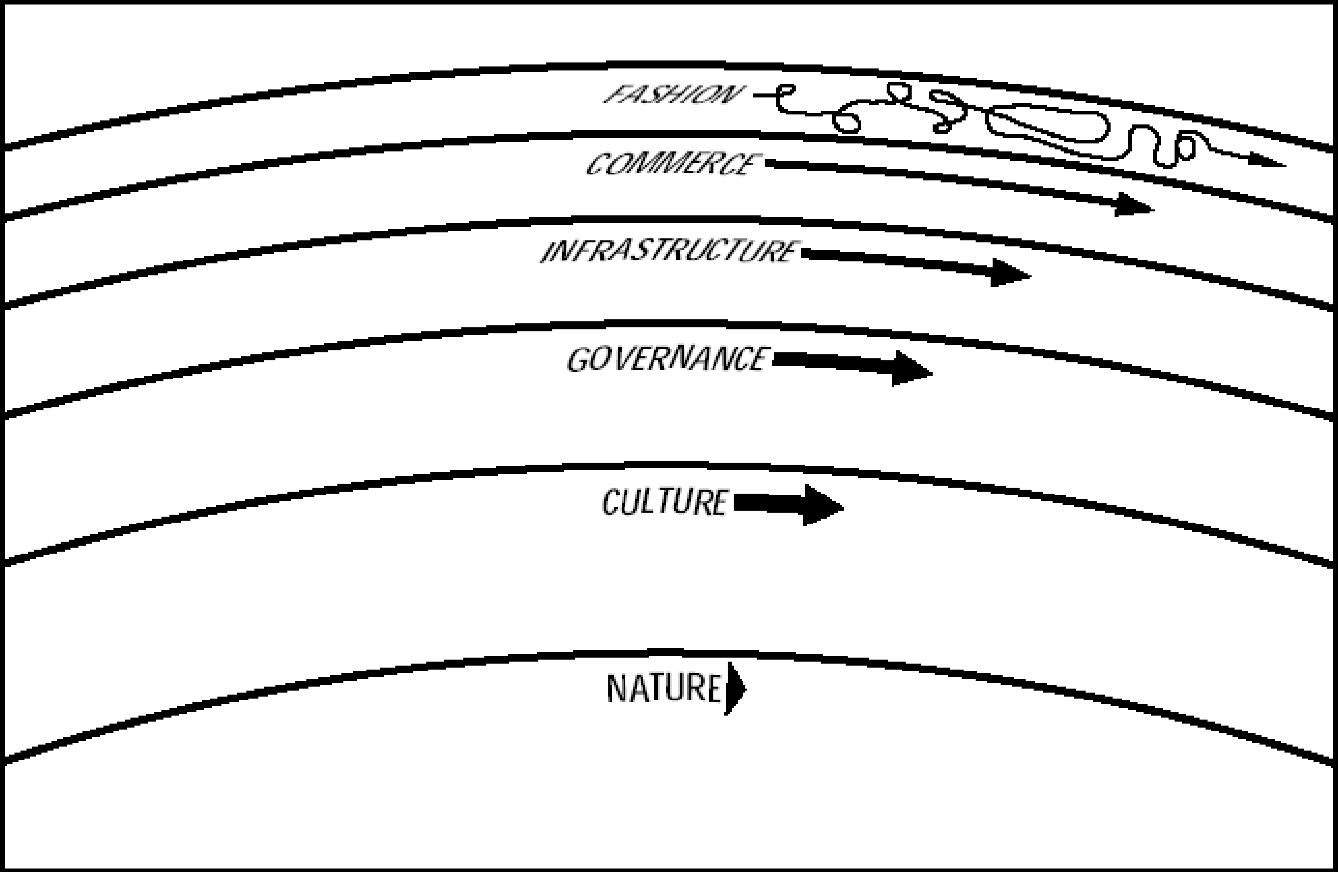
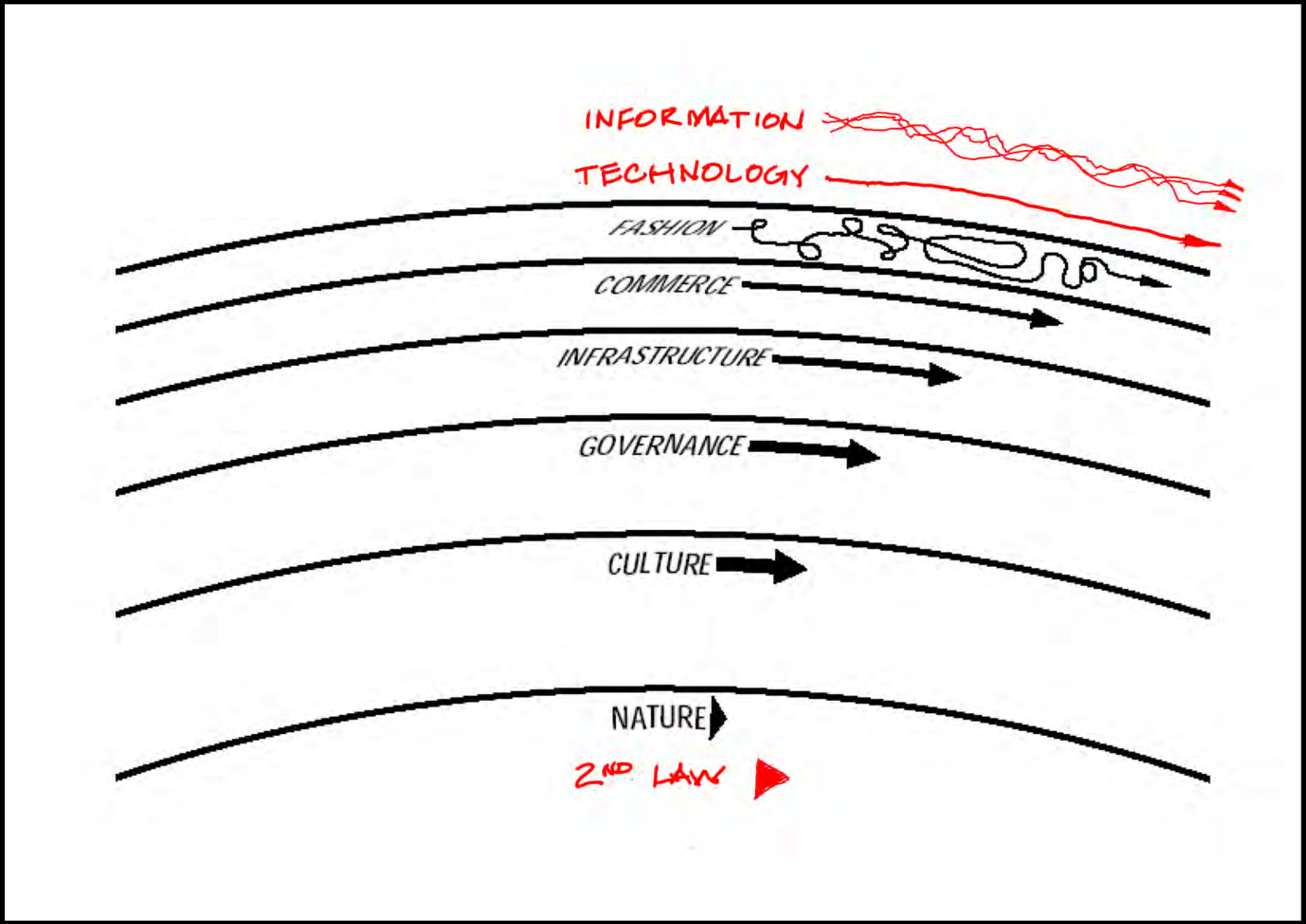
Stewart Brand's Shearing Layers of Change




INFORMATION
TECHNOLOGY
FASHION
COMMERCE
INFRASTRUCTURE
GOVERNANCE
CULTURE
NATURE
2ND LAW

The Conservation^2 Building = Efficiency • Longevity

Non-Mechanical Strategies
for
Energy-Efficient Collections Environments

Michael C. Henry PE, AIA
Watson & Henry Associates

The greenest BTU is the one never consumed

Non-Mechanical Strategies

- Utilize fixed & operable elements of the building & site
- Reduce peak external loads on the interior environment
- Moderate fluctuations from changing external or internal loads
- Thereby reduce the size/capacity of mechanical systems
- The systems can operate more efficiently, due to smaller range
- Require commissioning & maintenance, just like mechanical systems

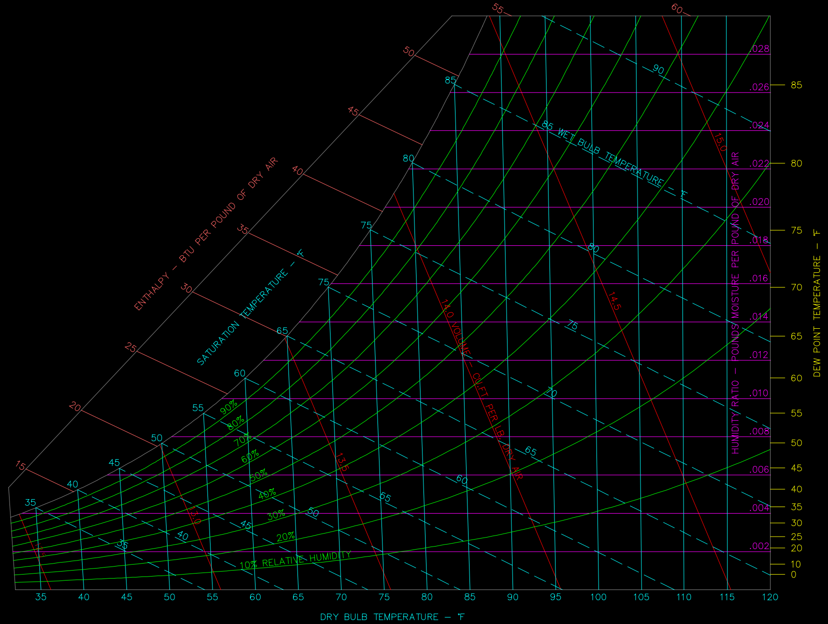
Any non-mechanical strategy must be developed for the specifics of each collection, climate, building, site & institutional capacity.

