
south-west façade from courtyard with earth tubes

Environmental Science and Chemistry Building

UNIVERSITY OF TORONTO SCARBOROUGH

As befits a new building for the study of environmental sciences and chemistry, this facility is strongly rooted in sustainable design solutions. This project is a showpiece for integrating the requirements of a modern and dynamic post-secondary academic campus plan and meets institutional objectives for stringent sustainable design targets. Laboratories have particular challenges to achieve energy efficiency, yet this project is LEED Gold certified.

The facility features collaborative learning opportunities while providing flexible lab space that ensures adaptability for the ever-changing nature of research and teaching methods. The 110,000-square-foot building connects laboratories and academic offices around a sky-lit atrium designed to encourage collaboration and exchange. Thematically, the Environmental Sciences and Chemistry Building is inspired by nature to reflect not only the academic pursuits of these disciplines but also its setting on the edge of a wooded ravine.

1. Features many unique and progressive systems intended to achieve a significant reduction in energy cost, and improve energy efficiency in a process-energy-driven building including geo-thermal boreholes beneath the building and earth tubes.
2. high performance building envelope including innovative solar shading
3. storm water capture and recycle
4. a solar renewable-ready green roof
5. 100% LED lighting throughout

west façade

east elevation with adjacent instructional centre

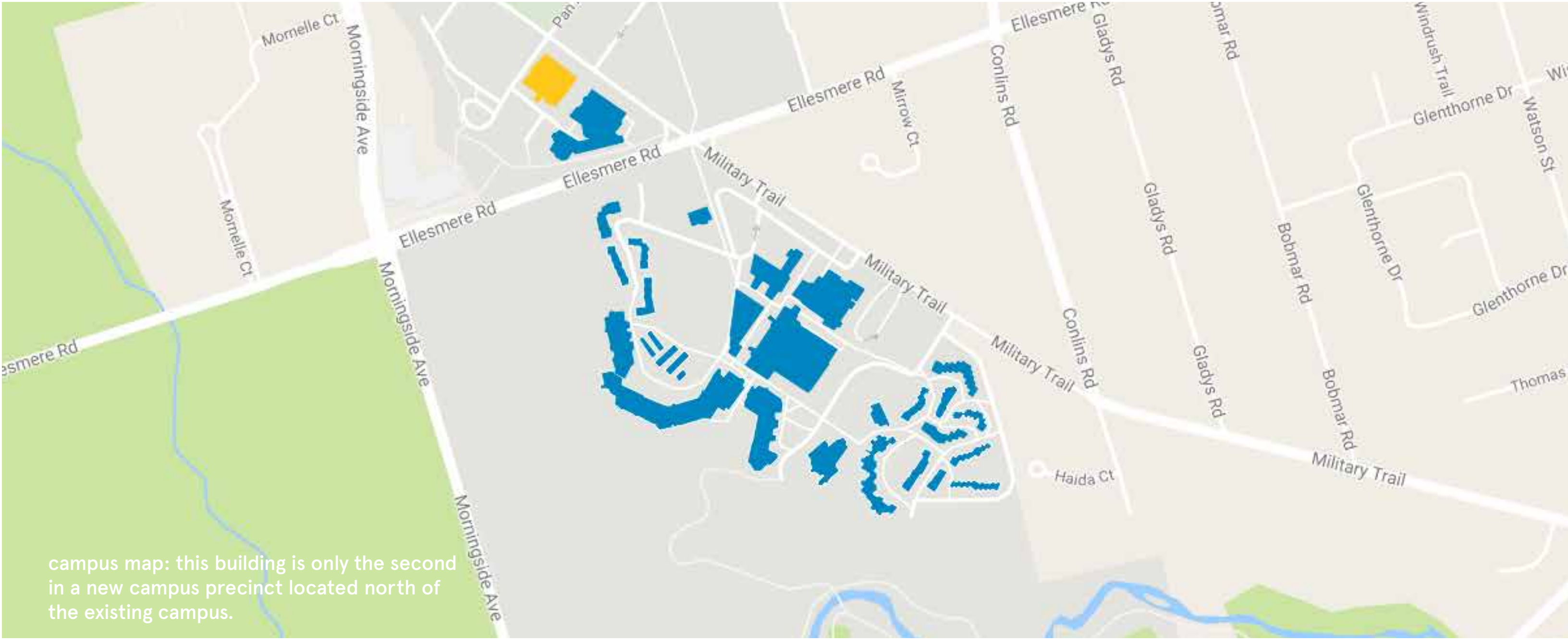
west elevation

south elevation

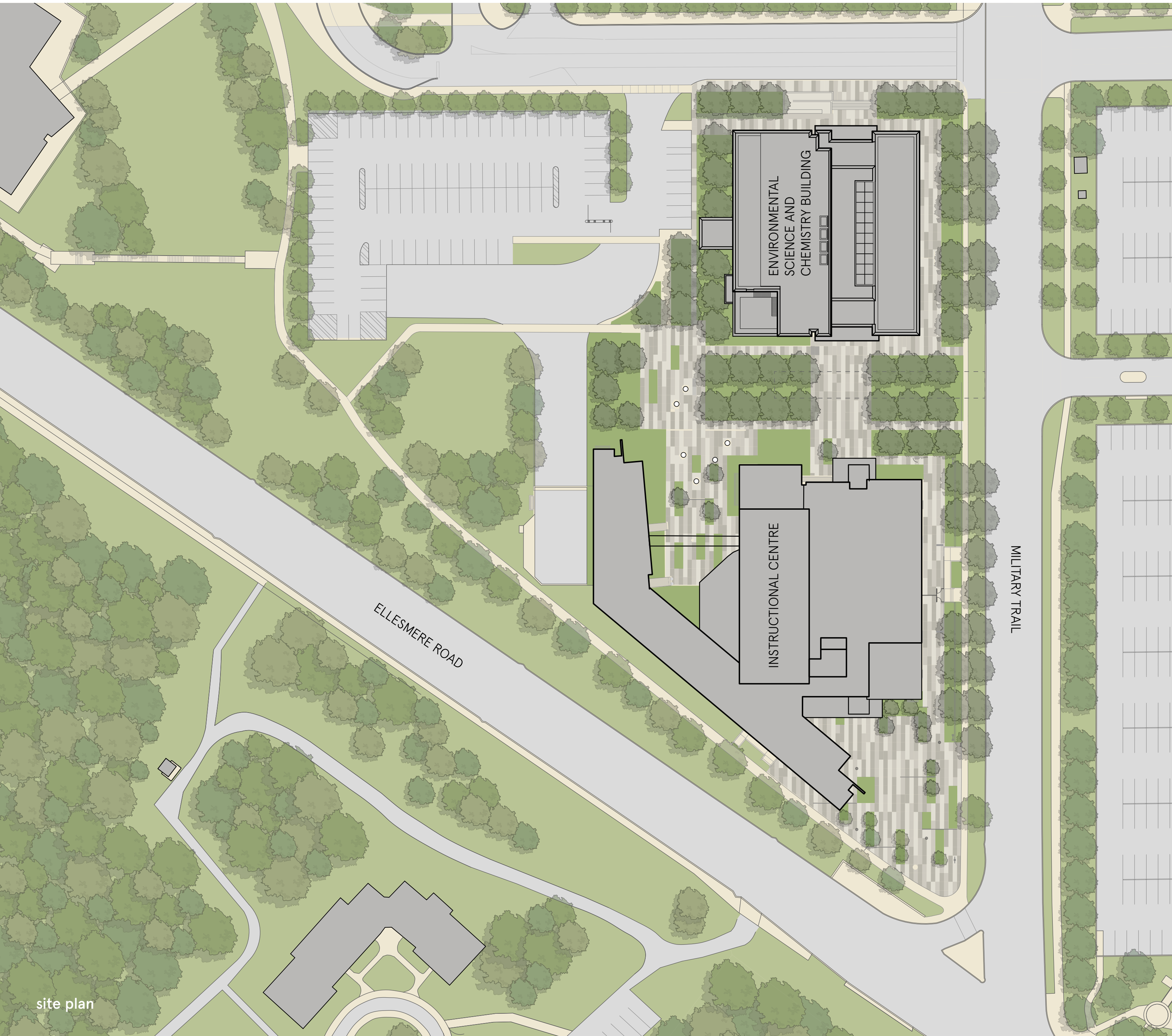
west elevation

Strategic Decisions

During design and construction, material selection and performance was approached as a collaborative effort to balance functionality and performance with sustainability. The design of the building envelope involved the architectural team, energy modeler, building science professional, material and system manufacturers and suppliers, as well as construction personnel in order to achieve the durability, thermal, and aesthetic performance targets for the project. Through a series of integrated design meetings, energy charrettes, and actual plant walkthroughs, the cladding system and innovative vertical solar shades were designed to minimize thermal bridging through the vertical shading fins, allow for maintenance and replacement both for the fins and curtainwall, and ensure air and water tightness throughout.



campus map: this building is only the second in a new campus precinct located north of the existing campus.



