



**INSTITUTE FOR THE
BUILT ENVIRONMENT**
COLORADO STATE UNIVERSITY

Resident Health & Wellbeing

A Research Case Study of Denver's Lakehouse Community

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The mission of the Institute for the Built Environment at Colorado State University is to advance the development of healthy, thriving places. We cultivate the wellbeing of communities by enabling interdisciplinary teams of faculty, students, and industry professionals to elevate the potential of their work. IBE is a pre-approved WELL survey provider.

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ABOUT LAKEHOUSE

Lakehouse was the first residential project in Colorado to achieve WELL Certification at the Gold level under the WELL Building Standard v1.

Completed in 2020 by NAVA Real Estate Development (NAVA), Lakehouse consists of 196 for-sale condominium and rowhome residences. NAVA set out to design a building with health and wellness best practices integrated into its homes and common areas to support and encourage a healthy lifestyle for residents. This includes promoting healthy living through the building materials and mechanical systems so that sound, air, light, and water quality are optimized, and providing customized wellness programming to residents with classes and events led by on-site staff and local health experts. The community sits beside Denver’s second-largest park and features an organic urban farm, 70-foot lap pool with hot tub, cutting-edge fitness lab, aquatics room, and sports and creative workshops. Biophilia was integrated throughout building design, from materials to artwork, to offer residents a journey through nature in an urban setting. For more details on Lakehouse’s WELL Certification, refer to Appendix A: WELL Scorecard and Appendix B: WELL Performance Verification Results.

ABOUT THE RESEARCH STUDY

In 2019, the Institute for the Built Environment (IBE) at Colorado State University (CSU) conducted a three-year research study on Lakehouse. **The study’s purpose was to assess the impact of Lakehouse’s sustainable, healthy design strategies and wellness programming on Lakehouse residents.** The study also met the requirements of the WELL post-occupancy survey feature (Feature 86 in WELL v1).

The findings support the hypotheses that residents’ satisfaction, health, wellbeing, and happiness would be significantly better after moving into Lakehouse than in prior residences. Most notably, residents reported improvements in social-emotional and physical health compared to while living in previous residences.

“There are so many moments of joy for me living in this community.”

- Lakehouse Resident

Key Study Results



Resident Satisfaction

Increased satisfaction with natural light, views, air quality, acoustics, safety, location, fitness equipment



Social Connections

Better relationships and more time spent socializing with neighbors



Emotional Health

Feeling happier and less stressed, experiencing better concentration and memory, having stronger connectedness to nature



Physical Health

Experiencing decreased health symptoms, spending less time sitting, feeling less tired

STUDY METHODOLOGY

The research study was approved by CSU’s Institutional Review Board, which is responsible for ensuring the ethical and equitable treatment of all human subjects in research conducted by CSU researchers. The research study used pre-occupancy and post-occupancy surveys to follow residents from their prior homes into Lakehouse, to assess changes they experienced related to their health, wellbeing, and happiness. The IBE research team surveyed individual residents before they moved into Lakehouse (i.e., while still living at their previous residence) and again approximately six to nine months after they moved into Lakehouse. Because Lakehouse’s health and wellness programming was initially delayed due to the COVID-19 pandemic, the first residents were not invited to complete a post-occupancy survey until approximately two years after they moved in. IBE interviewed residents to augment survey data.

