EAD514 RIVER ECOSYSTEM

INSTRUCTORS	LECTURE TIMES & VENUE	* INPORTANT DATES *
Prof Dr Chan Ngai Weng nwchan@usm.my **Prof Dr Mashhor Mansur** mashhor@usm.my	**Lectures: Fridays 3-5pm & 5.30-7.30pm** Room: BT3 School of Civil Engineering	**29 July 2008 Test #1 (1 Hour) Answer 2 out of 4 questions. (5%)** **Test #2 (1 Hour) – To be informed (5%)** **Assigment # 1 – 1000 words. Deadline 18 July (5%)** **Assigment #2- 1000 words. Deadline 1 August (5%)** **Assigment # 3 – To be informed (5%)** **Assigment # 4 – To be informed (5%)** **Mini-project # 1 – 2000 words. Deadline 12 Sept (5%)** **Mini-project # 2 – To be informed (5%)** **FINAL EXAM: (60%) – Answer 4 questions out of 5.**

COURSE OUTLINE

Rivers are vitally important for humans as they are for nature and other life forms. In terms of human society, rivers have historically been man's early settlement locations as they offer transport and accessibility via the seas and inland. They were the highways of the past. Hence great civilisations have sprung up on the banks of rivers. Even today, many capital cities, including Kuala Lumpur, are still on the banks of major rivers[1]. More than that, rivers are the life veins of a country and provide water supply for human society, irrigation for agriculture, water sources for industries; hydro-electric power supply, recreation and tourism, fisheries and aquaculture, and a whole range of other uses. All these have been emphasised in the myriad ways in which rivers have been used, altered, re-engineered, restored, conserved and rehabilitated for the benefit of human society. We do live in a human-centric world whereby almost all resources are channelled towards human society, leaving precious little for nature and other life forms that equally depend upon them[2].

However, as are with many natural resources, rivers do not solely belong to humans alone. Rivers mould the landscape giving us the unique features of geomorphology such as in the Great Canyon of the Colorado River in the USA, the three gorges in the Yangtze River in China, Niagara Falls between thee USA and Canada, the Iguaçu Falls in Brazil and others.

[1] Chan N W (Editor) (2002) *Rivers: Towards Sustainable Development.* Penang: Penerbit Universiti Sains Malaysia.

[2] Chan, N.W. (2004) Sustainable River Management in Malaysia: Involving All Stakeholders. In Aminuddin Ab. Ghani, Nor Azazi Zakaria, Rozi Abdullah and Mohd. Sanusi S. Ahmad (Editors) *"Rivers '04 Proceedings of the 1st International Conference on Managing Rivers in the 21st Century: Issues & Challenges"*. River Engineering and Urban Drainage Research Centre (REDAC), Engineering Campus, Universiti Sains Malaysia, 35-61.

The river and its riverine and aquatic environment support a wide range of flora and fauna. Our very own Sg Selangor is home to the famous "kelip-kelip" or fire flies in Kampong Kuantan, Selangor[3]. The minnow is now one of the least abundant fish species. Within the U.SA., the minnow currently survives in very limited locations in three tributaries to the Rio Grande; the middle Devils River, Pinto Creek, and San Felipe Creek and may also persist in the Rio Salado in Chihuahua, Mexico. Endangered salmons also depend on the river for their life-long migration down and up the Salmon River in Oregon, USA. In the Yangtze River in China, two species of aquatic mammals - the Chinese river dolphin (*Lipotes vexillifer*), and Yangtze finless porpoise (*Neophocaena phocaenoides*) are of special concern as they are threatened by pollution, habitat destruction, and fishing operations along this mighty river. Despite such importance and beauty, many rivers are not well conserved and protected from over-development and exploitation. Worse, many rivers are badly polluted to the extent that they are described as "dead" rivers. Ismail Serageldin, Chairman of the World Commission on Water for the 21st Century warned the world that the World's rivers are in "Crisis" as some are dying and others could die. More than half of the world's major rivers are being seriously drying up and polluted, degrading and poisoning the surrounding ecosystems, thus threatening the health and livelihood of people who depend upon them for irrigation, drinking and industrial water. "Overuse and misuse of land and water resources in river basins in both advanced industrial countries and developing countries is the primary cause for their decline," and "The land and water crisis in river basins contributed to the total of 25 million environmental refugees in 1998, which for the first time was more than the number of war-related refugees. By 2025, the number of environmental refugees could increase 4 times[4]."

