

**Making Spaces:
Bicycle Storage in Multi-Unit Residential Buildings
on the University of British Columbia Campus**

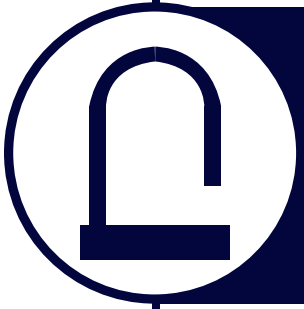
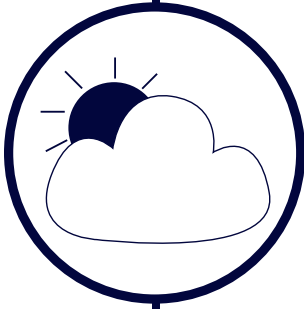
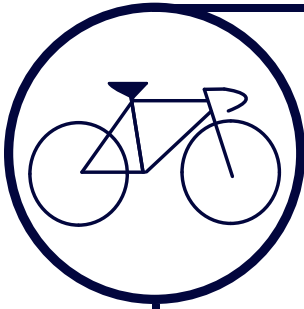
Cail Smith

University of British Columbia

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Making Spaces: Bicycle Storage in Multi-Unit Residential Buildings on the University of British Columbia Campus

Cail Smith - Master's Student
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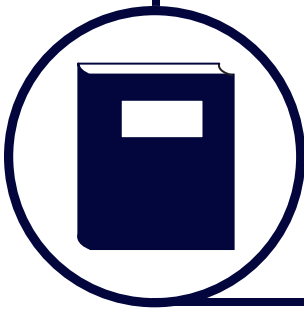
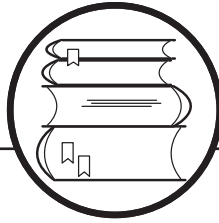


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This report was undertaken on the traditional, ancestral and unceded territory of the Musqueam people.

This project would not have been possible without the support of project partners the UBC SEEDS Program, Polygon Homes, UBC Properties Trust and E3 Eco Group.

David Gill, Helen Lui and Jeremy Field were key in maintaining the project's momentum and provided valuable resources at every turn. Dr. Alex Bigazzi supervised the academic pieces of the project and also provided critical information regularly. This project was significantly enriched by their guidance, but all errors are the author's own.

Building contacts provided valuable insight and access including Hugh Ker, property and building managers from AMW Alliance Real Estate Group and Village Gates Home as well as the residents of Dahlia House, Magnolia House, Nobel House and Sitka. UBC Sustainability staff including Penny Martyn and Kristy McConnel also contributed their information and time.

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Thanks to all.

This report is dedicated to June, Dan, Stella & Ben.

EXECUTIVE SUMMARY

This project, Bike Storage Facilities in UBC Residential Buildings, is a student-led university collaboration with the SEEDS Sustainability Program, Campus and Community Planning, UBC Properties Trust, and Polygon Homes. The E3 Eco Group also participated in this project on behalf of UBC Properties Trust and Polygon Homes.

This project is intended to:

1. *Determine bicycle storage demand in study buildings;*
2. *Suggest design and facilities management options for Class I & II bicycle storage; and,*
3. *Generate UBC PT & Polygon specific recommendations as well as recommendations for updated REAP guidelines and UBC Development Handbook for Campus + Community Planning.*

To meet this objectives, four studies were completed at six buildings:

1. *An occupancy study of Class I (secure indoor) bicycle parking;*
2. *A duration study of Class II (outdoor) bicycle parking;*
3. *A duration study of Class I storage; and,*
4. *A resident preference survey.*

Findings

Based on these studies, Class I & Class II bicycle storage is not meeting residents needs and demand for bicycle parking exceeds supply. The majority of residents store their bicycles in common Class I storage rooms, however occupancy studies and the resident survey reveal these rooms are overcrowded, encouraging other residents to store their bicycles in a variety of other locations such as in their units, on their decks and in Class II parking near the building.

Of bicycles in the common storage areas, approximately one-third were used regularly (once every two weeks or more); one-third were used occasionally (once every two months or more) and one-third not used during the study

period. This means there could be the potential to increase cycling mode share on campus by encouraging more residents to cycle regularly and to increase storage room utilization by improving the management of these rooms.

Recommendations

UBC-specific recommendations (and general best practices guidelines) were created based on the data collected, best practice reviews and contextual analysis, including:

- **Common Class I storage** should be located in visible locations and its capacity expanded through retrofits and parking minimums reflective of number of residents rather than number of units.
- **Class I bicycles lockers** should meet best practices for Class I storage and be built exclusively for bicycle storage.
- **Class II storage** should be located close to the building entrance and 25-50% of bicycle parking spaces should be covered.
- **Additional REAP credits** should be awarded to buildings which support a bicycle share site, add bicycle lockers and include bicycle storage in the design of the unit or unit's deck.
- **Retrofitting** should be done by allowing in-unit storage, adding bicycle lockers, and building bicycle cages in unused auto parking spaces.
- **UBC** should expand the existing bicycle share system or bring an **upgraded bicycle share system** to campus.
- To encourage residents to cycle, **UBC** should also **upgrade on-road campus cycling facilities** to match Dutch standards (ITCTI, 2007) or City of Vancouver AAA facilities guidelines (City of Vancouver, 2017).

Implementing these recommendations will help developers meet resident demands and likely increase cycling mode share on campus.

INTRODUCTION

PROJECT

As part of its commitment to sustainability, the University of British Columbia (UBC) created the SEEDS Sustainability Program to connect students, staff, faculty and community conducting on-campus research to consider and solve sustainability challenges at UBC.

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This project is intended to:

1. To determine bicycle storage demand in study buildings;
2. To suggest design and facilities management options for Class I & II bicycle storage; and,
3. To generate UBC PT & Polygon specific recommendations for improvements, as well as recommendations for updated REAP guidelines and an updated bicycle storage section of the UBC Development Handbook for Campus + Community Planning.

UBC

The University of British Columbia's (UBC) 400-hectare campus sits on a hill located 30 minutes from Vancouver's downtown on the traditional territory of the Musqueam people. The campus is bordered by the ocean on its north, south and east sides and by residential neighbourhoods and the Pacific Spirit Regional Park to the west.

There are three types of campus residents: students in residences, University Endowment Lands (UEL) residents and university neighbourhood residents. Residents of the five university neighbourhoods are represented by the University Neighbourhood Association (UNA).

Currently, UBC's residential neighbourhoods house approximately 12,000 people while residences house another 10,000 students (University Neighbourhood Association, 2017; UBC, 2014b). By 2041, these populations are expected to reach 16,000 student residents and 24,000 neighbourhood residents (UBC, 2014b).

UBC reports walking (88%), cycling (6%) and SOV (3%) trips are the most popular on-campus travel modes based on surveys of the campus community (Ibid). UBC transportation plans indicate on-campus travel monitoring will be

implemented using traffic counts noting speed, volume and mode as well as trip generation surveys. Findings have not yet been reported.

UBC residents are a captive population of potential cyclists. The distances between destinations on campus may be a barrier to walking travel, however cycling can reduce travel time and effort to create a more accessible campus, even for less mobile populations such as seniors and children (see Table 1). A more connected campus encourages residents to live, work and play on campus, a financially beneficial outcome.

Table 1
Key Destinations and Travel Times

Origin	Destination	Walk Time (mins)	Cycle Time (mins)
Wesbrook Village	MOA	38	12
	UBC Aquatic Centre	25	10
	Student Village	18	6
	Stadium Neighbourhood	11	3
East Campus	MOA	20	7
	UBC Aquatic Centre	6	2
	Wesbrook Village	18	6
	Stadium Neighbourhood	18	6

BUILDING PROFILES

Chaucer Hall

Completed Spring 2007

By Polygon Homes

Managed by

Southview Property Management

4 Floors, 92 units

1 to 3 Bedrooms

No Bicycle Storage Room

(Retrofitted cage in parkade)



Keats Hall

Completed Spring 2005

By Polygon Homes

Managed by

Stratawest Management

4 Floors, 92 units

1 to 3 Bedrooms

No Bicycle Storage Room



Sitka

Completed 2012

By Polygon Homes

REAP Version 2.1

AMW Alliance Real Estate Group

14 Floors, 81 units

2 Bedrooms

2 Bicycle Storage Room



Dahlia House

Completed Spring 2012

By UBC Properties Trust

REAP Version 2.1

Managed by Village Gates Home

4 Floors, 60 units

1 to 3 Bedrooms

6 Bicycle Storage Room

(Shared with Magnolia House)



Magnolia House

Completed Spring 2012

By UBC Properties Trust

REAP Version 2.1

Managed by Village Gates Home

4 Floors, 47 units

1 to 3 Bedrooms

6 Bicycle Storage Room

(Shared with Dahlia House)



Nobel House

Completed Spring 2015

By UBC Properties Trust

REAP Version 2.1

Managed by Village Gates Homes

6 Floors, 94 units

1 to 4 Bedrooms

1 Bicycle Storage Room





KEY TERMS

Moskovitz & Wheeler (2011):

Accumulation

Amount of time a bicycle is continuously parked at a facility.

Capacity

Maximum number of parked bicycles a facility is designed to accommodate at any given time.

Duration

Amount of time a bicycle is continuously parked at a facility.

Occupancy

Ratio of accumulation to capacity for a facility, expressed as ratio or percentage:

Occupancy = Accumulation/Capacity

Turnover

Ratio of volume to capacity for a facility:

Turnover = Volume/Capacity

Volume

Number of unique instances of a bicycle being parked at a facility over a period

The UBC development handbook (2016):

Class I Bike Storage:

"Parking intended for the long-term use of residents or employees, and may consist of attended facilities, inside bicycle lockers, or restricted access parking." (p. 7-4)

Class I Bike Storage:

"Parking intended for the short-term use of patrons or visitors, and may consist of bicycle racks located with natural surveillance in an accessible outside location." (p. 7-4)

GUIDING DOCUMENTS

Housing in development areas at UBC is primarily guided by two documents. The details of their bicycle storage design regulations can be found here:

The UBC Development Handbook (2016)

Residential buildings in designated development areas at UBC must follow the UBC Development Handbook guidelines. These development areas include all buildings in this project.

Residential Environment Assessment Program (REAP) (2014a)

REAP is a green building rating system designed specifically for new residential buildings at UBC. Developers must meet a minimum certification by meeting mandatory standards and adding their choice of additional credits.

MANDATORY

Bicycle Parking Space requirements

Multi-unit buildings:

- Class I: 1.5 spaces per unit
- Class II: One 16-stall rack per 35 units

Design Standards:

- Parking spaces must minimum dimensions of 0.6 x 1.8 x 1.9 m
- Aisles must have minimum width of 1.2 m
- Must be on hard surface
- Must be conveniently located and well-lit
- Must be "subject to visual surveillance of occupants in building served by racks" (p.7-4)
- Racks must be made from high quality materials and be securely anchored
- Racks must support the bicycle above its centre of gravity.
- Racks must allow frame and front-wheel to be locked.

MANDATORY

Design Standards:

- Meet UBC Development Handbook minimums
- Parking spaces must conform to minimum dimensions of 0.6 x 1.8 x 1.8 m
- Racks should have two points of contact for locking all types of bicycles.

ADDITIONAL CREDITS

Bicycle Parking Space requirements

Multi-unit buildings:

- Additional 0.25 spaces per unit (total 1.75)

Design Standards:

- In-building repair station
- 120V electrical outlet

LITERATURE REVIEW

When designing bicycle storage, architects and developers depend on local development guidelines to dictate form and function. Local governments and organizations are slowly understanding how these designs can influence transportation mode choices for residents of all types of buildings. In multi-unit buildings, the constrained space for shared storage amplifies these choices.

Local governments look to academic and municipal studies to base their bicycle storage standards. Most progressive literature reports bicycle storage should prioritize “spoiling the cyclists” by using high-quality materials and simple design (Celis & Bølling-Ladegaard, 2008). Beyond this framework, bicycle parking remains understudied in literature, especially for parking in residential areas and buildings. A review of the available English-language academic and municipal literature from North America, Europe and China related to residential storage follows and its relationship to this project’s best practice review, field studies and survey.

North American Trends & Research

Studies of bicycle parking are often based on motor vehicle parking literature which has a long history, despite its invention after the bicycle (Moskovitz & Wheeler, 2011; Ben-Joseph, 2012). Often these studies focus on user preference rather than looking at quantitative measures of use. Where academic literature discusses bicycle parking, it focuses on bicycle parking at transportation hubs (Pucher and Buehler, 2012; Pucher, de Lanversin, Suzuki & Whitelegg, 2012; Arbis, Rashidi, Dixit & Vadebona, 2016). Even literature related to bicycle storage at transit stations is often “coarse” and “without a strong empirical foundation” (Arbis et al., 2016, p. 496).

Several studies of destination and transit hub parking did offer methodologies useful for this study. The Moskovitz & Wheeler study of campus parking (2011) and University of Washington utilization studies (2006; 2008; 2010; 2012) offered base methodologies for this project. The Moskovitz & Wheeler methodology was used with minimal changes for the field study of Class II bicycle storage.

When looking for ways to study secure storage, a study of bicycle access at Melbourne’s metropolitan rail stations was a starting point (Rose, Weliwitiya, Tablet, Johnson & Subasinghe, 2016). For the study, researchers collected swipe card access data from secure bicycle storage facilities at Melbourne rail stations to “identify the trends and variability in use” of bicycle storage facilities (p.2).

Although this method could be used to study how often residents visited bicycle storage rooms, it does not allow researchers to know which bicycle has been used, which is important if residents are connected to multiple bicycles. It may also be overly invasive in residential studies when usage information can be connected to residential studies through their building access key. Aside from these studies, most research focused on user surveys.

Both Metro Vancouver (2012) and the City of Vancouver (Bell, 2015) investigated bicycle parking within the context of parking bylaws and standards. The Metro Vancouver study included a household survey which found residents frustrated “by the lack of secured and sufficient-sized bicycle parking facilities in their building” but it did not make strong recommendations (Metro Vancouver, 2012, p. 61).

The City of Vancouver’s report also included a small informal survey of residents as well as a best practice review. The report recommends four major updates to the bicycle storage section of Vancouver’s Parking Bylaw (Bell, 2015):

1. Moving the per unit storage minimum from 1.25 spaces to 2 spaces per unit;
2. Allowing in-unit bicycle storage (and anticipating this in unit design);
3. Guiding the design bylaw with a bicycle parking facility manual; and,
4. Initiating a bicycle storage retrofitting program.

The City of Vancouver is now considering how to integrate these results and other best practices into an updated bicycle parking section within the parking bylaw.

The San Francisco Municipal Transportation Agency (SFMTA) also created an extensive report of local long-term bicycle parking demand including a survey of San Francisco residents (2013). The report recommends collective bicycle lockers on the sidewalk or parking lane (like those found in the Netherlands, see Figure 1) be made available for at a cost for visitors. It does not provide specific suggestions for residents beyond a program to encourage property owners to install long-term lockers nearby and in parkades.

In Montreal, an online survey focused on the victim demographics, location and context of bicycle theft as related to parking facilities (Van Lierop, Grimsrud, & El-Geneidy, 2015). The study found theft was reduced when bicycles were locked with a U-lock using safe locking technique and higher rates of recovery when bicycles are registered and bicycle thefts are reported (Ibid.). Researchers also found increased theft during the night and in the months were most frequent in summer months. These results are likely most applicable to Class II, on-street parking which the report seems most concerned with.

International Trends & Research

Looking internationally, literature is available from the Europe and China. In London, low-cost interventions were found to be effective security measures for Class II storage. One study sought to reduce bicycle theft through stickers and signage encouraging proper locking techniques (Sidebottom, Thorpe & Johnson, 2009). Stickers attached to bicycle racks showed a reduction in bicycles locked to stand by only wheel OR frame and an increase in bicycles locked by wheel AND



Figure 1: Neighbourhood bicycle lockers in the Netherlands.

frame to the stand.

In another London study, using techniques from behavioural science, researchers found signs with human eyes and the text “CYCLE THIEVES: WE ARE WATCHING YOU” reduced theft by 62% (Nettle, Nott & Bateson, 2012). However, nearby areas saw a nearly incidental rise in theft, likely indicating thieves were displaced rather than deterred. Both of these interventions are relatively low cost, although they must be considered as a last line of defense for properly constructed parking facilities.

In Europe, the Danish Cyclists Federation’s Bicycle Parking Manual (Celis & Bølling-Ladegaard, 2008) and the CROW Manual (The Information and Technology Centre for Transport and Infrastructure [ITCTI], 2007) set the standard. The CROW manual focuses on a complete network of attractive, comfortable, safe and cohesive on- and off-road cycling facilities that encourage travel by bicycle. This begins at home, where Dutch policies require every home have 5m² of sheltered bicycle storage (ITCTI, 2007; Lusk, Wen, & Zhou, 2014).

In China, English-language academic studies of bicycle storage are limited and buried within examinations of larger trends. Like the United States, Canada and the Netherlands, interest in bicycles in China has waxed and waned bringing waves of infrastructures improvements (Lusk, 2012; Norcliffe, 2001). Currently, cycling mode share is decreasing in China, however some cities continue to retain a high cycling mode share despite a dip from the height of the bicycling trend during the more austere Chinese Communist Party governments in the mid-20th Century.

In Hangzhou, a city with a relatively high average incomes and levels of education two hours from Shanghai, many residents cycle weekly (Lusk, Wen & Zhou, 2014). In a survey, 40% of residents who own a car and 60% of residents who did not cycled weekly, facilitated by high levels of bicycle ownership and an extensive public bike share program. City residents also preferred bicycle parking sheds for storage (60% of men and 62.2% of women) whether they cycled regularly, occasionally or not at all (Ibid.). Sheds are defined as covered or enclosed at-grade

bicycling parking structures. This is consistent with other international studies of bicycle storage (Ibid).

Other bicycle storage designs trends in Asia may also influence bicycle storage in that region and abroad. Electric bicycles (e-bikes) are becoming more popular (Weinert, Ma, Yang & Cherry, 2007; Cherry & Cervero, 2007; Li, Wang, Yang, & Ding, 2017). The e-bike's popularity is tied to it's ability to extend journeys, especially in hilly terrain (Weinert, Ma, Yang & Cherry, 2007). Users typically require the ability to charge their batteries in storage areas (Cherry & Cervero, 2007). As this trend expands in North America, additional electrical outlets may be required where bicycles are stored.

Other international trends such as large automated bicycle storage units present scenarios where neighbourhood storage units may be possible. In the Netherlands and in Japan, these storage units are built so users can deliver

a bicycle to a unit above ground which will transport their bicycle to an underground storage slot for retrieval when needed (Ukrainian Centre for Cycling Excellence, 2012; Kohlstedt, 2015). This trend may be heightened by autonomous vehicles that may shift vehicle storage paradigms.

Conclusion

Although these studies have generated useful information for academics, local governments and other organizations, they provide inadequate quantitative and qualitative data to make detailed bicycle storage design decisions. At least part of the issue may be that even the basic recommendations (such as having parking at ground level) are suggested rather than enforced in local bylaws. This reports hopes to add to these studies and see better quality bicycle storage provided for residents of multi-unit residential buildings on campus.

STUDIES

STORAGE OCCUPANCY STUDY



This section details a moment-in-time study of Class I (long-term) bicycle storage in all participating buildings. The measures described are based on studies by Moskovitz & Wheeler (2016). The baselines determined through this study give context and depth to other parts of the project.

KEY FINDINGS

- Class II storage is not meeting resident demand.
- Overall, 95% of the parking spaces were occupied. Several rooms were above 100% occupancy.
- 25% of the bicycles in common storage rooms were non-standard bicycles and accessories such as children's bicycles or bicycle carriers.
- UBC Development Handbook guidelines for the space needed to install bicycle racks did not provide enough space to maneuver and park non-standard bicycles.

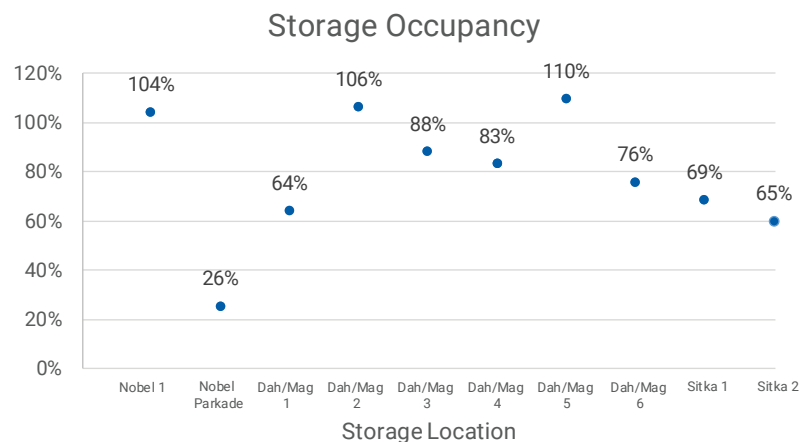


Figure 2: Class I storage rooms occupancy rates.

