Water Harvesting Potential in an Arid City: A Quantity Assessment for Tucson, Arizona

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Catalina Mountains
I-10 Highway
Santa Cruz River
Randolph Golf Course
Tucson Mountains
alluvial fan
I-19 Highway
scale (miles)
0
2
4
N

Water Use Facts (Tucson Water)

- 178 GPD (gross all uses)
- 115 GPD (net household only)
- 40-60 GPD (outdoor/landscape est.)

- Outdoor use is estimated to be between 30 and 50% of the delivered water depending on age of neighborhood, type of development and landscape character.

The Question:

- Is rainfall sufficiently abundant to be useful in desert city like Tucson?
  - How much rain falls on Tucson annually?
    - 200 square miles X 640 acre per mile = 128,000 acres X 1 foot rain = **128,000 acre feet/year** of water from rainfall annually.
  - How much water does Tucson use?
    - 1,000,000 people X 115 gallons/person/day X 365 days/year = 420 x 10^8 gallons / 7.48 gallons/cubic foot = 561 x 10^7 cubic feet / 43560 feet/acre = **129,000 acre feet/year** of water used
  - 128000/196000 = 65%

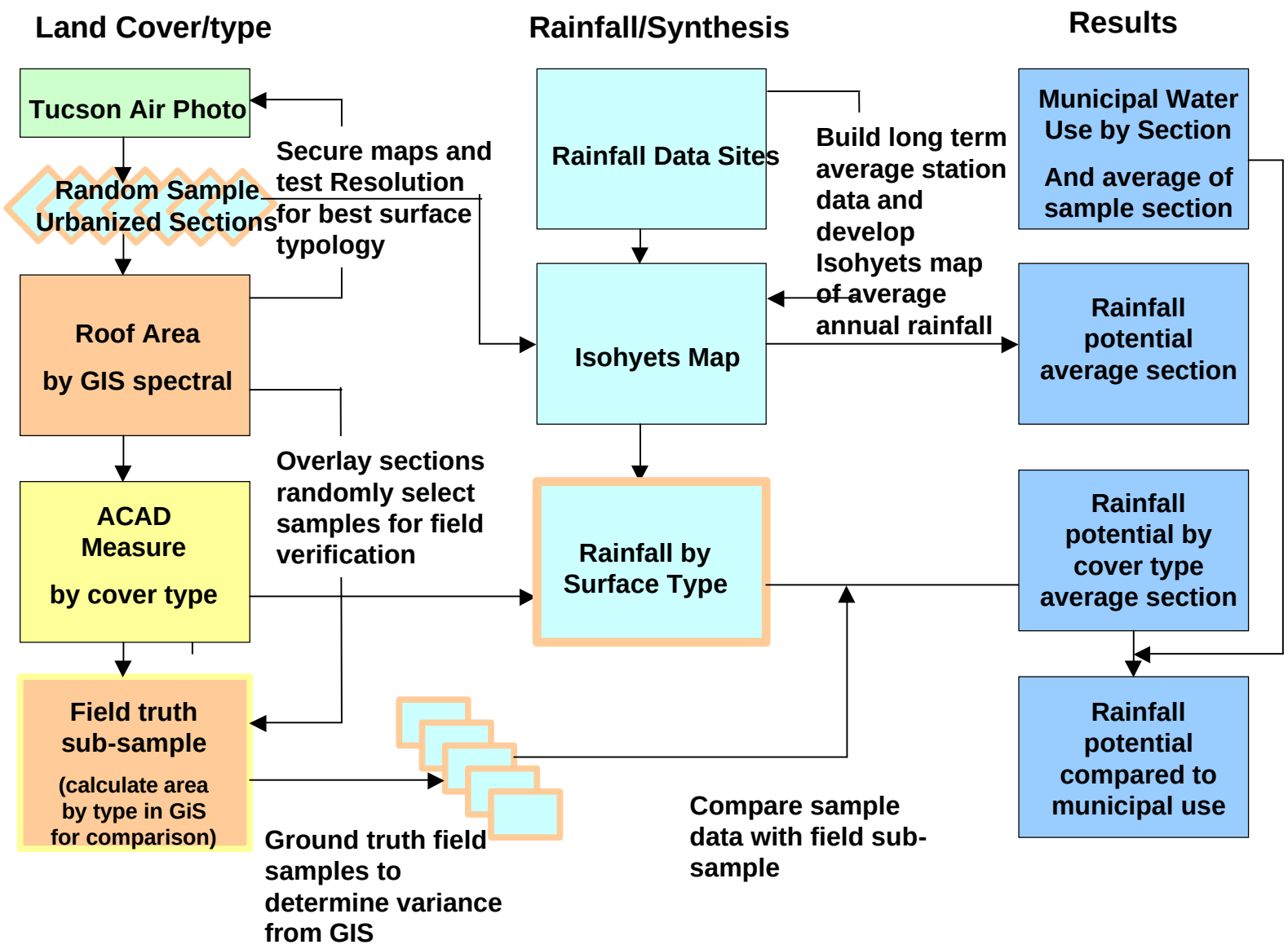
Research Objectives

- Determine annual rainfall on distinct land cover types in Tucson
- Evaluate potential impact that large scale rainfall harvesting could have in offsetting demand from water providers
- Explore potential of rainwater use for three categories of municipal water use
  - Landscape
  - Non-potable household use
  - Potable use

Methods

- Rainfall Data
  - Collect, Analyze and Map using GIS
- Rooftop Data (Sample Sections)
  - Spectral Analysis using GIS/Aerial photography
  - Field truth and error assessment
- Paving and Barren Data (Sample Section)
  - Delineation and mapping in CAD
  - Field truth and surface determination
- Landscape Data (Sample Section)
  - Calculated by L = T - (R+P+B)
- Water use from Water Utility (available by Section)
- Analysis and Comparison
- Evaluation of Potential (strategies and technologies)

RAINFALL QUANTITY ASSESSMENT METHODOLOGY



Rainfall Record

Central Tucson sites (varies by period)

