The University of British Columbia

Whole Systems Infrastructure Plan

Okanagan Campus / May 2016

a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

ACKNOWLEDGEMENTS

The University respectfully acknowledges the traditions and customs of the Okanagan Nation and its people in whose territory the campus is situated. The Syilx (Okanagan) people have been here since time immemorial. In September 2005, the Okanagan Nation Alliance officially welcomed UBC to traditional Syilx (Okanagan Nation) territory in an official ceremony,
Knaqs npi'lsmist, where UBC signed a Memorandum of Understanding with the Okanagan Nation.

As they have been stewards of this traditional territory since time immemorial, UBC works with the Okanagan Nation to ensure they are partners in the pursuit planning at the Okanagan Campus.

FOREWORD

UBC Okanagan, a campus acquired by UBC in 2005, has moved quickly to advance sustainability practices despite the challenge of rapid growth. Since 2007, the campus has achieved a 40% reduction in GHG emissions per student despite a 91% increase in building space and an 81% increase in student enrollment. New LEED® certified buildings, a closed-loop aquifer geo-exchange district energy system, and a unique ecosystem supported by on-site stormwater management strategies have yielded early sustainability performance benefits. The campus is currently at a pivotal point to deepen our sustainability performance against the backdrop of potential impacts and opportunities, ranging from climate uncertainty to renewable resources.

The Whole Systems Infrastructure Plan (WSIP) was developed parallel to and in support of the UBC Okanagan Campus Plan (2015), which provides a foundation for campus growth and development over the next 20 years and beyond. One of the four overarching goals of the Campus Plan is an explicit call to deepen our approach to sustainability through whole systems thinking.

"Campus growth should be managed through a whole systems (environment, economic and social sustainability" Lens to achieve a net-positive impact on the wellbeing of the campus community and ecology."

Departing from the traditional system-by-system infrastructure planning approach, the whole systems approach views the entire campus as an integrated set of systems. The objectives of the WSIP are wide reaching – from mitigating future climate change risks by reducing energy and carbon emissions, to reducing operational and maintenance costs and limiting our exposure to future price volatility, to supporting technological innovation, and creating an opportunity for research and development. In doing so, the WSIP will contribute to the wellbeing of students, faculty and staff, improve productivity and performance, and make the campus a highly desirable place to learn, work and live.

Implementation

The WSIP's implementation plan addresses energy, carbon, water, landscape, ecology, biodiversity and engagement. The first (five year) phase of the WSIP's energy and carbon reduction actions has already commenced with the establishment of an MOU with FortisBC for Partners in Energy Efficiency and the development of a dedicated Energy Team. This first phase is focused on Demand Side Management (DSM) for existing and new buildings, changing user behaviors and optimizing infrastructure performance. Funded through existing programs and incentive financing and rebates, these DSM actions are expected to reduce utility costs, while at the same time reducing GHG emissions from existing buildings. In parallel, the campus has initiated key policy updates

to inform comprehensive green building design guidelines that respond to environmental, social and economic sustainability performance imperatives; as well as the establishment of an Integrated Rainwater Management Plan to advance the WSIP's ecology and biodiversity imperatives.

For the long-term, the Okanagan campus is uniquely positioned to expand its existing district energy systems in order to support future growth while reducing GHG emissions. This approach leverages the significant investment in the existing district energy system and ensures that these investments are protected and enhanced. The WSIP recommends GHG emission reduction targets for the campus which will be evaluated and presented for Board approval. To ensure long term economic viability, UBC will balance the return on WSIP investments and targets against future campus growth, commodity and carbon pricing, renewable energy options and technology.

UBC is committed to being a leader in sustainability and the Whole Systems Infrastructure Plan is the Okanagan campus' path to an environmentally, socially and economically sustainable future. It is exciting to see that the collaborative and rigorous process of developing the WSIP has created alignment and capacity across the many UBC operational and administrative units on both campuses, including those responsible for the stewardship of the UBC Okanagan campus. We are committed, through this Plan, to ensure that these investments are protected and enhanced now and into the future.

Sincerely,

Deborah Buszard, Deputy Vice-Chancellor and Principal

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PART 1: VISION AND ROADMAP

1 INTRODUCTION

The global imperative of climate change is considered the greatest sustainability challenge facing organizations and communities today, and the effects are widespread. Building and infrastructure performance impact climate change through the release of greenhouse gas emissions, while climate change is altering local climates around the globe. One result of climate change is the change in rainfall patterns that are leading to significant challenges to the availability of water for people, agriculture, and the avoidance of summer fires. This is of particular concern for the Okanagan region of British Columbia. Climate change will continue to be one of the key drivers that will influence decision making at the University of British Columbia and inform how the institution as a whole will continue to evolve and improve its campus operations, policies and programs at its Okanagan Campus.

The University of British Columbia Okanagan (UBCO) Campus, in particular, is at a pivotal point for exploring opportunities for deepening its sustainability performance and establishing a framework for future infrastructure development required to support the future growth of its campus by 2030 and 2050. Guided by the principles of whole systems thinking, UBCO commissioned the *Whole Systems Infrastructure Plan* to examine opportunities at a campus scale, rather than at the individual building level, to optimize the performance of its infrastructure systems and uncover where synergies between systems and performance goals may exist.

Building upon UBCO's Campus Planning Principle #4, *"campus growth should be managed through a whole systems lens that incorporates environmental, economic and social sustainability outcomes, to achieve a net-positive impact on the well-being of the campus community and ecology,"* this plan establishes a future roadmap, targets, and a 5-Year Implementation Plan for improving the overall campus performance and ensuring that it is resilient to future changes in growth, utility rates, and climate change. More importantly, it substantiates the imperative of acting now and the cost of inaction, and outlines a framework for achieving significant carbon emission reductions—a cornerstone of the overall the infrastructure vision and plan.

Embedded within this roadmap is a 5-Year Implementation Plan that outlines recommendations for:

- optimizing the performance of existing infrastructure and buildings;
- deepening the performance of the next generation of new building construction planned for the campus in the next five years;
- developing a long-range district scale and potential renewable solutions for energy, water and stormwater; and
- strengthening the protection, restoration, and management of the unique Okanagan ecology of the campus.

Coupled with these recommendations is a recognition that successful implementation of this plan will require a shift in organizational thinking along with a strong commitment and leadership from key UBCO decision-makers and engagement from multiple stakeholders including staff, faculty and students.

1.1 WHOLE SYSTEMS INFRASTRUCTURE PLAN OBJECTIVES AND GOALS

UBC Okanagan established the following set of performance goals for the *Whole Systems Infrastructure Plan*:

Goal #1 Achieve a net positive performance in operational energy and carbon

Goal #2 Implement a framework that supports low embodied carbon in future development

Goal #3 Optimize water quality, supply, and security

Goal #4 Enhance and/or restore the ecology

Goal #5 100% diversion of stormwater from municipal systems

Goal #6 Strive towards full waste recovery/reuse

For purposes of this *Plan*, Goal #6 "Strive towards full waste recovery/reuse" was excluded from the scope of this deliverable. However, the notion of waste recovery is only considered in the context of optimizing the energy and carbon approach for the campus and as part the energy generation discussion under Goal #1.

In order to achieve the above performance goals, UBCO created the following guiding objectives that have provided an overarching framework for the analysis, assessment and recommendations proposed in this study. The *Whole Systems Infrastructure Plan* and recommendations are intended to:

1. Support the *20-Year Sustainability Strategy* for UBC (2014 draft);
2. Uphold the UBC's academic mission (Place and Promise and Aspire) and community wellbeing;
3. Minimize total cost of ownership;
4. Be easy to implement and maintain;
5. Optimize flexibility for expansion and change;
6. Maximize regional partnerships and benefits;
7. Support strategic decision making and risk management;
8. Build in resilience to climate change;

9. Acknowledge strengths, weaknesses, opportunities and constraints of the campus and surrounding context; and
10. Build on the campus' successes and broader best practices.

1.2 REPORT STRUCTURE

The *Whole Systems Infrastructure Plan* is structured in two parts. Part 1 summarizes the overall vision and implementation plan for UBCO, and Part 2 presents the technical analysis that supports the performance goals that address: energy, carbon, water, ecological landscape and biodiversity, and stormwater. Although waste was identified as a performance goal, it was excluded from the scope of this deliverable.

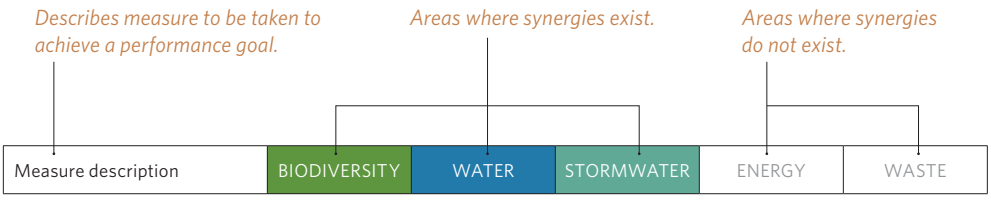
Part 1 includes a brief summary of the approach and methodology, context, a summary of recommended measures and implementation plan—along with recommendations for a governance structure and stakeholder engagement.

Part 2 provides a detailed summary of the approach and methodology undertaken to complete the study, and the analysis and recommendations for each performance goal, including:

- a summary of the overall existing conditions;
- measures for improvement and the related performance benefits;
- where possible, synergies with other performance measures;
- cost analysis and funding opportunities; and
- implementation recommendations.

The Appendices include a number of reference and supporting documents.

Where possible, after each measure proposed to achieve the key performance goals, a matrix of synergies is provided to demonstrate the effects of implementation in other areas. If synergies exist the box for the related area will be a solid colour.



2 APPROACH+METHODOLOGY

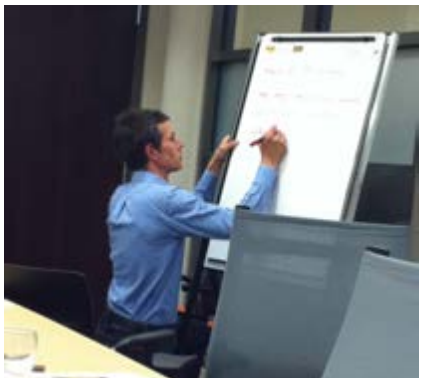
The UBCO *Whole Systems Infrastructure Plan* intends to define and support a long-term vision for creating a sustainable campus using a whole systems approach and to create a roadmap for successful implementation. The process undertaken to complete the *Whole Systems Infrastructure Plan* is based on a collaborative and integrated design approach that is grounded in the principles of whole systems thinking which support the following key factors:

- Enables optimized performance of buildings and infrastructure.
- Fosters interdisciplinary collaboration among diverse teams to understand how pieces work together as a system, and how to leverage potential synergies between systems.
- Results in optimization of an entire system as a whole, rather than its parts in isolation—a key principle of integrated design.
- Solves many problems at once; creating multiple benefits from single expenditures, and yields more diverse and widely distributed benefits.

Certain challenges and limitations exist when analyzing an existing campus as compared to designing a new campus. Regardless, this process and approach used for this planning effort has uncovered many day-to-day operational and occupant engagement challenges, and present a range of options for short and long-term performance improvements for the UBCO Campus. There are certainly many points of connectivity which largely exist between biodiversity, water, and stormwater, and between water, energy and waste. Key synergies between performance areas are reflected in each chapter, and are captured in an overall *Whole Systems Infrastructure Plan* matrix, presented in Appendix A.

The process for creating a near and long-term vision for sustainable infrastructure included the following key steps prior to the project commencing and throughout the project schedule:

1. **Whole Systems Presentation at the Campus Plan Design Charrette:** Held in June 2014, the purpose of this presentation was to introduce the whole systems concept and guiding principles of the emergent UBC Okanagan Campus Plan, 2015.
2. **Whole Systems Scoping Workshop:** Facilitated by UBC, a workshop was held in August 2014 that engaged key technical stakeholders across both campuses. The workshop allowed for meaningful exchange to take stock of existing system conditions, assets, constraints, trigger points for expansion, relevant studies and supportive documents, and systems integration opportunities. A key outcome of the workshop was the establishment of a preliminary list of whole systems plan objectives and key criteria for decision making.
3. **Integrated design workshops:** A series of workshops were held January 14-15, 2015, March 24, 2015, and May 27, 2015 in order to understand



the baseline conditions, explore a range of strategies shared, tested, and refined based on feedback from UBCO's team.

4. **Background Assessment:** An extensive review of UBCO's technical information and data related to buildings, systems, utilities, infrastructure on campus and supporting documentation describing the campus was undertaken to support the analysis through the lens of achieving the long-term regenerative sustainability goals and objectives.
5. **Performance Assumptions and Modeling:** Building upon the background assessment, performance assumptions related to campus growth rate and phasing of development were developed in consultation with UBCO. A range of measures for improvement were identified for the various building typologies and campus scale infrastructure, and for restoring, protecting, and managing the overall ecological system of the campus.
6. **Economic Modeling:** A Class C cost analysis was performed to review the trade-offs between the capital cost and the cost savings to be gained from implementing each specific measure. The analysis employed a life-cycle cost analysis over a study period of 15 years and applied criteria such as Net Present Cost (NPC) and payback period to provide useful information for decision making, i.e. for selecting certain measures above others.
7. **Evaluation of performance measures:** Based on the goals and objectives established for the project, a refined set of multi-attribute evaluation criteria were established in collaboration with UBCO to assist with evaluating the performance measures beyond simply evaluating them through a single lens of financial feasibility.
8. **Roadmap and Implementation development:** As a final step, the recommendations for achieving the sustainability goals for the Okanagan Campus form a long-term roadmap for the University for optimizing its performance. In addition, actions recommended for immediate implementation within the next 5 years are summarized within the study.

A detailed summary of the approach and methodology is included in Part 2.

3 CONTEXT


RES
DAYCARE
UNIVERSITY CENTRE
FIPKE CENTRE
ARTS & SCIENCES CENTRE
SCIENCE
LIBRARY
CREATIVE & CRITICAL STUDIES
ARTS
ADMIN.
ENGINEERING, MANAGEMENT & EDUCATION
EXISTING DES
EXISTING CHP
GYMNASIUM
REICHWALD HEALTH SCIENCES CENTRE
HOLLYWOOD ROAD NORTH
(FUTURE)
INNOVATION DRIVE
HOLLYWOOD ROAD
HIGHWAY 97
JOHN HINDLE DRIVE

UBC Okanagan Campus, located in Kelowna, British Columbia, has experienced a rapid development since the transition from Okanagan University College. Since 2005, campus floor space has nearly tripled, and since 2009, student enrollment has more than doubled. The Campus is 105 hectares, and has a student population of 8,400. The current floor area of campus is 83,000 m^2 of academic program area and 50,000 m^2 residential area, accommodating 1,680 student beds. The existing buildings on campus are categorized based on phases of development and split between academic and residences (see to Figure 1), and are referred to as:

1. Academic Legacy Buildings (old academic)—6 buildings, built between 1992 and 2001
2. New Academic Buildings—5 buildings, built 2008 and onwards
3. Residences—18 buildings, built between 1992 and 2010

The existing building stock and infrastructure has presented a number of performance and operational challenges, and is one of the drivers for developing a *Whole Systems Infrastructure Plan*.

In collaboration with the UBCO team, the following assumptions related to campus student growth were developed for the purposes of this Plan:

- 7% per year for 2015-2020
- 5% per year for 2020-2025
- 2% per year for 2025-2030
- At 2030: double capacity

These projection have been used to inform the technical performance modeling and analysis in this planning effort.

A summary of the key campus infrastructure systems reviewed as part of the *Whole Systems Infrastructure Plan* is described in more detail under each section for energy, carbon, water, ecological landscape and biodiversity, and stormwater (Part 2).

This section outlines further the context for this study with regards to the existing infrastructure, ecological and landscape setting in which UBCO is located, UBCO's Campus Plan and Sustainability commitments, and regional climate change implications.

3.1 UBCO EXISTING CAMPUS INFRASTRUCTURE OVERVIEW

The current campus infrastructure systems reviewed as part of the Whole Systems Infrastructure Plan consist of:

- District Energy System used for heating and cooling by academic buildings

LEGEND

Academic New
Academic Legacy
Residence

FIGURE 1 (FACING PAGE): CAMPUS PLAN OF EXISTING BUILDINGS

- Central Heating Plant used for heating of legacy academic buildings
- Natural gas distribution system
- Power distribution system
- Potable water distribution system
- Sewage water conveyance system

The infrastructure systems have been assessed to understand current operational challenges and feasible opportunities for upgrades to achieve UBCO's long-term sustainability goals. Each system is described in more detail in Part 2 Sections 4–7.

3.2 ECOLOGICAL CONTEXT

The UBC Okanagan Campus, located in Kelowna, British Columbia, is characterized by an intimate campus setting in the Okanagan Very Dry Hot Ponderosa Pine biogeoclimatic zone, which is the driest forested zone in BC, with hot, dry conditions in summer and cool conditions with little snow in winter. Mean annual precipitation (Kelowna Airport) is 298 mm; of which 102 mm (34%) falls as snow. Average July temperature is 19.5°C and average December temperature is -2.6°C. A detailed summary of the existing ecology and biodiversity context is presented as part of the introduction to the Ecological Landscape and Biodiversity Section.

3.3 UBC'S SUSTAINABILITY POLICY CONTEXT

UBC has already taken many steps towards institutionalizing sustainability best practices on campus through its investment in Campus Sustainability teams for both its Vancouver and Okanagan campuses, and has a number of guiding policies that have informed the University's efforts to optimize its performance with regards to greenhouse gas emissions (GHG), energy, waste, and water conservation, and green building development.

Of significance and relevance for the *Whole Systems Infrastructure Plan* are a number of UBC's guiding documents including:

1. *Place and Promise: The UBC Plan* (updated 2012)
2. UBC Sustainability Plan: *20-Year Sustainability Strategy* (2014)
3. UBC Point Grey *Climate Action Plan* 2010-2015

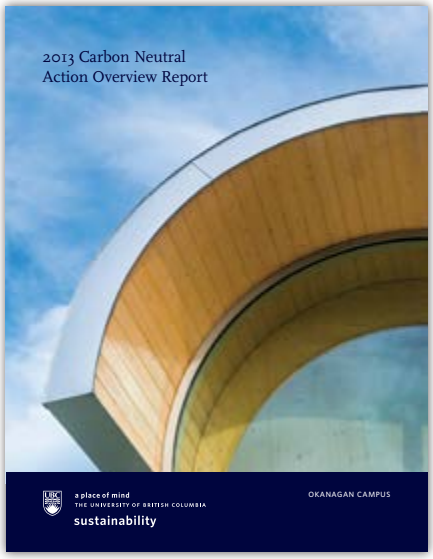
Place and Promise: The UBC Plan

Evident within UBC's strategic plan, *Place and Promise: The UBC Plan*[1], is UBC's strong commitment to sustainability as it identifies sustainability as one of nine commitments supported by a number of goals and actions.

1 University of British Columbia. *Place and Promise: The UBC Plan*. http://strategicplan.ubc.ca/the-plan/sustainability/

TABLE 1: UNIVERSITY OF BRITISH COLUMBIA SUSTAINABILITY GOALS

COMMITMENT	GOALS	
Select excerpts from Place and Promise: The UBC Plan		
Sustainability The University explores and exemplifies all aspects of economic, environmental and social sustainability.	1	Ensure UBC's economic sustainability by aligning resources with the University vision and deploying them in a sustainable and effective manner.
	2	Make UBC a living laboratory in environmental sustainability by combining its sustainability leadership in teaching, research and operations.
	3	Foster social sustainability through teaching, research and community engagement that promote vibrant human interaction and community cohesion.



20-Year Sustainability Strategy

Building upon its high level strategic commitments to sustainability, in 2014 UBC published its *20-Year Sustainability Strategy*[2] which recognizes that sustainability requires continuous improvement and it is more than just doing less harm but rather it is about how the University can have a lasting positive impact on both ecological and social systems. The 20-Year Plan proposes that by 2035 "...regenerative sustainability is embedded across the University throughout teaching, learning, research, operations and infrastructure, and the UBC Community." In support of this vision, UBC established the following five strategic goals which also form strong underpinnings for the objectives and goals established for the *Whole Systems Infrastructure Plan*:

1. A sustainability lens is applied to operational decision-making at UBC.
2. The integration of campus-scale energy, water, waste, and food systems is linked to improved quality of life for students, staff, faculty and campus community and to enhanced ecological integrity.
3. UBC continuously and iteratively improves sustainability practices through meaningful community and stakeholder engagement, collaboration and scenario analysis, directed at reaching solutions.
4. The built environment demonstrates regenerative design and operation throughout the UBC community.
5. Effective strategic partnerships are in place, leading to the development and application of real world solutions to sustainability challenges; UBC is a key contributor to dozens of such processes locally and around the world.

