Synopsis of the
Symposium on

The Saguenay Flood

Supervised by

Jacques Locat
Christiane Gagnon
and
Émilien Pelletier

Baie Éternité, fjord du Saguenay, Québec, source: Post

Part of the

Québec - 1998
Carrefour des Sciences de la Terre

Quebec City, Canada, May 20, 1998

Synopsis of the Symposium on

The Saguenay Flood

Held in Quebec City, May 20, 1998
During the
Carrefour des Sciences de la Terre

Supervised by
Jacques Locat, Christiane Gagnon and Émilien Pelletier

Objectives

The Symposium shed light on various facets of this catastrophic event. Special attention focused on factors such as the human impact (before, during and after), meteorological and hydraulic aspects (e.g., behaviour of dykes and dams, erosion), and an analysis of natural hazards and their effects on the environment. It also addressed the environmental impact (terrestrial and marine) and the factors inherent in reconstruction and relocation. The Symposium gathered together the major scientists involved during the flood and researchers who had already started analysing the various facets of the phenomenon. The Symposium was to generate future outlooks within the framework of the International Decade for Natural Disaster Reduction (IDNDR) in order to draw lessons and make recommendations of interest both to researchers and risk managers.

Sponsors

The Saguenay Flood Symposium was sponsored by Emergency Preparedness Canada, the Ministère des transports du Québec, Canadian Heritage/Parks Canada, and the Techmat and Cegertech companies.

Participation

The Symposium opened with a presentation by Roger Nicolet, President of the Ordre des ingénieurs du Quebec and past Chair of the Nicolet Commission on the Saguenay Flood. In all, more than 90 people actively participated by delivering conference presentations, developing posters and taking part in the round table held at the close of the Symposium.

A total of 30 papers and posters were delivered or displayed at the Symposium. A list of the various topics covered and the names of the different authors are presented below.

Summary of Topics Addressed

One of the key aims in organising this Symposium was to gather together a broad range of scientists, both from the humanities and the field of pure and applied science. In this regard, we believe the Symposium was a clear success. The nature of the discussions and intensity of the exchanges during the round table clearly validated the approach. Despite differences in the background and training of the various contributors, the debate was extremely productive for one and all. The sessions were also organised to foster interaction (see the Symposium program in Appendix 1).

The following list gives a good overview of the diversity of contributions.

- Risk Management and Engineering Practice: The Saguenay Case (R. Nicolet)
- Rivière Chicoutimi : Talk about a flood – A geographic outlook on the overall phenomenon (G.H. Lemieux)
- Impact of flooding on public health : Survey of the literature and case studies (G. Lalande, D. Maltais, S. Robichaud, A. Simard and N. Simard)
- Fluvial geomorphic effects of the July 1996 flooding, Saguenay Region, Southern Québec, Canada (D.E. Lawrence et G.R. Brooks)
- Saguenay fjord contamination: A summary of current knowledge (E. Pelletier)
- Residential flood damage : Lessons from the Saguenay (M. Leclerc, J. Marion, M. Heniche)
- Reconstruction management following torrential rains in the Saguenay (F. Morneau)
- Contribution of detailed surficial mapping in the reconnaissance of multi-event landslides in post-glacial marine clays (S.J. Paradis, D. Perret, C. Bégin)
- Retrospective analysis of landslides during the torrential rainfalls of July 1996 in the Saguenay (D. Demers, D. Robitaille, D. Perret, J. D'Astous)
- Rockfalls during the Saguenay flood (A. Drolet)
- Sedimentary movement in the Saguenay fjord: Effects of environmental perturbation on the composition and evolution of macrobenthic populations (C. Nozais and G. Desrosiers)
- Impact of the July 1996 floods on benthic meiofauna in the Saguenay fjord (G. Tita and G. Desrosiers)
- Micropaleontological and geochemical tracers of recent environmental changes in the Saguenay fjord (R. Devillers, V. Loucheur, S. Marmen, A. Bertini, A. de Vernal, C. Hillaire-Marcel, G. Bilodeau, J. Leduc and G. St-Onge)
- Thorium isotope systematics in box cored sediments from the outlet of the Baie des Ha! Ha!, Saguenay Fjord (Eastern Canada) (J. Savard, B. Ghaleb, D. Zhang et C. Hillaire-Marcel)
- The Saguenay flood: geochemical evolution of sediment in Baie des Ha! Ha! (Saguenay Fjord) (B. Deflandre and J.-P. Gagné)
- Butyltin contamination in the fjord (S. Robillard, E. Pelletier and R. St-Louis)

- Comparison of crossed array system surveys conducted in 1993 and 1997 in the area upstream from the Saguenay fjord : initial analysis of the 1996 layer and geomorphic factors (J. Locat, E. Kammerer, N. Doucet, J. Hughes-Clarke, L. Mayer, F. Maurice, E. Boulanger and P. Simpkin)
- Structure of a deposit sequence analysed by tomodensitometry - Example of the sequence created after the 1996 floods (J.-F. Crémer, B. Long and J. Locat)
- Consolidation of the 1996 layer covering contaminated sediment in the Baie des Ha! Ha! sector in July 1996 (F. Maurice, J. Locat, S. Leroueil, R. Glavez-Cloutier and R. Therrien)
- Major features of the flood research program (GRIR, UQAC) (C. Gagnon)
- Post-flood reconstruction planning and management in the Saguenay (M.-U. Proulx)
- Emergency preparedness lessons learned and still to be learned from the Saguenay disaster (T. Pauchant, P. Cazalis and D. Parent)
- Rivière des Ha! Ha!, epicentre of the flood: Geotechnical factors (J. Vallée)
- Particulate and colloidal + dissolved species within the water column of the Saguenay fjord: perturbations? (S. Alpay, A. Mucci et C. Hillaire-Marcel)
- Use of piezocone during the July 1996 Saguenay flood (R. Bouchard)
- Typology of landslides caused by heavy rains in mid-July 1996 in Saguenay/Lac St-Jean, Quebec (D. Perret, C. Bégin and D. Demers)
- Post-traumatic stress disorder: after the Saguenay flood (M. Fortin, C. Auger, S. Latour and M. Trudel)
- Analysis of the Rivière Chicoutimi flood and its geomorphic effects (M. Heniche, M. Leclerc, Y. Secretan, P. Boudreau and M. Lapointe)
- Performance of the sedimentary layer from the 1996 flood covering contaminated sediment in the Saguenay fjord : An opportunity for technological development (J. Locat, G. Desrosiers, A. de Vernal, J.-P. Gagné, R. Galvez-Cloutier, Y. Gratton, P. Hill, C. Hillaire-Marcel, B. Long, A. Mucci, E. Pelletier, P. Simpkin and R. Therrien)

Major Lessons

The summaries contained in this document should provide a good idea of the major technical lessons to be learned from this experience. During the question periods and the round table, many comments were made. The following is a summary of the main points arising from the various discussions.

- One of the factors emerging from this activity is the fundamental need for knowledge and information both for the public and for decision-makers. In his introduction, Mr. Nicolet squarely centred the debate on adequate risk management which hinges on frequent communication and discussions with the people involved.
- The human drama played out the Saguenay flood is perhaps less obvious but still persists in the behaviour of many of the people affected.
- Despite difficult conditions, infrastructure reconstruction in the Saguenay Region was carried out quickly and smoothly on the whole.
- Although the flood was certainly an unusual phenomenon, the area where it occurred regularly receives heavy rainfall.

- One major impact for the Saguenay fjord was the heavy supply of new sediment. However, this sediment supply could be beneficial by covering a large portion of the contaminated sediment previously existing in the fjord.
- Other inter-disciplinary exchanges of a similar nature should be encouraged.

After reading the following summaries, we are able to grasp the scope of studies and work in progress in the Saguenay region. Each of these may make separate findings. We consider it important to review the region's situation in the not too distant future (3 to 5 years).

Acknowledgements

The team responsible for organising the *Saguenay Flood Symposium* would like to thank the various agencies that provided financial support for this event. The funding received will allow us to prepare an additional publication combining the keynote papers (long summaries). Now in preparation, this document should be available in 1999. We also wish to thank the organisers of Québec 1998 – Carrefour des Sciences de la Terre for allowing us to hold this Symposium as part of its activities.

