# Hawai`i I-Plan

HAWAI`I GEOGRAPHIC INFORMATION COORDINATING COUNCIL

I-TEAM

Ua mau ke ea o ka `aina i ka pono

*The life of the land is perpetuated in righteousness*

*Hawai`i State Motto*

# Hawai`i I-Plan for Spatial Data

Version 1.1

July 29, 2003

Sponsored by HIGICC

**Hawai`i Geographic Information Coordinating Council**

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# EXECUTIVE SUMMARY

## Purpose of this Report

The State of Hawai`i is participating in a national initiative directed by the Office of Management and Budget (OMB) to build a comprehensive inventory of geospatial data for Hawai`i that can be shared among users of geospatial technologies, including government, education, private, and non profit organizations. As directed by OMB, an inventory and review of the issues and the resources required to build the comprehensive data set was performed, which shall be used to set a direction for obtaining the essential geographic data layers.

The Hawai`i Implementation Plan (I-Plan) is the first comprehensive review of the framework data layers as defined by the Federal Geographic Data Committee (FGDC) and expanded upon by the Hawai`i Geographic Information Coordinating Council (HIGICC). The Hawai`i I-Plan is a result of a series of meetings that identified statewide geospatial issues and information needs, and reflects the voluntary collaboration of subject matter experts from government, education, private, and non-profit organizations, known as the Hawai`i Implementation Team (I-Team).

## Intended Goals

- To establish a federally recognized Hawai`i I-Team.
- Produce an inventory of geospatial data within the state.
- Identify the completeness of the geospatial data sets.
- Present the current investment made into existing geospatial data sets.
- Identify resources needed to complete the essential datasets for the State.
- Satisfy the requirements for participating in the OMB/FGDC initiatives.
- Compete for resources available from federally funded programs coordinated by the OMB/FGDC.

## A Living Document

The Hawai`i I-Plan is a living document that will continually be refined. This is the first version in an ongoing process of coordinating the assessment of geospatial data development and future needs. As data sets are completed and resources are obtained to support the creation of geospatial data, the I-Plan will be updated and revised to reflect the current status of data development in Hawai`i.

The HIGICC will administer and approve revisions to the I-Plan and coordinate the activities of the I-Team. HIGICC is the body that will communicate/coordinate the spatial data needs to the OMB and FGDC, and coordinate the implementation of resources provided to the State of Hawai`i.

# INTRODUCTION

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## Hawai`i Spatial Data Infrastructure Implementation:

The I-Team Geospatial Information Initiative (I-Team Initiative) is the next phase of efforts to build a National Spatial Data Infrastructure (NSDI). The I-Team Geospatial Information Initiative is a joint project of the Federal Geographic Data Committee (FGDC), Federal Office of Management and Budget (OMB), the Council for Excellence in Government, Urban Logic, TIE, National States Geographic Information Council (NSGIC), National Association of Counties (NACo), and other strategic partners. As part of the effort to build a National Spatial Data Infrastructure (NSDI), the I-Team Initiative addresses the institutional and financial barriers to development of the NSDI at federal, state and local levels. It aims to create a coherent set of institutional and financial incentives to make it easier for all levels of government and the private sector to collaborate in the building of the next generation of framework data. By aligning participant needs and resources, the I-Team Initiative will help all levels of government and the private sector to save money, migrate from existing legacy systems, make better user of existing resources, and build the business case for additional public and private resources. [1]

The Hawai`i Geographic Information Coordinating Council (HIGICC) provides the regional component to the national Initiative. HIGICC has endorsed the OMB's I-Team concept for assessing the status of the FGDC Framework Data Themes. HIGICC established an I-Team committee at the November 7, 2002 Data Products Workshop. The goal of Hawai`i's I-Team Report is to devise a plan for development and long-term maintenance for each theme. This report represents the first phase of that effort.

The Hawai`i Geographic Information Coordinating Council (HIGICC) is an organization providing statewide GIS coordination. It is a "non-profit body consisting of members of Hawai`i 's GIS community. Our goal is to provide coordination of GIS activities among a wide range of GIS users in order to avoid duplication of effort, promote data sharing, and maintain data standards throughout the state."

The mission of HIGICC is "to bring together and continue to build the geographic community into a cohesive, recognized coordinating body that facilitates the use, development, sharing, and management of geographic data and communicates the value of geographic information to citizens and decision-makers. In the State of Hawai`i, GIS is recognized and effectively used as an invaluable tool by the government, business and the

[1] http://www.fgdc.gov/I-Team/library/background/TwoParaITeam.doc

citizens for understanding and managing our aina (environment). The Hawai`i GICC is a shared mechanism for the diverse community to identify, explore, and solve problems with geospatial information."[2]

The Hawai`i GIS community has a successful history that makes the I-Team process possible. A 1997 grant through the Framework Demonstration Project Program focused on development of a cadastral framework layer for the Island of Molokai to address issues not faced on the mainland. A Competitive Cooperative Agreements Program (CCAP) grant led to the Metadata workshop series, which then resulted in an FGDC metadata node being managed by the Office of State Planning. Kathy Covert from FGDC attended the April 1998 GISMAP conference to assist the Hawai`i GIS community in formalizing the Geographic Information Coordinating Council. In 2001, Ron Matzner of the FGDC's I-Team office made a presentation to HIGICC on the goals of the I-Team process. The attendees at the HIGICC Data Products workshop in November 2002 discussed the priority data themes and the formation of an I-Team for Hawai`i. [3]

## Overview of the Hawai`i I-Plan

The Hawai`i GIS community has endorsed the I-Team concept and process championed by the Office of Management and Budget (OMB I-Team)[4], the Federal Geographic Data Committee (FGDC)[5] and other strategic partners[6] for assessing the status of FGDC's seven Framework data themes. The Geographic Information Professionals throughout the State have identified nine additional data themes as important to the I-Team effort.

This Implementation Plan (I-Plan) identifies the organization structure of the Implementation Team (I-Team) for Hawai`i, defines a process for prioritizing data themes that will contribute to building the NSDI, and summarizes sixteen data themes that will be included in the prioritization process. The goal is to devise a plan for the development, distribution, and long-term maintenance of each theme.

## Jurisdiction

This plan addresses issues and information needs statewide for Hawai`i and reflects the collaboration of federal, state, county and local agencies, academia, the private and not-for-profit sectors.

[2] http://www.higicc.org/about.asp
[3] http://www.state.hi.us/dbedt/gis/gicc.htm
[4] http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html
[5] http://www.fgdc.gov
[6] http://www.fgdc.gov/I-Team/strategic.html

## Approach

*Framework Layers*. The I-Team has defined 16 priority data themes. These include the seven framework themes defined by the FGDC. An additional nine layers were defined at the 2002 Data Products Workshop. A listing of these data layers is below.

| *NSDI Framework Data:* | *Hawai`i Priority Data:* |
|---|---|
| 1. Geodetic Control | 8. Utilities |
| 2. Elevation/Bathymetry | 9. Structures |
| 3. Imagery | 10. Physical Environment and Natural Hazards |
| 4. Hydrography | 11. Cultural Features |
| 5. Transportation | 12. Terrestrial Layers |
| 6. Cadastral | 13. Marine Layers |
| 7. Governmental Units | 14. Scanned Maps |
| | 15. Data Distribution/Publishing |
| | 16. Cross-cutting issues |

Chapters 1 through 7 are the key chapters for the NSDI Framework layers in our I-Plan. These layers are the most widely used across all disciplines and among all levels of government.

Chapters 8 through 14 are more local to Hawai`i, and while not critical to the NSDI Framework, they are important layers locally.

Chapter 15 covers metadata issues and how the data is made available, either for download or through web services.

Chapter 16 covers those issues that crosscut two or more chapters. For example, addressing is part of chapters 5 and 6. Hawaiian names are part of many chapters.

