Spatial Information for Disaster Response in Australia

National Consultation Final Report

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Spatial Information for Disaster Response in Australia

Executive Summary

To enable the spatial information community to better support Australia's ability to manage natural disasters, disaster management agencies were consulted with a focus on disaster response and the 2009 Victorian bushfires and the 2011 Queensland floods. The consultation was a collaborative effort among the Cooperative Research Centre for Spatial Information (CRCSI), the Australian Space Policy Unit (SPU), and Geoscience Australia (GA). The consultation was one part of a two-part project that also involved a case study of recent disasters. This activity also coincided with the trial of a mobile satellite receiving station by NSW Land and Property Information (LPI) (formerly NSW Land and Property Management Authority (LPMA)).

Major findings of the consultation were:

1. Image and spatial information needs for disaster response are generally being met.
2. Standards for image products are needed for all phases of disaster management, but particularly for disaster response. This includes the definition of agreed-upon standardised products for which there is a quality control mechanism, and whose utility and limitations are documented and widely understood.
3. Disaster response can be continually improved through greater interaction between the operational disaster response and research communities, including a constant operational-research-operational feedback loop.
4. There is an ongoing need for constantly improving ways to extract information from imagery and enhance the value of image products for disaster response. This includes making spatial information products complementary to model development needs and operational usage.
5. Across all phases of disaster management, image data should be acquired in a way that enhances whole-of-sector accessibility.

Context and Background

Recent natural disasters have focussed world-wide attention on disaster response. The key question asked during disaster response is "Where is the flood/bushfire/earthquake zone?" and digital imagery is a proven way to obtain such information. Indeed, airborne and satellite imagery are fundamental to disaster response. The recent bushfires and floods in Australia have provided an opportunity for Australia to evaluate its digital imagery and spatial information needs and capabilities for disaster response.

In February 2011, the Cooperative Research Centre for Spatial Information (CRCSI) and Geoscience Australia (GA) in consultation with the Australian Space Policy Unit (SPU) launched a joint project to address this need.

The project has two parts:

1) Disaster Management Consultation – Workshop-based consultations were held across Australia with individuals from agencies that contribute to disaster response. Targeted agencies included police, fire, medical, civil defence, and others.
2) Retrospective Case Studies – Individuals from agencies directly involved in disaster response were interviewed to identify how satellite imagery was used as were individuals in the Victorian Black Saturday fires of 2009 and the Queensland floods of 2011.

Coinciding with this activity, the NSW LPI conducted a trial of a mobile satellite ground station receiving imagery information licensed from the Italian satellite COSMO-SkyMed. This activity was undertaken in collaboration with by researchers from the University of New South Wales and the mobile ground station was installed at LPI in Bathurst, NSW.

This document is the final report for Activity 1 only -- the Disaster Management Consultation phase. The final report on Activity 2 (Retrospective Case Studies) was completed in August 2011.

The Consultation Process

Consultation workshops were held in Melbourne, Brisbane, Sydney, and Canberra during June and July of 2011. To organise these workshops, the project team coordinated with commonwealth and state agencies to identify appropriate individuals in relevant organisations. This consultation included a number of individuals involved in recent Australian disasters. Appendix 1 contains details of workshops, individuals consulted, and organisations represented.

The scope of the consultations was focussed on image-based products used during the disaster response phase. Individuals targeted for consultation were those involved in tactical disaster response planning – i.e., those responsible for deploying resources during disaster response. Higher level individuals involved in strategic organisational disaster planning were also consulted, as were individuals whose focus is the production of spatial data products. Individuals and states involved with bushfires and floods – the major disaster types that affect Australia – were also represented. (Appendix 1 lists workshop attendees.)

Prior to the consultations, a scoping paper (Appendix 2) was distributed and workshop invitees contacted to assess current awareness and use of maps and other spatial information in disaster response. Prior to workshops invitees were asked to respond by email to the following questions:

1. Does your organisation use satellite imagery/data in responding to disaster/emergency situations? If yes, please discuss the type of imagery/data obtained and how it is used.
2. How does your organisation obtain satellite imagery/data (supplier, process, etc) and how is it utilised within your organisation during the emergency?
3. Are you aware of satellite imagery products (i.e., spatial information, maps, etc) that you believe would have assisted your organisation in a disaster response role, but were not able to be accessed/utilised? If yes, please provide details.

Outcomes

The requirements for imagery and image-derived products are extremely diverse during disaster response. Factors that affect data requirements for disaster response include geography, proximity to built infrastructure and weather conditions.

