earthquake magnitude, and the type of earthquake.

Figure 23 shows a generalized geologic map of Morrow County and shows the few fault lines in or near Morrow County. The DOGAMI analysis evaluated faults primarily to the north of the county.

Figure 23.   USGS Quaternary Faults in Morrow County



Source: USGS Interactive Map, consulted May 2024

Horse Heaven Fault

The part of the fault located closest to Morrow County is situated approximately 20 miles north of the City of Irrigon. It is a 111 miles long Quaternary fault that experiences slip of 0.2-0.04 mm/yr. The estimated maximum fault displacement could produce relatively large (Mw-7.1) crustal earthquakes, enough to pose a significant hazard (Personius and others, 2016). Although less is known about the recurrence interval of this fault compared to the CSZ, the Horse Heaven fault has a much higher damage potential in Morrow County due to its proximity to the source of shaking. The current understanding of this fault and various aspects of its frequency and magnitude is very limited.

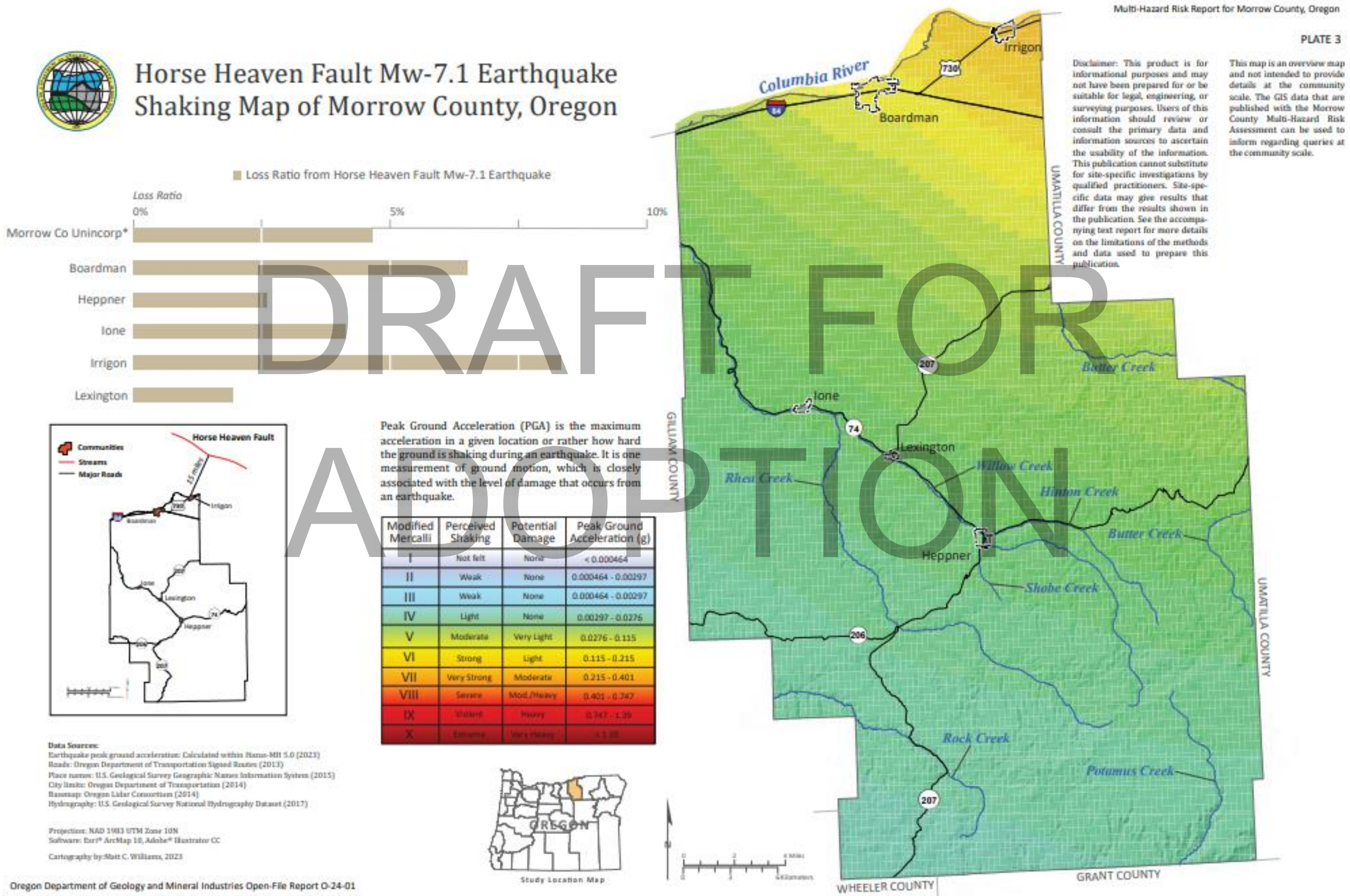
The extent of the earthquake hazard is measured in magnitude. As a result of an earthquake, several specific hazards related to earthquakes occur. These include ground shaking, landslides, liquefaction, and amplification. The severity of these hazards depends on several factors, including soil and slope conditions, proximity to the fault, earthquake magnitude, and the type of earthquake.

Below is a list of earthquake related hazards that occur either during or in the aftermath of an earthquake event.[51]

- **Ground Shaking**: When an earthquake occurs, motion is generated on the earth's surface that is caused by seismic waves. It is the primary cause of earthquake damage, and depends on the strength of the earthquake magnitude, type of fault, and distance to epicenter.
- **Earthquake-Induced Landslides:** Landslides that occur due to ground shaking from earthquakes. Many communities, especially those with steep slopes, face this risk.
- **Liquefaction**: When the ground shakes, wet granular soils are changed from a solid state to a liquid state, resulting in the loss of soil strength and its ability to support weight.
- **Amplification**: Soil and soft sedimentary rocks on and near the earth's surface can increase the magnitude of a seismic wave generated by an earthquake due to the ground shaking. As such, structures developed on soft and unconsolidated soil face greater risk. This is particularly dangerous for areas that include deep sediment filled basins and on top of ridges.

[51] Earthquake Hazards Overview | Pacific Northwest Seismic Network (pnsn.org)

Figure 24. Horse Heavens Mw 7.1 Crustal Earthquake Shaking Map



History

The Pacific Northwest Seismograph Network records roughly 1,000 earthquakes per year in Washington and Oregon. Between one and two dozen of these cause enough ground shaking to be felt by residents. Most are located in the western side of the Cascade Mountains. This part of Oregon has experienced four historic earthquakes of significance that were centered in the eastern Oregon region: the 1893 Umatilla earthquake, the 1936 Milton-Freewater earthquake, the 1951 Hermiston earthquake, and the 1976 Deschutes Valley earthquake. All were shallow crustal earthquakes.

There are also identified faults in the region that have been active in the last 20,000 years. The region has also been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area.

Though many small earthquakes have occurred (under Mw3), Table 39 lists records significant historical earthquakes with an epicenter near Morrow County area which may have had an impact on the County.[52]

Table 39. Historical Earthquakes within and affecting Morrow County

Date	Location	Magnitude	Remarks
Jan. 1700	Offshore CSZ	~ 9.0	Generated a tsunami that struck Oregon, Washington and Japan; destroyed Native American villages along the coast
Nov. 1873	Brookings area	7.3	May have been an intraplate event because of lack of aftershocks; felt as far away as Portland and San Francisco
Jul. 1936	Milton-Freewater, Oregon	6.4	Two foreshocks and many aftershocks felt; damage: $100,000 (in 1936 dollars), and accounting for inflation, almost $2.2 million (2023 dollars)
Apr. 1949	Olympia, Washington	7.1	Fatalities: eight; damage: $25 million (in 1949 dollars; over $320 million in 2023 dollars)
Nov. 1962	Portland, Oregon and Vancouver, Washington	5.5	Shaking lasted up to 30 seconds; resulting damages included extensive structural damage
Mar. 1993	Scotts Mills	5.6	$28 million in damage, damage to homes, schools, building, state buildings; crustal event
Sep. 1993	Klamath Falls	5.9 to 6.0	2 earthquakes causing 2 deaths and extensive damage; $7.5 million in damage to homes, commercial, and governmental buildings; crustal event

Source: A Look Back at Oregon's Earthquake History, 1841-1994, Wong and Bott

Earthquake Risk Assessment

Earthquakes are not scored and rated as a single hazard, but are scored by separating the Cascadia Subduction Zone earthquake and crustal earthquake for hazard scoring. As the probability and vulnerability for each of these earthquake types differ, separating hazards under the scoring and ranking process allows for better accuracy.

[52] "A Look Back at Oregon's Earthquake History, 1841-1994", Oregon Geology, pp. 125-139.

Probability Assessment

Morrow County is susceptible to deep intraplate events within the CSZ, where the Juan de Fuca Plate is diving beneath the North American Plate and shallow crustal events within the North American Plate.

According to the Oregon NHMP, the return period for the largest of the CSZ earthquakes (Magnitude 9.0+) is 530 years with the last CSZ event occurring 323 years ago in January of 1700. The probability of a 9.0+ CSZ event occurring in the next 50 years ranges from 7 – 12%. Notably, 10 - 20 “smaller” Magnitude 8.3 - 8.5 earthquakes occurred over the past 10,000 years that primarily affected the southern half of Oregon and northern California. The average return period for these events is roughly 240 years. The combined probability of any CSZ earthquake occurring in the next 50 years is 37 – 43%.

However, according to a U.S. Geological Survey paper, “Failure analysis suggests that by the year 2060, Cascadia will have exceeded ~27% of Holocene recurrence intervals for the northern margin and 85% of recurrence intervals for the southern margin".[53]

Establishing a probability for crustal earthquakes is difficult given the small number of historic events in the region. For more information, see the DOGAMI reports cited previously.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **both the North and South regions of the County have a probability of experiencing a Cascadia Subduction Zone (CSZ) earthquake as “Low", meaning one incident is likely within a 75-to-100-year period.**

This **rating has not changed s**ince the previous NHMP.

Additionally, based on the background and experience of the Morrow County NHMP Steering Committee, the group used the OEM-FEMA Methodology to assess **both the North and South regions of the County have a probability of experiencing a crustal earthquake:**

- **North County region probability ranked "Low", meaning one incident is likely within a 75-to-100-year period**; and
- **South County region probability ranked "Moderate", meaning one incident is likely within a 35-to-75-year period**.

*This rating has **remained the same for the North County** since the previous NHMP. A separate **ranking for the South County area is new** during this 2024 update.*

Vulnerability Assessment

Assets and infrastructure vulnerable to damage from earthquakes include large stocks of old buildings and bridges, hazardous materials facilities, extensive sewer, water, and natural gas pipelines, dams, a petroleum pipeline, and other critical facilities and private property located in the County. The relative or secondary earthquake hazards, such as liquefaction, ground shaking, amplification, and earthquake-induced landslides can be just as devastating as the earthquake.

[53] Turbidite event history—Methods and implications for Holocene Paleoseismicity of the Cascadia subduction zone, Goldfinger et al., 2012

According to the Oregon Department of Geology and Mineral Industries (DOGAMI) publication "Earthquake damage in Oregon: Preliminary Estimates of Future Earthquake Losses," Morrow County could have significant economic losses due to damage to buildings, communication systems, highways, and airports.[54] The study in the publication that models a 500-year return interval evaluated faults across Oregon and projected an average earthquake on each one, each with a 10% chance of producing an earthquake in the next 50 years. Every county in Oregon is at risk of earthquake damage in this scenario. The study estimates that Morrow County will have relatively few losses due to injuries, deaths, and few short-term shelter needs. Nevertheless, damage to structures would be high in terms of dollar losses. The study estimates that the economic losses for buildings would be ten million dollars, losses to highways $550,000, airports $392,000, and communication systems $46,000 (1999 dollars). Additionally, the study does not take unreinforced masonry buildings into consideration, which are typically older brick buildings often concentrated in an older downtown area such as Heppner. The likelihood of a huge earthquake in Morrow County is small, but the shaking we do experience from time to time has the potential to cause extensive damage.

The Multi-Hazard Risk Report for Morrow County (DOGAMI, 2023) provides a more focused earthquake hazard analysis providing a loss estimate analysis for a scenario in which the Horse Heavens fault experiences a Mw-7.1 earthquake. The loss estimate analysis approximates the loss (in dollars) to buildings, damage to critical facilities and potential for displaced people from this scenario.

Table 40. Horse Heaven Crustal Earthquake Result Summary

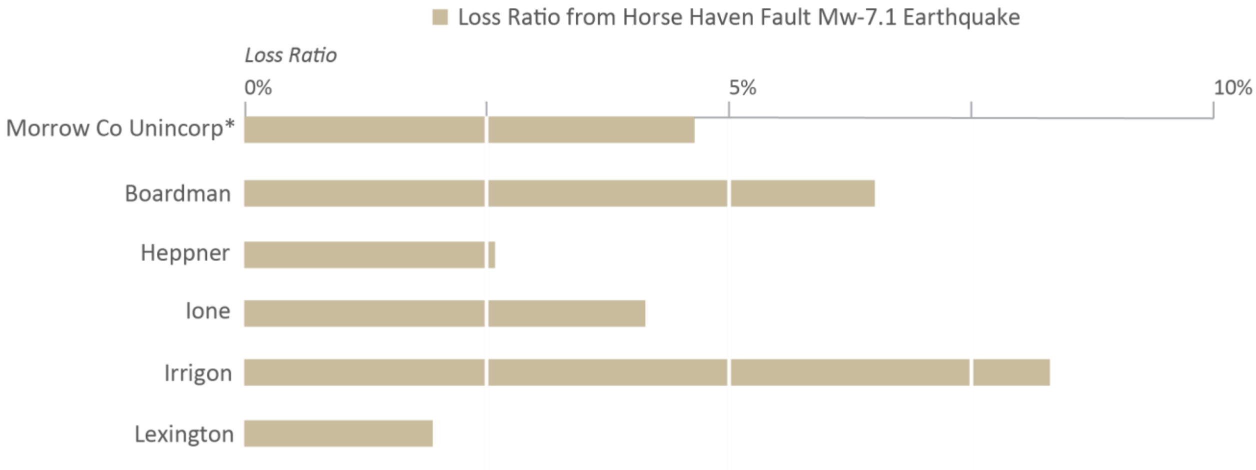
	Countywide Horse Heaven Fault Scenario Mw 7.1 Earthquake Results				
	Damaged Buildings	Loss Estimate	Loss Ratio	Non-Functioning Critical Facilities	Potential Displaced Population
Morrow County	576	$215.7 million	5.0%	2 of 20	144

Source: DOGAMI Morrow County Risk Report, 2023

Loss estimates from the earthquake scenario described in this report vary widely by community in Morrow County with the largest losses in Irrigon (8%) and Boardman (6%) and the least in Lexington (3%) as shown in Figure 25.

[54] DOGAMI Special Paper 29, Earthquake damage in Oregon: Preliminary estimates of future earthquake losses

Figure 25. Horse Heaven Fault Mw 7.1 earthquake loss ratio by Morrow County community



Source: DOGAMI Morrow County Risk Report, 2023

Table 41 is derived from Table B-2 within the DOGAMI Multi-Hazard Risk Report and presents the loss estimates for a Mw 7.1 crustal earthquake from the Horse Heaven fault. Areas near the simulated epicenter of the Horse Heaven Fault are likely to incur a significant amount of damage from an earthquake generated from it. The communities of Boardman and Irrigon have significantly higher estimated loss ratios compared to other communities in the study due to the level of shaking likely to occur.

Unreinforced masonry buildings and manufactured homes are more vulnerable to substantial damage during an earthquake compared to other nearby structures built to modern standards.

In the crustal earthquake scenario, the city of Irrigon is projected to experience the greatest proportion of structural damage as compared to the rest of the jurisdictions, more than twice that of most of the county. The only two critical facilities anticipated to be moderately to completely damaged in this scenario are the A.C. Houghton Elementary School and the Irrigon Jr./Sr, High School both located in Irrigon.

Table 41. Crustal Earthquake Loss Estimate

	Total Number of Buildings	Total Estimated Building Value ($)	Buildings Damaged Horse Heaven Fault M7.1	
			Damaged Buildings	Percent Damaged
Total County	8,480	4,271,375	576	6.8%
Boardman	1,214	823,077	75	6.2%
Heppner	797	229,967	28	3.5%
Ione	249	68,770	17	6.8%
Irrigon	867	217,274	122	14.1%
Lexington	212	55,260	6	2.8%
Unincorporated	5,141	2,877,028	329	6.4%

Source: Derived from Table B-2, DOGAMI Morrow County Risk Report, 2023

In addition to building damage, utility (electric power, water, wastewater, natural gas) and transportation systems (bridges, pipelines) are also likely to experience significant damage. In addition, there is a low probability that a major earthquake will result in failure of upstream dams.

Utility systems will be significantly damaged, including damaged buildings and damage to utility infrastructure, including water and wastewater treatment plants and equipment at high voltage substations (especially 230 kV or higher which are more vulnerable than lower voltage substations). Buried pipe systems will suffer extensive damage with approximately one break per mile in soft soil areas. There would be a much lower rate of pipe breaks in other areas. Restoration of utility services will require substantial mutual aid from utilities outside of the affected area.

For more information, see: Open-File-Report: O-2007-02 - Statewide seismic needs assessment: Implementation of Oregon 2005 Senate Bill 2 relating to public safety, earthquakes and seismic rehabilitation of public buildings, 2007; and DOGAMI Statewide Seismic Needs Assessment Using Rapid Visual Screening (RVS)

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed the **vulnerability of both regions of experiencing a Cascadia Subduction Zone (CSZ) earthquake:**

- **North County region vulnerability is "High"**, meaning more than 10% of the region's population and property would be affected by a major CSZ earthquake emergency or disaster; and

- **South County region vulnerability is "Low"**, meaning less than 1% of the region's population and property would be affected by a major CSZ earthquake emergency or disaster.

*This **rating has changed for both Regions** since the previous NHMP.* The rating has been further refined by area of the county and by type of earthquake since the previous NHMP.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **the vulnerability of both regions of experiencing a crustal earthquake:**

- **North County region vulnerability is "High**", meaning more than 10% of the region's population and property would be affected by a major crustal earthquake emergency or disaster; and

- **South County region vulnerability is "Low**", meaning less than 1% of the region's population and property would be affected by a major crustal earthquake emergency or disaster.

*This **rating has changed for both Regions** since the previous NHMP.* The rating has been further refined by area of the county and by type of earthquake since the previous NHMP.

Extreme Heat

Extreme Heat Risk Ranking Summary

Probability	Updates Made
North County: High **South County: Moderate**	-New Hazard
Vulnerability	
North County: Moderate **South County: Moderate**	

As the climate continues to warm, extreme heat events will be an emerging hazard with implications for public health as well as infrastructure. Extreme heat events are expected to increase in frequency, duration, and intensity in Oregon due to continued warming temperatures. Due to the growing occurrence and threat of extreme heat waves, Morrow County has decided to include Extreme Heat as a new natural hazard in their Natural Hazard Mitigation Plan. The 2020 Oregon Natural Hazard Mitigation Plan identifies Morrow County as being likely affected by extreme heat hazards.

An increasing number of extreme heat events have occurred in Morrow County in 2017, 2019, 2020, 2021, and 2022. Though extreme heat events are not as prevalent in Morrow County compared to other Oregon counties, statewide extreme heat occurs more often throughout the summer and varies in how extreme the temperature rises during a given event.

Characteristics

Extreme Heat is a period of abnormally, uncomfortably hot, and unusually humid weather typically lasting two or more days with temperatures outside the historical averages for a given area, as well as the numbers of days with temperatures above 90°F. Extreme heat can pose risk to communities in several ways, whether in isolation or in combination with each form extreme heat takes. The hazard may represent an increase in daily temperatures exceeding a threshold of safety for human beings, both for dehydration and potential for skin burns. Extreme heat events may exist as heat waves, a streak of consecutive days in which the daily high temperature is above the historical average and/or exceeds a threshold of safety. It is estimated that between 1999 and 2022, heat waves killed at least 19,021 Americans, according to the Centers for Disease Control and Prevention. That's more than any other single hazard-related deaths, including hurricanes, lightning, tornadoes, floods, and earthquakes. And it is largely an urban problem—the bulk of those deaths occurred in cities.[55]

The National Weather Service issues heat warnings when the heat index exceeds given local thresholds. The heat index is a measure of how hot it feels combining both temperature and relative humidity. As relative humidity increases, a given temperature can feel even hotter. Figure 26 displays NOAA's National Weather Service rubric for temperature and relative humidity according to the danger of heat-related illnesses.

[55] Climate Change Indicators: Heat-Related Deaths | US EPA

Figure 26. NOAA National Weather Service Heat Index

NWS Heat Index — Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: [National Weather Service]

Location and Extent

The extent and location of extreme heat can occur region-wide and can affect all segments of a jurisdiction. Urban places, such as cities, are more vulnerable to heat waves because that's where more people are concentrated but also because there is less vegetation to permit evaporation, cars and factories give off heat, and the proximity of asphalt roads and buildings store and radiate heat. On a hot summer day, urban areas can be 5°F to 18°F hotter than surrounding rural areas which is enough to turn a heat wave into a serious health crisis.

The Future Climate Projections report prepared by OCCRI for this NHMP update estimates several measures of extreme heat and projections for extreme cold as well. Extreme heat can refer to extremely warm daytime highs or overnight lows (days on which maximum or minimum temperatures are above a threshold or a probability relative to past decades), seasons in which temperatures are well above average, and heat waves. In the Pacific Northwest, a day on which the maximum temperature is at least 90°F often is considered to be an extremely warm day.

There are several mitigation actions that aim to reduce the urban heat island effect, including:

- Providing shaded areas throughout the County, including vegetation options such as planning appropriate trees to provide shade and passive cooling of buildings and to provide local cooling though evaporation. Non vegetation options are also available, such as latticed shade awnings above paved areas and exposed lots where trees are not viable options. These options will assist in reducing the heat island effect and provide shaded relief for people.

- Improving the reflective surfaces of urban roof tops to bounce light (heat) rather than absorbing it. Ideally, solar panel arrays could absorb sunlight and shade the roof tops from storing heat, while also providing a source of energy for the internal powering of fans, or air conditioning and diminish the draw on local and regional power demands at peak use periods.

History

A severe heat episode or "heat wave" occurs about every two to three years and typically lasts two to three days but can last as many as five days. A severe heat episode can be defined as consecutive days of temperatures in the upper 90s to around 100 degrees Fahrenheit. On average, the region experiences 20.8 days with temperatures above 90-degrees Fahrenheit each year, and an average historical baseline for the hottest day of the year at 97.7°F.[56]

As global temperatures have increased on average and changing climatic patterns are experienced, Oregon and Morrow County have experienced abnormally high temperatures and more frequent periods of heat. Morrow County has experienced higher 90s and triple digit temperatures in the past. During the recent 2021 “heat dome” that blanketed the Pacific Northwest, and many communities across Oregon, as well as Morrow County, reached new record high temperatures. During this extreme heat event, a total of 123 heat related deaths in the Pacific Northwest were reported resulting from limited access to air-conditioning and an increase in the number of drownings when residents sought relief in bodies of water. Widespread business closures and event postponements occurred. [57]

Dangerous heat is almost always associated with a weather event called a heat wave: multiple consecutive days on which maximum or minimum temperatures are above a threshold or a probability (O’Neill et al., 2023). Heat waves occur periodically as a result of natural variability in temperature, but human-caused climate change is increasing their frequency and intensity (Vose et al., 2017; IPCC, 2021). In the absence of human-caused climate change, the intensity of the June 2021 heat wave would have been virtually impossible (Philip et al., 2022).[58]

Extreme heat in June 2021 (Heeter et al., 2023) caused mortality of seedlings and saplings in plantations while scorching the canopy of mature trees (Still et al., 2023). High temperatures are a major contributor to desiccation of dead vegetation, whereas dry air reduces moisture in live vegetation. The drier the air, the more plants transpire and lose water. If tall trees cannot draw enough water from the soil, they may be at risk of embolism (Olson et al., 2018; Anfodillo and Olson, 2021) and more likely to die.[59]

Table 42 lists the most recent extreme heat events that Morrow County has experienced based on a recent search of the NOAA Storm Events Database.

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[56] 2023 OCCRI Future Climate Projection Report Morrow County

[57] https://www.climatehubs.usda.gov/hubs/northwest/topic/2021-northwest-heat-dome-causes-impacts-and-future-outlook

[58] 2023 OCCRI Future Climate Projection Report Morrow County

[59] Ibid.

Table 42. Morrow County Extreme Heat events 2003-2023

Date	Description
Jul. 2006	A broad upper ridge of unusually high height coupled with a thermally induced surface trough of low pressure lingered over the Pacific Northwest for several days. This pattern resulted in persistent offshore flow, and therefore many days of record-smashing high temperatures. Many cities in Oregon saw record-breaking daily high temperatures for multiple days in a row.
Jun. 2008	An upper-level ridge and thermal trough across the Pacific Northwest produced temperatures above 100 degrees for two consecutive days, breaking records in many locations. Two people died of heat-related illness.
Aug. 2008	Excessive Heat Event: An upper-level ridge and dry air brought excessive heat into eastern Oregon. Many locations experienced multiple days of at least 100-degree temperatures.
Jul. 2010	Excessive Heat Event: Temperatures topped 100 degrees for two successive days in Hermiston, Pendleton, 5 miles northeast of Pendleton, Ione, Echo, Arlington, and Umatilla.
Aug. 2011	A dry weak westerly flow aloft under a broad upper-level high pressure system combined with a surface thermal trough to bring several days of temperatures in the 90s.
Jul. 2020	An Upper-level ridge built over the region the last week of July resulting in very hot temperatures and may record highs. Temperatures exceeded 105 degrees in many locations, reaching upwards of 110 degrees.
Jun. 2021	A strong upper-level ridge of high pressure and a surface thermal trough brought several days of record high temperatures across the PNW, with many locations in the lower and higher elevations experiencing extreme heat risk during this event. The multiple days of extreme heat risk was attributed to several fatalities across the region. Several weather stations recording consecutive daily highs at 110 degrees and above
Jul. 2022	A potent upper-level ridge of high pressure moved over the region and persisted through the end of July and the first of August. Across the region, multiple areas in the lower elevations reached critical thresholds for heat risk, while many mountain zones saw consecutive days with high temperatures exceeding 95 degrees Fahrenheit.

Source: National Oceanic and Atmospheric Administration (NOAA), 2023

Extreme Heat Hazard Assessment

Probability Assessment

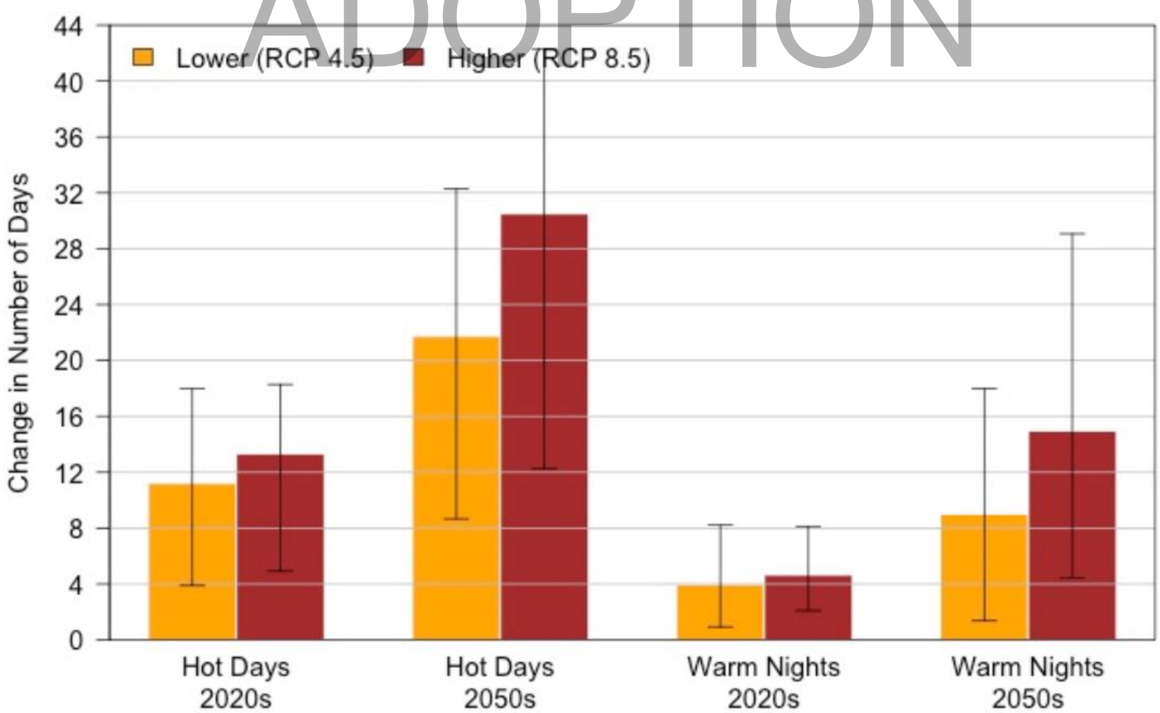
The OCCRI *Future Climate Projections Morrow County, Oregon* provides information about the probability of Extreme Temperatures occurring in the future in Morrow County. The report projects that the number, duration, and intensity of extreme heat events will increase as temperatures continue to warm. In Morrow County, the number of extremely hot days (where temperature is 90°F or higher) and the temperature on the hottest day of the year are projected to increase by the 2020s and 2050s. Compared to the 1971-2000 historical baselines, the number of days per year with temperatures 90°F or higher is projected to increase an average of 31 (range 12-42) by the 2050s. The temperature on the hottest day of the year is projected to increase by an average of about 8°F (range 3-11°F) by the 2050s. Data is shown in Table 43, Figure 27, and Figure 28.

Table 43. Projected future changes in extreme heat metrics in Morrow County.

	Average Historical Baseline	2020s		2050s	
		Lower	Higher	Lower	Higher
Hot Days	20.8 days	11.2 days (3.9-18)	13.3 days (4.9-18.3)	21.7 days (8.7-32.3)	30.5 days (12.3-42.3)
Warm Nights	3.7 days	4 days (0.9-8.2)	4.6 days (2.1-8.1)	9 days (1.4-18)	14.9 days (4.4-29.1)
Hottest Day	97.7°F	3.3°F (0.7-3.8)	3.9°F (1.1-5.4)	6°F (2.3-10.5)	8°F (2.9-11.3)
Warmest Night	66.1°F	2.5°F (0.7-3.8)	2.8°F (0.9-4)	4.4°F (1.7-7.1)	6.5°F (3.4-9.5)
Daytime Heat Waves	2.9 events	1.1 events (0.5-1.9)	1.3 events (0.8-1.9)	1.9 events (1.2-3.4)	2.3 events (1.4-3.9)
Nighttime Heat Wave	0.4 events	0.5 events (0-1)	0.6 events (0.3-1)	1.2 events (0.1-2.3)	1.8 events (0.3-3.2)

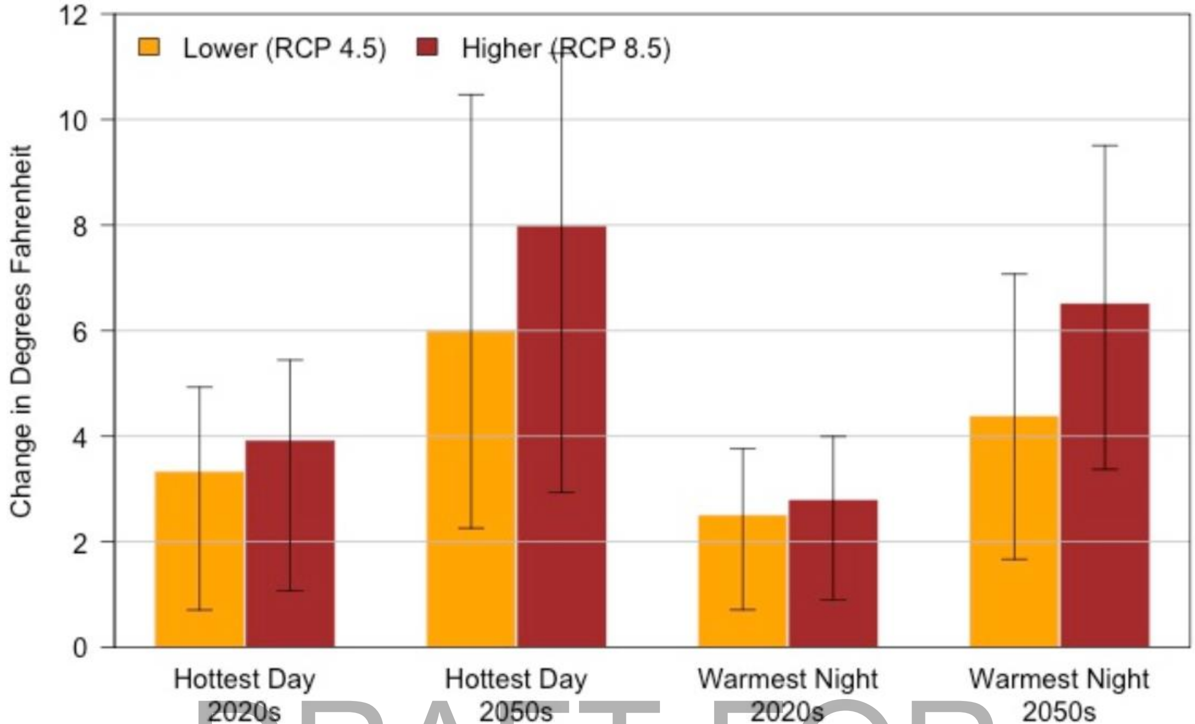
Source: Table 8, OCCRI (2023) Future Climate Projections for Morrow County, Oregon

Figure 27. Change in Number of Extreme Heat Days in Morrow County



Source: Figure 4, OCCRI (2023) Future Climate Projections for Morrow County, Oregon

Figure 28. Change in Magnitude of Extreme Heat in Morrow County



Source: Figure 5, OCCRI (2023) Future Climate Projections for Morrow County, Oregon

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **both the North and South regions of the County have a probability of experiencing a locally extreme heat event as "High" meaning one incident is likely within a 10-to-35-year period.**

*This is a **new natural hazard** to the 2024 Morrow County NHMP update .*

While extreme heat events can affect all regions of Morrow County, the severity and occurrence of these hazards differ between the regions with a higher likelihood of occurrence in the northern portion of the county.

Vulnerability Assessment

Heatwaves are extremely dangerous and the leading cause of weather-related deaths in the United States. As extreme heat events have been historically rare in Oregon, many residents do not have air conditioning in their homes, leaving them more vulnerable to heat-related illnesses and possible death. More vulnerable populations include children, the elderly, economically disadvantaged communities, those working outdoors, such as in agriculture or forestry, and people with preexisting conditions. Projected demographic changes, such as an increase in the proportion of older adults, will increase the number of people in some of the populations that are most vulnerable to extreme heat.

There are many different populations groups that are more vulnerable to extreme heat. Those at greatest risk for heat-related illness include infants and children up to 4 years of age, people 65 and older, people who are overweight, and people who are ill or on certain medications, as well as those who work outdoors. Furthermore, a significant percentage of the population does not have air conditioning, so once temperatures get into the 90s, it is quite uncomfortable. If a hot weather pattern persists for a few days, the situation gets worse because of the number of days in sequence. Studies show that heat-health related problems greatly increase once there are multiple days of extreme heat in a row. Oregon Public Health officials remind people to take precautions to avoid getting sick from extreme heat and be careful when swimming in Oregon's lakes, streams, and the ocean. Further breakdown on the socially vulnerable populations who could be disproportionately affected by a heat wave is discussed in Section II-Community Profile, Social/Demographic Profile – Social Vulnerability in Morrow County.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA to assess the vulnerability of both the North and South regions of the County to Extreme Temperature events. **Both areas of the county rated vulnerability to this hazard as "Moderate",** meaning between 1-10% of the unincorporated County's population would be affected by a major extreme temperature event.

Extreme temperature is a new hazard *in the Morrow County 2024 NHMP update.*

Flood

Flood Risk Ranking Summary	
Probability	**Updates Made**
North County: Low **South County: Moderate**	-2016 NHMP rated Probability as High -2016 NHMP rated Vulnerability as Medium - DOGAMI *Risk Report for Morrow County* for 100-year Flood and Channel Migration -NFIP data updated
Vulnerability	
North County: Low **South County: Moderate**	

The Mid-Columbia region of Oregon is subject to a variety of flood conditions. The most common type of flooding is associated with unseasonably warm weather during the winter months, which quickly melts high elevation snow. This condition has produced devastating floods throughout the region. These warm weather events usually occur December through February and can affect the entire state. Flash floods are almost always a summer phenomenon and are associated with intense local thunderstorms. The flash flood of June 1903 in the City of Heppner is a benchmark event. Heppner's vulnerability to flash flood hazards has since been reduced through the construction of the Willow Creek Dam. The region's other flood events are linked to normal seasonal snowmelt and run off from agricultural fields.

There are several rivers in the region that produce extreme flood conditions. Surprisingly, the Columbia River is not one of them, nor is the lower Deschutes River or the John Day River. The Columbia River is so regulated by upstream dams that it does not present much of a problem. This is partly reflected in the federal flood insurance rate maps for the various communities along the river. However, a swollen Columbia can back up tributary streams to the point where they constitute a significant hazard. This has occurred on a number of occasions. The lower Deschutes and John Day (Columbia River tributaries) are confined to fairly deep canyons with small floodplains. Consequently, they do not present the flood problems associated with smaller rivers, such as the Umatilla, the Walla Walla, and their tributaries.

Development in the floodplain, while permissible, may exacerbate flooding. When structures or fill are placed in the floodway or floodplain, water is displaced and can exacerbate flooding. Development raises the river levels by forcing the river to compensate for the flow space obstructed by the inserted structures and/or fill. When structures or materials are added to the floodway or floodplain and no fill is removed to compensate, serious problems can arise. Floodwaters may be forced away from historic floodplain areas, and as a result, other existing floodplain areas may experience floodwaters that rise above historic levels.

Over half of Morrow County's population lives in rural areas outside of cities, often close to or adjacent to a river. The portion of the population that lives in urban areas also often live close to a river. This can lead to development in the floodplain, both residential development and the utilities and infrastructure that supports these residents, alongside these rivers, which are also often within floodplain areas. The residential areas and needed infrastructure are the two most likely components of the community to be impacted by flooding.

Additionally, flooding is a public health concern. According to the Centers for Disease Control and Prevention, floodwater poses a variety of potential health risks, including the spreading and exposure to infectious diseases, chemical and electrical hazards, and injuries. Standing water from flooding can also increase insect populations, creating additional risk for insect-borne diseases. If clean-up efforts are delayed in the aftermath of a flood, water-damaged buildings can collect mold or experience sewage leakage, which poses a health risk to building occupants. To minimize these potential risks, it is important to expedite the clean-up and repair of the community impacted by the flood, including repairing water-damaged buildings and other clean-up efforts.

Characteristics

Flooding results when rain and snowmelt create water flow that exceeds the carrying capacity of rivers, streams, channels, ditches, and other watercourses. In Oregon, flooding is most common from October through April when storms from the Pacific Ocean can bring intense rainfall.

Floods occur in Morrow County during periods of heavy rainfall, with low-lying areas at particular risk of flooding. The flooding of developed areas may also occur when the amount of water generated from rainfall and runoff exceeds a storm water system's capacity.

Two types of flooding primarily affect Morrow County: riverine flooding and urban flooding. They are described in the following paragraphs. Another possible source of flooding, dam-failure, is also addressed in this chapter even though its causes may be quite different than the causes of rain-driven flooding.

Riverine Flooding

Riverine flooding is the overbank flooding of rivers and streams and is a natural process that adds sediment and nutrients to fertile floodplain areas. Flooding in large river systems typically results from large-scale weather systems that generate prolonged rainfall over a wide geographic area, causing flooding in hundreds of smaller streams, which then drain into the major rivers.

Shallow area flooding is a special type of riverine flooding. FEMA defines shallow flood hazards as areas that are inundated by the 100-year flood (floods with a 1% chance of occurring in one year) with flood depths of only one to three feet. These areas are generally flooded by low velocity sheet flows of water.

Riverine flooding sometimes occurs as flash flooding. Flash flooding usually is the byproduct of very heavy rains in a short period of time over a small geographic area, all of which combine to cause small streams to turn violent. Flash flooding is the most prevalent type of flooding event in Morrow County and can be poorly predicted by weather reports because most often the floods are a result of a microburst, which simply overwhelms both natural and constructed drainage systems.

Urban Flooding

As land is developed and converted from fields or woodlands to roads, parking lots, and structures, it loses its ability to absorb rainfall. Urbanization of a watershed changes the hydrologic systems of the basin, leading rainfall to collect and flow faster on impervious concrete and asphalt surfaces. This renders these systems unable to absorb rainfall properly back into the ground. Adding these elements to the hydrological systems can result in floodwaters that rise very rapidly and peak with violent force.

The majority of Morrow County is rural in nature, with a small amount of urbanized land. However, much of the population lives within cities or unincorporated communities which can have high concentrations of impermeable surfaces that either collect water or concentrate the flow of water.

During periods of urban flooding, streets carry water to culverts, leading to culverts and storm drains sometimes backing up with vegetative debris and causing localized flooding.

Dam Failure Flooding

Loss of life and damage to structures, roads, utilities, and crops may result from a dam failure. Economic losses can also result from a lowered tax base and lack of utility profits. These effects could possibly accompany the failure of one of the major dams in Morrow County. Six major water impoundment dams have been developed in Morrow County to serve flood control and water needs. Because dam failure can have severe consequences, FEMA requires applicable dam owners to develop Emergency Action Plans (EAP) for warning, evacuation, and post-flood actions (see Volume II, Built Environment Profile for further information). County officials may participate in the development of the EAP, however, the responsibility for developing potential flood inundation maps and facilitation of emergency response is the responsibility of the dam owner.

A new program was added under the FEMA National Dam Safety Program called the Rehabilitation of High Hazard Potential Dam (HHPD) Grant Program. Eligible high hazard potential dams are defined as non-federal dams that are:

1. Located in a state or territory with a dam safety program;
2. Classified as high hazard potential by the dam safety agency in the state or territory where the dam is located;
3. With a current, approved emergency action plan by the state or territorial dam safety agency;
4. Failing to meet minimum dam safety standards of the state or territory and poses an unacceptable risk to the public.

This grant is geared toward non-federal dams that are identified as High Hazard Potential, which is a classification standard for any dam whose failure or mis-operation will cause loss of human life and significant property destruction.[60] There is a Federally owned dam (Willow Creek Dam) located in Morrow County. However, Morrow County has no non-federal dams that meet the definition of High Hazard Potential dams based on the National Inventory of Dams records.[61]

For more detailed information regarding dam failure flooding, and potential flood inundation zones for a particular dam in the county, please refer to Chapter 2: Community Profile Section, Built Environment Section, or the 2022 Morrow County Emergency Operations Plan[62] available through Oregon Water Resources Department (OWRD) or through the relevant city, county, or tribal emergency managers, or first responders.

Channel Migration

Channel migration is a dynamic process by which a stream's location changes over time. This process includes channel bed and bank erosion, sediment deposition, and channel avulsion, a process in which the

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[60] Rehabilitation Of High Hazard Potential Dam (HHPD) Grant Program | FEMA.gov
[61] National Inventory of Dams (army.mil)
[62] 2022 Morrow County Emergency Operations Plan, morrow_county_eop_2022.pdf

stream abruptly moves to a new location on the floodplain. Many factors influence channel movement, including the local geology, size, and quantity of sediment within the river, discharge of water, vegetation, channel shape, and gradient. Human changes to the channel, such as the construction of dams and levees, also have a major impact on how a channel changes its course over time. In combination, these factors affect how a river's energy and erosive power is dispersed. Straight, steep streams have highly concentrated erosive power; by contrast, curving channels that flow across wide and flat floodplains allow the river to dissipate its energy over a wider area and for sediment to be deposited.

The area in which a stream channel moves laterally over a given time is known as a channel migration zone (CMZ). In places where development has occurred within the CMZ, structures are at risk for severe damage to foundations and infrastructure. The CMZ typically extends beyond the limits of the regulatory floodplain, but little consideration has commonly been given to this potential hazard. This factor contributes greatly to the level of risk that exists for many developed areas along streams, and in fact, many of the communities in Morrow County lie alongside channels show evidence of past migration. The frequency and severity of channel migration may change over time due to changes in climate and precipitation patterns, land use, and how waterways are managed. See Appendix E, the DOGAMI Multi-Hazard Risk Report for additional details.

Location and Extent

The Mid-Columbia region of Oregon is subject to a variety of flood conditions. The most common type of flooding is associated with unseasonably warm weather during the winter months, which quickly melts high-elevation snow. This condition has produced devastating floods throughout the region. Warm weather events usually occur December through February and can affect the entire state. Flash floods are almost always a summer phenomenon and are associated with intense local thunderstorms.

Flooding can be of extreme magnitudes in confined locations, such as canyons, or a costly nuisance, as in broad river valleys. The topography and geology of the Umatilla River Basin and Morrow County are conducive to runoff, and peak flows on many of the tributaries occur within hours of the passage of weather fronts. Historically, the highest flows usually occur during the period from November through March because of the heavy rains augmented by snow melts.

The surface materials susceptible to flooding include poorly drained, unconsolidated, fine-grained deposits of silt, sand, and gravel. Torrential flash flood events can introduce large deposits of sand and gravel to a drainage of otherwise poorly drained soils.

South Morrow County

The Willow Creek in southern portion of the County is famous in Oregon for the 1903 flash flood that caused the death of more than 200 people. It was a summer thunderstorm flood and was caused by a large amount of concentrated rainfall and a lack of vegetation in the watershed to slow it down. The City of Heppner, where the flood occurred, lies in a valley surrounded by steep slopes, and sits at the confluence of four streams: Willow Creek, Hinton Creek, Balm Fork, and Shobe Creek. The steep slopes of the hills surrounding these creeks, along with the prevalence of severe thunderstorms in the area, contribute to the likelihood of flash flooding.

According to the Heppner City Plan (1999), there was one flood per 4.6 years on average between 1883 and 1971. Due to this high incidence of flash flooding on the Willow Creek and other streams, the City of Heppner and the U.S. Army Corps of Engineers built the Willow Creek Dam across Willow Creek. This dam was completed in 1982 and the area subject to flooding was significantly reduced. However, since the Willow Creek Dam was constructed to intercept the waters from Willow Creek and Balm Fork only, the major flood hazard reduction occurred between the face of the dam and the confluence with Shobe Creek. Below Shobe Creek, an extensive area of the valley floor is still considered by FEMA as a designated flood hazard area. The flooding that occurred in 1971 was documented to have originated in the Shobe Creek watershed. As a result of the 1971 Shobe Creek flood, extensive work was done to construct a series of diversions in the Shobe Creek drainage, along with the conversion of cropland to the Conservation Reserve Program (CRP) under a program sponsored by the Soil Conservation Service. Since the construction of the Willow Creek Dam and the work done on the Shobe Creek drainage, no significant flooding has been documented within the City of Heppner.

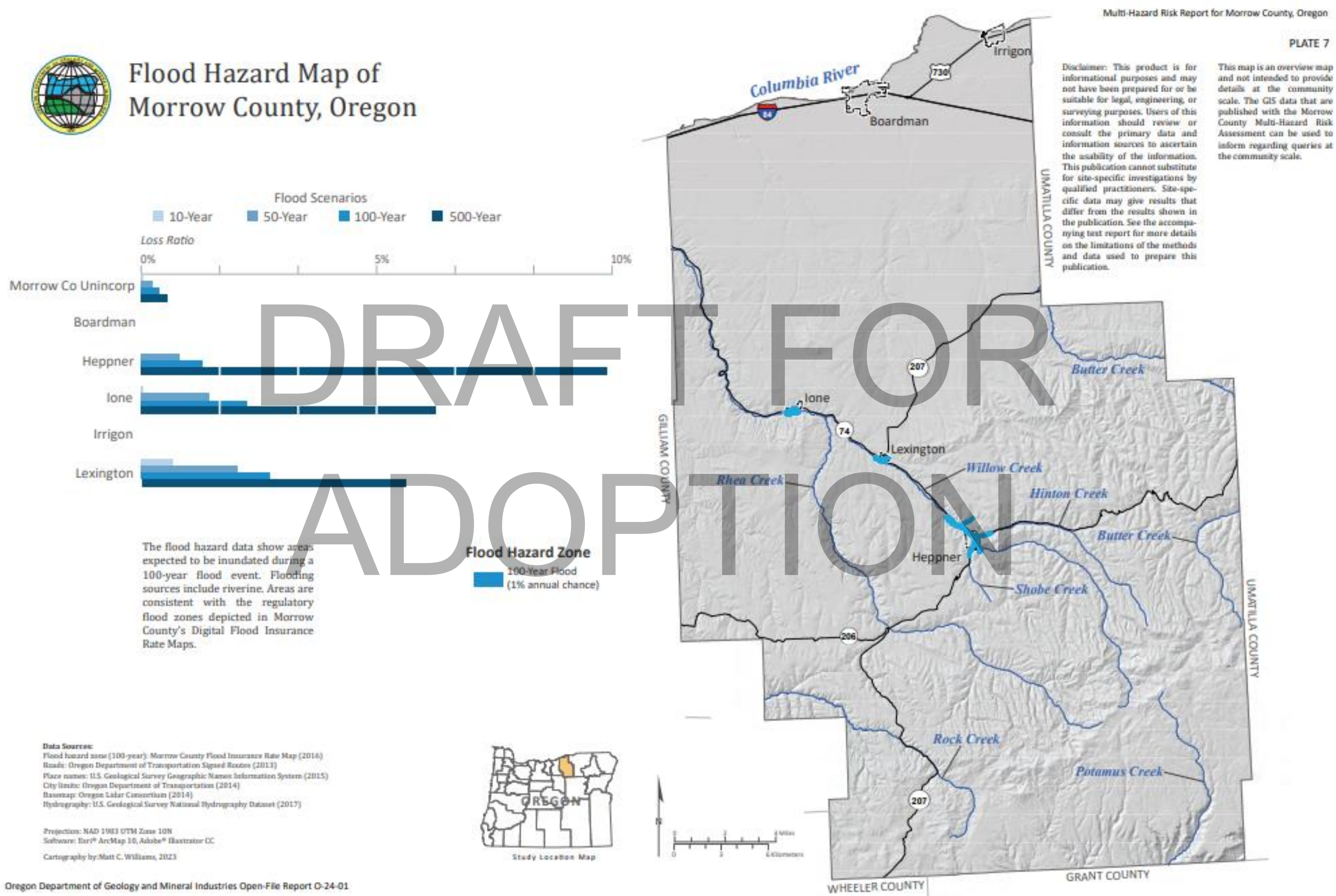
Lexington and Ione are also located on Willow Creek and experience localized flash flooding events. The U.S. Army Corps of Engineers has indicated that several of the tributaries of Willow Creek below the Willow Creek dam have the potential for flashfloods and warrant consideration toward providing a degree of flood protection. The drainages are Blackhorse Creek at Lexington, Reitmann, and Lorraine Canyons at Ione, and Rhea Creek at Ruggs. The Corps recommended that protection be investigated and provided if found to be feasible.

A new FEMA Flood Insurance Study was completed and became effective on December 18, 2007, for the entire county and the jurisdictions. Willow Creek and its tributaries received new estimates of the 10-, 50- and 100-year discharges to be used in the Morrow County Flood Insurance maps. The new study proposed smaller flood discharges due to the construction of the Willow Creek Dam and drainage work on Shobe Creek. However, the study revealed an increase in discharges coming from the drainages near Ione.

North Morrow County

The Columbia River is not a river of concern for extreme flood conditions because it is so regulated by upstream dams that it does not present a problem in Morrow County. There are, however, other flash flooding incidents in the northern portion of the County that do cause damage and disruption for the citizens and businesses of the County. The May 19, 2006, storm event is a good example of how a summer thunderstorm event can cause damage. The storm precipitated record-breaking hail and rain enough to wash out areas of local roads such as Bombing Range Road and portions of Highway 730.

Figure 29. Flood Hazard Map of Morrow County



History

Morrow County has several small tributaries in both unincorporated and incorporated areas that are susceptible to flooding, and have resulted in floods in the County's history, as seen in Table 44.

The flash flood of June 1903 in the City of Heppner is a benchmark event. Heppner's vulnerability to flash flood hazards has since been reduced through the construction of the Willow Creek Dam. The region's other flood events are linked to normal seasonal snowmelt and run-off from agricultural fields.

Table 44. Morrow County Flood History

Date	Flood Location and Description
1903	Willow Creek flood
1996	Statewide Heavy Rain and Flooding Emergency Declaration
1997	Statewide Flooding Emergency Declaration, Executive Order 97-09
April 23, 2005	Flash Flood in Ione; a flood control ditch was blocked in the city of Ione when a thunderstorm with heavy rain moved through the area. As a result, water backed up in the streets of the downtown Ione area flooding several businesses. One business reported having at least 14 inches of water inside. No significant damage was noted to any of the businesses from the flash flood. The property damage from this event is estimated at $2,000.
March 22, 2006	Flash Flood in Boardman; an irrigation embankment collapsed along the south side of Interstate 84. The resulting flash flood closed the interstate with at least 6 inches of flowing water and mud.
May 14, 2011	Flash Flood in Heppner and Lexington; one to two inches of rainfall within 1 hour caused flash flooding in the Heppner and Lexington areas. Although Willow Creek Dam was able to control a large amount of flow and allowed Shobe and Hinto to flow at high levels, some roads were inundated. A home, two basements, and a garage were flooded. Sandbags were used to protect homes and businesses. The city Public Work's crew coordinated with several local public officials to mitigate the damage and the Fire Chief oversaw the efforts.
June 2, 2011	Flash Flood in Heppner on Hinton and Willow Creeks damaged roads, bridges, and the Morrow County Fairgrounds. The Heppner elementary school was evacuated as a precaution.
April 23, 2012	Flash Flood in Heppner; heavy rainfall caused flash flooding in several areas of Heppner, including residences, the elementary school, sewage treatment plant, city shop, a bank, and the newspaper office. Roadways were also flooded, and debris cleanup had to ensue in 10 spots.
October 9, 2018	Two feet of water inside a residence due to heavy rain forced four adults and a child to leave their house on the 54200 Block of Highway 74 in Heppner.
April 9, 2019	Flooding along Hinton Creek took place on April 9th and 10th. The fairgrounds in Heppner were flooded as well as fields along the creek above Heppner.

Date	Flood Location and Description
August 7, 2023	Flash Flood in Ione; a heavy downpour that resulted in flash flooding across the town The Morrow County Emergency Manager posted pictures via social media that showed water overflowing drainage ditches and flowing over the roadway, muddy debris flowed into local businesses as well.

Source: 2016 Morrow County Hazard Annes for Flood; NOAA Storm Event Database consulted February 2024 Storm Events Database | National Centers for Environmental Information (noaa.gov)

Flood Hazard Assessment

Probability Assessment

The OCCRI *Future Climate Projections Morrow County, Oregon* report projects the intensity and occurrence of extreme precipitation will increase as the atmosphere warms and holds more water vapor. In Morrow County, the number of days per year with at least 0.75 inches of precipitation is not projected to change substantially. Nevertheless, by the 2050s, the amount of precipitation on the wettest day and wettest consecutive five days per year is projected to increase by an average of 15% (range 2-38%) and 10% (range 6–30%), respectively.

Furthermore, winter flood risk at mid- to low elevations in Morrow County, where temperatures are near freezing during winter and precipitation is a mix of rain and snow, is projected to increase as winter temperatures increase. The temperature increase will lead to a rise in the percentage of precipitation falling as rain rather than snow.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA for North and South county areas that assessed **the probability of experiencing a flooding event.**

- **North County region representatives ranked probability as "Low",** meaning one incident is likely within 75-100 years; and
- **South County region representatives ranked probability as "Moderate",** meaning one incident is likely within 35-75 years.

*This **rating is lower** (from High to Moderate and Low) than that in the previous NHMP.*

National Flood Insurance Program (NFIP)

Flooding can occur every year depending on rainfall, snowmelt or how runoff from development impacts streams and rivers. FEMA has mapped the 100 and 500-year floodplains in portions of Morrow County. This corresponds to a 1% and 0.2% chance of a certain magnitude flood in any given year. The 100-year flood is the benchmark upon which the National Flood Insurance Program (NFIP) is based.

The National Flood Insurance Program¬ (NFIP) was established in 1968 as a means of providing affordable flood insurance to the nation's flood-prone communities. The NFIP also seeks to reduce flood losses through regulations that focus on building codes and "sound floodplain management." Morrow County joined the NFIP on December 15, 1978. The County's role as an NFIP community requires that the County implement and enforce the NFIP's minimum floodplain management standards. The County has also participated in the Community Rating System (CRS) program historically, which offers discounts to flood insurance premiums for community members for activities beyond the minimum standards that provide additional protection to lives and properties. The County's participation in the CRS has been suspended pending the conclusion of the ongoing Community Assistance Visit (CAV) to which the County is currently subject.

Identification of Flood-Prone Areas - NFIP

Flood maps and Flood Insurance Studies (FIS) are often used to identify flood-prone areas. Morrow County joined the NFIP on April 1, 1981. Morrow County's current FIRM effective date is April 1, 1981, the FIRM Effective date for Ione, Heppner and Lexington is also April 1, 1981. For Boardman and Irrigon the FIRM Effective date is December 18, 2007 as shown in Table 45. FEMA has also conducted a number of CACs and CAVs, some of which are still to be closed by FEMA, shown in Table 46.

Table 45. Morrow County and City FIRM dates

Community	Initial Flood Boundaries Identified	Initial FIRM Identified	Current FIRM Effective
Morrow County	Jan. 24, 1975	Apr. 1, 1981	Dec. 18, 2007
Boardman	Sep. 12, 1975	Dec. 18, 2007	Dec. 18, 2007 (M)
Heppner	Nov. 23, 1973	Apr. 1, 1981	Dec. 18, 2007
Ione	Nov. 22, 1974	Apr. 1, 1981	Dec. 18, 2007
Irrigon	Oct. 3, 1975	Dec. 18, 2007	Dec. 18, 2007
Lexington	Sep. 6, 1974	Apr. 1, 1981	Dec. 18, 2007

Source: Federal Emergency Management Agency, National Flood Insurance Program
M: No Elevation Determined - All Zone A, C and X

Table 46. Morrow County and Cities CAC and CAV Dates

Community	CAC Date	CAV Date
Morrow County	Sept. 2, 2021 (being conducted by FEMA, not yet closed)	Sep. 30, 1993
Boardman	May. 10, 2022	-
Heppner	Sept. 2, 2021 (being conducted by FEMA, not yet closed)	Nov. 5, 2002
Ione	Dec. 9, 2020	Sep. 23, 1993
Irrigon	None	-
Lexington	Sept. 1, 2021 (being conducted by FEMA, not yet closed)	Sep. 23, 1993

Source: Federal Emergency Management Agency, National Flood Insurance Program ; CIS data provided by Oregon NFIP Coordinator, February 2024

Local floodplain codes based on the NFIP regulations (44 Code of Federal Regulations [CFR] Chapter 1, Section 60.3) require that all new construction in floodplains must be elevated at or above base flood level. Communities participating in the NFIP may adopt regulations that are more stringent than those contained in 44 CFR 60.3, but not less stringent.[63] Each city in Morrow County and the county itself employs someone to act as the floodplain manager whose job it is to apply those regulations.

[63] The National Flood Insurance Program (floodsmart.gov)

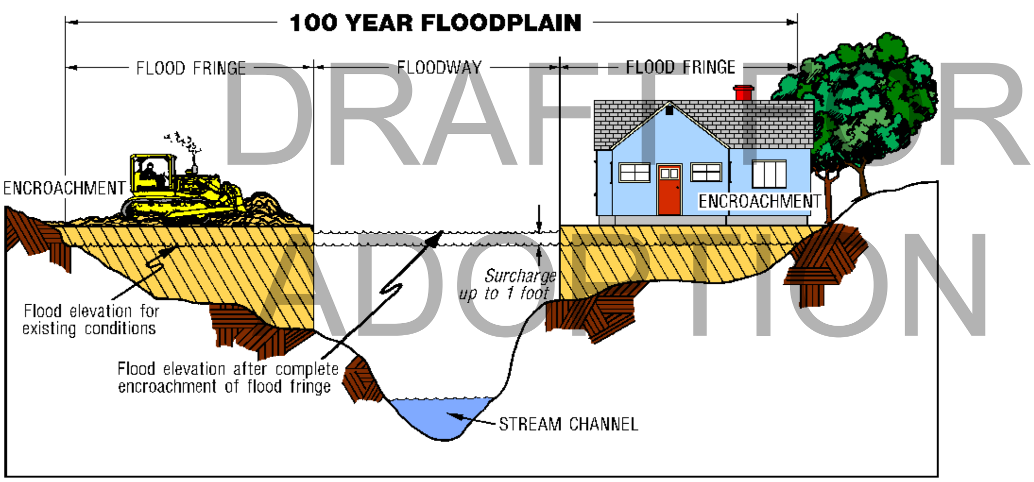
Flood Insurance Rate Maps (FIRM) and Flood Insurance Studies (FIS)

Floodplain maps are the basis for implementing floodplain regulations and for delineating flood insurance purchase requirements. A Flood Insurance Rate Map (FIRM) is the official map produced by FEMA, which delineates Special Flood Hazard Areas (SFHA) in communities where NFIP regulations apply. FIRMs are also used by insurance agents and mortgage lenders to determine if flood insurance is required and what insurance rates should apply.

Water surface elevations are combined with topographic data to develop FIRMs. FIRMs illustrate areas that would be inundated during a 100-year flood, floodway areas, and elevations marking the 100-year-flood level. In some cases, they also include base flood elevations (BFEs) and areas located within the 500-year floodplain.

Flood Insurance Studies and FIRMs produced for the NFIP provide assessments of the probability of flooding at a given location. FEMA conducted many Flood Insurance Studies in the late 1970s and early 1980s. These studies and maps represent flood risk at the point in time when FEMA completed the studies. However, it is important to note that not all 100-year or 500-year floodplains have been mapped by FEMA.

Figure 30. Floodplain Schematic



Source: US Army Corps of Engineers

As of 2024, Morrow County (including NFIP participating incorporated cities) has 31 National Flood Insurance Program (NFIP) policies in force, with Heppner having 13 polices, the greatest number of policies among participating communities in Morrow County. Also, Heppner is the only community in Morrow County that is a member of the Community Rating System (CRS), in which they have a Class 9 rating.

NFIP Risk Assessment – Repetitive Loss Properties

As of 2024, Morrow County (including NFIP participating incorporated cities) has 31 National Flood Insurance Program (NFIP) policies in force, with Heppner having 13 polices, the greatest number of policies among participating communities in Morrow County (see Table 47). Also, Heppner is the only community in Morrow County that is a member of the Community Rating System (CRS), in which they have a Class 9 rating.

The total value of flood insurance coverage for the entire County is just under $6 million. Morrow County has no Repetitive Loss Properties or Severe Repetitive Loss Properties.

Table 47. NFIP Policies and Claims.

Community	Number of Policies	Number of Repetitive Loss Properties	Total Coverage	Total Claims since 1978	Total Paid Since 1978
Morrow County	9	0	$2,208,000	2	$0
Boardman	0	0	$0	0	$0
Heppner	13	0	$2,222,000	2	$2,277
Ione	9	0	$1,353,000	1	$1,790
Irrigon	0	0	$0	0	$0
Lexington	1	0	$148,000	3	$11,542
Total	32	0	$5,931,000	8	$15,609

Source: Scott Van Hoff, personal communication, February 2023; CIS data provided by Oregon NFIP Coordinator, February 2024

NFIP and Floodplain Ordinances and Requirements

Morrow County manages floodplain development through their local floodplain ordinance. The Planning Department is the County's lead work group that implements NFIP requirements and application of Morrow County Revised Code Section 3.100 – Floodplain Overlay. The local floodplain ordinance is based on the State of Oregon model flood zone ordinance and is in compliance with the Code of Federal Regulations for the NFIP.

The NFIP for the County is managed by the Planning Director, currently Tamra Mabbott, and the Compliance Planner, currently Kaitlin Kennedy. The NFIP for the cities are managed by the following:

- Boardman: Carla McLane (Planning Official) or Nancy Orellana (Associate Planner)
- Heppner: John Doherty (City Manager)
- Ione: Liz Peterson (City Recorder/Clerk)
- Irrigon: Aaron Palmquist (City Manager)
- Lexington: Autumn Crumpton (City Recorder)

These administrators manage the floodplain management program for their community, oversees annual recertifications with the Community Rating System Insurance Services Office (ISO) CRS Specialists and NFIP Community Assistance Visits with the Oregon Department of Land Conservation and Development NFIP Coordinator. A Floodplain Manager for each city reviews all development activity in the Special Flood Hazard Area prior to issuance of applicable permits.

All projects within the County's Special Flood Hazard Area are reviewed by Morrow County's Certified Floodplain Manager for development permit requirements, including substantial improvement/damage of existing structures. Local officials determine if proposed work in a regulated SFHA or Interim Flood Hazard Area qualifies as a substantial improvement or repair of substantial damage as defined in SRC Chapter 601. The valuations for all projects are included in the initial development application and reviewed at submittal. For major improvements to existing structures, the applicant is notified that additional information is needed to determine substantial improvement/damage (SI/SD). In general, the project architect compiles the information needed to make the determination based on guidance in the FEMA Substantial Improvement/Substantial Damage Desk Reference, DLCD and FEMA support. If work on an existing structure constitutes substantial improvements or an existing structure is determined to be substantially damaged, then the existing structure must be brought into compliance with NFIP requirements for new construction. SRC Chapter 601 defines SI/SD as follows:

Substantial Improvement: Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 % of the market value of the structure before the "start of construction" of the improvement. This term includes structures which have incurred "substantial damage", regardless of the actual repair work performed. The term does not, however, include either:

1) Any project for improvement of a structure to correct existing violations of state or local health, sanitary, or safety code specifications which have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions; or
2) Any alteration of a "historic structure," provided that the alteration will not preclude the structure's continued designation as a "historic structure."

Substantial Damage: Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50 % of the market value of the structure before the damage occurred.

After a flood event, local building officials review flooded areas to determine areas that cannot be reoccupied and require a building permit for repairs. Based on the scope of repair work required, a substantial damage determination will be made in cooperation with the local officials responsible for reviewing floodplain development activity. Work on structures that are determined to be substantially damaged is considered to be substantial improvement regardless of the actual repair work performed.

Vulnerability Assessment

The DOGAMI *Risk Report for Morrow County* projects that a 100-year flood (1% chance) would incur losses of approximately $10 million and cause damage to approximately 0.2% of total structures throughout the county. The analysis included loss estimates for four flood scenarios (10-, 50-, 100-, and 500-year). The 100-year flood scenario is presented below because it is the standard probability that FEMA uses for regulatory purposes.

Table 48. Countywide 100-Year Flood Result Summary

	Countywide 100-Year Flood Loss				
	Number of Buildings Damaged	Loss Estimate	Loss Ratio	Damaged Critical Facilities	Potential Displaced Population
Morrow County	250	$10.3 million	0.2%	3 of 20	372

Source: DOGAMI Morrow County Risk Report, 2024

Exposure and Loss Analysis Results

In communities where most residents are not within flood designated zones, the loss ratio may not be as helpful as the actual replacement cost and number of residents displaced to assess the level of risk and impact from flooding. The Hazus-MH analysis also provides useful information for individual communities so that planners can identify problems and consider which mitigating activities will provide the greatest resilience to flooding.

The main flooding problems within Morrow County are primarily along Willow Creek and some of its tributaries as they flow through Heppner, Ione, and Lexington. The unincorporated county also has a high level of estimated damage (~$5 million) primarily from flooding occurring along Willow Creek and some of its tributaries.

Separate from the Hazus-MH flood analysis, DOGAMI did an exposure analysis by overlaying building locations on the 100-year flood extent. This analysis permitted an estimate of the number of buildings that are elevated above the level of flooding and the number of displaced residents. This was done by comparing the number of nondamaged buildings from Hazus-MH to the number of exposed buildings in the flood zone.

A small proportion (3.8%) of Morrow County's buildings were found to be within designated flood zones. Of the 324 buildings that are exposed to flooding, we estimate that 74 are above the height of the 100-year flood. Based on this analysis the cities of Heppner and Ione have the greatest number of potentially displaced residents (167 in Heppner and 152 in Ione) in the county with Lexington expecting 43 potentially displaced residents.

Table 49. Flood Loss Estimates (1% chance event)

	Total Number of Buildings	Total Estimated Building Value ($)	1% (100 year) Flood Scenario			
			Potentially Displaced Residents		Exposed Buildings	
			Number	Percent	Number	Percent
Morrow County	8,480	4,271,375	372	2.9%	324	3.8%
Boardman	1,214	823,077	0	0.0%	0	0.0%
Heppner	797	229,967	167	14.1%	148	18.6%
Ione	249	68,770	152	44.8%	103	41.4%
Irrigon	867	217,274	0	0.0%	0	0.0%
Lexington	212	55,260	43	18.1%	36	17.0%
Unincorporated	5,141	2,877,028	9	0.2%	37	0.7%

Source: DOGAMI Morrow County Risk Report, 2024

Critical Facility Vulnerability

Table 50 provides an inventory of vulnerable critical facilities determined to be within the 1% flood zone. Elevating these exposed structures would reduce the potential damage sustained from flooding.

Table 50. Flood Exposed Critical Facilities Inventory

Exposed Critical Facilities - 100 Year Flood - 1% Annual Chance				
Community	**School**	**Hospital**	**Fire Responders**	**Government Buildings**
Morrow County	***1***	***0***	***1***	***1***
Heppner	-	-	-	1
Ione	1	-	-	-
Lexington	-	-	1	-

Source: DOGAMI Morrow County Risk Report, 2023

Channel Migration Risk

Channel migration was mapped along Willow Creek and Rhea Creek, many areas of which show a very high level of risk from Channel Migration. According to the DOGAMI Risk Report for Morrow County, Channel Migration is projected to affect a small number of buildings (a total of 79) in Heppner, Ione, Lexington, and portions of unincorporated Morrow County, with a concentration of residential structures in Heppner. The value of these exposed buildings is approximately $14.5 million dollars, which is approximately 0.3 % of the total County building value. 2 critical facilities are exposed (Heppner STP and Ione Community Chater School), and Channel Migration could potentially displace 84 residents.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA for North and South County areas that **assessed the vulnerability of the community to flooding.**

- **North County region representatives ranked vulnerability as "Low"**, meaning a flooding event would affect less than 1% of the population; and
- **South County region representatives ranked vulnerability as "Moderate",** meaning a flooding event would affect between 1% and 10% of the population.

*This rating has **remained the same for the North County** since the previous NHMP. A separate **ranking for the South County area is new** during this 2024 update.*

DOGAMI Risk Report also evaluates Channel Migration hazard areas and risk. The Steering Committee did not identify this as a hazard to address in this plan, however the results may be useful in considering the risk to buildings in Morrow County caused by the tendency of rivers to migrate. The data indicates that 79 buildings valued at $14.5 million may be exposed in the county, with two of twenty critical facilities potentially exposed to this hazard, a school in Ione and a government building in Heppner. Heppner is at the highest risk with 3.3% of the city's buildings exposed followed by Ione with 1.7% of that city's buildings exposed to the effects of potential channel migration. This represents some residential structures along Willow Creek and Rhea Creek which are at risk from channel migration. For further information, consult the complete MHRA included in Appendix E.

Landslide

Landslide Risk Ranking Summary	
Probability	**Updates Made**
North County: Low **South County: Moderate**	-2016 NHMP rated Probability as High -2016 NHMP rated Vulnerability as Low - DOGAMI *Risk Report for Morrow County* for Landslide
Vulnerability	
North County: Low **South County: Moderate**	

One of the most common and devastating geologic hazards in Oregon is landslides. Average annual repair costs for landslides in Oregon exceed $10 million and individual severe winter storm losses can exceed $100 million.[64] As population growth continues to expand and development into landslide susceptible terrain occurs, greater losses are likely to result.

Characteristics

Landslides are downhill movements of rock, debris, or soil mass. The size and severity of a landslide usually depends on the geology of the area, as does the initial cause of the landslide. Landslides vary greatly in their volume of rock and soil, the length, width, and depth of the area affected, frequency of occurrence, and speed of movement. Some characteristics that determine the type of landslide are slope of the hillside, moisture content, and the nature of the underlying materials.

Different types of landslides occur depending on the type of origin, failure and their composition and characteristics. However, they are typically broken down into two categories: (1) rapidly moving, and (2) slow moving. Rapidly moving landslides present the greatest risk to human life, and people living in or traveling through areas prone to rapidly moving landslides are at increased risk of serious injury.

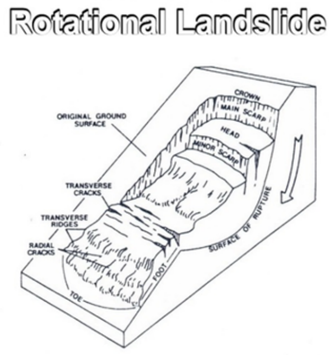
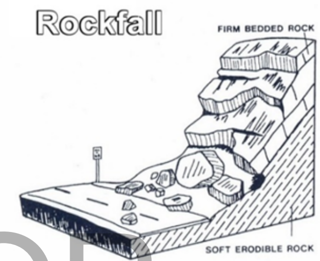
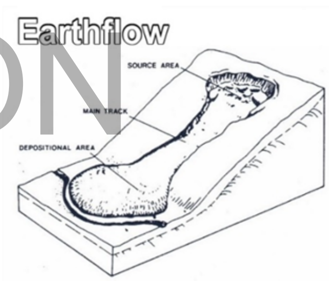
Slow moving landslides that move downhill slowly are said to "creep", as its movements are often slow and shallow enough to anticipate its arrival and manage it with adequate effort. Slow moving landslides can occur on relatively gentle slopes and can cause significant property damage but are far less likely to result in serious injuries than rapidly moving landslides.

Rapidly moving landslides are those that can happen rapidly and result in all the soil and rocks on a hillside to be stripped off and filling up the area at the bottom of the slope. Washouts caused by erosion can occur in Morrow County and occur when ditches or culverts beneath hillside roads become blocked with debris. If the ditches are blocked, run-off from slopes is inhibited during periods of precipitation. This causes the run-off water to collect in soil, and in some cases, cause a slide.

There are several different types of landslides, both slow and rapid (see Table 51):

[64] DOGAMI, "Landslide Loss Estimation Pilot Project in Oregon", 2002

Table 51. Description of Types of Landslides

Landslide Type	Description	Visual
Slides / Rotational	These landslides move in contact with the underlying surface. These movements include rotational slides (see figure ____) where sliding material moves along a curved surface, and translational slides where movement occurs along a flat surface. These slides are generally slow moving and can be deep. Slumps are small rotational slides that are generally shallow	 Source: Federal Emergency Management Agency. FEMA 182, Landslide Loss Reduction. FEMA (1989) p. 12.
Rockfall	These occur when blocks of material come loose on steep slopes. Weathering, erosion, or excavations, such as those along highways, can cause falls where the road has been cut through bedrock. They are fast moving with the materials free detached from a steep slope or cliff. The volume of material involved is generally small, but large boulders or blocks of rock can cause significant damage. A motorist was killed from a rock fall in 1993. The 1993 rock fall occurred near Klamath Falls during the 1993 Earthquakes.	 Source: Federal Emergency Management Agency. FEMA 182, Landslide Loss Reduction. FEMA (1989) p. 11.
Earthflow	These are liquid movements of landmass (e.g. soil and rock), which breaks up and flows during movement. Earthquakes are often the mechanism which trigger flows. Debris flows normally occur when a landslide moves downslope as a semi-fluid mass scouring, or partially scouring soils from the slope along its path. Flows are typically rapidly moving and also tend to increase in volume as they scour out the channel. Flows often occur during heavy rainfall, can occur on gentle slopes, and can move rapidly for large distances. One example of a flow in Oregon is the Dodson debris flow that occurred in 1996. This debris flow started high on the Columbia Gorge cliffs, and traveled far down steep canyons to form debris fans at Dodson.	 Source: Federal Emergency Management Agency. FEMA 182, Landslide Loss Reduction. FEMA (1989) p. 15.

Source: Federal Emergency Management Agency; Oregon Department of Geology and Mineral Industries

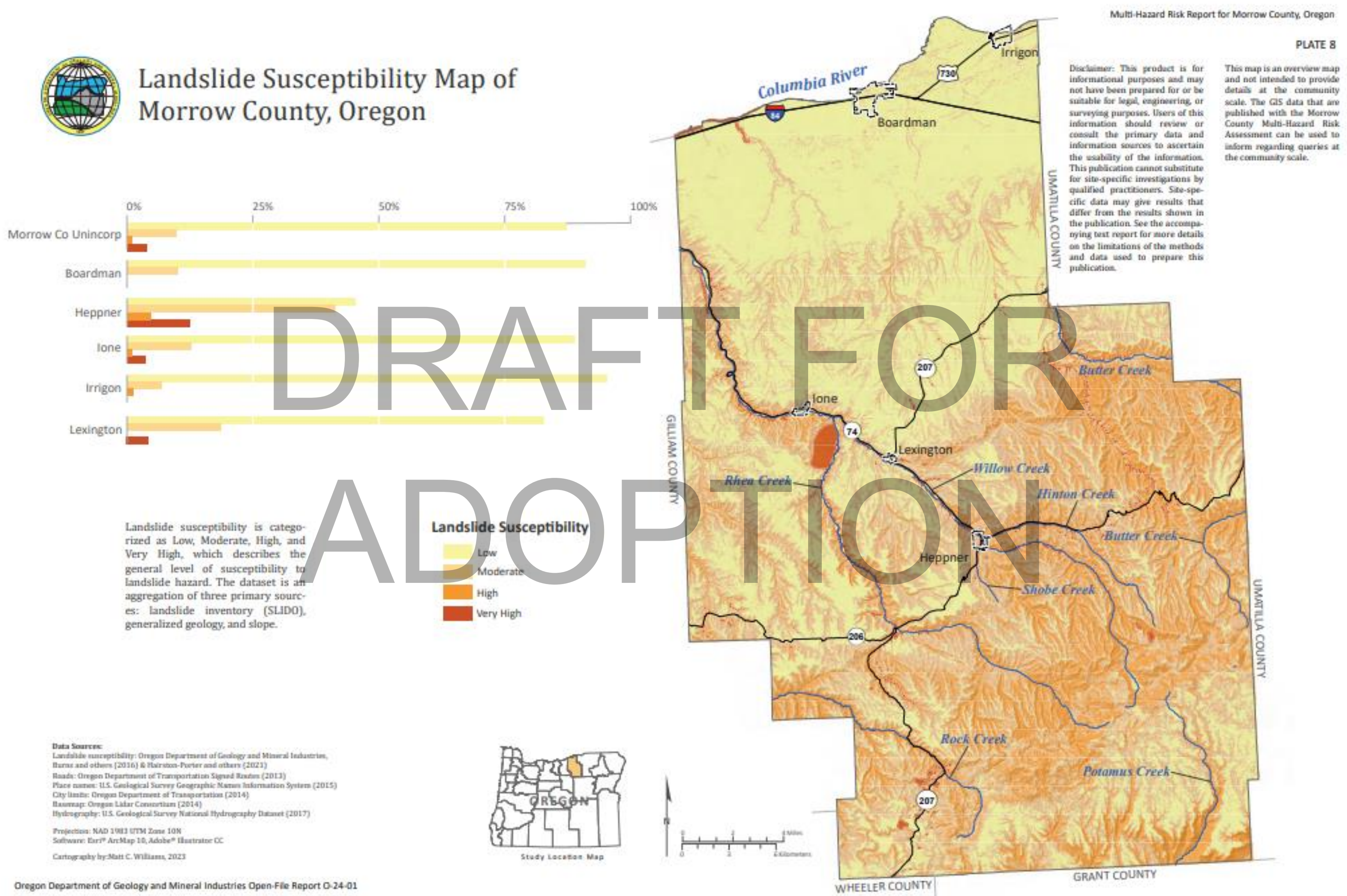
Location and Extent

Landslides are typically triggered by periods of heavy rainfall or rapid snowmelt, as well as earthquakes, volcanic activity, and excavations. Certain geologic formations are more susceptible to landslides than others, and landslides on steep slopes are more dangerous because their movement can be rapid. Although landslides are a natural geologic process, the incidence of landslides and their impacts on people can be exacerbated by human activities. Grading for road construction and development can increase slope steepness and decrease the stability of a hill slope by adding weight to the top of the slope, as well as removing support at the base of the slope, and increasing water content. Other human activities affecting landslides include excavation, drainage and groundwater alterations, changes in vegetation, as well as burn scars left from wildfires.

Landslides that most often occur in Morrow County are due to rain events and are generally not significant enough to block traffic. However, along Rhea Creek and Willow Creek Roads, landslide events have been most numerous and have been known to temporarily block traffic.

For Morrow County, many potential areas for a landslide are in hilly-forested areas (Figure 31). Landslides in these areas may damage or destroy some timber and impact logging roads. Many of the major highways in Morrow County are at risk of landslides at one or more locations with a high potential for road closures and damage to utility lines. Especially in the eastern portions of the County, with a limited redundancy of road network, such road closures may isolate communities.

Figure 31. Landslide Susceptibility Map of Morrow County, Oregon



The Oregon Department of Geology and Mineral Industries (DOGAMI) has been active in developing maps and collecting data on hazard risk. The final products might be useful for local geologists, engineers, planners, and policy makers interested in addressing landslide hazards. One of these products is the Statewide Landslide Information Database for Oregon (SLIDO). SLIDO is a compilation of landslides in Oregon that have been identified on published maps which allow users to view information on location, type, and other attributes related to identified landslides in the area.

Landslides can affect utility services, transportation systems, and critical facilities. Utilities, including potable water, wastewater, telecommunications, natural gas, and electric power are all essential to service community needs, and the loss of electricity has the most widespread impact on other utilities and on the whole community. Natural gas pipes may also be at risk of breakage from landslide movements as small as a few inches. These disruptions of infrastructure, roads, and critical facilities can have a long-term effect on the economy of the local community, as well as its ability to return to normal operation.

Table 52 shows landslide susceptibility exposure for Morrow County and its incorporated cities. Approximately 20% of the County land has high or very high landslide susceptibility exposure. Morrow County cities have a wide range of landslide exposure susceptibility (the highest in Hepper with 21.9% to the lowest in Irrigon with 0.2%).

Table 52. Landslide Susceptibility Exposure of Morrow County

	Sq Ft	Landslide Susceptibility Exposure,%			
		Low	Moderate	High	Very High
Morrow County	56,628,190,492	43.8%	35.9%	20.1%	0.2%
Boardman	112,562,441	87.0%	12.2%	0.8%	0.0%
Heppner	34,307,735	21.4%	56.7%	21.9%	0.0%
Ione	18,907,066	48.2%	33.9%	17.8%	0.0%
Irrigon	44,926,107	87.4%	12.5%	0.2%	0.0%
Lexington	12,483,669	56.8%	39.5%	3.7%	0.0%

Source: DOGAMI Morrow County Risk Report, 2023

Note that even if a County or city has a high percentage of area in a high or very high landslide exposure susceptibility zone, this does not mean there is a high risk, as risk is the intersection of hazard and assets.

History

Landslides may happen at any time of the year. Debris flows and landslides are a very common occurrence in hilly areas of Oregon, including portions of Morrow County. Many landslides occur in undeveloped areas and thus may go unnoticed or unreported. For example, DOGAMI conducted a statewide survey of landslides from four winter storms in 1996 and 1997 and found 9,582 documented landslides, with the actual number of landslides estimated to be many times the documented number. For the most part, landslides become a problem only when they impact developed areas and have the potential to damage buildings, roads, or utilities.

Many landslides are difficult to mitigate, particularly in areas of large historic movement with weak underlying geologic materials. As communities continue to modify the terrain and influence natural processes, it is important to be aware of the physical properties of the underlying bedrock as it, along with climate, dictates hazardous terrain.

Morrow County has had a history of landslides occurring in the area, primarily along the northern part of Willow Creek. A large proportion of these landslides are rockfall landslides.[65]

Landslide Hazard Assessment

Probability Assessment

The probability of rapidly moving landslide occurring depends on a number of factors, including steepness of slope, slope materials, local geology, vegetative cover, human activity, and water. There is a strong correlation between intensive winter rainstorms and the occurrence of rapidly moving landslides (debris flows). Consequently, the National Weather Service tracks storms during the rainy season, monitors rain gauges and snow melt and issues warnings as conditions warrant.

Geo-engineers with DOGAMI estimate widespread landslides about every 20 years; landslides at a local level can be expected every two or three years.

The OCCRI *Future Climate Projections Morrow County, Oregon* report states that as the occurrence and intensity of extreme and heavy precipitation increases, the risk of landslides increases.[66] Landslides are often triggered when heavy rainfall saturates soil, they can also be exacerbated by logging activity, road construction, and the damage resulting from previous wildfire events.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **the probability of both regions to experiencing a landslide:**

- **North County region probability has "Low", meaning one incident is likely within a 75-to-100-year period; and**
- **South County region probability has "High", meaning one incident is likely within a 10-to-35-year period.**

*This rating has **remained the same for the South County** since the previous NHMP. A separate **ranking for the North County area is new** during this 2024 update.*

Vulnerability Assessment

Vulnerability assessments assist in predicting how different types of property and population groups will be affected by a hazard. Population and property value impacts from future landslide occurrences can be assessed by analyzing parcel specific data at the city or county level. By using parcel-specific assessment data on land use and structures, specific landslide-prone and debris flow prone locations can be identified.

Landslides can occur on their own or in conjunction with other hazards, such as flash flooding. Depending upon the type, location, severity, and area affected, severe property damage, injuries and loss of life can be caused by landslide hazards. Landslides can damage or temporarily disrupt utility services, block off or damage roads, critical lifeline services such as police, fire, medical, utility and communication systems, and emergency response.

[65] Statewide Landslide Information Database for Oregon (SLIDO), DOGAMI
[66] OCCRI, Future Climate Projections Morrow County, 2023

Utilities, including potable water, wastewater, telecommunications, natural gas, and electric power are all essential to service community needs, and communities may suffer immediate damage and loss of service. Loss of electricity has the most widespread impact on other utilities and on the whole community. Natural gas pipes may also be at risk of breakage from landslide movements as small as an inch or two. Disruption of infrastructure, roads, and critical facilities may also have a long-term effect on the economy.

Roads and bridges are subject to closure during landslide events. Because many Morrow County residents, particularly those who are living in rural areas, are dependent on roads and bridges for travel to work or for services only available in urban areas, delays and detours are likely to have an economic impact on county residents and businesses. To evaluate landslide mitigation for roads, the community can assess the number of vehicle trips per day, detour time around a road closure, and road use for commercial traffic or emergency access.

Lifelines and critical facilities should remain accessible if possible, during a natural hazard event. The impact of closed transportation arteries may be increased if the closed road or bridge is a critical lifeline to hospitals or other emergency facilities. Therefore, inspection and repair of critical transportation facilities and routes is essential and should receive high priority. Losses of power and phone service are also potential consequences of landslide events. Due to heavy rains, soil erosion in hillside areas can be accelerated, resulting in loss of soil support beneath high voltage transmission towers in hillsides and remote areas. Flood events can also cause landslides, which can have serious impacts on gas lines.

The 2023 *Multi-Hazard Risk Report for Morrow County* provides a landslide exposure analysis. The exposure analysis calculates the number of buildings, their value, and associated populations exposed to the various landslide susceptibility scenarios. Determining landslide susceptibility, or the likelihood that a landslide would occur in an area, depends on the slope, surficial geology, soil type, and the presence of pre-existing landslides. Additionally, changing climate, precipitation patterns, land use, wildfire events, and land and forest management strategies may increase or decrease the susceptibility to landslides. DOGAMI analyzed areas of landslide susceptible to the following scenarios: medium, high, and very high. The landslide susceptibility scenarios are defined based on the influence of several factors on slope stability.

Table 53 shows the summary projections from the DOGAMI *Multi-hazard Risk Report for Morrow County* for landslide exposure based on the combination of high and very high landslide susceptibility. The DOGAMI report states that a landslide between high and very high landslide susceptibility would incur losses of approximately $140.3 million and cause damage to over 550 structures throughout the County, which would incur financial losses of approximately 3.3% of the total building value.

Table 53. Landslide Susceptibility Result Summary

	Countywide Landslide Exposure (High and Very High susceptibility)				
	Number of Exposed Buildings	Exposure Value	Percentage of Exposure Value	Critical Facilities Exposed	Potential Displaced Population
Morrow County	551	$140.3 million	3.3%	1 of 20	543

Source: DOGAMI Morrow County Risk Report, 2023

Heppner and Lexington are exposed to the greatest level of landslide risk (Table 54). Development in areas of moderate to steep slopes or at the base of steep slopes is at greater risk. Countywide, over 6% of buildings are in areas that are highly or very highly susceptible to landslides. Almost 14% of buildings in

Heppner are in areas of very high susceptibility to landslides. The value of these exposed buildings in this community total over $3 million.

Table 54. Landslide Exposure Analysis

	Total Number of Buildings	Total Building Value ($ in thousands)	Landslide Susceptibility			
			Exposed Buildings (High and Very High)		Value of Loss	
			Number	Percent	Value ($)	Loss Ratio
Morrow County	8,480	4,271,375	551	6.5%	140,321	3.3%
Boardman	1,214	823,077	0	0.0%	0	0.0%
Heppner	797	229,967	111	13.9%	30,944	13.5%
Ione	249	68,770	5	2.0%	1,997	2.9%
Irrigon	867	217,274	2	0.2%	775	0.4%
Lexington	212	55,260	10	4.7%	1,538	2.8%
Unincorporated	5,141	2,877,028	423	8.2%	105,067	3.7%

Source: DOGAMI Morrow County Risk Report, 2023

Critical Facility Vulnerability

Table 55 provides an inventory of vulnerable critical facilities that were determined to be exposed to the high and very high landslide susceptibility scenario.

Table 55. Landslide Exposed Critical Facilities Inventory

Exposed Critical Facilities - High and Very High Landslide Susceptibility				
Community	School	Hospital	Fire Responders	Government Buildings
Morrow County	***1***	***0***	***0***	***0***
Heppner	1	-	-	-

Source: DOGAMI Morrow County Risk Report, 2023

Noted areas of significant vulnerability include buildings in the communities and unincorporated county along Route 74 along Willow Creek and Route 74 where there are many debris flow deposits indicating potential for reactivated debris flows to impact important transportation routes in the county.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **the vulnerability of both regions to Landslide:**

- **North County region vulnerability is "Low",** meaning <1% of the region's population and property would be affected by a major landslide emergency or disaster; and
- **South County region vulnerability is "Moderate",** meaning 1-10% of the region's population and property would be affected by a major landslide emergency or disaster.

*This **rating has remained the same for the North County** since the previous NHMP. A separate ranking for the **South County area is new** during this 2024 update.*

Volcanic Event

Volcanic Event Risk Ranking Summary	
Probability	**Updates Made**
North County: Low **South County: Low**	-2016 NHMP rated Probability as Low -2016 NHMP rated Vulnerability as Low
Vulnerability	
North County: High **South County: Low**	

Characteristics

The Pacific Northwest lies within the "ring of fire," an area of very active volcanic activity surrounding the Pacific Basin. Volcanic eruptions occur regularly along the ring of fire, in part because of the movement of the Earth's tectonic plates. The Earth's outermost shell, the lithosphere, is broken into a series of slabs known as tectonic plates. These plates are rigid, but they float on a hotter, softer layer in the Earth's mantle. As the plates move about on the layer beneath them, they spread apart, collide, or slide past each other. Volcanoes occur most frequently at the boundaries of these plates, and volcanic eruptions occur when the hotter, molten materials (or magma) rise to the surface. In Oregon, volcanic activity can be found along the Cascade Range, which was formed by the Juan de Fuca plate sinking beneath the North American plate.[67]

The primary threat to lives and property from active volcanoes is from violent eruptions that unleash tremendous blast forces, generate mud and debris flows, and produce flying debris and ash clouds. The immediate danger area in a volcanic eruption generally lies within a 20-mile radius of the blast site. The location of Morrow County means volcanic eruptions only pose one real threat: ash fall. As a result, only ash fall will be discussed in terms of volcanic hazards.

Ash Fall

One of the most serious hazards from an eruption is the rock and dust-sized ash particles—called tephra—blown into the air. The tephra can travel enormous distances and are a serious by-product of eruptions. Within a few miles of the vent, the main tephra hazards include high temperatures as well as the risk of being buried and being hit by falling fragments. Within twelve miles, tephra may set fire to forests and flammable structures.

According to the 2020 Oregon NHMP, during an eruption, the ash fall deposition is controlled by the prevailing wind direction. The predominant wind pattern over the Cascades is westerly, and previous eruptions seen in the geologic record have resulted in most ash fall drifting to the east of the volcanoes.[68]

[67] Natural Hazards Mitigation Planning : Natural Hazards, 2020, DLCD State of Oregon
[68] Ibid.

Volcanic ash can contaminate water supplies, cause electrical storms, create health problems, and collapse roofs.

Location and Extent

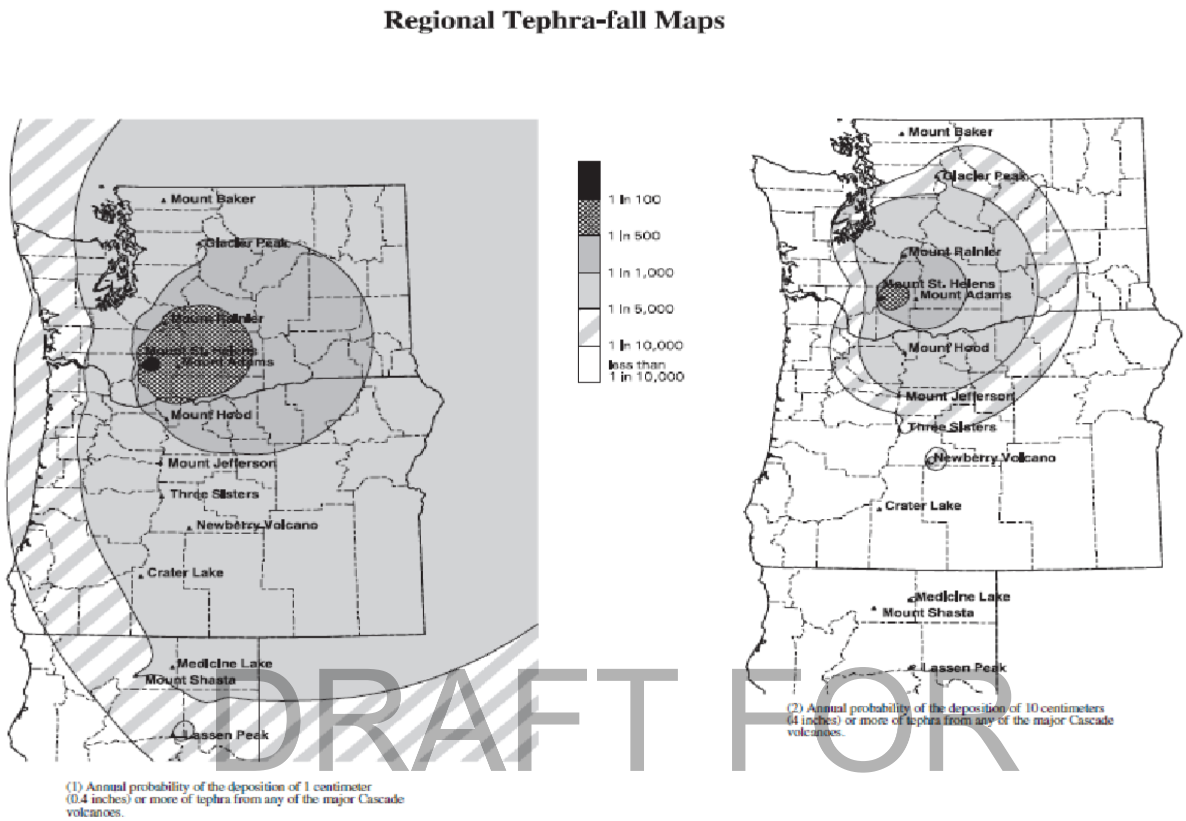
The eastern boundary of the Cascade Range is within 150 miles of Morrow County and the western boundary of Hood River and Wasco counties coincide with the Cascade Range. Several of their communities are very close to Mt. Hood, a well-known volcanic peak. In addition, both counties are less than 100 miles from Mt. St. Helens, and Mt. Adams in Washington State, two prominent volcanoes. The principal risks from these mountains include air borne tephra (ash), lahars, and pyroclastic flows from a Mt. Hood eruption. The primary risks from Mt. St. Helens and Mt. Adams, separated by distance and the Columbia River, include air borne tephra and the possibility of lahars reaching the Columbia River.

The Cascade Range has been an active volcanic area for about 36 million years as a result of the convergence between the North American and Juan de Fuca crustal plates. According to most interpretations, volcanism in the Cascades has been discontinuous in time and space, with the most recent episode of activity beginning about 5 million years ago and resulting in more than 3,000 vents. This activity is observable today as scientists closely monitor ongoing activity at Mount. St. Helens in Washington, the South Sister in Oregon, and other locations. If any of these volcanoes erupted, there would be a possibility of ash that could affect air and water quality.

Morrow County infrastructure and development could be severely impacted by volcanic ash falls derived from regional volcanic activity. The extent of damage from these hazards depends on the distance from the volcano, vent location, and type of hazardous events that occur during an eruption.

Scientists use wind direction to predict areas that might be affected by volcanic ash; during an eruption that emits ash, the ash fall deposition is controlled by the prevailing wind direction. The predominant wind pattern over the Cascades originates from the west and previous eruptions seen in the geologic record have resulted in most ash fall drifting to the east of the volcanoes. Regional tephra fall shows the annual probability of ten centimeters or more of ash accumulation from Pacific Northwest volcanoes. Figure 32 depicts the potential and geographical extent of volcanic ash fall more than ten centimeters from a large eruption of Mt. St. Helens. Additionally, Lassen Peak and Mount Shasta are active and potentially active volcanoes, respectively located in northern California. The proximity of these volcanic features suggests that, in the rare event of an eruption, Morrow County could be affected by ash fall and other air quality impacts.

Figure 32. Regional Tephra-fall Maps



Source: USGS Volcano Hazards in the Mount Jefferson Region, Oregon

History

Volcanoes in the Cascade Range have been erupting for hundreds of thousands of years. All the Cascade Range volcanoes are characterized by long periods of quiescence and intermittent activity. These characteristics make predictions, recurrence intervals, or probability very difficult to ascertain.

As evidenced by all of the basalt that underlies Morrow County, this region has been mightily influenced by volcanic activity. Despite the scary image of liquid basalt flowing over the central basin area, there has been no such activity since more than 15 million years ago. Today, any risk to Morrow County is perceived as coming from the volcanic Cascade Range to the west. There is no history of volcanic impacts in Morrow County, although volcanic history in the wider region, notably the Mt. St. Helens eruption in 1980, does show that a volcano could affect the County if a volcano in the Cascade Range erupted.

Table 56 presents the history of volcanic activity that affected Morrow County over the past 20,000 years.

Table 56. Historic Volcanic Activity Affecting Morrow County

Date	Location	Description
20,000 to 13,000 YBP	Polallie Eruptive episode, Mount Hood	Lava dome, pyroclastic flows, lahars, tephra
About 7,700 YBP	Parkdale, north-central Oregon	Eruption of Parkdale lava flow
About 1,500 YBP	Timberline eruptive period, Mount Hood	Lava dome, pyroclastic flows, lahars, tephra
1760-1810	Crater Rock/Old Maid Flat on Mount Hood	Pyroclastic flows in upper White River; lahars in Old Maid Flat; dome building at Crater Rock
1859-1865	Crater Rock on Mount Hood	Steam explosions and tephra falls
1907 (?)	Crater Rock on Mount Hood	Steam explosions

Source: State of Oregon Natural Hazard Mitigation Plan, 2020;
Note: YBP is Years Before Present

Volcanic Event Hazard Assessment

Probability Assessment

Because geologic history is fragmentary for these volcanoes, the probability of future explosive eruptions is difficult to estimate. Only two explosive episodes have occurred at the South Sister since the ending of the ice age (about 12,000 years ago). Given the fragmentary record, the annual probability of the South and Middle Sister entering a new period of eruptive activity has been estimated from one in several thousand to 1 in 10,000.[69]

Similar difficulties complicate predictions of future eruptions at Mount Jefferson. There have been four eruptive episodes since the end of the ice age (within the last 20,000 years). Such a frequency suggests an annual probability of about 1 in 4,000 to 1 in 3,000.[70]

Although the science of volcano predictions is improving, it remains challenging to predict a potential volcanic event. Ash fall, which will be the greatest impact, will impact the entire County. Impacts will be felt hardest by property managers (ranches, farmers, etc.) and by those relying upon clean surface water (for drinking water production and irrigation).

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **the probability of both regions to experiencing a Volcanic Event:**

- **North County region probability ranked "Low",** meaning one incident is likely within a 75-to-100-year period; and

[69] Tsunamis generated by subaerial mass flows, 2003, Walder et al.
[70] Ibid.

- **South County region probability ranked "Moderate",** meaning one incident is likely within a 35-to-75-year period.

*This rating has **remained the same for the North County** since the previous NHMP. A separate **ranking for the South County area is new** during this 2024 update.*

Vulnerability Assessment

The U.S. Geological Survey (USGS) lists the threat potential of volcanoes. According to the USGS there are nine volcanoes with Very High or High threat potentials in Oregon and Washington (listed here in order of threat potential): Mount St. Helens, Mount Rainier, Mount Hood, Three Sisters, Newberry, Mount Baker, Glacier Peak, Crater Lake, and Mount Adams (High).[71]

The primary threat to lives and property from active volcanoes is from violent eruptions that unleash tremendous blast forces, generate mud and debris flows (lahars), or produce flying debris and ash clouds. Volcano hazards are divided into proximal (near the volcano) and distal (far from the volcano).

Morrow County's proximity to a number of Cascade Range volcanoes places the region at risk from ash fallout originating from such an event. The greatest vulnerability the County faces from ash fall is the threat imposed on the possible health repercussions to residents with an emphasis on respiratory issues and the impact on infrastructure.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **the vulnerability of both regions of experiencing a Volcanic Event:**

- **North County region vulnerability is "High",** meaning more than ten (10)% of the region's population and property would be affected by a major a volcanic event emergency or disaster; and
- **South County region vulnerability is "Low"**, meaning less than one (1)% of the region's population and property would be affected by a major volcanic event emergency or disaster.