*Process*

A subcommittee work group of HIGICC's I-Team was formed to address each identified layer, with a group leader. Each work group represents agencies or organizations having mandated responsibility and/or programmatic need for the data. The work group is responsible for the completion of the following for the data layers associated with their respective theme:

- Detailed inventory of the existing data and providers
- Identifying existing standards
- Develop a strategy for completing the data layer
- Develop cost estimates and time requirements for completion of the data layer
- Assign responsibility for creation, integration, maintenance and distribution of the data layer

The I-Team data layers and work group chairs are as follows.

| **Planning Work Groups:** | **Planning Work Group Chairs:** |
|---|---|
| Document Editing and Consistency | Susan Bevacqua (NOAA/ National Marine Sanctuaries) and Ronald Salz (US Fish and Wildlife Service) |
| Geodetic Control | Ed Carlson (NOAA/National Geodetic Survey) |
| Elevation/Bathymetry | Henry Wolter (USGS National Mapping Div) |
| Imagery | Rhett Rebold (Pacific Disaster Center) |
| Hydrography | Pat Shade (USDA/NRCS) |
| Transportation | Goro Sulijoadikusumo (Hawai`i DOT) |
| Cadastral | Jon Hodge (City and County of Honolulu) |
| Governmental Units | Craig Tasaka (State of Hawai`i - DBEDT/OP/GIS) |
| Utilities | Ken Schmidt (CCHON) and Royce Jones (ESRI) |
| Structures | Harley Pennington |
| Physical Environment and Natural Hazards | Rod Low (ESRI) and Eric Yamashita |
| Cultural Features | Melia Lane-Kamahele (National Park Service) |
| Terrestrial Layers | Shannon McElvaney (Hawai`i Heritage Program) |
| Marine Layers | Darcee Killpack (NOAA/Pacific Services Center) |
| Scanned Maps | Craig Clouet (Kamehameha Schools) |
| Data Distribution/Publishing | Joan Esposo (State of Hawai`i - DBEDT/OP/GIS) |
| Cross-Cutting Issues | Royce Jones (ESRI) |

The first template document was sent to the work group chairs in February 2003. Their submissions were combined into the first draft of the Hawai`i I-Plan. The first draft was distributed for comment to the HIGICC and members of HIGICC and the greater Hawai`i GIS community on April 18, 2003. Comments and final edits were completed and the Final Draft Hawai`i I-Plan distributed on June 9, 2003. The document was reviewed at the HIGICC General Meeting on June 12, 2003. This led to modifications found in this document. New chapters may be needed to account for overlooked data sets, such as demographics, language, safety or disaster response planning. More input from colleagues and organizations must be addressed to make the I-Plan even more inclusive. And development of a Hawai`i geospatial strategic plan, that includes the findings in this document, should be a top priority. This document, will have a positive and long-term impact on spatial data development, integration and availability throughout the State of Hawai`i. All contributors should feel proud of the work we have accomplished together.

# CHAPTER SUMMARIES

**Chapter 1.** GEODETIC CONTROL**:** At this time there is a complete and accurate geodetic control layer for the State of Hawai`i. Such a layer is important in the development and maintenance of a seamless parcel layer for the state, and will allow all geospatial data to be brought into a common coordinate system at the time of data capture, reducing locational discrepancies between data sets. The geodetic control layer needs to maintained and updated following NGS' Federal Base Network guidelines and enhance the vertical control layer using NGS' Height Modernization program

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $ 2,000,000 | 0 | 2,000,000 |

**Chapter 2.** ELEVATION/BATHYMETRY**:** The development of a high-resolution elevation and bathymetry dataset is a high priority for the Hawai`i Geographic Information Coordinating Council (HIGICC); as such data can provide the foundation for many data themes. In addition, these data can be used for a variety of applications, such as watershed management, viewshed mapping, transportation planning and flood hazard mitigation and prevention, and hydrologic modeling studies. It is estimated that it will take more than **$2.75 million** to complete this theme. However, the first step should be to develop a coordinated approach by Federal, State, County, local and private partners, and the HIGICC, to identify all entities that will benefit from high-resolution elevation and bathymetry data, and to develop a streamlined funding mechanism for the cost-share contributions.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| Over $2,750,000 | Undetermined at this time | Undetermined at this time |

**Chapter 3.** IMAGERY**:** Hawai`i needs statewide coverage of both a consistent, flexible use, and widely available ortho imagery dataset that is high-resolution natural color and a perhaps lower resolution 4 band multispectral data set of similar coverage. This would be the base for developing many other critical data themes, such as parcels, structures, marine and terrestrial layers. Ortho imagery also provides an excellent source for smart growth planning, biomass determination to support fire behavior modeling, plant species identification, habitat mapping, and alien plant control. However, since the spatial data community in Hawai`i makes such broad use of imagery data, it is doubtful that any single imagery dataset will satisfy all possible applications. The Hawai`i IKONOS Consortium, coordinated by the Hawai`i Natural Heritage Program, allows for 1 meter color imagery of the state (by tiles for the main 8 islands) and 4 meter 4-band multispectral imagery for the same area, same configuration, and is perhaps the most viable forum for developing a state wide imagery dataset. As of 5/26/03, it would take **$1,380,000** to complete the IKONOS coverage. In addition, it is estimated that between

**$400, 000** and **$1,400,000** would be required to develop a higher resolution imagery dataset to satisfy other needs, such as post disaster damage assessments

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $1,780,000 - $2,780,000 | $367,000 (IKONOS Consortium contributions) | $1,413,000 - $2,413,000 |

**Chapter 4.** HYDROGRAPHY**:** It is estimated that **$330,000** will be needed to fund the completion of an integrated hydrography dataset for the State of Hawai`i. This dataset will integrate surface-water, ground water and water-quality spatial and attribute data in a watershed framework of the integrated hydrography theme. This would include three major tasks. These are; 1) validating and coding additional attributes for stream and ditch segments, 2) updating the National Wetland Inventory mapping for the islands of Niihau, Kauai, Molokai, Maui, Kahoolawe, Lanai and Hawai`i and 3) linking water-quality data to well and stream segments and to watershed attributes.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $467,500 | $137,500 | $330,000 |

**Chapter 5.** TRANSPORTATION**.** Transportation, within the context of spatial data infrastructure, pertains to facilities and assets involved with moving people and goods from one location to another via land, water or air. These facilities include airports, harbors and roads. The initial focus of most transportation framework data projects has been on the creation of a comprehensive road network data sets, beginning with accurate street centerline base maps for all public roads statewide with accuracy within five meters. The Department of Transportation (DOT) will be spending $700,000 this year to complete the Digital Videolog project that will result in updated highways base maps. If other agencies would piggyback on this project, most of the remaining 2,700 miles of roads can be completed within **$200,000**, as all mobilization and much of the equipment costs have already been covered. The basic data capturing activities can be completed within a budget of **$100,000**.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $1,000,000 | $700,000 | $300,000 |

**Chapter 6.** CADASTRAL**:** The parcel layer is probably the most frequently used cadastral dataset in the State of Hawai`i. It is often the foundation on which other layers, such as street centerlines, easements and zoning, is built. In addition, other critical themes, such as Government Units, are derived from the parcel layer. It is estimated that over **$600,000** will be needed to complete a multi-use parcel layer for the entire State.

