RESILIENCE PLAN FOR YELLOW LOT OFFICE BUILDING AND RED LOT PARKING STRUCTURE

STATE OF OREGON, DEPARTMENT OF ADMINISTRATIVE SERVICES
SALEM, OREGON

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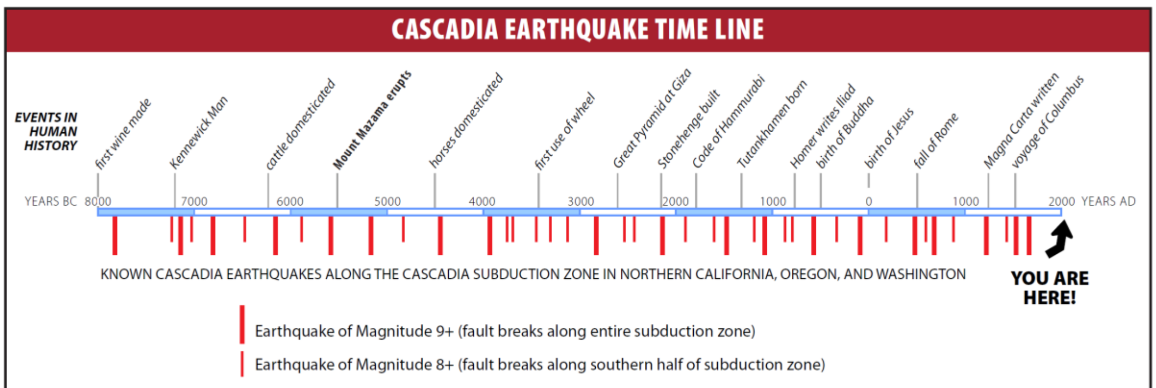
Executive Summary

Events like Hurricane Katrina in 2005, the Great East Japan M9.0 Earthquake and Tsunami in 2011, and Hurricane Sandy in 2012 have underscored the devastating impacts that natural disasters can inflict at a local, regional, state, and multi-state level. In February of 2013, the Oregon Seismic Safety Policy Advisory Commission submitted a report to the 77th Legislative Assembly entitled the *Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami*. The report discusses the risk that is faced by the citizens of Oregon from an impending Cascadia Subduction Zone earthquake and accompanying tsunami, and the gaps that exist between the current state of Oregon's infrastructure and where it needs to be. The *Oregon Resilience Plan* goes on to outline steps that can be taken over the next 50 years to bring the state closer to resilient performance through a systematic program of vulnerability assessments, capital investments in public infrastructure, new incentives to engage the private sector, and policy changes that reflect current understanding of the Cascadia threat.



Comparison of the history of subduction zone earthquakes along the Cascadia Subduction Zone in northern California, Oregon, and Washington, with events from human history. Ages of earthquakes are derived from study and dating of submarine landslides triggered by the earthquakes. Earthquake data provided by Chris Goldfinger, Oregon State University; time line by Ian P. Madin, DOGAMI.

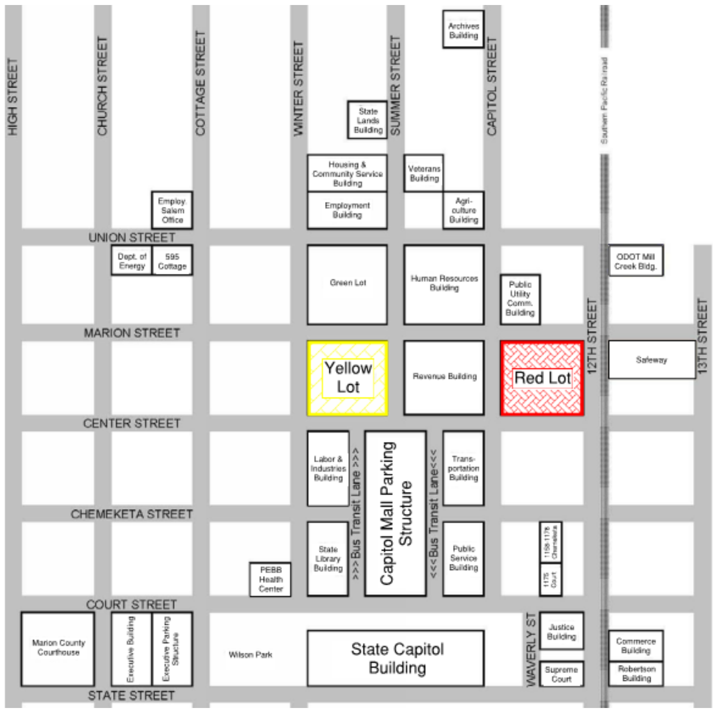
Historic Cascadia Subduction Zone Earthquake Timeline (DOGAMI 2010)