*This rating has **remained the same for the South County** since the previous NHMP. A separate **ranking for the North County area is new** during this 2024 update.*

[71] Ewert, J.W., Diefenbach, A.K., and Ramsey, D.W., 2018, 2018 update to the U.S. Geological Survey national volcanic threat assessment: U.S. Geological Survey Scientific Investigations Report 2018-5140.

Wildfire

Wildfire Risk Ranking Summary	
Probability	**Updates Made**
North County: High **South County: High**	-2016 NHMP rated Probability as High -2016 NHMP rated Vulnerability as Medium - History updated to account for recent wildfires - DOGAMI *Risk Report for Morrow County* for Wildfire - Community Wildfire Susceptibility Issues Updated
Vulnerability	
North County: Low **South County: High**	

Wildfire is a serious threat to the well-being and quality of life in Morrow County. While fires are a natural part of the ecosystem in Oregon, Morrow County, along with much of eastern Oregon, has had experience with wildfires in the past.

Wildfires can present a substantial hazard to life and property in growing communities, especially those expanding into previously wildland areas, which is known as the wildland urban interface (WUI). There is potential for severe losses due to development in the WUI areas in Morrow County.

Morrow County's Community Wildfire Protection Plan was promulgated in 2019 and substantially forms the basis of this section.[72]

Characteristics

Wildfires occur in areas with large amounts of flammable vegetation or structures that require a suppression response due to uncontrolled burning. Fire is an essential part of Oregon's ecosystem but can also pose a serious threat to life and property, particularly in the state's growing rural communities. The increase in residential development in interface areas has resulted in greater wildfire risk. Fire is a natural process that significantly contributes to ecological health. However, due to decades of fire suppression and exclusion policies and practices across a wide range of ecological systems, including forests and non-treed environments such as grass fields and sage brush steppes, have become overgrown with vegetation, creating ample fuel conducive for potential catastrophic wildfires to occur.

In the heavily forested area, the forests present a continuous fuel supply both vertically, in small, thin trees and dead branches (ladder fuels), and horizontally, in an abundance of dead and downed material on the forest floor. When a fire ignites in such a forest, the dead branches, sticks, twigs, and other material increase fire intensity and, with ladder fuels present, provide great opportunity for the fire to reach the forest canopy, resulting in a stand-killing crown fire. These conditions also affect the means in which prescribed fire and fuels treatment are applied to the landscape.

Current climate conditions, especially in drought years, influence the frequency, intensity, duration, and extent of fire. Summers are dry and lightning prone because a Pacific coast high-pressure system typically blocks precipitation for much of the season. In the upper elevations, where temperatures are low and rainfall is high, fires are less frequent than in the valleys. Larger climatic factors such as long-

[72] Morrow County 2019 Community Wildfire Protection plan (CWPP)

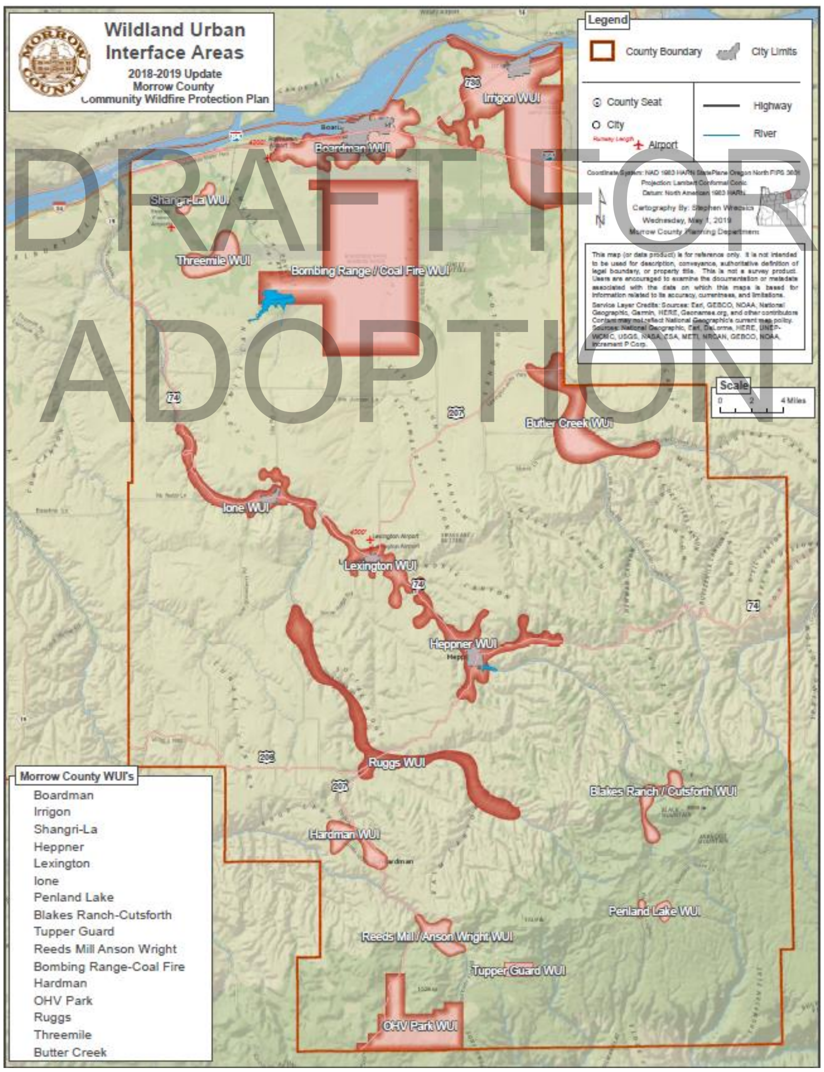
term global variations related to El Niño or to sunspot cycles also influence fire regimes, but this influence is confounded by local climatic variations, recent land management activities, and burns.

The following factors contribute significantly to wildfire behavior and increased wildfire risk.

The Wildland Urban Interface (WUI)

One challenge Morrow County faces regarding the wildfire hazard is from the increasing number of homes built on the urban/rural fringe compared to thirty years ago. Since the 1970s, Oregon's growing population has expanded further and further into wildland and previously undeveloped resource lands including forestlands, minimizing the space between developed areas and vegetation (see Figure 33). The "interface" between urban and suburban areas and the resource lands created by this expansion has produced a significant increase in threats to life and property from fires and has pushed existing fire protection systems beyond original or current design and capability. Furthermore, human activities increase the incidence of fire ignition and potential damage.

Figure 33. Wildland Urban Interface Zones in Morrow County



Source: [Morrow County 2019 Community Wildfire Protection plan (CWPP)]

Certain conditions increase the risk of significant interface fires. The most common conditions include hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and the presence of a large fuel load (dense vegetation). Once a fire has started, several conditions influence its behavior, including fuel, topography, weather, drought, and development.

Fuel

Fuel is the material that feeds a fire and is a key factor in wildfire behavior. Fuel is classified by volume and by type. Volume is described in terms of "fuel loading," or the amount of available vegetative fuel. Oregon, a western state with prevalent conifer, brush, and rangeland fuel types, is subject to more frequent wildfires than other regions of the nation. An important element in understanding the danger of wildfire is the availability of diverse fuels in the landscape, such as natural vegetation, manmade structures, and combustible materials. A house surrounded by brushy growth rather than cleared space allows for greater continuity of fuel and increases the fire's ability to spread. The accumulation of fuels around residential homes enables high intensity fires to flare and spread rapidly. Because of the many different possible "fuels" found in the interface landscape, firefighters have a difficult time predicting how fires will react or spread.

Topography

Topography influences the movement of air, thereby impacting a fire's course. For example, wildfire moves faster uphill due to the direction of ambient winds. If the percentage of uphill slope doubles, the rate of spread in wildfire will likely double. Gulches and canyons can funnel air and act as chimneys, which intensifies fire behavior and causes the fire to spread faster. Solar heating of dry, south-facing slopes produces upslope drafts that can complicate fire behavior. Unfortunately, hillsides with hazardous topographic characteristics are also desirable residential areas in many communities. This underscores the need for wildfire hazard mitigation and increased education and outreach to homeowners living in interface areas.

Weather

Weather patterns combined with certain geographic locations can create a conducive climate for wildfire activity. Areas where annual precipitation is less than 30 inches per year are extremely fire susceptible. High-risk areas in Oregon share a hot, dry season in late summer and early fall when high temperatures and low humidity favor fire activity. Predominant wind directions may guide a fire's path.

Drought

Recent concerns about the effects of climate change, particularly drought, are contributing to concerns about wildfire vulnerability. Unusually dry winters, or significantly less rainfall than normal, can lead to relatively drier conditions, and leave reservoirs and water tables lower. Drought leads to problems with irrigation, and may contribute to additional fires, or additional difficulties in fighting fires.

Human Causes

Human-caused wildfire is a growing concern, as the number of human-caused wildfires has grown significantly. Oregon has seen hundreds of fires started due to arson, debris burning, equipment use, recreational activities, and smoking. As more people are interacting with the wildland in some way and there is a growing interest in outdoor activities, the risk of human-caused wildfire grows.

Location and Extent

Wildfire poses a risk across the entire County, and is only exacerbated by development in WUI areas and the impact of climate change on climatic regimes. Fire susceptibility throughout the County dramatically increases in late summer and early autumn as summer thunderstorms with lightning strikes increases and vegetation dries out, decreasing plant moisture content and increasing the ratio of dead fuel to living fuel. However, various other factors, including humidity, wind speed and direction, fuel load and fuel type and topography can contribute to the intensity and spread of wildland. In addition, common human causes of wildfires include arson and negligence from various human activities.

Each region in Morrow County experiences the risk of wildfire differently due to varying topography, development and vegetation as seen in Figure 34. This map of Overall Wildfire Risk shows the product of the likelihood and consequence of wildfire on all mapped highly valued resources and assets combined: critical infrastructure, developed recreation, housing unit density, seed orchards, sawmills, historic structures, timber, municipal watersheds, vegetation condition, and terrestrial and aquatic wildlife habitat. This dataset considers the likelihood of wildfire >250 acres (likelihood of burning), the susceptibility of resources and assets to wildfire of different intensities, and the likelihood of those intensities. Figure 35 focuses on the likelihood or burn probability alone without considering what assets could be impacted.

North County

The northern region of the County contains most of the County's economic infrastructure, including the Port of Morrow with its associated industries, Bonneville Power Administration power lines, natural gas pipelines, and many more. The potential for wildfire in this portion of the County is less than the rest of the County for the following reasons: The farms and fields are irrigated, which means that water is available to keep the crops green and to lessen the ability of wildfire to spread and the area is more populated and contains two fire protection districts to respond to fires in the undeveloped shrub-steppe regions of the County. The ability of firefighters to protect this portion of the County is hampered, however, by the limited transportation network, which does not allow for quick coverage of the undeveloped areas of this portion of the County.

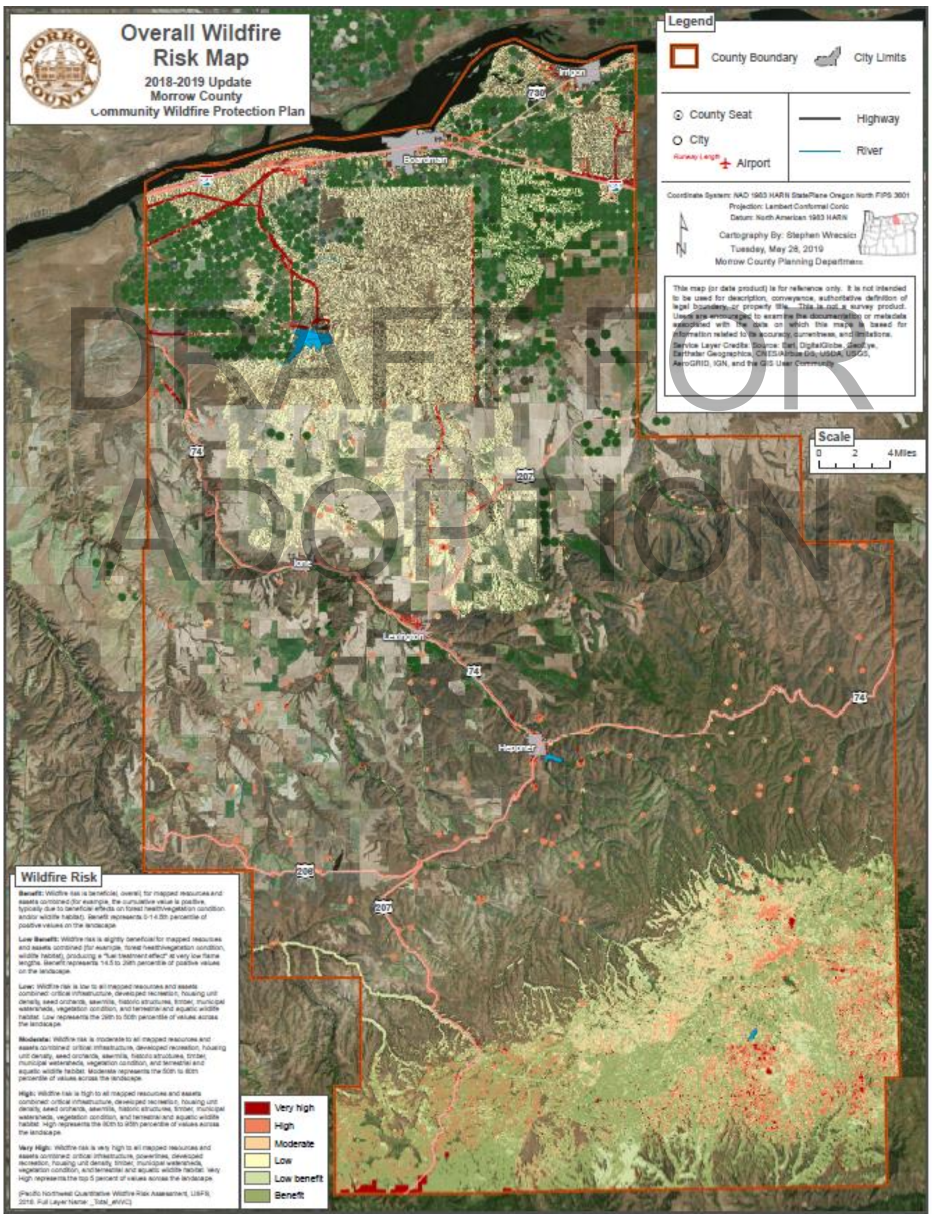
Central County

In the middle of the County, precipitation is too low for tree growth without the support of irrigation. Nevertheless, the fire protection districts respond to fires in this area more than in the forested southern region. The middle region of the County is mostly dry land ranges for the pasture of cattle and dryland wheat. The local fire protection districts most often respond to wildfires that were a result of a lightning strike, with less response when due to a human cause. The fires generally burn rangeland, Conservation Reserve Program (CRP) fields, and pastures. Heppner, Lexington, and Ione are located within this area.

South County

The southern region of the County is forested in the southeast corner of the County within the Umatilla National Forest. The topography of this part of the County is rugged as it is a part of a northwest spur of the Blue Mountains. The precipitation over this higher portion of the County does support conifer forests. These conifer stands, which cover some 205,000 acres, form an almost solid cover over the ridges and slopes of this area. About one thousand acres is juniper or scrub timber. The major species of conifers are ponderosa pine, Douglas-fir and western larch. The fire protection officials in this area characterize the fuel for wildfire potential in this region as very high. There are residential developments in the forested zone, which are the Blake Ranch area and the residential development around Penland Lake and around Cutsforth Park. Although the Blake Ranch area has been incorporated into the Heppner Rural Fire Protection District, the potential for life and property loss is high in the event of a fire due to distance from rural fire protection districts for most of the area. Increasingly, people are using this area for recreational use at the County run Off-Highway-Vehicle Park and more people spend holiday time during weekends and vacation periods here. The residents and visitors to these areas are often inadequately educated or prepared for the inferno that could sweep through the brush and timber, affecting safety and destroying property in minutes.

Figure 34. Overall Wildfire Risk in Morrow County



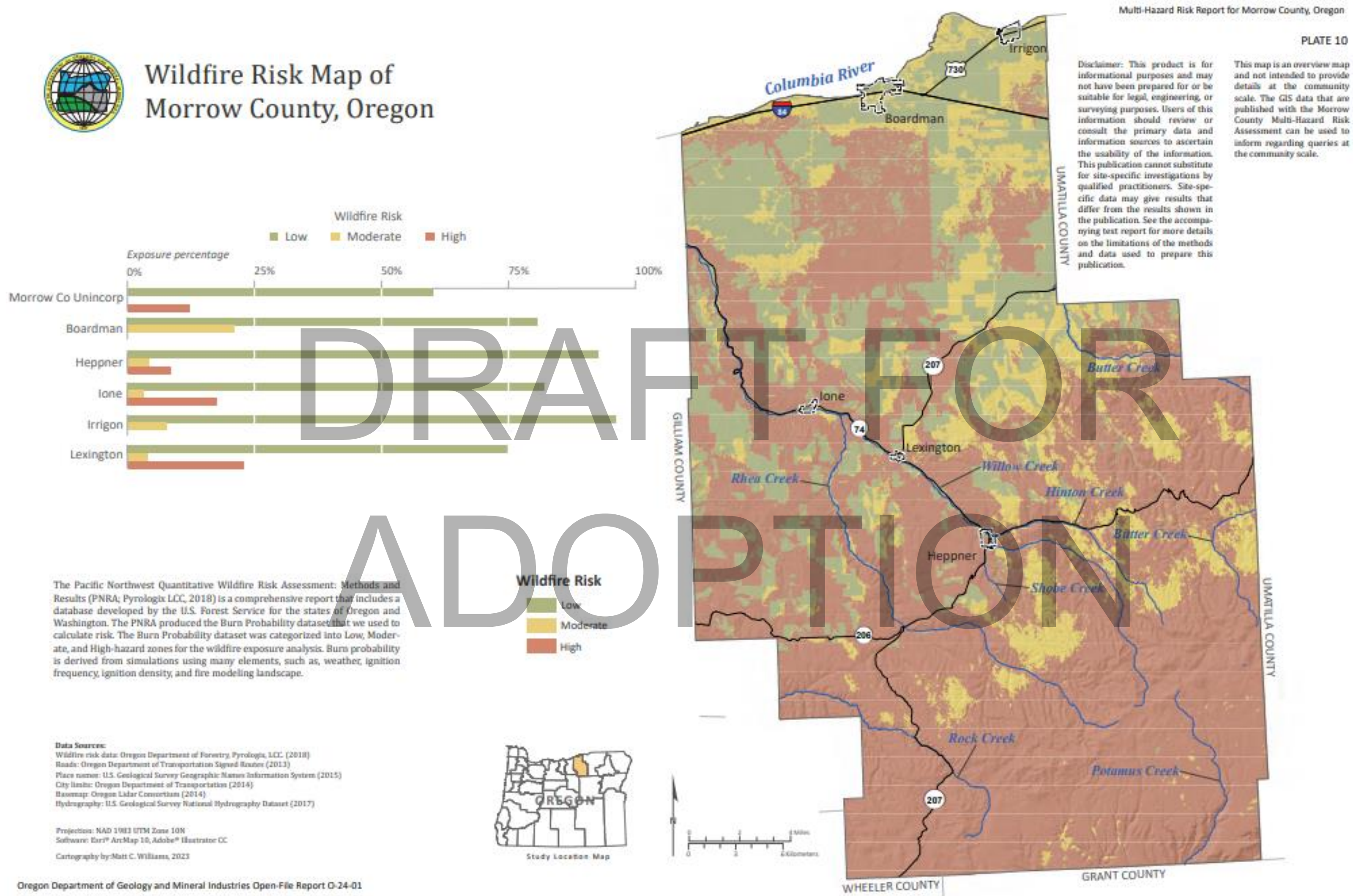
Source: [Morrow County 2019 Community Wildfire Protection plan (CWPP)]

The DOGAMI Multi-hazard Risk Report provides a plate (Figure 35) showing the burn probability across the county. This is only one factor in Wildfire Risk.

Fire susceptibility throughout the County dramatically increases in late summer and early autumn as summer thunderstorms with lightning strikes increases and vegetation dries out, decreasing plant moisture content and increasing the ratio of dead fuel to living fuel. However, various other factors, including humidity, wind speed and direction, fuel load and fuel type and topography can contribute to the intensity and spread of wildland. In addition, common human causes of wildfires include arson and negligence from various human activities.

The extent of wildfire risk goes beyond the wildfire itself. There are many secondary hazards related to wildfires, including poor air quality, impacted water quality, increased risk of landslides and erosion, and greater exposure to pollutants in the atmosphere. These secondary hazards can significantly impact the health and well-being of human lives, particularly those who have respiratory health-related concerns, as well as the safety of property and structures.

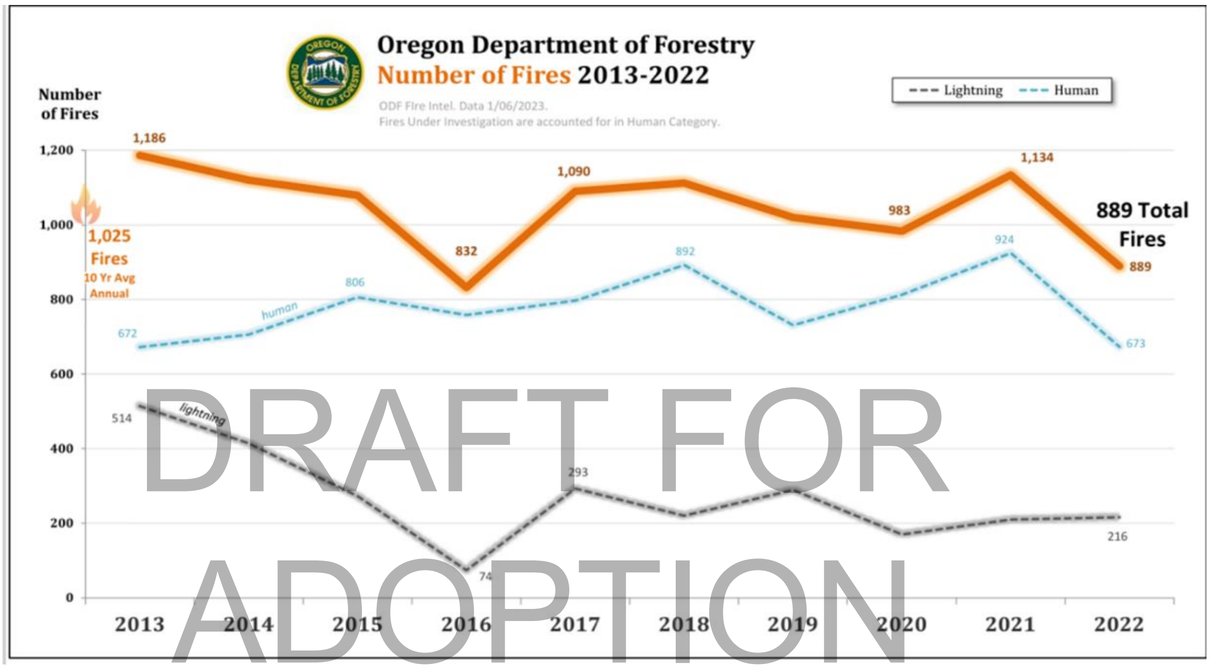
Figure 35. Wildfire Threat Map for Morrow County



History

Hundreds of wildfires have occurred in Oregon in just the past 10 years, with the ignition source of many of these fires due to human activity, while others were caused by natural processes. In general, human caused wildfires typically occur within and around populated areas, recreational areas, and near transportation corridors, while lightning caused wildfires are often in more remote locations. Figure 36 shows the total number of wildfires in Oregon, and a breakdown of how many were started from either natural origins and human origins between 2012-2022.

Figure 36. Number of Wildfires Across Oregon from 2012-2022



Source: [Oregon Department of Forestry](), 2022

The number of fires in Morrow County, from 1984 to 2003, ranged from 13 in 1993 to 105 in 1999 with a total of 873 fires during this time period burning more than 213,000 acres. Twenty-nine fires burned 300 acres or more during that period and of those, six were 5,000 acres or more. In July and August of 2000, the Governor signed a Determination of Emergency Conflagration Act Due to Fire in Morrow County. The fire that occurred at this time was the "Willow Creek Fire" which started at the junction of Eight Mile Road and Four Mile Canyon in Gilliam County and spread out of control to Morrow County.

The number of wildfires of 50-acres or larger from 2013 to 2018 ranged from approximately three in 2014, to ten in 2015, with a total of 37 fires 50-acres or larger burning more than 56,543 acres during a five-year period. Eighteen fires burned 500 acres or more during that five-year period and of those, 12 were 1000 acres or more. Due to inconsistent tracking of historic fire data, the chart below is incomplete for fire numbers and acreage burnt.

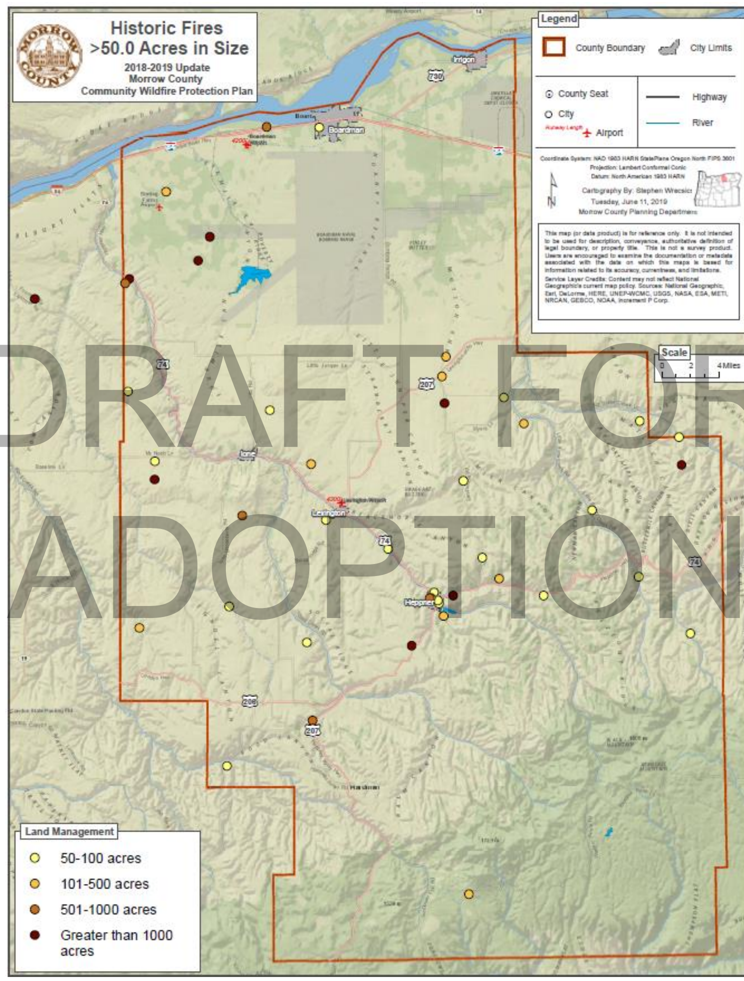
Many of the significant fire events in Morrow County occur as a result of dry lightning storms. Widespread dry lightning is fairly frequent, occurring approximately every one to three years. These episodes can cause 50-100 ignitions in one day requiring suppression. (See Table 57 and Figure 37).

Table 57. Significant Wildfires in Morrow County 2013-2023, >50-Acres in Size

Acreage Size Class	Total Acres Burned	Number of Fires
A. 50-100	1,430	12
B. 101-500	4,270	9
C. 501-1000	5,448	7
D. >1000	151,995	9
Total	163,143	37

Source: Federal Emergency Management Agency; Morrow County Community Wildfire Protection Plan, 2023

Figure 37. Historic Wildfires in Morrow County 2013-2023, >50-Acres in Size



Source: Morrow County 2019 Community Wildfire Protection plan (CWPP)

Wildfire Hazard Assessment

Probability Assessment

The Oregon NHMP notes that during a typical year, more than 2,500 wildland fires of any size are started on forest lands in Oregon. ODF and USFS estimate 66% of these fires are caused by human activity (1,650); the remainder result from lightning (850).

Historically, a much lower number of human-caused fires have occurred in the northwest, less than 2,000 per year on average, and an even smaller number of human-caused fires have occurred in Morrow County. However, changing conditions and the growing occurrences and severity of related hazards such as drought and extreme heat may contribute to a higher likelihood of ignitions from both sources but especially human activity. As many conditions that influence wildfire behavior and occurrence are demonstrated across large areas within Morrow County, this is continually creating a significant collective wildfire risk.

The 2023 *Multi-Hazard Risk Report for Morrow County* evaluates the probability of wildfire hazard to be higher for the central portion of Morrow County compared to the north and south portions of the county. The Wildfire Risk shown in Figure 35 shows the likelihood of a wildfire >250 acres burning a given location, based on wildfire simulation modeling. This is an annual burn probability, adjusted to be consistent with the historical annual area burned. While the probability of wildfire hazard is lower for the northern portion of Morrow County, it is still a possibility. Nearby wildfire prone areas also pose a risk related to evacuation routes and hazardous smoke.

The 2023 OCCRI *Future Climate Projections Morrow County, Oregon* report projects that wildfire frequency, intensity, and extent will continue to increase across the Northwest.[73] In part, the increased incidence of wildfire is due to growing drought conditions, increased number of extreme heat events, anthropogenic emissions and development occurring in the wildland urban interface (WUI).

Wildfire risk is expressed as the average number of days per year where fire danger is very high. Wildfire risk is projected to increase by 15 days (range -5-38) by the 2050s. Extreme fire weather during late summer and autumn increased by about 40% over the western United States and about 50% over western Oregon. This late season increase in wildfires is largely due to drier vegetation and warmer temperatures during dry wind events. Increased severity of wildfire events and the subsequent increase in wildfire smoke will impact the health of all demographics and vulnerable populations in particular.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **both the North and South regions of the County have a probability of experiencing a wildfire as “High", meaning one incident is likely within a 10-to-35-year period.**

*This **rating has not changed** since the previous NHMP.*

Vulnerability Assessment

Each year a significant number of people build homes within or on the edge of the forest (urban/wildland interface), thereby increasing wildfire hazards. Many Oregon communities (incorporated and unincorporated) are within, or abut, areas subject to serious wildfire hazards, complicating firefighting efforts and significantly increasing the cost of fire suppression. Additionally, the County contains a wide variety of forest and grassland ecosystems, including tracts of the Blue Mountains Forest and Umatilla National Forest. As these are managed under different entities, each has a different management approach of wildfire, impacting the overall probability of wildfire across the County. The buildup of fuel (e.g., brush, dead or dying trees) that leads to devastating wildfires is a very important factor and is the current focus of mitigation strategies.

[73] OCCRI, Future Climate Projections Morrow County, 2023

The 2023 *Multi-Hazard Risk Report for Morrow County* provides an analysis of the West Wide Wildfire Risk Assessment's Fire Risk Index (FRI) High Hazard category to identify the general level of susceptibility to wildfire hazard. The exposure analysis calculates and compares the number of buildings, their value, and associated populations exposed across three (3) different wildfire hazard scenarios that the community is vulnerable to (Low, Moderate and High).

The DOGAMI analysis concludes that wildfire poses at least a moderate threat to all Morrow County residents and structures. In every community in Morrow County, wildfire poses a threat to residents and structures where evacuation could be necessary.

Table 58 shows the summarized projections from the DOGAMI report for Morrow County for wildfire potential based on the combination of moderate and high wildfire hazard. The DOGAMI report projects that the combination of Moderate and High wildfire hazard would incur losses of approximately $1,350,500 and cause damage to over 3,000 structures throughout the County, which would incur financial losses of approximately 32% of the total building value.

Table 58. Wildfire Result Summary

	Countywide Wildfire Exposure (High or Moderate Risk)				
	Number of Buildings Exposed	Exposure Value ($ in thousands)	Percentage of Exposure Value	Critical Facilities Exposed	Potential Displaced Population
Morrow County	3,005	1,350.5	32%	5 of 20	3,226

Source: DOGAMI Morrow County Risk Report, 2023

The WUI for nearly every community in Morrow County has exposure to wildfire hazard, as documented in Table 59.

Table 59. Moderate and High Wildfire Hazard Exposure

	Total Buildings	Community Population	Moderate and High Wildfire Hazard			
			Exposed Structures		Displaced Residents	
			Number	Percent	Number	Percent
Morrow County	8,480	12,635	3,005	35.4%	3,226	26%
Boardman	1,214	4,338	212	17.5%	858	20%
Heppner	797	1,187	112	14.1%	194	16%
Ione	249	339	56	22.5%	69	20%
Irrigon	867	2,037	18	2.1%	55	2.7%
Lexington	212	238	74	34.9%	87	37%
Unincorporated	5,141	4,496	2,533	49.3%	1,963	44%

Source: DOGAMI Morrow County Risk Report, 2023

Approximately 26% of Morrow County's population may be displaced by wildfires within Morrow County. These people are expected to have mobility or access issues and/or may have their residences impacted by a wildfire. Populations with potential impacts from smoke and traffic disruptions are not accounted for within this analysis. It is important to note that impact from wildfires may vary depending on the specific area that experiences a wildfire. Unincorporated Morrow County has the most population at risk of displacement (1,963), although the population is dispersed throughout the County. Almost 40% of Lexington residents are exposed and vulnerable to displacement due to wildfire.

Critical Facility Vulnerability

Table 60 provides an inventory of vulnerable critical facilities with potential exposure to the Moderate or High wildfire hazard zone.

Table 60. Wildfire Exposed Critical Facilities Inventory

Exposed Critical Facilities - High or Moderate Wildfire Hazard					
Community	**School**	**Hospital**	**Fire Responders**	**Government Buildings**	**Airports**
Morrow County	***4***	***0***	***1***	***0***	***2***
Boardman	1	-	1	-	1
Heppner	1	-	-	-	-
Ione	1	-	-	-	-
Irrigon	1	-	-	-	-
Unincorporated	-	-	-	-	1

Source: DOGAMI Morrow County Risk Report, 2023

Community Wildfire Susceptibility Issues

Growth and Development in the Interface

Development of homes and other structures encroaching upon forest wildland and natural areas expands the WUI. These interface areas are characterized by a diverse mixture of varying housing structures, development patterns, ornamental and natural vegetation, and natural fuels.

In the event of a wildfire, vegetation, structures, and other flammable materials can merge into unpredictable events. Factors relevant to the fighting of wildfires within the interface include access, firebreaks, proximity of water sources, distance from a fire station, and availability of firefighting personnel and equipment. Reviewing past wildland/urban interface fires shows that many structures are destroyed or damaged for one or more of the following reasons:

- Combustible roofing material;
- Wood construction;
- Structures with no defensible space;
- Poor road access to structures limiting firefighting apparatus;
- Structures located on steep slopes covered with flammable vegetation;
- Limited water supply;
- Storage of firewood and combustibles beneath or around structures.

Road Access

Road access is a major issue for all emergency service providers. Insufficient space for emergency vehicles causes a challenging situation for emergency workers as they have limited or no access to structures. Due to the size of emergency vehicles, emergency personnel are challenged by narrow roads and limited access. When there is doubt concerning the stability of a residential bridge, or adequate turnaround space, emergency personnel may only work to remove the occupants, with limited to no ability to save structures.

Water Supply

Firefighters in remote and rural areas are faced with limited water supply and lack of hydrant taps. Rural areas are characteristically outfitted with small diameter pipe water systems, inadequate for providing sustained firefighting flows. Some rural fire districts are adapting to these conditions by developing secondary water sources.

Rural Services

People moving from more urban areas frequently have high expectations for fire protection services. Often, new residents do not realize that they are living outside of a fire protection district, or that the services provided are not the same as in an urban area. The diversity and amount of equipment and the number of personnel can be substantially limited in rural areas. Fire protection may rely more on the landowner's personal initiative to protect their own property. Therefore, public education and awareness plays a greater role in rural or interface areas. Growth and development in rural areas of Morrow County influence the WUI.

While historical losses from wildfires in Morrow County have been relatively low, additional development, and an increase in fuel loads, expands the public need for natural hazards mitigation planning in the County.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed the vulnerability of both regions of experiencing a Wildfire:

- **North County region vulnerability is "Low",** meaning >1% of the region's population and property would be affected by a major wildfire emergency or disaster; and
- **South County region vulnerability is "High",** meaning more than 10% of the region's population and property would be affected by a major wildfire emergency or disaster.

*This **rating has changed for both Regions** since the previous NHMP.*

Windstorms/Thunderstorms

Windstorm Risk Ranking Summary	
Probability	**Updates Made**
North County: High **South County: Moderate**	-2016 NHMP rated Probability as High -2016 NHMP rated Vulnerability as Medium
Vulnerability	
North County: Moderate	

Morrow County is often subject to intense gusts of high winds, windstorms, and thunderstorms. Although they are not usually life-threatening, high winds can disrupt daily activities, cause damage to buildings and structures, and increase the potential of other hazards. Some areas with little or no ground cover such as open agricultural fields experience blinding gusts of dust and road debris, including tumbleweeds, which become a hazard for travelers and an occasional disruption of local services. High winds sometimes cause severe transportation disruptions due to localized roadways being blocked with debris, downed trees over roadways, and low areas completely filled with windblown tumbleweeds.

Wildfires can be accelerated and made unpredictable by windstorms, which can cause grave danger to firefighters, emergency response personnel and residences, or other structures that happen to be in the path of a wayward wildfire. Lightning from Thunderstorms can spark fires. Effects of the windstorms may be seen in damage to agricultural systems such as circle irrigation units, to structures such as roof damage and cracked windows, and damage to trees and landscaping. Power outages due to downed or damaged power supply lines have the potential to disrupt emergency response during and after a destructive windstorm.

Characteristics

A Windstorm is generally a short duration event involving straight-line winds and/or gusts more than 50 mph. Windstorms at different speeds can have varying effects and extent of damage, which can be seen in the wind speed effect breakdown in Table 61. Winds speeds from 40-60 mph are common in the winter months, specifically between October to March, while thunderstorms usually occur in the summer months and can be accompanied by lightning. After a more severe windstorm, it can take communities days, weeks, or longer to return to normal activities.

Table 61. The Effect of Wind Speed

Wind Speed (mph)	Wind Effects
25-31	Large branches will be in motion.
32-38	Whole trees in motion; inconvenience felt walking against the wind.
39-54	Twigs and small branches may break off of trees; wind generally impedes progress when walking; high profile vehicles such as trucks and motor homes may be difficult to control.
55-74	Potential damage to TV antennas; may push over shallow rooted trees especially if the soil is saturated.
75-95	Potential for minimal structural damage, particularly to unanchored mobile homes; power lines, signs, and tree branches may be blown down.
96-110	Moderate structural damage to walls, roofs and windows; large signs and tree branches blown down; moving vehicles pushed off roads.
111-130	Extensive structural damage to walls, roofs, and windows; trees blown down; mobile homes may be destroyed.
131-155	Extreme damage to structures and roofs; trees uprooted or snapped.
Greater than 155	Catastrophic damage; structures destroyed.

Source: Washington County Office of Consolidated Emergency Management

Location and Extent

Extreme winds are experienced throughout all of Oregon. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge, so much so that these areas have special building code standards. All manufactured homes along the Columbia River Gorge that are within 30 miles of the Columbia River, must meet special anchoring (i.e., tie-down) standards (Section 307: Wind Resistance). High winds in this area of Oregon are legendary. The Columbia Gorge is the most significant east-west gap in the mountains between California and Canada. It serves as a funnel for east and west winds, where direction depends solely on the pressure gradient. [74]

High winds are especially common along the Columbia River and in the mountain ranges between October and March. Once set in motion, the winds can attain speeds of 80 mph, halt truck traffic, and damage a variety of structures and facilities. The average wind speed at Hood River is 13 mph, not much less than the notoriously windy Texas and Kansas plains whose wind speeds average 15 mph.[75]

Although windstorms can affect the entirety of Morrow County, they are especially dangerous near developed areas with large trees or tree stands, which can impact the surrounding exposed properties, as well as major infrastructure and above ground utility lines. The lower wind speeds typical in central Morrow County are still high enough to knock down trees and powerlines and cause property damage.[76]

[74] 2020 Oregon NHMP
[75] DOGAMI Multi-hazard Risk Report, 2023
[76] Ibid.

History

Morrow County has experienced several high wind events that have required disaster declarations to be made. Since 2016 the NOAA Storm Event Database records thirteen High Wind or Strong Wind events that impacted some part of Morrow County. Table 62 presents those recent events and significant windstorm events in Morrow County that led to a disaster declaration being officially declared.

Table 62. Significant Windstorms in Morrow County

Date	Description
October 1962	DR-136: Severe Storms
December 1995	DR-1107: Severe Storms, High Winds
Dec. 1996-Jan. 1997	DR-1160: Severe Winter Storms, Flooding
February 2002	DR-1405: Severe Winter Windstorms with High Winds
December 2012	Heppner experienced a wind Storm, several trees were knocked down. The City public works crew and a local telephone company worked together to clear the right of ways and restore access.
December 2018	DR-4258: Severe Winter Storms, Straight-line Winds, Flooding, Landslides and Mudslides
February 2016	Strong Wind
February 2017	High Wind: Winds peaked to 61 mph with passage of a cold front at Lexington Airport in Morrow County.
April 2017	High Wind: Measured wind gust of 65 mph 1 mile NW of Heppner
February 2018	High Wind
September 2020	High Wind
September-November 2020	DR-4562: Wildfires and Straight-line Winds
January 2021	High Wind
March 2021	High Wind
October 2021	High Wind measured a wind gust of 67 mph at 0900 PDT. A Facebook report from the town of Heppner indicated that several trees were downed by strong winds in the area.
November 2021	High Wind
April 2022	High Wind: A strong upper-level low coupled with cold front at the surface brought numerous wind and winter weather impacts across portions of eastern Washington and eastern Oregon. winds in the lower elevations during the day on April 4th.
November 2022	High Wind: A strong cold front pushed through the region during the afternoon on November 4th into the morning hours of November 5th accompanied by a strong low-level jet and tight surface pressure gradient. The strongest winds occurred late on the evening of November 4th and on the early morning of November 5th.
December 2022	High Wind
February 2023	Strong Wind: A trained spotter in Irrigon, OR measured a wind gust of 50mph at 2230 PST that also produced damage to roof shingles.

Source: Federal Emergency Management Agency, NOAA Storm Event Database Storm Events Database - Search Results | National Centers for Environmental Information (noaa.gov); 2016 Morrow County MJ NHMP - Cities

Additionally, severe weather in the form of windstorms is part of the history of the region from the 1903 flash flood tragedy in Heppner to the 1999 dust storm which caused a multiple automobile crash on September 25, 1999, in Umatilla County on Interstate 84 east of Morrow County. Morrow County has experienced tornadoes, as reported in The Oregon Weather Book, A State of Extremes:

> *"In Morrow County the same day a tornado formed on the McElligott Ranch property southwest of Ione and traveled eastwards 20 miles before disappearing on the outskirts of Lexington. The twister was accompanied by heavy rains and hail, some of which, near Heppner, was golf ball size. Two ranches near Lexington measured half an inch of rain in less than 10 minutes and in Sand Hollow, another rancher reported 1.20 inches in less than 30 minutes. The tornado passed over rangeland, dairy land, and wheat farms and caused no structural damage."*

Tornadoes occur in Morrow County more frequently than many people realize and the severe weather that accompanies them strikes at the road system in the form of flooding, the agricultural areas in the form of damaged crops, barns, buildings, and irrigation systems, and the residential areas with downed trees, roof damage and windblown debris. The storm event of May 19, 2006, had a reported funnel cloud in the Boardman area that was causing the National Weather Service to issue a tornado warning.

Windstorm Hazard Assessment

Probability Assessment

Changing weather patterns and a steady increase in the strength of storms within the past several years suggests that windstorms will frequently occur over the next decade. Table 63 shows the wind speed probability intervals that structures 33 feet above the ground would expect to be exposed to within a 25, 50 and 100-year period in the Mid-Columbia region. The table shows that structures in region 5, which includes Morrow County, can expect to be exposed to 675 mph winds in a 25-year recurrence interval (4% annual probability).

The OCCRI's 2023 report *Future Climate Projections Morrow County, Oregon* projects that while mean wind speeds and frequency of strong easterly winds during peak wildfire season will decrease, extreme winter wind speeds may increase.[77] These changes in wind patterns will affect natural disturbances, the provision of electricity, transportation safety, and contribute to the spread of wildfires and pollutants.

Table 63. Wind Speed Probability Intervals

	25-Year Event (4% annual probability)	50-Year Event (2% annual probability)	100-Year Event (1% annual probability)
Region 5 Mid-Columbia	75 mph	80 mph	90 mph

Source: Oregon Natural Hazard Mitigation Plan, 2020

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **both the North and South regions of the County have a probability of experiencing a Windstorm as "High",** meaning one incident is likely within a 10-to-35-year period.

[77] OCCRI, Future Climate Projections Morrow County, 2023

*This **rating has not changed** since the previous NHMP.*

Vulnerability Assessment

Windstorms can result in collapsed or damaged buildings, damaged or blocked roads and bridges, damaged traffic signals and/or streetlights. Windstorms can cause damage over 100 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Wind impacting walls, doors, windows, and roofs, may cause structural components to fail. Wind pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift and suction forces that act to pull building components and surfaces outward. The effects of winds are magnified in the upper levels of multi-story structures. As positive and negative forces impact the building's protective envelope (doors, windows, and walls), the result can be roof or building component failures and considerable structural damage. Debris carried along by extreme winds can directly contribute to loss of life and indirectly to the failure of protective building envelopes, siding, or walls of buildings.

When severe windstorms strike a community, downed trees, power lines, and damaged property can be major hindrances to emergency response and disaster recovery. Roads blocked by fallen trees during a windstorm may have severe consequences for access to emergency services. Emergency response operations can have difficulty accessing the community when roads are blocked or when power supplies are interrupted.

One of the most common problems associated with windstorms is power outages. High winds commonly occur during winter storms, and can cause trees to bend, sag, or fail (tree limbs or entire trees), encountering nearby distribution power lines. Fallen trees can cause short-circuiting and conductor overloading. Wind-induced damage to the power system causes power outages to customers, incurs cost to make repairs, and in some cases can lead to ignitions that start wildland fires.

Typically, the greatest damage caused by severe windstorms, thunderstorms and tornadoes in Morrow County are damages to structures of light construction such as manufactured homes, road blockages and other damage due to downed trees, flooding in low areas, and blowing debris.

The basic strategy adopted by power companies to avoid wind-induced damage is to maintain adequate separation between its transmission circuits and trees. This is done with tree height limitations and ongoing tree trimming.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **the vulnerability of both the North and South regions of the County to Windstorm as "Moderate"**, meaning 1 to 10% of the regions' population and property would be affected by a major windstorm emergency or disaster.

*This **rating has not changed** since the previous NHMP*.

Winter Storms

Winter Storm Risk Ranking Summary	
Probability	**Updates Made**
North County: High **South County: Moderate**	-2016 NHMP rated Probability as High -2016 NHMP rated Vulnerability as High
Vulnerability	
North County: High **South County: Moderate**	

Winter storms are among nature's most impressive spectacles. Their combination of heavy snow, ice accumulation, and extreme cold can totally disrupt modern civilization, closing roads and airports, creating power outages, and downing telephone lines.

For the most part, the wind aspects related to winter storms are addressed with windstorm hazard analysis preceding this section. Heavy precipitation aspects associated with winter storms in some parts of the state, which sometimes lead to flooding, are covered with floods. This section generally addresses snow and ice hazards and extreme cold.

Within the State of Oregon, Region 5 communities are known for cold winter conditions. This is advantageous in at least one respect: in general, the region is prepared, and those visiting the region during the winter usually come prepared. However, there are occasions when preparation cannot meet the challenge.

Drifting and blowing snow has brought highway traffic to a standstill. Also, windy, icy conditions have closed Oregon's principal east west transportation route, Interstate Highway 84, for hours. In these situations, travelers must seek accommodations sometimes in communities where lodging is very limited. And local residents also experience problems. During the winter, heat, food, and the care of livestock are everyday concerns. Access to and within farms and ranches can be extremely difficult and presents a serious challenge to local emergency managers as well as those who operate the ranches and farms. Impacts to livestock are among those ranchers must prepare for.

Characteristics

Severe winter storms can produce rain, freezing rain, ice, snow, cold temperatures, and wind. Ice storms accompanied by high winds can have destructive impacts, especially to trees, power lines, highway safety and utility services. Severe or prolonged snow events occur less frequently and are very geographic in nature.

The following are some primary characteristics of winter storms in Morrow County.[78]

[78] Winter Weather Safety, 2023

Weather Patterns

Severe winter storms affecting Oregon typically originate in the Gulf of Alaska and in the central Pacific Ocean. Oregon's latitude, topography, and nearness to the Pacific Ocean give the state diverse climates. Morrow County's climate generally consists of wet winters and dry summers. For Morrow County, winter storms are most common between the months of October through March.

Snow

Morrow County receives an average of only four days per year of measurable snow with snowfall accumulations rarely measuring more than one/tenth of an inch across the County.[79]

Severe snowfall events can result in loss of life, property, power, gas, and/or other service disruptions. The variable character of this hazard is determined by a variety of meteorological factors including snowfall, snowpack, rainfall, temperature, and wind.

Ice

Like snow, ice storms are comprised of cold temperatures and moisture, but subtle changes can result in varying types of ice formation, including freezing rain, sleet, and hail. While sleet and hail can create hazards for motorists when it accumulates, freezing rain can be the most damaging of ice formations. Ice buildup can bring down trees, communication towers, and wires creating hazards for property owners, motorists, and pedestrians.

Extreme Cold Weather

Extreme cold hazards can result in damage to infrastructure, pipes, power lines and roadways. Prolonged low temperatures, combined with power outages, can be hazardous to vulnerable populations, like the elderly.

Location and Extent

Winter storms affect all parts of Douglas County, and the entire County is susceptible to damaging severe weather. The County is known for cold winter conditions and is susceptible to damaging severe weather. Winter storms that bring snow and ice can impact all aspects of the community, including infrastructure (including powerlines and roads), the economy (including local businesses) and community members. Those resources and individuals that reside at higher elevations will experience more risk of snow and ice, but the entire County can face damage from winter storms and, for example, the hail or life threateningly cold temperatures that winter storms bring.

According to the National Weather Service:

> *Most snowstorms need two ingredients: cold air and moisture. Rarely do the two ingredients occur at the same time over western Oregon, except in the higher elevations of the Coast Range and especially in the Cascades. But snowstorms do occur over eastern Oregon regularly during December through February. Cold arctic air sinks south along the Columbia River Basin, filling the valleys with cold air. Storms moving across the area drop precipitation, and if conditions are right, snow will occur.*

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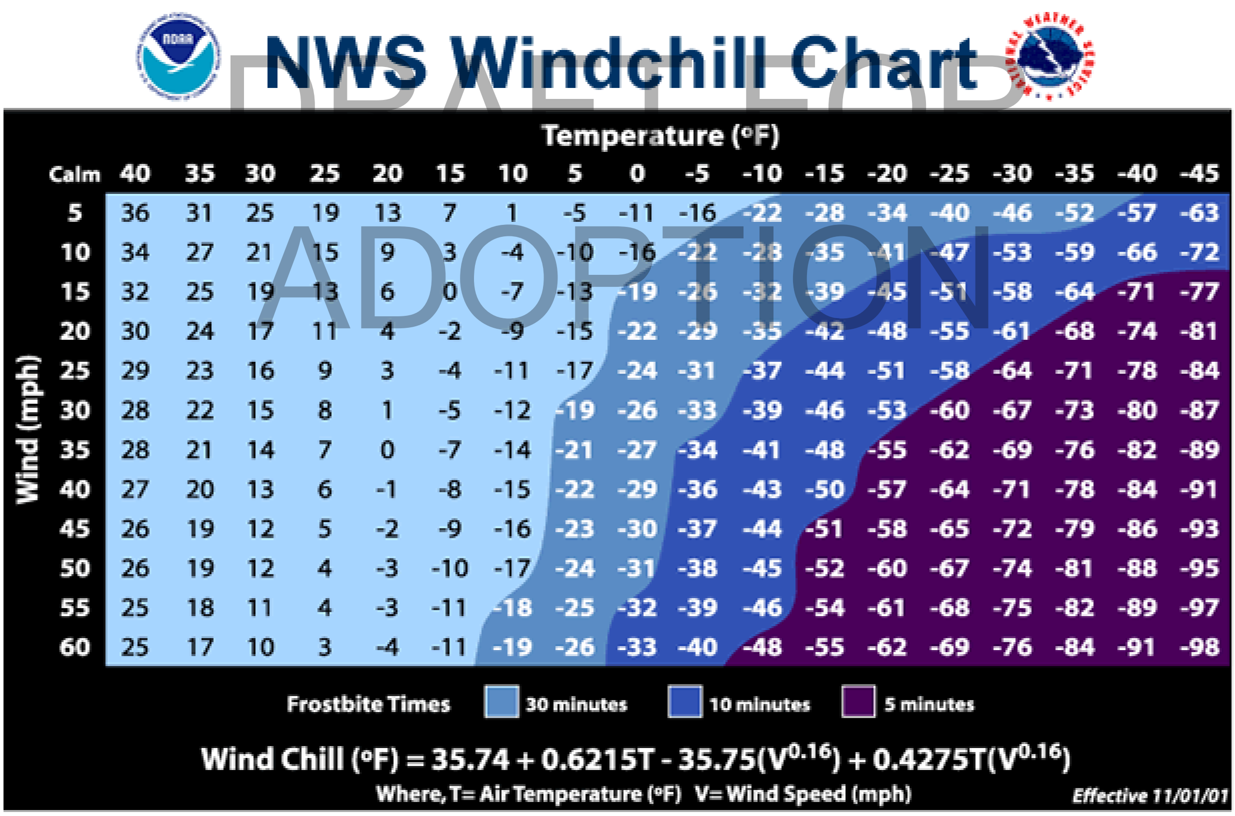
[79] Climate, National Weather Service, February 2024

However, it is not that easy of a recipe for western Oregon. Cold air rarely moves west of the Cascade Range. The Cascades act as a natural barrier, damming cold air east of the range. The only spigot is the Columbia River Gorge, which funnels the cold air into the Portland area. Cold air then begins deepening in the Columbia River valley, eventually becoming deep enough to sink southward into the Willamette valley. If the cold air east of the Cascades is deep, it will spill through the gaps of the Cascades and flow into the western valleys via the many river drainage areas along the western slope. The cold air in western Oregon is now in place. The trick is to get a storm to move near or over the cold air, which will use the cold air and produce freezing rain, sleet, and/or snow. Sometimes, copious amounts of snow are produced. Nearly every year, minor snowfalls of up to six inches occur in the western interior valleys. However, it is a rare occurrence for snowfalls of over a foot in accumulations [sic].

Furthermore, the combination of wind and low temperature in winter can be deadly. The wind chill index (see Figure 38) helps you determine when dangerous conditions develop that could lead to frostbite or hypothermia. It takes into account heat loss from the human body to its surroundings during cold and windy weather. The calculation utilizes wind speed in miles per hour and temperature in degrees Fahrenheit.

Figure 38. Wind Chill Chart



Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: https://www.weather.gov/bou/windchill

History

Morrow County has experienced some notable and significant storms, even within the past decade. All of the snow events occurred between November and April. Each of these events caused disruption to the community in some way, either through infrastructure damage or power outages.

Data from the NOAA Storm Event Database (Table 64) identities approximately 45 Winter Storm, Heavy Snow or Ice Storm events between January 1, 2003 and December 31, 2023 in Morrow County.

Table 64. Significant Snow Events in Morrow County, 2003-2023

Date	Event Type	Description
28-Dec-03	Heavy Snow	A winter storm brought heavy snow to all central and eastern Oregon, resulting in numerous minor motor vehicle accidents. Snowfall reached 9 inches in Lexington and 8 inches in Ione.
1-Jan-04	Heavy Snow	A powerful winter storm hit the Pacific Northwest and a deep surface low tracked across central and northeast Oregon. This resulted in heavy snow on the northwest side of the surface low track. Lexington reached 5 inches of snow.
6-Jan-04	Heavy Snow	Heavy snow fell across much of central and northern portions of Oregon. Irrigon received 5-6 inches.
8-Jan-04	Winter Weather	A mix of sleet and freezing rain occurred with ice accumulations less than a quarter inch.
15-Jan-05	Winter Storm	A mixture of snow and sleet fell in the Lower Columbia Basin.
17-Jan-05	Winter Weather	Light freezing rain fell, leading to icy roadways in the Lower Columbia Basin. Temperatures then remained below freezing through the night and early in the morning which resulted in continued icy roadways.
1-Mar-07	Heavy Snow	Heavy snow occurred in the Blue Mountains of Oregon. Snowfall amounts of 6 to 16 inches were measured.
28-Nov-07	Heavy Snow	Heavy snow was produced across the Blue Mountains.
26-Jan-08	Ice Storm	Sustained heavy snow and freezing rain occurred with snowfall reaching 9 inches Heppner and 8 inches in Irrigon.
20-Dec-08	Heavy Snow	Heavy snowfall occurred across the area. Snowfall reached 4 inches in Boardman and 4 inches in Ione.
12-Mar-10	Heavy Snow	Heavy snowfall occurred across the Blue Mountains.
21-Nov-10	Heavy Snow	Widespread heavy snowfall and very cold temperatures occurred, with snowfall reaching 6 inches in Irrigon
30-Nov-10	Heavy Snow	Blizzard conditions and visibility was 300 yards. Heavy snowfall also occurred, reaching updates of 12 inches outside of Heppner.
1-Jun-11	Heavy Snow	Persistent showers with heavy rainfall of 1 to 2 inches produced flooding on Willow and Hinton Creeks, with snowfall reaching 6.5 inches outside of Heppner
17-Jan-12	Heavy Snow	A storm with heavy snow and high winds caused many vehicle accidents, downed tree branches, power outages, and closed roads, including Interstate 84, and also closed schools. Snowfall reached 4 inches outside of Ione. Ice accumulation reached .25 inches in Ione and .38 inches in Lexington.
6-Dec-13	Heavy Snow	Snowstorm with snowfall reaching 9 inches in Lexington, 6 inches in Lexington, and 9 inches outside of Heppner.

Date	Event Type	Description
6-Feb-14	Heavy Snow	A winter storm pushed across central and northeast Oregon leading to several Winter Storm Warning and Winter Weather Advisories being issued for this system. Snowfall reached 5 inches in Heppner and 4 inches in Irrigon.
24-Feb-14	Ice Storm	Localized areas of freezing rain occurred across the Southern Blue Mountains, with ice accumulations reaching 1.00 over.
13-Nov-14	Heavy Snow	A significant winter weather occurred across most of central and northeast Oregon. Heavy snow occurred, along with portions of central Oregon reported between 0.50-1.00 of ice from freezing rain. Outside of Lexington reached 6 inches of snowfall.
14-Dec-16	Heavy Snow	Widespread heavy snow, with Lexington receiving 7 inches.
26-Dec-16	Heavy Snow	Heavy snow was brought to the Blue Mountains, Wallowa county and the Grande Ronde Valley.
3-Jan-17	Heavy Snow	Heavy snow fell across central and east-central Oregon.
7-Jan-17	Heavy Snow	Widespread snow to the Pacific Northwest.
10-Jan-17	Heavy Snow	Heavy snow was produced across portions of central and northeast Oregon. Also, heavy snow fell over portions of the Columbia River Gorge in both Oregon and Washington.
17-Jan-17	Ice Storm	A major winter storm brought significant snow and ice.
31-Jan-17	Heavy Snow	Significant snow over portions of the Columbia Basin of Washington and Oregon.
22-Jan-19	Winter Weather	Heavy snow in the Blue Mountains, reaching between 8 and 10 inches of new snow in the Blues. Highway 395 was closed for several hours due to very heavy snowfall rates and poor visibility.
4-Feb-19	Heavy Snow	A pair of storm systems brought significant snow to all elevations and brought 8 to 12 inches of snow to the Blue Mountains. Numerous accidents were reported due to slippery conditions. Interstate 84 for closed for several hours.
9-Feb-19	Heavy Snow	Heavy snow in much of the region, with snowfall totals reaching 8 to 12 inches in the Columbia River Gorge and around 4 inches in the Blue Mountains foothills.
11-Feb-19	Heavy Snow	A winter storm brought heavy snowfall to the Columbia River Gorge, Northern Blue Mountains and the Blue Mountain foothills. Snowfall reached 8 to 12 inches in the Columbia River Gorge, 6 to 10 inches in the northern Blue Mountain foothills, and 10 to 13 inches in the Blue Mountains.
24-Feb-19	Heavy Snow	A long duration snow event occurred, with snowfall rates greatly enhanced over central Oregon and where snowfall rates were over 1 inch per hour, in some places. Storm total snowfall amounts were estimated between 10 to 40 inches.
10-Apr-19	Heavy Snow	A cool late season system brought one last gasp of wintry weather to the Blue Mountains with storm total snowfall estimated between 5 to 10 inches with the highest amounts in the northern Blue Mountains above 5000 feet.

Date	Event Type	Description
26-Nov-19	Heavy Snow	Heavy snow fell across central and north central Oregon producing 4 to 10 inches of snow.
10-Jan-20	Heavy Snow	Heavy snow fell across central and north central Oregon producing 4 to 10 inches of snow.
4-Feb-20	Heavy Snow	A winter storm with copious moisture dumped 1 to 2+ feet of snow over the eastern mountains and valleys. This was the precursor to significant flooding that occurred later in the week when the snow melted due a warm-up and heavy rains.
13-Mar-20	Heavy Snow	A winter storm of moderate intensity brought snow to portions of central and northeast Oregon. Heppner was reported reaching 5 inches of new snow.
13-Nov-20	Winter Storm	Moderate to heavy snow occurred in the mountains and light to moderate snow accumulated in higher elevation valleys.
11-Feb-21	Heavy Snow	Moderate to heavy snow occurred across much of the area. It was reported that Lexington received approximately 8 inches of snowfall and Heppner reported roughly 10 inches of snowfall.
1-Dec-21	Heavy Snow	Bands of rain, freezing rain, and snow were produced across portions of the area, with snow being reported at lower elevations in the Columbia Basin and mountain locations across southeast Washington and northeast Oregon.
30-Dec-21	Heavy Snow	Moderate to heavy snow showers across the Cascades, Blues, and Wallowas, with moderate to heavy snow along the Blue Mountain foothills, and in valley locations across the northeast Oregon mountains. Heppner reported 6 inches of new snow.
1-Jan-22	Heavy Snow	Moderate to heavy snow showers, and some freezing rain across lower elevations. During this time the I-84 and several state and US highways were closed for extended periods of time due to increased traffic accidents from ice and/or accumulated snow on roadways. Outside of Heppner reported 8 inches of new snow.
10-Apr-22	Heavy Snow	Snow occurred across much of the region and resulted in snow accumulations in the mountains and lower elevations.
1-Nov-22	Heavy Snow	Moderate to heavy snow accumulated across the mountains in northeast Oregon, with snow amounts reaching 8 to 12 inches in some mountain zones.
4-Dec-22	Heavy Snow	Moderate snowfall occurred with prolonged snowfall resulting in heavy snow accumulations across the Lower Columbia Basin, portions of the eastern Columbia River Gorge, the Blue Mountain Foothills, and in the Yakima valley.
1-Feb-23	Heavy Snow	Heavy snow occurred in the eastern Mountains.

Source: Storm Events Database | National Centers for Environmental Information (noaa.gov)

Winter Storm Hazard Assessment

Probability Assessment

The OCCRI Future Climate Projections Morrow County, Oregon report projects cold extremes to become less frequent and intense as the climate warms. However, the frequency of cold extremes decreases at a slower rate than the increase of heat extremes. Cold extremes will diminish as winter temperatures warm and become less variable. It is estimated that the number of cold days (maximum temperature 32°F or lower) per year in Morrow County will decrease by an average of 9(range 4-13) by the 2050s, while the temperature on the coldest night of the year is projected to increase by an average of 9°F (range 0–16°F). The number of county residents vulnerable to extreme cold is likely to grow, although the decrease in incidence of cold extremes may offset a percentage of residents affected.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed **both the North and South regions of the County have a probability of experiencing a Winter Storm as "High",** meaning one incident is likely within a 10-to-35-year period.

*This rating has **remained the same for the North County** since the previous NHMP. A **separate ranking for the South County area is new** during this 2024 update.*

While winter storms of some degree of severity occur every year in Morrow County, the recurrence interval for significantly severe winter storms occur around every four years, as determined by the 2020 Oregon NHMP.[80]

Vulnerability Assessment

Morrow County is vulnerable to the whims of winter storms and the associated problems. The most common impacts of winter storms are temporary road closures. Associated hazards can include flooding due to storm events including mud flowing across roads from nearby agricultural fields, and tumbleweeds blocking roadways. Roads can become temporarily impassable due to snow accumulation.

Drifting and blowing snow has brought highway traffic to a standstill. Also, windy, and icy conditions have closed Oregon's principal east-west transportation route, Interstate Highway 84, for hours. In this way, the most likely impact of snow and ice events on Morrow County are road closures limiting access to and from impacted areas, especially roads to higher elevations. Closed roads due to debris and damage to infrastructure can become a major obstacle to providing critical emergency response, police, fire, and other disaster recovery services.

In addition to actual stormy conditions in the winter, dense, freezing fog can be a real hazard, especially on roadways and bridges.

Winter storms which bring snow, ice, and high winds can cause significant impacts on life and property, including downed trees and limbs, downed powerlines, and blocked roads. Winter storms with heavy wet snow or high winds and ice storms may result in power outages from downed transmission lines and/or poles. These impacts may pose a high risk of injury and loss of life, especially for more vulnerable populations and those residing in more rural areas. Many severe winter storm deaths occur because of traffic accidents on icy roads, heart attacks occurring from exertion while shoveling snow, and

[80] 2020 Oregon NHMP, 2020 Oregon NHMP

hypothermia from prolonged exposure to the cold. The temporary loss of home heating can be particularly hard on the elderly, young children, and other vulnerable individuals.

People who make their living from the land may be particularly vulnerable to the impacts of winter storms. During the winter, heat, food, and the care of livestock are everyday concerns. Access to farms and ranches can be extremely difficult and present a serious challenge to local emergency managers in the event of an emergency.

Based on the background and experience of the Morrow County NHMP Steering Committee the group used the OEM-FEMA Methodology to conduct an HVA that assessed the vulnerability of both regions to damage from Winter Storms:

- **North County region representatives ranked the vulnerability to Winter Storm as "High",** meaning more than 10% of the county's population and property would be affected by a major Winter Storm emergency or disaster; and
- **South County region representatives ranked the vulnerability to Winter Storm as "Moderate",** meaning 1 to 10% of the county's population and property would be affected by a major Winter Storm emergency or disaster.

*This rating has **remained the same for the North County** since the previous NHMP. A separate **ranking for the South County area is new** during this 2024 update.*

B. Vulnerability Assessment

The assessment of vulnerability based on the data in the Community Profile highlights social vulnerabilities within the community and the qualitative methodology developed by OEM and FEMA is intended to assign values to four factors that comprise risk to natural hazards.

1. Community Vulnerabilities

The Community Profile in Section II provides data on the demographic composition of people in Morrow County. Among the aspects of social vulnerabilities that may elevate risk to natural hazards in Morrow County are the high levels of poverty in rural portions of the county and the proportion of people who do not speak English well. These vulnerabilities relate to all natural hazards and may prevent information from being understood and used by households in which English is not the primary language spoken. Poverty may limit individual actions to reduce risk from natural hazards, placing limits on the improvements that can be made to dwellings that reduce risk from natural hazards. Poverty can impact families who are unable to afford air conditioning units to reduce the impact of extreme heat events.

The aging population within the county is another factor that exposes residents to risks from natural hazards. When common natural hazard events such as windstorms and winter storms cause power to be interrupted, the health of those people who depend on medical equipment such as dialysis machines or other essential equipment may be put in jeopardy.

Those people who make their living from the land in ranching, farming, fishing or forestry are also vulnerable to natural hazards such as drought, extreme heat and wildfire. The increased probability of climate driven natural hazard events can impact or destroy crops and forest resources.

The Project Manager led the Steering Committee through a qualitative assessment of hazard vulnerability using a method used widely in Oregon which assigns values to four factors related to risk. The OEM-FEMA Hazard Analysis Methodology was first developed by FEMA circa 1983, and gradually refined by OEM (now ODEM) over many years. During 1984, the predecessor agency to OEM (the Emergency Management Division) conducted workshops around the State of Oregon that resulted in all of Oregon's 36 counties producing the first versions of analyses using this methodology. In addition, many cities have also conducted an analysis using this method.

The methodology calls on participants to rank each natural hazard based on four factors that contribute to a Total Risk Score. Each of the four factors (History, Probability, Vulnerability and Maximum Threat) are ranked by the group of participants based on their experience, background and understanding of the best available data on the hazards being considered in the plan.

2. OEM-FEMA Methodology

The OEM-FEMA Methodology of developing an HVA is conducted by first identifying the community's relevant hazards, then scoring each hazard in four categories: history, probability, vulnerability, and maximum threat. This method provides local jurisdictions with a sense of hazard priorities, or relative risk.

Severity scores assigned to each category are based on the following:

- LOW = assign a score between 1 to 3 points
- MODERATE = assign a score between 4 to 7 points
- HIGH = assign a score between 8 to 10 points

History

History is the record of previous occurrences of identified natural hazards. An assessment of the history of a hazard in a jurisdiction assesses events for which the following types of activities were required: the Emergency Operations Center (EOC) was activated; three or more EOP functions were implemented; extraordinary multi-jurisdictional response was required; and/or local or tribal emergency was declared.

Severity scores are assigned based on the follow criteria:

- LOW = 0-1 event past 100 years, scores between 1 and 3 points
- MODERATE = 2-3 events past 100 years, scores between 4 and 7 points
- HIGH = 4 + events past 100 years, scores between 8 and 10 points

Probability

Probability is the likelihood of future occurrences of the natural hazard within a specified period of time. Morrow County evaluated the best available probability data to develop the probability scores presented below.

Severity scores are assigned based on the follow criteria:

- LOW = one incident likely within 75 – 100 years, scores between 1 and 3 points
- MODERATE = one incident likely within 35-75 years, scores between 4 and 7 points
- HIGH = one incident likely within 10-35 years, scores between 8 and 10 points

Vulnerability

Vulnerability assesses the extent to which people are susceptible to injury or other impacts resulting from a hazard as well as the exposure of the built environment or other community assets (social, environmental, economic, etc.) to hazards. The exposure of community assets to hazards is critical in the assessment of the degree of risk a community has to each hazard. As a matter of priority, special consideration is given to populations that are socially vulnerability (described in Section 2) given the disproportionate impact of recovering from a natural hazard event when socially vulnerable.

Under the HVA, vulnerability is scored assessing the percentage of population and property likely to be affected under an average occurrence of the hazard. Severity scores are assigned based on the follow criteria:

- LOW = < 1% affected, scores between 1 and 3 points
- MODERATE = 1 – 10% affected, scores between 4 and 7 points
- HIGH = > 10% affected, scores between 8 and 10 points

Maximum Threat

Maximum threat is the highest percentage of population and property that could be impacted under a worst-case scenario. Severity scores are assigned based on the follow criteria:

- LOW: < 5% population or property affected, scores between 1 and 3 points
- MEDIUM: 5 - 25% affected, scores between 4 and 7 points
- HIGH: >25% affected, scores between 8 and 10 points

Although this methodology is consistent statewide, the reported raw scores for each county are based on partially subjective rankings for each hazard. Because the rankings are used to describe the relative risk of a hazard within a county, and because each county conducted the analysis with a different team of people using slightly different assumptions, comparisons between local risk assessments must be treated with caution.

Table 65 and Table 66 present the rating for Probability for each of the natural hazards, and the rating for Vulnerability for each of the natural hazards, both as assessed by the Steering Committee members from North and South County areas present at the meetings during which the HVA was developed. The coloration of High, Medium and Low rankings is intended to make the table easier to evaluate.

Table 67 and Table 68 contain the Total Risk scores for each of the natural hazards as assessed by participants in North County and those in South County.

Table 65. Hazard Probability Summary

Hazard Probability	North County	South County
Air Quality	High	High
Dam Safety	Low	High
Drought	High	Moderate
Earthquake: Cascadia	Low	Low
Earthquake: Crustal	Low	Low
Extreme Temperature	High	Moderate
Flood	Low	Moderate
Landslide	Low	Moderate
Thunderstorms	High	High
Volcanic Event	Low	Low
Wildfire	High	High
Windstorm	High	Moderate
Winter Storm	High	Moderate

Table 66. Hazard Vulnerability Summary

Hazard Vulnerability	North County	South County
Air Quality	Moderate	High
Dam Safety	High	High
Drought	Moderate	Moderate
Earthquake: Cascadia	High	Low
Earthquake: Crustal	High	Low
Extreme Temperature	Moderate	Moderate
Flood	Low	Moderate
Landslide	Low	Moderate
Thunderstorms	High	High
Volcanic Event	High	Low
Wildfire	Low	High
Windstorm	Moderate	Moderate
Winter Storm	High	Moderate

Table 67. North Morrow County HVA

North Morrow County	History	Vulnerability	Maximum	Probability	Total Threat	H-M-L	Hazard
Winter Storm	20	45	90	70	**225**	H	1
Thunderstorms	20	40	80	70	**210**	H	2
Air Quality	20	35	70	70	**195**	H	3
Extreme Temperature	20	35	70	70	**195**	H	3
Windstorm	20	30	60	70	**180**	H	4
Drought	20	25	50	70	**165**	M	5
Earthquake: Cascadia	2	50	100	7	**159**	M	6
Earthquake: Crustal	20	40	80	7	**147**	M	7
Wildfire	20	5	10	70	**105**	M	8
Dam Safety	2	40	80	7	**129**	M	9
Volcanic Event	2	40	80	7	**129**	M	10
Flood	2	5	10	7	**24**	L	11
Landslide	2	5	10	7	**24**	L	11

Table 68. South Morrow County HVA

South Morrow County	History	Vulnerability	Maximum	Probability	Total Threat	H-M-L	Hazard
Thunderstorms	20	50	50	70	**190**	H	1
Wildfire	20	50	100	70	**240**	H	2
Air Quality	20	50	100	70	**240**	H	3
Drought	20	25	50	70	**165**	M	4
Extreme Temperature	20	25	10	70	**125**	M	5
Winter Storm	20	25	50	70	**165**	M	6
Windstorm	20	25	50	70	**165**	M	7
Flood	20	25	10	70	**125**	M	8
Landslide	20	25	10	70	**125**	M	9
Earthquake: Crustal	2	5	10	35	**52**	L	10
Earthquake: Cascadia	2	5	10	7	**24**	L	11
Volcanic Event	2	5	10	35	**52**	L	12
Dam Safety	2	50	100	7	**159**	M	13

C. Quantitative Risk Analysis

The third phase, risk assessment, involves estimating the damage, injuries, and costs likely to be incurred in a geographical area due to a natural hazard, either during or immediately after the event, or over a prolonged period.

The DOGAMI Multi-hazard Risk Report for Morrow County estimates the damage, injuries and costs associated with four of the natural hazards evaluated in this plan and channel migration, a natural hazard not identified by the communities in this NHMP update. The quantitative risk analysis was conducted using Hazus®-MH, a model and geospatial analysis tool that joins current scientific and engineering knowledge with the latest geographic information systems (GIS) technology to produce estimates of hazard-related damage based on a natural hazard event scenario.

A risk analysis summary for each community is provided in this section to illustrate the risk profile for each of the cities and the county. This section contains community-specific data to provide an overview of each community and the level of risk from each natural hazard analyzed.

Table 69. Unincorporated Morrow County (rural) hazard profile

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Unincorporated Morrow County (rural)	4,496	5,141	2	2,877,028,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	9	0.2%	34	0	5,659,000	0.2%
Earthquake	Horse Heaven Fault Mw-7.1	53	1.2%	329	0	132,228,000	4.6%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	348	7.7%	423	0	105,067,000	3.6%
Channel Migration	30-year erosion hazard	20	0.4%	25	0	5,507,000	0.2%
Wildfire	High and Moderate Risk	1,963	44%	2,533	1	1,120,243,000	39%

[1] Facilities with multiple buildings were consolidated into one building complex.

[2] No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Table 70. City of Boardman hazard profile

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Boardman	4,338	1,214	5	823,077,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	0	0.0%	0	0	0	0.0%
Earthquake	Horse Heaven Fault Mw-7.1	27	0.6%	75	0	55,846,000	6.8%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	0	0%	0	0	0	0%
Channel Migration	30-year erosion hazard	0	0%	0	0	0	0%
Wildfire	High and Moderate Risk	858	20%	212	2	164,489,000	20%

[1] Facilities with multiple buildings were consolidated into one building complex.
[2] No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

Table 71. City of Heppner hazard profile

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Heppner	1,187	797	7	229,967,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	167	14%	119	1	2,084,000	0.9%
Earthquake*	Horse Heaven Fault Mw-7.1	8	0.7%	28	0	5,877,000	2.6%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	163	14%	111	1	30,944,000	13%
Channel Migration	30-year erosion hazard	58	4.9%	46	1	7,675,000	3.3%
Wildfire	High and Moderate Risk	194	16%	112	1	25,440,000	11%

[1] Facilities with multiple buildings were consolidated into one building complex.
[2] No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

Drought, windstorm and winter storm affect large portions of the County and take in Heppner with their affects. These risks for Heppner do not vary from those risks facing the entire County. This is true also for Volcano, Earthquake and Landslide hazards.

Flood and Wildfire have the highest potential to affect Heppner, which is why Heppner has a Flash Flood Emergency Plan and has collaborated with the development of the County-wide Community Wildfire Protection Plan. Heppner participates in the NFIP program and enforces the flood plain development regulations as provided in Heppner's floodplain ordinances. The city is in the Community Rating System showing good floodplain management capacity in the city.

The City of Heppner did extensive storm water management about six years ago. They added three large catch basins along two streets to mitigate runoff to Willow Creek. Two large swales were built, one along Willow Creek and one along Hinton Creek. Several culverts were replaced and drainage improved along the steepest streets.

Table 72. City of Ione hazard profile

Community Overview							
Community Name		**Population**	**Number of Buildings**		**Critical Facilities[1]**		**Total Building Value ($)**
Ione		339	249		2		68,770,000
Hazus-MH Analysis Summary							
Hazard	**Scenario**	**Potentially Displaced Residents**	**% Potentially Displaced Residents**	**Damaged Buildings**	**Damaged Critical Facilities**	**Loss Estimate ($)**	**Loss Ratio**
Flood[2]	1% Annual Chance	152	45%	69	1	1,263,000	1.8%
Earthquake	Horse Heaven Fault Mw-7.1	4	1.2%	17	0	3,045,000	4.4%
Exposure Analysis Summary							
Hazard	**Scenario**	**Potentially Displaced Residents**	**% Potentially Displaced Residents**	**Exposed Buildings**	**Exposed Critical Facilities**	**Building Value ($)**	**Exposure Ratio**
Landslide	High and Very High Susceptibility	10	2.9%	5	0	1,997,000	2.9%
Channel Migration	30-year erosion hazard	6	1.8%	6	1	1,178,000	1.7%
Wildfire	High and Moderate Risk	69	20%	56	1	12,524,000	19%

[1]Facilities with multiple buildings were consolidated into one building complex.
[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Ione identifies particular concern with flash flooding, wildfire, and drought. Drainage improvements and no till farming practices have reduced risk of flash flooding. The city identifies further drainage infrastructure improvements to alleviate this threat.

Wildfire risk can be seasonally high at the time of wheat harvest. The fire district enforces a burn ban during high risk weather. Drought also has a profound effect on the hardships of agriculture

Table 73. City of Irrigon hazard profile

Community Overview				
Community Name	**Population**	**Number of Buildings**	**Critical Facilities[1]**	**Total Building Value ($)**
Irrigon	2,037	867	5	217,274,000

Hazus-MH Analysis Summary							
Hazard	**Scenario**	**Potentially Displaced Residents**	**% Potentially Displaced Residents**	**Damaged Buildings**	**Damaged Critical Facilities**	**Loss Estimate ($)**	**Loss Ratio**
Flood[2]	1% Annual Chance	0	0.0%	0	0	0	0.0%
Earthquake*	Horse Heaven Fault Mw-7.1	52	2.6%	122	2	17,478,000	8%

Exposure Analysis Summary							
Hazard	**Scenario**	**Potentially Displaced Residents**	**% Potentially Displaced Residents**	**Exposed Buildings**	**Exposed Critical Facilities**	**Building Value ($)**	**Exposure Ratio**
Landslide	High and Very High Susceptibility	10	0.5%	2	0	775,000	0.4%
Channel Migration	30-year erosion hazard	0	0%	0	0	0	0%
Wildfire	High and Moderate Risk	55	2.7%	18	1	14,245,000	6.6%

[1]Facilities with multiple buildings were consolidated into one building complex.
[2]No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

The City of Irrigon is projected to experience a higher loss ratio from a 7.1 Mw earthquake centered on the Horse Heavens fault than the other cities are. Wildfire exposure is also a notable hazard for this city.

Table 74. City of Lexington hazard profile

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Lexington	238	212	2	55,260,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	43	18%	28	1	1,285,000	2.3%
Earthquake*	Horse Heaven Fault Mw-7.1	1	0.4%	6	0	1,246,000	2.3%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	13	5.5%	10	0	1,538,000	2.8%
Channel Migration	30-year erosion hazard	0	0.0%	2	0	117,000	0.2%
Wildfire	High and Moderate Risk	87	37%	74	0	13,590,000	25%

[1]Facilities with multiple buildings were consolidated into one building complex.
[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

The City of Lexington is the jurisdiction with the highest level of exposure to Wildfire at 25%. Flood risk includes the potential impact to one of the two critical facilities identified in Lexington.

IV. MITIGATION PLAN GOALS & ACTION ITEMS

This section outlines Morrow County's strategy to reduce or avoid long-term vulnerabilities to the identified hazards. Specifically, this section presents a mission and specific goals and actions thereby addressing the mitigation strategy requirements contained in 44 CFR 201.6(c). The NHMP Steering Committee reviewed and updated the mission, goals and actionitems documented in this NHMP. Additional planning process documentation is in Volume II, Appendix B.

Mitigation Vision

The NHMP vision describes the long-term goals and aspirations, while painting a compelling picture of the organization's future aspirations. The vision of the Morrow County NHMP is:

To maximize Morrow County's resistance and resilience to natural hazards in both government and private sectors through preparedness and mitigation.

Mitigation Mission

The NHMP mission states the purpose and defines the primary functions of Morrow County's NHMP. It is intended to be adaptable to any future changes made to the NHMP and need not change unless the community's environment or priorities change. The mission of the Morrow County NHMP is:

To identify and reduce risk, work to prevent loss, and protect life, property, and the environment from natural hazard events through coordination and cooperation among public and private partners.

A. Mitigation Goals

Mitigation plan goals are more specific statements of direction that Morrow County residents and public and private partners can take while working to reduce the County's risk from natural hazards. These statements of direction form a bridge between the broad mission statement and action items.

The plan goals help guide the direction of future activities aimed at reducing risk and preventing loss from natural hazards. The goals serve as checkpoints as agencies and organizations begin implementing mitigation action items. The basis for Morrow County's goals concerning mitigation of natural hazard risks lies in the Comprehensive Plan, which directs the County to protect life and property from natural disasters and hazards. These goals exists in harmony with many other County planning programs from the Transportation System Plan to the ordinances, plans and policies of the Health Department, Planning Department, Public Works Department, and other entities such as Morrow County Emergency Management.

The following goals were updated for the 2024 Morrow County NHMP with the help of the NHMP Steering Committee. The goals reflect the mitigation priorities of both Morrow County and the cities of

Boardman, Heppner, Ione, and Irrigon and the town of Lexington. Each jurisdiction will adopt the following goals:

Mitigation Goals

Goal 1: Protection of Property:

- Lessen impact from natural disaster on individual properties, businesses, and public facilities by increasing awareness at the individual level and encouraging activities that can prevent damage and loss of life from natural hazards;
- Improve hazard assessment information to make recommendations for discouraging new development and encouraging preventative measures for existing development in areas vulnerable to natural hazards.

Goal 2: Education and Outreach:

- Further the public's awareness and understanding of natural hazards and potential risk, including social and economic vulnerability and mitigation efforts;
- Provide information on tools, partnership opportunities, and funding resources to assist in implementing mitigation activities, using best practices to engage underserved communities and individuals.

Goal 3: Preventative:

- Reduce the threat of loss of life and property from natural hazards by incorporating information on known hazards and providing incentives to make hazard mitigation planning a priority in land use policies and decisions, including plan implementation, with attention to barriers or opportunities in areas with underserved communities or for individuals or groups with heightened social vulnerability.

Goal 4: Partnership and Coordination:

- Identify mitigation or risk reduction measures that address multiple areas (i.e., environment, transportation, telecommunications);
- Coordinate public/private sector participation in planning and implementing mitigation projects throughout the county;
- Seek funding and resource partnerships for future mitigation efforts; and
- Strengthen communication and coordinate participation among and within public agencies, residents, non-profit organizations, business, and industry.

Goal 5: Structural Projects:

- When applicable, utilize structural mitigation activities to minimize risks associated with natural hazards.

Goal 6: Natural Resources:

- Preserve, rehabilitate, and enhance natural systems to serve natural hazard mitigation functions (i.e., floodplains, wetlands, watersheds, and urban interface areas); and

- Balance watershed planning, natural resource management, and land use planning with natural hazard mitigation to protect life, property, and the environment.

Goal 7: Emergency Services:

- Minimize life safety issues by promoting, strengthening, and coordinating emergency response plans; and
- Coordinate and integrate natural hazard mitigation activities, where appropriate, with emergency operations plans and procedures.

Communities in Oregon depend upon a Local Comprehensive Plan to organize and prioritize goals and policies for the community. These goals and policies assist with the implementation of planning, capital improvement, budgeting and other various decisions made to achieve the county's and each city's goals. This multi-jurisdictional NHMP, once acknowledged by FEMA, will subsequently be adopted by each jurisdiction as a support document for each local comprehensive plan. Action strategies and mitigation planning goals are thereby incorporated in the local jurisdictions plan for the purpose of implementation in the local decision-making process.

B. Action Items Development Process

Development of action items included a multi-step, iterative process that involved brainstorming, discussion, review, and revisions. Action items are developed through various sources, including community identified issues, study and report findings, steering committee discussion, and more. An illustration of how hazard related issues are developed into Action Items is illustrated below in Figure 39.

Figure 39. Development of Mitigation Actions

Many of the action items were created during the previous NHMP planning processes and were updated as necessary. During these processes, steering committees developed maps of local vulnerable populations, facilities, and infrastructure in respect to each identified hazard. Review of these maps generated discussion around potential actions to mitigate impacts to the vulnerable areas. The Department of Land Conservation and Development (DLCD) provided guidance in the development of action items by presenting and discussing actions that were used in other communities. DLCD also took note of ideas that came up in Steering Committee meetings and drafted specific actions that met the intent of the Steering Committee. All actions were then reviewed by the Steering Committee, discussed at length, and revised as necessary before becoming a part of this document.

Action Item Framework

Many of the NHMP's recommendations are consistent with the goals and objectives of each jurisdiction's (County, cities, special districts) existing plans and policies. Where possible, each jurisdiction will implement the NHMP's recommended actions through existing plans and policies. Plans and policies already in existence have support from residents, businesses, and policy makers. Many land-use, comprehensive, and strategic plans get updated regularly,and can adapt easily to changing conditions and needs. Implementing the NHMP's action items through such plans and policies increases their likelihood of being supported and implemented.

Action Item Development and Prioritization

The action items were developed through a two-stage process. In stage one, DLCD facilitated a work session with the entire steering committee to discuss vulnerabilities, risk profile, and to identify potential new mitigation actions. In the second stage, DLCD, working with the individual jurisdictions to evaluate the status of 2016 mitigation actions and to consolidate and revise them as necessary.

Table 75 identifies the status of 2016 Action Items and revisions that were made to them during the 2024 update process. Several 2016 Action Items were completed. Most of these were physical mitigation projects. Although Morrow County jurisdictions did not incorporate the NHMP into their Comprehensive Plans, the physical projects were identified in other plans or planning mechanisms already in place in the cities and the county.

Table 75. Status and Disposition of 2016 Action Items

2016 Action item	2024 Action ID	Status	Details	Disposition
Morrow County				
MC06-07	MC-MH-1	Not Complete, Revised		Retained, multi-hazard
MC06-09	MC-MH-2	Not Complete, Revised		Retained, multi-hazard
MC14-36	MC-MH-3	Not Complete		Retained, multi-hazard
-	MC-MH-4	New		
-	MC-MH-5	New		
MC06-08	MC-DR-1	Not Complete, Revised		Rewrite/Revise

2016 Action item	2024 Action ID	Status	Details	Disposition
MC06-13 MC06-21 MC06-22 MC06-23 MC06-26 MC06-27 MC06-28 MC06-29 MC06-30 MC06-31 MC06-32 MC06-14 MC06-15 MC06-16 MC06-17 MC06-18 MC06-18 MC06-19 MC06-20	MC-FL-1	Not Complete, Revised		Combined
MC14-41	MC-FL-2	Not Complete, Revised		Retained
MC14-38	MC-LS-1	Not Complete, Revised		Retained
MC06-03	MC-SW-1	Not Complete, Revised		Retained
-	MC-SW-2	New		
MC06-02	MC-WF-1	Not Complete, Revised		Retained
MC14-33	MC-WF-2	Not Complete		Retained, detail added
MC14-35	MC-WF-3	Not Complete, Revised		Retained, detail added
MC14-39	MC-WF-4	Not Complete, Revised		Retained
MC14-40	MC-WF-5	Not Complete, Revised		Retained, detail added
MC06-01	-	Completed		Removed
MC06-04	-	Discontinued		Removed
MC06-05	-	Completed		Removed
MC06-06	-	Cancelled		Combined with 2016 MC 14-35, 37, and 38
MC06-10	-	Completed		Removed
MC06-11	-	Cancelled		Combined with 2016 MC 14-35, 37, and 38
MC06-12	-	Completed	Larger culver installed	Removed
MC06-16	-	Completed	Ditches cleaned out	Removed
MC06-17	-	Completed		Removed
MC06-18	-	Completed	Ditches cleaned out	Removed
MC06-24	-	Completed		Removed
MC06-25	-	Completed		Removed
MC14-34	-	Discontinued		Removed
MC14-37	-	Completed		Removed

2016 Action item	2024 Action ID	Status	Details	Disposition
Boardman				
B06-02	B-DR-1	Not Complete, Revised		Retained
B14-03	B-MH-1	Not Complete, Revised		Retained
B06-01	-	Completed	City owns portable generator to operate lift station during power outages	Removed
Heppner				
H06-03	H-MH-1	Completed		Retained
-	H-MH-2	New		
-	H-MH-3	New		
H06-01	H-FL-1	Not Complete, Revised		Retained
-	H-FL-2	New		
-	H-FL-3	New		
H06-02	-	Discontinued		Removed
-	-	New	Heppner built a new fire station to serve the City of Heppner and the Heppner Rural Fire Protection District.	Completed
Ione				
-	IO-MH-1	New		
IN14-03	IO-DR-1	Not Complete, Revised		Retained, Incorporated into IO-DR-02
-	IO-DR-2	New		
IN06-01	IO-FL-1	Not Complete, Revised		Retained
IN06-02	IO-FL-2	Not Complete, Revised		Retained
IN14-05	IO-FL-3	Not Complete, Revised		Retained
IN14-03	-	Completed	This mitigation project was completed at the top of the hill. CRP land didn't have diversion for the canyon (flood last in 2008), after flood, they took some land out of CRP to create a detention pond.	Removed

2016 Action item	2024 Action ID	Status	Details	Disposition
IN14-04	-	Completed	This was resolved in 2022 with the removal of a flow barrier (underground stem wall) from roof runoff. Only two buildings were previously affected and none are now. Percolation tests (12 sites near park) showed that the park is highly compacted due to historic use as a railyard.	Removed
Irrigon				
IR06-03	IR-MH-1	Not Complete, Revised		Retained
IR14-07	IR-MH-2	Completed	Reader board installed at City Hall	Removed
-	IR-DR-1	New		
-	IR-DR-2	New		
IR14-06	IR-SW-1	Not Complete, Revised		Retained
IR14-01	-	Discontinued		Removed
IR06-02	-	Discontinued		Removed
IR06-04	-	Completed	No longer necessary. Well removed. New wells came online in 2009. New Action Item developed for backup power for new wells 3 and 4.	Removed
IR14-05	-	Completed		Removed
Lexington				
L06-04	LX-MH-1	Not Complete, Revised		Retained
L06-06	LX-DR-1	Not Complete		Retained
L06-07	LX-DR-2	Not Complete		Retained
L06-02	LX-FL-1			Retained
L06-08	LX-FL-2	Not Complete		Retained
L06-09	LX-FL-3	Not Complete		Retained
L06-01	-	Completed	Pump replacement was complete Aug. 2022.	Removed
L06-03	-	Completed		Removed
L06-05	-	Discontinued		Removed
Morrow County Health District				
-	HD-MH-1	New		
-	HD-MH-2	New		

Each steering committee member identified the top three (3) action items priorities that currently reflect their community's current conditions, needs, and capacity. The Jurisdictions will focus their attention and resource availability upon these achievable, high leverage activities over the next five years, though the top priority actions may shift due to changes in community risk, capacity, and funding.

Although this methodology provides a guide for the jurisdictions in terms of implementation, each jurisdiction has the option to implement any of the action items at any time. This option to consider all action items for implementation allows jurisdictions to consider mitigation strategies as new opportunities arise, such as capitalizing on funding opportunities. Mitigation actions that were not prioritized will be considered for prioritization during maintenance meetings.

Action Items – Matrix and Details

The tables below provide both a snapshot and details of the 2024 mitigation Action Items identified by representatives for each jurisdiction during Steering Committee meetings. (See Appendix B for details.)

Table **76** provides a summary matrix of action item numbers by jurisdiction and each hazard to which they identified being exposed as well as the goals addressed by each action.

The second table, Table 77 identifies the name and some details of each mitigation action item providing a brief description or notes, lead agency and potential partners, potential funding sources, projected cost, and a projected timeline. Priority, if known, is noted. A method for establishing priorities among the action items is discussed in Appendix C: Economic Analysis of Natural Hazard Mitigation Project.