The majority of these costs would be associated with creating digital parcel data for areas of the state where no such data currently exists.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $1,000,000 | $400,000 | $600,000 |

**Chapter 7.** GOVERNMENTAL UNITS**:** Several Government Unit and boundary layers for the state already exist as digital files. In certain cases, these government units are or could be subsets of other existing data layers, and therefore, if not already done, could be extracted to create the desired layer. For example, Hawaiian Home Land boundaries were derived from the parcel layer. There is a need for public agencies to acquire the parcel data layers that are not already public information. Most of the Neighbor Island parcels are proprietary data sets. It is a goal to acquire the rights to these data sets so that they are public information. It is estimated that it would take an additional **$200,000** to acquire and set up management procedures for these datasets.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $250,000 | $50,000 | $200,000 |

**Chapter 8.** UTILITIES**:** Utilities comprise a variety of different layers of infrastructure data managed primarily by local government agencies or private utility corporations, and include water, wastewater, storm drains, telecommunications, electric and gas layers. Much of the information for this chapter has not been received in time for this draft, however, or the local government utilities, priority has been placed on water and wastewater utilities with a high emphasis being placed on the updating of storm drains. It is roughly estimated that it would take an additional **$1,500,000** to complete this theme.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| Estimated between $1,000,000 and $2,000,000 | Estimated at $500,000 | Estimated between $500,000 and $1,500,000 |

**Chapter 9.** STRUCTURES**:** An estimated **$1,900,000** will be required to create a central repository and complete spatial inventory of buildings for the State of Hawai`i. Data about the location and shape of building structures are needed to support many different types of government services, including land use planning, construction permit approvals, tax assessment, utility management, homeland security, and other major programs.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $2,000,000 | $100,000 | $1,900,000 |

**Chapter 10.** PHYSICAL ENVIRONMENT AND NATURAL HAZARDS**:** Within the context of the Hawai`i I-Plan, the Physical Environment and Natural Hazards theme contains subcategories of geology, soils, weather and climate and natural hazards. Digital geologic map data will soon be publicly released for the Island of Hawai`i. But a major data gap exists for the remainder of the State. Soils data exists statewide and is gradually being updated to include conservation lands and changes in agricultural uses. A modest amount of funding is sought for the expert interpretation of soils attributes. For climatic data, piecemeal layers exist from various State sources, and additional layers are created though most will be licensed. An evapotranspiration layer will still be needed. Creation and maintenance of a layer of precise weather station locations that can be linked to archived historical data is a priority.

Within natural hazards, layers need to be maintained of historical events and the models created of areas and severity of potential risk from: coastal erosion/sea level rise, tsunami, inland erosion/landslide/rockslide, wildfire/drought, hurricane/windstorm/storm surge, flood, earthquake, and volcanic eruption/lava flow/emissions. There are several ongoing data projects, such as the revamping of the digital flood insurance rate maps and completion of tsunami inundation mapping. The highest priority un-funded gaps include completion of the high winds models for Maui and the Island of Hawai`i, storm-induced coastal flooding mapping, earthquake liquefaction modeling. Another priority, completion of coastal erosion mapping is tied to the issues of coastline mapping covered in the marine layers theme.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| TBD | TBD | TBD |

**Chapter 11.** CULTURAL RESOURCES**:** It is essential to note that cultural resources data for the State of Hawai`i cover a variety of agencies, resource types and stewards. While some this data is available from public sources, others of it are proprietary or restricted for security and sensitivity of data reasons. While it is estimated that up to **$1,000,000** will be needed to complete a compilation of as cultural resources theme and to develop a Metadata to clearinghouses, there is a stronger need to first develop a coordinated effort to identify agencies, organizations, and persons whom currently steward such data. The primary goal should be to strengthen communication, partnerships and data sharing. Cultural resources data is critical for prudent resource management, planning, permitting and consultation processes at both the state and federal levels as well as for education and outreach purposes. Note that the current allocation of funding does not include the value of heritage and legacy data sets already in place by various agencies.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $1,250,000 | $250,000 | $1,000,000 |

**Chapter 12.**TERRESTRIAL LAYERS**:** The summary for this chapter will be completed in Version 1.1.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| Undetermined at this time | Undetermined at this time | Undetermined at this time |

**Chapter 13.** MARINE LAYERS**:** Marine data are not considered framework data layers in most spatial data infrastructure plans. However, due to Hawai`i unique geography, coastal and marine data are essential to Hawai`i's spatial data community. Priority data sets representing the near-shore and marine environment are shoreline, marine habitats, marine managed areas, ocean and water quality, and marine uses. The two top priorities for data collection are a digital state shoreline and a common habitat classification for the Hawaiian archipelago. Currently over one-half million has been invested in these data layers, with over two million needed to complete these data sets. Coordination and partnership between all the federal and state agencies on data collection will be needed to meet the goals. As all these layers are very dynamic, constant updates and funding to maintain these data will be require as well.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $2,160,000 | $435,000 | $1,725,000 |

**Chapter 14.** SCANNED MAPS**:** As the effort to convert hard copy maps into raster data is so varied in nature, it is difficult to anticipate a cost. There are methods to estimate certain types and methods of imaging and storage which will begin to define costs. Whether outsourcing or in-house efforts are done, the same time and materials are required. Technology has played a major role in determining the cost and feasibility of scanning maps. There can never be a completion of this theme as maps and other spatial data are produced each day. There maybe a time in some distant future that all data is store digitally, even in vector format, however with the massive amount of existing data already in hard copy format clearly many millions of dollars are required to meet the existing inventory. At this stage, the gathering of interested stakeholders is where the focus should be. A cost for meetings, and bringing in experts to develop a plan constitutes the first budgeting requirements. Some agencies are already doing various projects and are spending money this fiscal year. A long-term goal of digitizing most historic maps in Hawai`i is an ambitious and costly endeavor.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| NA | NA | NA |

**Chapter 15.**DATA DISTRIBUTION/PUBLISHING**:** At this time, it is estimated that **$7,000** and an undetermined amount of additional staff time are required to complete and maintain one metadata clearinghouse for data developed in Hawai`i, to which all data developers/holders would submit their metadata for publication.

| TOTAL COST | FY03 PLANNED INVESTMENT | BUDGET SHORTFALL |
|---|---|---|
| $7,000 plus staff time | $0 | $7,000 + |

**Chapter 16.** CROSS-CUTTING ISSUES**:** The three primary cross cutting issues are spatial co-registration of features, Hawaiian place names and addresses and geocoding. Geocoding is critical for emergency response and homeland security. Hawaiian place names need to be used consistently to prevent confusion between data layers. Spatial co-registration to framework base maps during the data creation process to create long term benefits to overlay and analysis of datasets.

# CHAPTER 1:GEODETIC CONTROL

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**Theme Description:**[7]

A geodetic control network is the wire-frame or the skeleton on which continuous and consistent mapping, Geographic Information Systems (GIS), and surveys are based. To understand the function of geodetic control, we have to realize that a map or a plane survey is a flat representation of the curved world. If we want the maps to become an authentic representation of the real world, we have to be able to "paste" small pieces of (flat) map contents onto a curved world. The Geodetic Control is the mechanism that enables us to perform this "pasting" seamlessly, accurately and consistently.

Traditionally, geodetic control points are established as permanent physical monuments placed in the ground and precisely marked, located, and documented. Locating spatial features with respect to geodetic control enables the accuracy assessment of these features. Interest and activity regarding geodetic control has dramatically increased at all government levels because of the need for accurate maps and surveys used in geographic and land information systems.

With the advent of the Global Positioning System (GPS), the framework of the geodetic control network for Hawai`i should preferably be based on CORS (Continuously Operating Reference Stations). CORS stations provide an active geodetic control network, which enable GPS users to tie their positioning observations to the geodetic network without physically having to occupy a geodetic control point. Spatial data is georeferenced to the geodetic network by processing roving GPS receiver data with data from CORS stations. Hence, CORS stations offer lower cost, efficient and accurate positioning necessary to support National Spatial Data Infrastructure (NSDI) needs.

**Status:**

The state of Hawai`i has a highly accurate traditional geodetic network in place. New NAD83 (North American Datum of 1983) coordinates for a statewide network of 1,830 horizontal monuments were published in August 1993 (project 17624). These 1,830 new coordinates include 49 GPS monuments whose GPS-derived elevations also were published at that time. Statistics indicate that the NAD83 (1993) coordinates for most of the nearly 49 Hawai`i GPS monuments, in particular, are compatible with the coordinates for the existing CORS to within 2 centimeters (1 inch) horizontal accuracy and 6 centimeters (3 inches) vertical accuracy. Information for these monuments, which are all

[7] The source for much of this chapter is the State of New Jersey Spatial Data Infrastructure Implementation: I-Team Strategic Plan, March 2002. (http://njgeodata.state.nj.us/)

part of the National Spatial Reference System, are available in FGDC Spatial Data Transfer Standard (SDTS) point profile format, used for the transfer of data into a GIS. In addition six CORS stations are already operating in Hawai`i to support GIS and surveying activities.