If a major Cascadia Subduction Zone earthquake were to occur today, the State of Oregon, Department of Administrative Services (DAS) does not anticipate that any of their buildings in Western Oregon will be operational after the earthquake. It is expected that use of these DAS facilities will be impaired by a combination of damage to structural components (steel frame, concrete shear walls, etc.), damage to nonstructural components (cladding, sprinkler system, elevators, etc.), and damage to the utilities that supply the building (water, wastewater, electricity, etc.). It could easily take 30 days or significantly longer (3+ years) to make sufficient repairs to reoccupy damaged buildings (if repair is even practical) and reestablish utility services. The potential for significant flooding in the Willamette Valley also presents a major hazard for DAS facilities.

Oregonians rely on many services that are provided by the State government. If these services are delayed or unavailable, the ability of the State to recover quickly from a disaster will be in jeopardy. In order to provide for continuity of critical government functions, the vision of DAS is to construct a resilient office building that will be operational immediately after an earthquake or other disaster. In normal operational mode, the building will house one or more State agencies. Among other uses, this resilient office building could serve as a swing space for the Legislature while the State Capitol is being seismically retrofit. In post-disaster operational mode, the normal building tenants will be temporarily displaced in order to convert the building into workspace for those State agencies that have a critical role in providing continuity of government. It is anticipated that the resilient office building will operate 24 hours a day, seven days a week, when in post-disaster mode.

SEFT Consulting Group has led a team, consisting of a structural engineer, mechanical engineer and general contractor, to conduct a study to investigate the feasibility of constructing a resilient office building on the site of the current Yellow Lot parking area and a parking structure on the site of the current Red Lot parking area in the Capitol Mall area of Salem, Oregon. The basis for the proposed office building and parking structure was a feasibility study conducted in 2008 by Hennebery Eddy Architects. Consistent with typical design practice, the conventional new office building considered in the Hennebery Eddy Architects study was based on a building that is designed to meet the Life Safety performance objective, so that during a major earthquake the risk of serious injury to building occupants and bystanders is minimized. There is no expectation that such a code-minimum designed building would be able to be occupied after a major earthquake. This standard code-minimum design approach is shortsighted when viewed from a disaster resilience perspective.

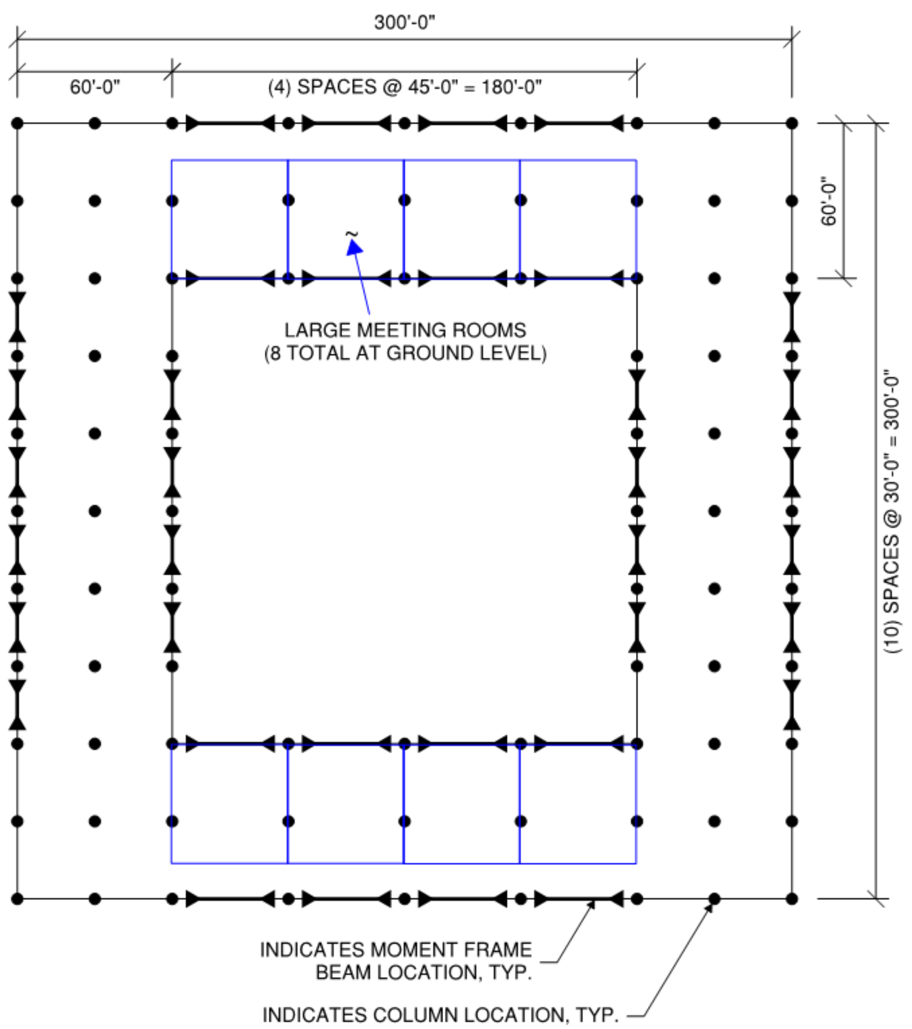
In order to achieve resilient design goals, a building must be able to meet the functional needs of the users in post-disaster operational mode. This means that the building structure must be safe and usable after the disaster. Also, this involves providing adequate thermal temperature regulation, lighting, and electrical power using alternative strategies than used in normal operational mode. Designing a building to be sustainable, particularly using a passive or high-performance/low-energy design approach, is beneficial for both normal and post-disaster operational modes. For instance, use of daylighting not only reduces day-to-day energy demands, but also provides an added benefit of reducing energy demands in post-disaster operational mode, when the building is anticipated to be essentially self-sufficient or “off-the-grid”, with two exceptions. First, the building may still rely on regular resupply of diesel fuel for the emergency generator every 96 hours, if the photovoltaic system is not functioning and critical building functions are being powered by the generator alone. Second, it is anticipated that building occupants will rely on external portable resources to provide telecommunications infrastructure (cell on wheels or cell on light truck).



