UNIVERSITY OF BRITISH COLUMBIA

UBC LEED Implementation Guide

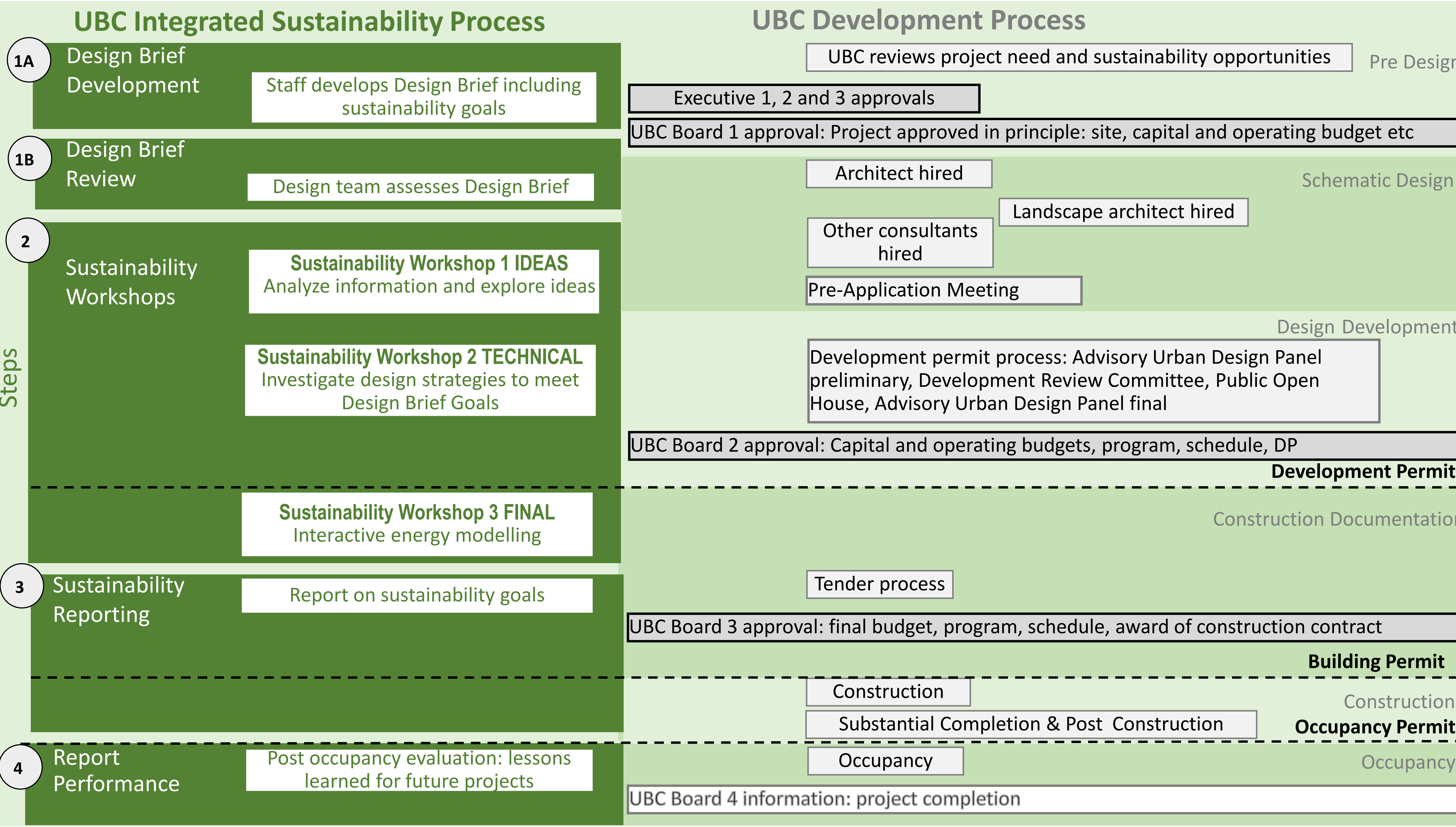
For Building Design and Construction v4.1

FEBRUARY 2022

Appendix Index

Appendix A

UBC Integrated Sustainability Process (February 2022)



UBC Integrated Sustainability Process
UBC Development Process
Steps
1A
Design Brief Development
Staff develops Design Brief including sustainability goals
1B
Design Brief Review
Design team assesses Design Brief
2
Sustainability Workshops
Sustainability Workshop 1 IDEAS
Analyze information and explore ideas
Sustainability Workshop 2 TECHNICAL
Investigate design strategies to meet Design Brief Goals
Sustainability Workshop 3 FINAL
Interactive energy modelling
3
Sustainability Reporting
Report on sustainability goals
4
Report Performance
Post occupancy evaluation: lessons learned for future projects
Pre Design
UBC reviews project need and sustainability opportunities
Executive 1, 2 and 3 approvals
UBC Board 1 approval: Project approved in principle: site, capital and operating budget etc
Schematic Design
Architect hired
Landscape architect hired
Other consultants hired
Pre-Application Meeting
Design Development
Development permit process: Advisory Urban Design Panel preliminary, Development Review Committee, Public Open House, Advisory Urban Design Panel final
UBC Board 2 approval: Capital and operating budgets, program, schedule, DP
Development Permit
Construction Documentation
Tender process
UBC Board 3 approval: final budget, program, schedule, award of construction contract
Building Permit
Construction
Construction
Substantial Completion & Post Construction
Occupancy Permit
Occupancy
Occupancy
UBC Board 4 information: project completion

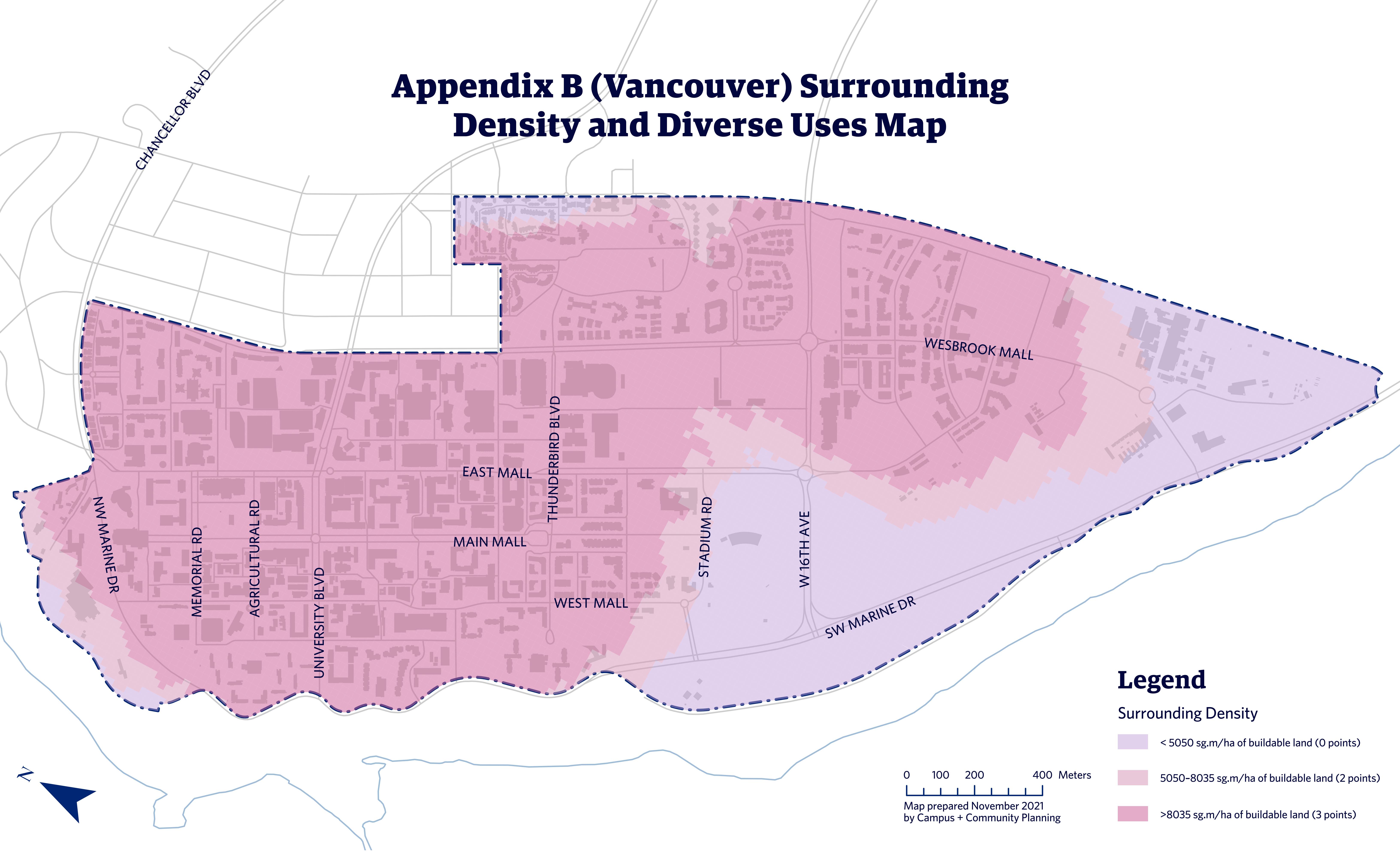
UBC INTEGRATED SUSTAINABILITY PROCESS - Major Capital Projects (updated February 2022)