Synopsis

RISK MANAGEMENT AND ENGINEERING PRACTICE: THE SAGUENAY CASE

NICOLET, Roger, Eng., Ordre des ingénieurs du Québec, 2020 rue Université, 18th floor, Montreal, Quebec, H3A 2A5.

In practising their profession, engineers come in daily contact with technology and nature. They are asked to manage a reconciliation of the two for the benefit of society. Although total security is impossible, engineers more than any other professionals are required to make decisions that involve a trade-off between zero risk and the cost of facilities. The Saguenay case shows that the combination of natural and technological elements can lead to unprecedented disasters if this synergy is not harnessed or if it is misunderstood and underestimated. The case in point also clearly illustrates that determining the various categories of risk is not enough; the synergetic effects of the various risk factors must also be identified. Unlikely events must be factored in when the impact of hypothetical systemic failures extends to the death of people and massive destruction of public or private property. Naturally, the "Saguenay flood" shows that risk prevention measures are required in order to put the emphasis on community and human safety. However, it also shows that communities must receive clear information and explanations on the risks confronting them. Involving the communities in question is the best guarantee that the trade-offs will be understood and accepted. Among other things, the popularisation process leads the way to the effective management of crises and their after-effects. From this standpoint, the ties between government authorities, communities and experts would benefit from extensive improvement. In a law-based society such as ours, the legal system plays a major role. A revision of the *Waterways Act* is imperative.

RIVIERE CHICOUTIMI: TALK ABOUT A FLOOD – A GEOGRAPHIC OUTLOOK ON THE OVERALL PHENOMENON

LEMIEUX, Gilles-H. Laboratoire de Télédétection, Université du Québec à Chicoutimi, 555 boul. de l'Université, Chicoutimi, Quebec, G7H 2B1, tlemieux@videotron.ca

Causes, consequences and lessons: On July 19, 20 and 21, 1996, torrential rainfalls pummelled the vast watershed of the Laurentian wildlife reserve north of Quebec City in Eastern North America for more than 50 hours. With the engorgement of waterways, these rainfalls triggered the biophysical transformation of forests, soils, the water table, lakes and rivers, and at the same time destroyed road systems and urban installations situated near waterways or in floodplains. This CDROM contains a brief, unpretentious analysis of the Rivière Chicoutimi flood, humbly offering a geographic and historical outlook on the overall phenomenon to place the event within its broader North American context (temporal and spatial) and perhaps lead to a better understanding of the experience. By underscoring a few lessons to be learned from the disaster, this scientific report provides for a better acceptance and the minimisation of future effects.

IMPACT OF FLOODING ON PUBLIC HEALTH: SURVEY OF THE LITERATURE AND CASE STUDIES

LALANDE, Gilles, MALTAIS, Danielle, ROBICHAUD, Suzie, SIMARD, Anne and SIMARD, Nathalie. Université du Québec à Chicoutimi, 555 boul. de l'Université, Chicoutimi, Quebec G7H 2B1

The July 1996 disaster affected many people. More than 16,000 were evacuated and 7,000 families witnessed extensive damage to their homes or neighbourhoods. Up to now, we have received much information on the climactic conditions that conspired toward this disaster and on the impact of flooding on land planning. However, few Quebec researchers have studied the flood's effects on the health of its victims. Yet American researchers have explored the effects of many types of collective traumas. Through these studies, researchers show that psychological after-effects are common among populations exposed to disaster (Bravo *et al.*, 1990; Green *et al.*, 1992). Some authors have observed an increase in depressive and somatic symptoms, emotional distress and anxiety. Some flood victims, like those in Buffalo Creek, exhibited psychological disorders 14 years after the event, including phobias, panic disorders and agoraphobia. This paper tries to succinctly describe the possible effects of flooding on the bio-psycho-social health of people. Our information comes from an exhaustive survey of the literature and reports of detailed interviews with approximately 30 disaster victims divided into four separate categories according to the damage to their home (total loss, major damage, moderate damage and minor damage). The presenters draw a tie between theory and practice by describing the differences and similarities between the results gleaned from the literature and from a qualitative analysis of the interviews.

References

Bravo, M. et al. (1990). "The psychological sequelae of disaster stress prospectively and retrospectively evaluated." American Journal of Community Psychology, 18(5), 661-680.

Green, B.L. et al. (1992). "Chronic posttraumatic stress disorder and diagnostic comorbidity in a disaster sample". Journal of nervous and mental disease, 180(12), 760-766.

FLUVIAL GEOMORPHIC EFFECTS OF THE JULY 1996 FLOODING, SAGUENAY REGION, SOUTHERN QUEBEC, CANADA

LAWRENCE, D.E., and BROOKS, G.R., Geological Survey of Canada, 601 Booth Street, Ottawa, ON, K1A 0E8

On July 18-21,1996, a major storm system stalled over the mouth of the St. Lawrence River and dropped record amounts of rain causing widespread flooding in southern Quebec. Flooding was particularly severe along river systems located south of the Saguenay-Lac Saint Jean area, where in excess of 200 mm of rain fell within a 36-hour period. Flooding along four rivers caused major geomorphic changes, the severity of which varied considerably from river to river and from reach to

reach along individual rivers. Along Rivière aux Sables and Rivière Chicoutimi, the floodwaters overtopped a number of small dams causing dramatic, yet localised, lateral bank erosion and incision. Major lateral channel erosion and avulsions occurred along the lower 10 km of Rivière à Mars causing extensive damage within the floodplain and on terraces along the valley bottom. The worst flooding in the region, relative to the size of the drainage basin, occurred along Rivière des Ha! Ha!, where overtopping and erosion of an earthfill dyke caused the rapid drainage of the Lac Ha! Ha! reservoir, compounding the effects of the flooding from the rainstorm. Over a distance of 35 km from Lac Ha! Ha! to the river mouth, flood water ravaged the valley bottom causing moderate to major channel widening and incision along relatively steeply sloped reaches, and major sedimentation (up to several metres) along more gently sloped reaches and at the river mouth. Overall, the July 18-21, 1996 flooding damaged or destroyed infrastructure (bridges, dams and roads) and numerous homes, and seriously impaired a number of major industries, making this one of Canada's most costly natural disasters.

SAGUENAY FJORD CONTAMINATION: A SUMMARY OF CURRENT KNOWLEDGE

PELLETIER, Émilien. Institut national de la recherche scientifique (INRS-Océanologie), 310 allée des Ursulines, Rimouski, Quebec, G5L 3A1, emilien_pelletier@uqar.uquebec.ca

The contamination of water and sediment in the Saguenay fjord has been extensively studied for approximately 30 years. Following the discovery of high mercury levels in the Nordic Shrimp, Pandalus borealis, in the early seventies, many successive sampling campaigns -- initially by Fisheries and Environment Canada and the Université Laval and later by the Université du Québec à Chicoutimi, the Centre océanographie de Rimouski and McGill University -- have detected not only mercury in the sediment of the fjord and its organisms, but also several other trace metals such as cadmium and zinc. The implementation in 1972 of stricter Canadian legislation governing industrial effluent triggered a direct and significant reduction in mercury contamination beginning in 1975 and led to a significant decrease in the mercury present in shrimp and other benthic organisms in later years. Other work launched by the Université du Québec à Chicoutimi in the early eighties and later pursued by Fisheries and Environment Canada and the Centre océanographique de Rimouski revealed major contamination in the fjord's sediment by many polycyclic aromatic hydrocarbons (PAH) including some with carcinogenic potential. These compounds result from the combustion of wood and fuel as well as certain industrial processes used in the Arvida region. As in the case of mercury, the industry's implementation of new, less polluting processes in the seventies and eighties substantially reduced the supply of these substances to the fjord. Lastly, recent work performed jointly by Fisheries and Environment Canada and the Centre océanographique de Rimouski revealed the presence of many organo-chlorinated compounds (PCB, dioxins, furanes, DDT, DDE, BHC and others) in the fjord's sediment and organisms. Nevertheless, these compounds, primarily airborne and generally present amounts below those found in the St. Lawrence Estuary, account for a very low level of contamination. The catastrophic rainfalls of July 1996 helped bury all of these contaminants under several centimetres of mud and sand in the Baie des Ha! Ha! and in a portion of the Bras Nord. Research work now in progress will help determine whether this burial is permanent or merely temporary.