Survey timing: September 2019 through June 2022

155 total unique participants across both surveys

	PRE-OCCUPANCY	POST-OCCUPANCY
SURVEYS DISTRIBUTED	286	261
SURVEYS COMPLETED	124	135
RESPONSE RATE	43%	52%

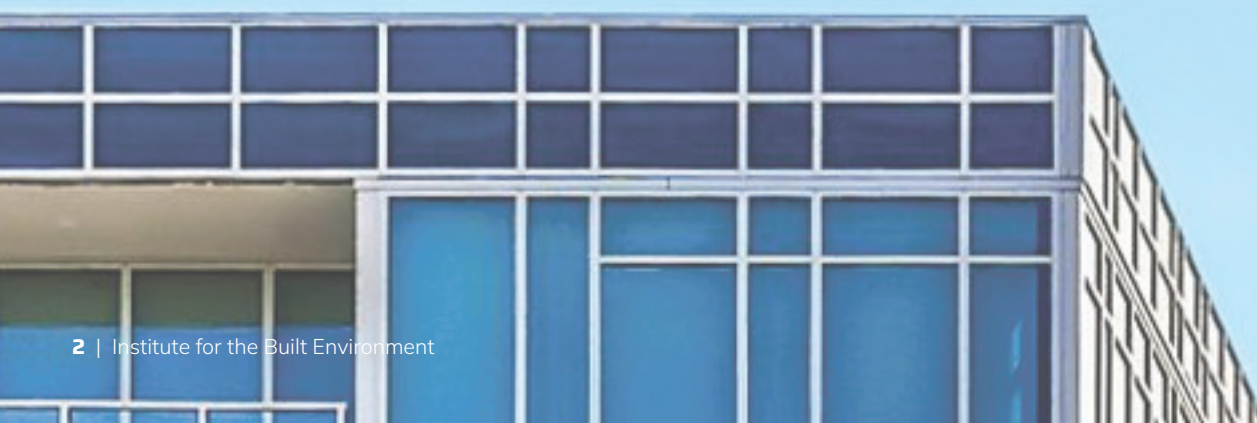
KEY FINDINGS

Nearly 45% of the variables analyzed in the study significantly changed in a positive way.

The study assessed 83 variables across four core areas: satisfaction with the building/community, physical health, emotional health, and social activity. There were statistically significant changes reflecting an improvement in 36 variables, showing that overall, residents experienced a positive change in their perceived health, wellbeing, and happiness after moving into Lakehouse. Only three variables changed in a negative way and 44 variables showed no significant change.

“The whole wellness aspect of Lakehouse was the biggest draw.”

- Lakehouse Resident





1. Resident Satisfaction

Overall, residents were more satisfied with the physical Lakehouse building, particularly wellness amenities, compared to their previous residences.

While there were no significant decreases in satisfaction, residents reported increases in satisfaction with views, amount of natural light, air quality, acoustics, and safety. Residents also significantly increased their rating of how impactful building location and on-site fitness equipment were in helping them lead a healthy lifestyle. Residents expressed that the fitness and educational classes, pool, and urban farm have met or exceeded their expectations – and that access to the garden, community kitchen, and nutrition-related education and experts has helped them to eat more mindfully, including eating more organic foods. Additionally, compared to their previous residences, significantly more residents reported that the views, building design, and location of Lakehouse enhanced their connection to nature.

Greater Satisfaction with Building Design at Lakehouse Compared to Prior Residences

VIEWS



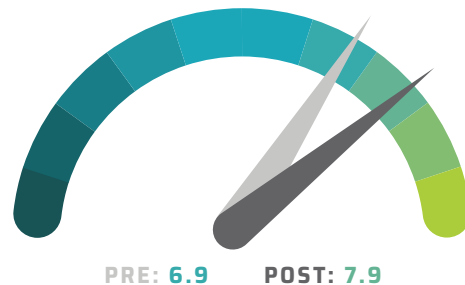
AIR QUALITY



AMOUNT OF NATURAL LIGHT



AIR FRESHNESS



Respondents' rating of air freshness increased by one full point, on a scale of 1 to 10, after moving to Lakehouse.

ACOUSTICS



LAKEHOUSE SUPPORTS RESIDENT COMFORT

- Floor-to-ceiling windows
- MERV-13 building air filtration system
- Enhanced sound mitigation
- Private outdoor space for every home
- Expansive 26,000+ square foot terrace
- Sloan's Lake and Rocky Mountain views

“The HVAC systems kept me more comfortable during the worst of this summer’s haze and ozone.” - Lakehouse Resident



2. Social Connections

Residents reported stronger social connections since joining the Lakehouse community: They considered more neighbors to be friends, spent more time with them, and had more fun.

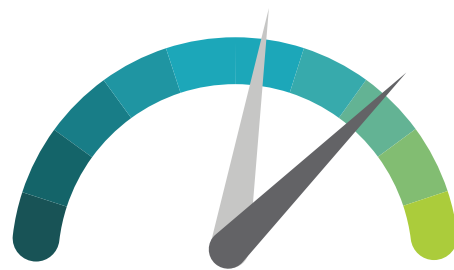
After moving into Lakehouse, residents expressed a significant increase in how many organized clubs/groups they were involved in, how many hours they spent engaging in learning opportunities, and how fun they rated life. They also reported increases in the number of neighbors they regularly interacted with, the number of hours they spent interacting with neighbors, and the number of neighbors they considered to be close friends, friends, and acquaintances. Residents attributed this to more opportunities to socialize when living at Lakehouse, thanks to amenities like common areas, community classes and events, and proximity to neighborhood amenities such as a movie theatre, restaurants, and Sloan’s Lake Park.



