MITIGATING INDUSTRIAL LAND USE IMPACT

through building and site design

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Introduction

Purpose

This guide provides

- **an overview of compatibility issues associated with industrial land uses**
- **examples of mixed-use industrial developments, and**
- **measures to mitigate issues through building and site design.**

The intent is to encourage industrial intensification in acknowledgement of the decreasing supply and increasing demand of industrial land in Metro Vancouver. The **4 Big Moves** provide the basis for this investigation, with particular relevance to Big Move 1, which seeks to protect remaining industrial lands.[1] By analyzing past strategies, assessing current scenarios, and presenting potential opportunities, industrial land use can be optimized and integrated within the region.

4 BIG MOVES

1. Protect Remaining Industrial Lands
2. Undertake a Regional Land Use Assessment
3. Strengthen Regional Policy
4. Seek Greater Consistency in Local Government Zoning Definitions and Permitted Uses

Threats to Industrial Lands

A significant shortage of industrial land Vancouver concerns increasing pressures from non-industrial uses, site adjacency issues, and a complex jurisdictional environment. There are only 842 hectares of industrial and mixed-employment lands in Vancouver; ~7% of the city's overall land base.[2] Not only are there significant economic incentives to maintain and protect industrial lands in Vancouver, there are also social and environmental implications. The concern extends to Metro Vancouver as well.

"Comprising only 4% of the region's land base, industrial lands are home to nearly 27% (364,000) of the region's 1.3 million jobs, while also supporting an additional 163,000 jobs through indirect and induced impacts."[1]

The significance of industrial lands is well-documented in previous reports (see "*Opportunities for the Intensive Use of Industrial Land*"[3] and "*Disappearing Industrial Land Could Take Vancouver's Economy With It*"[4]). High levels of employment, low vacancy rates, rising rental rates, strengthening environment protection, increased containerized cargo volumes, and growth in technology and logistics further indicate a need to address this issue. By assessing compatibility between different uses and exploring related opportunities, municipalities

can make more informed decisions around industrial land use planning and mixed uses.

Population growth on constrained land supply raises demand for industrial space and requires the intensification of industrial lands. This can be done by encouraging mixed-use developments with vertically stacked programs to minimize land coverage.[5] With the constant morphing of the industrial sector, land uses can no longer be simplified into exclusive zones and the types of operations and degrees of activity levels are increasingly important factors that inform regulations.

This guide explores the complexities of land use compatibility and presents options to ameliorate issues through regulation, policy, and design; it supports Metro Vancouver's aim to protect industrial and mixed employment designated land. This encourages growth of industrial activities and, therefore, essential regional services and economy. The need for industrial land protection is not limited to the City of Vancouver and this guide is a contribution to the body of work that other municipalities with similar concerns are developing.

Summary

Literature Review:

- Vancouver policies and other municipalities have similar definitions related to the classification of industrial lands and potential disturbances.
- There are seldom municipal documents that outline specific mitigation measures.
- Emerging industrial uses (e.g. technology-based manufacturers) are not addressed in many regulations.

Design Inventory

- Noise, odour, air quality, traffic/loading, visual/design, and lighting/electricity concerns can often be addressed through design solutions to improve compatibility between uses.
- The Design Inventory is a collection of these solutions and was composed through a literature review.
- Implementation of the appropriate strategies is ultimately decided through collaboration between architects/designers, consultants, planners, and the client.

Compatibility Matrix

This section contains a number of tables to assist in identifying compatibility between different uses for industrial intensification. These contain information regarding generalized concerns and impacts for industrial uses, BCBC major occupancy classifications, allowable adjacencies and minimum fire-re-

sistance ratings, an emerging industrial use: creative product manufacturing, and the Industrial Compatibility Matrix.

The Industrial Compatibility Matrix classifieds various industrial and non-industrial uses as either

- **Compatible:**
  Ideal for mixed-use developments
- **Compatible*:**
  Mixed-use requires mitigation
- **Incompatible:**
  Not appropriate for mixed-use.

Industrial Typologies

Characteristics and typical elements of traditional and emerging industrial buildings are identified to explore commonalities between different uses. Potential conflicts, example uses, and resources are highlighted for a selection of industrial operations as an attempt to group uses based on activity rather than program.

Case Studies

Twenty mixed-used industrial buildings are presented with design elements that address the industrial interface, including noise, odour, air quality, traffic/loading, visual/design, and lighting/electricity concerns. Basic project data is given, including zoning, FSR, number of floors site area, location, year built, architect, and developer. There are projects located within and beyond Vancouver.

Interview Insights

Architects, developers, and code consultants participated in an informal virtual interview and provided insights on Vancouver industrial land developments. These individuals were contacted because of their involvement with some of the Case Studies studied.

Application

Two hypothetical mixes of uses are curated with notes on regulation challenges and advantages. These provide a brief look into the processes required for mixed-use development approval.

Methodology

A literature review was conducted to research and collect compatibility elements and strategies implemented by various municipalities to intensify industrial lands.

Two main tools were created to address mixed-use site conflicts:

1. Building and site **design recommendations** to mitigate spatial conflicts related to the industrial interface and

2 An Industrial Land Use **Compatibility Matrix** that identifies the suitability of mixed-use zones.

Noise | Odour | Traffic/ Loading | Air Quality | Visual/ Design | Light/ Electricity

The building and design recommendations address specific building typologies where compatibility may be improved.

The inventory that isolates six components of the industrial interface - noise, odour, air quality, traffic/loading, visual/design, and lighting/electricity - and presents design elements as concrete measures to mitigate industrial land use nuisances. These are often associated with nuisances and can be mitigated at the architectural scale. To address potential concerns, a variety of “buffers”--elements that minimize the negative impacts of industry on the surrounding context--will be recommended. They have also been collected through a literature review.

Then, a number of tools are tabulated to help assess compatibility between uses, including generalized concerns and impacts, BC Building Code occupancy classifications, allowble adjacencies, creative product manufacturing

examples, and an Industrial Compatibility Matrix.

The Industrial Land Use Compatibility Matrix identifies the suitability of use and zoning applications in relations between industrial facilities and commercial and residential land uses. Factors considered include operational and market impacts; building and site requirements; and the compatibility of site and building location and adjacency. The basis for this matrix is the Residential Compatibility Matrix ,found in the Burrard Slopes Zoning Guidelines.

These are specific tools that may be implemented to encourage and support the resilience of industrial land use. Additionally, monitoring and measuring conflict points and characteristics is an essential task to ensure the effectiveness of mitigation and to maintain compatibility.

It is recognized that industrial typologies change through time and, consequently, spatial needs and stakeholder implications may not be permanent. Nonetheless, the provided guidance is developed with industry trend projections in mind.*

Considerations

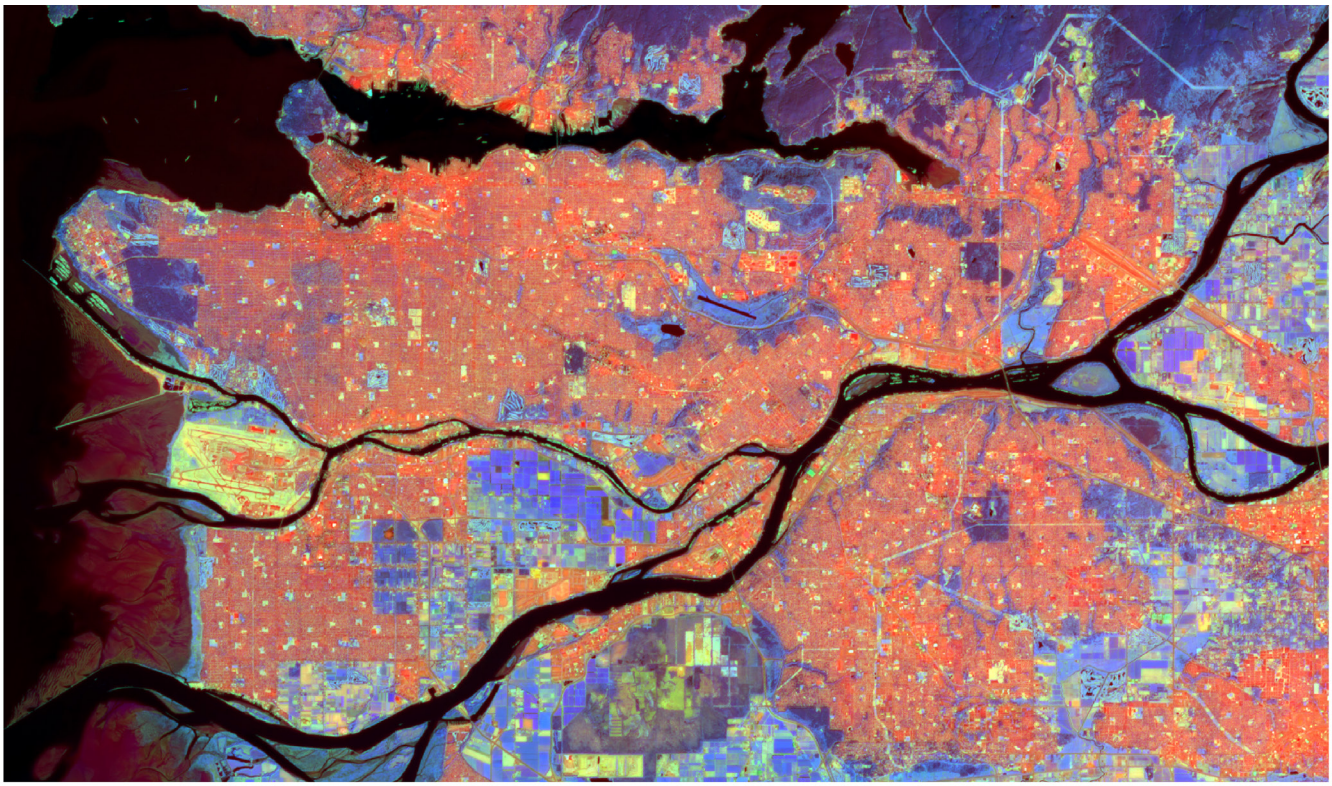
Generally, there are three scales of compatibility to consider:
building/plot: nuisances within the bounds of a site/parcel
street/block: nuisances between two or more sites/parcels
and
area/region: nuisances to the environment, beyond a local scale

This guide focuses on the building/plot scale and briefly touches on the street/block level. Items and strategies that compose the Design Inventory for industrial interface conflict mitigation are not meant to be an exhaustive, but rather a collection of potential design solutions. Additionally, there may be instances where a combination of approaches are needed for sufficient conflict mitigation.

A range of interventions can be implemented to maximize and prevent further loss of industrial land. Complaints can place city-serving industrial uses at risk because of nuisances to other higher market value uses like office and residential.

Types of Industrial Use

Considerations include both traditional and non-traditional industrial uses and recommendations distinguish them by creating more granularity and, therefore, more flexibility in zoning policies and regulations. This



This false color composite image uses Band 10 (Thermal Infrared), Band 6 (Shortwave Infrared) & Band 5 (Near Infrared) for a qualitative LST map. Various levels of orange to red represent warm to hot areas and levels of blue are cooler areas. Surface water areas are in shades of black.

Figure 1. Landsat-8 of Vancouver Area on Aug 9, 2018: Land Surface Temperature (LST). Image Source: urbanhi.net

guide focuses on light industrial uses, as they are most appropriate for mixed-use developments. Medium industrial uses may also be considered, though mitigation needs are likely to be more demanding. For the most part, heavy industrial uses are excluded from consideration as a recognition that mixed-use environments are unsuitable for certain occupations.

Sustainability

In the curation of the mitigation strategies, an emphasis is placed on environmentally

sensitive approaches, where interior is not preferenced over exterior surroundings; both are equally important when considering compatibility of land use. As the effects of climate change become more conspicuous and disruptive, the natural environment must be considered when designing to preserve the well-being of animals, atmosphere, humans, plants, and other constituents of the earth.

The combination of multiple uses within buildings can help with Vancouver's goal where "by 2030, 90% of people live within an easy walk/roll of their daily needs".[6] Intensification of industrial lands--especially with residential mixing--reduces distance between living and working and contributes to community-building through socioeconomic equity and diversity of land uses. Reduction of vehicular transportation also has direct implications on the design of buildings (e.g. parking stalls) and, as a result, may open up opportunities in the city for space-making.

Vancouver's Climate Emergency and Greenest City Action Plans detail the imperatives for these engagements.[6,7] Further study is recommended on strategies to engage sustainable industrial mixed-use building practices and constructions.

Limitations

Due to time and scope constraints, a limited number of interviews were conducted. More extensive communications with industry specialists and experts would be informative and valuable. Collaboration and education are ways to adapt to the dynamic nature of architecture and buildings--spaces that change over time according to the operations that occur. A thorough evaluation of compatibility between uses is challenging without understanding the processes and people who occupy the places of interest.

Another limitation of this guide is the lack of consideration between site conditions and programs. This includes issues like preservation of local ecologies. That is, industrial and non-industrial uses should be responsible for the protection and proliferation of landscape and nature in order to maintain compatibility between the environment and the population's well-being.

Not directly addressed here is the significance of well-designed spaces on the health of the built environment and their role in preventing and protecting against world-threatening situations, as shown through the COVID-19 pandemic.

Literature Review

The literature review draws on policy and regulation from municipal, regional, and provincial levels of government that address compatibility issues between land uses and mitigation of nuisances. These engage one or more components of the industrial interface, including noise, odour, traffic/loading, light, air quality, and visual/design elements. A collection of references with greater details for designing can be found at the end of the guide.

In the literature, strategies focus on spatially segregating incompatible land uses. Many city guidelines use separation distances and buffers to minimize site adjacency conflicts. Transitional zoning, or "use buffers", protect a zone from another by interposing an in-between district. Landscape buffers can be used to address visual conflicts, however, their application should be carefully considered. In general, policy and regulations for municipalities outside of Vancouver are broad and limited to spatial separation guidelines. Existing policy and literature has scarce resources that directly inform mixed-use industrial designs.

Although nuisances may be mitigated by the researched building and site design strategies, the mixing of uses is significantly influenced by the Vancouver Building By-Law and BC Building Code. These challenges are further addressed in the Compatibility Matrix and Application sections.

City of Toronto

Toronto has a similar industrial interface to Vancouver, involving significant port operations, strong presence of the film industry, diminishing land availability, and site adjacency issues. The *Port Lands Planning Framework* is a document that provides detailed intentions, descriptions, directions and recommendations for land use compatibility.[8]

Similar to Metro Vancouver's light, medium, or heavy industrial uses there are Class I, II, or III classifications, respectively, in Toronto. For sensitive land use, separation distances (physical distancing between uses), buffer uses (mutually compatible uses in-beween typically incompatible uses), and source and reception mitigation (design elements that reduce nuisances) are required. Their guideline provides the following separation distances and potential influence areas (where disturbances may travel):

Class	Separation Distance (min)	Potential Influence Area
I	20 m	70 m
II	70 m	300 m
III	300 m	1000 m

Figure 2. *Land Use Categories,* Source: City of Toronto

To regulate industrial land use conflicts, detailed noise, vibration, air quality, traffic, and

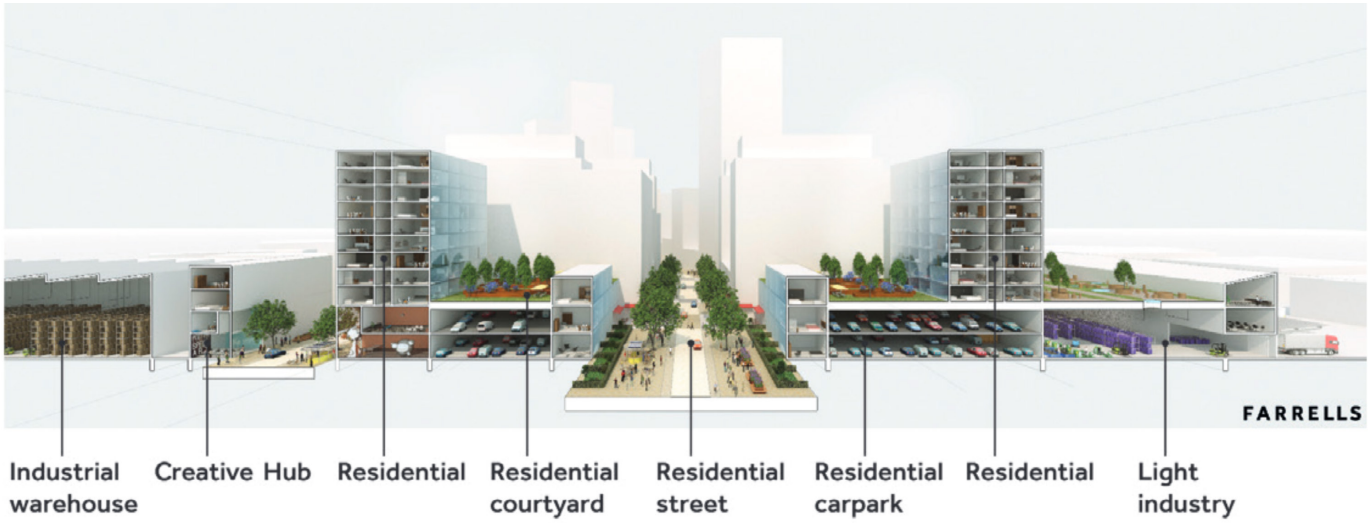


Figure 3. Land Use Relationships. Source: Making best use of London's industrial Land, Planning in London

environmental reports are required at the development review stage. These assess levels of emissions through measures like the decibel (dB) and parts per million (ppm) are typically completed by consultants.

The Land Use Compatibility section presents an example process from measurement to response of noise and air quality impacts in the Port Lands. Air quality was measured using an air quality dispersion model. Because of building height restrictions, this was not an issue; lower-height surroundings minimize exposure to harmful emissions. Noise Exposure Forecast contours were used to determine sound levels. These were found to be adequately below the environmental noise guideline.

Especially relevant is the need for animation and activation of the ground floor. Although this guide focuses on industrial, residential and office mixed-use, the City of Toronto has policy for at-grade street-related retail and services uses to be required, protected, and/or encouraged. This is specifically supported by *a minimum five meter at grade floor-to-ceiling height for new buildings*. By incorporating a convergence of creative uses on industrial lands, the spaces will be more attractive to lease and can provide services to local neighbourhoods.

Toronto has also identified a more flexible mixed-use land use called Productions, Interactive, and Creative (PIC) land use, which

Productions, Interactive, and Creative (PIC) land use in Toronto

Production studios
Carpenter's shops
Workshops
Artist and Performing Arts Studios
Galleries
Museums
Office uses associated with productions or creative sectors
Light manufacturing
Offices
Warehouses (excluding self-storage warehousing)
Printing and binding
Retail and service (excluding drive-through facilities)
Financial
Community infrastructure
Laboratory
Computer-related and educational uses
Some entertainment uses may be permitted

includes a variety of permitted and potentially compatible uses. As part of their rezoning policy, particular regions with residential uses have a minimum requirement of 25-30% gross floor area for PIC space.

To attract various industries, PIC mixed-use (cafes, restaurants, galleries, theatres, shops, music venues, and bars) should be encouraged in light industrial buildings.[8] (CIty of Toronto)

Ontario

Assessment of land use compatibility is extensively covered in Ontario's upcoming *Land Use Compatibility Guideline*.[9] There is a focus on medium and heavier industrial uses, where emissions are a significant disturbance. For example, natural resource manufacturing, composting facilities, landfills, meat and meat product processes, wastewater facilities, and others. Thus, in the case of any complaints, key tools that can be utilized are Area of Influence (AOI) and Minimum Separation Distance (MSD) where the goal is to increase isolation of sensitive land uses. This is in contrast to the current guide, where the mixing light industrial uses are encouraged and intensification of industrial lands is priority.

Ontario has developed five classes of major facilities based on the characteristics, noise, vibrations, dust (point/fugitive emissions), odour, scale of production, outside storage, process, process outputs, hours of operation, and on-site movement. The degree of adverse effect is a spectrum from low to high offensiveness (degree of disturbance). It is unclear how to classify uses that may have a range of effects between different characterstics. Ontario's Draft Land Use Compatibility Guideline appendices expand in greater detail specific mitigation applications and roles of municipalities and planning authorities.

City of London

Five key tasks have been studied by the Mayor of London in the *Industrial Intensification and Co-Location Study*[10]*:*

1. Define+Measure Industrial Intensification
2. Specifications and Construction Costs
3. Urban Scale Guidance
4. Testing Proposals
5. Deliverability Commentary

From this study, a number of insights can be gained. In order to open more possibilities for the intensification of land, floorspace ratios need to be carefully considered. Rather than developing policies based on industrial lands in general, addressing industrial floorspace is determined to be more appropriate. This document works from a 65% plot ratio of industrial to non-industrial concluding that the number "encourages stacking and the conversion of yard space to floor space, but the total quantum of space to reprovide that the rules sets in place is considered too onerous". They determined that floorspace measurement based on use-class was inflexible for the longer term but retained the existing class mix on a site. Vancouver's current legislation on floorspace calculation may respond to these findings by ensuring there is enough flexibility within policy to allow for opportunities to intensify industrial space within a single plot.

Typical Floor Loading Values

Small Industrial Use	2.5 - 15	kN/m²
Medium Industrial Use	33.6	kN/m²
Large Industrial Use	50	kN/m²

British Standards

Light Industrial	2.5	kN/m²
General Industrial	5.0	kN/m²
Storage	4.8	kN/m² *
Light Traffic	2.5	kN/m²
Heavy Traffic	15	kN/m²
Maximum Industry Standard	50	kN/m²

*per meter of storage height with minimum 15kN/m

Source: *Industrial Intensification and Co-Location*, City of London

Floor loadings are especially problematic for the viability of stacked industrial uses. There are regulatory and design-related issues. If industrial standards for floor loadings are much higher than other building type standards (as in London's case), then there may be unnecessary limits for mixed-use and lighter-load industrial operations. Additionally, the material requirements to satisfy industrial floor loads may be unachievable to build because of costs. London's policy recommends that higher floor loadings be placed on the ground floor and lower loadings on the upper floors for structural, occupant range, and cost rea-

sons. Although the upper floor uses become more restricted, the viability of stacked industrial buildings is improved.

Other spatial intensification measures that influence the feasibility of stacked industrial are average unit sizes and parking. It is noted that, while mezzanine space is useful for

DESIGN GUIDANCE	WORKSHOP/ STUDIOS	SMALL INDUSTRIAL	MEDIUM INDUSTRIAL	LARGE INDUSTRIAL
Ceiling height	3.5 - 4.4 m	4 - 8 m	6 - 13 m	10 - 13 m
Opening width x height (min.)	0.9 x any m	2.4-3 x 3.7 m	2.4-3 x 4 m	2.4-3 x 4 m
Yard depth	16 m	16 m	27 m	27 m
Localised extract system for noxious outputs	✓	✓	✓	✓
Non-structural walls	✓	—	—	—
Sliding and lockable division walls and/or doors	✓	—	—	—
Mezzanine levels (% floor area)	—	~10%	~10%	~10%
Separate staff/visitor access	—	✓	✓	✓
Roller-shuttered doors	—	✓	✓	✓
Design that minimizes flanking	✓	✓	✓	✓
Large Clear Spans	—	✓	✓	✓
Shared loading for HGV	✓	✓	✓	✓
High bay lighting	—	—	—	✓
Dock leveller	—	—	✓	✓
...STACKED INDUSTRIAL				
Wide corridors (min.)	1800 mm	3500 mm	3500 mm	3500 mm
Heavy-duty lift(s) (min. loading)	500 - 1000 kg	500 - 4000 kg	500 - 4000 kg	500 - 4000 kg
Ramped access (optional)	—	✓	✓	✓
...MIXED-USE INDUSTRIAL				
Separate passenger circulation cores for different uses	✓	✓	✓	✓
For >43 Rw dB concrete floor mass > 365 kg/m^2	✓	✓	✓	✓

Table 1. City of London Design Guidance for Industrial, Stacked-Industrial, and Mixed-Use Industrial Buildings.
Source: Industrial Intensification and Co-Location Study

occupants, it is not an intensification strategy. Should the effectiveness of intensification be measured, industrial floorspace (not including mezzanine space) is concluded to be the best indicator.

Defined classes of industrial typologies are tabulated, identifying footprint areas, class uses, parking considerations, and typical occupants. Interestingly, these classes are divided into small, medium, and large sizes rather than types of operations or activity levels. This is likely problematic for determining compatibility conflicts because the dimension of land is not necessarily related to the mitigation needs. Nonetheless, there are additional stacked and mixed industrial-residential requirements that are useful to note (Table 1). The design guidance can be negotiated to assist in mitigating compatibility and operation conflicts.

Stacked industrial model sites are explored in-depth with detailed descriptions of site and design conditions. For further reading regarding industrial intensification and residential co-location can be found in the studies *Industrial Intensification and Co-Location Study*[10] and *Industrial Intensification Primer*[11]. Guidance from these sources are also referenced in the Design Inventory chapter. On industrial intensification evaluation, a prototype tool in "Industrial Land Intensification: What is it and how can it be measured" may be explored.

City of Victoria

Managing Buffers for Land Use Compatibility contains the City of Victoria's guiding land use compatibility plan.[12] For a detailed description of threshold distances between uses and its measurements, this document can be used. Additionally, hazardous air pollutants, noise, dust, odour, and other risks are identified for a number of industrial uses, including metal products, chemical products, food/beverage, recreational services, textiles, transport and storage, wood products, and more.

New York City

The New York City Zoning Handbook outlines three major manufacturing districts: M1, M2, and M3.[13] These roughly correspond to light, medium, and heavy industries. In addition to zoning districts, New York City divides types of uses into 18 different Use Groups, expanding the light, medium, and heavy categories into different material operations.

Within M1 (light industrial districts) there is flexibility with the types of uses allowed. For instance, certain community facilities, like houses of worship and medical offices are allowed. Schools and hospitals are allowed under special circumstances. Additionally, a Special Mixed Use District pairs light industrial uses with residential as-of-right.

Orange County

A zoning chapter in the Orange County Municipal Code includes a Master Land Use Table that identifies permitted, conditional, accessory, and not permitted uses.[14] Zones include Residential, Commercial, Mixed Use, Industrial, Agricultural Open Space, and more. These zones are further expanded into accessory, agricultural, animal, automotive, care facility, entertainment, food/alcohol, housing, medical, miscellaneous, office, production/wholesale, recycling/waste, retail, school, service, and storage/warehouse uses. This Table is incorporated into the Compatibility Matrix in this paper.

Metro Vancouver

The framework for this research project is largely based on the *Best Practices for the Intensive Use of Industrial Land Discussion Paper*.[15] The Discussion Paper provides a broad summary of industrial land intensification techniques and practices and reviews local and international plans. There is a collection of buildings with details on the site uses, zoning, surrounding uses, land values, site sizes, floor ratios, site coverage, building height, parking spaces, and loading access.

Industrial Edges: Compatibility and Interface Issues in Metro Vancouver focuses on the coordination of different types of land use so that intensification is viable and stimulated.[16] Conflicts between industrial and residential lands arise from the industrial interface, which is comprised of topics related to noise, odour, dust, light, visual screening/design, and safety. General strategies to manage this interface are noted, mainly on physical buffering. This paper expands on these generalities and proposes ways to mitigate negative adjacencies to intensify industrial lands.

LAND USE MITIGATION STRATEGIES

- ⟶ **Macro-level buffering**
- ⟶ **Land Use buffering**
- ⟶ **On-Site Physical Separation**
- ⟶ **On-Site Mitigation Measures**
- ⟶ **One-Site Amenities/Positive Interface**

Industrial Edges: Compatibility and Interface Issues in Metro Vancouver

Zoning Policies

Setbacks, land use ratios, and height restrictions can be found in each of the zoning bylaws and guidelines. Some concerns with zoning policies are noted in the Interview Insights.

Design Inventory

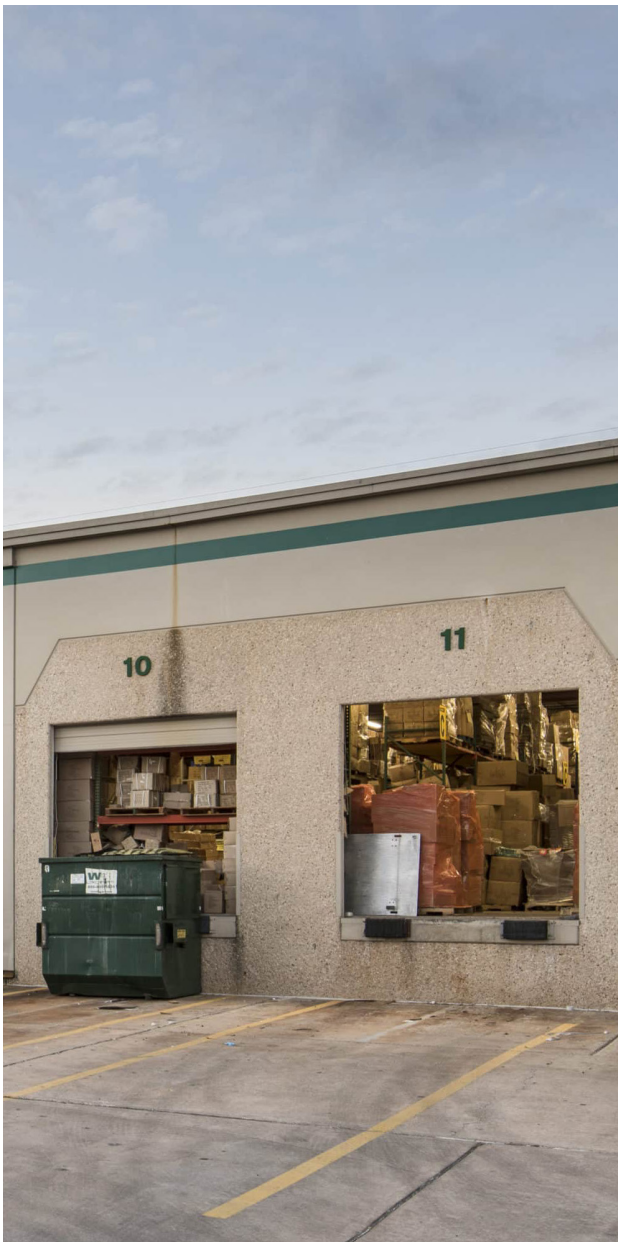


Image Source: AquilaCommercial.com

While there is an abundance of guidelines which addressed separation distances, there is a lack of documentation regarding architectural design interventions that can be implemented. Therefore, a **general architectural inventory for mitigation of the industrial interface -- noise, odour/dust, traffic/loading, light, air quality, and visual/design elements -- id-collected in this section**. These may be helpful for area plans, policy plans, and design proposals. Note that this is not meant to be an exhaustive list and alternative solutions are encouraged.

To a certain degree, there is a threshold of tolerance where users may accept temporary experiences of unpleasant noise, odour, light levels, and visual/design elements. This may be a communicated understanding of occupying industrial developments. Thus, it is not expected for designs to entirely eliminate these factors; however, it is expected for users to minimize them so that they are no longer nuisances.

The intention of this design inventory is to challenge traditional land use conflicts by presenting a collection of design solutions to improve the compatibility between different programs. Some strategies and elements may be combined to further ameliorate compatibility.

NOISE

Noise perception must be considered when integrating different types of building programs. Mixed-used spaces with residential units must follow sound transmission regulations outlined in the BC Building Code Section 5.8.[17] Professional experts should be consulted for acoustic regulation and sound insulation testing. This paper focuses on how noise can be controlled on-site to enhance compatibility between different uses.

Nature of Noise

There can be airborne or stucture-borne noise. Airborne noise is from source to receiver and travels in all directions, while structure-borne noise is unwanted vibrations through materials. Both forms may have the same source, however may require separate systems to control. Often the solutions to control noise are effective for vibrations as well.

Control and Measures

Because acoustic performance and flanking noise is governed by the point of poorest noise isolation, measures taken at the small-scale design level have significant impacts on noise levels. Airborne sound can be measured in transmission loss, sound transmission class (STC), or noise reduction coefficient (NRC). Noise can be controlled by the location and orientation of the noise source, the quality of noise-generating equipment, hours of noise occurrence, and screening. Sound levels must be monitored and determined at all times of day to ensure compliance with noise control measures.