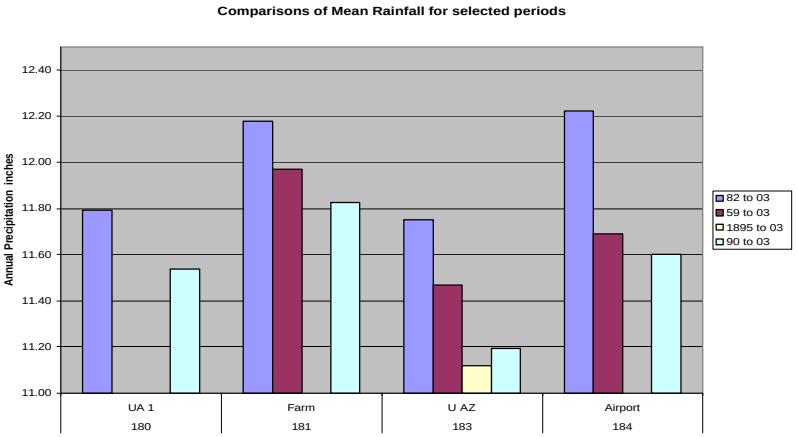
- 11.12 – 11.99 inches annually

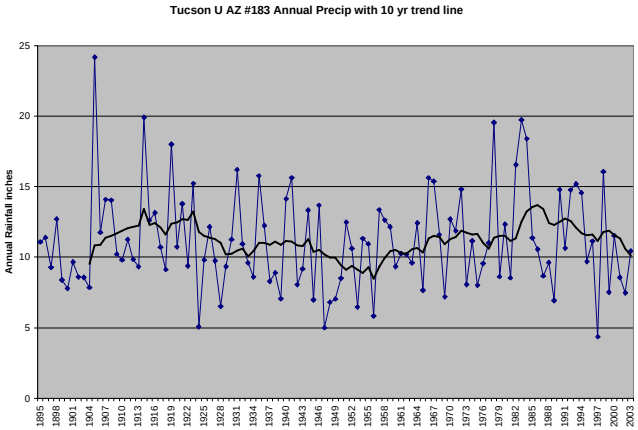
Cooperative observer sites (1990 - 2003)

- Average 12.93 inches annually
- Used for Isohyet rainfall map and rooftops

Rainfall associated with land cover

- Used 12.00 inches annually (rule of thumb)