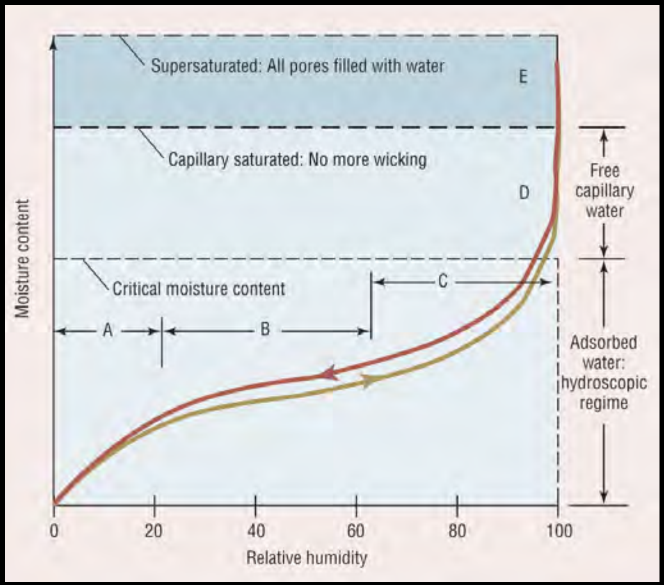
Julia Child said: *"A cookbook is only as good as its worst recipe"*

We should not look for recipes in collections conservation

Necessary Basics: The Physics of Air and Moisture

An understanding of psychrometrics & material response to moisture is essential to informed decisions about collections environments





J. F. Straube

"Scotty," Chief Engineer of the Starship Enterprise protested: "*I cannot ignore the laws of physics!* "

We cannot afford to ignore them either.

Necessary Basics: Know the Climate

The external thermal energy & moisture that drive the interior environment

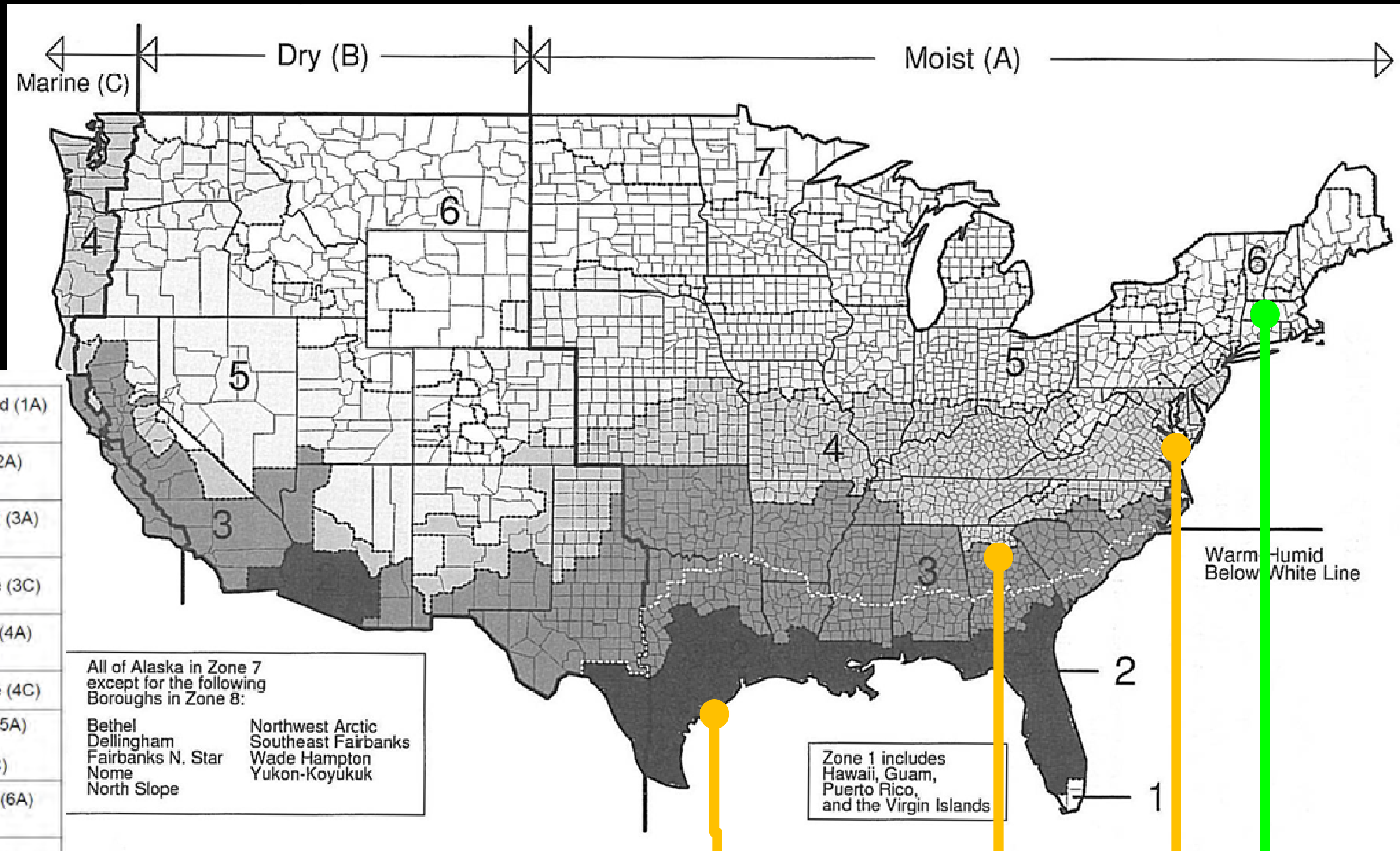
Cloud Cleaner, 2000 Robert & Shanna ParkeHarrison

Bob Dylan sang: *"You don't have to be a weatherman to know which way the wind is blowin'…"*

The way the wind is blowing today, we need to find better solutions.

17 Climate Zones in the US

1A and 1B	Very Hot –Humid (1A) Dry (1B)
2A and 2B	Hot-Humid (2A) Dry (2B)
3A and 3B	Warm – Humid (3A) Dry (3B)
3C	Warm – Marine (3C)
4A and 4B	Mixed-Humid (4A) Dry (4B)
4C	Mixed – Marine (4C)
5A, 5B, and 5C	Cool-Humid (5A) Dry (5B) Marine (5C)
6A and 6B	Cold – Humid (6A) Dry (6B)
7	Very Cold
8	Subarctic