Location of Current Yellow Lot and Red Lot Parking Areas

Yellow Lot Office Building

The Yellow Lot resilient office building is proposed to be five stories tall with the same maximum plan dimensions as the 2008 study Option A building and a similar total area of 288,000 square feet. The building will be designed and constructed to meet or exceed all applicable rules, regulations, codes, and standards (including, but not limited to, Oregon Revised Statutes, Oregon Administrative Rules, Executive Orders, DAS Policies, State Energy Efficient Design requirements, and state-required 1.5% for green energy technology in public buildings). Office space will be provided for approximately 1,100 employees of one or more State agencies, with around 800 people expected during typical operation due to diversity in schedules. Column locations have been specifically established to provide eight column-free hearing/meeting rooms at the ground floor level with plan dimensions of approximately 45 feet by 45 feet. A square donut-shaped plan configuration of the building has been adopted for this study in order to help facilitate daylighting and passive heating and cooling. The building will have an additional approximately 57,000 square feet of basement space that will be used to house mechanical equipment and storage space. A central courtyard will provide landscaped park-like space for building occupants, and potentially the general public. Hardware, fixtures and mechanical, electrical, and plumbing systems will be institutional grade to provide maximum service life. During normal operation (9am-5pm, five days per week), the office building will operate like any conventional office building, though it will use highly efficient, sustainable systems. By implementing these highly efficient and sustainable systems, the Yellow Lot office building will also be more easily transitioned for continuity of government use by State agencies in the event of a major disaster.



Yellow Lot Building Plan Configuration

After a large earthquake, or other disaster that causes significant damage and prevents the State from utilizing much of its existing office building inventory, the Yellow Lot resilient office building will be transformed into a government continuity of operations work center that will be capable of operating 24 hours a day, 7 days a week, to maintain critical government functions. In post-disaster operational mode, the number of employees in the building at any one time may increase from 1,100 to as many as approximately 1,600. The building will incorporate several sustainability (high-performance/low-energy) design features and backup utilities to maintain operation "off-the-grid", but employees should not expect the building to operate the same as before the disaster. In post-disaster operational mode building occupants should expect:

