2021

California Earthquake Early Warning Business Plan Update

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Cal OES
GOVERNOR'S OFFICE
OF EMERGENCY SERVICES

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1. Introduction

This is the update to the California Earthquake Early Warning Business Plan.

Senate Bill (SB) 438 (Hill, Chapter 803, Statutes of 2016) requires the Governor's Office of Emergency Services (Cal OES) to produce a Business Plan Update by February 1 annually. This update includes the statutory report elements, which cover:

- The overall progress of the implementation of the system.
- An update on funding acquired and expended.
- An update on contracts and requests for proposals.
- A summary of recommendations made by the California Earthquake Early Warning Advisory Board to Cal OES.

2. Progress of Earthquake Early Warning in California

Cal OES continues work to implement public alerting, which was launched in October 2019 by Governor Newsom on the 30th anniversary of the Loma Prieta Earthquake that ravaged the Bay Area and Santa Cruz. At that time California took a historic step toward making its residents and communities safer by beginning public alerting for earthquake early warning. This included deployment of the Nation's first statewide cell phone application for earthquake early warning, MyShake, as well as use of the Wireless Emergency Alert (WEA) system. While continuous improvements are ongoing, the system now provides critical, lifesaving services to the public.

Figure 1: Photo by Terry Chea/AP

The California Governor's Office of Emergency Services (Cal OES) provided the financing to initiate public alerting for earthquake early warning through the MyShake mobile application (app). Cal OES entered into an Inter-Agency Agreement with the University of California, Berkeley to advance a prototype version of MyShake to provide warnings in both English and Spanish. The app also incorporates training on the use of earthquake alerts, provides earthquake preparedness information, and allows users to report what they experience during an earthquake and see the reports of others. A research component of the app is also exploring if accelerometer data from phones can enhance the earthquake early warning network and decrease "blind zones." Under this concept, any phone where the app is installed is in effect a seismometer. Cal OES continues to ensure that U.C. Berkeley works to reduce latency times for alert delivery, improves the performance of the app as the

user base increases, and adds additional features to enable users to prepare and recover from earthquakes.

In February of 2019, Cal OES applied for a Federal Communications Commission (FCC) waiver to allow a WEA test for earthquake early warning. Cal OES led the multiagency effort, including the United States Geological Survey (USGS), the City of Oakland, and Alameda County to conduct the first earthquake early warning WEA test in history on March 27, 2019 in downtown Oakland. This test found that initial alerts could be transmitted through the WEA gateway and cell phone towers to reach phones in as little as four seconds.

The Oakland test was so successful that Cal OES expanded the effort to a second test in San Diego County. That test on June 27, 2019 was much larger and reached all residents, travelers, and people working within the geographic boundary of the County. The test found that the first alerts were received on cell phones within six seconds.

These two tests demonstrated that the ShakeAlert seismic activity feed could communicate directly with the WEA gateway and that the warnings could be disseminated rapidly enough for people and systems to take protective actions.

In August of 2020 a partnership with Google, USGS, and Cal OES resulted in an update of the Android operating system that provides earthquake warnings without having to download additional applications. This significant advancement has dramatically increased the number of people who receive alerts.

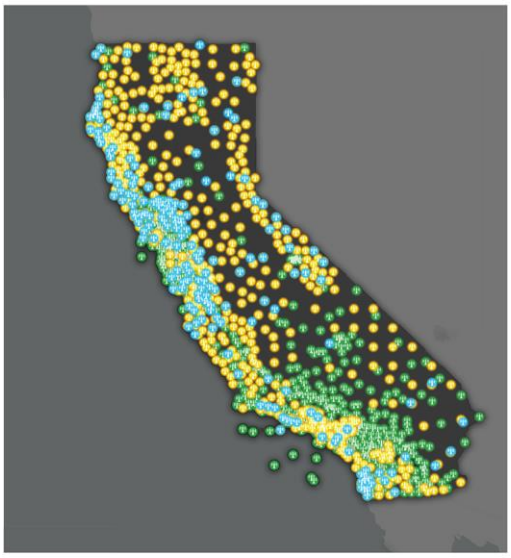
To date, a total of 29 of MyShake alerts and ten of WEA earthquake early warning alerts have been issued in California to approximately 109,000 MyShake users.

