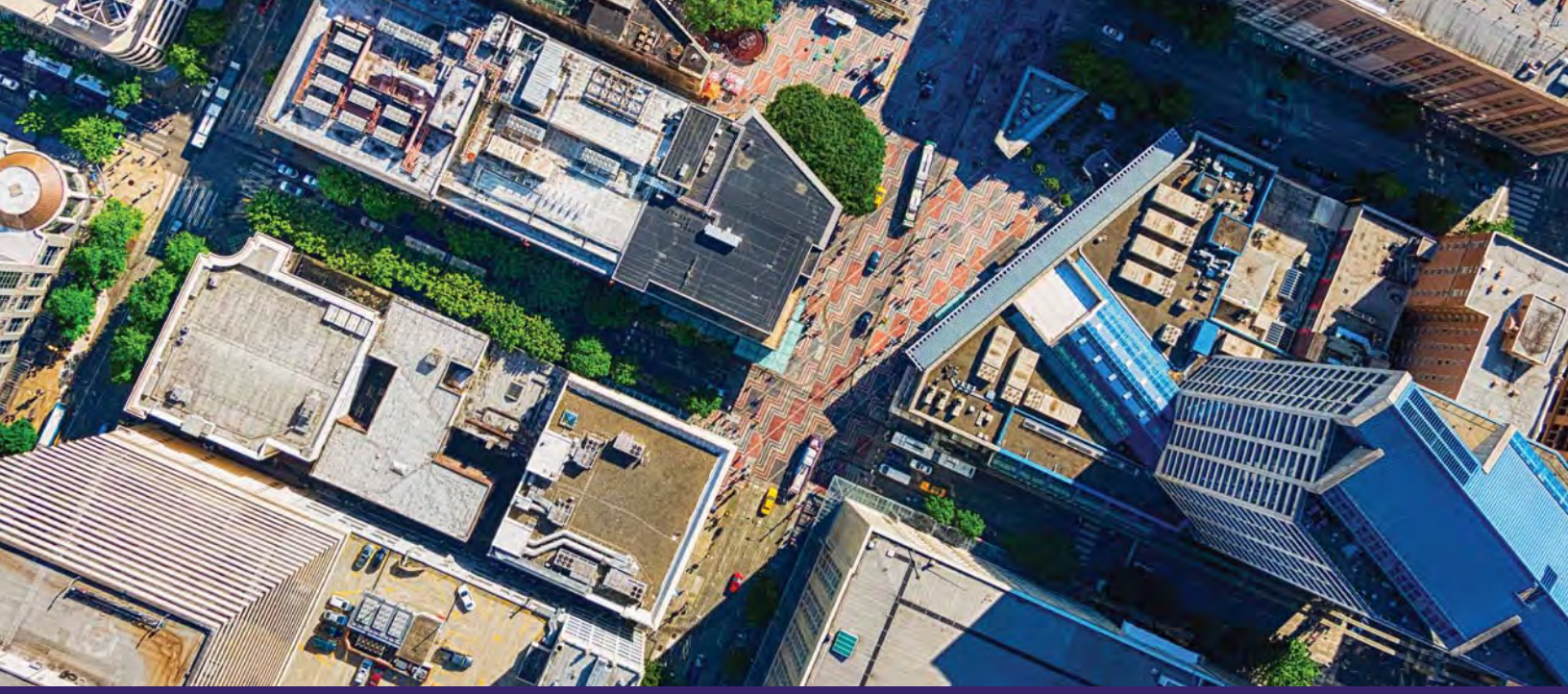

Seattle Department of Transportation

# THE FINAL 50 FEET
# URBAN GOODS DELIVERY SYSTEM

## Research Scan and Data Collection Project

**FINAL REPORT** January 19, 2018

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# INTRODUCTION

Urban goods delivery is an essential but little-noticed activity in urban areas. For the last 40 years, deliveries have been mostly performed by a private sector shipping industry that operates within general city traffic conditions.

However, in recent years e-commerce has created a rapid increase in deliveries, which implies an explosion of activity in the future. Meeting current and future demand is creating unprecedented challenges for shippers to meet both increased volumes and increasing customer expectations for efficient and timely delivery.

Anecdotal evidence suggests that increasing demand is overwhelming goods delivery infrastructure and operations. Delivery vehicles parked in travel lanes, unloading taking place on crowded sidewalks, and commercial truck noise during late night and early morning hours are familiar stories in urban areas.

These conditions are noticeable throughout the City of Seattle as our population and employment rapidly increase. However, goods delivery issues are particularly problematic in Seattle's high-density areas of Downtown, Belltown, South Lake Union, Pioneer Square, First Hill, Capitol Hill and Queen Anne, described as Seattle's "Center City".

Urban goods transportation makes our economy and quality of life possible. As the Seattle Department of Transportation (SDOT) responds to the many travel challenges of a complex urban environment, we recognize that goods delivery needs to be better understood and supported to retain the vitality and livability of our busiest neighborhoods.

U.S. cities do not have much information about the urban goods delivery system. While public agencies have data on city streets, public transportation and designated curbside parking, the "final 50 feet" in goods delivery also utilizes private vehicles, private loading facilities, and privately-owned and operated buildings outside the traditional realm of urban planning.

Bridging the information gap between the public and private sectors requires a new way of thinking about urban systems. Specifically, it requires trusted data sharing between public and private partners, and a data-driven approach to asking and answering the right questions, to successfully meet modern urban goods delivery needs.

Toward this end, SDOT has joined in partnership with the Urban Freight Lab in the Supply Chain Transportation and Logistics Center at the University of Washington, global and regional retailers, goods delivery firms, and building developers and managers to set clear and measurable goals, collect and analyze data, and pilot test promising strategies. The Urban Freight Lab (UFL) provides a standing forum to solve a range of short-term as well as long-term strategic urban goods problem solving, that provides evidence of effectiveness before strategies are widely implemented in the City.

This report includes information on the first of many research tasks planned for the partnership between SDOT and the Urban Freight Lab. This is the first assessment in any American city of the privately-owned and operated elements of the Final 50 Feet of goods delivery supply chains. These include private truck freight bays and loading docks, delivery policies and operations within buildings located in Center City.

CHAPTER 1

# INDUSTRY SECTOR RESEARCH SCAN

Three driving forces are rapidly transforming the urban goods delivery system in Seattle and other cities:

- The growth of e-commerce in dense urban centers;
- The strategic imperative for freight delivery firms to match the e-commerce growth curve and to provide fast and reliable delivery times expected by online shoppers; and
- The emergence of new technologies in the supply chain and logistics sectors.

While the retail sector is reshaping urban goods demand and truck traffic patterns, the contours of the City of Seattle's built environment are also in a period of dynamic change. The City is developing urban centers with walkable and enticing neighborhoods of residential and office towers, and planning for increased transit and bike lanes. Tech sector employees are filling high-rise office and residential towers in the downtown and South Lake Union areas. [1]

Seattle's downtown center set records for construction activity across residential, office and hotel sectors in 2016 [2]. Residential development was very strong and the Seattle Downtown Association predicts that there will be 6,000 new units constructed over the next year. Two-thirds of the buildings under development contain a residential component. In addition, nearly 12 million square feet of new office space is expected to be built by the end of 2019. This is about the same amount added in the previous 12 years, tripling the pace of office development downtown.

The U.S. Census Bureau listed Seattle as the fifth fastest-growing large U.S. city by numeric population increase from July 1, 2015 to June 30, 2016. [3] Seattle's population grew by 20,847 people during that time, and totals 704,352 in 2017. The 2010 Census put Seattle at 608,660, showing that the city grew by nearly 100,000 new people in just six years. Seattle's density is now around 8,350 residents per square mile. [4]

The City of Seattle was also the sixth most congested city in North America, and the fourth in the U.S. behind Los Angeles, San Francisco and New York, according to the 2016 TOMTOM Traffic Index.

Seattle's growth reflects global urbanization trends, and a deeper understanding of the trends reshaping the city's goods delivery system will be valuable in other urban centers. 54% of the world's population currently live in urban areas [5] and the World Bank estimates that by 2045, 2 billion more urban residents will be added to the number. A U.N. report predicts that by 2050, 66% of the world's population will reside in urban areas. [6] In North America in 2014, 82% of the population lived in urban areas. Cities consume close to 2/3 of the world's energy and account for more than 70% of global greenhouse gas emissions.

The City of Seattle is engaging in several innovative planning efforts to manage and improve transportation in the face of such growth. One Center City is a partnership formed by the City of Seattle, Sound Transit, King County, and the Downtown Seattle Association to build an integrated plan that makes it easier to get around and enjoy Center City both in the near-term and over the next 20 years. The plan's goals are to improve mobility, and foster vibrant street life and great public spaces. [7] The Seattle Department of Transportation (SDOT) published Seattle's first Freight Master Plan [8] in 2016. The plan recognizes anticipated growth and includes high-level policy recommendations and potential strategies to improve the urban goods delivery system.

The growth of total e-commerce sales is causing tremendous impacts on urban goods delivery systems.  It is putting pressure on local governments to rethink how they manage street curb parking and alley operations for trucks and other delivery vehicles. It is also forcing residential and office building developers and operators to plan for an influx of online goods.

This chapter will describe urban goods delivery trends in light of the City's anticipated growth.

# The Growth of E-Commerce: Moving More Goods, More Quickly

Growth in U.S. online sales has averaged more than 15% year-over-year since 2010.  E-commerce sales in 2016 were almost $395 billion, up 15.1% from 2015, while total retail sales increased by only 2.9% in the same time period.

E-commerce sales in 2016 were 8.1% of total sales, growing from 7.3% in 2015. [9] Surging growth in U.S. online sales has averaged more than 15% year-over-year since 2010.  In one day alone - Black Friday - web sales soared by 22% from 2015 to 2016. [10]

Amazon's role in this transformation cannot be overestimated. The total value of transactions by U.S. consumers on Amazon.com reached $147 billion last year, a 31% increase compared with $112 billion in 2015, according to Internet Retailer and ChannelAdvisor Corp. [11] That means Amazon alone was

**Figure 1-1.** Growth of U.S. E-Commerce Sales: 2006 - 2016

*Information retrieved from U.S Census Bureau [9]*

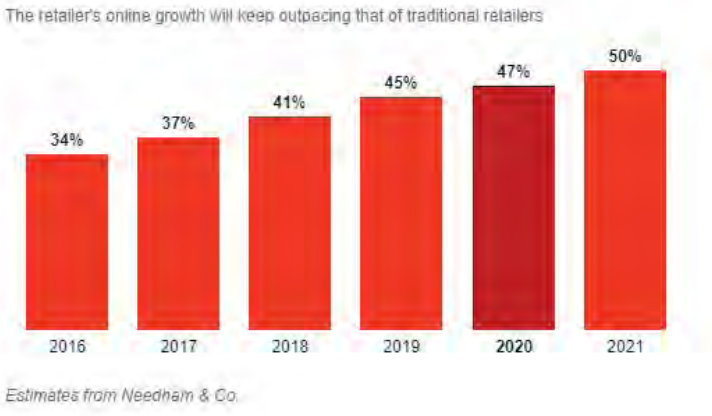
responsible for 66% of the $53.1 billion growth in U.S. retail e-commerce in 2016, and 27% of the $127.6 billion increase in the total retail market.

Many brick-and-mortar retailers have not been successful in integrating omnichannel sales platforms and can only expect to see Amazon's share of the e-commerce market grow. The online retailer, which accounted for about 34% of U.S. online sales in 2016, will grow market share to about 50% by 2021, helped by the popularity of its Prime membership program and its marketplaces, according to Wall Street firm Needham.

"We believe Amazon's established dominance in the U.S. is sustainable with Prime, mobile penetration and third-party growth," said Needham analyst Kerry Rice.

**Figure 1-2.** Amazon Dominates Online Shopping in the U.S. [12]

**Figure 1-3.** Amazon Predicted to Make Up To 50% of U.S. Online Sales by 2021 [13]



How many Americans are Amazon Prime members? According to data from Consumer Intelligence Research Partners (CIRP), membership has doubled in the United States over the last two years. The cost is $99 a year or $10.99 a month. The CIRP estimate puts Prime membership in 2017 at 80 million, each spending an average of $1,300 per year. [14] That's a 38% increase from an estimated 58 million members at the end of the same period in 2016. Amazon itself does not provide a Prime enrollment count.

Amazon operates a variety of fulfilment and distribution centers including small sortable, large sortable, large non-sortable, specialty fulfillment centers, apparel and footwear, redistribution centers, returns centers, 3PL outsourced facilities, Amazon Fresh and Amazon Pantry facilities. These facilities consolidate the products sold by Amazon or by third-party vendors to be packaged and shipped by Amazon. [15]

## Online shoppers' expectations for service are also rising

Millions of people who shop online now purchase more than half of their goods online. [16] 31% of all U.S. consumers bought food online in 2016. Some groups bought even more:

- 38% of city dwellers, vs. 30% of suburban and 25% of rural residents;
- 37% of parents vs. 28% without kids;
- 36% of Millennials. [17]

Two out of three online shoppers expect to be able to place an order as late as 5:00 p.m. for next-day delivery. Three out of five believe orders placed by noon should be delivered the same day, and one out of four believe orders placed by 4:00 p.m. or later should still be delivered on the same day. [18] In many large cities, Amazon Prime subscribers can now get free two-hour delivery on more than 25,000 items they might otherwise have bought at Walgreens or 7-Eleven. For an additional $7.99, orders arrive within an hour.

The modern shopper's purchase may be made in a physical store, online or via a mobile app. Consumer purchasing behavior will continue to change as smartphones and other devices provide increasing connectivity, giving consumers multiple channels to evaluate products, order, pay, collect, and return their purchases.

While the growth of e-commerce is exploding, most shopping still takes place in retail stores. For city residents, neighborhood retail is still all about location. One reason people are attracted to urban neighborhoods is because they prefer to walk more and drive less. Respondents in the 2015 National Multifamily Housing Council-Kingsley Apartment Resident Preferences Survey preferred walking to grocery stores and restaurants rather than driving by seven percentage points. [19].This lifestyle requires merchants to deliver goods to customers' homes, office buildings or stores close to where they live. Therefore, walkable communities rely as much on the goods delivery system as they do pedestrian infrastructure and transit services.

**Figure 1-4.** Consumers Use Multiple Channels to Research and Purchase Goods [18]

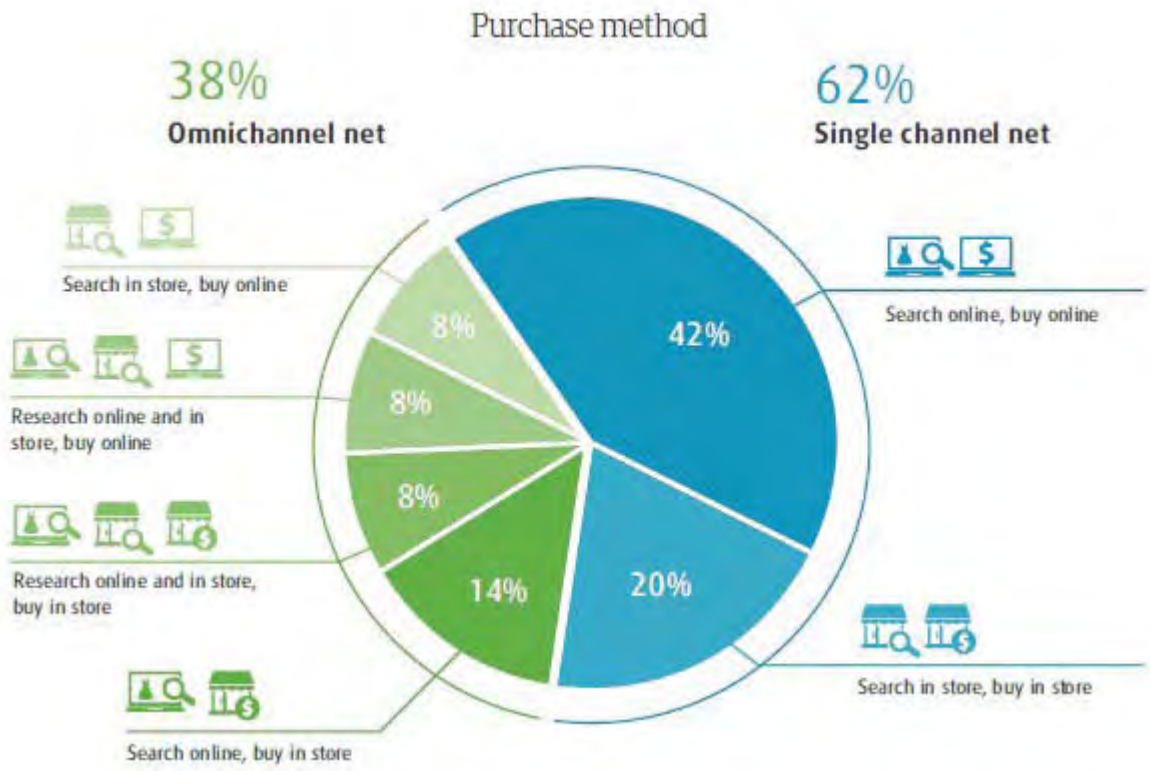


**Figure 1-5.** E-Commerce as a Percentage of Total Shipments/Sales/Revenues: 2014-2015 [20]

* Year-to-year comparisons are not statistically different at the 90 percent confidence level.
¹ Total merchant wholesale trade including manufacturers' sales branches and offices.
Note: For the estimates of e-commerce as a percentage of total shipments/sales/revenues by sector that are shown in this table, the corresponding standard errors can be found at <www.census.gov/data/tables/2015/econ/e-stats/2015-e-stats.html>.
Source: U.S. Census Bureau, 2015 Annual Survey of Manufactures; 2015 Annual Wholesale Trade Survey; 2015 Service Annual Survey; and 2015 Annual Retail Trade Survey.

One way to infer the future adoption of e-commerce in the retail sector is to look at the current adoption rate in the manufacturing and wholesale sectors.

In the most recent statistics released by the U.S. Census Bureau, e-commerce was the primary method of business-to-business sales in the manufacturing sector: representing 63.2% of all shipments in 2015, up from 61.4% in 2014. [20] This occurred even as the total value of shipments dropped 5.8% in the same time period, from $5,887.6 billion in 2014, down to $5,547.0 billion in 2015.

Total e-commerce sales for merchant wholesalers were up by 1.9 percent to $2,198.8 billion in 2015, from $2,158.8 billion in 2014.

# Urban Goods Delivery Firms Must Provide Fast and Reliable Delivery Times

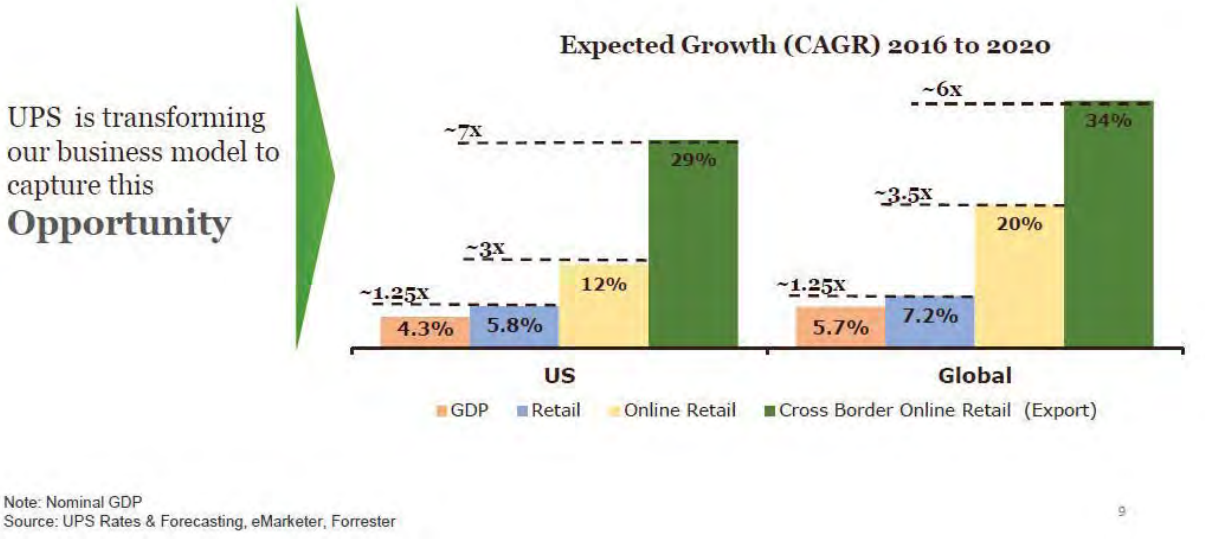
The strategic imperative for freight delivery companies, retailers, and cities is to create enough capacity to deliver all these packages and satisfy the growth in urban customer demand. Three delivery firms – UPS, USPS and FedEx – deliver the vast majority of packages in the U.S. In the short term, will they be able to meet their e-commerce customers' needs?

To put numbers to this problem, a Piper Jaffray analyst estimated that Amazon sold 7.2 billion items in 2016. In 2020 they expect them to sell 12.6 billion items. Amazon CEO Jeff Bezos has said that "We will take all the capacity that the U.S. Postal Service can give us and that UPS can give us and we still need to supplement it. So we're not cutting back. We're growing our business with UPS. We're growing our business with the U.S. Postal Service." [21]

## THREE PARCEL COMPANY PROFILES: INVESTING IN GROWTH

UPS delivered an average of 19 million packages per day across the globe in 2016, and daily U.S. air volume was 2.7 million packages and documents. [22] UPS's 2016 "The Smart Logistics Network: Invest. Grow. Deliver" report predicts that e-commerce will fuel their company's growth curve into the future. [23]

**Figure 1-6.** Online Retail is UPS's Growth Engine for the Future




Note: Nominal GDP
Source: UPS Rates & Forecasting, eMarketer, Forrester

As demand increased from online retailers in 2017, UPS began Saturday pickup and delivery service for Ground parcels in 15 metropolitan areas, including New York City and Chicago, following test operations last year in Atlanta and Los Angeles. By peak holiday season in November, 4,700 cities and towns will be part of the service area, growing to 5,800 in 2018. [24]

The carrier also continues to expand and upgrade its facilities to better handle e-commerce growth. UPS currently has 17 projects underway that total more than 5 million square feet "to create capacity and efficiency to support further B2B (business to business) and B2C (business to consumer) growth." Those initiatives increased operating costs by $35 million in the first quarter.

In 2016, Chris Karpenko, director of brand marketing for the U.S. Postal Service (USPS), said that the postal service delivers more e-commerce packages to homes than any other shipper. [25] "We identify this through the number of packages delivered to homes every day, and where the orders come from. We're seeing a lot of growth in our Parcel Select and Parcel Lightweight products for e-commerce, where shipments are consolidated and dropped into the closest destination delivery unit (DDU, i.e. any local postal office within a zip code) for final-mile delivery.

As for Sunday delivery, Karpekno said customers love it and adoption is growing fast – and not just for Amazon orders. "Amazon is certainly a part of it, and we've been expanding that relationship," he said.  Demand for Sunday delivery is driven by consumers, including the desire for faster fulfillment. This tends to happen much more in urban areas due to the economies of scale from greater density that benefits the carrier and merchants.

In FedEx's "2016 Annual Report: E-Commerce", the company states that "the holiday season of 2015 made it clear that e-commerce has enabled a full-scale retail revolution." The value proposition, however, remains the same — the ability to order a product online and have it reliably delivered to the consumer. FedEx is one of only three enterprises that together deliver 95% of all e-commerce orders in the United States. [26]

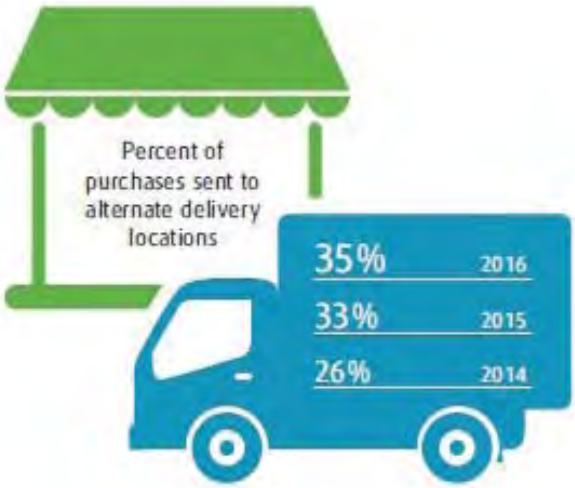
"It's imperative that we continue investing for profitable growth by expanding our network capacity to match the predicted increase in e-commerce shipments. FedEx Ground invested $1.6 billion in FY16, including automated hubs in Tracy, California and Ocala, Florida, and 19 additional automated stations. This will bring the number of automated hubs to 35 and the number of automated stations to 68. These operations are designed to sort packages at a high rate, minimize handling and lower costs."

In addition to capacity concerns, shippers and delivery firms are focused on managing returns more efficiently, and reducing the number of failed first deliveries to:

- Improve urban online shoppers' experiences and protect retailers' brands;
- Lower traffic congestion in cities, as delivery trucks could make up to 10% fewer trips while still completing the same number of deliveries;
- Cut costs for the retail sector and logistics firms;
- Cut crime and provide a safer environment;
- Ensure that all city neighborhoods can receive online orders, not just a few.

One strategy to accomplish these goals is to ship to alternate delivery locations such as lockers, parcel delivery firms or other retailers' stores.

**Figure 1-7.** Shoppers Use of Alternate Delivery Locations [18]



# New Technologies Are Transforming the Urban Goods Delivery System

Consumer purchasing behavior has changed drastically through the market penetration of smartphones and other handheld devices. This increasing connectivity gives consumers the option of using different channels to evaluate products, order, pay, collect, and return their purchases.  Technology is also enabling firms to address key supply chain and logistics issues.

This section focuses on technologies that have particular relevance to the Final 50 Feet of the supply chain.  The final 50' of the urban delivery system begins at the city-owned curb, commercial vehicle load zone, or alley; extends through privately-owned building freight bays and loading docks; and ends when the goods are received within a building.

## INCREASED VISIBILITY OF ASSETS

Information sharing and resource and product visibility across organizations is a chief requirement of emerging supply network and logistics management concepts such as integration, collaboration and synchronization.

One mechanism to achieve visibility is the development of inexpensive, flexible and robust RFID transporters, transceivers and navigation and environmental sensors that will provide reliable information regarding the location and status of shipments and mobile assets along the supply chain. [27]

RFID technology does not ensure continuous product visibility where there are no readers. Although it is technically possible to interface RFID readers to the Internet, the tags do not have this functionality yet. It could be tagged to positioning/navigation and wireless communication for this end. The integration of RFID with other sensors such as GPS, temperature, and humidity is especially important for some sectors such as the perishable food supply chain. The main obstacle is the high horsepower needs of such multifunctional devices.

RFIDs were developed for supply chains in 2000, and at that time were seen as a prerequisite to manage the Internet of Things (IoT).  A retail example is found at Burberry, which implemented RFID in select stores beginning in 2012. Wireless readers placed at various points in their stock control process read information about the product such as type and range. This technology helped Burberry with stock and quality control and enhances the customer's experience with in-store display screens. [27]

Parcel carriers consider tracking visibility a competitive necessity and typically use bar coding technology to manage millions of packages every day. The UPS My Choice and Quantum View; FedEx InSight, Tracking, and Delivery Manager; and USPS Tracking programs are sophisticated tools that improve customers' experience with package visibility and re-route options.

## SHARED-USE MOBILITY: START-UPS IN THE EXPRESS AND PARCEL DELIVERY SECTORS

Shared-use mobility generally refers to transportation services that provide flexible passenger and goods movement via public transit, ridesharing and commercial delivery vehicles. Transportation network companies (TNCs) such as Uber and Lyft are experiencing rapid growth.

These applications may be classified as:

- ON-DEMAND: The app acts as a broker between the users and the carriers with which they cooperate. They may also offer warehouse and packaging services.
- ON-THE-WAY: Companies such as Nimber and Roadie take advantage of the extra capacity of people already making a trip by putting them in contact with someone who needs to ship goods with a similar origin and destination. Users negotiate the price and the app is able to charge a percentage or a fixed fee.

**Table 1-1.** Shared-Use Mobility Firms in the Express and Parcel Delivery Sectors

| | CITIES COVERED | START YEAR | COMPANY FEE | MODES; PACKAGE SIZE | INSURANCE | OPERATION |
|---|---|---|---|---|---|---|
| **Nimber** | UK | 2016 | 20% | Walk, bike, car or van | Up to 500 pounds | Price negotiated between deliverers and users. "On-the way" |
| **Shyp** | SF, LA, NY, Chicago | 2013 | $5 | Bikes and cars | $100 | Deliverers pick up package, take it to warehouse and shipped by parcel carrier |
| **Rickshaw** | SF | 2013 | From $5.5 | Package delivery | | Broker. Cooperate with carriers. |
| **Roadie** | Atlanta, Dallas | | - | Up to pick-up truck or 500 lb. | $500 free, up to $10,000 | Price negotiated between deliverers and users. "On-the way". Price set based on mileage and package size |
| **UberRush** | NYC, SF, Chicago | 2014 | Base rate + per mile | 30 lb. in bikes; 50 lb. in cars | - | On-demand delivery |

In addition to the companies listed in Table 1, many other start-up companies such as Shipbob, TruckBird, Deliv, Shult, Postmates and Zipments are entering this crowded market.

## CLOUD BASED SERVICES AND OPEN, REAL-TIME DATA

Many new transportation applications have emerged with the liberalization of open data. One of the most prominent examples is found at Transportation for London (TFL). TFL partnered with Amazon Web Services (AWS) to launch their new website with cloud technology and provide the public with real-time traffic information. The web site got 600,000 visits per day in 2016 [28] and provided:

- Multi-mode journey planning sensitive to disruptions in the transportation system; managing 750,000 journey planning requests per day;
- Real time information about all modes;
- Real time public transit arrival predictions every 30 seconds;
- Open data source of all the real time data for app developers; over 5,000 are already working with this data. The road feeds have:
  - Live traffic camera images from 700 cameras, updated every 3 minutes that are useful to keep track of traffic conditions;
  - Live Traffic Disruptions with spatial information and details of closure.

The fact that AWS auto-scales on-demand hardware use for usage spikes during disruptions was a key reason in TFL's decision to work with AWS on this project.

Although there were no publicly available applications specially designed to improve urban freight movement in 2016, trucking and logistics companies use TFL's open data feed to obtain information about disruptions in the transportation network. This information provides valuable details of project works, such as projected start and end dates up to three months in the future. [29] Providing freight operators with accessible information is a key concern for the TFL's Strategic Risk Management Panel, which periodically monitors aspects such as the risk of road construction impacting journey time reliability. [30] Disruption information will be more accessible for the freight industry if and when the following three initiatives are completed [31]

- TFL Freight Route Prioritization: On-going work to ensure a more automated and joined up information provision.
- Transportation Scotland: Text-to-Speech app for freight users.
- A Truck Navigation app developed at the University of Leicester that considers features, such as weight and height of the truck, to plan routes. [32]

Other technologies implemented by TFL are Closed-Circuit Television (CCTV) and Automatic Number Plate Recognition (ANPR) camera system across London's transportation network. The cameras are used for real time traffic monitoring, enforcing traffic rules and regulations, and road user charging schemes, and support the efficient management and operation of road and rail networks.

One significant application of real-time information in the logistic sector is found in the UPS ORION (On-Road Integrated Optimization Navigation) program. It helped UPS cut distance travelled by 100 million miles in 2016, and is expected to be used for all U.S. routes in 2017. ORION uses online map data processed by UPS as well as information from 46,000 vehicles that carry GPS, sensors and drivers' handheld mobile device. [33]

The Swiss Post is developing an IoT based on LoRaWAN technology. Potential applications include the use of sensors for safe and tracked transportation of medicinal products. It can also be used to trigger automatic order placement when stocks run low. In addition, Swiss Post is testing commercial drones to explore the potential of this technology. [34]

According to one vehicle routing software survey, ArcGIS Network Analyst, Descartes Routing, Truckstops, Route4Me, Roadnet Transportation Suite are the most popular vehicle routing software applications. [35]

## SMART PARKING SOLUTIONS

Parking is a $24-25 billion industry in the U. S.  Although the top 50 U.S. parking lot and garage companies generate approximately 70% of all revenue; 90% of all lot and/or parking garage owners operate a single facility. [36]

The main drivers for smart parking system implementation are:

- Urban livability, transportation and environmental sustainability issues; and
- To enhance productivity and service operations.

Smart parking technologies include:

- Electronic parking payment systems such as:
  - Permit and Enforcement (P&E)
  - Mobile Parking Payment
  - Parking Access and Revenue Control (PARCS)
- Cloud-based permit application and issuance (e.g. print from home)
- Cashless financial transaction management
- Real time report generation
- Enforcement data such as outstanding citation payments
- Parking customer convenience applications (i.e. Parking Usage Recognition and Customer Service, PURCS) are used to make reservations, and provide guidance-to-spot applications, and process electronic payments.
- New Computer Vision with License Plate Recognition (LPR) cameras for vehicle detection and SkyEye cameras are used to monitor infrastructure.  The camera-based technology is also more cost-effective at around $50 per parking spot, whereas the sensor-based solutions may cost up to $600 per parking spot. [37]

The main goals when adopting smart parking technologies are:

- Lowering operating costs (e.g. reduce infrastructure foot print such as meters and labor costs)
- Building value for customers to drive occupancy revenues and facility value
- Reducing revenue leakage (e.g. improve revenue collection or reduce theft by cashiers)

The key challenge for smart parking providers is to grow in scale and service scope, e.g. the number of services offered such as occupancy and reservation. Implementation of cloud-based services that can achieve massive scales of deployment is limited by the difficulty of finding the right mix of technology for so many types of facilities. Also, a public requirement to serve a wide variety of customers (with and without smartphones) prevents vendors from achieving an infrastructure-less model for smart parking (e.g. eliminate all meters). Cloud-based smart parking systems also raise issues of maintaining the security and integrity of transaction data.

From an operations perspective, there are four parking service models that may affect how smart parking technology is implemented. In order of decreasing level of customer service they are:

1. Airports and Hospitals
2. Municipalities
3. Universities and Retail/Hotel/Event Venues, and
4. Commercial Parking Garages.

The fastest growth areas are in municipalities and facilities with large numbers of transient (non-regular) customers with parking fares that are medium-to-low. To take advantage of these services, municipalities must develop new innovative contracting models such as privatization, public-private partnerships and performance-based contracts. Some jurisdictions have been able to shift the risk to the private sector. For example, Los Angeles financed the lease payments of renewed assets through the incremental revenue generated by these new assets. [38]

Table 2 shows a partial list of smart parking system services provided by companies. These companies may be classified as follows:

- *Database software and technology:* companies such as Oracle provide services such as data warehousing and management, business intelligence software and user convenience mobile applications, but do not provide services related to the physical parking infrastructure.
- *Smart parking infrastructure and cloud-based data management:* services provided by companies such as IPS Group Inc. and CivicSmart install a basic smart parking system with smart meters or sensors and cloud-data management system. Some companies such as Fybr and Xerox provide a more advanced version of this smart parking system by adding demand-sensitive pricing.
- *Mobile user interface:* some companies are integrated in the system with the only function to provide cash-free transitions through mobile phones (e.g. PayMobile and Pay-by-phone). More advanced mobile applications provide additional services such as real-time availability information, reservations, and navigation (e.g. ParkMe, ParkRight, ParkMobile).

**Table 1-2.** Classification of Companies by Smart Parking Solution Offered

| | ELECTRONIC PARKING PAYMENT SYSTEM | | | | | USER CONVENIENCE APP (PURCS) |
|---|---|---|---|---|---|---|
| COMPANY | VEHICLE DETECTION SENSORS | SMART METERS OR HARDWARE MANUFACTURER | CLOUD-BASED SERVICES AND DATA MANAGEMENT | ADVANCED TECHNOLOGY SUCH AS DEMAND-SENSITIVE PRICING | MOBILE PARKING PAYMENT | REAL-TIME AVAILABILITY, NAVIGATION, RESERVATIONS |
| **Fybr** | | | | | | |
| **IPS Group Inc.** | | | | | | |
| **CivicSmart** | | | | | | |
| **Oracle** | | | | | | |
| **Xerox** | | | | | | |
| **ParkMobile** | | | | | | |
| **Pay-by-phone** | | | | | | |
| **Parker** | | | | | | |
| **ParkMe** | | | | | | |
| **PayMobile** | | | | | | |
| **ParkRight City of Westminster** | | | | | | |

*Information retrieved from companies' websites, July 2016*

In addition to the firms in Table 2, Xerox provides all of the services listed. Xerox develops mobility services and is a key player in the development of connected and automated vehicles. The company participated in Techlab at Mcity, the first controlled environment specifically developed to test the potential of connected and automated vehicle technologies, managed by the Mobility Transformation Center at the University of Michigan. [39]

**Table 1-3.** Example Smart Parking Projects

| PROJECT | MAJOR PARTICIPANT TECHNOLOGY COMPANIES | SIZE OF OPERATIONS (SPACES) | TECHNOLOGY IMPLEMENTED | FREIGHT ASPECTS IN SMART CURB MANAGEMENT |
|---|---|---|---|---|
| LA Express-Park [40]. | Xerox*<br>ParkMe (an Inrix company)<br>Parker<br>IPS Group | 6,000 on-street<br>7,500 off-street | Demand-responsive pricing<br>Electronic parking payment, including sensor-based P&E and Mobile Parking payment through ParkMobile<br>PURCS through Open data for app such as ParkMe and Parker | The smart parking system does not address freight issues. However, City of LA recommends future consideration of streets with greatest number of citations and considers metering instead of permit. [41] |
| Washington D.C. Mobile Payment [42] | ParkMobile LCC** | 17,000 on-street | Electronic parking payment, including P&E and Mobile Parking payment through ParkMobile | DDOT's previous actions include: metered loading zones and multispace meters. [43] Commercial vehicle zones can pay by phone or permit As part of the "Beyond Traffic: Smart City Challenge" they consider sensor-based commercial vehicle parking. [44] |
| SFPark [45] | Oracle<br>Fybr<br>IPS Group<br>CivicSmart<br>Affiliated Computer Solutions (Xerox)<br>Pay-By-Phone | 7,000 on-street including commercial vehicle zones<br>12,250 off-street in 15 parking garages | Demand-responsive pricing and special event pricing<br>Electronic parking payment, including sensor-based P&E and Mobile Parking. PARCS at garages<br>PURCS through Open data for app developers | Sensors at commercial vehicle spaces can be used for parking enforcement |
| City of Orlando [46] | IPS Group<br>ParkMe<br>PayMobile | 1,100 on-street smart parking meters<br>(562 of them have sensors) | Electronic parking payment, including sensor-based P&E and Mobile Parking through ParkMobile<br>PURCS through Open data for app such as ParkMe | |
| City of Westminster [47, 48] | ParkRight | 41,000 on and off street<br>(3,000 of them have sensors) | Electronic parking payment, including sensor-based P&E and Mobile Parking through ParkRight | The mobile app distinguishes loading parking zones from other types of spaces. There is an initiative to use e-permits with RFID synchronized with the ParkRight app |

CHAPTER 2

# URBAN GOODS DELIVERY PROFILES FOR PROTOTYPE BUILDINGS

# INTRODUCTION

In the goods delivery process, the time spent outside of the vehicle can be much longer than the driving time, taking up as much as 87% of the time [1,2]. However, analysis and documentation of the delivery activities after the driver leaves the truck are limited, with little published research or publicly-available data on this topic. An in-depth analysis of the driver's delivery procedure and performance during the final leg of the delivery process plays a vital role in understanding and improving urban freight delivery.

Understanding how goods move vertically within a building is important, because this activity can directly influence roadway capacity and performance. The lack of curbside space, due to excessively long stays by delivery workers, can increase urban congestion as other delivery vehicles circle city blocks while looking for parking spaces [3]. Vertical movements can also encompass non-value-added time, or time that unnecessarily increases the overall delivery time with no corresponding benefit to the customers [4]. These factors can cause negative cascading impacts on road congestion, adding costs and pressures to the trucking industry, building management, and city officials.

This chapter introduces the Lean philosophy and Value Stream Mapping (VSM) approaches to the delivery process flows in an office building in downtown Seattle. Lean production management and its applications are used to identify areas of improvement, which can enhance the overall quality of service and work performance [4]. Applying this new approach to the multi-step delivery process can help accurately measure the time needed for each step This is valuable given the number of factors involved in the delivery process, including the number of carriers, volume of goods, types of goods, and types of delivery vehicles. Further, breaking down the delivery process to a micro level with VSM can result in a better understanding of dwell times and failed deliveries.

The research team began by creating a process flow map of the office building as a way to visualize the components of the delivery process, as well as the gaps and non-value-added time. Identifying the processes that consume the most non-value-added time and the greatest variability helped identify strategies to improve the overall urban freight system and increase accountability for extended truck dwell times and failed deliveries.

At the first meeting in December 2016, the UFL members and SDOT discussed and articulated two priority goals for the Final 50 Feet Research Project:

1. Reduce truck dwell time at delivery stops.
2. Reduce the number of failed first deliveries.

To better understand factors contributing to these challenges, the SCTL research team approached the problem by observing and collecting data on the delivery processes at five different types of buildings in downtown Seattle: a hotel, an office building, a historical building, a retail center, and a residential building. The team developed an iPhone application to record data and used the results to create sequential process flow maps of goods delivery for each building.  The process flow maps summarize individual delivery tasks and the sequence and duration of each task. They also provided

insights into the operation sequences of key events and actions during deliveries to help pinpoint where delays may occur.