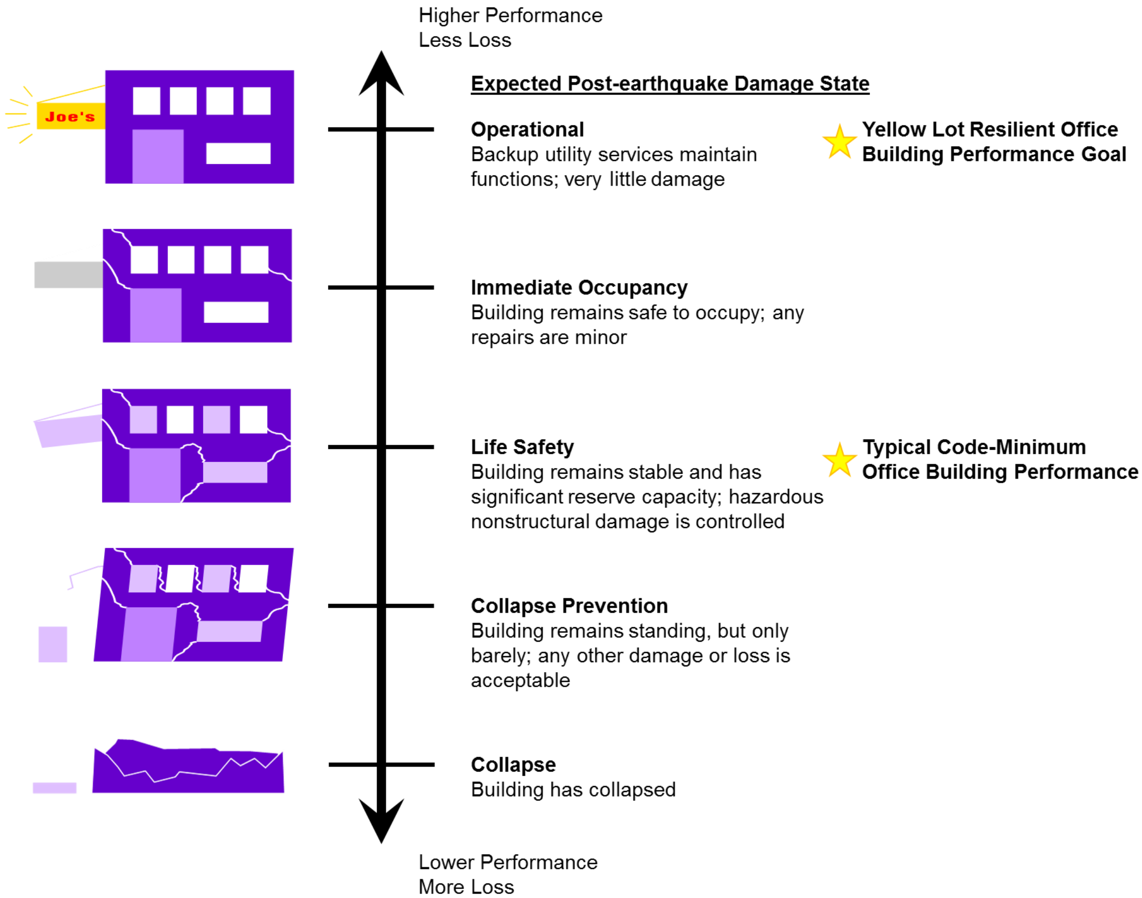
- A broad range of thermal comfort (wear sweaters if cold or light clothing if hot);
- Occupants may be asked to open and close windows for ventilation when outside temperatures are appropriate (may be uncomfortable to some);
- Potable water to be supplied from onsite wells with reverse osmosis filtering;
- No hot water will be provided;
- Lighting levels will be reduced to conserve power;
- Limited outlets will be supplied with backup power, others will not have power;
- Using laptop computers without external monitors;
- Sharing plugs for charging of battery operated devices;
- Limited copiers/office equipment, less than one per floor will be operational;
- Limited coffee stations, less than one per floor will be operational;
- Limited use of elevator to conserve power; and
- Limited telecommunications bandwidth.

In order to ensure that the building can be easily transitioned to post-disaster operational mode, to help provide for continuity of government after a major earthquake or other disaster, the building will be designed to be operational after a design level earthquake (an event with an approximate 500-year return period). This is a performance enhancement versus a conventional new office building that would typically be designed for Life Safety performance. Engineers will design the building for the seismic ground motions potentially anticipated at the site, including consideration of a Magnitude 9+ earthquake originating on the Cascadia Subduction Zone. To achieve operational building performance will require:

- Structural and nonstructural components of the building be properly designed;
- Mechanical and electrical equipment required after the earthquake be seismically certified to handle the anticipated level of earthquake shaking; and
- Design includes considerations for backup utilities for those that may be damaged and unavailable after the earthquake (electricity, water, wastewater, etc.).

Structural

The Yellow Lot building will be base isolated to provide superior seismic performance and will use steel moment frames as the lateral force resisting system above the isolation level to provide maximum flexibility for future office layouts. Reinforced concrete basement/moat walls will be constructed offset from the exterior face of the building in order to accommodate the expected movement of the building and isolators during an earthquake. The building columns and isolators will be supported by a mat slab foundation. The basement walls and mat slab will be designed like a bath tub to prevent flooding of the basement from the potentially high ground water table at the site.