site plan

north-east facade

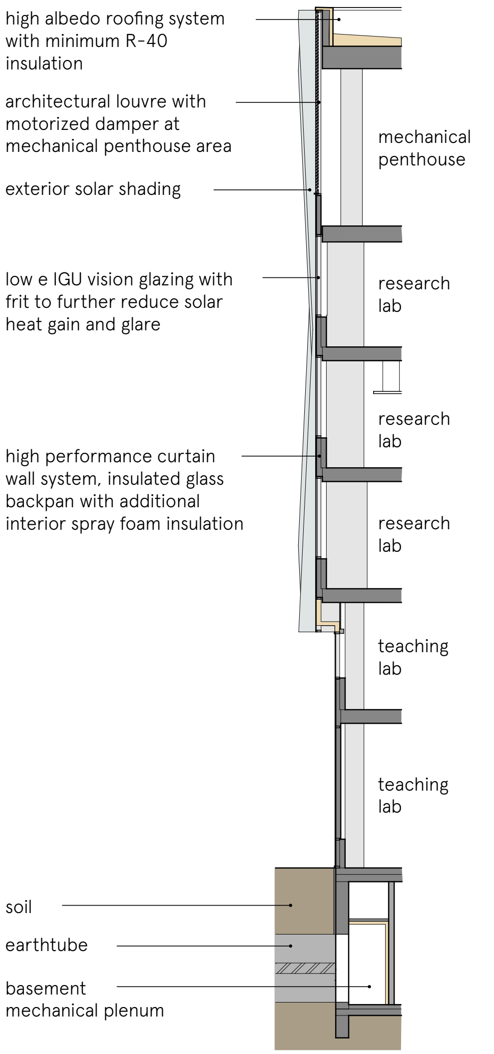
Community

The Environmental Sciences and Chemistry Building (ESCB) is located in a new campus precinct, which currently has one other academic facility, the Instructional Centre (IC), by the same architects. The adjacent buildings reference one another in material finishes and scale with an architectural character of masonry and curtainwall that serves to strengthen the pedestrian realm along the main campus thoroughfare, Military Trail.

The project encourages alternative forms of transportation including dedicated Level 2 charging stations for electric vehicles as well as designated carpooling spaces. Complementing these efforts, the campus is well served by existing public transit routes, including three Toronto Transit Commission bus routes as well as one GO bus route, resulting in a significant reduction in single-occupant vehicle use. Finally, UTSC is continuously striving to minimize their transportation footprint, and was successful in lowering the municipal bylaw requirements for total campus parking in aggregate.

Site Ecology

Both the ESC and IC building rely on a 510 m^3 infiltration gallery, located below the open space adjacent to the IC building. This infiltration gallery has been sized to accommodate rainfall from the 100-year storm, and allows this volume to slowly infiltrate into the ground, recharging subsurface aquifers. Additionally, the site has been planted with native or adaptive vegetation requiring minimal to no irrigation following establishment, while the green roof slows runoff and increases evapotranspiration, further mimicking regional ecological processes.



EAST-WEST SECTION A

1. atrium
2. elevator shaft
3. chem UG teaching lab support
4. material lift
5. teaching lab
6. catalyst Centre
7. primary dry research lab
8. office
9. fumehood intensive research lab
10. flume lab

Light and Air

To achieve an optimal balance between energy efficiency and daylight the building provides an efficient envelope design, including a unique fritted glazing to minimize solar heat gain and a high-performance curtainwall. An array of vertical sunshades of varying depths spans the south and west facades to mitigate the intensity and glare of the sun on the interior. These undulating forms enliven the façade creating an effect as sun and shadow move across the building that can be likened to the impression of a wind pattern on sand or water.

The fume hoods and work stations are oriented perpendicular to the exterior envelope, with interior glass partitions that allow for continuous, uninterrupted views from the interior core of the lab wing to the outdoors.

Ventilation was designed to promote an environment of well-being, with a cascading flow of air throughout the building. Starting from the earth tubes that provide 100% fresh air to the administrative wing, ventilation air is then transferred through the open atrium and into the lab wing, before being exhausted out through the fume hoods. Additional fresh air is added at several points to 'top-up' and provide the necessary volumes. This configuration not only maintains exceptional indoor environmental quality, but also allows for differential pressurization between the administrative wing and laboratory wing, which is essential for safety.

100% of faculty offices are within 7 metres of an operable window. The total building percentage is **21%** due to the need to control air flow in the laboratories.

All interior/exterior light fixtures are LED which significantly reduces the installed lighting power density without compromising light levels. Through an integrated lighting control system, including occupancy and daylight sensors, as well as occupant-controlled dimming in the administrative areas, the system is both responsive yet flexible to suit occupants' preferences and schedule. The projected annual energy consumption of the lighting system is **30 kwh/m²**.

open, transparent, flexible and adaptable teaching lab

central atrium


south-east façade

Water Conservation

Because an irrigation system was mandated, the project team designed a high-efficiency irrigation system that is primarily fed from captured rainwater from the building's roof surfaces. Combined, these strategies were calculated to achieve a 66% reduction in outdoor water use compared to a conventional, potable water-fed irrigation system.

Indoor plumbing fixtures provide a balance between durability, effectiveness, and water. Automatic sensors are used to further limit unnecessary fixture run time and improve conservation efforts. Combined, these measures resulted in over **35%** potable water savings compared to a conventional building.

The projected potable water consumption is **4,428 L/occupant/year or 1,952.8 m^3/occupant/year.**

Wellness

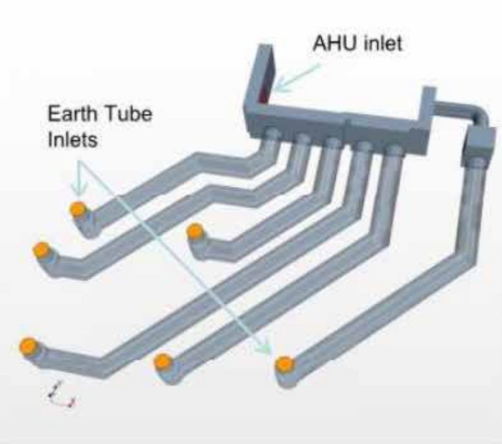
This five-storey building connects laboratories and academic offices around a sky-lit forum and crossroads designed to encourage collaboration and exchange facilitated by gathering spaces in wide corridors, meeting rooms and white boards throughout for spontaneous scenarios.