UBC Point Grey Climate Action Plan

UBC's *Climate Action Plan* (2010-2015) sets an important directive addressing climate change for the entire institution:

2 UBC. 2014. 20-Year Sustainability Strategy for the University of British Columbia Vancouver Campus. http://sustain.ubc.ca/our-commitment/strategic-plans-policies-reports/sustainability-plans

> Confronting the challenge of climate change, the University of British Columbia will advance solutions on campus that eliminate emissions, will accelerate efforts to respond to the impacts of climate change, and will partner locally and globally to demonstrate leadership and accountability to future generations.[3]

Embedded within this *plan* is an important framework that establishes UBC's commitment to mitigating GHG emissions and establishes targets for reducing emissions as compared to 2007 levels:

- 33 per cent by 2015
- 67 per cent by 2020
- 100 percent by 2050

Although these GHG emissions targets are for the UBC Point Grey Campus, UBC has a strong desire to identify similarly ambitious sustainability and GHG emissions reduction targets for the UBC Okanagan Campus.

UBC is currently updating its *Climate Action Plan* for 2015-2020, and is interested in developing a similar plan for its Okanagan Campus. Milestone recommendations from the *Whole Systems Infrastructure Plan* will inform the development of the UBCO *Climate Action Plan*.

Other Sustainability Initiatives

Additional sustainability-oriented plans that are proposed or under development for UBCO include the development of a Water Action Plan and Transportation Demand Pan.

In addition to these policies, UBC Point Grey and Okanagan Campuses have rolled out various staff, faculty and student engagement programs to promote a culture of conservation, and to benchmark and monitor performance in various areas related to water, waste, and energy. For example, the University's Sustainability Initiative and its Ambassador Program provide ongoing education programs related to its sustainability initiatives on both campuses. UBCO developed The Power of You program, a comprehensive strategy developed to engage staff and faculty in voluntary behaviour changes intended to reduce energy consumption in nine academic buildings on campus. Such engagement programs are an important part of the University's toolkit for optimizing and deepening its sustainability performance.

3 UBC. 2010. *Climate Action Plan* 2010-2015. http://sustain.ubc.ca/campus-initiatives/climate-energy/climate-action-plan

3.4 UBCO CAMPUS PLAN

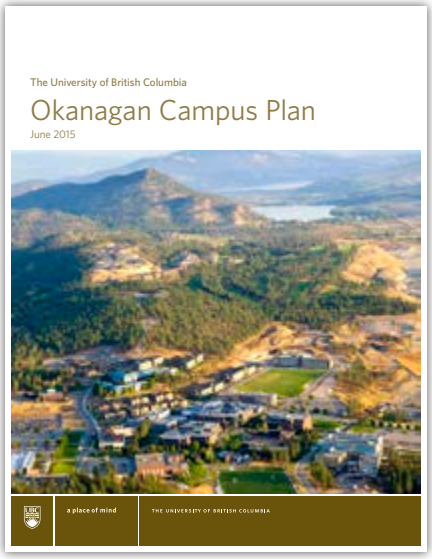
Established as a campus of the University of British Columbia in 2005, UBC Okanagan has experienced a 95% increase in floor area and an 81% increase in student enrolment since 2007. In 2005, UBCO developed a Campus Plan to guide the physical and landscape planning of the campus, and it was updated in 2009. In 2015, UBCO updated its Campus Plan to "...guide the physical evolution of the University's Okanagan Camps over the next 20 years"[4] and established the following vision statement for the future direction and development of the Campus:

> The University of British Columbia's Okanagan Campus aspires to be the centre for learning and innovation that produces global citizens through transformative personal growth and collaboration. Its people, places and activities are linked by a shared commitment to fostering community, and supporting social and ecological well-being. Deeply connected to the landscape, the campus is an accessible, intimate, and welcoming environment—a catalyst for positive change.
>
> *—Adopted by UBC of Board of Governors, September 2015*

The following core planning principles[5] were established for the Campus Plan:

1. **A Welcoming and Connected Campus:** Through design, programming and partnerships, strengthen physical and social connections on campus and to the surrounding community to create lasting and impactful relationships between people and places and nurture shared learning and innovation.
2. **Celebrating Place:** Strengthen the intimacy and legibility of campus spaces and places, while celebrating the surrounding Okanagan landscape, to achieve a distinguished and compact campus within an indigenous landscape setting.
3. **Campus Vitality:** Leverage campus growth to create a vibrant community, meeting the needs of all users and enabling students, staff, faculty and the broader community to connect, learn and linger.
4. **Whole Systems Infrastructure:** Manage campus growth through a whole systems (environment, economic and social sustainability) lens to achieve net-positive impact on the well-being of the campus community and ecology

4 University of British Columbia. 2015. The University of British Columbia Okanagan Campus Plan. June 2015.
5 University of British Columbia. 2015. The University of British Columbia Okanagan Campus Plan. June 2015



The Campus Plan supports the overall approach to developing a whole systems approach to infrastructure planning in order to optimize and deepen the long-term performance goals of the campus. This *Whole Systems Infrastructure Plan* is, therefore, regarded as a companion roadmap and plan for realizing the long-term sustainability goals for the University and Okanagan Campus.

3.5 REGIONAL CLIMATE CHANGE CONTEXT

It is widely recognized and scientifically supported that climate change is occurring and that communities across the globe are experiencing changes in temperature, precipitation and as such increased severity of storm events in some regions. The International Panel on Climate Change latest report concluded the following:

> Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.
>
> And,
>
> Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over the decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen.[6]

British Columbia is anticipated to experience greater warming and changes in precipitation regime than the global average, and depending on the different IPCC Emissions scenarios BC could see warming of 2 to 3°C or 3 to 5°C by the year 2080.[7] Understanding potential changes in the Okanagan climate is an important component of planning future infrastructure requirements for the UBCO Campus. UBCO is located in a semi-arid climate and currently experiences hot, dry summers and cold, dry winters.

The Pacific Climate Impacts Consortium (PICS) is a regional climate service centre at the University of Victoria that conducts quantitative studies on the impacts of climate change and climate variability in the Pacific and Yukon region.[8] PICS has developed a number of tools to help communicate the potential predicted regional impacts of climate change that are based on 15 Global Climate Model (GCM) and SRES emissions scenario combinations provided by the Intergovernmental Panel on Climate Change (IPCC). Using the Pacific Climate

6 International Panel on Climate Change. 2014. Climate Change 2014 Synthesis Report Summary for Policymakers http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf
7 Province of British Columbia, Ministry Home Research Branch. Climate Change. www.for.gov.bc.ca/hre/topics/climate.htm June 2015.
8 Pacific Climate Impacts Consortium. http://www.pacificclimate.org/about-pcic

Impacts Consortium's Plan2Adapt Tool, the following table summarizes the predicted changes in the Central Okanagan region for 2020 and 2050[9]:

TABLE 2: SUMMARY OF CLIMATE CHANGE IMPACTS FOR CENTRAL OKANAGAN IN 2020 AND 2050*

CLIMATE VARIABLE	SEASON	2020	2050
Mean Temperature	Annual	+1.0°C	+1.9°C
Precipitation %	Annual	+5.0%	-2% to +7.0%
	Summer	-5.0%	-11% to +10%
	Winter	+3.0%	-2.0% to +10%
Snowfall %	Summer	+7 %	-18% to +0%
	Winter	-33%	-58% to 1%
Growing Degree Days (degree days)	Annual	+178 degree days	+ 85 to -283 degree days
Heating Degree Days	Annual	-364 degree days	-517 to -201 degree days
Frost Free Days	Annual	+ 14 days	+7 to +21 days

*Note: See Appendix C for additional information on Climate Change impact and assumptions from PICS.

*Note: Data presented is for 2020s (i.e., up to 2030).

Based on the above data, the following trends are observed for the Okanagan region:

- Increased annual temperature.
- Increased annual precipitation. Although there is an increase, it may be anticipated that rainfall events are shorter and more intense.
- Decreased snowfall and snow pack leading to an overall decline in groundwater recharge and glacier fed water systems.

While recognizing these trends, greater attention and consideration should be given to:

- **Water Stewardship:** It will be important to consider how water conservation and reuse measures, along with programs to support water conservation-based behaviour can be implemented to prepare the campus for future potential water shortages. Although UBCO may be a moderate consumer of water in the broader region, this long-term imperative for the region will need to be monitored by UBCO and factored into UBCO's strategic planning and decision making processes, and how it positions itself a regional leader in this area.
- **Wildfire Management:** The region will remain susceptible to forest fires as summers are predicted to be warmer and dryer. The University

9 Pacific Climate Impacts Consortium Plan2Adapt Tool http://www.pacificclimate.org/analysis-tools/plan2adapt [April 2015]

will continue to remain diligent at managing its campus landscape and surrounding forest ecosystems carefully to help prevent spread of wildfires. A direct opportunity for the University will be to explore how a water reuse system will support the long-term fire management and suppression strategy for the campus.

- **Operational Costs and GHG Emissions:** With an increase in temperature, UBCO can expect an increase in the number of cooling days. As UBCO moves towards its long-term carbon neutrality goals, it will be important to consider the energy costs associated with an increase in cooling days, greenhouse gas implications and the possible opportunities for alternative fuel sources. Linked to this, UBCO can expect to see an increase in carbon tax and carbon offset costs over the next 15 years. Implementation of near and long-term energy conservation measures will assist in reducing these operational costs.


PENTICTON RD

4 WHOLE SYSTEMS ROADMAP

The UBCO *Whole Systems Infrastructure Plan* establishes a roadmap for improving the overall performance of the campus between now and 2050, and is based on a set of working assumptions related to student growth and development. While balancing the sustainability goals of the University, the Roadmap identifies near and long-term measures, and prioritizes actions for the first 5 years. Near term measures are identified as those having a positive net present cost (NPC), an acceptable payback period, an acceptable payback period associated with leveraging cyclical maintenance, and/or changing business practices without operational costs.

The *Whole Systems Infrastructure Plan* establishes a roadmap for improving the overall performance of the campus between now and 2030, and outlines a vision for how it will:

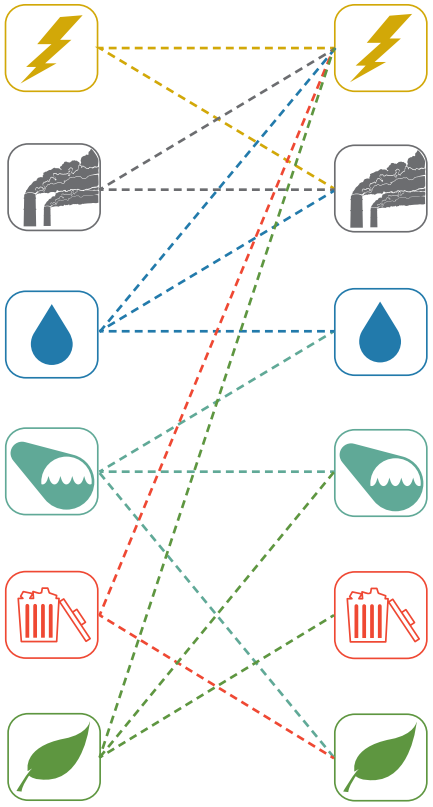
- Achieve a 64% potable water use reduction over baseline;
- Manage 100% of stormwater on-site;
- Use equal or less electricity;
- Use equal or less heating energy;
- Provide an ecologically rich and diverse campus environment; and
- Achieve 46% carbon reduction for campus operations compared to the 2007 baseline (79% compared to BAU), and within range of attaining carbon neutrality through off-site partnerships.

Achievement of this vision requires action and engagement at three important levels:

1. **Technological:** understanding the technical performance changes required to improve the performance of existing buildings, new construction, and landscaping projects as outlined in this infrastructure plan.
2. **Organizational:** identifying the institutional changes and/ or opportunities (i.e., policy, departmental, governance, and academic research) and funding needed to support a whole systems infrastructure approach.
3. **Behavioural:** establishing engagement and awareness programs necessary to facilitate conservation-based behaviour on campus by all (faculty, staff, and students).

The *Whole Systems Infrastructure Plan* recommends a framework and series of measures for each of the following performance areas, and calls out those measures most important to implement within the first 5 years for:

1. Energy and Carbon
2. Stormwater
3. Water
4. Ecological Landscape and Biodiversity
5. Governance and Implementation
6. Monitoring, Reporting and Updating the Plan



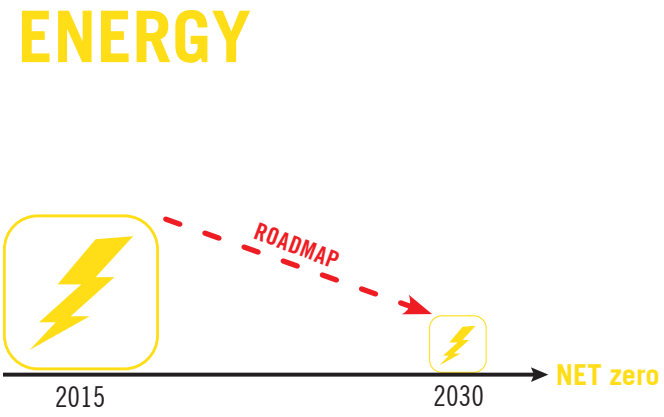
Potential synergies between performance areas.

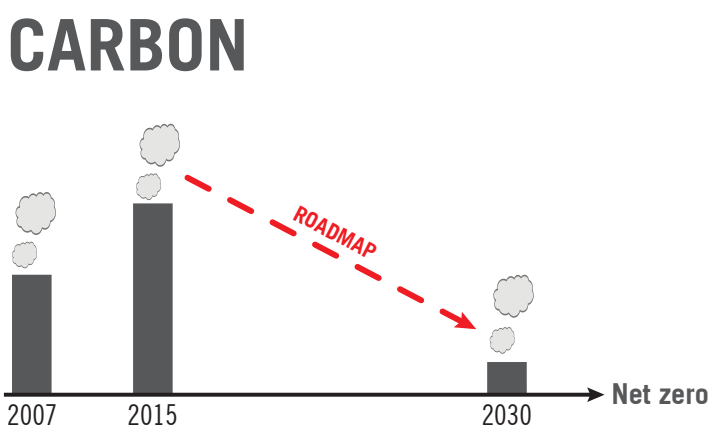
A detailed summary of the measures are presented in Part 2 of this *Infrastructure Plan*. These recommendations are based on principles of 1) reducing demand, 2) using resources (energy, water) more efficiently, 3) seeking alternative renewable resource supplies (water and energy), and 4) protecting and enhancing the natural landscape to increase biodiversity functions while also mitigating stormwater runoff.

The cost of inaction in each of these areas could be significant in a number of different ways:

- **Cost of Operations:** Inefficient performance of energy and water systems on UBCO Campus will lead to rising operational costs. This is of particular concern if utility rates and carbon tax costs increase in the future.
- **Cost of Carbon Offsets:** UBCO is responsible for off-setting carbon emissions based on provincial requirements. Based on UBCO's prioritization of energy conservation measures and preferred infrastructure approach, UBCO could realize up to $3 million in carbon offsets and carbon taxes savings by 2030.
- **Future Resiliency:** Changes in Federal and Provincial climate change policy, utility rates, carbon taxes, and the regional climate are imminent. Therefore, for example, investing in a water reuse treatment system will prepare the campus for anticipated water shortages for the region. More so, by expanding the CHP system, it will open the door for a wider range of renewable fuel sources and provide greater flexibility as compared to designing each new buildings with individual boiler systems. Switching to a biomass fuel source as part of the CHP expansion, UBCO could anticipate electricity, natural gas, carbon tax and carbon offset savings (escalated) of up to $31 million by 2030.
- **Loss of Biodiversity and Ecological Integrity:** Several species at risk have been identified on campus. Efforts should be made as the campus grows to protect, restore and manage the natural landscape in order to avoid loss of biodiversity and ecological functions while maintaining additional social sustainability values.
- **Institutional Leadership:** Universities compete annually for leadership status. Through the development and more importantly the implementation of this infrastructure plan, it will bolster UBC's leadership status regionally, nationally, and globally.
- **Institutional Reputation:** Universities market actively the merits of their campus and programs to attract, retain, and recruit new faculty, staff and students. Inaction in the sustainability arena could impact the University's reputation.

The opportunity for realizing this vision is presented below.





4.1 ENERGY AND CARBON

In 2010, UBC established a long-term vision and framework for attaining carbon neutral operations by 2050, with interim targets for its Point Grey Campus of 33% (by 2015), 67% (by 2020) and 100% (by 2050) below 2007 emissions as per the UBC *Climate Action Plan*. UBCO faces a challenge in reconciling energy costs and its long-term GHG emissions, and this *Infrastructure Plan* provides a roadmap and milestone metrics for GHG emissions reductions related to building operations. Campus electricity accounts for 65% of the overall campus energy consumption and 80% of overall energy cost per year; while natural gas accounts for as much as 96% of the campus carbon emissions.

GOAL #1:
Achieve a net positive performance in operational energy and carbon.

GOAL #2:
Implementation of a framework that supports low embodied carbon in future development.

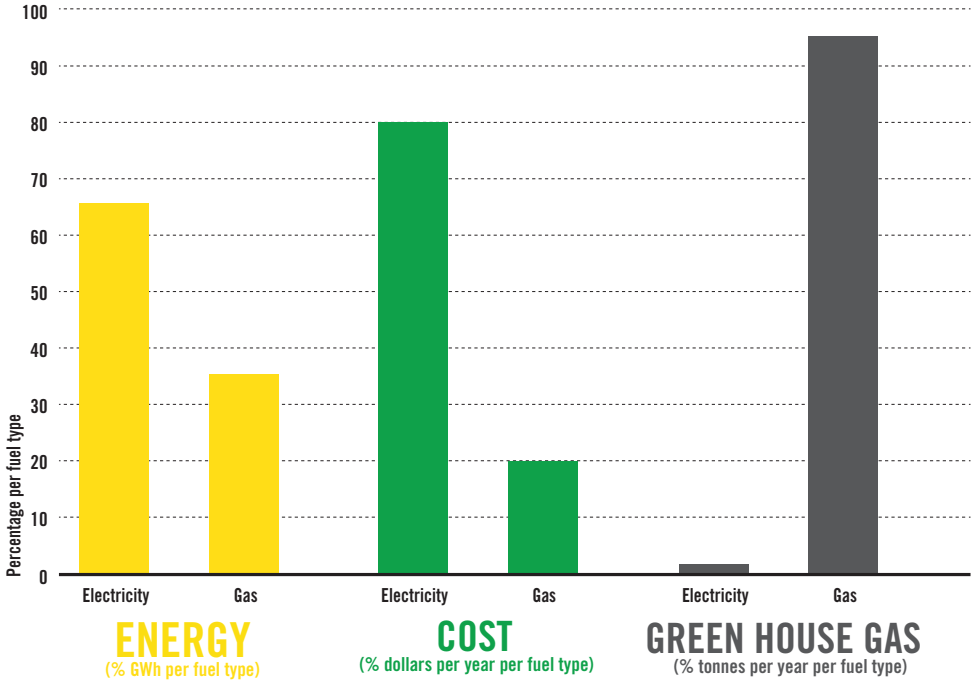


FIGURE 2: UBCO 2013 ENERGY—COST—GREENHOUSE GAS PROFILE

> "Save electricity costs to fund gas and GHG emissions reduction opportunities."

The *Whole Systems Infrastructure Plan* outlines an approach for reconciling this challenge and for achieving significant carbon reductions for UBC Okanagan Campus despite the potential doubling of campus building area and population by 2030.

Immediate implementation of energy and demand-side energy conservation measures will result in near-term electrical cost savings which can be used to finance measures that support large carbon reductions. Through implementation of a multi-pronged approach, UBCO could realize the following milestone targets:

- by 2020 achieve 33% carbon reduction as compared to BAU;
- by 2025 achieve 73% carbon reduction as compared to BAU; and
- by 2030 achieve 79% carbon reduction as compared to BAU.

