

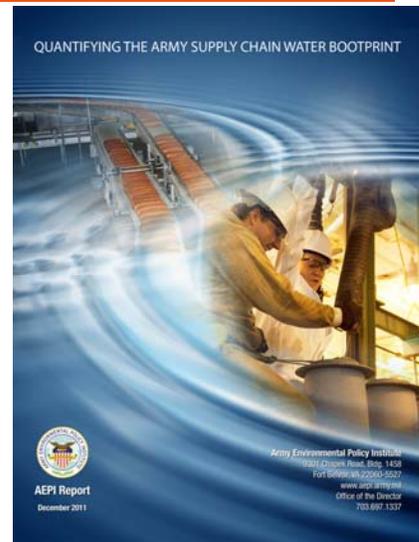
# Army Water Footprint Study

Francis Reilly, Chris Werle, LMI  
Marc Kodack, US Army

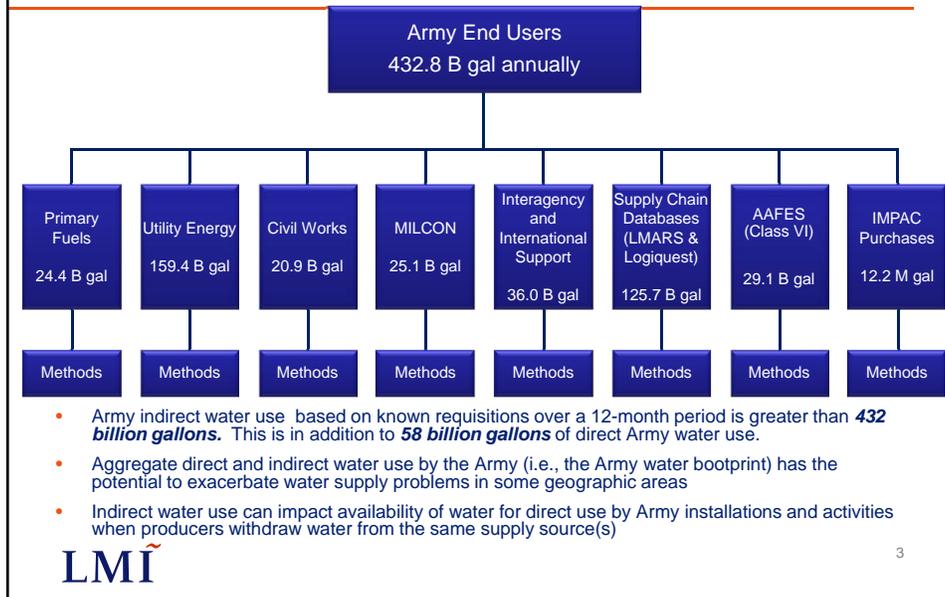


## Purpose

- The purpose of this study is to provide an initial quantitative estimate of the amount of water embedded in the goods and services the Army procures through the supply chain
- [www.AEPI.Army.mil](http://www.AEPI.Army.mil)