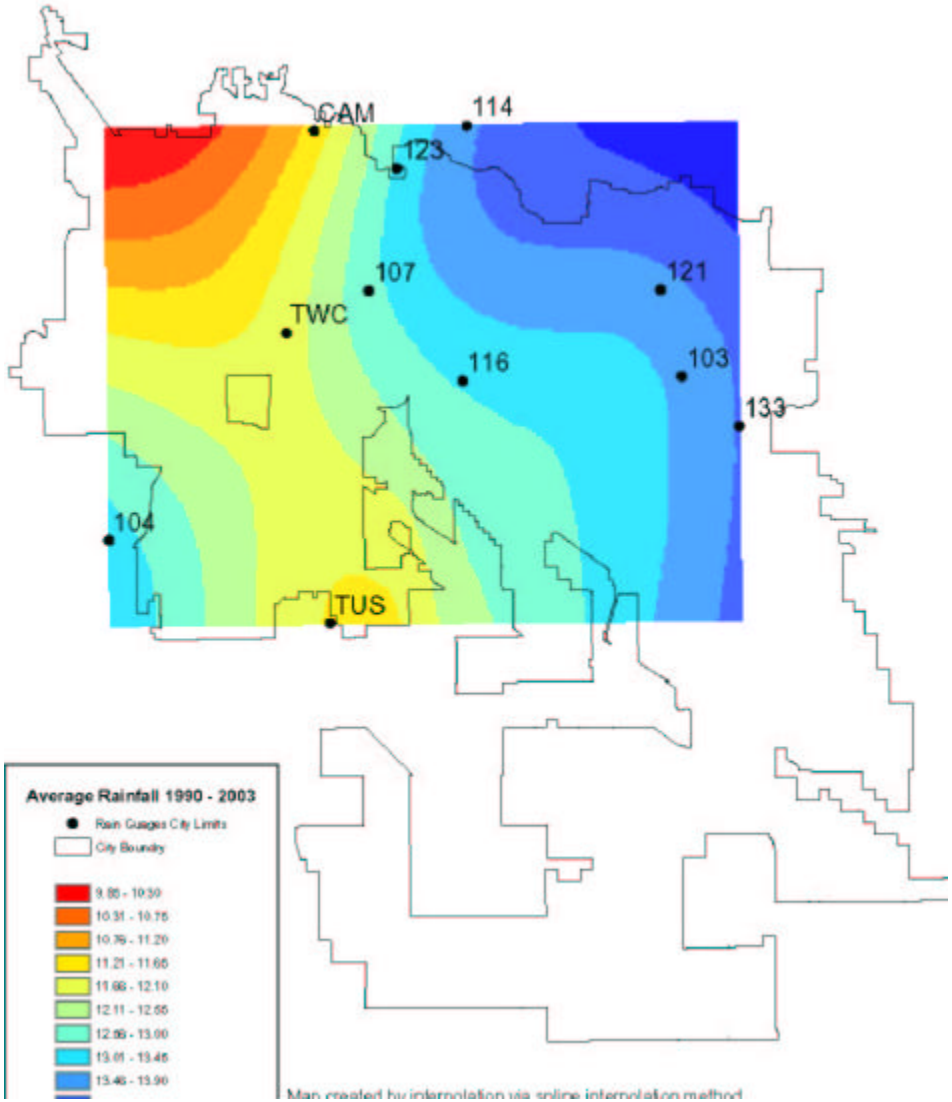


Fig. 3-1 – Rainfall isohyets and station location, Tucson 1990-2003 data

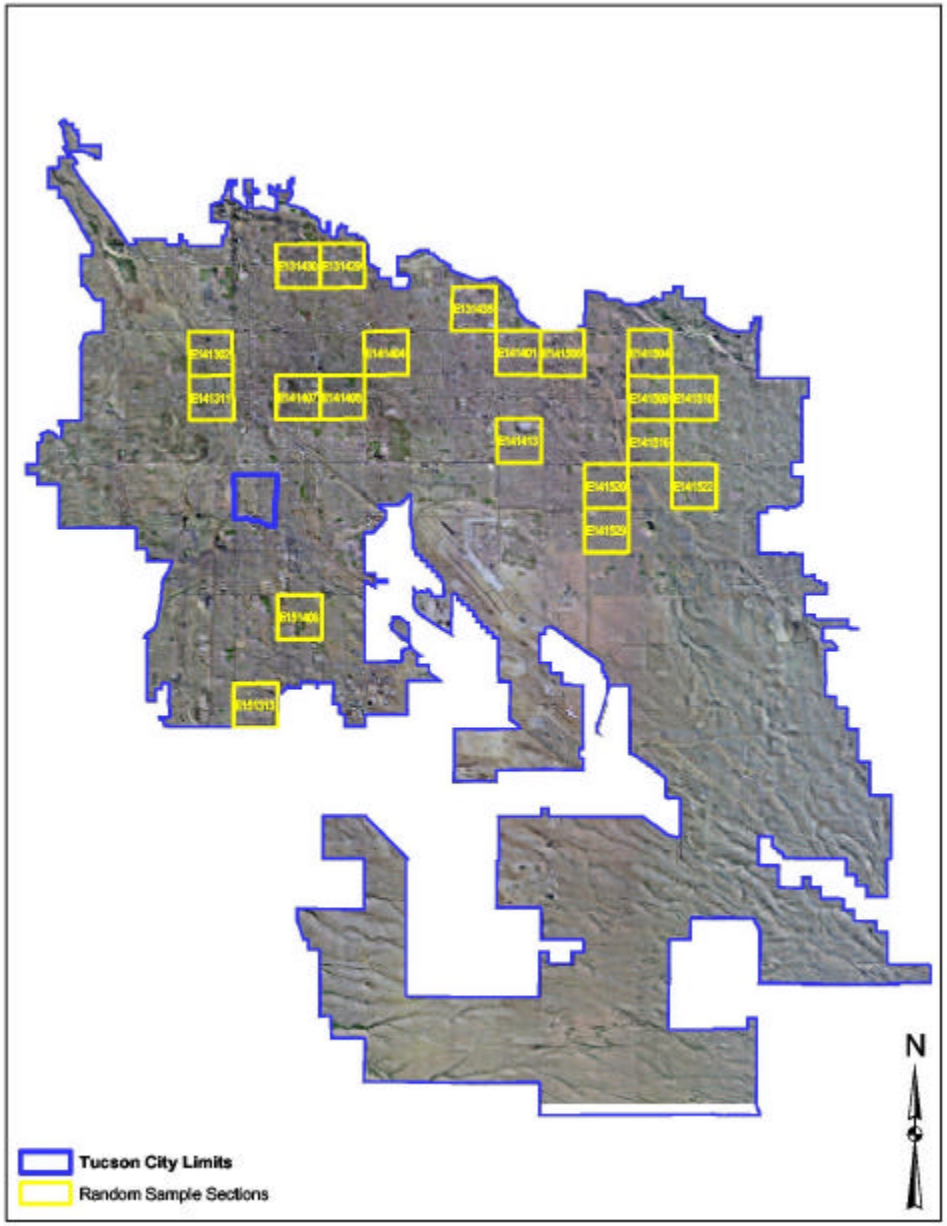
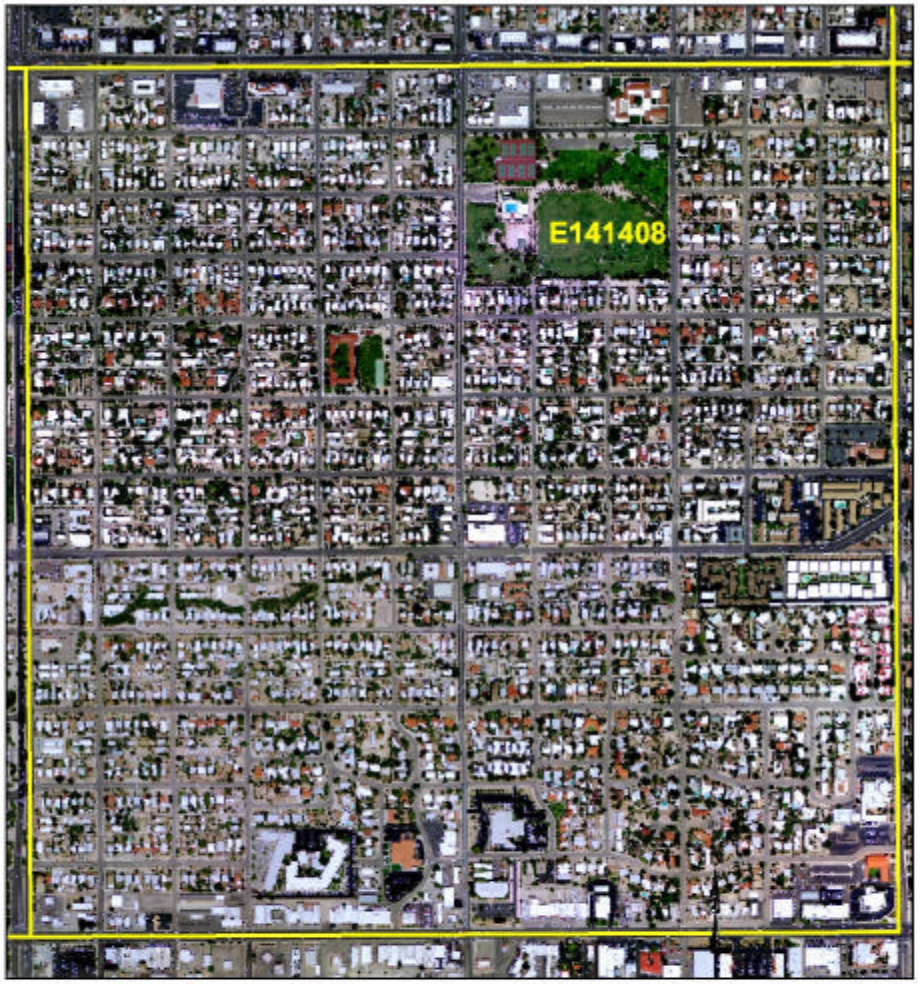


