THE UNIVERSITY OF BRITISH COLUMBIA

REPORT TO THE BOARD OF GOVERNORS
Agenda Item #3.3

SUBJECT	**SEISMIC RESILIENCE PLAN ASSESSMENT RESULTS, RECOMMENDATIONS AND NEXT STEPS**
MEETING DATE	**SEPTEMBER 21, 2017**

Forwarded to the Board of Governors on the Recommendation of the President

APPROVED FOR SUBMISSION

Santa J. Ono, President and Vice-Chancellor

For Information

Report Date	August 30, 2017
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EXECUTIVE SUMMARY

UBC places the safety of students, faculty and staff as its highest priority. Reducing or mitigating the risk of injury or death as a result of a seismic event is critical. As reported in June 2016 and April 2017, the plan for the seismic mitigation of the Vancouver campus is being updated to ensure that this risk is reduced as much as possible and as quickly as possible within the University's logistical and financial capacity.

In 1994, UBC undertook a comprehensive seismic assessment of the full building stock on the Vancouver campus. At that time, each building was classified on a scale from low to very high seismic risk. Some of the highest risk buildings identified at this time were seismically upgraded as part of the UBC Renew program undertaken between 2003 and 2011. In 2012, the University commissioned a follow-up study to upgrade the seismic assessment based on evolving earthquake science and building codes. This study changed some of the buildings' classifications to reflect this evolution. This work subsequently formed the basis for the seismic mitigation plan used up until now.

While several buildings have been retrofitted or replaced since 2012, at the time that this work was started, there were still 28 buildings (out of approximately 400) on the Vancouver campus classified as being at high or very high seismic risk, including ten for which there was no identified strategy or funding.

The need for an update was identified for three reasons as follows:

- The timeliness of the planned seismic upgrades needs to be re-evaluated with a goal to completing all remaining upgrades within the next 10 years if feasible.
- The science of different seismic fault lines has evolved significantly since the buildings were originally assessed in 1994 and re-evaluated in 2012. New fault lines and new earthquake intensities are now recognized that are more severe than were identified previously. As a result, the newest building codes are significantly more stringent than the ones used in the previous

assessments so the new evaluation needs to reflect these changes. While this change may mean that additional buildings are added to the list of buildings of concern, clearly, it is necessary to reflect this updated thinking in the seismic planning.

- Best-practice thinking around resilience, risk assessment and the ability of a major public institution like UBC to respond to a natural disaster like an earthquake has evolved. Bringing the plan to a level that reflects this best practice is necessary. This updated practice shows a more nuanced approach to seismic planning, reflecting a risk assessment approach that allows for a spectrum of needs to be addressed. While life safety is paramount, it looks beyond this one aspect to address the ability of an institution to resume operations after a disaster, and addresses broader technical aspects such as utility vulnerabilities and non-structural seismic hazards.

The analysis stage of the new seismic plan is now complete. This work reflects the latest thinking in seismic assessment and planning, recognizing that there are different seismic vulnerabilities for different buildings on campus and different levels of criticality for different kinds of spaces. The steps that have been completed are as follows:

- A seismic risk hazard assessment identifying the specific seismic risk of the Point Grey Campus has been done, and a multi-hazard assessment of all potential natural disasters and re-assessment of all Vancouver campus buildings was completed.
- Measurable resiliency objectives have been set in consultation with key stakeholders.
- A utilities assessment is complete, identifying vulnerabilities and potential failure points,
- A qualitative assessment of vulnerability related to fire following earthquake is complete.
- An initial screening and more in-depth analysis of over 340 buildings has been completed. Out of this, all buildings have been ranked on a scale from Tier I to Tier IV based on their likelihood of collapse in a Very Rare earthquake. In addition, based on the populations and contents, an assessment of the vulnerability of each building was completed. This analysis has led to a prioritized list of buildings for which a final, detailed engineering evaluation will be done to assess the suitability of renewal strategies.
- A resilience assessment of campus operations was done and a series of recommendations developed.
- A student housing vulnerability assessment has been completed.