## Bottom Line Up Front



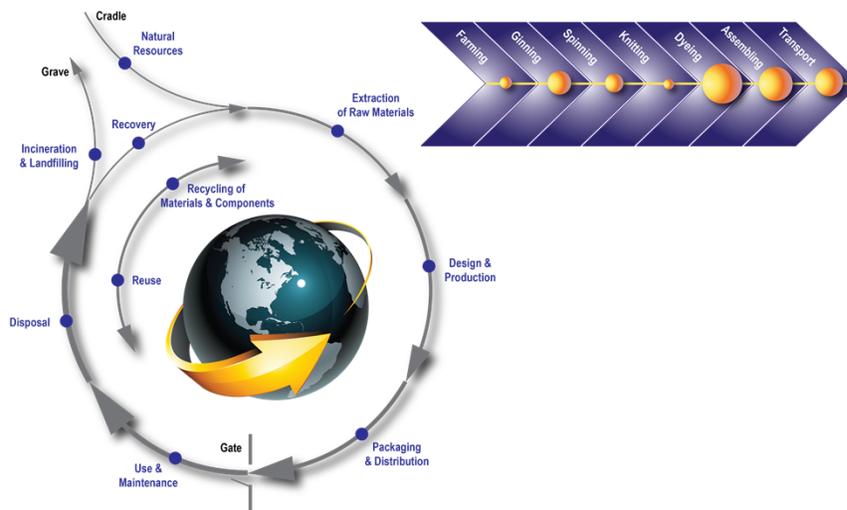
## Study Objectives

- Identify the components and suppliers of the Army supply chain
- Quantify how much water is needed to produce the goods and services the Army procures through the supply chain
- Consult with other organizations who have created, maintained, and actively monitor a sustainable supply chain
- Identify recommendations to incorporate study findings into the annual Army Sustainability Report
- Develop recommendations for Army policy, guidance, and strategic investments

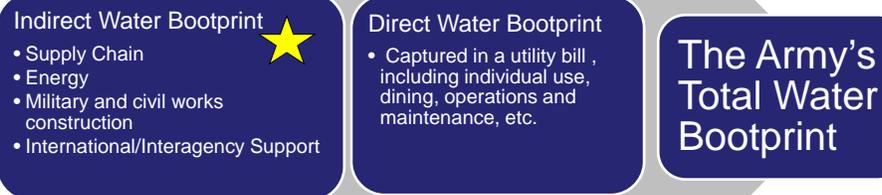
## What is the Army Water Footprint?

- An indicator of water use
  - Direct (operational) water use not considered
  - Indirect (supply chain) water use is “embedded”
- The water footprint is the volume of water used to produce one unit or piece
- The Army Footprint is the sum of the water footprints of all the products it procures

## Life Cycle Analysis



## Army Total Water Footprint



This study calculates the indirect water use

**LMI**

7

## Methods

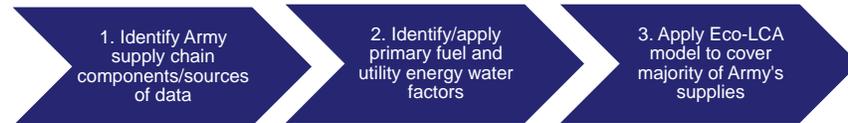
- Identify readily accessible supply chain components and data sources that contribute to the Army's water footprint and sources of this data
- Identify and apply primary fuel and purchased utility energy water factors to the known quantities procured
- Apply the Eco-LCA model to cover the remainder of the Army's supply chain purchases

**LMI**

8

## Steps of the Methodology

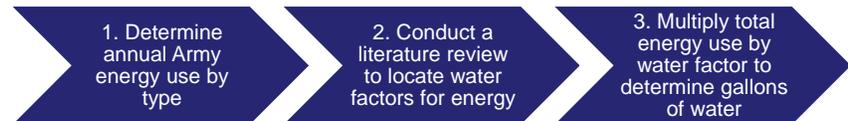
### GENERAL



### Eco-LCA – Input/Output Model Application



### Energy water factors method



LMI

9

## Data Sources

- Wholesale and retail procurement databases covering multiple classes of supply
  - Logistics Metrics Analysis Reporting System
  - LogiQuest
- IMPAC Card purchase records
- Army and Air Force Exchange Service (AAFES) sales records
- Civil Works Program and Military Construction expenditures
- Interagency and International Support expenditures
- Army Greenhouse Gas and Sustainability Data Report
  - Primary Fuel Consumption
  - Utility Energy Purchases

LMI

10

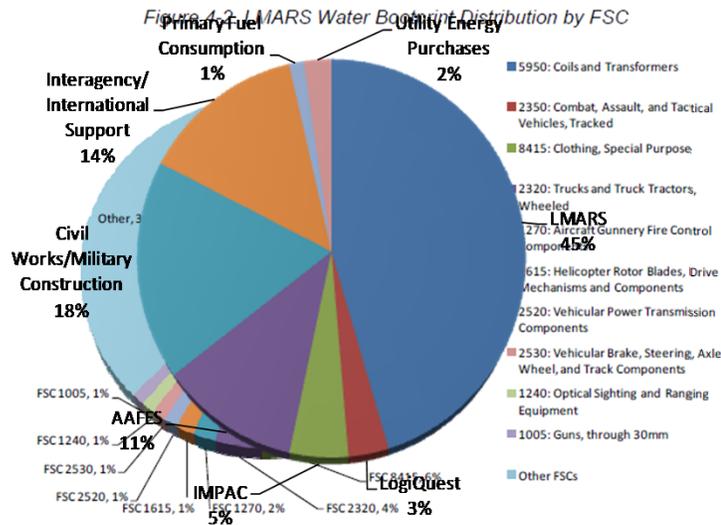
## Estimated Army 12-Month Indirect Water Footprint