Social connections are an often overlooked, but essential, factor in health and wellbeing. According to Vivek Murthy, U.S. Surgeon General, “Loneliness and weak social connections are associated with a reduction in lifespan similar to that caused by smoking 15 cigarettes a day.”¹ Recent national surveys suggest that approximately half of U.S. adults have reported experiencing loneliness.² Social capital counters loneliness and builds resilience because individuals can support one another in times of need.

Improvements in Social Health Factors

LIFE IS MORE FUN



PRE: 5.4 POST: 7.3

On a scale of 1 to 10, respondents’ rating of how fun their life is increased by nearly two full points after moving to Lakehouse.

“The social support and good community is something I’ve never experienced anywhere.”

- Lakehouse Resident

LAKEHOUSE SUPPORTS COMMUNITY

- Extensive communal spaces
- Farm-to-table shared kitchen & group cooking
- Oversized, year-round hot tub
- Group exercise classes
- Organized events, game nights and book clubs
- Educational opportunities



3. Emotional Health

Residents experienced improved emotional health after moving into Lakehouse.

They reported feeling less stressed, happier, and more connected to nature. Analyses showed decreases in residents’ frequency of feeling nervous; downhearted and blue; down in the dumps; tense; stressed; and easily annoyed and irritated. Analyses also identified significant increases in feeling safe, and in feeling happy and rejuvenated. Residents noted Lakehouse’s sense of community, beautiful views, and proximity to Sloan Lake as factors influencing their lower stress and stronger connection to nature.

Improvements in Emotional Health Symptoms

Respondents’ **negative** feelings decreased after moving to Lakehouse.

NERVOUS



DOWNHEARTED



TENSE



Respondents’ **positive** feelings increased after moving to Lakehouse.

HAPPY



REJUVENATED



NOT STRESSED AT ALL



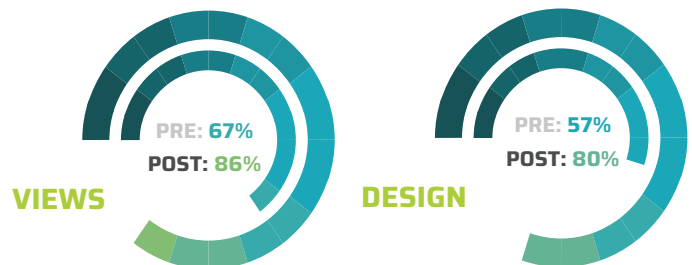
“Lakehouse has all the elements to create a less stressful environment.”
- Lakehouse Resident

LAKEHOUSE SUPPORTS CONNECTION TO NATURE

- Glass exterior provides views of natural setting
- Biophilic design elements
- Extensive landscaping
- Nature-inspired artwork
- Meditation gardens
- Location on Sloan’s Lake Park

Increased Connection to Nature

Respondents’ agreement that views and design enhanced their connection to nature increased after moving to Lakehouse.





Courtesy of NAVA



4. Physical Health

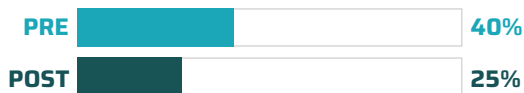
After moving into Lakehouse, residents experienced improved physical health, including being more active, experiencing fewer negative health symptoms, better concentration, and eating more organic foods.

Residents sat for significantly fewer hours after moving into Lakehouse, which is likely related to the increase in their rating of how impactful building location and on-site fitness equipment were in helping lead a healthy lifestyle. Every resident interviewed said they felt more active since moving to Lakehouse, calling out exercise classes, fitness equipment, and proximity to natural places as important factors. Analyses showed a lower frequency of several physical health symptoms in residents: dry, itching, irritated eyes; stuffy/runny nose and sinus congestion; and difficulty remembering things or concentrating. Additionally, analyses showed a significant decrease in severity of problems with tiredness, which coincided with a significant increase in use of blackout shades.

The percentage of residents' diets that were organic increased after moving to Lakehouse. Through interviews, residents noted positive changes in diet and commented that Lakehouse supports healthy eating via the organic urban farm, collaborative kitchen, cooking and nutrition-related educational classes, community events, and access to dietary experts. Notably, there was an association between nutritional programming and diet: those who participated in Lakehouse nutrition activities increased frequency of eating vegetables.

