Environmental Impacts and Considerations in Transportation Practices and Projects

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Session 1. Welcome and Introduction to the Seminar

- about instructor
- about PR TTT
- about yourself

About Instructor

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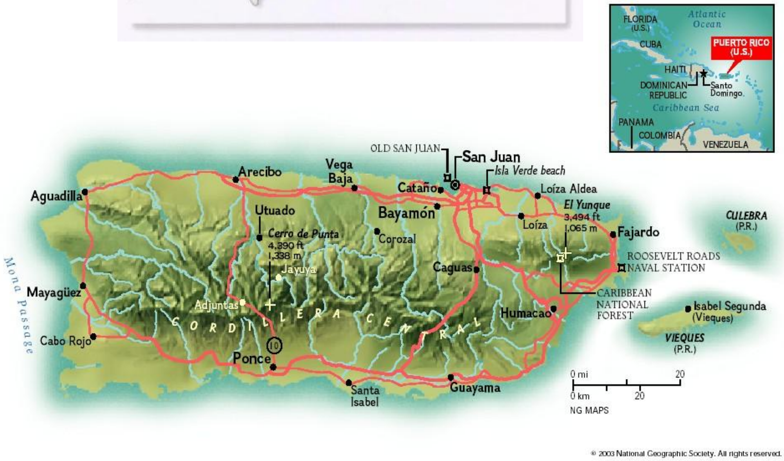
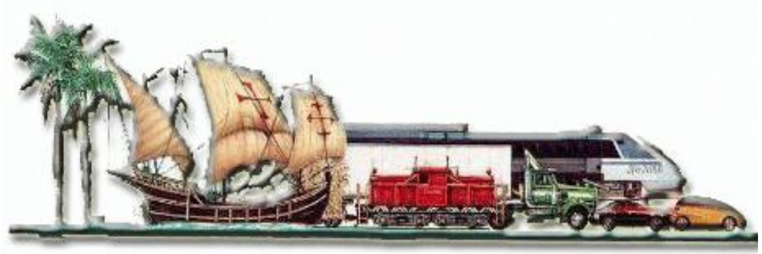


About PR TTT Center

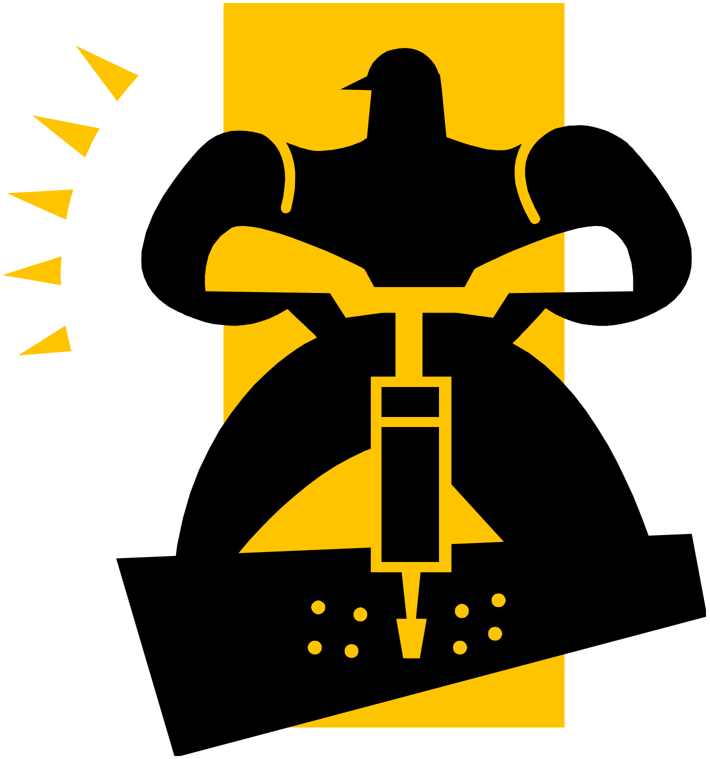


- PR Transportation Technology Transfer Center
- Established on April 1, 1986
- Locates at Department of Civil Engineering, University of Puerto Rico at Mayagüez
- One of 57 centers throughout the United States under the Local Technical Assistance Program (LTAP)
- Funded by several sources: Federal Highway Administration, Department of Transportation of Puerto Rico and the US Virgin Islands Department of Public Works.
- Provides service and technical information to, but are not limited to:

  Local officials of the 78 municipalities, the Puerto Rico Department of Transportation and Public Works and the Virgin Islands Department of Public Works

About yourself

- Let’s break the ice.



Seminar Topics

Session Topics

Day1 → Introduction to Seminar

Dubai Projects & Panama Canal

Environmental Impact Assessment

Impacts and Considerations in Road Transportation

Day 2 Environmental Water Quality Parameters

Impacts and Considerations in Ship Transportation

Impacts and Considerations in Air Transportation

Reuse and Recycle in Construction and Transportation

Introduction to the Seminar

Transportation vs. Environment

Seminar Topics

Dr. Sangchul (San) Hwang

- Definition
  - Transport or transportation
  - the movement of people and goods from one place to another
  - the Latin trans ("across") and portare ("to carry").
- Modes
  - Human-Powered
  - Animal-Powered
  - Road transportation
  - Rail transportation
  - Ship transportation
  - Aviation

- Environment
  - One's physical surroundings
  - Area, setting, ecology
  - Water, air, land

- Environmental Engineering
  - The application of engineering principles, under constraint, to the protection and enhancement of environmental quality & public health and welfare
- Transportation Engineering
  - The application of engineering principles to ensure the safe and efficient movement of people and goods

Health, Safety, & Quality

Impact of Urbanization on an Urban Ecology

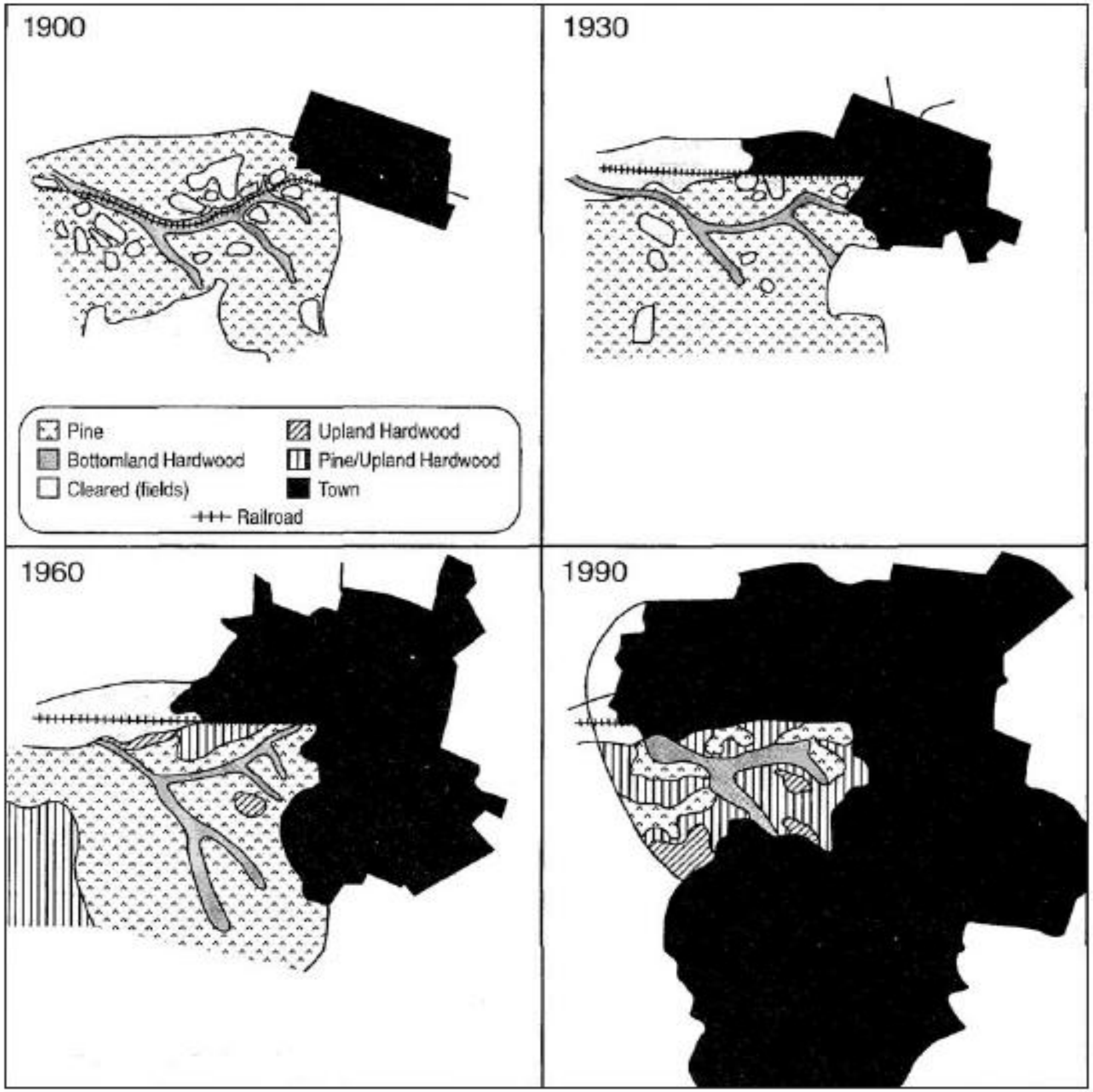
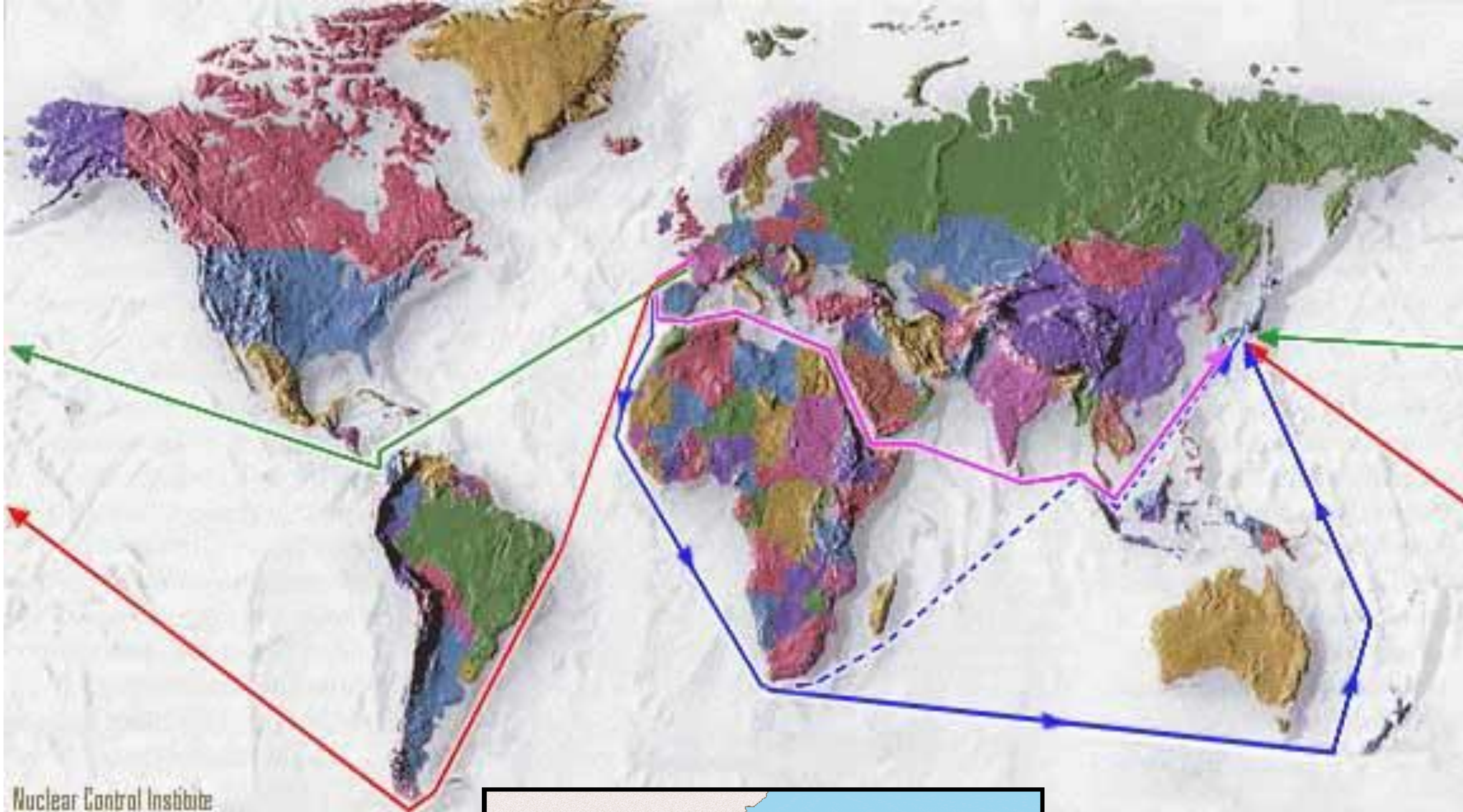


Figure 1. Impact of urbanization on an urban ecology, Aiken, SC.
Source: Wilds and White, 2001 (*12*).

- Highway and rail routes most likely to be used to transport high-level nuclear waste to Yucca Mountain, Nevada


Nuclear Control Institute


U.S.A.
Bahamas
Cuba
Mexico
Windward Passage
Haiti
Dominican Republic
Virgin Islands
Puerto Rico
Jamaica
Mona Passage
Anegada (Sombrero) Passage
Lesser Antilles
Belize
Guatemala
Honduras
El Salvador
Nicaragua
Costa Rica
Panama
Panama Canal
Colombia
Venezuela

Session Topics

Day1	Introduction to Seminar
	Dubai Projects & Panama Canal
	Environmental Impact Assessment
	Impacts and Considerations in Road Transportation
Day 2	Environmental Water Quality Parameters
	Impacts and Considerations in Ship Transportation
	Impacts and Considerations in Air Transportation
	Reuse and Recycle in Construction and Transportation

Dubai, UAE

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E
S
Image © 2006 TerraMetrics
Image © 2006 NASA
© 2006 Europa Technologies
© 2005 Google
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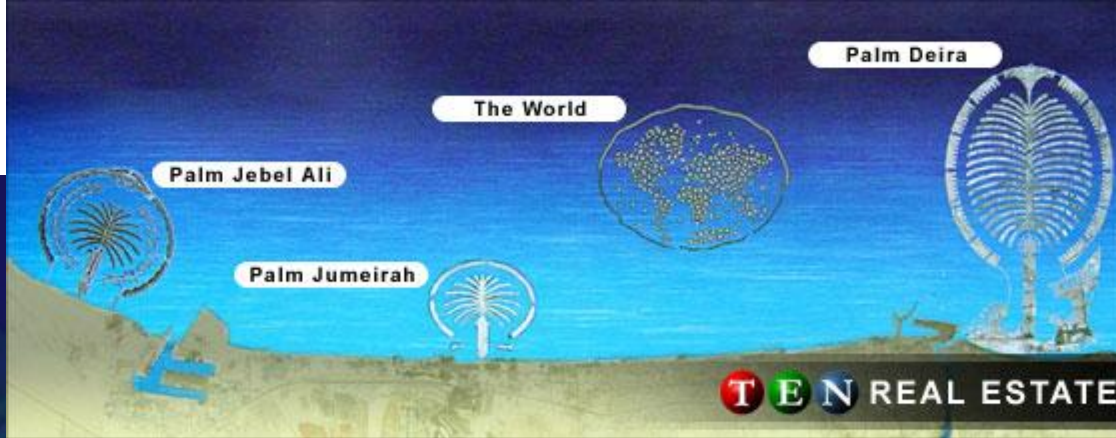
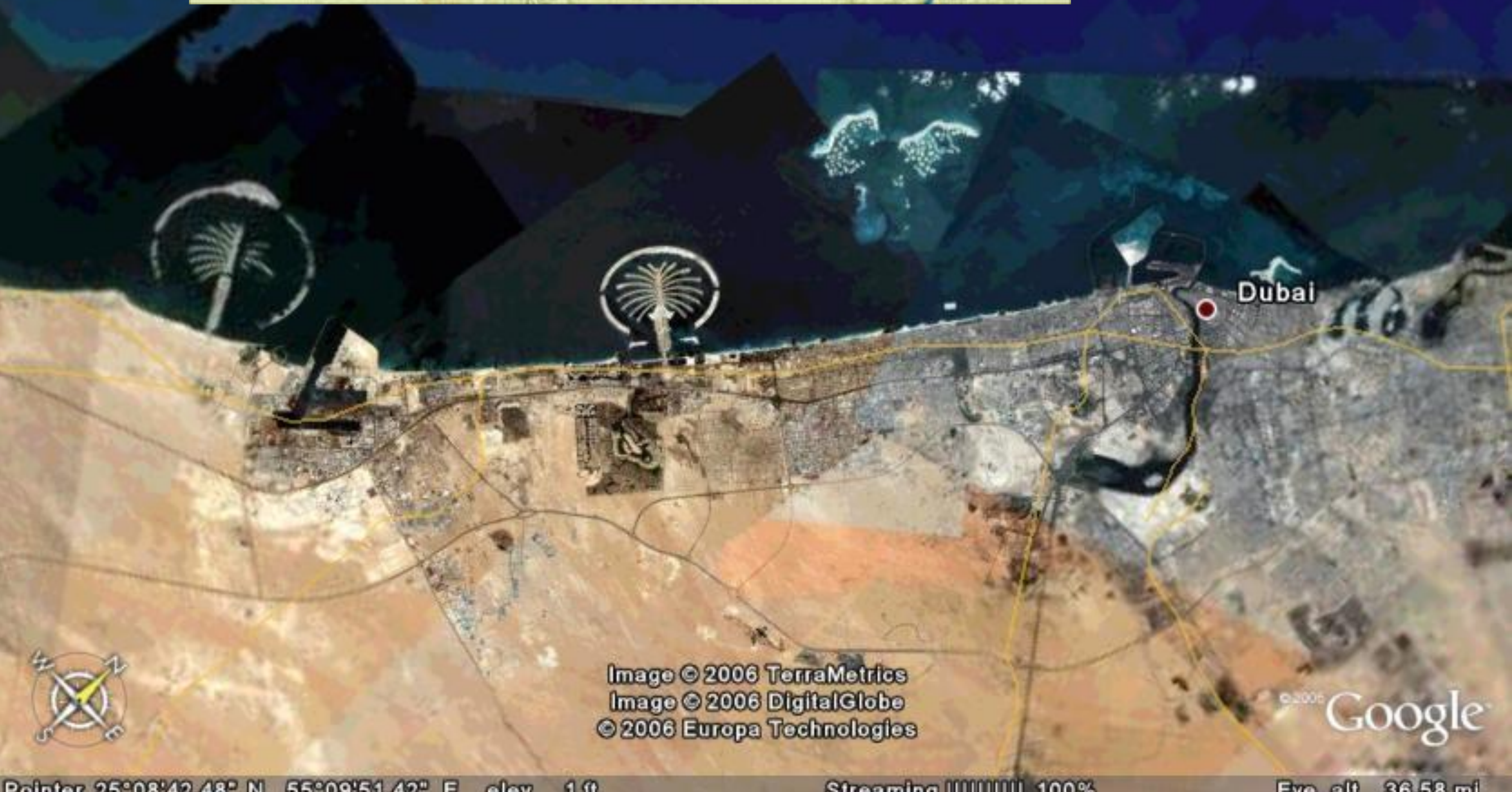

Palm Deira
The World
Palm Jebel Ali
Palm Jumeirah
TEN REAL ESTATE


Dubai
Image © 2006 TerraMetrics
Image © 2006 DigitalGlobe
© 2006 Europa Technologies
Google

Supplementary Slides

- **Nakheel begins monitoring of ecosystem at its projects**

  Nakheel, a leading property projects developer in Dubai, has started a ecosystem monitoring program at its marine and inland projects to advise the management on how to enhance different ecosystems.

They said **studies being done at 14 stations along the Palm Jumeirah indicate high diversity and healthy environmental conditions**.

Survey dives and assessment carried out along the **Waterfront Development Project** in Jebel Ali indicate **healthy coral communities**, they said.

Samples collected from 10 monitoring stations of the **World Island** also showed **high diversity of coral communities**.

More than 1,340 birds of eight species, mainly cormorant and ducks were counted in December in International City-Al Warsan a man-made freshwater lake.

Jumeirah Island also recently developed a man-made inland water project. "The ecological character of the saline and fresh water lakes indicates a good diversity of fresh and saline water plankton species," said the researchers. (Gulf News)

- Please see the attached documents, too.
  - Dubai Islands cause Environmental Controversy
  - Assessing the Environmental Impact of the Palm Jebel Ali in Dubai

www.latinamericanstudies.org

- Please see the attachment!

Impact of Development on the Panama Canal Environment

Stanley Heckadon Moreno

Journal of Interamerican Studies and World Affairs, Volume 35, Issue 3, Special Issue: The Future of Panama and the Canal (Autumn, 1993), 129-149.

Coffee Break

Session Topics

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	Impacts and Considerations in Road Transportation
Day 2	Environmental Water Quality Parameters
	Impacts and Considerations in Ship Transportation
	Impacts and Considerations in Air Transportation
	Reuse and Recycle in Construction and Transportation

Session 3. Environmental Impact Assessment

Fundamentals

Examples

Dr. Sangchul (San) Hwang

Type of Impact Assessments

- Climate Impact Assessment
- Demographic Impact Assessment
- Development Impact Assessment
- Ecological Impact Assessment
- Economic and Fiscal Impact Assessment
- Environmental Auditing
- **Environmental Impact Assessment**
- Environmental Management Systems
- Health Impact Assessment
- Project Evaluation
- Public Consultation
- Public Participation
- Risk Assessment
- Social Impact Assessment
- Strategic Impact Assessment
- Technology Assessment

- Under United States environmental law, an EIA is referred to as the *Environmental Impact Statement* (EIS), and originated in the National Environmental Policy Act (NEPA) that was enacted in the United States in 1969.

- Certain actions of federal agencies must be preceded by an EIS.
- Contrary to a widespread misconception, NEPA does not prohibit the federal government or its licensees and/or permittees from harming the environment, nor does it specify any penalty if the EIS turns out to be inaccurate, intentionally or otherwise.
- NEPA merely requires that plausible statements as to the prospective impacts be disclosed in advance. It is only a procedural requirement.

- Usually, an agency will release a *Draft Environmental Impact Statement* (DEIS) for comment.
- Interested parties and the general public have the opportunity to comment on the draft, after which the agency will approve the *Final Environmental Impact Statement* (FEIS).
- Occasionally, the agency will later release a *Supplemental Environmental Impact Statement* (SEIS).

- The adequacy of an EIS can be challenged in court. Major proposed projects have been blocked because of an agency's failure to prepare an acceptable EIS.
- One prominent example was the Westway landfill and highway development in and along the Hudson River in New York City.

Westway Project

- Westway was the name of a proposed project to put New York City's West Side Highway underground, first planned in 1972 and officially canceled in 1985.

- It would have involved extensive landfill in the Hudson River off Manhattan to accommodate a highway and real estate development.

- Westway had the agreement of all levels of government, which is very rare. The Federal Government agreed to pledge $1.3 billion dollars to the project if ground was broken on a certain date.

- However, a lawsuit was filed saying the Environmental study was not complete because they did not include the effect it would have on the mating habits of the striped bass in the Hudson River.

- A judge ordered them to complete the study, and because the next striped bass mating season was well after the date ground was supposed to be broken for funding, the project was finally cancelled in 1985.

Sierra Club over Nevada DoT

- Another prominent case involved the Sierra Club suing the Nevada Department of Transportation over its denial of Sierra Club's request to issue a supplemental EIS addressing air emissions of particulate matter and hazardous air pollutants in the case of widening US Highway 95 through Las Vegas.
  - the 4-lane expansion of US-95 adjacent to elementary schools in the city

- The case reached the 9th Circuit Court of the United States, which led to construction on the highway being halted until the court's final decision. The case was settled in June 2005 prior to the court's final decision.

- Several US state governments that have adopted "little NEPA's," i.e., state laws imposing EIS requirements for particular state actions and some of those state laws refer the required environmental impact studies as *Environmental Impact Reports* or *Environmental Impact Assessments*.

- For example, the California Environmental Quality Act (CEQA) requires an *Environmental Impact Report* (EIR).

- These various state requirements are yielding voluminous data not just upon impacts of individual projects, but also to elucidate scientific areas that had not been sufficiently researched.

- For example, in a seemingly routine *Environmental Impact Report* for the city of Monterey (CA), information came to light that led to the official federal endangered species listing of Hickman's potentilla, a rare coastal wildflower.

Lunch Break

Sustainability and others

- Sustainable Development
- Laws, Policies, and Regulations
- Tools and Methods
- * NCHRP Report 541 (from www.TRB.org)

- Gro Harlem Brundtland
  - Former Norwegian Prime Minister
  - Development that "meets the needs of the present without compromising the ability of future generations to meet their own needs."

- Economic and social change to improve human well-being while reducing the need for environmental protection
- Emphasized by EPA and DOE
- Better integration of environmental and community considerations into transportation engineering design
- Movement toward a transportation design approach that is both environmentally sensitive and reflective of a community's desire
  - i.e., Context-sensitive design/solutions (CSD/CSS)

TABLE 2 Traditional transportation planning process compared to process oriented toward sustainable development

Characteristic	Traditional Process	Process Oriented toward Sustainable Development
Scale	• Regional and network level	• Local, state, national, and global perspective
Underlying "Science"	• Traffic flow theory • Network analysis • Travel behavior	• Ecology • Systems theory
Focus of Planning and Investment	• Accommodate travel demand • Promote economic development • Enhance system safety • Catch up to sprawl	• Efficient use/management of existing infrastructure • Provide transportation capacity where appropriate (from ecology perspective) • Redevelopment of development sites • Reduce demand for single-occupant vehicles • Reduce material consumption and throughput
Government Economic Policies	• Promote new development on new land • Focus economic policy on productivity • Do not include secondary and cumulative impacts in policy analysis	• Promote reuse and infill development • Fully integrate economic policy with environmental policy • Include secondary and cumulative impacts as part of policy decision analysis
Timeframe	• 15–20 years planning • 4–8 years for decision-maker interest (elections)	• Short (1–4 years) • Medium (4–12 years) • Long (12– --- years)
Focus of Technical Analysis	• Trip-making and system characteristics between origins and destinations • Air-quality conformity • Benefits defined in economic terms	• Relationships between transportation, ecosystem, land use, economic development, and community social health • Secondary and cumulative impacts

Role of Technology	• Promote individual mobility • Meet government-mandated performance thresholds to minimize negative impacts • Improve system operations	• Travel substitution and more options • Benign technology • Total life-cycle perspective to determine true costs • More efficient use of existing system
Land Use	• Considered as a given based on zoning that accommodates autos • Separated from transportation planning	• Integral part of solutions set for providing mobility and sustainable community development • Infrastructure funding tied to sound land use planning • Increased density and preservation of open space/natural resources
Pricing	• Subsidies to transportation users • True "costs" to society not reflected in price to travel	• Societal cost pricing including environmental cost accounting • Value, that is, transportation priced as utility
Types of Issues	• Congestion • Mobility and accessibility • Environmental impact at macroscale • Economic development • Little concern for secondary/cumulative impacts • Social equity (increasingly)	• Global warming and greenhouse gases • Biodiversity and economic development • Community quality of life • Energy consumption • Social equity
Types of Strategies	• System expansion/safety • Efficiency improvements • Traffic management • Demand management (from perspective of system operating more smoothly) • Intelligent transportation systems	• Maintenance of existing system • Traffic calming and urban design • Multimodal/intermodal • Transportation–land use integration • Demand management (from perspective of reducing demand)/nonmotorized transportation • Education

Source: Characteristics for process oriented toward sustainable development synthesized from Newman and Kenworthy, 1999 (*15*), Maser, 1997 (*19*), and Haq, 1997 (*35*).

The Organization for Economic Co-operation and Development OECD)

TABLE 4 OECD's framework of sustainability indicators

Environmentally Significant Trends by Sector	
1. *Overall Traffic Growth and Mode Split* • Passenger traffic trends by mode (private cars, buses and coaches, railways, air) in passenger-kms • Freight traffic trends in vehicle-kms/road traffic trends in vehicle-kms • Trends of airport traffic, number of movements • Trends in tonnage handling in national harbors	2. *Infrastructure* • Capital expenditure, total and by mode 3. *Vehicles and Mobile Equipment* • Number of road vehicles (autos, commercial vehicles): total, gasoline, diesel, others
Environmental Impact	
1. *Resource Use* • Total final energy consumption of the transport sector (share in total, per capita, by mode) in tonnes of oil equivalent 2. *Air Pollution* • Transport emissions (CO_2, NOx, VOC, CO, etc) share in total, per capita, by mode) • Emissions per vehicle-km: CO_2, NOx, VOC, CO, etc. 3. *Water Pollution* • Tonnage of oil released through accidents and discharges during current operations	4. *Noise* • Population exposed to noise greater than i65 dB(A) from transport 5. *Waste* • Tonnage of transport-related waste • Tonnage of hazardous waste imported or exported 6. *Risk and Safety* • Number of people killed or injured • Tonne-kms of hazardous materials transported
Economic Considerations	
1. *Environmental Damage* • Environmental pollution damage relating to transport 2. *Environmental Expenditure* • Total expenditures on pollution prevention/clean-up • Research and development expenditures on quiet, clean, energy-efficient vehicles • Research and development expenditures on clean transport fuels	3. *Taxation and Subsidies* • Direct subsidies • Direct and indirect subsidies • Total economic subsidies • Relative taxation of vehicles and vehicle use 4. *Price Structure* • Trends in gasoline (leaded, unleaded), diesel, and other fuel prices and public transport prices in real terms 5. *Trade and Environment* • Indicator not yet developed

Source: Transport Canada, 1999 (*55*).

- Federal Laws
  - Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991
  - Transportation Equity Act for the 21st Century (TEA-21)
  - TEA-21 and ISTEA
    - Linked environmental issues with transportation planning
    - Planning needs to protect and enhance the environment, promote energy conservation, and improve quality of life
  - National Environmental Protection Act (NEPA) of 1969
    - Requires federal, state, and local governments to use systematic approach to incorporate the protection of the natural and human environment within project development

- Clean Water Act (CWA) Amendments of 1997
  - No discharge of dredged or fill material can be permitted if a practical alternative exists that is less damaging to the aquatic environment or if the nation's waters would be significantly degraded
- Clean Air Act (CAA) Amendment of 1990
  - Air quality standards, motor vehicle emissions, alternative fuels, toxic air pollutants, acid rain, and ozone depletion
- Endangered Species Act (1973, 1988)
  - Conservation of threatened and endangered plants and animals and the habitats in which they are found

- Title VI of the Civil Rights Act of 1964
  - Foundation for the issues related to environmental justice
  - No person in the United States on the ground of race, color, or national origin, should be excluded from participation in , be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance

- Executive Order 12898 of 1994, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
  - Required each federal agency to make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse health or environmental effects of its activities on minority and low income populations

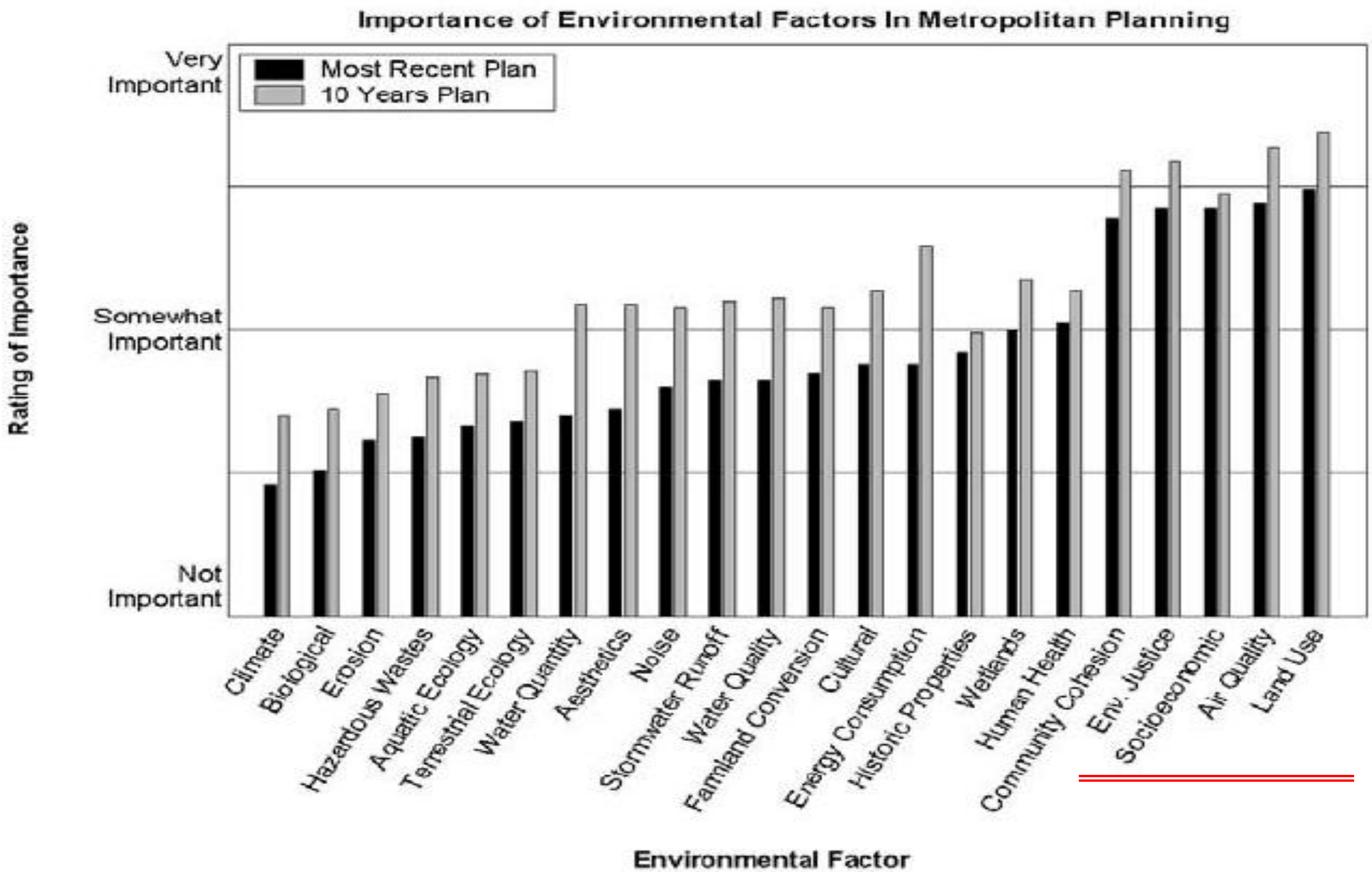
- Others can be found at www.fhwa.got.gov/environment

- State Laws (PR’s Laws)
  - Open Talk

- DOT: Department of Transportation
- MPO: Metropolitan Planning Organizations

Most Considered Environmental Factors

State DOTs

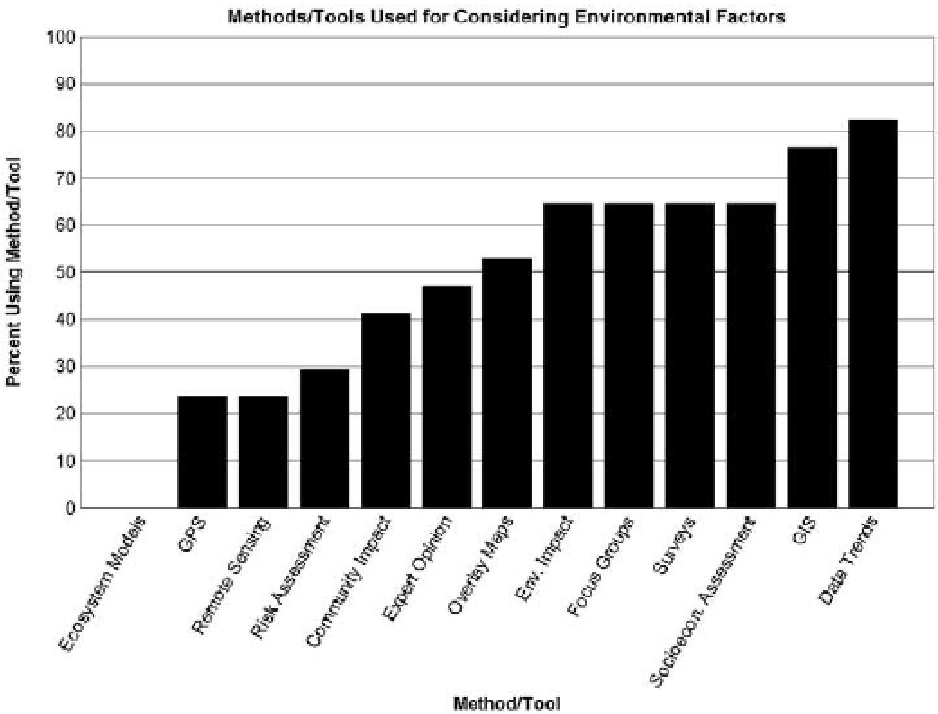


MPOs

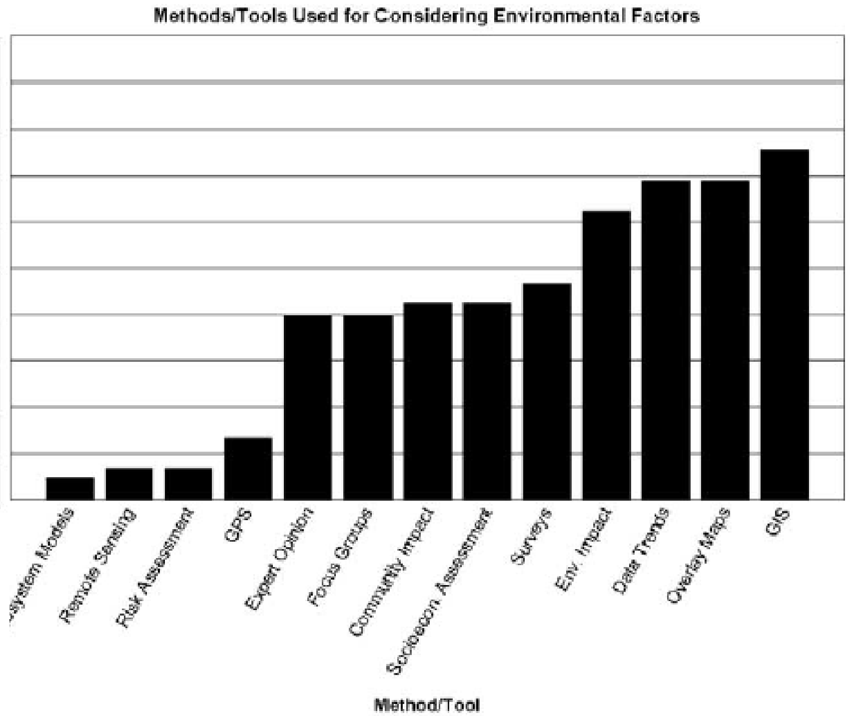
Figure 2. Importance of environmental factors, state DOTs and MPOs.