Noise Level Values for Various Spaces

Portions of Dwelling Unit	Noise Levels (dB)
Bedrooms	35
Living, Dining, and Recreation Rooms	40
Kitchen, Bathrooms, Hallways	45

City of Vancouver Zoning and Development Law FC-2, Feb 2021.[18]

Dwelling Units and every other space	Rating
Apparent Sound Transmission Class	47
Sound Transmission Class	50

Section 5.8.1. BC Building Code 2018 [17]

Office in Manufacturing, Laboratory or Test Areas requiring normal privacy	STC (min.)
Adjacent Offices	42
Manufacturing, Laboratory, or Test Areas	>42
Washrooms and Toilet Areas	42
Corridor or Lobby	37
Exterior of a Building	37-60

NAIMA Sound Control for Commercial and Residential Buildings[19]

Mitigation Strategies

Noise control can be done through absorption, barriers, and dampening. Sound buffers

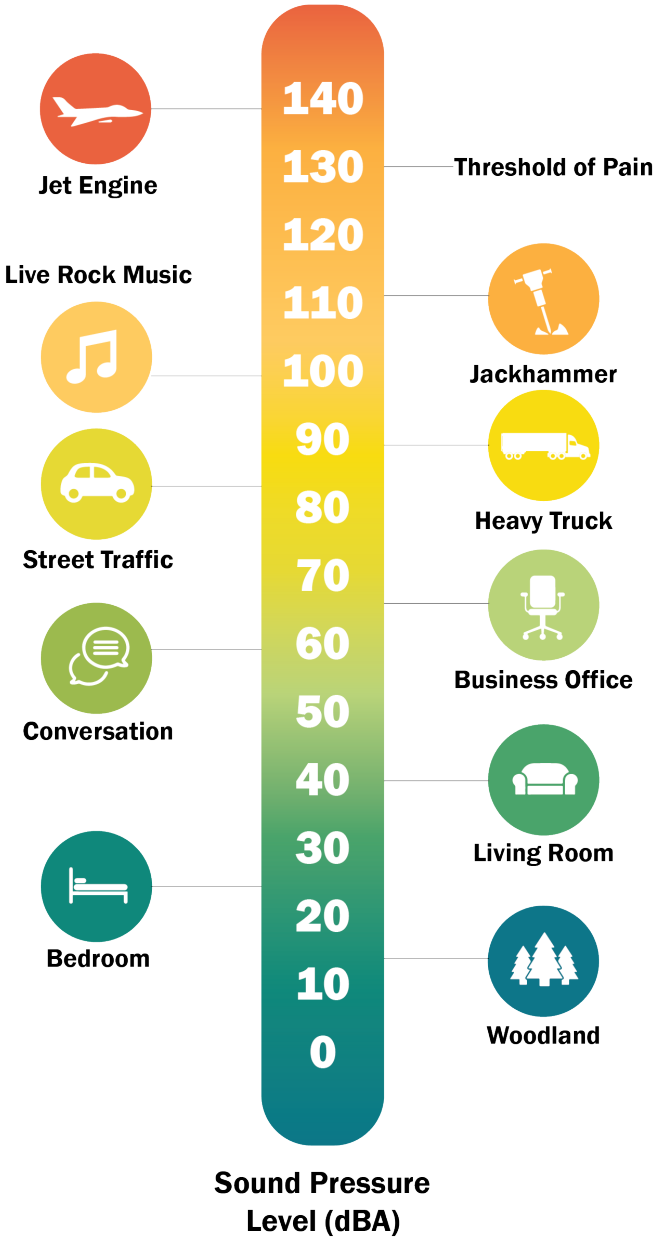


Figure 4. Sound Levels and Relevant Sources

Common Noise/ Vibration Concerns

Compressors/Pumps
Chillers
Air terminal units + Fans
Generators
Transformers
Planars/Routers/Saws
Mechanical system fans
Foot + Vehicle traffic
Air ducts

should have one of these qualities. They can be physical barriers or spatial separations. Height, distance, thickness, and materials all contribute to the degree of mitigation between noise receiver and source. Alternatively, systems that have the potential to produce noise should be designed and selected to have minimal impact on surroundings.

Transitional zoning can also be considered buffering, where there is a separation between two distinct uses via a mutually compatible use. Parking and services can act as acoustic buffers that protect residential from industrial uses. Examples of potential configurations can be found later in this paper.

Spatial separation while intensifying industrial lands can be achieved through thoughtful building massing, like U- or L-shaped forms.

Examples of Noise/Vibration Control Products & Systems[21]

Sound Control Baffle
Fibreglass Panel Absorber
Fibreglass Isolation Pad
Spring Isolation Mounts
Attenuation Blankets
Pipe and Duct Lag
Concrete Floors

This way high noise spaces can occupy the same site as those with low noise. Interior courtyards or garden space can also be an effective noise mitigation strategy that provides quiet and light-filled space within a building.

Although landscaped buffers may be presented as a viable noise solution, they only slightly attenuate noise and must be very high and dense for significant effectiveness.[20]

Rather than typical air-conditioning units, pressurized plenum space (area between ceiling and floor) can be used as an alternative to provide sound absorption and sound transmission loss. These can be appropriate for residential, office and light-industrial applications.

Regulation in Vancouver

The City of Vancouver does not regulate specific noise levels from industrial processes, however, there are maximum allowed noises from mechanical equipment. Hours of operations must also be factored into the noise compatibility between uses.

Vancouver By-Law Maximum Allowed Noise

	55-70 dB	45-65 dB
Monday - Friday	7am - 10pm	10pm - 7am
Saturday - Sunday	10am - 10pm	10pm - 10am

Variable times of uses can convert incompatible uses into compatible. For example, offices and theatre uses are compatible because the former operates during the day while the latter is typically occupied at night.

Note that setbacks for front, side, and back yards can be used to address off-site noise to increase separation distances, however, these are unlikely helpful for increasing the density of industrial land use on an individual plot.

Noise Compatibility Matrix

Land uses categorized by the average amount of noise generated can be seen in Table 1. If sound levels are consistently montiored and kept within compatible values it is possible to combine unconventional land uses together. For example, City Office Buildings and Warehouses are Clearly Compatible when the Energy Average is kept at or below 60 CNEL.

Land Uses	Energy Average (CNEL)						
	<	55	60	65	70	75	80>
Amphitheatre, Concert Hall, Auditorium, Meeting Hall	B	B	C	C	D	D	D
Mobile Home	A	A	B	C	C	D	D
Hospital, Library, School, Faith/Religious Uses	A	A	B	C	C	D	D
Hotel, Motel, Transient Lodging	A	A	B	B	C	C	D
Single Family, Multi-family, Faith/Religious Uses	A	A	B	B	C	D	D
Parks	A	A	A	B	B	D	D
Office building, Research & Development, Professional Office, City Office Building, and Hotel	A	A	A	B	B	C	D
Amusement Park, Miniature Golf, Health Club	A	A	A	B	B	D	D
Golf Courses, Nature Centres, Cemeteries, Wildlife Reserves	A	A	A	A	B	C	C
Commercial Retail, Bank, Restaurant, Movie Theatre	A	A	A	A	B	B	C
Automobile Service Station, Auto Dealer, Manufacturing, Warehousing, Wholesaling, Utilities	A	A	A	A	B	B	B
Agriculture	A	A	A	A	A	A	A

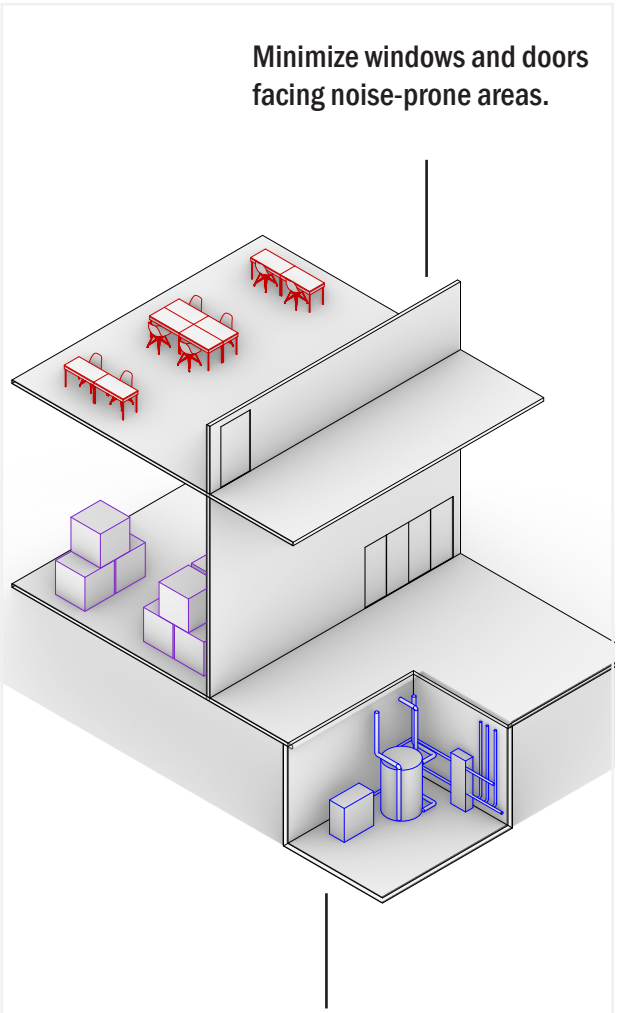
A: Clearly Compatible
B: Normally Compatible
C: Normally Incompatible
D: Clearly Incompatible

Table 2. Land Use and Noise Compatibility Matrix, City of Clovis[22]

Noise Receptor Mitigation

This section contains a number of design guidelines for noise mitigation. Additional ideas can be found in "*Sound Control for Commercial and Residential Buildings*".[19]

Guideline A: Strategic spatial orientation



Guideline B: Use sound absorptive material

To absorb airborne sound, use buffers that have high porosity, high density, and/or textured surfaces.

Effective Sound Absorbers for...
Walls

- Fibreglass;
- Stone and glass wool
- Green Walls
- Precast Concrete Sound Walls

Floors and Ceilings

- Open-celled foam
- Open-celled sponge rubber
- Carpet
- Ceiling Tiles – mineral wool/mineral fibre (Ceiling Attenuation Class (<25))
- Acoustical Metal Deck

Some recommended* criteria for buffers to be effective barriers to noise sources are:

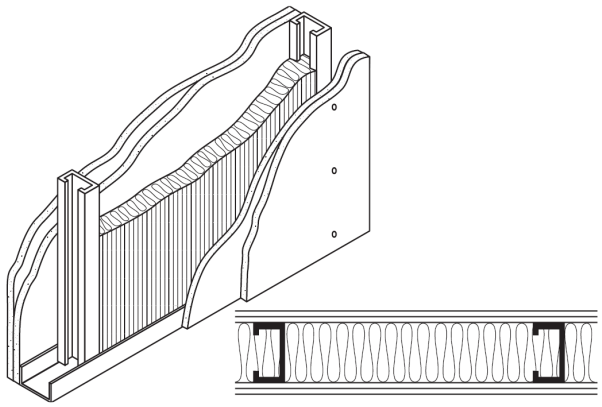
- min. density 20 kg/m^2
- min. height blocks view of the noise source
- min. 8 times the length of distance

Guideline C: High STC Wall and Floor/Ceiling Construction Assemblies

Construction assemblies are largely responsible for the direct transmission of sound between spaces. Therefore, walls, floors, and ceilings should be designed to with noise mitigation in mind. Isolation floors for shell-type buildings, higher-than-normal STC values are appropriate in order to maintain flexibility over time and accommodate a variety of occupants. Acceptable assemblies and their STC values are found in Table 9.10.3.1 of the BC Building Code.[23]

Figure 5. Select Wall Assemblies and Associated STC and Fire Rating Properties

STC-54 **(Figure 15)**

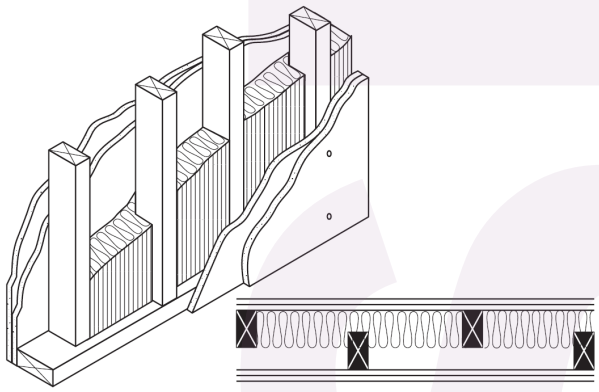


2½" metal studs (25 gauge), 24" o.c., double layer ½" gypsum board each side, one thickness (2½"-2¾") fiber glass batt insulation.

Fire rating - NR Balanced Finish

Variation	Construction	Finish*	STC	Fire Rating
15A	½" Type X GB *No insulation*	Balanced	45	2 hr.
15B	*⅝" Type X GB* *No insulation*	Balanced	48	2 hr.
15C	*⅝" Type X GB* (2½"-2¾") fiber glass batt	Balanced	57	2 hr.

STC-55 **(Figure 9)**

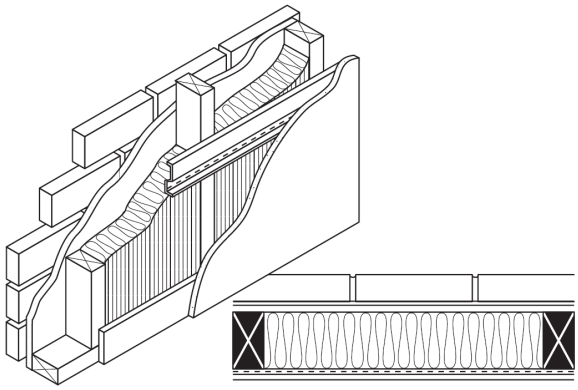


Staggered 2x4 wood studs, 24" o.c., double layer ½" Type X gypsum board each side, one thickness (3½"- 4") fiber glass batt insulation.

Fire rating - 1 hr. (est.) Balanced Finish

Variation	Construction	Finish*	STC	Fire Rating
9A	½" Type X GB *No insulation*	Balanced	52	1 hr. (est.)
9B	*Studs 16" o.c.* ½" Type X GB (3½"-4") fiber glass batt	Balanced	53	1 hr. (est.)
9C	*Studs 16" o.c.* *⅝" Type X GB* (3½"-4") fiber glass batt	Balanced	53	2 hr.

STC-58 **(Figure 21)**



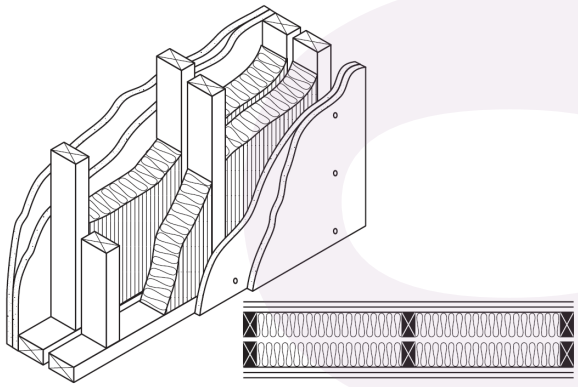
Exterior brick veneer, ½" air space, ¾" insulative sheathing, 2x4 studs, 16" o.c., resilient channel, ½" gypsum board, one thickness (3½"- 4") fiber glass batt insulation.

Fire Rating - NR

Variation	Construction	STC	Fire Rating
21A	*No insulation*	54	NR
21B	*No resilient channel* (3½"-4") fiber glass batt	56	NR

Source: Sound Control for Commercial and Residential Buildings.

STC-63 **(Figure 12)**



Double 2x4 wood studs, 16" o.c., double layer ½" Type X gypsum board each side, two thicknesses (3½"- 4") fiber glass batt insulation.

Fire rating - 1 hr. Balanced Finish

Variation	Construction	Finish*	STC	Fire Rating
12A	1/2" Type X GB *No insulation*	Balanced	54	1 hr.
12B	1/2" Type X GB *One thickness of* *(3½"-4") fiber glass batt*	Balanced	64	1 hr.
12C	*Studs 24" o.c.* ½" GB *One thickness of* *(3½"-4") fiber glass batt*	Balanced	65	NR

Guideline E: Sensitive Design of Noise Sources and Noise Receptors

Noise mitigation is important to address at the small-scale design level. In order to minimize the flanking of sound, thresholds between spaces require mitigation. Some recommendations to control sounds are:

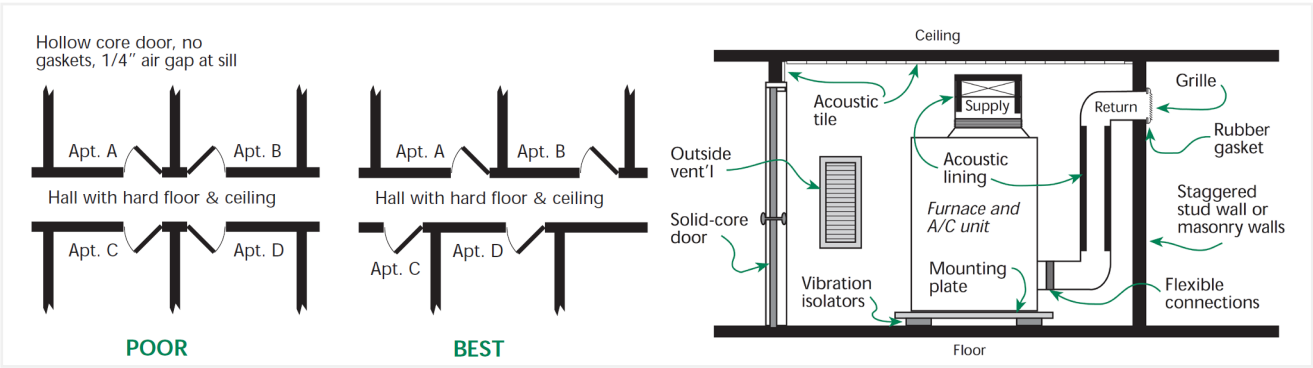
Noise Source Mitigation

- Connect vibrating equipment with flexible wiring and use isolation mounts.
- Surface mount any ceiling fixtures on resiliently mounted gypsum ceilings.
- Isolate piping from structures with resilient pads and sleeves, then seal for air tightness.
- Develop a well-planned layout to minimize the noise of flowing water.
- Consider position of 'blow out' safety vents on safety equipment
- Select quiet, high quality appliances and air conditioners.
- Select quiet external ballast on fluorescent fixtures.
- Install electrical distribution panels, phones, doorbells, intercoms, and other noise-creating devices on interior walls only - never on party walls or corridor walls.
- Non-opening windows

Noise Receptor Mitigation

- Stagger doors across hallways and use gasketing
- Use thick, insulating glass, or storm windows
- Minimize the size of windows facing noisy areas
- Do not install electrical outlets back to back
- Do not use recessed or "hi-hat" type fixtures without boxing in the fixture.
- Use fibre glass or cellulose insulation
- Enclose canopies or roof structures above industrial activity and yard space

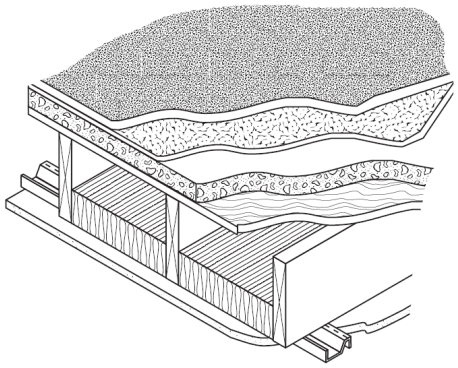
Figure 6. Noise mitigation diagrams



Source: Sound Control for Commercial and Residential Buildings.

Figure 7. Select Floor Assemblies and Associated STC and Fire Rating Properties

STC-58 IIC-74 **(Figure 26)**



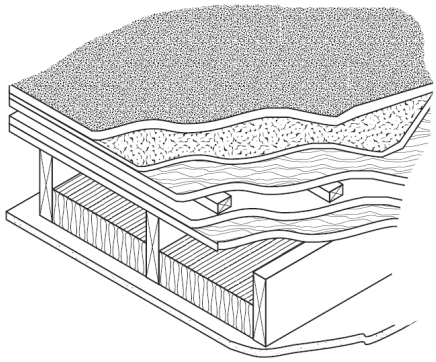
Concrete Floor

Carpet and pad, 1½" lightweight concrete floor, ⅝" plywood subfloor, 2x10 joists 16" o.c., one thickness (3½"- 4") fiber glass batt insulation, resilient channel, ½" Type X gypsum board.

Fire Rating - 1 hr. est.

Variation	Construction	IIC	STC	Fire Rating
26A	*No resilient channel No insulation*	59	47	NR
26B	*2x8 joists, 1⅝" lightweight concrete floor*	74	53	NR
26C	*2x8 joists, Vinyl floor instead of carpet and pad*	47	50	NR

STC-51 IIC-78 **(Figure 28)**



Plywood Floor

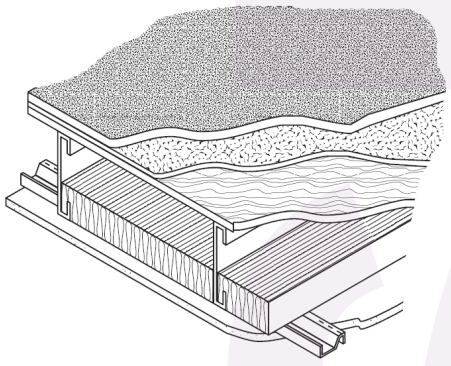
Carpet and pad, ⅝" plywood floor, 2" x 3" furring, ½" sound deadening board, ½" plywood subfloor, 2x8 wood joists, one thickness (3½"- 4") fiber glass batt insulation, ⅝" Type X gypsum board.

Fire Rating - NR

Variation	Construction	IIC	STC	Fire Rating
28A	*With vinyl floor instead of carpet and pad*	49	52	NR

Source: Sound Control for Commercial and Residential Buildings.

STC-56 IIC-71 **(Figure 27)**



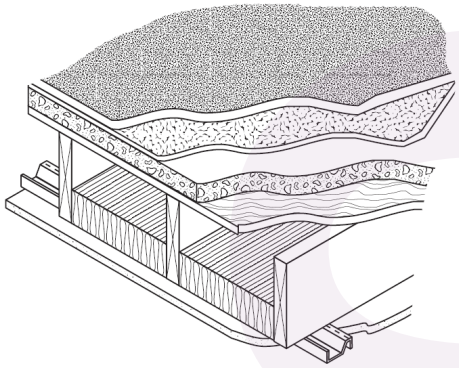
Steel Joist Floor

Carpet and pad, ¾" T&G plywood subwood subfloor, steel joists (7¼", 18 ga.) 24" o.c., one thickness (3½"- 4") fiber glass batt insulation, resilient channel, ⅝" gypsum board.

Fire Rating - NR

Variation	Construction	IIC	STC	Fire Rating
27A	*No resilient channel No insulation*	57	43	NR

STC-58 IIC-74 **(Figure 26)**



Concrete Floor

Carpet and pad, 1½" lightweight concrete floor, ⅝" plywood subfloor, 2x10 joists 16" o.c., one thickness (3½"- 4") fiber glass batt insulation, resilient channel, ½" Type X gypsum board.

Fire Rating - 1 hr. est.

Variation	Construction	IIC	STC	Fire Rating
26A	*No resilient channel No insulation*	59	47	NR
26B	*2x8 joists, 1⅝" lightweight concrete floor*	74	53	NR
26C	*2x8 joists, Vinyl floor instead of carpet and pad*	47	50	NR

ODOUR

In mixed-industrial buildings, noxious odours should be prevented from travelling across multiple spaces. Heavy operations that produce uncontrollable noxious odours are not appropriate for mixed-use buildings. For instance, poultry farms. Metro Vancouver regulates odourous air comtaminants in industrial permits, however, non-hazardous odours are often nuisances and can be addressed through good design.

Odour Assessment

Compared to other industrial interfaces odour may be more difficult to measure due to its subjective nature. “Urban Smellscapes”, describes odours as a nuisance when they are “out of place”.[24] Nonetheless, there are some measures that can be taken that test the duration, frequency, intensity, and location of noxious odours.

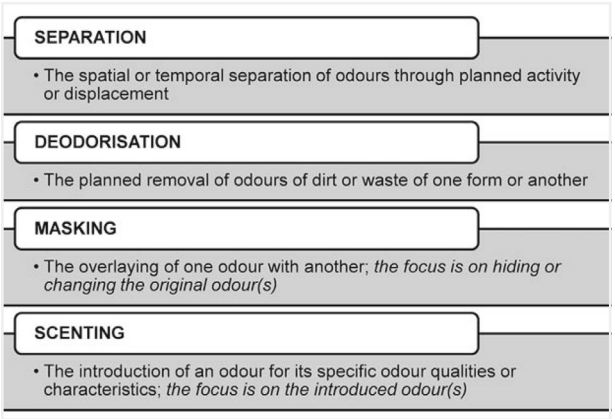


Figure. 7.5 Odour Assessments

Source: Henshaw, Urban Smellscapes

There are analytical and mixed-sensor-instrumental methods to assess the qualities of odorous substances. Gas chromatography and mass spectrometry; colorimetric tubes; portable multi-gas detectors; gas analysers; olfactometric tests; and triangular odor bag tests are methods that may be used in odour analysis. Estimation of emission rates, odour emission capacity, or field assessments may also be used.

External Influences

Wind speed and direction influence the dispersion and delivery of emissions. While higher wind speeds cause faster dispersion, it also may direct smells towards people.

For Vancouver, prevailing winds are generally from the East and strongest in the winter months. Sensitive land use design should acknowledge the dynamic nature of odours.

Site topography, spatial layout, and temperature impact the "smellscape experience". Odour consultants should analyze these factors to determine potential noxious emissions. Additionally, dialogue with the public and consideration of different perspectives regarding olfactory experiences are essential to the odour mitigation process.

Mitigation Strategies

Odour control can be implemented at the source, by dispersion, minimizing the effects, and/or reducing concentration.

Source

Some examples of odour sources are food operations, traffic emissions, chemical facilities, mechanical equipment pollution, and material handling.

Good operational and engineering practices can mitigate odours before they are released into the environment. Table A lists odour-emitting processes and strategies that may be implemented at the source.

Receptor

If the emission of odours cannot be prevented, there are some solutions to control their reception, including:

Plantings

There are numberous types of plantings and trees that can be used for the treatment of odor concerns. Foliage are multi-purpose by absorbing and masking unpleasant smells as well as acting as visual screens. While indus-

trial uses may not provide appropriate conditions for plantings, a strategy may be to locate them to the surroundings of the non-industrial uses instead. The figures below highlightsa few options, although certainly not an exhaustive list. For a comprehensive list of options for tree species, take a look at "Designing vegetation barriers for urban air pollutionabatement: a practical review for appropriate plantspecies selection " "Tree Species Selection for Green Infrastructre: A Guide for Specifiers" (Dr, Hirons, A. and Dr. Sjoman, H).

Carbon Air Filters

Removes vapour contaminants and volatile and semi-volatile compounds (e.g. industrial solvents) in a range of temperatures and humidity levels.

Benefits: Low cost and easily installed

Ozone Generators

Eliminates odorous substances through oxidation.

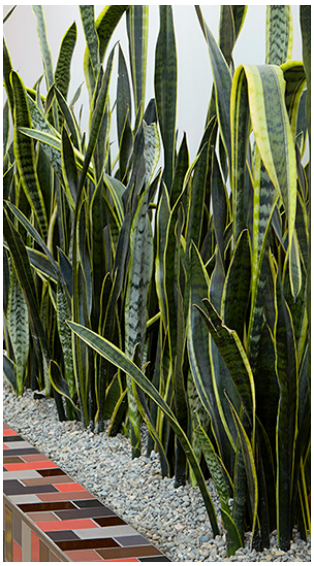
Benefits: No by-products and low maintenance

Odour Mitigating Foliage

Field Maple
Medium tree,
Typically <15m

Peace Lily
Small plant,
Typically 0.8m

Serviceberry
Medium tree,
Typically 10m



Sansevieria
Small plant,
Typically 0.70m

ODOUR-EMITTING PROCESS	ABSORPTION	ADSORPTION	BIOLOGICAL	THERMAL OXIDATION	CONDENSATION
Sewage Treatment	✓✓	✓✓	✓✓✓	✓	–
Food Processing and Kitchens	✓✓✓	✓	✓✓✓	✓	✓
Paints and Solvents	✓✓	✓✓	✓	✓✓✓	✓✓
Animals and Livestock	✓✓	✓	✓✓✓	–	–
Industrial/ Chemical Processes	✓✓	✓✓	✓	✓✓✓	✓✓
Oil and Gas	✓✓	✓✓	✓	✓✓✓	✓✓✓
Storage and Spills	✓✓✓	✓✓✓	✓	✓	–

✓✓✓ Common, typically used and established
✓✓ Use may be limited to specific process and scale
✓ Rare usage and limited research

Table 3. Comparison of engineering controls

Source: "Good Practices for Odour Management in Alberta"

Biological Scrubbers

Treats odours by filtering them through micro-organisms.
Low maintenance and little waste.

The type of odour is important to consider as intensity may not be associated with the perceived quality of smell. For example, Vancouver has a prominence of breweries in certain industrial areas. Alcohol beverage production is a significant sources of odour compared to other light/medium industrial processes, however, it scores low on offensiveness scales.*

Dispersion

Disperion dilutes air particles to minimize smells. There are two approaches to dispersing odours.

1. **Increase separation distance between odour source and receiver to allow dilution by dispersion.**
2. **Contain dispersion within enclosures to prevent odours from escaping.**

Minimization

Odours may be masked or neutralized with sprays. Gases or vapours are mixed to minimize the effects. Surfaces can be treated to avoid odour formation.

Location

Issues arise when odors are perceived in unexpected locations. Measurements should be made where the public would notice a smell. An odour baseline can be determined as a standard for measurements.

Open tanks and storage piles should be contained and situated away from residential and high occupancy areas.

Placement and operability of windows can prevent intrusion of odours.

In stacked mixed-use buildings, the placement of mechanical systems should be clearly separated from non-industrial units. If there are industrial programs on lower levels, odours and air pollutants from their operations may rise and disturb users above. This may be mitigated by redirecting emissions above surrounding uses. For example, by ventilating air through the building and onto rooftops rather than prodividng separate systems to individual units.

Regular maintenance and cleaning of HVAC systems will reduce the likelihood of mold or mildew buildup and prevent resulting smells.

Further Considerations

Typically, the occupant is expected to implement odour mitigation measures when they enter a space. These expectations may be outlined in strata laws. Cannabis facilities, laboratories, and furniture manufacturing are common industrial uses in Vancouver that require sensitive odour management. Because of noxious emissions, some strata corporations may restrict these use. However, the implementation of mitigation strategies would improve compatibility and provide opportunities to intensify industrial lands.

Cannabis Facilities

Cannabis facilities may include cultivation, harvesting, and processing of cannabis plants. Metro Vancouver's Discussion Paper, *A Proposed Emission Regulation for Cannabis Production and Processing Operations* outlines best practices and potential requirements to control emissions.[25]

Grow rooms require sufficient ventilation and temperature control. Grow tents exemplify ideal systems (Figure 8). An extractor fan, air intake vent, structure that guarantees a con-

stant flow of air, and carbon filter are components that must be controlled and monitored for mitigation of odor and air quality. Exhausted air can be directed towards tall and dense plantings and landscape areas (e.g. green roofs) to further absorb odours.

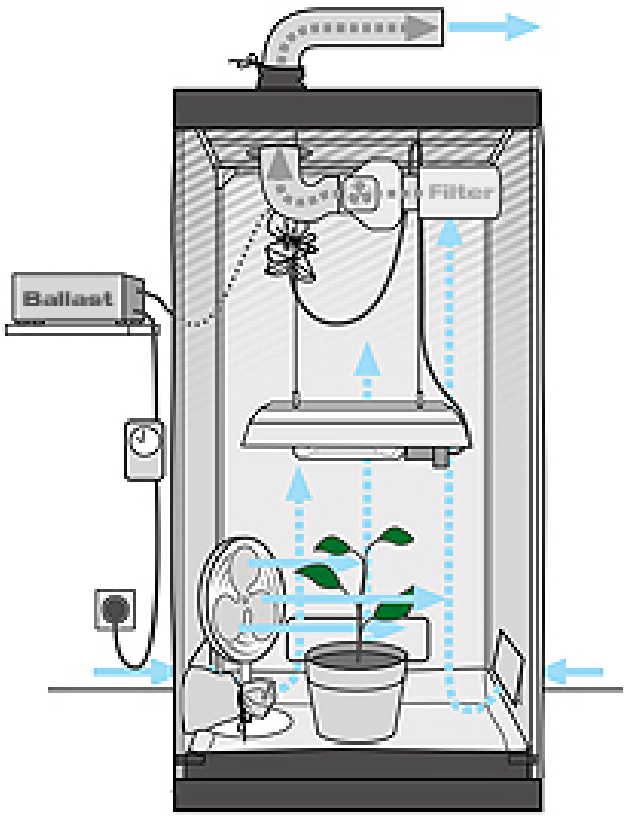


Figure 8. Cannabis Grow Tent Diagram (Image Source: Growmart.eu)

Laboratories

Laboratories often have misconceptions regarding their odour emissions. There are different types of labs with varying amounts of chemicals and emissions. Additionally, operations are well-regulated within the sector. Environmental standards and best management practices control potential adverse effects between uses. See the next section on air quality for more details.