UBC has been given a set of prioritized recommendations by our consultant Arup which have been placed into an action plan for moving forward. This action plan addresses items for campus buildings, utilities and operations. Some items are already under way and some will require further evaluation to determine exact scope and applicability for the university. The complete action plan is listed in the Recommendations and Next Steps section below.

The plan currently encompasses University-owned institutional facilities on the Vancouver campus, which represent the highest seismic risk to the University. The Okanagan campus was not included in the scope of work given the substantially lower seismic risk in the Okanagan. The plan also does not include neighbourhood market housing and community buildings or UBC off-site leased space, which fall outside the direct control of the University. The multi-hazard assessment and planning framework used for the Vancouver campus can be applied in the future to the Okanagan campus and to the neighbourhood facilities. Discussions will be initiated with the UBC Okanagan management team, UBC

Properties Trust and the University Neighbourhoods Association to explore options for implementation appropriate to the specific situation and needs of each group.

If this item was previously presented to the Board, please provide a brief description of any major changes since that time.	Since April 2017, our seismic consultant (Arup) has completed its assessment and provided the recommendations for next steps required to complete the updated seismic resilience plan.

INSTITUTIONAL STRATEGIC PRIORITIES SUPPORTED

✔ **Learning** ✔ **Research** ✔ **Innovation** ✔ **Engagement (Internal / External)** ✔ **International**

or ✔ **Operational**

DESCRIPTION & RATIONALE

SUMMARY OF RESULTS

Approach

Infrastructure Development and Risk Management Services have refreshed the seismic mitigation plan with a revised plan that reflects updated thinking with respect to earthquake science and the need to reflect not just life safety but also organizational resilience and ability to recover from major incidents. Arup, an internationally recognized engineering consulting firm, was engaged to work with UBC faculty and staff to undertake the necessary technical assessments and provide recommendations for the development the new seismic resilience plan. Arup has completed similar work for large financial, educational and government institutions around the world.

UBC has had a seismic mitigation plan for the Vancouver campus for over 20 years. This plan has undergone revisions as needed to reflect changes to codes and standards, with the most recent revision coming in 2012. In 2016, work commenced on updating the plan again. The new plan reflects the latest seismic science which indicates that the forecasted seismic hazard has increased significantly in the Lower Mainland. In addition, UBC asked the project team to consider seismic resilience as part of the plan. The goal is that ultimately, the university will not only make every effort to protect the lives of the campus community but also reduce the impacts of the earthquake and other natural hazards on the continuity of teaching and research, preserve buildings and building contents (including research specimens, collections, and data) and be a resource for the local community in the event of a disaster.

To this end, state-of-the art thinking and techniques were employed by the project team to virtually simulate earthquake damage and consequences both to utilities and buildings. Holistic resilience approaches, business continuity planning and a cost-benefit approach were also used. The holistic nature of the analysis means that it included not only the buildings as had been the focus in earlier plans but also included utilities, operations and financial impacts and strategies.

The project team worked with UBC faculty to refine the seismic hazard that was used in the analysis. The team used four different intensities of earthquake to understand not only how the campus will respond to the worst cases but also to the more frequent situations. The return periods of these intensities are as follows:

Intensity Level of Earthquake	Return Period (years)
Frequent	43
Probable	200
Rare	475
Very Rare	2,475

Based on this set of scenarios, the project team quantified the current situation, identified key risks and reviewed a series of three mitigation strategies for consideration.