The building conveys new thinking in laboratory design – open, transparent, flexible and adaptable, while providing a safe and secure work environment for students and researchers.

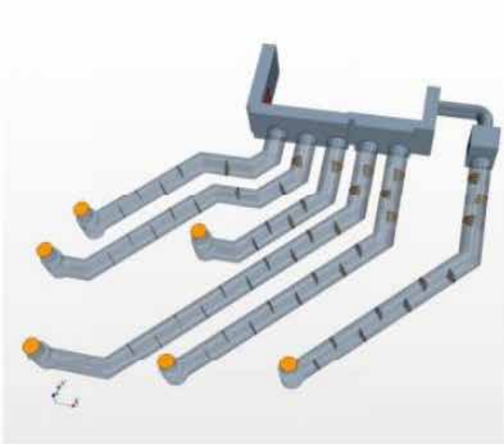
All finishes were selected to minimize off-gassing and chemical emissions, including compliance with volatile organic compound limits for liquid products used on the interior of the building and flooring finishes that were certified by recognized third-party organizations as low-emitting. Prior to occupancy, a series of tests were performed to verify the quality of the indoor environment.

lounge seating in atrium with transparent meeting room beyond

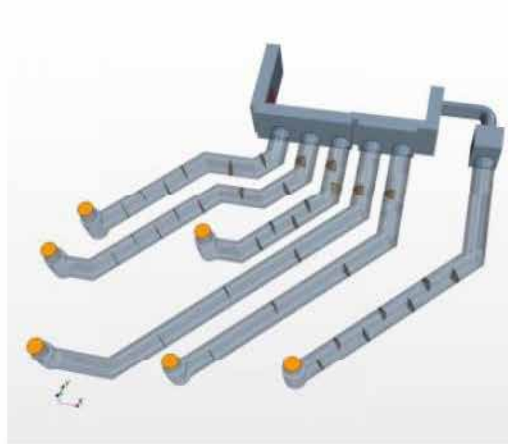
transparent meeting room in the atrium



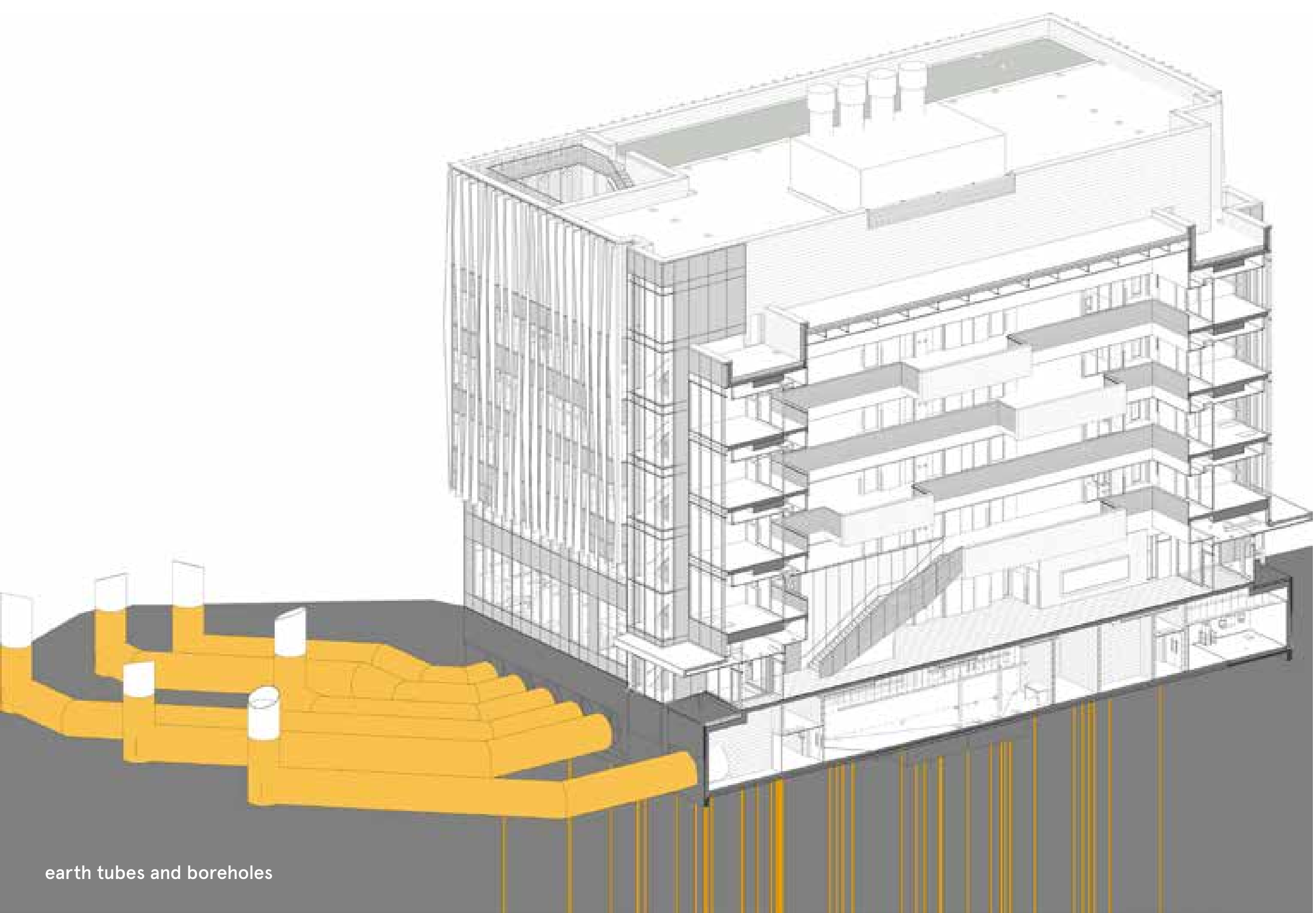
scenarios 1-3, base design



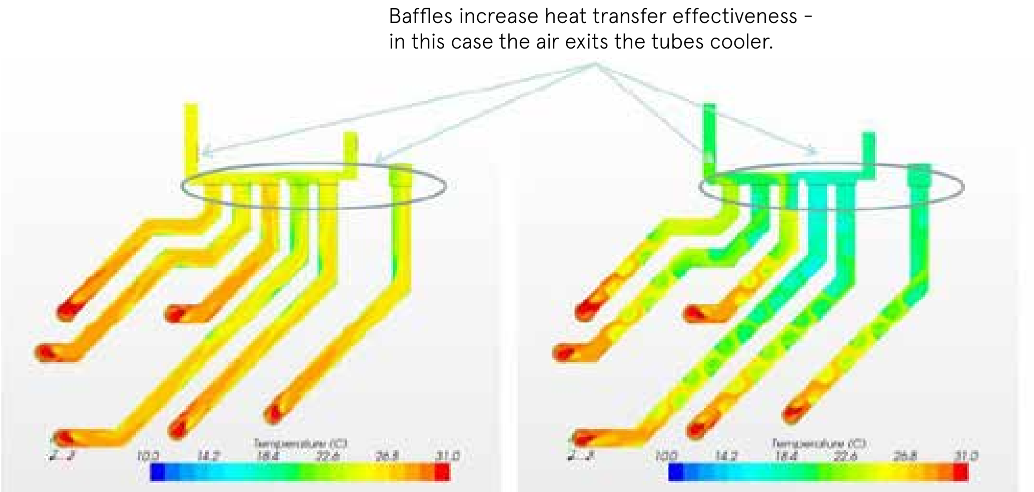
scenarios 4-6, with baffles



scenario 7, modified baffles



earth tubes and boreholes