RESIDENTIAL FLOOD DAMAGE: LESSONS FROM THE SAGUENAY

LECLERC, Michel, MARION, Joëlle, and HENICHE Mourad. Institut national de la recherche scientifique-Eau (INRS-Eau), P.O. Box 7500 Sainte-Foy, Quebec, G1V 4C7, Michel_Leclerc@inrs-eau.uquebec.ca

After the Saguenay floods of July 1996, dam reconstruction on the rivers downstream of Lac Kénogami and the creation of water flow and water level management plans for these waterways, consideration had to be given to the potential damage caused by a repetition of the extreme flooding experienced by the Saguenay in July 1996. The Ministère de l'Environnement et de la Faune du Québec therefore instructed the INRS-Eau to develop a functional relation, for the Rivière Chicoutimi, the Rivière aux Sables and Lac Kénogami, between residential damage possibly resulting from various potential floods, and the flow or level of water involved in these events. First of all, the damage evaluation was limited to permanent or seasonal residential housing stock. Although important, the other categories of damage such as damage to infrastructures or to the rivers themselves were not taken into account at this point. The applied approach uses a residential, geo-referenced definition of flood damage. The explanatory variable is the local depth of submersion. Depending on the circumstances, this variable is defined by measurements, or using the 2D hydrodynamic model (HYDROSIM model). The topography of the flood zones was determined using photogrametrics and processed with the MODELEUR software. The data used to determine the relation to the flow coefficient was supplied by raw data on compensation following the 1996 flood and municipal assessment data for each property (dependent variable). Four relations were identified between flood damage and submersion: groups of residences with or without a basement, and homes valued at less or more than $50,000. Cumulative residential damage curves for the three hydrographic units were developed on the basis of their flow coefficient. The future Lac Kénogami management plan can follow various distribution rationales mentioned in this article, including the status quo (1/3-2/3) based on the current management plan, or rationales based on economics, equity, the natural flow coefficient or engineering design limits.

RECONSTRUCTION MANAGEMENT FOLLOWING TORRENTIAL RAINS IN THE SAGUENAY

MORNEAU, François. Office of Reconstruction - Ministère des transports du Québec, 700 boul. René Levesque est, 14th floor, Quebec City, Quebec, G1R 5H1, f.morneau @sympatico.ca

The torrential downpour of July 1996 had a disastrous effect on the Saguenay/ Lac-St-Jean region and north-eastern Quebec. Ten people died, and 16,000 had to be evacuated. Most of the roads were impassable because of landslides and fluvial erosion. The force of the water washed out many bridges and rail lines, dykes and dams. More than 600 houses were destroyed and 850 seriously damaged. The overall cost of the disaster amounted to more than one billion dollars. In the early days following the downpour, an interdepartmental group produced an action plan to set guidelines for reconstruction in the areas devastated by the rivers. Three weeks after the rains, municipal governments and large

corporations were called to meetings to hear the government's policy on reconstruction. At these meetings, various preliminary maps of the disaster zones were presented to inform the parties involved of the need to avoid rebuilding in risk areas. The problem of rebuilding in devastated floodplains with an extremely active fluvial dynamic demanded an up-to-date mapping of the "new" floodplains. In terms of areas at risk of soil movement, preliminary geotechnical maps were also promptly developed and submitted to municipalities located in vulnerable areas. After meetings with the municipalities and site visits involving municipal officials and an interdisciplinary government team, redevelopment and reconstruction scenarios were developed for many locations. However, along highly destabilised rivers and especially at river mouths, infrastructure reconstruction was an extremely complex matter. Watershed committees were created for the Rivière Ha! Ha!, Rivière à Mars and Rivière St-Jean to develop an overall diagnosis and reach a consensus on the action to be taken. A river restoration program was launched, primarily to stabilise the shorelines and restore a hydro-sedimentological balance to the rivers in order to avoid the need for recurrent dredging at the river mouths. In some devastated areas of the Saguenay, reconstruction offered an outstanding opportunity to experiment with land management and planning methods that enlisted interdisciplinary co-operation, teamwork and public consultation to quickly identify feasible, lasting solutions for these environments.

CONTRIBUTION OF DETAILED SURFICIAL MAPPING IN THE RECONNAISSANCE OF MULTI-EVENT LANDSLIDES IN POSTGLACIAL MARINE CLAYS

PARADIS, S.J., PERRET, D., and BÉGIN, C. Geological Survey of Canada, Centre géoscientifique de Québec, 2535 boul. Laurier, P.O. Box 7500 Sainte-Foy (QC), G1V 4C7 paradis@gsc.nrcan.gc.ca

Landslides in the Chicoutimi-La Baie area of central Québec have been mapped at two main scales: a local detailed scale (1:1 000) for urban engineering and geotechnical purposes and a more regional scale (1:50 000) for earth scientists and land use planners. However, systematic surficial mapping using black and white aerial photographs at a scale of 1:15 000 has proven to be a more efficient method to investigate and understand the complex history and distribution of multi-event landslides. These landslides occur in thick marine clays that were deposited in Laflamme Sea between about 10,250 and 8,500 years B.P. Marine regression has left a series of stepped marine terraces at elevations ranging from 160 m down to modern shores of the Saguenay fjord. Detailed cartography shows that the regional scale (kilometric) landslide scars are laterally associated to some marine terraces and that a robust relative chronology can be established for large sets of landslides mainly on the basis of the staircase distribution of multi-scale scars.

RETROSPECTIVE ANALYSIS OF LANDSLIDES DURING THE TORRENTIAL RAINFALLS OF JULY 1996 IN THE SAGUENAY

DEMERS, Denis. Ministère des transports du Québec, Geotechnical and Geology Service, 930, Chemin Ste-Foy, 5th floor, Quebec City, Quebec, G1S 4X9, ddemers@mtq.gouv.qc.ca; ROBITAILLE, Denis. Ministère des transports du Québec, Geotechnical and Geology Service, 930, Chemin Ste-Foy, 5th floor, Quebec City, Quebec, G1S 4X9; PERRET, Didier, Centre géoscientifique de Québec, 2535, boul. Laurier, C.P. 7500, Sainte-Foy, Quebec, G1V 4C7, D'ASTOUS, Jacques. Ministère des transports du Québec, Geotechnical and Geology Service, 930, Chemin Ste-Foy, 5th floor, Quebec City, Quebec, G1S 4X9

Most of the landslides that occurred during the torrential rainfalls of July 1996 in the Saguenay affected slopes which did not erode at their base. The clayey soils of this region are generally stratified, super-consolidated and highly resistant to shearing. Many slopes considered stable by the standard stability calculation shore at the surface to varying depths. Retroactive analyses show that defining the hydraulic conditions of a slope and identifying mechanical soil properties are difficult tasks. In this regard, we must clearly identify the stratigraphy and thickness of the clayey surface crust, since thickness seems to have controlled the behaviour of many slopes during the torrential downpour.

ROCKFALLS DURING THE SAGUENAY FLOOD

DROLET, André. Ministère des transports du Québec, Geotechnical and Geology Service, 930, chemin Ste-Foy, 5th floor, Quebec City, Quebec, G1S 4X9, adrolet@mtq.gouv.qc.ca

During the sadly infamous deluge in the Saguenay on July 19 and 20, 1996, we saw many rockfalls occurring in a mountainous region. In these locations, heavy rains had saturated the soil (silt, sand, gravel and boulders) to a depth of one or two metres atop the bedrock (gneiss granite) on sloped flanks of 25- to 45- degrees. These saturated soils spilled down the slopes carrying the topsoil and trees with them. Five (5) of these detritus falls affected the road system, including three on highway 169, one on highway 170 and another on highway 172. The Geotechnical and Geological Service of Transports-Québec used the CRSP (Colorado Rockfall Simulation Program) software to perform simulations. Given the ever-present danger at the three Highway 169 sites, we had to install a Geobrugg catchment system (metal cable fence). This was the first time that Transports-Québec used this European-designed system in Quebec.