Current Situation and Key Risks

While the study results note that the current situation is actually better than the 2012 assessment indicated, there are still approximately 25% of the buildings on campus that have a greater than 20% risk of structural collapse in a Very Rare earthquake. These buildings are denoted as Tier III or IV on a scale that goes from Tier I to Tier IV. In comparison, modern codes define a benchmark of 10% risk of collapse in a Very Rare event. The distribution of buildings and the definition of the tiers are as follows:

Structural Vulnerability Tiers (Collapse Risk)	Probability of Collapse in Very Rare Earthquake	Number of Buildings
I	0% - 10%	165
II	11% - 19%	79
III	20% - 49%	55
IV	50% - 100%	29
	Total	**328**

The life safety risks associated with the collapse potential as well as with other building damage are shown in the table below. There is significant variability in the results obtained in this analysis as there is significant uncertainty associated with predictions such as these. Regardless, it underlines that action is necessary to reduce the potential for fatalities and injuries.

Earthquake Intensity Level	Anticipated Injuries	Anticipated Fatalities
Frequent	58	0
Probable	60	0
Rare	192	33
Very Rare	678	153

While life safety and injury risk are obviously paramount, downtime and lack of business continuity are also significant risks after an earthquake. The table below shows the proportion of campus spaces that are anticipated to be functional after different earthquake scenarios as well as the length of time to restore those areas that are disrupted. It is important to note that some of the facilities that are expected to be down include hospitals and other facilities that are needed for disaster response.

Intensity Level of Earthquake	% of Total Floor Space Functional Immediately Following Earthquake	Time to Restore 50% of the Total Floor Space to Functionality	Time to Restore 75% of the Total Floor Space to Functionality	Time to Restore 90% of the Total Floor Space to Functionality
Frequent	91%	0 days	0 days	0 days
Probable	35%	3.5 months	5 months	6.5 months
Rare	2%	6.5 months	7.5 months	<2 years
Very Rare	<1%	10.5 months	<2 years	>4 years

The targets that have been set for the campus as reported in the April 2017 Update to the Board are as follows:

Resilience-Based Objectives – UBC Point Grey Campus					
Earthquake Intensity	**Life Safety?**	**Continuity of Teaching**	**Continuity of Research**	**Housing Re-Occupancy**	**Preserve Assets?**
Frequent	Yes	< 24 hours	< 24 hours	Immediate	All
Rare	Yes	< 30 days	< 30 days	Immediate	All
Very Rare	Yes	< 1 semester	< 1 semester	< 1 semester	Only critical /invaluable

Clearly, while some of the projections meet the objectives, investment will be needed to align all of the projected performance with the targets set. The planned next steps are in line with this goal.

The costs associated with both the repair and replacement of contents that are projected to be lost were estimated as a part of this project. It is difficult to quantify the actual value of cultural artifacts, research specimens and collections of the type housed at UBC but as a starting point, the project team used insurance values provided by Risk Management Services. In additional analysis of the cost of downtime, economic losses caused by the interruption of the "business" of the university – lost tuition revenue and lost research grants – were used to assist in the prioritization of retrofit strategies. For context, the estimated total replacement value of the buildings on campus is approximately $6.5B and the estimated value of contents from the insurance valuation is $4.7B.

Earthquake Intensity Level	Estimated Costs to Repair Building Damage	Contents Losses
Frequent	$70M	$9M
Probable	$325M	$200M
Rare	$794M	$621M
Very Rare	$2.58B	$1.91B

Mitigation Options & Strategies

In order to understand how to address the challenge raised by the current state analysis, the project team looked at different strategies for prioritizing which buildings should be renewed first based on vulnerability.