Energy Present and Future

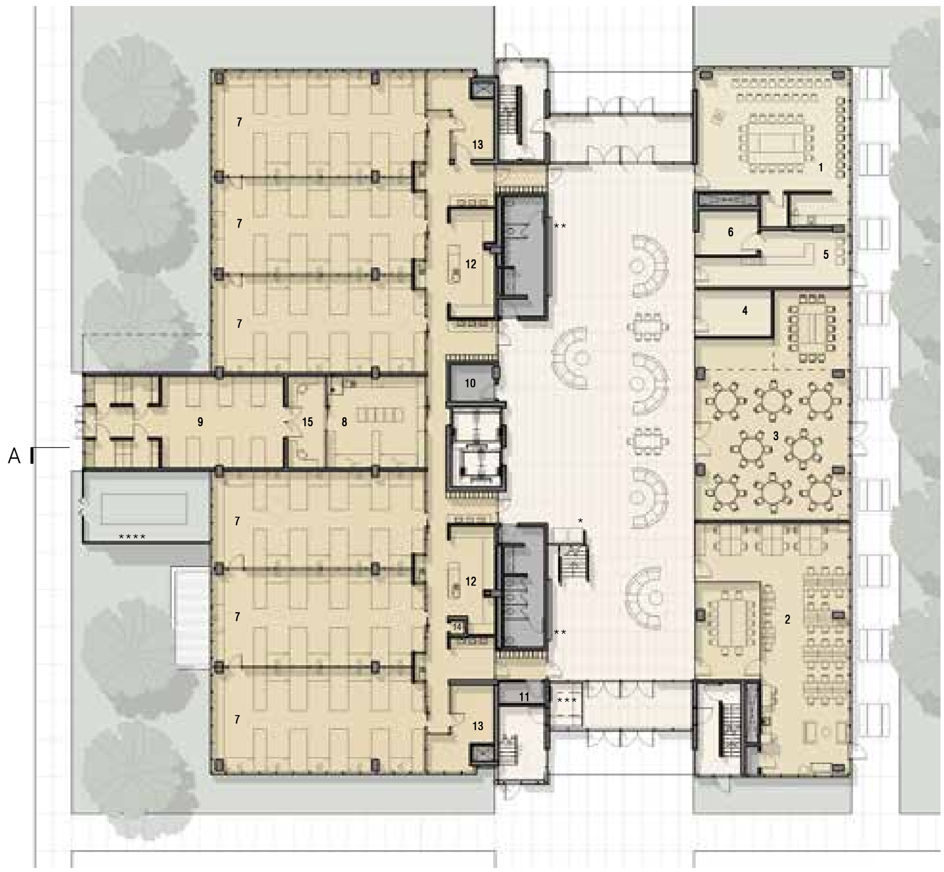
As an active research and teaching laboratory with nearly 120 fume hoods distributed in various labs throughout the laboratory wing, ventilation and make-up air posed a significant challenge to the design team. To improve energy efficiency, a series of earth tubes were designed to help temper incoming fresh air drawn from the adjacent courtyard before introducing it into the building. To optimize the efficiency of this system, a computational fluid dynamic (CFD) analysis was performed on the proposed design, and identified opportunities for improvement, specifically adding baffles and modifying their spacing throughout the tubes to reduce stratification, control static pressure, and achieve a uniform distribution across all six tubes. Based on the results of this analysis the modeled heat transfer effectiveness of these tubes increased from 29-32% to 51-56%.