Regrettably, rivers provide a convenient medium for transportation and serve as easy conduits for the discharge of varying domestic, commercial, industrial and agricultural effluents. Although the natural function of rivers is to act as drainage channels to convey excessive flows to the sea, many rivers are so over-taxed and grossly polluted that rivers are unable to cope. According to Hj Keizrul Abdullah (2002)[5], *"In its natural state, rivers play an important role in maintaining the ecological balance of the river basin. Through its self-purification abilities, the river is able to absorb and cleanse itself of wastes and impurities, thus maintaining a threshold of river water quality that is able to enrich the natural beauty and to support an abundance of flora and fauna. The opening up of catchment areas for human activities have resulted in adverse changes to the river regime, with more severe floods during the wet season and more pronounced dry spells. Consequently, the role played by the river have diminished in importance, and its ability to support the eco-system is greatly threatened. Today, many of our rivers are in an appalling state and in many urban areas, have been turned into open sewers."* Clearly, there is a need to conserve, protect and more importantly allow some aspects/resources of rivers to be retained for vital ecosystem functions (e.g. maintain adequate flow for pollution dilution, fauna spawning, wetlands etc) and to be used by other beneficiaries such as natural flora (e.g. wetlands) and fauna (e.g. salmon).

The above deplorable state of rivers is quite true of Malaysian rivers in general, though the country still has many pristine rivers (which need to be protected and conserved if we do not want to see them degenerate into "dead" rivers). In Malaysia, Prime Minister Abdullah Badawi has mentioned a few times about the deplorable state of rivers in the country. He stated that if he were to put a frog into the Sg Pinang some years ago, it would not survive. More recently, he switched the frog to a crocodile, saying that the crocodile will also not survive in Sg Pinang. Malaysia's rapid pace of industrialisation and economic development

[3] http://www.splash.com.my/fireflies/fireflies1.htm 10/07/08

[4] http://www.hewett.norfolk.sch.uk/curric/NEWGEOG/Africa/waterwa1.htm 10/07/08

[5] Hj Keizrul Abdullah (2002)Integrated River Basin Management. In N W Chan (Ed) *Rivers - Towards Sustainable Development.* Pulau Pinang: Penerbit Universiti Sains Malaysia, 3-14.

since the 1980s have brought much wealth to the people and fame to the country, but at the same time have overstressed its river systems. In some basins, rivers have reach the limits of easy water availability, and storage facilities such as dams, together with inter-basin and inter-state water transfers (e.g. from Pahang to Selangor and Kuala Lumpur) are needed to meet our needs during the dry seasons. In addition, the waste products of man and his activities have resulted in a number of rivers that are very polluted and here efforts are needed to rehabilitate them to manageable levels. Such rapid development have also resulted in the opening up of large tracts of land within river basins and this has resulted in not only increased sediment loading in the river systems but also in the aggravation of floods (Hj Keizrul, 2002). All these have also impacted negatively on river ecosystems. Many rivers are devoid of aquatic fauna. In the Sg Kelang, only the "Bandaraya" species of fish (a species of catfish) had survived the pollution. There is totally no vegetation along the river when it flows through the Federal Capital. It is more like a drain than a river. How then can one describe the Sg Kelang in Kuala Lumpur as a river?

Dams are a serious issue that has brought devastation to many rivers in the world. In Malaysia, the Sg Selangor Dam has been faced with much resistance from civil society[6]. According to the International Rivers' Organization[7], uncontrolled dam construction had choked more than half of the earth's major rivers with more than 50,000 large dams towards the end of the 20th Century. Though developed countries such as the USA, parts of the EU and Japan begun to reverse the trend by demolishing dams and "freeing" rivers (these actions are few and far between), developing countries have taken over from where the developed countries have lfet off. For example China is probably now the country that builds more dams at a faster rate than any other country. The Three Gorges Dam[8], while ostensibly bringing huge benefits to people, has "disastrous" consequences as well, most notably on the river environment and river ecosystems[9]. The IRO has documented that the consequences of such massive engineering dam building programs have been devastating. It claims that "…. *the world's large dams have wiped out species; flooded huge areas of wetlands, forests and farmlands, and displaced tens of millions of people. The "one-size-fits-all" approach to meeting the world's water and energy needs is also outdated:* ***better solutions*** *exist. While not every dam causes huge problems, cumulatively the world's large dams have replumbed rivers in a massive experiment that has left the planet's freshwaters in far worse shape than any other major ecosystem type, including tropical rainforests. In response, communities are starting to* ***take down dams***[10] *that have outlived their usefulness, as part of a broader river restoration movement"*.Given the facts about the negative effects of large dams on river ecosystems (as well as other effects) that has already happened in developed countries, it would be prudent for developing countries to reconsider other options other than sticking blindly to just dam building. Many countries have shown that there are viable options for development that are balanced between the need for development and the need for conservation. The two need not be mutually exclusive, but can in fact be complementary[11].