## GOALS

The goal of this approach was to identify specific infrastructure, actions, or circumstances that contribute to increased dwell time and failed first deliveries. With a better understanding of current practices in urban delivery systems, problem areas can be pinpointed and will later inform the development of pilot tests of possible solutions in real time in downtown Seattle

## METHODOLOGY

This chapter describes Urban Freight Lab methodologies in:

- Selecting five prototype buildings for data collection
- Creating data collection plans
- Performing data collection
- Generating process flow maps

## SELECTION OF FIVE PROTOTYPE BUILDINGS

Building Options in Downtown Seattle

One building in each of the following categories was selected for goods delivery observation:

1. Hotel (without a conference center);
2. Historic commercial and/or retail building with restaurants and/or bars in Pioneer Square;
3. Residential tower;
4. Office building with ground floor retail and/or restaurant; and
5. Retail building.

SCTL staff looked at a number of factors in determining potential observation sites: building size, freight delivery characteristics, and available parking locations. SCTL staff conducted site visits at each building, thoroughly inspecting the conditions and freight activities. Figure 2-1 shows the distribution of visited sites and Table 2-1 summarizes the names of the corresponding buildings.

**Figure 2-1.** Building Locations for Site Visit

**Table 2-1.** Table of Building Locations for Site Visit

| BUILDING TYPE | NUMBER | BUILDING NAME |
|---|---|---|
| **1. Hotel** | 1 | Four Seasons Hotel Seattle |
| | 2 | Fairmont Olympic Hotel, Seattle |
| | 3 | The Westin Seattle |
| | 4 | Hotel 1000 |
| | 5 | Inn at the Market Seattle |
| **2. Historical Building** | 1 | Cafe Bengodi |
| | 2 | Cafe Paloma |
| | 3 | Interurban Building |
| **3. Residential Building** | 1 | Insignia By Bosa |
| | 2 | Aspira Apartments |
| **4. Office Building** | 1 | Columbia Center |
| | 2 | Seattle Municipal Tower |
| **5. Retail Building** | 1 | Rainier Square |
| | 2 | Westlake Center |
| | 3 | Pacific Place |

The site visits provided useful insights on the goods delivery and pick-up activities at each building. Information gathered included short building descriptions, the street address, map location, building size, freight delivery characteristics, and the number of street parking spaces near the buildings. The research team pared down the options to 12 buildings as possible sites for this project. Detailed information of the 12 buildings is included in Appendix A.

**Table 2-2.** Top Choices of the Proposed Buildings

| BUILDING TYPE | BUILDING NAME |
|---|---|
| 1. Hotel | Four Seasons (tie) or Westin (tie) |
| 2. Historical Building | Interurban Building |
| 3. Residential Tower | Aspira Apartment |
| 4. Office Building | 520 Pike St. |
| 5. Retail Building | Pacific Place |

Table 2-2 summarizes the top choices of the proposed buildings from the voting results. Although the results indicate the preferences of the members, final decisions on the five prototype buildings were highly dependent on whether the permissions from the building managers could be obtained or not.

## OBTAINING PERMISSION FROM BUILDING MANAGERS

After narrowing down building options, SCTL pursued obtaining permission from the building managers to participate in the project. This process highlighted the importance of positive connections with the building managers, who often referred information on our project to other building managers. These references expedited obtaining permission at other buildings of interest.

The team also learned that the Seattle Police Department issues Shield Blast Letters to communicate with downtown property managers on issues of safety for the community. To avoid any misunderstanding of the intent of the UFL, the Seattle Police Department released a letter informing the property managers about the Final 50 research project. After the blast letter, one property manager contacted the SCTL Center to express interest in improving delivery systems in downtown Seattle by participating in the project.

After conducting individual meetings with the property managers, the team was granted access to observe at the following five buildings, as summarized in Table 2-3.

**Table 2-3.** Final Five Prototype Buildings

| CATEGORIES | BUILDING TYPES | BUILDING NAMES |
|---|---|---|
| 1 | Hotel | Four Seasons Hotel |
| 2 | Historical Building | Dexter Horton Building |
| 3 | Residential Tower | Insignia Tower |
| 4 | Office Building | Seattle Municipal Tower |
| 5 | Retail Building | Westlake Mall/Tower |

Prior to beginning data collection, the research team obtained permission letters (on letterhead) from the property management companies to inform carriers entering the building of the project and the research team's presence. Appendix B is a sample permission letter.

## DATA COLLECTION PLANNING

To prepare for data collection, the research team conducted a thorough planning process that included:

- Applying for and receiving exemption status from the UW Institutional Review Board (IRB) for conducting interviews with the carriers,
- Developing an application in the iPhone Operating System (iOS) to record data,
- Scheduling data collection shifts.

### Institutional Review Boards (IRB) Exemption

In the United States, universities are required to receive approval from the Institutional Review Board (IRB) when a research project includes human subjects. This process is to ensure the ethical conduct of research and protection of human participants. Since this phase of data collection involved observing the delivery activities of individual carriers by following them from the beginning to the end of their delivery processes, the research team submitted an IRB application and was approved for exempt status before data collection began. The IRB application forms and the letter received from IRB are included in Appendix C.

## DATA COLLECTION APPLICATION IN iOS

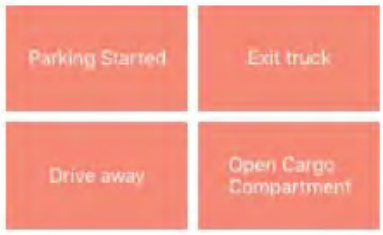
The Final 50 research team designed a data collection application specifically to capture timestamps for each individual tasks that drivers perform during a delivery. Task buttons are named and color coded by category in the application, as shown in Table 2-4.

The data collector taps a task button to initiate the start of the task, which prompts the ending task button to pop up. To stop recording, the data collector can tap the ending task button. This records the immediate time of tapping and calculates durations of each task. Additionally, new task names can be typed in manually. The application allows very accurate collection of various process tasks and durations. Whether or not the package is successfully delivered can also be recorded.

The user interface of the data collection application is shown in Figure 2-2. The user can input information such as the name of the building, location, and companies within the building. The application for each building type has unique task buttons to reflect the different delivery processes for each building.

**Figure 2-2.** User Interface of the Data Collection Application

**Table 2-4.** Color Coded Task Buttons on iOS Application

| COLOR CODE | TASK CATEGORY | TASK BUTTONS |
|---|---|---|
| Red | Parking And Open/Close Cargo Compartment |   |
| Gray | Common Activities Throughout The Delivery Process | |
| Green | Loading / Unloading and Check in and out | |
| Yellow | Travel Mode | |
| Blue | Receiving Goods | |

As shown in Figure 2-3, inputs from the data collectors and time-stamps of each task are saved in the web-based database in real-time. Real-time data allows support staff to monitor delivery activities and utilize delivery information without having to visit the site.

**Figure 2-3.** Web-based Database

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | parking started | 03-06-2017 09:27:06 | Seattle Municipal Tower | Test | Loading Dock | ups | Office Supplies | 1 | Lift ups automatically Note: |
| 1 | parking ended | 03-06-2017 09:27:08 | Seattle Municipal Tower | Test | Loading Dock | ups | Office Supplies | 1 | Lift ups automatically Note: |
| 1 | walk | 03-06-2017 09:27:13 | Seattle Municipal Tower | Test | Loading Dock | ups | Office Supplies | 1 | Lift ups automatically Note: |
| 1 | open cargo compartment | 03-06-2017 09:27:14 | Seattle Municipal Tower | Test | Loading Dock | ups | Office Supplies | 1 | Lift ups automatically Note: |
| 1 | unload a cart | 03-06-2017 09:27:16 | Seattle Municipal Tower | Test | Loading Dock | ups | Office Supplies | 1 | Lift ups automatically Note: |
| 1 | unload goods | 03-06-2017 09:27:18 | Seattle Municipal Tower | Test | Loading Dock | ups | Office Supplies | 1 | Lift ups automatically Note: |
| 1 | walk with | 03-06-2017 09:27:22 | Seattle Municipal Tower | Test | Loading Dock | ups | Office Supplies | 1 | Lift ups automatically Note: |
| 1 | goods on cart | 03-06-2017 09:27:24 | Seattle Municipal Tower | Test | Loading Dock | ups | Office Supplies | 1 | Lift ups automatically Note: |

## DATA COLLECTION SCHEDULE

The research team created a data collection schedule for February and March 2017 based on building availability. Data collection lasted one to two weeks at each building. Prior to starting data collection, the team visited each building to identify typical delivery activities at the building. Table 2-5 shows the schedules for the one-day pilot test and a week-long data collection.

**Table 2-5.** Data Collection Schedule

| BUILDING TYPES | BUILDING NAMES | PILOT TEST SCHEDULE | DATA COLLECTION PERIOD |
|---|---|---|---|
| Office Building | Seattle Municipal Tower | Friday, January 13, 2017 | Jan 30 - Feb 3 |
| Historical Building | Dexter Horton Building | Wednesday, January 25, 2017 | Feb 6 - Feb 10 |
| Hotel | Four Seasons Hotel | Tuesday, January 10, 2017 | Feb 13 - Feb 17 |
| Retail Building | Westlake Mall/Tower | Monday, February 13, 2017 | Feb 27 - Mar 10 |
| Residential Tower | Insignia Tower | Monday, February 20, 2017 | Mar 6 - Mar 17 |

The detailed data collection schedule can be viewed in Appendix D.

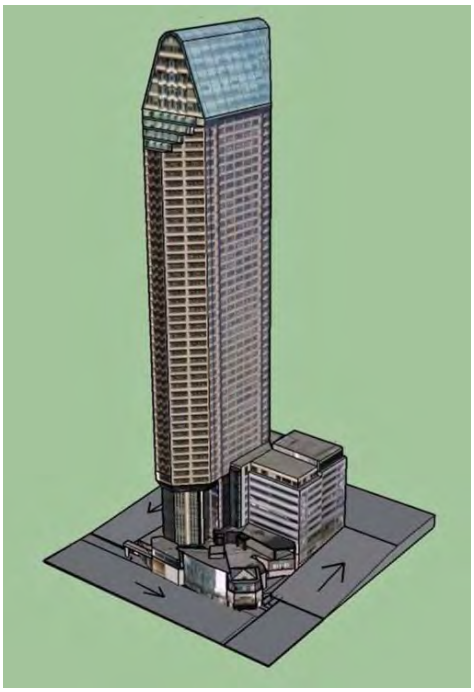
## DATA COLLECTION PROCESS

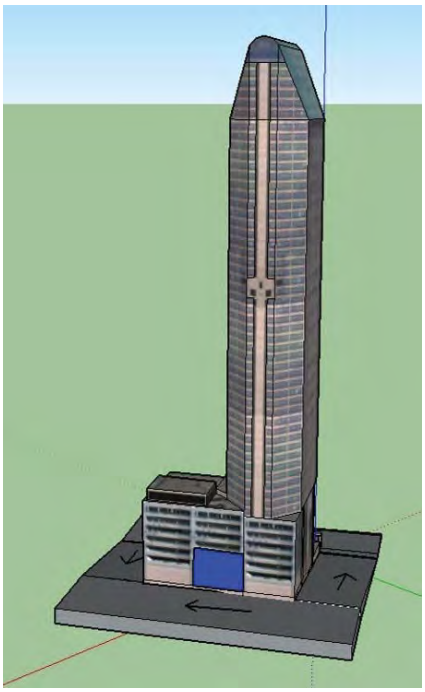
One-day pilot tests for data collection were performed at each building to identify the unique delivery operations and characteristics of each building, such as parking facilities and freight elevators, before beginning the week-long data collection project.  This section summarizes findings of the freight deliveries at the five data collection sites.

## OFFICE BUILDING: SEATTLE MUNICIPAL TOWER

The Seattle Municipal Tower is located at 700 5th Ave, Seattle, WA, 98104. Constructed in 1990, it has 62 floors with a total floor area of 990,540 square feet. Approximately 5,000 tenants occupy the tower in offices, gift shops, restaurants, and coffee shops. The entrance of the loading bay is located on 6th Avenue which is indicated by the blue rectangle in Figure 2-4. The building is surrounded by one-way streets, 5th Avenue, 6th Avenue, Cherry St, and Columbia St. as shown in Figure 2-4.

**Figure 2-4.** Road Network around the Seattle Municipal Tower





As shown in Figure 2-5, data collectors were positioned at the points shown on the map until a truck was parked either in the loading bay or on a street curb outside of the building. Data collection occurred between 9am-4pm on weekdays during the week of January 30, 2017. Once the truck was parked, a data collector approached to the driver and started following to observe his or her delivery process from beginning to end. The research team defined the beginning moment as when the truck started parking and concluded data collection the moment the driver pulled away from the building in his/her truck.

**Figure 2-5.** Street Layout around Seattle Municipal Tower

At this location, the loading bay has a capacity of seven parking spaces with the limited duration of up to 30 minutes. There is a security booth for a full-time security guard at the entrance of the loading bay. The loading bay is open from 6 am to 6 pm, with peak delivery time between 7 am and 2 pm.

**Figure 2-6.** Loading Bay at Seattle Municipal Tower

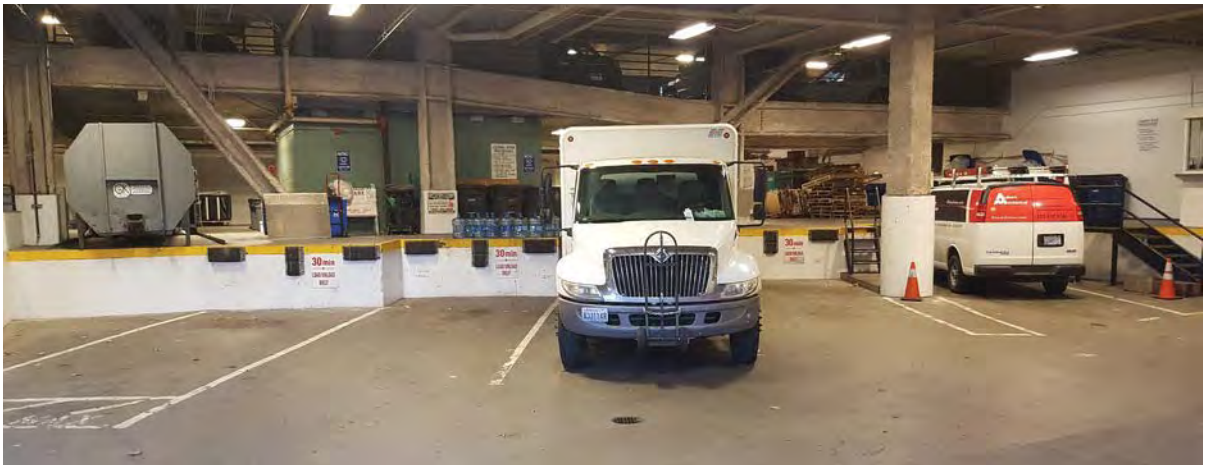
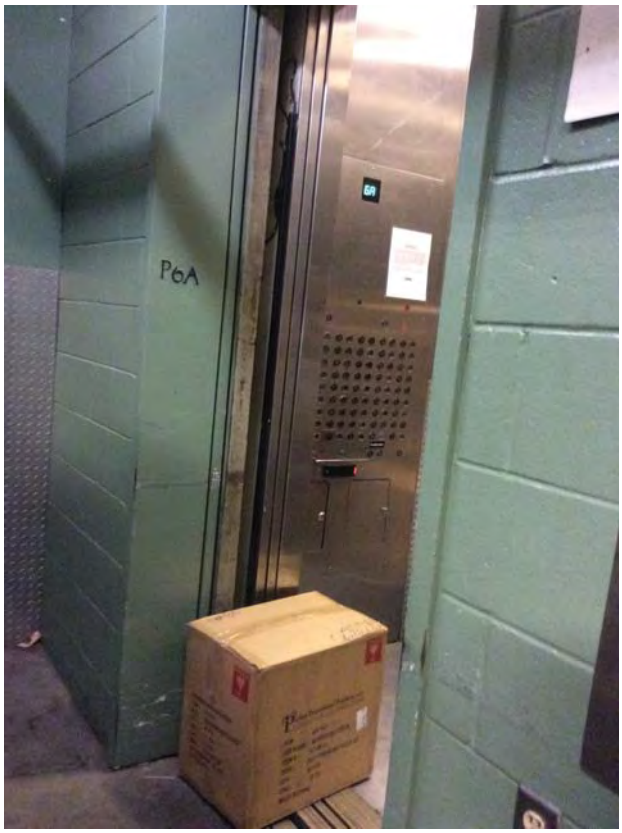


**Figure 2-7.** Entrance of the Freight Elevators at Seattle Municipal Tower

There are two freight elevators in the loading dock which require a security fob to access each floor. There are two types of security access cards: the key that grants access to all floors or a key that gives access to a limited number of floors needed for delivery. Drivers must obtain the freight elevator fob from the security guard by exchanging their government-issued identification cards.

**Figure 2-8.** Holding a Freight Elevator




As shown in Figure 2-8, drivers occasionally hold the freight elevator while making deliveries. This strategy may delay other deliveries if other drivers are waiting for freight elevator access on another floor.

Some floors have intercom systems to request access to the office areas. When the intercom system is not answered, the delivery person has to wait to call again or leave if there are no other options. This can delay the overall delivery process and increase the chance of failed deliveries.

**Figure 2-9.** Intercom System to Access an Office

**Figure 2-10.** Seattle Municipal Tower Mailroom

In addition to the Final 50 Feet project, the mailroom at Seattle Municipal Tower is conducting a pilot test with UPS to consolidate mail and parcels in the mailroom for delivery. Once the deliveries are received in the mailroom, staff log information on the received goods into the computer system and deliver them to the appropriate place in the building. The goal of this process is to increase security by logging the sources of the parcels that enter the building. Efficiency in the delivery process increases because the mailroom staff have access keys to individual offices that delivery people do not. As can be seen in Figure 2-10, the mailroom has its own freight elevator that is manually operated. This is because the mailroom is on a lower level than the loading bay freight elevator. Goods or carts from the building freight elevator need to be transferred to the mailroom freight elevator in order to be delivered to the mailroom. Due to safety concerns, people are not allowed on the mailroom freight elevator. Therefore, a delivery person has to take the stairs to enter (or exit) the mailroom.

# HISTORICAL BUILDING: DEXTER HORTON BUILDING

The Dexter Horton building is located at 710 2nd Avenue, Seattle, WA, 98104. Constructed in 1924, the building was one of the largest in the country when it opened, with 15 floors and total floor area of 336,500 square feet.

**Figure 2-11.** Dexter Horton Building

The building is between 2nd Avenue, with protected bike lanes, and 3rd Avenue, a main bus transit corridor. Columbia Street and Cherry Street are one-way streets. The building has six passenger elevators and 2 freight elevators. Passenger and freight elevators are open to the public although there is a security guard at the entrance on 3rd Avenue. Due to the steep slopes on Columbia St and Cherry St, it was interesting to note that some people enter the building through the 2nd Avenue entrance to take the elevator and exit the building on to 3rd Avenue.

The commercial loading and unloading zones and the 3-minute passenger drop-off zones on 2nd Avenue seem to be used interchangeably. Figure 2-13 shows the mixture of vehicle types on 2nd Avenue regardless of the type of the curb zone. As shown in Figure 2-14, the delivery person performed unloading and loading activities in the middle of the road in a passenger loading zone.

**Figure 2-12.** Street Layout around Dexter Horton Building

**Figure 2-13.** Parking Spaces on 2nd Avenue

**Figure 2-14.** Unloading Activities at 3 min Passenger Drop-Off Zone

**Figure 2-15.** Potential Conflict between a Delivery Person and a Cyclist

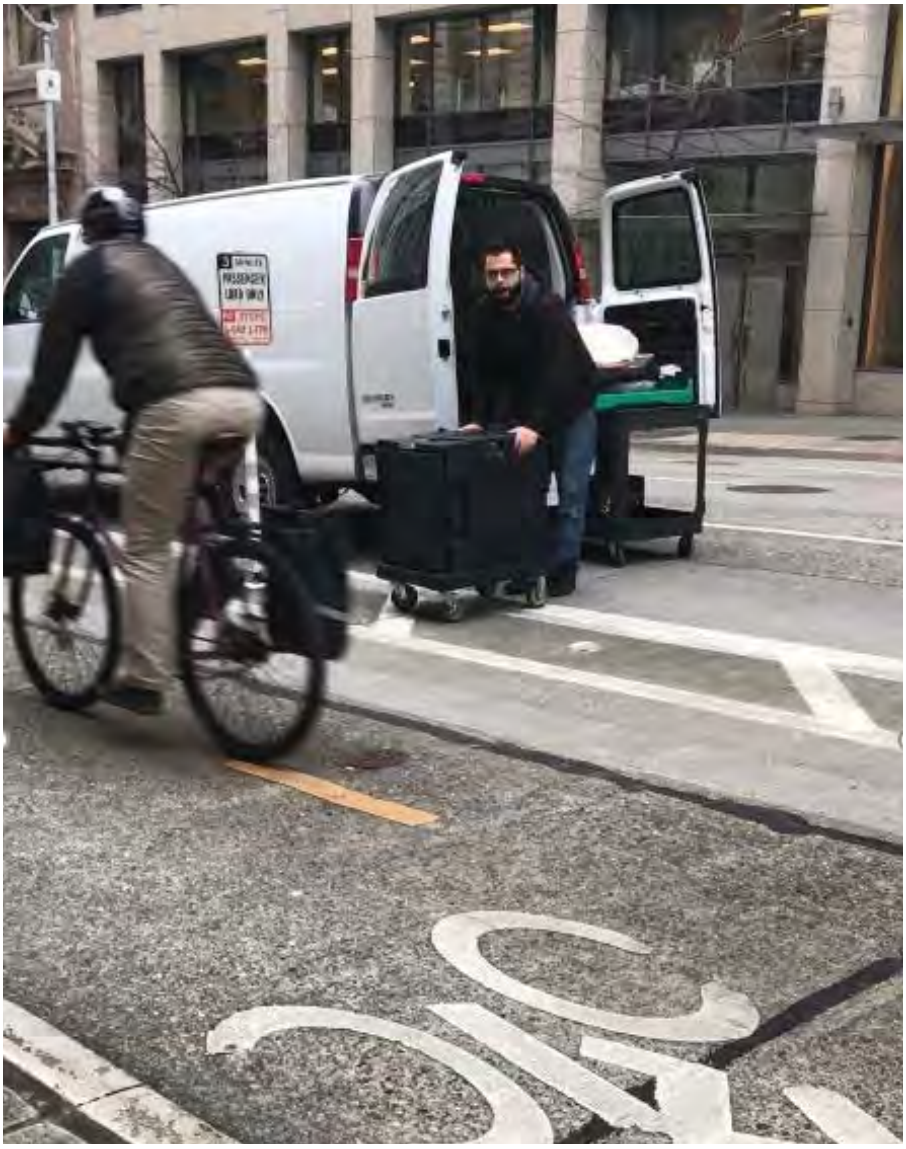


Figure 2-15 shows a delivery person waiting for a cyclist to pass so he can move the carts across the bike lanes. This may lead to safety concerns and increase the probability of conflicts between delivery people and cyclists.

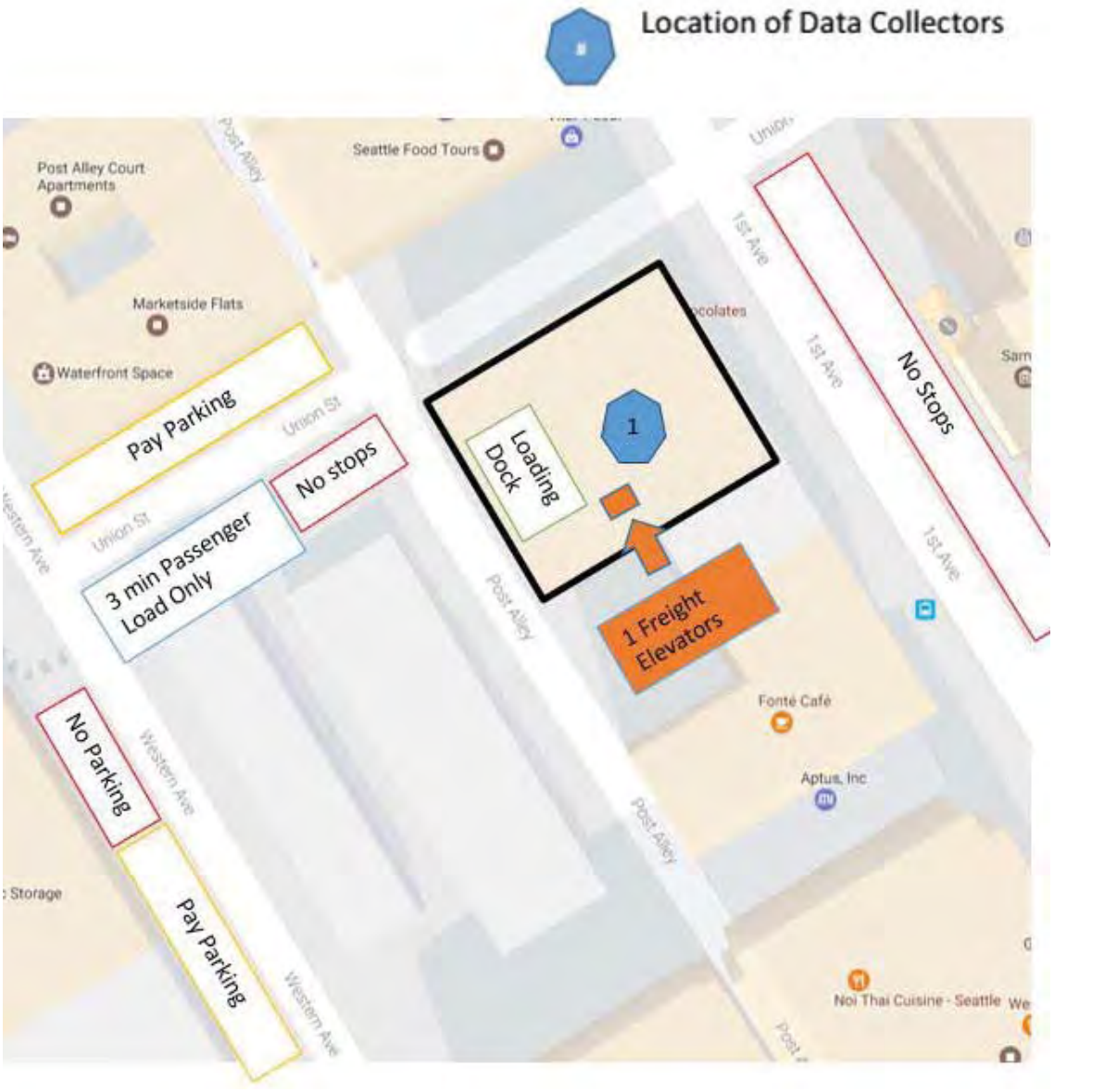
# HOTEL:
# FOUR SEASONS HOTEL

The Four Seasons Hotel is located at 99 Union St, Seattle, WA, 98101. Constructed in 2008, the building has 21 floors. Floors 1-10 operate as a hotel while floors 11-21 serve as residential condos. The building has 147 hotel rooms and 35 condo units.

**Figure 2-16.** Four Seasons Hotel (Google)

All deliveries made to the building are received through the loading bay located on the bottom floor of the west side. The loading bay is open from 7 am to 3 pm. There are three full-time hotel staff who take receipt of all deliveries. After logging the received packages into the computer system, they email or leave a voicemail for residents or guests to let them know they have a package. There is one concierge for residents and another one for guests. They are on duty 24/7 throughout the year, delivering packages to the guests and residents directly.

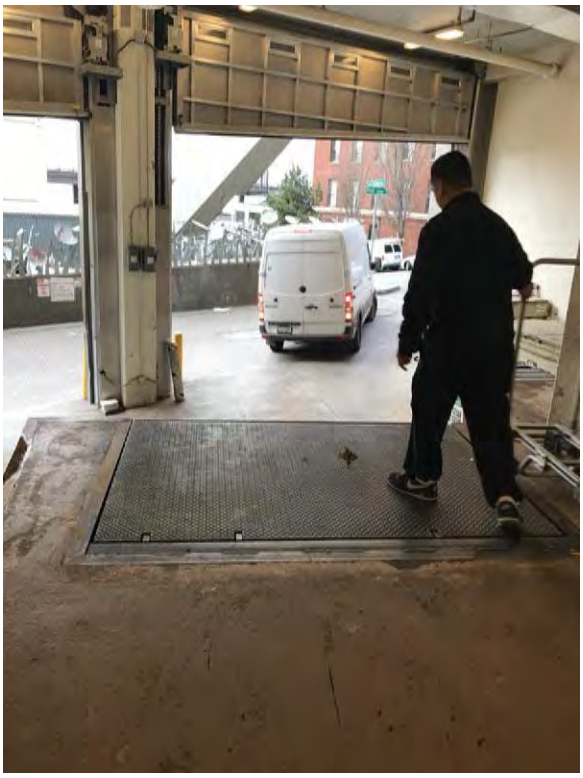
**Figure 2-17.** Street Layout around Four Seasons Hotel




As shown in Figure 2-17, there are three freight elevators at the building, which are mainly used by the hotel staff members when they distribute goods throughout the building. Hotel staff have a list of orders that the hotel restaurants and bars are expecting, and upon receipt of the deliveries the staff signs for each one. They also tag all food items with stickers that have the received date on them and store the items in one of many refrigerated rooms on site, where restaurant staff will pick them up. Hotel staff deliver received goods to the concierge for residents and guests.

**Figure 2-18.** Four Seasons Hotel Staff Handling Deliveries

**Figure 2-19.** Sharp Turn at the Entrance of Four Seasons Hotel Loading Bay



As can be seen in Figure 2-19, the trucks are required to manage very sharp turns to get in and out of the loading bay. Before the loading bay opens at 7 am, some of the delivery trucks line up to wait for the loading bay gates to open, idling in a queue on Union St.

# SHOPPING MALL: WESTLAKE MALL/TOWER

Westlake Mall is located at 710 2nd Avenue, Seattle, WA 98104. Constructed in 1988, it consists of a 4-story shopping center and a 25-story office tower, with a total floor area of 369,000 square feet. The shopping center has 22 businesses, including 5 cafes and restaurants.

**Figure 2-20.** Westlake Center/Tower (Google)

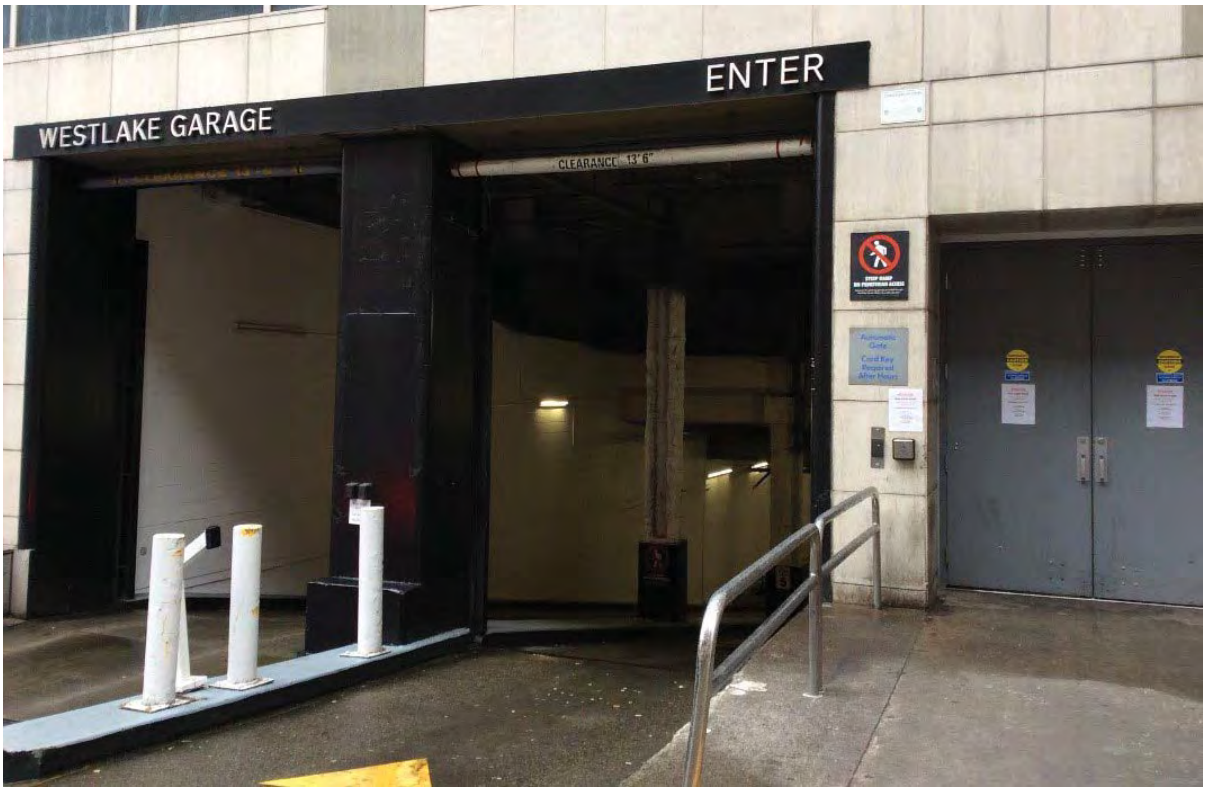
Delivery trucks can be parked at either the loading bay or street curbs, as shown in Figure 2-21, the building is surrounded by one-way streets between 4th and 5th Avenue. The entrance to the loading bay is located on Olive Way. There is only one commercial loading zone on Olive Way with a 'no stops' restriction between 6 – 9 am and 3 – 7 pm during rush hour. As shown in Figure 2-23, the tower has two elevators that connect to the parking garage where the loading dock is located, one freight elevator that requires a special access key from the building manager, and 6 passenger elevators that are guarded by security guards from 6 am to 10 pm. On the map in Figure 2-21, the tower location is indicated as a purple rectangle box.

**Figure 2-21.** Street Layout around Westlake Shopping Center/Tower

**Figure 2-22.** Delivery Truck at 3 min Passenger Drop-off Zone on 4th Avenue

During our observations, we saw that it was common for delivery trucks to park in the 3 minute passenger drop-off zones on 4th Avenue, as can be seen in Figure 2-22.

**Figure 2-23.** Westlake Garage on Olive Way




The entrance of the loading bay is located on Olive Way as shown in Figure 2-23. The clearance limit of the garage is 13’ 6” feet.

At the entrance of the garage, there is an information board that that indicates when the parking garage or loading dock is full. This information can be seen by the delivery truck drivers before they enter the loading bay, which helps the drivers avoid the undesirable situation of lining up at the loading dock when they could instead be searching for parking elsewhere.

**Figure 2-24.** Parking Information Board at Westlake Mall Garage

**Figure 2-25.** Steep Slope at Westlake Garage

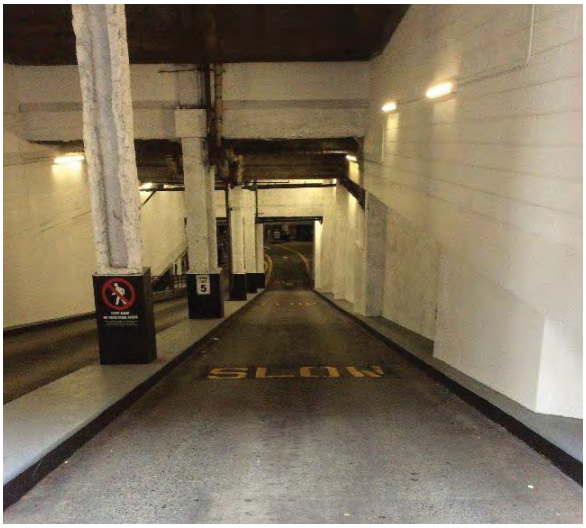
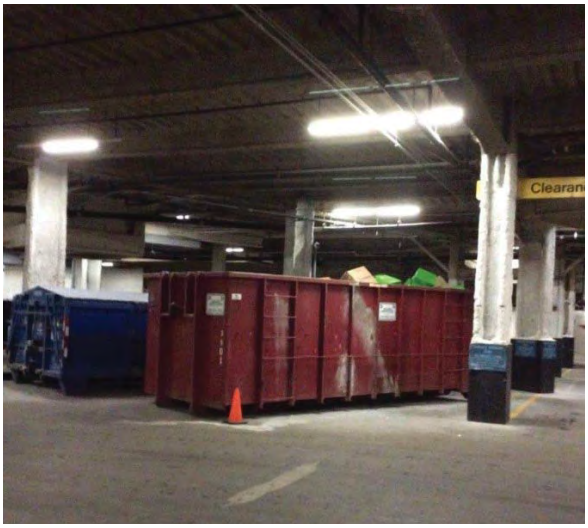



**Figure 2-26.** Truck Maneuvering Obstructions at Westlake



The entrance of the loading bay at Westlake is especially challenging because of the very steep slope. This makes it very difficult for big trucks to enter and exit (Figure 2-25). Recycling and garbage containers positioned across the loading dock also obstruct the turning range of large trucks.

The loading bay is shared by both the shopping center and tower, and is open from 6 am to 10 pm. Delivery drivers are required to contact the tower security guard to open the garage door for after hours.

**Figure 2-27.** Loading Dock at Westlake

At the loading bay, there is a security guard working from 6 am to 7 pm. After 7 pm, the tower security guard shares the duty of overseeing the garage. The peak delivery hours are from 10 am to 2 pm. Some of the retail stores have goods delivered during the night, so the property management company handles the schedule for night time deliveries.

**Figure 2-28.** Tight Hallway between Loading Dock and Freight Elevator at Westlake

There is a hallway that connects the loading dock to the secure freight elevator in the tower. In order to use the freight elevator, the delivery person must obtain the key card from the building management company located on the 4th floor. The hallway to the tower freight elevator appeared very tight for large deliveries, as shown in Figure 2-28.

# RESIDENTIAL TOWER: INSIGNIA TOWER

Insignia Tower is located at 588 Bell St, Seattle, WA 98121. The North and South Tower were constructed in 2015 and 2016 respectively. Each tower has 41 floors and approximately 350 units, resulting in 700 units total.

**Figure 2-29.** Insignia Tower

The North and South Towers have two separate loading docks in each parking garage. As shown in Figure 2-30, there is only one 30 minute commercial loading zone on 5th Avenue.

**Figure 2-30.** Street Layout around Insignia Tower

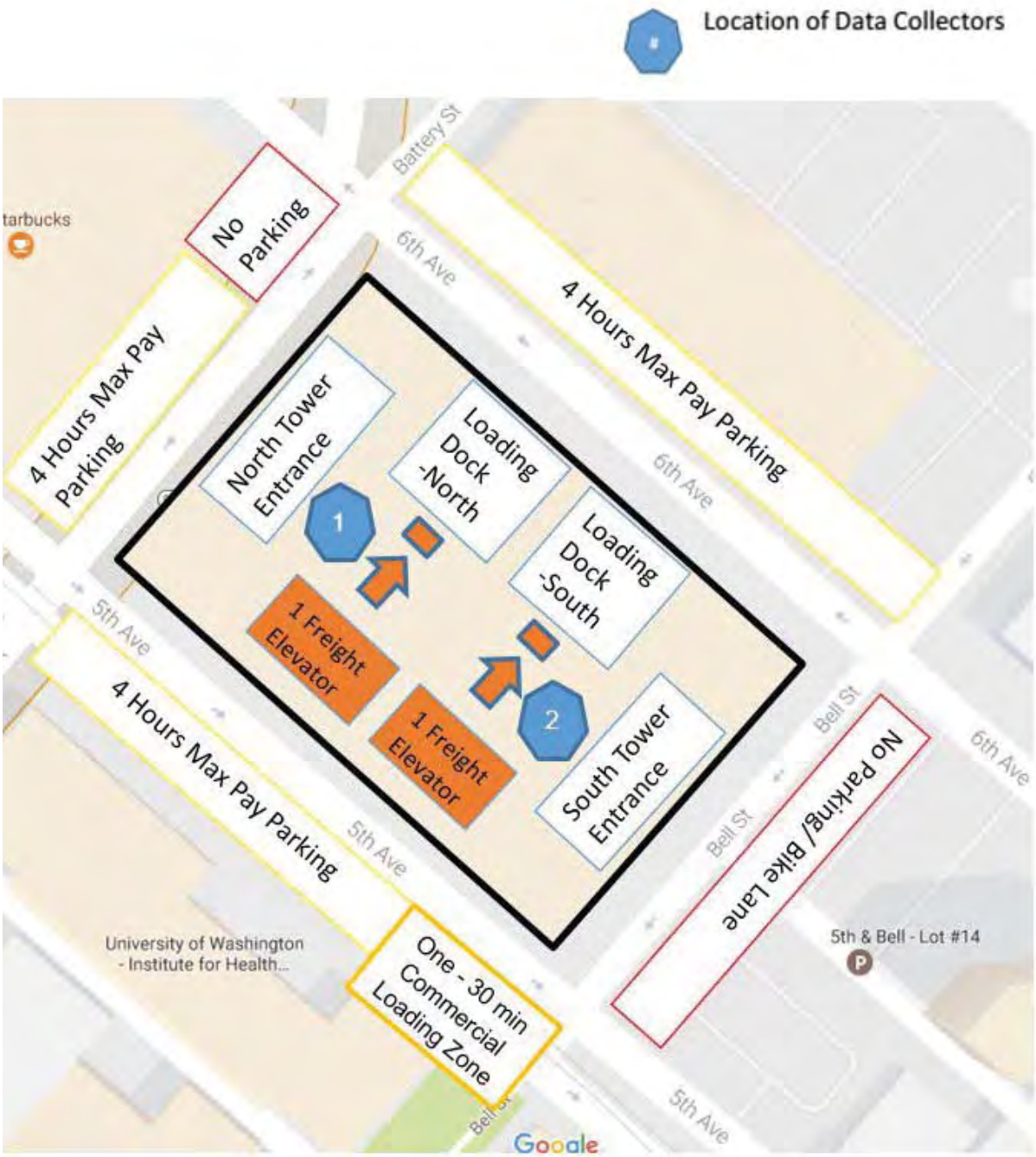
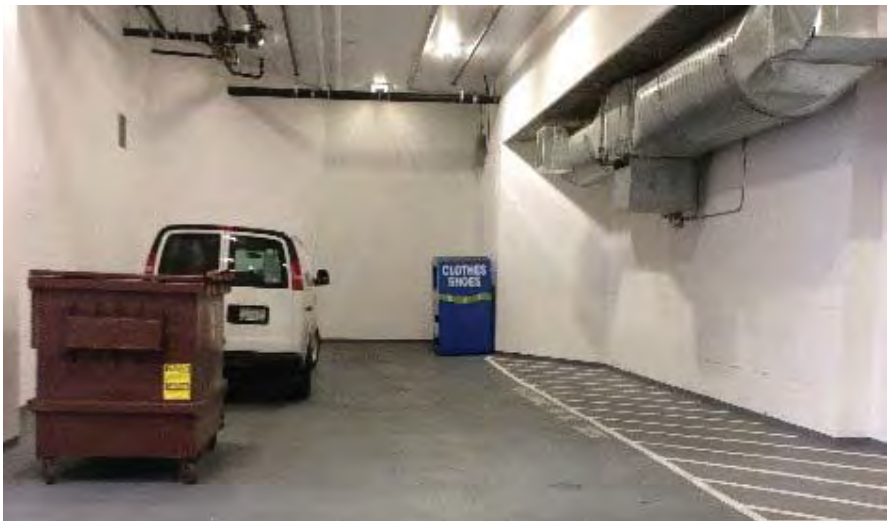


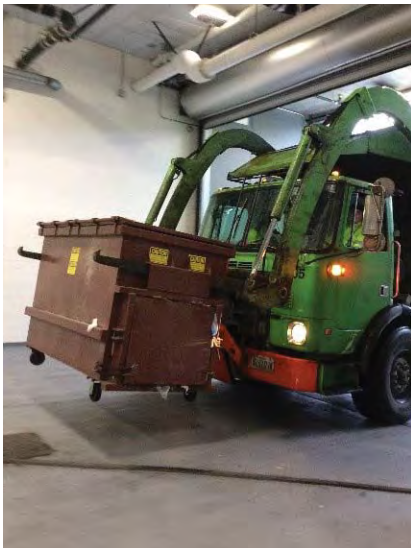
**Figure 2-31.** Loading Dock at Insignia Tower




Loading bays are located near the entrance of both parking garages. Both towers have special software for booking loading bays for freight deliveries. A reservation is required to use the loading bays because building staff need to open the garage door for the delivery trucks to access. Figure 2-31 shows a loading dock at Insignia Tower.

