MOUNT RAINIER NATIONAL PARK WILDERNESS MINIMUM REQUIREMENTS WORKSHEET

Project Title:	Mount Rainier Lahar Detection System Expansion **Draft**

MRDG Step 1: Determination

*Determine if Administrative Action is **Necessary***

Description of the Situation
What is the situation that may prompt administrative action?

Mount Rainier is an active volcano located in Mount Rainier National Park (MORA or park) near the growing Seattle-Tacoma metropolitan area.

The uniquely rugged and dynamic nature of the landscape in MORA is among the most beautiful in the National Park system. However, that same landscape also produces some of the greatest measurable hazards in North America. Mount Rainier has experienced episodic volcanic activity throughout its approximately 500,000-year history. Geologists have found evidence for a number of eruptions over the last 6,000 years, most recently 1,000 years before present. They have also found evidence for at least eight large lahars (or volcanic mudflows) produced by eruptions at the summit that reached into areas of the Puget Lowlands that today are populated by thousands of people. In addition, a ninth large lahar (the "Electron Mudflow") that occurred around 1500 A.D. and reached into areas now occupied by Orting and Sumner was initiated by a landslide, not an eruption.

Recent geologic and geophysical studies have found evidence of weak rock on the western flank around Sunset Amphitheater of Mount Rainier, suggesting that a future landslide-caused lahar down the Puyallup and/or Nisqually Rivers is a potential hazard that needs to be taken into account in addition to hazards associated with lahars that may be triggered by future eruptions of the volcano. Since the onset of landslides is inherently unpredictable, it is conceivable that a collapse-driven lahar like the Electron Mudflow could occur with little or no warning. In such an event, recent modeling indicates that a large lahar could reach Orting within 60 minutes along the Puyallup River, the Nisqually entrance to MORA within 10 minutes, and parts of Ashford within 20. In such a scenario, the principal mitigation strategy is to have a lahar detection system in place that can provide alerts to emergency managers and park personnel to provide as much time as possible for potentially affected populations to evacuate to high ground before a lahar arrives and to inform emergency response needs. To provide reliable early warning in the event of future volcanic unrest and eruption, the United States Geological Survey (USGS) issued a recommendation in 2008 that Very High Threat volcanoes like Mount Rainier should have 12-20 seismic and Global Positioning System (GPS) stations located within 20 kilometers of the summit. The actual number of required stations within that broad range depends on many factors that are specific to each volcano, especially the size of the volcano. For example, to achieve the same capabilities at Mount Rainier as at Mount St. Helens, more stations would be required because Mount Rainier is a larger volcano. In addition to the need to improve the volcano monitoring capabilities of the Mount Rainier volcano monitoring network, the capability to rapidly detect debris flows and lahars without producing false alarms is needed so that authorities inside and outside the park have as much time to act as possible to get people out of harm's way.

Lastly, Mount Rainier is the most heavily glaciated peak in the lower 48 and presents an unparalleled natural laboratory for the study of volcanic and glacial processes. As glaciers recede, unpredictable events such as glacial outburst floods may become more frequent in all park drainages. Such events threaten park infrastructure, including roads, trails, bridges, campgrounds, administrative areas, and other facilities, and pose a hazard to park visitors. Little is known about the initiation and propagation of these smaller events, but they are a key consideration in planning for sustainable visitor access to the park, its facilities, and recreational opportunities in wilderness. Research on processes in Mount Rainier has applications around the world, wherever similar geologic and volcanic features threaten the built environment and downstream communities.

As of December 2020, the Mount Rainier network of monitoring stations consists of 18 seismic and 6 GPS installations located within 20 kilometers (12 miles) of the summit, including 13 seismic and 6 GPS sites inside the park (some seismic and GPS stations are collocated; there are 13 total volcano monitoring sites in MORA). Five of these sites are in designated wilderness. The current network has been sited and equipped to monitor unrest associated with a volcanic eruption and detect large lahars on several major drainages at points near the park boundaries (more detail on the drainages can be found in the EA, page 4). However, real-time information that would be critical for early detection and tracking of Lahars and debris flows, including which drainages are affected, the volume of material, how fast it is moving, how far it will go downstream, and how soon it might reach residential areas, is not available from the existing network, nor is the ability to detect a spontaneous collapse-driven lahar in the higher risk area of weak rock on the western flank around Sunset Amphitheater of Mount Rainier.

Options Outside of Wilderness
Can action be taken outside of wilderness that adequately addresses the situation?

☐ YES	**STOP – DO NOT TAKE ACTION IN WILDERNESS**
☒ NO	**EXPLAIN AND COMPLETE STEP 1 OF THE MRDG**

Explain:
The existing volcano monitoring network would be unable to detect lahar events until several minutes after they initiate, and the impacted drainage would be more difficult to discern in a timely manner, meaning that events would impact use areas in the park with effectively no warning, and the warning time would be delayed for areas outside the park.

The improvements to lahar detection necessary for emergency managers to initiate evacuation of visitors and staff inside the park, as well as for residential areas near the park entrance, could not be gained by adding more monitoring stations outside of wilderness. In particular, infrasound instruments, which have been shown to be effective in detecting subaudible sound waves created by moving surface flows such as debris flows and lahars, can be significantly disrupted by topography, so multiple stations within each drainage are needed for reliable detection. Real-time data from stations is sent by digital radio signal, which requires line-of-sight to radio repeaters on high points around the drainages of interest. Most of these high points are also in designated wilderness.

Criteria for Determining Necessity
Is action necessary to meet any of the criteria below?

A. Valid Existing Rights or Special Provisions of Wilderness Legislation

*Is action necessary to satisfy valid existing rights or a special provision in wilderness legislation (the Wilderness Act of 1964 or subsequent wilderness laws) that **requires** action? Cite law and section.*

☐ YES ☒ NO

B. Requirements of Other Legislation

*Is action necessary to meet the requirements of **other federal laws**? Cite law and section.*

☒ YES ☐ NO

Explain:

John D. Dingell, Jr. Conservation, Management, and Recreation Act of 2019, Title V-Hazards and Mapping, Section 5001. National Volcano Early Warning and Monitoring System.

This legislation directs the USGS to establish a national volcano early warning and monitoring system. The legislation states that Secretary of the Interior “shall establish within the United States Geological Survey a system, to be known as the National Volcano Early Warning and Monitoring System, to monitor, warn, and protect citizens of the United States from undue and avoidable harm from volcanic activity.” The purposes of the volcanic monitoring system are to organize, modernize, standardize, and stabilize the monitoring systems of the volcano observatories in the United States, including the Cascades Volcano Observatory; and to unify the monitoring systems of volcano observatories in the United States into a single interoperative system.

The objective of the system is to monitor all the volcanoes in the United States at a level commensurate with the threat posed by the volcanoes by (1) upgrading existing networks on monitored volcanoes, (2) installing new networks on unmonitored volcanoes, and (3) employing geodetic and other components. Modernization activities under the system shall include the comprehensive application of emerging technologies, including digital broadband seismometers, real-time continuous GPS receivers, satellite and airborne radar interferometry, acoustic pressure sensors, and spectrometry to measure gas emissions.

Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act)

The Stafford Act is a 1988 amended version of the Disaster Relief Act of 1974. Section 202(a) states that "the President shall insure that all appropriate Federal agencies are prepared to issue warnings of disasters to State and local officials." In addition, Section 202(b) states that "the President shall direct appropriate Federal agencies to provide technical assistance to State and local governments to insure that timely and effective disaster warning is provided." The director of the USGS, through the Secretary of the Interior, has been delegated the responsibility to issue disaster warnings "for an earthquake, volcanic eruption, landslide, or other geologic catastrophe."

Earthquake Hazards Reduction Act of 1977

The Earthquake Hazards Reduction Act of 1977 sets as a national goal the reduction in the risks of life and property from future earthquakes in the United States through the establishment and maintenance of a balanced earthquake program encompassing prediction and hazard assessment research, seismic monitoring, and information dissemination. P.L. 101-614 reauthorizes the act.

C. Wilderness Character

Is action necessary to preserve one or more of the five qualities of wilderness character?

UNTRAMMELED

☐ YES ☒ NO

UNDEVELOPED

☐ YES ☒ NO

NATURAL

☐ YES ☒ NO

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

☐ YES ☒ NO

OTHER FEATURES OF VALUE

☐ YES ☒ NO

Step 1 Determination
*Is administrative action **necessary** in wilderness?*

Criteria for Determining Necessity

A. Existing Rights or Special Provisions	☐ YES	☒ NO
B. Requirements of Other Legislation	☒ YES	☐ NO
C. Wilderness Character		
Untrammeled	☐ YES	☒ NO
Undeveloped	☐ YES	☒ NO
Natural	☐ YES	☒ NO
Solitude/Primitive/Unconfined	☐ YES	☒ NO
Other Features of Value	☐ YES	☒ NO

Is administrative action **necessary** in wilderness?

☒ YES **EXPLAIN AND COMPLETE STEP 1 OF THE MRDG**

☐ NO **STOP – DO NOT TAKE ACTION IN WILDERNESS**

Explain:
The USGS is proposing a substantial upgrade to the present-day volcano monitoring network at Mount Rainier. The upgrade would improve the capabilities to detect unrest leading to an eruption (following the standards put forward in the NVEWS (National Volcanic Early Warning System), pursuant to Title II of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988) and would enable the capability to detect a large lahar within minutes of initiation,

with particular focus on a landslide-generated lahar down the Puyallup River and Tahoma Creek drainages.

The USGS is proposing to install modern monitoring stations that consist of multiple types of sensors in order to provide early detection capabilities of surface events such as lahars, debris flows, and outburst floods. Prioritizing the rapid detection of such events is intended to enable the NPS and the USGS to provide warning to areas of impact and initiate a response to the events as they are happening rather than minutes or hours after the fact.

In addition to the less-frequent large lahars, data collected using stations in the proposed network would also be useful in detecting smaller debris flows and outburst floods in Tahoma Creek and elsewhere in the park, which is important for both situational awareness and hazard mitigation in the park. The Tahoma Creek drainage itself has experienced over 33 debris flows since 1967, making it both a high-input management area due to the Westside Road and an excellent natural laboratory to further scientific understanding of debris flows. Recordings of debris flows are also important to the broader scientific community, as recordings of such flows on multiple high-quality stations are relatively rare and would help our understanding of their initiation and dynamics. The proposed network would also provide a long-term backbone for denser temporary deployments of instrumentation that would provide even higher-fidelity datasets that are critical for informing models of debris flow generation and movement. Such models would ultimately lead to an improved ability to detect and characterize debris flows on Mount Rainier as well as other places around the world, and would enable the park to better inform visitors, including wilderness users, of local hazards and how the park itself handles such events. Additional benefits that cannot yet be quantified are likely to result from the installation of the system, including enhancing our detection ability and understanding of rockfall, glacial dynamics, flooding, and potentially more. Finally, the proposed stations would improve volcano monitoring capabilities, including the ability to detect anomalous small earthquakes and ground deformation that often precede eruptions, and also to detect explosions that often accompany volcanic unrest and eruption.