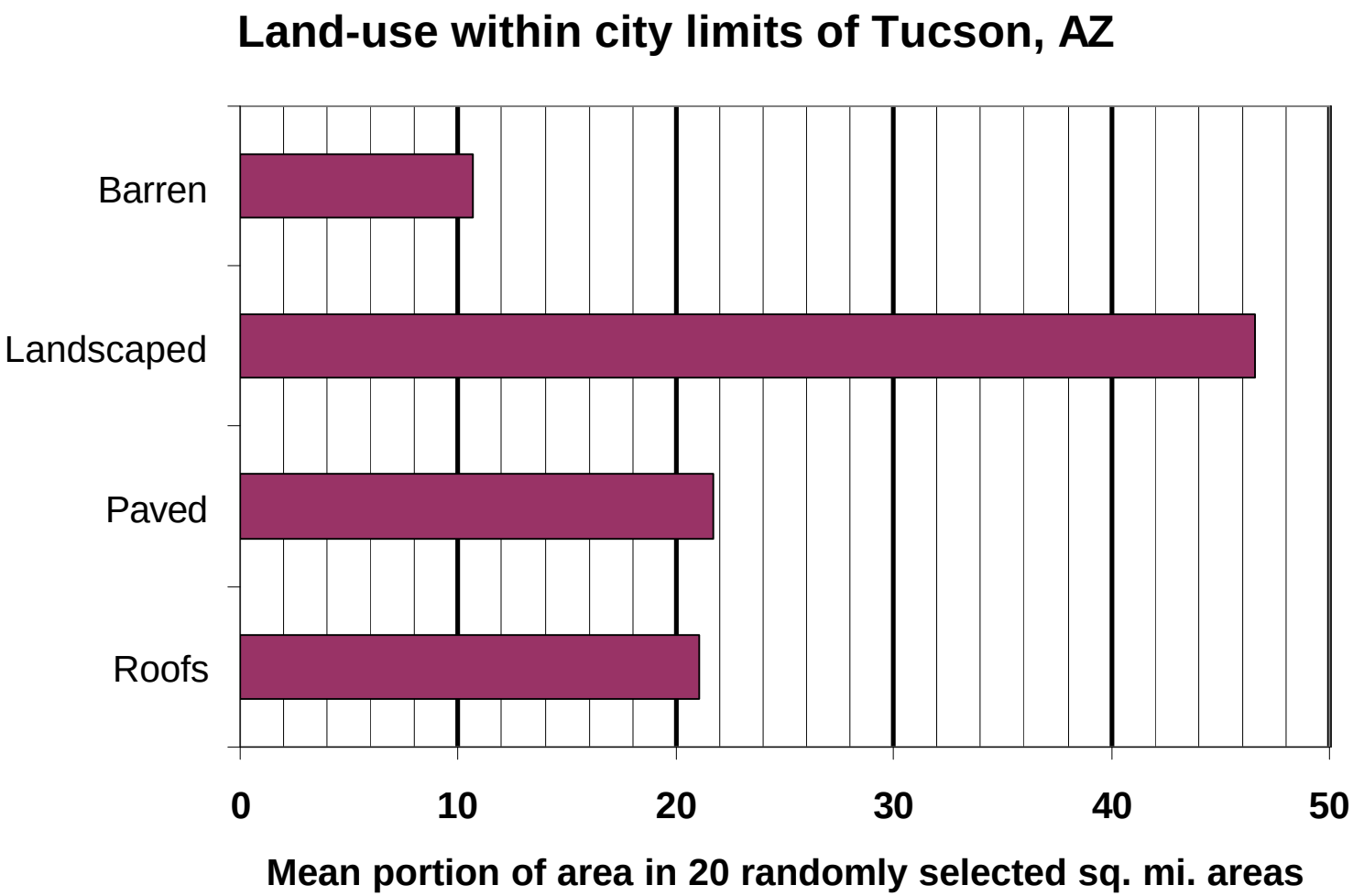
Fig. 3.2 – Tucson map with selected sections



Close up view of Section E141408 showing typical blend of roof types

Random Sample Sections

Tucson City Limits


Land-use within city limits of Tucson, AZ
Barren
Landscaped
Paved
Roofs
0
10
20
30
40
50
Mean portion of area in 20 randomly selected sq. mi. areas

Results (sampled urbanized sections)

- Average water use per section
  873 AFY (38.028 MMCF/Yr)
- Average rainfall per section
  644 AFY (28.053 MMCF/Yr)
- Rainfall volume as a percentage of water use = 74%