To help heat and cool the building, a ground source heat pump system over 70 boreholes drilled 600 feet deep was installed. This allows heat to be rejected into the field helping to cool the building during the summer months, and drawn upon in the winter to help warm the building.

Complementing this system is a high-efficiency heating and cooling plant consisting of three condensing boilers and perimeter radiant heating system, two magnetic bearing chillers, and four heat pump chillers. Both the ground source heat pump system and conventional heating and cooling plant work in concert, and are sequenced to optimize energy performance even further.

The roof of the building was designed to be PV-ready, including additional structural support and electrical conduit for a future renewable energy system. This offers the flexibility of gradually transitioning away from fossil fuel sources to a more renewable blend. Additionally, the ground source heat pump system, which provides both heating and cooling, is operated using electricity. Provided that this electricity is supplied from the future PV array, this will allow for both heating and cooling from renewable sources.

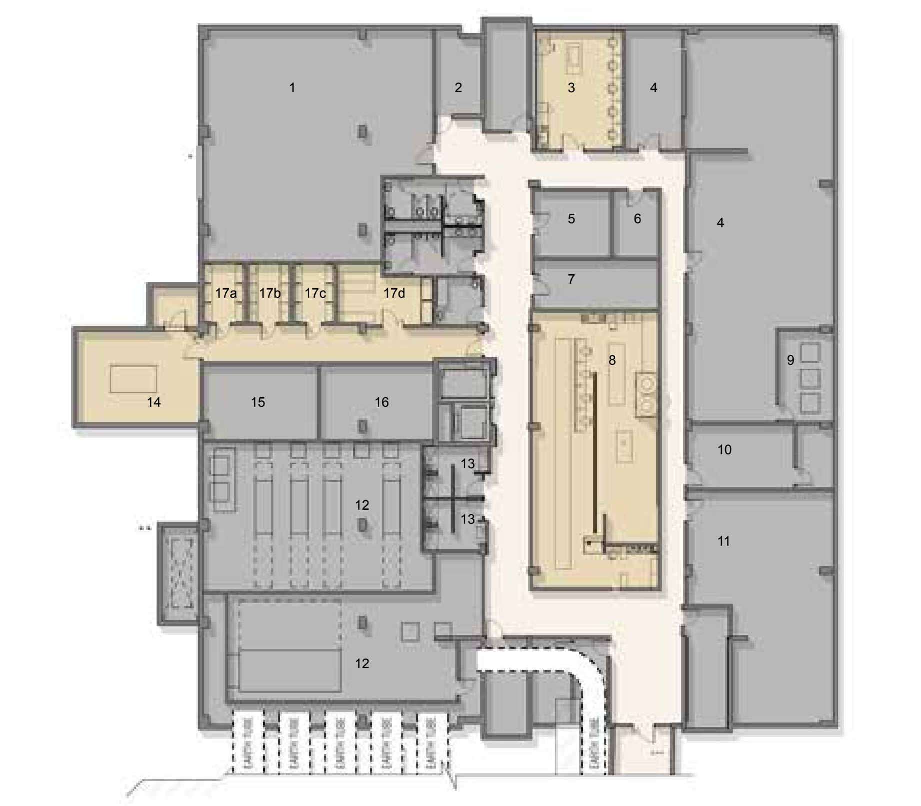
The projected annual energy consumption for the building is **7,789,143 kWh.**



GROUND FLOOR

1. board room
2. local program masters student group office
3. catalyst centre
4. multi-purpose room
5. police office
6. police support
7. fumehood intensive
8. teaching lab
9. chem UG teaching lab support
10. flammable + chemical storage
11. electrical closet
12. security closet
13. instrument room
14. tech office
15. material lift
16. tech office

* vending machine alcove
** atrium display case
*** earth tube glass floor display and green building kiosk
**** liquid nitrogen tank and enclosure



LOWER LEVEL

1. basement storage
2. laundry
3. microscope lab
4. facilities manager storage
5. fire panel room
6. IT closet
7. caretaker's room
8. flume lab
9. water meter room
10. central UPS room
11. electrical room
12. mechanical room
13. shower roomstair compressor
14. nitrogen storage
15. diesel fuel storage
16. acid neut. tank

