This presentation premiered at WaterSmart Innovations

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LIKE WATER FROM AIR!
SNWA AIR CONDITIONER CONDENSATE STUDY

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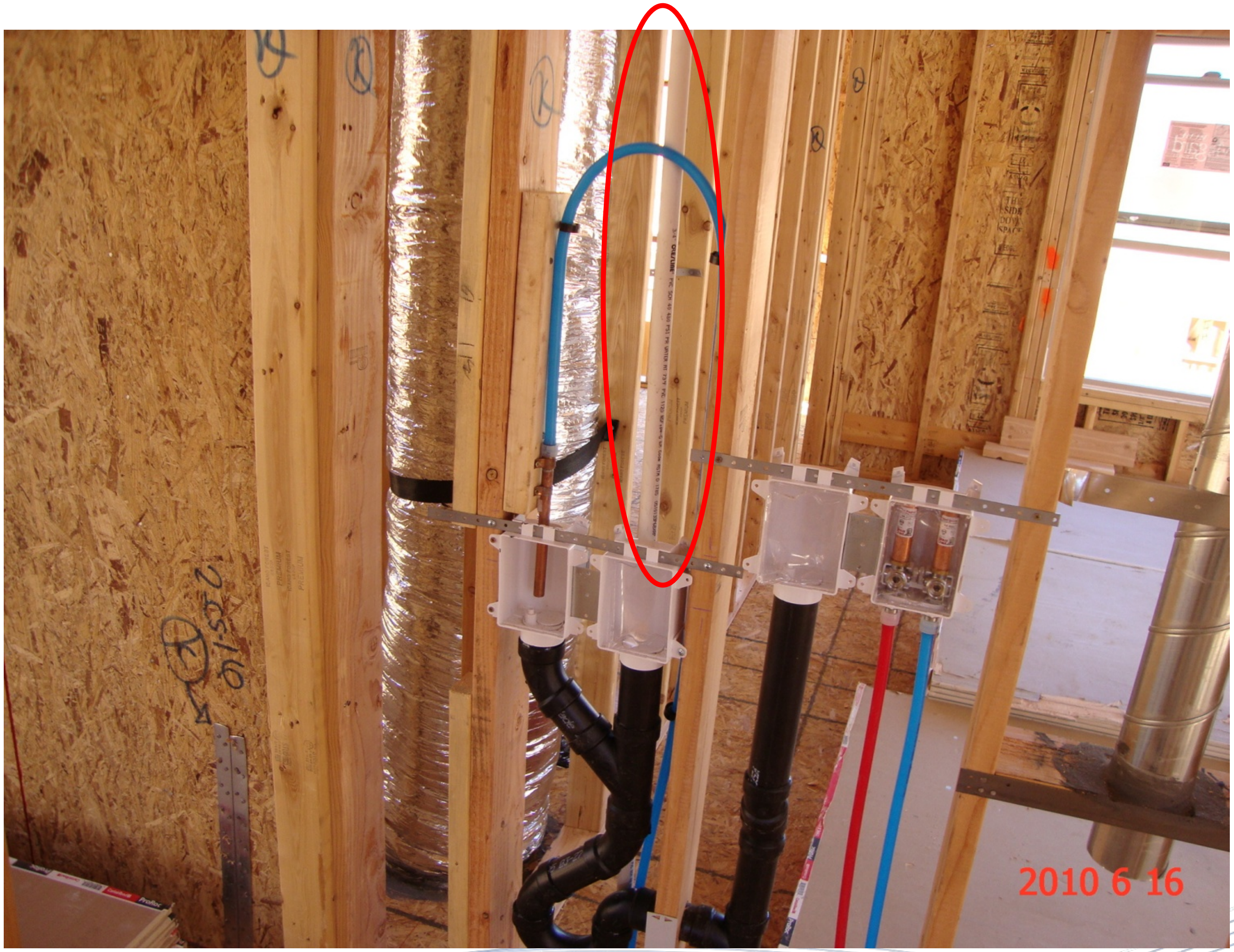
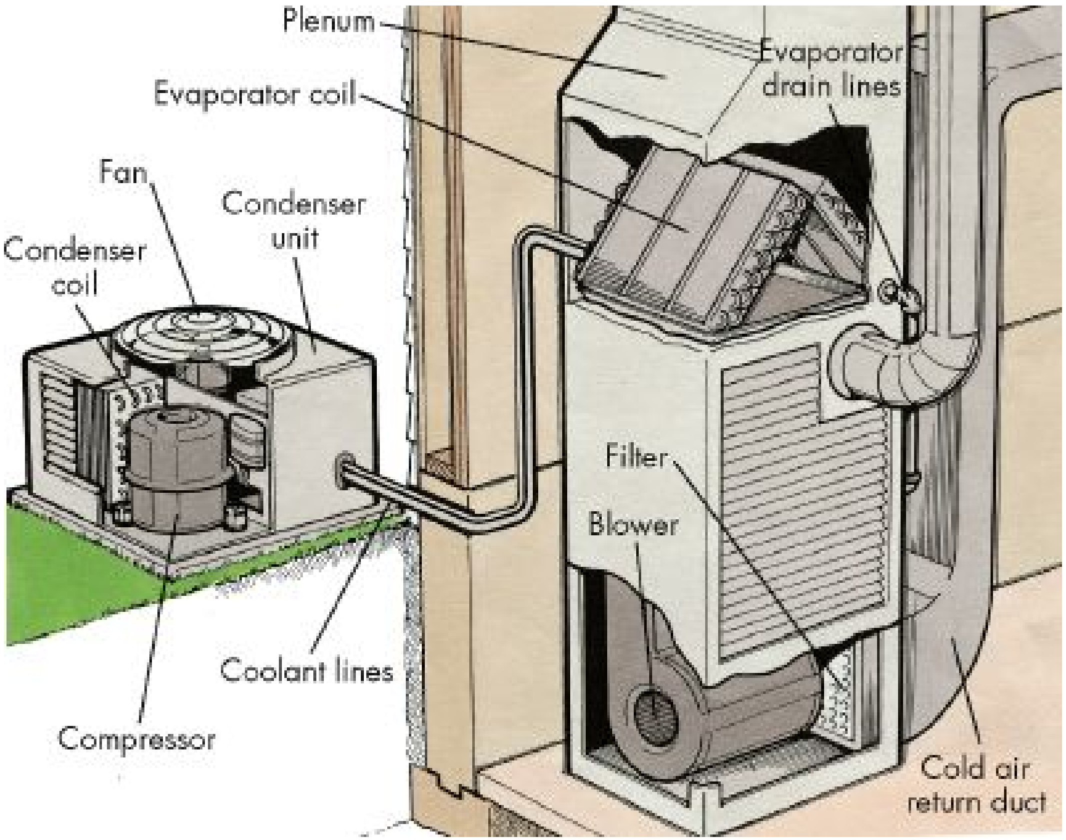
BACKGROUND