System Operations

The California Earthquake Early Warning Program continues to work with California Integrated Seismic Network (CISN) partner organizations and the Cal OES Public Safety Communications (PSC) Division to update and modernize seismic stations.

The California Earthquake Early Warning Program and Public Safety Communications successfully completed pilot projects, which successfully connected seismic stations to the California Public Safety Network (CAPSNET) microwave for telemetry transport to the CISN data processing center. This included a targeted investment in 2018 to create the California Earthquake Early Warning Microwave Telemetry Plan and to connect 25 percent of the seismic stations to the CAPSNET state microwave system (including funding acceleration of upgrades to CAPSNET equipment). Use of CAPSNET not only provides redundancy for data collection and transfer, but also capitalizes upon one of the fastest delivery methods using existing state public safety infrastructure. Additionally, in 2019 Cal OES partnered with the California High Speed Rail Authority to leverage newly acquired licensed radio spectrum throughout the state. This solution will enable stations in most of the state to have a dedicated, secure and licensed 'line of sight' telemetry link to the CAPSNET microwave.

Seismic Stations in California



California is approaching completion of the buildout phase outlined in the initial technical implementation plan. As a result, there was an assessment conducted with System Operation partners to better identify:

1. Current number of stations contributing to the system
2. How many more stations still need to be funded and installed

This assessment found that as of October 2020, there were 764 EEW stations completed and contributing to ShakeAlert of the 1,115 required to reach acceptable sensor density according to CISN partners. An additional 231 stations have been funded, but installation is not yet complete or the stations are waiting for telemetry. According to USGS, there are 74 stations (61 in Northern California and 13 in Southern California) that have not been funded or installed. Plans are underway for the USGS and Cal OES to both fund a portion of these stations. Many factors have affected the installation of stations including land use and environmental permits, weather, travel and access to the sites. Most recently, physical distancing restrictions required due to COVID-19, as well as interruptions in the supply chain to acquire equipment and materials have further delayed installations.

As the seismic system in California nears full build out, partners are shifting focus from build out to maintenance and ongoing operations. Ongoing allocations will be needed to fund equipment and staff to perform preventative and routine maintenance on sensors and associated equipment in order to keep stations operating effectively. Seismic stations, especially free field ground station, are

susceptible to damage and decay due to elements such as weather, vermin, and vandalism. On average, thirty percent of stations require monthly maintenance of some sort. The monthly maintenance ranges from minor fixes such as software updates and telemetry checks to more extensive repairs such as replacement of severed cables or stolen solar panels. In addition to routine maintenance, components need to be updated as technology advances along with replacement of outdated or inoperable equipment and parts.

For planning purposes, the average useful life of major system components is 5 to 25 years; the lifespan variations depend on environmental conditions at the site. Below is a list of standard components used at a seismic center that are not housed within another structure, and estimates of the average useful life.

Standard Equipment	**Useful Life (Years)**
Computer Processing Unit	5
Broadband Sensor	10
Accelerometer	10
Data Logger	10
Cables	10
Batteries (4-6 per station)	5-10
Cell Modem	5-10
Radio/Antennas	25
Solar Power System	25

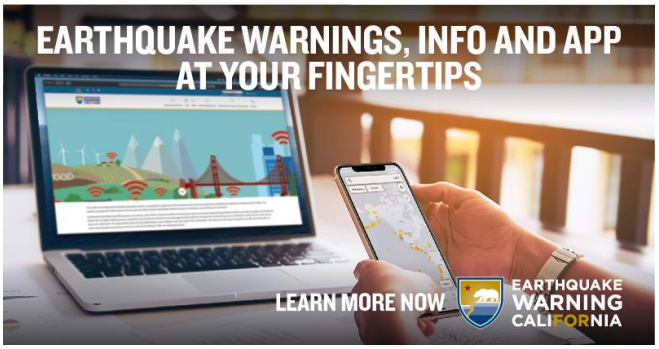
Update on Ongoing Funding Needs

The $16.4 million ongoing cost estimated in the 2018 CEEW Business Plan includes the following annual operation and maintenance costs:

Seismic Stations	$ 3,800,000
Global Positioning System (GPS) Stations	$ 2,300,000
Backbone Telemetry	$ 2,900,000
Outreach and Education	$ 3,500,000
Research and Development	$ 300,000
Program Management	$ 400,000
Contingency	$ 3,200,000
Total	**$16,400,000**

Since 2018 and during the transition from build-out to operation and maintenance, actual costs to maintain the system continue to be assessed. After consultation and review by system operation partners, the Advisory Board, and other experts, Cal OES will present any revisions to program maintenance costs in future business plan

updates. Consideration will be given to maximizing efficiencies while also projecting future needs of system end users and customers. Public Education



In October 2020, Cal OES launched a comprehensive public awareness campaign to educate all California residents about the states earthquake early warning system: Earthquake Warning California. The campaign directs Californians to no-cost tools, resources, and information, including how to access the smartphone MyShake App, Android Earthquake Alerts, Wireless Emergency Alerts (WEAs). The campaign also highlights and drives users to the www.earthquake.ca.gov website.

Campaign elements include an updated earthquake.ca.gov website, original creative television and digital ads, earned media, and public relations. As part of the public relations aspect of the campaign, there is ongoing, strategic efforts to educate key user groups such as local governments, first responders, businesses, the education sector, critical infrastructure providers, and non-profit organizations about the benefits of earthquake early warning. The campaign incorporates a main theme that many things can "Catch You Off Guard", but earthquakes don't have to, now that earthquake warnings are possible. Ads reflect a combination of tones ranging from informative to light-hearted, which were tested for effectiveness through focus groups. Since its launch of the in October 2020, the campaign has had almost 125 million impressions (an estimation of how many people viewed a product) through television and digital media.

Cal OES has also worked with the California Broadcaster's Association (CBA), within its Public Education Partnership Program, to distribute radio public service announcements throughout the state. These announcements inform Californians about earthquake early warnings and how to protect themselves and their families when an alert is received. During the duration of the CBA campaign, which primarily took place in September of 2018 through December of 2019 over 44,000 radio spots were aired statewide. Cal OES conducted a social media campaign in advance of, during, and since the launch utilizing Twitter and Facebook. Additionally, Cal OES incorporated earthquake early warning education into presentations at outreach events focused on seismic safety and broader emergency preparedness, including: Tsunami Preparedness Week, The Great Shakeout, and Cal OES' Preparedness Day.

Collaborative efforts between Cal OES and USGS continue to solidify roles and responsibilities now that the program is maturing and identifying strategies to expand the use of earthquake warnings in California and beyond. The general public, education, medical, business, transportation, public safety, utilities, telecommunications, and workforce protection will continue to be the focus of implementation and expansion efforts.

3. Funding

2016-17 Funding

Cal OES allocated the initial $10 million General Fund to contracts for sensor installation, social science research, education and outreach efforts, research to improve telemetry and mass alert distribution, and consultation on the original Business Plan. The details about funding and contracts are included in Appendix A

2017-18 Funding

Cal OES did not receive any additional funding to build out the system in 2017-18 and operation and maintenance funding was not yet needed.

2018-19 Funding

Cal OES allocated $15 million General Fund from the 2018-19 state budget for seismic station buildout and $750,000 in ongoing funds for four staff members and support to the California Earthquake Early Warning Advisory Board. Cal OES entered into Interagency Agreements with the CGS, the California Department of Water Resources (DWR), and U.C. Berkeley to support seismic station installation and telemetry. The details about funding and contracts are included in Appendix B.

2019-20 Funding

Cal OES received $16.3 million General Fund in the 2019-20 State Budget for seismic station installations, adding GPS stations to the network, continued telemetry improvements, and launching a statewide education and outreach campaign. The details about funding and contracts are included in Appendix C.

2020-21 Funding

Cal OES received a loan of $17.3 million from the California School Land Bank Fund to support ongoing operations and maintenance until a continuous funding stream is established. Cal OES is entering into a number of contracts and agreements to encumber the funding.

