Decision Support System (DSS) for the Laguna de Bay Basin

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"Building on IWRM Good Practices – The Laguna Lake Basin Experience"

NARBO 9th IWRM Training

One Tagaytay Place Hotel Suites, Tagaytay City

May 13, 2014

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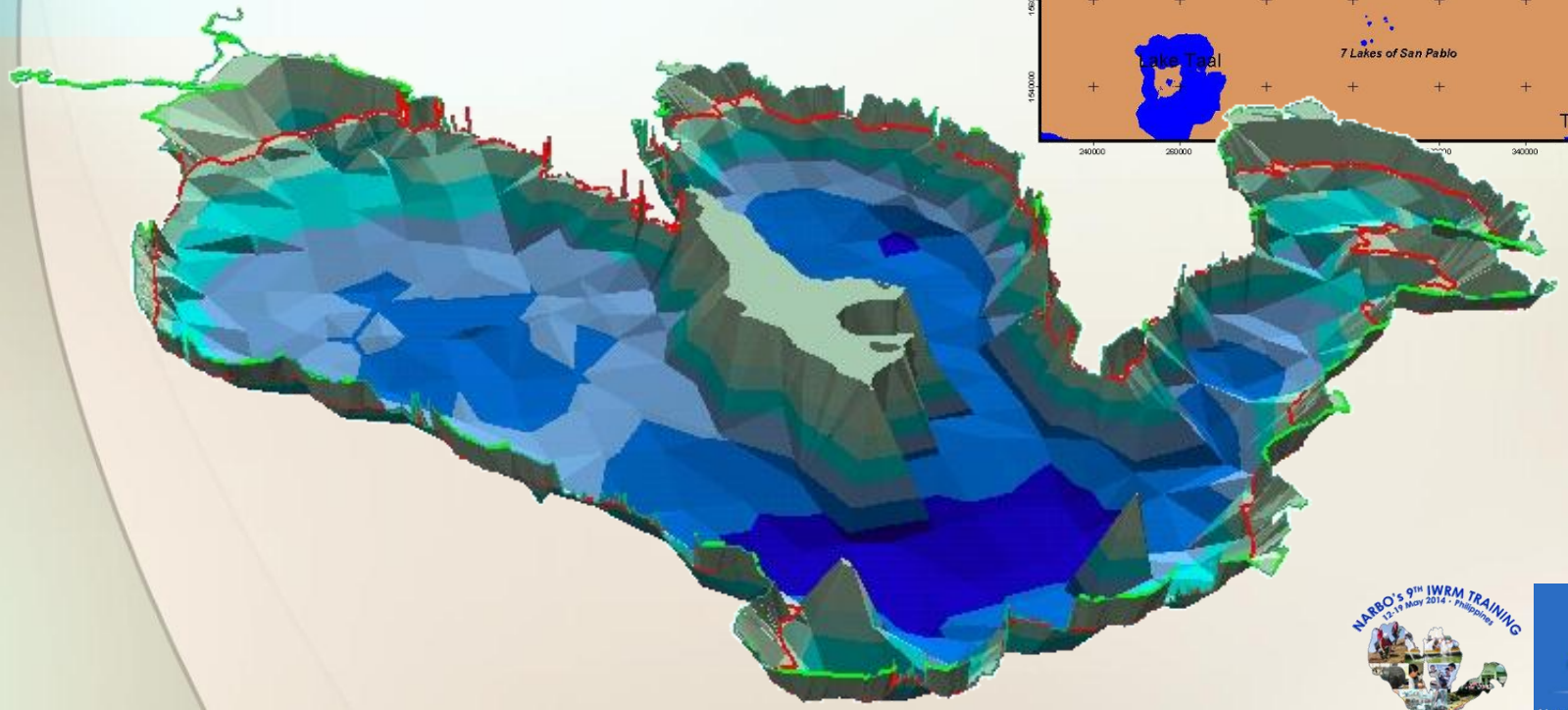
Laguna de Bay

- largest lake in the Philippines
- total surface area = some 900 km2
- average depth of the lake is 2.5 meters
- shoreline length = some 285 kilometers
- 3 distinct bays, the west bay, central bay, and east bay that converge towards the south



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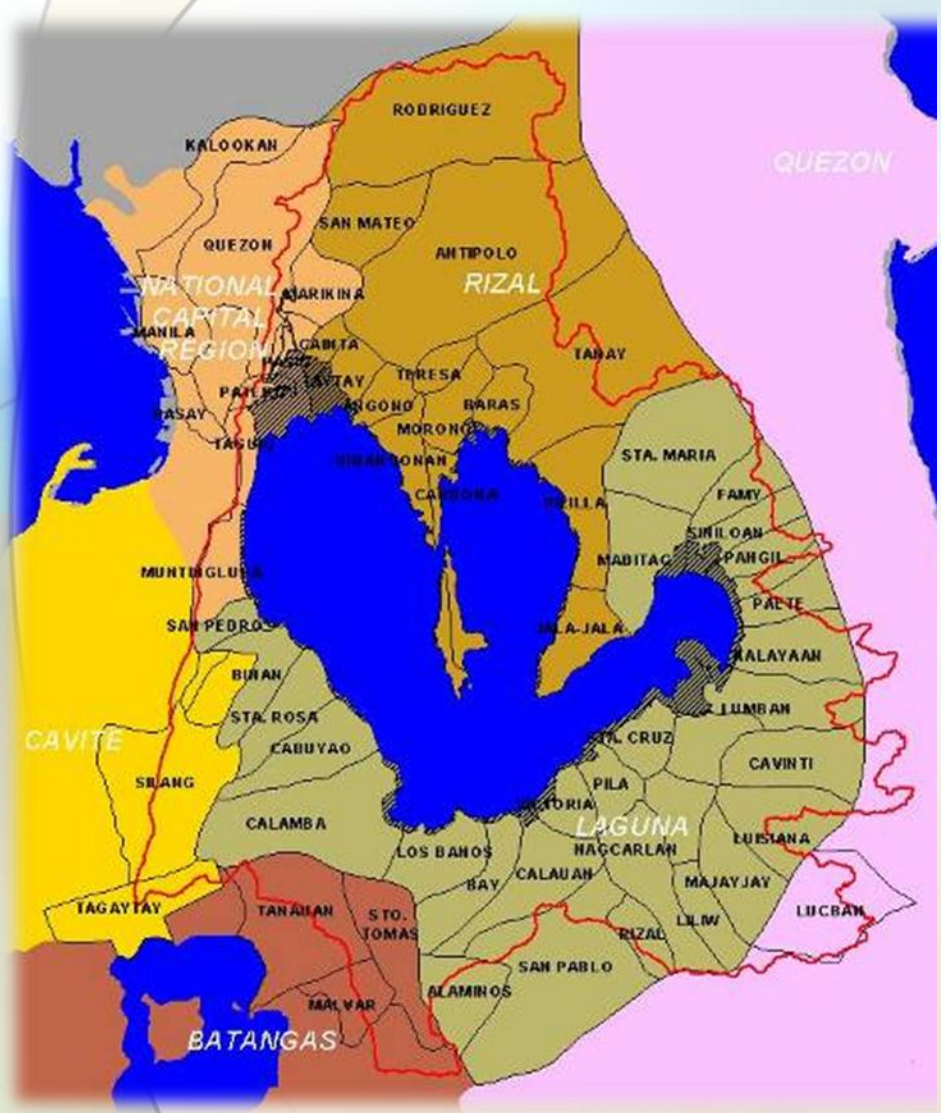
Laguna de Bay Watershed



- Some 100 streams drain into the lake
- divided into twenty-four (24) hydrological sub-basins
- watershed area = approx. 2,920 square kilometers
- Pasig River is the only outlet of the lake
- It cradles a region encompassing 6 provinces, 14 cities, 47 municipalities and 2,656 barangays, 188 of which are within lakeshore
- Laguna de Bay region = 3,880 square km

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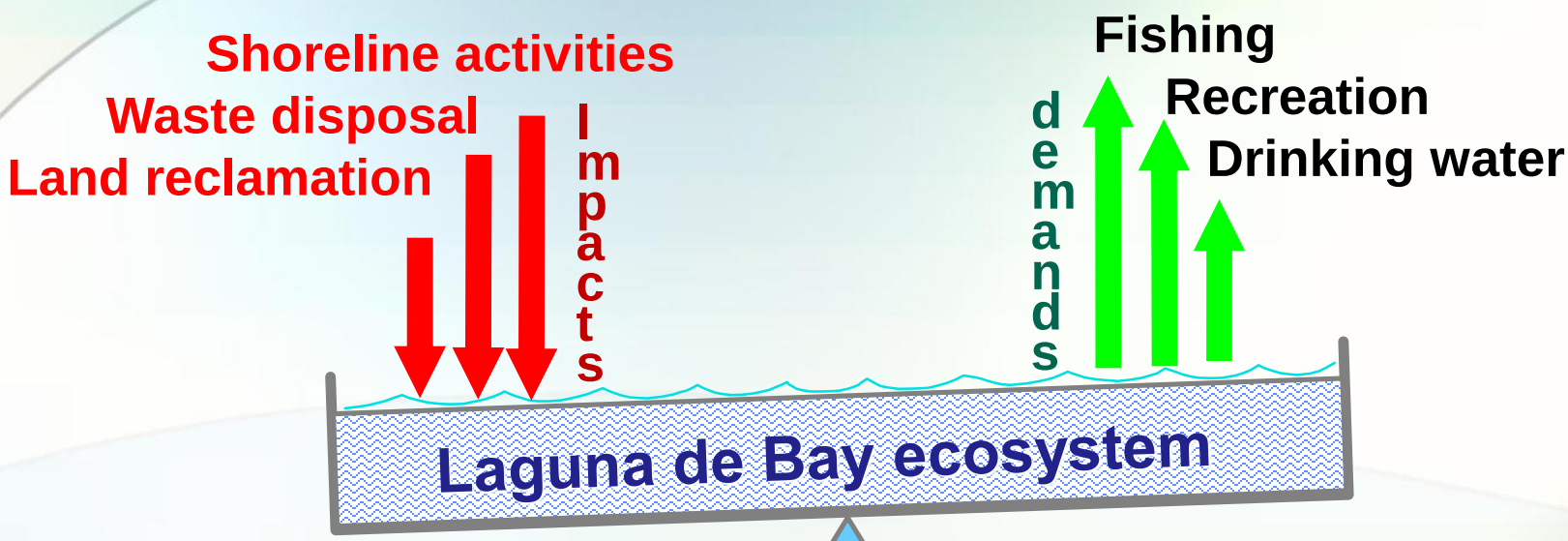
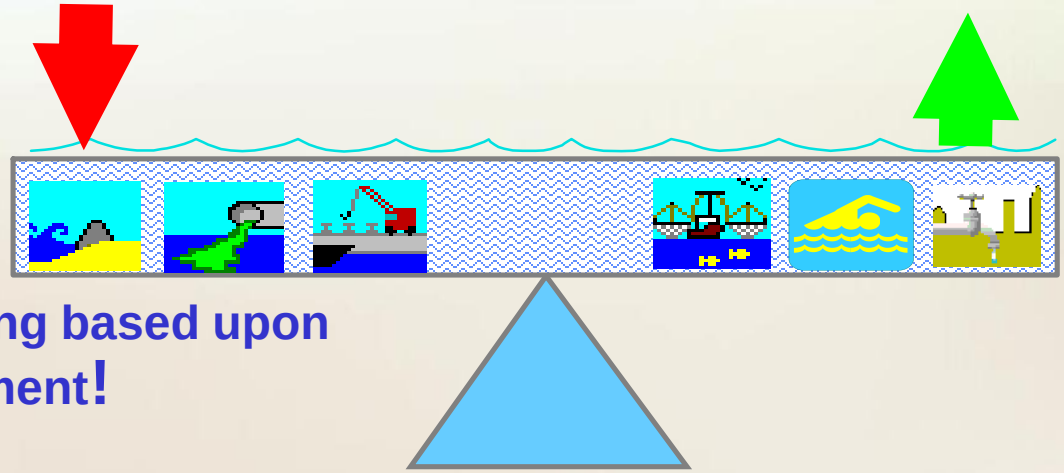
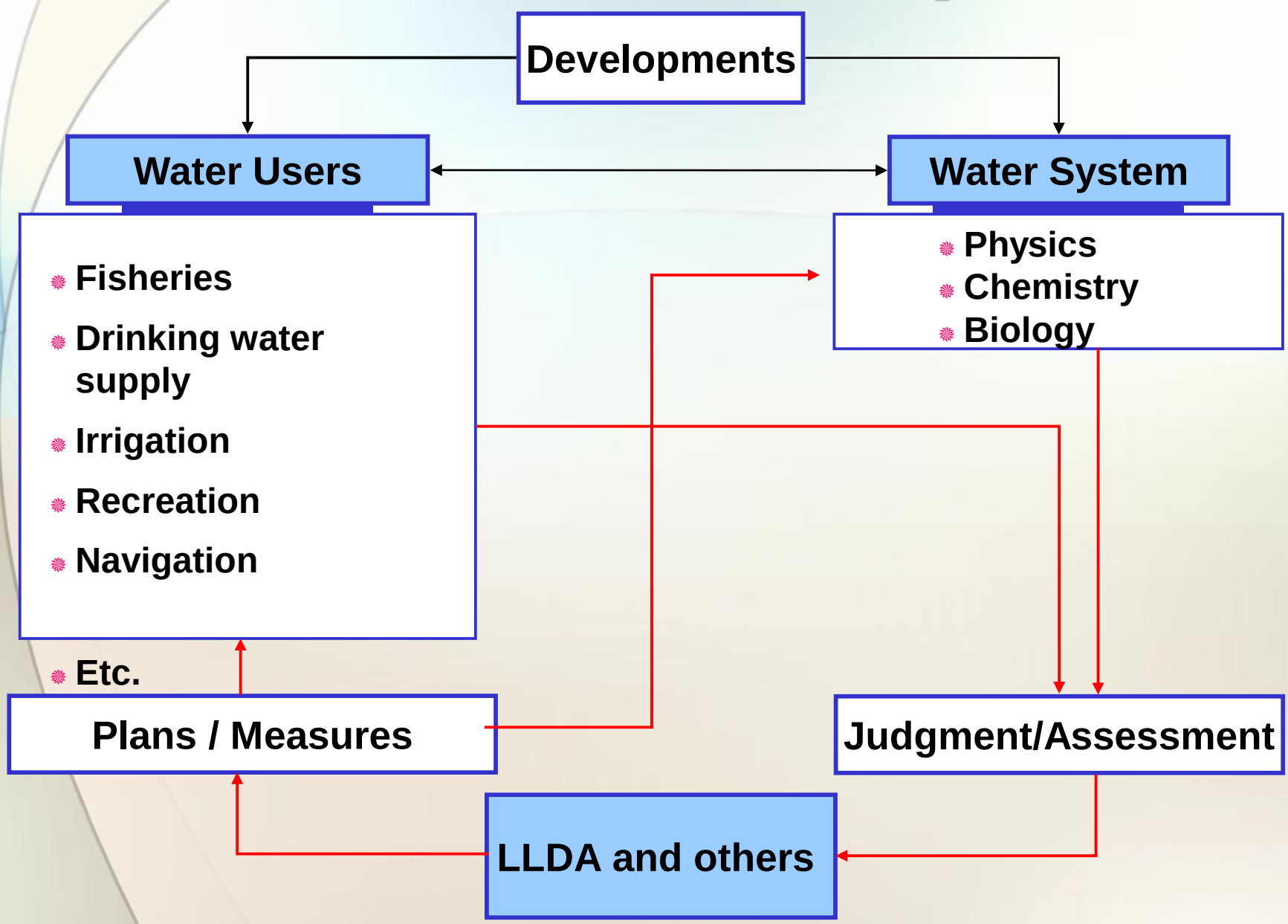


Out of balance: decision making without appropriate knowledge on system functioning



In balance: decision making based upon a comprehensive assessment!

LLDA and the IWRM process



Background

The Decision Support System

- ✓ The LLDA Decision Support System (LLDA DSS) was introduced by the Royal Government of Netherland by funding the project Sustainable Development of Laguna de Bay Environment (SDLBE) in year 2000.
- ✓ The LLDA Decision Support System (LLDA DSS) aims to integrate state-of-the-art software tools to provide an adequate scientific description of the Laguna de Bay water system (catchment and lake).

The LLDA DSS is an important tool to:

- Integrate research efforts in scientific disciplines and translate the results to the LLDA management level
- Provide a common and user-friendly framework for the analysis and comparison of management decisions
- Facilitate the comparison of many different management options and measures
- Repeat the decision making process in a consistent way after additional or different information has become available
- Increase the understanding of the relations between users and their water system

Background

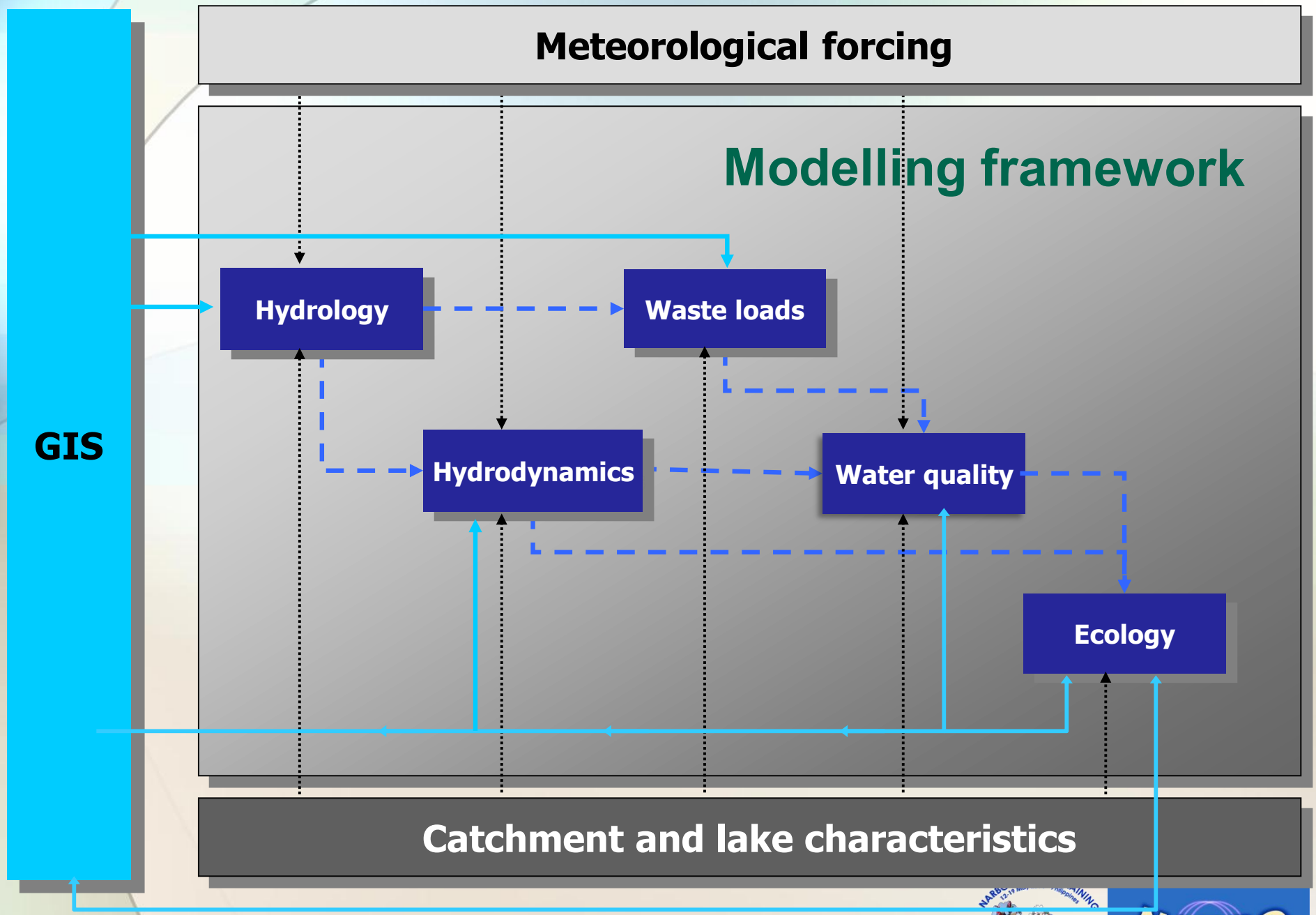
The DSS Objectives

- Establishment of an Integrated Water (Resources) Management (IWM) group by transfer of knowledge and capacity building;

- Establishment of an appropriate GIS / database and state-of-the-art set of modeling tools to support decision-making;

- Assessment and recommendations for technically and economically feasible solutions to water quality related problems, which form a bottleneck for the lake waters as drinking water reservoir, with due account to the various uses and environmental values of the lake system; and

- Recommendations and procedures for removing contaminated sediments from the lake bottom with full consideration of the environmental impacts of potential solutions.



The LLDA Decision Support System

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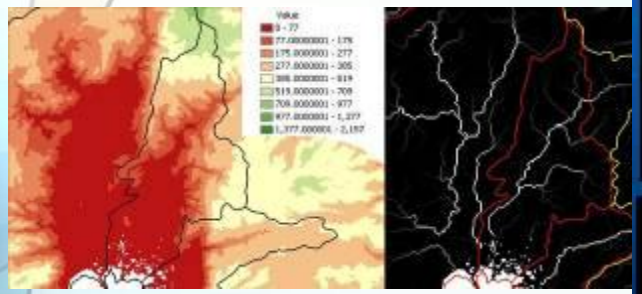
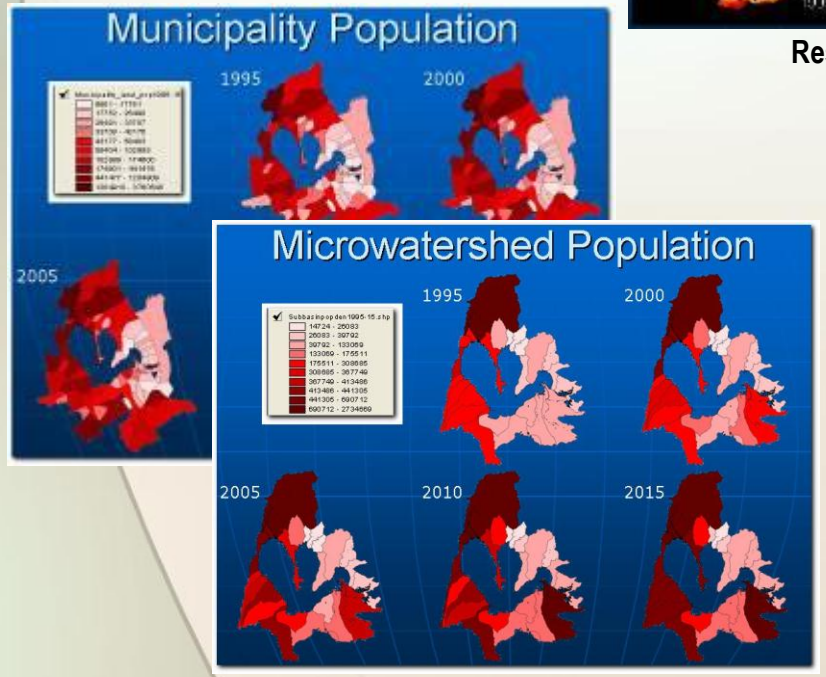
GIS and Remote Sensing

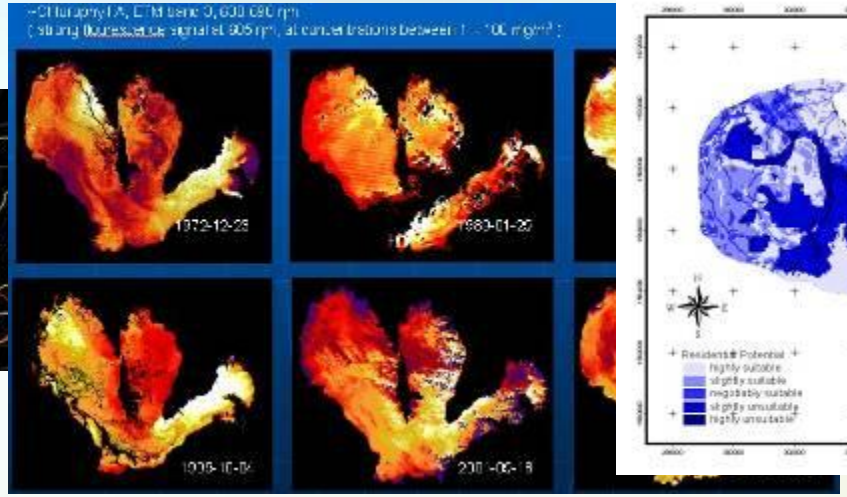
Datasets Verification

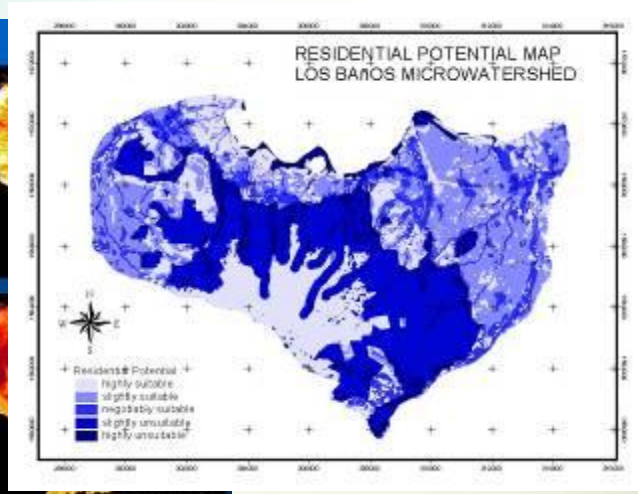


Datasets Simulation



Data Analysis





Research and application

- In conjunction with the Management Information Systems Division, central repository of spatial and non-spatial information
- Promotion, management, and advancement of GIS and Remote Sensing applications
- Provides necessary data for the Integrated Modeling Tools, and assists in regular planning and operation of the agency

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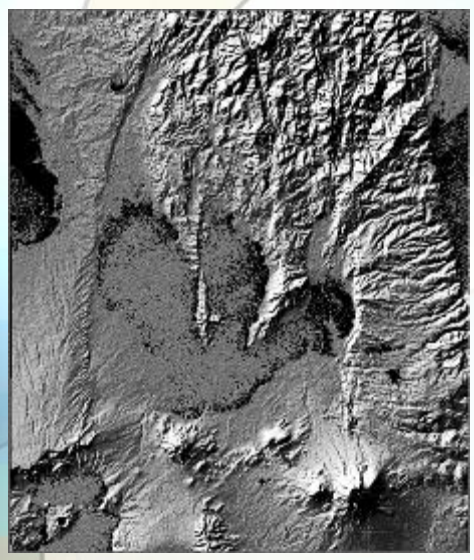
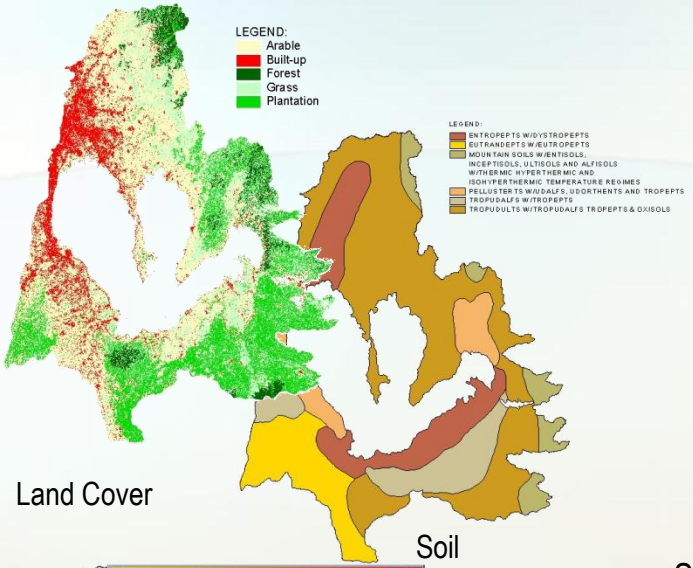
Hydrology Module



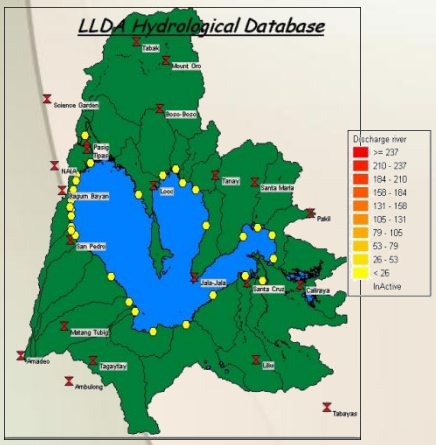
Topography



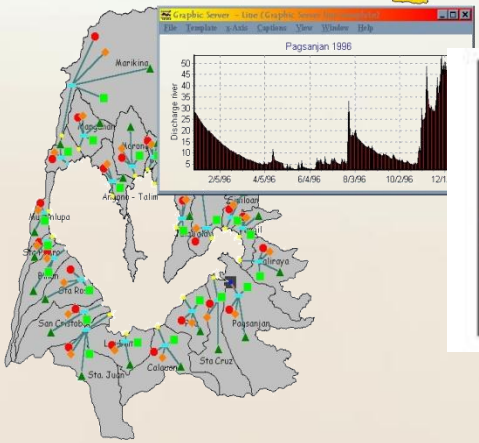
Land Cover

Soil

- It provides information on the water quantity flowing to the lake from a sub-basin perspective.
- Computation of water allocation and distribution. Simulates the hydrology (occurrence, circulation and distribution of water) with focus on the transformation of rainfall input into channel inflows and its corresponding catchment water balance.
- Result serves as input to lake hydrodynamic and the waste load modeling modules.