Improvements in Memory & Sleep

Difficulty remembering things or concentrating



*No to mild tiredness issues
(compared to moderate or severe issues)*



Improvements in Diet & Physical Activity

Diet 50% or more organic



*Access to fitness equipment very or extremely
impactful in helping lead a healthy lifestyle*





Above Images Courtesy of NAVA

Residents began moving into Lakehouse just prior to the start of the global COVID-19 pandemic, and this study was conducted throughout the pandemic. While the majority of study variables that changed did so in a positive way, a few changed negatively – in contrast to the study’s hypothesis, but in alignment with national trends. Analyses showed that three variables changed negatively for residents while living at Lakehouse: lower productivity at work, increased alcohol frequency, and increased symptoms of wheezing. Negative changes in productivity and alcohol are unsurprising given the COVID-19 pandemic, which has been reported to be associated with increased alcohol consumption³ and which interrupted work habits nationally.

Alcohol consumption at Lakehouse also relates to increased social connections, as residents often shared alcohol during gatherings. Although residents’ reports of wheezing increased to a small, but significant extent, their satisfaction with air quality significantly increased. This suggests that wheezing may be attributed to other factors, including COVID-19 and an exceptionally bad wildfire season in Colorado and the western U.S. in 2020-21.

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Time Spent Sitting

On average, post-occupancy respondents sat for 41 fewer minutes on weekdays and 26 fewer minutes on weekends than pre-occupancy respondents.



LAKEHOUSE SUPPORTS RESIDENT HEALTH

- Fitness lab
- Yoga and meditation studio
- Exercise and nutrition classes
- 70-foot lap pool
- Dry sauna
- Organic urban farm
- Blackout shades in all bedrooms

“We no longer have easy excuses to not exercise and eat healthy.”
- Lakehouse Resident

CONCLUSION

IBE's research offers evidence that Lakehouse's sustainable, healthy building design and wellness programming may be positively impacting the health, wellbeing, and happiness of residents. It is notable that despite being conducted during the COVID-19 pandemic, the study identified nearly 45% of measured variables (36 total variables) that significantly changed in a positive way and less than 4% in a negative way (the remainder had no significant change).

The COVID-19 pandemic may have subdued some otherwise positive changes. Replicating this study over a longer period of time will be needed to attribute changes in residents' health and wellbeing to the Lakehouse environment.

“We absolutely feel like we made the right decision coming here and that it's paying off in all sorts of ways.”
- Lakehouse Resident

REFERENCES

1. Murthy, V. Work and the Loneliness Epidemic. Harvard Business Review. Sept. 26, 2017. Work and the Loneliness Epidemic (hbr.org)
2. Our Epidemic of Loneliness and Isolation: The U.S. Surgeon General's Advisory on the Healing Effects of Social Connection and Community. 2023. <https://www.hhs.gov/sites/default/files/surgeon-general-social-connection-advisory.pdf>
3. Roberts A, Rogers J, Mason R, Siriwardena AN, Hogue T, Whitley GA, Law GR. Alcohol and other substance use during the COVID-19 pandemic: A systematic review. Drug Alcohol Depend. 2021 Dec 1; 229(Pt A): 109150. doi: 10.1016/j.drugalcdep.2021.109150. Epub 2021 Oct 29.

APPENDIX A

WELL SCORECARD

309 NAVA Lakehouse Condos
The WELL Building Standard v1.0 (September 2015)
Multifamily Residential
 WELL Supplemental Review Report
 Date: 09/24/2021