Garbage trucks pick up recycling and garbage containers from the loading dock. As shown in Figure 2-32, the height of the garage entrance is too short for the garbage truck to operate inside. Therefore, the garbage truck had to grab the container and back up on to 6th Avenue to lift up the container to complete its operation. Once the garbage container is emptied, the truck returns the container to the building and building staff move it back to the loading dock. Cars stuck behind the garbage truck had to wait until the truck finished its operation.

**Figure 2-32.** Garbage Truck Operation at Insignia Tower



The Insignia concierge scans all of the received deliveries and uses special software to register parcels. The system sends an email to the residents, notifying them for pick up. When perishable items are delivered (e.g. online grocery orders), the carrier has to deliver goods to the residents directly or leave them in a small fridge in the lobby for a short period of time. In order to use the passenger elevators, the concierge has to grant the delivery person access to the upper floors by using a fob for the elevator. In the case of food deliveries, or other deliveries that require access to the upper floors, the concierge calls the resident to confirm his/her deliveries before granting access to elevators. Residents sometimes pick up food from the drivers directly, outside of the building. According to the concierges, approximately 200 parcels/ day are delivered to the building in total.

During data collection, the research team observed that the 'No Parking' zone on Battery St, right in front of the North Tower entrance, was often occupied by delivery trucks (Figure 2-34).

**Figure 2-33.** Packages at the Insignia Concierge Desk

**Figure 2-34.** Delivery Truck parked at 'No Parking' Zone on Battery St

## PROCESS FLOW MAP

Based on the information gathered, the research team created five high-level process flow maps and one detailed process flow map. The process flow maps provide insights as to what elements of the delivery process consume the most time and are the most variable, and how each building's infrastructure is used during goods delivery. Not only does this include maneuvering in small spaces, but also delays in wayfinding among other things.

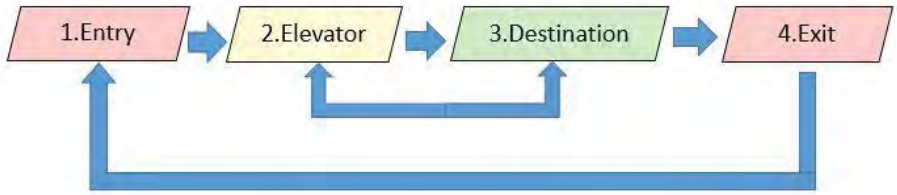
First, activities were divided into the following four sections as shown in Table 2-6.

**Table 2-6.** Sections of High-Level Process Flow

| SECTION | DESCRIPTION | EXAMPLE |
|---|---|---|
| 1. Entry | Activities at loading bay or street before deliveries are complete | Unloading/loading, obtaining security access etc. |
| 2. Elevator | Activities to go in and out of the elevator | Walking to the elevator, waiting for an elevator etc. |
| 3. Destination | Activities at the final destination | Talking with receptionist, receptionist signs for goods etc. |
| 4. Exit | Activities at loading bay or street after deliveries are complete | Walking back to the truck, close cargo compartment etc. |

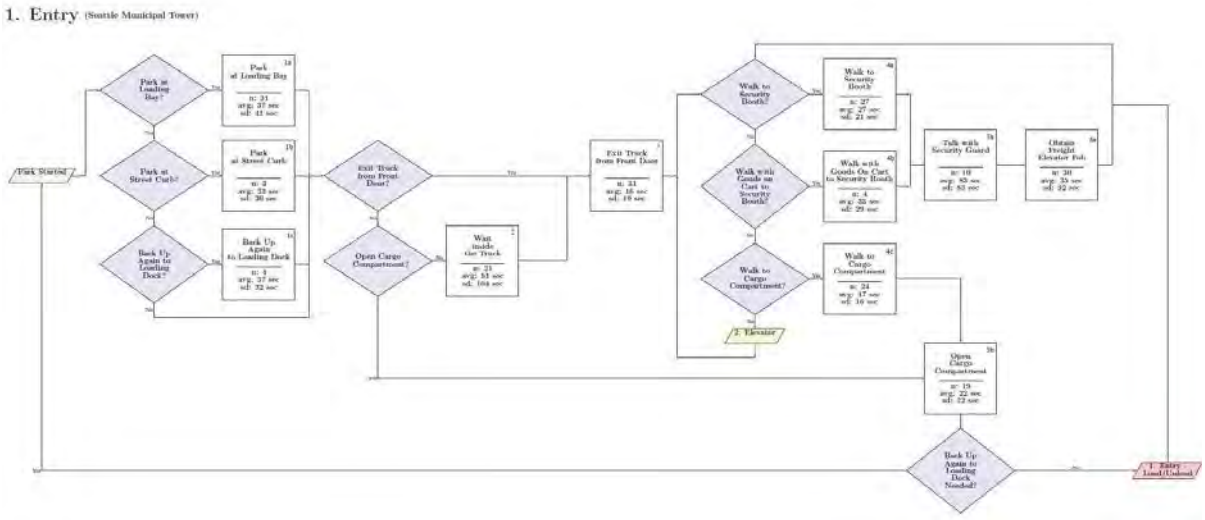
The relationship between each action is shown in Figure 2-35. In the case of multiple deliveries to one building, the delivery person can take the elevator several times to different locations, which is represented by the arrows between '2. Elevator' and '3. Destination'. If a delivery person needs to go back to the truck for another load after the first delivery, he or she will repeat the sequence again. . This relationship is described by the arrow between '4. Exit' and '1. Entry'.

**Figure 2-35.** Relationship of High-Level Process Flow




As can be found in Appendix H to K, detailed process flow maps include operational sequence diagrams with the average delivery time for each task. Figure 2-36 shows an entry section of the high-level process flow map of Seattle Municipal Tower. A parallelogram represents a node that connects from one section to another section. Due to the limitation on page size, some of the activities were further divided into subsections such as '1. Entry – Load/Unload'. Color coding from the high-level process flow matches with the detailed process flow map.

**Figure 2-36.** Example of Process Flow Map




Shown in Figure 2-36, a diamond box represents a decision node which has 'yes' or 'no' paths. A rectangle node shows a task name, a sample size in 'n', an average time spent in 'avg', and standard deviation in 'sd'. Each rectangle box has an ID number on the top right corner. This ID number matches with the spreadsheet that summarizes the same information in a list format. The spreadsheet includes the coefficient of variance (standard deviation /average) to compare the variations in each task. Figure 2-37 shows a portion of the spreadsheet. Appendix E is a full version of the detailed process flow map and Appendix F is the corresponding data spreadsheet for the office tower. Appendices G – J show the process flow maps for the historical building, hotel, shopping mall, and residential tower respectively.

**Figure 2-37.** Spreadsheet of Process Flow (Sample)

| Location | Order | Tasks | average (seconds) | standard deviation (seconds) | num | sd/avg | minimum (seconds) | maximum (seconds) | mode (seconds) |
|---|---|---|---|---|---|---|---|---|---|
| Entry | 1a | Parking Ended at Loading Bay | 37 | 41 | 31 | 1.12 | 3 | 165 | 4 |
| | 1b | Parking Ended at Street Curb | 33 | 30 | 3 | 0.89 | 12 | 67 | 12 |
| | 1c | Backing Up Again to Loading Dock | 37 | 32 | 3 | 0.87 | 13 | 73 | 13 |
| | 2 | Waiting Inside the Truck | 51 | 104 | 21 | 2.02 | 1 | 407 | 2 |
| | 3 | Exit Truck From Front Door | 16 | 19 | 31 | 1.2 | 3 | 90 | 3 |
| | 4a | Walk from Truck to Security Booth | 27 | 21 | 27 | 0.75 | 4 | 102 | 8 |
| | 4b | Walk With Goods On Cart to Security Booth | 33 | 29 | 4 | 0.88 | 6 | 75 | 26 |
| | 5a | Talking with security gaurd | 83 | 83 | 10 | 1 | 5 | 242 | 5 |
| | 6a | Obtain Freight Elevator Fob | 35 | 21 | 30 | 0.61 | 2 | 77 | 12 |
| | 4c | Walk to Cargo Compartment - Entry | 17 | 16 | 24 | 0.93 | 2 | 67 | 2 |
| | 5b | Open Cargo Compartment | 22 | 22 | 19 | 0.99 | 3 | 75 | 7 |
| | 6b | Organize Goods - Entry | 87 | 86 | 8 | 0.99 | 3 | 255 | 120 |
| | 6c | Exit Truck from Cargo Compartment | 3 | NA | 1 | NaN | 3 | 3 | 3 |
| | 7a | Take Cart Out | 31 | 33 | 23 | 1.05 | 1 | 124 | 1 |
| | 8a | Take Good(s) Out onto cart | 61 | 71 | 26 | 1.16 | 3 | 290 | 12 |
| | 7b | Take Good(s) And Cart Out Together | 64 | NA | 1 | NaN | 64 | 64 | 64 |
| | 7c | Take Good(s) Out | 51 | 23 | 8 | 0.45 | 26 | 84 | 26 |
| | 9a | Close Cargo Compartment | 15 | 13 | 15 | 0.87 | 2 | 48 | 3 |

As shown in Figure 2-37, the spreadsheet of process flow shows the average duration, standard deviation, sample size, coefficient of variation, minimum, maximum and mode of the delivery time. The coefficient of variation represents the ratio of the standard deviation to the mean, which is a useful statistical measurement for comparing the degree of variation from one data point to another even if the means are different from one another. A ratio bigger than 1 means the variation is greater compared to the mean. This means one person can perform the same tasks shorter than others. Those tasks could be minimized and further examined for more effective delivery strategies. The process flow map demonstrates that there are numerous steps in the delivery process. Some steps can be performed in parallel whereas others have to be done in sequence. Each delivery person can generate a great numbers of paths to complete tasks. Also, the tasks vary highly depending on building types and delivery operating systems. However, common time-consuming activities include using freight elevators, talking with a recipient, signing for deliveries by recipients, and waiting for access to the buildings.

With the data and process flow maps, SCTL researchers can further assess the current delivery systems in downtown Seattle. With a better understanding of the current practices in urban freight systems, dwell times and failed deliveries can be better understood, informing strategies to reduce these delivery challenges.

CHAPTER 3

# PRIVATE LOADING FACILITIES INVENTORY

## Introduction

The lack of available data about private freight loading/unloading infrastructure is evident in the case of planning approaches that aim to improve urban freight systems. Various studies have shown that scarcity and unsuitability of on-street and off-street truck loading /unloading facilities in the urban environment leads to illegal or inadequate parking. This includes double parking, parking on the curb, and parking in the turn lane. These parking behaviors reduce the roadway capacity, inconvenience pedestrians, create conflicts with other modes of transportation and ultimately lead to congestion and safety issues.

There is no published information on major U.S. cities that maintain a database with information on the location and features of private loading/unloading infrastructure (meaning, out of the public right of way). Since these facilities are often privately owned and managed, the public or other private stakeholders do not necessarily have access to information about these facilities. As a result, the ability of many cities to design and articulate their data requirements, to access and obtain the appropriate data, and use it for policy design and monitoring is often inadequate.

This chapter describes the development of a data collection method for documenting private urban freight infrastructure that does not require prior permission, is ground-truthed, and can be completed within reasonable cost and time constraints. This information will provide the City with a better understanding of the options available to delivery companies for parking and freight loading/unloading in private parking facilities that are accessible from streets and alleys.

## Goals

In response to this urban freight challenge, SDOT engaged with the Urban Freight Lab at the UW SCTL Center to collect information on the locations and capacity of freight truck loading/unloading private infrastructure (hereinafter referred to as private freight infrastructure) in the dense urban areas of Downtown Seattle, Uptown and South Lake Union.

This chapter outlines the development of an efficient and systematic data collection method to build a database system of private freight infrastructure that can be maintained by local governments. Additionally, it presents the results of applying the method for mapping these facilities in the downtown Seattle area.

## Methodology

The method includes the development of a survey form, survey collection app, data quality control process, data structure and a proposed typology for private freight infrastructure based on basic physical infrastructure characteristics.

# MAPPING THE CITY'S PRIVATE FREIGHT INFRASTRUCTURE

In order to determine whether truck load/unload spaces are well positioned to serve the community, manage competing demands, and provide sufficient capacity to meet current and future needs, one must know each facility's location and features. While street parking is well documented in Seattle's geospatial databases, private freight infrastructure, such as loading docks and loading bays, is not. Therefore, the research team's first step was to document the current locations and features of all truck load/unload spaces in the study areas.

## Step 1. Collect Existing Data

The research team used SDOT's publicly-available GIS layers of designated curbside parking , as well as King County's GIS layer of Seattle's alleys, to begin developing a multi-layer map of the truck load/unload locations in the city's urban centers.

Researchers in other large cities may find this data is readily available as well, making existing data collection a low-cost step that is easily scalable at the national level. The primary cost is staff time spent collecting the data layers, and working with agency staff to clean data points, if necessary. This could be internalized in agencies with GIS-trained staff, or purchased at a low cost from contractors if there is not a high requirement to clean the data for this purpose.

The research team reviewed the following Seattle GIS databases, further described in an attached data dictionary (Appendix K):

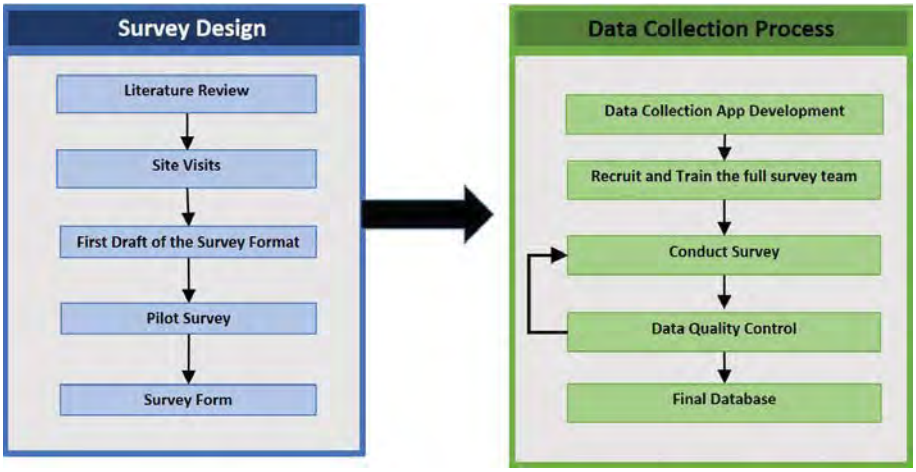
- Alleys
- Urban villages
- Arterial types
- Commercial
- Retail
- Food permit data
- Residential
- SDOT traffic lanes
- Curb space categories
- Block faces
- Year built

## Step 2. Develop Survey to Collect Freight Bay and Loading Dock Data

In addition to mapping geospatial data for on-street parking, private freight infrastructure also needed to be mapped. To accomplish this, the SCTL Center developed an original data collection process to record the GIS locations and infrastructure features of all private freight infrastructure in urban centers. The intention was to create a replicable, ground-truthed method.

The proposed methodology is represented in Figure 3-1. This methodology is a result of testing and revising the initial process that provided empirical evidence of the infrastructure surveyed and proved the validity of the research method. The different steps of the process are broadly classified into Survey Design and Data Collection Process and will be further explained in the corresponding sections below.

**Figure 3-1.** Overview of Methodology Used to Collect Data on Private Freight Bays & Loading Docks




### LITERATURE REVIEW

Previous reports, papers and building codes were reviewed to identify the terminology and key physical features of private freight infrastructure [1, 2, 3, and 4]. Additionally, two site visits in downtown Seattle provided the team with valuable field observations and testimonies from delivery drivers, concierges at residential towers and security officers.

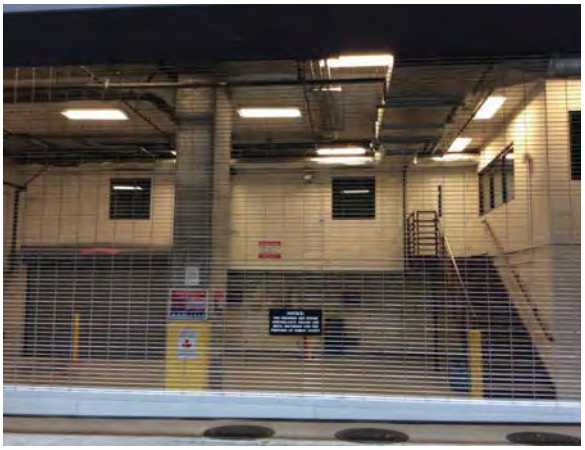
As a result of the literature review, the team defined two main categories of private freight infrastructure: loading bays (Figure 3-2) and exterior loading docks (Figure 3-3). It is worth noting that these are not the only types of infrastructure investigated in this data collection effort; the typology consists of three private freight infrastructure types that will be described further in a later section. Another finding in the literature review was an extended list of private freight infrastructure features that affect operations and can be grouped into **location, design and capacity features**.

One important **location feature** is the type of public right-of-way that provides access to the facility location. Poor layout or design of the roads or alley connecting the delivery access point to the street network may significantly affect how private freight infrastructure is used. A common example is inadequate alleyways, which delivery drivers tend to avoid if they have an alternative to make sure they are not blocked on their way out.

**Design features** include the dimensions of access points to the loading bay, such as vehicle doorway and dock doorway dimensions (width and height) and ground clearance restrictions (i.e. maximum vehicle height allowed). The access angle to the loading dock, which includes the access angle to the structure, the angle between the vehicle access trajectory and the traffic flow, the access grade ramp, whether the vehicle needs to back-in, maximum turning radius, maximum truck size and any additional security access measures such as physical barriers, access code and personal interaction all impact the delivery's operations.

**Capacity features** are the characteristics of the parking spaces and mechanical devices, such as the number of parking spaces, the apron (i.e. space for maneuvering and park), and the presence of a dock platform and dock-levelers.

**Figure 3-2.** Freight Loading Bay Inside a Seattle Building



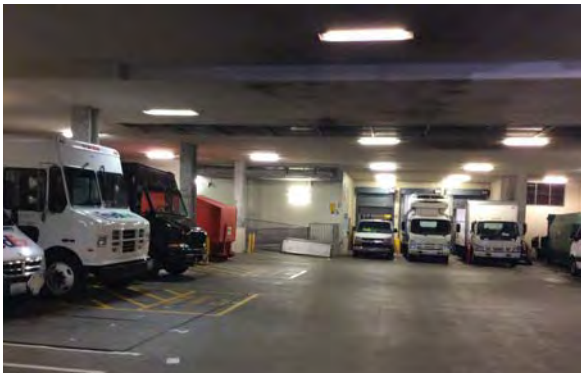
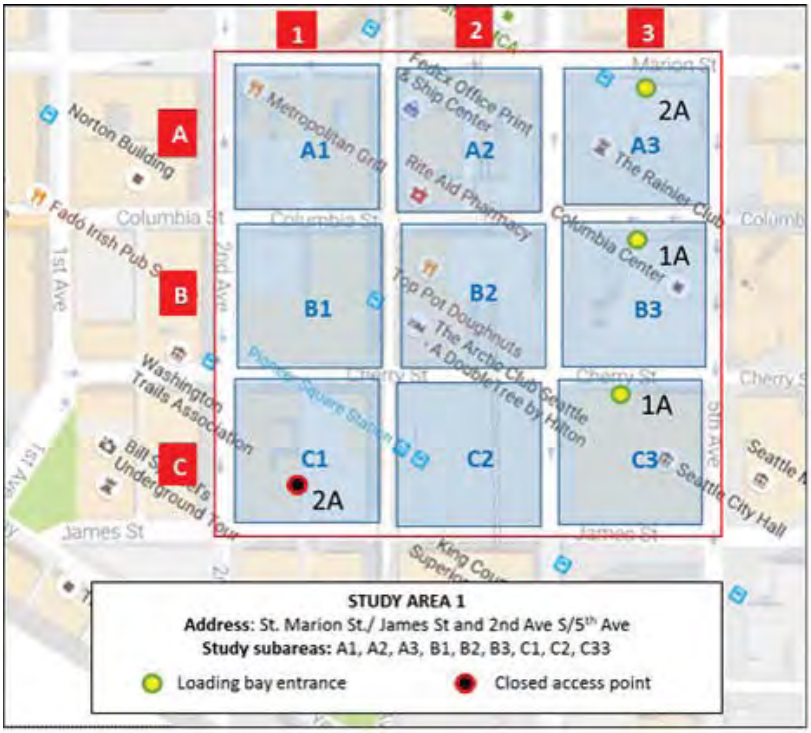


**Figure 3-3.** Closed Loading Dock

## Survey Design and Pilot Survey

The SCTL data collection team designed and pilot tested a survey to document the key observable features of private freight infrastructure and geocode their locations. After finalizing the instrument and developing an application for data collection, teams of SCTL graduate students (operating in pairs) tested it in downtown Seattle. The six-block pilot area is shown in Figure 3-4. The data collection team used laser measurement devices bought at a local home improvement store that cost less than $150 each, and completed measurements while standing on public sidewalks and in alleys.

**Figure 3-4.** Pilot Survey Study Area




The pilot survey proved that the team could quickly and easily measure the entrances to open freight bays on foot. The data collected gave the project manager a clear understanding of the average time it takes to complete the survey per city block, so he could create a funding staffing plan and schedule for full implementation.

The pilot showed difficulties in collecting complete data as some entrances were closed, and their interior could not be observed from the public right of way.

Other features of interest such as turning radius, maximum truck size, and centerline distance were not possible to measure in the field due to the complexity of the geometrical features, the lack of knowledge or unavailability of the facility staff, or a lack of exterior signage.

### Final Survey Form

The team utilized the results of the pilot test to develop the final data collection survey in Appendix L.

The final survey form contains four parts: a) general information, b) facility location and visuals, c) access design features and d) capacity.

## DATA COLLECTION PROCESS

### Development of a Data Collection App

The team developed an application using the online platform DeviceMagic. Along with cloud storage and visualization, it provides an interactive and easy-to-use tool to design mobile device survey forms compatible with both iOS and Android. The mobile data collection app instrument was chosen to make the process:

- Efficient: automation of data digitization and photo collection and storage
- Flexible: the form can be revised if surveyors encounter unforeseen infrastructure conditions that require a new data structure
- Speedy: Fast input of data in the field with automated questions and drop list answers.
- Low cost
- Accurate: decrease transcript errors and help reduce data lost in transit
- Data quality control: nearly real-time data collection monitoring and spatial visualization of completed surveys

The researchers bought two iPad mini 2s with 32 GB for the field survey for $360 each. With DeviceMagic loaded on the tablets, surveyors filled out the survey form, took and stored pictures, and used the devices' GPS capability to locate facilities. The survey form supported automatic entry of GPS locations, and allowed manual input of the same coordinates supported by offline Google maps. During the development of the data collection app, researchers also tested the questionnaire in the field to prevent logic errors.

### Recruiting and Training the Data Collection Team

The research team hired four University of Washington undergraduate students and trained them to conduct the survey.  Each team attended two 3-4-hour training sessions led by a supervisor. The first session instructed data collectors on freight infrastructure concepts and the second session focused on practical aspects of data collection. During the practical training, data collectors learned how to use the questionnaire app on the tablet and the laser device to measure physical features. As part of their training, the project manager also personally supervised the data collection teams' work on city streets during the first week of the full survey implementation.

## Conducting the Survey

SDOT contracted with the SCTL Center to map alleys and private freight loading bays in three of the city's designated urban centers: Downtown Seattle, Uptown and South Lake Union (see Figure 3-5). **The combined area has a regular street grid of 523 blocks, which took approximately 210 person hours for data collection.**

During data collection and data quality control process, hourly staff and supervisors were responsible for the following tasks:

- **Data Collection (Hourly Staff)**
  - Commute to and from study area
  - Circulate blocks surveying any private freight infrastructure
  - Work in 2-person teams: one member filling out the survey on the tablet, and the second member taking measurements and updating a progress sheet (i.e. hard-copy map of the study area) to keep track of every new surveyed location.

**Data Collection (Supervisor Staff)**

- Break down the study area into subareas
- Set partial objectives of data collection on a weekly basis, depending on the number of teams working at the same time and the size of the subarea
- Develop hard copies of subarea maps and distribute them to teams progressively
- Coordinate work schedule of teams
- Make sure data collectors are always equipped with data collection materials, safety equipment, and identification.

**Data Quality Control (Supervisor Staff)**

- Conduct data quality control checks of location and feature information (further explained below)

## Multi-Layer Communication with Stakeholders

Although the team did not experience technical difficulties while executing the full survey, they quickly ran into problems due to security concerns. On the third day of data collection, a team member was measuring a freight bay under a bank building from a nearby sidewalk. The building security guard reported them to the Seattle Police Department (SPD). A police officer arrived on the scene, reviewed the UW letter the data collectors carried explaining the project in partnership with the city, and called various city staff members to verify. The police officer could not reach the SDOT project manager, so the students had to stop their work for the day and regroup.

City police contacted the SDOT project manager the next day, as did a Federal Bureau of Investigation (FBI) agent responsible for homeland security. They were very reasonable, and suggested several changes to the security process that were implemented by the research team, including adding the SDOT manager's contact information to a letter on SDOT letterhead. SPD also notified all building

managers in the survey area through the Seattle Shield program, a pre- existing information exchange for building operators and the police. SDOT created a new webpage at http://www.seattle.gov/transportation/thefinal50feet.htm to periodically publish information on progress made during the full survey and to inform the public of where the surveyors would be in upcoming weeks. The team quickly learned that before conducting an on-street survey of private buildings, it is essential to have a multilayer communications plan in place for all parties with an interest in the survey area.

## Quality Control

The quality control process included the following tasks:

- Information transfer check 1: compare completed surveys with progress sheet filled out by data collectors to keep track of the number of surveys collected and their locations.
- GPS location accuracy check 1: in field, use offline Google Maps on the tablet during data collection to support the manual input of the location with a dropped pin.
- GPS location accuracy check 2: in office, compare the GPS location of the infrastructure collected in field with the location according to Google Maps' Street View feature.
- Data entry accuracy check 1: compare infrastructure features entered with the pictures taken during the survey.
- Data entry accuracy check 2: collaborate with experienced UPS truck drivers who serve the study area to identify survey locations that were closed during the survey. This step allowed us to rule out 110 potential locations that were not private freight infrastructure.
- GPS location and data entry accuracy check 3: The quality control process also resulted in secondary inspections at survey locations where the loading bay had not yet been surveyed or the survey could not be located based on the GPS location checks described above.

Each surveyed loading facility was inputted using the GPS (latitude and longitude) capabilities of the survey tablet, Google Maps, and paper maps distributed to survey teams. While applying the data quality control process, several location inaccuracies were identified and required manual adjustment. GPS often has problems in alleys and urban canyons due to poor line-of-sight with satellites. Google Maps can be inaccurate, particularly in alleys, and a paper map requires user interpretation. However, when the three GPS location accuracy methods were used as a crosscheck, the team could verify the accuracy of the locations that were delivered to SDOT in a latitude and longitude format.

This chapter documents an innovative and low-cost data collection procedure to map and catalog private freight infrastructure. Built from the ground up, this procedure was constantly evaluated and modified throughout the data collection process. Recommendations for improvements on geolocating private truck load/unload spaces can be found in Appendix O.

# DATABASE STRUCTURE

## Database Structure Diagram

Appendix M shows the data structure diagram of our database. Furthermore, this diagram is supported by our data dictionary, which describes the variables associated with each of the decisions and data features in our database.

## Typology of Delivery Infrastructure

One of the early findings during data collection was the variety of private freight infrastructure types. Based on the literature review and field experience, three types of infrastructure considered in the data structure were defined:

**Loading bay (Figure 3-5)**. An enclosed space inside the building with an entrance/exit point (e.g. roll up doors, garage doors) that act as a continuation of the upper parts of the building. This space is partially or completely dedicated to unloading and loading activities. It has entrances and exits greater than 8 feet by 8 feet for commercial vehicles. Loading bays can have loading docks and truck parking spaces with or without access to a loading dock.

**Figure 3-5.** Examples of Loading Bays in Downtown Seattle. (A) Detail of Loading Dock Inside Loading Bay, (B) Vehicle Door of Loading Bay

(A)

(B)

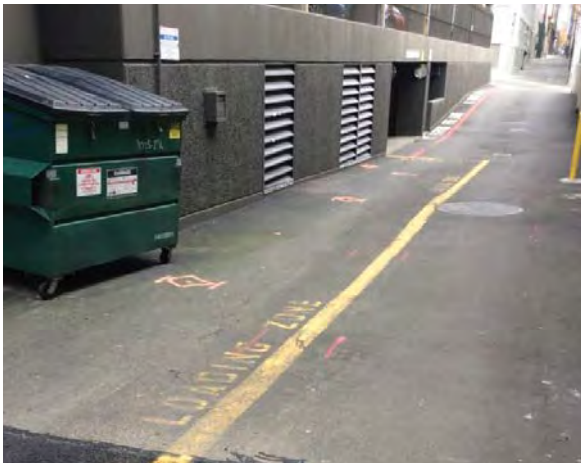
**Figure 3-6.** Examples of Exterior Loading Docks in Downtown Seattle. (A) Loading Dock with Platform Inside Building, (B) Loading Dock with Platform Outside the Building.

(A)

(B)

**Exterior loading dock (Figure 3-6).** A loading dock that is located outside of building exterior wall. Exterior loading docks can be completely open to the sky or partially or completely covered by a canopy or upper part of the building. Additionally, exterior loading docks can also include inside loading platforms, where trucks dock the cargo compartment to a dock door.

**Figure 3-7.** Examples of Exterior Loading Areas in Downtown Seattle. (A) Loading Area Accessed from Street, (B) Loading Area in Alleyway.



(A)

(B)

**Exterior loading area (Figure 3-7).** Space for loading and unloading located outside of the building exterior walls and without a loading dock. Exterior loading zones can be completely open to the sky, or partially or completely covered by a canopy or upper part of the building.

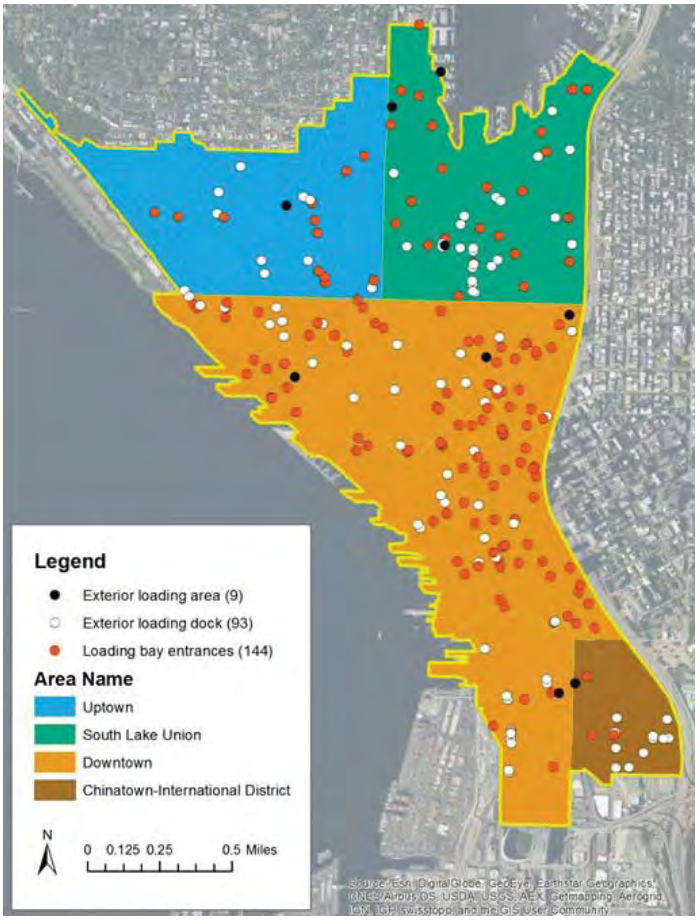
The research team's final analysis for Downtown Seattle, Uptown and South Lake Union found:

- 144 loading bays
- 93 exterior loading docks
- 9 exterior loading areas.
- 17 undefined locations that could be private freight infrastructure, but not enough information is available to confirm this.

There was considerable value in collaborating with private sector members of the Urban Freight Lab on this task. Data collectors in the field initially identified 382 potential freight loading bays and docks in the 3 urban centers. However, in 127 cases the doors were closed during the survey and there was no way to tell if those locations were actually used for freight deliveries. UPS had their local drivers, deeply knowledgeable about city routes, review the closed door locations as part of their work in the Urban Freight Lab. The Urban Freight Lab provided photos and other location information. That review allowed the Lab to rule out 87% (110) of the locations behind closed doors, reducing uncertainty in the findings from 31% to less than 5%.

This information is represented by the map in Figure 3-8.

**Figure 3-8.** Data Collection Results in Study Area



## Data Dictionary

### GENERAL DEFINITIONS

**Building exterior wall.** Walls of a building that separate spaces partly or completely unobstructed to the sky from spaces inside the building.

**Loading dock.** An elevated platform that facilitates shipping and delivery operations.

**Dock leveler.** An adjustable mechanized platform built into the edge of a loading dock. The platform can be moved vertically or tilted to accommodate the handling of goods or material to or from trucks.

**Angled.** Refers to facilities on bi-directional alleyways, where the entrance angle could be contrary or to traffic flow.

**Not a loading bay.** Undefined locations that were identified as not a loading bay based on responses of UPS truck drivers.

**Undefined.** A location that could potentially be a loading bay entrance/exit. No information is available because: a) a barrier impeded data collection, b) there was a lack of on-site signage identifying the facility as a private freight access point, and/or c) a lack of carrier drivers' survey responses identifying the facility as a private freight access point.

**Additional Code definitions**
Appendix N describes the data fields of our database and the code domain for each of these fields.

# FINDINGS AND FUTURE RESEARCH

Due to its unique partnership with SDOT, multiple industry sectors, and academia, the Urban Freight Lab moved from a concept to a going concern in 2017. This report covers the first of a suite of Final 50' research projects.

## Research Findings

1. Geocoding the location and features of all private truck load/unload bays and loading docks in three of Seattle's urban centers: downtown, uptown, and South Lake Union, provided evidence that the vast majority of buildings in these areas depend on public truck load/unload spaces to receive goods.

   This information matters because, when combined with the city's pre-existing curb data layer, it is the basis for planning a comprehensive truck load/unload space network in the city. It is the first time that a major U.S. city has had this information.

2. This project documented detailed goods delivery system process flows and delays for 5 prototype buildings in Seattle's Center City. The Final 50' begins where trucks stop, extends across intersections and sidewalks, and tracks goods deliveries into buildings. It is the first time that researchers have analyzed both the street network and the city's vertical space (office, hotel, retail, historic, and residential towers) as one unified goods delivery system. Although delivery companies have been well aware of challenges in the Final 50', this is new information for the public sector. It is leading them to re-examine building codes and regulations that affect outcomes in the delivery system.

## Future Research

The Urban Freight Lab transmitted the private truck load/unload space data layers to SDOT as they were completed in 2017. After viewing the data, SDOT engaged the Urban Freight Lab in a second Final 50' project to collect similar data for two additional urban centers: the First and Capitol Hill areas. The Lab will publish its second report including these findings, along with an occupancy study of truck use in curb space, and a tool kit for cities to replicate the geocoding methodology for private truck loading bays and docks in 2018.

Based on the results of the process flow analysis of the Seattle Municipal Tower done for this report, the Lab will pilot test a Common Carrier Smart Locker System at the Municipal Tower in 2018. The pilot will document the effectiveness, lessons learned, and costs of operating a smart common carrier locker system (a new automated mini-distribution node) in the Tower. Common carrier lockers allow

multiple carriers (delivery firms) to access the lockers, which would reduce the total footprint needed (vs. providing room for many company-branded lockers) in the Tower.

In the third Final 50' research project, the Lab is developing criteria to evaluate transit stations' suitability for common carrier locker systems.

The Urban Freight Lab's fourth Final 50' project will map the locations and truck-related features of all of the alleys in Center City and complete an alley occupancy study.  This research will be published in 2018.

When they have accurate data layers of the curbs, private truck load/unload spaces, and alleys, SDOT will have a complete picture of the truck load/unload network.

Final 50' project findings may be used to provide decision support to city officials and to private-sector firms managing scarce and expensive space in the City of Seattle.  By applying systems engineering and evidence-based planning, we can make receiving online goods as efficient as ordering them – without clogging city streets and curb space, or losing packages.

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# APPENDIX A –
# PRELIMINARY OBSERVATIONS ON THE PROTOTYPE BUILDINGS

The Supply Chain Transportation and Logistics (SCTL) Center has identified 12 buildings that could be suitable for creating urban goods delivery profiles, that are described in Chapter 2 of this report. These buildings are to be considered as one downtown building for each of the following prototypes:

- Hotel (without a conference center);
- Historic commercial and/or retail building with restaurants and/or bars in Pioneer Square;
- Residential tower;
- Office building with ground floor retail and/or restaurant; and
- Retail building.

The following pages contain short descriptions of the building options, and include the street address and map location, building size, freight delivery characteristics, and the number of street parking spaces near the buildings.

# 1. HOTELS

## 1.1. FAIRMONT HOTEL

**ADDRESS:**
411 University St, Seattle, WA 98101

**YEAR BUILT:**
December 1924

**FLOOR COUNT:**
14

**NUMBER OF ROOMS:**
450

**NUMBER OF RESTAURANTS:**
3

**NUMBER OF STREET PARKING SPACES ADJACENT TO BUILDING:**
CVLZ: 0
Paid Parking: 8
3-minute passenger load: 1
Taxi cabs only: 2

**NUMBER OF STREET PARKING SPACES ON THE BLOCK:**
CVLZ: 11
Paid parking: 37
3-minute passenger load: 15

**FREIGHT INFRASTRUCTURE:**
- ☑ Loading bay
- ☑ Contract with UPS for handling parcel deliveries

**ADDITIONAL INFORMATION:**
Due to the limitations of this period building, loading bay and truck parking spaces used by the hotel are located in the Ace parking facility across the street. The parking facility is connected with the hotel via an underground tunnel.

## 1.2. FOUR SEASONS HOTEL

**ADDRESS:**
99 Union St, Seattle, WA 98101

**YEAR BUILT:**
November 2008

**FLOOR COUNT:**
21
*Hotel* is located on floors 1 through 10, and Residences are located on floors 11 through 21

**NUMBER OF ROOMS:**
147

**NUMBER OF RESTAURANTS:**
1

**NUMBER OF STREET PARKING SPACES ADJACENT TO BUILDING:**
CVLZ: 1
Paid parking: 0
3-minute passenger load: 1
Taxi cabs only: 0

**NUMBER OF STREET PARKING SPACES ON THE BLOCK:**
CVLZ: 7
Paid parking: 4
3-minute passenger load: 4

**FREIGHT INFRASTRUCTURE:**
☑ 2 loading bays

**ADDITIONAL INFORMATION:**
The loading bays are located on Post Alley. Delivery trucks have to enter through Western Avenue.