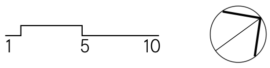
17a. acid storage

17b. inert gas storage

17c. base storage

17d. shelves storage

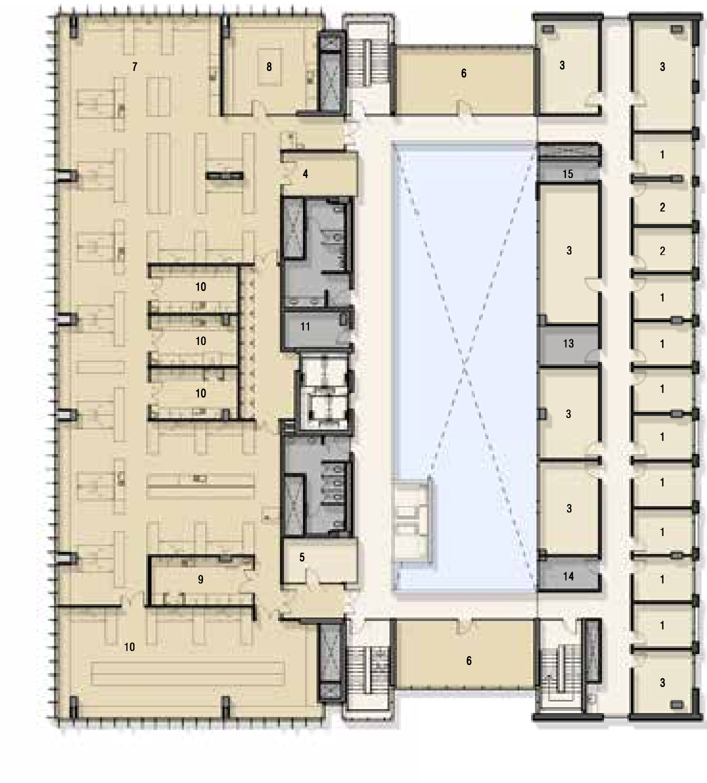
* knock-out panel for future tunnel connection
** intake plenum equipment removal
*** tunnel to IC



atrium with informal gathering space

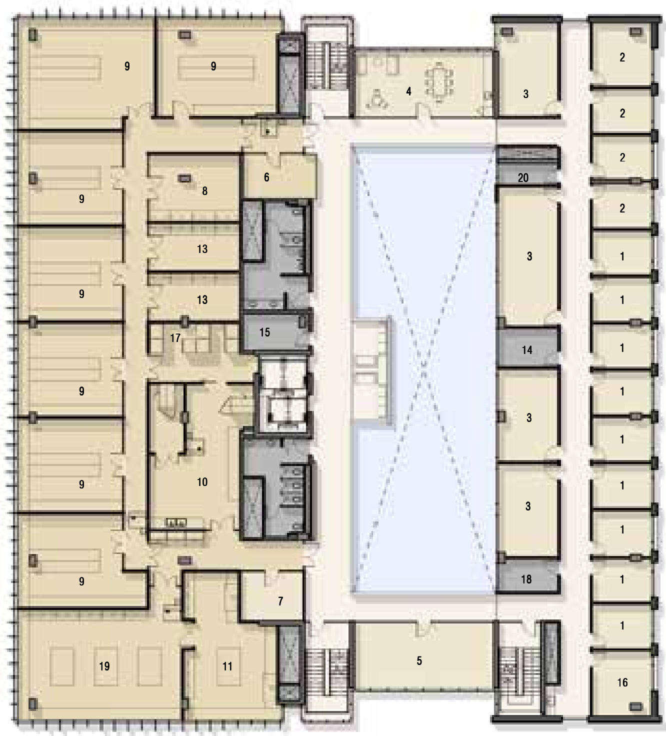
Materials and Resources

Through diligent monitoring during construction, the project was able to incorporate a significant quantity of sustainable materials, including over 20% recycled content, 32% regionally harvested and manufactured materials, and 100% reduction in added urea formaldehyde. Additionally, the project was able to divert 87% of construction waste from landfill through a combination of on site and off site separation.



FIFTH FLOOR

1. faculty office
2. post doc/RA office
3. grad office
4. NMR relaxometer room
5. meeting room/tech office
6. meeting room/lounge
7. fumehood intensive research lab
8. dry solvent room
9. CL2 lab support
10. instrument room
11. electrical closet
13. IT closet
14. janitor closet
15. security closet



