Recycling Fresh Water in Semiconductor Manufacturing

(September 14th, 2016)

Luc Ouellet, Eng.
Vice President, Technology Development
Teledyne DALSA Semiconductor

Luc Ouellet, Eng.

- Vice-president, process technology development, Teledyne DALSA
- Engineering physics, École Polytechnique, 1982
- More than 30 years in semiconductor technologies (Canada, USA, Japan, Korea, Singapore, Taiwan, …)
- Semiconductors, photonics, microfluidics, functional materials, surface treatments, ultra-high vacuum equipment designs, Micro-Electro-Mechanical-Systems (MEMS).
- More than 200 patents (55 patent families)
- At 140hrs/patent filing …
- Now education, mentorship & know-how transfer
- Member of the Scientific Committee of C2MI
- Married, father of 7 children
- Believe in sustained development … water reuse

Thank You !

SILICYCLE Inc. UltraPure SILICA GELS

ERE A Solution Company Environmental Remediation Equipment Inc.

Commission scolaire du Val-des-Cerfs conjuguer nos forces!

e2metrix

McGill University

Brio+ LAVE-AUTO INTELLIGENT

plt

Économie, Science et Innovation Québec

Économie, Innovation et Exportations Québec

Université Concordia University Montréal

TROJAN technologies™

h2o innovation

NSERC CRSNG

Schneider Electric

UQAR Université du Québec à Rimouski

UQTR Université du Québec à Trois-Rivières Savoir. Surprendre.

FEC

CRIQ Partenaire d'innovation

sherbrooke innopole

Centre des Technologies de l'Eau

Université de Sherbrooke

TELEDYNE DALSA Everywhereyoulook™

Bromont Ville branchée

Mitacs

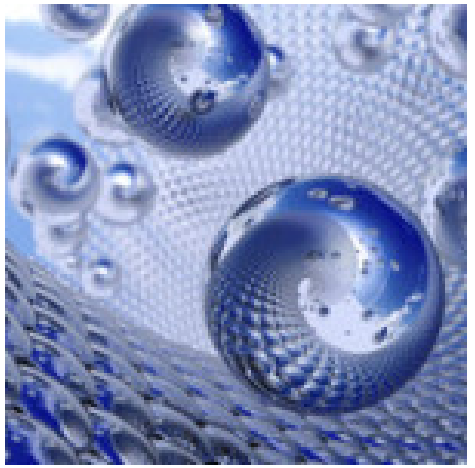
Environment and Climate Change Canada

Environnement et Changement climatique Canada

C2MI

Agenda

- Freshwater availability on Earth – An important issue (09h05-10h05)
  - ✓ Teledyne DALSA Semiconductor: A Leading Pure MEMS Foundry
  - ✓ C2MI's LIMS: R&D HQ of Teledyne DALSA Semiconductor Inc.
  - ✓ Earth: Very Little Freshwater Availability
- Coffee Break (10h05 - 10h20)
- Semiconductors – Impact of IofT on Earth's Freshwater (10h20-11h50)
  - ✓ Semiconductor Industry: Freshwater Withdrawal
  - ✓ Internet-of-Things: Freshwater Withdrawal
  - ✓ NASA: Water Recycling Technologies
  - ✓ C2MI's LIMS UPW – Organics, Metals, Ions
  - ✓ C2MI's Recycling Infrastructure
- Possible Project Structure
- Conclusions, Questions (11h50 - 12h15)



: Introduction Video

Pianist Ludovico Einaudi

TELEDYNE DALSA Everywhereyoulook™ : A Leading Pure MEMS Foundry

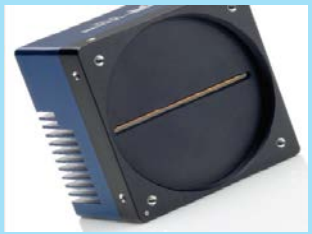
TELEDYNE DALSA Everywhereyoulook™ - A Leading Pure MEMS Foundry

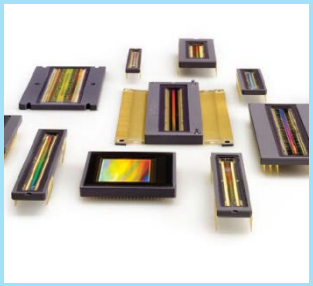
- Headquarters: Thousand Oaks, CA
- Markets:
  - Communications
  - Offshore exploration and production
  - Environmental monitoring
  - Energy and power generation
  - Commercial aviation
- Employees: ~10,000
- Revenue (2015) : $2.29B USD
- Public Trading : NYSE:TDY

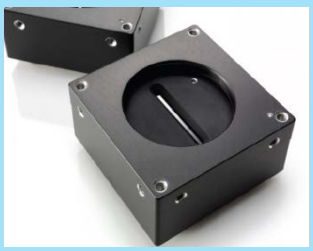
TELEDYNE DALSA Everywhereyoulook™ - A Leading Pure MEMS Foundry

Digital Imaging (Waterloo)

- 1D Vision
- 2D High End/Custom
- Image Sensors



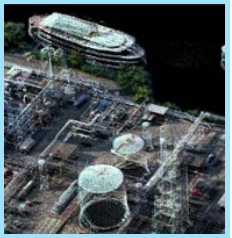


Digital Imaging (Montreal)

- 2D Mid Market
- Smart Cameras/Software
- Frame Grabbers
- LWIR

Lidar

- Aerial
- Terrestrial
- Mobile

Professional Imaging

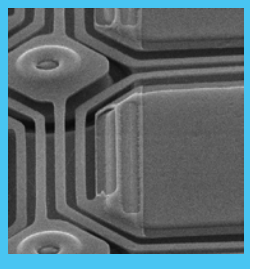
Detectors and Generators

- Healthcare X-Ray
- Industrial X-Ray
- Human Vision




Semiconductor (Bromont)

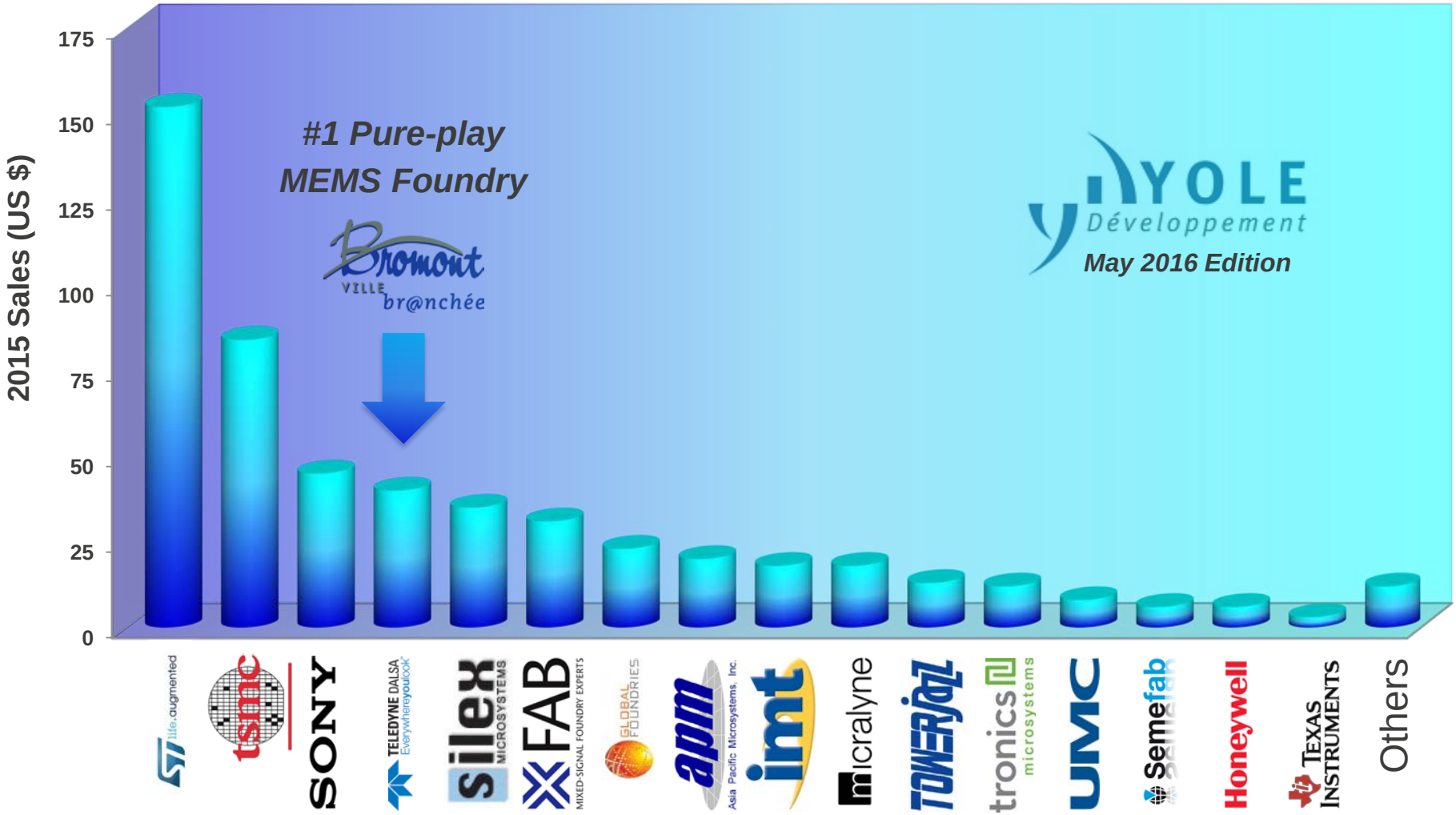
- MEMS
- CMOS
- Imaging/CCD

TELEDYNE DALSA Everywhereyoulook™ - A Leading Pure MEMS Foundry

- Teledyne DALSA Semiconductor
- Located in Bromont, Quebec, Canada
- 380 Employees
- 90 FTE Dedicated to R&D
- Image Sensors Manufacturing
- MEMS Manufacturing
- > 200 patents (> 50 families)
- #4 MEMS Foundry, Worldwide
- #1 Pure-play MEMS Foundry, Worldwide
- Strategic supplier to other Teledyne BUs for Image Sensors (visible & IR)

TELEDYNE DALSA Everywhereyoulook™ - A Leading Pure MEMS Foundry



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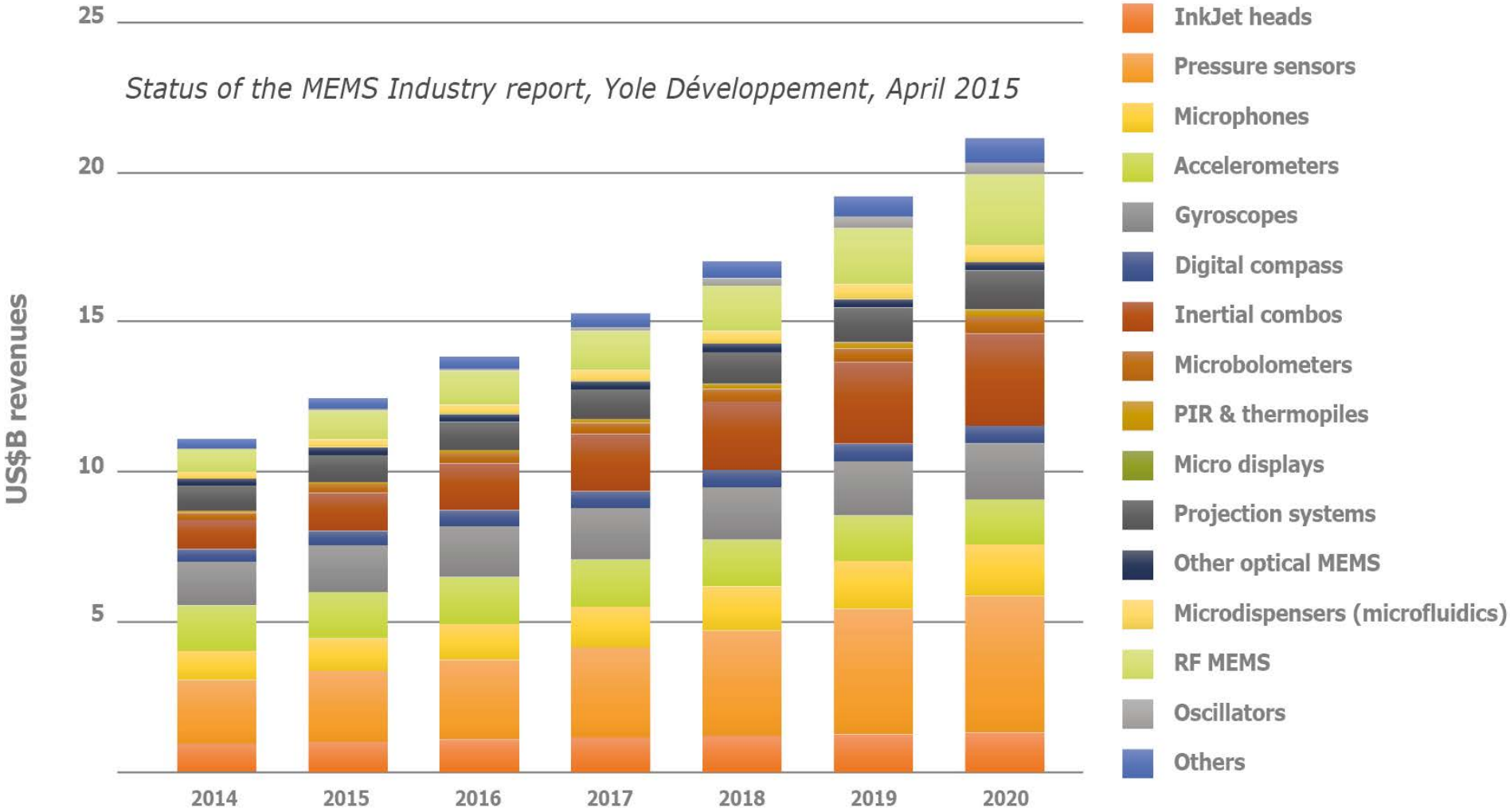
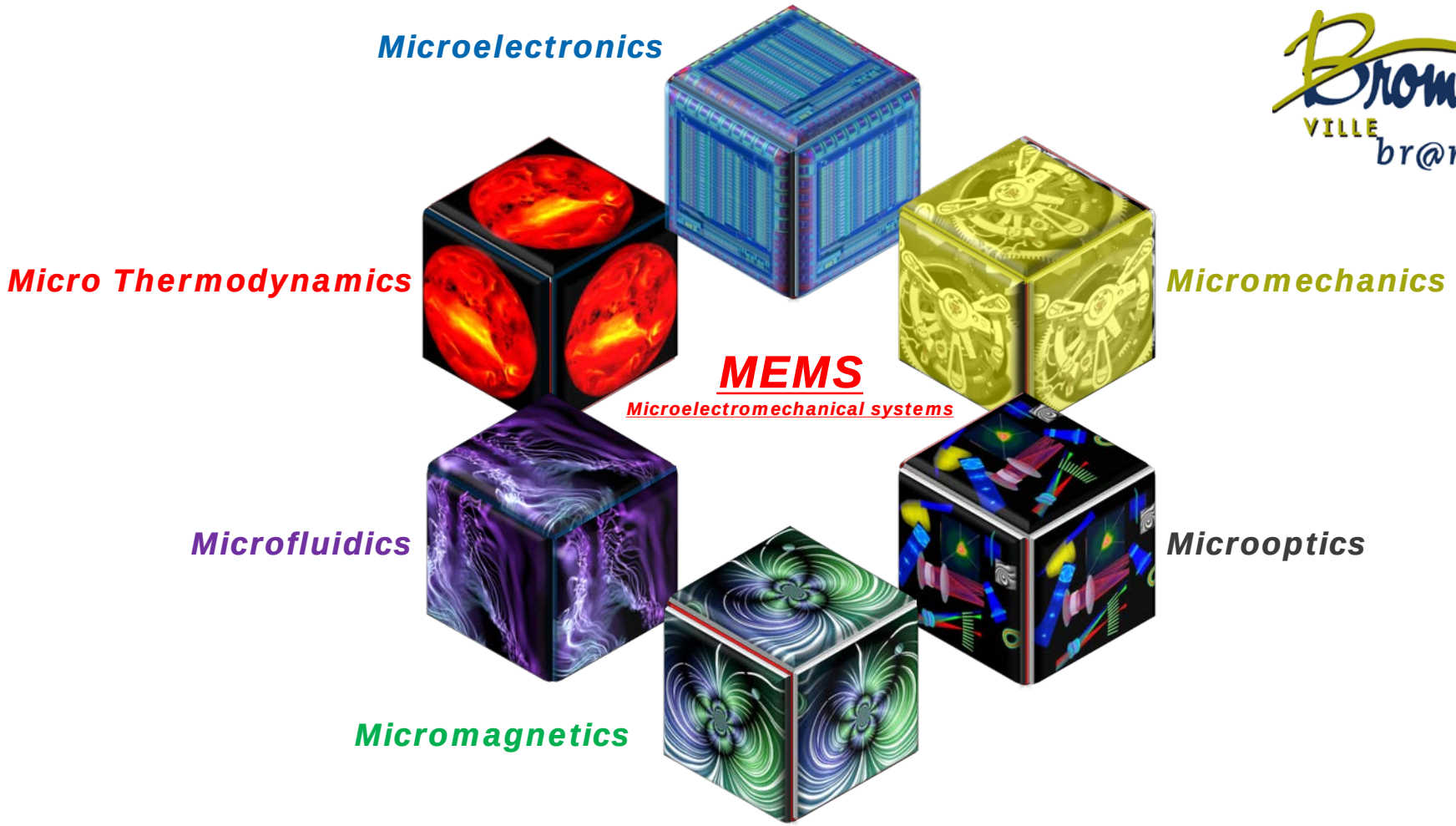


TELEDYNE DALSA Everywhereyoulook™ - A Leading Pure MEMS Foundry

Bromont VILLE branchée



TELEDYNE DALSA Everywhereyoulook™ - A Leading Pure MEMS Foundry

- Ensure an Economic & Sustainable Development
- Green ICT (http://www.teledynedalsa.com/corp/news/352/)
- Reduce the Environmental Impact
  - http://www.teledynedalsa.com/imaging/products/environment/
  - Environmental Management System (ISO 14001:2004)
  - EU RoHS2, China RoHS, EU REACH

Bromont VILLE br@nchée


CERTIFICATE OF REGISTRATION

This is to certify that

Teledyne DALSA Semiconductor Inc.
18, boulevard de l'Aéroport, Bromont, Québec J2L 1S7 Canada

operates an

Environmental Management System

which complies with the requirements of

ISO 14001:2004

for the following scope of registration

Manufacturing of integrated circuits and silicon wafer foundry.

Certificate No.: CERT-0067618 — Original Certification Date: March 12, 1998
File No.: 000742 — Current Certification Date: December 16, 2012
Issue Date: December 19, 2012 — Certificate Expiry Date: December 15, 2015

Chris Joupol, President, QMI-SAI Canada Limited

Guillaume Gignac, ing.f, Vice President, Corporate Operations, Accreditation & Quality, QMI-SAI Canada Limited

ANAB ACCREDITED — ISO 14001 — SAI GLOBAL

C2MI - LIMS* : R&D Headquarters of TDSI**

* Laboratoire d'Intégration des Micro-Systèmes
** Teledyne DALSA Semiconductor Inc.

C2MI - LIMS : R&D Headquarters of TDSI

www.c2mi.ca

C2MI - LIMS : R&D Headquarters of TDSI

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Canadian Universities & Colleges

CIMEQ

ÉTS Le génie pour l'industrie

Polytechnique Montréal

McGill

McMaster University

OPTECH

Université Laval

UBC

uOttawa

Université de Sherbrooke

University of Toronto

University of Waterloo

Research Institutes & Associations

CMC Microsystems

PHOTONSCANADA

INO

Mitacs

PRIMA

prompt

RESMIQ

RQMP

International Centres

cnrs

cea leti

LN2

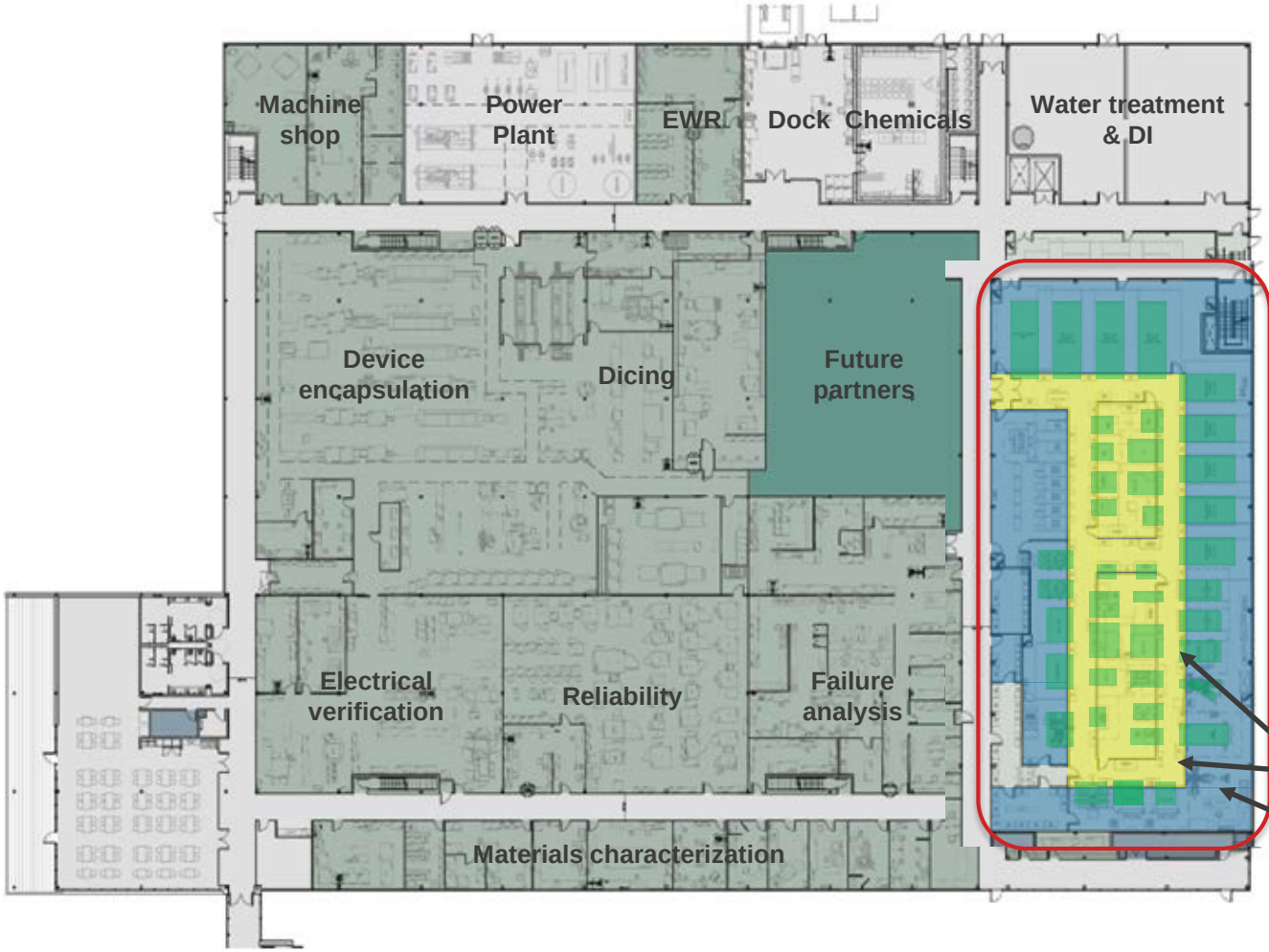
NANOELEC

C2MI - LIMS : R&D Headquarters of TDSI

Commercialization partners categories :

C2MI - LIMS : R&D Headquarters of TDSI

C2MI - LIMS : R&D Headquarters of TDSI



Standard		Particules/m³					
USA Fed STD 209E	ISO 14644-1	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1,0 µm	5,0 µm
1	ISO-3	1 000	237	102	35	8	0
10	ISO-4	10 000	2 370	1 020	352	83	0
100	ISO-5	100 000	23 700	10 200	3 520	832	29
1000	ISO-6	1 000 000	237 000	102 000	35 200	8 320	293

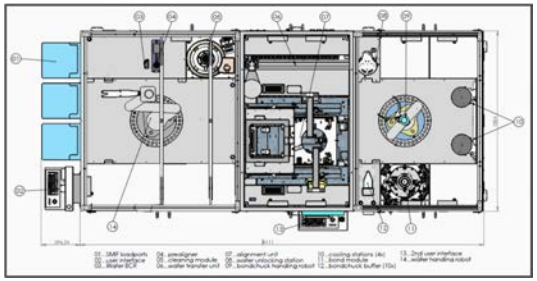
C2MI - LIMS : R&D Headquarters of TDSI

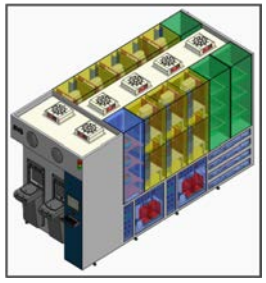
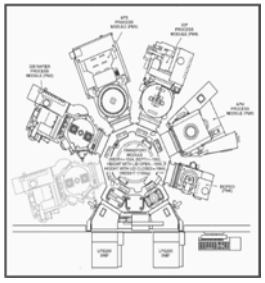











- Very Little Freshwater Availability

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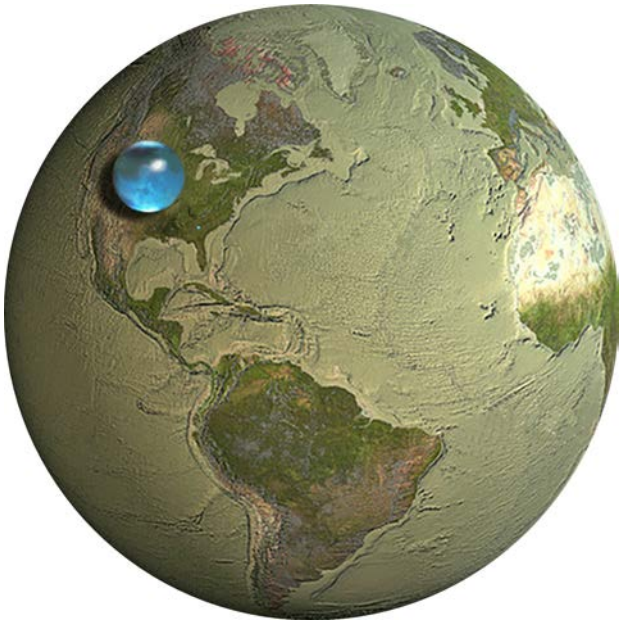
- Large drop - Relative water on Earth

World Health Organization

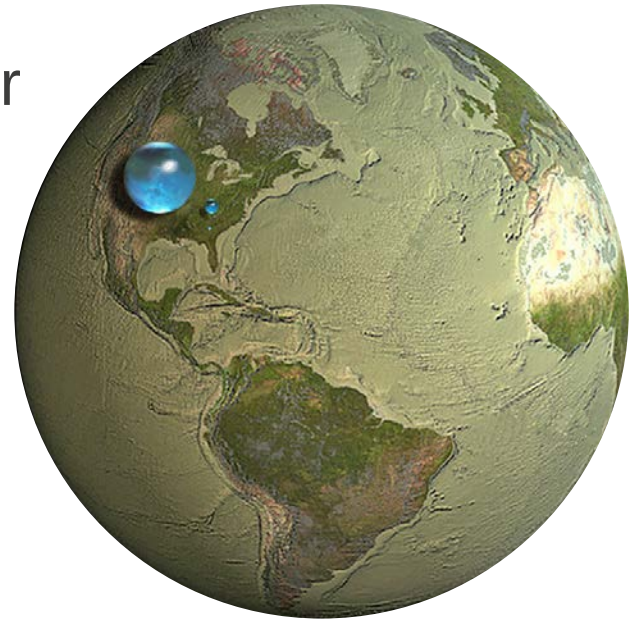


http://www.activeau.fr/repartition-eau-monde http://www.who.int/water_sanitation_health/mdg1/en/

