THE UNIVERSITY of TORONTO at SCARBOROUGH ***January, 2009***
Department of Physical & Environmental Sciences

Environmental Science EES B02H3
PRINCIPLES OF GEOMORPHOLOGY

The earth's surface form and its dynamic behaviour at range of spatial and temporal scales is an integral part of the physical, biological and human environment. It is strongly influenced by human activity, while at the same time imposing severe constraints upon that activity. The study of the earth's surface forms and their morphodynamic behaviour, both naturally and under the impact of human habitation, is the field of Geomorphology. It is the human interaction with the surface of the earth that gives rise to a number of environmental concerns: e.g. surface erosion, catastrophic floods, sea-level rise, land slides, water resources and water extraction, etc. In this introduction course (which builds on knowledge acquired in EES A05) we examine:

a) the conceptual and theoretical base for earth surface processes
b) the fundamental physical, chemical and biological processes responsible for transforming the earth's morphology
c) the nature and rates of morphological change
d) the morphodynamics of specific morphological systems (especially river basins, since virtually everyone globally lives within some form of drainage basin)
e) the environmental issues arising from human interaction with a dynamic landscape.

Emphasis in this course is placed upon developing a core understanding of sediment production and transport processes. Lectures will focus upon the conceptual basis for geomorphology, the chemical and physical processes responsible for the development of surface regolith, and mechanisms of the entrainment, transport and deposition of mass by : (a) gravitational stress; and (b) quasi-steady fluid flows (specifically in river environments). Lectures will provide the theoretical framework for the practical work, which will allow detailed study of the dynamics of these processes using laboratory simulations, and which will be applied to one "man-modified" geomorphic system – the Highland Creek Drainage Basin.

Instructor: Jovan R. Stefanovic (Room SW 410 , email: jovan.stefanovic@utoronto.ca)
Office hours: Tuesday 11:00 – 13:00
Teaching Assistant: Jovan R. Stefanovic

Technician: Chai Chen, Room SW 222

Lectures: Tuesday: 9:00 – 11: 00, Room BV 355

Videos: A selection of videos will be used to complement the lectures and practical exercises where appropriate. These will be shown in the assigned lecture room.

Practicals: Thursday: 9:00 – 11: 00 and 11:00 – 13:00
Room : SW 313 (UTSC),or Highland Creek or Physical Geography Building (UTSG)

There will be one practical approximately every two weeks. At least one laboratory exercise will be held at the St. George Campus (UTSG), in order to use the small re-circulating flume in the Physical Geography Building (PGB, 45 St. George Street); measurements will be made with electronic sensors and data will be recorded digitally using a data acquisition system. Students will make their own observations and collect their own data for subsequent analysis. Later in the term a field trip will be taken to the valley of Highland Creek to evaluate

the geomorphic processes operating today and the environmental issues associated with channel erosion and sedimentation. The Creek drains a small catchment (~ 100 km^2), which exhibits significant influences from "urbanization". It will provide an opportunity for students to use several basic geomorphic field techniques demonstrated in the laboratory earlier in the term, and will also act as a focus for an assessment of human impact upon fluvial systems and for small students projects.

Grades: Practical Exercises (4 x 10% each) total …**40%**
Examinations:
Mid-Term Exam (2 hours)…… **20%**
Final Examination (3 hours)……. **40%**

Note:

1. Check INTRANET regularly. All announcements, lecture notes and all other information will be posted on intranet.

2. The mid-term exam will held in the week after reading week

3. Emphasis is placed on practical work in this course, which will involve some time commitment. However, this is reflected positively in the final grade distribution.

