CLEVELAND CLINIC DATA CENTER PROJECT
CHALLENGES & SOLUTIONS

Cleveland Clinic

PRESENTERS

James Coe, PE, RCDD
Senior Vice President
Director of Critical Facilities
Syska Hennessy Group, Inc.

Vali Sorell, PE
Vice President
Critical Facilities Chief HVAC Engineer
Syska Hennessy Group, Inc.

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The Cleveland Clinic

- Founded in 1921
- Not-for-profit Group Practice (2nd Largest in U.S.)
- Over 43,890 Employees
- 3,000 Physicians and Scientists
- 11,400 Nurses
- 1,450 Bed Main Campus – 4,450 Beds System Wide
- 8 Community Hospitals & 16 Family Health Centers
- 204 Buildings for a total of 24M SF
- Cleveland Clinic System Statistics(2011):
  - Clinical visits: 5.1M with over 1M Same Day Appointments
  - Surgical cases: 200,800
  - Admissions: 157,470
  - ER Visits: 490,342

Cleveland Clinic 2012 Annual Report: “We Are All Caregivers”

Ashtabula County Medical Center

Cleveland Clinic Toronto

Euclid Hospital

Willoughby Hills Family Health Center

S.T.J. Health Center

Cleveland Clinic

Hillcrest Hospital

Avon Family Health Center

Elyria Family Health Center

Lakewood Hospital

Lutheran Hospital

South Pointe Hospital

Beachwood Family Health and Surgery Center

Westlake Family Health Center

Lakewood Family Health Center

Marymount Hospital

Lorain Family Health And Surgery Center

Solon Family Health Center

Twinsburg Family Health Center

Fairview Hospital

Lou Ruvo Center for Brain Health Las Vegas, Nevada

Independence Family Health Center

Medina Hospital

Strongsville Family Health and Surgery Center

Brunswick Family Health Center

Wooster Family Health Center

Chagrin Falls Family Health Center

West Palm Family Health Center

Cleveland Clinic Vision

The vision of Cleveland Clinic: Striving to be the world's leader in patient experience, clinical outcomes, research and education.

When Cleveland Clinic welcomed its first patients on February 28, 1921, its mission was clearly in place: *“Better care of the sick, investigation into their problems and further education of those who serve.”*

The doctors who founded Cleveland Clinic, drawing from military medicine, believed in diverse specialists working and thinking as a unit. This kind of cooperation, efficiency and shared vision has fostered excellence in patient care, research and education. These principles endure today at Cleveland Clinic, a nonprofit group practice.

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National Leader

Cardiology & Heart Surgery……	No. 1
Urology……	No. 1
Nephrology……	No. 1
Diabetes & Endocrinology……	No. 2
Ear, Nose & Throat……	No. 2
Gastroenterology……	No. 2
Rheumatology……	No. 2
Gynecology……	No. 3
Orthopaedics……	No. 3
Pediatric Neurology & Neurosurgery……	No. 3
Pulmonary……	No. 3

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Timeline

1997: Parker bldg. donated to Cleveland Clinic

1998: Parker bldg. becomes Cleveland Clinic Primary Datacenter

2001: Ambulatory EMR, Scheduling and Registration go live

2005: Health System rollout of integrated Inpatient EMR (blade technology)

2006

PARKER DATA CENTER

- Parker Building built in the 1920's with the Data Center added in the in the early 1980's
- Tier I Facility – limited redundant power and cooling systems
- Computer Room - 10,000s.f. divided into two rooms
- Raised Floor – 12" south room & 18" north room (air damming problems in both rooms)
- Power - 0.9MW
- Expansion – Building is land locked

2012

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Uptime Institute Tier Requirements

	Tier I	Tier II	Tier III	Tier IV
Active Capacity Components to Support IT Load	N	N+1	N+1	N after any failure
Distribution Paths	1	1	1 active and 1 alternate	2 simultaneously active
Concurrently Maintainable	No	No	Yes	Yes
Fault Tolerance (single event)	No	No	No	Yes
Compartmentalization	No	No	No	Yes
Continuous Cooling (load density dependent)	*	*	*	Yes (Class A)

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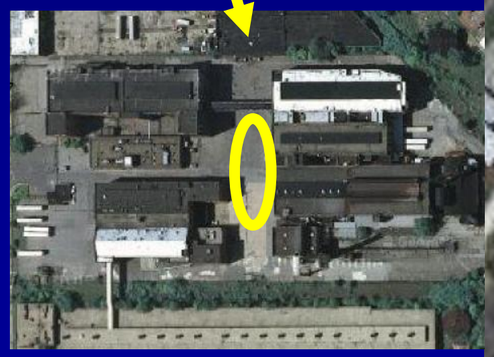
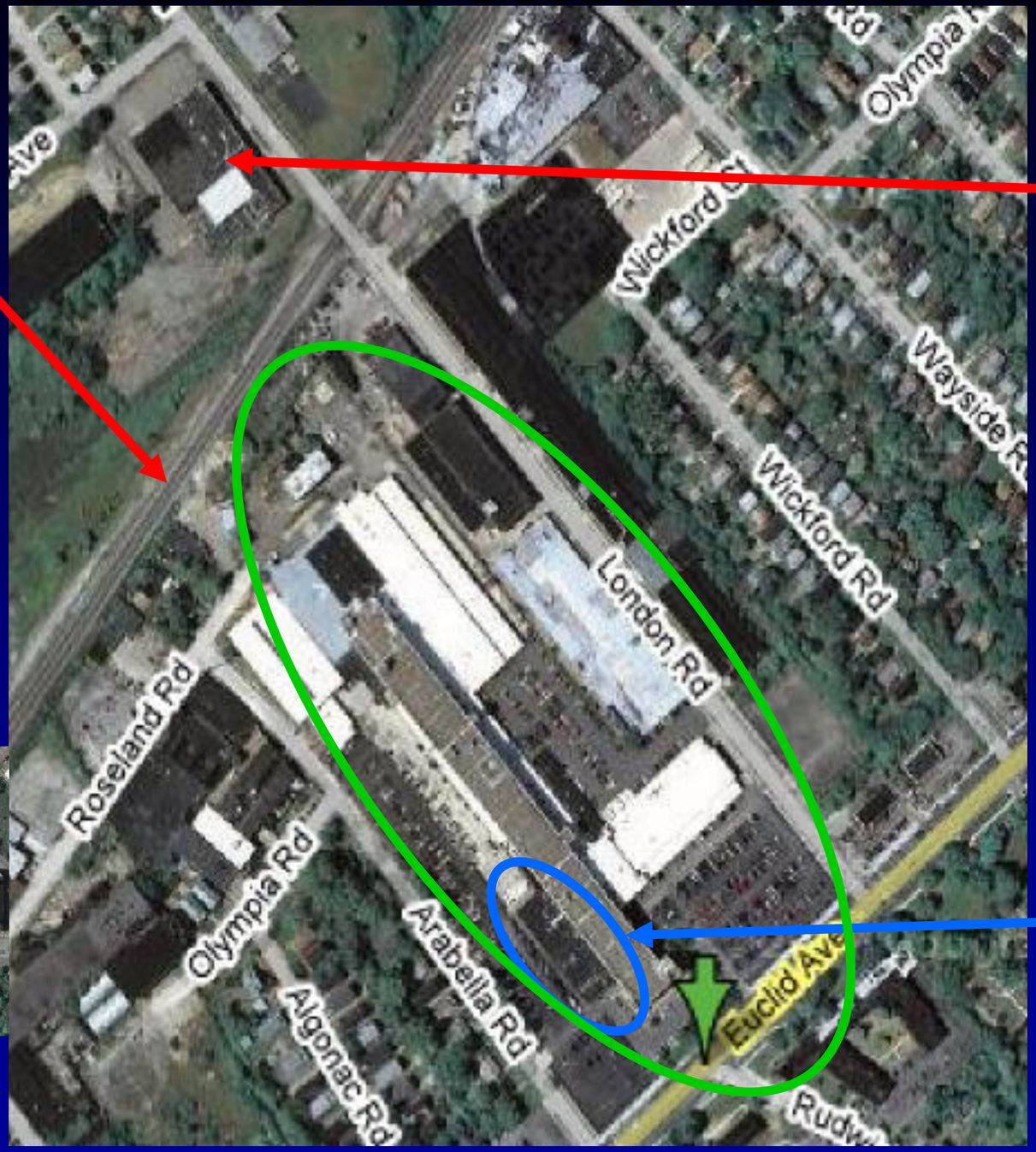
Parker Data Center Site Risks

Railroad Track (2007: train derail/explosion after passing Parker)

Surrounding Area Industrial Buildings





Superfund Cleanup Site EPA

Cleveland Clinic Multi-use Property

Data Center Floor

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2005: Parker Data Center Catastrophic Failure (July)

2006

1st Study New Tier III Data Center (September)

ITD Reorganization: Data Center Org established (November)

2007

Parker Data Center Upgrade Begins (March)

2nd Study New Tier III Data Center (November)

2008

Begin Land Search for New Data Center (January)

Parker Data Center Upgrade Complete (July)

3rd Study New Tier III Data Center (October)

2009

Design Begins (September)

Funding Approved (April)

2010

Construction Start (July 2010)

2012

Occupancy (January 9, 2012)

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Continuous Cooling (load density dependent)	*	*	*	Yes (Class A)

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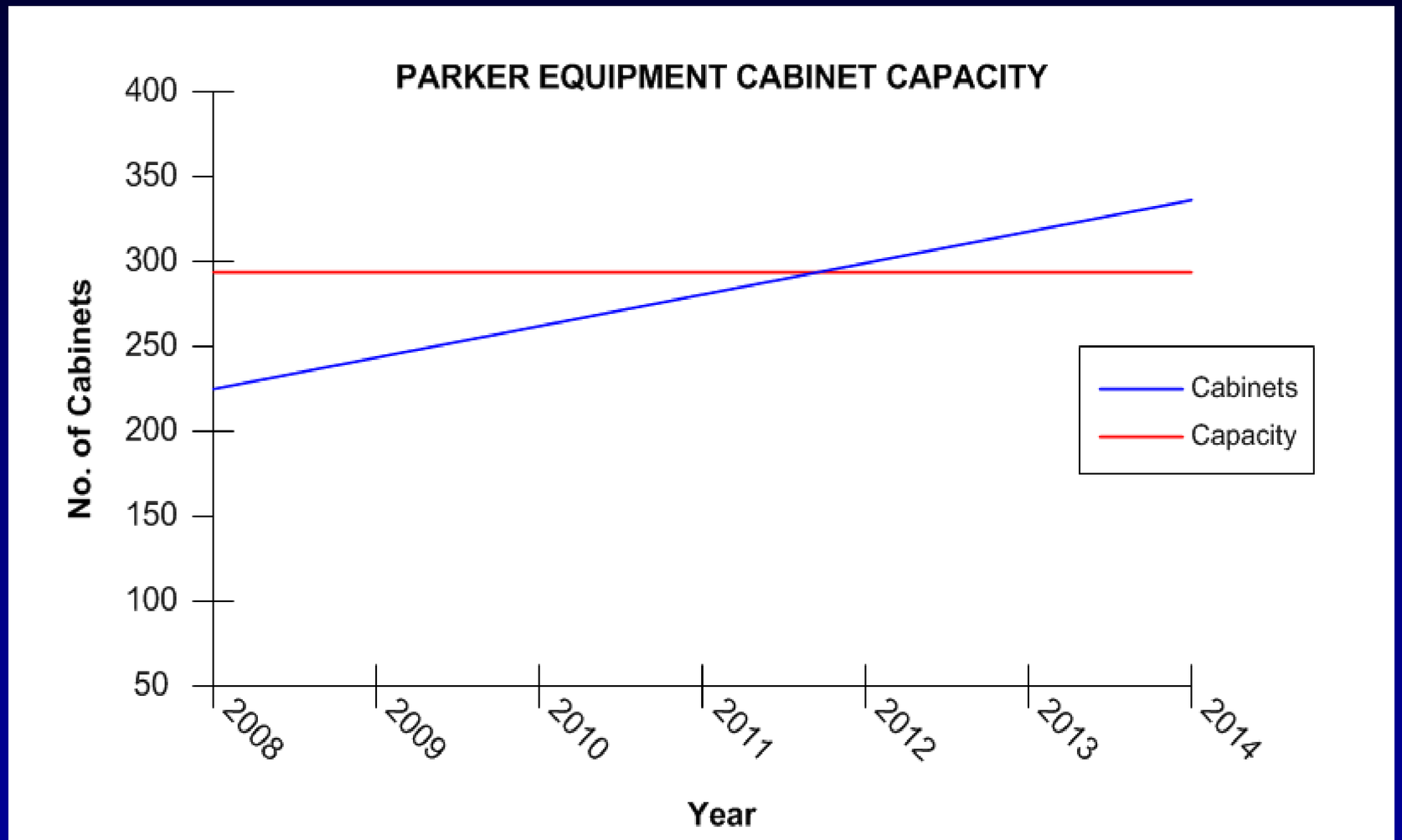
Expected Growth

Growth was forecasted at 6% per year but new applications were causing “large stair step” increases in servers and data storage



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Parker Preservation

- Created overflow site for all non-essential application servers (e.g., test & development, tier 2 & higher applications.
- Virtual server initiative (initial effort eliminated over 400 physical servers).
- Instituted a data center oversight committee to review all new hardware initiatives.
- Increased hardware decommissioning efforts.