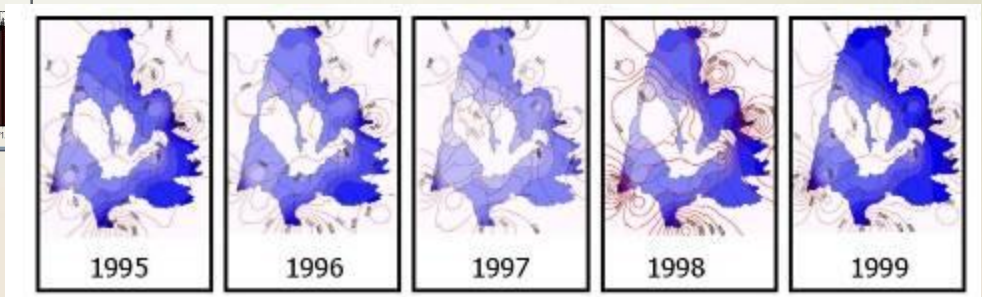


Time-Series Database



Coupling with Waste Load for Concentrations

Simulated Rainfall Distribution



Average catchment rainfall = 2,000 mm/yr

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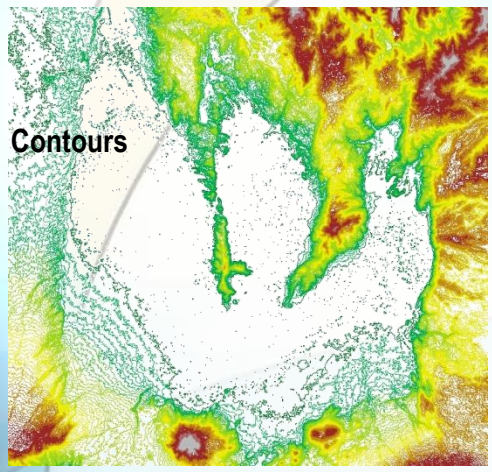
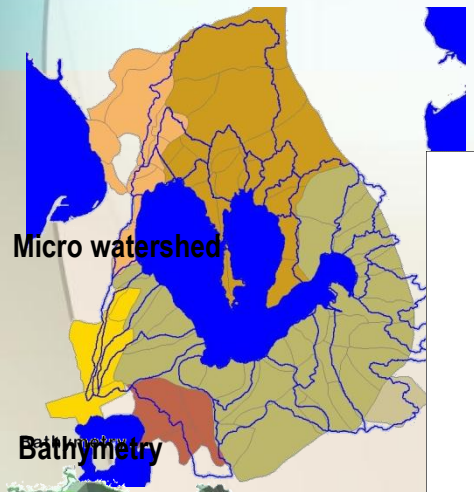
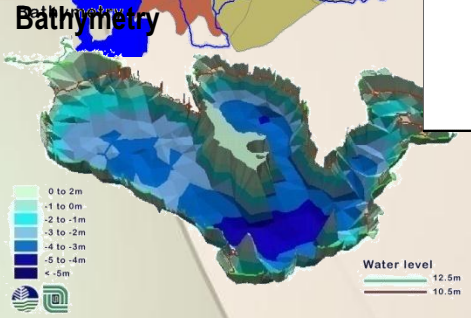
Hydrodynamics Module

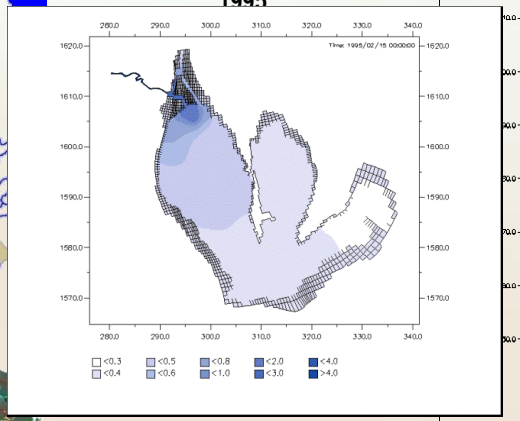


- understanding of the water balance of the Laguna de Bay in relation to the different forcing functions (changes in meteorology, bathymetry, catchment discharges, gate operations, etc.)
- Predictions on water circulation, flooding events, water level variations, flow velocity, saltwater intrusion, thermal pollution caused by industrial discharge extent of accidental spills, among others.
- The output of the model will serve as input for sediment transport, water quality and ecological modeling and can also be used to determine future changes in the lake water especially with respect to the projected infrastructure development.

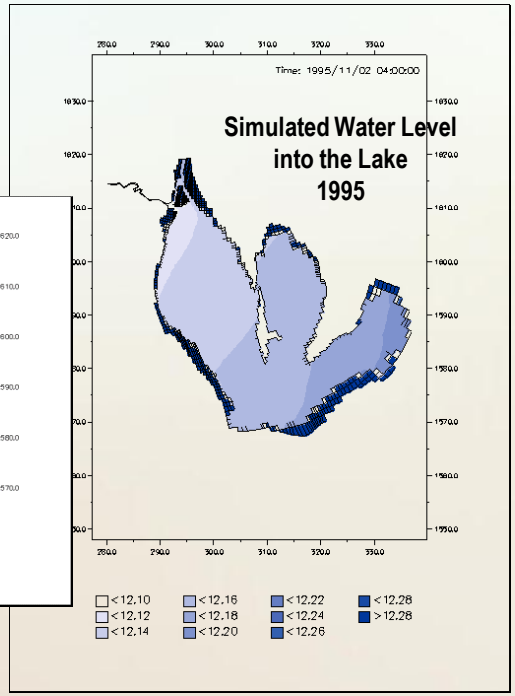




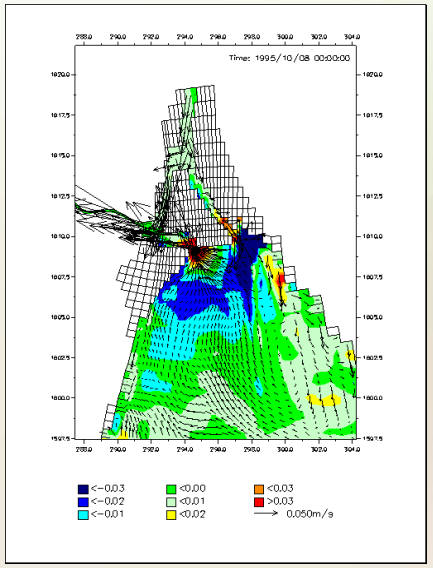
Simulated Salinity Intrusion into the Lake 1995



Simulated Water Level into the Lake 1995



Contours of the magnitude of Suface Water Current



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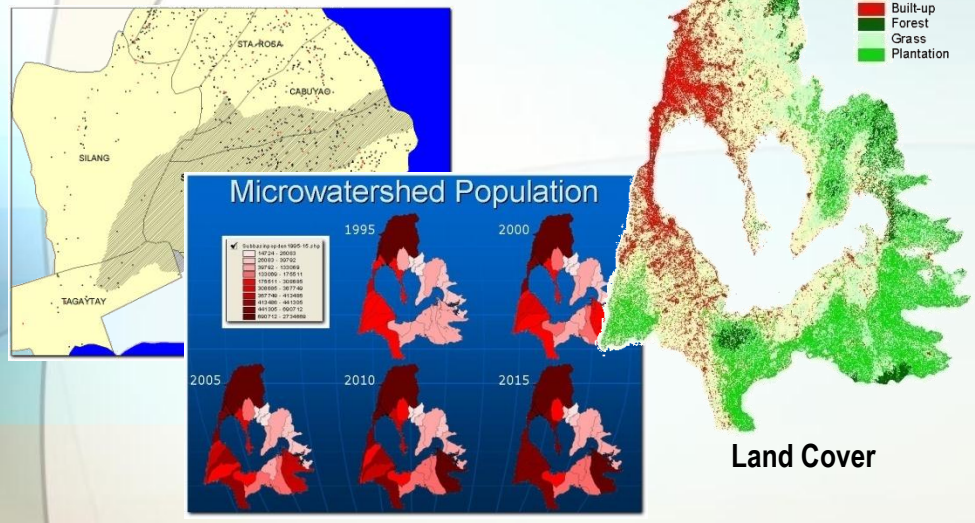
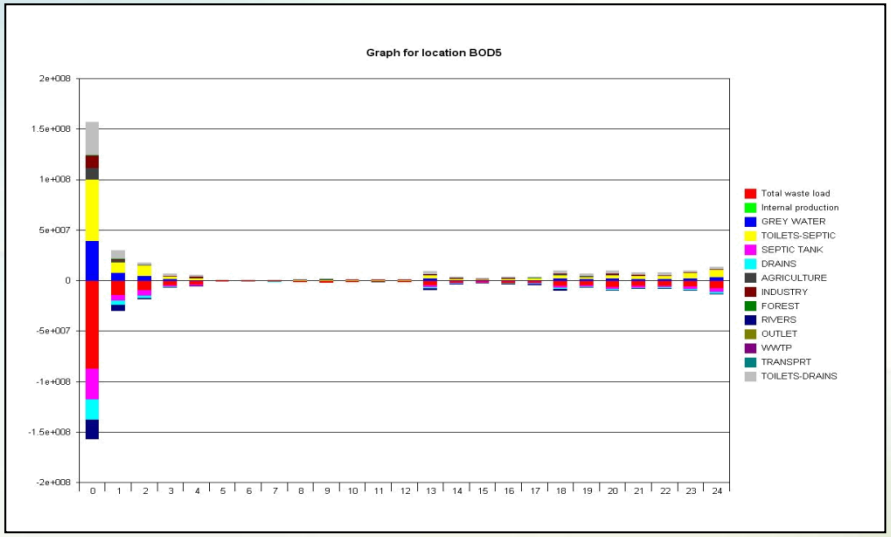
Waste Load Module

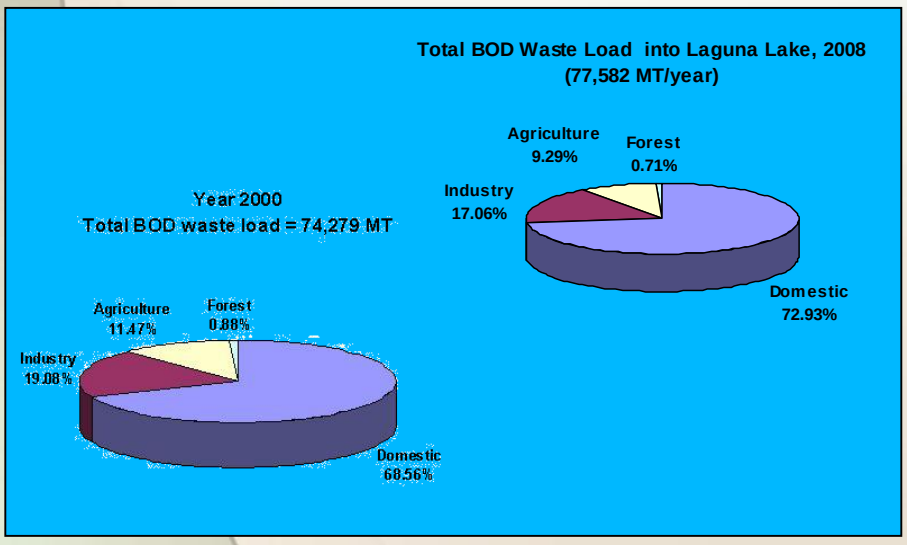
Establishment Locations



Land Cover



Watershed BOD Load , 2004
Production and Reduction



- It provides information on the waste loads on surface water within each sub-basin and allow for future waste load scenario generation.
- Specifies how, where and what kind of waste loads are produced in the catchment, and the kind and amount of treatment (capacity, efficiency, and location) it undergoes, and the final waste loads on surface water entering the lake.
- Computation of water allocation and distribution. Also, the result also serves as input to lake hydrodynamic and the waste load modeling modules.

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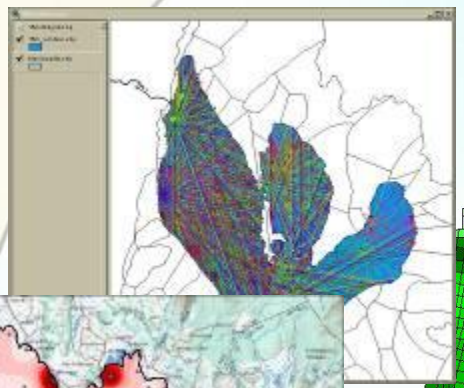
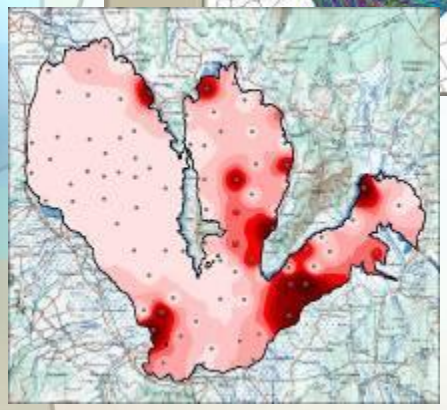
Water Quality Module

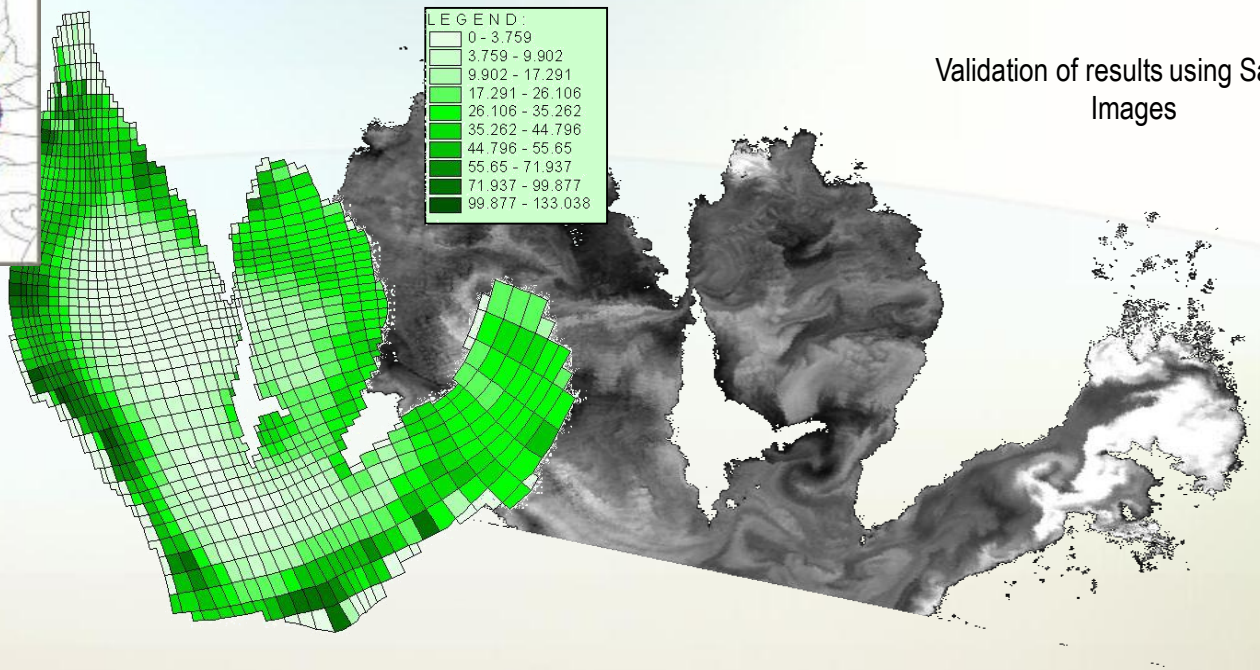
Fetch





Heavy Metals

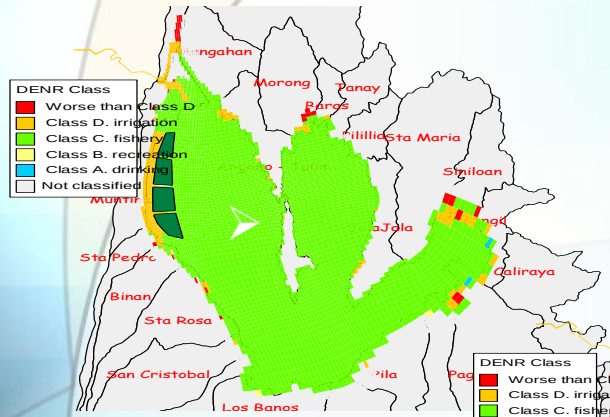
Simulated Chlorophyl-a Concentrations, for October 3, 1999



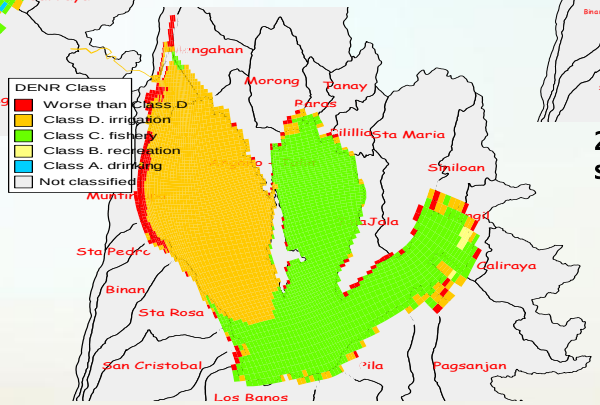
Validation of results using Satellite Images

- **understanding of the ecological and water quality processes**
- **calculates the concentrations of a number of substances relevant for water quality (e.g. salinity, BOD, nutrients, algae, oxygen, suspended sediment, heavy metals, etc.) throughout the entire lake, as influenced by water movement and by physical, chemical or biological processes.**
- **The output of the model will serve as input for sediment transport, water quality and ecological modeling and can also be used to determine future changes in the lake water especially with respect to the projected infrastructure development.**

Ecology Module



Simulated compliance with applicable DENR criteria for autonomous development (10 years from now), with the interceptor system



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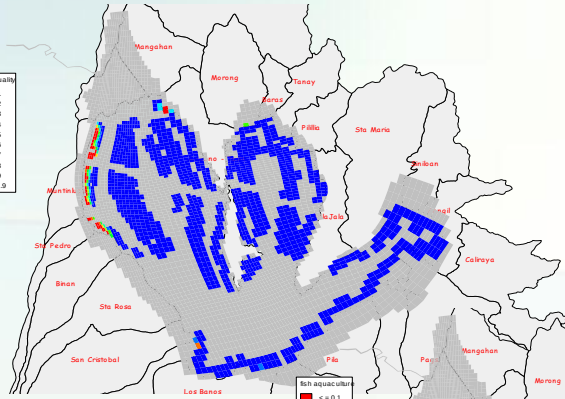
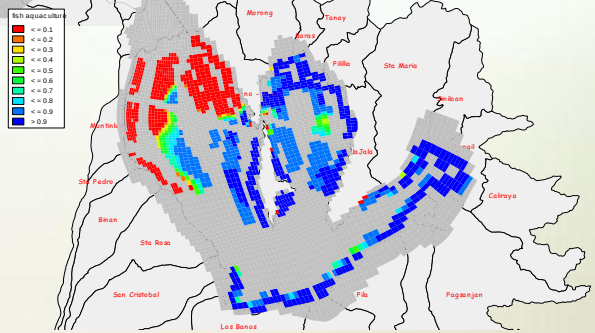


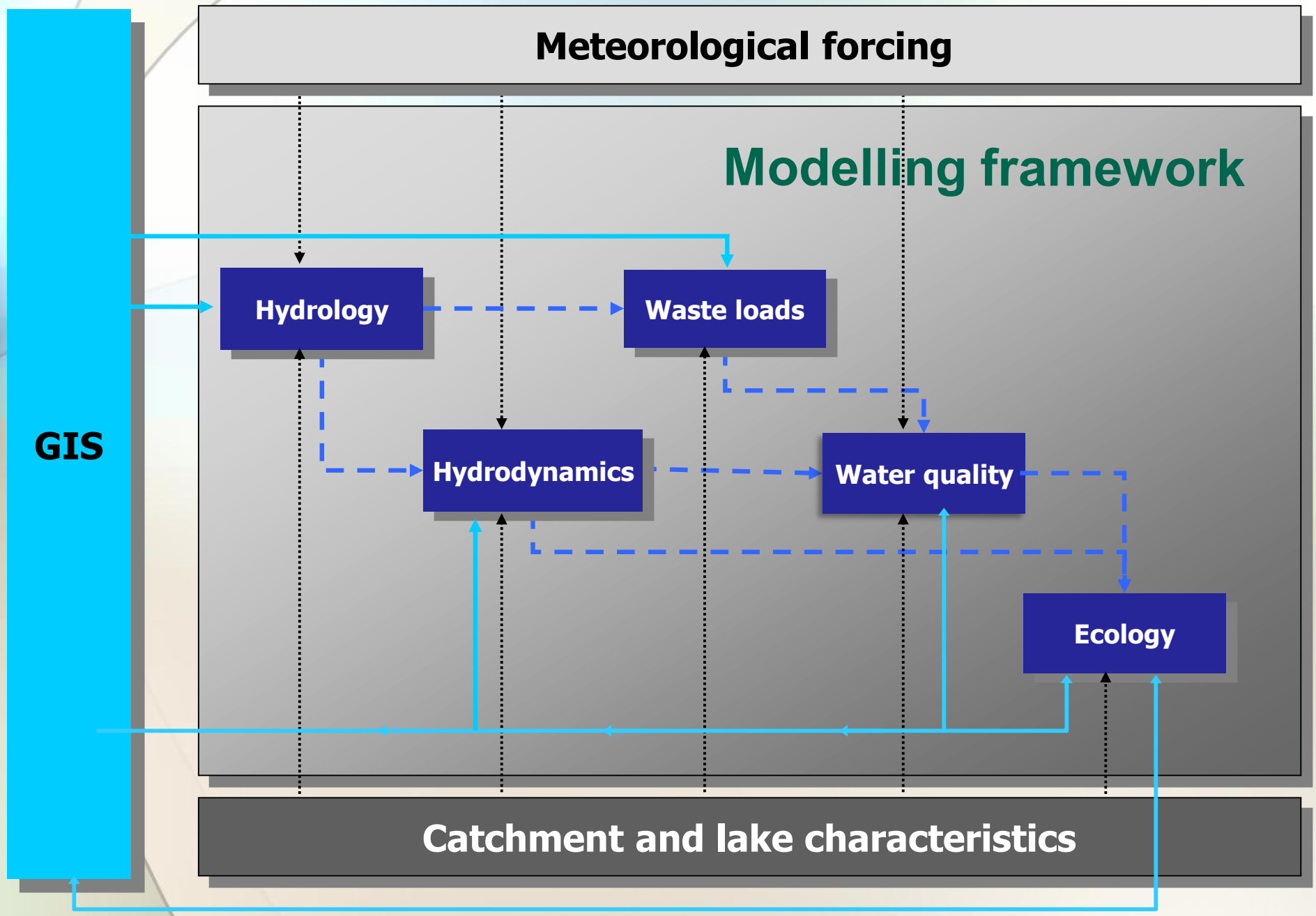
25 years with salt intrusion



25 years without salt intrusion

- **use to evaluate the results of the water quality model to determine environmental impacts of proposed management options, activities or projects on the suitability of various identified function in Laguna de Bay.**
- **provide necessary information about the status of Laguna de Bay for human use and natural values.**
- **understanding changes in the lake's suitability for varied uses in response to changes in environmental factors and water quality**