In many countries there is a fierce debate over the scope of river/watershed management – whether it should be limited to merely the technical and engineering aspects of river management, or should it encompass also river ecosystem management, and include cultural

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[6] http://www.magickriver.net/deepak.htm 10/07/08
http://www.malaysia.net/lists/sangkancil/2000-03/msg00203.html 10/07/08

[7] http://internationalrivers.org/en/node/287 10/07/08

[8] http://www.ctgpc.com/ 10/07/08

[9] http://internationalrivers.org/node/356 10/07/08

[10] The San Diego Union Tribun, July 24, 2007 & Albion Monitor *May 22, 1997* (http://www.monitor.net/monitor)

[11] Daly HE and Cobb J 1994 *For the common good: Redirecting the economy towards community, the environment band a sustainable future*. Boston: Beacon Press.
Naiman et al . 1998 Watershed Management. In Naiman, R.J. and R.E. Bilby. 1998. River ecology and management in the Pacific coastal ecoregion. Pages 1-10, in R.J. Naiman and R.E. Bilby (Editors). *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion*. Springer-Verlag, New York, 642-682.

aspects of river use. All these relate to important issues such as identifying appropriate spatial and temporal scales, monitoring and assessment, developing an adaptive management process, and using cultural values and philosophies that allow river/watershed management to be successful. We have seen the bad effects of what a rapidly increasing human population and an expanding economy in a fast developing country can do to alter river/watershed characteristics if rivers are not protected enough. Hence, it makes it essential to incorporate an ecological perspective into management of rivers if we harbour any hope of saving rivers as natural heritage (i.e. a healthy resource base) for future generations.

Unlike other courses in sustainable river management run with a focus on the technical/engineering aspects, this course takes the ecosystem approach. Not withstanding how beneficial technical/engineering management has brought to human society, either via innovative irrigation systems, flood control, river restoration, tide control etc., this course challenges the students to think with a revolutionary vision of *"letting the river run wild"* or "Giving the land back to rivers"[12]. It explores fundamental physical and hydrological functions of river ecosystems, ecological processes at the river/watershed scale (focusing on aquatic systems), identifies human-induced changes to ecological systems at local to global scales, and discusses natural and ecological approaches to improve river/watershed management. Specific topics include linkages between terrestrial and aquatic ecosystems, pervasive human alterations and their consequences, role of wetlands in water regulation (e.g. flood control), ecotourism, research, etc.

The *course objectives* are: To introduce students to the concept of rivers as a natural system that is intricately connected (via 3 levels of Connectivity: Longitudinal; Lateral; and Vertical); To equip students with strong fundamentals in the physical and hydrological functions of river ecosystems, and ecological processes at the river/watershed scale (focusing on aquatic systems); To study human-induced changes to ecological systems at local to global scales that are responsible for changes in the river and examine viable solutions; To learn about natural and ecological approaches to improve river/watershed management; To learn about river restoration; To study specific topics such as linkages between terrestrial and aquatic ecosystems, pervasive human alterations and their consequences; To study the types of riverine flora and how they interact with the river system; To study about the role of wetlands in water regulation (e.g. flood control), ecotourism, research, etc; and to mould engineering students into well-rounded individuals capable of thinking outside the "Engineering Box"..

The course format consists of lectures by the two instructors and invited speakers, readings from River Ecology and Management (Naiman and Bilby 1998), the USM School ,of Biological Sciences journal *BioScience*, *Rivers: Towards Sustainable Development* by Chan (2002), Aminuddin Ab. Ghani, Nor Azazi Zakaria, Rozi Abdullah and Mohd. Sanusi S. Ahmad (Editors) *"Rivers '04 Proceedings of the 1st International Conference on Managing Rivers in the 21st Century: Issues & Challenges"*. River Engineering and Urban Drainage Research Centre (REDAC), Engineering Campus, Universiti Sains Malaysia, and other vsuitable references. Appropriate websites on rivers and river ecosystems (e.g. The Drainage and Irrigation Department of Malaysia website http://www.water.gov.my/), and other related sources will be used. There will be frequent class discussion and debates. Field trips will form an integral part of the learning process in this course. Whenever appropriate, students will be taken on fieldtrips to visit field sites, rivers, Government departments, NGOs, local communities involved with river conservation, etc. As a practical example, students of EAD514 will also be put in charge to teach groups of secondary school students on the importance of rivers and river conservation. The course is designed to give students a broad overview of river management, hopefully making them better managers of rivers.