- Very Little Freshwater Availability

- Large drop - Relative water on Earth
- Small drop - Relative freshwater on Earth
- 80 countries - Sporadic lack of freshwater
- 28 countries - Regular lack of freshwater
- 1,1G humans - No access to freshwater
- 1,6M children/year die from diarrhea (bad water quality)
- 10 countries - 60% of Earth's freshwater reserve

World Health Organization



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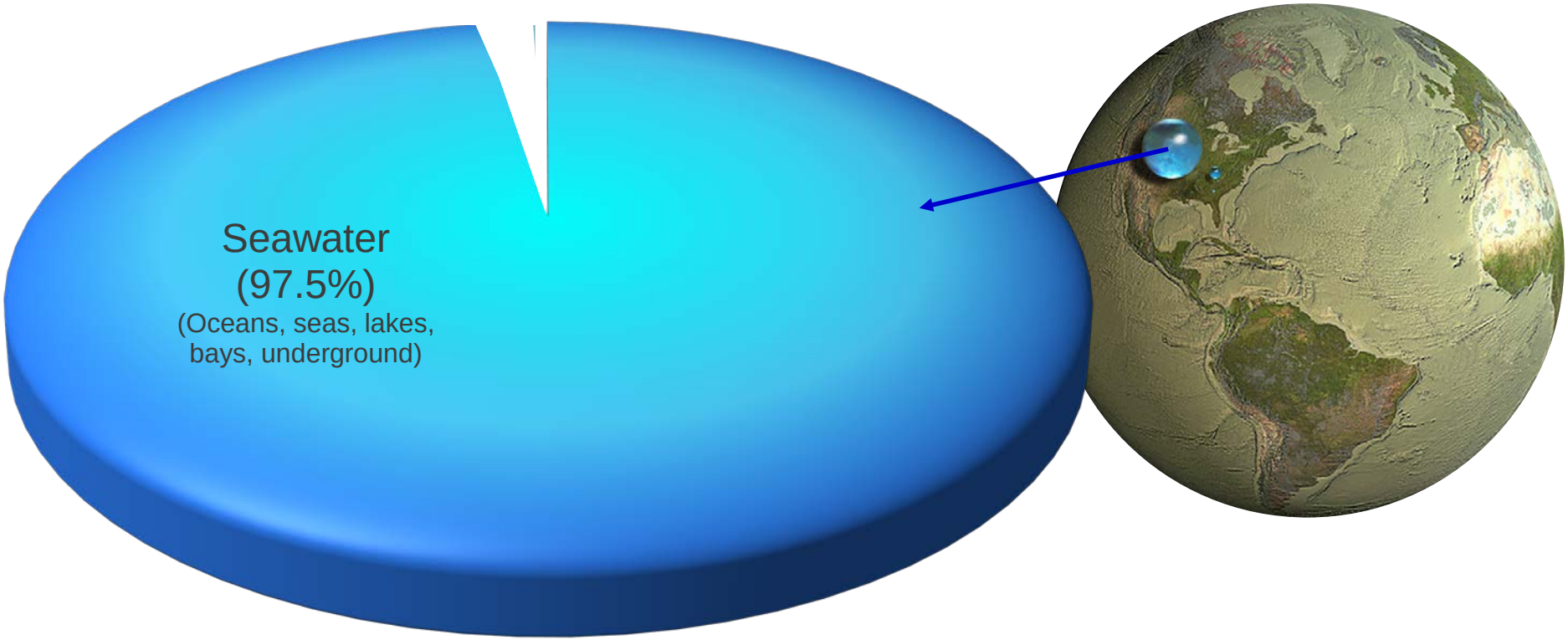
- Very Little Freshwater Availability

World Business Council for Sustainable Development

2006, SBN 2-940240-70-1



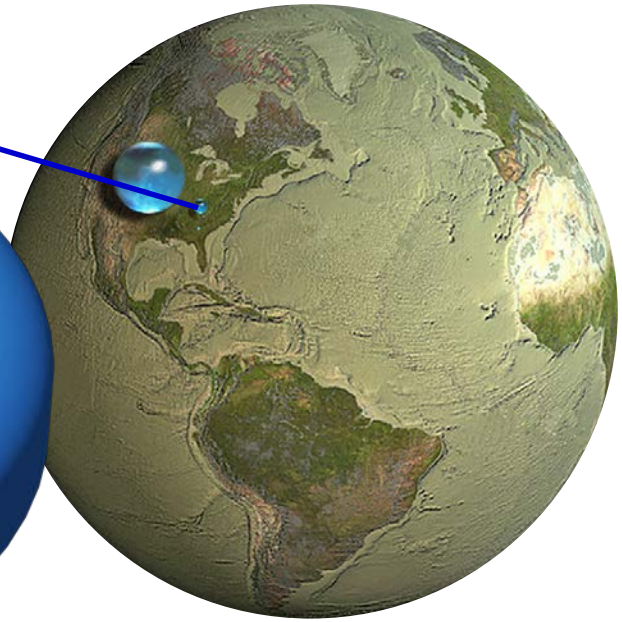
- Very Little Freshwater Availability

Solid Freshwater (1.75%)
(Icecaps, glaciers, Permafrost, eternal snow)

World Business Council for Sustainable Development

2006, SBN 2-940240-70-1

Seawater (97.5%)
(Oceans, seas, lakes, bays, underground)



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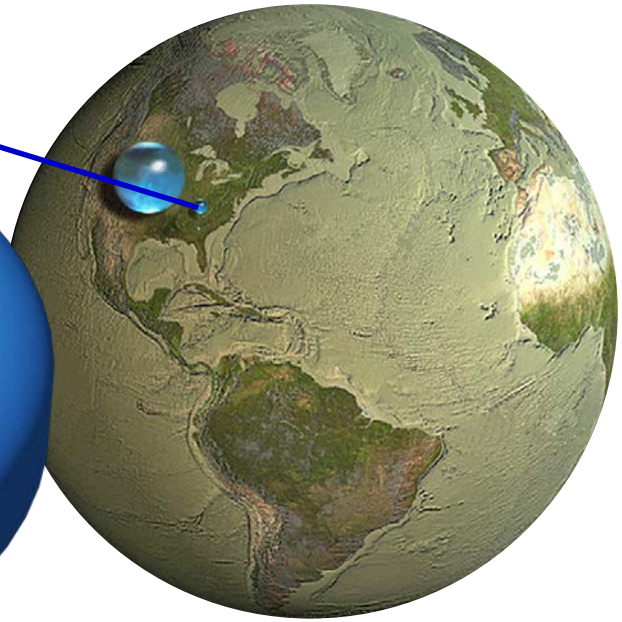

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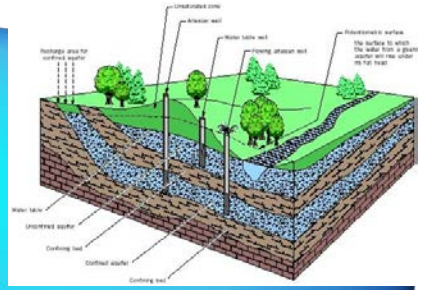

Underground (**10 - 30,000 years Old***)

Seawater (97.5%)
(Oceans, seas, lakes, bays, underground)

USA: 80-90% of available freshwater comes from underground

* http://www.waterencyclopedia.com/Ge-Hy/Groundwater-Age-of.html

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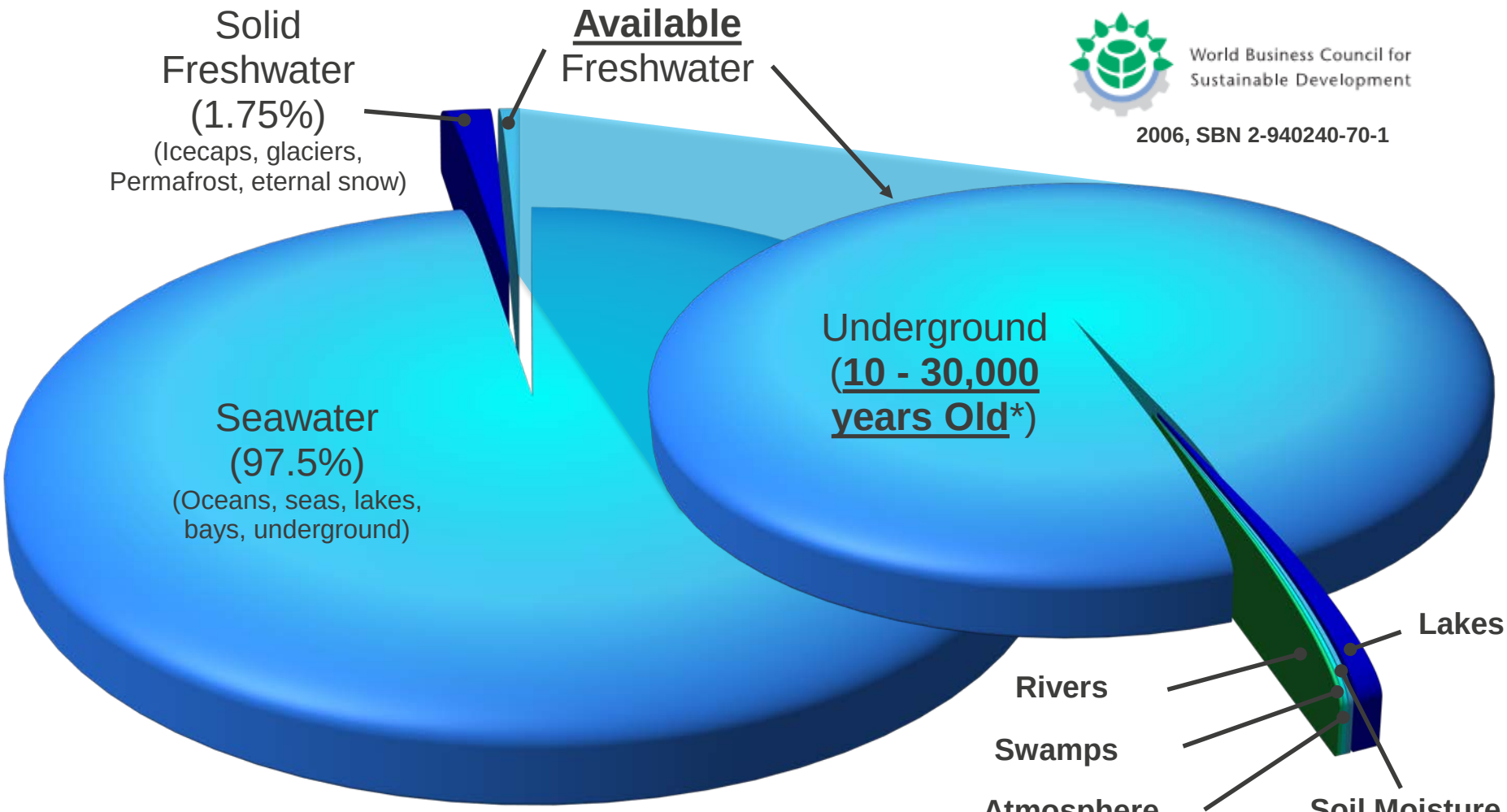

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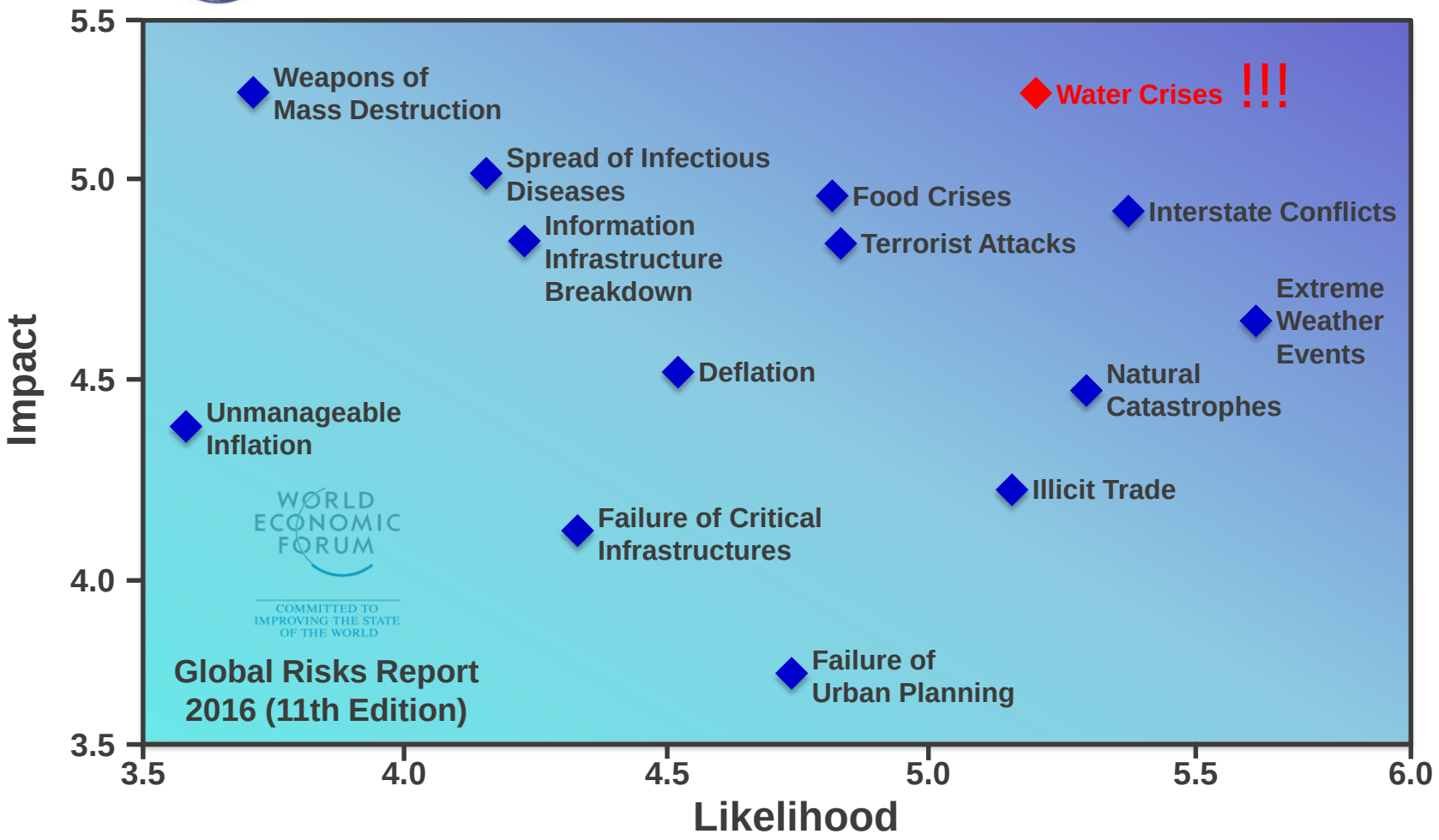

http://www3.weforum.org/docs/GRR/WEF_GRR16.pdf

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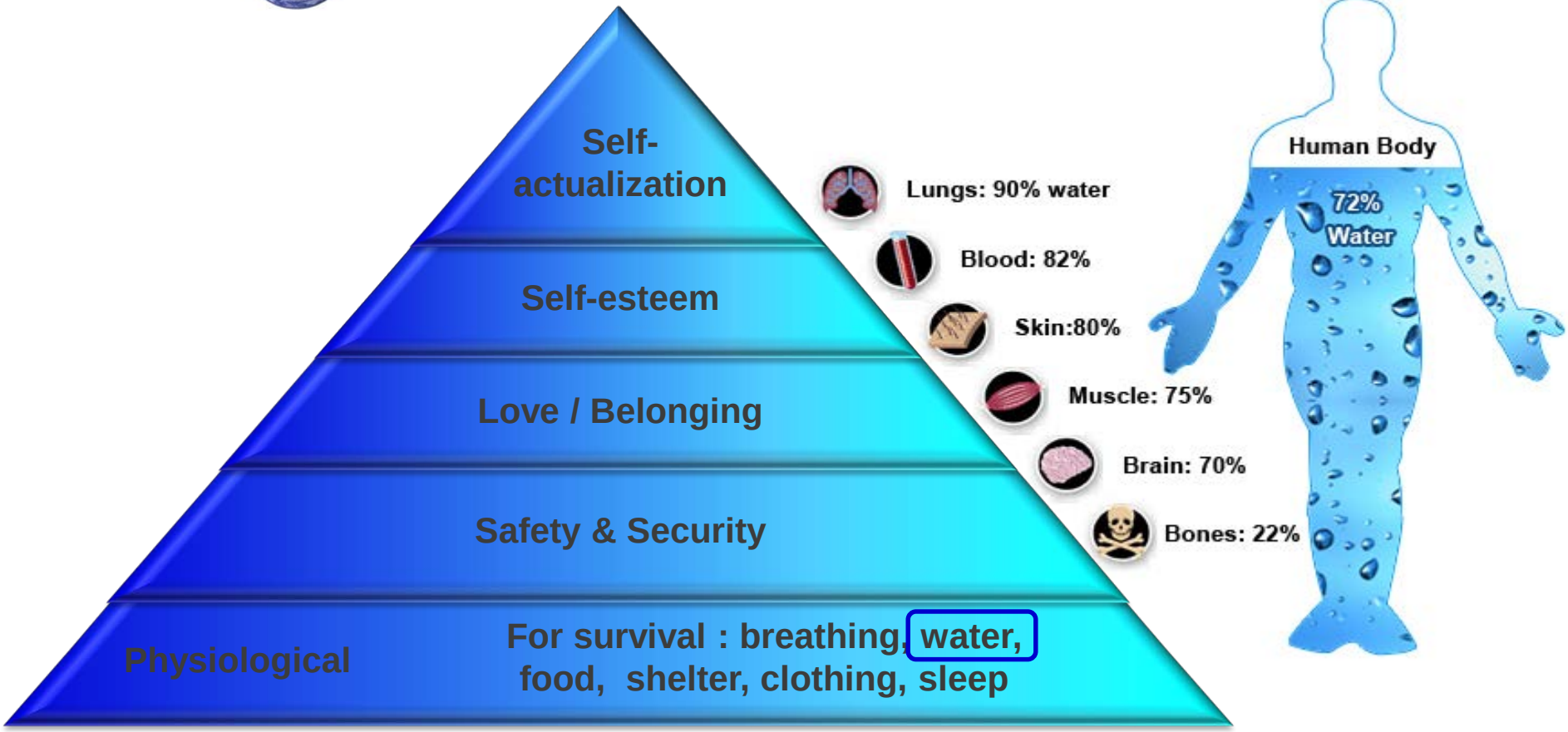

Maslow's hierarchy of needs from Psychology - The Search for Understanding by Janet A. Simons, Donald B. Irwin and Beverly A. Drinnien, West Publishing Company, New York, 1987

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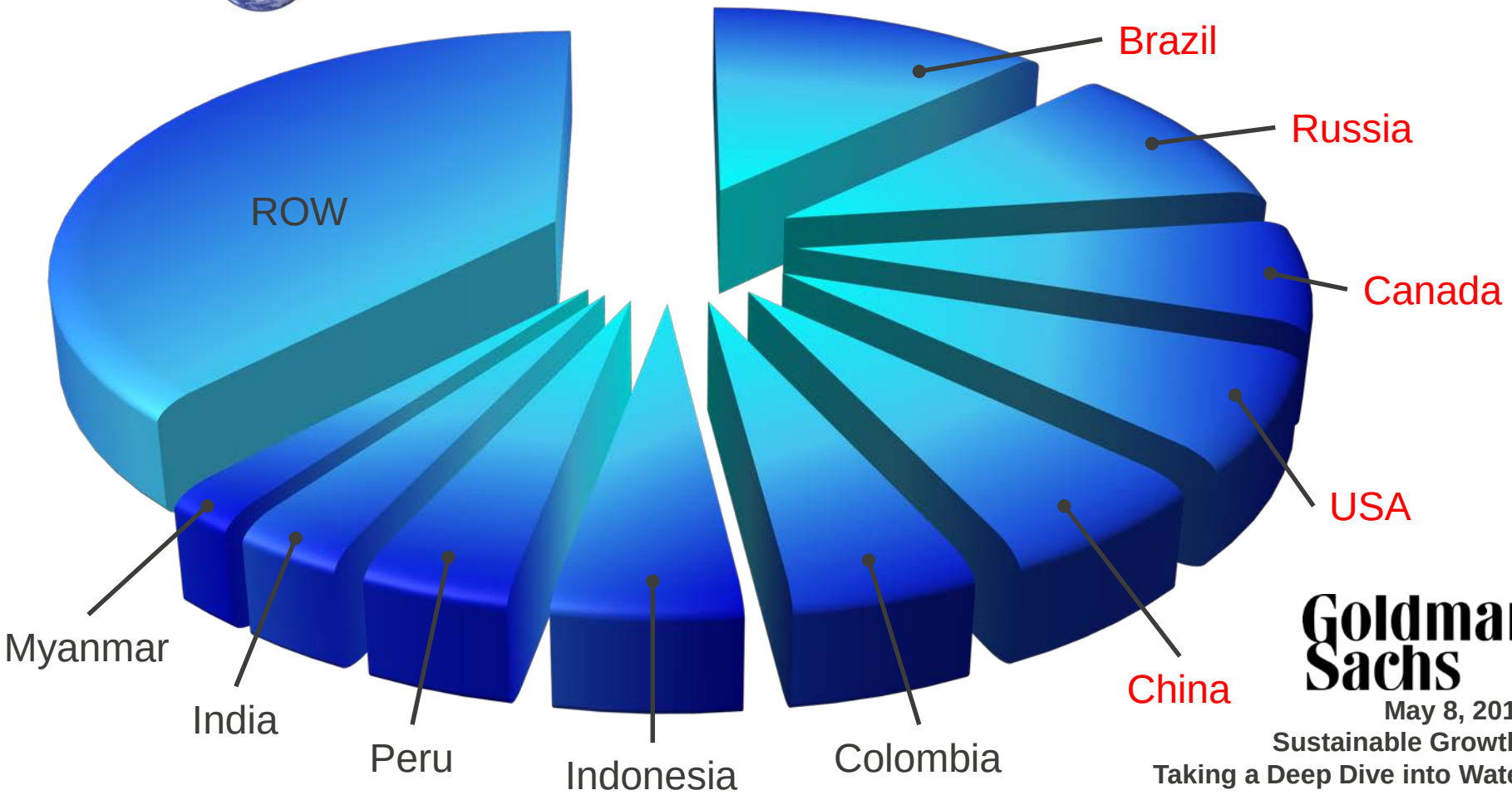

Goldman Sachs

May 8, 2013
Sustainable Growth:
Taking a Deep Dive into Water

http://www.goldmansachs.com/our-thinking/clean-technology-and-renewables/cohen/report.pdf

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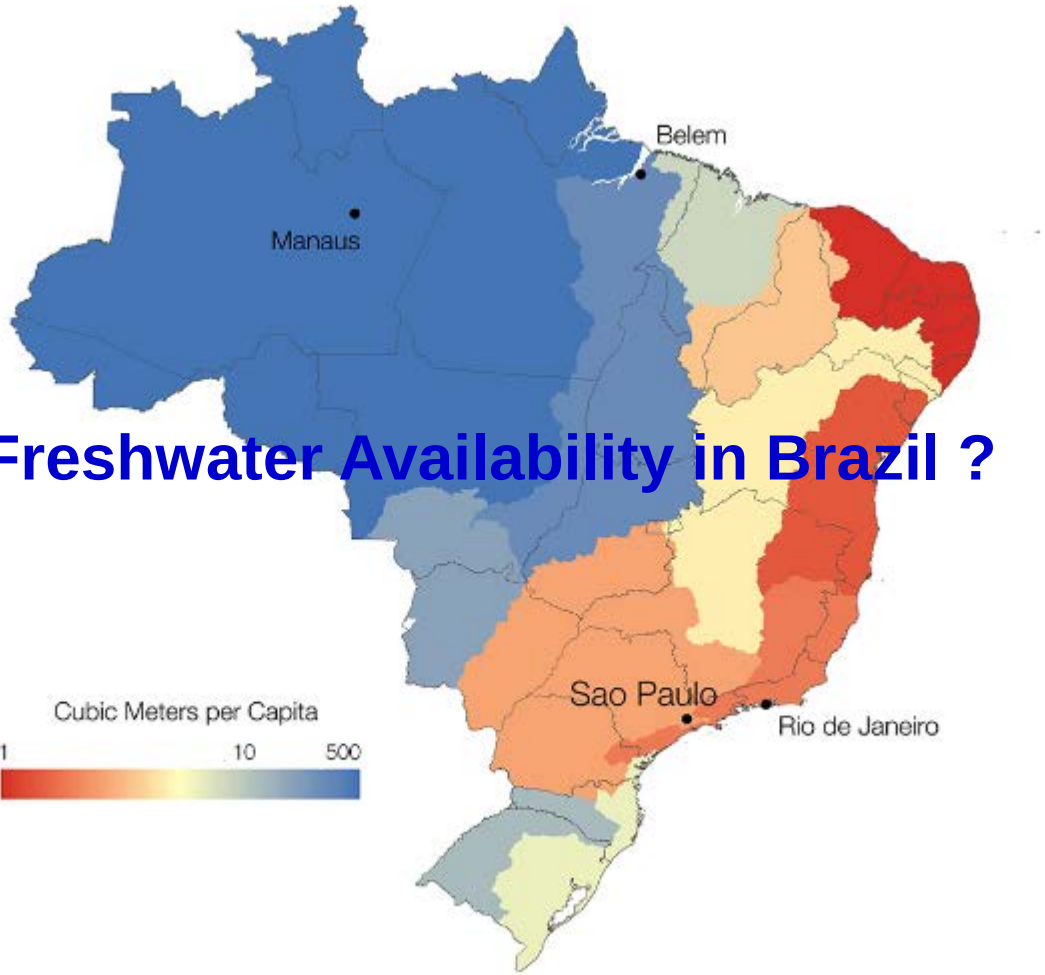

Freshwater Availability in Brazil ?

http://www.circleofblue.org/2014/world/sao-paulos-water-waiting-game-avoided-rationing-produced-huge-risk-severe-shortage/

- Very Little Freshwater Availability

http://www.wbur.org/npr/280770928/drought-could-drain-more-than-brazils-coffee-crop

- Very Little Freshwater Availability

http://www.sciencedirect.com/science/article/pii/S0959378007000064

- Very Little Freshwater Availability

www.agra-net.com/agra/agra-europe/crops/grains/russian-drought-mirrors-previous-wheat-failure-years-warns-analyst-441623.htm