If the proposed stations are not installed, the existing monitoring network would be unable to detect events until at least several minutes after they initiate, and the impacted drainage would be more difficult to discern in a timely manner, meaning that events would impact use areas in the park with effectively no warning, and the warning time would be reduced for areas outside the park. No installation would also eliminate any potential benefits to science and park planning, and the volcano monitoring capabilities at Mount Rainier would remain unchanged.

MRDG Step 2

*Determine the **Minimum** Activity*

Other Direction

*Is there "special provisions" language in legislation (or other Congressional direction) that explicitly **allows** consideration of a use otherwise prohibited by Section 4(c)?*

AND/OR

Has the issue been addressed in agency policy, management plans, species recovery plans, or agreements with other agencies or partners?

☒ YES	**DESCRIBE OTHER DIRECTION**
☐ NO	**SKIP AHEAD TO TIME CONSTRAINTS BELOW**

Describe Other Direction:
2006 NPS Management Policies

Section 6.3.6, Scientific Activities in Wilderness: "Scientific activities are to be encouraged in wilderness. Even those scientific activities (including inventory, monitoring, and research) that involve a potential impact to wilderness resources or values (including access, ground disturbance, use of equipment, and animal welfare) should be allowed when the benefits of what can be learned outweigh the impacts on wilderness resources or values. However, all such activities must also be evaluated using the minimum requirement concept and include documented compliance that assesses impacts against benefits to wilderness. This process should ensure that the activity is appropriate and uses the minimum tool required to accomplish project objectives. Scientific activities involving prohibitions identified in section 4(c) of the Wilderness Act (16 USC 1133(c)) may be conducted within wilderness when the following occur:

- The desired information is essential for understanding the health, management, or administration of wilderness, and the project cannot be reasonably modified to eliminate or reduce the nonconforming wilderness use(s); or if it increases scientific knowledge, even when this serves no immediate wilderness management purposes, provided it does not compromise wilderness resources or character. The preservation of wilderness resources and character will be given significantly more weight than economic efficiency and/or convenience.
- Compliance with the National Environmental Policy Act (including completion of documented categorical exclusions, environmental assessments/findings of no significant impact, or environmental impact statements/records of decision) and other regulatory compliance (including compliance with section 106 of the National Historic Preservation Act (16 USC 470f)) are accomplished and documented.

- All scientific activities will be accomplished in accordance with terms and conditions adopted at the time the research permit is approved. Later requests for exceptions to the Wilderness Act will require additional review and approval.
- The project will not significantly interfere with other wilderness purposes (recreational, scenic, educational, conservation, or historical) over a broad area or for a long period of time.
- The minimum requirement concept is applied to implementation of the project.

Research and monitoring devices (e.g., video cameras, data loggers, meteorological stations) may be installed and operated in wilderness if (1) the desired information is essential for the administration and preservation of wilderness and cannot be obtained from a location outside wilderness without significant loss of precision and applicability; and (2) the proposed device is the minimum requirement necessary to accomplish the research objective safely.

Park managers will work with researchers to make NPS wilderness area research a model for the use of low-impact, less intrusive techniques. New technology and techniques will be encouraged if they are less intrusive and cause less impact. The goal will be for studies in NPS wilderness to lead the way in 'light on the resource' techniques.

Devices located in wilderness will be removed when determined to be no longer essential. Permanent equipment caches are prohibited within wilderness. Temporary caches must be evaluated using the minimum requirement concept.

All scientific activities, including the installation, servicing, removal, and monitoring of research devices, will apply minimum requirement concepts and be accomplished in compliance with Management Policies, director's orders, and procedures specified in the park's wilderness management plan."

Section 8.4, Overflights and Aviation Uses: "Although there are many legitimate aviation uses, overflights can adversely affect park resources and values and interfere with visitor enjoyment. The Service will take all necessary steps to avoid or mitigate unacceptable impacts from aircraft overflights."

Section 8.2.3, Use of Motorized Equipment: "The Service will strive to preserve or restore the natural quiet and natural sounds associated with the physical and biological resources of parks. To do this, superintendents will carefully evaluate and manage how, when, and where motorized equipment is used by all who operate equipment in the parks, including park staff. Uses and impacts associated with the use of motorized equipment will be addressed in park planning processes. Where such use is necessary and appropriate, the least impacting equipment, vehicles, and transportation systems should be used, consistent with public and employee safety."

Mount Rainier National Park Wilderness Management Plan 1992

Administrative Use of Aircraft: "Permission to use helicopters in Wilderness is granted by the Superintendent. Helicopter use in Wilderness, for other than emergencies, will generally not be approved between July 1 and Labor Day and use is restricted to weekdays. Approval for use of helicopters in non-emergency situations will be granted only if it has been determined to be the minimum tool to achieve the purposes of the area or for protection of Wilderness values."

Research: "Monitoring devices for hydrological, seismic, hydrothermal or other purposes may be installed and operated in Wilderness only when park management has determined that the information is essential and cannot be obtained from a location outside of the Wilderness and the proposed device is the 'minimum tool' necessary to accomplish the study objective. Devices used for monitoring or research purposes are removed when they are no longer essential. All areas are restored to natural conditions at the completion of studies."

Mount Rainier National Park General Management Plan 2002

Geologic Hazards: The plan states, "Increased efforts would be made under the preferred alternative to educate and inform visitors and employees about the threat of geologic hazards and what to do if a debris flow or other event occurred. Such efforts might include…cooperating with the U.S. Geological Survey and others in monitoring geologic hazards in the park."

Time Constraints
What, if any, are the time constraints that may affect the action?

Time constraints on helicopter flights would be required for safety reasons and would include flying during daylight hours and avoiding flying during bad weather. Installation work, including helicopter flights, would be limited to September and October. Flights would begin after Labor Day to minimize impacts on visitors and to minimize impacts on nesting northern spotted owls and marbled murrelets. Installations would be completed before November to avoid winter conditions.

Components of the Action
What are the discrete components or phases of the action?

Component 1: Selection of the lahar monitoring locations
Component 2: Transportation of material to the monitoring sites
Component 3: Transportation of personnel to the monitoring sites
Component 4: On-site installation of the monitoring stations
Component 5: Maintenance of the monitoring stations
Component 6: Periodic equipment replacement
Component 7: Emergency repairs to aviation-dependent monitoring sites

MRDG Step 2: Alternatives

Alternative 1: USGS Proposed Action

Description of the Alternative
What are the details of this alternative? When, where, and how will the action occur? What mitigation measures will be taken?

The goal of the USGS Lahar Detection System proposal is to mitigate human risk by reducing the amount of time it takes for an alert to be sent out to potentially affected populations and communities after a lahar has been generated.

The expansion would also increase the number of total drainage areas covered by the alert system to include the Tahoma Creek and the Nisqually River drainages, which, along with the Puyallup River valley, are vulnerable to future non-eruptive landslide-caused lahars from Mount Rainier. An additional benefit of the expanded monitoring system would be to improve detection capabilities for smaller debris flow events, particularly along Tahoma Creek, which has experienced multiple debris flows since the late 1980s.

Under this alternative, lahar detection stations would be installed at 12 sites in the park, of which 9 would be in wilderness. The sites in wilderness would be Ararat South, Copper Mountain, Emerald Ridge (upgrade to an existing University of Washington site), Fremont Lookout, Gobblers Knob Lookout, Mildred Point, Shriner Peak Lookout, Tahoma Bridge, and Tolmie Peak Lookout. As described below and in Appendix B of the EA, the Fremont Lookout, Shriner Peak, and Tolmie Peak stations would function primarily as telemetry nodes for future stations installed along the Carbon, White, Ohanepecosh/Cowlitz, and Mowich River drainages in the event of future volcanic unrest at Mount Rainier and would not repeat data from any current or proposed stations. Instead, these installations would be part of a telemetry backbone that would enable rapid installation of new real-time monitoring stations along the White River drainage, something that would be required to help mitigate lahar hazards along the White River if Mount Rainier were to start exhibiting signs of volcanic unrest. The remaining nine stations would be installed to increase rapid detection along the west flank of Mount Rainier, which is the most vulnerable to a large lahar down the Puyallup River, Mowich, or Tahoma Creek drainages.

Role of Individual Stations in the Lahar Detection System

Ararat South

The Ararat South site would feature a seismometer and infrasound array and serve as a telemetry repeater for station Mount Wow along Tahoma Creek. Ararat South's roles would include:

- The Ararat South station would provide infrasound and seismometer detection capabilities for a lahar moving down Tahoma Creek, both to confirm that a lahar is moving down the drainage and to determine the location and velocity of the flow front.

- This station would provide redundancy if the monitoring stations at St. Andrews Rock and Emerald Ridge are destroyed by a landslide or lahar.
- The Ararat South station would improve volcano monitoring capabilities of the Mount Rainier volcano monitoring network through addition of a seismometer and infrasound array close to the summit.
- This station would improve the network's ability to detect and locate "surface events" such as avalanches, rockfalls, and debris flows, and events on the south and west flanks of the volcano.
- Ararat South would serve as a repeater for station Mount Wow. Without Ararat South, there would be no way to transmit real-time data from Mount Wow, making that site unusable for real-time lahar monitoring.

Copper Mountain

The Copper Mountain site would feature a seismometer, infrasound array, webcam, and GPS receiver. Copper Mountain's roles would include:

- Copper Mountain would provide infrasound detection capabilities for a lahar moving down Tahoma Creek, both to confirm that a lahar is moving down the drainage and to determine the location and velocity of the flow front.
- The webcam at Copper Mountain would play a key role in confirming the location of a landslide and the formation of a lahar.
- Similar to Ararat South, Copper Mountain's seismometer would play an important lahar detection role (see the Ararat South description above).
- Copper Mountain would provide redundancy if the monitoring stations at St. Andrews Rock and Emerald Ridge are destroyed by a landslide or lahar.
- Copper Mountain would improve volcano monitoring capabilities of the Mount Rainier volcano monitoring network through addition of a seismometer, infrasound array, and GPS receiver close to the summit.
- The infrasound array and seismometer at Copper Mountain would also improve the network's ability to detect and locate "surface events" such as avalanches, rockfalls, and debris flows on the south and west flanks of the volcano (see the Ararat South description above).