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Cleveland Clinic's Innovation & Growth are Driving Data Center Services

Health System Expansion

- Partnering, branding and management of clinical facilities
- Integration of acquisitions
- Expansion of hospital affiliates
- Development of Cleveland Clinic brand in niche locations
- Regional & global expansion

Patient Care

- Integrated medical records and diagnostic information
- Integrated 3D & high resolution imaging
- Cleveland Clinic quality standards
- Patient access to personal medical information
- Online, remote medical second opinions
- Real time information to physicians

Research, Safety, Privacy & Informatics

- Optimization of the Electronic Medical Record
- All electronic reimbursements
- Patient safety & privacy with respect to treatment, processes and records
- Data archiving to meet government requirements
- Exponential growth of data storage
- High reliability / availability
- Business Intelligence

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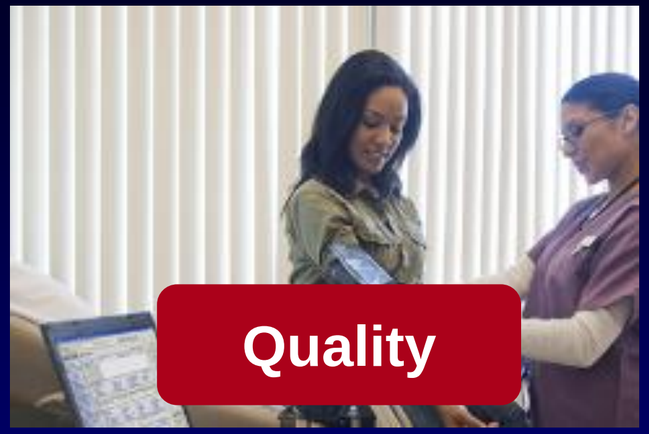
Cleveland Clinic Data Center Vision



An IT infrastructure which supports Cleveland Clinic's mission to provide compassionate health care of the highest quality in a setting of education and research.

- **On demand, always on, IT infrastructure**
- **Flexible computing power and storage**
- **World-class cost efficiency structure**
- **Bulletproof operational processes**
- **Market leadership in reliability, capability & coverage**

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Strategy

- Build a Tier III Enterprise Class Data Center
- Assure 7/24 x 365 “always on” reliable infrastructure
- Extend core network speed to the new data center facility
- Consolidate numerous decentralized locations into new Data Center
- Implement best practice processes that reduce or eliminate downtime
- Increase agility in response to the dynamic demand of the organization
- Highly Leverage both Server and Storage Virtualization technology
- Look for opportunities to utilize both external and internal Cloud computing

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Modular Data Center Program

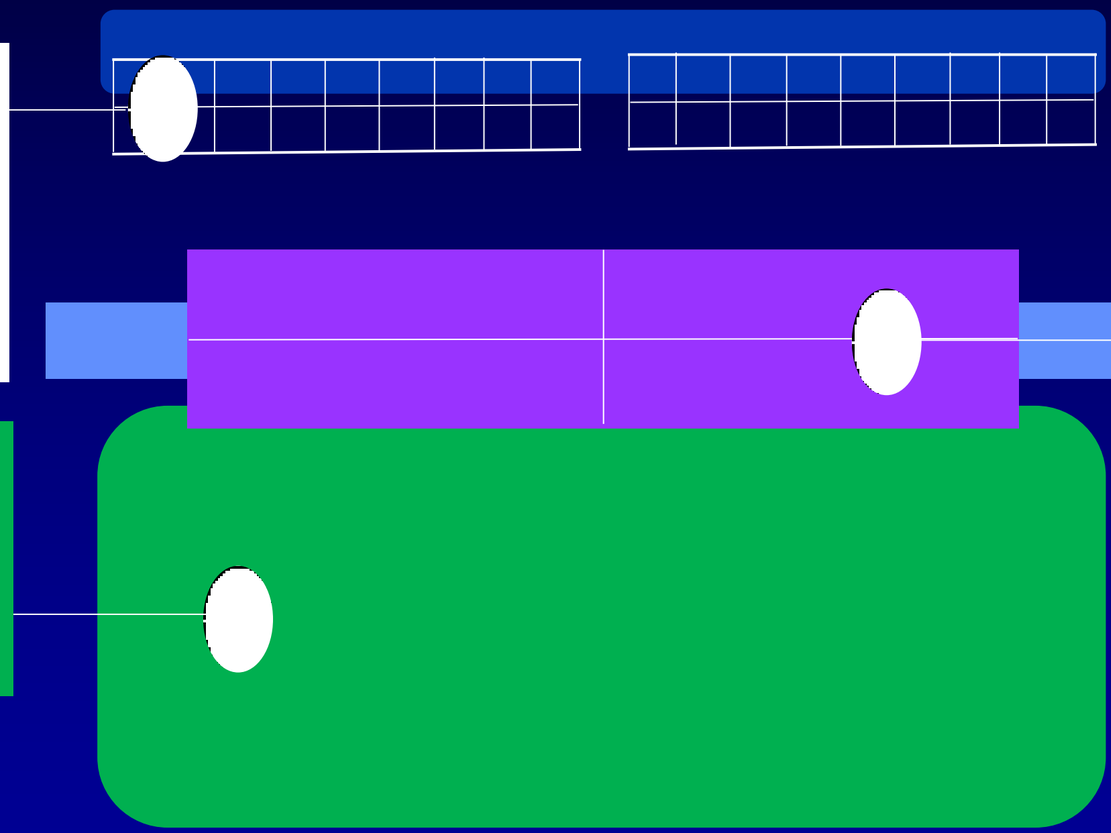
1. Data Center:
Approx. 110,000sf on 14 Acres

2. Comp. Room:
20,000sf raised floor

3. Pod: Approx. 12 cabinets with specific functions (e.g., servers, storage, backup, etc.

4. Facility Core:
Shared power and cooling systems, shipping/receiving, operations, security, storage, burn-in, offices, etc.

5. Expansion:
Adjacent land allowing for future data center build



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Alternative Comparisons

	Own	Lease	Collocation	Outsource
Time Frame	• Design & Build 31 mos. • Start Up 24 months	• Design & Build 31 mos. • Start Up 24 months	• Space Prep 24 mos. • Start Up 24 months	• Design/Build 31 mos. • Start Up 24 months • Integration 2-3 yrs.
Pros	• IT & Bldg. Control • IT & Bldg. Security • IT & Bldg. Flexibility • IT & Bldg. Expansion • Can lease space to 3rd party users	• IT Control • IT Security • IT Flexibility • IT Expansion • No affect on Debt • Capacity • Bldg Operating Lease	• No affect on Debt Capacity • Bldg. Operating Lease	• No affect on Debt Capacity • Costs could be operationalized
Cons	• Limit on Debt Capacity	• Limited Bldg. Flexibility, Control, Expansion • For Profit Landlord	• Searched N Ohio. No • existing locations meet • CC criteria • Compromise on location • and facility capabilities • Limited IT Control, • Security, Flexibility, • Expansion	• Bandwidth costs increase substantially • Compromise on location and facilities capabilities • Limited IT Control, Security, Flexibility, Expansion • Costs are very high for an organization our size.
Exit Strategy	• Transition to outsource through purchase • Sell or Lease to • Secondary IT market	• Transition to outsource • through purchase or • Sublease • Sell or Sublease to • Secondary IT market	• Cost to remove all • equipment and relocate • to new location • Sublease to Secondary • IT market	• Payment of unamortized • equipment and contract • Costs • Cost to purchase existing • equipment or new and

Site Selection

UPTIME Institute's Site Criteria for a Tier III Data Center

- Not located within 100-year flood plan
- Not located within the flight path of any nearby airport
- No less than ½ mile from a railroad or major highway
- No less than ¼ mile from airport, research lab, chemical or heavy manufacturing
- No less than ½ mile from military base
- No less than 1 mile from nuclear, munitions, or defense plant
- Not within high crime area
- Proximity to Electric Transmission Lines
- Availability of Telecommunications

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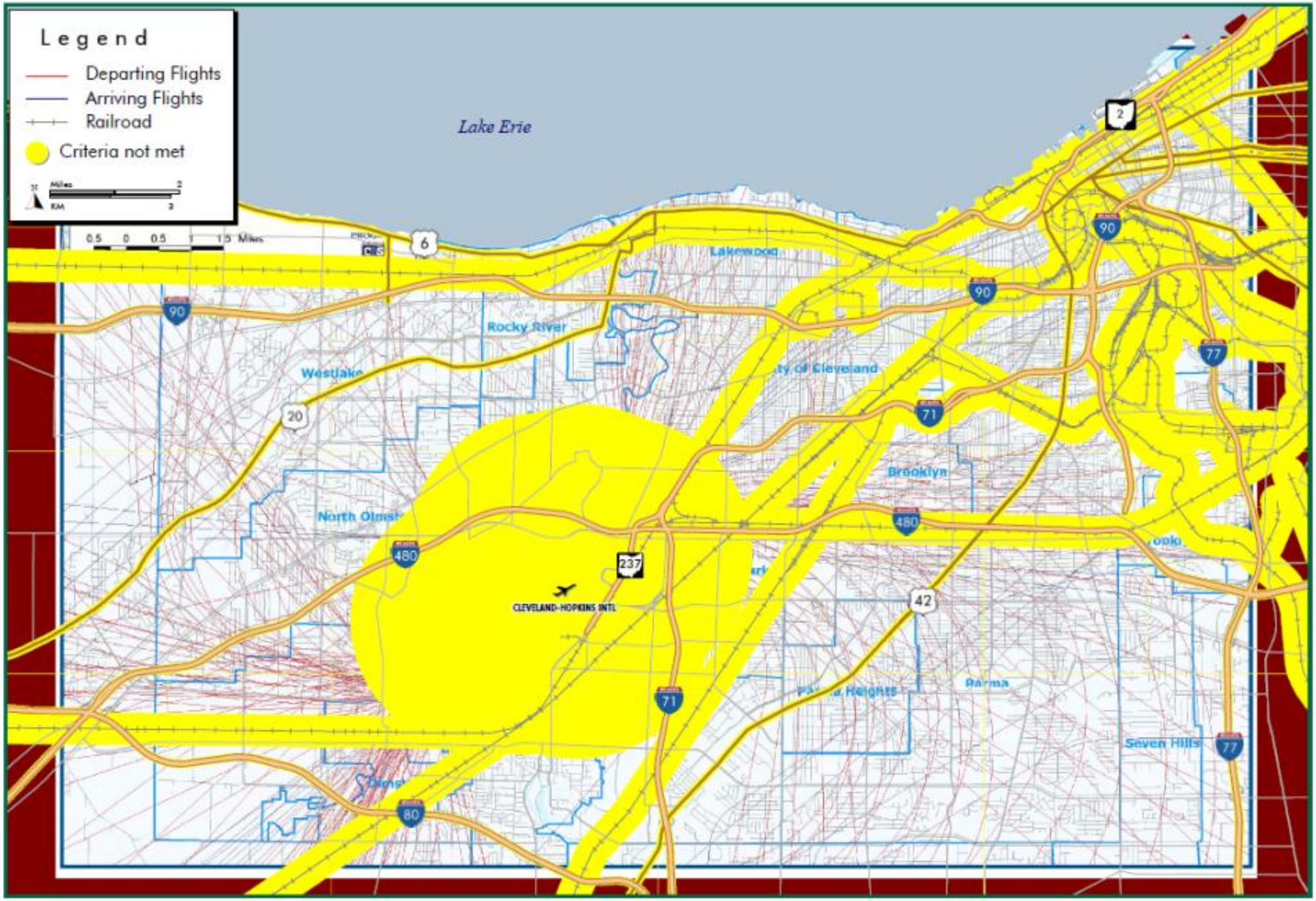
Northeast Ohio Site Selection Map