- Condensate is a by-product that is produced when our homes are being cooled by our air conditioners
- Air blows across air conditioner coils, water condenses and accumulates.
- In a single family residential home this water is typically drained away onto the property without being of much use.
- Some homebuilders have started to drain this water into the sanitary sewer system, potentially creating a new water resource for the Las Vegas Valley
- In 2007 SNWA began investigating the potential for condensate generation through small single site experimentation.
- In 2010, the decision was made to expand the experiment to include more sites.

CONDENSATE ROUTED TO SEWER



CONDENSATE SOURCE



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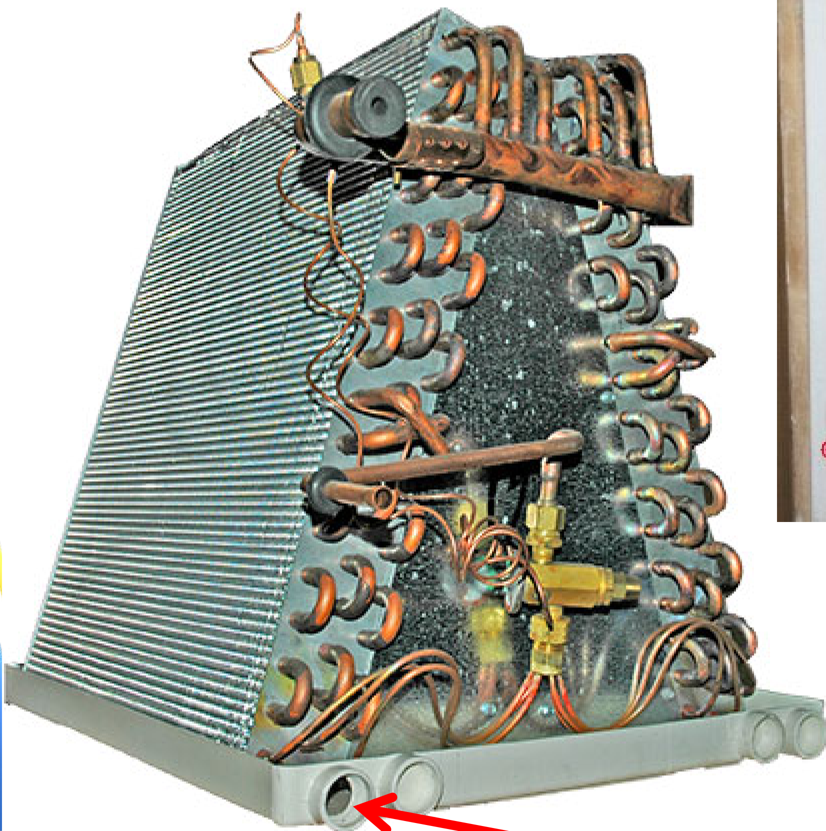


STUDY DESIGN

- Approximately 20 single family residential properties were chosen to participate in a year-long study to estimate the amount of condensate water generated from AC heat exchange operation.
- These participants were selected from interested SNWA employees within the Environmental Resources Department, SNWA Conservation Workgroup members and acquaintances of employees.

SITE SELECTION

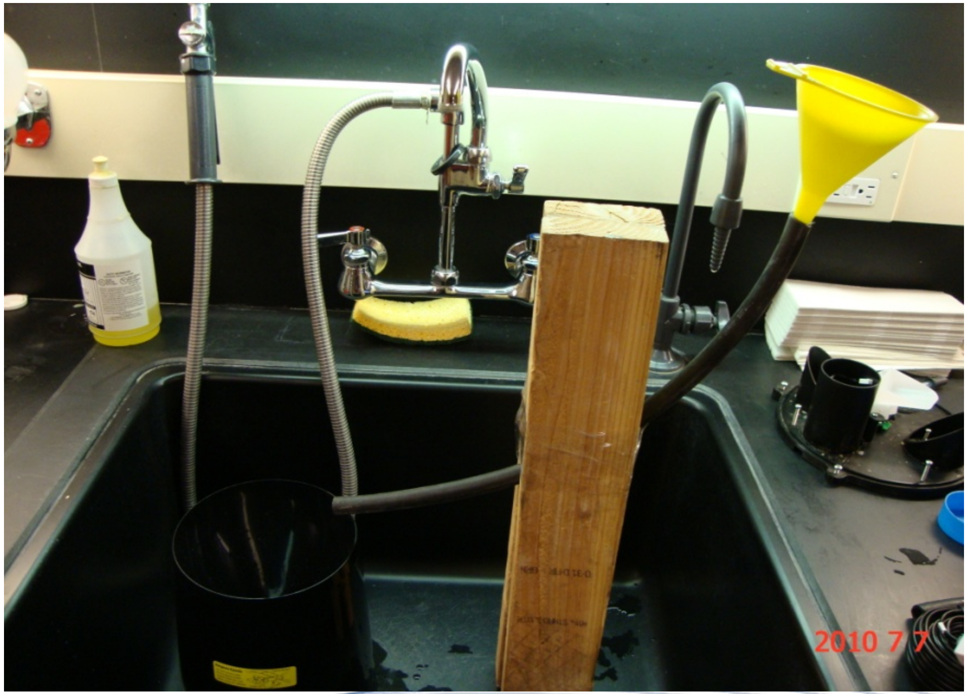
- Potential properties were then screened to determine suitability and ease of monitoring.
  - Include only homes with AC compressor units detached from the home (no roof mounted units) for ease of access to the condensate drain.
- 18 sites were used in the final analysis