The *Whole Systems Infrastructure Plan* outlines the following framework for achieving an optimized campus system and the long-term campus energy and carbon goals:

1. Form a campus energy management team to implement the *Infrastructure Plan* recommendations;
2. Create a revolving fund to finance ongoing energy improvements. This fund could be established from savings gained from the implementation of electrical and demand-side savings measures;
3. Establish baseline utility model in order to track savings;
4. Develop a campus-wide Behaviour Change and Engagement Strategy to promote and support campus awareness for resource conservation and DSM strategies required for whole systems plan implementation;
5. Develop and implement existing buildings energy conservation measures to achieve 5 year plan targets, reduce energy consumption of district energy systems, and make capacity available for future growth;
6. Update campus *Design Guidelines*, *Technical Guidelines*, and *LEED v4 Implementation Guide* with guidance for energy performance of new construction and energy efficient systems;
7. Optimize and verify the performance of the DES and continue to connect to academic buildings for heat sharing and cooling.
8. Expand CHP and DES piping systems as the campus constructs new academic and residential buildings;
9. Phase in fuel switch to carbon neutral sources to serve academic and residential buildings;
10. Plan for and pilot the integration of renewable energy technologies (i.e. solar PV) as the business case becomes more viable; and
11. Consider off-site partnerships to reach carbon neutrality by 2050.

Greater detail regarding this framework is presented in Part 2. An overall recommendation that includes the bundling of certain energy and carbon performance measures is presented in this *Infrastructure Plan*, and is summarized as follows:

- Implementation of academic building energy conservation measures coupled with phasing in a biomass central heating plant that connects both new academic and residences could result in 46% reduction in GHG emissions over 2007 baseline;
- Further reductions of 1-2% could be realized by installing solar photovoltaic systems on new academics buildings as the cost of solar technologies become a financially viable renewable energy source in British Columbia; and

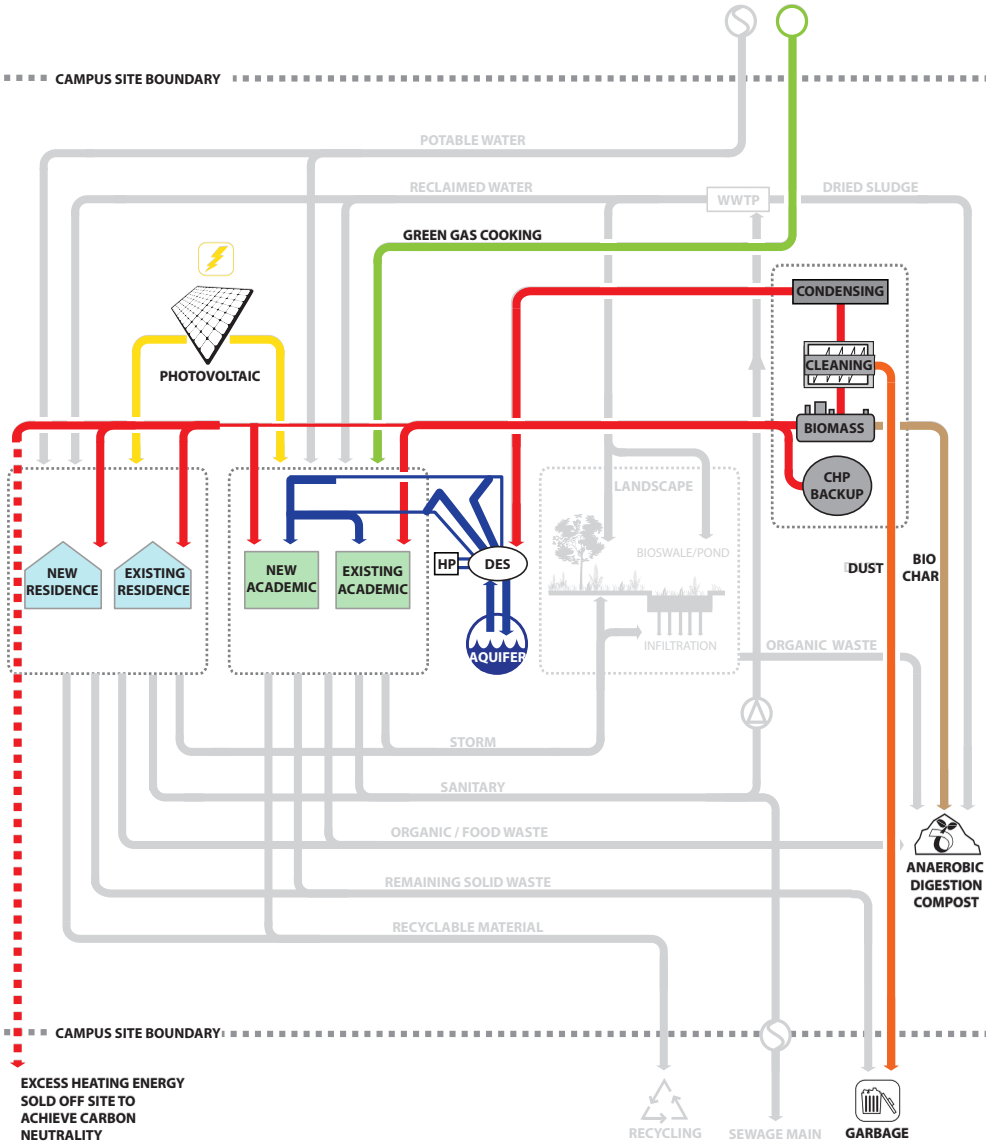


FIGURE 3: ENERGY SYSTEMS MAP

System interactions occur between many of the recommended energy and carbon reduction measures as shown in Figure 3.

- Attainment of carbon neutrality by 2050 could be realized through off-site partnerships with local industry.

Figure 3 is an energy systems map that shows conceptually how the campus energy infrastructure could evolve to integrate renewable fuel sources including biomass and photovoltaics systems, along with exploring off-site partnerships to reach the long-term goal of achieving carbon neutrality.

Figure 4 summarizes the energy and carbon plan as it relates to achieving UBCO's overall goal of achieving a net positive performance in operational energy and carbon. It also shows the preferred sequencing of energy conservation measures.

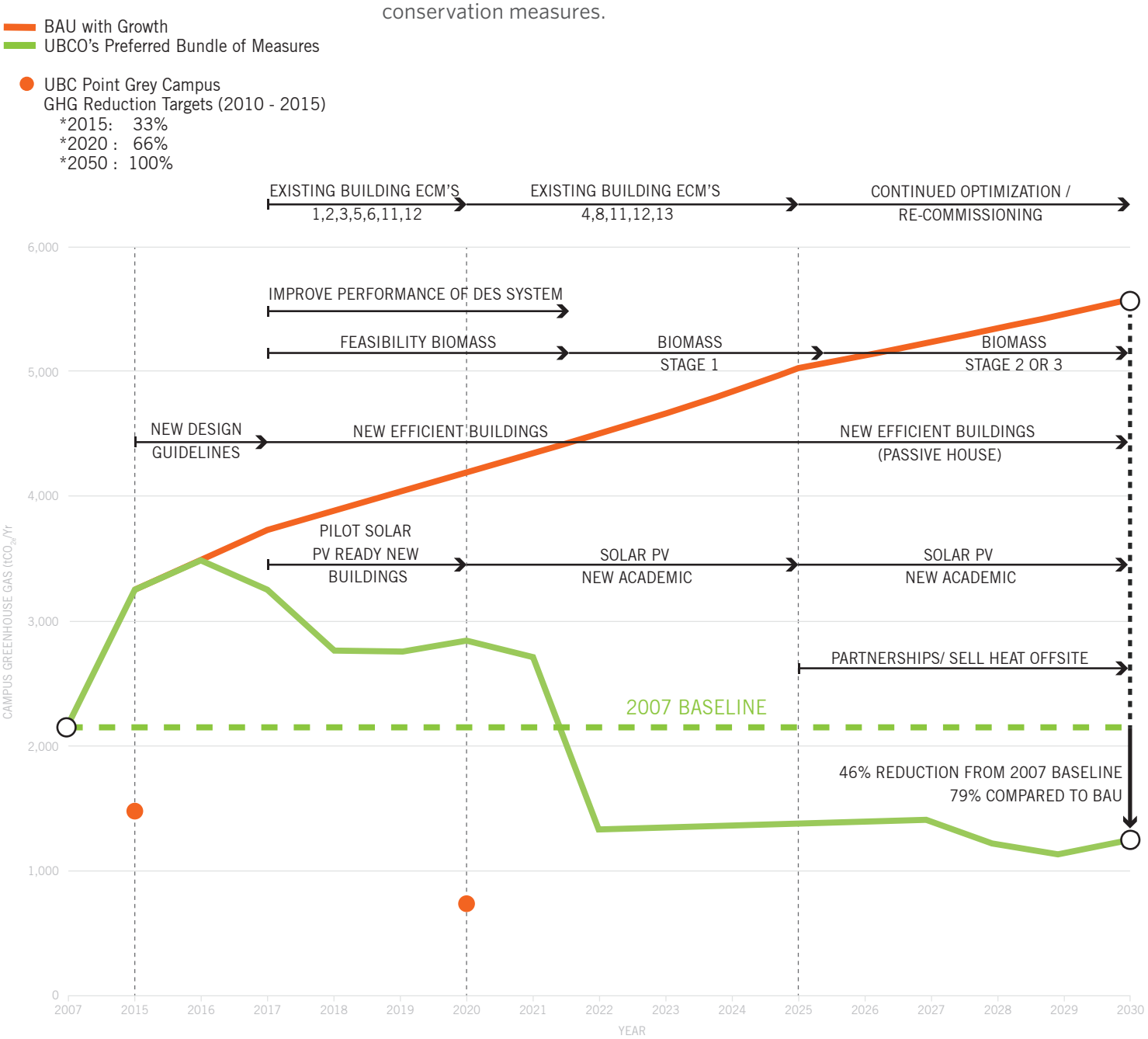
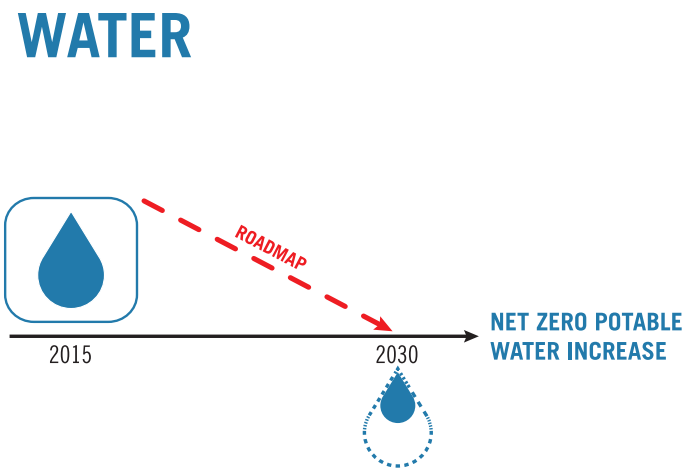


FIGURE 4: CAMPUS GREENHOUSE GAS EMISSIONS REDUCTION APPROACH

4.2 WATER



Water scarcity is a global priority, and is largely driven by climate change and lack of water demand-side management programs. A bold shift and commitment by UBCO is required to take a regional leadership position in implementing water conservation, on-site treatment and reuse best practices that are necessary for preparing the campus for anticipated long-term water shortages in the Okanagan region. The University is well-positioned to serve as a regional catalyst in demonstrating water conservation best practices. This leadership position will require taking a long-term vision to overcome near-term financial obstacles for the proposed water conservation and reuse plan. Despite the assumed doubling of campus building area and population by 2030 as compared to today, the *Whole Systems Infrastructure Plan* proposes a strategy that will enable the Campus to use less potable water and realize a net positive impact.

GOAL #3:
Optimize water quality, supply and security.

The *Whole Systems Infrastructure Plan* recommends the following framework for realizing a net positive outcome in terms of water performance:

1. Establish a water monitoring strategy to develop an accurate water use baseline for campus operations through the implementation of a water audit program and installation of water meters in all existing and new buildings;
2. Develop a long-term water management plan for the campus that establishes a policy for auditing, monitoring and tracking overall water performance;
3. Implement water conservation-based measures that have an acceptable payback and target pressure reducing valves, upgrade buildings with more efficient water fixtures as part of cyclical maintenance, and continue to phase in a drip irrigation system;
4. Update UBCO's *Design Guidelines, Technical Guidelines, and UBC LEED v4 Implementation Guide* for expected water performance of new construction and existing building upgrades;
5. Develop campus wide Behaviour Change and Engagement Strategy to promote and support campus resource conservation and DSM strategies required for whole systems plan implementation;
6. Pilot purple pipe installation in a new construction and a retrofit project on campus to determine the incremental cost and viability of preparing the campus for an on-site water treatment facility;

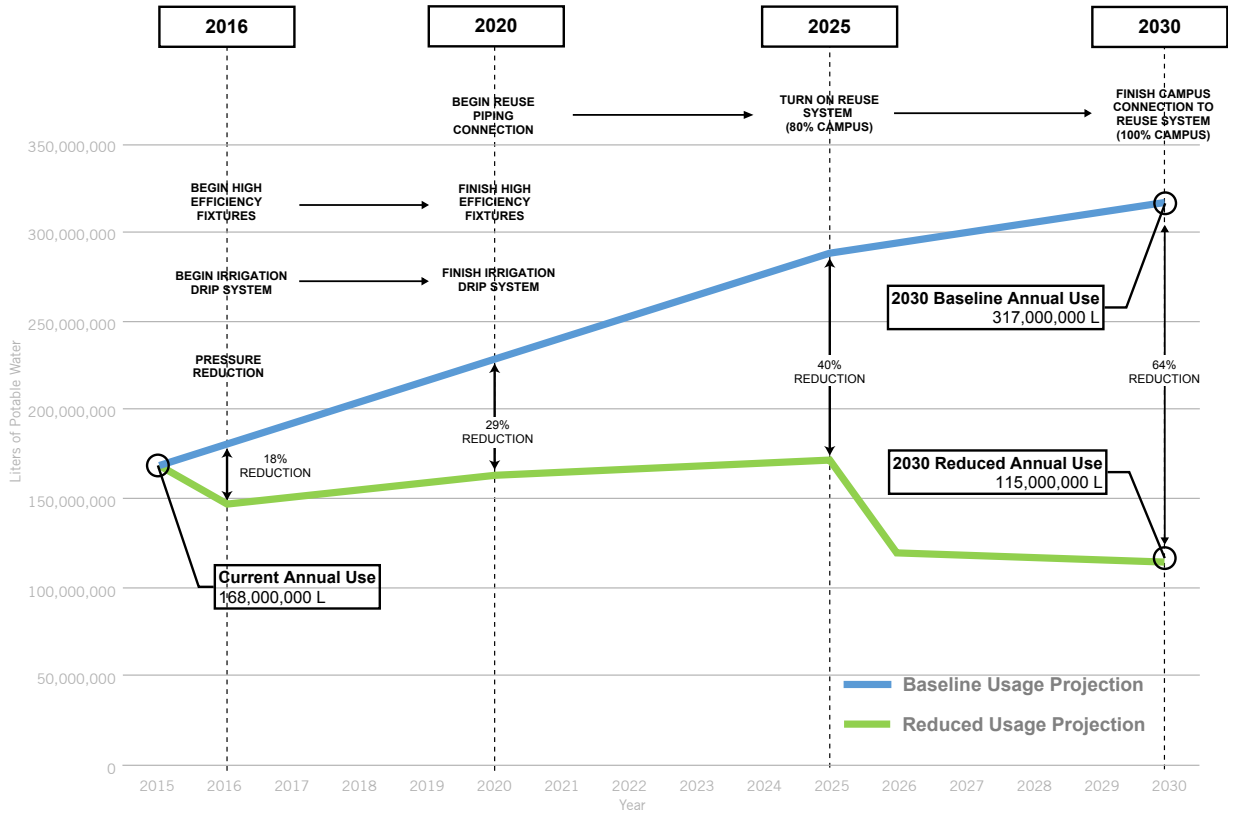


FIGURE 5: PROJECTED POTABLE WATER CONSERVATION SAVINGS

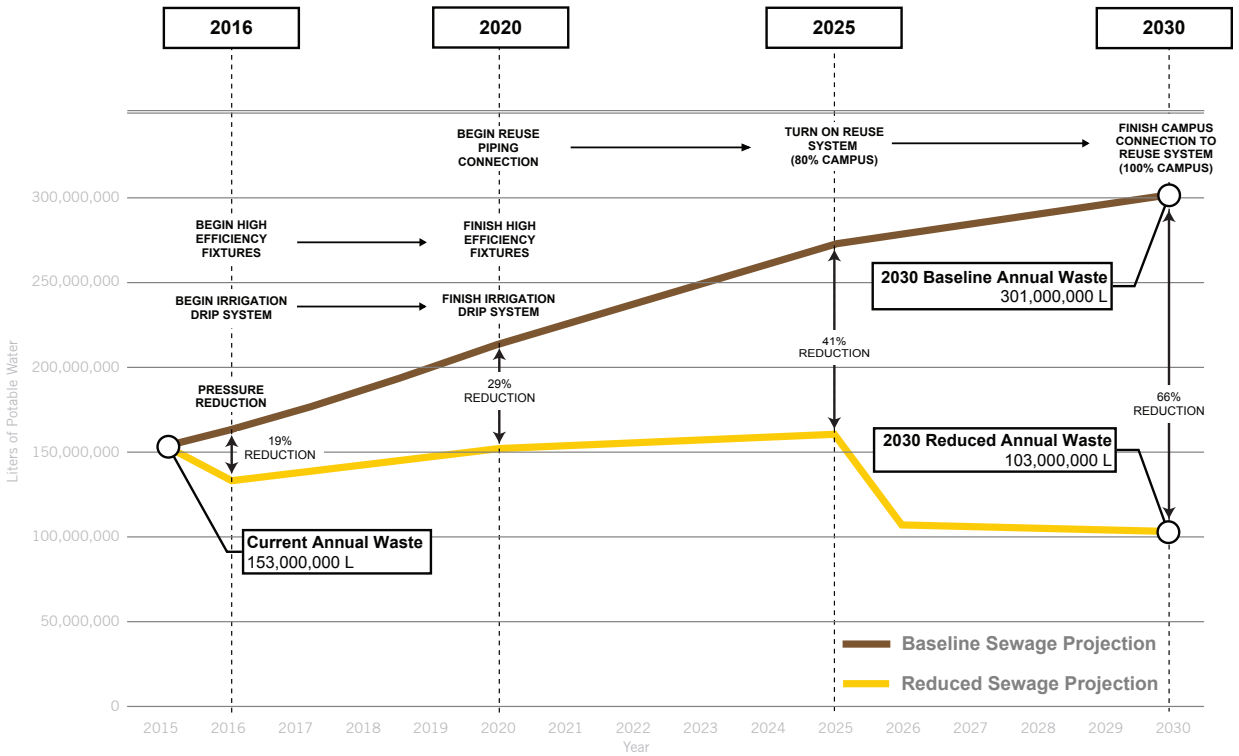


FIGURE 6: PROJECTED SEWAGE REDUCTION

System interactions occur between many of the recommended water measures as shown in Figure 7.