Cleveland, OH



The Short List

Properties available on the market that met the criteria

1. Brecksville Road, Brecksville (48 acres)
2. Miller Road, Brecksville (14.1 acres)
3. W Royalton Road, Broadview Heights (10.2 acres)
4. Landerhaven Drive Mayfield Heights (12 acres)

Properties Owned by the CC that met the criteria

5. Euclid Avenue (Cleveland Playhouse) Cleveland (11 acres)
6. Richmond Road (TRW excess land) Lyndhurst (75 acres)
7. Brecksville Road (ITC excess land) Independence (10 acres)

Properties Owned by the CC that did not meet the criteria

8. SE corner of I-480 & Darrow Road, Twinsburg (70 acres)
9. W Aurora Road Sagamore Hills (20 acres)
10. Ansel Rd & Mt Sinai Drive (old Mt. Sinai Hospital) Cleveland (40 acres)
11. 3050 Science Park Drive (CCAC campus) Beachwood (30 acres)

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Cuyahoga County Site Selection Map

Properties available on the market that meet the search criteria
1 9911 Brecksville Rd, Brecksville (48 acres)
2 Miller Rd, Brecksville (13 acres)
3 1521-1601 W Royalton Rd, Broadview Hts (10.21 acres)
4 Landerhaven Dr, Mayfield Hts (12 acres)
Properties Owned by the Cleveland Clinic that meet the search criteria
5 8500 Euclid Ave (Cleveland Playhouse) Cleveland (11 acres)
6 1900 Richmond Rd (TRW excess land) Lyndhurst (75 acres)
7 6801 Brecksville Rd (ITC excess land) Independence (10 acres)
Properties Owned by the Cleveland Clinic that do not meet the search criteria
8 SE corner of I-480 & Darrow Rd, Twinsburg (70 acres)
9 863 W Aurora Rd, Sagamore Hills (20 acres)
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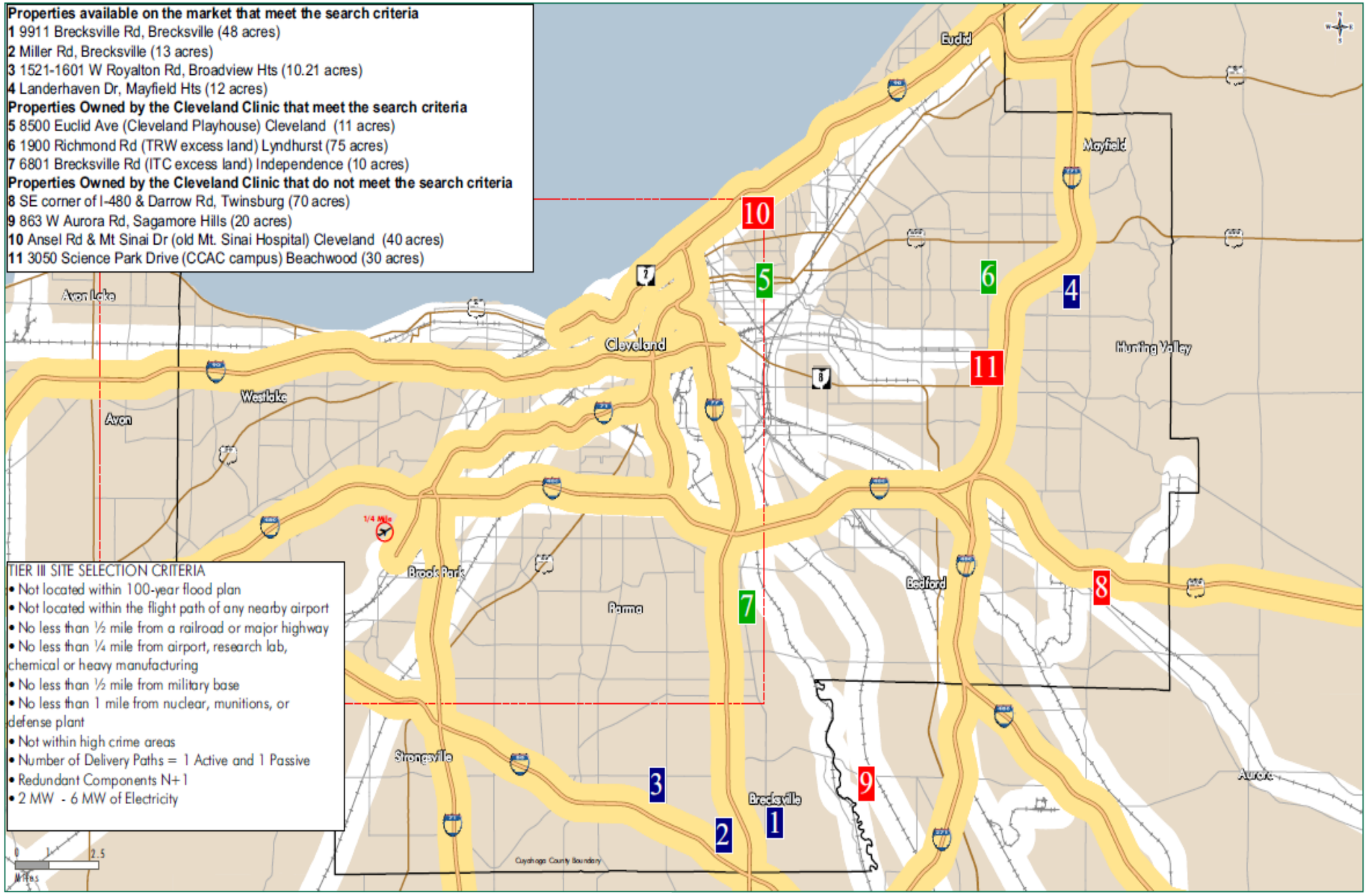


TIER III SITE SELECTION CRITERIA
- Not located within 100-year flood plan
- Not located within the flight path of any nearby airport
- No less than ½ mile from a railroad or major highway
- No less than ¼ mile from airport, research lab, chemical or heavy manufacturing
- No less than ½ mile from military base
- No less than 1 mile from nuclear, munitions, or defense plant
- Not within high crime areas
- Number of Delivery Paths = 1 Active and 1 Passive
- Redundant Components N+1
- 2 MW - 6 MW of Electricity

BRECKSVILLE POTENTIAL LOCATIONS

EMPLOYEES

- CRITICAL
- OTHER
- TECH SERVICES

DRIVE TIMES

- 0-30 MINUTES
- 30-45 MINUTES

DRIVE TIME ANALYSIS

0-30 MINUTES = 349 EMPLOYEES

30-45 MINUTES = 336 EMPLOYEES

45 + MINUTES = 128 EMPLOYEES

0-30 MINUTE DRIVE TIME ANALYSIS

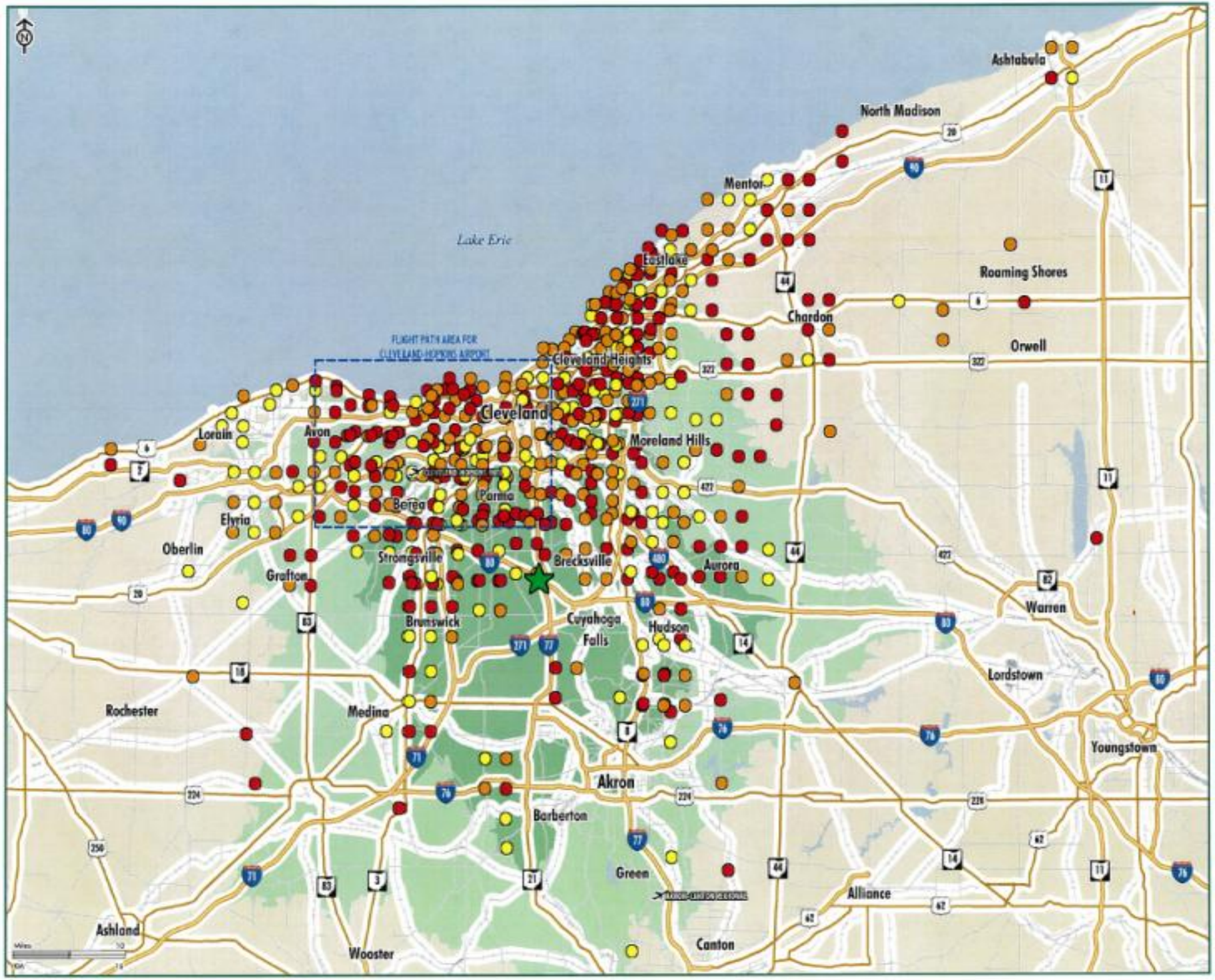
- 92 CRITICAL EMPLOYEES
- 117 OTHER EMPLOYEES
- 140 TECH SERVICE EMPLOYEES