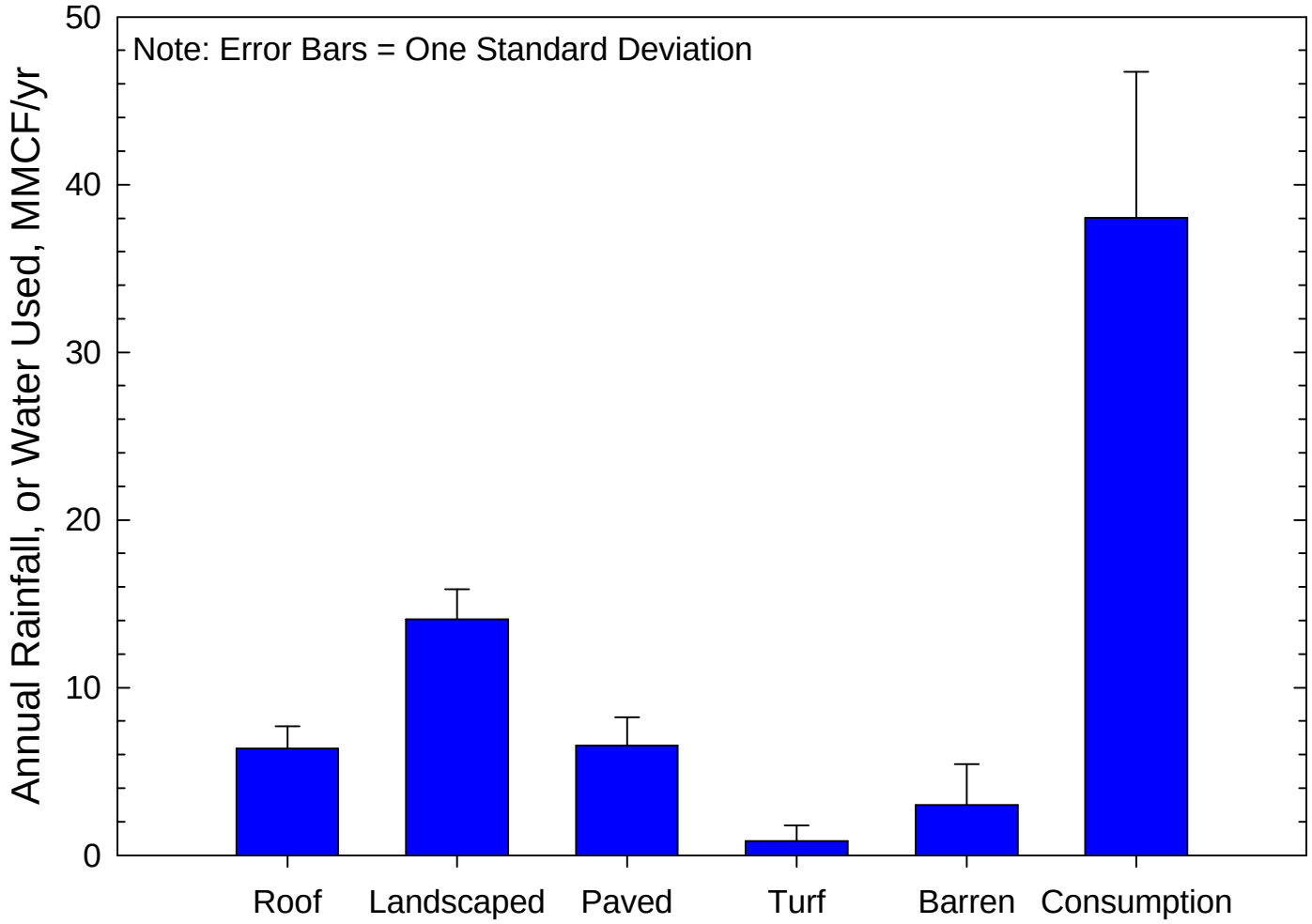
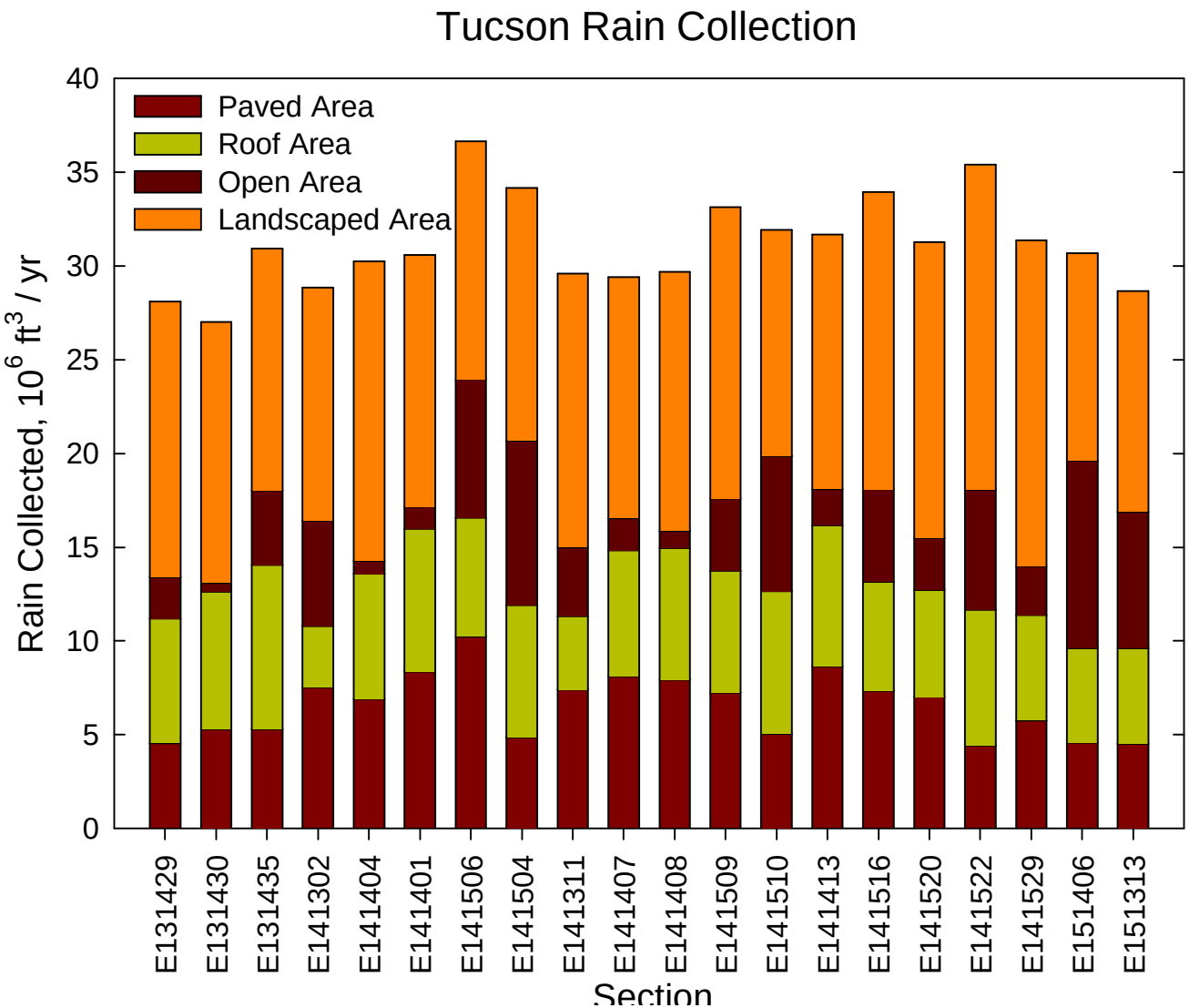