Building Performance Objectives (adapted from ASCE 2013)

Base Isolator Installed Adjacent to Perimeter Moat (courtesy of DIS)

Nonstructural

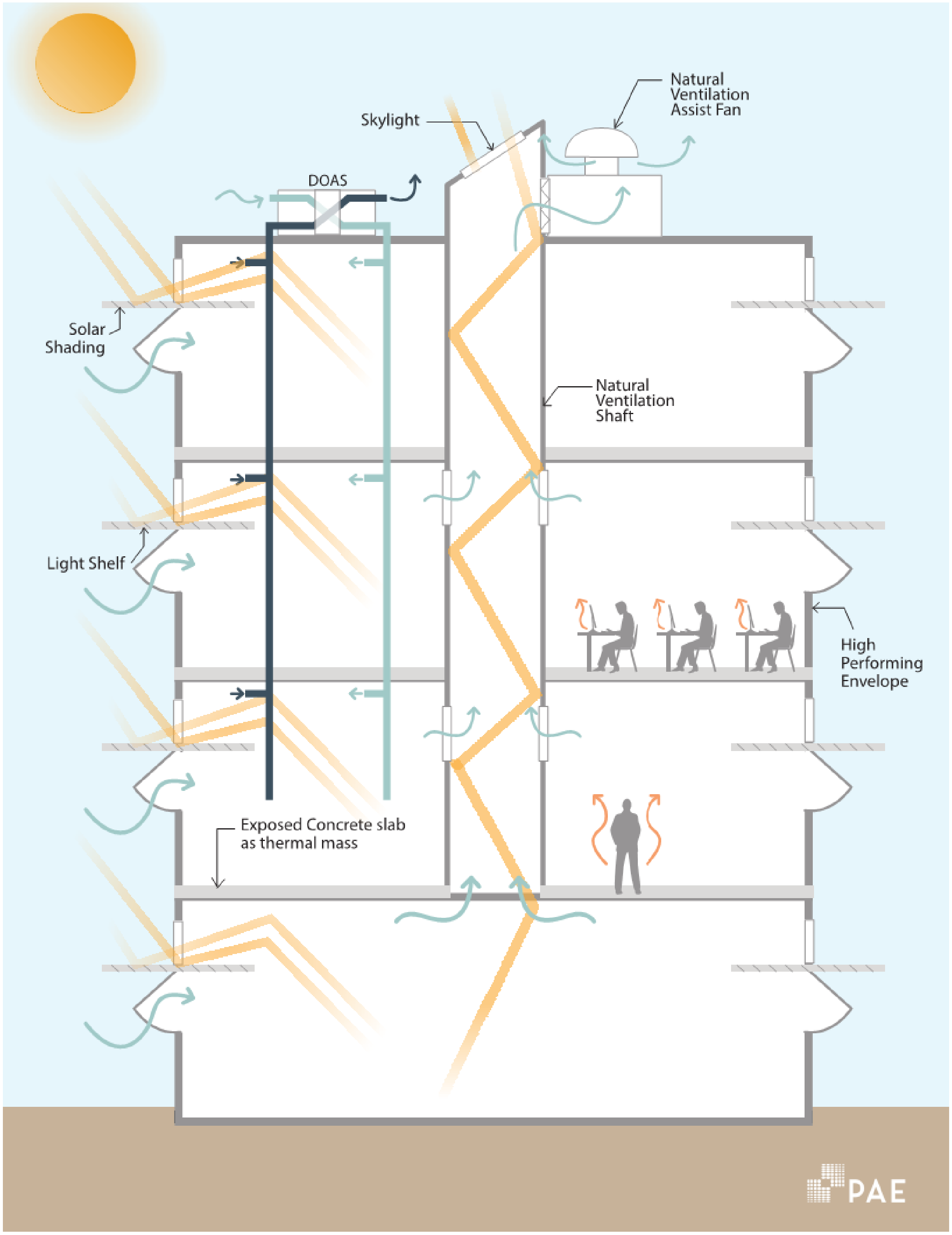
In order for the building to achieve an Operational performance objective, the building's nonstructural components (architectural, mechanical, electrical, and plumbing components) will be designed to provide Operational nonstructural performance for an expected hazard level event (design earthquake or 100-year flood). This will require providing seismic bracing for architectural, mechanical, electrical, and plumbing components along with owner provided furniture, fixtures, and equipment. Mechanical and electrical components that are required to remain operational after a major earthquake will be required to be seismically certified to ensure that they will function properly after experiencing earthquake induced shaking.

HVAC

In order to minimize energy demand during post-disaster operations, heating and cooling needs will be reduced as much as possible, even for normal operation. This will involve a high-performance building envelope to minimize thermal gain and loss. Natural ventilation will be used as the primary means of cooling, with a heat pump available to temper outside air in the warmest conditions. Heating will be primarily achieved through 70+% effective ventilation heat recovery and interior (lighting, equipment, and occupant) heat gain; again, the heat pump can provide some extra capacity for the coolest conditions. These passively-aided systems will result in a building energy use intensity (EUI) of roughly 30 kBtu/sf/yr. During normal operational mode the temperature setpoints will be 70°F in heating mode and 75°F in cooling mode. For post-disaster operational mode, the supplemental heating and cooling capacity will not be provided, leading to a wider operational temperature range of 60-80°F. Depending on particular outdoor conditions, temperatures may float up to 85°F if the outdoor temperature exceeds 90°F for more than two consecutive hours, or down to 57°F with outdoor temperatures below 20°F.