2A Hot-Humid: Corpus Christi, TX

3A Warm-Humid: Atlanta, GA

4A Mixed-Humid: Washington, DC

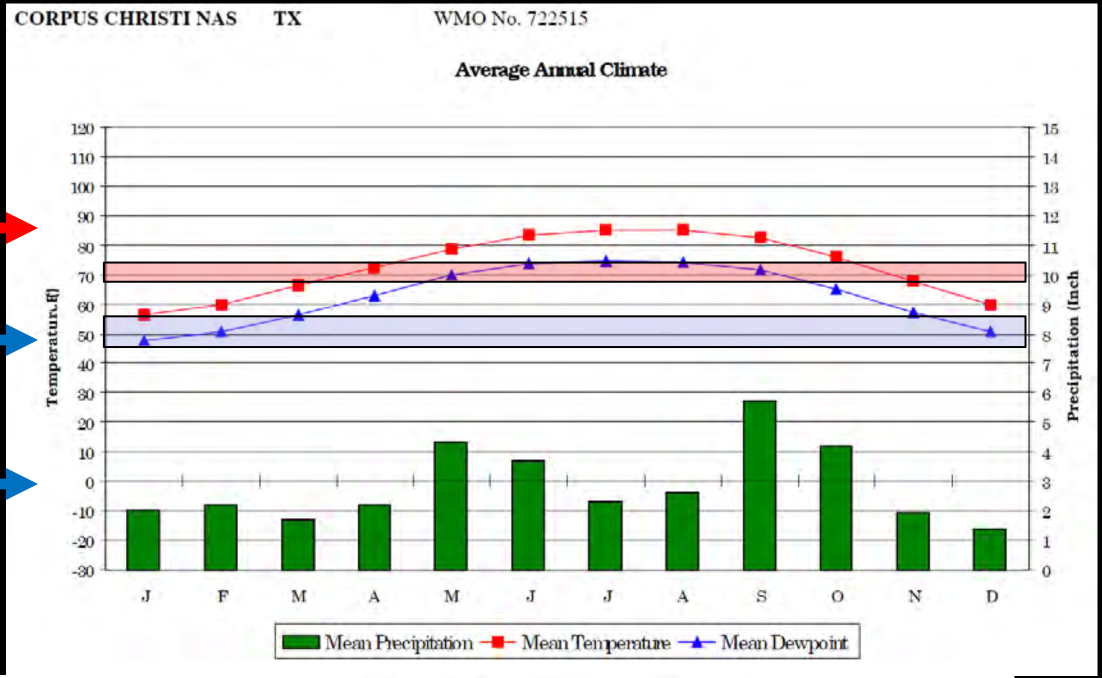
5A Cool-Humid: Chicopee, MA

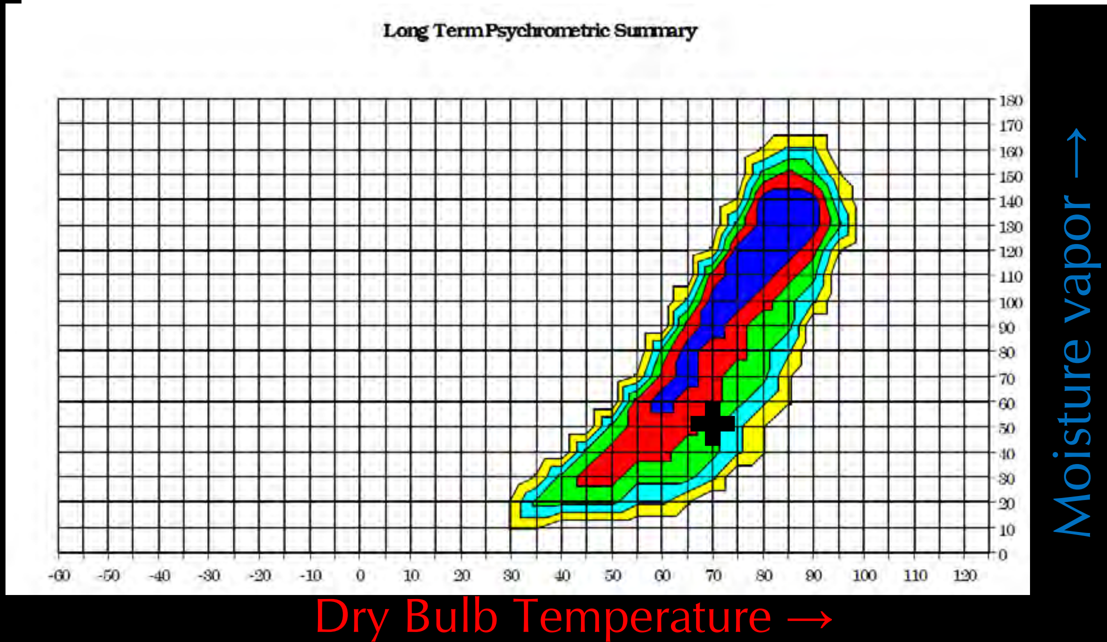
Zone 2A Hot-Humid
Corpus Christi, TX

Dry Bulb Temperature

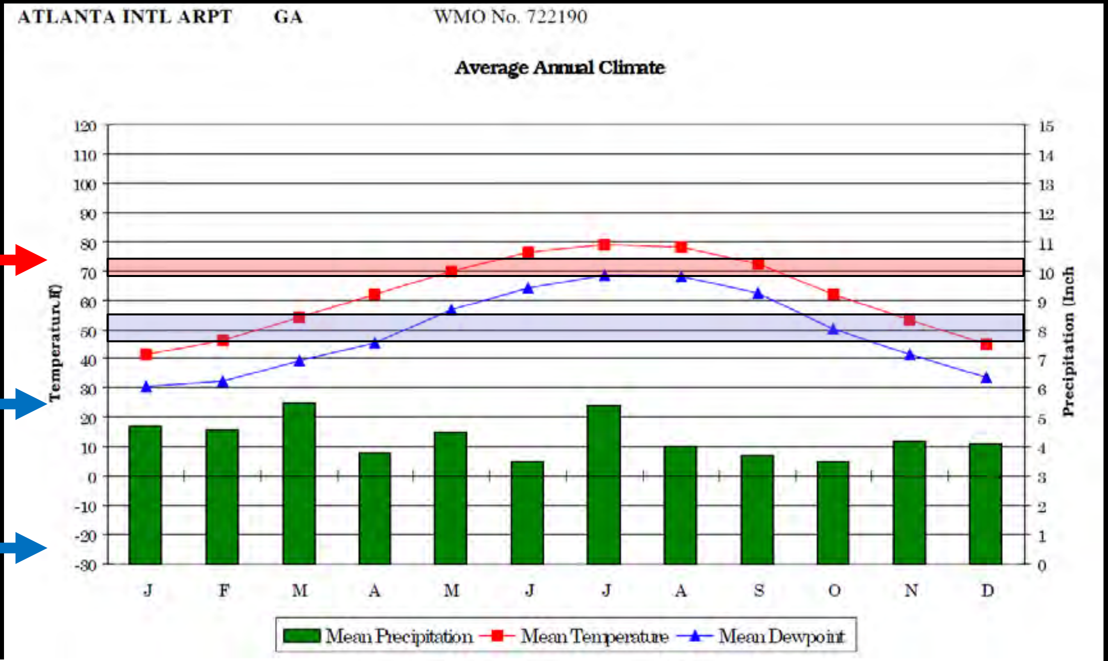
Dewpoint Temperature (Moisture Vapor)

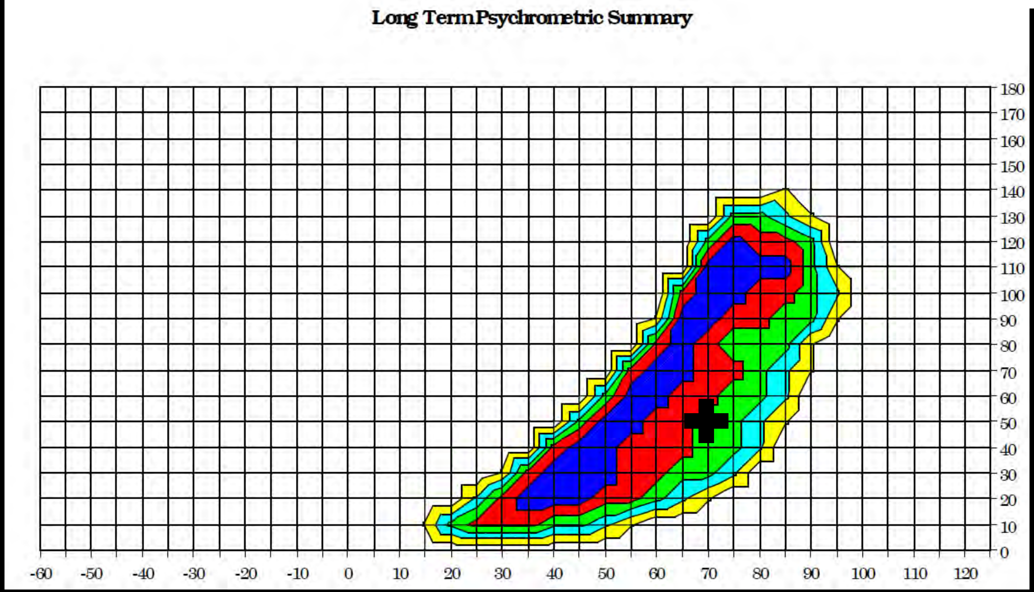
Rainfall





Zone 3A Warm-Humid
Atlanta, GA



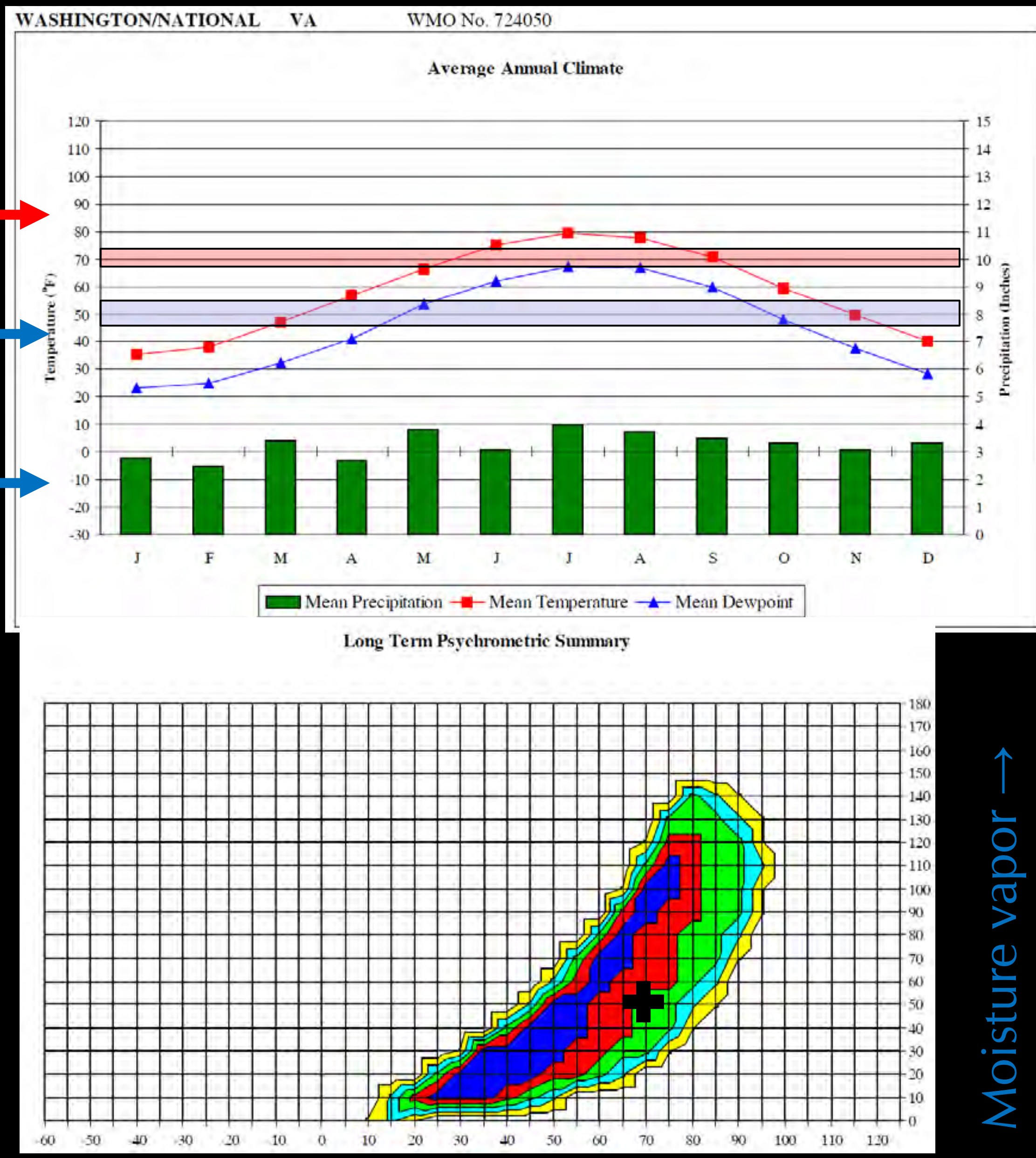


Zone 4A Mixed - Humid
Washington, DC

Dry Bulb Temperature

Dewpoint Temperature (Moisture Vapor)