RECOMMENDATIONS

- Increase required resident bicycle storage capacity requirements in Development Handbook and REAP Guidelines.
- Increase mandated storage capacity for children's bicycles and other non-standard bicycles and accessories in Development Handbook and REAP Guidelines.
- Expand or improve current bike share system on campus or introduce new bike share system on campus to reduce need to store bicycles (especially important for buildings built with lower bicycle storage minimums).
- Encourage residents to maximize the capacity of bicycles racks through informative materials and enforcement, if needed.

SITE

This survey included 344 bicycle parking spots in 9 rooms spread over 4 residential buildings: Nobel House (Nobel), Dahlia House (Dahlia), Magnolia House (Magnolia) and Sitka (see Figure 3). Dahlia and Magnolia residents share storage rooms, so the results from these buildings are grouped together. Storage rooms varied in location, size, layout and rack type (see Table 2 & Figure 4).

Most motor vehicle parking spaces in Nobel have also been retrofitted with a storage rack for two adult bicycles. To use the racks, residents must be able to lift a bicycle above their chest. They are located behind the parkade's gates and intended for residents, meeting UBC's definition of Class I storage (UBC, 2016).

Project partners Polygon and UBC PT selected the buildings for the study. Of the eight buildings contacted, four agreed to participate in the study. After selection, researchers sought approval for the study through building management and UBC's Research Ethics Board. After approval from management and the UBC Research Ethics Board, locations were studied in advance by viewing architectural drawing, when available, to ensure all bicycle storage rooms were counted and to determine capacity.



Figure 3: Map of occupancy study buildings in gold.

Table 2
Class I Storage Area Characteristics

Building	Location	Bicycle Storage Capacity	Common Storage Capacity per Unit	Room Size (ft ²)	Capacity to Floor Space	Rack Type (See Figure 4)	Distance to Nearest Vehicle Entrance (ft)	Notes
Dahlia & Magnolia	Room 1	14	0.6	230	1 : 16.5	V-ring	210	Narrow Entrance
	Room 2	16		330	1 : 21	V-ring	420	
	Room 3	17		405	1 : 24	V-ring	280	
	Room 4	6		120	1 : 20	V-ring	260	
	Room 5	84		1515	1 : 18	V-ring	170	
	Room 6	33		720	1 : 22	V-ring	170	
Nobel	Room 1	122	0.7	1144	1 : 9	Square Rack	160	Heated
	Parkade	82	Not applicable	Not applicable	Not applicable	Wall Rack	Varied	
Sitka	Room 1	32	1.6	Not available	Not available	Square Rack	Not available	
	Room 2	20		Not available	Not available	Square Rack	Not available	

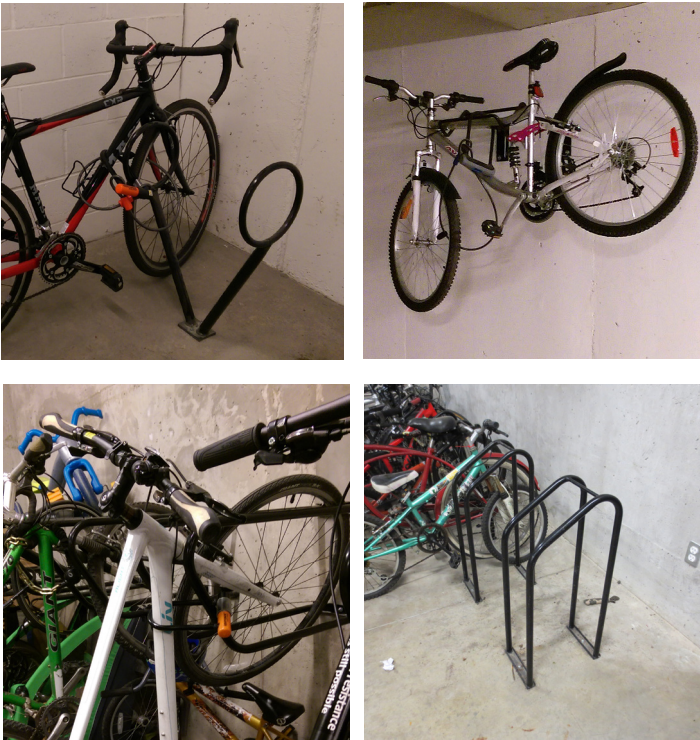


Table 3
Data Collection Metadata

Building	Date	Time	Weather
Nobel	February 23, 2017	1:10 p.m.	Sunny (High 6°C)
Dahlia & Magnolia	February 23, 2017	2:00 p.m.	Sunny (High 6°C)
Sitka	March 16, 2017	11:20 a.m.	Overcast (High 8.4°C)

Figure 4: (Clockwise from top left to right) V-rack; wall rack, wall-mounted square rack, floor-mounted square rack.

DATA COLLECTION

Data collection took place between 11:00 a.m. and 3:00 p.m. on weekdays in the early spring of 2017 (see Table 3 for study time and weather conditions). This time of day was chosen based on building manager availability as they supervised the counts.

As bicycles were tallied, they were marked as either as “in a designated rack spot” or as “not in a rack spot.” They were further divided into the categories standard adult, standard child, non-standard bicycles and accessories, e-bikes and other. Items in the “other category” (such as a motorcycle, a vacuum, strollers and push scooters) were not included in the quantitative analysis.

RESULTS

Bicycle counts create baseline measures for storage room capacity, accumulation and occupancy. Understanding these measures was a starting point for this project’s other studies.

Capacity

Capacity was based on the stated capacity from architectural drawings when available, otherwise spaces were counted.

The capacity of each room was generally related to the size of each storage room, with some rooms using their floor space more efficiently

(see “Capacity to Floor Space” column in Table 2). Although most of the rooms used space at a 1:20 ratio, Nobel’s large single storage room used the space extremely efficiently (1:9). This efficiency must be considered along with occupancy and other qualitative measures related to ease of use.

All storage rooms had racks installed in a way that met the Development Handbook bicycle storage design standards for width and length tied standard bicycle sizes (UBC, 2016, p.7-4). However, these minimums did not create rooms that served non-standard bicycles (such as cargo

bicycles) and their accessories (such as trailers). Often, these bicycles could not fit between racks or easily move in and out of parking spots (see Figure 5).

In Nobel House, the two-bicycle capacity of the floor-mounted square rack was reduced to a single bicycle as a wall-mounted rack. Some residents were able to balance two bicycles on a single wall mounted rack or store a carrier or child's bicycle below the rack.

In Sitka, how residents used the racks halved capacity. Rather than being using the square racks as double racks (as shown at Nobel House in Figure 6), Sitka residents were using each rack to store a single bicycle. Consequently, the building manager (and residents) reported these rooms were "full" which lead some residents to use Class II storage at ground level.

It was unclear why Sitka residents were using the racks differently than Nobel House residents. Additional capacity in Sitka may be possible by providing residents with an email explaining rack use and considering additional enforcement measures if needed.

Accumulation

The accumulation of bicycles in each room is connected to room size and capacity. Figure 7 shows the breakdown of bicycle types in different rooms. Overall, 75% (261) of the bicycles are standard adult bicycles. The other 25% (85) are bicycles that have different storage needs such as smaller racks, more space between racks or even an electrical outlet.

In the Sikta building, only 71% (25) of the 35 bicycles were adult while the remaining 29% (10) were children's bicycles. This may be related to building demographics (many non-standard bicycles and accessories are built for children) or due to room size. The UBC Properties Trust (UBC PT) buildings (Dahlia, Magnolia and Nobel) retained these divisions with a slightly higher percentage of adult bicycles (76%, 236) and lower percentage of children's bicycles (15%, 46).

Of the 40 bicycles stored in the Nobel parkade, 62% (13) were adult bicycles and 29% (6) were child bicycles. Some of the child-size bicycles were not able to fit on the racks and were placed on the ground. These racks were installed after the building opened due to resident comments.

Occupancy

Occupancy is a function of capacity and accumulation. The overall occupancy was 95%. As shown in Figure 8, many of rooms individually were near or over a 100% occupancy rate.

In the UBC PT buildings, occupancy was at 99% (excluding the Nobel House parkade). The Nobel House parkade storage had a much lower occupancy rate (26%). Residents clearly preferred secure storage rooms or may not have owned bicycles. As residents must rent car and bicycle parking spots in parkade together, this likely impacts the distribution of bicycles between the storage rooms and parkade storage.

The Sitka occupancy is also lower than the other rooms, 67% overall. As mentioned earlier, Sikta residents stored their bicycles in a way that minimized capacity on similar racks.



Figure 5: Non-standard orange bicycle does not have enough space behind it to back out easily.

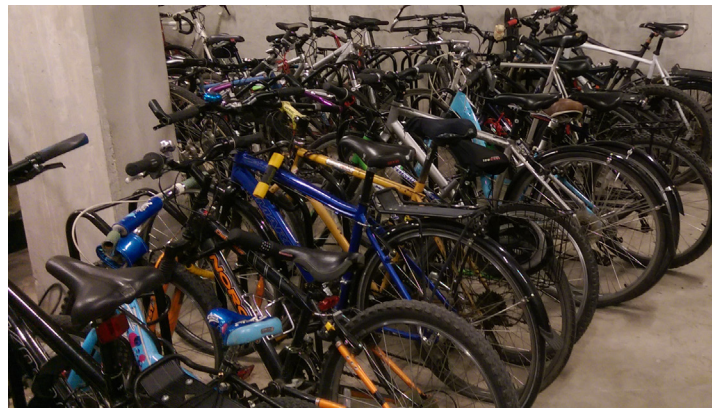


Figure 6: Square rack used on floor as double rack.

Types of Bicycles in Storage

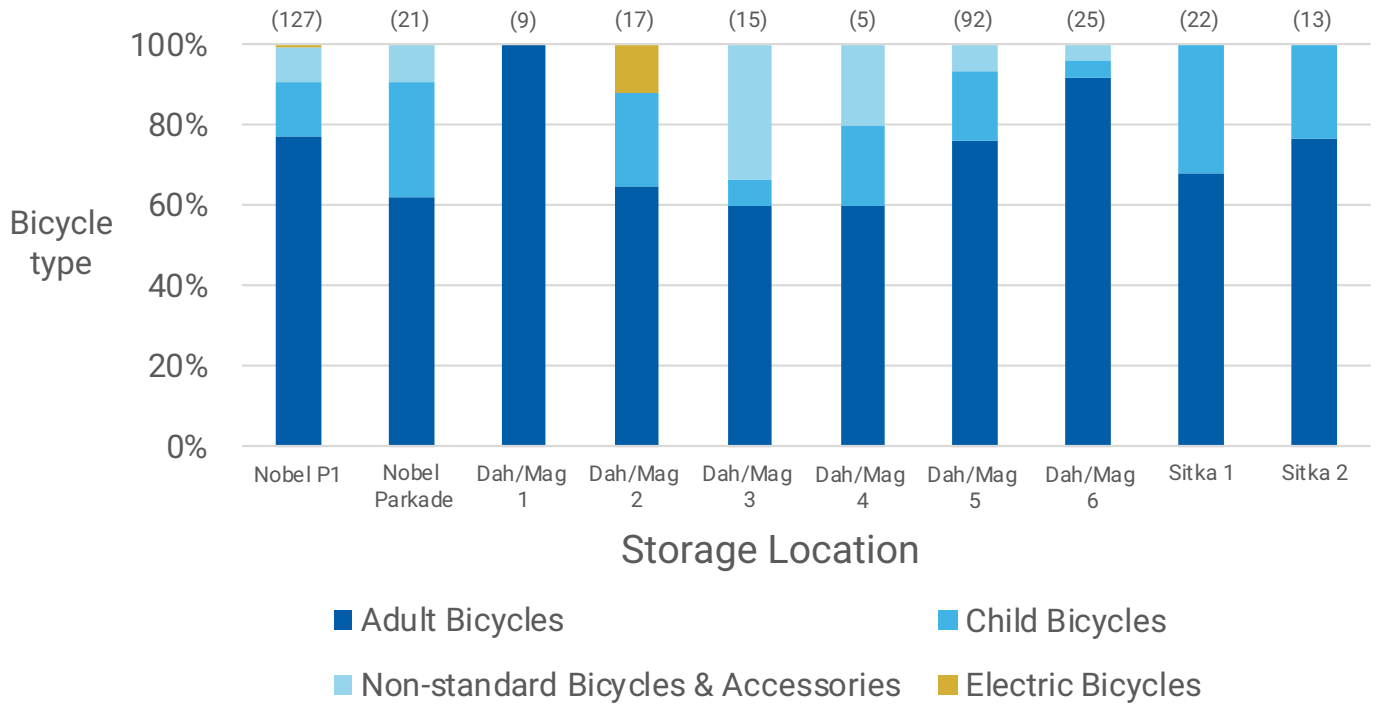


Figure 7: Bicycle types and accumulation in each storage location.

Storage Occupancy

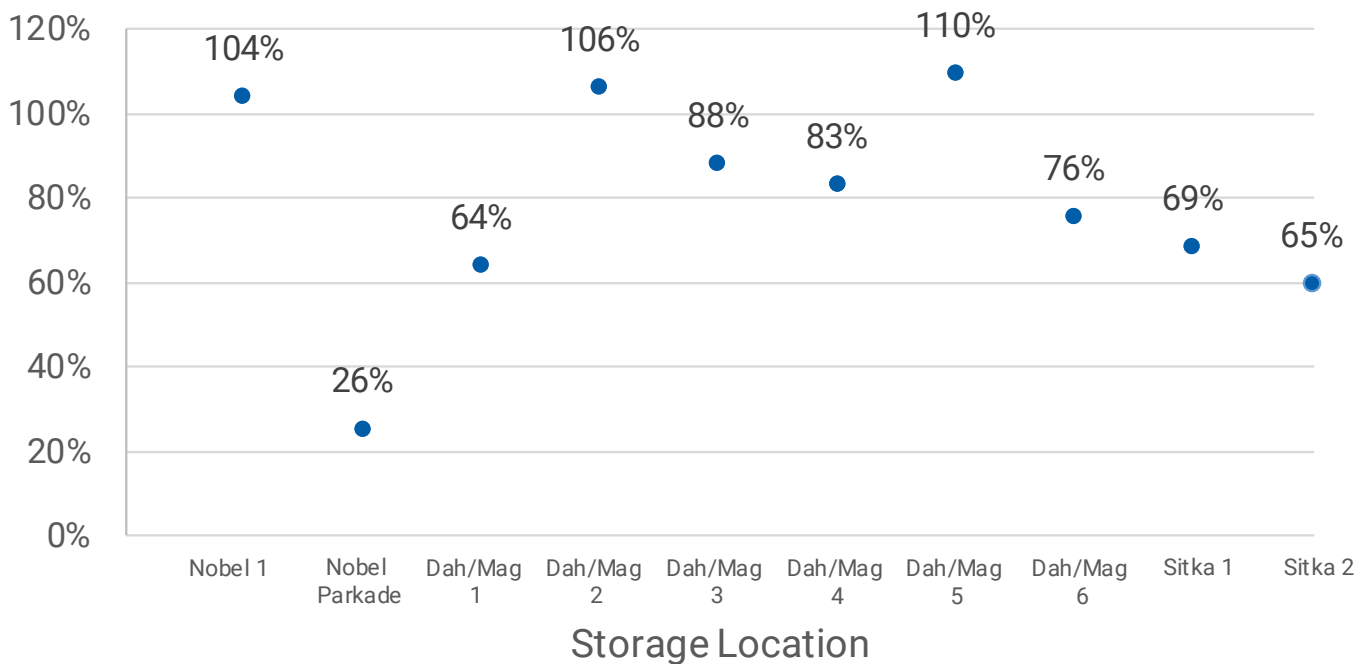


Figure 8: Class I storage rooms occupancy rates during data collection period.

DISCUSSION

The baseline measures outlined here provide information on how Class I storage is used by residents. As shown by the occupancy rates, designated storage rooms are well used by residents. Residents stored bicycles in these rooms even if they were unable to find or fit into a bicycle parking space or need to double park there bicycles.

However, as future sections will show, residents also store bicycles in class II storage and in units. This is likely related to occupancy rates, in addition to other influences.

Given space to capacity ratios, there are likely improvements that can be made to storage design to maximize capacity within development guidelines (UBC, 2016). In Sitka, storage capacity could be maximized by using racks more efficiently as well.

Possible Errors

Human error was the most likely source of error specifically related to the counting and

categorizing of bicycles. As mentioned above, the time of day and season may also influence the number of bicycles in the room.

In future studies, researchers should count bicycles during the early mornings or late nights of months with low bicycling mode share. Researchers could also do counts in pairs and verify the counting and categorization of bicycles through the count.

Conclusion

This field study provides a baseline for this project and future studies of residential bicycle storage on campus. Even if storage room capacity could be expanded to meet current demand (and development guidelines updated as well), it cannot meet the future demand.

Improvements to UBC cycling facilities will likely drive additional storage demand for many different types of bicycles. The design of Class I storage facilities must meet these conditions rather than current conditions.

OUTDOOR DURATION STUDY



This section details the moment-in-time study of Class II (short-term) bicycle storage in all participating buildings. The measures described are based on Moskovitz & Wheeler's methodology (2016). The baselines determined through this study give context and depth to other parts of the project.

KEY FINDINGS

- 83% of bicycles were parked for longer than four hours.
- 75% of all bicycles did not move during the study.
- 50% of spots were occupied, although this rate varied between racks likely related to rack location.
- Class II storage usage is related to distance from entrance and rack visibility.
- Residents, rather than visitors, were likely using the racks to store bicycles.
- Upgrading Class II storage by providing cover for and improving the location of racks could better meet resident needs.

RECOMMENDATIONS

- Locate Class II storage "on the way" to the building rather than "past" the building. Specifically, designers and architects should consider the site context and determine which way the majority of residents will leave and return to the building and site outdoor storage accordingly. In the UBC context, Class II storage should be located between the building entrance and the main cycling pathway to the UBC campus core and neighbourhood cores.
- Improve secure Class I storage so these outdoor Class II racks remain available for guests.
- Build bicycle storage in each residential unit.
- Build racks for, and rental agreements which allow, bicycle storage in first floor deck and patio areas. Especially in mid-density buildings, this could significantly reduce strain on Class I & II storage by providing more secure and weather-covered storage than current Class II storage.
- With the understanding that the primary users of Class II storage are residents, cover outdoor storage racks to protect bicycles from exposure to sun and rain without impeding rack visibility.
- Locate Class II storage where it will be easily accessible by residents and guests.

SITE

This study looked at 101 bicycle parking spots at 13 storage locations near 6 residential buildings: Nobel House, Dahlia House, Magnolia House, Keats Hall, Chaucer Hall & Sitka (Figure 9). These storage locations were all on the building property. Promontory, a residential building to the west, was also considered for study, but it had no designated outdoor storage.

The first eight sites were attached to the three study buildings to the south (Nobel House, Dahlia House and Magnolia House) and the remaining five sites were located near the three buildings to the north (Keats Hall, Chaucer Hall and Sitka) (Figure 10).

Although Moskovitz and Wheeler suggest selecting locations within walking distance, to visit these two sites within an hour, a bicycle trip between the northern and southern sites was required. To confirm all sites could be visited within an hour, a one-hour trial count was conducted the day before. Rack locations and photograph vantage points can be found in Figure 10.

The bicycle racks in this study varied and included ring and post racks, and clustered or coathanger racks.