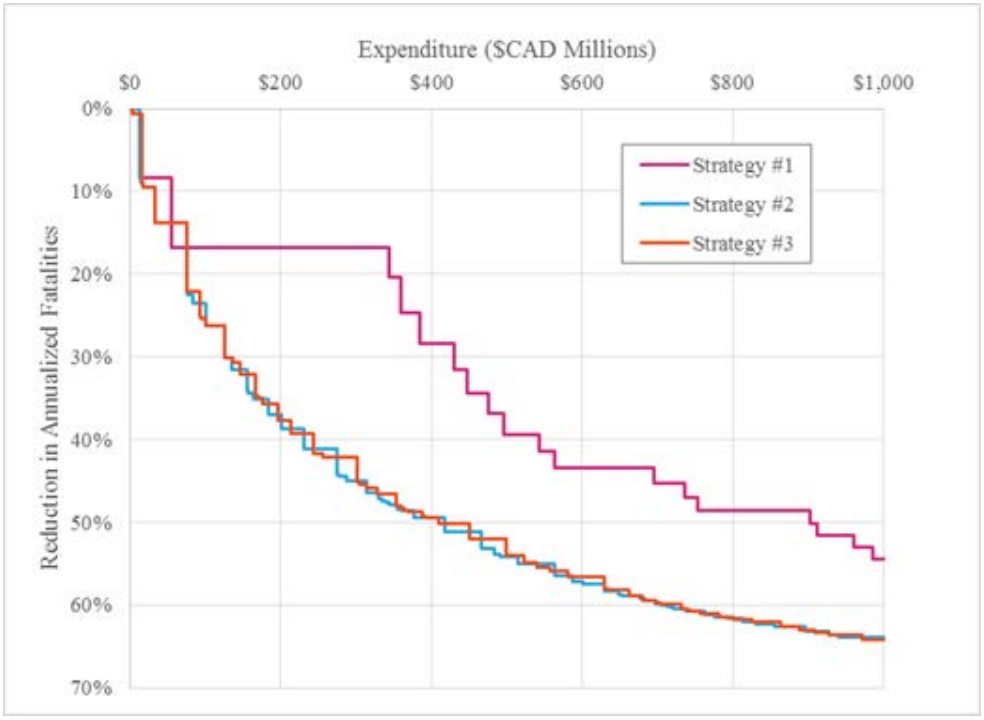
With improving life safety as the most important outcome of any building retrofits, three strategies were presented to UBC for consideration. All three strategies are based on the concept of a reduction in the projected annualized fatalities from all four earthquake scenarios. In other words, based on the projected fatalities presented in this report and statistically spreading them based on the earthquake return period, there is a quantified fatality risk for the campus around which progress can be measured.

Strategy 1 prioritizes the building retrofits based on the highest exposed population within a given building, ranking buildings in order of highest anticipated casualties.

While targeting the highest number of casualties may be appropriate, Strategy 2 looked at the cost-benefit equation of how many lives could be saved for a given capital expenditure. In other words, while at first it may sound odd to approach prioritization in this way, the graph below shows that the impact of using a least cost to save lives approach results in a greater reduction in the fatality risk for the campus than Strategy 1.

Strategy 3 is similar to Strategy 2 in terms of using most cost-effective reduction in fatality risk but also incorporates avoided repair costs and business interruption losses due to lost tuition or research grants in order to provide the most holistic look at the impacts of the possible retrofits. The results between Strategies 2 and 3 are comparable in terms of reduction in fatality risk.

The graph that follows compares the impacts of these three strategies in terms of reduction in fatality risk.



As a next step, UBC has prioritized all those buildings that are a high or very high priority under Strategy 1 as candidates for renewal. Starting with those buildings that have a high or very high rating in Strategy 2 or 3, the project team will complete a detailed engineering evaluation, examining the viability for retrofit strategies for these approximately 22 buildings. The list of buildings can be seen in Attachment 1.

Intensity Level of Earthquake	Electric Power	Water	Natural Gas	Thermal Energy	Sanitary Sewer
Frequent	6 hours	1 day	12 hours	0 days	0 days
Probable	1 day	61-65 days	2-6 days	0 days	4 days
Rare	2-3 days	65-70 days	7-13 days	0 days	6 days
Very Rare	7-13 days	68-76 days	14-40 days	0 days	8 days

Utilities

The consultant team noted that there was a high level of understanding by UBC staff of the vulnerabilities to the utility network and that actions have been taken to begin to address them. The most significant vulnerability is to the water supply thanks to the location of the main water distribution pumps within the Power House. Because the Power House is at significant risk of collapse, the amount of time needed to restore water service in all but the Frequent earthquake is lengthy.