Rainfall



Moisture vapor →

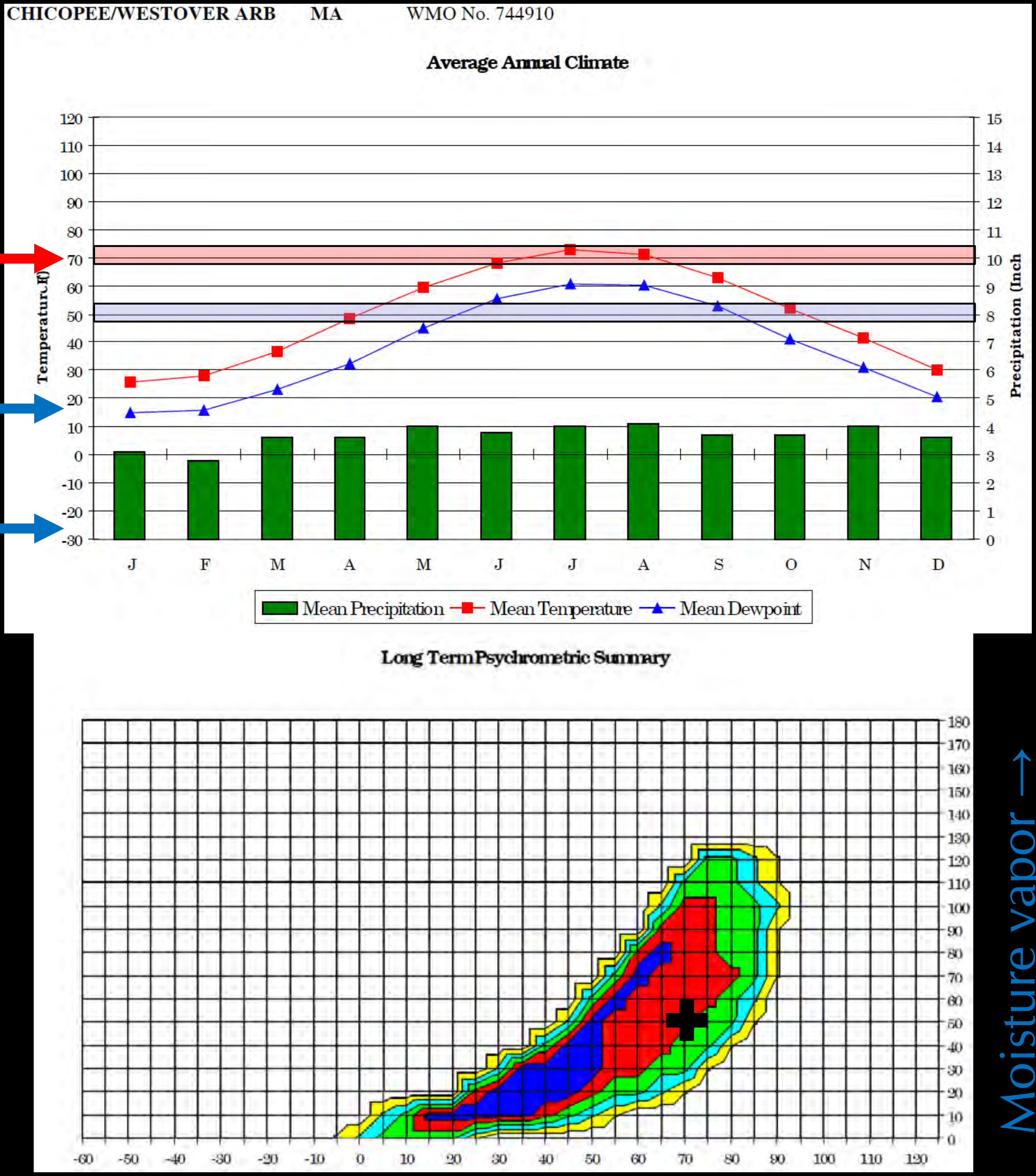
Dry Bulb Temperature →

Zone 5A Cool-Humid
Chicopee, MA

Dry Bulb Temperature

Dewpoint Temperature
(Moisture Vapor)

