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The Role of Hazus-MH in the Canadian Natural Disaster Management Strategy

K.J. Mickey and D.E. Coats

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The following report was based on a contract issued by Natural Resources Canada, Quantitative Geohazard Risk project. This work contributes to NRCan's Safety, Security and Governance strategic outcome by developing standardized tools, protocols and guidelines that help build a capacity to assess and manage risks associated with natural hazards. The work also contributes to ongoing efforts by Public Safety and Defence Research & Development Canada (Centre for Security Science) to establish an All-Hazards Risk Assessment Framework for Canada. The intended output of this work is to build capability for the use of Hazus in Canada and establish a foundation for developing an integrated outreach/training program that extends beyond the needs of the Emergency Management community.

Background: Damage and loss estimation models combine authoritative information about hazard potential and system vulnerabilities to predict the impacts and likely consequences of credible hazard events on people and the things they value. They provide a capability to anticipate and plan for a wide range of hazard event scenarios, thereby increasing situational awareness of the risk environment and the effectiveness of mitigation, response and recovery operations.

Hazus is a quantitative loss estimation methodology and software tool developed by the US Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). It supports risk-based planning activities that promote national disaster mitigation policies in the United States. It encompasses an integrated suite of analytical models, spatial decision support tools, and procedural guidelines for quantitative risk assessment of floods, earthquakes, and hurricanes. The methods and tools are based on state-of-the art scientific and engineering knowledge and industry standards for quantitative risk assessment. They provide a robust and standardized approach to loss estimation that is being adopted by emergency management organizations worldwide.

The Earth Sciences Sector of Natural Resources Canada has identified Hazus-MH as a best practice for quantitative loss estimation and is engaged in collaborative research and development activities with FEMA and its partners to adapt existing methods and tools for use in Canada. Methods are being tested and evaluated through targeted case studies in several provinces across Canada. The report represents the training/outreach component of a proposed multi-year Agreement between the Government of the United States and the Government of Canada to promote Cooperation in Science and Technology for Critical Infrastructure Protection and Border Security. A program based on the experiences and knowledge from the US Hazus experience, but for a Canadian context.

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Natural Resources Canada

The Role of Hazus-MH in the Canadian Natural Disaster Management Strategy

March 31, 2012

Submitted by:
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Introduction

In response to the obvious threat posed by recurring natural disasters, the Canadian Parliament enacted the Emergency Management Act of 2007 (S.C. 2007, c.15), which defines the roles and responsibilities for all federal departments across the full spectrum of emergency management including prevention/mitigation, preparedness, response and recovery and critical infrastructure[6].

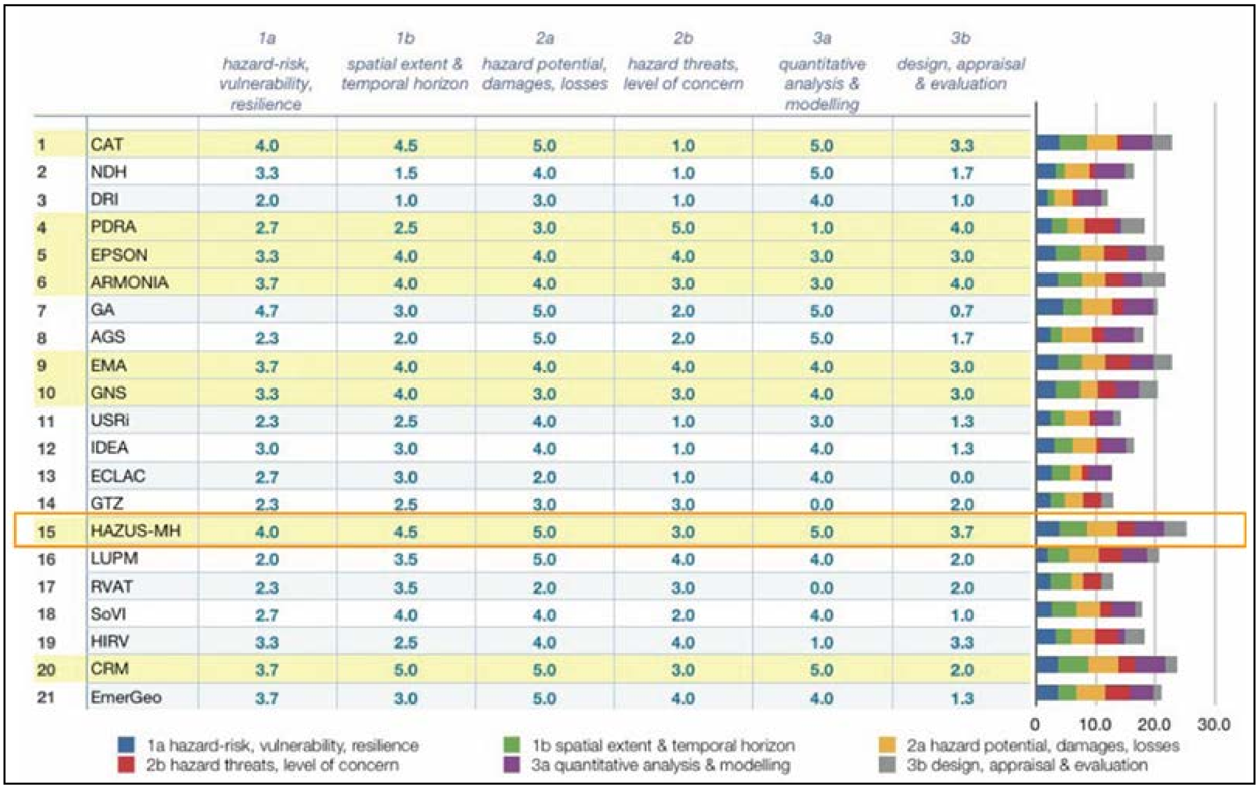
The act charges the Department of Public Safety and Emergency Preparedness with providing overall leadership in developing a National Disaster Management Strategy (NDMS) and "coordinating among government institutions and in cooperation with the provinces and other entities, emergency management activities" (S.C. 2007, c.15). Each of the other departments is directed by the act to identify the risks from natural disasters that are related to its sphere of responsibility and to develop an emergency management plan and supporting strategies appropriate to its responsibilities.