For more details on laboratory operations, see *Environmental Regulations and Best Management Practices*[26] and *Biosafety*[27]. Building attributes and considerations are decribed in the article “Research Laboratory”.[28]

Other resources that provide in-depth odour management tips are *Good Practices Guide for Odour Management in Alberta*[29] and *Odour Impact Assessment Handbook*[30].

AIR QUALITY

While air quality is often linked with odour, there are other emissions that should also be considered. Temperature, humidity, particulate matter and gaseous contaminants are all qualities of air. These can be composed of biological and non-biological matter and vary in size. Common indoor particles are fibres, dust, allergens, bacteria, vehicle exhause, viruses, and emissions from combustion sources. Managing air quality is highly regulated and requires mediation of environmental concerns.

Regulation in Vancouver

Metro Vancouver is the main regulatory governance body for air quality throughout the region. Regulations such as the *Green Buildings Policy for Rezonings*[31], *Zero Emissions Building*[32], *Higher Buildings Policy*[33], *Energy Step Code*[34], *and Integrated Air Quality and Greenhouse Gas Management Plan*[35] effectively address industrial and non-industrial air quality concerns. For instance, new low-rise mixed-use buildings with a residential component, are required by the Vancouver Building By-Law to have zero emissions equipment for space and hot water heating.

There are no minimum requirements in the BC Building Code regarding ventilation and air quality management for non-dwelling units.

Mitigation Strategies

Source reduction, ventilation, dilution, and air-cleaning devices are methods to improve air quality.

The most effective way to address air pollution is to encourage and support occupants who engage in sustainable processes and have minimal emissions. Otherwise, exhausting air with sufficient ventilation is also useful. However, this may have an adverse effect on the surroundings. Therefore, dilution may also be used, where the dispersion of particles reduces negative impacts. Proper application of in-room air cleaners[36] and vegetation barriers[37] can help mitigate localized air pollution. Fibrous media air filters and electronic air clearners (e.g. ionizers) are commonely used in duct-mounted and portable cleaners. Similar to odour mitigation strategies, gas-phase cleaning technologies use adsorbent media air filters (e.g. activated carbon).

Appropriate location and size of air cleaners will maximize their capacity to clean. Air cleaners should be placed without obstructions and portable units are best placed near occupant breathing zones. Sizing should correspond to the room size in which it is operated.

Venting units to the rooftop is an effective

Table 4. Comparison of MERV Data, Filter Type, and Prior Designations (Table 7.5-B)

MERV Level	Dust Spot %	Typical Particulate Filter Type	% 0.3–1 µm	% 1–3 µm	% 3–10 µm
1	N/A	Low-efficiency fiberglass and synthetic media disposable panels, cleanable filters, and electrostatic charged media panels	Too low efficiency to be applicable to ASHRAE Standard 52.2 (ASHRAE 2007) determination		
2	N/A				
3	N/A				
4	N/A				
5	N/A	Pleated filters, cartridge/cube filters, and disposable multi-density synthetic link panels			20–35
6*	N/A				36–50
7	25%–30%				50–70
8	30%–35%				>70
9	35%–40%	Enhanced media pleated filters, bag filters of either fiberglass or synthetic media, rigid box filters using lofted or paper media		>50	>85
10	50%–55%			50–65	>85
11	60%–65%			65–85	>85
12	70%–75%			>80	>90
13	80%–85%	Bag filters, rigid box filters, minipleat cartridge filters	>75	>90	>90
14	90%–95%		75–85	>90	>90
15	>95%		85–95	>90	>90
16	98%		>95	>95	>95
The following classes are determined by a different methodology than that of ASHRAE Standard 52.2 (ASHRAE 2007).					
NA	N/A	HEPA/ULPA filters evaluated using IEST Recommended Practice CC001.3 (IEST 1993). Types A through D yield efficiencies at 0.3 mm and Type F at 0.1 mm			99.97% IEST Type A
NA	N/A				99.99% IEST Type C
NA	N/A				99.999% IEST Type D
NA	N/A				>99.999% IEST Type F

* MERV 6 is prescribed by ASHRAE Standard 62-2001 (ASHRAE 2001) for minimum protection of HVAC systems.

MERV: Minimum Efficiency Reporting Value = Efficiency level of the filter

strategy for poor air quality mitigation. Rooftop ventilation complemented with a green roof addresses on-site and off-site disturbances. Extensive venting may have high financial costs and occupy a large amount of space. Therefore, the financial trade-off may detract from its applicaton.

In cold-shell designs (spaces not provided with HVAC, plumbing, electricity, and finishing) developers are unlikely to provide air quality mitigation strategies. It is the user's responsibility to control any disturbances.

Note that there are potential opportunities as well as conflicts that might result from these solutions. There may be design elements that can be shared between uses and, therefore, enhance compatibility. An example might be a bakery manufacturer sharing a single kitchen exhaust with a restaurant. Otherwise, there may be adverse implications on adjacent uses and a hierarchy of impacts might be required to determine which nuisance is of greater concern than another. For instance, operable windows provide direct ventilation, however they conflict with noise mitigation. Time of use, intensity, and duration are factors that can be used to control the industrial interface.

Specific Considerations

Part of the difficulty in addressing compatibilities in policy is the lack of granularity within uses. This is exhibited with laboratories.

Laboratory Design

The classification of laboratories requires greater detail to understand impacts on the surrounding environment. For example, wet labs have different demands than dry labs. Wet labs typically involve controlled environment areas and chemical experimentation. Examples are cell biology, tissue culture, and organic chemistry labs. Vivariums are more intensive versions where dedicated exhausting systems and lobbies are necessary. In dry labs, computers are the primary instruments. Examples are electron microscope, laser, and mass spectrophotometry labs. Particularly, the latter is less mechanically intensive than the former and thus is more compatible with non-industrial uses. Note that laboratories with equipment that require extensive ventilation, like fumehoods, are incompatible with residential uses because of design requirements. One reason is that air must be exhausted above the building. However, structural constraints reduce its mixed-use compatibility. Drilling holes in post-tensioned slabs risks damaging post-tension cables and must be carefully coordinated across disciplines. Additionally, vertical air vents occupy floorspace and reduce rentable area. The key to laboratory compatibility is flexibility and efficiency in design.[39]

A measurement that can be used to assess air quality is Air Changes per Hour (ACH). In Vancouver, only dwelling units are regulated by this means. They must have a mechanical ventilation system capable of providing at least 0.5 ACH during the cooler seasons[38]. There are, however, ASHRAE recommended air changes per hour. Combining uses with similar values will ensure efficient use of ventilation systems.

For more details regarding indoor air quality, refer to the ASHRAE Indoor Air Quality Guide.[38]

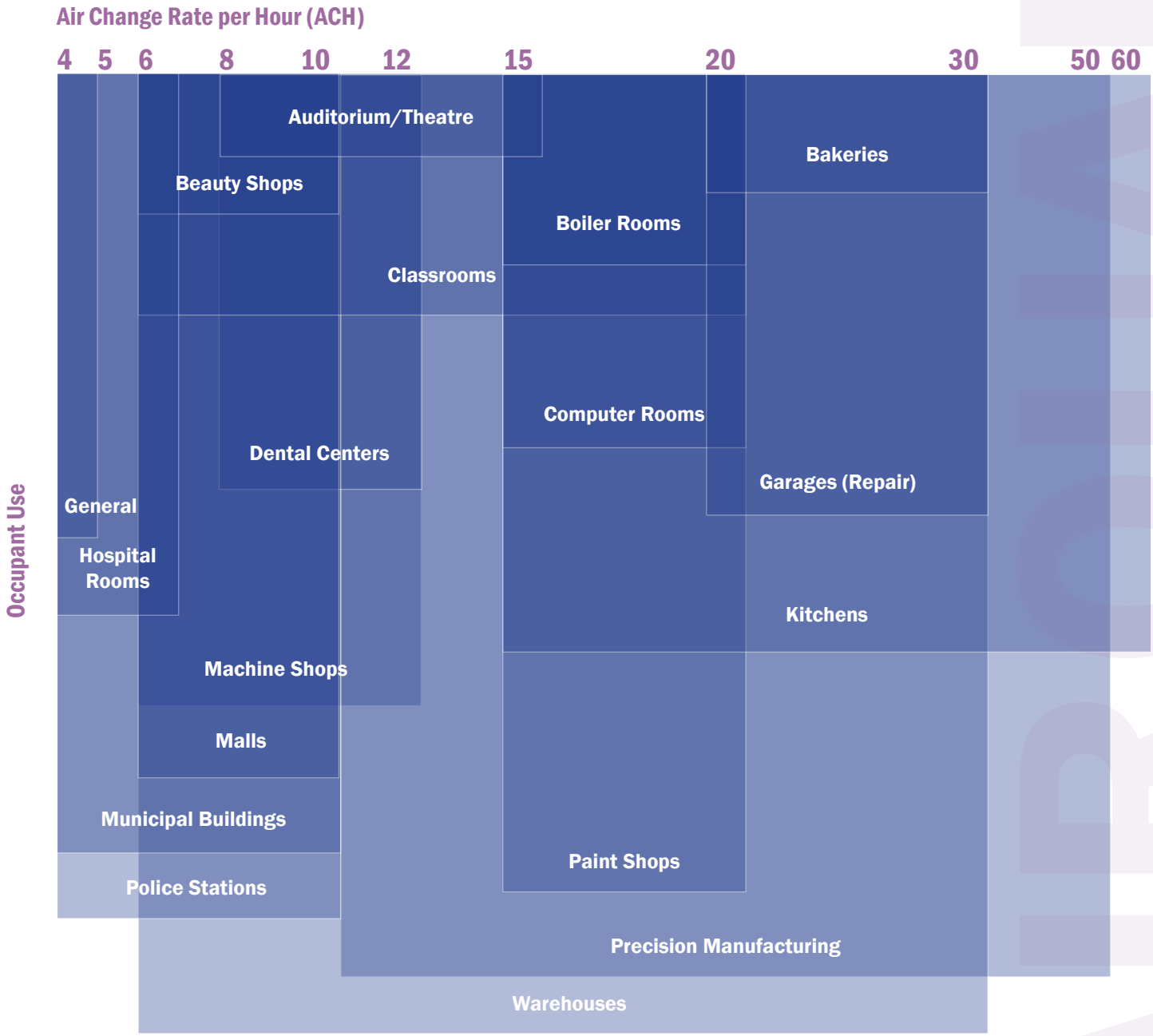


Figure 9. Graph of Occupant uses and their respective Air Change Rate per Hour. [40]

Table 5. ASHRAE Standard 62.1 Air Intake Minimum Separation Distances (Table 5.5.1)[41]

Object	Min. Distance ft (m)
Significantly contaminated exhaust (Note 1)	15 (5)
Noxious or dangeours exhaust (Note 2 and 3)	30 (10)
Vents, chimneys, and flues from combustion applicances and equipment (Note 4)	15 (5)
Garage entry, automobile loading area, or drive-in queue (Note 5)	15 (5)
Truck loading area or dock, bus parking/idling area (Note 5)	25 (7.5)
Driveway, street, or parking place (Note 5)	5 (1.5)
Thoroughfare with high traffic volume	25 (7.5)
Roof, landscaped grade, or other surface directly below intake (Notes 6 and 7)	1 (0.3)
Garbage storage/pick-up area, dumpsters	15 (5)
Coolinbg tower intake or basin	15 (5)
Cooling tower exhaust	25 (7.5)

- Note 1: Significantly contaminated exhaust is exhaust air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.
- Note 2: Laboratory fume hood exhaust air outlets shall be in compliance with NFPA 45 (NFPA 1991) and AIHA Z9.5 (AIHA 1992).
- Note 3: Noxious or dangerous exhaust is exhaust air with highly objectionable fumes or gases and/or exhaust air with potentially dangerous particles, bioaerosols, or gases at concentrations high enough to be considered harmful. Information on separation criteria for industrial environments can be found in ACGIH Industrial Ventilation Manual (ACGIH 1988) and in ASHRAE Handbook—HVAC Applications (ASHRAE 2003).
- Note 4: Shorter separation distances are permitted when determined to be in accordance with a) Chapter 7 of ANSI Z223.1/NFPA 54(ANSI/NFPA 2002)for fuel gas-burning appliances and equipment, b) Chapter 6 of NFPA 31 (NFPA 2001) for oil-burning
appliances and equipment, or c) Chapter 7 of NFPA 211 (NFPA 2003) for other combustion appliances and equipment.
- Note 5: Distance measured to closest place that vehicle exhaust is likely to be located.
- Note 6: No minimum separation distance applies to surfaces that are sloped more than 45° from horizontal or that are less than 1 in. (3 cm) wide.
- Note 7: Where snow accumulation is expected, distance listed shall be increased by the expected average snow depth

Table 6. Ashrae-defined minimum exhaust rates.[40]

Occupancy Category	Exhaust Rate (cfm/unit)	Exhaust Rate (cfm/m²)	Exhaust Rate (L/s unit)	Exhaust Rate (L/s m²)	Notes	Air Class
Arenas	-	0.50	-	-	B	1
Art Classrooms	-	0.70	-	3.5		2
Auto repair rooms	-	1.50	-	7.5	A	2
Barber shops	-	0.50	-	2.5		2
Beauty and Nail salons	-	0.60	-	3.0		2
Copy, printing rooms	-	0.50	-	2.5		2
Educational science laboratories	-	1.00	-	5.0		2
Janitor closets, trash rooms, recycling	-	1.00	-	5.0		3
Kitchenettes	-	0.30	-	1.5		2
Kitchens - commercial	-	0.70	-	3.5		2
Locker/dressing rooms	-	0.25	-	1.25		2
Locker rooms	-	0.50	-	2.5		2
Paint spray booths	-	-	-	-	F	4
Parking garages	-	0.75	-	3.7	C	2
Pet shops (animal areas)	-	0.90	-	4.5		2
Refrigerating machinery rooms	-	-	-	-		3
Residential kitchens	50/100	-	25/50	-	F	2
Soiled laundry storage rooms	-	1.00	-	5.0	G	3
Storage rooms, chemical	-	1.50	-	7.5	F	4
Toilets - private	25/50	-	12.5/25	-	F	2
Toilets - public	50/70	-	25/35	-	E, H	2
Woodwork shop/classrooms	-	0.50	-	2.5	D,H	2

NOTES:
A Stands where engines are run shall have exhaust systems that directly connect to the engine exhaust and prevent escape of fumes.
B When combustion equipment is intended to be used on the playing surface additional dilution ventilation and/or source control shall be provided.
C Exhaust not required if two or more sides comprise walls that are at least S0% open to the outside.
D Rate is per water closet and/or urinal. Provide the higher rate where perios of heavy use are expected to occur, e.g., toilets in theatres, schools, and sport facilites. The lower rate may be used otherwise.
E Rates for a toilet room intended to be occupaied by one person at a time. For continuous system operation during normal hours of use, the lower rate may be used. Otherwite use the higher rate.
F See other applicable standards for exhaust rate.
G For continuous system operation, the lower rate may be used. Otherwise use the higher rate.
H Exhaust air that has been cleaned to meet Class 1 criteria from Section 5.16.1 shall be permitted to be recirculated.

TRAFFIC/ LOADING

The changing nature of industry brings different expectations for vehicular traffic on-site. Designs must balance between street-level, building, and occupant needs. Traffic and loading affect the compatibility between industrial and non-industrial uses regarding parking spaces, loading bays, elevators, access points, noise, and visual implications. This section considers mitigating incompatibilities between the movement of people, vehicles, and goods.

Industry Challenges

On one hand Vancouver has increasingly limited ground-level space for loading bays and parking for delivery trucks despite distribution and logistics facilities driving demand for industrial property, typically requiring large-sized land parcels to support their activities. On the other hand, the types of industrial uses are evolving and expanding and may not have the traditional needs for loading. High tech industries may work primarily in office-like settings with minimal manufacturing activities.

Mitigation Strategies

Spatial Separation

For heavier traffic scenarios, industrial parking and loading may be placed away from residential units (Figure X). The industrial building

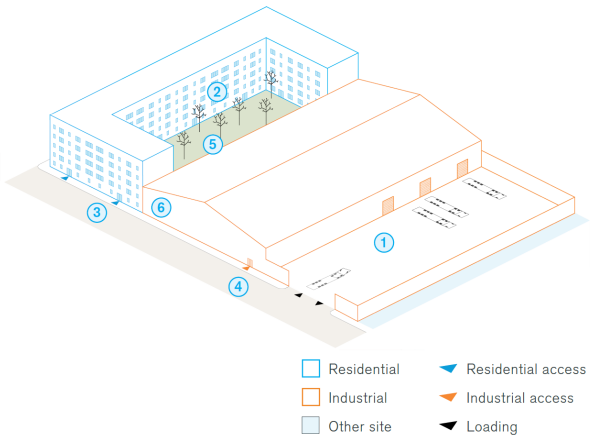


Figure X. Industrial Building as Buffer. Industrial Intensification Primer, Mayor of London

Figure Y. Parking as Buffer. Industrial Intensification Primer, Mayor of London

is in-between, acting as a buffer. A drawback is the large plot of land that is required.

Vertical Stacking

On smaller plots of land, parking and loading may act as a buffer between stacked industrial and non-industrial uses (Figure Y). However, upper-floor parking and loading have greater structural requirements. Long ramps, smaller spans and higher cost floor constructions are addititonal obstacles.

Access

Pedestrian lifts, loading bays and freight elevators are minimum requirements for industrial buildings. There are a number of related policies that may impede mixed-use developments and should be reconsidered.
Access from more than one side of a site allows for positive frontages that accomodate mixed-use occupation. This is better for separation of pedestrian, cycling, and vehicle access to reduce the risk of dangerous collisions. Ancillary spaces (e.g. bike parking) can also be used as use-buffers that acoustically mitigate industrial from residential programs.

Loading

The requirement for Class C loading spaces in buildings that have a gross floor area of 2,000 square meters is an expensive obligation that adds difficulty to industrial intensification.[42] It is often not necessary for the types of users occupying these spaces. For instance, video gaming, 3D printing, biotech, virtual reality,

creative economy, fitness centres, laboratories, and light manufacturing facilities are likely viable without Class C vehicles. Not to mention that the required and typical laneway dimensions do not facilitate access by such large vehicles. If the floor loading capacities are lowered for upper floors, build costs can be saved. This reduces the diversity of uses allowed in the space, however, it is common for these types of industrial uses to occupy office designations, which have higher financial value.

Upper-floor parking accessed via ramp is an option that maximizes valuable ground-level space while still providing traffic and loading needs of industrial programs. 640 Columbia St. (Brooklyn, NYC) is an example project that applies this. Efficient design involves straight ramps rather than spiral ramps for greater usable floorspace. Figure X presents a potential configuration for raised loading facilities.

If ventilation systems expel emissions to the roof, these exhausts should not be near spaces that can be occupied. However, this is undesirable because it removes valuable rooftop space. Instead, private exterior space can be provided above traffic and loading areas. (Figure 10) This can provide spatial continuity between non-industrial uses through a shared plaza.

Treatment of Laneways

Vehicular traffic and pedestrian access present a variety of compatibility conflicts. On one hand, laneways are primarily utilized by vehicles. On the other hand, pedestrian access is essential for reaching Vancouver's Climate Action Goals such as reducing carbon pollution created from burning gasoline and diesel in vehicles, supporting walkable and complete neighbourhoods, and supporting a transition to active transportation.[43] Mixed-use build-

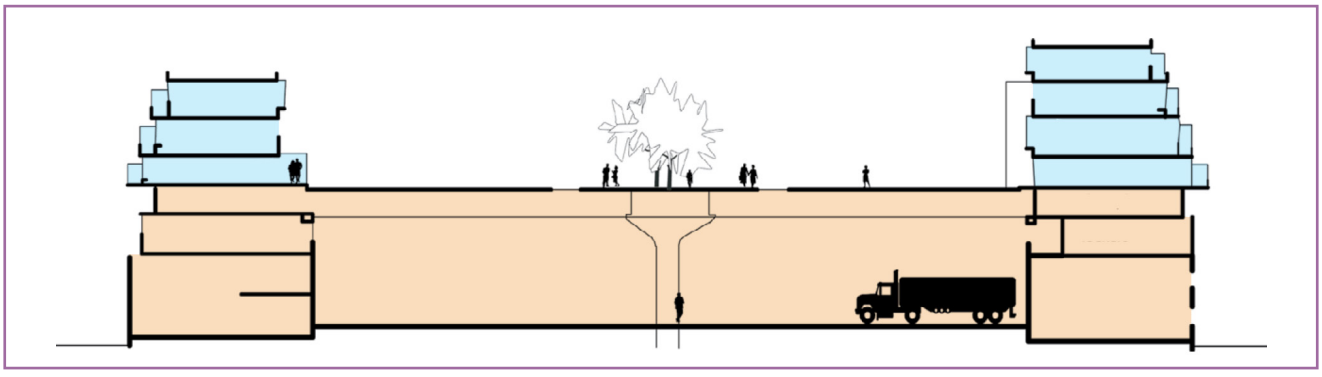


Figure 10. Industrial Building as Buffer. Image SourceL Industrial Intensification Primer, Mayor of London

ings are good candidates to facilitate community building and integration through the sensitive design of its laneways.[44] Pedestrian space can be enhanced along the street while preserving the laneway for truck and vehicle movements to minimize conflicts. Site location and vehicle movements should be professionally assessed to determine the safest pedestrian and vehicle routes and points of access. Methods include carving out walkable space into the building mass to enlarge the alleyway; inclusion of vegetation, lighting, and attractions at different times of the day and night to address conflicts between different forms of traffic; direct lighting to guide pedestrians towards safer areas; and place retail storefronts entrances along the alleyway to engage and attract the public.

Figure X. 640 Columbia St, NYC

Shared Lobbies

In industrial buildings with a residential component, the BC Building Code requires a separate means of egress; that is, a minimum of two service cores. Additionally, the Burrard Slopes C-3A Guideline requires separate lobbies and circulation for residential and non-residential uses. However, shared lobbies/egress provide opportunities to foster community and interaction between uses. The operation of fork lifts and pallet jacks in lobbies and corridors should be separated from general interior circulation to avoid injury and conflicts. Thus, there are certain classes of programs that are more appropriate for shared circulation and allowances may require case-by-case assessment. A starting point to this evaluation is to utilize the Industrial Compatibility Matrix. Security is also a concerns and requires additional infrastructure to enable shared lobbies.

Additional Considerations

Location is another factor that can improve compatibility between industrial and non-industrial uses. Close proximity to public transit helps reduce parking demands and activates the street for “walkable complete neighbourhoods”.[42]

VISUAL/ DESIGN

Visual and design elements can boost compatibility between uses in a variety ways. Mitigation strategies addressed here regard screening, sharing design elements, topography, and accessory/ancillary uses.

Jurisdiction Guidelines

Incorporating industrial uses into the look and character outlined in a jurisdiction's guideline can be a challenge. Introducing non-industrial uses can make this task easier, improving off-site compatibility by sensitive design of the street-front and massing.

Mitigation Strategies

Screening

Exposed mechanical systems and loading areas are nuisances and should be visually screened from occupiable spaces. Barriers such as foliage and fences may be used. Depending on the type of barrier, they can be multifunctional and also serve as noise mitigation. This is applicable to both on-site and off-site mitigation.

Sharing Design Elements

Uses with common design elements can work well together and have enhanced compatibility. The opposite is true as well: if a building has uses with entirely different infrastructure, they might be considered incompatible. Shared requirements may be in terms of structural grids, construction assemblies, and others. For instance, 11' modules are optimal for wet labs due to their interior layout. Buildings that cannot provide this spacing will not have as efficient of a design. Ideally, designs have a variety of unit sizes to accommodate different uses and the structural layout should allow for this flexibility.

It would be beneficial to study occupant-specific design elements in a variety of emerging and common uses in the future.

Topography

Sites that have significant elevation changes can be strategically utilized for land use conflict mitigation and to increase industrial intensification if direct loading can be achieved on multiple floors. There is potential to mitigate many forms of disturbance through engagement with the landscape and environment.

Accessory/Ancillary Uses

In cold-shell industrial buildings, because accessory uses are determined by occupants, developers may not be able to accurately predict a building's distribution of FSR. For example, industrial users who build office spaces in mezzanines reduce a percentage of the gross office floor area, which compromises the financial feasibility of a mixed-use industrial development.

It is recommended that only primary uses contribute to gross floor area calculations. Primary uses which independently construct alternative uses internally should not contribute to the overall site's principal use gross floor area. Especially with the emerging market trends towards technologically-focused industries, office spaces are in high demand within industrial spaces. Thus, flexibility must be provided.

Additional Considerations

Showcasing industrial operations can improve industrial and non-industrial compatibility by creating a relationship between interior and exterior environments and reducing segregation between spaces. Glazing along the street is a common and effective solution.

LIGHT/ ELECTRICITY

Lighting and electricity needs are particular to the type of industrial development but flexibility in design can encourage the mixing of uses. Site and building lighting conditions, power supply, and additional considerations.

Lighting

Incompatibility due to lighting can be related to luminance, glare, flicker, or color quality.

Zoning By-laws do not have lighting regulations, however BC Building Code Division B Section 9.34 outlines minimum standards for lighting in Housing and Small Buildings.[45] There are no particular values dedicated to mixed-use. District guidelines recommend minimizing disturbances with down-lights mounted on lower walls, on landscaped elements or free-standing pole lights with shaded fixtures. The Vancouver Sign By-Law (Part 9) has various illumination regulations for signs.[46]

The types of industrial uses appropriate for mixed use developments typically do not have intense lighting conditions. Tech offices and e-commerce businesses operate in environments similar to generic offices.

Bright site conditions at unwelcoming times of the day/night present a conflict that industrial programs may have with residential or commercial. This is often addressed in buiding guidelines strata laws by imposing restrictions for hours of operations.

To address lighting concerns, well-lit programs may be located near circulation space. This focuses light on circulation space and helps provide a sense of safety and guide wayfinding. Lighting should be provided to illuminate access routes without disturbing neighbours. At night the dary sky can be preserved by directing and screening light towards particular areas of interest. This is especially valuable for areas with observatories. For more details, take a look at San Diego County's Dark Skies Ordinance.[47]

Inappropriate shadowing should also be minimized by creative massing and strategic land-

Figure x. containing light, neri&hu, metalocus

generator

scape design.

Skylights allow natural light into upper level industrial space while mitigating issues of security and privacy.

Mixed-use buildings that incorporate automatic lighting control are more sustainable and energy-saving, ultimately lowering operations costs.

Power Supply

The nature of emerging industrial developments can require high demands for voltage supply. Uses that demand considerate amounts of power are less compatible with each other because of competing power supply. Therefore, combining multiple types of users with varying power demands is strategic to ensure sufficient service can be provided.

In cold shell buildings, three-phase 300-Amp (600 V) power is common and sufficient for most light industrial uses. Additional independent generators are necessary for certain industrial users in case of outages, like those in the tech sector who host servers and laboratories that need consistent and precise refrigeration.

Additional Considerations

Data centres are standalone uses because of the high power demands, continuous noise, extended hours of operation, and tight security requirements. Further constraints include space requirements for fuel and water storage, a transformer yard, and generators. Similar concerns surround uses that involve the Internet of Things (IotT). Nonetheless, if energy-saving practices are implemented and tested, there may be opportunity in the future to expand the application of this program. A benefit for compatibility would be the heat-recovery of generated electrical power.[48] At the policy level, energy targets can drive more environmentally-friendly operations."Use Best Practices to Design Data Center Facilities" describes design criteria for this emerging building type.[49]

Compatibility Matrix

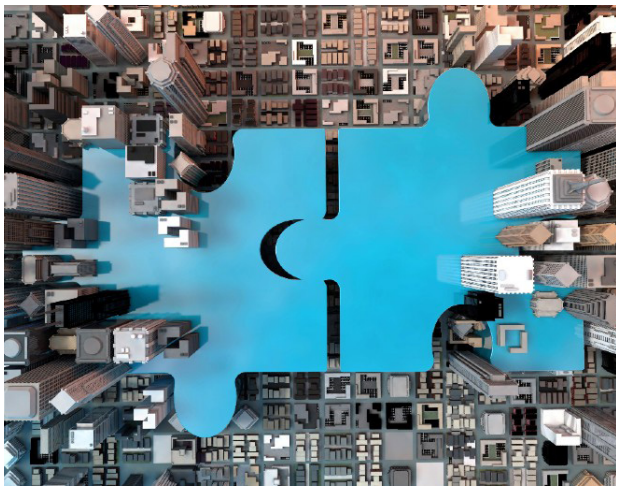


Image Source:

Industrial buildings are commonly built in a cold-shell condition (a non-specific design that is intended to maximize flexibility and enable a variety of tenants to occupy the space); however, compatibility mitigation is highly dependant on the type of user and their operations. Identifying more granularity within light industrial uses may help relieve restrictions between potentially compatible uses. The following table attempts to group similar activities for this purpose.

Assuming appropriate mitigation steps are taken to reduce the impacts of potential nuisances like loading/trucking, noise, odours, etc., flexibility can be introduced into current policies to respond to changes in the industrial sector. Some of these design strategies have been outlined earlier in this paper.

Compatible: No perceived compatibility issues between uses; able to operate adjacent to each other.
Compatible*: Compatible with proper measures to insure minimal nuisance is achieved.
Incompatible: Requires buffer for adjacent land use.
Noxious: Not appropriate for mixed-use and requires separation distance in-between.

The Burrard Slopes C-3A Residential Compatibility Matrix (Appendix A) informs the basis of this Industrial Compatibility Matrix.[50] The original matrix is curated and expanded here to include other use-types like Industrial-Office. With more identification of compatible uses, there are increased opportunities to intensify industrial lands. For example, office spaces can be good buffers between incompatible uses and help balance economic viability.

The **Industrial Compatibility Matrix** matches industrial and non-industrial uses to show the potential for intensification. By expanding the allowable uses, industrial land intensification is economically and spatially encouraged.

Uses are grouped in consideration of hazard levels, as defined in the Vancouver Building Bylaw 2019 Division B and their function. (Note that the hazard levels are not necessarily cause by emissions).

TABLE 7. GENERALIZED CONCERNS AND IMPACTS FOR INDUSTRIAL USES

Low
Medium
High

Rather than classifying uses as Light, Medium, or Heavy, the following table groups uses by their operations. The industrial interface includes air quality, odour, light, noise, traffic/loading, visual/design, and/or hours of operations as potential sources of land use conflicts. Within use categories, there are varying intensities and emissions of impact. However, Table 7 generalizes these to provide an overall conflict impact rating (low, medium, or high) and represents their typical behaviours which may impact mixed-use developments. These are also informed by the major occupancy classifications in the BC Building Code, which can be found on the following page. Once concerns are identified, the Design Inventory can be utilized to address compatibility issues and support the intensification of industrial lands and complete communities.

Use Category	Use Examples	Hazard Level	Overall Conflict Impact	Industrial Interface Concerns: Air Quality	Odour	Light	Noise	Traffic/ Loading	Visual/ Design	Hours of Operation
Material Manufacturing	Clothing, Jewellery, Textiles									
	Furniture, Wood, Paper									
	Metals, Vehicle parts									
Technology	Information Communication Technology									
	Creative Product Manufacturing									
	Data Centres									
Chemical Manufacturing	Dry Labs									
	Wet Labs (Biosafety Level 1)									
	High hazard labs (Biosafety Level 4)									
Warehouse and Distribution	Wholesaling									
	Storage Warehouse									
	Fulfillment Centre									
Food and Beverage Manufacturing	Bakery Products									
	Vertical Farming									
	Breweries									

BCBC MAJOR OCCUPAN

GROUP A

Division 1
Assembly occupancies intended for the production and viewing of the performing arts.

Motion picture theatres
Opera houses
Television studios admitting a viewing audience
Theatres, including experimental theatres

Division 2
Assembly occupancies not elsewhere classified in Group A.

Art galleries
Auditoria
Bowling alleys
Churches and similar places of worship
Clubs, nonresidential
Community halls
Courtrooms
Dance halls
Daycare Facilities for Children
Exhibition halls (other than classified in Group E)
Gymnasia
Lecture halls
Libraries
Licensed beverage establishments
Museums
Passenger stations and depots
Recreational piers
Restaurants
Schools and colleges, nonresidential
Undertaking premises

Division 3
Assembly occupancies of the arena type.

Arenas
Indoor swimming pools, with or without spectator seating
Rinks

Division 4
Assembly occupancies in which occupants are gathered in the open air.

Amusement park structures (not elsewhere classified)
Bleachers
Grandstands
Reviewing stands
Stadia

GROUP B

Division 1
Detention occupancies.