28 Preconditions Available
28 Preconditions Attempted
28 Preconditions Achieved
0 Preconditions Not Achieved

48 Optimizations Available
22 Optimizations Attempted
21 Optimizations Achieved
1 Optimizations Not Achieved



AIR		
Achieved	P	1 Air Quality Standards
Achieved	P	2 Smoking Ban
Achieved	P	3 Ventilation Effectiveness
Achieved	P	4 VOC Reduction
Achieved	P	5 Air Filtration
Achieved	P	6 Microbe And Mold Control
Achieved	P	7 Construction Pollution Management
Achieved	P	8 Healthy Entrance
Achieved	P	9 Cleaning Protocol
Achieved	P	10 Pesticide Management
Achieved	P	11 Fundamental Material Safety
Achieved	P	12 Moisture Management
Achieved	O	13 Air Flush
Achieved	O	14 Air Infiltration Management
Achieved	O	15 Increased Ventilation
	O	16 Humidity Control
Feature not applicable to project type	n/a	17 Direct Source Ventilation
	O	18 Air Quality Monitoring And Feedback
Achieved	P	19 Operable Windows
	O	20 Outdoor Air Systems
	O	21 Displacement Ventilation
Achieved	O	22 Pest Control
	O	23 Advanced Air Purification
	O	24 Combustion Minimization
	O	25 Toxic Material Reduction
	O	26 Enhanced Material Safety
	O	27 Antimicrobial Surfaces
	O	28 Cleanable Environment
Achieved	O	29 Cleaning Equipment
Feature not applicable to project type	n/a	29 Advanced Cleaning

WATER		
Achieved	P	30 Fundamental Water Quality
Achieved	P	31 Inorganic Contaminants
Achieved	P	32 Organic Contaminants
Achieved	P	33 Agricultural Contaminants
Achieved	P	34 Public Water Additives
Achieved	O	35 Periodic Water Quality Testing
	O	36 Water Treatment
Achieved	O	37 Drinking Water Promotion

NOURISHMENT		
Feature not applicable to project type	n/a	38 Fruits And Vegetables
Achieved	O	39 Processed Foods
Achieved	O	40 Food Allergies
	O	41 Hand Washing
	O	42 Food Contamination
Achieved	P	43 Artificial Ingredients
Achieved	P	44 Nutritional Information
Achieved	O	45 Food Advertising
Feature not applicable to project type	n/a	46 Safe Food Preparation Materials
Feature not applicable to project type	n/a	47 Serving Sizes
Feature not applicable to project type	n/a	48 Special Diets
Feature not applicable to project type	n/a	49 Responsible Food Production
Achieved	O	50 Food Storage
Achieved	O	51 Food Production
Feature not applicable to project type	n/a	52 Mindful Eating
	O	53 Food Environment
Feature not applicable to project type	n/a	57 Strategic Dining Design

10 Optimizations = Silver, 20 Optimizations = Gold, 39 Optimizations = Platinum

LIGHT		
	O	53 Visual Lighting Design
	O	54 Circadian Lighting Design
Achieved	P	55 Electric Light Glare Control
Feature not applicable to project type	n/a	56 Solar Glare Control
Feature not applicable to project type	n/a	57 Low-Glare Workstation Design
	O	58 Color Quality
	O	59 Surface Design
	O	60 Automated Shading And Dimming Co
Achieved	P	61 Right To Light
	O	62 Daylight Modelling
	O	63 Daylighting Fenestration
	O	62 Light at Night
	O	63 Circadian Emulation

FITNESS		
Achieved	P	64 Interior Fitness Circulation
Feature not applicable to project type	n/a	65 Activity Incentive Programs
Feature not applicable to project type	n/a	66 Structured Fitness Opportunities
Achieved	O	67 Exterior Active Design
Achieved	O	68 Physical Activity Spaces
Achieved	O	69 Active Transportation Support
Achieved	O	70 Fitness Equipment
Feature not applicable to project type	n/a	71 Active Furnishings
Feature not applicable to project type	n/a	72 Injury Prevention

COMFORT		
Feature not applicable to project type	n/a	72 Accessible Design
Feature not applicable to project type	n/a	73 Ergonomics: Visual And Physical
Not Achieved	O	74 Exterior Noise Intrusion
	O	75 Internally Generated Noise
Achieved	P	76 Thermal Comfort
Feature not applicable to project type	n/a	77 Olfactory Comfort
Feature not applicable to project type	n/a	78 Reverberation Time
Feature not applicable to project type	n/a	79 Sound Masking
Feature not applicable to project type	n/a	80 Sound Reducing Surfaces
	O	81 Sound Barriers
Feature not applicable to project type	n/a	82 Individual Thermal Control
	O	83 Radiant Thermal Comfort
Achieved	O	84 Impact Reducing Flooring