Data Sources	12-Month Cost (\$M)	12-Month Water Footprint (M gallons)	Gallons/\$
Logistics Metrics Analysis Reporting System (LMARS) <sup>a</sup>	\$18,945	117,319	6.19
LogiQuest Database <sup>a</sup>	\$1,443	8,367	5.80
International Merchant Purchase Authorization Card (IMPAC) <sup>b</sup>	\$3,788	12,175	3.21
Army and Air Force Exchange Service (AAFES) <sup>c</sup>	\$3,835	29,078	7.58
Civil Works/Military Construction <sup>a</sup>	\$12,444	46,041	3.70
Interagency/International Support <sup>a</sup>	\$10,021	36,003	3.59
Primary fuel consumption <sup>a</sup>	\$2,060	24,407	11.85
Utility energy purchases <sup>a</sup>	\$734.8	159,421	216.96
<b>TOTAL</b>	<b>53,274</b>	<b>432,812</b>	<b>8.12</b>

Notes: The cost presented in this table are in nominal dollars, and not adjusted to 1997 dollars, which was required to estimate the gallons of water.  
<sup>a</sup>Represents FY10 data.  
<sup>b</sup>Represents three quarters of FY10 data with extrapolation to a full year  
<sup>c</sup>Represents CY10 data; CY10 data, does not include gasoline sales, which are included under primary fuel consumption.  
<sup>d</sup>Represents the average of FY08 and FY10 data for petroleum based fuels, natural gas, and ethanol.  
<sup>e</sup>Represents the average of FY08 and FY10 data for purchased electricity; based on purchase of 10,790,558 MWh at an average cost of \$68.10/MWh (per EIA Monthly Energy Review, May 2012, Table 9.9, Average Industrial Retail Prices of Electricity, 2009) .



## The model revealed interesting use patterns



## Conclusions

---

- Army indirect water use based on known requisitions over a 12-month period is greater than **432 billion gallons**
- Aggregate direct and indirect water use by the Army (i.e., the Army water footprint) is **over 490 billion gallons** and has the potential to exacerbate local water supply problems
- Indirect water use can impact availability of water for direct use by Army installations and activities when producers withdraw water from the same supply source(s)



13

## Recommendations

---

- Operational
- Policy
- Procurement



14

## Recommendations

---

### Operational

- Conduct a more detailed analysis of the largest suppliers and their water sources.
- Identify critical supply chain products and services that are also large water users
- Identify time-sensitive products and services that may be delayed by water restrictions
- Develop a strategy to identify suppliers of critical products and services at risk of production curtailment when water shortages occur and provide a reliable alternative



15

## Recommendations (cont.)

---

### Policy

- Incorporate producer water use requirements and risk into Army policies and procedures
- Identify installations dependent on water-intensive energy sources in areas of potential water scarcity
- Ensure that life cycle cost estimates include an evaluation of water use requirements, availability, and potential risks
- Include a section in future ASRs highlighting the Army's progress in quantifying the supply chain water footprint



16

## Recommendations (cont.)

### Procurement

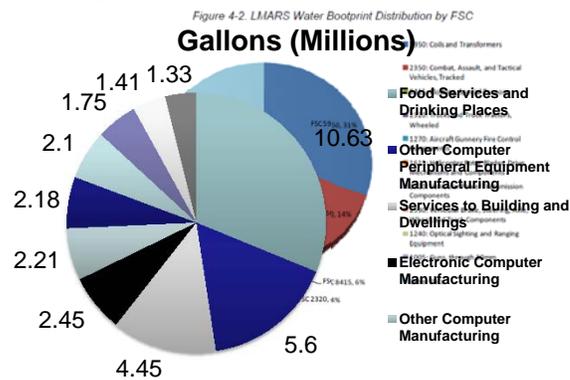
- Evaluate the feasibility of revising supply chain-related contracting procedures to include water use requirements for Army suppliers



17

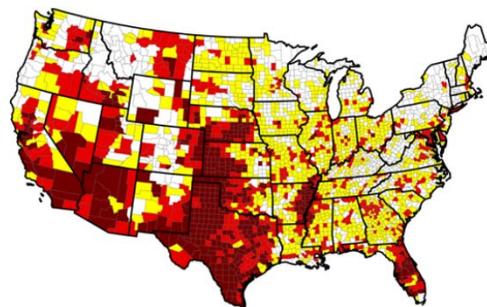
## What's Next?