Most Widely Used Tools

- Data trend analysis, GIS, environmental specific models, overlay maps, and focus groups



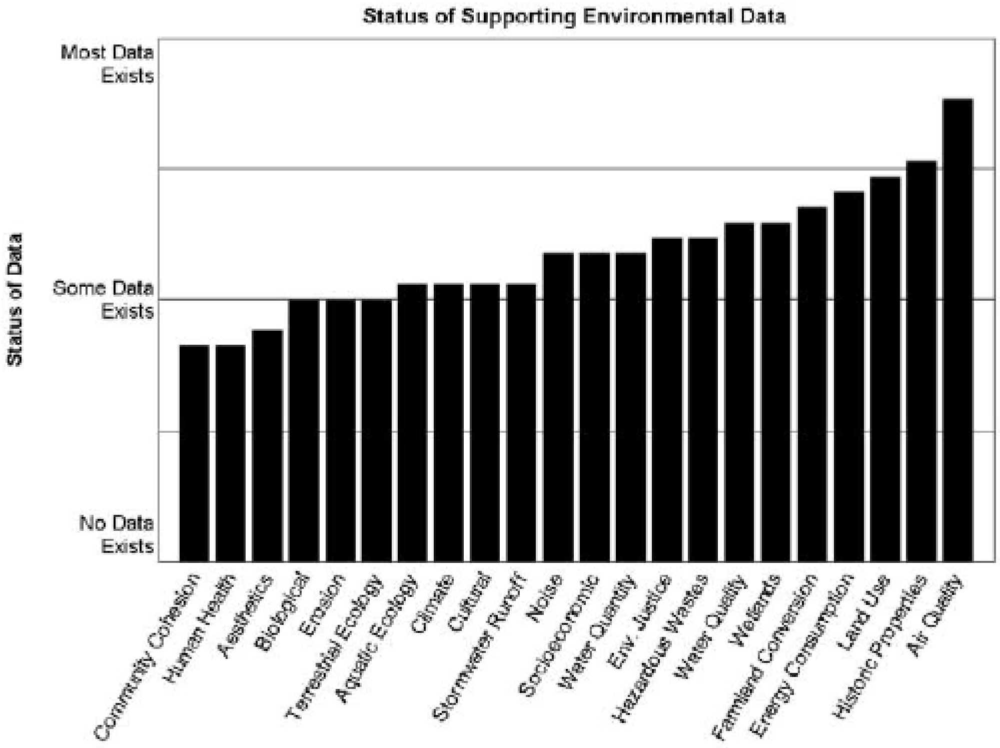
State DOTs



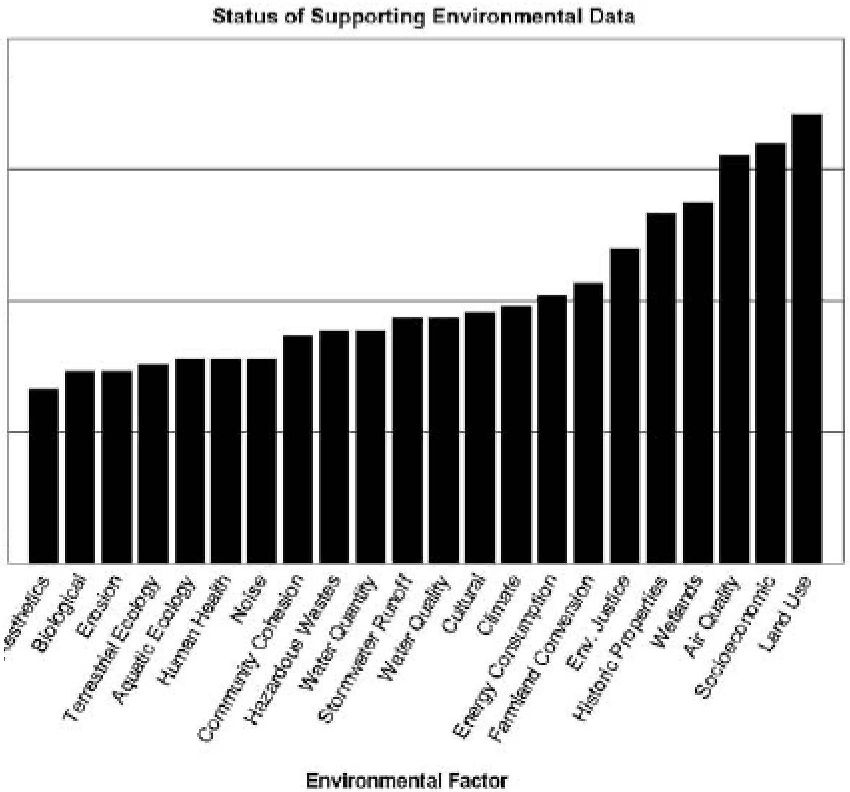
MPOs

Most Readily Available Data Types

- Air quality, socioeconomic, historic properties, energy consumption, and land use



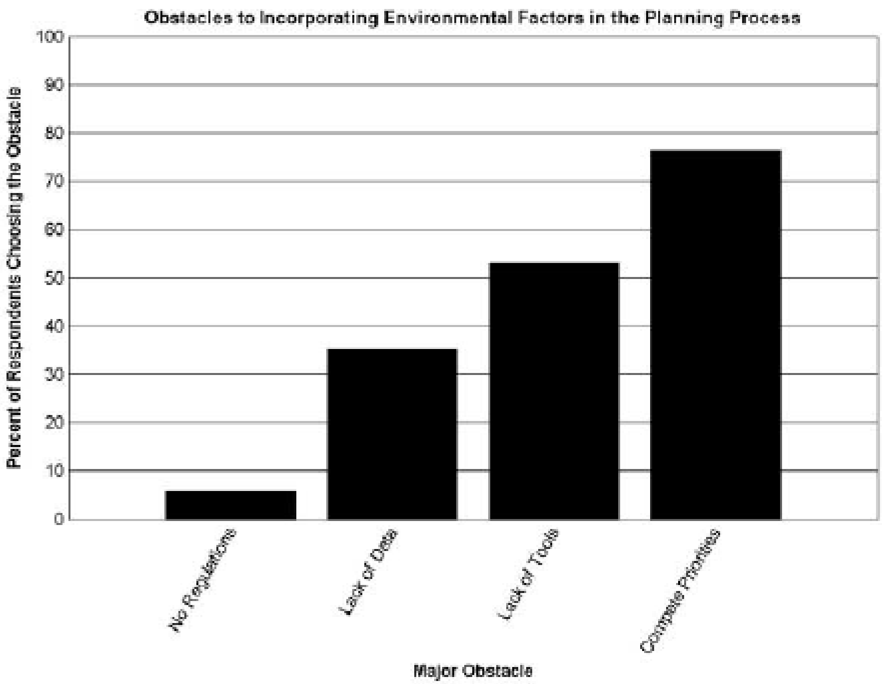
State DOTs



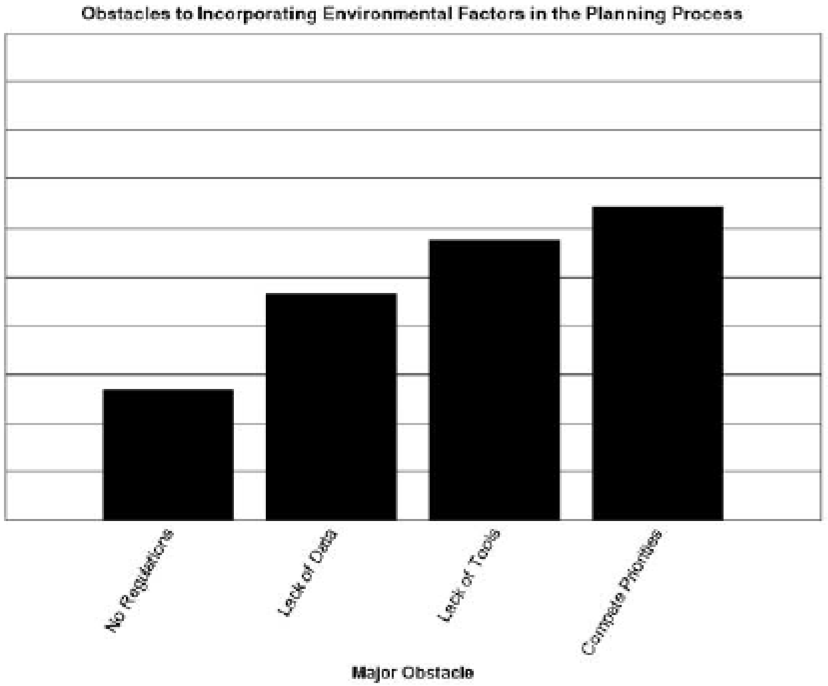
MPOs

Obstacles

- Competing priorities and lack of tools

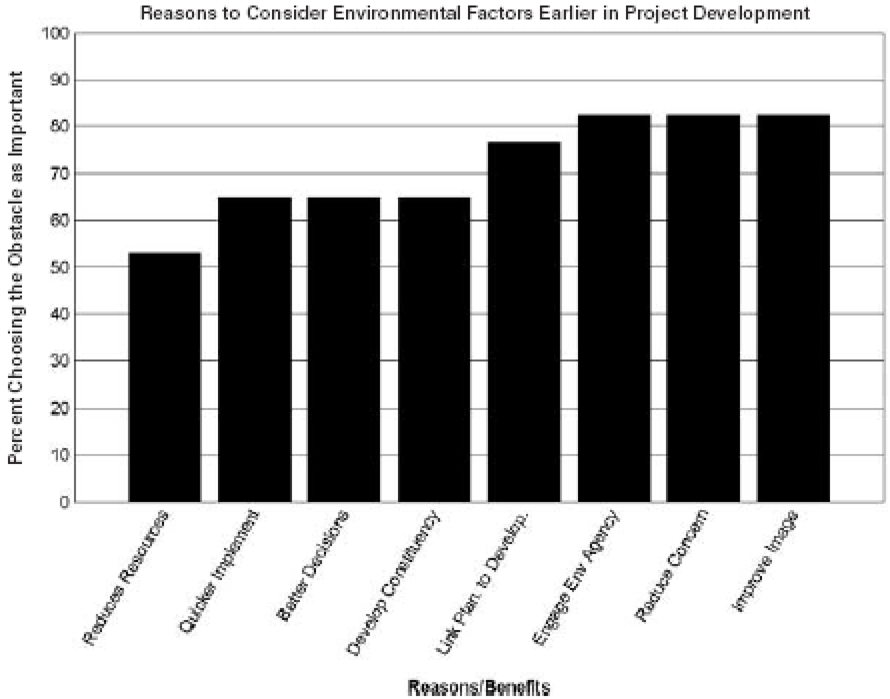


State DOTs

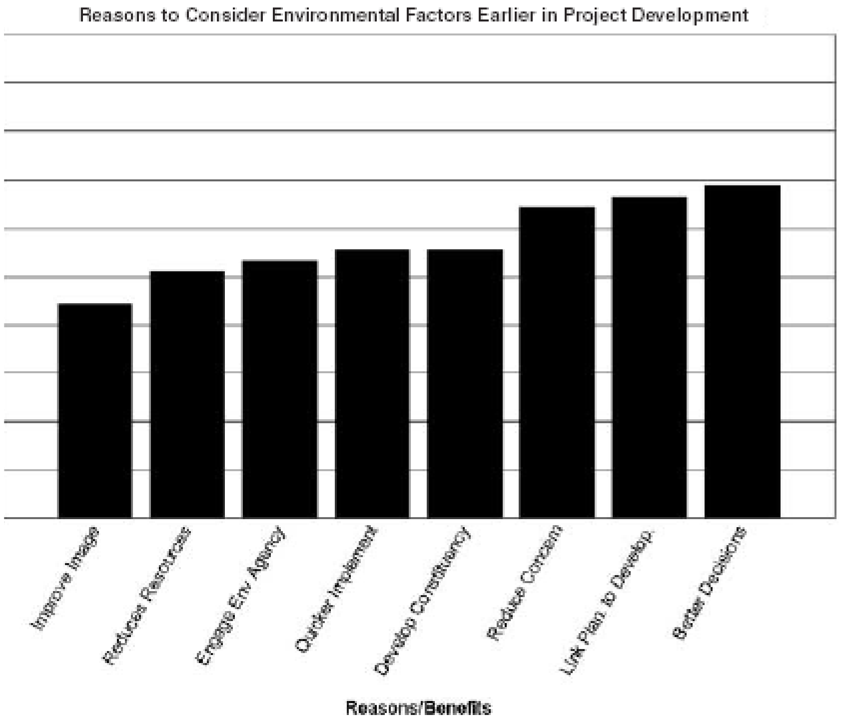


MPOs

Most Important Benefit



State DOTs



MPOs

Dr. Sangchul (San) Hwang

- Environmental Impact-Specific Models
  - Air Quality Model
    - EPA MOBILE vehicle emission factor model
      - Software tool for predicting gram/mile emissions of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), carbon dioxide (CO_2), particulate matter (PM) and air toxics from cars, trucks, and motorcycles under various conditions.
      - http://www.epa.gov/otaq/m6.htm

- FHWA’s CAL3QHC model
  - Uses MOBILE outputs
  - Estimates total air pollutant concentrations (CO or PM) near highways from both moving and idling vehicles.
  - Also estimates the length of queues formed idling vehicles at signalized intersections.

Mobile Source Emissions - Past, Present, and Future

MOBILE Model (On-road Vehicles)

NONROAD Model (Nonroad Engines, Equipment, and Vehicles)

NMIM (National Mobile Inventory Model)

MOVES (Motor Vehicle Emission Simulator)

Fuels Models

MOBILE6 Vehicle Emission Modeling Software

This Web page provides the MOBILE6 Vehicle Emission Modeling Software and related presentations and training resources. MOBILE6 is an emission factor model for predicting gram per mile emissions of Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NOx), Carbon Dioxide (CO_2), Particulate Matter (PM), and toxics from cars, trucks, and motorcycles under various conditions.

For further information or assistance regarding this web page or MOBILE6:

- MOBILE Model Information Contact: fax: (734) 214-4939 or email: Mobile (mobile@epa.gov)
- EPA-MOBILENEWS Listserver: Full description and subscription information 2K TXT

> NOTE: You will need Adobe Acrobat Reader, available as a free download, to view some of the files on this page. See EPA's PDF page to learn more about PDF, and for a link to the free Acrobat Reader.

- MOBILE6 Model
- Presentations
- Training
- Technical Documentation
- Workshop Documents
- Plans
- Main mobile sources modeling page
- Related Links

MOBILE6 Model

Key Topics: Transportation and Air Quality

Overview: Pollutants and Programs

Consumer Information

On-road Vehicles and Engines

Nonroad Engines, Equipment, and Vehicles

Fuels and Fuel Additives

Voluntary Programs

Transportation and Air Quality Planning

Modeling, Testing, and Research

- Biological resource model
  - Wetland Environmental Tool (WET)
    - Planning and ranking of wetland areas
  - USGS Habitat Evaluation Procedures (HEP)
    - Habitat-based impact assessment and resource management in both terrestrial and aquatic environment
    - http://www.fort.usgs.gov/products/software/hep/hep.asp

Habitat Evaluation Procedures (HEP)

Download Software:
HEP22.exe (143 KB)

The philosophy behind the Habitat Evaluation Procedures (HEP) is that an area can have various habitats, and that these habitats can have different suitabilities for species that may occur in that area. Further, we assume that the suitabilities can be quantified (via Habitat Suitability Indices [HSIs]) and that the different habitats have measurable areal extents. The overall suitability of an area for a species we postulate can be represented as a product of the areal extents of each habitat and the suitability of those habitats for the species.

If this is true, we may further postulate that as habitat changes through time, either by natural or human-induced processes, we can quantify the overall suitability through time by integrating the areal extent-suitability product function over time. Thus, we can quantitatively compare two or more alternative management practices of an area with regards to those practices affecting species in that area. For example, we can judge the effects of logging, mining, and cattle grazing, versus no use. Furthermore, HEP allows us to quantify the effects of mitigation (not so great a negative impact) or compensation (improve another like area to make up for lost habitat in the impacted area).

This is an important tool for land use managers, as they can quantify the effects of alternative management plans over time, and provide for mitigation and compensation that can allow fair use of the land and maintain healthy habitats for affected species.

The HEP accounting program uses the area of available habitat and Habitat Suitability Index (HSI) to compute the values needed for Habitat Evaluation Procedures (HEP) as described in the Ecological Services Manual (ESM 102) and the HEP training course Habitat Evaluation Procedures. The compiled program requires two floppy disk drives or a hard disk, and 64 kilobytes of RAM.

System Requirements

Staff Directory
Science Branches
Science Support
Product Library
Data & Metadata
Presentations
Publications
Software
Training
News & Events
Science Features
Search FORT

- Water resources model
  - EPA's Stormwater Management Model (SWMM)
    - Analysis of quality and quantity problems with urban runoff
    - http://www.epa.gov/ednnrmrl/models/swmm/index.htm

U.S. Environmental Protection Agency

Urban Watershed Management Research

Urban Watershed Management Research Home

Program Overview

Research Topics
» Wet-Weather Flow

Publications

Models
» Storm Water Management Model

Calendar

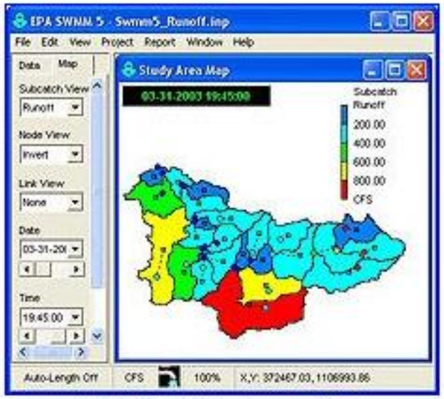
Related Links

Site Map

Storm Water Management Model (SWMM)

Version 5.0.007

- Description
- Capabilities
- Applications
- Support
- Downloads
- Links



SWMM 5 GUI. Larger View

Description

The EPA Storm Water Management Model (SWMM) is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each subcatchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps.

- USGS/FHWA's Bridge Scour Data Management System (BSDMS)
  - http://water.usgs.gov/software/bsdms.html
- Cornell Mixing Zone Expert System (CORMIX)
  - Analysis, prediction, and design of aqueous toxic or conventional pollutant discharge into diverse water bodies
  - http://www.cormix.info/

- Noise impact model
  - Federal Aviation Administration's Integrated Noise Model (INM)
    - Calculate noise exposure in the vicinity of civilian airports
    - http://www.faa.gov/about/office_org/headquarters_offices/aep/models/inm_model/

- Federal Highway Administration's Traffic Noise Model (TNM)
  - Roadway noise prediction
  - http://www.trafficnoisemodel.org/main.html
- Federal Transit Administration's FTANOISE model
  - Spreadsheet program for the assessment of rail noise exposure based on various train and track types

Aviation Policy, Planning & Environment Topics

- Aircraft Noise Issues
- Aircraft Noise Levels
- Airport Noise Compatibility Planning Toolkit
- Airport and Airway Trust Fund (AATF)
- Emissions & Noise
- Insurance Program
- Key Officials

Models

- Area Equivalent Method (AEM)
- Emissions and Dispersion Modeling System (EDMS)
- Heliport Noise Model (HNM)
- **Integrated Noise Model (INM)**
- System for

Integrated Noise Model (INM)

The Integrated Noise Model (INM) evaluates aircraft noise impacts in the vicinity of airports. INM has many analytical uses, such as:

- Assessing changes in noise impact resulting from new or extended runways or runway configurations
- Assessing new traffic demand and fleet mix
- Evaluating other operational procedures

A Standard Tool since 1978

The INM has been FAA's standard tool since 1978 for determining the predicted noise impact in the vicinity of airports. Statutory requirements for INM use are defined in FAA Order 1050.1E, Policies and Procedures for Considering Environmental Impacts; Order 5050.4A, Airport Environmental Handbook; and Federal Aviation Regulations (FAR) Part 150, Airport Noise Compatibility Planning.

- INM 6.1 Order Form (PDF)
- INM 6.1 (March 4, 2003)

Model Inputs

The Model utilizes the following inputs:

- Flight track information
- Aircraft fleet mix
- Standard defined aircraft profiles
- User defined aircraft profiles
- Terrain

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Seminar Topics

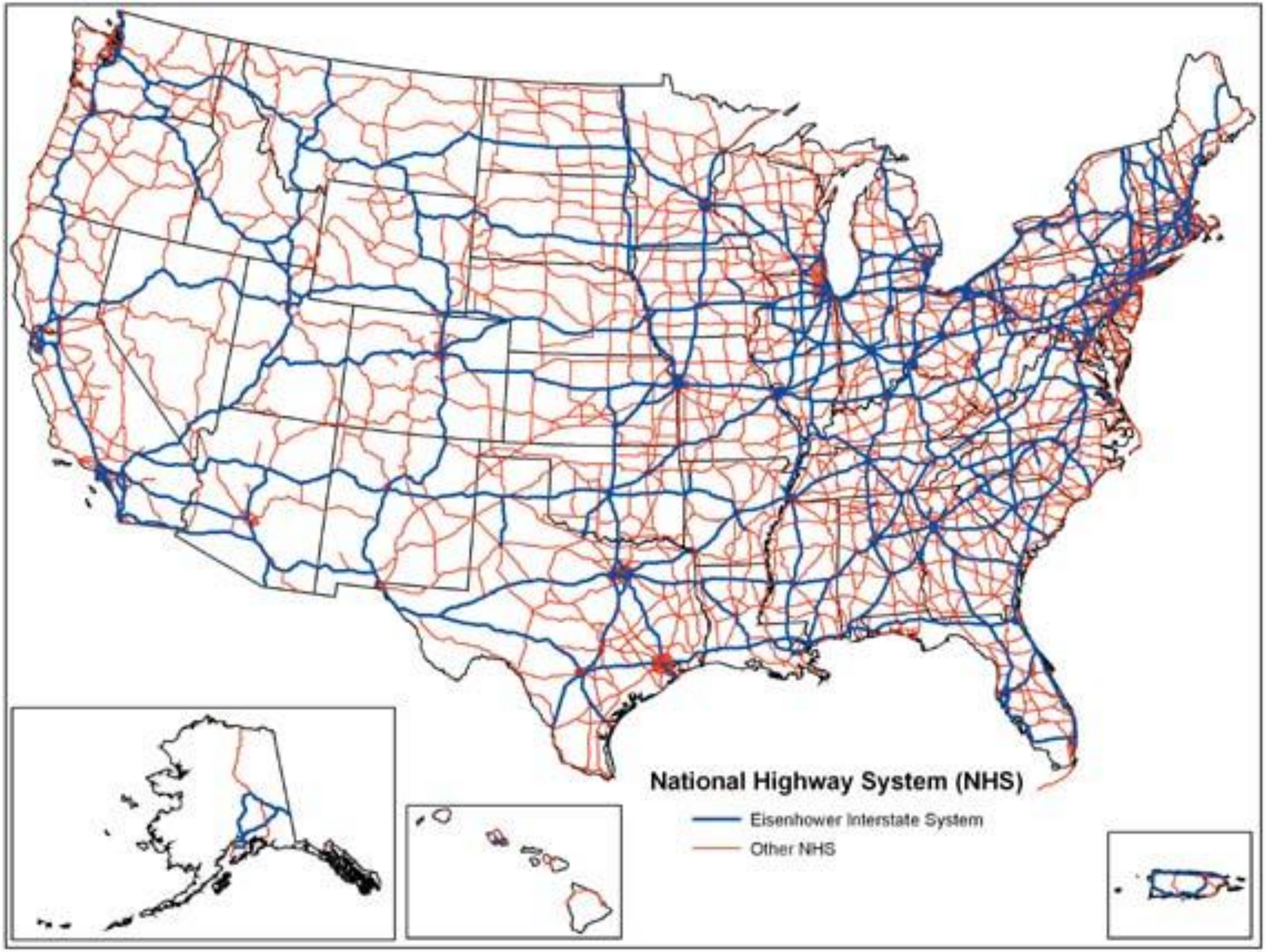
Session Topics

Day1	Introduction to Seminar
	Dubai Projects & Panama Canal
	Environmental Impact Assessment
	Impacts and Considerations in Road Transportation
Day 2	Environmental Water Quality Parameters
	Impacts and Considerations in Ship Transportation
	Impacts and Considerations in Air Transportation
	Reuse and Recycle in Construction and Transportation

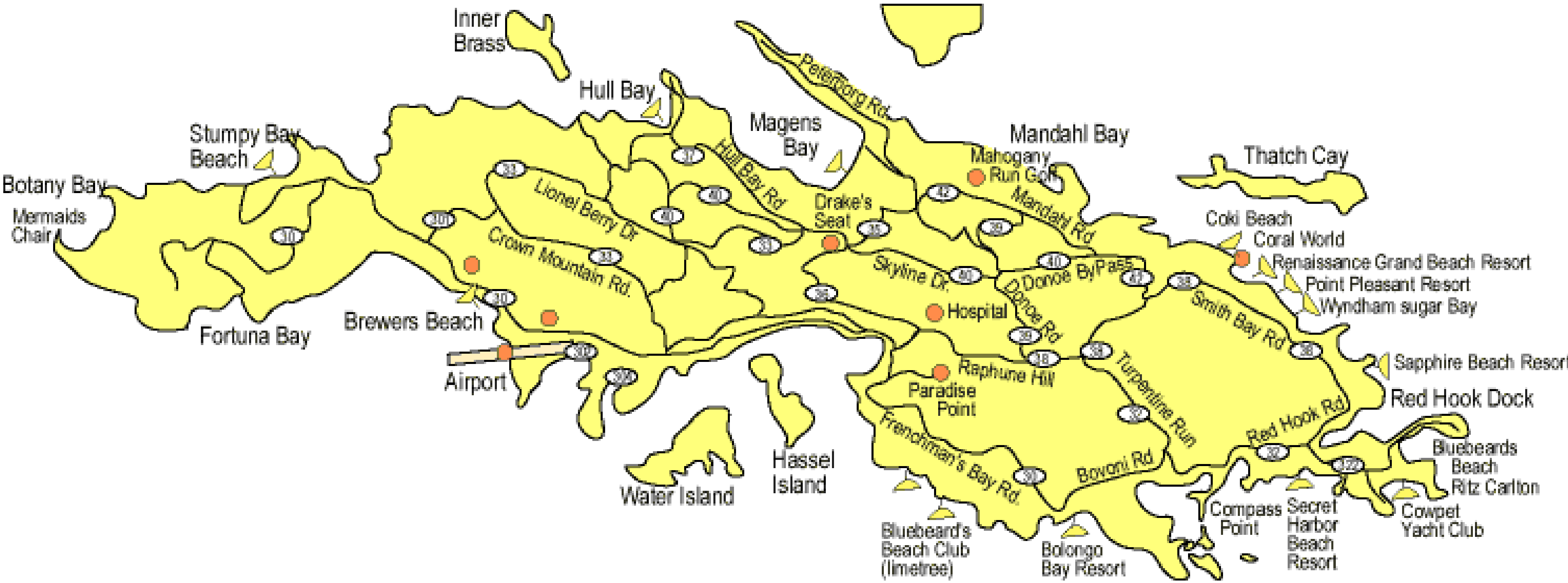
Session 4. Environmental Impacts and Considerations in Road Transportation 1

- Highway Runoff and Controls
- Surface Water Hydrology

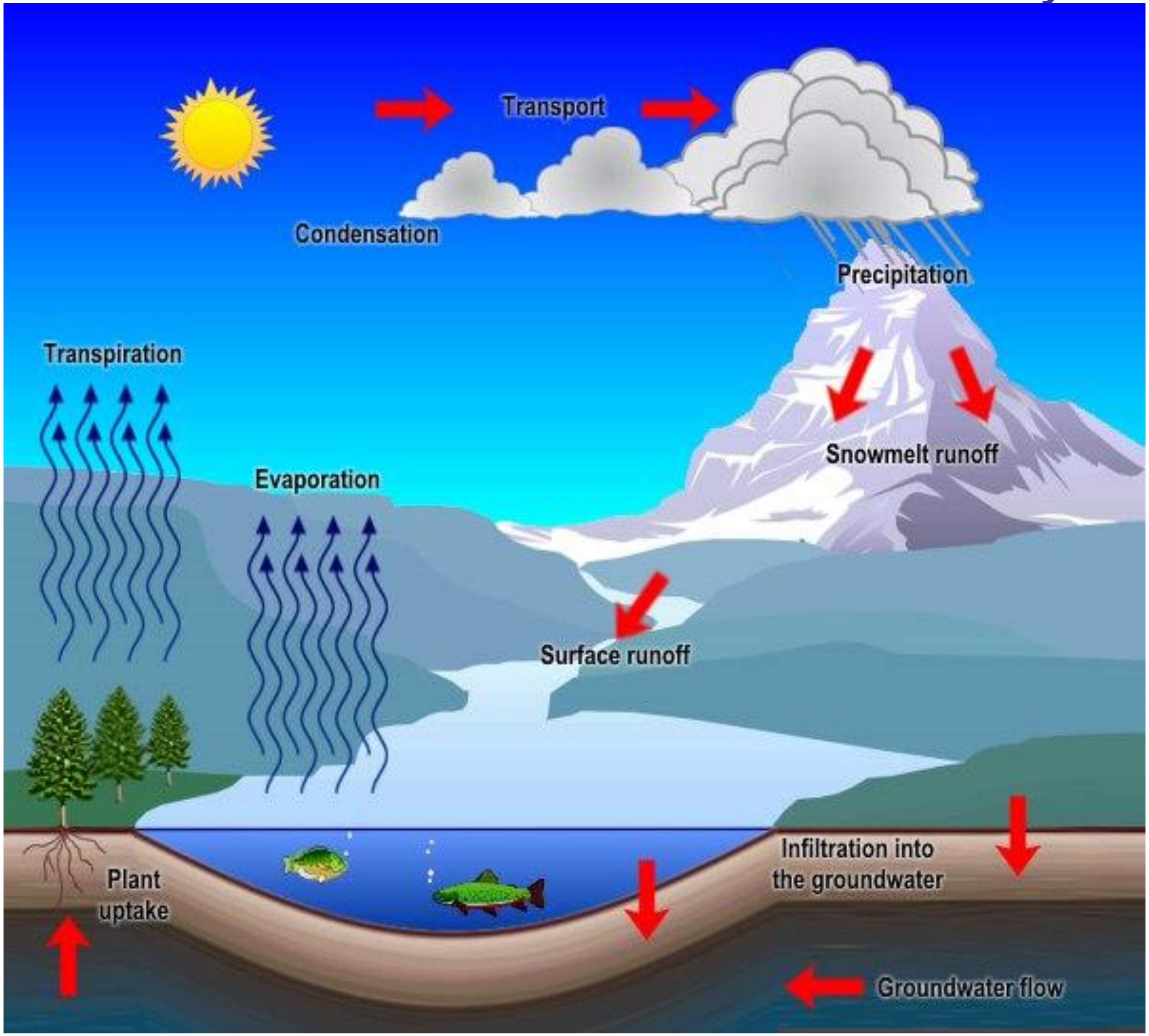
National Highway System



St. Thomas Roads



Hydrologic Cycle



Source:www.srh.noaa.gov/srh/jetstream/atmos/images/hydro.jpg

- To provide erosion and sediment controls and stormwater runoff controls before and after construction of highways (roads and other facilities).

- These controls, known as best management practices (BMPs), are designed to minimize the impact of pollutants in highway runoff on receiving water quality.

- Substantial non-point-source pollution in highway runoff
  - Particles impart turbidity (cloudiness) to water.
  - Not only is this turbidity aesthetically unpleasant (especially in drinking water), but the particles may also carry pathogenic microorganisms or toxic chemicals (especially heavy metals and pesticides).
  - Turbidity can also contribute to siltation of reservoirs, gill-clogging, and smothering of benthic (bottom-dwelling) organisms

Suspended Particulate matters flushing to Water Bodies (PR)

- 332,000 tons/year

LA PLATA LAKE: SEP., 1998

- Roadway suspended-solid loads may be reduced by:

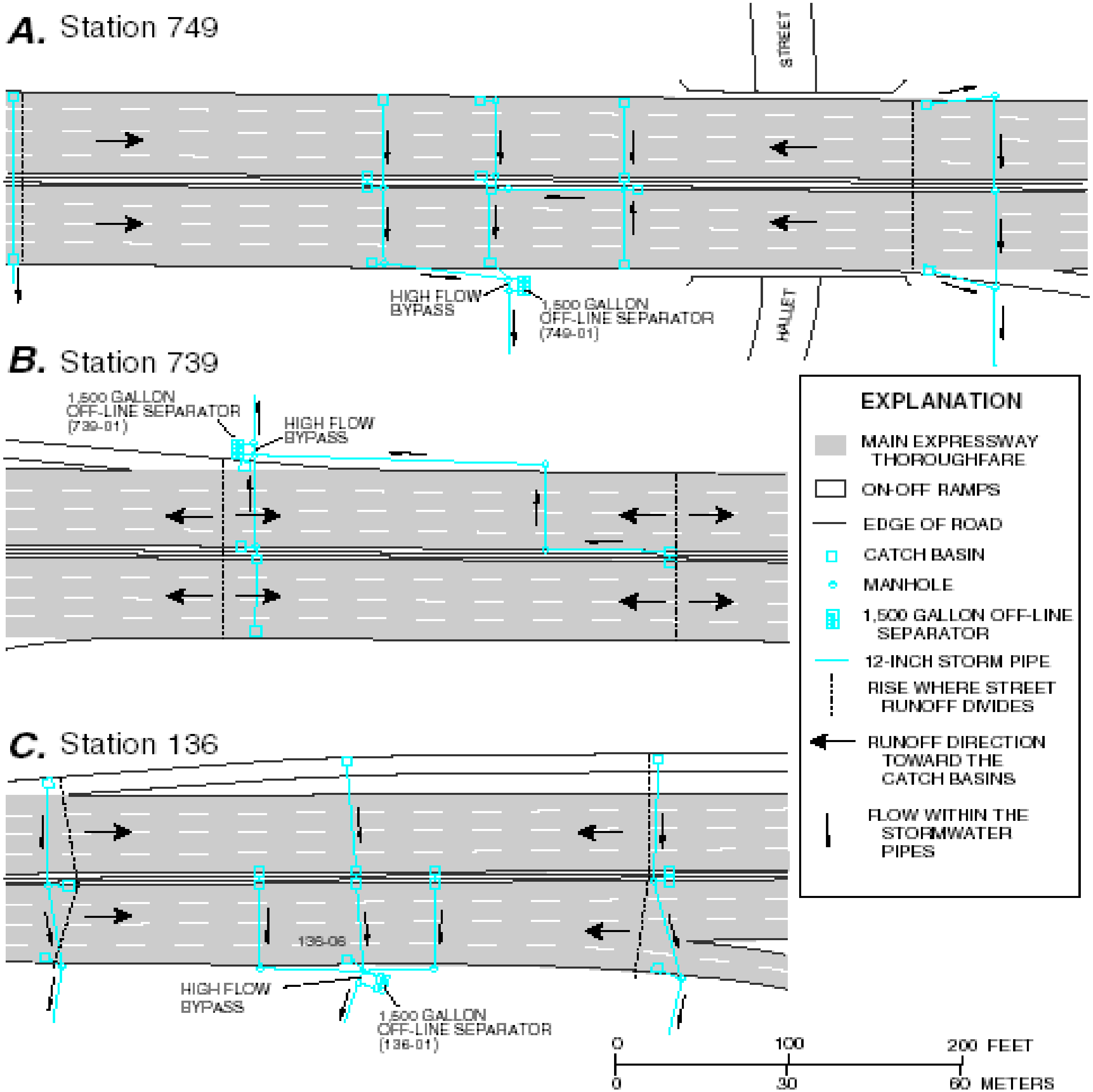
  (1) Diverting storm flows through various structural end-of-pipe devices,

  * wet ponds;
  * wetlands;
  * dry ponds; and
  * infiltration basins.

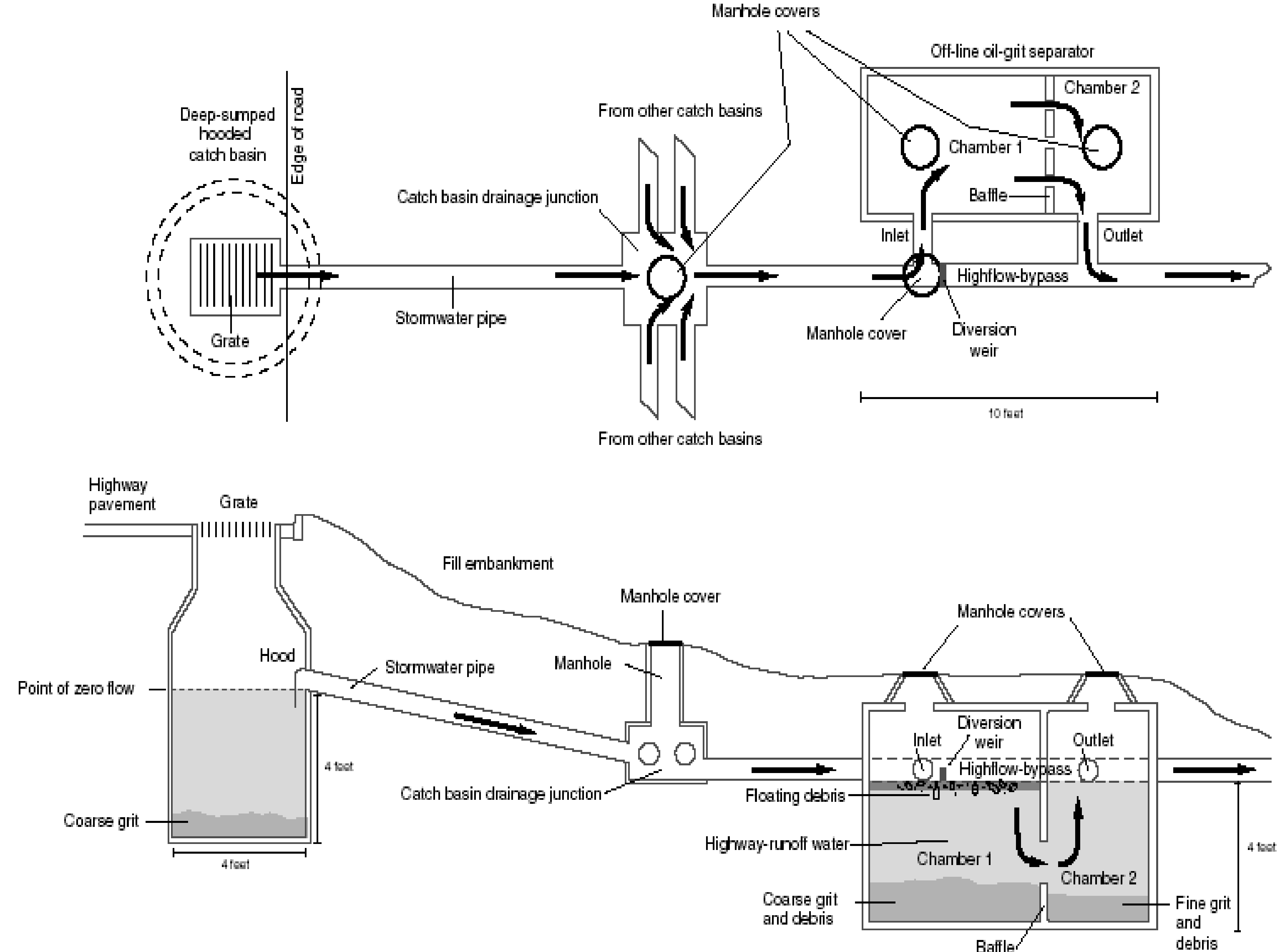
  or

  (2) Removing particulate matter from roadway surfaces prior to runoff transport (for example, source control).