Jails
Penitentiaries
Police stations with detention quarters
Prisons
Psychiatric hospitals with detention quarters
Reformatories with detention quarters

Division 2
Treatment occupancies.

Care facilities with treatment
Convalescent /recovery/rehabilitation centres with treatment
Hospices with treatment
Hospitals
Infirmaries
Nursing homes with treatment
Psychiatric hospitals without detention quarters
Respite centres with treatment

Division 3
Care occupancies.

Assisted/supportive living facilities
Care facilities without treatment
Children's custodial homes
Convalescent/recovery/rehabilitation centres without treatment
Group homes
Hospices without treatment
Nursing homes without treatment
Reformatories without detention quarters
Respite centres without treatment

ICY CLASSIFICATIONS[51]

GROUP C — Residential occupancies.

Apartments
Boarding houses
Clubs, residential
Colleges, residential
Convents
Dormitories
Hotels
Houses
Lodging houses
Monasteries
Motels
Schools, residential

GROUP D — Business and personal services occupancies.

Banks
Barber and hairdressing shops
Beauty parlours
Dental offices
Dry cleaning establishments, self-service, not using flammable or explosive solvents or cleaners
Laundries, self-service
Medical offices
Offices
Police stations without detention quarters
Radio stations
Small tool and appliance rental and service establishments

GROUP E — Mercantile Occupancies.

Department stores
Exhibition halls
Markets
Shops
Stores
Supermarkets

GROUP F

Division 1

High-hazard industrial occupancies

Bulk plants for flammable liquids
Bulk storage warehouses for hazardous substances
Cereal mills
Chemical manufacturing or processing plants
Distilleries
Dry cleaning plants
Feed mills
Flour mills
Grain elevators
Lacquer factories
Mattress factories
Paint, varnish and pyroxylin product factories
Rubber processing plants
Spray painting operations
Waste paper processing plants

Division 2

Medium-hazard industrial occupancies

Aircraft hangars
Box factories
Candy plants
Cold storage plants
Dry cleaning establishments not using flammable or explosive solvents or cleaners
Electrical substations
Factories
Freight depots
Helicopter landing areas on roofs
Laboratories
Laundries, except self-service
Mattress factories
Planing mills
Printing plants
Repair garages
Salesrooms
Service stations
Storage rooms
Television studios not admitting a viewing audience
Warehouses
Wholesale rooms
Woodworking factories
Workshops

Division 3

Low-hazard industrial occupancies

Creameries
Factories
Laboratories
Light-aircraft hangars (storage only)
Power plants
Salesrooms
Sample display rooms
Storage garages, including open air parking garages
Storage rooms
Warehouses
Workshops

TABLE 8. ALLOWABLE ADJACENCIES AND MINIMUM FIRE-RESISTANCE RATINGS

Data adapted from

BC Building Code Division B: Acceptable Solutions - Part 3 - Fire Protection, Occupant Safety, and Accessibiity, 3.1.3. Multiple Occupancy Requirements, Fire Separation of Major Occupancies (Table 3.1.3.1.)

Note: Major restrictions

No major occupancy of Group F, Division 1 shall be contained within a building with any occupancy classified as Group A, B or C.

Not more than one suite of residential occupancy shall be contained within a building classified as a Group F, Division 2 major occupancy

Major Occupancy	Minimum Fire-Resistance Rating of Fire Separation, hours												
	Adjoining Major Occupancy												
	A-1	A-2	A-3	A-4	B-1	B-2	B-3	C	D	E	F-1	F-2	F-3
A-1	-	1	1	1	2	2	2	1	1	2	X*	2	1
A-2	1	-	1	1	2	2	2	1*	1*	2	X*	2	1
A-3	1	1	-	1	2	2	2	1	1	2	X*	2	1
A-4	1	1	1	-	2	2	2	1	1	2	X*	2	1
B-1	2	2	2	2	-	2	2	2	2	2	X*	2	2
B-2	2	2	2	2	2	-	1	2	2	2	X*	2	2
B-3	2	2	2	2	2	1	-	1	2	2	X*	2	2
C	1	1*	1	1	2	2	1	-	1	2*	X*	2*	1*
D	1	1*	1	1	2	2	2	1	-	X	3	X	X
E	2	2	2	2	2	2	2	2*	X	-	3	X	X
F-1	X*	X*	X*	X*	X*	X*	X*	X*	3	3	-	2	2
F-2	2	2	2	2	2	2	2	2*	X	X	2	-	X
F-3	1	1	1	1	2	2	2	1*	X	X	2	X	-

In accordance to the fire-resistance separations, the ratings may also be interpreted in the following order:

1. Highly Compatible **2. Moderately Compatible** **3. Conditionally Compatible** **X. Not Allowed**

* Disclaimer: These adjacencies have exceptions to the above fire-resistance ratings. See the BC Buiding Code for details.

TABLE 9. EMERGING INDUSTRIAL: CREATIVE PRODUCT MANUFACTURING

Creative Product Manufacturing (CPM) is an emerging industrial use that requires greater clarification in Vancouver zoning policies to help advance industrial intensification. The definition in Section 2 of the zoning by-law is as follows,

"The use of premises for the creation, development, prototyping and ancillary marketing of products produced in a physical or digital form that are the result of a customised design process, including but not limited to: clothing design, furniture design, industrial product design, technological equipment design, and similar uses."

CPM is a broad term that is based on activity and operations rather than industry and program classifications. Thus there is a lack of general understanding with regards to what specific uses may fall under CPM and its potential to provide compatible programs in mixed use buildings is underdeveloped. In response to this, a number of relevant and emerging uses have been collected below. **Table 9 organizes particular uses and matches them to a potential occupancy group in the BC Building Code. These are presented from highest to lowest mixed-use potential (i.e. compatibility).** These are informed by their occupancy classification, operations, emissions, and potential users. The BC Building Code does not have a general occupancy category for CPM and interpretation regarding the major occupancy classification is ambiguous. To gain a better understanding of CPM and its type of users, manufacturing processes can be grouped within the following segments:[52]

- Museums and Galleries
- Libraries
- Marketing and Advertising
- Product Design, Fashion Design, and Graphic Design
- Architecture
- Crafts
- TV, Video, Photography, Film, and Radio
- Publishing
- Software and Computer Services
- Music, Performing, and Visual Arts

Higher mixed-use potential

A-2

USE CLASSIFICATION IN BCBC	
Art galleries Exhibition halls	
Licensed beverage establishments Museums	

D

Offices	Social Media Marketing

F-3

USE CLASSIFICATION IN BCBC	PROGRAM	PROGRAM
Factories	Snack Foods Maker	Musical Instrument Maker
	Watchmaker	Soap production
	Sports Equipment	Cultural products
	Embroiderer	Toy Maker
	Architectural acitivities	Fashion designing
Laboratories	Visual Effects	Augmented and virtual reality
	Creative hubs	3D Printing
	R&D	Maker space/multimedia lab
	Robotic systems	Hakerspace
Power plants	Blockchain technology	
Storage garages		
Warehouses	Cyber Security	
Salesrooms		
Storage rooms		

Lower mixed-use potential

F-2

USE CLASSIFICATION IN BCBC	PROGRAM
Repair garages	Equipment and Instrument repair
Television studios (without viewing audience)	Advertising production
	Photography studio
	Production studios
	Video Game production
	Sound recording and music production
Warehouses	
Wholesale rooms	
Woodworking factories	
Workshops	Pottery studio

TABLE 4. INDUSTRIAL COMPATIBILITY MATRIX

			Light				Medium				Heavy		
			Light Manufacturing		Warehouse	Other	Manufacturing (Material and Products)				Miscellaneous		
~~Category~~ Category	~~Description~~ Description	~~Land Use~~ Land Use	Food/Beverage Products Manufacturing, Coffee Roasters	Clothing, Creative Products, Jewellery, Textile or knit goods	Storage, Wholesale, Distribution Centre	Brewing/ Distilling, Bakery products	Chemical Products, Biotech	Furniture/Fixtures, Wood products, Pulp, rubber, Shoes/Boots, Leather, Paper, Plastics, Wood, Miscellaneous	Information Communication Technology, 3D Printing, VR, e-commerce	Linoleum, non-metallic mineral, machinery/ equipment, petroleum/coal, transportation equipment, metals, motor vehicle parts	Casino	Data Centre *	Aircraft landing place, Junk Yard/Shop, Cardlock fuel station, Booming Ground
Residential	Residential/ Dwelling Unit	D	Compatible*	Compatible*	Compatible*	Incompatible	Noxious	Noxious	Compatible*	Noxious	Noxious	Noxious	Noxious
	Artist Studio	C	Incompatible	Compatible	Compatible	Compatible*	Noxious	Compatible*	Compatible*	Incompatible	Noxious	Noxious	Noxious
	Bingo Hall	C	Incompatible	Compatible*	Compatible*	Compatible*	Incompatible	Noxious	Compatible	Noxious	Compatible	Noxious	Noxious
Commercial	Fitness Centre	C	Compatible*	Compatible	Compatible	Compatible*	Compatible*	Incompatible	Compatible	Noxious	Compatible	Noxious	Noxious
	Theatre	C	Noxious	Compatible*	Incompatible	Noxious	Noxious	Noxious	Incompatible	Noxious	Compatible*	Noxious	Noxious
	Sign Painting Shop	C	Incompatible	Compatible	Compatible	Incompatible	Compatible	Compatible	Compatible	Noxious	Incompatible	Noxious	Noxious
Institutional	Church	I	Incompatible	Compatible	Compatible	Incompatible	Compatible*	Noxious	Compatible*	Noxious	Noxious	Noxious	Noxious
Office	Design Offices	n/a	Compatible	Compatible	Compatible	Compatible	Compatible*	Compatible*	Compatible	Noxious	Noxious	Noxious	Noxious
	Info., Comm., Tech., Manufact. Offices	n/a	Compatible*	Compatible*	Compatible	Compatible	Compatible*	Compatible*	Compatible	Noxious	Noxious	Compatible*	Noxious
	General Office	O	Compatible	Compatible*	Compatible	Compatible	Compatible	Incompatible	Compatible*	Noxious	Compatible*	Noxious	Noxious
	Financial Institution	O	Compatible	Compatible*	Compatible	Noxious	Incompatible	Incompatible	Compatible*	Noxious	Incompatible	Noxious	Noxious
	Health Care Office	O	Compatible	Compatible*	Compatible	Incompatible	Compatible*	Incompatible	Compatible*	Noxious	Noxious	Noxious	Noxious
	Health Enhancement Centre	O	Compatible	Incompatible	Compatible	Incompatible	Compatible*	Incompatible	Incompatible	Noxious	Noxious	Noxious	Noxious
	Cannabis Store	R	Noxious	Compatible*	Compatible	Incompatible	Compatible*	Incompatible	Compatible	Noxious	Incompatible	Noxious	Noxious

* The City allows Bulk Data Storage as a conditional use in some industrial zones provided it is not on the ground floor. As per the VBBL, Bulk Data storage is F2 as a primary use, but can mix with office- or tech- related uses if it is considered a server room. In this case, it can be considered subsidiary/ancillary to the major occupancy it serves.

TABLE 4. INDUSTRIAL COMPATIBILITY MATRIX

			Light				Medium				Heavy		
			Light Manufacturing		Warehouse	Other	Manufacturing (Material and Products)				Miscellaneous		
Category	**Description**	**Land Use**	Food/Beverage Products Manufacturing, Coffee Roasters	Clothing, Creative Products, Jewellery, Textile or knit goods	Storage, Wholesale, Distribution Centre	Brewing/ Distilling, Bakery products	Chemical Products, Biotech	Furniture/Fixtures, Wood products, Pulp, rubber, Shoes/Boots, Leather, Paper, Plastics, Wood, Miscellaneous	Information Communication Technology, 3D Printing, VR, e-commerce	Linoleum, non-metallic mineral, machinery/ equipment, petroleum/coal, transportation equipment, metals, motor vehicle parts	Casino	Data Centre *	Aircraft landing place, Junk Yard/Shop, Cardlock fuel station, Booming Ground
Retail	Farmer's Market	R	Noxious*	Compatible*	Compatible	Compatible*	Noxious	Noxious	Compatible*	Noxious	Noxious	Noxious	Noxious
	Furniture or Appliance Store	R	Noxious	Compatible*	Compatible	Compatible*	Compatible*	Compatible*	Compatible*	Incompatible	Noxious	Noxious	Noxious
	Restaurant	R	Noxious	Incompatible	Compatible*	Compatible*	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious
	Grocery or Drug Store	R	Noxious	Incompatible	Compatible*	Incompatible	Incompatible	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious
	Liquor Store	R	Noxious	Incompatible	Incompatible	Compatible	Incompatible	Incompatible	Noxious	Noxious	Compatible*	Noxious	Noxious
	Pawnshop/ Second-hand store	R	Noxious	Compatible	Compatible	Incompatible	Incompatible	Compatible*	Incompatible	Noxious	Compatible	Noxious	Noxious
	Retail Store	R	Noxious	Compatible	Compatible	Incompatible	Incompatible	Compatible*	Noxious	Noxious	Compatible	Noxious	Noxious
	Small-scale Pharmacy	R	Noxious	Compatible	Compatible*	Noxious	Compatible	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious
	Vehicle Dealer	R	Noxious	Incompatible	Compatible	Noxious	Incompatible	Incompatible	Compatible	Incompatible	Compatible*	Noxious	Noxious
Service	Auction Hall	S	Noxious	Compatible	Compatible	Noxious	Incompatible	Incompatible	Compatible*	Incompatible	Compatible	Noxious	Noxious
	Animal clinic	S	Noxious	Compatible*	Incompatible	Noxious	Compatible*	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious
	Barber Shop	S	Noxious	Compatible	Compatible	Noxious	Compatible	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious
	Catering Establishment	S	Incompatible	Compatible*	Compatible	Compatible	Incompatible	Noxious	Noxious	Noxious	Compatible	Noxious	Noxious
	Laboratory	S	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible*	Noxious	Noxious	Noxious	Incompatible	Noxious

TABLE 4. INDUSTRIAL COMPATIBILITY MATRIX

			Light				Medium				Heavy		
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Category	**Description**	**Land Use**	Food/Beverage Products Manufacturing, Coffee Roasters	Clothing, Creative Products, Jewellery, Textile or knit goods	Storage, Wholesale, Distribution Centre	Brewing/ Distilling, Bakery products	Chemical Products, Biotech	Furniture/Fixtures, Wood products, Pulp, rubber, Shoes/Boots, Leather, Paper, Plastics, Wood, Miscellaneous	Information Communication Technology, 3D Printing, VR, e-commerce	Linoleum, non-metallic mineral, machinery/ equipment, petroleum/coal, transportation equipment, metals, motor vehicle parts	Casino	Data Centre *	Aircraft landing place, Junk Yard/Shop, Cardlock fuel station, Booming Ground
Service	Laundromat or Dry Cleaning	S	Incompatible	Compatible	Compatible	Compatible*	Compatible	Compatible*	Compatible*	Noxious	Incompatible	Noxious	Noxious
	Production or Rehearsal Studio	S	Incompatible	Compatible*	Compatible	Incompatible	Compatible	Incompatible	Incompatible	Noxious	Incompatible	Noxious	Noxious
	Hotel	S	Noxious	Compatible*	Compatible*	Compatible*	Noxious	Noxious	Noxious	Noxious	Compatible	Noxious	Noxious
	Workshop	S	Compatible*	Compatible	Compatible	Incompatible	Compatible	Compatible	Compatible	Noxious	Noxious	Noxious	Noxious
	Motor Vehicle Repair Shop	S	Incompatible	Incompatible	Compatible	Noxious	Incompatible	Compatible	Noxious	Compatible*	Noxious	Noxious	Noxious
	Motor Vehicle Wash	S	Noxious	Incompatible	Incompatible	Noxious	Incompatible	Noxious	Compatible*	Noxious	Noxious	Noxious	Noxious
Transportation/ Storage	Packaging Plant	T	Compatible	Compatible	Compatible	Compatible*	Compatible	Compatible	Compatible	Compatible*	Noxious	Noxious	Noxious
	Taxicab or Limosine Station	T	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Compatible	Noxious	Compatible	Noxious	Noxious
	Truck Terminal or Courier Depot	T	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Noxious	Compatible	Noxious	Noxious	Noxious
	Weighing or Inspection Station	T	Noxious	Noxious	Compatible	Noxious	Noxious	Noxious	Incompatible	Noxious	Noxious	Noxious	Noxious
	Works Yard	T	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious
Utility and Communication	Radio-Communication Station	U	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious
	Recycling Depot	U	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious
	Utility and Communication Uses	U	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious
	Waste Disposal Facility	U	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious	Noxious

Industrial Typologies

Evolving industrial operations entail new classifications and expansion of the definition, “industrial”. There are more possibilites to intensify industrial lands by including types of uses that are not yet addressed. Also, compatibility can be better understood by acknowledging and identifying variances within existing uses. This means re-evaluating definitions and collaborating between multiple disciplines, like experts in relevant fields--to gain specific insights on user needs.

This section is a collection of characteristics that are commonly found in traditional and non-traditional light-industrial buildings.

A number of industrial operations, potential conflicts, examples, and resources offer an alternative way of identifying industrial uses - according to their major operations. By grouping industrial uses in this way, conflicts are easier to identify and mitigation strategies can be shared.

Caltech Center For Autonomous Systems & Technologies. Image source: CoArchitects.com

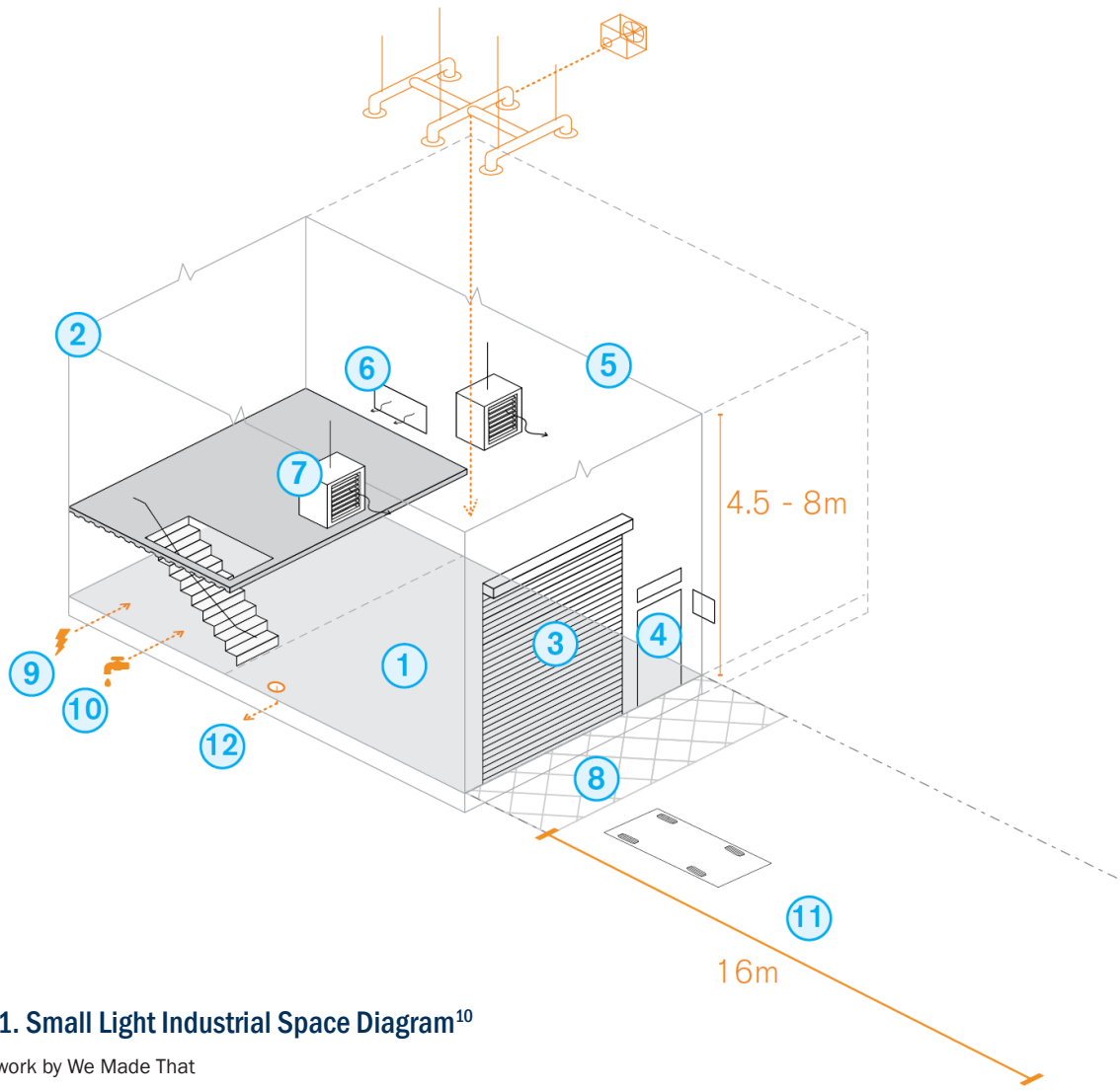


Figure 11. Small Light Industrial Space Diagram[10]

Based on work by We Made That

Image Source: Mayor of London - Industrial Intensification Primer

Typical Elements of a Small Light Industrial Space

1. Less than 500 m^2 floor area
2. Double height ceiling allows for administration mezzanine. May also be provided adjacent to loading doors in wider units.
3. Roller-shuttered doors for deliveries (min. height 3.7 m and width 2.4-3 m)
4. Separate staff/ visitor access with signage
5. Spanning structure for flexible internal layout without columns interruptions
6. Heating to office areas
7. Blow air heating for work areas
8. External loading area
9. 3 phase power
10. Water supply
11. Access to a clear 16 m deep yard space for van or small truck deliveries
12. Drainage from floors areas

Note: Typically rectangular plan form with ratio of long to short sides between 1:1 (where no particular traffic routes are dictated by process) and 3:1.

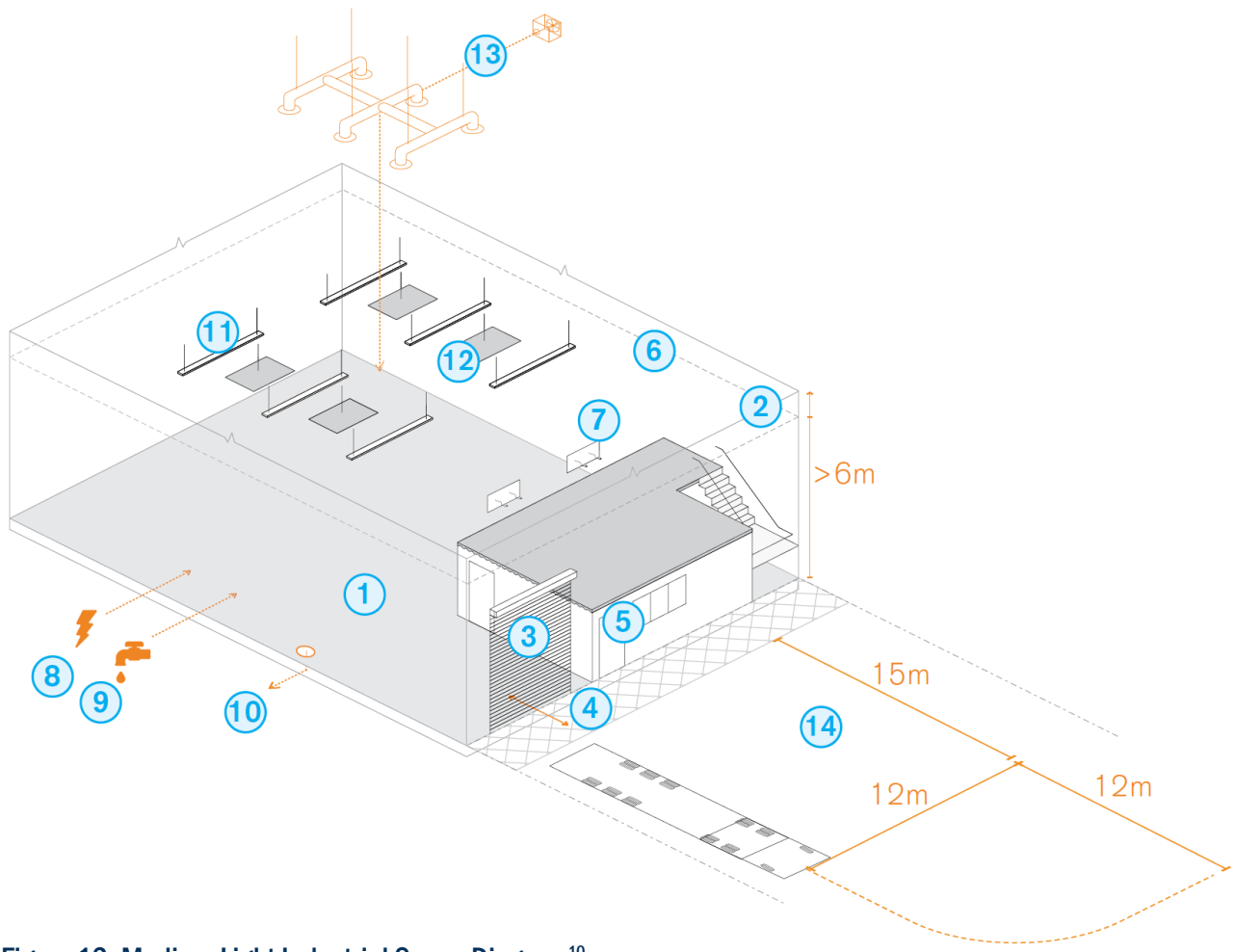


Figure 12. Medium Light Industrial Space Diagram[10]

Based on work by We Made That

Image Source: Mayor of London - Industrial Intensification Primer

Typical Elements of a Medium Light Industrial Space

1. Greater than 500 m^2 floor area
2. Double height ceiling allows for administration mezzanine. May also be provided adjacent to loading doors in wider units
3. Roller-shuttered doors for deliveries (min. height 4 m)
4. Smooth surface for internal to external movements, may require dock loading to meet height of HGVs
5. Separate staff/visitor access with signage
6. Large clear spans for flexible internal layout
7. Heating to office areas
8. 3 phase power
9. Water supply
10. Drainage from floor areas
11. High bay lighting
12. Radiant heating panels
13. Extract system
14. Yard space should allow 12 clear metres for HGV turning, 15 m for local bay and a clear min. height of 5.03 m for approach routes.

The following table describes compatibility concerns for major industries in Vancouver. Descriptions are sourced from *Section 2 Zoning and Development By-Law*. A brief note of relevant noxious operation processes is provided. These are not exhaustive or comprehensive, however they are indicative of mitigation needs and inform the compatibility matrix. See the compatibility matrix for a list of operational impacts.

Because the industrial typology encompasses such a great diversity of different uses, it is beneficial to subdivide them into classes. One way to do this is by assessing the noxious emissions and grouping industries based on potential disturbances. Light-industrial are the most compatible with non-industrial uses. In contrast, heavy industries must be standalone developments. Medium industrial uses are conditionally compatible with non-industrial depending on the operations and mitigation solutions.

Heavy Industrial Independent Uses

Aircraft Land Place
Animal Products Processing
Bulk Fuel Depot
Data Centre
Gasoline Station
Grain Elevator
Ice Manufacturing
Marina
Pulp Manufacturing
Recycling Depot
Waste Disposal Facility
Works Yard

A significant component of industrial uses is manufacturing. Traditionally, there have been five basic manufacturing processes:

- Repetitive
- Discrete
- Job Shop
- Continuous Process
- Batch Process

Contemporary considerations also include a sixth industry[53].

- 3D Manufacturing

Mechanical, electromechanical, electronic, and software-driven hardware products fall into the first three processes. Continuous process and batch process are operations that are defined by the production patterns and running times. Automation is covered in 3D Manufacturing.

For urban scale considerations, further research into the spatial requirements of each use is highly encouraged. By identifying design requirements of certain programs, there will be more flexibility for mixing different users.

Figure 13. Glyndebourne Production Hub (Image Source: Architecture Today)

Industrial Operation	Potential Conflicts	Example Uses	Resources
Mechanical Machinery-based	Running machines, emission of VOC, extensive cleaning operations, maintenance systems, automation, extended hours of operation etc. E.g. Textile manufacturing involves singeing, washing, steaming, bleaching, mercerizing, and dyeing. Note: Due to short product life manufacturers often prefer locations near consumers.	• Bakery products manufacturing • Food or Beverage Products • Paper Products Manufacturing • Coffee roaster • Cloud kitchen • Clothing, Fabrics, Textile or Knit Goods • Jewellery	***Sustainable Food and Beverage Industries***[54] Overview of food production and supply chains; the dairy, meat, coffee and tea industries; and food processing and packaging. **"Textile Manufacturing Processes"**[55] General overview of textile manufacturing. ***Materials and Manufacturing: An Introduction to How They Work and Why It Matters***[56] Comprehensive guide to concepts and applications. ***Manufacturing Facilities Design & Material Handling***[57] Textbook for facility design and layout.
Cultivation & Agriculture-based	Cultivation, processing, analytical testing, storing, fertilizing, etc. Note: Bright lighting and design issues related to security are also potential disturbances to adjacent uses. Some occupant-types have visual screening regulations that reduce public engagement with streetfront (e.g. Cannabis).	• Vertical farms • Cannabis	**"FVRD - Cannabis Regulation Update"**[58] Survey on public perception of Cannabis and production concerns. **"Cannabis and the Environment: What Science Tells Us and What We Still Need to Know"**[59] Description of potential operation conflicts.
Digital Entertainment Information Communication Technology and Data Storage	Automation, prototyping and testing, computer programming, 3D printing, server hosting, etc. Note: High security is often required. This may involve separated entranceways, restricted window placements, etc.	• Bulk Data Storage • Electrical Products or Appliances Manufacturing • 3D Printing • Virtual Reality • Robotics • E-commerce	**"Design Methods for Creative Industry Buildings"** [60] Functional, material, and strategic insights on Creative Industrial buildings. **"Departures from the Norm: Innovative Planning for Creative Manufacturing"**[61] Response to the changing industrial operations.

Industrial Operation	Potential Conflicts	Example Uses	Resources
Chemical-related	Material and chemical conditioning and containment, potentially reactive and hazardous chemicals, intense ventilation requirements. Note: Risk assessment required for biosafety labs, where classification is based on inherent characteristics. Risk Group 1: Low individual and low community risk Risk Group 2: Moderate individual risk, low community risk Risk Group 3: High individual risk, low community risk Risk Group 4: High individual risk, high community risk There are also Containment Levels 1-4, where CL1 requires no special design features and CL4 facilities are functionally isolated.	• Biosafety lab 1, 2, and 3 • Vivarium • Research lab	**"Lab Safety Design Standard"**[62] Design criteria for laboratory design **"Laboratory Biosafety Level Checklist & Microbe Guide"**[63] Overview of the types of Biosafety labs. **"Biosafety - Healthy and Safety Services"**[64] Descriptions and FAQs regarding biosafety labs. **"How to Reposition a Building for Life Science Tenants"**[65] Infrastructure essentials for life science buildings. **"Canadian Biosafety Standard (CBS) Second Edition"**[66] Government of Canada document with best practices and requirements.
Storage and Distribution	Loading and traffic needs, intensive lighting needs, extended hours of operation, and visual obstructions on site. Note: There are significantly different needs for conditioned versus unconditioned storage spaces. Heat, refrigeration, and controlled humidity warehouses require specific construction methods for their operations.	• Fulfillment centre • Warehouse • Distribution centre • Logistics	**"Warehouse and Distribution Centre"**[67] Overview of warehouse building attributes and requirements. **"15 Considerations in Warehouse Space Planning"**[68] Layout and design elemens for effective warehouse construction. **"Buildings for Industrial Storage and Distribution"**[69] Manual of Policies and Practices.
Film and Production	Set production, in-house effects capabilities, editing suites, production equipment storage, intensive lighting and electrical needs. Note: The film industry in Vancouver is generally located in clusters and occupy large areas of land. Studios may need backlots -- allocated outdoor space for film recording.	• Computer labs • Editing suites • Music production studios • Post + Visual Effects • Rehearsal rooms • Game production	**"Recording Studio Design"**[70] Detailed and general requirements for recording studios. **"TV production spaces"**[71] Various design considerations from sound transmission to wall floor constructions. **"Study of Film and Screen Industry Studios in the Port Lands and South of Eastern Employment District"**[72] Assess, examines, and identifies opportunities and concerns in the industry.

Case Studies

A select number of case studies is collected that highlight commonalities and showcase characteristics within these types of developments. The focus is on stacked buildings that include non-industrial and industrial uses. This intensification strategy is still emerging in Canada, therefore there is a shortage of precedents in Vancouver that have a variety of mixed-use programs. Local (within Vancouver) and international examples are presented here to highlight mitigation strategies and design elements for diversifying and intensifying industrial developments.