30-45 MINUTE DRIVE TIME ANALYSIS

- 69 CRITICAL EMPLOYEES
- 114 OTHER EMPLOYEES
- 153 TECH SERVICE EMPLOYEES

45+ MINUTE DRIVE TIME ANALYSIS

- 32 CRITICAL EMPLOYEES
- 35 OTHER EMPLOYEES
- 61 TECH SERVICE EMPLOYEES



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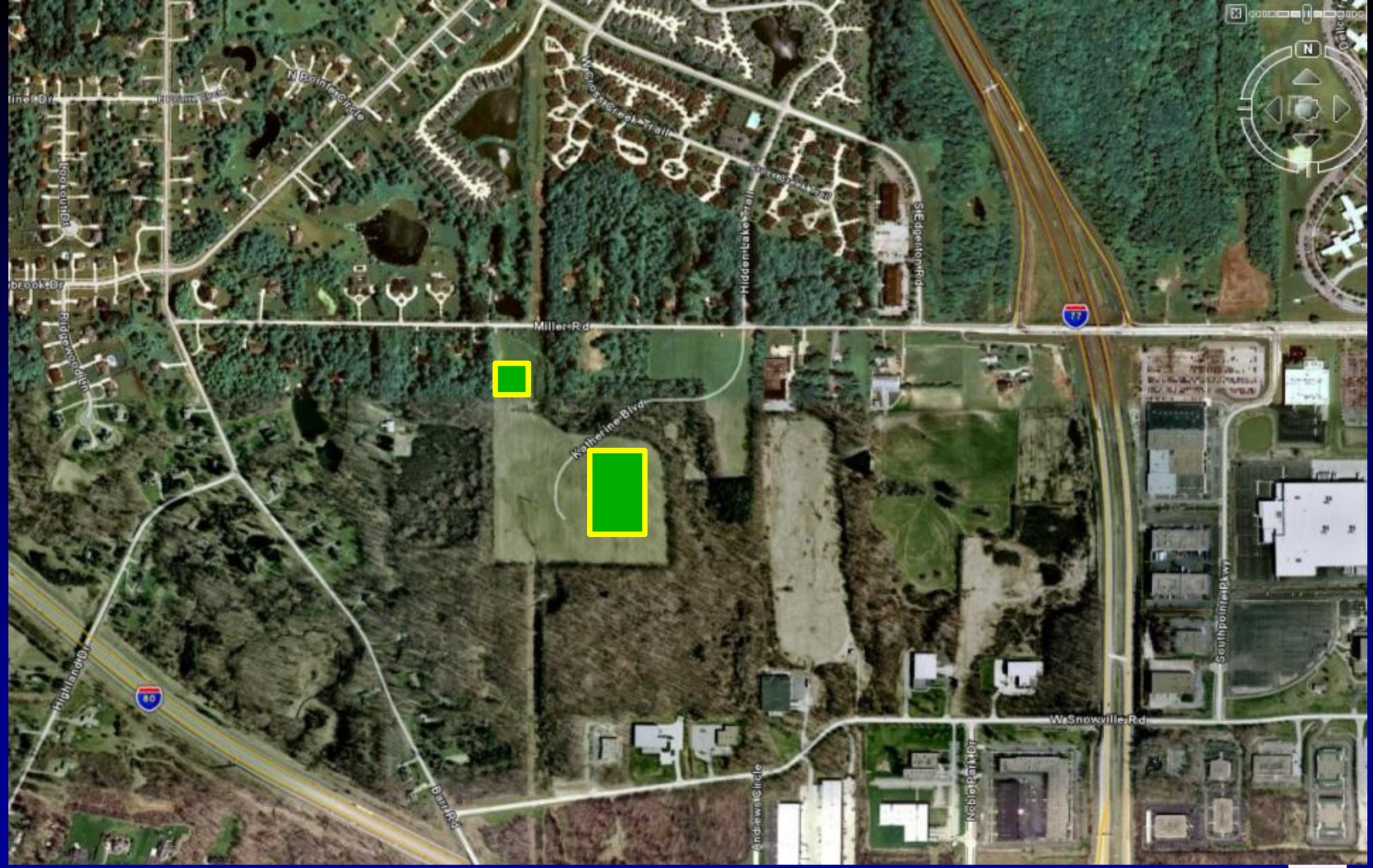

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Design Team

- MEP Engineer
- Construction Manager
- Owner's Representatives
- Architect
- General Technology Design
- Data Hall Cabling Design
- Commissioning Agent

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Basis for Design

- **Modular Building Approach**
- **Data Hall - Phase I = 20,000 SF**
- **Technology Equipment Rooms = 2,000 SF**
- **Infrastructure Space - Phase I = 63,000 SF**
  - Generators, UPS, Chillers, Telecom Rooms, Mechanical & Electrical Equipment Rooms, etc.
- **Office Work Area = 25,000 SF**
- **Phase I Power & Cooling Systems Design (Tier III):**
  - N + 1 Concurrently Maintainable Configuration
  - 3 MW Data Hall Equipment Load (150W / SF)
  - 1 MW Other Equipment Load
  - 18MW Fault Tolerant Substation
  - Chilled Water with Waterside Economizer
- **Telecommunications**
  - Diverse / Redundant Feeds
- **Green Building LEED® Goal: Silver**

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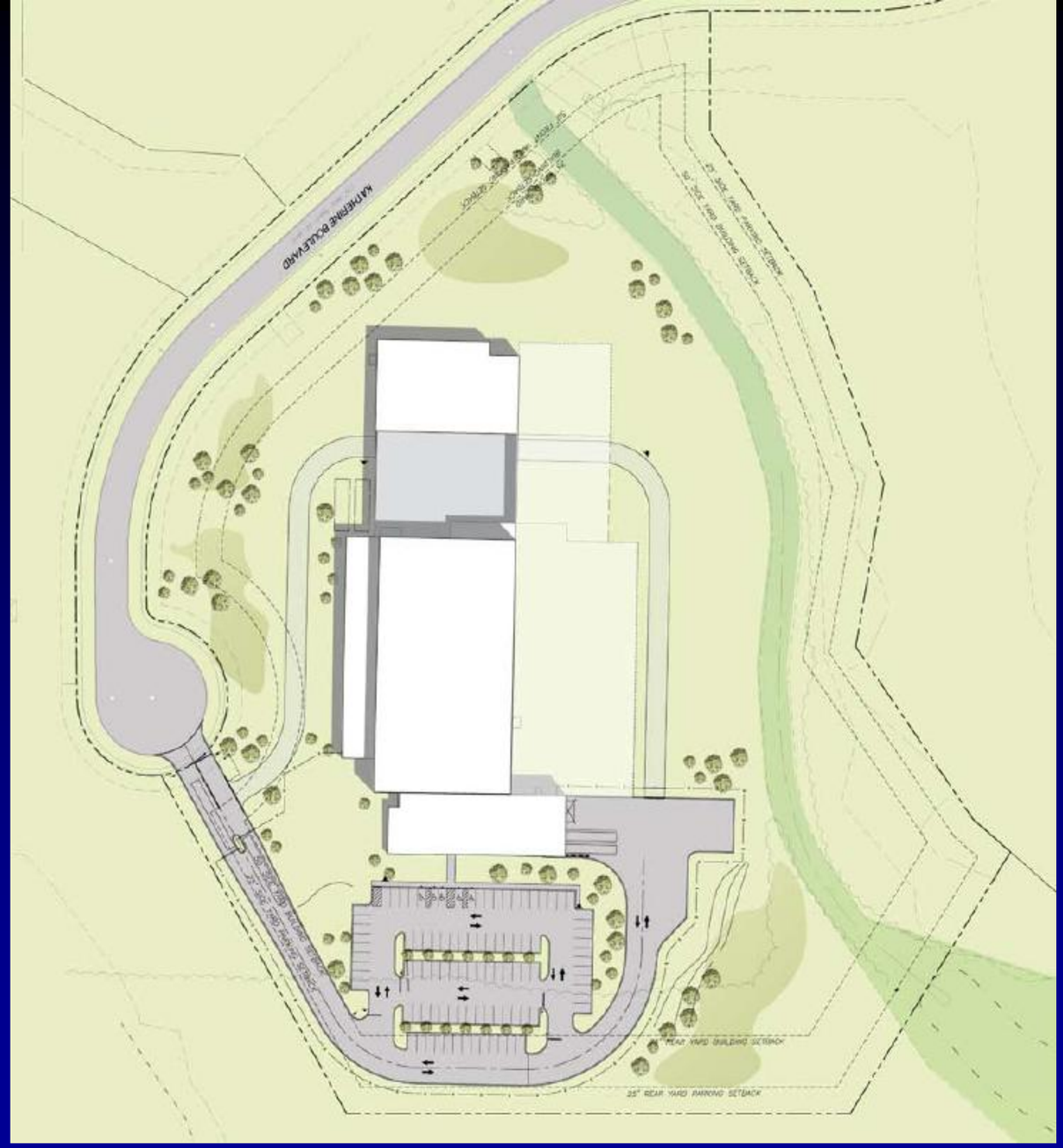

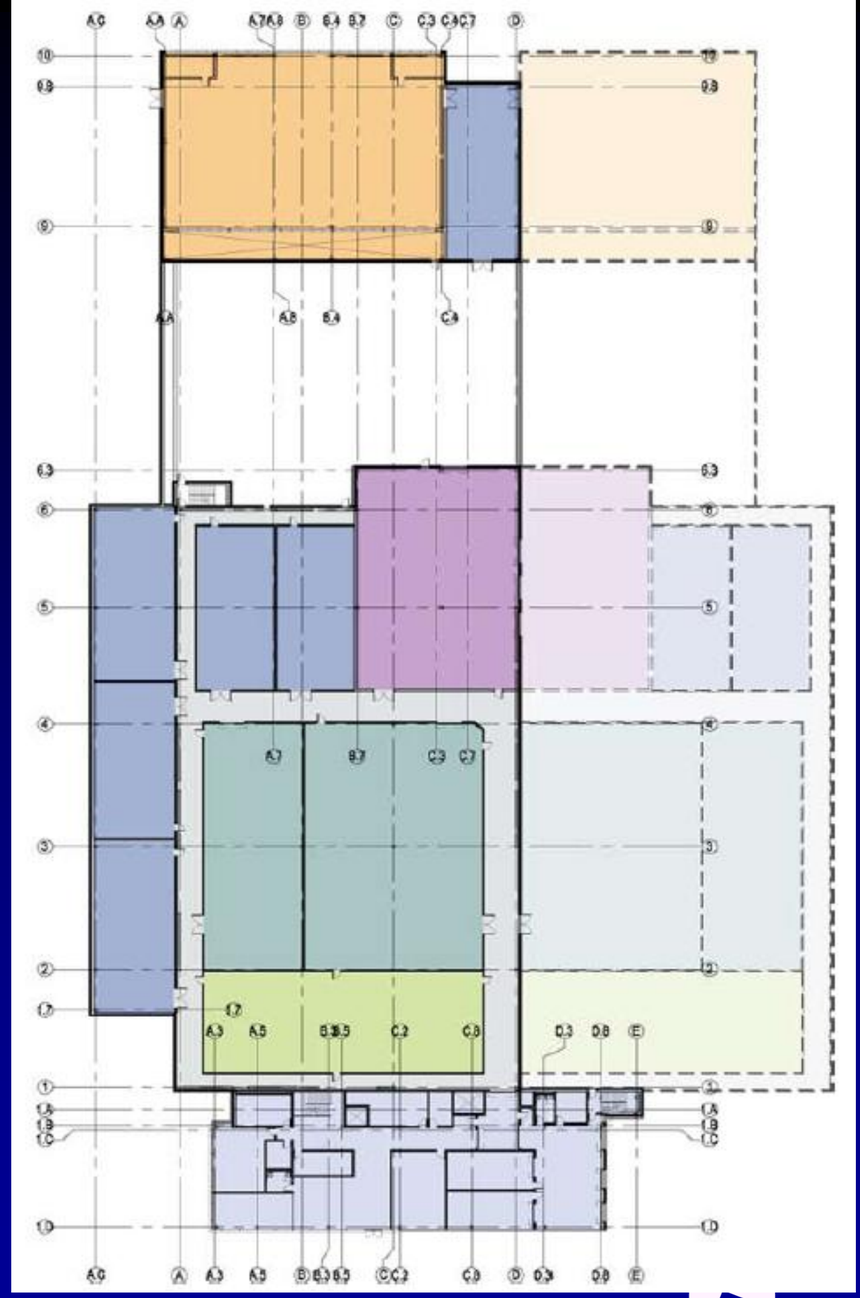

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Benefits of a Build to Suit Data Center

- A Facility that is tailored to the client's specific needs – one size does not fit all!
- Client Input on every design parameter.
- Decisions based on Life-cycle cost rather than just day-one capital cost
- "Building Blocks" logically selected and optimized around day-one and ultimate needs

Modular/Scalable

Day 1	20,000 SF	3,000KW	150W/SF	5KW/Cabinet
Day 2	30,000 SF	4,500KW	150W/SF	5KW/Cabinet
Ultimate	40,000 SF	6,000KW	150W/SF	5KW/Cabinet