Dr. Sangchul (San) Hwang



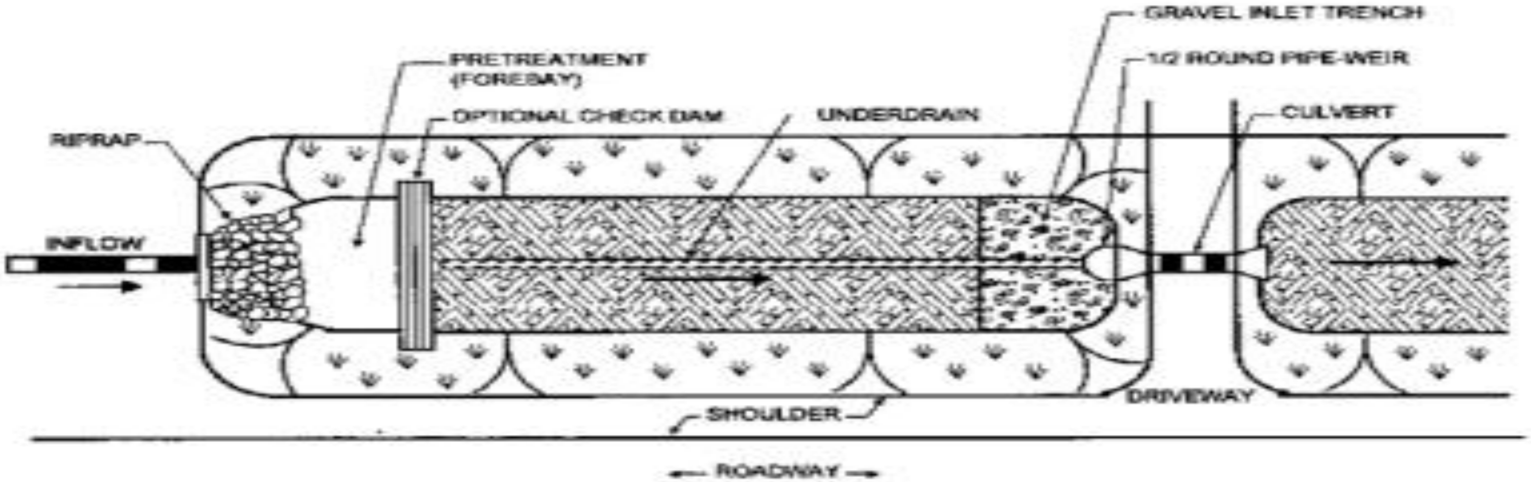
Dr. Sangchul (San) Hwang



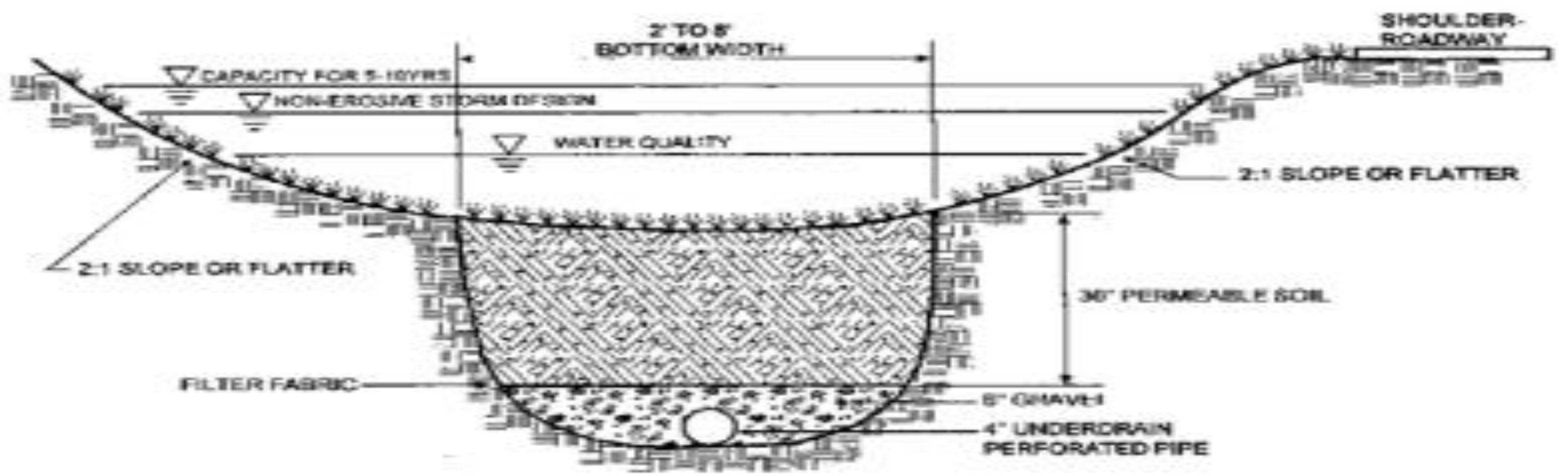
Manhole covers
Off-line oil-grit separator
Chamber 2
Deep-sumped hooded catch basin
Edge of road
From other catch basins
Chamber 1
Catch basin drainage junction
Baffle
Inlet
Outlet
Highflow-bypass
Stormwater pipe
Grate
Manhole cover
Diversion weir
10 feet
From other catch basins
Highway pavement
Grate
Fill embankment
Manhole cover
Manhole covers
Hood
Stormwater pipe
Manhole
Point of zero flow
Diversion weir
Inlet
Outlet
4 feet
Highflow-bypass
Catch basin drainage junction
Floating debris
Coarse grit
Highway-runoff water
4 feet
4 feet
Chamber 1
Chamber 2
Coarse grit and debris
Fine grit and debris
Baffle

Vegetated Swales

- grassed channel, dry swale, wet swale or biofilter
- Vegetated areas used in place of curbs or paved gutters to transport storm water runoff.
- Temporarily hold small quantities of runoff and allow it to infiltrate into the soil.



PLAN VIEW



www.stormwatercenter.net

SECTION

- Bioretention is a up-land water quality and water quantity control practice the uses the chemical, biological and physical properties of plants, microbes and soils for removal of pollutants from storm water runoff.

www.bioretention.com

TABLE 1

Typical pollutant concentrations in urban storm-water runoff for different land uses

Pollutant (units)	Median event mean concentration for land use		
	Residential	Mixed	Commercial
Biological oxygen demand (mg/L)	10	7.8	9.3
Chemical oxygen demand (mg/L)	73	65	57
Total suspended solids (mg/L)	101	67	69
Total lead (µg/L)	144	114	104
Total copper (µg/L)	33	27	29
Total zinc (µg/L)	135	154	226
Total Kjeldahl nitrogen (µg/L)	1900	1288	1179
Nitrate and nitrite (µg/L)	736	558	572
Total phosphorus (µg/L)	383	263	201
Soluble phosphorus (µg/L)	143	56	80

340A ■ ENVIRONMENTAL SCIENCE & TECHNOLOGY / AUGUST 15, 2005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Bioretention.com provides information about the design and construction of bioretention facilities for land planners, civil engineers, landscape architects, and environmental professionals. Although bioretention is one of the practices used in Low Impact Development (LID), Bioretention.com focuses solely on the actual facility design - not overall site design using the LID methodology.
If you think we are missing something click here to tell us about it. We value your input and opinion, and our goal is to make this site as comprehensive as possible.
So click a link to get going....
NEWS!!
National Low Impact Development Workshop Schedule announced!
Click here to learn more.
Low Impact Development site design IS possible!
Click here to learn more.
WISCONSIN has released new technical standards for bioretention.
Click here to learn more.
Delaware's Standards & Specifications for Green Technology BMPs was effective July 1, 2005
Click here
Home
WHAT IS IT?
COMPONENTS
DESIGN DETAILS
WHAT IS IT?
A quick overview
SIZING METHODS
Yes, there are several ways to size them
DESIGN SOFTWARE
Focus on more time on design - not the numbers - and be sure your bioretention is correctly sized.
BEFORE YOU DESIGN
A discussion of the components of bioretention
PRETREATMENT
FLOW ENTRANCE
PONDING AREA
PLANT MATERIAL
ORGANIC LAYER OR MULCH
PLANTING SOIL AND FILTER MEDIA
PEA GRAVEL DIAPHRAGM
UNDERDRAIN OR OUTLET
SURFACE OVERFLOW
THE DETAILS OF DESIGN
On to the stuff you need.
EROSION AND SEDIMENT CONTROL
SOIL MEDIA
UNDERDRAINS
FILTER MATERIALS
LANDSCAPING
Bioretention Types & Applications
Plant Material Guidelines
MAINTENANCE
A discussion of bioretention in residential applications and typical maintenance items
STATE REFERENCES
Links to guidance for all 50 states as related to bioretention
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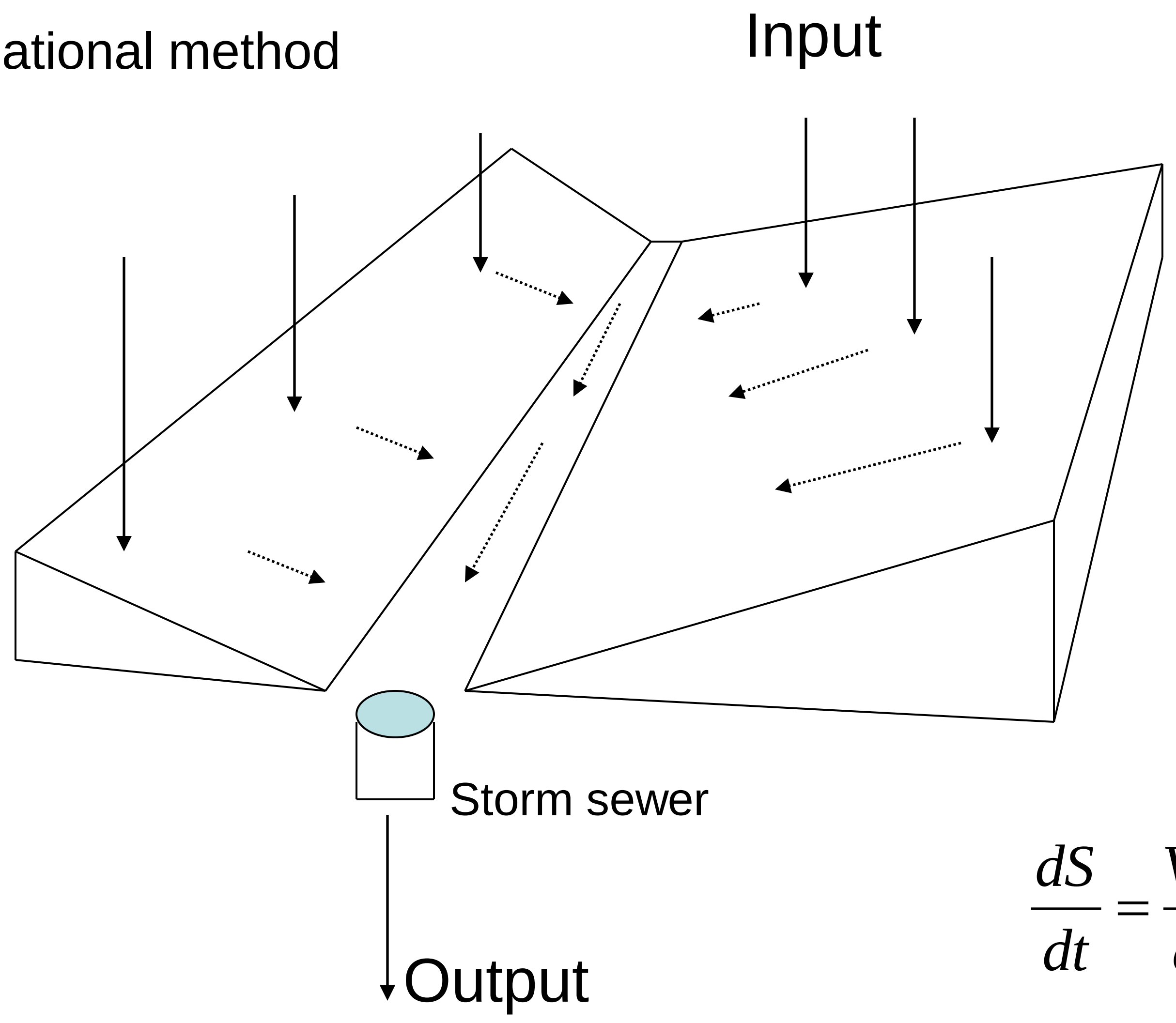
- Estimation of amount of runoff
- Estimation of time of arrival
- Estimation of probability of occurrence

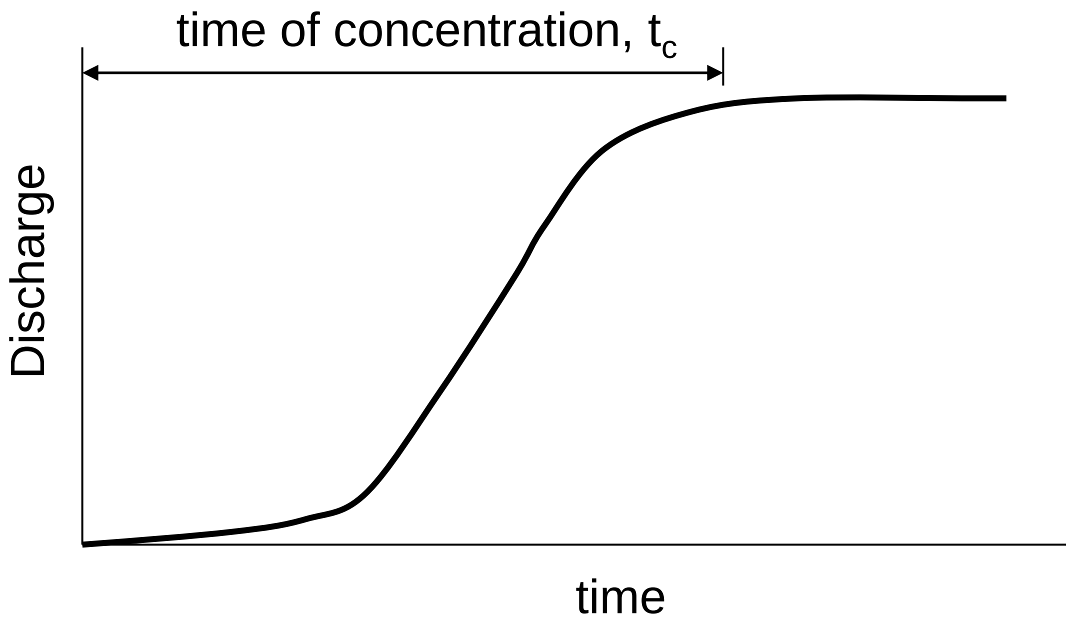
Estimation of amount of runoff

- Rational method



$$\frac{dS}{dt} = \frac{V_P}{dt} - \frac{V_R}{dt}$$

- If raining for a long time at a constant intensity, then



- t_c is the time required for direct runoff to flow from the hydraulically most remote part of the drainage area to the watershed outlet

$$at\ steady\ state,\ \frac{dS}{dt} = 0$$

$$\therefore \frac{V_P}{dt} = \frac{V_R}{dt}$$

$$\frac{V_p}{dt} = iA$$

$$\frac{V_R}{dt} = Q$$

only some fraction of rainfalls makes it to the discharge outlet

$$Q = 0.0028CiA$$

$$where\ Q = paek\ runoff\ rate,\ m^3/s$$

$$C = runoff\ coefficien\,t$$

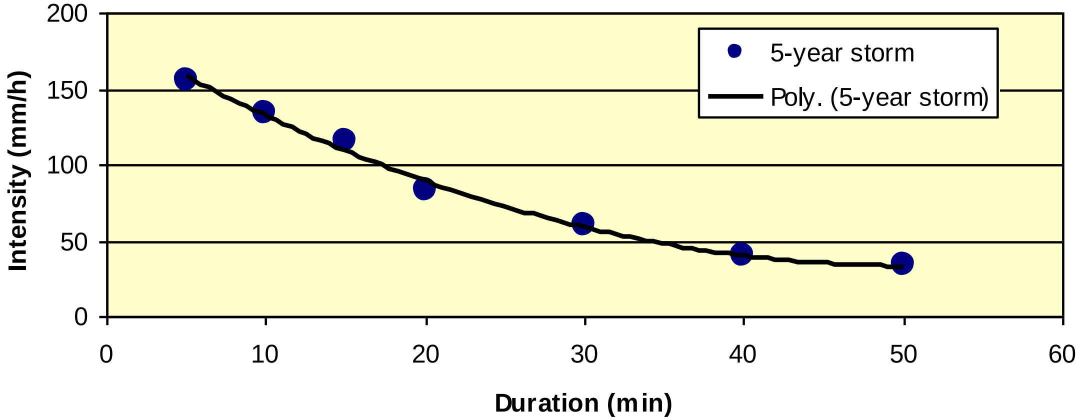
$$i = average\ rainfall\ intensity,\ mm/h$$

$$A = area\ of\ watershed,\ ha$$

$$0.0028 = conversion\ factor$$

- What is the peak discharge from the grounds of the School during a 5 year storm?
  - The School grounds encompass 16.2 ha plot. Assume average time of concentration of the grounds is 53 minutes. Use the rainfall data as below. The composition of the grounds is as follows:

Character of surface	Area (m^2)	Runoff coefficient
Parking lot, asphalt	11,150	0.85
Building	10,800	0.75
Lawns, heavy soil		
2.0% slope	35,000	0.17
6.0% slope	105,050	0.20
	Total = 162,000	



$$Peak\ discharge\ occurs\ at\ t_c$$

$$Q = 0.0028CiA = 0.0028C(30\ mm/h)A$$

$$CA = 0.85(11{,}150) + 0.75(10{,}800) + 0.17(35{,}000) + 0.20(105{,}050)$$

$$= 44{,}537.5\ m^2\ or\ 4.45\ ha$$

$$Therefore,\ Q = 0.0028(4.45)(30) = 0.37\ m^3/s$$

- Thus, a storm sewer large enough to handle 0.37 m^3/s of flow is required

- Estimate t_c (Federal Aviation Agency formula)

$$t_c = \frac{1.8(1.1 - C)\sqrt{3.28D}}{\sqrt[3]{S}}$$

$$\begin{aligned} where\ t_c &= time\ of\ concentration,\ min \\ C &= runoff\ coefficient \\ D &= overland\ flow\ distance,\ m \\ S &= slope,\ \% \end{aligned}$$

Estimation of probability of occurrence

$$Frequency\ of\ occurrence = \frac{1}{T}$$
$$= fn(benefit - cost)$$

- Estimation of construction cost: straightforward
- Environmental and sociological benefit: difficult to quantify

Estimation of probability of occurrence

- Extreme-value analysis (Annual series)
  - 12-month water year or hydrologic year: Oct. 1 ~ Sep. 30
  - Annual maxima series, or
  - Annual minima series
  - Flood data paper (Gumbel paper)
  - Example 2-8
- Yield analysis (Complete series)
  - In a duration curve
  - In a cumulative probability distribution function

Example 2-8. Perform an annual maxima extreme-value analysis on the data in Table 2-4. Determine the recurrence interval of monthly flows equal to or greater than 58.0 m^3/s. Also determine the discharge of the mean monthly annual flood.

TABLE 2-4
Average monthly discharge of the Wash River at Watapitac, MI (discharge in m^3/s)

Year	J	F	M	A	M	J	J	A	S	O	N	D
1969	2.92	5.10	1.95	4.42	3.31	2.24	1.05	0.74	1.02	1.08	3.09	7.62
1970	24.3	16.7	11.5	17.2	12.6	7.28	7.53	3.03	10.2	10.9	17.6	16.7
1971	15.3	13.3	14.2	36.3	13.5	3.62	1.93	1.83	1.93	3.29	5.98	12.7
1972	11.5	4.81	8.61	27.0	4.19	2.07	1.15	2.04	2.04	2.10	3.12	2.97
1973	11.1	7.90	41.1	6.77	8.27	4.76	2.78	1.70	1.46	1.44	4.02	4.45
1974	2.92	5.10	28.7	12.2	7.22	1.98	0.91	0.67	1.33	2.38	2.69	3.03
1975	7.14	10.7	9.63	21.1	10.2	5.13	3.03	10.9	3.12	2.61	3.00	3.82
1976	7.36	47.4	29.4	14.0	14.2	4.96	2.29	1.70	1.56	1.56	2.04	2.35
1977	2.89	9.57	17.7	16.4	6.83	3.74	1.60	1.13	1.13	1.42	1.98	2.12
1978	1.78	1.95	7.25	24.7	6.26	8.92	3.57	1.98	1.95	3.09	3.94	12.7
1979	13.8	6.91	12.9	11.3	3.74	1.98	1.33	1.16	0.85	2.63	6.49	5.52
1980	4.56	8.47	59.8	9.80	6.06	5.32	2.14	1.98	2.17	3.40	8.44	11.5
1981	13.8	29.6	38.8	13.5	37.2	22.8	6.94	3.94	2.92	2.89	6.74	3.09
1982	2.51	13.1	27.9	22.9	16.1	9.77	2.44	1.42	1.56	1.83	2.58	2.27
1983	1.61	4.08	14.0	12.8	33.2	22.8	5.49	4.25	5.98	19.6	8.5	6.09
1984	21.8	8.21	45.1	6.43	6.15	10.5	3.91	1.64	1.64	1.90	3.14	3.65
1985	8.92	5.24	19.1	69.1	26.8	31.9	7.05	3.82	8.86	5.89	5.55	12.6
1986	6.20	19.1	56.6	19.5	20.8	7.73	5.75	2.95	1.49	1.69	4.45	4.22
1987	15.7	38.4	14.2	19.4	6.26	3.43	3.99	2.79	1.79	2.35	2.86	10.9
1988	21.7	19.9	40.0	40.8	11.7	13.2	4.28	3.31	9.46	7.28	14.9	26.5
1989	31.4	37.5	29.6	30.8	11.9	5.98	2.71	2.15	2.38	6.03	14.2	11.5
1990	29.2	20.5	34.9	35.3	13.5	5.47	3.29	3.14	3.20	2.11	5.98	7.62

TABLE 2-5
Tabulated computations of annual maxima for the Wash River at Watapitae, MI

Year	Discharge (m^3/s)	Rank	$T = \frac{n+1}{m}$
1970	24.3	18	1.22
1971	36.3	11	2.00
1972	27.0	16	1.38
1973	41.1	6	3.67
1974	28.7	14	1.57
1975	21.1	19	1.16
1976	47.4	4	5.50
1977	17.7	20	1.10
1978	24.7	17	1.29
1979	13.8	21	1.05
1980	59.8	2	11.00
1981	38.8	8	2.75
1982	27.9	15	1.47
1983	33.2	13	1.69
1984	45.1	5	4.40
1985	69.1	1	22.00
1986	56.6	3	7.33
1987	38.4	9	2.44
1988	40.8	7	3.14
1989	37.5	10	2.20
1990	35.3	12	1.83

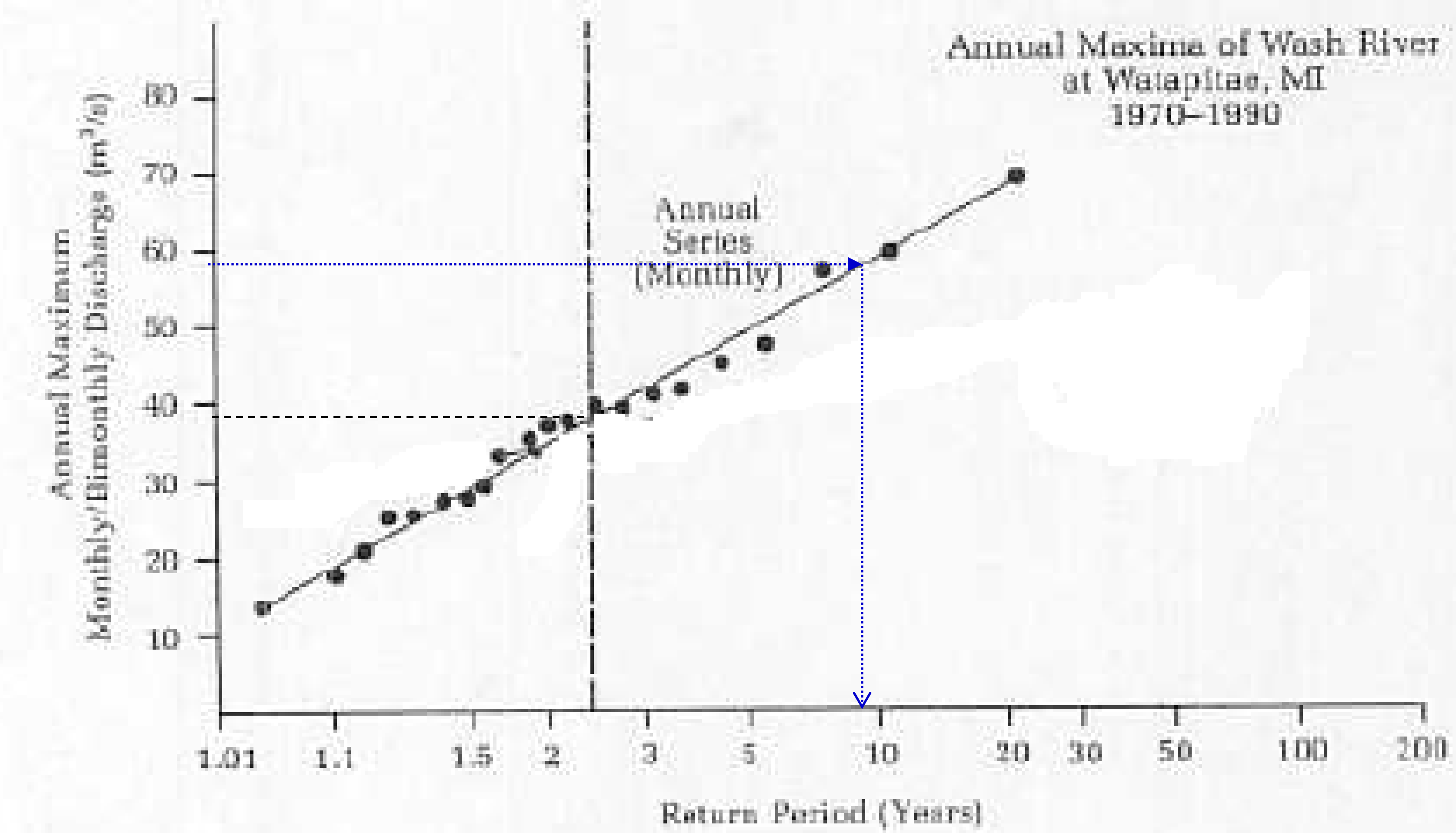


FIGURE 2-19
Gumbel plot of annual maxima of Wash River at Watapitae, MI.

- Perform an annual maxima extreme-value analysis on the River A data given in the table below. Determine the flow for a return period of **five** years. For this, use the table and Gumbel paper provided.

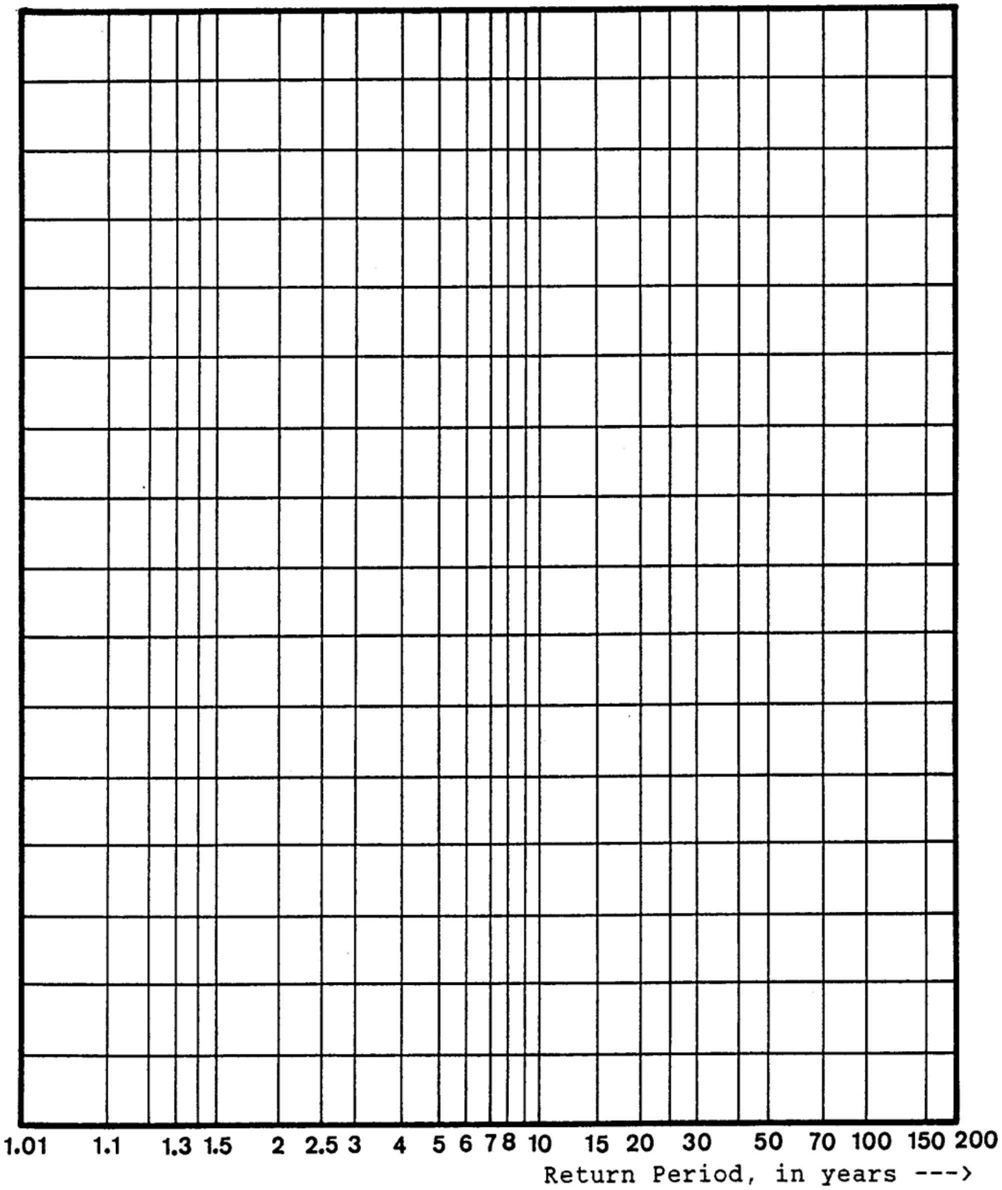
Hoko River near Sekiu, WA (Problem 2-21)

Mean monthly discharge (m^3/s) 1963–1973

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1963	12.1	15.0	8.55	9.09	5.78	1.28	2.59	1.11	.810	13.3	26.1	20.3
1964	27.3	12.2	18.0	8.21	4.08	3.62	4.53	2.44	4.28	7.67	13.3	14.7
1965	27.4	27.3	5.01	5.61	6.68	1.38	.705	.830	.810	7.31	16.8	19.6
1966	29.8	11.3	17.6	5.18	2.67	2.10	1.85	.986	1.54	10.3	17.0	39.0
1967	35.6	26.8	18.5	6.51	3.43	1.46	.623	.413	.937	25.7	14.2	27.8
1968	34.2	22.4	15.7	9.20	3.68	2.65	1.72	1.55	9.12	16.8	16.5	25.2
1969	17.2	18.5	12.9	12.8	3.74	2.23	1.19	.810	6.15	7.84	9.15	15.9
1970	17.3	12.1	8.50	17.7	3.85	1.32	.932	.708	4.22	7.96	13.9	25.4
1971	32.7	21.0	21.1	8.13	3.43	2.83	1.83	.932	2.22	10.7	22.7	22.0
1972	27.4	26.9	25.4	14.6	3.00	1.00	5.32	.841	2.00	1.14	11.8	37.8
1973	28.0	9.23	11.3	4.13	5.30	4.93	1.63	.736	.810	13.1	29.8	31.5

Year	Discharge (m^3/sec)	Rank	T = (n+1)/m

Gumbel Paper



- Dr. San Hwang is planning to build the Tropical Environmental Research Center on the east side of Road 108 as shown the Figure 1. The existing culvert was designed for a 5-year storm.
- Determine if the capacity of the culvert will be exceeded if it is not enlarged when the Center is built. Use the IDF curves in Figure 2.
- You may need the following equations:

$$t_c = \frac{1.8(1.1 - C)\sqrt{3.28D}}{\sqrt[3]{S}}$$

$$Q = 0.0028CIA$$

Figure 1

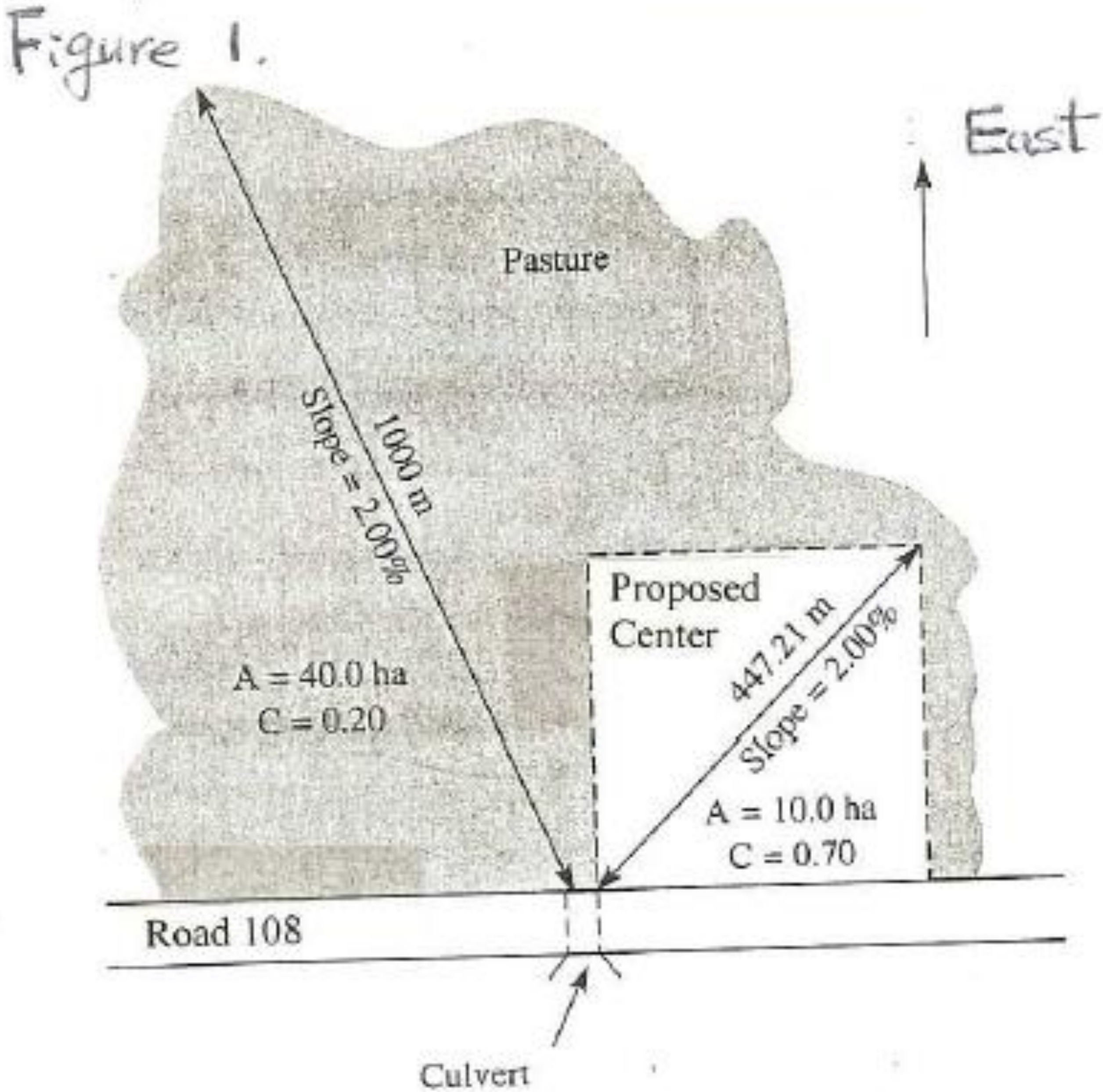


Figure 1.
East
Pasture
1000 m
Slope = 2.00%
A = 40.0 ha
C = 0.20
Proposed
Center
447.21 m
Slope = 2.00%
A = 10.0 ha
C = 0.70
Road 108
Culvert

Figure 2

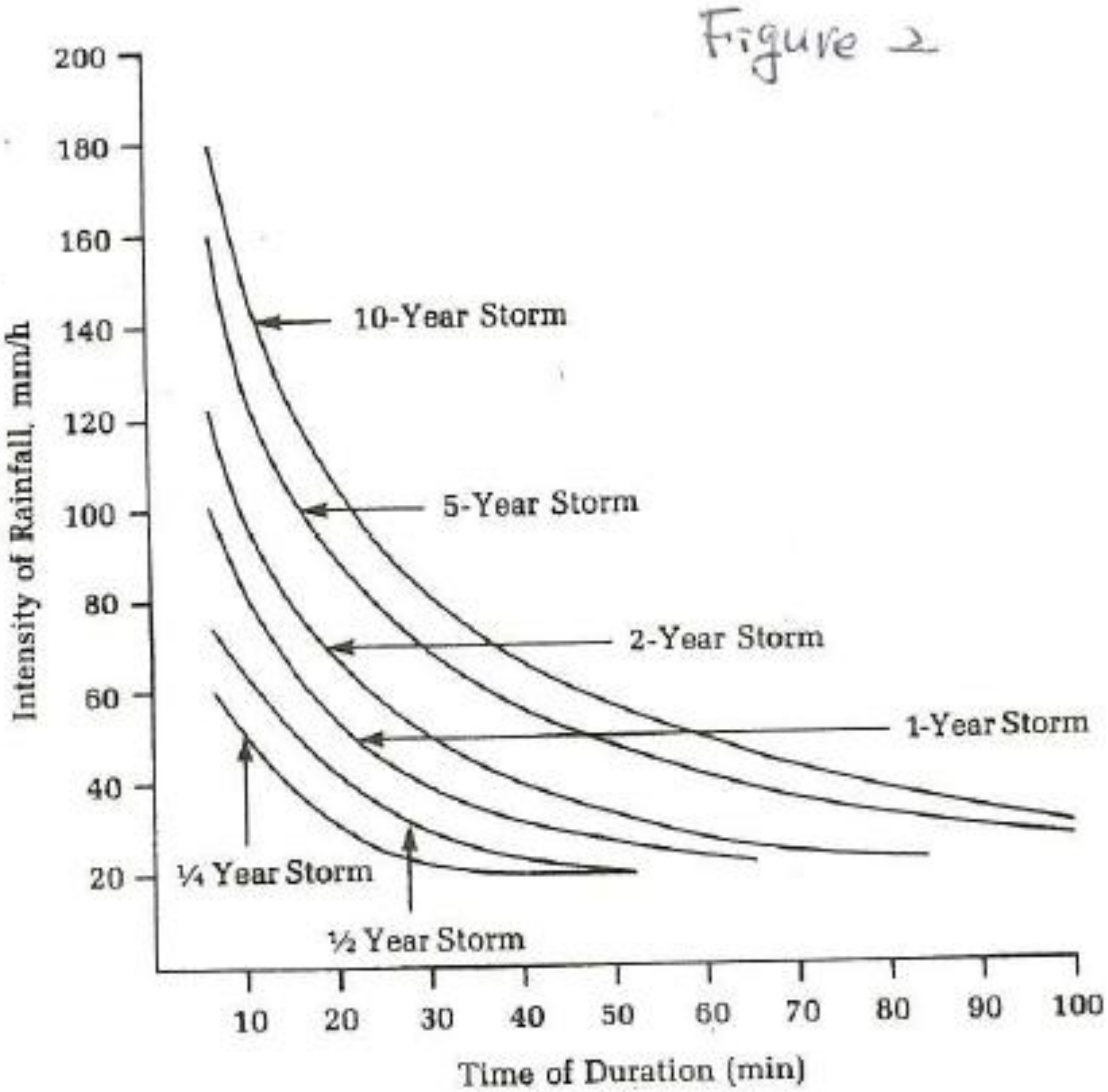


Figure 2
200
180
160
140
120
100
80
60
40
20
Intensity of Rainfall, mm/h
10-Year Storm
5-Year Storm
2-Year Storm
1-Year Storm
¼ Year Storm
½ Year Storm
10
20
30
40
50
60
70
80
90
100
Time of Duration (min)