Phase	Step	Responsibility	Description	Prerequisites	Deliverables	Participants
Pre-Design	**Step 1A: Design Brief Development**	C&CP	• Staff develops a guiding framework and a set of design goals and strategies, reflecting the particular project challenges and opportunities • Preliminary site analysis, orientation and massing study completed by staff	Stakeholder engagement	Design Brief (including: the project vision, urban design framework, green building requirements etc) reflecting the design aspirations of stakeholder groups	UBC stakeholders
	Board 1					
	Step 1B: Design Brief Review	Design Team	• Design Teams to assess and analyse the Design Brief and seek clarification of goals • Site visit occurs for architect and landscape architect	• Design brief prepared • Architect selected • Preliminary Owner's Project Requirements	Comprehensive understanding of the Design Brief document	UBC stakeholders and Design Team
Schematic Design	**Step 2: Sustainability Workshop 1** **IDEAS**	Organized by: Design Team	• The first workshop is a facilitated meeting which provides, using the design brief as a basis, a focus on site conditions, building massing & orientation, building materials, envelope attributes, sustainable energy and water systems, operational parameters and climate resiliency • Explore ideas for the project based on the Design Brief goals as well as UBC's GBAP goals, targets and vision	• **Schedule early enough in schematic design to inform massing decisions and encourage "out of the box" thinking** • Team's initial information analysis complete • Preliminary identification of dominant energy loads and indoor, outdoor, and process water demand • Owner's Project Requirements received	• With input from the entire design team, ideas are discussed which meet the Design Brief goals • Additional net positive design possibilities identified which align with UBC policies and GBAP vision • Passive design and synergies considered • Design options identified to be considered for LCA1 evaluation • LEED: preliminary scorecard, LEED certification level variance requested if applicable	• Key design team members • Key UBC stakeholders • Project Manager
	AUDP Pre-application					
	Step 2: Sustainability Workshop 2 **TECHNICAL**	Organized by: Design Team	• The second workshop is a facilitated meeting which investigates design strategy synergies that will meet the goals set out in the Design Brief • Preliminary energy/ carbon and water budget analysis are presented to verify targets, performance benchmarks, and potential strategies to achieve project goals • Explore synergies among systems and components.	• **Schedule with AUDP pre-application meeting during schematic design** • Completed preliminary LCA1 • Preliminary energy analysis complete • Review AUDP comments on sustainable outcomes	• Agreement on specific targets for each Design Brief goal • Conceptual building envelope design defined • Design strategies to address climate readiness identified • Preliminary energy performance analysis submitted • LCA informs structural and/or envelope system selection • Low carbon energy systems options defined for life cycle costing • Approach to bird friendly design identified • LEED: updated LEED scorecard	• Key design team members • Key UBC stakeholders • Project Manager
	Development Permit Process: Advisory Urban Design Panel (AUDP), Development Review Committee (DRC), public open house					
	Board 2					
	Development Permit (DP)					
Design Development	**Step 2: Sustainability Workshop 3** **FINAL**	Organized by: Design Team	• The final workshop is a facilitated meeting which uses **interactive energy modeling** to evaluate the trade-offs between carbon/energy performance, life cycle cost and system complexity. • Review potential energy/carbon reduction strategies to inform and refine energy system and envelope design relative to life cycle costs.	• **Schedule at the end of design development** • Energy model complete	• Consensus on carbon reduction, energy conservation and climate ready measures • Energy model report (include GHGI for emissions factors at DP) Life cycle costing for low carbon energy system options • Energy and GHGI targets finalized • LEED: updated LEED scorecard, credit variance requests, LEED Online Project Registration number	• Key design team members • Key UBC stakeholders • Project Manager
Construction Documents	**Step 3: Sustainability Reporting**	Design Team	Report on the cross cutting strategies used to achieve performance and process targets for each Design Brief goal and any additional strategies identified during the design process which align with UBC policies.	Submit before BP	• Meeting minutes and presentations from workshops 1,2 and 3 • LEED score card and credit variances • Final energy model (include appendix showing GHGI using current emissions factors) **Note: Submit prior to occupancy:** • Measurement and Verification (M&V) plan • Commissioning (Cx) Plan • LCA2 report and submittals	Design Team
	Board 3					
	Building Permit (BP)					
Construction/ Occupancy	**Step 4: Report Performance**	ID	UBC Staff to report broad outcomes from the project for inclusion in the Board 4 meeting minutes and for consideration by the Better Building Committee. Includes LEED status and energy/carbon metrics performance.	1 year of performance records available	• Feedback to inform future projects • Selected outcomes included in Board 4 report	UBC stakeholders
	Board 4					

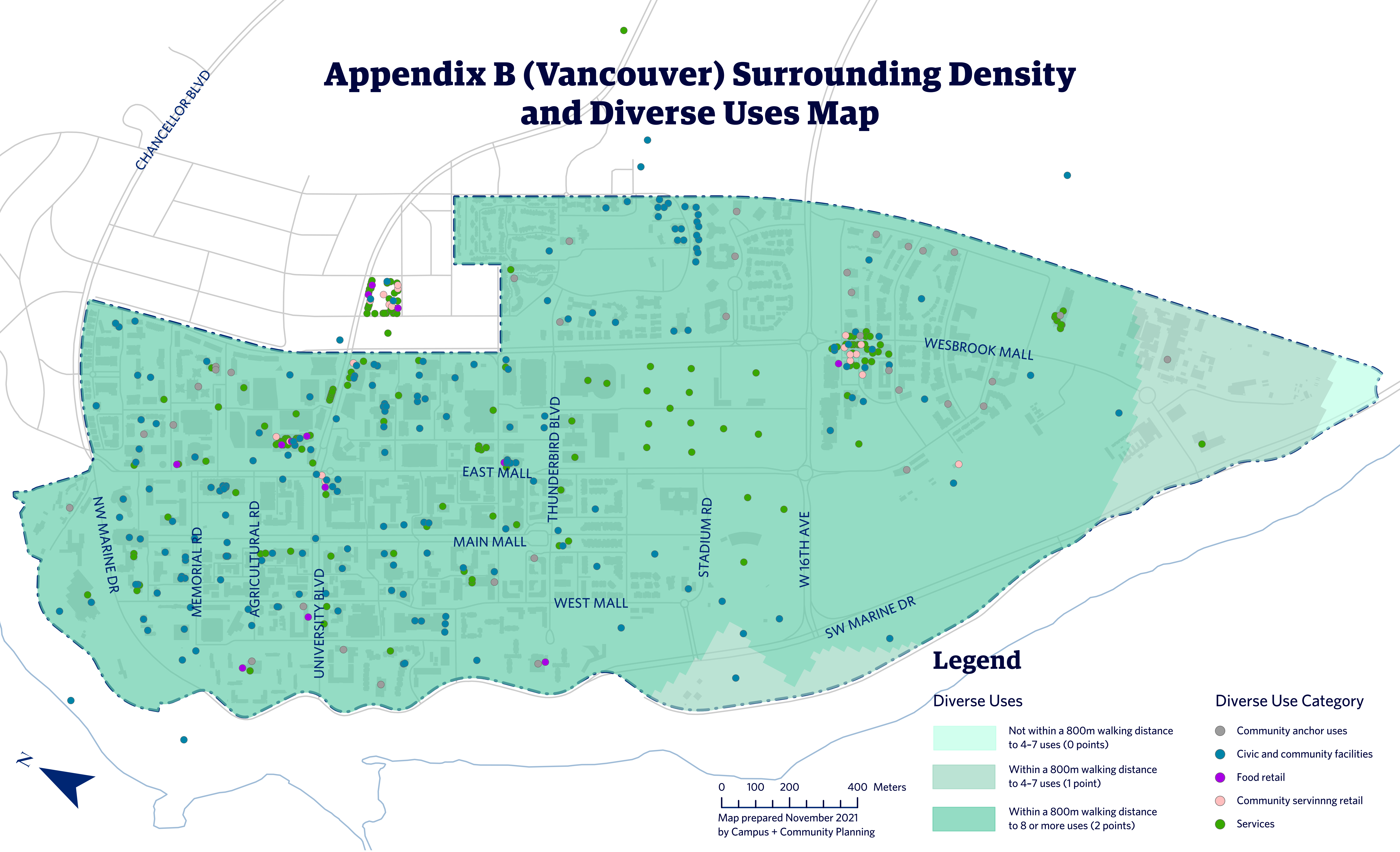
Appendix B

Surrounding Density And Diverse Uses Maps

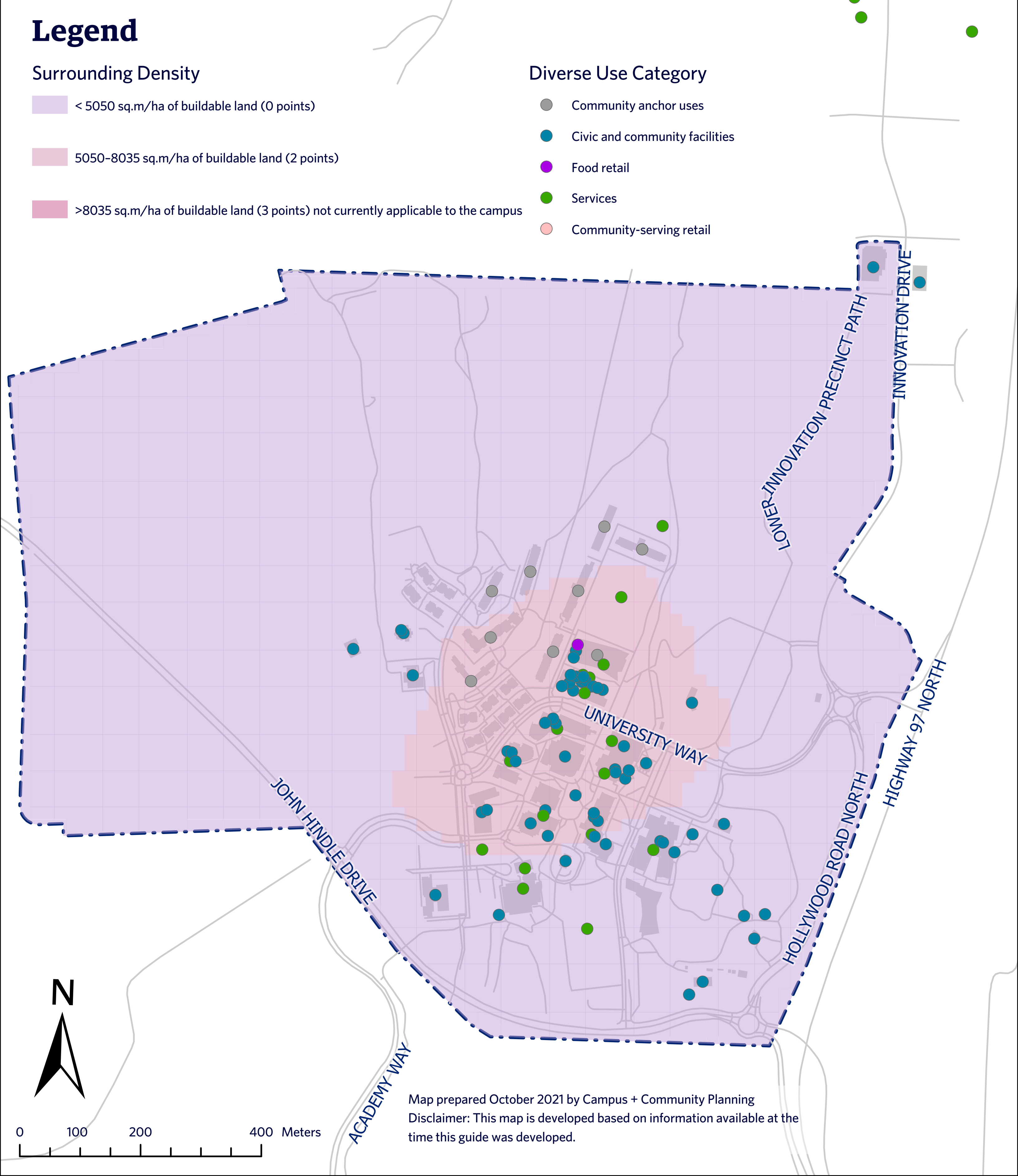
Appendix B (Vancouver) Surrounding Density and Diverse Uses Map



