Laboratory Resilience Case Studies

Case Studies: Purpose and Scope

Case studies can be useful in illustrating key aspects of resilience—both in terms of the challenges and potential solutions. We are grateful to those colleagues who responded to our call to share best practices with the readers of this guide. The case studies included in the matrix below represent a variety of applications, interventions, and client needs. We invite those with projects highlighting aspects of resilience, as discussed in this guide, to submit their own case studies for potential inclusion in the I²SL E-Library. Visit https://www.i2sl.org/elibrary/index.html (Resilience section) for more information.

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Photo	Project Info	Project Description and Resilience Approach	Resilience Strategies
 Photo: California Institute of Technology	**Tianqiao & Chrissy Chen Neuroscience Research Building** Owner: California Institute of Technology Submitter: AEI Scope: 145,000 gsf Location: Pasadena, CA Completed: 2020	The three-story, 145,000-sf research building will be home to the Tianqiao and Chrissy Chen Institute for Neuroscience at Caltech and the Institute's hub for neuroscience research. LEED Gold certification is anticipated. The primary electrical power service is provided by a 1.25 MW natural-gas-fired fuel cell farm, as part of a Power Purchase Agreement with Bloom Energy, with redundant service from Pasadena Water and Power. This allows the entire building load to be maintained, without interruption, during a disruption or loss of electrical service from either the fuel cell farm or the local utility. The double-ended unit substation is equipped with a programmable logic control and automatic switching between the two independent services. Emergency loads within the building are served by a central inverter with optional standby loads served by an existing 750KW generator, which also feeds the existing Broad Research Building. A commitment was made to purchase ultra-high-efficiency -80°C ULT freezers to reduce generator load and take advantage of the existing infrastructure.	• Utility feeds from on-campus and off-campus sources • Substation can switch between two independent sources • Optional standby loads backed up by shared generator • Installation of ultra-high-efficiency freezers to reduce load

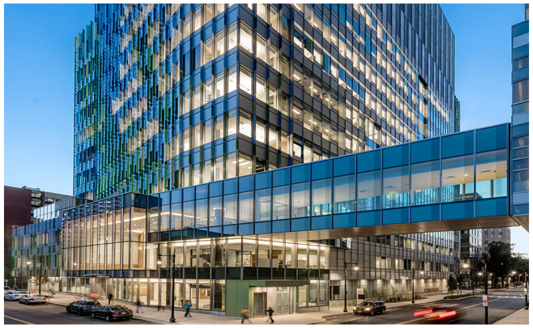
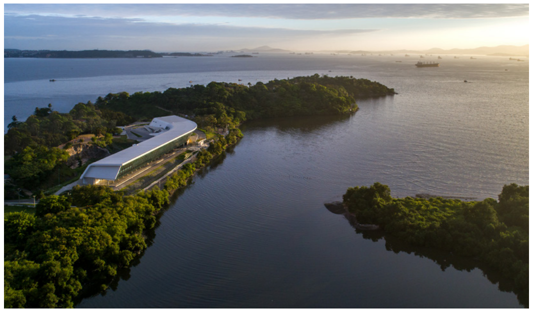
 	**Project Legacy Replacement Medical Center, Research Building** Owner: Southeast Louisiana Veterans Healthcare System Submitter: BR+A Scope: 125,000 gsf Location: New Orleans, LA Completed: 2016	This four-story research facility is housed in a former brewery building. Fifteen laboratories are located on the second and third floors, with a small-animal vivarium on the fourth floor. The building supports investigators developing non-addictive analgesics and better treatments for addictive disorders, and conducting biomedical investigations related to cancer, diabetes, PTSD, and dementia. The facility is located within a new 1.7 million-sf, 30-acre campus development that replaced a VA hospital lost during Hurricane Katrina. The campus has been designed as “VA Mission Critical” and has the capability to “defend in place” by providing all systems necessary (infrastructure, power, fuel, potable water, fire protection, water, and sanitary storage facilities) to survive for seven days without connection to city utilities, housing 1,000 individuals (patients and staff). The campus complies with the federal mandate of using 30% less energy than ASHRAE 90.1 (based on extensive modeling of both the skin of the various buildings and the MEP systems).	• Ability to shelter in place for seven days, housing 1,000 individuals • Uses 30% less energy than ASHRAE 90.1 • Achieved LEED Silver equivalent • Complete facility power generation with 10 2.5-MW generators (standby and emergency) • Fuel storage for seven days within waterproof enclosure above 500-year flood line (320,000 gal of fuel) • 280 Kgal potable water storage • 1.2M gal process water storage • 280 Kgal sanitary storage collection tank • 120 Kgal fire protection storage tank • 250 Kgal bleed water storage tank
	**Hale Building for Transformative Medicine** Owner: Brigham and Women’s Hospital Submitter: BR+A Scope: 650,000 SF Location: Boston, MA Completed: 2016	This new research lab and clinical building is located on the former Mass Mental Health Center site, consisting of 12 above-grade floors, two below-grade floors, a 400-car garage, and a below-grade central heating plant (featuring hot water boilers and a 4.0-MW reciprocating engine cogeneration facility). The cogen has a resilient black-start capability and supports 100% island-mode operation for the adjacent Shapiro Cardiovascular Center. This allows the building to remain in operation independently in case the local or national grid power experiences outages. The facility contains a 7T imaging and cyclotron suite, bridge and tunnel connections to the Shapiro building, neurosciences ambulatory care, conference center, and a 30,000-sf vivarium. It is LEED Gold certified with 37% energy cost savings.	• Black-start cogen capability • Ability for 100% island mode operation during grid outages • 37% energy cost savings