In response to this mandate, Natural Resources Canada (NRCan) investigated the development and implementation of tools designed to produce Quantitative Risk Analyses (QRA) for the natural disasters caused by geological events. After extensive research, NRCan identified a number of tools that can assist in producing these assessments including Hazus-MH (Hazus), a geographic information systems (GIS) based tool developed by the United States Federal Emergency Management Agency (FEMA). Hazus has proven to be a useful tool in the United States that promotes a new awareness or confirmation of specific areas that may be at risk. By quantifying the risk in dollars it has stimulated local and state government to identify and pursue appropriate mitigation measures. Hazus can also be used to demonstrate that disaster mitigation represents a good investment especially when non-structural costs, such as business interruption are included. A collateral benefit that has occurred is that Hazus has provided a platform for collaboration among federal agencies. By taking advantage of the scientific research generated by federal agencies like The US Geological Survey for ShakeMaps related to seismic events and flood insurance rate maps generated by FEMA to support the national flood insurance program, Hazus has provided a successful vehicle for making the value of that research felt at the local level. Presumably it would have the same impact for the work of NRCan, Environment Canada and other departments. Although developed for use in the United States, Hazus is also a potentially useful tool for quantifying risks in Canada from earthquakes, riverine and coastal flooding, storm surges, and hurricanes. Hazus could play a significant role in supporting the objectives of Public Safety Canada's proposed National Disaster Mitigation Program. By focusing attention on potential monetary losses, Hazus can move all levels of government toward

[6] Public Safety Canada (2012). *Emergency Management Act*. Retrieved from http://www.publicsafety.gc.ca/media/nr/2007/bk20070807-eng.aspx

a proactive disaster risk reduction approach. Figure 1 illustrates NRCan's comparative analysis of the suitability of geohazard risk analysis methods.

Figure 1. Suitability of Geohazard Risk Analysis Methods in Canada



		1a hazard-risk, vulnerability, resilience	1b spatial extent & temporal horizon	2a hazard potential, damages, losses	2b hazard threats, level of concern	3a quantitative analysis & modelling	3b design, appraisal & evaluation
1	CAT	4.0	4.5	5.0	1.0	5.0	3.3
2	NDH	3.3	1.5	4.0	1.0	5.0	1.7
3	DRI	2.0	1.0	3.0	1.0	4.0	1.0
4	PDRA	2.7	2.5	3.0	5.0	1.0	4.0
5	EPSON	3.3	4.0	4.0	4.0	3.0	3.0
6	ARMONIA	3.7	4.0	4.0	3.0	3.0	4.0
7	GA	4.7	3.0	5.0	2.0	5.0	0.7
8	AGS	2.3	2.0	5.0	2.0	5.0	1.7
9	EMA	3.7	4.0	4.0	4.0	4.0	3.0
10	GNS	3.3	4.0	3.0	3.0	4.0	3.0
11	USRi	2.3	2.5	4.0	1.0	3.0	1.3
12	IDEA	3.0	3.0	4.0	1.0	4.0	1.3
13	ECLAC	2.7	3.0	2.0	1.0	4.0	0.0
14	GTZ	2.3	2.5	3.0	3.0	0.0	2.0
15	HAZUS-MH	4.0	4.5	5.0	3.0	5.0	3.7
16	LUPM	2.0	3.5	5.0	4.0	4.0	2.0
17	RVAT	2.3	3.5	2.0	3.0	0.0	2.0
18	SoVI	2.7	4.0	4.0	2.0	4.0	1.0
19	HIRV	3.3	2.5	4.0	4.0	1.0	3.3
20	CRM	3.7	5.0	5.0	3.0	5.0	2.0
21	EmerGeo	3.7	3.0	5.0	4.0	4.0	1.3

FEMA initiated Hazus in 1992 at the recommendation of a National Academy of Sciences panel report (FEMA 176 and 177). The agency engaged the National Institute of Building Sciences (NIBS) to lead the creation of an earthquake risk assessment methodology that became a GIS-based software application. Hazus was created with a process that included state-of-the-art review of earthquake loss estimation methods, followed by methodology and software development and pilot testing.

The model was first released for earthquakes in 1997 and consisted of an inventory database, ground motion model, building and lifeline damage models, fire following earthquake model, direct and indirect economic loss models, and casualty model. Subsequent enhancements included a new bridge damage model and a single/group building analysis model. Development of a multi-hazard version of Hazus, which included earthquake, riverine and coastal flood, and hurricane wind models, was initiated in 1997 and released in early 2004. In 2002, prior to release of the flood model, the Flood Information Tool (FIT) was released to allow users to begin collecting and sorting local flood hazard and other pertinent data for enhanced analyses. Additional hazard modeling capabilities, including the ability to model the combined losses of hurricane winds and storm surge with the release of Hazus 2.0, were added to Hazus-MH in subsequent years. Throughout the history of Hazus, inventory data and methodology development always have been mirrored by software implementation efforts. The release of Hazus-MH was followed in early 2005 by the first maintenance release, Hazus-MH MR1. Subsequent releases have occurred on a mostly annual basis with the most recent release of Hazus 2.1 in January of 2012. Work is currently underway to add an additional capability, tsunami risk analysis, to the portfolio of hazards addressed by Hazus-MH.

In August 2011, NRCan entered into an agreement with FEMA to employ Hazus by adapting it for use in Canada as a QRA tool. NRCan has subsequently interacted with the developers of Hazus in the US to create a very similar tool for Canada that, while not yet fully developed and lacking many of the datasets that are provided to US users, is capable of demonstrating some of the outputs and reports that make Hazus such a valuable risk analysis tool in the US. In tests of the tool, NRCan has demonstrated how existing Canadian inventory and hazard-related data can be utilized to produce even better results.

In 2011 NRCan contracted The Polis Center (Polis) of Indiana University Purdue University-Indianapolis (IUPUI) to support a number of educational objectives. Polis has long been employed by FEMA to develop the curriculum for training emergency planners throughout the US in how to most effectively incorporate Hazus reports in their plans. Polis also has extensive experience in the application of Hazus for many diverse projects including the creation of the risk assessment component of more than 100 pre-disaster mitigation plans for local jurisdictions. As a result of this relationship with NRCan, Polis conducted two webinars and a four-day workshop on the use of Hazus. They also led a discussion, attended by NRCan staff and other invited guests, aimed at identifying lessons learned and best practices in the US that could be implemented in Canada in order to derive maximum value from Hazus. The following recommendations flow from the insights that were expressed at that meeting and the extensive experience of the Polis staff.

Summary of Recommendations

This report provides recommendations for incorporating Hazus quantitative risk analysis (QRA) tools and a Hazus education program as part of Canada's disaster management strategy. The recommendations are based on lessons learned and best practices developed through the Hazus program in the US. Table 1 lists a summary of the recommendations. Subsequent sections of the report provide additional detail for each recommendation.