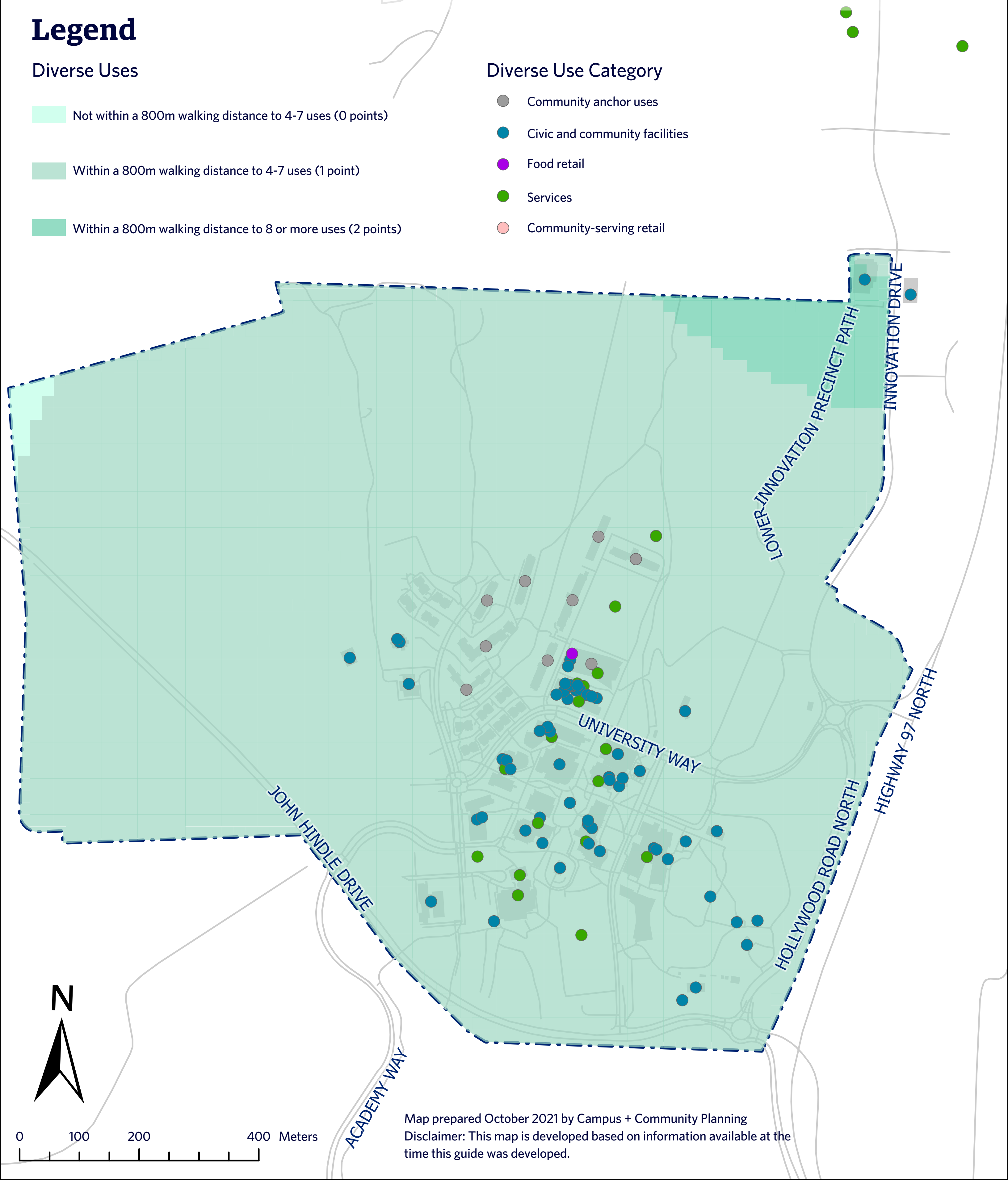
Appendix B (Vancouver) Surrounding Density and Diverse Uses Map