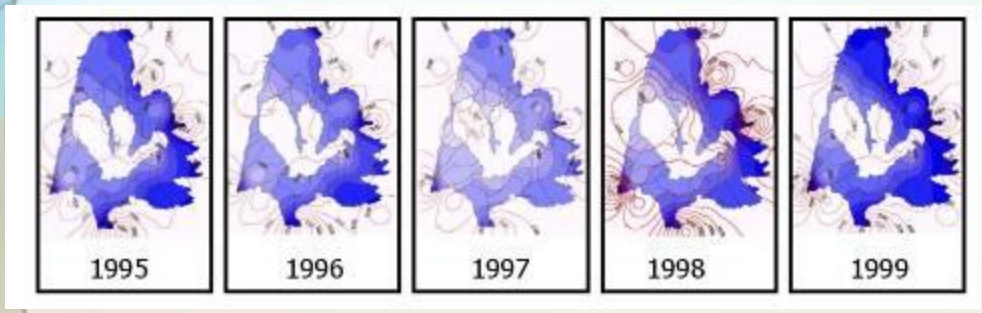
DSS APPLICATIONS



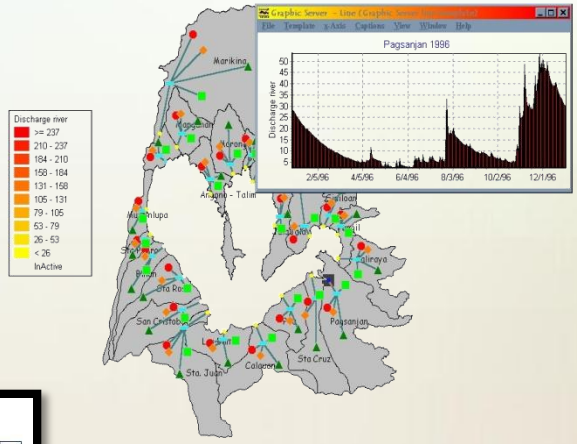
Hydrology Module

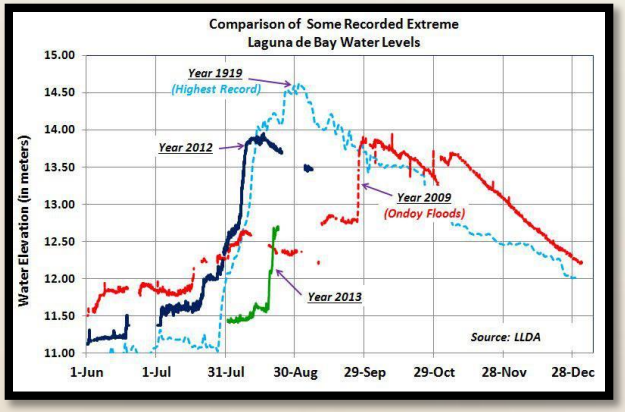
- Calculation of the Lake Water Balance
- Flood events analysis (DRRM/ Climate Change Adaptation)
- Repository of historical meteorological data (HYMOS Database)

Simulated Rainfall Distribution



Average catchment rainfall = 2,000 mm/yr





Coupling with Waste Load for Concentrations

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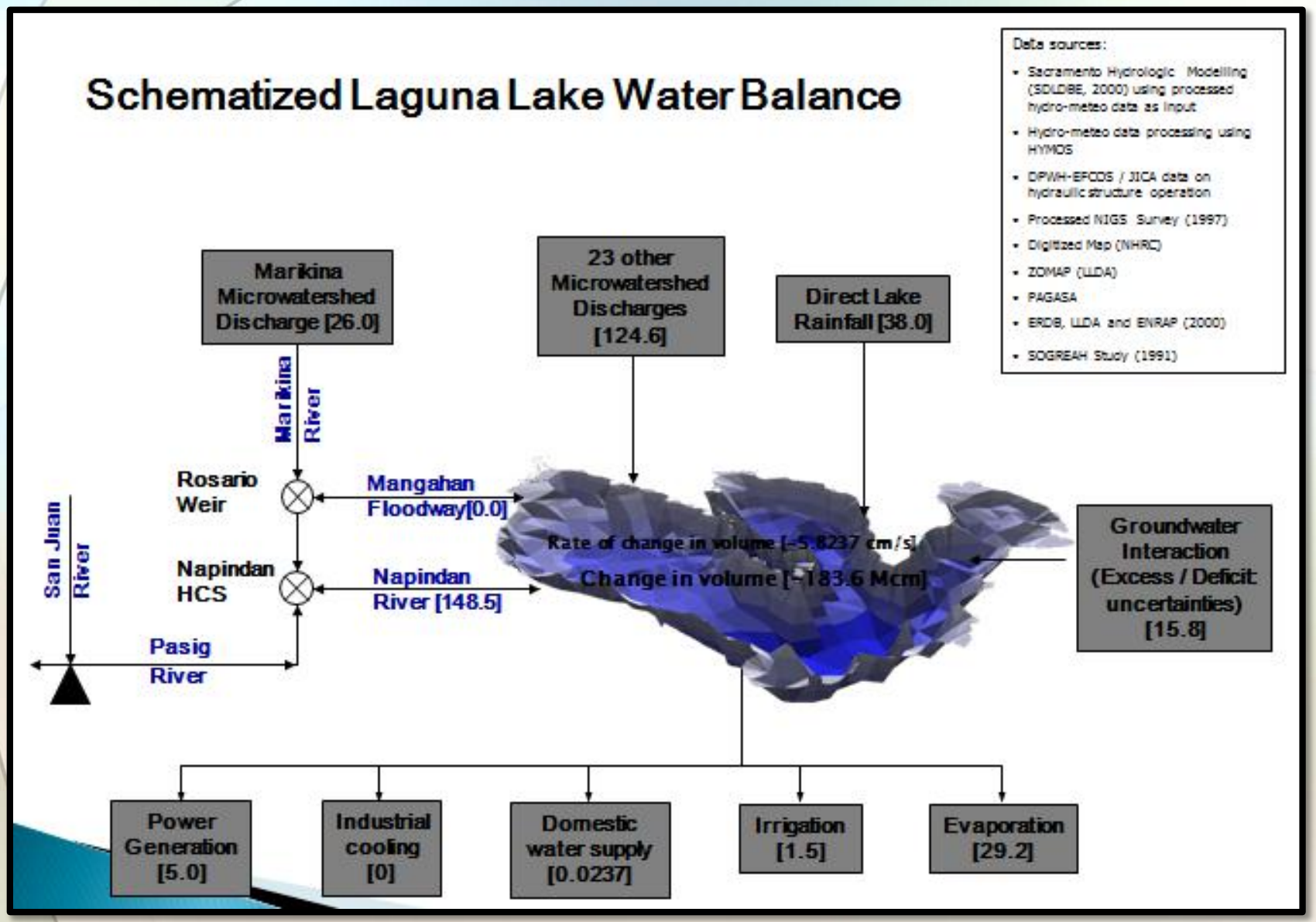
Schematized Laguna Lake Water Balance



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The 300 MLD Project of Maynilad

Volume of Water Extracted per Year (*from ERDB, 2000 Study*)		
From the Lake:		
Irrigation	32.68 MCM	89.53 MLD
Domestic	0.20 MCM	0.55 MLD
From rivers, springs, creeks:		
Irrigation	405.21 MCM	1,110.16 MLD
Domestic	52.56 MCM	144.00 MLD
Other uses	0.64 MCM	1.75 MLD
Total Consumptive Use per Year	**491.29 MCM**	**1,346.00 MLD**

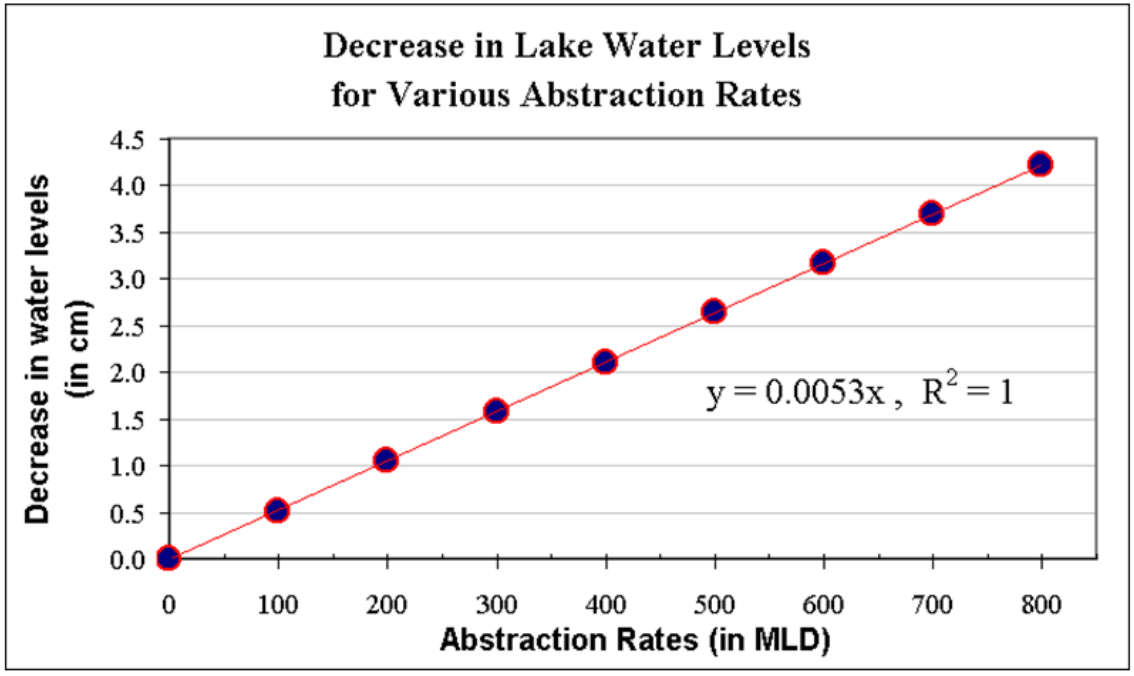
Lake Outflow thru the Pasig River = **150 m^3/s** (average)

equivalent to about **12,960 MLD.**

The 300 MLD requirement is only about **2.31%** of the total volume of excess water that flows towards Manila Bay.

The 300 MLD Project

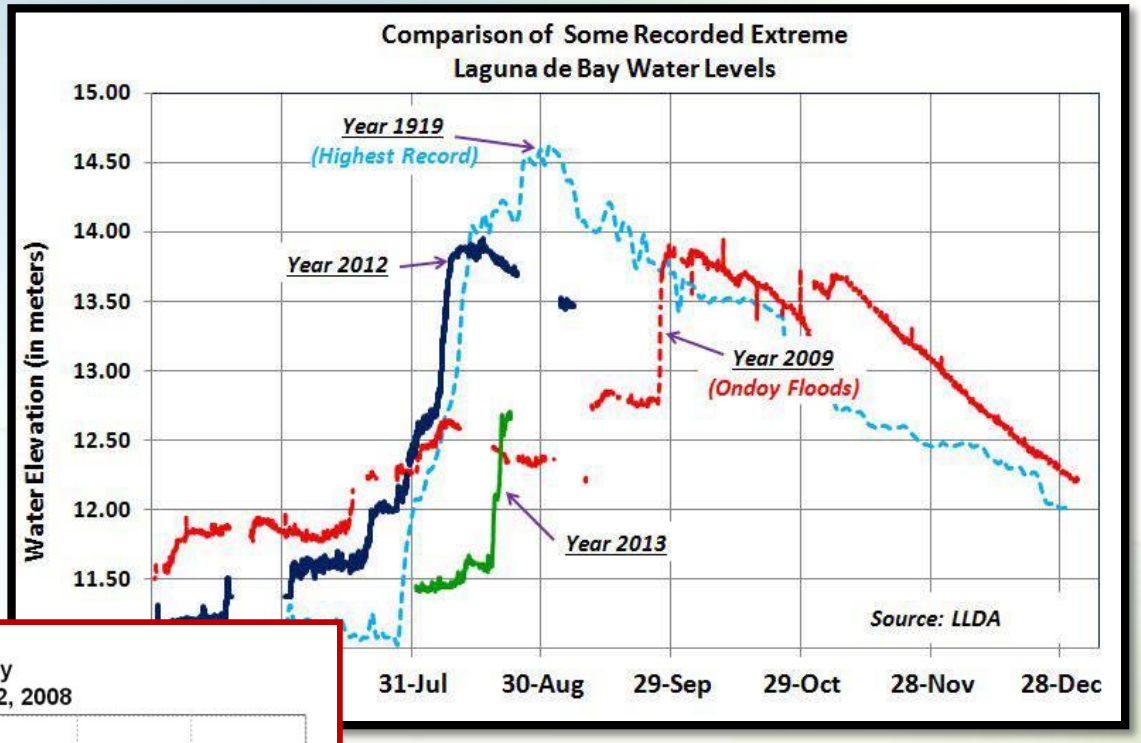
	Standard Run	Different Abstraction Rate Scenarios							
		100 MLD	*200 MLD*	*300 MLD*	*400 MLD*	*500 MLD*	*600 MLD*	*700 MLD*	*800 MLD*
Average Water Level (m)	11.808	11.802	11.796	11.788	11.783	11.777	11.769	11.763	11.757

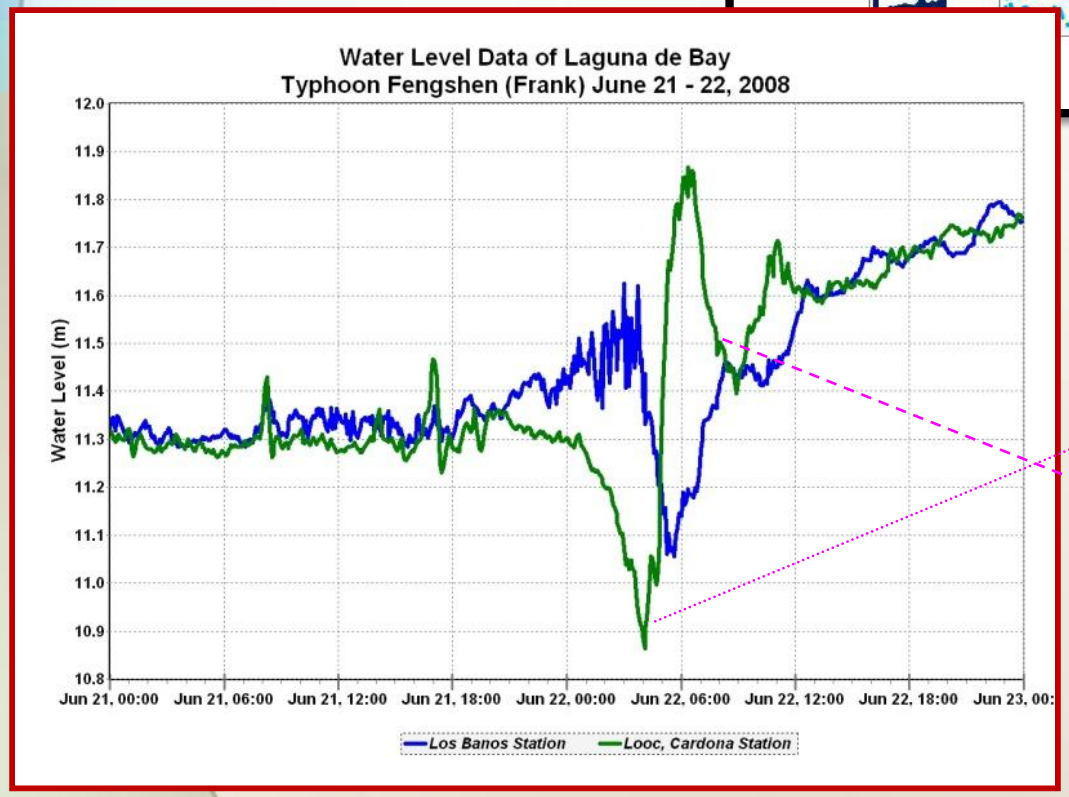


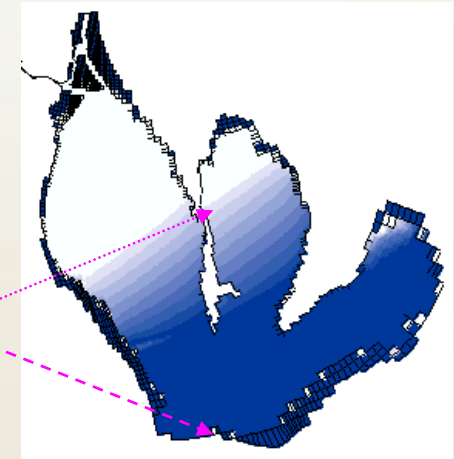
Analyses of the model results of the lake water balance showed a linear relationship of the rates of withdrawal with decreasing water level, of which

"a 0.53 cm decrease in water level is expected for every 100 MLD increment in abstraction rates".

Analysis of historical rainfall, water level, flooding events







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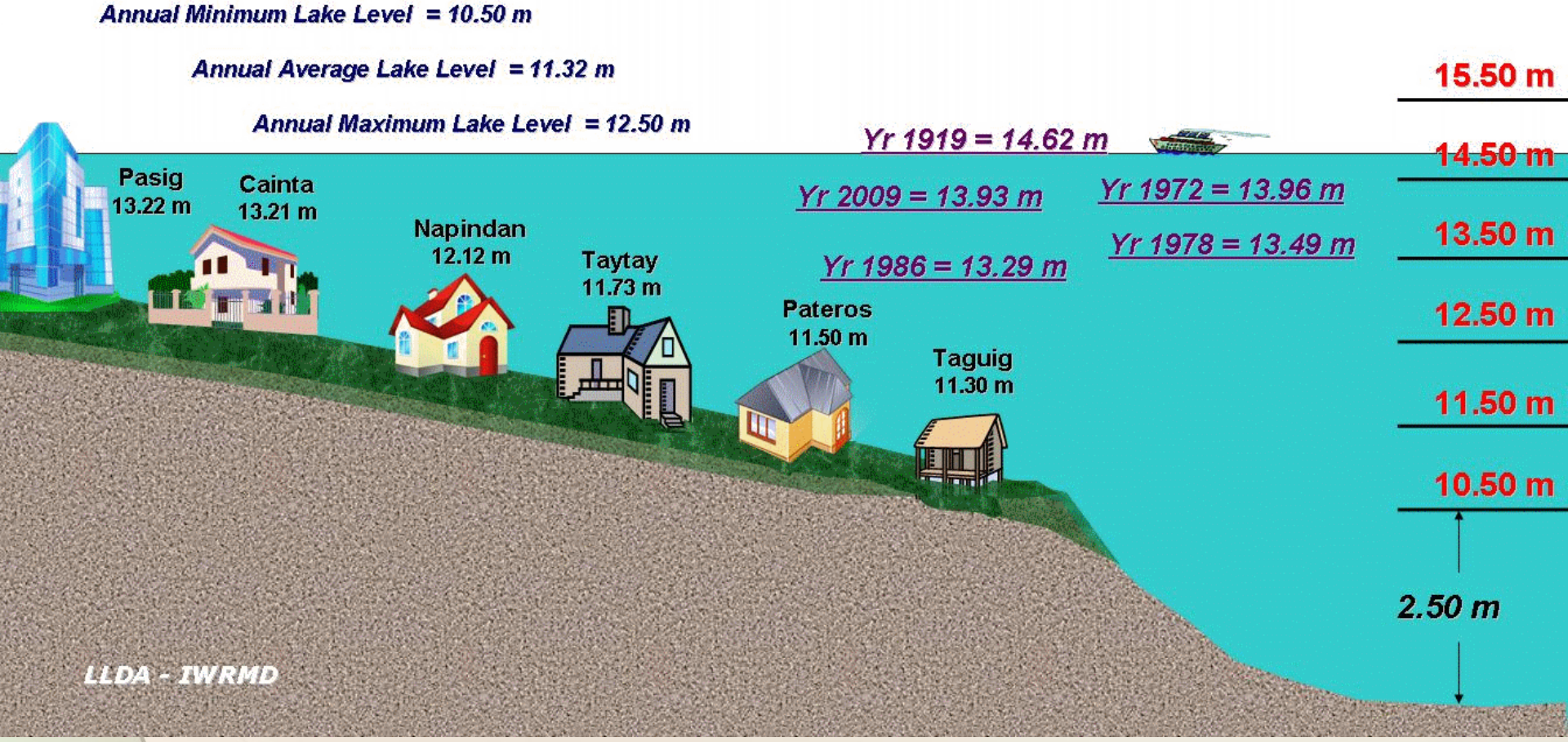
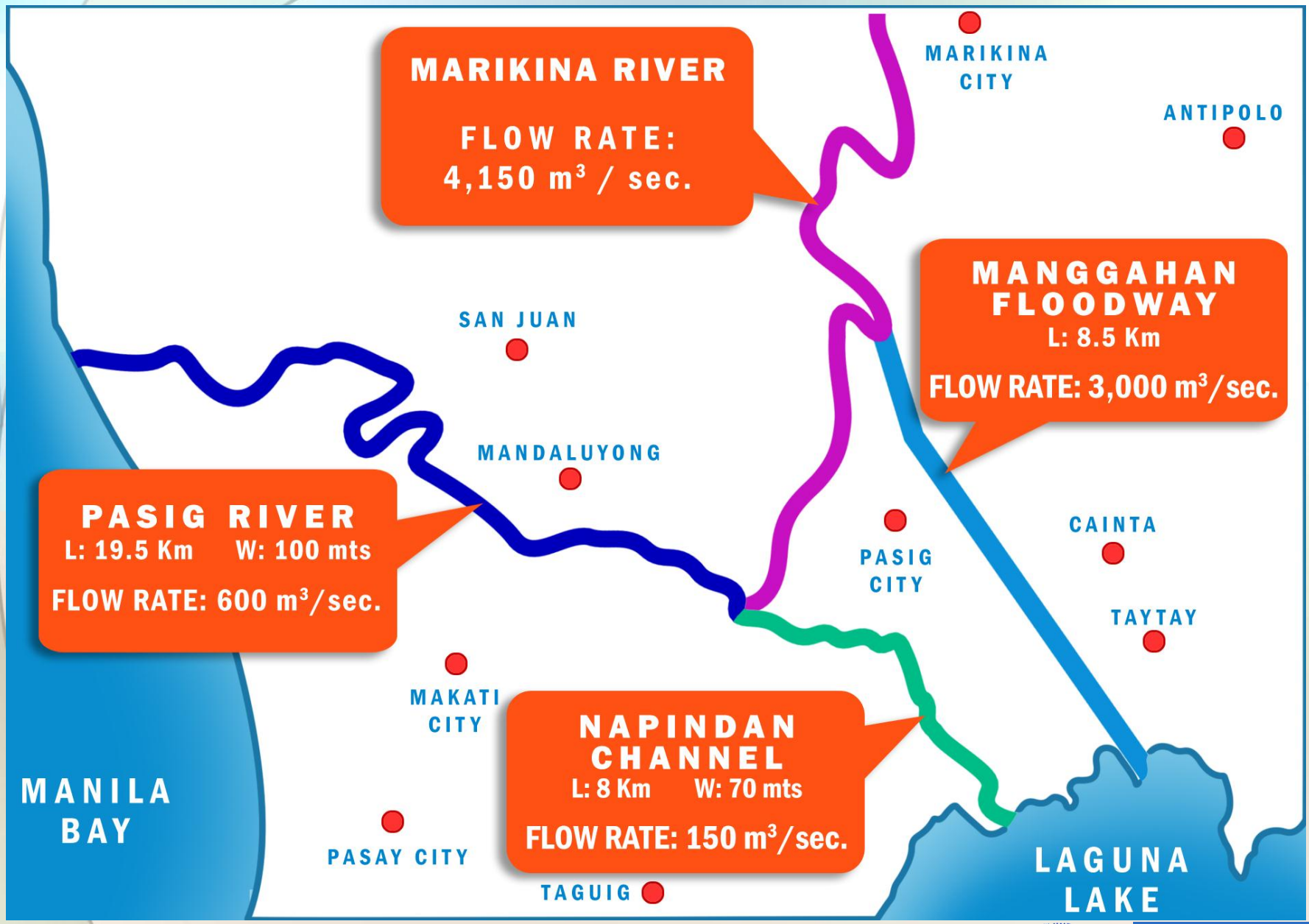
Under Extreme Weather Conditions



TYPHOON ONDOY (KETSANA)



DYNAMICS OF MARIKINA, PASIG & NAPINDAN RIVERS

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Laguna Lake Hydro-Matrix

LAKE WATER LEVEL (m)	LAKE SURFACE AREA (ha)	LAKE WATER VOLUME (Billion m^3)	LAKE OUTFLOW			No. OF DAYS TO RECEDE TO 10.5 m ELEVATION
			m3 / day (in Million)	liters / day (in Billion)	drums /day (in Million)	
15.0	120,461	6.93	45.4	45.4	227	160
14.5	118,778	6.33	40.3	40.3	201	153
14.0	115,120	5.74	34.9	34.9	175	146
13.5	111,018	5.18	29.6	29.6	148	138
13.0	107,240	4.63	24.4	24.4	122	128
12.5	103,946	4.10	19.3	19.3	97	116
12.0	99,066	3.59	17.2	17.2	86	91
11.5	95,485	3.11	17.5	17.5	87	59
11.0	91,134	2.64	16.2	16.2	81	30
10.5	87,549	2.19	13.7	13.7	68	--

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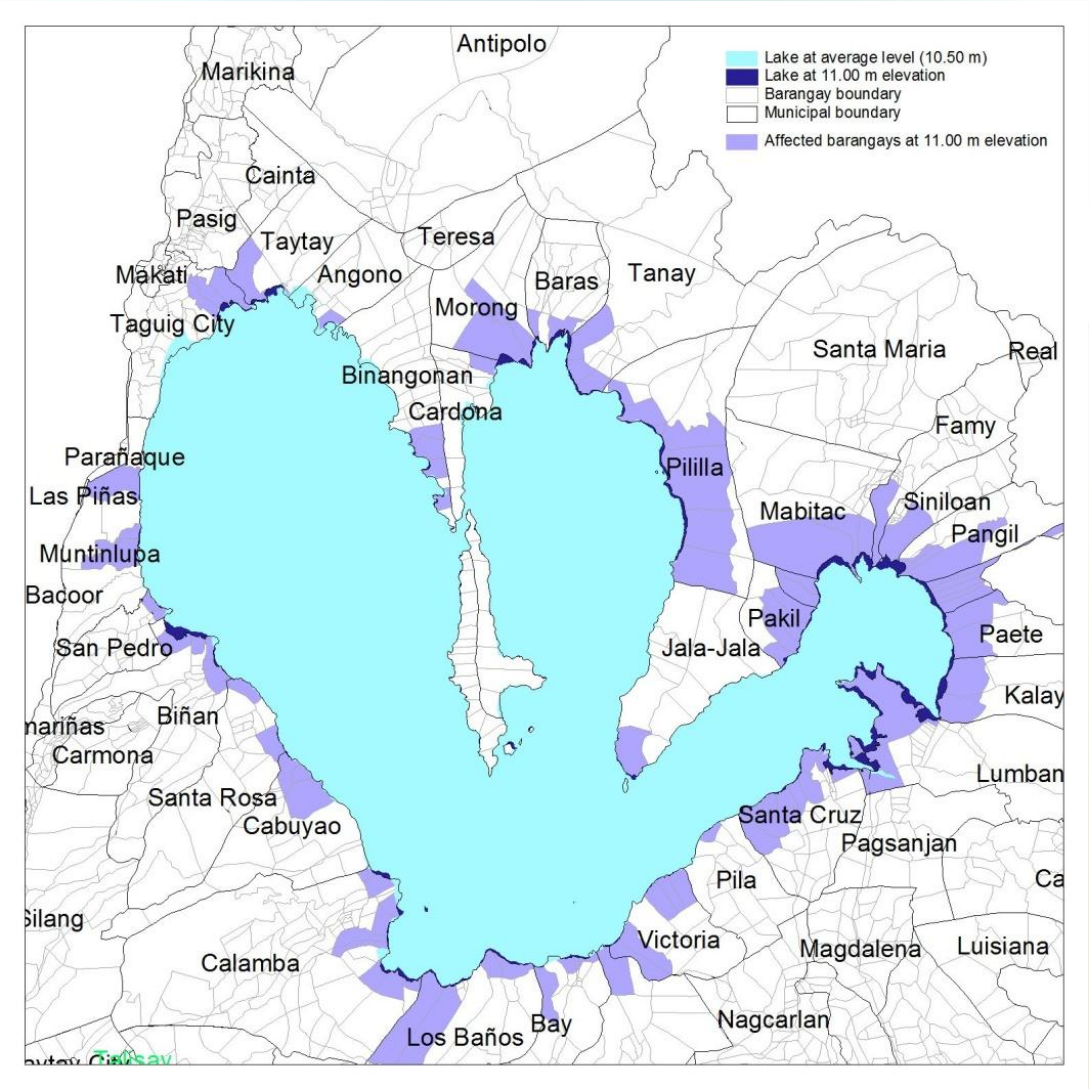
Mapping of affected Barangay and Population at certain Lake Level/elevation