Collection Methodologies

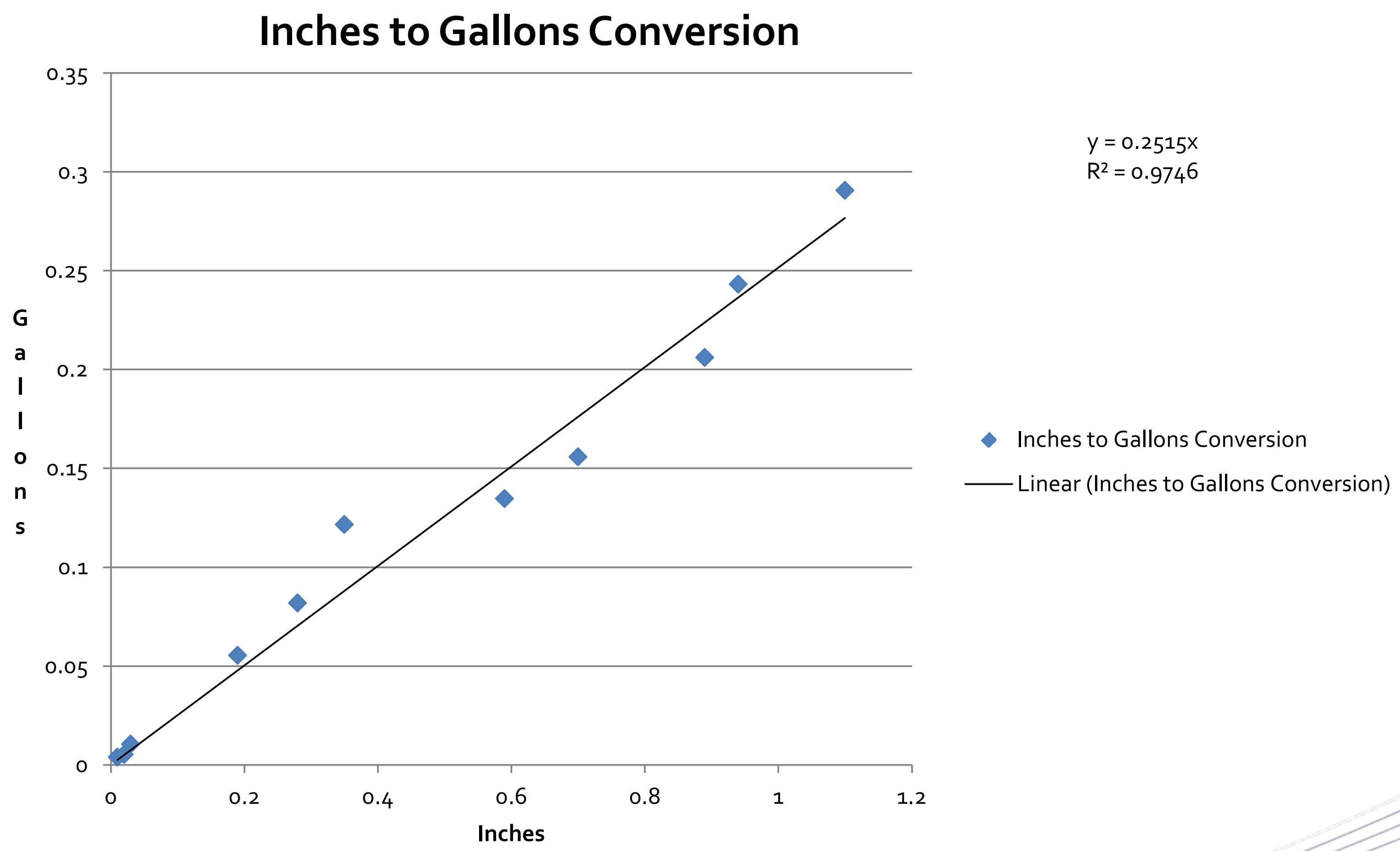
- Monitoring equipment consisted of tipping bucket rain gauges with on board dataloggers to measure the amount of water flowing from the drain
- Small dataloggers that recorded temperature and relative humidity were also obtained to allow correlation between weather and water generation.

RAIN GAUGE CALLIBRATION

- The rain gauge was calibrated to measure the difference between recorded intake and actual intake at different water rates



RAIN GAUGE CALIBRATION



COLLECTION METHODOLOGIES

- Layout and location of the condensate drain location required two methods to route water from the drain into the rain gauge.
  - 1. Flexible polyethylene tubing adapted to run from the outlet securely into the rain gauge
  - 2. Run small lengths of PVC tubing into the gauge, which often needed to be placed lower than ground level to ensure adequate angle for water entry before evaporation

COLLECTION METHODOLOGIES

COLLECTION METHODOLOGIES

- Testing was conducted to determine the difference in time that different angle had on flow rates.
- The results widely varied, but angles greater than 30 degrees were found to be optimal.
- All gauges were covered by composite utility box enclosures to protect them from the elements.