 Photo: ©HGA	**University Hall** Owner: UMass Boston Submitter: HGA Scope: 191,000 sf Location: Dorchester, MA Completed: 2016	University Hall is a four-story building containing general-purpose classrooms and three significant academic departments: Art, Performing Arts, and Chemistry. The intentional blending of Arts and Sciences creates a unique, collaborative learning experience. The facility incorporates state-of-the-art sustainable design strategies and received LEED Gold certification. To address storm surge flooding risk, the ground floor was elevated 10 feet above the FEMA-recognized floodplain. Limited areas of the ground floor below this elevation were extensively waterproofed and pumps placed on backup emergency power, with most mechanical equipment and the emergency generator located in a penthouse. To address high winds and intense precipitation, the building envelope and its supporting structure, including the extensively glazed atrium overlooking Boston Harbor, was designed and constructed with enhanced wind and water resistance.	• Ground floor elevated 10 ft above floodplain • Some areas below ground were waterproofed • Pumps placed on emergency power • Most mechanical equipment and generator located in penthouse • Envelope designed to address high winds and extreme precipitation
 Photo: ©HGA	**The Brooks Building** Owner: IYRS School of Technology & Trades Submitter: HGA Scope: 20,000 gsf Location: Newport, RI Completed: 2017	The campus of the International Yacht Restoration School (IYRS) is sited within a working waterfront business district in downtown Newport, RI. It sits on Spring Wharf (a FEMA VE flood zone), set back approximately 75 ft from the water. The program for the building includes two floors — 20,000 sf — of classroom and trade teaching areas for Composites Technology, Marine Systems, and Digital Modeling & Fabrication programs. Much of the program is technology-based and related to the use of modern materials. Teaching areas are located above an open parking level of 10,000 sf at grade, within the flood elevation. Utility, equipment, and machine rooms are located above the flood elevation, as are elevator components vulnerable to flooding. At grade, columns are encased in concrete to resist wave action, and foundations are designed to resist erosion related to storm surge. Walls at grade are limited in area, and other enclosures are designed as lightweight screens to partition storage and conceal parking. These enclosures are designed to break away in a severe flood event.	• Vulnerable equipment and elevator components located above flooding elevations • At-grade columns encased in concrete to resist wave action • Foundations design to resist erosion associated with storm surge • Breakaway enclosures for severe flood event