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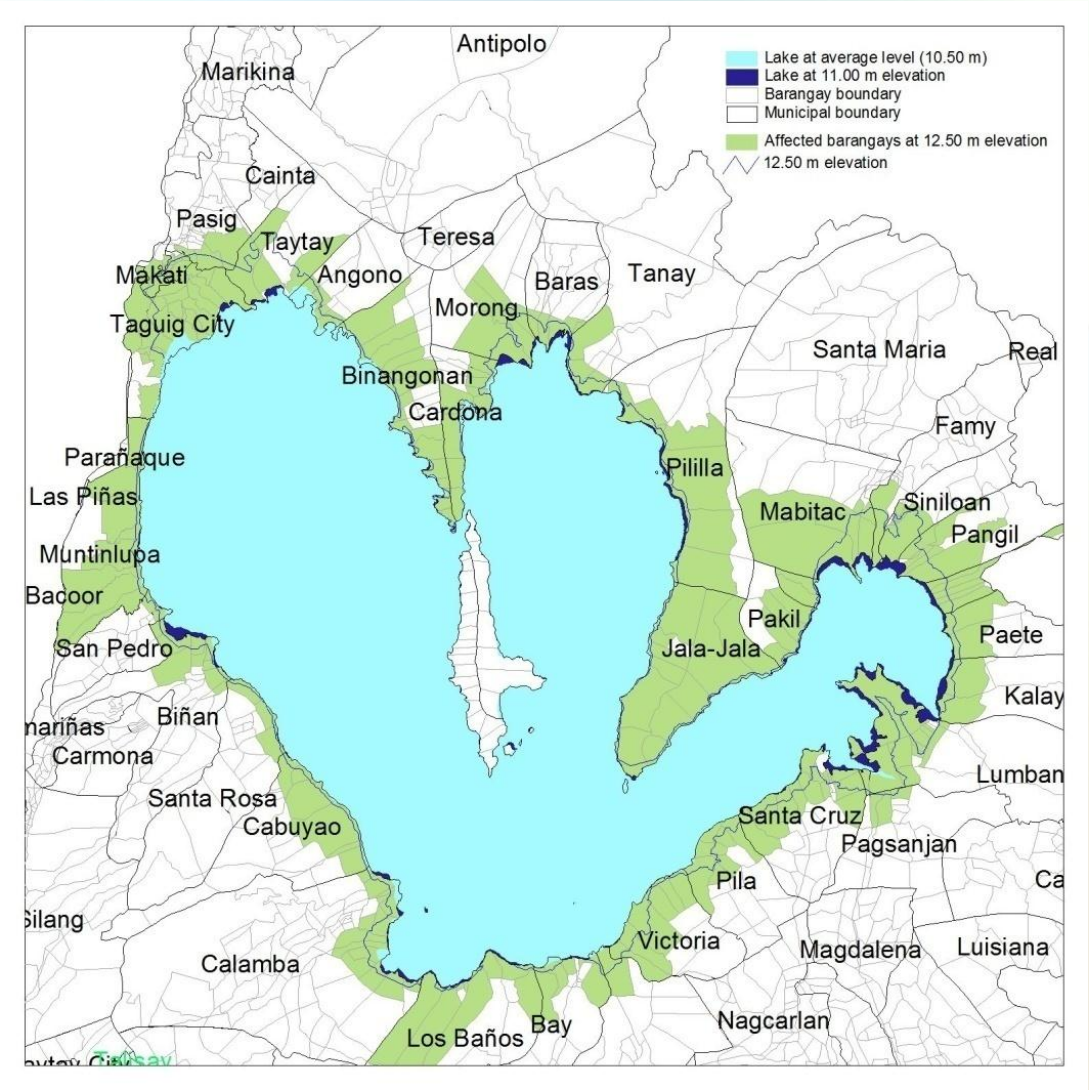
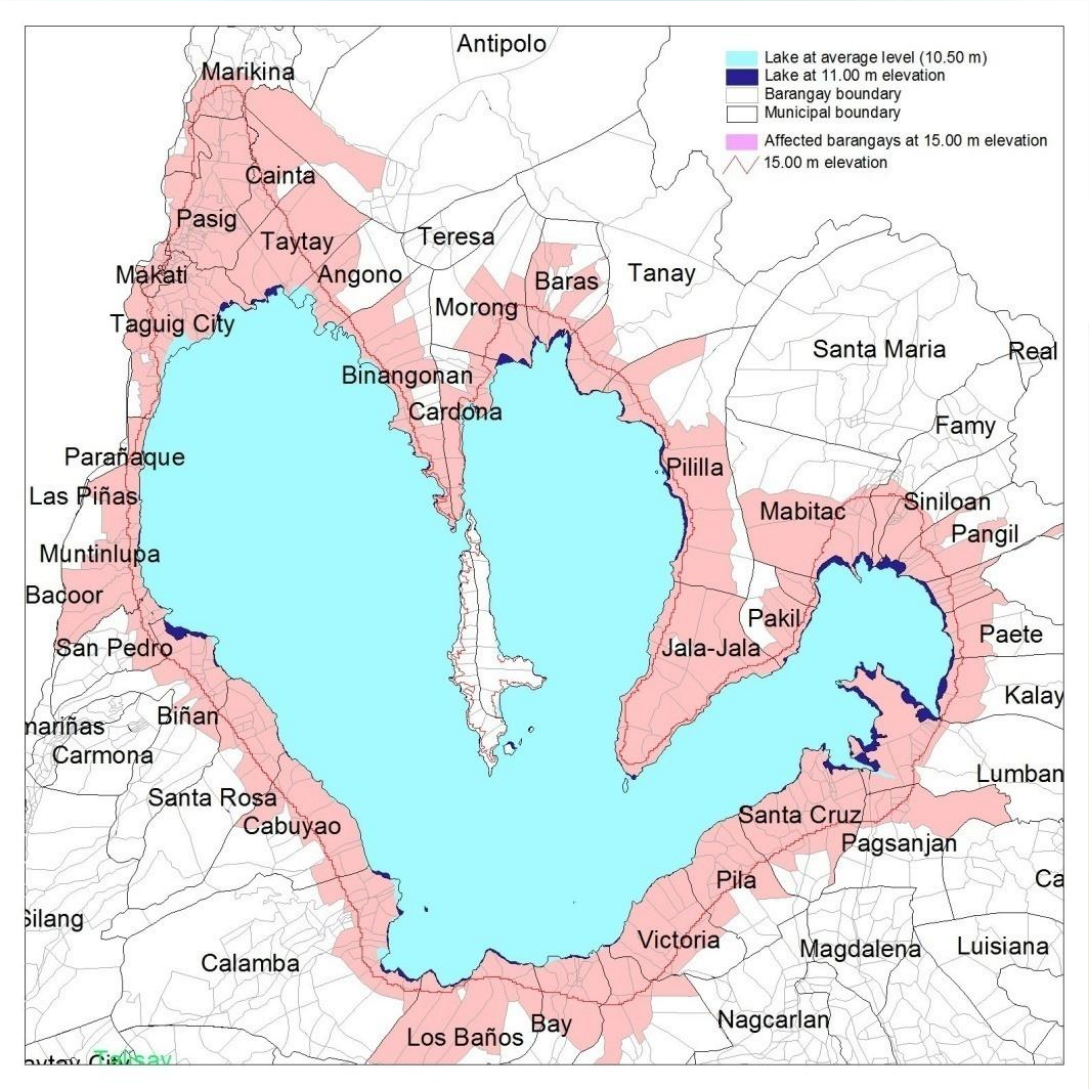
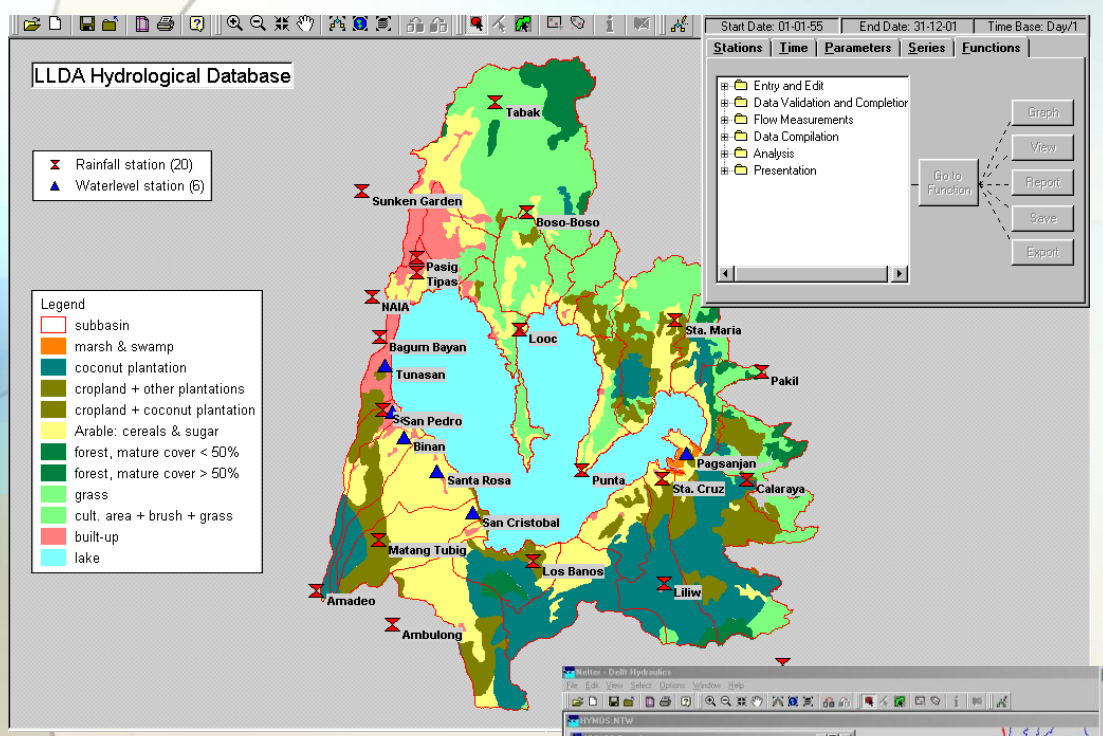


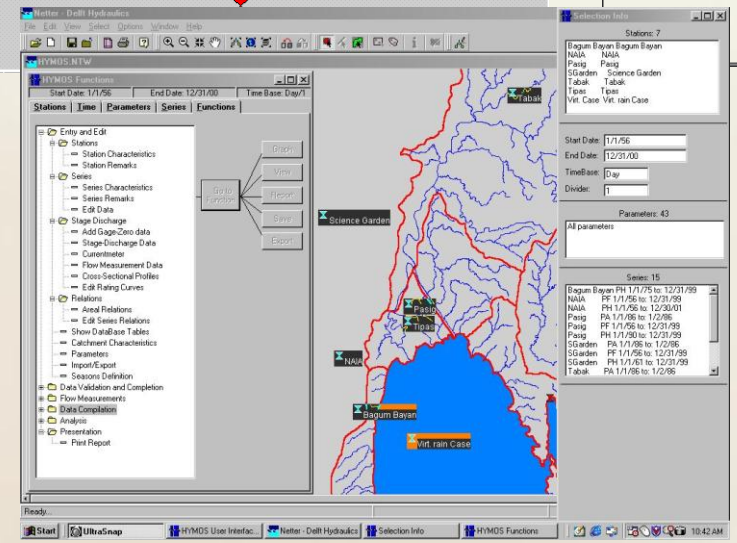
Mapping of affected Barangay and Population at certain Lake Level/elevation



The HYMOS Database



Time-Series Database



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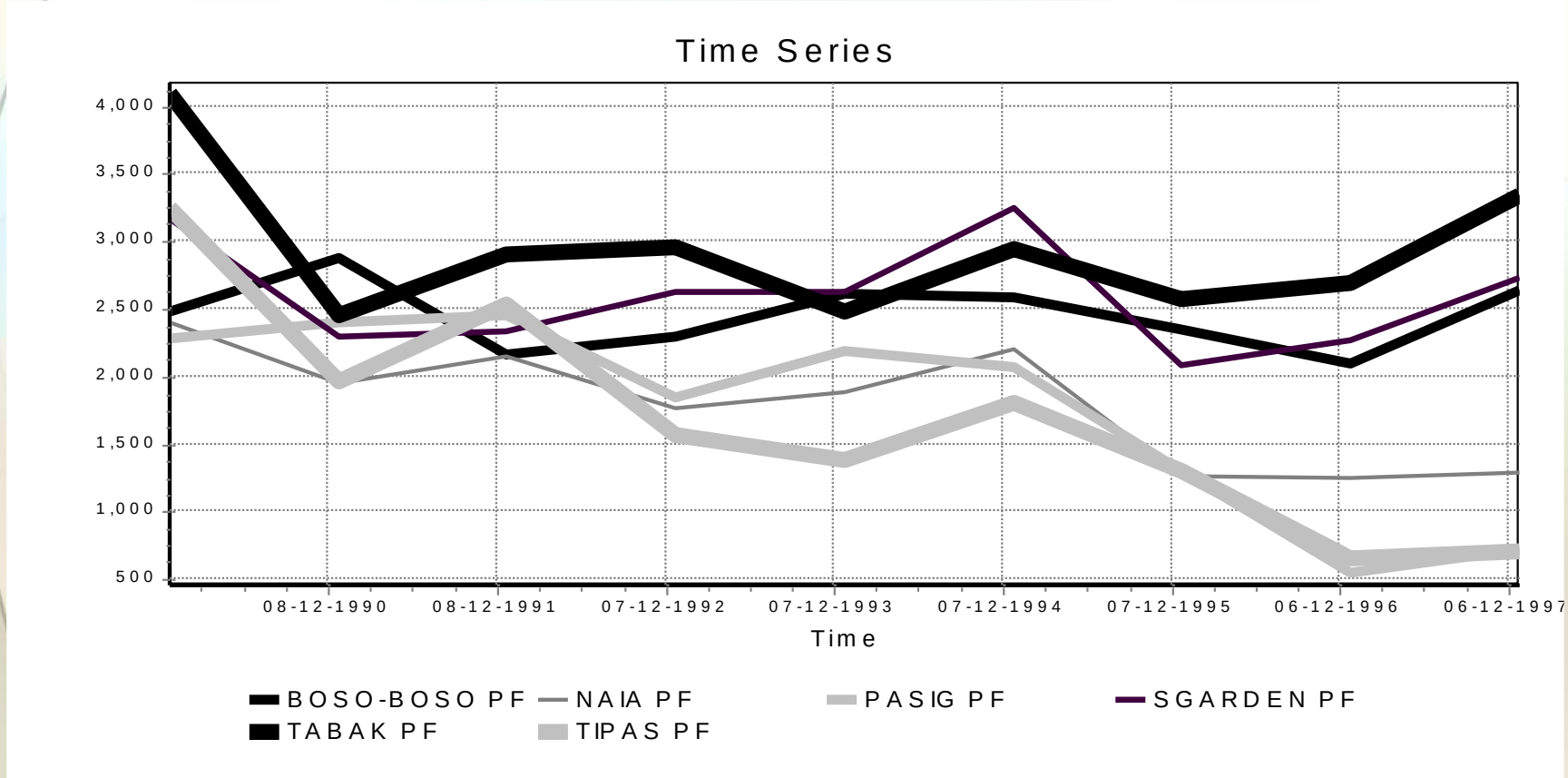
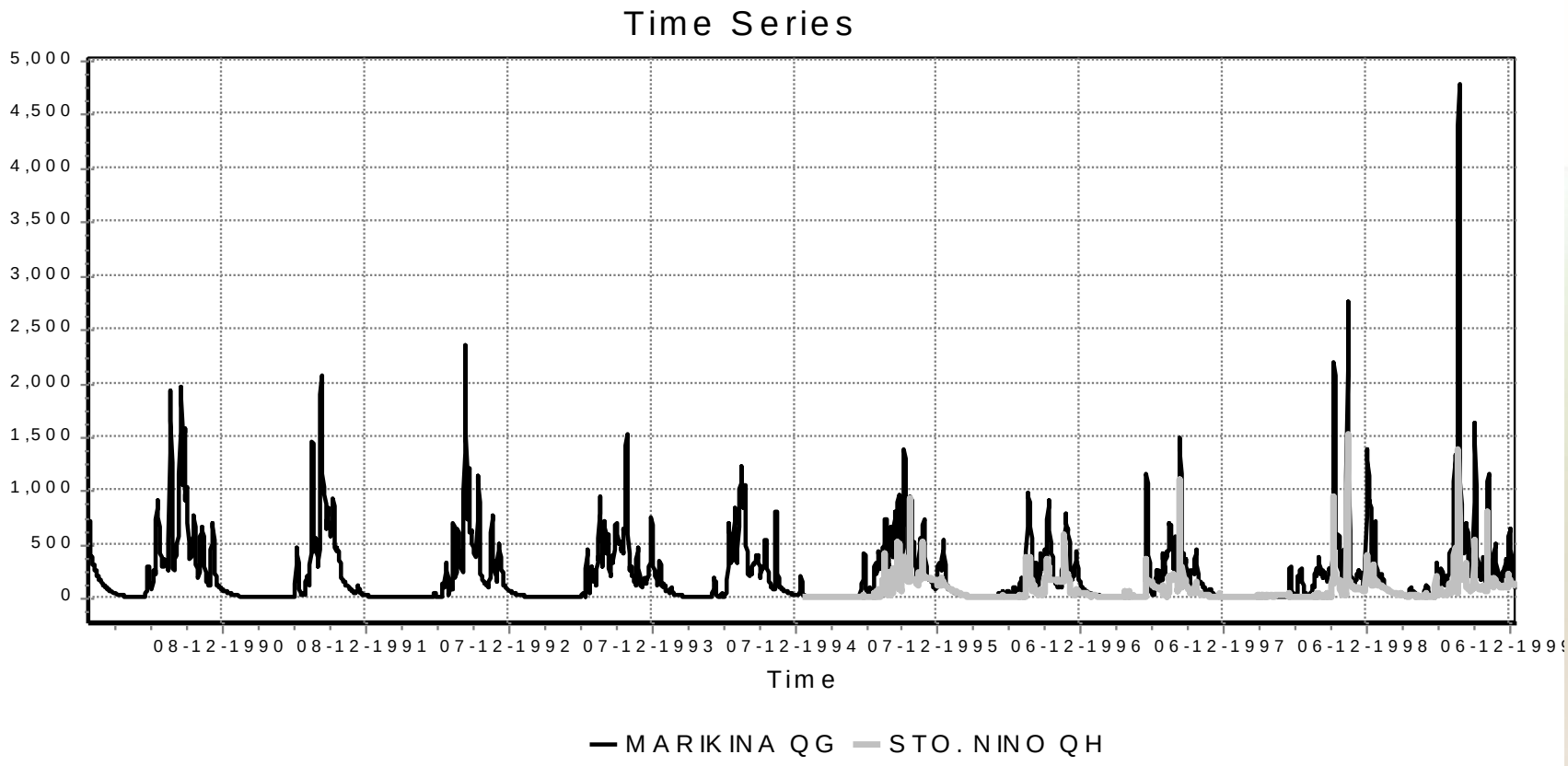
HYMOS Database - what it does...

- Analysis / quality control: comparison of rainfall stations



HYMOS Database - what it does...

- Modelling: first Sacramento results

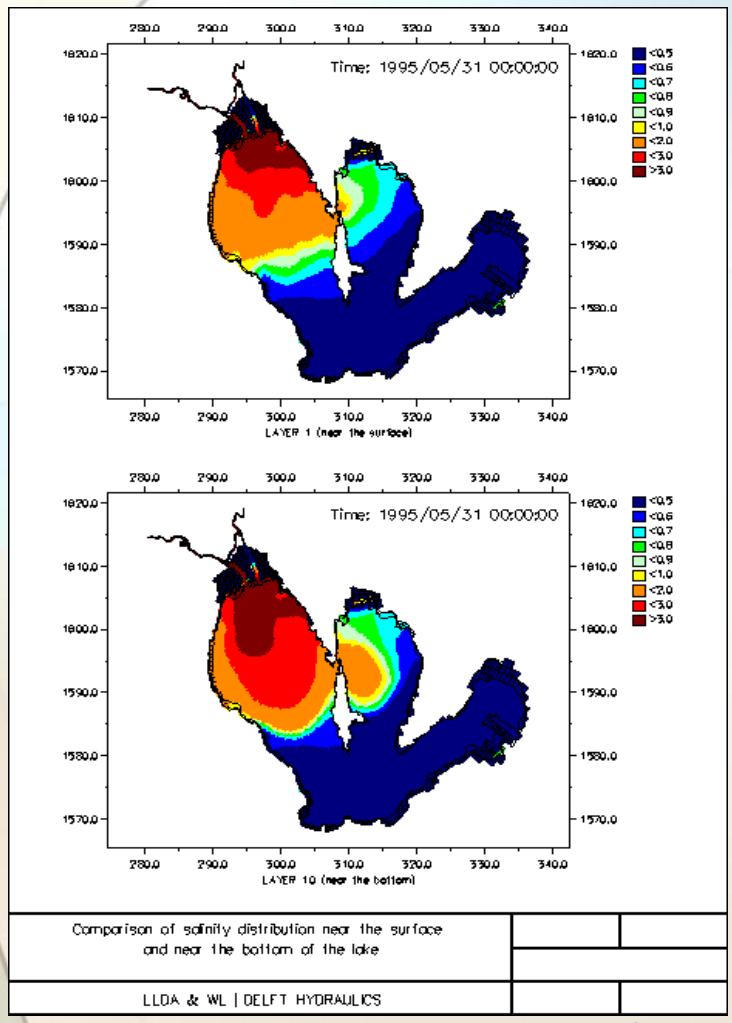


Hydrodynamics Module

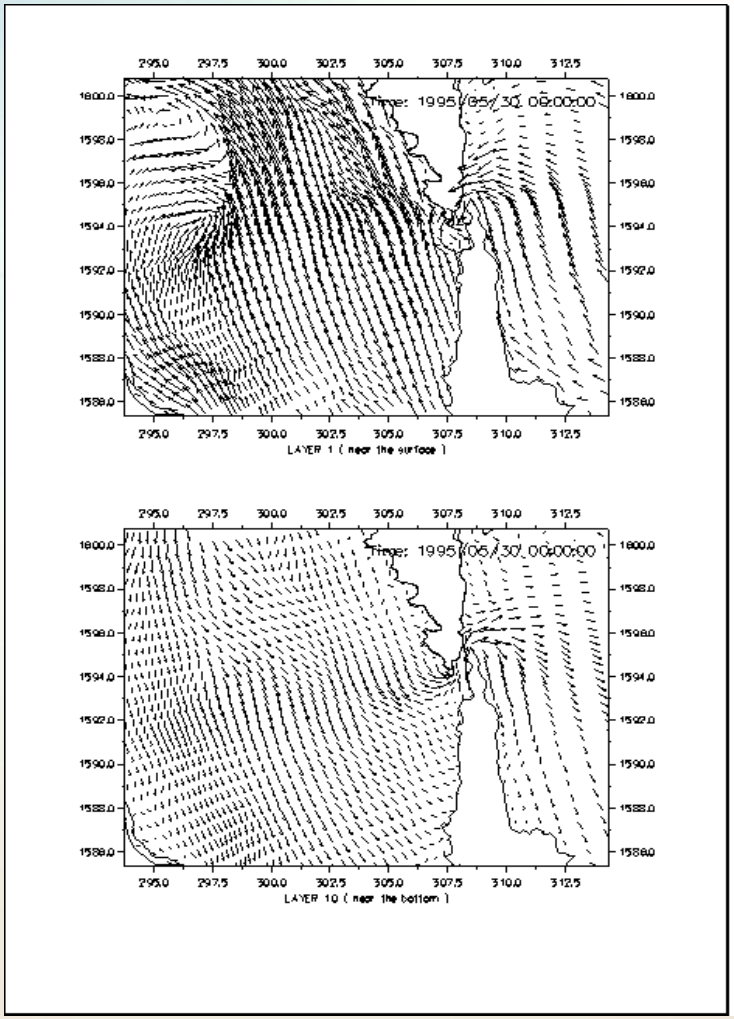
The model will provide water circulation predictions such as

- the effect of a typhoon on water movement, water level variations, flow velocity
- the amount of saltwater that may enter into the lake during dry season
- the extent of thermal pollution caused by industrial discharge
- the extent of accidental spill which may occur on the lake
- and will help in the analysis of environmental impacts caused by various infrastructure project on the lake among others.