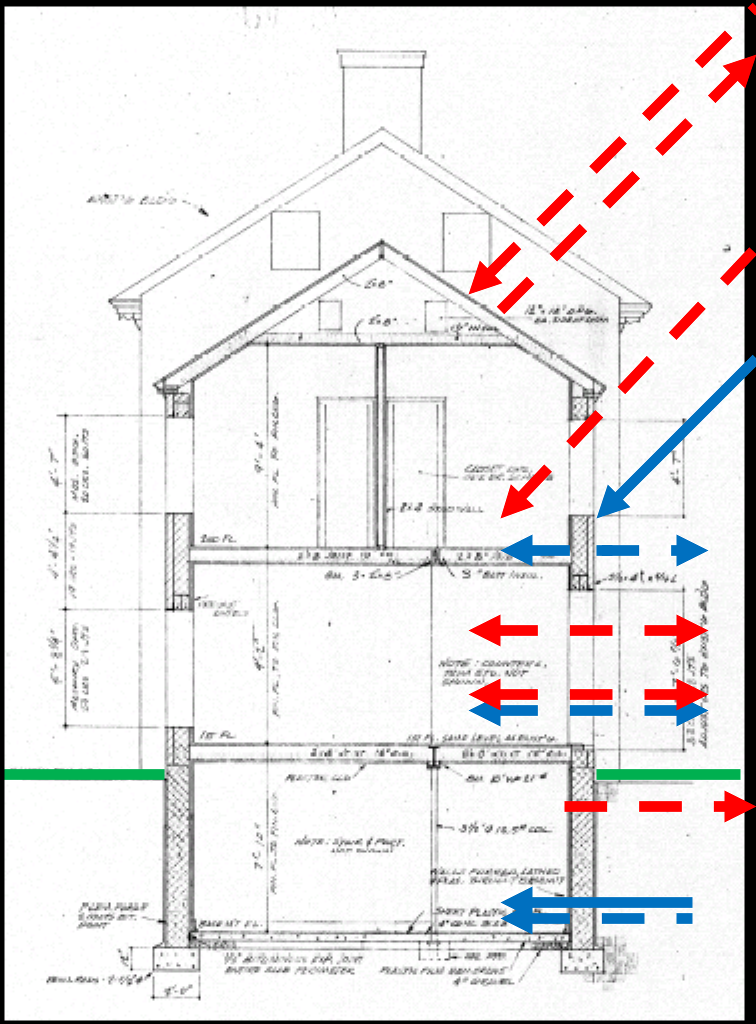
Rainfall



Moisture vapor →

Dry Bulb Temperature →

Climate results in external moisture & thermal energy loads



Thermal gains from solar radiation &
Thermal losses from night re-radiation

Thermal gains from solar radiation thru windows

Water (liquid) from rain, absorbed

Water (vapor) drying to inside or outside

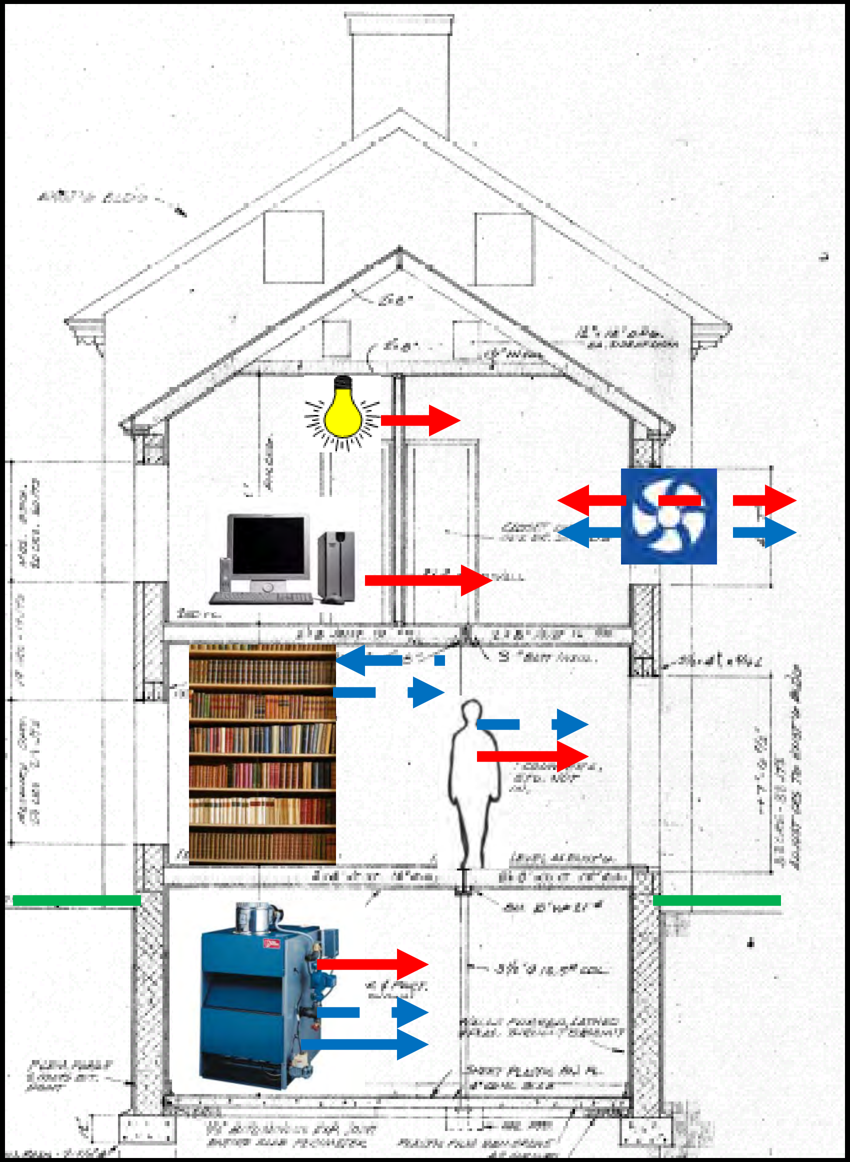
Thermal losses/gains due to convection
Thermal/Water vapor losses/gains w. air exchange

Thermal losses to soil at frost line, neutral below

Water (liquid + vapor) gains from soil moisture

These are dynamic, synergistic processes that we try to manage with the envelope

Building occupancy results in internal moisture & thermal energy loads



Thermal gains from lights & office equipment

Water (vapor) adsorption/desorption
of porous materials & contents

Thermal/Water vapor losses/gains
from ventilation air for occupant health

Thermal/Water vapor gains from occupants –

Thermal/ Water (liquid + vapor)
gains from building systems

We can manage these loads
in how we use & occupy the building

Essential Non-Mechanical Strategies




- Eliminate moisture at the source
  roof drainage, surface water & subsurface water
- Minimize uncontrolled air & moisture vapor infiltration/exfiltration
  entries, windows & doors, open flues, any envelope perforations
- Minimize or control direct & indirect solar gain
  shades/blinds/filters at windows, skylights & other glazing, <u>cool roofs</u>

"Excellent!" cried Watson
"Elementary," replied Holmes

These strategies are obvious, but are often overlooked or ignored

Essential Non-Mechanical Strategies



- Zone the building according to environmental needs
  more stable needs at interior, less stable needs along perimeter & under roof
- Separate collections zones from people "comfort" zones
  this is especially true for office areas where comfort affects productivity
- Separate collections from events/variable occupant loads

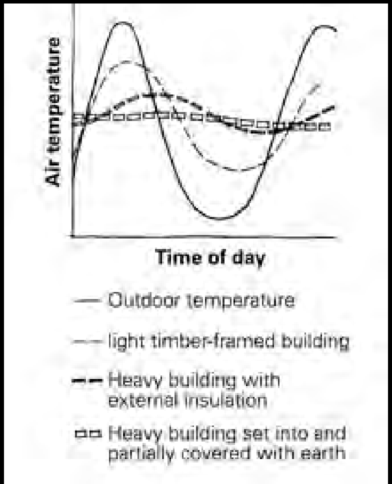
"Excellent!" cried Watson
"Elementary," replied Holmes

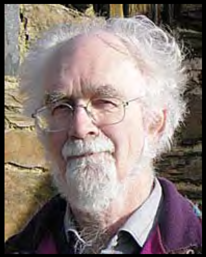
These strategies are obvious, but are often overlooked or ignored

Possible Strategy: Thermal Mass

It depends on climate, use & materials…

Michael C. Henry, 2006





Tim Padfield: *"The climate in unventilated stores & archives can be entirely passively controlled in temperate regions."*

In other climates, it can help.

Thermal Mass in Buildings

- Slows transport of thermal energy from outside to inside and reverse (+)
  but interior thermal loads may still dominate
- Stabilizes T & stable T yields stable RH (+)
  provided that there is no moisture vapor gain or loss in the space
- In Dry climates, can raise interior T (night) & lower interior T (day) (+)
  but this requires a substantial diurnal temperature range
- In Zone 2 Hot-Humid, thermal mass yields high interior T, lower RH (+/-)
- Provides thermal inertia when systems are off (+)

- In all climates, location of insulation (inside/outside) is critical (!)
- Less effective cool/cold zones if interior T is not maintained (!)
- In Zone 4A, Mixed-Humid, interior RH may be high in spring if interior T is low over winter (!)
- Must also address the roof (!)
  These tend to be low-mass due to cost and weight.

Possible Strategy: Simple Geothermal

Geothermal is the rage, but why buy all the pipes & pumps?

Janet Sheridan, W&HA, 2011

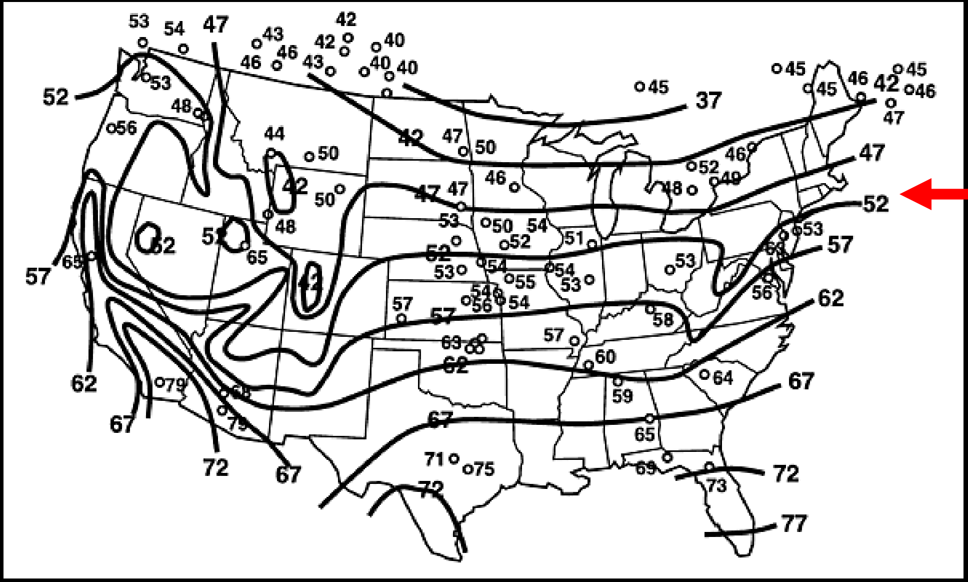
"My potatoes don't like light, mold or heat,
and I don't need air conditioning!
I put my money in that (earthen) bank!"

Problem solved?

Simple Geothermal: Earth-Banked & Below-Grade Structures

- A semi-infinite variant of high thermal mass design (+), (!)
- Soil T below frost line is more stable than ambient air T (+)
- Soil T below frost line is near the range of conservation T (+)
- Soil is a free heating or cooling source, when used passively (+)
- Soil type & groundwater are considerations for heat transfer (!)
- Exterior waterproofing is critical (!)
- Interior dew point temperature must be below wall temperature (!)