Table 76. Action Items: Morrow County

Action Item	Impacted Hazard										Plan Goals						
	Air Quality	Drought	Earthquake	Extreme Heat	Flood	Landslide	Volcanic Event	Windstorm	Winter Storm	Wildfire	1. Protection of	2. Education &	3. Prevention	4. Partnership & Coordination	5. Structural Projects	6. Natural Resources	7. Emergency Services
Multi-Jurisdictional																	
MJ-MH-1	x		x	x	x		x	x	x	x				x			x
Morrow County																	
MC-MH-1	x	x	x	x	x	x	x	x	x	x		x		x			
MC-MH-2	x	x	x	x	x	x	x	x	x	x	x	x		x			
MC-MH-3	x	x	x	x	x	x	x	x	x	x			x				
MC-MH-4	x	x	x	x	x	x	x	x	x	x				x			
MC-MH-5	x		x	x	x	x	x	x	x	x				x			x
MC-MH-6		x			x	x					x			x	x		
MC-FL-1					x										x		
MC-FL-2					x						x						
MC-LS-1					x	x							x				
MC-SW-1								x	x						x		
MC-SW-2								x	x	x			x				
MC-WF-1										x		x					
MC-WF-2										x	x						
MC-WF-3										x			x				
MC-WF-4										x	x			x			
MC-WF-5										x	x						
Boardman																	
B-DR-1		x	x				x	x	x	x					x		
B-MH-1	x	x	x	x	x	x	x	x	x	x	x	x					
Heppner																	
H-MH-1	x	x	x	x	x	x	x	x	x	x		x					x
H-MH-2	x	x	x	x	x	x	x	x	x	x	x		x	x	x		
H-MH-3		x	x	x	x	x	x	x	x	x					x		
H-FL-1					x							x					
H-FL-2					x										x		
H-FL-3					x									x			
Ione																	

Action Item	Impacted Hazard										Plan Goals						
	Air Quality	Drought	Earthquake	Extreme Heat	Flood	Landslide	Volcanic Event	Windstorm	Winter Storm	Wildfire	1. Protection of	2. Education &	3. Prevention	4. Partnership & Coordination	5. Structural Projects	6. Natural Resources	7. Emergency Services
IO-MH-1	x			x						x				x			
IO-DR-2		x			x				x						x		
IO-FL-1					x	x						x		x			
IO-FL-2					x						x				x		
IO-FL-3					x								x				
Irrigon																	
IR-MH-1		x								x				x	x	x	
IR-MH-2	x	x	x	x	x	x	x	x	x	x					x		x
IR-DR-1		x			x										x		
IR-DR-2		x													x	x	
IR-SW-1	x			x				x	x	x							
Lexington																	
LX-MH-1	x	x	x	x	x	x	x	x	x	x					x		
LX-DR-1		x		x	x									x	x		
LX-DR-2	x	x	x	x	x	x	x	x	x	x			x				
LX-FL-1					x	x									x		
LX-FL-2					x										x		
LX-FL-3					x										x		
Morrow County Health District																	
HD-MH-1	x	x	x	x	x	x	x	x	x	x				x	x		
HD-MH-2			x	x	x	x	x	x	x	x		x	x				

Table 77. Mitigation Action Item Details

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
Multi-Jurisdictional							
MJ-MH-1	Establish a coordinated county-wide approach or plan for Public Safety Power Shutoffs (power down for low humidity days – power outages in general)	It is essential to provide community-wide communication when PSPSs are occurring, to ensure the public are able to be proactive and prepare for the time while the power is out. Public concern was expressed about the potential for ignition of crop land below high tension power lines.	Community Planning Departments/ Utility Companies		HMGP; BRIC; Technical assistance funding		Short-Term (0 to 2 years)
Morrow County (MC)							
MC-MH-1	Provide Spanish-speaking community members with culturally appropriate outreach and resources concerning regional natural hazards and emergency alerts.	As outreach and educational resources are primarily focused on English speaking communities, this fails to account for the Spanish-speaking community members, who are a vulnerable population due to being underserved and have a lack of knowledge and awareness of hazard issues and related-resources. Ensuring that resources and outreach that is both provided in Spanish as well as is culturally appropriate and addresses the communities' concerns and needs is essential.	MC Planning Department, Emergency Management	High	HMGP; BRIC	Low (Less than $100,000)	Ongoing
MC-MH-2	Organize and maintain public awareness campaigns regarding natural hazards for the benefit of the community. (Target high-risk communities)	Identify opportunities to raise public awareness and implement education campaigns for community members within Morrow County's public and private high-risk hazard areas	MC Planning Department, MC Emergency Management	-	HMGP; BRIC	Low (Less than $100,000)	Ongoing

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
MC-MH-3	Consideration of broadening the NHMP to include all hazards.	There is a need for identifying the interconnectedness of natural disaster occurrences that can result in other, non-natural disaster events, such as power disruptions or gas line disturbances.	MC Planning Department; MC Emergency Management; Fire Districts, City Disaster Management staff, Port of Morrow	High	HMGP; BRIC; Community Grant - Technical Assistance (DLCD)	Low/ Medium	Short-Term (0 to 2 years)
MC-MH-4	Start and maintain CERT groups to be able to handle sheltering operations.	Beginning by recruiting volunteers, followed by providing and maintaining training. As well as identify capacity needs for the program, including funding, required equipment and materials.	MC Planning Department, MC Emergency Management, Jurisdictions, Red Cross	-	ODEM State Homeland Security Grant Program	Low/ Medium	Ongoing
MC-MH-5	Establish Emergency Communications System	In the event of an emergency, resilient emergency communication systems are vital. This will require determining city roles in implementing and maintaining the system.	MC Planning Department, MC Emergency Management	-	HMGP; BRIC	Medium ($100,000 to $500,000)	Short-Term (0 to 2 years)
MC-MH-6	Install automated shut down at head gates and pump stations at West Extension Irrigation District (WEID)	In the event of a canal failure, the water in the West Extension canals need to be stopped to avoid canal overflow and flooding in adjacent areas.	West Extension Irrigation District; State of Federal Resource Agency; Oregon Rural Action	High	FMA (and HMGP; BRIC)	Medium/ High	Short-Term/ Medium-Term

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
MC-FL-1	Improve vulnerable roads, canyons, and culverts, that frequently experience flooding from heavy rains, leading to washed out, unpassable roads.	There are many areas throughout the county that are washed out/flooded roads, which is exacerbated during heavy rains. There is a need to implement clearing, provide grading, increase culverts, raise roads, and re-route roads. Locations include: Alpine Lane #702 (some worked completed) Bert Peck Lane #616 Black Horse Road Clarks Canyon #966 (Some washed out spots, culvers plugged) Dee Cox Road #723 Fuller Canyon #612 Immigrant - Mud Build Up #550 Johnson Grade #526 Lindstrom Lane #538 Lloyd Road #924 Meadow Brook Road #643 Morgan East #537 Nichols Lane Road #620 Perlberg #675; Piper Canyon #647 Shobe Canyon #713 Stock Drive Lane #614 Turner Land #504 Wells Spring (Washed out)	Morrow County Road Department; Public Works, Planning Department; Landowners, DLCD, ODT	Medium	Road Fund; General Funds	Low/ Medium	Short-Term/ Medium-Term

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
MC-FL-2	Compliance with the National Flood Insurance Program	Drainages, such as the Willow Creek Valley area and other lesser-known areas, experience occasional devasting flooding. For these areas, and others it is important to adhere to ordinances aimed at mitigating flood risk to life and property.	Morrow County Planning Department; FEMA, ODEM	High	FMA	Medium ($100,000 to $500,000)	Ongoing
MC-LS-1	Develop updated policy language for landslide hazards and incorporate the landslide hazard data and maps into the Comprehensive Plan and land use zones that have landslide risks in order to mitigate landslide disasters	Use the DOGAMI list of identified landslide risk areas in Morrow County, and provide policy and mapping regarding this study, and incorporate land use planning and hazard reduction/mitigation into land use document. Design/ Permitting is currently underway; Next steps will include integrating Information/Data with other plans/reports/policies/studies etc.	Morrow County Planning Department; Emergency Management; DLCD, DOGAMI	Medium	HMGP; BRIC (Direct Technical Assistance); Community Grant - Technical Assistance (DLCD)	Low/ Medium	Short-Term (0 to 2 years)
MC-SW-1	Establish and maintain backup power for critical communication facilities in the event of a wind/winter storm	Redundant power sources are essential, especially when vulnerable power sources are affected due to a natural hazard. Backup power/generators don't exist for communication systems within the rural fire departments. This action will include establishing backup power for communication towers that do not yet have backup power. Currently, this action has been difficult to implement and maintain due to staffing issues, which have kept the emergency services	Morrow County Emergency Management; Rural Fire Protection Districts; Data District	High	HMGP; BRIC; Rural Development Assistance - Utilities; USDA	High	Long-Term (5+ years)

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
		department unable to work on the project.					
MC-SW-2	Place reflective signs or barriers along the road to prevent accidents.	Roads are difficult to differentiate from fields during extreme weather events, such as snow storm, which poses a challenge for snow plows. Such examples include Rattlesnake Canyon, the top of Gooseberry, and Rhea Creek. Per the city of Ione - roads fixes were completed in the last six months where snow plows were going off the road, but is a continual process.	Morrow County Transportation and Public Works, Emergency Management, Planning	-	HMGP; BRIC (Warning System)	Medium/ High	Medium to Long-Term
MC-WF-1	Public education for property owners and recreationists in fire-prone areas	Rural populations are often inadequately educated or prepared for wildfires, as they are often underserved and underrepresented. Providing outreach that specifically targets their needs and concerns is essential. This can be further addressed by providing material and resources in both English and Spanish.	Morrow County Public Works; Fire Protection Districts; ODOF, NFPA, USFS	High	BRIC	Low	Ongoing

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
MC-WF-2	Identify the proper fire district that will protect against fires in the Umatilla Chemical Depot District	The US Army Chemical Depot has been deactivated and is in the Base Realignment (BRAC) process. Along with the many tasks involved with this process, what entities will protect against wildfires in that area also needs to be addressed. This area has over 5,000 acres slated for wildlife refuge and habitat protection, more than 7,000 acres for use by the Oregon National Guard for training grounds and facilities, an estimated 1,077 acres for highway commercial/industrial uses, and over 2,000 acres of industrial grounds with approximately 943 acres of that property restricted to help preserve wildlife habitat that is presently in the area. Future steps for this action can include establishing a relationship and maintaining communication between fire district and depot district and establish plan of action.	Morrow County Planning Department; Emergency Management; Umatilla County partners in fire protection and planning, Fire districts, Local Reuse Authority	Medium	EPA - Environmental and Climate Justice (ECJ) program; HMGP; HMGP Post Fire	Low/ Medium	Medium-Term (2-5 years)
MC-WF-3	Update fire siting standards for siting development in Forest use Zones.	Current siting standards in the Forest Use Zone are inadequate relative to accessibility for response vehicles based on the Forest Practices Act. Some of the fire siting standards are unclear, have no compliance mechanisms and no indication as to who would provide enforcement. In order to address these deficiencies, as well as changes in wildfire risk, it will be important to	Morrow County Planning Department; Emergency Management; Fire Districts, USFS, ODF	High	HMGP; HMGP Post Fire; BRIC; Community Wildfire Risk Reduction Grant (OSFM)	Medium	Short-Term (0 to 2 years)

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
		design new, adequate standards and incorporate those standards into the Forest Use Zone siting requirements in the Zoning Ordinance.					
MC-WF-4	Identify specific individual responsible for and maintain communication among partner agencies for any emergency needs and responses to Army Corps of Engineers property next to the Columbia River.	Implementation (underway); There is confusion as to who responds to fires on the federal lands next to the river, either the local fire districts or the feds. There is a need to create an opportunity for the US Army Corps of Engineers, the USFW, the Port of Morrow, and the local rural fire protection districts to meet and discuss fire protection along the river. The intention is to develop an agreement as to who will fight fires on the federal properties next to the river. Future cooperation could contribute towards identifying opportunities for wildfire risk reduction on the land.	Morrow County Planning Department; Boardman and Irrigon Rural Fire Protection Districts, USACE, USFW, Port of Morrow	High	General funds	Low (Less than $100,000)	Short-Term (0 to 2 years)
MC-WF-5	Identify/Establish designated evacuation routes in the event of a wildfire in the residentially developed areas of southern Morrow County, particularly in the Blake Ranch area.	There is a need for designated fire evacuation routes in the event of a wildfire in the residentially developed areas of southern Morrow County and is especially important in the Blake Ranch area. Work to discuss with the appropriate authorities and develop designated fire evacuation routes where they are deemed to be needed in southern Morrow County	Morrow County Planning Department; Emergency Management; Heppner Rural Fire Protection District	High	HMGP; BRIC; HMGP Post Fire	Medium/ High	Medium-Term (2-5 years)

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
Boardman							
B-DR-1	Provide backup generator for water collector #2 in Boardman.	There is no back-up power for the collector well #2 if the primary power source were to go out during a power outage. Addressing this deficiency is essential, as this well is one of the main sources of water for Boardman.	Public Works Department	High	HMGP; BRIC	High	Medium-Term (2-5 years)
B-MH-1	Provide Spanish-speaking community members with culturally appropriate outreach and resources concerning regional natural hazards and emergency alerts.	As outreach and educational resources are primarily focused on English speaking communities, this fails to account for the Spanish-speaking community members, who are a vulnerable population due to being underserved and have a lack of knowledge and awareness of hazard issues and related-resources. Ensuring that resources and outreach that is both provided in Spanish as well as is culturally appropriate and addresses the communities' concerns and needs is essential.	Public Works Department	High	EPA - Environmental and Climate Justice (ECJ) program (Towards underserved and overburdened populations); HMGP; BRIC	Low (Less than $100,000)	Ongoing
Heppner							
H-MH-1	Improve emergency communications systems in the Willow Creek Valley.	All counties have gone to OR Alert system, which will help provide support as the city improves their emergency communication systems by tying into the already established system. Currently OR Alert is operating within Morrow County.	City of Heppner, County Emergency Management	High	HMGP; BRIC (Warning System)	Medium/ High	Medium-Term (2-5 years)

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
H-MH-2	Ensure that the fire station maintains a full staff of volunteers for both the rural and town stations.	Currently, all positions are full except for a single opening. Maintaining a full staff of volunteers will ensure that the community can better respond to hazards.	City of Heppner, Fire Districts; County Emergency Management	-	Oregon Fire Service Capacity Program (OSFM)		Ongoing
H-MH-3	Need redundancy in water system like backup pumps.	The city has 4 wells in a 12-mile line in the canyon, all of which are along one pipe, which was last upgraded 1984. Redundancy will be incorporated into the water system by implementing and maintain a new tank well separate from the existing line. This project is currently under contract with Anderson Perry, who is also working on updating the sewer and water master plan.	Partner: Business Oregon	High	Business Oregon (financing and grants); BRIC	High ($500,000+)	Medium-Term (2-5 years)

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
H-FL-1	Organize and maintain public awareness campaigns regarding floods for the benefit of the community. (Target high-risk communities)	The community will work to develop and implement outreach and educational campaigns focused on flood and water quality. The campaigns will have a focus on targeting high-risk and vulnerable communities, including those living in assisted living facilities, schools, etc. Other opportunities to hold these campaigns include places for community public gatherings such as public pools, churches, stores, etc. Such topics that will be addressed will include what to know in a massive flash, what to do when flash flood sirens go off, as there is a history of flooding in Willow Creek drainages.	City of Heppner, Fire Districts; County Emergency Management	High	EPA - Environmental and Climate Justice (ECJ) program (Towards underserved and overburdened populations); HMGP; BRIC	Low	Ongoing
H-FL-2	Sewer system improvements	The city's sewer plant is currently over 100 years old and is subject to flood risk. While there have been no significant floods recently, there are no plans to relocate the plant. A Wastewater Feasibility Study is in progress.	Partner: Business Oregon	High	Business Oregon (financing and grants)	High ($500,000+)	Medium-Term (2-5 years)
H-FL-3	Willow Creek Flood Study	Willow Creek floodplain in Heppner has been identified by the USACE as a priority for a flood study. This is due to many buildings, including residential buildings and water treatment facilitations located Willow Creek being at risk from flood hazards. Additionally, The Willow	City of Heppner, DOGAMI, USACE	-	FMA; HMGP; BRIC	Low/ Medium	Short-Term (0 to 2 years)

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
		Creek dam, if breached, would severely impact the communities of Heppner, Ione, and Lexington.					
Ione							
IO-MH-1	Consider developing a mass care capability for extreme heat and wildfire smoke.	This would be developed in order to address issues caused by extreme weather events and would assist in providing quality of aid.	City of Ione	-	HMGP; BRIC; HMGP Post Fire; Smoke Management-Community Response Plan Grant (DEQ)	Low/ Medium	Medium-Term (2-5 years)
IO-DR-2	Implement and maintain backup power sources needed for water.	In winter, the currently available 700k gallon tank is a one-week supply. In summer, an irrigation order would be used (Emergency Well Shut Down Plan). This backup power for water is extremely important to the community, especially in regard to the economic impact. For example, participants in the NHMP update noted that in 2023 the Water Master turned off many water rights throughout the community. This resulted in economic impacts, notable alfalfa crop irrigation.	City of Ione	High	HMGP; BRIC (FEMA); Rural Development Assistance – Utilities (USDA)	High	Medium-Term (2-5 years)
IO-FL-1	Education/ Training of FEMA requirements	There is a lack of knowledge in Ione concerning what is required and how/if/when anyone can develop, remodel, etc./ in the floodway and floodplain. To improve knowledge, trainings can be conducted for city officials, as well as review Ione's	City of Ione Floodplain Manager/ DLCD NFIP Coordinator	High	HMGP	Low	Ongoing

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
		Flood Plain Overlay Zone, and update Ione's Comp Plan to reflect new FP maps.					
IO-FL-2	Improve drainage in Reitman and Lorraine Canyons, resulting in automatically operated drainage, as opposed to manually operated haphazard pumps and hoses	Ione has no flood control mitigation for drainage from Reitman and Lorraine Canyons except for a "ditch" and a pump and hose system operated by passersby during an event. These areas, which have a mixture of uses, including residential, businesses, and undeveloped land, all experience flooding. Currently, the county road acts as a dam. There is a need to have an excavator to get this work done and keep this drainage open. Improvising the drainage system will take time and require working with County Public Works Dept to allow drainage under/over County road, and allow drainage to operate automatically, without the need for haphazard pumps and hoses.	Ione and Morrow County Planning and Public Works Departments	High	FMA; HMGP; BRIC	Medium/ High	Medium-Term (2-5 years)
IO-FL-3	Continue to meet Floodplain Management requirements by adhering to the City Flood Damage Prevention Ordinance #3-2007	No specific needs, existing MOUs with Morrow County and an IGA with the City of Boardman.	Morrow County Planning Department/ FEMA	High	FMA; City Budget	Medium ($100,000 to $500,000)	Ongoing
Irrigon							

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
IR-MH-1	Pursue establishing a collaboration with USACE regarding the risk management of undeveloped land east of Irrigon Marina owned by the USACE.	There is undeveloped land near the Irrigon Marina that is owned by the US Army Corps of Engineers. The land is primarily shrubs and herbaceous vegetation posing as a wildfire risk to Irrigon further exacerbated by drought. There is potential to collaborate with the USACE to manage/develop the land in a way that reduces wildfire risk. Currently, ACOE is the absentee landowners, while IRFPD provides structure protection.	City of Irrigon' s Planning Department	Medium	HMGP; HMGP Post Fire; BRIC	Medium/ High	Long-Term; Ongoing
IR-MH-2	Provide emergency information dissemination broadcasting.	Loss of power and ineffective communication during one or more emergencies is a concern for the city, as they would not be able to safely and effectively communicate with the public to reduce risk(s) in such events. This can be addressed by installing an electronic public reader board along NE Division St., which is viewable from Highway 730, and that is linked to city hall power supply (system generator). On-going service announcements and emergency broadcasting during emergencies due to loss of power would be maintained, and City Hall would function as the EOC (Emergency Operations Center) for Irrigon community.	City of Irrigon Port of Morrow, Morrow County, State, and Federal resource agencies	Medium	HMGP; HMGP Post Fire; BRIC	Medium/ High $35,000	Ongoing

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
IR-DR-1	Provide emergency backup power for Wells 3 and 4.	Secure and maintain a minimum 40 KW portable generator to run well systems during outages.	City of Irrigon; Partner with FEMA	High	HMGP; BRIC; FMA; Rural Development Assistance – Utilities (USDA)	Medium/ High $60k - $75K	Medium-Term (2-5 years)
IR-DR-2	Identify and secure additional water source.	Loss of primary water sources prior to and during one or more emergencies is a significant concern, as emergencies would not be able to be adequately prepared for and/or responded to. Additional water sources can help ensure that community needs are better met, and overall community capacity and resilience increases due to redundant water sources and resources are available.	City of Irrigon, Public Works	High	HMGP; BRIC; FMA; Rural Development Assistance – Utilities (USDA)	High $1.5M - $5M	Long-Term (5+ years)
IR-SW-1	Provide emergency backup power for Community Warming/Cooling Station #3	Multiple emergencies necessitate the use of warming/cooling (holding) area for residents, with a potential gathering area at Stokes Landing Senior Center. This would require a generator to be acquired to ensure backup power is available in the event of a power outage. These centers would continually operate during such event(s)/emergency. Secure a back-up generator (40 KW or larger) to run and maintain systems during such emergency.	Senior Center, City, County	Medium	HMGP; BRIC; FMA; Rural Development Assistance – Utilities (USDA)	Medium/ High $100,000	Medium-Term (2-5 years)
Lexington							

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
LX-MH-1	Obtain emergency generators for critical facilities.	Lexington is entirely dependent on electrical power in order to operate its water-well pump, which is the sole source of drinking water for the Town and its critical facility (Fire Department) functions. In the event of an emergency, generators would be needed to power communications at Town Hall and support shelter/mass care response (A project that currently is on schedule).	Lexington Town Council; State and/or Federal Resource Agency	High	HMGP; BRIC; Rural Development Assistance – Utilities (USDA)	Medium/ High	Short-Term (0 to 2 years)
LX-DR-1	Implement the Lexington water and sewer feasibility study.	The community is actively working with consultants to implement this action item. The Town of Lexington holds water rights to a second well. The water and sewer feasibility study is planned to be wrapped up in winter 2024. Next steps would be to determine/acquire locations for the second well.	Lexington	-	HMGP; BRIC	Low/ Medium	Short-Term (0 to 2 years)
LX-DR-2	Obtain Technical Assistance to update the Hazards Section of Town Comprehensive Plan and Zoning Ordinances.	Currently the Town of Lexington has no Hazards section included in its Comprehensive Plan, and does not have the staff with the technical training and skills to accomplish an update that will comply with state standards. Furthermore the city does not have the funds with which to obtain professional assistance. • Plan to work to obtain model plan updates, either from the state or from comparable cities which have incorporated such updates into their Plan.	Lexington Town Council/ DOGAMI, DLCD, ODEM, Morrow County	High	HMGP; BRIC; Oregon DOT/DLCD Transportation and Growth Management Grant program (Quick Response), DLCD Technical Assistance grants.	Low/ Medium	Medium-Term (2-5 years)

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
		• Make necessary adjustments specific to Lexington circumstances and needs using existing staff and volunteer services to accomplish these changes. • Seek funding to pay for professional services to review the Plan and modify as necessary to comply with mandatory standards.					
LX-FL-1	Creek channels cleared/ maintain flood dike.	Blackhorse Canyon is a dry bed and never has any water. Black Horse is likely the channel that needs to be treated. Actions would include keeping Willow Creek Channel and Blackhorse Channel clear of weeds and debris, maintaining the strength and height of ditch ("dike") on Blackhorse flow way.	Lexington Town Council; Umatilla/Morrow Community Connections, Two Rivers Work Crew, Corps of Engineers	Medium	FMA; HMGP; BRIC	Medium ($100,000 to $500,000)	Medium-Term (2-5 years)
LX-FL-2	Improve drainage on C Street	C Street lies at the lowest elevation in town and regularly accumulates significant water from storm run-off and flood events. Improved drainage combined with re-surfacing of the street will facilitate east-west travel through town during emergency events and decrease the potential for traffic hazards at the intersection of C Street and Highway 74. Apply for grant monies to accomplish the project and arrange for local match through a	Lexington Public Works	-	FMA; General Funds; potential bond	Medium ($100,000 to $500,000)	Short-Term (0 to 2 years)

2024 Action ID	Action Item	Description	Lead/ Partners	Priority	Potential Funding Source	Estimated Cost	Timeline
		combination of donated cash and general fund revenue (and bond?).					
LX-FL-3	Improve drainage on town streets	Storm water run-off backs up at culverts on C Street, East Street, F Street, Water Street, and Arcade Street in locations that threaten to spill over intersections with State highways or onto private property. This will be addressed by establishing a schedule for clearing the culverts, and assessing existing culverts to determine if a larger size is necessary to prevent clogging.	Lexington Public Works/Oregon Dept. of Transportation	-	FMA	Medium ($100,000 to $500,000)	Short-Term (0 to 2 years)
Morrow County Health District (MCHD)							
HD-MH-1	Backup power supplies for hospital and clinics	Redundant power sources are essential, especially when vulnerable power sources are affected due to a natural hazard, and such vulnerable power sources are providing power to critical community facilities.	MCHD/ Utility companies, Morrow County Planning Department	High	HMGP; HMGP Post Fire; BRIC	High	Short-Term (0 to 2 years)
HD-MH-2	Develop a plan for medically fragile community members during power outages.	Medically fragile and vulnerable populations are more vulnerable to natural disasters, such as those who live at home and are reliant on equipment powered by electricity – CPAPs, for example. Develop a plan to ensure that vital equipment remains powered by ensuring that reliable energy sources are maintained and prioritized for vulnerable people.	MCHD/ Utility Companies, Morrow County Planning Department	High	HMGP; BRIC; Community Grant - Technical Assistance (DLCD)	Low/ Medium	Short-Term (0 to 2 years)

C. Integration

To achieve risk reduction, it is necessary to consider natural hazards mitigation in jurisdictional planning processes, from land use to infrastructure to emergency response. Every advance in mitigation reduces impact, by decreasing the need for response and recovery and by increasing resilience.

Each jurisdiction engages in comprehensive planning and other processes that support hazard mitigation. Each jurisdiction in Morrow County develops an annual budget and a capital improvement budget, capital facilities plans, public works long term plans, and, environmental planning for parks and recreational properties. It is through these community planning processes that the mitigation actions are intended to be integrated. During the annual planning processes that originate with the budget, each jurisdiction considers what mitigation work can be considered and accomplished by integrating mitigation work into current planning mechanisms. All the jurisdictions in Morrow County emphasize improving public and place emphasis on integrating hazard mitigation into planning processes that promote co-benefits through current planning activities. Some jurisdictions see the value of integrating the NHMP into the Comprehensive Plan as a way to implement Goal 7 of the Oregon Land Use Planning Goals. A list of the mechanisms into which Morrow County jurisdictions can integrate hazard mitigation activities is provided in Section II under Political Capacity Profile.

Mitigation has become an integral part of the county's and cities' considerations in their planning and operations. Steering Committee members will be responsible for communicating the importance and necessity of integrating mitigation goals, objectives, and actions into the everyday business of the jurisdiction to those within their individual organizational structures responsible for developing and implementing the various planning and operations documents and processes. Steering Committee members will also engage in those planning and operations processes to the extent necessary and appropriate to ensure that mitigation goals, objectives, and actions are duly considered and incorporated as applicable and feasible.

DLCD has committed to assisting the jurisdictions with integration of the updated, FEMA-approved NHMP into comprehensive plans and other planning and operations processes and documents. The process for this endeavor may be discussed with each participating jurisdiction after this updated NHMP is approved.

D. Mitigation Activities and Resources

Mitigation through either regulatory or non-regulatory, voluntary strategies allow communities to gain cooperation, educate the public and provide solutions to ensure safety in the event of a natural disaster, according to the *Planning for Natural Hazards: Oregon Technical Resource Guide*. Beyond the planning and other processes available for integration, each jurisdiction has a variety of tools, assets, and resources available for implementing natural hazards mitigation. Many are the same or similar among the jurisdictions.

Many jurisdictions report limits to capacity due to small staff size or understaffing or difficult financial circumstances. Even so, the long experience of Morrow County and city staff with natural disasters elevates their individual and collective commitment to mitigation. Their mitigation strategies ground their visions and aspirations, demonstrating that they will use and leverage the tools, assets, and resources available to them as fully as possible to advance mitigation. City and county representatives identified focusing on improving communication and supporting their first responders as a high priority.

Integration of the NHMP into the Comprehensive Plan is another method of implementing the NHMP. The mechanism for integration is usually through consultation of experts with the elected board or commission to educate them about integrating new natural hazard data into zoning and development codes. Local jurisdictions must often rely on assistance and collaboration with other government agencies (local, state, or federal), or community-based organizations to implement these activities.

The following are mitigation programs and activities that are being implemented by city, county, regional, state, or federal agencies and organizations. Formerly provided as a directory in the 2016 NHMP it includes key publications and additional resources. The Community Service Center's Oregon Natural Hazards Workgroup at the University of Oregon Natural Hazards Workgroup at the University of Oregon developed the appendix which has been folded into Volume I of the NHMP during this update.

These activities and resources are categorized by hazard, as identified in the *2024 Morrow County MJNHMP*. In addition to what is identified here, the Grants appendix (Volume II: Appendix D), provides a comprehensive list of other mitigation resources.

Federal Resources

Multi-Hazard

Federal Emergency Management Agency

FEMA recommends preparing the home and the person for natural hazard events. (https://www.ready.gov/).

FEMA also recommends having a safe room in homes or small businesses to prevent residents and workers from "dangerous forces" of extreme winds to avoid injury or death. (https://www.fema.gov/fema-p-320-taking-shelter-storm-building-safe-room-your-home-or-small-business

National Oceanic and Atmospheric Administration

According to the NOAA National Severe Storms Laboratory, severe weather and storms use a variety of tools to forecast weather and storms. The National Severe Storms Laboratory is a major contributor to the scientific and engineering development of dual-polarized weather radar, which is now installed on the NWS weather radars. Dual-polarization radar can clearly identify rain, hail, snow, or ice pellets inside the clouds. In addition to observing a wide network of satellites, Doppler radars and automated surface observing systems, forecasters use their experience, together with computer forecast models to write and issue forecasts on what will happen next regarding weather and storms.

National Weather Service

The Portland Office of the National Weather Service issues severe winter storm watches and warnings when appropriate to alert government agencies and the public of possible or impending weather events. Four NWS offices cover Oregon: Portland (NW), Medford (SW), Pendleton (NE), and Boise (East and SE).

The watches and warnings are broadcast over NOAA weather radio and are forwarded to the local news media for retransmission using the Emergency Alert System.

The Oregon landslide warning system as developed in direct coordination with the Portland NWS office and state agencies (Burns et al., 2021), such as DOGAMI.

Hazard Mitigation Grant Program

Following a major disaster declaration, the FEMA Hazard Mitigation Grant Program provides funding for long-term hazard mitigation projects and activities to reduce the possibility of damages from all future fire hazards and to reduce the costs to the nation for responding to and recovering from the disaster.

Drought

NOAA National Integrated Drought Information System

The National Integrated Drought Information System (NIDIS) program was authorized by Congress in 2006 (Public Law 109-430) and reauthorized in 2014 and 2019 with an interagency mandate to coordinate and integrate drought research, building upon existing federal, tribal, state, and local partnerships in support of creating a national drought early warning information system to make climate and drought science accessible and useful for decision makers and stakeholders.

Earthquake

USGS National Earthquake Information Center

The USGS National Earthquake Information Center (NEIC) operates a 24-hour-a-day service to determine the location and magnitude of significant earthquakes in the United States and around the world as rapidly and accurately as possible. This information is communicated to federal and state government agencies who are responsible for emergency response, to government public information channels, to national and international news media, to scientific groups (including groups planning aftershock studies), and to private citizens who request information. The NEIC issues rapid reports for those earthquakes with magnitudes at least 3.0 in the eastern United States and 3.0 in the western United States.

In addition, the USGS ShakeAlert Earthquake Early Warning System detects earthquakes quickly so alerts can be delivered to people before they feel shaking. ShakeAlert is a warning system for the west coast of the United States and can be directly integrated into healthcare facility communication and control systems, such as intercoms, to warn people and protect patients and staff. ShakeAlert does not predict earthquakes, rather it detects an earthquake moments after it begins, so that alerts can be sent to people in the affected area. Because information travels faster than earthquake waves, alerts can reach people quickly, even before they begin to feel shaking. ShakeAlert can be enabled on most cell phones.

FEMA and National Earthquake Hazards Reduction Program

FEMA administers several grant programs intended to reduce the risks to people and property posed by earthquakes. Although FEMA's programs are not dedicated exclusively to earthquakes, they can be valuable sources of funding for risk reduction efforts targeting earthquakes or earthquakes and other hazards at state or local levels.

The National Earthquake Hazards Reduction Program (NEHRP) leads the federal government's efforts to reduce the fatalities, injuries and property losses caused by earthquakes. The NEHRP is a coordination of complementary activities between these four federal agencies Federal Emergency Management Agency (FEMA), National Institute of Standards and Technology (NIST), National Science Foundation (NSF), and U.S. Geological Survey (USGS).

NEHRP also partners with state and local governments, universities, research centers, professional societies and trade associations and businesses.
FEMA's National Earthquake Hazards Reduction Program (NEHRP) Earthquake State Assistance Grant Program was created to increase and enhance the effective implementation of earthquake risk reduction at the local level. NEHRP has two separate funding opportunities: Individual State Earthquake Assistance and Multi-State and National Earthquake Assistance funding opportunities, both of which are designed to increase and enhance the effective implementation of earthquake risk reduction at the national, state and local level.

Extreme Heat

National Oceanic and Atmospheric Administration

As part of the interagency National Integrated Heat Health Information System, NOAA launched Heat.gov in 2022, which is a website that provides clear, timely, and science-based information to understand and reduce the health risks of extreme heat. Heat.gov is intended for the public, decision-makers, and news media. This website provides real time updates regarding the percentage of the country that is under extreme heat advisories, watches, and warnings. The information provided on the website includes heat forecasts from NOAA's National Weather Service, Department of Health and Human Services monthly Climate and Health Outlook, and CDC's Heat and Health Tracker.

Regarding heat monitoring and forecasting, NOAA issues outlooks for excessive heat 8-14 days, as well as 3-7 days in advance and provides hourly forecasts, advisories, watches and warnings when dangerous heat becomes likely or imminent.

Flood

National Flood Insurance Program

The National Flood Insurance Program, Flood Insurance Rate Maps, Flood Insurance Study, and the Community Rating System are discussed in the Risk Assessment (Volume I: Section 3) under the Flood hazard. In addition to the NFIP and associated programs, the following are flood-related federal resources.

National Resources Conservation Service

The NRCS provides a suite of federal programs designed to assist state and local governments and landowners in mitigating the impacts of flood events. The Watershed Surveys and Planning Program and the Small Watershed Program provide technical and financial assistance to help participants solve natural resource and related economic problems on a watershed basis. The Wetlands Reserve Program and the Flood Risk Reduction Program provide financial incentives to landowners to put aside land that is either a wetland resource or that experiences frequent flooding. The Emergency Watershed Protection Program (EWP) provides technical and financial assistance to clearing debris from clogged waterways, restoring vegetation, and stabilizing riverbanks. The measures taken under EWP must be environmentally and economically sound and generally benefit more than one property.

Federal Emergency Management Agency Programs

FEMA resulted from the consolidation of five federal agencies that dealt with different types of emergencies. FEMA provides maps of flood hazard areas, various publications related to flood mitigation, funding for flood mitigation projects, and technical assistance. More information can be found in the Risk Assessment under the Flood hazard.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) plays a major role in a coordinated and complex system to reduce flood risks and provide water for hydropower generation, fish and wildlife enhancement, navigation, recreation, and other uses. Portland District's primary water management mission is to save lives and reduce property damage by reducing flood risks with measures both structural (such as dams) and non- structural (such as improving the natural function of floodplains).

Landslide

National Resources Conservation Service

The NRCS provides a suite of federal programs designed to assist state and local governments and landowners in mitigating the impacts of flood events. Since flood events can trigger landslide events, the NRCS programs provide a nexus. The Watershed Surveys and Planning Program and the Small Watershed Program provide technical and financial assistance to help participants solve natural resource and related economic problems on a watershed basis. The Wetlands Reserve Program and the Flood Risk Reduction Program provide financial incentives to landowners to put aside land that is either a wetland resource or that experiences frequent flooding. The Emergency Watershed Protection Program provides technical and financial assistance to clearing debris from clogged waterways, restoring vegetation, and stabilizing riverbanks. The measures taken under EWP must be environmentally and economically sound and benefit more than one property.

Volcano

U.S. Geological Survey

A major existing strategy to address volcanic hazards is to publicize and distribute volcanic hazard maps and information through USGS and state agencies, such as DOGAMI.

The volcanoes most likely to constitute a hazard to Oregon communities have been the subject of USGS research. Open-file reports address the geologic history of these volcanoes and lesser-known volcanoes in their immediate vicinity. These reports also cover associated hazards, the geographic extent of impacts, and mitigation strategies. They are available for the active volcanoes such as Mount St. Helens, the Three Sisters, Newberry Volcano, and Crater Lake. While there is not an Open-file reports for Mount Bachelor, there are other resource materials that provide considerable information.

Of note, after the 1980 eruption of Mount St. Helens, Congress provided increased funding that enabled the USGS to establish a volcano observatory for the Cascade Range. Located in Vancouver, Washington, the David A. Johnston Cascades Volcano Observatory was named for a USGS scientist killed at a forward observation post by the May 18, 1980, eruption (https://pubs.usgs.gov/fs/1997/fs165-97/fs165-97.pdf).

For more information, please refer to USGS at https://www.usgs.gov/programs/VHP.

Wildfire

The proposed role of the federal land managing agencies, such as the U.S. Forest Service and the Bureau of Land Management, in the wildland/urban interface is diverse. Their roles include reducing fuel hazards on the lands they administer; cooperating in prevention and education programs; providing technical and financial assistance; and developing agreements, partnerships, and relationships with property owners, local protection agencies, states, and other stakeholders in wildland/urban interface areas. These relationships focus on activities before a fire occurs, which render structures and communities safer and better able to survive a fire.

For more information, refer to the joint USDI and USDA site, *Forest and Rangelands* at https://www.forestsandrangelands.gov/.

Federal Emergency Management Agency Programs

FEMA is directly responsible for providing fire suppression assistance grants and, in certain cases, major disaster assistance and hazard mitigation grants in response to fires. The role of FEMA in the wildland/urban interface is to encourage comprehensive disaster preparedness plans and programs, increase the capability of state and local governments, and provide for a greater understanding of FEMA's programs at the federal, state, and local levels.

Fire Suppression Assistance Grants

FEMA's Fire Suppression Assistance Grants may be provided to a state only if the state has an approved hazard mitigation plan for the suppression of a forest or grassland fire that threatens to become a major disaster on public or private lands. These grants are provided to protect life and improved property, encourage the development and implementation of viable multi-hazard mitigation measures, and provide training to clarify FEMA's programs.

The grant may include funds for equipment, supplies, and personnel. A Fire Suppression Assistance Grant is the form of assistance most often provided by FEMA to a state for a fire. The grants are cost-shared with states. Once the federal grant money is provided to the state, it is passed along to local jurisdictions. This money would be passed along to Morrow County to be applied to projects. The U.S. Fire Administration (USFA) provides public education materials addressing wildland/urban interface issues, and the USFA's National Fire Academy provides training programs.

National Wildland/Urban Interface Fire Protection Program

Federal agencies can use the National Wildland/Urban Interface Fire Protection Program to focus on wildland/urban interface fire protection issues and actions. The Western Governors' Association can act as a catalyst to involve state agencies, as well as local and private stakeholders, with the objective of developing an implementation plan to achieve a uniform, integrated national approach to hazard and risk assessment and fire prevention and protection in the wildland/urban interface. The program helps states develop viable and comprehensive wildland fire mitigation plans and performance-based partnerships.

U.S. Forest Service

The U.S. Forest Service (USFS) implements a fuel-loading program to assess fuels and reduce hazardous buildup on federal forestlands.

The USFS has a fuel-loading program to assess fuels and reduce hazardous buildup on U.S. forestlands. The USFS is a cooperating agency and, it has an interest in preventing fires in the WUI, as fires often burn up the hills and into the higher elevation U.S. forestlands.

According to USFS *Wildland Fire* website, the USFS and other federal, tribal, state, and local government agencies work together to respond to tens of thousands of wildfires annually. Each year, an average of more than 73,000 wildfires burn approximately 7 million acres of federal, tribal, state, and private land and more than 2,600 structures.

The USFS recognizes the wildland fire management environment has profoundly changed. Longer fire seasons, bigger fires and more acres burned on average each year, more extreme fire behavior, and wildfire suppression operations in the WUI have become the norm. To address the challenges, the USFS and its federal, tribal, state, and local partners have developed and are implementing a *National Cohesive Wildland Fire Management Strategy* that has three key components: Resilient Landscapes, Fire Adapted Communities, and Safe and Effective Wildfire Response.

For more information, refer to https://www.fs.fed.us/managing-land/fire.

Bureau of Land Management (BLM)

The Bureau of Land Management (BLM) is responsible for "managing public lands for a variety of uses such as energy development, livestock grazing, recreation, and timber harvesting while ensuring natural, cultural, and historic resources are maintained for present and future use." According to their website, the BLM manages 1/10 of the nation's surface area and 30% of the nation's mineral and soils (https://www.blm.gov/about/our-mission).

In Oregon, BLM is responsible for fire protection for all federal agencies. They also provide fire protection on Oregon Department of State Lands (DSL) land and on some Oregon State Parks' lands. BLM has a memorandum of agreement with Oregon to provide support to the Rangeland Fire Protection Associations (RFPA) (Crouch, 2019).

There is a program through the BLM, called the Rural Fire Readiness Program. It's a separate cooperative agreement that a RFPA can sign with BLM; it removes them from the statewide memorandum of agreement with Oregon. The cooperative agreement provides more money to the RFPAs for training and equipment (Crouch, 2019). See the descriptions of Rangeland Fire Protection Associations, ODF, and the US Forest Service for additional information.

Firewise

Firewise is a program developed within the National Wildland/Urban Interface Fire Protection Program and is the primary federal program addressing interface fire. It is administered through the National Wildfire Coordinating Group whose extensive list of participants includes a wide range of federal agencies. The program is intended to empower local planners and decision makers. Through conferences and information dissemination, Firewise increases support for interface wildfire mitigation by educating professionals and the public about hazard evaluation and policy implementation techniques.

Firewise offers online wildfire protection information and checklists, as well as listings of other publications, videos, and conferences. The interactive home page allows users to ask fire protection experts questions, and to register for new information as it becomes available.

For more information on the Firewise program, contact Wildland/Urban Interface Fire Program C/o The National Fire Protection Association 1 Batterymarch Park, Quincy, MA 02269 and http://www.firewise.org.

FireFree Program

FireFree is a unique private/public program for interface wildfire mitigation involving partnerships among an insurance company and local government agencies. It is an example of an effective non-regulatory approach to hazard mitigation. Originating in Bend, Oregon the program was developed in response to that city's Skeleton Fire of 1996, which burned over 17,000 acres and damaged or destroyed 30 homes and other structures. Bend sought to create a new kind of public education initiative that emphasized local involvement. SAFECO Insurance Corporation was a willing collaborator in this effort.

The success of the program helped to secure $300,000 in FEMA "Project Impact" matching funds. By fostering local community involvement, FireFree also has the potential for building support for sound interface wildfire policy. For information on FireFree, contact: SAFECO Plaza T-8, Seattle, WA 98185, (206) 545-6188 https://www.firefree.org/

State Resources

Multi-Hazard

Statewide Planning Goals

There are 19 Statewide Planning Goals that guide land use in the State of Oregon. These became law via Senate Bill 100 in 1973. Goal 7, Areas Subject to Natural Disasters and Hazards, requires local governments to identify hazards and adopt appropriate safeguards for land use and development. Goal 7 advocates the continuous incorporation of hazard information in local land use plans and policies. The jurisdiction participating in this *2024 Morrow County Multi-Jurisdictional NHMP* has approved comprehensive plans that include information pertinent to Goal 7.
https://www.oregon.gov/lcd/OP/Pages/Goals.aspx

Oregon Department of Emergency Management

OEM is involved in many programs that mitigate the effects of natural hazards including the Hazard Mitigation Grant Program, co-sponsoring and participating in training workshops. Also, as part of its warning responsibilities, OEM notifies local public safety agencies and keeps them informed of potential and actual hazard events so prevention and mitigation actions can be taken.

Planning for Natural Hazards: Oregon Technical Resource Guide

This guide describes basic mitigation strategies and resources related to coastal hazards, floods, and other natural hazards, including examples from communities in Oregon.
https://scholarsbank.uoregon.edu/xmlui/handle/1794/1909

Oregon Department of Transportation

Oregon Department of Transportation (ODOT) travel information site, TripCheck, provides road conditions, weather information, and travel information. This website also provides information to help the public detour away from hazard areas during times of emergency. The TripCheck link also has road camera images to inform the public of road conditions prior to making a trip. https://tripcheck.com/

State Natural Hazard Risk Assessment

The risk assessment in the *2020 Oregon Natural Hazards Mitigation Plan* provides an overview of all the identified natural hazards in Oregon (in the State NHMP but not necessarily all the locally identified natural hazards) and identifies the most significant hazards in Oregon's recorded history. It has overall state and regional information and includes mitigation actions for the entire state. https://www.oregon.gov/lcd/NH/Documents/Approved_2020ORNHMP_00_Complete.pdf

Oregon State Building Code Standards

The Oregon's Building Codes Division adopts statewide standards for building construction that are administered by the state, cities and counties throughout Oregon. The codes apply to new construction and to the alteration of, or addition to, existing structures. The following are hazard-specific standards:

- Six levels of design and engineering specifications that are applied to areas according to the expected degree of ground motion and site conditions that a given area could experience during an earthquake. There are site-specific seismic hazard reports required for projects involving critical facilities and special occupancy structures. The Dwelling Code incorporates prescriptive requirements for foundation reinforcement and framing connections based on the applicable seismic zone for the area.
- Building Codes standards (both residential and other codes) are set to withstand 80 mph winds.
- Building Codes standards (both residential and other codes) are set to withstand specific snow loads.
- Building Code standards for structures within the floodplain and in landslide areas.

Local building officials are responsible for enforcing these codes. Although there is no statewide building code for substandard structures, local communities have the option of adopting a local building code to mitigate hazards in existing buildings. Oregon Revised Statutes allow municipalities to create local programs to require seismic retrofitting of existing buildings within their communities. The building codes do not regulate public utilities or facilities constructed in public right-of-way, such as bridges.

The 2017 *Oregon Residential Special Code* (*ORSC*) contains requirements for one- and two-family dwellings (https://codes.iccsafe.org/content/document/1018?site_type=public).

The *2019 Oregon Structural Special Code* (*OSSC*) contains provisions for grading and site preparation for the construction of building foundations (https://codes.iccsafe.org/content/OSSC2019P1).

Roadway Maintenance

ODOT is responsible for performing precautionary measures to maintain the safety and operability of major roads during storm conditions. The road maintenance programs are designed to provide the best use of limited resources to maximize the movement of traffic within the community during inclement weather.

During storm events, most agencies at the county and city level focus on clearing major arterial and collector streets first, and then respond to residential connector streets, school zones, transit routes, and steep residential streets as resources become available. The state, counties, and cities, may have agreements, including mutual aid agreements, about road maintenance responsibilities during day-to-day operations and who does what in storm situations. In general, highways receive more attention. For those routes on the National Highway System network, primary interstate expressways, and primary roadways will be cleared more quickly and completely than other roads.

Drought

Water Supply Availability Committee and Drought Readiness Council

Oregon Revised Statute (ORS) Chapter 536 identifies authorities available during a drought. To trigger specific actions from the Water Resources Commission and the Governor, a “severe and continuing drought” must exist or be likely to exist. Oregon relies upon two interagency groups to evaluate water supply conditions, and to help assess and communicate potential drought related impacts, the Water Supply Availability Committee and the Drought Readiness Council.

The Water Supply Availability Committee (WSAC) is a technical committee chaired by the Oregon Water Resources Department (OWRD). The WSAC provides the scientific foundation that decision-makers need to identify and respond appropriately to drought. The Committee consists of state and federal science and emergency preparedness agencies.

The WSAC meets early and often throughout the year to evaluate the potential for drought conditions. If drought development is likely, monthly meetings occur shortly after release of NRCS Water Supply Outlook reports for that year (second week of the month beginning as early as January) to assess conditions. The following are indicators used by the WSAC for evaluating drought conditions as identified in the OEM *Comprehensive Emergency Management Plan, Incident Annex 01 Drought*:

- Snowpack
- Precipitation
- Temperature anomalies
- Long range temperature outlook
- Long range precipitation outlook
- Current stream flows and behavior
- Spring and summer streamflow forecasts
- Ocean surface temperature anomalies (El Nino, La Nina)
- Storage in key reservoirs
- Soil and fuel moisture conditions
- NRCS Surface Water Supply Index

The other group that Oregon relies upon to evaluate water conditions is the Drought Readiness Council (DRC), which is co-chaired by the OWRD and OEM. The council consists of state agencies with natural resources management, public health, or emergency management expertise. The role of the DRC is to review local requests for assistance and make recommendations to the Governor regarding the need for state drought declarations.

Earthquake

Business Oregon, Infrastructure Finance Authority

Business Oregon's Infrastructure Finance Authority supports the Seismic Rehabilitation Grant Program (SRGP). This program is a State of Oregon competitive grant program that provides funding for the seismic rehabilitation of critical public buildings, particularly public schools and emergency services facilities. Public K-12 school districts, community colleges, and education service districts are eligible for the grant program. For emergency services facilities, the emphasis is on first responder buildings. This includes hospital buildings with acute inpatient care facilities, fire stations, police stations, sheriff's offices, 9-1-1 centers, and Emergency Operations Centers (EOCs).

Oregon Department of Emergency Management

September is National Preparedness Month, a time to raise awareness about preparing for disasters and emergencies before they happen. In addition, the Great Oregon ShakeOut occurs in October. OEM coordinates activities such as earthquake drills related to Great Oregon ShakeOut and encourages individuals to prepare for earthquakes by strapping down computers, heavy furniture and bookshelves in homes and offices.

Extreme Heat

Oregon Health Authority

Heat-related deaths and illness are preventable, yet annually many people succumb to extreme heat. The Oregon Health Authority (OHA) website provides accessible resources for members of the public, local health departments, and other organizations to assist ongoing outreach efforts to those most vulnerable to extreme heat events.

Flood

Oregon Water Resources Department

The OWRD is the state authority for dam safety with specific authorizing laws and implementing regulations. OWRD coordinates on but does not directly regulate the safety of dams owned by the United States or most dams used to generate hydropower. The OWRD has been striving to inspect the over 900 dams under its authority. The Dam Safety Program meets the minimum FEMA standard for Emergency Action Plans and sometimes exceeds FEMA guidance for dam safety inspections on schedule and for condition classification.

OWRD is the Oregon Emergency Response System contact in the event of a major emergency involving a state-regulated dam, or any dam in the State if the regulating agency is unknown. The Dam Safety Program also coordinates with the National Weather Service and the OEM on severe flood potential that could affect dams and other infrastructure.

State of Oregon Removal/Fill Law

The Oregon Removal/Fill Law, which is administered by the Oregon Department of State Lands (DSL), requires a permit for activities that would remove or fill 50 cubic yards or more of material in waters of the state (e.g., streams, lakes, wetlands).

Oregon’s Wetlands Protection Program

Oregon’s Wetlands Protection Program was created in 1989 to integrate federal and state rules concerning wetlands protection with the Oregon Land Use Planning Program. The Wetlands Program has a mandate to work closely with local governments and DSL to improve land use planning approaches to wetlands conservation. A local wetlands inventory is one component of that program. DSL also develops technical manuals, conducts wetlands workshops for planners, provides grant funds for wetlands planning, and works directly with local governments on wetlands planning tasks.

Silver Jackets

The Silver Jackets program is a joint state-federal-local flood mitigation subcommittee, which is tied to a national USACE initiative. In Oregon, Silver Jackets provides a forum where DLCD, DOGAMI, OEM, USACE, FEMA, U.S. Geological Survey (USGS), and additional federal, state and sometimes local and Tribal agencies can come together to collaboratively plan and implement flood mitigation, optimizing multi-agency utilization of federal assistance by leveraging state/ local/ Tribal resources, including data/ information, talent and funding, and preventing duplication among agencies.

Oregon established Silver Jackets as a subcommittee to the Interagency Hazard Mitigation Team (IHMT), with the primary intents of strengthening interagency relationships and cooperation, optimizing resources, and improving risk communication and messaging. The Oregon Silver Jackets act as a catalyst in developing comprehensive and sustainable solutions to state flood hazard challenges.

For more information regarding the Oregon Silver Jackets, refer to https://www.iwr.usace.army.mil/Silver-Jackets/State-Teams/Oregon/.

Landslide

Oregon Department of Geology and Mineral Industries

Regarding current landslide warning system in Oregon, DOGAMI’s *History of Oregon Landslide Warning System* (2021) states,

> The current landslide warning system developed over years with additions and modifications to the language and changes to system responsibilities. As of 2019, a notice about the potential for landslides or debris flows starts with NWS, by using unique language in their flood watch products. After receiving NWS flood watches with landslide language via an RSS feed, DOGAMI posts on its website an alert message including a link to the NWS flood watch message, sends out a press release to the affected areas, and responds to media inquiries. OEM broadcasts the alert through the Oregon Emergency Response System (OERS). ODOT turns on highway warning signs at the appropriate locations and posts alerts on the TripCheck website (https://tripcheck.com/) The current process was outlined in a June 2018 DOGAMI internal communication document on landslide/debris flow alerts, developed by Bill Burns and then DOGAMI Communications Director Ali Hansen.

Volcano

Oregon Department of Geology and Mineral Industries

A major existing strategy to address volcanic hazards is to publicize and distribute volcanic hazard maps and information through DOGAMI and USGS, as discussed above.

The volcanoes most likely to constitute a hazard to Oregon communities have been the subject of DOGAMI and USGS research. Open-file reports address the geologic history of these volcanoes and lesser-known volcanoes in their immediate vicinity. These reports also cover associated hazards, the geographic extent of impacts, and mitigation strategies. They are available for the active volcanoes such as Mount St. Helens, the Three Sisters, Newberry Volcano, and Crater Lake. While there is not an Open-file reports for Mount Bachelor, there are other resource materials that provide considerable information.

For more information, refer to DOGAMI at https://www.oregongeology.org/volcano/volcanoes.htm.

Wildfire

Oregon Revised Statute 215.730

ORS 215.730, Additional Criteria for Forestland Dwellings, provides criteria for approving dwellings located on lands zoned for forest and mixed agriculture/forest use. Under its provisions, county governments must require, as a condition of approval, that single-family dwellings on lands zoned as forestland meet the following requirements:

1. Dwelling has a fire retardant roof;
2. Dwelling will not be sited on a slope of greater than 40 %;
3. Evidence is provided that the domestic water supply is from a source authorized by OWRD and not from a Class II stream as designated by the State Board of Forestry;
4. Dwelling is located upon a parcel within a fire protection district or is provided with residential fire protection by contract;
5. If dwelling is not within a fire protection district, the applicant provides evidence that the applicant has asked to be included in the nearest such district;
6. If dwelling has a chimney or chimneys, each chimney has a spark arrester; and
7. Dwelling owner provides and maintains a primary fuel-free break and secondary break areas on land surrounding the dwelling that is owned or controlled by the owner.

If a governing body determines that meeting the fourth requirement is impractical, local officials can approve an alternative means for protecting the dwelling from fire hazards.

Oregon Revised Statute 477.015-061

Provisions in ORS 477.015-061, Urban Interface Fire Protection, were established through efforts of the ODF, the Office of the State Fire Marshal, fire service agencies from across the state, and the Commissioners of Deschutes, Jefferson, and Jackson Counties. It is innovative legislation designed to address the expanding interface wildfire problem within ODF Fire Protection Districts. Full implementation of the statute will occur on or after January 1, 2002. The statute does the following:

1. Directs the State Forester to establish a system of classifying forestland-urban interface areas;

2. Defines forestland-urban interface areas;
3. Provides education to property owners about fire hazards in forestland-urban interface areas. Allows for a forestland- urban interface county committee to establish classification standards;
4. Requires maps identifying classified areas to be made public;
5. Requires public hearings and mailings to affected property owners on proposed classifications;
6. Allows property owners appeal rights;
7. Directs the Board of Forestry to promulgate rules that set minimum acceptable standards to minimize and mitigate fire hazards within forestland-urban interface areas; and
8. Creates a certification system for property owners meeting acceptable standards. Establishes a $100,000 liability limit for cost of suppressing fires if certification requirements are not met.

Senate Bill 360

Senate Bill 360, passed in 1997, is state legislation put in place to address the growing wildland/urban interface problem. The bill has three purposes:

1. To provide an interface fire protection system in Oregon to minimize cost and risk and maximize effectiveness and efficiency;
2. To promote and encourage property owners' efforts to minimize and mitigate fire hazards and risks; and
3. To promote and encourage involvement of all levels of government and the private sector in interface solutions.

The bill has a five-year implementation plan that includes public education and outreach, and the development of rules, standards, and guidelines that address landowner and agency responsibilities. The success of Senate Bill 360 depends upon cooperation among local and regional fire departments, fire prevention cooperatives, and the ODF, which means that interagency collaboration, is vital for successful implementation of the bill. This cooperation is important in all aspects of wildland firefighting. Resources and funding are often limited, and no single agency has enough resources to tackle a tough fire season alone. The introductory language of Senate Bill 360 states, "The fire protection needs of the interface must be satisfied if we are to meet the basic policy of the protection of human life, natural resources, and personal property. This protection must be provided in an efficient and effective manner, and in a cooperative partnership approach between property owners, local citizens, government leaders, and fire protection agencies."

Senate Bill 762

In 2021, the Oregon Legislature passed Senate Bill 762 (SB-762) which required ODF to develop a new statewide wildfire risk map updating the current use of the 2018 Quantitative Wildfire Risk Assessment. ODF develop administrative rules with input from a 26-member rulemaking advisory committee. The rules, adopted by the Board of Forestry, establish the criteria by which the map is developed, updated, and maintained. The rules also included the following:

- Implement five statewide wildfire risk classes of extreme, high, moderate, low and no risk, based on weather, climate, topography, and vegetation.

- Develop a process in which a property owner may appeal a designation of wildfire risk class.
- Determine a process in which a property owner is notified of risk assignment of high or extreme.
- Develop maintenance criteria for the map.

The new Wildfire Risk Map was released on June 30, 2022, but was withdrawn for further consideration of public comment. When the map is re-released, it will show what properties in Oregon fall within the WUI, as defined by the Board of Forestry in rule in 2021. Oregon State University developed the map based on the rules adopted by the board and the best data available.

Following updated rules, based on Senate Bill 80 (2023), the map will show the assigned hazard classification for every tax lot in the state. Those that are both within the WUI and classified as high hazard will receive written notification from ODF and may be subject to future changes to defensible space and home building codes.

Until the map is re-released the statewide wildfire risk maps presented through Oregon Wildfire Risk Explorer are from the 2018 Quantitative Wildfire Risk Assessment. This is also the dataset used by the DOGAMI geologic hazard analysis performed for this NHMP update in 2022.

SB 762 also established new electric utility system mandates to identify and assist in mitigating wildfire risk. Sections 1 through 6 of the bill impact electric systems and the Public Utility Commission (PUC) directly and indirectly. Sections 3 – 5 focuses on requiring both investor-owned utilities (IOUs) and consumer-owned utilities (COUs) to operate under a risk-based wildfire protection plans. The IOUs must submit plans annually to the PUC for review and approval. The COUs must submit copies to the PUC of their wildfire mitigation plans once they have been approved by their governing body.

Oregon Department of Forestry

ODF is involved with local fire chiefs and local fire departments to provide training. Local firefighters can get a range of experience from exposure to wildland firefighting. Local firefighters can also obtain their red card (wildland fire training documentation) and attend extensive workshops combining elements of structural and wildland firefighting, defending homes, and operations experience (Wolf, 2001). ODF has been involved with emergency managers to provide support during non-fire events and for years, ODF has worked with industrial partners (big timber companies) to share equipment in the case of extremely large fires (Wolf, 2001).

Local Resources

Multi-Hazard

Community Emergency Response Team

The Community Emergency Response Team (CERT) program educates volunteers about disaster preparedness for the hazards that may occur where they live. The County has a dedicated and respected CERT team, who trains volunteers to assist their communities when a disastrous event overwhelms or delays the community's professional response.

Morrow County

The Morrow County Off Highway Vehicle (OHV) Park has been used as a significant base camp during fire season. The OHV Park could be a significant emergency management resource. The location and amenities available there provide an opportunity for such a base camp. ODF has expressed an interest in having a permanent facility on the site.

National Weather Service and Morrow County Emergency Management

The NWS can predict severe weather events that may trigger prolonged or flash flood events, landslide, and other severe weather. The NWS can issue notices to response agencies and to the public via television, radio, internet and Weather Radios (formerly Tone Alert Radios) when the potential for flooding is likely, for example. Morrow County Emergency Management, Morrow County Police, and the Morrow County Fire and Ambulance District coordinate with NWS when notices may be required to inform response agencies and the public of potential hazard events.

Morrow County Transportation System Plan (TSP)

The Morrow County Transportation Plan provides a framework of goals, objectives, and policies that guides the County's transportation system and recommends how the County invest its resources in future transportation programs and infrastructure to meet anticipated travel demands.

Other Existing Strategies and Programs

Existing strategies and programs at the state level are usually performed by the Oregon Public Utility Commission (OPUC), Building Code Division (BCD), ODF, OEM, and the Oregon Department of Transportation.

The Oregon Emergency Response System (OERS) coordinates and manages state resources in response to natural and technological emergencies and civil unrest involving multi-jurisdictional cooperation between all levels of government and the private sector (https://www.oregon.gov/oem/emops/Pages/OERS.aspx).

Oregon Public Utility Commission ensures operators manage, construct and maintain their utility lines and equipment in a safe and reliable manner. These standards are listed on this website: http://www.puc.state.or.us/PUC/safety/index.shtml. OPUC promotes public education and requires utilities to maintain adequate tree and vegetation clearances from high voltage utility lines and equipment.

Earthquake

Morrow County Public Schools

Morrow County Public Schools conduct earthquake drills regularly throughout Oregon and teach students how to respond when an earthquake event occurs.

Flood

Morrow County Planning Department

Community participation in the NFIP requires the adoption and enforcement of a local floodplain management ordinance that controls development in the floodplain. Communities participating in the NFIP may adopt regulations that are more stringent than those contained in 44 CFR 60.3, but not less stringent.

Elevation Certificate Maintenance

Elevation certificates are administered by Morrow County's Planning Department. The certificates are required for buildings constructed in the floodplain to demonstrate that the building is elevated adequately to protect it from flooding. The elevation certificate is an important administrative tool of the NFIP. It is used to determine the proper flood insurance premium rate; it can be used to document elevation information necessary to ensure compliance with community floodplain management regulations; and it may be used to support a request for a Letter of Map Amendment (LOMA), or Letter of Map Revision based on fill (LOMR-F).

Wildfire

Mutual Aid Agreements

Mutual Aid Agreements exist among the various fire authorities for support and help as needed. Each authority has its regulations and limitations, which dictates its fire management activity. ODF and the U.S. Forest Service have mutual aid agreements with the rural fire districts within Morrow County that allows for assistance to be provided regardless of jurisdiction. Morrow County also has Mutual Aid Agreements between them and Umatilla County for fire and emergency services.

V. PLAN IMPLEMENTATION & MAINTENANCE

This section details the formal process employed to ensure that the NHMP remains an active and relevant document. The plan implementation and maintenance process include a schedule for monitoring and evaluating the NHMP semi-annually, as well as updating the plan every five years. Finally, this section describes how the County will integrate public participation throughout the NHMP maintenance and implementation process.

A. Implementing the NHMP

The success of the NHMP depends on how well the outlined action items are implemented. Proper implementation and maintenance of the plan ensures that this plan will maximize County and/or city's efforts to reduce the risks posed by natural hazards. The respective County and/or city Planning Department will act as the agency responsible for implementing this process.

In an effort to ensure that the activities identified are implemented, the following steps will be taken: 1) the NHMP will be formally adopted, 2) a Steering Committeewill be assigned, 3) a convener shall be designated, 4) semi-annual meetings will be held, 5) the identified activities will be prioritized and evaluated, and 6) the NHMP will be implemented through existing plans, programs and policies.

1. NHMP Adoption

The Morrow County NHMP was developed and will be implemented through a collaborative process. After the NHMP is locally reviewed and deemed complete, the Morrow County Emergency Manager and the DLCD Project Manager will submit it to the State Hazard Mitigation Officer (SHMO) at the Oregon Department of Emergency Management (ODEM). When ODEM finds the plan satisfactory, their staff submits the NHMP to FEMA-Region X for review. This review addresses the federal criteria outlined in the FEMA Interim Final Rule 44 CFR Part 201. Upon preliminary approval by FEMA, the county and cities may adopt the NHMP via resolution. These resolutions of approval or adoption are sent to FEMA which then issues the Approval Letter which identifies the period of effectiveness of the plan. This letter states that the named plan holders have gained eligibility to apply for the Hazard Mitigation Grant Program, the Building Resilient Infrastructure and Communities program funds, and Flood Mitigation Assistance program funds among other FEMA grant programs.

2. Convener

The Morrow County Planning Department will serve as the convener for the NHMP and will take responsibility for the implementation of the NHMP and facilitate the Implementation Committee meetings. Each individual city will be responsible for convening locally to collaborate on plan implementation work and report back to the Implementation Committee. (See the table below for a list of conveners and bodies for each specific city). NHMP implementation and evaluation will be a shared responsibility among all the assigned Implementation Committee members.

Given the capacity constraints for the smaller jurisdictions included in this multi-jurisdictional plan, Planning Commissions and City Councils often serve as the reviewing body for implementation and maintenance of the NHMP. The City Manger or the Town Recorder may act as the representative of these bodies to the Implementation Committee, or the council may appoint their own representative.

The Convener's responsibilities include:

- Coordinate Implementation Committee meeting dates, times, locations, agendas and member notification;
- Facilitate and document the discussions and outcomes of committee meetings;
- Serve as a communication conduit between the Implementation Committee and the public/interested parties;
- Review status of mitigation actions and identify needs that can be addressed through new action items;
- Identify emergency management-related funding sources for natural hazard mitigation projects; and
- Utilize the Risk Assessment as a tool for prioritizing proposed natural hazard risk reduction projects.

3. Implementation Committee

The Morrow County Convener will maintain an NHMP Implementation Committee for updating and implementing the NHMP. The Steering Committee roles and responsibilities include:

- Attend future maintenance and NHMP update meetings (or designating a representative to serve in your place);
- Serve as the local evaluation committee for funding programs including FEMA funds as well as all other sources of funding for hazard mitigation and resiliency;
- Work with partners to identify funding for natural hazard risk reduction projects;
- Document the successes and lessons learned, and evaluate how these can be incorporated into future mitigation work;

- Evaluate and update the Natural Hazards Mitigation Plan following a disaster to address for new needs, vulnerabilities, and risks;
- Evaluate and update the Natural Hazards Mitigation Plan in accordance with the prescribed maintenance schedule;
- Develop and coordinate ad hoc and/or standing subcommittees as needed; and
- Coordinate public involvement activities.

Members

To make the coordination and review of the NHMP as broad and useful as possible, the steering committee will engage additional interested parties and partners, and other relevant hazard mitigation organizations and agencies to implement the identified action items. The interested parties engaged as part of the ongoing implementation and maintenance of the NHMP includes but is not limited to:

- City representatives
- Special district Representatives
- Watershed Districts
- Economic Development Agencies
- Local Utility Representatives
- Fire & Police Departments
- State and Federal Agencies
- Soil and Water Conservation Groups
- Other Nongovernmental Organizations
- Port Agencies

B. Implementing Through Existing Programs

The NHMP includes a range of action items that, when implemented, will reduce loss from hazard events in the County. Within the NHMP, FEMA requires the identification of existing programs that might be used to implement these action items. Morrow County and the participating cities currently address statewide planning goals and legislative requirements through their comprehensive land use plans, capital improvement plans, mandated standards and building codes. To the extent possible, Morrow County and participating cities will work to incorporate the recommended mitigation action items into existing programs and procedures.

Many of the recommendations contained in the NHMP are consistent with the goals and objectives of the participating cities and the County's existing plans and policies. Where possible, Morrow County and participating cities should implement the recommended actions contained in the NHMP through existing plans and policies. Plans and policies already in existence often have support from residents, businesses, and policy makers. Many land-use, comprehensive, and strategic plans get updated regularly and can adapt easily to changing conditions and needs. Implementing the action items contained in the NHMP through such plans and policies increases their likelihood of being supported and implemented.

Examples of plans, programs or agencies that may be used to implement mitigation activities include:

- City and County Budgets
- Community Wildfire Protection Plans
- Comprehensive Land Use Plans
- Economic Development Action Plans
- Zoning Ordinances and Building Codes

For additional examples of plans, programs or agencies that may be used to implement mitigation activities refer to list of plans in Volume I, Section 2, Political Capacity.

Both the county and the cities are subject to limitations on their abilities to expand and improve these identified capabilities. The small size of several Morrow County cities and the limited staff that come with small town administration is a restriction on these cities' ability to implement mitigation actions. Morrow County is also limited in its ability to expand and improve their identified capabilities as well. Currently, building permits for Morrow County are contracted through the City of Boardman . High levels of commercial and industrial development claim significant amounts of county planning staff time, reducing the ability of current staff to identify and apply for funds to conduct mitigation actions.

1. Plans

The Community Wildfire Protection Plan (CWPP): A CWPP is a plan developed collaboratively between Morrow County, community stakeholders that identify wildland fire hazards, prioritizes measures to reduce those hazards and recommends ways for homeowners and communities to reduce ignitability of County structures. This Collaboration between agency partners helps address the specific needs of our community, inform decision-makers, and guide interventions that protect life, property and infrastructure from wildfire. The Morrow County CWPP was updated and adopted in October 2023.

2. Policies and Ordinances

- Morrow County Land Use and Development Ordinance
- Morrow County Comprehensive Plan
- Oregon State Fire Marshall – Oregon Fire Service Mobilization Plan
- Oregon Statewide Planning Goals and Guidelines – Goal 7: Areas Subject to Natural Hazards
- US Department of the Interior – Pacific Northwest Operating Plan (2014)

- 2021 Oregon Wildfire Programs Summary (Senate Bill 762):

In 2021, the Oregon legislature passed Senate Bill 762, Oregon's first comprehensive wildfire preparedness and resiliency bill. This legislation created Wildfire Programs with a goal to advance fire protection in Oregon by mitigating the catastrophic impacts of wildfire on lives and property through three key strategies: creating fire-adapted communities, developing safe and effective responses, and increasing the resiliency of Oregon's landscapes. The Wildfire Programs established wildfire-related programmatic responsibilities, ranging from wildfire hazard mapping, defensible space, building codes, and land use to forest management, electric utilities, air quality, and public health. Investments totaled $195 million during Oregon's 2021-2023 budget.

3. 2023 Oregon Wildfire Programs Summary (Senate Bills 80, 82, and 644):

In 2023, the legislature continued the Wildfire Programs with a variety of adjustments, expanding some program areas and reducing others. The legislature passed two primary wildfire bills during the 2023 session to advance fire protection in Oregon: Senate Bill (SB) 80 and SB 82. In addition, SB 644 addresses wildfire mitigation as it relates to Accessory Dwelling Units.

- SB 80: A variety of improvements were made to the Wildfire Programs including: wildfire hazard mapping updates, expanding philanthropy pathways to the community risk reduction fund, creating the landscape resiliency fund, expanding clean air space authorities to non-profits, administrative updates to the advisory council, and advanced prescribed fire through a liability program.

- SB 82: Partnering with Oregon's insurance industry, transparency in rating and underwriting decisions by insurers is ensured, as it relates to wildfire threats. The bill also allows consumers to see how wildfire risk reduction efforts – such as establishing defensible space, hardening homes, and participation in wildfire community preparedness programs – may influence their insurance rating and the availability of insurance.

- SB 644: This bill amends requirements relating to wildfire hazard mitigation for development of accessory dwelling units (ADU) on lands zoned for rural residential use. The bill allows, but does not require, counties to permit ADUs in rural residential zones if the ADU complies with the construction provisions of section R327 of the Oregon Residential Specialty Code (wildfire hazard mitigation, also known as home hardening) regardless of location in the absence of the statewide wildfire hazard map.

4. Programs and Projects

- Oregon Department of Forestry (ODF)
- Federal Emergency Management Agency (FEMA) Programs
- Fire Management Assistance Grant Program
- Prescribed Burning
- Firewise
- FireFree Program

C. NHMP Maintenance

NHMP maintenance is a critical component of the NHMP. Proper maintenance of the NHMP ensures that it will maximize the County and participating Cities' efforts to reduce the risks posed by natural hazards. This section includes a process to ensure that a regular review and update of the NHMP occurs. The Steering Committee and local staff are responsible for implementing this process, in addition to maintaining and updating the NHMP through a series of meetings outlined in the maintenance schedule below.

The Steering Committee will meet on a semi-annual basis to complete the following tasks. During the first meeting the Steering Committee will:

- Review existing action items to determine appropriateness for funding;
- Educate and train new members on the NHMP and mitigation in general;
- Identify issues that may not have been identified when the NHMP was developed; and
- Prioritize potential mitigation projects using the methodology described below.

During the second meeting, the Steering Committee will:

- Review existing and new risk assessment data;
- Discuss methods for continued public involvement; and
- Document successes and lessons learned during the year.

These meetings are an opportunity for the cities and special districts to report back to the County on progress that has been made towards their components of the NHMP.

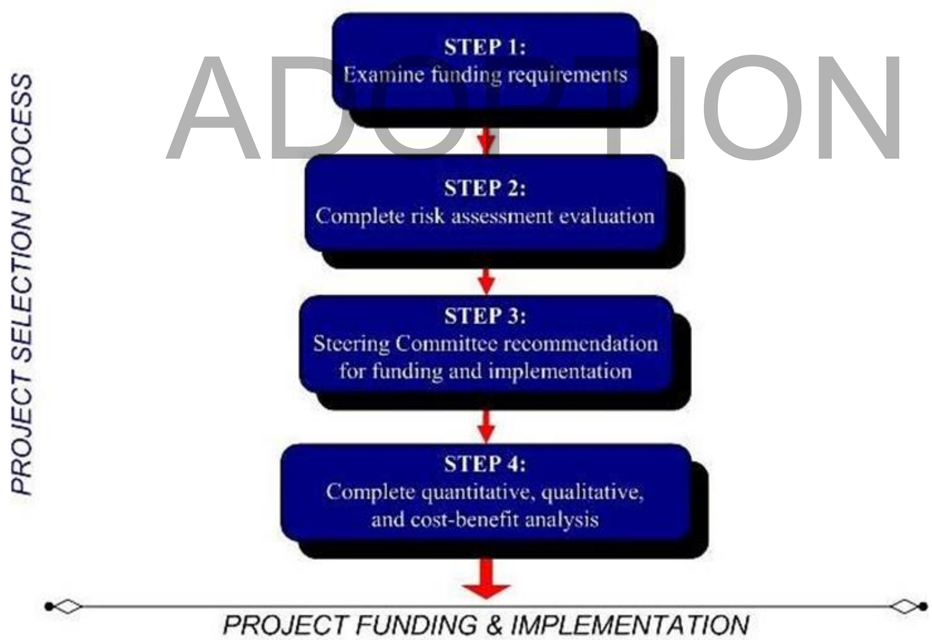
The convener will be responsible for documenting the outcome of the semi-annual meetings. The process the Steering Committee will use to prioritize mitigation projects is detailed in the section below and in more detail in Appendix C. The NHMP's format allows the County and participating Cities to review and update sections when new data becomes available. New data can be easily incorporated, resulting in a NHMP that remains current and relevant to the participating jurisdictions.

D. Project Prioritization Process

The Disaster Mitigation Act of 2000 requires that jurisdictions identify a process for prioritizing potential actions. Potential mitigation activities often come from a variety of sources; therefore, the project prioritization process needs to be flexible. Committee members, local government staff, other planning documents or the risk assessment may be the source to identify projects. The following four steps illustrate the project development and prioritization process, as well as seen in Figure 40**.**

- **Step 1 - Examine funding requirements:** The first step in prioritizing the Plan's action items is to determine which funding sources are open for application. Several funding sources may be appropriate for the County's/city's proposed mitigation projects. Examples of mitigation funding sources include but are not limited to FEMA's Building Resilient Infrastructure and Communities (BRIC), Flood Mitigation Assistance (FMA) program, Hazard Mitigation Grant Program (HMGP), National Fire Plan (NFP), Community Development Block Grants (CDBG), local general funds, and private foundations, among others. Because grant programs open and close on differing schedules, the County and/or city will need to examine upcoming funding streams' requirements to determine which mitigation activities would be eligible. The steering committee may consult with the funding entity, ODEM, or other appropriate state or regional organizations about project eligibility requirements. This examination of funding sources and requirements will happen during the steering committee semi-annual NHMP maintenance meetings.

Figure 40. Action Item and Project Review Process



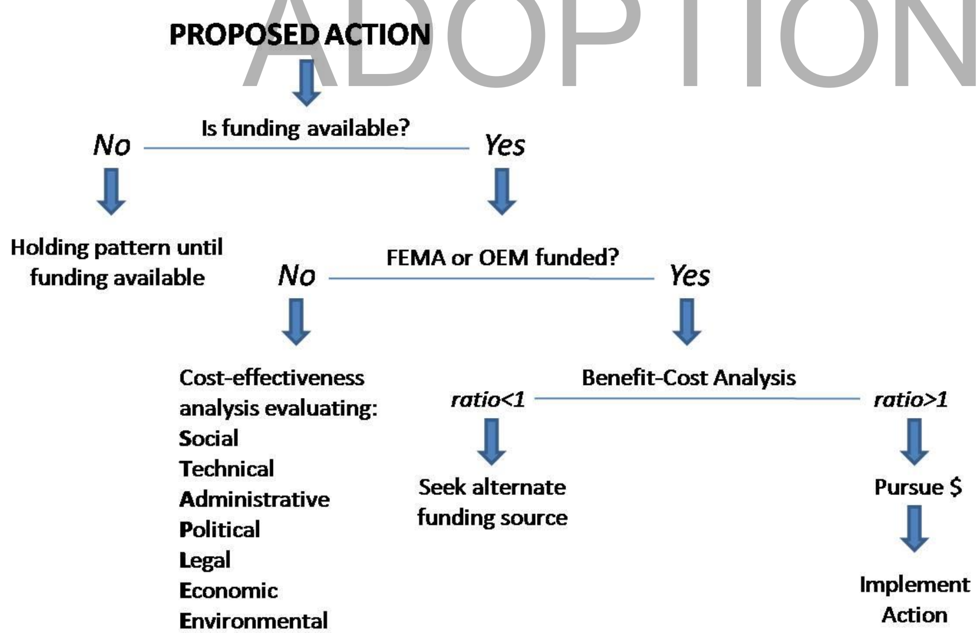
Source: Oregon Partnership for Disaster Resilience, 2008

- **Step 2 - Complete risk assessment evaluation:** The second step in prioritizing the NHMP's action items is to examine which hazards the selected actions are associated with and where these hazards rank in terms of community risk. The steering committee will determine whether the

NHMP's risk assessment supports the implementation of eligible mitigation activities. This determination will be based on the location of the potential activities, their proximity to known hazard areas, and whether community assets are at risk. The committee will additionally consider whether the selected actions mitigate hazards that are likely to occur in the future or are likely to result in severe/catastrophic damages.

- **Step 3 - Coordinating Body Recommendation:** Based on the steps above, the committee will recommend which mitigation activities should be moved forward. If the committee decides to move forward with an action, a coordinating organization will be designated to take further actions and, if applicable, documenting success upon project completion. The committee will convene a meeting to review the issues surrounding grant applications and to share knowledge and/or resources. This process will afford greater coordination and less competition for limited funds.
- **Step 4 - Complete quantitative and qualitative assessment, and economic analysis:** The fourth step is to identify the costs and benefits associated with the selected natural hazard mitigation strategies, measures, or projects. Two categories of analysis that are used in this step are: (1) benefit/cost analysis, and (2) cost-effectiveness analysis. Conducting benefit/cost analysis for a mitigation activity assists in determining whether a project is worth undertaking now, to avoid disaster-related damages later. Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. Determining the economic feasibility of mitigating natural hazards provides decision makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects. Figure 41 shows decision criteria for selecting the appropriate method of analysis.

Figure 41. Benefit Cost Decision Criteria



Source: Oregon Partnership for Disaster Resilience, 2010

If the activity requires federal funding for a structural project, the committee will use a FEMA-approved cost-benefit analysis tool to evaluate the appropriateness of the activity. A project must have a benefit/cost ratio of greater than one to be eligible for FEMA grant funding.

For non-federally funded or nonstructural projects, a qualitative assessment will be completed to determine the project's cost effectiveness. The committee will use a multivariable assessment technique called STAPLE/E to prioritize these actions. STAPLE/E stands for Social, Technical, Administrative, Political, Legal, Economic, and Environmental. Assessing projects based upon these seven variables can help define a project's qualitative cost effectiveness. OPDR at the University of Oregon's Community Service Center has tailored the STAPLE/E technique for use in natural hazard action item prioritization.

E. Continued Public Involvement

The participating jurisdictions are dedicated to involving the public directly in the continual reshaping and updating of the Morrow County NHMP. To ensure that these opportunities will continue, the county and participating jurisdictions will:

- Post copies of their plan on corresponding websites.
- Place articles in the local newspaper directing the public where to view and providefeedback; and
- Use existing newsletters such as community newsletters and utility bills to inform the public where to learn about natural hazard planning and to provide feedback.

In addition to the involvement activities listed above, Morrow County and the cities within it will incorporate mitigation awareness of natural hazards into emergency management public involvement activities such as Preparedness Fairs and wildfire awareness events. These events will be publicized in English and Spanish and will be posted on city and county websites.

F. Five-Year Review of Plan

This NHMP will be updated every five years in accordance with the update schedule outlined in the Disaster Mitigation Act of 2000. The Morrow County NHMP is due to be updated by September 18, 2029. The Convener will be responsible for organizing the Steering Committee to address NHMP update needs. The Steering Committee will be responsible for updating any deficiencies found in the NHMP and for ultimately meeting the Disaster Mitigation Act of 2000 NHMP update requirements.

During plan updates, the following questions will be asked to determine what actions are necessary to update the plan. Morrow County and/or the appropriate city will be responsible for convening the committee to address the questions outlined below.

- Are the plan's goals still applicable?
- Have new issues or problems related to hazards been identified in the community?
- Are there new partners that should be brought to the table?
- Are there new local, regional, state, or federal policies influencing natural hazards that should be addressed?

- Has the community successfully implemented any mitigation activities since the plan was last updated?
- Do existing actions need to be reprioritized for implementation?
- Are the actions still appropriate, given current resources?
- Have there been any changes in development patterns that could influence the effects of hazards?
- Are there new studies or data available that would enhance risk assessment?
- Has the community been affected by any disasters? Did the plan accurately address the impacts of this event?

The questions above will help the committee determine what components of the mitigation plan need updating. The committee will be responsible for updating any deficiencies found in the plan based on the questions above.

Morrow County

MULTI-JURISDICTIONAL NATURAL HAZARDS MITIGATION PLAN

VOLUME II: APPENDICES

TABLE OF CONTENTS

Appendix A: FEMA APA Letter, Plan Review Tool and Resolutions

DRAFT FOR ADOPTION

U.S. Department of Homeland Security
FEMA Region 10
130 228th Street, SW
Bothell, WA 98021-8627

FEMA

August 6, 2024

Stephen Richardson, State Hazard Mitigation Officer
Oregon Department of Emergency Management
3930 Fairview Industrial Drive SE
Salem, Oregon 97302

Reference: Adoption Required to Finish Morrow County Multi-jurisdictional Hazards Mitigation Plan Process

Dear Officer Richardson:

In accordance with applicable[1] laws, regulations, and policy, the United States Department of Homeland Security's Federal Emergency Management Agency (FEMA) Region 10 has determined the Morrow County multi-jurisdictional hazard mitigation plan meets all applicable FEMA hazard mitigation planning requirements except its adoption by:

Morrow County	City of Boardman	City of Heppner
City of Ione	City of Irrigon	City of Lexington

Local governments, including special districts, with a plan status of "Approvable Pending Adoption" are not eligible for FEMA mitigation grant programs with a hazard mitigation plan requirement.

The next step in the approval process is to formally adopt the hazard mitigation plan and send a resolution to the state for submission to FEMA. Sample adoption resolutions can be found in Appendix B of the Local Mitigation Planning Policy Guide.

An approved hazard mitigation plan, including adoption by the local government, is one of the conditions for applying for and/or receiving FEMA mitigation grants from the following programs:

- Hazard Mitigation Grant Program (HMGP)
- Hazard Mitigation Grant Program Post-Fire (HMGP-PF)
- Building Resilient Infrastructure and Communities (BRIC)
- Flood Mitigation Assistance (FMA)
- High Hazard Potential Dams Grants Program (HHPD)

Based on FEMA's review, the plan did not include all dam risk. Thus, the participating jurisdictions are not eligible for assistance from the HHPD Grant Program. If any participating jurisdictions with HHPDs are interested in this assistance, they should contact the FEMA Region 10 Hazard Mitigation

[1] Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended; the National Flood Insurance Act of 1968, as amended; and National Dam Safety Program Act, as amended; 44 CFR Part 201, Mitigation Planning; and Local Mitigation Planning Policy Guide (FP-206-21-0002).

Planning Team at FEMA-R10-MT_Planning@fema.dhs.gov, to learn more about how to include all dam risks in the plan.

Participating jurisdictions that adopt the plan more than one year after Approvable Pending Adoption status has been issued must either:

- Validate that their information in the plan remains current with respect to both the risk assessment (no recent hazard events, no changes in development) and their mitigation strategy (no changes necessary); or
- Make the necessary updates before submitting the adoption resolution to FEMA.

We look forward to receiving the adoption resolutions and discussing options for implementing this hazard mitigation plan. If we can help in any way, please contact the FEMA Region 10 Hazard Mitigation Planning Team at FEMA-R10-MT_Planning@fema.dhs.gov.

Sincerely,

Wendy Shaw, P.E.
Risk Analysis Branch Chief
Mitigation Division

Enclosures

cc: Joseph Murray, Oregon Department of Emergency Management

JF:JG:wls

Local Mitigation Plan Review Tool

Cover Page

The Local Mitigation Plan Review Tool (PRT) demonstrates how the local mitigation plan meets the regulation in 44 CFR § 201.6 and offers states and FEMA Mitigation Planners an opportunity to provide feedback to the local governments, including special districts.

1. The Multi-Jurisdictional Summary Sheet is a worksheet that is used to document how each jurisdiction met the requirements of the plan elements (Planning Process; Risk Assessment; Mitigation Strategy; Plan Maintenance; Plan Update; and Plan Adoption).
2. The Plan Review Checklist summarizes FEMA's evaluation of whether the plan has addressed all requirements.

For greater clarification of the elements in the Plan Review Checklist, please see Section 4 of this guide. Definitions of the terms and phrases used in the PRT can be found in Appendix E of this guide.

Plan Information	
Jurisdiction(s)	Morrow County, City of Boardman, City of Heppner, City of Ione, City of Irrigon, City of Lexington
Title of Plan	Morrow County Multi-Jurisdictional Natural Hazards Mitigation Plan
New Plan or Update	Update
Single- or Multi-Jurisdiction	Multi-jurisdiction
Date of Plan	7/5/2024
Local Point of Contact	
Title	Tamra Mabbott, Planning Director
Agency	Morrow County Planning Department
Address	215 NE Main Ave., Irrigon, Oregon 97844
Phone Number	541-922-4624
Email	tmabbott@co.morrow.or.us

Additional Point of Contact	
Title	Katherine Daniel, Natural Hazards Mitigation Planner and Gianna Alessi, Natural Hazards Mitigation Planner
Agency	Oregon Department of Land Conservation and Development
Address	635 Capitol St NE
Phone Number	971-375-3767 (KD) or 971-375-6791 (GA)
Email	Katherine.daniel@dlcd.oregon.gov and Gianna.alessi@dlcd.oregon.gov

Review Information	
State Review	
State Reviewer(s) and Title	Click or tap here to enter text.
State Review Date	Click or tap to enter a date.
FEMA Review	
FEMA Reviewer(s) and Title	Agathe Olier, CERC Planner Joshewa Fulton, FEMA Community Planner
Date Received in FEMA Region	7/12/2024
Plan Not Approved	Click or tap to enter a date.
Plan Approvable Pending Adoption	8/5/2024
Plan Approved	9/19/2024

Multi-Jurisdictional Summary Sheet

In the boxes for each element, mark if the element is met (Y) or not met (N).

#	Jurisdiction Name	A. Planning Process	B. Risk Assessment	C. Mitigation Strategy	D. Plan Maintenance	E. Plan Update	F. Plan Adoption	G. HHPD Requirements	H. State Requirements
1	Morrow County	Y	Y	Y	Y	Y	Y	N	NA
2	City of Boardman	Y	Y	Y	Y	Y		N	NA
3	City of Heppner	Y	Y	Y	Y	Y		N	NA
4	City of Ione	Y	Y	Y	Y	Y		N	NA
5	City of Irrigon	Y	Y	Y	Y	Y		N	NA
6	City of Lexington	Y	Y	Y	Y	Y		N	NA

Plan Review Checklist

The Plan Review Checklist is completed by FEMA. States and local governments are encouraged, but not required, to use the PRT as a checklist to ensure all requirements have been met prior to submitting the plan for review and approval. The purpose of the checklist is to identify the location of relevant or applicable content in the plan by element/sub-element and to determine if each requirement has been "met" or "not met." FEMA completes the "required revisions" summary at the bottom of each element to clearly explain the revisions that are required for plan approval. Required revisions must be explained for each plan sub-element that is "not met." Sub-elements in each summary should be referenced using the appropriate numbers (A1, B3, etc.), where applicable. Requirements for each element and sub-element are described in detail in Section 4: Local Plan Requirements of this guide.

Plan updates must include information from the current planning process.

If some elements of the plan do not require an update, due to minimal or no changes between updates, the plan must document the reasons for that.

Multi-jurisdictional elements must cover information unique to all participating jurisdictions.

Element A: Planning Process

Element A Requirements	Location in Plan (section and/or page number)	Met / Not Met
A1. Does the plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement 44 CFR § 201.6(c)(1))		
A1-a. Does the plan document how the plan was prepared, including the schedule or time frame and activities that made up the plan's development, as well as who was involved?	Section I, Subsection D-E, pp. 3-8; Appendix B	Met
A1-b. Does the plan list the jurisdiction(s) participating in the plan that seek approval, and describe how they participated in the planning process?	Section I, Subsection D, pp. 5-7	Met

Element A Requirements	Location in Plan (section and/or page number)	Met / Not Met
A2. Does the plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development as well as businesses, academia, and other private and non-profit interests to be involved in the planning process? (Requirement 44 CFR § 201.6(b)(2))		
A2-a. Does the plan identify all stakeholders involved or given an opportunity to be involved in the planning process, and how each stakeholder was presented with this opportunity?	Section I, Subsection D, pp. 5-7	Met
A3. Does the plan document how the public was involved in the planning process during the drafting stage and prior to plan approval? (Requirement 44 CFR § 201.6(b)(1))		
A3-a. Does the plan document how the public was given the opportunity to be involved in the planning process and how their feedback was included in the plan?	Section I, Subsection D, p. 8; App B	Met
A4. Does the plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement 44 CFR § 201.6(b)(3))		
A4-a. Does the plan document what existing plans, studies, reports and technical information were reviewed for the development of the plan, as well as how they were incorporated into the document?	Section II, Subsection G, pp. 74-77	Met

ELEMENT A REQUIRED REVISIONS
Required Revision: Click or tap here to enter text.

Element B: Risk Assessment

Element B Requirements	Location in Plan (section and/or page number)	Met / Not Met
B1. Does the plan include a description of the type, location, and extent of all natural hazards that can affect the jurisdiction? Does the plan also include information on previous occurrences of hazard events and on the probability of future hazard events? (Requirement 44 CFR § 201.6(c)(2)(i))		
B1-a. Does the plan describe all natural hazards that can affect the jurisdiction(s) in the planning area, and does it provide the rationale if omitting any natural hazards that are commonly recognized to affect the jurisdiction(s) in the planning area?	Section I, Subsection D, p.7	Met
B1-b. Does the plan include information on the location of each identified hazard?	Section III, Subsection A: **Drought**, p. 98; **Earthquake**, pp.105-108; **Extreme Heat**, pp.115-116; **Flood**, pp.124-126; **Landslide**, pp.136-137; **Volcano**, pp.144-145; **Wildfire**, pp.151-154; **Windstorms/ Thunderstorms**, p.163; **Winter Storms**, pp.168-169; Appendix E, pp. E-67-E-76	Met

Element B Requirements	Location in Plan (section and/or page number)	Met / Not Met
B1-c. Does the plan describe the extent for each identified hazard?	Section III, Subsection A: **Drought**, p.98; **Earthquake**, p.105-106; **Extreme Heat**, pp.115-116; **Flood**, pp.136-139; **Landslide**, pp.136-137; **Volcano,** pp.144-145; **Wildfire**, pp.151-153; **Windstorms/ Thunderstorms**, p.163; **Winter Storms,** pp.168-169	Met
B1-d. Does the plan include the history of previous hazard events for each identified hazard?	Section III, Subsection A, p. 87; Section III, Subsection A: **Drought**, pp.98-100 **Earthquake**, p.109; **Extreme Heat**, pp.116-117 **Flood**, pp.127-128; **Landslide**, pp.139-140; **Volcano,** pp.144-145; **Wildfire**, pp.155-156; **Windstorms/ Thunderstorms**, pp.164-165; **Winter Storms,** pp.169-172	Met

Element B Requirements	Location in Plan (section and/or page number)	Met / Not Met
B1-e. Does the plan include the probability of future events for each identified hazard? Does the plan describe the effects of future conditions, including climate change (e.g., long-term weather patterns, average temperature and sea levels), on the type, location and range of anticipated intensities of identified hazards?	**Climate Change,** Section II, Subsection A, p. 86; Appendix F, pp. F-4-F-65; **Probability of Future Events,** Section III, Subsection A: **Drought**, pp.100-101; **Earthquake**, p.110; **Extreme Heat**, pp.117-119; **Flood**, p.128; **Landslide**, p.140; **Volcano,** pp.146-147; **Wildfire**, pp.156-157; **Windstorms/ Thunderstorms**, pp.165-166; **Winter Storms,** p.173	Met
B1-f. For participating jurisdictions in a multi-jurisdictional plan, does the plan describe any hazards that are unique to and/or vary from those affecting the overall planning area?	Section III, Subsection A: **Drought**, p. 98; **Earthquake**, pp.107-108; **Extreme Heat**, pp.115-116 **Flood**, pp.124-125; **Landslide**, pp.136-137; **Volcano,** pp.144-145; **Wildfire**, pp.151-153; **Windstorms/ Thunderstorms**, p.163; **Winter Storms,** pp.168-169	Met

Element B Requirements	Location in Plan (section and/or page number)	Met / Not Met
B2. Does the plan include a summary of the jurisdiction's vulnerability and the impacts on the community from the identified hazards? Does this summary also address NFIP-insured structures that have been repetitively damaged by floods? (Requirement 44 CFR § 201.6(c)(2)(ii))		
B2-a. Does the plan provide an overall summary of each jurisdiction's vulnerability to the identified hazards?	Section III, Subsection A: **Drought**, pp.101-102 **Earthquake**, pp.110-113; **Extreme Heat**, pp.119-120; **Flood**, pp.132-134; **Landslide**, pp.140-142; **Volcano,** p.147; **Wildfire**, pp.157-161; **Windstorms/ Thunderstorms**, p.166; **Winter Storms,** pp.173-174	Met
B2-b. For each participating jurisdiction, does the plan describe the potential impacts of each of the identified hazards on each participating jurisdiction?	Section III, Subsection A: **Drought**, pp.101-102 **Earthquake**, pp.110-113; **Extreme Heat**, pp.119-120; **Flood**, pp.132-134; **Landslide**, pp.140-142; **Volcano,** p.147; **Wildfire**, pp.157-161; **Windstorms/ Thunderstorms**, p.166; **Winter Storms,** pp.173-174	Met
B2-c. Does the plan address NFIP-insured structures within each jurisdiction that have been repetitively damaged by floods?	Section III, Subsection A, pp. 130-132	Met

ELEMENT B REQUIRED REVISIONS
Required Revision: Click or tap here to enter text.

Element C: Mitigation Strategy

Element C Requirements	Location in Plan (section and/or page number)	Met / Not Met
C1. Does the plan document each participant's existing authorities, policies, programs and resources and its ability to expand on and improve these existing policies and programs? (Requirement 44 CFR § 201.6(c)(3))		
C1-a. Does the plan describe how the existing capabilities of each participant are available to support the mitigation strategy? Does this include a discussion of the existing building codes and land use and development ordinances or regulations?	Section II, Subsection B, pp. 50-52; Subsection G, pp. 72-84 Section V, Subsection B, pp.230-233;	Met
C1-b. Does the plan describe each participant's ability to expand and improve the identified capabilities to achieve mitigation?	Section V, Subsection B, p. 231	Met
C2. Does the plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement 44 CFR § 201.6(c)(3)(ii))		
C2-a. Does the plan contain a narrative description or a table/list of their participation activities?	Section III, Subsection A, pp.128-132	Met
C3. Does the plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement 44 CFR § 201.6(c)(3)(i))		
C3-a. Does the plan include goals to reduce the risk from the hazards identified in the plan?	Section IV, Subsection A, pp.185-186	Met

Element C Requirements	Location in Plan (section and/or page number)	Met / Not Met
C4. Does the plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement 44 CFR § 201.6(c)(3)(ii))		
C4-a. Does the plan include an analysis of a comprehensive range of actions/projects that each jurisdiction considered to reduce the impacts of hazards identified in the risk assessment?	Section IV, Subsection B, pp.191-210	Met
C4-b. Does the plan include one or more action(s) per jurisdiction for each of the hazards as identified within the plan's risk assessment?	Section IV, Subsection B, pp.191-210	Met
C5. Does the plan contain an action plan that describes how the actions identified will be prioritized (including a cost-benefit review), implemented, and administered by each jurisdiction? (Requirement 44 CFR § 201.6(c)(3)(iv)); (Requirement §201.6(c)(3)(iii))		
C5-a. Does the plan describe the criteria used for prioritizing actions?	Section IV, Subsection B, pp. 187-188; Section V, Subsection D, pp. 234-236	Met
C5-b. Does the plan provide the position, office, department or agency responsible for implementing/administrating the identified mitigation actions, as well as potential funding sources and expected time frame?	Section IV, Subsection B, pp.191-210	Met

ELEMENT C REQUIRED REVISIONS
Required Revision**:** Click or tap here to enter text.

Element D: Plan Maintenance

Element D Requirements	Location in Plan (section and/or page number)	Met / Not Met
D1. Is there discussion of how each community will continue public participation in the plan maintenance process? (Requirement 44 CFR § 201.6(c)(4)(iii))		
D1-a. Does the plan describe how communities will continue to seek future public participation after the plan has been approved?	Section V, Subsection E, p.236	Met
D2. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a five-year cycle)? (Requirement 44 CFR § 201.6(c)(4)(i))		
D2-a. Does the plan describe the process that will be followed to track the progress/status of the mitigation actions identified within the Mitigation Strategy, along with when this process will occur and who will be responsible for the process?	Section V, Subsection C, p.233; Subsection F, pp.236-237	Met
D2-b. Does the plan describe the process that will be followed to evaluate the plan for effectiveness? This process must identify the criteria that will be used to evaluate the information in the plan, along with when this process will occur and who will be responsible.	Section V, Subsection D, pp.235-236	Met
D2-c. Does the plan describe the process that will be followed to update the plan, along with when this process will occur and who will be responsible for the process?	Section V, Subsection F, pp.236-237	Met
D3. Does the plan describe a process by which each community will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement 44 CFR § 201.6(c)(4)(ii))		
D3-a. Does the plan describe the process the community will follow to integrate the ideas, information and strategy of the mitigation plan into other planning mechanisms?	Section II, Subsection G, pp.74-77; Integrating Information & Data; Section IV, Subsection B, Action Item MC-LS-1, p.137; Subsection C, p.211	Met
D3-b. Does the plan identify the planning mechanisms for each plan participant into which the ideas, information and strategy from the mitigation plan may be integrated?	Section II, Subsection G, pp.74-77	Met

Element D Requirements	Location in Plan (section and/or page number)	Met / Not Met
D3-c. For multi-jurisdictional plans, does the plan describe each participant's individual process for integrating information from the mitigation strategy into their identified planning mechanisms?	Section II, Subsection G, pp.74-77 Section IV, Subsection C, pp. 211-212	Met

ELEMENT D REQUIRED REVISIONS
Required Revision: Click or tap here to enter text.

Element E: Plan Update

Element E Requirements	Location in Plan (section and/or page number)	Met / Not Met
E1. Was the plan revised to reflect changes in development? (Requirement 44 CFR § 201.6(d)(3))		
E1-a. Does the plan describe the changes in development that have occurred in hazard-prone areas that have increased or decreased each community's vulnerability since the previous plan was approved?	Section II, Subsection D, p. 50-55	Met
E2. Was the plan revised to reflect changes in priorities and progress in local mitigation efforts? (Requirement 44 CFR § 201.6(d)(3))		
E2-a. Does the plan describe how it was revised due to changes in community priorities?	Section I, pp.4-5; Section II, Subsection A, p. 86; Section III, Subsection A: **Drought**, p.97; **Earthquake**, p.103; **Extreme Heat**, p.114; **Flood**, p.121; **Landslide**, p.135; **Volcano**, p.143; **Wildfire**, p.148; **Windstorms/ Thunderstorms**, p.162; **Winter Storms,** p.167	Met

Element E Requirements	Location in Plan (section and/or page number)	Met / Not Met
E2-b. Does the plan include a status update for all mitigation actions identified in the previous mitigation plan?	Section IV, Subsection B, pp,188-191	Met
E2-c. Does the plan describe how jurisdictions integrated the mitigation plan, when appropriate, into other planning mechanisms?	Section IV, Subsection C, p.211	Met
ELEMENT E REQUIRED REVISIONS		
Required Revision: Click or tap here to enter text.		

Element F: Plan Adoption

Element F Requirements	Location in Plan (section and/or page number)	Met / Not Met
F1. For single-jurisdictional plans, has the governing body of the jurisdiction formally adopted the plan to be eligible for certain FEMA assistance? (Requirement 44 CFR § 201.6(c)(5))		
F1-a. Does the participant include documentation of adoption?	Click or tap here to enter text.	Choose an item.
F2. For multi-jurisdictional plans, has the governing body of each jurisdiction officially adopted the plan to be eligible for certain FEMA assistance? (Requirement 44 CFR § 201.6(c)(5))		
F2-a. Did each participant adopt the plan and provide documentation of that adoption?	Click or tap here to enter text.	Not Met
ELEMENT F REQUIRED REVISIONS		
Required Revision: F2-a. Will be met once formal resolutions received.		

Element G: High Hazard Potential Dams (Optional)

HHPD Requirements	Location in Plan (section and/or page number)	Met / Not Met
HHPD1. Did the plan describe the incorporation of existing plans, studies, reports and technical information for HHPDs?		
HHPD1-a. Does the plan describe how the local government worked with local dam owners and/or the state dam safety agency?	Click or tap here to enter text.	Choose an item.
HHPD1-b. Does the plan incorporate information shared by the state and/or local dam owners?	Click or tap here to enter text.	Choose an item.
HHPD2. Did the plan address HHPDs in the risk assessment?		
HHPD2-a. Does the plan describe the risks and vulnerabilities to and from HHPDs?	Click or tap here to enter text.	Choose an item.
HHPD2-b. Does the plan document the limitations and describe how to address deficiencies?	Click or tap here to enter text.	Choose an item.
HHPD3. Did the plan include mitigation goals to reduce long-term vulnerabilities from HHPDs?		
HHPD3-a. Does the plan address how to reduce vulnerabilities to and from HHPDs as part of its own goals or with other long-term strategies?	Click or tap here to enter text.	Choose an item.
HHPD3-b. Does the plan link proposed actions to reducing long-term vulnerabilities that are consistent with its goals?	Click or tap here to enter text.	Choose an item.
HHPD4-a. Did the plan include actions that address HHPDs and prioritize mitigation actions to reduce vulnerabilities from HHPDs?		
HHPD4-a. Does the plan describe specific actions to address HHPDs?	Click or tap here to enter text.	Choose an item.
HHPD4-b. Does the plan describe the criteria used to prioritize actions related to HHPDs?	Click or tap here to enter text.	Choose an item.
HHPD4-c. Does the plan identify the position, office, department or agency responsible for implementing and administering the action to mitigate hazards to or from HHPDs?	Click or tap here to enter text.	Choose an item.

HHPD Required Revisions
Required Revision: Click or tap here to enter text.

Element H: Additional State Requirements (Optional)

Element H Requirements	Location in Plan (section and/or page number)	Met / Not Met
This space is for the State to include additional requirements.		
Click or tap here to enter text.	Click or tap here to enter text.	Choose an item.

Plan Assessment

These comments can be used to help guide your annual/regularly scheduled updates and the next plan update.

Element A. Planning Process

Strengths

- The plan gives detailed information about how public feedback was included throughout the planning process.

Opportunities for Improvement

- Consider incorporating existing plans and policies from neighboring community plans to strengthen existing plans, studies, and technical information during the next plan update.

Element B. Risk Assessment

Strengths

- The plan provides a detailed assessment of the FEMA flood maps and Flood Insurance Studies. It also explained the 100- and 500-year floodplains in detail.
- The plan provides an in-depth analysis of historical events in the planning area, as well as federally declared disasters.

Opportunities for Improvement

- Consider using local stories or incidents to further explain the impacts of hazard events.

Element C. Mitigation Strategy

Strengths

- The plan's mitigation actions are well-organized. Each jurisdiction has a clear action item for each identified hazard. Additionally, each action item is well-explained in its description.
- Appendix D is a valuable resource to identify grant programs and resources for mitigation items. Each state and federal grant source is described.

Opportunities for Improvement

- Consider creating a table listing each jurisdiction's capabilities. Include authorities, policies, programs, funding, and resources.
- For action items with a long timeline (5+ years), break the project down into smaller phases. This will allow the community to show progress on the action in the next plan, even if the project is not yet complete.

Element D. Plan Maintenance

Strengths

- The plan lists creative ways to keep the public involved in mitigation efforts. These include newsletters, local newspapers, publishing on websites, having events, and publicizing the events in both English and Spanish, which allows for a vulnerable population to join in the plan review.
- The questions to track the progress and status of the mitigation actions are detailed. This allows for a streamlined review process and knowing which actions have advanced or not.

Opportunities for Improvement

- Discuss whether the last plan's maintenance strategy faced any difficulty during the monitoring, evaluating, or updating efforts. These may serve as "lessons learned" for future plan updates.

Element E. Plan Update

Strengths

- The plan clearly describes changes in the community's development since the previous plan update.

Opportunities for Improvement

- A table that shows how each jurisdiction has integrated this plan into other mechanisms would be helpful.
- Adding in success stories can help strengthen the plan and act as best practices or lessons learned for future updates.
- The plan includes a status update for the previous plan's action items; however, explaining why mitigation actions were not completed or are discontinued, whether it was due to lack of personnel, lack of funding, etc., would be useful.
-

Element G. HHPD Requirements (Optional)

Strengths

- [insert comments]

Opportunities for Improvement

- [insert comments]

Element H. Additional State Requirements (Optional)

Strengths

- [insert comments]

Opportunities for Improvement

- [insert comments]

BEFORE THE BOARD OF COMMISSIONERS
FOR MORROW COUNTY, OREGON

IN THE MATTER OF A RESOLUTION	)	
ADOPTING THE 2024 MORROW COUNTY	)	RESOLUTION NO. R-2024-16
MULTI-JURISDICTIONAL NATURAL	)	
HAZARDS MITIGATION PLAN	)	

WHEREAS, natural hazards threaten life, businesses, property, and environmental systems throughout Morrow County.

WHEREAS, an understanding of the nature, extent, and potential impacts of natural hazards is the foundation for developing strategies to reduce or eliminate those impacts.

WHEREAS, natural hazards mitigation planning is the process through which such understanding and strategies are developed and a process for implementation is established throughout Morrow County.

WHEREAS, it is in the interest of Morrow County and the cities and special districts located therein to undertake natural hazards mitigation planning and implementation together as coordinated planning strengthens communities and better serves all.

WHEREAS, Morrow County and the Cities of Heppner, Lexington, Ione, Boardman and Irrigon previously prepared, implanted and updated multi-jurisdictional natural hazard mitigation plans in accordance with the Disaster Mitigation Act of 2000. Thes plans were each approved by the Federal Emergency Management Agency (FEMA) for a period of five years.

WHEREAS, the Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan update is the most recent and it expired in 2021.

WHEREAS, having a natural hazards mitigation plan developed in accordance with the Disaster Mitigation Act of 2000 and approved by FEMA is a prerequisite for local government eligibility for certain federal pre- and post-disaster mitigation funds.

WHEREAS, Morrow County and the Cities of Heppner, Lexington, Ione, Boardman and Irrigon and the Morrow County Health District, Heppner and Boardman Fire Districts each participated in completing the 2024 County Multi-Jurisdictional Natural Hazards Mitigation Plan in accordance with the Disaster Mitigation Act of 2000.

WHEREAS, as a result of coordinated planning, the 2024 Morrow County Multi-Jurisdictional Natural Hazards Mitigation Plan is based on the county's plan within Volume I and includes an individual addendum for each participating jurisdiction.

WHEREAS, adoption of the updated 2024 Morrow County Multi-Jurisdictional Natural Hazards Mitigation Plan is required for FEMA approval of the 2024 Morrow County Multi-Jurisdictional Natural Hazards Mitigation Plan and restored eligibility for certain federal pre- and post-disaster mitigation funds.

WHEREAS, adoption of the updated 2024 Morrow County Multi-Jurisdictional Natural Hazards Mitigation Plan demonstrates the Morrow County's commitment to reducing or eliminating the potential impacts of natural hazards and to achieving the Plan's goals.