Table 1. Summary of Recommendations

Tools and Data	Education Program
Recommendation 1 Include Hazus as a key QRA tool for Canada's disaster management strategy.	Recommendation 9 Identify stakeholders.
Recommendation 2 Establish one agency as overall manager of the Hazus program.	Recommendation 10 Establish incentives that encourage participation in educational offerings.
Recommendation 3 Develop a strategy for harvesting and maintaining available inventory.	Recommendation 11 Use traditional and non-traditional education methods.
Recommendation 4 Develop a strategy for maintaining essential facilities and critical infrastructure inventory.	Recommendation 12 Develop instructor cadres.
Recommendation 5 Develop a strategy for integrating available hazard data to support disaster planning activities.	Recommendation 13 Develop strategic partnerships.
Recommendation 6 Revise Hazus algorithms as necessary to support Canada's building construction standards.	Recommendation 14 Develop a system for documenting and sharing knowledge and feedback.
Recommendation 7 Revise Hazus algorithms as necessary to support individual building aggregation and analysis and produce desired output reports.	Recommendation 15 Provide opportunities for Hazus user collaboration
Recommendation 8 Develop pilot projects for earthquake and flood modeling.	Recommendation 16 Reevaluate education program strategy annually.

Quantitative Risk Analysis Tools and Data Recommendations

1. **Hazus should be specifically included in all supportive documentation as a key Quantitative Risk Analysis (QRA) tool for Canada's disaster management strategy.**

   Despite the fact that FEMA initiated the development of Hazus in 1992, it did not become a widely known or used tool for quantifying damages from natural disasters until after Congress passed the Disaster Mitigation Act of 2000. This act requires every incorporated jurisdiction in the US to produce a hazard mitigation plan in order to be eligible for federal assistance to undertake mitigation projects. All of the planning resources that support this activity specifically refer to Hazus as an effective damage estimation tool that is preferred for used in the creation of the risk assessment component of these mitigation plans[7]. Hazus is also highlighted as an important tool for identifying areas of heightened flood risk for further engineering studies as a part of FEMA's Risk MAP program for creating digital flood insurance rate maps for the national flood insurance program. Hazus is gradually becoming the standard that allows for direct comparisons of risks in various areas of the US. The US is still identifying additional ways to take advantage of Hazus in other phases of the disaster management cycle.

   In 2005, the Multihazard Mitigation Council of the National Institute of Building Sciences conducted an independent study for the US Congress funded by FEMA. The resulting report, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*[8], documents the study's conclusion that every dollar spent on mitigation saves four dollars in avoided future losses. While this study is specific to the US and does not take into consideration the particular mix of hazards that threaten Canada, it does confirm the intuitive assumption that it is cost effective to take steps to mitigate the effects of natural disasters.

   Canada has the opportunity to ensure that Hazus is employed creatively in a variety of ways in the disaster management strategy by referencing it as a preferred tool in all of the "How-To" documentation that supports the strategy. NRCan has already demonstrated that Hazus can be integrated into a risk-based, land-use evaluation through Community Viz with significant success, which could lead to better and safer land use planning. The NRCan

[7] Federal Emergency Management Agency (2011). *Hazard Mitigation Planning Resources*. Retrieved from http://www.fema.gov/plan/mitplanning/resources.shtm.
[8] Multihazard Mitigation Council (2005). *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*. Retrieved from http://www.floods.org/PDF/MMC_Volume1_FindingsConclusionsRecommendations.pdf.

initiative to integrate Hazus with the Canadian Multi-Agency Situational Awareness System could form the foundation of a national standard for using scientifically derived disaster loss estimates to better inform emergency management decisions.

2. Management and maintenance of the Canadian Hazus program should be coordinated by one agency with overall responsibility.

FEMA has been the parent of Hazus in the US from its inception. Management of Hazus has fallen under FEMA, but the various tasks associated with its ongoing development and maintenance have been distributed among many other organizations. For example, Polis, for a number of years, has led the development of the curriculum for the Hazus education program throughout the US, and the National Institute of Building Sciences has convened expert committees focused on each of the hazards to develop the methodologies implemented in the model. Beyond its formal oversight and management system, the implementation of Hazus in the US mitigation planning strategy provides opportunities for collaboration among federal agencies (United States Geological Survey, National Oceanic and Atmospheric Administration, United States Army Corps of Engineers, etc.), state agencies, universities and the private sector. The following outline identifies the organizations and their major roles in the US Hazus program.

A. **Program Management**
   FEMA Project Manager – Eric Berman
   FEMA Technical Monitors
   Emergency Management Institute (EMI) – oversees Hazus courses at EMI
B. **Independent Validation and Verification (IV&V)**
   Functions – Final testing and methodology development
   Lead: National Institute of Building Sciences
   - **Earthquake Model Methodology Development**
     - Earthquake Committee
       - Building Damage Subcommittee
       - Shake Beta Subcommittee
       - Casualties Subcommittee
     - Earthquake Model Validation
     - Software Committee
   - **Hurricane Model Methodology Development**
     - Wind Committee
     - Coastal Surge Committee
     - Software Committee
     - Beta Test Committee
   - **Flood Model Methodology Development**
     - Flood Committee

C. **Customer and Data Services (CDS)**
Zimmerman and Associates – CDS Contract Manager

Outreach (conferences, user group coordination, etc)
Atkins North America
Jamie Caplan Consulting

Education
The Polis Center

Software Development
Atkins North America – earthquake and shell
ABS Consulting - flood
Applied Research Associates - wind

3. Develop a strategy for harvesting and maintaining available inventory to support disaster planning activities.

Inventory refers to building (residential, commercial, industrial, etc.) and infrastructure information. It can be used to support all components of the disaster planning process including the quantitative risk analysis. In order to ensure that data is current and maintained, it is essential to define data stewards and establish memoranda of understanding with those stewards for seamless data sharing.

In the US, FEMA creates DVDs that include Hazus inventory for each state in addition to the Hazus modeling software. The DVDs are available to the public at no cost. The databases, known as "statewide data," are formatted exclusively for Hazus and contain a combination of aggregated and site specific data.

Aggregated data include - General Building Stock (GBS) which consists of census block and tract representations of building counts, area, and valuations broken down by how buildings are used as well as the materials from which they are constructed; agriculture; vehicles; and demographics. The residential component of the GBS is derived from census data, but information about industrial, commercial, and other properties is derived from other sources. GBS records were populated in 2000 and have been periodically updated using RS Means[9] projections.

Site-specific data include essential facilities such as hospitals and clinics; schools; police stations; fire stations; emergency operations centers; transportation facilities; utilities; high potential loss facilities such as dams and nuclear plants; and others. Site-specific records are not typically updated with new releases of Hazus.