Because of the vulnerability of the water supply, priority action items also include assessing and implementing additional strategies for both fire fighting water supply and potable water supply for after an earthquake. The following table illustrates the anticipated disruption times for the various utilities on campus under the four studied scenarios.

Operations

There were several findings related to operations but they are quite fine-grained. The most critical recommendations are outlined below in the Recommendations and Next Steps section. The highest priority recommendation is that UBC consider hiring a Chief Resilience officer so that oversight of the implementation of the seismic risk mitigation strategy is centralized under one person.

In addition, the consultant team evaluated UBC against a Campus Resilience Index. UBC scored a 2.9 out of 5 showing that there is some opportunity for improvement but that there are some areas where UBC has done significant work.

Recommendations and Next Steps:

Based on the work done by the project team, a series of priority recommendations have been presented to UBC. These recommendations fall into three categories – Buildings, Utilities and Operations. UBC have evaluated these recommendations and will act on them as follows:

Buildings:

1. A subset of buildings at the highest risk of collapse (Tiers III and IV) where the vulnerabilities are highest (such as a large building population, etc.) will undergo a detailed engineering evaluation to confirm the viability of each building's retrofit strategy for moving forward. Approximately 22 buildings will be evaluated using this methodology. The actual buildings that will be evaluated are listed in Attachment 1.
2. The non-structural life safety hazards in all campus buildings will be assessed over the coming year and a mitigation plan will be developed.
3. A series of guidelines will be created. The first will be a content protection guideline for the protection of valuable contents to be implemented as a part of the retrofit of existing buildings and as part of the development of new buildings. The second is a guideline to standardize UBC's approach to the seismic retrofit of existing buildings that will include clear performance indicators beyond the current expectation of a certain building code level as well as a set of criteria for what triggers a seismic retrofit. The final guideline will be for the seismic design of new buildings and will include performance criteria that target higher functionality targets than simply meeting current code.

Utilities:

1. Decommissioning the Power House and relocating the campus water pumps to a new location is a primary recommendation. A committee is currently investigating the options for the redevelopment of this area as part of a larger precinct plan.
2. Provision of backup water supply for firefighting is recommended. This recommendation will be considered. Work has already been undertaken to start looking at viable options.
3. Providing the physical and operational infrastructure for storing up to three days of diesel fuel for the campus utility systems is recommended. Energy and Water Services has already begun investigating a diesel tank farm in order to address this issue.
4. The final priority recommendation for utilities is to develop a strategy and the necessary infrastructure for distributing enough potable water to meet the anticipated needs of the campus population in the event of a protracted disruption to the water supply or damage to the Power House. This recommendation will be considered. Work has already been undertaken to start looking at viable options.

Operations:

1. The appointment of a Chief Resilience Officer similar to that appointed recently by the City of Vancouver is suggested to ensure that there is one person responsible for implementing the seismic strategy. This recommendation is being considered.
2. Life safety risks can be reduced through operational measures. There is a series of suggested actions which will be investigated, validated and prioritized.
3. The need to complete, validate and implement the emergency management plan that is currently in draft form was recommended as a priority. This work is under way.
4. Similarly, the need to prepare, complete and validate business continuity and contingency plans for hastening post-earthquake recovery was recommended as a priority as well. Again, this project has been started by Risk Management Services who will continue to work on it.
5. Finally, the recommendation was made to develop an interactive digital risk management platform to capture current building risks and to chart the progress of mitigation. This recommendation will be considered in the context of other information management and IT priorities.

The complete report from Arup, including recommendations can be found at http://www.infrastructuredevelopment.ubc.ca/infrastructure/projects/seismic.htm

In addition, discussions will be initiated with the UBC Okanagan management team, UBC Properties Trust and the University Neighbourhoods Association to investigate how the methodology used for the multi-hazard assessment and planning framework used in this work can be applied in those portfolios.