**Data Sources:**

The primary source for geodetic data is the National Geodetic Survey (NGS). NGS, known by other agency names in the past, has been responsible for establishing and maintaining a nation-wide geodetic control network since 1807. This network, currently called the National Spatial Reference System (NSRS), contains monumented survey stations whose horizontal and/or vertical coordinates are precisely surveyed and computed. In the past NGS was the only agency establishing, maintaining, and publishing high accuracy geodetic control. Due to the nature of the surveying technologies most horizontal control was on mountain peaks, and vertical control followed roads. To support mapping efforts state agencies such as the Department of Transportation (HI-DOT) would come off the NGS control and survey down to the area of interest using lower accuracy procedures and instruments, but adequate for their mapping projects. Therefore, many geodetic survey stations established with that technology are considered inaccessible by today's surveyors or inappropriate for using GPS technology. The control network continues to diminish in size as stations are destroyed due to construction and vandalism.

With the advent of modern technologies such as GIS, GPS and other electronic instruments, many state, county and local government agencies have undertaken the task of establishing geodetic control. Some of them elected to submit the data to NGS. Data submitted to NGS that comply with standards and specifications are incorporated into the NSRS. Many entities elect not to submit their data to the NGS but will provide those data upon request, while some entities will not provide those data outside the agency. The NSRS is made available free of charge by NGS through direct Internet access (http://www.ngs.noaa.gov/datasheet.html); other methods (CDs, paper products, etc.) incur a cost of dissemination.

Professional licensed surveyors in Hawai`i, who to establish geodetic control are encouraged to publish geodetic control coordinates within their own jurisdictions and in conjunction with the NGS.

**Standards:**

Standards for both the establishment of geodetic control and for data transfers are well documented. See FGDC (Federal Geographic Data Committee) Geospatial Positioning Accuracy Standards, Part 2:Standards for Geodetic Networks (FGDC-STD-007.2-1998), and the FGDC Spatial Data Transfer Standard (SDTS), Part 6:Point Profile (FGDC-STD-002.6).

**Priority:**

The geodetic control layer is of very high priority for Professional surveyors, GIS developers and spatial data gatherers in Hawai`i. The rationale being that if geodetic control is readily available throughout the state, all geospatial data will be brought into a common coordinate system at the time the data are collected. This is especially important for the development of a seamless parcel map for the state.

Since geodetic control is a fundamental infrastructure for geo-spatial analysis activities, the higher the interest levels in a geographic area, the higher the priority for good geodetic control. Since much of the data collection for geospatial data in Hawai`i will be done with GPS receivers, using the existing CORS system for establishing the Federal Base Network (FBN) and the Cooperative Base Network (CBN) in the state is of the highest priority. NAD83 coordinates will be expressed as geographic (latitude, longitude, orthometric height) and projected onto Hawai`i State Plane coordinates whose units are meters. Without such a network, high accuracy data (1.0 ft. ground resolution or better) will be more expensive and time consuming to compile.

**Estimated total investment in this theme:**

NGS' mission since 1807 is to establish and maintain the geodetic and leveling networks for all the states and territories. The Hawai`i geodetic network was started in 1871 and the work has been done as part of NGS' budget over the years.

**Estimated current state and local contributions:**

Hawai`i is supporting the Geodetic State Advisor program (http://www.ngs.noaa.gov/INFO/OnePagers/One-Pager_State_Advisor.pdf ) which is jointly funded between the state of Hawai`i and NGS.

**What is needed:**

A coordinated effort by the Federal Partners Team, the HI- DOT, Hawai`i Association of Land Surveyors (HALS) and Hawai`i Office of Planning to identify entities that are willing to assist in the establishment of the FBN and CBN (http://www.ngs.noaa.gov/INFO/OnePagers/One-Pager_FBN.pdf) and enhance the vertical component of the NSRS using NGS' Height Modernization program (http://www.ngs.noaa.gov:80/Slides/HTML_Ht_Mod/index.htm).

**What is the likely source:**

Municipal Government
County Government
HI Department of Transportation
U.S. National Geodetic Survey

U.S. NOAA – National Weather Service

U.S. Geological Survey
HI Utilities such as Hawaiian Electric and Water companies
Hawai`i Association of Land Surveyors
University of Hawai`i

**Estimated total investment needed to complete this theme:**

Following the FBN guidelines to maintain the geodetic horizontal network.
Getting the support of Congress and the Administration for 500K per year for four years for the Height Modernization for Hawai`i.

**Estimated current allocation of funding**

See above.

**Estimated budget shortfall:**

Depends on support from Congress and the Administration for the Height Modernization for Hawai`i.

**Possible ways to overcome this gap:**

TBD

**Most appropriate data steward:**

National Geodetic Survey

**Maintenance Process:**

Following NGS' FBN guidelines for replacing destroyed control points.

**Estimated Maintenance cost:**

To be done by in kind labor by either County Governments, HI Department of Transportation, U.S. National Geodetic Survey, U.S. Geological Survey, HI Utilities such as Hawaiian Electric and Water companies, and Hawai`i Association of Land Surveyors

# CHAPTER 2: ELEVATION/BATHYMETRY

Coordinator:
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**Theme Description:**

Elevation/Bathymetry refers to a spatially referenced vertical position above or below a datum surface. Elevation/Bathymetry data can be used as a representation of the terrain, depicting contours or depth curves and providing a three-dimensional perspective. The data can also be used for watershed management, viewshed mapping, transportation planning and flood hazard mitigation and prevention. In addition, elevation data are often combined with other spatial data layers for regional hydrologic modeling studies.

There are many ways to represent elevation datasets. The standard product that United States Geological Survey (USGS) produces and uses is represented as a digital elevation model (DEM) collected in 30- or 10-meter grid spacing with coverage in 7.5 by 7.5 minute blocks.

Bathymetry, unlike its terrestrial counterpart, elevation, doesn't have National Mapping Standards. The National Oceanic and Atmospheric Administration (NOAA) is drafting metadata standards at this time.

**Status:**

The National Map Division of USGS (USGS/NMD) has completed 10-meter seamless DEMs, National Elevation Datasets for all the main Hawaiian Islands.

One of the priority initiatives for the Hawai`i Geographic Information Coordinating Council (HIGICC) is to coordinate the development of a seamless high-resolution digital elevation model (DEM) for the entire state. A high-resolution DEM will be produced using Light Detection and Ranging (LIDAR) technology.

The HIGICC intends to develop high-resolution elevation data in collaboration with the USGS National Elevation Dataset (NED) initiative. The proposed high-resolution dataset will meet (Federal Emergency Management Agency (FEMA) specifications for the Digital Flood Insurance rate Map (DFIRM) products, having a vertical resolution of 2 feet statewide. The data will also be incorporated in the USGS TNM (The National Map).

While the NGDC (National Geophysical Data Center) serves as a clearinghouse for Bathymetry data, much of the Bathymetry data collected has been on a project-by-project basis and has not been archived by NGDC. There is no coordinating body that has

identified priority-mapping needs for Hawai`i. There is no overall clearinghouse or coordinating body for Bathymetry Data. NOAA National Marine Fisheries Service (NOAA/NMFS) is in the process of establishing a clearinghouse for Bathymetry data using Arc/IMS.

**Data Sources:**

In Hawai`i, the primary source for 10-meter DEMs is the USGS. The HIGICC is coordinating with the USGS/NMD to post the USGS 10-meter DEMs to the HIGICC web site. (http://www.higicc.org/) The primary source for bathymetry data is NGDC (www.ngdc.noaa.gov) and NOS.