Emerald Ridge – Upgrade of Existing Site

The Emerald Ridge site is an existing seismic station operated by the University of Washington. It would be upgraded to include both a modern seismometer and an infrasound array. Emerald Ridge's roles would include:

- Emerald Ridge would provide infrasound and seismometer detection capabilities for a lahar moving down Tahoma Creek and Puyallup River, both to confirm that a lahar has been created and to help determine which drainage(s) it is moving down.
- Emerald Ridge is the second-closest station to the source area for a landslide on the west flank (St. Andrews Rock is the closest), and also sits on a ridge that divides the Puyallup River and Tacoma Creek drainages. This location is important in two ways:
    - If a large landslide occurs in the northern part of the presumed source area, the closest station (St. Andrews Rock) would likely not survive, so Emerald Ridge

would then become the closest station to the source area and would provide information critical to tracking the initial moments of the landslide event and possible transition to a lahar.

  - If a large landslide occurs the southern part of the presumed source area, modeling indicates that a large lahar would be split by Emerald Ridge and go down both the Puyallup and Tahoma Creek drainages. Modeling also indicates that a large lahar would reach Emerald Ridge in 1 to 2 minutes and likely destroy it, providing early confirmation that a large lahar had been created and was moving down Tahoma Creek.

- Historically, Emerald Ridge has been the only seismic station in the Mount Rainier volcano monitoring network to clearly record small debris flows going down Tahoma Creek. However, telemetry from the site is unreliable at times and the seismometer is out of date. Upgrading the site will improve telemetry reliability and also the fidelity and quality of seismic recordings of debris flows and lahars.
- Emerald Ridge is a critical site in the Mount Rainier volcano monitoring network. It is the closest site to the summit on the southwestern flank and, since its installation in 1991, the site has proven to be quiet and highly sensitive to small earthquakes near the summit. Upgrading the seismometer and improving the reliability of the station would improve the precision and accuracy of earthquake locations beneath Mount Rainier, and the infrasound array would improve the ability of the network to detect explosions.
- Emerald Ridge would operate as a ShakeAlert station (https://www.shakealert.org/), enhancing the earthquake early warning capability at the volcano. Depending on the lahar trigger, a detection from the ShakeAlert system may be one of the earliest signs of a developing landslide.

Fremont Lookout

The Fremont Lookout site would function solely as a telemetry node. A station at Mount Fremont operated by the University of Washington is close to Fremont Lookout, so no seismometer is needed at Fremont Lookout. It would not repeat data from any current or proposed stations. Instead, its installation would be part of a telemetry backbone (along with Tolmie Peak and Shriner Peak) that would enable rapid installation of new real-time monitoring stations along the White River drainage, something that would be required to help mitigate lahar hazards along the White River if Mount Rainier were to start exhibiting signs of volcanic unrest.

Gobblers Knob

The Gobblers Knob Lookout site would feature a seismometer and would also serve as a telemetry repeater for stations Copper Mountain, Tahoma Bridge, and Tahoma Vista. Gobblers Knob's roles would include:

- Similar to Ararat South and Copper Mountain, the Gobblers Knob's seismometer would play an important lahar detection role (see the Ararat South description above). Although the seismometer at Gobblers Knob would provide data important for tracking lahars along the entire Tahoma Creek drainage, it would be particularly important for tracking lahars down the lower part of Tahoma Creek (along with Mount Wow, Tahoma Vista, and existing stations KAUT and GATE). In addition, if a lahar destroys stations GTWY, KAUT, Emerald Ridge, Tahoma Bridge, Tahoma Vista, and Mount Wow, Gobblers Knob would be the only station still in operation that could provide data necessary for detecting and tracking subsequent lahars and debris flows moving along the lower part of Tahoma Creek.

- Gobblers Knob would serve as a repeater for stations Copper Mountain (Copper Mountain), Tahoma Bridge, and Tahoma Vista. Without Gobblers Knob, there would be no way to transmit real-time data from Copper Mountain, Tahoma Bridge, and Tahoma Vista, making those sites unusable for real-time lahar monitoring.

Mildred Point

The Mildred Point site would feature a seismometer and infrasound array. Mildred Point's roles would include:

- Mildred Point would provide infrasound detection capabilities for a lahar or debris flow moving down the Kautz Creek and Nisqually Creek drainages, both to confirm that a lahar is moving down the drainages and to determine the location and velocity of the flow front.
- Mildred Point's seismometer would also play an important lahar detection role through use of seismic amplitude ratios (see the Ararat South description above).
- Similar to Ararat South and Copper Mountain, Mildred Point would improve volcano monitoring capabilities of the Mount Rainier volcano monitoring network through addition of a seismometer and infrasound array close to the summit.
- The infrasound array and seismometer at Mildred Point would also improve the network's ability to detect and locate "surface events" such as avalanches, rockfalls, and debris flows on the south flank of the volcano including the Nisqually glacier.

Paradise Parking Lot Tower

The Paradise Parking Lot Tower site would serve as a telemetry repeater for stations Ararat South, Mildred Point, and Mount Wow (repeated through Ararat South).

Shriner Peak

The Shriner Peak site would feature a seismometer and would also function as a telemetry node for future stations installed along the Ohanapecosh drainage in the event of future volcanic unrest at Mount Rainier. Shriner Peak's roles would include:

- Shriner Peak's primary role would be as a repeater. It would not repeat data from any current or proposed stations. Instead, its installation would enable rapid addition of telemetered real-time monitoring stations along the Ohanapecosh drainage that would repeat through Shriner Peak to a receive site outside MORA. Addition of stations along the Ohanapecosh River would be required to help mitigate lahar hazards to downstream communities if Mount Rainier were to start exhibiting signs of volcanic unrest.
- The seismometer at Shriner Peak would improve the ability of the seismic network to detect smaller lahars and debris flows down the Ohanapecosh River.
- The seismometer at Shriner Peak would also significantly improve the accuracy of earthquake locations at Mount Rainier, particularly in the southeast quadrant of MORA, which at present has only two seismic stations (RCM (Camp Muir) and OPCH

(Ohanapecosh Visitor Center)). The east side of MORA is an active seismic area, most recently hosting the M4.5 Cowlitz Chimneys earthquake in 2006 that was widely felt in MORA (Hartog et al. 2008).

Tahoma Bridge

The Tahoma Bridge site would feature a seismometer and a single infrasound sensor. Tahoma Bridge's roles would include:

- A large lahar would likely destroy Tahoma Bridge within 1 to 3 minutes of initiation, providing independent confirmation that a lahar was moving down Tahoma Creek and also providing information important for determining the velocity and size of the lahar.
- Tahoma Bridge would also provide seismic and infrasound data important for constraining the timing and velocity of smaller lahars and debris flows. Such information would improve MORA's situational awareness about such events, potentially improving response time for search and rescue efforts.

Tahoma Vista

The Tahoma Vista site would feature a seismometer and an infrasound array. Tahoma Vista's roles would include:

- If Tahoma Vista is located at Tahoma Vista along the Westside Road, a large lahar would likely destroy Tahoma Vista within 3 to 5 minutes of initiation, providing independent confirmation that a lahar was continuing to move down Tahoma Creek and also providing information important for determining the velocity and size of the lahar.
- If located at the alternate Tahoma Vista site, a large lahar would not destroy the site; in that event, Tahoma Vista would join Gobblers Knob, Ararat South, and Copper Mountain as the only sites that could provide data necessary for detecting and tracking subsequent lahars and debris flows moving along Tahoma Creek in the aftermath of the large lahar. In addition, the alternate site would provide infrasound coverage for the Puyallup River drainage.
- Either location has a unique view of the Tahoma Creek that is optimal for infrasound detection. Coupled with infrasound arrays at Copper Mountain and Ararat South, the Tahoma Vista infrasound array would provide complete infrasound coverage of the Tahoma Creek drainage down to its confluence with the Nisqually River.
- Tahoma Vista would also provide seismic and infrasound data important for constraining the timing and velocity of smaller lahars and debris flows. Such information would improve MORA's situational awareness about such events, potentially improving response time for search and rescue efforts.

Tolmie Peak

The Tolmie Peak Lookout site would feature a seismometer and would also function as a telemetry node for future stations installed along the Carbon and Mowich River drainages in the event of future volcanic unrest at Mount Rainier. Tolmie Peak Lookout's roles would include:

- Tolmie Peak Lookout's primary role would be as a repeater. It would not repeat data from any current or proposed stations; instead, its installation would enable rapid addition of telemetered real-time monitoring stations along the Carbon and Mowich River drainages, which would repeat through Tolmie Peak Lookout to a receive site outside MORA. Addition of stations along the Carbon and Mowich Rivers would be required to help mitigate lahar hazards to downstream communities if Mount Rainier were to start exhibiting signs of volcanic unrest.
- The seismometer at Tolmie Peak Lookout would significantly improve the accuracy of earthquake locations at Mount Rainier, particularly in the northwest quadrant of MORA, which at present has only two seismic stations (Carbon Ranger Station (CRBN) and Observation Rock (OBSR)).

Mount Wow

The Mount Wow site would feature a seismometer and a single infrasound sensor. Mount Wow's roles would include:

- A large lahar would likely destroy Mount Wow within 5 to 7 minutes of initiation, providing independent confirmation that a lahar was continuing to move down Tahoma Creek and also providing information important for determining the velocity and size of the lahar.
- Mount Wow would also provide seismic and infrasound data important for constraining the timing and velocity of smaller lahars and debris flows. In particular, the Mount Wow location is in the area where many recent debris flows have come close to or damaged the Westside Road; it is therefore uniquely situated to provide MORA with situational awareness about events that may have impacted the Westside Road, potentially improving response time for repairs as well as search and rescue efforts.

A summary of the design process for the Mount Rainier lahar detection system and a detailed description of each site's individual role in the lahar detection system is included in the EA as Appendix B. Additional construction details are found in the EA.

Power Tool Use for Installation

The USGS requires the use of the following power tools during the installation of the proposed Mount Rainier lahar detection infrastructure at stations located in the areas designated as wilderness. Additionally, the USGS requires the use of many of the same tools to conduct maintenance at these stations as needed. The tools include:

- Battery-powered drill (e.g., DeWalt 20v lithium battery ½-inch drill) for drilling holes in pipes, enclosures, and solar panel frames as needed.
- Battery-powered rock drill for drilling up to 1-inch-diameter holes at the Mount Wow alternative site (e.g., the "talus" site) and Tahoma Bridge to anchor enclosures.
- Battery-powered sawzall (e.g., DeWalt 20v lithium battery 1 1/8-inch stroke reciprocating saw) for cutting pipe, damaged hardware, and 2-inch U-bolts that become cross-threaded during installation or subsequent maintenance.
- Battery-powered bandsaw (e.g., DeWalt 20v lithium battery cordless band saw) for cutting pipe on-site during installation or subsequent maintenance.