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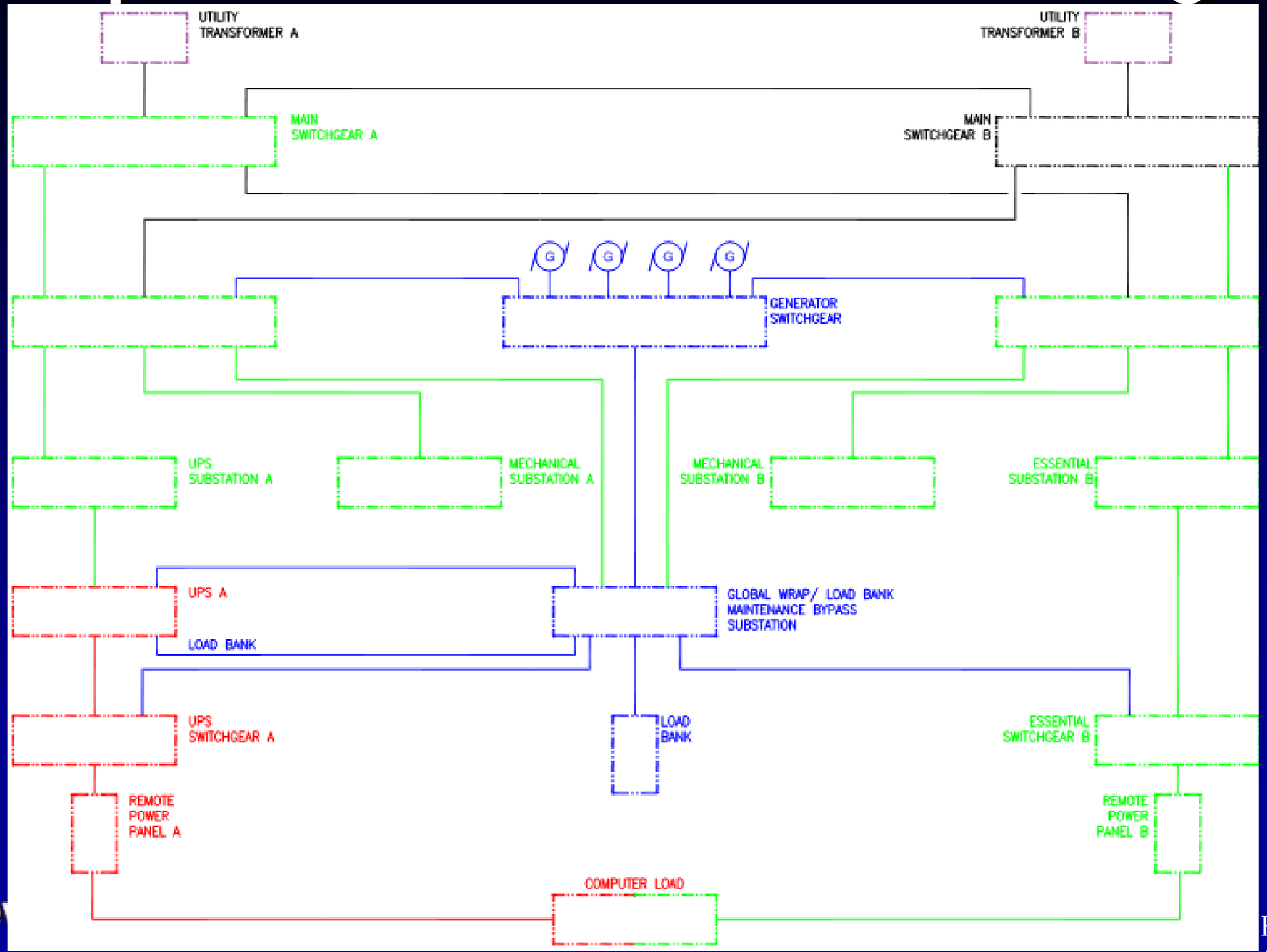
Simplified Electrical One-Line Diagram



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Simplified Electrical One-Line Diagram

- Similar to the Uptime Institute's design criteria for a Tier III Data Center with Client-selected deviations
- All MEP Equipment is configured as N + 1 for Concurrent Maintenance
- Two Redundant 18MW Transformers that supply two diverse 13.2KV feeders
- Ten 750KVA Liebert NXL UPS Modules in two 3 + 1 line-ups for critical load and two for other building systems. There is 600KW HVAC, Telecom, & Office Load on UPS.
- Critical Load fed via 32 PDUs and 88 RPPs

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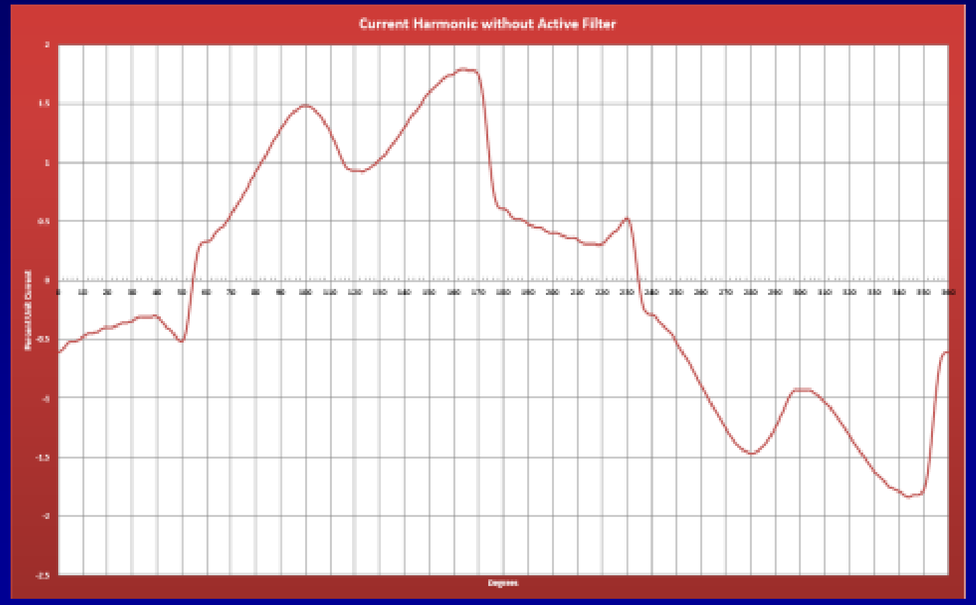
Harmonic Studies

- Variable Speed Drives on Motors result in optimal HVAC energy efficiency. Unfortunately they also result in Current and Voltage Harmonics that reduce electrical reliability
- After Careful Harmonic Study Analysis, a cost-optimized solution was selected:

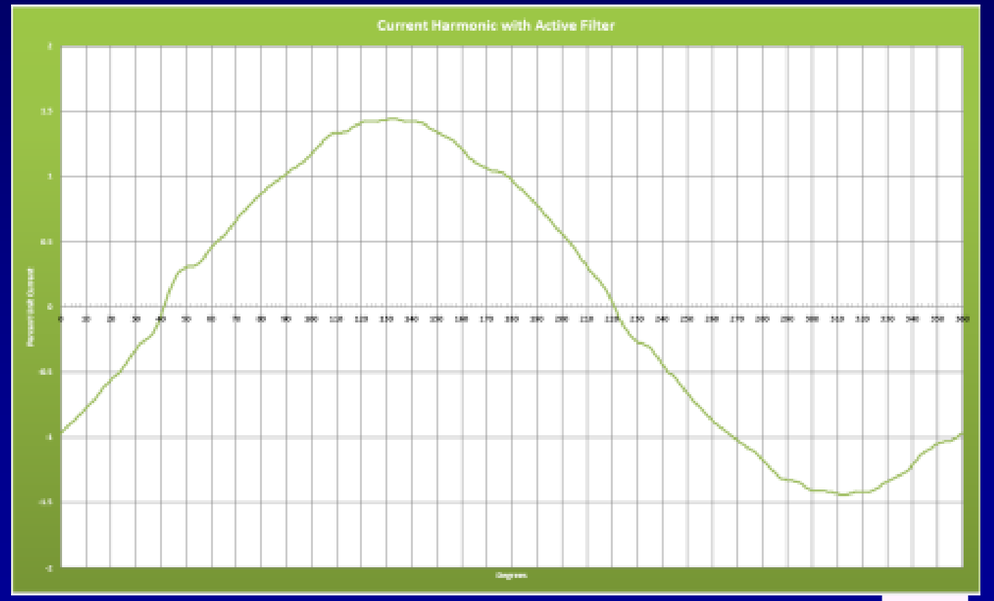
  Motors >= 20HP – Low Harmonic VFDs

  Motors < 20HP – 6-Pulse Harmonic Filters on VFDs

Before
WITHOUT Active Filter



After
WITH Active Filter



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Neher-McGrath Studies

- Underground feeders in concrete-encased duct-banks are a great solution for Greenfield data centers. However the heat that is generated in the conductors from the current conducted will not dissipate as easily as conductors in conduit exposed to the air.
- This condition results in reduced conductor ampacity that must be calculated by the engineer.

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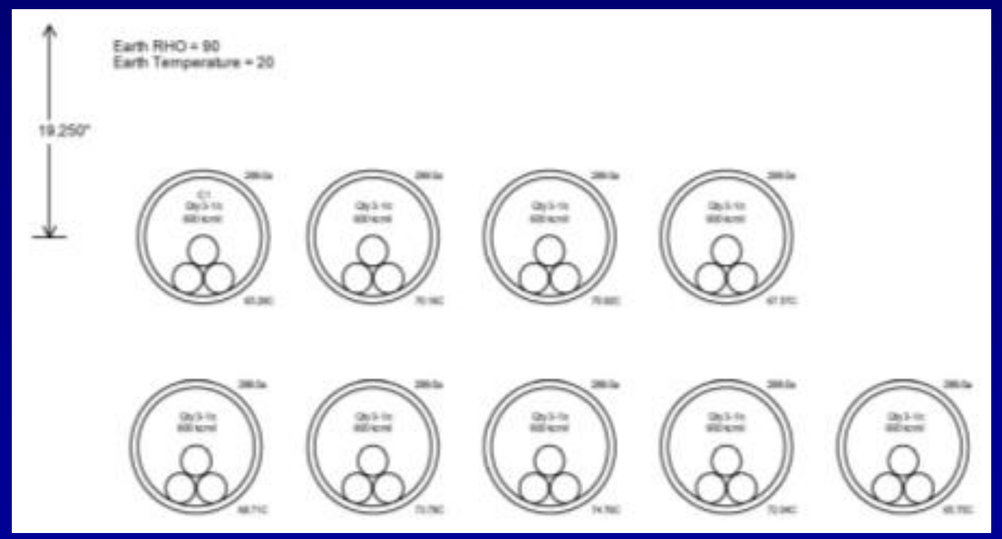
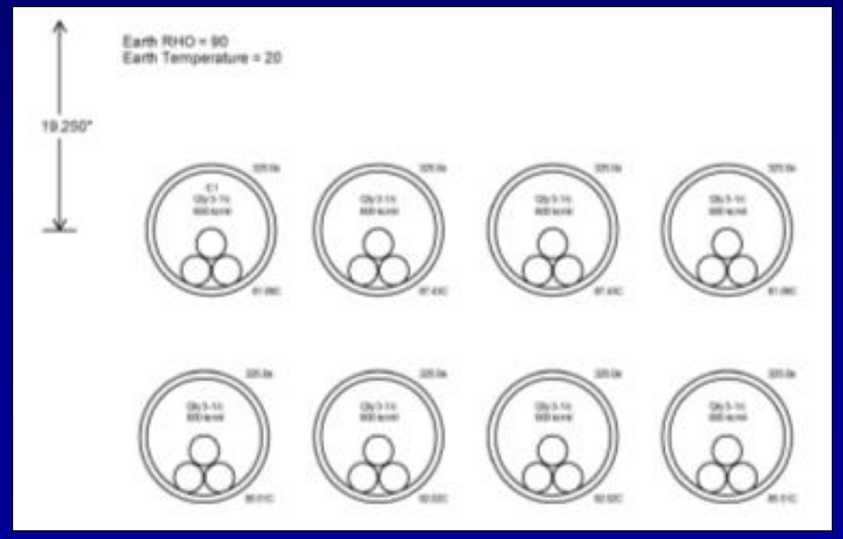
Neher-McGrath Studies

- In this case, the need was to conduct 2600 Amps current at 480V/3-phase
- In free air, this 600KCMIL conductor is rated for 420 Amps. 7 sets of conductors will do the job.
- The 8 Conduit Duct-bank resulted in each conductor carrying 325A with temperatures as high as 92 °C in the bottom row. Unfortunately the conductor was only rated for 75 °C. 23% de-rating per conductor is not enough.
- The 9 Conduit Duct-bank resulted in each conductor carrying 289A with temperatures as high as 74.8 °C in the bottom row. 31% de-rating will just meet the need.