[9] http://rsmeans.reedconstructiondata.com/

The accuracy of Hazus loss estimates relies on the quality of the inventory. Given that the Hazus DVDs are not comprehensively updated as the software is updated, models run in 2012 use datasets that, in some cases, are more than a decade out of date. To address this issue, experienced Hazus users will update the statewide data using more current, accurate datasets. FEMA has provided a Comprehensive Data Management System (CDMS) to help users update their Hazus statewide data. CDMS is generally used to manage Hazus data (import and export) for a specific installation on a single computer. The Hazus data may be updated locally, but not shared universally since a solution to manage Hazus data between users does not exist in the desktop version of CDMS. It has been implemented as a web-based solution in two states—South Carolina and Florida—but there is no national system in place for collecting and distributing updated Hazus inventory.

To avoid this problem, Canada should consider the following recommendations when implementing its inventory management strategy:

- A national or provincial data portal is a better data distribution option than Hazus DVDs.
- A portal of public databases may support many models, not just Hazus. Examples of public databases include census, parcels, E911 addresses, assessor, etc. from which Hazus databases may be constructed for local studies. Public databases are routinely maintained; therefore the Hazus inventory will be updated at the same time as the data from which it is sourced.
- Hazus inventory may be constructed globally or locally. The solution is largely dependent upon the availability and consistency of the public databases. If the data has been normalized and is widely available, universal ETL tools (like FME) can be deployed to create Hazus datasets using a top-down approach, i.e. the national government creates datasets for the local communities to use. If the data is not widely available, CDMS may be used to construct the Hazus inventory from local datasets through a bottom-up approach, i.e. local entities create the inventory and share with the national government.
- Data source options for non-public databases are typically limited, and utility information (pipelines, transmission towers, treatment plants, substations, etc.) can be difficult to harvest. Consider developing memoranda of understanding with agencies—such as the departments of health, education, and transportation—for sharing regional datasets. Access to critical infrastructure data may require special security privileges.
- Options for building and maintaining Hazus inventory should be piloted, potentially using a staged approach to accommodate funding and/or time constraints. Data analysis will identify the gaps and categorize the Hazus inventory classes based upon availability, cost, and model impacts.

The key to implementing Hazus as part of a community's risk assessment is in utilizing its local detailed data in the modeling process. It is assumed that the most heavily populated regions of Canada have developed excellent GIS data such as a parcel layer and point addresses. This data should be used whenever possible along with property valuation data to create building inventory for populating the Hazus database. Building inventory describes basic properties of every building in Canada that can be used for modeling. Table 2 lists key properties of building inventory.

Table 2. Building Inventory Properties

Property	Description
Occupancy type	Residential, commercial, industrial, etc.
Location	Latitude, longitude
Area	Occupied floor area
Value	Building replacement cost
Year built	Year of building construction
Construction	Wood, brick, concrete, etc.
Quality	Good, poor, high-code, low-code, etc.
Foundation type	Crawl, slab, basement
Number of stories	Number of stories in building

Building inventory has multiple purposes. Not only can this dataset be used by other hazard analysis models (fire, tornado, hazmat, tsunami), but it can also be used to update and maintain most of the Hazus inventory including GBS, essential facilities and user-defined facilities. User-defined facilities may either be structures that do not fit the standard Hazus definitions, such as historical landmarks or tourist attractions, or buildings that can be modeled in Hazus as points rather than aggregate data. Another potential benefit of building inventory is the support of Emergency Planning Facilities (EPFs) including emergency medical services, clinics, campus police stations, and more. These are layers that may not need to be modeled for disaster mitigation scenarios but may be of interest to emergency responders.

It is our understanding that as a part of the QRA project, NRCan has already developed FME translators for incorporating British Columbia Assessment Authority data into Hazus and that this tool could be modified for use in other Canadian provinces and territories. Inherent in this recommendation is an opportunity to build upon and leverage the significant work that has already gone into creating the national inventory of topographic information.

Appendix A includes an example of building inventory data harvesting used in Indiana to collect parcels, addresses, and other data for all 92 counties in the state.

4. Develop a strategy for maintaining essential facilities and critical infrastructure inventory.

Essential facilities are defined as police stations, fire stations, schools, hospitals, and emergency operations centers. The best data for these facilities as well as other critical infrastructure generally reside at the local or province/territory level. In the United States, this data is often collected by several different agencies and jurisdictions.

It is important to identify appropriate data stewards for each of these assets. In the United States, essential facility data and other critical facility information is collected by several agencies. The US Environmental Protection Agency (EPA) Facility Registry System (FRS), Department of Homeland Security Infrastructure Protection (HSIP), FEMA Hazus, and the United States Geological Survey (USGS) Government Names Information System (GNIS) all collect similar information often from different sources.

To avoid this problem, Canada should use industry standard tools and criterion to harvest the data from local and provincial data stewards and transform it into a format that supports the quantitative risk analyses as well as other federal programs.

The strategy should accomplish the following:

- Create and maintain accurate critical infrastructure locations and key attribute information as a single authoritative source, through role-based access and responsibilities in a Local -> State -> Federal model.
- Design a bottom-up stewardship, maintenance, and quality control model supported by this role-based authority, data responsibilities, and access of the project partners.
- Provide an efficient means of data access to meet the needs of the many levels of government and the multitude of associated programs. (The idea of mapping it once and using many times.)
- Honor & leverage existing investments in technology, processes, and business practices that are established and proven.
- Design local stewardship and maintenance frequency guidelines tied to any existing business requirements for QRA.
- Design an exchange network to allow each authorized user to interact with the master database.

Appendix B includes an overview of Indiana's current model for creating the essential facility data for hazard mitigation planning. The Polis Center has also been awarded a grant to submit the essential facility GIS data to a national exchange network. As part of this project, Polis will help design and develop a National States Geographic Information Council (NSGIC) critical infrastructure exchange network node for the stewardship and maintenance of essential facility GIS data. The state will coordinate with its authoritative sources and local data stewards for facility data gathering and updating (stewardship) for these various systems, thereby eliminating duplication of effort by the various federal government agencies as well as state and local government.

5. Develop a strategy for integrating available hazard data to support disaster planning activities.

With appropriate inputs that define the strength of the disaster and the characteristics of the impacted study region, Hazus is capable of generating boundaries and/or grids to define the estimated area impacted by earthquakes, riverine and coastal flooding, hurricane storm surge, or hurricane winds. Such boundaries and grids often have already been or could be created by geologists, meteorologists and other scientists using higher resolution input data and more sensitive modeling tools. This presents an important opportunity for collaboration among federal and provincial departments to achieve the goals and objectives of the National Disaster Mitigation Program. These hazard maps can easily be integrated into Hazus; this should be done whenever it will provide a more accurate representation of the hazard than could otherwise be produced by Hazus.

Examples of these data include, but are not limited to, the following.