Energy

The Yellow Lot office building will utilize passive heating and cooling strategies, plus control elements like daylighting, to reduce its electrical energy consumption under normal operation. Grid demand will be further reduced by onsite solar panels and battery storage. Natural gas will not be supplied to the building in order to minimize the potential risks associated with fires that may ignite following an earthquake.



Building Section Illustrating High-Performance/Low-Energy Features

For the electrical system, the key difference between normal and post-disaster operational modes will be the reduction of electrical loads to only the most critical services. In order to achieve this load shedding, the building distribution system will be structured into three distinct branches – normal, critical and life safety.

- Normal branch will serve all non-critical loads that will be present during normal operation.
- Critical branch will operate alongside the normal branch during normal operation with no perceivable difference between the loads served by the normal and critical branches. During a post-disaster period, the critical branch will remain operational while the normal branch will be disconnected. The critical branch will support the following loads: 50% of interior lighting, 33% of general purpose plug loads, and less than 5% of mechanical loads to supply ventilation fans as needed. Specialty equipment will be limited to a reduced number of coffee makers and printers (less than 3 of each).
- The life safety branch will include only egress lighting and fire pump equipment (if needed).

A local microgrid with full redundancy will be created using an onsite 1 MW diesel generator (located on the second level of the Red Lot parking structure) with a 96-hour fuel storage tank, a 700 kW rooftop photo-voltaic (PV) array on the Yellow Lot building, a 2 MW rooftop PV array on the Red Lot parking structure and a 1.5 MW battery system. A controls system will optimize when and how much each system will be used. Preference would be given to the renewable sources of PV and battery to minimize the use of diesel fuel in the event that it cannot be replenished every 96 hours. If fuel can be regularly replenished and there are no maintenance issues, the building will be able to run in critical mode indefinitely. If fuel became unavailable, it is anticipated that the 1.5 MW battery and 700 kW PV array on the Yellow Lot building could fully support the critical loads of the building without the generator for all but 40 days per year.

<u>Water</u>

The building will be connected to the municipal water supply for potable water and fire water. However, because the municipal supply may not be available after a major earthquake, a supply from an existing well on the Red Lot with onsite reverse osmosis (RO) treatment will be provided. The well will pump water to a day tank in the building and the water treatment skid will ensure proper water treatment in the tank. A booster pump will provide pressure to the building. The well pump, RO system and booster pump will all be on emergency power. It is recommended that a secondary connection point be provided to connect an external water tank or tanker truck, in cases the well is damaged during an earthquake or the well water becomes contaminated.

Wastewater

The municipal wastewater system is expected to be inoperable after a major earthquake. Therefore, an onsite, minimally energy using wastewater treatment system will be used. The system will be a constructed wetlands consisting of a solids separating tank, underground primary tank, at grade treatment units, polishing and disinfection system in a mechanical room and a dispersal system. The effluent will connect to the municipal wastewater pipe in normal mode, but will connect to a groundwater recharge field after a major event.

Constructed Wetlands Treatment Unit

Telecommunications

Following a major disaster that interrupts telecommunications services, portable communications systems can be deployed in the Capitol Mall area, such as cell on wheels (COWs) or cell on light trucks (COLTs). Since telecommunications equipment is continually evolving, it is recommended that DAS establish an agreement with a local telecommunications company to provide the necessary mobile infrastructure to support operating the building in post-disaster mode.

Resilience Strategy Summary

The Yellow Lot office building will incorporate several high-performance/low-energy features and additional specific resilience features to help facilitate continued operation of the building after a major disaster. These features and the associated initial construction cost difference versus conventional construction are summarized in the table below. These costs do not include the operational savings that results from reduced energy usage and lower mechanical system maintenance costs for these high-performance/low-energy features. Energy cost savings from the HVAC system alone could equal approximately $155,000 per year given current energy costs (electricity cost of $0.08/kWh).