**Standards:**

FEMA Base Map Standards for new Digital Flood Insurance Rate Map (DFIRM) products – vertical RMSE of 18.5 centimeters; horizontal RMSE of 1 meter; and DEM point spacing of 5 meters. http://www.fema.gov/mit/tsd/mm_lidar.htm.

Federal Geographic Data Committee (FGDC), Geospatial Positioning Accuracy Stands, and Part 3: National Standard for Spatial Data Accuracy (NSSDA). See FGDC-STD-007.3-1998. http://www.fgdc.gov/standards/status/sub1_3.html.

Federal Geographic Data Committee (FGDC), Draft Standard for Digital Elevation Data. http://www.fgdc.gov/standards/documents/proposals/prodigel.html.

**Priority:**

The development of a high-resolution elevation and bathymetry dataset is a high priority for the HIGICC.

**Estimated total investment in this theme:**

The estimated *total* investment for elevation data is $**350,000**. This is the amount that USGS/NMD has spent on the 30 & 10 meter DEMs.

There is no way to tell how much has been invested in bathymetry data. At this time it is estimated the NOAA has invested at least $3 million in this data set for the main Hawaiian Islands and the Northwestern Hawaiian Islands.

**Estimated current state and local contributions:**

The State of Hawai`i, HIGICC has currently not budgeted any funds for the elevation dataset. NOAA plans to spend $3 to $6 million in the next 3 to 5 years for bathymetry datasets.

**What is needed:**

A coordinated approach by Federal, State, County, local and private partners, and the HIGICC, to identify all entities that will benefit from high-resolution elevation and bathymetry data and to develop a streamlined funding mechanism for the cost-share contributions.

**What is the likely source:**

U.S. Army Corp of Engineers
U.S. Federal Emergency Management Agency
U.S. National Oceanographic and Atmospheric Administration
U.S. Environmental Protection Agency
U.S. Department of Transportation
U.S. Department of Interior (USGS, United States Fish and Wildlife Service, National Parks Service) thru OMB Circular A-16
State of Hawai`i Planning Department
City and County of Honolulu
Maui, Hawai`i and Kauai Counties.

**Total investments needed to complete this theme:**

At 2 ft contours it will take about $2,750,000 million to re-do the elevation data set for the Hawaiian Islands. (Note: This cost is exclusive of ground survey required, typically priced at $2,000 per day: Deliverables are for bare earth Digital Elevation Models, DEM's. Pricing does not include mobilization and ferry cost, which could be significant for Hawai'i.

**Possible ways to overcome this gap:**

As part of the NED initiative, the USGS has developed a program of partnering with state governments to improve the quality of existing elevation data. This partnership could be to include FEMA.

**Most appropriate data steward:**

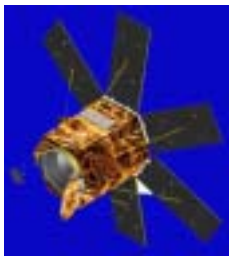
Elevation: USGS/NMD
Bathymetry: NOAA/NMFS

**Maintenance Process:**

As needed.

**Estimated Maintenance cost:**

# CHAPTER 3: IMAGERY



Coordinator: Rhett Rebold
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**Theme Description:**

In a broad sense, imagery refers to ortho photography from airborne platforms that include traditional film-based cameras or digital sensors, and satellite imagery from a variety of sensors including multi-spectral, hyperspectral, and synthetic aperture radar (SAR). Imagery datasets have a variety of uses. They can serve as a common spatial standard and as a display tool for other data. They also are an important source for smart growth planning, as well as a spectral source for vegetation type and location, biomass determination to support fire behavior modeling, plant species identification, habitat mapping, alien plant control, and baseline imagery supports the change detection that facilitates post disaster damage assessments. Our State needs statewide coverage of both a consistent, flexible use, and widely available ortho imagery dataset that is high resolution natural color and a perhaps lower resolution 4 band multispectral dataset of similar coverage.

**Status:**

There are a variety of ortho imagery datasets available and in use in Hawai`i. However, many of these datasets are project-based and may have a limited coverage area or have a very specialized collection profile. Some examples of this type of coverage are a limited area hyper spectral bathymetry study, or an extremely high-resolution air photo survey of one or more military bases for use in facilities management. These datasets are not widely used because they usually cover such small areas. They are often not widely available, either, for a variety of reasons, such as restrictive licensing, lack of ortho control in processing, or no processing at all.

A statewide coverage of a consistent, flexible use, and widely available ortho imagery dataset is needed. There are four current or relatively current datasets that are partial solutions to this need. They are:

**1. USGS Statewide Digital Ortho Quarter Quads (DOQQ's)**: 1 – 1.5 meter panchromatic UTM zone 4 and 5, NAD83 Datum, DOQ format (BIL), 1993 –1995

timeframe. (IDP, or imagery derived product, meaning they are only releasable to Federal agencies that sign non-disclosure agreements)

**Issue:** IDP DOQ's are only releasable to federal agencies and their contractors, because they are marked "U.S. Government Use Only" by NIMA (where the photography originated) and the USGS. This distribution is too small to allow this dataset to serve as the spatial standard that it should, given that most of the newer USGS spatial products for Hawai`i are either aligned with or derived from this dataset. (DLG's, DRG's, DEM's) For use as one would air photos, it is also getting quite out-of-date especially in areas of significant growth.

**2. EMERGE Statewide Digital Ortho Quarter Quads (DOQQ's)**: 1-meter digital false color Infrared, UTM zone 4 and 5, NAD83 Datum, MrSID format 1999 – 2003 timeframe. USDA/NRCS had contracted with EMERGE to fly the main eight Hawaiian Islands and to process the data to ortho spatial quality. NRCS owns this data, but makes it available to the geospatial community in Hawai`i in MrSID format.

**Issue:** Slow completion of this dataset over several years, as well as quality control issues, is causing GIS analysts to look elsewhere for similar data. Also, digital pixel mosaic, false color IR is not the optimum format for some applications; it is neither a good multispectral dataset nor is it a natural looking/layman accessible backdrop for the display of vector data or other information.

**3. NOAA/NOS Coastal Aerial Photography:** 1-meter natural color, scanned and rectified air photos, UTM zone 4, NAD83 Datum, geotiff format, 2000 timeframe. The dataset includes coastal land areas with reef only, often extends about one mile inland, but is widely available from the Pacific Disaster Center.

**Issue:** Although many of the most populated areas in Hawai`i are concentrated along its coastlines, many areas of interest and population are not. This dataset's area of coverage is far too limited.

**4. Hawai`i IKONOS Consortium:** 1 meter natural color imagery and 4 meter, 4-band multispectral imagery for of the state (by 25km$^2$ tiles for the main 8 islands). The consortium is a cost saving effort designed to achieve a consistent statewide imagery dataset. Federal, State, Nonprofit and even commercial organizations join the consortium at certain levels of investment and then are given access to all of the available purchased data. The Hawai`i Natural Heritage Program is coordinating this effort. They report that as of 5/26/03, some 162 tiles of 771 for the main 8 Hawaiian Islands have either been purchased have been spoken for. Each tile costs $2,264 including both 1 meter and 4 meter data and all fees and taxes.

**Issue:** Should the bulk of the State be covered as a result of this effort, it should constitute at least a 70 or 80% solution to the goal of this chapter, having high resolution natural color imagery of populated areas and relatively high resolution multispectral imagery data for at least the vegetated areas of the State. The areas of concern include

whether or not the dataset will indeed be completed and if 1 meter color fully satisfies some organization's needs for almost facilities-management-level resolution data.