For example, fast-moving floods in densely populated areas require very up-to-date (one hour or less) high spatial resolution data while slower-moving floods in sparsely populated areas enable more delayed information having a lower spatial resolution to be used. Similarly, bushfires close to built infrastructure and affected by strong weather conditions (i.e.; high winds) need high-resolution data regularly up-dated (within the last 15 minutes in some cases) while fires in uninhabited areas with calm weather conditions require less rigorous data.

This diversity of need accentuates the reality that there is no single data source, image product, or temporal scale that can be identified to meet all needs. Hence findings presented reflect issues raised by a large number of the individuals consulted and/or points that are particularly important to spatial information and its capacity to address disaster response and management needs.

It is relevant to note that the consultation activity focused only on the response phase of the disaster management cycle. This was primarily to understand the current use of spatial information, specifically from satellites, in time-critical situations, and to assess if existing capabilities meet current requirements for disaster response. Discussions during the consultation process identified that spatial information gathered during the disaster response phase is also very valuable to the other phases of the disaster management cycle -- recovery (i.e.; targeting assistance activity and reconstruction work) and preparation (i.e.; providing data for modelling floods and fire behaviour). An example of this is the use of spatial information to identify the extent of flooded or burned areas.

Major Findings

1. **Image and spatial information needs for disasters are generally being met.**

This finding does not mean that all image needs are currently being met nor that improvements to available imagery and image-derived products are not possible. However, organisations consulted either have access to suitable satellite or airborne imagery, or the means to obtain it through state-owned airplanes or standing contracts with private providers. In addition, the conversion of the imagery to meaningful information is either (semi-)automated, handled by the image acquisition authority, or efficiently addressed by in-house capability.

Nonetheless, at certain times and locations during disaster response, the timeliness of imagery and associated products can be poor. This is related to the size of the disaster, and also reflects disaster response requirements that change over time and space within a disaster zone.

2. **Standards for image products are needed for all phases of disaster management, but particularly for disaster response. This includes the definition of agreed-upon standardised products for which there is a quality control mechanism, and whose utility and limitations are documented and widely understood.**

This standardisation involves a number of aspects of imagery and image-derived products. One is the need to have a single authoritative map for themes that are used by multiple organisations and for multiple purposes. For example, in the recovery phase of a flood, the floodline is used by insurance companies, clean-up crews, and government relief agencies. For the Queensland floods, a map of floodline and associated meta-data established collaboratively by relevant government agencies were placed on the website of the Queensland Reconstruction Authority. Nonetheless, disaster management individuals consulted became aware of the existence of one or more other floodline maps of unknown provenance.

Of greatest concern during disaster response is the need to have imagery and image-derived products of a known and documented quality produced by accepted methodology. The importance of this was reinforced by a repeatedly specified need to have robust metadata about any imagery and image-derived products used in disaster response.

There was a consensus that the standardised image products that should be widely available are those that are of greatest value to address the most important needs. Hence there was agreement that an agreed suite of standardised products would be composed largely of “intermediate products” in the image processing chain recognising that individual agencies might modify or add value to those products in different ways.

There is a need to determine who will produce the agreed standardised image products. Predictably, different production and organisational models are employed in different states to obtain imagery and image-derived products that are used for disaster response.

These organisational models vary most in the level of centralisation which in turn impacts factors such as in-house capability, and the need and ability to improvise to respond to changing disaster conditions.

3. **Disaster response can be continually improved through greater interaction between the operational disaster response and research communities, including a constant operational-research-operational feedback loop.**

Though the imagery and associated products used in disaster response continue to evolve, workshop attendees consistently expressed a need for more and continuous information about evolving imagery and image-derived products. It was suggested that substantial benefits would be derived from:

- having a constantly updated "catalogue" of imagery and image products for disaster response,
- formalised experimental trials conducted continuously and collaboratively between researchers and disaster management personnel,
- up-skilling of disaster management personnel to make them more "spatially savvy" generally,
- and formal training in imagery and its analysis being offered to disaster management personnel.

The latter point was emphasised by expression of concern over the danger of having the production of a useful image product being dependent on a single person. Reluctance was expressed about adopting a particular product for use if its long-term continuity was threatened because of dependence on a single individual.

Also accentuated was the need for the research-based development and operational evaluation of imagery and image-derived products to be an ongoing activity. Workshop participants agreed that during the recent disasters they were inundated with offers of potentially valuable data and image products but whose quality and utility was unknown. Evaluation of such data and products cannot be undertaken during disaster response, particularly during large-scale disasters.