- Earthquake ground motion data from sources such as ShakeMap
- FEMA National Earthquake Hazard Reduction Program compliant soils maps
- Liquefaction maps
- Landslide susceptibility
- Digital Elevation Models
- LiDAR
- Existing digital flood boundaries
- High water marks

6. Revise Hazus algorithms as necessary to support Canada's building construction standards.

Hazus quantifies estimated economic and social impacts for specific disaster scenarios by applying appropriate damage or fragility curves to the population and built environment of affected areas. For example, these curves, which are created by a variety of government agencies, universities and the insurance industry, plot the degree of physical and economic impact on a structure based on hazards such as the depth of water in a flood event or the amount of shaking in an earthquake. Canada should review the damage and fragility curves built into the US version of Hazus to ensure that they are appropriate for conditions in Canada. It is our understanding that NRCan is already adding additional fragility functions based on research from the University of British Columbia's Earthquake Engineering Facility. Based on a full review of the functions for each hazard, the damage and fragility curve libraries should be adjusted and/or enhanced as necessary. In the US, the National

Institute of Building Science (NIBS) plays a coordinating role in achieving this end. Possibly the National Research Council could perform this function in Canada.

7. Revise Hazus algorithms as necessary to support individual building aggregation and analysis and produce desired output reports.

We have already recommended that it would be better to populate the Hazus database with a building inventory derived from a merger of the parcel layer, point addresses and assessment data creating user defined points whenever possible rather than to rely on estimated aggregations by census geographies. To take full advantage of this enhanced data it will be necessary to recode some of the Hazus loss estimation algorithms. For example, Hazus as currently configured does not derive, summarize and report shelter requirements and debris estimates when running individual building analyses. We believe that this would be an enhancement to Hazus for the US as well.

8. Develop pilot projects for earthquake and flood modeling.

Canada has pilot projects in the District of North Vancouver and the Ottawa-Montreal-Quebec City corridor, which have clearly demonstrated that it is possible to employ Hazus in Canada. It is recommended that Canada develop additional pilot projects to identify the data stewards, data gaps and overlaps, test the tools and processes to harvest and transform the data, and document the required Hazus enhancements within the QRA methodology. The pilot projects should also determine the required QRA outputs including reports and maps that are required to support Canada's disaster management strategy. These pilot projects are most useful and successful when they cross jurisdictional boundaries and when they engage multiple agencies in their completion. Pilot projects that run horizontally across departments, provincial ministries and municipalities would be optimum to achieve maximum results The pilot projects could be led by teams of physical scientists, policy analysts, and social scientists from a variety of agencies fostering greater collaboration. An important product of these pilots would be a work flow document which could be used to guide future users of Hazus in developing risk analysis.

Quantitative Risk Analysis Education Program Recommendations

The design and implementation of an effective education and outreach program is a key component of the overall disaster management strategy. Where applicable this program should integrate the lessons learned and resources developed as part of the US Hazus education program. Canada and the US should also seek opportunities to collaborate on the development and maintenance of educational products that meet the common needs of stakeholders in both countries.

9. Identify stakeholders.

The Education program should address the educational needs of key stakeholder groups including analysts, beneficiaries, data providers, and expert resources.

Analysts are the individuals who will attend the education and training sessions. They need to be empowered with the skills necessary to effectively use Hazus in conducting loss estimation studies for real-world applications. These individuals are likely to include GIS technicians. The education program is more than training, i.e. simply teaching the steps to complete a Hazus analysis. It must also describe the methodologies by which loss estimations are calculated and the steps that are associated with integrating improved hazard and exposure data into the modeling process. The specific educational offerings for analysts should be defined based on their roles and responsibilities as they relate to hazard modeling, database management, and policy implementation. To realize the full benefits of Hazus, trained Analysts should thus be more than simply Hazus-MH tool operators.

Beneficiaries are the decision makers who will benefit by using information generated by Hazus tools - such as studies which identify cost effective mitigation options or maps, tables, and reports that identify impacted areas in a disaster - but will not likely come in direct contact with Hazus or other related risk analysis tools. Beneficiaries include the policy makers who will use the information generated by QRAs to inform the development of rules and guidelines that can lead to safer communities.

Data providers generate information—such as characteristics about the built environment and population at risk—that can be integrated into Hazus or other QRA tools. They should understand the components of the risk analysis process that require their data. Agreements and operating procedures will enable the efficient collection and processing of that information.

Expert resources include members of the community that work with and understand Hazus methodologies including information about a hazard, information about what is at risk from the hazard, and scientifically-based approaches that relate the hazard to what is at risk in order to predict economic and social impacts. These individuals may include engineers, geoscientists, property assessors, and others who conduct research, create resources that inform Hazus modeling methodologies, or provide guidance for how to most effectively use Hazus in support of mitigation planning. They may or may not use Hazus in their own work; however, they should be made aware of the capabilities and needs of the Hazus user community. Securing the ongoing participation and guidance of experts is essential. An example of possible expert resource collaboration might be establishing working partnerships with end user communities in Canada - such as the Canadian Institute of Planners, Engineers Canada or professional emergency managers – to delineate how the Hazus methodology can be used to support risk-based and mitigation planning at local and regional scales in Canada.

In the United States, FEMA, working in collaboration with The Polis Center, has created a robust education program that provides introductory courses in GIS applications for emergency management and basic Hazus-MH functions. Our experience has shown that it is useful to have pairs of analysts and beneficiaries from each organization participate in introductory courses since that provides an opportunity to foster integration of knowledge between these stakeholders. The education program also includes advanced, hazard-specific courses that offer guidance on how Hazus predicts economic and social impacts from natural hazards. These courses identify strategies for collecting and inputting data, validating outputs, and using Hazus to support emergency management. Many of the advanced courses are designed to cater to the specific disciplines of key stakeholder communities such as floodplain managers, mitigation plan developers, and disaster operations support teams. Canada should consider adapting a similar model for classroom courses and outreach to its own stakeholders.

10. Establish incentives that encourage participation in educational offerings.

In the US, FEMA developed a certificate program to encourage participation in education and training. Individuals who complete a specific set of courses receive recognition as either a Hazus-MH Trained Professional or a Hazus-MH Practitioner. Recognition includes a certificate, lapel pin, and inclusion in a web listing of Hazus professionals. This program has prompted considerable interest, and informal surveys of course participants suggest that reasons for pursuing these credentials range from establishing credibility in order to pursue contractual work to establishing expertise in order to secure career advancement. Figure 2 describes the course requirements for obtaining a certificate.

Figure 2. Certification Requirements

Become a HAZUS-MH expert!

HAZUS Trained Professional Track: Provides a foundation of basic HAZUS-MH skills plus focused instruction on at least one hazard.

- E190 Introduction to ArcGIS (prior GIS experience may substitute)
- E313 Basic HAZUS MH
- E317 Comprehensive Data Management
- Minimum of ONE of the following: E170 HAZUS-MH for Hurricanes; E172 HAZUS-MH for Floods; or E174 HAZUS-MH for Earthquakes

HAZUS Practitioner Track: Expands upon the HAZUS Trained Professional track by incorporating specialized instruction in topic specific areas.