- Drill Down
- Develop ways to fathom vulnerability
- Develop a low cost entry level tool



## Next Steps – Drill Down?

- Continue to assess Army direct and indirect water use:
  - Refine Army indirect water use measurements
  - Review trends in Army indirect water use
  - Map Army water use particularly where supplies are generated from areas predicted to be at risk for water sustainability
  - Refine Army direct water use measurements
  - Combine data from Army direct (operational) water use and indirect water use to obtain a comprehensive water footprint



19

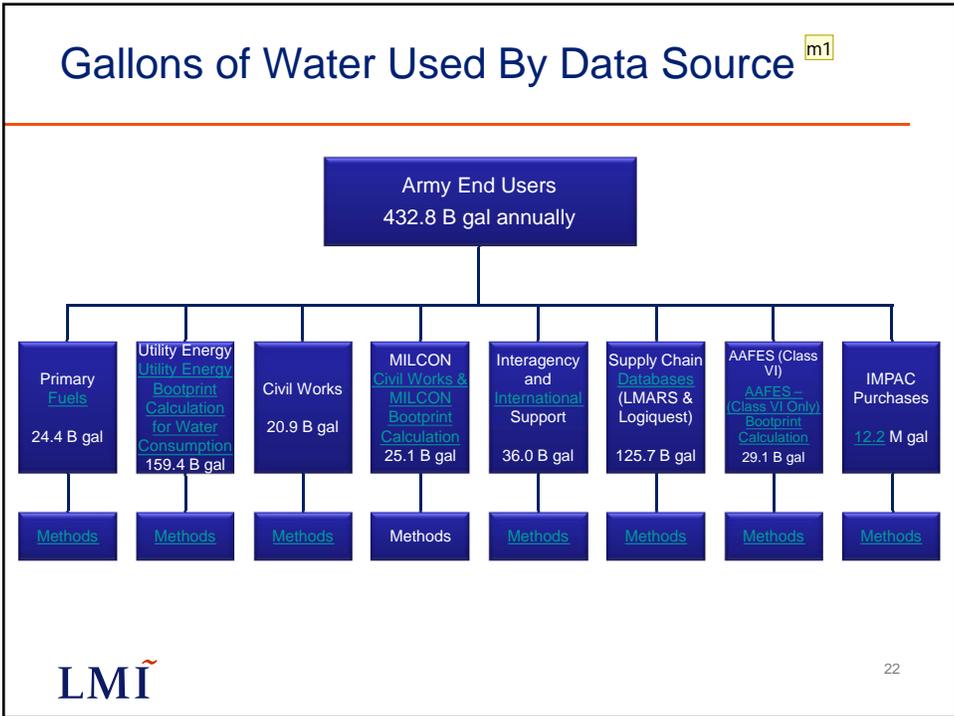
## Army Water Footprint Final Report Summary

Questions?



# Army Water Footprint Final Report Summary

Back-up Slides



## Slide 22

---

**m1** How is this slide different from slide 3, except it doesn't contain the text below?  
mcanes, 6/5/2012

## Primary Fuels Comparison Methodology

- Estimate water *consumption* using fuel data reported in the Army's GHG inventory
- Focus on bulk fuel purchases of petroleum-based fuels, ethanol, biodiesel, coal, natural gas, and propane
- Use water consumption factors derived from scientific literature to estimate a water footprint for fuels delivered to base
  - This includes supply chain from extraction and production through delivery
- Compare water consumption estimates to withdrawal estimates from other modeling techniques (e.g. Eco-LCA)