4. **There is an ongoing need for constantly improving ways to extract information from imagery and enhance the value of image products for disaster response. This includes making spatial information products complementary to model development needs and operational usage.**

Certain image products are valuable in their own right. In general these are products that show the location of a disaster and affected areas. Certain products – mainly those captured from airborne optical sensors -- require little image processing other than geo-registration to be useful in disaster response. Others – primarily those captured from satellite-mounted passive sensors – must undergo more processing such as terrain correction before they are useful to disaster response personnel.

Beyond improvements in image processing, the consultation revealed that certain image products are most useful as inputs into disaster-specific models. Workshop attendees whose focus is flood management noted that tactical decisions made during the response phase rely more on flood models that use digital image products as inputs rather than using image products in a stand-alone manner. Examples given were the use of flood surge models used to assess threats to road access and other built infrastructure, and bushfire experts similarly noted the need for models that better predict fire behaviour. Improving spatial information will improve outputs of existing models only where spatial information is of low quality relative to the modelling task; an example was given of digital elevation models (DEMs) with 10 m contours for much of rural Queensland being too coarse for adequate flood modelling. In many other situations, however, model outputs will best be improved through increased understanding by flood or bushfire experts of disaster behaviour rather than spatial information experts. Hence it is overly simplistic to assume that better spatial information will inevitably lead to better model outputs.

These findings suggest that there is a two-fold need relative to imagery and disaster response. First, there must be ongoing efforts to improve those processes that convert raw image data into disaster-ready information. Second, there is a need for the spatial information community to work in support of needs specified by the modelling community. It also requires the modelling community to constantly test model sensitivity to evaluate how disaster behaviour models can best be improved so that spatial scientists can optimise their efforts to support disaster modelling.

5. Across all phases of disaster management, image data should be acquired in a way that enhances whole-of-sector accessibility.

Workshop attendees consistently characterised inter-agency data-sharing during disaster management as being very good. This positive sense of cooperation also extended to the international community after Australia invoked the International Charter on Space and Major Disasters.

Despite the general willingness to share data, it was noted that certain image data held by Australian government agencies have been acquired under a license that forbids data-sharing. Similarly, image data may have been acquired by state agencies under a license that forbids use of the imagery for purposes other than those specified in the license agreement – something that potentially impacts the use of imagery for disaster management purposes. It is clear that during disaster response it would be useful for emergency services personnel to have access to the widest possible range of data. Consequently, efforts should be made to have individual agencies acquire imagery under licenses that do not prevent the use of the imagery for disaster response.

Notably, consultations of certain individuals outside the workshop format indicated that a number of federal and state agencies are taking steps to acquire imagery under whole-of-government licences. For example, Geoscience Australia has established an Optical Geospatial Radar and Elevation (OGRE) Procurement Panel that works with state government on centralised data acquisition.

Appendix 1. Workshop attendance by location and individual consultations..

1. Sydney June 7, 2011

Consultation was organised through the NSW Spatial Council Emergency Services Spatial Information Working Group (ESSIWG)

Members of ESSIWG:

Graham Chapman	NSW Police Force
Gareth Carter	NSW Rural Fire Services
Wayne Patterson	NSW Land and Property Management Authority
Alan Garside	NSW Land and Property Management Authority
Marina De Gabriele	NSW Fire and Rescue
Shane Conserdyne	NSW Emergency Infor. Coordination Group
Rees Bunker	NSW Emergency Infor. Coordination Group
Stephen Bible	Ambulance Service of NSW (Did not attend)
Rod Staggard	NSW State Emergency Services

2. Melbourne June 24, 2011

Andrew Matthews	Dept. of Sustainability and the Environment (DSE), Assistant Chief Fire Officer
Lee Gleason	Parks Victoria, Response and Planned Burning
Steve Grant	DSE
Mark Garvey	Manager GIS Service, Country Fire Authority (CFA)
David Nichols	Manager Research and Development, CFA
Geoff Spring	Assoc. of Public Safety Communications Officials of Australasia (APCOA)
Neil Wheeler	Melbourne Fire Brigade, ICT
Glenn Cockerton	Spatial Vision, Data and Systems Provider into Emergency Management
Kristin Carter	Strategic Analysis and Reporting, Metropolitan Fire and Emergency Services Board

3. Brisbane July 12, 2011

Mark Cushing	Manager, Environmental Information Systems Unit Department of Infrastructure and Planning, and Queensland Reconstruction Authority (QRA)
Matt Coleman	ROAMES (Remote Observation Automated Modelling Economic Simulation) Capability Development Manager, Ergon Energy
Mark Volz	Ergon Energy, Far North QLD
Mark Wallace	Queensland Fire and Rescue Service
Matt Higgins	Queensland Department of Environment and Resource Management (DERM), GNSS
Darren Gould	GIS Unit, QLD Police
George Curran	Cooperative Research Centre for Spatial Information
Paul Brown	Spatial Image Unit, DERM