Light-Industrial +Office

+ Daycare

+ Residential

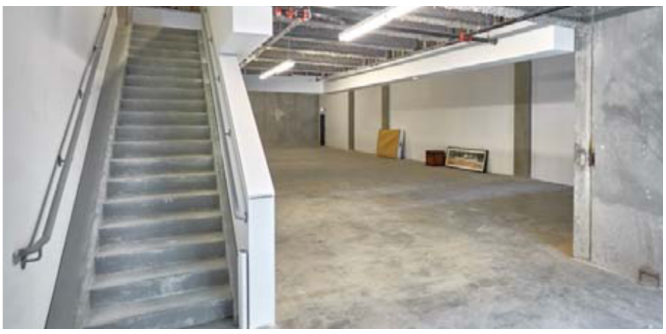
+ Residential + Retail

+ Retail + Office

+ Retail + Residential +Office

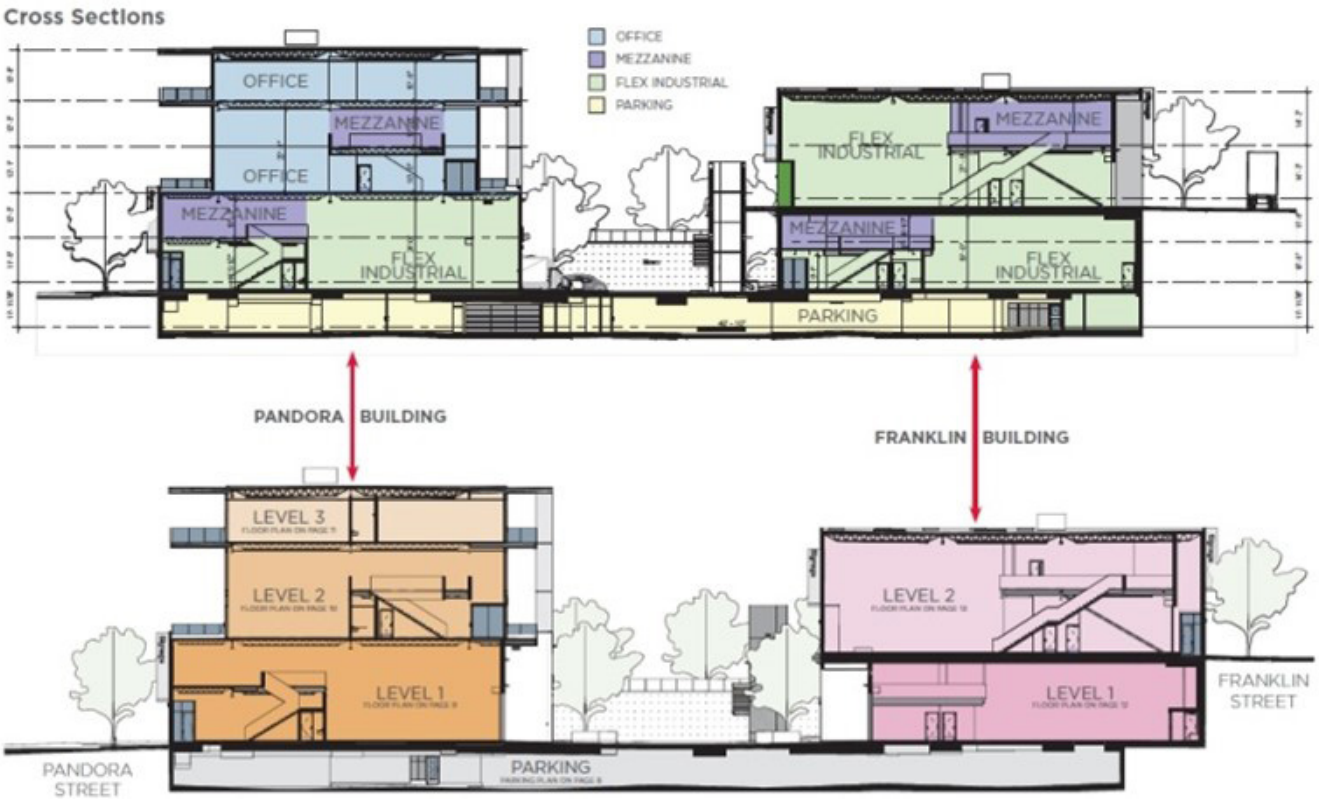
Mixed Use Residential

IRON WORKS



VANCOUVER

LIGHT-INDUST



Traffic/Loading

- Common dock loading with levelers
- Underground parking
- Freight and passenger elevator from parkade to lobby and mews
- Electric vehicle charging stations

Visual/Design

- Yard space concealed between buildings
- Showroom, office, industrial, and warehouse spaces
- 24’ ceiling heights on ground level
- Massing of building maintains neighbourhood street-scape

Air Quality

- Heat pumps in individual units

Lighting

- Automatic lighting in common areas

Zone	FSR	Floors	Site Area
I-2	2.03	4	102,400
Location	**Year Built**	**Architect**	**Developer**
220 Victoria Drive	2019	TKA+D	Conwest Group

TRIAL + OFFICE

MARINE LANDING

VANCOUVER

LIGHT-INDUST

Traffic/Loading

- 439 parking stalls
- At-grade and underground parking
- 50 oversized parking stalls
- At-grade loading bays for each unit
- Exterior 6’ corridors
- Separation of freight and pedestrian traffic
- 9’ parkade ceilings
- 3 freight elevators
- 2 passenger elevators

Visual/Design

- Variable ceiling heights
  Level 1 21’. Level 2 16’, Level 3+4 13’, Level 5 12’, Level 6 11’
- Flexible unit sizes (600-34,000 SF)
- Yard space concealed between buildings

Air Quality/Odour

- Kitchen exhaust up to roof

Zone	FSR	Floors	Site Area
I-2	2.42	6	340,000 SF
Location	**Year Built**	**Architect**	**Developer**
8188 Manitoba St	2024 est.	MGBA	Wesbild Dev.

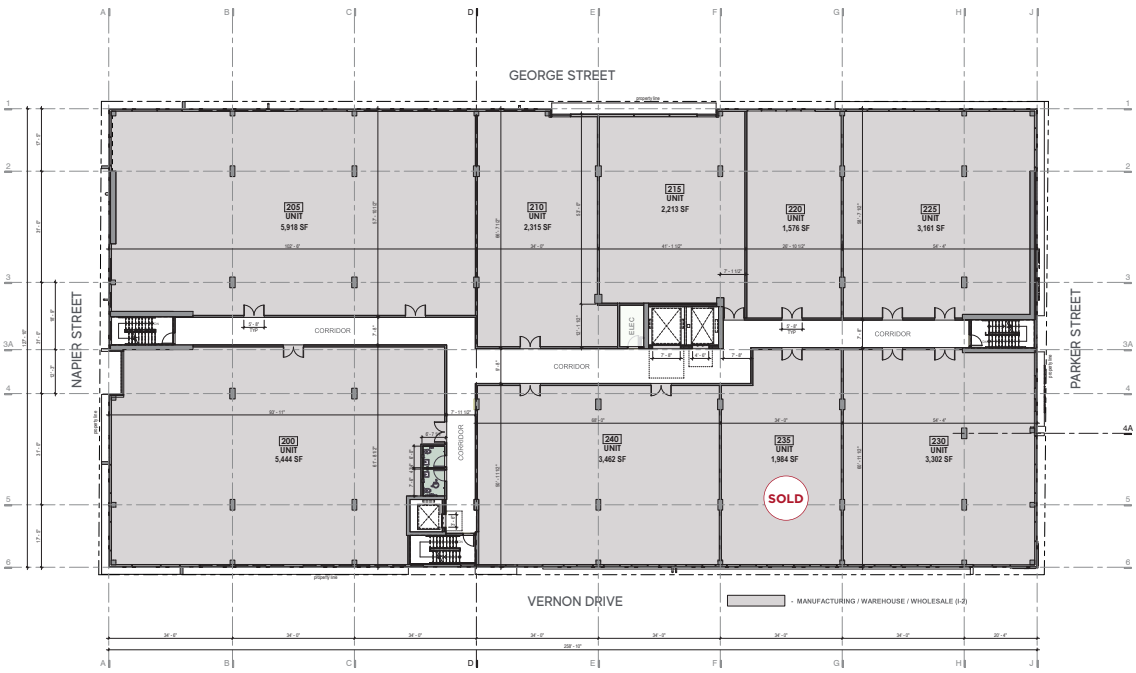
TRIAL + OFFICE

EVOLUTION BLOCK

VANCOUVER

LIGHT-INDUST

FLOOR 2 / CREATIVE INDUSTRIAL



Traffic/Loading

- Common loading court with dock loading and levellers
- Underground parking loading space accommodates up to 10’ clearance
- 2 high-speed oversize capacity elevators

Air Quality

- Separate metered utilities for full autonomy
- Rooftop exhaust piping

Noise

- Efficient heating and cooling systems
- Concrete construction

Visual/Design

- 10’6-13’6” Office floor-to-ceiling height
- 18’ Creative industrial clear and ceiling heights
- Flexible unit sizes (1,400 - 35,000 SF)
- HVAC aluminum louver screen and gate

Lighting/Electricity

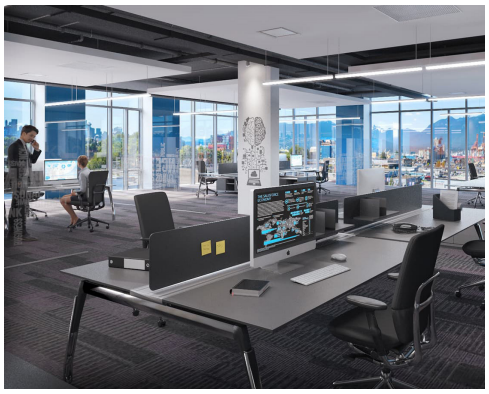
- Full height, energy performance glazing on North and South
- Generator provided

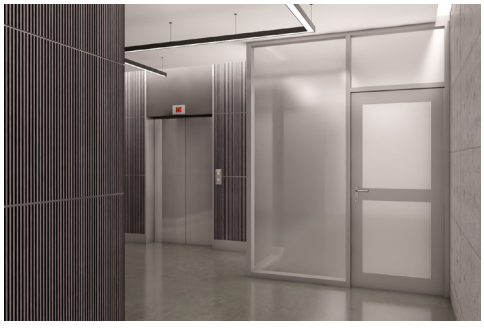
Odour

- Underground garbage/recycling

Zone	FSR	Floors	Site Area
I-2	3.0	4	34,816 SF
Location	**Year Built**	**Architect**	**Developer**
1055 Vernon Dr	2021	Christopher Bozyk	PC Urban

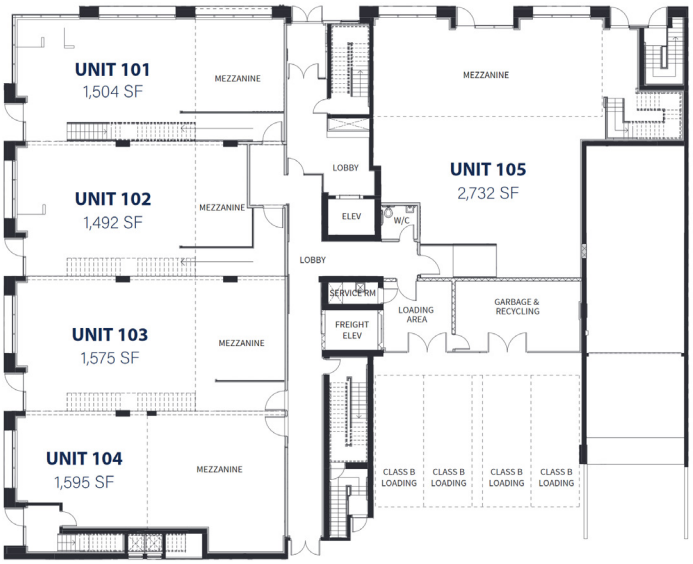
TRIAL + OFFICE

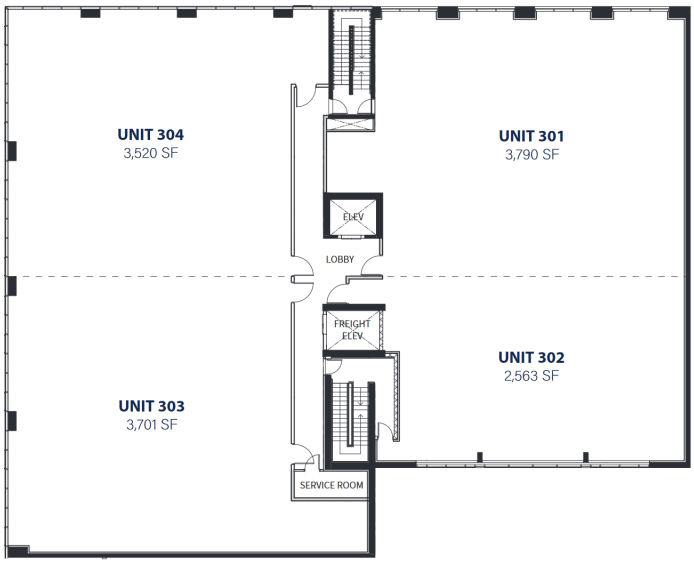




VANCOUVER

LIGHT-INDUST





Traffic/Loading

- Floor 250 lb/SF load
- Freight elevator
- Underground parking

Odour

- Ventilation and mechanical systems on roof-top above occupiable programs

Lighting

- 200 amps, 3-phase electrical service per unit
- High efficiency lighting

Visual/Design

- Oversized double pane windows throughout
- 32’ clear ceiling on Level 1 (12-14’ ceiling mezzanine)
- 15’ clear ceiling on Level 3
- Screening of mechanical systems

Air Quality

- Fan coil HVAC to all units

Noise

- Concrete construction

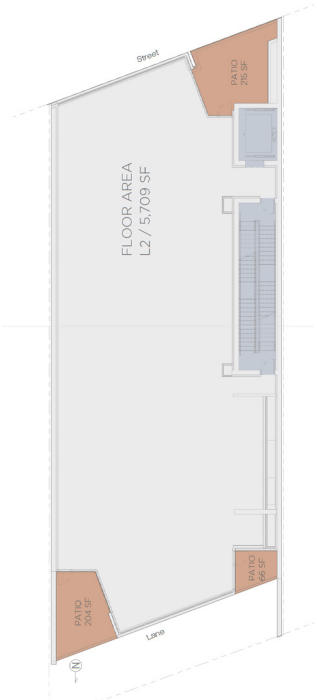
Zone	FSR	Floors	Site Area
I-2		5	18,391 SF
Location	**Year Built**	**Architect**	**Developer**
1308 Adanac	2022 est.	TKA+D	Union Allied

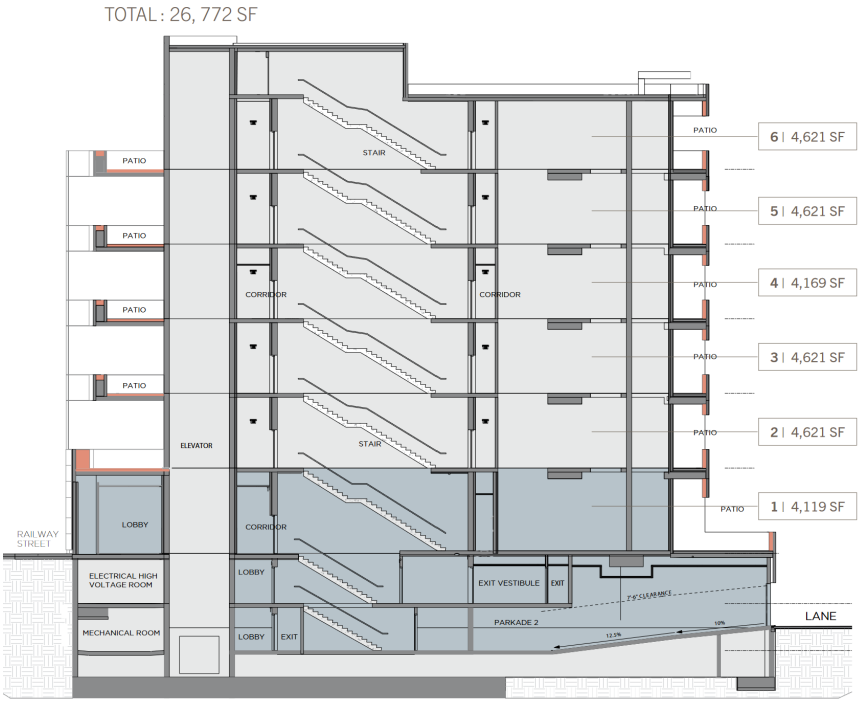
TRIAL + OFFICE

BENCH RAILTOWN

VANCOUVER

LIGHT-INDUST





Traffic/Loading

- 2 loading bays with dock levellers
- 2 class 'A' loading spaces on level P1
- 100 lbs/psf live loading on all floors
- Dual entry elevator off common entrance
- Oversized door and freight capacity
- Electric vehicle charging stations
- Underground parking

Air Quality

- High efficiency heat pumps (1 ton per 350 square feet

Visual/Design

- 16' ceiling heights on ground level; 14' on floors 2-6
- Massing of building maintains neighbourhood street-scape
- Occupant use is CPM

Lighting

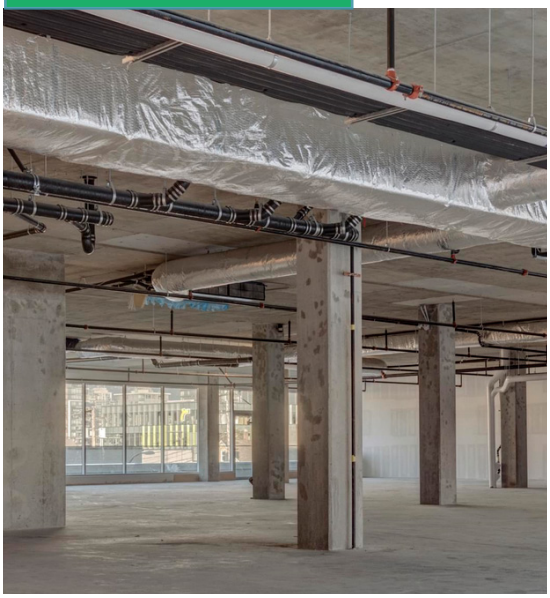
- 600A 347/600V three phase main service
- Ample floor to floor electrical capacity
- Lighting connections according to tenant's space plan

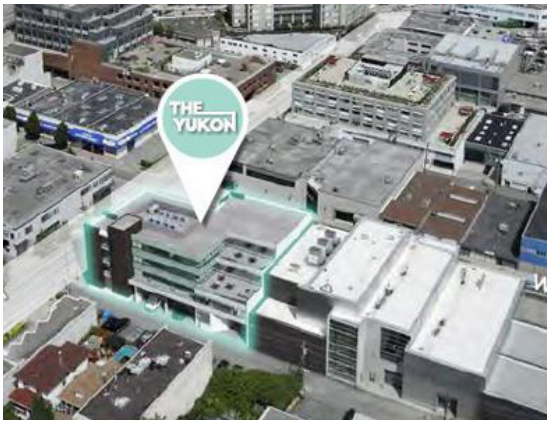
Noise

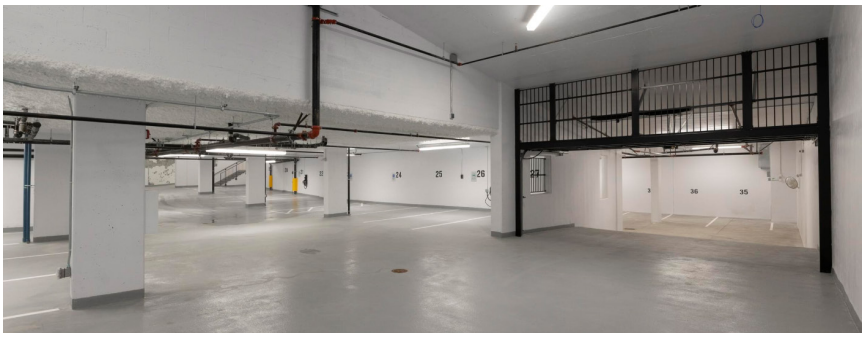
- Concrete slabs and columns
- Double glazed windows
- Below-ground mechanical room

Zone	FSR	Floors	Site Area
I-4	5.35	6	6,580
Location	**Year Built**	**Architect**	**Developer**
353 Railway St.	2020	Gair Williamson	Rendition Dev.

TRIAL + OFFICE







VANCOUVER
LIGHT-INDUST

Level 1

Level 4

Traffic/Loading

- 83 parking stalls (3 levels underground)
- Commercial Class B loading bays off alleyway (one shared, serviced by scissor lift; two separate, for purchase)
- Double-door elevator for light industrial spaces

Noise

- Concrete construction

Visual/Design

- 17’ ceiling on ground floor
- 11’ ceiling on floors 2-4
- Customizable unit sizes
- Mechanical unit screening at roof

Air Quality

- Ventilation at rooftop

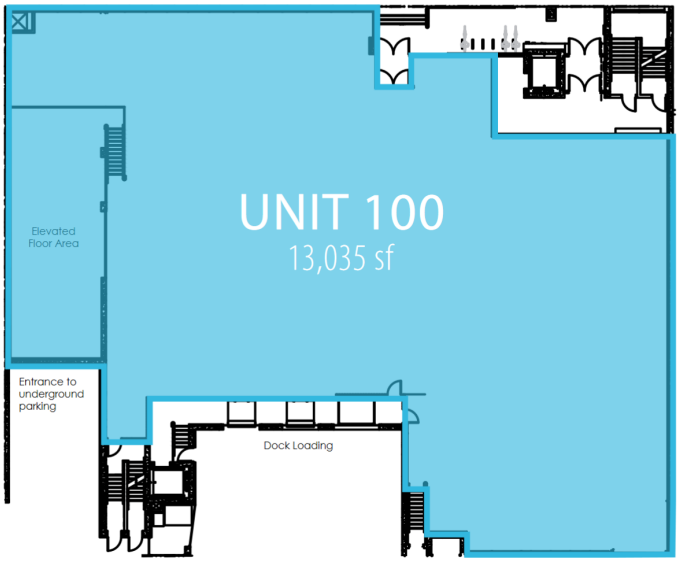
Lighting

- Motion-activated lighting

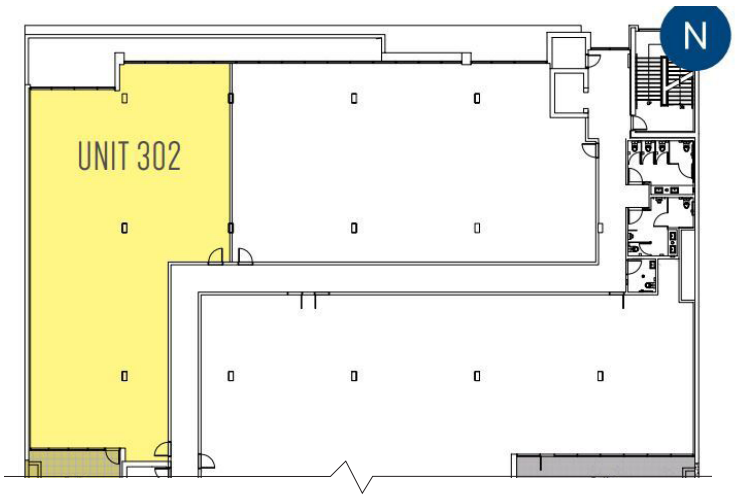
Zone	FSR	Floors	Site Area
I-1	3.00	4	48,619 SF
Location	**Year Built**	**Architect**	**Developer**
2238 Yukon St.	2018	Proscenium Arch.	Chard Dev.

TRIAL + OFFICE

VANCOUVER
LIGHT-INDUST



Level 1



Upper Level

Traffic/Loading

- 2 levels underground parking
- Loading elevator provides access to only P1 level
- Class A loading bay in P1
- 3 Class B loading bays accessed via the lane

Visual/Design

- 11-17' ceilings
- Shell condition for flexibility
- Variable unit sizes

Noise

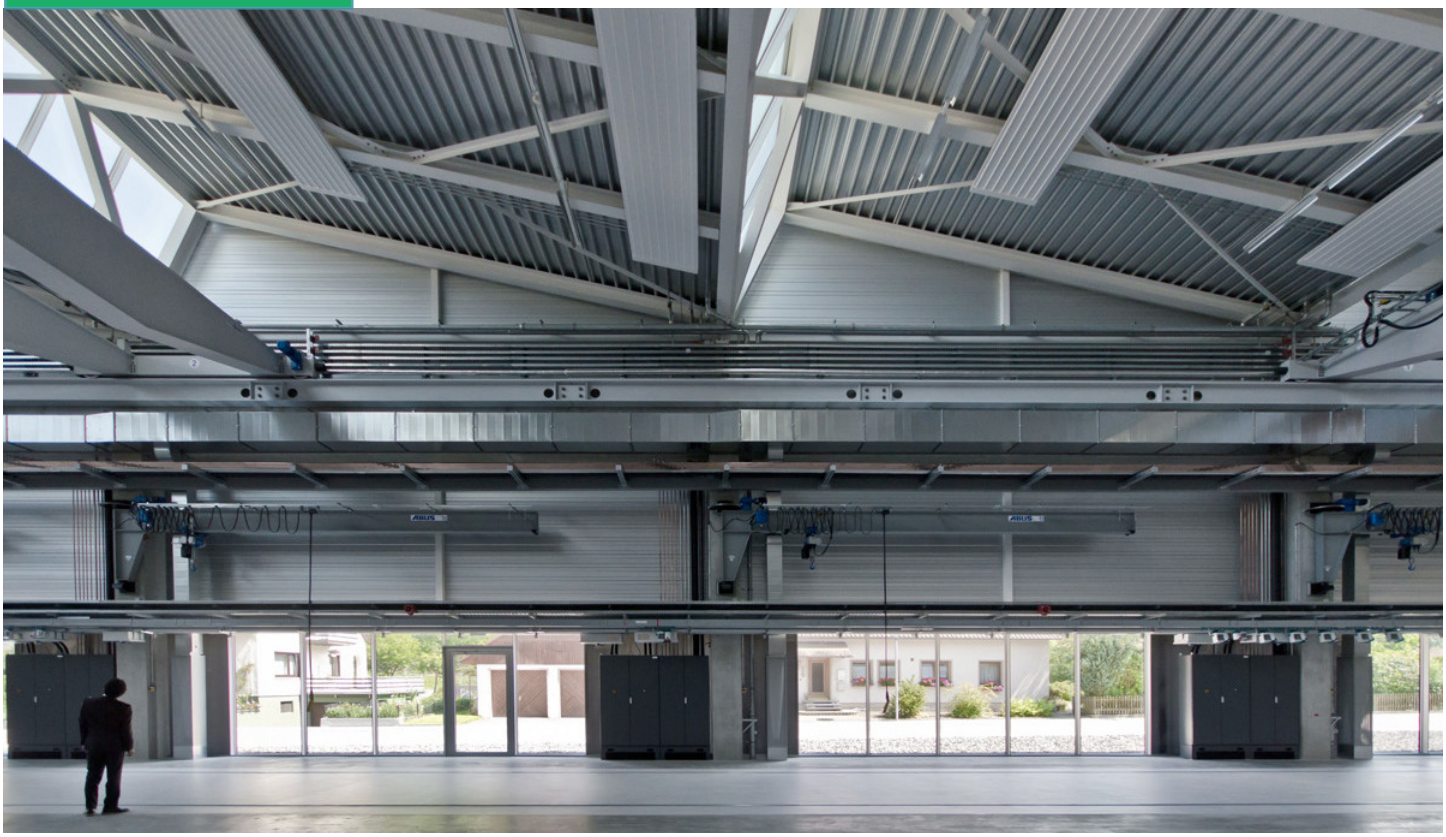
- Heat pump protection required in strata
- Composite metal cladding to minimize noise
- Post-tensioned slab

Lighting

- 3 Phase - 200 Amps
- Abundant natural light

Zone	FSR	Floors	Site Area
I-1	3.00	4	54,575
Location	**Year Built**	**Architect**	**Developer**
34 W 7th Ave.	2018	Proscenium Arch.	Chard Dev.

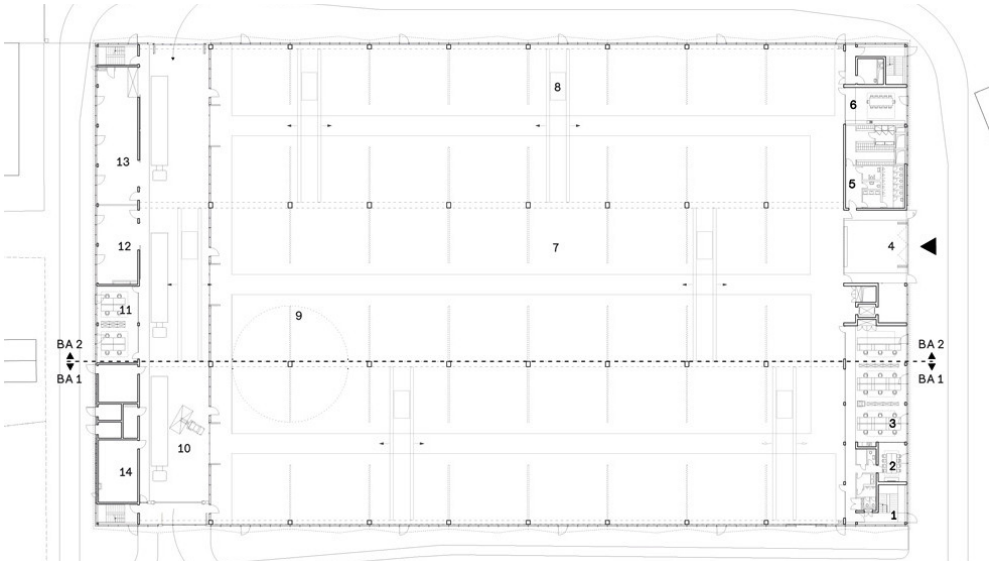
TRIAL + OFFICE



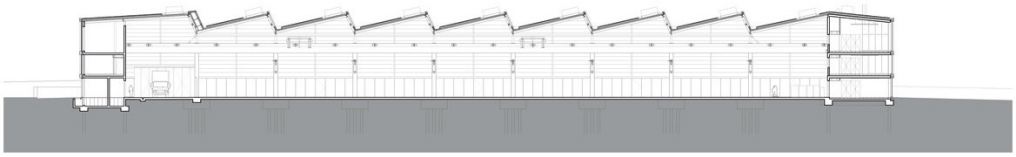
PRODUCTION HALL HETTINGEN

HETTINGEN

LIGHT-INDUST



1. Entrance stage 1
2. Conference room
3. Offices
4. Future main entrance
5. Locker room
6. Break room
7. Production hall
8. Crane runway
9. Lever
10. Dispatch hall
11. Dispatch office
12. Storage
13. Carpenter
14. Power station



Longitudinal section

Traffic/Loading

- Drive through loading bay

Air Quality

- Open plan production hall

Noise

- Office uses along perimeter; manufacturing along interior
- Mechanical room separated with loading bay as use buffer
- Offices spatially separated by circulation or storage

Visual/Design

- Column-free, flexible space
- 13m ceiling
- 24m wide bays
- Steel construction
- corrugated metal and glass to scale the building to the neighboring single family houses
- roof as a 5th facade planted with local vegetation to better integrate into the scenic valley.