Coffee Break

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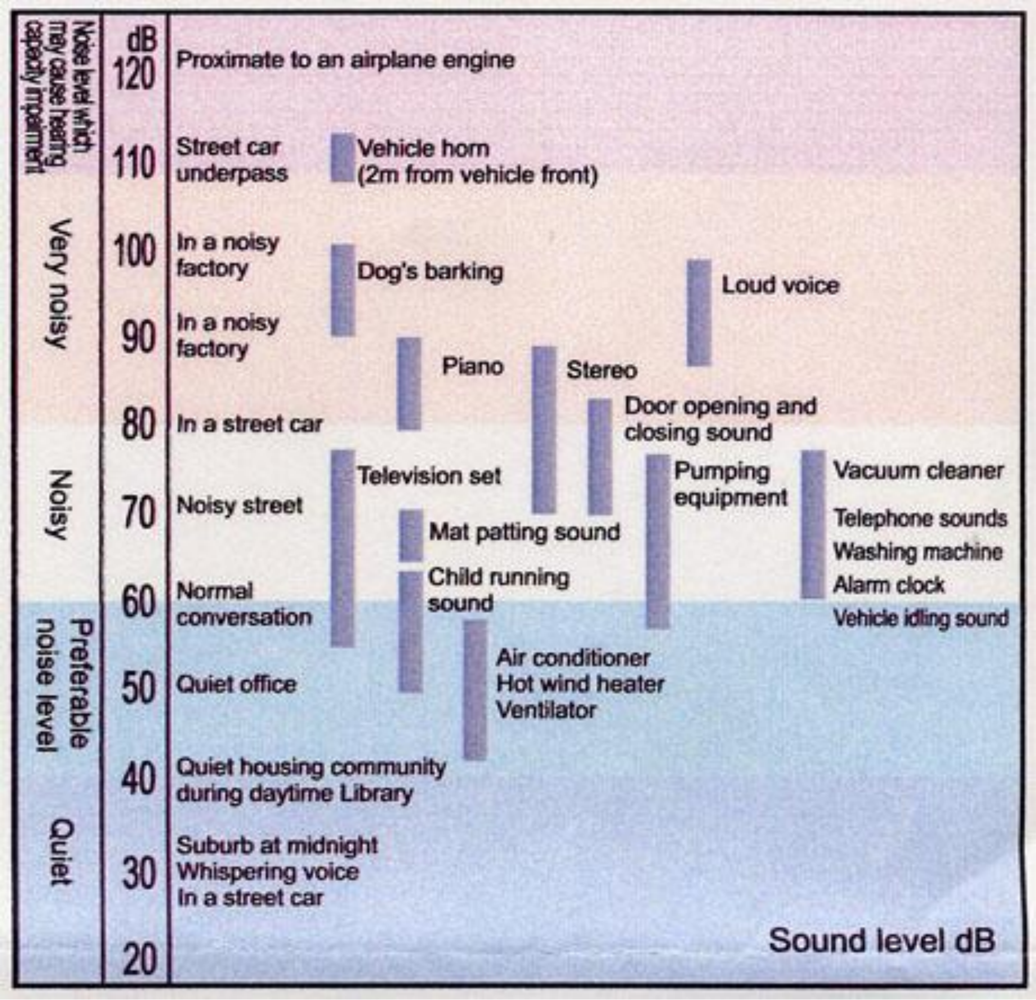
Session 5. Environmental Impacts and Considerations in Road Transportation 2

- Noise Management
- Air Pollution Control

Dr. Sangchul (San) Hwang

Noise Level

- Noise: Impairs hearing and increases stress



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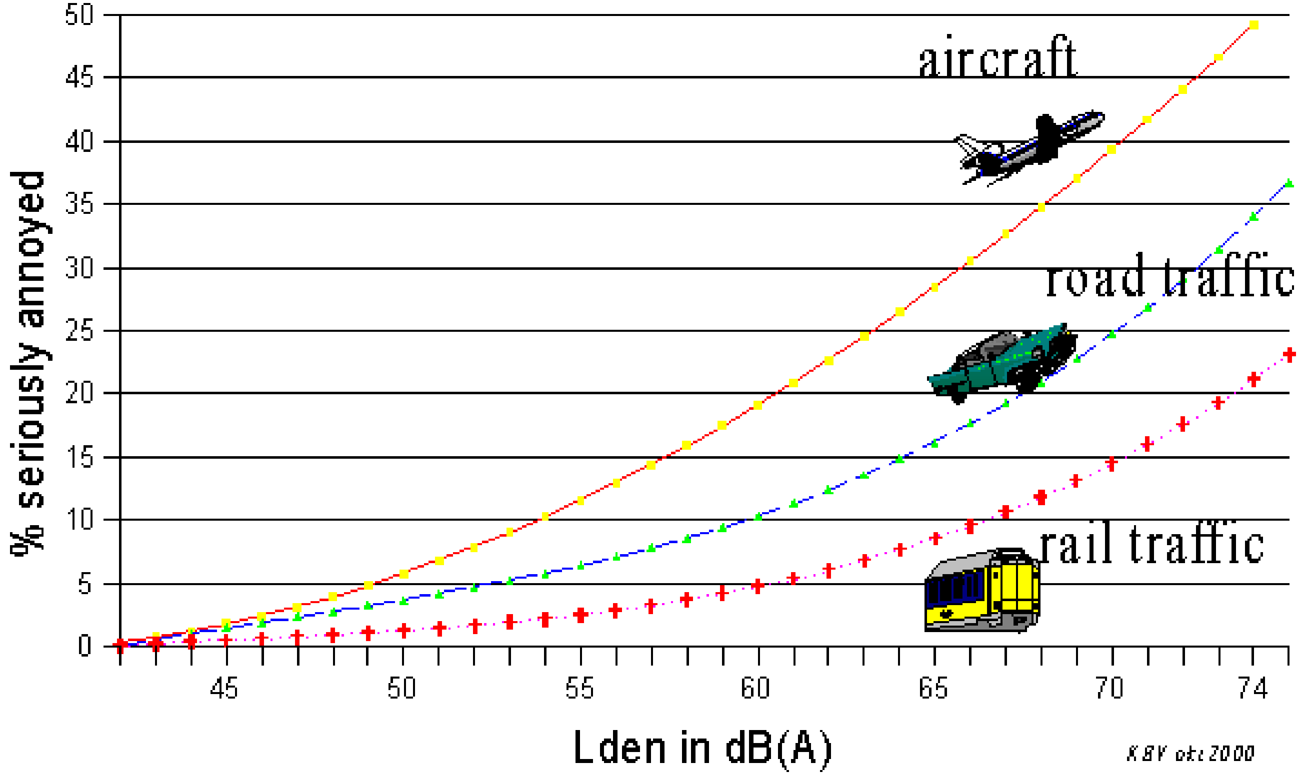
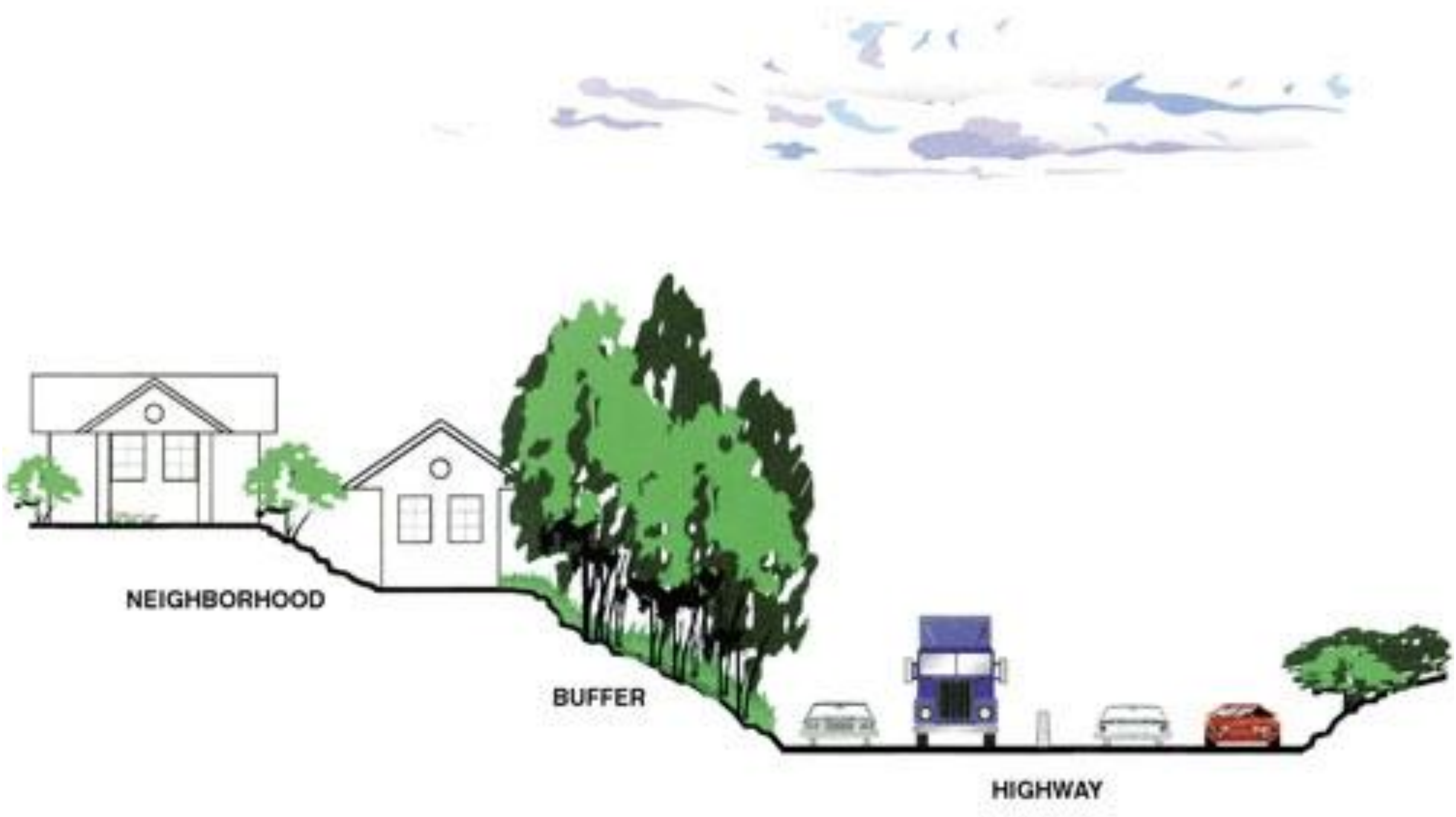
Seriously annoyed by noise



Noise Buffer



FHWA Roadway Construction Noise Model - Microsoft Internet Explorer

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FHA Roadway Construction Noise Model

Roadway Construction Noise Model (RCNM) - example case.cas

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Input Data

Case Description:

Receptor

	Description	Land Use	Daytime Baseline (dBA)	Evening Baseline (dBA)	Nighttime Baseline (dBA)
1	N-231 in C17A6	Residential	78.0	75.0	71.0
2					
3					
4					

Noise Metric: L10

Noise Limit Criteria

L10 Calculation

Receptor #1

Noise Limits

Equipment **Receptor #1: N-231 in C17A6**

	Active	Description	Impact Device	Usage(%)	Spec Lmax (dBA)	Actual Lmax (dBA)	Distance to Receptor (feet)	Estimated Shielding (dBA)
1	✓	Compactor (ground)		20%	80.0	83.2	50.0	0.0
2	✓	Concrete Saw		20%	90.0	89.6	50.0	0.0
3	✓	Dozer		40%	85.0	81.7	50.0	0.0
4	✓	Flat Bed Truck		40%	84.0	74.3	50.0	0.0
5	✓	Excavator		40%	85.0	80.7	50.0	0.0
6								

Results

Receptor #1: N-231 in C17A6

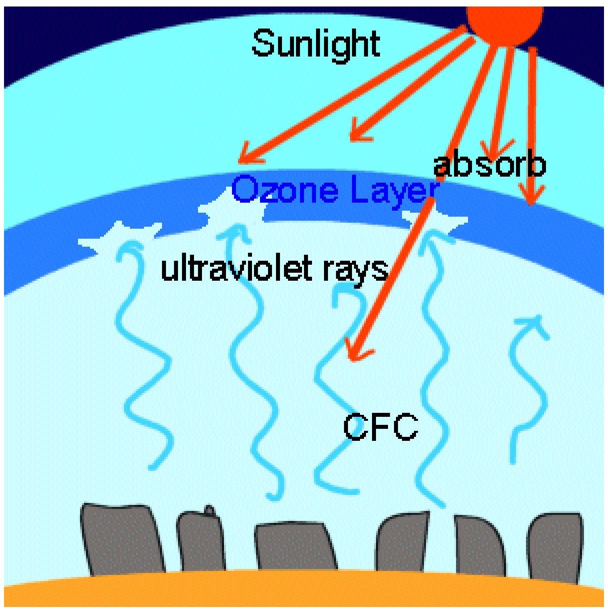
		Calculated (dBA)		Noise Limits (dBA)						Noise Limit Exceedance (dBA)					
				Day		Evening		Night		Day		Evening		Night	
	Equipment	Lmax*	L10	Lmax	L10	Lmax	L10	Lmax	L10	Lmax	L10	Lmax	L10	Lmax	L10
	Total	89.6	88.3	85.0	83.0	85.0	80.0	80.0	74.0	4.6	5.3	4.6	8.3	9.6	14.3
1	Compactor (ground)	83.2	79.2	85.0	83.0	85.0	80.0	80.0	74.0	None	None	None	None	3.2	5.2
2	Concrete Saw	89.6	85.6	85.0	83.0	85.0	80.0	80.0	74.0	4.6	2.6	4.6	5.6	9.6	11.6
3	Dozer	81.7	80.7	85.0	83.0	85.0	80.0	80.0	74.0	None	None	None	0.7	1.7	6.7
4	Flat Bed Truck	74.3	73.3	85.0	83.0	85.0	80.0	80.0	74.0	None	None	None	None	None	None
5	Excavator	80.7	79.7	85.0	83.0	85.0	80.0	80.0	74.0	None	None	None	None	0.7	5.7

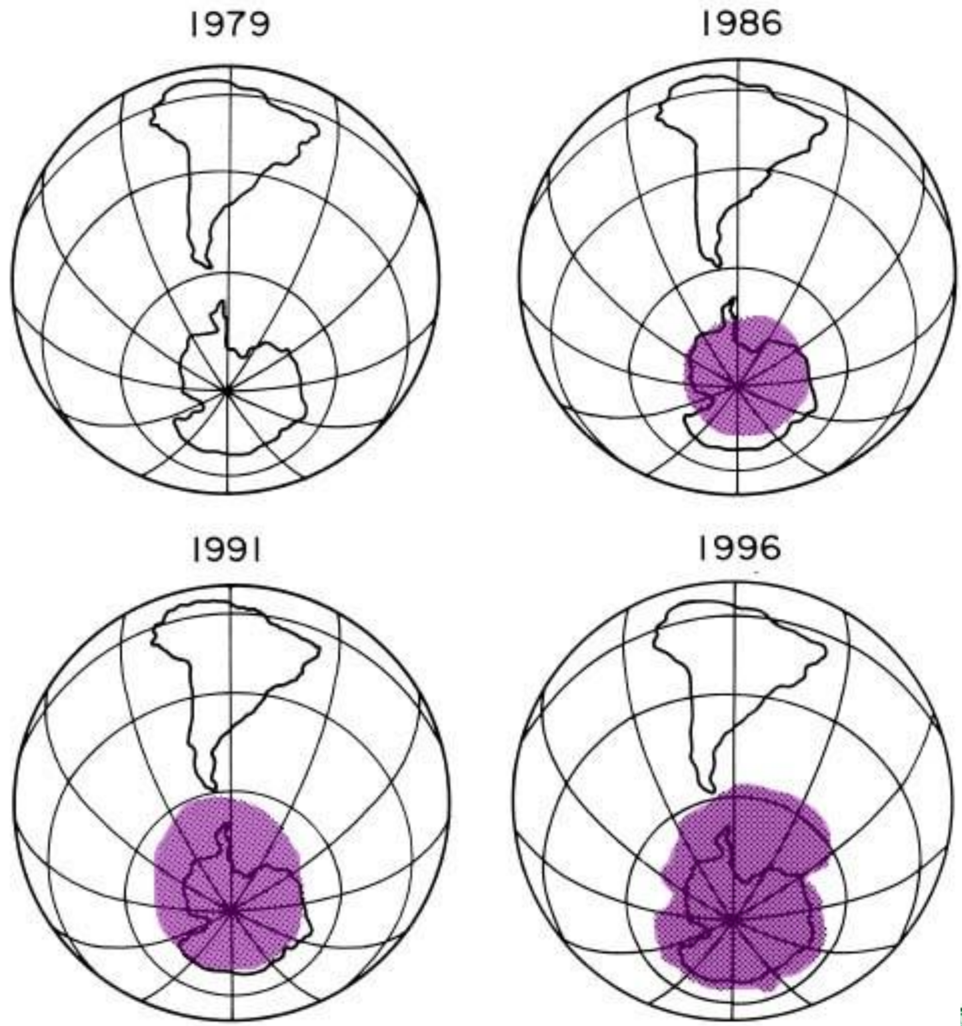
*Total Lmax is the value for the loudest piece of equipment

- Ozone Layer Depletion
- Green House Effect
- Global Warming
- Hybrid Cars

Ozone Layer Depletion

- What?
- How?
- Significance



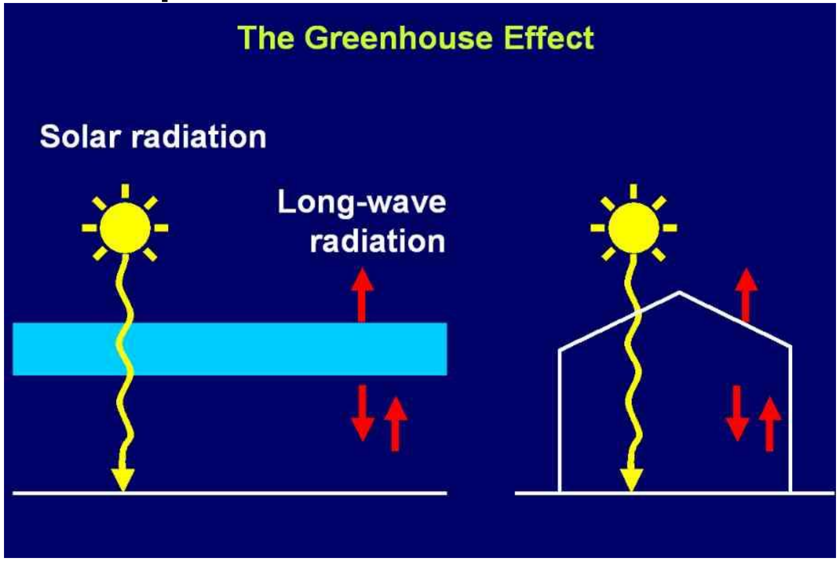


www.okiu.ac.jp/Language/ contest/02/12/ozone.html

- Ozone layer:
  - A UV barrier 20 to 40 km up in the atmosphere
- Depletion by:
  - Chlorofluorocarbons (CFCs)
    - Aerosol propellants, refrigerants
  - Natural volcanic activities
    - Sulfuric acid aerosol
- Significance
  - Skin cancer: estimated a 5% reduction could result in a 10% increase in skin cancer
  - Eventual massive incineration
- Prevention
  - Replacement of CFCs with HFCs (hydrofluorocarbons)

- CO_2
  - Relatively transparent to shortwave UV
  - But, adsorb and emit long wave (infrared or heat energy)
- Other green house gases: CH_4, N_2O (nitrous gases), CFCs

- Solar Energy (sunlight) is short-wavelength radiation which easily penetrates the Earth's atmosphere and warms the Earth; only about one quarter of incoming sunlight is reflected by the atmosphere.
- The warmed Earth emits long-wavelength radiation (infrared waves or heat energy) back into space; these longer waves are mostly reflected back to Earth by the atmosphere

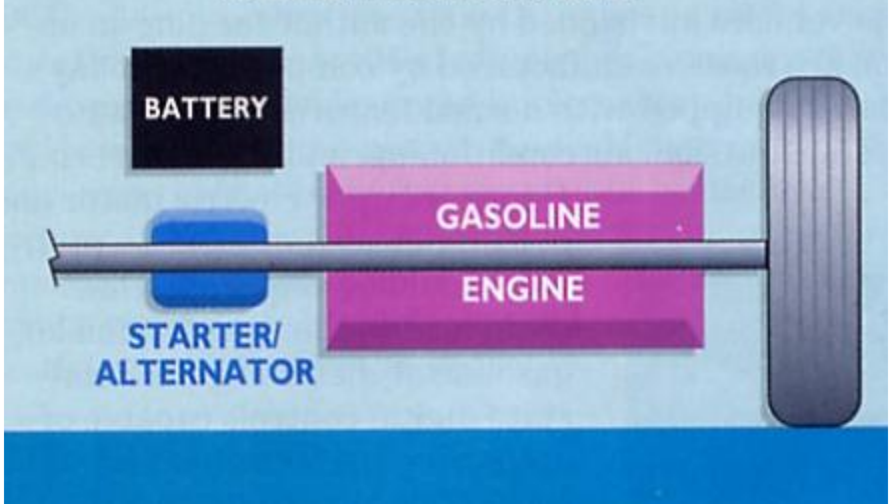


http://www.st-edmunds.cam.ac.uk/

- "At least 42 million acres of tropical forest are lost each year, approximately 100 acres/minute."
- The United Nations Environment Program estimates that by 2025, average world temperatures will have risen by 1.5°C/2.7°F with a consequent rise of 20 cm/7.9 in in sea level
- National Research Council (NRC) estimates a temperature rise of 1 to 5^{o}C by the year 2040
- Intergovernmental Panel on Climate Change projects a rise of 0.8 to 3.5 ^{o}C by 2100

- Micro hybrid

FIGURE I. MICRO HYBRID*



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MICRO HYBRID

Engine cut-off – Whenever the vehicle stops, the engine is turned off to save gasoline.

Engine restart – When the driver pushes the accelerator, the integrated starter/alternator initiates acceleration of the vehicle and simultaneously starts the gasoline engine.

Acceleration – The integrated starter/alternator assists the gasoline engine in accelerating the vehicle until the desired speed is reached and during other short periods of acceleration.

Cruising – The gasoline engine alone propels the vehicle.

Fuel efficiency increase compared with non-hybrid: 10%.

- Mild hybrid

MILD HYBRID

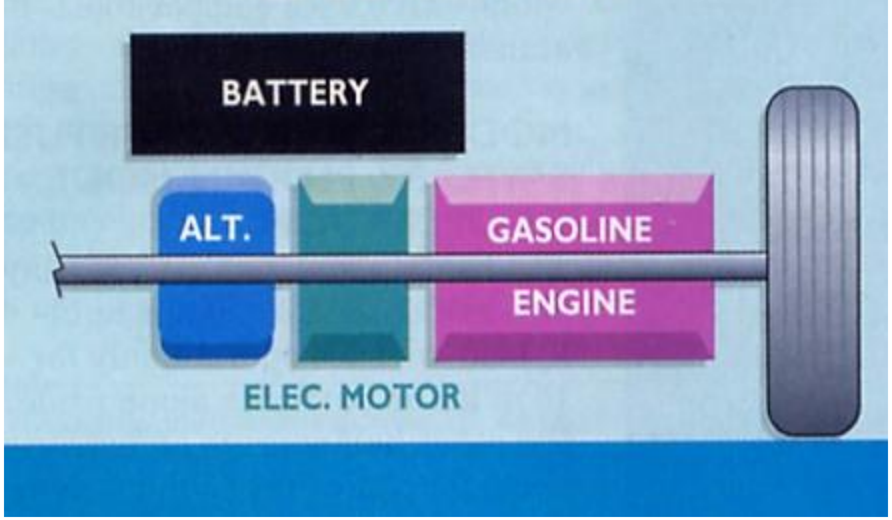
Electric motor assists gasoline engine – The main difference between the micro and mild hybrids is that the integrated starter/alternator is replaced with a separate electric motor and alternator that perform the same functions.

Gasoline engine dominates – In a mild hybrid vehicle, the electrical motor seldom propels the vehicle alone.

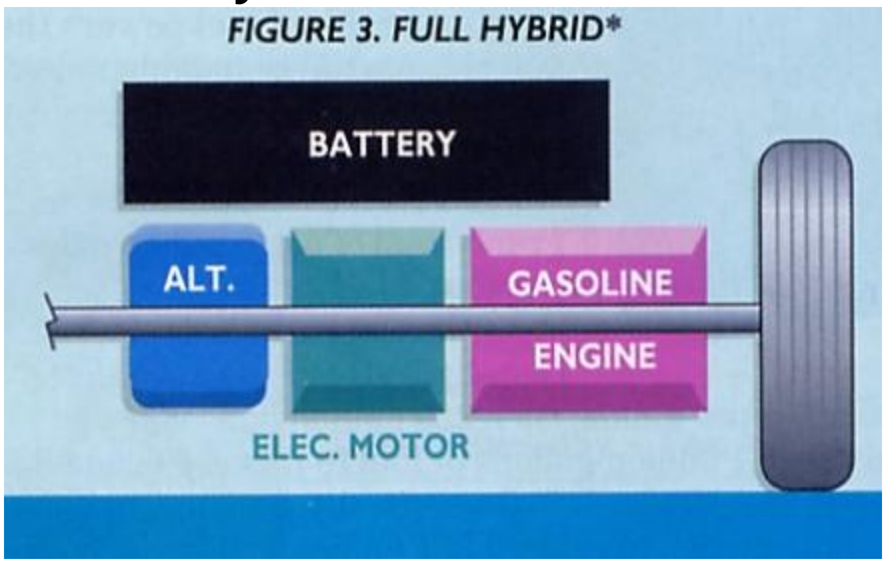
Larger electrical components – Compared with the micro hybrid, the electric motor, alternator, and the battery pack are larger and play a greater role in the operation of the vehicle.

Fuel efficiency increase compared with non-hybrid: 20-25%

FIGURE 2. MILD HYBRID*



- Full hybrid



FULL HYBRID

Larger electrical components – The configuration for the full-hybrid is essentially the same as for the mild-hybrid except that the electric motor, alternator, and battery pack are larger.

Full electric propulsion – The electric motor can and often does propel the vehicle alone, particularly in city (start-stop) driving.

Smaller gasoline engine – The gasoline engine may be smaller because the electric motor is larger.

Sophisticated control system – The control system is more complex in order to optimize the power management.

Fuel efficiency increase compared with non-hybrid: 40-45%

- Plug-in hybrid

PLUG-IN HYBRID

Electrical connection – The plug-in hybrid is similar to the configuration of the full-hybrid. The battery pack has a connection to an outside (utility) source of electrical energy for charging.

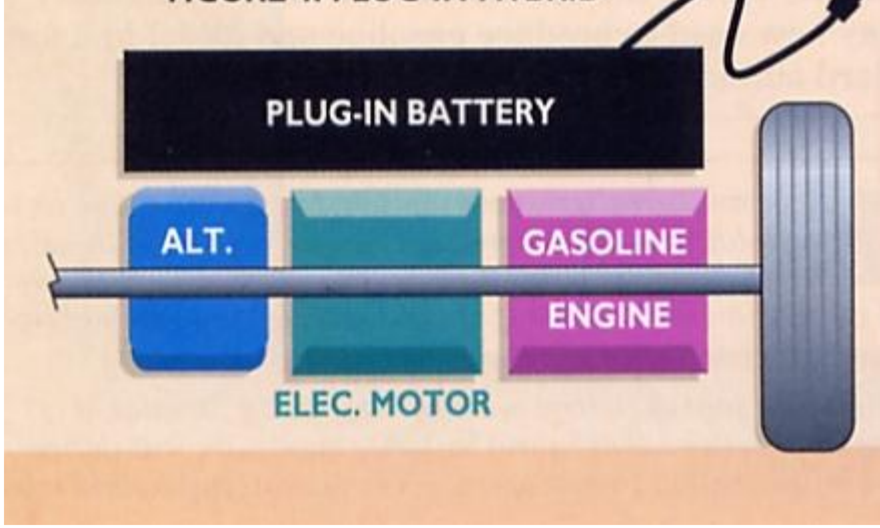
Larger electrical components – The battery pack, alternator, and electric motor are considerably bigger.

Smaller gasoline engine – The gasoline engine may be smaller.

Sophisticated control system – Control system must prevent charging of the battery by using the gasoline engine until the battery reaches the minimal level required for full-hybrid operation.

Fuel efficiency increase compared with non-hybrid: No gasoline is used at all while traveling within the range of the batteries. After that, fuel effieciency is comparable to that of full hybrids (above).

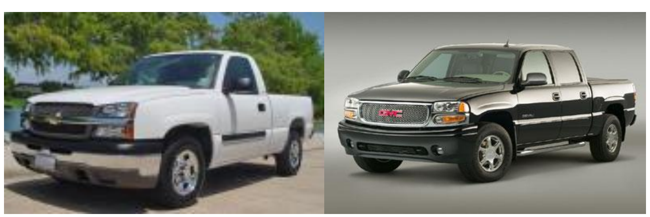
FIGURE 4. PLUG-IN HYBRID*



- Full hybrids

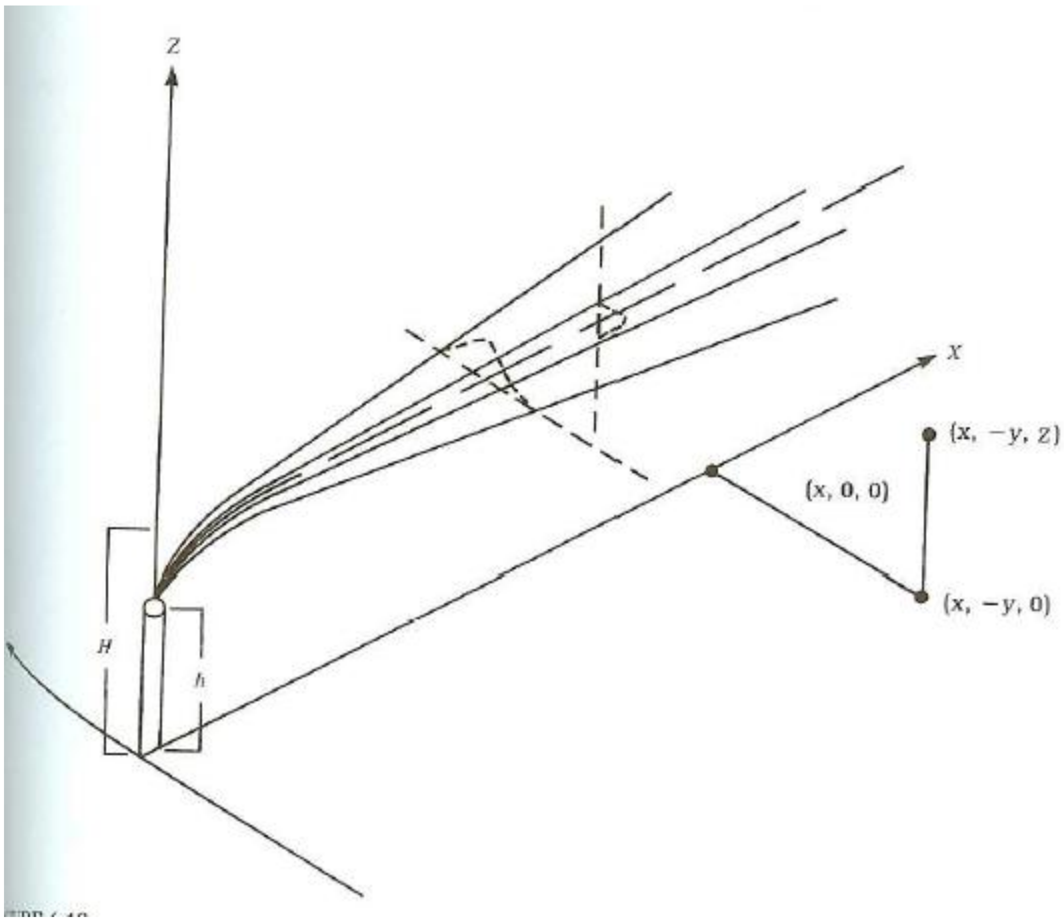

- Mild hybrids

- Micro hybrids



Dispersion Model from Point Source

- Basic Gaussian dispersion model



$$\chi_{(x,y,0,H)} = \left[\frac{E}{\pi s_y s_z u}\right]\left[\exp\left[-\frac{1}{2}\left(\frac{y}{s_y}\right)^2\right]\right]\left[\exp\left[-\frac{1}{2}\left(\frac{H}{s_z}\right)^2\right]\right]$$

where $\chi_{(x,y,0,H)}$ = downwind concentration at ground level, g/m^3

E = emission rate of pollutants, g/s

s_y, s_z = plume standard deviations, m

u = wind speed, m/s

x, y, z and H = distances, m

$$Effective\ stack\ height\ \ H = physical\ stack\ \ height, h\ +\ the\ plume\ rise,\ \Delta H$$

$$\Delta H = \frac{v_s d}{u}\left[1.5 + \left(2.68 \times 10^{-2}(P)\left(\frac{T_s - T_a}{T_s}\right)d\right)\right]$$

where v_s = stack velocity, m/s

d = stack diameter, m

u = wind speed, m/s

P = pressure, kPa

T_s = stack temperature, K

T_a = air temperature, K

$How\ to\ get\ s_y\ and\ s_z?$

$-\ s_y\ and\ s_z\ depend\ on\ the\ turbulent\ structure$
$or\ stability\ of\ the\ atmosphere\ (Table\ 6-6)$

$-Figures\ 6-19\ and\ 6-20$

$-alternatively,\ Martin's\ equations$

$$s_y = ax^{0.894}$$

$$s_z = cx^d + f$$

$$a, c, d, and\ f\ are\ in\ Table\ 6-7$$

TABLE 6-6
Key to stability categories

Surface wind speed (at 10 m) (m/s)	Day[a]			Night[a]	
	Incoming solar radiation				
	Strong	Moderate	Slight	Thinly overcast or ≥ 4/8 Low cloud	≤ 3/8 Cloud
<2	A	A–B	B		
2–3	A–B	B	C	E	F
3–5	B	B–C	C	D	E
5–6	C	C–D	D	D	D
>6	C	D	D	D	D

TABLE 6-7
Values of a, c, d, and f for calculating s_y and s_z

Stability class	a	$x \leq 1$ km			$x \geq 1$ km		
		c	d	f	c	d	f
A	213	440.8	1.941	9.27	459.7	2.094	−9.6
B	156	100.6	1.149	3.3	108.2	1.098	2
C	104	61	0.911	0	61	0.911	0
D	68	33.2	0.725	−1.7	44.5	0.516	−13
E	50.5	22.8	0.678	−1.3	55.4	0.305	−34
F	34	14.35	0.74	−0.35	62.6	0.18	−48.6

Source: D. O. Martin.