NOW, THEREFORE, BE IT RESOLVED THAT THE MORROW COUNTY BOARD OF COMMISSIONERS ADOPTS THE 2024 MORROW COUNTY NATURAL HAZARDS MITIGATION PLAN UPDATE THEREBY REPLACING THE 2016 NATURAL HAZARDS MITIGATION PLAN.

Section 1 Title of Resolution:

This Resolution shall be known, and may be cited, as the "2024 NATURAL HAZARDS MITIGATION PLAN".

Section 2 Effective Date:

This Resolution shall be effective immediately upon its adoption.

ADOPTED BY THE MORROW COUNY BOARD OF COMMISSIONERS THIS 18th DAY OF SEPTEMBER 2024.

BOARD OF COMMISSIONERS OF MORROW COUNTY, OREGON

David Sykes, Chair

Jeff Wenholz, Commissioner

Roy Drago Jr., Commissioner

Approve as to Form:

Gregory V. Goebel

Morrow County Counsel

Appendix B: Planning and Public Process

This appendix describes the changes made to the Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan during the 2024 NHMP update process and process by which the Steering Committee and the project managers completing the update. Also included in this appendix is a description of the public engagement work conducted by the Steering Committee during the update.

Project Background

Morrow County and the cities of Boardman, Heppner, Ione, and Irrigon and the Town of Lexington partnered with the Oregon Department of Land Conservation and Development (DLCD) to update the 2016 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan. The Disaster Mitigation Act of 2000 requires communities to update their mitigation plans every five years to remain eligible funding from the Hazard Mitigation Grant Program, Building Resilient Infrastructure and Communities Grant Program, and Flood Mitigation Assistance Program.

DLCD and the Steering Committee made several changes to update and consolidate the NHMP. Major changes are documented and summarized below.

2024 NHMP Update Changes

The sections below discuss only *major* changes made to the NHMPs during the 2024 NHMP update process. Major changes include the replacement or deletion of large portions of text, changes to the NHMP's organization, new mitigation action items, and the addition of city and special district addenda to the NHMP. If a section is not addressed in this memo, then it can be assumed that no significant changes occurred.

This update of the plan consolidates the Hazard Specific Annexes and the City Annexes into the Basic Plan. The plan now consists of Volume I: Basic Plan and Volume II: Appendices.

The appearance of the plan was revised to reflect the Department of Land Conservation and Development style and format.

Front Pages

- The NHMP's cover has been updated.
- Acknowledgements have been updated to include the 2024 project partners and planning participants.
- The FEMA approval letter, review tool, and resolutions of adoption are included but have been relocated to an appendix for a more streamlined plan document.

Volume I: Basic Plan

Volume I provides the overall NHMP framework for the 2024 Multi-jurisdictional NHMP update. Volume I includes the following sections:

Plan Summary

The 2024 NHMP includes an updated NHMP summary that provides information about the purpose of Natural Hazard Mitigation planning and describes how the NHMP will be implemented.

Section 1: Introduction

Chapter 1 summarizes the 2024 NHMP update process, and provides an overview of how the NHMP has been reorganized.

Section 2: Community Profile

Recent data was used to update the Community Profile. The nature of the communities in Morrow County were characterized with census and American Community Survey data has incorporated updated data, including from the census and employment records.

Section 3: Hazard Identification and Risk Assessment

This section consists of three phases: hazard identification, vulnerability assessment, and risk analysis. Hazard identification involves the identification of hazard characteristics, geographic extent, its intensity, history of occurrences in the area, and probability of occurrence. Thorough hazard specific information was consolidated here rather than provided in a separate section of the plan. The second phase attempts to predict how different types of property and population groups will be affected by the hazard. The third phase involves estimating the damage, injuries, and costs likely to be incurred in a geographic area over a period. Changes include:

- Two new hazards were identified by the NHMP Steering Committee to be of growing risk to the community and thus important to assess and address through mitigation actions. These include Air Quality and Extreme Heat.
- Hazard identification, characteristics, history, probability, vulnerability, and hazard specific mitigation activities were updated. Outdated and extraneous information was removed and replaced with the most current information.
- Links to specific hazard studies and data are embedded directly into the NHMP where relevant and available.
- NFIP information was updated.
- The hazard vulnerability analysis was updated by the Steering Committee through the OEM-FEMA Vulnerability Assessment. The results of this risk assessment exercise was included in the Risk Assessment section.
- Findings from the DOGAMI Risk Report for Morrow County were incorporated into the relevant hazards: Earthquake, Flood, Landslide, Tsunami, and Wildfire.
- Future climate variability and impacts were discussed for each climatic hazard. Information was primarily sourced from the OCCRI Future Climate Projection Report for Morrow County.

Chapter 4: Mission, Goals, and Action Items

This chapter provides the basis and justification for the mission, goals, and mitigation actions identified in the NHMP. Major changes to Chapter 4 include the following:

- The 2016 goals were retained as is.

- During the reviewing and updating of Action Items, the NHMP Steering Committee decided to create a new category of Action Items, Multi-Jurisdictional This category identifies actions that multiple jurisdictions identified for their own mitigation strategies. They are grouped together under the Multi-Jurisdictional category but represent a common action to be carried out by multiple jurisdictions.
- All action items were reviewed, revised, and prioritized. Actions that were completed or that were removed were identified separately from Ongoing and Project focused Mitigation Actions. Potential funding sources and principal office or individual in charge of implementation were listed for each mitigation action.
- Major changes of action items are indicated below:
    - All Action IDs were relabeled in order to identify which hazard the action is addressing and ease of identification.
    - Multi-Jurisdictional action item categorization was added.
    - Morrow County Health District added two action items under their jurisdiction
    - **New**
        - MJ-MH-1
        - MC-MH-4
        - H-MH-2
        - H-MH-3
        - H-FL-2
        - H-FL-3
        - IO-MJ-1
        - IO-DR-2
        - IR-DR-1
        - IR-DR-2
        - HD-MH-1
        - HD-MH-2
    - **Combined**
        - MC-FL-1 is a combination of the following:
            - MC06-13
            - MC06-21
            - MC06-22
            - MC06-23
            - MC06-26
            - MC06-27
            - MC06-28
            - MC06-29
            - MC06-30

- MC06-31
- MC06-32
- MC06-14
- MC06-15
- MC06-16
- MC06-17
- MC06-18
- MC06-18
- MC06-19
- **MC06-20**

- **Completed (2016 IDs used)**
  - MC06-01
  - MC06-05
  - MC06-10
  - MC06-12: Larger culvert installed
  - MC06-16: Ditches cleaned out
  - MC06-17
  - MC06-18: Ditches cleaned out
  - MC06-24
  - MC06-25
  - MC14-37
  - B06-01: City owns portable generators
  - H06-02: Discontinued, revised to CERT program action (MC-MH-3)
  - IR14-01
  - IR06-02
  - IR06-04: Back up power provided for wells #1
  - IR14-05
  - IR14-07: Reader board installed at City Hall
  - L06-03
- **Cancelled (2016 IDs used)**
  - MC06-04
  - MC06-06: Action separated into separate action items
  - MC06-11: Action separated into separate action items
  - MC14-34
  - L06-05

Chapter 5: Plan Implementation and Maintenance

Morrow County Planning Department and Morrow County Emergency Management will continue to convene and coordinate the County Steering Committee during the Implementation and Maintenance phase.

Volume II: Appendices

Below is a summary of the appendices included in the 2024 NHMP:

Appendix A: FEMA APA Letter, Plan Review Tool, Resolutions

The approval letter is not included here. It is located at the front of Volume I. The remaining official FEMA documents are here as well as the resolutions for each of the jurisdictions.

Appendix B: Planning and Public Process

This planning and public process appendix reflects changes made to the Morrow County NHMP and documents the 2024 planning and public process.

Appendix C: Economic Analysis of Natural Hazard Mitigation Projects

Updates are provided for the economic analysis of natural hazard mitigation projects.

Appendix D: Grant Programs and Resources

Updates were made to grant programs and resources, including adding in the FEMA Mitigation Grant Programs table that notes which mitigation program covers which type of mitigation strategy or project.

Appendix E: DOGAMI Multi-Hazard Risk Report

This new section contains the *Multi-Hazard Risk Report for Morrow County, Oregon* by Oregon Department of Geology and Mineral Industries (DOGAMI)..

Appendix F: OCCRI Future Climate projections: Morrow County

This new section contains the *Future Climate Projections Morrow County, Oregon (2023)* report by the Oregon Climate Change Research Institute (OCCRI).

Public Information and Participation Process

Morrow County is dedicated to directly involving the public in the review and update of the natural hazard mitigation plan. The county has posted information about the NHMP update on both the Planning Department and the Emergency Management Department webpages. The county provided detailed information about the nature of the natural hazards that Morrow County is exposed to. The county also provided contact information to allow residents to request information about the plan and the process of updating it.

Secondly, the residents of Morrow County, Boardman, Heppner, Ione, Irrigon and Lexington were offered the opportunity to provide feedback about the NHMP both through flyers and at

an in person open house during the development of the plan update (See Figure 5). This Open House was advertised using a flyer (Figure 4 Morrow County Open House Flyer

Figure 5 Morrow County Open House Event

Figure 3). This Open House Flyer was published in the Local Newspaper, the Heppner Gazette Times on Tuesday April 17th. The Gazette is a county-wide publication, and in some cases is available for free at locations throughout Morrow County, the Planning Department office being one. Physical copies of the flyer were posted, but no translation was provided. However, there was access available to translation services during the open house, if needed.

At the Open House, there was only one attendee, who discussed their concerns on fire susceptibility and fallow wheat ground in southern Morrow County.

Morrow County made the draft NHMP update available via their website following the completion of the draft. The draft NHMP update was available on the county's website for further review and comment at this third opportunity during the OEM and FEMA review period.

The NHMP will continue to be available to the public through the county's website and the public will be engaged during the implementation phase of this plan through Steering Committee maintenance meetings. The plan will be reviewed by the NHMP Steering Committee at plan maintenance meetings held on a semiannual basis.

Figure 1. Morrow County Planning Department Webpage

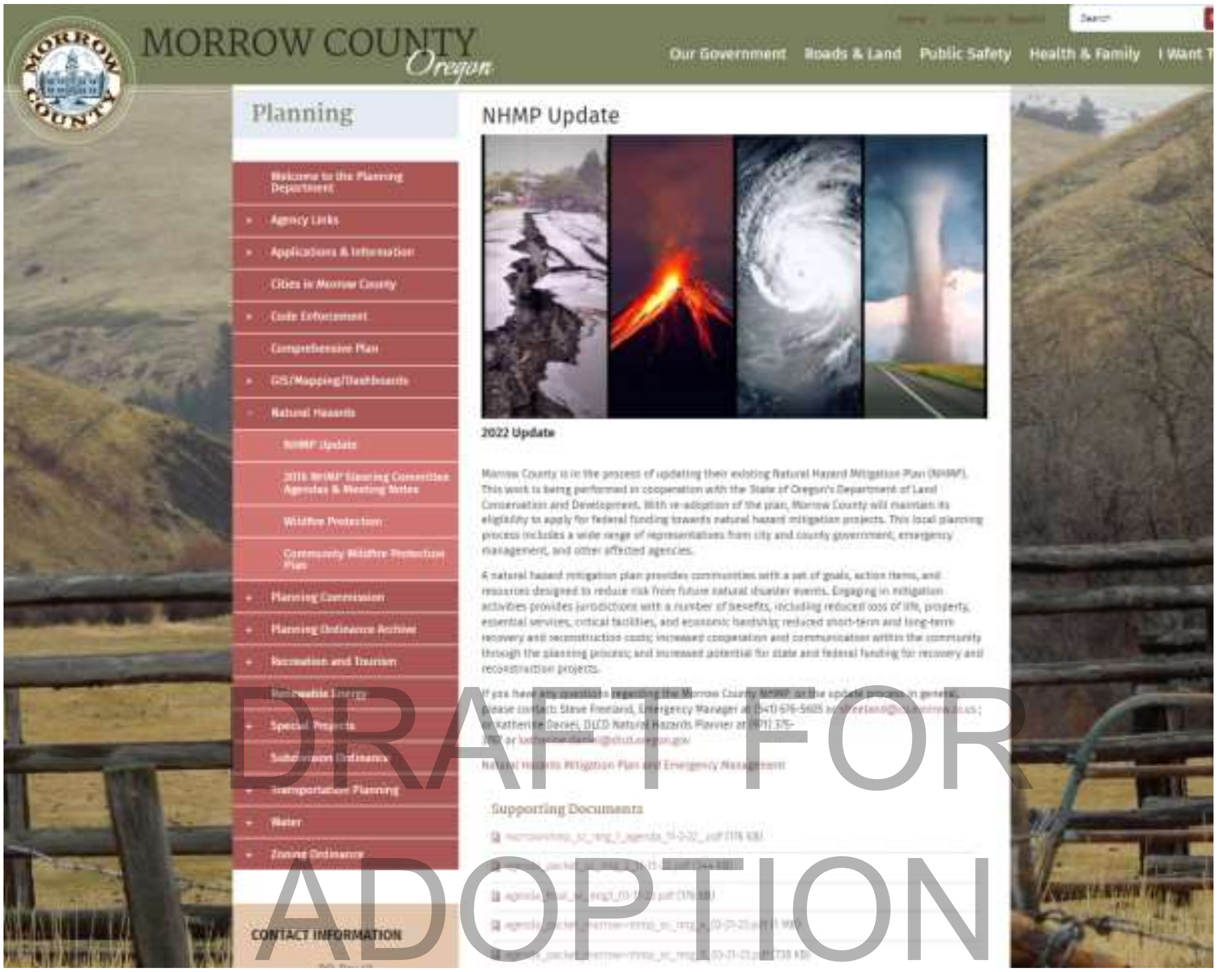


Figure 2. Morrow County Emergency Management Department Webpage

Figure 3. NHMP Informational Flyer

Morrow County

Natural Hazards Mitigation Plan Update

Visit Morrow County's NHMP Webpage:

https://www.co.morrow.or.us/planning/page/nhmp-update

Heppner Flood of 1903

FEMA Map from https://msc.fema.gov

About the Plan

Morrow County's existing Natural Hazards Mitigation Plan (NHMP) expired February 27, 2022. NHMPs must be updated every five years.

Morrow County is collaborating with the Oregon Department of Land Conservation and Development (DLCD) to update the NHMP. The updated NHMP will be a multi-jurisdictional document that includes the county's five incorporated cities and town. The updated NHMP will ensure the county and other plan holder entities maintain eligibility for federal disaster-related funding—specifically, Hazard Mitigation Assistance (HMA).

This project is made possible by the federal Hazard Mitigation Grant Program (HMGP). The HMGP assists states, tribes, and local communities in implementing long-term hazard mitigation measures following a major disaster declaration to reduce the risk of loss of life and property from future disasters.

A Steering Committee, co-chaired by County Emergency Manager, Paul Gray, and GIS Planning Technician, Stephen Wrecsics, is working with DLCD to update the NHMP. The NHMP is targeted for completion and adoption in 2024.

Vision:

To maximize Morrow County's resistance and resilience to natural hazards in both government and private sectors through preparedness and mitigation.

Blowing Dust Sign on I-84

FOR MORE INFORMATION:

Stephen Wrecsics, GIS Planning Technician | Phone: (541) 922-4624 | Email: swrecsics@co.morrow.or.us

H. Paul Gray, Morrow County Emergency Manager | Phone: (541) 256-0122 | Email: pgray@co.morrow.or.us

Figure 4 Morrow County Open House Flyer

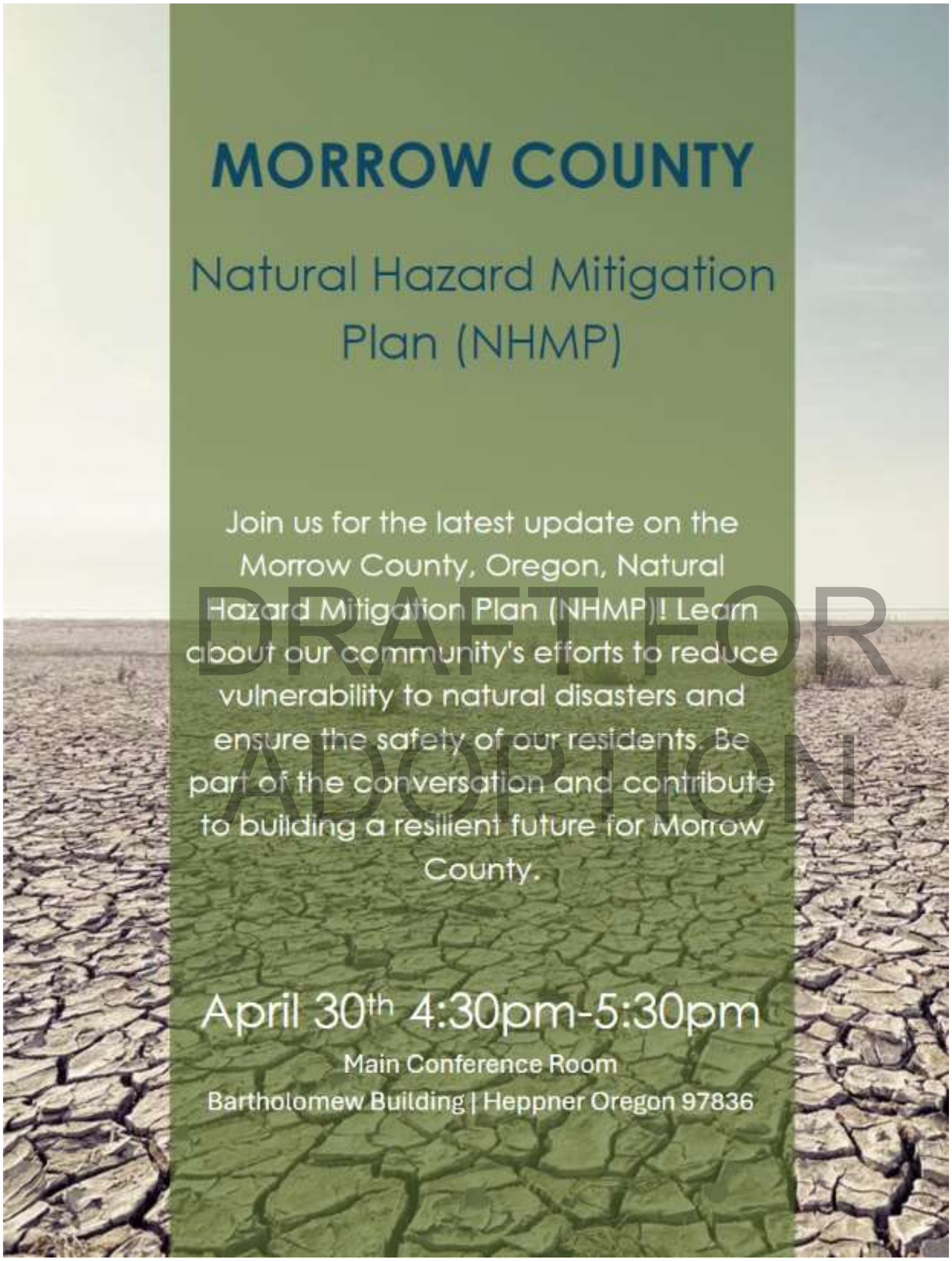


Figure 5 Morrow County Open House Event

Morrow County Steering Committee

Steering Committee members are familiar with the Morrow County community and how it is affected by natural hazard events. The Steering Committee was composed of representatives of each of the cities within the county. The Steering Committee was supported by Interested Parties representing multiple fire districts, the Soil and Water Conservation District, Columbia Basin Electric Coop and the Confederated Tribes of the Umatilla Indian Reservation. The project manager guided the group through the update process including risk assessment, goal confirmation and prioritization, action item review and development and information sharing and public outreach. The Steering Committee met formally on the dates listed below and meeting topics are also summarized below. Meeting agendas and adopted meeting notes are provided as well.

November 2, 2022: Project introduction and establishment of project practices, the need to conduct public outreach activities during the development of the plan and a proposed schedule for completion of the project.

November 15, 2022: Prior plan mitigation strategy actions were the primary topic of this meeting as well as the content of updated city annexes. The Steering Committee decided to conduct separate risk assessments for the northern and southern portions of the county. The use of Box and completion of cost share forms were also discussed.

January 17, 2023: The Steering Committee identified the natural hazards that will be addressed by the NHMP update. The group identified two new hazards, Extreme Temperatures and Air Quality. Tornado was recategorized under Thunderstorms. Other natural hazards that carry over from the 2016 plan include Drought, Earthquake (Cascadia), Earthquake (Crustal), Flood, Landslide, Thunderstorm, Windstorm, Winter Storm, Wildfire, and Volcanic Event. A total of twelve natural hazards are addressed by this NHMP update. The meeting also included an OEM methodology Hazard Vulnerability Assessment (HVA) for the North County and individual updates from the cities about meetings held locally to discuss mitigation strategies.

February 21, 2023: Susan Millhauser joins the project as a Natural Hazard Planner and Project Manager to replace Pam Reber. The agenda included confirmation of the natural hazards identified at the previous meeting were relevant for both north and south county areas. Susan informed the group that Dam Safety is to be addressed in the plan update per FEMA guidance issued in April 2023.

March 21, 2023: The project timeline was adjusted to better reflect the time for outreach efforts on risk assessment and also on mitigation strategies. New FEMA requirements for addressing High Hazard Potential Dam risk and how to message that to the public as well as mitigation strategy requirements with a focus on equitable outcomes.

April 18, 2023: Matt Williams, Geohazard Analyst for the Department of Geology and Mineral Industries, presented the results of the multi-hazard risk analysis he completed for Morrow County with respect to landslide, earthquake, flood, channel migration, and wildfire. The Steering Committee discussed the ranking of the hazards using the OEM methodology HVA with the DOGAMI analysis in mind. The north and south county rankings were finalized.

May 16, 2023: Erica Fleishman, Director of the Oregon Climate Change Research Institute provided an overview of the Future Climate Projections report prepared for Morrow County regarding the projected impact of a warming climate on the natural hazards addressed in the Morrow County Multi-Jurisdictional NHMP update. The development of maps for the plan and progress reports were the other topics covered at this meeting.

July 18, 2023: The meeting purpose was to provide updates to the OCCRI Future Climate Projections report (Erica Fleishman) and to summarize the findings of the draft DOGAMI report so that the Steering Committee could discuss any updates needed to the OEM Methodology HVA. This was postponed. Public outreach and feedback to incorporate into the NHMP were also considered in light of the departure of the convener from county employment.

Small group meetings: DLCD project managers met in small groups with all the city representatives and the county and health district participants so that focused mitigation strategies could be the sole purpose of the meeting.

Figure 6. November 2, 2022 Steering Committee meeting #1 agenda

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Kickoff Meeting
AGENDA

Wednesday November 2, 2022
1:00 PM– 3:00 PM
HYBRID – North Morrow Govt Center, Don Adams Conference Room & Online

Welcome/Introductions	**1:00 pm**
• Please share your name, title, and jurisdiction.	H. Paul Gray, Emergency Manager
NHMP Project Overview	**1:15 pm**
• IGA/ Scope of Work & FEMA Guidance • Data sources: DOGAMI/ OCCRI Reports • Meetings, Information Requests – Monthly Nov-June	Pamela Reber, DLCD H. Paul Gray, Emergency Manager
Public & Internal Engagement	**2:00 pm**
• Discuss public engagement strategies. • Introduce the use of Box file sharing website. • Internal project team recommended	Pamela Reber, DLCD H. Paul Gray, Emergency Manager
Cost Share & Rate Documentation	**2:20 pm**
• No cash required! Please track your time. • Please send name of financial official.	Pamela Reber, DLCD
Discussion	**2:30 pm**
• Plan needs & communication strategies • Discuss public engagement strategies. • Introduce the use of Box file sharing website.	Pamela Reber, DLCD H. Paul Gray, Emergency Manager Tamra Mabbott, Planning Director
Next Steps	**2:55 pm**
• Establish regular meeting times • Start rate documentation & Submit cost share	All

Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan

Figure 7. November 2, 2022 Steering Committee meeting #1 adopted notes

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Kickoff Meeting
NOTES

Wednesday November 2, 2022
1:00 PM– 3:00 PM
HYBRID – North Morrow Govt Center, Don Adams Conference Room & Online

Attendees:

Eleven people representing five jurisdictions and one state agency attended the kickoff meeting of the 2023 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan.

In-person
H. Paul Gray, Morrow County Emergency Manager, Project Convener
Stephen Wrecsics, Morrow County Planning GIS Technician
Tamra Mabbott, Morrow County Planning Director
Carla Mclane, Irrigon Contract Planner/ Boardman Planning Official
Pam Reber, DLCD Natural Hazard Planner, Project Manager
Online
Kraig Cutsforth, Heppner City Manager
Elizabeth (Liz) Peterson, Ione City Manager
Karen Pettigrew, Boardman City Manager
Emily Roberts, Morrow County Health District
Dawn Hert, DLCD Eastern Oregon Regional Representative
Ashley Edwards, DLCD Planning Grants Coordinator

Welcome/Introductions:

- Attendees signed in on the in-person sign in sheet and then introduced themselves via Zoom.
- A change to the agenda was made that moved up the cost share and rate documentation part of the meeting to occur after the NHMP project introduction.

NHMP Project Overview:

- The DLCD IGA is recommended but not required. The requirements are that all jurisdictions must adopt the final FEMA-approved plan or notify DLCD in writing that do not plan to do so; and all non-federally funded individuals need to submit quarterly cost share after tracking their time on the project.
- Concerns about the IGA were shared, as well as the timing of it being shared with the cities. Discussion about the IGA resolved the issues and all of the participating 2016 jurisdictions are expected to participate for the 2023 update.

Cost Share and Rate Documentation

- Please submit cost share quarterly.

1

- Please send the name and email address of your financial official to Ashley Edwards Ashley.EDWARDS@dlcd.oregon.gov and she will reach out. A good start date might be July 1, 2022.

NHMP Project Overview (continued):

- DLCD secured funds for two reports to inform the Morrow County risk assessment: the DOGAMI Natural Hazard Risk Report and the OCCRI Future Conditions Report.
- Discussion about the robust plan maintenance work that was done 2017-2020.
- Carla, Stephen shared their knowledge of the past planning process.
- Carla is representing both Irrigon and Boardman for the project.
- Need identified: FEMA update requirements; problem statement and action item development guidance; updated Cascadia information from DOGAMI and coordination of critical facilities; need to develop additional Cascadia earthquake event planning for future grants (state/ regional coordination of disasters would be helpful).

Public & Internal Engagement:

- Jurisdictions are lead on internal and external communication for this project.
- Document and report your activities to Pam and Paul.
- Link to the County NHMP website. **Morrow County MJ NHMP Website:** https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan
- Paul presented the plan update schedule and reviewed the public engagement activities.

Discussion:

A go-around of the local jurisdictions for local needs and outreach was held.

- Heppner: A little new to the project. Heppner uses Facebook for outreach and is lucky to have the Sheriff's Office there. The hazards are pretty obvious.
- Morrow County: Looking to update the action items, and formatting.
- Discussion about how what the previous understanding of the requirements were—that old action items were not "allowed" to be removed.
- Interest of group in improving how the plan appearance and layout.
- Review of the action items and how to develop new action items. Boardman and Irrigon will have stormwater needs (public works action item to update stormwater standards was an example given).
- Limited interest in changing the hazard chapters, but documenting hazard events was noted. However, interest in volcanic activity from the Three Sisters was identified. Hot springs can indicate volcanic activity near the surface—like near Diamond in Harney County (noise like freight train). Cascades eruptions being triggered by Cascadia, but no conversation when Mt Hood does blow—and potential impacts on the Columbia Gorge, like I-84 closing at Cascade Locks, etc.
- Discussion about Port/ LEPC engagement; question about making NHMP an all-hazards plan, but coordination with port for action item development is the first step. After-action reports from exercises can help drive funding.

Next Steps:

- Action item status updates were proposed for next meeting.
- Schedule was discussed for a regular meeting time. Paul prefers not to meet on Wednesday due to the BoC meetings. Stephen doesn't work Mondays.
- Tuesdays 2-4pm were selected for a monthly meeting; Ione-not the second Tuesday, others the first Tuesday.
- Next meetings: November 15th and January 17th
- Paul is planning to send everyone their action items.
- Pam to share example mitigation actions; Pam to review existing spreadsheet for action items.
- Stephen is willing to upload anything to Box from past plan updates that is missing.

Figure 8. November 15, 2022 Steering Committee meeting #2 agenda

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan

2023 Update Meeting AGENDA

Tuesday November 15, 2022

2:00 PM– 4:00 PM

HYBRID – North Morrow Govt Center, Don Adams Conference Room & Online

https://us06web.zoom.us/j/86115898343?pwd=SFRHd24ySjJObkNzdUVLSTE2MFJNdz09

Meeting ID: 861 1589 8343 Passcode: 97836

Welcome/Introductions	**2:00 pm**
• Please share your name, title, and jurisdiction. • Review and approve notes from meeting #1	H. Paul Gray, Emergency Manager Pamela Reber, DLCD
Review past action items	**2:15 pm**
• City action review • Countywide action item review • Discussion	All
City Annexes	**3:00 pm**
• Discuss existing annexes • Share template • Discussion	All
Discussion	**3:30 pm**
• Open forum for questions and concerns • Optional topics (if time allows): Goals & HVA	All
Next Steps	**3:55 pm**
• Start rate documentation & Submit cost share	All

Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan

Figure 9. November 15, 2022 Steering Committee meeting #2 adopted notes

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
NOTES

OREGON
Department of Land Conservation & Development

Tuesday November 15, 2022
2:00 PM–4:00 PM
HYBRID – North Morrow Govt Center, Don Adams Conference Room & Online
Meeting recording: https://dlcd.box.com/s/n8vf3pkgrpkxnwbnjohwb6wdszrytalx

Attendees:

Eleven people representing five jurisdictions and one state agency attended the second meeting of the 2023 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan.

In-person
Aaron Palmquist, City of Irrigon City Manager
Katie Imes, Town of Lexington City Councilor
Rolf Prag, City of Boardman
Stephen Wrecsics, Morrow County Planning GIS Technician
Carla McLane, Irrigon Contract Planner/ Boardman Planning Official
Pam Reber, DLCD Natural Hazard Planner, Project Manager
Online
Kraig Cutsforth, Heppner City Manager
H. Paul Gray, Morrow County Emergency Manager, Project Convener
Veronica Hess, Lexington Town Recorder
Sandi Pointer, Morrow County Public Works
Dawn Hert, DLCD Eastern Oregon Regional Representative

Welcome/Introductions:

- Attendees in the room and on Zoom introduced themselves.
- A change to the agenda was made to provide additional time to focus on the 2016 actions items and existing annexes and the proposed template. May not get to the goals and Hazard Vulnerability Assessment included in the packet; we will discuss at the January meeting.
- The meeting notes from November 2, 2022 were reviewed and approved.

Review Past Mitigation Action Items:

- Status update steps were reviewed. Other plan update needs and potential partners could also be noted.
- Morrow County road action items were identified in past plans in response to storm events that preceded the plan updates, feedback from Morrow County Public Works is needed. At the same time need to consider stormwater management and DEQ requirements. The existing

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stormwater master plan is vague. Best practices need to be in place but not something that FEMA would fund.

- Two lists – 2016 and 2023:
  - 2016 status column update - chose one word: Complete, Discontinued, Started, Not Started, Revise (keep project but revise as needed); avoid the term "ongoing". It was clarified that completed actions do not need to be carried forward into the new plan.
  - 2023 list will include continuing action items and new ones in priority order. Typically organized by target hazard and related risks for FEMA funding consideration. FEMA is looking for more specific costs (best estimate) and timelines (use the suggested timeframes). For now, include initial priority of High, Medium, Low; can revise later in the process.
- A populated spreadsheet template will be sent out after the meeting for the jurisdictions to work on before the next meeting in January.
- Discussed hazard identification and whether hazards of concern that aren't natural hazards, such as dam failure, gas lines, air quality, etc., can be included. It was clarified they can be included if there is potential for triggering by a natural hazard.
- Discussed water quality and nitrate contamination issue and DLCD received clarification from OEM that if another federal agency, such as EPA, would fund, then FEMA won't. However, the plan can identify infrastructure projects to address natural hazards, such as drought, through water conservation, stored water, etc. that could also help to address water quality issues.
- Boardman and Heppner 2016 projects were discussed.
- The group discussed if it would make sense to elevate some projects to county-wide issues, such as language barriers, public information campaigns, recruitment of Red Cross and CERT volunteers, FEMA-required education to qualify for grants, etc. to be implemented in conjunction with the cities. For example, this would support a county grant application that covers the county and the cities, such as for translating webpages into Spanish.
- It was agreed that each city should include and prioritize the actions they plan to do and to also have a combined table that shows shared actions with lead identified, such as the county that will need to report out.
  - A combined table or matrix should include a "other jurisdiction" column and a could use different numbering system, e.g. Year-Hazard-Priority.
- At a later meeting the committee should discuss how to incorporate addressing county-wide and cross-jurisdictional collaboration into the plan's goals.
- Discussed FEMA National Incident Management System (NIMS) IS 100 training to qualify for certain grants for equipment, such as generators. Not necessarily to receive a mitigation grant but helps to have everyone trained.

City Annexes

- The Basic Plan and Annex Organization was reviewed using the table of contents. Not all sections will need to be in the annex, such as Section 5 – plan implementation and maintenance. The jurisdiction annex template also has suggestions about what to include in the plan process, participation, and adoption section.
- Clarified that the final plan and annexes will include both 2023 jurisdiction priority actions and 2016 action item status updates.

- 2016 plan didn't tie mitigation actions to hazards. The 2023 summary table in each annex can be augmented to do this so that specific hazards to be mitigated are clear.
- The basic plan will include an overview of the hazards and identified projects. It could be augmented with a matrix that ties to the hazards as well as the plan goals. There is also a robust annex for each hazard.
- The jurisdiction annexes are then tailored to each area, e.g., flooding in the south counties. and then more specific information included in the appropriate city annexes that detail hazard characteristics, history, and vulnerability (what has been remediated and what remains), on page 4 of the annex template.
- For the hazard profile section, DLCD will include improved data from DOGAMI, including a HAZUS analysis on floods and geohazards.
- It was clarified that the steering committee will be doing a subjective risk analysis at the local level, called the HVA (Hazard Vulnerability Assessment). It was agreed to do two: one focused on the north county and one focused on the south county.
    - Would like to have updated hazard chapters before finalizing the HVA, using process outlined in the packet.
- For annexes, there has been recent press coverage of volcanic issues that might be informative.

Next Steps:

- Submit cost share before the next meeting, due either monthly or quarterly. Fill out date, activities, hours, and sign. For staff and City Council members. The form is available in Box. Also document the rate of staff who are not federally funded. Please email financial official contact information to Pam. Ashley will contact them.
- Reviewed how to use the Box online folder.
- Reviewed Hazard Mitigation Assistance eligible activities grant assistance that is currently available, the application is due March 2023.
- Before the January meeting the jurisdictions should work on the mitigation project status updates, after that the focus will be on the annexes. Pam can provide support and also will coordinate with Carla on Boardman and Irrigon.
    - Suggestion to look at the 2016 city annex to help to populate the 2023 status action items.
    - Pam to meet with Katie and Veronica to support Lexington's work as well as support to engage the Lexington City Council once some of the hazard chapters are updated. Pam or Paul could help to present when there is more information to share.
- The next meeting will include a focus on Hazard ID. For example, is Extreme Heat relevant? Pam and Paul will work to firm up hazards that are specific to Morrow County.
    - It was noted that county did a lot of work on the 2016 plan to define the hazards.
    - May want to add wildfire smoke – air quality in general. Dust storms and sand blows would fit in under air quality, as well related to summer wind events.
    - What about freezing fog? That fits in with winter storms.
- Timeline: aiming to have drafts by the summer to get public input.

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Figure 10. January 17, 2023 Steering Committee meeting #3 agenda

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
AGENDA

OREGON
Department of Land Conservation & Development

Tuesday January 17, 2023
2:00 PM– 4:00 PM
HYBRID – North Morrow Govt Center, Don Adams Conference Room & Online
https://us06web.zoom.us/j/88995279347?pwd=Q2l4czByRSsyTEVUdm8ycGJJc2Exdz09
Meeting ID: 889 9527 9347 Passcode: 97836

Welcome/Introductions	**2:00 pm**
• Please share your name, title, and jurisdiction. • Review and approve notes from meeting #2	H. Paul Gray, Emergency Manager Pamela Reber, DLCD
Hazard ID	**2:15 pm**
• Review current vs. proposed hazards • Discussion	All
Hazard Vulnerability Analysis – North County	**2:30 pm**
• Conduct a preliminary ranking of the proposed hazards.	All—Focus on Boardman & Irrigon
Progress Report: action item status & annexes	**3:15 pm**
• Please share action items that might be relevant for others to collaborate on or add to their mitigation action list. • Comments on revised annex template welcome.	All
Review plan goals	**3:45 pm**
• If time allows, and for reference in our next steps in action item development.	All—Focus on Boardman & Irrigon
Next Steps	**3:55 pm**
• Work on annex edits in coordination with Pam. • Next meeting: rank South County hazards	Next meeting in Lexington 2/21/23

Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan

Figure 11. January 17, 2023 Steering Committee meeting #3 adopted notes

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Kickoff Meeting
NOTES

OREGON
Department of Land Conservation & Development

Wednesday January 17, 2023
2:00 PM– 4:00 PM
HYBRID – North Morrow Govt Center, Don Adams Conference Room & Online
Meeting recording: https://dlcd.box.com/s/9tauv0hu7e38ebvnk5qy34r7hd0khc9c

Attendees:

Ten people representing four jurisdictions, one state agency, and one tribe attended the third meeting of the 2023 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan.

In-person
Aaron Palmquist, City of Irrigon City Manager (left at 3pm)
Rolf Prag, City of Boardman
Carla McLane, Irrigon Contract Planner/ Boardman Planning Official
H. Paul Gray, Morrow County Emergency Manager, Project Convener
Online
Kraig Cutsforth, Heppner City Manager
Veronica Hess, Lexington Town Recorder
Sandi Pointer, Morrow County Road Department
Robert Fossek, Confederated Tribes of The Umatilla Indian Reservation (CTUIR) Emergency Management Coordinator)
Pam Reber, DLCD Natural Hazard Planner, Project Manager
Dawn Hert, DLCD Eastern Oregon Regional Representative

Welcome/Introductions:

- Attendees introduced themselves via Zoom.
- As the notes were not prepared, a discussion occurred about the need for notes as the meetings are recorded. The group did sound interested in having notes, but agreed that a summary of each meeting with the attendee list would be sufficient for inclusion in the plan.
    - Also, when you meet internally, please email Pam the date, attendance, and a few sentences as to what was discussed.

Hazard ID:

- At the last meeting, the steering committee chose to conduct two hazard rankings—one for the hazards of the northern half and then the southern half of the county, in order to capture the unique risks of these different climatic regions and geographies.
- The following hazards were proposed by the project team to the steering committee for discussion and prioritization. Adjustments can be made later if newer data becomes available.
    - Air Quality (incl. impacts of inversion and wildfire smoke)

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- Drought
- Earthquake:
    - Cascadia Subduction Zone Event
    - Crustal Event
- Flood
- Landslide
- Severe Weather:
    - Extreme Heat
    - Thunderstorms (incl. lightning)
    - Windstorm (incl. dust storms and tornado)
    - Winter Storm (incl. freezing fog)
- Wildfire
- Volcanic Event

- There were two changes to this Hazard list:
    - Extreme Heat was changed to Extreme Temperature to also reflect extended below zero freezing levels.
    - Tornado was moved from one Severe Weather subcategory to another—from windstorm to thunderstorm.

Hazard Vulnerability Analysis – North County

- All risk assessment is relative, and the analysis is a subjective ranking of local priorities using a methodology developed by Oregon Emergency Management (OEM), which allows for comparison across the state.
- The goal is to have discussion that results in the group's consensus of priority hazards, for both individual plan-holding entities and as a group to inform development of action items, including some that may be collaborative. Priority hazards should have the highest score.
- The HVA instructions were reviewed then the group discussed and scored each hazard while Pam filled out the ranking spreadsheet, including specific hazard impacts and/or the logic used for ranking each hazard.
- Initial severity rankings of 1, 5, and 10 were used. Adjustments to the initial severity ratings were then discussed and agreed upon to better reflect the range of vulnerability and to help prioritize between hazard risks. Updates can be made later.
- Discussed the interconnected hazards and vulnerability of extreme heat, drought, wildfire, and windstorm. There's increasing potential for FEMA to fund natural infrastructure projects to increase soil stability, for example, to mitigate impacts.
- Discussed where the HVA score sheet will be in the plan document; it was confirmed that it can be in the annexes for each jurisdiction. The committee can revisit and discuss further as the plan is developed.

Progress Report: action item status & annexes:

- Pam reached out to the fire districts and one special district is interested in becoming a plan holder. It will be important to engage as many special districts as possible in the plan review process.
- Boardman (met 1/12/23, Carla, Rolf, and City Engineer):

- Reviewed the action items and project spreadsheet. Didn't identify any new actions at this time but added information on status. The City is undergoing significant water and wastewater upgrade based on a general obligation bond process, which will allow some of the older action items to be fulfilled.
- Reviewed the annex template and filled in the plans section.

- Irrigon (met 1/13/23, Carla and Aaron): Reviewed the action items and added one new one into the spreadsheet and reviewed the annex and started putting in plans.
  - Will focus on adding additional information, such as the HVA, into each annex, with additional narrative.
- Lexington (Pam and Veronica): Have started to fill in the narrative, there will be more information added to the community profile and updated the plans list.
- General annex updates:
  - There will be need for more coordination to ensure consistency in headings.
  - DOGAMI Risk Report should be forthcoming in the next couple of months. The Oregon Climate Change Research Institute contract is also being executed. There has been discussion with both about providing support on meeting the new FEMA requirements. The annex template includes an example from the DOGAM Risk Report, which DLCD will provide for each annex.
  - Received a critical facilities GIS layer from Stephen which was sent to DOGAMI to use. If the cities have separate critical facilities GIS layers send to Pam.
    - If it's the layer from the 2016, probably the best data for Boardman and Irrigon, but Carla would like to view it to see if any additions, e.g., the new fire station in Boardman.
  - The Hazard Characteristics section is another place to focus. Includes narrative about locally specific events and vulnerabilities that will be augmented by the DOGAMI Risk Report.
  - The Mitigation Strategy can also be started, a good place to include pictures of completed projects.
  - **Deadline for first draft of the annex document: March 21, 2023.**
- FEMA new plan requirements require asset and infrastructure considerations. DLCD has determined that the best way to meet those would be to set up targeted meetings with utility managers to ask where their system is at risk or if there is anything missing in the plan update, identify opportunities to collaborate on project funding, etc. The committee brainstormed utility partners or others with assets to interview:
  - Windwave – fiber optics; Umatilla Electric (north end); Columbia Basin Electric (south end); PTD Fast - fiber and wireless to homes and businesses; CenturyLink - now Lumen in north county; water, wastewater, port districts; Cascade Natural Gas; GTN gas pipeline (comes in at Ione)
  - Pam will work with Paul and OEM to develop questions, followed by setting up meetings / interviews. The committee will need to help with some of the interviews.
- General action item status updates (2016 Action Item Status Update with 2023_01-17-23.xlsx on Box):
  - All five cities have done initial action item status updates to the 2016 and 2023 lists.
  - A Morrow County meeting still needs to be set up.

- More resolution will need to be added to the 2023 mitigation actions, such as timeline and costs especially. Without a $ number it's difficult to understand the project scope.
- Discussed and agreed upon the format of the mitigation action descriptions form template for the annexes.
  - Shared the Curry County example in Box, it can include space for maps and other images. Also included a combined table of county and city actions.
  - Pam will provide an action item form template to the jurisdictions.

Plan Goals:

- Briefly discussed the plan goals for the 2016 plan.
- It would be wonderful for everyone to take these back to their jurisdictions and decision-makers as an educational opportunity along the way so they have context before the plan / annexes come to them for their review.

Next Steps:

- Continue work on actions & annexes.
  - Meet internally with relevant staff.
  - Continue to track time and engagement activities. Cost share forms are due April 15, 2023 for January through March 2023.
  - Pam to provide an action item form template to the jurisdictions.
- Outreach To Do
  - Link to project website! Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan
  - Suggest interested parties, engage community representatives in action item development.
- Next Committee Meeting: Tuesday, February 21, 2 PM – 4 PM in Lexington and via Zoom.

Figure 12. February 21, 2023 Steering Committee meeting #4 agenda

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
AGENDA

OREGON
Department of Land Conservation & Development

Tuesday February 21, 2023
2:00 PM– 4:00 PM

HYBRID – Lexington City Hall (425 F St, Lexington, OR 97839) & Online
Join Zoom Meeting:
https://us06web.zoom.us/j/6877555033?pwd=akxNZ0hJd0U4WWJBS3F5MXpyWEV3UT09
Meeting ID: 687 755 5033; Passcode: Lexington
One tap mobile: +17193594580,,6877555033#,,,,*826960756# US

Welcome/Introductions	**2:00 pm**
• Please share your name, title, and jurisdiction. • Review and approve notes from meeting #2 and #3 • Review project timeline	Stephen Wrecsics, GIS Planning Technician, Morrow County Susan Millhauser, DLCD
Hazard ID	**2:15 pm**
• Review current vs. proposed hazards. • Discussion	All—Focus on south Morrow County
Hazard Vulnerability Analysis – South County	**2:30 pm**
• Conduct a preliminary ranking of the proposed hazards.	All—Focus on south Morrow County
Progress Report: action item status & annexes	**3:15 pm**
• Share action items that might be relevant for others to collaborate on or add to their mitigation action list. • Comments on revised annex template welcome.	All
Review plan goals	**3:45 pm**
• If time allows, and for reference in our next steps in action item development.	All—Focus on south Morrow County
Next Steps	**3:55 pm**
• Continue to refine annexes and action items, annex drafts due 3/21/23.	Next meeting: 3/21/23 in Irrigon, North Morrow Government Center & Online

Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan

Figure 13. February 21, 2023 Steering Committee meeting #4 adopted notes

Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan 2023 Update Meeting NOTES

OREGON
Department of Land Conservation & Development

Tuesday February 21, 2023

2:00 PM– 4:00 PM

HYBRID – Lexington City Hall (425 F St, Lexington, OR 97839) & Online

Meeting recording: https://dlcd.box.com/s/ogaa3nxvyimy98mus1jfbkf6h4e2w9i1

Meeting presentation: https://dlcd.box.com/s/hyrgf1184vf3tphcrlfq6v1jmy5kup31

Attendees:

Ten people representing four jurisdictions, two special districts, one utility, one tribe, and one state agency attended the fourth meeting of the 2023 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan.

In-person
Veronica Hess, Lexington Town Recorder
Steven Rhea, Fire Chief, Heppner
Emily Roberts, Morrow County Health District

Online
Kraig Cutsforth, Heppner City Manager
Rolf Prag, City of Boardman
Tamra Mabbott, Morrow County Planning Director
Kevin Payne, District Manager, Morrow SWCD
Jake Calvert, Columbia Basin Electric Cooperative
Robert Fossek, Confederated Tribes of The Umatilla Indian Reservation (CTUIR) Emergency Management Coordinator)
Susan Millhauser, DLCD Natural Hazard Planner, Project Manager

Welcome/Introductions:

- Attendees introduced themselves.
- The meeting notes from November 15, 2002, and January 17, 2023 were briefly discussed and and accepted.
  - **Reminder that when you meet internally, please email Susan the date, meeting length, who attended, and a few sentences as to what was discussed.**
- The project timeline was reviewed and it was noted that milestones have shifted out two months. An updated timeline will be shared with the steering committee.
  - Project map development will begin in the coming month and discussed in March and April, followed by the mitigation strategy, and public review.
  - The draft DOGAMI report should be available in the next month, which will inform the mapping, and the report from OCCRI should be forthcoming in the spring. The

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committee can then loop back to the HVAs and prioritized projects to see if there are any needed changes or updates.

Hazard ID:

- Steering committee members reviewed the updated list of hazards discussed at the January meeting and confirmed that the hazards were also relevant for the south county. Adjustments can be made later if newer data becomes available.
    - Air Quality (incl. impacts of inversion and wildfire smoke)
    - Drought
    - Earthquake:
        - Cascadia Subduction Zone Event
        - Crustal Event
    - Flood
    - Landslide
    - Severe Weather:
        - Extreme Temperature
        - Thunderstorms (incl. lightning and tornado)
        - Windstorm (incl. dust storms)
        - Winter Storm (incl. freezing fog)
    - Wildfire
    - Volcanic Event
    - New FEMA requirements add dam safety to the list of hazards. More information forthcoming, the committee will need to discuss for both north and south county.

Hazard Vulnerability Analysis – North County

- All risk assessment is relative, and the analysis is a subjective ranking of local priorities using a methodology developed by Oregon Emergency Management (OEM), which allows for comparison across the state.
- The goal is to have discussion that results in the group's consensus of priority hazards, for both individual plan-holding entities and as a group to inform development of action items, including some that may be collaborative. Priority hazards should have the highest score.
- The HVA instructions were reviewed then the group discussed and scored each hazard while Pam filled out the ranking spreadsheet, including specific hazard impacts and/or the logic used for ranking each hazard.
- Initial severity rankings of 1, 5, and 10 were used.
- The committee didn't have time to discuss adjustments to the initial severity ranking to better reflect the range of vulnerability, which can help to prioritize between hazard risks. So this will need to be discussed at the March 2023 meeting.
- Link to HVA for north and south county (working draft): https://dlcd.box.com/s/3hgkumkxaje4w2dd6zuah0liw0u9rzq3

Progress Report: action item status & annexes:

- Heppner – Kraig will start work soon.
- Lexington – Veronica will be reviewing the 2016 action items with the public utilities director.

- **Deadline for first draft of the annex document: March 20, 2023. Susan is available to meet with cities in south county to support the annex updates.**
- General action item status updates (2016 Action Item Status Update with 2023_01-17-23.xlsx on Box):
    - All five cities have done initial action item status updates to the 2016 and 2023 lists. Cities and county to continue to work on action item status updates.
    - More resolution will need to be added to the 2023 mitigation actions, such as timeline and costs especially. Without a $ number it's difficult to understand the project scope.
    - Susan will provide a mitigation action description form template for each jurisdiction to start to fill out.
        - Linked here on Box: 20230227_Morrow-2023_Mitigation-Action-Descriptions_template
        - See the Curry County example in Box; it can include space for maps and other images. Curry County also included a combined table of county and city actions.

Plan Goals:

- Not discussed due to time.

Next Steps:

- Jurisdictions (Cities, Morrow County Health District) continue work on annexes. Continue to meet internally with relevant staff. **Deadline for first draft of the annex document: March 20, 2023.**
    - Meet internally with relevant staff. Susan is available to work with south county cities and MCHD on annexes
- Continue work on mitigation action item status updates (County, Cities, MCHD). Meet internally with relevant staff.
    - Susan to provide an action item form template to the jurisdictions.
- Continue to track time and engagement activities. Cost share forms are due April 15, 2023 for January through March 2023.
    - Link to updated cost share form
    - Link to updated instructions
- Mapping next steps – Willow Creek Valley – Stephen put together a new floodplain map that is a good resource.
- Outreach To Do
    - Link to project website! Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan
    - Suggest interested parties, engage community representatives in action item development.
- Next Committee Meeting: Tuesday, March 21, 2 PM – 4 PM in Irrigon, North Morrow Government Center & Online via Zoom.

Figure 14. March 21, 2023 Steering Committee meeting #5 agenda

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
AGENDA

OREGON
Department of Land Conservation & Development

Tuesday March 21, 2023
2:00 PM– 4:00 PM

HYBRID – North Morrow Annex (215 NE Main Ave., Irrigon) & Online
Join Zoom Meeting
https://us02web.zoom.us/j/89601631440?pwd=NGhLeFVWMktDMmUyejRoYkJOa3R3UT09
Meeting ID: 896 0163 1440, Passcode: 708358
One tap mobile: +12532050468,,89601631440#,,,,*708358# US

Welcome/Introductions	**2:00 pm**
• Please share your name, title, and jurisdiction. • Review and approve notes from meeting #4 • Review project timeline	Stephen Wrecsics, Morrow County Tamra Mabbott, Morrow County Susan Millhauser, DLCD
Draft Risk Assessment	**2:10 pm**
• Finish preliminary ranking of the proposed hazards (HVA) for south Morrow County (10m) • Discuss High Hazard Potential Dams (HHPD) (10m) • Affirm overall priorities and hazard risk rankings (10m)	All
Mitigation Strategy: Review Plan Goals	**2:40 pm**
• Reaffirm and/or make updates ○ New FEMA requirements to address planning for climate change and equitable outcomes, community lifelines, and HHPD • For reference in our next steps in action item development.	All
Project Map Development	**3:10 pm**

• Review 2016 NHMP maps
• Discuss potential updates and data needs
  ○ Critical facilities and infrastructure
  ○ Community lifelines
  ○ Socially and economically vulnerable communities
	All

Progress Report: Mitigation Actions & Annexes	3:40 pm
• Share action items that might be relevant for others to collaborate on or add to their mitigation action list. • Review Mitigation Action descriptions template and table template	All
Next Steps	**3:55 pm**
• Continue to refine annexes and action items, including mitigation action description forms. Updated mitigation actions and annexes due 4/17/23. • Review/refine project maps. • Discuss mitigation strategy and plan maintenance process. • Presentation from Oregon Climate Change Research Institute (OCCRI) and review of Department of Geology and Mineral Industries (DOGAMI) report to be scheduled → refine risk assessment/inform mitigation strategy	Next meeting: 4/18/23 in Irrigon, North Morrow Government Center & Online

Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan

Figure 15. March 21, 2023 Steering Committee meeting #5 adopted notes

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
NOTES

OREGON
Department of
Land Conservation
& Development

Tuesday March 21, 2023
2:00 PM– 4:00 PM
HYBRID – North Morrow Annex (215 NE Main Ave., Irrigon) & Online
Meeting recording: https://dlcd.box.com/s/lf93qrvv6ki5zqvz4me9ey03293pslpd
Meeting presentation: https://dlcd.box.com/s/0q7pwlfybt5x3ev28tl8p57ge9xc33j8

Attendees:

Eleven people representing five jurisdictions, one special district, one utility, and one state agency attended the fifth meeting of the 2023 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan.

In-person
Aaron Palmquist, City of Irrigon, City Manager
Carla Mckane, Irrigon Contract Planner/ Boardman Planning Official
Tamra Mabbott, Morrow County Planning Director
Stephen Wrecsics, Morrow County GIS Technician
Susan Millhauser, DLCD Natural Hazard Planner, Project Manager

Online
Elizabeth Peterson, City of Ione, City Manager
Shad Hass, City of Ione, Public Works Director
Veronica Hess, Lexington Town Recorder (partial)
Brian Kollman, Operations Manager, Columbia Basin Electric Cooperative for Andy Fletcher
Jared Huddleston, Morrow Soil and Water for Kevin Payne, District Manager Morrow SWCD
Dawn Hert, DLCD Eastern Oregon Regional Representative

Welcome/Introductions:

- Attendees introduced themselves.
- The meeting notes from February 21, 2023 were briefly discussed and accepted.
- The Steering Committee reviewed the updated project timeline to better reflect the outreach strategy:
    - The risk assessment will be available for public review in April/May, hosted on the County website with feedback via email to the County, with cities helping to get out the word.
        - The County will advertise in local papers and post on the website and cities can share and get the word out.
        - We need to be very clear what is meant by natural hazards, e.g., does not include nitrate contamination of drinking water.

        - Make sure that the public is aware of the timeline for adoption, e.g., here's where we're at in the process and the projected timeline for adoption.
    - Public review/input of the mitigation strategies will happen in the summer, with two meetings or open houses, one held in north county and the other in south county.
        - County/cities are responsible for doing the outreach, DLCD can help with the content and putting together materials.
        - Discussed having a simple flyer that's double-sided, including translation to Spanish – the County may have some budget for translation. County-wide close to minority-majority Spanish-speaking population
        - Originally planned for outreach via a booth at the County Fair via Emergency Manager. For the last NHMP Planning had a booth at the Watermelon Festival.
        - Also, should reach out to the Chambers of Commerce.
    - For adoption, planned for October-December 2023, each city and the county will have to hold a public hearing.
        - Is there support available for the cities? Paul initially indicated he would be available to attend council hearings to provide support. Need to confirm with Paul. As we get closer to adoption, we should revisit the strategy.
        - Cities must adopt their annexes, which are included in the full county plan to be adopted by the BCC. It's the jurisdictions' responsibility to keep their decision-makers in the loop so feedback can be incorporated prior to presenting the annexes and plan for adoption. The draft risk assessment might be a good step to share with city councils/BCC.
        - Boardman and Irrigon plan to adopt the NHMP as a standalone document. Afterwards, there may be adoption by reference to the Comp Plan as part of Goal 7 work. Can adopt by reference to allow for future plan updates without having to do a comp plan amendment.

Draft Risk Assessment

- Discussed the preliminary ranking of the proposed hazards via the Hazard Vulnerability Assessment (HVA) for south Morrow County.
    - At the February meeting, which was focused on south county, the group confirmed the list of hazards and completed most of the HVA but ran out of time to wrap it up. The north county HVA was completed in January.
    - Susan will follow up with Ione, Lexington, and Heppner staff to adjust ratings to reflect south county hazard priorities.
    - Overall priorities and hazard risk rankings still need to be reviewed and affirmed by the steering committee. Can revisit after the draft DOGAMI risk assessment is presented and discussed.
- Discussed High Hazard Potential Dams (HHPD). FEMA's National Dam Safety Program now requires local NHMPs to address dam safety for HHPD grant eligibility.
    - There are seven dams in Morrow County, per the National Inventory of Dams (army.mil), which the committee discussed in terms of risk.
        - The Willow Creek Dam outside of Heppner, owned by the USACE, is the only one identified in the inventory as a High Hazard Potential Dam and it has an Emergency Action Plan, which is the required plan.
        - Why don't we also talk about dams outside the county that could impact Morrow county, such as a potential impact from McNary Dam? There's no limit

  - Let's make sure transportation networks, energy grid, fuel delivery, etc. are identified through this process to understand their vulnerabilities.
  - Communication facilities, broadband, etc. Owners may not want them mapped but we can inquire about what owners are doing to ensure these are resilient to natural hazards. Are there projects the county can support to help better protect these facilities?
  - Steering committee to refine priority community lifelines.
    - Susan can the reach out to communications, energy, other companies as a neutral third party.
- The committee discussed the plan goals generally considering the new FEMA requirements.
  - Committee] put a lot of time into the goals last time, they are high enough level – unless there's a red flag for FEMA for what is or isn't in there, would rather not make any changes.
  - Goal 1 – should it also include people? Goal 1 is focused on protecting property to make sure the people that live/work there are safe. Goal 3 is preventative and focused on reducing the threat of loss of life and property.
    - FEMA's focus is on investing to project community investments. Look at other plans, Umatilla?
    - Focus is on mitigation to protect property that can affect lives. Don't want it to be too broad to go past natural hazards.
  - Goal 7 – second bullet might actually be more easily achieved due to restructuring Emergency Management into a standalone function.
  - Susan to review then share back by email with the group.

Project Map Development

- Reviewed the 2016 NHMP maps and 2018-2019 CWPP maps and discussed potential updates and data needs related to critical facilities and infrastructure, community lifelines, and socially and economically vulnerable communities.
  - Boardman and Heppner have new fire stations.
- What about bridges? Have the shape files from the CWPP, would be smart to identify for evacuation routes planning, identify as critical pinch point. Could include a project to identify which bridges or routes are substandard from an emergency response perspective.
- CWPP communities at risk – ODF Communities at Risk Report, came out in 2020. Stephen recalls they identified during the update.
- Confirm any updated fire protection districts near Irrigon, Boardman is serving an area but there hasn't been a vote yet to change the boundary.
- Any historic fires > 50 acres in size since the update?
- Discussed how WUI was determined in the CWPP. Identified areas of impact with concentrations of buildings, then did a buffer around them.
  - The WUI map may look different now, the bombing range now has fire protection but they're no longer dropping live munitions. Higher risk around the bombing range, but there is a 50–60-foot fire break. Confirm Cecille is on the WUI map, on Hwy 74 northwest of Ione.
- Are there geographic areas, types of communities such as manufactured home parks in the county that are more at risk?

- Area of landslide alluvial fan showing a historic/ prehistoric landslide was mapped. Don't use red!
- Stephen suggested for lifelines having a set of separate maps. Come up with a list and share with the cities to put on the map for their city, for example, food distribution center, fuel storage, etc. Having critical facilities elevated will help to prioritize. He will send maps to the cities for mark up and review.

Progress Report: Mitigation Actions & Annexes 3:40 pm

Mitigation actions discussion:

- Boardman and Irrigon action items from Carla were sent to Pam. Didn't yet identify any new action items, will need the form.
- Need an estimated cost for each mitigation project and timeline, which department is leading if more than, and priority for that organization. An action item form template is on Box, can customize for each jurisdiction. Susan will share links again in the follow up email.
- County – Stephen got updates from the roads department. Reviewed county actions, most are road improvements. Reach out to Sandy to see if there should be a flood mitigation project for the fairgrounds in Ione.
- Ione – Willow Creek 1979 flood took out the bridge, which has since been raised and hasn't backed up and flooded since. Rhea Creek dumps into Willow Creek. Is there an upstream opportunity for mitigation? Or a project to remap the floodplain? Ione met with FEMA representative, and it will cost $$ to do the work and a study. Important to include on the project list to help identify funding for a study if it hasn't been done yet, to lead to floodplain remapping (LOMAR) as many properties are still paying for flood insurance when that may not have to.
    - Liz will send Susan the City Council report from a couple of years ago.
- Lexington – A similar project could be beneficial, an assessment of flood mitigation that is appropriate to reduce the overall floodplain area if possible. Regarding Lexington water feasibility project, should call out looking for additional sources of water for the city, only have a single system and no back up (study next steps).
- Heppner – has a similar need for a backup water supply system. Hospital doesn't have enough water pressure to do appropriate fire suppression. Susan noted her conversation with Kraig, reflected on another spreadsheet, about the engineering studies being done.
- Are there language updates that should be tweaked? Example from Heppner (H06-03), is there newer updated language or references?
- Need to provide out more detail on the worksheets, can note if there's a change in need or technology. How do you reflect an old project that needs to be tweaked? Can it be renumbered, so the original intent isn't lost? Don't want to delete old projects but can add with a new number. Can cross-reference the old numbers.
    - Susan will look at how other plans have done that, don't want to lose the intent.
- Possible generators from Amazon for well backup electricity? Could lead to a project update, for example, to address a specific issue a different way.
- Susan to combine and send out to everyone with links and next steps. Need additional information about which hazards are being addressed with which projects, such as enlarging culverts, cost estimates, etc.
- Reviewed the mitigation action table template that will include all of the actions by hazard, with cross-refences to joint projects.

Annexes:

- Liz and Chad talked with Pam about the Ione annex.
- Irrigon and Boardman have started, and Carla will continue to work on those.
- Susan will check in with other jurisdictions.

Next Steps:

- Continue to refine annexes and action items, including mitigation action description forms. Updated mitigation actions due 4/17/23. Annexes can continue to be refined over the next two months.
- Continue to track time and engagement activities. Cost share forms are due April 15, 2023 for January through March 2023. Susan will send out at the first week of April to everyone as reminder with steering committee meetings filled in, please add additional meetings or time spent otherwise.
  - Link to updated cost share form
  - Link to updated instructions
- Outreach To Do
  - Link to project website! Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan
  - Suggest interested parties, engage community representatives in action item development.
- Review/refine project maps – Stephen with feedback from the jurisdictions.
- Presentation from OCCRI and review of DOGAMI report still to be scheduled.
- Carla will email Susan for Box access.
- Next Committee Meeting: Tuesday, April 18, 2 PM – 4 PM in Irrigon, North Morrow Government Center & Online via Zoom.

Figure 16. April 18, 2023 Steering Committee meeting #6 agenda

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
AGENDA

OREGON
Department of Land Conservation & Development

Tuesday April 18, 2023
2:00 PM– 4:00 PM

HYBRID – North Morrow Annex (215 NE Main Ave., Irrigon) & Online
Join Zoom Meeting
https://us02web.zoom.us/j/89601631440?pwd=NGhLeFVWMktDMmUyejRoYkJOa3R3UT09
Meeting ID: 896 0163 1440, Passcode: 708358
One tap mobile: +12532050468,,89601631440#,,,,*708358# US

Welcome/Introductions	**2:00 pm**
• Please share your name, title, and jurisdiction • Review and approve notes from meeting #5	Stephen Wrecsics, Morrow County Tamra Mabbott, Morrow County Susan Millhauser, DLCD
DOGAMI Draft Risk Assessment	**2:05 pm**
• Presentation and Q&A	Matt Williams, Oregon Department of Geology and Mineral Industries, Geohazards Analyst
NHMP Draft Risk Assessment	**3:05 pm**
• Discuss overall priorities and hazard risk rankings	All
Mitigation Strategy: Review Plan Goals	**3:15 pm**
• Discuss / finalize draft updated goals ○ New FEMA requirements	All
Project Map Development	**3:30 pm**
• Review updated NHMP maps	All
Progress Report: Mitigation Actions & Annexes	**3:45 pm**
• Share action items that might be relevant for others to collaborate on or add to their mitigation action list.	All
Next Steps	**3:55 pm**
• OCCRI Future Projects Report presentation • Draft risk assessment review and feedback • Continue to refine annexes and action items, including mitigation action description forms. • Discuss mitigation strategy & plan maintenance process.	Next meeting: 5/16/23 in Irrigon, North Morrow Government Center & Online

Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan

Figure 17. April 18, 2023 Steering Committee meeting #6 adopted notes

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
NOTES

OREGON
Department of Land Conservation & Development

Tuesday April 18, 2023
2:00 PM– 4:00 PM
HYBRID – North Morrow Annex (215 NE Main Ave., Irrigon) & Online
Meeting presentation: https://dlcd.box.com/s/gpzxr6zhltvp3jzwa150khezalsfiswl

Attendees:

Ten people representing four jurisdictions, one special district, and two state agencies attended the sixth meeting of the 2023 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan.

In-person
Tamra Mabbott, Morrow County, Planning Director
Stephen Wrecsics, Morrow County, GIS Technician
Rolf Prag, City of Boardman, Special Projects Coordinator

Online
Aaron Palmquist, City of Irrigon, City Manager
Carla McLane, City of Irrigon, Contract Planner/City of Boardman, Planning Official
Steve Rhea, Heppner Rural Fire Protection District, Fire Chief
Veronica Hess, Town of Lexington, Town Recorder
Matt Williams, Oregon Department of Geology and Mineral Industries, Geohazards Analyst
Susan Millhauser, DLCD, Natural Hazard Planner, Project Manager
Dawn Hert, DLCD, Eastern Oregon Regional Representative

Welcome/Introductions:

- Attendees introduced themselves.
- The meeting notes from March 21, 2023 were briefly discussed and accepted.

DOGAMI Draft Risk Assessment

- Matt Williams, Geohazards Analyst with the Department of Geology and Mineral Industries (DOGAMI) presented the draft DOGAMI Risk Assessment, and the steering committee provided feedback.
    - Draft report, goal is to receive feedback from committee members at the meeting or afterwards (matt.williams@dogami.oregon.gov, 971-940-4908). DLCD will receive a Word document of the draft report and data sets with hazard results so parts can be included in the NHMP and its annexes, as well as a public facing document that is more generalized.
        - Stephen will send an updated critical facilities list to Matt if there are updates after jurisdictions review draft maps.

Morrow County MJNHMP Steering Committee Meeting, April 18, 2023 Page 1

    - Not scoped yet to look at dam safety and some other factors.
    - Assessor and building footprint data combined into the building data set that's used in FEMA's Hazus hazard identification software analysis of risk to people and property.
        - SC: In terms of population density, may want to consider Blake's Ranch and Penland Lake communities within the national forest. DOGAMI: The buildings will be included in the analysis but not included in a separate table, but they can be pulled out of the GIS data.
    - Higher than typical value in commercial/industrial buildings in Boardman.
    - Hazard impact on critical facilities - model doesn't consider actual infrastructure like runway and water treatment ponds, only considers buildings.
    - Landslide mapping data and channel migration data was recently developed (2021).
    - Horse Heaven fault – quaternary fault which means it moved in the last 10,000 years roughly.
    - Flood – 500-year is higher than typical.
        - SC: Hinton Creek is the source of continued flooding, not Willow Creek, and other contributing creeks as you get closer to Lexington and Ione. Try to coordinate with the Corps.
    - Landslide – most of hazard is along Route 74 leading to potential roadblocks. For areas that have more data, such as landslides, there is a higher degree of confidence.
    - Channel migration from Willow Creek and Rhea Creek.
    - Wildfire is using burn probability layer overlaid with structures. CWPP is another source of data.

NHMP Draft Risk Assessment

- The committee discussed the preliminary ranking of the proposed hazards via the Hazard Vulnerability Assessment with the draft DOGAMI Risk Assessment in mind. See notes in the 4/18/23 HVA spreadsheet (linked here on Box).
    - Clarified that per FEMA, High Hazard Potential is a classification standard for any dam whose failure or mis-operation will cause loss of human life and significant property destruction.
    - Updates were made to north county earthquake hazard and dam safety was completed.
    - For south county, dam safety was completed, and the overall rankings were discussed and completed.

Mitigation Strategy: Review Plan Goals

- There wasn't time to discuss – Susan will send via email and ask for people to review/come to the May meeting ready to discuss and finalize.

Project Map Development

- Jurisdictions were asked to review updated critical facilities and new community lifelines maps, shared by Stephen earlier in the month.
- Feedback was received from Irrigon.
- Stephen reviewed the online maps and spreadsheet to make comments. Jurisdictions need to review and provide feedback to Stephen soon so we can discuss the maps in May.

Progress Report: Mitigation Actions & Annexes

Mitigation actions discussion:

- Susan encouraged jurisdictions to continue to refine mitigation actions, especially timeline and costs.

Annexes:

- Carla is working on draft for Irrigon and Boardman and will be refining in the next few weeks. Susan will be working on the other jurisdictions.

Next Steps:

- Jurisdictions should continue to refine action items, including mitigation action description forms. Cost and timeline information needs to be included.
- Send completed 2023 Q1 cost share forms to Susan; forms for review and signature were sent out on April 6, 2023.

- Next Committee Meeting: Tuesday, May 16, 2 PM – 4 PM in Irrigon, North Morrow Government Center & Online via Zoom.
  - OCCRI Future Climate Projections Report presentation
  - Review/refine project maps based on feedback from the jurisdictions
  - Review draft updated goals

- Draft risk assessment review and feedback

- Ongoing Outreach To Do
  - Link to project website! Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan
  - Suggest interested parties, engage community representatives in action item development.

Figure 18. May 16, 2023 Steering Committee meeting #7 agenda

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
AGENDA

OREGON
Department of Land Conservation & Development

Tuesday May 16, 2023
2:00 PM– 4:00 PM

HYBRID – North Morrow Annex (215 NE Main Ave., Irrigon) & Online
Join Zoom Meeting
https://us02web.zoom.us/j/83708135932?pwd=YjliMmtnQVFaV0NiSk9BZkt1dW9Tdz09
+13462487799,,83708135932#,,,,*521047# US (Houston)

Welcome/Introductions	**2:00 pm**
• Please share your name, title, and jurisdiction • Review and approve notes from meeting #6	Stephen Wrecsics, Morrow County Tamra Mabbott, Morrow County Susan Millhauser, DLCD
Future Climate Projections for Morrow County	**2:05 pm**
• Presentation and Q&A	Erica Fleishman, Director, Oregon Climate Change Research Institute, Professor, College of Earth, Ocean, and Atmospheric Sciences Oregon State University
Mitigation Strategy: Review Plan Goals	**2:50 pm**
• Discuss / finalize draft updated goals	All
Project Map Development	**3:15 pm**
• Review updated NHMP maps	All
NHMP Draft Risk Assessment	**3:30 pm**
• Side by side comparison HVA	All
Progress Report: Mitigation Actions & Annexes	**3:45 pm**
• Share action items that might be relevant for others to collaborate on or add to their mitigation action list.	All
Next Steps	**3:55 pm**
• Draft risk assessment review and feedback	Next meeting: to be determined
• Continue to refine annexes and action items, including mitigation action description forms. • Discuss mitigation strategy & plan maintenance process.	

Morrow County MJ NHMP Website: https://www.co.morrow.or.us/emergency/page/natural-hazard-mitigation-plan

Figure 19. May 16, 2023 Steering Committee meeting #7 adopted notes

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
NOTES

OREGON
Department of
Land Conservation
& Development

Tuesday May 16, 2023
2:00 PM– 4:00 PM
HYBRID – North Morrow Annex (215 NE Main Ave., Irrigon) & Online
Meeting presentation: https://dlcd.box.com/s/lrdg3wqzep91njhbb3k4kq51x1jmloxg
Zoom meeting recording: https://dlcd.box.com/s/9ankb8g6zgrho99gq35lekri6why1vn9

Attendees

12 people representing six jurisdictions, one special district, one state agency, and one state research institute, attended the seventh meeting of the 2023 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan.

Online
Tamra Mabbott, Morrow County, Planning Director
Stephen Wrecsics, Morrow County, GIS Technician
Rolf Prag, City of Boardman, Special Projects Coordinator
Carla McLane, City of Irrigon, Contract Planner/City of Boardman, Planning Official
Kraig Cutsforth, City of Heppner, City Manager
Elizabeth Peterson, City of Ione, City Manager
Veronica Hess, Town of Lexington, Town Recorder
Danielle Hoeft, Morrow County Health District
Emily Roberts, Morrow County Health District, CEO
Dwayne Marsh, Morrow County Health District, Pioneer Memorial Hospital
Erica Fleishman, Director, Oregon Climate Change Research Institute
Susan Millhauser, DLCD, Natural Hazard Planner, Project Manager

Welcome/Introductions

- Attendees introduced themselves.
- The meeting notes from April 18, 2023 were discussed and accepted.

Future Climate Projections for Morrow County

The Oregon Climate Change Research Institute (OCCRI) provides county-level climate projection reports relevant to natural hazards in support of DLCD's work with counties to update their NHMPs. More information available at https://blogs.oregonstate.edu/occri/projects/dlcd/.

Erica Fleishman, OCCRI Director, and Professor, College of Earth, Ocean, and Atmospheric Sciences at Oregon State University, provided an overview of what will be included in the draft Future Climate Projections report for Morrow County.

- Providing a general overview today, we'll have the draft written report in about three weeks for the Steering Committee to review and comment on.

- Opportunity today to provide feedback about areas the committee wants to specifically address.
- The focus is on the impacts of climate change on infrastructure and people, per new FEMA requirements.
- Reviewed demographics, pulling from Oregon population projections, census data, other sources for vulnerable populations. Any local information or data is welcome.
- Reviewed historic climate baseline and climate projections.
- Overview of climate impacts, will receive more detailed information in the report:
  - Extreme heat will become more frequent.
  - Magnitude of extreme heat will increase.
  - Cold extremes are becoming less frequent and intense, not as rapid as heat increases. We should have less but they are going to be warmer.
  - Precipitation – not a whole lot of change for Morrow County. However, precipitation is becoming flashier, more precipitation in the form of rain rather than snow.
  - Increased winter flood risk. Erica would like any available data from cities about residences and structures in flood prone areas.
  - Drought – summer soil moisture projected to increase with more summer runoff, but lower summer precipitation.
  - Wildfire based on vegetation dryness, soil moisture, and atmosphere; increase in the number of days with higher fire danger and additional days with drier atmosphere. Source of fires – about 1/3 are human-caused in Morrow. Map of fire ignitions.
  - Air quality will be reduced – increase of wildfire smoke and fine particulate matter, number of smokey days and concentration of fine particulate matter.
  - Windstorms – little evidence that wind speed and patterns are changing across the state. However, when we get strong winds, it's more likely to be hotter and drier with associated increased risk.
  - Loss of wetlands – related to groundwater.
  - Expansion of non-native invasive species - related to changes in carbon dioxide, temperature, and precipitation.
- Summary tables will show risks with levels of confidence.

Steering Committee questions and discussion:

- How do we incorporate this into the NHMP?
  - Elements will be included in the hazards section. Can also be used to help determine if there are any changes to possible priorities. More of a filter or a lens through which to prioritize mitigation projects.
  - Some of the social vulnerability impacts might be considered differently, e.g., language and alert systems and enhanced protections for outdoor workers.
- Local floodplain data sources – Floodplain development permit is a local permit; Boardman does the building permits. Heppner has a Floodplain Manager (Kim).
- Language issues or concerns about how climate change was discussed. 90% of the information could be decoupled from the term climate change. Could focus more on climate trends.
  - Average annual temperature slide – how to best explain the trends based on historical data and climate projections?
    - In part it's related in increase in GHGs, which has sped up the rate of increase as well as total increase. Trend is unmistakably upward globally. Can show what's in the record as well as the projections.

- The natural world can rebound, this has happened in the past. How do we consider that?
  - Agree that nature will rebound, this is more concerned about impacts of increased hazards due to climate change on people, where they live and how they work, as well as potential impacts of displacement of people from certain areas.
- County-specific priority hazards include winter storms, ice, and freezing fog.
  - OCCRI can't make projections for ice or freezing fog but can address these hazards in the report.
    - Difference in elevation creates differences in localized weather. North County inversion due to the Columbia River. From the Gorge to the Wallula Gap.

Mitigation Strategy: Review Plan Goals

- The Steering Committee discussed the draft updated goals, had no concerns, and agreed to the proposed updates.
  - Regarding the additional focus on economic and social vulnerability, having broader goals may provide opportunities to address multiple issues, such as homelessness – where is housing built considering natural hazard risks and could funding from a variety of sources, including FEMA, be combined to help with housing people.

Project Map Development

- Jurisdictions were asked to review updated critical facilities and new community lifelines maps (Critical Infrastructure/Community Lifelines).
  - Stephen will resend the link to spreadsheet to the committee.
  - Feedback has been received from Irrigon and Lexington.
  - Critical infrastructure maps are pretty much done – added the new the Ione Rural Fire Protection District station and school and the new firehall in Lexington.
- Discussed including energy facilities, such as local transmission lines post 911. How do we want to include on the maps? How do other communities do this?
  - We could have two maps – one released to the public with a list of critical infrastructure and another one not for public release. Not sure about public information requests.
- Stephen will do vicinity maps for the annexes.
- Do people find it helpful to have a map or maps showing social vulnerability for the county?
  - Map for Morrow County from the CDC/ADSTAR (Agency for Toxic Substances and Disease Registry) Social Vulnerability Index interactive map was shared in the PowerPoint (https://www.atsdr.cdc.gov/placeandhealth/svi/interactive_map.html). Uses 2020 census tract data for four key social vulnerability indicators: socioeconomic status, household characteristics, racial and ethnic minority status, and housing type and transportation.
  - PSU beta tool in development using the same CDC data/2020 census tract data, where the varies SVI attributes can be weighted: http://stage.prcprojects.us/equity
  - Census tract data, not a very granular look. Morrow County has just three census tracts which cover a very large geography. Not sure how it would be used for mitigation planning. If not useful, why include.
- Could map locations for people seeking shelter and accessing electricity.
  - Potential mass shelter sites should be included on the critical facilities maps.
- Does Morrow County Health District have data about social vulnerability?

- Don't have a list of people who are on medical equipment (oxygen, CPAP machines, refrigeration needs for prescriptions) related to power outages.
    - Ask Paul? How do larger cities do this? Not all people are MCHD patients.
    - Could develop a project to ask people to sign up for alerts through emergency management who might have special needs. Add to mitigation actions
- The disaster preparedness plan from MCHD shows where they will revert to provide services, which may be helpful information for the other jurisdictions, but don't have a map. Emily asked her staff to send it to Susan.

NHMP Draft Risk Assessment

- A side-by-side comparison of the Hazard Vulnerability Assessments for north and south county was shared. The steering committee made updates to both last month; we will revisit after receiving the DOGAMI risk assessment report. See notes in the 4/18/23 HVA spreadsheet (linked here on Box).

Progress Report: Mitigation Actions & Annexes

Mitigation actions discussion:

- Susan encouraged jurisdictions to continue to refine mitigation actions, especially timeline and costs.
- The mitigation action template form and proposed combined table examples were shared with the committee.

Annexes:

- Carla is working on draft for Irrigon and Boardman and will be refining in the next few weeks.
- Susan will be working on the other jurisdictions' annexes.

Next Steps

- Draft risk assessment review and feedback
- Continue to refine annexes and action items, including mitigation action description forms.
- Discuss mitigation strategy & plan maintenance process.

Next meeting

- To be determined. Propose not meeting in June, with a meeting in July, potentially July 12, 2-4pm.
- Susan will send out a doodle poll.

Figure 20. July 18, 2023 Steering Committee #8 agenda

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
AGENDA

OREGON
Department of Land Conservation & Development

Tuesday July 18, 2023
2:00 PM– 4:00 PM

HYBRID – North Morrow Annex (215 NE Main Ave., Irrigon) & Online
Join Zoom Meeting
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Welcome/Introductions	**2:00 pm**
• Please share your name, title, and jurisdiction • Review and approve notes from meeting #7	Stephen Wrecsics, Morrow County Tamra Mabbott, Morrow County Susan Millhauser, DLCD
Future Climate Projections for Morrow County	**2:05 pm**
• Report Updates • Feedback	Erica Fleishman, Director, Oregon Climate Change Research Institute, Oregon State University
NHMP Draft Risk Assessment	**2:25 pm**
• Risk assessment review and discussion • Updates to the HVA • Public outreach and feedback approach	Susan
Progress Report: Mitigation Actions & Annexes	**3:15 pm**
• Continue to refine action items • Status of annexes	All
Project Map Development	**3:45 pm**
• Review updated NHMP maps	Stephen
Next Steps	**3:55 pm**
• Continue to refine annexes and action items, including mitigation action description forms. • Discuss mitigation strategy & plan maintenance process. • Cost share due July 21	Next meeting: to be determined

Morrow County MJ NHMP Website: https://www.co.morrow.or.us/planning/page/nhmp-update

Figure 21. July 18 Steering Committee #8 draft notes

Draft

Morrow County
Multi-Jurisdictional
Natural Hazard Mitigation Plan
2023 Update Meeting
NOTES

OREGON
Department of Land Conservation & Development

Tuesday July 18, 2023
2:00 PM– 4:00 PM
HYBRID – North Morrow Annex (215 NE Main Ave., Irrigon) & Online
Meeting presentation: https://dlcd.box.com/s/07wyx4dnmuaprvttcggo8wpmbc83esca
Zoom meeting recording: https://dlcd.box.com/s/ltxdx4psx1mnggvuoh7xu96ued9s2s6

Attendees

8 people representing two jurisdictions, one special district, one state agency, and one state research institute, attended the eighth meeting of the 2023 Morrow County Multi-Jurisdictional Natural Hazard Mitigation Plan.

Online
Stephen Wrecsics, Morrow County, Associate Planner
Tommy Wolf, City of Heppner, Interim City Manager (replacing Kraig Cutsforth)
Danielle Hoeft, Morrow County Health District
Emily Roberts, Morrow County Health District, CEO
Dwayne Marsh, Morrow County Health District, Pioneer Memorial Hospital
Erica Fleishman, Director, Oregon Climate Change Research Institute
Dawn Hert, DLCD, Eastern Oregon Regional Representative
Susan Millhauser, DLCD, Natural Hazard Planner, Project Manager

Welcome/Introductions

- Attendees introduced themselves.
- The meeting notes from May 16, 2023 were discussed and accepted.

Future Climate Projections for Morrow County

The committee was provided a draft of the Future Climate Projections for Morrow County report in mid-June for review and feedback; no feedback was received.

Erica Fleishman, OCCRI Director, and Professor, College of Earth, Ocean, and Atmospheric Sciences at Oregon State University, attended the meeting to review the final report, including changes made based on the committee's questions and feedback from the May 2023 meeting, including (see meeting presentation linked above for details):

- Adjustments were made to compare the historical period with the projected changes for the period we're in now. Projected averages are a little higher than what's been observed over the past years. Comparing observations with projections were within a reasonable range.

Morrow County MJNHMP Steering Committee Meeting, July 18, 2023 Page 1

Draft

- Updates were made to clarify the period of record and how it compares to historic levels of greenhouse gas (GHG) emissions and global climate change since industrialization, with the data supporting an unprecedented change in the geologic record.
- Included in the report is what's occurred with three main GHGs and how they compare to carbon dioxide in terms of impact.
    - Carbon dioxide sticks around for 300 years, methane contribution is about 12 years, etc. The net increase is caused by people. Understandings this can help to prioritize investment in reduction.
- Added more information regarding freezing rain and fog, as well as ice accretion. These are tricky to model. Also reviewed the response of these to climate change, with the result being not much change with medium confidence.
- Committee discussion and questions:
    - Appreciate the updates to explain the historic record, current period, and projections.
    - How are we doing in terms of not exceeding IPCC projections of 2°C warming?
        - A: Globally we're at 1.5°C and Oregon is fairing slightly better.
    - Are there portions of the state that will receive a greater impact than others?
        - A: Generally speaking, some changes are based on geography – where in the state in terms of impacts such as types of storms and what they'll deliver, temperature extremes. Heat and drought are the main issues in eastern Oregon, including effects on public health, wildfire suppression, more precipitation as rain rather than snow which affects water availability in many parts of the state. Oregon is not projected to get more humid. These may be long term, with mitigation harder and adaptation an important strategy. Also, for eastern Oregon it will be important to consider the potential influx of people from a Cascadia Subduction Zone earthquake.
    - In the NHMP it'll be important to identify areas that could serve as cooling centers, which can double as clean air shelters, respite from wildfire smoke, warming, etc. as a mitigation action.
    - The NHMP could also talk about trends in drought, regardless of the impacts of climate change and future projections.
- Erica is available to answer any additional questions.

NHMP Draft Risk Assessment

The goal is to review information from the Oregon Department of Geology and Mineral Industries (DOGAMI) report, consider what we learned from the OCCRI Future Climate Projections report, and then discuss updates to the Hazard Vulnerability Assessment based on this new information to potentially revise the Hazard Vulnerability Assessment.

Risk assessment review and discussion - Matt Williams from the Oregon Department of Geology and Mineral Industries (DOGAMI) presented an overview of the risk assessment at the April committee meeting. DOGAMI's draft Multi-Hazard Risk Report for Morrow County is in technical review so not yet available to the public. Susan provided an overview of the report, briefly summarized below and in the presentation linked above, including committee questions and discussion:

- The DOGAMI report describes the methods and results of a natural hazard risk assessment for Morrow County communities. The results quantify the impacts of natural hazards to each community and enhance the decision-making process in planning for disaster.

- Three main tasks include 1) Compiling an asset database, 2) Identifying and using the best available hazard data, and 3) Performing natural hazard risk assessment.
- Results broken out into geographic areas: Unincorporated Morrow County (rural), City of Heppner, City of Irrigon, City of Boardman, City of Ione, and City (Town) of Lexington
- Limited the project scope to natural hazard impacts on buildings and population because of data availability, the strengths and limitations of the risk assessment methodology, and funding availability. They did not directly analyze impacts to the local economy, transportation routes, community lifelines, stored hazardous materials, land values, socially vulnerable populations, or the environment.
- Impacts to building and population include number of red-tagged and yellow-tagged buildings, building value loss estimate and loss ratio, non-functioning critical facilities, and potentially displaced population.
- Focus on geologic hazard scenarios and wildfire risk assessment:
    - Earthquake Risk Assessment
    - Flood Risk Assessment
    - Landslide Risk Assessment
    - Channel Migration Risk Assessment
    - Wildfire Risk Assessment
- Detailed draft tables and charts are included in the presentation, linked above.
- The report includes conclusions and recommendations.
- Q: Regarding actions to reduce impacts from earthquakes, is there funding for retrofitting buildings?
    - A: An outcome of the NHMP is to identify and prioritize mitigation projects and identify potential funding sources.

Updates to the HVA – The committee decided to wait to discuss an update of the Hazard Vulnerability Assessment as there was only one city representative at the meeting. The goal will be to review and revise the HVA considering the results of the DOGAMI and OCCRI reports. Also, the HVA results will need to be revisited for some hazards to ensure that they reflect the committee's priory rankings. Susan will reach out to the cities to try and get something scheduled, one call for north county and another for south county.

Public Outreach and Feedback Approach

Susan shared the project timeline and noted that the risk assessment was scheduled to be completed in the spring but has been delayed as we just received the draft DOGAMI report and suggested developing revising the schedule and extending the project timeline.

- Originally the outreach plan included outreach during the County Fair and holding meetings in both north and south county.
- The risk assessment and draft mitigation actions can be shared and reviewed separately or together as the draft plan.
- We've had some conversation about placing ads, developing a high-level summary to post on the County and jurisdiction's websites along with the draft plan, and promote through local chambers and other channels. We should also consider how to best connect with people who speak Spanish.
- The schedule shows the community meetings to be held in late August, and with a revised schedule will have time to better plan for them and include the risk assessment and mitigation

Draft

actions, which will be of interest to community members, partners, and other governments, such the Tribes, adjacent counties, local utilities, special districts, etc.

- The steering committee needs to start thinking about potential dates and venues for the community meetings. We can work offline but do need to start planning meetings.
- Since we are just receiving the DOGAMI report the risk assessment has been pushed out, so everything needs to be pushed out further.
- Would suggest pushing the Plan Review to the end of the year or early January, with a fall (October?) steering committee meeting to discuss and refine the mitigation strategy and plan maintenance process. Followed by steering committee review and then OEM/FEMA review followed by local/county review and adoption. The grant period of performance ends Sept 30, 2024, and the project must be complete by June 30, 2024 (90 days prior to allow for OEM closeout) so we have some time to extend the process to ensure good public review and feedback.
- Susan will follow up with a revised project schedule in consultation with the County.
    - Stephen confirmed the County Planning Department doesn't have any potential FEMA grant applications; he was unsure of any from Emergency Management.
    - Susan will try and connect with Paul Grey, who recently resigned from the County, to see if he is aware of anything in the works.
- Tommy, City of Heppner, asked about strategies to ensure city councils were being updated in advance of being asked to review and approve their annexes. Susan noted that originally Paul had offered to make presentations to city councils. However, he has not been involved in the process for the past several months and now no longer works for the County so the County may want to consider another approach.

Progress Report: Mitigation Actions & Annexes

Mitigation actions discussion:

- Susan encouraged jurisdictions to continue to refine mitigation actions, especially timeline and costs. She will follow up with the jurisdictions and touch base with Carla about Irrigon and Boardman.

Annexes:

- Carla was absent so didn't receive an update on drafts for Irrigon and Boardman.
- Susan will be working on the other jurisdictions' annexes and will follow up accordingly. She and Emily, MCHD, will connect over any outstanding needed information.

Project Map Development

There were no updates to share.

Next Steps

- Cost Share due, forms coming soon!
    - Continue to track time for meetings and work outside of SC meetings
- Draft risk assessment review and feedback.
- Continue to refine annexes and action items, including mitigation action description forms.
- Discuss mitigation strategy & plan maintenance process.
- Review draft plan.

Next meeting

- To be determined in the fall. Susan will send out a doodle poll.

Link to project website and send me your link! https://www.co.morrow.or.us/planning/page/nhmp-update

Appendix C: Economic Analysis of Natural Hazard Mitigation Projects

This appendix was developed by the Oregon Partnership for Disaster Resilience at the University Oregon's Institute of Policy Research and Engagement. It has been reviewed and accepted by the Federal Emergency Management Agency as a means of documenting how the prioritization of actions shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

The appendix outlines three approaches for conducting economic analyses of natural hazard mitigation projects. It describes the importance of implementing mitigation activities, different approaches to economic analysis of mitigation strategies, and methods to calculate costs and benefits associated with mitigation strategies. Information in this section is derived in part from: The Interagency Hazards Mitigation Team, *State Hazard Mitigation Plan*, (Oregon Department of Emergency Management, 2000), and Federal Emergency Management Agency Publication 331, *Report on Costs and Benefits of Natural Hazard Mitigation*. This section is not intended to provide a comprehensive description of benefit/cost analysis, nor is it intended to evaluate local projects. It is intended to (1) raise benefit/cost analysis as an important issue, and (2) provide some background on how an economic analysis can be used to evaluate mitigation projects.

Why Evaluate Mitigation Strategies?

Mitigation activities reduce the cost of disasters by minimizing property damage, injuries, and the potential for loss of life, and by reducing emergency response costs, which would otherwise be incurred. Evaluating possible natural hazard mitigation activities provides decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects.

Evaluating mitigation projects is a complex and difficult undertaking, which is influenced by manyvariables. First, natural disasters affect all segments of the communities they strike, including individuals, businesses, and public services such as fire, law enforcement, utilities, and schools.

Second, while some of the direct and indirect costs of disaster damages are measurable, some of the costs are non-financial and difficult to quantify in dollars. Third, many of the impacts of such events produce "ripple-effects" throughout the community, greatly increasing the disaster's social and economic consequences.

While not easily accomplished, there is value from a public policy perspective in assessing the positive and negative impacts from mitigation activities and obtaining an instructive benefit/cost comparison. Otherwise, the decision to pursue or not pursue various mitigation options wouldnot be based on an objective understanding of the net benefit or loss associated with these actions.

Mitigation Strategy Economic Analyses Approaches

The approaches used to identify the costs and benefits associated with natural hazard mitigation strategies, measures, or projects fall into three general categories: benefit/cost analysis, cost- effectiveness analysis and the STAPLE/E approach. The distinction between the three methods is outlined below:

Benefit/Cost Analysis

Benefit/cost analysis is a key mechanism used by the state Oregon Department of Emergency Management (OEM), the Federal Emergency Management Agency, and other state and federal agencies in evaluating hazard mitigation projects and is required by the Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 9288, as amended.

Benefit/cost analysis is used in natural hazards mitigation to show if the benefits to life and property protected through mitigation efforts exceed the cost of the mitigation activity.

Conducting benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster-related damages later. Benefit/cost analysis is based on calculating the frequency and severity of a hazard, avoiding future damage, and risk. In benefit/cost analysis, all costs and benefits are evaluated in terms of implemented. A project must have a benefit/cost ratio greater than 1 (i.e., the net benefits will exceed the net costs) to be eligible for FEMA funding.

Cost-Effectiveness Analysis

Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. This type of analysis, however, does not necessarily measure costs and benefits interms of dollars. Determining the economic feasibility of mitigating natural hazards can also beorganized according to the perspective of those with an economic interest in the outcome.

Hence, economic analysis approaches are covered for both public and private sectors as follows.

Investing in Public Sector Mitigation Activities

Evaluating mitigation strategies in the public sector is complicated because it involves estimatingall of the economic benefits and costs regardless of who realizes them, and potentially to a largenumber of people and economic entities. Some benefits cannot be evaluated monetarily, but still affect the public in profound ways. Economists have developed methods to evaluate the economic feasibility of public decisions which involve a diverse set of beneficiaries and non-market benefits.

Investing in Private Sector Mitigation Activities

Private sector mitigation projects may occur on the basis of one or two approaches: it may bemandated by a regulation or standard, or it may be economically justified on its own merits. Abuilding or landowner, whether a private entity or a public agency, required to conform to a mandated standard may consider the following options:

- Request cost sharing from public agencies;
- Dispose of the building or land either by sale or demolition;
- Change the designated use of the building or land and change the hazard mitigationcompliance requirement; or
- Evaluate the most feasible alternatives and initiate the most cost-effective hazard mitigation alternative.

The sale of a building or land triggers another set of concerns. For example, real estate disclosure laws can be developed which require sellers of real property to disclose known defects and deficiencies in the property, including earthquake weaknesses and hazards to prospective purchases. Correcting deficiencies can be expensive and time consuming, but their existence can prevent the sale of the building. Conditions of a sale regarding the deficiencies and the price of the building can be negotiated between a buyer and seller.

STAPLE/E Approach

Considering detailed benefit/cost or cost-effectiveness analysis for every possible mitigation activity could be very time consuming and may not be practical. There are some alternate approaches for conducting a quick evaluation of the proposed mitigation activities which could be used to identify those mitigation activities that merit more detailed assessment. One of thosemethods is the STAPLE/E approach.

Using STAPLE/E criteria, mitigation activities can be evaluated quickly by steering committees ina synthetic fashion. This set of criteria requires the committee to assess the mitigation activitiesbased on the Social, Technical, Administrative, Political, Legal, Economic and Environmental (STAPLE/E) constraints and opportunities of implementing the particular mitigation item in yourcommunity. The second chapter in FEMA's How-To Guide "Developing the Mitigation Plan –

Identifying Mitigation Actions and Implementation Strategies" as well as the "State of Oregon's Local Natural Hazard Mitigation Plan: An Evaluation Process" outline some specific considerations in analyzing each aspect. The following are suggestions for how to examine eachaspect of the STAPLE/E approach from the "State of Oregon's Local Natural Hazard Mitigation Plan: An Evaluation Process."

Social: Community development staff, local non-profit organizations, or a local planning boardcan help answer these questions.

- Is the proposed action socially acceptable to the community?
- Are there equity issues involved that would mean that one segment of the community is treated unfairly?
- Will the action cause social disruption?

Technical: The city or cCounty public works staff and building department staff can help answer these questions.

- Will the proposed action work?
- Will it create more problems than it solves?
- Does it solve a problem or only a symptom?
- Is it the most useful action in light of other community goals?

Administrative: Elected officials or the city or County administrator can help answer these questions.

- Can the community implement the action?
- Is there someone to coordinate and lead the effort?
- Is there sufficient funding, staff, and technical support available?
- Are there ongoing administrative requirements that need to be met?

Political: Consult the mayor, city council or city board of commissioners, city or County administrator, and local planning commissions to help answer these questions.

- Is the action politically acceptable?
- Is there public support both to implement and to maintain the project?

Legal: Include legal counsel, land use planners, risk managers, and city council or County planning commission members, among others, in this discussion.

- Is the community authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity?
- Are there legal side effects? Could the activity be construed as a taking?
- Is the proposed action allowed by the comprehensive plan, or must the comprehensive plan be amended to allow the proposed action?
- Will the community be liable for action or lack of action?
- Will the activity be challenged?

Economic: Community economic development staff, civil engineers, building department staff, and the assessor's office can help answer these questions.

- What are the costs and benefits of this action?
- Do the benefits exceed the costs?
- Are initial, maintenance, and administrative costs taken into account?
- Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private?)
- How will this action affect the fiscal capability of the community?
- What burden will this action place on the tax base or local economy?
- What are the budget and revenue effects of this activity?
- Does the action contribute to other community goals, such as capital improvements or economic development?
- What benefits will the action provide? (This can include dollar amount of damages prevented, number of homes protected, credit under the CRS, potential for funding under the HMGP or the FMA program, etc.)

Environmental: Watershed councils, environmental groups, land use planners and natural resource managers can help answer these questions.

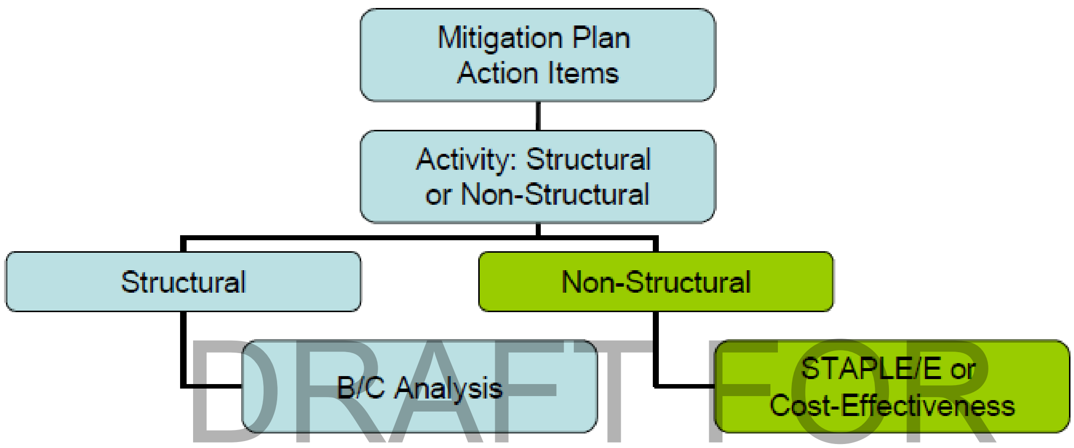
- How will the action impact the environment?
- Will the action need environmental regulatory approvals?
- Will it meet local and state regulatory requirements?
- Are endangered or threatened species likely to be affected?

The STAPLE/E approach is helpful for doing a quick analysis of mitigation projects. Most projectsthat seek federal funding and others often require more detailed benefit/cost analyses.

When to Use the Various Approaches

It is important to realize that various funding sources require different types of economicanalyses. Figure 1 is to serve as a guideline for when to use the various approaches.

Figure 1 Economic Analysis Flowchart



Source: Oregon Partnership for Disaster Resilience. 2005

Implementing the Approaches

Benefit/cost analysis, cost-effectiveness analysis, and the STAPLE/E are important tools in evaluating whether to implement a mitigation activity. A framework for evaluating mitigation activities is outlined below. This framework should be used in further analyzing the feasibility ofprioritized mitigation activities.

1. *Identify the Activities*

Activities for reducing risk from natural hazards can include structural projects to enhance disaster resistance, education and outreach, and acquisition or demolition of exposed properties, among others. Different mitigation projects can assist in minimizing risk to natural hazards but do so at varying economic costs.

2. *Calculate the Costs and Benefits*

Choosing economic criteria is essential to systematically calculating costs and benefits of mitigation projects and selecting the most appropriate activities. Potential economic criteria to evaluate alternatives include:

- *Determine the project cost:* This may include initial project development costs, and repair and operating costs of maintaining projects over time.
- *Estimate the benefits:* Projecting the benefits, or cash flow resulting from a project can be difficult. Expected future returns from the mitigation effort depend on the correct

specification of the risk and the effectiveness of the project, which may not be well known. Expected future costs depend on the physical durability and potential economic obsolescence of the investment. This is difficult to project. These considerations will also provide guidance in selecting an appropriate salvage value. Future tax structures and rates must be projected. Financing alternatives must be researched, and they may include retained earnings, bond and stock issues, and commercial loans.

- *Consider costs and benefits to society and the environment:* These are not easily measured but can be assessed through a variety of economic tools including existence value or contingent value theories. These theories provide quantitative data on the value people attribute to physical or social environments. Even without hard data, however, impacts of structural projects on the physical environment or to society should be considered when implementing mitigation projects.
- *Determine the correct discount rate:* Determination of the discount rate can just be the risk-free cost of capital, but it may include the decision maker’s time preference and also a risk premium. Including inflation should also be considered.