[12] http://archives.cnn.com/2000/NATURE/08/29/salmon.dam/index.html 10/07/08

LECTURE & READINGS SCHEDULE

LECTURE 1: Functions of Rivers: An Introduction

1. Chan N W (2002) *Rivers: Towards Sustainable Development. Penang: Penerbit USM.*
2. Hj Keizrul Abdullah (2002)Integrated River Basin Management. In N W Chan (Ed) *Rivers - Towards Sustainable Development.* Pulau Pinang: Penerbit Universiti Sains Malaysia, 3-14.

Davies B R and Wal K F (1986) The Ecology of river systems. Dordrecht: W. Junk.

LECTURE 2 (INVITED SPEAKER – DR CHRIS BARROW, UNIVERSITY OF SWANSEA): River Basin Development Planning and Management: A Critical Review

1. Barrow CJ (1998) River Basin Development Planning and Management: A Critical Review. *World Development.* Vol. 26 No. 1 , pp. 171-186, 1998.
2. Gardiner J, ed. (1991) *River Projects and Conservation: A manual for Holistic Appraisal*. Chichester: Wiley.
3. House MA (1991) River basin management in the UK. *Water Science and Technology* 23 (1-3), 57-64.

LECTURE 3: River Ecology: An Introduction

1. Chan N W (2002) *Rivers: Towards Sustainable Development. Penang: Penerbit USM.*
2. Naiman, R.J. and R.E. Bilby. 1998. River ecology and management in the Pacific coastal ecoregion. Pages 1-10, in R.J. Naiman and R.E. Bilby (Editors). *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion*. Springer-Verlag, New York.

LECTURE 4: River Geomorphology

1. Montgomery, D.R. and J.M. Buffington. 1998. Channel processes, classification, and response. Pages 13-42, in R.J. Naiman and R.E. Bilby, *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.
2. Benda, L.E. et al. 1998. Dynamic landscape systems. Pages 261-288, in R.J. Naiman and R.E. Bilby, *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York. (2 parts in e-reserve)

LECTURE 5: Stream Classification

1. Naiman, R.J. 1998. Biotic stream classification. Pages 97-119, in R.J. Naiman and R.E. Bilby (Editors). *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.
2. *Riparian Typology, Chapter 3* in R.J. Naiman, H. Décamps, and M.E. McClain. 2005. *Riparia.* Academic Press, San Diego.
3. Latterell, J.J., J.S. Bechtold, R.J. Naiman, T.C. O'Keefe, and R. Van Pelt. 2006. Dynamic patch mosaics and channel movement in an unconfined river valley of the Olympic Mountains. *Freshwater Biology* 51:523-544.

LECTURE 6: Land-water Linkages

1. Gregory, S.V., F.J. Swanson, and W.A. McKee. 1991. An ecosystem perspective of riparian zones. *BioScience* 41:540-551.
2. Naiman, R.J., K.L. Fetherston, S. McKay, and J. Chen. 1998. Riparian forests. Pages 289-323, in R.J. Naiman and R.E. Bilby (Editors). *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.
3. Naiman, R.J., R.E. Bilby, and P.A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. *BioScience* 50:996-1011.

LECTURE 07 (INVITED SPEAKER – ASSOC. PROF DR CHE SALMAH MD RAWI, SCHOOL OF BIOLOGICAL SCIENCES, UNIVERSITI SAINS MALAYSIA): Aquatic Insect, Biodiversity and Biological Classification of Rivers

1. Ward, J.V., and J.A. Stanford. 1982. Thermal responses in the evolutionary ecology of aquatic insects. *Ann. Rev. Entomol.* 27:97-117.

2. Hershey, A.E. and G.A. Lamberti. 1998. Stream macroinvertebrate communities. Pages 169-199, in R.J. Naiman and R.E. Bilby, *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.
3. Pollock, M.M. 1998. Biodiversity. Pages 430-454, in R.J. Naiman and R.E. Bilby, *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.