Example

- It has been estimated that the emission of SO_2 from a coal-fired power plant is 1,656.2 g/s. At 3 km downwind on an overcast summer afternoon, what is the centerline concentration of SO_2 if the wind speed is 4.5 m/s? (note: centerline implies y=0)
  - Stack parameters:
    - Height = 120 m
    - Diameter = 1.2 m
    - Exit velocity = 10.0 m/s
    - Temperature = 315 ^oC
  - Atmospheric conditions:
    - Pressure = 95 kPa
    - Temperature = 25 ^oC

$$H = 120 + \frac{(10)(1.2)}{4.5}\left[1.5 + \left(2.68 \times 10^{-2}(95)\frac{588-298}{588}1.2\right)\right] = 128.0 \ \ m$$

$$Atmospheric \ \ stability \ \ class = D$$

$$s_y = 190 \ \ m \ \ and \ \ s_z = 65 \ \ m$$

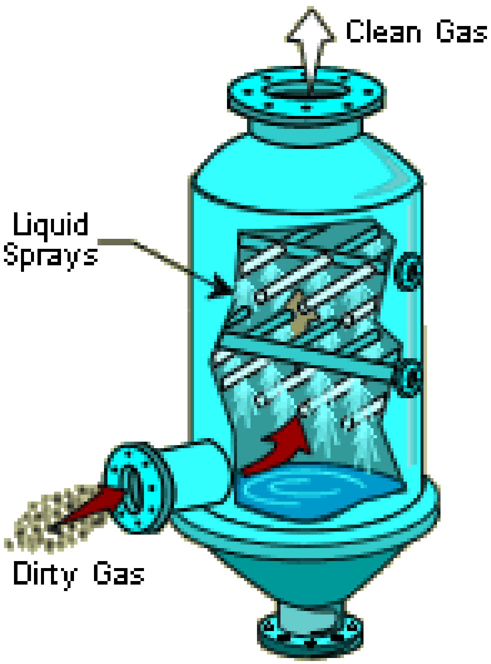
$$Thus,$$

$$\chi = \frac{1,656.2}{\pi(190)(65)(4.5)} exp\left[-\frac{1}{2}\left(\frac{0}{s_y}\right)^2\right] exp\left[-\frac{1}{2}\left(\frac{128}{65}\right)^2\right] = 1.4 \times 10^{-3} \ \ g/m^3 \ \ of \ \ SO_2$$

Air Pollution Control of Gaseous Pollutants

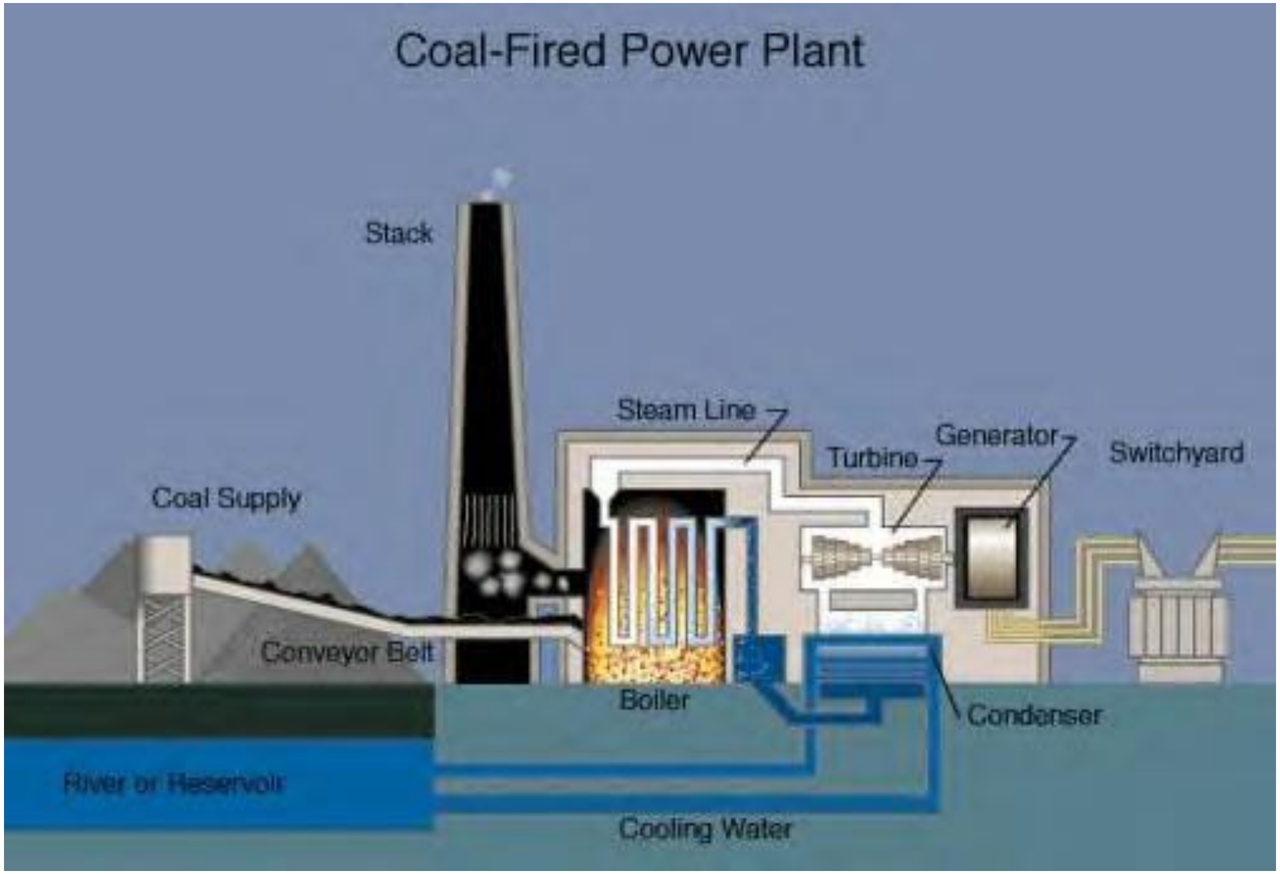
- Absorption
  - A mass transfer from a gas phase to liqui
  - Example: wet scrubber
- Adsorption
  - A mass transfer onto the adsorbent
  - Example: activated carbon adsorption
- Combustion
  - Incineration
- Flue Gas Desulfurization (FGD)

Figure 6. Spray Tower Scrubber



www.epa.gov

Energy Generation



www.tva.gov

Desulfurization

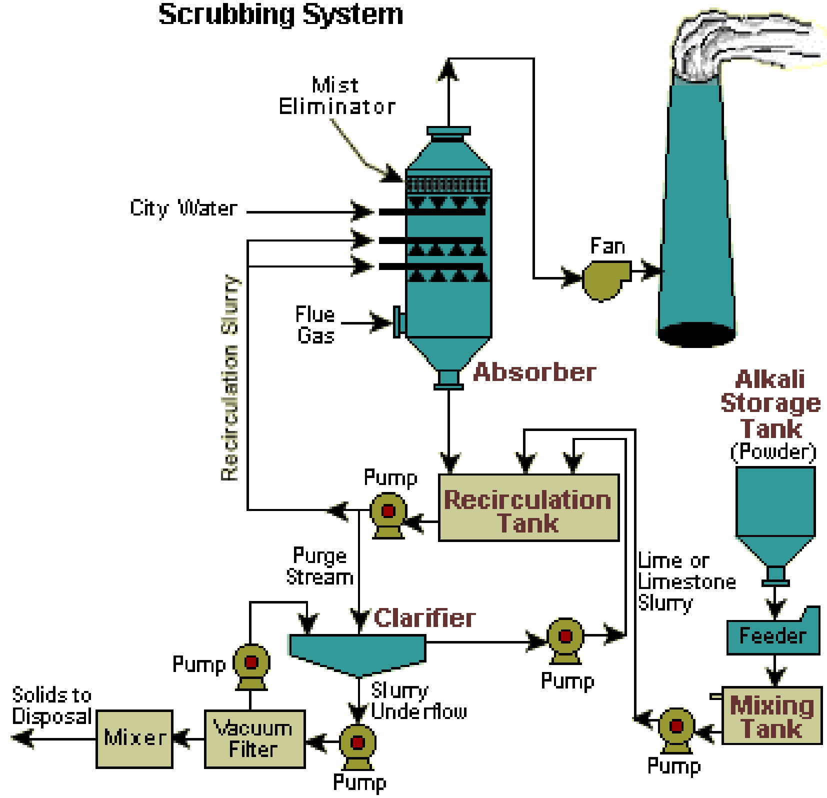
- Lime (CaO), caustic soda (NaOH), soda ash (Na_2CO_3), or ammonia (NH_4)

$$SO_2 + CaCO_3 \rightarrow CaSO_3 + CO_2$$

$$SO_2 + Ca(OH)_2 \rightarrow CaSO_3 + H_2O$$

$$Also \quad partly, \quad CaSO_3 + 0.5O_2 \rightarrow CaSO_4$$

Figure 1. Example Flowchart of a Limestone-Based SO_2 Scrubbing System



www.epa.gov

Figure 3. Spray-Dryer-Type Dry Scrubber

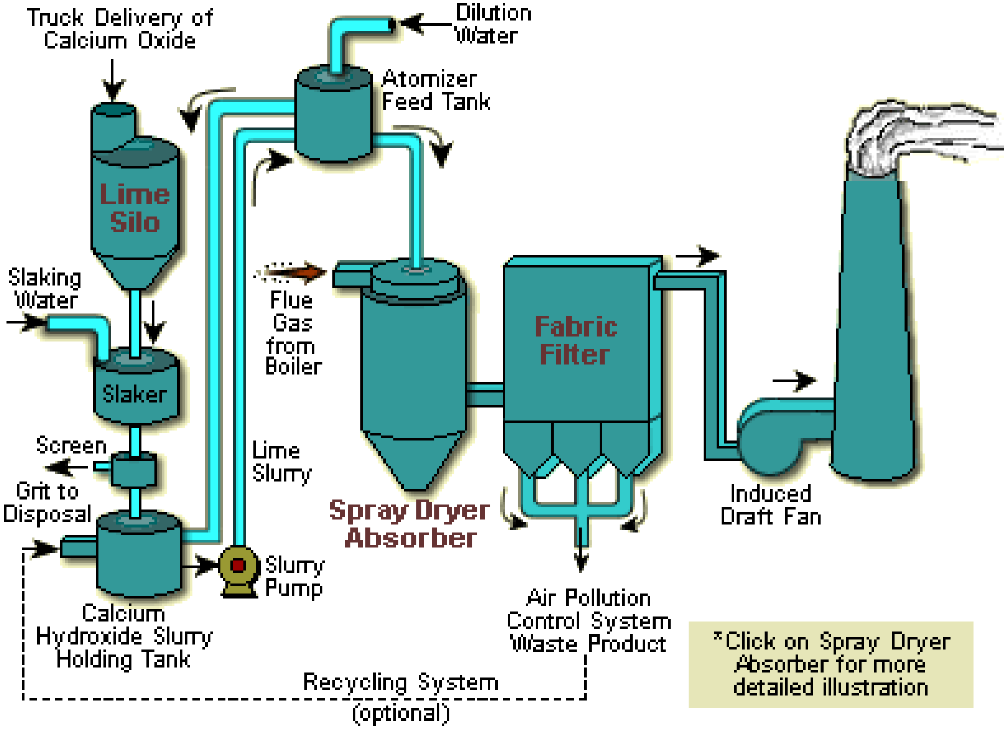
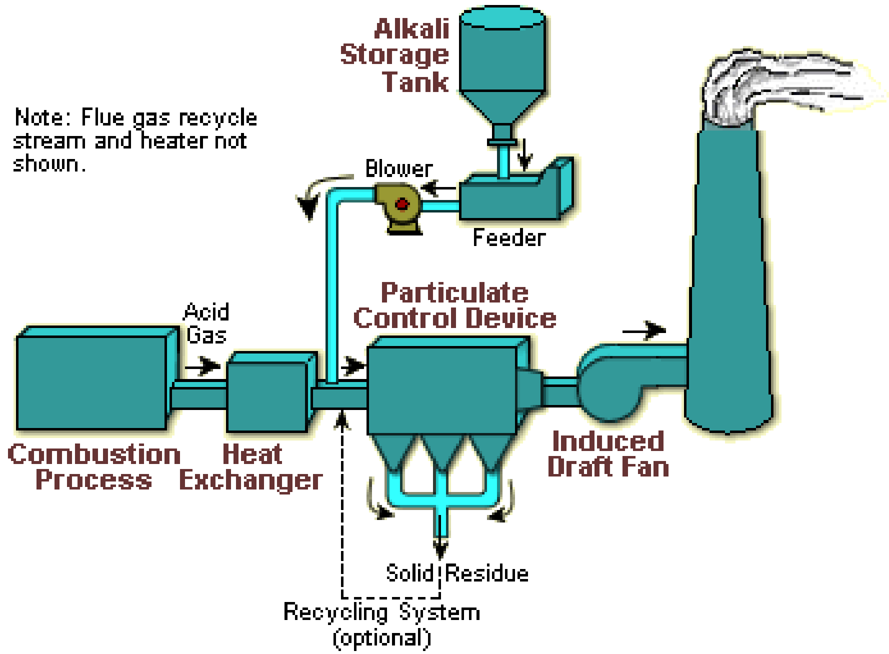


Figure 4. Dry-Injection-Type Dry Scrubber



www.epa.gov

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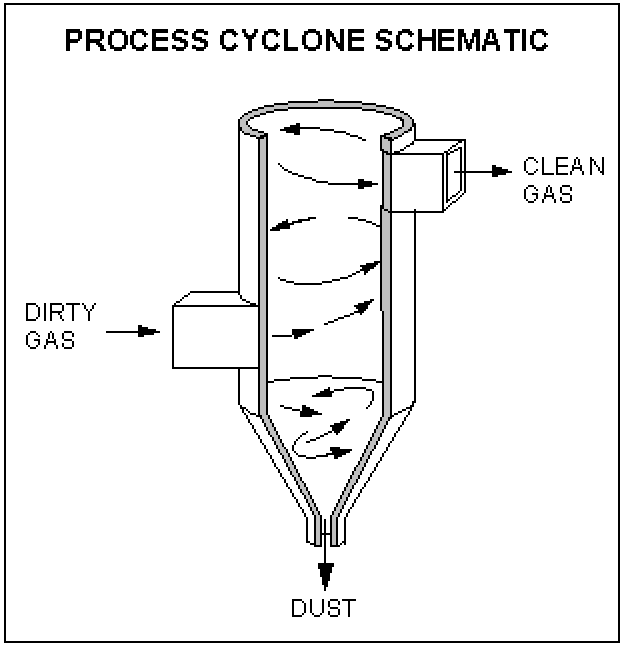
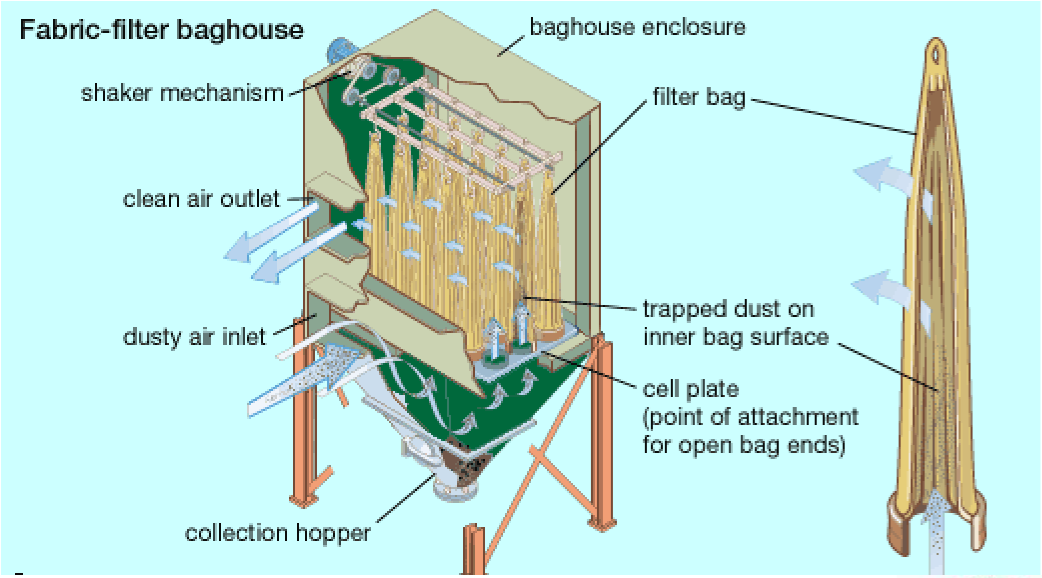
- Cyclone
  - Good for particle sizes grater than about 10 μm
- Baghouse filter
  - When high efficiency control of particles smaller than 5 μm is desired

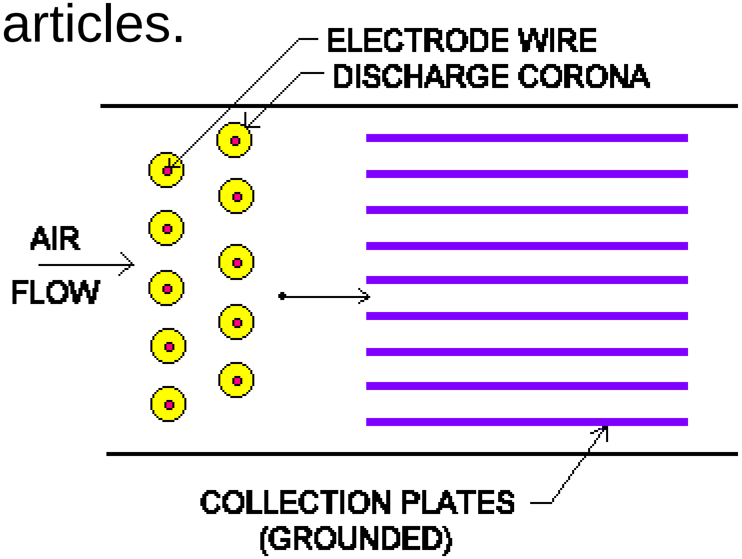


www.meridianeng.com



www.pcsesp.com

- Electrostatic precipitation (ESP)
  - High efficiency
  - The corona wires are maintained at several thousand volts which produces a corona that releases electrons into the airstream.
  - These electrons attach to dust particles and give them a net negative charge.
  - The collecting plates are grounded and attract the charged dust particles.



www.engr.psu.edu

www.sharperimage.com

- This is all for Day 1

1

Session 6. Welcome, Day 1 Review, and Day 2 Preview

Dr. Sangchul (San) Hwang

Day 1 Review

- Welcome and Introduction to the Seminar
- Environmental Impact Assessment
  - Fundamentals and Examples
- Environmental Factors in Transportation Planning
  - Sustainable Development, Laws, Policies, and Regulations, & Tools and Methods
- Environmental Impacts and Considerations in Road Transportation 1
  - Highway Runoff and Surface Water Hydrology
- Environmental Impacts and Considerations in Road Transportation 2
  - Noise Management and Air Pollution Control

Day 2 Preview

- Introduction to Environmental Quality Parameters
  - Water Quality and Hazardous Wastes
- Environmental Impacts and Considerations in Ship Transportation
  - Ballast Water (Biodiversity) and Oil Spills
- Environmental Impacts and Considerations in Air Transportation
  - Noise Controls and Air/Water Quality
- Green Engineering in Transportation Projects
  - Waste Tires, Coal Combustion Byproducts, Construction and Demolition Debris
- Adjournment

Session Topics

Day1 — Introduction to Seminar
- Dubai Projects & Panama Canal
- Environmental Impact Assessment
- Impacts and Considerations in Road Transportation

Day 2 → Environmental Water Quality Parameters
- Impacts and Considerations in Ship Transportation
- Impacts and Considerations in Air Transportation
- Reuse and Recycle in Construction and Transportation

Session 7. Introduction to Environmental Quality Parameters

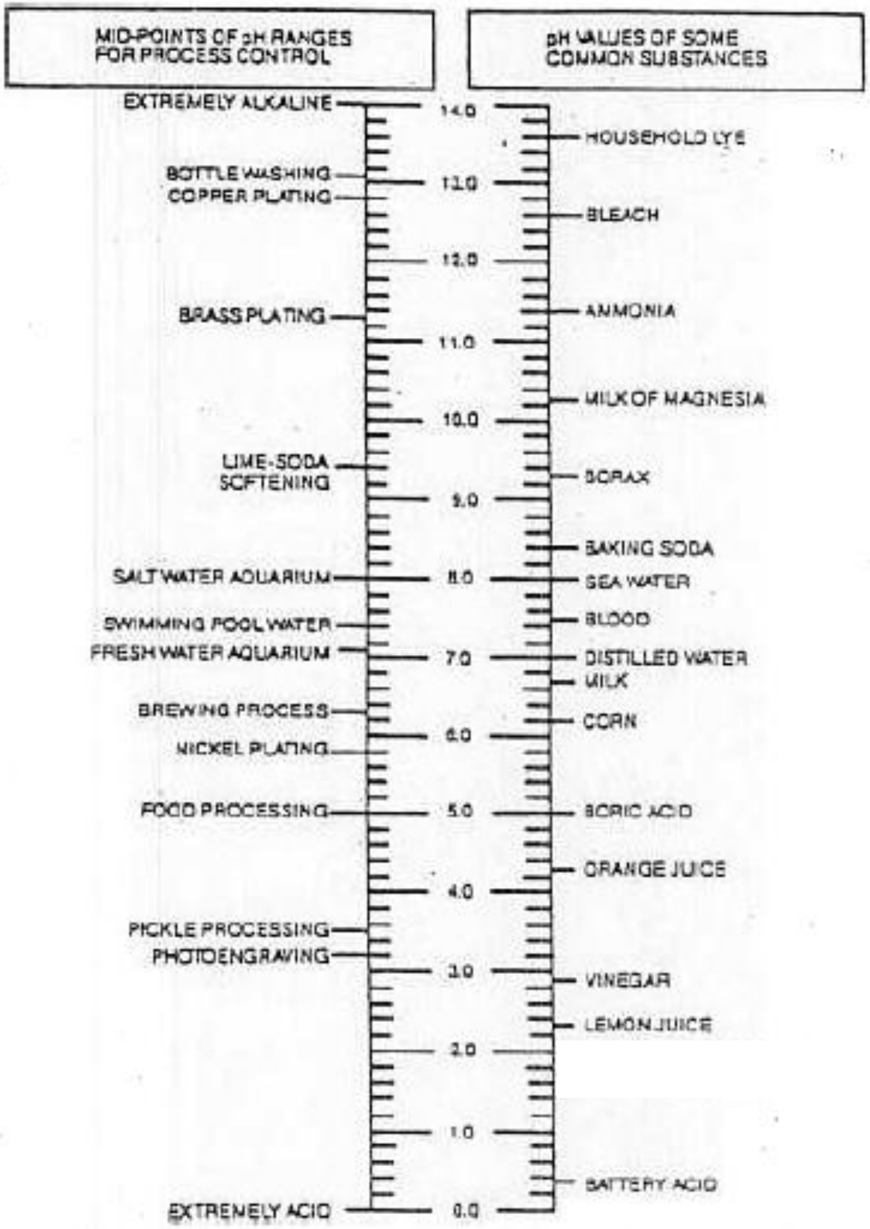
Water Quality

Hazardous Wastes

Dr. Sangchul (San) Hwang

- BOD, COD, SS
- Coral reef smothering
- N, P

- pH
  - The degree of acidity or alkalinity of a solution
- Dissolved oxygen (DO)
  - Major determinant of water quality
  - Saturation of oxygen in water is a function of temperature and pressure, also depend on the concentration of dissolved solids, with higher solids reducing oxygen solubility


MID-POINTS OF pH RANGES FOR PROCESS CONTROL
pH VALUES OF SOME COMMON SUBSTANCES
EXTREMELY ALKALINE
14.0
HOUSEHOLD LYE
BOTTLE WASHING
COPPER PLATING
13.0
BLEACH
12.0
BRASS PLATING
AMMONIA
11.0
MILK OF MAGNESIA
10.0
LIME-SODA SOFTENING
BORAX
9.0
BAKING SODA
SALT WATER AQUARIUM
8.0
SEA WATER
SWIMMING POOL WATER
BLOOD
FRESH WATER AQUARIUM
7.0
DISTILLED WATER
MILK
BREWING PROCESS
CORN
6.0
NICKEL PLATING
FOOD PROCESSING
5.0
BORIC ACID
ORANGE JUICE
4.0
PICKLE PROCESSING
PHOTOENGRAVING
3.0
VINEGAR
LEMON JUICE
2.0
1.0
BATTERY ACID
EXTREMELY ACID
0.0

Oxygen Solubility in Fresh Water (at one atmosphere)

Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	14.60	12	10.76	24	8.40	36	6.82
1	14.19	13	10.52	25	8.24	37	6.71
2	13.81	14	10.29	26	8.09	38	6.61
3	13.44	15	10.07	27	7.95	39	6.51
4	13.09	16	9.85	28	7.81	40	6.41
5	12.75	17	9.65	29	7.67	41	6.31
6	12.43	18	9.45	30	7.54	42	6.22
7	12.12	19	9.26	31	7.41	43	6.13
8	11.83	**20**	**9.07**	32	7.28	44	6.04
9	11.55	21	8.90	33	7.16	45	5.95
10	11.27	22	8.72	34	7.05		
11	11.01	23	8.56	35	6.93		

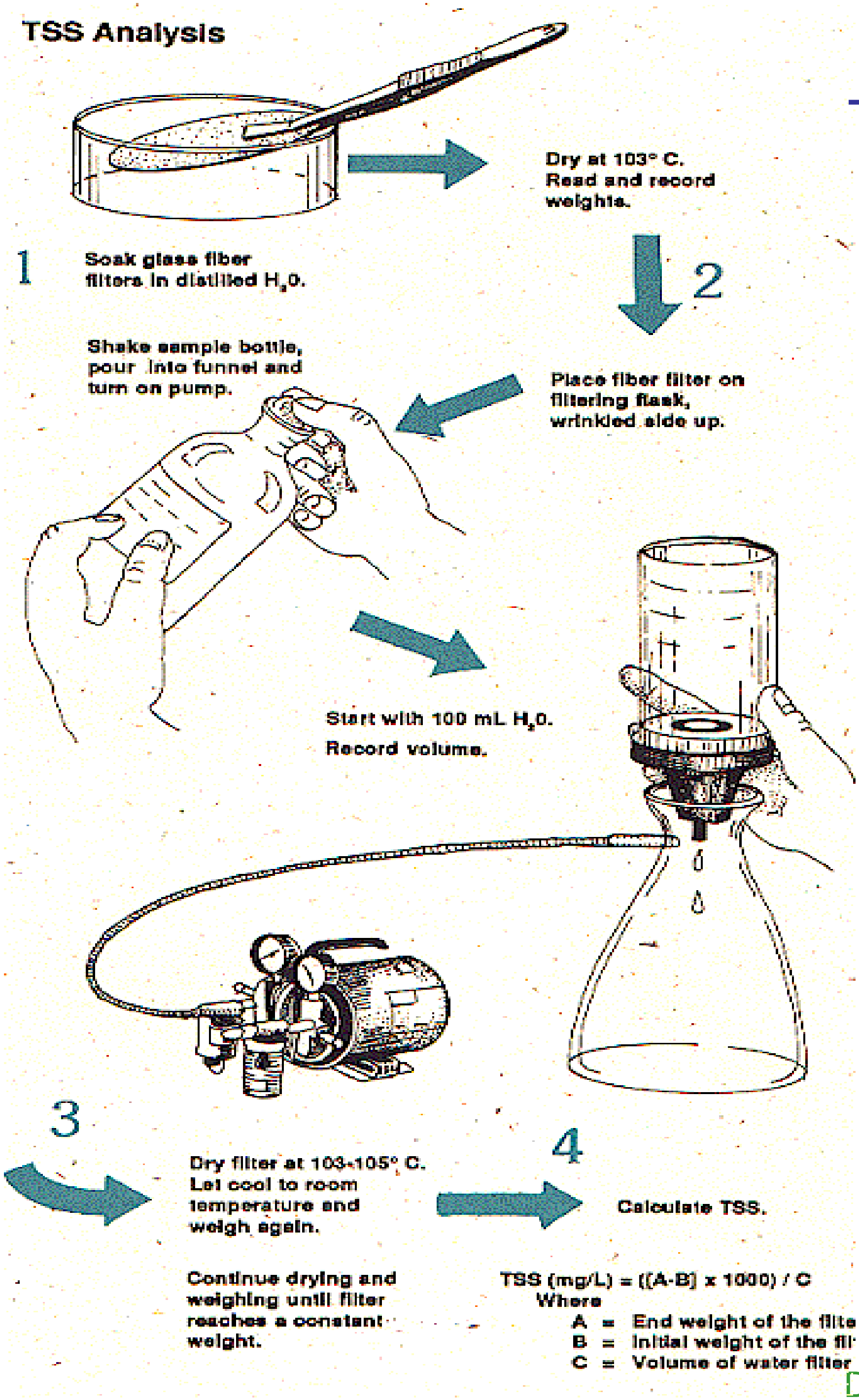
- BOD is not a measure of some specific pollutant
- Rather, it is a measure of the amount of oxygen required by aerobic bacteria and other microorganisms while stabilizing (decomposing) decomposable organic matter
- 5-day BOD (BOD_5), ultimate BOD (BOD_u)

- Low BOD (i.e., low rate of oxygen use)
  1) Absence of contamination,
  2) M's are not interested in consuming the available organics,
  3) M's are not capable of decomposing the organics, and/or
  4) M's are dead or dying

Solids and Nitrogen

- Solids
  - Total solids = (suspended solids + dissolved solids)
  - Total solids = (volatile solids + fixed solids)
  - Can be detrimental to aquatic life or to people who drink water
- Nitrogen
  - Organic nitrogen: nitrogen tied up in high-energy compounds such as amino acids and amines
  - Ammonia nitrogen (NH_4^+-N), nitrate nitrogen (NO_3^--N), nitrite nitrogen (NO_2^--N)
  - Total *Kjeldahl* nitrogen (TKN) = organic nitrogen + ammonia nitrogen

TSS Measurement



- To determine the potential for the presence of infectious agents such as pathogenic bacteria and viruses

- Pathogens (disease-causing organisms) of importance
  - *Salmonella*, *Shigella*, the hepatitis virus, *Entamoeba hystolytica*, *Giardia lamblia*, and *Cryptosporidium*

- Measures of bacteriological quality
  - Use of indicator organisms called *coliforms*
    - If a large number of coliforms are present, there is a good chance of recent pollution by wastes from warm-blooded animals, and therefore the water "may" contain pathogenic organisms
    - But this is not proof of the presence of such pathogens.
    - The opposite is also true
  - Center for Excellence in Environmental Quality
    - PR Water Resources & Environmental Research Institute
    - US EPA
    - Seminar: July 31 – August 3, 2007
      - Testing and Monitoring of Indicator Microorganisms
        - » Total, fecal, and E-Coli
        - » Enterococci

- The most commonly used units are mg/L and ppm.

  mg/L = milligrams per liter = 10^{-3} g/L

  ppm = parts per million

  1 mg/L = 1 ppm

- Higher concentrations are sometimes expresses as percentages

  e.g., for sludges, slurries, chemical solutions, etc.

  1% = 10,000 mg/L

- The units ug/L and ppb have recently become very common

  ug/L = micrograms per liter = 10^{-6} g/L

  ppb = parts per billion

  1 ug/L = 1 ppb

- Even lower concentration units such as ng/L and pg/L are sometimes used.

  ng/L = nanograms per liter = 10^{-9} g/L (= part per trillion, ppt)

  pg/L = picograms per liter = 10^{-12} g/L

  fg/L = femtograms per liter = 10^{-15} g/L

- Eroded soil from construction sites streams and lakes
  - excess turbidity that harms aquatic life,
  - increases water-treatment costs,
  - makes the water less useful for recreation
  - clogs drainage ditches, stream channels, water intakes, and reservoirs, and
  - destroys aquatic habitats.

ARECIBO, PR

Dr. Sangchul (San) Hwang

MANATI, PR

Dr. Sangchul (San) Hwang

CARRAIZO LAKE DREDGING

Dr. Sangchul (San) Hwang

Coral Reef Smothering

www.coralreefecosystems.com

Dr. Sangchul (San) Hwang

- a waste with properties that make it dangerous or potentially harmful to human health or the environment.
  - liquids, solids, contained gases, or sludges.
- In regulatory terms, a RCRA hazardous waste is a waste that appears on one of the four hazardous wastes lists (F-list, K-list, P-list, or U-list), or exhibits at least one of four characteristics—ignitability, corrosivity, reactivity, or toxicity.
- Hazardous waste is regulated under the Resource Conservation and Recovery Act (RCRA) Subtitle C.

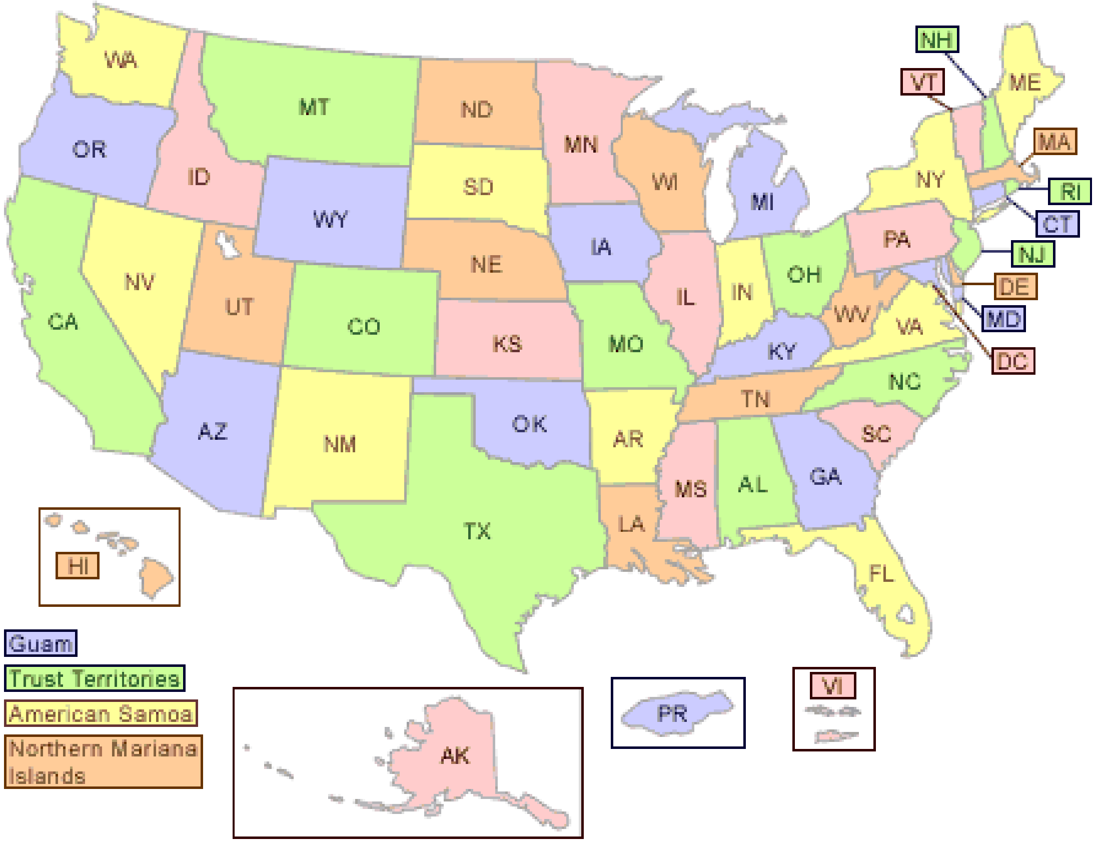
- The F-list (non-specific source wastes).
  - wastes from common manufacturing and industrial processes, such as solvents that have been used in cleaning or degreasing operations.
- The K-list (source-specific wastes).
  - wastes from specific industries, such as petroleum refining or pesticide manufacturing.
  - Certain sludges and wastewaters from treatment and production processes in these industries
- The P-list and the U-list (discarded commercial chemical products).
  - specific commercial chemical products in an unused form.
  - Some pesticides and some pharmaceutical products become hazardous waste when discarded.

Four Characteristics

- Ignitability
  - can create fires under certain conditions, are spontaneously combustible, or have a flash point less than 60 °C (140 °F).
  - waste oils and used solvents.
- Corrosivity
  - acids or bases (pH less than or equal to 2, or greater than or equal to 12.5) that are capable of corroding metal containers, such as storage tanks, drums, and barrels.
  - Battery acid is an example.
- Reactivity
  - unstable under "normal" conditions. They can cause explosions, toxic fumes, gases, or vapors when heated, compressed, or mixed with water.
  - Examples include lithium-sulfur batteries and explosives.
- Toxicity
  - harmful or fatal when ingested or absorbed (e.g., containing mercury, lead, etc.).
  - Toxicity is defined through a laboratory procedure called the Toxicity Characteristic Leaching Procedure (TCLP)

National Priorities List (NPL) Sites

- NPL is the list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories
- 1279 Sites as of March 26, 2010



Dr. Sangchul (San) Hwang


British Columbia
Saskatchewan
Manitoba
Ontario
Quebec
North Dakota
South Dakota
Oregon
Wyoming
Nevada
Utah
Texas
Vermont
New Hampshire
Massachusetts
Rhode Island
Connecticut
New Jersey
Delaware
Maryland
District of Columbia
North Atlantic Ocean
Gulf of Mexico
Mexico
Cuba

Top of page

Puerto Rico (14 sites)

Site Name	City	CERCLIS ID	Final Listing Date	Site Score	Federal Facility Indicator	Additional Information	Map It!
Atlantic Fleet Weapons Training Area - Vieques	Vieques	PRN000204694	02 / 11 / 2005		Yes	Site Listing Narrative Site Progress Profile Federal Register Notice	
Barceloneta Landfill	Florida Afuera	PRD980509129	09 / 08 / 1983	41.11	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Cidra Ground Water Contamination	Cidra	PRN000204538	07 / 22 / 2004	50.00	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Fibers Public Supply Wells	Jobos	PRD980763783	09 / 21 / 1984	35.34	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Juncos Landfill	Juncos	PRD980512362	09 / 08 / 1983	32.57	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Maunabo Area Ground Water Contamination	Maunabo	PRN000205831	09 / 27 / 2006	50.00	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Papelera Puertorriquena, Inc.	Utuado	PRD090290685	09 / 23 / 2009	34.69	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Pesticide Warehouse I	Arecibo	PRD987367349	09 / 27 / 2006	50.00	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Pesticide Warehouse III	Manati	PRD987367299	04 / 30 / 2003	50.00	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
San German Ground Water Contamination	San German	PRN000205957	03 / 19 / 2008	50.00	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Scorpio Recycling, Inc.	Candeleria Ward	PRD987376662	02 / 04 / 2000	50.00	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Upjohn Facility	Barceloneta	PRD980301154	09 / 21 / 1984	41.92	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Vega Alta Public Supply Wells	Vega Alta	PRD980763775	09 / 21 / 1984	42.24	No	Site Listing Narrative Site Progress Profile Federal Register Notice	
Vega Baja Solid Waste Disposal	Rio Abajo Ward	PRD980512669	07 / 22 / 1999	50.37	No	Site Listing Narrative Site Progress Profile Federal Register Notice	

Top of page

SAN GERMAN GROUND WATER CONTAMINATION | San German, Puerto Rico

Site Location:

The San German Ground Water Contamination site consists of a ground water plume with several potential sources of contamination. The site is located in the municipality of San German, Puerto Rico.

Site History:

The San German Urbano public water system consists of seven wells and two surface water intakes serving an estimated population of 25,000 people. Industrial activity in the area has contributed to contamination of these wells, one of which was ordered closed by the Puerto Rico Department of Health (PRDOH) due to high levels of chemical solvents in the water. Other wells have shown lower levels of contamination during routine monitoring. Nearby manufacturing facilities are believed to be sources of the contamination.

Site Contamination/Contaminants:

The contaminants of concern are tetrachloroethylene (PCE), trichloroethylene (TCE), and cis-1,2-dichloroethylene (cis-1,2-DCE). These chemicals are solvents used in areas such as degreasing, industrial cleaning, and dry cleaning. The contaminants are believed to have adverse health effects when ingested or inhaled.

Potential Impacts on Surrounding Community/Environment:

The drinking water supply for San German relies on local water. The contaminated plume lies within a designated Wellhead Protection Area, indicating that the local groundwater is a necessary component of the municipal drinking water supply. One well has already been taken out of service due to contamination; other wells are showing levels of contamination that require monitoring in order to protect public health. With inclusion of this site on the National Priorities List, EPA will begin an investigation to determine the sources of contamination, and continue to monitor the drinking water supply for San German.

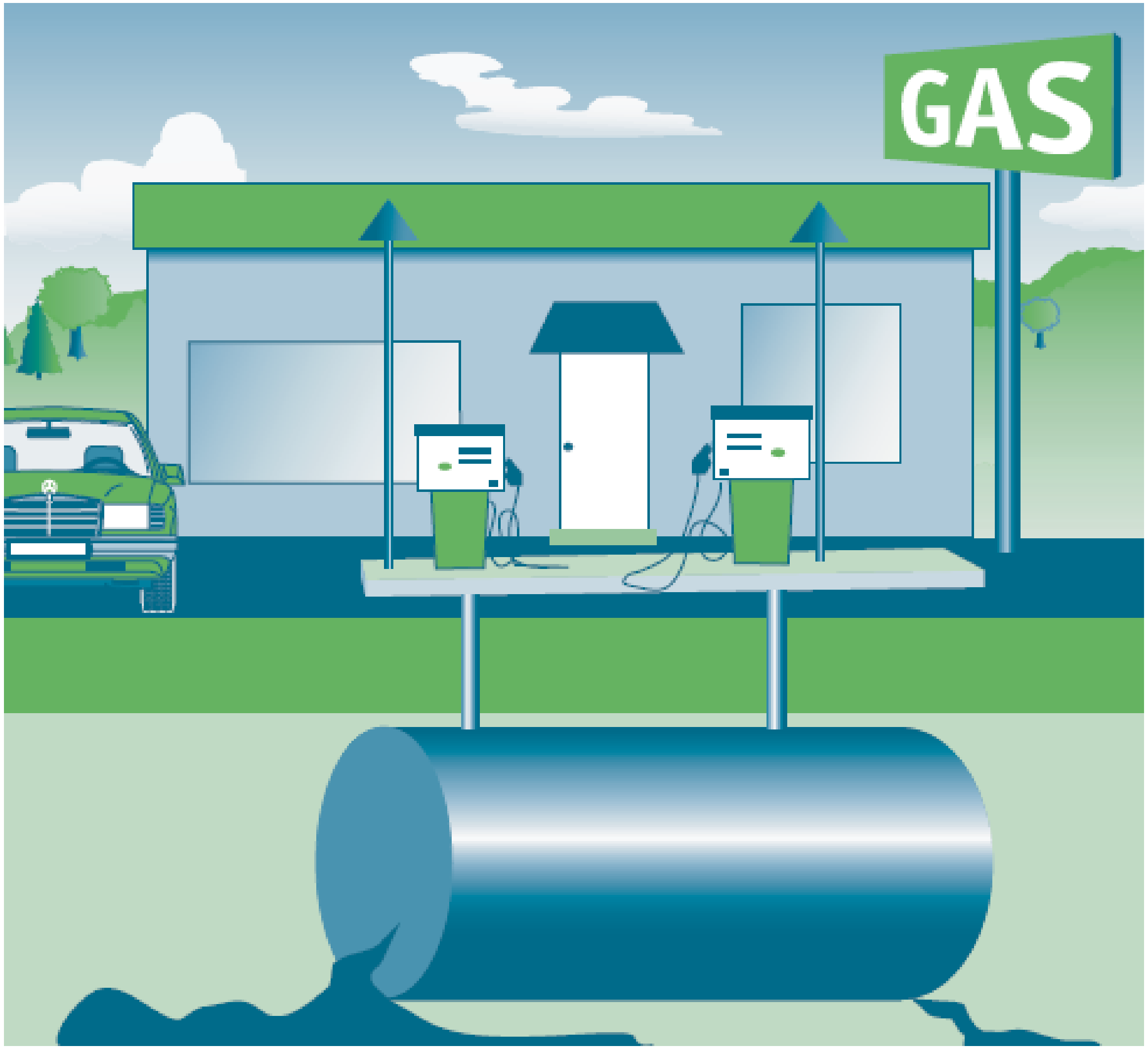
Response Activities (to date):

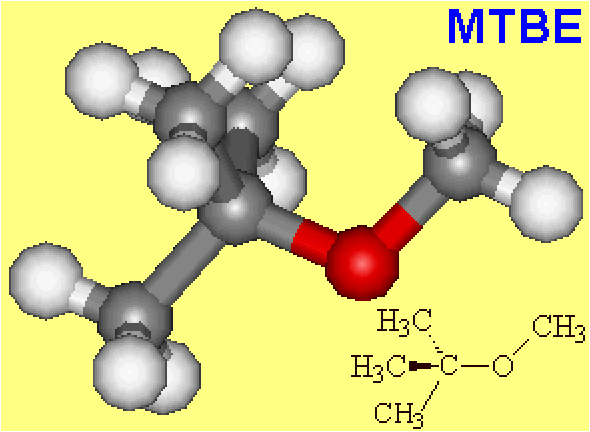
In January 2007, EPA initiated an investigation of three locations in San German which were identified as potential sources to the ground water plume. Surface and subsurface soil samples and ground water samples were collected from the ara. As a result of this effort, potential sources of the ground water plume have been identified. EPA will expand this investigation to further define the nature and extent of the contamination. The PRDOH has taken action to protect human health by monitoring the drinking water supply, and removing a contaminated well from the distribution system.