Yellow Lot Building Resilience Strategy Summary

System	Conventional Office Building	Resilient Office Building	Approximate Cost Delta
Structural	-Steel moment frame -Reinforced concrete spread footings	-Base isolated steel moment frame -Reinforced concrete mat foundation and moat walls	(+) $12,500,000
Nonstructural	-Design seismic bracing with 1.0 Importance Factor	-Design seismic bracing with 1.5 Importance Factor -Special seismic certification testing for mechanical and electrical equipment	(+) $1,200,000
HVAC	-Code-minimum building envelope allowing excessive heat gain/loss -Natural gas fired boilers -Rooftop mounted chillers -Significant ductwork	-High-performance building envelope -Building configuration to maximize passive thermal regulation -Light shelves/shades -Operable windows -Exposed thermal mass (concrete floors) -Natural ventilation stacks	(+) $4,500,000
Energy	-Commercial electric -Commercial natural gas	-Building configuration to maximize daylighting -Passive design to minimize HVAC system energy demands -PV from Yellow Lot building and Red Lot parking structure with battery storage -Commercial electric backup in normal operational mode and diesel generator backup in post-disaster operational mode -No natural gas to minimize risk from fire following earthquake	(+) $8,000,000
Water	-Municipal potable water supply	-Municipal potable water supply in normal operational mode -Well water potable supply in post-disaster operational mode	(+) $175,000
Wastewater	-Municipal wastewater collection	-Onsite constructed wetlands with effluent to municipal wastewater in normal operational mode and groundwater recharge field in post-disaster operational mode	(+) $1,000,000
Tele-communications	-Typical provider	-Typical provider in normal operational mode - Portable system (COW, COLT) with potentially reduced bandwidth in post-disaster operational mode	TBD

Red Lot Parking Structure

In the 2008 Hennebery Eddy feasibility study the Yellow Lot building contained 575 stalls of underground parking and a conventional parking structure with an additional 570 stalls was proposed to be located on the Red Lot (total of 1,145 stalls). This current study considers four options for a stand-alone parking structure on the Red Lot:

- 6 levels of parking (approximately 1,504 stalls) with 24,300 sq. ft. of ground level retail space
- 5 levels of parking (approximately 1,236 stalls) with 24,300 sq. ft. of ground level retail space
- 6 levels of parking (approximately 1,577 stalls)
- 5 levels of parking (approximately 1,309 stalls)

Each parking level has a plan area of approximately 93,150 square feet. The proposed parking structure uses spiral entrance and exit ramps, similar to the short-term parking structure at the Portland International Airport. The main parking structure will use steel buckling restrained braced frames as the lateral force resisting system and the ramps will use circular concrete shear walls that form the center core of the ramps. The historical performance of conventional parking garages in past earthquakes has been less than reliable. Use of the spiral ramps and flat parking levels will help to ensure that the structural performance of the parking structure does not impact the functionality of the rooftop solar array or emergency generator located on the second level.

The parking structure will be designed for immediate occupancy structural performance for the expected earthquake hazard level. The rooftop solar array and emergency generator located on the second level and their associated components will we designed for Operational nonstructural performance for the expected earthquake hazard level. Designing to these high performance levels will help ensure that the generator and solar array can provide power to operate the Yellow Lot office building in post-disaster operational mode for a relatively minor cost premium. The nonstructural performance objective for other nonstructural components is Position Retention performance (similar to a typical design). The ground level retail space will not be provided with backup utilities and will likely not be functional after a major earthquake.

Construction Cost Estimate

Yellow Lot Office Building

The estimated total project cost for construction of the resilient Yellow Lot office building and basement storage is presented in the table below, based on an assumed construction start date of May 2019. Where applicable, the cost estimate presented in the 2008 Hennebery Eddy feasibility study was used as the basis of this cost estimate, with appropriate escalation (11% from 2008 to 2010 and 25% from 2010 to 2019, 36% total).

This estimate includes the initial costs associated with the resilient design features described in this report.

The high-performance/low-energy design features incorporated in the resilient Yellow Lot office building will provide an additional benefit by reducing the operating and maintenance costs associated with lighting, heating, and cooling.

Yellow Lot Office Building Total Project Cost Summary

Description	Project Cost	
	Total	per sq. ft.
Yellow Lot resilient office building – 5 story, 288,000 sq. ft. office building	$167,899,998	$582.99
Basement space – 57,000 sq. ft.	$3,938,844	$69.10
Total	$171,838,842	

Red Lot Parking Structure

The estimated total project cost for construction of four different parking structure options is summarized in the table below. Options 1 and 2 provide six and five levels of parking, respectively and include approximately 24,300 square feet of ground floor retail space (cold dark shell, without any allowance for tenant improvements). Options 3 and 4 provide six and five levels of parking, respectively. These cost estimates are based on an assumed construction start date of May 2019. These cost estimates also include an allowance for demolition of the existing Real Estate Building that is located on the Red Lot site. The 2008 Hennebery Eddy Red Lot Feasibility Study indicated that the Red Lot site may potentially be contaminated from a former dry-cleaning facility that previously occupied the site and possible residential oil underground storage tanks. The Red Lot parking structure cost estimate does not include any costs associated with remediation of such potential contamination.