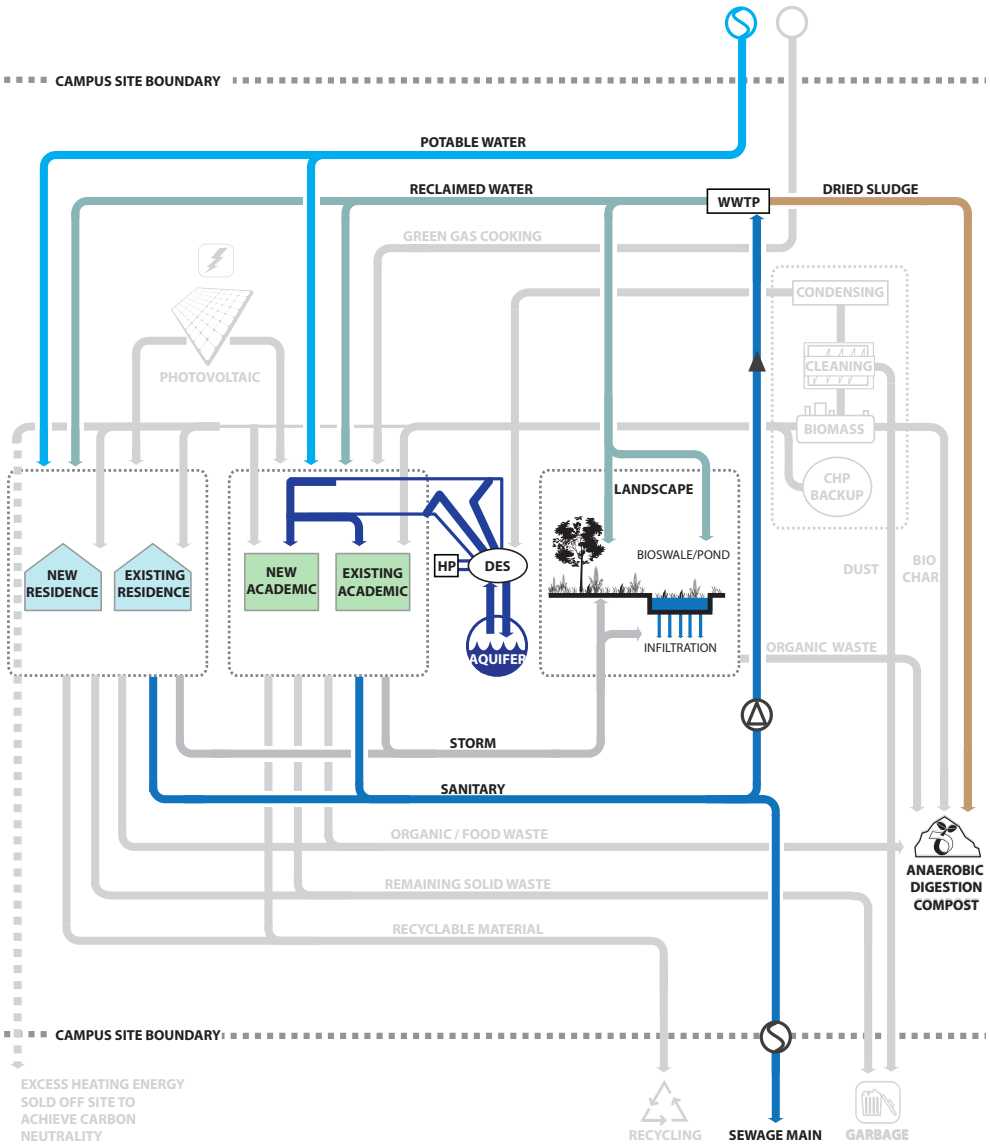


FIGURE 7: WATER SYSTEM MAP

7. Phase in purple pipe distribution for reclaimed water as DES and CHP expansion occurs on campus in order to minimize site disturbance, maximize construction cost efficiency of infrastructure, and enable buildings to be ready for when the reclaimed water system is activated;
8. Monitor the key performance indicators for broader adoption of purple pipe ready buildings and campus wide infrastructure; and
9. As a business case becomes more viable, phase in an on-site water reuse system to prepare the campus for long-term water scarcity and potential escalation in water rates.

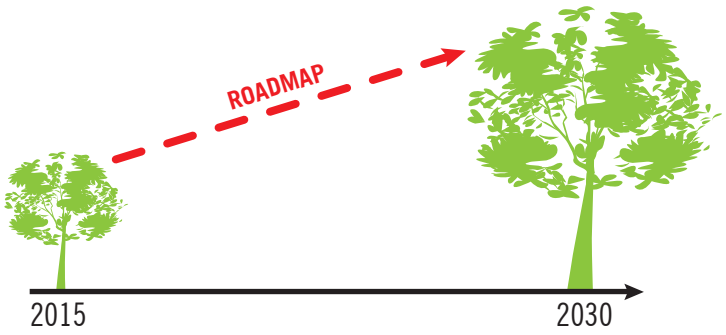
Figure 5 and 6 show the recommended phasing of water conservation measures, milestone savings and sewage reduction between now and 2030, while accounting for projected growth. Through implementation of multi-pronged approach, UBCO could realize the following milestone targets:

- by 2020 achieve 29% water use reduction as compared to BAU;
- by 2025 achieve 40% water use reduction as compared to BAU; and
- by 2030 achieve 64% water use reduction as compared to BAU.

Figure 7 illustrates the potable and sanitary systems on campus, and the possibility of introducing a wastewater treatment plant (WWTP) to provide reclaimed water to service academic and residential buildings, and landscape irrigation. The systems map shows the interactions between water, waste, stormwater and landscape systems, and the future potential of managing these resource flows on campus (i.e., diverting sewage sludge to anaerobic digestion compost system).

4.3 ECOLOGICAL LANDSCAPE AND BIODIVERSITY

BIODIVERSITY



GOAL #4:
Enhance and/or restore the ecology.

Ecosystems play a vital role in providing a range of services in terms of supporting soil formation, providing fresh water and habitat, regulating climate, and providing education and recreational value. Biodiversity is also a fundamental part of a well-functioning ecosystem. *The Whole Systems Infrastructure Plan* outlines a vision for providing an ecologically rich and diverse campus environment and will provide additional cultural, aesthetic, and recreational value to the broader community.

Successful implementation of this vision can be measured against an overarching metric of amount of natural area (ha) that will increase on campus over time. Part 2 outlines additional metrics that could be developed to track, for example, increase in native habitats, biodiversity, and social engagement.

The following framework is recommended for restoring and enhancing the ecological landscape at UBCO and is consistent with the 2015 Campus Plan:

1. Protect existing ecological features during campus development;
2. Create a compact campus core that integrates buildings and landscapes that capitalize on natural systems;
3. Collect and filter stormwater to enhance an expanded wetland network on campus;
4. Incorporate native plant communities into the campus landscape; and
5. Enhance the use of the campus as a learning landscape.

Closely linked with these recommendations is the approach for mitigating stormwater and conserving potable water supplies on campus. Synergies between systems are discussed in greater detail in Part 2, and are illustrated, for example, in Biodiversity Measure 2 listed below.

Biodiversity Measure 2 Create a Campus Core that Integrates Buildings and Landscapes that Capitalize on Natural Systems	BIODIVERSITY	WATER	STORMWATER	ENERGY	WASTE

4.4 STORMWATER

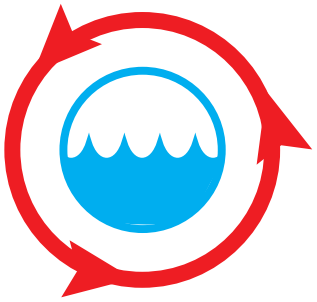
100% of stormwater is currently managed on-site at UBCO through an existing network of storm pipes, overland flow routes, ditches, swales and ponds. The *Whole Systems Infrastructure Plan* builds upon existing stormwater planning efforts to provide a framework that integrates low impact development (LID) strategies that will enable the campus continue to divert 100% of stormwater from municipal systems between now and 2030:

1. Collect and filter stormwater to an enhanced and expanded wetland network;
2. Where conditions permit on campus, infiltrate runoff from buildings and impervious surfaces in the campus core;
3. Implement specific stormwater improvements relative to the 2011 *Stormwater Management Plan* by placing a higher priority on using LID stormwater management methods where site conditions are suitable; and
4. Update the stormwater management plan to reflect the 2015 Campus Plan and incorporate LID strategies.

Closely linked with these recommendations is the approach for enhancing and restoring biodiversity functions on campus, as illustrated below:

Stormwater Measure 1 Collect and filter stormwater to enhance wetlands	BIODIVERSITY	WATER	STORMWATER	ENERGY	WASTE

STORMWATER



2030

GOAL #5:
100% diversion of storm-water from municipal systems

4.5 OPTIMIZING PERFORMANCE AND SYNERGIES

Through the implementation of the *Whole Systems Infrastructure Plan*, significant savings will be realized across all performance streams and the following metrics and targets are recommended for future tracking and monitoring of UBCO's success.

TABLE 3: PERFORMANCE METRICS

	METRIC	CURRENT PRACTICE 2013	2030 BAU	2030 PROPOSED	% CHANGE OVER BAU 2020	% CHANGE OVER BAU 2025	% CHANGE OVER BAU 2030
Energy	kWh/m^2	334	220	129	-35%	-40%	-41%
GHG*	tonnes/yr	3,317	5,591	1,177	-33%	-73%	-79%
GHG* compared to 2007 baseline	tonnes/yr	2,186	5,591	1,177	+30%	-48%	-46%
Water	m^3/m^2/year	1.3	1.1	0.4	-29%	-40%	-64%
Waste to landfill**	tonnes/yr	931	1,978	453	-	-	-51%
Stormwater	% leaving site	0%	0%	0%	0%	0%	0%
Biodiversity	Ha of habitat	not specified	0%	+15%	+5%	+10%	+15%

Across each of the performance areas (energy and carbon, ecological landscape and biodiversity, and stormwater), synergies are realized in multiple ways and these are discussed in greater detailed in Part 2 of the *Infrastructure Plan*:

- **Strategic phasing:** Strategic phasing of key infrastructure measures will allow for simultaneous scheduling and installation cost savings. For example, it is recommended to phase in purple piping with the expansion of the DES and CHP infrastructure system to realize efficiency with infrastructure construction costs. Phasing of key infrastructure systems are detailed in series of infrastructure phasing maps presented in Figures 8 and 9, as well are presented in Part 2.
- **Multiple technical benefits derived from single measures:** One of the key benefits of undertaking a whole systems approach is the opportunity to capitalize on multiple benefits and synergies resulting from the interconnection points of performance measures. Measures related to the ecological landscape and biodiversity functions have synergistic benefits with water, stormwater, and energy performance areas. For example, expanding a network of wetlands on campus not only increases the biodiversity potential on campus, but assists with mitigating stormwater on-site and contributes to the overall learning landscape.

- **Multiple qualitative benefits derived from the *Plan*:** Many qualitative benefits may be attributed to undertaking this planning effort and implementing the recommendations. Increasing UBCO's sustainability leadership position, opportunity to secure new donor funding, and ability to attract, recruit, and retain new faculty, staff and students are all potential benefits resulting from this effort.
- **Multiple quantitative benefits derived from the *Plan*:** Through implementation of the Plan, the University could realize significant savings in greenhouse gas emissions, potable water and energy use reduction, and in turn economic savings. It is estimated that the University could anticipate electricity, natural gas, carbon text, and carbon offset savings (escalated) of up to $31 million by 2030.

Figure 8 and 9 illustrates at a conceptual level the flow and distribution of resources on campus, and how resources can be managed on campus (i.e., stormwater) and the potential for long-term off-site partnerships (i.e., selling heat off-site, green gas) may assist UBCO in reaching its carbon neutrality target. It also depicts how the measures proposed in this *Whole Systems Infrastructure Plan* come together to optimize the performance of buildings (i.e., energy and water meters, purple piping, LID strategies, building scale renewables) and the overall campus with the ultimate vision of realizing net positive outcomes in terms of performance. Appendix A summarizes all of the recommended measures and the potential synergies that exist between them. Appendix B includes conceptual service plans for the proposed Infrastructure Plan systems.

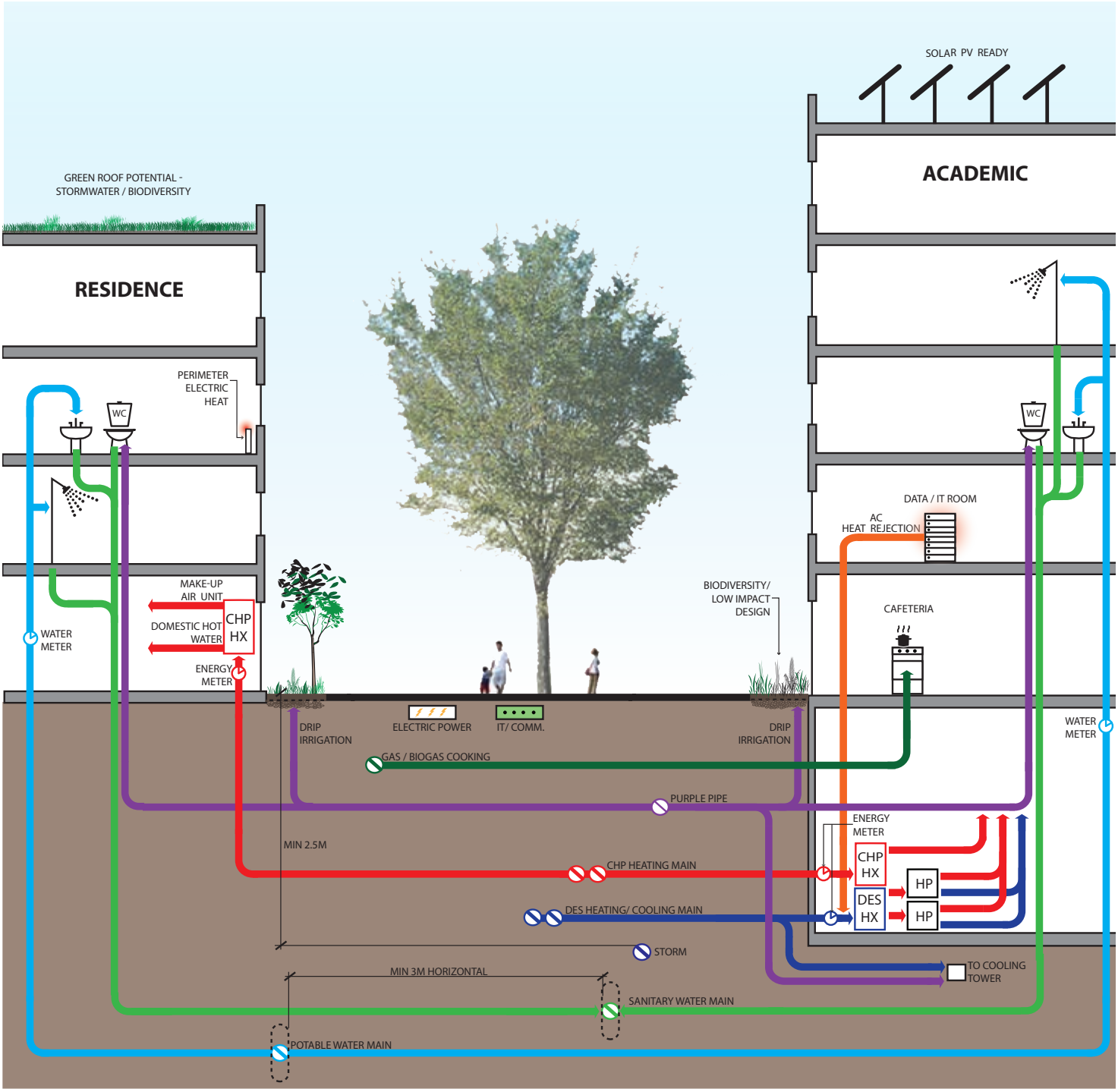


FIGURE 8: UBCO STREET SECTION

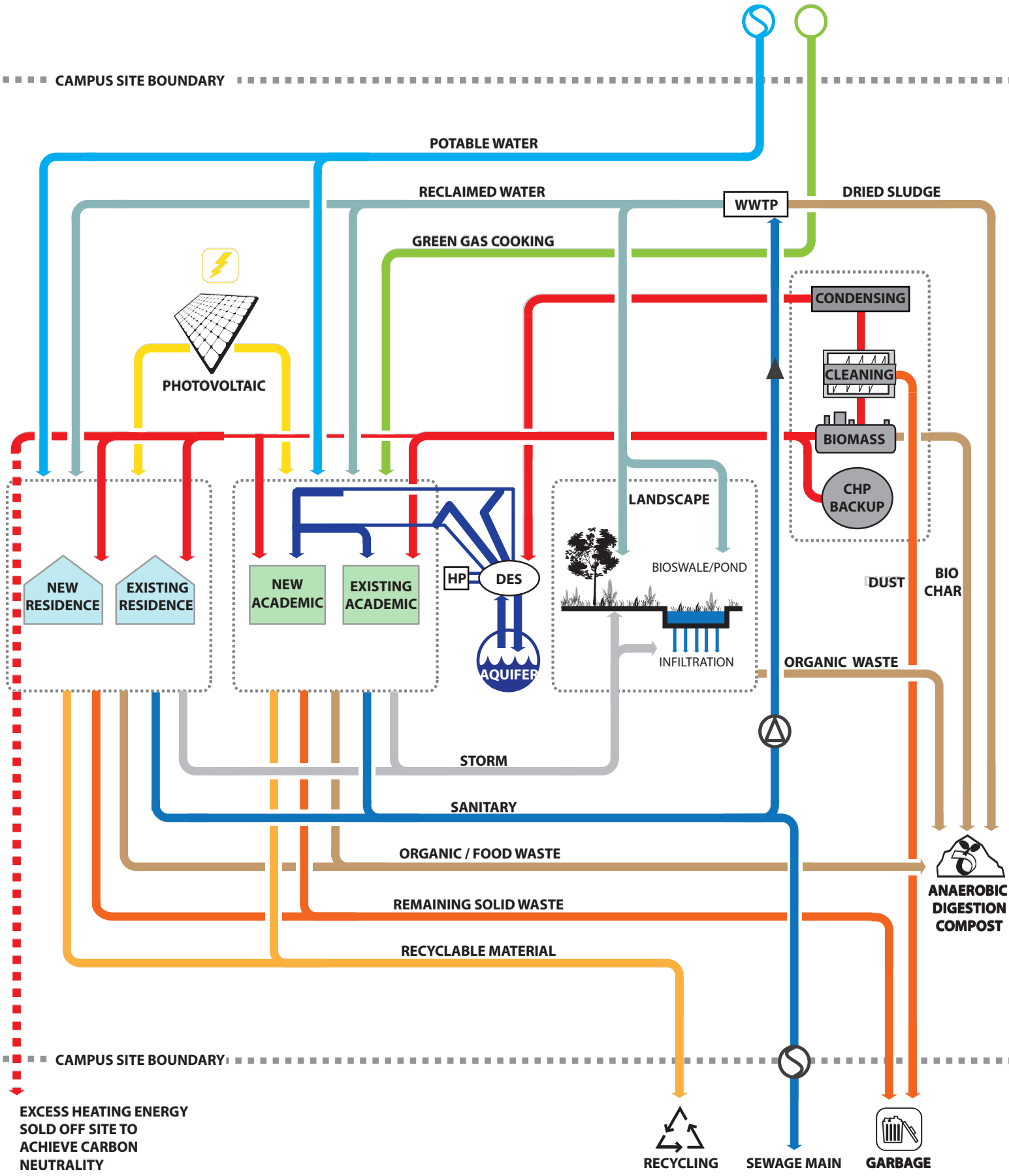


FIGURE 9: UBCO WHOLE SYSTEM INFRASTRUCTURE MAP

5 FIVE YEAR IMPLEMENTATION PLAN

The *Whole Systems Infrastructure Plan* presents a range of measures that contribute to the overall long-term sustainability performance goals of the University and can be rolled at various milestones between now and 2030, and will set up the University for sustained performance. This section focuses on the immediate measures and actions that are recommended for implementation within the next five years.

Implementation of these measures are broken into three streams: 1) energy and carbon, 2) water, and 3) biodiversity and stormwater. A self-financing approach to implementing the energy and water measures is used to prioritize these measures. In other words, the implementation plan identifies those measures that have a short payback, can be accomplished within 3-5 years, and that have a big impact in terms of water, energy or GHG savings. UBCO is then able to capture these savings in, for example, a revolving sustainability fund which can then be used to fund future conservation measures. Based on efforts already underway on campus, UBCO's Sustainability Office is able to build upon financial savings of $180,000 realized from the Power of You energy engagement campaign to provide seed funding for some of the initial recommendations put forth in this study. Whereas, a stewardship approach is recommended for implementing and funding the biodiversity and stormwater measures. Opportunities for linking these measures to a donor campaign or research grant funding are considered as more likely funding mechanisms for these measures.

To support the successful implementation of the *Whole Systems Infrastructure Plan* and its performance goals, a number of key components need to be established within the first 5 years in order to ensure the long-term success of the plan. In addition, key resources, guidelines and plans will need to be updated, developed, and implemented by various UBCO departments (acronyms listed) identified with each strategy listed below and approved by the Board of Governors. These key components and resources include:

1. **Form a Energy and Water Management Team:** Develop a energy and water management team to implement, monitor and track the *Infrastructure Plan* recommendations. This team should be made up of a minimum of two people with engineering and control system backgrounds capable of implementing the proposed water, energy and carbon measures. These positions could be funded through savings already realized from the Power of You energy engagement campaign (CORM).
2. **Infrastructure Expansion and Optimization:** Expansion of the CHP, optimization of DES, and feasibility of biomass system are near and long-term components of optimizing campus performance and realizing long-term carbon savings (CORM).