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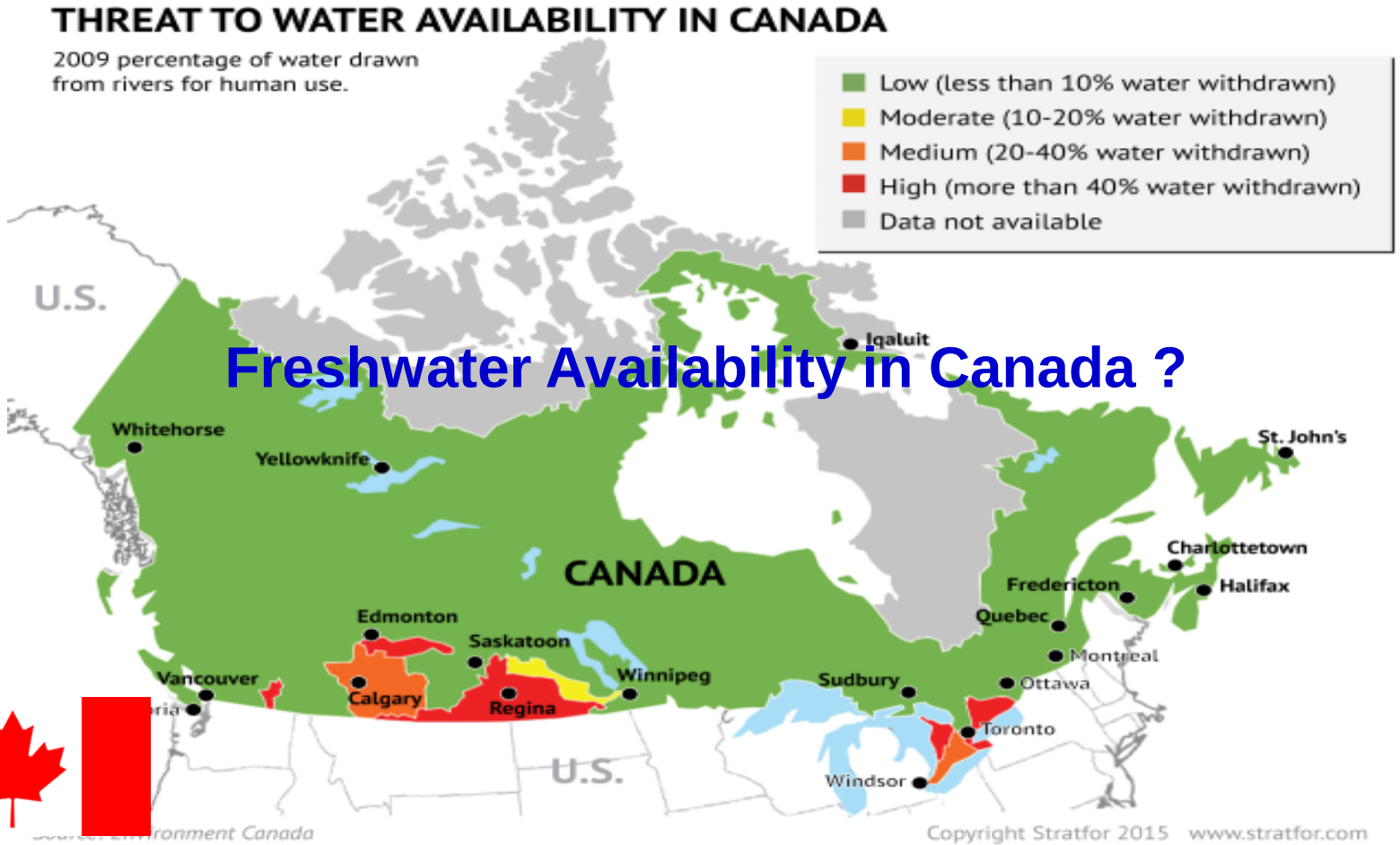

Freshwater Availability in Canada ?

https://www.stratfor.com/analysis/why-canada-cannot-export-its-water

- Very Little Freshwater Availability

Foote Field, Edmonton, 2015

Kamloops, British Columbia, 2015

Freshwater Availability in Canada ?

http://www.drinetwork.ca/

http://edmontonjournal.com/news/local-news/drought-conditions-in-alberta-threaten-crops-as-edmonton-the-driest-region-in-province

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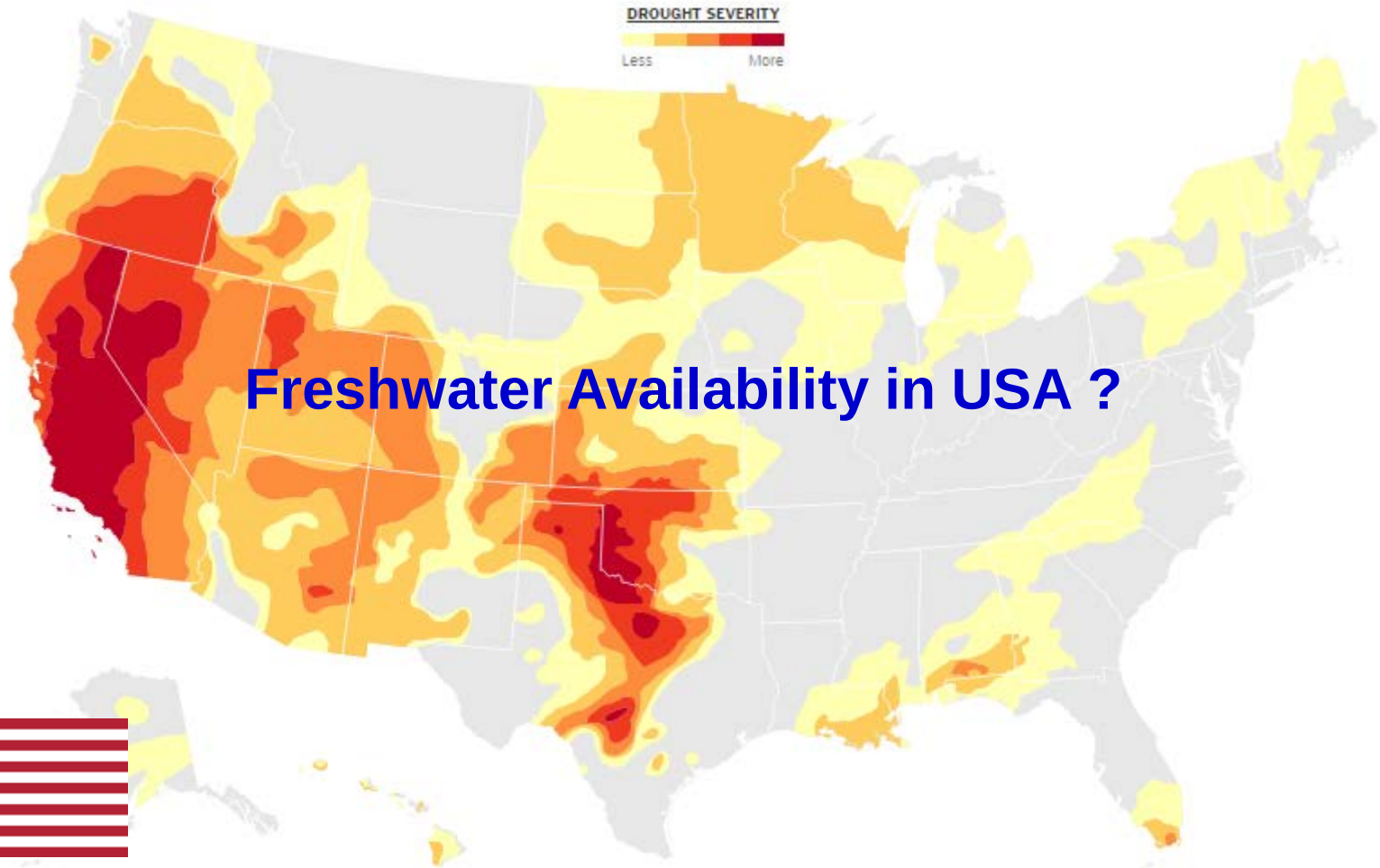
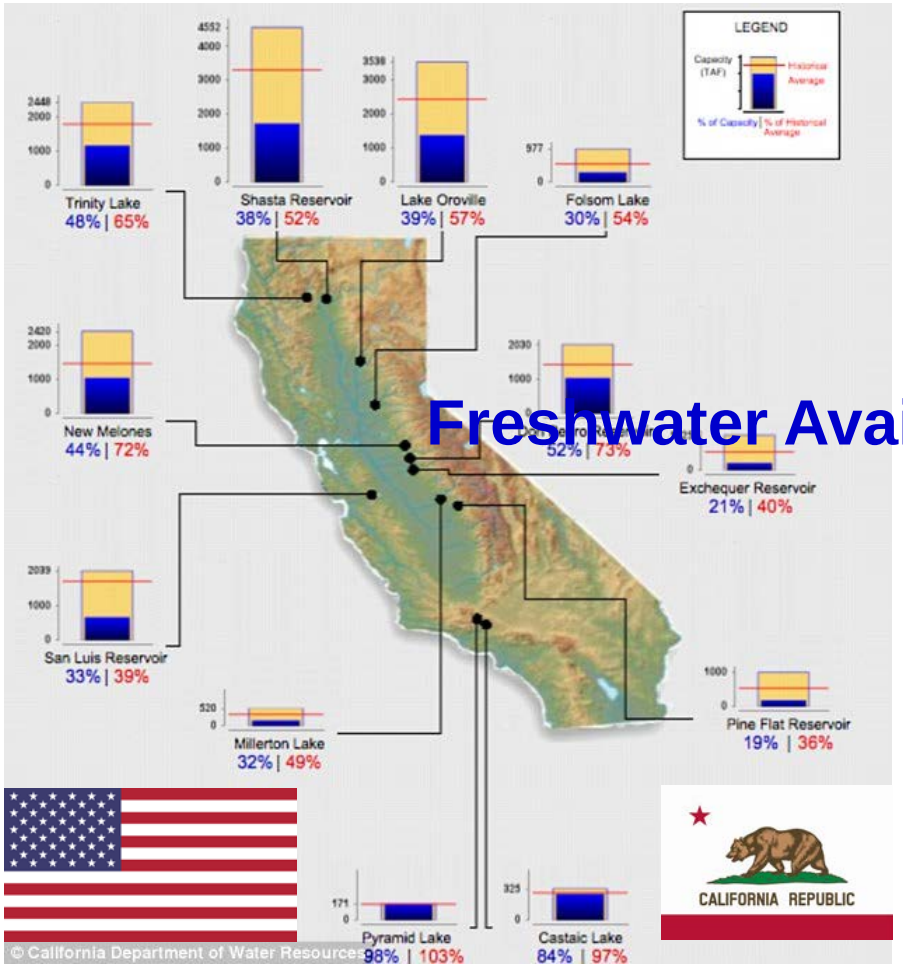


Freshwater Availability in USA ?

http://www.nytimes.com/interactive/2014/upshot/mapping-the-spread-of-drought-across-the-us.html?_r=0

- Very Little Freshwater Availability



Bidwell Marina, July 20, 2011

Bidwell Marina, August 19, 2014

Freshwater Availability in USA ?

Folsom Lake, July 20, 2011

Folsom Lake, January 2014

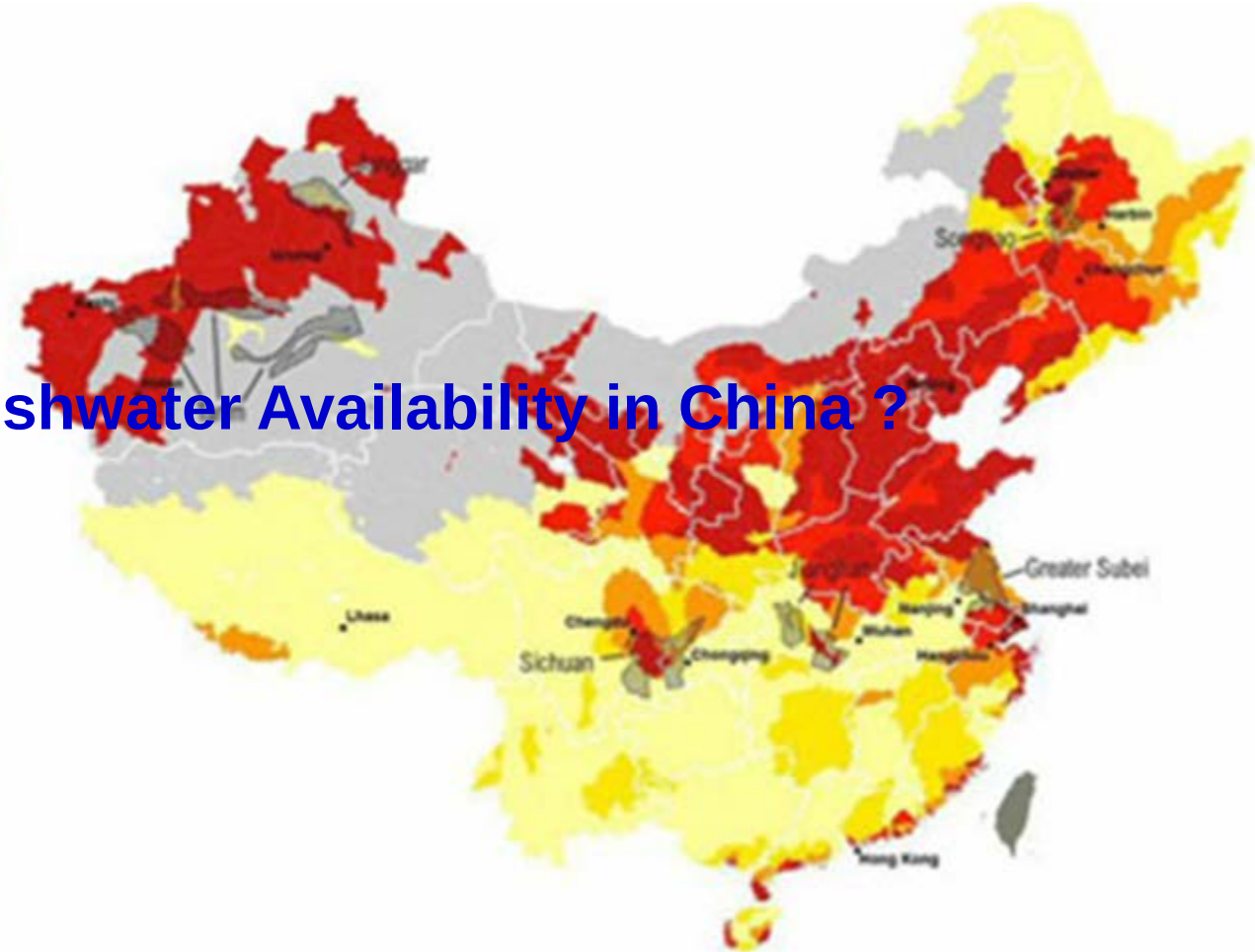
Lake Oroville, July 20, 2011

Lake Oroville, August 19, 2014

http://alerte-plus.blogspot.ca/2014/02/shocking-photos-avant-et-apres-montrent.html

- Very Little Freshwater Availability

Freshwater Availability in China ?



http://www.wri.org/blog/2014/09/tale-3-countries-water-risks-global-shale-development

- Very Little Freshwater Availability

Freshwater Availability in China ?

https://cdn.asiancorrespondent.com/wp-content/uploads/2011/05/ChinaDroughtMay26.jpg
http://news.xinhuanet.com/english2010/china/2011-04/27/13847209_41n.jpg

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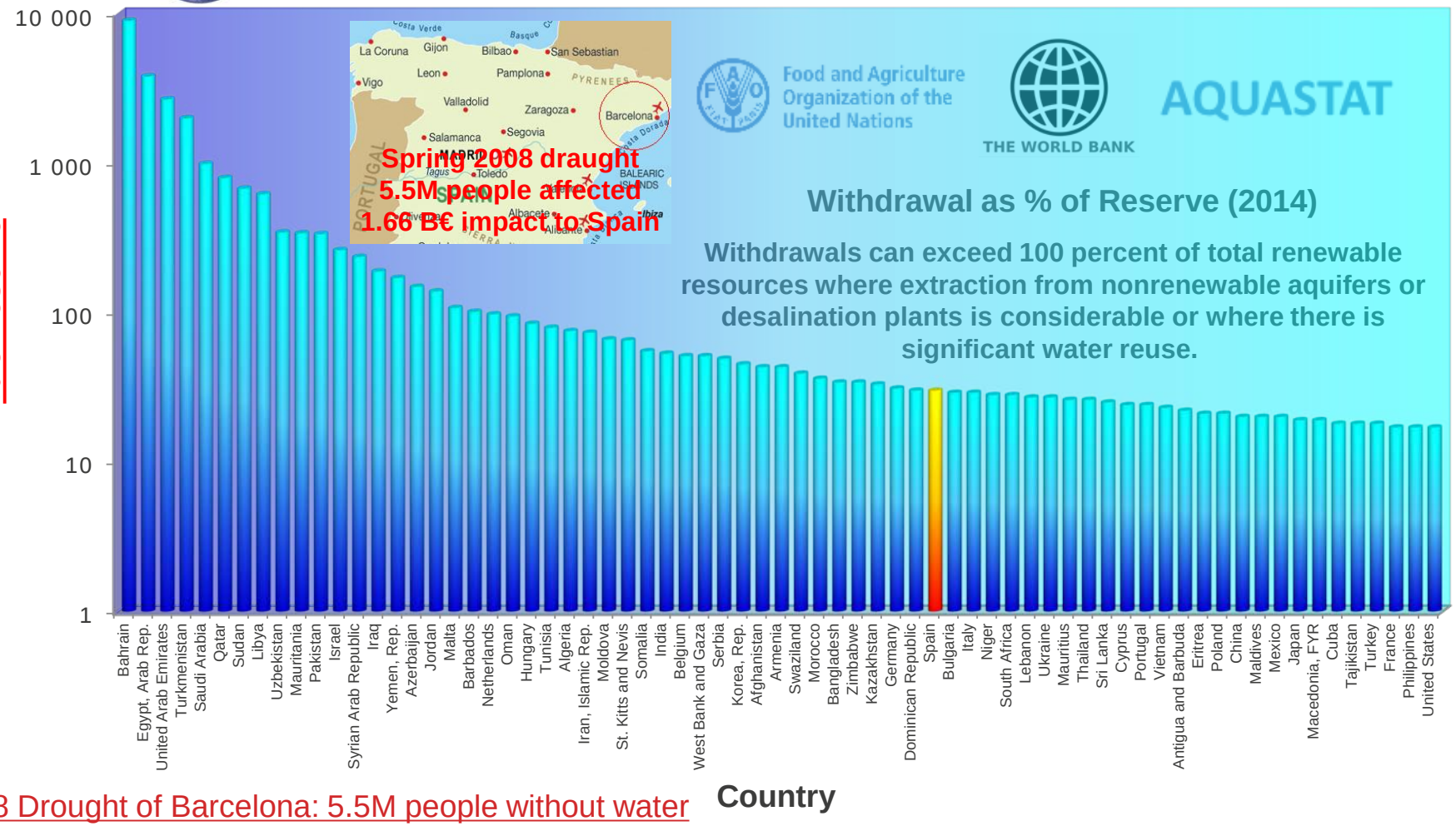

2008 Drought of Barcelona: 5.5M people without water

http://data.worldbank.org/indicator/ER.H2O.FWTL.ZS/countries

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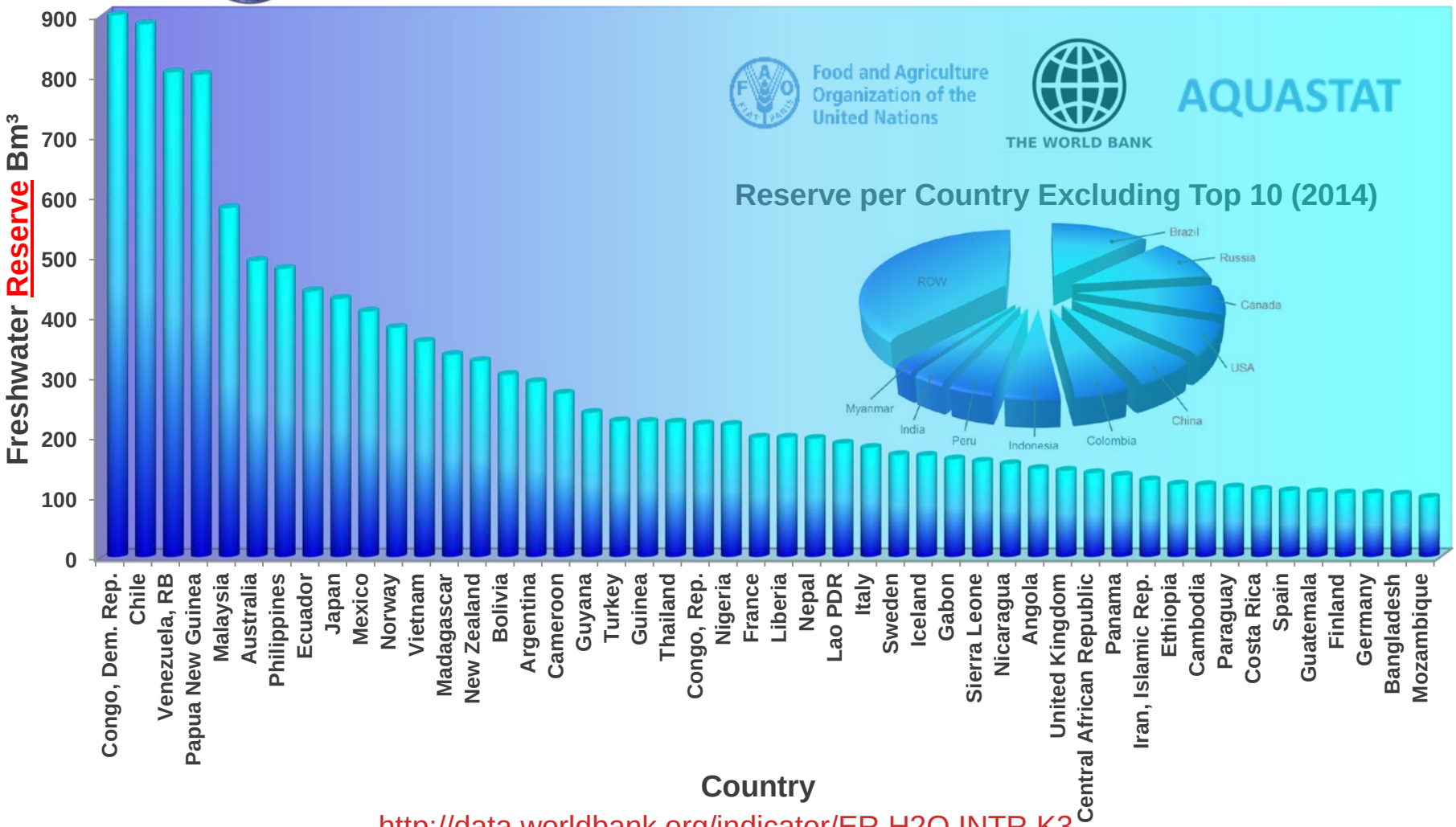

http://data.worldbank.org/indicator/ER.H2O.INTR.K3

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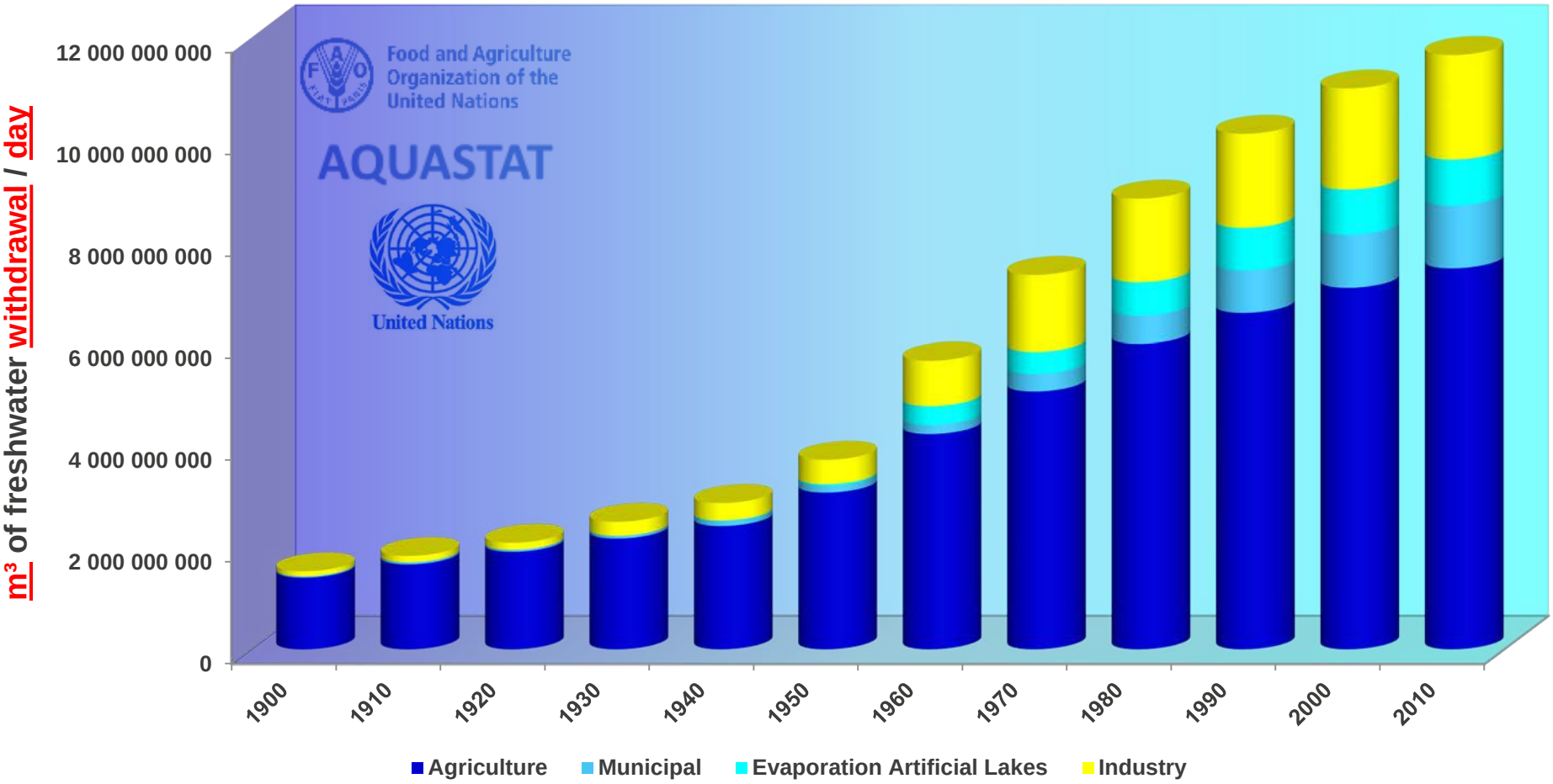
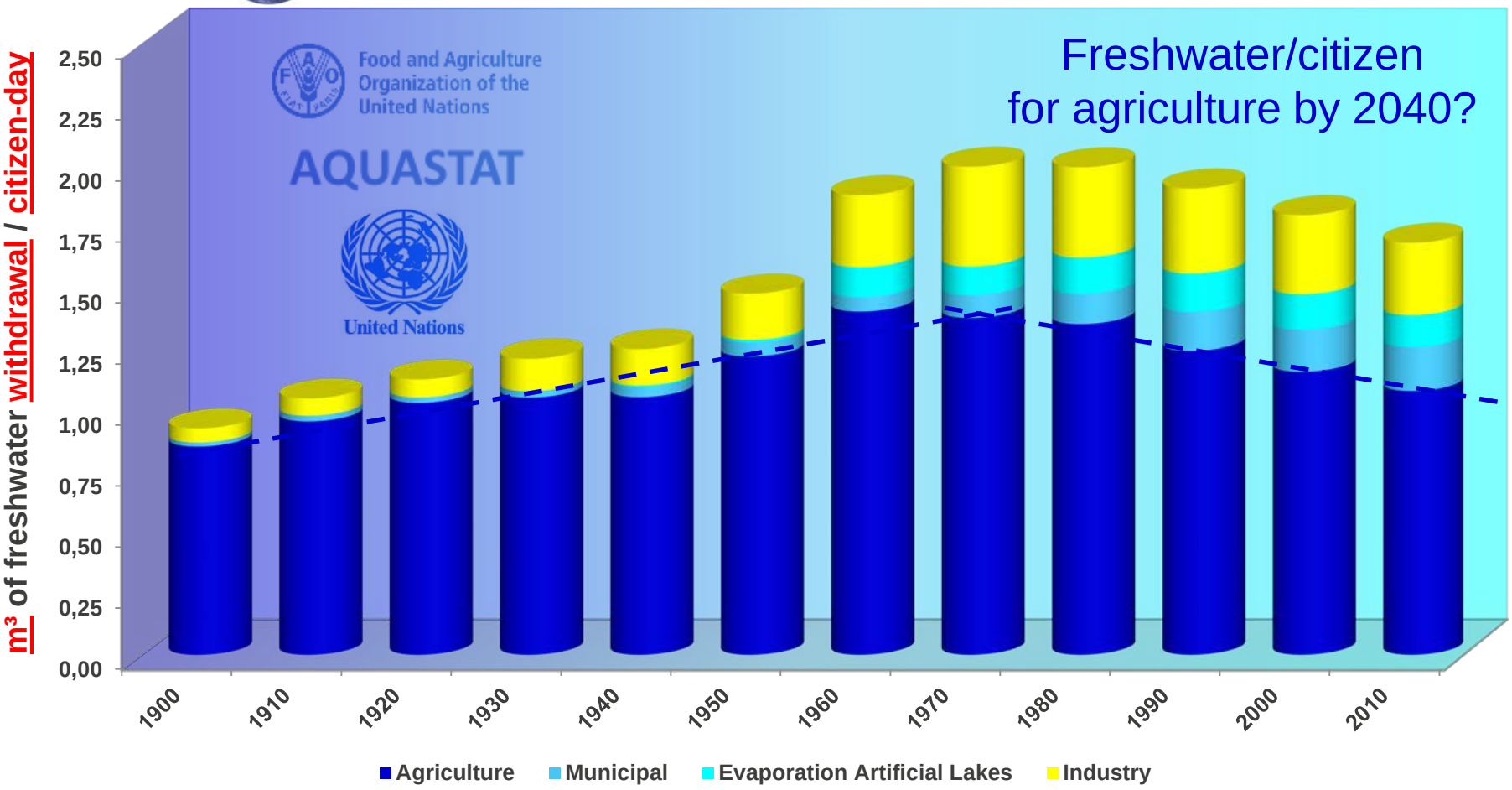


www.fao.org/nr/water/aquastat/water_use/index.stm ONU (World Population Prospects: The 2015 Revision