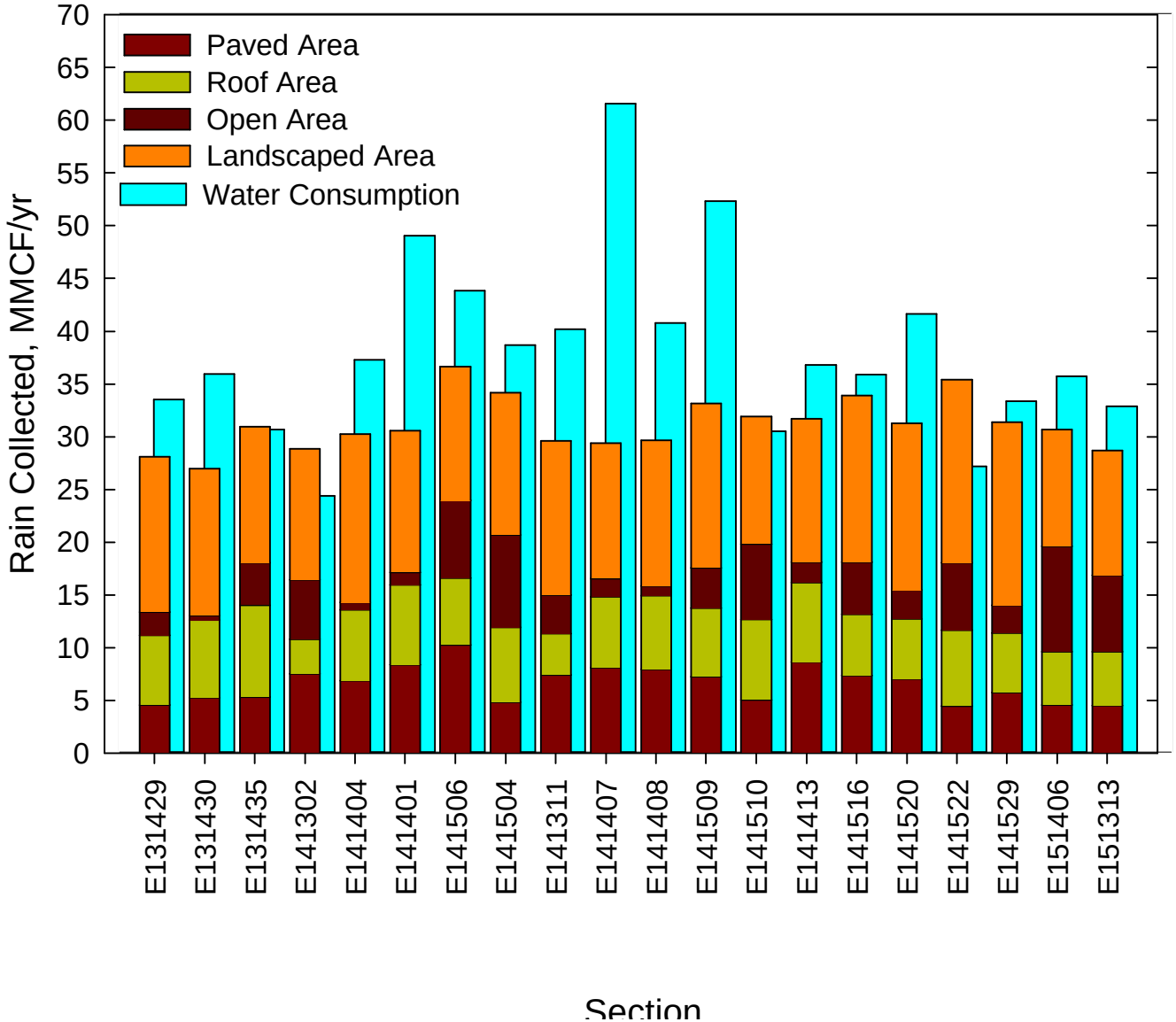