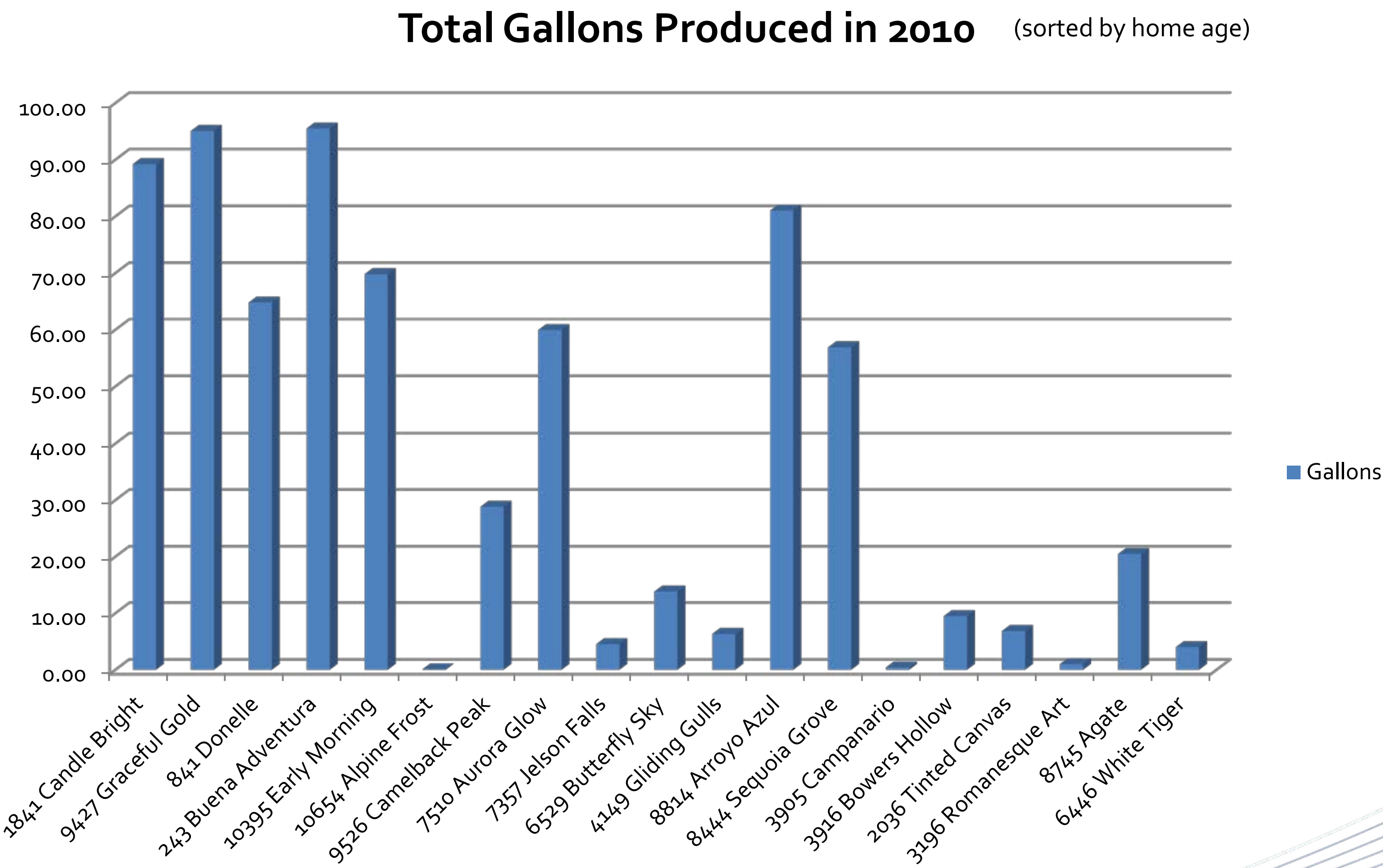
COLLECTION METHODOLOGIES

- The second installation method was preferred over concern from the amount of time the condensate water would sit in the flexible piping before entering the gauge.
- Testing showed little evaporative loss, but the small amounts of water being generated overall led to caution winning out over ease of installation.
- Participants completed a brief demographic survey & signed a research agreement.
- Equipment types were catalogued as well as thermostat settings recorded.