The cost of the proposed solar panel array on the Red Lot parking structure roof is included in the parking structure cost estimates. We understand that in addition to satisfying the 1.5% for green energy technologies requirement for the parking structure, the cost of this Red Lot solar array will help to meet deferred obligations from previous projects.

Red Lot Parking Structure Options Cost Summary

Option	Description	Project Cost		
		Total	per sq. ft.	per stall
1	6 levels of parking (1504 stalls) with 24,300 sq. ft. of ground level retail space	$59,541,541	$95.25	$39,589
2	5 levels of parking (1236 stalls) with 24,300 sq. ft. of ground level retail space	$50,620,689	$97.97	$40,955
3	6 levels of parking (1577 stalls)	$56,913,536	$91.05	$36,090
4	5 levels of parking (1309 stalls)	$47,992,521	$92.89	$36,663

Function-Based Cost Comparison

The 2008 Hennebery Eddy feasibility study included a total project cost estimate of $159,137,679 for the construction of the approximately 288,000 square foot Option A conventional office building with 575 underground parking stalls on the Yellow Lot. The 2008 study also included a total project cost estimate of $21,776,630 for a 570 space conventional parking structure on the Red Lot. When escalated to a May 2019 construction start date these two projects total $226,142,887. The total project cost for the resilient Yellow Lot office building and Red Lot parking structure (with approximately 1,577 parking stalls), as described in this report, is equal to $228,752,378 or approximately 101.1% of the total project cost for the Yellow Lot conventional office building with underground parking and the additional conventional Red Lot parking structure as described in the 2008 Hennebery Eddy feasibility study. Therefore, the resilient Yellow Lot office building and Red Lot parking structure concept, developed as part of this study, is expected to provide comparable office space and over 400 additional parking stalls, that will perform significantly better during and after an earthquake or other major disaster, for almost the same cost as the Option A Yellow Lot conventional office building and Red Lot conventional parking structure from the 2008 study, escalated to a May 2019 construction start date.

In addition to the resilience features described in this report, the major differences in estimated construction cost between the 2008 Yellow Lot conventional office building and Yellow Lot resilient office building presented in this current study are attributed to:

- Structural costs increased due to base isolation system;
- Removal of underground parking decreased cost;
- Removal of raised access floor throughout building decreased cost; and
- General conditions were reduced to better align with a contractors estimate of actual general conditions.

Function-Based Total Project Cost Comparison

	Scope	Project Cost	
		January 2010 Construction Start	May 2019 Construction Start
2008 Study Option A	Yellow Lot conventional office building with underground parking (575 stalls)	$159,137,679	$198,922,099
	Red Lot conventional parking structure (570 stalls)	$21,776,630	$27,220,788
	Total (Yellow Lot conventional office building with 1,145 parking stalls)		**$226,142,887**
Resilient	Yellow Lot resilient office building		$171,838,842
	Red Lot parking structure Option 3 (1,577 stalls) with rooftop solar array		$56,913,536
	Total (Yellow Lot resilient office building with 1,577 parking stalls)		**$228,752,378 (101.1%)**

Next Steps

This study identified several additional items for future consideration during the design and implementation phases for the resilient Yellow Lot office building and Red Lot parking structure, including but not limited to the following:

- Zoning Variances – the estimated height of the Yellow Lot office building and six level parking structure on the Red Lot would exceed the height permitted by City of Salem zoning regulations. A variance will be required in order to construct the proposed Yellow Lot office building and/or a six level parking structure;
- Passive design – the high-performance/low-energy design approach recommended in this report will require further design development and early collaboration between the architect, mechanical engineer, and structural engineer to ensure the design will achieve the desired passive performance;
- Geotechnical investigation – a complete geotechnical investigation should be completed, as required by the Oregon Structural Specialty Code and ASCE 7. If geotechnical hazards, such as seismically induced liquefaction, are identified, those hazards should be appropriately mitigated using advanced analysis, geotechnical ground improvements, or other appropriate methods;
- Water well investigation – the suitability of the Red Lot water well to be utilized as a post-earthquake water source should be evaluated in further detail;
- Peer review – it is recommended that DAS retain a qualified structural and resilience peer review team to provide quality assurance review during the design phase of the project;

- USRC rating – the Yellow Lot office building should be designed and constructed to satisfy the requirements for a US Resiliency Council Platinum rating;
- Combined heat and power district – a potential exists to utilize the large generator even in normal operational mode as a combined heat and power system. The design team should coordinate with DAS to investigate the potential for a district energy system for State-owned buildings in the Capitol Mall area; and
- Emergency generator operations and maintenance – DAS facility staff should develop a comprehensive maintenance program for both the generator and fuel to help ensure that it will run properly when needed. Alternatively, it may be possible to contract with Portland General Electric to include the generator as part of their dispatchable generation system in exchange for assistance with maintenance and routine testing under load.