 Photo: Mark Herboth Photography LLC	**Coastal Studies Institute** Owner: Coastal Studies Institute Submitter: Clark Nexsen Scope: 52,000 gsf Location: Outer Banks, NC Completed: 2013	Located on the Outer Banks of North Carolina, the Coastal Studies Institute (CSI) is designed to withstand and respond to the harsh dynamic coastal environment. Due to threats of hurricanes and flooding, the building's infrastructure and architecture are designed around the principles of resilience, minimizing energy, and protecting the surrounding water and ecosystems. This new 200-acre research campus includes a marine services building and a 52,000-sf research laboratory building. Sited along an east-west orientation, the research building is elevated and features a bent form maximizing both daylighting and views. The design includes rainwater collection, clerestory windows, south-facing sun shading, condensate collection, a borrowed well-water geothermal system, on-site wastewater treatment, and created wetlands and bioretention areas to restore the natural habitat. During an event such as a power outage, a back-up generator is utilized to allow key research to continue and preserve all critical research samples and data. The passive solar design allows occupants to continue working, as 95% of the spaces receive daylight and all offices employ natural ventilation.	• Independent on-site stormwater system of wetlands and bioretention ponds • Independent on-site wastewater system • Borrowed well water geothermal system • Elevated form, lifting all primary education and research spaces up a floor • Passive solar design
 Photo: Anton Grassl, courtesy GoodyClancy	**James E. Clyburn Research Center** Owner: Medical University of South Carolina Submitter: GoodyClancy Scope: 208,000 gsf Location: Charleston, SC Completed: 2011	The Clyburn Research Center, comprising the Drug Discovery Building and the Bioengineering Building, brings together scientists, faculty, and students from the state's three research universities — MUSC, the University of South Carolina, and Clemson University — as well as representatives from private industry, to advance biomedical research and technology transfer. This complex provides research laboratories, teaching laboratories, vivarium, imaging, and convening facilities. Occupying an important site on the MUSC campus, it shapes a new outdoor green space. As Charleston is subject to hurricanes and significant storm surge, the design incorporates multiple responses to climate change. Buildings in historic Charleston have traditionally sat directly on natural grade. However, the revised FEMA flood map requires the buildings be raised more than five feet. The new landscaped quad negotiates the grade change from street level up to the new first floor. Nevertheless, to maintain full accessibility, the complex includes a grade-level vestibule with an elevator. That vestibule is constructed of impervious materials and incorporates special fittings at the entry doors to receive flood-protection boards when required.	• Primary MEP equipment located at roof/penthouse • Vivarium located on top floor • First-floor elevation set above flood level • Crawlspace below structured slab allows flood waters to pass • At-grade vestibule constructed of impervious materials • Glazing specified to resist wind-blown debris

 Photo: ©James Steinkamp Photography	**L'Oréal Research & Innovation Center** Owner: L'Oréal Submitter: Perkins&Will Scope: 142,420 gsf Location: Ilha de Bom Jesus, Rio de Janeiro, Brazil Completed: 2017	The new L'Oréal Corporate Research & Innovation Center, strategically located on a waterfront site in Rio de Janeiro, Brazil, establishes a new research identity for the international beauty products leader in Brazil. The project represents L'Oréal's deep commitment to sustainability. A common theme throughout the design is adaptability at multiple scales: in the building's approach to the environment; in its research focus and organization; and, in a more extreme sense, in laboratory design allowing rapid reconfiguration. Design inspiration comes from the legacy of modern Brazilian architecture's relationship to nature, conforming itself into the landscape, emerging as a sinuous object, interfering with the existing ecology as minimally as possible. The health of interdependent systems appears throughout the project in many forms. The entire site is carbon neutral and designed to meet the Living Building Challenge, in addition to LEED Platinum targets. As a "green lung" infiltration system, it takes in contaminated water, filters the water through building and ecological systems (like filtration gardens, toilets, a green roof, even some processes in the lab), and, through gravity, returns clean water to the bay.	• Photovoltaic (PV) array designed to generate 15% of demand • 100% back-up generator power • Filtering gardens (on-site building waste treatment) • Water re-use collection cisterns
 Photo: Tom Arban Photography Inc.	**Vale Living with Lakes Centre** Owner: Laurentian University Submitter: Perkins&Will Scope: 28,441 gsf Location: Sudbury, ON Completed: 2011	The Living with Lakes Centre is a collaborative, working laboratory situated on the drinking water reservoir for the City of Greater Sudbury in Ontario, Canada. Beneath the surface of this picturesque landscape lies an immense mineral wealth of metals, which were retrieved through the burning of sulfide minerals to extract nickel, causing sulfur dioxide and acid rain and a blackened wasteland. The design led to the inclusion of a rain and grey water reuse system that is filtered through limestone and a bioswale before being collected in an existing wetland. The Centre draws water from the wetland for flushing toilets, cleaning, and irrigation — reducing potable water use by almost 80%. Energy needs were addressed through the use of a closed-loop ground-source heat pump system, combined with in-floor radiant heating/cooling (and an HRV unit) for the majority of energy use. Through the implementation of these strategies, the Centre uses 77% less energy, almost 80% less water, and costs $75,000 less per year to operate than a conventional building.	• Rain and grey water reuse, reducing potable water needs by 80% • Heat pump system that led to efficiency as well as redundancy in energy needs • 77% less energy dependence than a comparable conventional facility