- For installing the GPS monument at Copper Mountain, the following power tools are required:
    - A 4000W gas-powered generator to operate corded power tools needed for building the short-braced GPS monument.
    - An AC-powered handheld hammer drill to drill four 1.5-inch-diameter and 6-foot-deep holes into bedrock.
    - An AC-powered 1-gallon air compressor for powering a pneumatic epoxy dispenser.
    - A small portable AC-powered welder to tack weld the three angled legs of the GPS monument to the central vertical rod (required for stabilizing the monument).
    - A battery-powered vacuum (DeWalt 20v lithium battery) for removing fine dust out of the 6-foot-deep GPS monument holes.
    - A battery-powered hand grinder with cut off wheel (DeWalt 20v lithium battery).

All Stations

The proposed fiberglass enclosures are designed to be streamlined, self-efficient, and almost entirely prebuilt off-site prior to installation. Power tool use during installation of the fiberglass enclosures would be on an as-needed basis and would be limited to minutes-long durations only.

Mount Wow Alternative (Mount Wow Talus) and Tahoma Bridge

The hut enclosures must be secured to the ground to a shallow depth to prevent any movement on sloping terrain. Because the Mount Wow Talus and Tahoma Bridge station enclosures are, by necessity, installed on a rock surface, this requires drilling holes in the rock to install J bolts that secure the base (flange) of the hut to the ground using compact cordless SDS Max rotary hammer drills. (Note: The Mount Wow site along the road would not require use of an SDS Max drill.)

Copper Mountain

Installation of the GPS monument at the Copper Mountain site will require additional motorized equipment – specifically, a generator, a welder, a small air compressor, a pneumatic adhesive dispenser, and a hammer drill as described above.

Power Tool Use for Maintenance

Short- and long-term ice, snow, and wind damage may create unanticipated situations where additional modifications to the solar panel frames and telemetry infrastructure will be necessary to repair damaged equipment. Such repairs may require the use of the same power tools noted above, except for those needed only for the installation the GPS monument at Copper Mountain. Modifications to metal infrastructure, especially steel and aluminum, without power drills and saws can be time prohibitive or impossible depending on the type and thickness of the metal.

Specific examples where power tools will be required during maintenance include:

- Replacement of lightning protection that has failed or was damaged at a location near a ground rod attached to the enclosure.
- Drilling precision holes in the solar panels or the enclosure to adjust or repair damaged solar panel mounting.
- Removal of or cutting off large stainless steel bolts that have been damaged by snow and ice conditions or are rusted, seized, or cross-threaded.
- Adjustments and replacement of metal pipes or angle brackets used for solar panel framing damaged by ice, snow, or wind loading. In this case, both a drill and saw would be used in very limited durations to remove old rusted or damaged hardware and secure new pipe and hardware as needed.

A description of the power tools to be used and a detailed rationale for power tool use is provided in Attachment A.

Helicopter Use for Installation

The sites within wilderness would require the use of helicopters for initial installation and subsequent maintenance. Installation would require up to seven round trips to each project location by a small helicopter carrying sling loads. Helicopters used would be small (such as A-Stars, Bell Jet Rangers, or Hughes 500 series). Helicopters would take off from the Kautz helibase or the Sunrise parking area (available only in late September/October). The total number of helicopter flights would be about 63 during installation over a 2-month period (September and October), with installations potentially extending into September/October 2022 if weather or other conditions do not allow for completion of installations in 2021. Sites would be evaluated one year post-installation to determine if active restoration is needed to restore natural conditions at monitoring sites. Should revegetation be necessary, helicopter flights may be required to transport seedlings to areas where transport on foot is infeasible. This would require up to two flights per site where active revegetation is needed – one flight to deliver seedlings and one flight to remove supplies after planting. With the addition of potential flights for revegetation, up to eight total round-trip flights would be needed for each site for installation, and the total number of round-trip flights associated with installation would be about 72. Flight time for installation would be about 1 to 2 hours per day at each site over a period of 2 days, or about 32 to 63 hours of total flight time during installation over a 2-month period (September and October) each year for 2 years.

Helicopter Use for Maintenance

Sites would typically be accessed by foot for routine tuning and maintenance, but additional helicopter flights would be required for anticipated equipment and battery replacement, requiring four round trips per site every 5 years. Tuning refers to unexpected adjustments or repairs to stations within the first two years after installation. The USGS has found that that some sites require tuning after installation, which sometimes requires helicopter use to deliver heavy or bulky equipment, or to remove damaged equipment. Additional flights may also be needed if urgent repairs are required and foot access is not available, for example during winter months.

About 243 maintenance flights would be performed over a period of 30 years. Flight time for maintenance would be about 22 to 243 hours for maintenance flights over a period of 30 years. Flights for tuning and emergency repairs are included in this total. Flights for emergency repairs could potentially occur in months other than September and October.

For comparison, the total number of flight hours in the park from 2015 to 2019 averaged 142 flight hours per year, consisting mostly (about 95 percent) of small helicopters, and a small proportion (less than 5 percent) consisting of large helicopters such as CH-47 Chinook and Blackhawk. Helicopter use for Alternative 1 and the other alternatives is summarized in Step 2: Alternatives Comparison in Table 1.

Component Activities
How will each of the components of the action be performed under this alternative?

Comp #	Component of the Action	Activity for this Alternative
X	*Example: Transportation of personnel to the project site*	*Example: Personnel will travel by horseback*
1	Selection of the lahar monitoring locations	Nine out of 12 stations would be within wilderness.
2	Transportation of material to the monitoring sites for installation	All materials and equipment would be transported by helicopters.
3	Transportation of personnel to the monitoring sites during installation	Personnel would hike to and from the sites.
4	On-site installation of the monitoring stations	Installation would use power tools.
5	Maintenance of the monitoring stations	Access sites on foot for routine tuning and maintenance work.
6	Periodic equipment replacement	Transport replacement batteries and other large or heavy components by helicopter.
7	Emergency repairs to aviation-dependent monitoring sites	Access sites by aircraft when objective hazards preclude access on foot.

Wilderness Character
What is the effect of each component activity on the qualities of wilderness character? What mitigation measures will be taken?

UNTRAMMELED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒

1	Nine out of 12 stations would be within wilderness	☐	☐	☒
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
Alternative 1 would not adversely affect the untrammeled quality. The lahar detection stations would not increase human manipulation or control of the components or processes of ecological systems inside wilderness; therefore, the untrammeled quality of wilderness would be preserved.

UNDEVELOPED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Nine out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☒	☐
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Alternative 1 would have both permanent and temporary effects on the undeveloped quality of wilderness. Construction activities would introduce noise and sights of additional human occupation, which would adversely affect the undeveloped quality of the wilderness. Use of

mechanized equipment, such as power tools, and use of a helicopter for material delivery would introduce unnatural sounds during installation and maintenance work. Use of power tools is described in Attachment A. Impacts on the undeveloped quality during construction would generally be low, and disturbance would be mostly contained to a brief construction period at each site. Elevated noise levels from the use of mechanized equipment would occur during construction for a period lasting 2-3 days at each site. Use of a helicopter to transport material would result in a temporary increase in noise that would affect the undeveloped quality of wilderness for about one to two hours per day over a period of about two days at each site. The total number of helicopter flights would be about 72 during installation over a 2-month period (which would occur September –October 2021 and possibly extend into September-October 2022 depending on weather conditions and other factors) and about 243 maintenance flights over a period of 30 years. This would represent an increase of about 25 to 50 percent in flight time during the 1 to 2-year installation period and an increase of about 3 to 6 percent in flight time compared to the existing number of flights over the 30-year maintenance period. Helicopters would deliver materials to the project sites via sling loads during installation. Maintenance flights would also involve sling loads to deliver and remove heavy equipment. Crews would hike to the sites to reduce the number of flights for both installation and maintenance. Maintenance flights could also involve landings in the wilderness if critical outages occur when sites are not accessible by foot.

After installation, the presence of new structures and installations at Emerald Ridge, Ararat South, Copper Mountain, Mildred Point, and Tahoma Bridge would degrade the undeveloped wilderness quality by introducing visible signs of human occupation. Under this alternative, the number of standalone seismic installations in wilderness would increase from 5 to 9. The other installations would be collocated with existing developments and installations. The number of stations dependent on aircraft would increase from 5 to 13. As previously described, the physical footprint of all installations in wilderness would be less than 0.1 acre within the Mount Rainier Wilderness, which totals 228,400 acres. The installation locations were designed to minimize visibility to the greatest extent practicable by using screening from vegetation and topography. Stations would be painted to reduce their visibility and placed strategically to minimize detection by the casual visitor; however, several of the sites would be potentially visible to the public from nearby as well as from a distance, including popular peaks and viewpoints. Installation of the sites at Emerald Ridge, Ararat South, Copper Mountain, and Mildred Point would affect relatively unimpacted sites with large viewsheds within designated wilderness, mostly within the upper Tahoma Creek watershed. These sites would be situated so they would be hard to see from established trails; however, visitors travelling off trail could come across these facilities or see them from a distance. Wilderness users encountering these facilities could feel that their wilderness experience has been degraded by the presence of these signs of human occupation.

The installation on Ararat South would be encountered by some hikers climbing to the summit, and would tend to dominate the experience of the highest point on the summit; however, the summit is broad and visitors exploring the summit area could find places where the installation is not visible. The installation at Mildred Point would be out of sight of the majority of hikers who do not venture past the end of the maintained trail; however, for some hikers continuing up the ridge to experience the area without the aid of recreational developments, the installation would be encountered and dominate the experience of the area within several hundred feet. The Mildred Point site would also be visible from a distance from many of the higher elevations of Van Trump Park.

The Copper Mountain site would be partially visible to climbers attempting the summit, but would not dominate the experience of the undeveloped summit or interfere with views of Mount Rainier or the surrounding landscape. The installation at Emerald Ridge would not be visible to the majority of on-trail hikers, but would be encountered by visitors exploring the area without the aid of recreational developments, and would tend to dominate the experience of the location within 100 to 200 feet or greater. These impacts would persist for as long as the lahar detection sites are present in the wilderness, potentially indefinitely. The Tahoma Bridge site would be mostly screened from view by vegetation and would not likely be seen by visitors but would completely dominate the experience of a visitor who ventured a short distance off trail to the outcrop, which currently provides an elevated view of the Tahoma Creek drainage out of sight of the more highly visited Wonderland Trail and suspension bridge.