- Very Little Freshwater Availability



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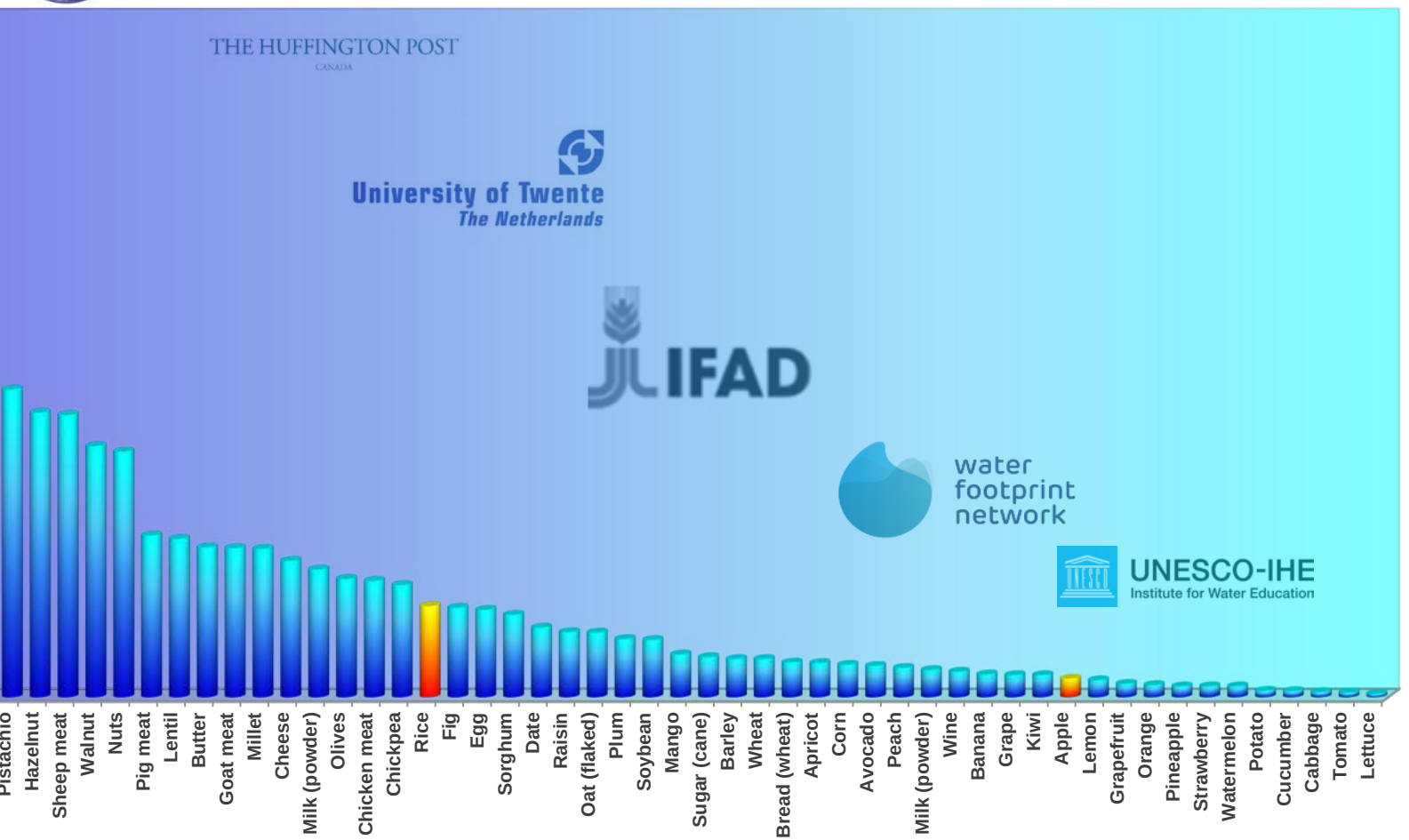
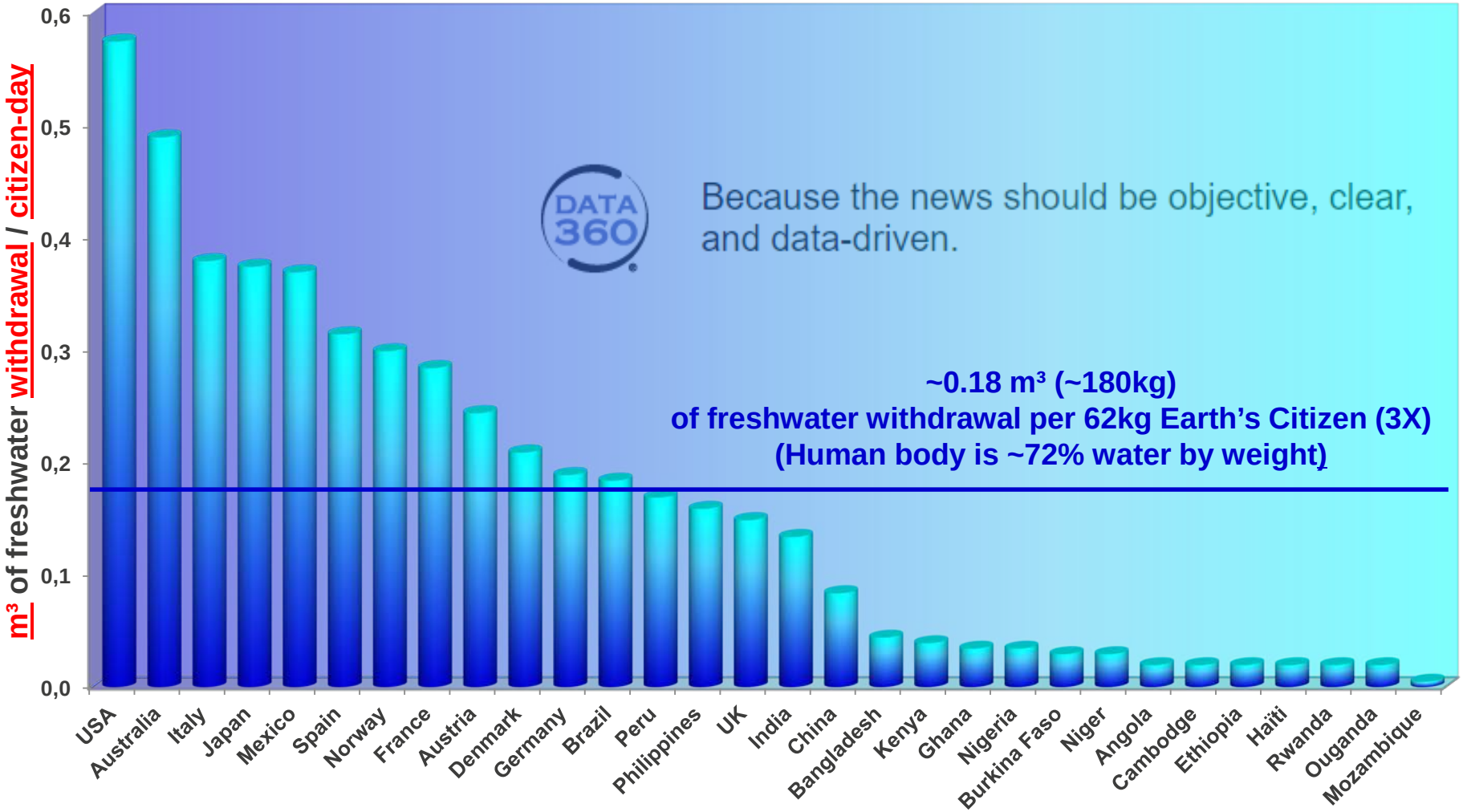


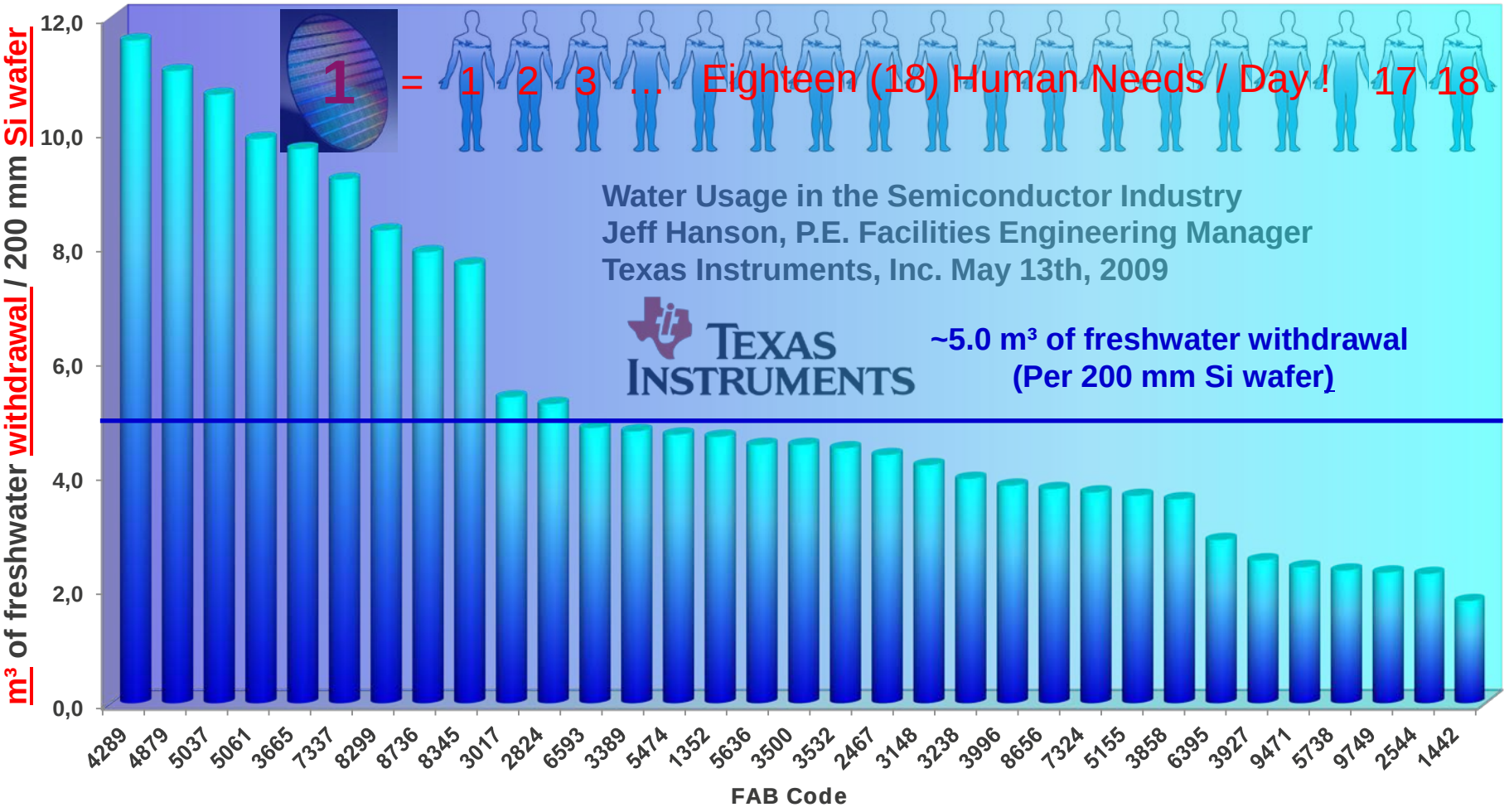
The green, blue & grey water footprint of farm animals & animal products The water footprint of food

- Very Little Freshwater Availability

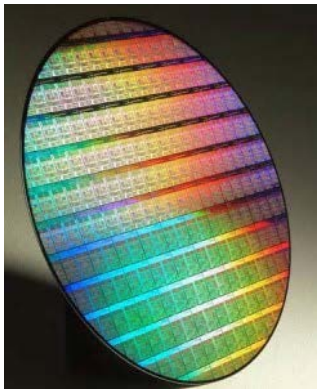


bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-12-439 https://en.wikipedia.org/wiki/Body_water

- Very Little Freshwater Availability



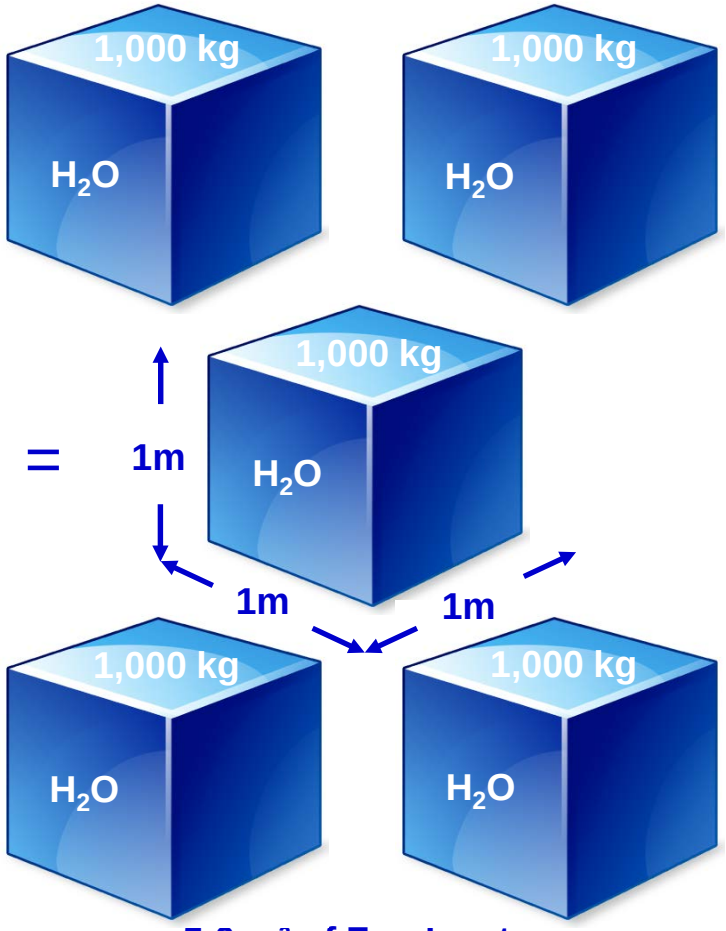
- Very Little Freshwater Availability



One (1)

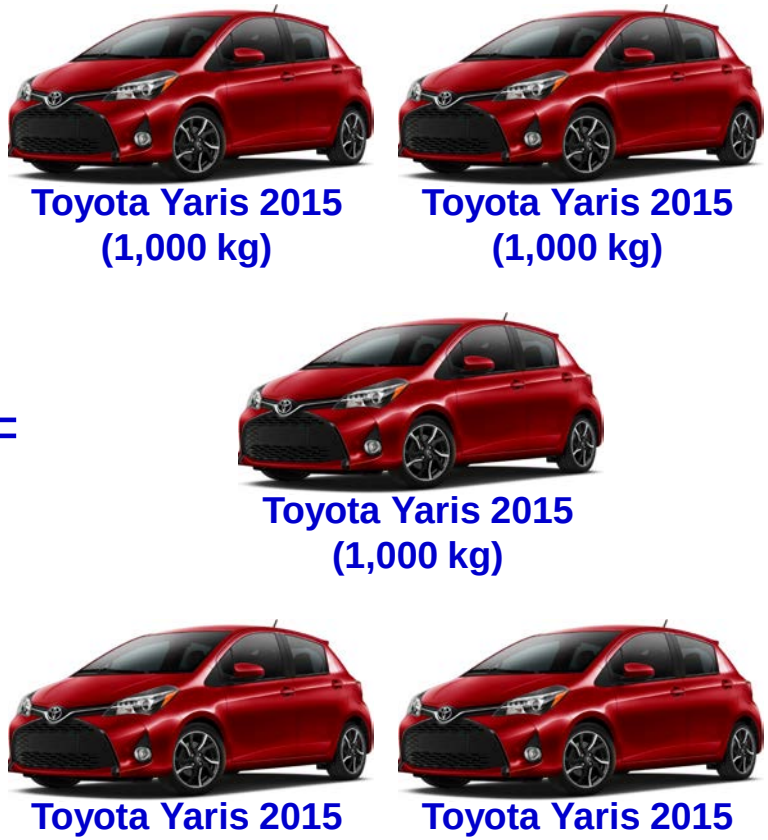
200mm Si wafer

=



5.0 m³ of Freshwater
(5,000 kg)

=



Toyota Yaris 2015
(1,000 kg)

Toyota Yaris 2015
(1,000 kg)

Toyota Yaris 2015
(1,000 kg)

Toyota Yaris 2015
(1,000 kg)

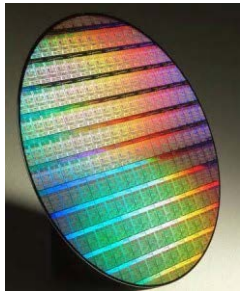
Toyota Yaris 2015
(1,000 kg)

- Very Little Freshwater Availability

TSMC's Fab-12, 300mm GIGAFAB™, Hsinchu Science Park, Hsinchu, Taiwan, R.O.C.

GLOBAL FOUNDRIES NXP SONY

SAMSUNG TEXAS INSTRUMENTS intel



: Important Freshwater Withdrawal

Infineon life.augmented tsmc

UMC TOSHIBA RENESAS

: (10h05 - 10h20)

GLOBAL FOUNDRIES

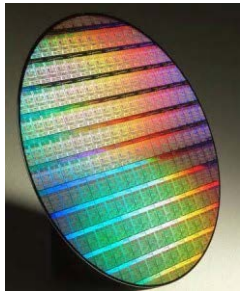
NXP

SONY

SAMSUNG

Texas Instruments

intel



: Important Freshwater Withdrawal

Infineon

life.augmented

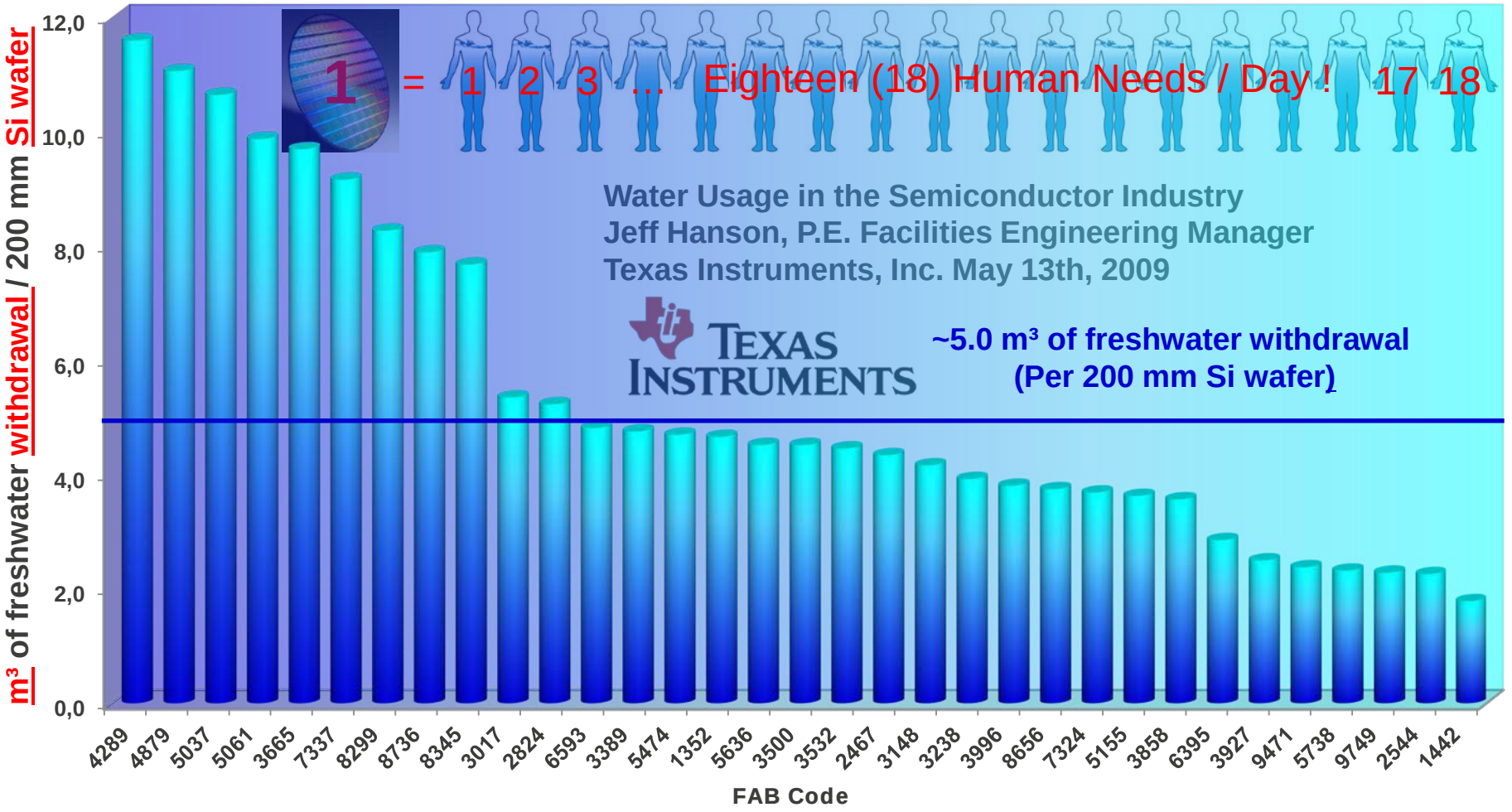
tsmc

UMC

TOSHIBA

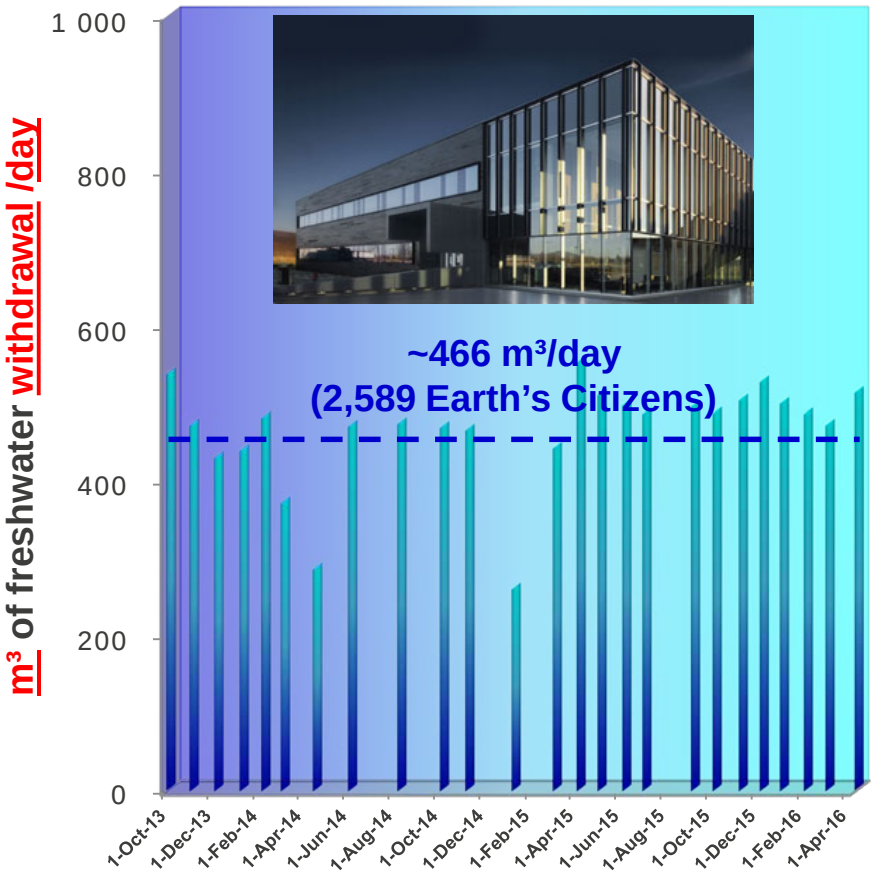
RENESAS

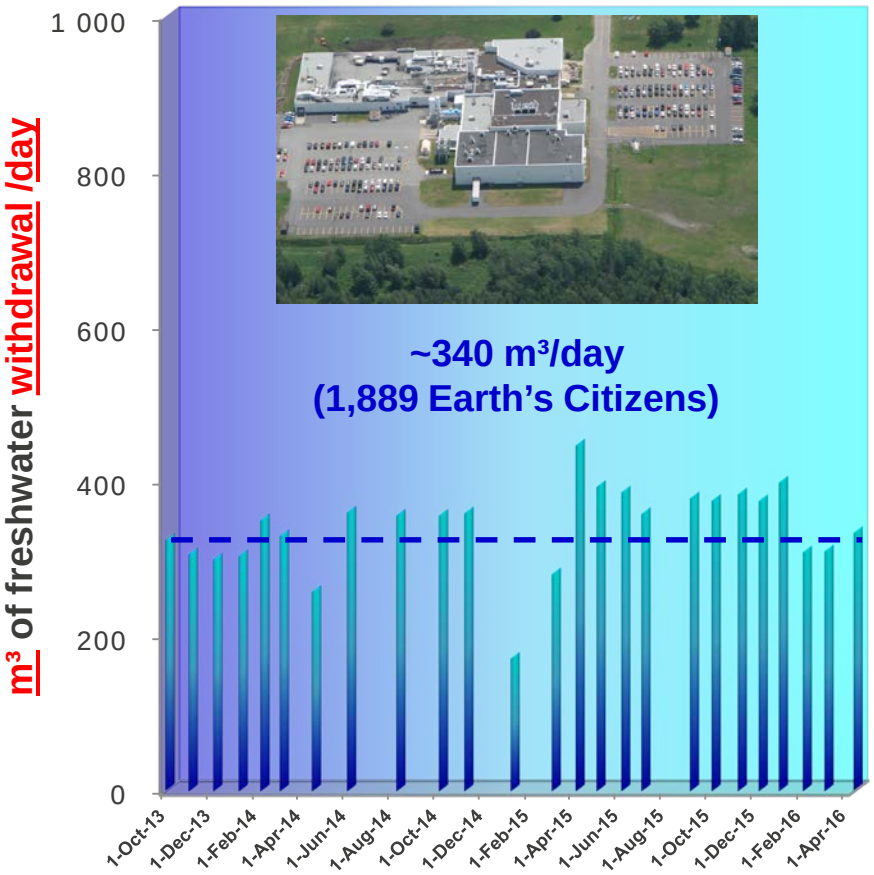
: Important Freshwater Withdrawal



: Important Freshwater Withdrawal

C2MI TELEDYNE DALSA Everywhereyoulook™





Bromont = 7,649 Citizens

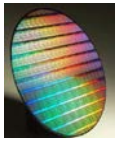
: Important Freshwater Withdrawal

TSMC's Fab-12, 300mm GIGAFAB™, Hsinchu Science Park, Hsinchu, Taiwan, R.O.C.