3. **Building Use Consolidation Analysis:** Immediate analysis of how the campus can consolidate building use during summer months will be an important step in achieving immediate energy savings.
4. **Update UBCO Design Guidelines:** Update the campus *Design Guidelines (including Landscape Vision), Technical Guidelines, and LEED v4 Implementation Guide* guided by staff in CP+D and C+CP to provide policy direction for energy, carbon, water, and ecosystem performance/ landscape for new construction and major renovations.
5. **Update the 2011 Stormwater Management Plan:** Update the stormwater management plan for the campus, and complete a Geotechnical Soils Analysis to inform infiltration strategies (CP+D).
6. **Update the 2006 Wildfire Management Plan:** Update the Fire Management Plan to reflect changes in the Campus Plan and Whole Systems Infrastructure Plan (CP+D/CORM).
7. **Develop Campus Wide Behaviour Change and Engagement Strategy:** Use this strategy to promote and support campus awareness for resource conservation and DSM strategies required for the Whole Systems Infrastructure Plan implementation (CP+D/OSO).
8. **Establish and Deploy a Stewardship Plan/Public Benefits Plan:** In collaboration with UBC's Development and Alumni Engagement Office, develop a stewardship plan or a public benefits plan that identifies research, partnerships, and donor funding opportunities associated with the *Whole Systems Infrastructure Plan* and *2015 Campus Plan* (CP+D/ C+CP).
9. **Implement Whole Systems Plan:** Establish an implementation, monitoring, reporting and updating framework that will facilitate the long-term success of the Whole Systems Infrastructure Plan (CP+D/ OSO).

Below is a summary of the measures to be implemented within the first 5 years of this *Plan*. Greater detail and discussion regarding each of these recommendations is presented in Part 2 of this study. Appendix D includes a summary of the recommendations presented in each of the performance areas.

TABLE 4: 5-YEAR IMPLEMENTATION PLAN SUMMARY

ENERGY + CARBON	Year 1-2	Year 3- 5
Develop a dedicated 2 person Energy Team on campus to implement, monitor and report on campus energy and carbon performance.	⊙	
Establish a revolving fund to finance ongoing energy improvements. This fund could be established from savings gained from the implementation of electrical and demand-side savings measures.	⊙	⊙
Develop a campus-wide Behaviour Change and Engagement Strategy to promote and support campus awareness for resource conservation and DSM strategies required for whole systems plan implementation.	⊙	⊙
Energy Conservation Measures (ECMs) Existing Buildings: Implement ECMs 1,2,3,6, and 11 in year 1-2, and ECMs 1,2,3,5,6, and 11-12 in years 3-5 to realize large electrical demand and cost savings.	⊙	⊙
Engage UBCO Risk Management Services for lab air change rate reductions and other lab measures.	⊙	
Commission students to do background studies: summer/winter occupancy, lab energy reduction opportunities, electrical demand, night/weekend shut-downs.	⊙	⊙
Continue with re-commissioning efforts on campus to improved existing building operations.	⊙	⊙
Campus Scale Infrastructure: Perform a study to show the performance (energy and cost) of the DES and the building side heat pumps during summer winter and shoulder seasons. This study should also identify additional waste heat sources that could reject heat into the DES during the winter e.g. data centres and electrical rooms. Use this information to improve management of DES.		⊙
Campus Scale Infrastructure: Complete a detailed business case and feasibility study for CHP and biomass expansion system integration. As part of this study, evaluate the feasibility of using recovered heat from the flue gas as a heating source for the DES.		⊙
Campus Scale Infrastructure: Connect the DES loop south campus, add cooling towers for heat rejection.		⊙
Pilot solar ready buildings to determine incremental costs of implementing solar PV on new construction projects.		⊙
Update UBCO's *Design Guidelines*, *Technical Guidelines*, *UBC LEED v4 Implementation Guide*, and *Project Design Briefs* with guidance for energy performance of new construction and energy efficient systems.	⊙	
Set up the program and start research for development of strategic Embodied Carbon Framework and include recommendations in UBCO's *Design Guidelines*.		⊙
Consider off-site partnerships (Landfill/Fortis, adjacent Airport Development) to sell excess heat off-site to reach carbon neutrality by 2050.		⊙

WATER	Year 1-2	Year 3- 5
Establish a campus-wide monitoring strategy and water metering program (for each building, cooling and irrigation) to develop an accurate water use baseline for campus operations through the implementation of a water audit program and installation of water meters in all existing and new buildings.	●	
Engage summer students to assist with establishing baseline water performance and audit of buildings.	●	
Develop a long-term water management plan for the campus that establishes a policy for auditing, monitoring and tracking overall water performance, and for overcoming short-term focus on capital cost vs. long-term imperative to plan for water shortages.	●	
Develop a campus wide Behaviour Change and Engagement Strategy to promote and support campus resource conservation and DSM strategies required for the whole systems plan implementation.	●	
Update UBCO's *Design Guidelines, Technical Guidelines*, and *UBC LEED v4 Implementation Guide, and Project Design Briefs* for expected water performance of new construction and existing building upgrades.	●	
WCM 1: Lower academic buildings pressures to 40 psi and Residence buildings to 60 psi.	●	
WCM 2: Begin water efficient fixture replacement program of buildings as building upgrades are due (i.e., Monashee, Similkameen).	●	
WCM 3: Continue to phase in planned drip irrigation program (FM 5-year plan); include recommendation for Xeriscaping in landscape vision.	●	
WCM 4: Pilot purple pipe installation in a new construction and a retrofit project on campus to determine the incremental cost and viability of preparing the campus for an on-site water treatment facility.		●
WCM 4: Phase in purple pipe distribution as DES and CHP expansion occurs on campus in order to minimize site disturbance, maximize construction cost efficiency of infrastructure.		●
WCM 4: Monitor the key performance indicators for broader adoption of purple pipe ready buildings and campus wide infrastructure.		●

ECOLOGICAL LANDSCAPE AND BIODIVERSITY	YEAR 1-2	YEAR 3- 5
BM 1: Continue to densify and focus development in the campus core.	●	●
BM 1: Avoid incremental loss of natural areas including woodlands and indigenous grasslands during campus expansion.	●	●
BM 1+3: Update the *2011 Stormwater Management Plan* to address rainfall capture and wetland creation, and consideration of and changes in the 2015 Campus Plan.	●	
BM 2+4: Update UBCO *Design Guidelines* to include requirements for integrating natural systems into new construction and landscape projects.	●	
BM 2: Increase tree cover by 10 to 25% in the campus core.	●	●
BM 2: Implement the recommendations of the *2006 Wild Fire Management Plan.*	●	
BM 2: Increase tree planting in and adjacent to parking area to provide summer shading.	●	●
BM 2: Develop staff training to support best practices including irrigation and soil management.	●	●
BM 2: Test best practices for expanding natural areas in order to determine costs of transitioning to this landscape typology.	●	
BM 3: Expand the number of and range of wetlands types associated with parking areas or other larger impermeable areas for biodiversity enhancement (open water, marshes, willow thicket, seasonally flooded areas) and stormwater management.		●
BM 4: Test native planting and maintenance strategies in order to increase the use of native species.	●	●
BM 4: Work with UBCO faculty to design landscape areas and develop planting strategies to benefit specific species or species groups such as native pollinators, butterflies, and birds which are compatible with developed areas.	●	●
BM 4: Showcase the use of the Okanagan landscape as part of the campus identity.		●
BM 5: Develop an education, awareness and outreach program that communicates the measures and benefits of the biodiversity plan.	●	●
BM 5: Expand opportunities and resources to use natural areas as part of the campus' research and learning program, and seek opportunities to align with UBCO's academic program.	●	●
BM 5: Identify student research projects that support the implementation and monitoring of the biodiversity measures in order to establish baseline metrics and goals for improvement.	●	●
BM 5: Test opportunities for an internal (faculty/staff) or external (broader community) garden or collaborative agriculture.		●
BM 5: Develop community volunteer programs to help support the long-term stewardship of the biodiversity-based programs (i.e., trail building & maintenance, community gardens, species monitoring etc.).	●	●
BM 5: As part of developing a Public Benefits and Stewardship Plan for UBCO, integrate biodiversity measures that place a priority on protection, restoration, and long-term management of the native landscape.	●	
General: Update *Project Design Brief* for new capital project to include performance requirements to use LID methods, maximize biodiversity in landscaping, consider on a project per project basis green-roof feasibility.	●	●

STORMWATER	Year 1-2	Year 3- 5
SWM 1 +3: Update the *2011 Stormwater Management Plan* to address rainfall capture, infiltration, and wetland creation, and potential integration of LID methods.	●	
SWM 1: Expand the number of wetlands associated with parking areas or other larger impermeable areas.	●	
SWM 1: Increase the range of wetland types for biodiversity enhancement (open water, marshes, willow thicket, seasonally flooded areas).	●	
SWM 2: Complete a geotechnical soil investigation to better understand infiltration rates of different locations on campus and to the potential for infiltration opportunities. This would identify where LID techniques are most appropriate.	●	
SWM 2: Test best practices for using LID methods in certain areas on campus.	●	●
SWM 2: Consider, as part of updating the UBCO's *Design Guidelines*, a recommendation on which buildings are best suited for a green roofing strategy, recognizing that green roofs may not be suitable for all building. Include recommendations for plant species selection for LID strategies in order to minimize maintenance costs, ability to sustain dry seasons, and maximize ecological value.	●	
SWM 3: Update the *2011 Stormwater Management Plan* (SWMP) to reflect the *2015 Campus Plan* and measures SWM-1 and SWM-2. The SWMP will need to confirm size of expanded wetland complex.	●	
General: Establish a program for monitoring and maintaining the performance of the campus stormwater system.		●
Expand opportunities and resources to use natural areas as part of the campus' research and learning program.	●	
General: Develop a donor strategy or campaign to secure funding for biodiversity and stormwater measures.		●
General: Expand opportunities and resources to use natural areas as part of the campus' research and learning program.	●	●
General: Update *Project Design Brief* for new capital project to include performance requirements to use LID methods, maximize biodiversity in landscaping, consider on a project per project basis green-roof feasibility and permeable paving.	●	●

5.1 GOVERNANCE STRUCTURE AND MONITORING

Implementation of the *Whole Systems Infrastructure Plan* will require a collaborative and coordinated effort of many UBC constituents. The Emergent Governance Model (Figure 10) assigns responsibility for developing and implementing the Whole Systems Infrastructure Plan as a companion to the 2015 Campus Master Plan.

Phase I represents the development of the technical and supporting analysis for the *Whole Systems Infrastructure Plan*. Within this phase, governance oversight has been provided by a Steering Committee comprised of representatives from UBC leadership, staff and academics. A Project Management Team has directed the project's overall technical and project management and the engagement of a Technical Working Group responsible for informing the plan's development. The

planning process has been led by Perkins Will, supported by an interdisciplinary consultant team, responsible for development of the Roadmap, Targets and 5-Year Implementation Plan. Expert peer review has been provided by Rocky Mountain Institute. Stakeholders involved in Phase I include representatives from UBC Campus and Community Planning, Campus Planning and Development, Energy and Water Services, Campus Operations and Risk Management, Facilities Management, Student Housing and Hospitality Services, IT Services, Infrastructure Development, UBC Properties Trust, Finance and Operations, Treasury, UBCO School of Engineering, UBC Centre for Interactive Research on Sustainability (CIRS), and UBC School of Architecture & Landscape Architecture. FortisBC and GEID were consulted by the interdisciplinary consultant team as part of the planning process.

Phase II represents the policy and program development stage, which will be led jointly by UBC Point Grey and UBC Okanagan and advised by UBC Point Grey Energy and Water Services. Informed by targets and recommendations in the *Plan*, these groups will be responsible for developing policy and programs to guide the implementation of the *Whole Systems Infrastructure Plan*. Future work will be informed by, but not be limited to developing:

- Detailed technical and financial feasibility studies for DES and CHP infrastructure expansion;
- Detailed technical and financial feasibility analysis for Biomass conversion;
- Amendments to the *Design Guidelines* for campus buildings and landscape;
- A detailed Infrastructure Servicing Plan to implement systems expansions proposed in the *Whole Systems Infrastructure Plan*;
- An updated *Stormwater Management Plan*;
- Behaviour Change and Demand-Side Management Programs to help meet resource conservation targets and waste reduction goals; and
- A Public Benefits Plan, in collaboration with UBC Development and Alumni Engagement, that establishes of an overall funding and stewardship approach with particularity attention to the Public Realm and related Biodiversity and Stormwater measures. This will include a detailed funding strategy that identifies sources of funding and the pursuit of industry partnerships, research and donor contributions.

Review and/or approval by UBC Executive and/or Board of Governors will occur at this stage as necessary.

Phase III represents the project approval and implementation phase. UBC Okanagan Campus Planning and Development (CP+D) and Campus Operations and Risk Management (CORM) will be responsible for project viability and

implementation. Campus Planning and Development (CP+D) and Campus and Community Planning (C+CP) will be responsible for project approvals in accordance with the *Whole Systems Infrastructure Plan* and established processes. Campus Operations and Risk Management will be responsible for implementing future infrastructure projects on campus, with oversight by Campus Planning and Development. A proposed UBC Energy and Water Services Advisory Board will provide critical peer review for technical and financial feasibility of large-scale infrastructure projects such as the biomass energy and wastewater treatment systems, prior to executive and/or Board of Governors approval, as applicable.

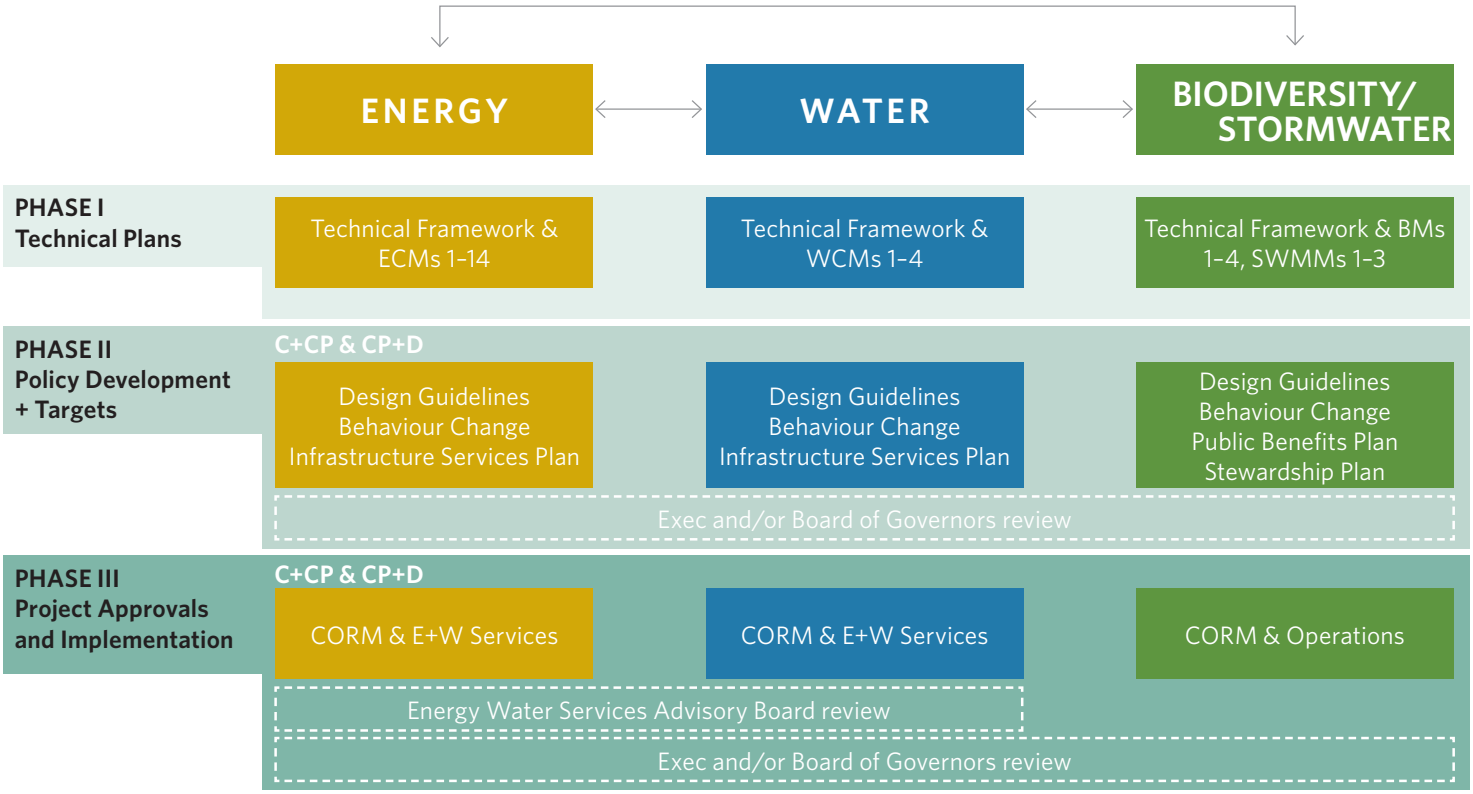


FIGURE 10: EMERGENT GOVERNANCE STRUCTURE

5.2 STAKEHOLDER ENGAGEMENT

Successful implementation and realization of the performance benefits derived from UBCO's *Whole Systems Infrastructure Plan* will require a shift in organizational thinking along with strong commitment and leadership from key UBCO decision-makers and engagement from multiple stakeholders including staff, faculty, and students. Often the gap between predicted and actual performance is a result of a change in predicted building occupancy, lack of leadership to advance performance improvements, under performance in building operations, lack of building commissioning, and limited occupant awareness of conservation measures.

A targeted campus-wide engagement and behaviour change strategy is needed to facilitate a fundamental shift in how campus stakeholders engage with and operate buildings and systems on campus. Investment in a such as a strategy supports UBC's broader mission for the UBCO Campus to be a 'Living Lab' environment, one in which can test, monitor, track and improve efforts overtime in each of the prescribed performance areas of this plan. Each member of the UBCO community will have an important role to play in realizing this vision.

A campus-wide engagement and behaviour change strategy could encompass some of the following stakeholder engagement opportunities:

- **Campus-wide Conservation Awareness Campaigns:** Continue with successful awareness programs regarding energy and water demand-side management strategies and other conservation measures. As part of a campus-wide campaign, consider implementing energy and water education programs across campus to communicate resource conservation measures and resulting savings.
- **University Sustainability Initiative Ambassador Program:** Initiate an Ambassador program, similar to UBC Point Grey Campus, to include an overview of the *Whole Systems Infrastructure Plan* goals and actions, specific resource conservation and stewardship measures. For example, use the Ambassadors to broaden the awareness of student, faculty, staff, and outside visitors to the campus and empower them to become stewards of the ecological landscape by engaging in programs associated with trail maintenance, community gardens or ongoing research.
- **Student Housing and Hospitality Services' Residence Life Program:** Update the Residence Life Program with information that encourages new students to become environmental stewards of their campus and adopt resource conservation-based behaviour. Communicate the trade-offs and benefits associated with conservation and demand-side management efforts, such as, turning off plug-loads, computers when not in use, lighting when not needed, and understanding occupant behaviour in relation to energy demands.

- **Academic Program:** Identify opportunities within the academic program to link academic learning objectives with outdoor learning activities and specific ecological landscape programmatic elements. Similarly, encourage staff and faculty to lead by example and become stewards of the landscape in adopting best practices and linking faculty research to the surrounding ecological landscape.
- **Research Program:** Identify opportunities for students to carry out research studies that can support the benchmarking and monitoring of the campus's energy, carbon, and water performance. The research program will support load reduction, and optimization of building performance. There is large opportunity to attract students to conduct research on larger scale systems, such as the biomass system or solar PV farm development. There is an opportunity to link the expertise found within academic departments with the needs of Facilities Management and UBCO Sustainability Office. Similarly, seek out opportunities for students to conduct research to support the long-term success, stewardship, and monitoring of the ecological landscape, biodiversity, and stormwater measures.

Anticipated outcomes resulting from a campus-wide Behaviour Change and Engagement Strategy will be that it:

- Establishes UBCO as thought leader on climate change, and on regional and global water scarcity;
- Demonstrates UBCO's adoption of energy, greenhouse gas, and water conservation best practices;
- Provides a strong underpinning and support for the long-term goal of enhancing and restoring the ecological landscape on campus;
- Empowers UBCO's community to become stewards of these natural landscape elements that not only offer stormwater functions, but are ecologically rich and provide a cultural, aesthetic, and recreational value to the community; and
- Enables campus stakeholders to apply whole system lessons and best practices in their day-to-day lives and become environmental stewards in the communities in which they reside.