RESULTS

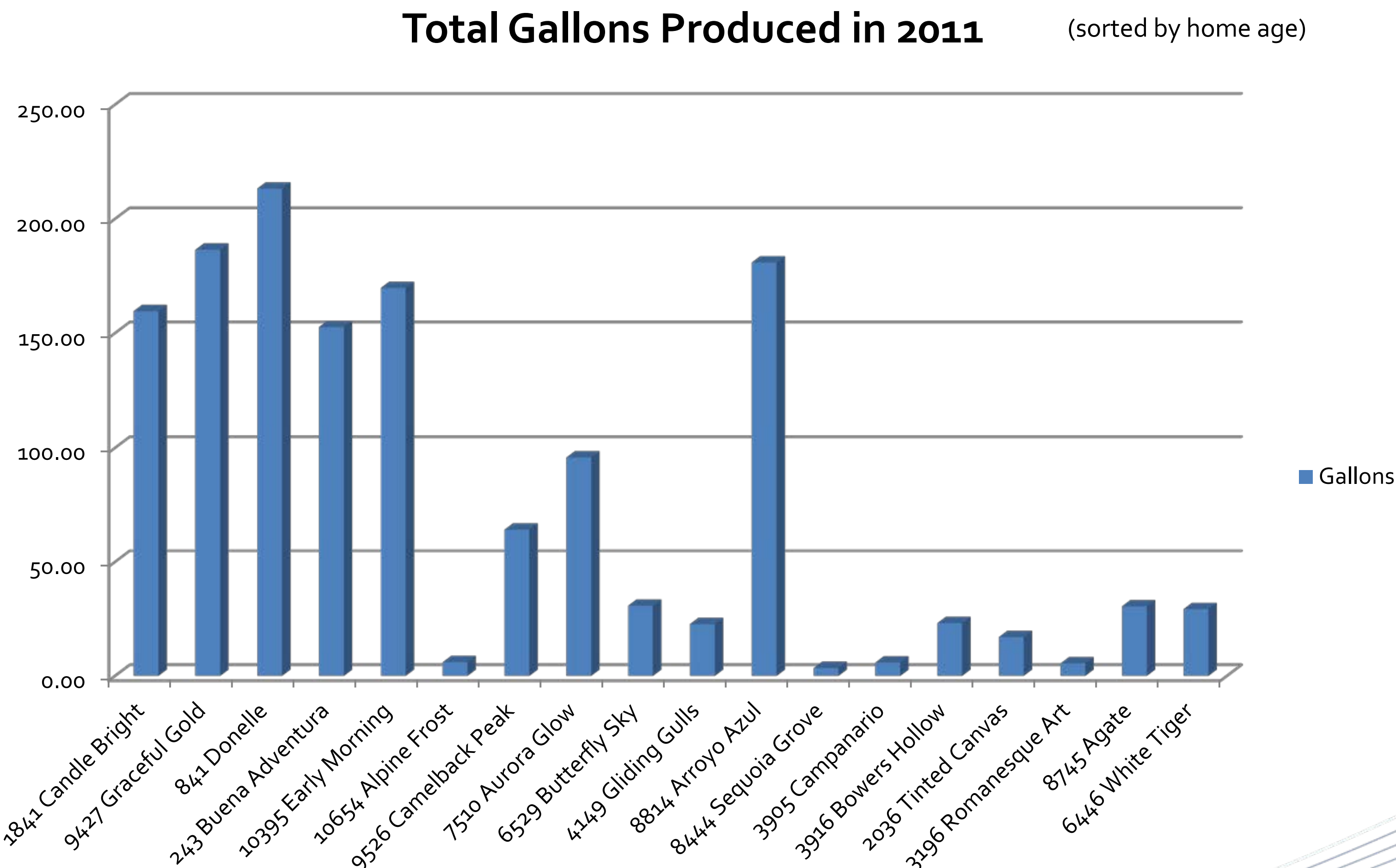
- Data was collected for approximately 1 year, starting in late July of 2010 and ending in October of 2011.
- There was wide variation in the total annual amount of condensate generated.

RESULTS



Total Gallons Produced in 2010
(sorted by home age)
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1841 Candle Bright
9427 Graceful Gold
841 Donelle
243 Buena Adventura
10395 Early Morning
10654 Alpine Frost
9526 Camelback Peak
7510 Aurora Glow
7357 Jelson Falls
6529 Butterfly Sky
4149 Gliding Gulls
8814 Arroyo Azul
8444 Sequoia Grove
3905 Campanario
3916 Bowers Hollow
2036 Tinted Canvas
3196 Romanesque Art
8745 Agate
6446 White Tiger
Gallons

RESULTS



Total Gallons Produced in 2011
(sorted by home age)
250.00
200.00
150.00
100.00
50.00
0.00
1841 Candle Bright
9427 Graceful Gold
841 Donelle
243 Buena Adventura
10395 Early Morning
10654 Alpine Frost
9526 Camelback Peak
7510 Aurora Glow
6529 Butterfly Sky
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8814 Arroyo Azul
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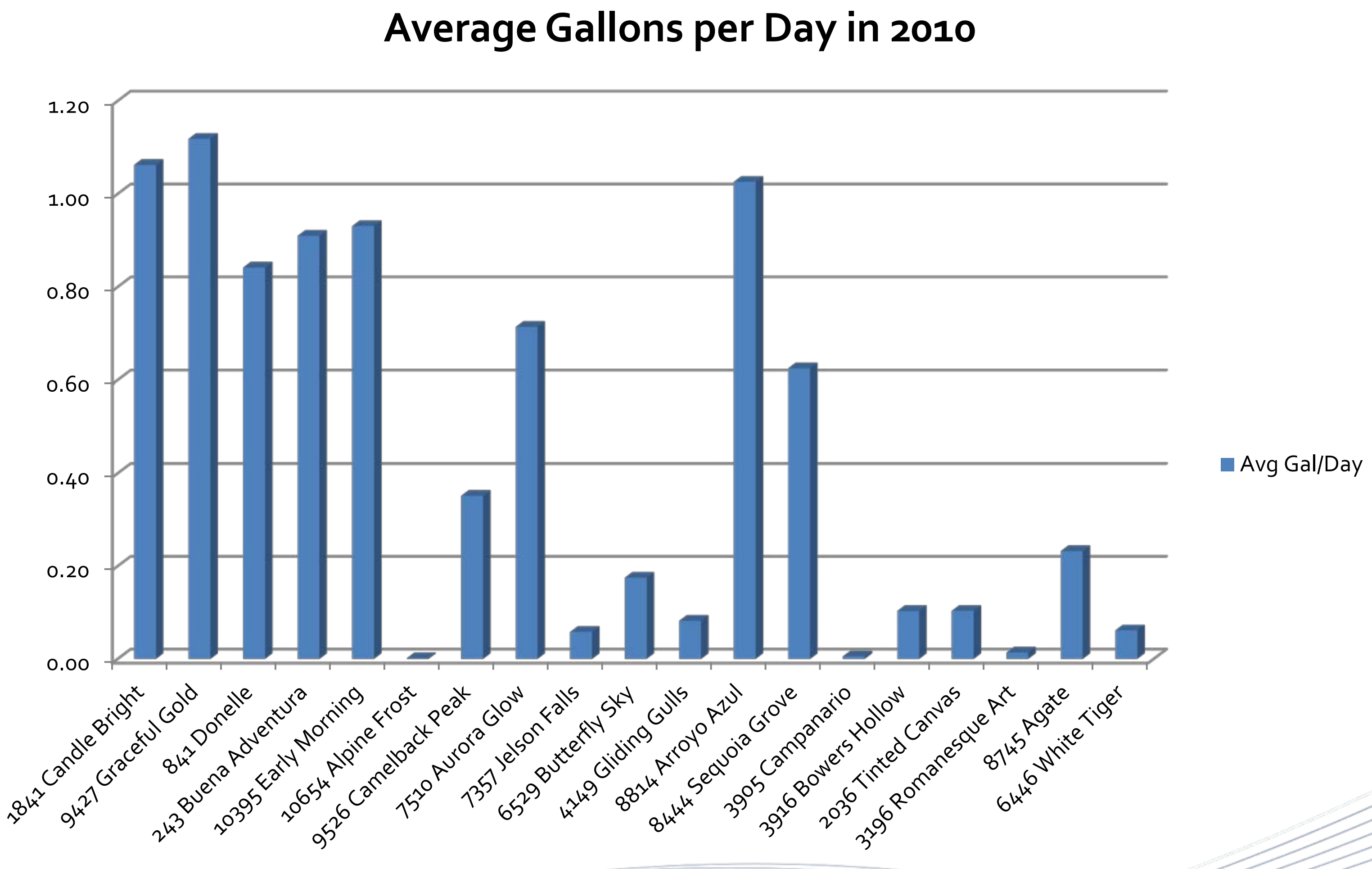
Gallons