Fig. 3.3 – Average annual rainwater harvesting potential by landscape type.


Tucson Rain Collection
Paved Area
Roof Area
Open Area
Landscaped Area
Rain Collected, 10^6 ft^3 / yr
0
5
10
15
20
25
30
35
40
E131429
E131430
E131435
E141302
E141404
E141401
E141506
E141504
E141311
E141407
E141408
E141509
E141510
E141413
E141516
E141520
E141522
E141529
E151406
E151313
Section

Tucson Rainwater Harvesting



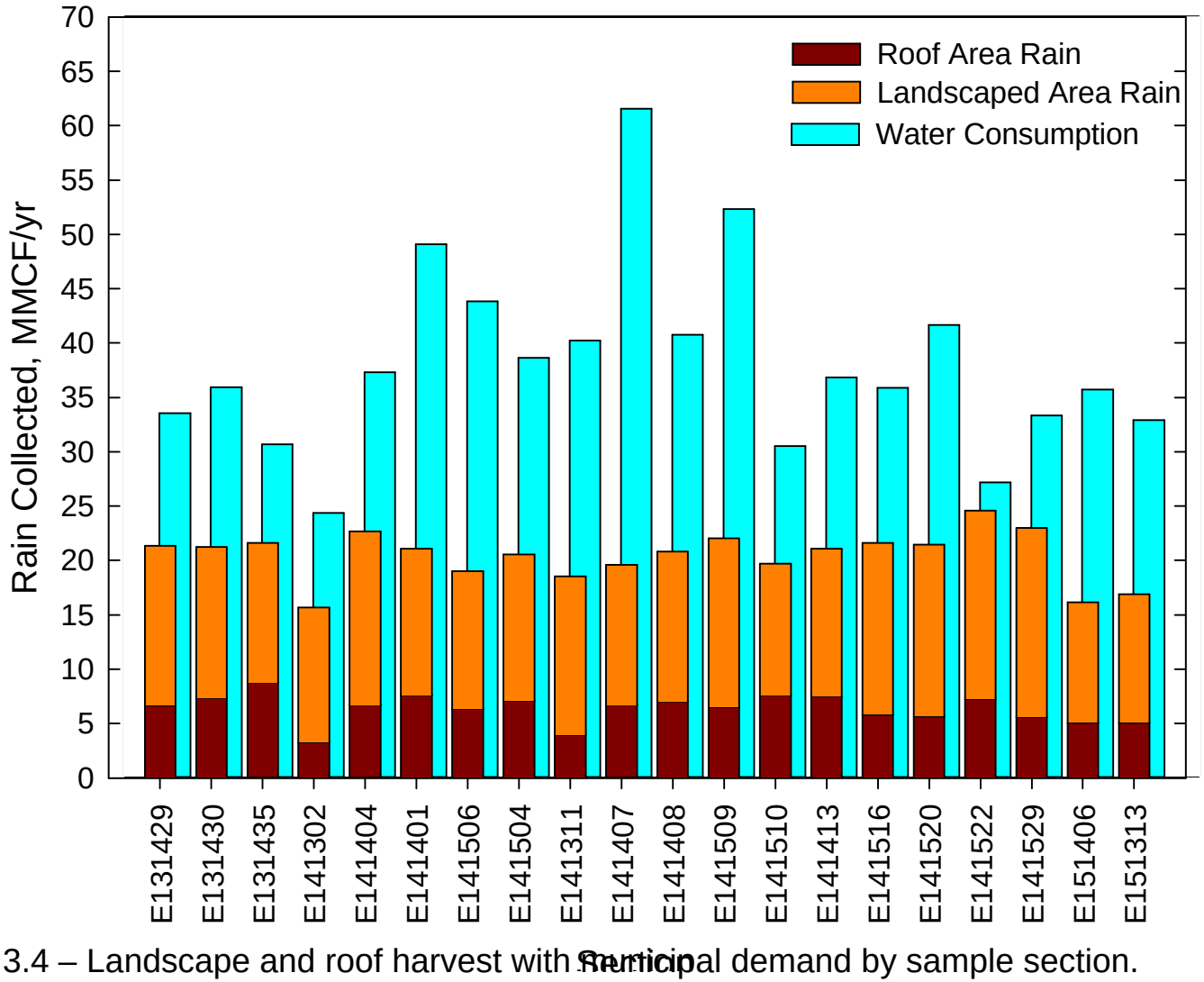
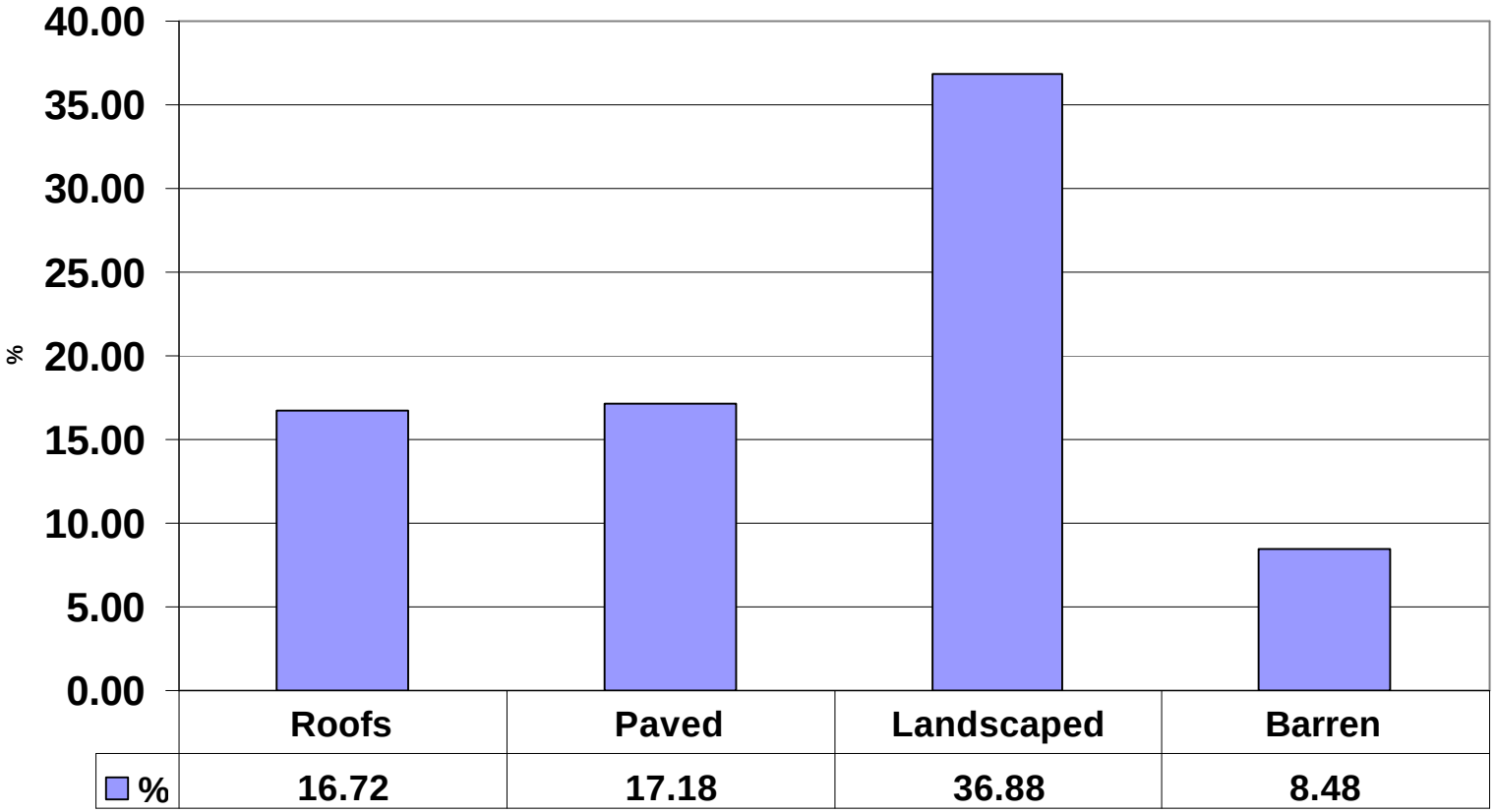