The Fremont Lookout, Gobblers Knob, Shriner Peak, and Tolmie Lookout sites would be collocated with existing lookout structures, thus reducing the impacts to the undeveloped wilderness quality. The fire lookouts have been evaluated for necessity through the park's Wilderness Management Plan, and satisfy the minimum requirement as historic features, but also for their necessity for administration of the wilderness through the provision of communication infrastructure and other administrative uses. The additional impact of adding solar panels or buried seismometers at these sites would be consistent with those administrative uses.

NATURAL

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Nine out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☒	☐
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒

7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
Alternative 1 would alter less than 0.1 acre of vegetation within the 228,400-acre wilderness, and impacts are expected to recover to a natural state over time. Due to the small scale and widely separated nature of the proposed sites, and the implementation of mitigation measures to reduce impacts, Alternative 1 would have only minimal adverse effects on plants, animals, air, water, or ecological processes. There would be some site-specific negative impacts on natural resources (soils, vegetation, and soundscape) during installation, and potentially maintenance, of structures in currently undeveloped wilderness. It is also possible that foot traffic from maintenance visits or curious visitors could cause the development of social trail impacts where they do not currently exist. Noise and activity from construction and helicopters have the potential to affect breeding and roosting behaviors of spotted owls and marbled murrelets; however, with implementation of mitigation measures, the project is not expected to adversely affect these species.

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Nine out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Helicopter trips to install monitoring stations would affect solitude when aircraft are flying over or landing in wilderness. Impacts would affect individuals encountering aircraft as well as those who could hear the aircraft from distant locations. These effects would vary among individuals, depending on where visitors encountered the helicopter use, and would be temporary, limited to about 63 trips during installation over a 2-month period (September and October) in 2021 with extension into September/October 2022 if installations are not completed in 2021. With the

addition of potential flights for revegetation, up to eight total round-trip flights would be needed for each site for installation, and the total number of round-trip flights associated with installation could be up to 72. About 243 maintenance flights would occur over a period of 30 years.

After installation, the structures would have small effects on solitude or unconfined recreation. The presence of the monitoring stations would negatively affect the primitive nature of the wilderness. Individuals who came across a site could have their wilderness experience negatively affected by the feeling of being monitored and by the feeling that modern humans have occupied and will return to the site. The stations might serve as curiosities that attract more users to the sites but would not reduce opportunities for solitude or primitive and unconfined recreation overall. As described under the undeveloped quality, stations would be painted to reduce their visibility and placed to minimize being detected by the casual visitor. However, the greatest impact would be experienced by the visitor who expends the greatest effort to pursue the opportunity for solitude, and therefore has a higher expectation of solitude.

OTHER FEATURES OF VALUE

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Nine out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
The four proposed monitoring stations on the Fremont, Gobblers Knob, Shriner Peak, and Tolmie Peak fire lookouts would affect contributing features to the National Historic Landmark District. Impacts on these features are described in detail in the Historic Districts, Structures, and Cultural Landscapes section of the EA. These historical structures predate the wilderness designation and contribute to wilderness character to the extent that they tell the story of historical use of the wilderness area. Modern installations and modifications contribute to a shift in visitor perception of the structures as historic features toward a perception as modern administrative facilities. Instruments would be painted to reduce their visibility and placed

strategically to minimize detection by the casual visitor; however, several of the instruments would be potentially visible to the public.

The dynamic glacial and volcanic features of Mount Rainier contribute to wilderness character as a geologic feature of value, as identified in the park's Wilderness Character Narrative. While Alternative 1 would not have a positive or negative effect on this quality, study of these unique features would fulfill the public purposes of scientific and educational use. Data collected using the detection sites would be useful to the park for hazard mitigation and situational awareness for wilderness users. The data collected could ultimately lead to an improved ability to detect and characterize debris flows on Mount Rainier as well as other volcanoes around the world, and would enable the park to better inform visitors, including wilderness users, of local hazards. Data collected would benefit the broader scientific community, including enhancing detection ability and understanding of rockfall, glacial dynamics, flooding, and other processes. Finally, the proposed stations would improve volcano monitoring capabilities, including the ability to detect anomalous small earthquakes and small amounts of surface deformation that often precede eruptions and also to detect explosions that often accompany volcanic unrest and eruption.

MRDG Step 2: Alternatives

Alternative 2: No Action Alternative

Description of the Alternative *What are the details of this alternative? When, where, and how will the action occur? What mitigation measures will be taken?*

Under the No Action Alternative, the NPS would not approve the USGS permit to install additional lahar monitoring stations. Monitoring of volcanic activity at MORA would be conducted at existing monitoring stations (see Figure 1 of the EA). Current monitoring stations include the following:

- Camp Schurman
- Camp Muir
- Carbon River Ranger Station
- Emerald Ridge
- Kautz Creek
- Longmire
- Mount Fremont (approximately 0.7 mile northeast of the lookout)
- Nisqually Gateway
- Observation Rock
- Ohanapecosh
- Panhandle Gap
- Paradise
- Paradise Precipitation Tower
- St. Andrews Rock (located inside the Sunset Amphitheater)
- Sunrise

The USGS would continue to monitor volcanic activity at the seismic and GPS monitoring sites listed above and maintain these sites as needed. From 2009 to 2019, the USGS flew 47 total helicopter sling loads to 6 sites, which is about 8 flights per site over 11 years. The USGS estimates that about 3 to 4 maintenance trips per site would be needed every 5 years for the six existing monitoring sites that are helicopter dependent, for a total of about 144 flights over 30 years.

Component Activities *How will each of the components of the action be performed under this alternative?*

Comp #	Component of the Action	Activity for this Alternative
X	*Example: Transportation of personnel to the project site*	*Example: Personnel will travel by horseback*

1	Maintenance of the existing monitoring stations	Access sites on foot for routine tuning and maintenance work.
2	Periodic equipment replacement	Transport replacement batteries and other large or heavy components by helicopter.
3	Emergency repairs to aviation-dependent monitoring sites	Access sites by aircraft when objective hazards preclude access on foot.

Wilderness Character
What is the effect of each component activity on the qualities of wilderness character? What mitigation measures will be taken?

UNTRAMMELED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
This alternative would not adversely affect the untrammeled quality. Continued maintenance of the existing stations would not increase human manipulation or control of the components or processes of ecological systems within wilderness; therefore, the untrammeled quality of wilderness would be preserved.

UNDEVELOPED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Maintenance of existing stations would have temporary effects on the undeveloped quality of wilderness. Use of mechanized equipment, such as power tools, and use of helicopters for

material delivery would introduce unnatural sounds during installation and maintenance work. No new monitoring sites would be constructed in wilderness.

NATURAL

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
The No Action Alternative would have negligible new impacts on vegetation within the 228,400-acre wilderness, resulting in minimal adverse effects on plants, animals, air, water, or ecological processes. As described for Alternative 1, noise and activity from construction and helicopters have the potential to affect behaviors of spotted owls and marbled murrelets; however, with implementation of mitigation measures, the project is not expected to adversely affect these species.

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Helicopter trips to install monitoring stations would affect solitude when aircraft are flying over or landing in wilderness. As described for Alternative 1, helicopter use would be temporary. Helicopter use would be less than under Alternative 1, involving an estimated 144 maintenance flights over a period of 30 years.

OTHER FEATURES OF VALUE

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒

1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
No new impacts would occur to historic structures. No new data would be collected using the new detection sites because the new sites would not be installed. The benefits to the park and USGS for hazard mitigation and situational awareness for wilderness users described for Alternative 1 would not occur.

MRDG Step 2: Alternatives

Alternative 3 | USGS proposal with alternative sites

Description of the Alternative
What are the details of this alternative? When, where, and how will the action occur? What mitigation measures will be taken?

This alternative would be the same as the USGS Proposed Action, except for specific locations where a modification to the proposal is included to avoid or minimize potential for adverse effects on historic properties. Alternative sites were identified for Fremont Lookout, Mount Wow, Shriner Peak, Tahoma Vista, and Tolmie Peak. This alternative is described in greater detail in the EA.

Component Activities
How will each of the components of the action be performed under this alternative?

Comp #	Component of the Action	Activity for this Alternative
X	*Example: Transportation of personnel to the project site*	*Example: Personnel will travel by horseback*
1	Selection of the lahar monitoring locations	Eleven out of 12 stations would be within wilderness.
2	Transportation of material to the monitoring sites for installation	All materials and equipment would be transported with helicopters.
3	Transportation of personnel to the monitoring sites during installation	Personnel would hike to and from the sites.
4	On-site installation of the monitoring stations	Installation would use power tools.
5	Maintenance of the monitoring stations	Access sites on foot for routine tuning and maintenance work.
6	Periodic equipment replacement	Transport replacement batteries and other large or heavy components by helicopter.
7	Emergency repairs to aviation-dependent monitoring sites	Access sites by aircraft when objective hazards preclude access on foot.

Wilderness Character
What is the effect of each component activity on the qualities of wilderness character? What mitigation measures will be taken?

UNTRAMMELED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☐	☐	☒
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
This alternative would not adversely affect the untrammeled quality. The lahar detection stations would not increase human manipulation or control of the components or processes of ecological systems inside wilderness; therefore, the untrammeled quality of wilderness would be preserved.

UNDEVELOPED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☒	☐
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
The alternative station sites would have both permanent and temporary effects on the undeveloped quality of wilderness. Use of mechanized equipment, such as power tools, and use of helicopters for material delivery would introduce unnatural sounds during installation and maintenance work. Under this alternative, both Mount Wow and Tahoma Ridge would be installed and maintained by aircraft. This increases the number of aircraft-dependent sites in wilderness from 5 to 15.

As described for the USGS Proposed Action, impacts on the undeveloped quality during construction would generally be low, and elevated noise levels from the use of mechanized equipment would occur during construction over a two-week period each year over two years while use of a helicopter to transport material would result in a temporary increase in noise that would affect the undeveloped quality of wilderness for about one to two hours per day over a period of about two days at each site. The total number of helicopter flights would be greater than under the USGS Proposed Action, with about 88 trips (16 more than the USGS Proposed Action) during installation over a two-month period (September and October) and about 297 maintenance flights over a period of 30 years (54 more than the USGS Proposed Action). This would represent an increase of about 31 to 62 percent in flight time during the 2-year installation period and an increase of about 4 to 7 percent in flight time compared to the existing number of flights over the 30-year maintenance period.