4. The final date for withdrawal from winter courses without academic penalty is March 22, 2009.

N.B. Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the Access Ability Services Office as soon as possible. The UTSC Access Ability Services staff (located in S 302) are available by appointment to access specific needs, provide referrals and arrange appropriate accommodations (416 287 -7560 or *ability@utsc.utoronto.ca* . The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

Tentative Lecture Schedule

Jan. 6 **Course Orientation:** outline of programme; organization of programme

Fundamentals of Geomorphology I: Philosophy and Historical Development:
Geomorphology: Theory & Practice
Geomorphological Equation, Geomorphological Systems
Geomorphology & Environmental Impact Assessment
Teleological, Inherent, Historical
Taxonomic & Functional
Realistic Paradigm
Conventionalism & Environmentalism

Jan. 13 **Fundamentals of Geomorphology II:**
Space-Time; landform orders; climatic geomorphology
Geomorphic systems; process – response models; magnitude and frequency
Endogenic & exogenic processes; tectonics & global geomorphology

ASSIGNMENT 1: MORPHOMETRY OF HIGHLAND CREEK

Jan. 20 **Fundamentals of Geomorphology III:** Text Ritter, Chapter 1
Thermodynamic basis for geomorphology; mass & energy conservation
Mass flux in geomorphic systems; equilibrium states & evolution
Rheology of materials; fluids, solids, plastics
Newton's Laws of Motion

Jan. 27 **Mechanics of Solids & Fluids:** Text Robert, Ch.2,
Laminar & turbulent flow; Reynolds & Froude Numbers; regimes of flow
Steady uniform flow; velocity structure & bed friction
Boundary layers

Feb. 3 **Mechanics of Solids &Fluids (Continued)**
Open channel hydraulics
Oscillatory flow
Glacial processes; Rheology of ice, ice motion, dynamics of ice bodies, mass balance
Flume experiment briefing

ASSIGNMENT 2: STREAM ENERGETICS (KINEMATICS)

Feb. 10 **Sediment Entrainment/ Transport by Fluids (Water-Air):** Text Robert, Ch.3 & 4
Critical thresholds for entrainment
Transport modes & rates; Bedforms in streams
Sediment transport in air/deserts
Models of sediment transport

Feb. 16 – 20. READING WEEK (No classes)

Feb. 24. **Mid-term exam**

Mar. 3 **Where does sediment come from?**

The Rock Cycle & the Geomorphological Cycle
Physical weathering; Chemical weathering
The structure of rocks; mineral stability; weathering products & resistates
Residual landforms; karst landscape

Video: Erosion and weathering: looking at the land

Mar.10 **Sediment Entrainment & Transport by Gravitational Stresses:**

Material strength; Mass wasting & subsurface and surface water stability analysis; types of mass movement

Video: The Rissa Landslide

ASSIGNMENT 3: ***WATER & SEDIMENT DISCHARGE IN NATURAL CHANNELS (Bed Load and Suspended Load)***

Mar. 17 **Fluvial Morphology:** Robert, Ch.5

Channel form; hydraulic geometry relationships; cross-profile; long profile
Meandering, braided and anastamosing channels

ASSIGNMENT 4: ***WATER & SEDIMENT DISCHARGE IN NATURAL CHANNELS (Solution and Total Load)***

Mar. 24. **Fluvial Morphodynamics I:**

Time scales of adjustment
Water & Sediment Loads
Channel dynamics
Response of fluvial systems to change
Basin denudation

Video: Running Water: River, Erosion & Deposition

Mar 26.or Apr.2 **Excursion: Highland Creek: A Man-modified Fluvial System**

Hydrological system; Sources, transfers & storage of water and solids; Floods
Sediment flux; Basin denudation
Monitoring geomorphic systems
Landform Dynamics & Environmental Issues
Humans as geomorphological agents; gemorphological hazards
Engineering & environmental planning
http://www.trca.on.ca/water_protection/strategies/highland/#hot

Mar. 31 **Fluvial Morphodynamics II:**

Channel inception & network evolution
Rivers & humans
Channel engineering & urbanization impacts

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EES BO2 H3 Readings

1. **Course notes will be posted on the intranet, so check intranet regularly.**

2. **Although there is no perfect text for the course, I am asking you to buy one text; however, I will ensure that there is a copy in the library on reserve and I will be referring frequently to several other texts to give more general overviews of the topics covered in the course, and to allow some choice when other texts are not available.**

Required Text:

Robert, A., 2003. River Processes: an introduction to fluvial dynamics. Oxford University Press Inc., New York, 214 pp.

Basic Reference Sources:

Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, EOLSS Publishers, Oxford ,UK, [http://www.eolss.net]

Goudie, A. (ed.), 2004. Encyclopedia of Geomorphology. Routledge, London.