SEDIMINARY SUPPLY IN THE SAGUENAY FJORD: EFFECTS OF ENVIRONMENTAL PERTURBATION ON THE COMPOSITION AND EVOLUTION OF MACROBENTHIC POPULATIONS

NOZAIS, Christian and DESROSIERS, Gaston. Coastal Environment Research Group, Oceanography Department, Université du Québec à Rimouski, 310 allée des Ursulines, Rimouski, Quebec, G5L 3A1, Christian_Nozais@uqar.uquebec.ca

The flash floods that descended on in the Saguenay/Lac-St-Jean Region in July 1996 led to a sudden and extensive supply of land-sourced sediment, especially in the Baie des Ha! Ha! and the Saguenay fjord. These supplies caused the abrupt burial of all biological components of the benthic ecosystem, triggering a loss of biodiversity. A long-interval (one year) monitoring program was developed to understand the benthic ecosystem re-colonisation process by macrofauna. The campaign launched in September 1996 involved 16 stations spread out between the Baie des Ha! Ha! and the Saguenay fjord. Two (2) of the 11 sampling stations in the Baie des Ha! Ha! (located on the flood rivers) were characterised by the total absence of macrobenthic organisms. At the 14 other stations, densities never exceeded more than 49 specimens/600 cm^2. The Annelid Polychetes dominated 11 of the 14 other stations, while molluscs comprised a majority at only one of the stations located in the fjord. Nine families of Polychetes were present, with Cirratulidae, Lumbrineridae and Maldanidae apparently the most prevalent at all of the stations. An analysis by whole-relation groupings reveals the combination at certain stations. Stations 2, 3, 5 and 6, located on one of the flood rivers, form a very distinct group compared to stations 7, 9, 10 and 12 located at the Baie des Ha! Ha! outlet. The first group represents stations severely affected by sedimentary supply, while the second consists of stations less affected by such supply. The second campaign mounted in August 1997 under the monitoring program involved a total of 9 stations. The preliminary results suggest a major influx of one Macoma-genre bivalve at some of the stations. The Macoma genre is usually considered an early coloniser of anoxic zones. The results obtained during the two monitoring station campaigns will be discussed in terms of the macrobenthic re-colonisation process in a deepwater ecosystem.

IMPACT OF THE JULY 1996 FLOOD ON BENTHIC MEIOFAUNA IN THE SAGUENAY FJORD

TITA, G., and DESROSIERS, G. Department of Oceanography, Université du Québec à Rimouski, 310 allée des Ursulines, Rimouski, Quebec, G5L 3A1

In May 1996, samples were taken at three stations in the upper Saguenay fjord basin for a study of benthic meiofauna: Stn. A (outlet of Baie des Ha!Ha!), Stn. B (St-Rose-du-Nord), Stn. C (Cap Trinité). The data obtained are used here as a reference for a study of the impact of the July 1996 flood on meiofauna in the fjord and its recolonisation process. For the latter two studies, two oceanographic missions were performed (September 1996 and August 1997). During these two missions, 5 stations were sampled: Stn 2, 7, 9 (in the Baie des Ha! Ha!), Stn 13 (in of the Baie des Ha! Ha!), Stn. 13 (outlet of the Baie des Ha! Ha!), Stn. 18 (between St-Rose-du-Nord and Cap Trinité). The purpose of

the first mission was to assess the impact of a large layer of terrigenic sediment deposited in the Baie des Ha! Ha! and in the upstream portion of the upper fjord basin. The impact was especially severe in the Baie des Ha! Ha! (Stn. 2, 7, 9). Here, meiofauna densities fell drastically by more than 97% (T-test: $P<0.01$). At the Baie des Ha! Ha! outlet (Stn. 13), the reduction was lower (90%) but nonetheless significant (T-test: $P<0.05$). At Stations 2, 7, 9 and 13, two meiofauna groups disappeared (ostracodes and kinorhynches). At Station 18, although only a very fine layer of sediment (<1 mm) barely noticeable to the naked eye was deposited, total meiofauna density fell significantly by 55% (T-test: $P<0.05$). This decrease results from a sharp decline in nematode densities (T-test: $P<0.05$) and the absence of nauplii. The latter were also missing from the four other stations. At Station 18, it seems likely that the perturbation was of a chemical nature. Traces of hydrocarbons visible to the naked eye were observed in the sediment of this station. The second mission (August 1997) allowed us to begin a study of recolonistion in the affected areas. Generally, we can already observe that meiofauna densities in the Baie des Ha! Ha! and at its outlet are significantly higher (T-test: $P<0.05$). However, they still remain significantly lower than those observed prior to the flood (T-test: $P<0.05$). At Station 18, meiofauna densities did not differ significantly from those present prior to the flood. At all of the stations, nauplii had reappeared.

MICROPALEONTOLOGICAL AND GEOCHEMICAL TRACERS OF RECENT ENVIRONMENTAL CHANGES IN THE SAGUENAY FJORD

DEVILLERS, R., LOUCHEUR, V., MARMEN, S., BERTINI, A., BIANCHI, A., DE VERNAL, A., HILLAIRE-MARCEL, C., BILODEAU, G., LEDUC, J. and SAINT-ONGE, G. GEOTOP, Université du Québec à Montréal, P.O. Box 8888, Montreal, Quebec, H3C 3P8, c3470@er.uqam.ca

Microflora (diatoma, pollen, dinocysts, etc.), microfauna (foraminifera, thecamoebae) and geochemical (organic and inorganic carbon; d15N and d13C of organic matter) analyses were performed on surface sediment samples and on a core from the upper Saguenay basin to retrace environmental changes. The core, extracted by gravity from the centre of the basin (MB-97-12TWC; 48°21.76'N-70°23.72'; 270 m; cf. Sag Site-30), includes a sequence almost 3 metres thick. Generally, in the surface sediments and in the MB-97-12TWC core, micropaleontological biomarkers and tracers reveal an epicontinental deposit environment dominated by terrestrial supplies. The 13C readings of organic matter are lower than -25.5 %, and 15N readings range between 4.4 and 5.5 %. Among the organic membrane microfossils, we find grains of pollen and Pteridophyta spores most frequently (105-106/cm^3) while marine aquatic microfossils (dinoflagellate cysts and organic foraminifera networks) are rare. Carbonated marine microfossils (coccolitha, foraminifera) are sometimes present. Microfauna is not abundant (0-3 tests/cm^3) and consists primarily of agglutinate-test benthic foraminifera. Diatoma are extremely abundant and present in concentrations of about 109 valves/cm^3. In the MB-97-12TWC core sample, the lower portion (under 80 cm in depth) is characterised by a particularly pronounced terrigenic signature: 13C and 15N readings are less than -26.5% and 4.6% respectively, C/N ratios are approximately 25, pennala diatoma are relatively more widespread and foraminifera are exceptionally rare (<1 test/cm^3). Also, between 120 and 80 cm deep, we record minimum 13C readings and microfossil concentrations, as well as a high degree of fragmentation (>60%) in diatoma, indicating high detrital supplies, a turbulent

environment or sedimentary alteration. The base of the core, especially the interval between 80 and 120 cm, therefore includes singular sediments. From a regional stratigraphic standpoint, this may reflect the deposits resulting from the earthquake of 1663 (cf. Syvitski and Schafer, Sed. Geol. 104: 127-153, 1996).

THORIUM ISOTOPE SYSTEMATICS IN BOX CORED SEDIMENTS FROM THE OUTLET OF THE BAIE DES HA! HA!, SAGUENAY FJORD (EASTERN CANADA)

SAVARD, J., GHALEB, B., ZHANG, D. and HILLAIRE-MARCEL, C. GEOTOP, Université du Québec à Montréal, P.O. Box 8888, Centre-ville, Montréal (QC) H3C 3P8

Box coring of the Saguenay fjord sediment at the outlet of the Baie des Ha! Ha! (48°21.74 N; 70°42.30 W; water depth 233 m) allowed the recovery of a 53 cm sequence. The top of the sequence includes a ~ 10 cm-thick layer which was deposited during the 1996 flood. Multi-sensor tracking examination of the core suggests a very energetic sedimentary environment, with some cyclic trends at the base of the sequence. Twelve 0.5 cm-thick sub-samples were selected for Th isotope measurements on unspiked samples using a-spectrometry technique. The 230Th/232Th activity ratios are relatively constant. The observed mean value (0.56 ±0.02) characterises eastern Canadian shield derived supplies. It indicates here minimum changes in sources and grain size of recent detrital supplies, including those of the 1996 flood. The 228Th/232Th ratios show large fluctuations between a maximum value of 1.25±0.03 at top, and a minimum value of 0.85± 0.02 at about 15 cm below surface. In the overlying water column, a 228Th/232Th ratio of 1.53±0.04 was measured on suspended particulate matter (SPM). The lower value at box-core top may simply be due to fast mixing of fresh SPM with (i) older sediment from downcore, and/or (ii) a sediment transported through the nepheloid layer and showing a lesser excess in 228Th (vs 232Th), adding to some 228Th-excess decay. Nevertheless, the large 228Th/232Th ratio variations observed downcore will help to constrain biological mixing of the sediment, through time, when re-sampling the site in forthcoming years. Due to the fact that the deficit in 228Th (vs 232Th) in the subsurface of the core could be due to 228Ra deficits in the incoming sediment, the 228Th/232Th profile is likely to evolve at a time scale based on the half lives of the two radio-isotopes involved (i.e., 228Ra ~ 6 yr and 228Th ~ 2 yr).