[The description of the site (release) is based on information available at the time the site was evaluated with the HRS. The description may change as additional information is gathered on the sources and extent of contamination. See 56 FR 5600, February 11, 1991, or subsequent FR notices.]

For more information about the hazardous substances identified in this narrative summary, including general information regarding the effects of exposure to these substances on human health, please see the Agency for Toxic Substances and Disease Registry (ATSDR) ToxFAQs. ATSDR ToxFAQs can be found on the Internet at http://www.atsdr.cdc.gov/toxfaq.html or by telephone at 1-888-42-ATSDR or 1-888-422-8737.

Remediation of Petroleum-Contaminated Soils





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MTBE and TBA

- MTBE has been blended into gasoline in the United States since 1979, initially at a low percentage as an octane enhancer (API 1998). Later, in response to the 1990 Clean Air Act Amendments and other factors, it was added to gasoline at higher concentrations (commonly 11% to 15% by volume) as an oxygenate to make gasoline burn cleaner in those areas of the country not meeting air quality standards.
- TBA has been less extensively blended with gasoline as a fuel oxygenate. However, TBA is also often found in association with MTBE in gasoline as a manufacturing by-product. Typically, MTBE used for blending contains TBA ranging from about 0.03% to 0.8% (Shell Global Solutions 2003).
- Releases of MTBE-blended gasoline from leaking underground storage tanks, surface spills, and other sources have resulted in sites with groundwater impacts requiring remedial action.

- Groundwater pump and treat (P&T)
- Air sparging
- in situ bioremediation
- in situ chemical oxidation (ISCO)
- Phytoremediation
- Monitored natural attenuation (MNA)

- Extracting contaminated groundwater for treatment at the surface. The treated water may be replaced to the aquifer; discharged to a surface water body such as a stream; discharged to a sewer system; or in some cases, blended with water contributing to an industrial or public water supply.
- The principal advantages of P&T with aboveground treatment over in situ treatment are hydraulic control, and the increased process control and confidence in treatment effectiveness because of the ability to directly monitor and modify treatment parameters.

Cleanup times in P&T

- The objective of a P&T remedy should be to return groundwater to a usable condition within a reasonable time frame. Therefore, estimated cleanup time is a large factor in determining whether a P&T remedy is feasible.

- Because cleanup times and remedial costs depend upon the pumping rate, estimates of cleanup time are explicitly or implicitly based upon the number of “pore volumes” that must be pumped.

- USEPA's batch flush model

$$PV = (\ -\ ) R \ln\left(\frac{C_{WT}}{C_{WO}}\right)$$

where

$PV =$ *number of pore volumes required to reach the* C_{WT}

$C_{WT} =$ *cleanup concentration in groundwater (mass/volume)*

$R =$ *retardation factor (dimensionless)*

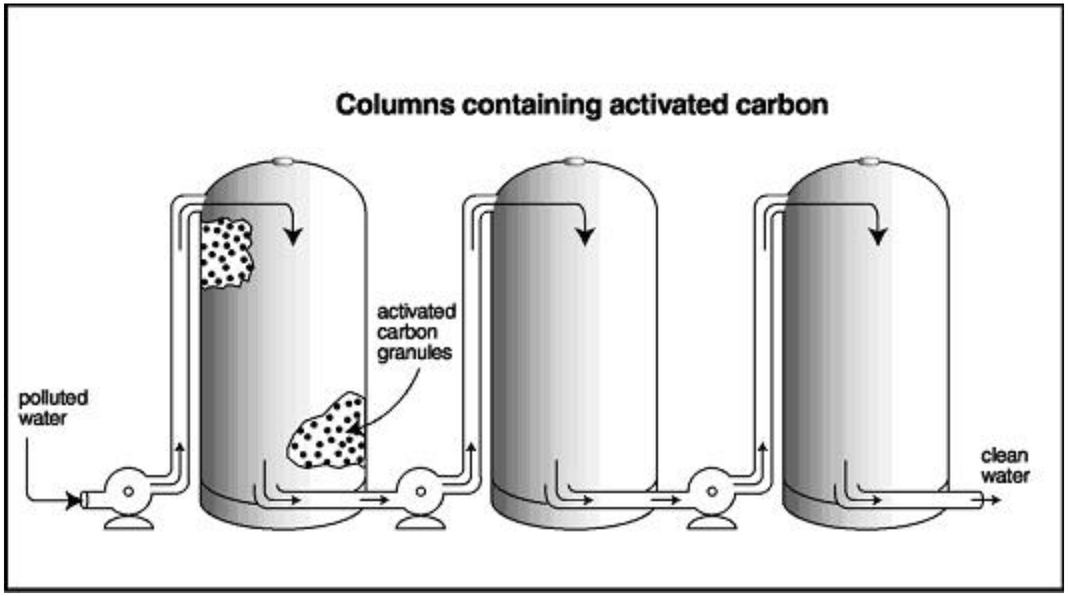
$C_{WO} =$ *initial contaminant concentration in groundwater (mass/volume)*

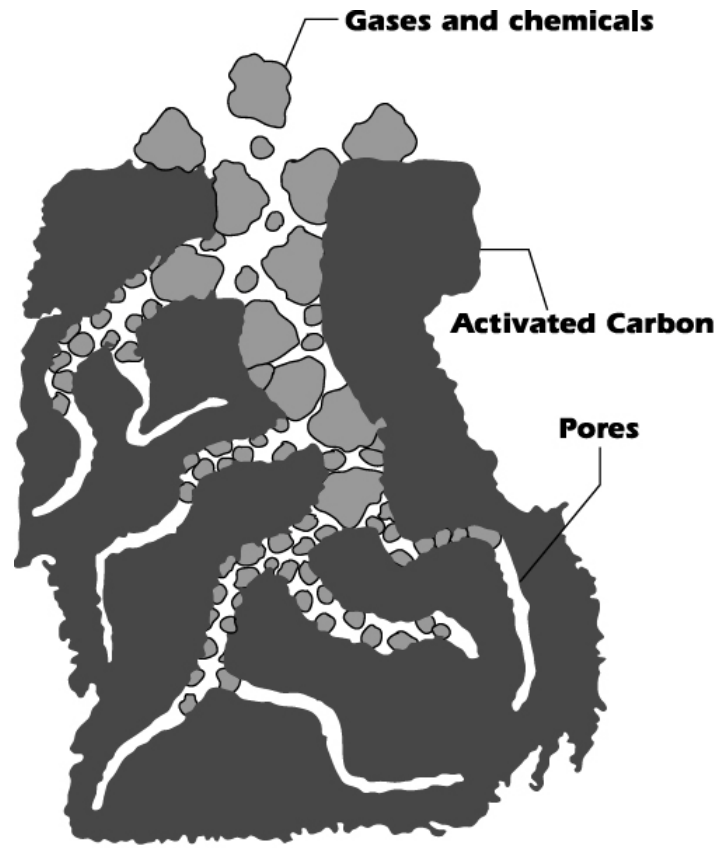
one pore volume = the amount of water stored in the contaminated portion of the aquifer

Aboveground Treatment

- Adsorption
  - Granular activated carbon
  - Resin adsorption
- Air stripping
- Advanced oxidation processes
  - UV/H_2O_2
  - H_2O_2/O_3 (peroxone)
- Ex-situ biodegradation
  - Suspended growth bioreactor
  - Attached growth bioreactor

Adsorption

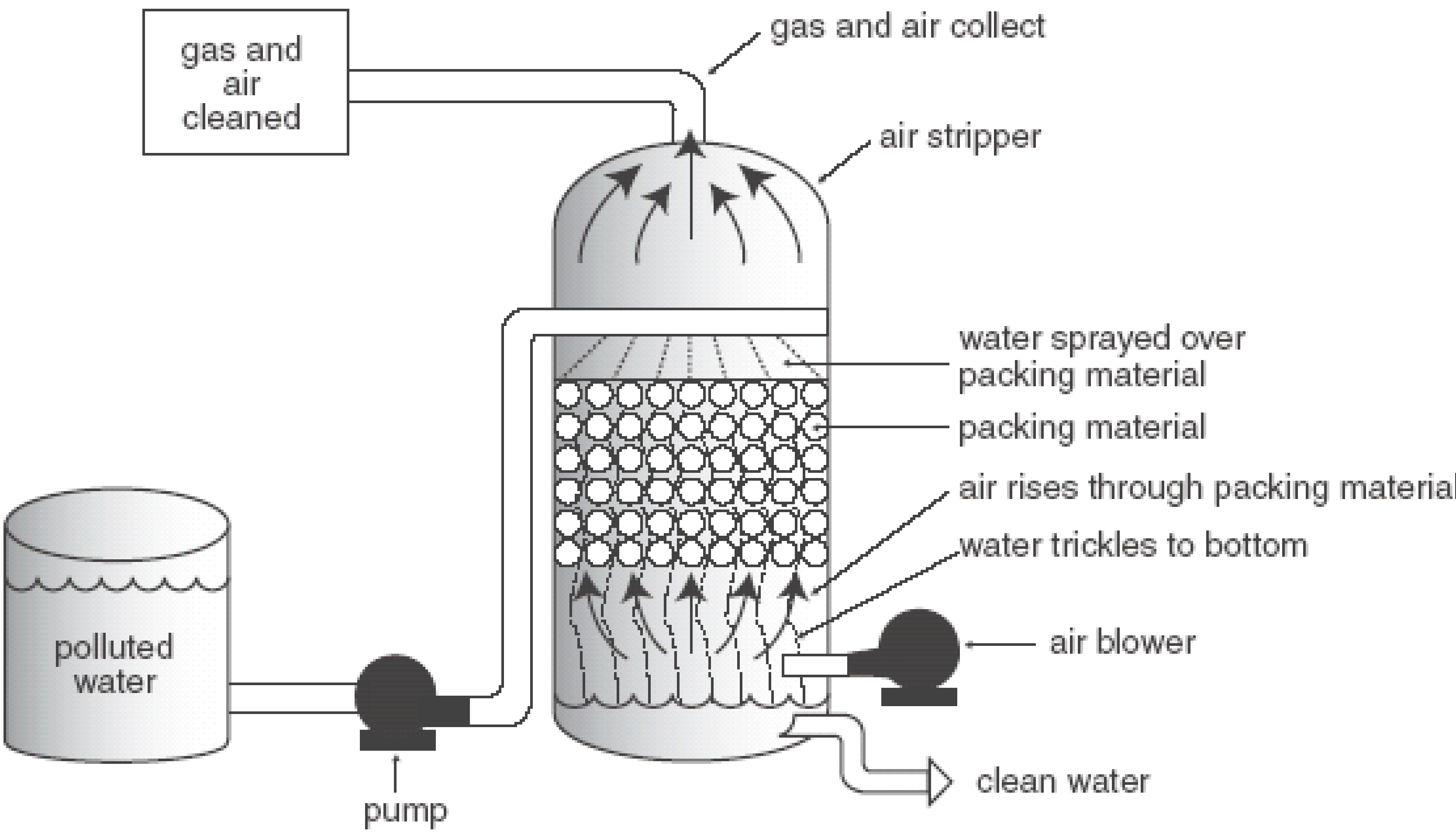




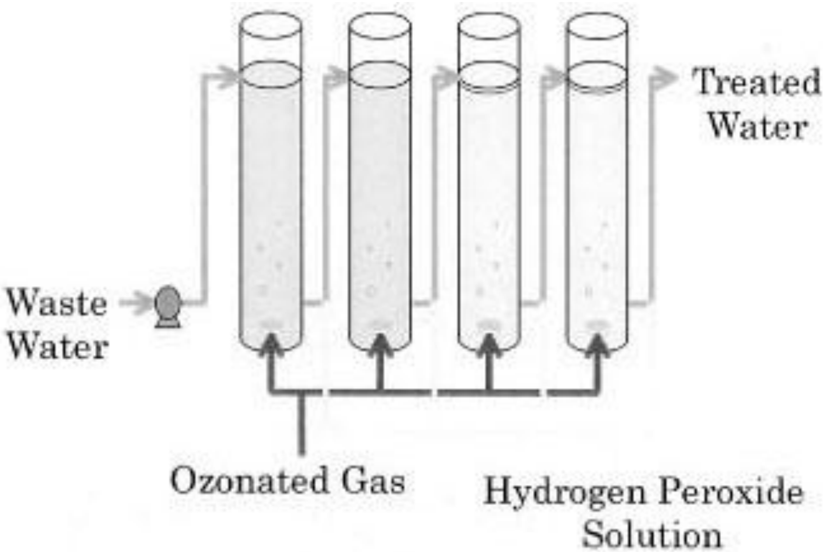
Activated Carbon adsorbs gases and chemicals

www.allerair.com

Packed Tower Air Stripper



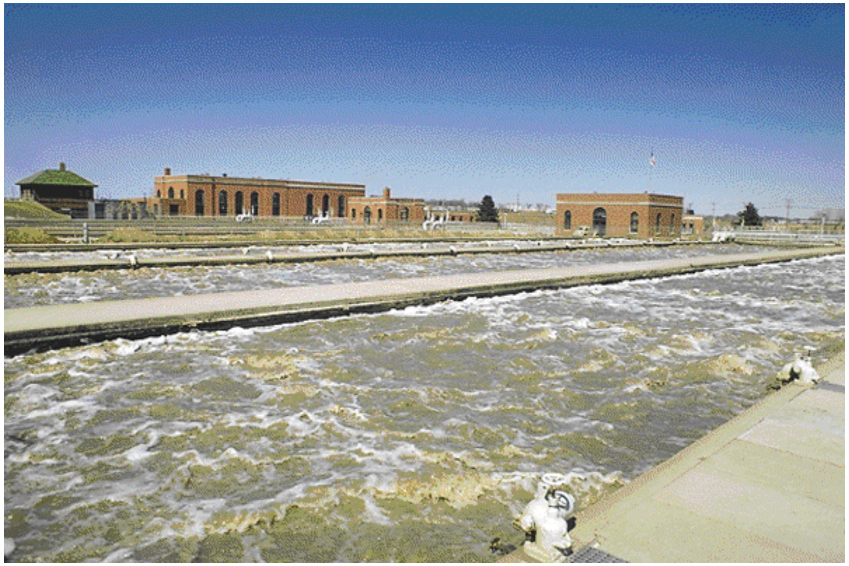
- UV/H_2O_2
- H_2O_2/O_3 (peroxone)
  - Direct oxidation of substances by liquid ozone ($O_3(aq)$)
  - Oxidation of compounds by •OH produced during ozone decomposition



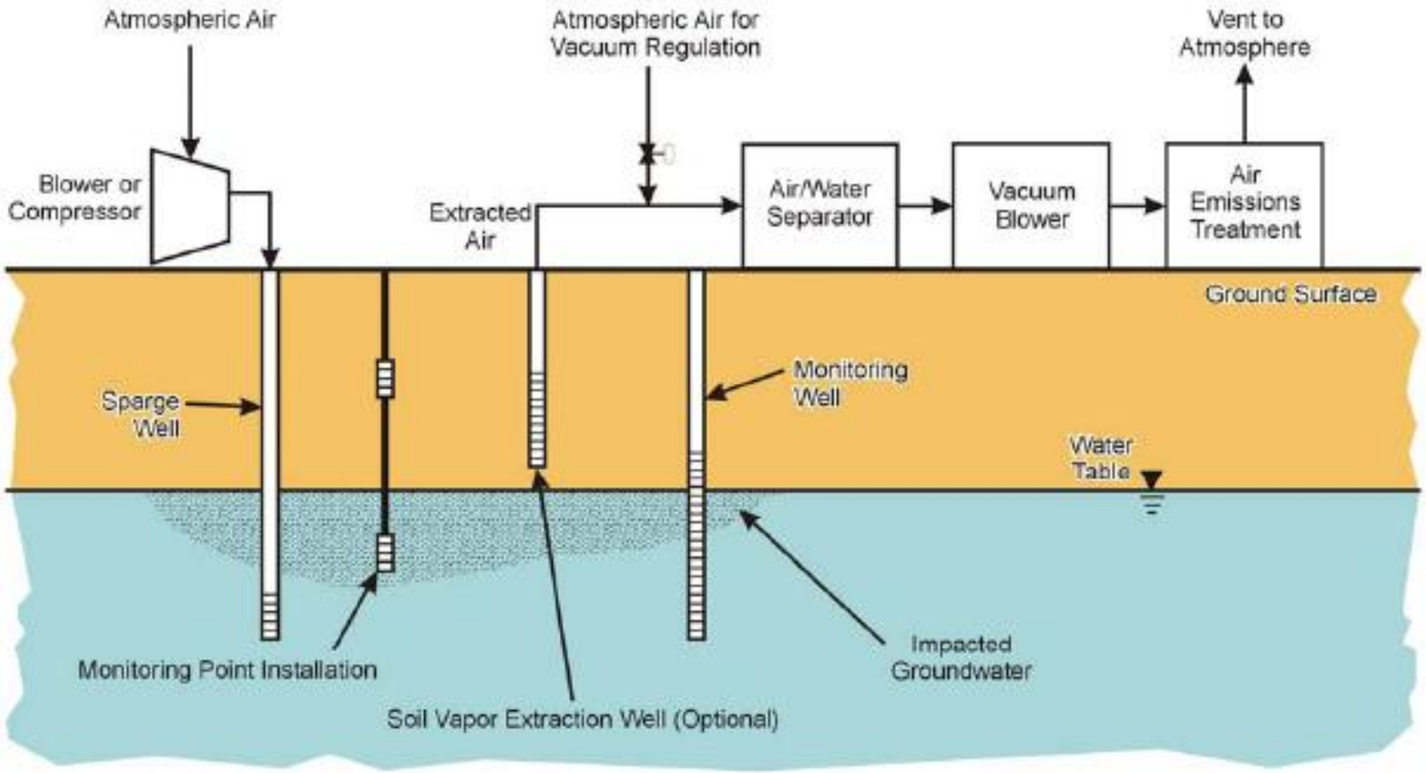
▲Schematic diagram of multiple injection O_3/H_2O_2 treatment system

Ex situ Biodegradation

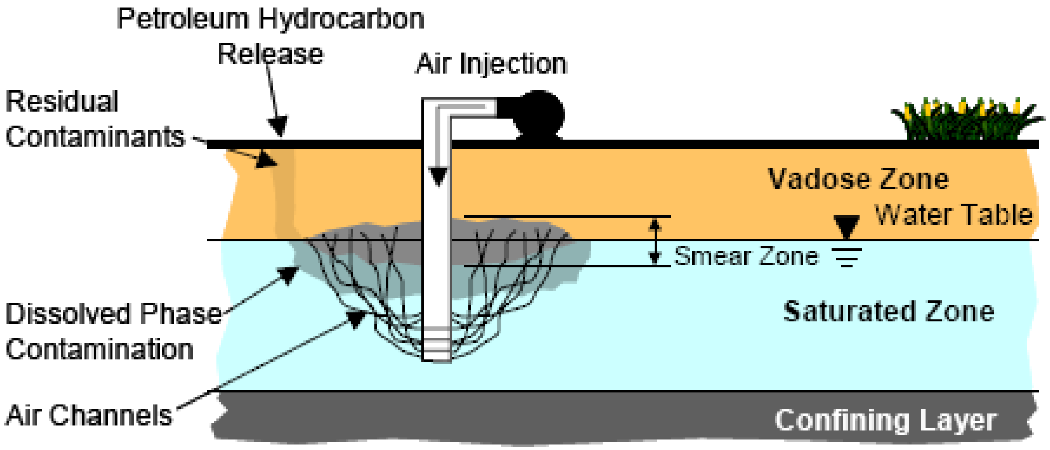
- Activated sludge process
- Trickling filter

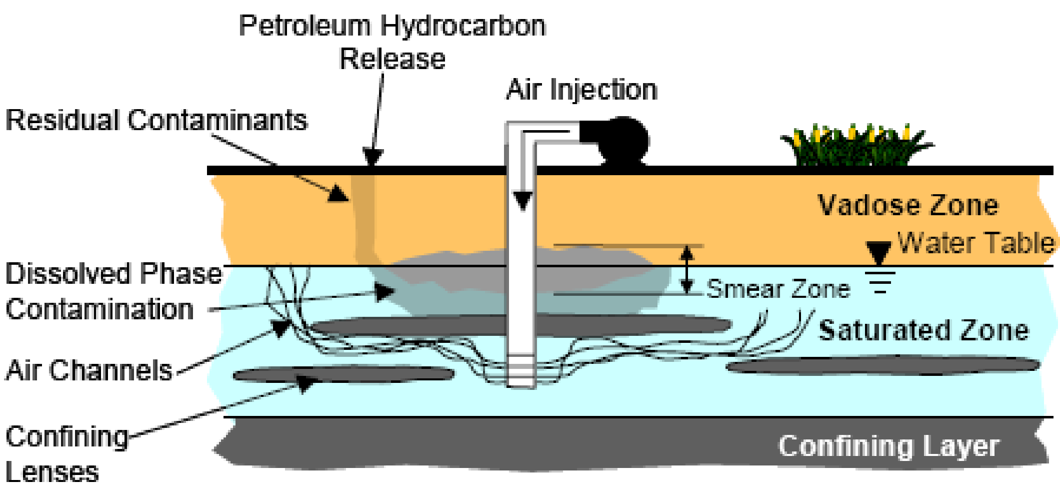


Air Sparging



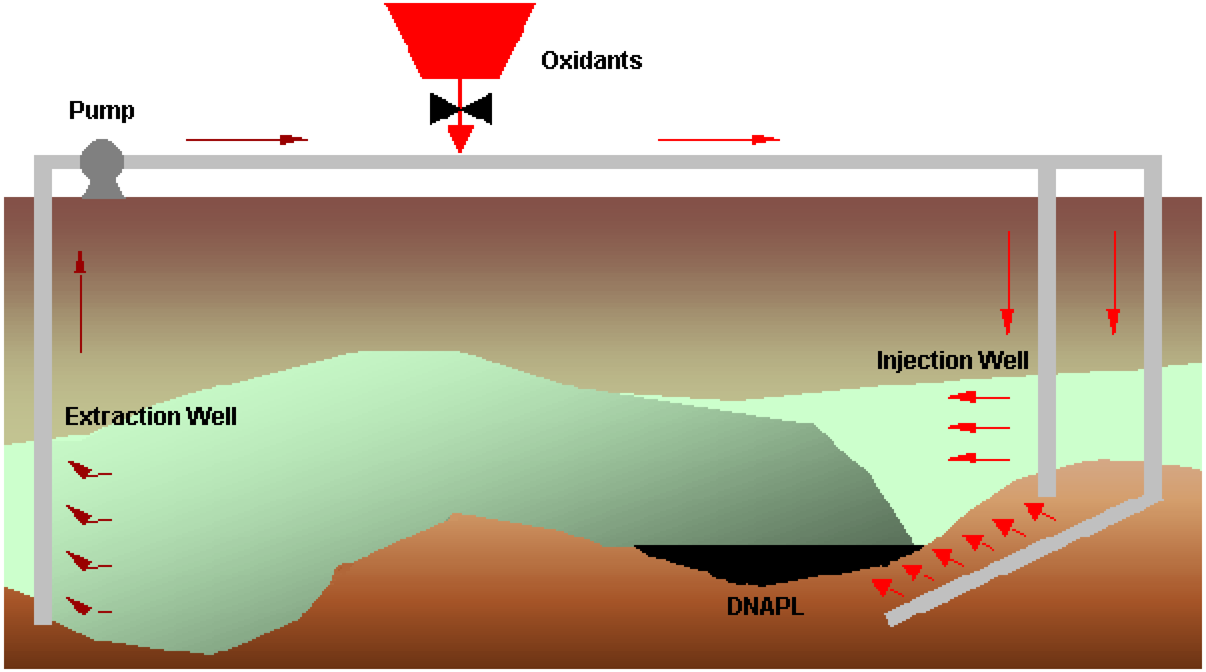
Heterogeneity





In situ Chemical Oxidation

- In situ Fenton oxidation (H_2O_2 + Fe)
- In situ permanganate ($KMnO_4$) oxidation



$$\bullet OH$$

Key Reactions in Fenton Oxidation

$$H_2O_2 + Fe^{2+} \rightarrow Fe^{3+} + OH^- + {}^{\bullet}OH$$

$$H_2O_2 + Fe^{3+} \rightarrow Fe^{2+} + {}^{\bullet}O_2^- + 2H^+$$

$${}^{\bullet}O_2^- + H^+ \leftrightarrow HO_2^{\bullet}$$

$${}^{\bullet}O_2^- + Fe^{3+} \rightarrow Fe^{2+} + O_2$$

$$HO_2^{\bullet} + Fe^{3+} \rightarrow Fe^{2+} + HO_2^-$$

Typical Oxidants

Compound	Oxidation potential (volts)	Relative oxidizing power (Cl_2 = 1.0)	Effectiveness on MTBE and BTEX	Potential limitations
Hydroxyl radical[a] (Fenton's reagent)	2.8	2.1	Yes	pH, k-lower, temp
Sulfate radical[b]	2.6	1.9	Yes	Not widely used, catalysts not fully developed
Ozone	2.1	1.5	Yes	Capital equipment
Persulfate	2.0	1.4	Yes	Not widely used
Hydrogen peroxide	1.8	1.3	Yes	pH, k-lower, temp
Permanganate	1.7	1.2	No	k-lower, slower reaction

[a] Formed during Fenton's reagent process and as product of ozone application.
[b] Formed by activating persulfate with a catalyst.
Sources: Leethem 2002, McGrath and O'Reilly 2003, Cookson and Sperry 2002.

$\bullet OH$

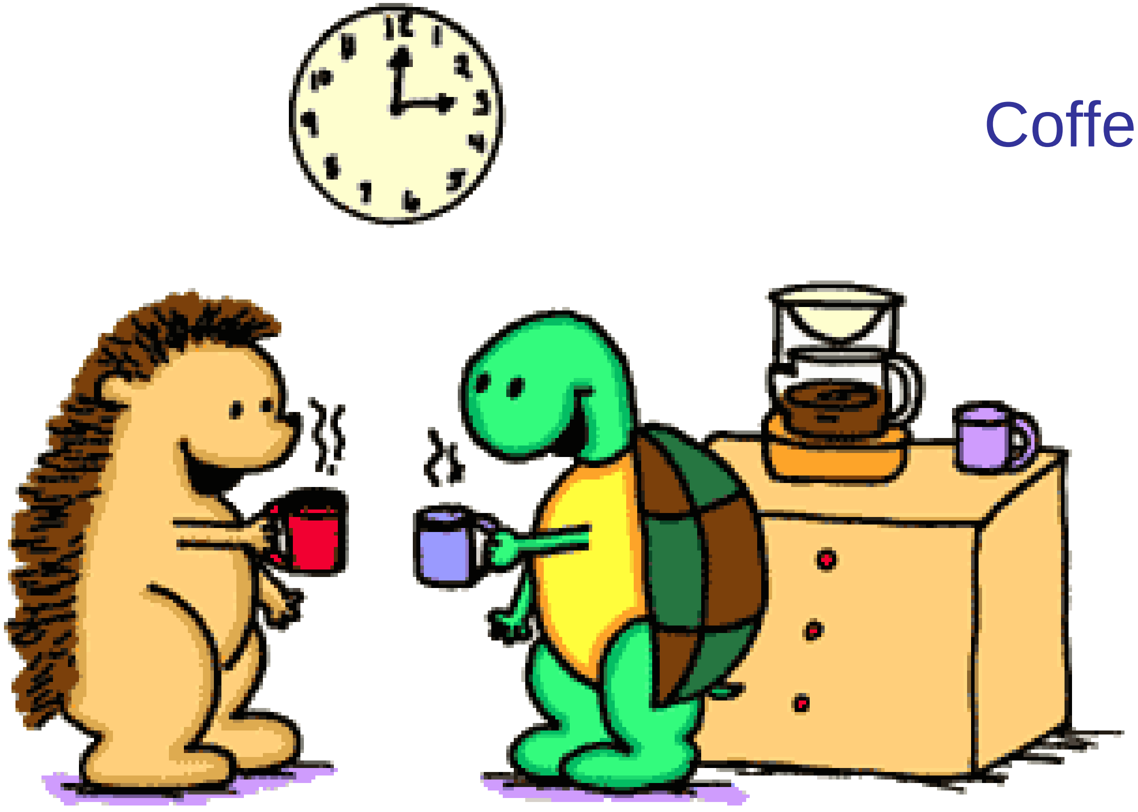
Reactants	Rate constants ($M^{-1}sec^{-1}$)
Benzene	7.8×10^{9}
2-Chlorophenol	1.2×10^{10}
Naphthalene	5×10^{9}
Nitrobenzene	3.9×10^{9}
Phenol	6.6×10^{9}
Tetrachloroethylene	2.6×10^{9}
Toluene	3.0×10^{9}
Trichloroethylene	4.2×10^{9}
Vinyl chloride	1.2×10^{10}

Cost

Technology	Character-ization	Capital cost (equipment and construction)	Operation and mainte-nance	Monitoring and reporting	Time-frame	Ability to control process	Primary limitations
Pump and treat	$$	$$–$$$	$$–$$$	$$	Months–years	High	Sensitive to discharge requirements
Air sparging	$–$$	$–$$	$–$$	$	Months–years	Moderate	Fine grain material; fugitive emissions
In situ bioremedia-tion	$$$	$	$	$$–$$$	Months–years	Low–moderate	Accurate delivery; mixing
In situ chemical oxidation	$$–$$$	$$–$$$	$	$$	Days–months	Low–moderate	Accurate delivery; mixing
Phytoremedia-tion	$$	$$	$–$$	$$–$$$	Years	Low	Root depth and residence time; seasonality
Monitored natural attenuation	$$$	$	$	$$$	Years–decades	Low	Timeframe; going to completion (e.g., meeting cleanup goals)

Note: Table applies to dissolved-phase (plume) remediation and is not specific to source zones.

Coffee Break



www.imgag.com

Seminar Topics

Session Topics

Day1	Introduction to Seminar
	Dubai Projects & Panama Canal
	Environmental Impact Assessment
	Impacts and Considerations in Road Transportation
Day 2	Environmental Water Quality Parameters
	Impacts and Considerations in Ship Transportation
	Impacts and Considerations in Air Transportation
	Reuse and Recycle in Construction and Transportation

Session 8. Environmental Impacts and Considerations in Ship Transportation

- Ballast Water (Biodiversity)
- Oil Spills

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Ferry Service Type Examples

(a) Water Taxi (Baltimore)

(b) Auto Ferry (British Columbia)

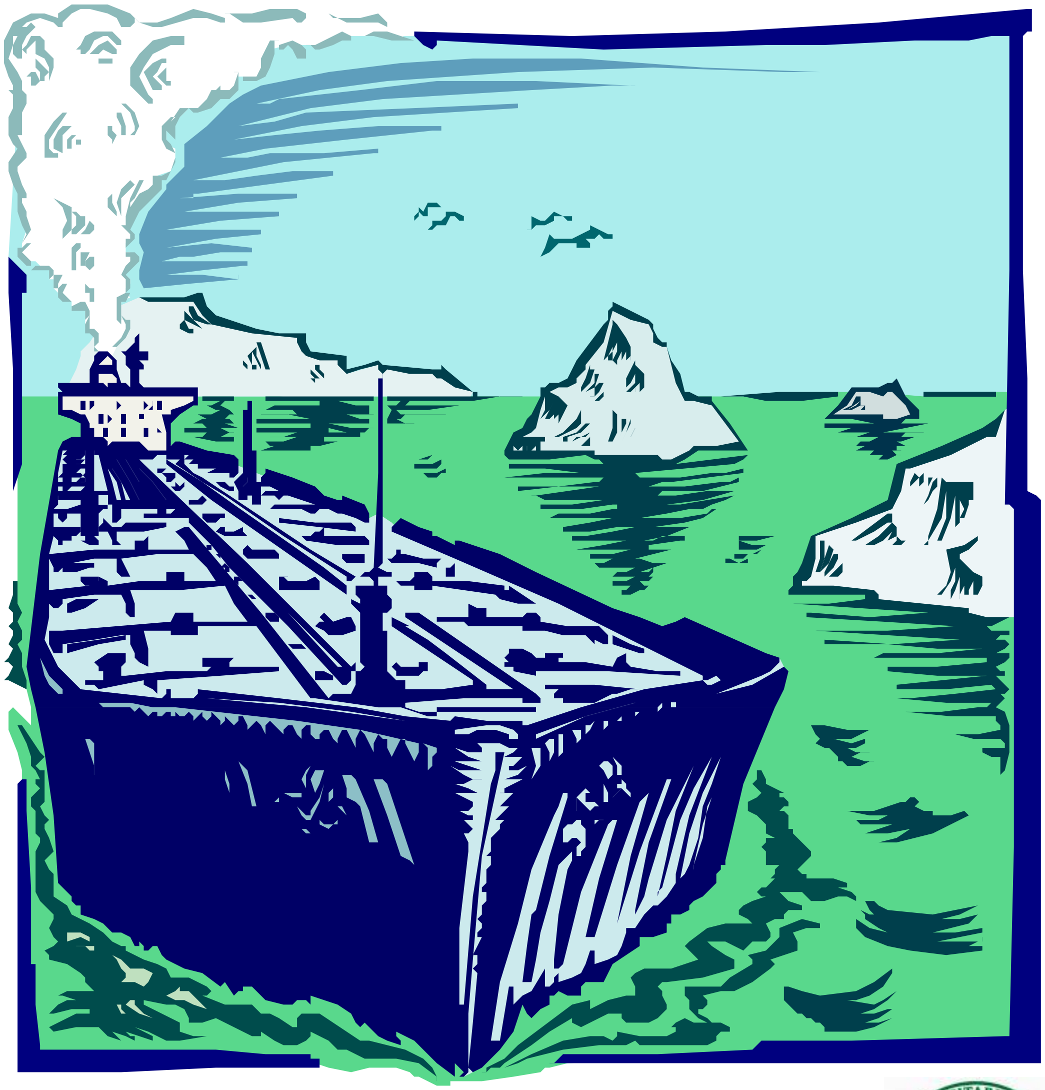
(c) Passenger Ferry (San Francisco)

(d) Passenger Ferry (Boston)

Source: TCRP Report 100, Transit Capacity and Quality of Service Manual, 2nd edition, 2003

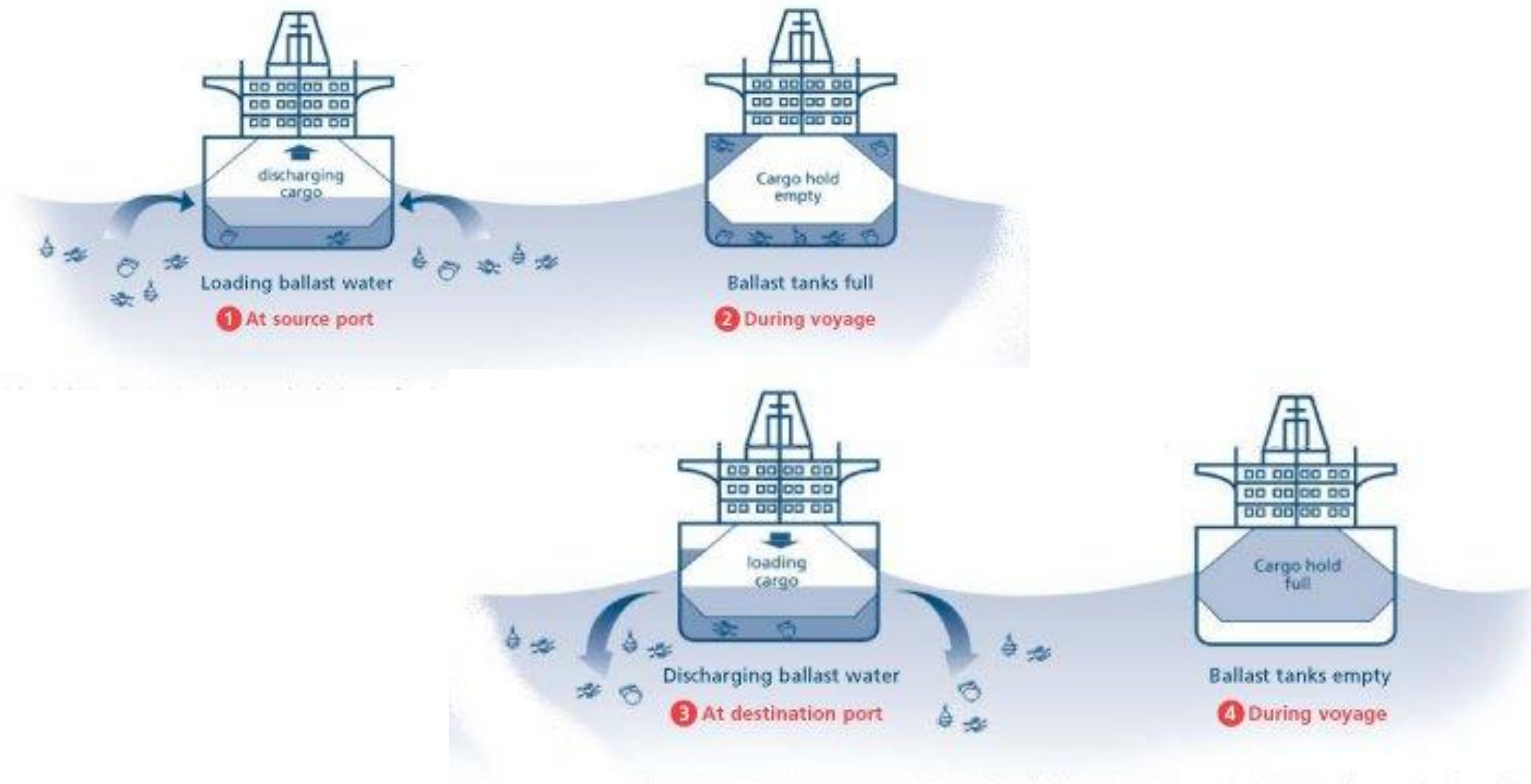
Ballast Water

- Four greatest threats to the world's oceans
  1. Ships' ballast water
  2. Land-based sources of marine pollution
  3. Overexploitation of living marine resources, and
  4. Physical alteration and destruction of marine habitat



Ballast Water

- Water carried by ships to ensure stability, trim and structural integrity
- When a ship is empty of cargo, it fills with ballast water. When it loads cargo, the ballast water is discharged

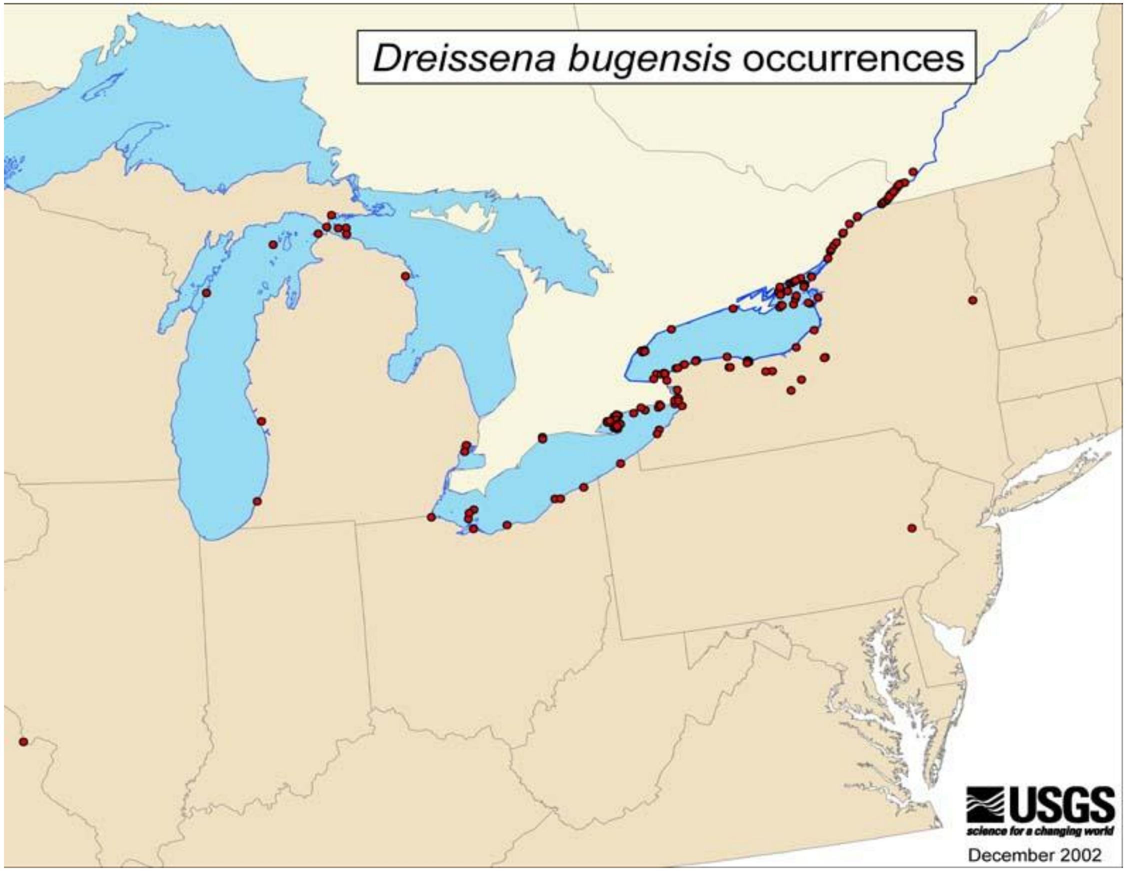


Ballast Water Amount

VESSEL TYPE	DWT	BALLAST CONDITION			
		NORMAL (tonnes)	% of DWT	HEAVY (tonnes)	% of DWT
Bulk carrier	250,000	75,000	30	113,000	45
Bulk carrier	150,000	45,000	30	67,000	45
Bulk carrier	70,000	25,000	36	40,000	57
Bulk carrier	35,000	10,000	30	17,000	49
Tanker	100,000	40,000	40	45,000	45
Tanker	40,000	12,000	30	15,000	38
Container	40,000	12,000	30	15,000	38
Container	15,000	5,000	30	n/a	
General cargo	17,000	6,000	35	n/a	
General cargo	8,000	3,000	38	n/a	
Passenger/RORO	3,000	1,000	33	n/a	

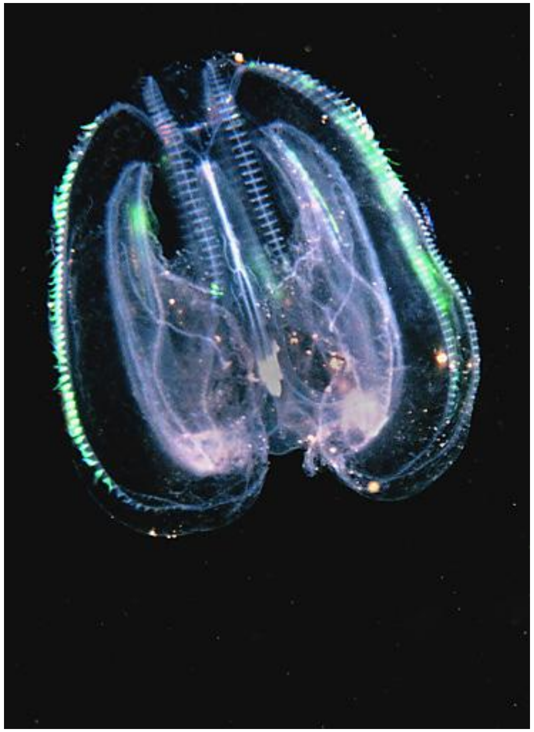
- In the USA, the European Zebra Mussel Dreissena polymorpha has infested over 40% of internal waterways and may have required between US$750 million and US$1 billion in expenditure on control measures between 1989 and 2000.