Middleton, G.V. (ed.), 2004. Encyclopaedia of Sediments and Sedimentary Rocks. Kluwer Academic Publishers, Amsterdam.

Ritter, D.F., Kochel, R.C. and Miller, J.R. 2002, Process Geomorphology, 4th Edition, McGraw Hill, Boston, 560 pp.

Additional Texts:

Allen, P.A., 1997, Earth Surface Processes. Blackwell Science, Oxford, 404 pp.

Chorley, R.J., 1978. Bases for theory in geomorphology. In: C. Embleton, Brunsden, D. and Jones, D.K.C. (eds.) *Geomorphology: present problems and future prospects*, Oxford University Press, Oxford, p. 1-24.

Gregory, K.J., and Walling, D.E., 1976. Drainage Basin, Form and Process. Edward Arnold, London, 456 pp.

Knighton, D., 1998, Fluvial Forms and Processes: a New Perspective. Arnold, London, 383 pp.

Schumm, S.A., 1977. The Fluvial System, John Wiley & Sons, New York, 338 pp.

Smith, D.I., and Stoppe, P., 1978. The River Basin: An Introduction to the Study of Hydrology, Cambridge University Press, 120 pp.

Statham, I., 1978. Earth Surface Sediment Transport. Oxford University Press, 184 pp.

3. Recommended General References:

The following texts are available in the library and cover all the major topics of this course; some will be referred to explicitly as required, but the listing will also provide a source for your own readings or research:

Allen, J.R.L. 1994. Fundamental properties of fluids and their relation to sediment transport processes. Chapter 2 in: *Sediment Transport and Depositional Processes*, edited by K. Pye, Blackwell Scientific Publications, Oxford, p. 25-60.

Anderson, M.G. (ed.), 1988. Modelling Geomorphological Systems, Wiley, Chichester.

Bell, M. and Walker, J.C., 1992. Late Quaternary environmental change: physical and human perspectives. Longman Scientific & John Wiley and Sons Inc., N.Y., 273 pp.

Benke, A.C. and Cushing, C.E., 2005. Rivers of North America. Academic Press, NY, 1168 pp.

Best, J., 1996. The fluid dynamics of small-scale alluvial bedforms. Chapter 3 in: Carling, P.A. and Dawson, M.R. (eds.), 1996. *Advances in Fluvial Dynamics and Stratigraphy*, John Wiley & Sons, Chichester, 530 pp.

Brookes, A., 1988. Channelized Rivers: perspectives for environmental management. Chapter IV – Physical Effects. John Wiley & Sons, Chichester.

Calow, P. and Petts, G.E. (eds.), 1994. The Rivers Handbook. Volume 2. Blackwell Scientific Publications, Oxford.

Carling, P.A. and Dawson, M.R. (eds.), 1996. Advances in Fluvial Dynamics and Stratigraphy, John Wiley & Sons, Chichester, 530 pp.

Carson, M.A., 1971. The mechanics of erosion, Pion, London.

Carson, M.A. and Kirkby, M.J., 1972. Hillslope Form and Process, Cambridge University Press, 475 pp.

Chorley, R.J., Schumm S.A. and Sugden, D.E., 1984. Geomorphology, Methuen, London, 605 pp.

Collinson, J.D. and Thompson, D.B., 1997. Sedimentary Structures, 2nd Edition, Unwin Hyman, London. Chapter 3: Basic properties of fluids, flows and sediment.

Dingman, S.L., 1984. Fluvial Hydrology, W.H. Freeman & Co., New York, 384 pp.

Dorva, J.M., Montgomery,D.R., Palcsak, B.B. and F.A. Fitzpatrick, (eds.), 2001. Geomorphic Processes and Riverine Habitat. American Geophysical Union, Washington, 253 pp.

Dunne, T., and Leopold, L.B., 1978. Water in Environmental Planning, W.H. Freeman & Co., San Francisco.

Embleton, C. and Thornes, J., 1979. Process in Geomorphology, Edward Arnold, London, 436 pp.

Gregory, K.J., and Walling, D.E. (eds.), 1987. Human activity and environmental processes, Wiley, Chichester.