Hydrodynamics Module



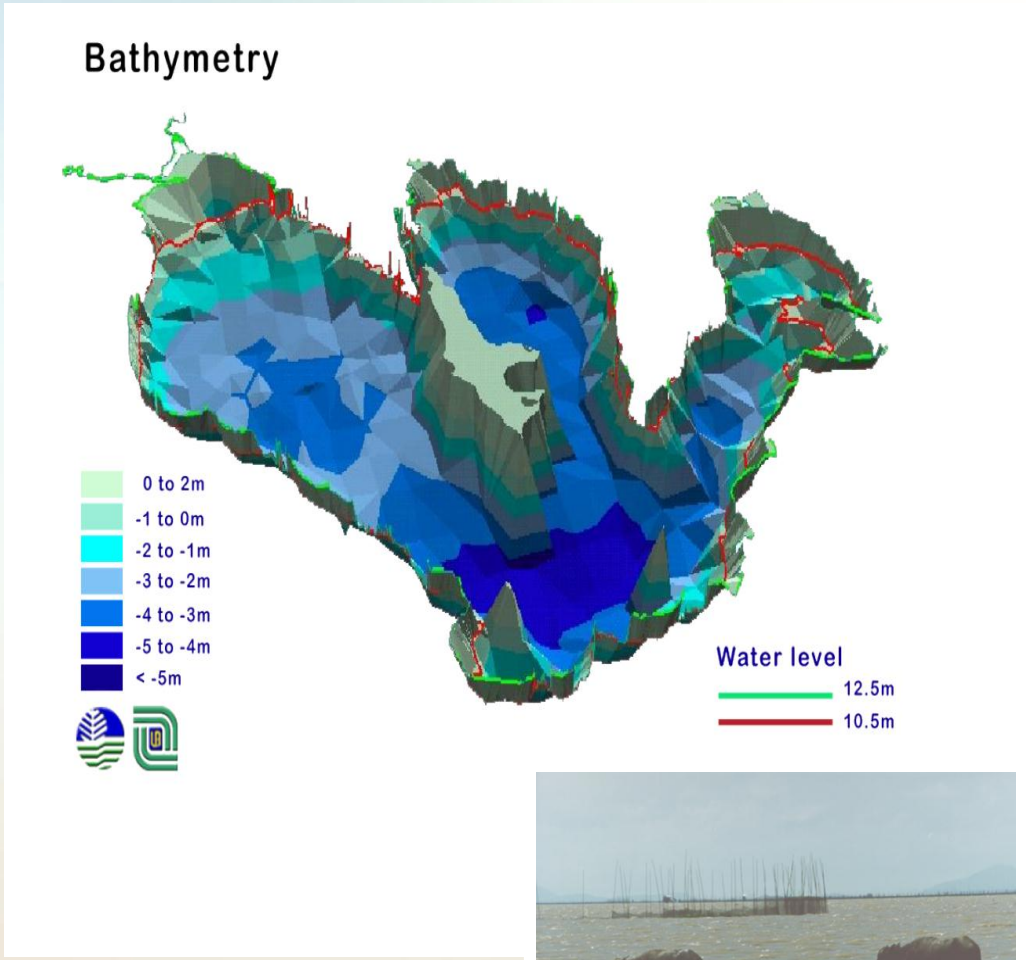
Salinity distribution near the surface and near the bottom of the lake



Flow velocity near the surface and bottom of the lake

Bathymetry Studies 1963, 1973, 1983, 1997

Year of acquisition of bathymetry data	Shallowing Rate (mm/year)
1963 vs. 1983	3.23
1983 vs. 1997	9.68
1963 vs. 1997	8.36



The lake became shallower by 0.30 meters or about one foot (from 1960s to 1990s)

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Waste Load Module

- Impact Assessment of **LISCOP** Sub-projects
- **Pollution Loading** in Laguna de Bay
- **Total Pollutant Loading** (TPL) Study in Laguna de Bay - Pasig River - Manila Bay Watershed
- **Total Pollutant Loading** (TPL) Study in Meycauyan-Marilao-Obando (MMO) Watershed

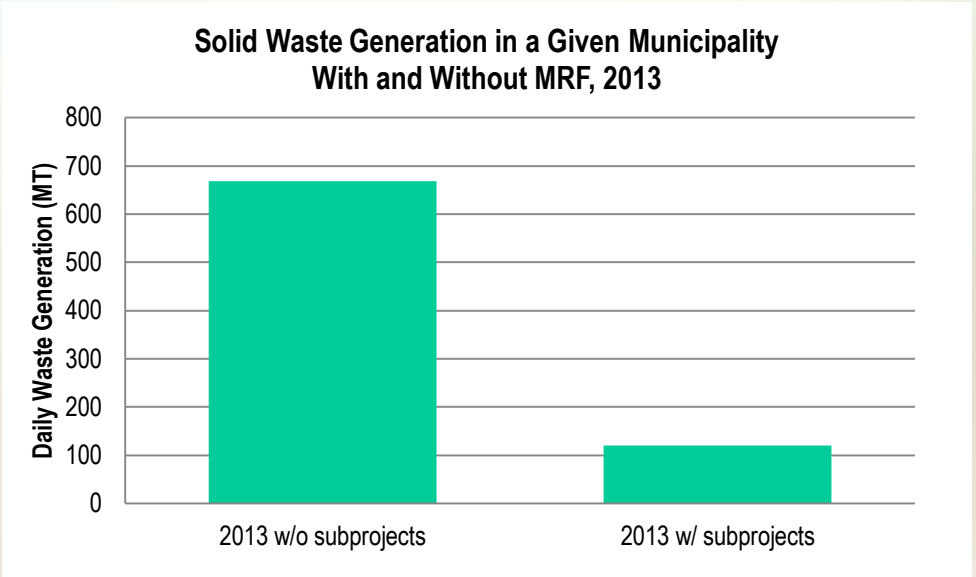
Impact assessments of the LISCOP Sub-projects

Impacts of MRF on Solid Waste Generation

Solid Waste Generation per Day (2013)				
	2013	without Sub Project (MT/day)	MRF Capacity (%)	w/ Sub Project (MT/day)
1	Sta. Cuz	42.7	36	27.33
2	Liliw	126	46	68.04
3	GMA	30.9	100	0
4	Morong	9.48	100	0
5	Siniloan	17	100	0
6	Angono	36.07	100	0
7	Teresa	3.31	100	0
8	kalayaan	106	100	0
9	Nagcarlan	20.26	33	13.57
10	Mabitac	5.6	100	0
11	Tanay	30.11	100	0
12	Pila	15	41	8.85
13	Victoria	15	100	0
14	Pangil	7.58	88	0.91
15	Pakil	6.99	85	1.05
16	lucban	13	76	0
17	Antipolo	182.6	100	0
18	Sta. Maria	3.37	25	2.8
19	Rizal	2.35	25	1.8
20	Paete	9.2	25	6.9
21	Pagsanjan	10.43	25	7.82
	Total	692.99		139.07

- 82% or 551.67 MT per day solid waste reduction in 21 LGU

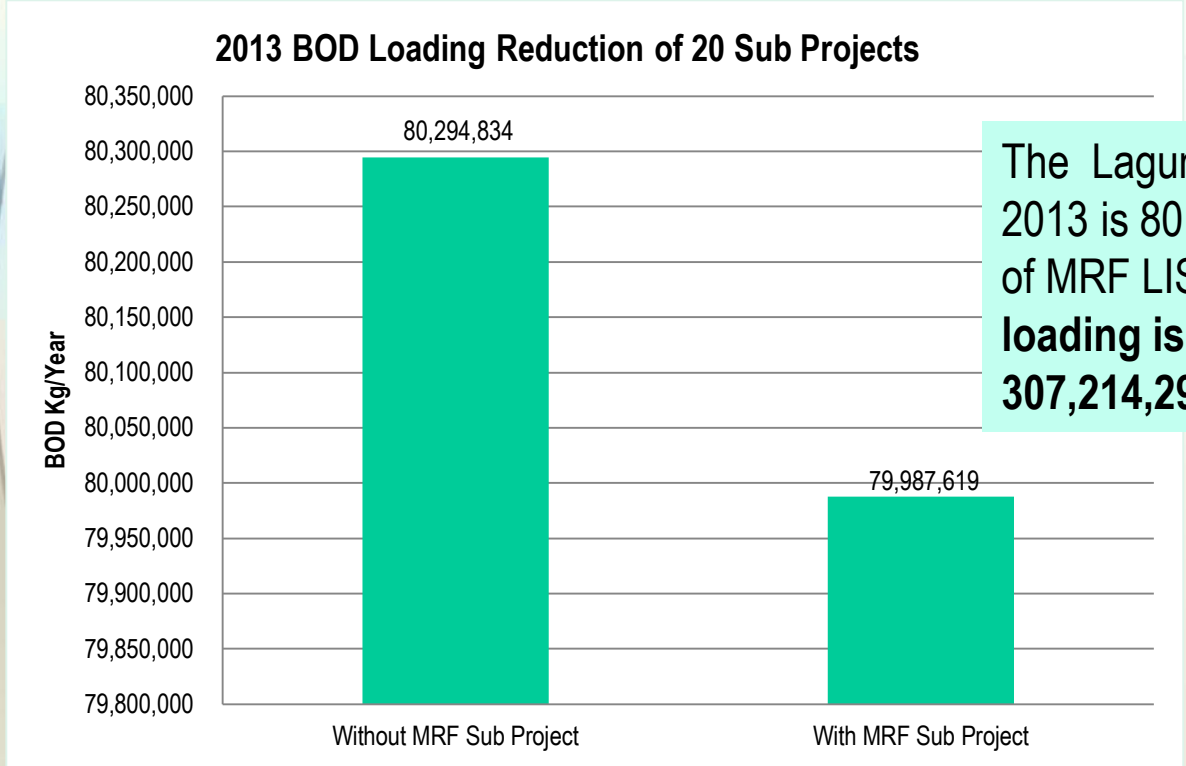
Daily Solid Waste Generation
- without MRF = 692.99 Tons/day or 69 trucks
- with MRF = 139.07 Tons/day or 14 trucks



* Assumption 1truck=10 tons

Impact assessments of the LISCOP Sub-projects

Impacts of MRF on BOD Loading



The Laguna de Bay BOD loading for year 2013 is 80,295 MT/yr. With the intervention of MRF LISCOP sub projects, **BOD loading is reduced at about 0.38% or 307,214,29 kg or 307 MT/yr**.

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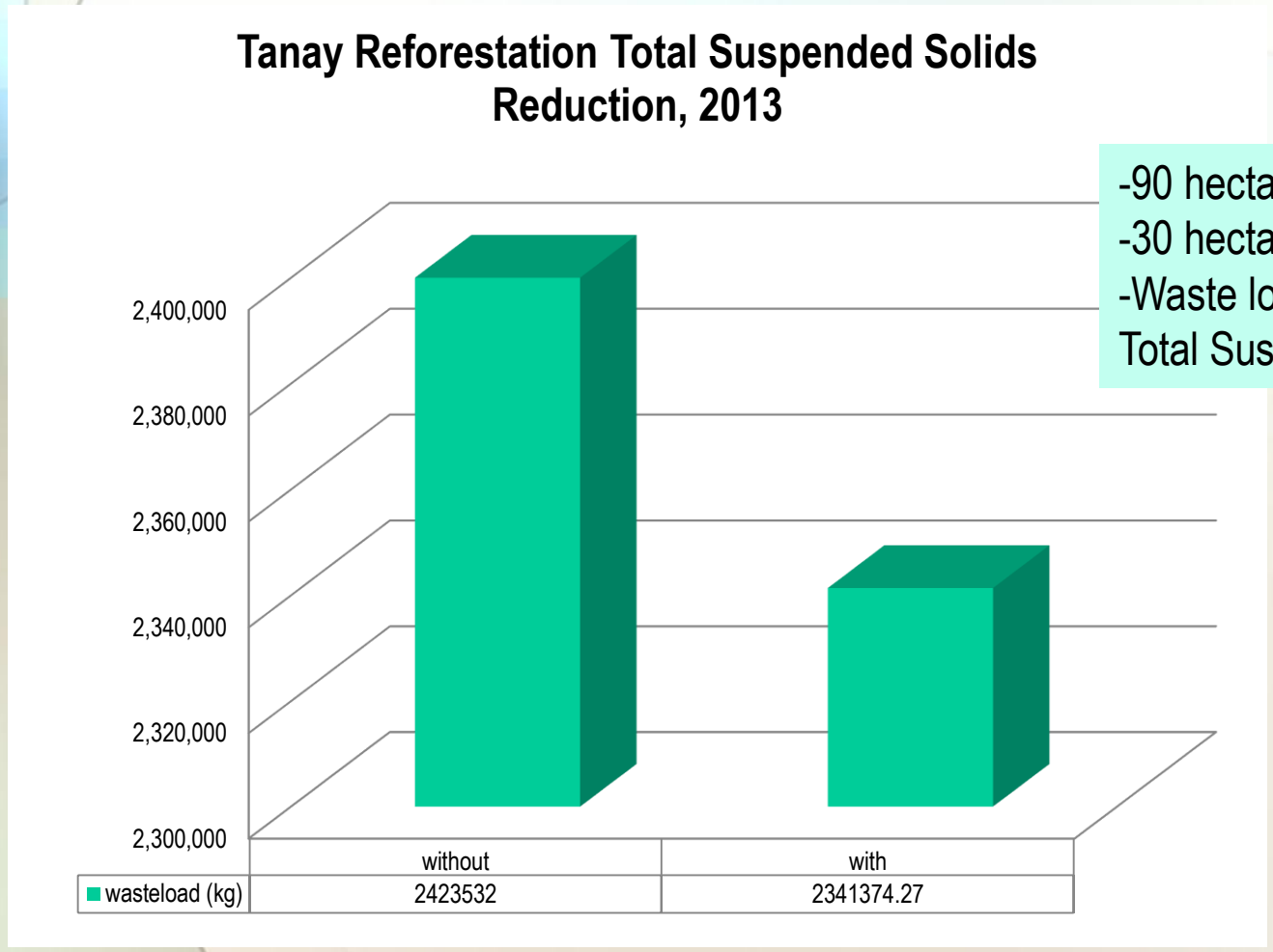
Impact assessments of the LISCOP Sub-projects

Impacts of the Tanay Reforestation on TSS Loading



-90 hectares plantation
-30 hectares of grassland
-Waste load reduction of 3.39% for Total Suspended Solid (TSS)

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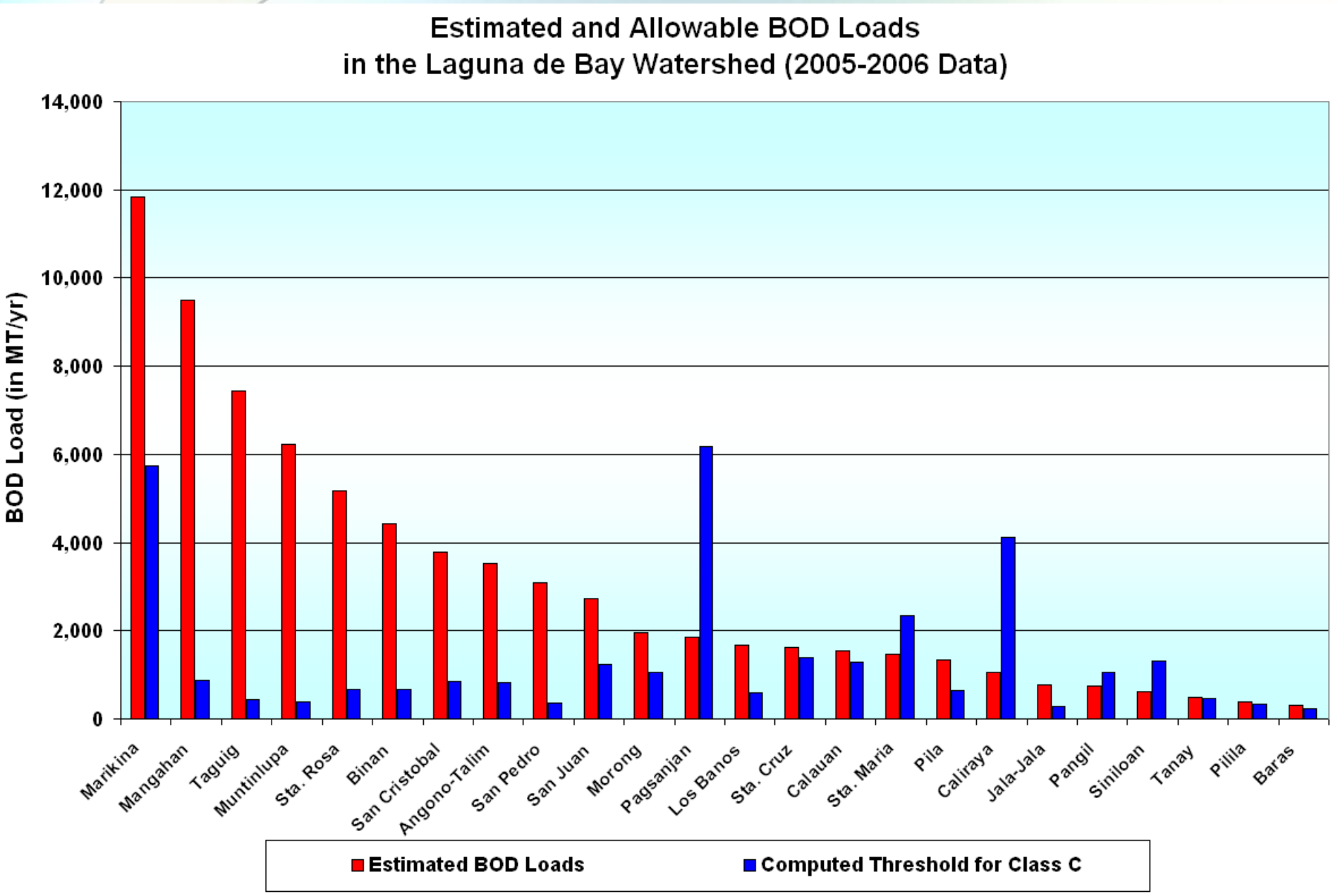
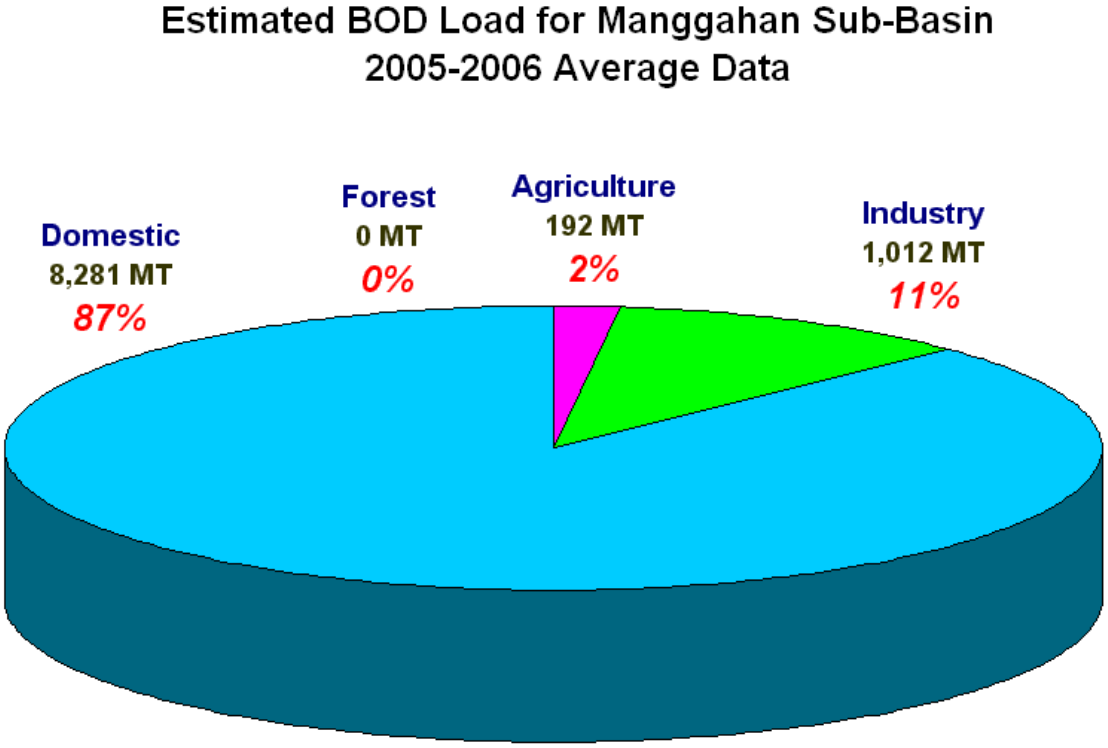

Estimated and Allowable BOD Loads
in the Laguna de Bay Watershed (2005-2006 Data)
BOD Load (in MT/yr)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Marikina
Mangahan
Taguig
Muntinlupa
Sta. Rosa
Binan
San Cristobal
Angono-Talim
San Pedro
San Juan
Morong
Pagsanjan
Los Banos
Sta. Cruz
Calauan
Sta. Maria
Pila
Caliraya
Jala-Jala
Pangil
Siniloan
Tanay
Pilila
Baras
Estimated BOD Loads
Computed Threshold for Class C

Example: Manggahan Sub-basin..

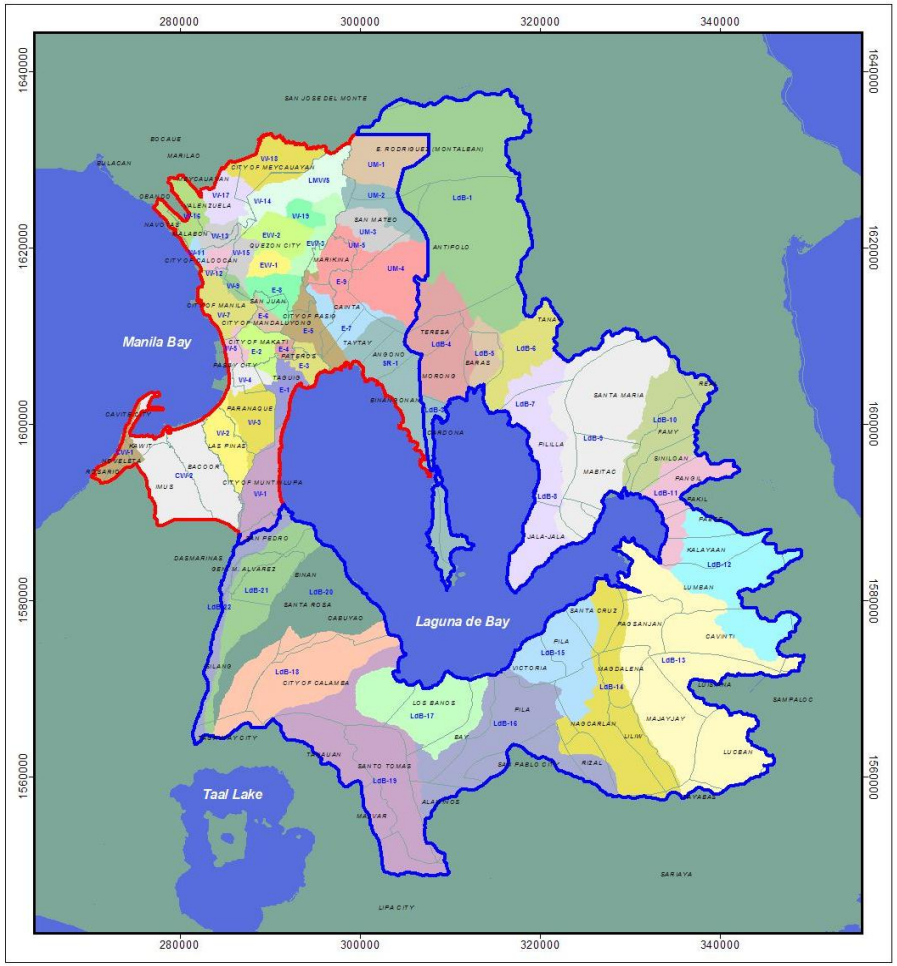


"Even if we achieve 100% environmental compliance for industrial sources, the river system will never meet Class C"

Should focus more on reducing pollution from domestic sources..

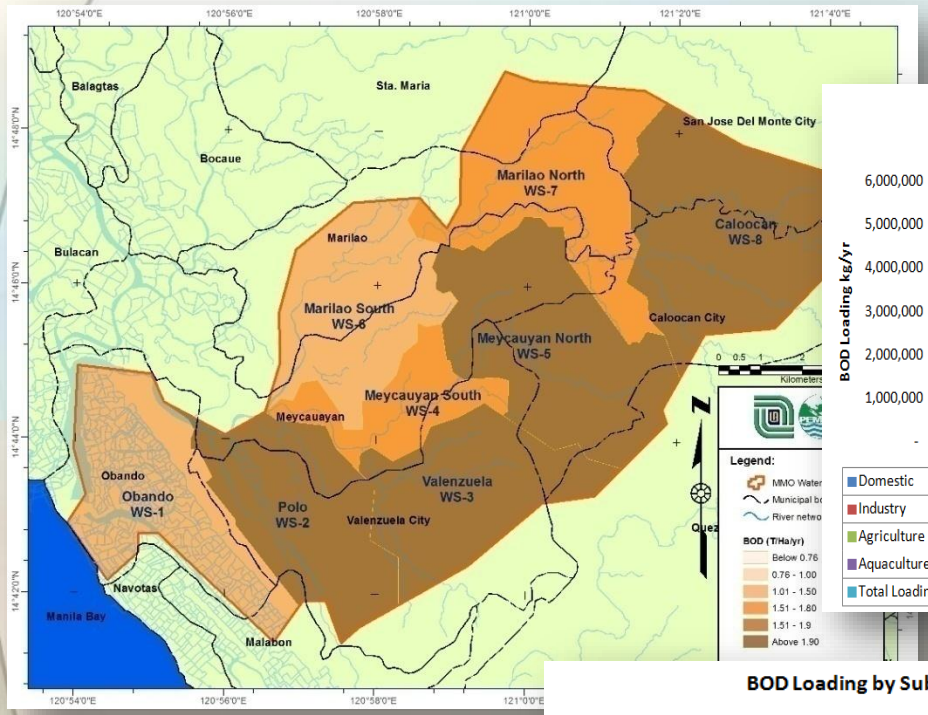
Maximum Load to meet Class C Standard = 867 MT

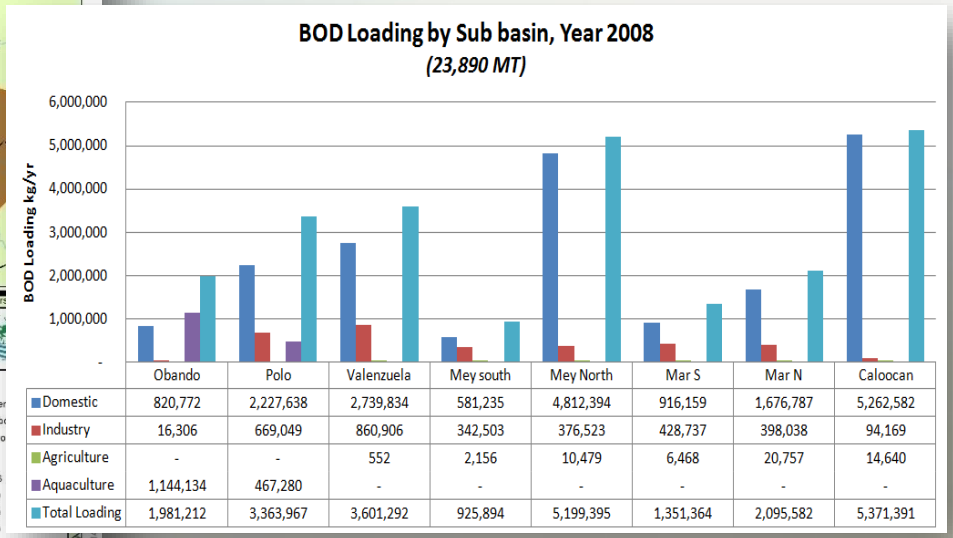
Total Pollutant Loading (TPL) Study in Laguna de Bay - Pasig River - Manila Bay Watershed



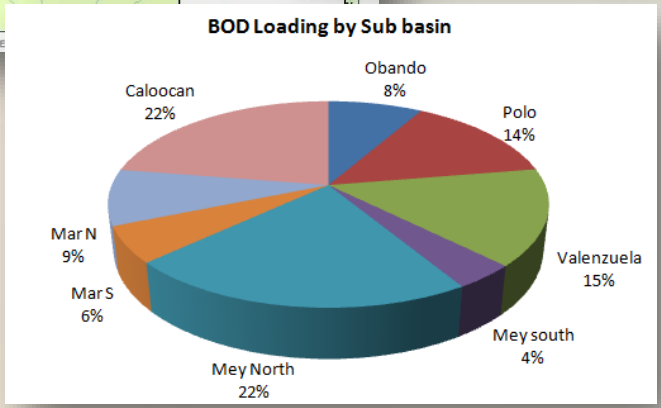
1. **Determine the total pollutant loadings to the Laguna Lake-Pasig River-Manila Bay watershed**
2. **Identify "hotspots" within the watershed based on existing and projected conditions**
3. **Facilitate access to a decision-support system for decision makers at the national and local levels regarding the recovery of Manila Bay**

Total Pollutant Loading (TPL) Study in Meycauyan-Marilao- Obando (MMO) Watershed





	Obando	Polo	Valenzuela	Mey south	Mey North	Mar S	Mar N	Caloocan
Domestic	820,772	2,227,638	2,739,834	581,235	4,812,394	916,159	1,676,787	5,262,582
Industry	16,306	669,049	860,906	342,503	376,523	428,737	398,038	94,169
Agriculture	-	-	552	2,156	10,479	6,468	20,757	14,640
Aquaculture	1,144,134	467,280	-	-	-	-	-	-
Total Loading	1,981,212	3,363,967	3,601,292	925,894	5,199,395	1,351,364	2,095,582	5,371,391