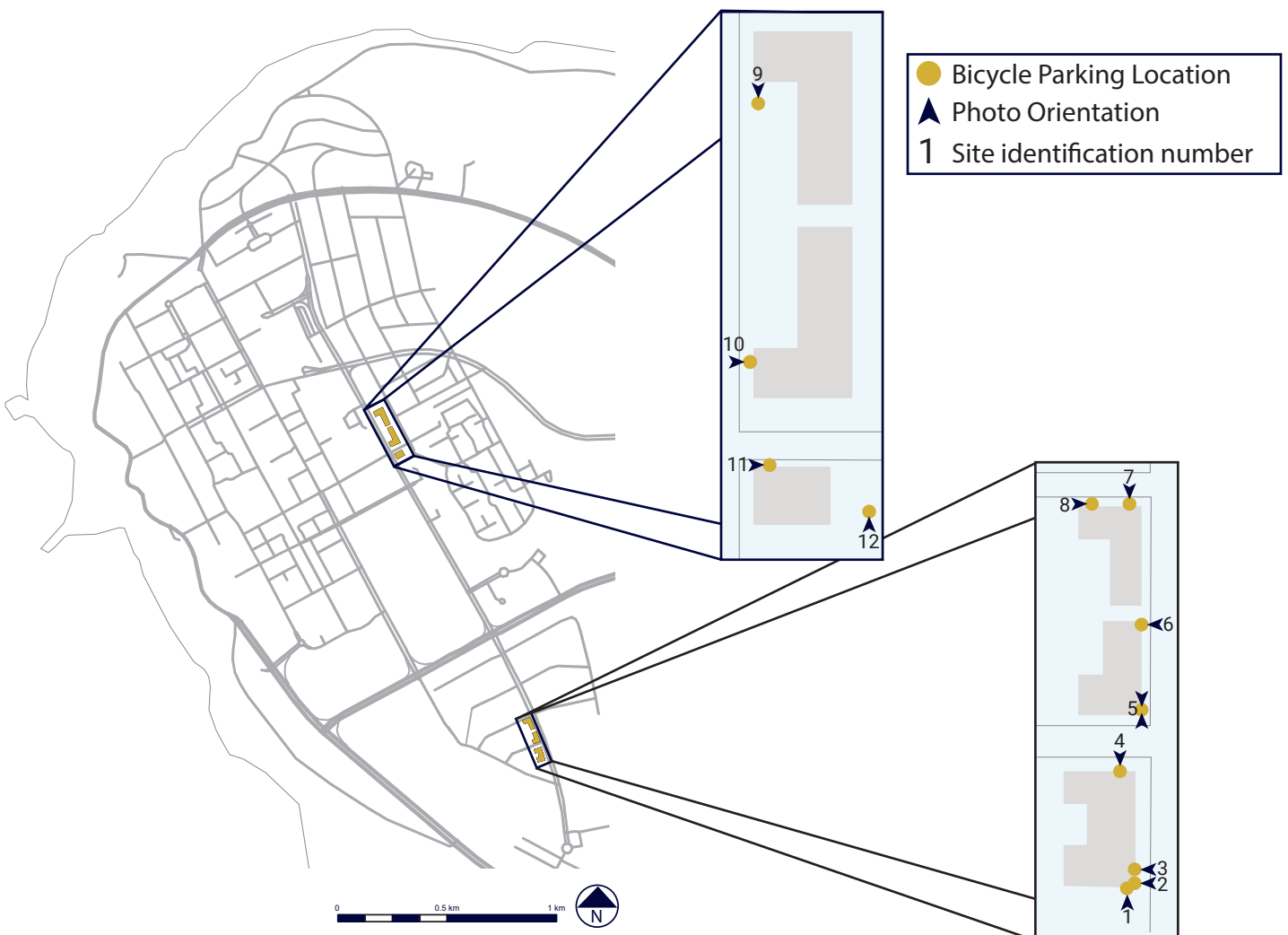


Figure 9: Map of outdoor duration study buildings in gold.

Figure 10: Inset, photograph orientation and site numbers

DATA COLLECTION

Data collection took place over 11 hours from 8:00 a.m to 7:00 p.m on October 24, 2016. The weather was overcast until the 12:00 p.m. hour when light rain began which turned to heavy rain by the 3:00 p.m. hour.

Every hour, a photograph was taken from each noted vantage point in the designated order. The first photograph was taken on the hour. To prevent inconsistencies in travel time, the researcher began the photographs of the northern set of buildings (sites 9 to 13) at 17 minutes past every study hour.

After field data collection, every photograph was organized by site and time (Figure 11). As in Moskovitz & Wheeler's study, every parking event ("arrival, presence, and departure of a bicycle at a parking facility") was recorded using in a series of site matrices (2016, p. 67). Departing from the original method, trips where the presence, departure and return of a single bicycle were noted are labeled linked trips.

As set out in Moskovitz & Wheeler's method, bicycles parked on nearby pathways and street furniture were not counted due to potential inconsistencies in data collection.



Figure 11: Photos from site 7 over the study period.

RESULTS

This study focused on determining the accumulation, volume, duration, turnover and occupancy for these sites.

Results

Over 11 hours, 55 parking events (the parking volume) were recorded. The two linked parking events were counted once. Using these numbers, the overall turnover rate (parking events/capacity) was 0.54. Each site had an individual turnover rate of between 0.00 to 0.88. Collectively, the parking spots beside the northern buildings (market housing) had a lower turnover ratio of 0.45 (see Figure 12).

Duration

Using the Portland Bureau of Transportation's categorization of bicycle parking duration, parking

events were divided into short-term (>2 hours), midterm (>2 and <4 hours), and long-term (>4 hours) (in Moskovitz & Wheeler, 2016). The number of all day events (from beginning of study period to end) were also noted (Figure 12).

Of 48 parking events, 83% (40) lasted longer than four hours. Of the bicycles stored long-term, 90% (36 bicycles or 75% of all bicycles stored long term) were not move for the entire duration of the study. As in the Moskovitz & Wheeler study (2016), "a calculated duration of 1 h ($D = 1$) theoretically had an actual duration between 0 and 2 [hours]" (p. 69). Given the study was 11 hours, there may have been bikes that left before the study began or returned after the study ended which would create more linked trips. Additionally, those bicycles stored for the entire day may have arrived before and departed after the study began.

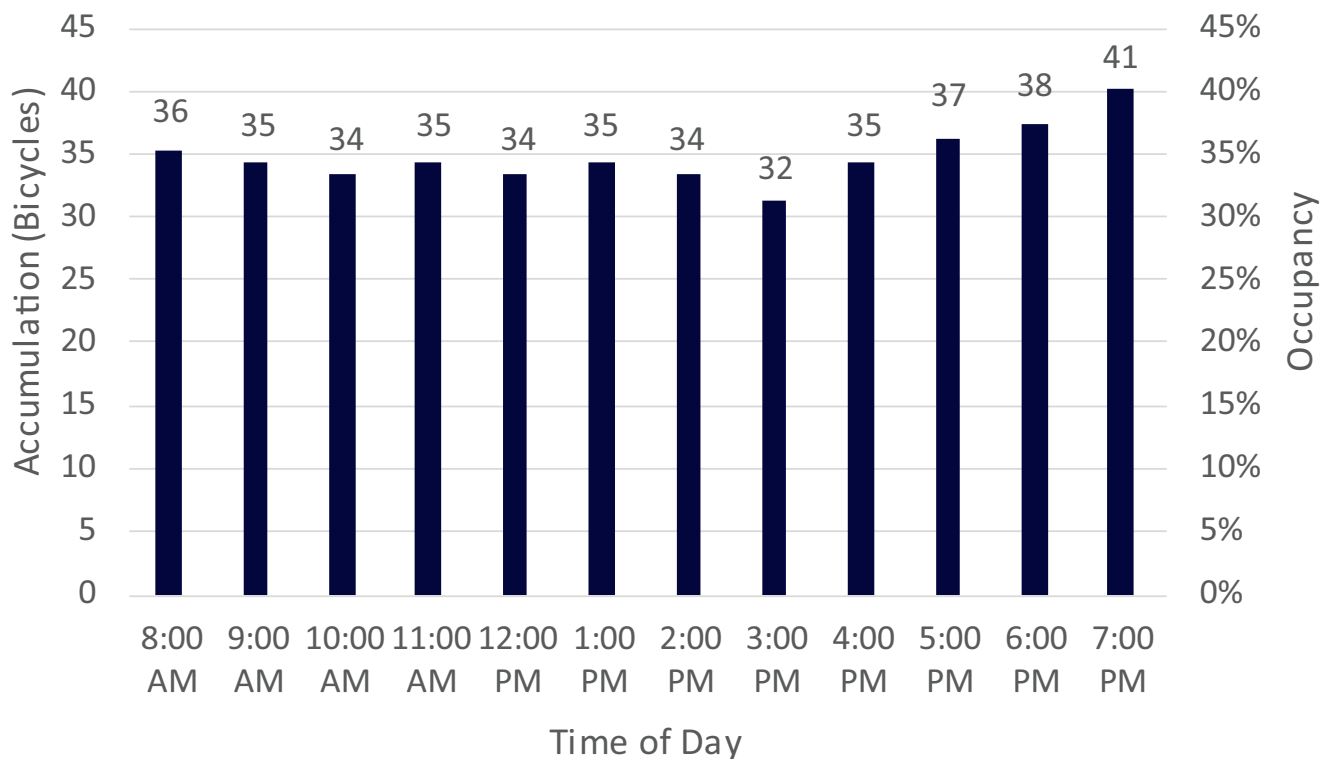


Figure 12: Overall accumulation of bicycles through the day.

Accumulation and Occupancy

Accumulation and occupancy give insight into how the outdoor storage is used overall. In Figure 12, it's clear that there is only a slight increase in bicycles stored later in the day. However, the majority of bicycles do not move throughout the day.

Although the occupancy reaches just under 50% of capacity, looking at different racks shows a variety of peak occupancy rates (Figure 13). Although occupancy may vary at individual sites, the number of bicycles at the station remains relatively stable throughout the day.

DISCUSSION

Residents of the five buildings have a close relationship to this Class II bicycle storage. Since many bicycles were stored for longer than a day, these bicycles are likely owned by residents. This is counter to the expected and ideal use for this type of outdoor Class II storage which lacks weather cover and additional security.

Choosing these risks over secure underground storage may occur for two reasons. First, residents may enjoy direct ground access to their bicycles, despite weather exposure and reduced

theft. Second, high occupancy rates in secure Class I storage (see previous study) may force residents to seek other locations to store their bicycles.

Although these were not included in this study, residents also store bicycles in first floor units and on first floor balconies. Reasons for doing this are likely also related to the direct access and high Class I storage occupancy rates (see previous section). This type of storage violates rental agreements and strata bylaws.

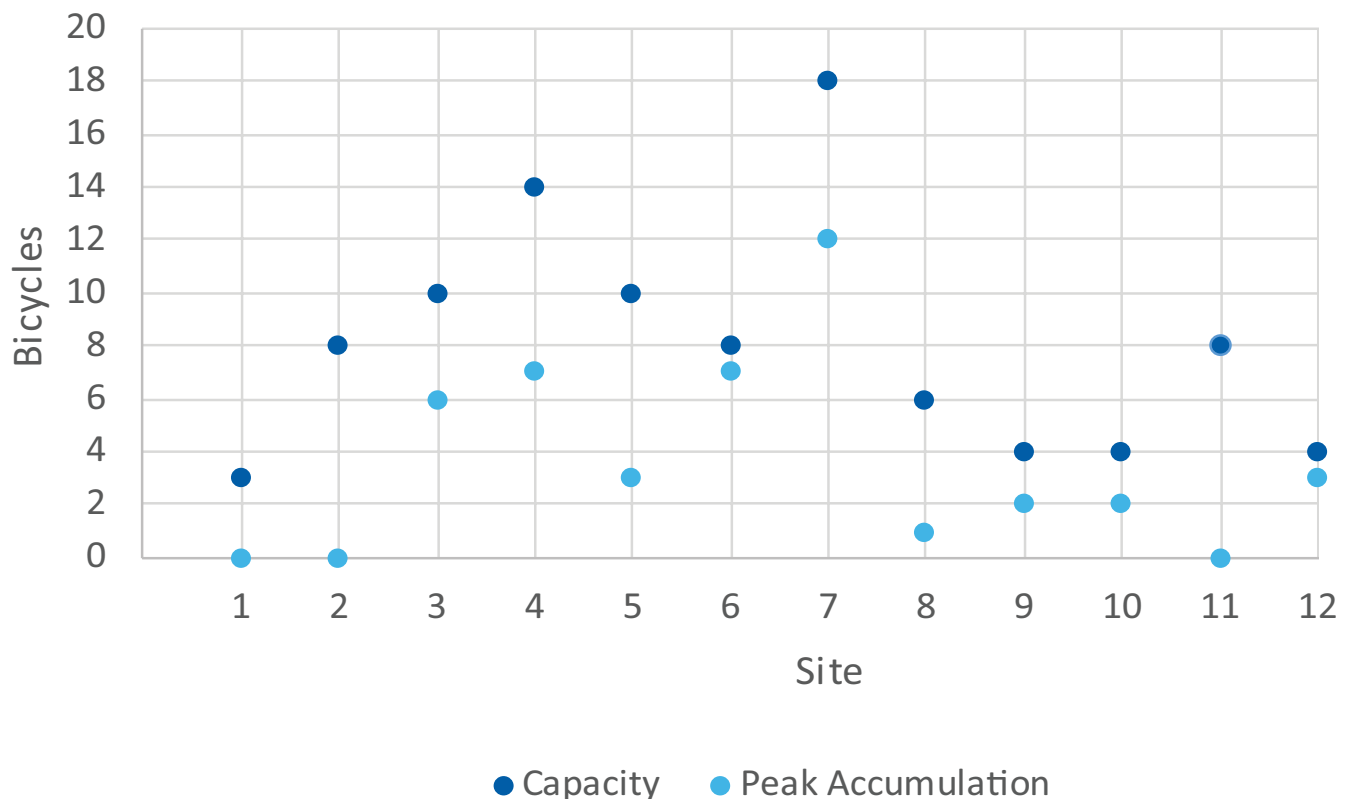


Figure 13: Rack capacity as compared to peak accumulation during the study period.

The simplest way to change these results is by increasing secure storage for residents and allowing residents to store bicycles in their unit's indoor and outdoor spaces. This could include widening hallways and unit entrance doorways so bicycles could better pass corridors than without damaging the building. If this is not possible or sustainable through the transfer of the building to the building owners (i.e. the strata council or building management), then Class II bicycle storage should be designed or retrofitted to accommodate typical rather than ideal use.

Additionally, varied occupancy rates for different racks likely relates to distance from building entrances and visibility of storage racks to street users and residents. Considering rack location relative to these two factors should be encouraged when siting rack locations and could be further examined in the future. Further study is needed to determine the exact impact of these factors.

Possible Errors

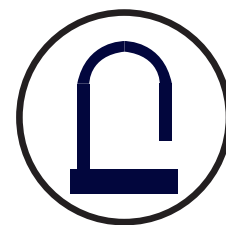
This type of data set could be prone to several types of errors, aside from the possible variations in actual duration. The limited time frame of the study may have missed bicycles leaving, returning or doing both outside of the study. Linked trips may also have been missed if a bicycle parked at another storage location outdoors or within the building.

Conclusion

Overall, the challenge for Class II storage is not a lack of storage, but a lack of Class II storage that meets resident needs. Better located racks that offer passive surveillance and an "on the way" location will better suit resident needs. Additional weather protection would also suit the long-term storage needs of residents and prevent resident bicycles from rusting in the rainy climate. Rather than focusing on the ideal use of Class II storage, typical use of these racks should be the focus of their location and design.

INDOOR DURATION STUDY

In Class I bicycle storage rooms, bicycle locks were marked and monitored to determine which bicycles are being moved and when they are moved. These results give depth to the study of room design as well as resident use of bicycles.



KEY FINDINGS

- 64% of monitored bicycles were moved during the study.
- 27% of marked bicycles moved within the first week.
- Small increases in use were related to weather and local events.
- Bicycles closer to the door and the centre aisle were the most used.

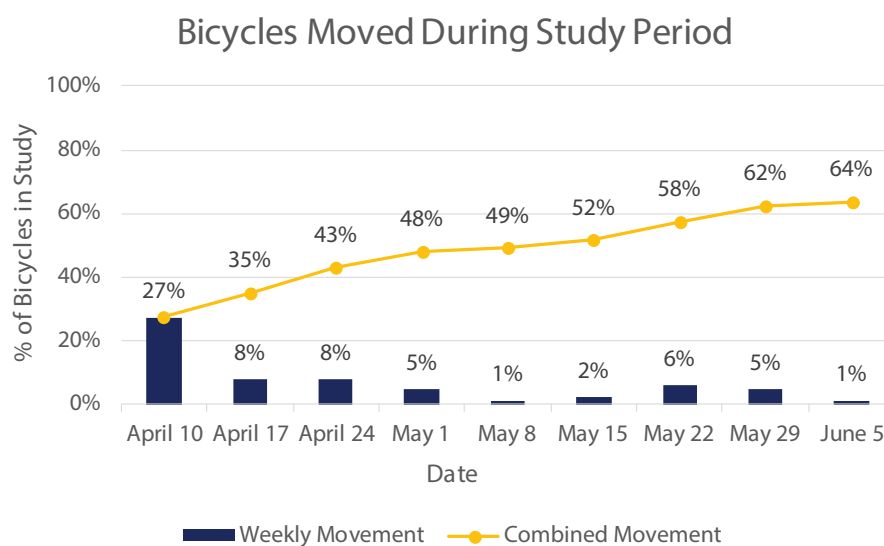


Figure 14: Percentages of bicycles which moved during the study period.

RECOMMENDATIONS

- Build rooms that allow residents to quickly access bicycles.
- Provide space for residents to maintain and repair bicycles.
- Monitor and maintain of bicycle storage rooms.
- Remove abandoned bicycles on an annual or semi-annual basis.
- Encourage regular cleaning and maintenance of rooms.
- Consider providing long-term bicycle storage and short-term bicycle parking for residents.

SITE

In this study, researchers marked and monitored 165 bicycle locks in 4 bicycle storage rooms in 3 of UBC's Properties Trust residential buildings: Nobel House (Nobel), Dahlia House (Dahlia) and Magnolia House (Magnolia) (see Figure 15). The Dahlia and Magnolia results are grouped as their residents share storage rooms.

Researchers selected these rooms after previewing them with the permission of the building management. Nobel's room is the only dedicated common bicycle storage room in the building. Rooms 2, 3 and 5 in the Dahlia & Magnolia parkade were selected based on their varied distance from the vehicle entrance. The location of the rooms relate to the parkade is mapped in Figure 16.

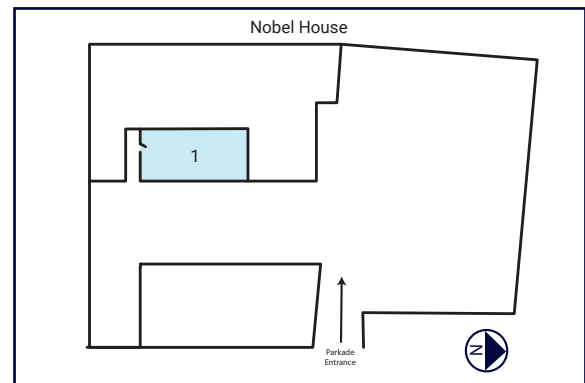
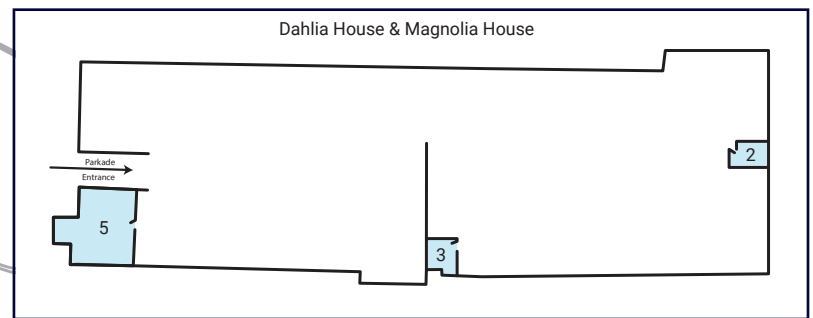


Figure 15: Map of indoor duration study buildings in gold.

Figure 16: Map of study rooms in the 1st parkade level.

METHODOLOGY

During the literature review for this project, researchers found minimal studies of bicycle parking duration. The Moskowitz & Wheeler study (2011) study did provide a useful base vocabulary, however their photography method did not provide an efficient way to monitor Class II storage over a long term period.

A study by Rose et al. (2016) monitored long-term bicycle storage use at Melbourne rail stations to “identify the trends and variability in use” using key card access data (p.2). This methodology allowed them to monitor five stations over five years, but it could not determine which sections of the room bicycles were stored in. Additionally, given that access data could be tied back to tenants in the UBC PT buildings, linking residents and storage use was unnecessarily invasive.

Starting from these methodologies, researchers created this method to monitor long-term bicycle storage and determine which rooms and which sections of rooms saw the most use. Before beginning the study, all residents in these buildings were emailed to inform them of the study (see Appendix A).

UBC’s Research Ethics Board approved this study in February 2017. As part of the approval process, researchers chose to create an opt-out process for residents (rather than an opt-in) to capture abandoned bicycles. Residents opted-out of the study by placing a note on their bicycle or bicycles asking researchers not to count their bicycles. One unit in a Dahlia & Magnolia bicycle storage room choose to opt-out.