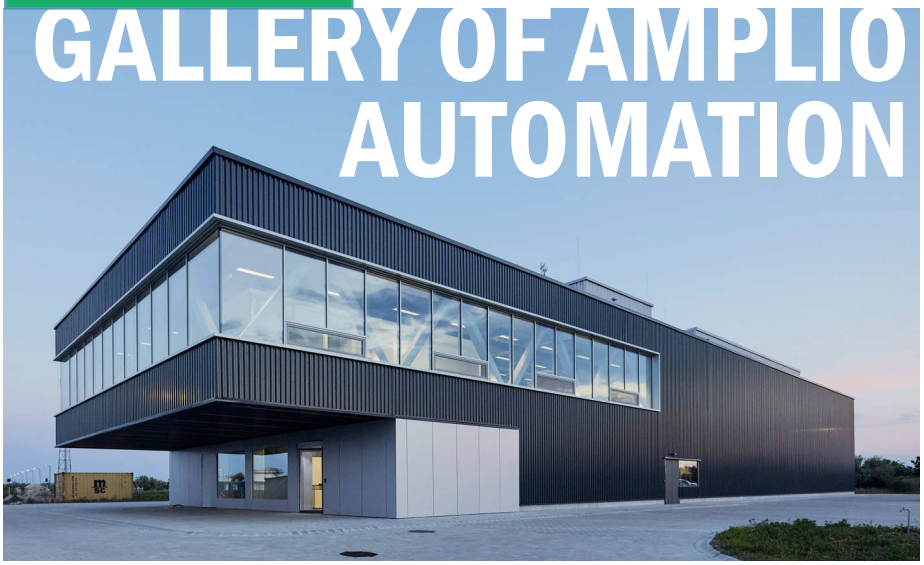
Lighting

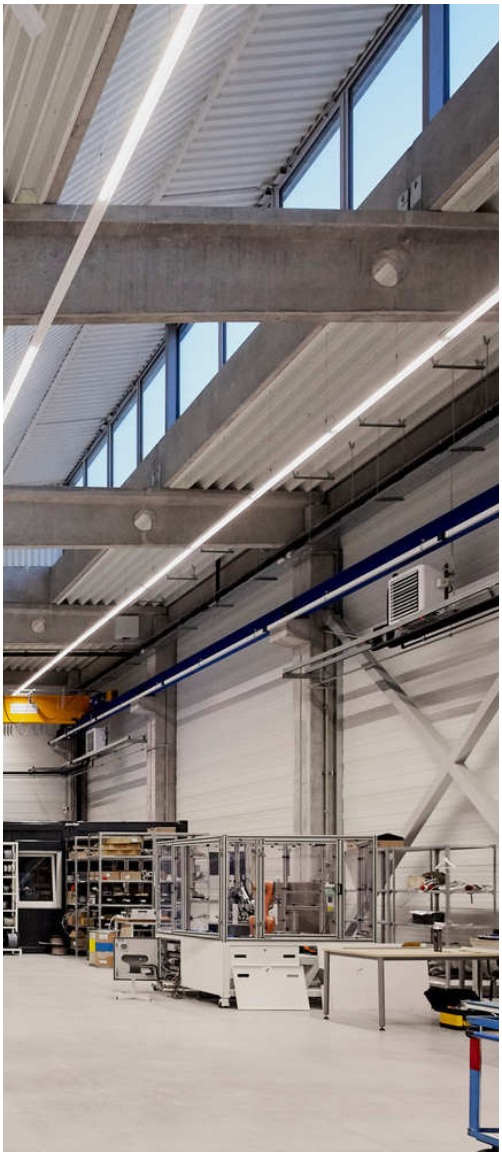
- Abundant natural light for industrial and offices

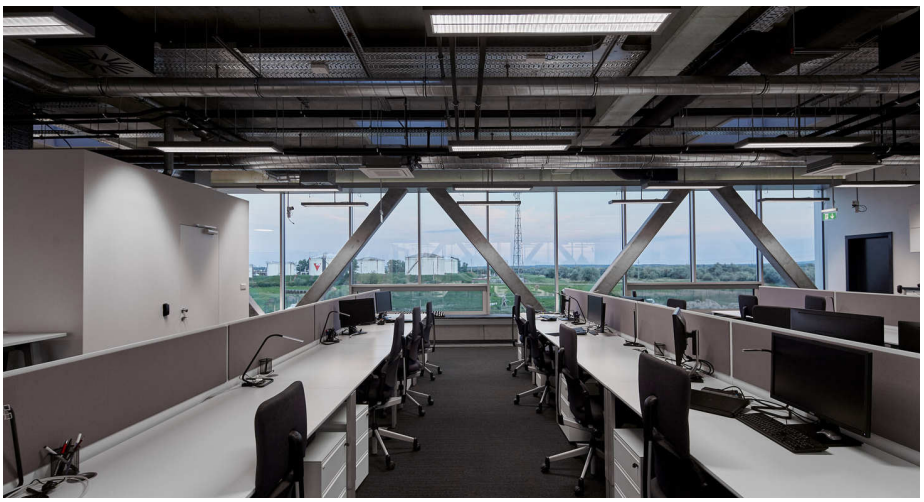
Zone	FSR	Floors	Site Area
N/A	-	1-3	126,475 SF
Location	**Year Built**	**Architect**	**Developer**
Hettingen, Germany	2018	Barkow Leibinger	N/A

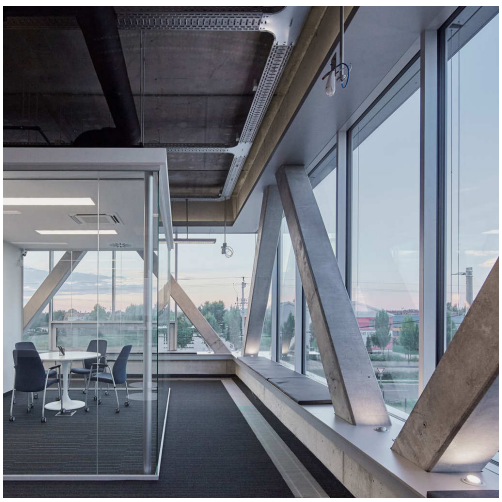
TRIAL + OFFICE

GALLERY OF AMPLIO AUTOMATION



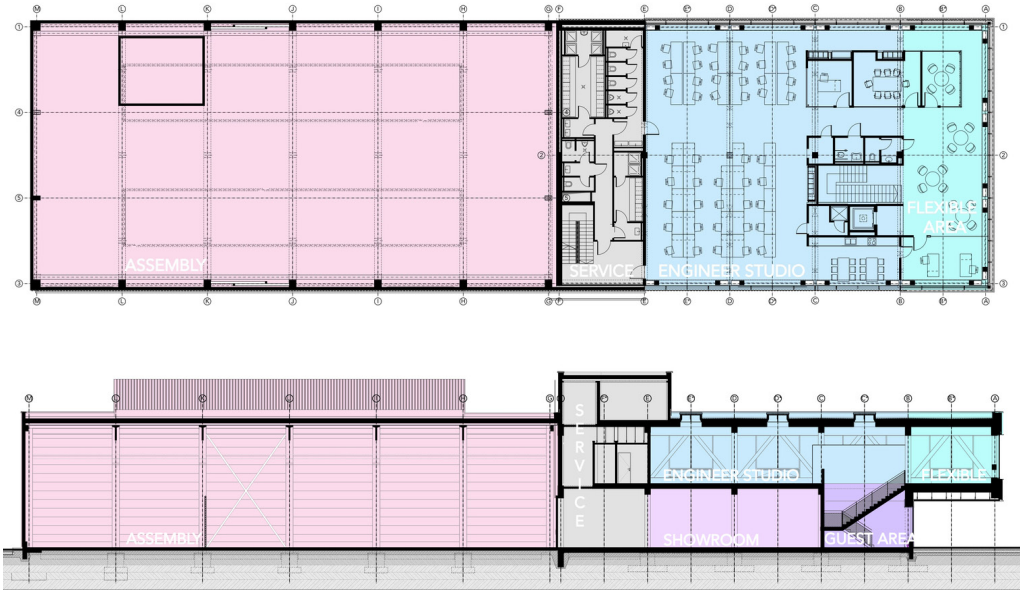


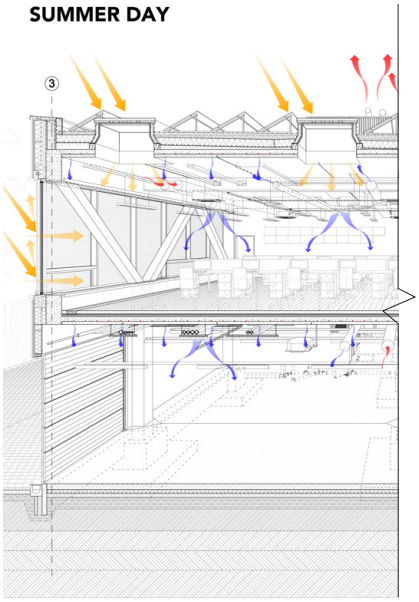




SZELESFEHERVAR

LIGHT-INDUST





Traffic/Loading

- 2 loading bays
- Covered parking under flexible space/lounge

Air Quality

- Access control system detects human presence; building knows exactly how many people are in each room and adjusts the lighting, ventilation, and heating accordingly
- Natural ventilation
- Fully automated HVAC system

Odour

- HVAC systems on rooftop

Visual/Design

- Smart automated storage
- Aluminum composite exterior facade
- Clashless construction engineering

Lighting

- Large glass windows around office
- Skylight in assembly space
- LED lighting

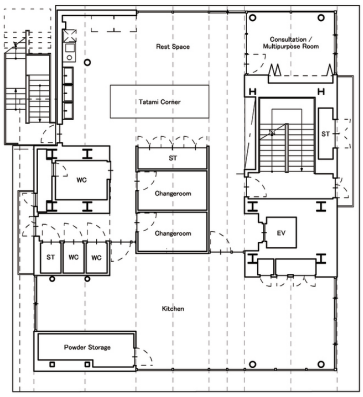
Noise

- Carpet office floors for acoustic dampening
- Concrete walls

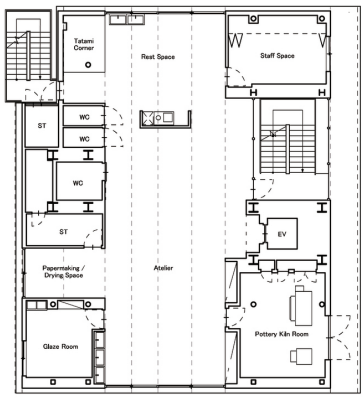
Zone	FSR	Floors	Site Area
-	-	2	19,375 SF
Location	**Year Built**	**Architect**	**Client**
Szelesfehervar, Hungary	2018	T2.a Architects	Amplio

TRIAL + OFFICE

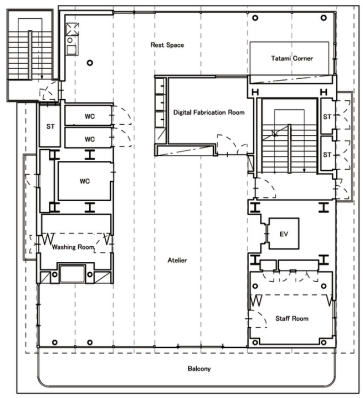
PALETTE



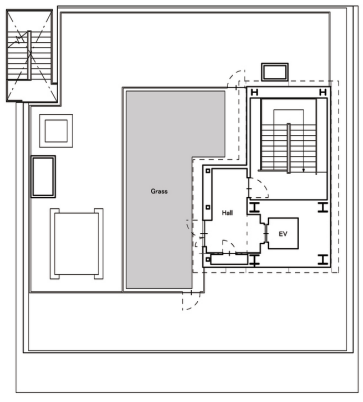
2F PLAN



3F PLAN



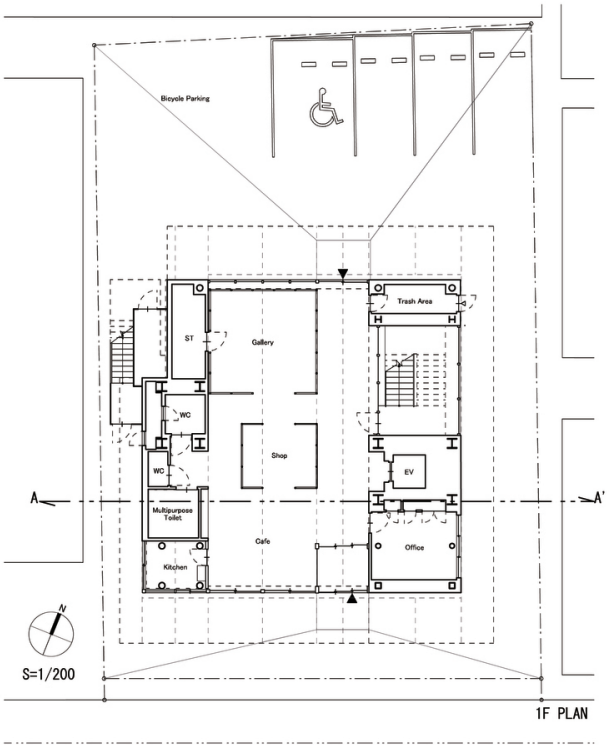
4F PLAN

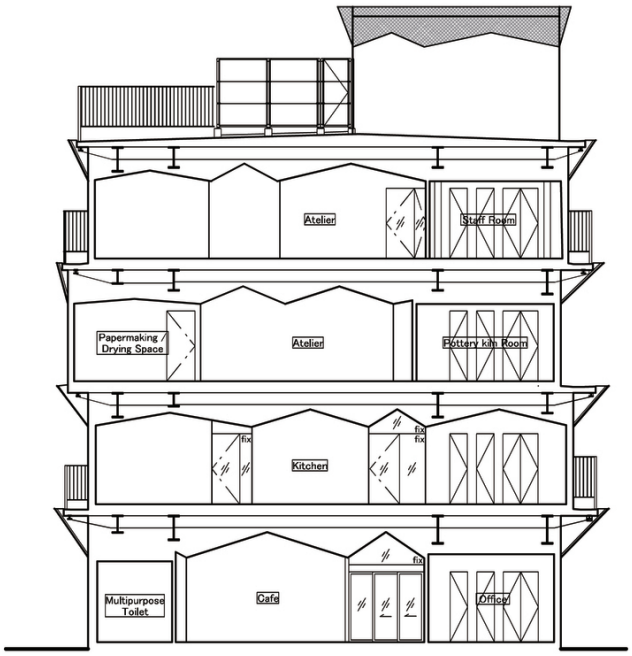


5F PLAN

YODOGAWA WARD

LIGHT-INDUST





Traffic/Loading

- Shared lobby
- Accessible

Air Quality

- Cross-ventilation

Noise

- Concrete flooring; brick walls
- Mechanical system on rooftop

Lighting

- Abundant natural light

Visual/Design

- Facility for Support Services for Disabled where people with intellectual disabilities engage in manufacturing work
- Includes confectionary factory, ceramics factory (with kiln), printing factory with silk-screen equipment, art studio, cafe, gallery, studios, and shop

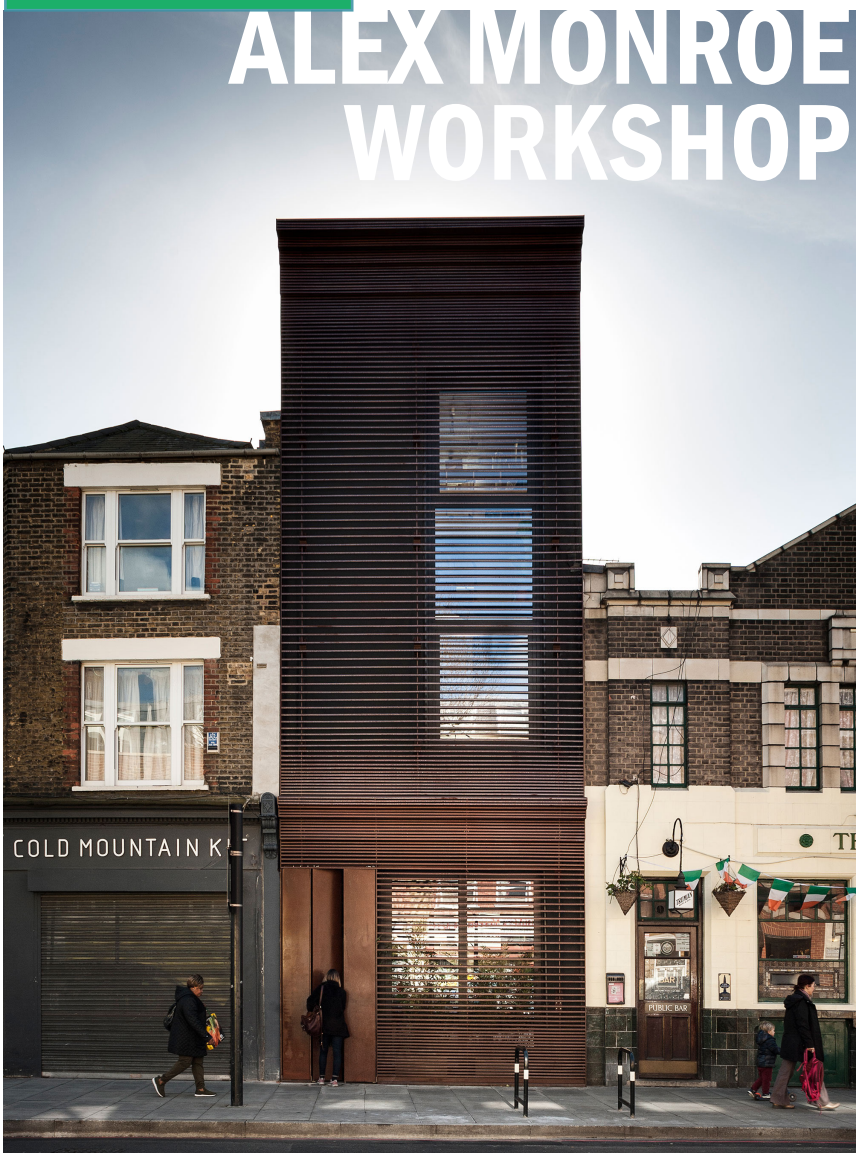
Odour

- Waste area spatially separated from programs by circulation
- Mechanical system on rooftop

Zone	FSR	Floors	Site Area
-	-	5	2185 SF
Location	**Year Built**	**Architect**	**Developer**
Yodogawa Ward, Osaka	2019	Kosuke Bando Architects	N/A

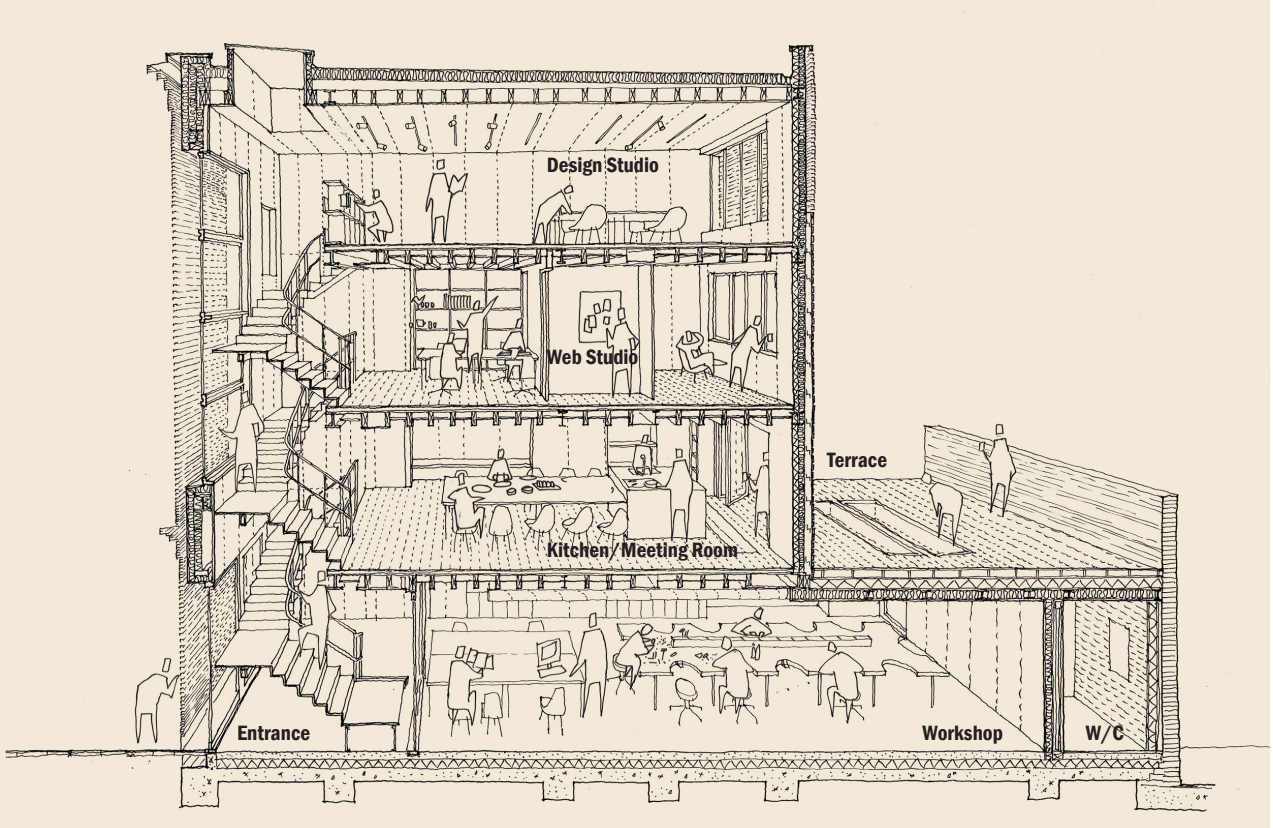
TRIAL + OFFICE

ALEX MONROE WORKSHOP



LONDON

LIGHT-INDUST



Traffic

- Staircase circulation acts as buffer against street

Odour

- Greater height than surrounding buildings

Air Quality

- Stack effect in stair atrium operable roof light
- Natural Ventilation in offices

Noise

- Mineral wool insulation

Visual/Design

- Hand-made jewellery workshop on ground floor, office spaces on floors 1-3. Located between pub and shop.
- Horizontal metal blade facade is sensitive to streetscape and creates gradient of exposure to public

Lighting

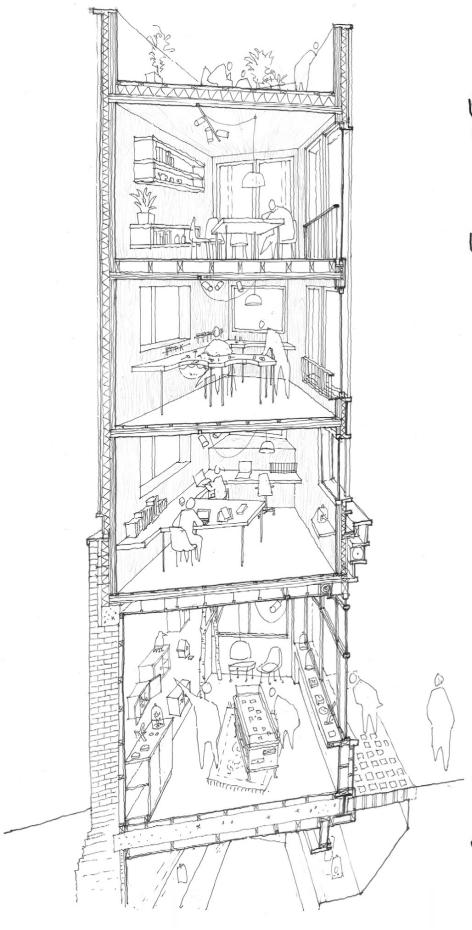
- Light modulated by steel facade (external shading)
- Natural daylight from terrace illuminates workshop

Zone	FSR	Floors	Site Area
-	-	4	2153 SF
Location	**Year Built**	**Architect**	**Client**
42 Tower Bridge Road, London	2016	DSDHA	Alex Monroe

TRIAL + OFFICE

LONDON

LIGHT-INDUST



R Roof Terrace

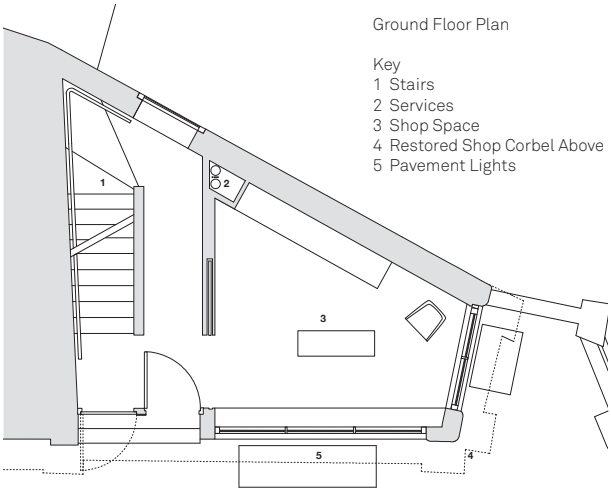
3 Meeting Room

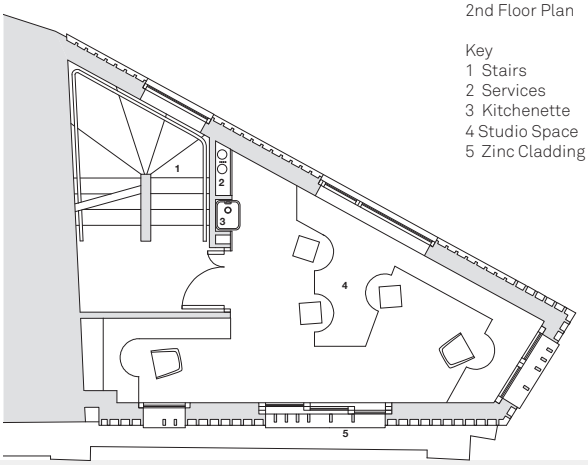
2 Workshop

1 Studio

G Shop

B Dispatch





Traffic

- Sliding doors to workshop open onto street for interaction with public

Noise

- Heavier machinery located in basement studio

Air Quality

- Operable windows for natural ventilation

Visual/Design

- Hand-made jewellery workshop, studio, boutique shop, meeting space, roof terrace.

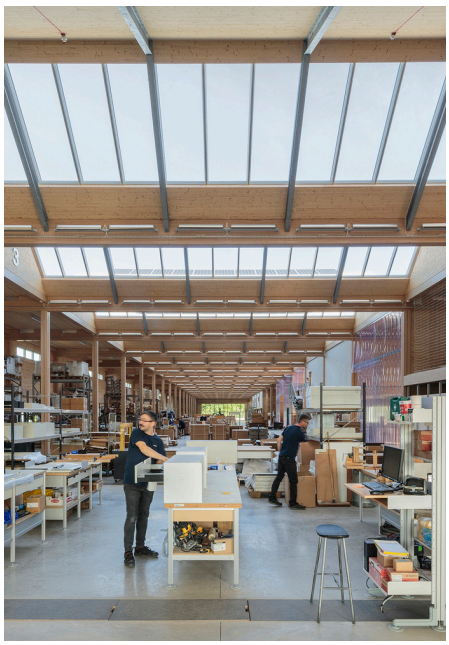
Lighting

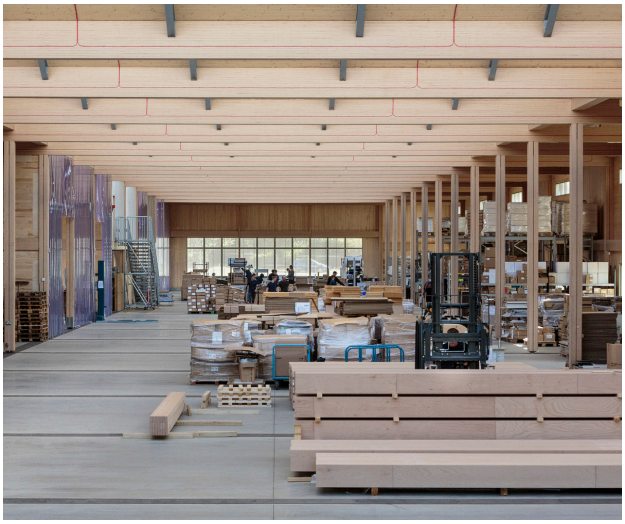
- Double-height glazed area on south facade, across workshop and meeting rooms

Zone	FSR	Floors	Site Area
-	-	4	1237 SF
Location	**Year Built**	**Architect**	**Client**
Snowsfields, UK	2012	DSDHA	Alex Monroe

TRIAL + OFFICE

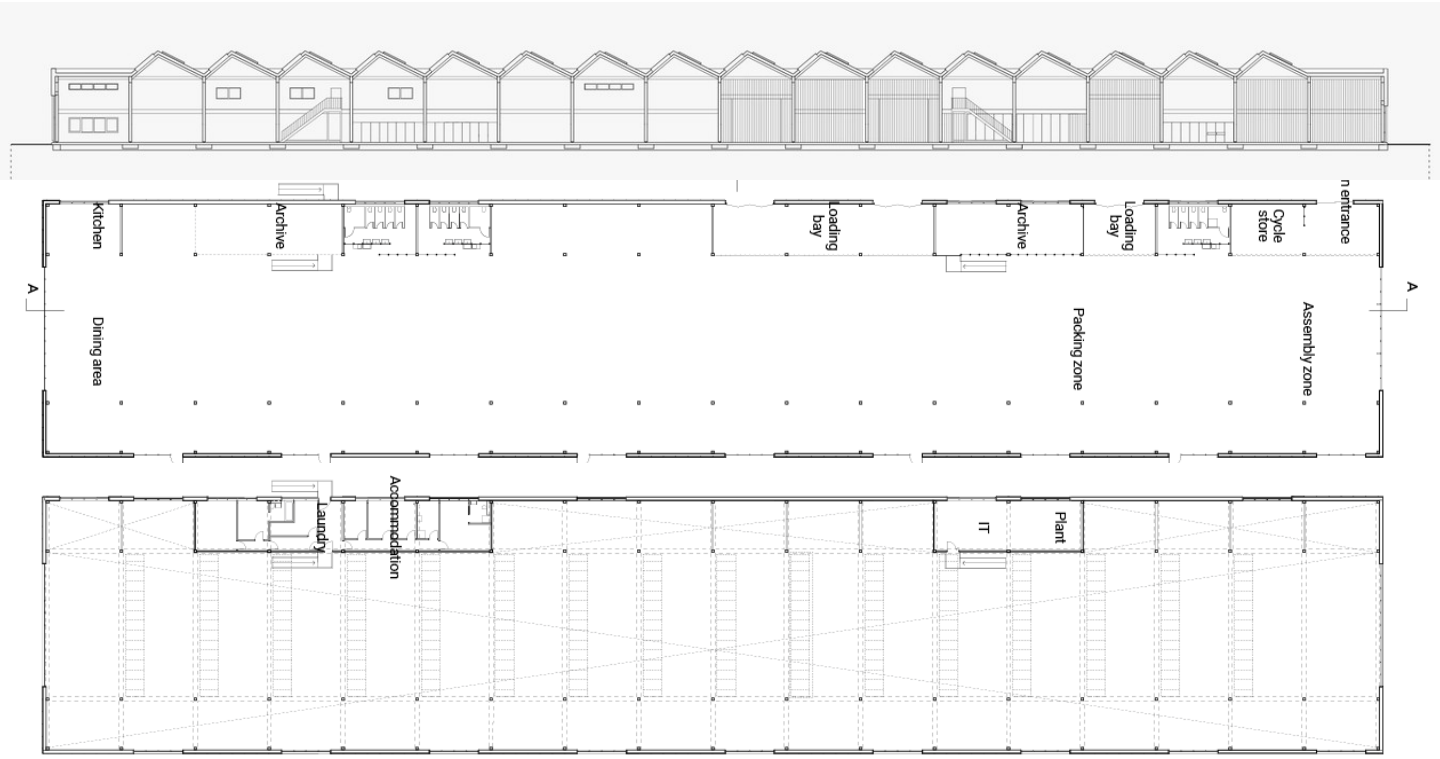
VITSOE HQ





ROYAL LEAMINGTON SPA

LIGHT-INDUST



Traffic/Loading

- Walking distance of town's centre
- 3 loading bays

Air Quality

- Natural cross-ventilation
- High air-tightness 0.85m³/h/m² at 50 PA
- Long grass provides evaporative cooling

Noise

- Concrete floor
- Wood fibre insulation
- Acoustic hoods to separate sound-sensitive spaces
- The undulating landscape form attenuates adjacent road noise while absorbing rainwater

Visual/Design

- offices, research and development, showroom, museum, software development, product assembly, kitchen and dining, overnight accommodation
- Part of the building will be used as a rehearsal space by local dance-circus company
- 6m tall ceilings
- 19 7.5 m bays