: Important Freshwater Withdrawal

- A semiconductor Fab withdraws a lot of freshwater
- Many Fabs are located in arid or semi arid regions
- Of 160 (Y2011) world's Fabs:
  - ✓ 79 are in Yangtze River Delta region of China (Shanghai, Jiangsu, Zhejiang);
  - ✓ 31 are in Bohai Ring region (Beijing,Tianjin, Hebei, Shandong, Liaoning)
  - ✓ Areas suffering from water stress through extreme scarcity

https://cambridgewirelessblog.wordpress.com/2016/05/18/china-semiconductors-and-some-implications/
http://chinawaterrisk.org/resources/analysis-reviews/8-things-you-should-know-about-water-and-semiconductors/



: Important Freshwater Withdrawal

TSMC operates three (3) 300-mm GIGAFAB™:

FAB-12
Hsinchu Science Park,
Hsinchu, Taiwan, R.O.C

FAB-14
Tainan Science Park,
Tainan, Taiwan, R.O.C

FAB-15
Central Taiwan Science Park,
Taichung, Taiwan, R.O.C

TSMC operates seven (7) 200-mm FAB:

FAB-3

FAB-5

FAB-8

Hsinchu Science Park,
Hsinchu, Taiwan, R.O.C.
Baoshan Reservoir II
(32,180,000 m³ Capacity)

FAB-6
Tainan Science Park,
Tainan, Taiwan, R.O.C.

FAB-10
Songjiang,
Shanghai, China

FAB-11
Camas,
WA U.S.A.

SSMC
(TSMC-NXP JV)
Singapore

http://www.tsmc.com/download/csr/2013_tsmc_csr/english/pdf/e_8_4.pdf
http://www.tsmc.com/english/dedicatedFoundry/manufacturing/locations.htm

: Important Freshwater Withdrawal

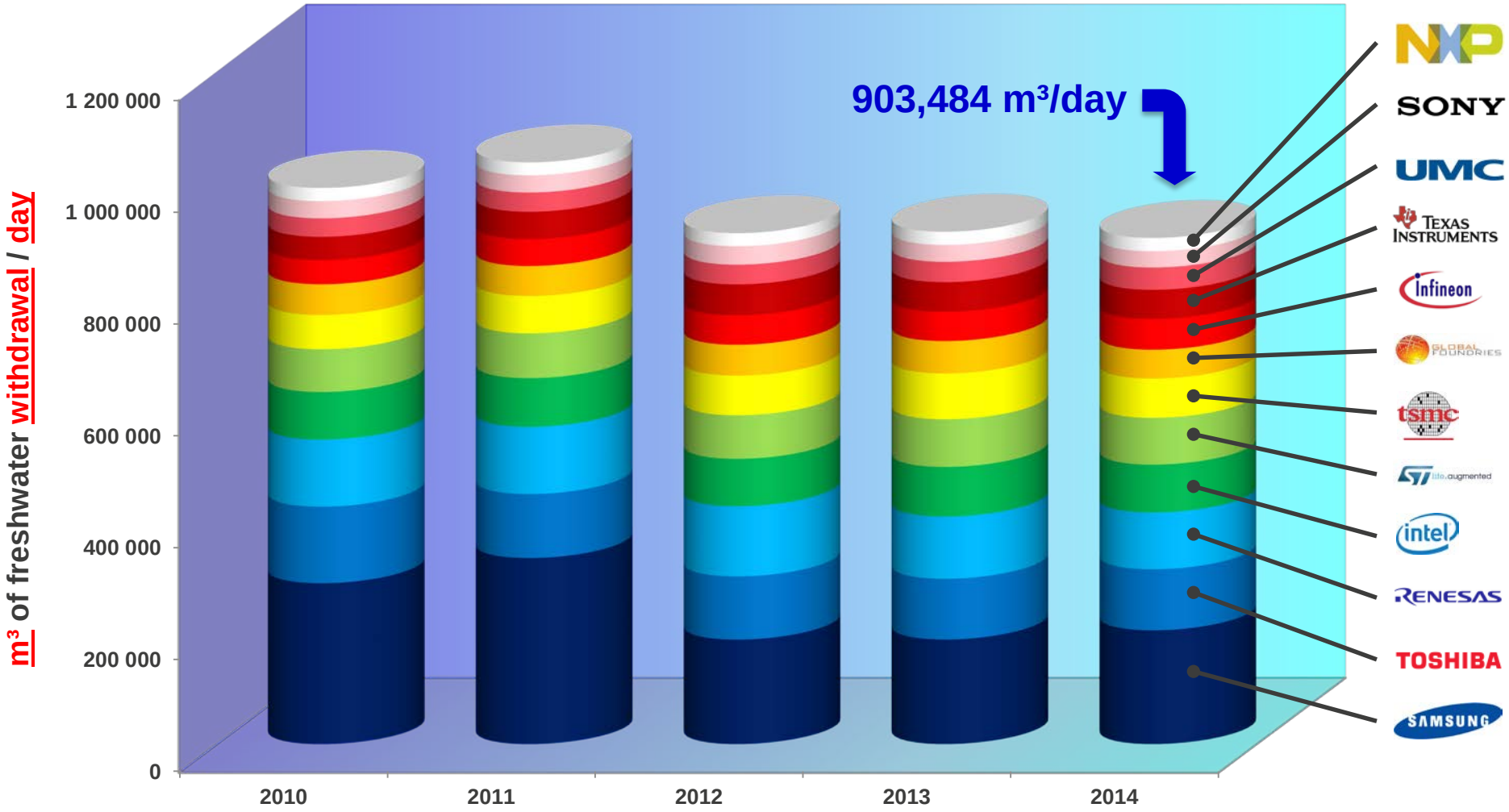
GLOBAL FOUNDRIES

Saratoga County Water Authority approved a 10-year contract to sell water to GlobalFoundries. About 19,000 m^3/day, which is more than **all of its other customers combined.**

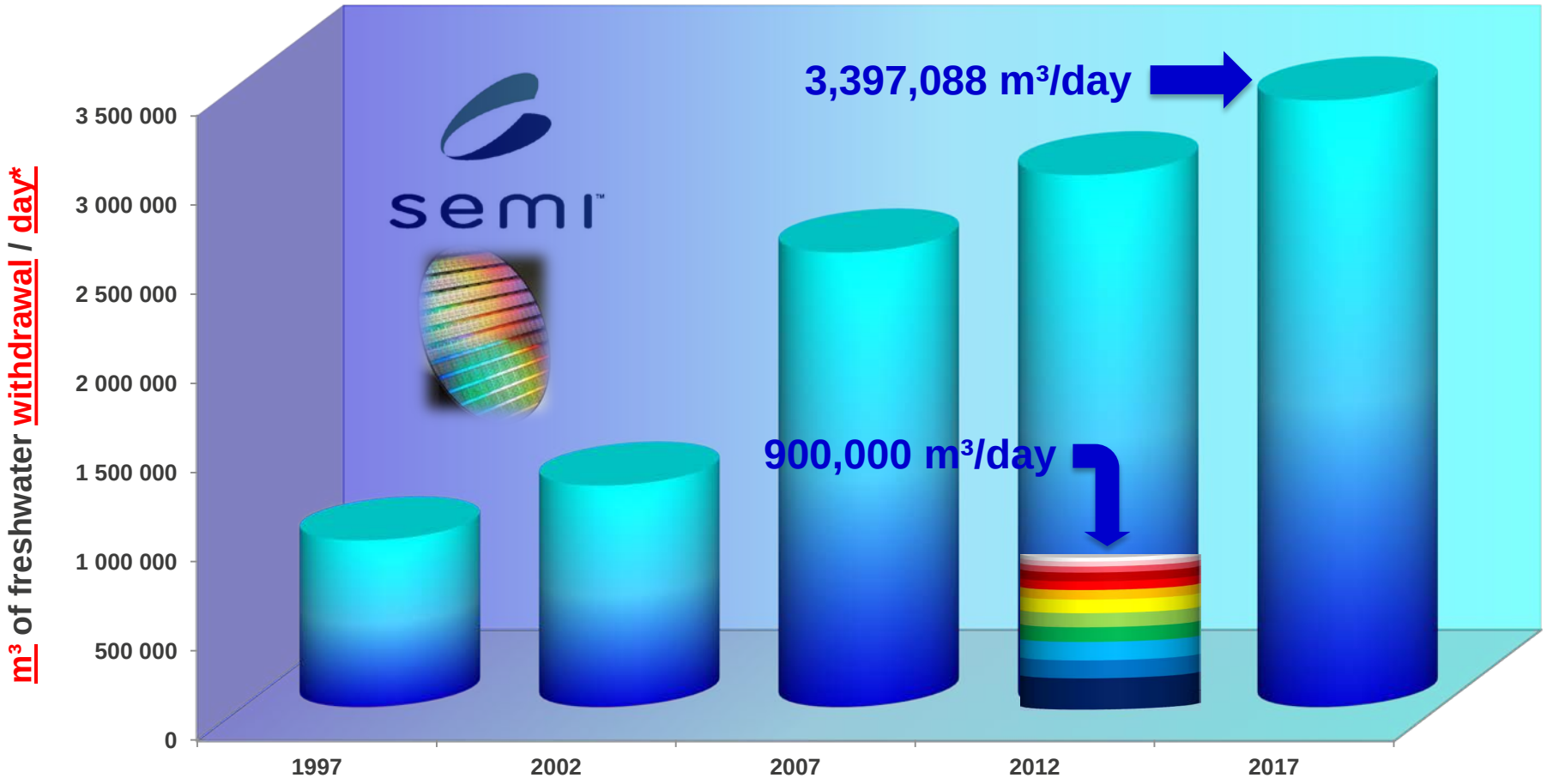
GlobalFoundries' FAB-8, Malta, USA (Close to Saratoga Lake)

http://poststar.com/news/local/saratoga-county-water-authority-inks-deal-with-globalfoundries/article_7b7651ae-7461-11e1-befc-0019bb2963f4.html

: Important Freshwater Withdrawal



: Important Freshwater Withdrawal



*** Assuming 5.0m³/200mm wafer**

http://www.semi.org/en/en/node/56726?id=fabpage

: Important Freshwater Withdrawal

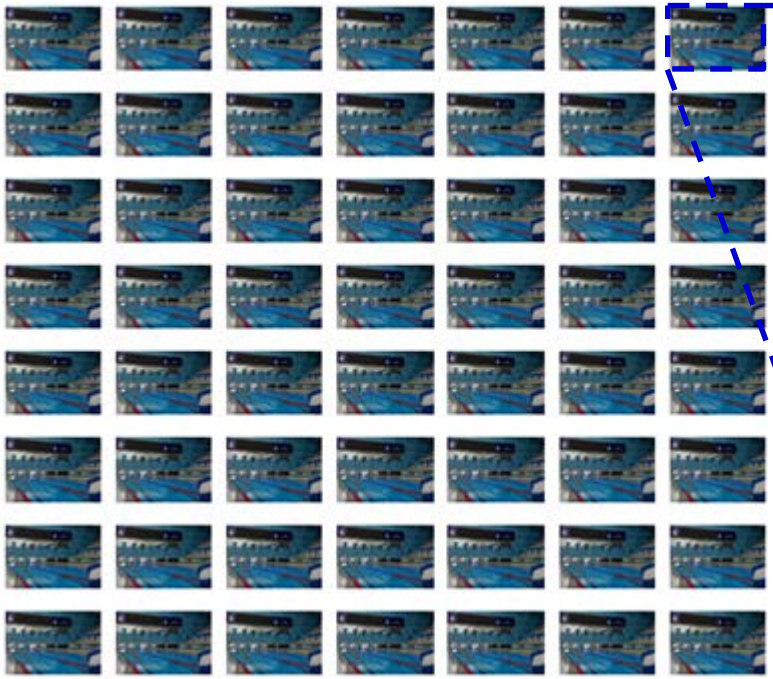
Asia's Top 3 Wastewater Treatment Plants

	Mm^3/Day
Shanghai Bailonggang	2.00
Hong Kong Stonecutters	1.70
Tokyo Morigasaki	1.54
	5.24

http://www.lselectric.com/the-top-10-biggest-wastewater-treatment-plants/

: Important Freshwater Withdrawal

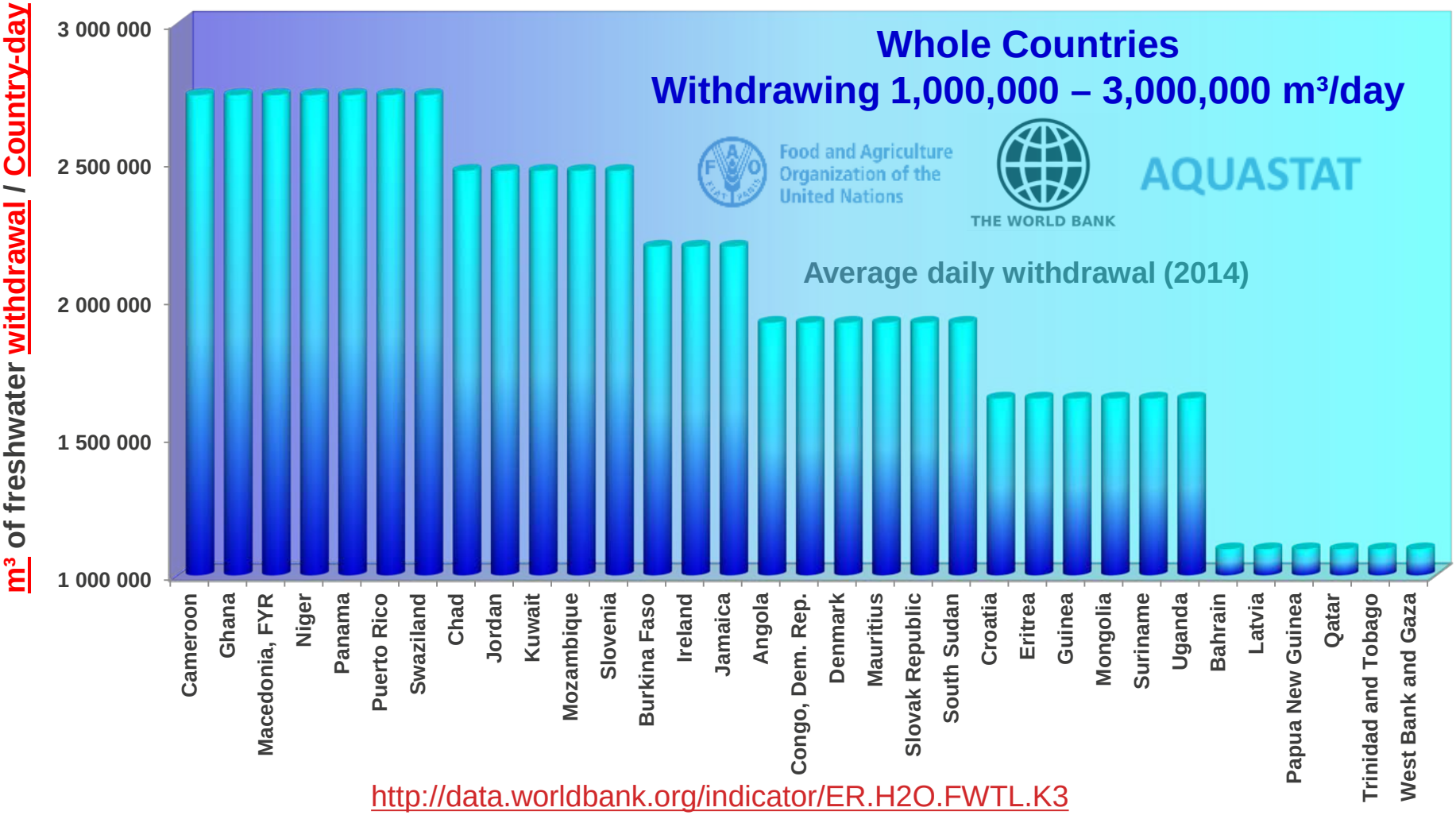
3,397,088 m³/day



2,500m³ freshwater per Olympic sized swimming pool (Baku 2015 European Games)

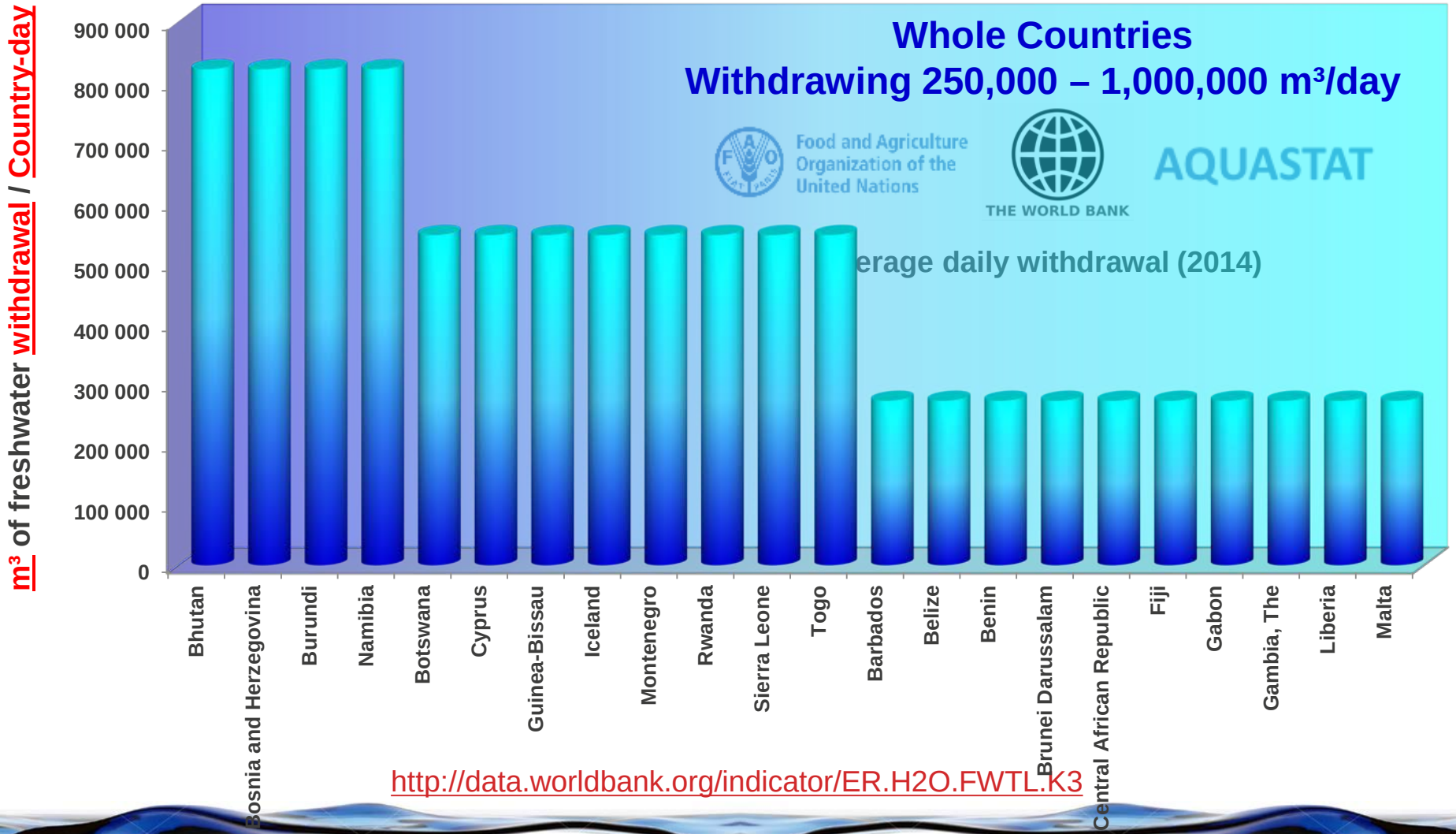
https://en.wikipedia.org/wiki/Olympic-size_swimming_pool

: Important Freshwater Withdrawal



http://data.worldbank.org/indicator/ER.H2O.FWTL.K3

: Important Freshwater Withdrawal



http://data.worldbank.org/indicator/ER.H2O.FWTL.K3

: Important Freshwater Withdrawal

- Antigua and Barbuda
- Cabo Verde
- Comoros
- Congo, Rep.
- Djibouti
- Dominica
- Equatorial Guinea
- Grenada
- Lesotho
- Luxembourg
- Maldives
- Monaco
- Sao Tome & Principe
- Seychelles
- St. Kitts and Nevis
- St. Lucia
- St. Vincent and the Grenadines
- American Samoa
- Andorra
- Aruba
- Bahamas, The
- Bermuda
- Cayman Islands
- Curacao
- Faroe Islands
- French Polynesia
- Greenland
- Guam

Whole Countries
Withdrawing <250,000 m³/day

Food and Agriculture Organization of the United Nations

THE WORLD BANK

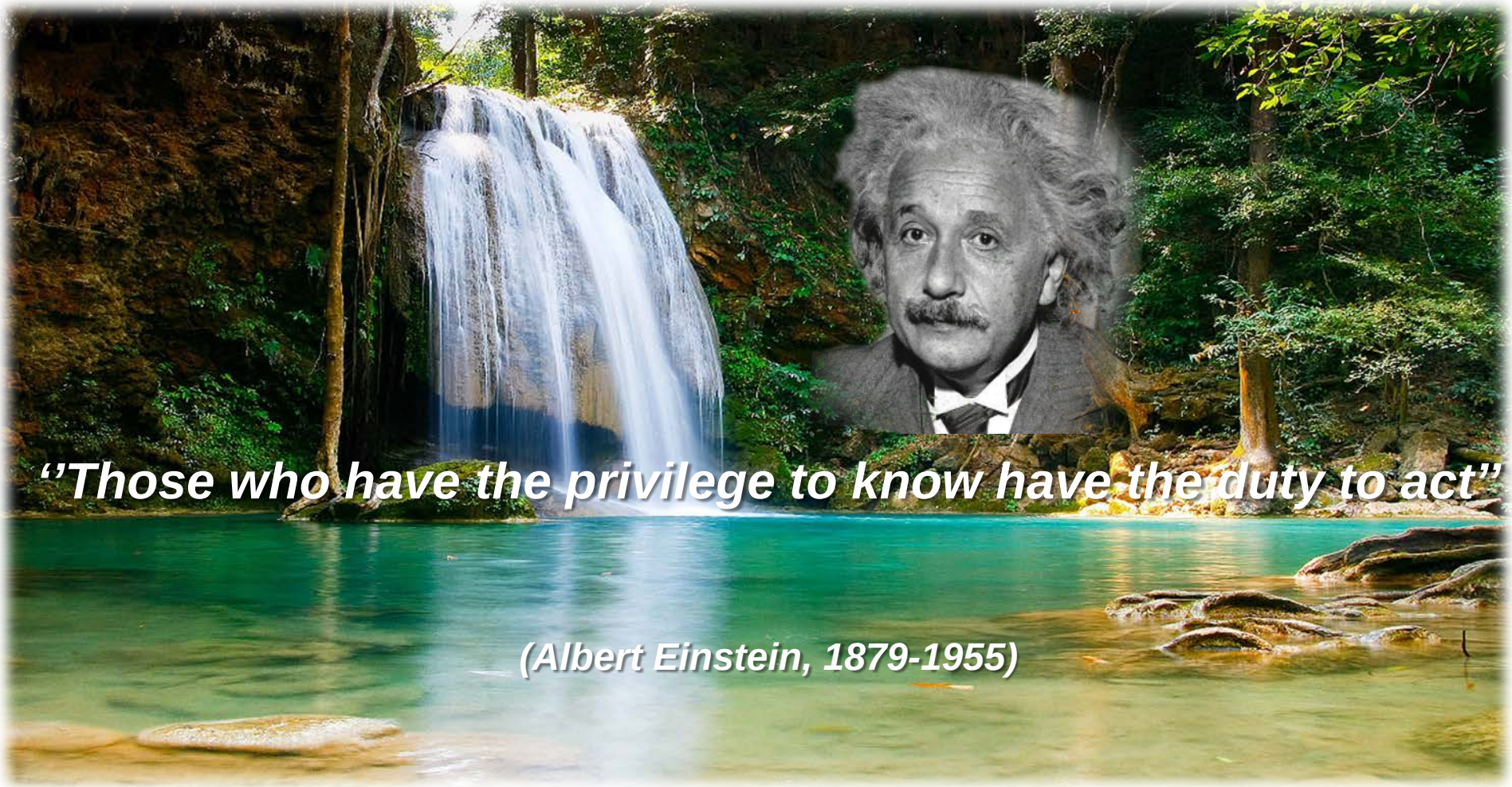
AQUASTAT

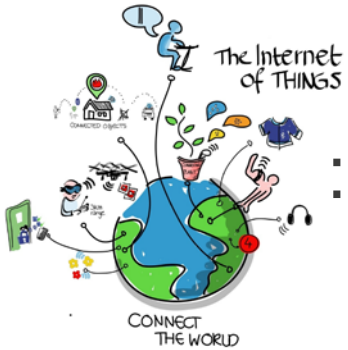
Average daily withdrawal (2014)

- Isle of Man
- Kiribati
- Liechtenstein
- Macao SAR, China
- Marshall Islands
- Micronesia, Fed. Sts.
- New Caledonia
- Northern Mariana Ils
- Palau
- Samoa
- San Marino
- Singapore
- St Maarten (Dutch part)
- Solomon Islands
- St. Martin (French part)
- Tonga
- Turks & Caicos Islands
- Tuvalu, Vanuatu
- Virgin Islands (U.S.)

http://data.worldbank.org/indicator/ER.H2O.FWTL.K3

: Important Freshwater Withdrawal





: Acceleration of Freshwater Withdrawal

: Acceleration of Freshwater Withdrawal

: Acceleration of Freshwater Withdrawal

Internet of Things to overtake mobile phones by 2018: Report

Published Jun 1, 2016, 6:27 pm IST

Deccan Chronicle, June 1, 2016

: Acceleration of Freshwater Withdrawal

http://www.leasocial.net/wp-content/uploads/2014/12/Cours-10-LInternet_des_objets-20141208.pdf