4. Canberra July 22, 2011

Norman Mueller	Geoscience Australia
Monica Osuchowski	Geoscience Australia
Gordon Cheyne	Geoscience Australia
Mark Crosweller	Commissioner, ACT Emergency Services Agency

Peter Florent	Department of Human Services
Lucy Tate	Department of Human Services
Greg Smith	Defense Imagery and Geospatial Organisation

5. Individual consultations

John Arrowsmith	Emergency Management QLD
Mark Garvey	Country Fire Authority Victoria (Also present at June 24 Melbourne consultation)
Gary Morgan	Department of Sustainability and the Environment Victoria
Steve Jacoby	Queensland Department of Natural Resources & Mines and Chair of QSIIC (Queensland Spatial Information Infrastructure Council)
Craig Lapsley	Victoria Fire Services Commissioner
Chris Thomas	Victoria Fire Services Commissioner

Appendix 2. Pre-consultation Scoping Paper.

Spatial Information for Disaster Response

A Scoping Paper

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Background

Recent natural disasters world-wide have heightened awareness of the need to respond quickly and efficiently. Among the important aspects of disaster response is location provided by various forms of spatial information. Hence one of the key questions in disaster response is "Where?"

1. Where is the fire/flood now?
2. Where are the areas that have already been burned/flooded?
3. Where are the fires/floodwaters most severe?
4. Where are the people and houses that are currently threatened?
5. Where are the access roads to reach those people/houses?

Recent catastrophic bushfires and floods provide an opportunity to examine disaster response so that Australia is better-prepared for future disasters. The Cooperative Research Centre for Spatial Information (CRCSI), the Australian Space Policy Unit (ASPU), and Geoscience Australia (GA) have embarked on a collaborative project to undertake such an examination. The goal of this effort is to harvest learnings from responses to recent disasters with a specific focus on satellite imagery. This will be achieved within this project using a three part approach:

1. A series of case studies will be prepared that address the use of spatial information (including satellite imagery) in response to recent floods and bushfires.
2. Consultation workshops will be held across Australia with emergency response personnel to better understand current spatial information use, needs, and possibilities.
3. A mobile satellite imagery receiving station will be trialled to evaluate its capacity to provide more timely remotely sensed image products than are currently available.

The second of these points is the focus of this scoping paper. The three partners in this project will undertake a series of national workshops targeted at organisations and individuals involved in disaster response. The primary goal of this consultation is to document how satellite imagery is currently being used by disaster response experts, and how this spatial information might better serve the Australian emergency management community. The focus of the consultation will be satellite imagery and the map-based products derived from it. Improvements identified may relate to technical aspects of spatial information such as spatial resolution and timeliness of imagery. However, consultations will also address other types of improvements of spatial information such as presentation format, linkage with other databases and types of information, delivery mechanisms and capabilities, and jurisdictional issues.

Consultation Scope

A. Disaster Cycle

There are four aspects of disaster planning that occur in a continual cycle.

- **Planning and Mitigation** identifies long-term systemic changes that will minimise the impacts of a disaster event.
- **Preparedness** is undertaken after Planning and Mitigation and is essentially the implementation of the planning that has been undertaken.
- **Response** starts when a potential disaster has been identified, continues during the actual occurrence of the disaster, and extends to the period immediately after the disaster event.
- **Recovery** begins after the emergency conditions of the Response phase have been stabilised.
- The disaster cycle then re-enters the **Planning and Mitigation** phase.

Although it is impossible to consider any one of these phases in isolation of the others, the national consultation of the present project will be undertaken with a central focus on Response. Specifically, this means that consultations will primarily address spatial information needs during the most time-critical period when the timely acquisition, processing, and delivery of spatial information must be optimised. Recent disasters in Australia have focussed attention on Response-critical needs such that it is an ideal time to undertake the proposed consultation for the two types of disasters that most affect Australia – bushfire and flood.

B. Satellite Imagery and Information

There are numerous types of spatial information provided through satellite technologies – e.g., global positioning system (GPS), geographic information systems (GIS), imagery -- as well as a number of related or enabling factors and technologies such as hand-held devices and wireless infrastructure. Just as individual phases of the disaster cycle cannot be examined in complete isolation of other phases, individual types of spatial information and enabling technologies cannot be considered in isolation of each other. For example, the ability to create improved spatial information is of little value if the information created cannot be delivered when and where it is wanted -- particularly in the crisis management context of disaster response. For tactical and operational disaster response, spatial information is needed at different spatial and temporal scales, it needs to be presented in different formats and be supported by different levels of interactivity, and it must be possible to combine different types of spatial information to support different disaster response activities.