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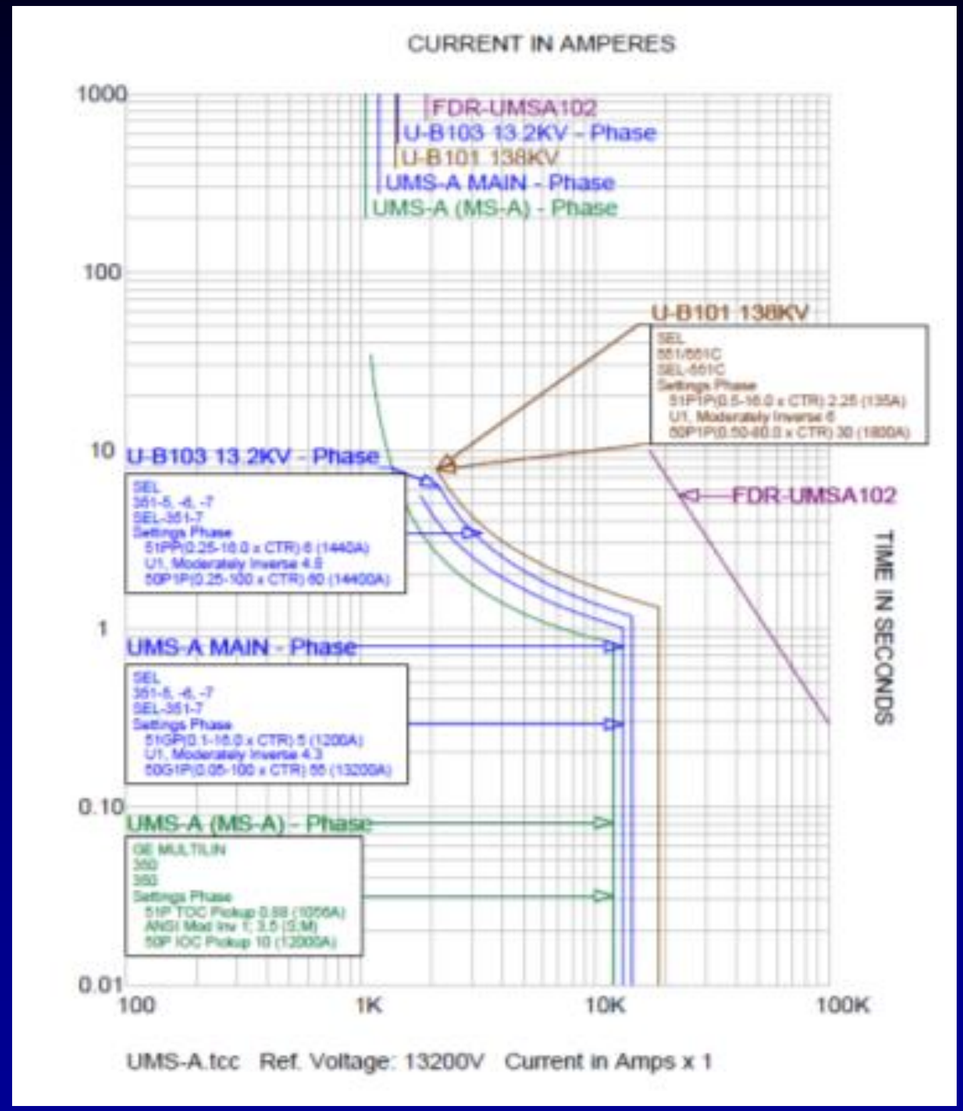
Circuit Breaker Coordination Studies

- Circuit Breakers have two primary functions:
  1. De-energize down-stream conductors, switch-gear and equipment for maintenance and other activities
  2. Isolate the circuit in the event of an over-current condition resulting from over-load or short circuit
- To maximize equipment availability, it is imperative that the circuit-breaker closest to the over-load or short-circuit trip prior to upstream breakers that might feed other unaffected equipment.
- The engineer must specify circuit breakers that can be coordinated with each other over the anticipated voltage and current ranges.
- Once the switchgear is selected, a detailed study is required to calculate the optimum circuit breaker settings for instantaneous trip, short time trip and time delay, and long time trip and time delay.



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Arc Flash Studies

- An arc flash is the light and heat produced from an electric fault supplied with sufficient electrical energy to cause substantial damage or harm, fire or injury.
- Arc flash temperatures can reach or exceed 35,000 °F (20,000 °C) at the arc terminals. The massive energy released in the fault rapidly vaporizes the metal conductors involved, blasting molten metal and expanding plasma outward with extreme force.
- Reducing hazard by design:
- Three key factors determine the intensity of an arc flash on personnel.
    1. The amount of fault current available at a point in the electrical system
    2. The time until an arc flash fault is cleared
    3. The distance an individual is from a fault arc.
- Various design and equipment configuration choices can be made to affect these factors and in turn reduce the arc flash hazard.

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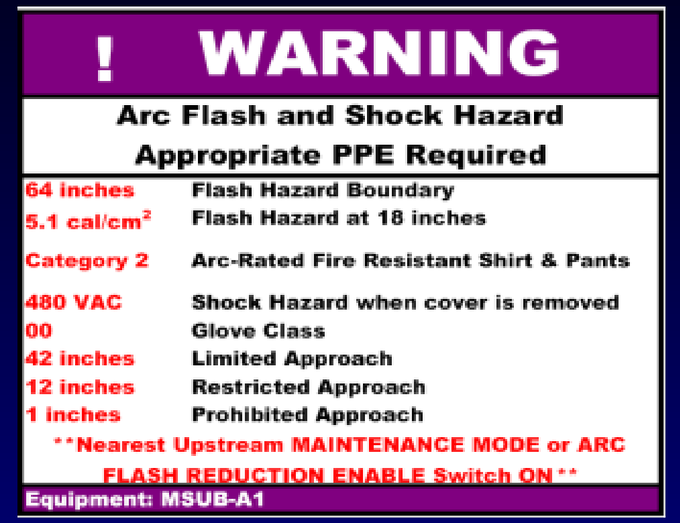
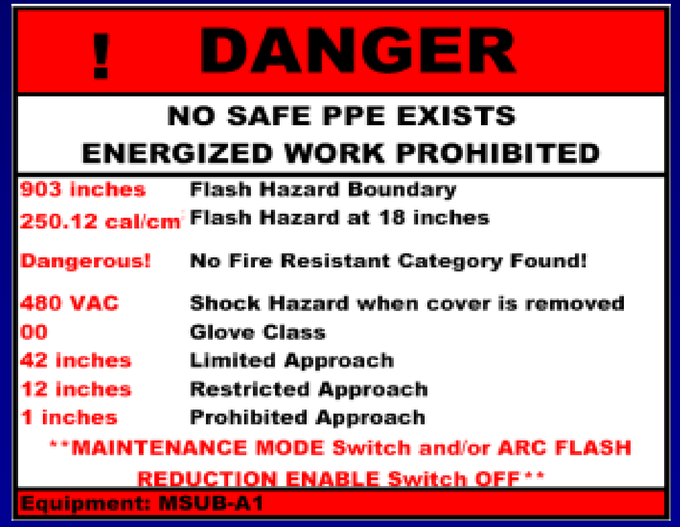
Arc Flash Studies

- At Cleveland Clinic Data Center, we utilized a Switchable Instantaneous Trip on select upstream breakers
- This option allowed for safer thermal-scan testing and/or breaker racking in/out.
- Note the difference in Hazard Energy Level and Arc Flash Boundaries with the Arc Flash Reduction Switch “on” and “off”.
- Note also that the system will NOT coordinate properly when the Arc Flash Reduction Switch is “on”.





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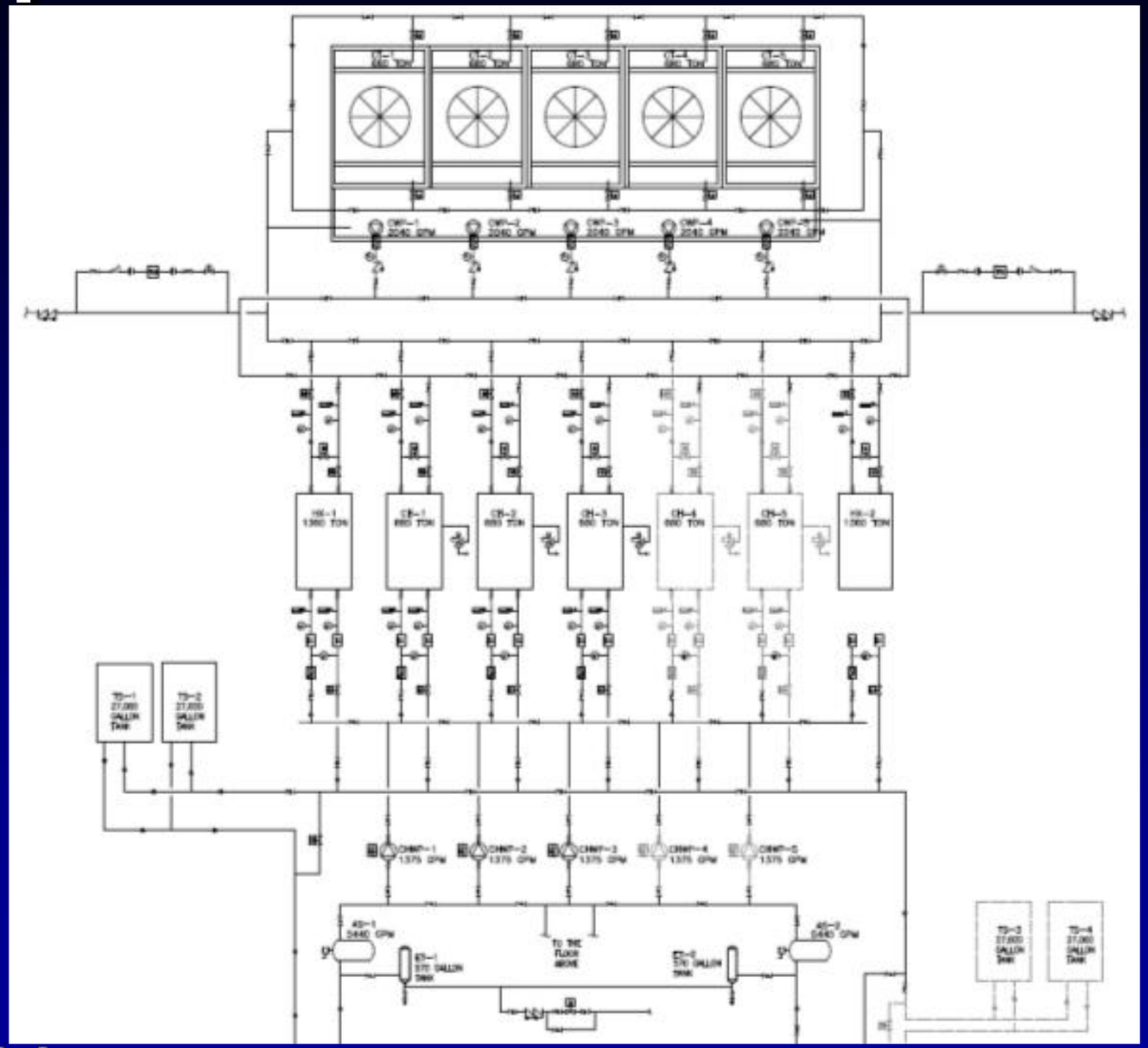
Simplified Mechanical One-Line



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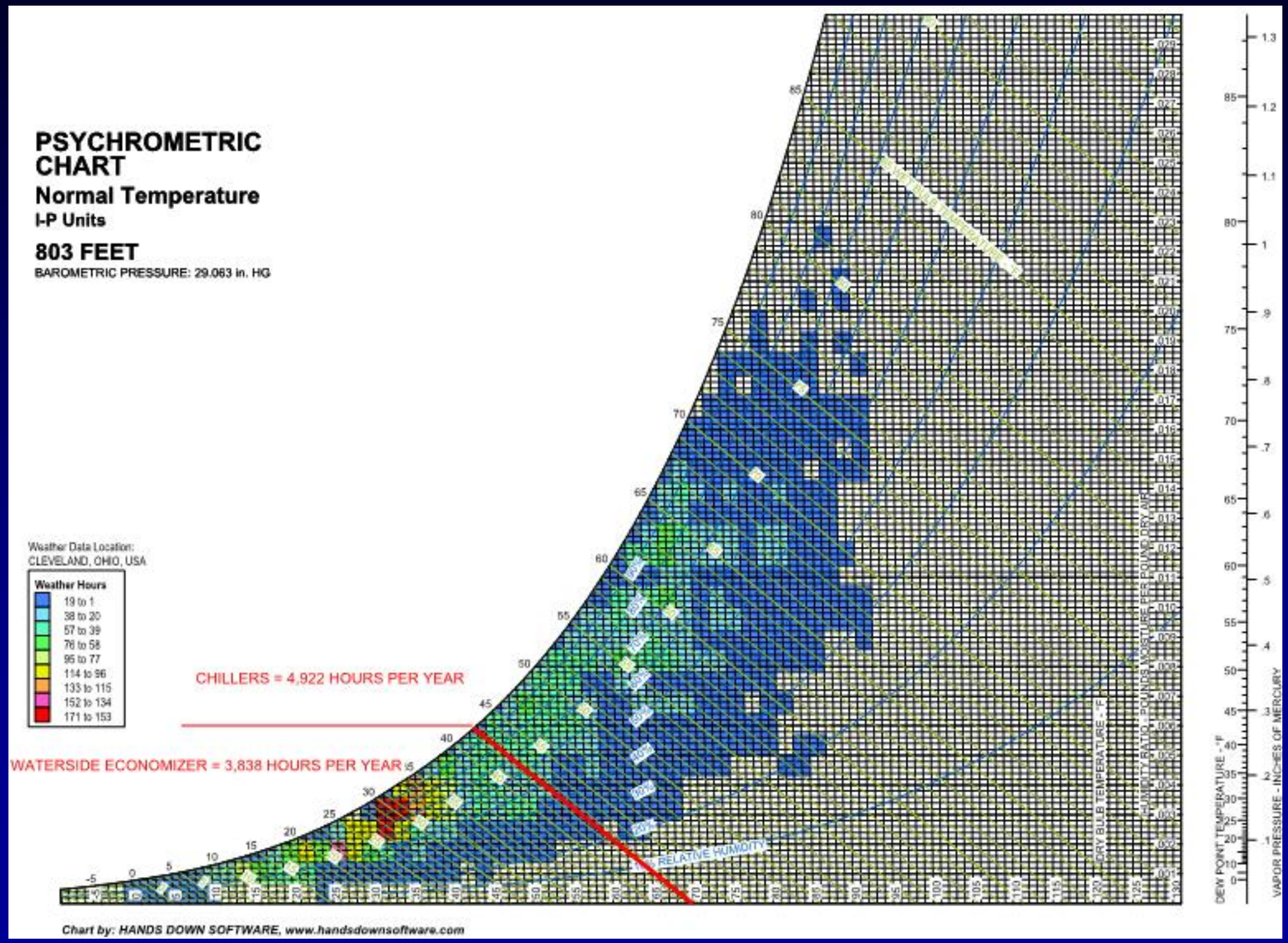
Water-Side Economizer

- Bin Analysis: 3838 Hours per year (44%) with Chillers completely off-line.