http://www.geo4va.vt.edu/A1/A1.htm

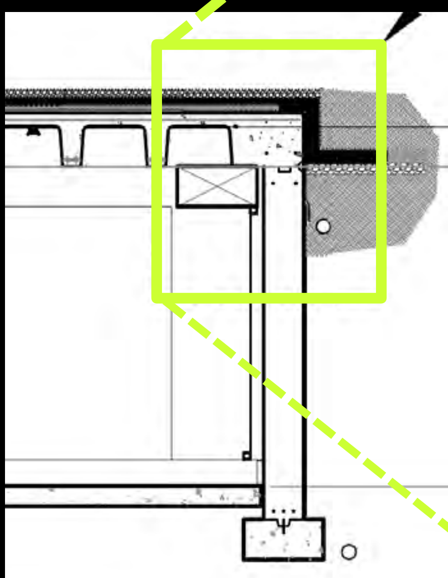


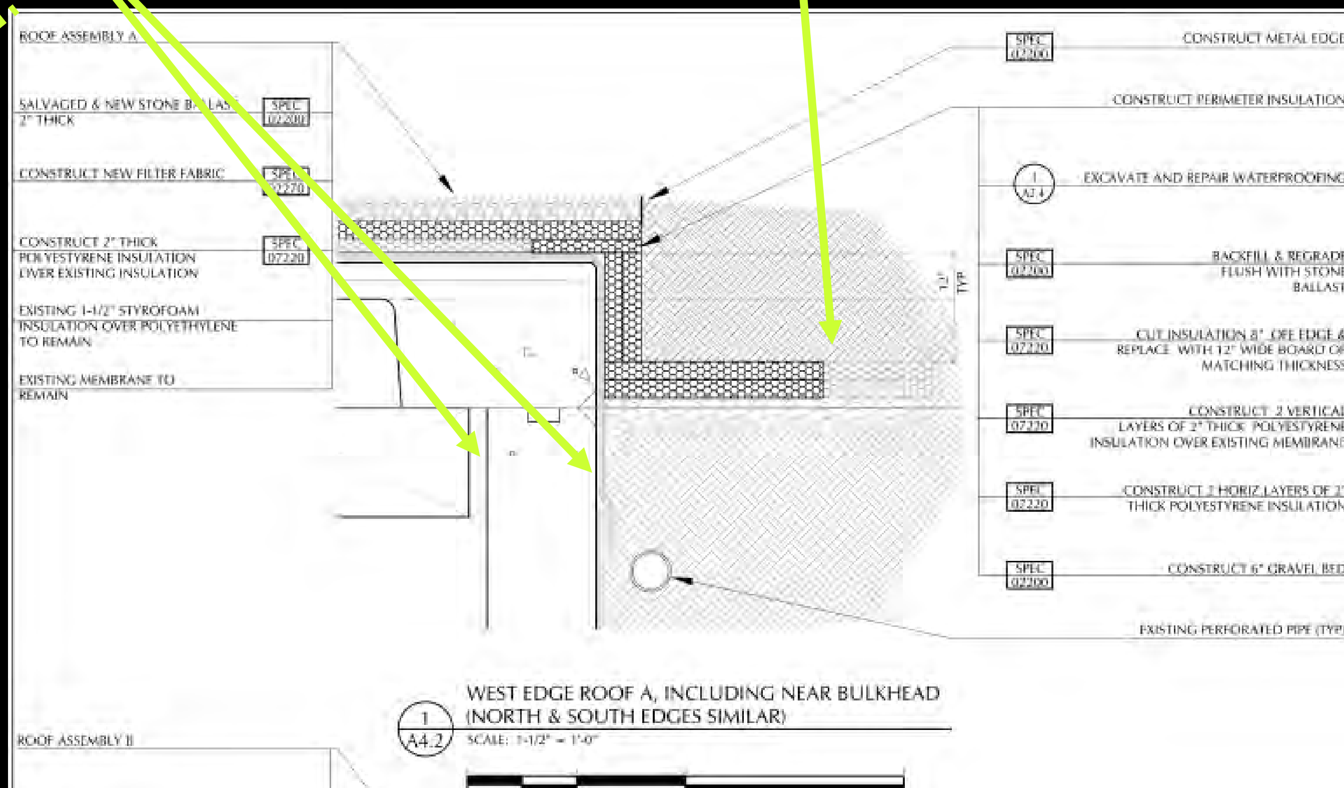
Average soil temperature below frost line

Earth-Banked & Sub-Grade Structures: Rethinking Insulation

frost-protected foundation design

- Insulation "apron" around structure, just below grade
- No insulation inside/outside the wall below frost line



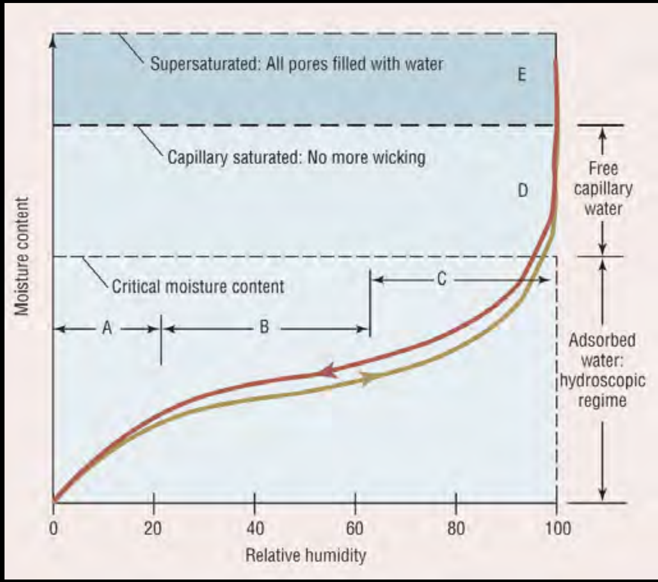


Watson & Henry Associates

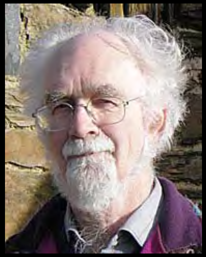
Possible Strategy: Moisture Buffering Building Materials

It depends on climate, building use & materials…

Michael C. Henry, 2003



J. F. Straube



Tim Padfield: *"Passive climate control of museum exhibition rooms is limited by the large air exchange required by people."*

Passive strategies cannot overcome large air exchange or internal loads

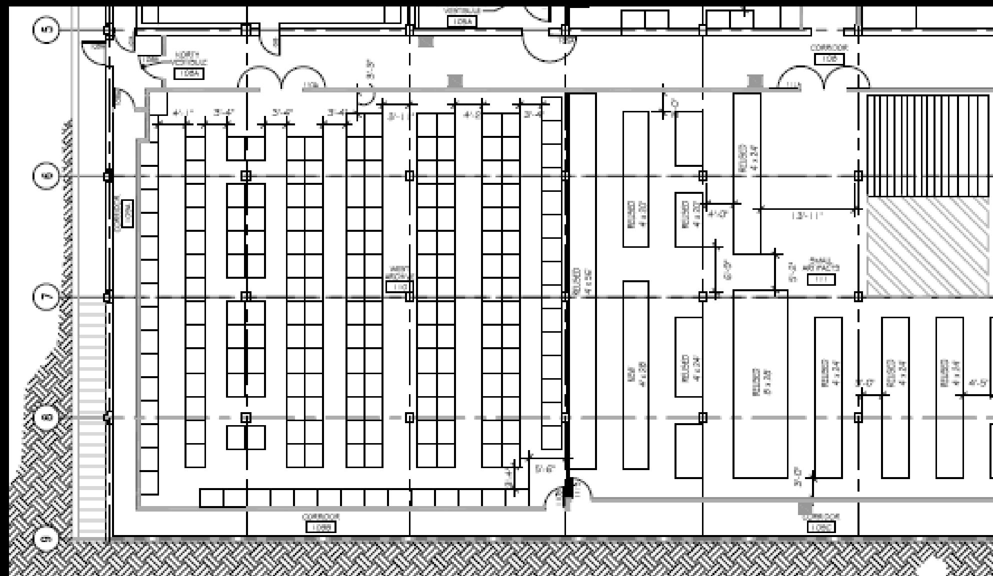
Moisture Buffering with Building Materials

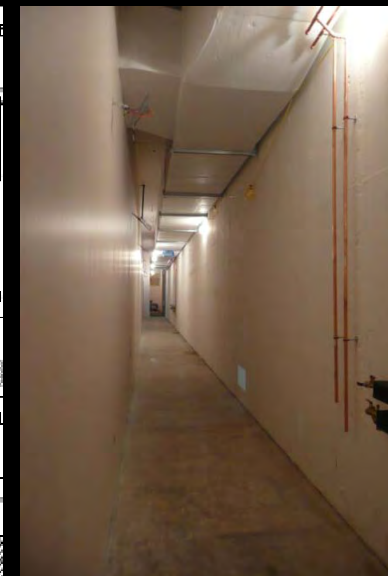
- Can moderate daily variations in interior RH (+)
  But response (adsorption/desorption) time is slow
- Can moderate seasonal variations in interior RH (+)
  But this applies to buildings with low occupancy, small infiltration & very small ventilation loads
- Provides buffering when systems are shut down (+)

- Does not remove excess moisture from interior or exterior sources (!)
  Dehumidification is required for these loads
- Buffering must be substantial relative to moisture capacity of room air (!)
- Response time depends on surface area of the buffer material (!)
  Paints and coatings may diminish performance
- Porous construction materials may require long drying time.

Possible Strategy: Cascaded Thermal & Moisture Gradients

Box in box enclosures





Michael C. Henry, 2008

L. L. Bean (the company): *"The "layering" method is the most effective way to dress for a wide range of winter conditions."*

It can work for buildings, too.

Box in Box, Layered Enclosures

- Distributes functions of the exterior wall between two walls (+)
  vapor control is in warm interior wall, resolves condensation issue
  exterior wetting and drying remains with the exterior wall
  leaks are in the corridor
- Reduces steep moisture vapor gradients across the wall assembly (+)
- Enhances thermal stability (+)
  isolates space from exterior T swings and radiant gains/losses
- Allows adaptation of existing conventional exterior wall assemblies (+)
  An excellent rehabilitation/adaptive reuse strategy

- Requires additional space for perimeter corridors (!)
- Extra cost of wall construction (!)
- Roof must be dealt with also (!)

Possible Strategy: Collection Housing

We focus on space T & RH,
but what does the stored material experience?