4. Contracts and Requests for Proposals

Cal OES will enter into Inter-Agency Agreements and Non-Competitive Bids with System Operations partners for the continued development, operation and maintenance of the statewide seismic network and processing centers.

Cal OES will also offer support for research and development through Inter-Agency Agreements and contracts to continue the support behind the MyShake App; machine learning to decrease the time it takes to estimate the magnitude and location of an earthquake,; and update the existing CISN display to incorporate earthquake early warning and create a new CISN web interface that is mobile device compatible.

Cal OES will request proposals to continue education and outreach efforts that launched in October of 2020. The campaign objectives will continue to increase user participation and educate Californians that earthquake warnings are available, how to receive them and how to use them.

5. California Earthquake Early Warning Advisory Board

The Advisory Board held its initial meeting on June 22, 2017 and has held subsequent meetings on the following dates:

- November 30, 2017
- April 30, 2018
- September 27, 2018
- March 7, 2019
- September 26, 2019
- August 5, 2020

Advisory Board members made several recommendations about the development of the program during the meetings. Key Advisory Board policy focus areas in 2019 and 2020 included:

Launch of Public Alert and Warning: Members of the Advisory Board recommended capitalizing on existing emergency alerting systems that the public is already familiar with while continuing to innovate and evaluate new warning systems. There was also interest in reducing latency of alerting wherever possible.

> **Response:** Cal OES conducted two tests of the WEA System, which was previously thought to have higher latencies than acceptable for effective earthquake early warnings. Additionally, Cal OES worked with researchers at U.C. Berkeley to develop and launch an earthquake early warning app that is now providing the general public with earthquake early warning along with a research platform to improve seismic detection via smartphones.

Launch of Education and Outreach Campaign: Members of the Advisory Board provided feedback about the program name, general outreach campaign and strategy.

> **Response:** The Advisory Board provided feedback on the campaign and new proposed program names. That feedback was incorporated along with focus group responses in the final campaign construction.

Finance: The Advisory Board strongly recommended that the California Earthquake Early Warning Program conduct a Benefit Cost Analysis for the system and recommended that the program be funded by industries that would reduce their earthquake risk the most.

> **Response:** The Benefit Cost Analysis will be released upon completion of final review. The report will examine how end users can maximize the California Earthquake Early Warning System to reduce risk.

6. Long Term Funding

Earthquake Warning California requires $17,300,000 annual funding to support operations and maintenance, telemetry, outreach and education, research and development, and program management, including a portion of Cal OES staffing. Cal OES continues to explore a sustainable and equitable path to long-term funding with industries and other sectors that will benefit from this technology. In the course of this process, the following considerations have emerged as important in both the sequencing and sourcing of future funds:

- State investment – The state's front-end investment of General Fund has both enabled and accelerated the deployment of earthquake early warning statewide.
- Benefit/Cost – The benefit/cost analysis identified sectors and industries who stand to achieve the greatest risk reduction from earthquake early warning, providing an analysis-driven business case for investing in the system.
- Education and Outreach – Over one million Californians have downloaded the MyShake app and many more are now able to receive Android Earthquake Alerts. A comprehensive education campaign, which began in October 2020, is designed to increase downloads and provide focused sector-based outreach to promote system benefits such as workforce safety and automated actions that reduce earthquake losses.

Combined, these factors continue to build credibility and trust in this system and will lend to a comprehensive investment program going forward.

7. Conclusion

The public launch of the California Earthquake Early Warning System followed many years of hard work and statewide leadership. The State's efforts began with SB 135 in 2013 (Chapter 342, Statutes of 2013), which stated that California will develop a statewide Earthquake Early Warning system through a public-private partnership. Since 2013, California has taken significant steps to realize this vision. In 2016, statute was enacted designating Cal OES as lead to develop a statewide Earthquake Early Warning Program. With a governance structure in place and cumulative state investment of over $59.3 million in General Fund and one-time loans, this effort has advanced to the point where the public is now receiving alerts. Cal OES led an effort to begin public notification years ahead of projections made in the original Business Plan.

Further work remains in continuing to adopt innovations in technology, increase and diversify delivery methods, reduce latencies, provide robust and continuous public education, and increase the use of the system in industrial settings.