## 1.3. WESTIN SEATTLE

**ADDRESS:**
1900 5th Ave, Seattle, WA 98101

**YEAR BUILT:**
North Tower 1982, South Tower 1969

**NUMBER OF ROOMS:**
891

**NUMBER OF RESTAURANTS:**
3

**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 1
Paid parking: 9
3-minute passenger load: 4

**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 7
Paid parking: 39

**FREIGHT INFRASTRUCTURE:**
- [x] Loading bays

**ADDITIONAL INFORMATION:**
The Westin loading dock is secured and available 24 hours. Onsite FedEx office manages all the parcels and delivery items: Approximately 20 to 160 parcels / day.

# 2. HISTORIC BUILDINGS

## 2.1. INTERURBAN BUILDING

**ADDRESS:**
157 Yesler Way, Seattle, WA 98104

**YEAR BUILT:**
1890

**FLOOR COUNT:**
6 floors

**FOOTAGE:**
57,760 ± SF on 0.31 Acres

**BUSINESSES LOCATED ON THE GROUND FLOOR:**
Tat's Deli
ABC Imaging, print solutions and digital document management services
NIRMAL'S, Indian restaurant
Pizza Professionals

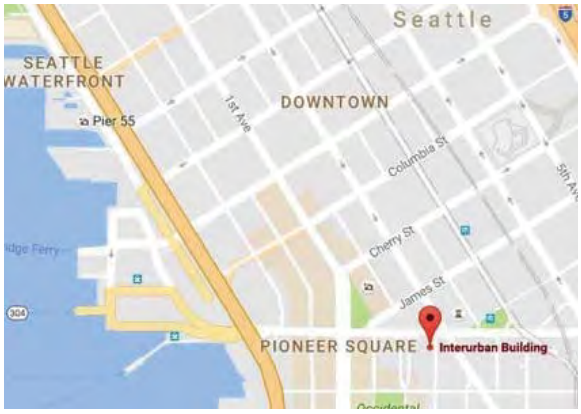
**ACCESS TO AN ALLEY:**
The alley is adjacent to the building. Tat's Deli and Nirmal's have access to the alley.

**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 1
Paid parking: 18

**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 7
Paid parking: 12

**FREIGHT INFRASTRUCTURE:**
- ☑ Back doors to the alley
- ☑ Alley

**ADDITIONAL INFORMATION:**
The businesses adjacent to the alley get deliveries from the alley. Those without alley access take deliveries through the front door, and trucks serving them have to park on the street.



## 2.2. CAFÉ PALOMA

**ADDRESS:**
93 Yesler Way, Seattle, WA 98104

**YEAR BUILT:**
1916

**FLOOR COUNT:**
5 floors

**FOOTAGE:**
57,760 ± SF on 0.31 Acres

**BUSINESSES LOCATED ON THE GROUND FLOOR:**
Café Paloma
Cigar shop

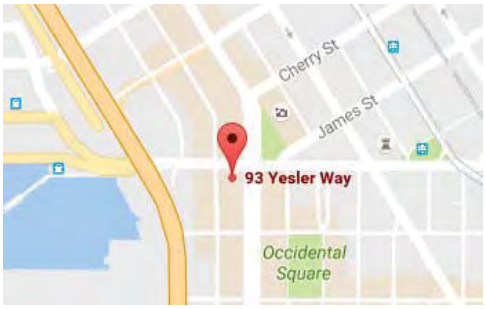
**ACCESS TO AN ALLEY:**
Alley is adjacent to the building. There is one entrance to the building in the alley.

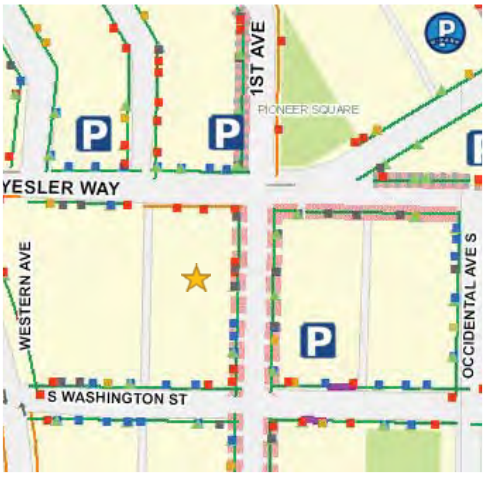
**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 0
Paid parking: 20

**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 7
Paid parking: 12

**FREIGHT INFRASTRUCTURE:**
- [x] Alley

**ADDITIONAL INFORMATION:**
SCTL did not see many deliveries to this building during their daytime observation.



# 3. RESIDENTIAL TOWERS

## 3.1. INSIGNA BY BOSA

**ADDRESS:**
588 Bell St, Seattle, WA 98121

**YEAR BUILT:**
2015-2016

**FLOOR COUNT:**
41 floors

**UNITS COUNT:**
700 units

**BUSINESSES LOCATED ON THE GROUND FLOOR:**
US Bank

**ACCESS TO AN ALLEY:**
No alley

**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 1
Paid parking: 7

**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 2

**PAID PARKING:**
58

**FREIGHT INFRASTRUCTURE:**
- [x] Loading bay
- [x] 24 hrs. Concierge Services
- [x] Parcel Room
- [x] Freight elevator in the North tower

**ADDITIONAL INFORMATION:**
The North Tower and South Tower are connected inside the building. North and South Insigna towers have two separate loading docks at each parking garage. Although retail spaces were not open in Nov. 2016, the loading bay is not likely to be shared as it is secured for the residential area.

There is a loading and consolidation area on the second level of the lobby in South Tower. Both towers have special software for scheduling freight (including booking loading bays). They also have software for registering incoming parcels. When perishable items are delivered (e.g. Blue Apron, Amazon Fresh) the carrier has to deliver it to the residents directly or leave them in a small fridge in the lobby for a short period of time.

Approximately 200 parcels/ day are delivered.

## 3.2. ASPIRA APARTMENT

**ADDRESS:**
1823 Terry Ave, Seattle, WA 98101

**YEAR BUILT:**
2009

**FLOOR COUNT:**
37 floors

**UNITS COUNT:**
325 units

**FLOOR AREA:**
346,000 sq. ft

**BUSINESSES LOCATED ON THE GROUND FLOOR:**
Seattle Pho + Bar

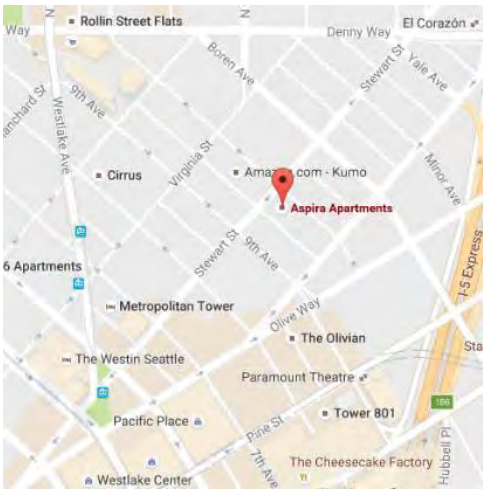
**ACCESS TO AN ALLEY:**
Alley is adjacent to the building

**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 1
Paid parking: 9

**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 4
Paid parking: 36

**FREIGHT INFRASTRUCTURE:**
- [x] Loading bay
- [x] 24 hrs. Concierge Services
- [x] Parcel Room
- [x] Freight elevator

**ADDITIONAL INFORMATION:**
Delivery people usually have keys to the building to put packages to the storage room. Typically receives 30 -150 package/day.



# 4. OFFICE BUILDINGS

## 4.1. SEATTLE MUNICIPAL TOWER

**ADDRESS:**
700 5th Ave, Seattle, WA 98104

**YEAR BUILT:**
1990

**FLOOR COUNT:**
62 floors Floor area: 990,540 sq. ft.

**POPULATION:**
~5,000 tenants

**BUSINESSES LOCATED ON THE GROUND FLOOR:**
Bebas and Amigos
Chew Chews Eatery
Core Bistro
Starbucks
Serina M Salon
Treasures Gifts and Snacks

**ACCESS TO AN ALLEY:**
No alley available.

**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 7
Paid parking: 7
3-minute passenger load: 6

**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 1
Paid parking: 28
3-minute passenger load: 10

**FREIGHT INFRASTRUCTURE:**
- ☑ 5 loading bays + 2 parking spaces on the side of loading bays
- ☑ Amazon lockers
- ☑ Freight elevator

**ADDITIONAL INFORMATION:**
Open public access from 6am to 6pm. 7am and 2pm are the peak hours for delivery. If there are trucks in queue, arriving trucks may use loading zone on the adjacent street and deliver the goods on foot.

## 4.2. COLUMBIA CENTER

**ADDRESS:**
700 5th Ave, Seattle, WA 98104

**YEAR BUILT:**
1985

**FLOOR COUNT:**
76 floors

**FLOOR AREA:**
1,538,000 sq. ft.

**BUSINESSES LOCATED IN THE BUILDING:**
Food court
Starbucks

**ACCESS TO AN ALLEY:**
No alley available

**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 1
Paid parking: 7
3-minute passenger load: 6

**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 11
Paid parking: 20
3-minute passenger load: 19

**FREIGHT INFRASTRUCTURE:**
- ☑ 5 loading bays
- ☑ Freight elevator
- ☑ Secured entrance

**ADDITIONAL INFORMATION:**
The tallest building in Seattle. SCTL spoke with a delivery person who was delivering dough from 3rd Avenue and Spring St. to the bakery on the 1st floor of the Columbia Center. He illegally parked at the curb for the short period of time. At first floor Starbucks, we were informed that their delivery system is early morning and overnight delivery. At the food court in the center, a worker told SCTL that all the food supplies come through the loading docks at 3rd floor. On the 3rd floor, the mail boxes were located and the room was connected to the loading docks where most of freights are delivered. In order to use the loading dock, people need to call to access. Open hours are from 6am to 6pm. Open 24hrs for people with a key. 30min maximum. Contacting their management team is highly encouraged.

## 4.3. 520 PIKE TOWER

**ADDRESS:**
520 Pike St, Seattle, WA 98101

**YEAR BUILT:**
1983(renovated in 2000)

**FLOOR COUNT:**
29 story

**TOTAL RETAIL FLOOR AREA:**
396,821 sq. ft.

**NUMBER OF BUSINESSES IN THE SHOPPING CENTER:**
1st floor - H&M

**ACCESS TO AN ALLEY:**
Alley is adjacent to the building

**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 6
Paid parking: 6
3-minute passenger load: 3

**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 6
Paid parking: 28

**FREIGHT INFRASTRUCTURE:**
- ☑ Secured entrance
- ☑ Freight elevator

**ADDITIONAL INFORMATION:**
Bldg. manager reported two issues that cause delivery firms to prefer entering through the front door from the street instead of using the alley freight bay:

Steep, narrow ramp from interior loading bay to main floor freight elevator;

Uneven pavement in the alley causes loaded hand carts to tip over.from 6am to 6pm. Open 24hrs for people with a key. 30min maximum. Contacting their management team is highly encouraged.

# 5. RETAIL BUILDINGS

## 5.1. PACIFIC PLACE

**ADDRESS:**
600 Pine St, Seattle, WA 98101

**YEAR BUILT:**
1998

**FLOOR COUNT:**
5 story

**TOTAL RETAIL FLOOR AREA:**
335,000 ft²

**NUMBER OF BUSINESSES IN THE SHOPPING CENTER:**
110 stores
11 cafes and restaurants
Access to an alley: No alley available

**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 0
Paid parking: 0
3-minute passenger load: 1

**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 5
Paid parking: 12
3-minute passenger load: 4

**FREIGHT INFRASTRUCTURE:**
- [x] 9 loading bays
- [x] Secured entrance
- [x] Amazon Lockers
- [x] Freight Elevators

**ADDITIONAL INFORMATION:**
The loading bays are open from 8am to 4pm. After hours truck drivers have to call the security guard to open the garage door. The freight elevator stops at some of the stores, directly. The stores that don't have access to the freight elevator can access it through the back hall (behind-the-scenes area for operations).

No time limits in the loading docks.

## 5.2. WESTLAKE SHOPPING CENTER

**ADDRESS:**
400 Pine St, Seattle, WA 98101

**YEAR BUILT:**
1988

**FLOOR COUNT:**
4 story shopping center and 25 story office tower

**TOTAL RETAIL FLOOR AREA:**
369,000 sq. ft.

**NUMBER OF BUSINESSES IN THE SHOPPING CENTER:**
22 including 5 cafes and restaurants, and Nordstrom Rack

**ACCESS TO AN ALLEY:**
No alley available

**NUMBER OF STREET PARKING ADJACENT TO BUILDING:**
CVLZ: 1
Paid parking: 1
3-minute passenger load: 4

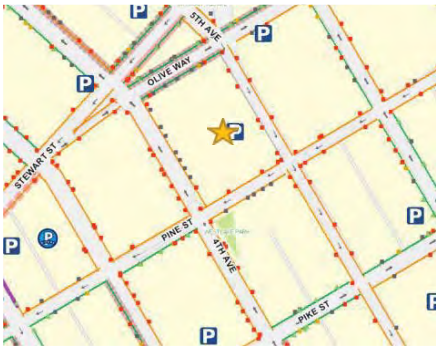
**NUMBER OF STREET PARKING WITHIN THE BLOCK:**
CVLZ: 9
Paid parking: 14
d) 3-minute passenger load: 7

**FREIGHT INFRASTRUCTURE:**

- [x] Loading bays
- [x] Secured entrance
- [x] Fed Ex Drop Off
- [x] UPS Drop Off

**ADDITIONAL INFORMATION:**
The building includes a hotel, cafes, restaurants, retail, and office space.

Loading dock is secured; not even clerks are allowed to go in. Parking area with loading dock is secured and access to the parking lot was limited.



## APPENDIX B –
## SAMPLE NOTIFICATION LETTER TO CARRIERS

BUILDING COMMUNIQUÉ CBRE

# Dexter Horton Building

Transportation Research Project- January 25, 2017

This letter is to inform all the carriers entering the Dexter Horton Building that members from the University of Washington's Supply Chain Transportation and Logistics (SCTL) Center in cooperation with the Seattle Department of Transportation (SDOT) are monitoring your delivery activities as a part of a research project. The purpose of this study is to better understand goods delivery in highly developed urban settings in the 'Final 50 Feet'.

We understand that your complex delivery step involves parking, building access, physical delivery, inventory sign-off and even payment, and all this must be performed in tight and crowded spaces and under demanding time constraints.

With your cooperation, UW and SDOT can use the gathered information to improve delivery to buildings downtown and potentially traffic flow in the Central Business District.

If you have any questions or concerns, please feel free to contact the following SDOT staffs for more information.

Christopher Eaves P.E.
Senior Civil Engineering Specialist
Office: 206-684-4524
Cell: 206-650-3699
Christopher.eaves@seattle.gov

Jude Willcher A.I.C.P.
Strategic Advisor
Office: 206-684-4059
Jude.willcher@Seattle.gov

Thank you,

CBRE Property Management
Dexter Horton Building

CBRE

# APPENDIX C –
# LETTER FROM THE INSTITUTIONAL REVIEW BOARD

UNIVERSITY of WASHINGTON
HUMAN SUBJECTS DIVISION

**NOT HUMAN SUBJECTS**

January 18, 2017

Linda T. Boyle
+1 206 616-0245
linda@uw.edu

Dear Linda T. Boyle:

On January 18, 2017, the University of Washington Human Subjects Division reviewed the following application:

| | |
|---|---|
| Type of Review: | Initial Study |
| Title of Study: | Final Fifty Feet Project |
| Investigator: | Linda T. Boyle |
| IRB ID: | STUDY00001013 |
| Funding: | Name: City of Seattle, Grant Office ID: 63-1717, SDOT Final 50 |
| IND, IDE, or HDE: | None |

**The Human Subjects Division determined that the proposed activity does not involve human subjects, as defined by federal and state regulations. Therefore, review and approval by the University of Washington IRB is not required.**

This determination applies only to the activities described in this application.

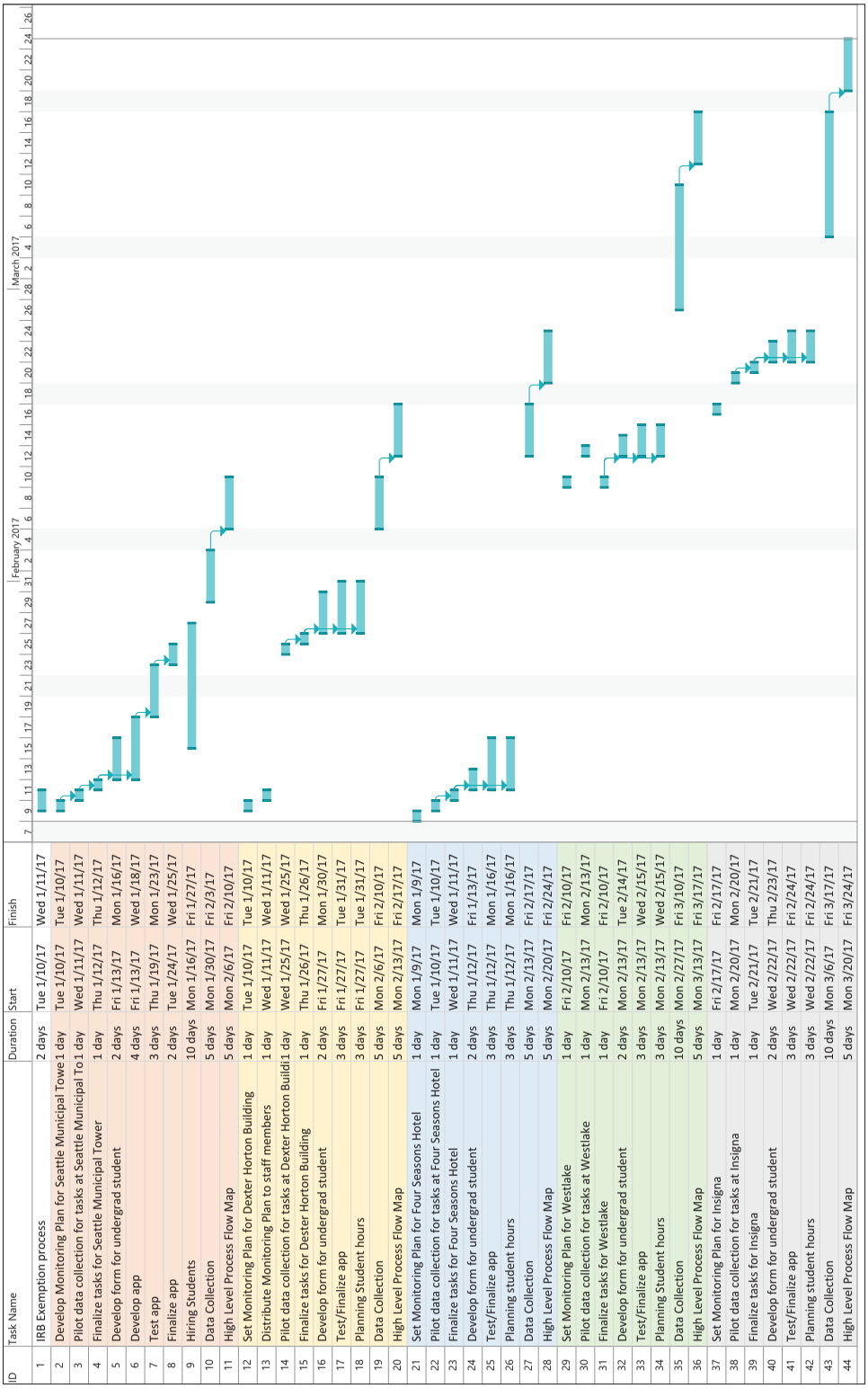
If you consider changes to the activities in the future and know that the changes will require IRB review (or you are not certain), you may request a review or new determination by submitting a Modification to this application.

We wish you great success.

Sincerely,

Jennifer McBride
Review Administrator, Team B
mcbride@uw.edu
206-221-7862

# APPENDIX D –
# DETAILED SCHEDULE FOR DATA COLLECTION FOR CREATING DELIVERY PROFILE

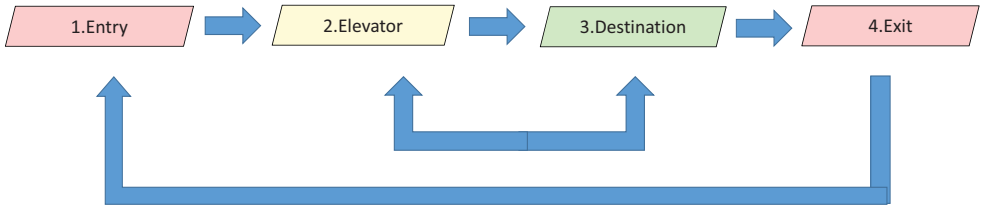


| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | IRB Exemption process | 2 days | Tue 1/10/17 | Wed 1/11/17 |
| 2 | Develop Monitoring Plan for Seattle Municipal Towe | 1 day | Tue 1/10/17 | Tue 1/10/17 |
| 3 | Pilot data collection for tasks at Seattle Municipal To | 1 day | Wed 1/11/17 | Wed 1/11/17 |
| 4 | Finalize tasks for Seattle Municipal Tower | 1 day | Thu 1/12/17 | Thu 1/12/17 |
| 5 | Develop form for undergrad student | 2 days | Fri 1/13/17 | Mon 1/16/17 |
| 6 | Develop app | 4 days | Fri 1/13/17 | Wed 1/18/17 |
| 7 | Test app | 3 days | Thu 1/19/17 | Mon 1/23/17 |
| 8 | Finalize app | 2 days | Tue 1/24/17 | Wed 1/25/17 |
| 9 | Hiring Students | 10 days | Mon 1/16/17 | Fri 1/27/17 |
| 10 | Data Collection | 5 days | Mon 1/30/17 | Fri 2/3/17 |
| 11 | High Level Process Flow Map | 5 days | Mon 2/6/17 | Fri 2/10/17 |
| 12 | Set Monitoring Plan for Dexter Horton Building | 1 day | Tue 1/10/17 | Tue 1/10/17 |
| 13 | Distribute Monitoring Plan to staff members | 1 day | Wed 1/11/17 | Wed 1/11/17 |
| 14 | Pilot data collection for tasks at Dexter Horton Buildi | 1 day | Wed 1/25/17 | Wed 1/25/17 |
| 15 | Finalize tasks for Dester Horton Building | 1 day | Thu 1/26/17 | Thu 1/26/17 |
| 16 | Develop form for undergrad student | 2 days | Fri 1/27/17 | Mon 1/30/17 |
| 17 | Test/Finalize app | 3 days | Fri 1/27/17 | Tue 1/31/17 |
| 18 | Planning Student hours | 3 days | Fri 1/27/17 | Tue 1/31/17 |
| 19 | Data Collection | 5 days | Mon 2/6/17 | Fri 2/10/17 |
| 20 | High Level Process Flow Map | 5 days | Mon 2/13/17 | Fri 2/17/17 |
| 21 | Set Monitoring Plan for Four Seasons Hotel | 1 day | Mon 1/9/17 | Mon 1/9/17 |
| 22 | Pilot data collection for tasks at Four Seasons Hotel | 1 day | Tue 1/10/17 | Tue 1/10/17 |
| 23 | Finalize tasks for Four Seasons Hotel | 1 day | Wed 1/11/17 | Wed 1/11/17 |
| 24 | Develop form for undergrad student | 2 days | Thu 1/12/17 | Fri 1/13/17 |
| 25 | Test/Finalize app | 3 days | Thu 1/12/17 | Mon 1/16/17 |
| 26 | Planning student hours | 3 days | Thu 1/12/17 | Mon 1/16/17 |
| 27 | Data Collection | 5 days | Mon 2/13/17 | Fri 2/17/17 |
| 28 | High Level Process Flow Map | 5 days | Mon 2/20/17 | Fri 2/24/17 |
| 29 | Set Monitoring Plan for Westlake | 1 day | Fri 2/10/17 | Fri 2/10/17 |
| 30 | Pilot data collection for tasks at Westlake | 1 day | Mon 2/13/17 | Mon 2/13/17 |
| 31 | Finalize tasks for Westlake | 1 day | Fri 2/10/17 | Fri 2/10/17 |
| 32 | Develop form for undergrad student | 2 days | Mon 2/13/17 | Tue 2/14/17 |
| 33 | Test/Finalize app | 3 days | Mon 2/13/17 | Wed 2/15/17 |
| 34 | Planning Student hours | 3 days | Mon 2/13/17 | Wed 2/15/17 |
| 35 | Data Collection | 10 days | Mon 2/27/17 | Fri 3/10/17 |
| 36 | High Level Process Flow Map | 5 days | Mon 3/13/17 | Fri 3/17/17 |
| 37 | Set Monitoring Plan for Insigna | 1 day | Fri 2/17/17 | Fri 2/17/17 |
| 38 | Pilot data collection for tasks at Insigna | 1 day | Mon 2/20/17 | Mon 2/20/17 |
| 39 | Finalize tasks for Insigna | 1 day | Tue 2/21/17 | Tue 2/21/17 |
| 40 | Develop form for undergrad student | 2 days | Wed 2/22/17 | Thu 2/23/17 |
| 41 | Test/Finalize app | 3 days | Wed 2/22/17 | Fri 2/24/17 |
| 42 | Planning student hours | 3 days | Wed 2/22/17 | Fri 2/24/17 |
| 43 | Data Collection | 10 days | Mon 3/6/17 | Fri 3/17/17 |
| 44 | High Level Process Flow Map | 5 days | Mon 3/20/17 | Fri 3/24/17 |

## APPENDIX E –
## SEATTLE MUNICIPAL TOWER DETAILED PROCESS FLOW MAP

# Delivery Process Flow Map
# Office Building:
# Seattle Municipal Tower

High Level Process Flow Map

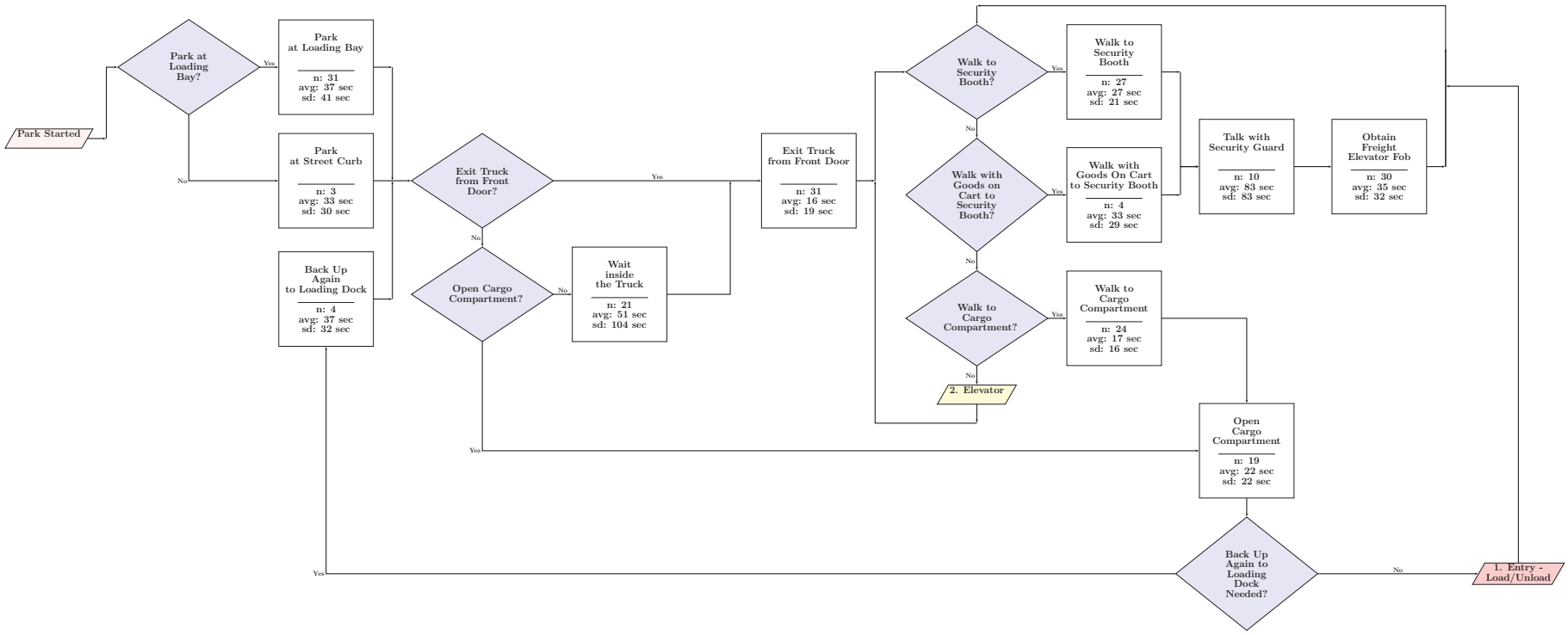



Total Number of Trucks Observed: 34
Types of Delivery Observed:

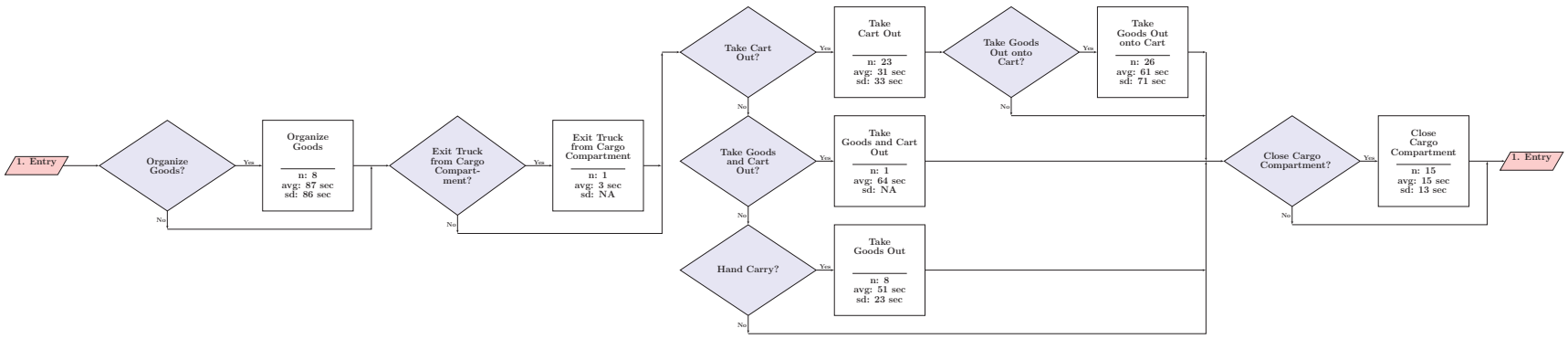
| Office Supplies | Packages | Food | Mails | Recycle | Furniture | Total |
|---|---|---|---|---|---|---|
| 17 | 5 | 6 | 4 | 1 | 1 | 34 |

Average Total Delivery Duration: 24 min
Minimum Delivery Duration Observed : 8 min 42 seconds
Maximum Delivery Duration Observed: 2 hours 4 min

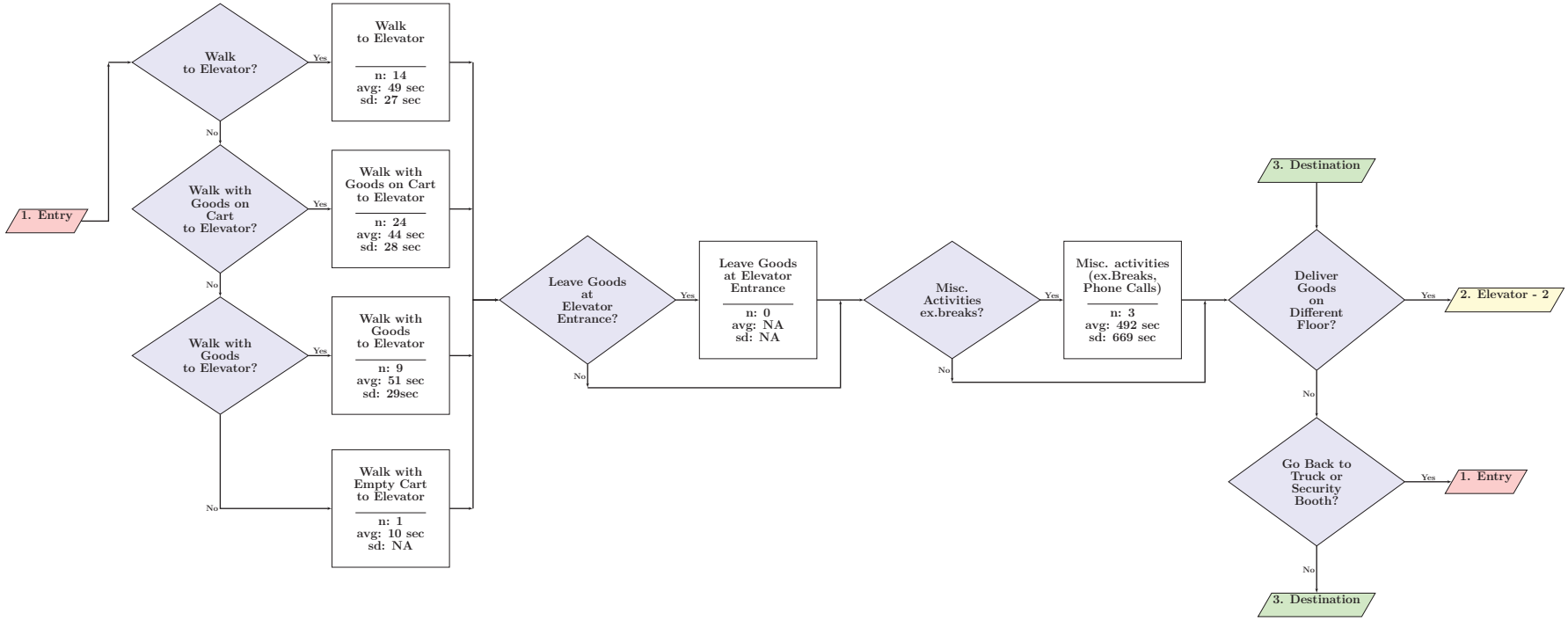
# 1. Entry (Seattle Municipal Tower)



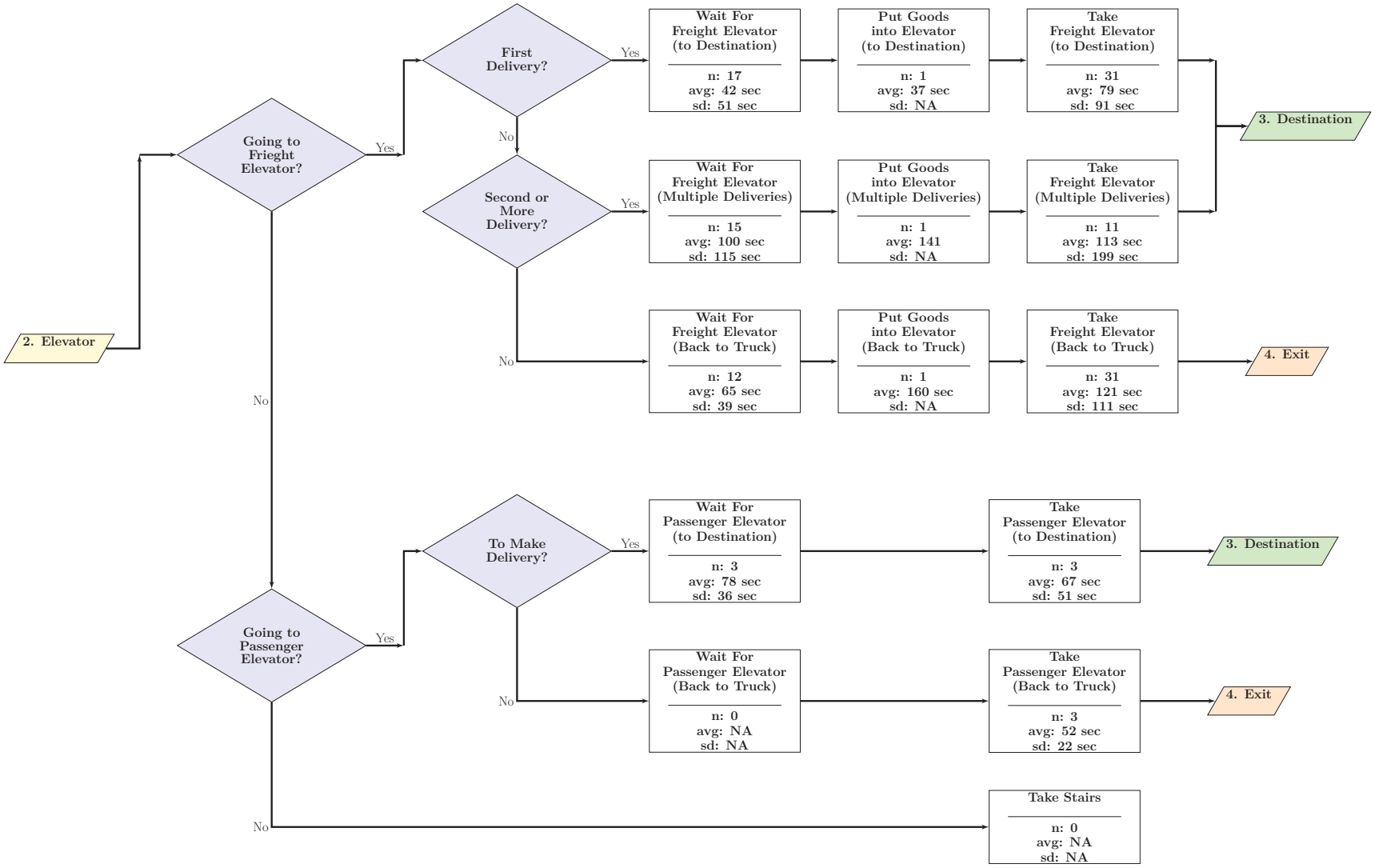
## 1. Entry - Load/Unload (Seattle Municipal Tower)



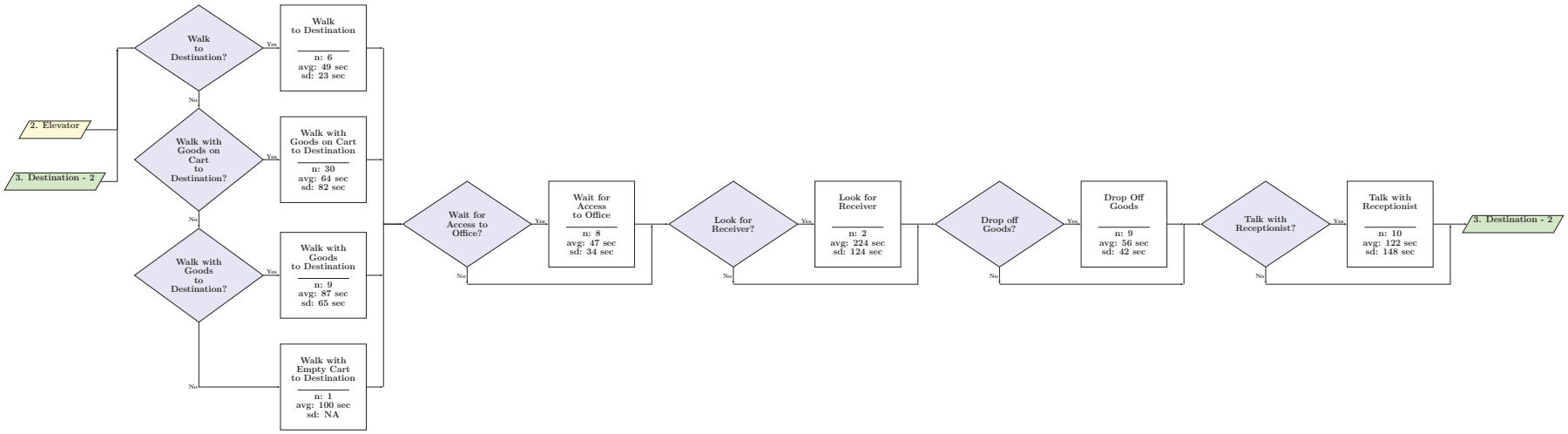
## 2. Elevator (Seattle Municipal Tower)



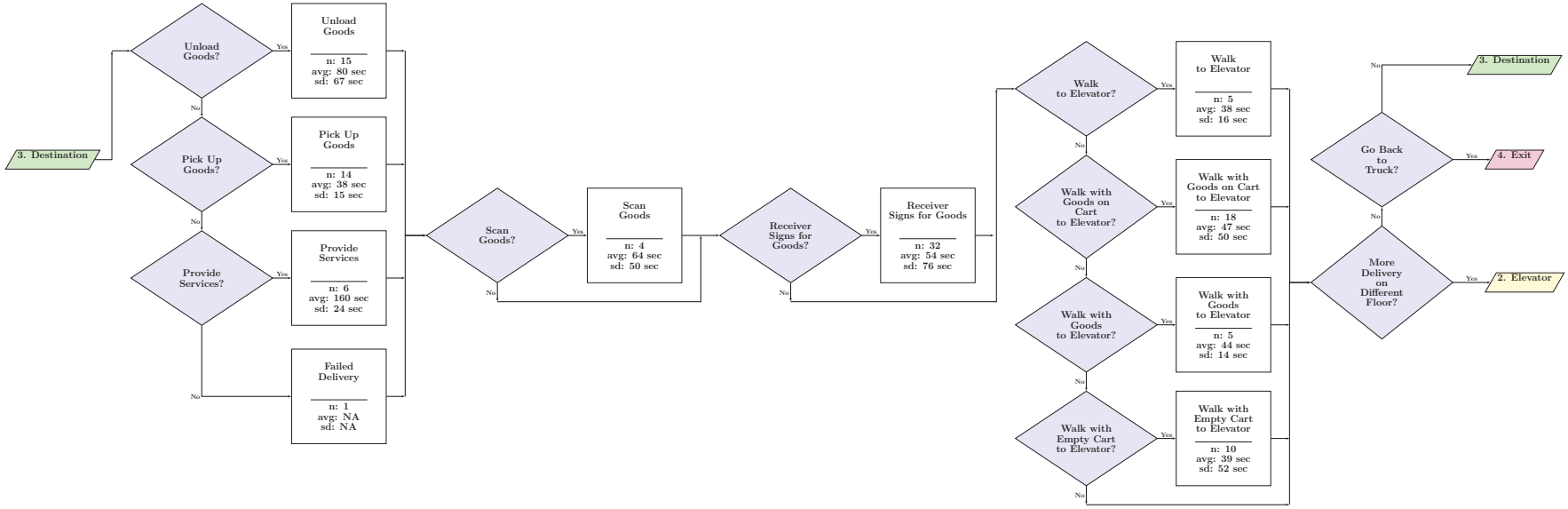
# 2. Elevator - 2 (Seattle Municipal Tower)