## Data Sources

**Table A**

| Sources of Existing Data | | | | |
|---|---|---|---|---|
| Agency/Vendor | Sensor | Contact | Address | Phone |
| USGS DOQ | NTM satellite | Henry Wolter hwolter@usgs.gov | U.S. Geological Survey<br>677 Ala Moana Blvd<br>Suite 415<br>Honolulu, Hawaii 96813 | Tel: 808-587-2409<br>Cell: 808-295-4713<br>Fax: 808-587-2401 |
| EMERGE | Digital airborne imagery | Pat Shade Pat.shade@hi.usda.gov | NRCS Hawaii<br>300 Ala Moana,<br>Room 4-118<br>Honolulu, HI 96850 | Tel: 808-541-2600 ext. 120<br>Fax: 808-541-1335 |
| NOAA/NOS | Aerial photography | Rhett Rebold rrebold@pdc.org | Pacific Disaster Center<br>590 Lipoa Pkwy<br>Suite 259, Kihei, Maui, HI 96753 | Tel: 808-891-7932<br>Fax: 808-891-0526 |
| IKONOS Consortium | Digital satellite imagery | Shannon McElvaney mcelvane@hawaii.edu | Hawai`i Natural Heritage Program<br>Center for Conservation Research and Training<br>677 Ala Moana Blvd., Suite 705,<br>Honolulu, HI 96813 | Tel: 808-587-8600<br>Cell: 808-222-8531<br>Fax: 808-587-8599 |
| **Potential Sources of Imagery Data** | | | | |
| Agency/Vendor | Sensor | Contact | Address | Phone |
| Air Survey Hawaii (ASH) | Aerial Photography | Brenda C. Timas (Office Manager)<br>Jay Whiteford (Owner) | 22 Lagoon Drive, Honolulu, HI 96819 | Tel: 808-833-4881<br>Fax: 808-839-7046 |
| Radarsat, Inc. www.rsi.com | QuickBird | Farida Raghina FRaghina@rsi.ca<br>North American Sales and Service | 13800 Commerce Parkway<br>MacDonald Dettwiler Building<br>Richmond, BC<br>Canada V6V 2J3 | Tel: 604-231-4985<br>Fax: 604-244-0404 |
| Space Imaging www.spaceimaging.com | IKONOS | Dan Bellissemo Dbellissemon@spaceimaging.com | 12076 Grant Street<br>Thornton, CO 80241 | Tel: 800-425-2997 (Customer Service) |

| | | | | |
|---|---|---|---|---|
| Science and Technology International www.sti-services.com | Airborne Multispectral | Jonathan C. Gradie, Ph.D. jgradie@sti-hawaii .com | 733 Bishop Street, Suite 3100 Honolulu, HI 96813 | Tel: 808-540-4710 Fax: 808-540-4850 |

**Standards:**

Due to the wide variety of data sources and types, standards for data include:
FGDC standards for metadata (http://www.fgdc.gov/metadata/meta_stand.html)
USGS and NOAA/NOS aerial photography standards (http://oceanservice.noaa.gov/mapfinder/products/photos/welcome.html)
American Society for Photogrammetry & Remote Sensing (ASPRS)'s standards (http://www.asprs.org/asprs/resources/standards.html)

Certainly any new imagery dataset should be as spatially accurate as the USGS DOQQ's (http://rmmcweb.cr.usgs.gov/public/nmpstds/doqstds.html) or better. Generally, for many applications, 1 meter or smaller pixel size is adequate resolution for imagery to be used as display backdrops of for manual feature extraction. Additional spectral bands such as three visible bands and at least one reflected IR band could allow spectral feature classification at lower spatial resolutions. Cloud cover should generally be less than 10% for the dataset, although it can be decided whether a higher amount can be tolerated in the highest elevations in order to speed collection.

**Priority:**

**Priority 1 – Obtain 1 meter natural color IKONOS of the main Eight Islands**
This is obtainable through the IKONOS Consortium and is recommended as the most likely to satisfy many data users. Although it doesn't satisfy some data users need for additional resolution, it seems the most likely to actually come to fruition.
**Priority 2 – Obtain .3 meter of the more densely populated areas of the State**
This is obtainable through Air Survey Hawai`i or other qualified aerial photography companies that have experience flying in our State's challenging island conditions. This dataset could be collected for less than half the total price of the IKONOS purchase but processing costs make it potentially costly depending on methodology and total area of what is considered densely populated.
**Priority 3 – Obtain 4 meter 4 band multispectral imagery of the main Eight Islands**
This is obtainable through the IKONOS Consortium and is recommended as the most likely to satisfy many data users who need multispectral for vegetation issues. Although it may not satisfy some data users who may need to break out very small occurrences of specific plant species it will achieve a 90% solution by allowing medium sized plant groups to be identified. It is by far the most likely dataset to actually come to fruition due to its consistency, price, and good organization of the collection effort. (As opposed to airborne multispectral or 2 meter Quickbird multispectral.)
**Priority 4 – Obtain 2 meter 4 band multispectral imagery of the main Eight Islands**

This is obtainable through Quickbird or airborne multispectral collection companies such as STI. It would allow for great discernment of small groups of plants but would be more expensive and would demand close management of consistency.

**Estimated total investment in this theme:**

$1.75 million would cover the complete IKONOS Consortium purchase including both the 1 meter color and the 4 meter multispectral for the main 8 islands. Approximately $367,000 of this total is already purchased, ordered, or has been expressed as intent to purchase. It would take an additional $1.38 million to complete the coverage.

**Estimated current state and local contributions:**

Hawai`i state and local agencies hold some specialized imagery data and have also in some cases, contributed to the IKONOS Consortium effort. Exact dollar amounts of current contributions are unknown.

**What is needed:**

Since the spatial data community in Hawai`i makes such broad use of imagery data, it is doubtful that any single imagery dataset will satisfy all possible applications. Some example applications could include: use as a common spatial control standard, a display backdrop for other data, a source for smart community growth planning, a spectral source of vegetation type and location, a source for biomass determination to support fire behavior modeling, or for alien plant control. Generally, for many applications, visible color imagery, 1 meter or smaller pixel size is adequate resolution for imagery to be used as display backdrops or for manual feature extraction. Multispectral imagery that has three visible bands and at least one reflected IR band could allow spectral feature classification at lower spatial resolutions, such as 2-4 meter pixel sizes. At least the two following datasets are necessary for many applications:

**1.** Natural Color photography or satellite imagery that has .25 – 1 meter pixels for at least all populated areas of the State, if not the entire main eight Hawaiian Islands. It should be ortho rectified into the same geographic space as the USGS data: UTM zones 4 and 5 with a NAD1983 datum.

Sources: Air Survey Hawaii , (ASH), EarthWatch, Inc, and Space Imaging, (see Table A for contact information)

**2.** Multispectral imagery either airborne or satellite that has 2 – 4 meter pixels and covers the entire main eight Hawaiian Islands. The imagery should have three visible bands and at least one reflected IR band. It should be ortho rectified into the same geographic space as the USGS data: UTM zones 4 and 5 with a NAD1983 datum.

Sources: EarthWatch, Inc, Space Imaging, Science and Technology International (see Table A for contact information)

**What is the likely source:**

In lieu of a large benefactor agency (such as USGS, NRCS, NOAA) paying for such a dataset as part of their mission; some kind of local group would have to be formed. A Hawai`i -wide consortium of spatial data users, perhaps a subset of those organizations represented at HIGICC. The currently existing IKONOS Consortium is perhaps the most viable forum and source.

**Estimated total investment needed to complete this theme:**

**High-resolution natural color dataset** approx: $400,000 to $875,000 (high end is 1 meter color map precision IKONOS for all of the main 8 islands, low end is .3 meter color aerial photography of just the more densely populated areas of the State)
**Multispectral dataset** approx: $875,000 to $1.4 million for (low end is 4 meter IKONOS and high end is 2 meter airborne multispectral) Quickbird 2.2 meter multispectral is on the low side of the middle.

**Estimated current allocation of funding:**

$367,000 total has been already purchased, ordered, or has been expressed as intent to purchase in the IKONOS Consortium.