Appendix B (Okanagan) Surrounding Density and Diverse Uses Map

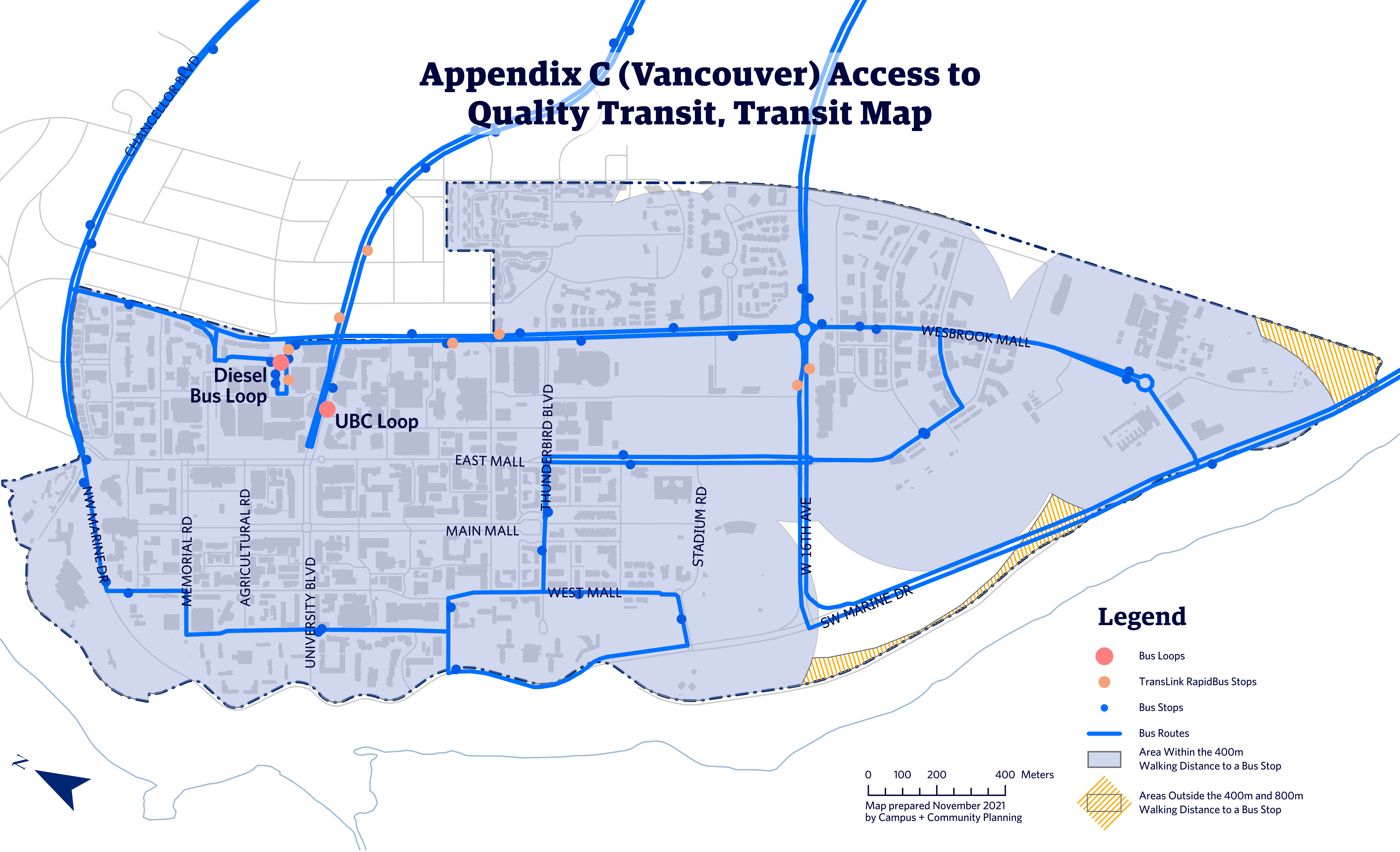


Appendix B (Okanagan) Surrounding Density and Diverse Uses Map

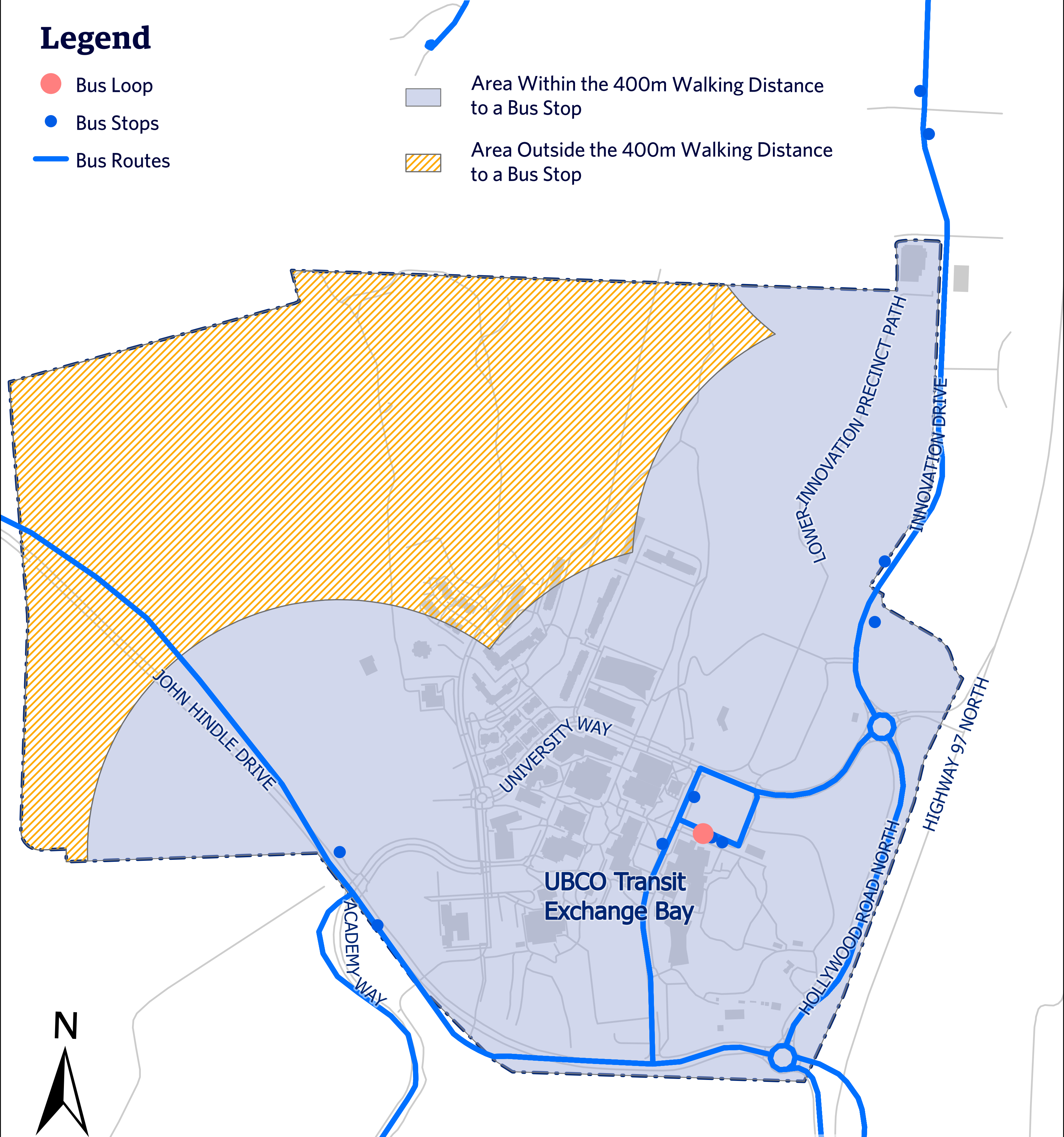


Appendix C
Transit Maps

Appendix C (Vancouver) Access to Quality Transit, Transit Map



Appendix C (Okanagan) Access to Quality Transit, Transit Map

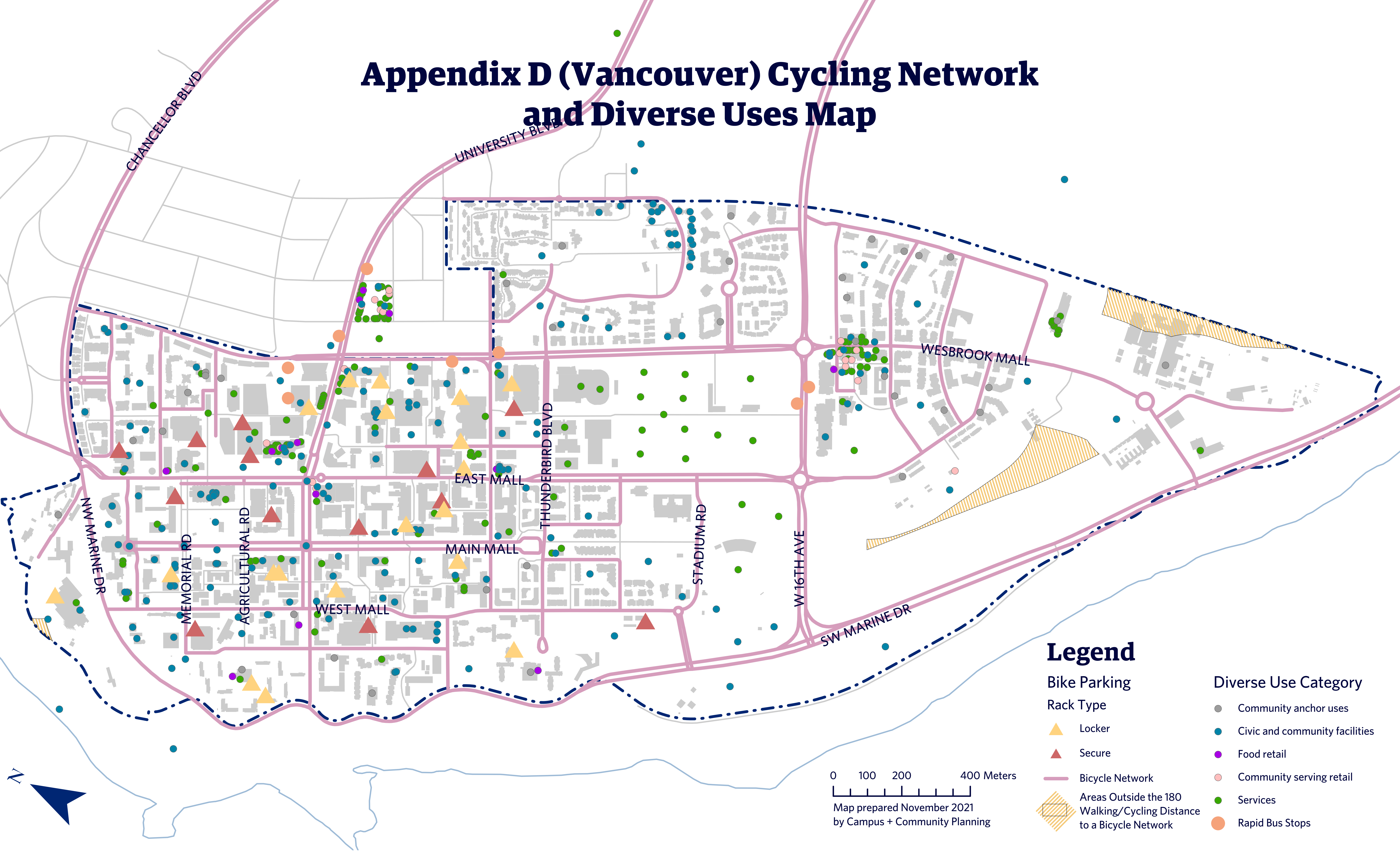


Map prepared October 2021 by Campus + Community Planning
Disclaimer: This map is developed based on information available at the time this guide was developed.

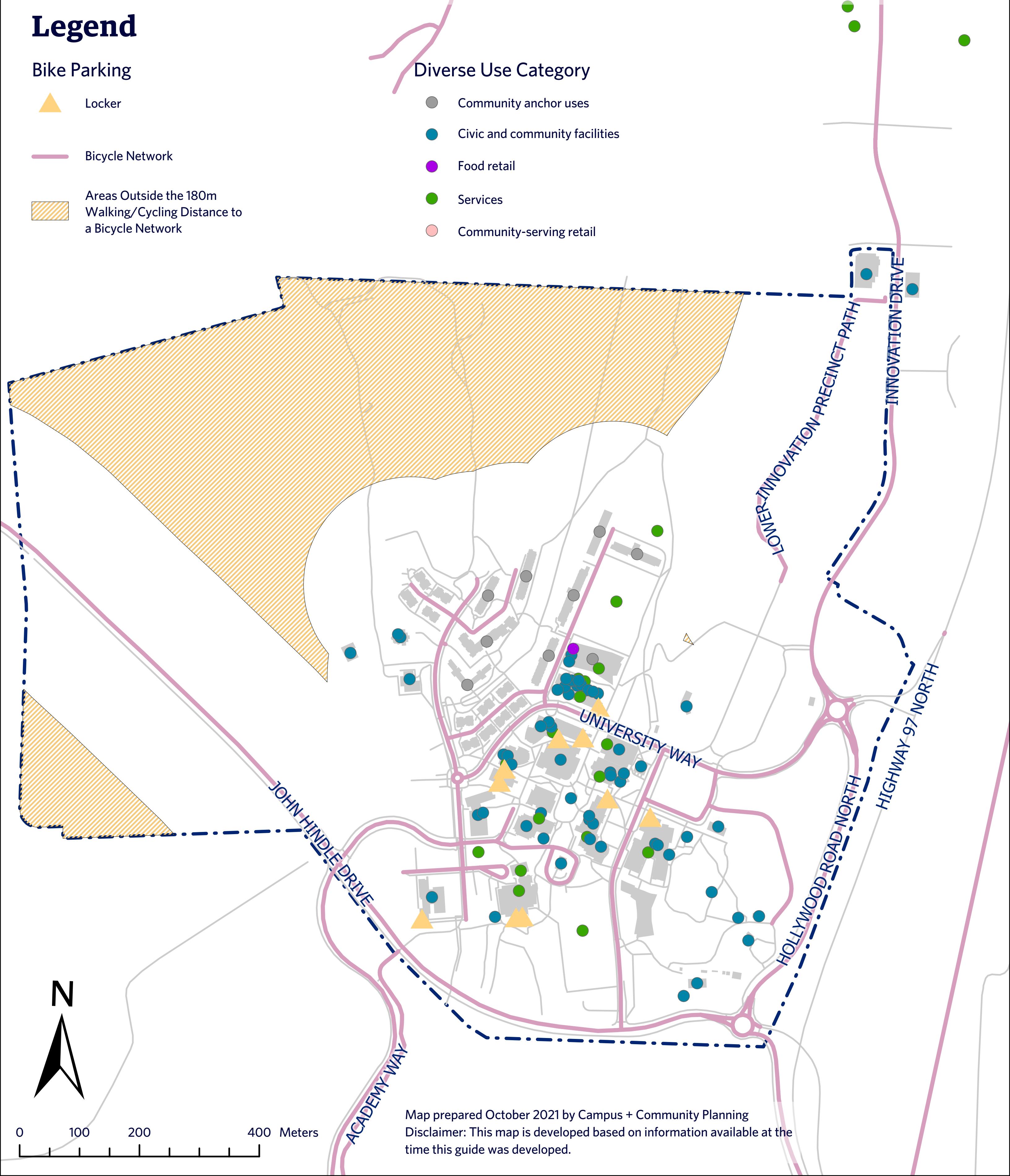
Appendix D

Cycling Networks and Diverse Uses Map

Appendix D (Vancouver) Cycling Network and Diverse Uses Map



Appendix D (Okanagan) Bicycle Facilities, Cycling Network and Diverse Uses Map

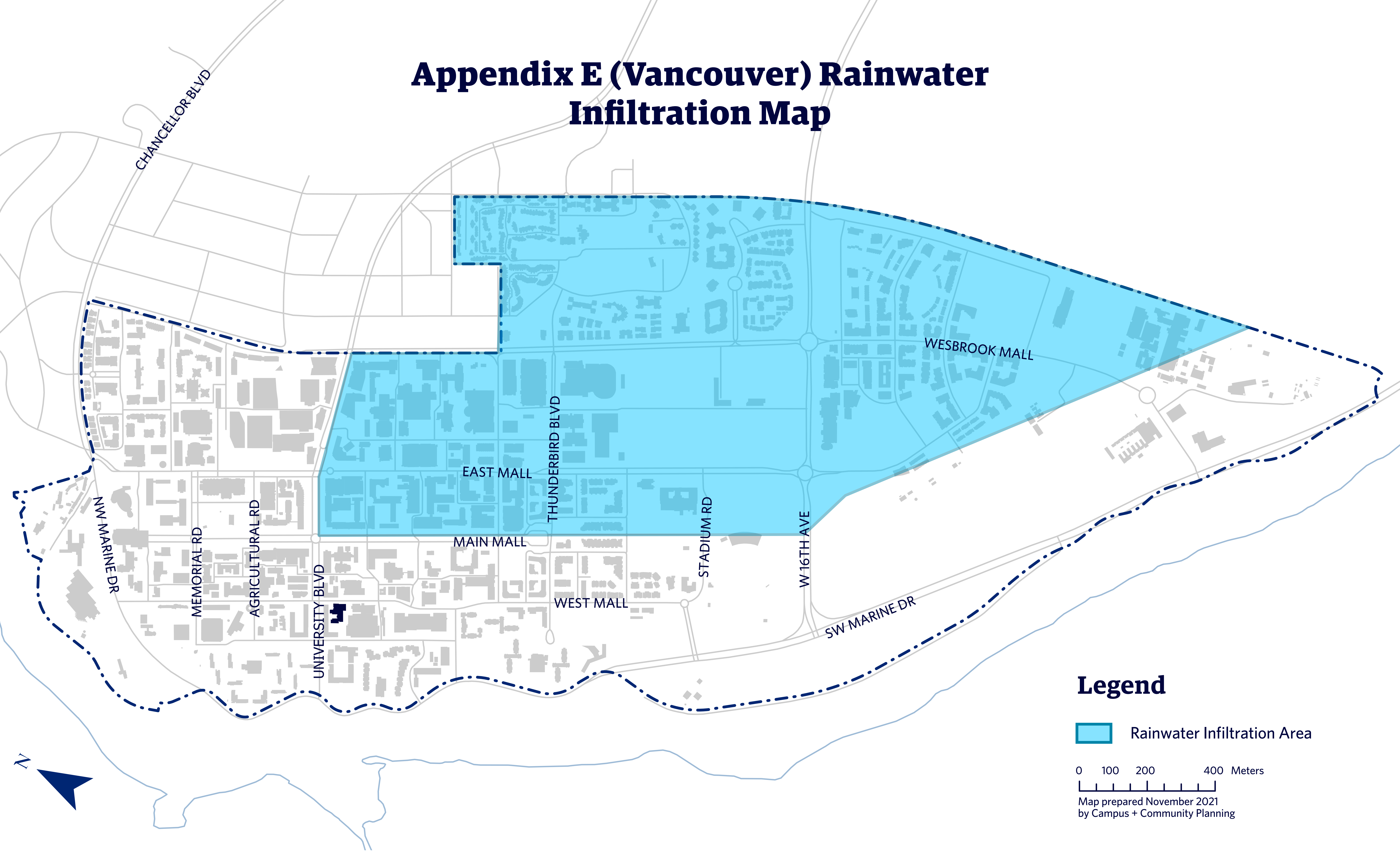


Map prepared October 2021 by Campus + Community Planning
Disclaimer: This map is developed based on information available at the time this guide was developed.