On April 3, 2017 between 1 p.m. and 3 p.m., researchers began the study by placing a small strip of blue painter’s tape (ScotchBlue™ Delicate Surface Painter’s Tape with 3M™ Edge-Lock™ Paint

Line Protector, 2080EL-24NF, 24 mm x 55 m, 60-day clean removal) on the locks of bicycles locked to storage racks. These were placed so owners would need to move or break the tape to unlock their bicycle. The tape adhered well on many types of locks without leaving a residue and is recommended for future studies.

Researchers noted the number of marked locks on premade worksheets sheets that divided the room into sections. In addition to relevant metadata, researchers recorded the number of marked locks, bicycle rack capacity for the section (typical between 6-8 parking spots) and unlocked bicycles in each section.

When they returned in the subsequent weeks, researchers recorded on annotated worksheets the number of remaining pieces of tape. To determine which section marked locks should be counted in, researchers would use the previously recorded capacity to determine section size (i.e. for a section with a capacity of 8, counting 8 parking spots and recording anything within that section).

To prevent errors, researchers counted the remaining pieces of tape and checked these against the initial lock count and previous weeks lock count as they went. Multiple bicycles locked using a single lock were treated as a single bicycle. Multiple bicycles locked to a single parking spot with multiple locks were recorded separated. Child-size bicycles, non-standard bicycles and bicycle accessories (such as carriers) were included in the study, provided they were locked to a bicycle rack. Researchers excluded unlocked bicycles and bicycles not locked to a bicycle rack as they could potentially be moved or used without removing the marking tape.

DATA COLLECTION

The study took place between Monday, April 3, 2017 and Monday, June 2, 2017. During the first session, locks were marked with tape and their number of marked locks were recorded. This study did not focus on bicycles in regular use so there was no attempt to mark bicycles that were out of room during study period.

To study which bicycles remained in storage areas, researchers returned every Monday between 1 p.m. to 8 p.m. to record any changes to tape placement. During this period, there were a variety of weather changes and local events that could have impacted bicycling use (see Figure 17). Building management provided a key fob to researchers to gain access to these buildings.

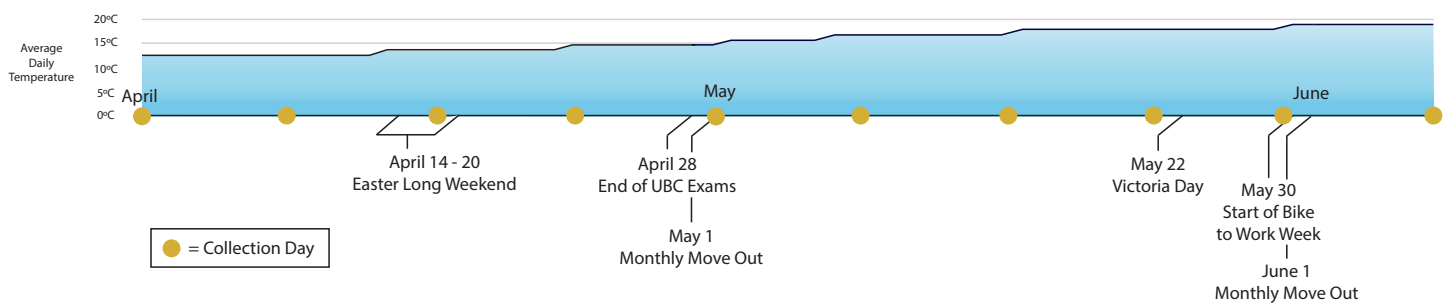


Figure 17: Map of indoor duration study buildings in gold.

RESULTS

The results of this study were broken down by building (see Table 4). Overall, residents moved just under two-thirds of bicycles (64%, 105 bicycles, see Figure 18). This percentage remained similar in both buildings although the Nobel room had slightly more movement (59 bicycles, 69% of the room) and Dahlia and Magnolia rooms have slightly less (46 bicycles, 58% of the rooms). Looking over all rooms, 36% of bicycles never moved over the 10 week study period.

During the first collection after locks had been marked, 27% of bicycles moved. The following nine weeks saw relatively little movement (37%). This does not include bicycles that may have been in use during the initial marking period. There was a slight bump on May 22 after the warm long weekend and on May 29 during more warm weather, towards the end of the month (when tenants move out) and on the first day of the regional Bike to Work week (see Figure 17).

Table 4
Weekly totals of the number of bicycles moved

	April 10	April 17	April 24	May 1	May 8	May 15	May 22	May 29	June 5
Nobel 1	29	34	41	45	47	48	51	58	59
Dah/Mag 2	4	9	9	9	10	10	10	10	10
Dah/Mag 3	2	3	3	3	3	3	3	3	3
Dah/Mag 5	11	13	18	22	22	24	31	32	33
Total	46	59	71	79	81	85	95	103	105

Bicycles Moved During Study Period

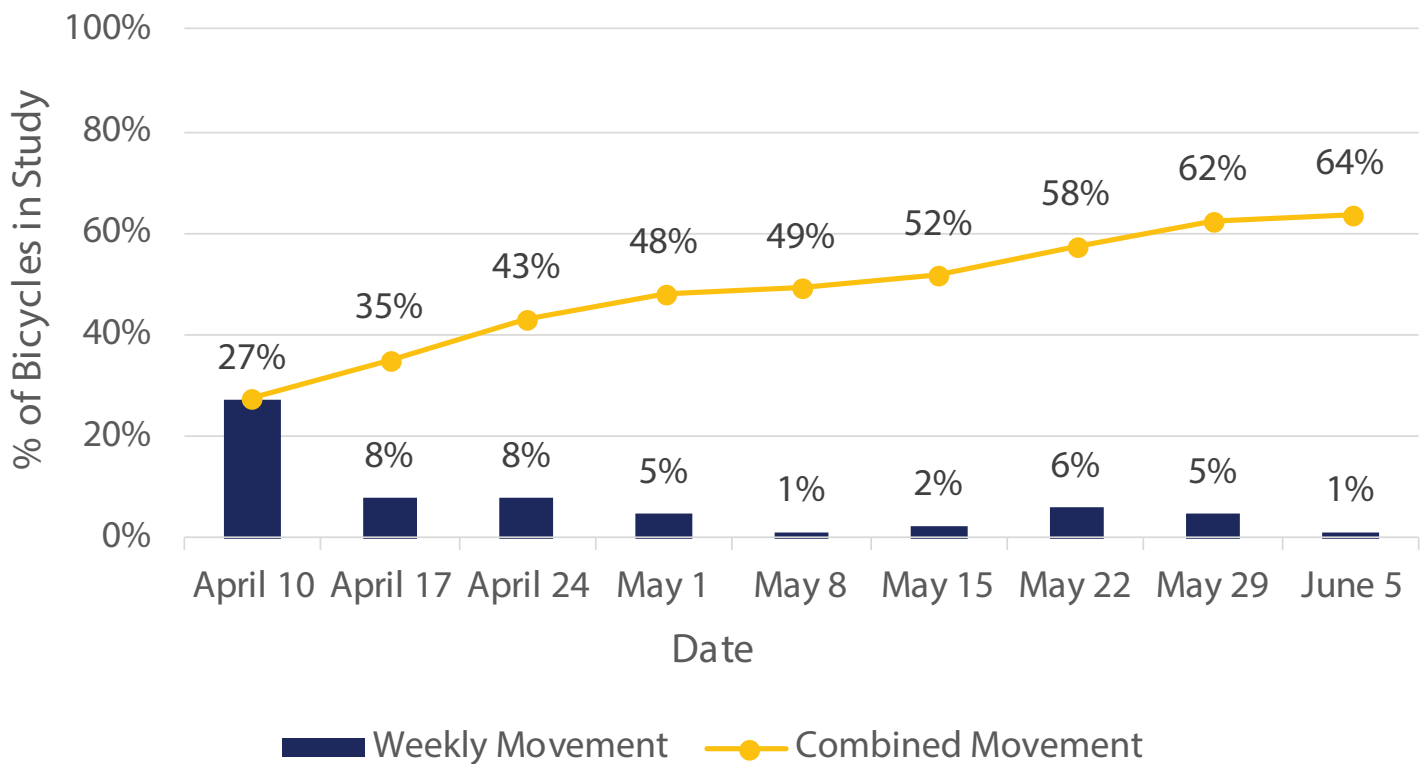


Figure 18: Percentages of bicycles that moved during the study period.

These results can be broken down further into overall movement in different sections of the bicycle storage rooms (see Figure 19). These diagrams show that bicycles accessed from the larger rooms during the study were more likely to be toward the front of the room and closer to the centre aisle. This is even more pronounced during the second week of data collection.

In the smaller rooms, the amount of room to maneuver the bicycle seemed to be important. However, after initial two week period, there was almost no change in the number of bicycles moved.

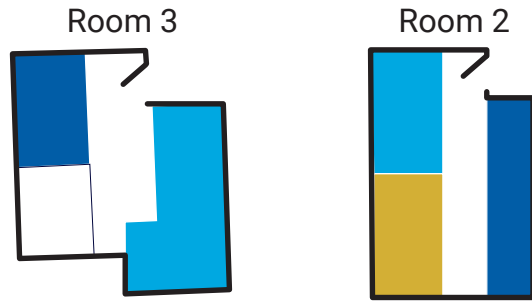
Although most sections had movement by the end of the study period, there were several sections which saw no movement at all. This was most obvious in Dahlia and Magnolia Room 5.

It is also clear that bicycles in Nobel Room 1 had more regular use (within first two weeks) than those bicycles in Dahlia & Magnolia Room 5. Only one section saw over 60% of bicycles moved.

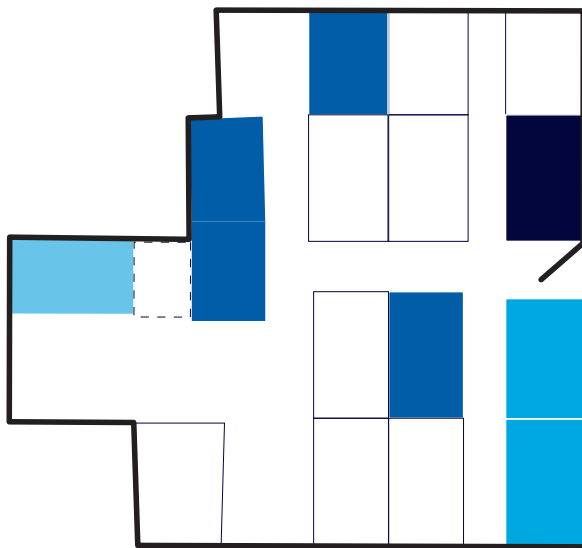
The areas used may not directly relate to resident preference. Residents are constrained to use spaces that are already open.

APRIL 17, 2017 - After 2 Weeks

Dahlia House & Magnolia House



Dahlia House & Magnolia House
Room 5

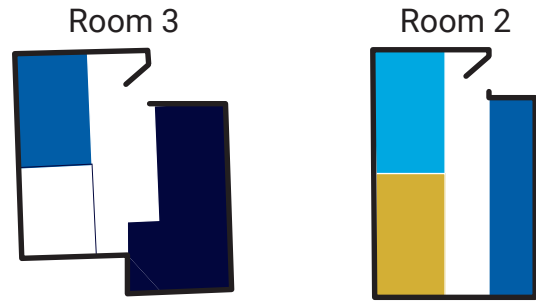


Nobel House
Room 1

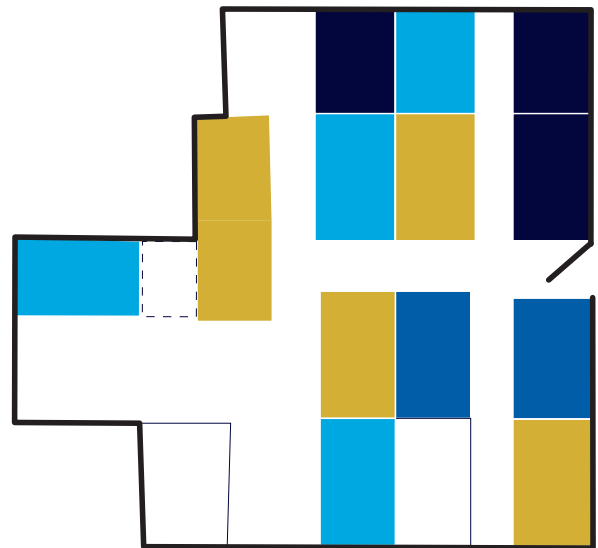


JUNE 5, 2017 - After 9 Weeks

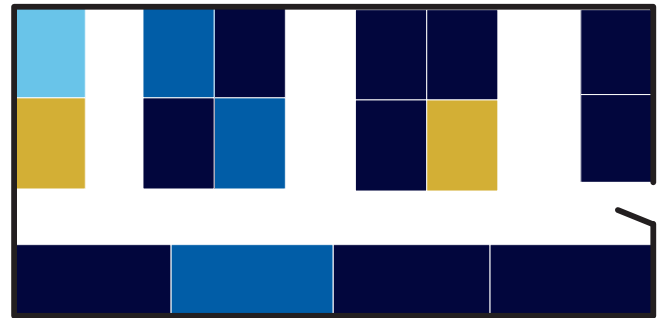
Dahlia House & Magnolia House



Dahlia House & Magnolia House
Room 5



Nobel House
Room 1



Percentage of Bicycles Moved

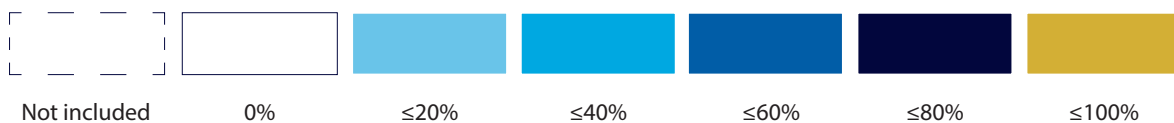


Figure 19: Cumulative total percentages of bicycles moved during the 2nd week of data collection (April 17, 2017) and final 9th week (June 5, 2017) of data collection. Rooms are not to scale.

DISCUSSION

The most obvious outcomes of these results are the findings relating to the design and maintenance of Class I storage rooms. Room design could be improved by providing better access to each set of racks. By widening aisles, residents will be better able to access racks. Guidelines could also stipulate a minimum and maximum room size. This will prevent rooms that are too small to maneuver in or so large long aisles are created.

Regular maintenance for storage rooms can also help building management and residents keep each rack accessible. Removing abandoned bicycles on a yearly or bi-yearly basis ensures abandoned bicycles do not taking up valuable storage space. Beyond these types of changes, resident behaviour should be considered.

From these findings, there are two main groups of room users that can be addressed: those who moved their bicycles and those who did not.

The majority of bicycle owners ($\geq 64\%$) in these storage rooms buildings access and presumably use their bicycles. And although they may not be daily bicycling commuters (and therefore may not have had their bicycles marked), 27% of the room users did move their bicycles regularly (based on bicycle movement within the first week).

Improved residential cycling facilities and other campus road and destination cycling facilities will support these residents and encourage them to use their bicycles more often. Since staff and family housing requires at least one tenant in each unit work at the UBC Point Grey campus, many residents live within a 15-minute bicycle commute. Polygon buildings likely also house many residents with a regular commute to nearby campus destinations.

The second group of owners pose several questions regarding bicycle storage in multi-use buildings. First, how often should residents be expected to ride their bicycles? Second, should

residents be able to own and store bicycles they use irregularly, perhaps only a couple times a year or less? These questions are important to the design and management of bicycle storage at UBC and the wider community.

The residents who own the 36% of bicycles (or more given unlocked bicycles could not be studied) need additional consideration. Ideally, all residents should have access to bicycles regardless of how often they ride as cycling is a healthy and sustainable option for transportation and recreation. However, if the storage of irregularly used bicycles impedes the bicycles used more often, solutions are needed to reduce this conflict.

Bicycles may be irregularly used for several reasons. First, they may be secondary or tertiary bicycles of residents (i.e. recreation or touring bicycles) which are only used seasonally. Second, these bicycles could be owned by residents who fall into the “interested but concerned” category (Gellar, n.d.). This group of bicycle owners would likely bike more often if additional cycling facilities were provided on campus. However, they may still not bicycle regularly and could represent a receptive group for a bike share program.

A bike share program with high station density near residential areas on campus could allow bicycle owners to give up their bicycles without reducing their access to cycling. It would also remove the burden of bicycle maintenance from these owners. UBC Sustainability could even provide a discount for staff and faculty living on campus for the bicycle share.

Although they may not become the most regular users of the bike share, ready to go bicycles will likely be more alluring to this group than a bicycle in a dark storage room requiring maintenance. Some of these residents may still prefer to store their bicycles, without using them, over longer periods. For these residents, it may be worthwhile to consider providing long term storage.

Possible Errors

Errors for this study relate to tape placement and removal. Initially, the tape was placed on a part of the lock that would need to move to open the lock to prevent possible disruption to bicycle owners and damage to lock. However, it was occasionally unclear which parts of the bicycle lock moved which introduced potential monitoring errors. For future studies, despite possible additional disruption to participants, placing the tape over the key slot or combination dials would be preferred. No residue was left on locks from the high-quality painter's tape, so damage to locks with similar tape in weather-protected areas is unlikely.

The removal of the tape also created potential errors as it could be removed by anyone with access to the storage room. Residents from the building or a resident's guests could purposefully or accidentally remove the tape from their own lock as well as others without using their bicycle. They could also reapply or place their own tape down to prevent researchers from recording the opening of the lock. These types of errors are difficult to reduce with using this method.

Finally, due to crowding in the bicycle room, researchers could be unable to find an affixed

piece of tape due to crowding issues or count a lock in the wrong section of the room. To reduce this potential error, as noted above, researchers were careful to compare results with previous weeks while in the storage room.

As no market housing buildings were able to participate in this duration study, further study is also needed into whether bicycle storage rooms are used the same way in market housing.

Conclusion

Class I storage rooms are areas of movement influenced by their design and management. Just under two-thirds were used in a sunny two-month period while one-third were not. The reasons why residents use or do not use their bicycles are varied and complex and storage is one part of a residents decision to own and use a bicycle.

Many residents already access their bicycles for transportation or recreation. If supporting these residents and encouraging bicycle owners is UBC's goal, then there are numerous changes in storage rooms and beyond that can be made. Which changes residents prefer and the best practices for improving designs are discussed later in this report.

RESIDENT SURVEY

A survey questionnaire was distributed to residents to collect data on bicycle storage demand and resident storage preferences. Responses led to new recommendations for study partners and provided context for the field studies and best practice reviews.



KEY FINDINGS

- 88% of residents wanted improvements to bicycle storage.
- Improving security was the top concern for residents.
- 94% of respondents felt bicycle storage was “important” or “very important” to them.
- 86% of respondents store their bicycles in common storage rooms.
- 75% of respondents used their bicycle daily.
- 60% of residents who did not own a bicycle felt better storage would encourage them to obtain a bicycle.
- Residents without children and only 1-2 bicycles preferred in-unit storage.
- Residents who used storage lockers wanted more covered, less crowded and easier to enter storage.

RECOMMENDATIONS

- Develop bicycle storage minimums on a per bedroom rather than per unit basis. There should also be a per unit minimum (e.g. 1.5 spaces per one-bedroom unit, and an additional bicycle parking space for every additional bedroom).
- Allow residents to store their bicycles in their units or on their decks. If not all units can be included, then allow units with direct ground level access to store bicycles in their unit or allow children’s bicycles to be stored in all units or decks.
- Provide bicycle storage lockers designed and designated for bicycle storage alone. For buildings undergoing retrofitting, these could be located in unused vehicle parking spaces.
- If assigning storage rooms or lockers, assign residents to storage rooms closest to their unit.
- Reduce distance between the elevators, vehicle entrances and bicycle storage so that the majority of bicycle storage is “on the way” to elevators or entrances to units.
- Consider solutions beyond increasing bicycle storage minimums such as bike share.

SITE

This survey targeted the residents living in four residential buildings: Nobel House (Nobel), Dahlia House (Dahlia), Magnolia House (Magnolia) & Sitka (see Figure 20). Detailed profiles of these buildings can be found in the introduction and are summarized in Table 5.

UBC Properties Trust (UBC PT) developed Nobel, Dahlia and Magnolia , mid-density rental buildings managed by Village Gate Homes. These buildings are staff and faculty housing and every unit must have at least one tenant who is a full-

time, permanent faculty or staff member at UBC (Village Gate Homes, n.d). Magnolia and Dahlia residents share their bicycle storage facilities.

Polygon Homes developed Sitka which is managed by its strata council, which in turn contracts services from AWM-Alliance Real Estate Group. Sitka is a privately-owned tower, so residents may be live-in owners or tenants. Owners who do not live on site also receive emails through the building's email list.