Army End Users

## Comparison of Water Withdrawal and Consumption for Army Energy Purchases

	Withdrawal - Eco-LCA Model (million gallons)	Consumption - Literature Factors (million gallons)
Primary Fuel Consumption	24,407	3,267
Utility Energy Purchases	159,421	6,109
<b>Total</b>	<b>183,828</b>	<b>9,376</b>



Army End Users

## Primary Fuels Bootprint Calculation for Water Consumption

Primary Fuels Annual Water Consumption	
Fuel Type	Gallons of Water (Billions)
Gasoline	1.390
Jet Fuel/Aviation Gas	0.470
LPG/Propane	0.0003
Diesel	0.401
Fuel Oil	0.087
LPG (electricity)	0.006
Residual Oils	0.025
Biodiesel	0.694
Ethanol	0.112
Coal	0.015
Natural Gas	0.067
<b>Total</b>	<b>3.267</b>

LMI

Army End Users

## Utility Energy Water Consumption Methodology

- Water consumed in the generation of electricity that is produced off-post and purchased by the Army
- Estimates generated by multiplying energy purchased by water consumption factors derived from scientific literature, which consider:
  - Mining, extraction, beneficiation, production, and transportation of raw fuels used to generate electricity and steam
  - Water consumed while producing electricity (e.g., cooling water, make-up water, flue gas desulfurization)

LMI

Army End Users

## Utility Energy Footprint Calculation for Water Consumption

Utility Energy- Purchase of Electricity & Steam	
Fuel Type	Gallons of Water (Billions)
Coal Electric	1.337
Oil Electric	0.107
Natural Gas Electric	0.188
Nuclear Electric	0.753
Hydroelectric	3.269
Biomass (WTE)	0.432
Wind	0.000
Solar	0.003
Geothermal Electric	0.008
Other Fossil Fuel Electric	0.011
Other Unknown	0.002
<b>Total</b>	<b>6.110</b>

LMI

Army  
End  
Users

## Civil Works & MILCON Methods

- Obtain from HQ, USACE total amount spent in FY10 on Civil Works & MILCON construction
- Align various construction categories to appropriate Eco-LCA model economic market sectors
- Adjust expenditures to 1997 economy using CPI conversion factors
- Multiply adjusted expenditures in each construction category by applicable water use factor/\$1M to determine total water footprint

LMI

Army End Users

## Civil Works & MILCON Bootprint Calculation

Civil Works Component	FY10 Funded (\$M)	CPI Conversion Factor <sup>a</sup>	FY10 Expenditures (\$M) (Adjusted)	Water Use (L/\$1M)	Water Use (Gal/\$1M)	Total Water Use (Billion Gal)
Construction <sup>b</sup>	\$ 2,028	0.74	\$1,501	18,378,103	4,854,981	7.287
Operation and Maintenance <sup>b</sup>	\$ 2,400	0.74	\$1,776	18,378,103	4,854,981	8.622
Investigations <sup>c</sup>	\$ 162	0.74	\$ 120	10,728,093	2,834,062	0.340
Mississippi River & Tributaries <sup>d</sup>	\$ 340	0.74	\$ 252	20,769,003	5,486,590	1.383
Regulatory Program <sup>e</sup>	\$ 190	0.74	\$ 141	38,689,146	10,220,591	1.441
Expenses <sup>b</sup>	\$ 185	0.74	\$ 137	18,378,103	4,854,981	0.665
Office of the ASA(CW) <sup>f</sup>	\$ 5	0.74	\$ 4	9,469,558	2,501,593	0.010
FUSRAP <sup>g</sup>	\$ 134	0.74	\$ 99	43,738,844	11,554,580	1.144
MILCON <sup>b</sup>	\$ 7,000	0.74	\$ 5,180	18,378,103	4,854,981	25.149
<b>CIVIL WORKS TOTALS</b>	<b>\$5,444</b>	<b>N/A</b>	<b>\$4,030</b>	<b>N/A</b>	<b>N/A</b>	<b>20.892 billion</b>
<b>MILCON TOTALS</b>	<b>\$ 7,000</b>	<b>0.74</b>	<b>\$ 5,180</b>	<b>18,378,103</b>	<b>4,854,981</b>	<b>25.149 billion</b>
Civil Works / MILCON Water Bootprint (Gal)	46.041 Billion	Or 69,759 Olympic sized swimming pools				

Civil Works Source: FedSources Analysis, 15 Nov 2010, based on OMB FY11 Budget of the US Government, 1 Feb 2010.