The focus of the present consultation will be the delivery of satellite imagery and associated value-added products for disaster response. The goal of the consultation will be to identify imagery needs for tactical and operational disaster response while at the same time raising awareness among the disaster management community of current technological capabilities and limitations of satellite imagery. The consultation will also necessarily address related issues such as information delivery, jurisdictional control, data quality, and local capability.

Consultation Process and Outcomes

Consultation workshops will be held in May 2011 in Brisbane, Melbourne, Sydney, Perth, and Canberra. The case study that is Part 1 of this project will have been completed at that point and will provide necessary background to assess the current state-of-use of spatial information for specific disasters.

Whereas the case study will draw on first-hand experiences of those obtaining and utilising satellite imagery to respond to the flooding emergency, the consultations are targeted at disaster response decision-makers who require spatial information to perform their functions. Participants invited to the workshops will include:

- Police, Fire, Ambulance agencies;
- Rural fire services representatives;
- State Emergency Service (SES) personnel;
- Commonwealth and State Emergency Management agencies;
- Defence personnel responsible for emergency response assistance;
- Commonwealth and State government areas with involvement in spatial information or emergency management.

The consultation workshops will be organised to produce a final report be organised as follows:

- Current use of satellite imagery and spatial information (i.e.; maps) in disaster response
- Spatial information (i.e.; maps and satellite imagery) requirements for disaster response
- Jurisdictional and coordination issues
- Summary of spatial information needs

Information to address these will be compiled across the five workshops and organised as needed based on type of disaster, agency, divisional, and individual responsibility, critical information needs, and any other factor that is deemed relevant.

Fundamentals of Satellite Imagery

It is assumed that disaster management professionals are generally familiar with satellite imagery and derived maps and their capabilities for disaster management. However, to facilitate a consultation process that will better enable the needs of the disaster management community to be harmonised with technological capabilities, a brief outline of relevant digital image topics is presented.

There are fundamentally two types of sensors, active and passive. Active sensors, such as radar or lidar (laser), send out energy of a particular wavelength and record how much returns to the sensor. Passive sensors, commonly referred to as optical, are akin to conventional cameras as they record the light from the sun's energy that is reflected from the landscape. Active and passive sensors form images that contain information about landcover and the earth's surface (Fig. 1). For disaster management, images produced from passive sensors generally require less processing (see below) than those produced by active sensors, but passive sensors are of limited use in cloudy conditions or when smoke obscures an area. Conversely, active sensors such as radar have the capacity to penetrate clouds and haze.

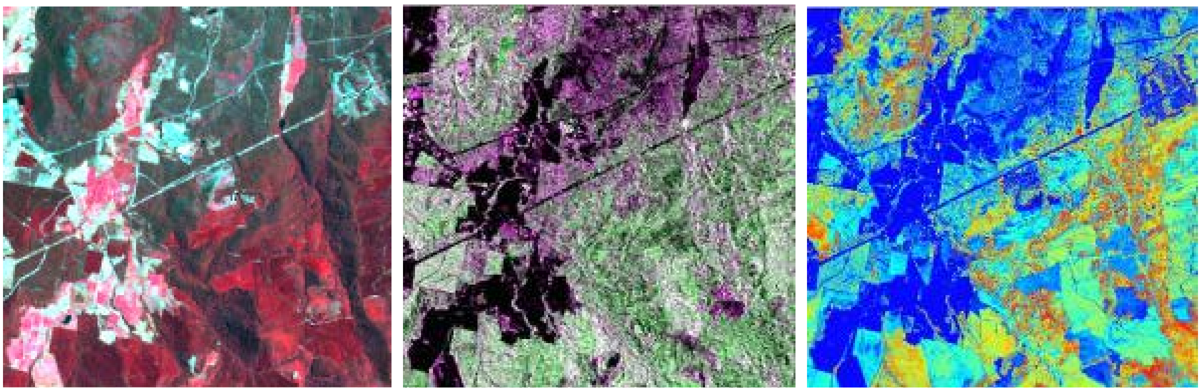

Figure 1. Examples of images from active and passive sensors; colour schemes were user-selected. From left to right – a)passive (optical; dense vegetation is bright red), b)active (radar), c)active (lidar).

Images can be acquired from equipment mounted on satellites and airplanes. Airplane-mounted sensors can provide imagery on an as-needed basis, but the cost can be relatively high. Satellite-mounted sensors provide regular periodic coverage, but the acquisition date for a given area cannot be controlled.