Goudie, A., 1981. Geomorphological Techniques, George Allen & Unwin, 395 pp.

Haan, C.T., Barfield, B.J. and Hayes, J.C., 1994. Design hydrology and sedimentology for small catchments, Academic Press, San Diego.

Hails, J.R., 1977 (ed.). Applied Geomorphology, Elsevier, Amsterdam.

Herschy, R.W., 1995. Streamflow measurement. 2nd Edition, E & FN Spon, London, 524 pp.

Huggett, R.J., 1991. Climate, earth processes and earth history, Springer-Verlag, N.Y.

Julien, P.Y., 2002. River Mechanics. Cambridge University Press, Cambridge, 454 pp.

Julien, P.Y., 1998. Erosion and Sedimentation. Cambridge University Press, Cambridge, 298 pp.

Komar, P.D., 1996. Entrainment of sediments from deposits of mixed grain sizes and densities. Chapter 4 in: Carling, P.A. and Dawson, M.R. (eds.), 1996. *Advances in Fluvial Dynamics and Stratigraphy*, John Wiley & Sons, Chichester, 530 pp.

Leopold, L.B., Wolman, M.G., and Miller, J.P., 1964. Fluvial Processes in Geomorphology, Freeman, San Francisco, 524 pp.

Morisawa, M., 1985. Rivers, form and process, Longman, London, 222 pp.

Morisawa, M., 1968. Streams: their Dynamics and Morphology, McGraw-Hill Inc., Toronto, 175 pp.

McCullagh, P., 1978. Modern concepts in geomorphology, Oxford University Press, Oxford.

Naiman, R.J. (ed.), 1992. Watershed management: balancing sustainability and environmental change, Springer-Verlag, N.Y.

Ollier, C.D., 1969. Weathering, American Elsevier Publ. Co. Inc., New York, 304 pp.

Parsons, A.J. and Abrahams, A.D. (ed.), 1992. Overland Flow: hydraulics and erosion mechanics, Chapman & Hall Inc., New York, 450 pp.

Rhoads, B.L. and Thorn, C.E. (eds.), 1996. The Scientific Nature of Geomorphology, Wiley, New York.

Richards, K., 1987. Rivers: Form and Process in Alluvial Channels, Methuen & Co. Ltd., London, 358 p.

Schumm, S.A., 1973. Slope Morphology, Dowden, Hutchinson & Ross, Stroudsbury, PA.

Selby, M.J., 1985. Earth's Changing Surface: An Introduction to Geomorphology, Clarendon Press, Oxford, 607 pp.

Slaymaker, O. (ed.), 1990. Field experiments and measurement programmes in geomorphology, UBC Press, University of British Columbia, Vancouver, 236 pp.

Summerfield, M.A., 1991. Global Geomorphology: an introduction to the study of landforms, John Wiley & Sons, Inc., New York, 537 pp.

Thorn, C.E., 1988. An introduction to theoretical geomorphology, Unwin Hyman, Boston.

Thorn, C.E. (ed.), 1982. Space and time in geomorphology, Allen & Unwin, Boston.

Thornes, J.B. and Brunsden, D., 1977. Geomorphology and time, Methuen & Co. Ltd., London, 208 pp.

Tinkler, K.J., 1985. A short history of geomorphology, Croom Helm, London.

Toy, T.J. and Hadley R. (eds.), 1987 Geomorphology and reclamation of disturbed lands, Academic Press, Orlando, 480 pp.

Weyman, D.R., 1978. Runoff Processes and Streamflow Modelling, Oxford University Press, 54 pp.

Williams, J.J., 1996. Turbulent flow in rivers.Chapter 1 in: Carling, P.A. and Dawson, M.R. (eds.), 1996. *Advances in Fluvial Dynamics and Stratigraphy*, John Wiley & Sons, Chichester, 530 pp.

***NOTE:* THESE BOOKS ARE NOT TO BE READ FROM COVER TO COVER, THEY ARE FOR REFERENCE ONLY OR FOR USE WITH LABORATORY QUESTIONS & FOR THOSE WHO ARE PATICULARLY INTERESTED!!!!** Specific readings from the texts listed at the beginning, the alternate texts, the reference material and others will be designated as different sections of the course proceed.