Notes: a: = 161.3/218.1

b: Model sector = Other New Construction

c: Model sector = Architectural and Engineering Services

d: Model sector = Water, Sewer, and Pipeline Construction

e: Model sector = Other Federal Government Enterprises

f: Model sector = Office Administrative Services

g: Model sector = Waste Management and Remediation Services

MILCON Source: US Army Corps of Engineers, Directorate of Military Programs, MILCON overview as of 31 Aug 2010

**LMI**

Army  
End  
Users

## Interagency & International Support Methods

- Obtain from HQ, USACE total amount spent in FY10 on I&IS construction and other services
- Align various construction categories to appropriate Eco-LCA model economic market sectors
- Adjust expenditures to 1997 economy using CPI factors
- Multiply adjusted expenditures in each construction category by applicable water use factor/\$1M to determine total water footprint

**LMI**

Army End Users

## Interagency & International Support Footprint Calculation

IIS Program Component	FY10 Funded (\$M)	CPI Conversion Factor <sup>a</sup>	FY10 Funded (\$M) (Adjusted)	Water Use (L/\$1M)	Water Use (Gal/\$1M)	Total Water Use (Billion Gal)
Interagency Support <sup>b</sup>	\$ 2,014	0.74	\$1,490.0	18,378,103	4,854,981	7.234
International Support, Europe, South America, Pacific, and Middle East <sup>b</sup>	\$ 7,006	0.74	\$5,184.0	18,378,103	4,854,981	25.168
International Support, Foreign Military Sales <sup>b</sup>	\$ 940	0.74	\$ 696.0	18,378,103	4,854,981	3.379
Cooperative Threat Reduction <sup>b</sup>	\$ 59	0.74	\$ 44.0	18,378,103	4,854,981	0.214
Civil-Military Emergency Preparedness <sup>c</sup>	\$ 2	0.74	\$ 1.5	20,769,003	5,486,590	0.008
<b>TOTALS</b>	<b>\$10,021</b>	<b>N/A</b>	<b>\$7,415.5</b>	<b>N/A</b>	<b>N/A</b>	<b>36.003</b>
<b>Water Footprint (Gal)</b>	<b>36.003 Billion</b>	Or 54,550 Olympic Sized Swimming pools worth of water				

Source: HQ USACE Website "USACE Support for Other PGMS – FY10 Expenditures".  
<http://www.usace.army.mil/Search/results.aspx?k=USACE%20support%20for%20other%20PGMS%20-%20FY10%20expenditures>

Notes:  
 a: =161.3/218.1  
 b: Model sector = Other Construction  
 c: Model sector = Social Assistance



Army End Users

## Supply Chain Databases – LMARS & Logiquest Methods

- Obtained FY2002 – 2010 data from Logistics Metrics Analysis Reporting System (LMARS) and Logiquest
- Align (LMARS & Logiquest) records (at the FSC level and where required to the NIIN level) to appropriate Eco-LCA model economic market sectors
- Adjust expenditures to 1997 economy using CPI conversion factors
- Multiply adjusted expenditures in each construction category by applicable water use factor/\$1M to determine total water footprint



Army End Users

## Supply Chain Databases Bootprint Calculation

LMARS	
Fiscal Year	Total Gallons of Water (Billions) - Adjusted for CPI (1997)
2003	76.0
2004	85.6
2005	90.6
2006	88.0
2007	88.9
2008	85.0
2009	81.5
2010	117.3

Logiquest	
Fiscal Year	Total Gallons of Water (Billions) - Adjusted for CPI (1997)
2003	51.8
2004	27.0
2005	48.0
2006	26.6
2007	25.0
2008	29.4
2009	48.7
2010	8.4



[Army End Users](#)

## AAFES – (Class VI Only) Methods

- Obtain from AAFES total amount spent in FY10 on gasoline, other retail, food & beverages, and personal care items (overseas concessions etc.)
- Align categories to appropriate Eco-LCA model economic market sectors
- Adjust expenditures to 1997 economy using CPI conversion factors
- Multiply adjusted expenditures in each construction category by applicable water use factor/\$1M to determine total water footprint.