**Estimated budget shortfall:**

$1.38 million to complete the IKONOS Consortium coverage, undetermined if other sources are selected with possible more limited coverage areas, etc.

**Possible ways to overcome this gap:**

The current IKONOS Consortium could be considered at least a 70 to 80% solution to the gap, should enough agencies and departments buy into this process. That effort allows for 1 meter color imagery of the state (by tiles for the main 8 islands) and 4 meter 4-band multispectral imagery for the same area, same configuration. Perhaps the optimal solution would be 1. Some kind of statewide .3-meter resolution color air photo or of .62-meter color Quickbird could be bid for the high-resolution dataset; and 2. An airborne 2-meter multispectral or 2 meter Quickbird multispectral dataset to satisfy the need for spectral information.

**Most appropriate data steward:**

Perhaps the Hawai`i Natural Heritage Program, should the IKONOS Consortium, which they manage prove successful. HIGICC, MHPCC, PDC, USGS, NOAA, or DBEDT are other possibilities, based on willingness/ability to serve.

**Maintenance Process:**

Update imagery of the same type and resolution every 2-4 years especially in high growth areas. Update the spectral dataset as needed based on application or damage/change to vegetation.

**Estimated Maintenance cost:**

Approximately $50 per square kilometer; updated as needed. Obviously, some set up savings in waiting to do large areas simultaneously.

# CHAPTER 4: HYDROGRAPHY

Coordinator: Patricia Shade
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**Theme Description:**

A hydrography dataset refers to several data layers that map hydrologic features and locations of hydrologic data sampling sites, as well as linked attribute databases. Through various federal and state programs there is a growing need to study the environment by way of a holistic approach. To this end, the proposed Hawai`i hydrography dataset will integrate surface-water, ground-water and water-quality spatial and attribute data in a watershed framework.

The National Hydrography Dataset (NHD) provides the framework for the surface-water part of the hydrography dataset. The NHD combines digital spatial data for surface water features such as rivers, streams, ponds and springs with river-reach information that allows analysis and display of water-related data in a stream segment order, from headwaters to watershed outlet. This NHD framework supports the linkage of additional databases maintained by various government agencies in Hawai`i.

In addition to surface-water features, there are several other hydrologic data layers that address ground-water features such as ground-water development wells, ground-water monitoring sites, and aquifer system boundaries.

The third aspect of the integrated hydrography dataset addresses both surface- and ground-water quality through the mapping of data collection sites and establishing links with water-quality databases.

A final aspect of the hydrography dataset will support the study of crosscutting issues of a regulatory nature such as zoning and habitat protection, through the delineation of wetlands. The Hawai`i integrated hydrography dataset will support federal, state and county government programs.

**Status:**

**Table B**

| Theme | Source | Standards | Status |
|---|---|---|---|
| Hydrologic Unit Boundari (watershed 5th level and subwatershed 6th level) | USDA Natural Resources Conservation Service | National Map Accuracy Standards for 1:24,000 scale maps | Complete |
| National Hydrography Dataset | U.S. Geological Survey | National Map Accuracy Standards for 1:24,000 scale maps | Complete |

| | | | |
|---|---|---|---|
| Wells | State of Hawai`i Commission on Water Resource Management (CWRM) | Locations by GPS and/or generated from latitude and longitude from 1:24,000 scale maps | Complete, continuously updated by CWRM |
| Aquifer system boundaries – administrative | State of Hawai`i Commission on Water Resource Management | digitized from maps of various scales exceeding 1:24,000 | Complete |
| Aquifer system boundaries – water resource protection | State of Hawai`i Department of Health | National Map Accuracy Standards for 1:24,000 scale maps | Complete |
| Drainage basin areas for stream gauging stations | U.S. Geological Survey | National Map Accuracy Standards for 1:24,000 scale maps | Complete for Kauai, unknown for remainder of State |
| Wetland delineation | National Wetlands Inventory U.S. Fish and Wildlife | National Map Accuracy Standards for 1:24,000 scale maps | Complete |
| Attribute databases: | | | |
| Surface-water diversion database: Point layer of withdrawal locations and database of withdrawal volumes | State of Hawai`i Commission on Water Resource Management | Database to be linked to watershed and National Hydrography Dataset themes | Withdrawal volumes, approximately 20% verified Database linkage 0% complete |
| Aquatic survey database Survey locations by stream segment Database of biologic information and habitat conditions | State of Hawai`i Department of Land and Natural Resources, Aquatic Resources Division | Database to be linked to watershed and National Hydrography Dataset themes | Database linkage 0% complete |
| Stream discharge measurements | U.S. Geological Survey http://waterdata.usgs.gov/HI/nwis | Stream discharge data to be linked to watershed and National Hydrography Dataset themes | Database linkage 0% complete |
| Drinking water quality database | State of Hawai`i Department of Health and City and County of Honolulu Board of Water Supply | Database to be linked to watershed and wells themes | Database linkage 0% complete |
| Stream water quality data | U.S. Geological Survey http://waterdata.usgs.gov/HI/nwis | Stream water quality data to be linked to watershed and National Hydrography Dataset themes | Database linkage 0% complete |
| Ground-water quality data | U.S. Geological Survey http://waterdata.usgs.gov/HI/nwis City and County of Honolulu Board of Water Supply | Ground-water quality data to be linked to watershed and wells themes | Database linkage 0% complete |

| | | | |
|---|---|---|---|
| | Maui County Department of Water Supply<br>Hawai`i County Department of Water Supply<br>Kauai County Department of Water Supply | | |
| Ground-water quality data | EPA STORET http://www.epa.gov/STORET/dbtop.htm/ | Ground-water quality data to be linked to watershed and wells themes | Database linkage 0% complete |

**Data Source:**

There are multiple sources for the proposed Hawai`i integrated hydrography dataset as listed by theme in above. Most datasets are publicly available except where noted below.

| Theme | Source | Contact | Remarks |
|---|---|---|---|
| Hydrologic Unit Boundaries | USDA Natural Resources Conservation Service | Patricia Shade<br>(808) 541-2600 x120 | In review for publication approval |
| National Hydrography Dataset (NHD) | U.S. Geological Survey | http://nhd.usgs.gov/index.html | |
| Wells | State of Hawai`i Commission on Water Resource Management (CWRM) | (808) 587-0265 | For homeland security, data not available on-line |
| Aquifer system boundaries-administrative | State of Hawai`i Commission on Water Resource Management (CWRM) | http://www.state.hi.us/dbedt/gis/dlnraq.htm | |
| Aquifer system boundaries | State of Hawai`i Department of Health | (808) 586-4258 | |
| Drainage areas for stream-gaging stations | U.S. Geological Survey | (808) 587-2400 | |
| Wetland delineations | U.S. Fish and Wildlife, National Wetlands Inventory | http://www.state.hi.us/dbedt/gis/wetlnds.htm | |
| | | | |
| Surface-water diversion database: Point layer of withdrawal locations and database of withdrawal volumes | State of Hawai`i Commission on Water Resource Management | (808) 587-0265 | |
| Aquatic survey | State of Hawai`i Department of Land | (808) 587-0100 | |

| | | | |
|---|---|---|---|
| database Survey locations by stream segment Database of biologic information and habitat conditions | and Natural Resources, Aquatic Resources Division | | |
| Stream discharge measurements | U.S. Geological Survey http://waterdata.usgs.gov/HI/nwis | (808) 587-2400 | |
| Drinking water quality database | State of Hawai`i Department of Health and<br>City and County of Honolulu Board of Water Supply<br>Maui County Department of Water Supply<br>Hawai`i County Department of Water Supply<br>Kauai County Department of Water Supply | (808) 586-4258<br>(808) 527-6124<br>(808) 270-7550<br>(808) 961-8670<br>(808) 245-5446 | |
| Stream water quality data | U.S. Geological Survey | (808) 587-2400 | |
| Ground-water quality data | U.S. Geological Survey<br>City and County of Honolulu Board of Water Supply<br>Maui County Department of Water Supply<br>Hawai`i County Department of Water Supply<br>Kauai County Department of Water Supply<br>EPA STORET | (808) 587-2400<br>(808) 527-6124<br>(808) 270-7550<br>(808) 961-8670<br>(808) 245-5446<br>http://www.epa.gov/STORET/dbtop.htm/ | |

**Standards:**

The key base data layers were developed following National Map Accuracy Standards for 1:24,000 scale maps (http://mapping.usgs.gov/standards/).