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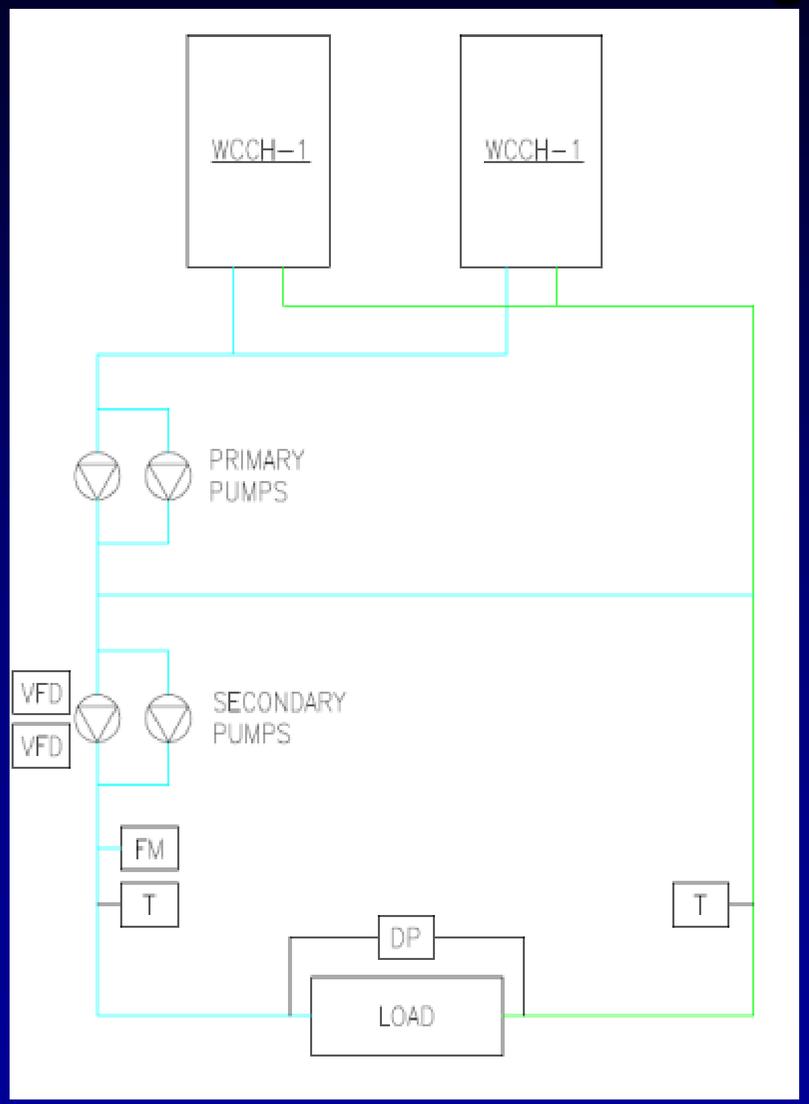
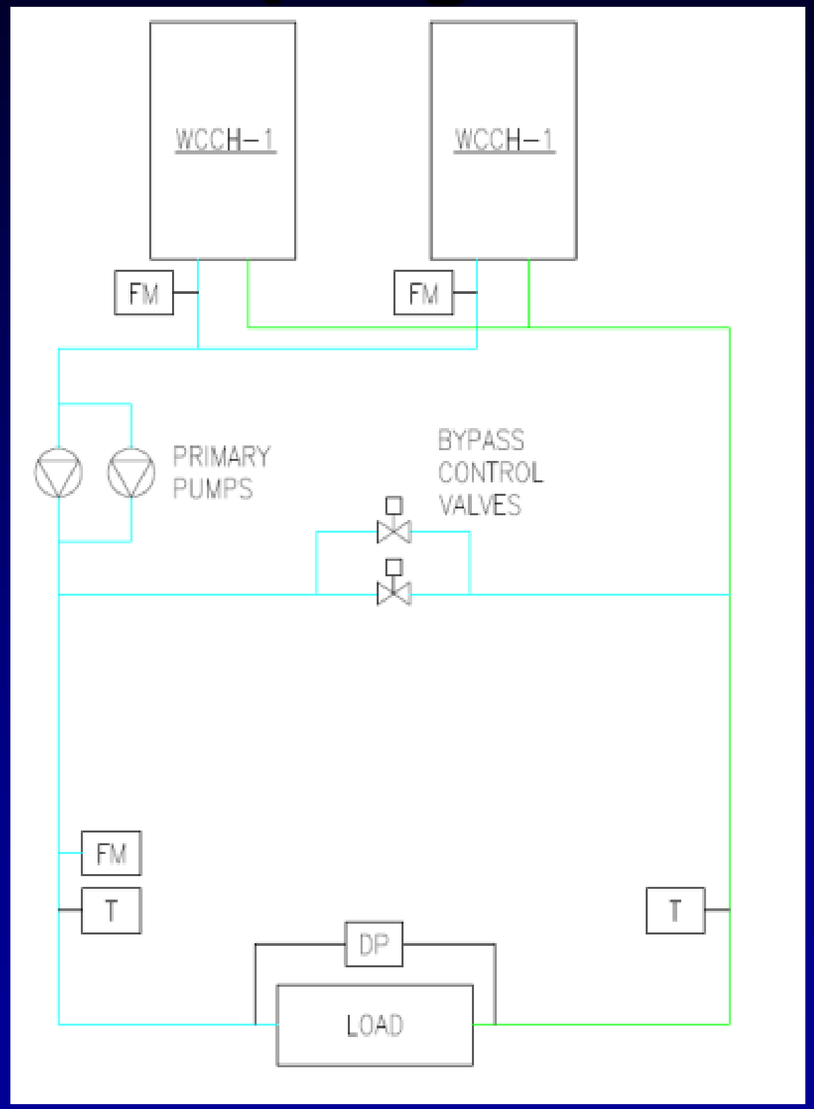
Primary-Secondary vs. Variable Primary Pumping





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Thermal Storage

- Comparable to UPS Batteries since they provide continuous chilled water until the Chillers can be restored to full operation.
- Pressurized with continuous flow
- Since continuous flow, no valve operation is required to utilize the stored Chilled Water.

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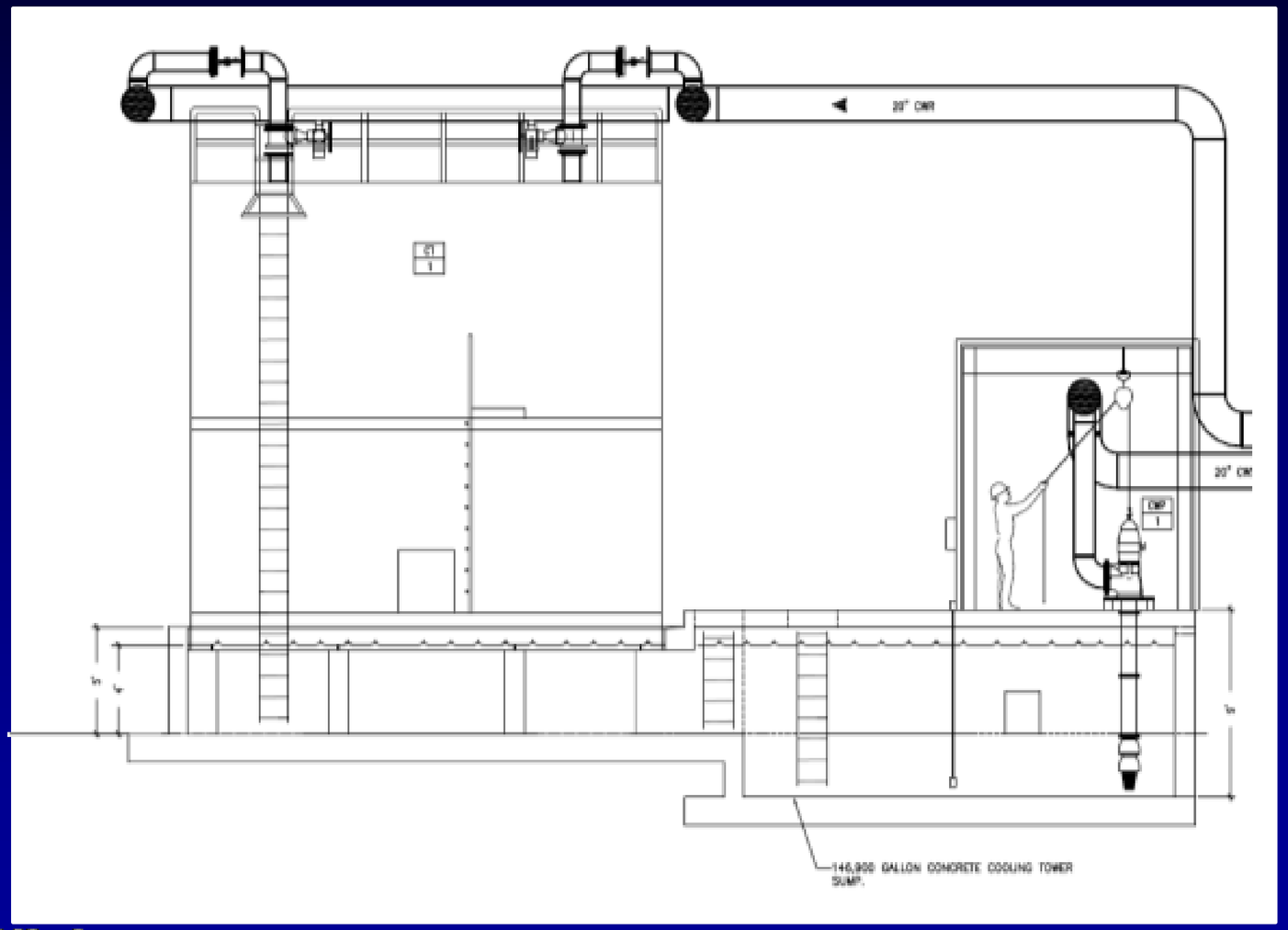
Makeup Water Storage

- Cooling Tower Sumps as Makeup Water Storage (recessed in ground)
- Condenser Water Pumps submerged in Cooling Tower Sumps