THIRD FLOOR

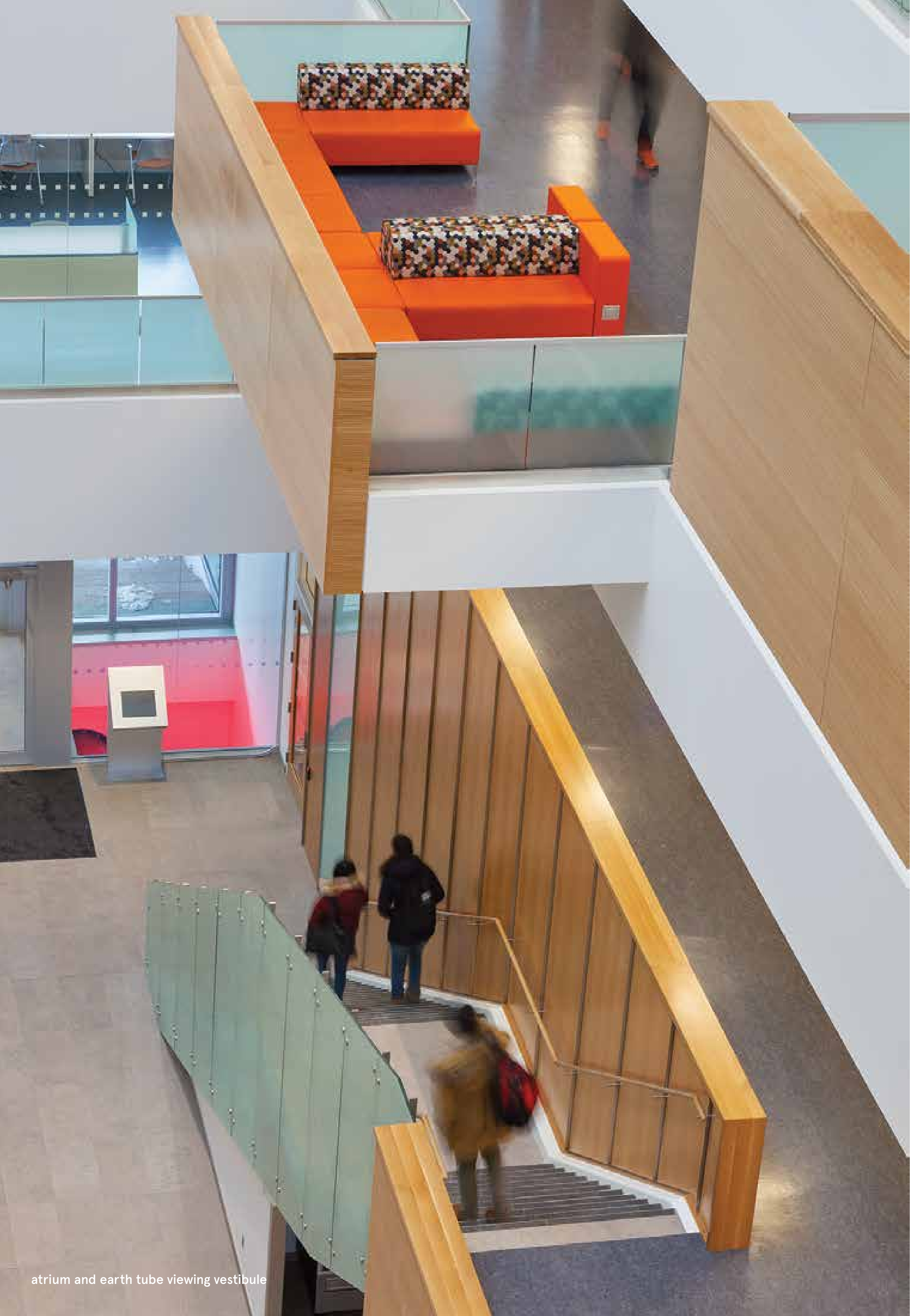
1. faculty office
2. post doc/RA office
3. grad office
4. faculty/staff/lounge
5. visitor office
6. dry research support
7. TA/sessional meeting room
8. dry research support
9. primary dry research lab
10. glasswash & sterilization
11. wet support lab
13. dry equipment room
14. IT closet
15. electrical closet
16. librarian office
17. storage/freezers
18. janitor closet
19. wet chemistry lab
20. security closet

transparent teaching lab with views to the exterior

Building Life Cycle Considerations

A structural grid in the lab wing allows for flexibility over all five levels of the building and the numerous lab benching layouts and configurations required by the functional program and room data sheets. This modular design approach together with demountable lab benching system is essential to allow the building to easily respond to the ever-changing nature of research and teaching methodologies.

The layout includes four main laboratory service shafts for supply and exhaust duct risers, which are evenly spaced across the building's length. This reduces congestion from the significant amount of ductwork, piping and drains needed for the laboratories. Concentrating these shafts enable more flexibility for modifications to the surrounding spaces. Similarly, electrical infrastructure is evenly distributed along the inner core of the lab wing, which allows for easy modification to the lab interior partition layout. All mechanical and electrical services are provided using a top down "open dance floor" approach for maximum flexibility over time. This also ensures clear sight lines within the teaching labs. Architectural, mechanical and electrical components, as well as finishes for the labs have been carefully chosen to ensure their durability, ease of maintenance and ability to create great spaces conducive to learning and scientific investigation.



atrium and earth tube viewing vestibule


earth tubes


earth tube viewing vestibule

Education and Information Sharing

As part of an integrated learning component, one of the earth tubes is translucent below the entrance vestibule, where an information kiosk explains the technology. A glass screen and floor opening permit students to see the earth tube in action; wind deflectors and coloured LEDs are integrated to illustrate the air movement within the tube and emphasize the heating and cooling these tubes extract from the latent energy of the soil.

Additionally, while conventional buildings tend to enclose mechanical and electrical support services behind walls or above a ceiling, a conscious effort was made to leave the ceilings exposed, which showcases the complex network of air distribution, support services, sensors, and infrastructure.