- E190 Introduction to ArcGIS (prior GIS experience may substitute)
- E313 Basic HAZUS-MH
- E296 Application of HAZUS-MH for Mitigation Planning
- E179 Application of HAZUS-MH for Disaster Operations
- E317 Comprehensive Data Management
- Minimum of ONE of the following: E170 HAZUS-MH for Hurricanes; E172 HAZUS-MH for Floods; or E174 HAZUS-MH for Earthquakes

Professionals and Practitioners will receive a certificate, lapel pin, and a listing on FEMA's website upon completion of their respective curriculum track.

Hazus-MH courses may also meet the continuing education requirements of other organizations such as the URISA Geographic Information Certification Institute. However, the FEMA Hazus program has no formal relationships with any professional association. We recommend that Canada pursue recognition of the completion of Hazus courses by key Canadian professional associations such as Engineers Canada and Geoscientists Canada, or the national Canadian Institute of Planners and their provincial counterparts. Such recognition would serve as a powerful incentive for individuals to enroll in Hazus courses.

11. Use traditional and non-traditional education methods.

The education program should apply a variety of methods for delivering educational products and announcements. Examples include webinars, self-guided virtual or desktop courses, instructor-led virtual or traditional classroom courses, social media, virtual community of practice online support, and more. By engaging in the use of multiple technologies, Canada can reduce costs such as labor, travel, facility and other expenses that are typically associated with setting up and conducting onsite classroom courses.

12. Develop instructor cadres.

Course instructors should be required to demonstrate proficiency both in the subject matter being presented as well as in teaching methods and theory. FEMA addresses this by requiring authorized Hazus-MH instructors to meet a rigorous set of requirements that include

- Satisfactory completion of an exam designed to test familiarity with course content, software design, and modeling methodology
- Completion of a train-the-trainer course
- Co-teaching with a certified instructor
- Ongoing satisfactory student evaluations
- Additional training and testing as necessary with changes in software or course design

Most of the Hazus-MH classroom courses currently supported by FEMA are thirty-two contact hours in length. As is the case with most software training courses, these courses are traditionally offered in full day sessions over consecutive days. This works well in cases where practitioners must travel long distances to a training location or when they must complete the training in a short period of time in order to begin employing the learned skills toward project goals. It is also the most cost effective option for offering a course taught by an instructor who must travel to a training location. It should also be noted that qualified instructors – such as those in academic institutions - could also choose to teach the Hazus curriculum in short segments offered over a series of weeks or months. Availability of training over an extended period would work well for university students or practitioners who cannot devote multiple consecutive days to a Hazus course.

13. Develop strategic partnerships.

Strategic partnerships with higher education institutions and private sector entities can be beneficial for a number of reasons including:

- Many higher education institutions and private sector companies have computer labs that may be suitable for teaching Hazus-related courses.
- Conducting courses in collaboration with higher education institutions may lead to opportunities to educate students who, upon graduation, can become active members of the professional community.
- Faculty and staff at higher education institutions and private sector organizations may serve as expert resources and/or analysts.

14. Develop a system for documenting and sharing knowledge and feedback.

It is important to develop and maintain a robust system for capturing knowledge from key team members. This system will maximize the efficiency of software development and appropriately document model methodologies.

As the risk assessment strategy in Canada evolves it will be very important that lessons learned are captured. This will ensure that critical and relevant knowledge is retained and reused as people enter and leave the program. It is especially important that a core knowledge base be established early in the program in order to capture this information as the program expands.

15. Provide opportunities for Hazus user collaboration

Opportunities for Hazus users to collaborate should be encouraged and supported. Two of the most significant examples of this in the United States are an annual national Hazus conference and Hazus user groups. FEMA has facilitated a national Hazus conference for the past few years. This conference offers a venue for Hazus stakeholders to learn about the latest current and planned developments for Hazus as well as to become informed about the work being done by users within the Hazus community.

FEMA has also facilitated the growth of Hazus user groups in the United States. These groups provide a forum for stakeholders to meet on a regular basis throughout the year. Each group designs its own strategy for serving the users within its region. Most user groups meet by conference call on a monthly basis for the purpose of discussing issues and opportunities that are relevant to Hazus users within the area served by the group.

As the Hazus program evolves in Canada, consideration should be given to how best to leverage existing resources, such as the already successful Canadian Hazus Users Group, and how to develop new resources such as conferences or social media tools that will encourage Hazus stakeholder collaboration.

16. Reevaluate education program strategy annually.

The Education program strategy should be reevaluated on a regular basis in terms of the audiences it serves, the content that it offers, and the methods by which it is delivered.

Appendix A
Indiana Local Building Inventory Data Harvesting Overview

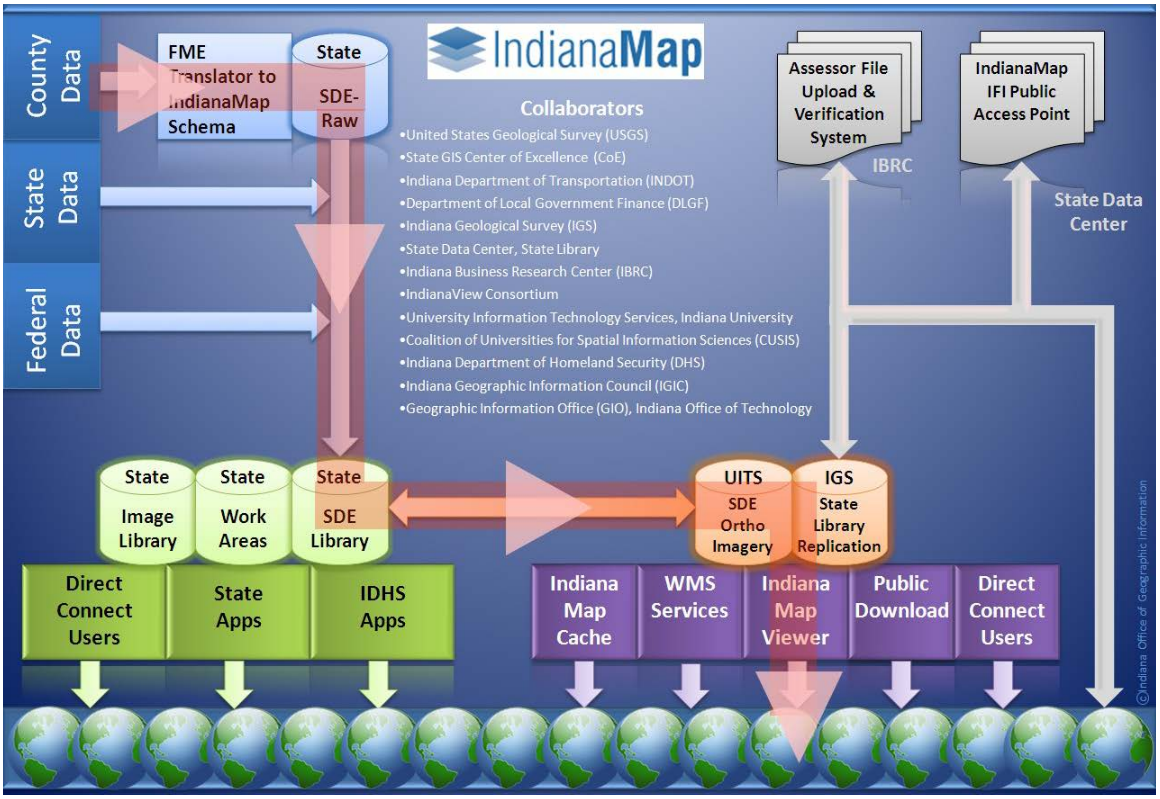
The state of Indiana has developed a public source for map data, called IndianaMap[10], for all 92 counties in the state. Each county maintains computerized mass appraisal data, which contains data suitable for quantitative risk analysis including property and building valuations, building replacement costs, property use (i.e. residential, commercial, etc,) square footage, construction, and year built. Currently 87 counties maintain unique parcel information in a variety of formats. The remaining five rural counties are in the process of building this parcel fabric. The common attribute link to the mass appraisal data is a unique property identification number.