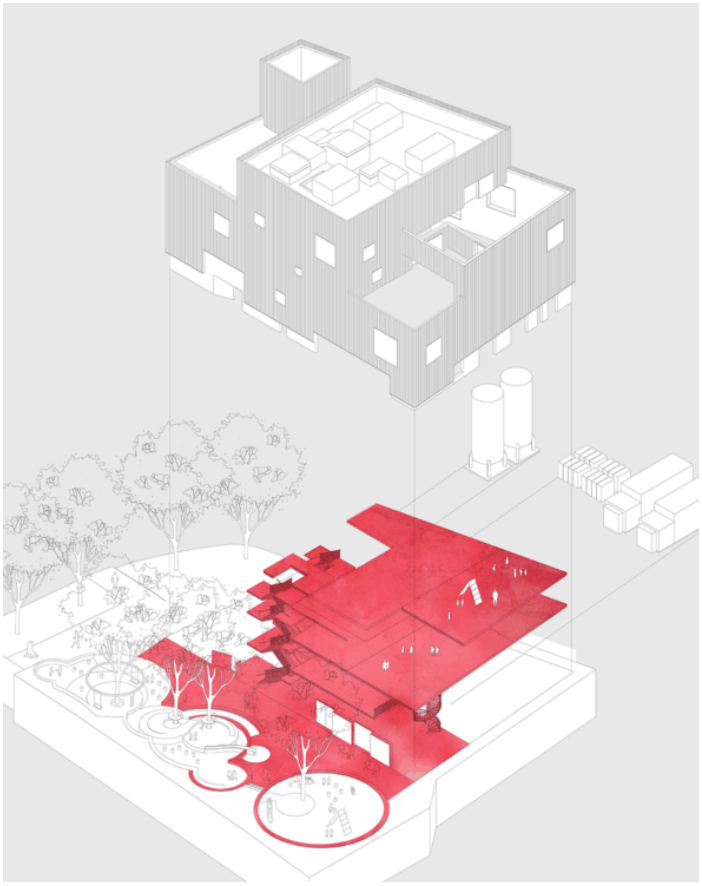
Lighting

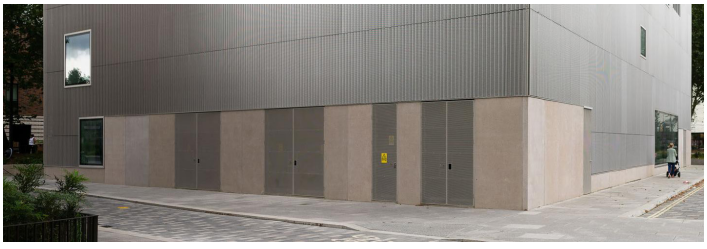
- North-facing saw-tooth skylights for natural daylight
- LED lighting

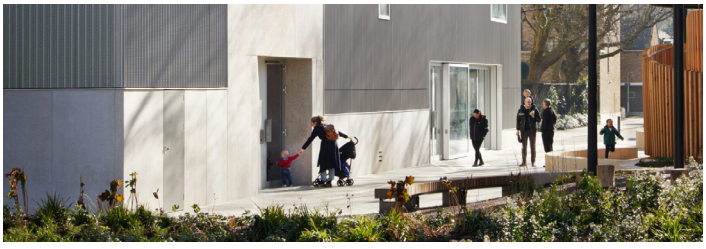
Zone	FSR	Floors	Site Area
-	-	2	39,581 SF
Location	**Year Built**	**Architect**	**Client**
Royal Leamington Spa, UK	2017	Vitsœ and Martin Francis	Vitsoe

TRIAL + OFFICE

ENERGY HUB

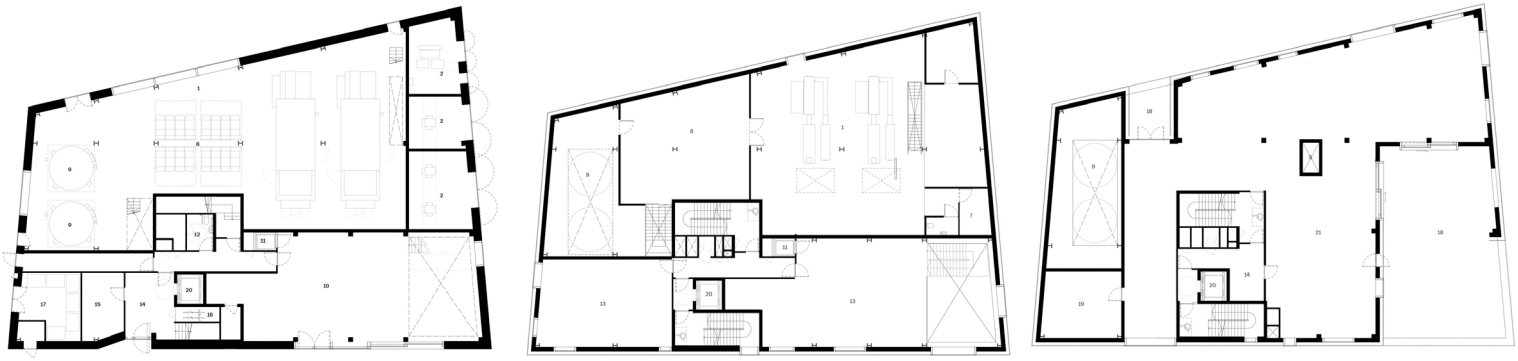


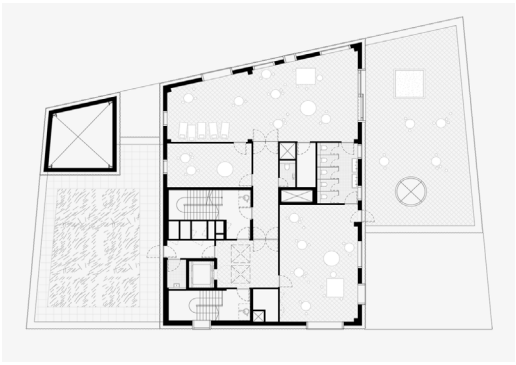


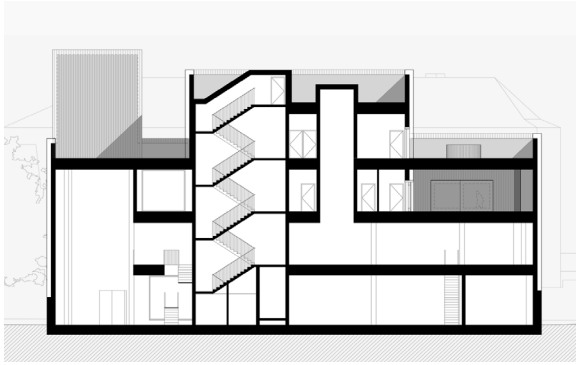


LONDON

LIGHT-INDUSTR







Energy Production + Distribution:
1. Eon demise
2.Substations
3.Stack
5. CHP riser
6. Boilers
7. Eon welfare facilities
8. Boiler room
9. Hot water tanks

Cafe/ Multi use space:
10. Cafe/multi use front of house
11. Platform lift
12. WCs
13. Cafe back of house

Nursery
14. Entrance foyer
15. Buggy Store
16. Bike store
17. Bin store
18.Terrace
19. Plant room
20. Lift
21. Nursery demise

Traffic/Loading

- Separate entrances to nursery and cafe
- Pedestrian and platform lift

Air Quality

- Uses natural gas and biomethane to deliver low carbon heat and hot water

Noise

- Concrete and steel construction
- Mechanical systems separated by circulation
- Strategic use organization as buffer

Visual/Design

- Energy centre, cafe, pocket park, and nursery
- Double height cafe and community space
- Fences conceal mechanical systems at ground level

Lighting

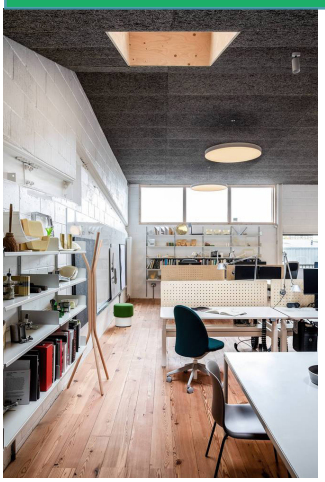
- Triple-height skylight

Odour

- Non-operable windows in odour-prone areas to prevent from entering interior spaces
- Chimney directs odour and air above programs

Zone	FSR	Floors	Site Area
-	-	4	25,833 SF
Location	**Year Built**	**Architect**	**Client**
Heygate St, London	2020	Morris+Company	Pearson Lloyd

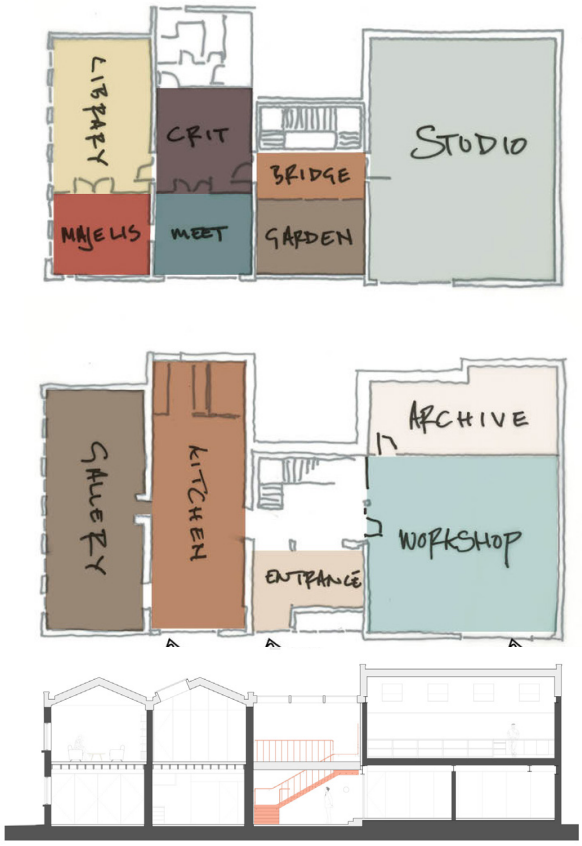
RIAL + DAYCARE

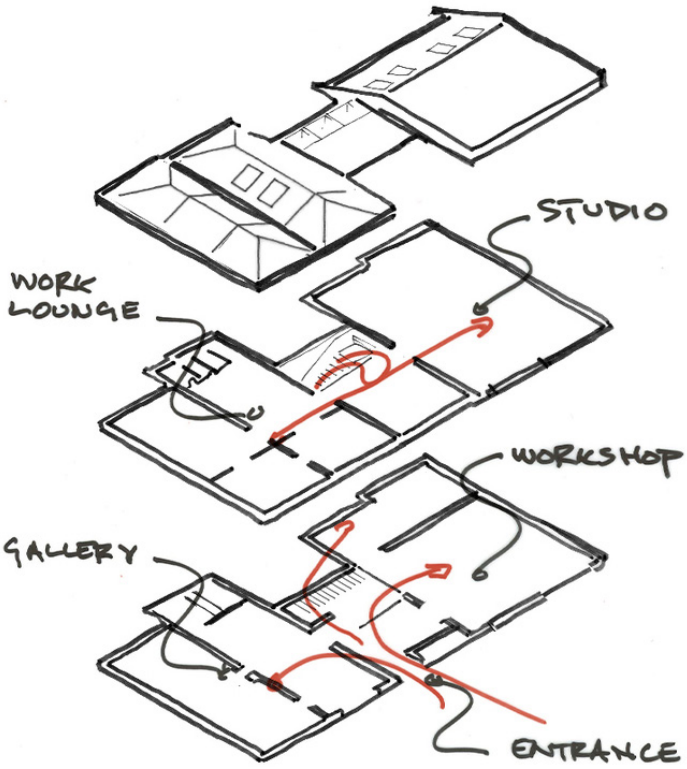


YORKTON WORKSHOPS

LONDON

LIGHT-INDUSTRIA





Traffic/Loading

- Central shared lobby
- Floor material made from same material as stage floors and haulage trucks

Air Quality

- Natural cross-ventilation

Noise

- Concrete floor slabs
- Wood-fibre acoustic ceiling panels

Visual/Design

- Studio, workshop, and meeting and exhibition rooms
- Restoration and retrofit project

Lighting

- North-facing window openings and east- and south-facing roof lights
- Low energy lighting powered by PV panels

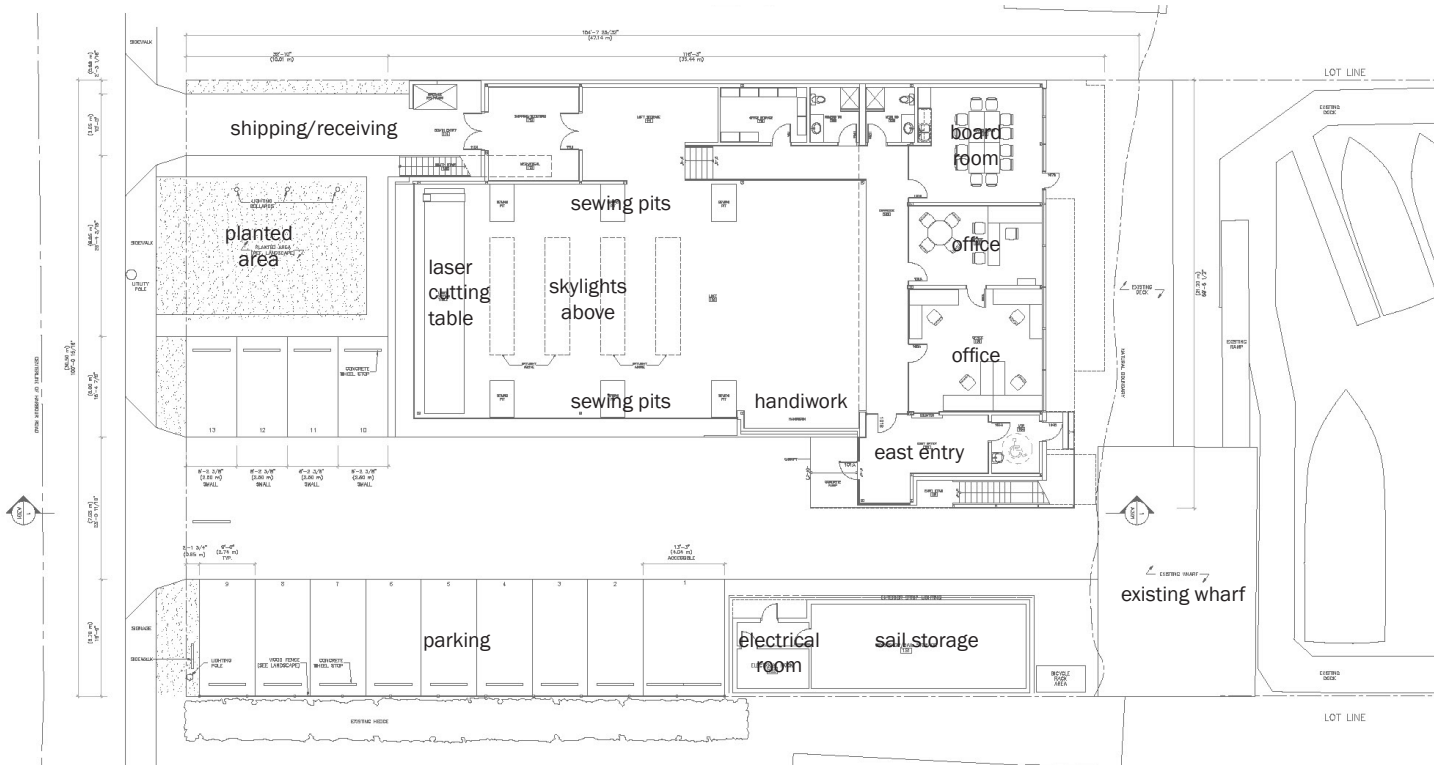
Zone	FSR	Floors	Site Area
-	-	2	5,920 SF
Location	**Year Built**	**Architect**	**Client**
London	2020	Cassion Castle Arch.	Pearson Lloyd

AL + RESIDENTIAL

HARBOUR SAIL LOFT+RESIDENCES

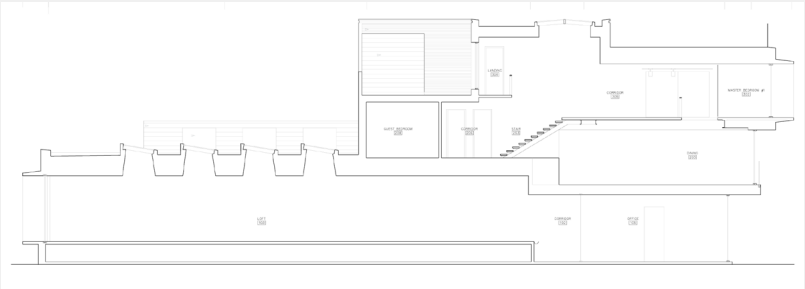
SIDNEY

LIGHT-INDUSTRIA



Traffic/Loading

- Separate shipping/receiving area from visitor parking



Visual/Design

- Making-loft positioned close to the street to reveal the activity within

Lighting/Electrical

- Electrical and mechanical systems spatially separated from high occupancy areas
- Abundant natural lighting in making area with skylights

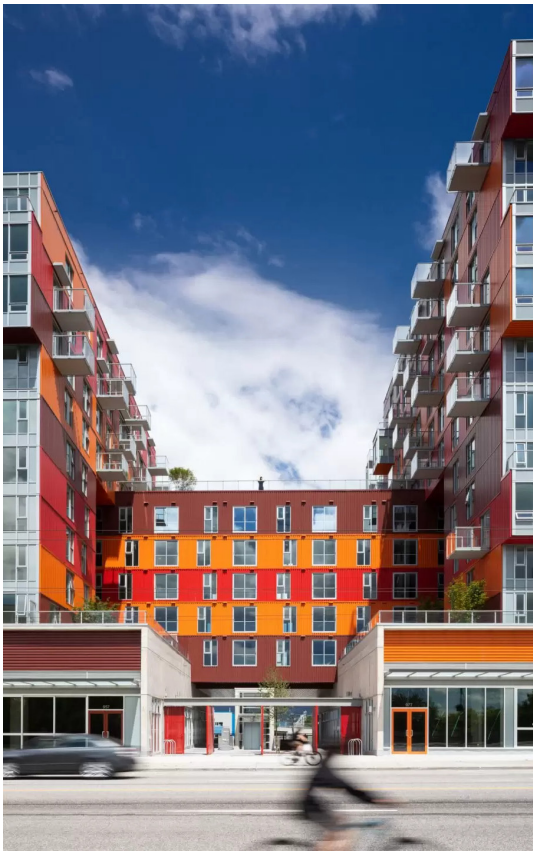
Noise

- Strategic organization of program: Dwelling space located above offices rather than manufacturing space

Zone	FSR	Floors	Site Area
-	-	3	12,200 SF
Location	**Year Built**	**Architect**	**Developer**
Sidney, BC	2014	Checkwitch Poiron	-

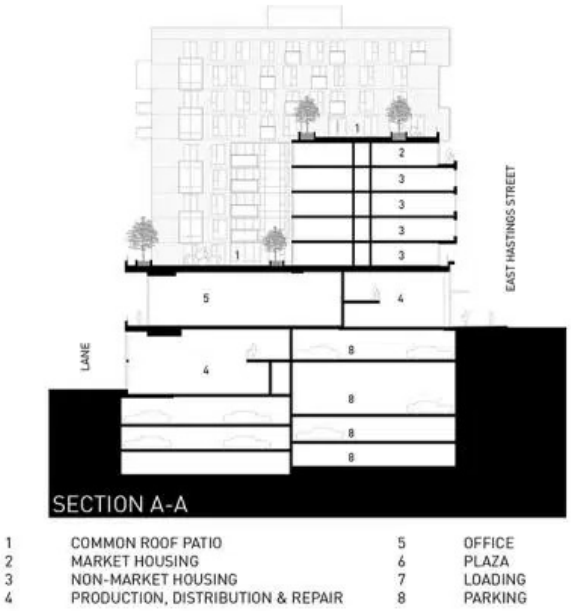
AL + RESIDENTIAL

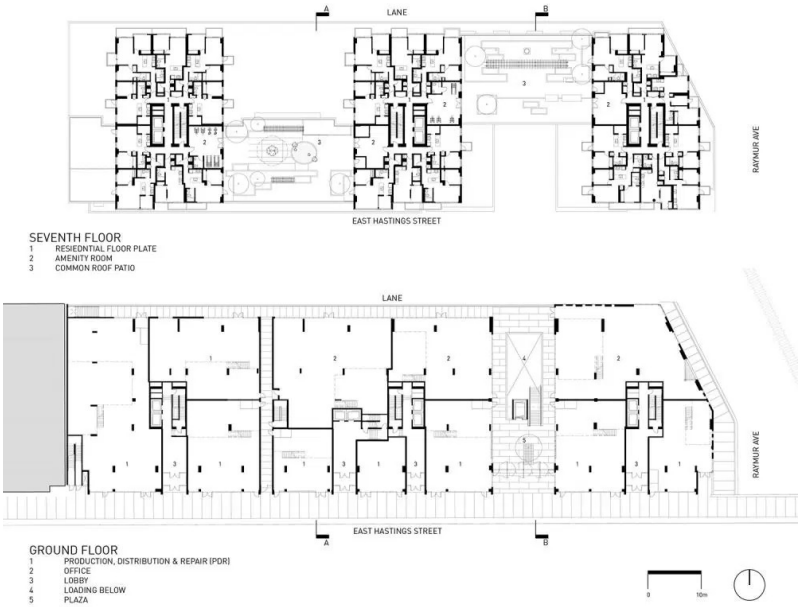
STRATHCONA VILLAGE



VANCOUVER

RESIDENTIAL+ LIGHT-INDUST





Noise

- Strata law limiting noisy equipment or machinery in or around the strata lot between 11pm and 7am
- No loud noise may be made in the outdoor amenity areas after 10:00 p.m
- Purchasers are informed of nearby industrial uses and the potential for noise and disruption
- Office and parking as use buffer between industrial and residential components
- Increased separation with loading space with plaza and tall ceilings

Visual/Design

- 19' ceiling height for light industrial uses
- Fence around ourdoor mechanical systems
- Production-distribution-repair at front street level with glazed facades

Traffic/Loading

- Shared grade level loading area (covered)
- Secured underground parking
- Freight elevator
- 1 Class A and 2 Class B loading spaces (res)
- 6 Class A and 3 Class B loading spaces (non-res)
- 10 meter wide wedge along the eastern edge of the site parallel to the existing rail line

Air Quality

- Separate ventilation systems between industrial units and upper residential floors.

Lighting/Electricity

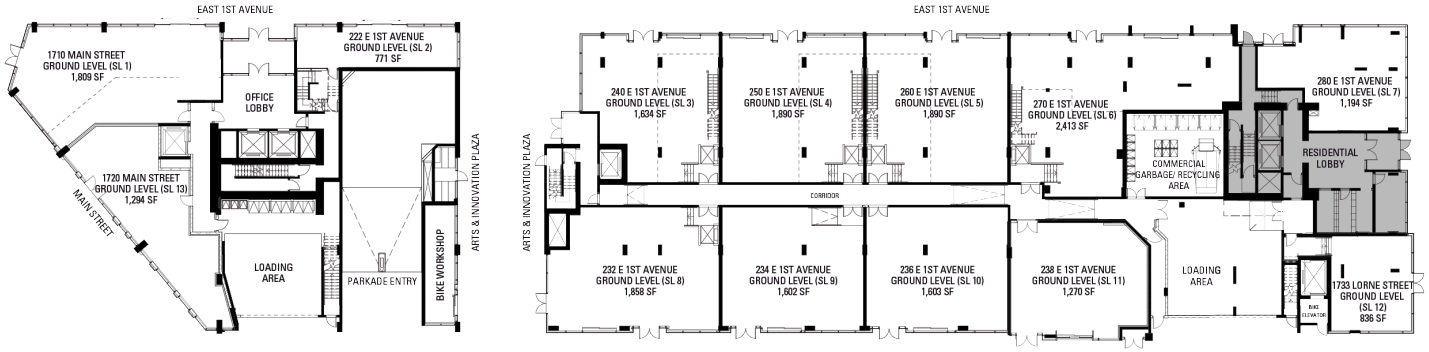
- 200/600 V service

Zone	FSR	Floors	Site Area
CD-1	6.15	6	36,600
Location	**Year Built**	**Architect**	**Developer**
939 East Hastings St	2017	MGBA	Wesbild Dev.

TRIAL + RETAIL

VANCOUVER

RETAIL + LIGHT-INDUST



Traffic/Loading

- 1 parking stall/1,500 SF
- 4 class-B loading bays at grade
- 2 class-A loading bays on P1 level
- 1st Ave units include 10 FT wide glass slidingdoor
- 8X10 FT overhead doors on select units
- Double panel pedestrian entry doors
- EV charging stations
- Shared lobbies
- Unobtrusive column spacing

Lighting/Electricity

- Connection to Vancouver's neighbourhood energy utility
- Energy Step Code 3
- 208/120V 3-phase service with K-13 rated transformers

Visual/Design

- Energy efficient glazing with natural light
- 35,000 SF creative industrial space with storefront-style windows
- 1,175 - 11,000 SF units
- 15-20' + exposed ceilings Industrial
- 11' high ceilings for Office spaces
- Art wall on side of Office

Noise

- Implements Energy Step Code Level 3

Air Quality

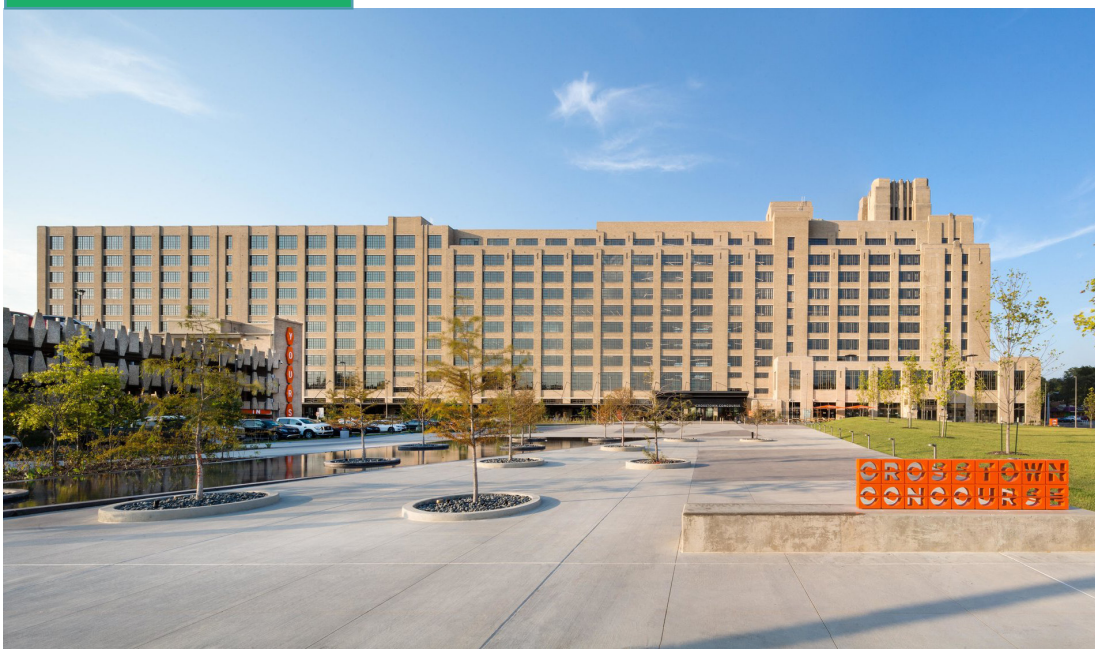
- HVAC through a 4-pipe fan coil system
- Customizable ventilation

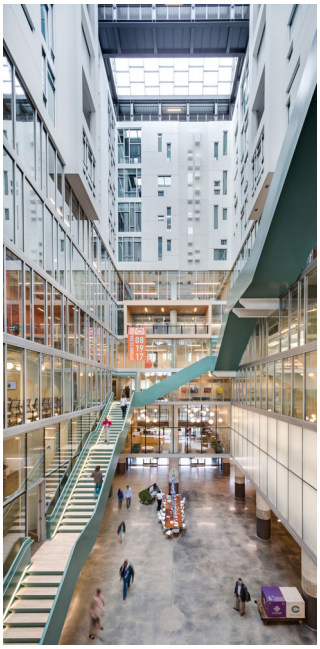
Odour

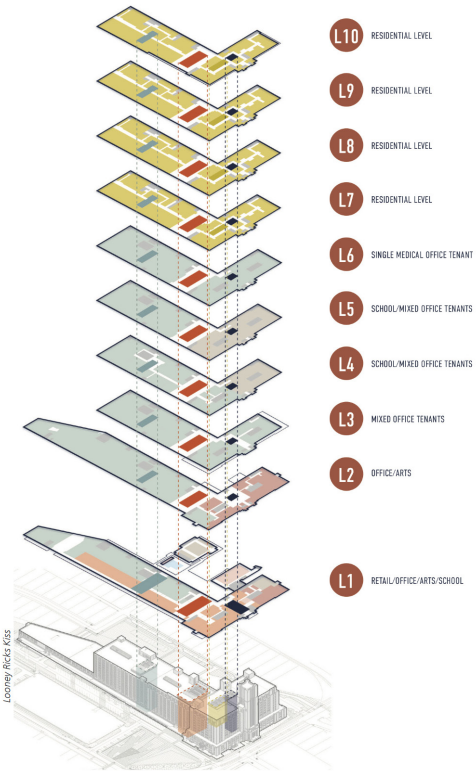
- Grease trap locations available at the P1 Level

Zone	FSR	Floors	Site Area
FC-2	6.5	7-11	~36,600
Location	**Year Built**	**Architect**	**Developer**
220 E 1st Ave	2023 est.	GBL	Hungerford/QuadReal

TRIAL + OFFICE

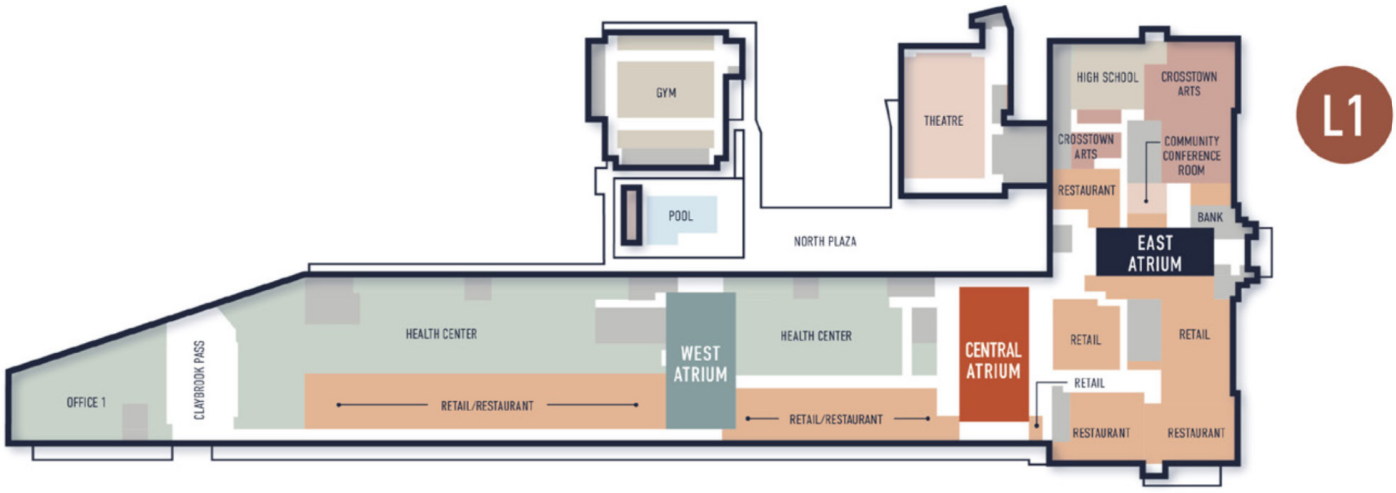






MEMPHIS

RETAIL + RESID
LIGHT-INDUST



Traffic/Loading

- Flat slab floor loading 250 lb/ft2
- Shared lobby and entrance
- Glass-lined atrium walls around offices
- Freight elevator that services all floors

Lighting/Electricity

- Natural light
- include a district 3.5 mw, 9.6-million BTU per hour combined heat and power (CHP)
- Three 10-story atria

Noise

- Concrete construction
- Brick walls

Visual/Design

- Programs include high school; YMCA fitness center; theater; free art gallery; radio station; apartment units; and dental clinic
- Tall ceilings in residential
- Concrete columns spaced 20’ O.C.