THE SAGUENAY FLOOD: GEOCHEMICAL EVOLUTION OF SEDIMENT IN THE BAIE DES HA! HA! (SAGUENAY FJORD)

DEFLANDRE, Bruno and GAGNÉ, Jean-Pierre. Laboratoire d'Analyses et d'Études en Géochimie Organique (LAEGO), Groupe de Recherche en Environnement Côtier (GREC), Oceanography Department, Université du Québec à Rimouski, 310 allée des Ursulines, Rimouski (QC), G5L 3A1, bruno_deflandre@uqar.uquebec.ca, jean-pierre_gagne@uqar.uquebec.ca

Historically, the Saguenay fjord is a region known for the severe contamination of its surface sediments. This contamination primarily results from urbanisation and industrial development. In the 1980s, a

general breakthrough in awareness led to improvements in the quality of surface sediment in the Saguenay fjord. In July 1996, the Saguenay region experienced torrential rains that triggered flash flooding in many of the rivers along the Saguenay fjord. Portions of the Baie des Ha! Ha! and the Bras Nord of the Saguenay fjord received significant new deposits of sediment that covered the existing sediments. Our work, which began a month after the flood and will continue for the next two years, currently enables us to assess the geochemical evolution of the new, emerging environment. The parameters measured include porosity, salinity, redox potential, the elementary C/N ratio, the C%, and the percentage of dissolved organic carbon and chlorophyll A. They reveal a major perturbation of the sedimentary column. We observed strong vertical and horizontal gradients for these parameters one month after the supply of new sediment in the Baie des Ha! Ha!. Temporal monitoring of this event shows that the geochemical changes in the sedimentary column have diminished, but remain visible. The geochemical tracers measured allows us to specify the thickness of the layer of new sediment. An analysis of aliphatic hydrocarbons shows that the new layer of sediment is not contaminated. However, saline anomalies were observed in the interstitial waters, suggesting the movement of organic matter and associated substances, which could lead to the remobilization of buried organic and inorganic contaminants. We discuss the geochemical impact of the July 1996 flood on the sedimentary column primarily in terms of the transformation of organic matter and what will become of the associated contaminants. Our interpretation is based on the historical context of synsedimentary changes specific to Saguenay fjord sediment.

BUTYLTIN CONTAMINATION IN THE FJORD

ROBILLARD, Sophie. Département d'océanographie, Université du Québec à Rimouski, Rimouski, Quebec, G5L 3A1, Sophie_robillard@uqar.uquebec,ca, PELLETIER, Émilien, Institut National de la Recherche Scientifique (INRS-Océanologie), 310 allée des Ursulines, Rimouski, Quebec, G5L 3A1, SAINT-LOUIS, Richard. Pavlova Océanologie, 981 de la Pointe, Pointe-au-Père, Quebec, G5M 1N7

Despite the many studies already conducted on contamination of the Saguenay fjord, some aspects of this contamination still escape us. In the late 1970s, new anti-stain paints for ship hulls were marketed throughout the world both for large merchant and military ships and small pleasure craft. These paints were designed to reduce crusting caused by marine organisms that attach to a ship's hull after extended periods in the water; it contains a toxic ingredient called tributyltin (TBT). This compound disperses in marine waters and today constitutes one of the most hazardous toxic substances ever introduced into the marine environment. Every year, several dozen large merchant ships arrive in the Saguenay fjord bringing butyltin contamination with them. Preliminary research reveals the presence of TBT and its derivative compounds in the fjord's sediments in concentrations ranging from 10 to 30 ng Sn/g sec. Compared to certain port areas in Canada and Europe, these readings are low but nevertheless far higher than amounts observed in Gulf of St. Lawrence sediment. As in other cases of contamination, the fjord's deep basin acts as a retention and sedimentation basins for particulate that takes on contaminants upstream of the Saguenay river or from the surface layer of the fjord. With all of the new data gathered on the Saguenay sediments and organisms, we can develop a new digital model to explain and predict the circulation of butyltin and what becomes of it in a coastal environment. Lastly, we would note that

TBT like other contaminants can be used as a tracer to study the possible remobilisation of pollutants in the Baie des Ha! Ha! following the 1996 flood since the mud supplied by flooding rivers obviously contained no butyltin, a substance used only in marine paints and to manufacture PVC plastics.

COMPARISON OF CROSSED ARRAY SYSTEM SURVEYS IN 1993 AND 1997 IN THE UPSTREAM AREA OF THE SAGUENAY FJORD: PRELIMINARY ANALYSIS OF THE 1996 LAYER AND GEOMORPHIC FACTORS

LOCAT, Jacques. Department of Geology and Geological Engineering, Université Laval, Sainte-Foy, Quebec, G1K 7P4, locat@ggl.ulaval.ca, KAMMERER, Édouard (UNB); DOUCET, Normand (IML); HUGHES-CLARKE, John (UNB), MAYER, Larry (UNB); MAURICE, France (U. Laval), BOULANGER, Éric (U. Laval) and SIMPKIN, Peter (INRS).

The Institut Maurice Lamontagne in Mont-Joli has been conducting surveys since 1993. In the beginning, the Saguenay fjord was used to develop the method and adapt this technology to the needs of the Canadian Hydrographic Service. Using the SIMRAD EM 1000 probe, this method produces bathymetric maps accurate from 10 to 20 cm in waters 200 m deep. Readings are taken at a top speed of 14 knots. In addition to the probe data, corrected for a variety of dynamic parameters (rolling, pitching, etc.), the various differential geographic positions are continuously recorded during the readings, with a spatial resolution of less than 1 m. In 1993, it took 14 days to cover the sector and in 1997, only 4 days. The main purpose of the 1997 coverage was to analyse the signature of the sedimentary layer deposited abruptly during the 1996 flood. The aim was to see whether this survey technique could be used to map the distribution of the 1996 layer and monitor its evolution in terms of sedimentary movement or density changes. A comparison of the two readings shows a “build-up” in the Mars and Ha! Ha! river deltas. Overall, the remainder of the sector displays no significant changes in bathymetric variation. We would point out that the 1996 layer varies from 10 to 50 cm in thickness, and is spread evenly from the deltas to the mouth of the Baie des Ha!Ha!. However, back-scatter data from the emitted signal provides a very different image. The 1996 layer being very soft and engorged with water, the return signal is altered (dark patches), which raises the possibility of locating areas covered with a layer of fine sediment using these patches. The superposition of granulometric data and water content (or density) data support the mapping performed using 1997 readings. The 1997 readings also confirm the presence of specific morphological structures, such as an erosion mound and a terrace or shelf of still uncertain origin (erosion or tectonic). A description of these latter elements is supported by seismic reflection readings (SEISTEK).