Foekje Boersma, 2007

Buffering by Collections Housings

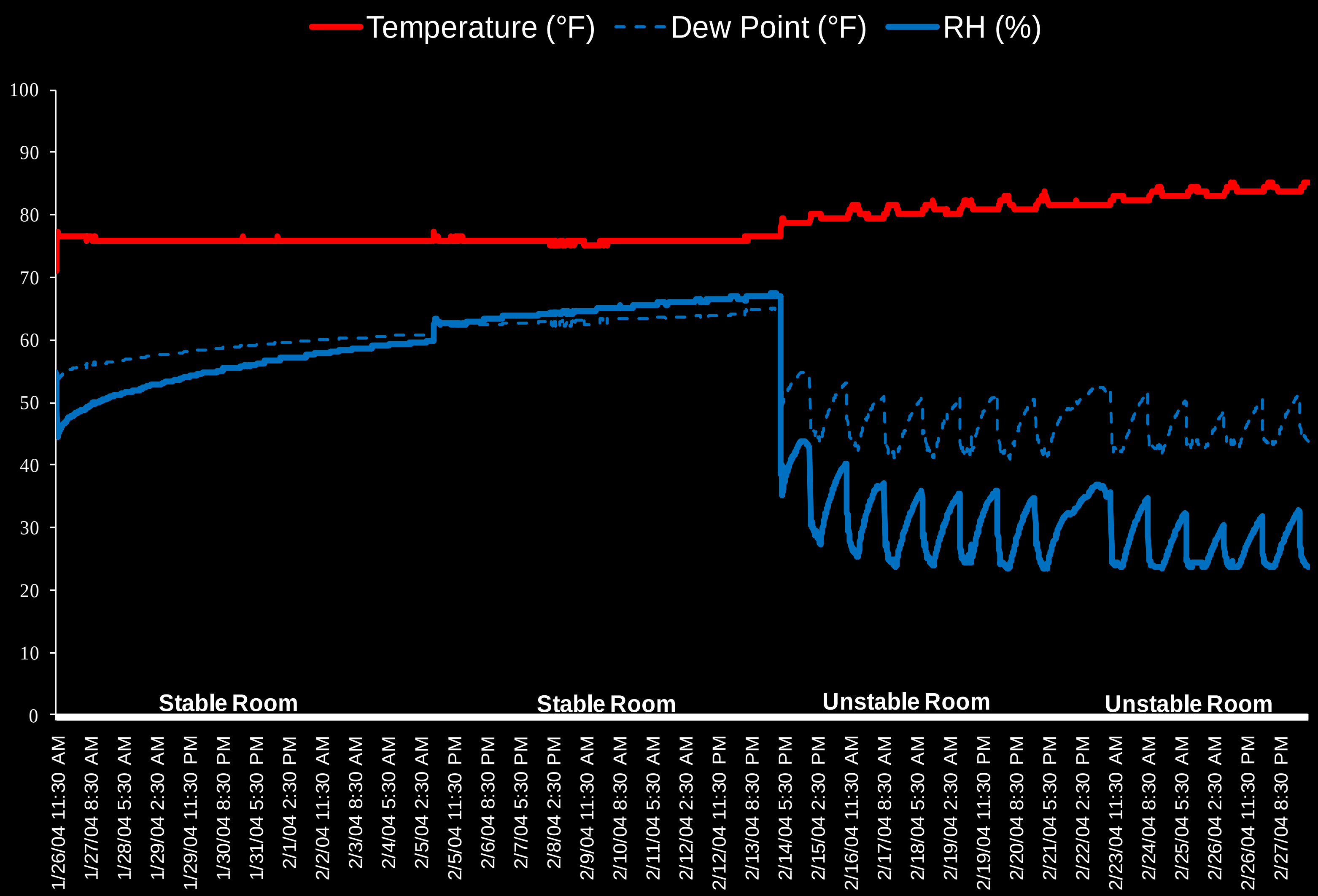
A simple field trial for buffering of textiles & paper in housings & cabinets in a passive, thermally massive, moisture-buffered, double-wall collections storage & archives building near Ahmednaggar India

Michael C. Henry, 2003

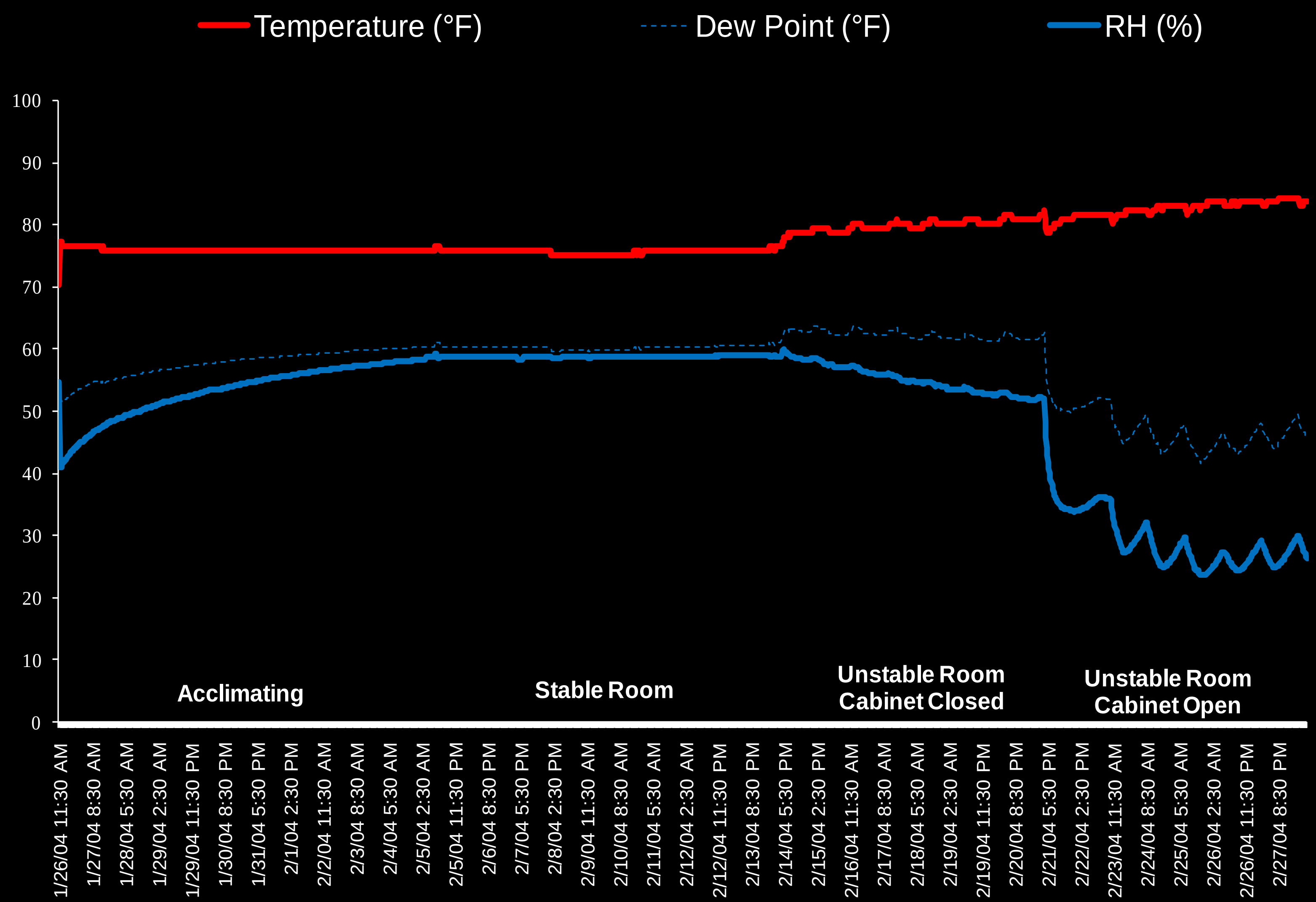
Michael C. Henry, 2003

- Interval 1: proxy materials acclimated in stable unconditioned room
- Interval 2: in *Coroplast®* boxes, set in metal cabinets with gasketed doors closed in stable room
- Interval 3: moved to unstable room, cabinet doors remain closed
- Interval 4: cabinet doors opened in unstable room