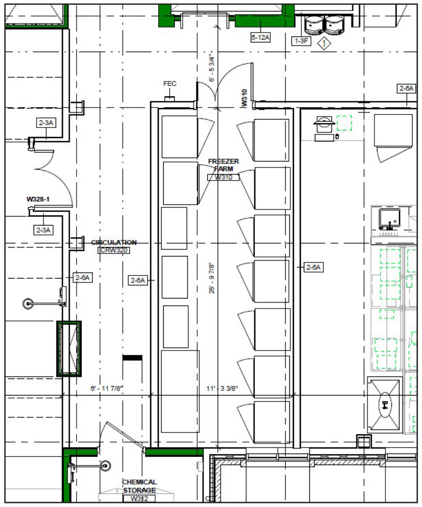
 Photo: UC Boulder	**Co-localization of research equipment** Owner: CU Boulder Submitter: CU Boulder Scope: New wing of existing research building Location: Boulder, CO Completed: 2020	The University of Colorado Boulder (CU Boulder) is connecting co-localization of research equipment with laboratory building projects (renovation, new construction) benefiting energy savings, resilience, and reduced infrastructure costs. An example is the creation of a freezer room in a newly constructed research wing of the Ramaley Biology building. In 2020, when research groups moved into the wing, instead of placing their ultra-low temperature (ULT) freezers in individual labs as before, the majority were placed in a secure, shared freezer room. This approach reduced construction costs by 1) concentrating freezer infrastructure needs; 2), improved energy efficiency by focusing cooling to the shared space; and 3) increased resilience through the co-localizing of critical cold storage units, making the freezer room a clear priority for redundant power and support if an extended power outage occurs. Resilience is enhanced by the fact that ULT freezers have monitors to notify lab members if there is a freezer failure, and, as more freezer rooms are created in multiple buildings, it opens up the opportunity for coordination between the freezer rooms for duplication of the most critical research samples.	• Secure, shared spaces with co-localized equipment • Cost-effective approach to redundant power infrastructure • Easily located critical resources in emergencies • Equipment monitoring technology • Copies of critical samples in multiple locations
 Photo: ©HGA	**Health | Science | Technology** Owner: Lehigh University Submitter: Vanderweil & HGA Architects and Engineers Scope: 194,000 gsf Location: Bethlehem, PA Completed: 2021	The HST Building creates a home for Lehigh University's new College of Health and dramatically increases Lehigh's capacity for interdisciplinary research while subtly promoting the health, well being, and individual resilience of researchers, staff, and visitors. The design team incorporated the new college's goal for promoting health into the conceptual design to develop creative solutions satisfying other intersectional goals, like fostering collaboration. The design includes strategies that are shown to reduce stress, enhance creativity, improve well being, and expedite healing. These include active design (e.g. prominent stairs); biophilic design (e.g. living wall, planters, natural materials); enhanced indoor air quality (e.g. MERV-13 filtration, DOAS system); reflective spaces (e.g. meditation, lactation rooms); and outdoor amenities (e.g. café, terrace, reflection garden). A brise soliel screen on the south façade features an organic cellular pattern visually representing the research within; casts a forest-like light within the write-up and collaboration spaces; and provides shade contributing to the 60% energy savings vs. its I²SL benchmark. The design is on track for both LEED-NC Gold and Fitwel Three Stars certifications.	• Fitwel certification for occupant health, biophilic design, enhanced indoor air quality, reflective spaces • Emergency preparedness policies, notifications • Reclaimed water for toilet flushing