5.3 SUMMARY

The *Whole Systems Infrastructure Plan* provides UBC Okanagan Campus with a long-term vision for deepening its sustainability performance and establishes a framework for future infrastructure development required to support the doubling of its campus by 2030 and beyond. Embedded within this *Plan* is a 5-Year Implementation Plan which proposes an approach for:

- optimizing the performance of existing infrastructure and buildings;
- deepening the performance of the next generation of buildings planned for the campus in the next five years;
- developing a long-range district scale and potential renewable solutions for energy, water and stormwater; and
- strengthening the protection, restoration, and management of the unique Okanagan ecology of the campus.

Part 2 of this *Infrastructure Plan* provides the detailed technical analysis that supports this vision for how UBCO will:

- Achieve a 64% potable water use reduction over baseline;
- Manage 100% of stormwater on-site;
- Use equal or less electricity;
- Use equal or less heating energy;
- Achieve 46% carbon reduction for campus operations compared to the 2007 baseline (79% compared to BAU), and within range of attaining carbon neutrality through off-site partnerships; and
- Provide an ecologically rich and diverse campus environment that provides cultural, aesthetic, and recreational value to the broader community.

Implementation of this vision is possible and requires a bold shift in organizational thinking along with a strong commitment and leadership from key UBCO decision-makers and engagement from multiple stakeholders including staff, faculty and students. The UBCO *Whole Systems Infrastructure Plan* establishes a platform for exemplifying UBC's vision for its Campus as a "Living Lab" and embeds principles of sustainability across its operations and infrastructure.

CREDITS

The University of British Columbia would like to acknowledge the work carried out by the UBC/UBCO Core Project Management Team, Steering Committee, Technical Team and Perkins+Will's consultant team which included AME Consulting Group, BTY Group, Smith + Anderson, PFS Studio, Raincoast Applied Ecology, 2020 Engineering and CTQ Consultants.

The University would also like to recognize the important contributions of the Rocky Mountain Institute as special advisors to the Project, as well as FortisBC for their sponsorship contribution to this planning exercise.

The UBC Okanagan Campus Whole Systems Infrastructure Plan was developed between January and September 2015 by Perkins+Will's interdisciplinary consultant team in collaboration with UBC Point Grey and UBC Okanagan, and with contribution from the Rocky Mountain Institute. The Whole Systems Infrastructure planning process occurred in parallel with and supports the UBC Okanagan Campus Plan (2015). It responds to Campus Planning Principle #4, "Campus growth should be managed through a whole systems lens that incorporates environmental, economic and social sustainability outcomes, to achieve a net-positive impact on the well-being of the campus community and ecology," by establishing a future roadmap, targets and a 5 year implementation plan for improving the overall campus performance and ensuring that it is resilient to future changes in growth, utility rates, climate change and other unanticipated changes. This Plan will also position UBC as a leader in undertaking a whole systems approach to planning future infrastructure.

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FortisBC

GLOSSARY

GLOSSARY OF TERMS

ACH	Air Changes per Hour
AD	Anaerobic Digestion
ASHP	Air-source heat pumps
BAS	Building Automation System
BAU	Business as Usual
BMS	Building Management System
CHP	Central Heating Plant
C+CD	Campus and Community Development
C+CP	Campus and Community Planning
COP	Coefficient of Performance
CORM	Campus Operations and Risk Management
CP+D	Campus Planning and Development
DDC	Direct Digital Control
DES	District Energy System
DHW	Domestic Hot Water
DSM	Demand Savings Management
EA	Exhaust Air
EUI	Energy Use Intensity
GCM	Global Climate Model
GHG	Green House Gas
GHGRTA	Green House Gas Reduction Target Act (Province of BC)
HVAC	Heating Ventilation and Air Conditioning
IPCC	International Panel on Climate Change
LID	Low Impact Development
MAU	Make-up Air Units
NECB	National Energy Code for Buildings
OSO	Okanagan Sustainability Office
PICS	The Pacific Climate Impacts Consortium
PRV	Pressure Reduction Valve

PV	Photovoltaic
SHGC	Solar Heat Gain Coefficient
SHW	Solar Hot Water
SWMP	Stormwater Management Plan
UBC	University of British Columbia
UBCO	University of British Columbia Okanagan
VFA Ltd.	VFA Ltd. Report is an Asset Funding Needs Report
WSHP	Water Source Heat Pump
WUI	Water Use Intensity

The following acronyms are used in the implementation tables and correspond to the measures presented in each of the performance sections of the *Whole Systems Infrastructure Plan*:

ECM	Energy Conservation Measure
WCM	Water Conservation Measure
BM	Ecological Landscape + Biodiversity Measure
SWM	Stormwater Measures

APPENDICES

Appendix A: Performance Measures Matrix

Summary of UBCO Whole Systems Infrastructure Plan Proposed Measures

28-Sep-15

Water Measures	Biodiversity	Water	Stormwater	Energy	Waste	Phase 1: 2015-2020	Phase 2: 2020-2025	Phase 3: 2025 -2030
Conduct Water Audit (UBC)								
Install Water Meters								
WCM1: Operation Pressure Reduction (Adjust PRVs)								
WCM2: Replace inefficient water fixtures in older buildings (UBC)								
WCM3: Switch to drip irrigation								
WCM4: Install (purple) piping for grey water toilet flushing (functional at 2020)								
WCM4: Implement a Campus Scale Water Treatment/Reuse System								

Stormwater Management Measures	Biodiversity	Water	Stormwater	Energy	Waste	Phase 1: 2015-2020	Phase 2: 2020-2025	Phase 3: 2025 -2030
SW 1: Collect and filter stormwater to enhance wetlands								
SW 2: Infiltrate runoff from buildings + impervious surfaces in the campus core								
SW3: Implement specific stormwater improvements relative to CTQ plan								

Biodiversity Measures	Biodiversity	Water	Stormwater	Energy	Waste	Phase 1: 2015-2020	Phase 2: 2020-2025	Phase 3: 2025 -2030
BM 1: Protect Existing Ecological Features during Campus Development	■	■	■	■		→	→	→
BM 2: Create a Campus Core that Integrates Buildings and Landscapes that Capitalize on Natural Systems	■	■	■	■		→	→	→
BM 3: Collect and filter stormwater to enhance eetlands	■	■	■			→	→	→
BM 4: Integrate Indigenous Plants into the Campus Landscape	■	■	■	■		→	→	→
BM 5: Enhance the use of the campus as a learning landscape	■	■	■			→	→	→

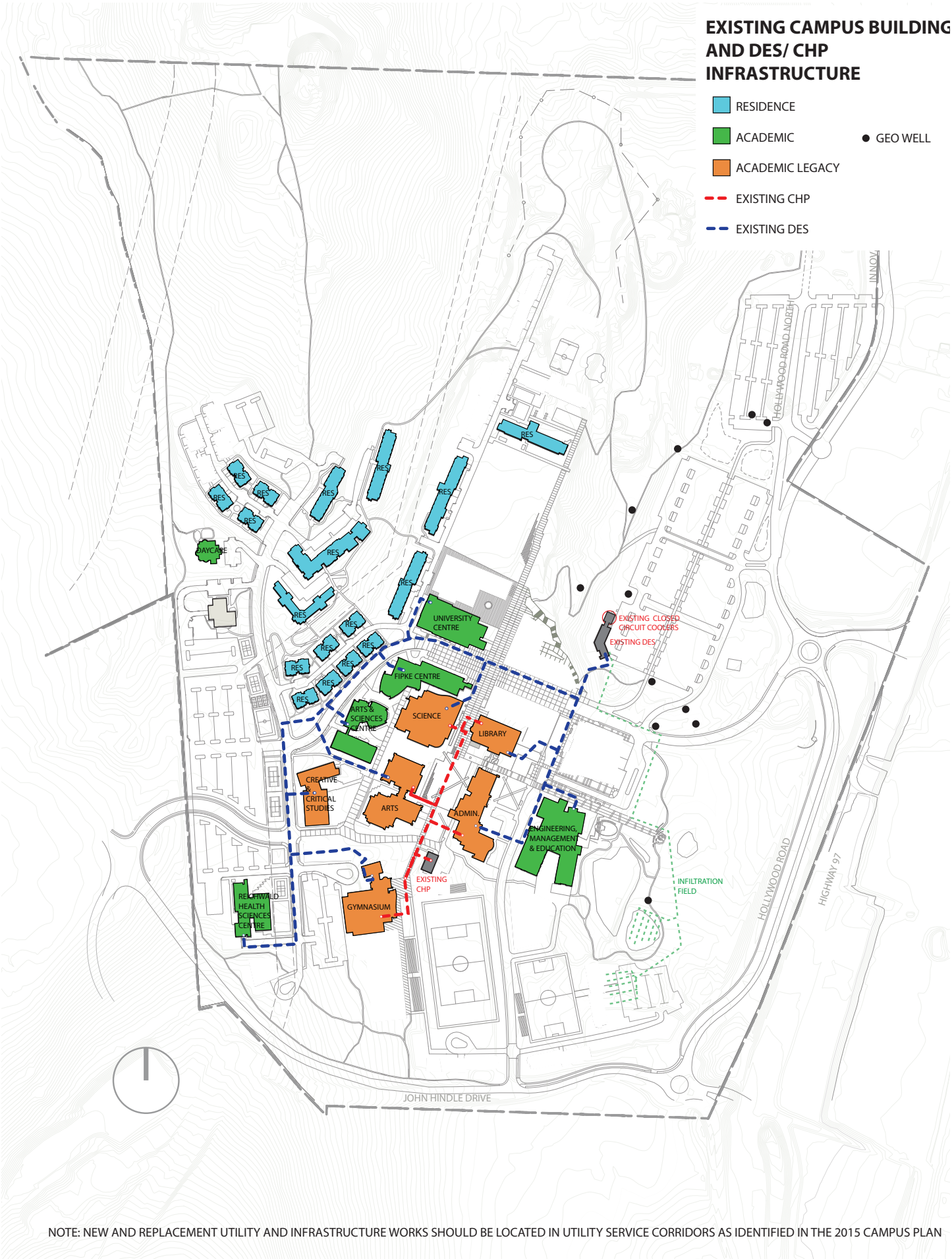
Existing Building Energy Conservation Measures	Biodiversity	Water	Stormwater	Energy	Waste	Phase 1: 2015-2020	Phase 2: 2020-2025	Phase 3: 2025 -2030
ECM 1: Building Use Consolidation				■		→		
ECM 2: Lab Air Change Night Set Back				■		→		
ECM 3: Lab Air Heat Recovery, Unoccupied Airflow Reduction				■		→		
ECM 4: Lab Air Quality Management - Indoor air quality monitoring AirCuity				■			→	
ECM 5: Lab Air Quality Management - EA VAV / Wind system				■		→		
ECM 6: Night HVAC Set-back For Academic (Excluding Labs)				■		→		
ECM 7: Sewer Heat Recovery (residences)				■				
ECM 8: Washroom Exhaust Heat Recovery (residences)				■			→	
ECM 9: Air Source Heat Pumps for ventilation (residences)				■				
ECM 10: Air-to-water Heat Pumps for DHW preheat (residences)				■				
ECM 11: Lighting Power Upgrades (academic and residential)				■		→	→	
ECM 12: Plug Load Controls				■		→	→	
ECM 13: Exterior Lighting Upgrades				■			→	→
ECM 14: HR chillers (legacy buildings)				■				
General Recommendation: Re-commissioning of buildings				■		→	→	→

New Construction Measures	Biodiversity	Water	Stormwater	Energy	Waste	Phase 1: 2015-2020	Phase 2: 2020-2025	Phase 3: 2025 -2030
NCM1: Establish new EUI targets for new construction, & incrementally improve over time by 25%, 40%, 50%.						→	→	→
NCM2: Establish New Construction Design Guidelines						→		

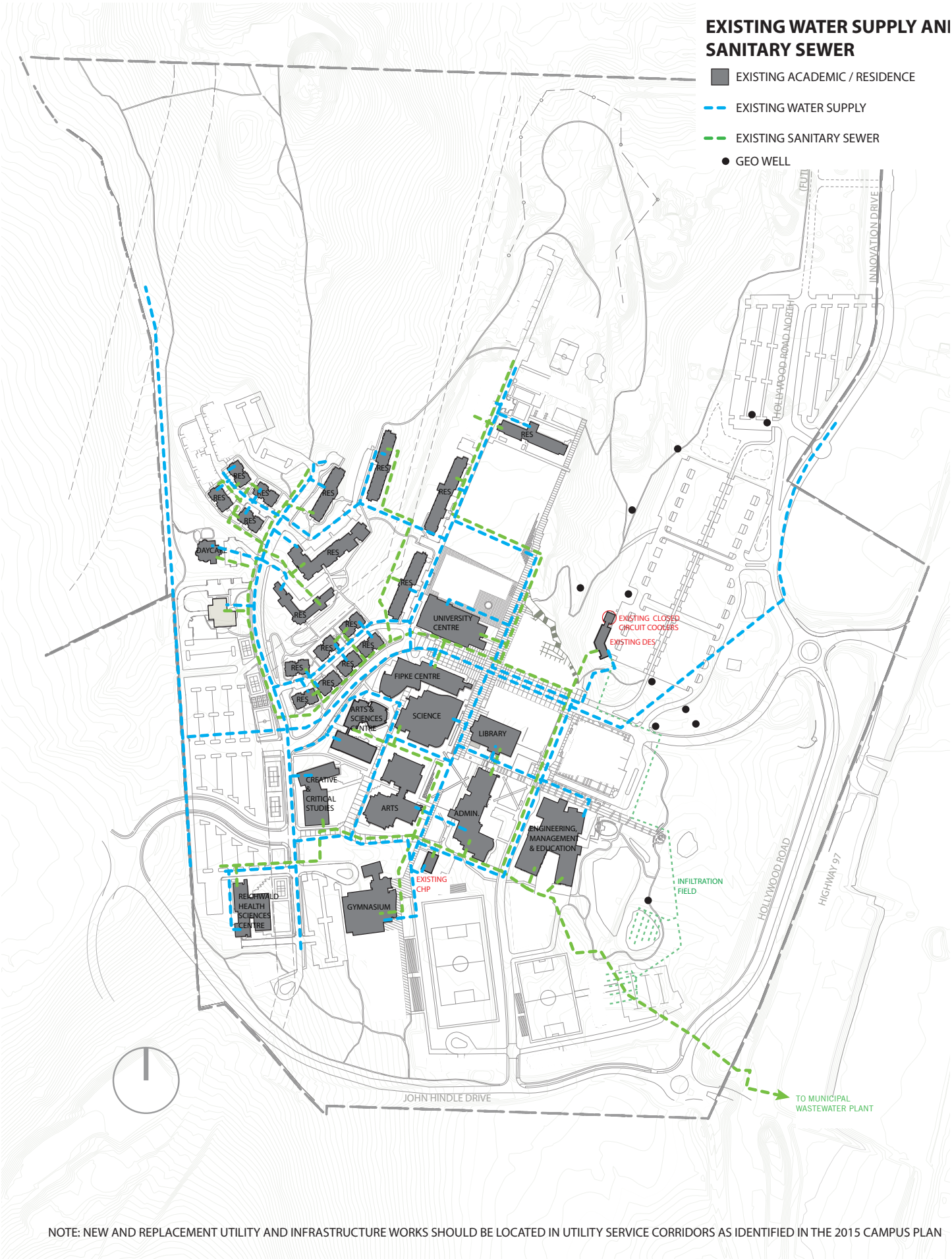
Alternative Fuel Sources	Biodiversity	Water	Stormwater	Energy	Waste	Phase 1: 2015-2020	Phase 2: 2020-2025	Phase 3: 2025 -2030
AFS1: Use biomass as fuel source and CHP expansion							→	→
AFS2: Renewable Energy – Solar HW (residences DHW)								
AFS3. Renewable Energy – Solar PV							→	→
AFS4. Waste to Energy								
AFS5. Anaerobic Digestion								
AFS6. Landfill Gas (City/Landfill/Fortis Partnership)						→	→	→

Appendix B: Conceptual Servicing Plans

A set of conceptual servicing plans were developed to communicate the strategies proposed as part of the *Infrastructure Plan*.



NOTE: NEW AND REPLACEMENT UTILITY AND INFRASTRUCTURE WORKS SHOULD BE LOCATED IN UTILITY SERVICE CORRIDORS AS IDENTIFIED IN THE 2015 CAMPUS PLAN



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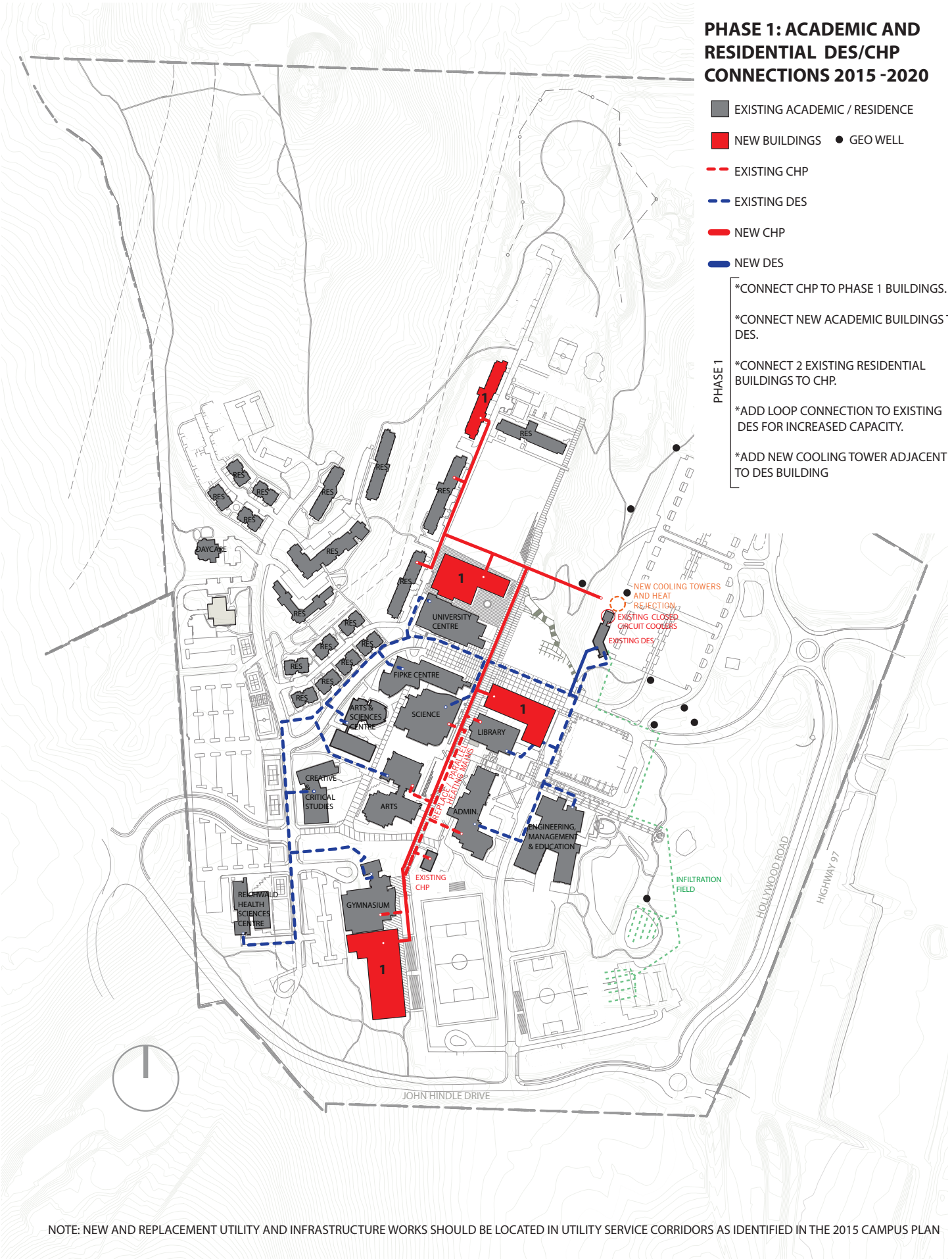