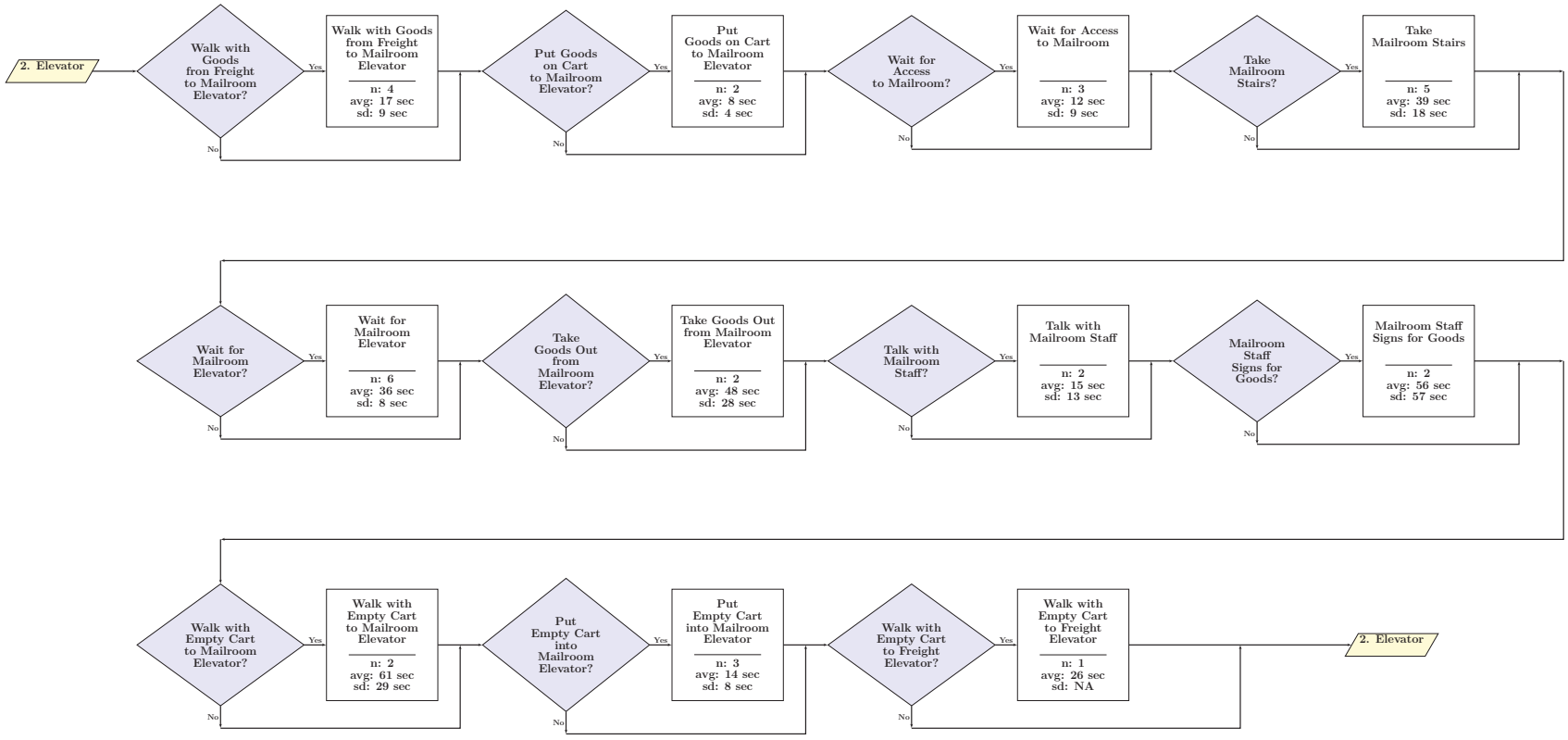
## 3. Destination (Seattle Municipal Tower)



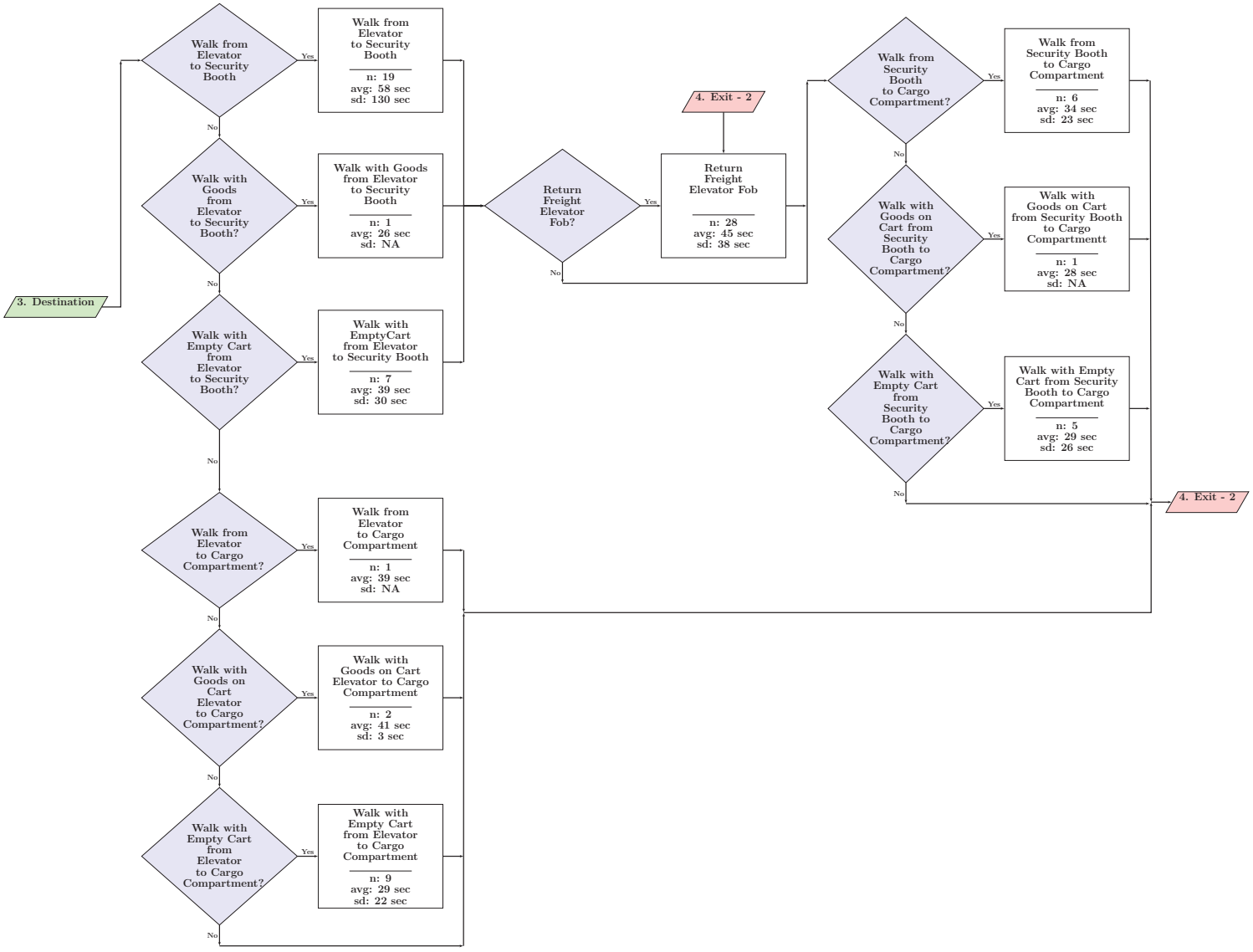
## 3. Destination - 2 (Seattle Municipal Tower)



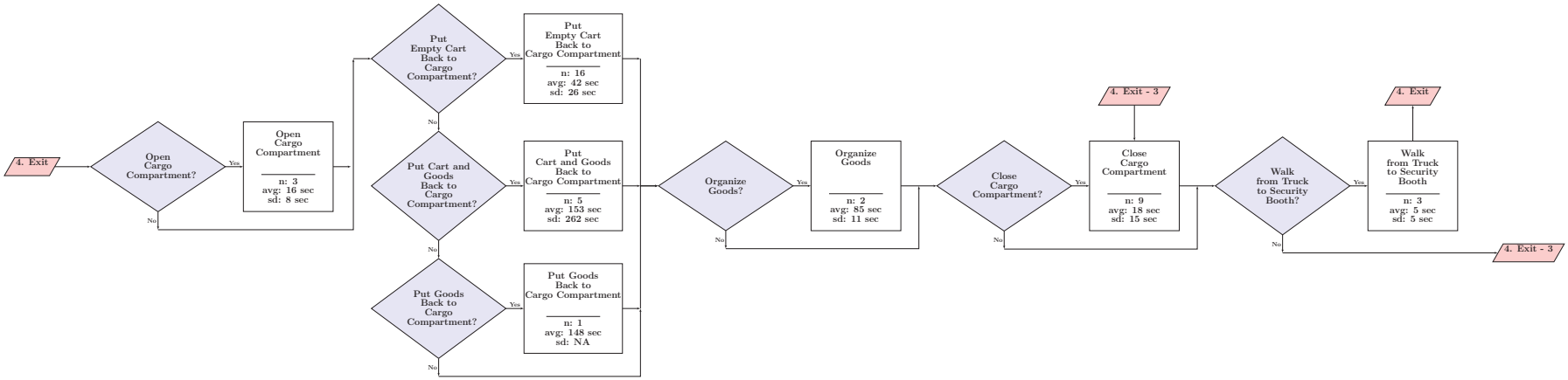
## 3. Destination-Mailroom (Seattle Municipal Tower)



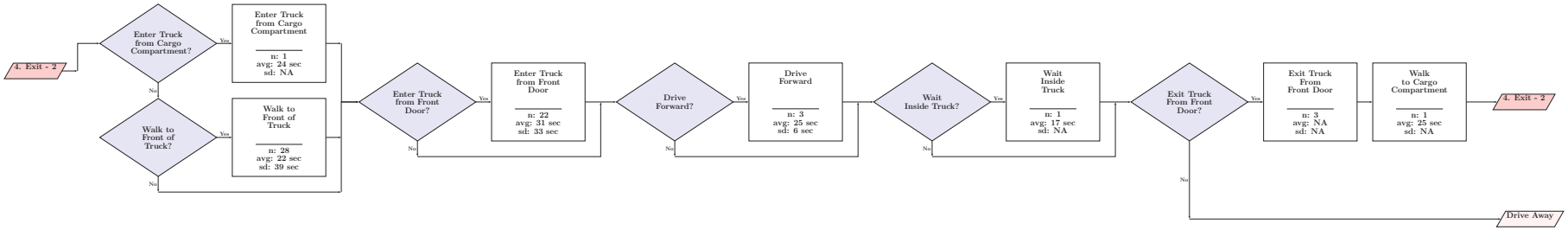
# 4. Exit (Seattle Municipal Tower)



## 4. Exit - 2 (Seattle Municipal Tower)



## 4. Exit-3 (Seattle Municipal Tower)



# APPENDIX F –
# SEATTLE MUNICIPAL TOWER - SUMMARY OF PROCESS STEP DATA

| LOCATION | TASKS | AVERAGE (SECONDS) | STANDARD DEVIATION (SECONDS) | SD/AVG | MINIMUM (SECONDS) | MAXIMUM (SECONDS) | MODE (SECONDS) |
|---|---|---|---|---|---|---|---|
| ENTRY | Parking Ended at Loading Bay | 37 | 41 | 1.12 | 3 | 165 | 4 |
| | Parking Ended at Street Curb | 33 | 30 | 0.89 | 12 | 67 | 12 |
| | Backing Up Again to Loading Dock | 37 | 32 | 0.87 | 13 | 73 | 13 |
| | Waiting Inside the Truck | 51 | 104 | 2.02 | 1 | 407 | 2 |
| | Exit Truck From Front Door | 16 | 19 | 1.2 | 3 | 90 | 3 |
| | Walk from Truck to Security Booth | 27 | 21 | 0.75 | 4 | 102 | 8 |
| | Walk With Goods On Cart to Security Booth | 33 | 29 | 0.88 | 6 | 75 | 26 |
| | Talking with security guard | 83 | 83 | 1 | 5 | 242 | 5 |
| | Obtain Freight Elevator Fob | 35 | 21 | 0.61 | 2 | 77 | 12 |
| | Walk to Cargo Compartment - Entry | 17 | 16 | 0.93 | 2 | 67 | 2 |
| | Open Cargo Compartment | 22 | 22 | 0.99 | 3 | 75 | 7 |
| | Organize Goods - Entry | 87 | 86 | 0.99 | 3 | 255 | 120 |
| | Exit Truck from Cargo Compartment | 3 | NA | NaN | 3 | 3 | 3 |
| | Take Cart Out | 31 | 33 | 1.05 | 1 | 124 | 1 |
| | Take Good(s) Out onto cart | 61 | 71 | 1.16 | 3 | 290 | 12 |
| | Take Good(s) And Cart Out Together | 64 | NA | NaN | 64 | 64 | 64 |
| | Take Good(s) Out | 51 | 23 | 0.45 | 26 | 84 | 26 |
| | Close Cargo Compartment | 15 | 13 | 0.87 | 2 | 48 | 3 |

| LOCATION | TASKS | AVERAGE (SECONDS) | STANDARD DEVIATION (SECONDS) | SD/AVG | MINIMUM (SECONDS) | MAXIMUM (SECONDS) | MODE (SECONDS) |
|---|---|---|---|---|---|---|---|
| Elevator | Walk To Elevator | 49 | 27 | 0.56 | 12 | 105 | 44 |
| | Walk With Good(s) On Cart from truck to elevator | 44 | 28 | 0.64 | 9 | 129 | 29 |
| | Walk With Good(s) from truck to elevator | 51 | 29 | 0.57 | 17 | 105 | 29 |
| | Walk with Empty Cart from truck to elevator | 10 | NA | NaN | 10 | 10 | 10 |
| | Leave Goods At Elevator Entrance | NA | NA | NA | NA | NA | NA |
| | Miscellaneous Activities (Breaks, Talking on Phone) | 492 | 669 | 1.36 | 29 | 1259 | 29 |
| | Wait for Freight Elevator - Up | 42 | 51 | 1.22 | 3 | 193 | 10 |
| | Putting Goods into the freight elevator - Up | 160 | NA | NaN | 160 | 160 | 160 |
| | Took Freight Elevator - Up | 79 | 91 | 1.15 | 4 | 486 | 35 |
| | Wait for Freight Elevator - 2 or More Deliveries | 100 | 115 | 1.15 | 5 | 475 | 5 |
| | Putting Goods into the freight elevator -2nd delivery | 141 | NA | NaN | 141 | 141 | 141 |
| | Took Freight Elevator - 2 or More Deliveries | 113 | 199 | 1.76 | 20 | 710 | 53 |
| | Wait for Freight Elevator - Down | 65 | 39 | 0.6 | 20 | 126 | 20 |
| | Putting Goods into the freight elevator -down | 37 | NA | NaN | 37 | 37 | 37 |
| | Took Freight Elevator - Down | 121 | 111 | 0.92 | 2 | 427 | 30 |
| | Wait for Passenger Elevator - Up | 78 | 36 | 0.47 | 54 | 120 | 54 |
| | Took Passenger Elevator - Up | 67 | 51 | 0.76 | 36 | 126 | 36 |
| | Took Passenger Elevator - Down | 52 | 22 | 0.42 | 32 | 76 | 32 |

| LOCATION | TASKS | AVERAGE (SECONDS) | STANDARD DEVIATION (SECONDS) | SD/ AVG | MINIMUM (SECONDS) | MAXIMUM (SECONDS) | MODE (SECONDS) |
|---|---|---|---|---|---|---|---|
| Destination | Walk from elevator to destination | 49 | 23 | 0.46 | 19 | 81 | 36 |
| | Walk with Good(s) from elevator to destination | 87 | 65 | 0.74 | 26 | 196 | 26 |
| | Walk With Good(s) On Cart from elevator to destination | 64 | 82 | 1.28 | 10 | 421 | 10 |
| | Walk with Empty Cart from elevator to destination | 100 | NA | NaN | 100 | 100 | 100 |
| | Waiting for Access to the office | 47 | 34 | 0.72 | 13 | 111 | 22 |
| | Looking for Receiver | 224 | 124 | 0.55 | 136 | 311 | 136 |
| | Drop off Package | 56 | 42 | 0.74 | 6 | 156 | 6 |
| | Talking with receptionist | 122 | 148 | 1.21 | 16 | 464 | 16 |
| | Unload Goods | 133 | 166 | 1.25 | 11 | 501 | 21 |
| | Pick up | 35 | 13 | 0.36 | 20 | 60 | 25 |
| | Service (Load Vending, catering) | 279 | 106 | 0.38 | 117 | 382 | 117 |
| | Scanning | 64 | 50 | 0.78 | 7 | 120 | 7 |
| | Receiver Signs off | 54 | 76 | 1.42 | 3 | 404 | 11 |
| | Walk from destination to elevator | 38 | 16 | 0.43 | 25 | 64 | 25 |
| | Walk With Good(s) On Cart from destination to elevator | 47 | 50 | 1.07 | 3 | 193 | 10 |
| | Walk with Good(s) from destination to elevator | 44 | 14 | 0.32 | 25 | 56 | 56 |
| | Walk with Empty Cart from destination to elevator | 39 | 52 | 1.34 | 2 | 180 | 2 |

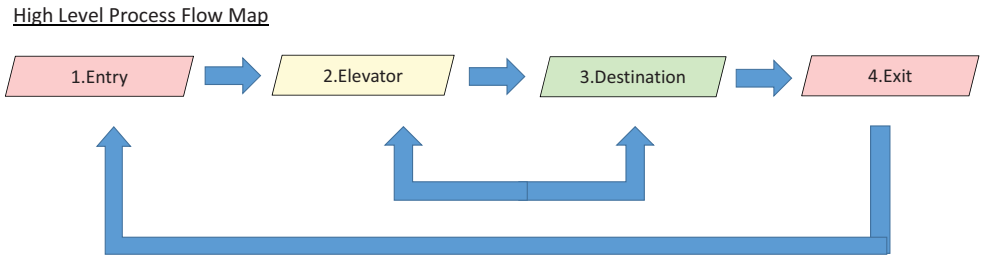
| LOCATION | TASKS | AVERAGE (SECONDS) | STANDARD DEVIATION (SECONDS) | SD/AVG | MINIMUM (SECONDS) | MAXIMUM (SECONDS) |
|---|---|---|---|---|---|---|
| Destination - Mailroom | Walk with Goods from freight elevator to mail room elevator | 17 | 9 | 0.51 | 8 | 29 |
| | Putting cart with goods into mail room elevator | 8 | 4 | 0.47 | 5 | 10 |
| | Waiting for Access to the mail room | 12 | 9 | 0.76 | 2 | 20 |
| | Take mail room stairs | 39 | 18 | 0.47 | 10 | 61 |
| | Wait for mail room elevator | 36 | 8 | 0.21 | 29 | 47 |
| | Take carts out from the mail room elevator | 48 | 28 | 0.58 | 28 | 67 |
| | Load mails from mail room elevator | 105 | NA | NaN | 105 | 105 |
| | Talking with Mail Room Staff | 15 | 13 | 0.85 | 6 | 24 |
| | Mail room staff - sign off | 56 | 57 | 1.03 | 15 | 96 |
| | Walk with empty cart from desk to mail room elevator | 61 | 29 | 0.48 | 40 | 81 |
| | Putting empty cart into mail room elevator | 14 | 8 | 0.56 | 6 | 22 |
| | Walk with Empty Cart from mail room to elevator | 26 | NA | NaN | 26 | 26 |

| LOCATION | TASKS | AVERAGE (SECONDS) | STANDARD DEVIATION (SECONDS) | SD/AVG | MINIMUM (SECONDS) | MAXIMUM (SECONDS) | MODE (SECONDS) |
|---|---|---|---|---|---|---|---|
| Exit | Walk from elevator to Security Booth | 58 | 130 | 2.23 | 3 | 580 | 24 |
| | Walk with Good(s) from Elevator to Security Booth | 26 | NA | NaN | 26 | 26 | 26 |
| | Walk with Empty Cart from elevator to Security Booth | 39 | 30 | 0.79 | 16 | 105 | 24 |
| | Return Freight Elevator Fob | 45 | 38 | 0.84 | 5 | 156 | 6 |
| | Walk from Security Booth to Cargo Compartment | 34 | 23 | 0.67 | 9 | 70 | 9 |
| | Walk with Good(s) On Cart from Security Booth to Cargo Compartment | 28 | NA | NaN | 28 | 28 | 28 |
| | Walk with Empty Cart from Security Booth to Cargo Compartment | 29 | 26 | 0.9 | 10 | 75 | 10 |
| | Walk from Elevator to Cargo Compartment | 39 | NA | NaN | 39 | 39 | 39 |
| | Walk With Good(s) On Cart from Elevator to Cargo Compartment | 155 | NA | NaN | 155 | 155 | 155 |
| | Walk with Empty Cart from elevator to Cargo Compartment | 28 | 18 | 0.65 | 9 | 60 | 9 |
| | Walk with Good(s) on Cart from elevator to Cargo Compartment | 41 | 3 | 0.07 | 39 | 43 | 39 |
| | Open Cargo Compartment - Exit | 16 | 8 | 0.5 | 8 | 24 | 8 |
| | Put Empty Cart back to cargo compartment | 42 | 26 | 0.62 | 5 | 98 | 33 |

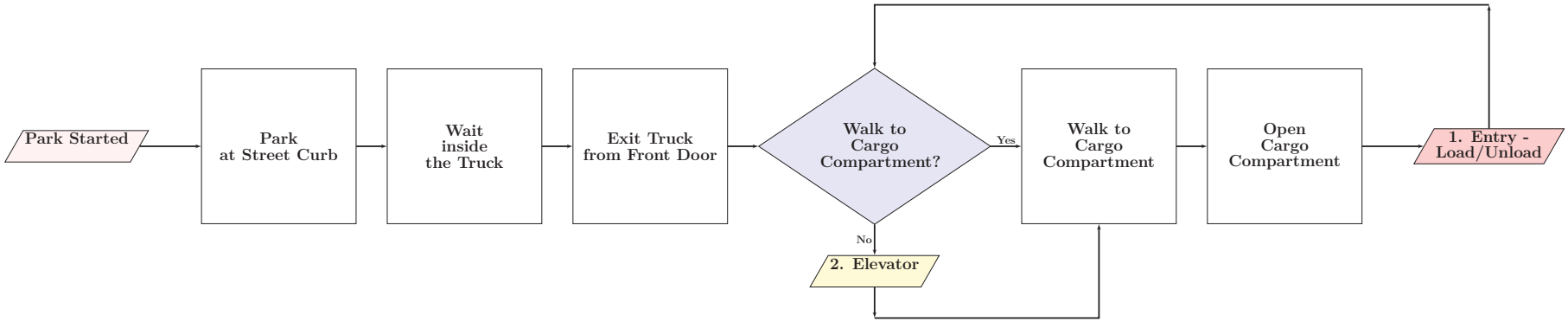
| LOCATION | TASKS | AVERAGE (SECONDS) | STANDARD DEVIATION (SECONDS) | SD/AVG | MINIMUM (SECONDS) | MAXIMUM (SECONDS) | MODE (SECONDS) |
|---|---|---|---|---|---|---|---|
| Exit | Put Cart & Goods back to cargo compartment | 153 | 262 | 1.71 | 28 | 622 | 28 |
| | Put Goods back to cargo compartment | 148 | NA | NaN | 148 | 148 | 148 |
| | Organize Goods - Exit | 85 | 11 | 0.13 | 77 | 92 | 77 |
| | Close Cargo Compartment - Exit | 18 | 15 | 0.87 | 5 | 54 | 5 |
| | Walk from Truck to Security Booth - Exit | 6 | 5 | 0.76 | 2 | 11 | 2 |
| | Enter Truck from Cargo Compartment | 24 | NA | NaN | 24 | 24 | 24 |
| | Walk to front of truck | 22 | 39 | 1.75 | 4 | 210 | 8 |
| | Enter truck from front door | 31 | 33 | 1.08 | 1 | 124 | 7 |
| | Drive Forward | 25 | 6 | 0.25 | 18 | 30 | 18 |
| | Waiting Inside the Truck - Exit | 17 | NA | NaN | 17 | 17 | 17 |
| | Exit Truck From Front Door | NA | NA | NA | NA | NA | NA |
| | Walk to Cargo Compartment - Exit | 25 | NA | NaN | 25 | 25 | 25 |

## APPENDIX G –
## DEXTER HORTON BUILDING - HIGH-LEVEL PROCESS FLOW MAP

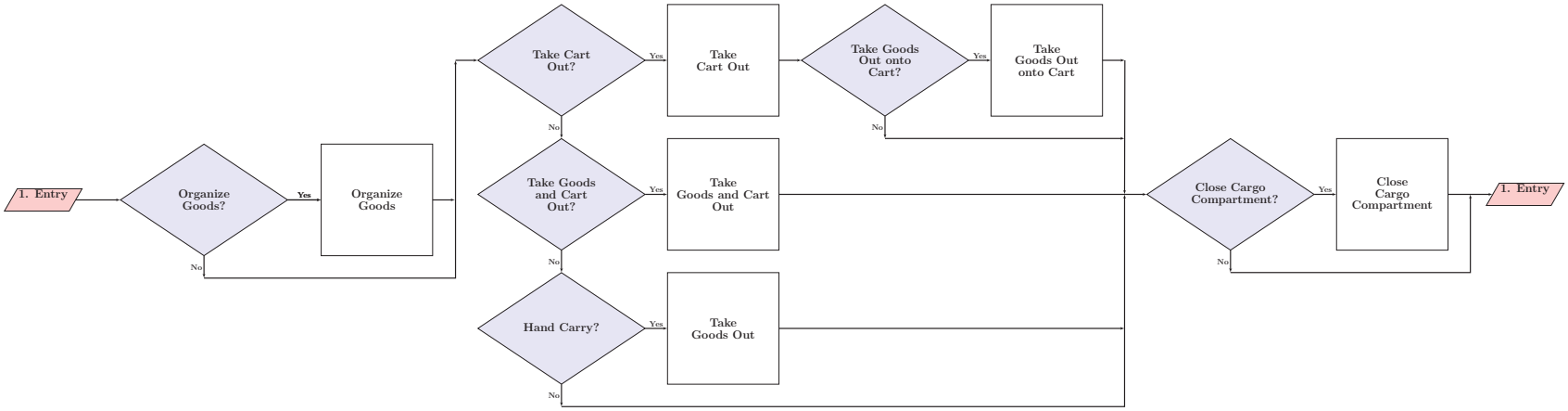
# Delivery Process Flow Map
# Historical Building:
# Dexter Horton Building



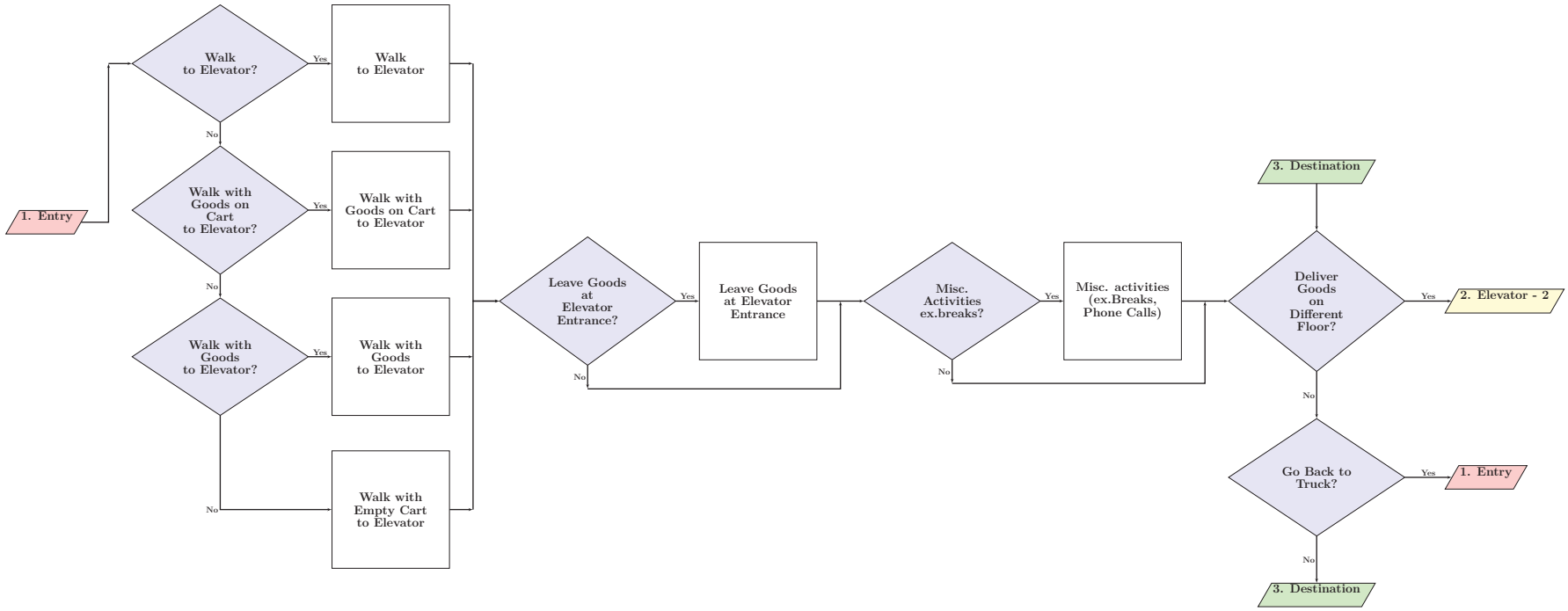
# 1. Entry (Dextor Horton Building)



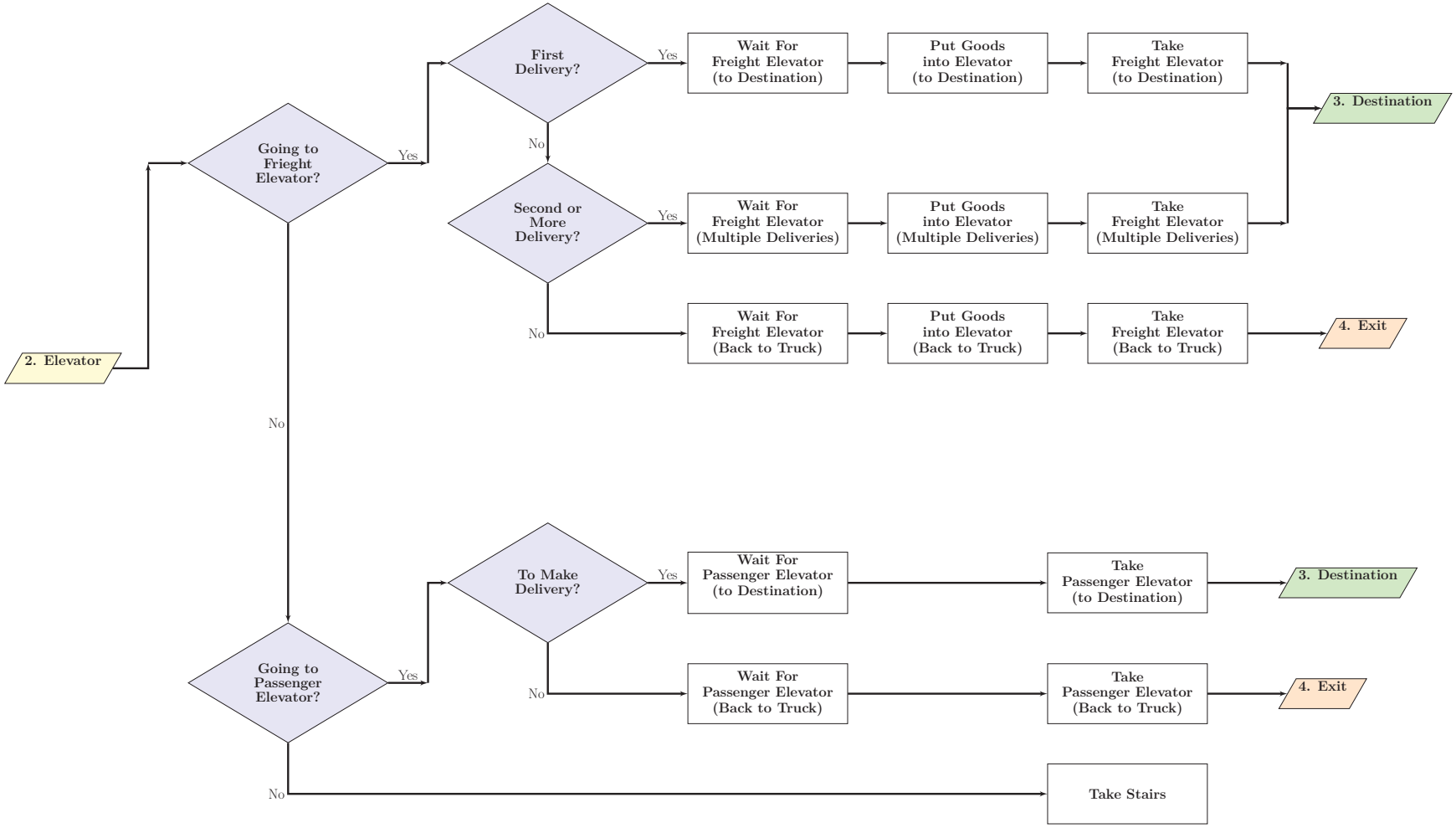
## 1. Entry - Load/Unload (Dexter Horton Building)



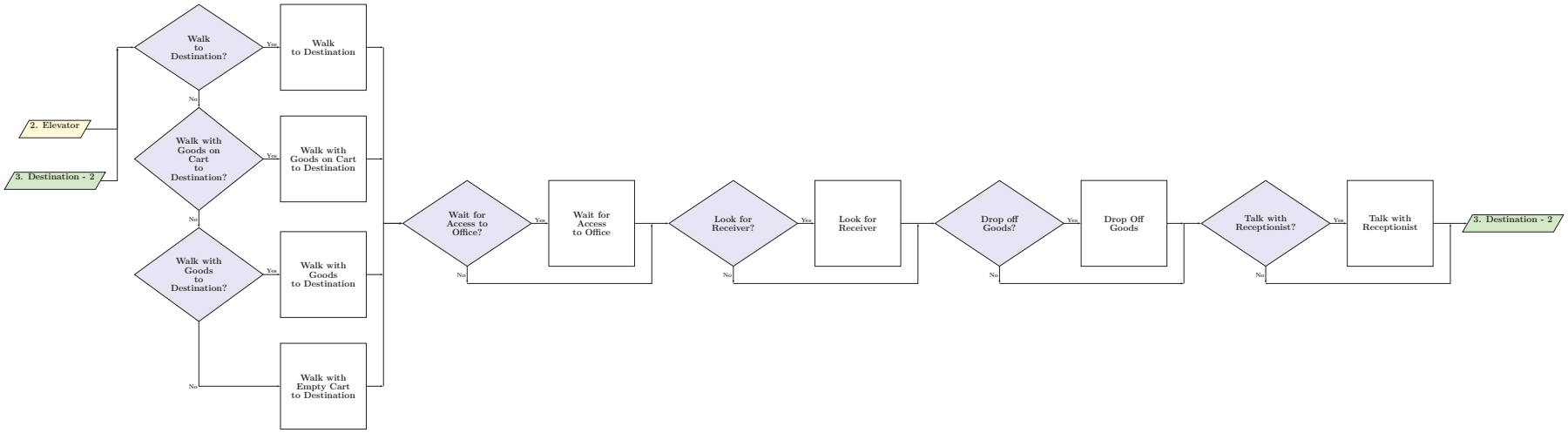
## 2. Elevator (Dexter Horton Building)



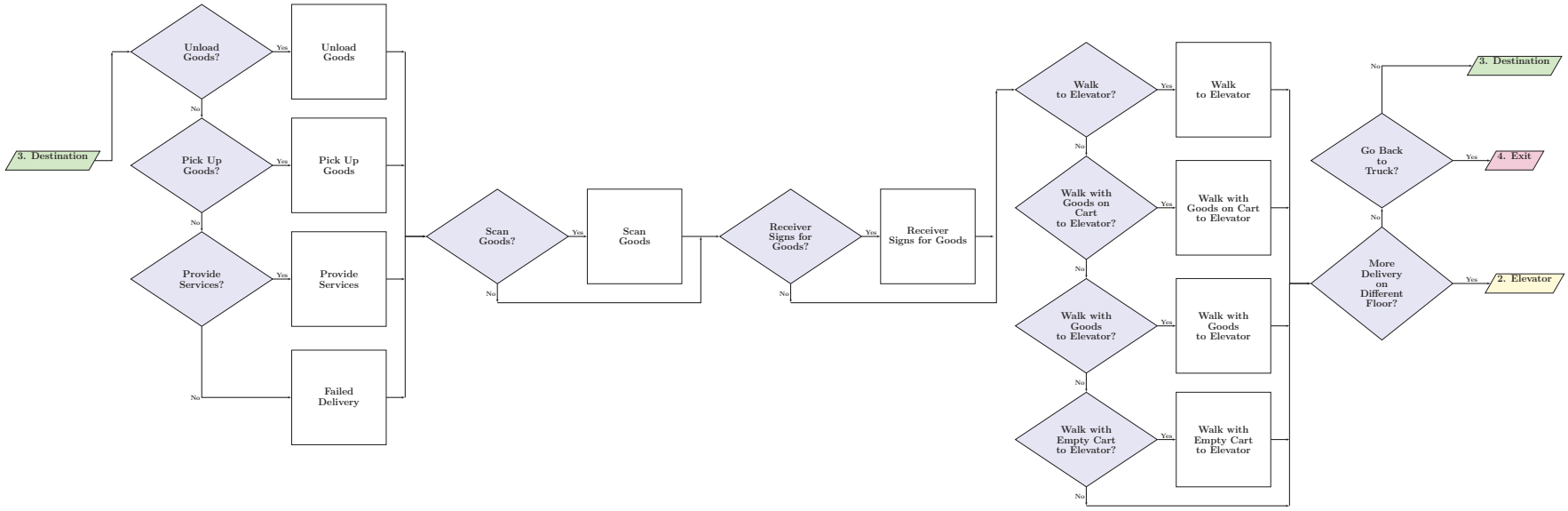
# 2. Elevator - 2 (Dexter Horton Building)



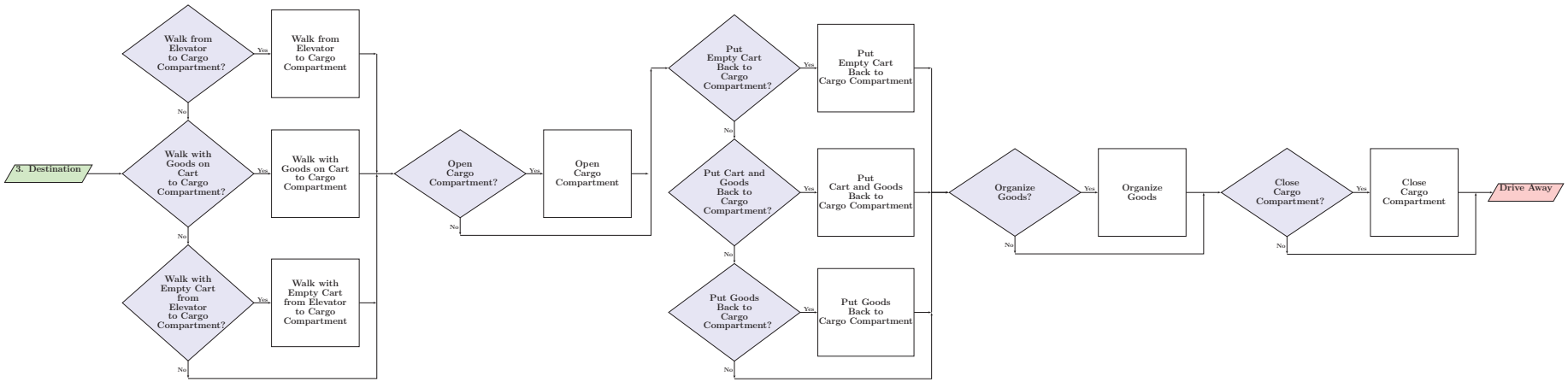
## 3. Destination (Dexter Horton Building)