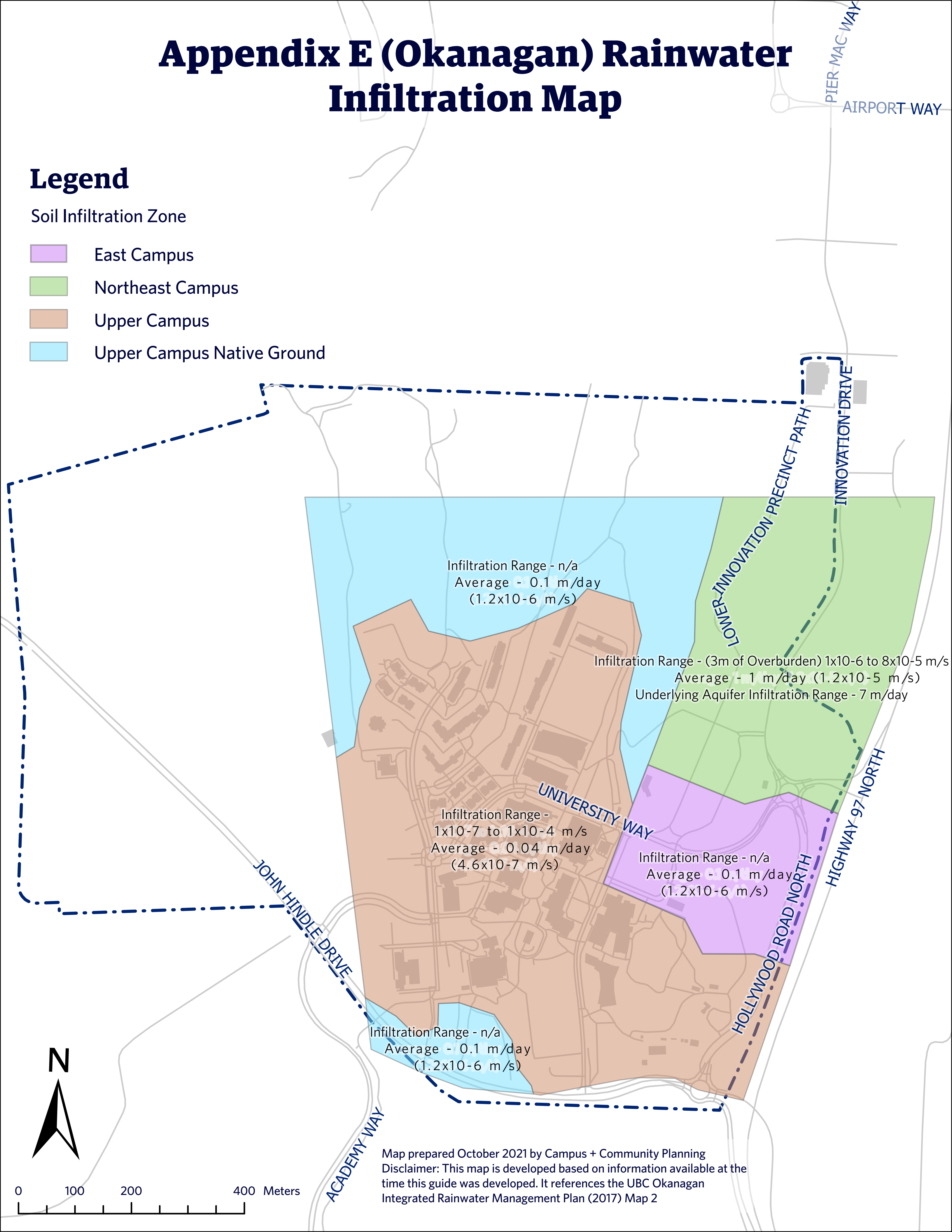
Appendix E

Rainwater Infiltration Map

Appendix E (Vancouver) Rainwater Infiltration Map



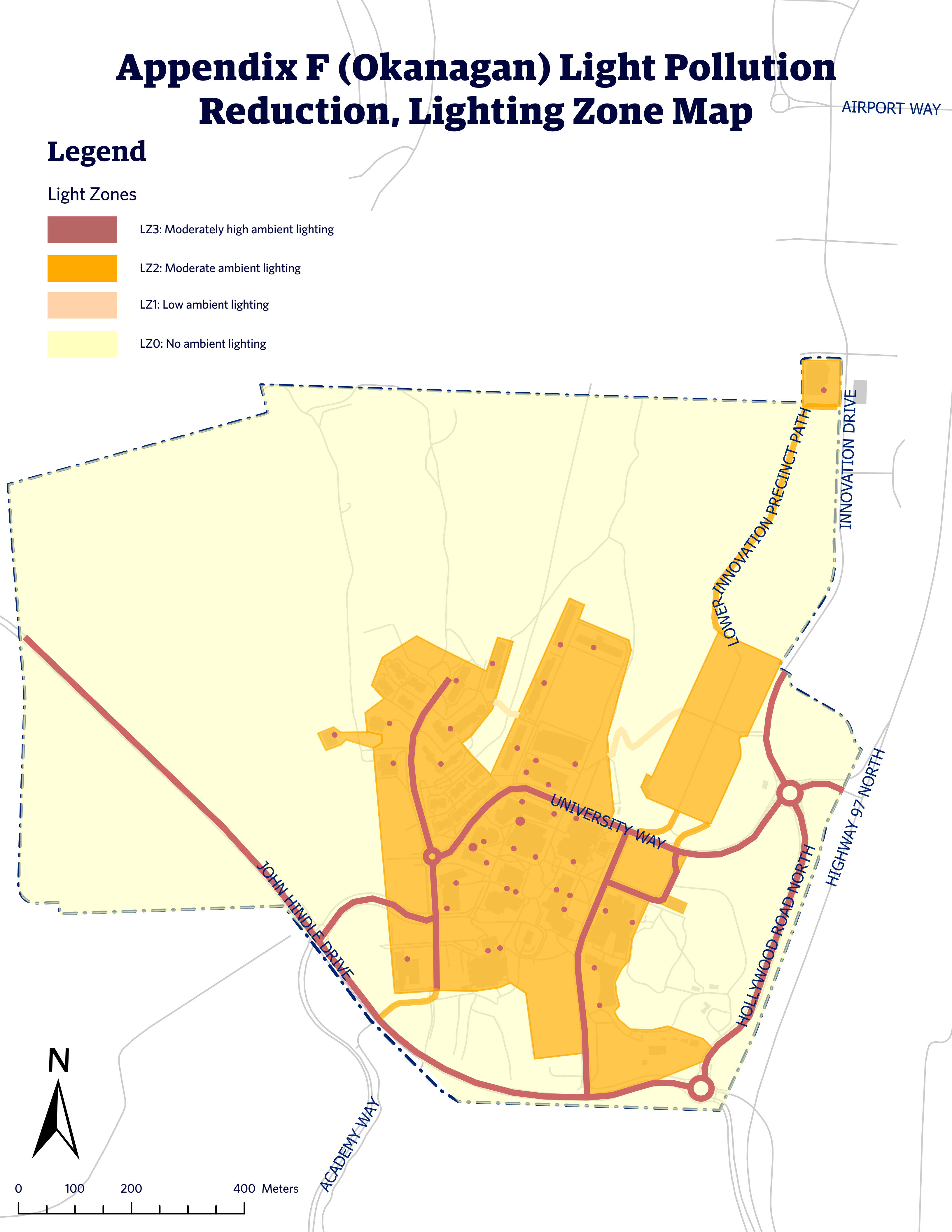
Appendix E (Okanagan) Rainwater Infiltration Map



Map prepared October 2021 by Campus + Community Planning
Disclaimer: This map is developed based on information available at the time this guide was developed. It references the UBC Okanagan Integrated Rainwater Management Plan (2017) Map 2

Appendix F
Lighting Zone Map

Appendix F (Okanagan) Light Pollution Reduction, Lighting Zone Map



Appendix G
Okanagan Campus Process Water Data

UBC OKANAGAN SUEZ SERVICE REPORT

September 10, 2021

CUSTOMER: UNIVERSITY OF BRITISH COLUMBIA
SITE: OKANAGAN CAMPUS, GEO EXCHANGE, KELOWNA, BC
ATTENTION: Neil De Beyer

Comments: The Silica in the city water is 7.8 ppm and silica in Fluid Cooler is 23.6 ppm.
The Chlorides in the city waster is 7.2 ppm and Fluid Cooler #3 is 21.8 ppm.