STRUCTURE OF A DEPOSIT SEQUENCE ANALYSED BY TOMODENSITOMETRY – EXAMPLE OF THE SEQUENCE CREATED FOLLOWING THE 1996 FLOODS

CRÉMER, Jean-François, and LONG, Bernard F. Institut National de la Recherche Scientifique (INRS-Océanologie), Rimouski, QC, G5L 3A1 jean-francois_cremer@uqar.uquebec.ca; LOCAT, Jacques, Department of Geology and Geological Engineering, Université Laval, Sainte-Foy, Quebec, G1K 7P4

Following the 1996 floods, a large amount of sediment from the watersheds adjoining the Saguenay fjord entered the Baie des Ha! Ha! and the Bras Nord. To characterise these deposits according to their supply and remobilisation potential, a series of core samples was taken in the region using either a 70 cm deep box core or a gravity core three metres deep during a mission in July 1997. These samples were analysed with the axial tomodensitometer of the Centre Hospitalier Régional de Rimouski (GE model B7590k Hi Speed CT/i). The use of helicoidal axial tomodensitometry in geology allows us to study a sample without destroying it and qualitatively and quantitatively evaluate its means of insertion, sediment density, granulometry and compaction. Length-wise and cross-section scans can be quickly performed at a series of chosen angles. The very high-density resolution of this device and the computer processing of images also reveals sedimentary structures that might escape notice using conventional methods. Studies of Saguenay samples have revealed various types of facies characteristic of this supply method. Slide facies are most common and can be divided into massive, apparently or actually unstratified, layered sub-layers interlaced with a mixture (containing boulders, clay pebbles and other coarse-grained materials in a non-layered matrix) and small landslide debris. This horizon, less than 40 cm thick, contrasts with older deposits which are generally of the gravity type. One year after implementing this horizon, no altered surface structure was detected in the top part of the core. Nevertheless, it will have to be analysed in detail to be compared with next year's sample during the new sampling campaign, in order to check whether a partial remobilisation could occur either under the effect of hydrodynamic conditions or the influence of bioturbation, which should increase with re-colonisation of the site.

CONSOLIDATION OF THE 1996 LAYER COVERING CONTAMINATED SEDIMENT IN THE BAIE DES HA! HA! SECTOR (SAGUENAY FJORD), QUEBEC: PRELIMINARY DATA

MAURICE, France, and LOCAT, Jacques, Department of Geology and Geological Engineering, Université Laval, Sainte-Foy, QC, G1K 7P4, fmaurice@ggl.ulaval.ca, LEROUEIL, Serge, GALVEZ-CLOUTIER, Rosa, Department of Civil Engineering, Université Laval; and THERRIEN, René. Department of Geology and Geological Engineering, Université Laval

During the summer of 1997, more than 60 surface samples were collected upstream of the Saguenay fjord, particularly from the Baie des Ha! Ha!. Some samples were also gathered using a box core device. The following tests were performed on these samples: granulometry, liquid and plastic limits, water content, intact shear resistance (boxed core samples) and altered shear resistance. Based on these various analyses, two integrated samples were prepared. These samples were homogenised and

placed in SEDCON cells to initially monitor the sedimentation phase and the consolidation phase. Both SEDCON tests provided an reference curve applicable to a case of rapid supply (e.g., turbidity or mud slide). These curves can therefore be used to compare the current consolidation of sediment assessed on the basis of various liquidity index profiles obtained from boxed core samples to the SEDCON curves. For example, the 22 cm 1996 layer observable at the centre of the Baie des Ha! Ha!, exhibits the typical liquidity index profile of a normally consolidated sediment but one that was deposited quickly and non-bioturbed: value that regularly falls from 4.0 to 3.0. The in situ profile of shear resistance in the 1996 layer is also typical of a non-bioturbed sediment with an even increase depending on depth. As soon as we encounter the bioturbed layer, the variations are visibly more uneven. This data will serve as a reference for changes observed in years to come. The same SEDCON curves can also be used to forecast changes in the vacuum index following burial. The basic test makes it possible to simulate a burial of 10 metres which, at a sedimentation rate of approximately 1 to 10 mm per year, would reflect a period of time amounting to 10,000 or 1,000 years.

POST-FLOOD RECONSTRUCTION PLANNING AND MANAGEMENT IN THE SAGUENAY

PROULX, Marc-Urbain, Université du Québec à Chicoutimi, 555, boul. de l'Université, Chicoutimi (QC) G7H 2B1

There is no official planning or management procedure directly applicable to natural disasters. However, stability being a model of the past, planing theory increasingly views a state of turmoil as the major characteristic of the environment in which the planned object is to be placed. The appropriate techniques exist within the major components of planning. These techniques have been tested and enriched with each experiment, especially those concerning a state of turmoil such as that caused by natural disasters. This paper analyses the experience of reconstruction planning and management following the Saguenay flood. We begin by illustrating the land management and social and economic issues raised by planning activities performed prior to the flood in this region. Next, we will see how decision-makers used the planning process first to manage the crisis and then to reconstruct after the flood. A description of the reconstruction work is given using an inventory of the actions taken. Lastly, our analysis will allow us to visualise how planning components were tangibly applied to the case presented. Special attention will be given to economic development factors. A few lessons will be inferred from our analysis.

MAJOR FEATURES OF THE FLOOD RESEARCH PROGRAM (GRIR, UQAC)

GAGNON, Christiane, Department of the Humanities, Groupe de recherche et d'interventions régionales, Université du Québec à Chicoutimi, 555 boul. de l'Université, Chicoutimi, Quebec, G7H 2B1, Christiane_Gagnon@uqac.uquebec.ca

Confronted with the major social, ecological or economical issues involved in last summer's flooding, a multidisciplinary team of researchers from the Université du Québec à Chicoutimi took the initiative to establish a research program on the causes and effects of a disaster like the July 1996 flood. This innovative research program is intended to be multidisciplinary and results from a spontaneous process of co-operation with other academic institutions and the regional community. The primary objective of the program is three-fold: 1) to understand the overall causes and effects of this natural disaster; 2) to draw practical, concrete lessons for all of the social stakeholders involved, whether decision makers, workers or the communities affected; 3) to identify factors that can be generalised to other situations for more effective forecasting, planning, decisions, remedial action, and impact monitoring.

EMERGENCY PREPAREDNESS LESSONS LEARNED AND STILL TO BE LEARNED FROM THE SAGUENAY DISASTER

PAUCHANT, Thierry C., Hautes Études Commerciales, 3000, chemin de la côte Ste-Catherine, Montréal, Quebec, H3T 2A7, pauchant@hec.ca, CAZALIS, Pierre, École Nationale d'Administration Publique, 555, boul. Charest est, Quebec, Quebec, G1K 9E5, PARENT, Daniel, Hautes Études Commerciales, 3000, chemin de la côte Ste-Catherine, Montreal, Quebec, H3T 2A7

The authors of this paper describe the lessons learned and not yet learned from the Saguenay disaster in terms of emergency preparedness in Quebec and in Canada. This assessment is based on the recommendations put forward in the evaluation report on administrative action taken during the disaster (the "Cazalis Report") and on dam safety (the "Nicolet Report"). In conclusion, the authors stress the urgency of developing an "emergency preparedness culture" in Quebec and in Canada.

RIVIERE DES HA! HA!, EPICENTRE OF THE FLOOD: GEOTECHNICAL FACTORS

VALLÉE, Jean, Department of Applied Science, Université de Québec à Chicoutimi, Chicoutimi, Quebec, G7H 2B1, jvallee@uqac.uquebec.ca

This paper describes the most perturbed river in the Saguenay region during the 1996 flood. The overtopping of an earthfill dyke and two small concrete dams, a major avulsion, erosion and the significant conveyance of sediment, widening and straightening of the riverbed are described from a geotechnical standpoint. A new mapping of old landslides in the area downstream of the river provides an understanding of their effects on the river's bed. Different portions of this river are synthetically

presented using a computer technique (chromostereography), a new tool for visualising land in three-dimensions and of interest to many disciplines.

PARTICULATE AND COLLOIDAL + DISSOLVED SPECIES WITHIN THE WATER COLUMN OF THE SAGUENAY FJORD: PERTURBATIONS?