All five of the alternative sites at Fremont Peak, Mount Wow Talus, Shriner Peak Alternative, Tahoma Vista Ridge, and Tolmie Peak Alternative would introduce visible signs of human disturbance to the wilderness. The Mount Fremont station would not be visible from the Fremont Lookout, but would be visible in the distance from the Wonderland Trail, and would be highly visible to anyone venturing beyond the end of the maintained Mount Fremont trail. The Mount Wow Talus station would be highly visible from Westside Road. The Shriner Peak Alternative would be screened from view from the Lookout Tower by vegetation, but would have the potential to dominate the experience of a visitor venturing beyond the end of the maintained trail or navigating to the summit before the trail is melted out. The Tahoma Vista Ridge site would be in a location that is rarely visited and is not accessed by any routes or way trails. The Tolmie Peak Alternative site would not be visible from the Tolmie Lookout; however, it would have a large viewshed into the upper Carbon and upper Mowich drainages and would be located on a social trail accessed from the main trail leading to the lookout, with a high likelihood of being encountered by visitors (several hundred per day during peak periods).

The total footprint of the installations in wilderness would be greater than under Alternative 1 but would still be less than 0.1 acre. Under this alternative, the number of standalone installations in currently pristine wilderness would increase from 5 to 15, twice as many new, standalone installations as Alternative 1. The alternative installation locations were designed to minimize visibility to the greatest extent practicable by using screening from vegetation and topography. The Tahoma Vista Ridge site would be unlikely to be encountered by visitors due to its remote location away from any way trails, named peaks, or travel routes. Wilderness users encountering Mount Fremont, Mount Wow Talus, Shriner Peak Alternative, or Tolmie Peak Alternative facilities could feel that their wilderness experience has been degraded by the presence of these signs of human occupation. These impacts would persist for as long as the lahar detection sites are present in the wilderness, potentially indefinitely.

NATURAL

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☒	☐
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
This alternative would alter less than 0.1 acre of vegetation within the 228,400-acre wilderness, and impacts are expected to recover to a natural state over time. Due to the small scale and widely separated nature of the proposed sites, and the implementation of mitigation measures to reduce impacts, the action would have minimal adverse effects on plants, animals, air, water, or ecological processes, but greater effects than Alternative 1. However, there is a possibility that foot traffic from maintenance visits or curious visitors could cause the development of social trail impacts where they do not currently exist. As described for Alternative 1, noise and activity from construction and helicopters has the potential to affect behaviors of spotted owls and marbled murrelets; however, with implementation of mitigation measures, the project is not expected to adversely affect these species.

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒

5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Helicopter trips to install monitoring stations would affect solitude when aircraft are flying over or landing in wilderness. As described for Alternative 1, helicopter use would be temporary. Helicopter use would be greater than under Alternative 1, increasing to 77 trips during installation, up to 11 trips for revegetation, and about 297 maintenance flights over a period of 30 years.

After installation, the structures would have greater effects on solitude or unconfined recreation relative to Alternative 1. The presence of the monitoring stations would negatively affect the primitive nature of the wilderness. Individuals who came across a site could have their wilderness experience negatively affected by the feeling of being monitored and by the feeling that modern humans have occupied and will return to the site. The presence of the stations might serve as curiosities that attract more users to the sites. Sites would be located close to popular destinations and would therefore be more likely to be encountered by the casual visitor. However, the greatest impact would be experienced by the visitor who expends the greatest effort to pursue the opportunity for solitude, and therefore has a higher expectation of solitude. The opportunity for solitude in an unmodified setting, without the aid of recreational developments, is uniquely protected by the wilderness designation, when compared to other public lands. In this alternative, the difficulty of finding a pristine site to experience solitude away from the frequently visited lookout structures would be increased, and opportunities for solitude would be reduced relative to the USGS Proposed Action.

OTHER FEATURES OF VALUE

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒

7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
One proposed monitoring station on Gobblers Knob, would affect a contributing feature to the National Historic Landmark District. Impact to this feature are described in detail in the Historic Districts, Structures, and Cultural Landscapes section of the EA. This historical structure predates the wilderness designation and contributes to wilderness character to the extent that it tells the story of historical use of the wilderness area. Modern installations and modifications contribute to a shift in visitor perception of the structure as a historic feature toward a perception as a modern administrative facility. As described above under the undeveloped quality, stations could potentially have adverse effects on scenic quality, especially the Mount Wow Talus and Tolmie Peak Alternative sites, which would be highly visible. Instruments would be painted to reduce their visibility and placed strategically to minimize detection by the casual visitor; however, several of the instruments would be potentially visible to the public. In addition, the Mount Wow alternate site would not be within the footprint of the historic West Side Road corridor but would be visible on the talus slope nearby.

As in Alternative 1, study of Mount Rainier's geologic features would fulfill the scientific and educational purposes of wilderness. Data collected using the detection sites would also be useful to the park for hazard mitigation and situational awareness for wilderness users. These benefits would be the same as described for Alternative 1.

MRDG Step 2: Alternatives

Alternative 4: Modified Lahar Detection and Volcano Monitoring with deferred installation at three locations (Fremont, Tolmie, Shriner) contingent on future evidence of volcanic unrest

Description of the Alternative
What are the details of this alternative? When, where, and how will the action occur? What mitigation measures will be taken?

This alternative would reduce the number of installations by eliminating the Tolmie Peak, Fremont and Shriner Peak monitoring sites from the proposal. The primary role at these three locations is to function as a repeater for future stations in the event of future volcanic unrest at Mount Rainier. Elimination of these three installation sites would reduce the total number of new installations in wilderness in the near term by deferring installation to a later date after volcanic unrest has been detected. This would require rapid deployment of both additional real-time monitoring stations and repeaters in the event volcanic unrest at Mount Rainier were to occur in the future. Elimination of the Tolmie Peak and Shriner Peak sites would also eliminate the addition of seismometers that would otherwise improve the accuracy of earthquake locations at Mount Rainier and the ability to detect smaller lahars and debris flows down the Carbon, White, Ohanepecosh/Cowlitz, and Mowich River drainages. Elimination of these sites would also reduce volcano monitoring capabilities. A summary of the design process for the Mount Rainier lahar detection system and a detailed description of each site's individual role in the lahar detection system is included in the EA as Appendix B.

Component Activities
How will each of the components of the action be performed under this alternative?

Comp #	Component of the Action	Activity for this Alternative
X	*Example: Transportation of personnel to the project site*	*Example: Personnel will travel by horseback*
1	Selection of the lahar monitoring locations	Six out of nine stations would be within wilderness.
2	Transportation of material to the monitoring sites for installation	All materials and equipment would be transported by helicopters.
3	Transportation of personnel to the monitoring sites during installation	Personnel would hike to and from the sites.
4	On-site installation of the monitoring stations	Installation would use power tools.
5	Maintenance of the monitoring stations	Access sites on foot for routine tuning and maintenance work.
6	Periodic equipment replacement	Transport replacement batteries and other large or heavy components by helicopter.
7	Emergency repairs to aviation-dependent monitoring sites	Access sites by aircraft when objective hazards preclude access on foot.

Wilderness Character

What is the effect of each component activity on the qualities of wilderness character? What mitigation measures will be taken?

UNTRAMMELED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☐	☐	☒
2	All materials and equipment would be transported by helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☒	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☒	☐	☒

Explain:
Alternative 4 would not adversely affect the untrammeled quality. The lahar detection stations would not increase human manipulation or control of the components or processes of ecological systems in wilderness; therefore, the untrammeled quality of wilderness would be preserved.

UNDEVELOPED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported by helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☒	☐
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Construction activities would introduce noise and sights of additional human occupation, which would adversely affect the undeveloped quality of the wilderness. Use of mechanized equipment, such as power tools, and use of a helicopter for material delivery would introduce unnatural sounds during installation and maintenance work. Use of power tools is described in Attachment A. Impacts on the undeveloped quality during construction would generally be low, and disturbance would be mostly contained to a brief construction period at each site. Elevated noise levels from the use of mechanized equipment would occur during construction over a two-week period each year over two years while use of a helicopter to transport material would result in a temporary increase in noise that would affect the undeveloped quality of wilderness for about one to two hours per day over a period of about two days at each site. The total number of helicopter flights would be less than under the USGS Proposed Action, with about 48 trips (24 fewer than the USGS Proposed Action) during installation over a 2-month period (September and October) and about 189 maintenance flights over a period of 30 years (54 fewer than the USGS Proposed Action). This would represent an increase of about 17 to 34 percent in flight time during the 2-year installation period and an increase of about 3 to 6 percent in flight time compared to the existing number of flights over the 30-year maintenance period. Crews would hike to the sites to reduce the number of flights for both installation and maintenance.

After installation, the presence of new structures and installations at Emerald Ridge, Ararat South, Copper Mountain, Mildred Point, and Tahoma Bridge would degrade the undeveloped wilderness quality by introducing visible signs of human occupation. Under this alternative, the number of standalone seismic installations in wilderness would increase from 5 to 9. The other installations would be collocated with existing developments and installations. The number of stations dependent on aircraft would increase from 5 to 10. Installation of the sites at Emerald Ridge, Ararat South, Copper Mountain, and Mildred Point would affect relatively unimpacted sites with large viewsheds within designated wilderness, mostly within the upper Tahoma Creek watershed. These sites would be situated so they would be hard to see from established trails; however, visitors travelling off trail could come across these facilities or see them from a distance. Wilderness users encountering these facilities could feel that their wilderness experience has been degraded by the presence of these signs of human occupation.

As previously described, the installation on Ararat South would be encountered by some hikers climbing to the summit and would tend to dominate the experience of the highest point on the summit; however, the summit is broad and visitors exploring the summit area could find places where the installation is not visible. The Gobblers Knob Lookout site would be collocated with an existing lookout structure, thus reducing the number of installations and visual impacts on the undeveloped wilderness quality. The installation at Mildred Point would be out of sight of most hikers who do not venture past the end of the maintained trail; however, for some hikers continuing up the ridge to experience the area without the aid of recreation developments, the installation would be encountered and dominate the experience of the area within several hundred feet. The Mildred Point site would also be visible from a distance from many of the higher elevations of Van Trump Park. These impacts would persist for as long as the lahar detection sites are present in the wilderness, potentially indefinitely.

NATURAL

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported by helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
Alternative 4 would alter less than 0.1 acre of vegetation within the 228,400-acre wilderness, and impacts are expected to recover to a natural state over time. Due to the small scale and widely separated nature of the proposed sites, and the implementation of mitigation measures to reduce impacts, Alternative 4 would have only minimal adverse effects on plants, animals, air, water, or ecological processes. However, there is a possibility that foot traffic from maintenance visits or curious visitors could cause the development of social trail impacts where they do not currently exist. As described for Alternative 1, noise and activity from construction and helicopters has the potential to affect behaviors of spotted owls and marbled murrelets; however, with implementation of mitigation measures, the project is not expected to adversely affect these species.