Asset	Parameter	LCL	UCL	Jun	Jul	Aug	Sep
GENGARD GN8143	INVENTORY (LITRES)	--	--	--	--	--	300.0
	INVENTORY (KG - CALCULATED)	--	--	--	--	--	--
SPECTRUS NX1101	INVENTORY (LITRES)	--	--	--	--	--	10.0
	INVENTORY (KG - CALCULATED)	--	--	--	--	--	--
SPECTRUS NX1106	INVENTORY (LITRES)	--	--	--	--	--	10.0
	INVENTORY (KG - CALCULATED)	--	--	--	--	--	--
CORRSHIELD OR4407	INVENTORY (LITRES)	--	--	--	--	--	180.0
	INVENTORY (KG - CALCULATED)	--	--	--	--	--	--

Asset	Parameter	LCL	UCL	Jun	Jul	Aug	Sep
DES CLOSED LOOP	CONDUCTIVITY (uS)	--	--	--	--	--	1105.0
	POTASSIUM (PPM)	140	170	--	--	--	170.0
	pH	7.8	8.2	--	--	--	8.1
	MICROBIO (CFU/mL)	--	--	--	--	--	110.0

Asset	Parameter	LCL	UCL	Jun	Jul	Aug	Sep
FLUID COOLER MAKE-UP	TOTAL HARDNESS (PPM as CaCO3)	--	--	--	--	--	128.0
	CALCIUM HARDNESS (PPM as CaCO3)	--	--	--	--	--	84.0
	MAGNESIUM HARDNESS (PPM as CaCO3)	--	--	--	--	--	44.0
	M-ALKALINITY (PPM as CaCO3)	--	--	--	--	--	112.0
	pH	--	--	--	--	--	7.7
	CONDUCTIVITY (uS)	--	--	--	--	--	290.0
FLUID COOLER 1	TOTAL HARDNESS (PPM as CaCO3)	400	450	--	--	--	--
	CALCIUM HARDNESS (PPM as CaCO3)	--	--	--	--	--	--
	MAGNESIUM HARDNESS (PPM as CaCO3)	--	--	--	--	--	--
	M-ALKALINITY (PPM as CaCO3)	250	350	--	--	--	--
	pH	8.3	9	--	--	--	--

Asset	Parameter	LCL	UCL	Jun	Jul	Aug	Sep
	CONDUCTIVITY (uS)	800	900	--	--	--	--
	MOLYBDATE (PPM as MoO4)	0.65	1	--	--	--	--
	MICROBIO (CFU/mL)	--	--	--	--	--	--
	FILTERED PHOSPHATE (PPM PO4)	--	--	--	--	--	--
	UNFILTERED PHOSPHATE (PO4)	--	--	--	--	--	--
	CALCULATED CYCLES (CONDUCTIVITY)	--	--	--	--	--	3.472
	CALCULATED CYCLES (CALCIUM)	--	--	--	--	--	--
	CALCULATED CYCLES (MAGNESIUM)	--	--	--	--	--	--
FLUID COOLER 2	TOTAL HARDNESS (PPM as CaCO3)	400	450	--	--	--	--
	CALCIUM HARDNESS (PPM as CaCO3)	--	--	--	--	--	--
	MAGNESIUM HARDNESS (PPM as CaCO3)	--	--	--	--	--	--
	M-ALKALINITY (PPM as CaCO3)	250	350	--	--	--	--
	pH	8.3	9	--	--	--	--
	CONDUCTIVITY (uS)	800	900	--	--	--	--
	MOLYBDATE (PPM as MoO4)	0.65	1	--	--	--	--
	MICROBIO (CFU/mL)	--	--	--	--	--	--
	FILTERED PHOSPHATE (PPM PO4)	--	--	--	--	--	--
	UNFILTERED PHOSPHATE (PO4)	--	--	--	--	--	--
	CALCULATED CYCLES (CONDUCTIVITY)	--	--	--	--	--	2.876
	CALCULATED CYCLES (CALCIUM)	--	--	--	--	--	--
	CALCULATED CYCLES (MAGNESIUM)	--	--	--	--	--	--
FLUID COOLER 3	TOTAL HARDNESS (PPM as CaCO3)	400	450	--	--	--	392.0
	CALCIUM HARDNESS (PPM as CaCO3)	--	--	--	--	--	248.0
	MAGNESIUM HARDNESS (PPM as CaCO3)	--	--	--	--	--	144.0
	M-ALKALINITY (PPM as CaCO3)	250	350	--	--	--	340.0
	pH	8.3	9	--	--	--	8.81
	CONDUCTIVITY (uS)	800	900	--	--	--	844.0
	MOLYBDATE (PPM as MoO4)	0.65	1	--	--	--	0.91
	MICROBIO (CFU/mL)	--	--	--	--	--	120.0
	FILTERED PHOSPHATE (PPM PO4)	--	--	--	--	--	--
	UNFILTERED PHOSPHATE (PO4)	--	--	--	--	--	--
	CALCULATED CYCLES (CONDUCTIVITY)	--	--	--	--	--	2.91
	CALCULATED CYCLES (CALCIUM)	--	--	--	--	--	--
	CALCULATED CYCLES (MAGNESIUM)	--	--	--	--	--	--

Appendix H

District Energy System Guidance and Utility Data

Appendix H – Utility Data and District Energy System Guidance, Vancouver Campus

Updated February 2022

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Background

The University of British Columbia has recently converted its heritage steam system to a modern high-efficiency hot water district energy system. This $88 million project was completed in 2016 and replaces the existing steam system with a new hot water boiler plant, 14km of distribution piping, and 131 energy transfer stations throughout the academic core.

In November 2021, the Biomass Expansion project was completed, tripling the capacity of the existing plant; base loading UBC's district energy system with clean biomass.

New buildings must connect to the district energy system as a source of external heat where practical to reduce life cycle costs and greenhouse gas emissions (GHG) (by way of the renewable thermal energy from the Bioenergy Research and Demonstration Facility (BRDF)).

There are three main district energy sources at UBC:

- The BRDF's biomass boilers – the 6 MW and a new 12 MW thermal energy boilers which run on wood waste and produce renewable thermal energy. These will serve as the primary energy source to the district energy system.
- The BRDF's cogeneration unit – a 2 MW_e combined heat and power engine is fueled by a mix of natural gas and renewable natural gas (RNG). 2.4 MW of thermal energy is recovered from the engine which is also base loaded.
- The Campus Energy Centre (CEC) - consists of three 15 MW high-efficiency hot water boilers fueled by natural gas for winter peak loads.

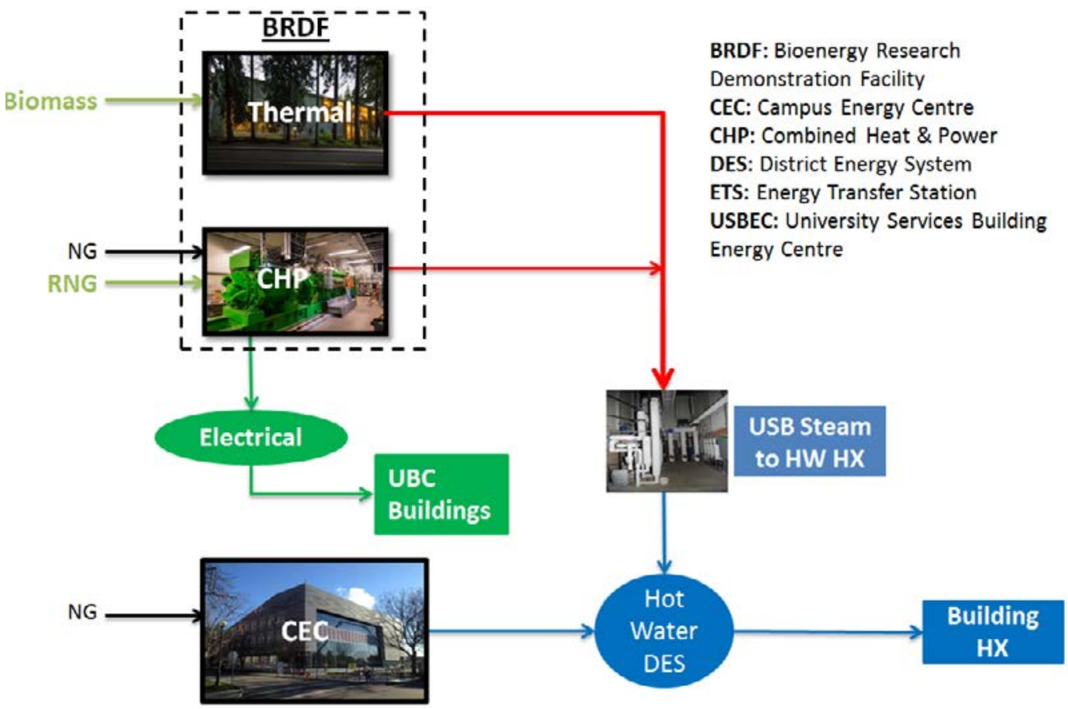


Figure 1 – UBC Thermal & Electrical Generation

UBC Utility Rates and Emissions Factors

Fiscal Year: April 1, 2022 - Mar 31, 2023

The following flat rate structures are to be used when a project is pursuing Option 1, Path 1 and Path 2 for the Optimize Energy Performance LEED Credit. These rates shall be adjusted to Virtual DES rates as required.

For Buildings Connected to the DES: Option 1, Path 1

Flat DES Rates	Description	Value	Units	Notes
UBC DES	UBC, DES Thermal Hot Water	$ 29.81	/MWh	Delivered Thermal Energy to Building including all upstream losses and effects.
BC Hydro	BC Hydro Electricity	$ 69.64	/MWh	Blended UBC rate, with carbon

Ancillaries Rates (for use with Athletics and Student Housing projects)

Flat DES Rates	Description	Value	Units	Notes
UBC DES	UBC, DES Thermal Hot Water	$ 90.00	/MWh	Cost of thermal energy charged to Ancillaries customers.
BC Hydro	BC Hydro Electricity	$ 87.81	/MWh	Blended UBC rate, with carbon
Natural Gas	Fortis BC gas rate	$ 14.06	/GJ	

For Buildings Connected to the DES: Option 1, Path 2

Flat DES Rates	Description	Value	Units	Notes
Biomass	Biomass Input into DES	$ 5.01	/GJ	Blended commodity rate, with carbon
Natural Gas	Interruptible Gas Input into DES	$ 10.31	/GJ	Blended commodity rate, with carbon
Renewable Natural Gas	RNG Input into DES	$ 12.75	/GJ	Blended commodity rate, with carbon
BC Hydro	BC Hydro Electricity	$ 69.64	/MWh	Blended UBC rate, with carbon
UBC DES	UBC, DES Thermal Hot Water	$ 29.81	/MWh	Based on calculated value in green table below.

For Buildings NOT Connected to the DES

Utility Energy Rates	Description	Value	Units	Notes
Fortis Rate 25	Non-DES Gas Rate (Non-Interruptible)	$ 12.18	/GJ	Blended commodity rate, with carbon
BC Hydro	BC Hydro Electricity	$ 69.64	/MWh	Blended UBC rate, with carbon

Utility Emission Factors

All new buildings are required to meet UBC's GHGI targets. Building emissions calculations are to use the emission factors of the electricity grid and the DES in the table below. Because the DES uses biomass as a base load and natural gas for peaking, the emission factor for the DES varies throughout the year as the campus heating demand fluctuates. Energy modelers should apply the emission factors below to the results of the energy model to calculate total emissions for the project.