[Army End Users](#)

## AAFES – (Class VI Only) Footprint Calculation

Parameter	AAFES Sales Category/Eco-LCA Model Market Sector		
	Retail Less Gas/Retail Trade	Food & Beverages/ Food & Drinking Places	Concession/Personal Care Services
CY10 Retail Sales (\$M)	\$ 2,840.2	\$ 412.8	\$ 582.4
CPI Conversion Factor	0.811 <sup>b</sup>	0.723 <sup>c</sup>	0.793 <sup>d</sup>
CY10 Retail Sales (\$M) (Adj)	\$ 2,303.4	\$ 298.5	\$ 461.9
Water Use (Gal/\$1M)	7,536,079	28,462,191	6,982,491
Total Water Use (Gal)	17,358,347,953	8,494,683,147	3,225,073,088
Water Footprint (Gal)	29.078 Billion	Or 44,058 Olympic Sized Swimming pools worth of water	

Source:  
Michael J. Smietana, P.E.  
V.P. Support Division  
Real Estate Directorate  
Army & Air Force Exchange Service  
Data obtained 24 Feb 11.

Notes:  
a: =101.3/238.6  
b: =141.7/174.6  
c: =159.1/219.98  
d: =163.9/206.6



Army End Users

## IMPAC Purchases Methods

- Determine total amount Army spent in FY10 on IMPAC transactions from DoD GSA Smart Pay data
  - Using three quarters of FY10 data, extrapolate for FY10 Q4 to obtain 12 months of expenditures
- Align to appropriate Eco-LCA model economic market sector (sector = retail trade)
- Adjust expenditures to 1997 economy using CPI conversion factors
- Multiply adjusted expenditures by retail trade water use factor per \$1M to determine total water footprint



Army End Users

**IMPAC Purchase Card Program**  
**Army GPC Statistics – FY10 through 30 June 2010**  
**(Purchases extrapolated for 12 months of data)**

GPC Merchant Group	FY10 purchases (\$ million)	CPI	FY10 purchases (\$ million adjusted)	Water use (gallons/\$1 million)	Total water use (gallons)
Wholesale Trade	\$1,360.7	0.740	\$1,006.4	4,177,473	4,204,004,903
Business Expense	\$784.9	0.740	\$580.5	3,363,722	1,952,525,462
Other	\$387.5	0.740	\$286.6	3,982,538	1,141,336,912
Office Services	\$356.6	0.688	\$245.4	2,501,593	613,978,270
Building Services	\$215.3	0.688	\$148.2	2,501,593	370,682,208
Office Supplies	\$103.8	0.809	\$84.0	7,095,803	595,881,063
Hotels	\$102.0	0.729	\$74.3	9,264,382	688,784,227
Mail/Telephone	\$95.2	0.740	\$70.4	3,363,722	236,770,241
Medical	\$87.8	0.689	\$60.5	7,536,079	456,061,632
MRO Supplies	\$85.6	0.740	\$63.3	3,031,566	191,871,694
Vehicle Expense	\$66.3	0.425	\$28.1	11,659,569	327,950,318
Food and Beverages	\$56.8	0.723	\$41.1	28,462,191	1,168,841,365
Other Travel	\$28.1	0.742	\$20.9	3,308,965	69,049,551
Money	\$22.3	0.742	\$16.5	1,884,946	31,132,328
Auto/RV Dealers	\$15.2	1.044	\$15.9	3,467,184	55,016,978
Rental Cars	\$7.6	0.740	\$5.6	3,467,184	19,506,008
Landscaping/Horticultural Svcs	\$5.7	0.688	\$3.9	2,767,843	10,919,998
Retail Services	\$3.1	0.740	\$2.3	7,536,079	17,087,642
Veterinary Services	\$2.0	0.688	\$1.4	10,199,603	14,037,417
Agricultural COOP	\$0.8	0.688	\$0.6	8,307,757	4,573,489
Airline	\$0.7	0.742	\$0.5	10,371,951	5,128,812
<b>Totals</b>	<b>\$3,788</b>		<b>\$2,756.2</b>		<b>12,175,140,516</b>