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported by helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Helicopter trips to install monitoring stations would affect solitude when aircraft are flying over or landing in wilderness. Impacts would affect individuals encountering aircraft as well as those who could hear the aircraft from distant locations. These effects would vary among individuals, depending on where visitors encountered the helicopter use, and would be temporary and limited to about 42 trips during installation over a 2-month period (September and October) each year for 2 years, up to 6 flights for revegetation, and about 189 maintenance flights over a period of 30 years.

After installation, the structures would have small effects on solitude or unconfined recreation. The presence of the monitoring stations would negatively affect the primitive nature of the wilderness. Individuals who come across a site could have their wilderness experience negatively affected by the feeling of being monitored and by the feeling that modern humans have occupied and will return to the site. The stations might serve as curiosities that attract more users to the sites but would not reduce opportunities for solitude or primitive and unconfined recreation overall. As described under the undeveloped quality, stations would be painted to reduce their visibility and placed to minimize being detected by the casual visitor. However, the greatest impact would be experienced by the visitor who expends the greatest effort to pursue the opportunity for solitude, and therefore has a higher expectation of solitude.

OTHER FEATURES OF VALUE

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported by helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
The proposed monitoring station on the Gobblers Knob fire lookout would affect contributing features to the National Historic Landmark District. Impacts on these features are described in detail in the Historic Districts, Structures, and Cultural Landscapes section of the EA. These historical structures predate the wilderness designation and contribute to wilderness character to the extent that they tell the story of historical use of the wilderness area. Modern installations and modifications contribute to a shift in visitor perception of the structures as historic features toward a perception as modern administrative facilities. Instruments would be painted to reduce their visibility and placed strategically to minimize detection by the casual visitor; however, several of the instruments would be potentially visible to the public.

The dynamic glacial and volcanic features of Mount Rainier contribute to wilderness character as a geologic feature of value, as identified in the park's Wilderness Character Narrative. While Alternative 4 does not have a positive or negative effect on this quality, study of these unique features would fulfill the public purposes of scientific and educational use.

Data collected using the detection sites would be useful to the park for hazard mitigation and situational awareness for wilderness users, as described for the other alternatives. Elimination of the Tolmie Peak and Shriner Peak sites would eliminate the addition of seismometers that would otherwise improve the accuracy of earthquake locations at Mount Rainier and the ability to detect smaller lahars and debris flows down the Ohanapecosh River. Other than the elimination of data from these two sites, the data collected under Alternative 4 would be the same as the other alternatives.

MRDG Step 2: Alternatives Not Analyzed

Alternatives Not Analyzed
What alternatives were considered but not analyzed? Why were they not analyzed?

Install USGS Monitoring Stations as Originally Proposed

The original USGS proposal that was submitted to the NPS in December 2019 (see Appendix B of the EA) proposed several sites, five of which were approved and installed in 2020. As described above under the USGS Proposed Action (Alternative 1), MORA and USGS staff worked collaboratively to refine the USGS proposal for the remaining 12 locations to further mitigate the potential for adverse effects. Although some elements of the original proposal were retained in Alternative 1, the overall proposal was resubmitted and incorporates modifications to several of the proposed monitoring stations as described in the attached PPRs.

Locate All New Long-Term Seismic/GPS Monitoring Stations Outside Wilderness

Because the intent of the proposed project is to more effectively determine the cause of and to monitor the hazards associated with the Mount Rainier volcano, placing the stations outside wilderness would mean locating them off the volcano and would therefore not meet the purpose and need of the project (except the five monitoring stations addressed under a separate clearance process, as described above in Alternative 1: USGS Proposed Action). The short amount of time between the initiation of an event on the west side of the volcano and downstream impacts requires instrumentation within the potentially impacted drainages. Surrounding instrumentation is required (e.g., Mildred Point) to assess the extent of the hazard, such as whether one or multiple drainages are being impacted. Infrasound in particular is most effective when placed near the impacted drainage, as pressure waves in the atmosphere have been shown to be distorted or shadowed by local topography.

Increase the Number of Stations Proposed by the USGS

The USGS provided a summary of the larger system that was considered but not included in the proposal. An overall summary regarding the development of the proposal has been provided by the USGS, and specific language about a more robust system is included in the EA under *Alternatives Considered but Dismissed*. However, as descried in the EA, additional sites were not considered for this proposal because a) current scientific understanding is that these other drainages are not as vulnerable to spontaneous non-eruptive landslide-caused lahars, b) the primary purpose of this project is to improve lahar detection capabilities, not volcano-monitoring capabilities, and c) the impact on wilderness would be far greater. A summary of the design process for the Mount Rainier lahar detection system, including an initial proposal for as many as 40 stations, with about half of the stations within the park, is included in Appendix B of the EA.

Nonmotorized Transport of Materials to the Project Sites

Hiking or horseback transport of materials to and from the project site was not considered given the weight and dimensions of the equipment and the time constraints. The monitoring stations are too heavy to carry to the site via nonmotorized means.

Installation Using Only Nonmotorized Tools

This alternative is the same as the USGS Proposed Action (Alternative 1) except that no power tools would be used during installation; only hand tools would be used for installation. Helicopters would be used to transport materials and equipment to the project site. Use of hand tools would require additional time for installation, and could potentially require additional helicopter flights, or require flights to extend over a longer period.

This alternative was eliminated from consideration because it would not be practical to eliminate all power tools from the Proposed Action. It would not be possible to achieve the needed precision drilling holes in metal pipe with manual tools. In addition, although cutting metal materials such as trim, bolts, and conduit with a handheld hacksaw may be possible, some cuts would be in areas that are awkward or constricted by other structural elements and would require a different approach to design. Installation would take longer and require a longer weather window, and possibly repeat visits, increasing the duration of temporary impacts on solitude and severity of trampling on vegetation. Finally, hand drilling deep holes, without power tools, would require additional laborers and multiple days of work. The technique was historically used to split, blast, or otherwise destroy rock, and precision drilling for the type of anchors needed for these installations would require an experienced team, which is not available. Manual hand drilling was abandoned in the early 20th century in favor of pneumatic drilling. Hand drilling is used today for wilderness trail maintenance (breaking rock) or placement of small (several inch long) structural anchors, but is not a viable option for the proposed installations. A detailed summary of the power tools proposed for use and justification for their use is found in Attachment A.

MRDG Step 2: Alternatives Comparison

Alternative 1:	USGS Proposed Action
Alternative 2:	No Action Alternative
Alternative 3:	USGS proposal with alternative sites
Alternative 4:	Modified Lahar Detection and Volcano Monitoring with installation at three locations (Fremont, Tolmie, Shriner) deferred pending evidence of volcanic unrest

Factors to be considered in comparing the alternatives include the effects of each alternative on the qualities of wilderness character and prohibited uses under Section 4(c) of the Wilderness Act. Differences between the alternatives would primarily result from differences in effects on the undeveloped, solitude and opportunities for unconfined recreation, and other features of value qualities of wilderness character.

Prohibited Uses
Alternatives 1, 3, and 4 would include construction of new installations in wilderness and landing of aircraft within wilderness, which are prohibited uses under the Wilderness Act. Each helicopter trip would include a landing via sling load to deliver materials. The number of helicopter trips and new installations would vary between the alternatives, as summarized in Table 1.

Untrammeled
None of the alternatives would affect the untrammeled quality of wilderness character.

Natural
The action alternatives (Alternatives 1, 3, and 4) would have similar, very minor impacts on the natural quality of wilderness. The No Action Alternative (Alternative 2) would not result in new impacts on this quality.

Undeveloped
Use of mechanized equipment, such as power tools, and use of helicopters for material delivery would affect the undeveloped quality of wilderness by introducing unnatural sounds during installation and maintenance work. Use of helicopters would vary between alternatives, as shown in Table 1 below. Power tools would be used for Alternatives 1, 3, and 4. The undeveloped quality of wilderness would also be affected under the action alternatives by the presence of new installations in wilderness. The impacts of the new installations would be

similar between the alternatives but would be proportional to the number of new stand-alone stations in wilderness and the number of new stations in undeveloped wilderness (Table 1).

Solitude and Opportunities for Unconfined Recreation

The alternatives would result in small differences in temporary impacts on solitude when aircraft are flying over or landing in wilderness, which would be proportional to the number of helicopter flights for each alternative (Table 1). In addition, the structures would have small effects on solitude and opportunities for unconfined recreation after installation, which would vary between Alternatives 1, 3, and 4, depending on the number of new stand-alone stations in wilderness and the number of new stations in undeveloped wilderness (Table 1).

Other Features of Value

New stations would be collocated with existing historic fire lookouts at four sites (Alternative 1) or one site (Alternatives 3 and 4). No new stations would be collocated with existing historic fire lookouts in Alternative 2 (No Action Alternative). Modern installations and modifications would affect the other features of value quality of wilderness character by contributing to a shift in visitor perception of the structures as historic features toward a perception as modern administrative facilities.

Scientific Purpose/Benefit

Study of Mount Rainier's geologic features would fulfill the scientific and educational purposes of wilderness. Data collected using the detection sites would also be useful to the park for hazard mitigation and situational awareness for wilderness users. These benefits would be the same under all three action alternatives, except elimination of the Tolmie Peak and Shriner Peak stations in Alternative 4 would eliminate the addition of seismometers that would otherwise improve the accuracy of earthquake locations at Mount Rainier and the ability to detect smaller lahars and debris flows down the Ohanapecosh River. No change to current data collection would occur under Alternative 2 (No Action).

Table 1. Comparison of Alternatives

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Existing sites requiring helicopter use	6	6	6	6
New sites requiring helicopter use	9	0	11	6
Helicopter flights for maintenance of existing sites over 30 years (24 trips per site)[1]	144	144	144	144
Helicopter trips for installation of new sites (7 trips per site, plus 1 trip per site for revegetation)	72	0	88	48
Additional helicopter trips for tuning and maintenance of new sites over 30 years (27 trips per site)[2]	243	0	297	189
New stand-alone stations in wilderness	4	0	9	4
New stations in undeveloped wilderness	8	0	10	5
New stations collocated with historic fire lookouts	4	0	1	1

[1]Assumes up to four maintenance trips per site every 5 years for 30 years.

[2]Assumes three trips for tuning after 1 to 2 years plus four trips every 5 years (24 flights) over 30 years for maintenance.

MRDG Step 2: Determination

Refer to the **MRDG Instructions** before identifying the selected alternative and explaining the rationale for the selection.

Selected Alternative

☐	Alternative 1:	USGS Proposed Action
☐	Alternative 2:	No Action Alternative
☐	Alternative 3:	USGS proposal with alternative sites
☐	Alternative 4:	Modified Lahar Detection and Volcano Monitoring with installation at three locations (Fremont, Tolmie, Shriner) deferred pending evidence of volcanic unrest

Explain Rationale for Selection:

Mitigation measures are found in Appendix A of the EA.