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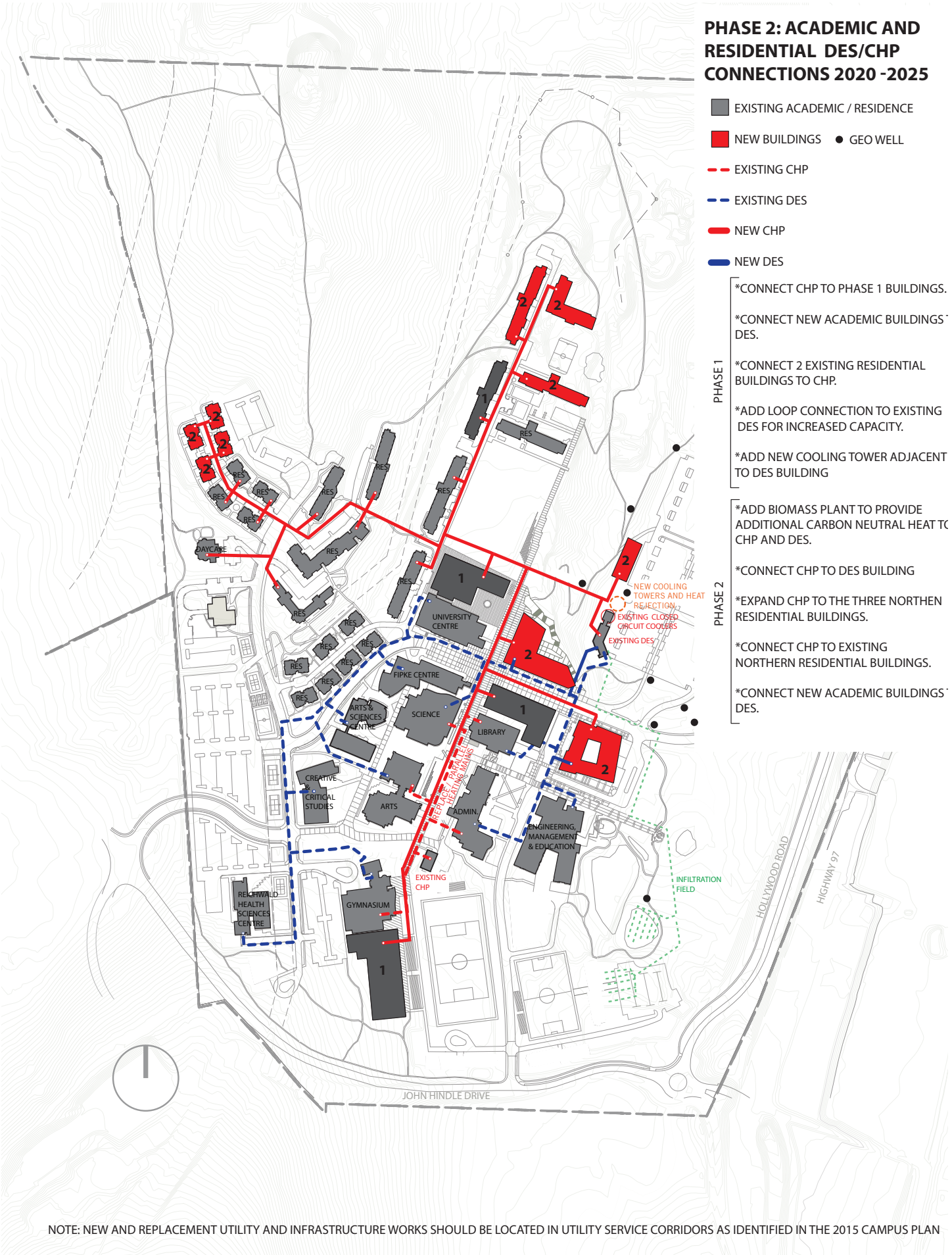

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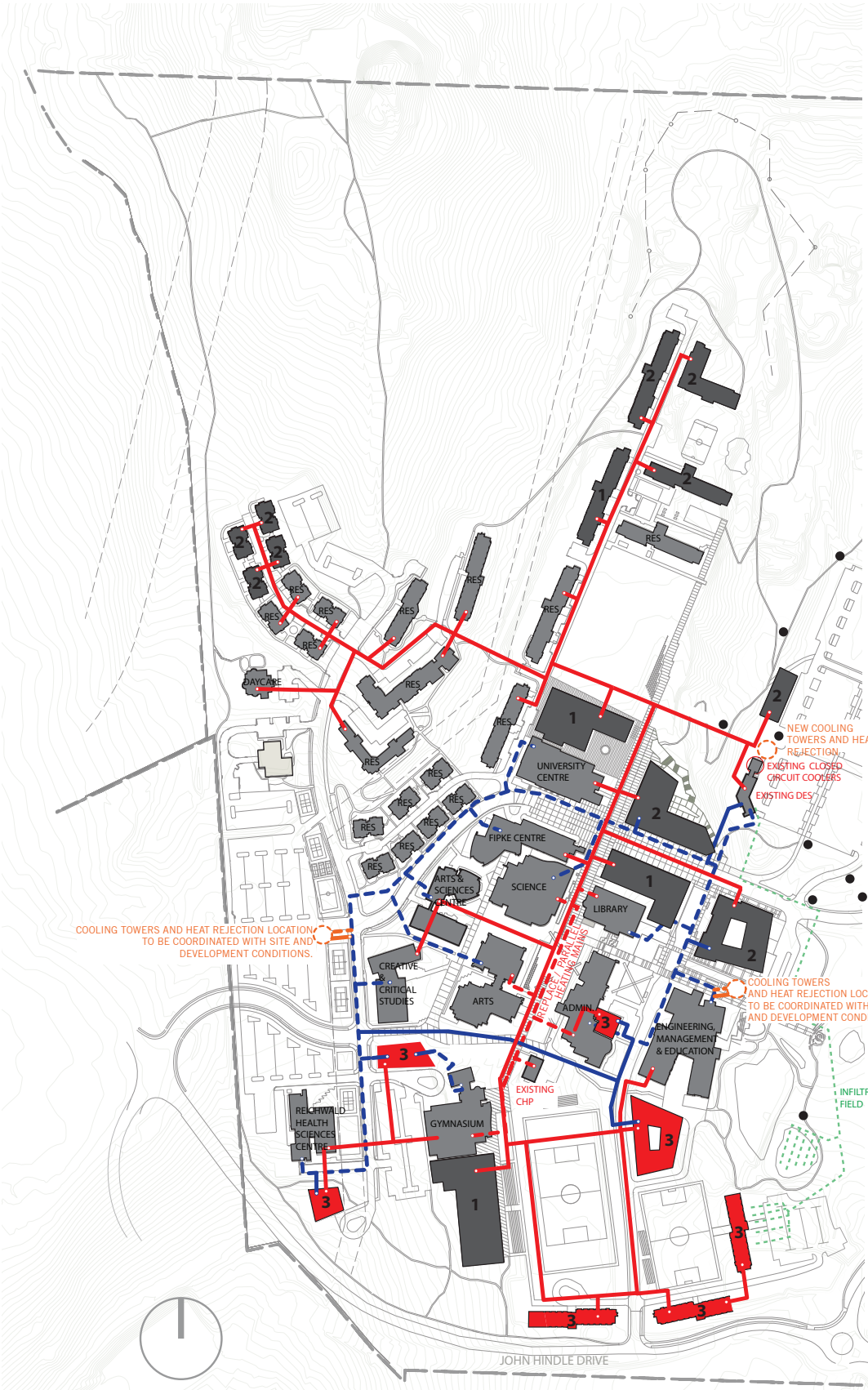


PHASE 3: ACADEMIC AND RESIDENTIAL DES/CHP CONNECTIONS 2025 - 2030

- EXISTING ACADEMIC / RESIDENCE
- NEW BUILDINGS
- GEO WELL
- EXISTING CHP
- EXISTING DES
- NEW CHP
- NEW DES

PHASE 1

*CONNECT CHP TO PHASE 1 BUILDINGS.

*CONNECT NEW ACADEMIC BUILDINGS T DES.

*CONNECT 2 EXISTING RESIDENTIAL BUILDINGS TO CHP.

*ADD LOOP CONNECTION TO EXISTING DES FOR INCREASED CAPACITY.

*ADD NEW COOLING TOWER ADJACENT TO DES BUILDING

PHASE 2

*ADD BIOMASS PLANT TO PROVIDE ADDITIONAL CARBON NEUTRAL HEAT TO CHP AND DES.

*CONNECT CHP TO DES BUILDING

*EXPAND CHP TO THE THREE NORTHEN RESIDENTIAL BUILDINGS.

*CONNECT CHP TO EXISTING NORTHERN RESIDENTIAL BUILDINGS.

*CONNECT NEW ACADEMIC BUILDINGS T DES.

PHASE 3

*CONNECT EXISTING ENGINEERING MANAGEMENT & EDUCATION BUILDING AND NEW SOUTHERN RESIDENTIAL BUILDINGS TO NEW SOUTHERN CHP LOC

*EXPAND DES TO PHASE 3 ACADEMIC BUILDINGS.

*CONNECT CHP TO EXISTING ACADEMIC BUILDINGS IN CENTRE OF CAMPUS.

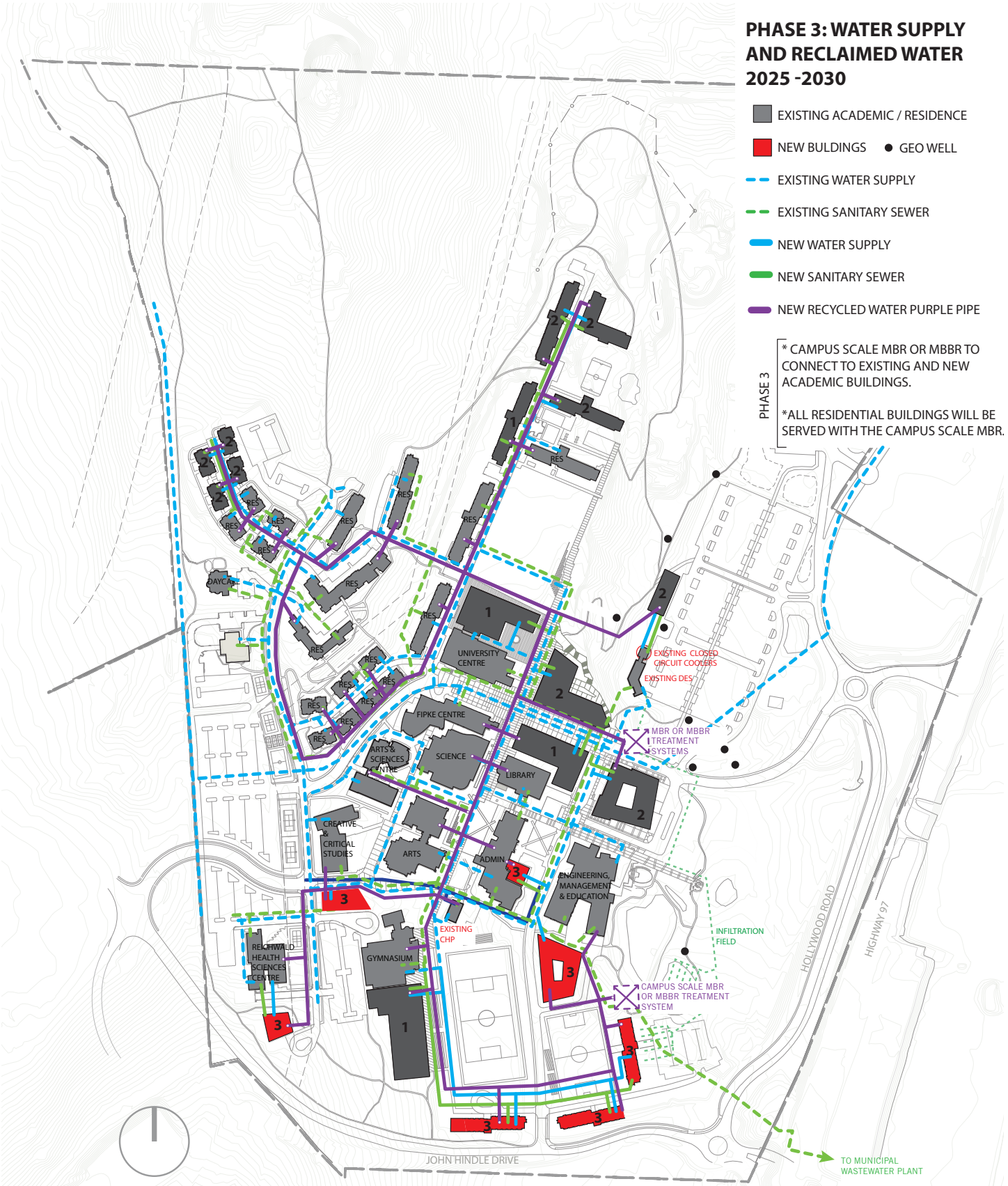
*IN SEVERAL INSTANCES CHP PIPING IS R THROUGH BUILDINGS TO REDUCE COST.

*USE DES AS A CONDENSER WATER LOOI

*ADD TWO NEW COOLING TOWERS TO INCREASE HEAT REJECTION CAPACITY.

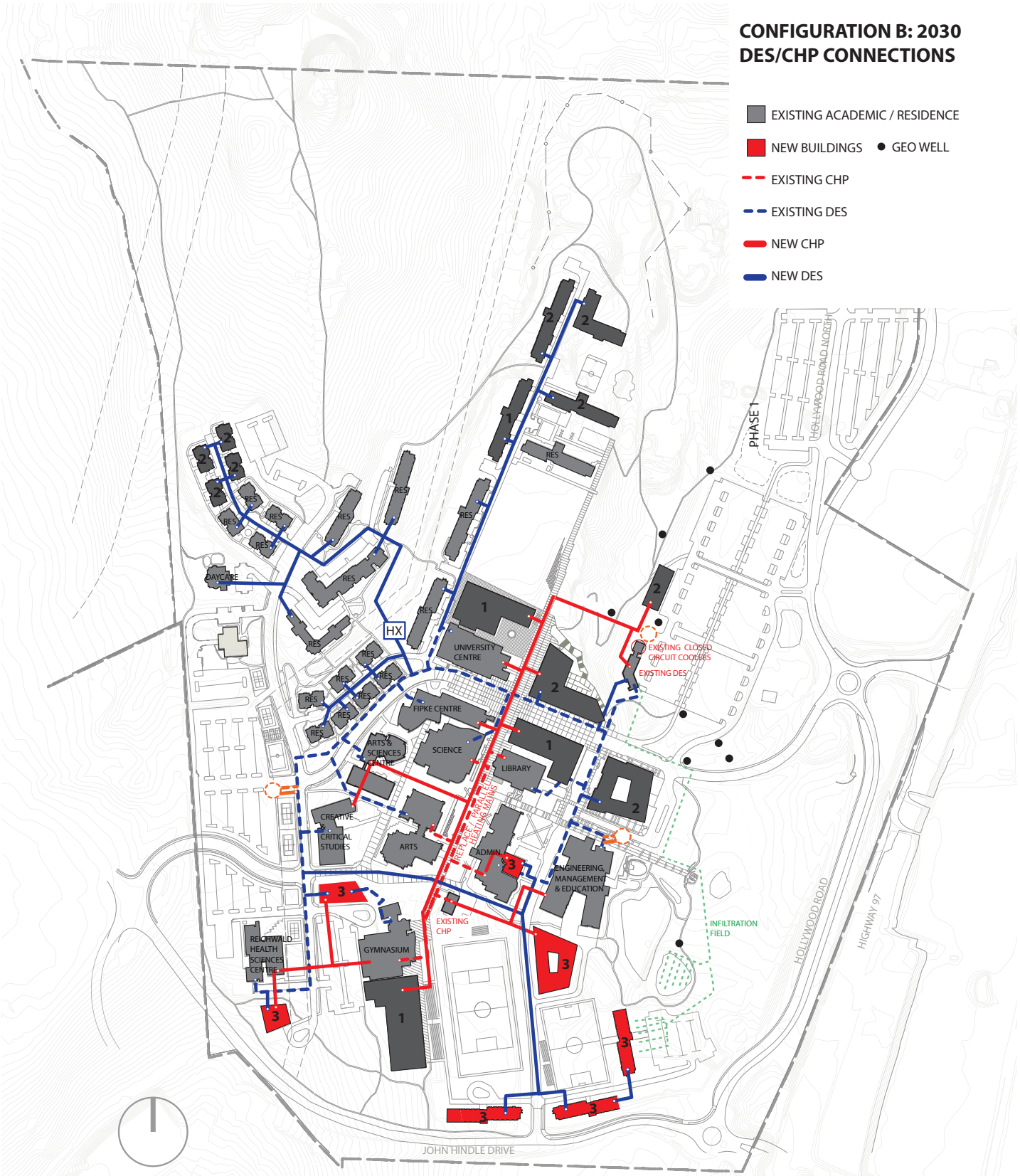
*CLOSE AND LOOP DES PIPING

NOTE: NEW AND REPLACEMENT UTILITY AND INFRASTRUCTURE WORKS SHOULD BE LOCATED IN UTILITY SERVICE CORRIDORS AS IDENTIFIED IN THE 2015 CAMPUS PLAN



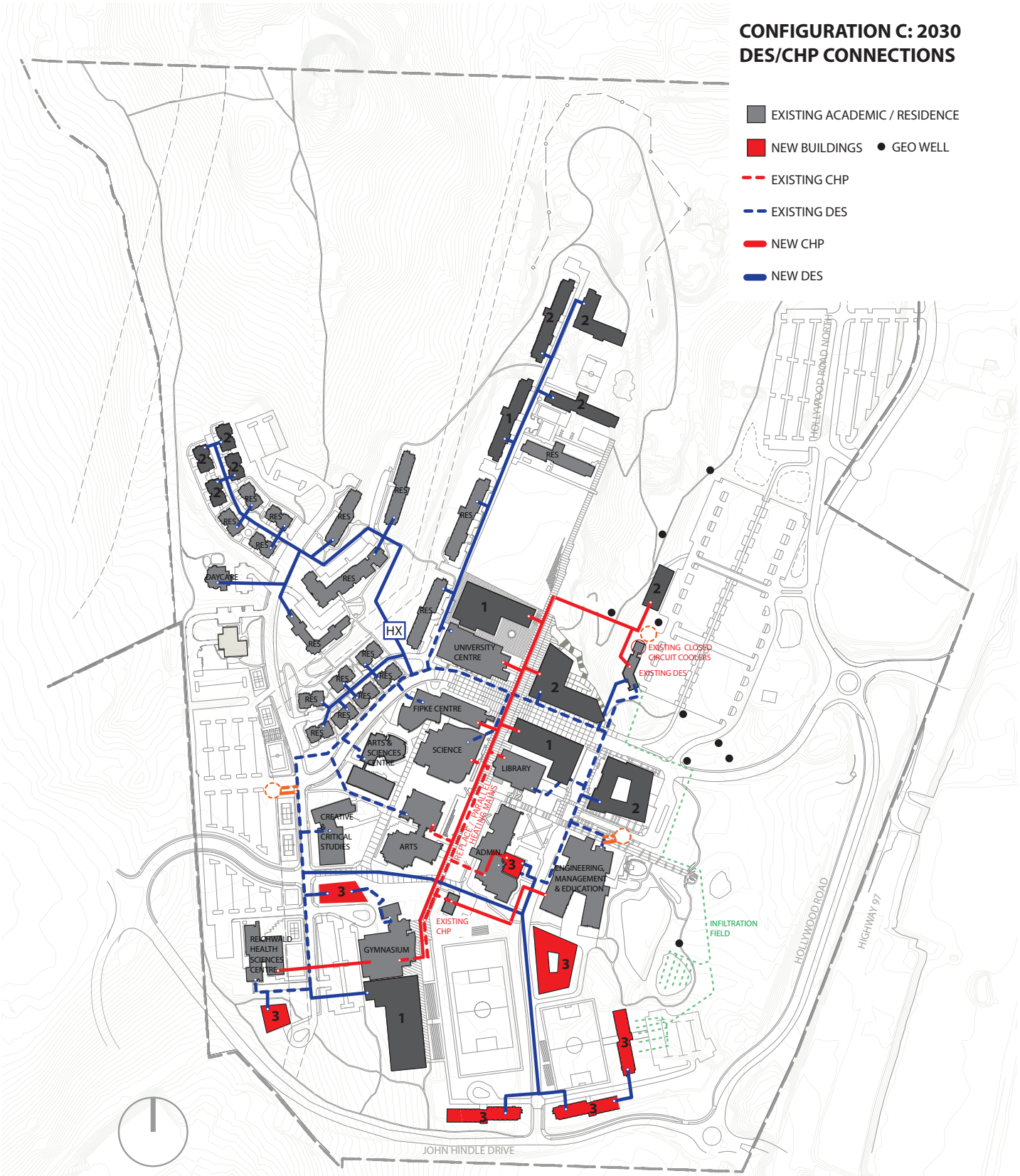
NOTE: NEW AND REPLACEMENT UTILITY AND INFRASTRUCTURE WORKS SHOULD BE LOCATED IN UTILITY SERVICE CORRIDORS AS IDENTIFIED IN THE 2015 CAMPUS PLAN