Table 5
Surveyed Building Characteristics

Building	Number of storage rooms	Residential Units	Range of Unit Size	Sample Size (n)
Dahlia	6	60	1-3 bedrooms	17
Magnolia		47	1-3 bedrooms	11
Nobel	1 (+ parkade spaces)	94	1-4 bedrooms	36
Sitka	2	81	2 bedrooms	7



Figure 20: Map of surveyed study buildings in gold.

METHODOLOGY

This survey was created with input from project partners to provide background and context for the field studies. It was open to all residents and residential unit owners above the age of 18. The survey questionnaire was composed of 18 discrete questions related to the respondent's building, demographics, bicycle storage needs, interest in cycling and suggestions for improving bicycle storage (see Appendix B). Due to survey branching, no respondent could answer all questions (see Figure 21).

Initial outreach to building management began in October 2016 with help from study partner, E3 Eco Group. A community member contacted through the local University Neighbourhood Association (UNA) was contracted to translate the survey into Simplified Chinese to target Mandarin speakers. The UBC Research Ethics Board approved the survey in February 2016.

Researchers created the survey using FluidSurvey, UBC's online survey tool. As the survey was only for residents of these buildings, all recruitment was through email mailing lists maintained by building management. This lists should be distributed to all residents and owners of these buildings. Survey respondents were entered into a drawing for one of four gift cards of \$25.00 from local businesses.

Dahlia, Magnolia and Nobel House residents received their initial email link to the survey via listserv on March 6, 2017 and received an email reminder on March 22, 2017. Sitka residents received their initial email from their Strata Management group on March 13, 2017. Sitka management declined to send a follow-up email to residents. The survey was closed to all responses on April 10, 2017.

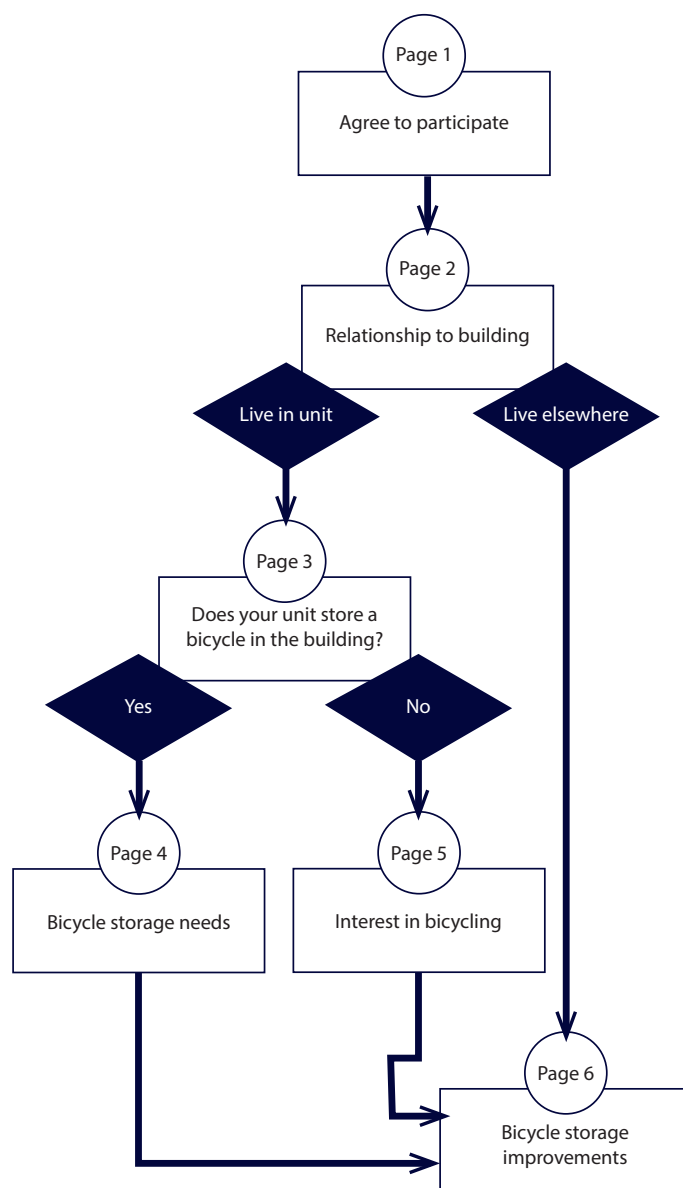


Figure 21: Survey branching diagram

RESULTS

Respondent Profiles

There were 74 responses to the survey (2 of these were to the Simplified Chinese survey). Three of these responses were not included in the analysis as they did not indicate which building they had a relationship with or indicated “Other” as the building they were connected to.

All the residents of UBC PT buildings are renters and this was reflected in the survey with all 64 respondents from this building identifying as tenants. Of the 7 Sitka responses, 5 are owners living in the unit, 1 was an owner living elsewhere and 1 was a tenant. Respondents took an average of 12 minutes to complete the survey.

The survey asked respondents to provide the number of persons in their household by their age range. The household profile for each building is compared below to census tracts: 0069.01 (which includes Sitka) and 0069.02 (which includes Dahlia, Magnolia and Nobel) from the 2016 national census (Table 6).

The average Sitka household is smaller than the census tract average while the UBC PT buildings’ averages are higher. The adult to child ratios follow a similar trend (Statistics Canada, 2017).

Residents also provided their primary occupation and household income range (Table 7). Given that residents of the UBC Properties buildings must have at least one tenant working at UBC, it is not surprising that most respondents work at UBC. The median household income in the survey sample was in the \$100,000 to \$124,999 range which is higher than UBC’s census tract (\$35,698 in the 2011 National Household Survey), which includes many students, and Vancouver’s (\$56,113) (Statistics Canada, 2011).

The link between bicycling and income is unclear, however those with a higher income in North America are more likely to own a bicycle and have better storage options (Heinen, Van Wee & Maat, 2010).

Most respondents (94%) felt bicycle storage is “important” or “very important” to them (Figure 22). This survey is likely biased towards residents who were more interested in bicycle storage. Given the limited responses from Sitka residents, this is likely a greater issue for this building. Bicycle storage is clearly an important issue for many residents of these buildings.

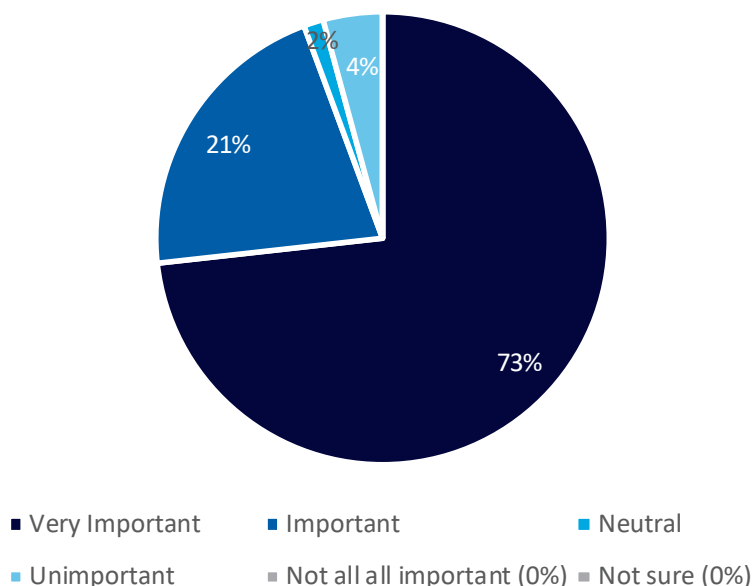


Figure 22: Residents responses to “How important is bicycle parking to you?”

Table 6

Respondent summary chart.

*Source: Census 2016 (Statistics Canada, 2017)

Location	Responses from Building (n = 71)	Average Household Size (persons)	Percentage of Households Adults (18+)
Dahlia	24%	2.6	77%
Magnolia	15%	2.5	74%
Nobel	51%	3.4	61%
Sitka	10%	1.8	100%
CT 0069.01*	-	2.3	87% (19+)
CT 0069.02*	-	2.3	82% (19+)

Occupation Chart

Percentages do not add to 100% due to rounding. *Percentages are too low to report individually.

Location	Full time at UBC	Full time elsewhere	Part time at UBC	Part time elsewhere	Studying at UBC	Studying elsewhere	Unpaid work at home	Retired	Other
Dahlia	87%	7%	0%	0%	7%	0%	0%	0%	0%
Magnolia	91%	0%	0%	9%	0%	0%	0%	0%	0%
Nobel	74%	11%	0%	3%	6%	0%	0%	0%	6%
Sitka*	-	-	-	-	-	-	-	-	-

Table 7

Income Chart

Percentages do not add to 100% due to rounding.

Under \$10,000	\$10,000 to \$24,999	\$25,000 to \$49,000	\$50,000 to \$74,999	\$75,000 to \$99,999	\$100,000 to \$124,999	\$125,000 to \$149,999	\$150,000 to \$174,999	\$175,000 to \$199,999	\$200,000 to \$249,999	\$225,000 to \$249,999	Over \$250,000	Unsure or Don't Want to Say
2%	0%	2%	5%	26%	20%	9%	8%	5%	2%	3%	3%	17%

Bicycle Storage Needs

Respondents who indicated they live in a building unit and store a bicycle on site were then asked a series of question related to their bicycle storage needs. These included the number of bicycles stored at the building, the bicycles storage locations and their opinion of the storage rooms.

Self-reported bicycle numbers reveal residents store a variety of different bicycles at the building (Table 8). Using these numbers to create averages of bicycles per unit, modes and maximums reveals that some UBC PT buildings units have more bicycles stored than storage development minimums (UBC, 2016 ; Table 9). These averages are much higher than the Sitka residents, although the Sitka sample size is quite small. The varied number of bedrooms per unit likely related to average household size and average bicycles per unit.

Those with bicycles were also asked where they store their bicycles (Figure 23). For this question, multiple answers could be selected and many respondents did select multiple locations (therefore, percentages stored do not add to 100%). Most respondents (86%) reported storing their bicycles in Class I storage rooms. The "Other" responses (14%) included storage in the parkade hanging racks in Nobel; the residences of other family members and childcare locations.

Storing bicycles in units and on unit decks (and transporting bicycles through hallways and elevators to take them there) puts residents in violation of their strata or rental agreements.

Respondents were also asked how often they used their bicycles. The most-used bicycle typically saw daily (75%) or weekly (20%) use. The least-used bicycle moved daily (49%), weekly (18%), monthly (14%) or less (20%). These high rates of use may be related to interest in storage.

Finally, residents who own bicycles were asked to rate the quality of bicycle storage rooms (Class I storage) in their buildings (Figure 24). They were asked whether they agreed with the statements that the storage rooms were "secure (free from theft)," "safe (free of hazards)," "accessible (easy to access from the ground level)," "easy to use (easy room to get bikes into)," and "easy to park in (many spots are available)."

Overall, satisfaction typically feel below 40%, except for how residents rated safety. Residents of Dahlia and Magnolia house seemed satisfied with the safety of rooms (70%), but divided on how secure and easy to use. Many (60%) were unsatisfied with the availability of parking spaces.

In Nobel House, more residents rated the quality measures neutrally (29-11% of responses "neutral" for each measure). They rated the ease of use and easy of parking much lower than the Dahlia and Magnolia residents. Few responses were received for Sitka, but residents seemed satisfied with the security and ease of parking, but less positive about the safety, accessibility and ease of use.

Table 8
Bicycles stored by respondents.

Location	Standard Adult Bicycles	Non-standard bicycles & large accessories	E-bikes	Children's bicycles	Other types of bicycles	Total bicycles reported stored by respondents
Dahlia	30	6	0	9	0	45
Magnolia	16	3	0	5	0	24
Nobel	78	12	0	29	2	121
Sitka	3	0	0	0	0	3

Table 9

Relationships between units and number of bicycles stored.

Location	Average number of bicycles stored per unit (of all respondents)	Average number of bicycles stored per unit (of respondents who are storing bicycles)	Mode of Standard Adult Bicycles stored	Maximum of Standard Adult Bicycles stored
Dahlia	2.6	3.5	2	4
Magnolia	2.2	3.4	2	4
Nobel	3.4	4.3	3	8
Sitka	0.3	1	1	1

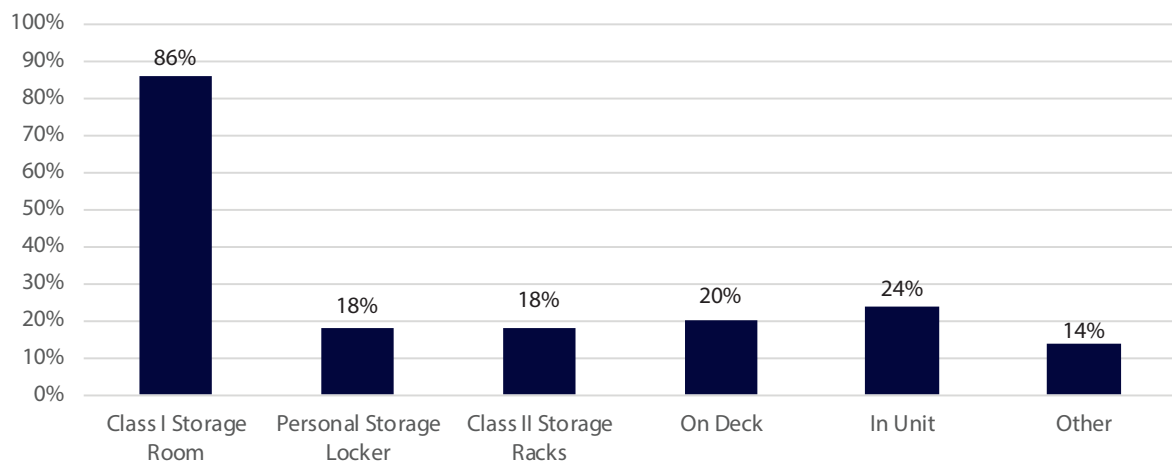


Figure 23: Locations of stored bicycles.

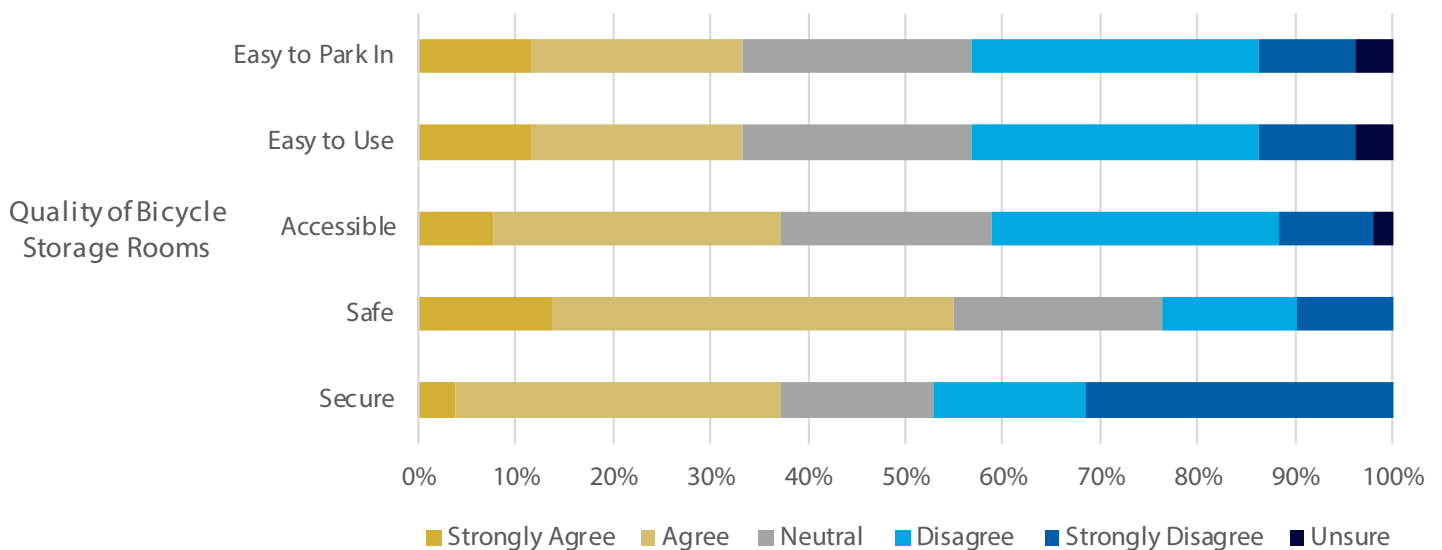


Figure 24: Residents ratings of bicycle storage (n=51).

Interest in Storing Bicycles

Respondents who did not own bicycles branched into a different series of questions that asked them about their interest in purchasing a bicycle and, if they were interested, why they had not done so yet.

Of the 17 residents without bicycles, 11 responded they were interested in owning a bicycle (Figure 25). These 11 respondents could select up to 12 discrete reasons why they did not yet have a bicycle. Residents were discouraged by the bicycle storage room is too hard to get in and out of (3); wanting to store the bike in the unit (2), owning a bicycle being too expensive (1) and the bicycle storage room being unsecure (1), unsafe (1) and too full (1). One respondent also felt it was too expensive to own a bicycle.

All respondents who did not own bicycles were also asked if better bicycle storage would increase the likelihood they would own a bicycle (Figure 26). Many (60%) said this would improve the chance they would acquire a bicycle. These two questions show some potential demand from residents of all buildings if storage is improved.

Rating Bicycle Storage

In the final section, respondents provided feedback on the current bicycles storage in their building and a large majority were in favour of improvements (88%).

Residents provided further feedback by ranking a series of hypothetical improvements to their

storage from most preferred to least preferred. Those with the highest ranking were assigned a value of "1," and the next ranked "2" and so on down to the least preferred being assigned a value of "8" for each resident. Since respondents did not have to rank all improvements, any improvements that were not ranked were also assigned a value of "8." Finally, ranking values were summed for each improvement. Rankings with the lowest value were the most preferred and rankings with the highest value were the least preferred.

"I do not trust the bike rooms to hold anything of value and consider them to be useless."

- Dahlia Resident

Those who answered this question positively were also asked to rank the type of improvements that could be made (Table 10). Residents in all buildings were interested in more secure storage. UBC PT residents were also interested in storage at ground level and less crowded storage while Sitka residents ranked storage in their unit and covered storage as their top ranked improvements beyond security.

Residents were also able to write-in additional suggestions for improvements. Thirty respondents choose to write in a response and many of them reiterated concerns related to security and overcrowding. They also identified other possible

Interest in Owning Bicycle
(n=17)

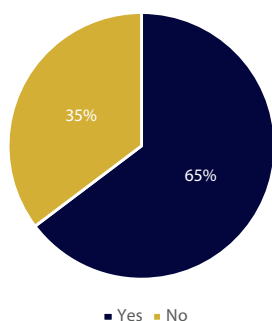


Figure 25: Residents without a bicycle interest in owning one.

Interest in Owning Bicycle
if Better Storage (n=15)

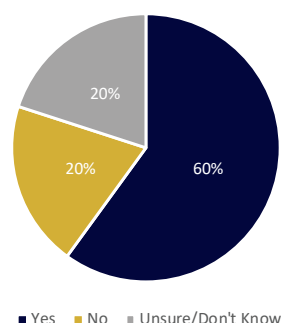


Figure 26: Residents interested in owning a bicycle who would be more interested if bicycle storage was improved.

improvements such as bicycle cleaning stations (5); individually assigned rack spots (5); racks for different sizes of bicycles (such as carriers, children's bicycles and bicycles with baskets) (4); bicycle lockers (2); more general storage (2); bike share (1) and better lighting (1).

Two other themes were threaded through these open-ended comments and others within the survey. First, five residents specifically mentioned

"The bike room we are assigned to is in the opposite corner of a connected building, requiring us to walk through the entire parkade. While this is totally doable and we do it daily (with small children, groceries, bags, etc), the management has been unwilling to assign bike storage space closer to the tenant[s] unit."
– Magnolia Resident

"We would absolutely need a washing station...even to share [it] with cars."

– Dahlia Resident

difficulties looking after children and transporting large carriers while navigating multiple doorways and gates every day, especially when transportation additional loads like groceries. They wanted architects and developers to consider how they would travel from unit to parkade to vehicle entrance and back again.

Second, four respondents asked for more support for bicycle owners in UBC PT buildings given UBC's sustainability principles. A Nobel resident mentioned that bicycle parking in the parkade only be rented with motor vehicle parking spots favoured motor vehicle owners. These possible improvements and themes will be considered in the final best practices chapter of this report.