Many agencies and organizations require a seamless parcel fabric that extends across jurisdictions. Initially, state agencies asked counties to send a copy of the data on DVD or via ftp. This data sharing met with limited success. In response, the state of Indiana incentivized each county to share its data by offering a small grant to set up a Web feature service using the Open GIS Consortium (OGC) implementation specification. The state harvests the data monthly and converts, transforms, and integrates both spatial and non-spatial data through repetitive conversion processes to a common format for use by federal, state, and local partners.

The state of Indiana employs an FME spatial data transformation platform from Safe Software Inc out of Surrey, BC to integrate the data for 85 of the 92 counties. This process has many benefits. First and foremost, it does not require the local communities to alter their current procedures for creating and maintaining GIS data in any way; second, communities do not have to package their data and forward it to the state because it is harvested regularly and automatically. The FME process creates a seamless uniform dataset from 92 county files containing approximately three million parcels. Figure 3 illustrates the data integration and distribution process.

[10] *IndianaMap* (2012). Retrieved from http://indianamap.org

Figure 3. Indiana Map Process



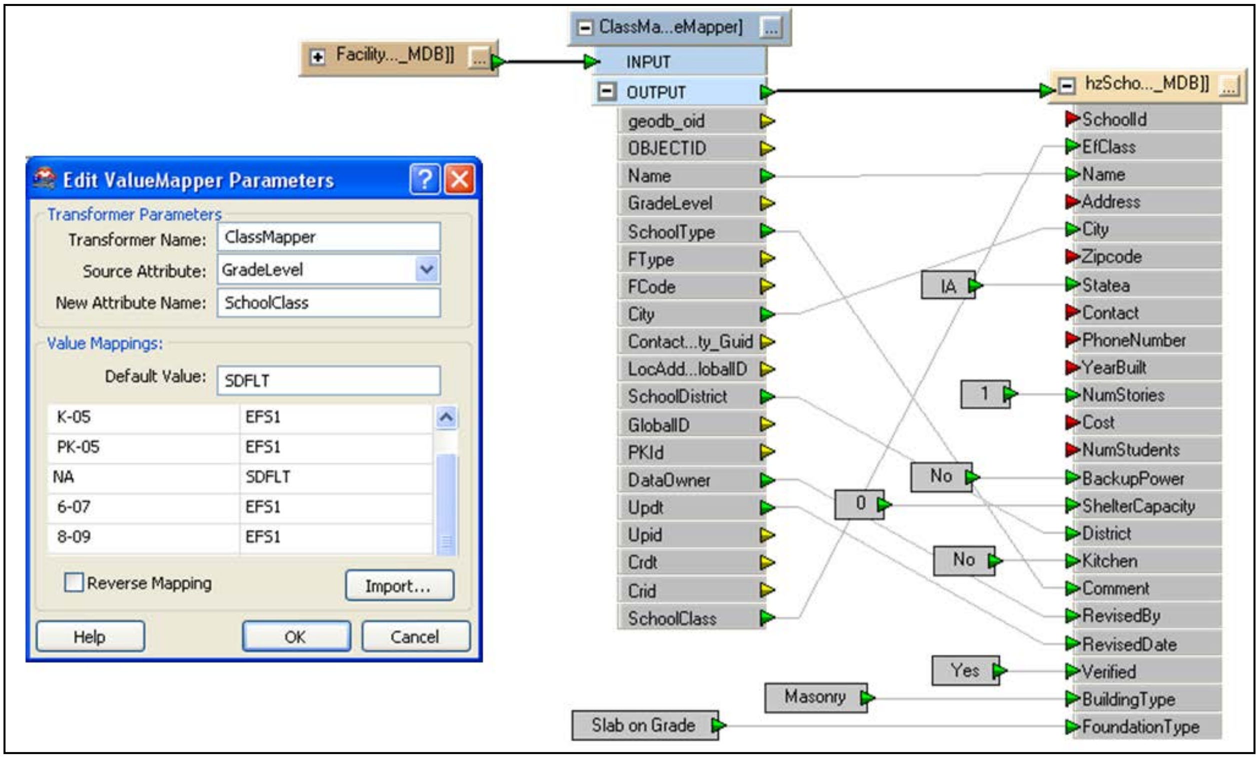
A second FME process is used to create building inventory for disaster management. In Indiana, local governments maintain near real time websites of property information including the building inventory attributes identified in Table 2. Extracts of assessors' data can be obtained monthly, but is rolled up on an annual basis. The Polis Center creates the building inventory for each county, using this annual rollup, for use in emergency and disaster planning. The data is used to prepare local (county-level) QRAs or to analyze risks and vulnerabilities at the state level. It is also clipped to a watershed to support FEMA's RiskMAP discovery process which involves the collection and analysis of knowledge that can be used to identify flood risk.

The major steps in the building inventory FME process are as follows:

1. The assessors' data files are joined to the parcels based on a unique identification number.
2. Parcels that are coded as vacant in the assessors' data are deleted.
3. The parcel use code is translated into the Hazus occupancy classification.
4. Algorithms calculate remaining Hazus attributes according to the quality of the assessors' data.
5. Where no data exists, FME loads required default values.

Figure 4 illustrates the FME database transformation process.