References

Hartog et al. 2008

Approvals

Which of the prohibited uses found in Section 4(c) of the Wilderness Act are approved in the selected alternative and for what quantity? [To be completed after review of public comments on draft MRDG]

Approved?	Prohibited Use	Quantity
☒	Mechanical Transport:	
☒	Motorized Equipment:	
☐	Motor Vehicles:	
☐	Motorboats:	
☒	Landing of Aircraft:	
☐	Temporary Roads:	
☐	Structures:	
☒	Installations:	

Record and report any authorizations of Wilderness Act Section 4(c) prohibited uses according to agency policies or guidance.

Refer to agency policies for the following signature authorities:

Prepared:

Name Position

Signature ______________________ Date ______________

Recommended:

Name Position

Signature ______________________ Date ______________

Recommended:

Name Position

Signature ______________________ Date ______________

Approved:

Name ______ Position ______

Signature ______________________ Date ______________

Attachment A

Description and Rationale for Power Tool Use

Attachment A

UGSS Power Tool Needs for Rainer Lahar Detection System Station Installations and Maintenance

The USGS requires the use of the following power tools during the installation of the proposed Rainier Lahar Detection infrastructure at stations located in the areas designated as wilderness. Additionally, the USGS requires the use of many of the same tools to conduct maintenance at these stations as needed. The tools include:

1.) Battery-powered drill (for example, DeWalt 20v Lithium Battery ½ inch drill) for drilling holes in pipe, enclosure, and solar panel frames as needed.
2.) Battery-powered rock drill for drilling up to 1-inch diameter holes at the Mount Wow alternative (e.g., the “talus” site) and Tahoma Bridge to anchor enclosures.
3.) Battery-powered sawzall (for example, DeWalt 20v Lithium Battery 1 1/8-inch stroke reciprocating saw) for cutting pipe, damaged hardware, and 2-inch U-bolts that become cross threaded during installation or subsequent maintenance.
4.) Battery-powered bandsaw (for example, DeWalt 20v Lithium Battery Cordless Band Saw) for cutting pipe onsite during installation or subsequent maintenance.
5.) For installing the GPS monument at Copper Mountain, the following power tools are required:
    a. A 4000W gas-powered generator to operate corded power tools needed for building the short-braced GPS monument. Primary need is to power an AC-powered air compressor, an AC-powered hammer drill, and an AC-powered welder (described below), all of which are essential to building a stable and rigid GPS monument. The generator will be run during daylight hours for up to 12 hours total over the 2-3 days required to install the site.
    b. An AC-powered hand-held hammer drill to drill four 1.5”-diameter and 6-foot-deep holes into bedrock, including 3 holes for angled legs and 1 for the central leg of the GPS short-braced monument. Stainless steel rods will be placed into these holes and then welded together to achieve the required stability for the GPS monument. Depending on the strength of bedrock, the drilling would last up to 8 hours spread out over the 2-3 days required to install the site.
    c. An AC-powered 1-gallon air compressor for powering a pneumatic epoxy dispenser that is required for placing highly viscous epoxy down to the bottom of the four 6-foot-deep holes that will be filled with stainless steel rods that make up the GPS monument. An air hose will be connected to the compressor and a pneumatic epoxy dispenser will be attached to the other end of the air hose. The dispenser uses high pressure air to drive epoxy through a nozzle and into the holes drilled into rock before the stainless-steel rods for the GPS monument are inserted. The epoxy dispenser does not make any noise; however, the air compressor will generate noise when it is running and pressurizing air to be stored in the tank. The air compressor will run for 10 minutes for each of the 4 holes.
    d. A small, portable AC-powered welder to tack weld the three angled legs of the GPS monument to the central vertical rod (required for stabilizing the monument).

e. A battery-powered vacuum (DeWalt 20vl Lithium battery) for removing fine dust out of the 6-foot-deep GPS monument holes.
f. A battery-powered hand grinder with cut off wheel (DeWalt 20v Lithium battery). The grinder can accommodate both a cut-off wheel and grinder wheel. The cut-off wheel will be used to make precision cuts of the excess length for each of the four stainless-steel rods that form the legs of the GPS monument. The grinder attachment will be used to grind the end of each rod down to a scallop point, which is required in order for the ends to be tack welded on to the central stainless-steel rod of the GPS monument. Cumulative time using the grinder tool will not exceed about ten minutes.

Installations:

All stations: The proposed fiberglass enclosures are designed to be streamlined, self-efficient, and almost entirely prebuilt off-site prior to installation. Power-tool usage during installation of the fiberglass enclosures would be used on an as-needed basis and would be limited to minutes-long durations only. Use cases for the battery-powered drill include drilling additional precision holes on the enclosure as needed and to secure critical lightning protection and grounding equipment. Use case for the battery-powered sawzall and bandsaw include cutting pipe as needed during the installation to ensure proper fitting.

Stations WOW alternative (Mount Wow Talus) and TABR (Tahoma Bridge): The hut enclosures must be secured to the ground to a shallow depth to prevent any movement on sloping terrain. Because the Mount Wow Talus and Tahoma Bridge station enclosures are, by necessity, installed on a rock surface, this requires drilling holes in the rock to install J bolts that secure the base (flange) of the hut to the ground. This is of extra importance at these sites as the enclosures are close to the edge of very steep terrain. At both sites there will be 4 holes drilled (maximum depth 9”) for these bolts. Additionally, there will be up to 4 holes drilled (maximum depth 9”) into the rock adjacent to the sides of the hut for a pipe flange that will secure the antenna mast. The hole depth and diameter are considerably greater than a traditional climber’s rock bolt. Specifically, the diameter is at least double a traditional anchor hole; the lack of available tools, combined with the scaling in force necessary to drive the bit, render hand drilling impractical and likely impossible. In the past drilling these holes required a generator and corded rotary SDS Max rock hammer drill. With modern advancements in battery-powered tools these relatively shallow holes can be drilled with much quieter and more compact cordless SDS Max rotary hammer drills; therefore, a generator is not required. The holes will not exceed 1” in diameter or 9” in depth. Each hole should take under 10 minutes to drill. When not drilling, the drill is not noticeably louder than a standard 20V or comparable lithium-battery hand drill. The noise level while drilling depends on the hole size and rock type, but in general it is quieter than a low-flying helicopter. The drill weighs 15lbs with additional weight for bits and batteries. The set of drilling equipment is compact and will not require any additional helicopter support above the maximum number of proposed slings. (Note: The Mount Wow site along the road would not require use of an SDS Max drill).

Station COPP: Installation of the GPS monument at the Copper Mountain (COPP) site will require additional motorized equipment – specifically, a generator, a welder, a small air compressor, a pneumatic adhesive dispenser, and a hammer drill. For the GPS monument to be useable for volcano monitoring, it needs to be robust enough to withstand snow/ice creep and freeze-thaw cycles as well as wind abrasion; if the monument is deformed by even an inch, it becomes much less usable for volcano monitoring. There is broad experience in best-practices for GPS monument design that has been achieved courtesy of trial-and-error monument designs, and scientists today have a good understanding of design and construction requirements for a stable GPS monument (https://kb.unavco.org/kb/article.php?id=301). This includes being able to drill a precise vertical hole 6 feet into rock, as well as additional holes required for bracing legs that all have to be drilled to a specified depth and at a specified angle. There is no hand-tool that can perform this task to the precision required for a stable monument – a corded, powered hammer drill is required for this task. Substantial air pressure that cannot be achieved in a non-mechanized manner is required to clear the 6-foot holes and fill them with non-shrink epoxy. A battery-powered vacuum is needed to clear the holes after drilling, and a small, corded AC-powered air compressor with a pneumatic adhesive dispenser attachment is required to pump epoxy in the drilled holes that support the GPS monument legs. In addition, field-welding of the bracing legs to the central monument is required; there is no non-motorized way to achieve welding in the field. Since there is no battery-powered equivalent for an air compressor, welder, or hammer drill, a generator is needed to power these tools. Lastly, because the monument legs are solid stainless-steel rods, a battery-powered hand grinder is required to cut the rods to an exact length and at the necessary angle for proper welds at the center point. It is prohibitively difficult to precisely cut and scallop the ends of stainless rods for precise welds with a non-mechanized tool.

Maintenance:

Short- and long-term ice, snow, and wind damage may create unanticipated situations where additional modifications to the solar panel frames and telemetry infrastructure will be necessary to repair damaged equipment. Such repairs may require the use of the same power tools noted above, with the exception of those needed only for the installation the GPS monument at COPP. Modifications to metal infrastructure, especially steel and aluminum, without power drills and saws can be time-prohibitive or impossible depending on the type and thickness of the metal.

Specific examples where power tools will be required during maintenance include:

1.) Replacement of lightening protection that has failed or was damaged at a location near a ground rod attached the enclosure.
2.) Drilling precision holes in the solar panels or the enclosure to adjust or repair damaged solar panel mounting.
3.) Removal or cutting off of large stainless-steel bolts that have been damaged by snow and ice conditions and/or are rusted, seized, or cross-threaded.
4.) Adjustments and replacement of metal pipes or angle brackets used for solar panel framing damaged by ice, snow, and/or wind loading. In this case, both a drill and saw would be used in very limited durations to remove old rusted or damaged hardware and secure new pipe and hardware as needed.

Motorized tool alternatives:

Drilling holes in metal pipe: These are modern installations, constructed of modern materials, that require precision construction. We are not aware of a practice of drilling precision holes in metal pipe with a manual hand drill as a discipline of traditional tool use. The torque, pressure, and precision required would be difficult, if not impossible, to achieve using a manual drill, freehand.

Cutting metal pipe: Metal trim, pipes, bolts, and conduit can be cut using a manual hacksaw. The time required varies according to the gauge of the metal, but we estimate an order of magnitude difference in the time required for each cut. Some cuts would be in areas that are awkward or constricted by other structural elements and would require a different approach to design. Installation would take longer and require a longer weather window and possibly repeat visits, increasing the duration of temporary impacts to solitude and severity of trampling on vegetation. Hacksaws will be used for installation and maintenance when practical.

Drilling holes in rock: Deep holes can be driven in rock with a manual hammer drill. Holes this deep would require a technique called double-jacking. This slow, very physical process can be dangerous for inexperienced users, as there is a higher potential for significant injury. Hand-drilling of deep holes would require additional laborers and multiple days of work. The technique was historically used to split, blast, or otherwise destroy rock, and precision drilling for the type of anchors needed for these installations would require an experienced team, which is not available. Manual hand drilling was abandoned in the early 20th century in favor of pneumatic drilling. Hand drilling is used today for wilderness trail maintenance (breaking rock) or placement of small (several inch long) structural anchors but is not a viable option for the proposed installations.