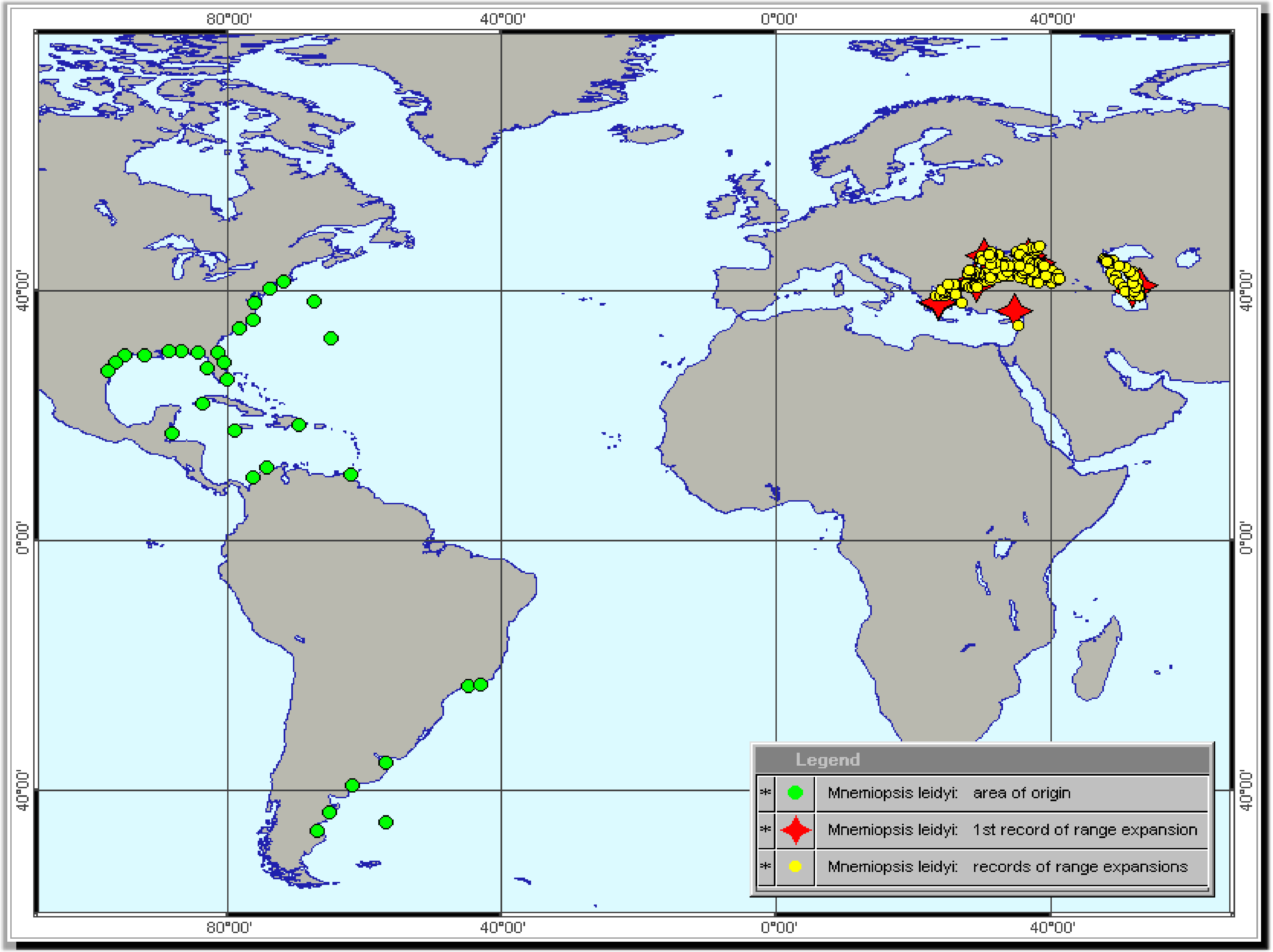
- The larval mussels settle in water pipes and grids, impeding the flow of water through these pipes. Sometimes waste from the mussels causes water fouling.



Mnemiopsis leidyi

- In the Black Sea, the filter-feeding North American jellyfish Mnemiopsis leidyi has on occasion reached densities of 1kg of biomass/m^2.
- It has depleted native plankton stocks to such an extent that it has contributed to the collapse of entire Black Sea commercial fisheries.

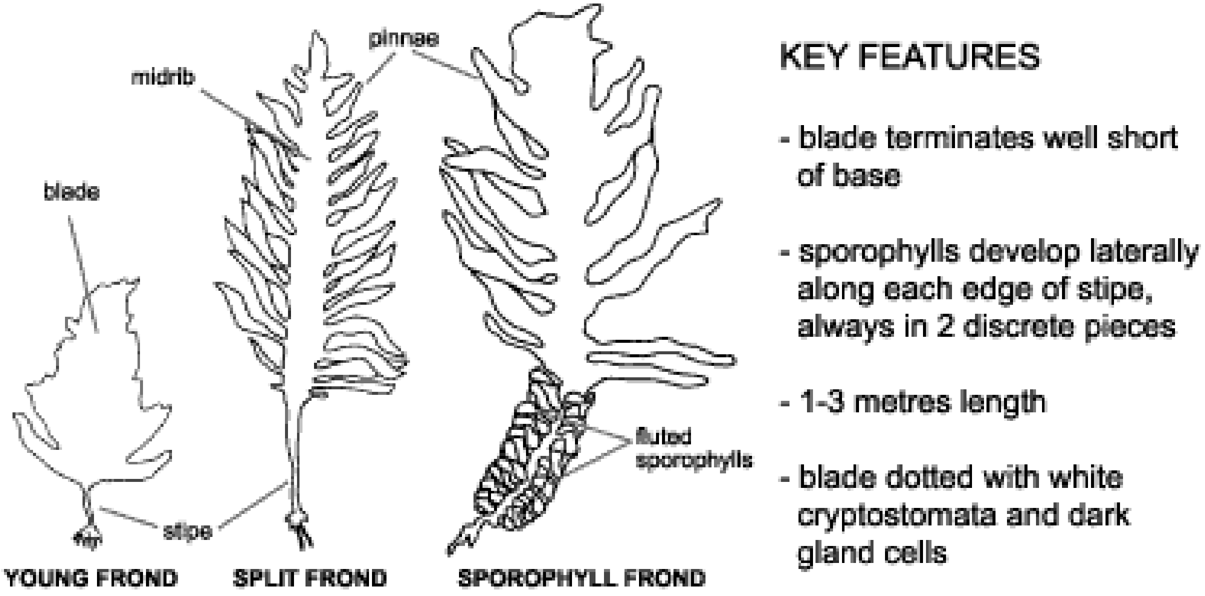



80°00'
40°00'
0°00'
40°00'
40°00'
0°00'
40°00'
Legend
Mnemiopsis leidyi: area of origin
Mnemiopsis leidyi: 1st record of range expansion
Mnemiopsis leidyi: records of range expansions

Undaria pinnatifida

- In southern Australia, the Asian kelp Undaria pinnatifida is invading new areas rapidly, displacing the native seabed communities.

www.separationsnow.com



www.marine.csiro.au

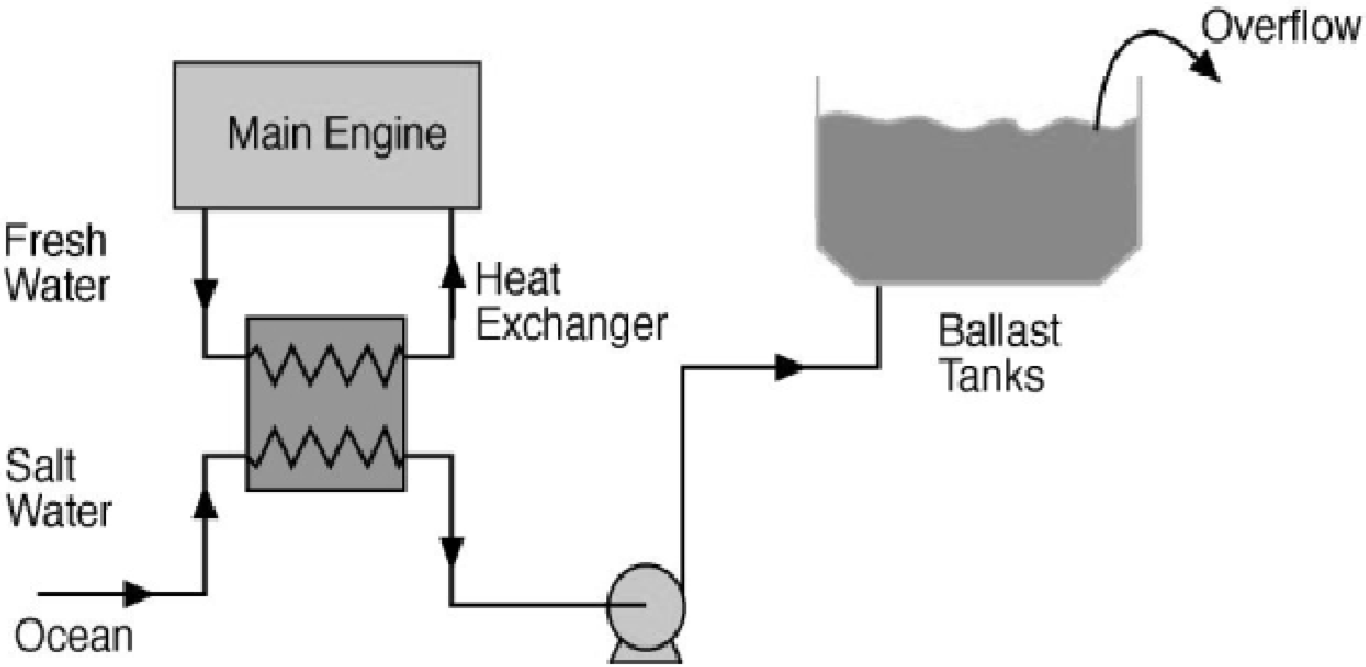
- In several countries, introduced, microscopic, ‘red-tide’ algae (toxic dinoflagellates) have been absorbed by filter-feeding shellfish, such as oysters. When eaten by humans, these contaminated shellfish can cause paralysis and even death.

- It is even feared that diseases such as cholera might be able to be transported in ballast water.

Ballast Water Treatment

- Physical/mechanical treatment methods
  - Filtration and separation.
- Physical/chemical treatment methods
  - Sterilization by ozone, ultra-violet light, electric currents and heat treatment.
- Biochemical treatment methods
  - Biocides to ballast water to kill organisms.
- Various combinations of the above.

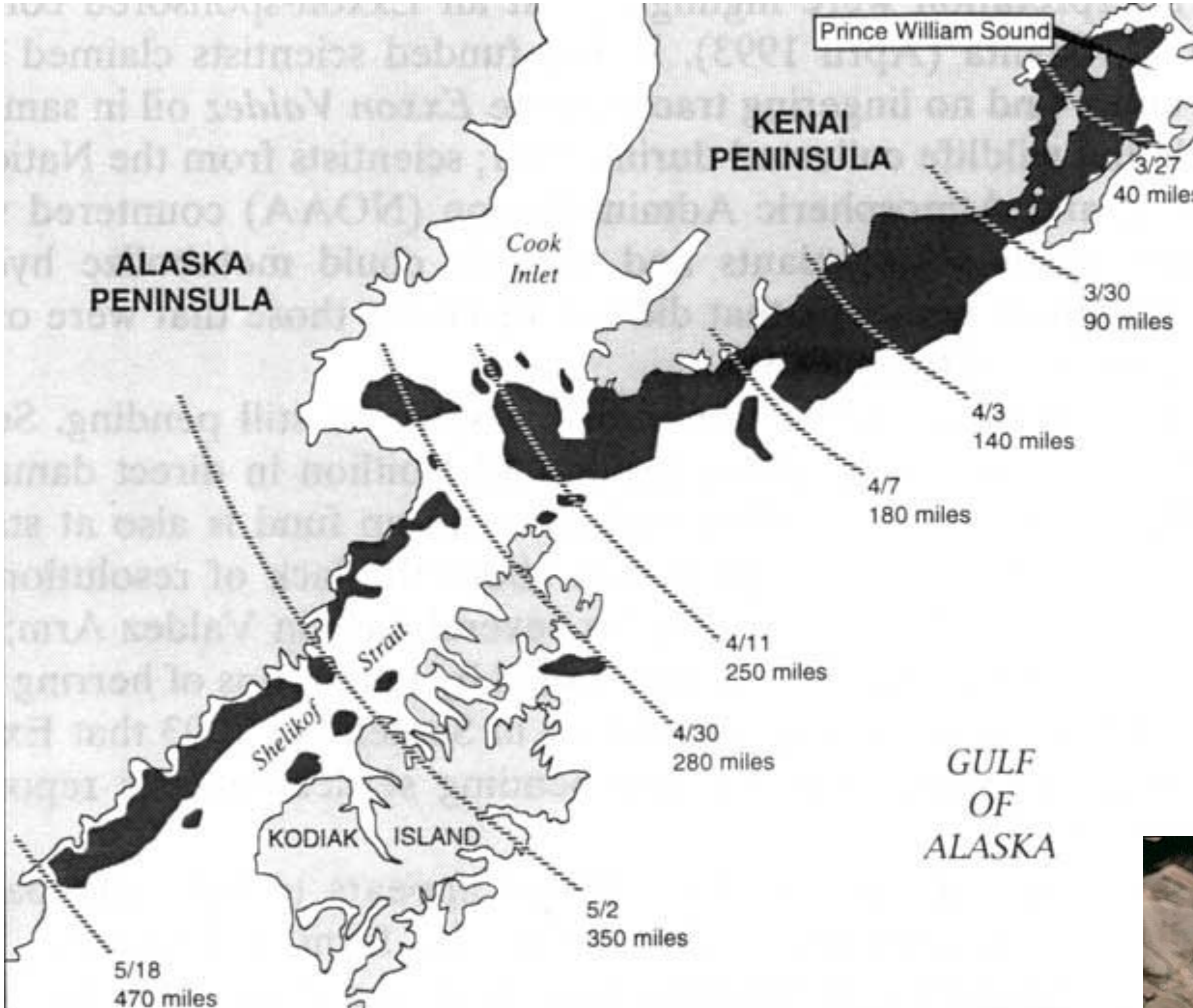
- Heat


Main Engine
Fresh Water
Heat Exchanger
Salt Water
Ocean
Overflow
Ballast Tanks

Environmental Oil Contamination

- In late December 1979, the tank barge Peck Slip ruptured while passing offshore the eastern shore of Puerto Rico. No. 6 oil was lost, impacting sand beaches and mangroves

Exxon Valdez (1989)



www.unu.edu

Lunch Break

www.landers.co.uk

Seminar Topics

Session Topics

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	Impacts and Considerations in Air Transportation
	Reuse and Recycle in Construction and Transportation

Session 9. Environmental Impacts and Considerations in Air Transportation

- Noise Controls
- Air/Water Quality

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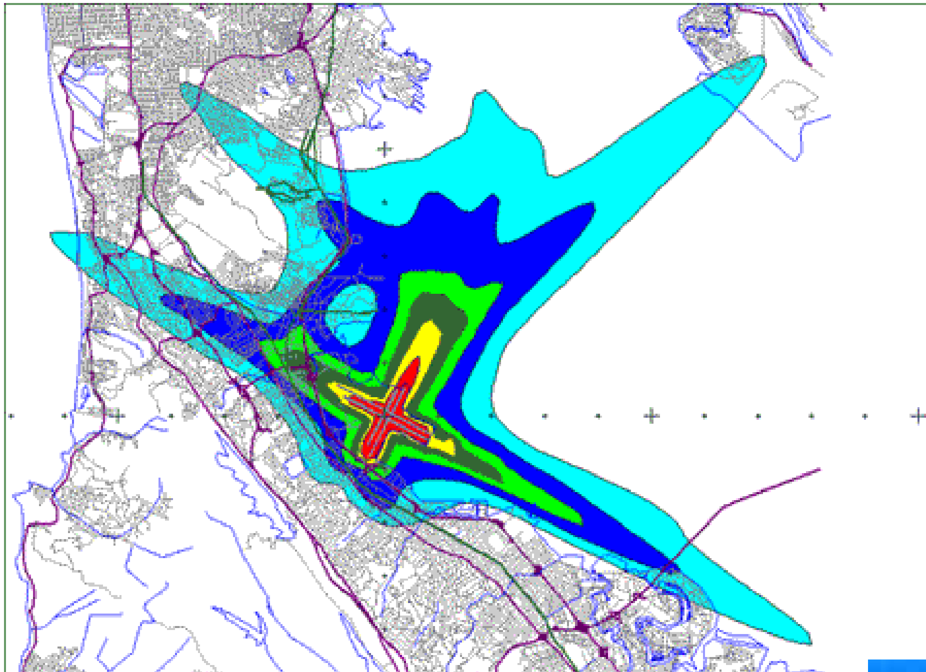
St. Thomas Airport

St. Croix Airport



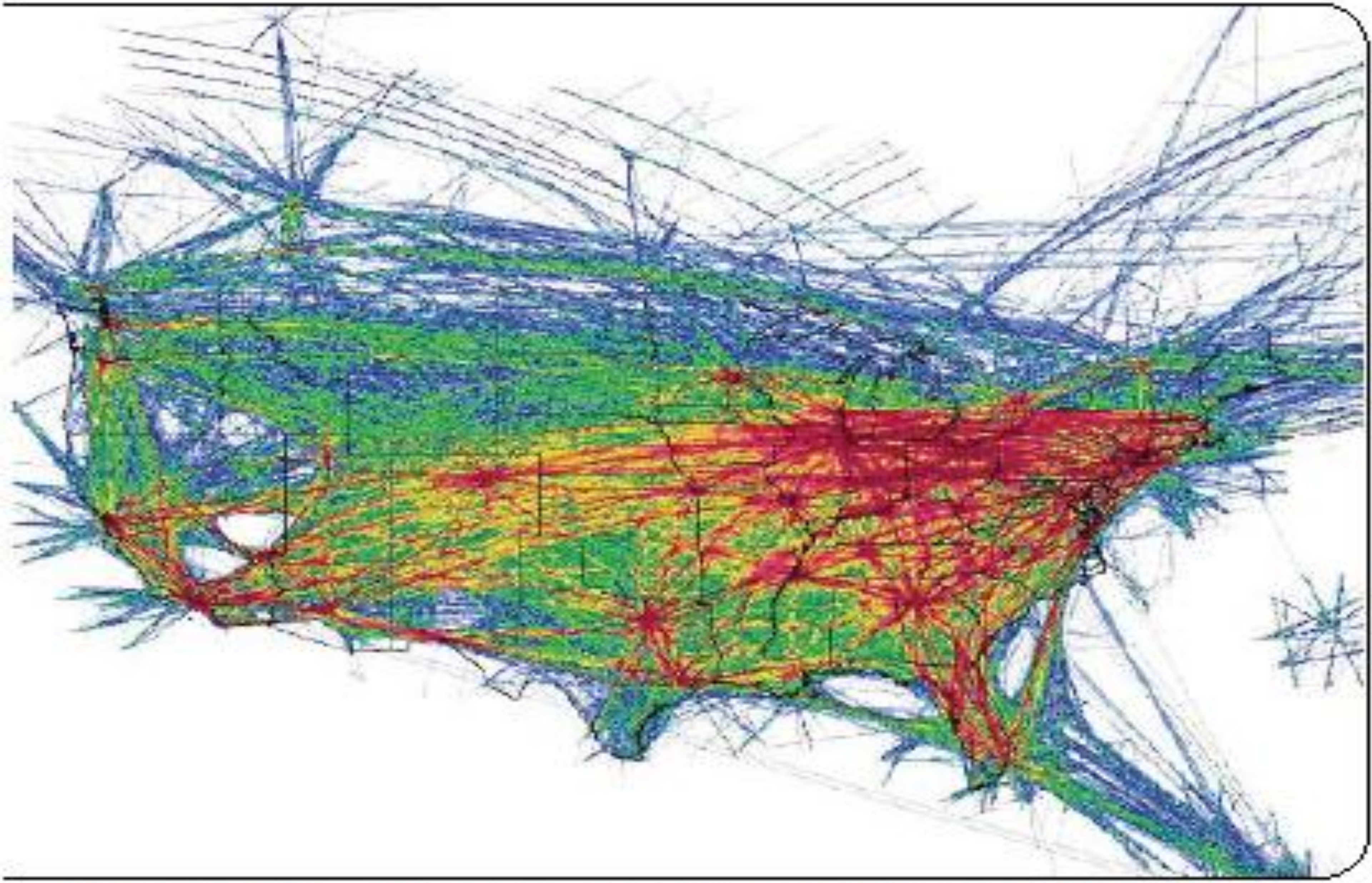
www.volpe.dot.gov

pages.prodigy.net

dB

DECIBEL RATINGS

db	DECIBEL RATINGS
30	Soft Whisper, Quiet Library
40	Quiet Room
50	Moderate Rainfall
60	Ordinary Conversation, Dishwasher
70	Busy Traffic, Vacuum Cleaner
80	Noisy Restaurant, Alarm Clock, Busy Street
90	Lawnmower, Shop Tools, Truck Traffic, Sub-way
100	Pneumatic Drill, Chain Saw, Snowmobile
110	Rock Band, Model Airplane, Car Horn
120	Jet Plane Take Off, Amplified Rock Music at 4-6 feet, Loud Car Stereo
130	Jack Hammer
140	Gun Shot Blast, Air Raid Siren, Jet Engine
150	Jet Plane Noise



U.S. Air traffic for a 24-hour period taken from the FAA Enhanced Traffic Management System (ETMS) which integrates data from FAA air traffic control radar.

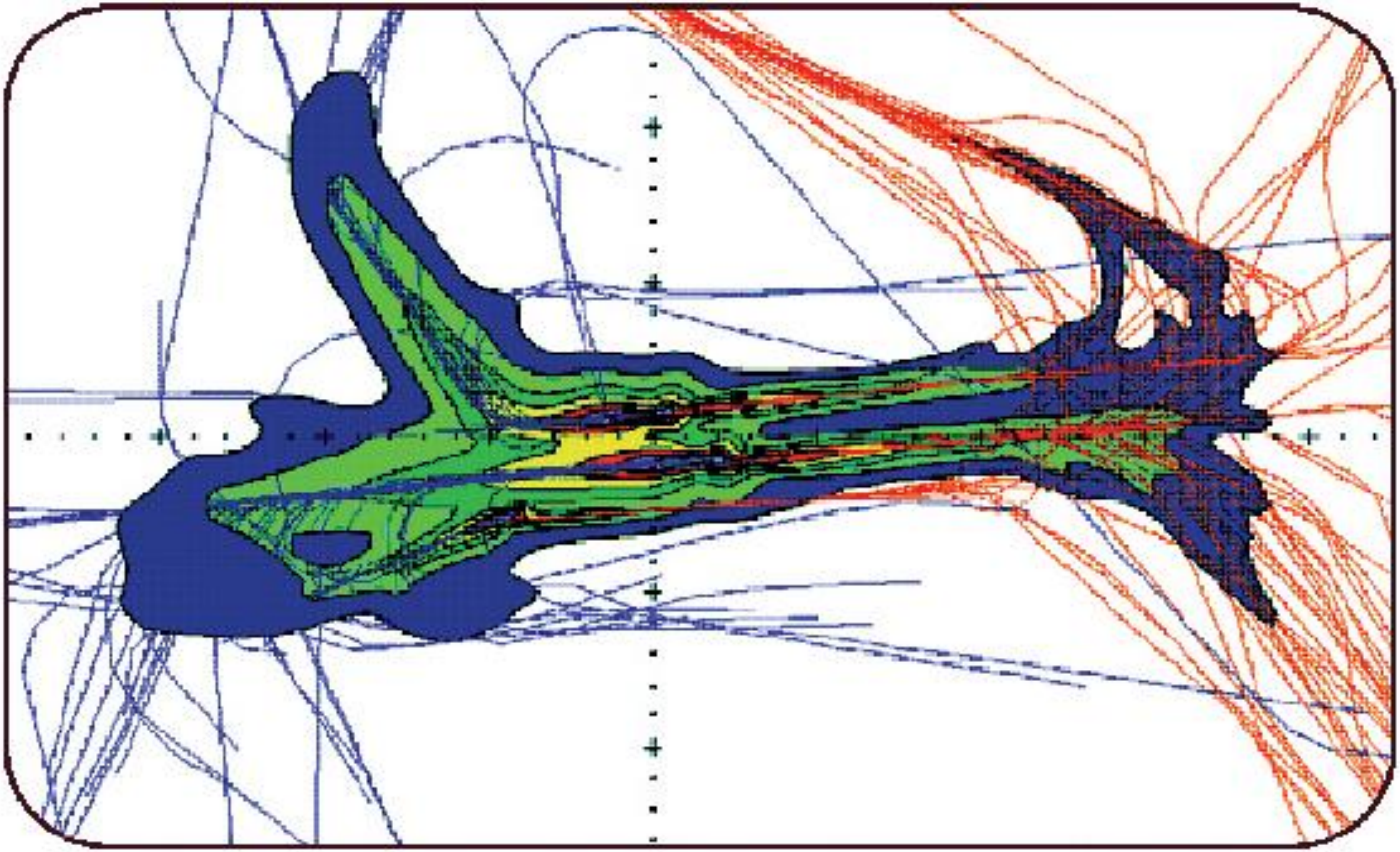
- Aircraft noise is the single most significant local objection to airport expansion and construction

- Aviation enables economic growth. However, environmental issues caused airport officials to cancel or indefinitely postpone expansion projects at 12 of the 50 busiest U.S. airports in the last 10 years [GAO 2000c].

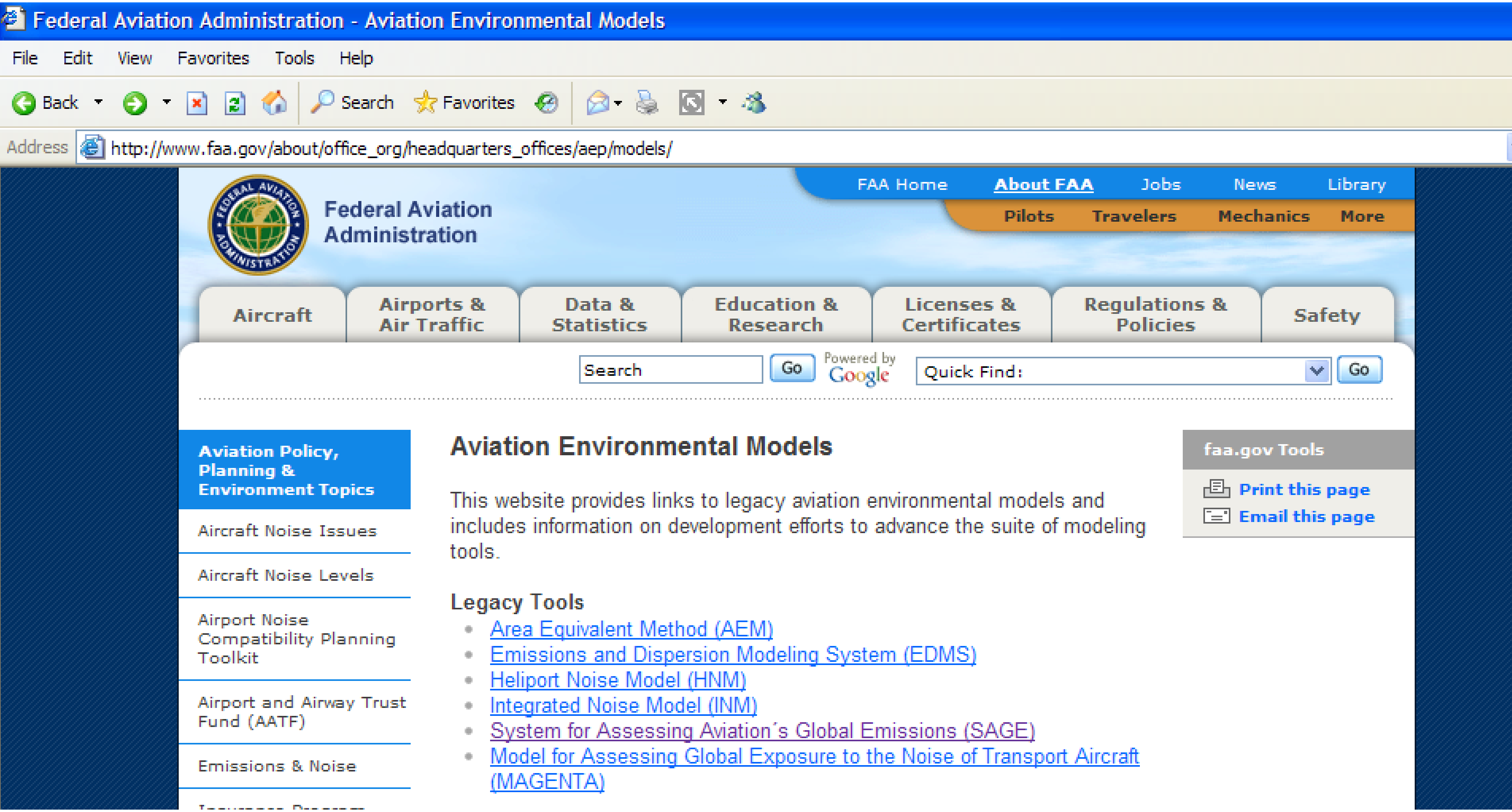
- The dominant concern was noise, followed by water quality and then local air quality. In the future, noise and local air quality are expected to be the most significant concerns.

Some Facts and Figures

- In 2000, approximately 0.5 million people in the United States lived in areas with noise levels above 65dB DNL.
  - where greater than 12% of the population may be highly annoyed
- In 2000, approximately 5 million people in the United States lived in areas with noise levels above 55dB DNL.
  - where greater than 3% of the population may be highly annoyed
- There has been a further 10% reduction in the number of people impacted since 2000 due to:
  - the earlier than expected retirement of certain aircraft in light of the economic downturn and the events of 9/11, and
  - the continuing reduced traffic in the U.S. system compared to 2000



The FAA Integrated Noise Model (INM) is the principal tool used around the world for assessing the noise of aircraft around airports. Shown here are contours of day-night noise level (blue = 55dB-65dB, green = 65dB-75dB) and departure and arrival flight tracks (blue and red respectively) for a major international airport.


Federal Aviation Administration - Aviation Environmental Models
File Edit View Favorites Tools Help
Back Search Favorites
Address http://www.faa.gov/about/office_org/headquarters_offices/aep/models/
FAA Home About FAA Jobs News Library
Pilots Travelers Mechanics More
Federal Aviation Administration
Aircraft
Airports & Air Traffic
Data & Statistics
Education & Research
Licenses & Certificates
Regulations & Policies
Safety
Search Go Powered by Google Quick Find: Go
Aviation Policy, Planning & Environment Topics
Aircraft Noise Issues
Aircraft Noise Levels
Airport Noise Compatibility Planning Toolkit
Airport and Airway Trust Fund (AATF)
Emissions & Noise
Aviation Environmental Models
This website provides links to legacy aviation environmental models and includes information on development efforts to advance the suite of modeling tools.
Legacy Tools
Area Equivalent Method (AEM)
Emissions and Dispersion Modeling System (EDMS)
Heliport Noise Model (HNM)
Integrated Noise Model (INM)
System for Assessing Aviation's Global Emissions (SAGE)
Model for Assessing Global Exposure to the Noise of Transport Aircraft (MAGENTA)
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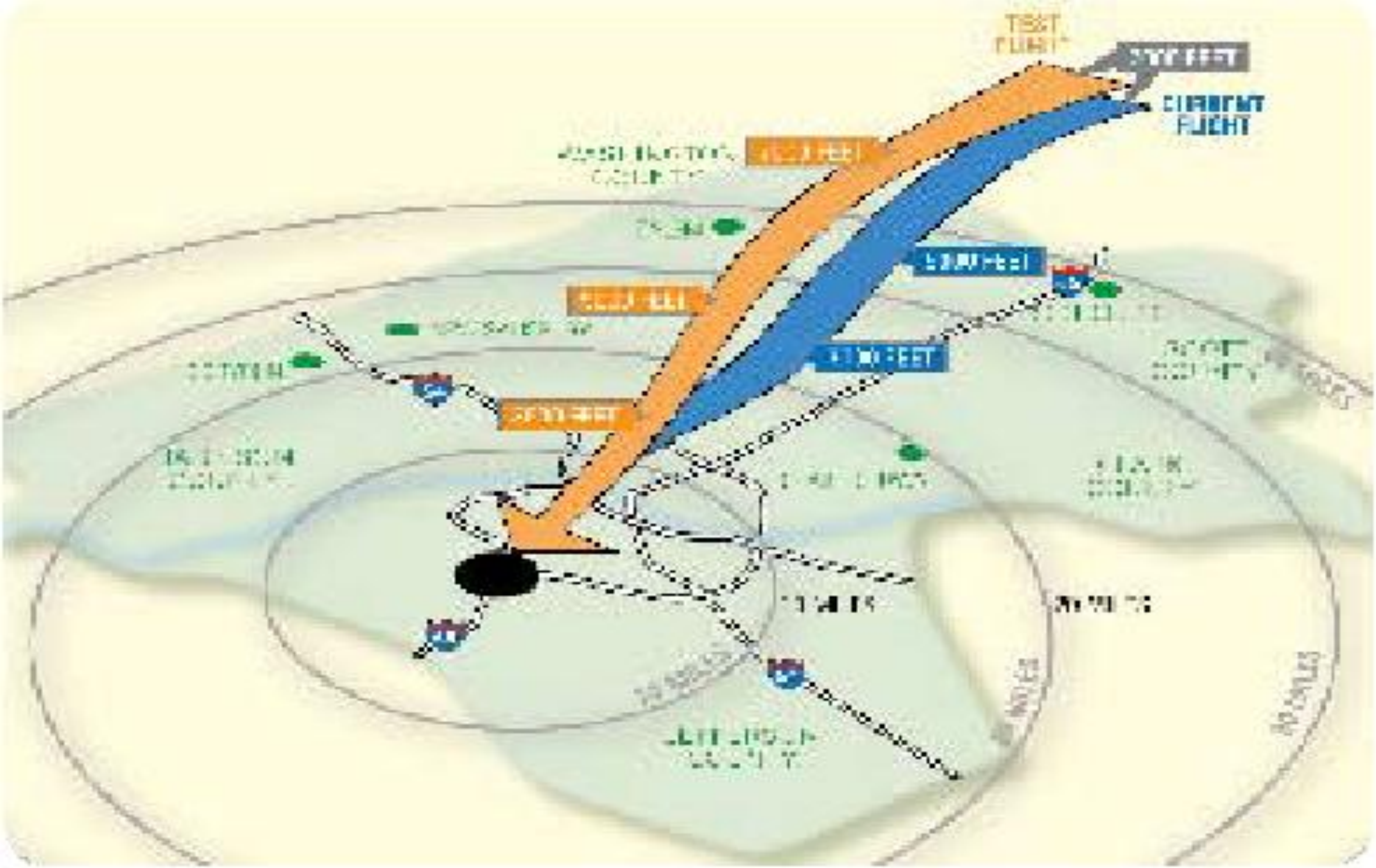
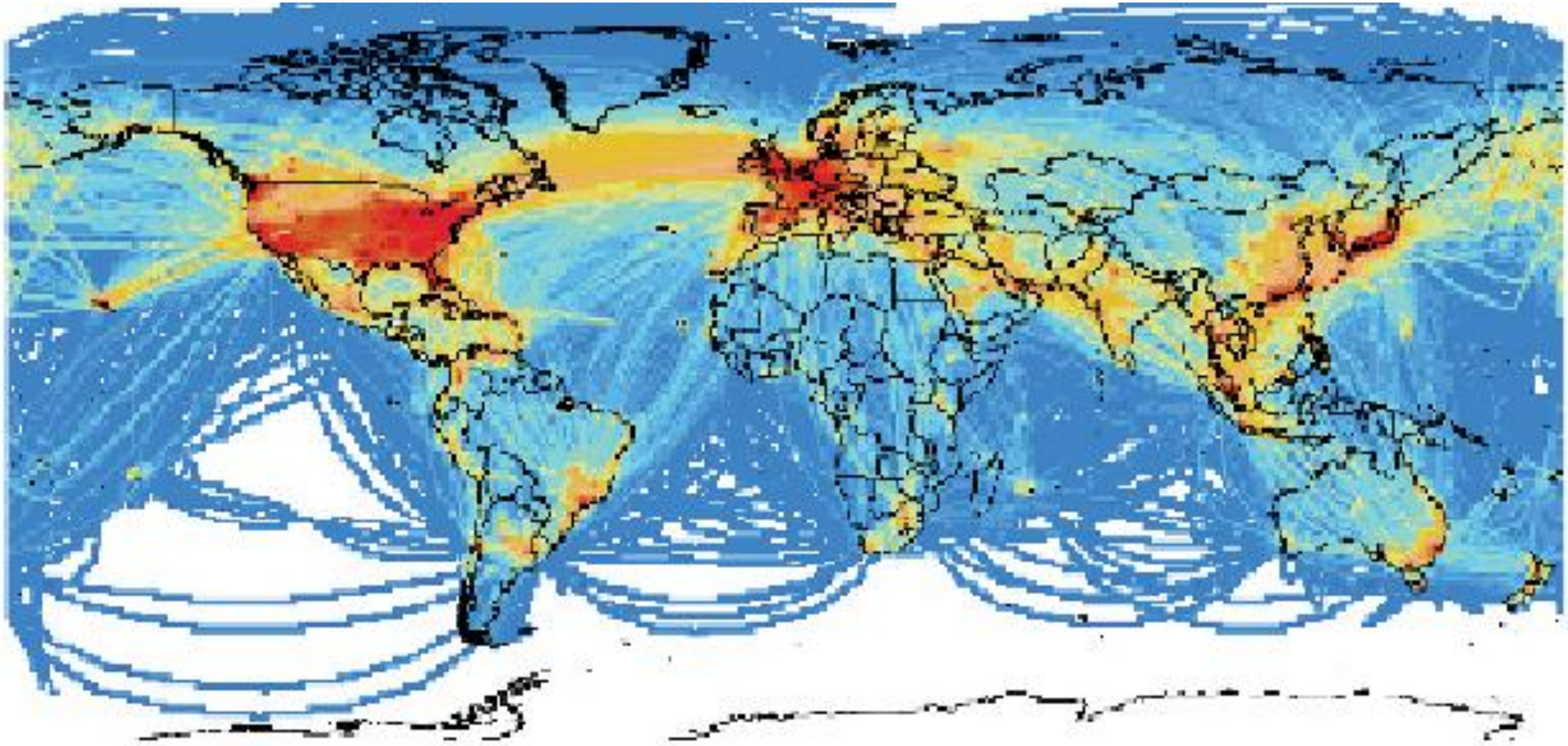


Standard flight paths, such as the one at Louisville (shown in blue) involve a series of stepped descents. New continuous descent approach procedures, collaboratively developed by an FAA/NASA/industry/academia team, have been shown reduce noise impacts by keeping aircraft higher, longer. They have also been shown to reduce fuel burn and emissions of local air quality pollutants. (Illustration © The [Louisville] Courier Journal.)