Table 10
Resident Ranking of Improvements to Bicycle Storage (* = Tie Ranking)

Location	Overall	Dahlia & Magnolia	Nobel	Sitka
Storage at ground level	4	2	4	8
Storage in my unit	7	8	7	1*
Storage spots exclusively for my unit	3	4	3	5
Less crowded storage	2	3	1	7
Easier to enter storage	5*	7	5	4
Covered storage	5*	5	6	3
Secure storage (protected from theft)	1	1	2	1*
Adding a bike repair station	8	6	8	6

Relationships to Ratings

After looking at these questions individually, variations in storage ratings were used to determine if different groups of residents rated possible changes to their building storage differently (see Table 11). First, households with and without children were compared to the average ratings. For the most part, these groups stayed relatively close to the average overall ranking on most possible upgrades except for preferences for in-unit storage and less-crowded storage. Those without children preferred in-unit storage (which may relate to having more expensive bicycles) while those with children were interested in less crowded storage.

The number of bicycles also made a difference in rankings for in-unit storage and crowding. Those without bicycles ranked almost every upgrade lower than the overall average except for ground-level access. Residents with one or two bicycles ranked in-unit storage, easier to enter storage and secure storage much higher. Interest in storage within units and secure storage may again relate to residents owning more valuable, among other possibilities.

Ranking averages are also compared in Table 11 to where residents reported storing their bicycles. Since over most respondents reported storing bicycles in the Class I storage, these rankings were very close to the overall average. Responses from residents who stored their bicycles in other storage locations showed rankings related to their storage choice. For example, residents who stored their bicycle outside were more interested in covered and secure storage than the overall average.

"Children's bikes need to be close to our unit if not in the unit [or] on the balcony. For the kids to use the bikes regularly, they need to be able to get them without any difficulty."

– Dahlia Resident

Two other groups showed a noticeable variation from the overall average: residents who reported storing bicycles in storage lockers and in their unit. Residents who used storage lockers ranked covered, less crowded and easier to enter storage

Table 11

Relationships between average ranking of possible improvements and number of children, number of bicycles and storage location for households (HH).

Averages	Storage at ground level	Storage in my unit	Storage spots exclusively for my unit	Less crowded storage	Easier to enter storage	Covered storage	Secure storage	Adding a bike repair station
Overall	5.0	5.8	4.4	4.0	5.1	4.9	2.8	6.1
HH with children	5.0	6.3	4.3	3.5	4.9	5.0	2.9	6.3
HH without children	5.1	5.2	4.4	4.7	5.3	4.9	2.7	5.9
HH without bikes	4.8	6.0	4.0	5.4	6.3	5.6	3.9	6.6
HH with 1-2 bikes	5.2	5.2	4.5	4.5	4.5	4.9	2.5	6.4
HH with 3+ bikes	5.0	6.0	4.5	3.4	4.9	4.7	2.6	5.8
HH using common storage room	5.0	6.2	4.6	3.4	4.7	4.7	2.6	5.8
HH using storage locker	5.0	6.1	4.3	2.4	4.1	3.9	3.6	6.6
HH using Class II storage	4.9	5.8	5.3	4.9	5.4	3.3	2.1	5.4
HH using unit deck	4.1	6.1	4.4	4.1	4.6	4.4	2.1	6.3
HH using unit	5.4	3.6	5.5	4.9	5.0	4.1	1.8	6.6
HH using other location	4.3	6.6	2.6	3.0	6.3	6.0	2.1	7.3

much higher than other residents. Unfortunately, it is difficult to determine whether residents who prefer less crowded and easier to enter locker space or if residents find the Class I storage rooms too difficult to enter and use their storage lockers instead. Regardless of which implication is correct, these results shows that residents either find their storage hard to navigate or would be more likely to use storage rooms if they were easier to use.

Those respondents who reported storing their bicycles in-unit also had a preference for in-unit storage (more than two ranks above the average) and were less interested in reducing crowding and more interested in secure storage. Interestingly, they were also less interested in storage spots exclusively for their bicycle than other households. Again, these results may signal respondents consider their bicycles too valuable to store anywhere except their unit. To have them switch to another storage location, it would likely need to be as secure as their unit.

"In the past 5 years we have 2 bikes stolen and one destroyed as result of an attempted theft, with a total loss of >\$6000 (these were racing and touring bicycles). All bikes were locked with high quality u-locks."

– Magnolia Resident

Looking over all the results, secure storage remained the highest ranked improvement that could be made to building storage for all groups. More than anything else, residents wanted to

know their bicycles would be safe from theft or tampering. Given that "50% of cyclists had been victims of bicycle theft" (Bachand-Marleau, Lee et al., 2012 d in Van Lierop, Grimsrud & El-Geneidy, 2015, p. 5), theft and security is a common concern for many bicycle owners, not just these residents. Although numerous bicycles were unlocked in storage rooms, they may be bicycles with a lower value to residents or they may not have considered locking their bicycle as a viable security measure. Suggestions property managers and developers can take improve security can be found in the final best practices chapter.

Possible Errors

The distribution method of this survey created several possible errors. First, since units were not sent an individual link, multiple members of a household or a single resident could fill out the survey multiple times. Second, residents must be receiving and reading emails from the building listserv to receive the survey notice. Sitka residents also did not receive a survey closing reminder toward the end of the survey period.

Although there was a Simplified Chinese version of the survey, a language barrier may still have prevented residents not fluent in English from responding. Residents who could read Simplified Chinese would need to view the bottom half of the email to see this letter, possibly leading to a lower response rate. Possible participants who cannot read English or Simplified Chinese could not take this survey. In the future, targeting UNA households with different methods, such as distributing surveys through grade schools as is done in China should be considered (Lusk, Wen & Zhou, 2014).

DISCUSSION

The responses to survey questions provide information of value to recommendations for the function and form of bicycle storage in these buildings.

Bicycle Storage Minimums

To begin with, the higher average number of bicycles stored per unit in UBC PT buildings than Sitka directly relates to the residential demographics and design of these buildings.

A unit with two to four bedrooms, especially in family-based housing, will likely have a household-size average at or above the census tract's 2.3-person size. Despite additional storage in the parkade, residents of Nobel (which has larger three or four bedroom units) ranked reducing crowding as their top way to improve bicycle storage.

Currently, bicycle storage minimums are assessed on a per unit basis (UBC, 2014b; UBC, 2016). These minimums do not reflect the number of possible residents, which may be connected to the overcrowding in storage areas. This holds true in Nobel (which has larger three or four bedroom units), where residents ranked reducing crowding as their top way to improve bicycle storage (Figure 24). To reduce overcrowding, bicycle storage minimums aligned with the number of residents living in the building rather than a standard measurement for all units.

"The current bike storage is awful, we should at least be able to keep bikes in our [unit]."

– Sitka Resident

Raising minimums could support individually assigned spots as minimums would guarantee an acceptable minimum number of spots per unit. UBC PT residents were interested in parking spaces assigned to their unit. However, there would likely always be residents who would like to store more bicycles than they are assigned. Alternative solutions, in addition to increasing Class I storage minimums, should be considered to alleviate pressure on commons storage areas.

When considering the number of bicycles residents stored, the amount of latent demand should also be considered. Many residents who did not own a bicycle and were interested in owning one reported improved bicycle storage would encourage them. An increased supply of bicycle storage or improvements to storage may induce further demand. As UBC improves other on- and off-road bicycling facilities in residential areas and on campus, demand will likely grow.

"I would like to see bikes valued the same or more than cars, considering UBC is trying to be more sustainable. Some people in Nobel House who pay for a parking space get private bike storage racks with their parking space. My household makes ~\$75,000 per year annually and we don't have a car; we depend on bikes and public transit. I just wish UBC would value us and try to support us more since we are actually more... sustainable in terms of our lifestyle without a car. It is already quite expensive to live on campus just to work at UBC."

– Nobel Resident

Improving Bicycle Storage Quality

Reducing occupancy ratios (overcrowding) by comfortably meeting current and latent storage demand should not be the only consideration for improving bicycle storage. Many residents also felt that bicycle storage rooms were not sufficiently secure and wanted to see security upgrades (see Figure 24 and Table 10). Several residents directly linked security and their decision to store bicycles in their unit or on their deck.

There are several types of solutions to improve security including improving surveillance (passive and active), allowing residents to store bicycles in their units and providing bicycle lockers. Residents with expensive bicycles may be willing to pay an additional cost for a locker or added deposit for in-unit storage. Providing this type of storage could reduce overcrowding and improve security for residents with the most expensive bicycles.

Removing expensive bicycles from common storage may even reduce overall bicycle theft in the building, although further study would be

needed. Many of these concerns with security and overcrowding were also mentioned by residents who did not own a bicycle.

Dahlia, Magnolia and Nobel residents were also interested in storage at ground level. Some of the bicycle rooms are not “on the way” to the entrance from most units. One Dahlia and Magnolia resident reported being assigned a room across the parkade far from their unit. Reducing these distances could improve the connection between street and unit for residents who bicycle.

Sitka residents rating of current storage and ranking of possible improvements to bicycle storage were quite different than UBC PT buildings. However, the response rate was much lower, so all results for this building should be considered with the low sample numbers in mind.

“I think UBC should prioritize bike storage space rather than cars if we are truly to make this a sustainable community. There are so many empty parking spaces which are wasting space when we really need more biking storage. I end up using public transit instead of getting exercise by riding my bike sometimes because it is such an issue.”

– Nobel Resident

The Sitka resident who did respond to the survey had the same storage security concerns as UBC PT residents. They were also interested in covered storage and easier to enter storage. This indicates that storage may be difficult to access and encourage residents to store outside the building where their bicycles are exposed to weather.

Embedded in the decision to improve guidelines for bicycle storage and retrofit existing parking is to what degree UBC would like to encourage bicycle transportation on campus. Increasing bicycle storage minimums and improving bicycle storage will likely increase the number of residents who want to store bicycles and the number of bicycles they store. These are only valuable outcomes if Campus + Community Planning desires these outcomes.

Conclusion

Overall, the survey results outline the demands and potential demand in the building for bicycle storage, which may be comparable to similar buildings at UBC PT. However, as Sitka residents were only 10% of the respondents, further study is needed into how responses may differ for residents of market housing on campus. Residents were also able to provide feedback on their opinions of bicycles storage and suggestions for changes deepening responses.

These results can be used to narrow and select best practices solutions for the design and management of bicycle storage for privately- and institutionally-owned residential at UBC.

BEST PRACTICES

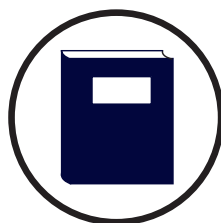
BEST PRACTICES FOR BICYCLE

STORAGE IN MULTI-UNIT BUILDINGS

The following best practice guidelines are provided as a supplement to bicycle storage facilities discussions. They are intended for use for residents, architects, developers and policy makers looking at mid-rise and high-rise multi-unit residential buildings. Measurements and suggestions are given in brief in these guides. Those looking for specific drawings related to suggested measurement lengths can find many suggestions in the resource list where best practices were drawn from.

RESOURCES

1. Bell, P. (2015). [Coming to a stop: All ages and abilities bicycle parking in new and existing development.](#)
2. Broom, N. (2015). [Essentials of bike parking: Selecting and installing bicycle parking that works.](#) Association of Pedestrian and Bicycle Professionals.
3. Cambridge City Council. (2010). [Cycle parking guide: For new residential developments.](#)
4. Celis, P., & Bølling-Ladegaard, E. (2008). [Bicycle parking manual.](#) The Danish Cyclists Federation.
5. City of Toronto. (2008). [Guidelines for the design and management of bicycle facilities.](#)
6. Information and Technology Centre for Transport and Infrastructure [ITCTI]. (2007). Design manual for bicycle traffic. Ede, de Netherlands: CROW.
7. Luton, J. (2005). [Bicycles at rest: a bicycle parking best practices guide.](#)
8. Lusk, A., (2016). [Promoting bicycling through creative design: Innovations for bicycles and cycling facilities.](#)



BICYCLING SPACE MINIMUMS

BEST PRACTICES

Local bicycle parking minimums and green building standards for new developments often apply to large regions. They do not consider the demographics of the building residents or the buildings location and cultural context. In the Netherlands, federal minimums are 2 to 2.5 bicycles for every 100 m² (1075 ft²). It is assumed that each resident will own more than one bicycle (ITCTI, 2007). For LEED, standards are set relative to the number of occupants (Canada Green Building Council, 2009). Unlike UBC and Vancouver standards, these minimums are decided based on the number of people who typically live in different sized units (UBC, 2016; City of Vancouver, 2014). Moving away from per unit minimums to per bedrooms or an area measure (m²) which creates storage capacity that better reflects residents' storage demands.

More over, these guidelines treat capacity as static and do not encourage developers to build in any potential for capacity expansion if trends changing (ITCTI, 2007). The Danish Cyclists Federation suggests "good parking boosts demand" and encourages building for up to a 25%

increase in capacity (Celis & Bølling-Ladegaard, 2008, p. 14). Even during the design phase, developers and architects should consider how bicycle parking could be expanded in the future through additional space in storage rooms, adding secure above ground parking and converting vehicle parking spaces.

Going further, minimums could also consider bicycle storage through the whole building, including units. Bicycle-oriented development (BOD) integrates bicycle use into the entire building by designing all elevators, corridors, ramps and units with bicycles in mind (e.g. the 8-house by BIG). These projects can be more economically efficient because of the cost difference between bike parking and motor vehicle parking. Guidelines should be written to encourage these types of developments.

Ultimately, bicycle parking minimums should focus on anticipating the number of residents rather than the number of units. See the following tables for examples of Class I & II storage in selected cities (Table 12) and green building systems (Table 13).

Table 12

Comparison of Class I & II storage minimums in different cities.

Location	Class I Storage Minimum	Class II Storage Minimum
UBC Development Handbook (2016)	1.5 / unit	16 / 35 units (0.46/unit)
UBC Vancouver Campus Plan: Design Guidelines (2010)	0.75-1.5 / unit	0.2 / dwelling (25% under cover)
City of Vancouver (2014)	1.25 / unit	Min. 6 / building (>20 units)
City of Vancouver (Low Rise, Ground-Oriented) (2014)	1.25 - 2.25 / unit	1 / unit = <20 units ; >20 = Min. 6
City of Richmond (2009)	1.25 / unit	0.2 / unit
Simon Fraser University (City of Burnaby, 2005)	1 / unit	0.2 / unit
District of Squamish (2012)	2 / unit	Min. 6 / building (>10 units)
City of North Vancouver (2017)	1.5 / unit	0-19 units = 0 ; 20-59 units = 6; 60+ = 6/60 units
District of North Vancouver (2017)	0.2 / unit	Min. 6 / building
City of Coquitlam (2016)	1.25 / unit	Min. 6 / building
City of Surrey (2017)	1.2 / unit (where there are >30 motor vehicle parking spaces)	Min. 6 / building
City of New Westminster (2001)	1.25 / unit	Min. 6 / building
Cambridge, England (2010)	1 / bedroom up to 3 bedrooms, then +1 / bedroom	-
Central City plan district, City of Portland, Oregon (2017)	1.5 / unit	1 / 20 units (min 4)
Hong Kong (Government of HK, 2016)	Within 2 km of rail station = 1 / 15 units; Further than 2 km from rail station = 1/30 units	-

Table 13

Comparison of Class I & II storage minimums in different green-building rating systems.

Rating System	Class I Storage Minimum	Class II Storage Minimum
REAP Version 3.0/2.1 (UBC, 2014a; 2009)	1.5 / unit (+ 0.25 optional)	16 / 35 units (0.46/unit)
LEED for Homes V2009 (Mid-rise Buildings) (Canada Green Building Council 2009)	Spaces for 15% of Occupants (Optional Credit) Assume 2 residents/studio & 1 bedroom, +1 for each additional bedroom	-
LEED V4 (U.S. Green Building Council, 2017)	Spaces for 30% of occupants (Min. 1 / unit)	Spaces for 2.5% of peak visitors (Min 4)
Dutch Building Decree (ITCTI, 2007)	Class I storage will be 6.5% of usable dwelling surface (~1 / occupant)	Relative to building context.
Association of Pedestrian and Bicycle Professionals (Broom, 2015)	0.5 / bedroom (Min. 2)	0.05 / bedroom (Min. 2)
Ecological Urbanism (Rueda, de Cáceres, Cuchí, & Brau, 2012)	~2 / unit	Relative to building context.

CLASS II RACK LOCATION

BEST PRACTICES

CHECKLIST

- ☐ Easy to Find
Parking should be “on the way” to building entrance from key destinations and bike routes. Visitors should be able to bike up to racks, rather than dismount. This encourages guests to bicycle and discourages them from locking to street furniture.
- ☐ Visible
Parking racks should be visible not just to cyclists but to all street users to reduce the chance of collisions.
- ☐ Away From Pathways
Located in a way that does not limit other street users’ movements by placing racks in line with street furniture and landscaping.
- ☐ On-site
Racks should be a maximum of 15 m (50 ft) from the main entrance or significant side entrance.
- ☐ Safe Day & Night
Passive surveillance can be encouraged by placing racks near areas with high volumes of foot traffic, such as building entrances, and in view of residents. Racks should be located near street lights or a dedicated light source to lengthen to encourage nighttime use and surveillance.
- ☐ Sheltered
Protected from rain.
- ☐ Attractive
The racks and area immediately around them should be kept clean and in good condition.

Class II bicycle storage is “intended for the short-term use of patrons or visitors” (UBC, 2016, p.7-4). Inadequate or inappropriate locations for Class II storage can harm street users and discourage visitors from bicycling.

AVOID

- Abandoned bicycles and clutter. Clean garbage and remove unclaimed bicycles regularly.

CHALLENGES

- Space
Consider angled parking, grouping racks together and in-street corrals.

EXAMPLES



Figure 27: Covered racks at Spirit & Ultima are “on the way” to the entrance.



Figure 28: At Academy, racks are hidden past the entrance and guests are forced to dismount to find them.

CLASS I STORAGE LOCATION

BEST PRACTICES

CHECKLIST

☐ At Grade/Ground-Level

Bicycle storage should be placed at ground level for easy access, if possible. Ground-level access can also improve resiliency to flooding and earthquakes when parkades may become too dangerous to enter. Bicycles can be especially useful for traveling to water and food distribution points when fuel is not available and roads are impassable to automobiles and transit.

☐ Reduces Space Conflicts

Storage should be located where it reduces conflicts between residents driving and bicycling as they enter and leave the property. If not available at ground level, storage should still reduce conflict by being located on the first level of the parkade and having a separate bicycle entrance.

☐ Easy to Find

Storage rooms should be intuitively placed at the ground level or the first level of the parkade close to the vehicle and elevator entrances. Rooms should be clearly marked as bicycle storage.

☐ On-site

Storage should be on-site unless significantly more secure storage can be provided nearby. Examples of these types of Class I storage include automated parking systems from Japan and the Netherlands.

Class II bicycle storage is for the "use of residents or employees, and may consist of attended facilities, inside bicycle lockers, or restricted access parking" (UBC, 2016, p.7-4). Storage rooms that are hard to find or dangerously placed can discourage residents from bicycling or cause injury.

AVOID

- Any routes to storage that involve elevators or stairs with bicycle channels.
- Bicycle storage on 2nd level of parkade or end of parkade where automobiles and bicycles must mix for relatively long periods of time.

CHALLENGES

- Limited ground level space and room for ramps.

☐ Accessible & Convenient

Residents should be able to travel from unit to storage to street with minimal obstacles. Ramp grades into parkade should be comfortable for those on bicycles (max 7% grade rather than vehicles (15% standard).

☐ Secure

Class I storage should be located in very visible areas within sight of other residences, businesses and open spaces where there are relatively high foot traffic volumes and room doors should be well-lit and in sight of surveillance cameras, where installed.

CLASS I ROOM ORGANIZATION

BEST PRACTICES

CHECKLIST

☐ For all types of bicycles

There are many types of non-standard bicycles (children's, cargo, long-tail, recumbent, tandem, folding, big tire) and large accessories (carriers, trailers, baskets, panniers). These all have unique space needs such as different lengths, pedal heights and widths (details are provided in the Capital Regional District "Trip Enhancement Facilities" (2008).

These bicycles should have ample room to maneuver into and out of the room and aisle. Consider aisle lengths, space between racks and turning radius at doorway to find a good fit.

☐ Comfortable

Rooms would be painted light colours and well-lit. A minimum and a maximum number of bicycles should be allowed in each room.

☐ Accessible

Doors should be wide enough for bicycles to enter and pass beside each other (2 m/6.6 ft). The number of doorways between the street and storage should be minimal and they should not be in quick succession if there are multiple doors (at least 3.5 m/11.5 ft between them). Corridors should be wide enough for bicycles to travel and turn around in.

☐ Easy to Use

Residents of all ages and abilities should be able to use most parking spaces. Racks that are hanging or require residents to lift bicycles are not accessible for these users.

Class I (Long-term) storage rooms should provide residents with locations to store their bicycles. If rooms are not secure, accessible and comfortable to use, residents may cycle less, abandon bicycles or store bicycles in other locations (such as in units or outside building).