BENEFITS
Learning, Research, Financial, Sustainability & Reputational

The most direct benefits of the updated plan will be the ability of the campus community to better understand and quantify the risks and vulnerabilities associated with the updated seismic events that are likely to strike the Point Grey campus. A clearer and more nuanced assessment of these risks and vulnerabilities will enable UBC to move to a point where the seismic plan is a more comprehensive, best practice plan that will result in a safer campus. It will also be able to be benchmarked against other leading institutions.

As part of the proposed plan, clear, measurable goals will be set which can be reported on to Executive and the Board of Governors. These goals will allow for a transparent dialogue with the campus community so that all concerned will understand the priority that UBC places on safety and resilience.

In addition, by engaging in a broader assessment of vulnerabilities associated with seismic resilience, some of the vulnerabilities associated with climate change or other natural hazards will be addressed. Utility vulnerabilities are a clear example where increasing storm intensities and seismic issues can all be addressed at the same time.

RISKS
Financial, Operational & Reputational

The most significant risk to this project is, in fact, the risk of not updating the plan. Ignoring best practice would mean that there would be an increased risk of loss of life or serious injury to members of the campus community.

Beyond that, staying at a code-based assessment methodology means that a broad assessment of business risk and business continuity associated with seismic events is not possible. While it will be necessary from a financial and logistical perspective to complete all seismic upgrades and retrofits over a number of years, this kind of nuanced assessment will allow for a more thorough evaluation of how to optimally allocate resources.

Finally, by completing both the multi-hazard assessment and utility assessment, the University will be more holistically addressing strategic risks related to seismic vulerability and interface fires.

COSTS
Capital & Lifecycle Operating

The estimated cost to deliver the building-related priority recommendations, including the detailed engineering analysis of the 22 priority buildings, is $1.0 - 1.5 million. This expense will be funded in the 2017-18 fiscal year through the central operating budget.

The estimated cost to complete the work associated with the Power House and campus water pumps is $16M but the timing for this project will depend on the outcomes of the precinct planning study for that area that is currently under way.

Further investigation and evaluation will be undertaken to establish budget costs for the other priority recommendations. In addition, significant further analysis is necessary to confirm the capital cost associated with the required seismic retrofits of campus buildings. Cost estimates will be prepared as part of the detailed engineering analysis of the 22 priority buildings identified.

FINANCIAL
Funding Sources, Impact on Liquidity

Until the costs have been developed, it is not possible to determine the optimal avenues for funding and financing. A complete proposal will be brought forward when the plan has been fully developed.

SCHEDULE
Implementation Timeline

The seismic plan update has taken longer than initially targeted due to the large scale of building and utility infrastrcture and the intensive scope of the multi-hazard assessment. The following schedule provides a timeline for completion of recommended next steps.

Priority Recommendation	Estimated Completion Date
Detailed evaluation of 22 buildings	April 2018
Non-Structural Hazard Assessment	September 2018
Guidelines for Contents, Retrofits & New Bldgs	January 2018
Decommission Power House	TBD – based on precinct plan
Water Supply Option Study (Fire & Potable)	September 2018
Diesel Infrastructure Study	February 2018
Operations Priorities	TBD

CONSULTATION
Relevant Units, Internal & External Constituencies

The work for this investigation is being led by the Seismic Steering Commmittee. This committee includes representatives from Infrastructure Development, Building Operations, Finance, Energy & Water Services, and Risk Management Services. In addition, the Seismic Steering Committee is working closely with Professor Carlos Ventura and his team in the UBC Earthquake Engineering Research Facility. Project management is being done by Project Services (Infrastucture Development).

Previous Report Date	April 13, 2017
Decision	Information
Action / Follow Up	Substantial hazard assessment and building evaluation work has been undertaken to inform the seismic mitigation plan update.