: Acceleration of Freshwater Withdrawal

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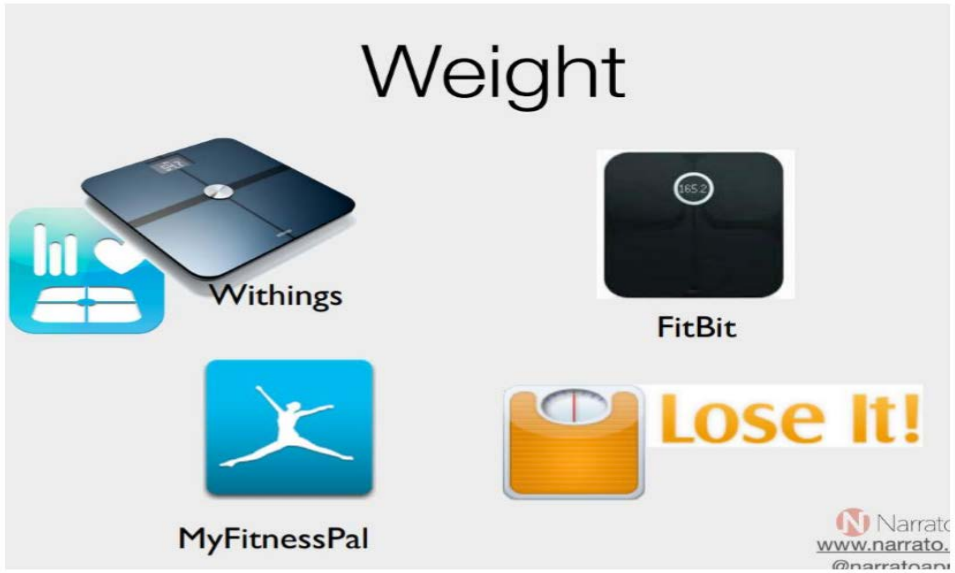

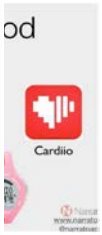

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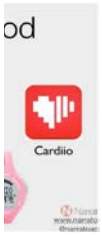
: Acceleration of Freshwater Withdrawal



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: Acceleration of Freshwater Withdrawal

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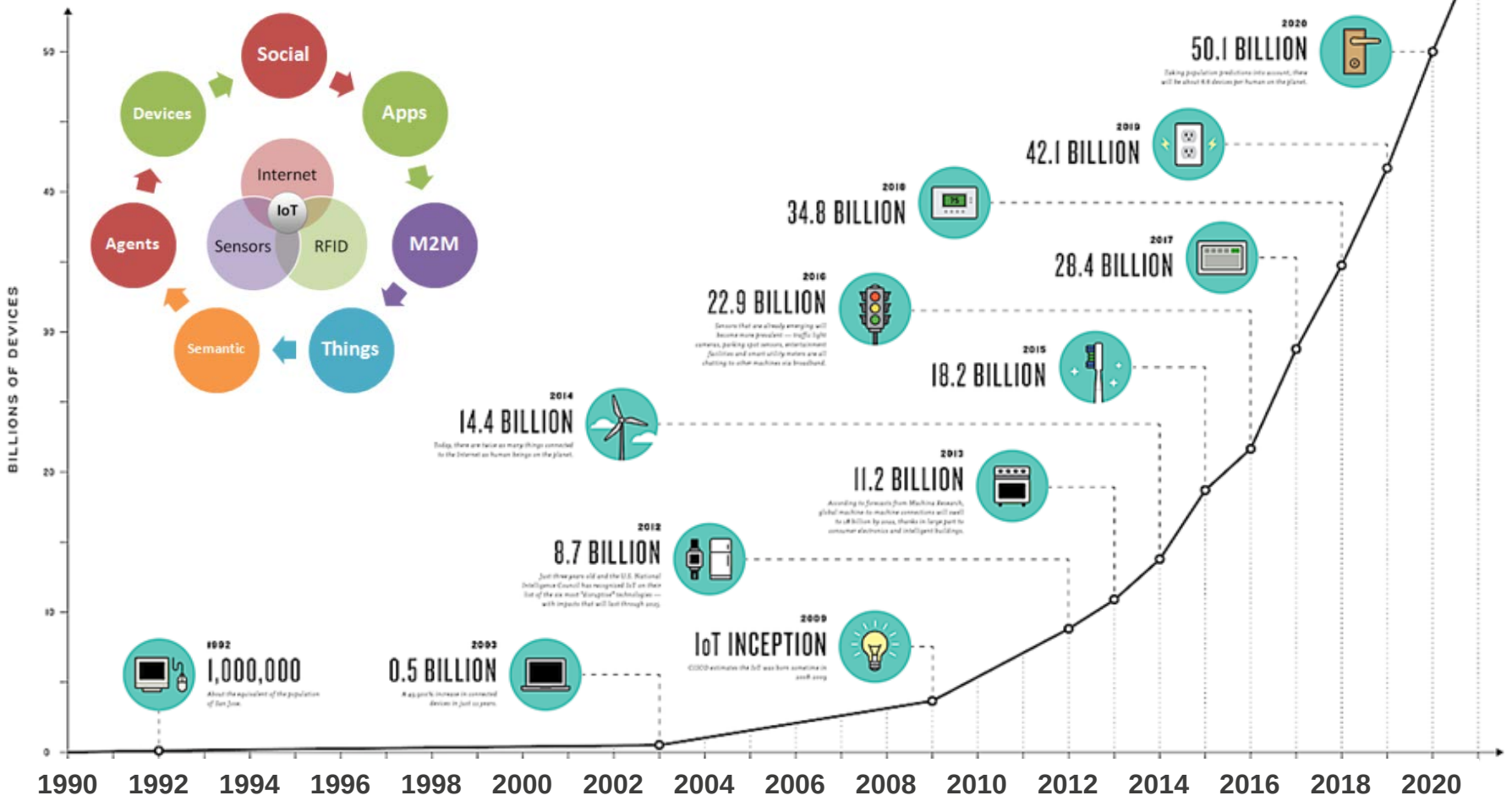
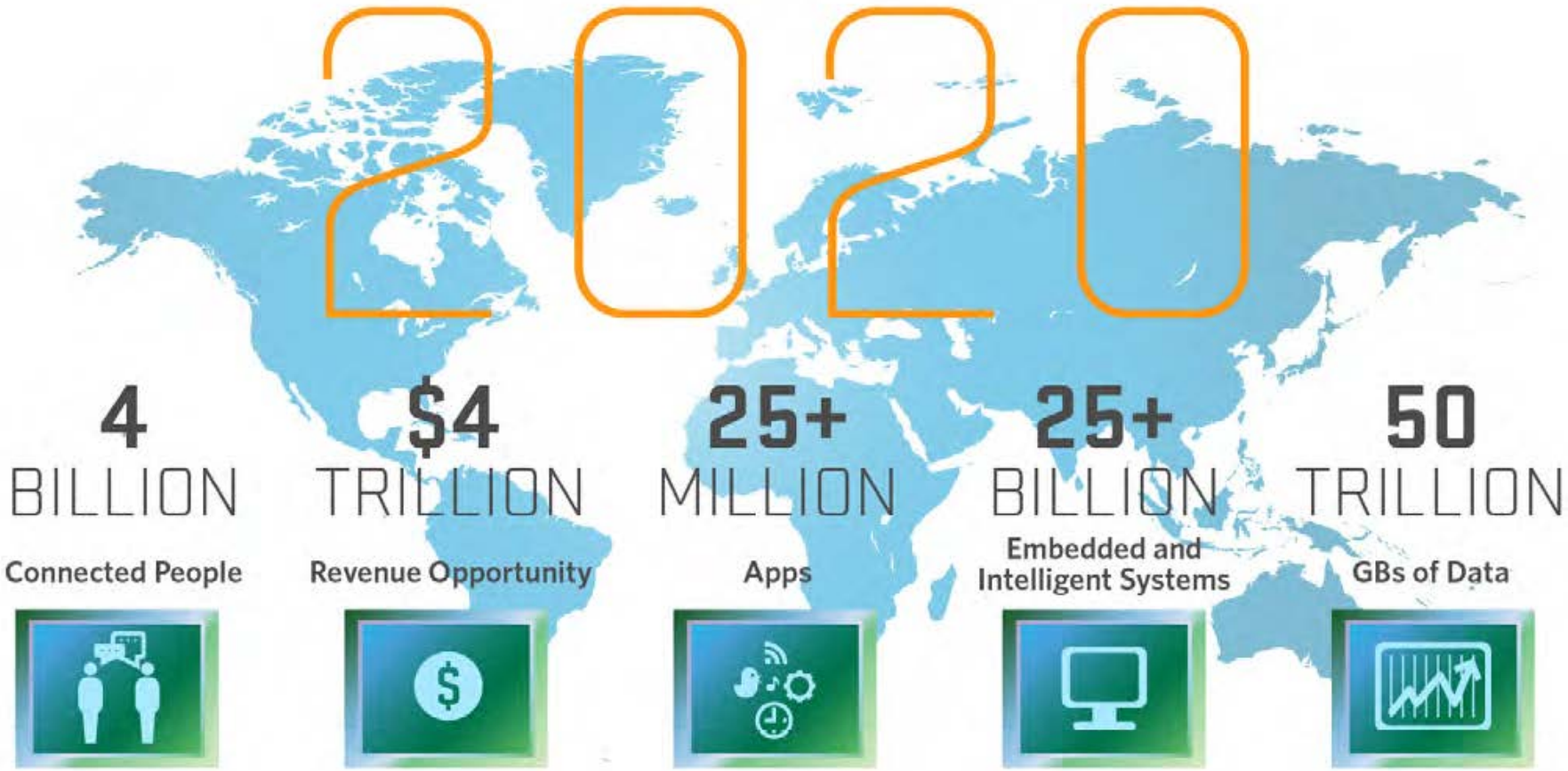
: Acceleration of Freshwater Withdrawal



http://www.theconnectivist.com/2014/05/infographic-the-growth-of-the-internet-of-things/

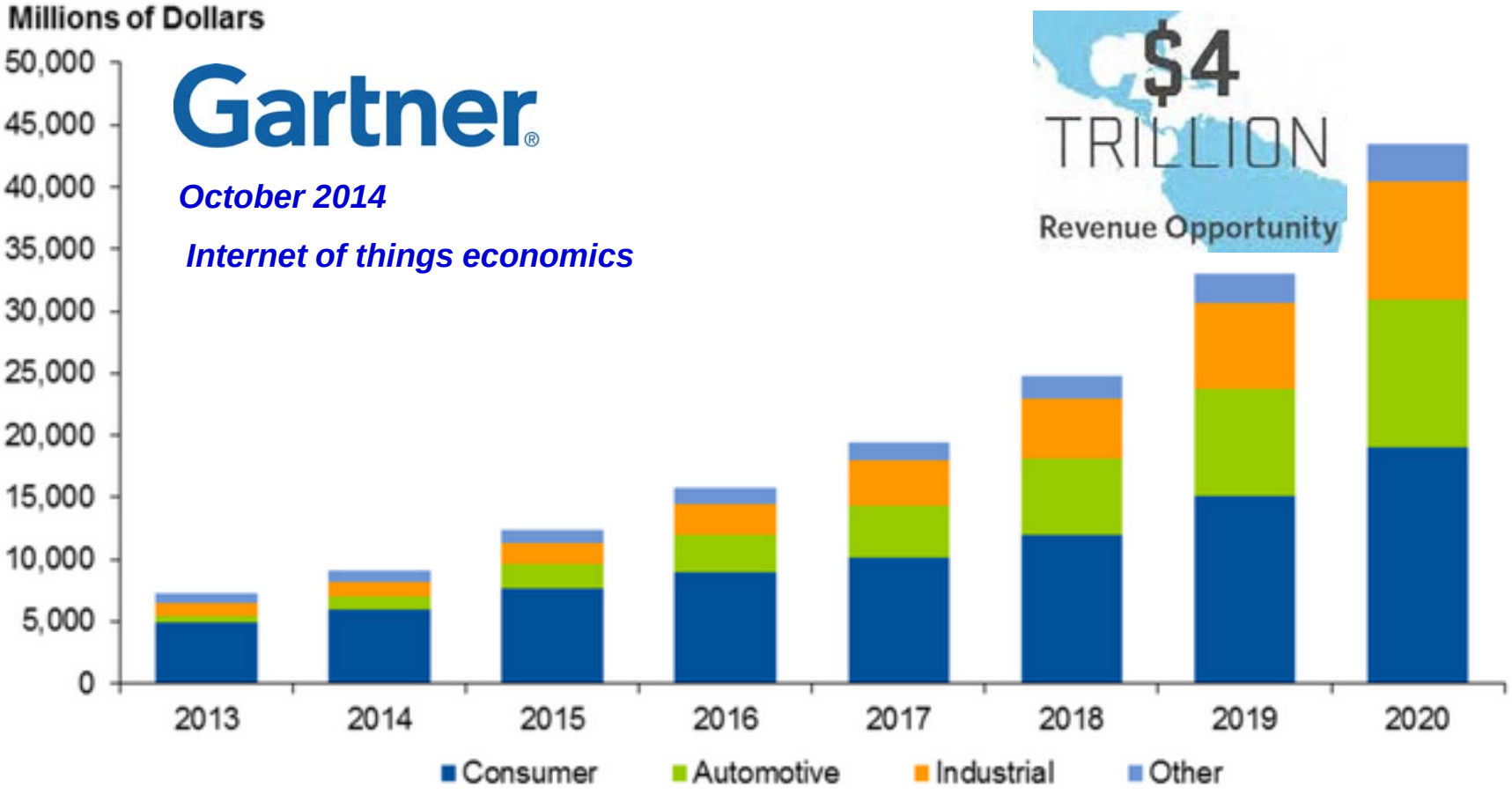
: Acceleration of Freshwater Withdrawal



Source: Mario Morales, IDC

http://trak.in/tags/business/2016/05/04/internet-of-things-revolution/

: Acceleration of Freshwater Withdrawal



Gartner®

October 2014

Internet of things economics

$4 TRILLION Revenue Opportunity

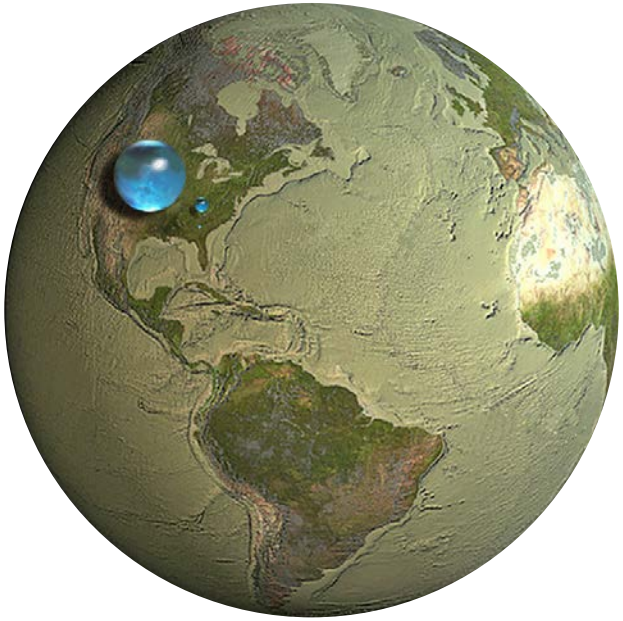
http://www.gartner.com/newsroom/id/2895917

: Acceleration of Freshwater Withdrawal

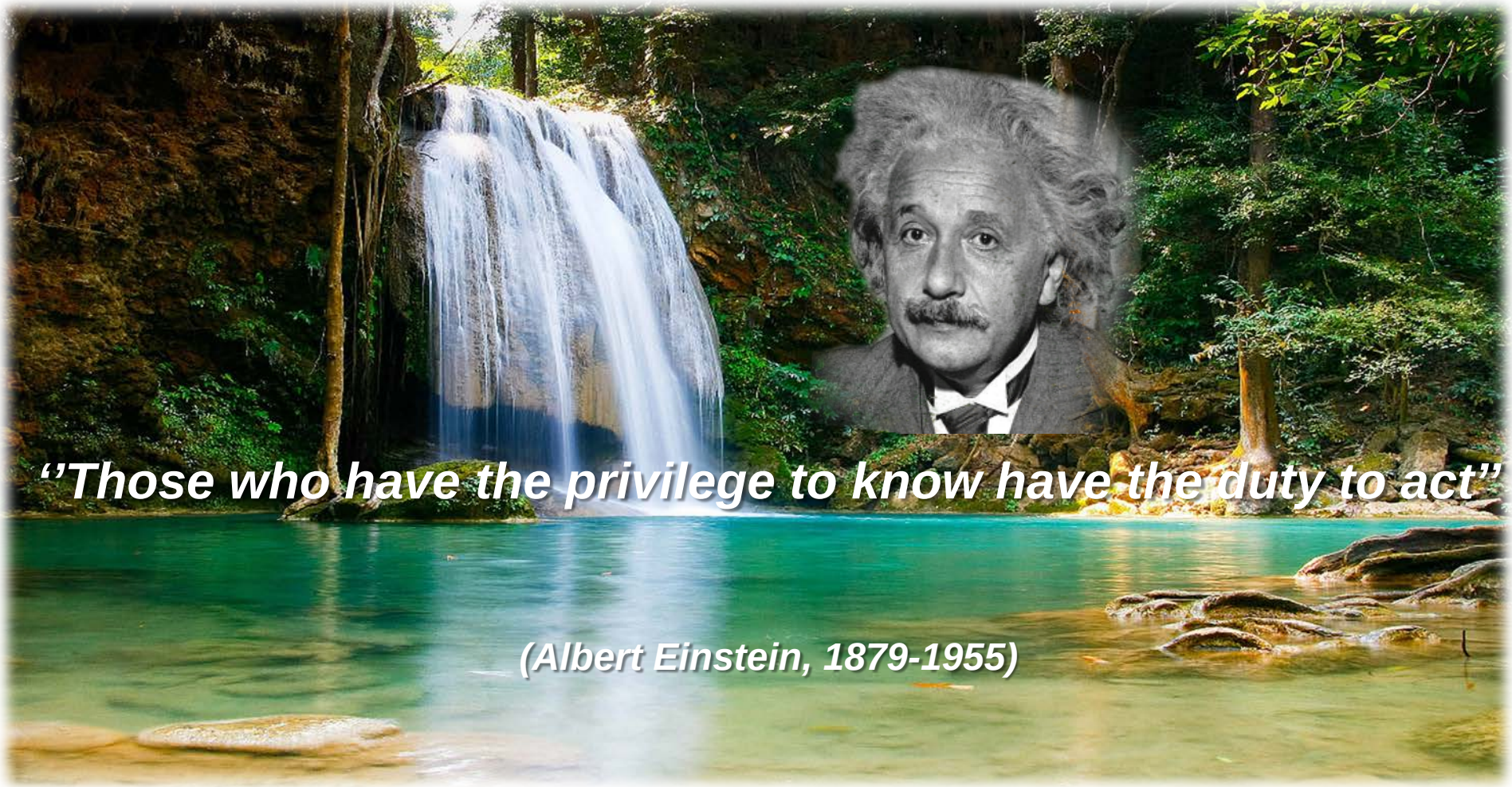
Fresh (Safe)

World Health Organization

Water



: Acceleration of Freshwater Withdrawal



''Those who have the privilege to know have the duty to act''

(Albert Einstein, 1879-1955)

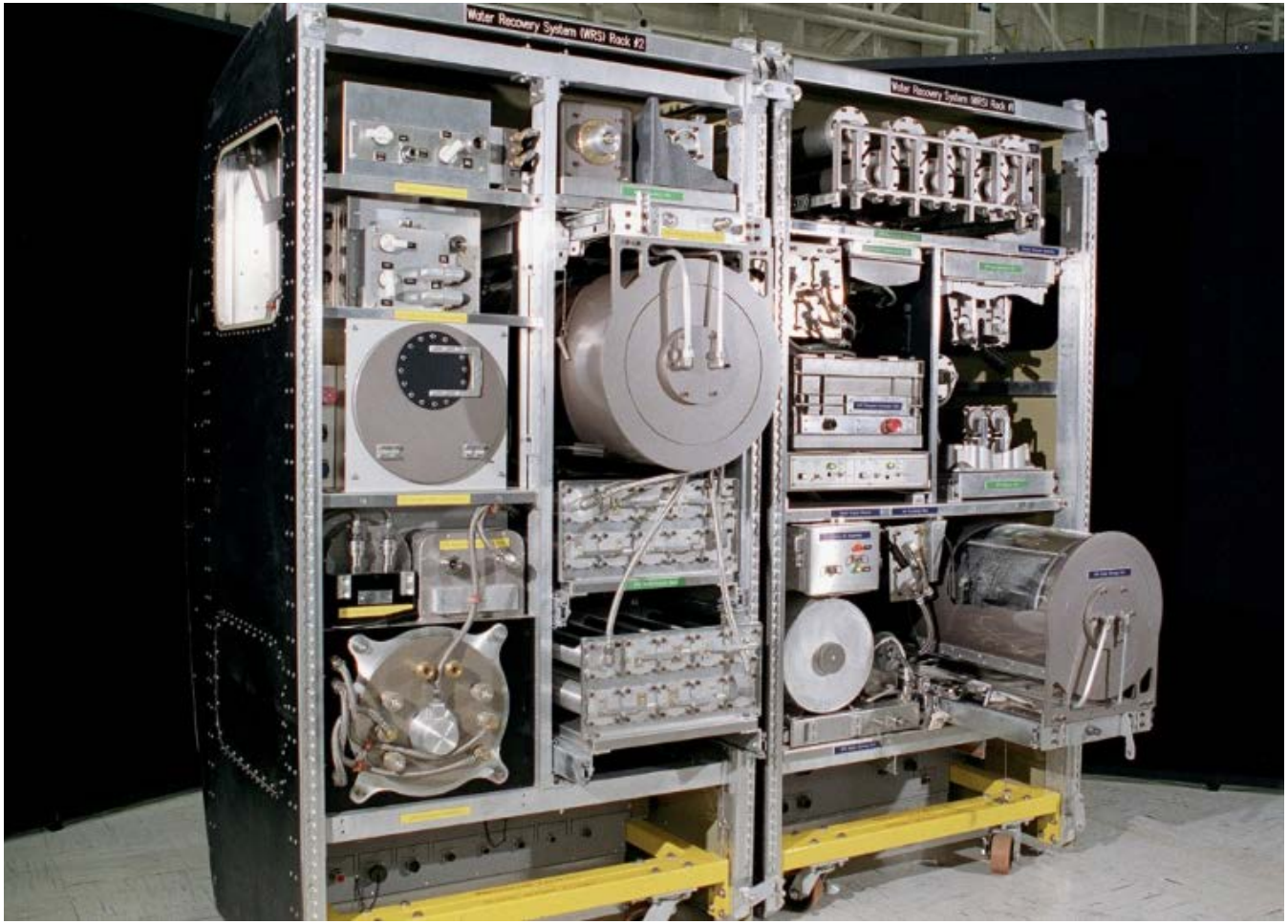
NASA : Water Recycling Technologies

NASA: Water Recycling Technologies

- Impractical to stock water in the International Space Station
- ISS' closed loop system does recycle water from urine
- NASA:
  - ✓ "The water that we produce meets or exceeds most municipal water product standards"
  - ✓ "It tastes like bottled water"

https://www.nasa.gov/pdf/146558main_RecyclingEDA(final)%204_10_06.pdf
http://www.iflscience.com/space/american-astronauts-drink-eachother-pee-russians-refuse/

NASA: Water Recycling Technologies



http://www.universetoday.com/101775/an-inside-look-at-the-waterurine-recycling-system-on-the-space-station/

NASA: Water Recycling Technologies

- The Environmental Control and Life Support System (ECLSS) water recycling system prevent the launch of roughly 10,000 pounds of water per crew member.
- ECLSS reclaims wastewater in a 3-step process:
  - ✓ Filter for particles and debris
  - ✓ Semipermeable membranes for organics & inorganics
  - ✓ Catalytic oxidation for VOCs & bacteria
- Good to the last drop !

http://www.space.com/10725-space-spinoff-technology-water-recycling.html

C2MI - LIMS : UPW* - Organics

* Ultra Pure Water

C2MI - LIMS : UPW - Organics

Pesticides

- Diquat < 50 µg/L
- Diuron < 100 µg/L
- Carbaryl < 70 µg/L
- Phorate < 1.4 µg/L
- Diazinon < 14 µg/L
- Dicamba < 85 µg/L
- Terbufos < 0.5 µg/L
- Parathion < 35 µg/L
- Simazine < 9.0 µg/L
- Dinosèbe < 7.0 µg/L
- Trifluraline < 35 µg/L
- Cyanazine < 9.0 µg/L
- Bromoxynil < 3.5 µg/L
- Paraquat (en dichlorures) < 7.0 µg/L
- Atrazine et ses métabolites < 3.5 µg/L
- Aldicarbe et ses métabolites < 7.0 µg/L
- Acide dichloro-2,4-phénoxyacétique (2,4-D) < 70 µg/L
- Acide (4-chloro-2-méthylphénoxy) acétique < 30 µg/L

Pesticides

- Malathion < 140 µg/L
- Diméthoate < 14 µg/L
- Piclorame < 140 µg/L
- Métribuzine < 60 µg/L
- Chlorpyrifos < 70 µg/L
- Carbofurane < 70 µg/L
- Glyphosate < 210 µg/L
- Bendiocarbe < 27 µg/L
- Métolachlore < 35 µg/L
- Méthoxychlore < 700 µg/L
- Diclofop-méthyle < 7.0 µg/L
- Azinphos-méthyle < 17 µg/L
- Aldrine et dieldrine < 0.7 µg/L

Autres substances organiques

- Microcystines (équiv. toxique de microsytine-LR) < 1.5 µg/L
- Tétrachloro-2,3,4,6 phénol < 70 µg/L
- Tétrachlorure de carbone < 5.0 µg/L
- Acides haloacétiques < 60 µg/L
- Trichloro-2,4,6 phénol < 5.0 µg/L
- Benzo(a)pyrène < 0.01 µg/L
- Nitrilotriacétique, acide (NTA) < 280 µg/
- Benzène < 0.5 µg/L
- Trihalométhanes < 80 µg/L
- Dichlorométhane < 50 µg/L
- Trichloroéthylène < 5.0 µg/L
- Pentachlorophénol < 42 µg/L
- Chlorure de vinyle < 2.0 µg/L
- Tétrachloroéthylène < 25 µg/L
- Dichloro-1,2 éthane < 5.0 µg/L
- Monochlorobenzène < 60 µg/L
- Dichloro-2,4 phénol < 700 µg/L
- Dichloro-1,1 éthylène < 10 µg/L
- Dichloro-1,4 benzène < 5.0 µg/L
- Dichloro-1,2 benzène < 150 µg/L

LégisQuébec Source officielle

Publications Québec

Développement durable, Environnement et Lutte contre les changements climatiques

Québec

Loi sur la qualité de l'environnement - Règlement sur la qualité de l'eau potable

C2MI - LIMS : UPW - Organics

Pesticides

- Diquat < 2.0 µg/L
- Diuron < 0.5 µg/L
- Carbaryl < 0.05 µg/L
- Phorate < 0.07 µg/L
- Diazinon < 0.04 µg/L
- Dicamba < 0.1 µg/L
- Terbufos < 0.05 µg/L
- Parathion < 0.15 µg/L
- Simazine < 0.01 µg/L
- Dinosèbe < 0.1 µg/L
- Trifluraline < 0.05 µg/L
- Cyanazine < 0.03 µg/L
- Bromoxynil < 0.05 µg/L
- Paraquat (en dichlorures) < 0.3 µg/L
- Atrazine et ses métabolites < 0.1 µg/L
- Aldicarbe et ses métabolites < N/A
- Acide dichloro-2,4-phénoxyacétique (2,4-D) < 0.1 µg/L
- Acide (4-chloro-2-méthylphénoxy) acétique < 0.3 µg/L