- Emissions of nitrogen oxides (NOx), carbon monoxide (CO), unburned hydrocarbons (UHC) and particulate matter (PM) from a variety of airport sources contribute to local air quality deterioration, resulting in human health and welfare impacts.

CO_2 Emissions



This output from the FAA System for assessing Aviation's Global Emissions (SAGE) shows the world-wide distribution of aircraft carbon dioxide emissions for 2000. SAGE calculates aircraft emissions on a flight-by-flight basis as a function of aircraft type and detailed flight profile information. The results can be used to assess the impact of various mitigation strategies on fuel burn and emissions at airport, regional and global levels.

Airport/Aircraft Deicing and Anti-Icings

- Posing threats to animal and human health
- Killing wildlife
- Producing foamy, neon-colored creek water which existed near homes, wells and a wildlife refuge
- Threatening plants on land and water downstream

Dr. Sangchul (San) Hwang

- Type I, II, III, and IV.
- All current formulations in the U.S. use either ethylene glycol or propylene glycol as a freezing point depressant.
- Type I is the most commonly used fluid and is used primarily for aircraft deicing.
  - These types of fluids, which contain either ethylene glycol or propylene glycol, water, and additives, remove accumulated ice and snow from aircraft surfaces.

- Types II, III, and IV were developed for antiicing and form a protective anti-icing film on aircraft surfaces to prevent the accumulation of ice and snow.
  - Anti-icing fluids are composed of either ethylene glycol or propylene glycol, a small amount of thickener, water, and additives.
  - The additives in aircraft deicing and anti-icing fluids may include corrosion inhibitors, flame retardants, wetting agents, identifying dyes, and foam suppressors.

1. Elimination of glycol-based fluids through the development of an environmentally benign alternative fluid;
2. Minimization of the volume of fluid applied to aircraft through the development of better fluids, improved application methods, and innovative aircraft deicing technologies;
3. Development of collection and disposal strategies that prevent the release of ADF-contaminated wastewater to the environment; and
4. Development of glycol recycling methods.

1. Adoption of alternative pavement deicing/anti-icing chemicals that are less harmful to the environment;
2. Reduction or elimination of pavement deicing/anti-icing chemicals through the implementation of alternative deicing/anti-icing technologies; and
3. Minimization of the amount of agents applied through the use of good maintenance practices, preventive anti-icing techniques, and runway condition monitoring systems.

- Inexpensive, environmentally benign deicing/anti-icing chemicals
  - non-glycol-based aircraft deicing and anti-icing agents
  - antifreeze molecules found in overwintering larvae of the beetle *Dendroides canadensis*
  - antifreeze molecules found in polar fish.

bugguide.net

Aircraft Deicing Fluid Minimization Methods

- Type IV which has a longer holdover time
  - Less amount of fluid usage
  - More toxic?
- Preventive anti-icing rather than deicing
- Forced-Air Aircraft Deicing Systems ($$$)
- Computer-Controlled Fixed-Gantry Aircraft Deicing Systems ($$$)
- Infrared Aircraft Deicing Technology ($$$)
- Hot Water Aircraft Deicing (safety, anyways water)
- Mechanical deicing
  - more effective at removing snow rather than ice. When performed incorrectly, they can damage aircraft antennas and sensors.
  - generally only practical for smaller aircraft; for large aircraft, they can be prohibitively time-consuming and labor intensive.

Coffee Break

Session Topics

Day1
- Introduction to Seminar
- Dubai Projects & Panama Canal
- Environmental Impact Assessment
- Impacts and Considerations in Road Transportation

Day 2
- Environmental Water Quality Parameters
- Impacts and Considerations in Ship Transportation
- Impacts and Considerations in Air Transportation
- Reuse and Recycle in Construction and Transportation

Session 10. Green Engineering in Transportation Projects

- Waste Tires
- Coal Combustion Byproducts
- Construction and Demolition Debris

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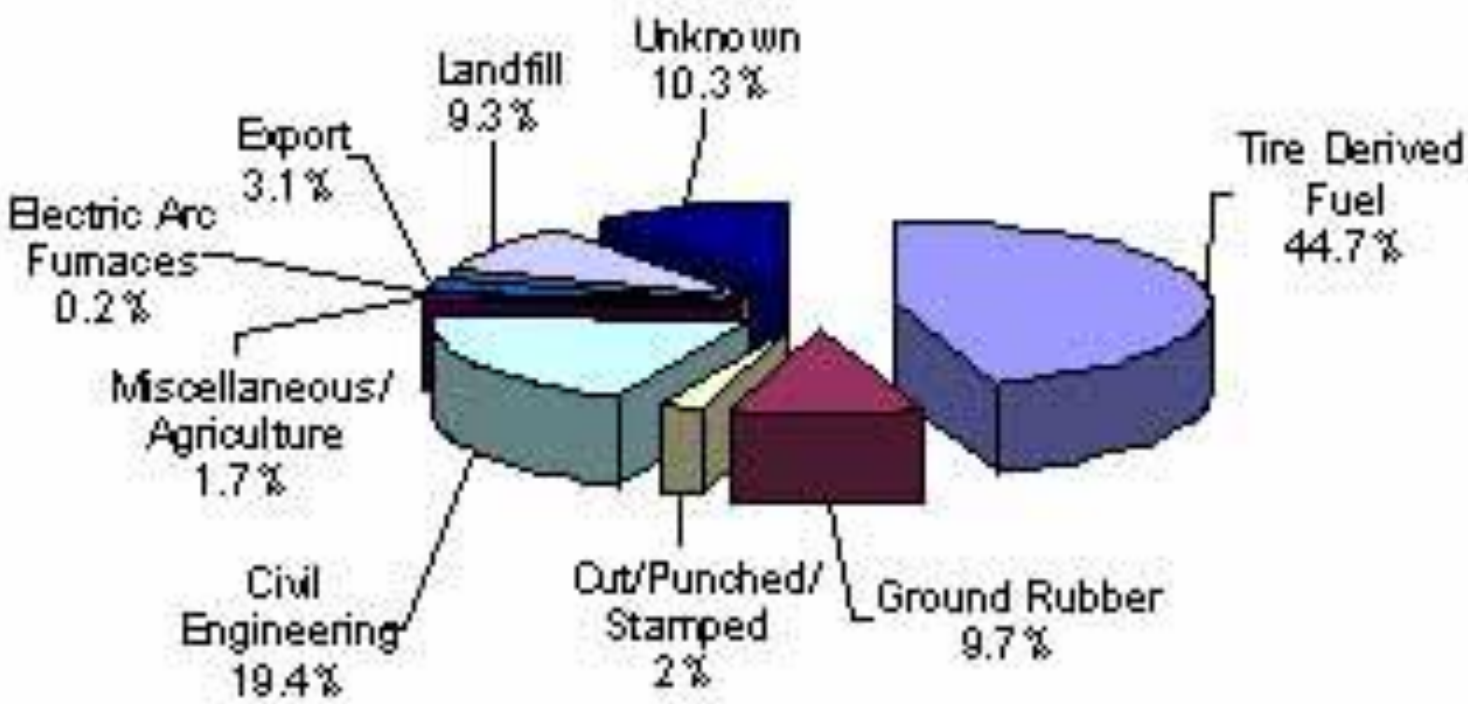
Figure 2: U.S. Scrap Tire Disposition 2003



Alternative Applications for Waste Tires

Size	Applications
Whole tire	Artificial reefs and breakwaters Playground equipment Erosion control Highway crash barriers
Split or punched tire	Gaskets, washers, shims, and insulators Floor mats, belts and shoe soles Dock bumpers Muffler hangers

Size	Applications
Shredded tire	Lightweight road construction materials Playground gravel substitutes Alternative daily cover at landfills and leachate drainage material Sludge composting
Ground rubber	Rubber and plastic products Rubber railroad crossings Stadium playing surfaces and running tracks Friction brake material Injection-molded products and extruded goods Additives for asphalt pavements

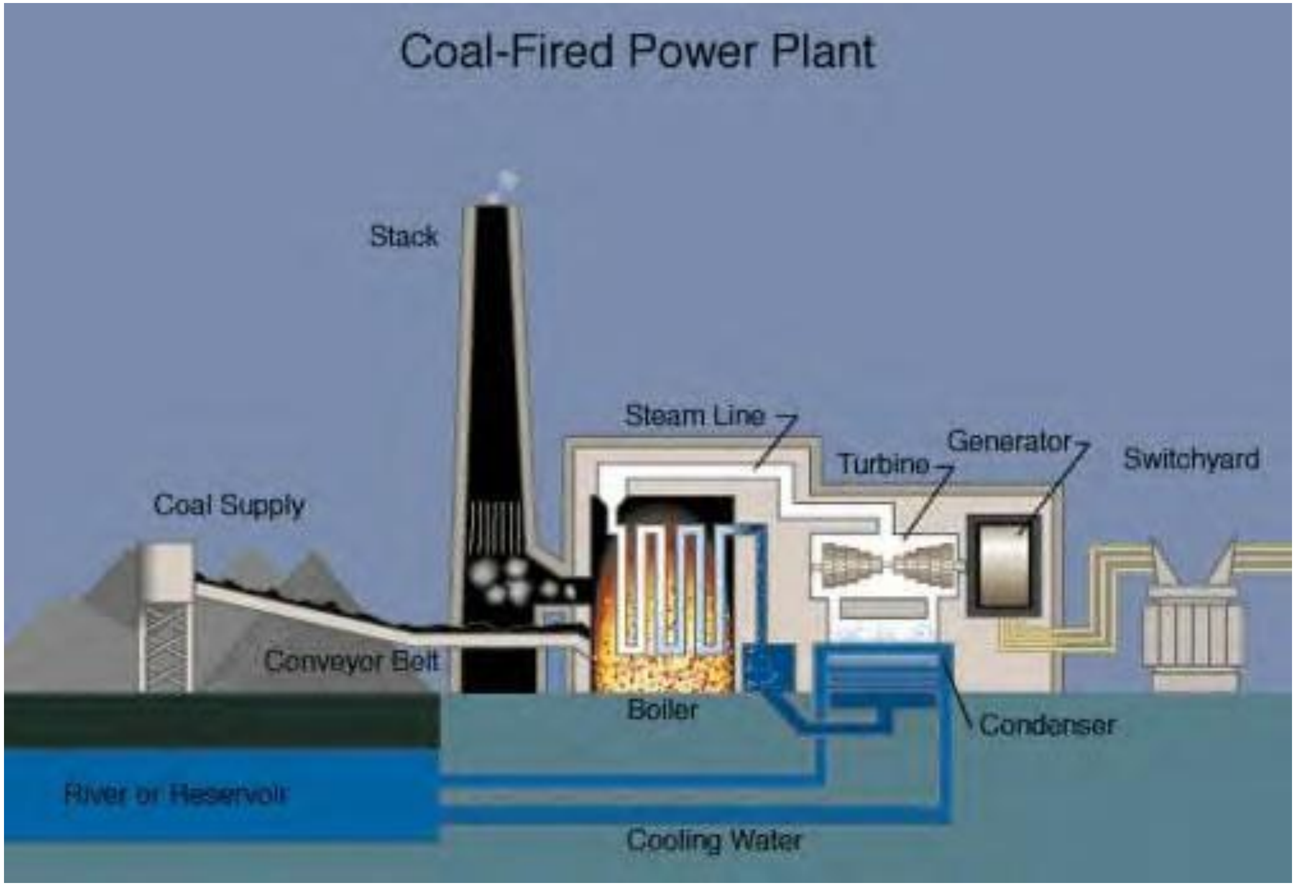
US-Mexico Border

- Potential public and environmental threats
- Potential breeding grounds for mosquitoes and other vectors
- Smoke from fire can cause severe health threats

Before Clean Up (May 2004)

After Clean Up (May 2005)

Energy Generation and Combustion Byproducts

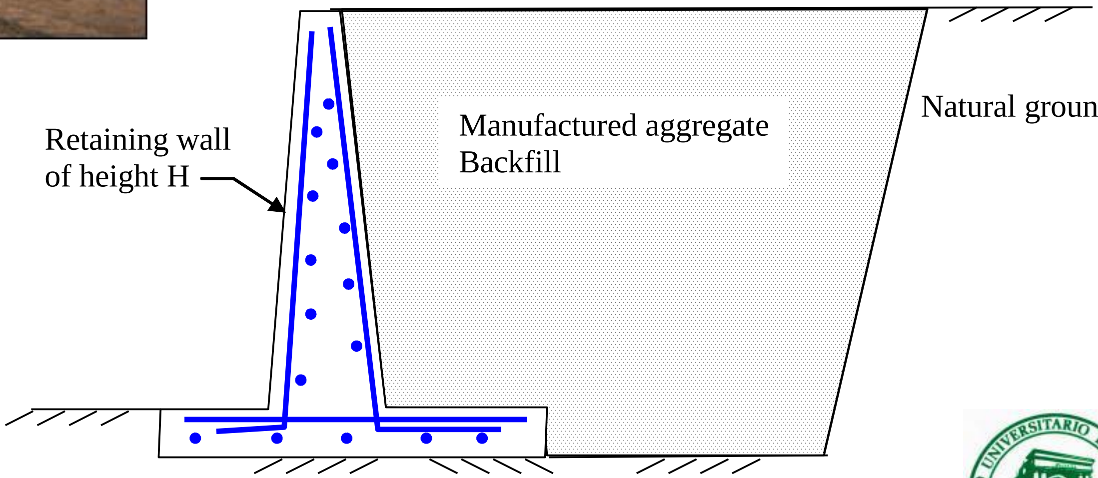


www.tva.gov

- Fly ash and Bottom ash
  - Asphalt Concrete – Mineral Filler
    - used as a substitute mineral filler in asphalt paving mixtures.
    - Increase asphalt stiffness
    - Improve the overall resistance of pavements
    - fill the voids in a paving mix and serve to improve the cohesion of the binder (asphalt cement) and the stability of the mixture.

Coal Combustion Byproducts

- Road base and subbase
- Structural backfill



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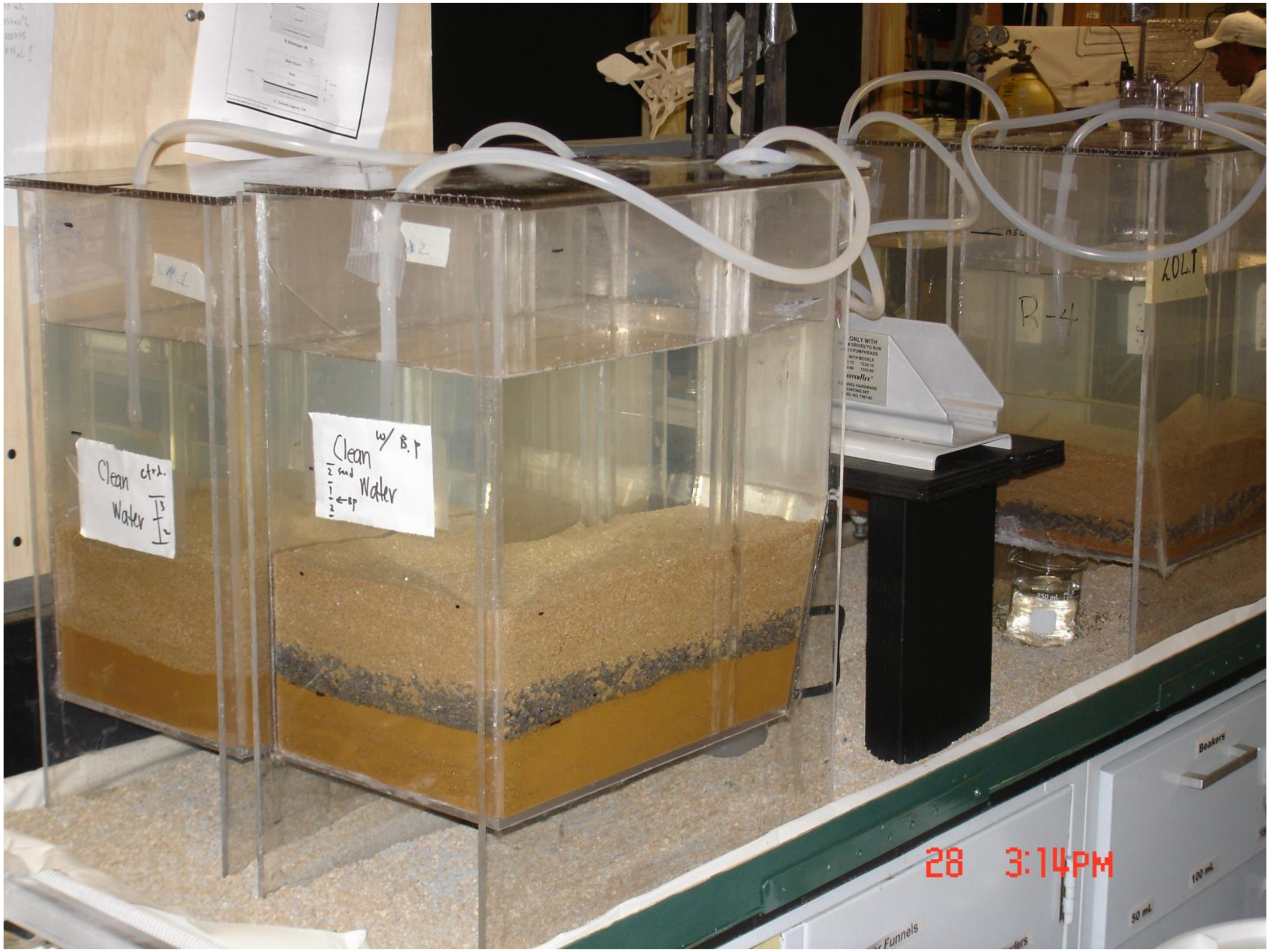
Sediment Capping Amendment



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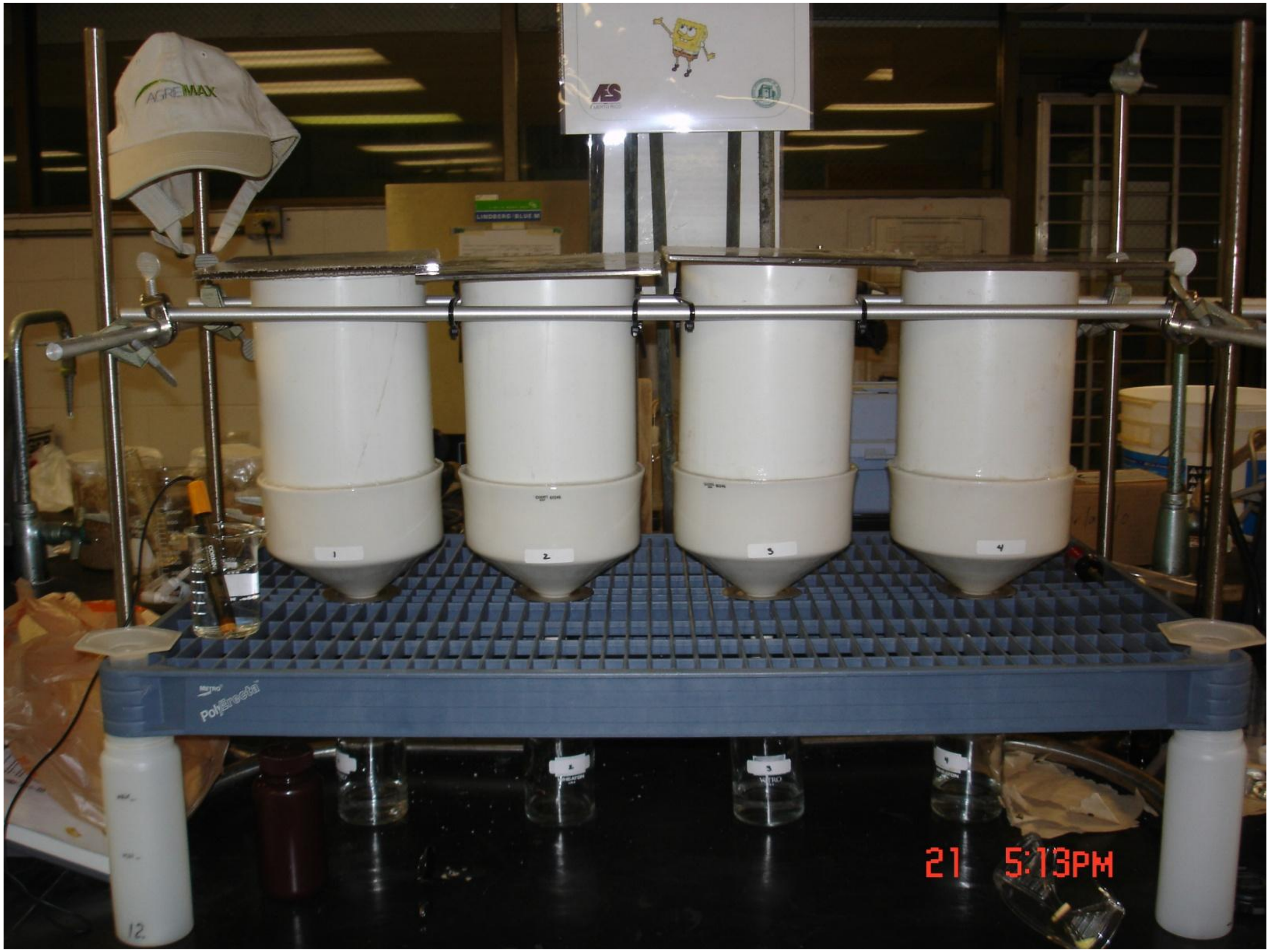
Landfill Daily Cover



Clay Soil Conditioning

Construction and Demolition (C&D) Debris

Arkansas River Bridge Demolition (www.mesalek.com)

Construction and Demolition (C&D) Debris

- Materials generated during the construction, renovation, and demolition of buildings, roads, and bridges.
  - concrete,
  - wood (from buildings),
  - asphalt (from roads and roofing shingles),
  - gypsum (the main component of drywall),
  - metals,
  - bricks,
  - glass,
  - plastics,
  - salvaged building components (doors, windows, and plumbing fixtures), and
  - trees, stumps, earth, and rock from clearing sites.

Typical Sources and Characteristics of C&D Debris

Source	Characteristics
Building construction (reusable materials)	Clean bricks, concrete blocks, concrete or stone facades, tiles, ceramics, roofing tiles, undamaged windows, roofing and metal/vinyl siding, wooden cabinets, counters, flooring, staircases/trim, plumbing/electrical fittings, carpeting, clean insulation, and wooden beams/facades.
Building construction and demolition (recyclable materials)	Broken bricks, concrete blocks, concrete or stone facades, ceramics, and roofing tiles, damaged or broken window glass, fixtures, wooden beams, trim, trees, metal siding, roofing material, and scrap aluminum door and window frames.
Building construction (reusable materials)	Mixed waste not suitable for separation, materials that cannot be reused or recycled, asphalt shingles, linoleum flooring, hazardous wastes including asbestos. Wood wastes consist of framing and form lumber, treated wood, plywood and particleboard, and wood contaminated by paint, asbestos, or insulation.
Demolition of physical facilities including concrete structures	Concrete (without metal reinforcing), concrete (with metal reinforcing), fill material (earth, gravel, sand), ferrous metals (beams, wall studs, piping) brick, stone, wood products, electrical and plumbing fixtures, electrical wiring and mixed rubble, and miscellaneous wastes.
Excavation/leveling	Earth, earth-contaminated wood, sand, stones, and mixed materials found during excavation.

(Tchobanoglous & Kreith, 2002)

Heavy construction	Mixed waste including wood products, roofing materials, wallboard, insulation materials, ferrous and nonferrous metals (wall studs, piping, wiring, ductwork), and carpeting.
Humanmade disasters (acts of sabotage or terrorism)	Mixed waste not suitable for separation, materials that cannot be reused or recycled, asphalt shingles, linoleum flooring, hazardous wastes including asbestos. Concrete (with and without metal reinforcing), fill material (earth, gravel, sand), miscellaneous wastes, plus materials from the demolition of buildings as previously discussed.
Natural disasters (hurricanes, tornadoes, earthquakes)	Mixed waste not suitable for separation, materials that cannot be reused or recycled, trees, asphalt shingles, linoleum flooring, and hazardous wastes including asbestos. Concrete (without metal reinforcing), concrete (with metal reinforcing), fill material (earth, gravel, sand), miscellaneous, plus materials from the demolition of buildings as previously discussed.
Road construction	Asphalt, concrete (without metal reinforcing), concrete (with and without metal reinforcing), fill material (earth, gravel, sand), and miscellaneous (separated metal reinforcing, metal signs, signposts, guard rails, culverts).
Site clearing	Timber, underbrush, earth, concrete, steel, rubble, and other waste materials (paper, plastic, brick, organics).

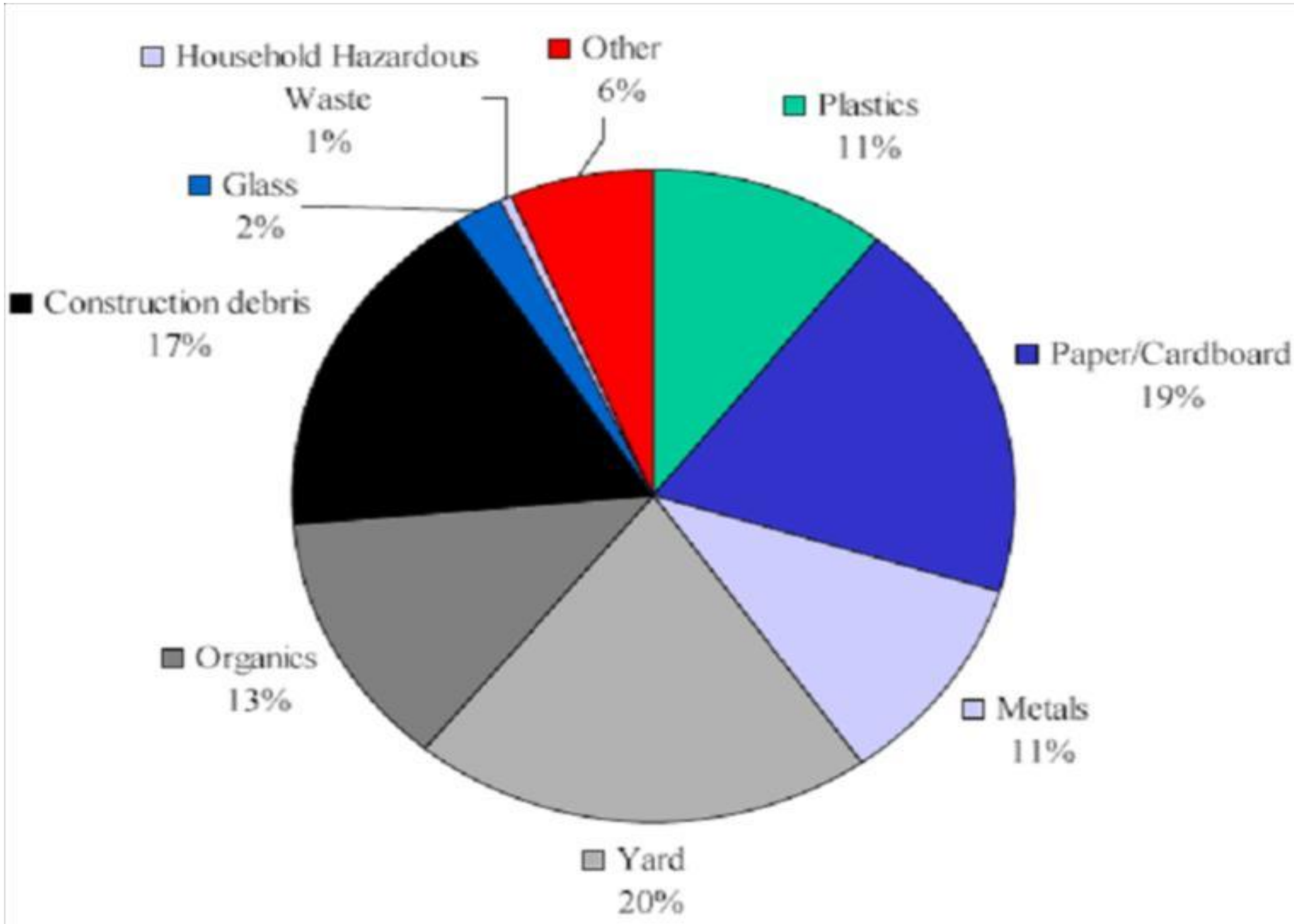
Source: Adapted in part from SWANA (1993), U.S. EPA (1996), and Franklin Associates (1998).

(Tchobanoglous & Kreith, 2002)

Facts and Figures in C&D Debris

- Building-related C&D debris
  - 136 million tons in US in 1996
  - 2.8 lb/capita/d
  - 43% from residential sources
  - 57% from nonresidential sources
- Nonbuilding-related C&D debris (estimated)
  - 2.0 lb/capita/d
  - ~100 million tons in US
- 3,500 facilities for the recovery and recycling of C&D debris (2002)
- 20~30% of the C&D debris was recycled (1996)

PR Solid Waste Characteristics (in 2001)



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Typical Processing for C&D Debris

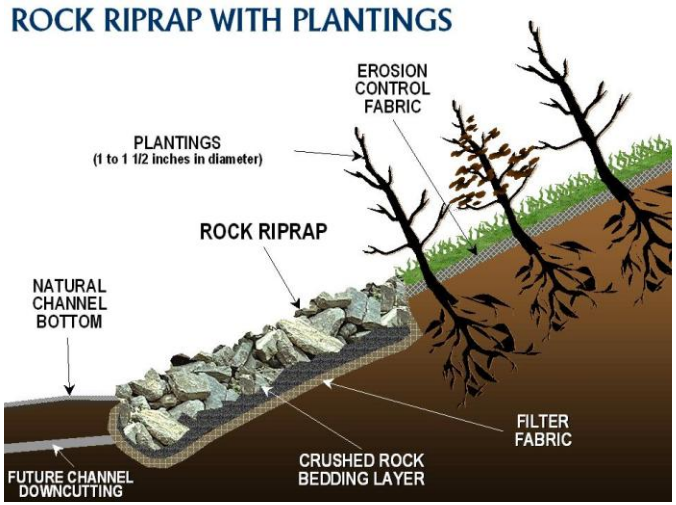
- Manual separation
  - Wood, concrete blocks, brick, metals, etc.
- Crushing, grinding, pulverizing and screening
  - Concrete
- Grinding and/or pulverizing
  - Asphalt
- Grinding and/or pulverizing and screening
  - Wood
- Magnetic separation
- Multistage screening
  - soil

www.camrose.com

www.oprema-vrbovec.hr

Typical Recycling Opportunities for C&D Debris

- Shredded and/or chipped wood
  - Landscape mulch, animal bedding, compost amendment, boiler fuel source, landfill cover material
- Crushed concrete
  - Construction material, road subbase, rip rap
- Crushed asphalt
  - Roofing material, paving material, pothole repair
- Pulverized drywall (gypsum)
  - Remanufacture, animal bedding,
  - Lime replacement for soil, cat litter
- Separated metals
- Screened soil
  - Landscaping, fill material, landfill cover

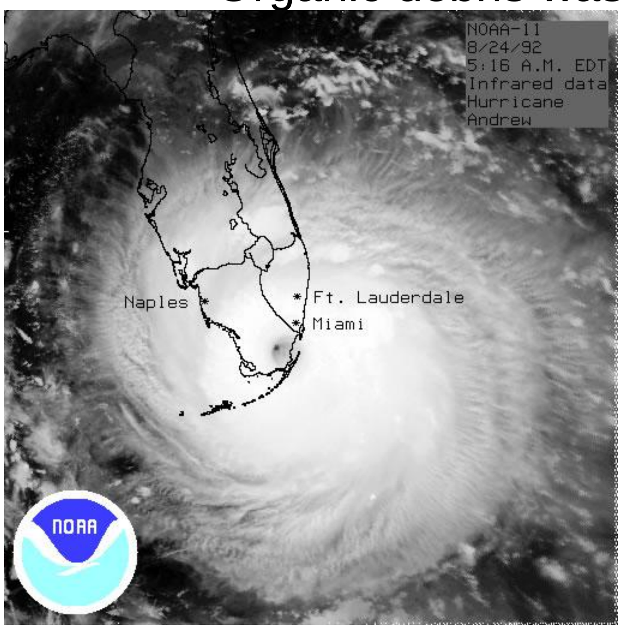


www.cityofcarrollton.com

- C&D landfill vs. MSW landfill
  - C&D debris is not classified as an RCRA hazardous waste or as an RCRA municipal solid waste
    - Therefore, most C&D landfills are not required to provide the same level of protection as MSW landfills
      - Lower tipping fees for C&D landfills
  - 35 ~ 45 % of building-related C&D → to C&D landfills (Yr 2002)
  - 20 ~ 40% of building-related C&D → to MSW landfills (Yr 2002)
  - About 50% of nonbuilding-related C&D → to C&D and/or MSW landfills (2002 estimation)

Debris from Natural Disasters

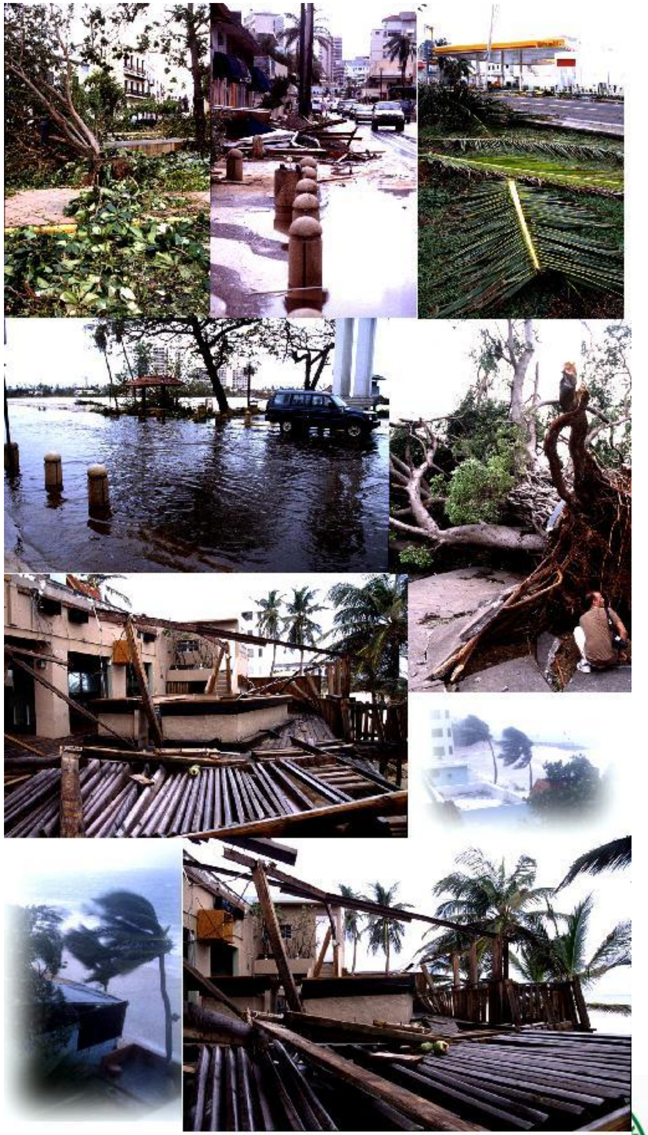
- Floods, windstorms, hurricanes, tornadoes
- When Hurricane Andrew hit Miami area in 1992,
  - About 40 million tons of construction- and demolition-type debris
  - Landfills in Miami did not have capacity to hold 40 million tons of wastes
    - Organic debris was burned in large burn pits at the processing sites



garnet.acns.fsu.edu

www.abovetopsecret.com

- On September 21, 1998, Hurricane Georges swept across Puerto Rico.
- The eye of the hurricane was 25-30 miles wide and passed within 15 miles of the capital, San Juan, leaving a trail of devastation in its wake.
- Some areas received up to 26 inches of rain within 24 hours.
- Flooding, landslides, and catastrophic losses in infrastructure resulted.



www.padawitz.de

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Debris from Manmade Disasters

- Tragic events in Sep. 11, 2001
- >1.6 million tons of debris
- Hauled to Fresh Kills landfills on Staten Island

www.epa.gov

www.osha.gov

"That's all folks!"