	Emission Factor (kgCO2e/MWh)
Electricity	
	10.67*
District Energy Average Rates**	
Jan	87
Feb	67
Mar	68
Apr	35
May	12.9
Jun	11.8
Jul	9.7
Aug	8.7
Sep	47
Oct	63
Nov	73
Dec	93

* Note: BC Hydro grid emission factors fluctuate annually with the amount of energy imported from high carbon intensity grids. This value (10.67) represents the grid emission factor without considering energy imports, and is consistent with Step Code and City of Vancouver modeling practices. Updated emission factors from BC Hydro can be found here: https://www2.gov.bc.ca/gov/content/environment/climate-change/industry/reporting/quantify/electricity

** Note: DES emission factors vary year-to-year based on weather and actual operation of the DES. Values in this table are to be used for all compliance modeling, as these were the values used in establishing the GHGI targets. If needed, current actual emission factors can be obtained from UBC Energy & Water Services.

UBC DES Monitored Values

BRDF Thermal Boiler

Biomass Input	159,426	GJ
BRDF Thermal Gas Input	650	GJ
Biomass Thermal Output	32,329	MWh
Thermal Efficiency	72.7%	
Biomass Cost	$5.01	/GJ
Rate 25 NG Cost	$12.18	/GJ

BRDF Expansion Boiler

Biomass Input	280,638	GJ
BRDF Exp Gas Input	1,000	GJ
BRDF Exp Output	58,220	MWh
Thermal Efficiency	74.4%	
Biomass Cost	$5.01	/GJ
Rate 25 NG Cost	$12.18	/GJ

BRDF Cogen

Natural Gas Input	67,400	GJ
Renewable Natural Gas Input	107,207	GJ
Cogen Thermal Output/Waste Heat	14,774	MWh
Cogen Electrical Output	16,006	MWh
Thermal Efficiency	30%	
Electrical Efficiency	33%	
Total Cogen Efficiency	63%	
Natural Gas Allocated to Thermal	-	GJ
Renewable Natural Gas Allocated to Thermal	-	GJ
Natural Gas Allocated to Electrical	67,400	GJ
Renewable Natural Gas Allocated to Electrical	107,207	GJ
Cogen Gas Cost	$10.31	/GJ
Cogen RNG Cost	$12.75	/GJ

CEC Hot Water Boilers

CEC Gas Input	139,663	GJ
CEC Thermal Ouptut	33,752	MWh
CEC Efficiency	87%	
Rate 22 NG Cost	$10.31	/GJ

Parasitic Loads

BRDF Electricity Consumption	4248	MWh
CEC Electricity Consumption	856	MWh
Electrical Costs	$69.64	/MWh

Thermal Distribution Losses

Distribution System Heat Losses	4,172	MWh
% Distribution Losses from Thermal Outputs	3.0%	

All in Thermal DES Efficiency

Total Boiler Energy Input	581,377	GJ
Total Energy Produced	139,075	MWh
Total Energy Delivered to Buildings	134,903	MWh
DES Heating Plant Efficiency	86%	
District Energy Thermal Efficiency	84%	

GHG Emission Factors

Biomass GHG EF	2.24	kgCO2/GJ
NG GHG EF	49.87	kgCO2/GJ
RNG GHG EF	0.29	kgCO2/GJ
Electrical GHG EF	10.67	kgCO2/MWh

DES GHG Emissions

GHGs	GHG total	
BRDF Thermal	390	tCO2e
BRDF Expansion	678	tCO2e
CEC	6,965	tCO2e
Cogen	-	tCO2e
Parasitic	54	tCO2e
Total GHGs	8,087	tCO2e
GHG per GWh delivered	**60.0**	**tCO2e/GWh delivered**

DES Proposed Model Inputs		
District Energy Thermal Efficiency	84%	
Parasitic Electrical & Pumping Energy per Thermal Delivered	37.83	kWh electrical per MWh thermal delivered.
Weighted Average Cost per Thermal Energy Delivered	29.81	$/MWh
Weighted Average GHG	60.0	tCO2/GWh delivered

CHP equation inputs from the BRDF Cogen		
X_{heat} =	11%	
Total District Heat Provided =	134,903	MWh (used for calculating $BLDG_{HEAT}$)
CHP_ELEC_{TOTAL}	16,006	MWh
$CHP_{FUEL\ Natural\ Gas}$	67,400	GJ of NG
$CHP_{FUEL\ Renewable\ Natural\ Gas}$	107,207	GJ of RNG

UBC Renewable Energy/BRDF Submission Documentation

The Bioenergy Research Demonstration Facility (BRDF) houses two production units that provide thermal energy to UBC's district energy system:

- The BRDF's biomass boiler – a base loaded 18 MW thermal energy boiler which runs on wood waste and produces renewable thermal energy.
- The BRDF's cogeneration unit – a 2 MW_e combined heat and power engine is fueled by a mix of natural gas and renewable natural gas (RNG). 2.4 MW of thermal energy is recovered from the engine for the district energy system.

The values below reflect the most recent projected figures based on the actual measured values for the renewable energy generated by the BRDF's biomass boiler. These values are updated every few years by UBC's Energy and Water Department.

The BRDF produces the equivalent of 7.38% of UBC's annual electricity consumption; however, this portion is not yet eligible for renewable energy credit as it is produced for Fortis Renewable Natural Gas.

For Projects connected to DES:

Thermal		
Total Thermal Delivered to Campus:	152,687	MWh
Thermal Supplied by BRDF:	101,055	MWh
% Thermal Supplied by BRDF to DES:	66.2%	

UBC hereby confirms that:

- The renewable energy reported is allocated directly to the DES and not directly to any building in particular.
- Within the DES renewable energy allocation, no renewable energy was assigned specifically to the DES central plant building, if any (in a separate LEED application), is also being counted toward the renewable energy contribution of the connected project building.
- That no renewable energy is being double-counted among any connected project buildings in separate LEED applications.
- That UBC, the DES owner and operator, maintains rights to the environmental benefits of the site-generated renewable energy.

UBC LEED v4.0 DES Modelling Approach

Optimize Energy Performance

Option 1 - Path 1 Building Stand-Alone

Option 1, Path 1 is not a recommended compliance path for UBC projects as it does not allow for DES GHG credits for Optimize Energy Performance. UBC recommends that the Energy Modeler use either the EApc95 Alternative Compliance Path; averaging the best two of three metrics, or Option 1, Path 2 for DES connected new construction projects.

If Path 1 must be used, this energy model accounts only for downstream equipment (including building DES heat exchangers), upstream DES equipment is not accounted. Proposed and Baseline are modelled using purchased energy according to the reference guide.

1. Energy Rates

   For the purposes of this Path, a flat rate structure has been calculated by UBC on a campus scale for both electricity and thermal energy. UBC's blended rate for BC Hydro electricity should be used as UBC is charged energy and demand on a campus level, not a building by building level. Please refer to the flat virtual energy rates given in*UBC Utility Rates and Emissions Factors* (page 3).

Option 1 - Path 2 Full DES Performance Accounting

Option 1, Path 2 Full DES Accounting is the recommended compliance path for UBC projects as it allows for projects to take credit for the DES' low carbon intensity. This energy model scope accounts for both downstream equipment and upstream equipment.

Full DES Accounting following LEED v4.0 Option 1, Path 2 with the EApc95 Alternative Compliance Path; averaging the best two of three metrics of energy cost, GHGs, and energy source is another preferred methodology. This allows projects to take credit for the DES' low carbon intensity while still balancing cost of source energy. This energy model scope accounts for both downstream equipment and upstream equipment.

UBC's overall DES efficiency is better than the standalone ASHRAE 90.1-2010 baseline boiler plant in terms of energy efficiency and is much better in terms greenhouse gas emissions due to the biomass component of the BRDF. Option 1 - Path 2 also allows for a significant renewable energy credit to be taken for Renewable Energy Production that cannot be taken credit for under Option 1 - Path 1.

1. Energy Rates

   UBC's DES plant operates under a specific and atypical rate structure[1] that actively takes advantage of an interruptible rate strategy (Rate 22) for load management as required by Fortis BC. For this reason the rate structure used for this path shall be the rate structure as applied to UBC's DES. Refer to *UBC Utility Rates and Emissions Factors* (page 3)

[1] Pg 364, LEED v4.0 Reference Guide for Green Building Design and Construction

2. Proposed Building, DES-equivalent plant

a. District Energy Thermal Efficiency/Heating Plant Efficiency

A virtual plant with the same efficiencies as the upstream district energy heating system shall be modelled. The entire upstream district energy system consists of a piping distribution network fed from two plants: the BRDF Biomass Boiler and the Campus Energy Centre's gas boilers. CHP is modelled separately as explained in *BRDF CHP Fuel Consumption* below. Each unit's main and auxiliary energy inputs and outputs are measured and monitored by UBC. The natural gas and electrical consumption of each plant (CEC and BRDF), the biomass consumption of the BRDF Biomass Boiler, and the thermal output of each plant is monitored. The monitored data has been combined with analytical methods that extrapolate the measured data based on heating degree days to determine total annual natural gas consumption, electrical consumption, biomass consumption and thermal output taking into consideration the output expected from the biomass expansion. The values determined from this analysis are summarized in *UBC DES Monitored Values*. *UBC DES Monitored Values* provides UBC's overall annual average District Energy Thermal Efficiency that should be used in the proposed building model plant, as well as the equivalent tCO_2/GWh delivered for thermal energy should the project team pursue this credit based on GHG's instead of cost or energy efficiency. The District Energy Thermal Efficiency includes all operational effects such as standby, equipment cycling, partial load operation, internal pumping, and thermal losses.

b. Pumping Energy and other electrical parasitic loads

All electrical loads, including distribution pumping energy, for the CEC and BRDF are measured and monitored by UBC. These values are updated every few years in Appendix H. The total annual electricity consumption for the BRDF and CEC are added and divided by the annual DES thermal output to come up with a kWh per MWh thermal delivered.

This kWh/MWh number represents the parasitic electrical and pumping energy and is to be multiplied by the Proposed Building's thermal load to the DES. **The resulting total kWh's shall be added as an annual auxiliary electrical load in the Proposed Building, see *UBC DES Monitored Values*.**

c. Thermal Distribution Losses

Thermal Distribution Losses are already accounted for in the District Energy Thermal Efficiency given in *UBC DES Monitored Values*. No adjustments need to be done by the energy modeler.

At present, a number of thermal meters at the building level are not correctly reporting and collecting through UBC's ION Meter Database, this means it is not a reliable measurement of thermal distribution losses from UBC's DES.

A detailed engineering analysis was completed of the district energy distribution system to calculate thermal losses. The heat loss formula below was used to calculate total distribution losses throughout the entire UBC district energy piping network:

$$W = \frac{2\pi\ (Tm - Ta)}{3.42\ x\ 12\ (\frac{Ln\left(\frac{Di}{Dp}\right)}{Ki} + \frac{Ln\left(\frac{Dj}{Di}\right)}{Kj})} x\ Sf$$

Where W is Watts of heat loss per foot of pipe. A detailed description of the formula and variable definitions can be found on Urecon's website[2].