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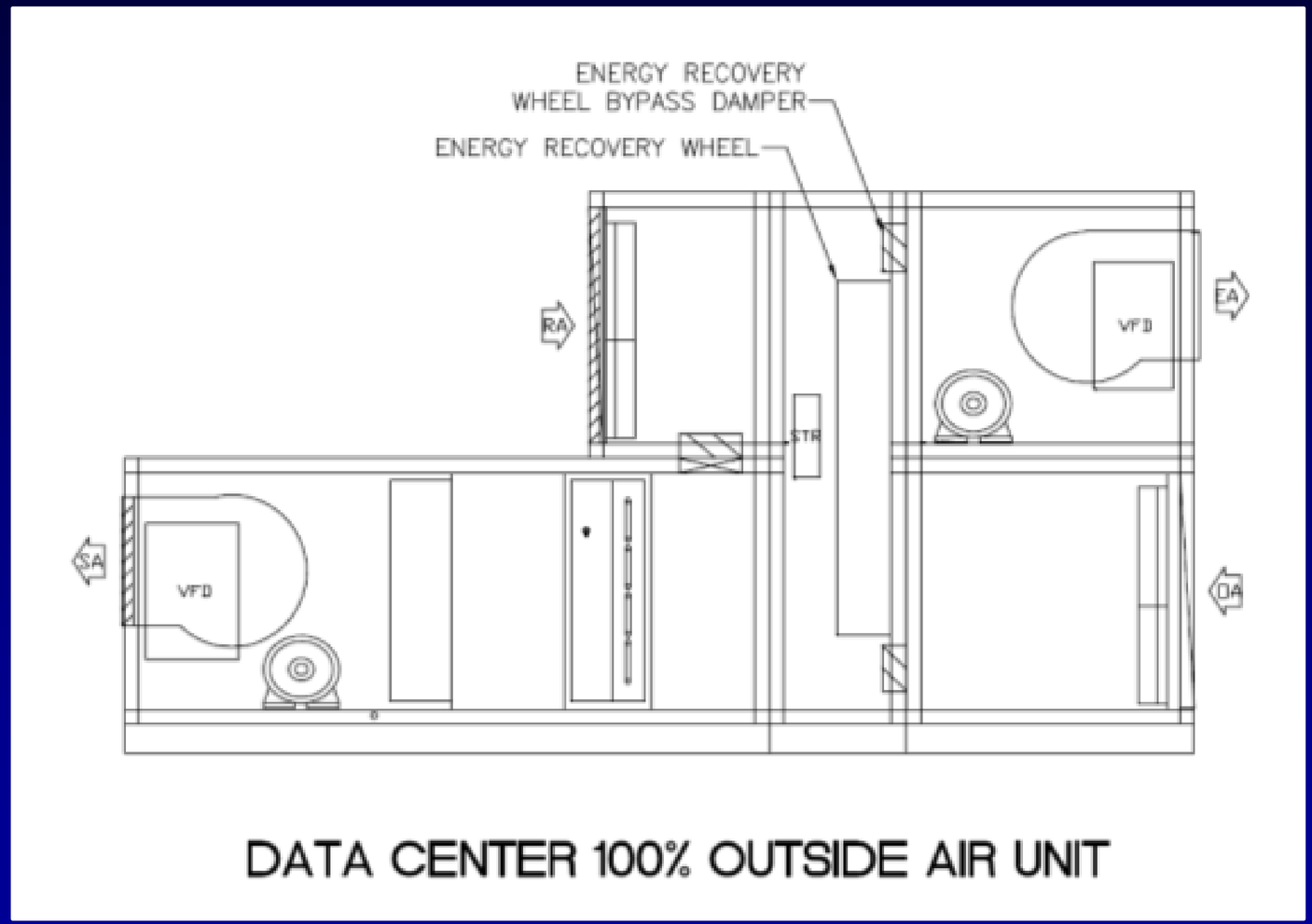
Outside Air Unit

- Energy Recovery Wheel in the Make-up Air Air-Handlers (graphic)
- Improved Energy performance of M/U air system since less energy is wasted.



DATA CENTER 100% OUTSIDE AIR UNIT

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Computational Fluid Dynamics (CFD) Studies

- Proof of concept that Server Inlet Air-Cooled Solution proposed will perform as required.
- Demonstrate the need for Hot-Aisle containment in the high density areas
- Calculate the Thermal ride-though time of the system upon loss of chilled water cooling until servers start to over-heat.

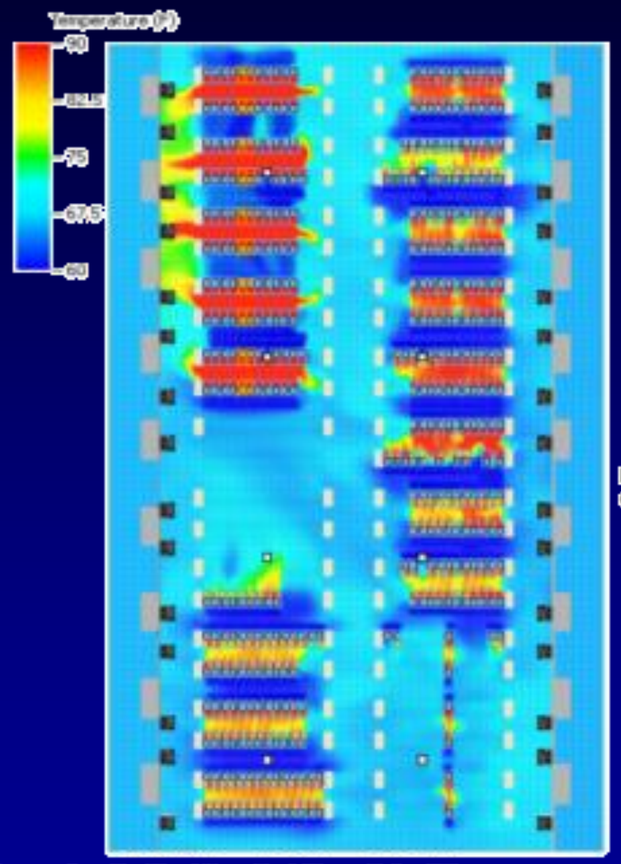

Figure 2: Temperature Profile at Four Feet Above Raised Floor

Figure 3: Mean Inlet Temperature Through Cabinets

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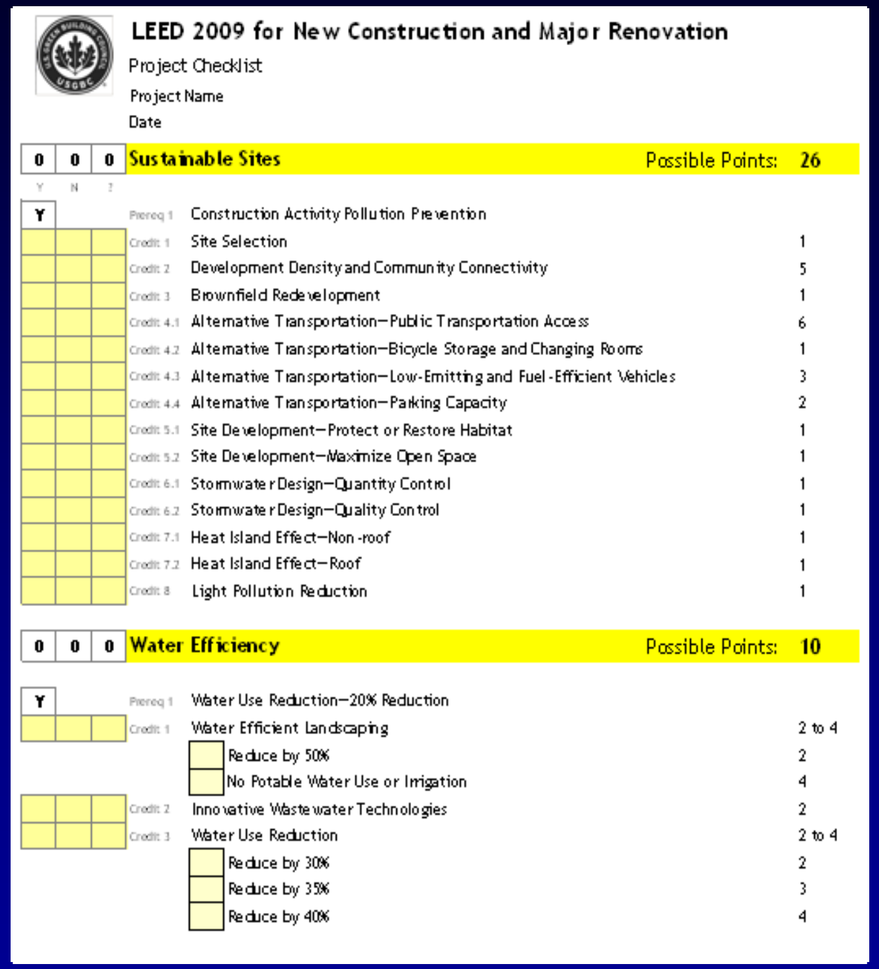
LEED Silver | Sustainable Building Elements

- Optimize energy performance
- Enhanced commissioning
- Low-emitting materials
- Recycled materials
- Recycled construction waste
- Construction activity pollution prevention
- Alternate transportation
- Site development
- Storm water design
- Light pollution reduction



LEED 2009 for New Construction and Major Renovation

Project Checklist

Project Name

Date

Y	N	?			
0	0	0	**Sustainable Sites**	Possible Points:	**26**
Y			Prereq 1 Construction Activity Pollution Prevention		
			Credit 1 Site Selection		1
			Credit 2 Development Density and Community Connectivity		5
			Credit 3 Brownfield Redevelopment		1
			Credit 4.1 Alternative Transportation—Public Transportation Access		6
			Credit 4.2 Alternative Transportation—Bicycle Storage and Changing Rooms		1
			Credit 4.3 Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles		3
			Credit 4.4 Alternative Transportation—Parking Capacity		2
			Credit 5.1 Site Development—Protect or Restore Habitat		1
			Credit 5.2 Site Development—Maximize Open Space		1
			Credit 6.1 Stormwater Design—Quantity Control		1
			Credit 6.2 Stormwater Design—Quality Control		1
			Credit 7.1 Heat Island Effect—Non-roof		1
			Credit 7.2 Heat Island Effect—Roof		1
			Credit 8 Light Pollution Reduction		1
0	0	0	**Water Efficiency**	Possible Points:	**10**
Y			Prereq 1 Water Use Reduction—20% Reduction		
			Credit 1 Water Efficient Landscaping		2 to 4
			Reduce by 50%		2
			No Potable Water Use or Irrigation		4
			Credit 2 Innovative Wastewater Technologies		2
			Credit 3 Water Use Reduction		2 to 4
			Reduce by 30%		2
			Reduce by 35%		3
			Reduce by 40%		4

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Parker-to-Brecksville Move

- Project Team of over 250 IT personnel under the leadership of 12 project managers
- 15 Months of Planning
- 3 Months to ready the Data Center (Network & Storage)
- 12 Move Events
- Each Move Event was broken down into 15 minute increments; each increment then divided into tasks to be completed
- Specialized computer equipment movers with GPS tracking on every truck
- Each piece of equipment was bar-coded and recorded as it left Parker and as it arrived at Brecksville
- Extensive communication network to notify end users

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Photo Tour

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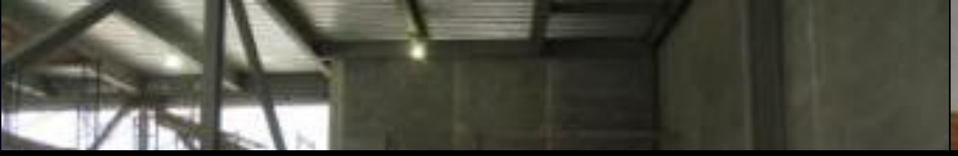


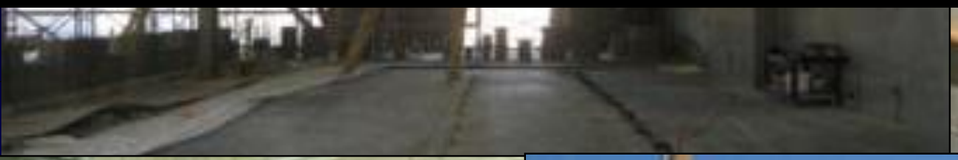
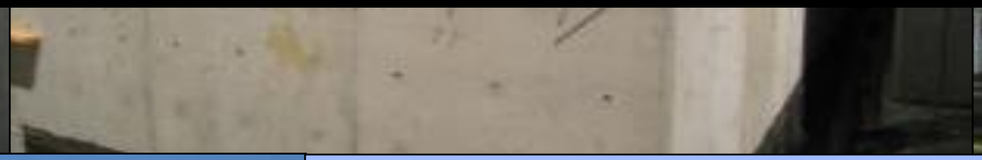



Project Facts

- 110,000 SF, Tier III Data Center
- 34,000 SF of 36-inch raised access floor
- 2,000 tons of precast concrete walls
- 23 miles of underground conduit and 20 miles of overhead conduit containing 125 miles of electrical branch and feeder wire
- 1.4 mile steel piping system including 1,822 valves
- 60,000 gallons of fuel oil storage
- Five 2.5 MW generators providing the power equivalent to over 3,700 homes
- 11,000 cubic yards of concrete
- Computer room power equals 150 watts / SF

Award Winning

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