3. Analyze and Rank the Activities

Once costs and benefits have been quantified, economic analysis tools can rank the possible mitigation activities. Two methods for determining the best activities given varying costs and benefits include net present value and internal rate of return.

- *Net present value:* Net present value is the value of the expected future returns of an investment minus the value of the expected future cost expressed in today’s dollars. If the net present value is greater than the projected costs, the project may be determined feasible for implementation. Selecting the discount rate and identifying the present and future costs and benefits of the project calculates the net present value of projects.
- *Internal rate of return:* Using the internal rate of return method to evaluate mitigation projects provides the interest rate equivalent to the dollar returns expected from the project. Once the rate has been calculated, it can be compared to rates earned by investing in alternative projects. Projects may be feasible to implement when the internal rate of return is greater than the total costs of the project. Once the mitigation projects are ranked on the basis of economic criteria, decision-makers can consider other factors, such as risk, project effectiveness, and economic, environmental, and social returns in choosing the appropriate project for implementation.

Economic Returns of Natural Hazard Mitigation

The estimation of economic returns, which accrue to building or landowners as a result of natural hazard mitigation, is difficult. Owners evaluating the economic feasibility of mitigationshould consider reductions in physical damages and financial losses. A partial list follows:

- Building damages avoided;
- Content damages avoided;

- Inventory damages avoided;
- Rental income losses avoided;
- Relocation and disruption expenses avoided; and
- Proprietor’s income losses avoided.

These parameters can be estimated using observed prices, costs, and engineering data. The difficult part is to correctly determine the effectiveness of the hazard mitigation project and theresulting reduction in damages and losses. Equally as difficult is assessing the probability that anevent will occur. The damages and losses should only include those that will be borne by the owner. The salvage value of the investment can be important in determining economic feasibility. Salvage value becomes more important as the time horizon of the owner declines.

This is important because most businesses depreciate assets over a period of time.

Additional Costs from Natural Hazards

Property owners should also assess changes in a broader set of factors that can change as a result of a large natural disaster. These are usually termed “indirect” effects, but they can have a very direct effect on the economic value of the owner’s building or land. They can be positive or negative, and include changes in the following:

- Commodity and resource prices;
- Availability of resource supplies;
- Commodity and resource demand changes;
- Building and land values;
- Capital availability and interest rates;
- Availability of labor;
- Economic structure;
- Infrastructure;
- Regional exports and imports;
- Local, state, and national regulations and policies; or
- Insurance availability and rates.

Changes in the resources and industries listed above are more difficult to estimate and require models that are structured to estimate total economic impacts. Total economic impacts are the sum of direct and indirect economic impacts. Total economic impact models are usually not combined with economic feasibility models. Many models exist to estimate the total economic impacts of changes in an economy. Decision makers should understand the total economic impacts of natural disasters in order to calculate the benefits of a mitigation activity. This suggests that understanding the local economy is an important first step in being able to understand the potential impacts of a disaster, and the benefits of mitigation activities.

Additional Considerations

Conducting an economic analysis for potential mitigation activities can assist decision-makers in choosing the most appropriate strategy for their community to reduce risk and prevent loss from natural hazards. Economic analysis can also save time and resources from being spent on inappropriate or unfeasible projects. Several resources and models are listed on the following page that can assist in conducting an economic analysis for natural hazard mitigation activities.

Benefit/cost analysis is complicated, and the numbers may divert attention from other important issues. It is important to consider the qualitative factors of a project associated with mitigation that cannot be evaluated economically. There are alternative approaches to implementing mitigation projects. With this in mind, opportunities rise to develop strategies that integrate natural hazard mitigation with projects related to watersheds, environmental planning, community economic development, and small business development, among others.

Incorporating natural hazard mitigation with other community projects can increase the viability of project implementation.

Appendix D: Grant Programs and Resources

Introduction

There are numerous state and federal funding sources available to support natural hazard mitigation projects and planning. The following section includes an abbreviated list of the most common funding sources utilized by local jurisdictions in Oregon. Because grant programs often change, it is important to periodically review available funding sources for current guidelines and program descriptions.

State Programs

AmeriCorps/Resource Assistance for Rural Environments (RARE), University of Oregon

https://rare.uoregon.edu/

The mission of the RARE AmeriCorps Program is to increase the capacity of rural communities to improve their economic, social, and environmental conditions, through the assistance of trained graduate-level members who live and work in communities for 11 months. Members assist communities and agencies in the development and implementation of plans for achieving a sustainable natural resource base and improving rural economic conditions while gaining community building and leadership skills.

Coastal Grants, DLCD

https://www.oregon.gov/lcd/OCMP/Pages/Grants.aspx

The Oregon Coastal Management Program (OCMP) at Oregon Department of Land Conservation and Development (DLCD) is pleased to announce a new National Oceanic and Atmospheric Administration (NOAA) funding opportunity designed to build a Climate Ready Nation under the 2021 Bipartisan Infrastructure Law (also known as the Infrastructure Investment and Jobs Act (IIJA)) and available only through coastal management programs. The objective of this initiative is to increase resilience through landscape-scale habitat restoration and conservation in coastal ecosystems nationwide and promote coastal resilience in underserved coastal communities as well as those most vulnerable to climate impacts.

Community Risk Reduction Grants, OSFM

https://www.oregon.gov/osp/programs/sfm/Pages/OSFM-Grants.aspx

The Oregon State Fire Marshall (OSFM) grant programs provides the following funding sources.

- ***Community Wildfire Risk Reduction Grant:*** This grant program is open to local governments, special districts, structural fire service agencies, and non-governmental organizations. This grant funds wildfire risk reduction projects, equipment, and staff.

- ***Oregon Fire Service Capacity Program:*** The Fire Service Capacity Program is for small- to medium-sized agencies that need more permanent positions for firefighters and fire prevention staff. This grant is available to Oregon's local fire districts and departments for funds to support up to two firefighters and two fire prevention personnel.
- ***Engine Program:*** This $25-million program is purchasing and strategically placing new firefighting equipment across Oregon. The OSFM is purchasing type 3, type 6, and tactical tenders to assist local host agencies in keeping fires small and away from communities.
- ***Community Wildfire Protection Plan (CWPP) Investments:*** In February 2023, the OSFM made a strategic one-time $2.7 million investment at the local and county levels through CWPP. Projects will happen in 25 CWPP planning areas located in Baker, Benton, Clackamas, Coos, Crook, Curry, Deschutes, Douglas, Gilliam, Hood River, Jackson, Jefferson, Josephine, Lake, Lane, Lincoln, Linn, Malheur, Marion, Morrow, Multnomah, Polk, Wallowa, Wheeler, and Yamhill counties. Projects include promoting wildfire-specific community risk reduction efforts, community education, defensible space projects, home assessments, media campaigns, signage, fuel mitigation programs, and grant funds.

Community Grants, DLCD

https://www.oregon.gov/lcd/cpu/pages/community-grants.aspx

The DLCD Community Services Division offers grants to empower local and tribal governments to improve planning. **The grants can pay to update comprehensive plans, modernize land use ordinances, or augment other planning activities.** The general fund grant program, administered by the community services division, is funded by the Oregon legislature. Changes to the grant program can arise based on changes in state priorities, the economy, and other factors. In general, the funding follows the state's two-year budget cycle and is part of DLCD's agency budget.

Grants and Supports for Emergency Shelter, ODHS

https://www.oregon.gov/dhs/EmergencyManagement/Pages/emergency-shelter.aspx

Oregon Department of Human Services (ODHS) proves assistance for local governments, Tribal Nations and public education providers to address shelter needs for:

- Cleaner air shelters during wildfire smoke and other poor air quality events
- Cooling and warming shelters

Oregon Senate Bill 80 (SB 762 fixes) proposes to extend eligibility to non-profits and faith-based organizations.

Landscape Resiliency Program, ODF

https://www.oregon.gov/odf/pages/landscape-resiliency-program.aspx

This grant program funded landscape-scale projects that reduce wildfire risk on public and private forestlands and rangelands, and in communities near homes and critical infrastructure through restoration of landscape resiliency and reduction of hazardous fuels. Oregon Department of Forestry (ODF), with input from the Landscape Resiliency Project work group and the public, has awarded $20 million for nine projects during the 2021–23 biennium.

Oregon Watershed Enhancement Board

While OWEB's primary responsibilities are implementing projects addressing coastal salmon restoration and improving water quality statewide, these projects can sometimes also benefit efforts to reduce flood and landslide hazards. In addition, OWEB conducts watershed workshopsfor landowners, watershed councils, educators, and others, and conducts a biennial conference highlighting watershed effort statewide. Funding for OWEB programs comes from the general fund, state lottery, timber tax revenues, license plate revenues, angling license fees, and other sources. OWEB awards approximately $20 million in funding annually. More information at:

http://www.oregon.gov/OWEB/Pages/index.aspx

Resilience Hubs and Networks Grant, ODHS

https://www.oregon.gov/odhs/emergency-management/Pages/about.aspx

Oregon Department of Human Services (ODHS), Office of Resilience and Emergency Management, is developing a new program to provide grants, support and technical assistance to communities for planning and establishing resilience hubs and networks in Oregon, per HB 3409 (2023), effective date July 27, 2023. ODHS staff anticipate having the program established winter 2023-2024.

Seismic Rehabilitation Grant Program

The Seismic Rehabilitation Grant Program (SRGP) provides state funds to strengthen public schools and emergency services buildings so they will be less damaged during an earthquake.Reducing property damage, injuries, and casualties caused by earthquakes is the goal of the SRGP.

http://www.orinfrastructure.org/Infrastructure-Programs/Seismic-Rehab/

Small Forestland Grant Program (SFGP), ODF

https://www.oregon.gov/odf/pages/small-forestland-grant-program.aspx

The SSFGP offered the following two funding opportunities: the Small Forestland Grant and the Firewise Community Grant. Both opportunities require grant dollars are spent reducing the risk of high severity wildfire through the reduction of hazardous fuel on small forestland owner properties. Both opportunities were scored prioritizing high-risk watersheds, but lower risk watersheds were not excluded from applying. All invoices from both program components must be submitted by successful recipients no later than June 15, 2023.

Smoke Management-Community Response Plan Grant, DEQ

https://www.oregon.gov/deq/aq/Pages/Smoke-Resources.aspx

Communities throughout Oregon are at various stages of planning and preparing for the potential impacts from prescribed fire and wildfire smoke. To create a successful community response plan for smoke, communities need to partner with local stakeholders and apply the best practices and resources to meet the needs of their residents. In 2022, DEQ awarded grants to 20 local and tribal governments to develop comprehensive community response plans for smoke management and to three local entities and businesses to pilot projects promoting alternatives to open burning. Once the grant period is completed, DEQ will share community response plans and best practices from the grant awardees.

Special Public Works Fund

The Special Public Works Fund (SPWF) provides funds for publicly owned facilities that supporteconomic and community development in Oregon. Funds are available to public entities for: planning, designing, purchasing, improving and constructing publicly owned facilities, replacing publicly owned essential community facilities, and emergency projects as a result of a disaster. Public agencies that are eligible to apply include: cities, counties, County service districts, (organized under ORS Chapter 451), tribal councils, ports, districts as defined in ORS 198.010, and airport districts (ORS 838). Facilities and infrastructure projects that are eligible for funding are: airport facilities, buildings and associated equipment, levee accreditation, certification, and repair, restoration of environmental conditions on publicly-owned industrial lands, port facilities,wharves, and docks, the purchase of land, rights of way and easements necessary for a public facility, telecommunications facilities, railroads, roadways and bridges, solid waste disposal sites, storm drainage systems, wastewater systems, and water systems.

https://www.orinfrastructure.org/Infrastructure-Programs/SPWF/

State Interagency Hazard Mitigation Team (IHMT)

http://www.oregon.gov/oem/Councils-and-Committees/Pages/IHMT.aspx

Find IHMT meeting dates and locations, agendas, minutes and meeting materials. The State IHMT is made up of about 18 state agencies involved with natural hazards. The State IHMT meets quarterly to understand losses arising from natural hazards, coordinate recommended strategies to mitigate loss of life, property, and natural resources, and maintain the Oregon Natural Hazards Mitigation Plan.

State Preparedness and Incident Response Equipment (SPIRE), OEM

https://www.oregon.gov/oem/emresources/Grants/Pages/Spire.aspx

Oregon House Bill 2687 became effective in August 2017. It established a grant program to distribute emergency preparedness equipment to local governments and other recipients to be used to decrease risk of life and property resulting from an emergency. Items purchased must qualify as capital assets, meaning individual items must cost at least $5,000. A total of $5,000,000 is available to procure emergency preparedness equipment to help Oregon communities prepare, respond, and recover from emergencies. During the 2021 Legislative Session, HB 2426 added Urban Search and Rescue (USAR) equipment to the list and required that USAR equipment receive the highest priority. The contact for the SPIRE program is Carole Sebens, Grants Coordinator, Carole.L.Sebens@oem.oregon.gov/

Urban and Community Forestry Inflation Reduction Act, ODF

https://www.fs.usda.gov/managing-land/urban-forests/ucf/2023-grant-funding

The Inflation Reduction Act (IRA) is a federal law that makes historic investments in clean energy and climate action. The IRA advances the Justice40 Initiative, which commits to providing 40 percent of climate, clean energy, and infrastructure investment benefits to overburdened and underserved communities. The IRA provides up to $1.5 billion to the United States Forest Service (USFS) for urban and community forestry investments to foster 1) increased and equitable access to urban tree canopy, 2) broadened community engagement in local urban forest planning, tree planting, and management activities, and 3) improved community and urban forest resilience. The Oregon Department of Forestry's

(ODF's) Urban and Community Forestry (UCF) Program received $26.6 million in IRA grant funding from the USFS to support two grant programs.

FEMA: Pre-/Post-Disaster Mitigation Programs

Hazard Mitigation Grant Program, FEMA

The Hazard Mitigation Grant Program (HMGP) provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The HMGP involves a paper application which is first offered to the counties with declared disasters within the past year, then becomes available statewide if funding is still available.

http://www.fema.gov/hazard-mitigation-grant-program

Building Resilient Infrastructure and Communities Grant Program

The Building Resilient Infrastructure and Communities (BRIC) program provides funds to states,territories, Indian tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding theseplans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. BRIC grants are to be awarded on a competitive basis and without reference to state allocations, quotas, or other formula-based allocation of funds. The BRIC grant program is offered annually; applications are submitted online. Applicants need a user profile approved by the State Hazard Mitigation Officer, which should be garnered well before the application period opens.

https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities

Flood Mitigation Assistance Program

The overall goal of the Flood Mitigation Assistance (FMA) Program is to fund cost-effective measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other National Flood Insurance Program (NFIP) insurable structures.This specifically includes:

- Reducing the number of repetitively or substantially damaged structures and the associated flood insurance claims;
- Encouraging long-term, comprehensive hazard mitigation planning;
- Responding to the needs of communities participating in the NFIP to expand their mitigation activities beyond floodplain development activities; and
- Complementing other federal and state mitigation programs with similar, long-term mitigation goals.

http://www.fema.gov/flood-mitigation-assistance-program

Detailed program and application information for federal post-disaster and non-disaster programs can be found in the FY15 Hazard Mitigation Assistance Unified Guidance, available at: https://www.fema.gov/media-library/assets/documents/103279. Note that guidance regularly changes.

Verify that you have the most recent edition. Flood mitigation assistance is usually offered annually; applications are submitted online. Applicants need a user profile approved by the State Hazard Mitigation Officer, which should be garnered well before the application periodopens.

For Oregon Department of Emergency Management (OEM) grant guidance on Federal HazardMitigation Assistance, visit: https://www.oregon.gov/OEM/emresources/Grants/Pages/HMA.aspx

Contact: shmo@mil.state.or.us

Hazard Mitigation Assistance (HMA), FEMA

Detailed program and application information for federal disaster and non-disaster programs can be found in the Hazard Mitigation Assistance Program and Policy Guide, dated March 23, 2023, note that guidance regularly changes. Verify that you have the most recent edition. Flood mitigation assistance is usually offered annually; applications are submitted online. Applicants need a user profile approved by the State Hazard Mitigation Officer (SHMO), which should be garnered well before the application period opens.

For Oregon Department of Emergency Management (OEM) grant guidance on Federal Hazard Mitigation Assistance, visit: https://www.oregon.gov/OEM/emresources/Grants/Pages/HMA.aspx

Contact: Anna Feigum, State Hazard Mitigation Officer (SHMO), anna.r.feigum@oem.oregon.gov

https://www.fema.gov/grants/mitigation

Hazard Mitigation Grant Program (HMGP), FEMA

The HMGP provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The HMGP involves a paper application which is first offered to the counties with presidentially declared disasters within the past year, then becomes available statewide if funding is still available. FEMA administers the grant.

As of January 2024, FEMA will fund net-zero energy projects, including solar, heat pumps and efficient appliances, through the Public Assistance program (discussed below), but also funding net-zero energy projects for the HMGP to encourage more communities to use net-zero projects that increase community resilience.

https://www.fema.gov/grants/mitigation/hazard-mitigation

Rehabilitation of High Hazard Potential Dam (RHHPD) Grant Program, FEMA

The RHHPD awards provide technical, planning, design and construction assistance in the form of grants for rehabilitation of eligible high hazard potential dams. A state or territory with an enacted dam safety program, the State Administrative Agency, or an equivalent state agency, is eligible for the grant.

https://www.fema.gov/emergency-managers/risk-management/dam-safety/rehabilitation-high-hazard-potential-dams

Eligible Activities for FEMA Mitigation Grants

While project eligibility must meet all requirements set in the FEMA Hazard Mitigation Assistance Guide, Table 1 summarizes eligible activities that may be funded by the HMA programs. Eligible projects are categorized into three categories – Capability- and Capacity-Building, Mitigation projects, and Management costs.

The table is not comprehensive, and applicants and sub applicants can submit new and innovative activities that may not be specifically outlined below.

Table 1 Eligible Mitigation Activities by FEMA Program

Eligible Projects	HMGP	HMGP Post-Fire	BRIC	FMA
1. Capability- and Capacity-Building				
New Plan Creation and Updates	Yes	Yes	Yes	Yes*
Planning-Related Activities	Yes	Yes	Yes	No
Project Scoping/Advance Assistance	Yes	Yes	Yes	Yes
Financial Technical Assistance	No	No	No	Yes
Direct Non-financial Technical Assistance	No	No	Yes	No
Partnerships	No	No	Yes	Yes
Codes and Standards	Yes	Yes	Yes	No
Innovative Capability- and Capacity- Building†	Yes	Yes	Yes	Yes
2. Mitigation Projects				
Property Acquisition	Yes	Yes	Yes	Yes
Structure Elevation	Yes	Yes	Yes	Yes
Mitigation Reconstruction	Yes	Yes	Yes	Yes
Localized Flood Risk Reduction	Yes	Yes	Yes	Yes
Non-Localized Flood Risk Reduction	Yes	Yes	Yes	Yes**
Stabilization	Yes	Yes	Yes	Yes
Dry Floodproofing Non-Residential Building	Yes	Yes	Yes	Yes
Tsunami Vertical Evacuation	Yes	Yes	Yes	No
Safe Room	Yes	Yes	Yes	No
Wildfire Mitigation	Yes	Yes	Yes	No
Retrofit	Yes	Yes	Yes	Yes†

Eligible Projects	HMGP	HMGP Post-Fire	BRIC	FMA
Secondary Power Source	Yes	Yes	Yes	No
Warning System (excluding earthquake early warning system)	Yes	Yes	Yes	No
Earthquake Early Warning System	Yes	Yes	Yes	No
Aquifer Recharge, Storage and Recovery	Yes	Yes	Yes	Yes***
Innovative Mitigation Project††	Yes	Yes	Yes	Yes
3. Management Costs				
Management Costs	Yes	Yes	Yes	Yes

Source: FEMA, Hazard Mitigation Assistance Program and Policy Guide, 2023

Non-FEMA Federal: Pre-/Post-Disaster Programs

Climate Resilience Regional Challenge, NOAA

Approximately $575 million will be available for projects that build the resilience of coastal communities to extreme weather (e.g., hurricanes and storm surge) and other impacts of climate change (e.g., sea level rise, drought). Funding is made possible by the Inflation Reduction Act, a historic, federal government-wide investment that is advancing NOAA's efforts to build Climate-Ready Coasts. This new, competitive grant program provides the opportunity to collaboratively implement transformational regional projects that build immediate and long-term resilience in coastal areas

https://coast.noaa.gov/funding/ira/resilience-challenge/

Community Development Block Grant Program

The Community Development Block Grant Program (CDBG), administered by HUD, promotes viable communities by providing:

- Decent housing;
- Quality living environments; and
- Economic opportunities, especially for low- and moderate-income persons.

Eligible activities most relevant to natural hazards mitigation include acquisition of property for public purposes; construction/reconstruction of public infrastructure; community planning activities. Under special circumstances, CDBG funds also can be used to meet urgent community development needs arising in the last 18 months which pose immediate threats to health and welfare. Grants are awarded based on specific projects as they are identified.

https://www.hud.gov/program_offices/comm_planning/cdbg-dr

Community Development Block Grant Mitigation Program, HUD

The CDBG-MIT Program funds pose a unique opportunity for eligible grantees to use this assistance in areas impacted by recent disasters to carry out strategic and high-impact activities to mitigate disaster risks and reduce future losses. The CDBG-MIT defines mitigation as activities that increase resilience to disasters and reduce or eliminate the long-term risk of loss of life, injury, damage to and loss of property, and suffering and hardship by lessening the impact of future disasters. CDBG-MIT activities should align with other federal programs that address hazard mitigation to create a more cohesive effort at the federal, state, and local level.

https://www.hud.gov/program_offices/comm_planning/cdbg-dr/cdbg-mit

Community Energy Programs (CEP), U.S. Department of Energy

Community Energy Programs (CEP) provides federal support and resources to local and tribal governments, public schools, nonprofit organizations, workforce development groups, and other community-serving entities. The CEP includes the following: Energy Efficiency and Conservation Block Grant (EECBG) Program, Renew America's Nonprofits Program, Renew America's Schools Program, Communities Local Energy Action Program (Communities LEAP), and Workforce Development and Business Owner Training Program.

https://www.energy.gov/scep/community-energy-programs

Dam Emergencies Collaborative Technical Assistance (CTA) Program, FEMA

FEMA is offering a Collaborative Technical Assistance (CTA) series to help communities at risk of dam-related flooding to better understand their risk landscape and the potential consequences of dam-related emergencies. The CTA will include planning for emergencies related to operational discharges or dam-related infrastructure failure.

https://www.fema.gov/emergency-managers/risk-management/dam-safety/technical-assistance

Disaster Assistance Program, HUD

There are four types of loans available from the U.S. Small Business Administration (SBA): home and personal property loans; business physical disaster loans; economic injury loans; and military reservist injury loans. When physical disaster loans are made to homeowners and businesses following disaster declarations by the SBA, up to 20% of the loan amount can go towards specific measures taken to protect against recurring damage in similar future disasters.

https://www.sba.gov/funding-programs/disaster-assistance

Disaster Recovery Unit (DRU), U.S. Department of Education

The DRU coordinates disaster recovery work across the U.S. department of education. The DRU supports k-12 and higher education school communities to restore learning following a federally declared natural disaster. Additionally, the DRU manages work with other U.S. government agencies to ensure effective and efficient use of the department's natural disaster recovery resources.

https://www.ed.gov/disasterrelief

Disaster Resources, HUD

The U.S. Department of Housing and Urban Development (HUD) provides a variety of disaster resources listed below. We also partner with Federal and state agencies to help implement disaster recovery assistance. Under the National Response Framework, FEMA and the Small Business Administration (SBA) offer initial recovery assistance.

https://www.hud.gov/disaster_resources

Emergency Management Performance Grants (EMPG), FEMA

Emergency Management Performance Grant program helps state and local governments to sustain and enhance their all-hazards emergency management programs.

https://www.fema.gov/grants/preparedness/emergency-management-performance

Food and Nutrition Service (FNS) Disaster Resources, USDA

The FNS coordinates with state, local, and voluntary organizations to provide nutrition assistance to those most affected by a disaster or emergency. USDA Foods are currently stored in every state and U.S. territory and may be used by state agencies or local disaster relief organizations to provide food to shelters or people who are sheltering in place. If retail food stores are operating in the impacted area, state agencies may request to operate a Disaster Supplemental Nutrition Assistance Program (D-SNAP).

https://www.fns.usda.gov/disaster/disaster-assistance

Grid Resilience and Innovation Partnerships (GRIP) Program, U.S. Department of Energy

The U.S. Department of Energy's Grid Deployment Office is administering a $10.5 billion GRIP Program to enhance grid flexibility and improve the resilience of the power system against growing threats of extreme weather and climate change. The programs will help accelerate the deployment of transformative projects that will ensure the reliability of the power sector's infrastructure, so all American communities have access to affordable, reliable, clean electricity anytime, anywhere. The program includes three funding mechanisms: Grid Resilience Utility and Industry Grants, Smart Grid Grants, and Grid Innovation Program.

https://www.energy.gov/gdo/grid-resilience-and-innovation-partnerships-grip-program

HOME Investments Partnerships Program (IPP), HUD

The HOME IPP provides grants to states, local government and consortia for permanent and transitional housing (including support for property acquisition and rehabilitation) for low-income persons.

https://www.hud.gov/program_offices/comm_planning/home

National Dam Safety Program (NDSP) State Assistance Grant Program, FEMA

The primary purpose of the NDSP State Assistance Grant Program is to provide financial assistance to the states for strengthening their dam safety programs. The states use NDSP funds for the following types of activities:

- Dam safety training for state personnel
- Increase in the number of dam inspections
- Increase in the submittal and testing of Emergency Action Plans
- More timely review and issuance of permits
- Improved coordination with state emergency preparedness officials
- Identification of dams to be repaired or removed
- Conduct dam safety awareness workshops and creation of dam safety videos and other outreach materials

https://www.fema.gov/emergency-managers/risk-management/dam-safety/grants

National Estuary Program (NEP) Watersheds Grant, Restore America's Estuaries

Restore America's Estuaries, in close coordination with and financial support from EPA, administers the NEP Watersheds Grants. This grant program funds projects within one or more of the NEP boundary areas and supports the following Congressionally set priorities:

- Loss of key habitats resulting in significant impacts on fisheries and water quality such as seagrass, mangroves, tidal and freshwater wetlands, forested wetlands, kelp beds, shellfish beds, and coral reefs;
- Coastal resilience and extreme weather events including flooding and coastal erosion related to sea level rise, changing precipitation, warmer waters, or salt marsh, seagrass, or wetland degradation or loss and accelerated land loss;
- Impacts of nutrients and warmer water temperatures on aquatic life and ecosystems, including low dissolved oxygen conditions in estuarine waters;
- Stormwater runoff which not only can erode stream banks but can carry nutrients, sediment, and trash into rivers and streams that flow into estuaries;
- Recurring harmful algae blooms;
- Unusual or unexplained marine mammal mortalities; and
- Proliferation or invasion of species that limit recreational uses, threaten wastewater systems, or cause other ecosystem damage.

https://www.epa.gov/nep

Neighborhood Stabilization Program (NSP), HUD

The NSP was established for the purpose of providing emergency assistance to stabilize communities with high rates of abandoned and foreclosed homes, and to assist households whose annual incomes are up to 120% of the area median income.

https://www.hud.gov/program_offices/comm_planning/nsp

Preparedness Grants, FEMA

FEMA's Preparedness grants support citizens and first responders to ensure we work together as a nation to build, sustain and improve our capability to prepare for, protect against, respond to, recover from and mitigate terrorism and other high-consequence disasters and emergencies.

https://www.fema.gov/grants/preparedness

Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT), FHWA

Administered by the Federal Highway Administration (FHWA), housed in the U.S. Department of Transportation, the vision of the PROTECT Discretionary Grant Program is to fund projects that address the climate crisis by improving the resilience of the surface transportation system, including highways, public transportation, ports, and intercity passenger rail. Projects selected under this program should be grounded in the best available scientific understanding of climate change risks, impacts, and vulnerabilities.

https://www.fhwa.dot.gov/environment/protect/discretionary/

Public Assistance (PA) Grant Program, FEMA

The objective of the PA Grant Program is to aid State, Tribal and local governments, and certain types of Private Nonprofit organizations so that communities can quickly respond to and recover from major disasters or emergencies declared by the President.

In January 2024, FEMA expanded funding to tackle the climate crisis, improve resilience, and cut energy costs through net-zero projects. It will fund net-zero energy projects, including solar, heat pumps and efficient appliances, through the PA program, which covers the rebuilding of schools, hospitals, fire stations and other community infrastructure investments post-disasters.

http://www.fema.gov/public-assistance-local-state-tribal-and-non-profit

Readiness and Emergency Management for Schools (REMS)

REMS supports education agencies, with their community partners, manage safety, security, and emergency management programs. The REMS Technical Assistance (TA) Center helps to build the preparedness capacity (including prevention, protection, mitigation, response, and recovery efforts) of schools, school districts, institutions of higher education (IHEs), and their community partners at the local, state, and Federal levels. REMS TA Center also serves as the primary source of information dissemination for schools, school districts, and IHEs for emergencies.

http://rems.ed.gov/

Regional Catastrophic Preparedness Grant Program (RCPGP), FEMA

The RCPGP plays an important role in the implementation of the National Preparedness System. RCPGP supports the building of core capabilities essential to achieving the National Preparedness Goal of a secure and resilient nation by providing resources to close known capability gaps in Housing and Logistics and Supply Chain Management, encouraging innovative regional solutions to issues related to catastrophic incidents, and building on existing regional efforts.

Housing was added as a strategic priority for this grant program in 2023 to accompany equity, climate resilience, and readiness. Priority will also be given to projects that address the needs of disadvantaged communities that might be at special risk because of current and/or future hazards, including those associated with climate change.

https://www.fema.gov/grants/preparedness/regional-catastrophic

Rural Development Assistance – Utilities, USDA

USDA's Rural Utilities Service (RUS) provides much-needed infrastructure or infrastructure improvements to rural communities. These include water and waste treatment, electric power and telecommunications services. All these services help to expand economic opportunities and improve the quality of life for rural residents.

https://www.rd.usda.gov/about-rd/agencies/rural-utilities-service

Rural Development Assistance – Housing, USDA

USDA's Rural Housing Service (RHS) offers a variety of programs to build or improve housing and essential community facilities in rural areas. We offer loans, grants and loan guarantees for single- and multifamily housing, childcare centers, fire and police stations, hospitals, libraries, nursing homes, schools, first responder vehicles and equipment, housing for farm laborers and much more. The RHS also provide technical assistance loans and grants in partnership with non-profit organizations, Indian tribes, state and federal government agencies, and local communities.

https://www.rd.usda.gov/about-rd/agencies/rural-housing-service

Safeguarding Tomorrow Revolving Loan Fund Program, FEMA

The Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act became law on January 1, 2021, and authorizes FEMA to provide capitalization grants to states, eligible federally recognized tribes, territories and the District of Columbia to establish revolving loan funds that provide hazard mitigation assistance for local governments to reduce risks from natural hazards and disasters. These low interest loans will allow jurisdictions to reduce vulnerability to natural disasters, foster greater community resilience and reduce disaster suffering.

https://www.fema.gov/grants/mitigation/storm-rlf

Water Research Grants, EPA

The EPA funds water research grants to develop and support the science and tools necessary to develop sustainable solutions to current water resource problems, ensuring water quality and availability in order to protect human and ecosystem health.

https://www.epa.gov/research-grants/water-research-grants

Water Resources Projects for Small or Disadvantaged Communities, USACE

The U.S. Army Corps of Engineers (USACE) is launching a pilot program to fully fund small water resources projects for economically disadvantaged communities. A more detailed description of the requirements for a project proposal can be found in the WRDA 2020 Section 165 policy guidance issued on June 12, 2023.

https://www.usace.army.mil/Missions/Civil-Works/Project-Planning/Legislative-Links/wrda_2020/

WaterSMART Grants, USBR

Through WaterSMART Grants, the U.S. Bureau of Reclamation (USBR) provides financial assistance to water managers for projects that seek to conserve and use water more efficiently, implement renewable energy, investigate and develop water marketing strategies, mitigate conflict risk in areas at a high risk of future water conflict, and accomplish other benefits that contribute to sustainability in the western United States. Cost-shared projects that can be completed within two or three years are selected annually through a competitive process. Three categories of WaterSMART Grants are offered through separate funding opportunities: Water and Energy Efficiency Grants; Small-Scale Water Efficiency Projects; and Water Marketing Strategy Grants.

https://www.usbr.gov/watersmart/

Federal: Fire Resources

Assistance to Firefighters Grant (AFG) Program Resources, FEMA

https://www.fema.gov/grants/preparedness/firefighters/assistance-grants

FEMA's Assistance to Firefighters Grant Program provides a variety of resources listed below. The purpose of the grant is to provide equipment, protective gear, emergency vehicles, training, and other resources needed to protect the public and emergency personnel from fire and related hazards. The funds are available to fire departments, non-affiliated emergency medical services organizations, and state fire training academies. The funds enhance operations efficiencies, foster interoperability, and support community resilience.

Community Wildfire Defense Grant (CWDG) Program, USDA-FS

https://www.fs.usda.gov/managing-land/fire/grants

The CWDG is intended to help at-risk local communities and Tribes; plan for and reduce the risk of wildfire. The program, which was authorized by the Bipartisan Infrastructure Law, prioritizes at-risk communities in an area identified as having high or very high wildfire hazard potential, are low-income, or have been impacted by a severe disaster that affects the risk of wildfire. The program provides funding to communities for two primary purposes:

- Develop and revise Community Wildfire Protection Plans (CWPP).
- Implement projects described in a Community Wildfire Protection Plan that is less than ten years old.

The CWDG also helps communities in the wildland urban interface (WUI) implement the three goals of the National Cohesive Wildland Fire Management Strategy.

Fire Management Assistance Grant (FMAG) Program, FEMA

The FMAG Program is available to states, local and tribal governments, for the mitigation, management, and control of fires on publicly or privately owned forests or grasslands, which threaten such destruction as would constitute a major disaster.

https://www.fema.gov/assistance/public/fire-management-assistance

Fire Prevention and Safety (FP&S), FEMA

The FP&S grant property is part of the AFG program noted above and supports projects that enhance the safety of the public and firefighters from fire and related hazards. The primary goal is to reduce injury and prevent death among high-risk populations.

https://www.fema.gov/grants/preparedness/firefighters/safety-awards

National Fire Plan (NFP), USDA/USDOI

The NFP provides technical, financial, and resource guidance and support for wildland fire management across the United States. This plan addresses five key points: firefighting, rehabilitation, hazardous fuels reduction, community assistance, and accountability.

http://www.forestsandrangelands.gov/

Staffing For Adequate Fire and Emergency Response (SAFER)

The SAFER program was created to provide funding directly to fire departments and volunteer firefighter interest organizations to help them increase or maintain the number of trained, "front line" firefighters available in their communities.

https://www.fema.gov/grants/preparedness/firefighters/safer

Wildfire Smoke Preparedness in Community Buildings Grant Program, EPA

Wildfire Smoke Preparedness in Community Buildings is a new federal grant program to support enhancing community wildfire smoke preparedness. It provides grants and cooperative agreements to States, federally recognized Tribes, public pre-schools, local educational agencies, and non-profit organizations for the assessment, prevention, control, and/or abatement of wildfire smoke hazards in community buildings and related activities.

https://www.epa.gov/indoor-air-quality-iaq/wildfire-smoke-preparedness-community-buildings-grant-program?utm_content=&utm_medium=email&utm_name=&utm_source=govdelivery&utm_term=#Eligible

Federal Mitigation: Research, Hazard Mapping and Technical Assistance

Decision, Risk, and Management Science Program, NSF

Administered through the National Science Foundation (NSF), scientific research is funded that is directed at increasing the understanding and effectiveness of decision making by individuals, groups, organizations, and society. Disciplinary and interdisciplinary research, doctoral dissertation research, and workshops are funded in the areasof judgment and decision making; decision analysis and decision aids; risk analysis, perception, and communication; societal and public policy decision making; management science and organizational design. The program also supports small grants for exploratory research of a time-critical or high-risk, potentially transformative nature.

http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5423

Clean Water State Revolving Fund (CWSRF), EPA

The EPA administers this fund. The purpose is to fund water quality projects, including all types of nonpoint source projects, watershed protection or restoration projects, estuary management projects, and more traditional municipal wastewater treatment projects. Grant awards are based on specific projects as they are identified.

https://www.epa.gov/cwsrf

Community Action for a Renewed Environment (CARE), EPA

The administrator of the CARE funding source is the EPA. The purpose is to fund the removal or reduction of toxic pollution. The grant award is based on specific projects as they are identified.

https://www.epa.gov/international-cooperation/community-action-renewed-environment-care-roadmap-10-step-plan-improve

Community Change Equitable Resilience Technical Assistance, EPA

The Community Change Grant Equitable Resilience technical assistance will provide free design and project development assistance, community engagement, and partnership development workshops that support climate resilience and environmental justice activities in disaster-prone areas.

https://www.epa.gov/inflation-reduction-act/community-change-equitable-resilience-technical-assistance

Community Change Grants Technical Assistance, EPA

Office of Environmental Justice and External Civil Rights at EPA is committed to providing robust technical assistance and resources to eligible entities. This assistance is in direct response to feedback from communities and environmental justice leaders who have long called for technical assistance and capacity building support for communities and their partners as they work to access critical federal resources. There are two programs dedicated for the Community Change Grants, which include Community Change Technical Assistance (CCTA) and Community Change Equitable Resilience Technical Assistance (CCER TA).

https://www.epa.gov/inflation-reduction-act/community-change-grants-technical-assistance

Cooperating Technical Partners (CTP), FEMA

The CTP mission is to strengthen the effectiveness of the NFIP and support FEMA's mitigation objectives. The CTP Program leverages partnerships to deliver high-quality hazard identification and risk assessment products, provide outreach support and empower communities to take action to reduce risk based on informed, multi hazard-based data and resources.

https://www.fema.gov/flood-maps/guidance-partners/cooperating-technical-partners

Earthquake Resilience Guide for Water and Wastewater Utilities

There are three steps in this guide: Step 1 – Understand the Earthquake Threat. Step 2 – Identify Vulnerable Assets and Determine Consequences. Step 3 – Pursue Mitigation and Funding Options.

Emergency Response for Drinking Water and Wastewater Utilities, EPA

The Environmental Protection Agency (EPA) has a variety of tools and guidance to support drinking water and wastewater utility preparedness and response. Resources include:

https://www.epa.gov/waterutilityresponse

Emergency Watershed Protection (EWP) Program, USDA-NRCS

The EWP Program provides technical and financial assistance for relief from imminent hazards in small watersheds, and to reduce vulnerability of life and property in small watershed areas damaged by severe natural hazard events.

https://www.nrcs.usda.gov/programs-initiatives/ewp-emergency-watershed-protection

Federal Funding for Water and Wastewater Utilities in National Disasters, EPA

The Federal Funding for Water and Wastewater Utilities in National Disasters (Fed FUNDS website gives utilities information about federal disaster funding programs. Although Fed FUNDS focuses on major disasters, you can use the information for any incident that disrupts water or wastewater services or damages critical infrastructure.

https://www.epa.gov/fedfunds

Federal Land Transfer / Federal Land to Parks Program, USDOI-NPS

The National Park Service Identifies, assesses, and transfers available federal real property for acquisition for state and local parks and recreation, such as open space.

http://www.nps.gov/ncrc/programs/flp/index.htm

National Coastal Zone Management (CZM) Program, NOAA

The National CZM Program comprehensively addresses the nation's coastal issues through a voluntary partnership between the federal government and coastal and Great Lakes states and territories. Authorized by the Coastal Zone Management Act of 1972, the program provides the basis for protecting, restoring, and responsibly developing our nation's diverse coastal communities and resources. The CZM Program provides grants for planning and implementation of non-structural coastal flood and hurricane hazard mitigation projects and coastal wetlands restoration.

https://coast.noaa.gov/czm/

National Earthquake Hazard Reduction Program (NEHRP), NSF

Through broad based participation, the NEHRP attempts to mitigate the effects of earthquakes. Member agencies in NEHRP are the US Geological Survey (USGS), the National Science Foundation (NSF), the Federal Emergency Management Agency (FEMA), and the National Institute for Standards and Technology (NIST). The agencies focus on research and developmentin areas such as the science of earthquakes, earthquake performance of buildings and other structures, societal impacts, and emergency response and recovery.

http://www.nehrp.gov/

National Flood Insurance Program (NFIP), FEMA

The NFIP provides insurance to help reduce the socio-economic impact of floods. The NFIP insurance is made available to residents of communities that adopt and enforce minimum floodplain management requirements.

https://www.fema.gov/flood-insurance

NFIP Flood Maps, FEMA

Floods occur naturally and can happen anywhere. They may not even be near a body of water, although rivers and coastal flooding are two of the most common types. Heavy rains, poor drainage, and even nearby construction projects can put the community at risk for flood damage. Flood maps (referred to as Flood Insurance Rate Maps or "FIRM") are one tool that communities use to know which areas have the highest risk of flooding. FEMA maintains and updates data through flood maps and risk assessments.

https://www.fema.gov/flood-maps

North American Wetland Conservation (NAWC), USDOI-FWS

NAWC fund provides cost-share grants to stimulate public/private partnerships for the protection, restoration, and management of wetland habitats. The grant funds projects for wetlands conservation in the United States, Canada, and Mexico.

https://www.fws.gov/program/north-american-wetlands-conservation

Partners for Fish and Wildlife (PFW), USDOI-FWS

The PFW program provides financial and technical assistance to private landowners interested in pursuing restoration projects affecting wetlands and riparian habitats.

https://www.fws.gov/program/partners-fish-and-wildlife

Secure Rural Schools and Community Self-Determination Act of 2000, USDA-FS

Reauthorized for the fiscal year 2022, it was originally enacted in 2000 to provide five years of transitional assistance to rural counties affected by the decline in revenue from timber harvests on federal lands. Funds have been used for improvements to public schools, roads, and stewardship projects. Money is also available for maintaining infrastructure, improving the health of watersheds and ecosystems, protecting communities, and strengthening local economies.

https://www.fs.usda.gov/working-with-us/secure-rural-schools

USGS Natural Hazards

The USGS Natural Hazards Mission Area includes six science programs including Coastal & Marine Geology, Earthquake Hazards, Geomagnetism, Global Seismographic Network, Landslide Hazards, and Volcano Hazards. Through these programs, the USGS provides alerts and warnings of geologic hazards and interactive maps and data.

https://www.usgs.gov/mission-areas/natural-hazards

Wetlands Reserve Easements (WRE), USDA-NCRS

The WRE program provides assistance to protect and restore wetlands through easements and restoration agreements.

https://www.nrcs.usda.gov/programs-initiatives/wre-wetland-reserve-easements

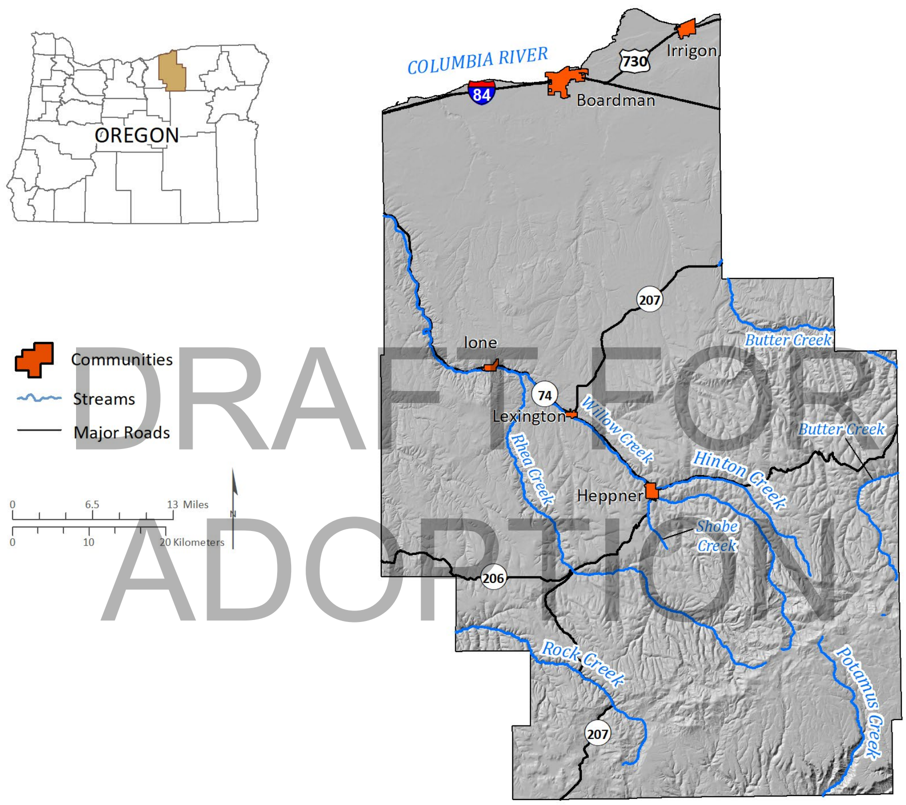
APPENDIX E: MULTI-HAZARD RISK REPORT

State of Oregon
Oregon Department of Geology and Mineral Industries
Ruarri J. Day-Stirrat, State Geologist

OPEN-FILE REPORT O-24-01

MULTI-HAZARD RISK REPORT FOR MORROW COUNTY, OREGON

INCLUDING THE CITIES OF BOARDMAN, HEPPNER, IONE, IRRIGON, AND LEXINGTON



by Matt C. Williams[1], Nancy C. Calhoun[1], and Jason D. McClaughry[1, 2]

2024

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DISCLAIMER

This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. This publication cannot substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from the results shown in the publication.

Cover image: Study area of the Morrow County Risk Report. Map depicts Morrow County, Oregon and communities included in this report.

WHAT'S IN THIS REPORT?

This report describes the methods and results of a natural hazard risk assessment for Morrow County communities. The results quantify the impacts of natural hazards to each community and enhance the decision-making process in planning for disaster.

Expires: 12/1/2024

Oregon Department of Geology and Mineral Industries Open-File Report O-24-01
Published in conformance with ORS 516.030

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Appendix E

GEOGRAPHIC INFORMATION SYSTEM (GIS) DATA

See the digital publication folder for files.
Geodatabase is Esri® version 10.7 format. Metadata are embedded in the geodatabase and are also provided as separate .xml format files.

Morrow_County_Risk_Report_Data.gdb

Feature dataset: Asset_Data

feature classes:

- Building_footprints (polygons)
- Communities (polygons)
- UDF_points (points)

Metadata in .xml file format:

Each dataset listed above has an associated, standalone .xml file containing metadata in the Federal Geographic Data Committee Content Standard for Digital Geospatial Metadata format

EXECUTIVE SUMMARY

This report was prepared for the communities of Morrow County, Oregon, with funding provided by the Federal Emergency Management Agency (FEMA). It describes the methods and results of a natural hazard risk assessment performed in 2022 and 2023 by the Oregon Department of Geology and Mineral Industries (DOGAMI). The purpose of this project is to provide communities with detailed risk assessment information to enable them to compare hazards and act to reduce their risk. The risk assessment results quantify the impact of natural hazards to this community and enhance the decision-making process in planning for disaster.

We arrived at our findings and conclusions by completing three main tasks: compiling an asset database, identifying and using the best available hazard data, and performing natural hazard risk assessment.

- In the first task, we created a comprehensive asset database for Morrow County by synthesizing assessor data, U.S. Census information, FEMA Hazus®-MH general building stock information, and building footprint data. This work resulted in a single dataset of building points and their associated building characteristics (i.e., construction materials, number of floors, usage, etc). Using these data, we were able to represent accurate spatial locations and vulnerabilities on a building-by-building basis.
- The second task was to identify and use the most current and appropriate hazard datasets for the study area. Most of the hazard datasets used in this report were created by DOGAMI and produced using peer-reviewed methods and with high-resolution, lidar topographic data. Although not all the data sources used in the report provide complete, countywide information, each hazard dataset used was the best available at the time of the analysis. Data sources and coverage are discussed in detail for each hazard in **Assessment Overview and Results**.
- In the third task, we analyzed risk using Esri® ArcGIS Desktop® software. We took two risk assessment approaches: (1) estimated loss (in dollars) to buildings from floods and earthquakes using the Hazus-MH methodology, and (2) calculated the number of buildings, their value, and associated populations exposed to earthquake, and flood scenarios, or susceptible to varying levels of hazard from landslides, channel migration, and wildfire. Details on recurrence intervals, susceptibility, hazard levels and other particulars are discussed in detail for each hazard in **Assessment Overview and Results**.

The findings and conclusions of this report show the wide range of potential impacts hazards could have on the communities of Morrow County. A Mw-7.1 earthquake occurring on a nearby crustal fault (Horse Heaven Fault) has the potential to cause moderate damage and losses to areas in the northern portion of Morrow County. We demonstrate the potential for reduction in earthquake damages and losses through seismic retrofits using the building code simulations in the Hazus-MH earthquake model. Flooding is a threat for some communities in the study area (Heppner, Ione, and Lexington) and we quantify the number of elevated structures that are less vulnerable to flood hazard to better understand the level of mitigation needs for these communities. Our analysis shows that areas along Willow Creek and State Highway 74 are at greatest risk from landslide hazards. Approximately 5% of the county's residential buildings are exposed to channel migration hazard along Willow Creek and Rhea Creek. The wildfire exposure analysis shows a High risk for most of the county, with most of Morrow County's population and critical facilities at High risk.

The information presented in this report is designed to increase awareness of natural hazard risk, to support public outreach efforts, and to aid local decisionmakers in developing comprehensive plans and natural hazard mitigation plans. This study can help emergency managers identify vulnerable critical facilities and develop contingencies in their response plans. The results of this study are designed to be used to help communities identify and prioritize mitigation actions that will improve community resilience.

Results were broken out for the following geographic areas:

- Unincorporated Morrow County (rural)
- City of Heppner
- City of Irrigon
- City of Boardman
- City of Ione
- City of Lexington

Selected countywide results
Total buildings: 8,480
Total estimated building value: $4.3 billion

Horse Heaven Fault Magnitude-7.1 Earthquake Scenario
Red-tagged buildings[a]: 103
Yellow-tagged buildings[b]: 473
Loss estimate: $216 million

100-year Flood Scenario
Number of buildings damaged: 250
Loss estimate: $10 million

Landslide Exposure (High and Very High Susceptibility)
Number of buildings exposed: 551
Exposed building value: $140 million

Channel Migration Zone (Erosion Hazard Area – 30-year):
Number of buildings exposed: 79
Exposed building value: $14 million

Wildfire Exposure (High and Moderate Risk):
Number of buildings exposed: 1,624
Exposed building value: $350 million

[a]Red-tagged buildings are considered uninhabitable due to complete damage
[b]Yellow-tagged buildings are considered limited habitability due to extensive damage

1.0 INTRODUCTION

A *natural hazard* is an environmental phenomenon that can negatively impact humans, and *risk* is the likelihood that a hazard will result in harm. A natural hazard risk assessment identifies the applicable hazards and analyzes their impacts on the built environment and population, including the cost of recovery. Risk assessments provide key foundational information that can be used to develop mitigation plans, strategies, and actions, so that steps can be taken to prepare for a potential hazard event.

Key Terms:

- *Vulnerability:* Characteristics that make people or assets more susceptible to a natural hazard.
- *Risk:* Likelihood of occurrence multiplied by consequence; the degree of probability that a loss or injury may occur as a result of a natural hazard.

This report is a multi-hazard risk assessment analyzing individual buildings and resident population in Morrow County. Morrow County is situated in the northcentral part of Oregon, typically characterized as the Columbia Plateau, and is subject to natural hazards, including earthquakes, riverine flooding, landslides, channel migration, and wildfires. This report provides detailed and comprehensive analyses of the risks posed by these natural hazards as well as a comparative perspective not previously available.

1.1 Purpose

The purpose of this project is to help communities in the study area better understand their risk and increase resilience to earthquakes (including ground shaking, liquefaction, and coseismic landslides), riverine flooding, landslides, channel migration, and wildfire natural hazards that are present in their communities. This is accomplished by using the best available, most accurate, and detailed information about these hazards to assess the number of people and buildings at risk.

The main objectives of this study are to:

- compile a database of critical facilities, tax assessor data, buildings, and population distribution data,
- incorporate and use existing data from the most current geologic, hydrologic, and wildfire hazard studies,
- perform exposure and Hazus–based risk analyses, and
- share this report widely so that all interested parties have access to its information and data.

The body of this report describes our methods and results. Two primary methods (Hazus-MH loss estimation and exposure) were used to assess risk, depending on the type of hazard. Results for each hazard type are reported on a countywide basis within each hazard section, and community-wide results are reported in detail in **Appendix A: Community Risk Profiles**. **Appendix B** contains detailed risk assessment tables. **Appendix C** is a more detailed explanation of the Hazus-MH methodology. **Appendix D** lists acronyms and definitions of terms used in this report. **Appendix E** contains tabloid-size maps showing countywide hazard maps.

1.2 Study Area

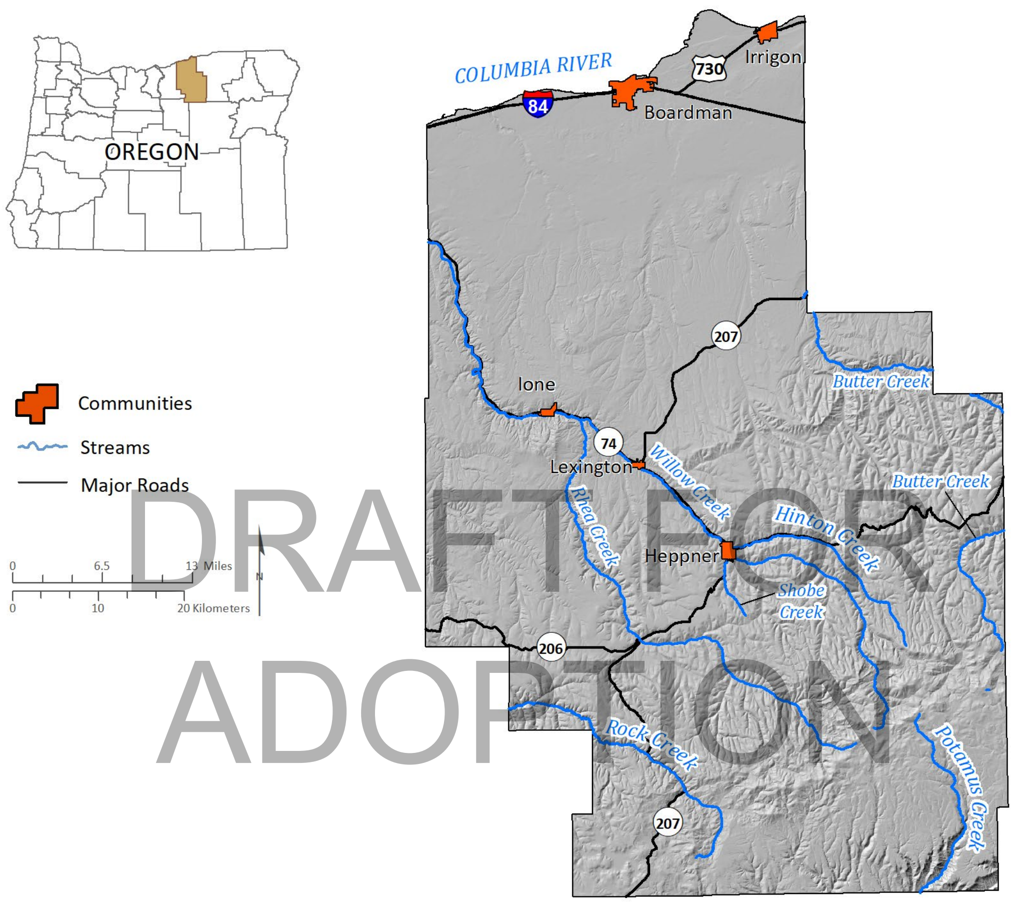
The study area for this project includes the entirety of Morrow County, Oregon (**Figure 1-1**). The study area is located in the northeastern portion of the state; the county is bordered by Gilliam County to the west, Wheeler County to the southwest, Grant County to the south, Umatilla County to the east, and by the Columbia River to the north. The total area of Morrow County is 5,260 square kilometers (2,031 square miles). A significant portion of the county is privately-owned agricultural land, primarily growing wheat using center pivot irrigation. There are also large uninhabited areas where the county jurisdiction extends into the Umatilla National Forest.

The geography of north and central Morrow County consists mostly of the rolling topography representative of the Columbia Plateau. The southern portion of the county extends into the margins of the Blue Mountains and is primarily composed of canyons. There are very few trees in this part of Oregon and land cover is primarily grasses or other types of agricultural vegetation; undeveloped areas tend to be rocky and barren scrublands.

The population of Morrow County is nearly 13,000 based on an estimated population for each community in 2021 from the Portland State University (PSU) Population Research Center https://www.pdx.edu/population-research/population-estimate-reports. This region of the state is sparsely populated with most of the development occurring in the county's five incorporated cities. The

City of Heppner is the county seat and has a population of nearly 1,200. The City of Boardman has the largest population with approximately 4,300 people (roughly one-third of the county's total population). The other three incorporated communities in Morrow County are Ione, Irrigon, and Lexington (**Figure 1-1**).

Figure 1-1. Study area: Morrow County with communities identified in this study.



1.3 Project Scope

For this risk assessment, we limited the project scope to natural hazard impacts on buildings and population because of data availability, the strengths and limitations of the risk assessment methodology, and funding availability. We did not directly analyze impacts to the local economy, transportation routes, community lifelines, stored hazardous materials, land values, socially vulnerable populations, or the environment. While we recognize that climate change does affect, and in many cases increases, risk from natural hazards, it was also not examined in this study. Depending on the natural hazard, we used one of two methodologies: loss estimation or exposure. Loss estimation was modeled using methodology from Hazus®-MH (FEMA, 2012a, 2012b, 2012c), a tool developed by FEMA for calculating damage to buildings from flood and earthquake. Exposure is a simpler methodology, in which buildings are categorized based on their location relative to various hazard zones. To account for impacts on population (permanent residents only), city and county population numbers from the PSU Population Research Center data was used to distribute people into residential structures based on square footage (https://www.pdx.edu/population-research/population-estimate-reports).

A critical component of this risk assessment is a countywide building inventory developed from building footprint data (Williams, 2021) and the Morrow County tax assessor database (acquired 2022). The other key component is a suite of datasets that represent the currently best available science for a variety of natural hazards. The geologic hazard scenarios were selected based on expert knowledge of the datasets; most datasets are DOGAMI publications. In addition to geologic hazards, we included wildfire hazard in this risk assessment. The Oregon Department of Forestry (ODF) provided recommendations on the use of wildfire datasets for risk analysis. The following is a list of the natural hazards and the risk assessment methodologies that were applied. See **Table 1-1** for data sources.

Earthquake Risk Assessment

- Hazus-MH loss estimation from a Horse Heaven Fault earthquake magnitude (Mw)-7.1 scenario. Includes earthquake-induced or "coseismic" liquefaction, soil amplification class, and landslides.

Flood Risk Assessment

- Hazus-MH loss estimation to four recurrence intervals (10%, 2%, 1%, and 0.2% annual chance)
- Exposure to 1% annual chance recurrence interval.

Landslide Risk Assessment

- Exposure based on Landslide Susceptibility Index and landslide deposit mapping (Low to Very High)

Channel Migration Risk Assessment

- Exposure based on the 30-year erosion hazard.

Wildfire Risk Assessment

- Exposure based on Wildfire Burn Probability (Low to High)

Table 1-1. Hazard data sources for Morrow County.

Hazard	Scenario or Classes	Spatial Extent	Data Source
Earthquake	Horse Heaven Fault Mw-7.1	Countywide	U.S. Geological Survey (USGS) (Personius and others, 2016) accessed via Hazus fault database
Coseismic landslide	Susceptibility – wet (3-10 hazard classes)	Statewide	DOGAMI (Madin and others, 2021)
Coseismic liquefaction	Susceptibility (1-5 classes)	ʺ	ʺ
Coseismic soil amplification class	National Earthquake Hazards Reduction Program (A-F classes)	ʺ	ʺ
Flood	Depth Grids: 10% (10-yr) 2% (50-yr) 1% (100-yr) 0.2% (500-yr)	Countywide	DOGAMI (Appleby and others, 2021) – derived from FEMA (2007) data
Landslide	Deposits	Inhabited portions of Morrow County	DOGAMI (Hairston-Porter and others, 2021)
	Susceptibility (Low, Moderate, High, Very High)	Statewide	DOGAMI (Burns and others, 2016)
Channel Migration	Susceptibility (Not Exposed, Exposed)	Hinton, Rhea, and Willow Creeks	DOGAMI (Appleby and others, 2021)
Wildfire	Overall Wildfire Risk (Low, Moderate, High)	Regional (Pacific Northwest, US)	Oregon Department of Forestry (ODF) (Gilbertson-Day and others, 2018)

1.4 Previous Studies

Wang (1998) used Hazus-MH to estimate the impact from a Mw-8.5 Cascadia Subduction Zone (CSZ) earthquake scenario on the state of Oregon. The results of this study were arranged into individual counties. Morrow County was estimated to experience <1% loss ratio in the Mw-8.5 CSZ scenario, due to the distance from the earthquake source.

We did not compare the results of this project with the results of the previous study because the of the lack of detail and accuracy of the building information and site-specific earthquake inputs used in the previous study relative to what was used in this study. Comparative analysis was not part of the scope of this project.

2.0 METHODS

We used a quantitative approach to assess the level of risk to buildings and people from natural hazards. The two modes of analysis were Hazus-MH loss estimation and exposure analysis.

2.1 Hazus-MH Loss Estimation

> ***Key Terms:***
> - *Loss estimation:* Damage in terms of value that occurs to a building in an earthquake or flood scenario, as modeled with Hazus-MH methodology. This is measured as the cost to repair or replace the damaged building in US dollars.
> - *Loss ratio:* Percentage of estimated loss relative to the total value.

We used Hazus-MH version 5.0 (FEMA, 2020), which was the latest version available when we began this risk assessment. According to FEMA (FEMA, 2012a, p. 1-1), “Hazus provides nationally applicable, standardized methodologies for estimating potential wind, flood, and earthquake losses on a regional basis. Hazus can be used to conduct loss estimation for floods and earthquakes […]. The multi-hazard Hazus is intended for use by local, state, and regional officials and consultants to assist mitigation planning and emergency response and recovery preparedness. For some hazards, Hazus can also be used to prepare real-time estimates of damages during or following a disaster.”

Hazus-MH can be used in different modes depending on the level of detail required. Given the high spatial precision of the building inventory data and quality of the natural hazard data available for this study, we chose the user-defined facility (UDF) mode. This mode makes loss estimations for individual buildings relative to their “cost,” which we then aggregate to the community level to report loss ratios. Costs used in this mode are associated with rebuilding using new materials, also known as replacement cost. Replacement cost is determined using a method called RSMeans valuation (Charest, 2017) and is calculated by multiplying the building area (in square feet) by a standard cost per square foot. These standard rates per square foot are in tables within the default Hazus-MH database.

Damage functions are at the core of Hazus-MH. The damage functions stored within the Hazus-MH data model were developed and calibrated from the observed results of past disasters. We estimated damage and loss by intersecting building locations with natural hazard layers and applying damage functions based on the hazard severity (e.g., depth of flooding) and building characteristics (e.g., first floor height). **Figure 2-1** illustrates the range of building loss estimates from a Hazus-MH flood analysis. In this example, most buildings within the 100-year flood zone are estimated to experience losses ranging from >0 to >15%. Buildings with a first-floor height above the level of flooding and those outside the flood zone are expected to experience no losses.

Figure 2-1. 100-year flood zone and building loss estimates example in City of Heppner, Oregon.

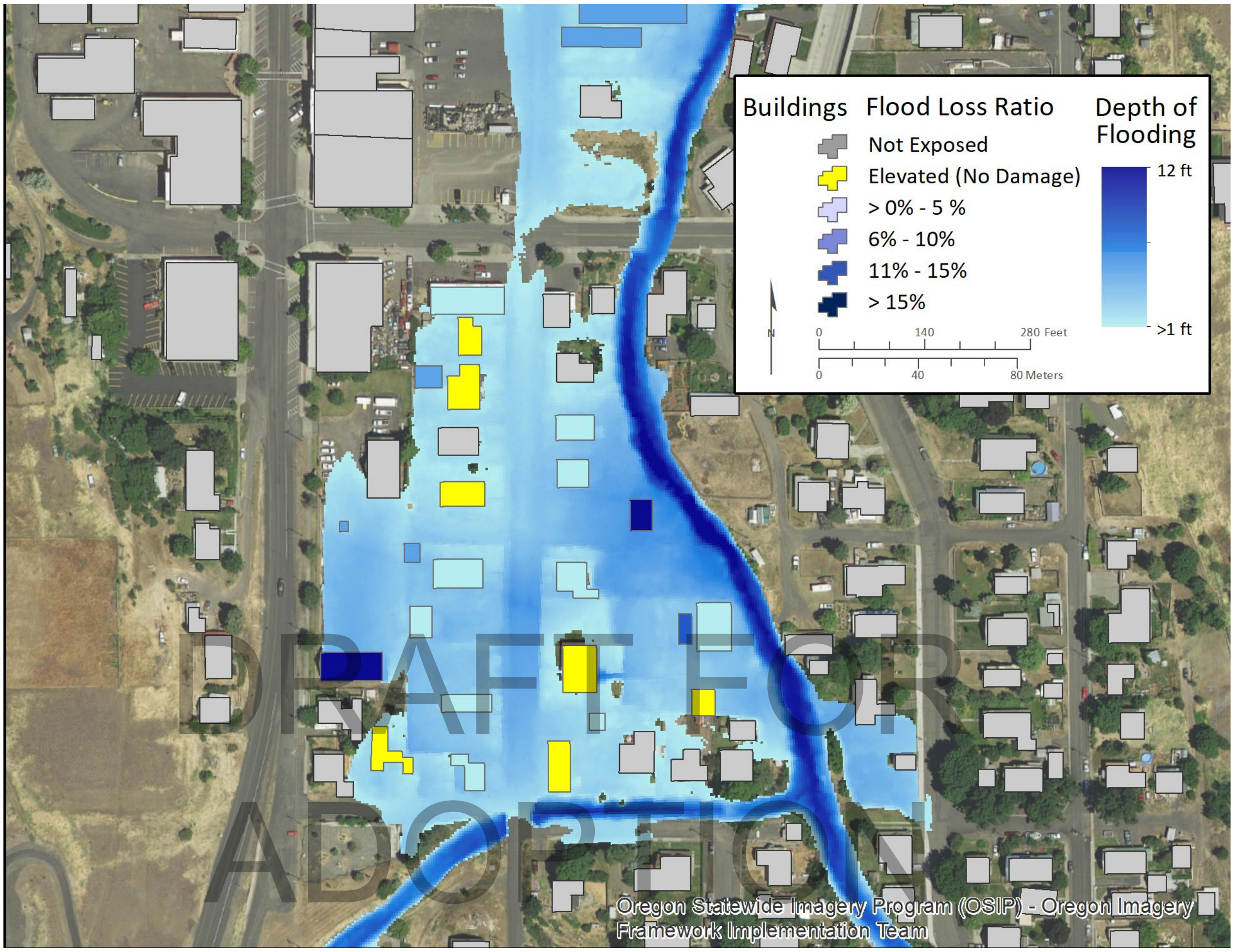


Image source: Oregon Statewide Imagery Program, 2017

Depth grid: Derived from the effective FEMA Flood Insurance Rate Map data for Morrow County, 2007

2.2 Exposure

Since loss estimation using Hazus-MH is not available for all types of hazards, we used exposure analysis to assess landslide, channel migration, and wildfire risk. Exposure methodology identifies the buildings and population that are within a particular natural hazard zone. This is an alternative to the more detailed loss estimation method for those natural hazards that do not have available damage models like in Hazus. It provides a way to easily quantify what is and what is not threatened. Exposure results are communicated in terms of total building value exposed, rather than a loss estimate. For example, Figure 2-2 shows buildings that are exposed to different levels of landslide susceptibility with building footprints colored based on what susceptibility zone the center of the building is within.

Key Terms:

- *Exposure:* Determination of whether a building is within or outside of a hazard zone. No loss estimation is modeled.
- *Building value:* Total monetary value of a building. This term is used in the context of exposure.

Exposure is used for landslide, wildfire, and channel migration. For comparison with loss estimates, exposure is also used for the 1% annual chance flood, that is a flood that has a 1% chance of occurrence in any given year.

Figure 2-2. Landslide susceptibility and building exposure example in the City of Heppner, Oregon.

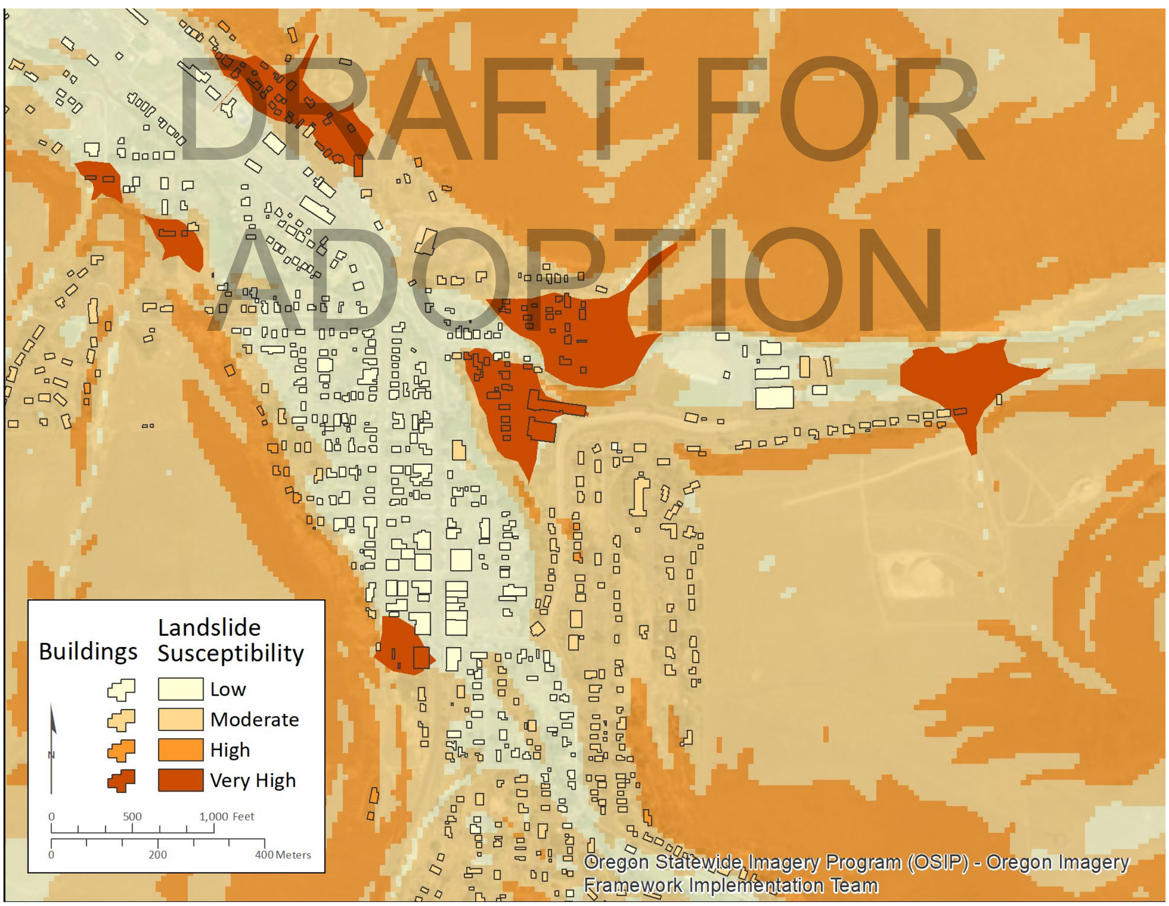


Image source: Oregon Statewide Imagery Program, 2017

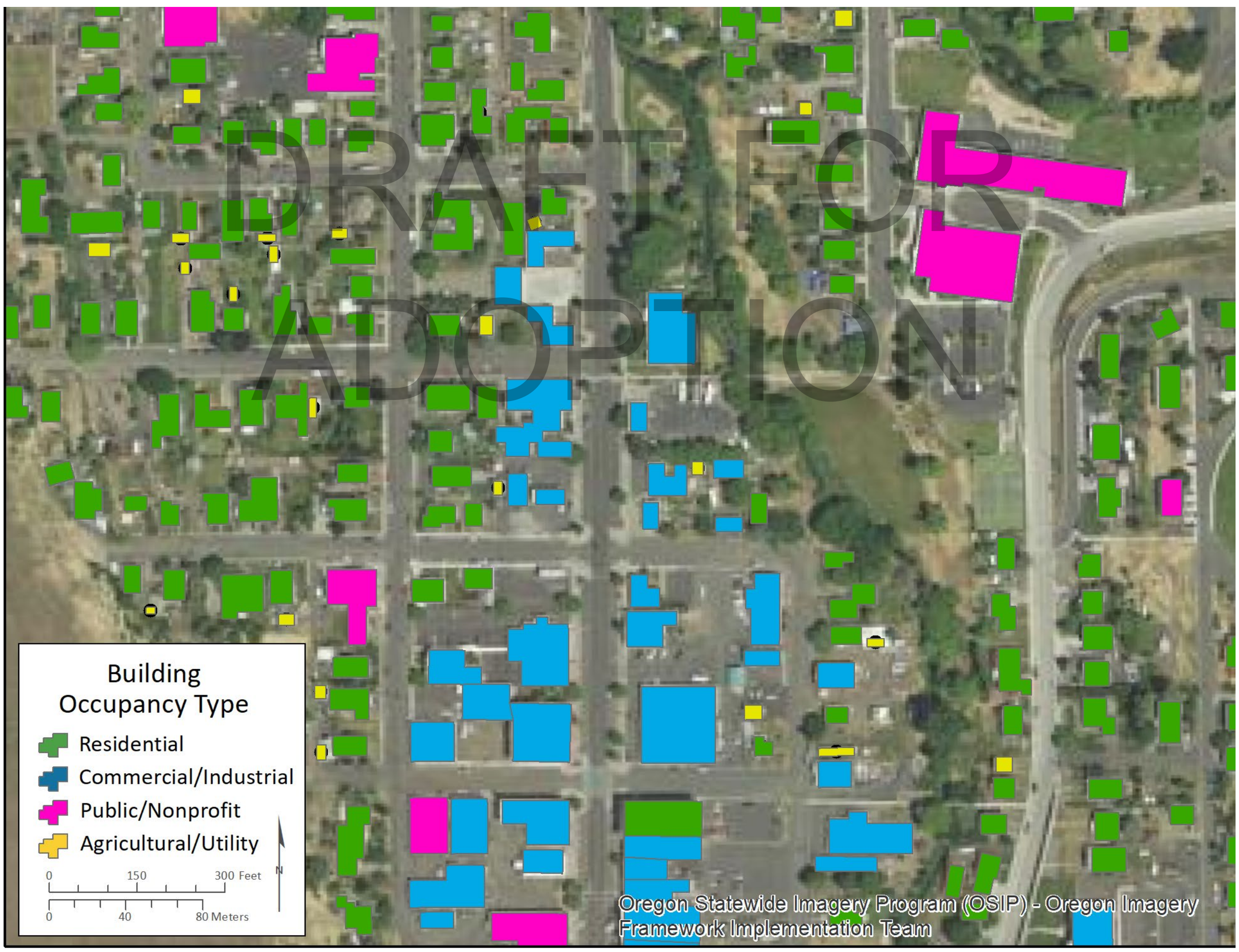
Landslide data source: Morrow County landslide deposits, (Hairston-Porter and others, 2021) and landslide susceptibility overview map of Oregon, (Burns and others, 2016)

2.3 Building Inventory

A key piece of the risk assessment is the countywide building inventory. This inventory consists of all buildings larger than 9.3 square meters (100 square feet), as determined from digitized building footprint data from Williams, 2021. **Figure 2-3** shows an example of building inventory occupancy types used in the Hazus-MH and exposure analyses in Morrow County. See also **Appendix B, Table B-1** and **Appendix E, Plate 1** and **Plate 2.**

To use the building inventory within Hazus-MH, we converted the building footprint polygons to points and migrated them into a UDF database with standardized field names and attribute domains. The UDF database formatting allows for the correct damage function to be applied to each building. Hazus-MH version 2.1 technical manuals (FEMA, 2012a, 2012b, 2012c) provide references for acceptable field names, field types, and attributes. The fields and attributes used in the UDF database (including building seismic codes) are discussed in more detail in **Appendix C.2.2**.

Figure 2-3. Building occupancy types, City of Heppner, Oregon.



The number of buildings and total building value varies per community varies significantly in Morrow County, with 212 buildings and $55 million for Lexington to 1,214 buildings and $823 million for

Boardman (**Table 2-1).** A table detailing the occupancy class distribution by community is included in **Appendix B: Detailed Risk Assessment Tables**.

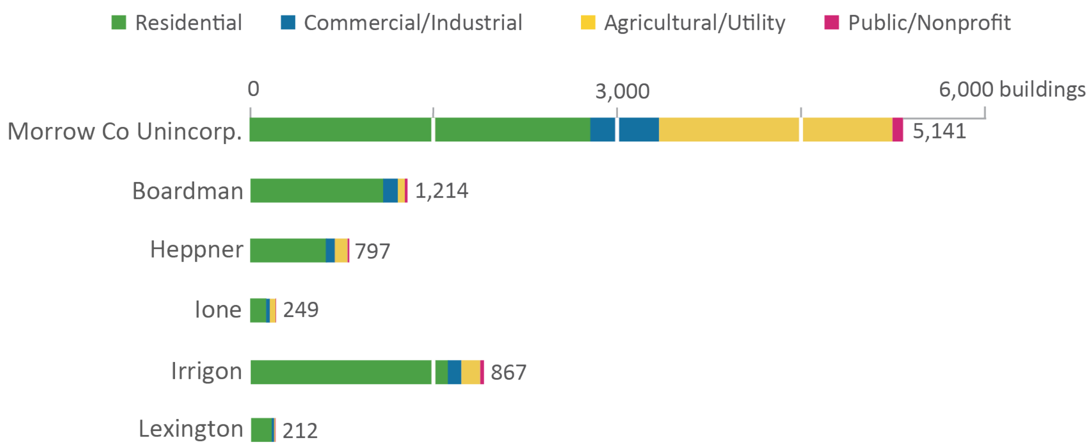
Table 2-1. Morrow County building inventory.

Community	Total Number of Buildings	Percentage of Total Buildings	Estimated Total Building Value ($)	Percentage of Total Building Value
Unincorp. Morrow Co. (rural)	5,141	61%	2,877,027,000	67%
Boardman	1,214	14%	823,077,000	19%
Heppner	797	9.4%	229,967,000	5.4%
Ione	249	2.9%	68,770,000	1.6%
Irrigon	867	10%	217,274,000	5.1%
Lexington	212	2.5%	55,260,000	1.3%
Total Study Area	8,480	100%	4,271,375,000	100%

The building inventory was developed from a statewide building footprints dataset developed in 2021 called the Statewide Building Footprints for Oregon, release 1 (SBFO-1) (Williams, 2021), which covers all of Morrow County. The building footprints provide a location and 2D outline of a structure. The total number of buildings within the study area was 8,480. We define buildings to be permanent structures with walls and a roof that can be occupied by people (Williams, 2021). Other structures, such as dams, water tanks/towers, sewage and water treatment tanks, tents, small garden sheds, hoop-houses or other plastic-covered greenhouses, and grain silos were not considered buildings and were not included in this analysis.

The Morrow County Assessment Office supplied tax assessor records, which we formatted for use in the risk assessment. The assessor data contains an array of information about each improvement (i.e., building). Tax lot data, which contains property boundaries and other information regarding the property, was obtained from the county assessor and was used to link the buildings with assessor data. The linkage between the two datasets resulted in a database of UDF points that contain attributes for each building. These points are used in the risk assessment for both loss estimation and exposure analysis. **Figure 2-4** illustrates the building value and occupancy class across the communities of Morrow County.

Figure 2-4. Community building value in Morrow County by occupancy class.



Critical facilities are important to note because these facilities play a crucial role in emergency response efforts. We embedded identifying characteristics into the critical facilities in the UDF database so they could be highlighted in the results. Critical facilities data came from the DOGAMI Statewide Seismic Needs Assessment (SSNA; Lewis, 2007). We updated the SSNA data by reviewing Google Maps™ data. The critical facilities we identified include hospitals, schools, fire stations, police stations, emergency operations, and military facilities. In addition, we included other buildings based on specific community input and structures that would be essential during a natural hazard event, such as public works and water treatment facilities. Communities that have critical facilities that can function during and immediately after a natural disaster are more resilient than those with critical facilities that are inoperable after a disaster. Critical facilities are present throughout the county with most located in incorporated communities (**Table 2-2**). Critical facilities are listed for each community in **Appendix A**.

Table 2-2. Morrow County critical facilities inventory.

	Hospital & Clinic		School		Police/Fire		Emergency Services		Military		Other*		Total	
Community	Count	Value ($)	Count	Value ($)	Count	Value ($)	Count	Value ($)	Count	Value ($)	Count	Value ($)	Count	Value ($)
	(all dollar amounts in thousands)													
Unincorp. Morrow Co. (rural)	0	0	0	0	0	0	0	0	0	0	2	3,386	2	3,386
Boardman	0	0	3	49,207	2	10,507	0	0	0	0	0	0	5	59,713
Heppner	0	0	1	9,008	2	4,033	0	0	0	0	1	157	4	13,198
Ione	0	0	1	9,023	1	892	0	0	0	0	0	0	2	9,915
Irrigon	1	515	3	45,413	1	811	0	0	0	0	0	0	5	46,739
Lexington	0	0	0	0	1	504	0	0	0	0	1	377	2	881
Total County	1	515	8	112,651	7	16,747	0	0	0	0	4	3,920	20	133,832

Note: Facilities with multiple buildings were consolidated into one building.

* Category includes buildings that are not traditional (emergency response) critical facilities but considered critical during an emergency based on input from local stakeholders (e.g., water treatment facilities or airports).

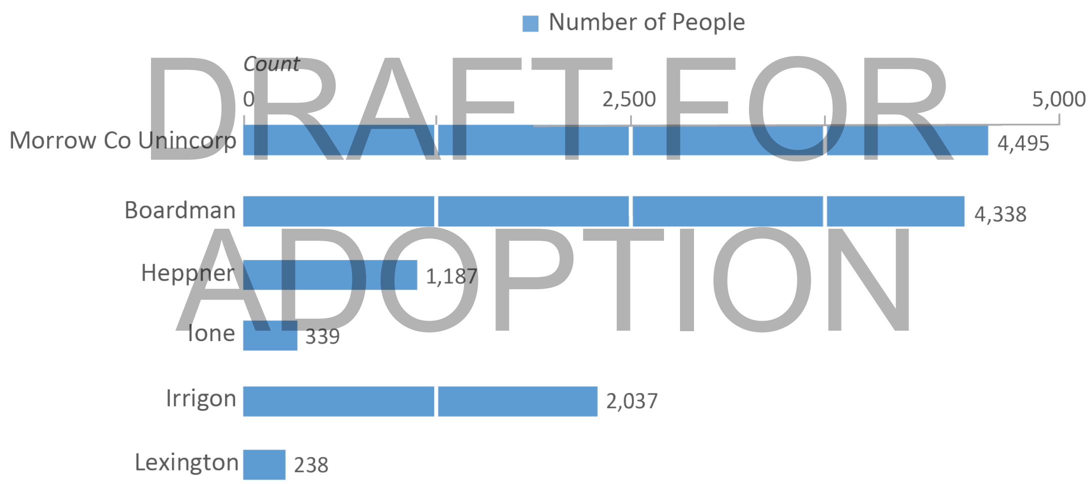
2.4 Population

The UDF database was designed to allow us to estimate the number of people at risk from natural hazards. Within the UDF database, the PSU Population Research Center estimates of permanent residents was distributed proportionally among residential buildings based on building area. Estimates for every incorporated community, as well as the entire county, were available from the PSU data (**Figure 2-5**).

We did not examine the impacts of natural hazards on nonpermanent populations (e.g., tourists), whose total numbers fluctuate seasonally. Due to lack of information within the assessor and census databases, we cannot distinguish between vacation homes and primary residences. Therefore, our method distributes some of the permanent residents into vacation homes, however they make up a small portion of the residential building stock in most communities (U.S. Census Bureau, 2020b).

From the PSU Population Research Center data, we assessed the risk of the 12,635 residents within the study area that could be affected by a natural hazard. For each natural hazard, except for the earthquake scenario, a simple exposure analysis was used to find the number of potentially displaced residents within a hazard zone. For the earthquake scenario the number of potentially displaced residents was based on residents in buildings estimated to be significantly damaged by the earthquake.

Figure 2-5. Population by Morrow County community.



3.0 ASSESSMENT OVERVIEW AND RESULTS

In this risk assessment, we considered five natural hazards (earthquake, flood, landslide, channel migration, and wildfire) that pose a risk to Morrow County. The assessment describes both localized vulnerabilities and the widespread challenges that impact all communities. While results of this risk assessment do not typically represent singular hazard events, they do quantify the potential overall level of risk present for assets and residents. The loss estimation and exposure results, as well as the rich datasets included with this report, can lead to greater understanding of the potential impacts of natural disasters. Communities can become more resilient to future disasters by utilizing the results in plan updates and developing future action items for risk reduction.

In this section, results are presented for the entire study area. The study area includes all five cities and the remaining unincorporated areas of Morrow County. Individual community results are in **Appendix A: Community Risk Profiles.**

3.1 Earthquake

An earthquake is a sudden movement of rock on each side of a fault in the earth's crust, which abruptly releases strain that has accumulated. The movement along the fault produces waves of shaking that spread in all directions. If an earthquake occurs near populated areas, it may cause casualties, economic disruption, and extensive property damage (Madin and Burns, 2013).

Two earthquake-induced hazards, also called coseismic hazards, are liquefaction and landslides. Liquefaction occurs when saturated soils substantially lose bearing capacity due to ground shaking, causing the soil to behave like a liquid; this action can be a source of tremendous damage. Coseismic landslides are mass movement of rock, debris, or soil induced by ground shaking. Losses and exposure due to earthquakes in this report include damages derived from shaking as well as liquefaction and landsliding.

3.1.1 Horse Heaven Fault earthquake scenario

Hazus-MH offers two methods for estimating loss from earthquake, one being probabilistic and the other deterministic (FEMA Hazus-MH, 2012b). The probabilistic method uses USGS National Seismic Hazard Maps, which are derived from seismic hazard curves calculated on a grid of sites across the United States that describe the annual frequency of exceeding a set of ground motions as a result of all possible earthquake sources (USGS, 2017). The deterministic method uses a specific seismic scenario event, such as a CSZ Mw-9.0 event. We used the deterministic scenario to simulate a nearby crustal earthquake, which provides a scenario of highest potential damage for earthquake hazard in Morrow County.

The earthquake scenario examined for this report is the Horse Heaven Fault, the closest part of the fault to the study area is located approximately 20 miles north of the City of Irrigon. It is a 179-km (111-mile)-long Quaternary fault that experiences slip of 0.2-0.04 mm/yr (0.008-0.002 in/yr)(Personius and others, 2016). The estimated maximum fault displacement could produce relatively large (Mw-7.1) crustal earthquakes, enough to pose a significant hazard (Personius and others, 2016). Although less is known about the recurrence interval of this fault compared to the CSZ, the Horse Heaven Fault has a much higher damage potential in Morrow County due to its proximity to the source of shaking. The current understanding of this fault and various aspects of its frequency and magnitude is very limited.

3.1.2 Cascadia Subduction Zone earthquake scenario

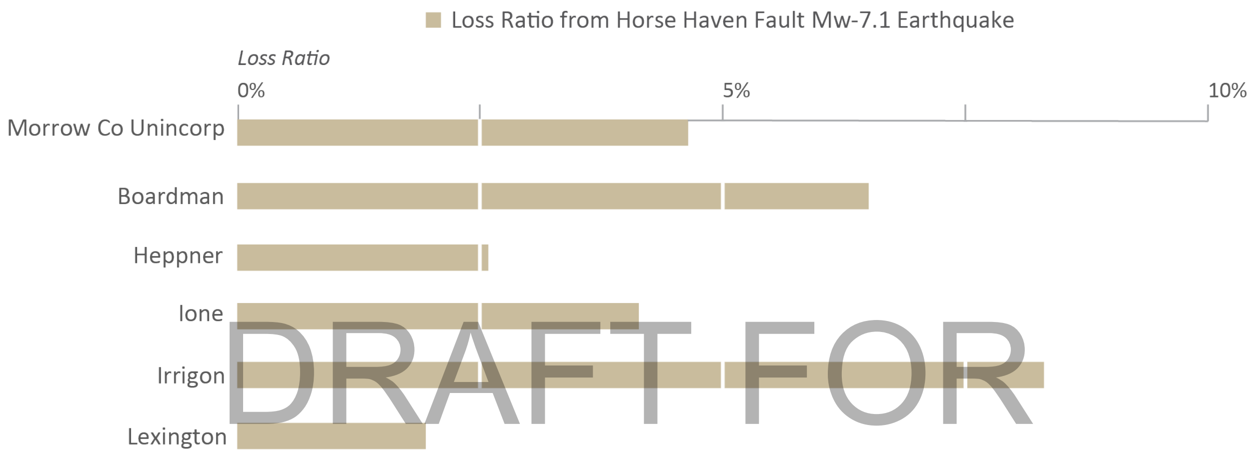
While an earthquake produced by the CSZ is expected to be very large (Mw-9.0) and will cause wide-ranging impacts in western Oregon, Morrow County would likely see very minor shaking causing a small amount of damage. The Oregon Seismic Hazard Database (OSHD, Madin and others 2021) calculate that ground shaking (PGA,measured in units of g-force (g)) produced from a CSZ Mw-9.0 in Morrow County would range from 0.06 g to 0.18 g. According to the Mercalli scale, ground motion values in this range correspond to potential damage ranging from None to Very light. Based on these estimates, we selected the local crustal fault scenario as the best scenario to characterize the risk from earthquake in Morrow County.

3.1.3 Data sources

The Mw-7.1 Horse Heaven Fault deterministic scenario was selected as the most appropriate for communicating earthquake risk for Morrow County. The default Hazus-MH earthquake scenario database contained the location and orientation of the fault and provided a recommended maximum magnitude for use in a simulated earthquake event. The epicenter was manually selected along the fault and was located at the closest proximity to buildings within the study area.

The following hazard layers used for our loss estimation are derived from work conducted by Madin and others (2021): National Earthquake Hazard Reduction Program (NEHRP) soil classification, landslide susceptibility (wet), and liquefaction susceptibility. The liquefaction and landslide susceptibility layers were used by the Hazus-MH tool to calculate the probability and magnitude of permanent ground deformation caused by these factors. Hazus-MH uses a characteristic magnitude value to calculate the impacts of liquefaction and landslides. For this study, we followed the details provided in the default Hazus-MH database and used Mw-7.1 as the characteristic event.

Figure 3-1. Horse Heaven Fault Mw-7.1 earthquake loss ratio by Morrow County community.



3.1.4 Countywide results

Because an earthquake can affect a wide area, every building in Morrow County will by shaken by a Horse Heaven Fault Mw-7.1 earthquake. Hazus-MH loss estimates (see **Table B-2)** for each building are based on a formula where coefficients are multiplied by each of the five damage state percentages (None, Low, Moderate, Extensive, and Complete). These damage states are correlated to loss ratios that are then multiplied by the total building replacement value to obtain a loss estimate (FEMA, 2012b). Loss estimates from the earthquake scenario described in this report vary widely by community in Morrow County with the largest losses in Irrigon (8%) and Boardman (6%) and the least in Lexington (3%) (**Figure 3-1**).

In keeping with earthquake damage reporting conventions, we used the Applied Technology Council - 20 post-earthquake building safety evaluation color-tagging system to represent damage states (Applied Technology Council, 2020). Red-tagged buildings correspond to a Hazus-MH damage state of "Complete," which means the building is uninhabitable. Yellow-tagged buildings are in the "Extensive" damage state, indicating limited habitability. The number of red or yellow-tagged buildings we report for each community is based on an aggregation of the probabilities for individual buildings (FEMA, 2012b).

Critical facilities were considered nonfunctioning if the Hazus-MH earthquake analysis showed that a building or complex of buildings had a greater than 50% chance of being at least moderately damaged (FEMA, 2012b). Because building specific information is more readily available for critical facilities and due to their importance after a disaster, we chose to report the results of these buildings individually.

The number of potentially displaced residents from an earthquake scenario described in this report was based on the formula: ([Number of Occupants] * [Probability of Complete Damage]) + (0.9 * [Number of Occupants] * [Probability of Extensive Damage]) (FEMA, 2012b). The probability of damage state was determined in the Hazus-MH earthquake analysis results.

Morrow County Horse Heaven Mw-7.1 earthquake results:

- Number of red-tagged buildings: 103
- Number of yellow-tagged buildings: 474
- Loss estimate: $215,720,000
- Loss ratio: 5%
- Nonfunctioning critical facilities: 2 of 20
- Potentially displaced population: 144

The results indicate that Morrow County could incur moderate losses (5%) due to a Horse Heaven Fault Mw-7.1 earthquake. The primary contributing factor to damage is proximity to the fault, where closer structures are more likely to incur more damage relative to structures that are further away. Buildings in Irrigon and Boardman that are approximately 24 to 40 kilometers (15 to 25 miles) away from the simulated epicenter along the Horse Heaven Fault will have a higher probability of damage than other parts of Morrow County.

Although damage caused by coseismic landslides was not specifically looked at in this report, it likely contributes a small amount to the estimated damage from the earthquake hazard in Morrow County. Landslide exposure results show that 3.3% of buildings in Morrow County are within a Very High or High susceptibility zone. This suggests that a similar percentage of the earthquake loss estimated in this study may be due to coseismic landslides.

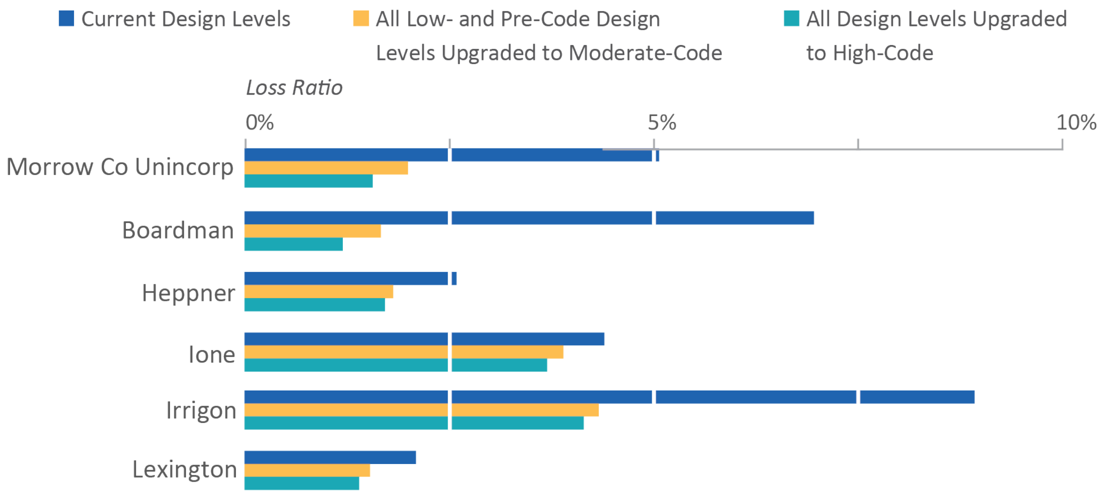
Building vulnerabilities such as the age of the building stock and occupancy type are also contributing factors in loss estimates. The first seismic buildings codes were implemented in Oregon in the 1970s (Judson, 2012) and by the 1990s, modern seismic building codes were being enforced. Nearly 70% of Morrow County's buildings were built before the 1990s. In Hazus-MH, manufactured homes are one occupancy type that performs poorly in earthquake damage modeling. Communities that are composed of an older building stock and more vulnerable occupancy types are expected to experience more damage from earthquake than communities with fewer of these vulnerabilities.

If buildings could be seismically retrofitted to higher code standards, earthquake risk would be greatly reduced. A simulation wherein all buildings are upgraded to at least Moderate code level results in a loss ratio of 2.1%. This is a 58% reduction from the 5% loss ratio calculated for the current condition of Morrow County's building stock. A second simulation bringing all buildings up to High code level results in a loss ratio of 1.7%, a 60% reduction from current design levels. The relatively small improvement between the Moderate and High building code simulations implies that efforts to upgrade buildings in order to reduce earthquake damages need not exceed Moderate (**Figure 3-2**). While retrofits can decrease earthquake vulnerability, for areas of high landslide or liquefaction, additional geotechnical mitigation may be necessary to have an effect on losses.

Key Terms:

- *Seismic retrofit:* Structural modification to a building that improves its resilience to earthquake.
- *Design level:* Hazus-MH terminology referring to the quality of a building's seismic building code (i.e., Pre, Low, Moderate, and High). Refer to **Appendix C.2.3** for more information.

Figure 3-2. Horse Heaven Fault Mw-7.1 earthquake loss ratio in Morrow County, with simulated seismic building code upgrades.



3.1.5 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk to earthquake hazard:

- Areas near the simulated epicenter of the Horse Heaven Fault are likely to incur a significant amount of damage from an earthquake generated from it. The communities of Boardman and Irrigon have significantly higher estimated loss ratios compared to other communities in the study due to the level of shaking likely to occur.
- Unreinforced masonry buildings and manufactured homes are more vulnerable to substantial damage during an earthquake compared to other nearby structures built to modern standards.

3.2 Flooding

The frequency and severity of flooding may change over time due to changes in climate and precipitation patterns, land use, and how we manage our waterways. This study represents our current understanding of flood hazards and flood risk, but we recognize that flood models and risk assessments will need to be updated with time and changing conditions.

In its most basic form, a flood is an accumulation of water over normally dry areas, typically due to excessive rain or snowmelt. Floods become hazardous to people and property when they inundate an area where development has occurred. Floods are a commonly occurring natural hazard in Morrow County and have the potential to create public health hazards and safety concerns, close and damage major highways and railways, damage structures, and cause major economic disruption. More rare flood issues such as flash flooding, ice jams, post-wildfire floods, and dam safety were not examined in this report.

A typical method for determining flood risk is to identify the probability and impact of flooding. The annual probabilities calculated for flood hazard used in this report are 10%, 2%, 1%, and 0.2%, henceforth referred to as 10-year, 50-year, 100-year, and 500-year scenarios, respectively. The ability to assess the probability of a flood and the level of accuracy of that assessment is influenced by modeling methodology advancements, better understanding of hydrologic factors, and longer periods of record for the stream or water body in question.

In 1903, the community of Heppner experienced one of the deadliest natural disasters in the state's history, leaving a profound mark on the community and its residents. Triggered by a sudden and intense cloudburst, the floodwaters surged down Willow Creek and overwhelmed the unsuspecting town with a wall of water on the afternoon of June 14. The torrential deluge, estimated to have reached heights of up to 40 feet, swept away homes and businesses and took the lives of 247 individuals. It took many decades for Heppner to recover from this disaster. Willow Creek Dam now prevents this type of flooding from occurring and stands as a reminder of effective mitigation action and emergency planning (FEMA. 2007).

The major rivers and creeks within the county are the Columbia River and Butter, Hinton, Potamus, Rhea, Rock, Shobe, and Willow creeks. In addition, there are several tributaries to these major streams that have mapped flood zones. All of these streams are subject to flooding and have the potential to damage buildings within the floodplain, but these streams do not represent the entirety of potential flood sources in Morrow County. The analysis for the flood risk in Morrow County was limited to the modeled floods for streams included in FEMA's Flood Insurance Study (FIS).

The impacts of flooding are determined by adverse effects to human activities within the natural and built environment. These adverse impacts can be reduced through mitigation efforts, such as elevating structures above the expected level of flooding or removing structures through FEMA's property acquisition ("buyout") program.

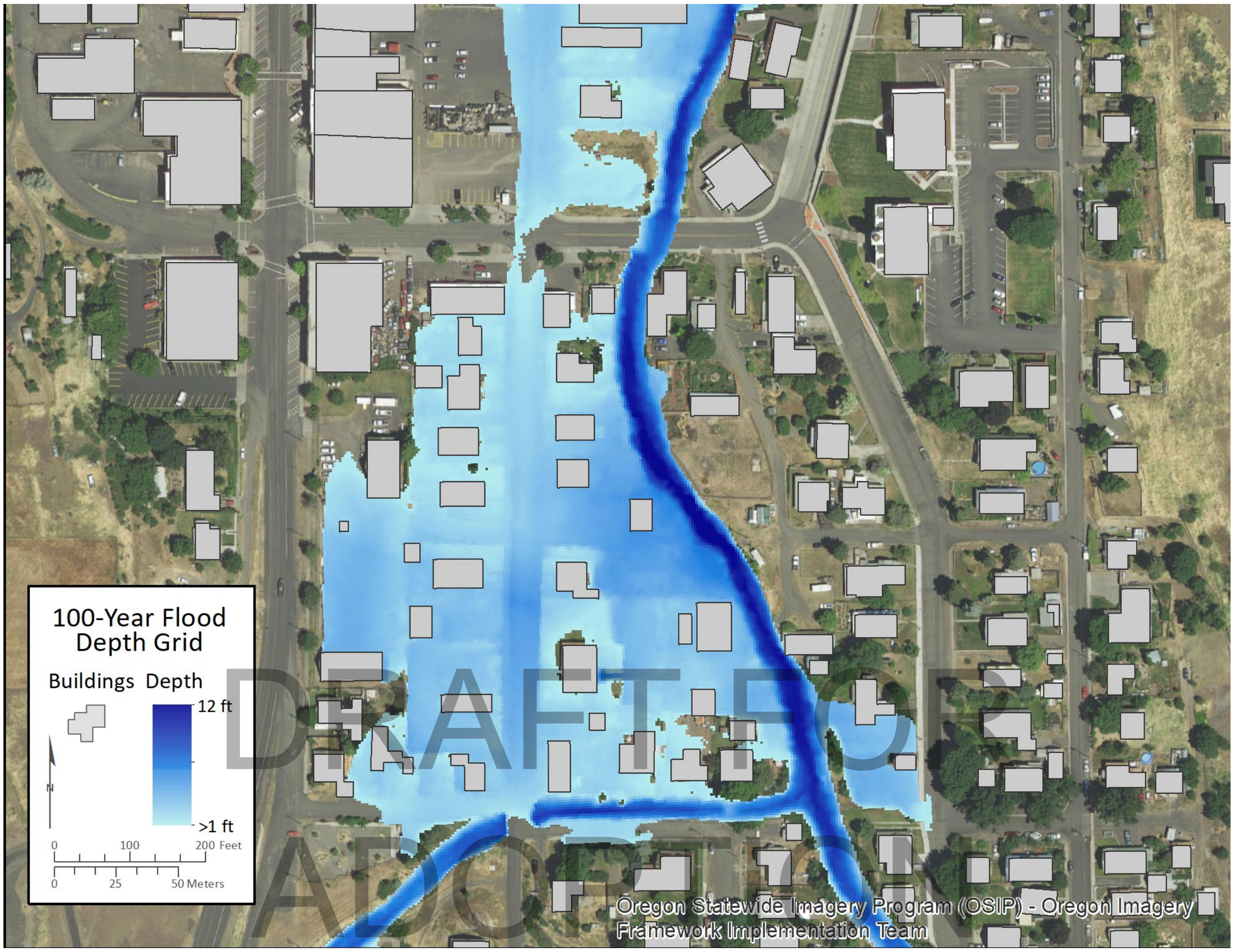
3.2.1 Data sources

The FIS and Flood Insurance Rate Maps (FIRMs) for the study area were updated and made effective in 2007 (FEMA, 2007); these were the primary data sources for the flood risk assessment. Flooding inevitably occurs in areas outside of the detailed mapped areas, however due to limited data availability and variable data resolutions, no other data sources were used in this study. Further information regarding National Flood Insurance Program (NFIP) related statistics can be found at FEMA's website: https://nfipservices.floodsmart.gov/reports-flood-insurance-data.