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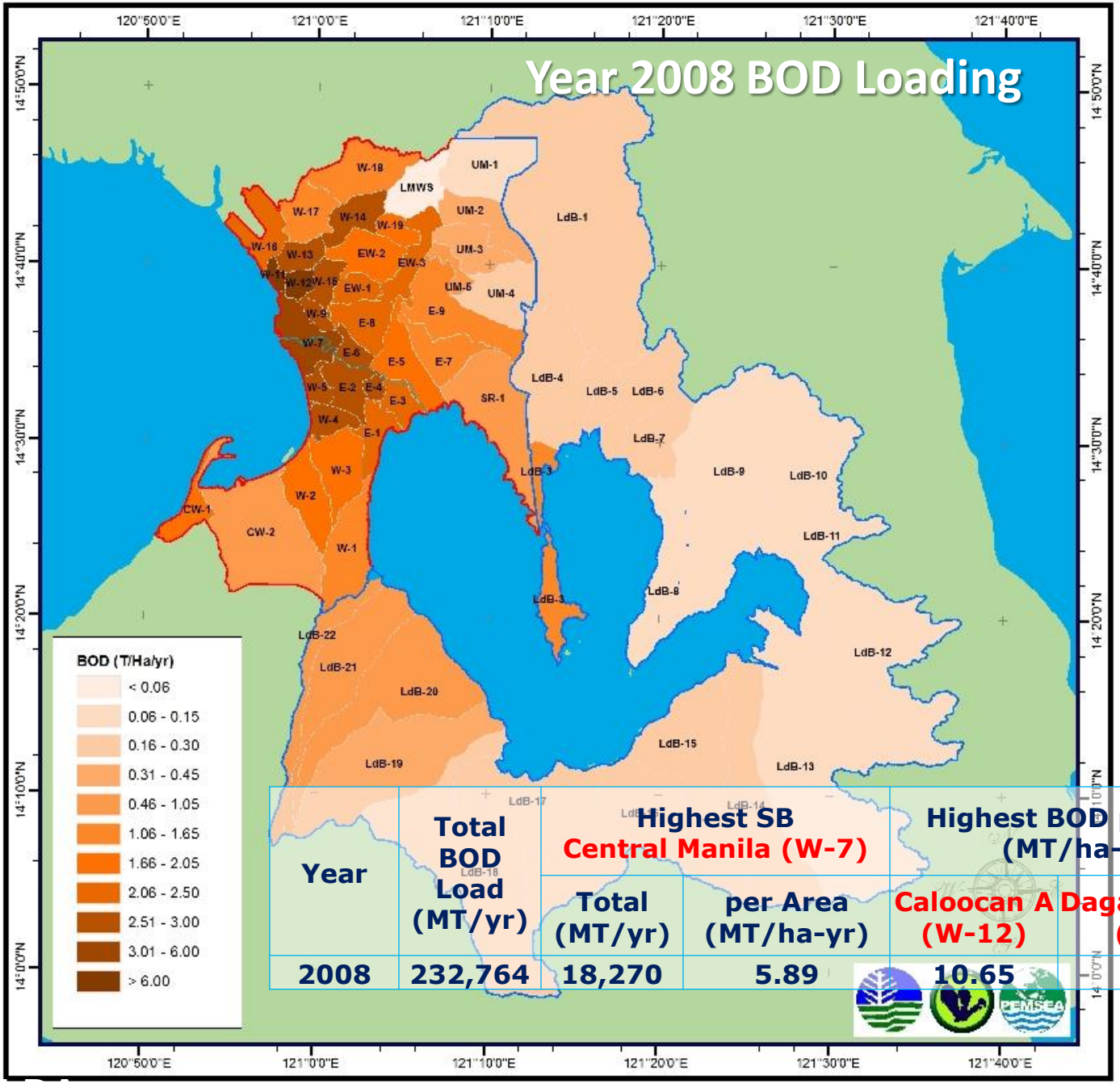
Year 2008 BOD Loading



Year	Total BOD Load (MT/yr)	Highest SB Central Manila (W-7)		Highest BOD per Area (MT/ha-yr)	
		Total (MT/yr)	per Area (MT/ha-yr)	Caloocan A (W-12)	Dagat-dagatan (W-11)
2008	232,764	18,270	5.89	10.65	8.25

MANILA BAY WATERSHED
CW-2 Cavite-Kawit
CW-1 Cavite-Rosario
E-1 Taguig
E-2 Makati
E-3 Pateros
E-4 Bonifacio
E-5 Pasig
E-6 Mandaluyong-San Juan
E-7 Taytay
E-8 Quezon South
E-9 Cainta-Marikina
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UM-1 Rodriguez
UM-2 Maly
UM-3 Ampid
UM-4 Nangka
UM-5 San Mateo
W-1 Muntinlupa
W-2 Las Pinas
W-3 Paranaque
W-4 Pasay-NAIA
W-5 South Manila
W-7 Central Manila
W-9 Sampaloc
W-11 Dagat-Dagatan
W-12 Caloocan A
W-13 Malabon-Tullahan
W-14 QC-Novaliches
W-15 Quezon West
W-16 Navotas
W-17 Valenzuela
W-18 Caloocan B
W-19 Malabon

LAGUNA DE BAY WATERSHED
LdB-1 Marikina
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LdB-7 Pililla
LdB-8 Binangonan-jala
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LdB-16 Calauan
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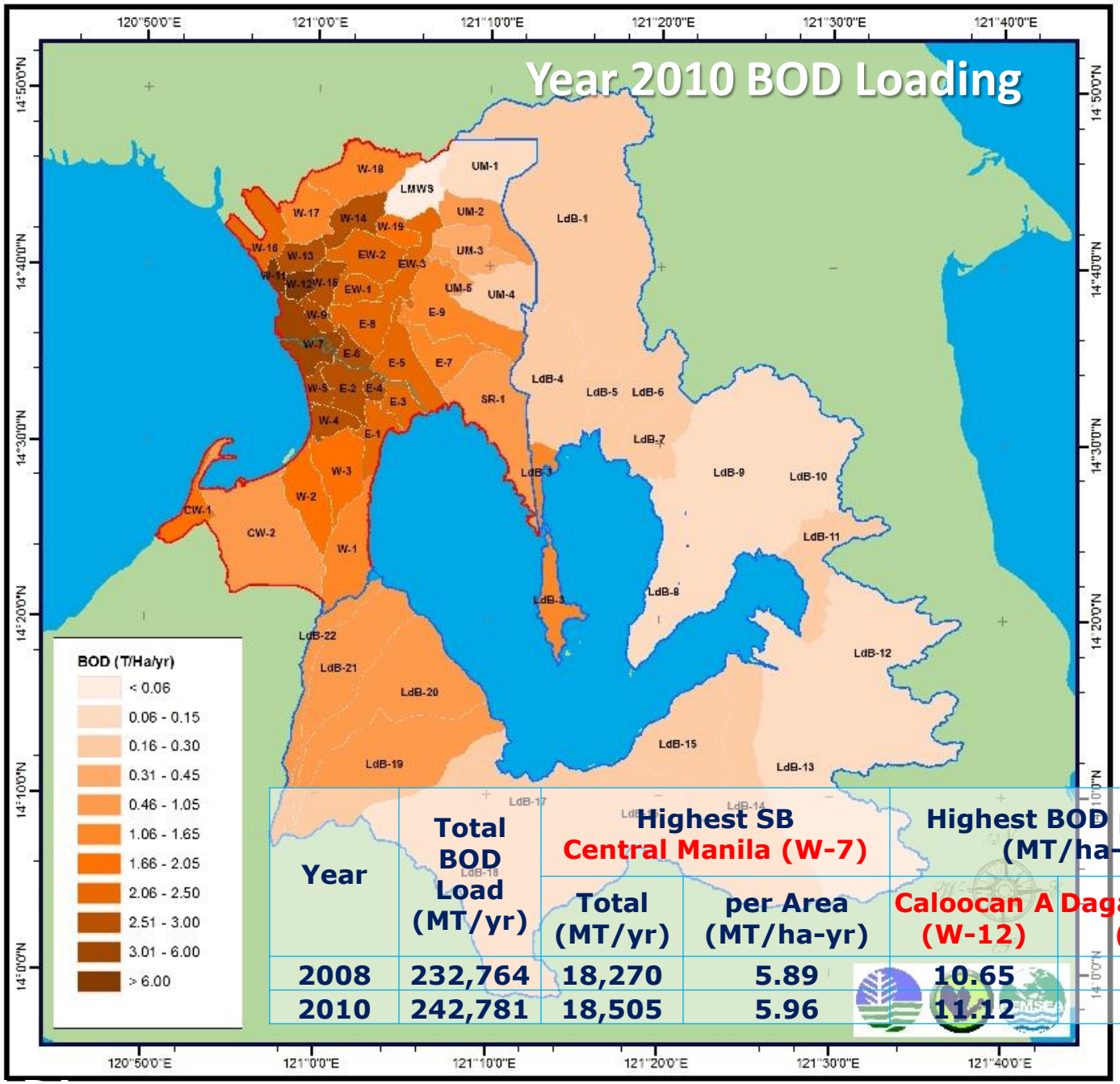
LdB-18 San Juan
LdB-19 San Cristobal
LdB-20 Cabuyao
LdB-21 Biñan
LdB-22 San Pedro

Year 2010 BOD Loading



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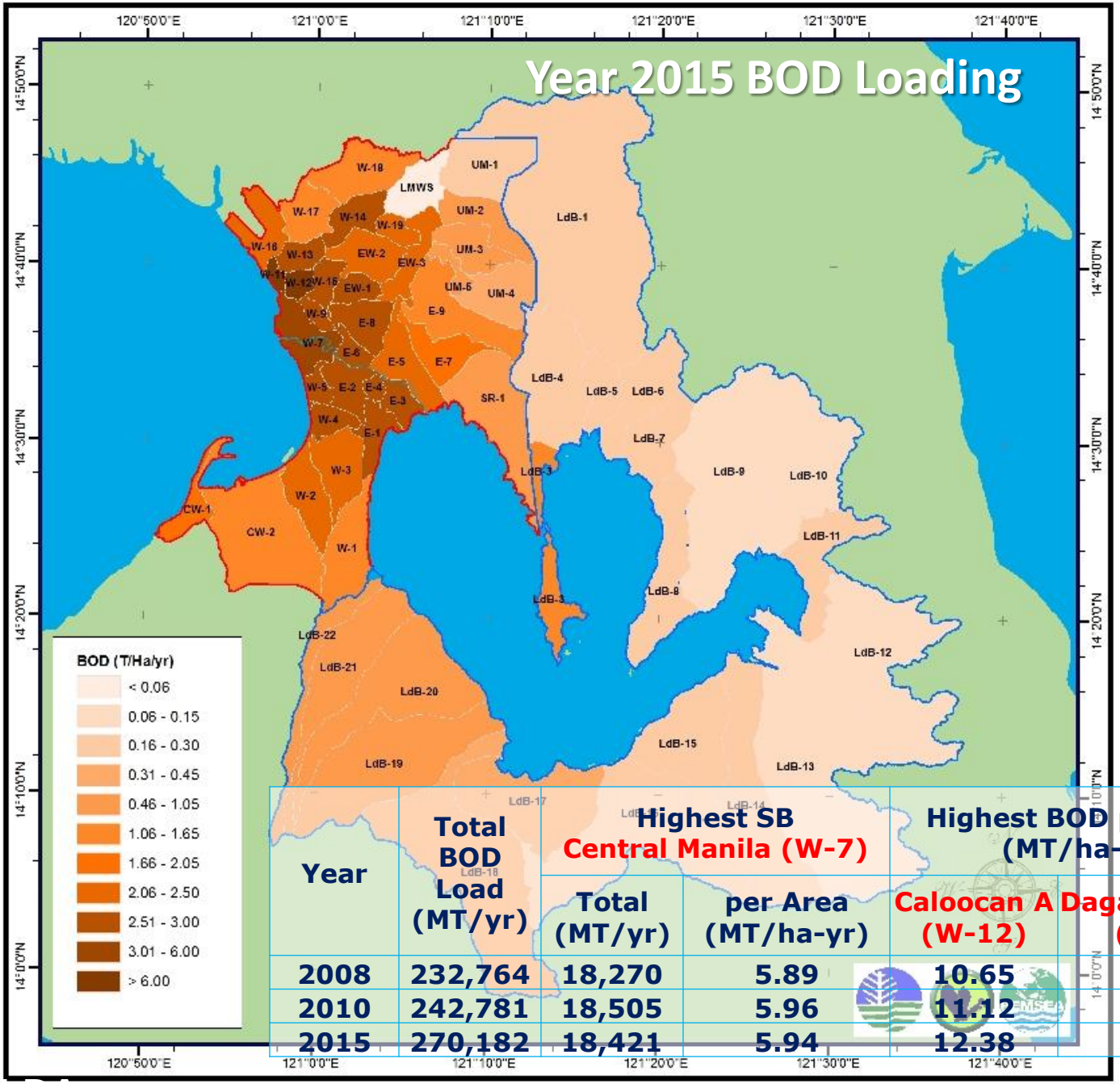
Year 2015 BOD Loading



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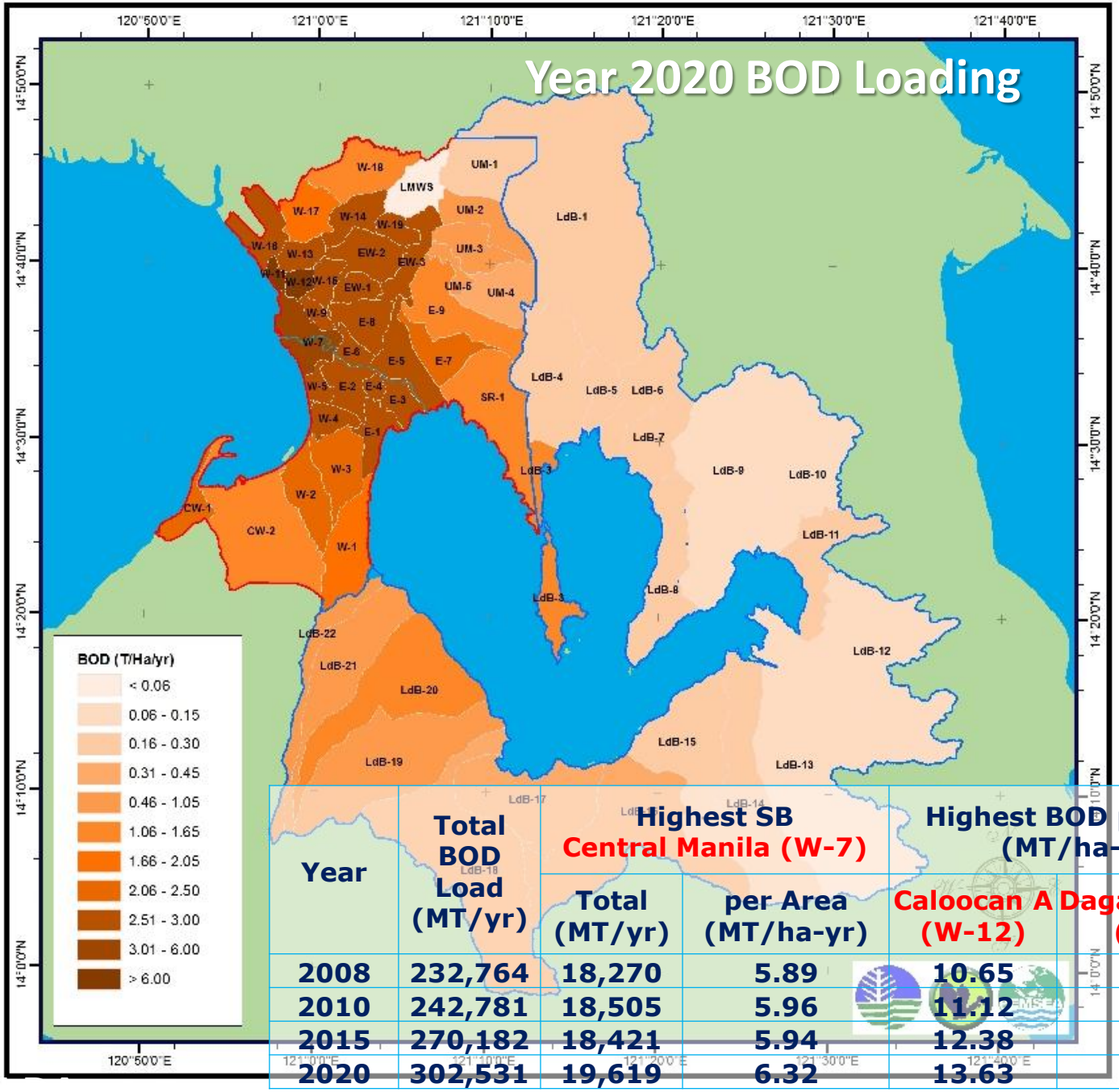
Year 2020 BOD Loading



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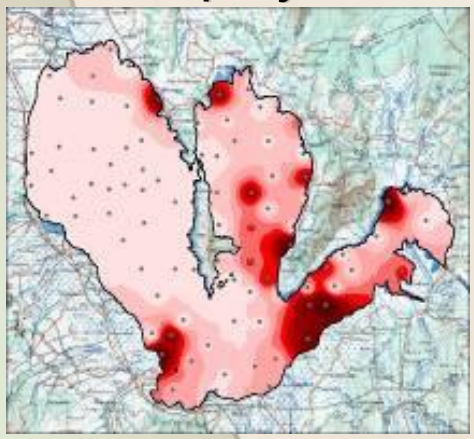
2015	270,182	18,421	5.94	12.38	9.34
2020	302,531	19,619	6.32	13.63	10.22

Water Quality Module

- calculates the concentrations of a number of substances relevant for water quality (e.g. salinity, BOD, nutrients, algae, oxygen, suspended sediment, heavy metals, etc.) throughout the entire lake, as influenced by water movement and by physical, chemical or biological processes.
- The output of the model will serve as input for sediment transport, water quality and ecological modeling and can also be used to determine future changes in the lake water especially with respect to the projected infrastructure development.

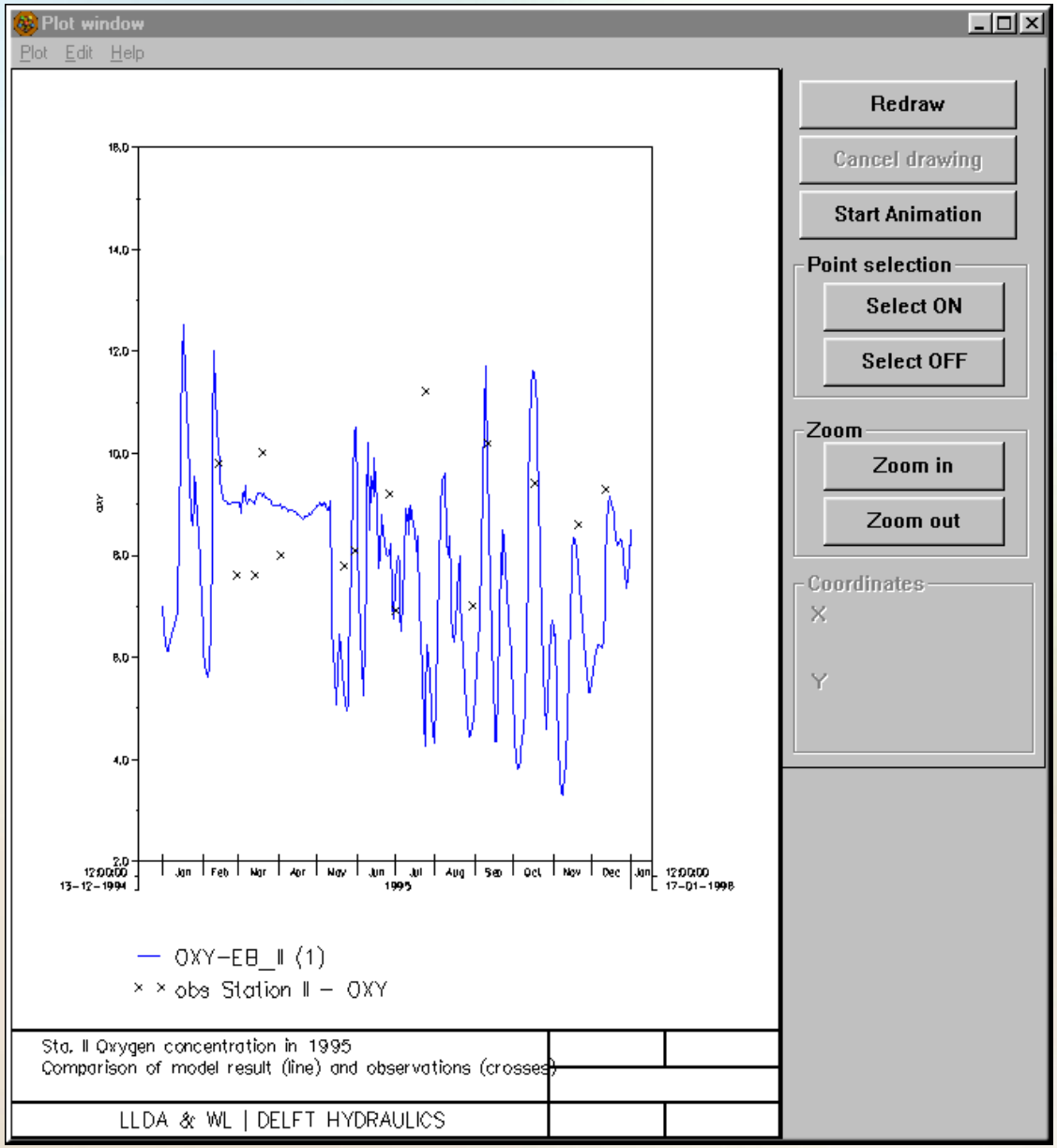


Water Quality Module

MODEL RESULT:

Time-series Plot - Sta. II Oxygen Concentration in 1995. (from *.his file)

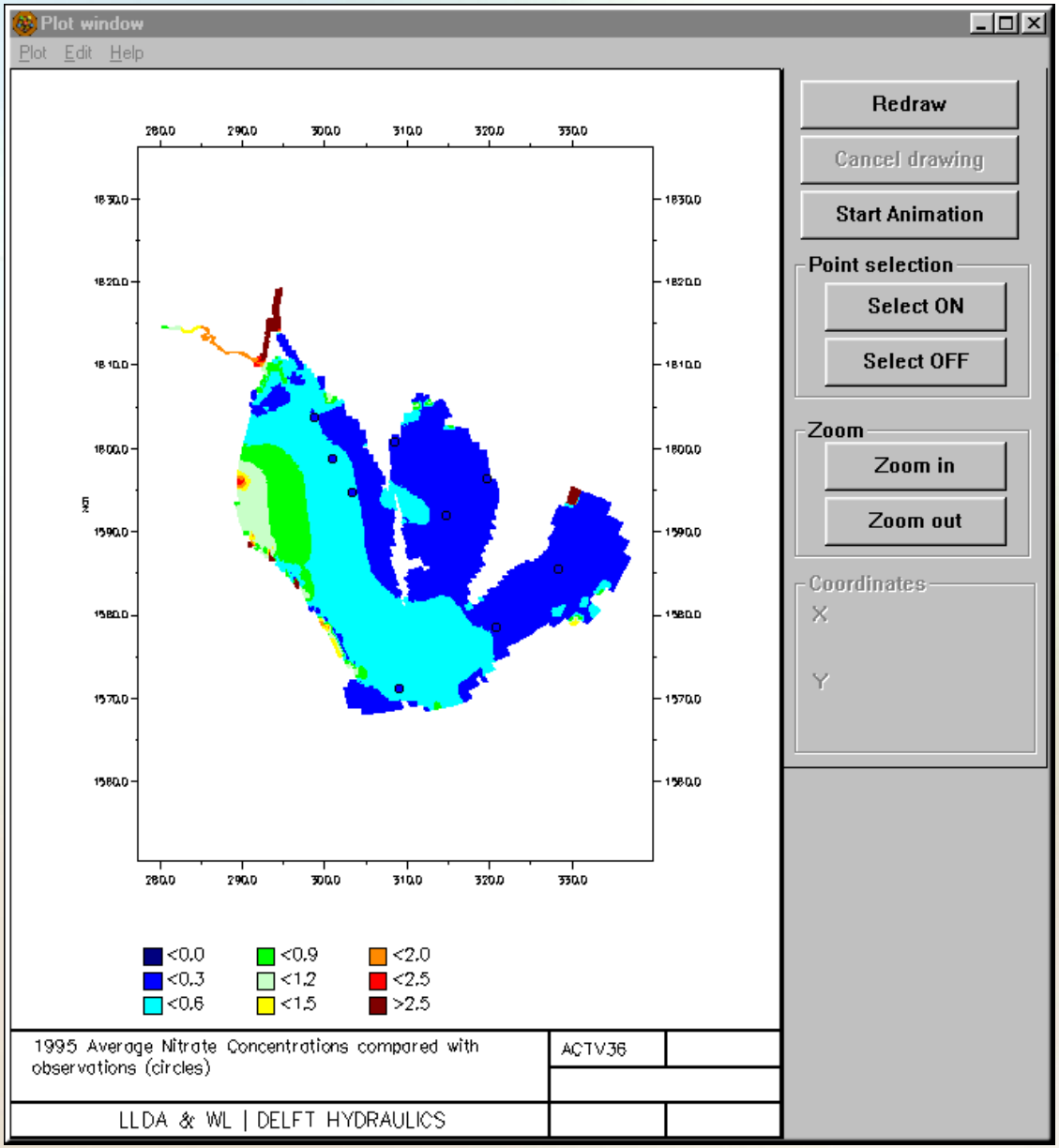
Comparison of model result (line) and observations (crosses)



Water Quality Module

MODEL RESULT:

Map Plot- 1995 Average Nitrate Concentration compared with observations (circle)
(from *.map file)