Pesticides

- Malathion < 0.02 µg/L
- Diméthoate < 0.03 µg/L
- Piclorame < 0.05 µg/L
- Métribuzine < 0.02 µg/L
- Chlorpyrifos < 0.04 µg/L
- Carbofurane < 0.07 µg/L
- Glyphosate < 1.0 µg/L
- Bendiocarbe < 0.03 µg/L
- Métolachlore < 0.03 µg/L
- Méthoxychlore < 0.02 µg/L
- Diclofop-méthyle < 0.1 µg/L
- Azinphos-méthyle < 0.05 µg/L
- Aldrine et dieldrine < N/A

Autres substances organiques

- Microcystines (équiv. toxique de microsytine-LR) < N/A
- Tétrachloro-2,3,4,6 phénol < 0.3 µg/L
- Tétrachlorure de carbone < 0.1 µg/L
- Acides haloacétiques < N/A
- Trichloro-2,4,6 phénol < 0.3 µg/L
- Benzo(a)pyrène < 0.002 µg/L
- Nitrilotriacétique, acide (NTA) < N/A
- Benzène < 0.1 µg/L
- Trihalométhanes < 23.4 µg/L
- Dichlorométhane < 0.3 µg/L
- Trichloroéthylène < 0.1 µg/L
- Pentachlorophénol < 0.4 µg/L
- Chlorure de vinyle < 0.1 µg/L
- Tétrachloroéthylène < 0.1 µg/L
- Dichloro-1,2 éthane < 0.1 µg/L
- Monochlorobenzène < 0.1 µg/L
- Dichloro-2,4 phénol < 0.3 µg/L
- Dichloro-1,1 éthylène < 0.1 µg/L
- Dichloro-1,4 benzène < 0.1 µg/L
- Dichloro-1,2 benzène < 0.1µg/L

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C2MI - LIMS : UPW - Organics

Pesticides

- Diquat
- Diuron
- Carbaryl
- Phorate
- Diazinon
- Dicamba
- Terbufos
- Parathion
- Simazine
- Dinosèbe
- Trifluraline
- Cyanazine
- Bromoxynil
- Paraquat (en dichlorures)
- Atrazine et ses métabolites
- Aldicarbe et ses métabolites
- Acide dichloro-2,4-phénoxyacétique (2,4-D)
- Acide (4-chloro-2-méthylphénoxy) acétique

Pesticides

- Malathion
- Diméthoate
- Piclorame
- Métribuzine
- Chlorpyrifos
- Carbofurane
- Glyphosate
- Bendiocarbe
- Métolachlore
- Méthoxychlore
- Diclofop-méthyle
- Azinphos-méthyle
- Aldrine et dieldrine

Autres substances organiques

- Microcystines (équiv. toxique de microsytine-LR)
- Tétrachloro-2,3,4,6 phénol
- Tétrachlorure de carbone
- Acides haloacétiques
- Trichloro-2,4,6 phénol
- Benzo(a)pyrène
- Nitrilotriacétique, acide (NTA)
- Benzène
- Trihalométhanes
- Dichlorométhane
- Trichloroéthylène
- Pentachlorophénol
- Chlorure de vinyle
- Tétrachloroéthylène
- Dichloro-1,2 éthane
- Monochlorobenzène
- Dichloro-2,4 phénol
- Dichloro-1,1 éthylène
- Dichloro-1,4 benzène
- Dichloro-1,2 benzène

ASTM INTERNATIONAL Standards Worldwide

ASTM E-1 UPW

Standard Guide for Ultra-Pure Water Used in the Electronics and Semiconductor Industries (ASTM D5127-13)

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C2MI

BALAZS™ nanoanalysis

Analyseur TOC R2_AIT127_PV.PV

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- Dichloro-1,2 benzène

C2MI - LIMS : UPW* - Metals

* Ultra Pure Water

C2MI - LIMS : UPW - Metals

- Aluminum – N/A
- Antimony < 6.0 µg/L
- Arsenic < 10 µg/L
- **Barium < 1,000 µg/L**
- Bismuth - N/A
- **Boron < 5,000 µg/L**
- Cadmium < 5.0 µg/L
- Calcium - N/A
- Chromium < 50 µg/L
- Cobalt - N/A
- **Copper < 1,000 µg/L**
- Gallium - N/A
- Germanium - N/A
- Iron - N/A
- Lead < 10 µg/L
- Lithium - N/A
- Magnesium - N/A
- Manganese - N/A
- Mercury < 1.0 µg/L
- Molybdenum - N/A
- Nickel - N/A
- Potassium - N/A
- Selenium < 10 µg/L
- Silver - N/A
- Sodium - N/A
- Strontium - N/A
- Tin - N/A
- Titanium - N/A
- Tungsten - N/A
- Uranium < 20 µg/L
- Vanadium - N/A
- Zinc - N/A

LégisQuébec Source officielle

Publications Québec

Développement durable, Environnement et Lutte contre les changements climatiques Québec

Loi sur la qualité de l'environnement - Règlement sur la qualité de l'eau potable

C2MI - LIMS : UPW - Metals

- Aluminum < 10 µg/L
- Antimony < 1.0 µg/L
- Arsenic < 1.0 µg/L
- Barium < 20 µg/L
- Bismuth - N/A
- Boron < 20 µg/L
- Cadmium < 0.5 µg/L
- Calcium - N/A
- Chromium < 1.0 µg/L
- Cobalt - N/A
- Copper < 1.0 µg/L
- Gallium - N/A
- Germanium - N/A
- Iron < 5.0 µg/L
- Lead < 1.0 µg/L
- Lithium - N/A
- Magnesium - N/A
- Manganese < 14 µg/L
- Mercury < 0.1 µg/L
- Molybdenum - N/A
- Nickel - N/A
- Potassium - N/A
- Selenium < 2.0 µg/L
- Silver - N/A
- Sodium - N/A
- Strontium - N/A
- Tin - N/A
- Titanium - N/A
- Tungsten - N/A
- Uranium < 1.0 µg/L
- Vanadium - N/A
- Zinc - N/A

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C2MI - LIMS : UPW - Metals

- Aluminum < 0.05 µg/L
- Antimony - N/A
- Arsenic - N/A
- Barium < 0.05 µg/L
- Bismuth - N/A
- Boron < 0.30 µg/L
- Cadmium - N/A
- Calcium < 0.05 µg/L
- Chromium < 0.05 µg/L
- Cobalt - N/A
- Copper < 0.05 µg/L
- Gallium - N/A
- Germanium - N/A
- Iron < 0.05 µg/L
- Lead < 0.05 µg/L
- Lithium < 0.05 µg/L
- Magnesium < 0.05 µg/L
- Manganese < 0.05 µg/L
- Mercury – N/A
- Molybdenum - N/A
- Nickel < 0.05 µg/L
- Potassium < 0.05 µg/L
- Selenium – N/A
- Silver - N/A
- Sodium < 0.05 µg/L
- Strontium < 0.05 µg/L
- Tin - N/A
- Titanium - N/A
- Tungsten - N/A
- Uranium – N/A
- Vanadium - N/A
- Zinc < 0.05 µg/L

ASTM INTERNATIONAL Standards Worldwide

ASTM E-1 UPW

Standard Guide for Ultra-Pure Water Used in the Electronics and Semiconductor Industries (ASTM D5127-13)

C2MI - LIMS : UPW - Metals

- Aluminum < 0.002 µg/L
- Antimony < 0.002 µg/L
- Arsenic < 0.003 µg/L
- Barium < 0.0005 µg/L
- Bismuth < 0.001 µg/L
- Boron = **0.077 µg/L**
- Cadmium < 0.003 µg/L
- Calcium < 0.02 µg/L
- Chromium < 0.003 µg/L
- Cobalt < 0.0005 µg/L
- Copper < 0.002 µg/L
- Gallium < 0.001 µg/L
- Germanium < 0.003 µg/L
- Iron < 0.01 µg/L
- Lead < 0.001 µg/L
- Lithium < 0.001 µg/L
- Magnesium < 0.002 µg/L
- Manganese < 0.002 µg/L
- Mercury < 0.02 µg/L
- Molybdenum < 0.004 µg/L
- Nickel < 0.002 µg/L
- Potassium < 0.01 µg/L
- Selenium – N/A
- Silver < 0.001 µg/L
- Na < 0.005 µg/L
- Sr < 0.0005 µg/L
- Tin < 0.003 µg/L
- Ti < 0.002 µg/L
- W < 0.005 µg/L
- Uranium – N/A
- V < 0.001 µg/L
- Zinc < 0.005 µg/L

C2MI

BALAZS nanoanalysis

Balasz W0174-UPW-N-R-C Metals (Inductively Coupled Plasma – Mass Spectrometry)

C2MI - LIMS : UPW - Metals

- Aluminum **= 0.024 µg/L**
- Antimony < 0.002 µg/L
- Arsenic < 0.003 µg/L
- Barium **= 0.0013 µg/L**
- Bismuth < 0.001 µg/L
- Boron = **0.130 µg/L**
- Cadmium < 0.003 µg/L
- **Calcium < 3.500 µg/L**
- Chromium < 0.003 µg/L
- Cobalt **= 0.0009 µg/L**
- Copper **= 0.030 µg/L**
- Gallium < 0.001 µg/L
- Germanium < 0.003 µg/L
- Iron **= 0.053 µg/L**
- Lead < 0.001 µg/L
- Lithium < 0.001 µg/L
- Magnesium **= 0.26 µg/L**
- Manganese **= 0.005 µg/L**
- Mercury < 0.02 µg/L
- Molybdenum < 0.004 µg/L
- Nickel **= 0.006 µg/L**
- Potassium **= 0.46 µg/L**
- Selenium – N/A
- Silver < 0.001 µg/L
- **Na = 2.400 µg/L**
- Sr **= 0.010 µg/L**
- Tin < 0.003 µg/L
- Ti < 0.002 µg/L
- W = **0.026 µg/L**
- Uranium – N/A
- V < 0.001 µg/L
- Zinc **= 0.051 µg/L**

Balasz W0174-UPW-N-R-C Metals (Inductively Coupled Plasma – Mass Spectrometry)

C2MI - LIMS : UPW - Metals

- Aluminum **= 0.22 µg/L**
- Antimony < 0.02 µg/L
- Arsenic < 0.02 µg/L
- Barium **= 0.03 µg/L**
- Bismuth < 0.04 µg/L
- Boron < 0.5 µg/L
- Cadmium < 0.03 µg/L
- Calcium **= 3.2 µg/L**
- Chromium < 0.03 µg/L
- Cobalt < 0.02 µg/L
- Copper **= 1.0 µg/L**
- Gallium < 0.04 µg/L
- Germanium < 0.05 µg/L
- Iron **= 0.3 µg/L**
- Lead < 0.05 µg/L
- Lithium < 0.03 µg/L
- Magnesium **= 0.43 µg/L**
- Manganese < 0.03 µg/L
- Mercury < 0.05 µg/L
- Molybdenum < 0.05 µg/L
- Nickel < 0.05 µg/L
- **Potassium = 2.3 µg/L (KOH in slurry)**
- Selenium – N/A
- Silver < 0.03 µg/L
- Na **= 12.0 µg/L**
- Sr **= 0.02 µg/L**
- **Tin = 0.011 µg/L**
- Ti < 0.05 µg/L
- W < 0.02 µg/L
- Uranium – N/A
- V < 0.03 µg/L
- Zinc **= 0.16 µg/L**

Balasz W0174-UPW-N-R-C Metals (Inductively Coupled Plasma – Mass Spectrometry)

C2MI - LIMS : UPW* - Ions

* Ultra Pure Water

C2MI - LIMS : UPW - Ions

- Ammonium (NH_4^+) - N/A
- Bromide (Br^-) < 10.0 µg/L
- Chloride (Cl^-) < 4,600 µg/L
- Fluoride (F^-) < 1,500 µg/L
- Nitrate (NO_3^-) < 9,000 µg/L
- Nitrite (NO_2^-) < 1,000 µg/L
- Phosphate (HPO_4^{-2}) - N/A
- Sulphate (SO_4^{-2}) - N/A

LégisQuébec Source officielle

Publications Québec

Développement durable, Environnement et Lutte contre les changements climatiques Québec

Loi sur la qualité de l'environnement - Règlement sur la qualité de l'eau potable

C2MI - LIMS : UPW - Ions

- Ammonium (NH_4^+) - N/A
- Bromide (Br^-) < 0.1 µg/L (Detection Limit)
- **Chloride (Cl^-) = 36,400 µg/L**
- Fluoride (F^-) = 60 µg/L
- Nitrate (NO_3^-) = 70 µg/L
- Nitrite (NO_2^-) = 70 µg/L
- Phosphate (HPO_4^{-2}) - N/A
- Sulphate (SO_4^{-2}) - N/A

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C2MI - LIMS : UPW - Ions

- Ammonium (NH_4^+) < 0.10 µg/L
- Bromide (Br^-) < 0.10 µg/L
- Chloride (Cl^-) < 0.10 µg/L
- Fluoride (F^-) < 0.10 µg/L
- Nitrate (NO_3^-) < 0.10 µg/L
- Nitrite (NO_2^-) < 0.10 µg/L
- Phosphate (HPO_4^{-2}) < 0.10 µg/L
- Sulphate (SO_4^{-2}) < 0.10 µg/L

ASTM INTERNATIONAL Standards Worldwide

ASTM E-1 UPW

Standard Guide for Ultra-Pure Water Used in the Electronics and Semiconductor Industries (ASTM D5127-13)

C2MI - LIMS : UPW - Ions

- Ammonium (NH_4^+) < 0.02 µg/L (Detection Limit)
- Bromide (Br^-) < 0.02 µg/L (Detection Limit)
- Chloride (Cl^-) = **0.03 µg/L**
- Fluoride (F^-) < 0.03 µg/L (Detection Limit)
- Nitrate (NO_3^-) < 0.02 µg/L (Detection Limit)
- Nitrite (NO_2^-) < 0.02 µg/L (Detection Limit)
- Phosphate (HPO_4^{-2}) < 0.02 µg/L (Detection Limit)
- Sulphate (SO_4^{-2}) < 0.05 µg/L (Detection Limit)

Balasz W0121-UPW-N-R-C Ions (Ion Chromatography)

C2MI - LIMS : UPW - Ions

- Ammonium (NH_4^+) < 0.02 µg/L (Detection Limit)
- Bromide (Br^-) < 0.02 µg/L (Detection Limit)
- Chloride (Cl^-) = **2.70 µg/L**
- Fluoride (F^-) **= 2.00 µg/L**
- Nitrate (NO_3^-) < 0.02 µg/L (Detection Limit)
- Nitrite (NO_2^-) < 0.02 µg/L (Detection Limit)
- Phosphate (HPO_4^{-2}) < 0.02 µg/L (Detection Limit)
- Sulphate (SO_4^{-2}) **= 1.10 µg/L**

Balasz W0121-UPW-N-R-C Ions (Ion Chromatography)

C2MI - LIMS : UPW - Ions

- **Ammonium (NH_4^+) = 48,000 µg/L**
- Bromide (Br^-) < 50 µg/L (Detection Limit)
- Chloride (Cl^-) < 20 µg/L (Detection Limit)
- Fluoride (F^-) < 10 µg/L (Detection Limit)
- Nitrate (NO_3^-) < 50 µg/L (Detection Limit)
- **Nitrite (NO_2^-) = 710 µg/L**
- Phosphate (HPO_4^{-2}) < 50 µg/L (Detection Limit)
- Sulphate (SO_4^{-2}) < 50 µg/L (Detection Limit)
- **Silica Dissolved = 2,200 µg/L (SiO_2 Nanoparticles)**
- **Silica Total = 8,700 µg/L (SiO_2 Nanoparticles)**

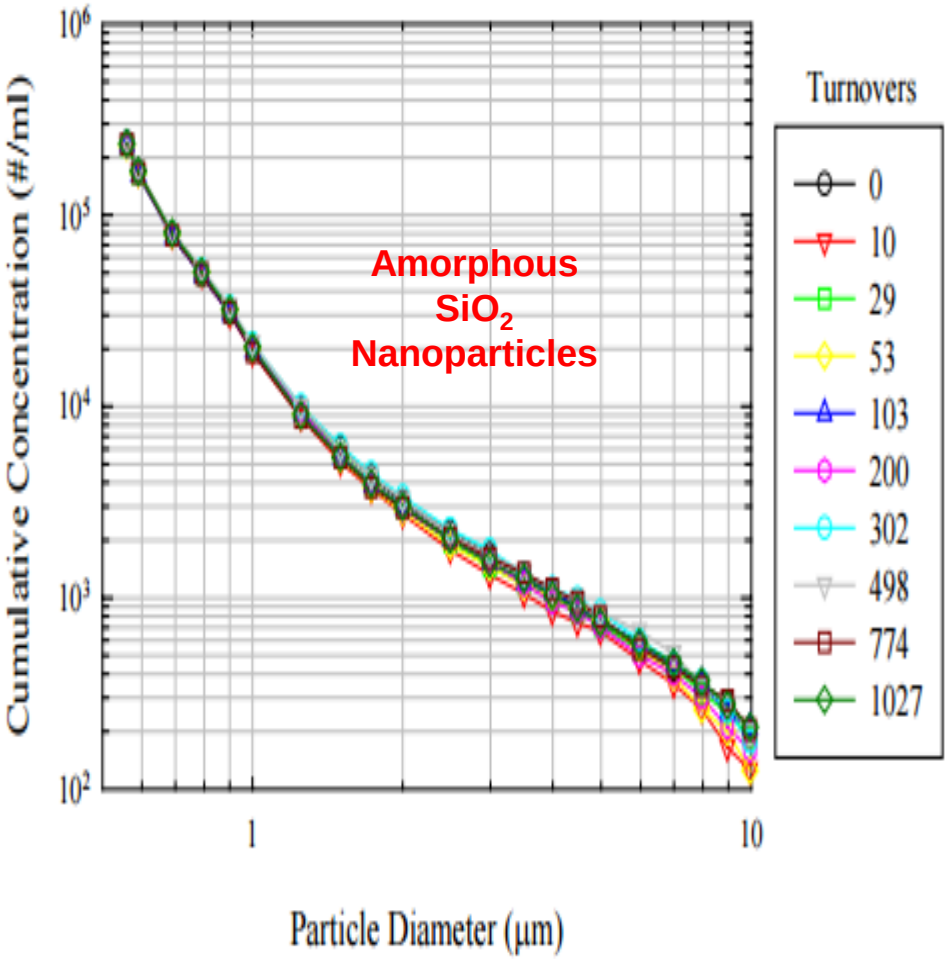
Balasz W0121-UPW-N-R-C Ions (Ion Chromatography)

C2MI - LIMS : UPW - Ions

CAS NO: 7732-18-5
COMPONENT: De-Ionized Water
PERCENT: 75
PERMISSIBLE
OSHA PEL: Not Applicable
ACGIH TOTAL DUST: Not Applicable

CAS NO: 1310-58-3
COMPONENT: Potassium Hydroxide
PERCENT: < 1
OSHA PEL: 2 mg/m3 C
ACGIH TOTAL DUST: Corrosive

CAS NO: 112945-52-5
COMPONENT: Silica, Amorphous, Fumed Crystalline Free
PERCENT: 25
OSHA PEL: *None Listed
ACGIH TLV: *None Listed



Balasz W0121-UPW-N-R-C Ions (Ion Chromatography)

C2MI - LIMS : UPW* - Recycling Infrastructure

* Ultra Pure Water

C2MI - LIMS : UPW* - Recycling Infrastructure

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Québec

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C2MI

BALAZS™ nanoanalysis

C2MI - LIMS : UPW - Organics

C2MI - LIMS : UPW* - Recycling Infrastructure

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C2MI

BALAZS™ nanoanalysis

C2MI - LIMS : UPW - Metals

C2MI - LIMS : UPW* - Recycling Infrastructure

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C2MI - LIMS : UPW - Ions

C2MI - LIMS : UPW* - Recycling Infrastructure

DI Water - C2MI

T1.0.04
(Pulta déjà présent)
Drain Tank 4
Return to C2MI for treatment

CMP- I2.1.00

Main Entrance

I2.1.01
Platen 1

I2.1.02
Platen 2

I2.1.03
Platen 3

SC1 used

SC1 | Brush 1 | Brush 2 | SRD

I2.1.04
Mixing Tank

T3.0.03
(Regroupement de conduites)
Silicon / Silicon oxide Slurry - Drain line

T3.0.05
(Regroupements de conmduites)
Water drain line

T3.0.06
(Regroupements de conduites)
Water drain line

T3.0.04
(Regroupement de conduites)
SC 1 - Drain line

C2MI - LIMS : UPW* - Recycling Infrastructure

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BALAZS™ nanoanalysis

C2MI - LIMS : UPW - Metals

C2MI - LIMS : UPW* - Recycling Infrastructure

LégisQuébec Source officielle

Publications Québec

Développement durable, Environnement et Lutte contre les changements climatiques Québec

Bromont VILLE branchée www.bromont.com

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C2MI

BALAZS™ nanoanalysis

C2MI - LIMS : UPW - Ions

C2MI - LIMS : UPW* - Recycling Infrastructure

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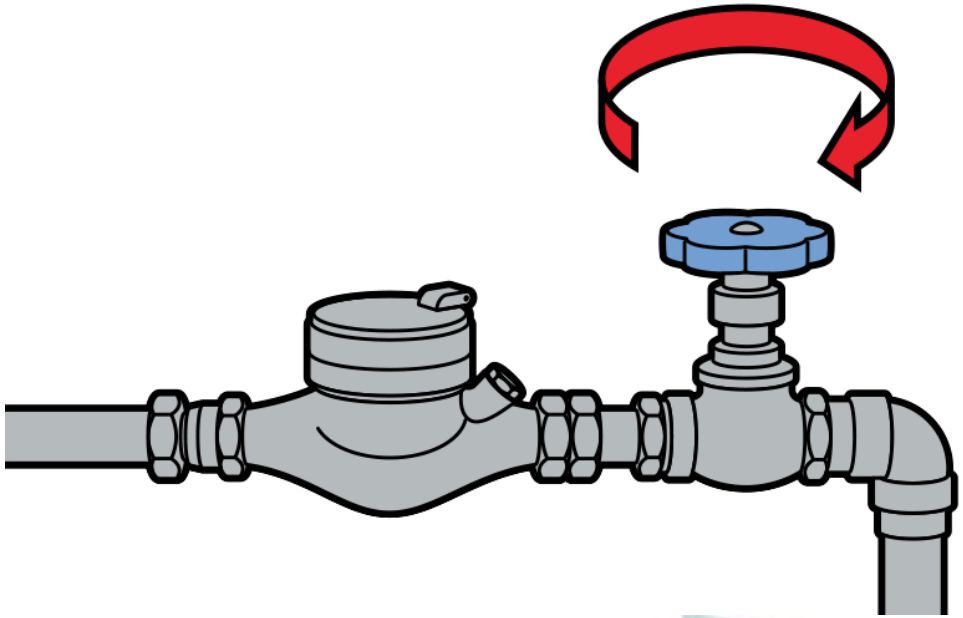
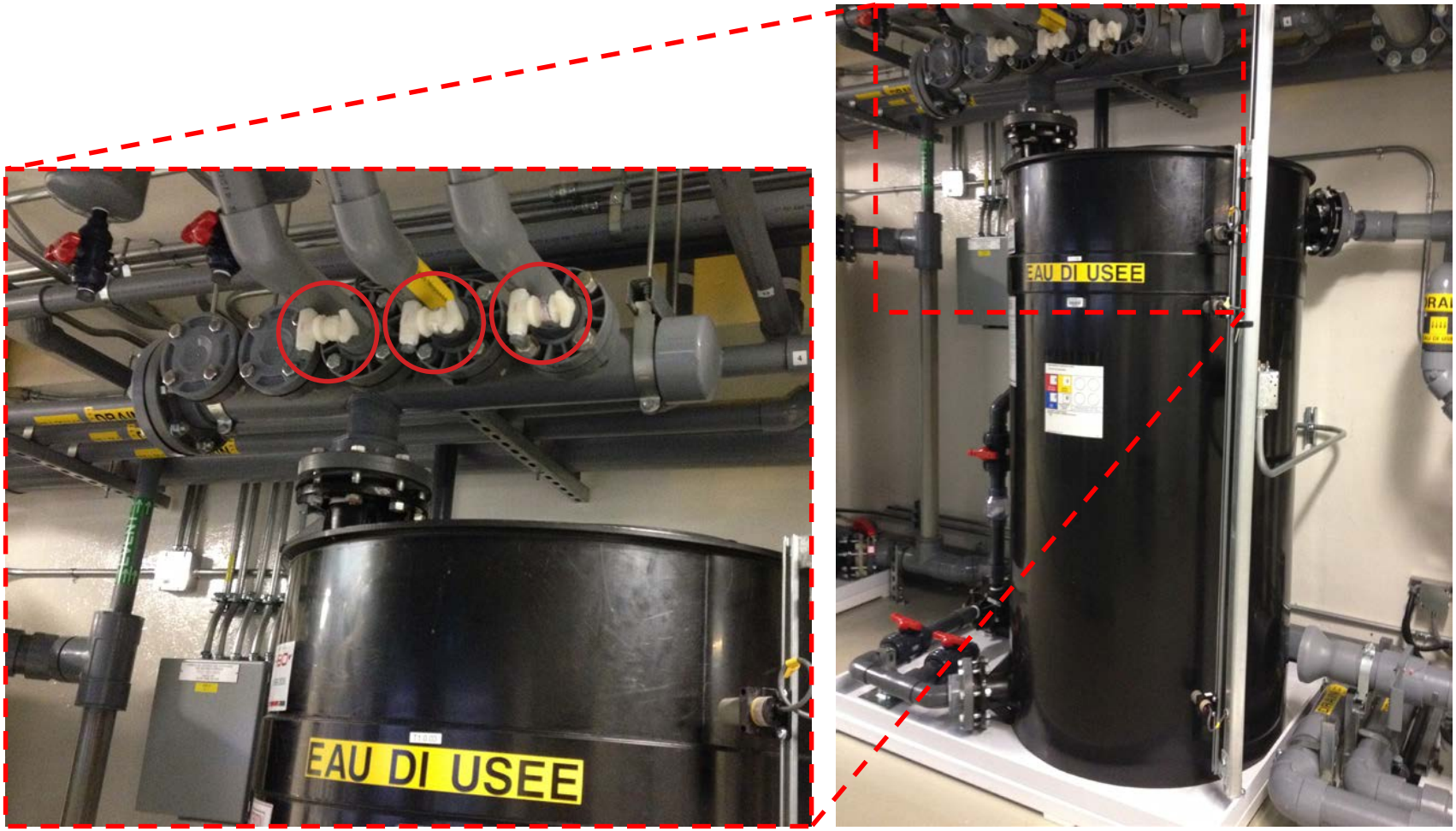
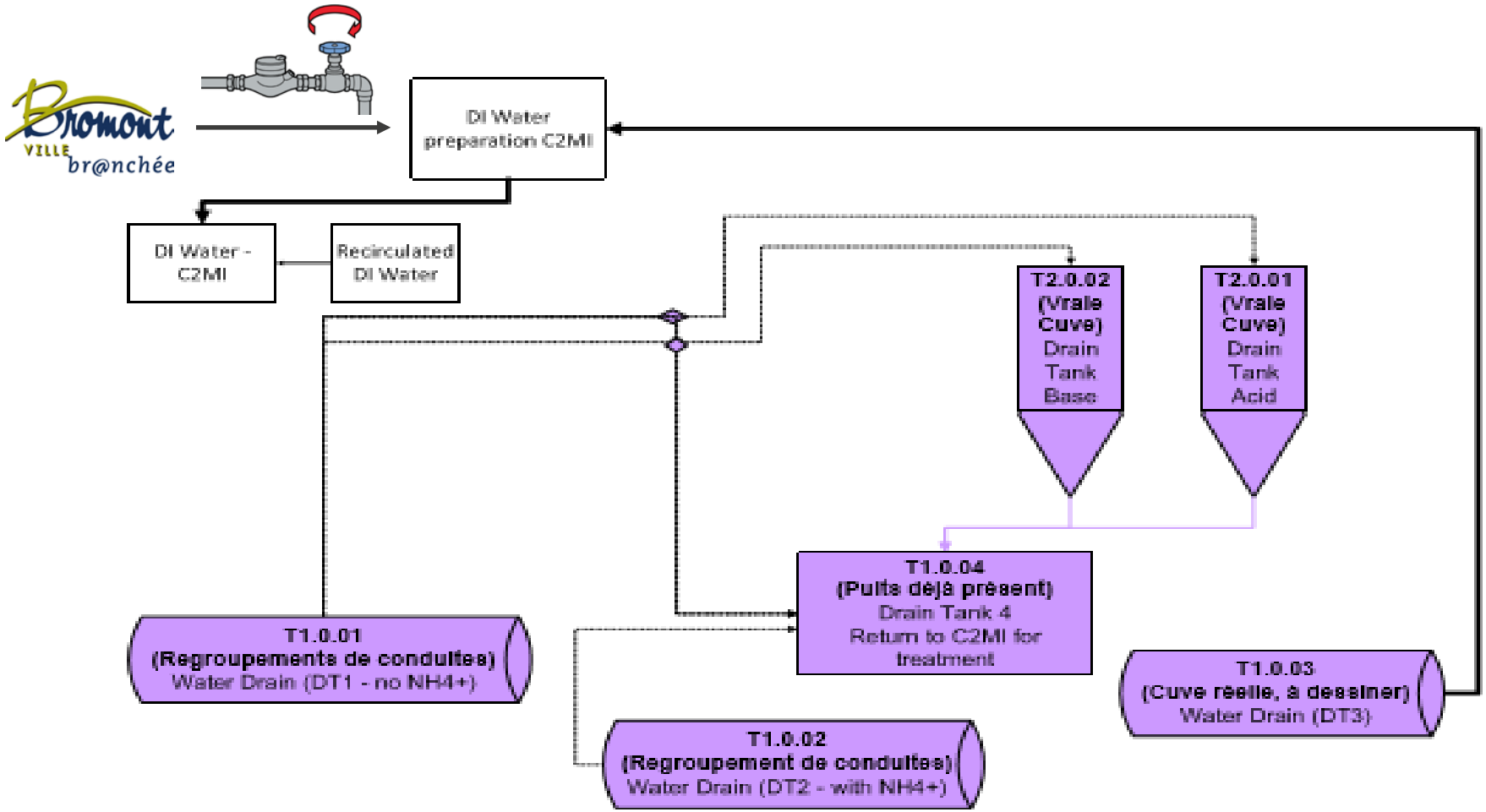