LECTURE 08 (INVITED SPEAKER – TO BE INFORMED) : Fish Community Dynamics
1. Li, H.W., C.B. Schreck, C.E. Bond, and E. Rexstad. 1987. Factors influencing changes in fish assemblages of Pacific Northwest streams. Pages 193-202 in W.J. Matthews and D. C. Heins (editors). *Community and evolutionary ecology of North American stream fishes.* University of Oklahoma Press, Norman, OK.
2. Reeves, G.H., P.A. Bisson, and J.M. Dambacher. 1998. Fish communities. Pages 200-234, in R.J. Naiman and R.E. Bilby, *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York. (2 parts in e-reserves.)

LECTURE 09: Role of Decomposition, Benthic Organic Matter and Trophic Dynamics
1. Bisson, P.A. and R.E.Bilby. 1998. Organic matter and trophic dynamics. Pages 373-398, in R.J. Naiman and R.E. Bilby, *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.
2. Latterell, J.J. and R.J. Naiman. 2007. Sources and dynamics of large logs in a temperate floodplain river. *Ecological Applications* 17:1127-1141.
3. Bilby, R.E. and P.A. Bisson. 1998. Function and distribution of large woody debris. Pages 324-346, in R.J. Naiman and R.E. Bilby, *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.

LECTURE 10: Suspended Organic Matter (SOM)
1. McClain, M.E., R.E. Bilby, and F.J. Triska. 1998. Nutrient cycles and responses to disturbance. Pages 347-372, In: R.J. Naiman and R.E. Bilby, *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.

LECTURE 11: Biogeochemical/Microbial Processes
1. McClain, M.E., R.E. Bilby, and F.J. Triska. 1998. Nutrient cycles and responses to disturbance. Pages 347-372, In: R.J. Naiman and R.E. Bilby, *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.

….LECTURE 15: Role of Animals
1. Naiman, R.J. and K.H. Rogers. 1997. Large animals and the maintenance of system-level characteristics in river corridors. *BioScience* 47:521-529.
2. Naiman, R.J., R.E. Bilby, D.E. Schindler, and J.M. Helfield. 2002. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. *Ecosystems* 5:399-417.

…..***LECTURE 16: Stream Ecosystem Theory***
1. Naiman, R.J., J.M. Melillo, M.A. Lock, T.E. Ford, and S.R. Reice. 1987. Longitudinal patterns of ecosystem processes and community structure in a subarctic river continuum. *Ecology* 68:1139-1156.
2. Webster, J.R. and J.L. Meyer. 1997. Organic matter budgets for streams: a synthesis. *Journal of the North American Benthological Society* 16:141-161.
3. Poole, G.C. 2002. Fluvial landscape ecology: addressing uniqueness within the river discontinuum. *Freshwater Biology* 47: 641-660

…….***LECTURE 17: Rivers of the Future***
1. Pimentel, D. and 9 others. 1997. Water resources: agriculture, the environment and society. *BioScience* 47: 97-106.
2. Jackson, R.B., S.R. Carpenter, C.N. Dahm, D.M. McKnight, R.J. Naiman, S.L. Postel, and

S.W. Running. 2001. Water in a changing world. *Ecological Applications* 11:1027-1045.
3. Naiman, R.J. and M.G. Turner. 2000. A future perspective on North America's freshwater ecosystems. *Ecological Applications* 10:958-970.

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Lecture PowerPoints
http://staff.washington.edu/ekp5/powerpoint.shtml 4/7/08
Lecture 1: Orientation
Lecture 2: Hydrology
Lecture 3: Geomorphology
Stream Classification
Lecture 4: Riparian Ecology
Lecture 6: Biodiversity
Lecture 7: Hyporheic Zones
Lecture 8: BOM
Fish Community Dynamics (Pete Bisson)
Lecture 10: Seston
Lecture 11: River Ice (Josh Latterell)
Lecture 12: Microbial/Biogeochemical Processes
Lecture 13: Decomposition
Lecture 14: System Metabolism
Lecture 15: Role of Large Animals
Lecture : Rivers of the Future

Lab PowerPoints
Lab 1: Introduction, birds and terrestrial animals
Lab 2: Lotic Fishes & Riparian Animals
Lab 3: Macroinvertebrates
Lab 4: Amphibians
Lab 5: Riparian Vegetation