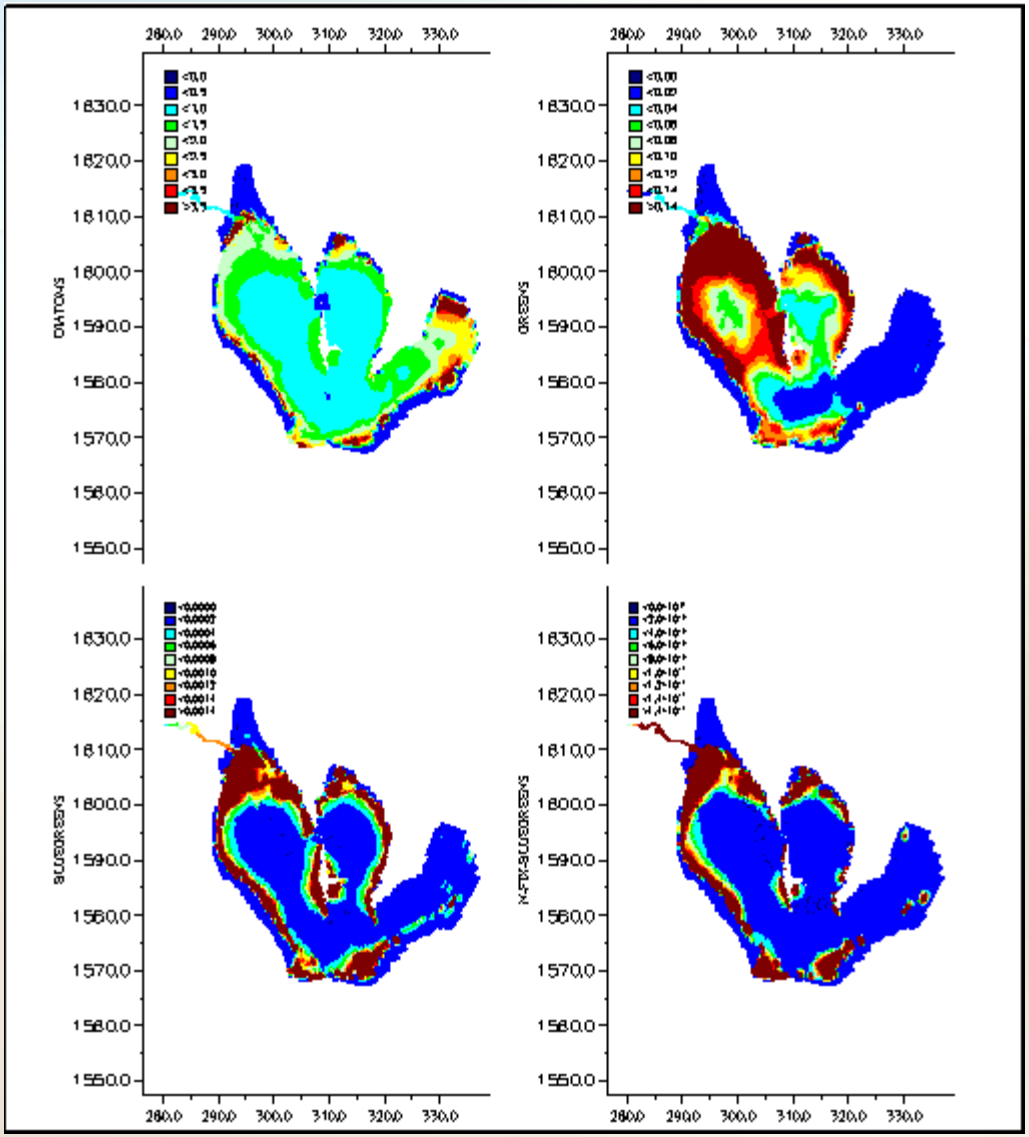


Water Quality Module

MODEL RESULT:

Map Plots-1995 average concentrations of the 4 algae species groups:

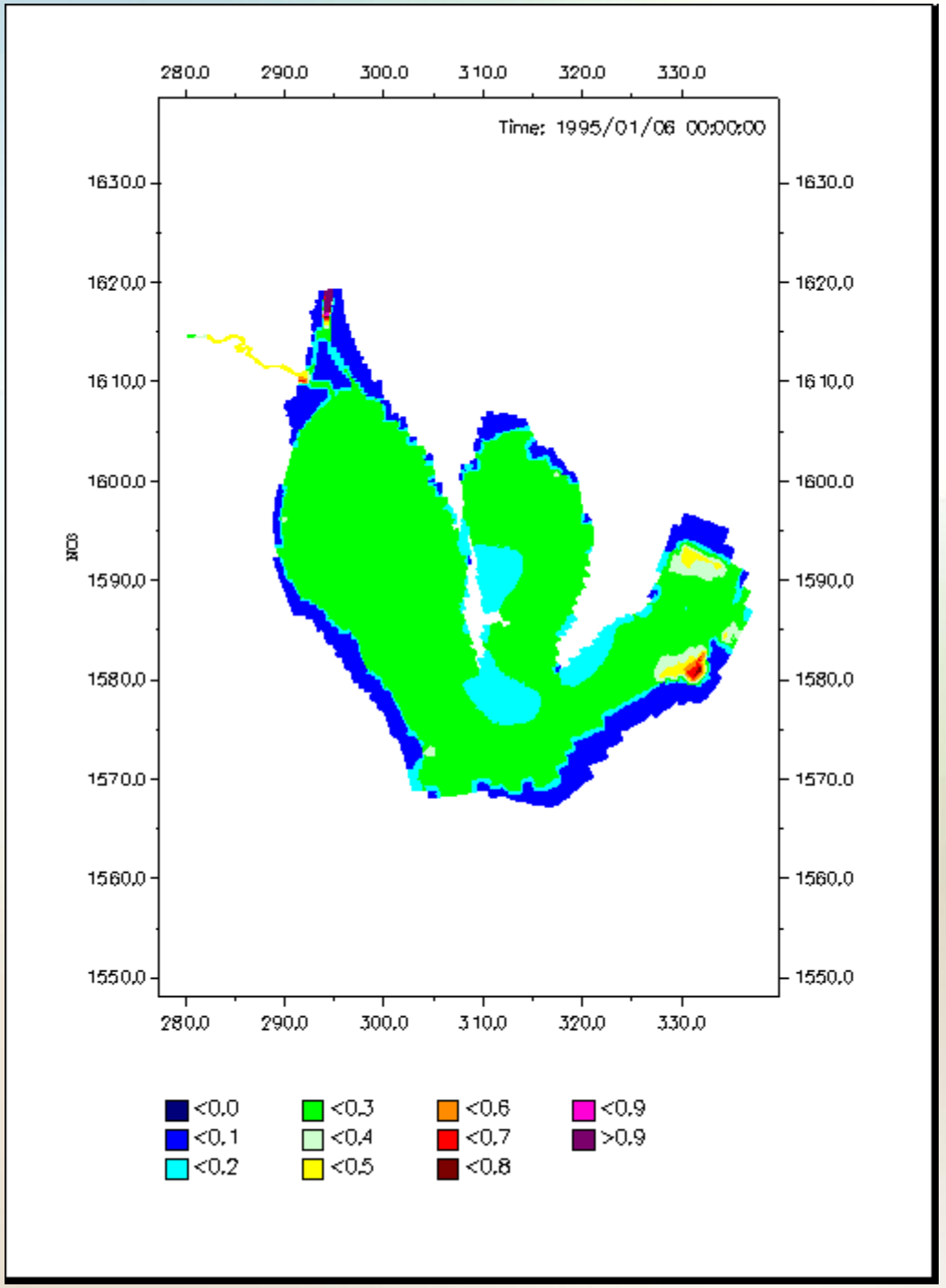
- diatoms (upper left)
- greens (upper right)
- bluegreens (lower left)
- N-fixing bluegreens (lower right)



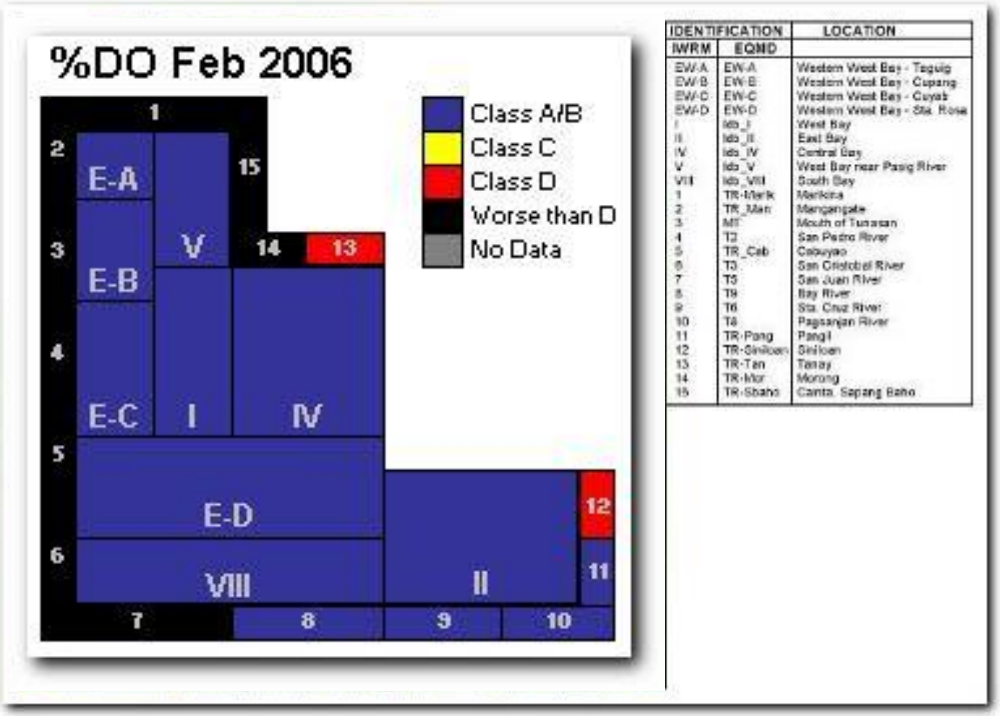
Water Quality Module

MODEL RESULT:

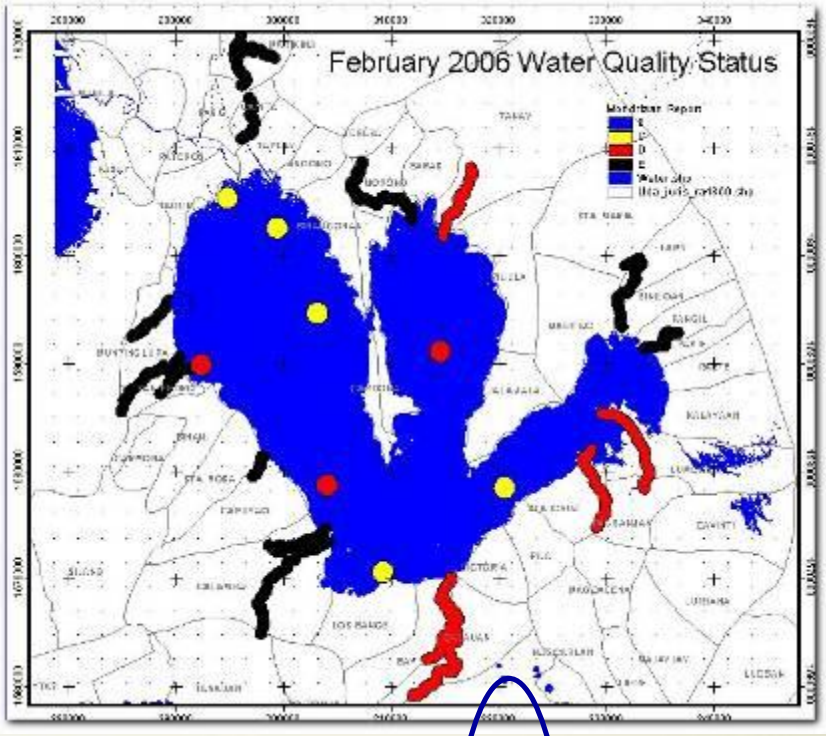
water quality simulation
(1995 Nitrate concentrations)



River and Lake Status



IDENTIFICATION		LOCATION
IWRM	EQMD	
EW-A	EW-A	Western West Bay - Taguig
EW-B	EW-B	Western West Bay - Cupang
EW-C	EW-C	Western West Bay - Cuyab
EW-D	EW-D	Western West Bay - Sta. Rosa
I	sb_I	West Bay
II	sb_II	East Bay
IV	sb_IV	Central Bay
V	sb_V	West Bay near Pasig River
VIII	sb_VIII	South Bay
1	TR-Marik	Marikina
2	TR_Man	Mangangate
3	MT	Mouth of Tunasan
4	T2	San Pedro River
5	TR_Cab	Cabuyao
6	T3	San Cristobal River
7	T5	San Juan River
8	T9	Bay River
9	T6	Sta. Cruz River
10	T4	Pagsanjan River
11	TR-Pang	Pangil
12	TR-Sinilo an	Siniloan
13	TR-Tan	Tanay
14	TR-Mor	Morong
15	TR-Baho	Canta. Sapang Baho



STATION		MONDRIAAN MONTHLY STATUS 2005											
ID	Location	january	february	march	april	may	june	july	august	september	october	november	december
I	Central West Bay												
II	East Bay												
IV	Central Bay												
V	Northern West Bay												
VIII	South Bay												
E-A	Taguig												
E-B	San Pedro												
E-C	Binan												
E-D	Sta. Rosa												
1	Marikina River												
2	Mangangate River												
3	Tunasan River												
4	San Pedro River												
5	Cabuyao River												
6	San Cristobal River												
7	San Juan River												
8	Bay River												
9	Sta. Cruz River												
10	Pagsanjan River												
11	Pangil River												
12	Siniloan River												
13	Tanay River												
14	Morong River												
15	Sapang Baho River												

* Only listed parameters with DENR water quality criteria for freshwater systems have been included in the assessment of the overall status

STATION		MONDRIAAN MONTHLY STATUS 2006				
ID	Location	january	february	march	april	may
I	Central West Bay					
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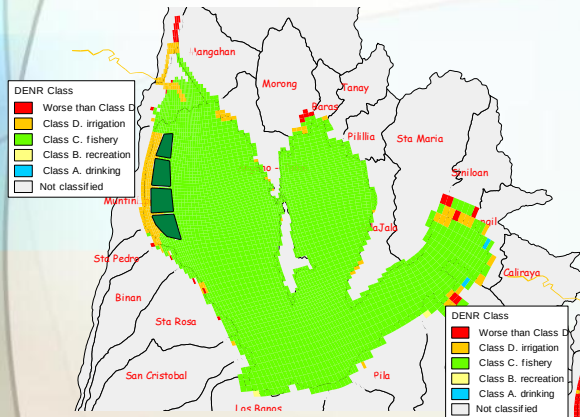
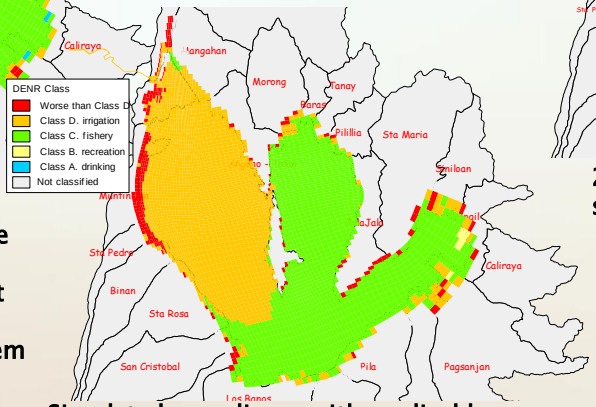
9	Sta. Cruz River					
10	Pagsanjan River					
11	Pangil River					
12	Siniloan River					
13	Tanay River					
14	Morong River					
15	Sapang Baho River					

Ecology Module

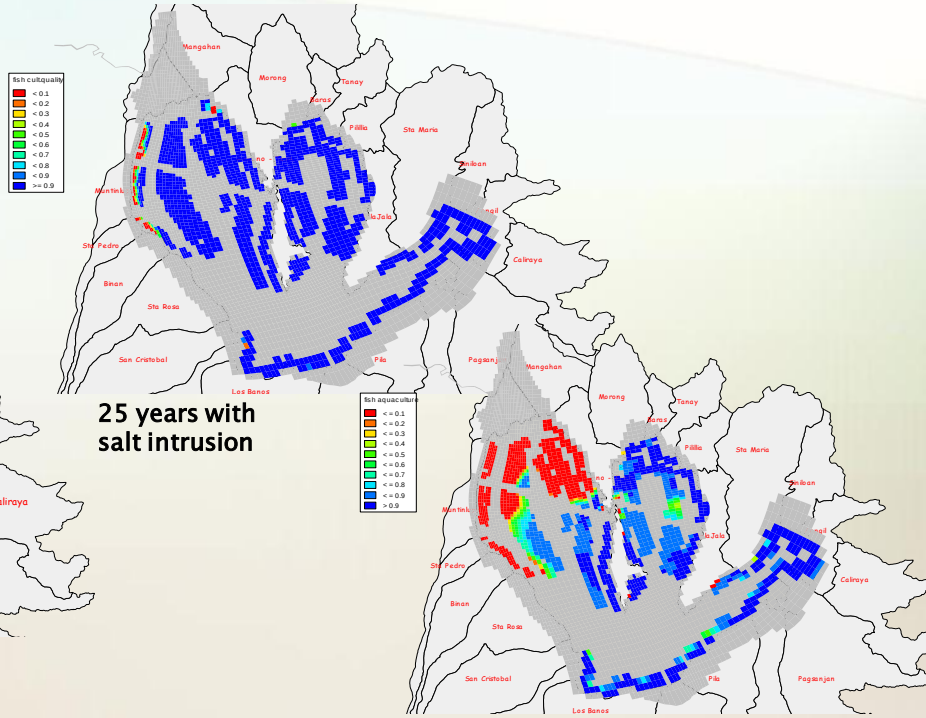
- provide necessary information about the status of Laguna de Bay for human use and natural values
- understanding changes in the lake's suitability for varied uses in response to changes in environmental factors and water quality



Simulated compliance with applicable DENR criteria for autonomous development (10 years from now), with the interceptor system



Simulated compliance with applicable DENR criteria for autonomous development (10 years from now), without the interceptor system



25 years with salt intrusion

25 years without salt intrusion

NARBO's 9TH IWRM TRAINING 12-19 May 2014 · Philippines

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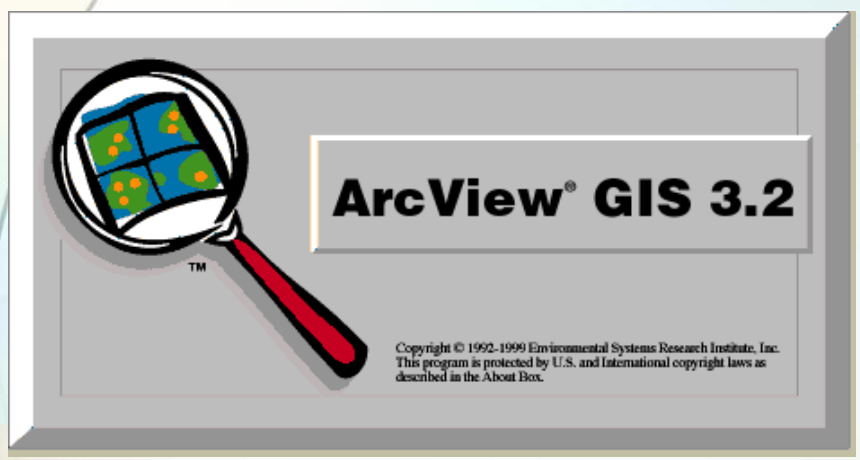
Geographic Information Systems

- Delineation of watershed
- Map generation as input for the DSS modules
- Mapping of model results
- Development of a **Hydrological Atlas of the LdB**
- Landcover change analysis
- Central repository/database for spatial data
- Generation of flood maps

Coupling of GIS and Delft3D software



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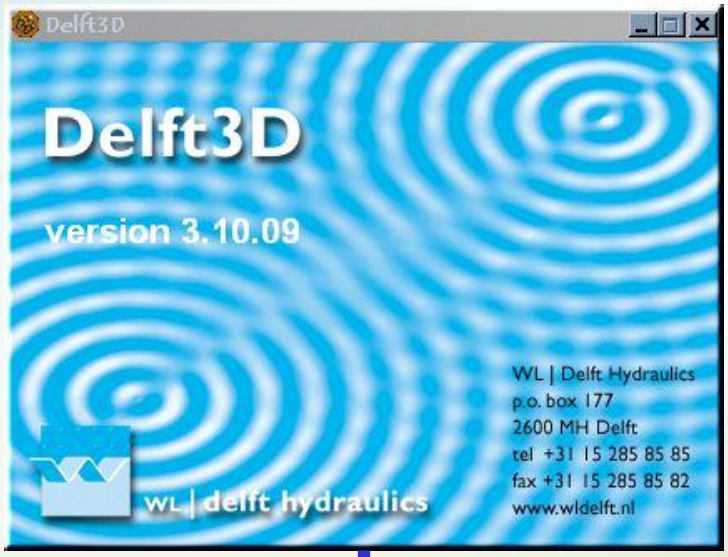
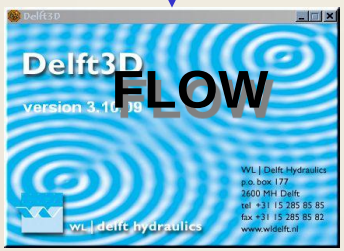
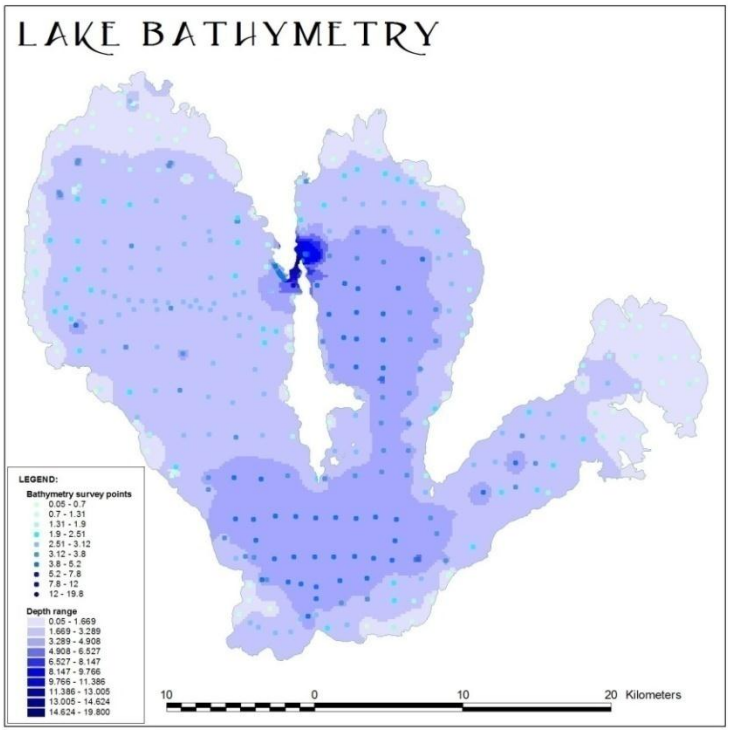
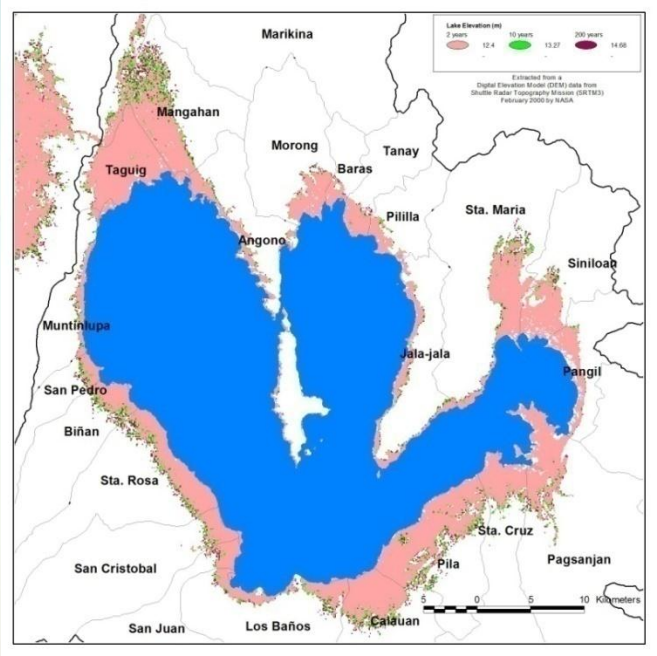


- exporting and importing land boundary file
- view results of simulations
- data analysis/data processing