DOGAMI developed the 10-, 50-, 100-, and 500-year depth grids from detailed stream model information within the study area (Appleby and Williams, 2021). DOGAMI used high-resolution lidar collected in 2018 and 2019 to create the depth grids (Morrow County 3DEP 2018 project and USGS 3DEP 2019 for Natural Resources Conservation Service project - Oregon Lidar Consortium; see http://www.oregongeology.org/lidar/collectinglidar.htm).

The depth grids were used in this risk assessment to determine the level to which buildings are impacted by flooding. Depth grids are raster GIS datasets in which each digital pixel value represents the depth of flooding at that location within the flood zone (**Figure 3-3**). Depth grids for four riverine flood recurrence intervals (10-, 50-, 100-, and 500-year) were used for loss estimations and, for comparative purposes, exposure analysis. Each flood scenario is designated by a recurrence interval or the probability in any given year of a flood of that magnitude occurring. For example, the 100-year flood has a 1% annual chance of occurring.

Figure 3-3. **Flood depth grid example in the City of Heppner, Oregon.**



The Hazus-MH flood model uses an individual building's depth of flooding, first floor height above ground, and presence of a basement to estimate the flood damage. The model's damage functions are unique based on Building Type; for example, a mobile home is predicted to experience a different level of damage than a concrete, commercial building given the same depth of flood. Hazus-MH flood model and damage functions were created based on decades of historical flood damage observations.

For Morrow County, occupancy type attributes were available from the assessor database for most buildings. Where individual building information was not available from assessor data, we used street-level imagery to estimate these important building attributes. Only buildings in a flood zone or within 152 meters (500 feet) of a flood zone were examined closely in this manner for more accurate information on first-floor height and basement presence. Because our analysis accounted for building first-floor height, buildings that have been elevated above the flood level were not given a loss estimate—but we did count residents in those structures as displaced. We did not look at the duration that residents would be displaced from their homes due to flooding. For information about structures exposed to flooding but not damaged, see the **Exposure analysis** section.

3.2.2 Countywide results

For this risk assessment, we imported the countywide UDF data and depth grids into Hazus-MH and ran a flood analysis for four flood scenarios (10-, 50-, 100-, and 500-year). We used the 100-year flood scenario as the primary scenario for reporting flood results (also see **Appendix E, Plate 7**). The 100-year flood has traditionally been used as a reference level for flooding and is the standard probability that FEMA uses for regulatory purposes. See **Table B-3** for multi-scenario cumulative results.

Morrow Countywide 100-year flood loss:

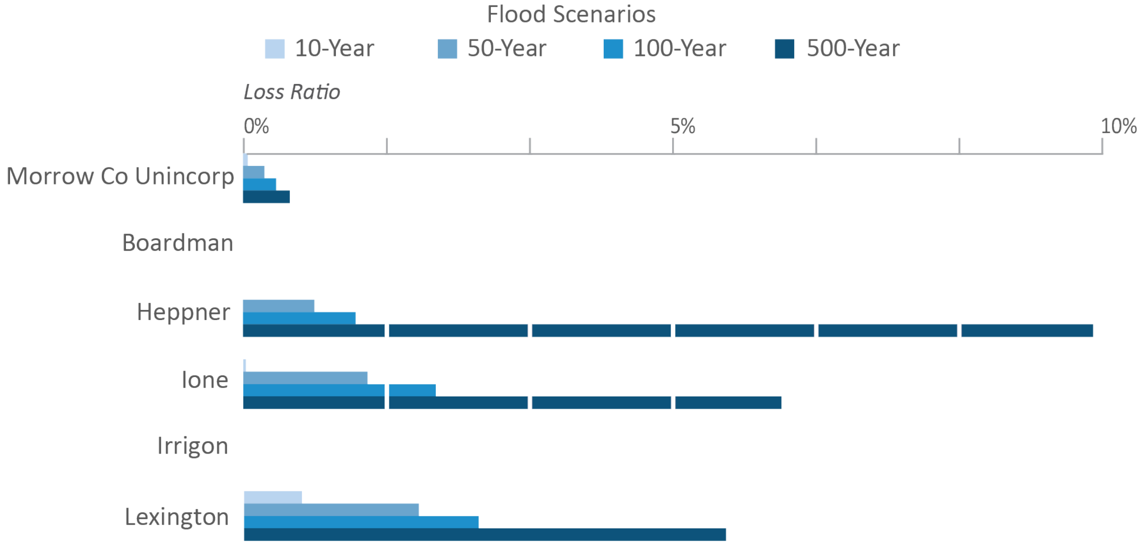
- Number of buildings damaged: 250
- Loss estimate: $10,291,000
- Loss ratio: 0.2%
- Damaged critical facilities: 3 of 20
- Potentially displaced population: 371

3.2.3 Hazus-MH analysis

The Hazus-MH loss estimate for the 100-year flood scenario for the entire county is over $10 million. While the loss ratio of flood damage for the entirety of Morrow County is 0.2%, the impact to areas of development near flood-prone streams is significant (**Figure 3-4**). In communities where most residents are not within flood designated zones, the loss ratio may not be as helpful as the actual replacement cost and number of residents displaced to assess the level of risk and impact from flooding. The Hazus-MH analysis also provides useful information for individual communities so that planners can identify problems and consider which mitigating activities will provide the greatest resilience to flooding.

The main flooding problems within Morrow County are primarily along Willow Creek and some of its tributaries as they flow through Heppner, Ione, and Lexington. The unincorporated county also has a high level of estimated damage (~$5 million) primarily from flooding occurring along Willow Creek and some of its tributaries. (**Figure 3-4**).

Figure 3-4. Ratio of flood loss estimates by Morrow County community.



3.2.4 Exposure analysis

Separate from the Hazus-MH flood analysis, we did an exposure analysis by overlaying building locations on the 100-year flood extent. We did this to estimate the number of buildings that are elevated above the level of flooding and the number of displaced residents. This was done by comparing the number of nondamaged buildings from Hazus-MH to the number of exposed buildings in the flood zone. A small proportion (3.8%) of Morrow County's buildings were found to be within designated flood zones. Of the 324 buildings that are exposed to flooding, we estimate that 74 are above the height of the 100-year flood. This evaluation also estimates that 43 residents might have mobility or access issues due to surrounding water. See **Detailed Risk Assessment Tables: Table B-4** for community-based results of flood exposure.

3.2.5 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk of flood hazard:

- Many buildings located along Willow Creek are at risk from flood hazard.
- The Willow Creek dam, if breached, would severely impact the communities of Heppner, Ione, and Lexington.
- Many residential buildings and water treatment facilities in the City of Heppner are exposed to flood hazard.

3.3 Landslide Susceptibility

Landslides are mass movements of rock, debris, or soil. There are many different types of landslides in Oregon. In Morrow County, a total of 1,085 landslide deposits were mapped as part of Open-file Report O-21-14 (Hairston-Porter and others, 2021), most of which are debris flow fans and earth flow (moving saturated fine-grained materials) deposits. The vast majority are within canyons located in the southern part of the county. The steep canyon slopes are comprised of basalt flows with a thin cover of soil and colluvium (mixed, loose materials on a slope). Intense rainfall, often associated with summer thunderstorms, triggers debris flows on steep slopes, which leave deposits at the mouths of side canyons.

There are also a few larger deep-seated translational landslides in the Blue Mountain area (Hairston-Porter and others, 2021).

In the more populated areas around Boardman there are virtually no landslides because the Columbia Plateau terrain is very flat. However, Heppner and other small towns in the canyons of southern Morrow County have numerous debris flow and earth flow deposits at the mouths of side streams and gullies (Hairston-Porter and others, 2021).

Factors that influence landslide type include slope steepness, water content, and geology. Many triggers can cause a landslide: intense rainfall, earthquakes, or human-induced factors like water concentration, excavation along a landslide toe or loading at the top. Landslides can cause severe damage to buildings and infrastructure. Fast-moving landslides may pose life safety risks and can occur throughout Oregon (Burns and others, 2016).

This study represents our current understanding of landslide hazard to measure the risk of landsliding in Morrow County. However, changing climate, precipitation patterns, land use, wildfire events, and land and forest management strategies may increase or decrease the susceptibility to landslides.

3.3.1 Data sources

We used the data from recent landslide inventory mapping of the inhabited areas and transportation corridors of Morrow County (Hairston-Porter and others, 2021) based on lidar using methods outlined in DOGAMI Special Paper 42 (SP-42: Burns and others, 2009). The landslide deposits that were identified and mapped in this inventory are designated as Very High landslide hazard areas in this analysis (**Figure 3-5**).

For areas outside of DOGAMI's 2021 landslide inventory mapping, we used data from the Statewide Landslide Susceptibility Map (Burns and others, 2016). Burns and others (2016) used the best available landslide, geology and slope data to calculate relative susceptibility levels (Very High, High, Moderate, Low) across the state. Mapped landslides from SLIDO, a statewide inventory of landslides, directly define the Very High landslide susceptibility zones, while statistical results from generalized geology and slope maps define the other relative susceptibility zones (Burns and others, 2016).

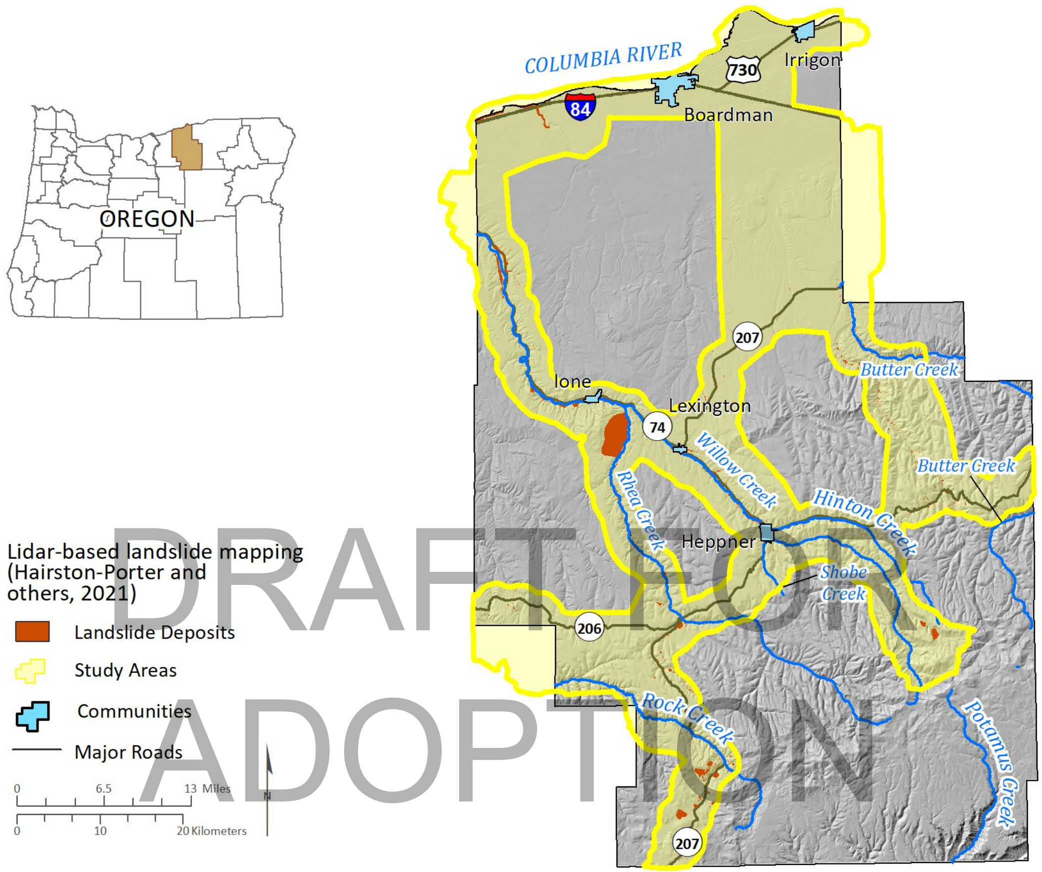
SLIDO, Release 3.2 (Burns and Watzig, 2014) is an inventory of mapped landslides in the state of Oregon. SLIDO is a compilation of past studies; some studies were completed very recently using new technologies, like lidar-derived topography, and some studies were performed more than 50 years ago. Consequently, SLIDO data vary greatly in scale, scope, and focus and thus in accuracy and resolution across the state.

The SLIDO data have the inherent limitations of SLIDO and of the generalized geology and slope maps used to create the map. Therefore, the SLIDO varies significantly in quality across the state, depending on the quality of the input datasets. Another limitation is that susceptibility mapping does not include some aspects of landslide hazard, such as runout, where the momentum of the landslide can carry debris beyond the zone deemed to be a High hazard area.

For this risk assessment, we took a conservative approach and overlaid the new landslide inventory from Hairston-Porter and others, 2021, which are equivalent to Very High susceptibility, and replaced the Very High susceptibility zones in the SLIDO (Burns and others, 2016). Areas that were previously mapped as Very High in the SLIDO but were outside of the new landslide mapping were changed to High zones.

We used the data from the combined SLIDO (Burns and others, 2016) and new landslide mapping (Hairston-Porter and others, 2021) in this report to identify the level of susceptibility of a given area to landslide hazards. We overlaid building and critical facilities data on landslide susceptibility zones to assess the exposure for each community. The total dollar value of exposed buildings was summed for the study area and is reported below (**Detailed Risk Assessment Tables: Table B-5**). We also estimated the number of people threatened by landslides. Land value losses due to landslides and potentially hazardous unmapped areas that may pose real risk to communities were not examined for this report.

Figure 3-5. Extent of 2021 DOGAMI landslide mapping in Morrow County



3.3.2 Countywide results

We found that areas along Willow Creek and some of its tributaries have a high level of exposure to landslide hazard. The communities of Heppner, Ione, and Lexington that lie within these river valleys are at higher risk from landslide hazard than other areas in the county. Many of the major roads that correspond to the river valleys are also at risk from landslides. Areas in terrain with moderate to steep slopes or at the base of steep hillsides may be exposed to landslides. The percentage of building value exposed to Very High and High landslide susceptibility is approximately 3.3% for the entire study area.

We combined High and Very High susceptibility zones as the primary scenario to provide a general sense of community risk for planning purposes (see **Appendix E, Plate 8**). These susceptibility zones represent areas with the highest potential impact to a community, either because a past landslide has been mapped in that location (Very High) or the combination of geology and slope is well-suited for failure (High).

It is important to note that within the landslide inventory, the debris flow deposits are almost entirely estimated to be "prehistoric," meaning the geologist mapping them estimated that there has not been debris flow activity on the fan for at least 150 years. This may mean that there is a low recurrence rate of debris flows in these areas, though a more detailed study would be needed to make that determination.

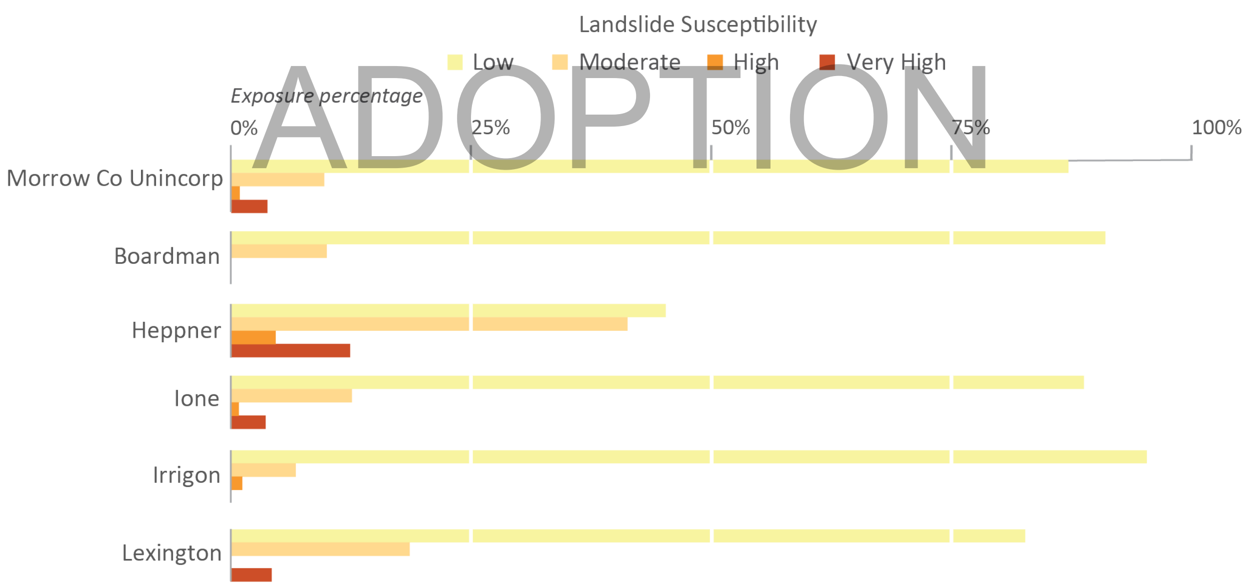
For this risk assessment we compared building locations to geographic extents of the landslide susceptibility zones (**Figure 3-6**). The exposure results shown below are for the High and Very High susceptibility zones. See **Appendix B: Detailed Risk Assessment Tables** for exposure analysis results of all susceptibility categories.

Morrow Countywide landslide exposure (High and Very High susceptibility):

- Number of buildings: 551
- Value of exposed buildings: $140,321,000
- Percentage of total county value exposed: 3.3%
- Critical facilities exposed: 1 of 20
- Potentially displaced population: 543

The two largest communities in Morrow County, Boardman and Irrigon, are located on gentle terrain found along the Columbia River, which is typically classified as having Low susceptibility to landslides. However, there are developed areas along Willow Creek that are more susceptible to landslide hazard. Landslide hazard is present throughout the central portion of Morrow County along major transportation routes, which may present challenges for planning and mitigation efforts. Awareness of nearby areas of landslide hazard is beneficial to reducing risk for every community and rural area of Morrow County.

Figure 3-6. Landslide susceptibility exposure by Morrow County community.



3.3.3 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk to landslide hazard:

- Buildings in the communities and unincorporated county along Route 74 are exposed to High and Very High landslide hazard.
- Many debris flow deposits are present along Willow Creek and Route 74, which could impact important transportation routes in the county.

3.4 Channel Migration

Channel migration is a dynamic process by which a stream's location changes over time. This process includes channel bed and bank erosion, sediment deposition, and channel avulsion, a process in which the stream abruptly moves to a new location on the floodplain. Many factors influence channel movement, including the local geology, size and quantity of sediment within the river, discharge of water, vegetation, channel shape, and gradient. Human changes to the channel, such as the construction of dams and levees, also have a major impact on how a channel changes its course over time. In combination, these factors affect how a river's energy and erosive power is dispersed. Straight, steep streams have highly concentrated erosive power; by contrast, curving channels that flow across wide and flat floodplains allow the river to dissipate its energy over a wider area and for sediment to be deposited (Rapp and Abbe, 2003).

The area in which a stream channel moves laterally over a given time is known as a channel migration zone (CMZ). In places where development has occurred within the CMZ, structures are at risk for severe damage to foundations and infrastructure. The CMZ typically extends beyond the limits of the regulatory floodplain, but little consideration is given to this potential hazard. This factor contributes greatly to the level of risk that exists for many developed areas along streams (Rapp and Abbe, 2003). Many of the communities in Morrow County lie alongside channels that show evidence of past migration.

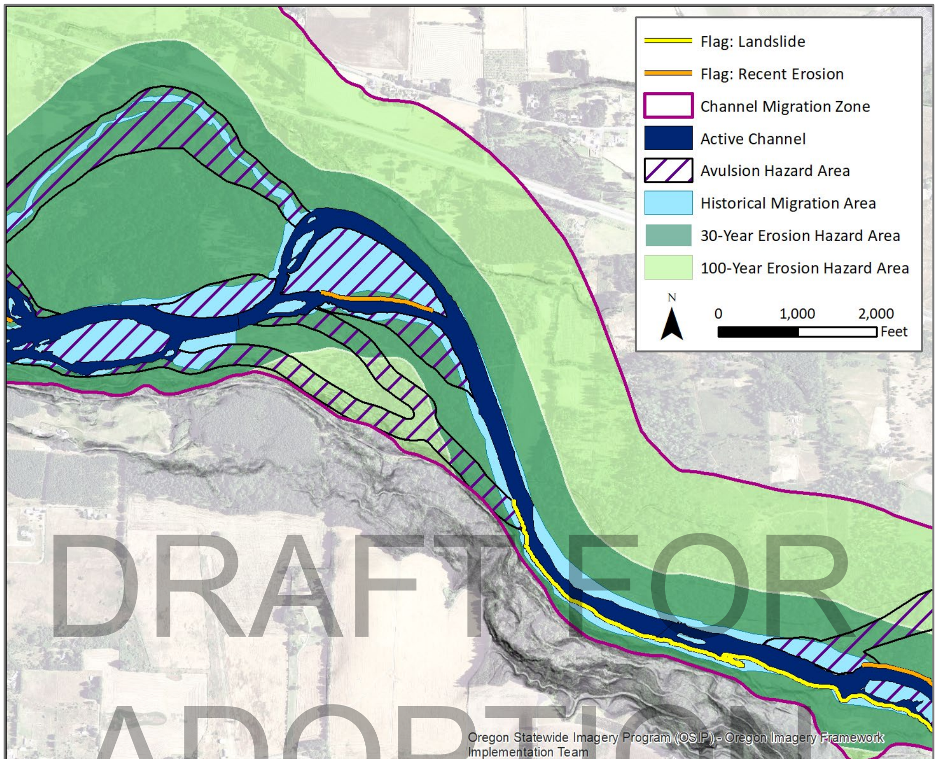
The frequency and severity of channel migration may change over time due to changes in climate and precipitation patterns, land use, and how we manage our waterways. This study represents our current understanding of channel migration hazards and risk, but we recognize that channel migration mapping and risk assessments will need to be updated with time and changing conditions.

3.4.1 Data sources

The channel migration zones used for this report were developed by Appleby and others (2021) for Hinton Creek, Rhea Creek, and Willow Creek. DOGAMI's CMZ mapping considers areas of historical channel migration, potential future erosion, and channel avulsion; these areas are mapped based on geology, historical aerial imagery, lidar topography, limited field work, and measured rates of historical channel migration. The CMZ is subdivided into seven components: the active channel, historical migration area, 30-year and 100-year erosion hazard areas, the avulsion hazard area, and flagged streambanks that are actively eroding or adjacent to landslides (**Figure 3-7**). The methodology for calculating each component and how they are combined are described in Appleby and others (2021).

To assess the exposure within each community, we overlaid buildings and critical facilities on the 30-year erosion hazard area within the CMZ. While there is risk throughout the CMZ, we chose to examine the structures within the 30-year erosion hazard area, because it represents areas of high frequency where many structures would be impacted as opposed to the less frequent, higher impact 100-year erosion zone. We estimated the total dollar value of exposed buildings and the number of people potentially displaced from the 30-year CMZ and reported these values in the following section. Land value losses due to CMZ were not examined for this report.

Figure 3-7. Example diagram of the components of a CMZ map in Oregon, including the active channel (AC) in dark blue, historical migration area (HMA) in light blue, avulsion hazard area (AHA) with hatched lines, 30-year and 100-year erosion hazard areas (EHA) in dark and light green, flagged streambanks with yellow and orange lines, and channel migration zone (CMZ) boundary outlined in magenta (from Appleby and others, 2021).



3.4.2 Countywide results

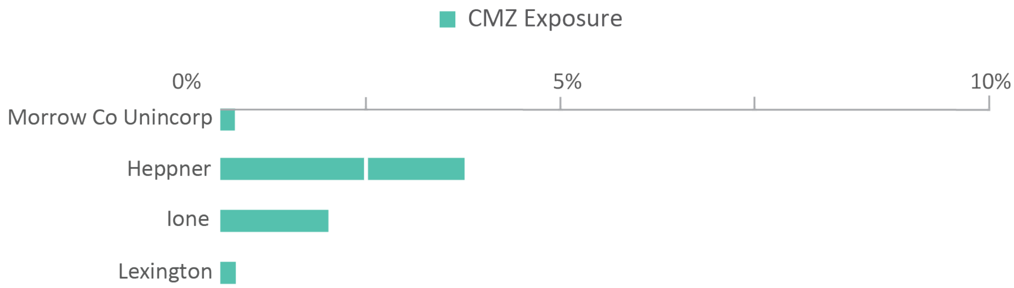
Mapped channel migration areas along Willow Creek and some areas along Rhea Creek show a Very High level of risk from this hazard. To quantify risk, we performed an exposure analysis that determined which buildings were within or outside of the CMZ (see **Appendix E: Plate 9**). Due to the frequency of shifting channel patterns in these streams, channel migration hazard presents some risk to communities in Morrow County.

Morrow Countywide channel migration exposure (30-year Erosion Hazard Area):

- Number of buildings: 79
- Value of exposed buildings: $14,477,000
- Percentage of total county value exposed: 0.3%
- Critical facilities exposed: 2 of 20
- Potentially displaced population: 84

Overall, a small number of buildings in Heppner, Ione, Lexington, and the portions of the unincorporated county are within areas where channel migration is likely to occur. A concentration of residential structures in Heppner are mapped within the potential CMZ. **Figure 3-8** illustrates the distribution of exposed building value due to channel migration for the communities of Morrow County. See **Appendix B: Detailed Risk Assessment Tables** for complete analysis results.

Figure 3-8. 30-year erosion hazard exposure by Morrow County community.



3.4.3 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk to channel migration hazard:

- Some residential structures along Willow Creek and Rhea Creek are at risk from channel migration.
- Several structures in the community of Heppner are at risk from channel migration.

3.5 Wildfire

Wildfires are a natural part of the ecosystem in Oregon. However, wildfires can present a substantial hazard to life and property in growing communities. The most common wildfire conditions include hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation). Once a fire has started, its behavior is influenced by numerous conditions, including fuel, topography, weather, drought, and development (Gilbertson-Day and others, 2018). Post-wildfire natural hazards can also present risk. These usually include flood, debris flows, and landslides. Post-wildfire geologic hazards were not evaluated in this project.

The 2019 Morrow County Community Wildfire Protection Plan (MCCWPP) recommended that the county develop policies that improve wildfire response, identify and evaluate wildfire risk, and develop strategies for wildfire risk reduction. Brush and grasslands cover large portions of the study area and play an important role in the local economy, but also can contribute to wildfire risk (MCCWPP, 2019). Contact the Morrow County Planning Department for specific requirements related to the county's comprehensive plan.

The frequency, intensity, and severity of wildfires may change over time due to changes in climate, drought conditions, urbanization, and how we manage our forested lands. This study represents our current understanding of wildfire hazards and wildfire risk, but we recognize that wildfire models and risk assessments will need to be updated with time and changing conditions.

3.5.1 Data sources

The Pacific Northwest Quantitative Wildfire Risk Assessment (PNRA): Methods and Results (Gilbertson-Day and others, 2018) is a comprehensive report that includes a database of spatial information related to wildfire hazard developed by the U.S. Forest Service for the states of Oregon and Washington. The steward of this database in Oregon is the ODF. The database was created to assess the level of risk residents and structures have to wildfire. For this project, the burn probability dataset, a dataset included in the PNRA database, was used to measure the risk to communities in Morrow County.

Using guidance from ODF, we categorized the Burn Probability dataset into Low, Moderate, and High-hazard zones for the wildfire exposure analysis. Burn probability is derived from simulations using many elements, such as, weather, ignition frequency, ignition density, and fire modeling landscape (Gilbertson-Day and others, 2018).

Burn probabilities (mean annual burn probability) were grouped into three hazard categories:

- Low wildfire hazard (0.0001 – 0.0002 or 1/10,000-year – 1/5,000-year)
- Moderate wildfire hazard (0.0002 – 0.002 or 1/5,000-year – 1/500-year)
- High wildfire hazard (0.002 – 0.04 or 1/500-year – 1/25-year)

We overlaid the buildings layer and critical facilities on each of the wildfire hazard zones to determine exposure. In certain areas no wildfire data is present which indicates areas that have minimal risk to wildfire hazard (see **Appendix B: Detailed Risk Assessment Tables)**. The total dollar value of exposed buildings in the study area is reported in the following section. We also estimated the number of people threatened by wildfire. Land value losses, infrastructure, and environmental impacts due to wildfire were not examined for this project.

3.5.2 Countywide results

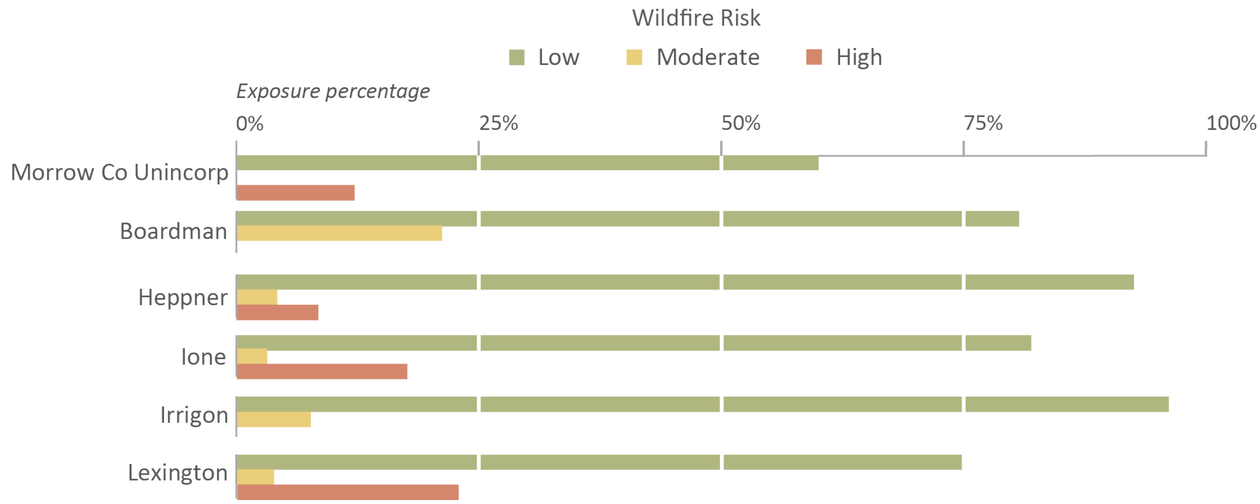
The High and Moderate hazard categories were chosen as the primary scenarios for this report because it represents areas that have the highest potential for losses. However, Low hazard is not the same as no hazard. Moderate wildfire risk is included with High risk in the assessment of exposure, because under certain conditions moderate risk zones can be very susceptible to burn. In combining the High and Moderate risk categories within Morrow County, we can emphasize areas where lives and property are most at risk.

Morrow Countywide wildfire exposure (High or Moderate Risk):

- Number of buildings: 3,005
- Value of exposed buildings: $1,350,531,000
- Percentage of total county value exposed: 32%
- Critical facilities exposed: 5 of 20
- Potentially displaced population: 3,226

For this risk assessment, the building locations were compared to the geographic extent of the wildfire risk categories. Over 3,000 buildings in the county are exposed to High or Moderate wildfire hazard. Wildfire risk is widespread and is present for most parts of Morrow County (see **Appendix E, Plate 10**). Ione and Lexington have the highest percentage of exposure to High and Moderate wildfire. See **Appendix B: Detailed Risk Assessment Tables** for multiscenario analysis results.

Figure 3-9. Wildfire risk by Morrow County community.



3.5.3 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk to wildfire hazard:

- Wildfire poses at least a moderate threat to all Morrow County residents and structures. In every community in Morrow County, wildfire poses a threat to residents and structures where evacuation could be necessary.
- The probability of wildfire hazard is higher for the central portion of Morrow County compared to the north and south.
- While the probability of wildfire hazard is lower for the northern portion of Morrow County, it is still a possibility. Nearby wildfire prone areas also pose a risk related to evacuation routes and hazardous smoke.

4.0 CONCLUSIONS

The purpose of this study is to provide a better understanding of potential impacts from multiple natural hazards at the community scale. We accomplished this by using the latest natural hazard mapping, loss estimation tools and exposure analyses to quantify risk to buildings and potential displacement of permanent residents. This detailed approach provides new context for the county's risk reduction efforts. We note several important findings based on the results of this study:

- **Moderate damage and losses for northern Morrow County can occur from a Horse Heaven Fault Mw-7.1 earthquake**—Based on the results of the Horse Heaven Fault Mw-7.1 earthquake simulation, northern Morrow County would experience some impact and disruption. Results show that this earthquake could cause 6% to 8% building value losses. Boardman and Irrigon can expect earthquake damage due to proximity to the simulated epicenter along the Horse Heaven Fault and ground deformation related to liquefaction. High vulnerability within the building inventory (primarily unreinforced masonry) and manufactured homes also contributed to losses expected in the county.
- **Retrofitting buildings to modern seismic building codes can reduce damages and losses from earthquake shaking**—In our Horse Heaven Fault simulation with all buildings

hypothetically updated to moderate code, the estimated loss for the county was reduced from 5% to 2.1%; a 58% reduction. A second simulation further upgrading buildings to high code levels only reduced losses by an additional 2%, suggesting that efforts to upgrade buildings need not extend beyond moderate to dramatically improve community resilience. Communities with older buildings, that were constructed below the moderate seismic code standards are the most vulnerable and have the greatest potential for risk reduction. For example, the City of Boardman could reduce losses from 6.8 to 1.7% for a Horse Heaven Fault event by retrofitting all buildings to at least moderate code. This significant reduction (75%) is a result of the high number of unreinforced masonry buildings within the city. While seismic retrofits are an effective strategy for reducing earthquake shaking damage, it should be noted that earthquake-induced liquefaction hazards will also be present in areas along the Columbia River and Willow Creek and these hazards require different geotechnical mitigation strategies.

- **Some communities in the study area are at High risk from flooding**—Many buildings within the floodplain are vulnerable to significant damage from flooding. At first glance, Hazus-MH flood loss estimates may give a false impression of lower risk because they show lower damages within individual communities relative to other hazards we examined. This is likely due to the difference between the type of results from Hazus loss estimation and exposure analysis, as well as the limited area impacted by flooding. Flooding is one of the most frequently occurring natural hazards with recurrence intervals of 10s to 100s of years versus earthquake hazards with recurrence intervals of 100s to thousands of years. We estimate that an average of 9% building value loss occurs for buildings within the 100-year flood zone. The areas most vulnerable to flood hazard within the county are buildings along Willow Creek in the communities of Heppner, Ione, and Lexington. Many residential buildings throughout the cities of Heppner and Ione are exposed to flood hazard.
- **Elevating structures in the flood zone reduces vulnerability**—We used flood exposure analysis in addition to Hazus-MH loss estimation to identify buildings that were not damaged but were within the area expected to experience a 100-year flood. By using both analyses in this way, the number of elevated structures within the flood zone could be quantified. This showed possible mitigation needs in flood loss prevention and the effectiveness of past activities. For example, in the City of Ione a third of the buildings exposed to flooding are elevated above the base flood elevation (BFE) and as a result their flood losses are significantly lower than Heppner, which only has a few elevated buildings. Based on the number of buildings exposed to flooding throughout the county, many would benefit from elevating above the level of flooding.
- **Landslide risk is Moderate for some areas in the county**—The recent landslide mapping used in this study was created using lidar and modern mapping methods to develop very accurate landslide hazard maps. We used exposure analysis to assess the threat from landslide hazards. The developed areas along the transportation corridor of Highway 74 and residential areas throughout and nearby the City of Heppner are highly susceptible to landslide hazards. Nearly 15% of the buildings in Heppner are exposed to Very High or High landslide hazard.
- **Exposure analysis shows that buildings in the riverine valleys of the study area are at risk to channel migration hazard**—Exposure analysis shows that channel migration hazard is a threat to communities and buildings along Willow Creek and Rhea Creek. The City of Heppner has High risk from channel migration hazard, with approximately 5% of residents exposed to the 30-year erosion zone.

- **Wildfire risk is High for most of the county**—Exposure analysis shows that buildings throughout Morrow County are vulnerable to wildfire hazard. While wildfire risk is lower for Irrigon and Boardman, it is still a threat to these communities. Due to the amount of brush and grasslands, the central portion of county (Heppner, Ione, and Lexington) corresponds to High and Moderate wildfire hazard. Nearly 40% of the buildings in the unincorporated county are within areas of High or Moderate wildfire hazard.
- **Most of the county's critical facilities are at greatest risk from wildfire hazard relative to other hazards in the study area**— Because of their importance during and after a natural disaster, we identified and examined critical facilities. We have estimated that 25% (5 of 20) of Morrow County's critical facilities are at risk of becoming nonfunctioning due to wildfire. We found that three critical facilities are exposed to flood hazard, two for earthquake and channel migration and one for landslide susceptibility.
- **The biggest cause of displacement to population is wildfire hazard**—Potential displacement of permanent residents from natural hazards was estimated within this report. We estimated that there is risk to 26% of the population in the county from wildfire hazard. Landslide and flood hazards are a potential threat to 4.3% and 2.9% respectively of permanent residents A small percentage of residents are vulnerable to displacement from channel migration (0.65%) and earthquake (1.1%) hazards.
- **This report allows communities to compare risk across hazards and prioritize their needs**—Each community within the study area was assessed for natural hazard exposure and loss. This allowed for comparison of risk for a specific hazard between communities. It also allows for a comparison between different hazards, though care must be taken to distinguish between loss estimates and exposure results. Both types of results can assist communities in developing plans that address their unique needs.

5.0 LIMITATIONS

There are several limitations to keep in mind when interpreting the results of this risk assessment.

- **Spatial and temporal variability of natural hazard occurrence** – With the exception of earthquakes, other hazards like flood, landslide, channel migration, and wildfire are extremely unlikely to occur across the fully mapped extent of the hazard zones. For example, areas mapped in the 100-year flood zone will be prone to flooding on occasion in certain watersheds during specific events, but not all at once throughout the entire county or even an entire community. While we report the overall impacts of a given hazard scenario, the losses from a single hazard event probably will not be as severe and widespread.
- **Loss estimation for individual buildings** – Hazus-MH is a model, not reality, which is an important factor when considering the loss ratio of an individual building. On-the-ground mitigation, such as elevation of buildings to avoid flood loss, has been only minimally captured. Also, due to a lack of building material information, assumptions were made about the distribution of wood, steel, and unreinforced masonry buildings. Loss estimation is most insightful when individual building results are aggregated to the community level because it reduces the impact of data outliers.
- **Loss estimation versus exposure** – We recommend careful interpretation of exposure results. This is due to the spatial and temporal variability of natural hazards (described above) and the

inability to perform loss estimations due to the lack of Hazus-MH damage functions. Exposure is reported in terms of total building value, which could imply a total loss of the buildings in a particular hazard zone, but this is not the case. Exposure is simply a calculation of the number of buildings and their value and does not make estimates about the level to which an individual building could be damaged.

- **Population variability** – Some of the communities in Morrow County have vacation homes and rentals, which are typically occupied during the summer. Our estimates of potentially displaced people rely on permanent populations published in the 2020 U.S. Census (United States Census Bureau, 2020b) and adjusted for population growth based on PSU Population Research Center data. As a result, we are slightly underestimating the number of people that may be in harm's way on a summer weekend.
- **Data accuracy and completeness** – Some datasets in our risk assessment had incomplete coverage or lacked high-resolution data within the study area. We used lower-resolution data where there was incomplete coverage or where high-resolution data were not available. We made assumptions to amend areas of incomplete data coverage based on reasonable methods described within this report. Data layers in which assumptions were made to fill gaps are building footprints, population, some building specific attributes, and landslide susceptibility. Many of the datasets included known or suspected artifacts, omissions and errors, however repairing these problems was beyond the scope of the project and are areas needing additional research. We are aware that some uncertainty has been introduced from these data amendments at an individual building scale, but at community-wide scales the effects of the uncertainties are slight.
- **Changing Conditions** – This assessment did not account for potential changes in climate, land use, or population; it is a snapshot of Morrow County's current risk from natural hazards. Human-induced climate change poses a significant and widespread risk to people around the world. In Oregon, climate change is expected to impact future floods, wildfires, and landslides, but quantifying this impact was beyond the scope of this study.

6.0 RECOMMENDATIONS

The following actions are needed to better understand hazards and reduce risk to natural hazard through mitigation planning. These implementation areas, while not comprehensive, touch on all phases of risk management and focus on awareness and preparation, planning, emergency response, mitigation funding opportunities, and hazard-specific risk reduction activities.

6.1 Awareness and Preparation

Natural hazard awareness is crucial to lowering risk and lessening the impacts of natural hazards. When community members understand their risk and know the role that they play in preparedness, the community will become a much safer place to live. Awareness and preparation not only reduce the initial impact from natural hazards, but they also reduce the time a community needs to recover from a disaster, commonly referred to as "resilience."

This report is intended to provide local officials with a comprehensive and authoritative profile of natural hazard risk to underpin their public outreach efforts.

Messaging can be tailored to stakeholder groups. For example, outreach to homeowners could focus on actions they can take to reduce risk to their property. The DOGAMI Homeowners Guide to Landslides (https://www.oregon.gov/dogami/Landslide/Documents/ger_homeowners_guide_landslides.pdf) provides a variety of risk reduction options for homeowners who live in High landslide susceptibility areas. This guide is one of many existing resources. Agencies partnering with local officials in the development of additional effective resources could help reach a broader community and user groups.

6.2 Planning

This report can help local decisionmakers develop their local plans by identifying geohazards and associated risks to the community. The primary framework for accomplishing this is through the comprehensive planning process. The comprehensive plan sets the long-term trajectory of capital improvements, zoning, and urban growth boundary expansion, all of which are planning tools that can be used to reduce natural hazard risk.

Another framework is the natural hazard mitigation plan (NHMP) process. NHMP plans focus on characterizing natural hazard risk and identifying actions to reduce risk. Additionally, the information presented here can be a resource when updating the mitigation actions and inform the vulnerability assessment section of the NHMP plan.

While there are many similarities between this report and an NHMP, the primary difference is that the risk assessment is not a planning document. Additional difference can be the hazards or critical facilities that are examined in each report. Differences between the reports may be due to data availability or limited methodologies for specific hazards. The critical facilities considered in this report may not be identical to those listed in a typical NHMP due to the lack of damage functions in Hazus-MH for nonbuilding structures and to different considerations about emergency response during and after a disaster.

6.3 Emergency Response

Critical facilities will play a major role during and immediately after a natural disaster. This study can help emergency managers identify vulnerable critical facilities and develop contingency plans. Additionally, detailed mapping of potentially displaced residents can be used to reevaluate evacuation routes and identify vulnerable populations to target for early warning.

The building database that accompanies this report presents many opportunities for future predisaster mitigation, emergency response, and community resilience improvements. Vulnerable areas can be identified and targeted for awareness campaigns. These campaigns can be aimed at predisaster mitigation through, for example, improvements of the structural connection of a building's frame to its foundation. Emergency response entities can benefit from the use of the building dataset through identification of potential hazards and populated buildings before and during a disaster. Both reduction of the magnitude of the disaster and a decrease in the response time contribute to a community's overall resilience.

6.4 Mitigation Funding Opportunities

Several state and federal funding options are available to communities that are susceptible to natural hazards and have specific cost-effective mitigation projects they wish to accomplish. The Oregon Office of Emergency Management (OEM) State Hazard Mitigation Officer (SHMO) can provide communities assistance in determining eligibility, finding mitigation grants, and navigating the mitigation grant application process. OEM has produced a document that can assist local officials in applying for mitigation funds (https://www.oregon.gov/OEM/Documents/Oregon_Hazard_Mitigation_Grant_Program_Handbook.pdf).

At the time of writing this report, FEMA has five programs that assist with mitigation funding for natural hazards: Hazard Mitigation Grant Program (HMGP), HMGP Post-Fire Assistance, Pre-Disaster Mitigation Grant Program, Building Resilient Infrastructure and Communities grant program, and Flood Mitigation Assistance (https://www.fema.gov/grants/mitigation). The SHMO can help with finding further opportunities for earthquake and tsunami assistance and funding.

6.5 Hazard-Specific Risk Reduction Actions

6.5.1 Earthquake

- Evaluate risks to transportation networks and bridges due to earthquake shaking and other coseismic hazards.
- Evaluate critical facilities for seismic preparedness by identifying structural deficiencies and vulnerabilities to dependent systems (e.g., water, fuel, power).
- Evaluate vulnerabilities of critical facilities. We estimate that 10% of critical facilities (**Appendix A: Community Risk Profiles**) will be damaged by an earthquake scenario described in this report, which will have many direct and indirect negative effects on first-response and recovery efforts.
- Identify communities and buildings that would benefit from seismic upgrades.

6.5.2 Flood

- Map areas of potential flood water storage areas.
- Identify structures that have repeatedly flooded in the past and would be eligible for FEMA's "buyout" program.
- Additional risk reduction strategies may be found on FEMA's website at https://www.ready.gov/floods.

6.5.3 Landslide

- Create modern landslide inventory and susceptibility maps.
- Monitor ground movement in High susceptibility areas.
- Evaluate risks to transportation networks and land value losses due to landslide in future risk assessments.
- Study the risk from landslides that may experience channel erosion at the toe of the landslide.
- Additional risk reduction strategies may be found on FEMA's website at https://www.ready.gov/landslides-debris-flow.

6.5.4 Wildfire-related geologic hazards

- Evaluate post-wildfire geologic hazards, including flood, debris flows, and landslides.
- Additional risk reduction strategies may be found on FEMA's website at https://www.ready.gov/wildfires.

6.5.5 Channel migration

- Future development in areas with the largest CMZs could incorporate CMZ mitigation strategies into plans and designs.
- Evaluate the losses in land value or productivity due to channel migration.
- Evaluate risks to transportation networks and bridges due to channel migration.
- Identify areas suitable for conservation corridors along rivers that are at risk from channel migration. These can be multipurpose, including areas that provide or improve flood water storage, riparian and aquatic habitat restoration, and climate change resilience, and water quality.

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9.0 APPENDICES

APPENDIX A. COMMUNITY RISK PROFILES

A risk analysis summary for each community is provided in this section to encourage ideas for natural hazard risk reduction. Increasing disaster preparedness, public hazards communication, and education, ensuring functionality of emergency services, and ensuring access to evacuation routes are actions that every community can take to reduce their risk. This appendix contains community-specific data to provide an overview of the community and the level of risk from each natural hazard analyzed. In addition, for each community a list of critical facilities and assumed impact from individual hazards is provided.

A.1 Unincorporated Morrow County (Rural)

Table A-1. Unincorporated Morrow County (rural) hazard profile.

Community Overview

Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Unincorporated Morrow County (rural)	4,496	5,141	2	2,877,028,000

Hazus-MH Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	9	0.2%	34	0	5,659,000	0.2%
Earthquake	Horse Heaven Fault Mw-7.1	53	1.2%	329	0	132,228,000	4.6%

Exposure Analysis Summary

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	348	7.7%	423	0	105,067,000	3.6%
Channel Migration	30-year erosion hazard	20	0.4%	25	0	5,507,000	0.2%
Wildfire	High and Moderate Risk	1,963	44%	2,533	1	1,120,243,000	39%

[1]Facilities with multiple buildings were consolidated into one building complex.
[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (BFE).

Table A-2. Unincorporated Morrow County (rural) critical facilities.

	Flood 1% Annual Chance	**Horse Heaven 7.1 Moderate to Complete Damage**	**Landslide High and Very High Susceptibility**	**Channel Migration Zone**	**Wildfire High or Moderate Risk**
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**
Boardman Airport	-	-	-	-	-
Lexington Airport	-	-	-	-	X

A.2 City of Boardman

Table A-3. City of Boardman hazard profile.

Community Overview					
Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)	
Boardman	4,338	1,214	5	823,077,000	

Hazus-MH Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	0	0.0%	0	0	0	0.0%
Earthquake	Horse Heaven Fault Mw-7.1	27	0.6%	75	0	55,846,000	6.8%

Exposure Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	0	0%	0	0	0	0%
Channel Migration	30-year erosion hazard	0	0%	0	0	0	0%
Wildfire	High and Moderate Risk	858	20%	212	2	164,489,000	20%

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (BFE).

Table A-4. City of Boardman critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	Horse Heaven 7.1 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk
	Exposed	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**
Boardman Police Department	-	-	-	-	X
Boardman RFPO	-	-	-	-	-
Riverside Jr/Sr High School	-	-	-	-	-
Sam Boardman Elementary School	-	-	-	-	-
Windy River Elementary	-	-	-	-	X

A.3 City of Heppner

Table A-5. City of Heppner hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)		
Heppner		1,187	797	7	229,967,000		
Hazus-MH Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	167	14%	119	1	2,084,000	0.9%
Earthquake*	Horse Heaven Fault Mw-7.1	8	0.7%	28	0	5,877,000	2.6%
Exposure Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	163	14%	111	1	30,944,000	13%
Channel Migration	30-year erosion hazard	58	4.9%	46	1	7,675,000	3.3%
Wildfire	High and Moderate Risk	194	16%	112	1	25,440,000	11%

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (BFE).

Table A-6. City of Heppner critical facilities.

	Flood 1% Annual Chance	**Horse Heaven 7.1 Moderate to Complete Damage**	**Landslide High and Very High Susceptibility**	**Channel Migration Zone**	**Wildfire High or Moderate Risk**
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**
Heppner Elementary	-	-	X	-	-
Heppner Fire Department	-	-	-	-	-
Heppner Jr/Sr High School	-	-	-	-	X
Heppner Police Department	-	-	-	-	-
Heppner STP	X	-	-	X	-
Morrow County Sheriff	-	-	-	-	-
Pioneer Memorial Hospital	-	-	-	-	-

A.4 City of Ione

Table A-7. City of Ione hazard profile.

Community Overview				
Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Ione	339	249	2	68,770,000

Hazus-MH Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	152	45%	69	1	1,263,000	1.8%
Earthquake	Horse Heaven Fault Mw-7.1	4	1.2%	17	0	3,045,000	4.4%

Exposure Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	10	2.9%	5	0	1,997,000	2.9%
Channel Migration	30-year erosion hazard	6	1.8%	6	1	1,178,000	1.7%
Wildfire	High and Moderate Risk	69	20%	56	1	12,524,000	19%

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (BFE).

Table A-8. City of Ione critical facilities.

	Flood 1% Annual Chance	Horse Heaven 7.1 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**
Ione Community Charter School	X	-	-	X	X
Ione RFPD	-	-	-	-	-

A.5 City of Irrigon

Table A-9. City of Irrigon hazard profile.

Community Overview					
Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Irrigon	2,037	867	5	217,274,000

Hazus-MH Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	0	0.0%	0	0	0	0.0%
Earthquake*	Horse Heaven Fault Mw-7.1	52	2.6%	122	2	17,478,000	8%

Exposure Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	10	0.5%	2	0	775,000	0.4%
Channel Migration	30-year erosion hazard	0	0%	0	0	0	0%
Wildfire	High and Moderate Risk	55	2.7%	18	1	14,245,000	6.6%

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (BFE).

Table A-10. City of Irrigon critical facilities.

	Flood 1% Annual Chance	**Horse Heaven 7.1 Moderate to Complete Damage**	**Landslide High and Very High Susceptibility**	**Channel Migration Zone**	**Wildfire High or Moderate Risk**
Critical Facilities by Community	**Exposed**	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**
A C Houghton Elementary	-	X	-	-	-
Irrigon Elementary School	-	-	-	-	X
Irrigon Jr/Sr High School	-	X	-	-	-
Irrigon Medical Center	-	-	-	-	-
Morrow County Sheriff's Dept.	-	-	-	-	-

A.6 City of Lexington

Table A-11. City of Lexington hazard profile.

Community Overview				
Community Name	Population	Number of Buildings	Critical Facilities[1]	Total Building Value ($)
Lexington	238	212	2	55,260,000

Hazus-MH Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood[2]	1% Annual Chance	43	18%	28	1	1,285,000	2.3 %
Earthquake*	Horse Heaven Fault Mw-7.1	1	0.4%	6	0	1,246,000	2.3%

Exposure Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	13	5.5%	10	0	1,538,000	2.8%
Channel Migration	30-year erosion hazard	0	0.0%	2	0	117,000	0.2%
Wildfire	High and Moderate Risk	87	37%	74	0	13,590,000	25%

[1]Facilities with multiple buildings were consolidated into one building complex.

[2]No damage is estimated for exposed structures with "First floor height" above the level of flooding (BFE).

Table A-12. City of Lexington critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	Horse Heaven 7.1 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk
	Exposed	**>50% Prob.**	**Exposed**	**Exposed**	**Exposed**
Lexington VFD	X	-	-	-	-
Morrow County Public Works	-	-	-	-	-

APPENDIX B. DETAILED RISK ASSESSMENT TABLES

Table B-1. Morrow County building inventory.

	(all dollar amounts in thousands)															
	Residential			**Commercial and Industrial**			**Agricultural**			**Public and Nonprofit**			**All Buildings**			
Community	**Number of Buildings**	**Building Value ($)**	**Building Value per Community Total**	**Number of Buildings**	**Building Value ($)**	**Building Value per Community Total**	**Number of Buildings**	**Building Value ($)**	**Building Value per Community Total**	**Number of Buildings**	**Building Value ($)**	**Building Value per Community Total**	**Number of Buildings**	**Number of Buildings per Study Area Total**	**Building Value ($)**	**Value of Buildings per Study Area Total**
Unincorp. Morrow Co (rural)	2,651	621,359	22%	414	1,531,208	53%	2,014	578,667	20%	62	145,795	5.1%	5,141	61%	2,877,028	67%
Boardman	994	255,163	31%	124	485,723	59%	80	11,094	1.4%	16	71,097	9%	1,214	14.3%	823,077	19.3%
Heppner	591	132,553	58%	68	44,519	19%	115	8,476	3.7%	23	44,419	19%	797	9.4%	229,967	5.4%
Ione	165	38,114	55%	25	13,223	19%	52	5,607	8.2%	7	11,825	17%	249	2.9%	68,770	1.6%
Irrigon	718	140,648	65%	31	13,124	6%	100	7,995	3.7%	18	55,507	26%	867	10%	217,274	5.1%
Lexington	135	27,643	50%	28	16,549	30%	44	3,782	6.8%	5	7,286	13%	212	2.5%	55,260	1.3%
Total County	5,254	1,215,480	28%	690	2,104,346	49%	2,405	615,621	14%	131	335,929	8%	8,480	100%	4,271,376	100%

Table B-2. Horse Heaven Fault Mw-7.1 Earthquake loss estimates.

			(all dollar amounts in thousands)							
			Total Earthquake Damage							
			Buildings Damaged				All Buildings Changed to At Least Moderate Code			
	Total Number of Buildings	Total Estimated Building Value ($)	Yellow-Tagged Buildings	Red-Tagged Buildings	Sum of Economic Loss	Loss Ratio	Yellow-Tagged Buildings	Red-Tagged Buildings	Sum of Economic Loss	Loss Ratio
Unincorp. Morrow Co (rural)	5,141	2,877,028	270	59	132,228	4.6%	148	29	59,363	2.1%
Boardman	1,214	823,077	66	9	55,846	6.8%	15	2	14,131	1.7%
Heppner	797	229,967	23	5	5,877	2.6%	20	5	4,331	1.9%
Ione	249	68,770	14	3	3,045	4.4%	12	3	2,522	3.7%
Irrigon	867	217,274	96	26	17,478	8%	55	11	10,121	4.7%
Lexington	212	55,260	5	1	1,246	2.6%	3	1	779	1.4%
Total County	8,480	4,271,376	474	103	215,720	5%	253	51	91,247	2.1%

Table B-3. Flood loss estimates.

			(all dollar amounts in thousands)											
			10% (10-yr)			**2% (50-yr)**			**1% (100-yr)**			**0.2% (500-yr)**		
Community	**Total Number of Buildings**	**Total Estimated Building Value ($)**	**Number of Buildings**	**Loss Estimate**	**Loss Ratio**	**Number of Buildings**	**Loss Estimate**	**Loss Ratio**	**Number of Buildings**	**Loss Estimate**	**Loss Ratio**	**Number of Buildings**	**Loss Estimate**	**Loss Ratio**
Unincorp. Morrow Co (rural)	5,141	2,877,028	14	849	0.03%	30	4,124	0.1%	34	5,659	0.2%	51	9,658	0.3%
Boardman	1,214	823,077	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0.0%
Heppner	797	229,967	0	0	0.0%	74	1,219	0.5%	119	2,084	0.9%	372	23,249	10%
Ione	249	68,770	5	13	0.02%	26	671	1.0%	69	1,263	1.8%	113	4,402	6.4%
Irrigon	867	217,274	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0.0%
Lexington	212	55,260	6	162	0.3%	25	826	1.5%	28	1,285	2.3%	47	2,962	5.4%
Total County	8,480	4,271,375	25	1,024	0.02%	155	6,840	0.2%	250	10,291	0.2%	583	40,271	0.9%

Table B-4. Flood exposure.

					1% (100-yr)		
Community	**Total Number of Buildings**	**Total Population**	**Potentially Displaced Residents from Flood Exposure**	**% Potentially Displaced Residents from Flood Exposure**	**Number of Flood Exposed Buildings**	**% of Flood Exposed Buildings**	**Number of Flood Exposed Buildings Without Damage**
Unincorp. Morrow Co (rural)	5,141	4,496	9	0.2%	37	0.7%	3
Boardman	1,214	4,338	0	0%	0	0%	0
Heppner	797	1,187	167	14%	148	19%	29
Ione	249	339	152	45%	103	41%	34
Irrigon	867	2,037	0	0%	0	0%	0
Lexington	212	238	43	18%	36	17%	8
Total County	8,480	12,635	371	2.9%	324	3.8%	74

Table B-5. Landslide exposure.

(all dollar amounts in thousands)

Community	Total Number of Buildings	Total Estimated Building Value ($)	Very High Susceptibility: Number of Buildings	Very High Susceptibility: Building Value ($)	Very High Susceptibility: Percent of Building Value Exposed	High Susceptibility: Number of Buildings	High Susceptibility: Building Value ($)	High Susceptibility: Percent of Building Value Exposed	Moderate Susceptibility: Number of Buildings	Moderate Susceptibility: Building Value ($)	Moderate Susceptibility: Percent of Building Value Exposed
Unincorp. Morrow Co (rural)	5,141	2,877,028	332	90,141	3.1%	91	14,926	0.5%	1,112	243,015	8%
Boardman	1,214	823,077	0	0	0%	0	0	0%	83	68,764	8%
Heppner	797	229,967	72	23,086	10%	39	7,858	3.4%	356	92,701	40%
Ione	249	68,770	4	1,703	2.5%	1	294	0.4%	34	6,554	10%
Irrigon	867	217,274	0	0	0%	2	775	0.4%	41	10,375	5%
Lexington	212	55,260	10	1538	2.8%	0	0	0%	37	9,676	18%
Total County	8,480	4,271,375	418	116,468	2.7%	133	23,853	0.6%	1,663	431,085	10%

Table B-6. Channel migration exposure.

(all dollar amounts in thousands)

Community	Total Number of Buildings	Total Population	Total Estimated Building Value ($)	Channel Migration Hazard (30-year): Potentially Displaced Residents from Channel Migration Exposure	% Potentially Displaced Residents from Channel Migration Exposure	Number of Buildings Exposed	Building Value ($)	Ratio of Exposure Value
Unincorp. Morrow Co (rural)	5,141	4,496	2,877,028	20	0.4%	25	5,507	0.2%
Boardman	1,214	4,338	823,077	0	0%	0	0	0%
Heppner	797	1,187	229,967	58	4.9%	46	7,675	3.3%
Ione	249	339	68,770	6	1.8%	6	1,178	1.7%
Irrigon	867	2,037	217,274	0	0%	0	0	0%
Lexington	212	238	55,260	0	0%	2	117	0.2%
Total County	8,480	12,635	4,271,375	84	0.7%	79	14,477	0.3%

Table B-7. Wildfire exposure.

(all dollar amounts in thousands)

Community	Total Number of Buildings	Total Estimated Building Value ($)	High Hazard: Number of Buildings	High Hazard: Building Value ($)	High Hazard: Percent of Building Value Exposed	Moderate Hazard: Number of Buildings	Moderate Hazard: Building Value ($)	Moderate Hazard: Percent of Building Value Exposed
Unincorp. Morrow Co (rural)	5,141	2,877,028	1,442	311,068	11%	1,091	809,175	28%
Boardman	1,214	823,077	0	0	0%	212	164,489	20%
Heppner	797	229,967	70	16,174	7.0%	42	9,266	4.0%
Ione	249	68,770	49	10,762	16%	7	1,762	2.6%
Irrigon	867	217,274	0	0	0%	18	14,245	6.6%
Lexington	212	55,260	63	11,999	22%	11	1,591	2.9%
Total County	8,480	4,271,375	1,624	350,003	8.2%	1,381	1,000,528	23%

APPENDIX C. HAZUS-MH METHODOLOGY

C.1 Software

We performed all loss estimations using Hazus®-MH 5.0 and ArcGIS® Desktop® 10.2.2.

C.2 User-Defined Facilities (UDF) Database

A UDF database was compiled for all buildings in Morrow County for use in both the flood and earthquake modules of Hazus-MH. The Morrow County assessor database (acquired in 2022) was used to determine which taxlots had improvements (i.e., buildings) and how many building points should be included in the UDF database.

C.2.1 Locating buildings points

The Oregon Department of Geology and Mineral Industries (DOGAMI) used the SBFO-1 (Williams, 2021) dataset to help precisely locate the centroid of each building. Extra effort was spent to locate building points along the 1% and 0.2% annual chance inundation fringe. When buildings were partially within the inundation zone, the building point was moved to the centroid of the portion of the building within the inundation zone. An iterative approach was used to further refine locations of building points for the flood module by generating results, reviewing the highest value buildings, and moving the building point over a representative elevation on the lidar digital elevation model to ensure an accurate first floor height.

C.2.2 Attributing building points

Populating the required attributes for Hazus-MH was achieved through a variety of approaches. The Morrow County assessor database was used whenever possible, but in many cases that database did not provide the necessary information. The following is list of attributes and their sources:

- **Longitude** and **Latitude** – Location information that provides Hazus-MH the x and y-position of the UDF point. This allows for an overlay to occur between the UDF point and the flood or earthquake input data layers. The hazard model uses this spatial overlay to determine the correct hazard risk level that will be applied to the UDF point. The format of the attribute must be in decimal degrees. A simple geometric calculation using GIS software is done on the point to derive this value.
- **Occupancy class** – An alphanumeric attribute that indicates the use of the UDF (e.g., 'RES1' is a single-family dwelling). The alphanumeric code is composed of seven broad occupancy types (RES = residential, COM = commercial, IND = industrial, AGR = agricultural, GOV = public, REL = nonprofit/religious, EDU = education) and various suffixes that indicate more specific types. This code determines the damage function to be used for flood analysis. It is also used to attribute the Building Type field, discussed below, for the earthquake analysis. The code was interpreted from "Stat Class" or "Description" data found in the Morrow County assessor database. When data was not available, the default value of RES1 was applied throughout.
- **Cost** – The replacement cost of an individual UDF. Loss ratio is derived from this value. Replacement cost is based on a method called RSMeans valuation (Charest, 2017) and is calculated by multiplying the building square footage by a standard cost per square foot. These standard rates per square foot are in tables within the default Hazus database.

- **Year built** – The year of construction that is used to attribute the Building Design Level field for the earthquake analysis (see “Building Design” below). The year a UDF was built is obtained from Morrow County assessor database. When not available, the year of “1900” was applied.
- **Square feet** – The size of the UDF is used to pro-rate the total improvement value for taxlots with multiple UDFs. The value distribution method will ensure that UDFs with the highest square footage will be the most expensive on a given taxlot. This value is also used to pro-rate the **Number of People** field for Residential UDFs within a census block. The value was obtained from DOGAMI’s building footprints; where (RES) footprints were not available, we used the Morrow County assessor database.
- **Number of stories** – The number of stories for an individual UDF, along with Occupancy Class, determines the applied damage function for flood analysis. The value was obtained from the Morrow County assessor database when available. For UDFs without assessor information for number of stories that are within the flood zone, closer inspection using Google Street View™ or available oblique imagery was used for attribution.
- **Foundation type** – The UDF foundation type correlates with First Floor Height values in feet (see Table 3.11 in the Hazus-MH Technical Manual for the Flood Model [FEMA Hazus-MH, 2012a]). It also functions within the flood model by indicating if a basement exists or not. UDFs with a basement have a different damage function from UDFs that do not have one. The value was obtained from the Morrow County assessor database when available. For UDFs without assessor information for basements that are within the flood zone, closer inspection using Google Street View™ or available oblique imagery was used to ascertain if one exists or not.
- **First floor height** – The height in feet above grade for the lowest habitable floor. The height is factored during the depth of flooding analysis. The value is used directly by Hazus-MH, where Hazus-MH overlays a UDF location on a depth grid and using the **first-floor height** determines the level of flooding occurring to a building. It is derived from the Foundation Type attribute or observation via oblique imagery or Google Street View™ mapping service.
- **Building type** – This attribute determines the construction material and structural integrity of an individual UDF. It is used by Hazus-MH for estimating earthquake losses by determining which damage function will be applied. This information was unavailable from the Morrow County assessor data, so instead it was derived from a statistical distribution based on **Occupancy class**.
- **Building design level** – This attribute determines the seismic building code for an individual UDF. It is used by Hazus-MH for estimating earthquake losses by determining which damage function will be applied. This information is derived from the **Year Built** attribute (Morrow County assessor) and state/regional Seismic Building Code benchmark years.
- **Number of people** – The estimated number of permanent residents living within an individual residential structure. It is used in the post-analysis phase to determine the amount of people affected by a given hazard. This attribute is derived from default Hazus database (United States Census Bureau, 2020a) of population per census block and distributed across residential UDFs and adjusted based on population growth estimates from PSU Population Research Center.
- **Community** – The community that a UDF is within. These areas are used in the post-analysis for reporting results. The communities were based on incorporated area boundaries; unincorporated community areas were based on building density.

C.2.3 Seismic building codes

Oregon initially adopted seismic building codes in the mid-1970s (Judson, 2012). The established benchmark years of code enforcement are used in determining a "design level" for individual buildings. The design level attributes (Pre-code, Low code, Moderate code, and High code) are used in the Hazus-MH earthquake model to determine what damage functions are applied to a given building (FEMA, 2012b). The year built or the year of the most recent seismic retrofit are the main considerations for an individual design level attribute. Seismic retrofitting information for structures would be ideal for this analysis but was not available for Morrow County. **Table C-1** outlines the benchmark years that apply to buildings within Morrow County.

Table C-1. Morrow County seismic design level benchmark years.

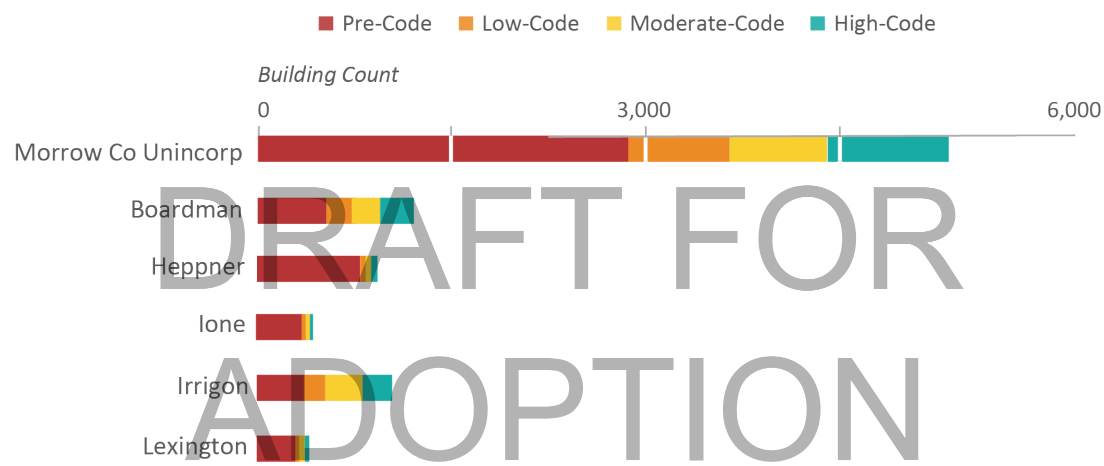
Building Type	Year Built	Design Level	Basis
Single-Family Dwelling (includes Duplexes)	prior to 1976	Pre Code	Interpretation of Judson (Judson, 2012)
	1976–1991	Low Code	
	1992–2003	Moderate Code	
	2004–2016	High Code	
Manufactured Housing	prior to 2003	Pre Code	Interpretation of OR BCD 2002 Manufactured Dwelling Special Codes (Oregon Building Codes Division, 2002)
	2003–2010	Low Code	
	2011–2016	Moderate Code	Interpretation of OR BCD 2010 Manufactured Dwelling Special Codes Update (Oregon Building Codes Division, 2010)
All other buildings	prior to 1976	Pre Code	Business Oregon 2014-0311 Oregon Benefit-Cost Analysis Tool, p. 24 (Business Oregon, 2015)
	1976–1990	Low Code	
	1991–2016	Moderate Code	

Table C-2 and corresponding **Figure C-1** illustrate the current state of seismic building codes for the county.

Table C-2. Seismic design level in Morrow County.

		Pre Code		Low Code		Moderate Code		High Code	
Community	Total Number of Buildings	Number of Buildings	Percentage of Buildings	Number of Buildings	Percentage of Buildings	Number of Buildings	Percentage of Buildings	Number of Buildings	Percentage of Buildings
Unincorp. Morrow Co (rural)	5,141	2932	57%	700	14%	682	13%	827	16%
Boardman	1,214	549	45%	202	17%	206	17%	257	21%
Heppner	797	658	83%	48	6%	46	6%	45	5.7%
Ione	249	175	70%	9	4%	39	16%	26	10%
Irrigon	867	307	35%	136	16%	313	36%	111	13%
Lexington	212	155	73%	13	6%	21	10%	23	11%
Total County	8,480	4776	56%	1108	13%	1307	15%	1289	15%

Figure C-1. **Seismic design level by Morrow County** community.



C.3 Flood Hazard Data

DOGAMI developed depth grids from flood hazard data in 2021 (Appleby and others, 2021) based on 2007 FEMA Flood Insurance Study (FEMA, 2007). For riverine areas, flood elevations for the 10-, 50-, 100-, and 500-year events for each stream cross-section were used to develop depth of flooding raster datasets or "depth grids".

A study area-wide, 2-meter, lidar-based depth grid was developed for each of the 10-, 50-, 100-, and 500-year annual chance flood events. The depth grids were imported into Hazus-MH for determining the depth of flooding for areas within the FEMA flood zones.

Once the UDF database was developed into a Hazus-compliant format, the Hazus-MH methodology was applied using a Python (programming language) script developed by DOGAMI (Bauer, 2018). The analysis was then run for a given flood event, and the script cross-referenced a UDF location with the depth grid to find the depth of flooding. The script then applied a specific damage function, based on a UDF's Occupancy Class [OccCls], which was used to determine the loss ratio for a given amount of flood depth, relative to the UDF's first-floor height.

C.4 Earthquake Hazard Data

The following hazard layers used for our loss estimation are derived from work conducted by Madin and others (2021): NEHRP soil classification, liquefaction susceptibility and wet landslide susceptibility. The liquefaction and landslide susceptibility layers together with NEHRP were used by the Hazus-MH tool to calculate ground motion layers and permanent ground deformation and associated probability. The default value of 5 feet was used for the water table depth value.

During the Hazus-MH earthquake analysis, each UDF was analyzed given its site-specific parameters (ground deformation) and evaluated for loss, expressed as a probability of a damage state. Specific damage functions based on Building Type and Building Design Level were used to calculate the damage states given the site-specific parameters for each UDF. The output provided probabilities of the five damage states (None, Slight, Moderate, Extensive, Complete) from which losses in dollar amounts were derived.

C.5 Post-Analysis Quality Control

Ensuring the quality of the results from Hazus-MH flood and earthquake modules is an essential part of the process. A primary characteristic of the process is that it is iterative. A UDF database without errors is highly unlikely, so this part of the process is intended to limit and reduce the influence these errors have on the final outcome. Before applying the Hazus-MH methodology, closely examining the top 10 largest area UDFs and the top 10 most expensive UDFs is advisable. Special consideration can also be given to critical facilities due to their importance to communities.

Identifying, verifying, and correcting (if needed) the outliers in the results is the most efficient way to improve the UDF database. This can be done by sorting the results based on the loss estimates and closely scrutinizing the top 10 to 15 records. If corrections are made, then subsequent iterations are necessary. We continued checking the "loss leaders" until no more corrections were needed.

Finding anomalies and investigating possible sources of error are crucial in making corrections to the data. A wide range of corrections might be required to produce a better outcome. For example, floating homes may need to have a first-floor height adjustment or a UDF point position might need to be moved due to issues with the depth grid. Incorrect basement or occupancy type attribution could be the cause of a problem. Commonly, inconsistencies between assessor data and taxlot geometry can be the source of an error. These are just a few of the many types of problems addressed in the quality control process.

APPENDIX D. ACRONYMS AND DEFINITIONS

D.1 Acronyms

CRS	Community Rating System
CSZ	Cascadia subduction zone
DLCD	Oregon Department of Land Conservation and Development
DOGAMI	Department of Geology and Mineral Industries (State of Oregon)
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FRI	Fire Risk Index
GIS	Geographic Information System
NFIP	National Flood Insurance Program
NHMP	Natural hazard mitigation plan
NOAA	National Oceanic and Atmospheric Administration
ODF	Oregon Department of Forestry
OEM	Oregon Emergency Management
OFR	Open-File Report
OPDR	Oregon Partnership for Disaster Resilience
PGA	Peak ground acceleration
PGD	Permanent ground deformation
PGV	Peak ground velocity
Risk MAP	Risk Mapping, Assessment, and Planning
SHMO	State Hazard Mitigation Officer
SLIDO	State Landslide Information Layer for Oregon
UDF	User-defined facilities
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WUI	Wildland-urban interface
WWA	West Wide Wildfire Risk Assessment

D.2 Definitions

1% annual chance flood – The flood elevation that has a 1-percent chance of being equaled or exceeded each year. Sometimes referred to as the 100-year flood.

0.2% annual chance flood – The flood elevation that has a 0.2-percent chance of being equaled or exceeded each year. Sometimes referred to as the 500-year flood.

Base flood elevation (BFE) – Elevation of the 1-percent-annual-chance flood. This elevation is the basis of the insurance and floodplain management requirements of the NFIP.

Critical facilities – Facilities that, if damaged, would present an immediate threat to life, public health, and safety. As categorized in HAZUS-MH, critical facilities include hospitals, emergency operations centers, police stations, fire stations and schools.

Exposure – Determination of whether a building is within or outside of a hazard zone. No loss estimation is modeled.

Flood Insurance Rate Map (FIRM) – An official map of a community, on which FEMA has delineated both the SFHAs and the risk premium zones applicable to the community.

Flood Insurance Study (FIS) – Contains an examination, evaluation, and determination of the flood hazards of a community and, if appropriate, the corresponding water-surface elevations.

Hazus-MH – A GIS-based risk assessment methodology and software application created by FEMA and the National Institute of Building Sciences for analyzing potential losses from floods, hurricane winds, and earthquakes.

Lidar – A remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. Lidar is popularly used as a technology to make high-resolution maps.

Liquefaction – Describes a phenomenon whereby saturated soil substantially loses strength and stiffness in response to an applied stress, usually an earthquake, causing it to behave like liquid.

Loss Ratio – The expression of loss as a fraction of the value of the local inventory (total value/loss).

Magnitude – A scale used by seismologists to measure the size of earthquakes in terms of energy released.

Risk – Probability multiplied by consequence; the degree of probability that a loss or injury may occur as a result of a natural hazard. Sometimes referred to as vulnerability.

Risk MAP – The vision of this FEMA strategy is to work collaboratively with state, local, and tribal entities to deliver quality flood data that increases public awareness and leads to action that reduces risk to life and property.

Riverine – Of or produced by a river. Riverine floodplains have readily identifiable channels.

Susceptibility – Degree of proneness to natural hazards that is determined based on physical characteristics that are present.

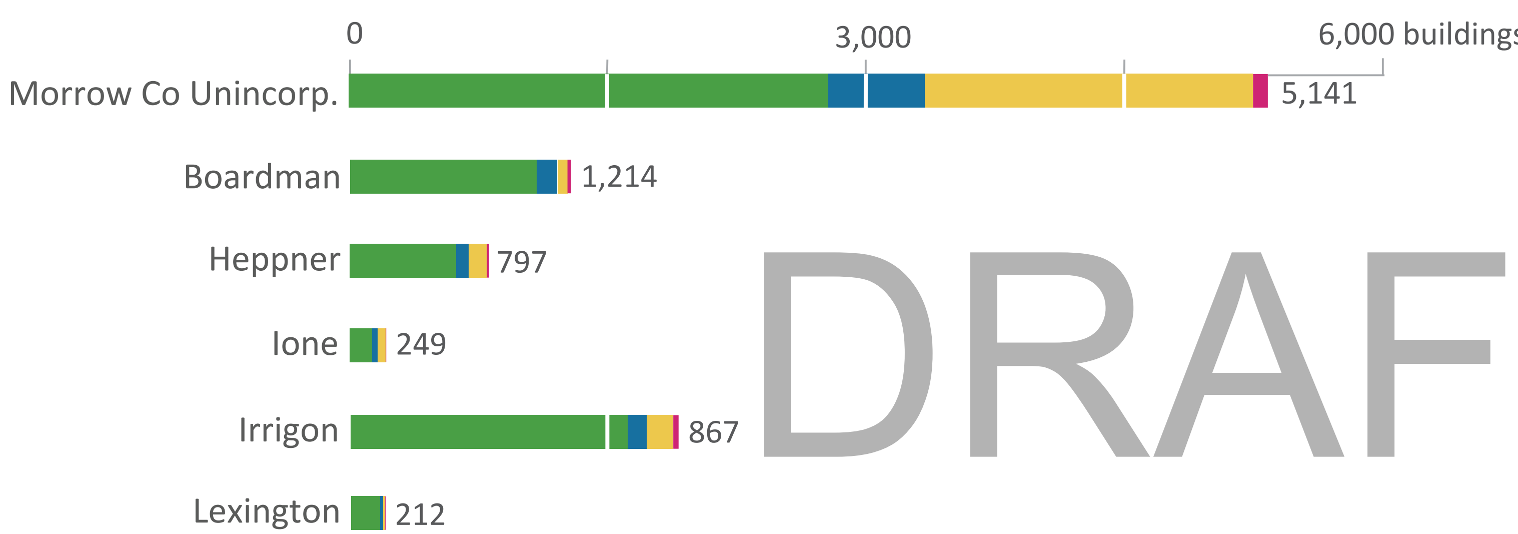
Vulnerability – Characteristics that make people or assets more susceptible to a natural hazard.

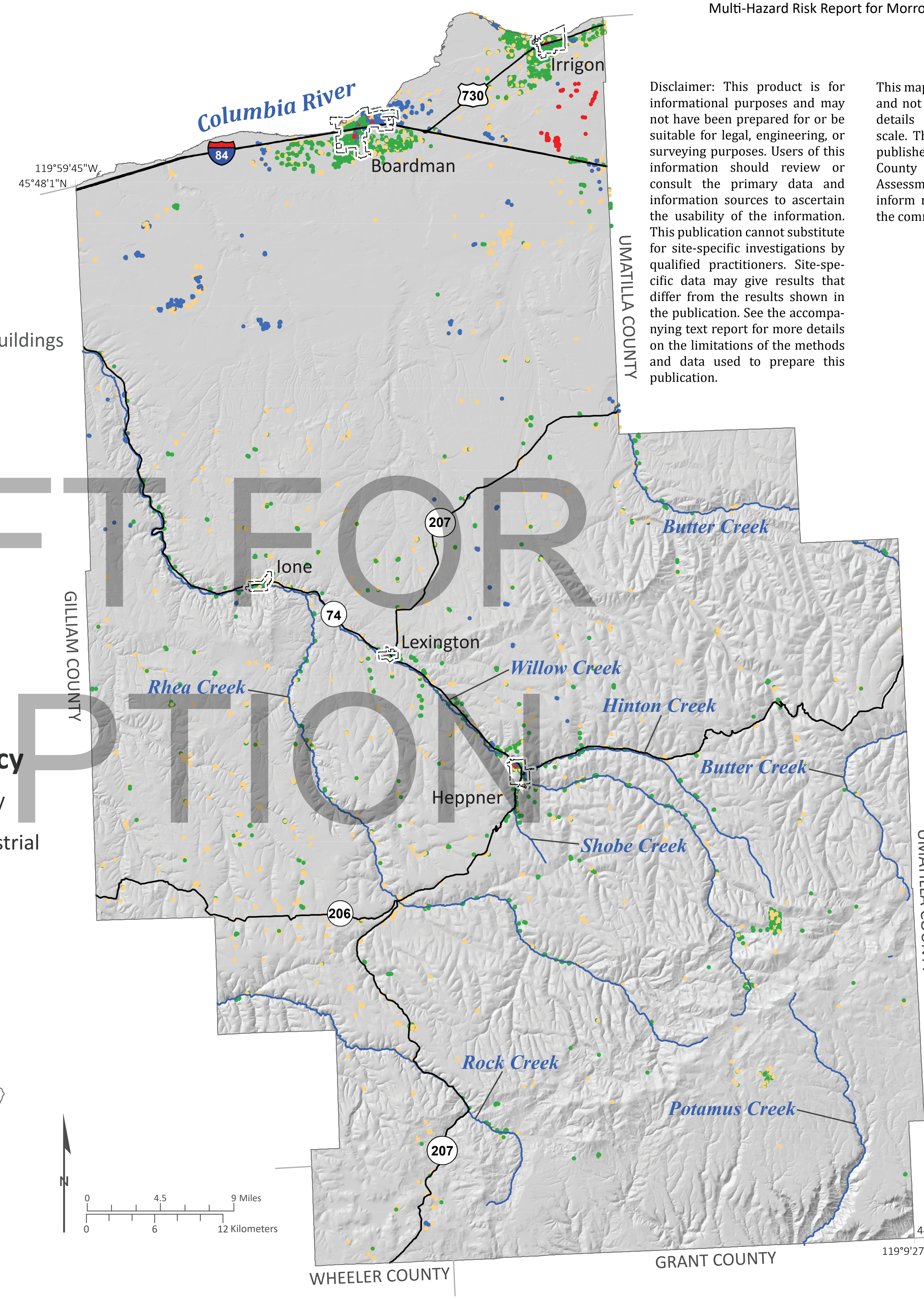
APPENDIX E. MAP PLATES

See appendix folder for individual map PDFs.

PLATE 1

Building Distribution Map of Morrow County, Oregon





Building Occupancy

- Agricultural / Utility
- Commercial / Industrial
- Public / Nonprofit
- Residential

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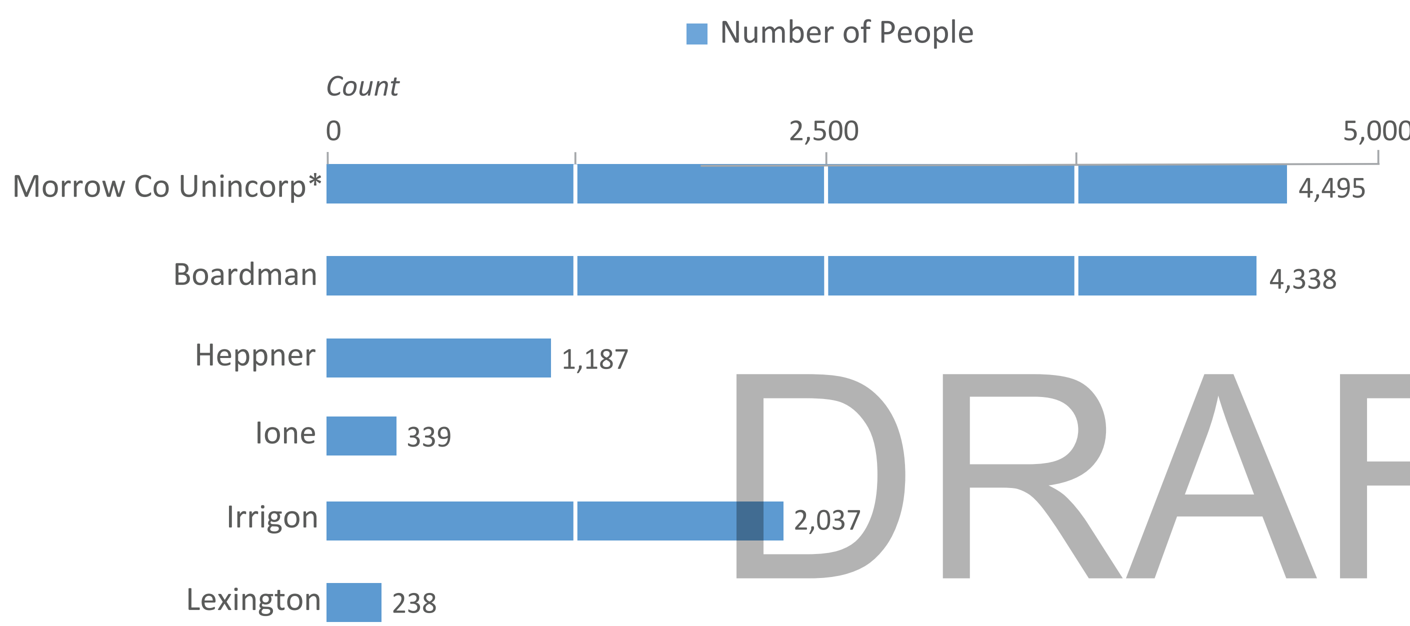
Data Sources:
Building footprints: Statewide Building Footprints of Oregon (2021)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

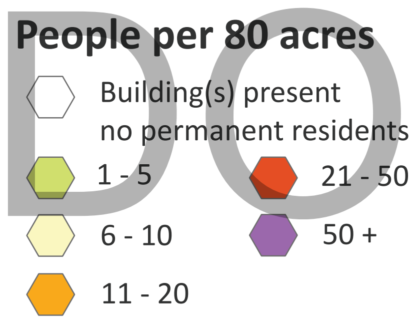
Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

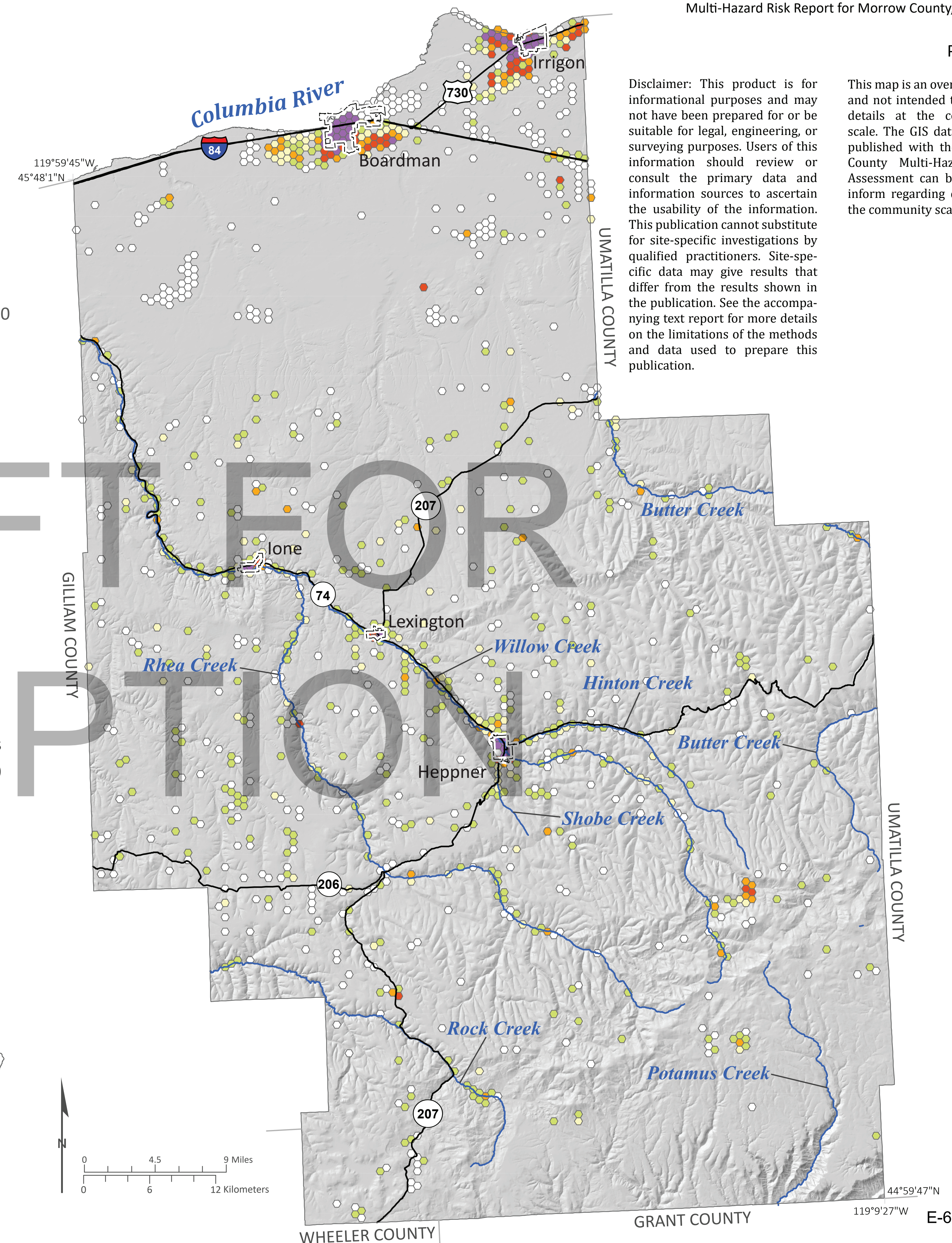
Cartography by:Matt C. Williams, 2023

Study Location Map

Population Density Map of Morrow County, Oregon







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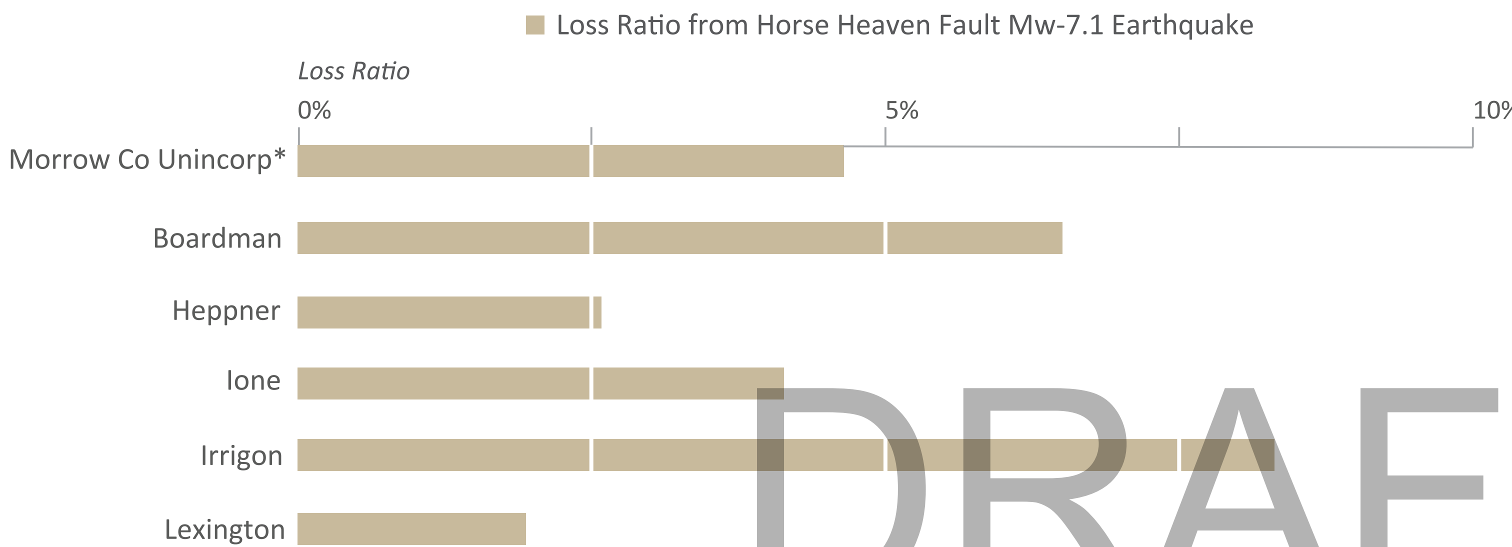
Data Sources:
Population data: PSU Population Research Center (2021)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

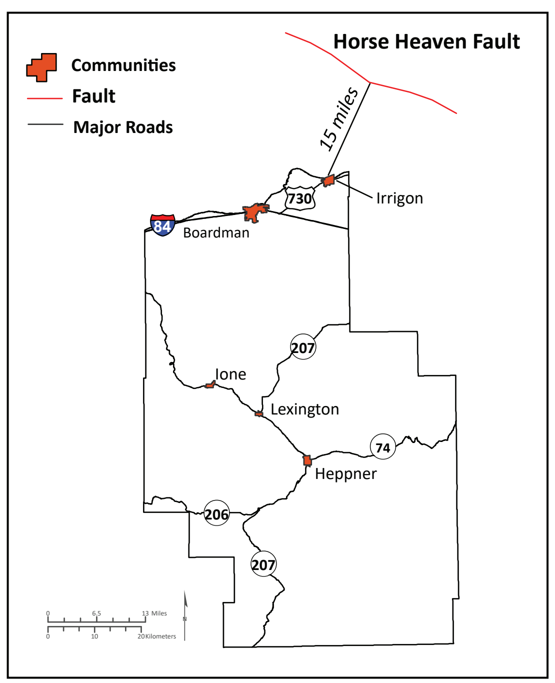
Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

Cartography by:Matt C. Williams, 2023

Study Location Map

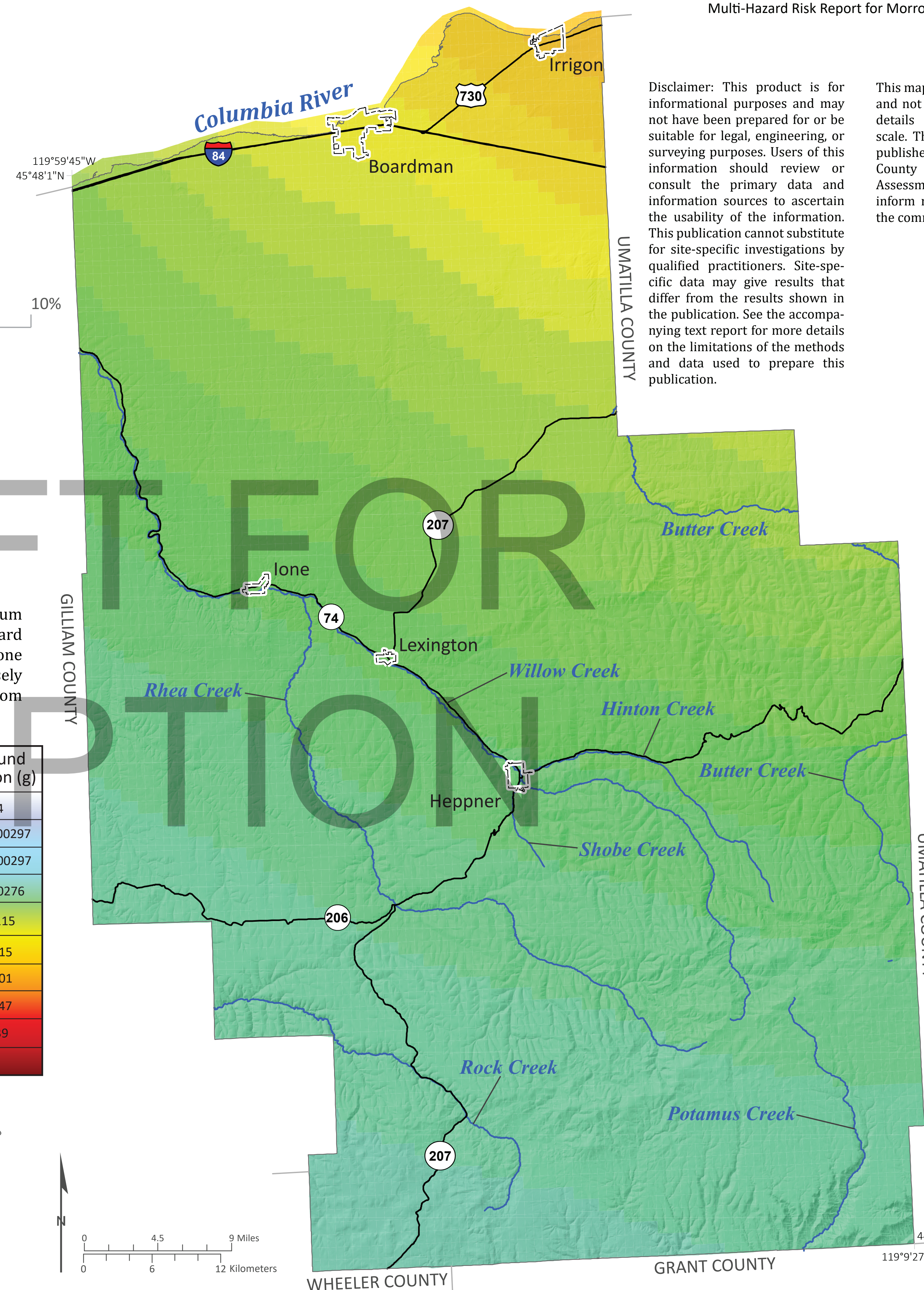
Horse Heaven Fault Mw-7.1 Earthquake Shaking Map of Morrow County, Oregon





Peak Ground Acceleration (PGA) is the maximum acceleration in a given location or rather how hard the ground is shaking during an earthquake. It is one measurement of ground motion, which is closely associated with the level of damage that occurs from an earthquake.