RESULTS



Average Gallons per Day in 2010
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1841 Candle Bright
9427 Graceful Gold
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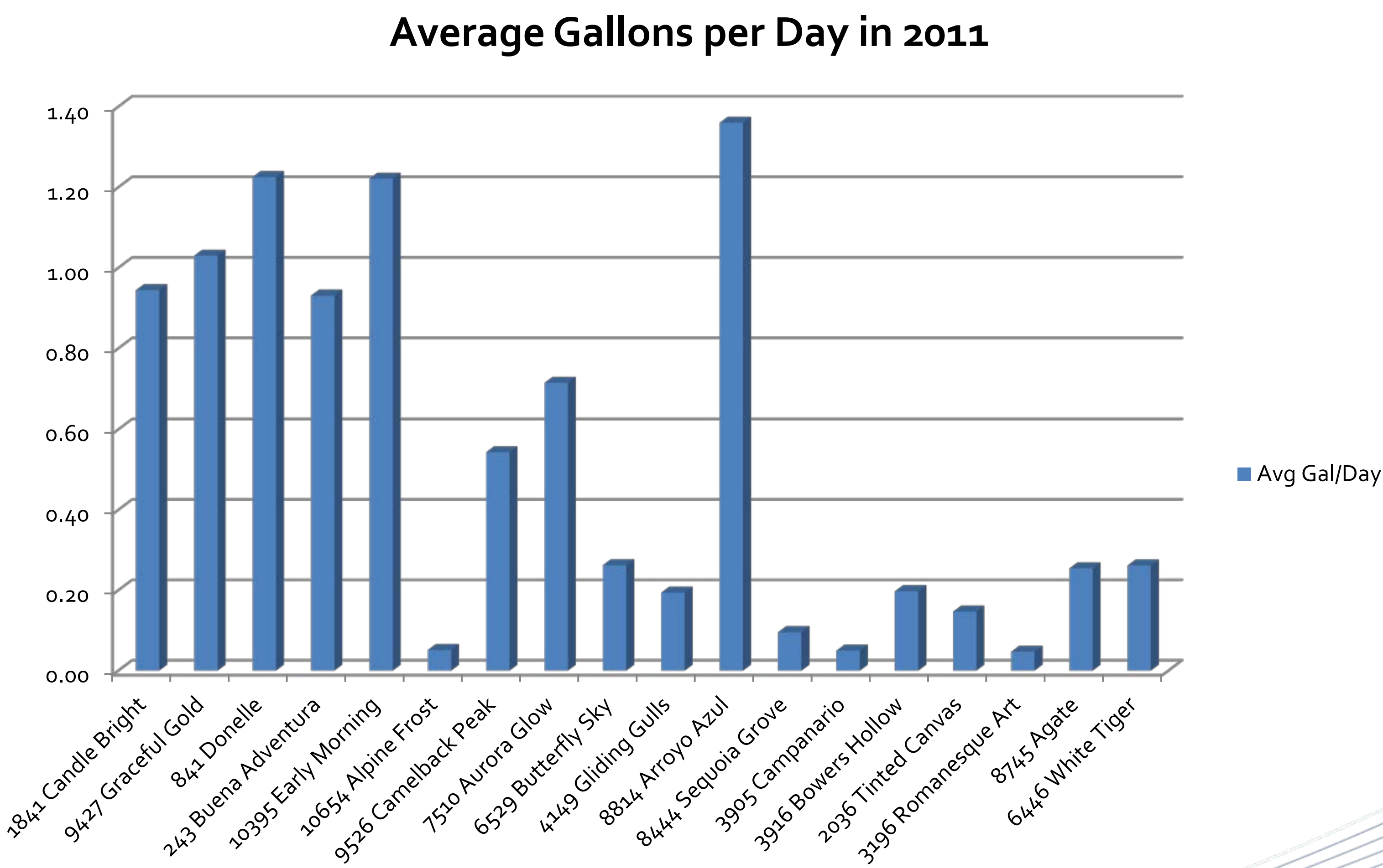
Avg Gal/Day

RESULTS


Average Gallons per Day in 2011
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1841 Candle Bright
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Avg Gal/Day

RESULTS 2011

	Total Gallons	Gallons per Day
Minimum	5.45	0.05
Average	81.94	0.55
Maximum	213.20	1.36
Standard Deviation	76.57	.47

RESULTS ALL DATA

	Total Gallons	Gallons per Day
Minimum	6.06	0.03
Average	114.84	0.49
Maximum	281.49	1.08
Standard Deviation	99.98	.38

REGRESSION MODEL

- Why model?
- We developed & ran many multivariate models using both hourly and averaged daily values with various other inputs.
- Our best model used these variables:

Variable	Definition
OrigInches	Original un-shifted condensate measurement
AvgPCT_RH	Daily avaraged percent relative humidity
DewPtCinF	Averaged dew point in degrees farenheit
WetBulb	Averaged wet bulb temperature in degrees farenheit
CONST_YR	Construction year of the house
N_BED	Number of bedrooms
N_AC	Number of air conditioning units
N_PEEPS	Number of permanent residents
SHOWER_MIN	Average of total minutes of shower time per day
COOL_SHARE	Participates in NV Energy's Cool Share program
LOW_TEMP	Lowest temperature measured at vent

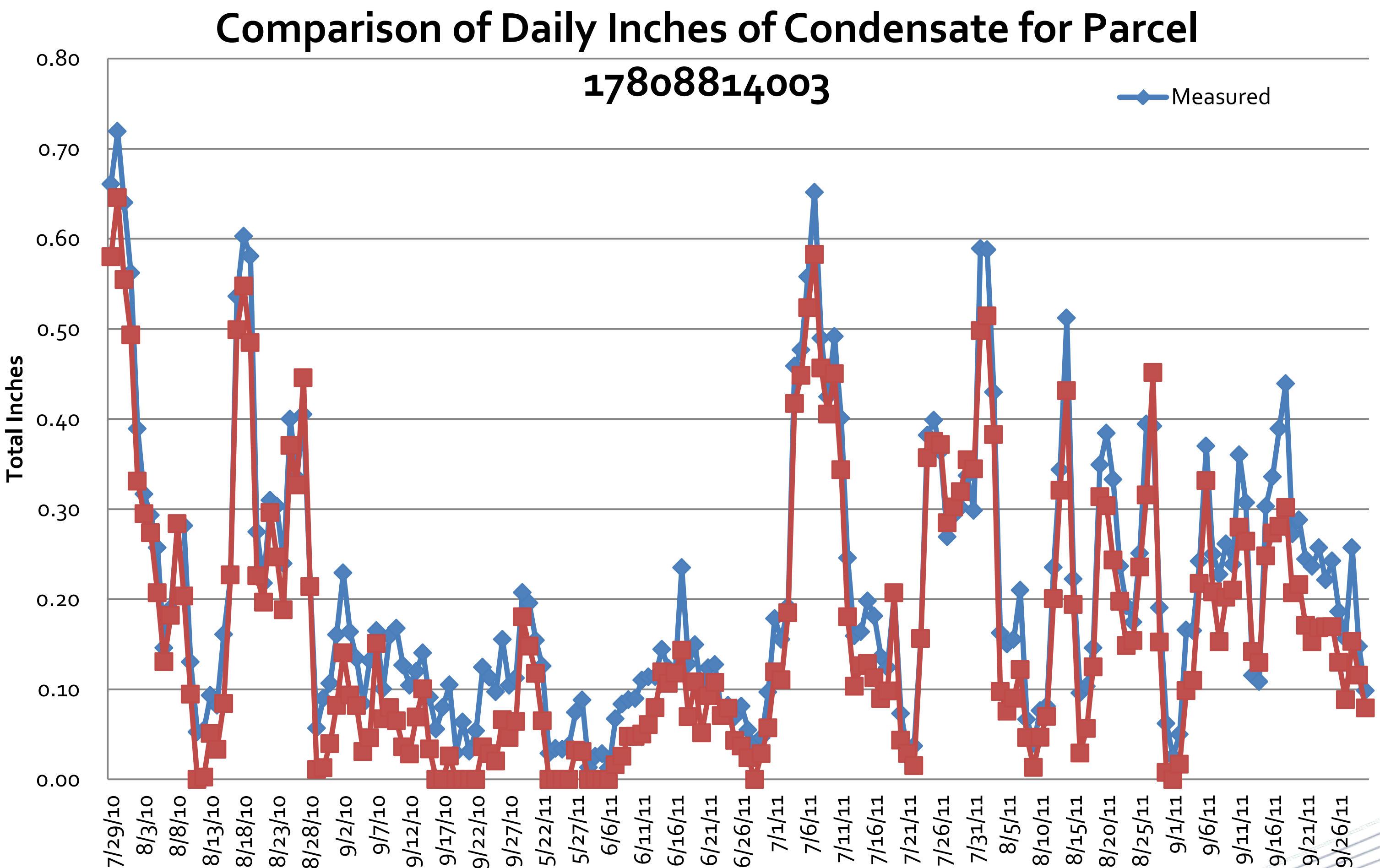
REGRESSION MODEL

Final Model

Regression Summary for Dependent Variable: OffsetInches (3HrShiftAvg.sta)
R= .89574154 R^2= .80235290 Adjusted R^2= .80033235
F(11,1076)=397.10 p<0.0000 Std.Error of estimate: .10933

N=1088	Beta	Std.Err. of Beta	B	Std.Err. of B	t(1076)	p-level
Intercept			24.48042	2.035986	12.0239	0.000000
OrigInches	0.685528	0.018309	0.63164	0.016870	37.4420	0.000000
AvgPCT_RH	-0.090326	0.026625	-0.16926	0.049891	-3.3926	0.000718
DewPtCinF	0.101864	0.041159	0.00141	0.000568	2.4749	0.013481
WetBulb	0.235363	0.030361	0.01004	0.001295	7.7521	0.000000
CONST_YR	-0.260855	0.021476	-0.01253	0.001032	-12.1461	0.000000
N_BED	0.238209	0.030511	0.11684	0.014966	7.8074	0.000000
N_AC	0.377711	0.044242	0.19564	0.022915	8.5375	0.000000
N_PEEPS	0.157722	0.021910	0.04242	0.005893	7.1987	0.000000
SHOWER_MIN	0.341588	0.054480	0.00405	0.000645	6.2699	0.000000
COOL_SHARE	0.090386	0.029097	0.06562	0.021124	3.1063	0.001944
LOW_TEMP	-0.460551	0.064506	-0.01430	0.002003	-7.1397	0.000000

RELATIVELY WELL FITTING SITE



WATER QUALITY

- Why?
- Samples were taken at eight of the sites in August 2010 and were sent to the lab for analysis
- Additional samples were obtained at two sites in May 2011 and were also sent for analysis
- It was a struggle to get sufficient water in a timespan conductive to analyses.