Previous Report Date	June 14, 2016
Decision	Information
Action / Follow Up	Project team has undertaken work to update the seismic mitigation plan.

Attachment 1 – List of Buildings Identified for Detailed Engineering Evaluation

The following buildings are prioritized for detailed engineering evaluation that will include the identification of specific deficiencies and vulnerabilities, confirmation of the initial assessment risk of collapse and evaluation of retrofit opportunities including assessing the costs and benefits.

The listed buildings are those that are either "High" or "Very High" in Mitigation Strategy #1. The further evaluation work will commence with those buildings that are a "High" or "Very High" priority ranking in Strategy 2 or 3 (highlighted in green) and will move through the list from there. Those buildings highlighted in grey will not be evaluated further as there is either current seismic work under way or there is a redevelopment plan in the works for those sites.

Building Name	Structural Vulnerability Tiers (Collapse Risk)	Mitigation Strategy #1 Priority	Mitigation Strategy #2 Priority	Mitigation Strategy #3 Priority	Additional Comments
LOWER MALL RESEARCH STATION	III	high	medium	medium	Detailed engineering evaluation planned
ANTHROPOLOGY AND SOCIOLOGY BUILDING	IV	high	medium	medium	Detailed engineering evaluation planned
BOOKSTORE	III	high	high	high	Detailed engineering evaluation planned
CHEMISTRY B BLOCK, SOUTH WING	IV	high	medium	medium	Detailed engineering evaluation planned
J. B. MACDONALD BUILDING	III	high	medium	medium	Detailed engineering evaluation planned
CIVIL AND MECHANICAL ENGINEERING BUILDING	IV	high	high	medium	Detailed engineering evaluation planned
THE LEONARD S. KLINCK BUILDING	IV	high	high	high	Detailed engineering evaluation planned
CIVIL AND MECHANICAL ENGINEERING STRUCTURES LAB	IV	very high	very high	very high	Detailed engineering evaluation planned
MACLEOD BUILDING	IV	very high	high	high	Detailed engineering evaluation planned
H. R. MACMILLAN BUILDING	IV	very high	high	high	Detailed engineering evaluation planned
CECIL GREEN PARK HOUSE	III	high	high	high	Detailed engineering evaluation planned
ROBERT F. OSBORNE CENTRE - UNIT 1	IV	very high	very high	very high	Detailed engineering evaluation planned
ROBERT F. OSBORNE CENTRE - UNIT 2	IV	high	high	high	Detailed engineering evaluation planned
CHEMISTRY A BLOCK, CHEMISTRY PHYSICS BUILDING	III	high	medium	medium	Detailed engineering evaluation planned
PURDY PAVILION (UBC HOSPITAL)	III	high	medium	low	Coordination with VCH needed
KOERNER PAVILION (UBC HOSPITAL)	III	very high	medium	medium	Coordination with VCH needed
MEDICAL SCIENCES BLOCK C	IV	very high	very high	very high	Detailed engineering evaluation planned

WOODWARD BIOMEDICAL LIBRARY	III	high	high	high	Detailed engineering evaluation planned
DETWILLER PAVILION 1 (UBC HOSPITAL)	III	high	low	low	Coordination with VCH needed
FRANK FORWARD BUILDING	III	high	medium	medium	Detailed engineering evaluation planned
MUSEUM OF ANTHROPOLOGY	IV	high	high	high	Seismic design under way
MUSIC BUILDING	IV	very high	very high	high	Detailed engineering evaluation planned
GEORGE CUNNINGHAM BUILDING	IV	high	very high	very high	Currently swing space but ultimately planned for removal
DOUGLAS KENNY BUILDING (PSYCHOLOGY)	III	high	medium	medium	Detailed engineering evaluation planned
WESBROOK BUILDING	IV	very high	very high	very high	Currently swing space but ultimately planned for removal