Specific sensor and platform combinations affect image characteristics and the frequency of coverage. Airborne data can provide images with high resolution – i.e., circa 1 metre – at a frequency controlled only by budget and flight conditions. Numerous satellite-based sensors have been launched by different countries and the characteristics of their imagery varies widely. Table 1 provides some examples.

Table 1. Examples of image characteristics from different satellite-mounted sensors.

Name	Country	Sensor Type	Pixel Size	Frequency[1]	Other
SPOT	France	Optical	1.5 and 6 m	Can be 1-day	Can provide stereo coverage
LANDSAT Thematic Mapper	United States	Optical	30 m	16 days	Can provide thermal imaging
PALSAR	Japan	Radar	7 to 44 m	46 days	
MODIS	United States	Optical	250 and 500 m	1 to 2 days	

[1]"Frequency" is the number of days between repeat coverage of a particular location.

Imagery characteristics affect its utility for various applications and ability to produce value-added products that are useful for disaster management. There is often a tendency to acquire imagery with the highest/finest spatial resolution. However, the ability of imagery to penetrate clouds, or higher frequency, or cost are all important considerations.

Once imagery is acquired, a certain amount of processing is required before it can be used. At a minimum, it must be geo-referenced (i.e., related to a geographic location). The amount of subsequent processing required depends on eventual use. Figure 1a underwent no processing beyond geo-referencing; Figures 1b and 1c required considerably more processing to produce the images shown. As an indication of time required to convert raw satellite data to a useful map, the MAPS trial linked to this consultation has demonstrated that for Queensland flood mapping eight hours are required to convert raw radar data into a map of flood level.

Potential Image Products

In this final section, we provide examples of image products that can and are being produced to assist in disaster management. These are provided here to demonstrate the types of maps that can and are being produced to assist disaster response and to generate discussion on how satellite imagery might be used in disaster response in Australia.

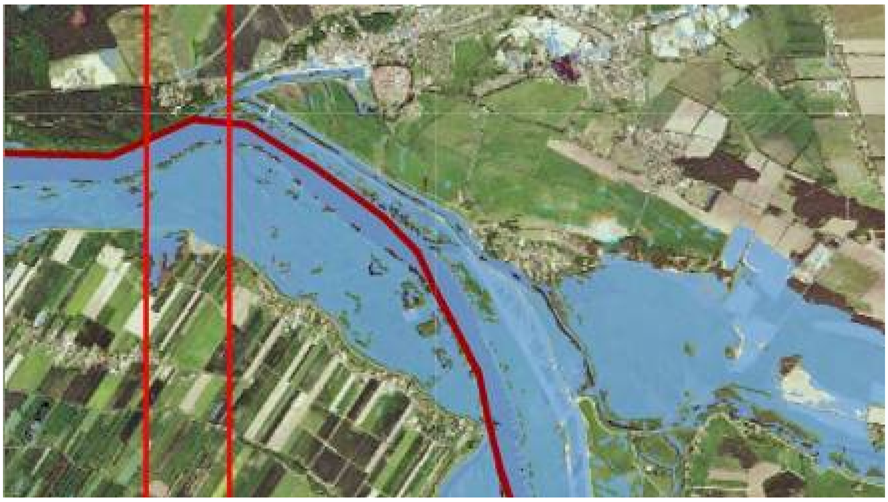

Figure 2. Flood extent.