 Photo: Payette / Cape Cod Community College / Commonwealth of Massachusetts	**Wilkens New Science & Engineering Center** Owner: Cape Cod Community College Submitter: Vanderweil & Payette Scope: 39,000 gsf Location: Barnstable, MA Completed: 2022	The Wilkens Science and Engineering Center is intended to exemplify commitment to net zero emissions, as CCCC was one of the original signatories to the American College & University Presidents' Climate Commitment. It replaces an existing building. Through detailed energy modeling and life cycle cost assessment, the design team concluded that an electric-driven air-source heat pump solution would pay back within the life of the equipment. Several energy conservation measures proactively minimize the annual EUI to 52 kBtu/sf, with rooftop PV-reducing net EUI to 19 kBtu/sf and a parking PV canopy making the facility net positive energy. To continue operation and mitigate damage from extended loss of power during winter storms and maintain heating during extreme cold weather, the air source heat pump system is supplemented by a high-efficiency boiler. An energy and emissions analysis determined that the net effect of the boiler on emissions over the life of the system was negligible, while providing fuel and equipment redundancy as well as net cost savings on emergency generator capacity.	• Air-source heat pump heating • Backup condensing boiler • 224kW rooftop and 330kW parking PV arrays • High-performance envelope, thermal sweater corridor reduce heating • Energy recovery ventilation, minimized hood exhaust
 Photo: Behnisch Architekten	**Allston Science and Engineering Complex** Owner: Harvard University Submitter: van Zelm Engineers/Behnisch Architekten Scope: 544,000 gsf Location: Allston, MA Completed: 2020	Harvard's new Science and Engineering Complex is designed to house numerous critical academic and research programs with approximately 100,000 sf of programming located below grade, some as deep as 30 feet below. The resilience planning focused on flooding and was informed by climate change projections. A design flood elevation (DFE) of 20.5 feet above present sea level was established, below which the building and site were designed to prevent water intrusion. The 1.5-MW emergency generator and main emergency power distribution equipment were located on the roof. Electrical substations were located at least 15 feet above the lowest basement level. All critical mechanical equipment was located on a mezzanine at least 6 feet above the lower basement levels. No below-grade air intakes or areaways were provided. The lowest level was compartmentalized with bulkheads (like a ship). High-capacity flood evacuation pumps were provided in each section, as a last line of defense should flooding occur based on water intrusion. All below-grade foundation penetrations were carefully sealed. The project has been awarded LEED Platinum certification and obtained the Living Building Challenge Materials Petal certification.	• Design flood elevation informed by climate change projections • Critical equipment located above DFE when possible • Critical equipment raised above lower basement elevations • No below-grade air intakes or areaways • Bulkheads installed in lower levels • Waterproof sealing and landscape buffers for flood protection • Installation of flood evacuation pumps • Provisions for PV array on roof • Rainwater recapture with 78,000 gal on-site storage • Full-building electrical back-up by off-site power generation • Redundant main electrical feeders to building

 Photo: Bill Timmerman	**Energy Systems Integration Facility** Owner: U.S. Department of Energy NREL Submitter: SmithGroup Scope: 182,500 gsf Location: Golden, CO Completed: 2013	The mission of the Department of Energy's National Renewable Energy Laboratory (NREL) includes education. So its Energy Systems Integration Facility both promotes and exhibits energy efficiency, heat recovery, and resilience. Its expandable high-performance data center makes 100°F water at its racks — enough now to heat administrative and conference spaces, and eventually enough for high-bay energy research labs and/or other campus buildings. In the summer, the data center needs no chillers, as excess heat flows to cooling towers after thermosyphon precooling. The up-to-10mW data center boasts a world-class power usage effectiveness (PUE) of only 1.04 — beside the "free campus heater" benefit. The administrative wing's advanced fenestration design, natural ventilation, and host of other low-energy features limit energy use intensity to 25 kBtu/sf/year. When including significant process needs in its labs — which promote our smart grid and hydrogen economy — the facility's overall EUI of 191 kBtu/sf/year contributed to a LEED V2.2-NC Platinum Rating. Energy efficiency is important to everyone, and we can realize significant energy improvements — and greater resilience — through integration.	• Up-to-10mW data center needs no chillers • Data center also serves as a direct building heater • Thermosyphon halves cooling tower water use • 25 EUI office wing, 1.04 PUE data center
 Photo: SmithGroup	**Biological & Environmental Program Integration Center (BioEPIC)** Owner: University of California Regents, U.S. Department of Energy Submitter: SmithGroup Scope: 74,000 gsf Location: Berkeley, CA Completed: Under Construction	BioEPIC is the second of four to five research buildings planned at the Lawrence Berkeley National Lab Bayview site. BioEPIC houses biological and environmental sciences, supported by EcoPOD environmental chambers, growth chambers, open and dedicated lab spaces, a greenhouse, and an electron microscope suite. BioEPIC is on a brownfield site over 10 to 70 feet of existing fill. Remediation of contaminated soils and the design of a stormwater retention system (bioretention) limits filtration into the aquifer and prevents settlement. Earthquake monitoring sensors will study how BioEPIC performs in a seismic event. This research will be used to advance the resilient design of future buildings. Medium chilled water is provided from a central Modular Utility Plant at 55 to 58°F, providing free cooling from the combination of cooling towers and plate-and-frame heat exchangers for over 50% of the year. Supplemental cooling and all heating are provided by a combination of water and air source heat pumps. Resiliency in the power system is achieved by a medium-voltage substation fed from two sources.	• No natural gas used for space or water heating (lab bench turrets only) • Dual sources to medium-voltage substation • Daylight and visual connection provided by optimized envelope, mitigating solar gain, glare • EUI: 196 kBtu/sf/year full building, 137 without process loads (48% better than ASHRAE 90.1) • LEED Gold target