Air Quality

- High efficient HVAC
- Residential has individual central heat and air

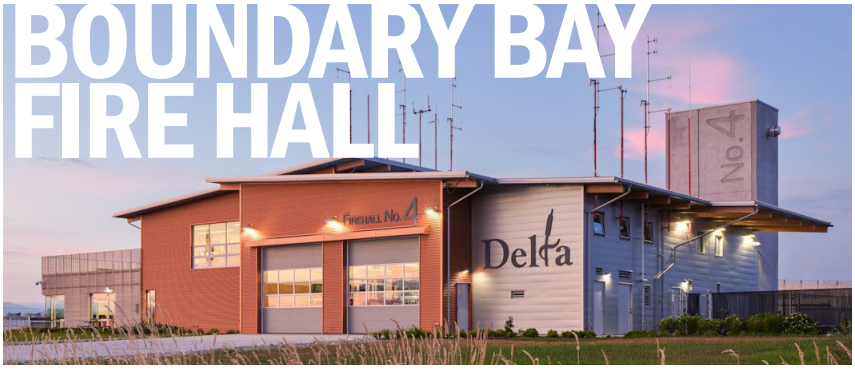
Odour

- Non-operable windows in residential

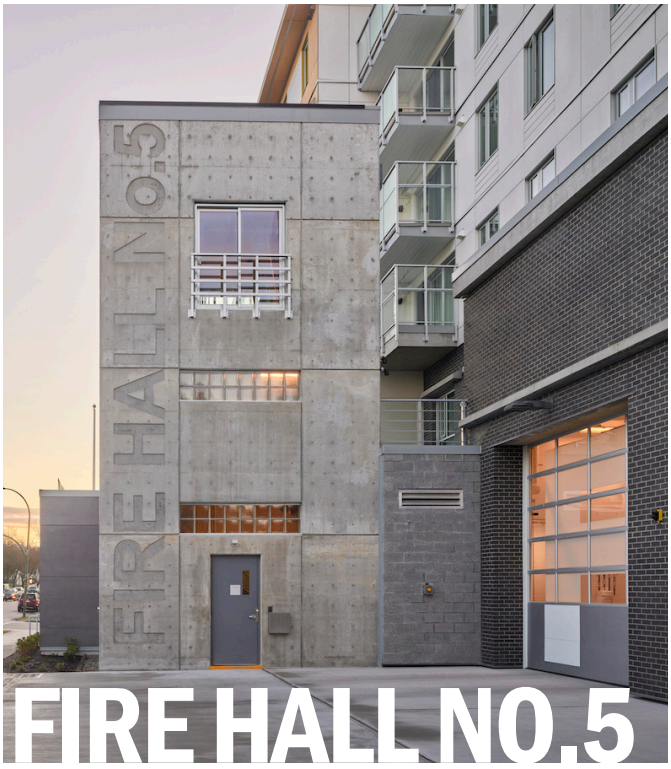
Zone	FSR	Floors	Site Area
-	-	14	1,300,000 SF
Location	**Year Built**	**Architect**	**Client**
Memphis, US	2017	Dialog, Looney Ricks Kiss	Rosan Inc.

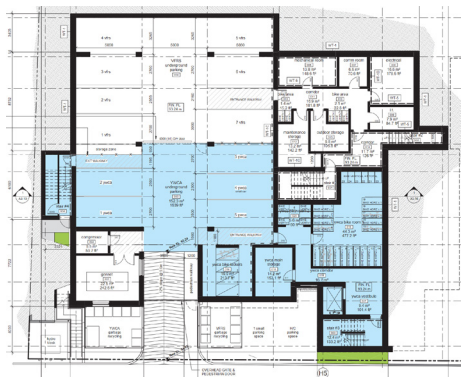
DENTIAL+
TRIAL + OFFICE

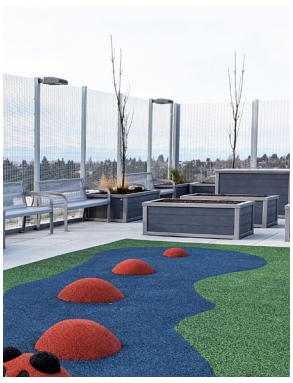
BOUNDARY BAY FIRE HALL



DELTA







VANCOUVER

MIXED-USE

Traffic/Loading

- Concrete flooring - raft slab
- Two fire truck loading bays
- Built to post-disaster standards - withstands 1.5 times the seismic force of a typical building.

Noise

- Canopied area to shelter speakers and allows for briefings to public

Odour

- Spatial separation from the nearby Burn Building training facility.

Visual/Design

- Fire station, municiple emergency operations centre, live-fire training facility, and administrative instruction centre.
- In-house dormitory

Air Quality

- LEED certified

Lighting

- Brightly colored flooring in sleeping quarters
- Oversized graphics to add energy and assiste wayfinding for dwelling spaces

Zone	FSR	Floors	Site Area
-	-	2	14,350 SF
Location	**Year Built**	**Architect**	**Developer**
7978 Churchill St	2019	Johnston Davidson	-

Traffic/Loading

- Separated entrances to residences
- Built to post-disaster standards - withstands 1.5 times the seismic force of a typical building.
- Concrete fire station, wood framed housing above

Visual/Design

- 31 housing suites
- Communal rooftop with garden space

Noise

- Exhaust fan silencer
- Generator located below-ground and designed with sound attenuation by acoustic engineer
- Compressor located below-ground and design with sound attenuation by acoustic engineer
- Truck noise actiivity monitored and roughly scheduled

Zone	FSR	Floors	Site Area
CD-1	2.69	6	21,000 SF
Location	**Year Built**	**Architect**	**Developer**
3090 E 54th Ave	2014	Johnston Davidson	-

RESIDENTIAL

Interview Insights

Ten interviews were conducted to gain a better insight on Vancouver's industrial land use, related conflicts, and practiced methods of mitigation. The responses helped inform this research paper and provide a basis for the next steps that can be taken to advance industrial intensification. Planners, architects, developers, and consultants were contacted in this process. Questions revolved around compatibility issues and mitigation strategies. Some examples of the questions asked are:

- Does your practice consider land use compatibilities when looking for/targeting tenants?
- What do industrial occupants look for when searching for rental spaces?
- What are specific design strategies to mitigate issues related to: loading/traffic, odour, noise, visual/design, and air quality?
- Have there been any issues regarding hours of operations for industrial processes?
- Are there any occupants you see opportunity to inhabit mixed-use industrial buildings?
- What are advantages and disadvantages to vertical mixed-use stacking?
- Are there any areas where you think policy could help mitigate conflicting uses?

Image source: ALTA Language Services, altalang.com

Interviews Summary

In general, responses highlighted the changing character of the industrial sector and opportunities to update relevant policies. Mixed-use industrial buildings in Vancouver are typically built by developers as cold-shell designs on strata property with the intent of stratification. This means that compatibility conflicts are not reliably predictable and it is the responsibility of the tenant to mitigate. Therefore, strata bylaws and tenant agreements may play a large role in regulating how property and common property may be compatible.

Roles and Responsibilities

Ongoing discussions between policy authorities, proponents of developments, and owners/operators are necessary for effective land use conflict mitigation, Ontario's *Proposed Land Use Guidelines** note some questions to address in these discussions. For example, Who will pay for the mitigation measures?

These interviews provide a better understanding of the roles and responsibiliies that different stakeholders have in the sector. Some of these participants and their influences are:

Developers:
Create strata laws that typically govern which industrial occupants are allowed in a space. Efforts are focused on the financial feasibility of a project and therefore do not filter tenants according to the industrial interface.

Architects:
Aim to provide good design while helping developer/client achieve their goal. Likely, do not implement mitigation strategies without direct instruction. Collaborate with engineers, where there is potential to recommend mitigating construction elements.

Tenants:
Responsible for implementing strategies for potential industrial interface conflict s. These are guided by strata laws, which often which includes noise, hours of operation, odour, and traffic/loading regulation.

Planners:
Provide zoning guidelines and regulate design responses to context. Facilitate interdisciplinary communication.

The following is a collection of **actions and/or effects** and **suggested steps** obtained through the interviews. Note that these are not necessarily evaluated conclusions, but rather communicated insights.

General Comments

- **There are not many precedents of vertically stacked mixed-use industrial developments in Canada and the nature of the industrial occupant is changing.**
  Some examples can be found in Asia and Europe, however, the climate and regulations are quite different compared to Vancouver. Building occupants often exhibit office-like activities and/or engage in operations with little to no impact on surrounding uses.

- **Compatibility conflicts can be avoided and mixed-uses incentivized by rewarding good design.**
  e.g. Offer increased building density (FSR) to achieve a desireable occupancy mix and incentivize development of market-driving uses to enable the build out of more affordable industrial space (e.g. office).

- **Industrial uses are evolving such that the technology sector resembles office environments.**
  Contemporary industrial uses are often of the "light" category, where emissions and implications on the surrounding environment are minimal. Extreme separation (e.g. large separation distances) between industrial and non-industrial uses is no longer applicable in many cases.
  Separation of uses should be reevaluated, especially in three-dimensions (i.e. vertically/horizontally/diagonally).

- **Costs of mitigation strategies (e.g. increased floor loadings, number of elevators, ventilation systems, etc.) can be balanced via mixed-use programs.**
  Currently, office space is rented at a higher value than industrial space. Since offices have less intensive operations and, therefore, lighter building requirements they are highly suitable for upper floor occupation. This encourages the vertical stacking of uses and may offset costs related to traffic, noise, odour, ventilation, and similar concerns.

- **To encourage and facilitate growth of mixed-use industrial developments, keep an open mind and continue dialogue between disciplines.**
  Holistic communication between all departments is necessary for effective progress and stakeholder perceptions of industrial operators kept relevant and up-to-date. Misunderstandings can be mitigated by discussions initiated by policymakers.

- **Some emerging tech industries are most appropriate as standalone uses.**
  e.g. Data centres require large rooms for servers, massive amounts of cooling, and large electrical demand and load.

- **Industrial developments mixed with residential programs are challenging.**
  Restrictions between occupancy classifications

in the BC Building Code restrict F1 and F2 from mixing with any dwelling unit (some exceptions exist). Additionally, design requirements can be expensive and/or intrusive. For example, air vents may need to be strategically mapped to rooftops and compromise floor space.
However, F1 industrial uses are compatible with residential uses and the cost of a unit may offsdet the surrounding nuisances. This may be a strategy to determine which types of occupants would be more appropriate for mixed-use developments with residential components.

- **Communication and social contexts regarding surrounding land use emissions and potential nuisances can be considered a mitigation strategy.**
  Residential users that are aware of and regularly exposed to the potential nuisances in the area may have greater tolerance to the industrial interface, like noise levels. For example, caretaker units or social housing in industrial areas scarcely result in complaints; however these locations may lack amenities and services in close proximity.

- **The pandemic has not significantly changed the design of mixed-use industrial buildings.**
  However, touchless features are increasingly popular - though not particular to mixed-use applications.

Mitigation Strategies

- **Save costs and anticipate different user groups in the building design.**
  The floor loading capacities can inform the location of user groups. Higher floor loading capacity is costly, but required for industrial operations.
  A strategy may be to provide a gradient of loading values, where

LOADING CAPACITY: HIGHER → LOWER

LEVEL: GROUND → ROOF

However, the ground level is desired by many non-industrial uses, therefore, the design should provide compromises.
An alternative model would be to place the loading above-ground such that:

LOADING CAPACITY: LOWER → HIGHER → LOWER

LEVEL: GROUND → ROOF

In this case, the costs of the heavier floor construction may be offset by non-industrial rental rates on the ground floor.
Common floor loading values are:

OFFICE	100 lb/SF
LIGHT INDUSTRIAL	150 lb/SF
TRADITIONAL INDUSTRIAL	300 lb/SF

- **The industrial interface is seldom intentionally addressed in the design.**
  Compatibility is typically not a concern for designers/developers. This is partially due to the need to make predictions of tenant operations to implement mitigation strategies. However, users are often not determined early enough during in the design project.
  There are some common design elements that may unintentionally act as compatibility measures. For example, visual screening of mechanical systems.

- **Prioritize activation of the streetfront.**
  Reward designs that dedicates space for the public. Give back to the street and then consider vehicle loading and traffic.

- **Users have increasing electrical demands as emerging industrial users are technology-oriented.**
  Typical power provision for offices is 200-400 Amps, but 600 Amps for industrial operations is increasingly popular. Users who require continuous power for refrigeration or cooling needs may require a dedicated/back-up generator for their unit.

- **Flexibility in design can accomodate changing needs of industrial users. The minimum facilities provided in cold shell designs should be generous and allow tenants to customize spaces.**
  Layout:
    Smaller and varied unit sizes promote diversity of users. Tall floor-to-floor heights are essential to industrial uses.
  Mechanical:
    Oversize mechanical systems to provide opportunities for different tenant types.
  Ventilation:
    Use localized ventilation units but also supply some units the option for rooftop ventilation. The provision of space for future ventilation routing adds flexibility by enabling occupancy by a wider range of users with different ventilation requirements.
    Note: Although rooftop ventilation is effective for odour and noise mitigation, it may be more expensive, subtract clear ceiling height space, and restrict the use of valuable roof space.
  Traffic/Loading:
    Allow vertical movement of goods with a common dock and service elevator.

- **Noxious aspects of the industrial interface may be avoided by organizing the hours of operations.**
  Operations in mixed-use developments that do not occur at same time of day can increase compatibility because disturbances cannot be noticed.

- **Waste facilities are typically underground and regulations cover odour mitigation.**

Adequate ventilation should be provided and exhaust air discharged through HEPA filters and continuously monitored.

- **A single parkade entrance/exit can negatively constrain vehicle movement.**
  Traffic movement, alleyway activation and pedestrial movement may be improved by providing more than one parkade access; however, additional entryways that cross pedestrian areas and sidewalks present additional conflict and safety concerns.

- **Plumbing can be a challenge to coordinate between stacked non-industrial and industrial programs.**
  Pipe locations and water systems need to be carefully considered because of spatial configurations and different operating requirements (e.g. flush valve versus flush tank), especially with dwelling units.

- **Traffic and loading requirements are evolving with the prominence of lighter industrial uses.**
  Class C loading bays are not relevant for mixed-use light industrial projects; the size of large trucks do not fit in the laneway. The types of industrial users going into these spaces have little to no loading requirements.
  Alleyway activation with pedestrian access conflicts with traffic/loading requirements.
  Policy might consider regulating in favor of on-street loading outside of business hours.

Policy and Regulation

- **Overly-broad policies can be refined to increase room for sector growth and respond to the changing industry.**
  Current understandings of "industrial" are unclear. Reassess the definition of industrial. Break down industrial uses into different subcategrories to create a more flexible and less prescriptive regulatory environment.

- **Use definitions change depending on the occupant.**
  For instance, principal research and testing to one occupant may be considered as accessory uses to another.
  e.g. Climbing gyms may be a testing lab for equipment or a fitness centre.

- **Accessory space and FSR calculations are restrictive and not optimized for mixed-use occupation.**
  Accessory uses contribute to FSR calculations despite it being the tenant's responsibility. e.g. if an industrial user builds office space into their unit, the overall building FSR for office space is reduced. Additionally, the amount of area allowed for amenity space is too small, especially considering industrial occupants who often desire adjacent office space.
  External corridors on upper floors are included in FSR calculations which discourages their application, however they may improve building

efficiency and increase valuable rentable area. On the other hand, balconies and decks are excluded with a certain limit.

- **Site-specific design solutions are not adequately addressed in policy.**
  e.g. entering a site at the highest point is not optimal. Topography changes can embraced by strategic design and recognized in zoning policies to mitigate concerns like noise and traffic and loading conflicts. Sensitive design should be rewarded.

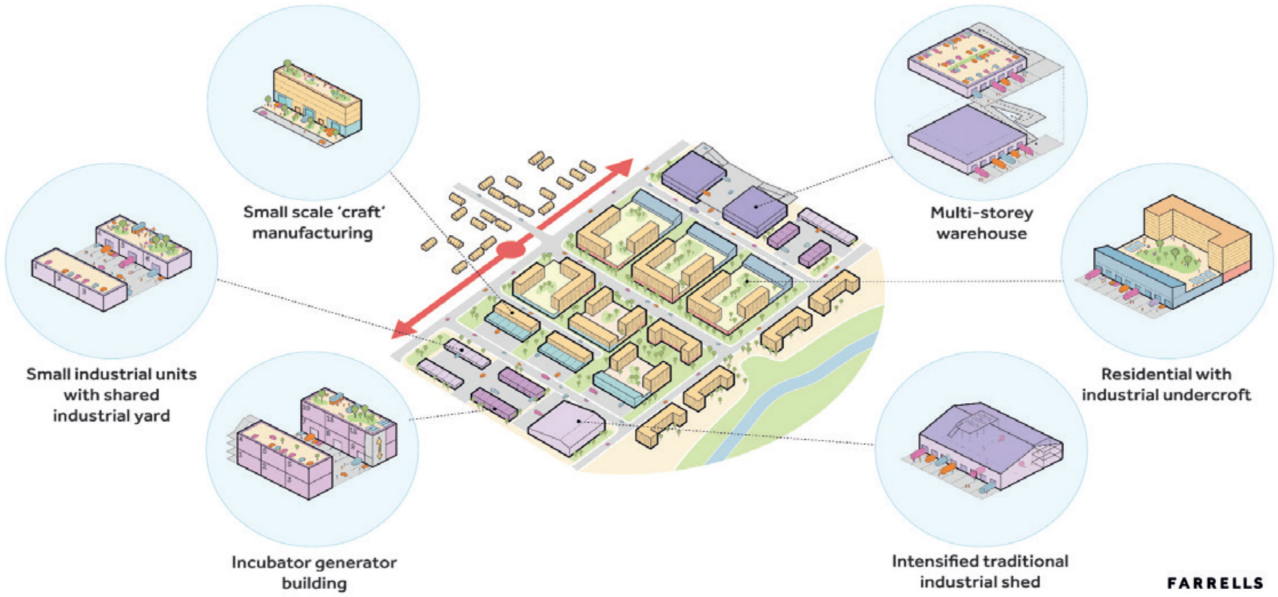
- **Current FSR zoning regulations constrain building forms.**
  Contextual approaches that respond to irregular parcel areas should be encouraged rather than designating uses to particular floors, which dictating a building's layout. Consider alternative solutions to the typical linear design that results from traditional separation of industrial-non-industrial relationships.

- **Slow and delayed correspondence with the City freezes the development of projects.**
  The current process is linear and would benefit from a branched system. Key issues should be decided early in the process. Consider outsourcing evaluations to speed up projects. Encourage mixed-use developments by simplifying regulations.

Image Source: Gordon Sayle/City of Vancouver Archives COV-S167---: CVA 515-7

APPLICATION

This section proposes potential combinations of light industrial and non-industrial uses to exemplify different configurations and the potential need for accommodative policy and regulatory changes. These theoretical scenarios reconsider zoning by program and perhaps consider operational and activity-based practices. Two cases are presented, each including an industrial use that have minimal impacts on the surrounding environment and would not be problematic with appropriate buffers put in place. By combining non-traditional uses together and including emerging industries into regulations, the opportunities for intensifying industrial lands can expand. This section highlights on-site programmatic compatibilities. and where intensification can occur. Note that context and scale of use and operation may contribute to the exacerbation or reduction of conflicts.



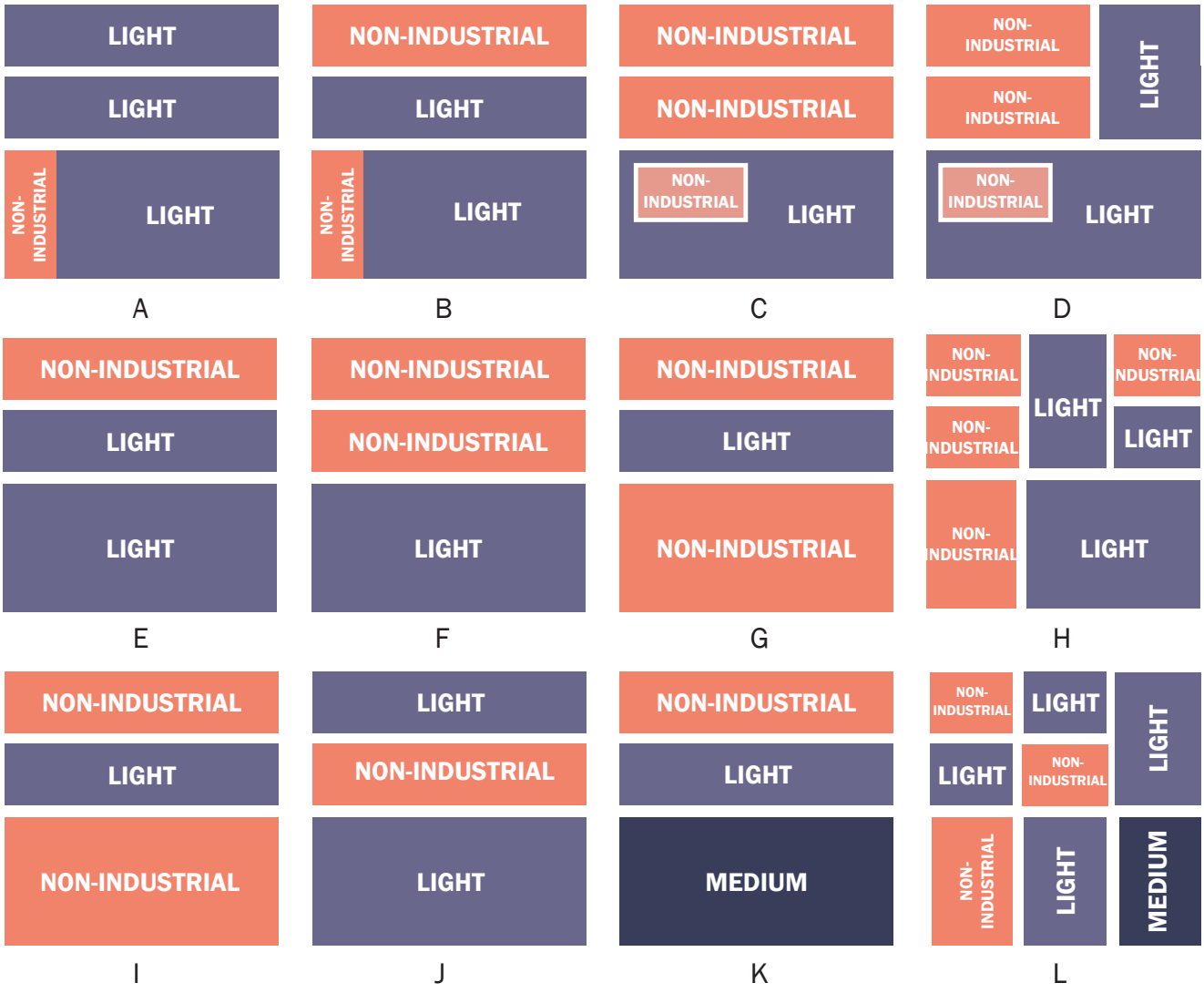


Figure 14. Potential Mixed-Use Configurations

OPPORTUNITIES

(Potential configurations)

- **Ground-floor non-industrial as accessory use.**
  (A, B, C, D, H, L)
- **Non-industrial mezannines for offices.**
  (C, D)
- **Double- or Triple-Height spaces as buffers.**
  (C, D, F, H, L)
- **Use-buffers to separate typically incompatible programs.**
  (G, H, J, L)
- **Valuable top-floor space for non-industrial.**
  (B, D, E, F, G, H, I, K, L)
- **Shared freight facilities by vertically stacking.**
  (A, B, D, E, H, L)
- **Non-industrial uses can provide services for industrial uses.**
  (All)

A number of potential mixed-use configurations are diagrammed in Figure 14. Non-industrial, light-industrial (F-3 occupancy), and medium-industrial (F-2 occupancy) uses are placed in relation with one another. The areas can be interpreted in section (vertical stacking) or in plan (horizontal layering). These are relevant only with the assumption that programs that score high on compatibility are chosen. Otherwise, appropriate mitigation strategies must be put in place in order to minimize conflicts between users.

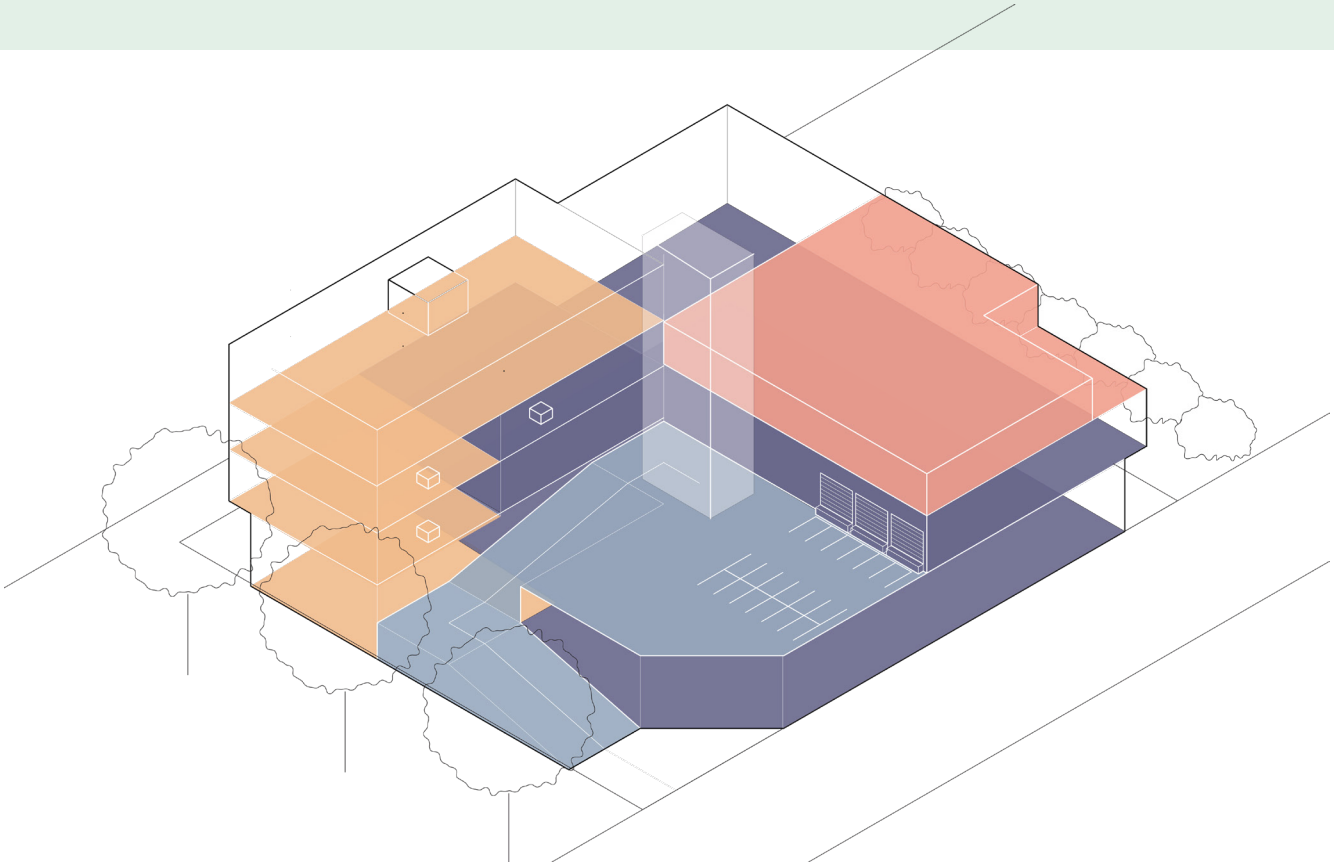
Vertical stacking has notable advantages for industrial intensification. For example, double or triple height spaces can act as buffer space between uses and also allow for freight facilities and elevators to be shared.

The traditional model of mixed-use development stratifies uses such that entire levels are dedicated to a specific program. This is increasingly less common as industries become more interdisciplinary and collaborative in thier practices. In response to this, the fourth column of the Potential Mixed-use Configurations presents more flexible organizations with multiple user types along the same coordinate.

The following page presents two hypothetical mixes that are comprised of a variety of programs. Relevant regulatory details and challenges are provided.

HYPOTHETICAL MIX A

DAYCARE	A2	assembly
DWELLING UNITS	C	residential
MAKER SPACE	F3	light industrial
VR LAB	F3	
COFFEE ROASTER	F3	
+ COFFEE SHOP	accessory	



HYPOTHETICAL MIX B

FITNESS GYM	A2	gymnasia
TECH OFFICE	D	office
ARCHITECTURE STUDIO	D	
3D PRINTING SHOP	F3	light industrial
WHOLESALING	F3	
BAKERY MANUFACTURER	F3	

HYPOTHETICAL MIX A

BC Building Code major challenges:

- Permitted major occupancy must be A2 or C.
- Minimum 2 h fire separation between A2 and other occupancies is expensive.
- Separate circulation required for dwelling units.

City of Vancouver Zoning By-Law major challenges:

- Light industrial not permitted in certain zones, although the use is minimally intrusive.
- F3 accessory use (e.g. shop for coffee roaster) tightly limited in floor area.

Potential Advantages

- Minimal conflict between uses.
- Accessory space serves entire building.
- Daycare can be used by occupants.
- Upper-level parking and loading free up valuable ground-level space.
- Higher rent rates possible for top-floor occupants.

Relevant regulation:

Table 3.1.2.5.
Major Occupancy Classification and Fire Safety Requirements for Child Care Facilities
Forming Part of Sentence **3.1.2.5.(3)**

Major Occupancy Determination			**Fire Safety Requirements for Major Occupancy**				
Age of Children (months)	Number of Children[6]	Major Occupancy Permitted	Sprinkler (suite or entire building)	Fire Alarm	Smoke and CO_2 Detectors Alarms	Fire Separation From Remainder of Building	Emergency Lighting
≥ 30	≤ 8 and more than 2	C[1]	No	No	Yes	No	Yes[2]
< 30	≤ 8 and more than 2	C[1]	Yes[5]	No	Yes[3]	No	Yes[2]
Any	≤ 8 and more than 2	C[4]	Yes[5]	Yes	Yes[3]	2 h	Yes
Any	>8 and more than 2	A2	Yes	Yes	Yes[3]	2 h	Yes

Notes
[1] Applies to one and two family dwellings or row houses
[2] Emergency lighting to conform to Subsections 3.2.7. and 9.9.12. where applicable
[3] Coverage to include all areas within the suite, except closets and kitchens
[4] Applies to buildings other than one or two family dwellings or row houses
[5] Suite only
[6] Children mean persons under the age of 13 years.

Compatible with F-3

HYPOTHETICAL MIX B

BC Building Code major challenges:

- Minimum 3 h fire separation between D and F3 is expensive.

City of Vancouver Zoning By-Law major challenges:

- Fitness Centre may be a Conditional Use (e.g. MC-1&2)
- Light industrial not permitted in certain zones, although the use is minimally intrusive.
- Tech office likely to be considered industrial in zoning, limiting its placement.

Potential Advantages

- Loading bays adjacent to industrial spaces.
- Double height industrial spaces.
- Shared freight and loading for light industrial.
- Variable unit sizes possible and dynamic building form encouraged with stacking.

CONCLUSION

Further study

The monetary implications of industrial land use conflicts and mitigation are not discussed in this paper, however, this is a significant component to consider. For related reading that expands on this topic, *The Interbay Public Development Advisory Committee's Recommendations and Implementation Plan*[73] and *Port Lands Planning Framework*[8] provide a sufficient starting point to explore in a future study.

Ownership of land and management options has been excluded in this discussion, however, there may be potential conflicts. For instance, industrial demands versus community needs.

Additionally, there may be developments in policy and guidelines that respond to concerns regarding climate change that are not addressed here.

Consideration of changing attitudes towards parking and the future of autonomous vehicles should also be kept in mind in the planning of land designations.

Future investigations should explore a structural process to proposals and discussions for building code acceptable and alternative solutions. There is currently a lack of formal strategies to communicate and implement regulatory operations. A collection of measures that increase compatibility to ease hazard classifications would assist in advancing industrial intensification by accelerating approval and policy-related procedures. More certainty can be created ini the documentation of flexibility in the BC Building Code and Vancouver Zoning By-Laws.

Conclusion

This project is a response to the City of Vancouver's diminishing industrial lands, evolving industrial sector, and growing demand. In summary,

- Review of the City's policies reveal areas of ambiguity that require refinement for the intensification of industrial lands.
- Research into other municipalities provide a broader understanding of emerging industrial sectors and strategies to mitigate their noxious interfaces.
- Specific design elements can be mitigation strategies to improve compatibility between different uses.
- The Industrial Compatibility Matrix organizes compatibility to identify appropriate mixed-use programs.
- Case studies within and outside of Vancouver showcase the opportunities for effective design in mixed-use industrial developments. Hypothetical mixes exemplify potential compatibilities between uses.

Mitigating industrial land use impacts through building and site design will support the Climate Emergency Action Plan and 4 Big Moves, as the intensification of industrial spaces will protect Vancouver's economy as well as fight against climate change.

In order to meet needs and expand the supply of industrial floor space, the City seeks to balance the intensification of industrial lands while considering the impact on surrounding communities.

By identifying, securing, densifying, and promoting space for industrial lands, the growth of economic activity and jobs in the industrial sector can be sustained.

Complete, walkable neighbourhoods can be achieved by mixing uses and providing amenities for users without requiring long-distance travelling, reducing vehicle emissions and encouraging pedestrian movement.

By utilizing the tools described in this guide, (e.g. Design Inventory and Industrial Compatibility Matrix) designers, planners, and other stakeholders can make more informed decisions to advance sustainable practices, facilitate economic activity, and have productive discussions across disciplines.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Thank you

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