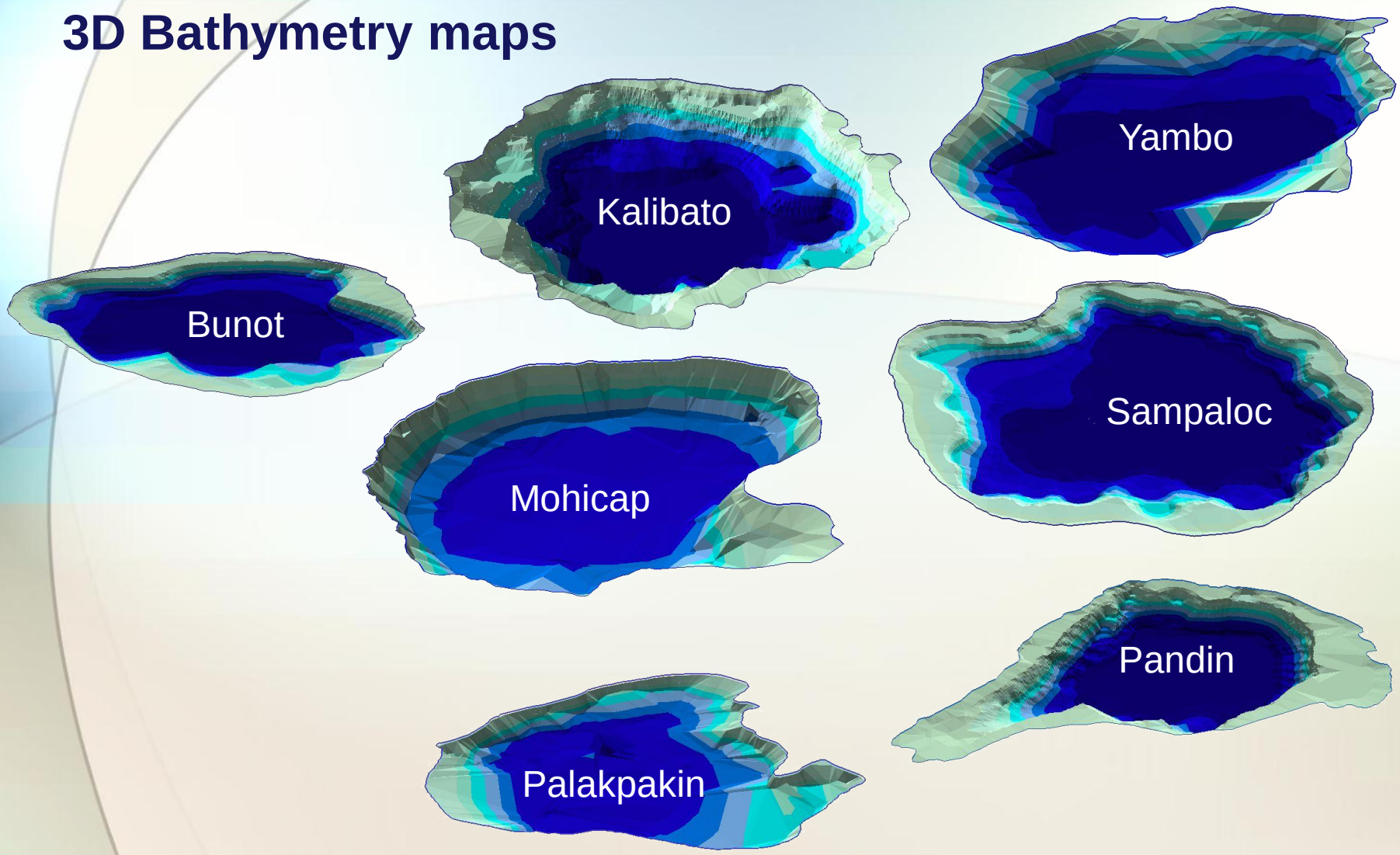


Bathymetry and Flood Maps



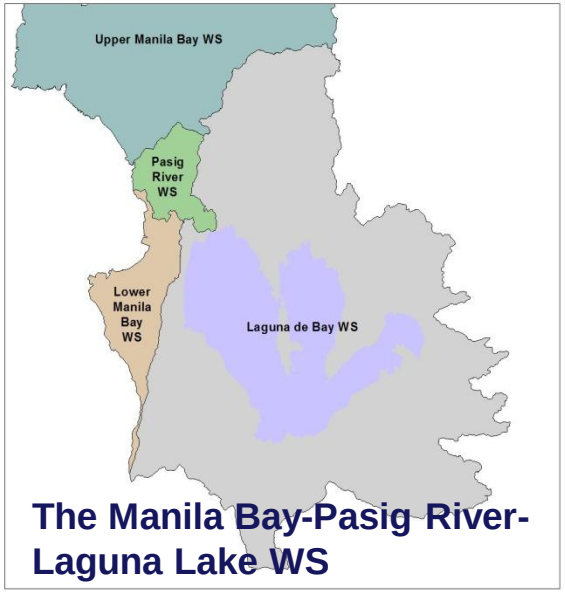


3D Bathymetry maps

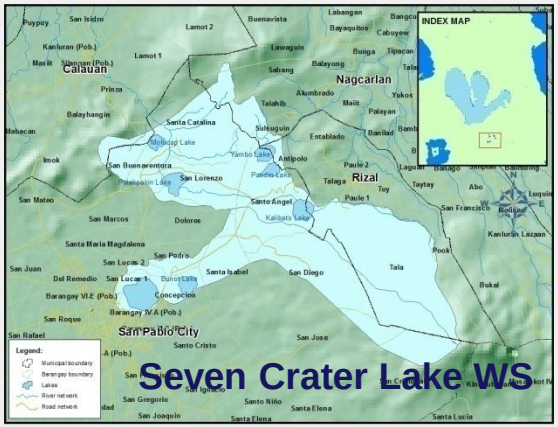


The Seven Crater Lakes of San Pablo City

Delineation of watershed

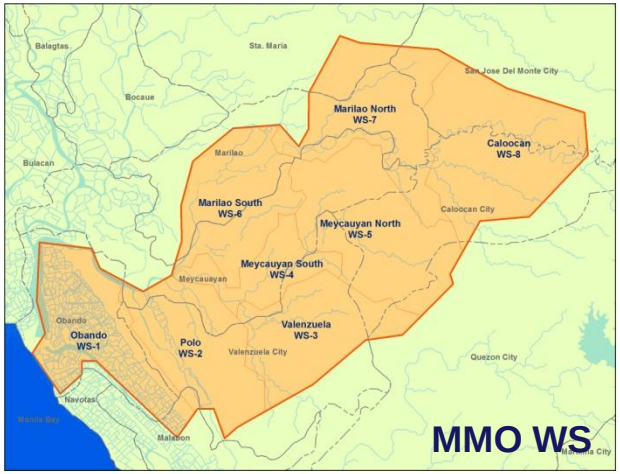


The Manila Bay-Pasig River-Laguna Lake WS

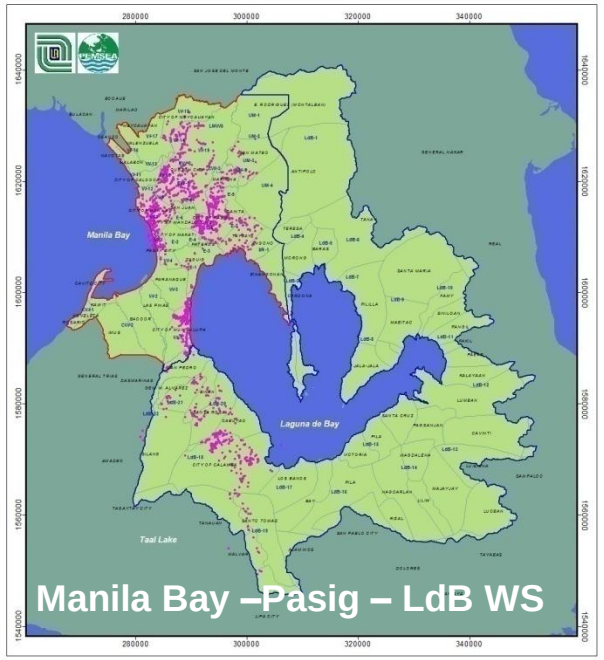


Seven Crater Lake WS

Manila Bay WS

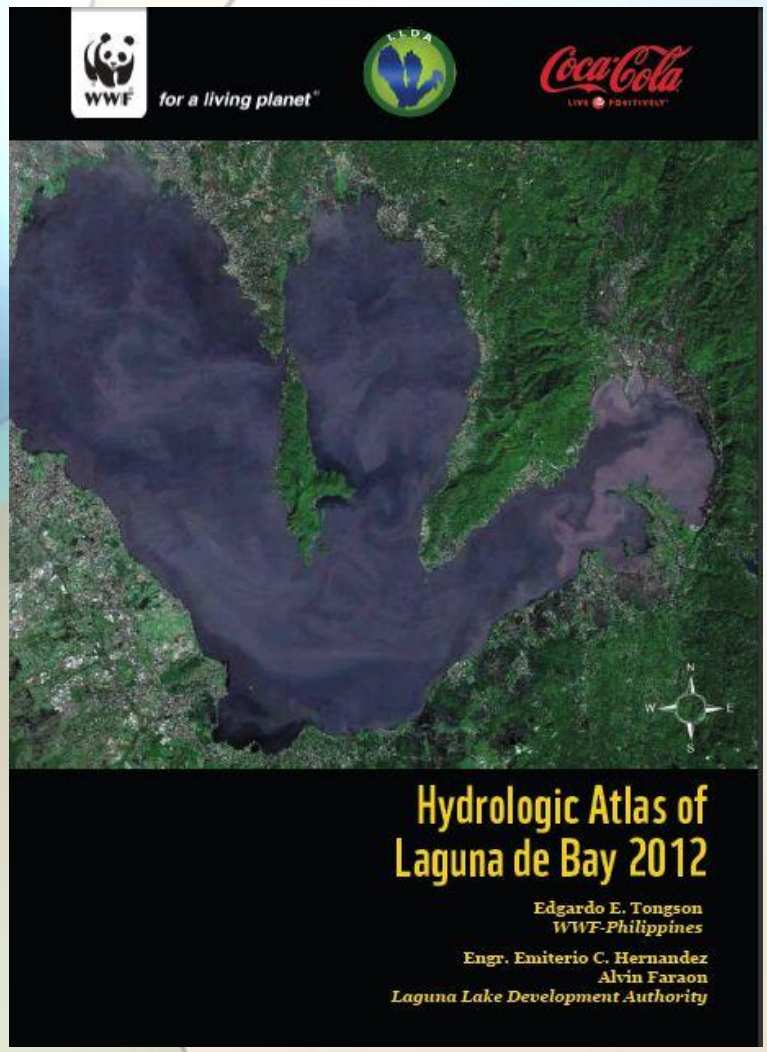


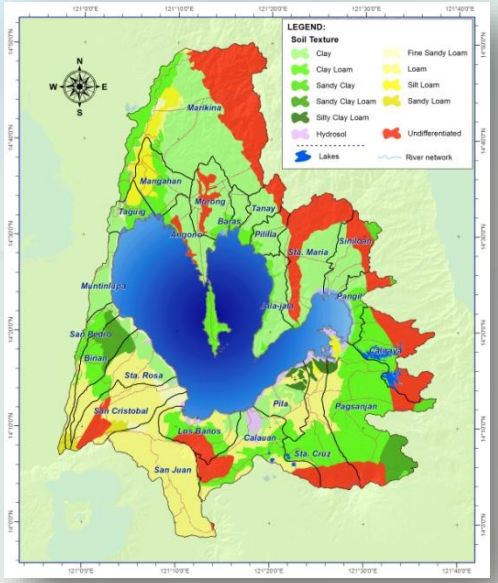
MMO WS

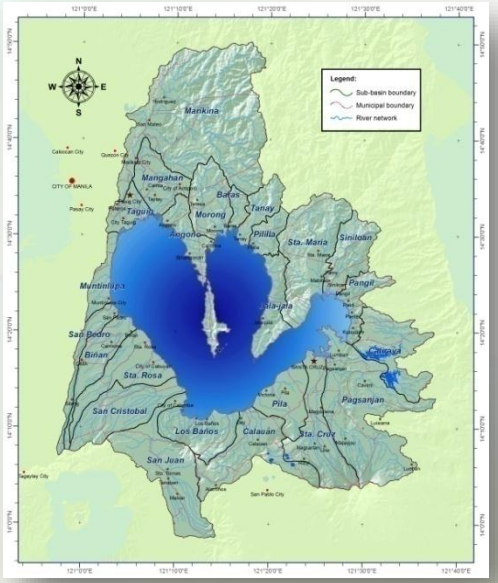


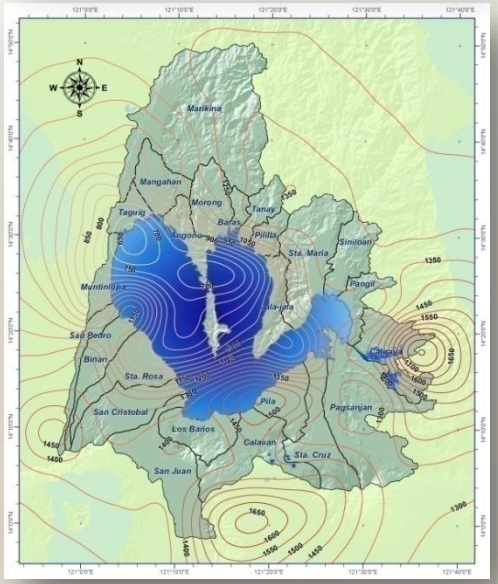
Manila Bay –Pasig – LdB WS

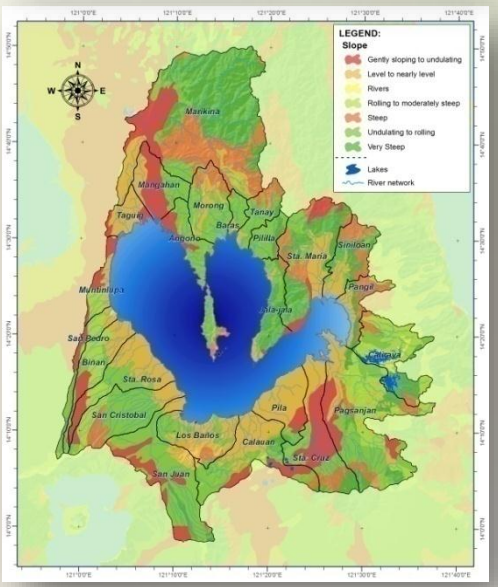
Hydrological Atlas of the LdB Region



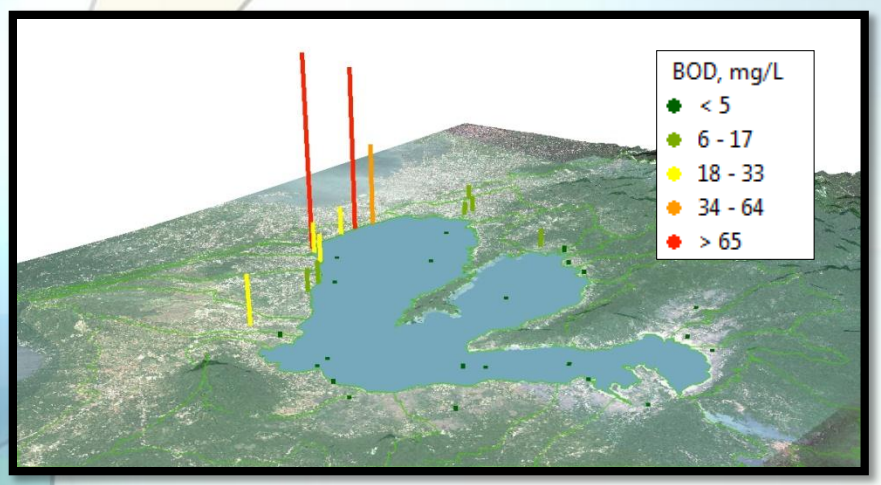


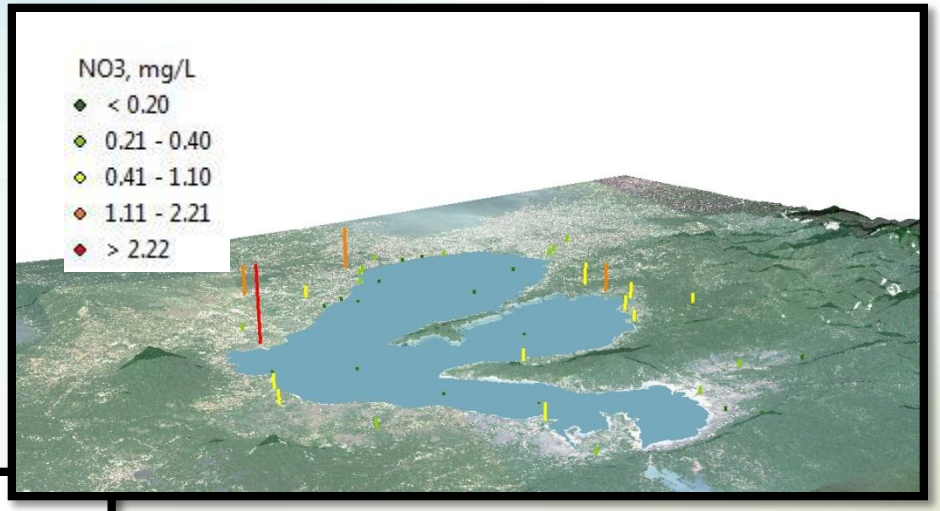


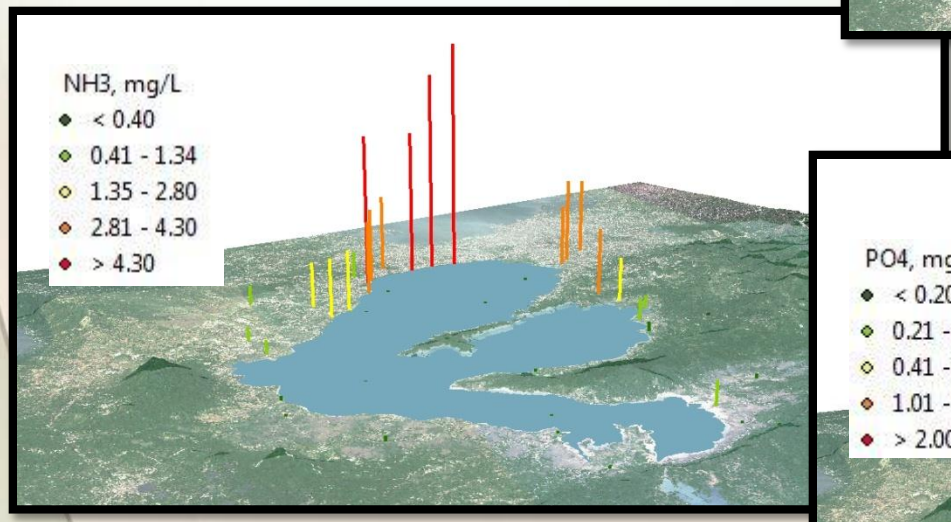


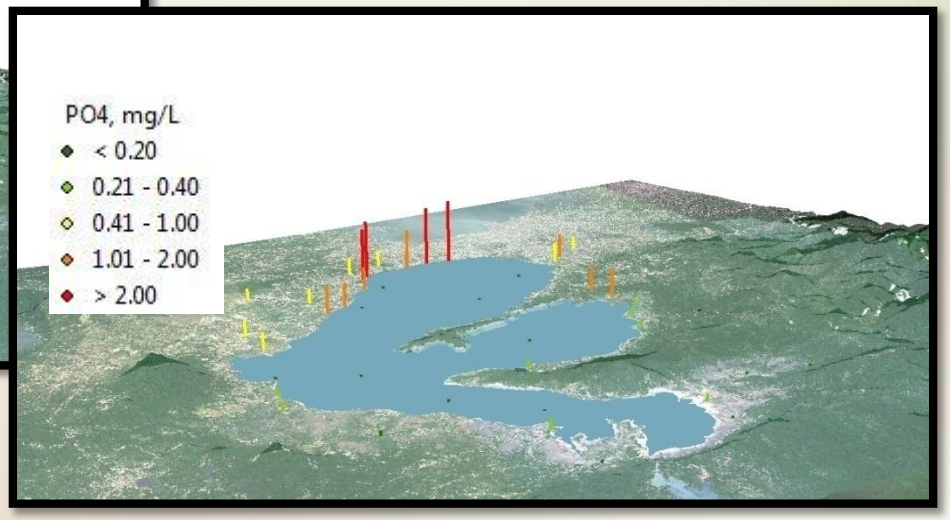


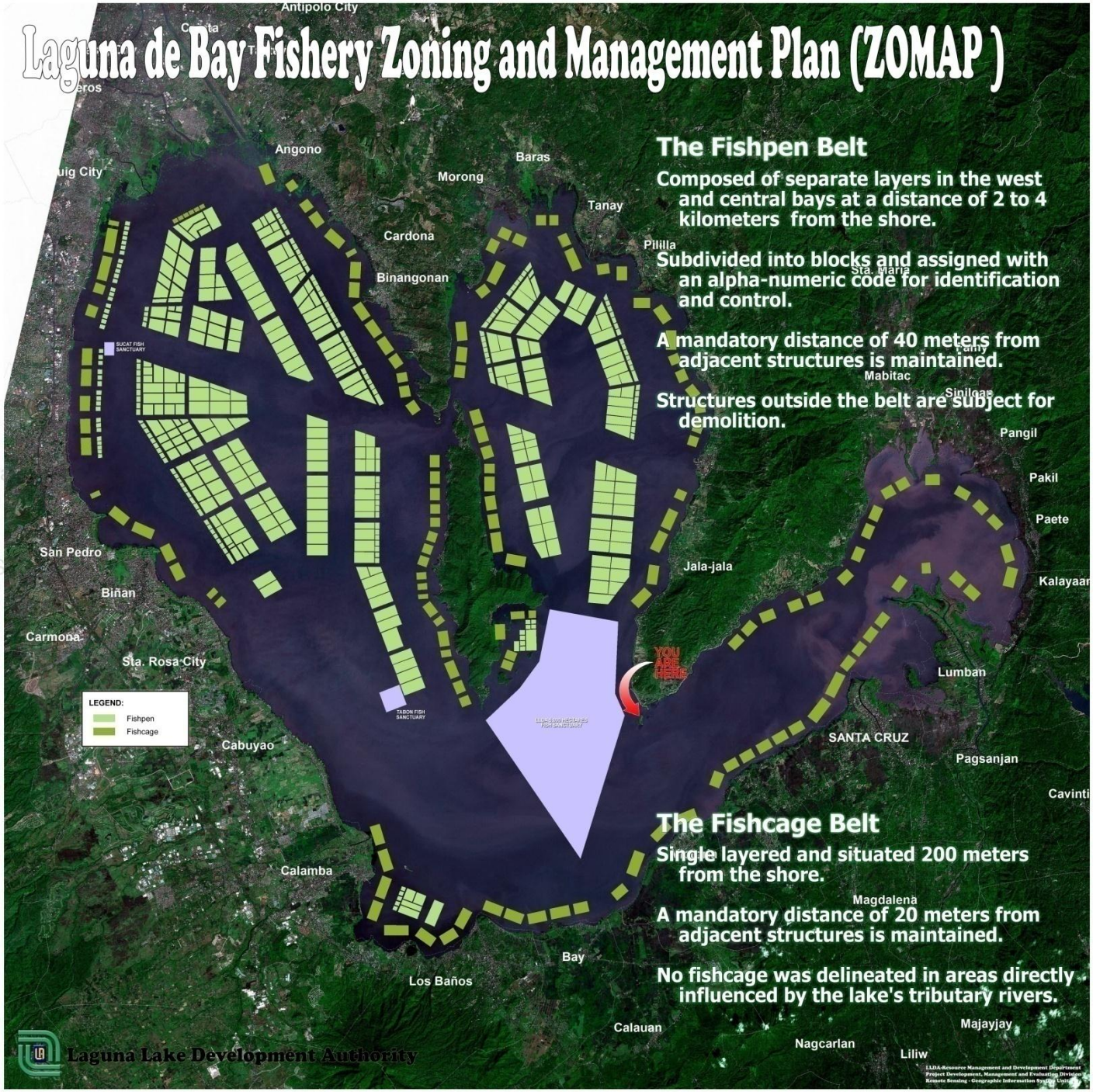
Water Quality Results 3D mapping



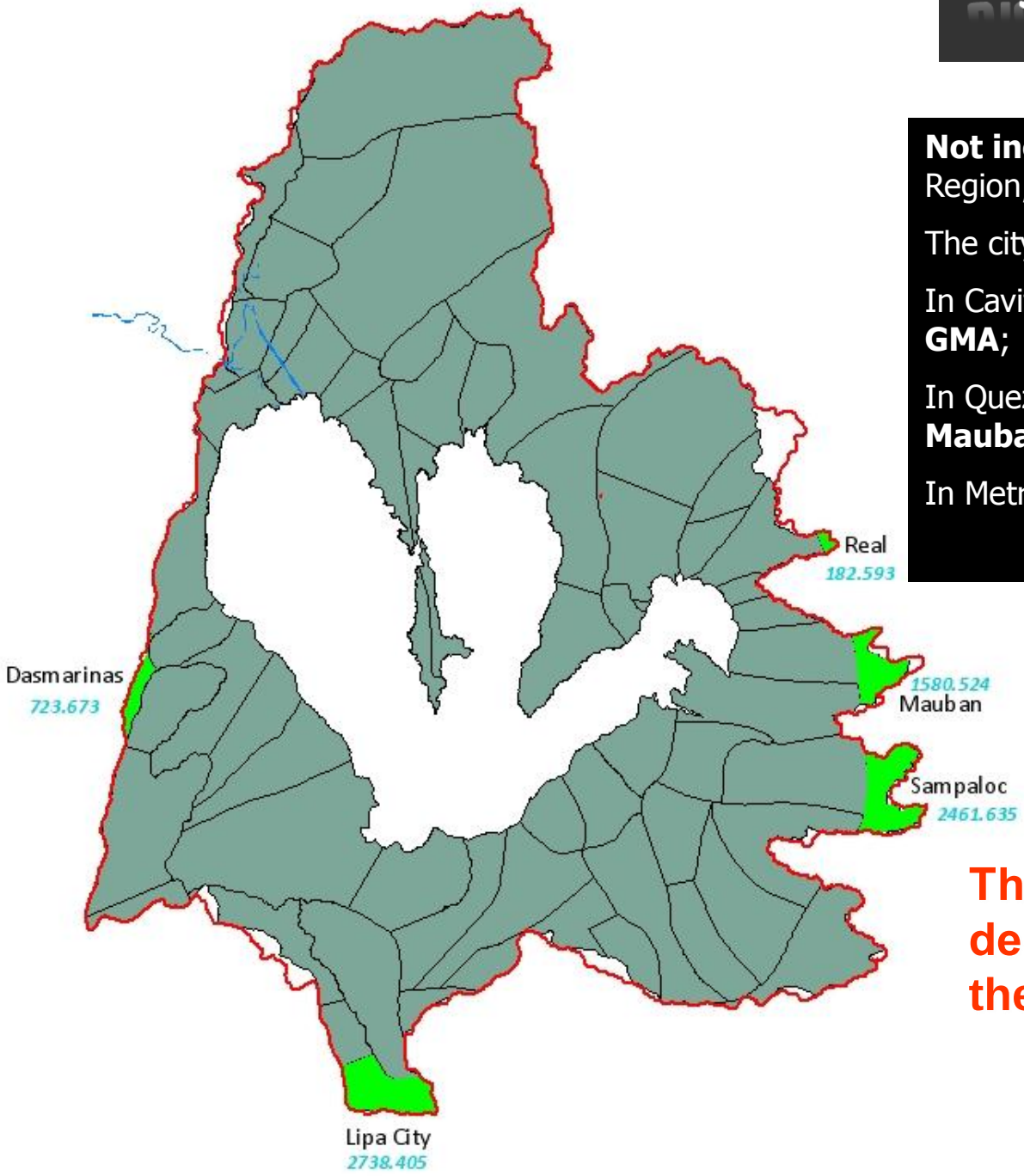








Digitized from NAMRIA Map



Not included in the LdB Region;

The city of **Lipa**;

In Cavite: **Dasmarinas, GMA**;

In Quezon: **Sampaloc, Mauban, Real**

In Metro Mla: **MAMASAN**

The expanded "Laguna de Bay Region" under the Proposed LLDA Bill

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Opportunities and Challenges for the DSS

- As much as LLDA is the only government agency having a mandate on a hydrologically-determined jurisdiction, it has been developing and improving on the implementing IWRM. Experiences and key lessons learned should be harnessed.
- The DSS is a flexible tool and can be utilized on other locations.
- DSS is an interconnected set of modeling tools. Models by nature are refined by calibration using actual data. Data sharing is still a sensitive issue locally.
- Institutionalization of DSS in LLDA introduces a new approach of government and Academic institution collaboration on researches and implementation.
- Confidence, acceptance, and utilization of modeling technologies for local planning, decision and policy making

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Opportunities and Challenges for IWRM

- The lake has become an important economic resource to a growing population
- The lake is a viable source of raw water to address the current and future water requirement
- Existence of other agencies, entities and volunteers dedicated to monitoring/preserving the lake or the watershed
- Poor compliance of watershed users to regulatory and economic measures for environmental improvement
- Lack of common vision for the lake thus the lack of strict consideration for environmentally sound and viable practices
- Existing and increasing land and water use conflicts

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Plans and Recommendations

- To upgrade outdated softwares and hardwares;
- To **further train and equip LLDA technical staffs on the use of the models;**
- To strengthen the use of DSS as a tool for IWRM in the decision making process within the purview of a science-based management options for the agency;
- Increasing the capacity of LLDA as RBO thru expanding the capabilities and application of existing LLDA's DSS to include projections & assessment of water-related disaster events & climate change; simulations of adaptation measures

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- Expansion of LLDA DSS

  LLDA enters into a Memorandum of Agreement with Manila Bay Coordinating Office (MBCO) to:

✓ facilitate the upgrading of the LLDA's existing models and in the development of the Manila Bay 3D Hydrodynamic and Water Quality Model that can be linked to the existing 3D model for Laguna de bay;

✓ expand the application of LLDA's Ecological Model coupled with Waste Load Model to cover the Manila Bay;

The MOA will include the following:

- Estimate allocation of allowable pollutant discharge loadings, based on the results;
- Include existing and planned STPs in the schematization for routing domestic loads;
- Run model scenarios to consider various intervention measures (i.e, impacts of STPs, sewerage, BMP for agriculture and industry sources, etc.)
- **Develop water quality models for Manila Bay and Pasig River;**
- **Modeling other major rivers (NMTT, Pampanga River) draining into Manila Bay.**

Thank You!!!

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