## 3. Destination - 2 (Dexter Horton Building)

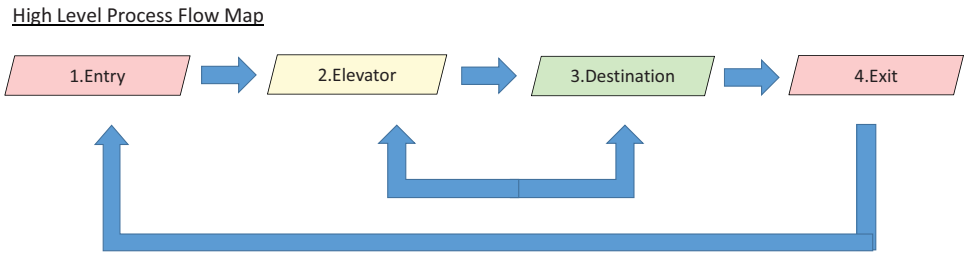


## 4. Exit (Dexter Horton Building)

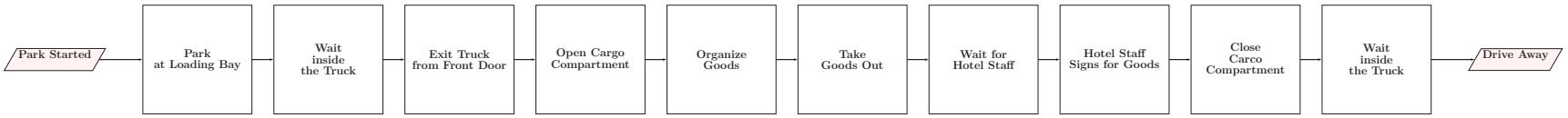


## APPENDIX H –
## FOUR SEASONS HOTEL – HIGH-LEVEL PROCESS FLOW MAP

# Delivery Process Flow Map
# Hotel:
# Four Seasons Hotel

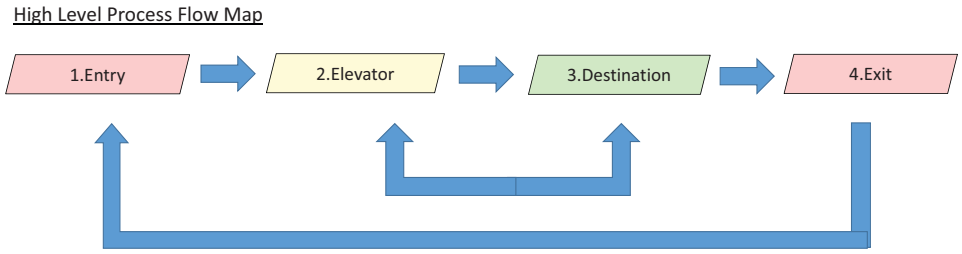


## Delivery Process Flow (Four Seasons Hotel)

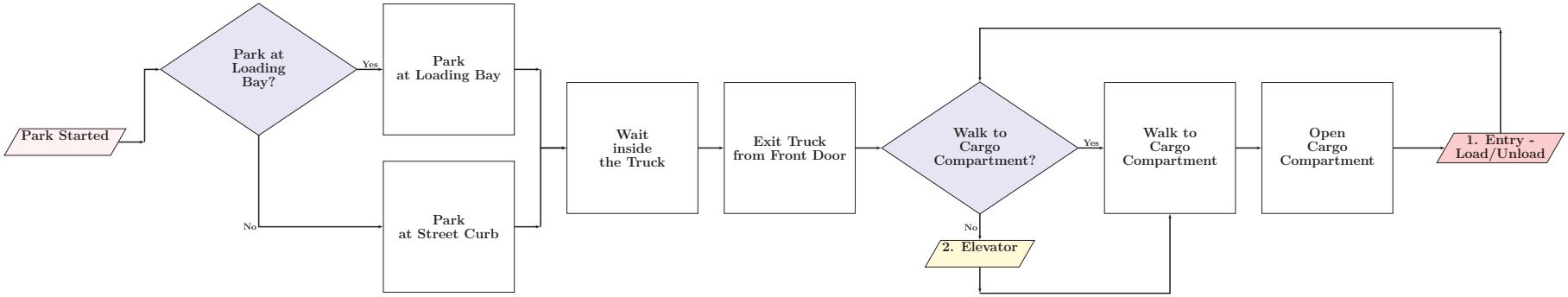


## APPENDIX I –
## WESTLAKE TOWER AND CENTER – HIGH-LEVEL PROCESS FLOW MAP

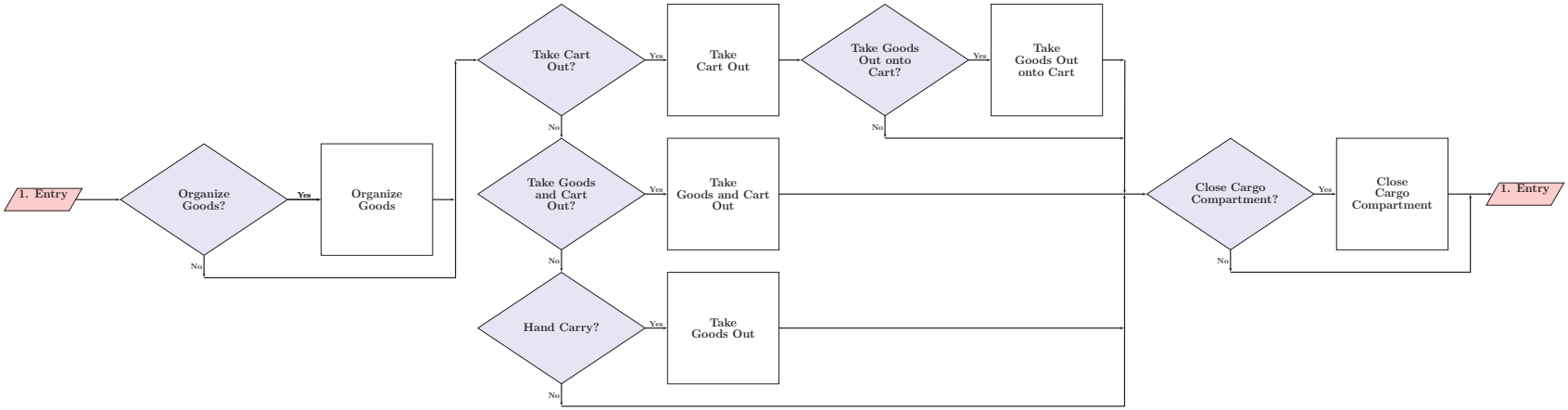
# Delivery Process Flow Map
# Shopping Mall:
# Westlake Mall/Tower



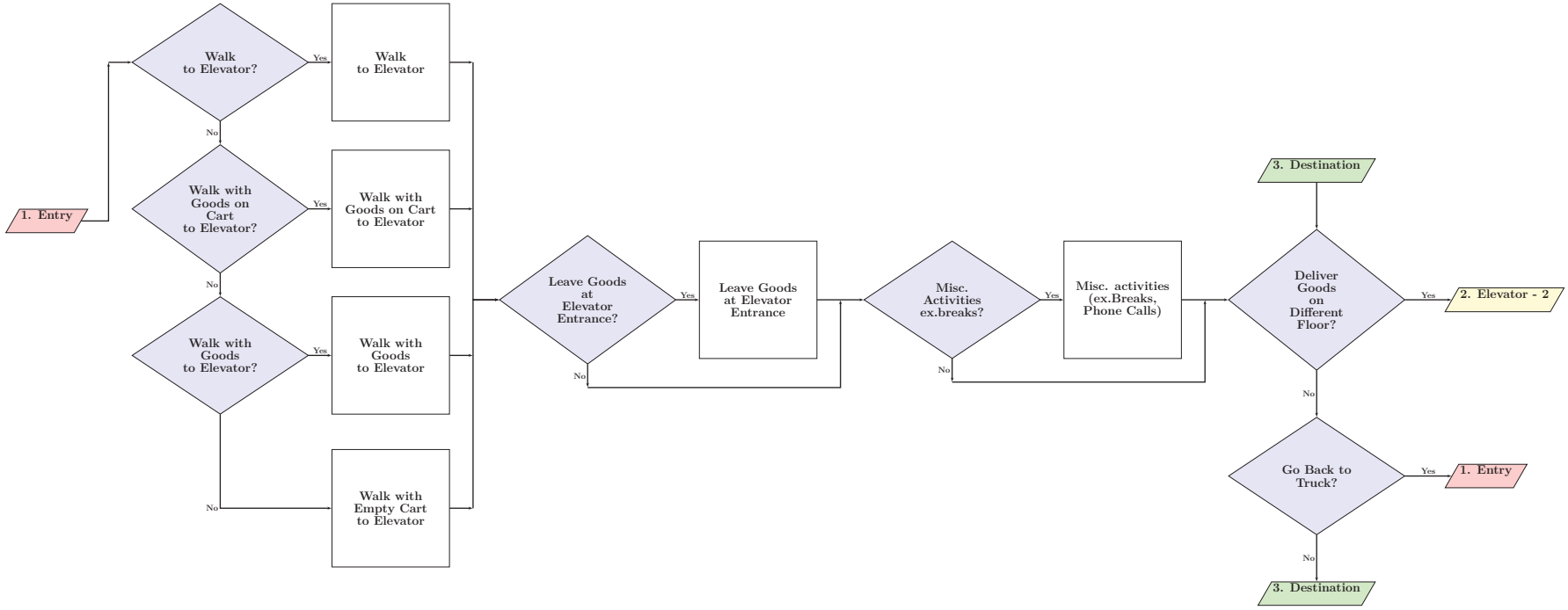
# 1. Entry (Westlake Mall/Tower)



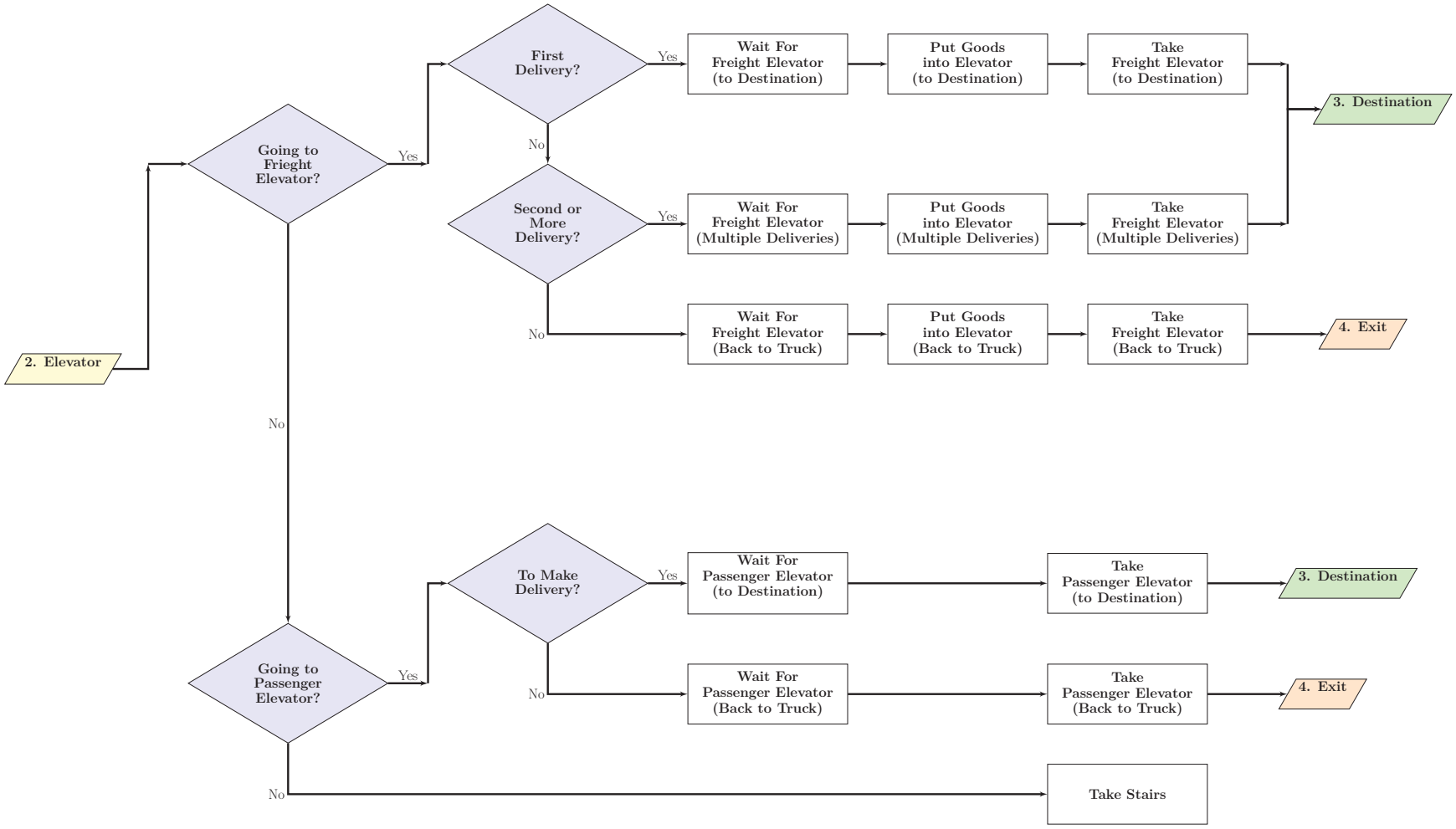
## 1. Entry - Load/Unload (Westlake Mall/Tower)



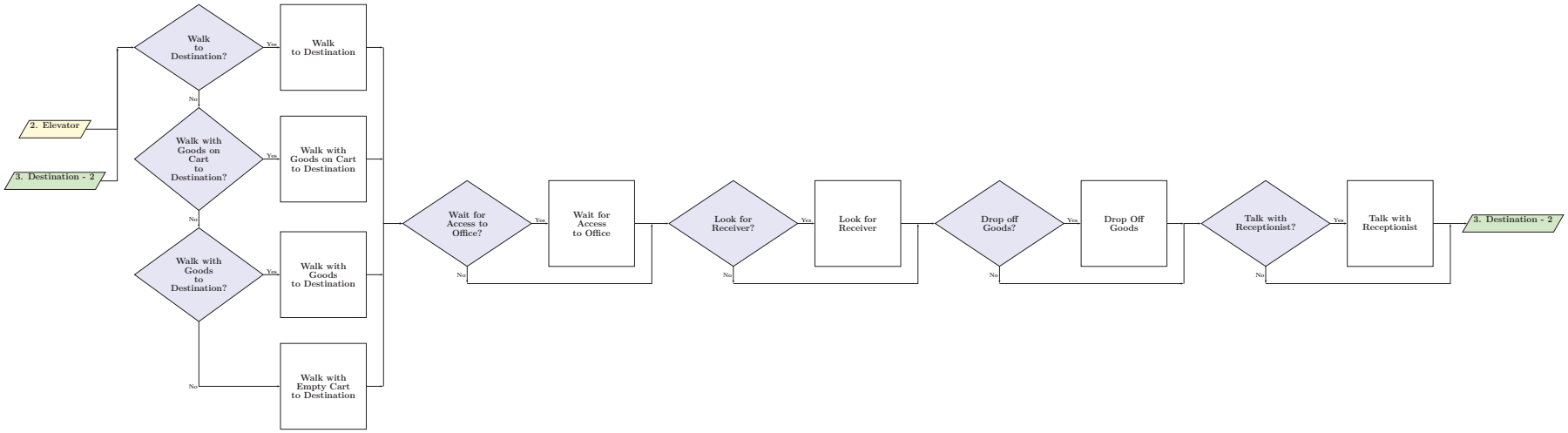
## 2. Elevator (Westlake Mall/Tower)



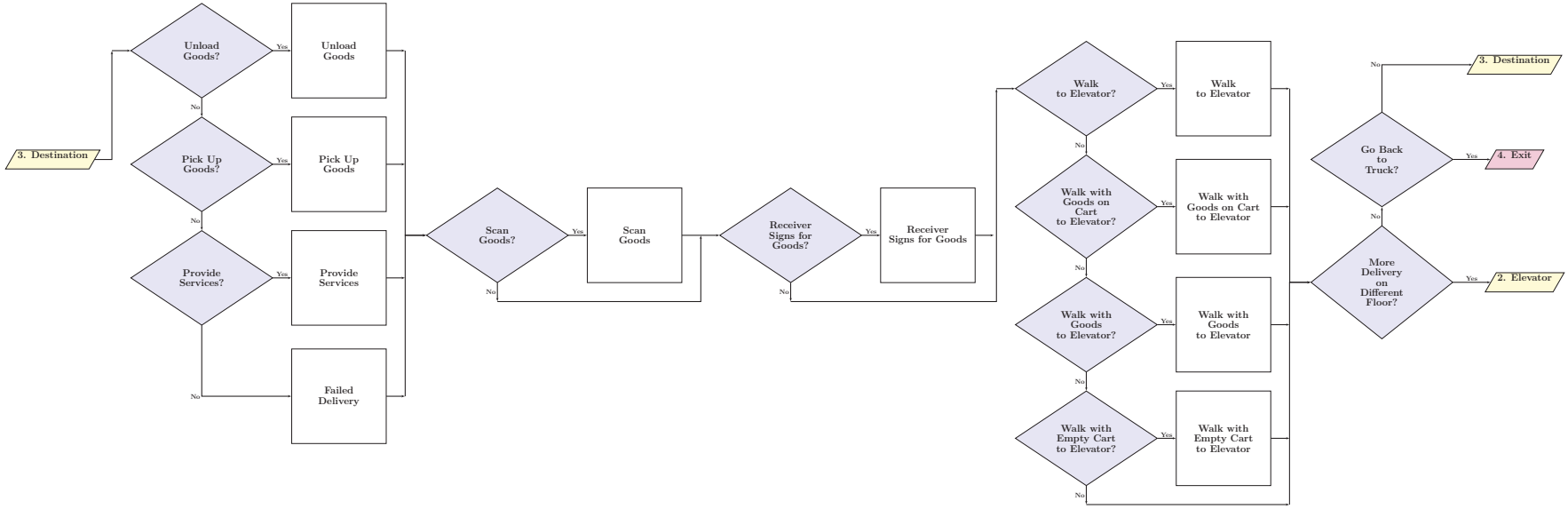
# 2. Elevator - 2 (Westlake Mall/Tower)



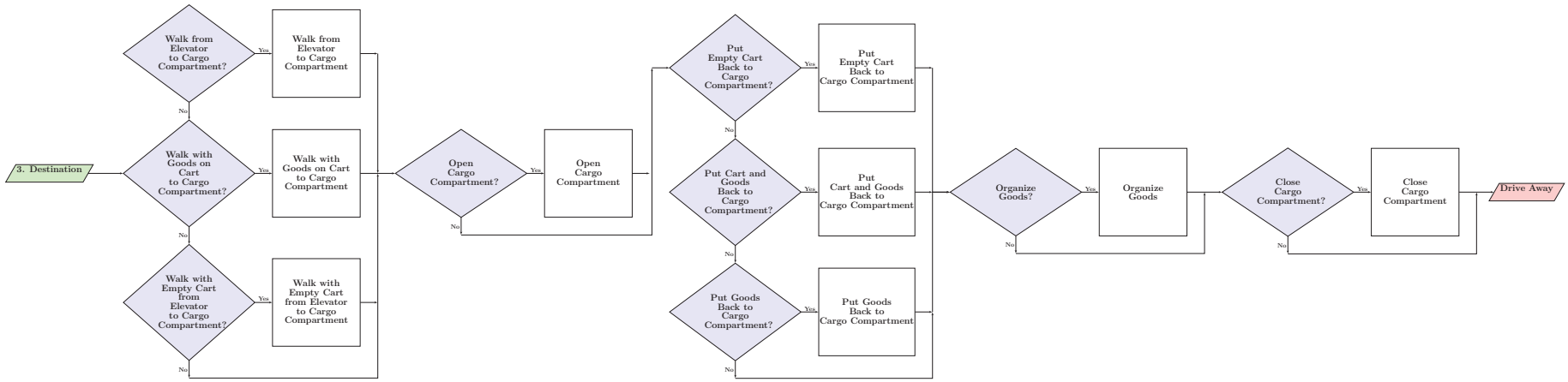
## 3. Destination (Westlake Mall/Tower)



## 3. Destination - 2 (Westlake Mall/Tower)



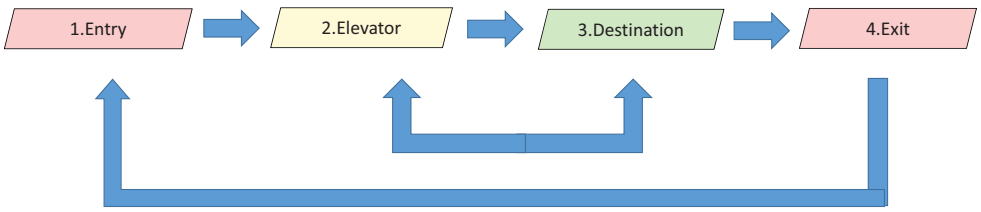
## 4. Exit (Westlake Mall/Tower)



## APPENDIX J –
## INSIGNIA TOWER – HIGH-LEVEL PROCESS FLOW MAP

# Delivery Process Flow Map
# Residential Building
# Insignia Tower

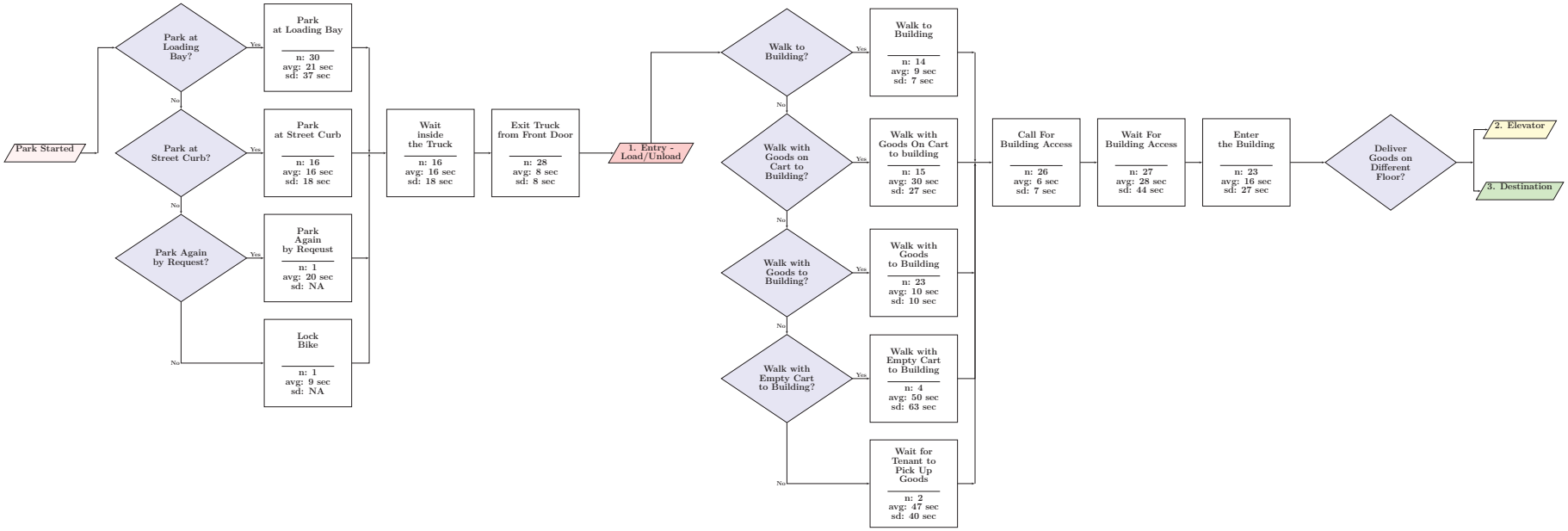
High Level Process Flow Map



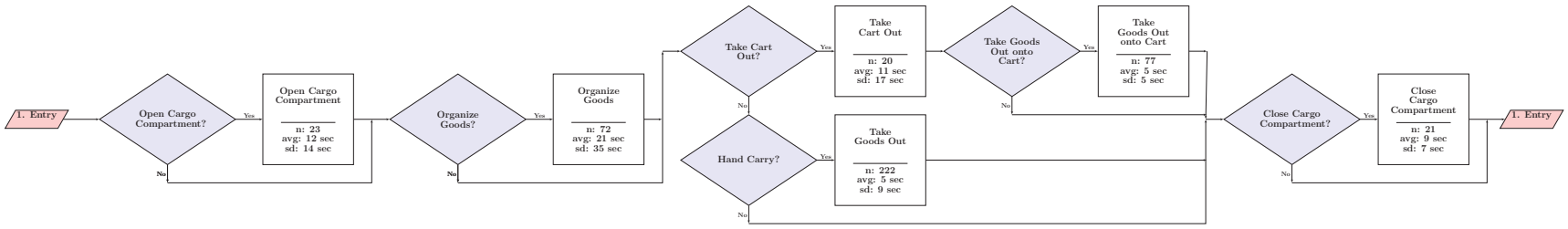

Total Number of Trucks Observed: 42
Types of Delivery Observed:

| Packages | Food | Groceries | Furniture | Mail | Total |
|---|---|---|---|---|---|
| 22 | 8 | 7 | 4 | 1 | 42 |

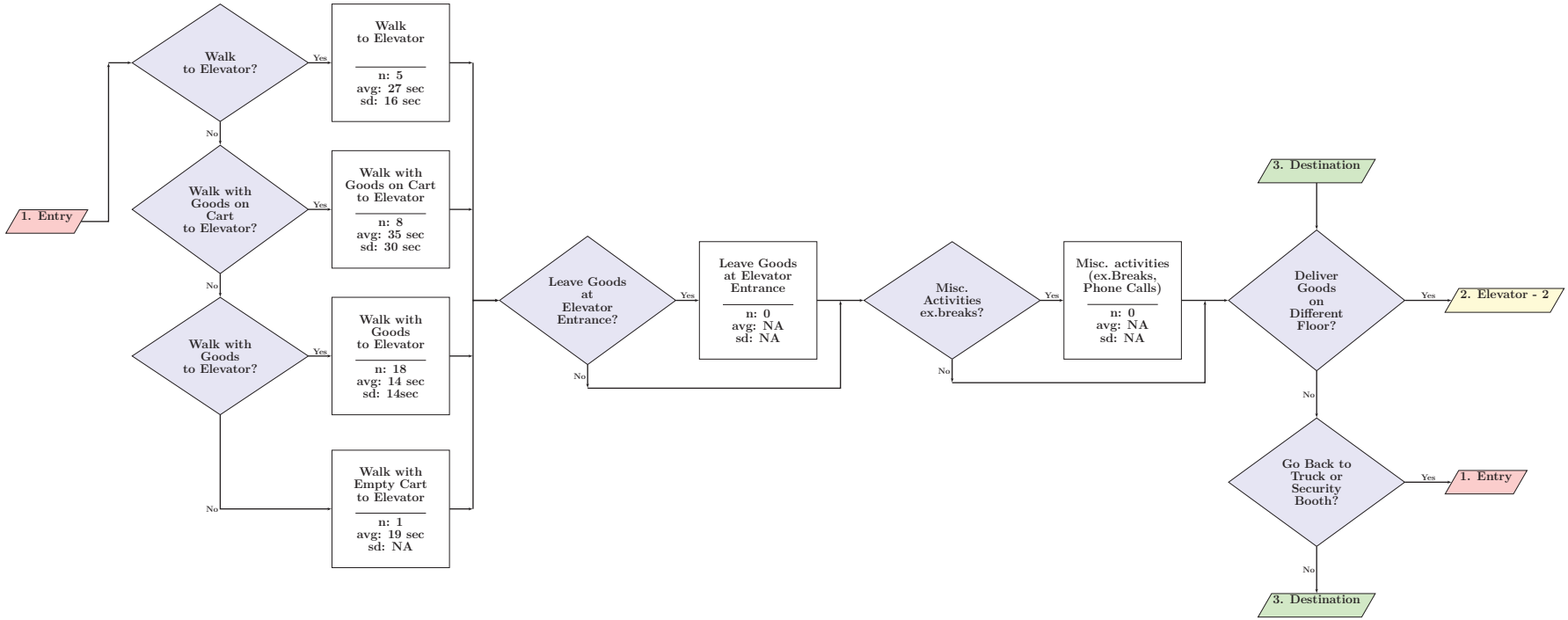
## 1. Entry (Insignia Tower)



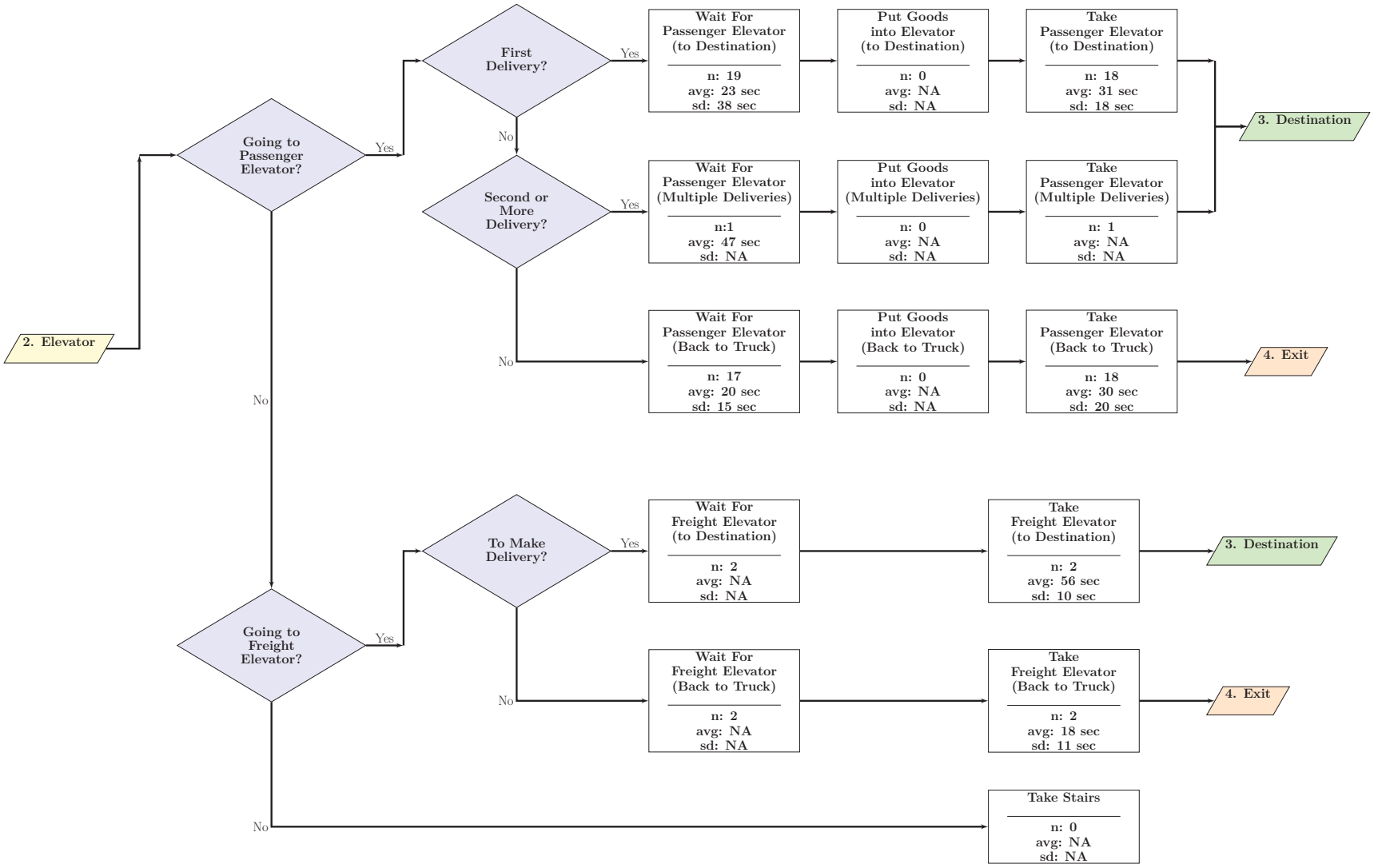
## 1. Entry - Load/Unload (Insignia Tower)



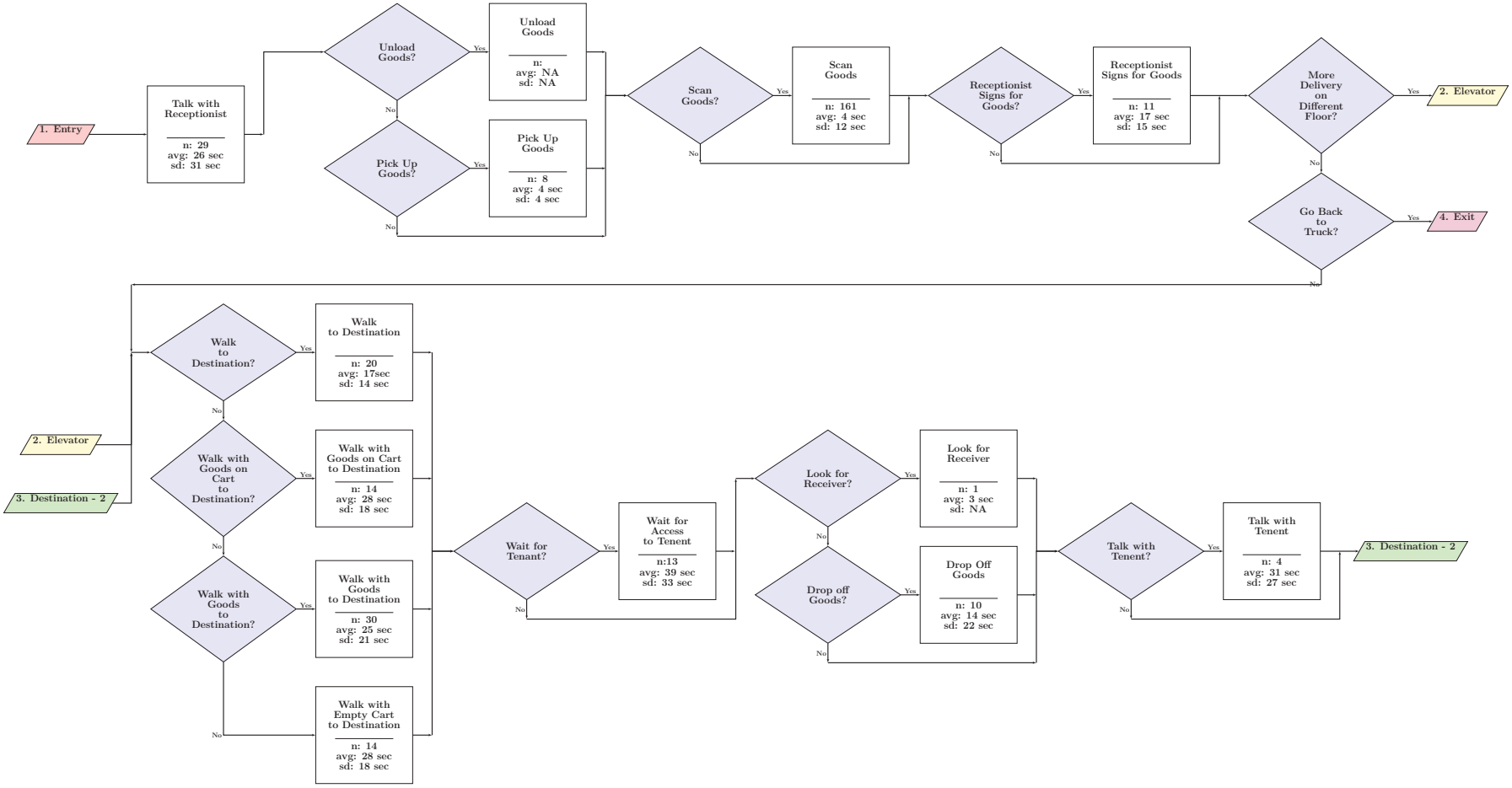
## 2. Elevator (Insignia Tower)



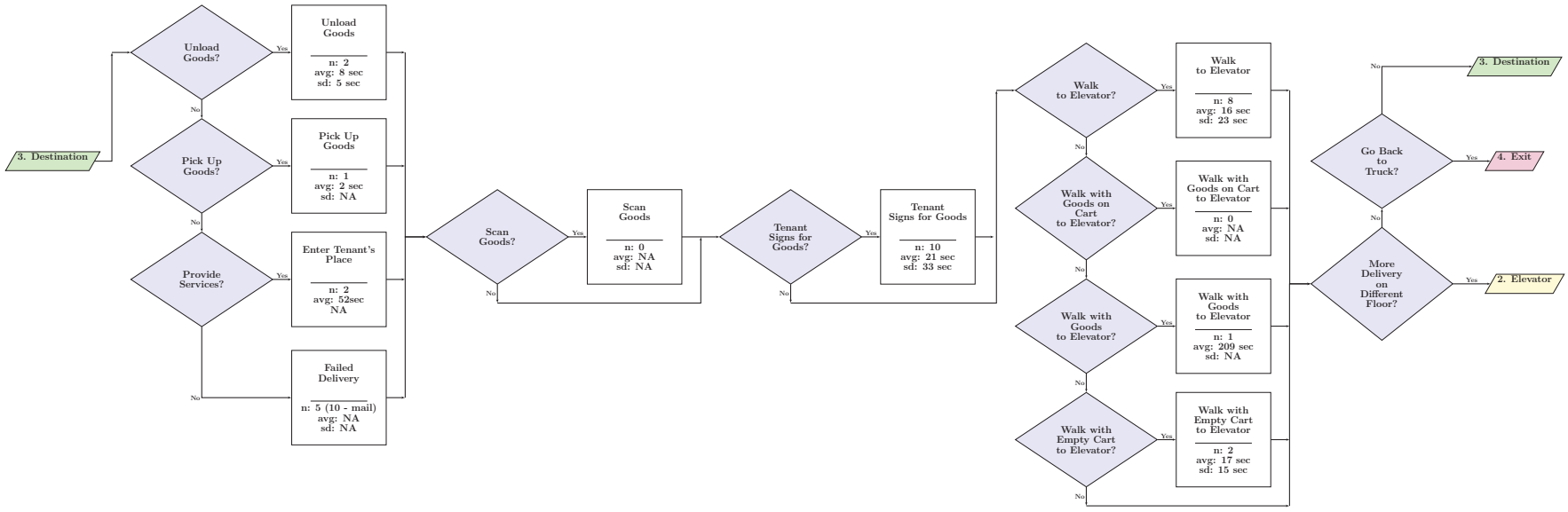
# 2. Elevator - 2 (Insignia Tower)



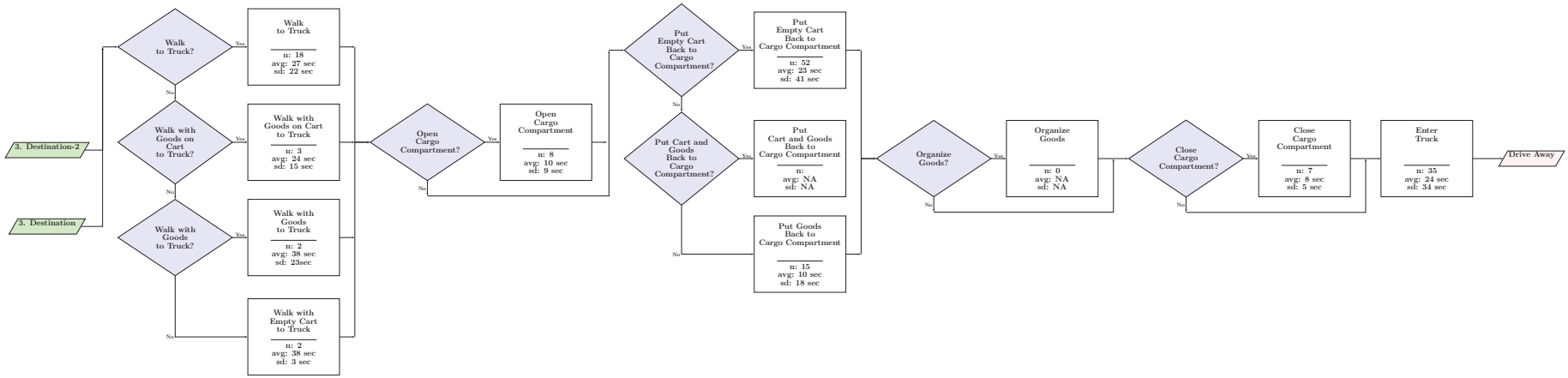
## 3. Destination (Insignia Tower)



## 3. Destination - 2 (Insignia Tower)



## 4. Exit (Insignia Tower)



# APPENDIX K –
# DATA DICTIONARY AND MAP COLLECTION

## Description

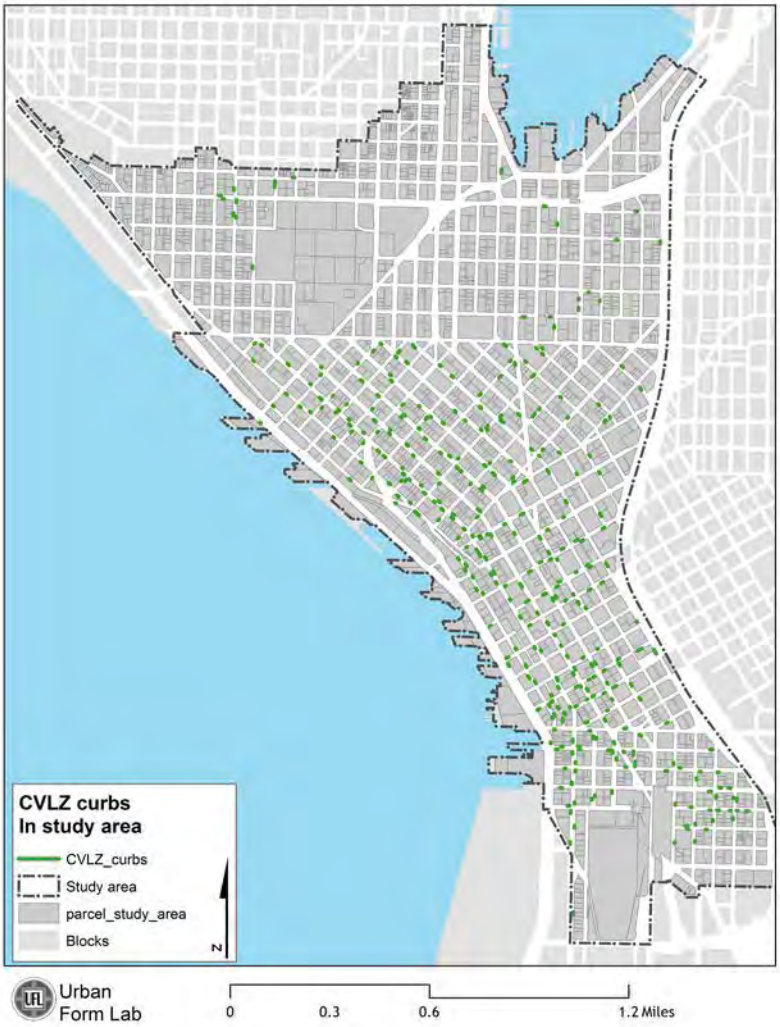
The following describes the maps layers and shows simple maps of each layer for the ArcGIS map package, “Final50_Task2_showcase.pkg”.