ALPAY, S., and MUCCI, A., Earth and Planetary Sciences, McGill University, 3450 University, Montréal QC, H3A 2A7, salpay@geosci.lan.mcgill.ca, HILLAIRE-MARCEL, C., Département des Sciences de la Terre, GEOTOP, Université du Québec à Montreal, Montréal, QC, H3C 3P8

Anthropogenic and natural trace metals are removed from the water column by several possible pathways that include direct adsorption onto particulate matter and "colloidal pumping". These natural contaminant remediation schemes may become so efficient that trace metal concentrations in the underlying sediment become anomalously elevated. To characterise the nature and sources of adsorbates and substrates, temporal and spatial distributions of particulate and colloidal + dissolved species were measured within the freshwater lens, at the thermohalocline, and in the fully oxygenated marine water column at four stations along the main axis of the Saguenay fjord (Quebec, Canada). The pre-determined sampling schedule included measurements before and after the flood event of June 1996. Perturbations within the water column at the monitoring stations within the sampling time interval before and after the flood cannot be uniquely ascribed to the flood disaster. Preliminary results of the overall study (May 1996 to present) suggest the predominance of colloidal material at the thermohalocline that coincides with the turbidity maximum. Results of parallel and sequential filtrations on polycarbonate membranes (0.4, 0.1, 0.05 and 0.03 mm) reveal no difference in "dissolved" organic carbon, As, Si, and Al concentrations. If there is a distinct colloidal metal pool, then it would appear that filtration on polycarbonate membranes is an inadequate isolation technique. The total (unfiltered) concentrations of As and Si and their colloidal + dissolved concentrations (<0.4 mm) are nearly identical throughout the water column. Colloidal + dissolved As concentrations appear to behave conservatively along the salinity gradient. In each size fraction, Si concentrations display maximum values in the surface freshwater, intermediate values at the thermohalocline and minimum values in the underlying marine water. Al concentrations show a similar distribution with water depth, but the total (unfiltered) concentrations exceed the colloidal + dissolved concentrations by one order of magnitude. Additional riverine analyses suggest that spillage or air fall of particulate Al from aluminium smelting operations upstream may provide a substrate for adsorption of trace metals within the fjord. Evidence from analyses of C:N, d13C (from material collected on glass fibre filters), and 234Th (from particle concentration by cross-flow ultrafiltration) suggests that the composition and residence times of particulate matter vary both temporally and spatially.

USE OF PIEZOCONE DURING THE JULY 1996 FLOOD IN THE SAGUENAY

BOUCHARD, Régis. PDG Techmat Inc., 3306, boul. St-François, Jonquière, Quebec, G7X 2W9, bouchardr@techmat.qc.ca

The torrential rains of July 19 and 20, 1996, and the resulting floods, left their mark on the topography of the shores of the Saguenay's major rivers. The quick drainage of many artificial reservoirs and the river bed erosion and shoreline erosion caused by the strong currents sculpted almost vertical cliffs in the silt deposits along these waterways. The impact of the phenomena generated by the rain therefore had major consequences for natural soils and human structures. The rebuilding of roads, bridges, dams and the stabilisation of weak slopes demanded many investigative campaigns. In carrying out these campaigns, the use of piezocone made it possible to characterise the soils encountered quickly and efficiently. The presentation provides a brief description of the geological background of soil in the Saguenay followed by a few examples of popularised applications that show the advantages of the investigation technique.

TYPOLOGY OF LANDSLIDES CAUSED BY HEAVY RAINS IN MID-JULY 1996 IN SAGUENAY/LAC SAINT-JEAN, QUEBEC

PERRET, Didier et BÉGIN, Christian. Geological Survey of Canada, GSC-Quebec, Sainte-Foy, QC, G1V 4C7, dperret@gsc.NRCan.gc.ca, DEMERS, Denis. Ministère des transports du Québec, Sainte-Foy, Quebec, G1S 4X9

The torrential rainfall that beat down on the Saguenay and Lac Saint-Jean (Quebec) region from July 19 to 21, 1996 was responsible for more than 1,000 landslides. A photographic interpretation, on a scale of 1:15,000, showed that approximately 90% of landslides occurred outside the alluvial corridors in areas free of fluvial erosion. The most severely affected areas involved marine clay deposits in low-lying areas of the region where local concentrations exceeded one hundred or so movements per km^2. To clarify the failure mechanisms, 267 landslide sites were studied for a detailed geomorphometric ground description. Movements were identified by the general shape of the scar, the distance of upstream and downstream encroachments, the known or suspected depth of the surface failure, and the position of the failure point on the slope. Although many landslides were of a mixed nature, we can nevertheless distinguish among the following four main types: (1) surface failures, where the break point runs more or less parallel to the slope and affects only the ground cover and root zones; (2) shallow flows, most affecting a thickness of material ranging approximately from 1 to 3 or 4 metres and confined to the altered clayey crust; (3) deep, rotational landslides, usually retrogressive, affecting materials at depths of at least 8 metres; and (4) mud slides, much more long than wide, characterised by a failure point located in the upper section of the slope. The geomorphic analysis also shows that shallow failures usually occur on highly convex hillsides, while mud slides affect the face or front of spurs. Finally, the proposed typology was related to the geology and geotechnical properties of the materials in question.

POST-TRAUMATIC STRESS DISORDER: AFTER THE SAGUENAY FLOOD

FORTIN, Martin. Department of Family Medicine, Université de Québec à Chicoutimi, Chicoutimi Family Medicine Unit, Sagamie Hospital, 305 St-Vallier, Chicoutimi, Quebec, G7H 5H6, mfortin@saglac.qc.ca; AUGER, C., LATOUR, S. and TRUDEL, M., Chicoutimi Family Medicine Unit, Sagamie Hospital, 305 St-Vallier, Chicoutimi, Quebec, G7H 5H6.

Objective: Measure the prevalence of post-traumatic stress disorder and emotional distress three months after the Saguenay flood. *Methodology*: Descriptive study using a telephone questionnaire addressed to a population of disaster victims and a test group. *Location*: the City of Chicoutimi. *Participants*: The consenting adult population of a flooded neighbourhood (n=62) and a randomly selected, voluntary test group among the population of a neighbouring area (n=79). Principal measurements of findings: Positivity for diagnostic criteria for post-traumatic stress disorder and a high score on the emotional distress questionnaire. *Findings*: The population and the test groups were socio-demographically comparable. A post-traumatic stress prevalence of almost 20% was found for the disaster victim group, representing a ratio score of 6.08 (IC95%: 1.63; 22.64). Emotional distress was present among 29% of disaster victims for a ratio score of 2.42 (IC95%: 1.04 ; 5.61). The questionnaires used were translations and adaptations of the "PTSD Reaction Index" and the "Self Reporting Questionnaire". *Conclusion*: The Saguenay flood generated psychological after-effects that were measurable three months later. Health workers must be informed of the psychological effects of natural disasters in Quebec.

ANALYSIS OF THE RIVIÈRE CHICOUTIMI FLOOD AND ITS GEOMORPHIC EFFECTS

HENICHE, Mourad, LECLERC, Michel, SECRETAN, Yves, and BOUDREAU, Paul, Institut national de la recherche scientifique - Eau (INRS-Eau), P.O. Box 7500 Sainte-Foy, Quebec, G1V 4C7, Mourad_Heniche@inrs-eau.uquebec.ca, LAPOINTE, Michel, Department of Geography, McGill University, 805 Sherbrooke St. West, Montreal, Quebec, H3A 2K6

During events in the Saguenay in July 1996, the overabundance of rainfall and runoff in the watershed saturated the water regulation capacity of the Lac Kenogami reservoir upstream of the inhabited areas of the Saguenay. A two-dimensional hydrodynamic simulation of the Rivière Chicoutimi flood and an analysis of the morphological changes which affected the reaches of the dam were performed following the incident. The hydrological supply of 2500 m^3/s into the watershed was redistributed between the Rivière Chicoutimi and Rivière aux Sables after laminating at 1800 m^3/s (1100 and 700, respectively). This distribution was significantly affected by upstream catchment facilities (Portage-des-Roches and Pibrac), their natural distribution possibly quite different without the dams. The Rivière Chicoutimi flood largely exceeded the natural hydraulic capacities of the river and the drainage capacities of downstream dams (Chute-Garneau, Pont Arnaud, Elkem Métal and Abitibi-Stone in Chicoutimi). The transitory, hydrodynamic simulations performed with the model make it possible to reconstitute the transfer of floodwaters in the Rivière Chicoutimi. Topographical data on the mean-water bed and the floodplain

were gathered from a wide variety of sources (including photogrammetrics) and which had to be reconciled with a highly advanced hydro-geomatic tool called MODELEUR. At the Chute-Garneau and Pont Arnaud dams, the river's water level overflowed the concrete works and caused a massive incision the of fluvial-marine deposits supporting the dams. This phenomenon is like an avulsion. At Chute Garneau, erosion affected a volume of 147,000 m^3 while the sedimentary figure for Pont Arnaud amounts to 750,000 m^3. It is possible that the natural capacity (pre-dam) of the runoff sections were overloaded, which raises serious doubts concerning the appropriateness of the drainage concept used at the hydroelectric station. Internet address: http://www.inrs-eau.uquebec.ca/saguenay.