Modified Mercalli	Perceived Shaking	Potential Damage	Peak Ground Acceleration (g)
I	Not felt	None	< 0.000464
II	Weak	None	0.000464 - 0.00297
III	Weak	None	0.000464 - 0.00297
IV	Light	None	0.00297 - 0.0276
V	Moderate	Very Light	0.0276 - 0.115
VI	Strong	Light	0.115 - 0.215
VII	Very Strong	Moderate	0.215 - 0.401
VIII	Severe	Mod./Heavy	0.401 - 0.747
IX	Violent	Heavy	0.747 - 1.39
X	Extreme	Very Heavy	> 1.39



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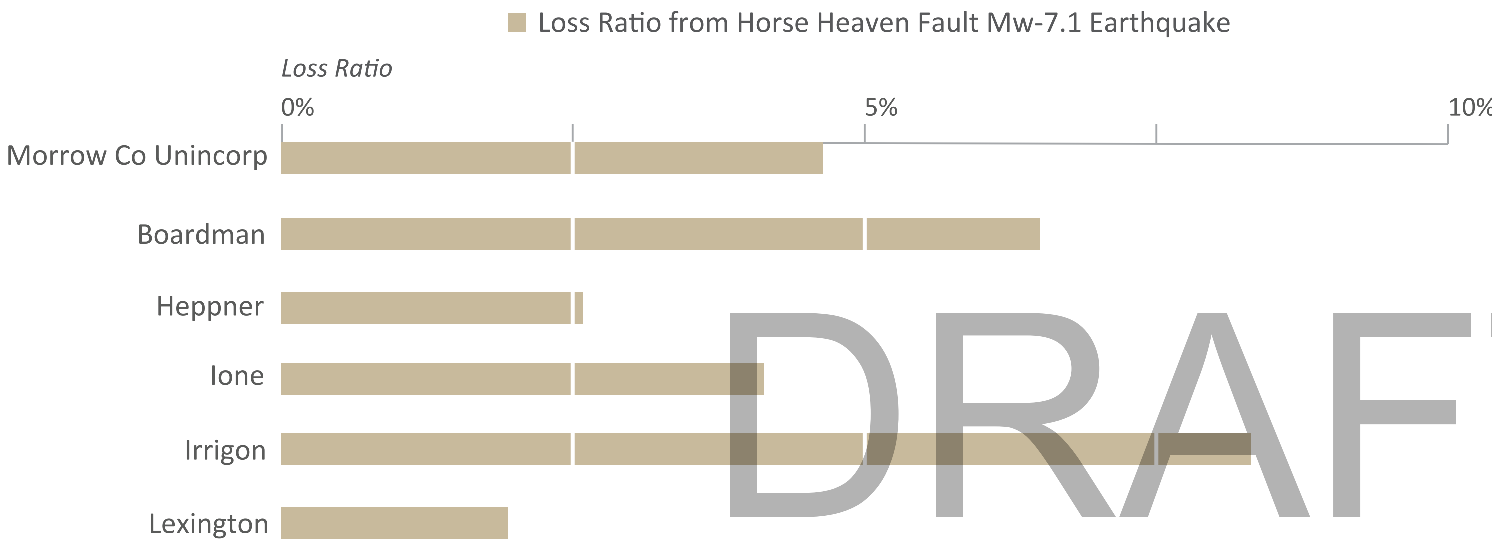
Data Sources:
Earthquake peak ground acceleration: Calculated within Hazus-MH 5.0 (2023)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

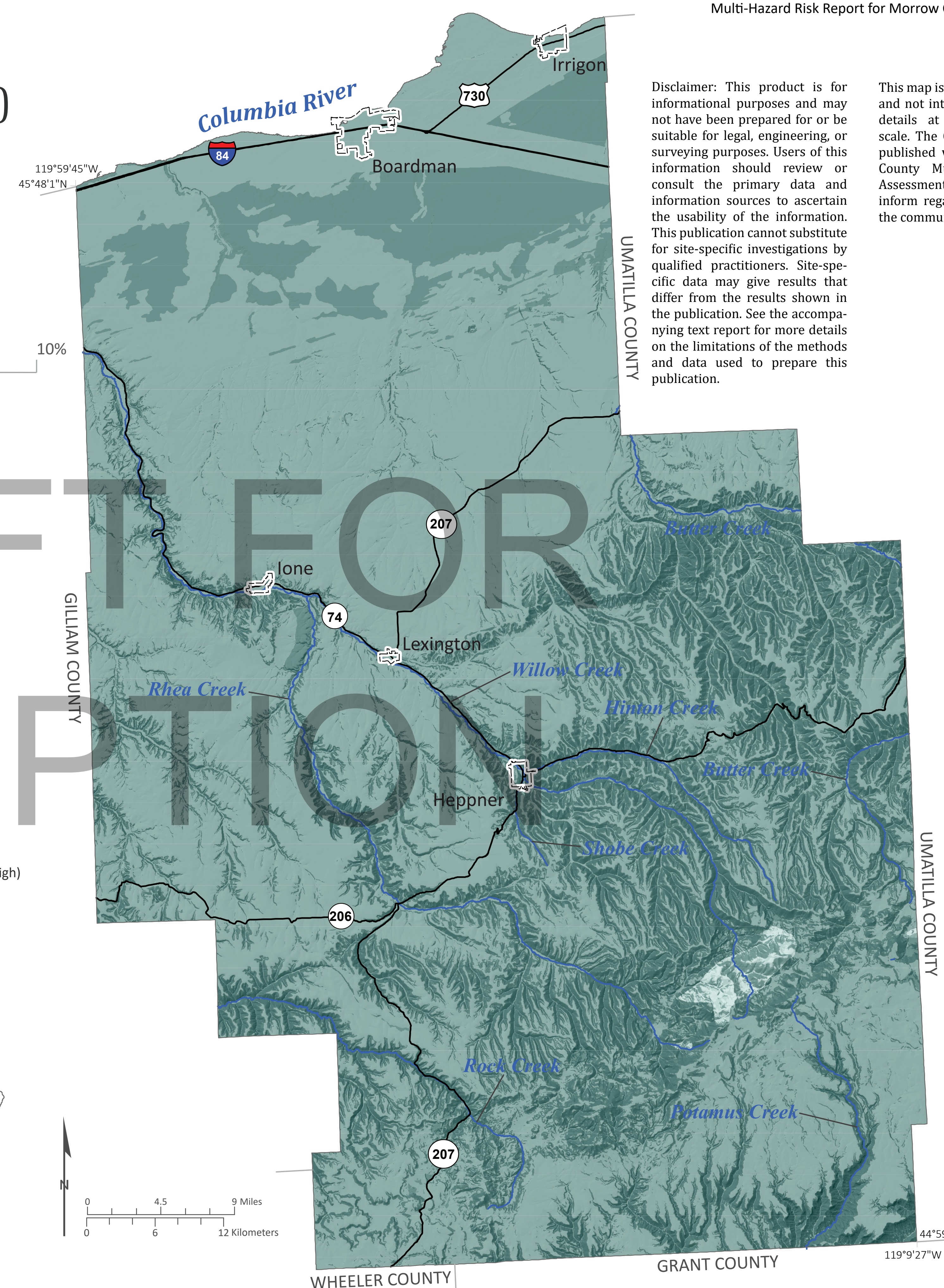
Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

Cartography by:Matt C. Williams, 2023

Study Location Map

Coseismic Landslide Susceptibility (Wet) Map of Morrow County, Oregon





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DRAFT FOR ADOPTION

Coseismic landslide is a type of ground deformation that occurs during an earthquake where slope failure creates a mass movement of rock and debris. Saturated ground increases the susceptibility of a landslide occuring from seismic shaking. Coseismic landslides are a significant factor in the risk from earthquake hazard.

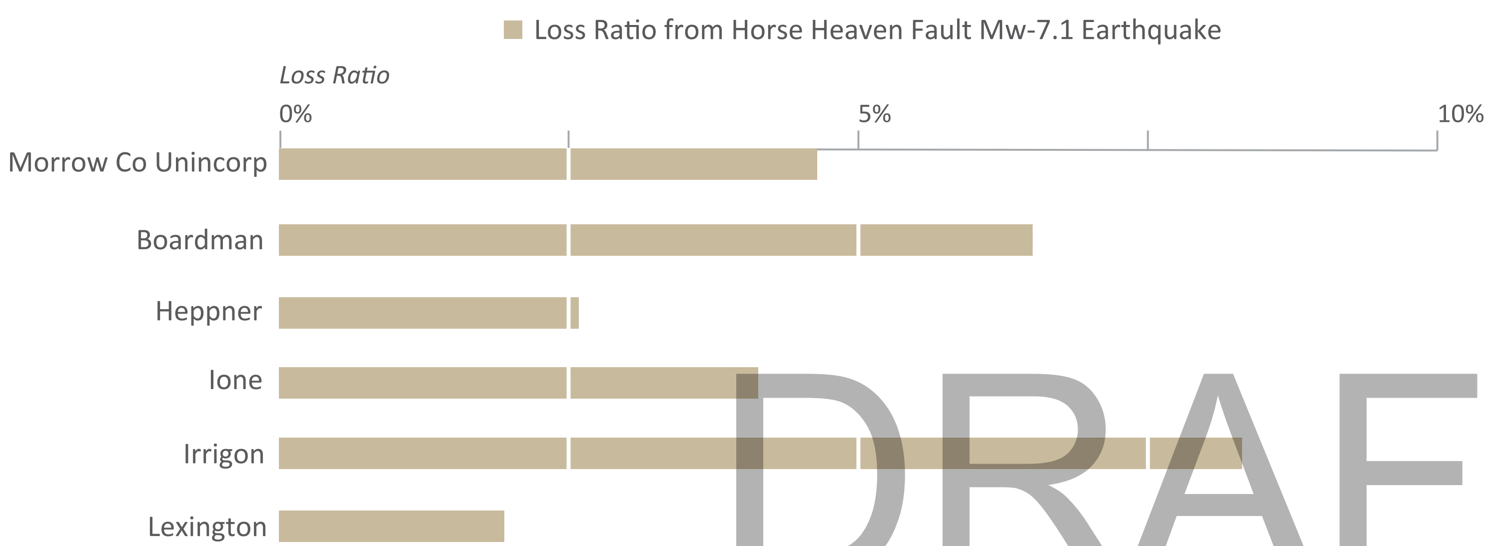
Data Sources:
Coseismic Landslide (wet): Oregon Department of Geology and Mineral Industries (2021)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

Cartography by:Matt C. Williams, 2023

Study Location Map

Liquefaction Susceptibility Map of Morrow County, Oregon



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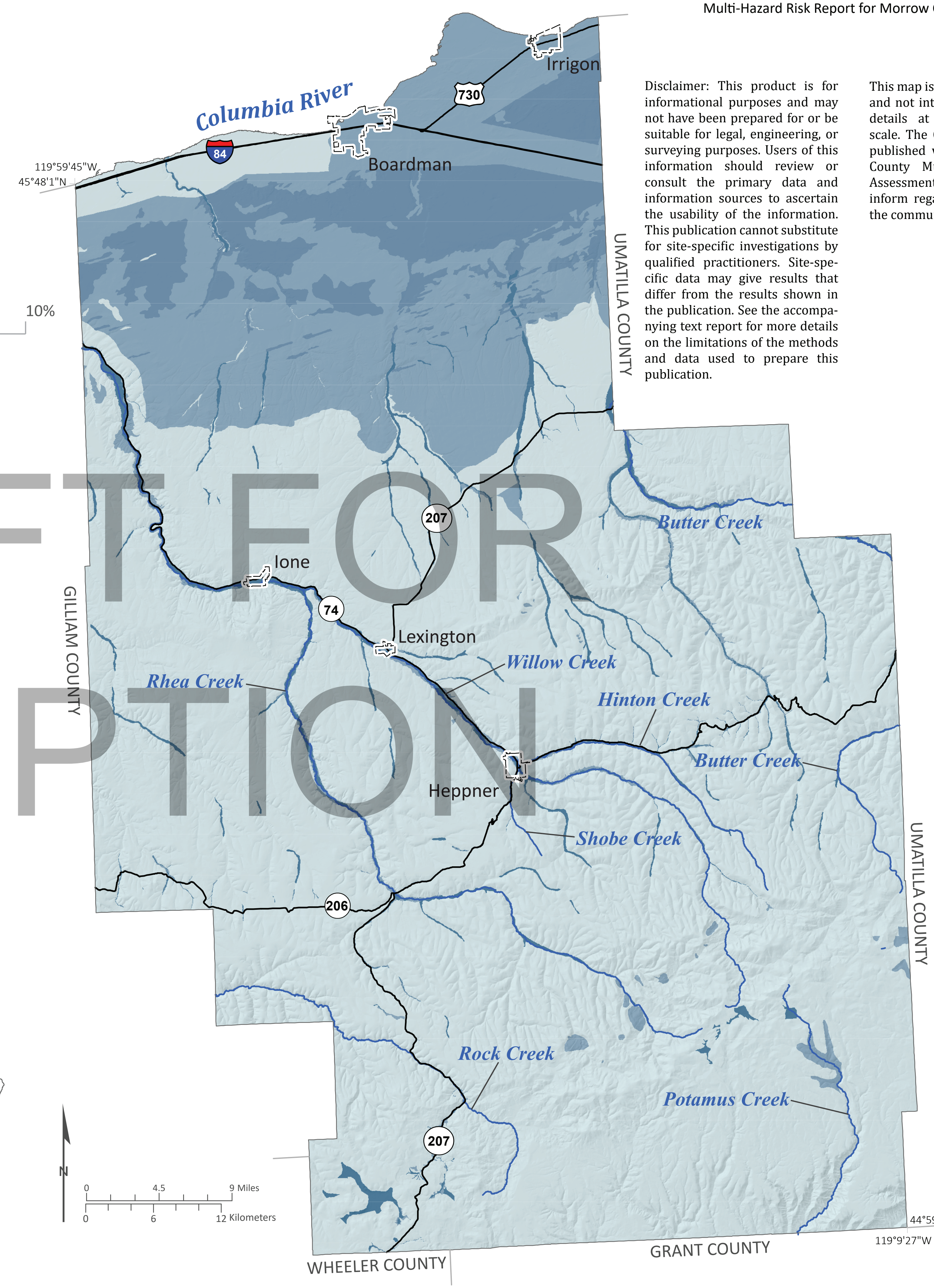


Liquefaction is a type of ground deformation that occurs during an earthquake where saturated soil contracts and liquefies. The ground that becomes liquefied can no longer support heavy structures that are built on top of it. Liquefaction is a significant factor in the risk from earthquake hazard.

Liquefaction Susceptibility

- Low or None
- Moderate
- High
- Very High

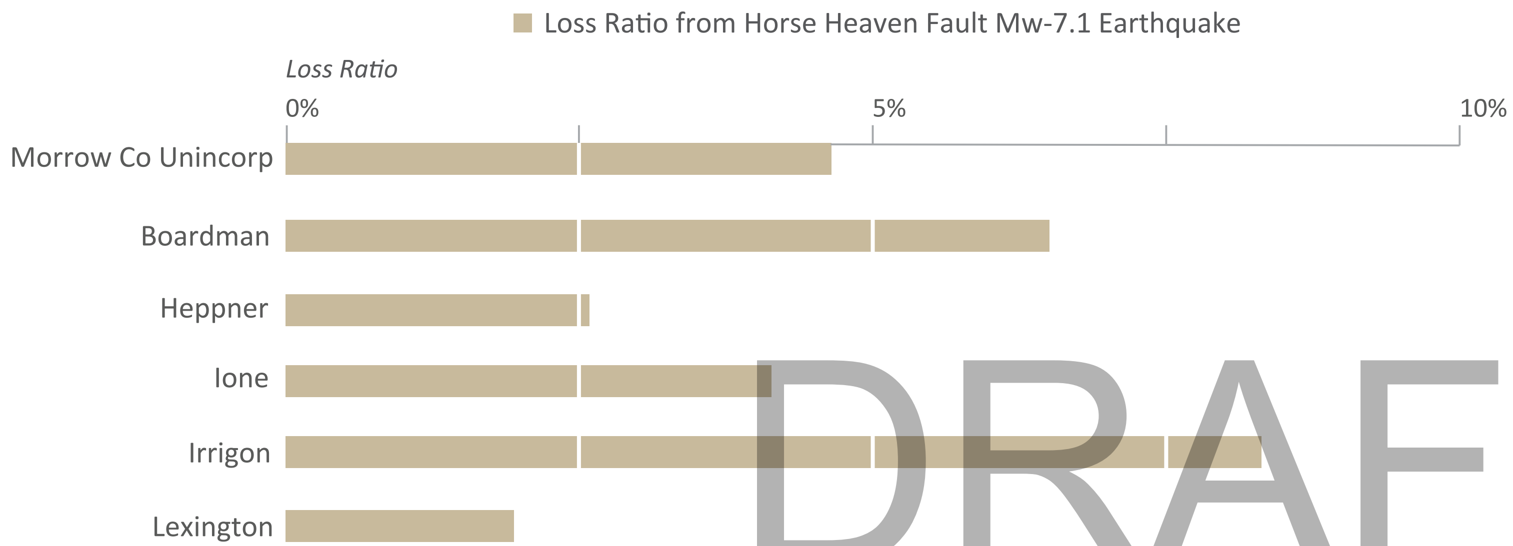
Data Sources:
Liquefaction susceptibility: Oregon Department of Geology and Mineral Industries (2021)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

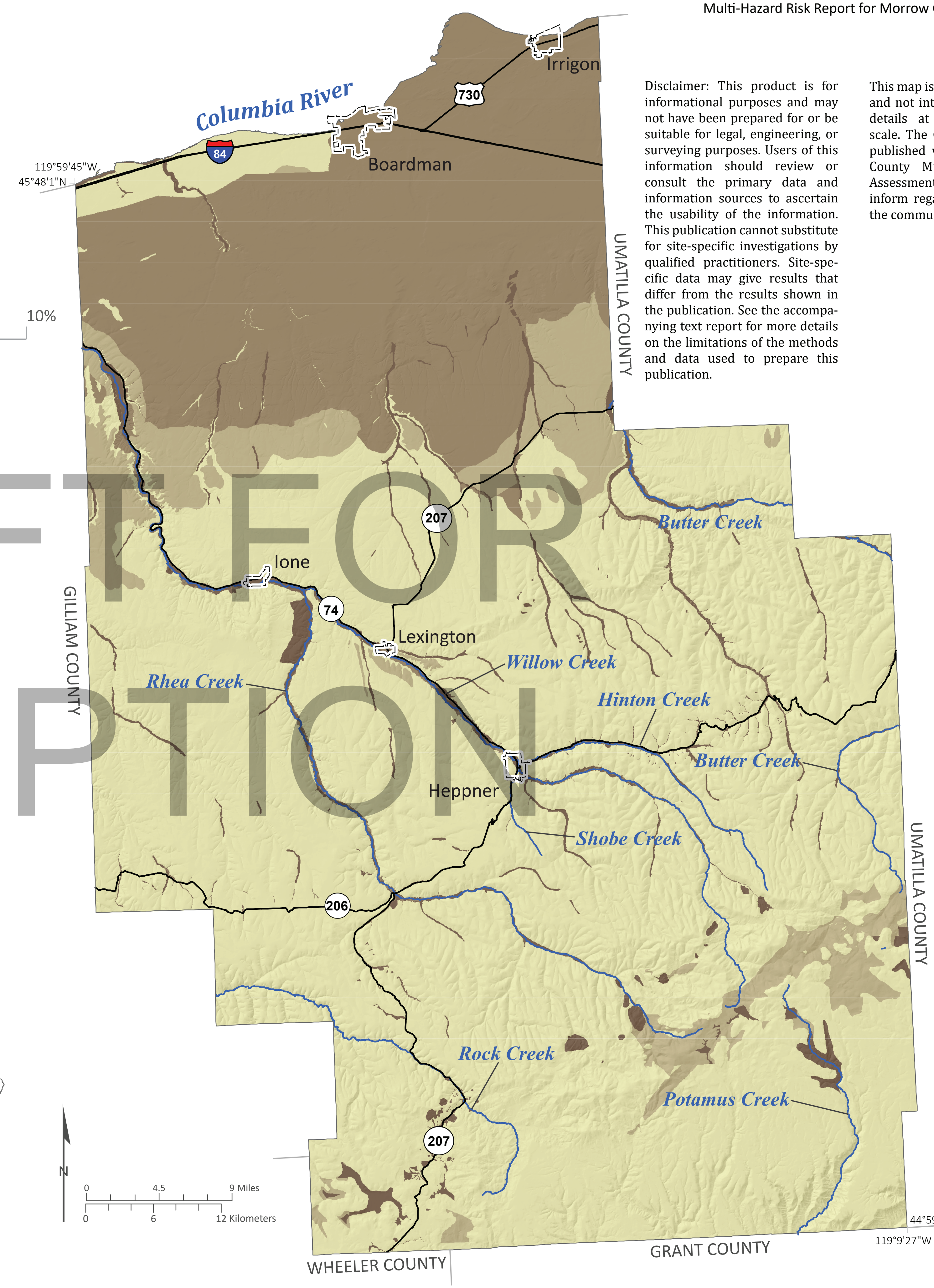
Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

Cartography by:Matt C. Williams, 2023

Study Location Map

Site Amplification Class Map of Morrow County, Oregon





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Site Amplification is the degree to which soil types attenuate (weaken) or amplify (strengthen) seismic waves produced from an earthquake. The National Earthquake Hazards Reduction Program (NEHRP) classifies these geologic units into soft rock (B), dense soil or soft rock (C), stiff soil (D), and soft clay or soil (E, F). NEHRP soils can significantly affect the level of shaking and amount of damage that occurs at a specific location during an earthquake

NEHRP Class

- B
- C
- D
- E, F

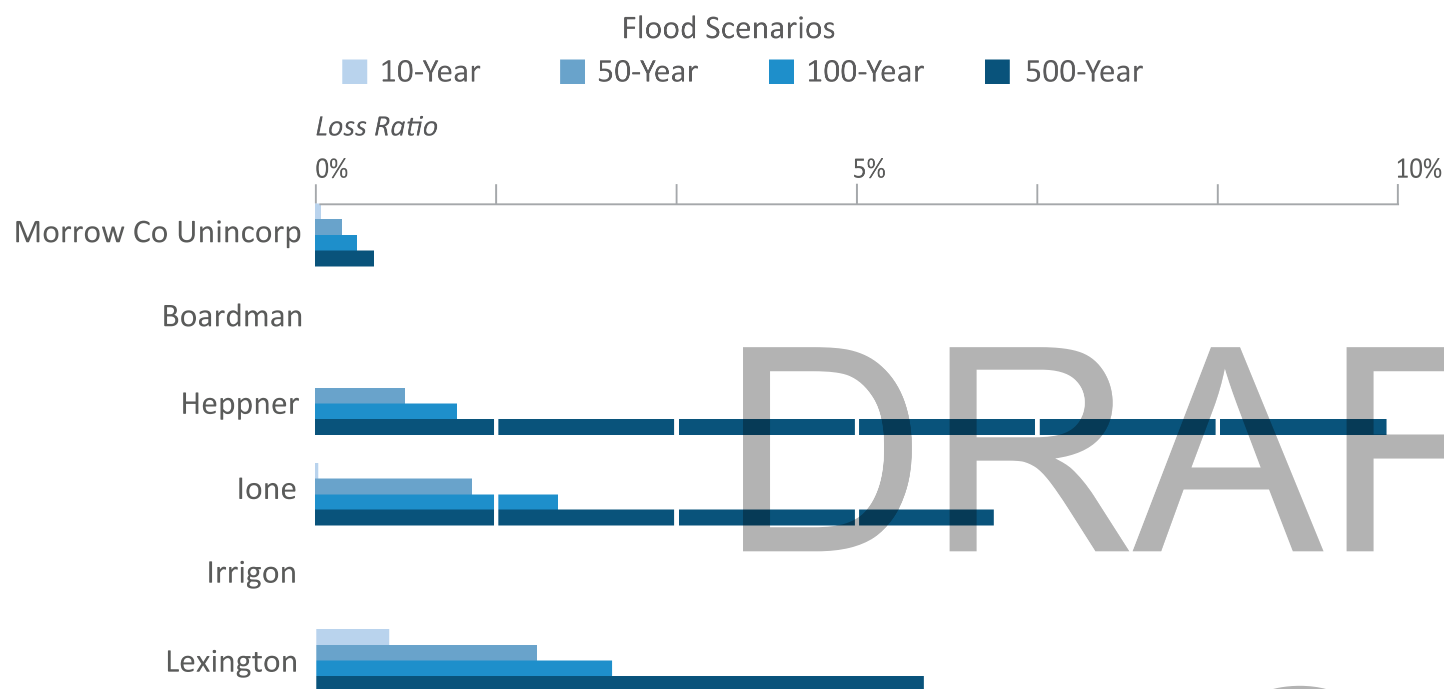
Data Sources:
Soil amplification: Oregon Department of Geology and Mineral Industries (2021)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

Cartography by:Matt C. Williams, 2023

Study Location Map

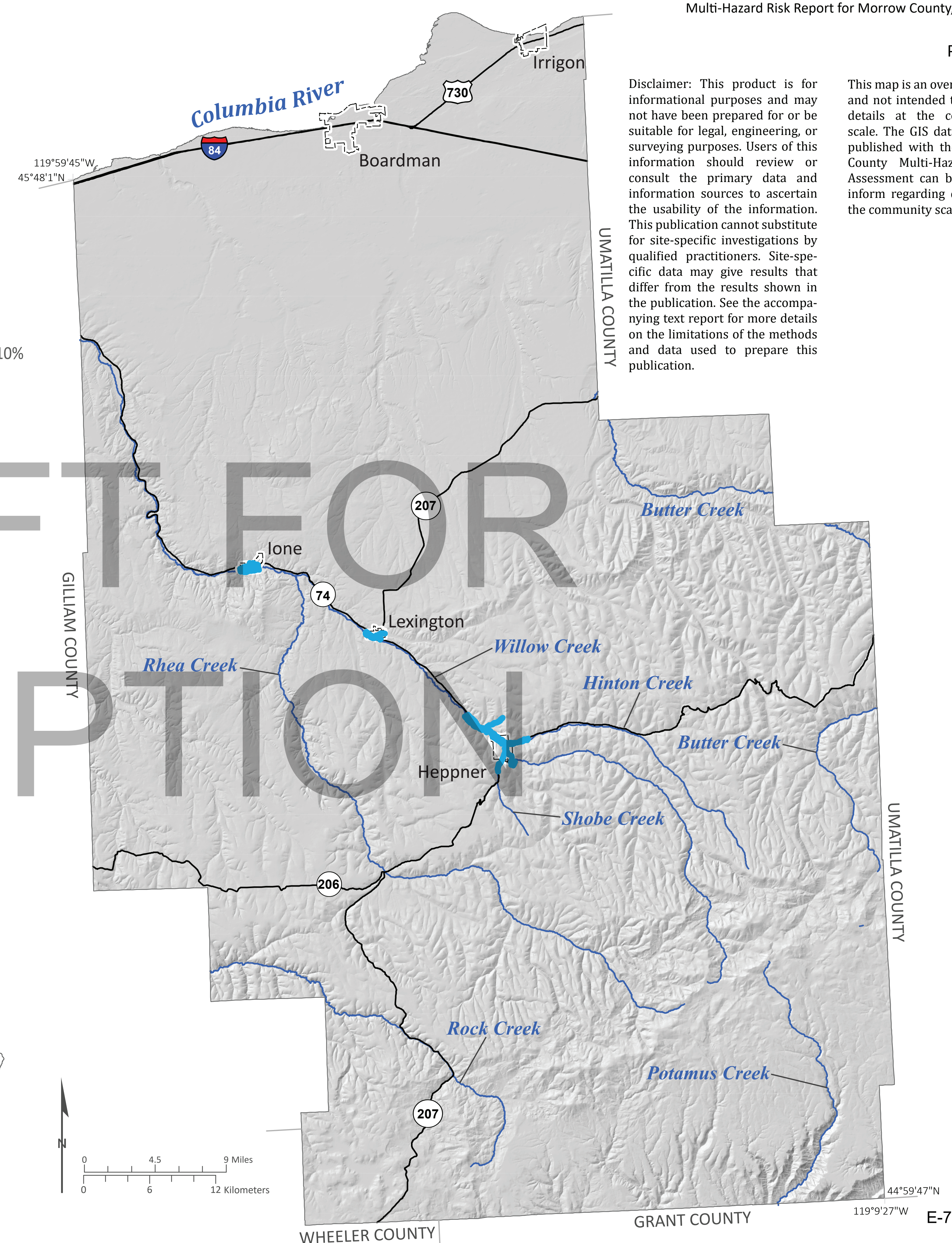
Flood Hazard Map of Morrow County, Oregon



The flood hazard data show areas expected to be inundated during a 100-year flood event. Flooding sources include riverine. Areas are consistent with the regulatory flood zones depicted in Morrow County's Digital Flood Insurance Rate Maps.

Flood Hazard Zone

100-Year Flood (1% annual chance)



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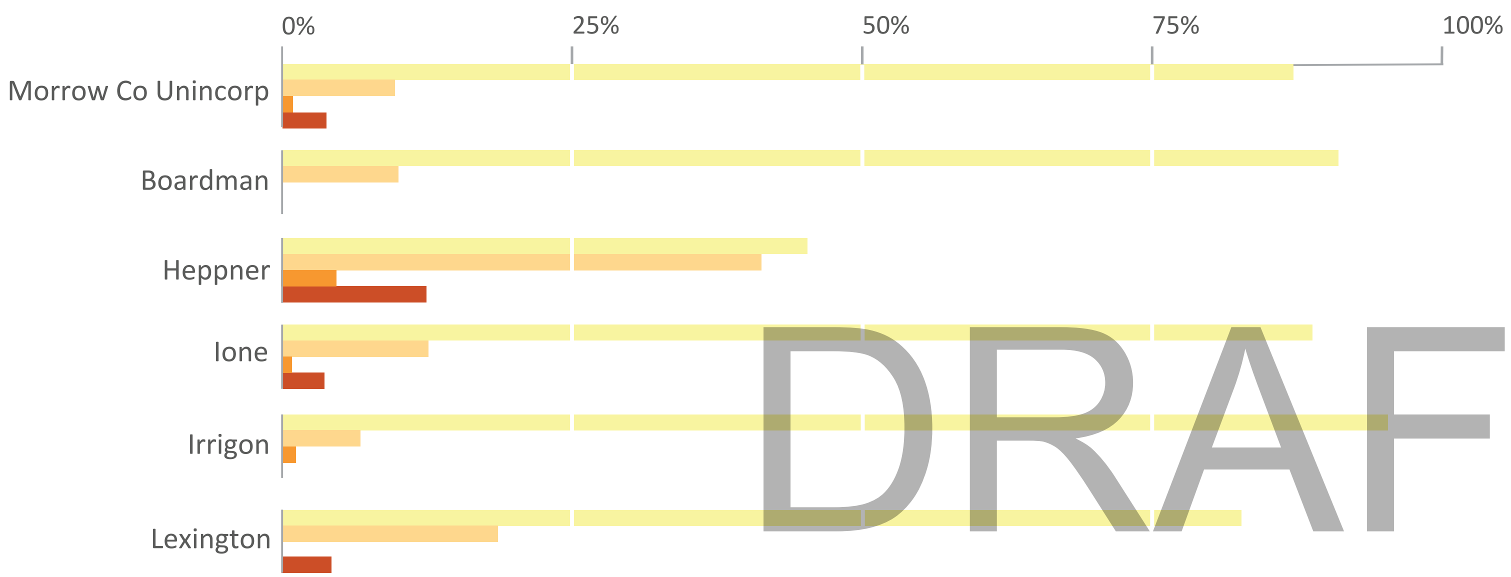
Data Sources:
Flood hazard zone (100-year): Morrow County Flood Insurance Rate Map (2016)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

Cartography by:Matt C. Williams, 2023

Study Location Map

Landslide Susceptibility Map of Morrow County, Oregon



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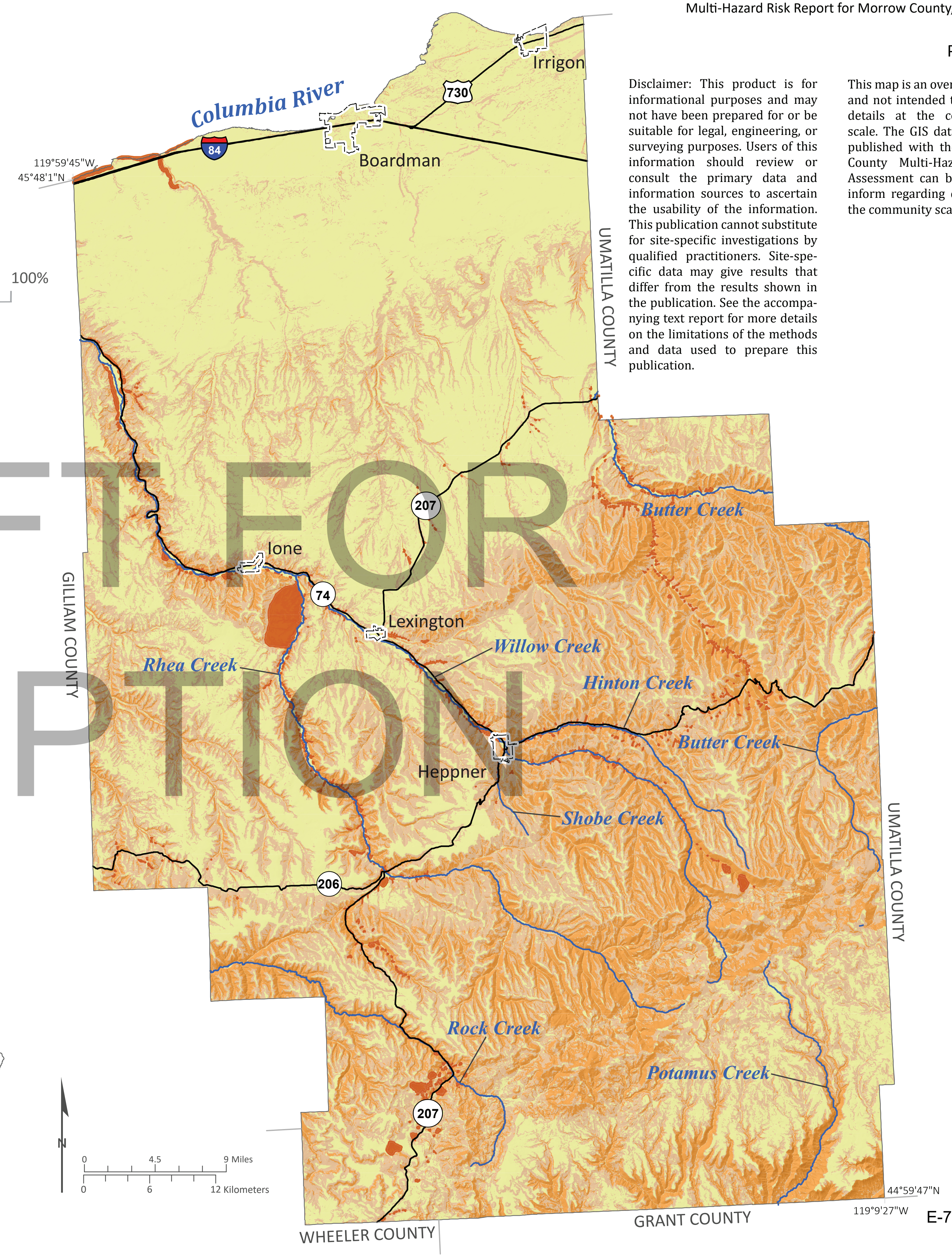


Landslide susceptibility is categorized as Low, Moderate, High, and Very High, which describes the general level of susceptibility to landslide hazard. The dataset is an aggregation of three primary sources: landslide inventory (SLIDO), generalized geology, and slope.

Landslide Susceptibility

- Low
- Moderate
- High
- Very High

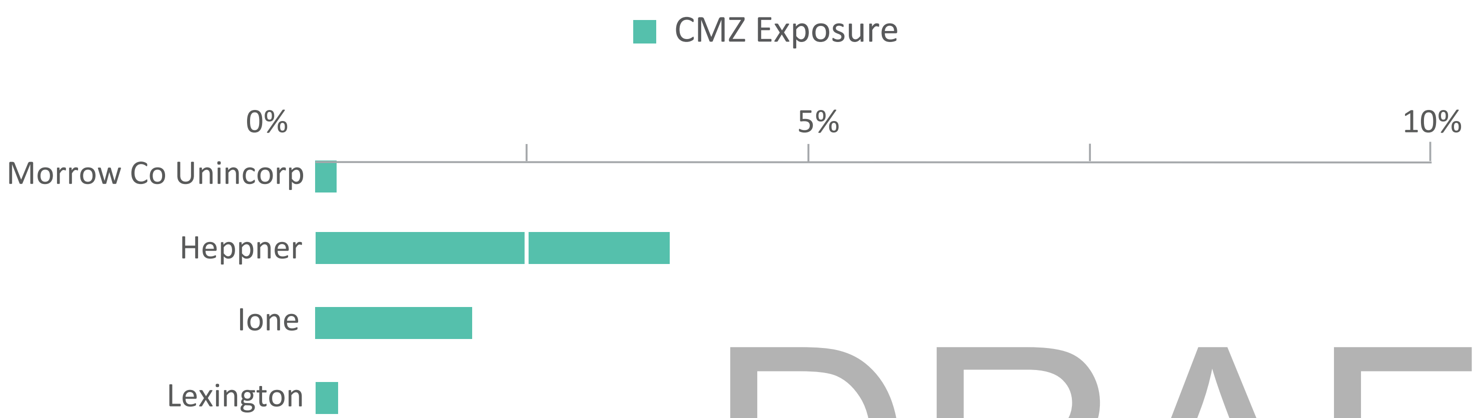
Data Sources:
Landslide susceptibility: Oregon Department of Geology and Mineral Industries, Burns and others (2016) & Hairston-Porter and others (2021)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

Cartography by:Matt C. Williams, 2023

Study Location Map

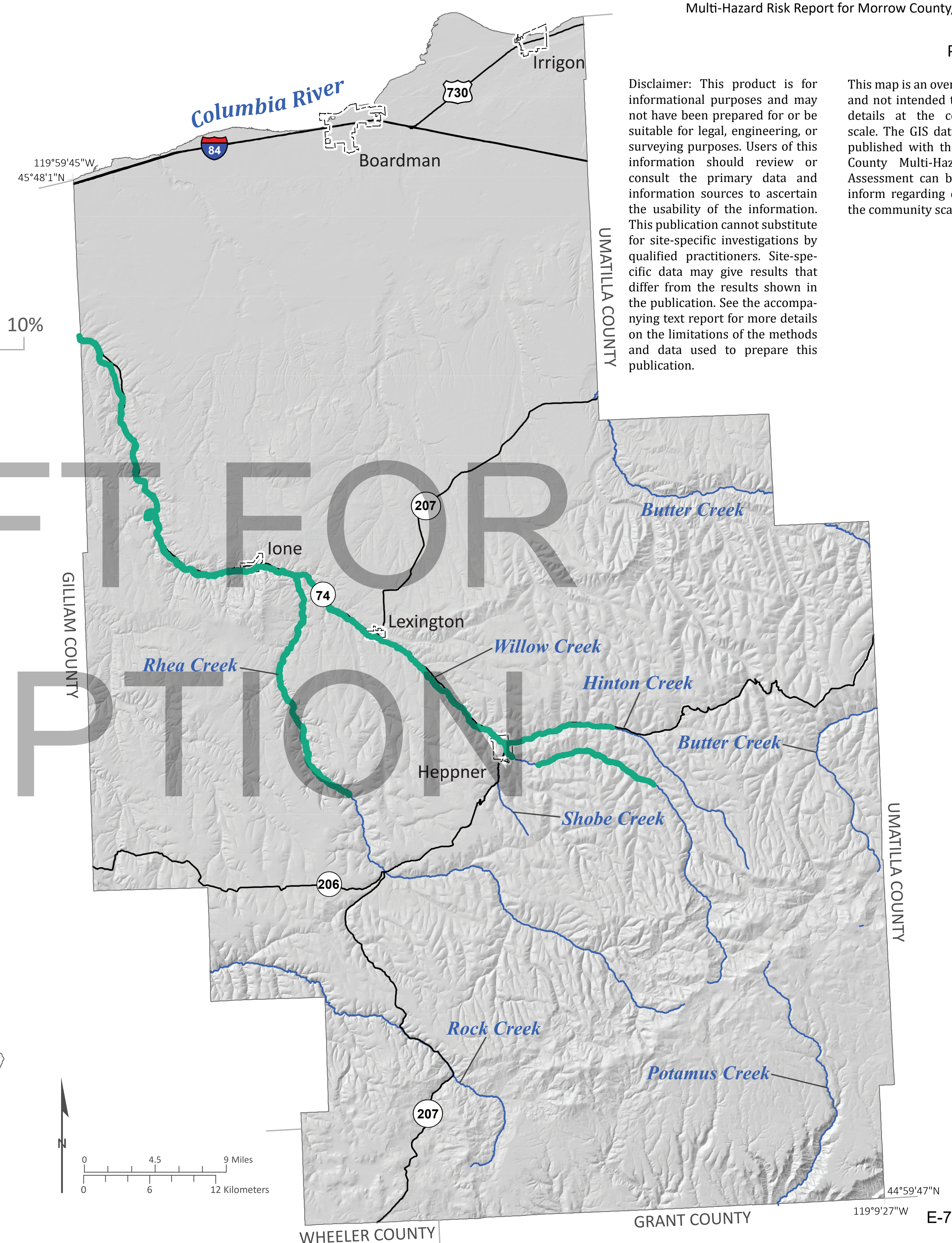
Channel Migration Hazard Map of Morrow County, Oregon



Channel migration is a process by which a stream's course changes over time due to bank erosion and stream deposition. The channel migration zone is defined by the 30-year Erosion Hazard Area (EHA). Shown are the 30-year in Morrow County. Buildings within these areas are at greater risk to channel migration hazard than other areas.

Channel Migration Hazard Zone

30-Year Erosion



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This map is an overview map and not intended to provide details at the community scale. The GIS data that are published with the Morrow County Multi-Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Study Location Map

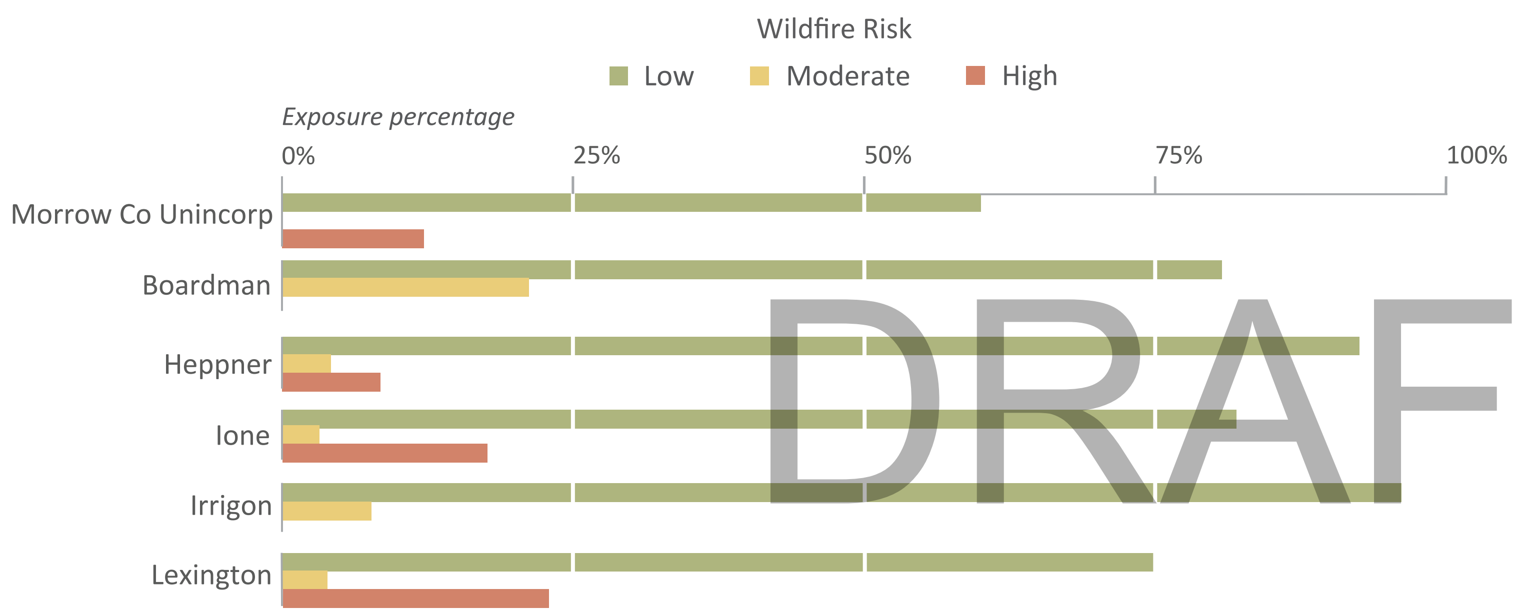
Data Sources:
Channel migration zone (30-year): DOGAMI (Appleby and others, 2021)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

Cartography by:Matt C. Williams, 2023

PLATE 10

Wildfire Risk Map of Morrow County, Oregon



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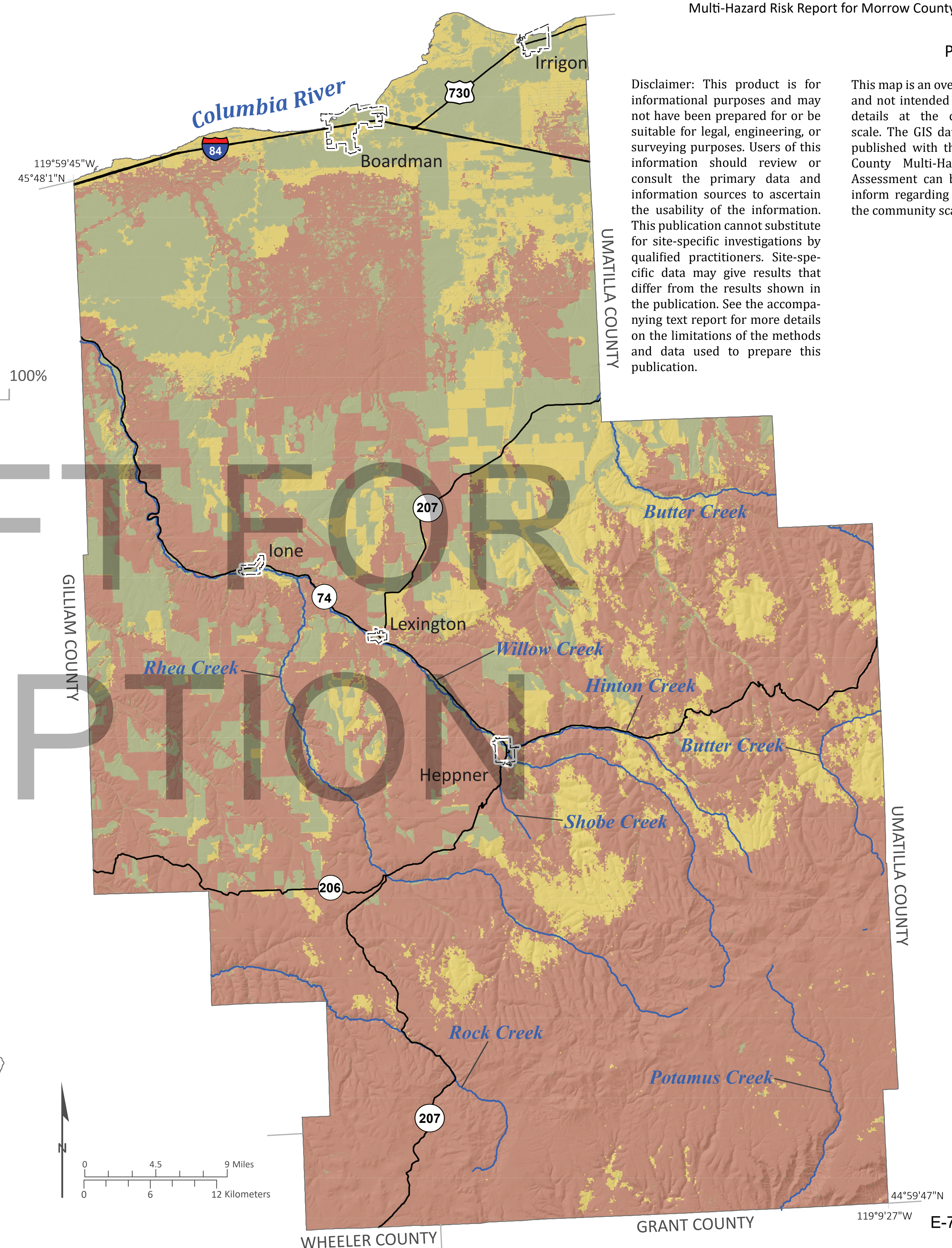

The Pacific Northwest Quantitative Wildfire Risk Assessment: Methods and Results (PNRA; Pyrologix LCC, 2018) is a comprehensive report that includes a database developed by the U.S. Forest Service for the states of Oregon and Washington. The PNRA produced the Burn Probability dataset that we used to calculate risk. The Burn Probability dataset was categorized into Low, Moderate, and High-hazard zones for the wildfire exposure analysis. Burn probability is derived from simulations using many elements, such as, weather, ignition frequency, ignition density, and fire modeling landscape.

Data Sources:
Wildfire risk data: Oregon Department of Forestry, Pyrologix, LCC. (2018)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 UTM Zone 10N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

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Study Location Map

APPENDIX F: FUTURE CLIMATE PROJECTIONS MORROW COUNTY

Future Climate Projections Morrow County, Oregon

June 2023

Oregon Climate Change Research Institute

OCCRI

Future Climate Projections: Morrow County, Oregon

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June 2023

Cover Photograph: View of the Columbia River from Irrigon Wildlife Area, Morrow County, Oregon

Table of Contents

Executive Summary

Climate change is expected to increase the occurrence of many climate-related natural hazards and to increase climate-related risks to assets, such as people, buildings, and infrastructure. Confidence that the risk of heat waves will increase is very high (Table 1) given strong evidence in the peer-reviewed literature, consistency among the projections of different global climate models, and robust scientific principles that explain why temperatures increase in response to ongoing emissions of greenhouse gases. In areas where the human population is growing, and especially where it is aging, both the absolute number and the proportion of people at risk of negative health outcomes from heat exposure is increasing. Confidence that the risk of many other natural hazards will increase as climate changes is high or medium (Table 1), reflecting moderate to strong evidence and consistency among models. The latter risks are influenced by multiple factors in addition to increasing temperatures. Confidence that the risk of windstorms will change is low given that projections suggest relatively few to no changes and evidence is limited.

Table 1. Projected direction and level of confidence in changes in the risks of climate-related natural hazards and associated risks to assets. Very high confidence means that the direction of change is consistent among nearly all global climate models and there is robust evidence in the peer-reviewed literature. High confidence means that the direction of change is consistent among more than half of models and there is moderate to robust evidence in the peer-reviewed literature. Medium confidence means that the direction of change is consistent among more than half of models and there is moderate evidence in the peer-reviewed literature. Low confidence means that the direction of change is small compared to the range of model responses or there is limited evidence in the peer-reviewed literature.

	Low Confidence	Medium Confidence	High Confidence	Very High Confidence
Risk Increasing		Drought Expansion of Non-native Invasive Species Reduced Air Quality Loss of Wetlands	Heavy Precipitation Flooding Wildfire	Heat Waves
Risk Unchanging	Windstorms			
Risk Decreasing				Cold Waves

In this report, we present climate projections for Morrow County that are relevant to specified natural hazards for the 2020s (2010–2039) and 2050s (2040–2069) relative to the 1971–2000 historical baseline. The projections are based on multiple global climate models for both a lower greenhouse gas emissions scenario (RCP 4.5) and a higher emissions scenario (RCP 8.5). Unless otherwise noted, all projections in this executive summary refer to the 2050s, relative to the historical baseline, under the higher emissions scenario. Projections for both time periods and emissions scenarios, and potential consequences for assets given current demographic data and projected population trends, are included in the main report.

Heat Waves

The number, duration, and intensity of extreme heat events will increase as temperatures continue to warm. In Morrow County, the number of extremely hot days (those on which the temperature is 90°F or higher) and the temperature on the hottest day of the year are projected to increase by the 2020s and 2050s under both the lower and higher emissions scenarios. The number of days per year with temperatures 90°F or higher is projected to increase by an average of 31 (range 12–42) by the 2050s under the higher emissions scenario. The temperature on the hottest day of the year is projected to increase by an average of about 8°F (range 3–11°F) by the 2050s. Projected demographic changes, such as an increase in the proportion of older adults, will increase the number of people in some of the populations that are most vulnerable to extreme heat.

Cold Waves

Cold extremes will become less frequent and intense as the climate warms. The number of cold days (maximum temperature 32°F or lower) per year in Morrow County is projected to decrease by an average of 9 (range 4–13). The temperature on the coldest night of the year is projected to increase by an average of 9°F (range 0–16°F). The number of county residents vulnerable to extreme cold is likely to grow, although this increase may be offset somewhat by the decrease in incidence of cold extremes.

Heavy Precipitation

The intensity of extreme precipitation is expected to increase as the atmosphere warms and holds more water vapor. In Morrow County, the number of days per year with at least 0.75 inches of precipitation is not projected to change substantially. Nevertheless, the amount of precipitation on the wettest day and wettest consecutive five days per year is projected to increase by an average of 15% (range 2–38%) and 10% (range -6–30%), respectively. The number of days per year that exceed a threshold for landslide risk that is based on prior 18-day precipitation accumulation is not projected to change substantially. However, landslide risk depends on multiple factors, and this metric does not reflect all aspects of the hazard.

River Flooding

Winter flood risk at intermediate to low elevations in Morrow County, where temperatures are near freezing during winter and precipitation is a mix of rain and snow, is projected to increase as winter temperatures increase. The temperature increase will lead to an increase in the percentage of precipitation falling as rain rather than snow.

Drought

Drought, as represented by low spring snowpack and low summer precipitation, is projected to become more frequent in Morrow County, although summer soil moisture and runoff in the county are projected to increase. The incidence of related negative physical and mental health outcomes, especially among low income, tribal, rural, and agricultural communities, is likely to increase.

Wildfire

Wildfire frequency, intensity, and area burned are projected to continue increasing in the Northwest. Wildfire risk, expressed as the average number of days per year on which fire danger is very high, is projected to increase in Morrow County by 15 days (range -5–38). The average number of days per year on which vapor pressure deficit is extreme is projected to increase by 30 (range 13–43).

Reduced Air Quality

Climate change is expected to reduce outdoor air quality. The risks to human health from wildfire smoke in Morrow County are projected to increase. From 2004–2009 to 2046–2051, under a moderate emissions scenario, the number of days per year with poor air quality due to elevated concentrations of wildfire-derived fine particulate matter is projected to increase by 150%. The concentration of fine particulate matter on those days is projected to increase by 108%.

Loss of Wetlands

Projected effects of climate change on wetlands in the Northwest include reductions in water levels and hydroperiod duration. If withdrawals of ground water do not increase, then wetlands that are fed by ground water rather than surface water may be more resilient to climate change.

Windstorms

Wind patterns affect provision of electricity, transportation safety, and the spread of wildfires and pollutants. Mean wind speeds in Oregon are projected to decrease slightly, but extreme winter wind speeds may increase, especially in western Oregon. The frequency of strong easterly winds during summer and fall, however, is projected to decrease slightly.

Expansion of Non-native Invasive Species

In general, non-native invasive plants in Morrow County are likely to become more prevalent in response to projected increases in temperature and the frequency, duration, and severity of drought. However, many of these responses are uncertain, are likely to vary locally, and may change over time.

Introduction

Industrialization has increased the amount of greenhouse gases emitted worldwide, which is causing Earth's atmosphere, oceans, and lands to warm (IPCC, 2021). Climate change and its effects already are apparent in Oregon (Dalton *et al.*, 2017; Mote *et al.*, 2019; Dalton and Fleishman, 2021; Fleishman, 2023). Climate change is expected to increase the likelihood of natural hazards such as heat waves, heavy precipitation, flooding of rivers and streams, drought, wildfires, and poor air quality, and to decrease the likelihood of cold waves.

We analyzed the influence of climate change on natural hazards in Morrow County, Oregon, and explored potential effects of those natural hazards on the county's assets. Products of our analysis include county-specific data, graphics, and narrative summaries of climate projections related to ten climate-related natural hazards (Table 2). This information will be integrated into the county's Natural Hazards Mitigation Plan and can be used in other county plans, policies, and programs.

Table 2. Selected natural hazards and related climate metrics.

Heat Waves Hottest Day, Warmest Night Hot Days, Warm Nights	**Cold Waves** Coldest Day, Coldest Night Cold Days, Cold Nights
Heavy Precipitation Wettest Day, Wettest Five Days Wet Days, Landslide Risk Days	**River Flooding** Annual Maximum Daily Flows Atmospheric Rivers Rain-on-Snow Events
Drought Summer Flow, Spring Snow Summer Soil Moisture Summer Precipitation	**Wildfire** Fire Danger Days Extremely Dry Air Days
Reduced Air Quality Days with Unhealthy Smoke Levels	**Loss of Wetlands**
Windstorms	**Expansion of Non-native Invasive Species**

In 2020, an estimated 12,329 people lived in Morrow County (PRC, 2023a). The county's population is projected to increase by 11% by 2040, and by another 15% (or 28% relative to 2020) by 2069 (PRC, 2023b). Social factors affect the probability that natural hazards will negatively affect individuals and communities. For example, inequities in housing, education, income, and transportation access affect how different populations respond to heat, drought, and other extremes (Ho *et al.*, 2021). The U.S. Centers for Disease Control and Prevention developed and maintains a social vulnerability index for use in planning and response to hazardous events (Flanagan *et al.*, 2011; ATSDR, 2022). The index encompasses 16 variables, which are aggregated into four themes: socioeconomic status, household characteristics, racial and ethnic minority status, and housing type and transportation. From 2016–2020, the percentages in Morrow County of persons living below the 150% poverty level, aged 25 and older with no high school diploma, aged 17 and under, with limited English, and with racial and ethnic minority status, and the percentages of mobile homes and crowded households (Table 3), were among the highest 10% relative to other counties in Oregon; higher values indicate higher vulnerability (ATSDR, 2022).

Table 3. Measures of social vulnerability in Morrow County, Oregon, as estimated on the basis of the 2016–2020 American Community Survey (ATSDR, 2022). Housing cost burden is defined as an occupied housing unit with a household annual income below $75,000 and monthly housing costs that equal or exceed 30 percent of annual income. Single-parent households include one or more children under the age of 18. Racial and ethnic minority status includes individuals who identify as Hispanic, Latino (of any race), Black, African American, American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander, two or more races, and other non-White races. Multi-unit housing refers to housing structures with ten or more units. Crowded housing is defined as an occupied housing unit with more people than rooms. Number of households without a broadband internet subscription is not included in calculation of the overall social vulnerability index. CI, confidence interval. Percentage, percentage of population or number. Percentages for some variables do not correspond exactly to raw values.

Social vulnerability metric	Population or number	CI	Percentage	CI
Total population	11,425			
Number of housing units	4699	4670–4728		
Number of households	4093	3970–4216		
Socioeconomic status				
Below 150% poverty	3696	3123–4269	32.5	27.5–37.5
Unemployed	181	116–246	3.6	2.3–4.9
Number of cost-burdened housing units	853	685–1021	20.8	16.7–24.9
No high school diploma	1579	1358–1800	21.9	18.9–24.9
No health insurance	945	677–1213	8.3	6.0–10.6
Household characteristics				
Aged 65 or older	1715	1625–1805	15.0	14.2–15.8
Aged 17 or younger	3159	3111–3207	27.6	27.2–28.0
Civilian with a disability	1976	1696–2256	17.3	14.8–19.8
Single-parent household	190	114–266	4.6	2.7–6.5
Speaks English less than well	929	751–1107	8.8	7.1–10.5
Racial and ethnic minority status				
Minority	4727	4631–4823	41.4	40.6–42.2
Housing type and transportation				
Number of multiple-unit homes	126	54–198	2.7	1.2–4.2
Number of mobile homes	1591	1399–1783	33.9	29.8–38.0
Number of crowded housing units	299	205–393	7.3	5.0–9.6
Number of households with no vehicle	83	41–125	2.0	0.9–3.1
People in group quarters	52	18–86	0.5	0.2–0.8

People in households without a broadband internet subscription	2102	1656–2548	18.5	18.4–18.6

Future Climate Projections Background

Introduction

The county-specific future climate projections presented here are derived from 10–20 global climate models and two scenarios of future global emissions of greenhouse gases. The spatial resolution of projections from global climate models has been increased through downscaling to better represent local conditions. County-level summaries of changes in climate metrics (Table 2) are projected to the beginning and middle of the twenty-first century relative to a historical baseline. More information about the data sources is in the appendix.

Global Climate Models

Global climate models are computer models of Earth's atmosphere, ocean, and land and their interactions over time and space. Climate models generally refer to both general circulation models (GCMs) and Earth system models (ESMs). GCMs simulate the interactions between the atmosphere and the land and ocean, whereas ESMs also simulate more-detailed chemical and biological processes that interact with the physical climate. Global climate models are grounded in the fundamental laws of physics and are the most sophisticated tools for understanding Earth's climate. However, they still necessarily simplify the climate system. Because there are several ways to simplify climate in a global model, different climate models yield somewhat different projections. Accordingly, the scientific community usually examines projections from multiple global climate models.

Over time, the spatial resolution of GCMs has increased and more physical, chemical, and biological processes, such as wildfire emissions and dynamic vegetation change, have been included (Figure 1). The climate models from the sixth phase of the Coupled Model Intercomparison Project (CMIP6), the climate modeling foundation of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), generally have higher resolution, better represent Earth system processes, and improve simulation of recent mean values of climate change indicators relative to climate models from fifth phase of the Coupled Model Intercomparison Project (CMIP5) (IPCC, 2021). However, some CMIP6 models overestimate observed temperatures in the twentieth century, likely because they yielded a greater increase in temperature in response to modeled changes in cloud patterns (Dalton *et al.*, 2021; IPCC, 2021). Consequently, the IPCC ranked climate models on the basis of their ability to reproduce twentieth-century temperatures, and used only the most accurate models to project warming given different scenarios of greenhouse gas emissions (Hausfather *et al.*, 2022).

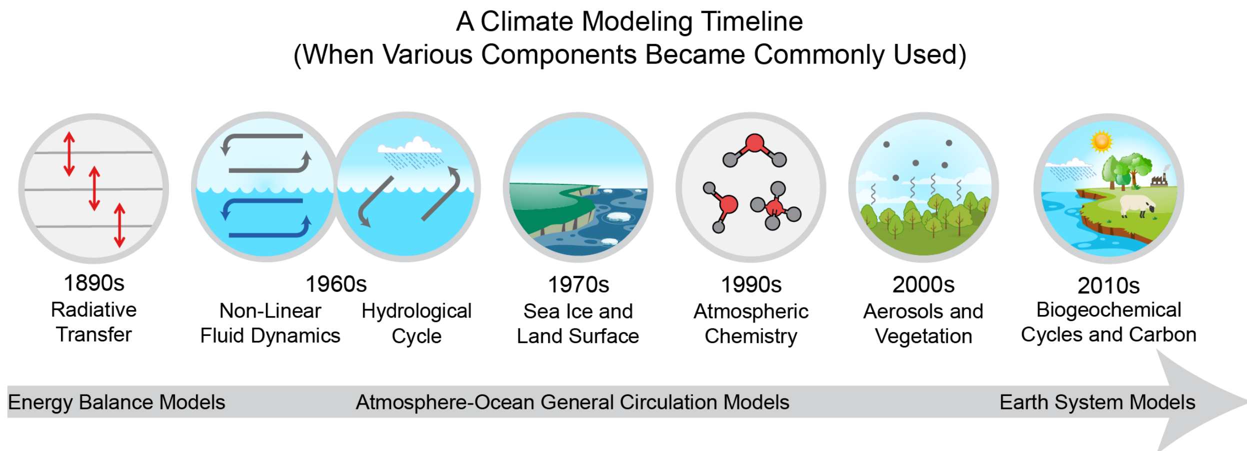

Figure 1. As scientific understanding of climate has evolved over the last 120 years, increasing amounts of physics, chemistry, and biology have been incorporated into global climate calculations. Over the second half of the twentieth century, as computing resources became available, such knowledge also was incorporated into global climate models. (Source: science2017.globalchange.gov)

Differences in simulations of Oregon's projected average temperature between CMIP5 and CMIP6 were estimated in the fifth Oregon Climate Assessment (Dalton *et al.*, 2021). The group of CMIP6 models generally projected greater warming over Oregon than the group of CMIP5 models. This outcome was due to the inclusion of several of the CMIP6 models that produce greater warming than most models given the same concentration of greenhouse gases.

One measure of climate sensitivity, the equilibrium climate sensitivity (ECS), is an estimate of the increase in global temperature after it stabilizes over hundreds to thousands of years following a doubling of carbon dioxide concentrations from pre-industrial levels. On the basis of observations, paleoclimate data, and other evidence, the ECS of Earth was estimated to be within 4.5–7.2°F (66% likelihood) or 3.6–9.0°F (90% likelihood) (Forster *et al.*, 2021). The scientific community typically evaluates climate model outputs on the basis of how close they are to this range of ECS. ECS in all CMIP5 models was less than 9°F, whereas about one-fifth of the CMIP6 models had an ECS above 9°F (Hausfather *et al.*, 2022). Although there is a 5% likelihood that Earth's ECS is above 9°F, the CMIP6 climate models with ECS >9°F overestimate the observed warming and therefore are considered less valid and reliable than those with ECS ≤9°F. Consequently, use of the average and range of the CMIP6 model ensemble likely will yield inaccurate projections of future climate (Hausfather *et al.*, 2022).

It is best practice to analyze and present an average and range of projections from at least ten global climate models with realistic climate sensitivity that simulate the historical climate well (Mote *et al.*, 2011; Hausfather *et al.*, 2022; Dalton and Bachelet, 2023). In this report, we rely on projections from 10–20 CMIP5 models (see *Appendix*), all of which have realistic climate sensitivities and are still considered valid and useful in evaluating future climate (Dalton and Bachelet, 2023). Additionally, locally relevant, high-resolution projections from these models are readily available. It will be advantageous to consider

CMIP6 climate projections after the scientific community has further evaluated the projections and associated impacts and high-resolution projections are vetted for geographic regions with different characteristic climates (Dalton and Bachelet, 2023).

Greenhouse Gas Emissions

Gases that lead to climate change. The major gases in the atmosphere that contribute to climate change are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (EPA, 2023). These gases absorb energy radiated by Earth's sun-heated surface, then redirect a portion of that energy back to the surface, causing further warming. Water vapor traps heat in the same manner. CO_2, CH_4, N_2O, and water vapor exist naturally in the atmosphere and are essential for maintaining Earth's temperature within a range that is habitable by living organisms. This is called the greenhouse effect. Human activities are increasing the quantity of CO_2, CH_4, N_2O, and fluorinated gases in the atmosphere, enhancing the greenhouse effect by trapping additional energy (heat). As concentrations of CO_2, CH_4, N_2O, and fluorinated gases increase, the oceans warm and more water evaporates into the atmosphere, exacerbating increases in temperature that are caused by emissions of the former gases.

Carbon dioxide (CO_2) in the atmosphere is produced by natural processes, such as plant respiration and volcanic eruptions, and by human activities. Increases in atmospheric concentrations of CO_2 account for about 65% of climate change since 1750 (Table 4) (Forster *et al.*, 2021). Nearly all of those increases result from human activities, especially consumption of coal, gasoline, and other fossil fuels (Lindsey, 2022). CO_2 also is released to the atmosphere during production of cement (Andrew, 2019) and when forests are harvested for timber or burned and converted to agricultural, industrial, or residential uses.

Ice cores document that for at least 400,000 years, the atmospheric concentration of CO_2 ranged from about 180–280 parts per million (ppm) (Bauska, 2022). During the late 1700s, as the Industrial Revolution began, CO_2 concentrations were around 280 ppm. By 2000, the concentration approached 370 ppm. As of 2022, the concentration was 417 ppm (Table 4). Therefore, the rate at which human activities are adding CO_2 to the atmosphere is increasing. Current concentrations of CO_2 are similar to those during the mid-Pliocene, more than 4 million years ago. At that time, the average global temperature was 7˚F higher than during the mid 1700s and sea levels were about 75 feet higher than today. Because CO_2 in the atmosphere persists for 300–1000 years (Buis, 2019), the process and effects of climate change cannot easily be reversed, even if human behavior and emissions change rapidly.

Table 4. Current values, trends, and other metrics of atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) and percentage of global emissions and contributions to climate change. Ppm, parts per million. Ppb, parts per billion. Total anthropogenic greenhouse gas emissions in 2019 were 59 gigatonnes of CO_2-equivalent.

Metric	CO_2	CH_4	N_2O
Atmospheric concentration, 2022 (NOAA, 2023)	417 ppm	1912 ppb	336 ppb
Percentage increase, 1750–2019 (Forster *et al.*, 2021; Gulev *et al.*, 2021)	47	156	23
Global warming potential over 100 years, relative to CO2 (Smith *et al.*, 2021)	1	28	273
Atmospheric lifetime (years) (Smith *et al.*, 2021)	300–1000 (Buis, 2019)	12	109
Percentage of net global sources of each gas that was produced by human activities during the years noted (Canadell *et al.*, 2021)	100 (2010–2019)	51–65 (2008–2017)	43 (2007–2016)
Percentage of total anthropogenic greenhouse gas emissions, 2019 (Dhakal *et al.*, 2022)	75 (64 fossil fuel combustion and industrial processes; 11 land use, land use change, and forestry)	19	5
Contribution to climate change (percentage of total effective radiative forcing, 1750–2019) (Forster *et al.*, 2021)	65	16	6

Net emissions of methane (CH_4), of which 51–65% are produced by human activity (Canadell *et al.*, 2021), account for about 16% of climate change since the Industrial Revolution (Table 4) (Forster *et al.*, 2021). The primary natural cause of CH_4 emissions is decomposition of plants in wetlands (EPA, 2023). Among human sources of CH_4, agriculture is the greatest contributor, followed closely by use of fossil fuels (IEA, 2023). Rice farming and digestion and excretion by livestock generate considerable volumes of CH_4. Production and transportation of oil, gas, coal, and bioenergy produce almost as much

CH_4 as agriculture. Decomposition of materials in landfills, biomass burning, and other sources also emit CH_4.

The atmospheric concentration of CH_4 has increased by more than 150% since the start of the Industrial Revolution (Table 4). The concentration of CH_4 in the atmosphere is much lower than that of CO_2—currently more than 1900 parts per billion (1.9 ppm) (Table 4) (Gulev *et al.*, 2021). However, each molecule of CH_4 traps about 28 times more heat than each molecule of CO_2 over 100 years. CH_4 in the atmosphere persists for about 12 years (Smith *et al.*, 2021).

Forty-three percent of net global sources of nitrous oxide (N_2O) is produced by human activity (Canadell *et al.*, 2021), primarily production and use of nitrate in conventional and organic agricultural fertilizers (Tian *et al.*, 2020). N_2O also is produced by burning of fossil fuels and vegetation. Atmospheric concentrations of N_2O increased by 23% from 1750–2019 (Gulev *et al.*, 2021), and accounted for about 6% of climate change during that period (Table 4) (Forster *et al.*, 2021). A molecule of N_2O persists in the atmosphere for about 109 years and, over 100 years, traps about 273 times more heat than a molecule of CO_2 (Table 4) (Smith *et al.*, 2021).

Nearly all fluorinated gases are produced by humans. The major classes of fluorinated gases are hydrofluorocarbons, perfluorocarbons, sulfur hexafluorine (SF_6), and nitrogen trifluorine (NF_3). Among fluorinated gases, hydrofluorocarbons are the greatest contributors to climate change. Hydrofluorocarbons are used as refrigerants, solvents, fire retardants, and to propel aerosols and foam (EPA, 2023). A molecule of most hydrofluorocarbons can trap hundreds to thousands of times more heat than a molecule of CO_2 over 100 years, and some hydrofluorocarbons persist in the atmosphere for up to 228 years (Smith *et al.*, 2021). Substitutions that will not contribute to climate change are under development.

Perfluorocarbons are generated during aluminum production and are necessary for manufacture of semiconductors (EPA, 2023). They can persist in the atmosphere for thousands to tens of thousands of years, and some trap as much as 12,400 times more heat per molecule than CO_2 (Smith *et al.*, 2021). SF_6 and NF_3 also are used to manufacture semiconductors. In addition, SF_6 is used in magnesium production, to trace gas leaks, and to insulate electricity transmission systems (EPA, 2023). SF_6 persists for about 1000 years and traps 24,300 times more heat per molecule than CO_2 over 100 years. NF_3 persists for about 569 years and traps about 17,400 times more heat per molecule than CO_2 over 100 years (Smith *et al.*, 2021).

Climate models and emissions scenarios. When scientists use global climate models to project climate, they make assumptions about the future volume of global emissions of greenhouse gases. The models then simulate the effects of those emissions on the atmosphere, oceans, and land over the coming centuries. Because the precise amount of greenhouse gases that will be emitted in the future is unknown, scientists use multiple scenarios of greenhouse gas emissions that correspond to plausible societal trajectories.

The CMIP5 models used scenarios called Representative Concentration Pathways (RCPs), which describe concentrations of greenhouse gases, aerosols, and other factors through the year 2100. These concentrations affect the level of outgoing long-wave radiation from

Earth's surface, thus radiative forcing. Radiative forcing is the total amount of energy retained in the atmosphere after absorption of incoming solar radiation, which is affected by the reflectivity of Earth's surface, and emission of outgoing long-wave radiation. The higher the volume of global emissions, the greater the radiative forcing and projected increase in global temperature (Figure 2).

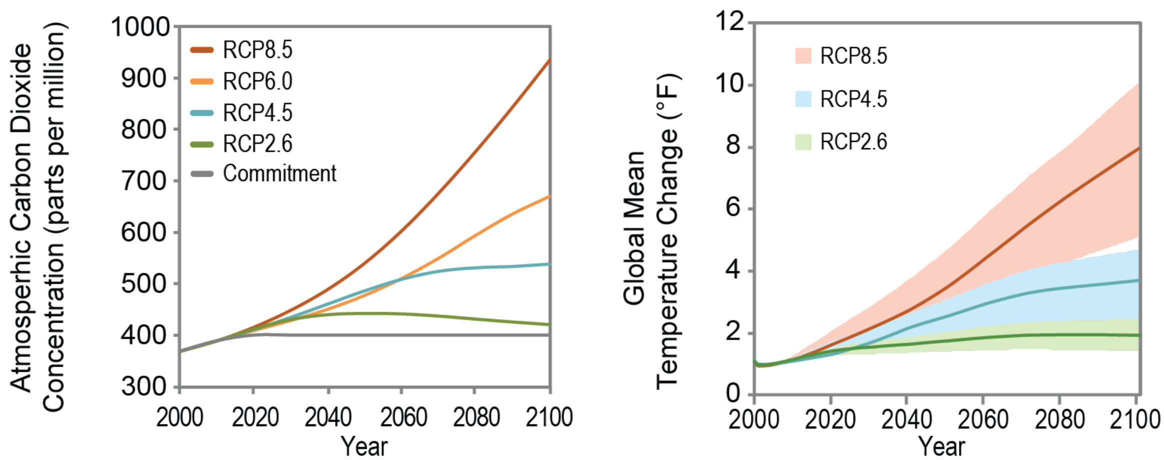

Figure 2. Future scenarios of atmospheric carbon dioxide concentrations (left) and projections of global temperature change (right) resulting from several different emissions scenarios, called Representative Concentration Pathways (RCPs), that were considered in the fourth National Climate Assessment (Hayhoe *et al.*, 2017). In the left plot, the gray line represents a scenario in which atmospheric carbon dioxide concentrations remain constant upon reaching 400 parts per million; this concentration was exceeded in 2013 and continues to increase. In the right plot, the solid line and shading represent the mean and range of simulations from global climate models included in CMIP5. (Source: science2017.globalchange.gov/chapter/4/)

CMIP6 models used scenarios called Shared Socio-economic Pathways (SSPs). The SSPs reflect assumptions about future population, technological, and economic growth that were paired with the different levels of emissions associated with the CMIP5 RCPs (IPCC, 2021). Projections in this report are based on both a lower emissions pathway (RCP 4.5) and a higher emissions pathway (RCP 8.5) that are often described as representing moderate reductions and business-as-usual increases in greenhouse gas emissions, respectively (Hayhoe *et al.*, 2017). These two RCPs are the most common scenarios in the peer-reviewed literature, and high-resolution data representing the effects of these scenarios on local climate are available.

Downscaling

Global climate models simulate the climate across large, contiguous grid cells. One to three grid cells cover the state of Oregon. To make these coarse-resolution simulations more locally relevant, outputs are combined statistically with historical observations, yielding higher-resolution projections. This process is called statistical downscaling. The future climate projections in this report were statistically downscaled to a resolution of about 2.5 by 2.5 miles (Abatzoglou and Brown, 2012). More information about downscaling is in the appendix.

Future Time Periods

When analyzing global climate model projections, it is best practice to compare the average of simulations across at least 30 future years to the average of simulations across at least 30 recent past years. The average over those 30 past years is called the *historical baseline*. We present projections averaged over two future 30-year periods, 2010–2039 (2020s) and 2040–2069 (2050s), relative to the historical baseline from 1971–2000 (Table 5). The 2020s projections reflect changes that have occurred or will occur in the coming decade. Projections for the 2050s reflect conditions a few decades into the future that potentially can be addressed by current planning efforts.

Table 5. Historical and future time periods over which projections were averaged.

Historical Baseline	2020s	2050s
1971–2000	2010–2039	2040–2069

Because each of the 20 CMIP5 models from which we obtained projections is based on slightly different assumptions, each yields a slightly different value for the historical baseline. Therefore, we do not present the average and range of projected absolute values of variables. Instead, we present the average and range of projected changes in values of climate variables relative to each model's historical baseline. We also present the average of the 20 historical baselines to aid in understanding the relative magnitude of projected changes. The average projected change can be added to the average historical baseline to infer the average future value of a given variable. The average projected change and historical baseline are included in the tables.

How to Use the Information in this Report

Because the observational record may not include plausible future values of some climate variables or the plausible future frequency of some extreme events, one cannot reliably anticipate future climate by considering only past climate. Future projections from GCMs enable exploration of a range of plausible outcomes given the climate system's complex response to increasing atmospheric concentrations of greenhouse gases. Projections from GCMs should not be interpreted as predictions of the weather on a given date, but rather as projections of climate, which is the long-term statistical aggregate of weather (Walsh *et al.*, 2014).

The projected direction and magnitude of change in values of climate variables in this report are best interpreted relative to the historical climate under which a particular system or asset evolved or was designed to operate. For this reason, considering the projected changes between historical and future periods allows one to envision how natural and human systems may respond to future climate conditions that are different from past conditions. In some cases, the projected change may be small enough for the existing system to accommodate. In other cases, the projected change may be large enough to require adjustments, or adaptations, to the existing system. However, engineering or design projects would require an analysis that is more detailed than we present in this report.

The information in this report can be used to

- Explore a range of plausible future outcomes that reflect the climate system's complex response to increasing concentrations of greenhouse gases
- Envision how current systems may respond to climate conditions different from those under which the systems evolved or were designed to operate
- Inform evaluation of potential mitigation actions within hazard mitigation plans
- Inform assessment of the likelihood of occurrence of a particular climate-related hazard

Average Temperature

Oregon's annual average temperature warmed at a rate of 2.2°F per century from 1895 through 2021 (Fleishman, 2023). Average temperature is expected to continue increasing during the twenty-first century; the rate of warming depends on the level of emissions (IPCC, 2021). By the 2050s (2040–2069), relative to the 1970–1999 historical baseline, Oregon's average temperature is projected to increase by 3.6°F (range 1.8–5.4°F) under a lower emissions scenario (RCP 4.5) and by 5.0°F (range 2.9–6.9°F) under a higher emissions scenario (RCP 8.5) (Dalton *et al.*, 2017, 2021; Fleishman, 2023). Summers are projected to warm more than other seasons (Dalton *et al.*, 2017, 2021; Fleishman, 2023).

Annual average temperature in Morrow County increased at a rate of 2.3°F per century from 1895 through 2022 (NCEI, 2023). The simulated average temperature over the historical baseline period (49.3°F) is consistent with observations over the same time period (49.2°F). During the twenty-first century, average temperature in the county is projected to warm at a rate similar to that of Oregon as a whole (Figure 3). Projected increases in average temperature in the county, relative to the historical baseline in each global climate model (GCM), range from 0.8–3.7°F by the 2020s and 1.7–7.4°F by the 2050s, depending on emissions scenario and GCM (Table 6).

Over the 13 years for which observations overlap the 2020s projections (2010–2022), the average temperature was projected to increase by 1.7°F, relative to the historical baseline, under the lower emissions scenario and by 1.9°F under the higher emissions scenario (Table 6). The observed change over these 13 years was 1.3°F, and observed total CO_2 emissions fell between the two emissions scenarios (Burgess *et al.*, 2020).

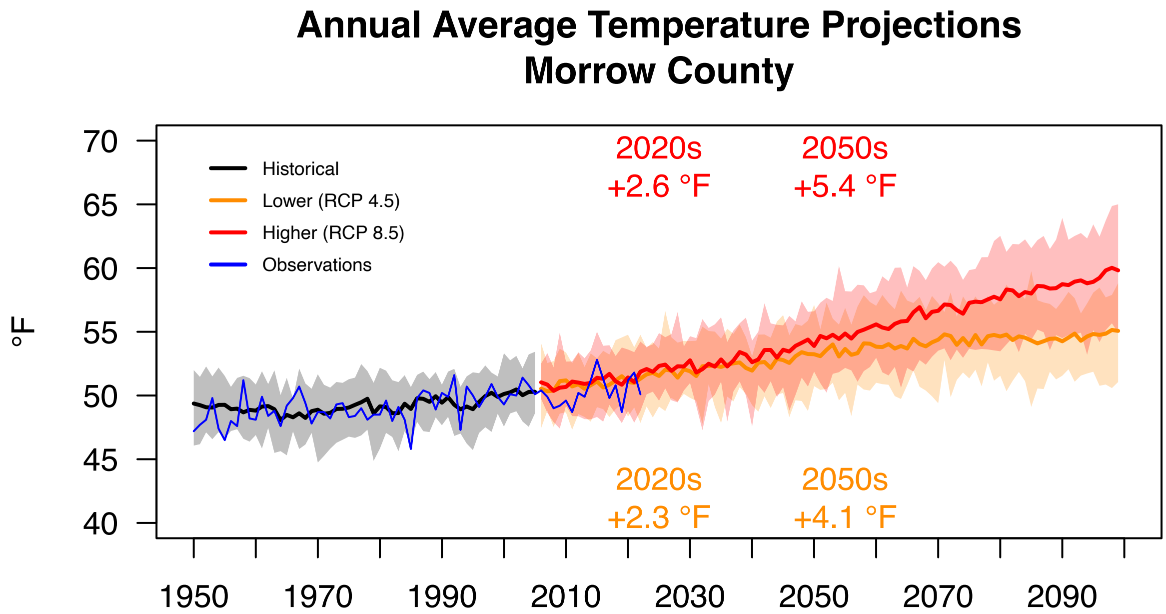

Figure 3. Projected annual average temperature in Morrow County as simulated by 20 downscaled global climate models under a lower (RCP 4.5) and a higher (RCP 8.5) greenhouse gas emissions scenario. Solid lines and shading represent the 20-model mean and range, respectively. The figure shows the multiple-model mean differences between the historical baseline period (1971–2000) and the 2020s (2010–2039 average) and 2050s (2040–2069 average). Observations (blue line) are from the National Oceanic and Atmospheric Administration's National Centers for Environmental Information Climate at a Glance, www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/time-series.

Table 6. Projected changes in annual temperature in Morrow County between the 1971–2000 baseline period and future periods. Values are averages across 20 global climate models (range in parentheses). The 20-model average and range of temperature averaged over the historical baseline period (1971–2000) was 49.3°F (48.6–49.7).

Emissions Scenario	**Past**		**Future**	
	Baseline (1971–2000 average)	Recent Past (2010–2022 average)	2020s (2010–2039 average)	2050s (2040–2069 average)
Observations	49.2°F	+1.3°F		
Lower (RCP 4.5)		+1.7°F (0.1–3.0)	+2.3°F (0.8–3.7)	+4.1°F (1.7–5.8)
Higher (RCP 8.5)		+1.9°F (0.7–2.8)	+2.6°F (1.4–3.7)	+5.4°F (2.6–7.4)

Heat Waves

Heat is the leading cause of weather-related deaths in the United States (Khatana *et al.*, 2022). Extreme heat and home air conditioning are less common in Oregon than in many other parts of the country, leaving residents more vulnerable when extreme heat occurs. For example, record-breaking heat in June 2021 caused more than 100 deaths in Oregon, mostly inside homes without air conditioning (O'Neill *et al.*, 2023). Dangerous heat is almost always associated with a weather event called a heat wave: multiple consecutive days on which maximum or minimum temperatures are above a threshold or a probability (O'Neill *et al.*, 2023). Heat waves occur periodically as a result of natural variability in temperature, but human-caused climate change is increasing their frequency and intensity (Vose *et al.*, 2017; IPCC, 2021). In the absence of human-caused climate change, the intensity of the June 2021 heat wave would have been virtually impossible (Philip *et al.*, 2022). Additionally, the period over which heat waves occur is lengthening. For example, in Portland, Oregon, the duration of the heat wave season increased by 7 days per decade from 1961–2010 (Habeeb *et al.*, 2015). This trend is exemplified by the heat wave in May 2023, which broke several high-temperature records for the same date and month across the northwestern United States and Canada. High-pressure ridges caused both the June 2021 and May 2023 heat waves (earthobservatory.nasa.gov/images/151349/summer-temperatures-arrive-early).

Extreme heat can refer to extremely warm daytime highs or overnight lows (days on which maximum or minimum temperatures are above a threshold or a probability relative to past decades), seasons in which temperatures are well above average, and heat waves. In the Pacific Northwest, a day on which the maximum temperature is at least 90°F often is considered to be an extremely warm day. The number of such days increased significantly across Oregon since 1951 (O'Neill *et al.*, 2023). The heat index is a measure of perceived heat that reflects both temperature and relative humidity and is more relevant to human health than temperature alone. As relative humidity increases, a given temperature can feel hotter. The National Weather Service issues heat warnings when the heat index exceeds given local thresholds. Across Oregon, heat waves rarely are humid (Rastogi *et al.*, 2020), and the heat index generally is similar to the actual temperature. Nevertheless, the average number of hours per year in Oregon with a heat index of at least 90°F increased significantly since 1981 (O'Neill *et al.*, 2023).

The number of extremely warm nights is also increasing. In western Oregon, nights on which the minimum temperature was at least 65°F were rare before 1990, but the number of such nights has increased significantly in some areas during the past two decades (O'Neill *et al.*, 2023). In addition, evidence of increases in the number of summer extreme heat events that are defined by nighttime minimum temperatures is stronger than evidence of increases in the number of those defined by maximum temperatures (Dalton and Loikith, 2021).

The number, duration, and intensity of extreme heat events in Oregon is projected to increase due to continued increases in mean temperatures (Dalton and Loikith, 2021; O'Neill *et al.*, 2023). Climate models generally agree that changes in temperature extremes largely are linearly correlated with changes in the mean temperature. However, some mechanisms, which are the subject of active research, might cause a more substantial increase in extreme temperature than mean temperature (O'Neill *et al.*, 2023). For example, Arctic amplification (increasing similarity of temperatures from the equator to the North Pole, caused in part by the melting of Arctic sea ice) may alter the shape and position of the midlatitude jet stream, thereby contributing to an increase in the number of summer heat waves in Oregon (O'Neill *et al.*, 2023; Rupp and Schmittner, 2023). In addition, dry soils can amplify extreme heat events through their relative lack of evaporative cooling (O'Neill *et al.*, 2023).

Here, we present projected changes in three metrics of extreme daytime heat (maximum temperature) and nighttime heat (minimum temperature) (Table 7).

Table 7. Metrics and definitions of heat extremes.

Metric	Definition
Hot Days	Number of days per year on which maximum temperature is 90°F or higher
Warm Nights	Number of days per year on which minimum temperature is 65°F or higher
Hottest Day	Highest value of maximum temperature per year
Warmest Night	Highest value of minimum temperature per year
Daytime Heat Waves	Number of events per year in which the maximum temperature on at least three consecutive days is 90°F or higher
Nighttime Heat Waves	Number of events per year in which the minimum temperature on at least three consecutive days is 65°F or higher

In Morrow County, the number of hot days and warm nights, and the temperature on the hottest day and warmest night, are projected to increase by the 2020s (2010–2039) and 2050s (2040–2069) under both the lower (RCP 4.5) and higher (RCP 8.5) emissions scenarios (Table 8, Figure 4, Figure 5). For example, by the 2050s under the higher emissions scenario, the number of hot days, relative to each GCM's 1971–2000 historical baseline, is projected to increase by 12–42. The average number of hot days per year is projected to be 31 more than the average historical baseline of 21 days. The average number of days per year with a heat index of 90°F or higher is projected to be 26 more than the average historical baseline of 12 days (Dalton and Loikith, 2021). The average number of warm nights per year is projected to be 15 more than the average historical baseline of 4.

Under the higher emissions scenario, the temperature on the hottest day of the year is projected to increase by 2.9–11.3°F by the 2050s relative to the GCMs' historical baselines. The average projected increase in temperature on the hottest day is 8.0°F above the average historical baseline of 97.7°F. The average projected increase in temperature on the warmest night is 6.5°F above the average historical baseline of 66.1°F.

Under the higher emissions scenario, the numbers of daytime and nighttime heat waves are projected to increase by 1.4–3.9 and 0.3–3.2, respectively, by the 2050s relative to the GCMs' historical baselines. The average number of daytime and nighttime heat waves is projected to increase by 2.3 and 1.8, respectively, above the average historical baselines of 2.9 and 0.4 (Table 8, Figure 6).

Table 8. Projected future changes in extreme heat metrics in Morrow County. Changes from the 1971–2000 baseline were calculated for each of 20 global climate models and averaged across the 20 models (range in parentheses) for a lower (RCP 4.5) and higher (RCP 8.5) emissions scenario and for the 2020s (2010–2039 average) and 2050s (2040–2069 average). The average projected change can be added to the average historical baseline to infer the average projected future value of a given variable.

	Average Historical Baseline	2020s		2050s	
		Lower	Higher	Lower	Higher
Hot Days	20.8 days	11.2 days (3.9-18)	13.3 days (4.9-18.3)	21.7 days (8.7-32.3)	30.5 days (12.3-42.3)
Warm Nights	3.7 days	4 days (0.9-8.2)	4.6 days (2.1-8.1)	9 days (1.4-18)	14.9 days (4.4-29.1)
Hottest Day	97.7°F	3.3°F (0.7-4.9)	3.9°F (1.1-5.4)	6°F (2.3-10.5)	8°F (2.9-11.3)
Warmest Night	66.1°F	2.5°F (0.7-3.8)	2.8°F (0.9-4)	4.4°F (1.7-7.1)	6.5°F (3.4-9.5)
Daytime Heat Waves	2.9 events	1.1 events (0.5-1.9)	1.3 events (0.8-1.9)	1.9 events (1.2-3.4)	2.3 events (1.4-3.9)
Nighttime Heat Waves	0.4 events	0.5 events (0-1)	0.6 events (0.3-1)	1.2 events (0.1-2.3)	1.8 events (0.3-3.2)

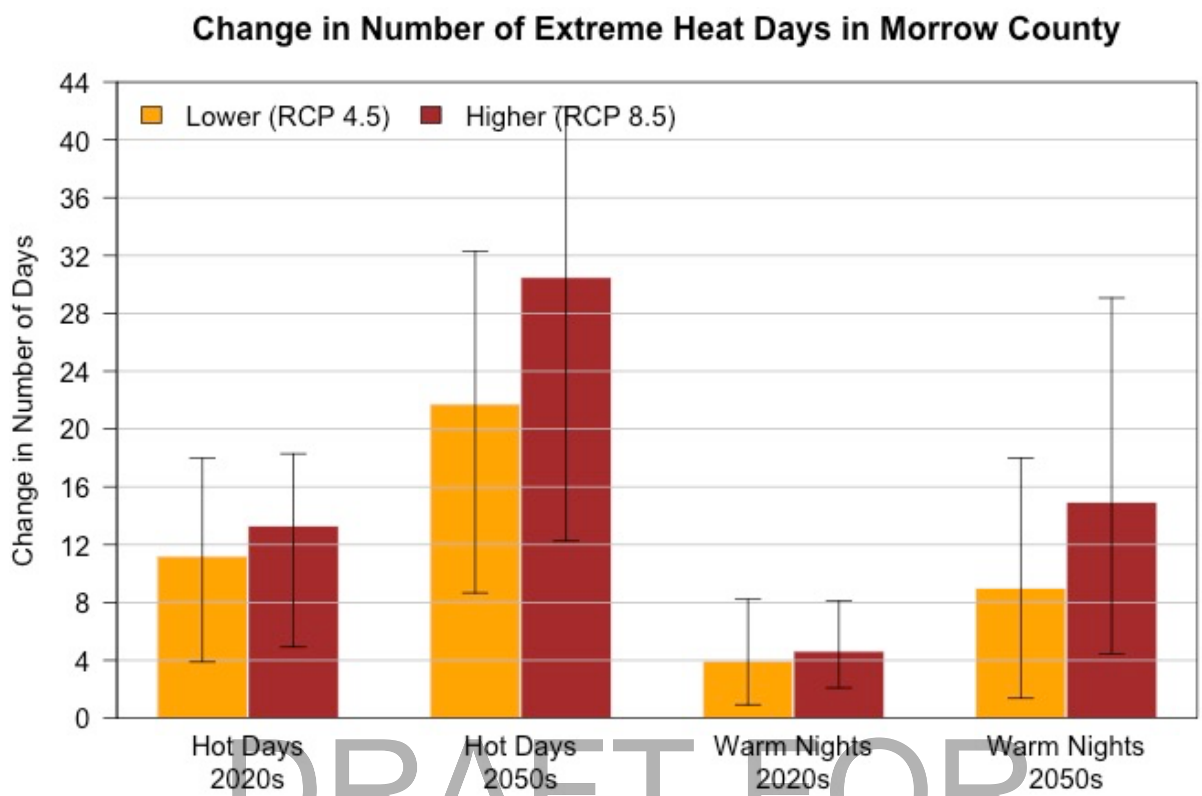

Figure 4. Projected changes in the number of hot days (left two sets of bars) and warm nights (right two sets of bars) in Morrow County by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the historical baseline (1971–2000 average), under two emissions scenarios. Changes were calculated for each of 20 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 20 models. Hot days are those on which the maximum temperature is 90°F or higher; warm nights are those on which the minimum temperature is 65°F or higher.

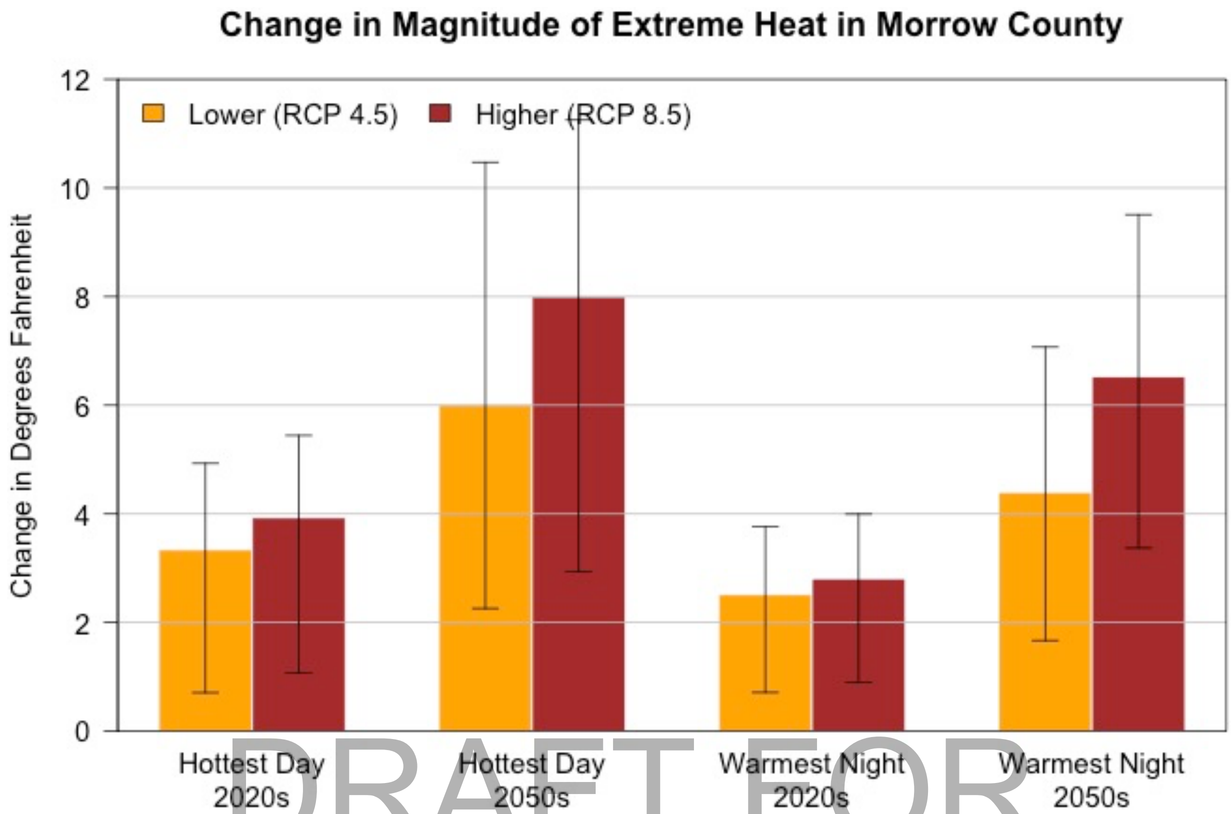

Figure 5. Projected changes in the temperature on the hottest day of the year (left two sets of bars) and warmest night of the year (right two sets of bars) in Morrow County by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the historical baseline (1971–2000 average), under two emissions scenarios. Changes were calculated for each of 20 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 20 models.

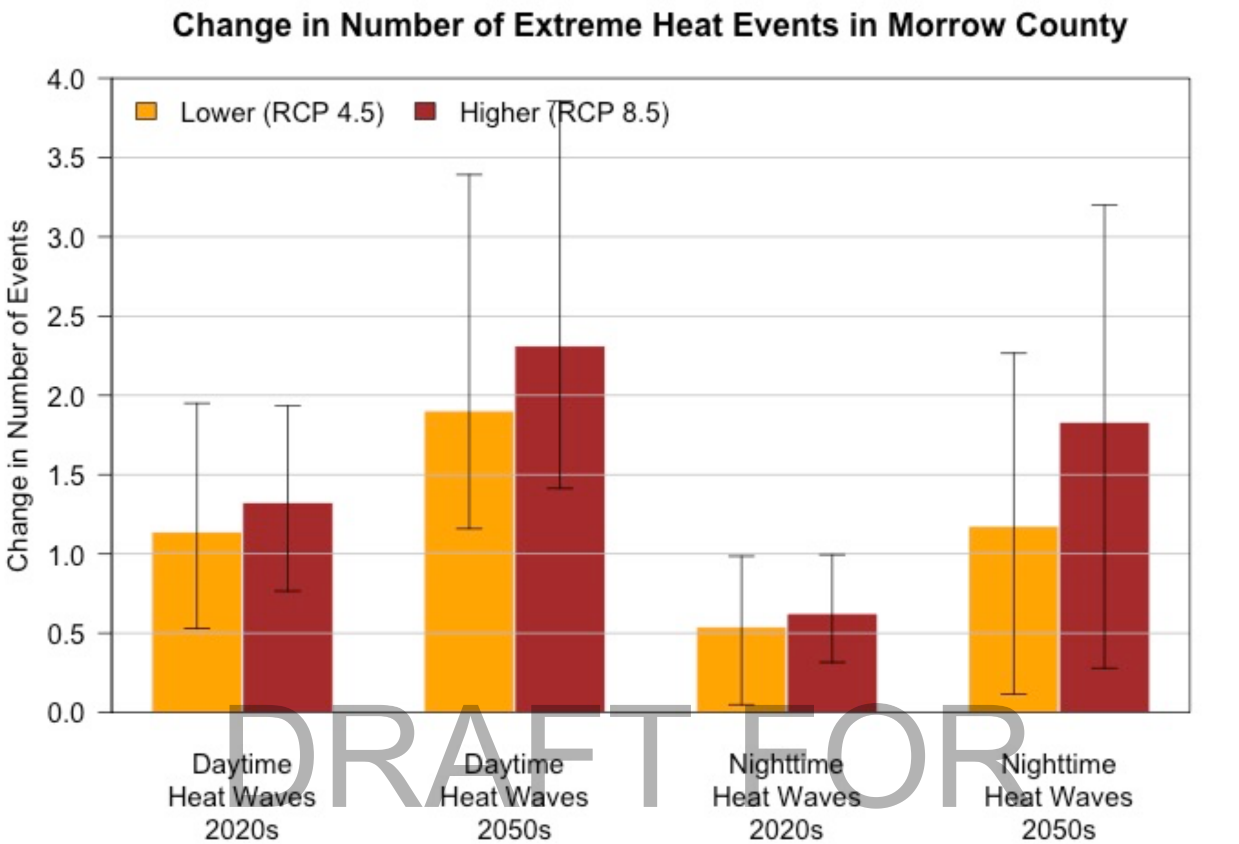

Figure 6. Projected changes in the number of daytime heat waves (left two sets of bars) and nighttime heat waves (right two sets of bars) in Morrow County by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the historical baseline (1971–2000 average), under two emissions scenarios. Changes were calculated for each of 20 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 20 models. Daytime heat waves are defined as three or more consecutive days on which the maximum temperature is 90°F or higher; nighttime heat waves are three or more consecutive days on which the minimum temperature is 65°F or higher.

Potential Effects of Extreme Heat on People

Certain populations are considered especially vulnerable to heat-related illness and death; extreme heat also exacerbates interpersonal violence (Miles-Novelo and Anderson, 2019; Stechemesser *et al.*, 2022). These populations include agricultural, forestry, and other outdoor workers; residents of urban heat islands; people with preexisting conditions or without housing or air conditioning; pregnant women; older adults; children; low-income communities; and communities of color (York *et al.*, 2020; Ho *et al.*, 2021).

Outdoor workers. The U.S. Bureau of Labor Statistics does not track occupational employment and wages in Morrow County. However, the Oregon Employment Department includes Baker, Grant, Harney, Malheur, Morrow, Umatilla, Union, and Wallowa Counties in its Eastern Oregon employment data and projections (OED, 2023). Within Eastern Oregon in 2021, an estimated 4359 individuals were employed in farming, fishing, and forestry and 4125 were employed in construction and extraction. Employment in those two sets of occupations was projected to increase by 5% and 15%, respectively, by 2031. As of 2018, an estimated 1018 migrant farmworkers (including those producing livestock) and 2022 seasonal farmworkers were employed in Morrow County (Rahe, 2018). Employment is not necessarily correlated with residence.

Urban areas. As of 2020, about 71% of Morrow County's population (8722 people) lived within the urban growth boundaries of Boardman, Heppner, Ione, Irrigon, and Lexington (PRC, 2023b). A projected 75% and 82% of the county's residents will live within urban growth boundaries by 2040 and 2070, respectively (PRC, 2023b). Population densities in cities in Morrow County generally are not considered high, so urban heat island effects on human health may not be extreme.

Preexisting conditions. From 2014–2017, about 54% of adults in Morrow County (4700 people) were living with one or more chronic health conditions (MCCHIP, 2021). In 2020, Morrow County's age-adjusted prevalence of many preexisting conditions that could be exacerbated by extreme heat ranged from 7% to more than 30% (Table 9). Age-adjusted prevalence data allow for comparisons in space or time as age distributions vary. These data were provided by the PLACES project, a collaboration between the U.S. Centers for Disease Control and Prevention and Robert Wood Johnson Foundation. PLACES reports measures of chronic diseases at the county level across the United States (chronicdata.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-County-Data-20/swc5-untb). Data are derived from the Behavior Risk Factor Surveillance System (BRFSS), sponsored by the U.S. Centers for Disease Control and Prevention's National Center for Chronic Disease Prevention and Health Promotion, other Centers for Disease Control and Prevention centers, and federal agency partners; and the U.S. Census.

Table 9. Prevalence of preexisting conditions among adults (aged 18 and older) in Morrow County, Oregon, in 2020 (blood pressure data are from 2019). Data source: PLACES project.

Preexisting condition	Age-adjusted prevalence (%)	
	Value	Range
Chronic obstructive pulmonary disease	7.7	6.8–8.6
Coronary heart disease	6.7	6.1–7.2
Current asthma	11.4	10.9–12.0
Fair or poor self-rated health status	20.1	18.0–22.3
Physical health not good for ≥14 days	12.7	11.7–13.7
High blood pressure	30.4	29.4–31.3
Depression	22.9	21.9–24.1
Mental health not good for ≥14 days	17.0	16.0–18.0

Without housing or air conditioning. As of 2017, no Morrow County resident was estimated to be unhoused (OHA, 2019). However, a separate estimate indicated that 48.5 per 1000 students enrolled in kindergarten through grade 12, or about 112 children, were unhoused (OHA, 2019). Statewide, an estimated 34% of housing units did not have air conditioning in 2020 (EIA, 2022).