## Extent

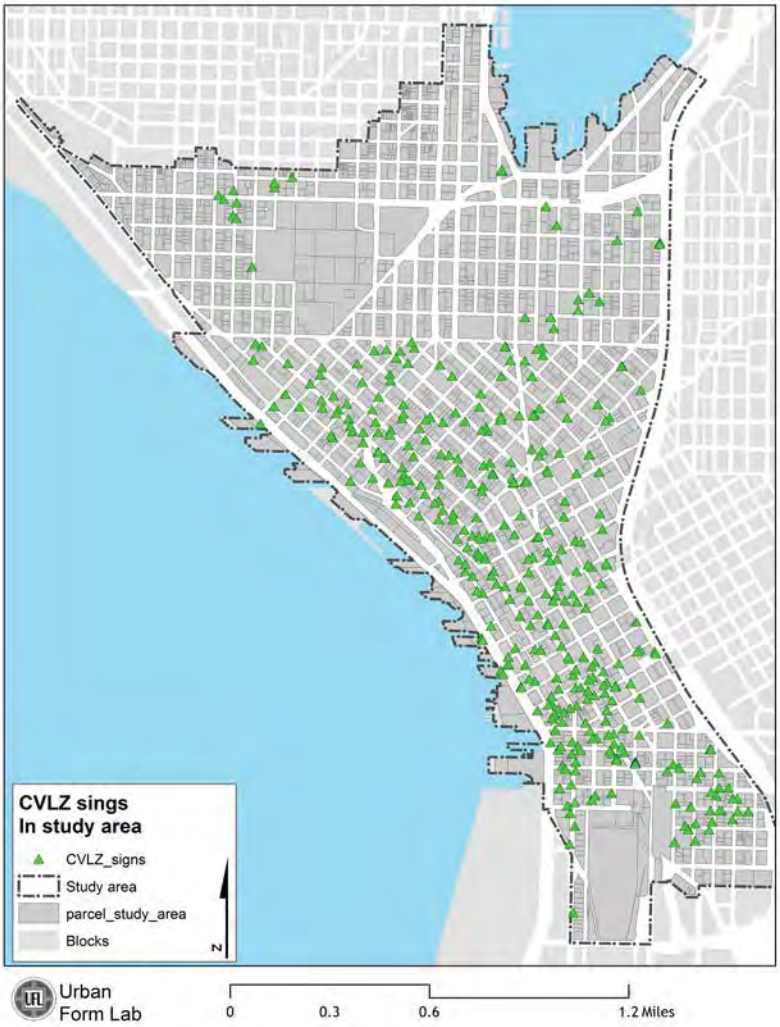
All layers have been clipped to a spatial extent that covers downtown Seattle, First Hill, Capitol Hill and parts of Lower Queen Anne and SoDo. Data will need to be downloaded from sites listed herein to gain full extent of all data.

| LAYERS | DETAILS |
|---|---|
| **Task2B_stateplane** | **Description:**<br>Points showing the locations of loading bays/docks in Task2B study area.<br>**Source:**<br>Urban Freight Lab Final 50 Task 2B data collection |
| **Total_area** | **Description:**<br>Polygon layer represented as a dotted line showing the boundaries of the UFL Final 50 Task 2B data collection area.<br>**Source:**<br>Urban Freight Lab Final 50 Task 2B data collection |

| LAYERS | DETAILS |
|---|---|
| **Alleys** | **Description:**<br>Line segments representing alleys.<br>**Source:**<br>http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=trans_network_car<br>**Notes:**<br>The alleys in this layer are a subset of street segments from the King County Metro Transportation Network layer for car mode. Alleys were identified from this layer by selecting the line segments having the A73 code (indicating alleys) in the CFCC_ID field. This layer contains all of the same fields as the source material. See above URL for description of fields. |

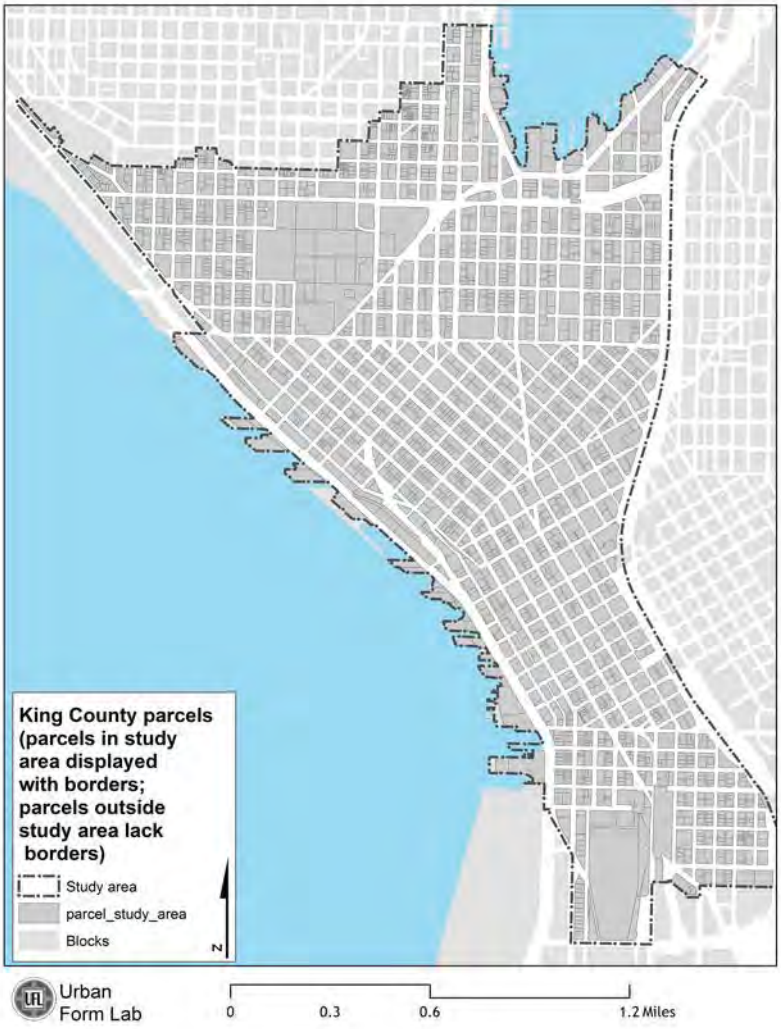



| LAYERS | DETAILS |
|---|---|
| **CVLZ_curbs** | **Description:**<br>CVLZs represented as lines along blocks.<br><br>**Source:**<br>https://data.seattle.gov/Transportation/SDOT-Curb-Space-Categories/77ms-czxg<br><br>**Notes:**<br>Commercial vehicle load zones from SDOT's Curb Space Categories dataset. The Curb Space Categories dataset represents curbs as line segments along blocks, marking the location where sidewalks meet streets. Only curbs with paid parking are represented in the original data. The curb along the block is divided into different segments by use. The SPACETYPE and SPACETYPEDESC fields in the attribute table list the different uses. The CVLZ_curb layer was created by selecting only those curb uses that were associated with CVLZs (as indicated by their description type in the SPACETYPEDESC field) and were adjacent to CVLZ street parking signs as represented in the CVLZ_signs layer. |




| LAYERS | DETAILS |
|---|---|
| **CVLZ_signs** | **Description:**<br>Street parking sign locations represented as points.<br><br>**Source**:<br>https://data.seattle.gov/Transportation/SDOT-Street-Parking-Signs/erv6-k5zv<br><br>**Notes:**<br>The CVLZ street signs come from SDOT's Street Parking Signs data. This dataset represents the locations of every parking sign by category type. The CVLZ_signs layer was created by selecting signs with the Commercial Vehicle Load Zones value in the CATEGORYDE field. |

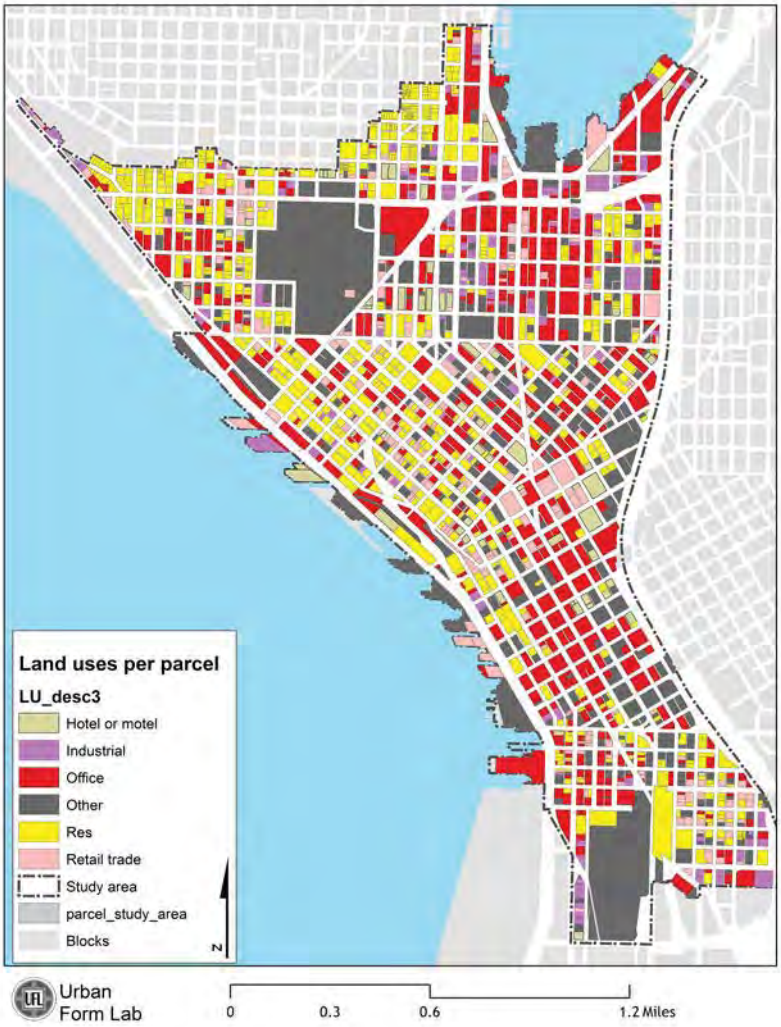
| LAYERS | DETAILS |
|---|---|
| **Parcel** | **Description:**<br>King County tax assessor parcels.<br><br>**Source:**<br>http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=parcel<br><br>**Notes:**<br>The KC parcel data was left unchanged. In the associated ArcMAP package, the parcels are represented as grey without outlines. Thus the borders between parcels are not visible. The end result is that the parcels form blocks. |




| LAYERS | DETAILS |
|---|---|
| **parcel_study_area** | **Description:**<br>Parcels within the Final 50 Task 2 study area.<br>Source: http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=parcel<br>**Notes:**<br>1. Layer contains parcels from the King County parcel layer clipped to the Final 50 Task 2 study area. This dataset was heavily cleaned to remove parcels that were not relevant for analysis such as parcels representing sections of water and parcels representing railroad rights of way.<br>2. This parcel layer is to be joined with the parcel_study_area_landuse.csv table described below so that land use classifications and gross/net square footage could be displayed at the parcel level.<br>3. The map package includes multiple copies of this layer so that the different land uses could be displayed separately. |

*Table continued next page*

| LAYERS | DETAILS |
|---|---|
| **parcel_study_area** | 4. Fields:<br>• OBJECTID_1: Unique identifier used for GIS manipulations<br>• Shape: geometry type, used for GIS manipulations<br>• MAJOR: 6-digit identifier stored in character string format. Values may have leading zeroes.<br>• MINOR: 4-digit identifier stored in character string format. Values may have leading zeroes.<br>• PIN: The Parcel Identification Number used by King County. The Major and the Minor are combined into a 10-digit string with leading zeroes. Each parcel has a unique PIN.<br>• PIN_num: numeric version of the PIN. The PIN field above is represented in string format and can be only matched to another string variable. Because ArcGIS automatically converts the PIN into a numeric format when a CSV is imported, numeric formats of the PIN are useful for joining to the CSV file. The major difference between PIN and PIN_num is that the later lacks leading zeroes.<br>• SITEID: Unique identifier used for GIS processing<br>• Presentuse: The numeric code indicating the predominant present land use on the parcel as determined by the King County tax assessor.<br>• Presentu_1: The text of the predominant present land use on the parcel as determined by the King County tax assessor. Corresponds to the numeric code in the presentuse field.<br>• Present_2: The predominant present land use on the parcel categorized into 4 groups: Office, Res (residential), Industrial, and Retail trade.<br>• Shape_Length: length of the parcel in linear feet.<br>• Shape_Area: area of the parcel in square feet. |

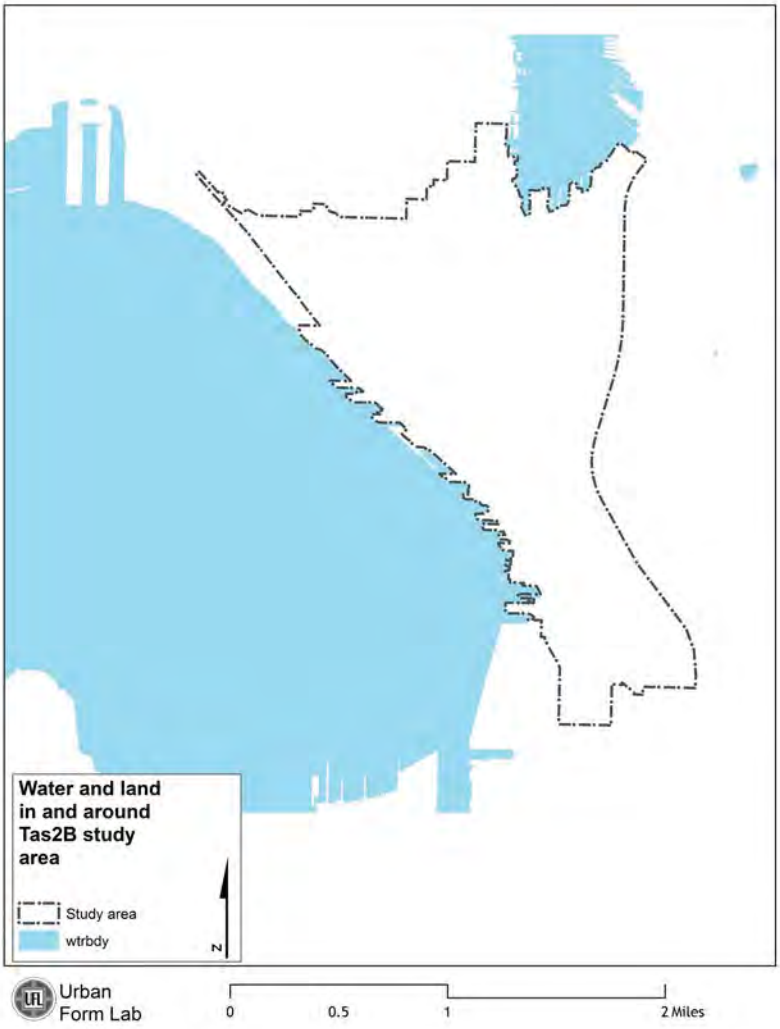



| LAYERS | DETAILS |
|---|---|
| **parcel_study_area_landuse.csv** | **Description:**<br>A parcel-level table stored as a CSV file. Contains information about land use, year of structure built on parcel, number of stories of building on parcel, gross square feet and net square feet.<br><br>Sources: The parcel_study_area shapefile layer (above) and tables from King County tax assessor parcel-level data (http://info.kingcounty.gov/assessor/DataDownload/default.aspx).<br>The following tax assessor tables were used:<br>• Apartment Complex<br>• Condo Complex<br>• Commercial Building |

*Table continued next page*

| LAYERS | DETAILS |
|---|---|
| **parcel_study_area_landuse.csv** | **Notes:**<br>Fields from the various tables above were combined into one table. Fields for the condo and apartment tables were integrated by hand to consolidate residential year built data and number of residential units.<br>• OBJECTID: Unique identifier used for GIS processing.<br>• MAJOR: Parcel identifier, up to 6 digits in length, stored in numeric format. Analogous to the MAJOR field in the parcel_study_area layer except it is in numeric format. Lacks leading zeroes.<br>• MINOR: Parcel identifier, up to 4 digits in length, stored in numeric format. Analogous to the MAJOR field in the parcel_study_area layer except it is in numeric format. Lacks leading zeroes.<br>• PIN_num: numeric version of the PIN field in the parcel_study_area layer. The PIN field in that layer is represented in string format and can be only matched to another string variable. Because ArcGIS automatically converts the PIN into a numeric format when a CSV is imported, numeric formats of the PIN are useful for joining to the CSV file to the parcel layer. The major difference between PIN_num and PIN is that the former lacks leading zeroes.<br>• LU_desc2: The predominant present land use on the parcel categorized into 5 groups: 'Office', 'Res' (residential), 'Industrial', 'Retail trade', and 'Other'. Analogous to the presentu_2 in parcel_study_area layer.<br>• LU_desc3: The predominant present land use on the parcel categorized into 6 groups: 'Office', 'Res' (residential), 'Industrial', 'Retail trade', 'Other', and 'Hotel or motel'. In the LU_desc2 field hotels and motels were classified as 'Res'.<br>• Hotel: The predominant present land use on the parcel categorized into 2 groups: 'Other' and 'Hotel or motel'.<br>• Industrial: The predominant present land use on the parcel categorized into 2 groups: 'Other' and 'Industrial'.<br>• Office: The predominant present land use on the parcel categorized into 2 groups: 'Other' and 'Office'.<br>• Residential: The predominant present land use on the parcel categorized into 2 groups: 'Other' and 'Res'.<br>• Retail: The predominant present land use on the parcel categorized into 2 groups: 'Other' and 'Hotel or motel'.<br>• Year_blt: The year structure was built on parcel. Consolidated from com_yrblt and res_yrblt fields in same table. When parcels contained year built information for both commercial and residential uses the oldest year was chosen.<br>• Com_yrblt: The year commercial structure on parcel was built.<br>• Com_nstories: Number of stories of commercial structure on parcel.<br>• Com_GrossSqft: Gross square footage of commercial structures on parcel.<br>• Com_NetSqft: Net square footage of commercial structures on parcel.<br>• ComplexDescr: The complex description fields from the KC tax assessor condo complex and apartment complex tables consolidated into one field.<br>• Res_yrblt: The year residential structure was built on parcel.<br>• Res_nunits: Number of units of residential structure on parcel. |

| LAYERS | DETAILS |
|---|---|
| **Street_Network_Database** | **Description:**<br>SDOT-maintained layer of streets in Seattle.<br><br>**Source:**<br>https://data.seattle.gov/dataset/Street-Network-Database/afip-2mzr |



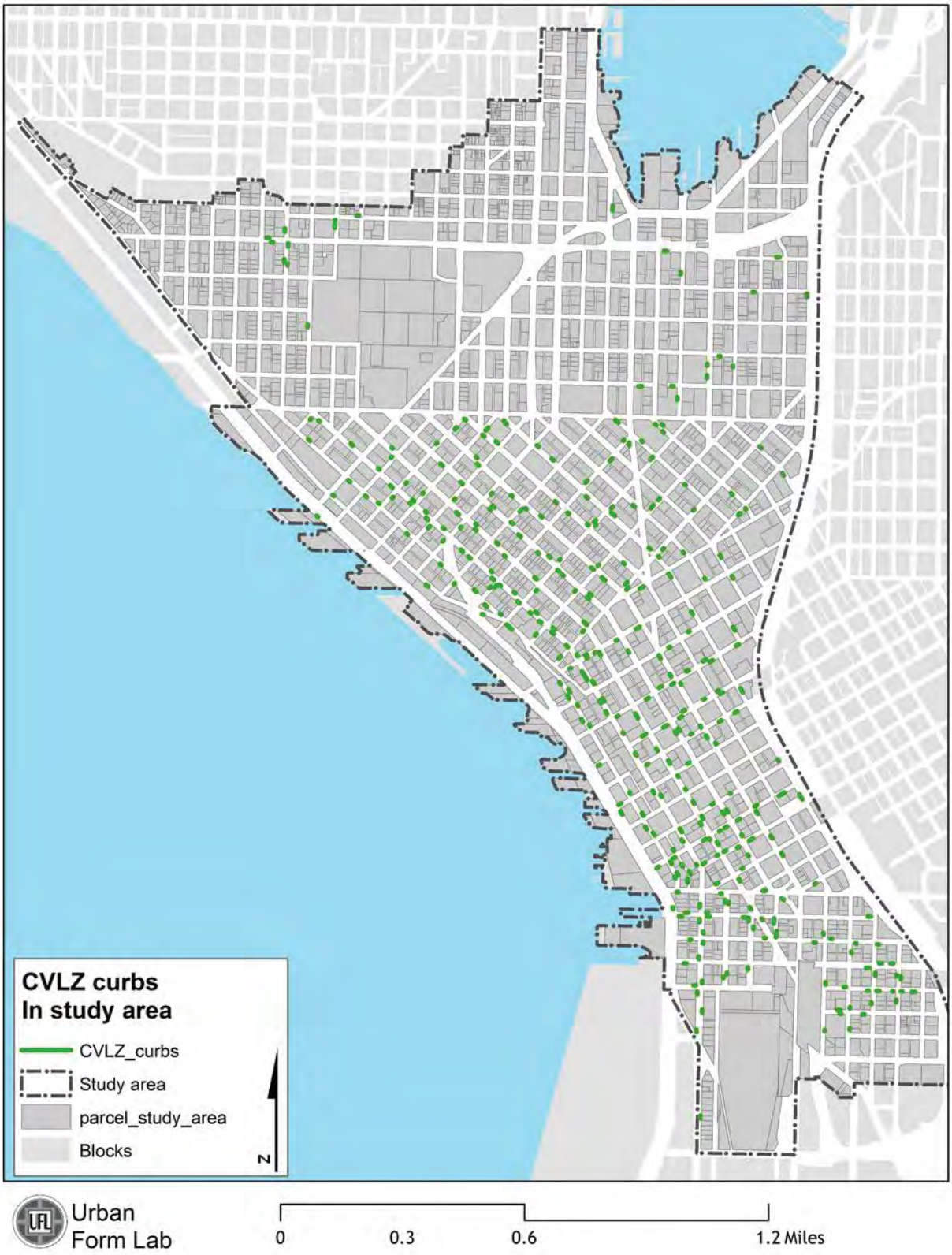

| LAYERS | DETAILS |
|---|---|
| **wtrbdy** | **Description:**<br>Shows all water bodies within Puget Sound region.<br><br>**Source:**<br>http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=wtrbdy |

| LAYERS | DETAILS |
|---|---|
| **World Imagery** | **Description:**<br>A satellite imagery layer.<br><br>**Source:**<br>This layer is a standard feature of ArcGIS<br><br>**Notes:**<br>To display this layer, turn off the wtrbdy and parcel layers. |

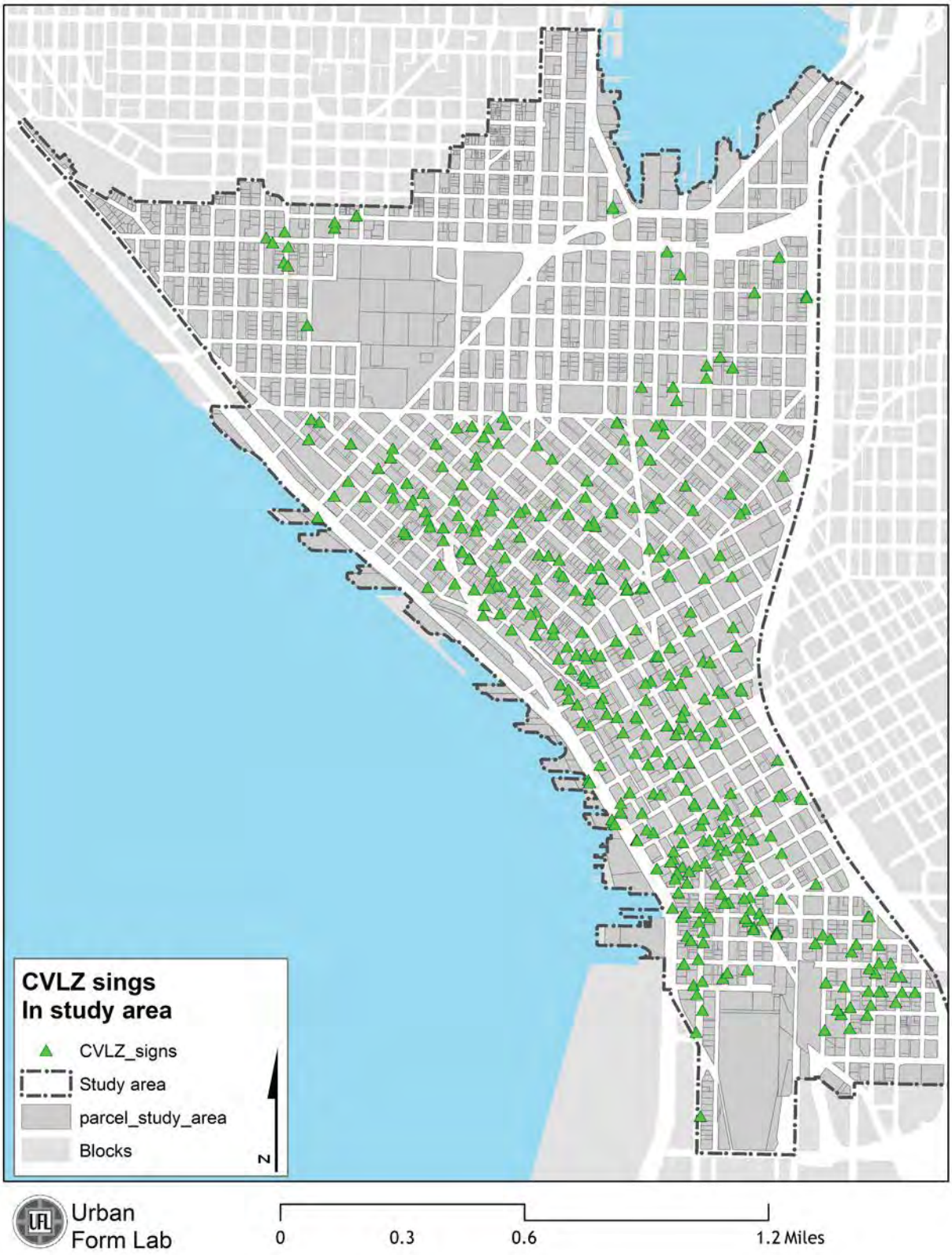
**Map 1:** Layers: Task2B_stateplane & total_area
Base layer: wtrbdy, parcel, parcel_study_area

**Map 2:** Layers: alleys — whole study area
Base layer: wtrbdy, parcel, parcel_study_area

**Map 3:** Layers: CVLZ_curbs — whole study area
Base layer: wtrbdy, parcel, parcel_study_area, & total_area

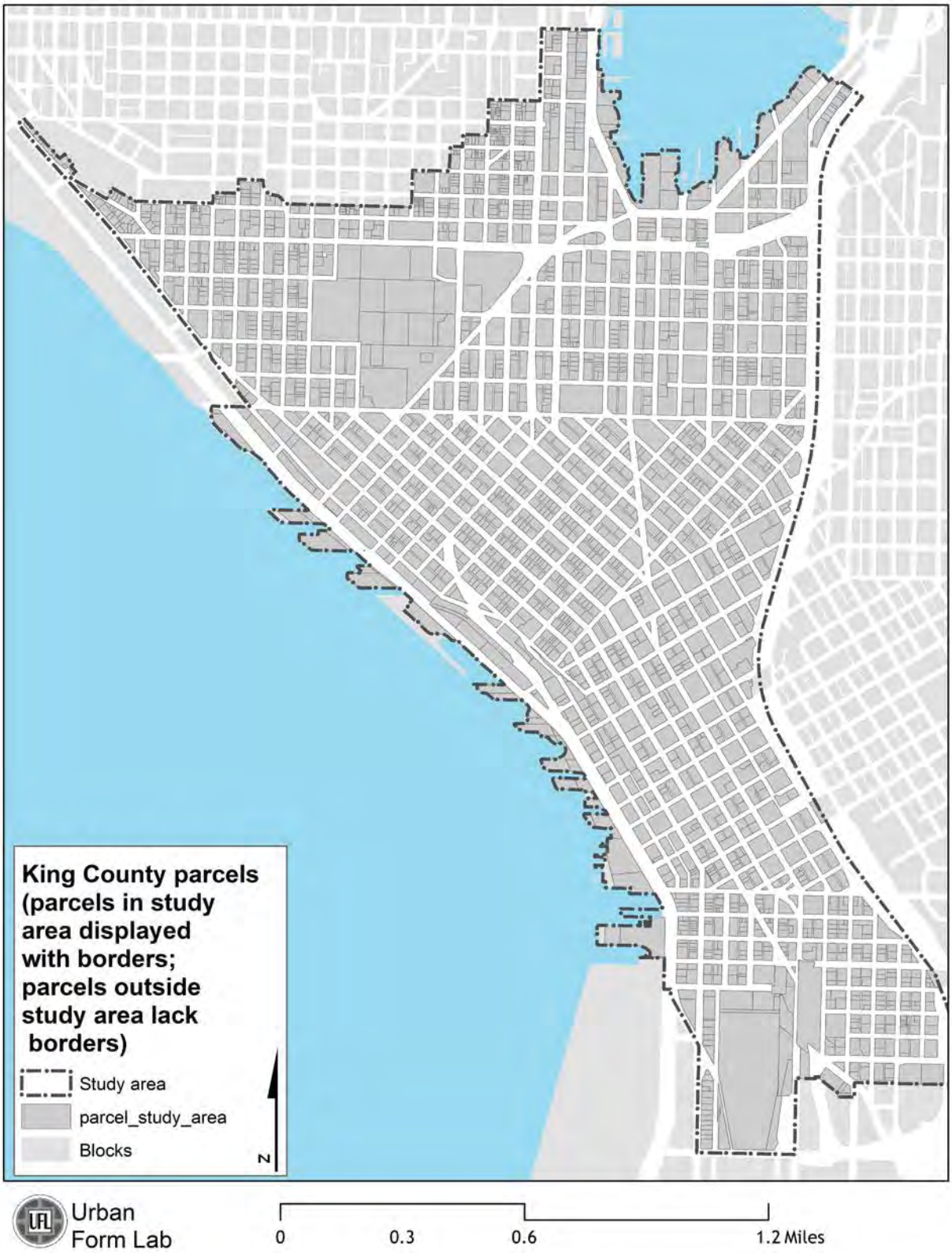


**Map 4:** Layers: CVLZ_signs — whole study area
Base layer: wtrbdy, parcel, parcel_study_area, & total_area

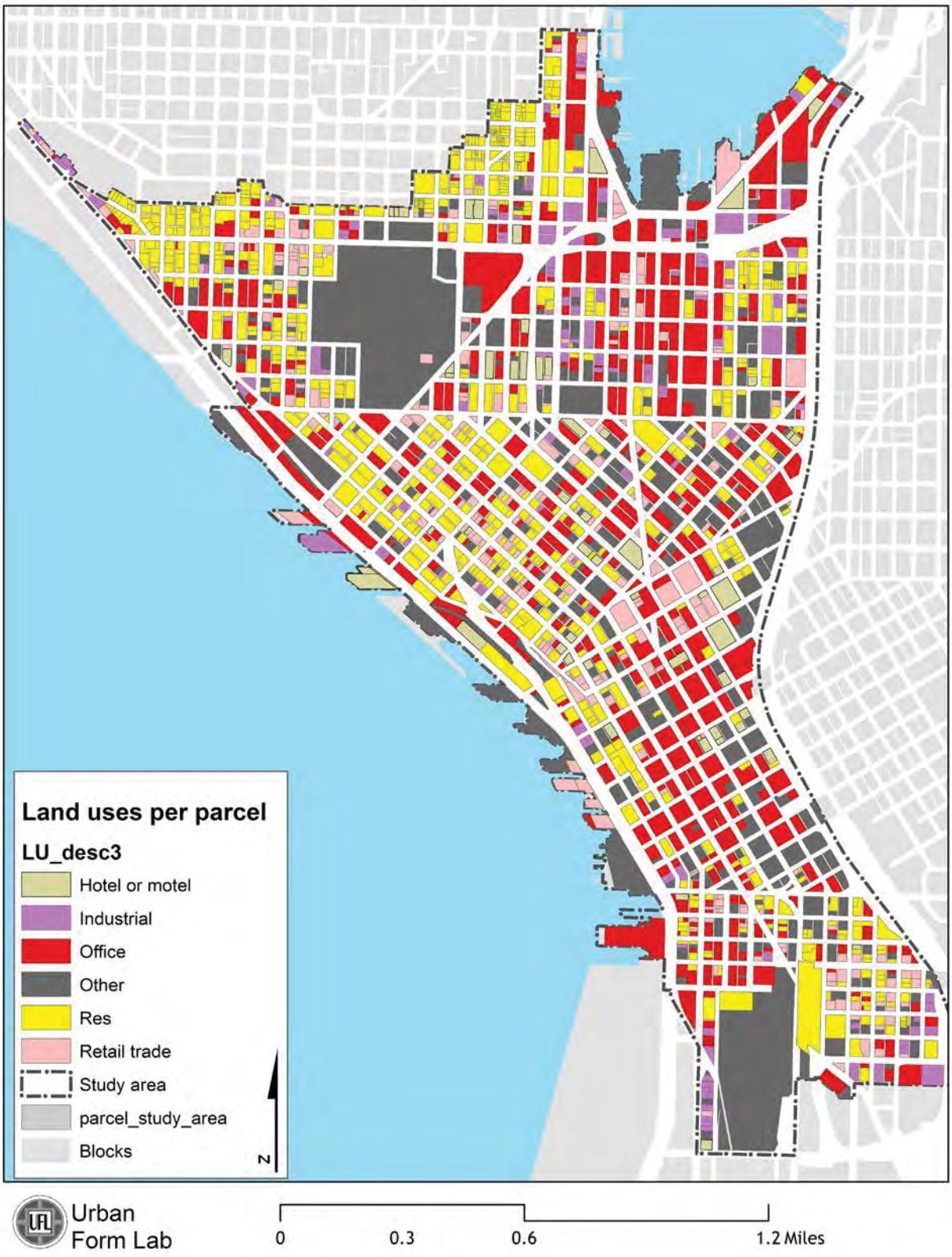


**Map 5:** Layers: parcel (displayed without borders to depict blocks)
Base layer: wtrbdy & total_area

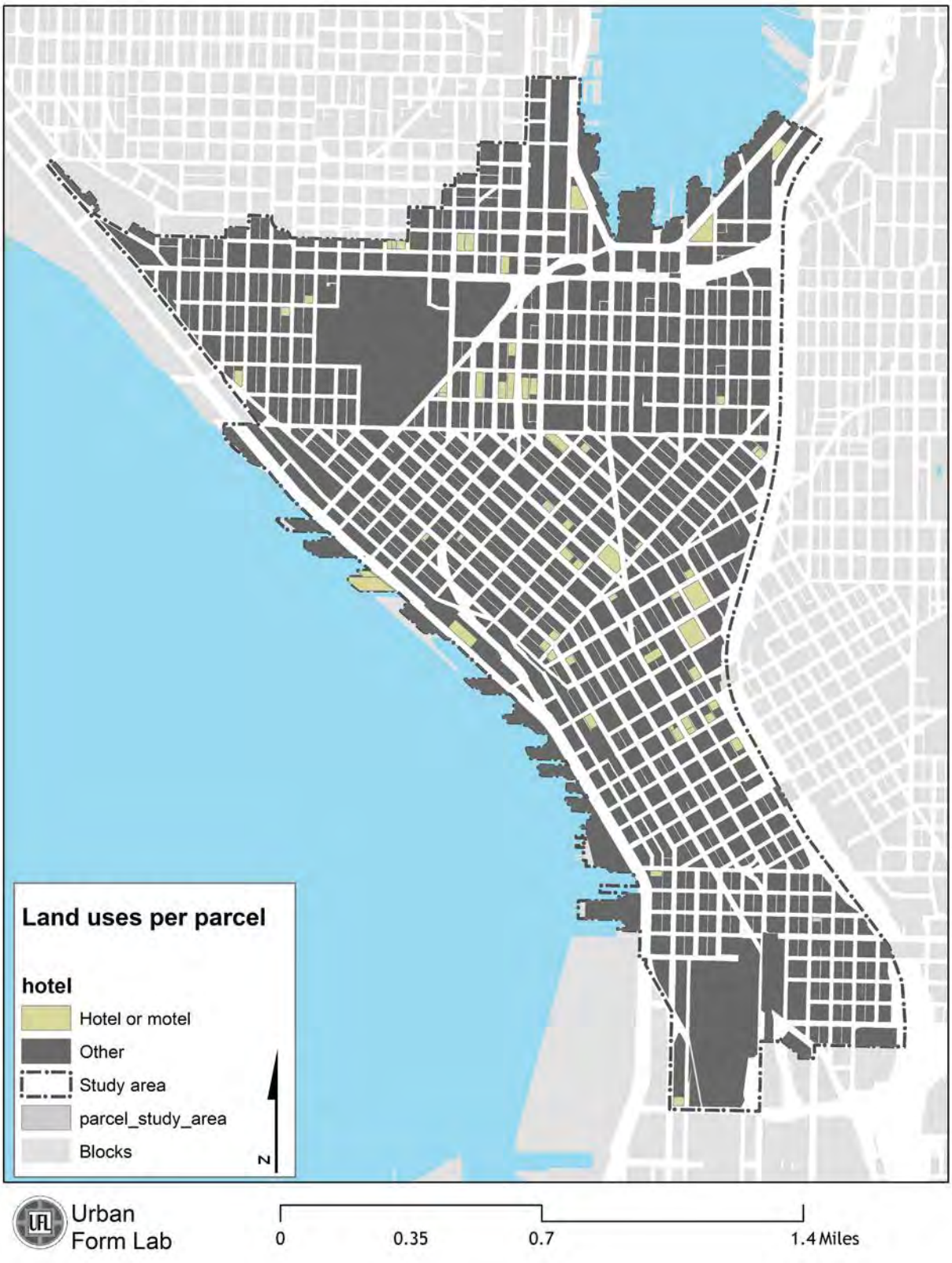
**Map 6:** Layers: parcel_study_area & parcel
Base layer: wtrbdy & total_area