MIND		
Achieved	P	84 Health And Wellness Awareness
Achieved	P	85 Integrative Design
Feature not applicable to project type	n/a	86 Post-Occupancy Surveys
Achieved	P	87 Beauty And Design I
Achieved	P	88 Biophilia I - Qualitative
Feature not applicable to project type	n/a	89 Adaptable Spaces
Feature not applicable to project type	n/a	90 Healthy Sleep Policy
Feature not applicable to project type	n/a	91 Business Travel
Feature not applicable to project type	n/a	92 Workplace Health Policy
Feature not applicable to project type	n/a	93 Workplace Family Support
Feature not applicable to project type	n/a	94 Self-Monitoring
Feature not applicable to project type	n/a	95 Stress And Addiction Treatment
Feature not applicable to project type	n/a	96 Altruism
	O	97 Material Transparency
Feature not applicable to project type	n/a	98 JUST Organization
	O	99 Beauty And Design II
	O	100 Biophilia II - Quantitative
	O	95 Health Through Housing Equity
Feature not applicable to project type	n/a	94 Education Space Provisions

INNOVATION		
Achieved	O	101 Innovation Feature I
Achieved	O	102 Innovation Feature II
Achieved	O	103 Innovation Feature III
Achieved	O	104 Innovation Feature IV
	O	105 Innovation Feature V

APPENDIX B

WELL PERFORMANCE VERIFICATION REQUIREMENTS for WELL Features Completed by Lakehouse

The verification measures of all WELL Features completed for Lakehouse fell within WELL requirements, as represented in this table.

PARAMETER	WELL FEATURE	MEASUREMENT (UNITS)	WELL THRESHOLD MET AT LAKEHOUSE
INDOOR AIR QUALITY	01. Air Quality Standards	Formaldehyde (ppb) TVOC ($\mu\text{g}/\text{m}^3$) Carbon Monoxide (ppm) PM2.5 ($\mu\text{g}/\text{m}^3$) PM10 ($\mu\text{g}/\text{m}^3$) Ozone (ppb) Radon (pCi/L)	<27 <500 <9 <15 <50 <51 <4
	06. Microbe and Mold Control	Wavelength (nm) or regular inspection	= 254
	11. Fundamental Material Safety	Asbestos Lead (%) in wetted surfaces Lead (ppm) in paint/ductwork/conduits/roof	= 0 <0.25% <100
	13. Air Flush	$^{\circ}\text{C}$ Relative humidity	$\geq 59^{\circ}\text{C}$ <60%
	15. Increased Ventilation	Outdoor air supply rates	>30%
WATER	30. Fundamental Water Quality	Turbidity (NTU) Total coliforms <i>E. Coli</i>	<1 ND ND
	31 Inorganic Contaminants	Lead (mg/L) Arsenic (mg/L) Antimony (mg/L) Mercury (mg/L) Nickel (mg/L) Copper (mg/L)	<0.01 <0.01 <0.006 <0.002 <0.012 <1
	32 Organic Contaminants	Styrene (mg/L) Benzene (mg/L) Ethylbenzene (mg/L) Polychlorinated biphenyls (mg/L) Vinyl Chloride (mg/L) Toluene (mg/L) Xylenes (total: m, p, and o) (mg/L) Tetrachloroethylene (mg/L)	<0.0005 <0.001 <0.3 <0.0005 <0.002 <0.15 <0.5 <0.005
	33 Agricultural Contaminants	Atrazine (mg/L) Simazine (mg/L) Glyphosate (mg/L) 2,4-Dichlorophenoxyacetic Acid (mg/L) Nitrate (mg/L)	<0.001 <0.002 <0.7 <0.07 <50
	34 Public Water Additives	Total chlorine (mg/L) Chloramine (mg/L) Total trihalomethanes (mg/L) Total haloacetic acid (mg/L) Fluoride (mg/L)	<50 <4 <4 <0.08 <0.06 <4
	36 Drinking Water Promotion	Aluminum (mg/L) Chloride (mg/L) Manganese (mg/L) Sodium (mg/L) Sulfate (mg/L) Iron (mg/L) Zinc (mg/L) TDS (mg/L)	< 0.2 <250 <0.05 <270 <250 <0.3 <5 <500
LIGHT	55. Electric Light Glare Control	α ($^{\circ}$) for cd/m ² ranges	15 $^{\circ}$ for 20k-50k 20 $^{\circ}$ for 50k-500k 30 $^{\circ}$ for 500k+
COMFORT	76. Thermal Comfort	Adherence with ASHRAE Standard 55-2013 5.3 and 5.3 Operative kitchen temperature (F)	N/A <80
	P4. Impact Reducing Flooring	Impact Insulation Class	≥ 50



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