C2MI

C2MI - LIMS : UPW* - Recycling Infrastructure



C2MI - LIMS : UPW* - Recycling Infrastructure



- Possible Project Structure

- Possible Project Structure

Économie, Science et Innovation Québec

Pour un Québec vert et prospère

Stratégie de développement de l'industrie québécoise de l'environnement et des technologies vertes

- Le financement du gouvernement du Québec s'élève à près de 282 M$ sur 6 ans dont 237,5 M$ pour **soutenir le développement des technologies vertes**, dont celui **du traitement de l'eau**. La stratégie vise à :
  - ✓ **Soutenir des projets et initiatives de recherche industrielle;**
  - ✓ **Appuyer les projets de mise au point et de démonstration de technologies;**
  - ✓ Aider à la diffusion d'information sur les projets de recherche sur les technologies vertes en cours dans les universités;
  - ✓ Améliorer les mécanismes de certification environnementale et la mise en place des mesures facilitant la réalisation des projets de démonstration.

https://www.economie.gouv.qc.ca/objectifs/ameliorer/r-d-et-innovation/page/strategies-10453/?no_cache=1&tx_igaffichagepages_pi1%5Bmode%5D=single&tx_igaffichagepages_pi1%5BbackPid%5D=12513&tx_igaffichagepages_pi1%5BcurrentCat%5D=&cHash=bada3edaaa5fc85a3555dd0c5a1c8a9f#c20937

- Possible Project Structure

NSERC CRSNG

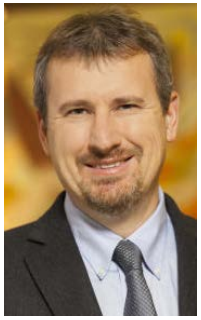
Environment Canada

UNIVERSITÉ LAVAL
Chaire de recherche du Canada sur les normes de gestion du développement durable

- Robert Déziel, Gestionnaire du Bureau régional du Québec du CRSNG depuis le 4 juin 2012: Mécanisme de financement du CRSNG pour la recherche et le développement coopératif

Robert Déziel

- Olivier Boiral, Titulaire de la Chaire de recherche du Canada sur les normes de gestion du développement durable et la responsabilisation des organisations. Lancée en janvier 2016, la Chaire a pour mission d'analyser l'intégration du développement durable dans les organisations, la transparence des informations divulguées et l'imputabilité des dirigeants dans ce domaine.



Olivier Boiral

Canada Research Chair in Sustainable Development Management Standards

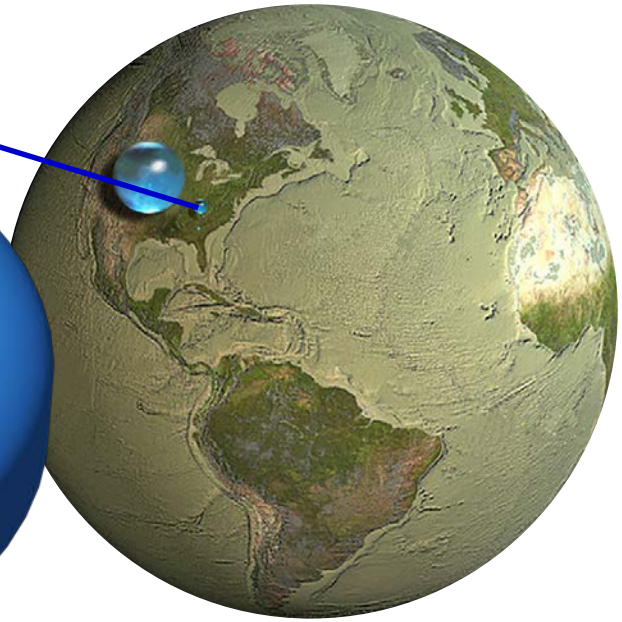

When?
Where?
Conclusion
Who?
Who?

: Conclusion

Solid Freshwater (1.75%)
(Icecaps, glaciers, Permafrost, eternal snow)

Available Freshwater

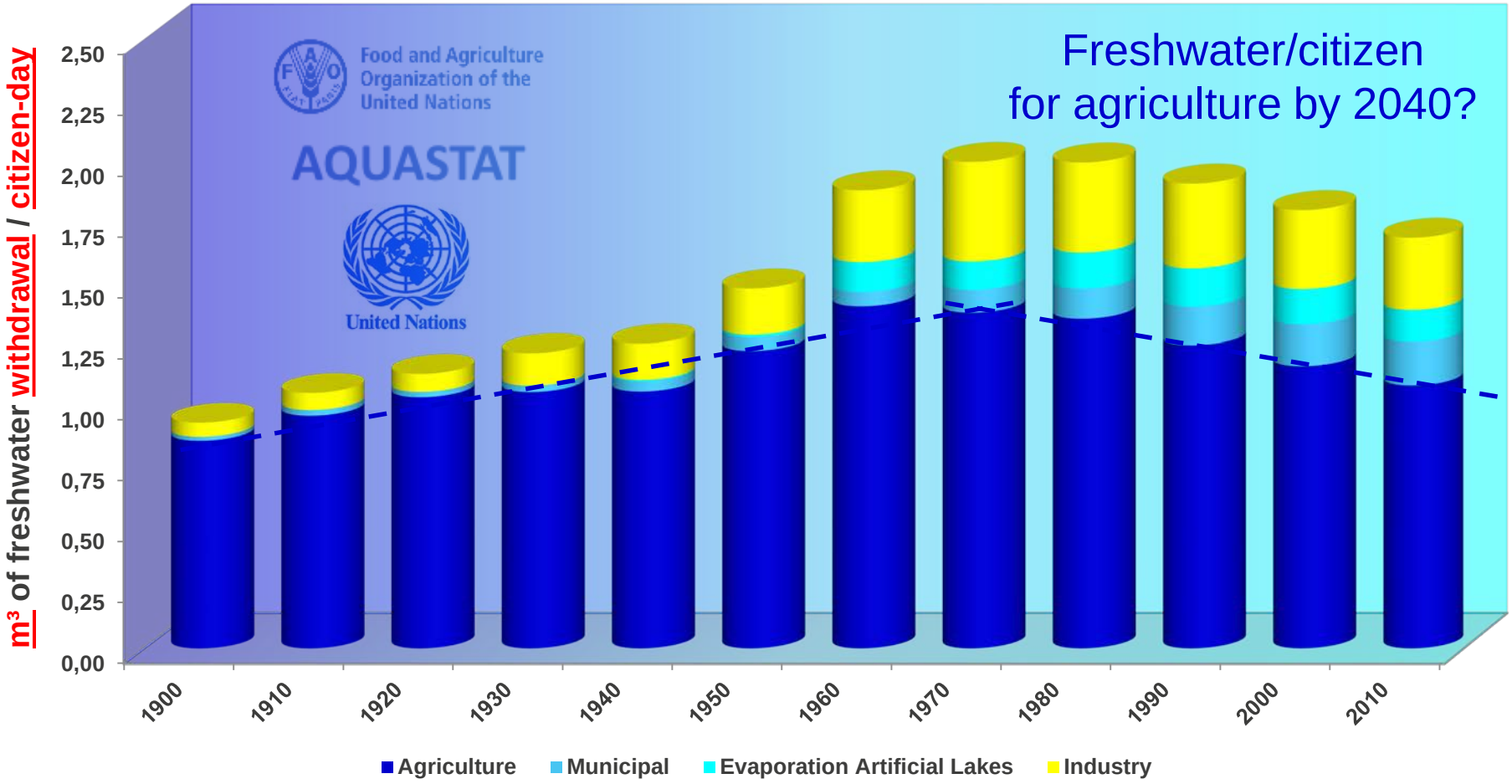
Seawater (97.5%)
(Oceans, seas, lakes, bays, underground)



World Business Council for Sustainable Development

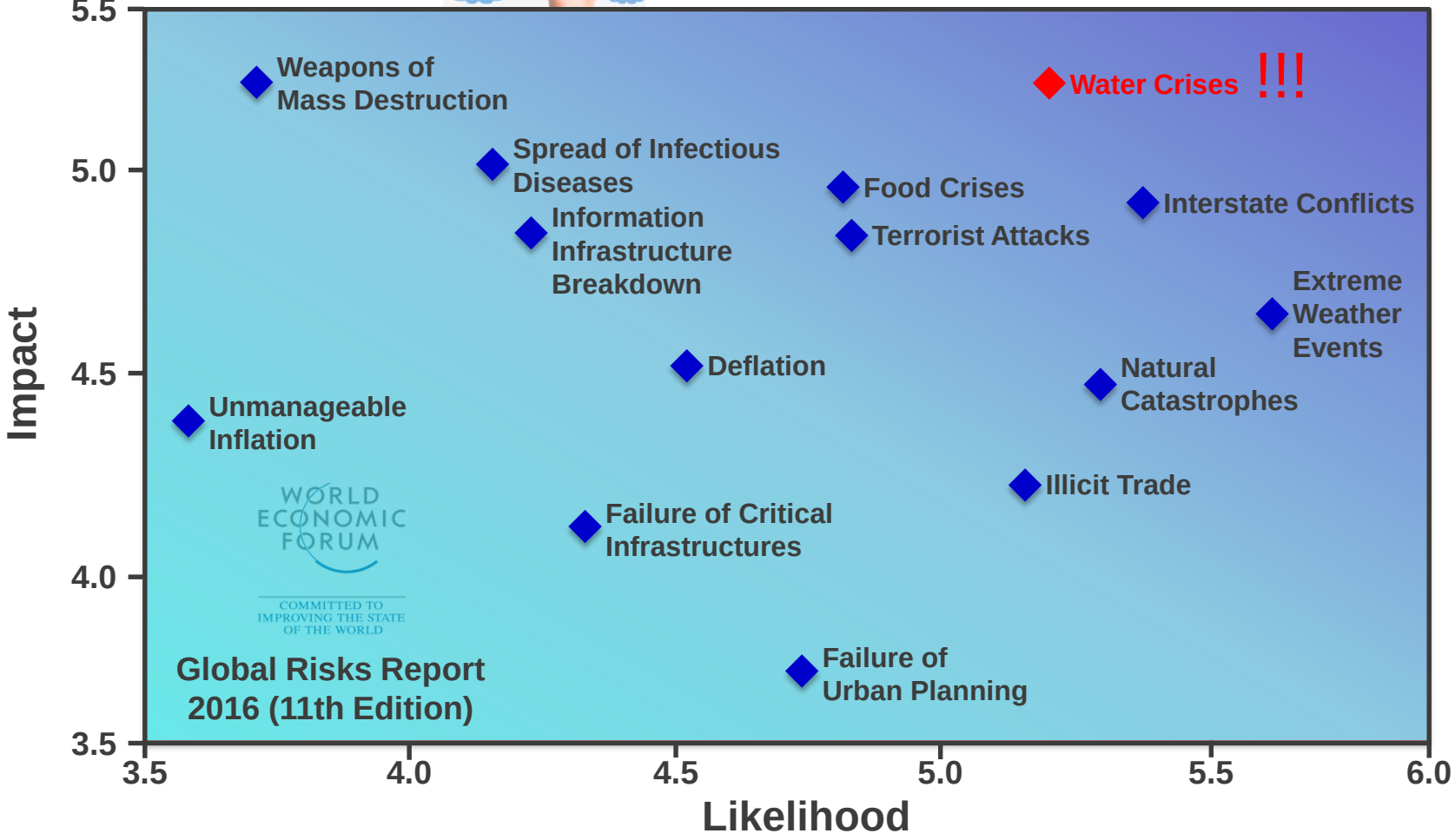
2006, SBN 2-940240-70-1

: Conclusion



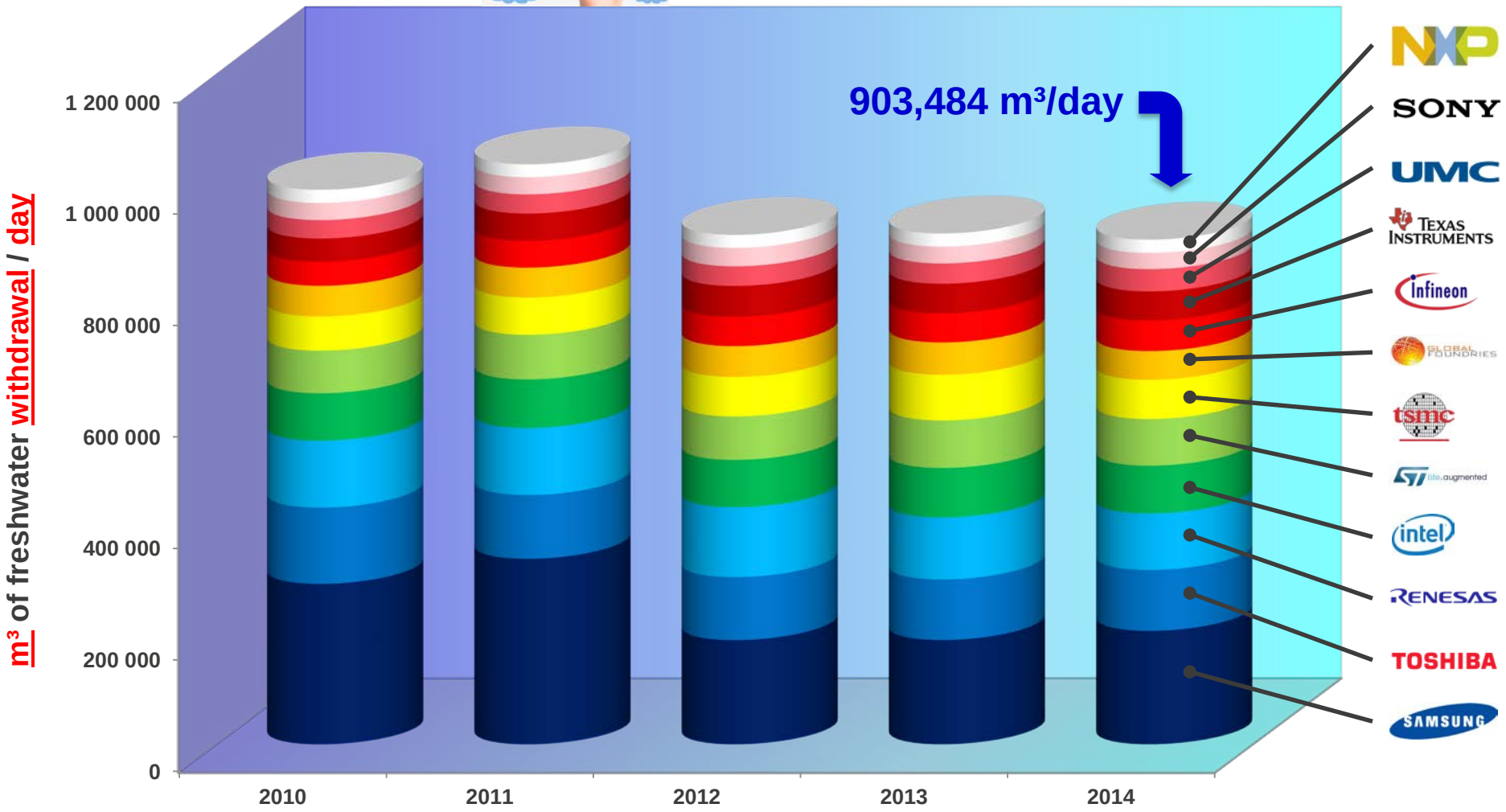
www.fao.org/nr/water/aquastat/water_use/index.stm ONU (World Population Prospects: The 2015 Revision

: Conclusion

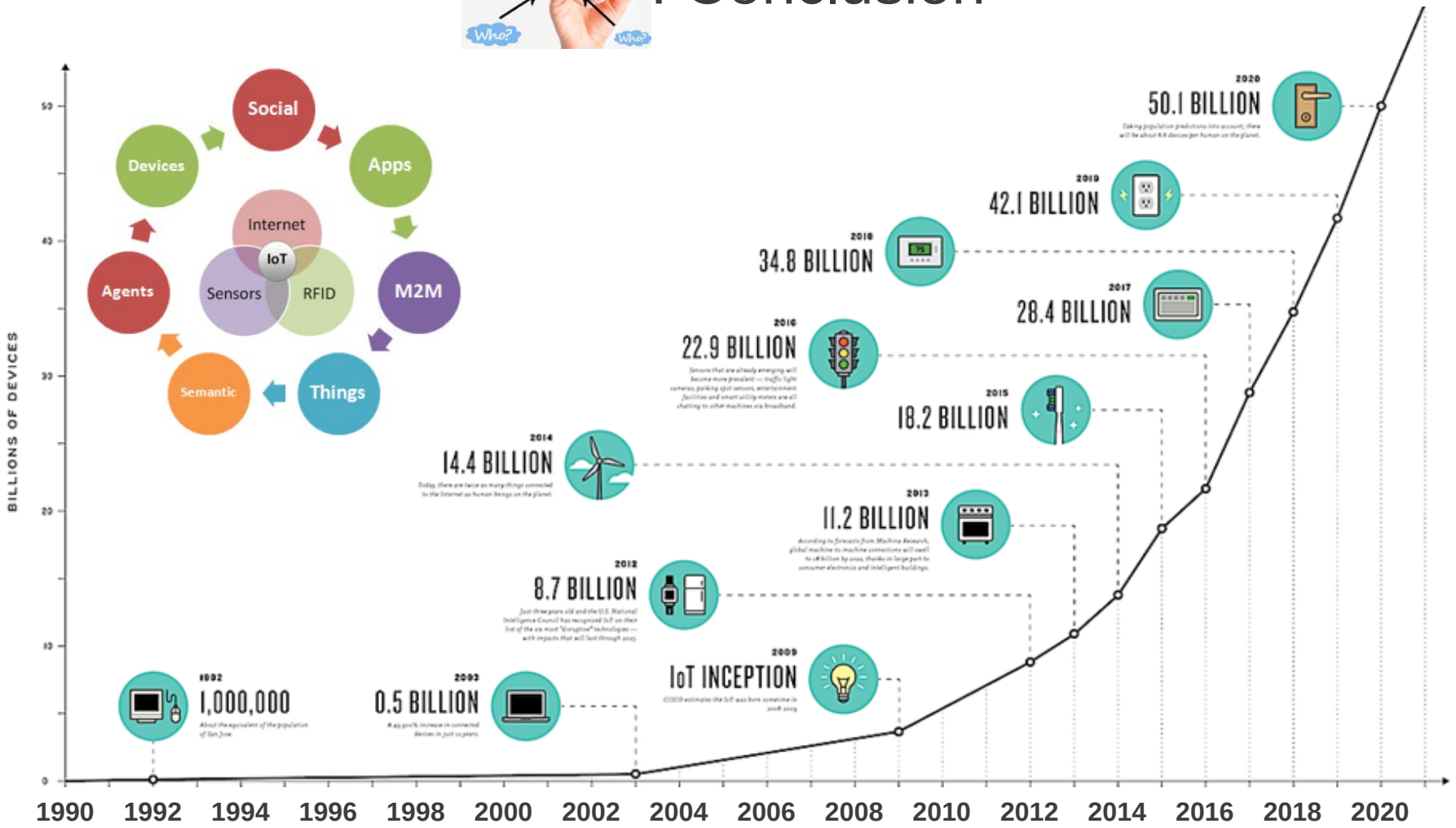


http://www3.weforum.org/docs/GRR/WEF_GRR16.pdf

: Conclusion



: Conclusion



http://www.theconnectivist.com/2014/05/infographic-the-growth-of-the-internet-of-things/

: Conclusion

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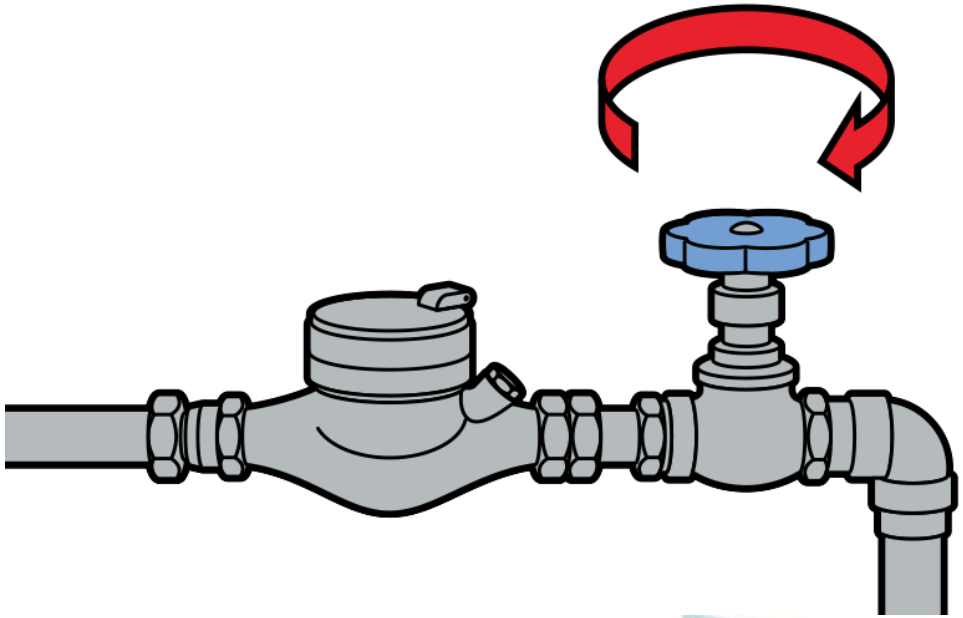
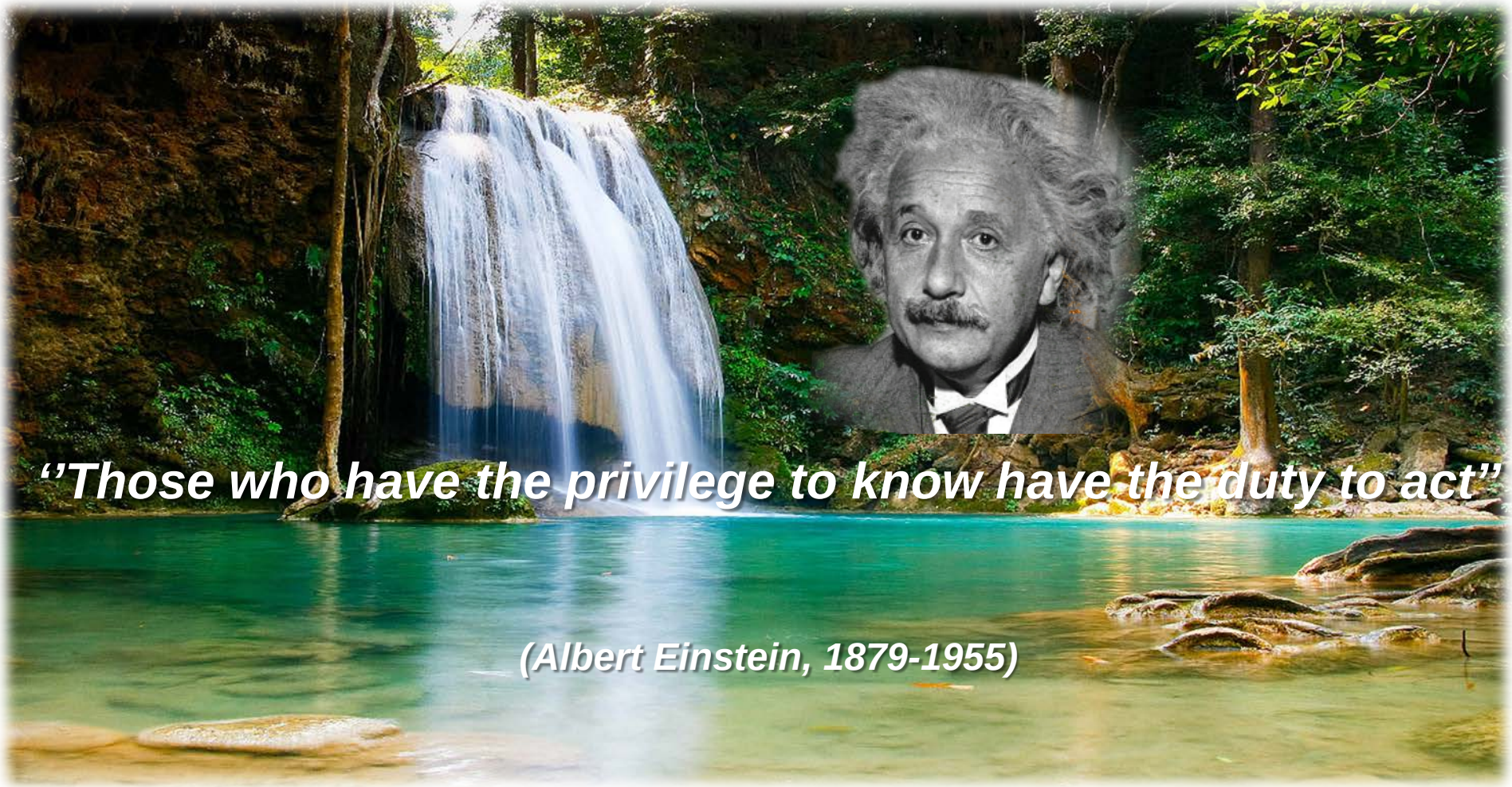


C2MI

: Conclusion



''Those who have the privilege to know have the duty to act''

(Albert Einstein, 1879-1955)