WATER QUALITY

- General

ANALYTE	Min	Average	Max	StdDev	N
Alkalinity, HCO3	0.000	23.363	62.900	20.85967	10
Alkalinity, Total	8.530	33.376	62.900	16.21143	10
Conductivity	137.000	256.000	426.000	94.47869	10
D.F.E.	-69.000	-24.000	43.000	59.15235	3
Hardness, Total	0.350	4.303	9.600	3.68068	10
Hardness, Non-CaCO3	-27.000	-12.333	11.000	20.42874	3
o-Phosphate as P	0.001	0.002	0.003	0.00125	10
pH	4.360	5.025	6.000	0.49998	10
Saturation Index	-3.960	-5.463	-7.490	1.35063	7
TDS	28.800	44.340	84.400	20.70000	10
Temperature (deg. Celsius)	21.000	21.471	22.100	0.38607	7

* relevant units in mg/L

WATER QUALITY

- Trace Metals (mg/L)

ANALYTE	Min	Average	Max	StdDev	N
Aluminum	0.970	6.677	8.300	5.985	10
Copper	0.083	1.328	4.500	1.416	10
Manganese	0.089	0.089	0.089	0.089	10
Zinc	0.068	2.069	9.100	2.865	10

WATER QUALITY - BIOLOGICALS

- All 7 sites tested for Daphnia toxicity came back positive
- The same 7 sites tested negative for Legionella
- All 7 sites came in under 0.5 ppb for the Algal Toxin Value test
- All 5 sites tested for Stachybotrys Chartara (aka. "Toxic" or "Black Mold") came back negative.
- 2 sites tested positive for Scytalidium spores
- 3 sites tested positive for Histoplasma spores

CONCLUSIONS

- Modest volumes (avg. ½ gallon per day) of condensate can be generated from home air-conditioners during the conditioning season.
- The volumes are highly variable at different sites and highly dependent on weather and other factors. Avg 81-115 gallons per year for an average site but can be next to nothing to over 280 gpy.

CONCLUSIONS

- It takes a lot of homes to make serious discussion of supplementing return-flow credits worthwhile. If 115 gals/residence then each acre-foot would require 2834 homes that are plumbed to sewer.
- Assuming we study other property types with large A/C units in the future we may quantify more conservation potential.
- Remember though it could be considered "free" paper water to SNWA.

CONCLUSIONS

- Best model suggests that weather, home age, number of A/C units, people and bedrooms, amount of showering time, participation in Cool Share program and how much people cool their homes are associated variables in condensate generation.
- There are more probably more factors we don’t know than know (ex. detailed A/C settings and configuration of piping among others).

CONCLUSIONS

- Generation of highly non-mineralized condensate results in aggressive water.
- Carbonic acid (H_2CO_3) is formed by reaction of highly pure water with CO_2 in atmosphere.
- This causes metals to be stripped from contacted A/C components.
- Water chemistry supports this, though phenomenon already documented in literature.

CONCLUSIONS

- Appear to catch other contaminants like some dust-borne molds.
- No “toxic mold” found in samples.
- While the two molds found can cause health issues in dust, occurrence in water not a recognized threat.

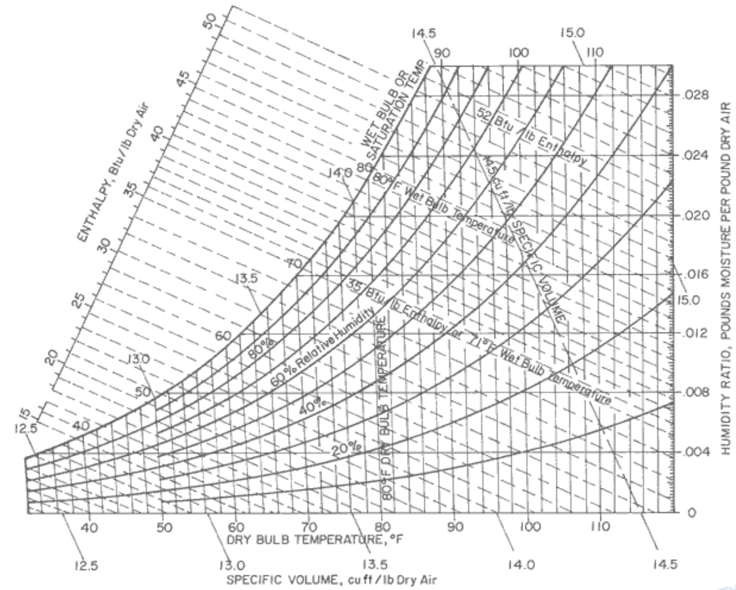
CONCLUSIONS

- In terms of builders routing to washing machine box, probably a safe and reasonable alternative to routing outside.
- Metals in relatively trace amounts and acidity will be swamped out by relatively basic wash waste water.
- Risk of mold spores much greater from simple blowing in of air from doors, windows, and leaks than dry opening of condensate drain pipe.

CONCLUSION

- It does work nicely for supplemental irrigation of a small collection of plants.

QUESTIONS?


ENTHALPY, Btu/lb Dry Air
WET BULB OR SATURATION TEMP
52 Btu/lb Enthalpy
90°F Wet Bulb Temperature
SPECIFIC VOLUME
35 Btu/lb Enthalpy or 71°F Wet Bulb Temperature
80% 60% Relative Humidity 40% 20%
80°F DRY BULB TEMPERATURE
DRY BULB TEMPERATURE, °F
SPECIFIC VOLUME, cu ft/lb Dry Air
HUMIDITY RATIO, POUNDS MOISTURE PER POUND DRY AIR