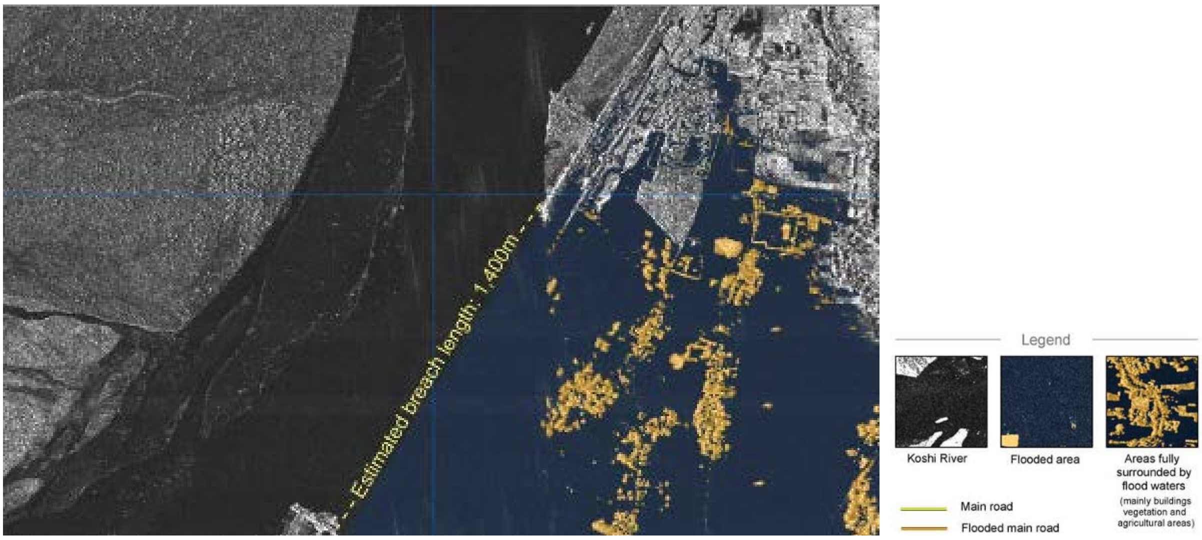

Figure 3. Embankment breach.

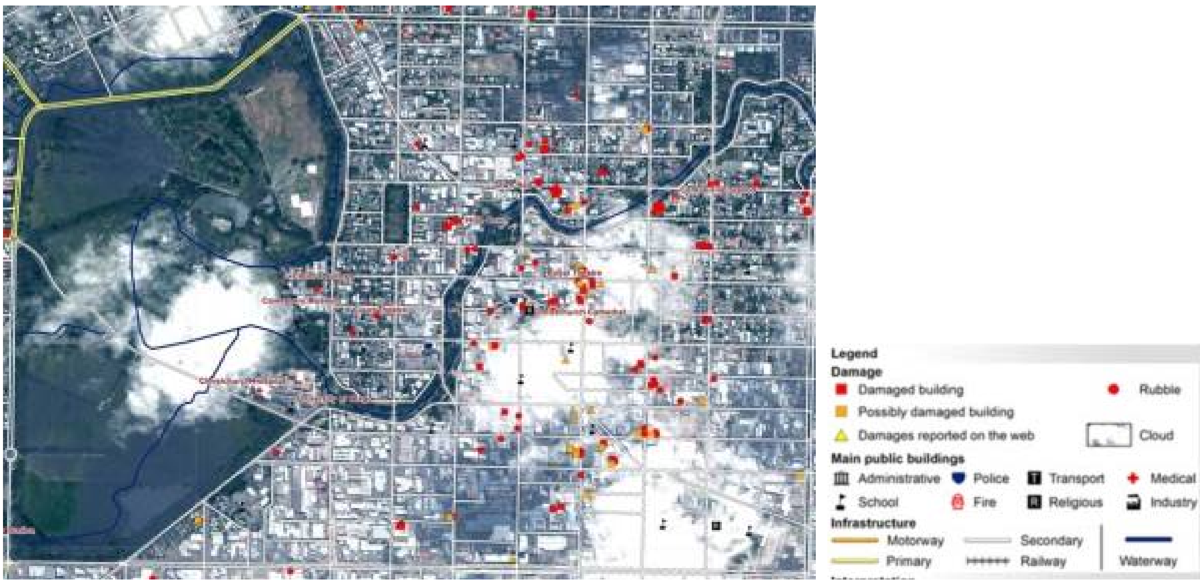

Figure 4. Damage record.

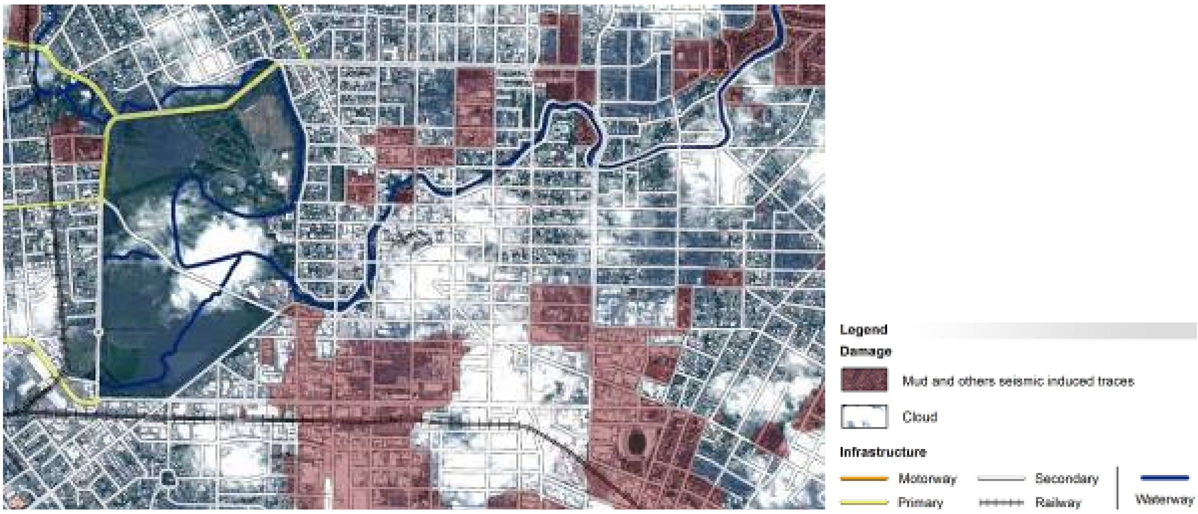

Figure 5. Impact zones.