AVOID

- Racks which require residents to lift bicycles.
- Two-tier racks. Even those with a mechanical assist can be difficult to use.
- Long aisles and overly large bicycle rooms.

CHALLENGES

- Encouraging users to park in back room.
- Can include different types of storage or amenities like compressed air or bicycle repair stands to draw users to back (Celis & Bølling-Ladegaard, 2008, 2008).

☐ Secure

Rooms should be secured with an electronically controlled locks and open with a fob or access card. Doors should be reinforced, self-locking and self-closing. Rooms should be fully-enclosed, rather than caged.

☐ Supportive

Not all residents are familiar with the basics of bicycle storage. Information on maintenance, rack use and encouraging high-quality bicycle locks (i.e. U-locks) should be posted within each room.

BICYCLE RACK DESIGN

BEST PRACTICES

In North America, residents and visitors expect secure bicycle racks which can support their bicycle at their destination. Poor rack design can damage bicycles and encourage theft. Visitors who are not provided with adequate racks may lock their bicycles to nearby trees or street furniture causing clutter and property damage.

CHECKLIST

☐ Fits all bicycles

A parking spot's dimensions are typically 1.8 m x 0.6 m (6 ft x 2 ft), but cargo bikes and bikes can be wider and up to 3 m (10 ft) long. The width between racks should be slightly wider than two bicycle handlebars and slightly longer than the bicycle. A percentage of spots should accommodate non-standard bicycles and large accessories (25%-33% is suggested). Many manuals offer guidelines aisle and rack spacing including the Information and Technology Centre for Transport and Infrastructure [ITCTI]'s Design manual for bicycle traffic (see Section 3.2 of manual).

☐ Secure

Racks should be durable to reduce the risk of theft or vandalism. Users should easily be able to lock the frame and wheel with a standard U-lock.

☐ Well-made

Racks should be made of carbon steel (galvanized, powder coated, thermoplastic) or stainless steel.

☐ Easy to use

Users of all ages and abilities should be able to park bicycles with ease (needing to use only one hand is a good measure). If a minimal number of tiered or hanging racks must be installed, they included a manual assist.

☐ Stable

Bicycle should easily balance (against two-points of contact or more) on the rack without any damage to the bicycle. If racks are built in inverted U-shape or similar shape, a lower bar should be included for children's bicycles to lean against (see Figure 30).

☐ Easy to Clean

Racks should be easy to clean and clean around. Avoid racks that require more than two anchor points for a two-bicycle rack.

AVOID

- Installing bicycle racks in the spiral, wave, coat hanger, grid/comb/tooth form or any rack where a bicycle is held primarily by the wheel. These are unstable, bend bicycle wheels and encourage theft.
- Forcing owners of non-standard bicycles and accessories (like cargo bikes and trailers) to park in standard parking spots. These bicycles may use more room than necessary or users will not be able to securely lock them.
- Aesthetically pleasing racks that are not recognizable as racks or reduce functionality.
- Racks that hang bicycles by the wheel.

CHALLENGES

- Racks used incorrectly. Mitigate by posting instructions on how to use rack.
- Vandalism and wear.
- Locations interfering with pedestrian movement.
- Allowing riders to “ride up” to racks as they are often on sidewalks.

EXAMPLES



Figure 29: At Sage, cluster racks are not ideal as they force bicycles together and fit only standard bicycles. If necessary, they could be used for Class II storage only.



Figure 30: At the Laureates, inverted U or staple racks are simple and efficient. A low bar can provide small bicycles something to lean against.



Figure 31: V-racks are difficult to balance bicycles against and can't support small and long bicycles without kickstands.



Figure 32: Ring and post locks also provide a stable and secure rack. Other posts can be retrofitted with rings to create them.

BICYCLE STORAGE LOCKERS

BEST PRACTICES

CHECKLIST

☐ Sturdy & Low Maintenance

Lockers should be durable and have tamper-proof fixtures. They should be made from sheet metal or fibreglass.

☐ Be perforated

All items stored in bicycle lockers should be bicycles or related accessories (helmets, air pumps, etc.). To prevent the storage of other items or dangerous goods, it should be possible to see into lockers.

☐ Roll-in/Roll-out

Opening lockers as well as removing and returning bicycles must be done with ease. Vertical (hanging) lockers should not be used as many people are unable to use them and they often fit only standard bicycles. Doors should have a clearance of at least 90° and remain open without being held.

☐ Well-located

Lockers should be out of the way of pedestrian and vehicles but still be easy to find at ground level or on the first level of the parkade. They should be within site of any security cameras and in areas of relatively high foot traffic.

Bicycle storage lockers are designed specifically for bicycles. They offer additional security and weather-protection in comparison to outdoor storage racks. Incorrectly installed lockers can damage property and encourage theft.

AVOID

- Cheap lockers that do not offer security comparable to common storage areas.
- Lockers not built for bicycles.

CHALLENGES

- High per bicycle space requirements

EXAMPLES



Figure 33: Outside the Life Science Centre, UBC bicycle storage lockers.



Figure 34: Bicycle drum in the Netherlands, another style of locker.

CLASS II STORAGE MANAGEMENT

BEST PRACTICES

CHECKLIST

- ☐ Regular

Bi-weekly or monthly checks of rooms and lockers should be part of regular building maintenance. A yearly procedure should be in place to remove any abandoned bicycles. A garbage can and metal waste bin should be provided in large rooms and emptied regularly.
- ☐ Routine

Residents should be able to anticipate and understand the cleaning, repairing and bicycle removal procedures for Class I & II storage.
- ☐ Include Repair and Bicycle Removal

Damaged racks should be repaired or removed as quickly as possible. Bicycle removal involves notifying residents in advance (2-4 weeks), tagging bicycles (with a weather-proof tie or sticker if outside) and removing bicycles who's tag has not been removed (or attached). Branding the process may increase buy-in, such as in Copenhagen where it is named the "Bike Vulture" program.
- ☐ Standard

These routines should be part of standard operating procedures as soon as the first resident moves in. They should be incorporated into contracts with building management companies and initial strata bylaws.
- ☐ Supportive of Bicycle Users & Community

Signage can remind users to lock their wheel & frame; remind thieves they are under surveillance and let users know when or how often bicycles will be removed (see Figure 35).

Managing and maintaining bicycle storage involves keeping rooms and lockers clean and working. Rooms without management systems can become uncomfortable for users and may influence their mode share choices or encourage them to store their bicycle in less secure locations.

AVOID

- Allowing bicycles to be stored in ways that may injure residents (especially children). Warn users stacking or significantly overfilling storage areas that their bicycles may be removed and help them find a better storage location.

CHALLENGES

- Abandoned bicycles
- Bicycle storage used to store unrelated objects.

EXAMPLES

- See next page for sample maintenance checklist and posted information.



Figure 35: By UBC Student Village, signs inform users of maintenance process.

BIKE RACKS & ROOM

CHECKLIST

INDOOR

- ☐ Doors opening smoothly
- ☐ Door locking automatically
- ☐ Locks working
- ☐ Room swept
- ☐ Debris removed
- ☐ Only bicycles and accessories stored
- ☐ Moving parts on racks working (Tiered-racks)
- ☐ Garbage Clean

Notes

OUTDOOR

- ☐ Racks in good shape
- ☐ No garbage or bicycle parts on ground
- ☐ No abandoned or broken bicycles
(Missing pieces, flat tires, rusty chains, etc.)

Notes

Information below or similar can be posted for residents.

DIY Bike Repair & Bike Donations

These organizations can help residents repair bicycles and take donated bicycles. They also sell used bicycles.

The Bike Kitchen (UBC Campus)
604-827-7333 - 1896 East Mall

Our Community Bikes
604-879-2453 - 2429 Main Street

RIDE ON Again
604-736-7433 - 2255 West Broadway
(Donations & sales only. Sells new & used bikes)

Bike Advocacy

Find resources at:

HUB
bikehub.ca

BEST
best.bc.ca

Register your bike with



Garage 529 (project529.com)

Bike Stores & Repair Shops

These stores sell and perform repairs.

More Bikes (Wesbrook Village)
604-558-1528 - 3322 Shrum Lane

West Point Cycles (Point Grey)
604-224-3536 - 3771 W 10th Avenue

Bikes For All
604-872-4534 - 112 E 7th Avenue

Side Saddle (Female-focused)
604-428-2453- 2496 Victoria Drive

Bike Doctor
604-873-2453- 137 W Broadway

Tandem Bike Cafe (Repairs Only)
604-428-2453- 3195 Heather Street

VanCycle (Mobile repairs)
778-881-3278

Room maintenance needed? Call _____

CONCLUSION

RECOMMENDATIONS

The following recommendations are made based on the data collected, best practice reviews and contextual analysis.

Some of the recommendations made here have already part of the guidelines in the UBC Vancouver Campus Plan (2010). These recommendations are significantly detailed and provide an excellent jumping off point for changes to the Development Handbook and REAP Guidelines.

Recommendations have been divided into design, policy, REAP, retrofitting and UBC-scale recommendations. Recommendations for further study are also included.

DESIGN

Class I

- **Improve Security.**

Changes may include improving lighting; adding more secure doors and surveillance cameras; posting "area under surveillance" signs; and locating bicycle storage where it is visible to foot traffic, as well as other residences and businesses.

- **Change minimum requirements from per unit minimums to per occupant minimums.**

This could be approximated by bedrooms or floor space. Examples can be found in the best practice section.

- **Require a minimum number of storage spaces be built for non-standard bicycles and accessories.**

Signs designating these spots for non-standard bicycles should be posted and enforced if necessary.

- **Set a maximum number of storage spaces that can be provided vertically.**

Richmond regulations state a 33% maximum (City of Richmond, 2009)

- **Provide outlets for e-bikes.**

Look to the Vancouver Campus Plan for details (2016).

- **Require Class I storage be on the first parkade floor or above.**

- **Require Class I storage be as close to vehicle entrances and elevators as possible.**

Residents driving and bicycling should mix for as little time as possible.

- **Lower parkade ramp grades to 6-7%.**

- **Require all doors between storage and exit should be self-holding and self-locking.**

- **Create bicycle locker construction guidelines.**

Bicycle storage lockers should be constructed exclusively for bicycles and not general storage lockers. They should follow the same guidelines regarding access, distance to entrances and self-holding doors as common storage areas.

Class II

- **Require storage be "on the way" from key destinations.**

This provides convenience and surveillance. Visitors should be able to "ride up" to outdoor storage without dismounting.

- **Require storage be within 15 m/50 ft of a main entrance.**

- **Require weather protection.**

Covering 25-50% is recommended.

- **Reduce Class II storage minimums for projects where developer agrees to provide covered Class II storage in visible location adjacent to the entrance.**

- **Provide space for future bike share system.**

RECOMMENDATIONS

REAP

REAP Requirements

- **Match Development Handbook Guidelines**

Additional REAP Credits

- **Provide space for and sponsor a bike share station.**

This should be contingent on a bicycle share system agreement at UBC being signed or stations already being installed. Campus + Community Planning should have input into station location both on-site and within neighbourhood context.

- **Allow and provide for bicycle storage in unit or on decks.**

This must be included as a covenant to allow bicycles within the building including in elevators and corridors. Additionally, unit doors and corridors should be of a width to accommodate bicycles. See Totem Park residence for example of storage system.

- **Provide bicycle storage lockers, in addition to common storage minimums (or potentially a small percentage of common storage).**

These must be designated exclusively for bicycles and bicycle accessories. Lockers must meet best practice industry standards and meet the Class I standards in the Development Handbook regarding location, solid floor, etc.

FUTURE STUDY

- **Consider number of stalls rented in UBC PT buildings.**
- **Examine storage demand in market housing further.**

POLICY & MANAGEMENT

- **Fulfill development minimums in common storage areas.**
- **Allow residents with ground level access to store bicycles on decks and in units.**
- **Allow residents with children's bicycles to store them in units.**
- **Require bicycle storage be cleaned regularly.**
- **Encourage residents to register their bicycles with the Vancouver Police Department's Garage 529 project.**

RETROFITTING

- **Install bicycle lockers on street or in parkades.**
Lockers similar to those used on the central campus could bring additional capacity to buildings. Vinyl wraps could make them more aesthetically pleasing, if needed as is done with utility boxes on campus. Covered, on-street bicycle corrals may also be considered.
- **Install bicycle cages or lockers in motor vehicle parking spaces in parkades to expand storage.**
- **Provide hardware for storage on unit decks.**

UBC-SCALE

To encourage cycling, UBC should:

- **Expand the purple and yellow bike share system (first generation system) or bring an upgraded system (third generation system) to campus.**
- **Upgrade UBC on-road cycling facilities to match Dutch standards (ITCTI, 2007) or City of Vancouver AAA facilities guidelines (City of Vancouver, 2017)**

POLYGON HOMES

Polygon Homes (Polygon) collaborated on this project looking to better understand storage demands and resident needs. Anecdotally, they reported underutilized bicycle storage and hoped to find ways to make storage into an amenity for owners and residents of their properties.

RESULTS

Capacity and Occupancy

Class I (indoor) bicycle storage rooms in Polygon buildings have a mid-sized capacity and are at or over 100% occupancy (as storage is used, see Table 14). Relative to units, common storage is meeting or below storage minimum requirements. Bicycles stored in these rooms are primarily standard adult- or child-size bicycles. Other objects stored included scooters, strollers and a small fridge.

Sitka residents were unfortunately using racks in a way that minimized capacity. An immediate increase in capacity would come from encouraging residents to use each rack as a double, rather than single, capacity rack.

Although not all Class II (outdoor) storage is ideally located, there is ample parking in easy to find locations in newer Polygon buildings that are “on the way” to front entrances. Like all buildings in study, residents at Polygon buildings used the outdoor storage for long-term storage resulting in abandoned or damaged bicycles. A building manager also which a building manager mentioned residents store bicycles in Class II storage and regularly report theft from these racks.

Table 14
Capacity & Occupancy in Polygon Storage rooms.

Location	Capacity (True/As Used)	Accumulation	Occupancy	Common Storage/Unit
Sitka - Room 1	32/16	17	67% / 138%	1.6
Sitka - Room 2	20/10	13	65% / 130%	

Duration and Use

All strata councils in Polygon buildings declined to participate in duration studies. The average amount of bicycle use in Polygon buildings likely resembles that of UBC Properties Trust (UBC PT) buildings where there are a mix of daily commuters, weekend recreational users, sunny day users and storage-only users of Class I & II storage (and possibly in unit storage). Duration likely varies based on the demands of these users.

Unlike the UBC PT rooms, Polygon rooms were better designed with ample aisle space minimizing the “end of aisle” or “back of room” spaces that were used less often during the duration study. Maintaining these design features will likely encourage bicycle-use in the future.

Resident Preferences & Interest

The sample size for Sitka was very low, receiving only seven responses (two in Simplified Chinese), however 86% of respondents felt bicycle storage was “Important” or “Very Important.” Since there are around 30 bicycles stored and only three residents reported storing bicycles, there are likely other residents who are interested in bicycle storage, but did not reply to the survey.

Of the seven respondents, three did not own a bicycle, but were interested in buying one (a choice they reported may be influenced by storage). Sitka respondents said they stored their bicycles in a variety of locations including in the common storage room, in individual lockers, in outdoor storage and in their unit. One resident label the storage as “awful” and wanted to be allowed to store bicycles in their own unit.

Sitka respondents were also asked about the quality of storage. Those who used storage were asked to rate the security, safety, accessibility (easy to access from ground level), ease of use (easy to get bikes into room) and ease of parking (many spots available). Residents ranked accessibility and easy of use as the lowest measures relative to easy to park as the highest. The small sample size makes interpretation beyond this difficult.

Respondents were split (4 to 3) on whether storage should be improved (this was not correlated with who owned a bicycle). They rated “storage in my unit;” “secure storage;” “covered storage” (for outdoor storage); and “easier to enter storage” as the top improvements that could be made (in that order). Many of these changes could be addressed in the development phase as well as be retrofitted by the Sitka strata council. As most respondents were owners, Sitka residents may have considered the financial implications of any improvements more than UBC PT residents.

Additional considerations

In early discussions, Polygon staff identified owners and residents from Mainland China as a population of interest regarding bicycle demand and interest. As mentioned, survey responses were low for all Sitka residents, however English-language literature does offer some potential insights into this population’s preferences.

First, Hangzhou, a city with higher incomes and an educated population, has seen less of a drop-in bicycle mode share than most cities in China. This retain of cycling trips is due to high-quality on-road facilities and a successful bike share program (Lusk, Wen & Zhou, 2014). This study also revealed both men and women preferred to store their bicycles in parking sheds (defined as at grade,

and covered or enclosed), which matches other international preference surveys) (Ibid.).

Second, electronically-assisted (e-bikes) bicycles are growing in popularity in China, especially among women (Weinert, Ma, Yang & Cherry, 2007; Cherry & Cervero, 2007). Residents from China could potentially bring the trend to Canada. E-bikes could benefit residents traveling to and from the hilly UBC Point Grey campus regularly. Both of these studies show there is a potential for bicycles to be positively viewed by newcomers from these regions, if they are not already.

Overall

Overall, Class I storage rooms have reached capacity, despite reports of it being underused. Residents are interested in alternative secure options for Class I storage, including in unit storage. A separate issue is whether storage rooms are underutilized. Residents who do not have an opportunity to bicycle (or enough reason to bicycle) may benefit from better on-road facilities as well as bicycle share options.

STRENGTHS

1. Gradually improving siting and rack quality of Class II locations with each development.
2. Organizing Class I storage rooms for easy maintenance around racks and easy parking by avoiding long aisles.
3. Meeting per unit minimums in common storage in 2-bedroom building (in Sitka).

TOP RECOMMENDATIONS

1. Improve Class I storage room location by reducing distances between vehicle entrance, storage rooms and elevators to improve resident experience. Consider number of doors in path and ramp grade as well.
2. Meet storage minimums in common storage (rather than lockers tied to units or parking storage), especially for larger buildings with 3-4 bedroom units .
3. Ask UBC Campus + Community Planning to meet your off-road cycling facilities with on-road cycling facilities to help parking become an amenity rather than a minimum. This may include supporting initiatives like bicycle share (explored more fully in the rest of the report).

UBC PROPERTIES TRUST

UBC Properties Trust (UBC PT) became involved with this project to better understand resident demand for bicycle storage and whether storage was meeting those demands. They are looking for cost-efficient design and retrofitting options.

RESULTS

Capacity and Occupancy

UBC PT rooms had a wide range of capacities, however almost every room was near or over 100% occupancy (number of bicycles related to parking spaces). The rooms held a variety of different types of bicycles including several bicycle trailers which often had difficulty finding racks to lock to. Notably, none of the UBC PT common storage rooms came close to meeting UBC development standards (0.6-0.7 spots/unit vs. standard 1.5).

In Nobel use, parkade racks provided additional parking, however they were not able to accommodate any non-standard bicycles. These racks were underutilized (25% occupancy) potentially due to this and, as one resident mentioned in the survey, they were tied to the purchase of a motor vehicle parking spot.

Duration and Use

Commuters and recreational riders stored bicycles on Class I (indoor) and Class II (outdoor) storage racks. Many residents may also use indoor racks exclusively for long-term bicycle storage as 31% of bicycles in Nobel storage rooms and 42% of bicycles in Dahlia/Magnolia were not moved during the 9-week study period.

There was high regular use of bicycles in all UBC PT bicycle storage rooms. Within the first week, 33% of bicycles in Nobel rooms and 20% of bicycles in Dahlia & Magnolia were used, excluding bicycles that may have been used during the marking day. During the initial two weeks of study, bicycles closest to the entrance, rather than at the end of aisles were more likely to be used.

Resident Preferences & Interest

Bicycle storage was clearly an important issue for the 64 respondents from UBC PT buildings. Of these respondents, 95% saw bicycle storage as “very important” (75%) or “important” (20%) to them. Residents who stored bicycles in the building reported an average of 3.5 - 4.3 bicycles stored. Around 50% of these were reported to be stored in bicycle storage rooms, while the remaining bicycles were distributed evenly between personal storage lockers (9%), outdoor storage racks (8%), decks (12%), in-unit storage (13%) and other (8%). This represents significant demand not being met by common storage areas.

Residents' opinions of storage also showed that Dahlia & Magnolia residents were more satisfied overall with storage than Nobel residents. Dahlia & Magnolia residents rated their rooms as very safe (70% agreed they were safe), but less felt rooms were secure (50%), easy to access (45%), easy to use (45%) and parking spots were easy to find (25%). Nobel residents rated all of these measures lower and no respondents believed it was easy to find spots (which matches occupancy results).

All residents were also able to give feedback on potential improvements. Residents were interested in less crowded storage, more secure storage, ground level storage and spots exclusively for units. Meeting these demands, especially as retrofitting projects, can be achieved quickly.