A calculated distribution heat loss of 14,700 GJ/year was determined through this methodology for UBC's hot water distribution network. This is compared to the total annual thermal energy delivered to the UBC campus to get a percentage distribution loss relative to load. This percentage is found in *UBC DES Monitored Values* and is updated annually. Because the distribution heat losses are static, the percentage will change annually depending on total thermal energy distributed by the DES annually. **This percentage is already incorporated in the District Energy Thermal Efficiency provided in *UBC DES Monitored Values*.**

d. BRDF CHP Fuel Consumption

LEED v4.0 gives special guidance for cogeneration plants, so processes related to UBC's CHP system have not been included in the DES Proposed Model Inputs given in *UBC DES Monitored Values*. Instead, the fuel attributed to the LEED building by the CHP plant shall be calculated as per pg. 366 – 368 of the LEED v4.0 reference guide using the inputs to the equations as provided in *UBC DES Monitored Values*. Because there are two fuel inputs associated with the BRDF cogen, there will be two CHP_{FUEL} calculated by the energy modeler: one for natural gas, and one for renewable natural gas. The $CHP_{FUEL\ Natural\ Gas}$ and $CHP_{FUEL\ Renewable\ Natural\ Gas}$ shall then be multiplied by the utility rates as given in *UBC Utility Rates and Emissions Factors*. The same shall be done for any process added to the baseline building.

[2] http://www.urecon.com/tracing/heat_loss.html

UBC LEED v4.1 DES Modelling Approach

Optimize Energy Performance

Option 1

Energy Performance Compliance is the preferred pathway, as it aligns with UBC Green Building Action Plan and the Climate Ready Requirements for UBC Buildings. Pursuing Option 1 is required to count savings in the Renewable Energy and the Grid Harmonization credit. Project teams may choose to follow EA Pilot ACP 143 which allows either ASHRAE 90.1 or NECB to be used as the reference energy code. Note that projects applying the pilot are evaluated based on energy consumption and greenhouse gas emissions. Projects that use NECB as the reference code must still comply with certain mandatory requirements. Refer to EA ACP Pilot 143. District energy system (DES) modeling methodology, and guidance on how to account for DES carbon profiles and upstream equipment and distribution efficiencies, has not yet been published as part of the LEED v4.1 credit language. Until this direction becomes available project teams should consider using the LEED v4.0 methodology for DES modeling per Option 1, Path 2: Full accounting of DES upstream and downstream equipment. Project teams should confirm the approach used for DES modeling with GBCI Canada (via leedcoach@gbcicanada.ca) at the early stages of schematic design.

Renewable Energy

LEED v4.1 does not define biomass as a renewable energy source unless harvested within the campus boundary. As such, the renewable energy contribution from the Academic District Energy System will not contribute. It is recommended that project teams investigate updates or pilot paths associated with biomass treatment for this credit as it applies to renewable energy system.

Appendix H UBCO District Energy System

There are presently two district energy systems at UBCO. The Low Temperature District Energy System (LDES) provides ambient temperature water via a 2-pipe system over PVC pipeline. The LDES is connected to legacy buildings for heating only and provides heating and cooling to 13 newer academic buildings on campus. The Medium Temperature District Energy System (MDES) distributes 80°C (176°F) water via an insulated carbon steel pipe system to 5 Legacy buildings. None of the current residential-only buildings are presently connected to either LDES or MDES. Compared to stand alone buildings, connection to the LDES has emerged as the preferred approach on the main campus and innovation precinct to provide heating and cooling for the campus.

The long-term strategy on the UBCO campus is that all heating and cooling loads are to be met using district hot and chilled water. If district heating and cooling is not provided at the time of initial construction, the design should be compatible with the parameters of UBCO's DES to enable future connection.

Energy utility inputs, costs and GHG factors for district provided heating and cooling will be provided by UBCO to the design team early in the project as part of the project's Design Brief and OPR. Note that utility costs include both energy values and significant peak demand charges. Note that there are ongoing changes to the campus DE system and it is up to the design team to determine how to model the DES connection for LEED applications. UBCO Operations (Energy Team) can provide available historical data as needed.

UBCO energy targets are calculated based on thermal energy delivered to the building. Due to district-level heat recovery capability, energy consumption is measured based on net heating/cooling consumption using an hourly resolution. During heating dominant periods cooling is considered to be free and the heating load is considered as the net of heating less cooling. The reverse is true during cooling dominated periods.

Appendix I

UBC's Whole Building Life Cycle Assessment Guidelines

Institutional building

1 Identify building type

BASELINE
Building built to conventional materials and systems

ALTERNATIVE 1
Building built with improved envelope materials

ALTERNATIVE 2
Building structure including advanced construction systems

2 Identify potential carbon contributors

To reduce the carbon footprint by upgrading/replacing materials/systems

3 Define system boundaries

Cradle to grave (Cradle to grave + Module D*)

4 Define functional unit

FU is an institutional building operating for 60 years

5 Define LCA Scope

INCLUDE
- sub-structure (foundations)
- Superstructure
- enclosed parking
- Envelope
- Windows
- exterior doors
- interior walls and doors gypsum wall board

EXCLUDE
- Landscape
- excavation, temporary elements
- Finishes
- electrical and mechanical services/equipment
- stairs and handrails door/window hardware millwork
- furnishings

6 Inventory generation

- Prefer Canada databases and EPD's. Provide assumptions: material replacement cycles and data sources on a data quality matrix
- Data sets must be compliant with ISO 14040, ISO 14044, ISO 21930 and EN 15804.
- Data Input: Bill of materials input method or BIM-integrated input method

7 Calculate and compare the carbon footprint

- Carbon footprint is to be calculated on **ATHENA, TALLY or ONE CLICK LCA** and latest **TRACI** version
- Determine maximum project embodied carbon target achieved

8 Communicate the Results for alternative 1 and alternative 2

Report with **HOTSPOT ANALYSIS** related to building materials, life cycle stages and structural components

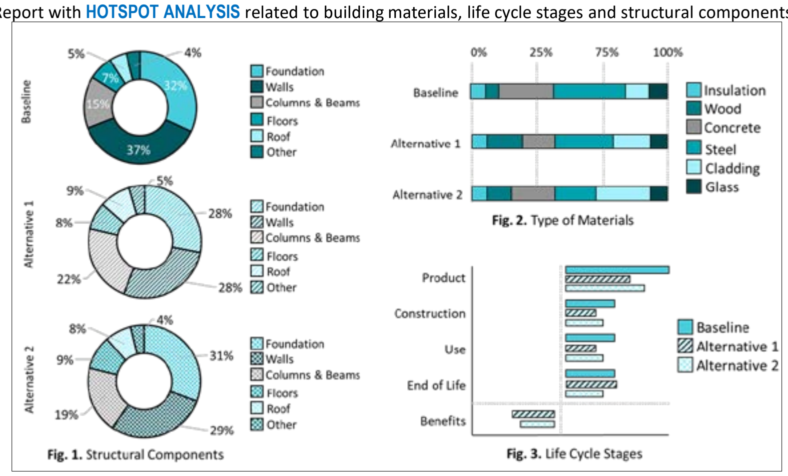


Fig. 1. Structural Components

Fig. 2. Type of Materials

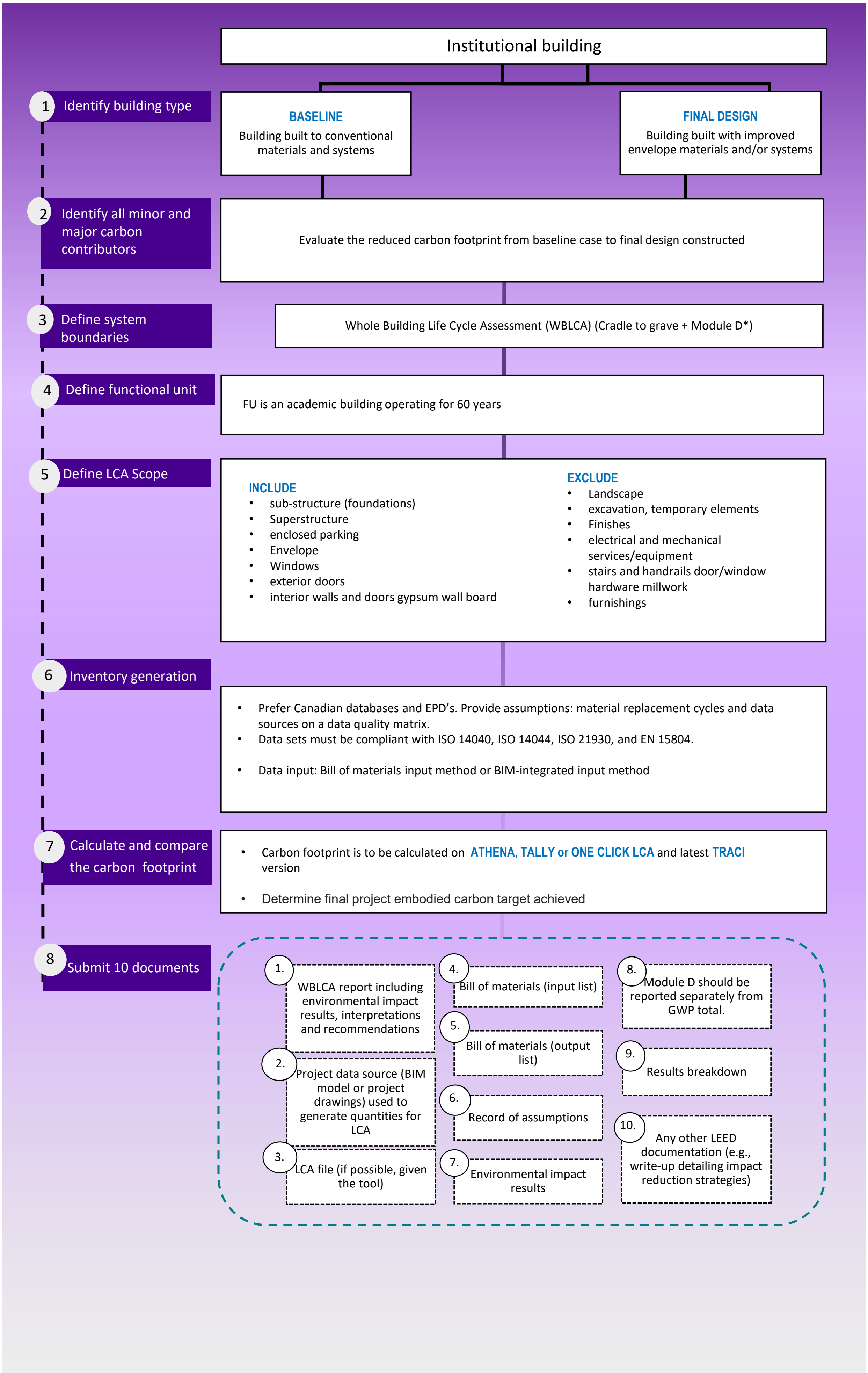
Fig. 3. Life Cycle Stages

*Sample results

9 Recommendations

From the tested alternatives recommend the most feasible option

LCA1: AT TIME OF DEVELOPMENT PERMIT



LCA2: AT TIME OF OCCUPANCY PERMIT