Appendix A. 2016-17 Spending Allocations

Contractor	Description	Funding Allocation
Seismic Station Installation and Maintenance		**Total: $6,484,000**
California Geological Survey	70 strong motion station upgrades	$250,000
California Institute of Technology	10 new broadband stations	$527,000
United States Geological Survey	70 new strong motion stations	$3,145,000
University of California, Berkeley	33 new broadband stations	$2,562,000
Education and Training		**Total: $2,261,000**
National Broadcasters Association	Public awareness campaign	$2,138,000
California Geological Survey	Outreach to science teachers to assist in warning development	$40,000
Cal OES Office of Public Information	Communication equipment	$45,000
California State University, Fullerton	Research by Dr. Michele Wood to identify research gaps	$38,000

Research and Development		**Total: $670,000**
American Public Television Stations	Purchase and install equipment to attach to PBS stations to test datacasting capabilities with EEW	$170,000
Cal OES Public Safety Communications	Demonstration project to connect stations to seismic laboratories over the state microwave network in northern and southern California	$500,000
Finance / Business Plan		**Total: $250,000**
Blue Sky Consulting	Research and production of the original Business Plan	$250,000
Staffing, operations and maintenance (6 months)		**Total: $335,000**
2016-17 State General Fund Budget Allocation		**Total: $10,000,000**

Appendix B. 2018-19 Spending Allocations

Contractor	Description	Funding Allocation
Seismic Station Installation and Maintenance		**Total: $7,895,000**
California Geological Survey	8 new strong motion seismic stations and 24 upgraded strong motion seismic stations	$1,380,000
California Department of Water Resources	11 new or upgraded strong motion seismic stations and 13 new or upgraded combination strong motion and broadband stations	$1,000,000
University of California, Berkeley	55 new combination broadband and strong motion seismic stations and 5 upgraded combination broadband and strong motion seismic stations	$5,500,000
Department of General Services Permitting Fee	Fund additional workload capacity to review land use permit applications	$15,000
Statewide Telemetry Plan		**Total: $5,895,000**
Cal OES Public Safety Communications Division	Connect up to 25% (280) of EEWS seismic stations to the state microwave network	$5,895,000
Research and Development		**Total: $1,210,000**
University of California, Berkeley	Expand the use of the MyShake app to deliver earthquake early warning alerts to the public. Cell phones will also be used to use to crowd source seismic event data. This data can potentially help reduce alert latency	$1,210,000
2018-19 State General Fund Budget allocation		**Total: $15,000,000**

Appendix C. 2019-20 Spending Allocations

Contractor	Description	Funding Allocation
Seismic Station Installation and Maintenance		**Total: $7,900,000**
California Geological Survey	Establish Real-Time Data System at CGS and interactive map of seismic activity for emergency response, upgrade 40 or more strong motions seismic stations, and install and conduct training on Earthworm algorithm software training to create redundant EEW data processing capability within the state	$1,600,000
University of California, Berkeley	EEW State Microwave Project – Install microwave link to Warren Hall and connect 50 EEW remote seismic sites to microwave telemetry, 18 New and Upgraded Broadband/Geodetic stations, and EEW datacenter upgrades including 7 servers, microwave connection equipment and VPN routers	$3,200,000
California Institute of Technology	EEW State Microwave Project – Connect 100 EEW remote seismic sites to the State Microwave, 20 New or Upgraded Stations Broadband or Geodetic Stations, and EEW datacenter upgrades including 4 servers and routers	$3,100,000
Education and Training		**Total: $6,900,000**
Pulsar Advertising	Public awareness and education campaign	$6,900,000
Research and Development		**Total: $1,500,000**
University of California, Berkeley	Continue to support and enhance MyShake for statewide mobile earthquake notification.	$800,000
California Geological Survey	Update the existing CISN display (maintaining priority for emergency responders and creating a new public web application that will utilize ShakeAlert (with USGS approval), both will be mobile friendly	$400,000
University of California, Berkeley	Conduct research to enhance alerting abilities by reducing latency, alerting during aftershock sequences and reducing no warning zones	$300,000
2018-19 State General Fund Budget allocation		**Total: $16,300,000**