Additional considerations

Unfortunately, these studies could not confirm whether non-residents used building storage. Removing abandoned bicycles regularly can deter non-residents from storing bicycles as could a registration or tagging program. Providing residents with tags (with more available on request) could also provide more concrete demand numbers. Additional tags tied to unit could highlight discrepancies between household and bicycles (i.e. household without children but multiple children's bicycles) and create

accountability over multiple years (i.e. households that register multiple bicycles which change multiple times per year may be “flipping” bicycles).

Overall

As UBC PT anticipated, resident demands were not being met. Meeting storage demand should be done by improving maintenance routine and expanding capacity, two issues which are likely tied and should be addressed in tandem.

Regular maintenance routine should be established, including cleaning debris and abandoned bicycles from rooms. In most bicycle rooms, debris ranging from broken locks to a vacuum remained around bicycles through out the study. Like the care of other common areas, this task should be lead by building management. Given the higher turnover in the building, disorganization and debris may be related to residents who are no longer in the building.

As noted in the study, bicycle storage is important to many residents. Management can engage these residents in room care by posting maintenance information and placing garbage and metal recycling bins in the rooms. Increasing capacity will likely also encourage room care.

Capacity can be increased by allowing residents to store bicycles in unit; improving outdoor storage; and adding additional parking spaces. The cheapest and simplest way to decrease crowding is to permit residents to store bicycles in their units or on their decks, especially residents

who have ground level access. However, as residents rank this low as an improvement, it may not be a popular solution.

Instead, covering and expanding outdoor storage racks (for weather protection) will also decrease pressure on indoor storage racks. Since some racks are not ideally situated, UBC PT may even want to consider adding covered, on-street bicycle corrals in front of the building.

Finally, capacity itself should be addressed by adding storage rooms, bicycle changes and bicycle lockers. In the survey alone, Nobel residents reported storing 121 bicycles, giving a storage demand of 1.29 spaces / unit *not including residents who did not take the survey*. Common bicycle storage rooms should meet 100% of the minimum development capacity requirements.

High-quality lockers which offer security on par with storage rooms may help meet demand, even for pre-built buildings. Lockers and bicycle drums can be installed in unused parking spots in parkades or at ground level.

There may be a tendency to view unused bicycles as taking up space. To reframe the issue, building management and Campus + Community Planning should consider how these residents could be encouraged to ride their bicycles more. UBC PT buildings have an active and engaged population interested in cycling. Making short- and long-term changes to bicycle storage will support these residents.

STRENGTHS

1. The largest storage rooms were usually close to vehicle entrance and elevator
2. Large rooms were well-lit and well-used, likely contributing to high ratings for safety of rooms.
3. Bicycle washing and maintenance station in Nobel House.

TOP RECOMMENDATIONS

1. Install bicycle lockers, bicycle cages or “bicycle drum” style storage.
2. Cover outdoor storage and place in more prominent locations.
1. In-unit storage, at least for children’s bicycles and units with direct ground access.

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APPENDICES

APPENDIX A

Email to residents informing them of the duration study in common bicycle storage rooms. Information was provided in English & Simplified Chinese.

Project: Bike Storage Facilities in UBC Residential Buildings

Dear Resident of [Building],

This email is a notification that your building will be the site of an in-depth study of [two] your bike parking rooms. This is a follow-up to the survey sent to your building regarding the study “Best Practices for Bike Storage Facilities in Multi-unit Residential Buildings.” This study of bike parking rooms will be used to update the guidelines for bicycle parking in UBC residential buildings and potentially change the design and retrofitting of bicycling facilities in buildings on the UBC campus and other locations.

For this study, every bike in these [two] bike rooms will be monitored over the course of four months. A small plain sticker (approximately the size of a small paper clip) will be placed on each bike lock in location where the sticker must be moved or broken to unlock the bike to determine if the bike has been used. For the course of study, the researcher will check each lock to see if the sticker has been moved. On the final check, the researcher will remove all remaining stickers.

Your [Property Manager/Strata Council] has approved this study in principle, however, your bike(s) do not have to be included in the study:

- **If you do not wish your bicycle to be monitored**, please place a note on your bicycle with the phrase “do not include” no later than [date of study commencement] or contact your building manager.
- **If you would like to have your bike monitored**, simply leave your bike in the study room. If you move your bike for a ride or maintenance during the study period, simply remove or break the sticker.
- Residents without bikes in the bike parking room will not be able to participate in this part of the study.

Regardless of whether you would like to have your bicycle monitored,
please only move or break the sticker on your own bike(s).

For this study, there are potential benefits and costs for buildings residents depending on their cycling and bike storage habits. This study may encourage or discourage bike use. It may encourage residents of the building to remove bicycle which are not being used, freeing space in the bike parking room or increase interest in the bike parking room. Some residents may benefit from these potential effects, while others may not.

If you have any questions about this project, please contact the primary investigator, Dr. Alex Bigazzi (alex.bigazzi@ubc.ca) or the student researcher, Cail Smith (cail.smith@ubc.ca).

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Ethics at 604-822-8598 or if long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598.

Thank you in advance for your time.

通知: UBC多层公寓自行车存放设施调查

亲爱的[insert building name] 居民,

您的大厦即将被邀参加UBC「多层公寓自行车存放设施」的研究调查。这后续调查的目的是为「多层公寓里最佳的自行车库储设计方案」作更深入的研究。这项研究的结论将应用于UBC多层公寓自行车库设计指引, 并可能应用在UBC校园内和其他地点的自行车库设计和翻新项目。

这后续调查将会对自行车库里的每一辆自行车进行一个为期四个月的监控。调查员将会在每个车锁上贴上一块回型针大小的保固贴纸, 每當要使用自行車時, 在鎖上的貼紙會被撕下或被打破以确定自行车是否有被使用过。研究员会定期检查每个自行车锁上的貼紙, 看看自行车有否被移动。在研究结束前, 研究员将把所有剩余的贴纸在锁上消除。

您大厦的[物业经理(property manager)/ 业主委员会(strata council)]已原则上批准了这项研究。

- 如果您不希望参与这次研究, 请在[Insert Deadline Here]之前在自行车挂上印有 “do not include” 的纸条, 或与您的物业经理联系。
- 如果您希望参与这次研究, 只需把自行车留在车库里。如果您在研究期间需要使用自行车, 只需打破保固贴纸。
- 没有自行车停放车库里的居民将无法参加这次的研究。

无论你是否想参与这次研究, 为了研究准确性,

请只撕下或打破您自己自行车锁上的保固贴纸。

这项研究有可能对大厦居民对自行车的使用和存放的习惯带来正面或负面的影响。本研究有可能会鼓励居民移走一直未被使用的自行车, 以及有助增加车库里中的空位, 增加居民对使用自行车库的兴趣。这项研究有可能对每个居民都带来不同的影响。

如果您有对这个项目的任何问题, 可以致电邮至 alex.bigazzi@ubc.ca 联系首席负责人 Dr. Alex Bigazzi或致电邮至cail.smith@ubc.ca 联系研究员Cail Smith。如果您有任何提问或投诉有关予作为研究参与者的权利以及您对这次调查研究的经验, 请联系UBC 研究操守委员会的投诉热线604-822-8598, 海外请致电至长途免费电话号码1-877-822-8598 或致电邮至 RSIL@ors.ubc.ca 。

谢谢您的宝贵时间。

APPENDIX B

English and Simplified Chinese versions of online survey.



THE UNIVERSITY OF BRITISH COLUMBIA

Bike Storage in UBC Residential Buildings (V2)

Page 1

Invitation to Participate

Dear Building Resident,

You have received this email invitation to participate in the study "Best Practices for Bike Storage Facilities in Multi-unit Residential Buildings" because you live in a property built by UBC Properties Trust or Polygon Development on the UBC campus. The study is being conducted by the Primary Investigator, Dr. Alex Bigazzi, and an Applied Science Master's Student, Cail Smith, with support from the UBC SEEDS Sustainability Program.

The following survey will ask you some questions about your household and how you use (or don't use) the bicycle storage in your building. Your feedback on this survey will be used to update the guidelines for bicycle parking in UBC residential buildings and potentially change the design and retrofitting of bicycling facilities in buildings on the UBC campus and other locations.

The survey should take no longer than 15 minutes to complete. Once the survey is done, you may choose to enter your contact information in a draw for one of four gift cards for \$25.00.

Participation in this anonymous survey is optional. Any identifying information will be removed before the analysis or results are presented to the study partners (UBC Properties Trust & Polygon Development).

If you have any questions about this project, please contact the primary investigator, Dr. Alex Bigazzi, at alex.bigazzi@ubc.ca. If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Ethics at 604-822-8598 or if long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598.

If you understand the statements above, are over 18 years of age, and consent to participate in the study, click the "I agree" button to begin the survey.

By clicking "I agree," you are consenting to participate in this survey.

☐ I agree.

☐ I do not agree.

Where You Live

Which building are you most connected to? What is your connection?

You are most connected to the building you live in.

If you rent multiple units, choose the building you rent the most units in. Please answer the rest of the survey based on your answer for this question.

	Magnolia House	Dahlia House	Noble House	Sitka	Chaucer Commons	Keats Hall	Promontory	The Laureates	Other
Rent unit & live in	☐	☐	☐	☐	☐	☐	☐	☐	☐
Rent unit(s) to tenants but live elsewhere	☐	☐	☐	☐	☐	☐	☐	☐	☐
Own unit & live in	☐	☐	☐	☐	☐	☐	☐	☐	☐
Own unit(s) but mainly live elsewhere	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐	☐	☐	☐	☐

How important is bicycle parking to you as an owner or renter of the building selected above?

Very important	Important	Neutral	Unimportant	Not at all important	Not sure
☐	☐	☐	☐	☐	☐

Your household

How many people, including yourself, live in your unit?

Please include any roommates.

Adults (age +18, including yourself)	0
Children (age 0 to 5)	0
Children (age 5 to 17)	0

Does anyone living in your unit store a bicycle in or outside your building?

☐ Yes	☐ No
---------------------------	--------------------------

Tell us about your bikes and bike storage needs.

How many of the following do those living in your unit (your household) keep inside or near your building?

Please include bicycles stored in your unit, storage area, bicycle storage room, parking garage or outdoor bike racks.

Standard adult bicycles

0

Non-standard adult bicycles & large accessories (including tandems, tricycles, cargo bikes, trailers and carriers without electric assist)

0

E-bikes (including all bikes with electric assist)

0

Children's bicycles

0

Other types of bikes

0

You own 0 bike(s) and accessories.

Please consider all the bikes your household owns. On average, how often is the **most used bike** ridden?

	Daily	Weekly	Bi-weekly	Monthly	Less than once a month	Never used.
Between April & Sept	☐	☐	☐	☐	☐	☐
Between Oct & March	☐	☐	☐	☐	☐	☐

Where does your household store their bikes?

Check all that apply.

- ☐ In the bike storage room (a common room exclusively for bike storage)
- ☐ In our personal storage locker (a storage area exclusively for your unit's use)
- ☐ On bike racks outside the building
- ☐ On our deck
- ☐ In our unit
- ☐ Other, please specify...

Type here

Please state whether you agree with the following sentences.

The **bike storage room(s)** in my building are:

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unsure
Secure (Free from theft)	☐	☐	☐	☐	☐	☐
Safe (Free of hazards)	☐	☐	☐	☐	☐	☐
Accessible (Easy to access from the ground level)	☐	☐	☐	☐	☐	☐
Easy to Use (Easy room to get bikes into)	☐	☐	☐	☐	☐	☐
Easy to Park In (Many spots are available)	☐	☐	☐	☐	☐	☐

Tell us about your interest in bicycling.

Are you or anyone living in your unit interested in owning a bike?

Yes

No

What is preventing you or this person from getting a bike?

Check all that apply.

- ☐ Don't know how to ride a bike.
- ☐ I don't know where to store a bike.
- ☐ I want to store my bike in my unit.
- ☐ The bike storage room is not secure.
- ☐ The bike storage room is not safe.
- ☐ The bike storage room does not have any room for new bikes.
- ☐ The bike storage room is too hard to get in and out of.
- ☐ The bike storage room is too far from the ground level.
- ☐ It's too expensive to buy or own a bike.
- ☐ It's too dangerous to ride a bike.
- ☐ It's too far from where I want go to own a bike.
- ☐ Other, please specify...

Type here

Would improved bike storage make you or this person more likely to own a bike?

- ☐ Yes
- ☐ No
- ☐ Unsure/Don't know

Tell us how to improve bike storage.

Would you like improved bike storage in your building?

Yes

No

Please rank your preference for the following possible improvements to your building's bicycle storage.

1 = most preferred, 9 = least preferred.

A. Storage at ground level	1 = most preferred	1
B. Storage in my unit	2	2
C. Storage spots exclusively for my unit	3	3
D. Less crowded storage	4	4
E. Easier to enter storage	5	5
F. Covered storage (protected from rain, etc)	6	6
G. Secure storage (protected from theft)	7	7
H. A bike repair station	8 = least preferred	8

Are there any other improvements to your building's bike storage you would like?

Type here

For your primary occupation, you are...?

- ☐ Working Full Time at UBC
- ☐ Working Full Time elsewhere
- ☐ Working Part Time at UBC
- ☐ Working Part Time elsewhere
- ☐ Studying at UBC
- ☐ Studying elsewhere
- ☐ Performing unpaid work in my home
- ☐ Retired
- ☐ Other

What is the estimated total yearly income of everyone living in your unit?

- ☐ Under \$10,000
- ☐ \$10,000 to \$24,999
- ☐ \$25,000 to \$49,999
- ☐ \$50,000 to \$74,999
- ☐ \$75,000 to \$99,999
- ☐ \$100,000 to \$124,999
- ☐ \$125,000 to \$149,999
- ☐ \$150,000 to \$174,999
- ☐ \$175,000 to \$199,999
- ☐ \$200,000 to \$224,999
- ☐ \$225,000 to \$249,999
- ☐ \$250,000 or over
- ☐ Unsure/Don't want to say

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Thank you for participating.

If you wish to enter the draw for a gift card, please input your email below.
Your email will not be connected to your survey response.

To leave this page, please click submit.

Email:

Type here

Please click submit to finish the survey.



邀请函

亲爱的居民,

这封电子邮件向你发出邀请参与由卑诗大学 (UBC) SEEDS可持续性发展计划组为UBC物业信托管理和Polygon住宅建商在UBC校园内的公寓住宅进行研究. 研究名为「多层公寓中的自行车存放设施的最佳方式」。该研究由主研究者, Dr. Alex Bigazzi 和应用科学硕士研究生, Cali Smith 跟UBC SEEDS 可持续性发展计划组共同进行研究。

下面的调查将问您有关于您的家庭和您如何使用或不使用在公寓内的自行车存放设施, 您对本次调查的反馈意见将被用于更新UBC公寓的自行车停放的指导方针以及改善现在UBC 校园内及其他地点的自行车库设计和翻新项目。

完成本调查大约需要15分钟. 一旦调查完成后, 您可以选择输入您的联系方式以抽奖方式赢得一张\$ 25礼品卡。

这是一个匿名调查, 您可选择参与与否。任何个人识别信息将会在分析前除去以及结果被呈交给学术研究伙伴前除去 (UBC物业管理信托及Polygon住宅建筑商)。

如果你对这个项目的任何问题, 可以致电邮至alex.bigazzi@ubc.ca联系项目负责人Dr. Alex Bigazzi。如果您有任何提问或投诉关于作为研究参与者的权利以及您对本次调查研究经验, 请联系UBC 研究操守委员会的投诉热线604-822-8598, 海外请致电至长途免费电话号码1-877-822-8598 或致电邮至RSIL@ors.ubc.ca。

如果你已年满18周岁, 并理解跟同意参加此研究项目, 请点击「我同意」按钮开始有关调查。

我理解跟同意参加此研究项目, 请点击「我同意」按钮开始有关调查。

☐ 我同意

☐ 我不同意

关于您的住址

您的大厦名稱。
您是租客, 承租人, 自住, 或是投資者

如果你是投資者拥有多个出租物業, 请选择出租最多住宅的大厦。
请根据您对此问题的答案回答余下的问卷。

	Magnolia House	Dahlia House	Noble House	Sitka	Chaucer Hall	Keats Hall	Promontory	The Laureates	Other
租客	☐	☐	☐	☐	☐	☐	☐	☐	☐
承租人, 替家人或朋友租住上址	☐	☐	☐	☐	☐	☐	☐	☐	☐
自住	☐	☐	☐	☐	☐	☐	☐	☐	☐
投資	☐	☐	☐	☐	☐	☐	☐	☐	☐
其他	☐	☐	☐	☐	☐	☐	☐	☐	☐

您觉得自行车存放设施对您有多重要?

非常重要	重要	中立	不重要	毫不重要	不知道
☐	☐	☐	☐	☐	☐

关于您的家庭

您的住宅内共住了多少人?

请包括室友。

成人 (18岁以上)	0
儿童 (0至5岁)	0
儿童 (5至17岁)	0

在您住宅里, 是否有成员把自行车存放在大厦内或存放在户外?

☐ 是☐ 否

关于您對自行车和自行车存储设施的需求。

请统计在您住宅里(包括家人或室友),有多少自行车和跟自行车有关配件装备停放于大厦内或大厦附近？

这地方包括存储在您的住宅，存储区，自行车存放室，停车库或户外自行车防盗架上。

普通自行车

0

特殊车形和有关配件装 （包括多人单车， 三轮车，
载货单车， 儿童拖车， 无辅助拖车）

0

电动辅助自行车

0

儿童自行车

0

其他类型的自行车

0

您总共有 0 辆自行车和跟其有关配件装备

在您住宅里，□□□的自行车的是在什么月份和使用的次数？

	每天一次	每周一次	隔周一次	每月一次	每月不到一次	从未使用过
四月和九月之间						
十月和三月之间						

您的自行车存放在：

请对勾所有适用的选择

- 在自行车库
- 在大厦储藏室内
- 在室外自行车防盗架
- 在阳台内
- 在住宅内
- 其他，请说明...

Type here

您有多同意下列有关你大厦的自行车库的句子：

	非常同意	同意	中立	不同意	非常不同意	不确定
有效防止车辆被盗						
安全舒适的内部环境						
地点方便, 邻近地面						
易于使用, 容易带自行车出入自行车库						
容易找到停车位						

关于您使用自行车的兴趣

您或您家人或室友是否会考虑买一辆自行车？

是否

是什么原因阻止您或您家人或室友去购买一辆自行车？

对勾所有适用的选择。

- ☐ 不懂得如何骑自行车
- ☐ 无存储空间
- ☐ 不能把我的自行车存放在住宅内
- ☐ 自行车库不能上锁
- ☐ 自行车库不安全
- ☐ 自行车库没有多余空间
- ☐ 自行车库位置很不方便
- ☐ 自行车库位置隐蔽的地下层
- ☐ 自行车产品定位太高,价格太贵
- ☐ 骑自行车风险过高
- ☐ 交通不方便,离我想去地方太远了
- ☐ 其他, 请说明...

Type here

改善当前自行车存放设施会否让您更想拥有一辆自行车？

- ☐ 会
- ☐ 不会
- ☐ 不知道

关于如何改善自行车库

您认为您的大厦的自行车库是否需要改善？

是

否

请按个人偏好,顺序排列以下能够改善您的大厦自行车库的项目

1 = 最优先选择的项目, 8 = 最后选择的项目

A.存储于地面楼层	1 = 最优先选择的项目	1
B.存放于住宅内	2	2
C.存储于私人专用车位内	3	3
D.有更多存储空间	4	4
E.车库地点方便出入	5	5
F.有盖的自行车库	6	6
G.安全有锁的自行车库	7	7
H.自行车维修站	8 = 最后选择的项目	8

请提供其他可以改善自行车存放室的意见:

Type here

您是从事什么职业？

- ☐ 在UBC全职工作
- ☐ 在UBC外全职工作
- ☐ 在UBC兼职工作
- ☐ 在UBC外兼职工作
- ☐ UBC学生
- ☐ 其他学院的学生
- ☐ 无酬家务劳动者
- ☐ 退休人士
- ☐ 其他

☐ 退休人士

☐ 其他

您的家庭一年总收入大约是：

☐ 少於 \$10,000

☐ \$10,000 to \$24,999

☐ \$25,000 to \$49,999

☐ \$50,000 to \$74,999

☐ \$75,000 to \$99,999

☐ \$100,000 to \$124,999

☐ \$125,000 to \$149,999

☐ \$150,000 to \$174,999

☐ \$175,000 to \$199,999

☐ \$200,000 to \$224,999

☐ \$225,000 to \$249,999

☐ \$250,000 或以上

☐ 不清楚/不想透露

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感谢您的参与。

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您的电子邮件地址:

Type here

提交完成调查