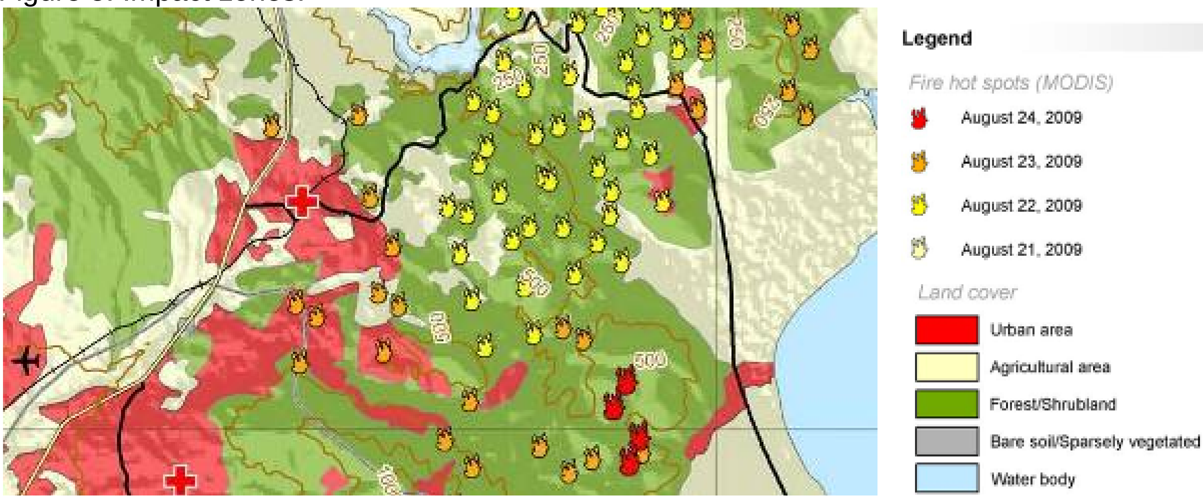

Figure 6. Bushfire hot spots.

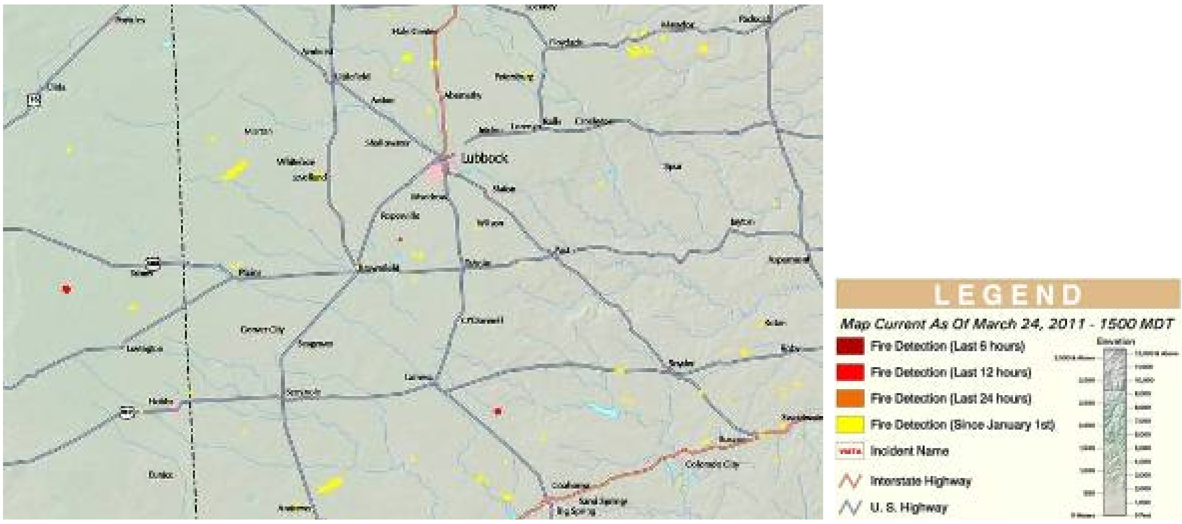

Figure 7. Recorded fires.