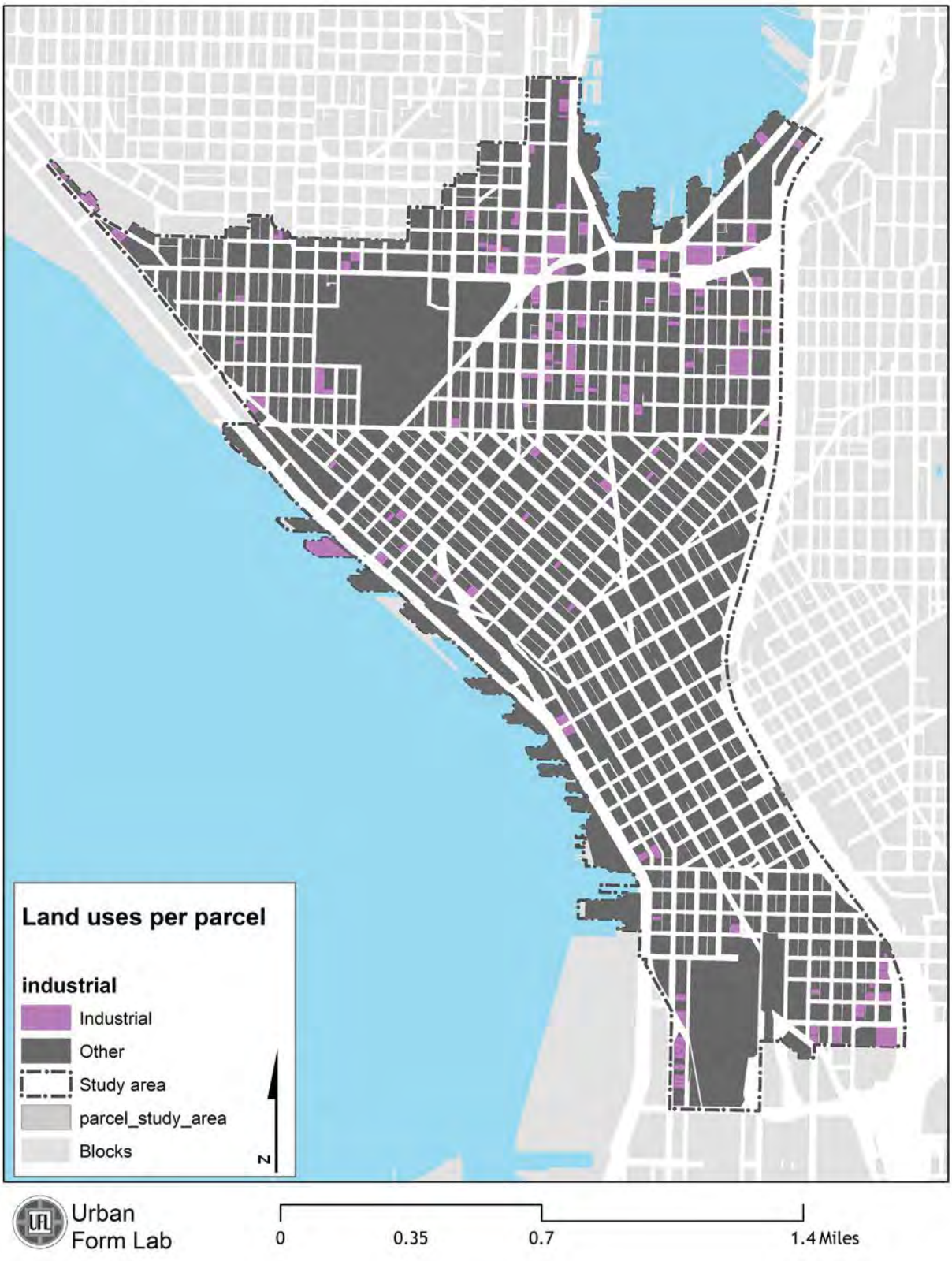
**Map 7:** Layers: parcel & parcel_study_area
Table: parcel_study_area_landuse.csv; Field: LU_desc3
Base layer: wtrbdy & total_area



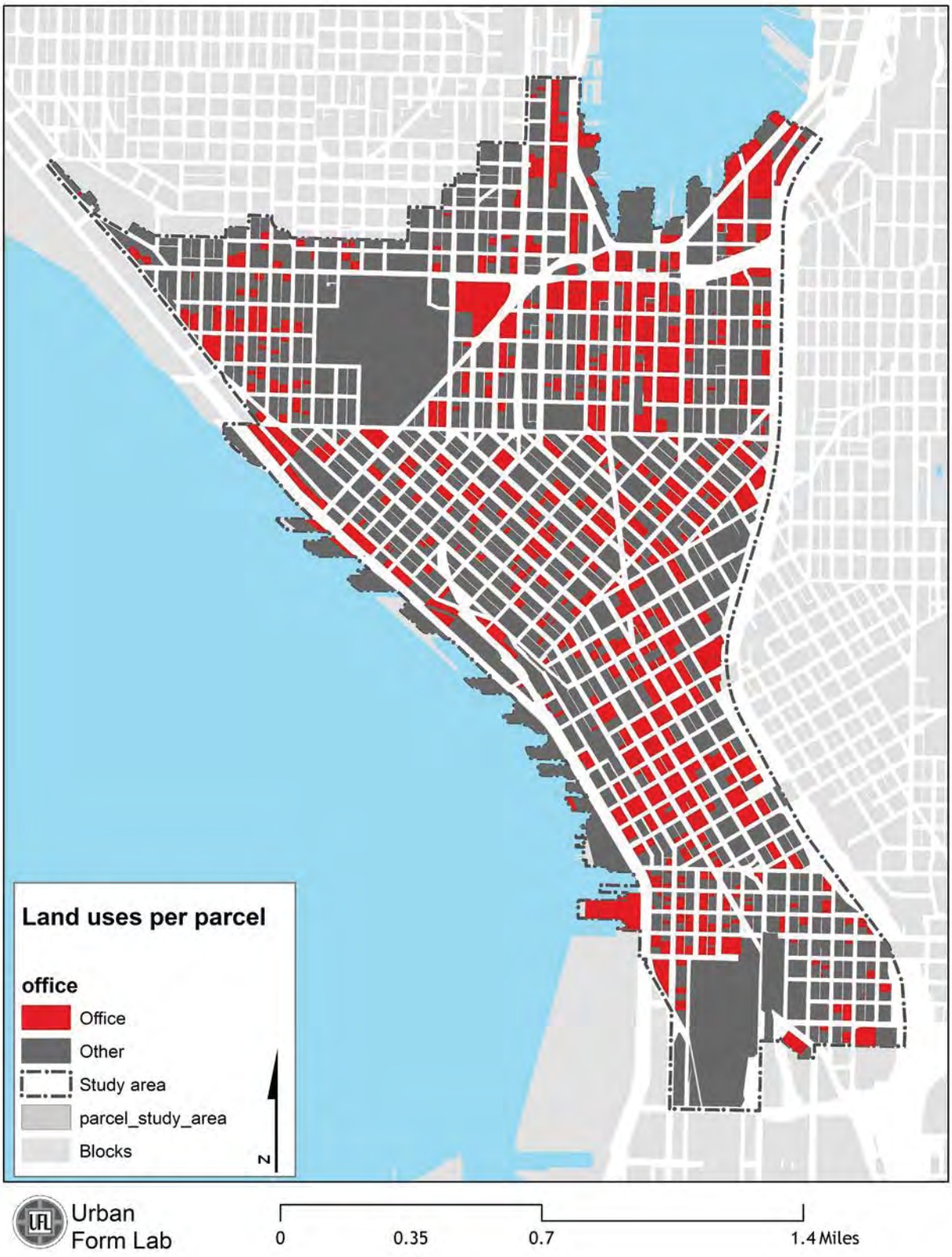
**Map 8:** Layers: parcel & parcel_study_area
Table: parcel_study_area_landuse.csv; Field: hotel
Base layer: wtrbdy & total_area



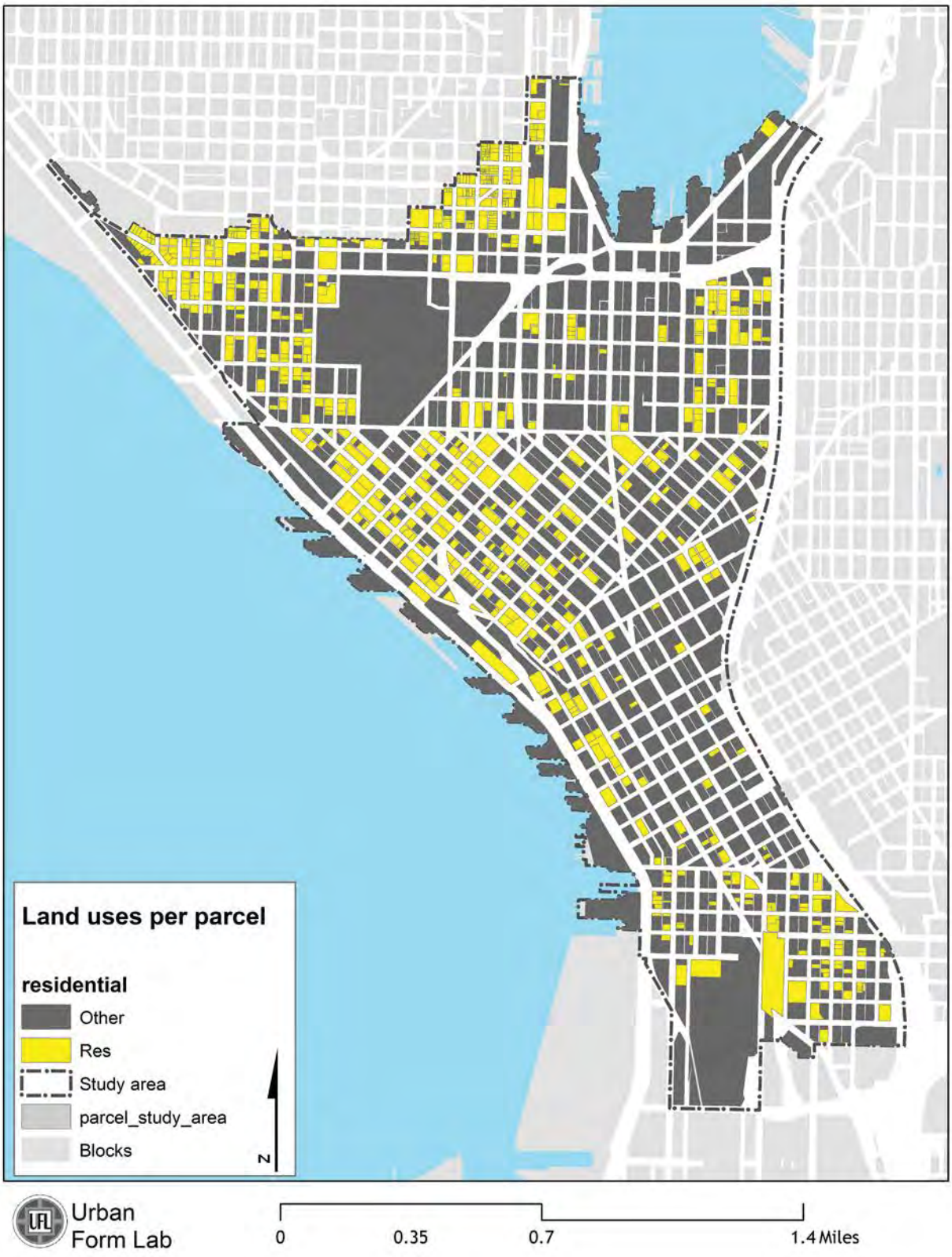
**Map 9:** Layers: parcel & parcel_study_area
Table: parcel_study_area_landuse.csv: Field: industrial
Base layer: wtrbdy & total_area



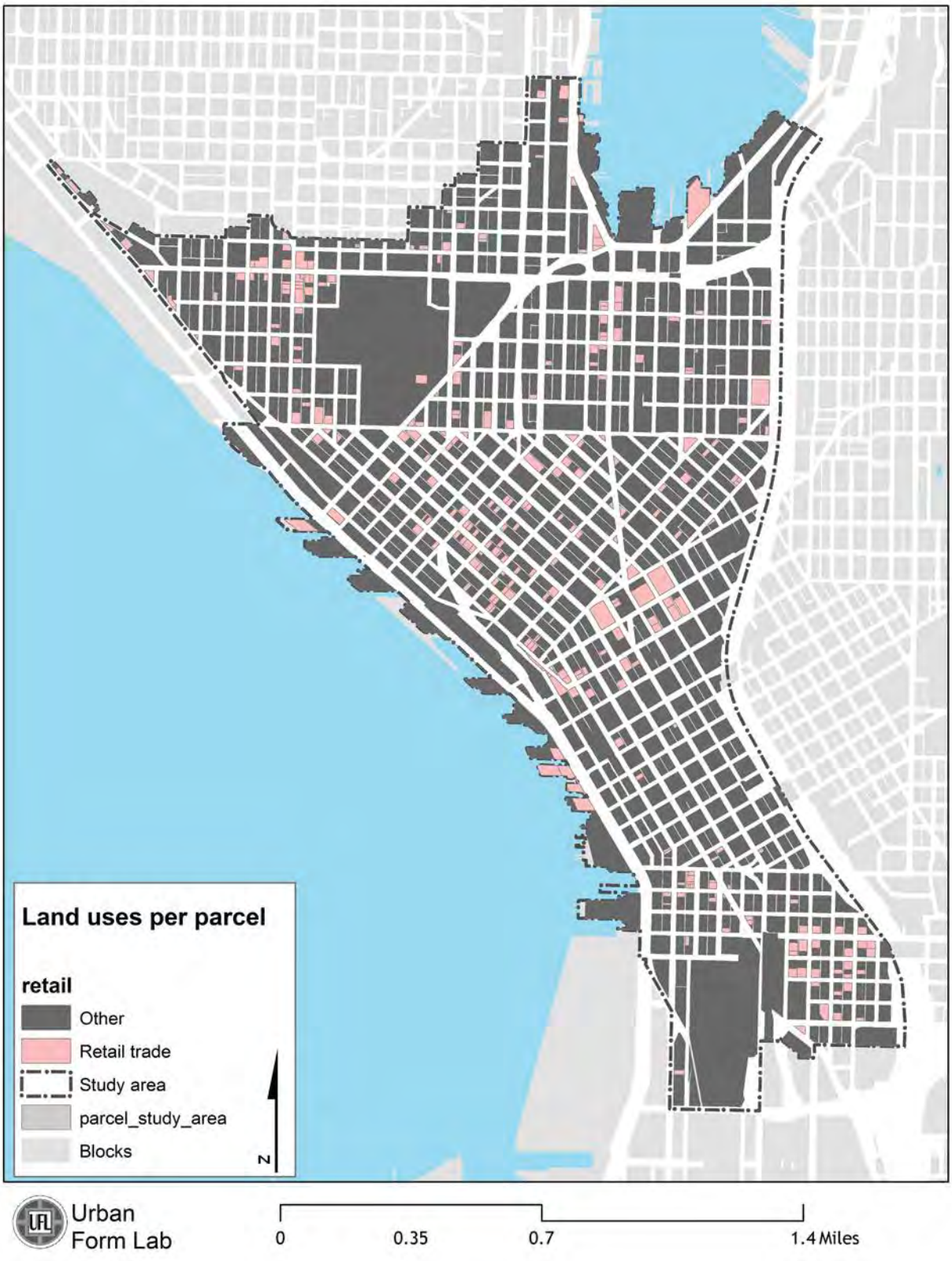
**Map 10:** Layers: parcel & parcel_study_area
Table: parcel_study_area_landuse.csv; Field: office
Base layer: wtrbdy & total_area



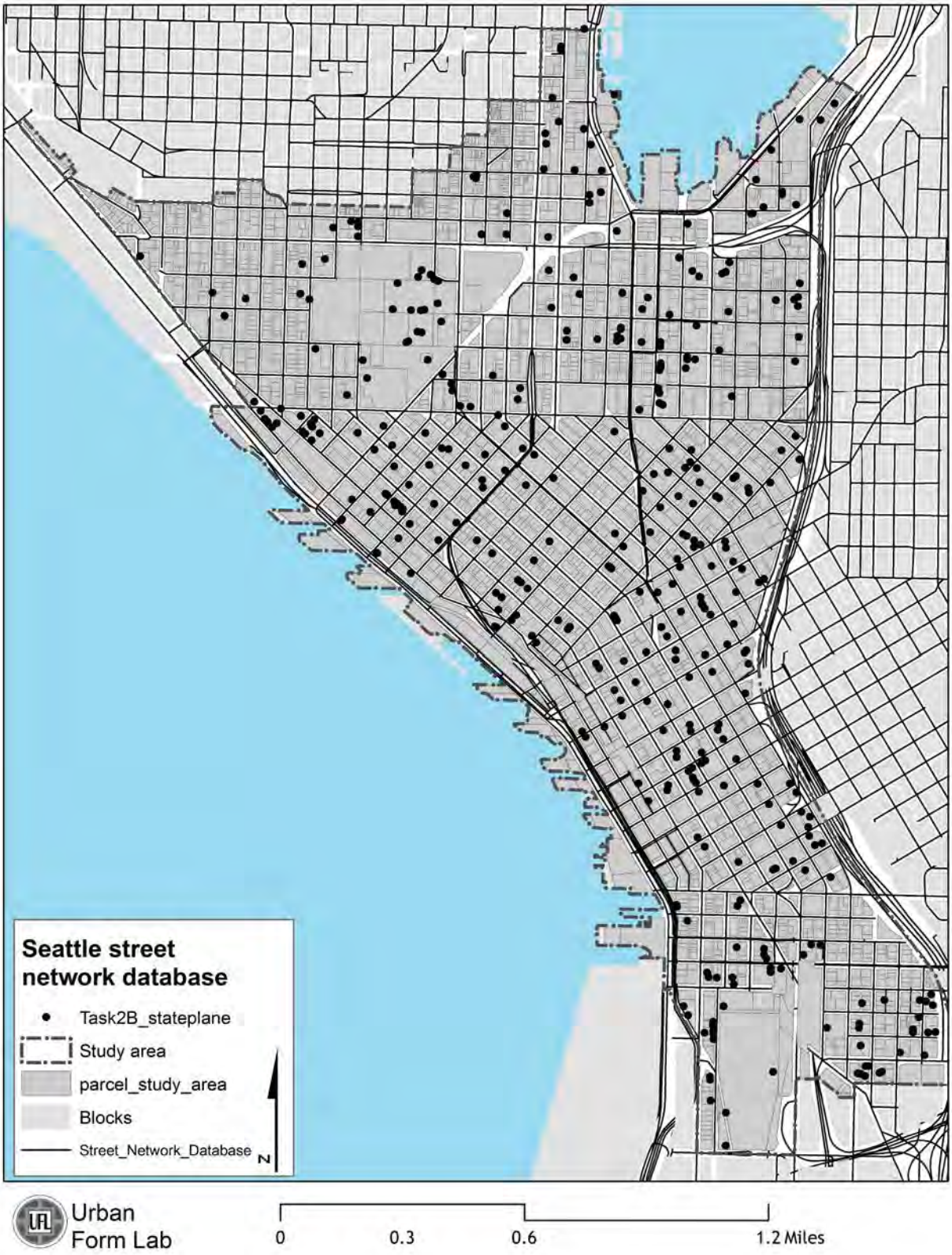
**Map 11:** Layers: parcel & parcel_study_area
Table: parcel_study_area_landuse.csv; Field: residential
Base layer: wtrbdy & total_area



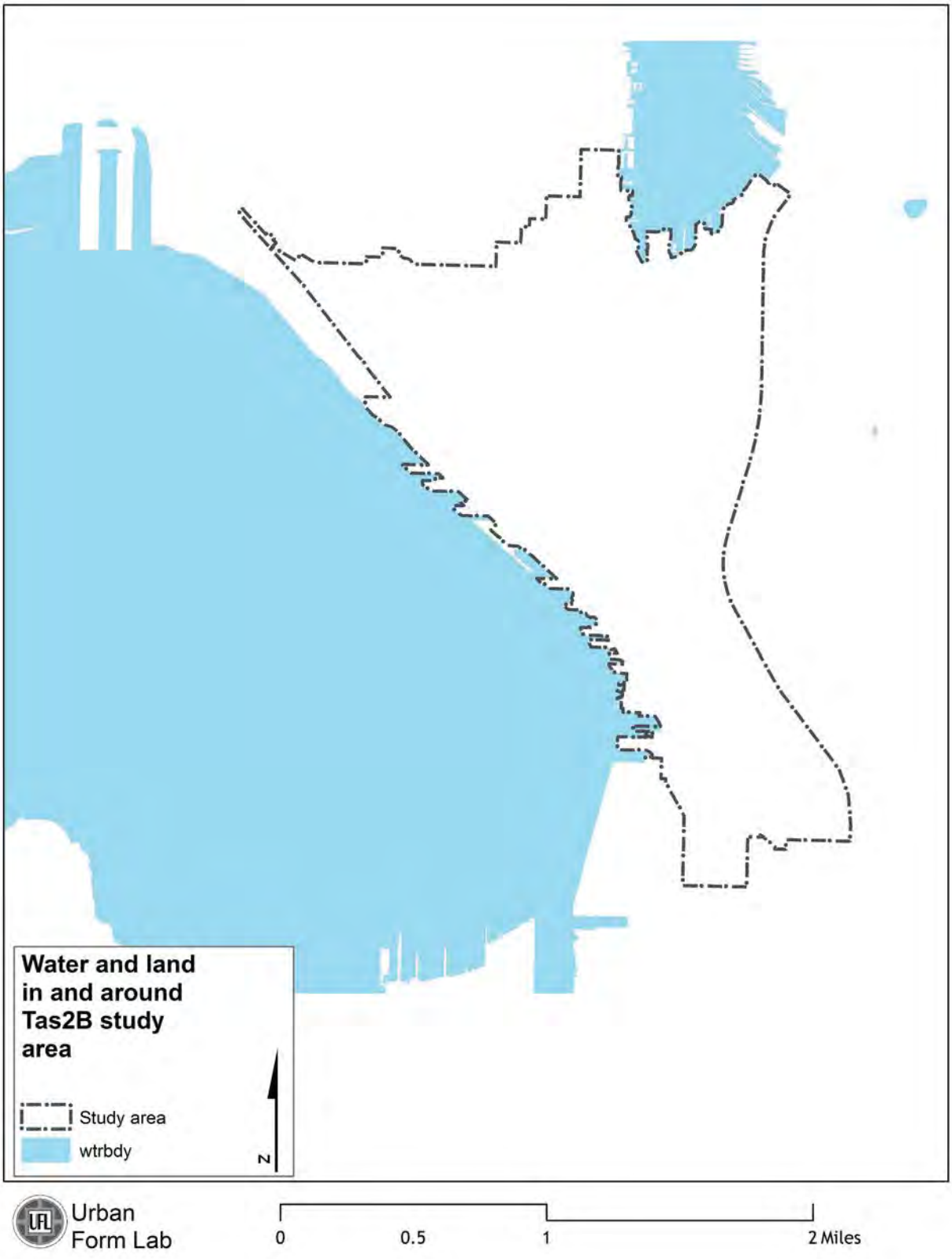
**Map 12:** Layers: parcel & parcel_study_area
Table: parcel_study_area_landuse.csv; Field: retail
Base layer: wtrbdy & total_area



**Map 13:** Layers: Street_Network_Database, Task2B_stateplane
Base layer: wtrbdy, parcel, parcel_study_area, & total_area



**Map 14:** Layers: wtrbdy & total_area
Base layer: wtrbdy & total_area



**Map 15:** Layers: World Imagery & Task2B_stateplane
Base layer: total_area

# APPENDIX L –
# DATA DICTIONARY AND MAP COLLECTION

## Off-Street Loading Infrastructure Survey Process

**Survey ID :** _____

**Data Collector Name :** _____ **Date:** _____ **Time:** _____

### PART I. Facility Location

**1. PICTURES OF THE INFRASTRUCTURE ACCESS AND PUBLIC RIGHT AWAY**

**2. GPS COORDINATES**

**3. NAME OF CLOSEST ACCESS STREET:** _____

**4. ACCESS ROAD TYPE**

☐ Alleyway ☐ One way alleyway ☐ Street

*If the answer is "One way alleyway".*

***4.1 Alleyway direction :***

☐ North to South ☐ South to North ☐ East to West ☐ West to East

### PART II. Facility Design Features

**5. FACILITY TYPE**

☐ Loading bay access ☐ Exterior loading area ☐ Exterior loading dock ☐ Undefined

*If the answer is "Loading bay access":*

***5.1 Door width:*** _____ ***ft***

***5.2 Clearance:*** _____ ***ft***

***5.2 Vehicle Access Type:***

☐ Exit ☐ Entrance ☐ Entrance and exit

*If the answer is "Exit":*

*5.2.1 Access Exit Angle:*

☐ *Perpendicular* ☐ *Angled to traffic flow* ☐ *Angled contrary to traffic low* ☐ *Angled*

*If the answer is "Entrance" or "Entrance or exit":*

*5.2.3 Access Entrance Angle*

☐ Perpendicular ☐ Angled to traffic flow ☐ Angled contrary to traffic low

☐ Parallel to traffic low ☐ Angled

*5.2.4 Access Entrance Maneuver:* ☐ *Drive-in* ☐ *Back-in*

*If the answer is "Exterior loading dock":*

*5.3 Access Entrance Angle*

☐ Perpendicular ☐ Angled to traffic flow ☐ Angled contrary to traffic low

☐ Parallel to traffic low ☐ Angled

*If the answer is "Exterior loading dock" or "Exterior loading area": (if the facility is covered)*

*5.5 Clearance:* _____ *ft*

**6. SECURITY MEASURES TO ACCESS THE FACILITY** *(Select all options that apply.)*

☐ Physical barrier ☐ Access code ☐ Personal Interaction ☐ No barrier

## PART III. FACILITY CAPACITY

**7. TOTAL OF PARKING SPACES :** _____

**8. IS THERE A DOCK PLATFORM?** ☐ Yes ☐ No

*If the answer is "Yes":*

*10.1 Total of parking spaces with loading dock :* _____

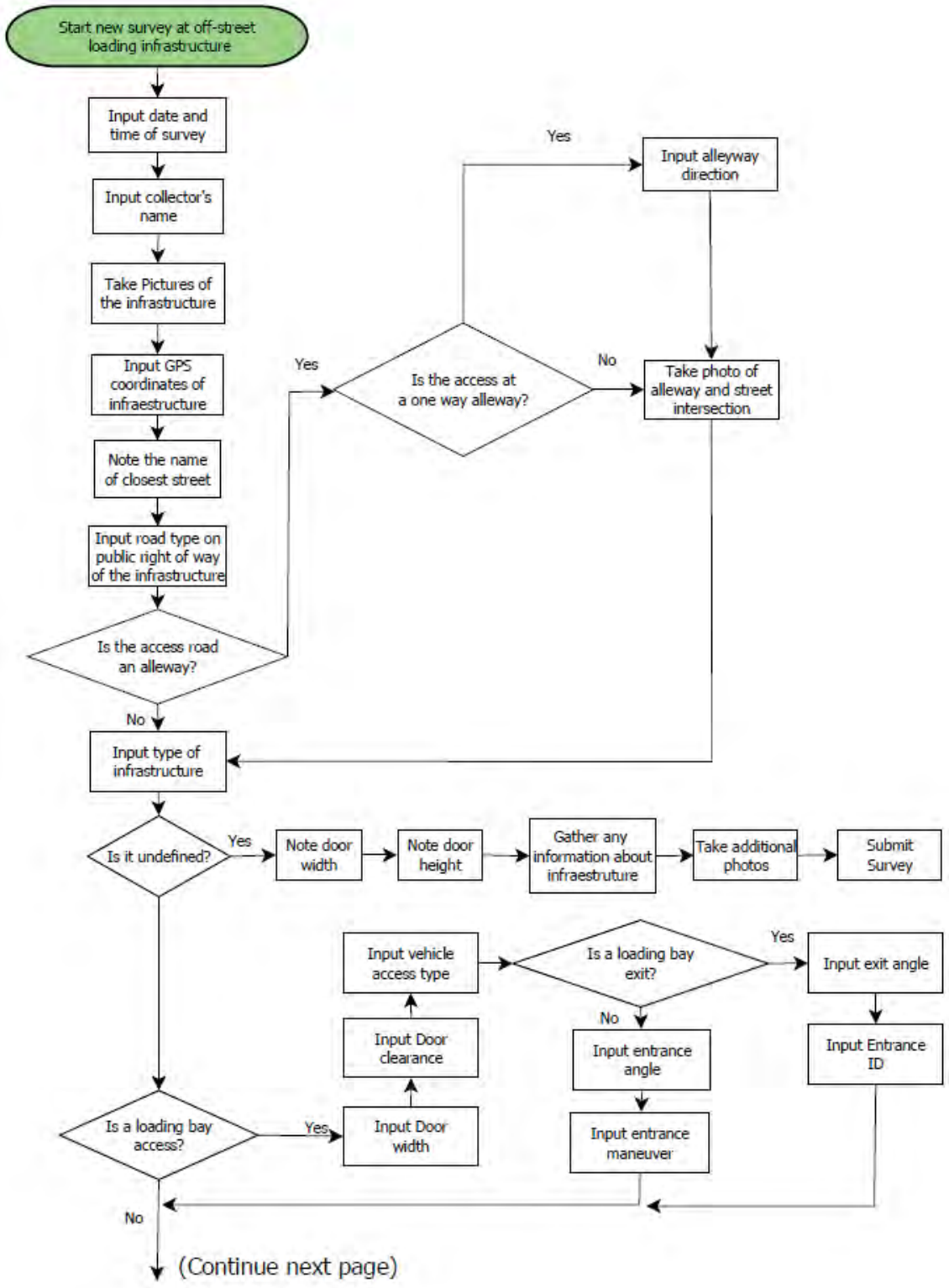
*10.2 Loading dock height:* _____ *ft*

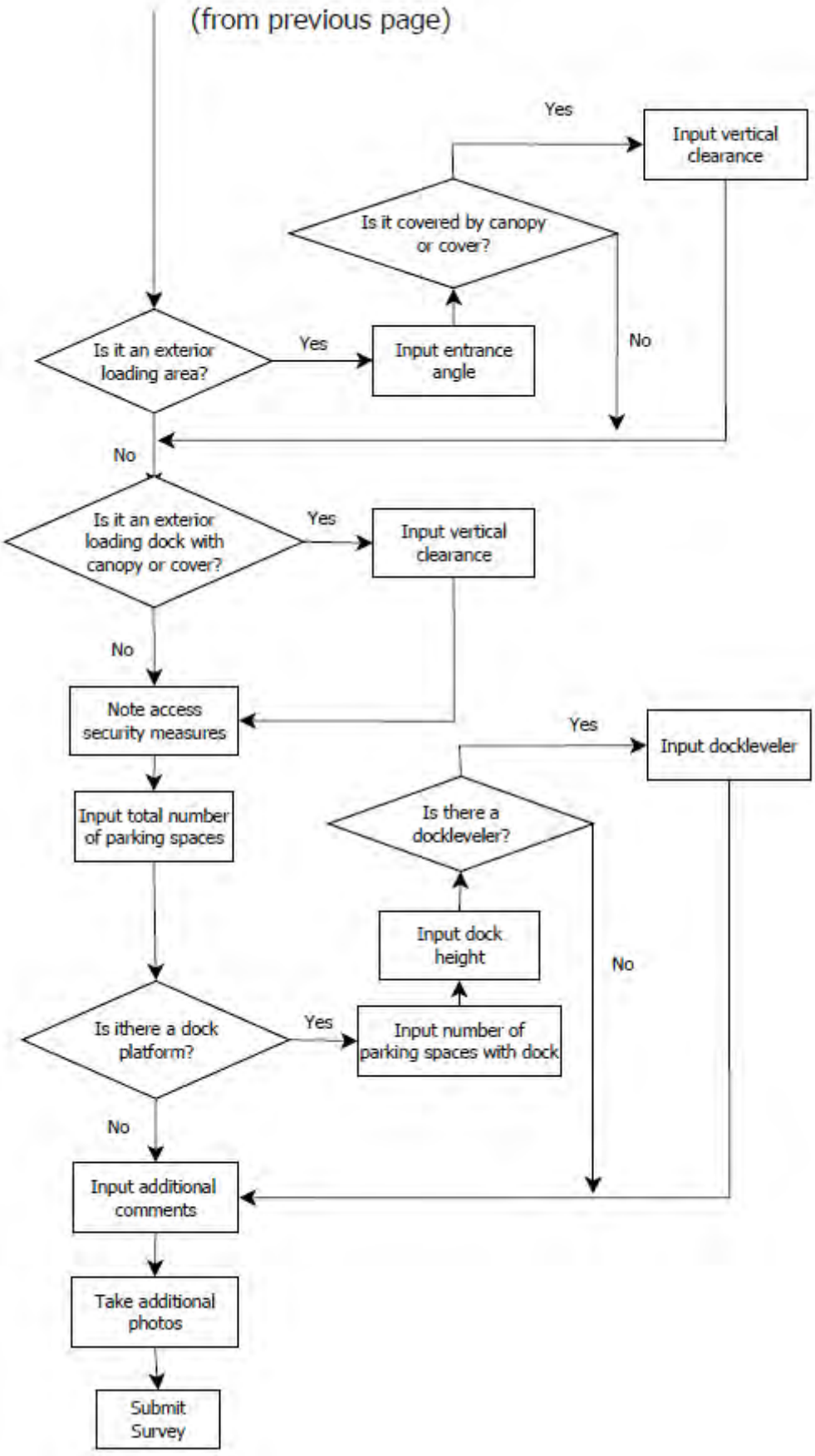
*10.3 Is there a dock leveler?* ☐ *Yes* ☐ *No*

**9. ADDITIONAL COMMENTS :**

**10. PICTURES OF FACILITY ACCESS AND CAPACITY**

# APPENDIX M –
# DATA STRUCTURE DIAGRAM




(from previous page)
Yes
Input vertical clearance
Is it covered by canopy or cover?
Is it an exterior loading area?
Yes
Input entrance angle
No
No
Is it an exterior loading dock with canopy or cover?
Yes
Input vertical clearance
No
Note access security measures
Yes
Input dockleveler
Input total number of parking spaces
Is there a dockleveler?
Input dock height
No
Is ithere a dock platform?
Yes
Input number of parking spaces with dock
No
Input additional comments
Take additional photos
Submit Survey

# APPENDIX N –
# DATABASE VARIABLES DEFINITIONS

**Table 1.** Database variables definitions

| ATTRIBUTE | CODE DOMAIN | DESCRIPTION |
|---|---|---|
| **KEY_ID** | None | Freight infrastructure ID. |
| **POINT_X** | In linear feet calculated with ArcGIS | X coordinate of the infrastructure access point from GIS coordinates.<br>Projected Coordinate System: NAD_1983_HARN_StatePlane_ Washington_North_FIPS_4601_Feet<br>Accuracy: 10 ft. accuracy |
| **POINT_Y** | In linear feet calculated with ArcGIS | Y coordinate of the infrastructure access point from GIS coordinates.<br>Projected Coordinate System: NAD_1983_HARN_StatePlane_ Washington_North_FIPS_4601_Feet<br>Accuracy: 10 ft. accuracy |
| **LONGITUDE** | In decimal degrees calculated with ArcGIS | Longitude of the infrastructure access point from GIS coordinates<br>World Geodetic System: System: GCS_WGS_1984<br>Accuracy: 10 ft. accuracy |
| **LATITUDE** | In decimal degrees calculated with ArcGIS | Latitude of the infrastructure access point from GIS coordinates<br>World Geodetic System: System: GCS_WGS_1984<br>Accuracy: 10 ft. accuracy |
| **STREET** | None | Infrastructure access point located on street. Name of the street from which the facility access is located.<br>Infrastructure access point located on alleyway. Name of the street closest to where the facility access is located. |
| **ROAD_TYP** | Alleyway, One way Alleyway, Street | Type of public road for vehicles from where the facility may be accessed.<br>**Street**: infrastructure access point is accessible from a street.<br>**Alleyway**: infrastructure access point is accessible from an alleyway.<br>**One way alleyway**: infrastructure access point is accessible from alleyway with sign indicating one-way vehicular flow. |
| **ALLEY_DIR** | North to South, South to North, East to West, West to East | Traffic direction of one-way alleyway. Otherwise, "**NA**". |

| ATTRIBUTE | CODE DOMAIN | DESCRIPTION |
|---|---|---|
| **INF_TYPE** | Loading bay access, Exterior loading dock, Exterior loading area, Not a loading bay, Undefined | Type of freight infrastructure See Section 4. Definitions for a further description of the categories of this variable. |
| **CLEARANCE** | In feet | **Loading bay entrance/exit**: Clearance of vehicle entrance was collected from clearance signs at the location or it was measured as the vertical distance between the ground and upper inside border of the vehicle entrance.<br>**Exterior loading dock**: In the case of covered loading docks with loading platforms out of the exterior walls of the building, clearance is measured as the smallest vertical distance between the ground and the structure covering the loading platform.<br>**Exterior loading zone**: In the case of covered exterior loading zones, clearance is measured as the smallest vertical distance between the ground and the structure covering the loading zone. |
| **DOOR_WIDTH** | In feet | **Loading bay entrance/exit**: The width is the measure door width of the vehicle entrance/exit.<br>Otherwise "**NA**". |
| **VH_ACC_TYP** | Exit, Entrance, Entrance same as exit | **Loading bay entrance/exit**: The type of vehicle access.<br>Otherwise, "**NA**" |
| **ENTR_ANGLE** | Perpendicular, angled to traffic flow, angled contrary to traffic flow, parallel to traffic flow, Angled | Loading bay entrance/exit with:<br>● VH_ACC_TYP = **Entrance**: Entrance angle refers to the angle between a vector perpendicular to the entrance towards the traffic flow outside the building and a vector parallel to the traffic flow from which the infrastructure is accessed.<br>● VH_ACC_TYP = **Entrance same as exit**: Entrance angle refers to the angle between a vector perpendicular to the entrance towards the traffic flow outside the building and a vector parallel to the traffic flow from which the infrastructure is accessed.<br>Exterior loading dock: **Angle** refers to the angle between a vector perpendicular to the plane of the loading dock platform towards the traffic flow and a vector parallel to the traffic flow.<br>ENTR_ANGLE = **Angled** refers to facilities on bi-directional alleyways, where the entrance angle could be contrary or to traffic flow.<br>Otherwise, "**NA**". |
| **EXIT_ANGLE** | Perpendicular, angled to traffic flow, angled contrary to traffic flow, angled | For VH_ACC_TYP = **Exit**: exit angle refers to the angle between a vector perpendicular to the entrance towards the traffic flow outside the building and a vector parallel to the traffic flow from where the vehicle exits the infrastructure.<br>Angled refers to facilities on bi-directional alleyways, where the entrance angle could be contrary or to traffic flow.<br>Otherwise, "**NA**". |

| ATTRIBUTE | CODE DOMAIN | DESCRIPTION |
|---|---|---|
| **ENTR_ID** | None | For VH_ACC_TYP = **Exit**: FAP_ID of the corresponding loading bay entrance/exit.<br>Otherwise, "**NA**" |
| **EN_MANEUVR** | Drive-in, back-in | For VH_ACC_TYP = **Entrance** and VH_ACC_TYP = **Entrance and exit**: Entrance maneuverability of trucks to enter loading bay.<br>Otherwise, "**NA**". |
| **ACC_SEC** | Physical barrier (e.g. gate), access code, personal interaction, no barrier. | Type of security measure used to access the facility.<br>**Access code**: keypad in which code must be inputted to access facility.<br>**Personal interaction**: access to facility granted via interaction with a gatekeeper such as a guard or receptionist.<br>**No barrier**: no barriers to access facility |
| **SPACES** | None | Total Number of Truck Spaces. |
| **SPACES_LD** | None | Number of Truck Spaces with Loading Dock |
| **DOCK_LEV** | Yes or No | For FAP_ID = **Loading bay** or FAP_ID = **loading dock**: Indicates the presences or not of a dock leveler.<br>Otherwise, "NA" |
| **DOCK_HEIGHT** | In feet | For FAP_ID = **Loading bay** or FAP_ID = **loading dock**: the height of loading dock platform.<br>Otherwise, "**NA**". |
| **OBSERV** | None | Specific observation about the location |

# APPENDIX O –
# IMPROVEMENT RECOMMENDATIONS FOR GEOLOCATING PRIVATE TRUCK LOAD/UNLOAD SPACES

1. **Accuracy of GPS location records** may improve if measures are put in place to remind data collectors to double check the device's GPS recording accuracy. Moreover, existing databases such as the King County parcel database and the City of Seattle's Building Outlines database could support the collection of geolocations in-field to facilitate the combination of existing datasets and the newly collected data. During this first data collection, staff based location decisions on Google Maps, which was not updated with detailed building information or parcel information. As a result, numerous survey locations had to be analyzed and rectified in-office to match the parcel and building outline datasets.

2. **Datum transformation issues.** The GPS device´s readings are in geographic coordinates that are referenced to a geographic coordinate system (GCS). A GCS includes an angular unit of measure, a prime meridian, and a datum that is based on a spheroid. In order to display and analyze these points in mapping software such as ArcGIS, however, they must be converted to a projected coordinate system (PCS). A PCS applies a mathematical transformation that converts spherical units of latitude/longitude to a planar x-y coordinate system, which is necessary for mapping the points. This conversion from a GCS to a PCS is called a geographic transformation, and multiple transformations may be required if the coordinate systems do not match at different steps of the data collection and analysis process. These transformations introduce error in the data and therefore should be minimized. In the case of SDOT, the preferred PCS is NAD_1983_HARN_StatePlane_Washington_North_FIPS_4601_Feet.

3. **Data processing issues.** Different software applications can be used to make the most of the data collected. These applications may include, but are not limited to, R statistical software package, Microsoft Excel, and ArcGIS. Each of these software packages have different requirements that, among other things, affect the data formatting. If these discrepancies among software packages are not considered, the result may be a significant loss of information, such as truncated coordinate values or misrepresentation of missing values.

4. **A more systematic data collection quality control.** A more participatory data quality control process may improve resource allocation in future data collection efforts. This improved process should include ongoing quality control checks by data collectors in a systematic way, so that the data cleaning tasks are less burdensome and do not rely on the supervisors. Future data structures and data collection procedures may consider complementary data quality control checks by different staff so that errors are spotted and corrected without accumulating.

5. **Consider the possibility of new types of loading facilities.** Private freight infrastructure was surprisingly varied. Although the typology does a thorough job of explaining the cases observed, some flexibility in the data structure should be considered in future data collections to allow for new facility types.

6. **Define more precise access security measures.** The vast majority of the private freight infrastructure surveyed is privately owned and is commonly used to store and handle valuable goods. This leads to a complex environment of private spaces that must be accessible while remaining secure. Future data collection should more precisely define access barriers, such as outdoor property gates, that may limit access to the facility. These were not originally considered part of the data collection due to the complexity of building spaces.

7. **Construct a carrier survey more efficiently.** The research team's survey of UPS drivers proved to be a remarkable success in terms of cooperation with the private sector to understand the freight system. The development of future carrier surveys should be based on tools that automate the transfer of information from the database to standard survey questionnaires to make the process more efficient. Candidate tools for this task include Access and Latex.

8. **Better collect and report pictures.** Visuals proved to be an excellent tool for data quality control and reporting purposes. However, some pictures showed inconsistent angles and were not helpful. Stronger guidelines should be developed to help data collectors take better pictures in the field to accurately inform location identification, share and easily store all photos taken, and retrieve photos with an identification system.