Vulnerable life stage or age class. An average of 169 people per year were born in Morrow County from 2015–2017 (MCCHIP, 2021). About 10% of the births did not receive sufficient prenatal care, and a total of 15 pregnancies were among teens (10–17 years of age) (MCCHIP, 2021). The percentage of Oregon residents of reproductive age (15–44) is projected to decrease from an estimated 39% in 2020 to 36% in 2045 (PRC, 2023c). If 49.1% of Morrow County's population in that age range is female (U.S. Census Bureau, 2023), and about 5% of women of reproductive age are pregnant at any given time (CDC, n.d.), then the estimated annual number of pregnant women in Morrow County will increase by about 6 (5%) from 2020 to 2045 (PRC, 2023b).

The percentage of Morrow County residents aged 65 and older from 2016–2020, about 15% (Table 3), is lower than the statewide estimate of 19% in 2020. Trends in the county are difficult to estimate quantitatively, but the percentage of older residents likely will increase (PRC, 2023c). Statewide, the percentage of residents under the age of 15 is projected to decrease from 17% in 2020 to 14% in 2045 (PRC, 2023c). If trends in Morrow County are similar, then the projected number of residents aged 15 and younger will decrease by 80 (1%) from 2020 to 2045 (PRC, 2023b).

Low income. In 2019, about 15% of adults in Morrow County were living in poverty, and the percentage of people aged 17 or younger who were living in poverty was especially high (33%) in Boardman (MCCHIP, 2021). In 2020, 36–94% of students in the Morrow County School District were enrolled in the free and reduced-cost school lunch program (MCCHIP, 2021).

Communities of color. An estimated 41.4% of Morrow County's population identify as non-White (Table 3).

Summary

The number, duration, and intensity of extreme heat events will increase as temperatures continue to warm. In Morrow County, the number of extremely hot days (those on which the temperature is 90°F or higher) and the temperature on the hottest day of the year are projected to increase by the 2020s and 2050s under both the lower and higher emissions scenarios. The number of days per year with temperatures 90°F or higher is projected to increase by an average of 31 (range 12–42) by the 2050s, relative to the 1971–2000 historical baselines, under the higher emissions scenario. The temperature on the hottest day of the year is projected to increase by an average of about 8°F (range 3–11°F) by the 2050s. Projected demographic changes, such as an increase in the proportion of older adults, will increase the number of people in some of the populations that are most vulnerable to extreme heat.

Cold Waves

Extremely cold temperatures in Oregon generally occur when Arctic air moves into the state from the north and east (O'Neill *et al.*, 2023). As a result of human-caused climate change, Arctic air is warming more rapidly than the global mean temperature. Therefore, the intensity and frequency of cold extremes in the Northwest and worldwide decreased over the past century (Vose *et al.*, 2017; IPCC, 2021; O'Neill *et al.*, 2023). At many locations across Oregon, the annual number of days on which the minimum temperature is below freezing has decreased significantly since 1940 (O'Neill *et al.*, 2023).

The frequency of cold extremes is expected to continue decreasing (Vose *et al.*, 2017; IPCC, 2021), although more slowly than the frequency of heat extremes will increase (O'Neill *et al.*, 2023). Extreme cold will still be possible during the next several decades, but will become increasingly rare as winter temperatures warm and become less variable (O'Neill *et al.*, 2023; Rupp and Schmittner, 2023).

Older adults, infants and children, rural residents, unhoused individuals, and people with preexisting cardiovascular or respiratory conditions are considered most susceptible to extreme cold (Conlon *et al.*, 2011; NCHH, 2022). Recent and projected estimates of these populations are summarized in *Heat Waves*.

Here, we present projected changes in three metrics of extreme daytime cold (maximum temperature) and nighttime cold (minimum temperature) (Table 10).

Table 10. Metrics and definitions of cold extremes.

Metric	Definition
Cold Days	Number of days per year on which the maximum temperature is 32°F or lower
Cold Nights	Number of days per year on which the minimum temperature is 0°F or lower
Coldest Day	Lowest value of maximum temperature per year
Coldest Night	Lowest value of minimum temperature per year
Daytime Cold Waves	Number of events per year in which maximum temperature on at least three consecutive days is 32°F or lower
Nighttime Cold Waves	Number of events per year in which minimum temperature on at least three consecutive days is 0°F or lower

The number of cold days and nights in Morrow County is projected to decrease by the 2020s (2010–2039) and 2050s (2040–2069) under both the lower (RCP 4.5) and higher (RCP 8.5) emissions scenarios (Table 11, Figure 7). For example, climate models projected that by the 2050s under the higher emissions scenario, the number of cold days will decrease by 3.5–13.3 relative to each GCM's 1971–2000 historical baseline. The average projected number of cold days per year is 9 less than the average historical baseline of 14 days. The average projected number of cold nights per year is 1 less than the average historical baseline of 1.4 days. The average projected decrease in the number of daytime cold waves is 1.1 less than the average historical baseline of 2 events. Nighttime cold waves are rare in Morrow County (Table 11, Figure 7, Figure 9).

Similarly, the temperatures on the coldest day and night are projected to increase by the 2020s and 2050s under both emissions scenarios (Table 11, Figure 8). For example, by the 2050s under the higher emissions scenario, the temperature on the coldest night of the year is projected to increase by 0.0–15.8°F relative to the GCMs' historical baselines. The average projected increase in the temperature on the coldest night is 9.0°F above the average historical baseline of 1.0°F. The average projected increase in the temperature on the coldest day is 6.8°F above the average historical baseline of 17.7°F (Table 11, Figure 8).

Table 11. Projected future changes in extreme cold metrics in Morrow County. Changes from the 1971–2000 baseline were calculated for each of 20 global climate models and averaged across the 20 models (range in parentheses) for a lower (RCP 4.5) and higher (RCP 8.5) emissions scenario and for the 2020s (2010–2039 average) and 2050s (2040–2069 average). The average projected change can be added to the average historical baseline to infer the average projected future value of a given variable.

	Average Historical Baseline	2020s		2050s	
		Lower	Higher	Lower	Higher
Cold Days	14.3 days	-4.3 days (-7.8 - 1.3)	-5.5 days (-9.5 - -1.2)	-7.5 days (-10.3 - -2.7)	-8.6 days (-13.3 - -3.5)
Cold Nights	1.4 days	-0.4 days (-1.3 - 0.8)	-0.7 days (-1.3 - 0.2)	-0.9 days (-1.6 - 0.1)	-1 days (-1.6 - 0.1)
Coldest Day	17.7°F	2.1°F (-2 - 5)	3.6°F (0.1 - 7.3)	5.6°F (0.3 - 10.3)	6.8°F (0 - 11.7)
Coldest Night	1°F	3°F (-2.3 - 8.6)	5°F (0.6 - 11.1)	7.3°F (0.9 - 12.8)	9°F (0 - 15.8)
Daytime Cold Waves	2 events	-0.6 events (-1.2 - 0.4)	-0.7 events (-1.4 - -0.1)	-1 events (-1.6 - -0.4)	-1.1 events (-1.9 - -0.4)
Nighttime Cold Waves	0.2 events	0 events (-0.1 - 0.1)	-0.1 events (-0.2 - 0.1)	-0.1 events (-0.3 - 0.1)	-0.1 events (-0.3 - 0)

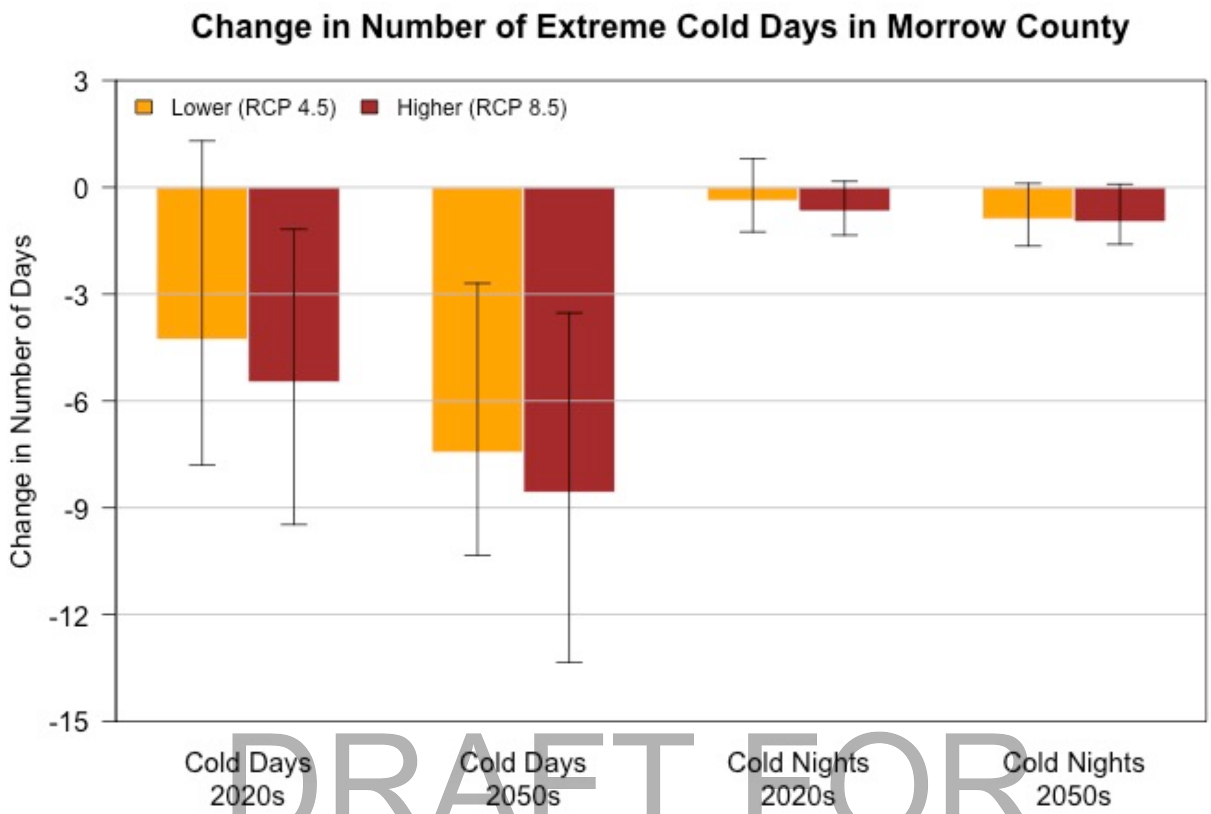

Figure 7. Projected changes in the number of cold days (left two sets of bars) and cold nights (right two sets of bars) in Morrow County by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the historical baseline (1971–2000 average), under two emissions scenarios. Changes were calculated for each of 20 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 20 models. Cold days are those on which the maximum temperature is 32°F or lower; cold nights are those on which the minimum temperature is 0°F or lower.

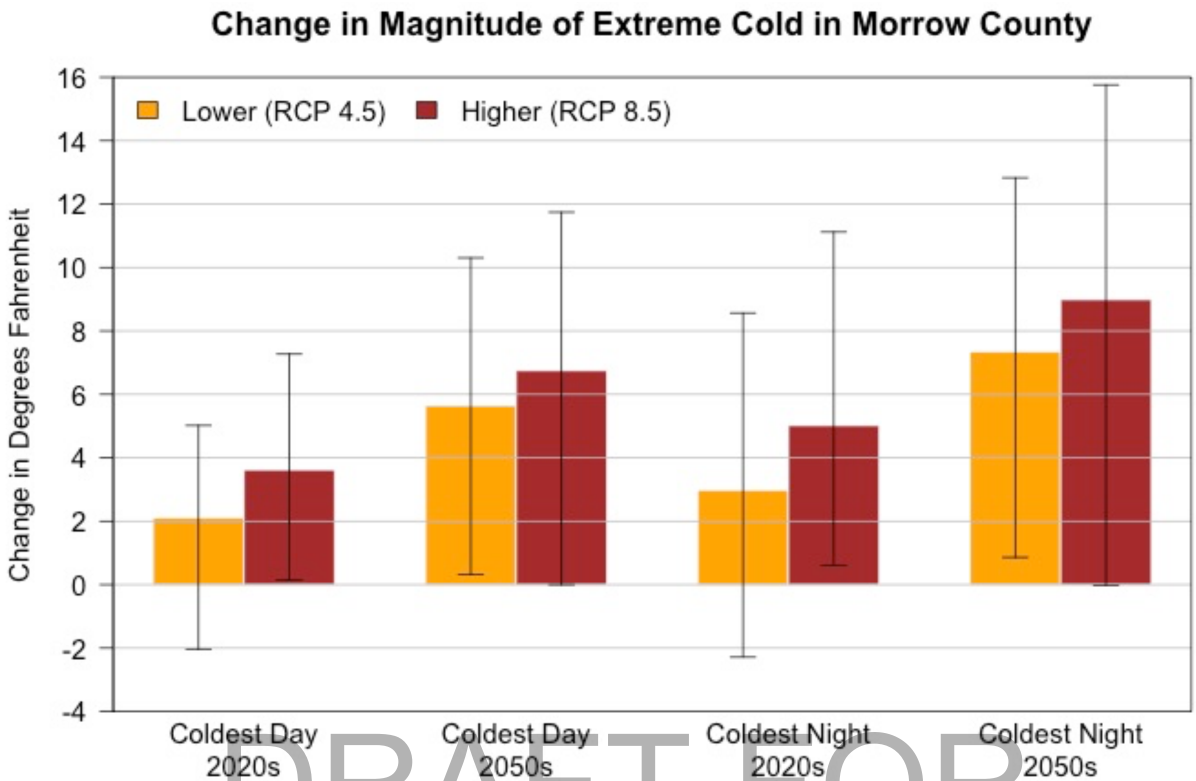

Figure 8. Projected changes in the temperature on the coldest day of the year (left two sets of bars) and coldest night of the year (right two sets of bars) in Morrow County by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the historical baseline (1971–2000 average), under two emissions scenarios. Changes were calculated for each of 20 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 20 models.

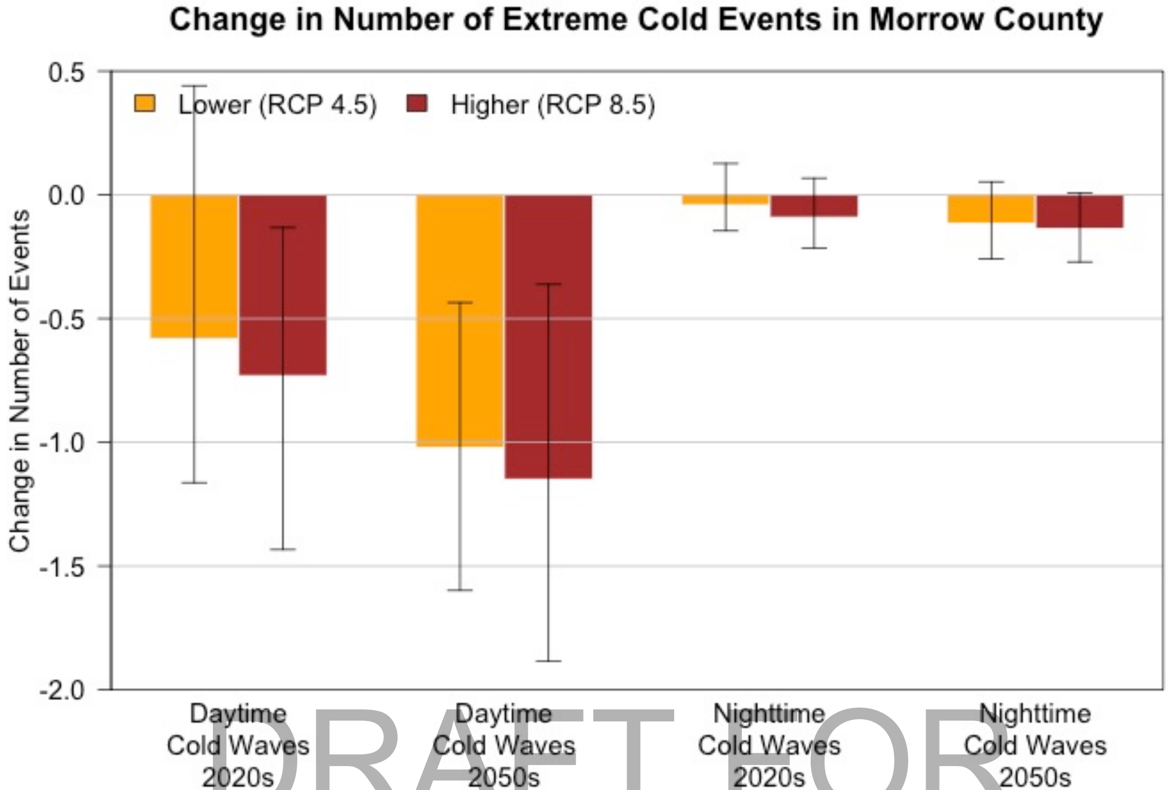

Figure 9. Projected changes in the number of daytime cold waves (left two sets of bars) and nighttime cold waves (right two sets of bars) in Morrow County by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the historical baseline (1971–2000 average), under two emissions scenarios. Changes were calculated for each of 20 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 20 models. Daytime cold waves are defined as three or more consecutive days on which the maximum temperature is 32°F or lower; nighttime cold waves are three or more consecutive days on which the minimum temperature is 0°F or lower.

Freezing Rain and Ice Accretion

Freezing rain forms when water droplets that are super-cooled, or that remain liquid even at temperatures below freezing, freeze on contact with a surface (Degelia *et al.*, 2016). Ice accretion refers to the process by which a layer of ice accumulates on solid objects that are exposed to freezing rain, drizzle, or fog. Because freezing rain intensities tend to be low, only long-duration events typically lead to appreciable ice accretion on surfaces (McCray *et al.*, 2019).

Published observations of ice loads from freezing rain on structures are rare (Changnon and Creech, 2003). The frequency of freezing rain is projected to increase over most of Canada and decrease over most of the eastern and central United States during the twenty-first century (Lambert and Hansen, 2011; Klima and Morgan, 2015; Jeong and Sushama, 2018; McCray *et al.*, 2022). Little change or some increase in the frequency of freezing rain, even under high warming scenarios, is projected in the Intermountain West, including Morrow County, and the Columbia Gorge. In coastal Oregon and Washington, by contrast, the projected frequency of freezing rain declines in the future (Jeong *et al.*, 2018; McCray *et al.*, 2022). Even so, whether the amount of freezing rain will increase or decrease is unclear, and varies among climate models, emissions scenarios, and temporal extents (Jeong *et al.*, 2018). One analysis projected decreases in the amount of ice accretion with a 50-year return period (a 2% probability of occurring in any given year) over southwestern and central-western Oregon, but no change in northern Oregon (Jeong *et al.*, 2019). Moreover, published projections of freezing rain trends usually have been provided as maps covering extensive areas (e.g., the conterminous United States or Canada, the United States, and northern Mexico), making it difficult to quantify county-level average projections.

Summary

Cold extremes will become less frequent and intense as the climate warms. The number of cold days (maximum temperature 32°F or lower) per year in Morrow County is projected to decrease by an average of 9 (range 4–13) by the 2050s, relative to the 1971–2000 historical baselines, under the higher emissions scenario. The temperature on the coldest night of the year is projected to increase by an average of 9°F (range 0–16°F) by the 2050s. The number of county residents vulnerable to extreme cold is likely to grow, although this increase may be offset somewhat by the decrease in incidence of cold extremes.

Heavy Precipitation

There is greater uncertainty in projections of future precipitation than projections of future temperature. Precipitation has high natural variability, and the atmospheric patterns that influence precipitation are represented differently among GCMs. Globally, mean precipitation is likely to decrease in many dry regions in the subtropics and mid-latitudes and to increase in many mid-latitude wet regions (IPCC, 2013; Stevenson *et al.*, 2022). Because the location of the boundary between mid-latitude increases and decreases in precipitation varies among GCMs, some models project increases and others decreases in precipitation in Oregon (Mote *et al.*, 2013).

Observed annual precipitation in Oregon is highly variable and has not changed significantly over the period of record. Annual precipitation in Oregon is projected to increase somewhat over the twenty-first century, although natural variability will continue to dominate this trend (Dalton *et al.*, 2017, 2021; Fleishman, 2023). On average, summers in Oregon are projected to become drier and other seasons to become wetter. However, some models project increases and others decreases in each season (Dalton *et al.*, 2017, 2021; Fleishman, 2023). In addition, regional climate models project larger increases in winter precipitation east of the Cascade Range than west of the Cascade Range, which suggests a weakened rain shadow effect in winter (Mote *et al.*, 2019).

Extreme precipitation in the Northwest is governed by atmospheric circulation and its interaction with complex topography (Parker and Abatzoglou, 2016). Atmospheric rivers—long, narrow swaths of warm, moist air that carry large amounts of water vapor from the tropics to mid-latitudes—generally result in extreme precipitation across large areas west of the Cascade Range, and are associated with the majority of fall and winter extreme precipitation events in Oregon. By contrast, low pressure systems that are not driven by westerly flows from offshore often lead to locally extreme precipitation east of the Cascade Range (Parker and Abatzoglou, 2016).

The frequency and intensity of heavy precipitation has increased across most continents since the 1950s (IPCC, 2021). Observed trends in the frequency of extreme precipitation across Oregon vary among locations, time periods, and metrics, but overall, the frequency has not changed substantially. As the atmosphere warms, it holds more water vapor. As a result, the frequency and intensity of extreme precipitation is expected to increase (Dalton *et al.*, 2017, 2021; Kossin *et al.*, 2017). Regional climate models project a larger percentage increase in precipitation extremes east of the Cascade Range than west of the Cascade Range (Mote *et al.*, 2019; Rupp *et al.*, 2022). Additionally, the projected percentage increase in extreme precipitation tends to be larger on the leeward side of the Coast and Cascade Ranges than on the windward side (Rupp *et al.*, 2022). Climate models also project an increase in the number of days on which an atmospheric river is present, and an increase in the proportion of total annual precipitation across the Northwest that is delivered by atmospheric rivers (Dalton *et al.*, 2021).

Here, we present projected changes in four metrics of precipitation extremes (Table 12).

Table 12. Metrics and definitions of precipitation extremes.

Metric	Definition
Wettest Day	Highest one-day precipitation total per water year (1 October–30 September)
Wettest Five Days	Highest consecutive five-day precipitation total per water year
Wet Days	Number of days per water year on which precipitation exceeds 0.75 inches
Landslide Risk Days	Number of days per water year that exceed the landslide threshold developed by the US Geological Survey for Seattle, Washington (see https://pubs.er.usgs.gov/publication/ofr20061064). P3/(3.5-.67*P15)>1, where ▪ P3 = Precipitation accumulation on prior days 1–3 ▪ P15 = Precipitation accumulation on prior days 4–18

In Morrow County, the amount of precipitation on the wettest day and wettest consecutive five days per year is projected to increase on average by the 2020s (2010–2039) and 2050s (2040–2069), relative to the 1971–2000 historical baseline, under both the lower (RCP 4.5) and higher (RCP 8.5) emissions scenarios (Table 13, Figure 10). Some models project decreases in these metrics for certain time periods and scenarios.

Climate models project that by the 2050s under the higher emissions scenario, the amount of precipitation on the wettest day of the year, relative to each GCM's 1971–2000 historical baseline, will increase by 1.8–37.8% (Figure 10). The average projected amount of precipitation on the wettest day of the year is 15.4% greater than the average historical baseline of 0.7 inches.

By the 2050s under the higher emissions scenario, the amount of precipitation on the wettest consecutive five days of the year is projected to change by -6.4–29.5% (Figure 10). The average projected amount of precipitation on the wettest consecutive five days is 10.4% above the average historical baseline of 1.5 inches.

Table 13. Projected future changes in extreme precipitation metrics in Morrow County. Changes from the 1971–2000 baseline were calculated for each of 20 global climate models and averaged across the 20 models (range in parentheses) for a lower (RCP 4.5) and higher (RCP 8.5) emissions scenario and for the 2020s (2010–2039 average) and 2050s (2040–2069 average). The average projected change can be added to the average historical baseline to infer the average projected future value of a given variable.

	Average Historical Baseline	2020s		2050s	
		Lower	Higher	Lower	Higher
Wettest Day	0.7 inches	9.7% (-1.5-23.5)	8.4% (-6-24.7)	13.3% (-2.9-29.4)	15.4% (1.8-37.8)
Wettest Five-Days	1.5 inches	5.7% (-9.8-22.1)	4.4% (-9-16.8)	7.7% (-4.2-23)	10.4% (-6.4-29.5)
Wet Days	0.6 days	0.2 days (-0.1-0.5)	0.1 days (-0.1-0.4)	0.3 days (0-0.5)	0.3 days (0-0.7)
Landslide Risk Days	0.5 days	0.1 days (-0.2-0.4)	0.1 days (-0.3-0.4)	0.1 days (-0.1-0.3)	0.2 days (-0.1-0.6)

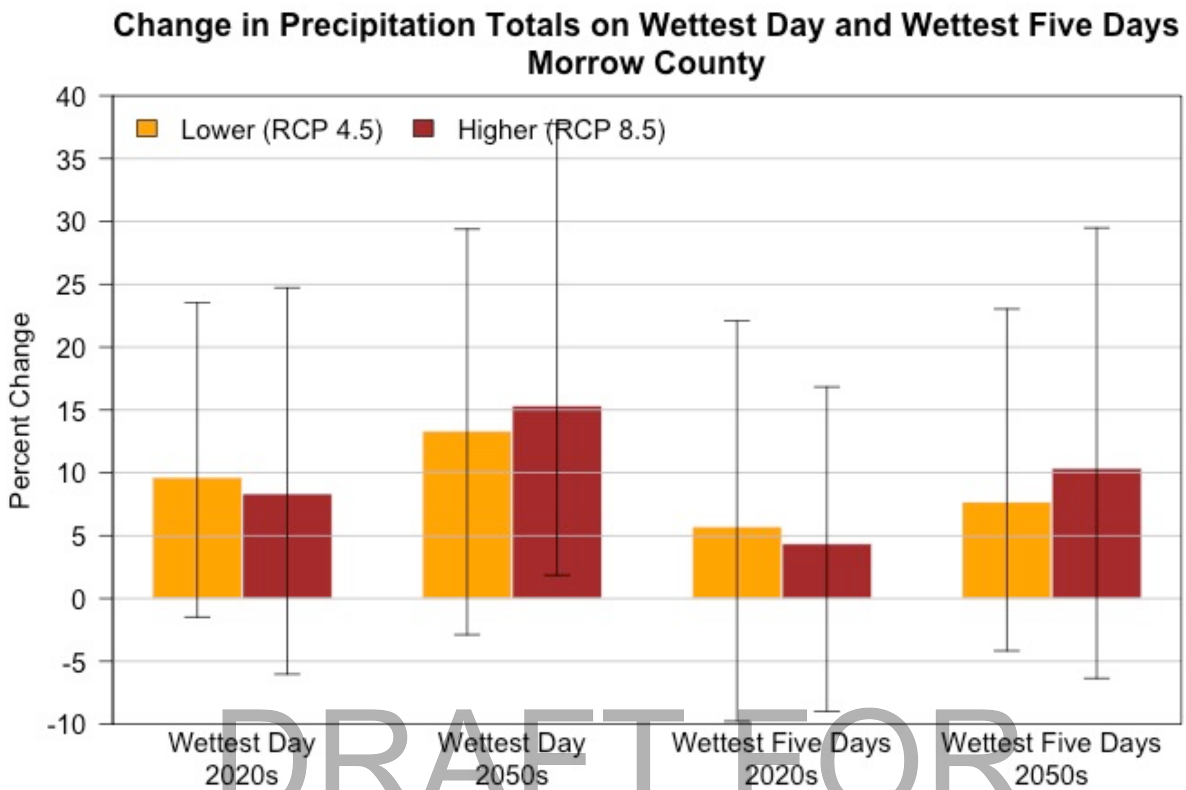

Figure 10. Projected percent changes in the amount of precipitation on the wettest day of the year (left two sets of bars) and wettest consecutive five days of the year (right two sets of bars) in Morrow County by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the historical baseline (1971–2000 average), under two emissions scenarios. Changes were calculated for each of 20 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 20 models.

The average number of days per year on which precipitation exceeds 0.75 inches is not projected to change substantially (Figure 11). For example, by the 2050s under the higher emissions scenario, the number of wet days per year is projected to increase by 0.3 (range -0.0–0.7). The historical baseline is an average of 0.6 days per year.

Landslides are often triggered by rainfall when the soil becomes saturated. As a surrogate measure of landslide risk, we present a threshold based on recent rainfall (cumulative precipitation over the previous 3 days) and antecedent precipitation (cumulative precipitation during the 15 days prior to the previous 3 days). By the 2050s under the higher emissions scenario, the average number of days per year in Morrow County on which the landslide risk threshold is exceeded is projected to remain about the same, with a change of 0.2 (range -0.1–0.6) (Figure 11). The historical baseline is an average of 0.5 days per year. Landslide risk depends on multiple site-specific factors, and this metric does not reflect all aspects of the hazard. Also, the landslide risk threshold was developed for Seattle, Washington, and may be less applicable to other locations.

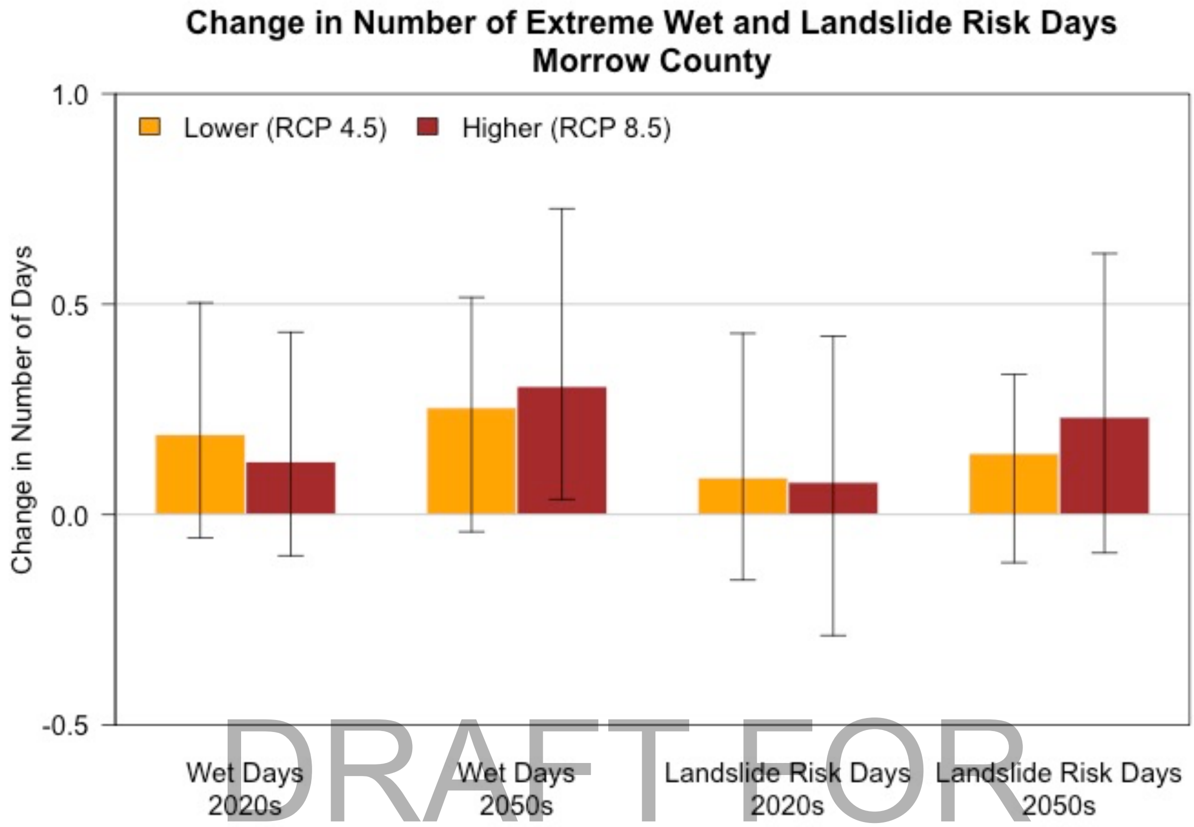

Figure 11. Projected changes in the number of wet days (left two sets of bars) and landslide risk days (right two sets of bars) in Morrow County by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the historical baseline (1971–2000 average), under two emissions scenarios. Changes were calculated for each of 20 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 20 models.

Landslide risk also can become high when heavy rain falls on an area that burned within approximately the past five to ten years. The probability that extreme rainfall will occur within one year after an extreme fire-weather event in Oregon or Washington was projected to increase by 700% from 1980–2005 to 2100 under the higher emissions scenario (Touma *et al.*, 2022). Similarly, projections suggested that by 2100, 90% of extreme fire-weather events across Oregon and Washington are likely to be succeeded within five years by three or more extreme rainfall events (Touma *et al.*, 2022). Although fire weather is not synonymous with wildfire, these results highlight the increasing likelihood of compounded climate extremes that elevate the risk of natural hazards.

Populations considered particularly vulnerable to the direct and indirect effects of extreme precipitation, from the storms themselves to floods and landslides, include people dependent on medical equipment that requires electricity, older adults, and children and pregnant women (York *et al.*, 2020; Ho *et al.*, 2021). Recent and projected estimates of populations that are older, younger, and of childbearing age are included in previous sections. Some utility companies provide consultation and additional outreach to individuals who are dependent on electricity for a medical device. Among the diverse health risks associated with extreme precipitation are injuries, toxic exposures, displacement, disruptions in medical care, and negative mental health outcomes (York *et al.*, 2020; Ho *et al.*, 2021).

Summary

The intensity of extreme precipitation is expected to increase as the atmosphere warms and holds more water vapor. In Morrow County, the number of days per year with at least 0.75 inches of precipitation is not projected to change substantially. Nevertheless, by the 2050s, the amount of precipitation on the wettest day and wettest consecutive five days per year is projected to increase by an average of 15% (range 2–38%) and 10% (range -6–30%), respectively, relative to the 1971–2000 historical baselines, under the higher emissions scenario. The number of days per year on which a threshold for landslide risk, which is based on prior 18-day precipitation accumulation, is exceeded is not projected to change substantially. However, landslide risk depends on multiple factors, and this metric does not reflect all aspects of the hazard.

Streams in the Northwest are projected to shift toward higher winter runoff, lower summer and fall runoff, and earlier peak runoff, particularly in snow-dominated regions (Raymondi *et al.*, 2013; Naz *et al.*, 2016). These changes are expected as a result of increases in the intensity of heavy precipitation; warmer temperatures that cause more precipitation to fall as rain and less as snow, and snow to melt earlier in spring; and increasing winter precipitation and decreasing summer precipitation (Dalton *et al.*, 2017, 2021; Mote *et al.*, 2019).

Warming temperatures and increasing winter precipitation are expected to increase flood risk in many basins in the Northwest, particularly mid- to low-elevation, mixed rain-and-snow basins in which winter temperatures are near freezing (Tohver *et al.*, 2014). The greatest projected changes in peak streamflow magnitudes are at intermediate elevations in the Cascade Range and Blue Mountains (Safeeq *et al.*, 2015). Regional hydroclimate models project increases in extreme high flows throughout most of the Northwest, especially west of the Cascade crest (Salathé *et al.*, 2014; Najafi and Moradkhani, 2015; Naz *et al.*, 2016). One study that used a single climate model projected an increase in flood risk in fall due to earlier, more extreme storms, including atmospheric rivers; and an increase in the proportion of precipitation falling as rain rather than snow (Salathé *et al.*, 2014). Rainfall-driven floods are more sensitive to increases in precipitation than snowmelt-driven floods. Therefore, the projected increases in total precipitation, and in rain relative to snow, likely will increase flood magnitudes in the region (Chegwidden *et al.*, 2020).

The Columbia River is within a snow-dominated basin in which flow peaks during late spring snowmelt (Figure 12). By the 2050s (2040–2069), under both emissions scenarios, streamflow in the Columbia River at McNary, upstream of Morrow County, is projected to peak earlier in spring as warmer temperatures cause the snowpack to melt earlier. In addition, winter streamflow is projected to increase due to increased winter precipitation and a greater percentage of precipitation falling as rain rather than snow. Mean monthly flows do not translate directly to flood risk because floods occur over shorter periods of time. However, increases in monthly flow may imply increases in flood likelihood, particularly if increases are projected to occur during months in which flood occurrence historically has been high.

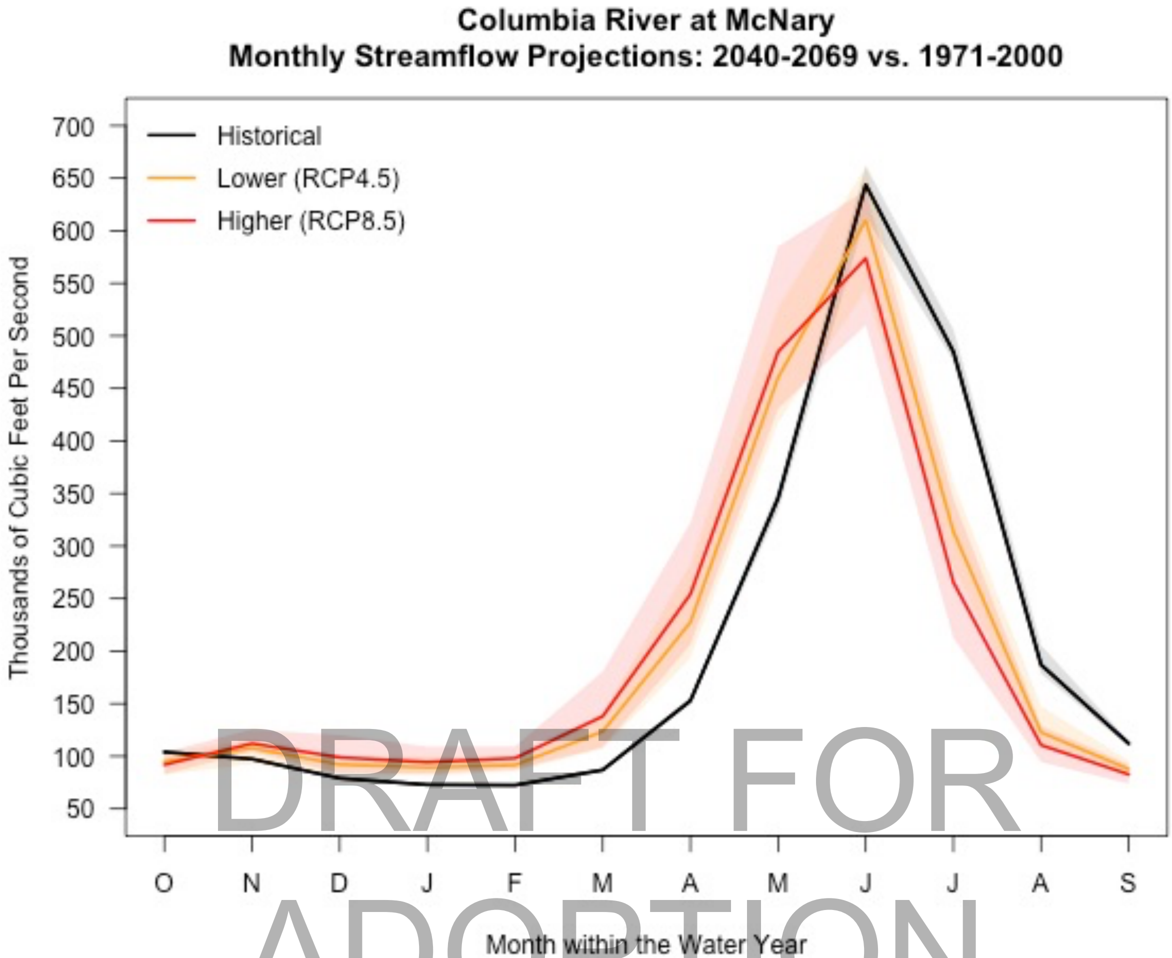

Figure 12. Simulated monthly, bias-corrected, non-regulated streamflow at the Columbia River at McNary in 2040–2069 compared to 1971–2000. Solid lines and shading represent the mean and range across ten global climate models. (Data source: Integrated Scenarios of the Future Northwest Environment, climatetoolbox.org/tool/future-streamflows)

Across the western United States, the average magnitudes of major floods are projected to increase by 14–19% by 2010–2039, 21–30% by 2040–2069, and 31–43% by 2070–2099, compared to the 1971–2000 historical baseline, under the higher emissions scenario (Maurer *et al.*, 2018). Major floods are defined as daily peak flow magnitudes that are associated with 100-year to 10-year return periods (1–10% probability that this daily flow magnitude will be exceeded in a given year). However, along the Columbia River bordering Oregon, peak flows are projected to decrease as a result of the complex interaction between earlier snowmelt and the transition to a greater proportion of precipitation falling as rain rather than snow (Maurer *et al.*, 2018). Likewise, within the Columbia River basin, projected major flood magnitudes by 2050–2099, compared to 1950–1999, increased nearly everywhere and varied by dominant precipitation type (Queen *et al.*, 2021). Projected increases in major flood magnitudes were smallest for the Columbia River along the Oregon border. For example, on the Columbia River at McNary, flood levels with 10-year and 100-year return periods (10% and 1% probability, respectively, that this daily flow magnitude will be exceeded in a given year) were projected to increase on average by 2% and 5%, respectively, from 1950–1999 to 2050–2099 under the higher emissions scenario (Queen *et al.*, 2021).

Some of the Northwest's highest floods occur when large volumes of warm rain from atmospheric rivers fall on a deep snowpack (Safeeq *et al.*, 2015). The frequency and amount of moisture transported by atmospheric rivers is projected to increase along the West Coast in response to increases in air temperature (Kossin *et al.*, 2017), which in turn increases the likelihood of flooding (Konrad and Dettinger, 2017).

Future changes in the frequency of rain-on-snow events likely will vary along elevational gradients. At lower elevations, the frequency is projected to decrease due to decreasing snowpack, whereas at higher elevations the frequency is projected to increase due to the shift from snow to rain (Surfleet and Tullos, 2013; Safeeq *et al.*, 2015; Musselman *et al.*, 2018). The likely effects on streamflow of such changes in frequency of rain-on-snow events vary. For example, projections for the Santiam River, Oregon, indicated an increase in annual peak daily flows with return intervals less than 10 years, but a decrease in annual peak daily flows with return intervals of 10 or more years (Surfleet and Tullos, 2013). Average runoff from rain-on-snow events in watersheds in western Oregon and the mid-Columbia River basin was projected to decline due to depletion of the snowpack (Musselman *et al.*, 2018), which may imply that the driver of floods in these areas shifts from rain-on-snow events to rainfall that exceeds soil capacity (Berghuijs *et al.*, 2016; Musselman *et al.*, 2018). Wildfires and shifts in vegetation that affect soil properties also will likely affect water transport, but hydrological models generally have not accounted for these processes (Bai *et al.*, 2018; Wang *et al.*, 2020; Williams *et al.*, 2022).

Potential Effects of Projected Flooding on Infrastructure

First Street Foundation (2023) estimated that 1453 properties in Morrow County (24%) have a >26% probability of being severely affected by flooding by 2050. Among the structures at major risk of flooding (Table 14) are 509 residences (28%), 96 commercial properties (39%), 6 critical infrastructure facilities (e.g., hospitals; police, fire, and power stations; and water treatment facilities) (17%), and 9 (41%) of social facilities (schools, houses of worship, museums, and government or historic buildings) (Table 14). Of the 3750 miles of roads in Morrow County, 1283 (34%) were estimated to be at major risk of flooding (First Street Foundation, 2023).

Table 14. 30-year cumulative probability of flooding to different depths and First Street Foundation's associated risk characterizations.

		30-year cumulative probability					
		≤0.06	>0.06–0.12	>0.12–0.27	>0.27–0.47	>0.47–0.96	>0.96
Flood depth	0–3"	Low	Moderate	Moderate	Major	Major	Severe
	>3–6"	Low	Moderate	Moderate	Major	Major	Severe
	>6–9"	Moderate	Moderate	Major	Major	Severe	Extreme
	>9–12"	Moderate	Moderate	Major	Severe	Severe	Extreme
	>12–24"	Moderate	Major	Major	Severe	Extreme	Extreme
	>24"	Major	Major	Severe	Extreme	Extreme	Extreme

Relatively little information is available on the number of residential and other structures in Morrow County that are within the 100-year floodplain (the area that has a 1% probability of flooding in a given year). Two non-residential structures in the floodplain were approved by the Morrow County Planning Department in 2022 and 2023. In Heppner, 393 structures have been built on the 114 acres (46 hectares) within the 100-year floodplain.

Summary

Winter flood risk at intermediate to low elevations in Morrow County, where temperatures are near freezing during winter and precipitation is a mix of rain and snow, is projected to increase as winter temperatures increase. The temperature increase will lead to an increase in the percentage of precipitation falling as rain rather than snow.

Drought

Drought can be defined in many ways (Table 15), but most fundamentally is insufficient water to meet needs (Redmond, 2002; O'Neill *et al.*, 2021; O'Neill and Siler, 2023). Drought is common in the Northwest, particularly because seasonal precipitation is lowest during the warmest season (O'Neill and Siler, 2023). The incidence, extent, and severity of drought increased over the last 20 years relative to the twentieth century, and this trend is expected to continue (O'Neill *et al.*, 2021; O'Neill and Siler, 2023).

Table 15. Definitions and characteristics of various drought classes. (Sources: O'Neill *et al.*, 2021; O'Neill and Siler, 2023; Fleishman *et al.*, unpublished)

Drought Class	Definition and Characteristics
Meteorological	• lack of precipitation • evaporative demand that exceeds precipitation for 90 days or longer
Hydrological	• extended periods of meteorological drought that affect surface or subsurface water supply, such as streamflow, reservoir and lake levels, or ground water levels • tends to evolve more slowly than meteorological drought and to persist for longer than six months
Agricultural	• occurs when lack of surface or subsurface water adversely affects agricultural production • reflects precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, and reduced availability of water for irrigation
Socioeconomic	• occurs when meteorological, hydrological, or agricultural drought reduces the supply of an economic or social good or service • often affects issuance of state and federal drought declarations
Ecological	• undesirable changes in ecological state caused by deficits in water availability • usually caused by meteorological or hydrological drought • sensitivity to water limitation varies among species and life stages
Flash	• rapid-onset period of elevated surface temperature, low relative humidity, precipitation deficit, and a rapid decline in soil moisture • tends to develop and intensify rapidly within a few weeks, and may be generated or magnified by prolonged heat waves
Snow	• snowpack—or snow water equivalent (SWE)—is below average for a given point in the water year, traditionally 1 April • often presages hydrological drought during the ensuing spring and summer in snowmelt-dominated watersheds • warm snow drought refers to below-average snowpack that results primarily from above-average winter temperatures • dry snow drought refers to below-average snowpack that results primarily from below-average winter precipitation

Drought often affects human health indirectly, such as through food scarcity and the increased incidence of infectious, chronic, and vector-borne diseases. Moreover, drought affects both physical and mental health (Vins *et al.*, 2015). Low income, tribal, rural, and farming and farmworker communities are especially susceptible to negative health effects as a result of drought and associated water scarcity and poor water quality (York *et al.*, 2020; Ho *et al.*, 2021). Recent and projected estimates of low income, rural, and some farmworker populations are presented in previous sections. As of 2022, an estimated 2.6% of Morrow County residents identified as one race and as American Indian or Alaska Native (U.S. Census Bureau, 2023).

By 2100, annual mean precipitation in Oregon is projected to increase by 5–10% (O'Neill and Siler, 2023). However, summers in the state are expected to become drier and warmer (Dalton *et al.*, 2021; Fleishman, 2023). As winters become warmer, snowpack across Oregon is projected to decline by approximately 25% by 2050 relative to 1950–2000 (Siirila-Woodburn *et al.*, 2021). The decline in snowpack across the western United States is projected to reduce summer soil moisture in the mountains (Gergel *et al.*, 2017). Climate change is also expected to reduce summer streamflows in snow-dominated and mixed rain and snow basins across the Northwest as snowpack melts earlier and summer precipitation decreases (Dalton *et al.*, 2017; Mote *et al.*, 2019). For example, summer flow is projected to decrease in the Columbia River (Figure 12) by the 2050s. As mountain snowpack declines, seasonal drought will become less predictable and snow droughts will increase the likelihood of hydrological and agricultural drought during the following spring and summer (Dalton and Fleishman, 2021; Fleishman, 2023).

We present projected changes in four variables indicative of drought: low spring (April 1) snowpack (snow drought), low summer (June–August) soil moisture from the surface to 55 inches below the surface (agricultural drought), low summer runoff (hydrological drought), and low summer precipitation (meteorological drought). We present drought in terms of a change in the probability of exceeding the magnitude of seasonal drought conditions for which the historical annual probability of exceedance was 20% (5-year return period) (Figure 13).

Summer precipitation and spring snowpack in Morrow County is projected to decline, but summer soil moisture and runoff are projected to increase (Hegewisch and Abatzoglou, n.d.). By the 2050s under the higher emissions scenario, the annual probabilities of snow and meteorological drought are projected to increase to approximately 62% (1.6-year return period) and 27% (3.6-year return period), respectively. The annual probabilities of agricultural and hydrological drought are not projected to change substantially (Figure 13).

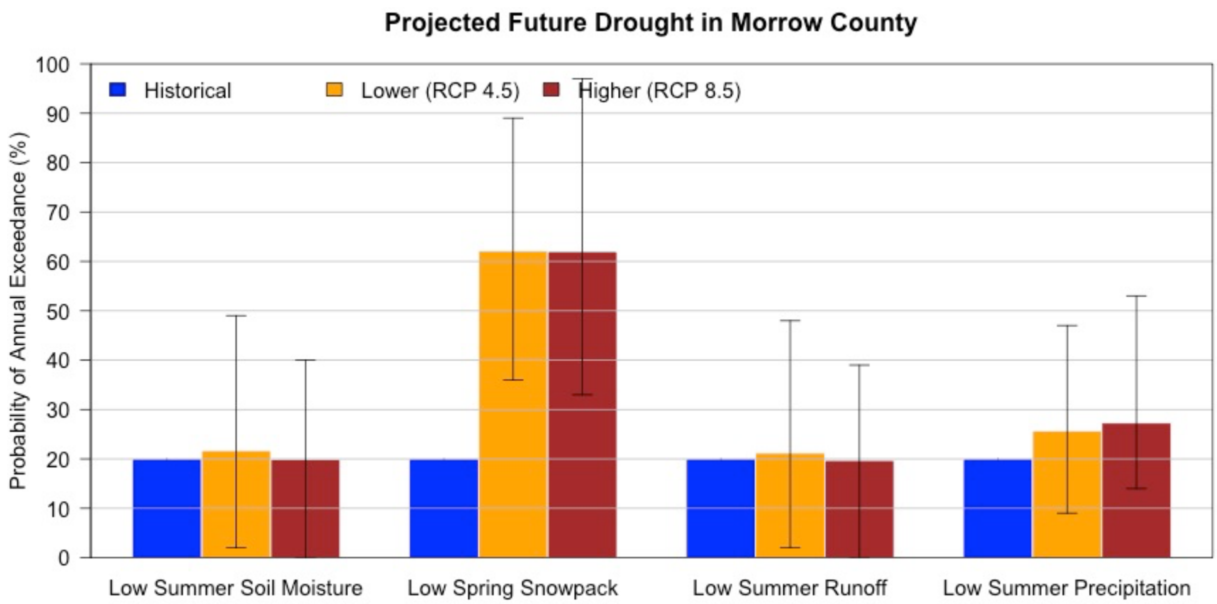

Figure 13. Projected probability of exceeding the magnitude of seasonal drought conditions for which the historical annual probability of exceedance was 20%. Projections are for the 2050s (2040–2069), relative to the historical baseline (1971–2000), under two emissions scenarios. Seasonal drought conditions include low summer soil moisture (average from June through August), low spring snowpack (April 1 snow water equivalent), low summer runoff (total from June through August), and low summer precipitation (total from June through August). The bars and whiskers represent the mean and range across ten global climate models. (Data source: Integrated Scenarios of the Future Northwest Environment, climate.northwestknowledge.net/IntegratedScenarios)

Summary

Drought, as represented by low spring snowpack and low summer precipitation, is projected to become more frequent in Morrow County by the 2050s, although summer soil moisture and runoff in the county is projected to increase on average. The incidence of related negative physical and mental health outcomes, especially among low income, tribal, rural, and agricultural communities, is likely to increase.

Wildfire

Morrow County extends from north of the Columbia River south to the Umatilla National Forest near the Blue Mountains. Much of the county's vegetation is sagebrush-dominated. Projection of contemporary wildfire risk requires an understanding of interactions among plant physiology, climate, and human activities.

Aridity, Heat, and Wildfire Risk

Drought across the western United States has been exacerbated by warmer winters and springs, which drive an overall decline in mountain snowpack and earlier snowmelt (Westerling, 2016), and by longer summers. Extreme heat in June 2021 (Heeter *et al.*, 2023) caused mortality of seedlings and saplings in plantations while scorching the canopy of mature trees (Still *et al.*, 2023). High temperatures are a major contributor to desiccation of dead vegetation, whereas dry air reduces moisture in live vegetation. The drier the air, the more plants transpire and lose water. If tall trees cannot draw enough water from the soil, they may be at risk of embolism (Olson *et al.*, 2018; Anfodillo and Olson, 2021) and more likely to die. Dry dead or living vegetation is more likely to burn than wet vegetation. Because concurrent heat and drought are becoming more common (Alizadeh *et al.*, 2020), the volume of stressed or dead vegetation and wildfire risk are increasing.

Trees that become drought-stressed generally are more vulnerable to outbreaks of native and non-native insects and to pathogens that can lead to the trees' death. For example, densities of mountain pine beetles (*Dendroctonus ponderosae*), which are native to eastern Oregon, generally are low, but eruptions can result in 60% stand-level mortality over tens to hundreds of square kilometers (Abrams *et al.*, 2021). Mountain pine beetles carry fungi that can hasten tree death, especially during a drought, by disrupting water transport. The species usually has one generation per year, but may be able to reproduce twice per year as temperatures increase.

The dryness of the air, also called evaporative demand, is characterized by the vapor pressure deficit (VPD). The VPD is the difference in atmospheric pressure between the current amount of water vapor in the air and the maximum amount of water the air can hold at a given temperature (dew point). VPD is increasing globally, and CMIP6 climate models indicate that human emissions of greenhouse gases explained 68% of the observed VPD increase from 1979 through 2020 (Zhuang *et al.*, 2021). These models also project that across the western United States, given a higher emissions scenario, warm season VPD over the next 30 years will increase at a rate similar to that observed from 1979 through 2020 (Zhuang *et al.*, 2021). Area burned is more strongly correlated with VPD than with other drought indices or variables, such as temperature and precipitation (Sedano and Randerson, 2014; Williams *et al.*, 2014; Seager *et al.*, 2015; Rao *et al.*, 2022). CMIP5 models projected that increases in VPD will contribute substantially to wildfire risk in Oregon (Ficklin and Novick, 2017; Chiodi *et al.*, 2021) and across the West (Abatzoglou *et al.*, 2021a; Zhuang *et al.*, 2021; Juang *et al.*, 2022).

From 1985 through 2017, the annual area burned by high-severity fires across forests in the western United States increased eightfold (Parks and Abatzoglou, 2020). The frequency of large wildfires in forests has also increased: such fires now occur nearly every year in the Northwest (Rupp and Holz, 2023). About half of the observed increase in vegetation dryness in the western United States from 1984 through 2015—again, driven mainly by the dryness of the air—and 16,000 square miles (4.2 million hectares) of burned area were attributable to human-caused climate change (Abatzoglou and Williams, 2016).

Projected effects of climate change on ecosystems dominated by sagebrush (primarily *Artemisia tridentata*) vary, but widespread vegetation shifts are projected by the end of the century due to increases in the frequency of wildfires (Shafer *et al.*, 2001; Creutzburg *et al.*, 2014). Most projections suggest that the distribution of sagebrush will shift to the north and contract in the south as frost-sensitive, warm-desert plant species expand north and as the lower elevational extent of woodlands moves downslope. In addition, sagebrush is expected to become increasingly fragmented by large, homogenous extents of invasive non-native grasses (Davies and Nafus, 2012) that are highly flammable; wildfires in areas dominated by such grasses can cause high sagebrush mortality (Baker, 2006).

Historically, wildfires were less active overnight, and the probability of fire expansion generally was evaluated on the basis of daytime conditions. However, across the western United States, the number of nights during which atmospheric conditions are conducive to burning has increased by 45% since 1979 (Balch *et al.*, 2022). The intensity and duration of wildfires is expected to increase as nights continue to become hotter and drier (Chiodi *et al.*, 2021; Balch *et al.*, 2022).

Land Use and Wildfire Risk

Projections that include concurrent increases in aridity, temperature, and intensification of land use (which leads to an increase in human ignitions; see below) indicate that area burned and the frequency and intensity of wildfires will continue to increase in the Pacific Northwest (Sheehan *et al.*, 2015; Dalton *et al.*, 2017; Mote *et al.*, 2019; Dalton and Fleishman, 2021; Rupp and Holz, 2023). Under the lower emissions scenario, the average annual area burned in Oregon's forests is expected to increase by at least 50% over the next several decades (Rupp and Holz, 2023). In addition, a 3.6°F increase above the average annual temperature from 2002–2020 was projected to double the annual number of extreme, single-day spreading wildfires in the western United States (Coop *et al.*, 2022). The interactions among housing development, the growth of tourism in forested areas, and increasing atmospheric dryness suggest that past projections of changing wildfire risk in the West may be underestimates (Rao *et al.*, 2022).

Extreme wildfires often occur when vegetation is dry and weather conditions conducive to fire, including high temperatures, aridity, and wind speeds (Reilly *et al.*, 2022), coincide. These fires can cause widespread loss of structures and the loss of human lives (Abatzoglou *et al.*, 2021b). The 2020 Labor Day fires in the western Cascade Range (Higuera and Abatzoglou, 2021) were enabled in part by a warm and dry summer (as is typical in Oregon) that caused vegetation to dry, strong east winds that carried extremely dry air, and human-caused ignitions.

Human activities have modified fire dynamics in western forests, woodlands, and shrublands through fragmentation and exploitation of these ecosystems; increased recreational activity; the introduction of highly flammable, non-native annual grasses; and replacement of indigenous or lightning-ignited fires by extensive fire suppression and vegetation management. Over one-third (36%) of Morrow County is classified as fire-prone dry shrubland and 14%, mainly in the southern part of the county in the Umatilla National Forest, as evergreen forest (Oregon Explorer, 2023). Thirty-four percent of the county is classified as agricultural (mostly wheat production and cattle pasture) and two percent as urban.

Over 80% of ignitions in the United States are now human-caused (Balch *et al.*, 2017). Morrow County's low population density may affect the relatively low percentage (34%) of ignitions in the county from 2008 through 2019 that were human-caused (Short, 2022). Ignitions from power generation, transmission, or distribution, often due to high winds, have been identified as the cause of many fires in California and the 2020 fire in the western Cascade Range, but lightning is frequent in the mountains in southern Morrow County. Longer summers and human activities have increased the temporal and geographic extent of the fire season (Balch *et al.*, 2017; Bowman *et al.*, 2020; Jones *et al.*, 2022), increasing the probability that an ignition in late summer could spread across large areas.

Management practices likely affected the severity of the 2020 wildfires in Oregon (Allen *et al.*, 2019; Downing *et al.*, 2022). Uniform canopy structure can lead to subcanopy winds that transport moisture out of the watershed (Drake *et al.*, 2022). Crowning and torching associated with dry trees may increase the potential for long-distance spot fires that can cause rapid expansion of the fire front and overwhelm suppression efforts (Rothermel, 1991; Koo *et al.*, 2010; Storey *et al.*, 2020). Firebrands can be carried far by strong winds: in September 2017, embers from the Eagle Creek fire jumped across the Columbia River and started some spot fires on the Washington side.

Duration and Magnitude of Wildfire Risk

The duration of the wildfire season is increasing across the western United States (Dennison *et al.*, 2014; Jolly *et al.*, 2015; Westerling, 2016; Williams and Abatzoglou, 2016), and the duration of the fire weather season in forests of the Northwest increased by 43% from 1979 through 2019 (Jones *et al.*, 2022). Accelerated warming and drying at higher elevations has made wildfire possible in an additional 11% of forests in mountains of the western United States (Alizadeh *et al.*, 2021). Anthropogenic emissions increased the likelihood of extreme fire weather during fall by about 40% over the western United States and about 50% over western Oregon, largely because vegetation in fall is becoming drier and warmer temperatures are coinciding with dry winds (Hawkins *et al.*, 2022). Similarly, the number of days per year on which fire danger was extreme increased by 166% from 1979 through 2019 (Jones *et al.*, 2022). Extreme fire danger was defined as the highest 5% of values of the Canadian Fire Weather Index, which is based on estimates of fuel moisture derived from temperature, precipitation, humidity, and wind (Van Wagner, 1987; Jones *et al.*, 2022).

The Northwest Interagency Coordination Center (gacc.nifc.gov/nwcc/) uses the 100-hour fuel moisture (FM100) index to predict fire danger. FM100 is a measure of the percentage of moisture in dead vegetation of 1–3 inch diameter and is calculated from precipitation, temperature, and relative humidity according to the equations in the National Fire Danger Rating System (Bradshaw *et al.*, 1984). A majority of climate models project that FM100 will decline by the 2050s (2040–2069) under the higher emissions scenario (Gergel *et al.*, 2017), increasing fire danger across Oregon. Projections of the Keetch–Byram Drought Index, a common fire index that is based on the response of vegetation moisture to precipitation and temperature, suggested that within the Northwest, the area with high fire danger in summer will increase by 345% from 1996–2004 to 2086–2094 under the higher emissions scenario (Brown *et al.*, 2021). All of these methods project that in Oregon, the number of summer days with high fire danger will increase through the end of the twenty-first century, particularly in the Cascade Range, Coast Range, and Klamath Mountains (Brown *et al.*, 2021).

Projected Wildfire Risk in Morrow County

Here, we estimate the future change in wildfire risk with two metrics, FM100 and VPD, that are proxies for extreme fire danger, or conditions under which wildfire is likely to spread. We present projected changes in the average annual number of days on which FM100 is very high and VPD is extreme for two future periods, both of which we compare to the historical baseline (1971–2000 average), under two emissions scenarios. We define a day with very high fire danger as one on which the FM100 value (moisture on the forest floor or at the base of other vegetation) is comparable to the lowest (driest) 10% of values within the historical baseline period. Historically, fire danger was very high on 36.5 days per year. By the 2050s under the higher emissions scenario, the average number of days per year on which fire danger is very high in Morrow County is projected to increase by 15 (range -5–38) (Figure 14).

Similarly, we define a day with extreme VPD (dry air) as a day within the warm season (March–October) on which VPD is comparable to the highest (driest) 10% of values within the historical baseline period. Historically, VPD was extreme on 24.5 days per year. Under the higher emissions scenario, the average number of days per year on which VPD is extreme in Morrow County is projected to increase by 30 (range 13–43) by the 2050s (Figure 15).

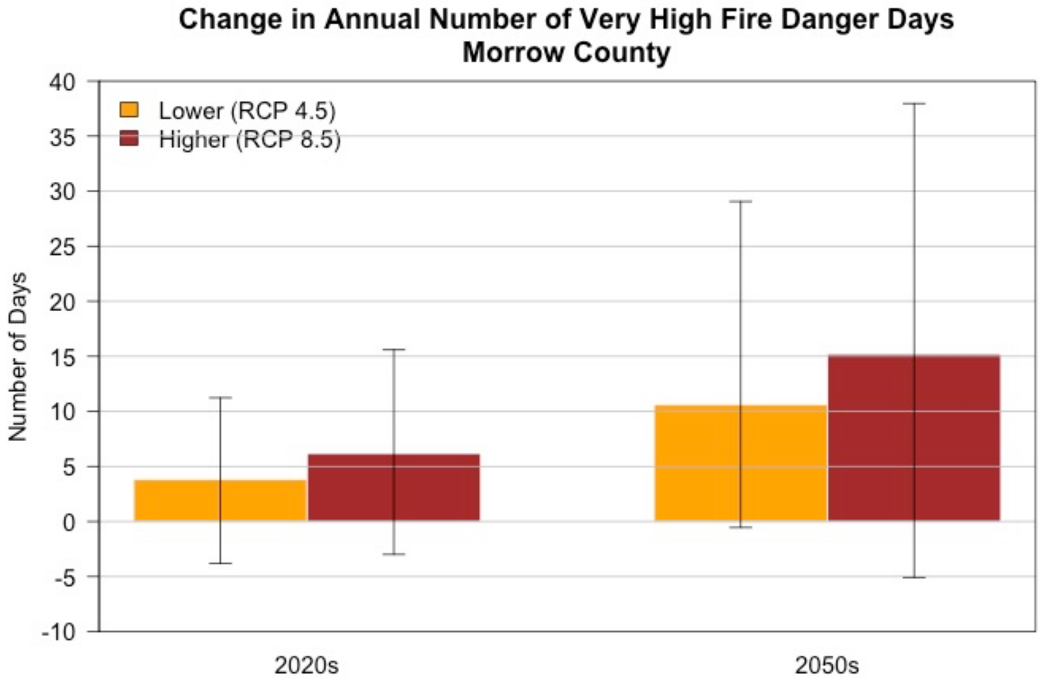

Figure 14. Projected changes by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the 1971–2000 historical baseline and under two emissions scenarios, in the number of days on which fire danger in Morrow County is very high. Changes were calculated for each of 18 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 18 models. Eighteen of the full set of 20 models that were used to project temperature and precipitation included the data necessary to estimate fire danger. (Data source: Climate Toolbox, climatetoolbox.org/tool/Climate-Mapper)

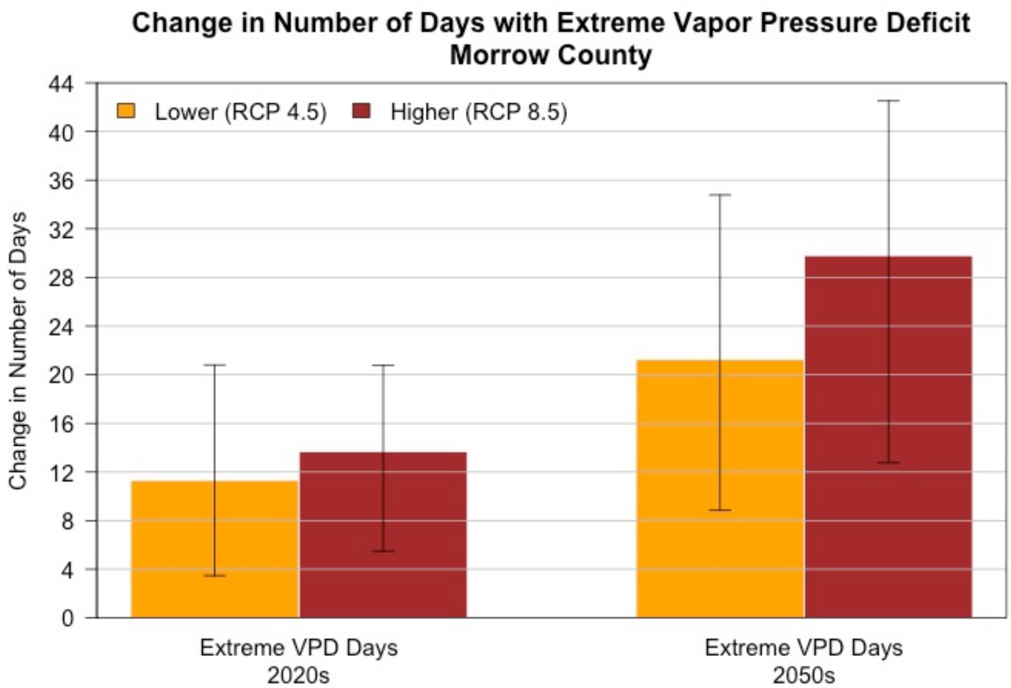

Figure 15. Projected changes by the 2020s (2010–2039 average) and 2050s (2040–2069 average), relative to the 1971–2000 historical baseline and under two emissions scenarios, in the number of days on which vapor pressure deficit in Morrow County is extreme. Changes were calculated for each of 20 global climate models relative to each model's historical baseline, then averaged. Whiskers represent the range of changes across the 20 models. (Data source: Climate Toolbox, climatetoolbox.org/tool/Climate-Mapper)

Summary

Wildfire frequency, intensity, and area burned are projected to continue increasing in the Northwest. Wildfire risk, expressed as the average number of days per year on which fire danger is very high, is projected to increase in Morrow County by 15 days (range -5–38) by the 2050s. The average number of days per year on which vapor pressure deficit is extreme is projected to increase by 30 (range 13–43) by the 2050s.

Reduced Air Quality

Climate change is expected to reduce outdoor air quality. Warmer temperatures may cause an increase in ground-level ozone concentrations, while more numerous and intense wildfires generate higher concentrations of fine particulate matter (particles less than 2.5 micrometers in diameter [$PM_{2.5}$]) and other pollutants (Rohlman *et al.*, 2023). Moreover, increases in pollen abundance and the duration of the pollen season are likely to increase concentrations of airborne allergens.

Poor air quality is expected to exacerbate allergy and asthma conditions and increase the incidence of respiratory and cardiovascular illnesses and death (Fann *et al.*, 2016). Excess asthma events due to $PM_{2.5}$ from wildfire smoke are projected to increase in Oregon by about 42 per 10,000 persons, resulting in a projected increase in cost of more than $250,000 per 10,000 persons (Stowell *et al.*, 2021). Those at high risk of adverse health outcomes as a result of wildfire smoke include people with preexisting conditions, outdoor workers, children, pregnant women, older adults, and rural and tribal communities (York *et al.*, 2020; Ho *et al.*, 2021). Poor air quality and increases in airborne allergens are most likely to affect communities with low incomes, high non-White or farmworker populations, or that are near highways and industrial facilities; outdoor workers; and those with preexisting conditions (York *et al.*, 2020; Ho *et al.*, 2021). Recent and projected estimates of many of these populations are presented in previous sections.

Wildfire Smoke

Over the past several decades, the wildfire season has become longer. Wildfire severity, often defined as the percentage of vegetation mortality within a fire perimeter, also may increase, especially in relatively wet ecosystems and high elevations (Rogers *et al.*, 2011; Creutzburg *et al.*, 2017; Halofsky *et al.*, 2020). These trends are expected to continue as a result of factors including traditional forest management practices (Downing *et al.*, 2022), increasing human population density in areas with high fire risk (Radeloff *et al.*, 2018), and climate change (Sheehan *et al.*, 2015). Wildfire smoke poses a much greater threat, in terms of deaths and total costs to society, than wildfire flames per se (Fleishman, 2023). Wildfire smoke also impairs visibility near ground level and at altitudes where firefighting aircraft and evacuation helicopters fly (Nolte *et al.*, 2018). Hazardous levels of air pollution are most common near wildfires, but extensive fires in the western United States and Canada in recent decades have generated taller plumes of smoke and injected a greater volume of $PM_{2.5}$ at high altitudes, increasing long-range transport of these particulates and posing a health hazard to larger numbers of people both near to and far from those wildfires (Wilmot *et al.*, 2022; Rupp and Holz, 2023).

Wildfires are the primary cause of exceedances of air quality standards for $PM_{2.5}$ in western Oregon and parts of eastern Oregon (Liu *et al.*, 2016), particularly in August and September (Wilmot *et al.*, 2021). Woodstove smoke and diesel emissions, especially under winter inversion layers, also contribute to poor air quality in Oregon (Oregon DEQ, 2016; Liu and Peng, 2019). Fine particulate matter from vehicles, woodstoves, and power plants can be regulated, but it is much more difficult to control wildfires.

Across the western United States, $PM_{2.5}$ concentrations from wildfires are projected to increase 160% by 2046–2051, relative to 2004–2009, under a moderate emissions scenario (SRES A1B) (Liu *et al.*, 2016). The SRES A1B scenario, which is from a generation of emissions scenarios that preceded CMIP5, is most similar to RCP 6.0 (Figure 2). CMIP6 models that were integrated with an empirical statistical model projected that $PM_{2.5}$ concentrations in August and September in the Northwest will double under a lower (SSP5-4.5) emissions scenario and triple under a higher (SSP5-8.5) emissions scenario by 2080–2100 compared to 1997–2020 (Xie *et al.*, 2022). The Oregon Department of Environmental Quality monitors $PM_{2.5}$ during wildfire seasons with the U.S. Environmental Protection Agency's Air Quality Index (AQI), which classifies air quality on the basis of potential health effects. Concentrations of $PM_{2.5}$ from wildfire smoke from June 1 through October 20 began to increase and become less healthy around 2012 (Oregon DEQ, 2023).

Exposure to $PM_{2.5}$ aggravates chronic cardiovascular and respiratory illnesses (Cascio, 2018). In addition, because exposure to $PM_{2.5}$ increases susceptibility to viral respiratory infections, exposure to wildfire smoke is likely to increase susceptibility to and the severity of reactions from COVID-19 (Henderson, 2020). During 2020, in 18 of 19 Oregon counties analyzed, the number of reported COVID-19 cases increased on days with active wildfire smoke (Zhou *et al.*, 2021). Active wildfire smoke was defined as concentrations of $PM_{2.5}$ that exceeded 21 $\mu g\ m^{-3}$, a value within the moderate category of the AQI. Furthermore, wildfire smoke can disrupt outdoor recreational and social activities, in turn affecting physical and mental health (Nolte *et al.*, 2018). For example, on September 11, 2020, Portland's air quality deteriorated to hazardous and was the worst among major cities worldwide, causing many park closures and halting most outdoor activities (Green, 2020).

The negative effects of wildfire smoke extend beyond human health. For example, during the 2020 wildfire season, 62% of Oregon wineries reported not only unhealthy air that delayed harvest but impacts such as ash on grape skins and reduced sunlight that affected the size of grape clusters (IPRE, 2021). Eighteen percent of Oregon wineries reported smoke damage to their wines, with the majority of red wine grape varieties, particularly Pinot Noir, discarded by producers or not harvested (IPRE, 2021). The thin skin of Pinot Noir, Oregon's signature grape, makes smoke exceptionally damaging.

Wildfires emit ozone precursors that in hot and sunny conditions react with other pollutants to increase the concentration of ozone. From 2000 through 2020, the frequency, duration, and area of co-occurrence of $PM_{2.5}$ and ozone increased in the western United States (Kalashnikov *et al.*, 2022), including the Pacific Northwest (Buchholz *et al.*, 2022). The population exposed to persistent extreme $PM_{2.5}$ and ozone levels in the West increased by 25 million person-days per year over the period 2001–2020 (Kalashnikov *et al.*, 2022; Rupp and Holz, 2023).

Projected Changes in Air Quality in Morrow County

We present projections of future air quality that are based on $PM_{2.5}$ from wildfire smoke. Smoke wave days are defined as two or more consecutive days on which simulated, county-averaged, wildfire-derived $PM_{2.5}$ values are in the highest 2% of simulated daily values from 2004 through 2009 (Liu *et al.*, 2016). Smoke wave intensity is defined as the concentration of $PM_{2.5}$ on smoke wave days. Liu *et al*. (2016) projected mean number of smoke wave days and mean smoke wave intensity for two six-year periods, 2004–2009 and 2046–2051, under a moderate emissions scenario. More information about their methods is in the appendix. The number of smoke wave days in Morrow County is projected to increase by 150% and the intensity of smoke on those days is projected to increase by 108% (Figure 16).

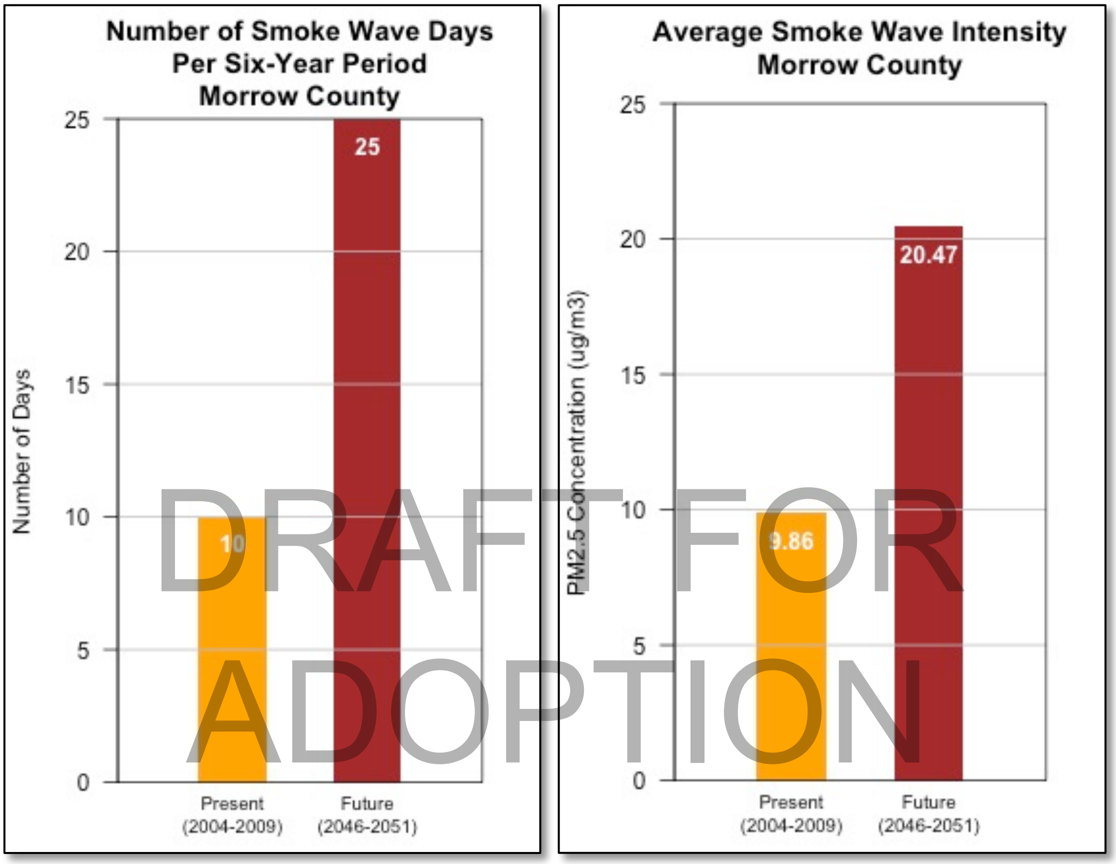

Figure 16. Simulated present (2004–2009) and future (2046–2051) number (left) and intensity (right) of smoke wave days in Morrow County under a moderate emissions scenario. Values represent the average among 15 global climate models. (Data source: Liu et al. 2016, khanotations.github.io/smoke-map/)

Allergens and Other Airborne Organic Materials

Many plants are responding to changes in climate and atmospheric concentrations of carbon dioxide by producing more pollen, and by producing it earlier in spring and for longer periods of time (Ziska *et al.*, 2009). From 1990 through 2018, the duration of pollen seasons increased by about 20 days and pollen concentration increased by 21% in the conterminous United States (Anderegg *et al.*, 2021), including northern California (Paudel *et al.*, 2021).

Fungal spores could also become more abundant following extreme floods or droughts, which are expected to become more common. The period during which outdoor airborne mold spores are detectable increased in the last 20 years as a result of increasing concentrations of carbon dioxide and changes in climate and land use (Paudel *et al.*, 2021). Furthermore, because both ozone and fine particulate matter affect the sensitivity of respiratory systems to airborne allergens, the combined effects of climate change, air pollution, and changes in vegetation phenology will likely increase the severity of respiratory diseases and allergies (D'Amato *et al.*, 2020).

Summary

Climate change is expected to reduce outdoor air quality. The risks to human health from wildfire smoke in Morrow County are projected to increase. From 2004–2009 to 2046–2051, under a moderate emissions scenario, the number of days per year with poor air quality due to elevated concentrations of wildfire-derived fine particulate matter is projected to increase by 150%. The concentration of fine particulate matter on those days is projected to increase by 108%.

Loss of Wetlands

In the United States, wetlands are defined under the Clean Water Act as “areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.” Wetlands also may be associated with the edges of lakes and with streams and rivers (Halofsky *et al.*, 2019).

Wetlands and their associated plants and animals are likely to be affected by increases in air temperature, which generally are correlated with increases in freshwater temperature; decreases in snowpack and summer stream flows; and increases in evapotranspiration (Lee *et al.*, 2015). Projected effects in the Northwest include reductions in water levels and hydroperiod duration, and may be most pronounced in wetlands that become temporary in dry years (Lee *et al.*, 2015). Wetlands along low-gradient, wide valley bottoms that are dominated by riparian trees and understory species may be most susceptible to decreases in flow and water volume, in part because recruitment of some riparian plant species depends on seasonal flooding (Dwire *et al.*, 2018). Wetlands that are fed primarily by ground water may have more consistent temperature, water chemistry, and water levels than wetlands that are fed primarily by surface water (Halofsky *et al.*, 2019). However, effects of climate change on ground water aquifers that are recharged by snowpack are uncertain (Dwire *et al.*, 2018). Moreover, where increasing aridity leads to greater demand for ground water, decreases in ground water availability may affect wetlands.

The U.S. Department of Agriculture’s Natural Resources Conservation Service offers financial assistance opportunities for farmers, ranchers, and forest owners in Morrow County to conserve wetlands. As of 2020, riparian buffers were installed on 1188 acres (481 hectares) in Morrow County that were enrolled in the U.S. Department of Agriculture Farm Service Agency’s Conservation Reserve Program. This voluntary, public–private partnership provides financial incentives and payments for restoration of wetlands and riparian ecosystems in agricultural areas. The intent of the program is to establish riparian buffers that will shade rivers and streams, protect water quality, provide habitat for riparian- and stream-associated animal species, prevent erosion, and reduce the likelihood of downstream flooding.

The 2016 Oregon Conservation Strategy (www.oregonconservationstrategy.org), developed by the Oregon Department of Fish and Wildlife, includes the Boardman Area as a conservation opportunity area that can contribute meaningfully to achieving goals for conservation of wetland- and riparian-associated aquatic and terrestrial animals. The Boardman Area includes lands near the Boardman Conservation Area and Willow Creek Wildlife Area, and is noted for its high densities of breeding Long-billed Curlew (*Numenius americanus*). The East Cascades Audubon Society also highlights bird communities in riparian areas at Ruggs, Willow Creek Reservoir, and Willow Creek Road.

Summary

Projected effects of climate change on wetlands in the Northwest include reductions in water levels and hydroperiod duration. If withdrawals of ground water do not increase, then wetlands that are fed by ground water rather than surface water may be more resilient to climate change.

Windstorms

Wind patterns in the northwestern United States affect natural disturbances, public health, and multiple sectors. For example, variability in wind speed affects generation of wind power and, via downed power lines, the reliability of electricity transmission. Changes in wind speed and direction also affect the safety of transportation by air, land, and sea and the spread of wildfires and pollutants, including wildfire smoke and allergens. In Oregon, average near-surface wind speeds are expected to decrease slightly in response to global climate change (Pryor *et al.*, 2012; Jeong and Sushama, 2019; Chen, 2020; Mass *et al.*, 2022). However, a decrease in the average wind speed may not translate to a decrease in the speed of strong winds. Although projections are highly uncertain, climate models tend to agree that the magnitude of extreme wind speed will increase in western Oregon (Pryor *et al.*, 2012; Jeong and Sushama, 2019). Such increases are not projected in eastern Oregon. An extreme wind refers to an annual maximum wind speed with a given average return period, such as 20 or 50 years (annual exceedance probability of 5% or 2%, respectively).

Oregon's location accounts for some of the uncertainty in the response of strong winds to human-caused emissions of greenhouse gases. The state's most severe windstorms occur from October through April and are associated with extratropical cyclones (cyclones that occur from 30–60˚ latitude) (Read, 2003, 2007; Mass and Dotson, 2010). Future changes in wind speeds in extratropical cyclones are expected to be small, but the projected poleward shift in the tracks of these cyclones could lead to substantial changes in extreme wind speeds in some regions (Seneviratne *et al.*, 2021). One study indicated that by 2081–2099 relative to 1981–1999, assuming the higher emissions scenario, extratropical cyclones that generate severe winds will shift northward by an average of 2.2° over the North Pacific Ocean (Seiler and Zwiers, 2016). Therefore, these extratropical cyclones will become more frequent north of 45°N and less frequent and weaker south of 45°N. Oregon lies between about 42˚N and 46˚N. Accordingly, although Seiler and Zwiers (2016) did not examine the landfall location of severe cyclones, it is uncertain whether the frequency of severe landfalling extratropical cyclones and the distribution of wind speeds will change in Oregon.

The intensity of strong offshore (easterly) winds, which are most common in summer and in fall before the onset of the rainy season, typically is lower than that of winter windstorms. Nevertheless, offshore winds play a major role in summer heat waves in Oregon, including the record-breaking June 2021 heat wave (Chang *et al.*, 2021), because they displace cooler marine air west of the Cascade Range (Brewer and Mass, 2016). Projections from global climate models, assuming the higher emissions scenario, suggest a decrease in the frequency of strong offshore winds over western Oregon and Washington in July and August, with about a 50% reduction from 1970–1999 to 2071–2100 in the number of days with easterly wind speeds greater than approximately 11 miles per hour (5 meters per second) measured at approximately 5000 feet (1.5 km or 850-hPa) above Earth's surface (Brewer and Mass, 2016).

Easterly winds were key drivers of the largest wildfires on record in western Oregon, including the 2020 Labor Days fires (Abatzoglou *et al.*, 2021b; Mass *et al.*, 2021; Reilly *et al.*, 2022). The results of regional climate models that accounted for topographic effects on wind indicated that from the preindustrial to the current era, the frequency of fall (September through November) easterly winds along the Cascade Range in Oregon decreased by about 2% (Hawkins *et al.*, 2022). The latter research defined easterly winds as those with horizontal speeds of at least 13 meters per second (approximately 29 miles per hour) and downward speeds of at least 0.6 Pascals per second (at 32°F, approximately 2 inches per second or 10 feet per minute), both measured at 10,000 feet (700 hPa) above Earth's surface, and near-surface relative humidity no greater than 30%. By the year 2099 relative to 1970, assuming the higher emissions scenario, the frequency of 10-meter (approximately 33 feet) easterly winds with a daily maximum speed exceeding 3.4 meters per second (7.6 miles per hour), which is one standard deviation above the average wind speed, decreased modestly west of the Cascade Range (Mass *et al.*, 2022). For example, in Alpine, Washington, the annual number of days with such winds decreased from 15 to 11 (Mass *et al.*, 2022).

Understanding of how anthropogenic emissions may affect local winds in Oregon remains limited. Due to their coarse spatial resolution, global climate models and all but the highest-resolution regional climate models cannot adequately simulate mountain slope, valley, and coastal winds, sea breezes, and winds associated with mesoscale convective systems (Doblas-Reyes *et al.*, 2021). Large numbers of simulations from multiple high-resolution (1 to 10 km [0.6 to 6 mi]) regional climate models ultimately will be required to estimate changes in these types of winds across Oregon with high confidence.

Summary

Wind patterns affect provision of electricity, transportation safety, and the spread of wildfires and pollutants. Mean wind speeds in Oregon are projected to decrease slightly, but extreme winter wind speeds may increase, especially in western Oregon. The frequency of strong easterly winds during summer and fall, however, is projected to decrease slightly.

Expansion of Non-native Invasive Species

Changes in climate and atmospheric concentrations of carbon dioxide can affect the distribution and population dynamics of native and non-native species of animals and plants that are considered to be invasive or pests in natural and agricultural systems. Species-environment relations are not static (MacDonald, 2010; Walsworth *et al.*, 2019). Therefore, even when the current ecology of a species is well understood, it often is difficult to predict with confidence how the species will respond to projected changes in climate, especially when climate change interacts with land-use change or other environmental changes. Species adapt not only in response to climate change but in response to all types of environmental change, including management actions (Thomas *et al.*, 1979; Skelly *et al.*, 2007; Winter *et al.*, 2016). These responses may be rapid, on the order of years or decades, particularly among organisms with short generation times (Boughton, 1999; MacDonald *et al.*, 2008; Willis and MacDonald, 2011; Singer, 2017). Adaptive capacity also is affected by whether individuals can move freely or whether habitat fragmentation and other barriers impede movement (Thorne *et al.*, 2008; Willis and MacDonald, 2011; Fleishman and Murphy, 2012). Monocultures, dense populations, and even-aged populations of animals or plants generally are more susceptible to pests and pathogens than individuals in areas with higher species richness or populations with greater demographic diversity.

The Morrow County Weed Advisory Board classifies 17 species of non-native invasive plants as noxious weeds and an additional 19 species as weeds of economic importance (Table 16). Noxious weeds are any plant determined by the weed advisory board, and declared by the county's Board of Commissioners, to be injurious to public health, crops, livestock, land, or property and mandated for control. Weeds of economic importance are those with limited distribution in the county and targeted for intensive control or eradication where feasible. Although little is known about how many of these species may to respond to climate change, some evidence suggests how others may be affected. In general, non-native invasive plants in Morrow County are likely to become more prevalent in response to projected changes in climate. However, many of these responses are uncertain, and are likely to vary locally. Moreover, the responses may change over time.

Table 16. Noxious weeds and weeds of economic importance as designated by the Morrow County Weed Advisory Board.

Noxious weeds	Growth form
Common crupina (*Crupina vulgaris*)	Annual forb
Dalmatian toadflax (*Linaria dalmatica*	Perennial forb
Flowering rush (*Butomus umbellatus*)	Perennial aquatic
Houndstongue (*Cynoglossum officinale*)	Biennial or short-lived perennial forb
Leafy spurge (*Euphorbia esula*)	Perennial forb
Mediterranean sage (*Salvia aethiopis*)	Biennial forb
Musk thistle (*Carduus nutans*)	Biennial forb
Plumeless thistle (*Carduus acanthoides*)	Biennial forb
Purple loosestrife (*Lythrum salicaria*)	Perennial forb
Rush skeletonweed (*Chondrilla juncea*)	Perennial forb

Scotch thistle (*Onopordum acanthium*)	Annual or biennial forb
Spikeweed (*Centromadia pungens*)	Annual forb
Tansy ragwort (*Senecio jacobaea*)	Biennial or short-lived perennial
Whitetop (hoary cress) (*Lepidium draba*)	Perennial forb
Yellow flag iris (*Iris pseudocorus*)	Perennial aquatic
Yellow toadflax (*Linaria vulgaris*)	Perennial forb
Yellow starthistle (*Centaurea solstitalis*)	Annual forb
Weeds of economic importance	**Growth form**
Canada thistle (*Cirsium arvense*)	Perennial forb
Cereal rye (*Secale cereale*)	Annual grass
Diffuse knapweed (*Centaurea diffusa*)	Biennial forb
Field bindweed (*Convolvulus arvensis*)	Perennial forb
Field dodder (*Cuscuta* spp.)	Annual vine
Johnsongrass (*Sorghum halepense*)	Perennial grass
Jointed goatgrass (*Aegilops cylindrica*)	Annual grass
Kochia (*Bassia scoparia*)	Annual forb
Medusahead rye (*Taeniatherum canput-medusae*)	Annual grass
Myrtle spurge (*Euphorbia myrsinites*)	Perennial forb
Perennial pepperweed (tall whitetop) (*Lepidium latifolium*)	Perennial forb
Perennial sowthistle (*Sonchus arvensis*)	Perennial forb
Poison hemlock (*Conium maculatum*)	Biennial forb
Puncturevine (*Tribulus terrestris*)	Annual forb
Russian knapweed (*Acroptilon repens*)	Perennial forb
Spotted knapweed (*Centaurea stoebe*)	Short-lived perennial forb
St. Johns wort (*Hypericum perforatum*)	Perennial forb
Ventenata (*Ventenata dubia*)	Annual grass
Water hemlock (*Cicuta douglasii*)	Perennial forb

Carbon Dioxide, Nitrogen, and Ozone Concentrations

Increasing concentrations of carbon dioxide affect some plants' primary productivity, water-use efficiency, and nutrient content. Increases in photosynthesis in response to increases in carbon dioxide are more common in plants with C3 metabolism than in plants with C4 metabolism. C4 metabolism has evolved multiple times, usually as an adaptation to hot, dry climate. Plants with C4 metabolism lose considerably less water per unit of carbon dioxide absorbed, and tend to photosynthesize more efficiently, than plants with C3 metabolism. By contrast, tolerance of the herbicide glyphosate tends to increase more in C4 plants, including kochia, than in C3 plants as carbon dioxide increases (Chen *et al.*, 2020).

Experiments suggested that the photosynthetic rate and biomass of Canada thistle, and the number and length of the species' spines, are likely to increase as ambient concentrations of carbon dioxide increase throughout the twenty-first century, and may have increased during the twentieth century (Ziska, 2002). Whether the root biomass of Canada thistle responds positively to increases in carbon dioxide concentrations, especially independent of increases in temperature, is unclear (Ziska *et al.*, 2004; Tørresen *et al.*, 2020), and may vary in space.

Changes in climate, ongoing human additions of nitrogen to the environment, and their interactions affect the growth and competitive relations among plant and animal species (Greaver *et al.*, 2016). The competitive advantage of non-native forbs and grasses over native species of plants may be strongest in relatively warm and dry areas, which often coincide with lower elevations (Dodson and Root, 2015). Additionally, non-native invasive plants generally gain a competitive advantage from nitrogen deposition. For example, the size of yellow starthistle plants increased substantially in response to experimentally increased nitrogen deposition, whereas co-occurring native plants responded less strongly (Dukes *et al.*, 2011). How field experiments with supplemental nitrogen relate to changes in nitrogen deposition or availability as a result of climate change is uncertain.

As tropospheric concentrations of ozone continue to increase, productivity of native and agricultural plants generally is expected to decrease. However, ozone tolerance in weedy, vegetatively reproducing species may increase relatively quickly, allowing them to gain a competitive advantage over some crops (Grantz and Shrestha, 2006).

Heat

Many non-native invasive plants tolerate high temperatures, but responses to interactions between temperature and other climate variables can be complex. For example, the flowering phenology of purple loosestrife, which readily colonizes wetlands, is adapted to the duration of the growing season. At northern latitudes, including Oregon, purple loosestrife flowers early, at a small size; at southern latitudes, it flowers later, at a larger size (Colautti and Barrett, 2013). Early flowering limits reproductive growth of purple loosestrife, and northern plants generally produce fewer seeds and have less population-level genetic variation than southern plants (Colautti *et al.*, 2010). Climate change is expected to prolong the growing season, and therefore to increase the long-term viability of purple loosestrife, although local adaptation may be relatively slow due to genetic constraints of flowering time (Colautti *et al.*, 2010, 2017).

Precipitation

Changes in the amount and timing of precipitation may contribute to expansion or contraction of different non-native invasive plants. Normal to high precipitation can decrease the viability of certain non-native invasive plants, at least in some contexts. In forests in western Oregon, occurrence of Canada thistle was associated negatively with annual precipitation (Gray, 2005).

Spotted knapweed may be outcompeted by some native grasses (e.g., bluebunch wheatgrass [*Pseudoroegneria spicata*]) during drought, but may have a competitive advantage when precipitation is closer to average (Pearson *et al.*, 2017). Monocultures of spotted knapweed appear to be less affected by drought (Pearson *et al.*, 2017).

Yellow starthistle is somewhat sensitive to drought and can be outcompeted by natives that are more tolerant of dry conditions (Dlugosch *et al.*, 2015; Young *et al.*, 2017). Whether drought limits vegetative growth of purple loosestrife is unclear. Increased spring temperatures and decreased precipitation associated with the El Niño–Southern Oscillation in some parts of the species' range were associated with early flowering and aboveground biomass accumulation, but not with total aboveground biomass, inflorescence lengths (an indicator of reproductive output), or timing of senescence (Dech and Nosko, 2004).

Wildfire and Other Disturbances

The density and distribution of weedy plants tends to increase in response to ground disturbance, whether from wildfire, livestock grazing, recreational activities, or removal of overstory trees and shrubs. Some non-native plants also contribute to a positive feedback cycle by increasing the probability of disturbances that facilitate their population growth. For example, the rapid expansion of ventenata grass and other non-native invasive grasses has increased fine-fuel biomass and spatial continuity of fuels in sagebrush-dominated ecosystems (Kerns *et al.*, 2020; Tortorelli *et al.*, 2020). Canada thistle can establish readily in soils that have been disturbed by high-severity wildfires or by logging (Reilly *et al.*, 2020).

Summary

In general, non-native invasive plants in Morrow County are likely to become more prevalent in response to projected increases in temperature and the frequency, duration, and severity of drought. However, many of these responses are uncertain, are likely to vary locally, and may change over time.

Appendix

We projected future climate and hydrology on the basis of outputs from twenty global climate models (GCM) and two emissions scenarios (Representative Concentration Pathway [RCP] 4.5 and RCP 8.5) from the fifth phase of the Coupled Model Intercomparison Project (CMIP5) (Table A1).

Table A1. The 20 global climate models (GCMs) from the fifth phase of the Coupled Model Intercomparison Project (CMIP5) represented in this report. Asterisks (*) indicate the ten GCMs used as inputs to the Variable Infiltration Capacity hydrological model in the Integrated Scenarios of the Future Northwest Environment project. Carets (^) indicate the GCMs that do not include daily relative humidity.

Model Name	**Modeling Center**
BCC-CSM1-1	Beijing Climate Center, China Meteorological Administration
BCC-CSM1-1-M*	
BNU-ESM	College of Global Change and Earth System Science, Beijing Normal University, China
CanESM2*	Canadian Centre for Climate Modeling and Analysis
CCSM4*^	National Center for Atmospheric Research, USA
CNRM-CM5*	National Centre of Meteorological Research, France
CSIRO-Mk3-6-0*	Commonwealth Scientific and Industrial Research Organization/Queensland Climate Change Centre of Excellence, Australia
GFDL-ESM2G	NOAA Geophysical Fluid Dynamics Laboratory, USA
GFDL-ESM2M	
HadGEM2-CC*	Met Office Hadley Center, UK
HadGEM2-ES*	
INMCM4	Institute for Numerical Mathematics, Russia
IPSL-CM5A-LR	Institut Pierre Simon Laplace, France
IPSL-CM5A-MR*	
IPSL-CM5B-LR	
MIROC5*	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies, Japan
MIROC-ESM	
MIROC-ESM-CHEM	

MRI-CGCM3	Meteorological Research Institute, Japan
NorESM1-M*^	Norwegian Climate Center, Norway

MACA Downscaling

The coarse horizontal resolution of the GCM outputs (100–300 km) was statistically downscaled to a resolution of about 6 km with the Multivariate Adaptive Constructed Analogs (MACA) statistical downscaling method, which is skillful in complex terrain (Abatzoglou and Brown, 2012). A detailed description of the MACA method is at climate.northwestknowledge.net/MACA/MACAmethod.php. The MACA method uses gridded observational data to train the downscaling. It applies bias corrections and matches the spatial patterns of observed coarse-resolution to fine-resolution statistical relations. The downscaled variables include daily maximum and minimum temperature, maximum and minimum relative humidity, specific humidity, precipitation, wind, and downward solar radiation at the surface from 1950 through 2099. All simulated climate data were bias-corrected with quantile mapping, which adjusts simulated values by comparing the cumulative probability distributions of simulated and observed values. In practice, the simulated and observed values of a variable over the historical time period are sorted and ranked, and each value is assigned a probability of exceedance. The bias-corrected value of a given simulated value is assigned the observed value that has the same probability of exceedance as the simulated value. The historical bias in the simulations is assumed to be constant. Therefore, the relations between simulated and observed values in the historical period were applied to the future scenarios. Climate data in the MACA outputs reflect quantile mapping relations for each non-overlapping 15-day window in the calendar year.

Climate and Fire Danger Variables

We used MACA-downscaled minimum and maximum temperature and precipitation data to characterize heat waves, cold waves, and heavy precipitation. We characterized wildfire risk on the basis of vapor pressure deficit (VPD) and 100-hour fuel moisture (FM100), which were computed by the Integrated Scenarios of the Future Northwest Environment project (climate.northwestknowledge.net/IntegratedScenarios/) with the MACA climate variables according to the equations in the National Fire Danger Rating System (Bradshaw *et al.*, 1984). FM100 projections are only available for 18 GCMs because two models (CCSM4 and Nor-ESM1-M) do not include relative humidity at a daily time step. Calculation of FM100 requires daily relative humidity data.

Hydrological Simulations and Variables

The Integrated Scenarios project used MACA downscaled climate data as the inputs to their simulations of hydrology, which they ran with the Variable Infiltration Capacity (VIC) hydrological model (VIC version 4.1.2.l; Liang *et al.*, 1994 and updates). VIC was applied to ten GCMs and run on a 1/16° x 1/16° (6 km) grid (Table A1). We used the hydrological simulations of snow water equivalent (SWE), runoff, and soil moisture to project drought. The Integrated Scenarios project bias-corrected hydrology variables (except SWE) for each month with quantile mapping. The project estimated daily streamflow by routing daily runoff from VIC grid cells to selected locations along the stream network. Where records of naturalized flow were available, the daily streamflow estimates were bias-corrected for each month with quantile mapping. As a result, their statistical distributions matched those of the naturalized streamflows. We used streamflow data from the Integrated Scenarios project to characterize changes in the timing of seasonal streamflow, which affects the likelihood of drought and flooding, and changes in extreme flood magnitudes.

Air Quality Data

Our projections of air quality are based on smoke wave data from Liu et al. (2016), which are available at khanotations.github.io/smoke-map/. We used two variables, "Total # of SW days in 6 yrs" and "Average SW Intensity". The former is the number of days within each time period on which the concentration of fine particulate matter ($PM_{2.5}$), averaged within the county, exceeded the 98th quantile of the distribution of daily, wildfire-specific $PM_{2.5}$ values from 2004 through 2009 (smoke wave days). The latter is the average concentration of $PM_{2.5}$ across smoke wave days within each time period. Liu et al. (2016) used 15 GCMs from the third phase of the Coupled Model Intercomparison Project under a moderate emissions scenario (SRES-A1B) as inputs to a fire prediction model and the GEOS-Chem three-dimensional global chemical transport model. The available data include only the multiple-model mean value (not the range), which should be interpreted as the direction of projected change rather than the actual expected value.

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