CONFIGURATION B: 2030 DES/CHP CONNECTIONS



NOTE: NEW AND REPLACEMENT UTILITY AND INFRASTRUCTURE WORKS SHOULD BE LOCATED IN UTILITY SERVICE CORRIDORS AS IDENTIFIED IN THE 2015 CAMPUS PLAN

CONFIGURATION C: 2030
DES/CHP CONNECTIONS



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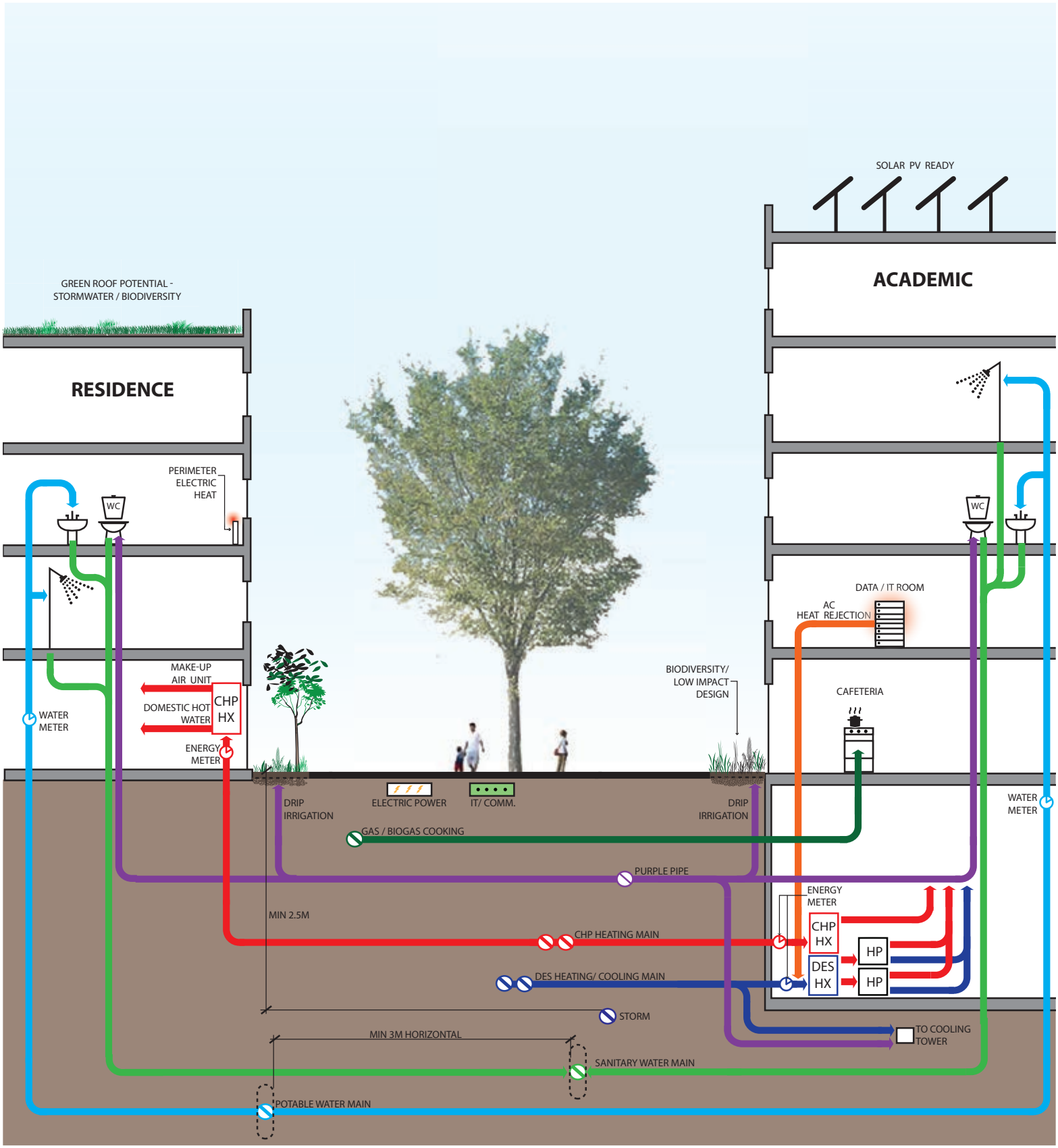


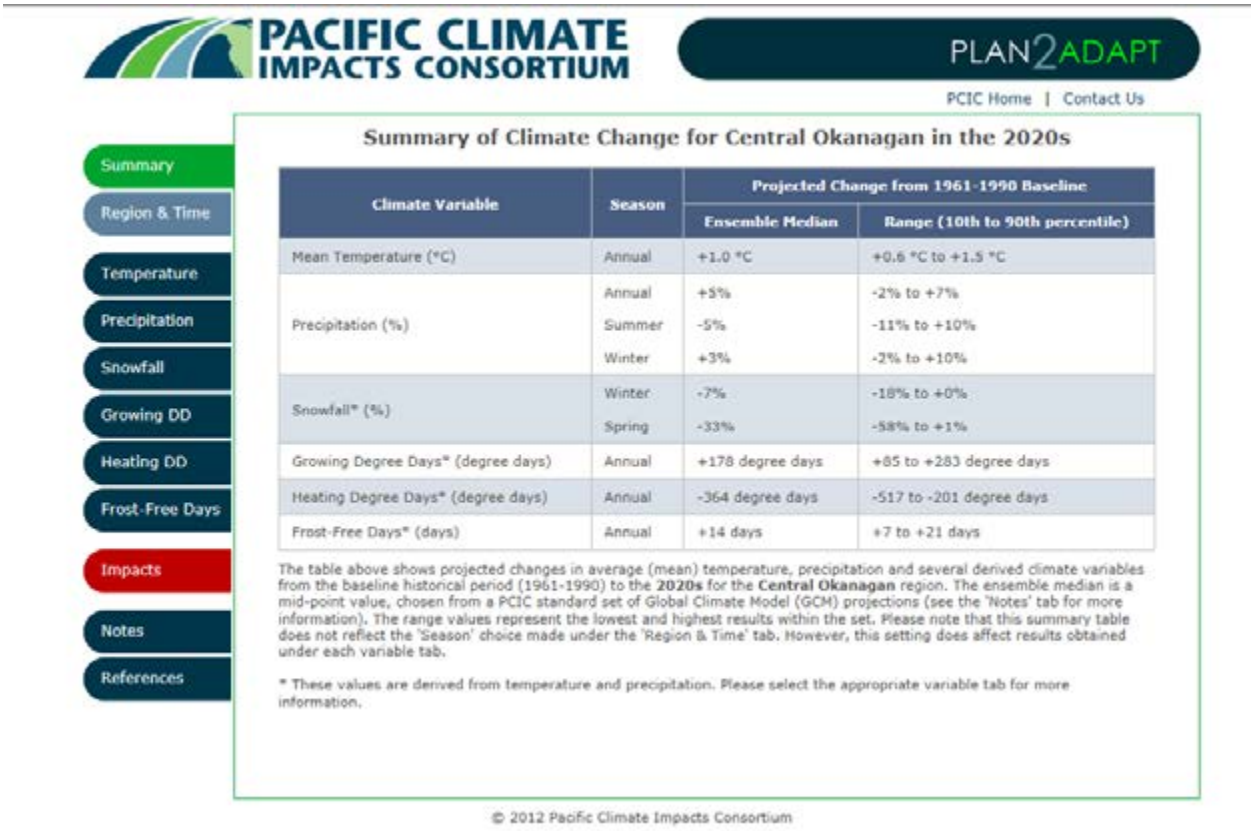
UBCO STREET SECTION

NOTES:

*POTABLE WATER, STORM, AND SANITARY PIPES TO BE A MINIMUM OF 2.5 METERS DEEP TO AVOID FROST.
*POTABLE WATER TO BE AT MINIMUM 3 METERS HORIZONTAL FROM STORM , SANITARY, RECLAIMED PURPLE PIPE.
*SERVICES TO STAGGERED SUCH THAT THEY MAY BE INDIVIDUALLY EXCAVATED WITHOUT DISRUPTING OTHER SERVICES.

HP : HEAT PUMP
CHP HX : CENTRAL HEATING PLANT HEAT EXCHANGER
200ϕ CHP : CENTRAL HEATING PLANT
DES HX : DISTRICT ENERGY SYSTEM HEAT EXCHANGER
450ϕ DES : DISTRICT ENERGY SYSTEM
200-250ϕ POTABLE WATER MAIN
150ϕ RECLAIMED WATER MAIN
~75ϕ GAS/ BIOGAS COOKING

Appendix C: Pacific Climate Impacts Consortium: Summary of Climate Change Data for Central Okanagan



PACIFIC CLIMATE IMPACTS CONSORTIUM

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Summary

Region & Time

Temperature

Precipitation

Snowfall

Growing DD

Heating DD

Frost-Free Days

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References

Summary of Climate Change for Central Okanagan in the 2020s

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	Range (10th to 90th percentile)
Mean Temperature (°C)	Annual	+1.0 °C	+0.6 °C to +1.5 °C
Precipitation (%)	Annual	+5%	-2% to +7%
	Summer	-5%	-11% to +10%
	Winter	+3%	-2% to +10%
Snowfall* (%)	Winter	-7%	-18% to +0%
	Spring	-33%	-58% to +1%
Growing Degree Days* (degree days)	Annual	+178 degree days	+85 to +283 degree days
Heating Degree Days* (degree days)	Annual	-364 degree days	-517 to -201 degree days
Frost-Free Days* (days)	Annual	+14 days	+7 to +21 days

The table above shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the **2020s** for the **Central Okanagan** region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (see the 'Notes' tab for more information). The range values represent the lowest and highest results within the set. Please note that this summary table does not reflect the 'Season' choice made under the 'Region & Time' tab. However, this setting does affect results obtained under each variable tab.

* These values are derived from temperature and precipitation. Please select the appropriate variable tab for more information.

Summary
Region & Time
Temperature
Precipitation
Snowfall
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Summary of Climate Change for Central Okanagan in the 2050s

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	Range (10th to 90th percentile)
Mean Temperature (°C)	Annual	+1.9 °C	+1.1 °C to +2.7 °C
Precipitation (%)	Annual	+7%	-2% to +11%
	Summer	-11%	-24% to -1%
	Winter	+7%	-4% to +16%
Snowfall* (%)	Winter	-14%	-26% to -2%
	Spring	-57%	-76% to -13%
Growing Degree Days* (degree days)	Annual	+359 degree days	+206 to +541 degree days
Heating Degree Days* (degree days)	Annual	-664 degree days	-954 to -400 degree days
Frost-Free Days* (days)	Annual	+24 days	+13 to +36 days

The table above shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the **2050s** for the **Central Okanagan** region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (see the 'Notes' tab for more information). The range values represent the lowest and highest results within the set. Please note that this summary table does not reflect the 'Season' choice made under the 'Region & Time' tab. However, this setting does affect results obtained under each variable tab.

* These values are derived from temperature and precipitation. Please select the appropriate variable tab for more information.

APPENDIX D: SUMMARY OF PERFORMANCE RECOMMENDATIONS

Energy/Carbon Conservation Measures	<5 years	5-10 years	10-20 years
Develop a 2 person dedicated energy team on campus to implement the infrastructure plan, monitor and report on campus energy and carbon performance.	●		
Establish a revolving fund to finance ongoing energy improvements. This fund could be established from savings gained from the implementation of electrical and demand-side savings measures	●		
Develop a campus-wide Behavior Change Engagement Strategy to promote and support campus awareness for resource conservation and DSM strategies required for whole systems plan implementation	●		
Energy Conservation (ECMs) Existing Buildings: Implement ECMs 1, 2, 3, 5, 6, 11-12 to realize large electrical demand and cost savings, and make capacity available within existing DES for future growth.	●		
Energy Conservation (ECMs) Existing Buildings: Continue to Implement ECMs 4, 5, 8, 11-13 to realize large electrical demand and cost savings. ECM 8 and 13 consider as part of cyclical maintenance programs.		●	●
Implement electrical demand reduction strategies when not occupied to reduce electrical energy use, and to expand capacity of DES.	●	●	
Engage UBCO Risk Management Services for lab air change rate reductions and other lab measures.	●		
Commission students to do background studies: summer/winter occupancy, lab energy reduction opportunities, electrical demand, night/weekend shut-downs.	●	●	
Continue with re-commissioning efforts on campus to improved existing building operations.	●	●	●
Campus Scale Infrastructure: Perform a study to show the performance (energy and cost) of the DES and the building side heat pumps during summer winter and shoulder seasons. This study should also identify additional waste heat sources that could reject heat into the DES during the winter e.g. data centres and electrical rooms. Use this information to improve management of DES.	●		
Campus Scale Infrastructure: Complete a detailed business case and feasibility study for CHP and biomass expansion system integration. As part of this study, evaluate the feasibility of using recovered heat from the flu gas as a heating source for the DES.	●		
Campus Scale Infrastructure: Develop a biomass heating plant to feed into the CHP and configure biomass flue gas heat recovery system to heat DES in the winter. Prior to implementation of the biomass conversion, test the concept for flu gas heat recovery by connecting the CHP and DES directly.		●	●
Campus Scale Infrastructure: Connect the DES loop south campus, add cooling towers for heat rejection.	●		●
Campus Scale Infrastructure: Complete final infrastructure expansion in Phase 3.			●
Update UBCO's *Design Guidelines*, *Technical Guidelines*, *LEED Implementation Guide*, and *Project Design Briefs* with guidance for energy performance of new construction and energy efficient systems.	●		
Pilot solar ready buildings to determine incremental costs of implementing solar PV on new construction projects.	●		

Energy/Carbon Conservation Measures	<5 years	5-10 years	10-20 years
Plan for the integration of renewable energy technologies (i.e., building level PV, and solar PV Farm) as the business case becomes more viable.		○	◉
Set up the program and start research for development of strategic Embodied Carbon Framework and include recommendations in UBCO's Design Guidelines.	◉		
Consider off-site partnerships with City of Kelowna FortisBC, adjacent Airport Development, to establish availability of green gas for cooking, and to sell excess heat off-site to reach carbon neutrality by 2050.	◉	◉	◉

Water Conservation Measures	<5 years	5–10 years	10–20 years
Low Hanging Fruit Actions			
Establish campus wide monitoring strategy and water metering program (for each building, cooling and irrigation) to develop an accurate water use baseline for campus operations through the implementation of a water audit program and installation of water meters in all existing and new buildings.	●		
Engage summer student to assist with establishing baseline water performance and audit of buildings	●		
Develop a long-term water management plan for the campus that establishes a policy for auditing, monitoring and tracking overall water performance, and for overcoming short-term focus on capital cost vs. long-term imperative to plan for water shortages.	●		
Develop a campus wide Behaviour Change and Engagement Strategy to promote and support campus resource conservation and DSM strategies required for the whole systems plan implementation.	●	●	●
Update UBCO's *Design Guidelines*, *Technical Guidelines*, and *UBC LEED v4 Implementation Guide* for expected water performance of new construction and existing building upgrades	●		
Update Project Design Brief for new capital project to include performance requirements to install high efficiency fixtures, adjust PRVs, for landscaping use LID and high efficiency irrigation, make purple pipe ready	●		
WCM 1—Operating Pressure Reduction (Adjust PRV's)			
Lower academic buildings pressures to 40 psi and Residence buildings to 60 psi (could be completed in a single year; or less)	●		
WCM 2—High Efficiency Fixtures			
Begin water efficient fixture replacement program of buildings as building upgrades are due (i.e., Monashee, Similkameen)	●		
Complete water efficient fixture replacement program for existing buildings		●	
WCM 3—Switch to Drip Irrigation and use non-potable water			
Continue to phase in planned drip irrigation program (FM 5yr. plan); include recommendation for Xeriscaping in landscape vision document.	●		
Complete drip irrigation program		●	
WCM 4—Implement Campus Scale MBR treatment system for reuse			
Pilot purple pipe installation in a new construction and a retrofit project on campus to determine the incremental cost and viability of preparing the campus for an on-site water treatment facility	●		
Phase in purple pipe distribution as DES and CHP expansion occurs on campus in order to minimize site disturbance, maximize construction cost efficiency of infrastructure.	●	●	
Monitor the key performance indicators for broader adoption of purple pipe ready buildings and campus wide infrastructure.		●	
As business case becomes more viable, phase in an on-site water reuse system.			●
Complete a detailed feasibility study for campus reuse system integration (WCM 4)	●		

Ecological Landscape + Biodiversity Measures	<5 years	5–10 years	10–20 years
BM 1—Protect Existing Ecological Features During Campus Development.			
Continue to densify and focus development in the campus core.	●	●	●
Avoid incremental loss of natural areas including woodlands and indigenous grasslands during campus expansion.	●	●	●
Update the *2011 Stormwater Management Plan* to address rainfall capture and wetland creation, and consideration of and changes in the 2015 Campus Plan.	●		
Consider underground parking under new buildings to limit surface area parking.		●	●
Develop habitat restoration plans for the escarpment slope, eastern meadow slope, and pine woodland.		●	
Update UBCO *Design Guidelines* to include requirements to protect and enhance bird habitat during campus development.	●		
BM 2—Create a Campus Core that Integrates Buildings and Landscapes that Capitalize on Natural Systems			
Update UBCO *Design Guidelines* and *Project Design Briefs* to include requirements for integrating naturalized systems into new construction and landscape projects, along with performance requirements to use LID methods, and consider on a project per project basis green-roof feasibility.	●	●	●
Where possible, increase tree cover by 10% in the campus core while balancing requirements of the 2006 *Wild Fire Management Plan*.	●	●	●
Continue to implement the recommendations of the 2006 *Wild Fire Management Plan*.	●		
Increase tree planting in and adjacent to parking area to provide summer shading.	●	●	
Develop staff training to support best practices including irrigation and soil management.	●	●	
Test best practices for expanding naturalized areas in order to determine costs of transitioning to this landscape typology.	●		
Plant trees in areas such as the escarpment slope which do not increase fire risk near buildings and infrastructure.		●	
Review opportunities to grow plant material campus (i.e., on-site plant nursery) for use in landscaping and restoration activities.		●	
BM 3—Collect and Filter Stormwater to Enhance Wetlands			
Update the *2011 Stormwater Management Plan* to address rainfall capture, infiltration, and wetland creation.	●		
Expand the number of and range of wetlands types associated with parking areas or other larger impermeable areas for biodiversity enhancement (open water, marshes, willow thicket, seasonally flooded areas) and stormwater management.	●	●	
Monitor stormwater quality within the campus drainage system.		●	
BM 4—Integrate Indigenous Plants into the Campus Landscape.			
Update UBCO *Design Guidelines* and project *Design Briefs* to incorporate requirements for native planting for new construction projects.	●		
Test native and adaptive planting and maintenance strategies in order to increase the use of these species.	●		

Ecological Landscape + Biodiversity Measures	<5 years	5–10 years	10–20 years
Work with UBCO faculty to design landscape areas and develop planting strategies to benefit specific species or species groups such as native pollinators, butterflies, and birds which are compatible with developed areas.	●		
Showcase the use of the Okanagan landscape as part of the campus identity.	●		
BM 5—Enhance the Use of the Campus as a Learning Landscape.			
Develop an education, awareness and outreach program that communicates the measures and benefits of the biodiversity plan.	●		
Expand opportunities and resources to use natural areas as part of the campus' research and learning program, and seek opportunities to align with UBCO's academic program.	●	●	●
Identify student research projects that support the implementation and monitoring of the biodiversity measures in order to establish baseline metrics and goals for improvement.	●	●	●
Test opportunities for an internal (faculty/staff) or external (broader community) garden or collaborative agriculture.	●	●	●
Provide funding for student research on priority topics such as campus bird populations, species at risk enhancement, and monitoring pollinator and butterfly use of native plant communities.	●		
Develop community volunteer programs to help support the long-term stewardship of the biodiversity-based programs (i.e., trail building & maintenance, community gardens, species monitoring etc.).	●	●	●
As part of developing a Public Benefits and Stewardship Plan for UBCO, integrate biodiversity measures that place a priority on protection, restoration, and long-term management of the native landscape	●		

a place of mind
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