Fig. 3.4 – Landscape and roof harvest with municipal demand by sample section.

Rainfall on Surfaces as Portion of Potable Water Delivered to 20 Selected Sq. Miles in Tucson, AZ



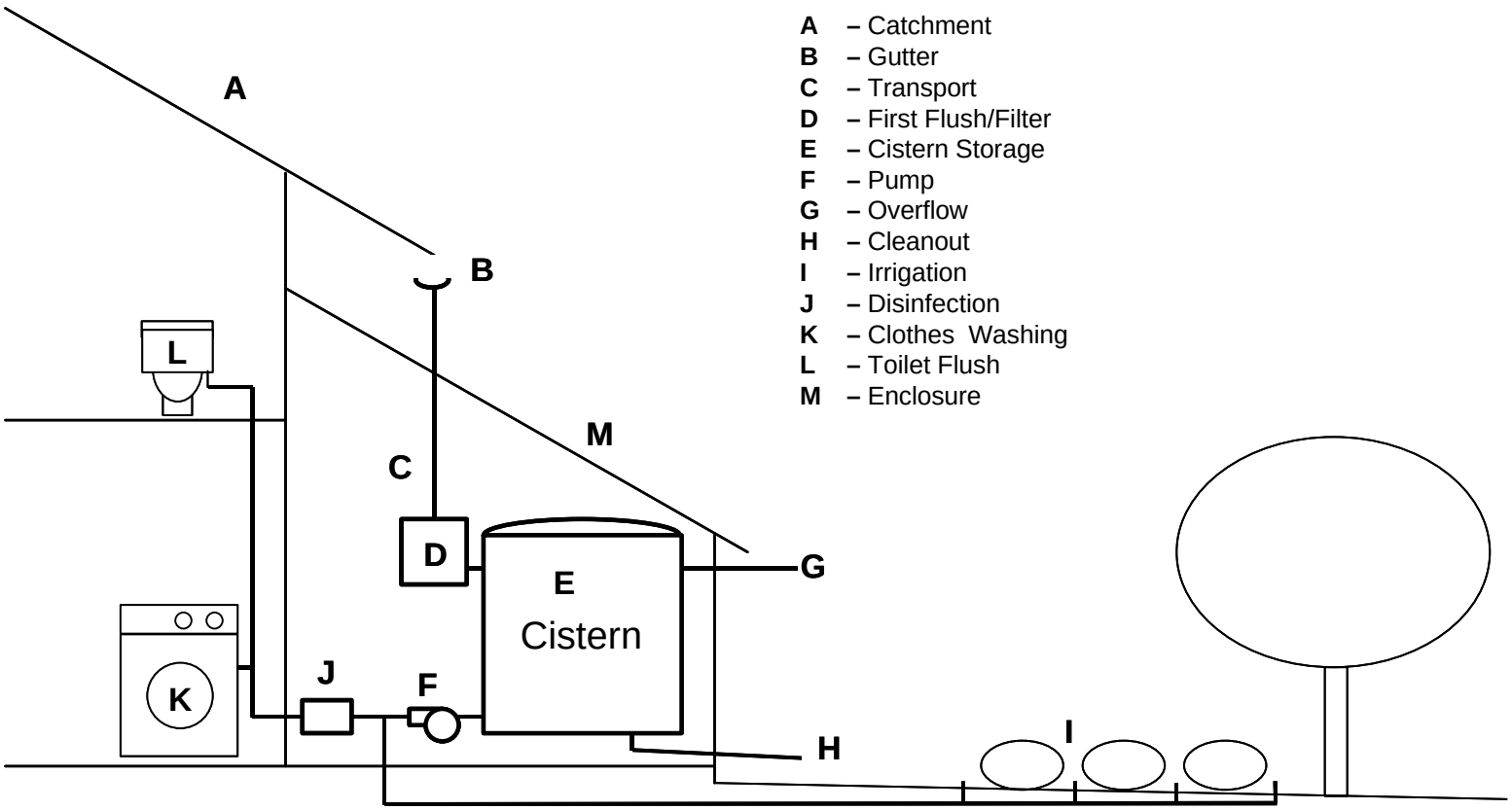
Conclusion

- Rainwater could provide for a substantial reduction in outdoor water use.
- Rainwater is suitable in both quantity and quality for both outdoor use and non potable indoor use with:
  - Supporting systems and technology,
  - Onsite retention and landscape strategies,
  - Climate appropriate landscape planting.
- Rainwater should be recognized as an essential part of the limited water resource mix for the arid Southwest.
- Rainwater management is easier at the top of the water shed.

Challenges

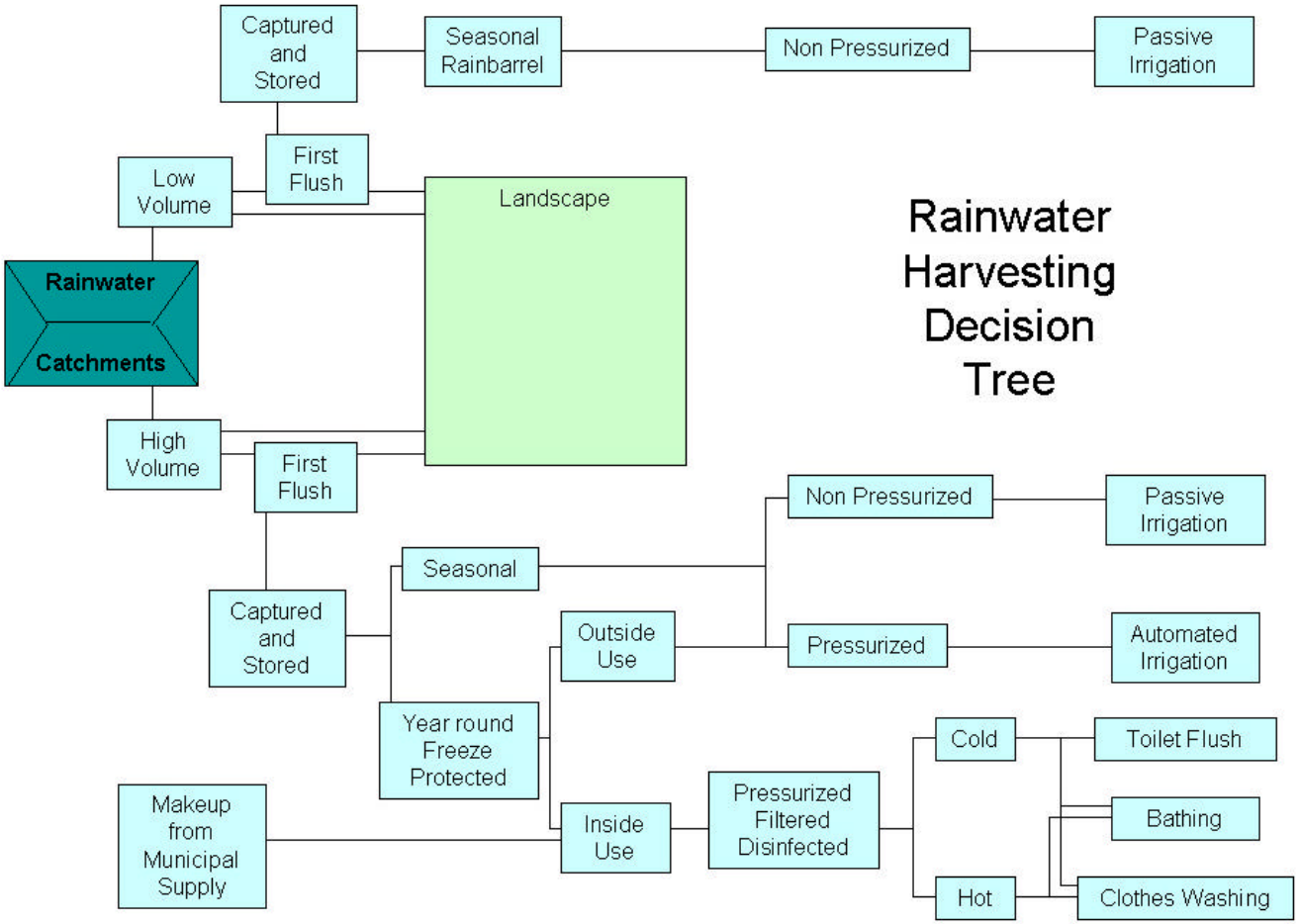
- Water policy
  - Downstream use mandates?
  - Subtracting calculated contribution to the regional water balance?
- Technology and systems
  - How to change traditional civil design practices?
  - Best ways to use rainwater to offset municipal demand?
- Geography and climate
  - Can rainwater availability be matched to demand?
- Safety
  - Is rainwater safe for the designated use?
- Adoption
  - Mandated
  - Promotion and incentive

Rainwater Harvesting System



A – Catchment
B – Gutter
C – Transport
D – First Flush/Filter
E – Cistern Storage
F – Pump
G – Overflow
H – Cleanout
I – Irrigation
J – Disinfection
K – Clothes Washing
L – Toilet Flush
M – Enclosure

System Option Analysis



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Thank You