Figure 4. FME Process



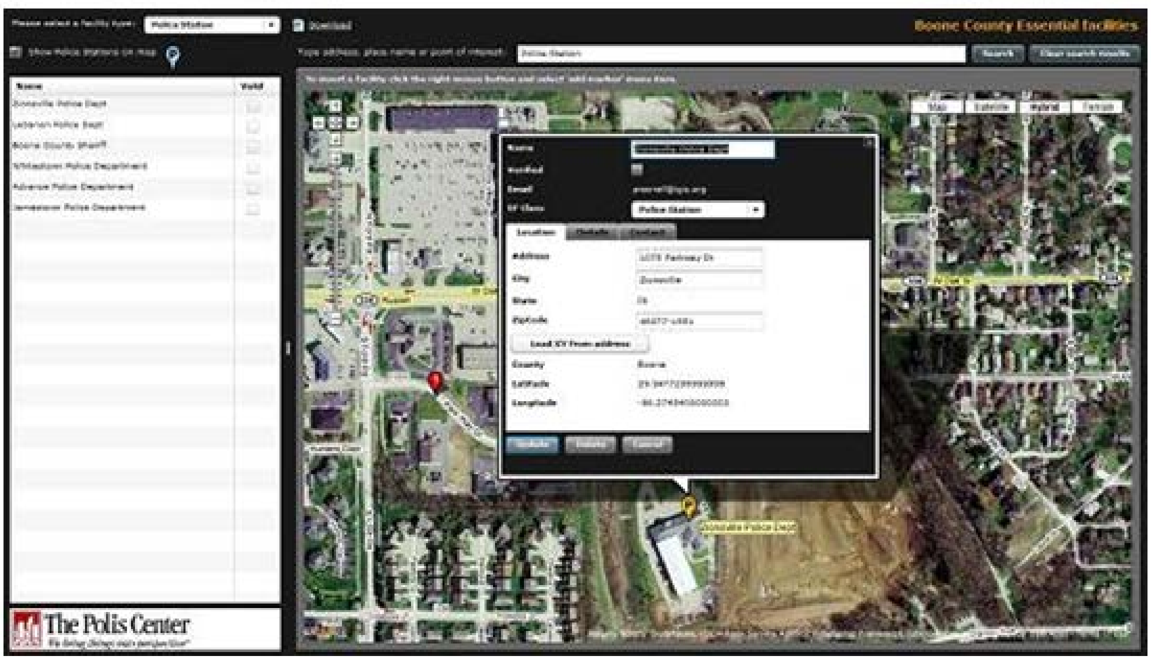
Implementing a similar building inventory process on a national scale in Canada will greatly enhance the usefulness of tools like Hazus throughout the country. Hazus users could simply pull the data appropriate to their regions of study into the Hazus database through automated procedures, and then run disaster models of their choice.

Appendix B
Indiana Local Essential Facility Data Harvesting Overview

The Polis Center has helped more than 75 of Indiana's 92 counties develop multi-hazard mitigation plans. As part of this effort, Polis collected or created Hazus-compliant essential facilities databases for each county. Polis used available state data from the Indiana Department of Health and Indiana Department of Education, for medical and education facilities respectively, along with local data to build the databases. The local emergency management staff then added information that is not maintained by the state agencies, such as building replacement costs.

The Polis Center has implemented a Web 2.0 map interface database to integrate the local data into a single statewide database. Figure 5 shows a screenshot of the tool.

Figure 5. Interactive Data Tool



The application uses role-based guidelines to address data access and security. Figure 6 demonstrates the architecture of the tool.

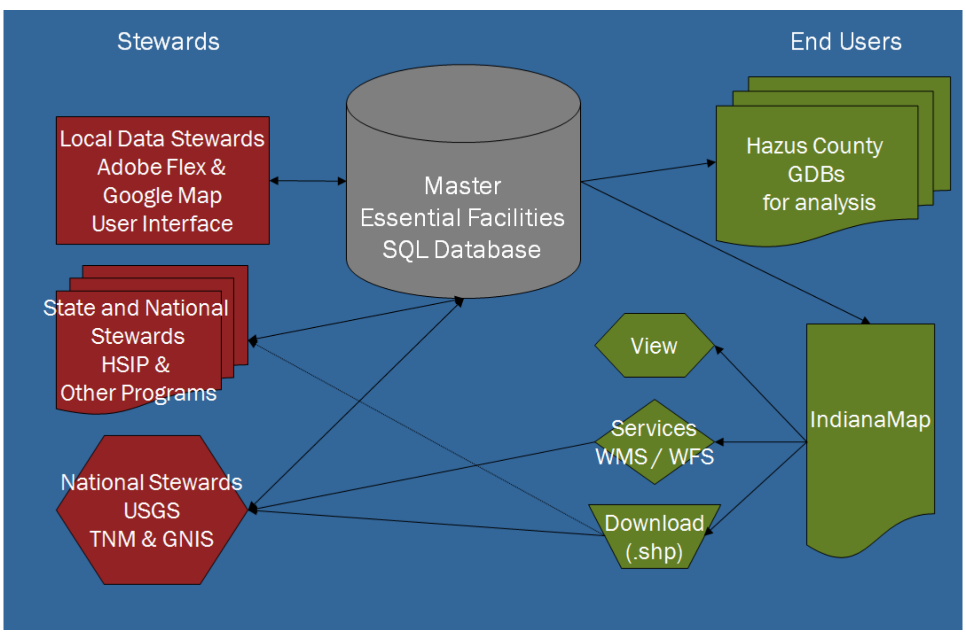
Application-based roles. Authorized user based on application data of interest (Hazus, HSIP, GNIS, FRS). Database View will query and display only those features and attributes that are associated with that application.

Authoritative source role. Authorized user based on specific domain knowledge and authorization. Local/state data steward who can add, move, or delete points from the database but does not necessarily know all attribute values to load or see all attributes associated with the feature.

Attribute maintenance role. Authorized user based on specific domain knowledge and authorization. State or federal agency data steward with knowledge of specific attribute information; this user cannot add, move, or delete points from the database.

Administrator & quality control role. Authorized user based on specific domain knowledge and authorization. State-level person responsible for overall stewardship of certain layers. All editing operations are available.

Figure 6. Tool Architecture



The next step is to connect this to the aforementioned NSGIC critical infrastructure exchange network node, which will consume the Indiana data with five other states' data. Each state will have its unique harvesting script based on the state's unique format and attributes. The final data on the NSGIC node will be consistent across states and available for the US Environmental Protection Agency (EPA) Facility Registry System (FRS), Department of Homeland Security Infrastructure Protection (HSIP), FEMA Hazus program, and the US Geological Survey (USGS) Government Names Information System (GNIS).

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