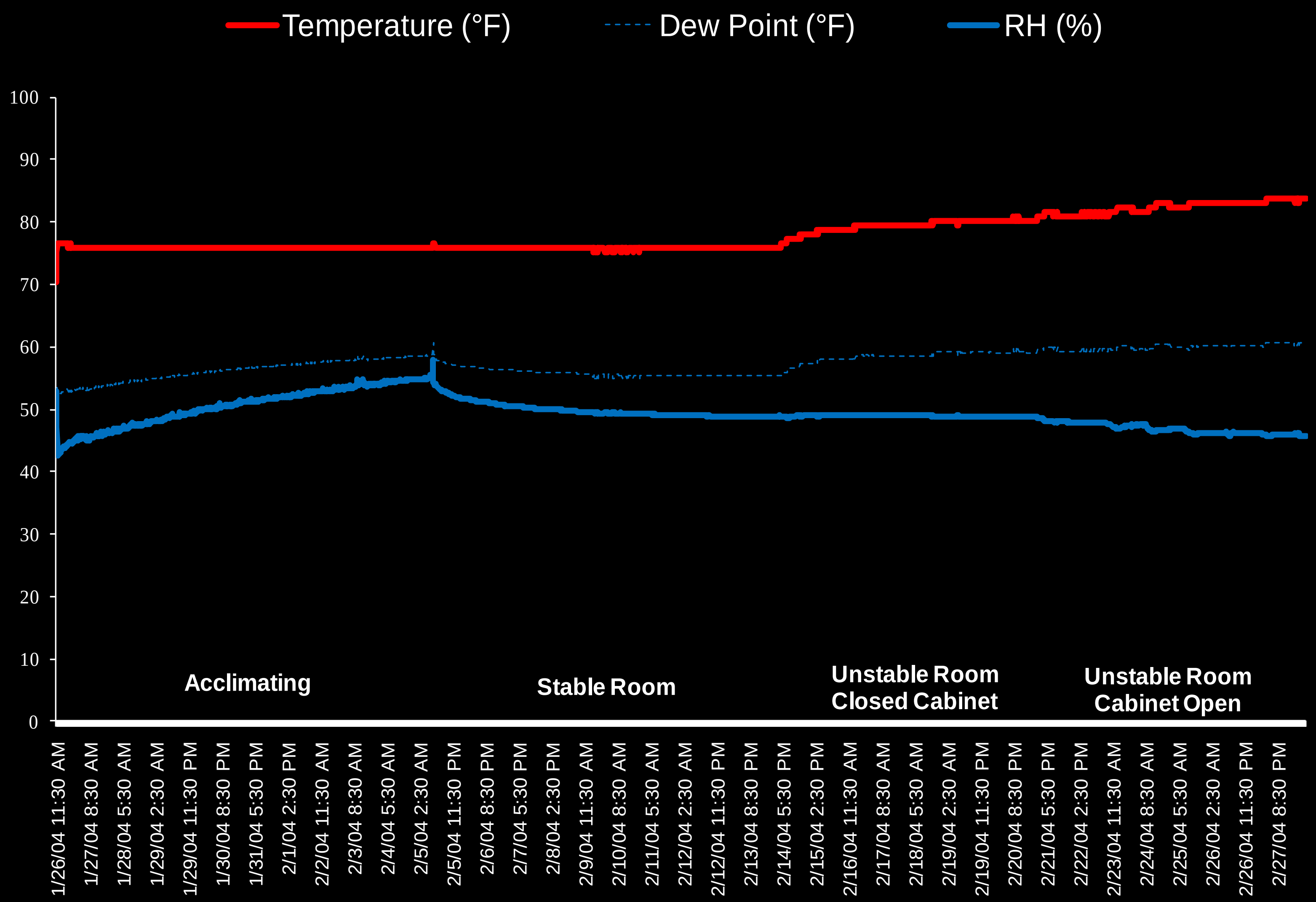
Housing Trial: Room Conditions



Housing Trial
Textile Bundle in Box



Housing Trial
Paper in Box



Essential Strategy: Measure Results

Is our knowledge of what is needed for collections longevity "meagre & unsatisfactory"?

Coastline Measure, 1987 Mark Tansey

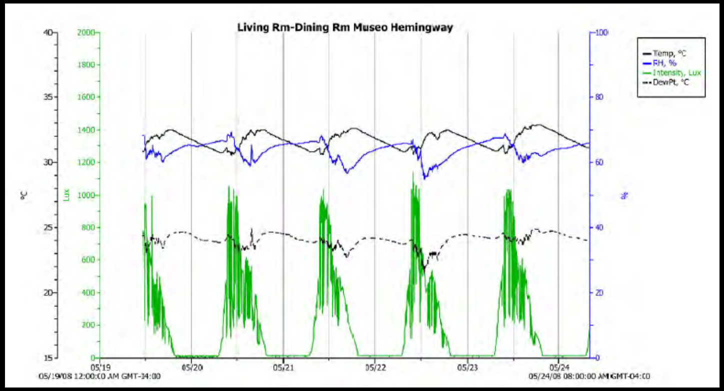
Lord Kelvin said: *"…when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind."*

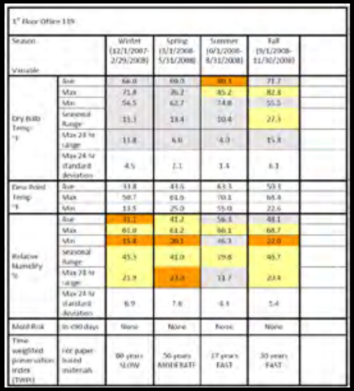
Essential Data

- Exterior conditions: *external thermal energy & moisture loads*
- Energy consumption: *what is used to moderate external conditions*
- Operational costs: *what is spent to operate "within spec"*
- Interior loads: *occupant loads, equipment & lighting*
- Interior conditions: *resultant interior environmental conditions*

But we should have a measurable benefit to justify the costs, so add:

- Preservation indices: *estimated benefit based on calculations*
- Material change rate: *detectable rate of collections material change*





1st Floor Office 119

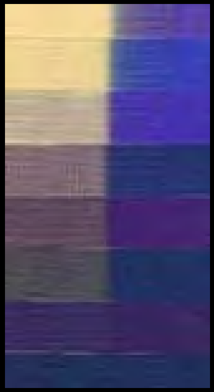
Season / Variable		Winter (12/1/2007-2/29/2008)	Spring (3/1/2008-5/31/2008)	Summer (6/1/2008-8/31/2008)	Fall (9/1/2008-11/30/2008)
Dry Bulb Temp °F	Ave	66.0	69.0	80.1	71.7
	Max	71.8	76.2	85.2	82.8
	Min	56.5	62.7	74.8	55.5
	Seasonal Range	15.3	13.4	10.4	27.3
	Max 24 hr range	11.8	6.0	4.0	15.8
	Max 24 hr standard deviation	4.5	2.1	1.4	6.3
Dew Point Temp °F	Ave	33.8	43.6	63.3	50.3
	Max	50.7	61.6	70.1	64.4
	Min	13.5	25.0	55.0	22.6
Relative Humidity %	Ave	33.1	41.2	56.3	48.1
	Max	61.0	61.2	66.1	68.7
	Min	15.8	20.1	46.3	22.0
	Seasonal Range	45.3	41.0	19.8	46.7
	Max 24 hr range	21.9	23.0	13.7	23.4
	Max 24 hr standard deviation	6.9	7.6	4.1	5.4
Mold Risk	In <90 days	None	None	None	None
Time weighted preservation index (TWPI)	For paper based materials	80 years SLOW	56 years MODERATE	17 years FAST	30 years FAST

Measuring Results: Detecting Change in Collections

We need better methods for repeatable measurement of small change:

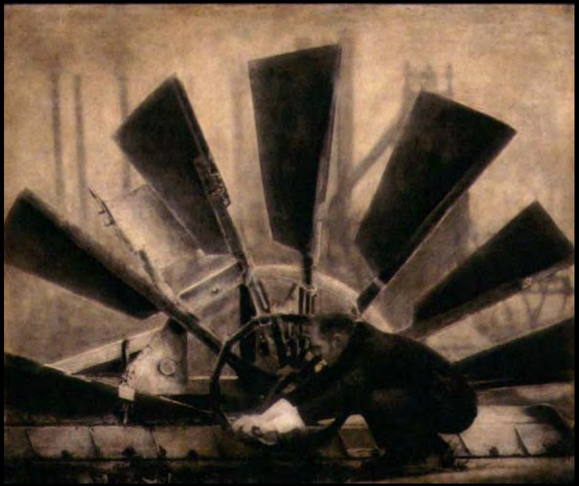
- Observation of a vulnerable object/material (qualitative):
  periodic, optical or enhanced-optical, non-invasive
- Observation/testing of a proxy object/material (qualitative/quantitative):
  periodic, enhanced-optical, chemical-mechanical
  examples: blue wool scales, corrosion coupons
- Dosimetry monitoring by proxy (quantitative):
  real-time, measurement of change in proxy material
  examples: OnGuard® corrosion logger, LiDO, stain gauge & chip



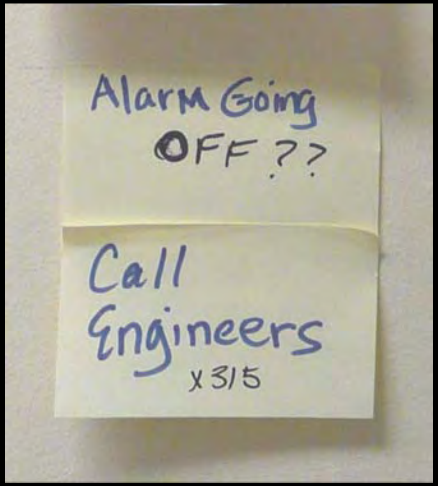




Essential Strategy: When the Lights Go Out

Require robust, resilient & survivable buildings for collections



Windmaker, 2000 Robert & Shanna ParkeHarrison



- Infrastructure failure?
- Natural disasters?
- Evacuation of staff?
- Obsolescence of systems?
- Rolling brownouts or rationing?
- Increased energy costs?

Essential Strategy: Economic Justification

Use Life Cycle Cost Analysis (LCCA)

The Everett Collection

LCCA allows fair comparison of non-mechanical strategies with conventional mechanical strategies, because LCCA accounts for total cost of ownership.

Life Cycle Cost Analysis: Total Cost of Ownership

All quantifiable costs of ownership of a building, system or component, incurred over its complete life cycle at present day value:

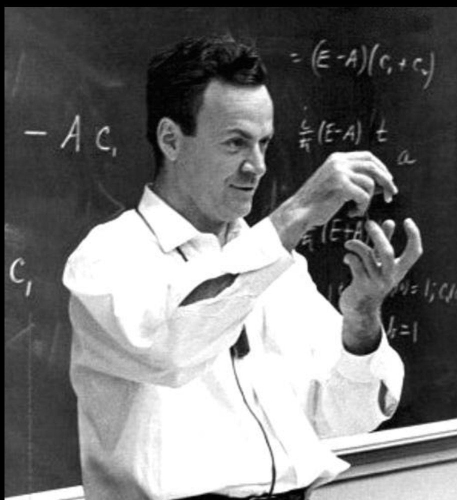
- Initial Costs: purchase, acquisition, design, construction
- Energy Costs: fuel, electricity
- Operation Costs: service, maintenance, repair, mid-life upgrades
- Replacement Costs: at end of service life
- Residual Costs: salvage values (credit) & removal/disposal costs
- Finance Charges: interest payments on loans for the above
- Fees & taxes: carbon taxes or offsets, if incurred

Life Cycle Cost Analysis: Service Life Considerations

Four significant factors for a building with a nominal 100 year life cycle:

- Energy Costs: for environmental management & lighting
- Operation Costs: for service, maintenance, repair, mid-cycle upgrades for mechanical & electrical systems
- Replacement Costs: for systems and components with short service life
- Residual Value: resale of salvage values (credit) at end of life cycle

A closing thought



Dr. Richard P. Feynman said:
*"Our responsibility is to do what we can,
learn what we can,
improve the solutions,
and pass them on."*

Seems like a good way of working out our *Conservation*^{2} issues

Thank you for listening