PERFORMANCE OF THE SEDIMINTARY LAYER FROM THE 1996 FLOOD COVERING CONTAMINATED SEDIMENT IN THE SAGUENAY FJORD: AN OPPORTUNITY FOR TECHNOLOGICAL DEVELOPMENT

LOCAT, Jacques, Department of Geology and Geological Engineering, Université Laval, Sainte-Foy, Quebec, G1K 7P4, locat@ggl.ulaval.ca; DESROSIERS, Gaston, (UQAR), DE VERNAL, Anne, (UQAM); GAGNÉ, Jean-Pierre, (UQAR); GALVEZ-CLOUTIER Rosa, (U. Laval); GRATTON, Yves, (INRS), HILL, Philip, (UQAR); HILLAIRE-MARCEL, Claude, (UQAM); LONG, Bernard (INRS); MUCCI, Alphonso, (McGill); PELLETIER, Émilien, (INRS); SIMPKIN, Peter, (INRS); and THERRIEN, René, (U. Laval).

The 1996 Saguenay flood disaster spread more than 6 million tonnes of relatively clean sediment over contaminated sediment in the Baie des Ha! Ha! and the Bras Nord (section upstream of the Saguenay fjord). Preliminary observations show that this layer varies in thickness from 10 to 50 cm. Early after the 1996 flood, a multidisciplinary team gathered to assess from various angles the permanency of this layer and its effectiveness as a geological barrier to the migration of contaminants. This study will require developing tools and methods for assessing the environmental performance of the cover layer, restoring the site and forecasting contaminant movement and the integrity and stability of this layer. Such a problem demanded a research program that carefully integrates various disciplines such as geology, biology, chemistry and hydraulics. Lasting five years, the project created combines researchers from many universities in and outside Quebec. The results of this five-year research project should make it possible to: (1) provide an answer concerning the effectiveness of the cover layer; (2) satisfactorily identify the species living in the fjord that may act as indicators of the site's environmental restoration; (3) develop digital or conceptual models to evaluate and predict the chemical reactions around the edges of the cover layer; (4) provide a digital simulation model for predicting the conveyance of contaminants across the cover layer; (5) show how this layer will resist erosion and earthquakes; and (6) combine these various tools and techniques into an approach useful for planning, developing and predicting the performance of cover layers (natural or artificial) on contaminated sediment. We are using this Symposium to launch the project and present the preliminary results on various aspects of the research program. The Natural Sciences and Engineering Research Council of Canada and Alcan funded this project.

APPENDIX 1

Program of the 1996 Saguenay Flood Symposium
May 20, 1998

Period	Title	Names
1 + 2	Risk management and engineering practice: The Saguenay Case	Roger NICOLET (O.I.Q.)
3	Rivière Chicoutimi : Talk about a flood – A geographic outlook on the overall phenomenon	Gilles H. LEMIEUX (UQAC)
4	Impact of flooding on public health: Survey of the literature and case studies	Gilles LALANDE, Danielle MALTAIS, Suzie ROBICHAUD and Anne SIMARD (UQAC)
5	Fluvial geomorphic effects of the July 1996 flooding, Saquenay Region, Southern Quebec, Canada	D.E. LAWRENCE and G.R. BROOKS (CGC)
6	Saguenay fjord contamination: A summary of current knowledge	Émilien PELLETIER (INRS-Océanologie)
7	Residential flood damage: Lessons from the Saguenay	Michel LECLERC, Joëlle MARION and Mourad HENICHE (INRS-Eau)
8	Reconstruction management following torrential rains in the Saguenay	François MORNEAU (MTQ)
	Lunch	
9	Emergency preparedness lessons learned and still to be learned from the Saguenay disaster	Thierry C. PAUCHANT (HEC), Pierre CAZALIS (ENAP) and Daniel PARENT (HEC)
10	Rivière des Ha! Ha!, epicentre of the flood: Geotechnical factors	Jean VALLÉE (UQAC)
11	Particulate and colloidal + dissolved species within the water column of the Saguenay Fjord: perturbations ?	Salma ALPAY and Alphonso MUCCI (McGill)
12	Use of piezocone during the July 1996 Saguenay flood	Régis BOUCHARD (Techmat)
13	Typology of landslides caused by heavy rains in mid-July 1996 in Saguenay/Lac Saint-Jean, Quebec.	Didier PERRET, Christian BÉGIN, and Denis DEMERS (CGC et MTQ)
14	Post-traumatic stress disorder: After the Saguenay flood	Martin FORTIN, C. AUGER, S. LATOUR and M. TRUDEL (UQAC)
15	Analysis of the Rivière Chicoutimi flood and its geomorphic effects	Mourad HENICHE, Yves SECRETAN, Paul BOUDREAU and Michel LAPOINTE (INRS-Eau)
16	Performance of the sedimentary layer from the 1996 flood covering contaminated sediment in the Saguenay fjord: An opportunity for technological development	Jacques LOCAT (Laval), G. DESROSIERS (UQAR), A. DE VERNAL (UQAM), J.-P. GAGNE (UQAR), R. GALVEZ-CLOUTIER (Laval), Y. GRATTON (INRS), P. HILL (UQAR), C. HILLAIRE-MARCEL (UQAM), B. LONG (INRS), A. MUCCI (McGill), E. PELLETIER (INRS), P. SIMPKIN (INRS) and R. THERRIEN

		(Laval)

POSTER SESSIONS– POSTERS	
Title	**Names**
Contribution of detailed surficial mapping in the reconnaissance of multi-event landslides in post-glacial marine clays.	S. PARADIS, D. PERRET and C. BÉGIN (CGC)
Impact of the July 1996 flood on benthic meiofauna in the Saguenay fjord	G. TITA and Gaston DESROSIERS (UQAR)
The Saguenay flood: Geochemical evolution of sediment in the Baie des Ha! Ha! (Saguenay fjord)	Bruno DEFLANDRE and Jean-Pierre GAGNÉ (UQAR)
Sedimentary movement in the Saguenay fjord: Effects of environmental perturbation on the composition and evolution of macrobenthic populations	Christian NOZAIS and Gaston DESROSIERS (UAR)
Retrospective analysis of landslides during the torrential rains of July 1996 in the Saguenay	Denis DEMERS, Denis ROBITAILLE, and Didier PERRET (MTQ and CGC)
Rockfalls during the Saguenay flood	André DROLET (MTQ)
Thorium isotope systematics in box cored sediments from the outlet of the Baie des Ha! Ha!, Saguenay Fjord (Eastern Canada)	J. SAVARD, B. GHALEB, D. ZHANG and Claude HILLAIRE-MARCEL (UQAM)
Consolidation of the 1996 layer covering contaminated sediment in the Baie des Ha! Ha! sector (Saguenay fjord) in July 1996, Quebec: preliminary data	France MAURICE, Jacques LOCAT, Serge LEROUEIL, Rosa GALVEZ-CLOUTIER and René THERRIEN (Laval)
Comparison of crossed array system surveys conducted in 1993 and 1997 in the area upstream from the Saguenay fjord: Initial analysis of the 1996 layer and geomorphic factors	Jacques LOCAT, Édouard KAMMERER, Normand DOUCET, John HUGHES-CLARKE, Larry MAYER, France MAURICE, Éric BOULANGER and Peter SIMPKIN (Laval)
Structure of a deposit sequence analysed by tomodensitometry – Example of the sequence created after the 1996 floods	Jean-François CRÉMER, Bernard F. LONG and Jacques LOCAT (INRS-Laval)
Micropaleontological and geochemical tracers of recent environmental changes in the Saguenay fjord	R. DEVILLERS, LOUCHEUR, V., MARMEN, S., BERTINI, A., BIANCHI, A., DE VERNAL, A. and C. HILLAIRE-MARCEL (UQAM)
When a river changes course – Avulsion of the Baie de la Ha! Ha! in July 1996	Michel LAPOINTE, Michel LECLERD, Normand BERGERON and Yves SECRETAN (INRS-Eau)
Post-flood reconstruction planning and management in the Saguenay	Marc-Urbain PROULX (UQAC)
Major features of the flood research program (GRIR, UQAC)	Christiane GAGNON (UQAC)
Butyltin contamination in the fjord	Sophie ROBILLARD, Émilien PELLETIER and Richard SAINT-LOUIS (INRS-Océanologie)