The two standards for the National Hydrography Dataset will be applicable to the Hydrography theme. These standards are described in "USGS Technical Instructions for the National Hydrography Dataset-High Resolution,", November 1997, and the "USGS National Mapping Program Technical Instructions: Standards for National Hydrography Dataset" July 1999.

Stream naming conventions will follow those reported in Geographical Names Information System (GNIS) (http://geonames.usgs.gov/).

Hydrologic unit naming conventions will follow those outlined in the Federal Geographic Data Committee (FGDC) proposal, version 1.0, March 1, 2002 Federal Standards for Delineation of Hydrologic Unit Boundaries (http://www.fgdc.gov/standards/status/huc.html).

**Priority:**

The first task is to create a current and representative dataset by validating the attribute coding of stream and ditch segments in the National Hydrography Dataset (http://nhd.usgs.gov/index.html). As remnants of plantation agriculture, many ditches are in a state of disrepair and/or abandoned. Thus, an attribute code to reflect ditch condition should be added.

The second task is to continue updating/validating the National Wetland Inventory layer. Because wetland determinations require the skills of soil scientists, biologists and hydrologists, this is a major undertaking that will require cooperation between the United States Fish and Wildlife Service (USFWS) and the Natural Resources Conservation Service (NRCS) to guide the project. Currently, (FY03), the USFWS is updating the wetlands mapping on the island of Oahu. This effort required site visits by a coordinated team of scientists from USFWS, NRCS and several State agencies. Recently there have been new wetland determinations on military lands that may be incorporated into the updated wetland layer. The availability of these military area determinations is not known at this time, but they would substantially lessen the workload.

The third task is to determine the methodology for linking all the attribute databases to the hydrography theme. The Commission on Water Resource Management is currently developing methods to link the aquatic survey and streamflow diversion databases to a watershed theme. Much of the water-quality data maintained by USGS as well as the Environmental Protection Agency‘s Storage and Retrieval database (STORET - http://www.epa.gov/storet/) data are available on-line. The State of Hawai`i Department of Health (DOH) and the counties’ Department of Water Supply also maintain water-quality data. It is likely that a contract through the private sector will have to be implemented to compile these water-quality data from the various agencies, and to download data that are available on-line, and then link these data to the hydrography theme.

**Estimated total investment in this theme:**

TBD

**Estimated current state and local contributions:**

TBD

**What is needed:**

There are three major tasks to complete the integrated hydrography dataset.
1) Validate and code additional attributes for stream and ditch segments
2) Update the National Wetland Inventory mapping for the islands of Niihau, Kauai, Molokai, Maui, Kahoolawe, Lanai and Hawai`i
3) Link water-quality data to well and stream segments and to watershed attributes

Task 1 can be contracted through the private sector, to be accomplished in the first year. The activities would include:
- reviewing all line segments in the NHD dataset for attribute accuracy regarding ditch or stream coding and editing as necessary and
- researching the current condition and use of all ditch segments and coding attributes.

Task 2 will require heads-up digitizing from image analysis and on-site visits to delineate wetland areas. The timeline estimated to accomplish these tasks for Niihau, Kauai, Molokai, Lanai, Kahoolawe, Maui and Hawai`i is 3 years.

Task 3 can be contracted through the private sector, to be accomplished in the first year. The activities include:
- compiling water-quality data from various State and County agencies,
- downloading water-quality data from various on-line sites and
- developing a method to link these data to the hydrography dataset.

**What is the likely source:**

The Hawai`i Water Resources Division of USGS could accomplish task 1 as part of their water resources data collection program that is cooperatively funded by the State of Hawai`i Commission on Water Resource Management.

The FWS and NRCS Hawaii cooperatively fund the work to accomplish task 2. FWS would provide all digitizing map services, and NRCS Hawaii can provide color infrared ortho-rectified quarter quadrangle imagery. NRCS also can provide scanning, ortho-rectifying, and mosaics of older photography where current, digital imagery are not available. Scientists from both agencies can collaborate during site visits.

The work to accomplish task 3 could be contracted through the private sector funded by the agencies currently maintaining these data including the State of Hawai`i Department of Health, the U.S. Geological Survey and the County Departments of Water Supply.

**Total investments needed to complete this theme:**
The estimated total investment to complete this theme is $467,500**.**

**Estimated current allocation of funding:**
The State Commission on Water Resource Management is currently working on linking the aquatic survey and streamflow diversion databases to attributes in a watershed theme. This contribution can be estimated at $100,000 of in-kind services. U.S. Fish and

Wildlife is updating the National Wetland Inventory dataset for the island of Oahu in FY03. FWS is funding this work at a cost of approximately $37,500.

**Estimated budget shortfall:**

$330,000
Task 1 can be completed for a cost of $10,000.
Task 2 can be completed for a cost of $245,000
Task 3 can be completed for a cost of $75,000

**Possible ways to overcome this gap:**

For task 1 it is possible that in FY04 the USGS Hawai`i and the State of Hawai`i Commission on Water Resource Management could cooperatively fund the effort as part of their water-resource data collection program.

For task 2, the FWS currently has funding mechanisms in place for wetland mapping. By NRCS cooperatively supplying digital imagery, scanning and ortho-rectification services, and on-site scientific collaboration, the FWS Hawai`i wetland mapping project can more successfully compete for internal FWS funds. By competing for funding each year to update 1 county at a time, it is estimated completion costs are:

Kauai County - $32,500
Maui County - $65,000
Hawai`i County - $147,500

It is estimated that $75,000 will be needed to fund the linking and continuous update of linked attribute databases in the first year by a private contractor. After the methodology is established, it is assumed that agencies providing the attribute data would, as part of their data collection programs, include the continuous updating of the integrated hydrography theme. Perhaps the Hawai`i Geographic Information Coordinating Council (HIGICC) can write a grant proposal to raise these funds.

**Most appropriate data steward:**

The State of Hawai`i Commission on Water Resource Management

**Maintenance Process:**

The maintenance costs and update frequencies have not been determined. However, once the process of linking updated attribute data has been programmed, the effort by each data steward would be minimal to maintain the hydrography dataset.

**Estimated Maintenance Costs:**

TBD

# CHAPTER 5: TRANSPORTATION


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**Theme Description:**

Transportation, within the context of spatial data infrastructure, pertains to facilities and assets involved with moving people and goods from one location to another via land, water or air. These facilities include airports, harbors and roads.

The initial focus of most transportation framework data projects has been on the creation of comprehensive road network datasets, beginning with accurate street centerline base maps. With respect to the extent of the State's road network, in 2002, public agencies throughout Hawai`i reported a total of over 4,200 miles of roads open to the public as defined under Title 23 Code of Federal Regulations (CFR) Part 460. The bulk of these public roads included approximately 3,200 miles under County jurisdiction and roughly 900 miles under State jurisdiction. There are also hundreds of miles of roads throughout Hawai`i under private or military jurisdiction, including unpaved/unimproved roads.

**Status:**

There are a number of datasets for all major transportation facilities with varying degrees of completeness and accuracy. Many of the datasets, which contain very accurate facility or asset specific information, are not publicly available. Therefore, different agencies use different datasets between agencies and even within agencies. For example, the Army Corps of Engineers, U.S. Navy and various state agencies maintain separate datasets for harbors and navigable waterways in Hawai`i. The same is true for air travel, where agencies such as the U.S. Air Force and State Department of Transportation, Airports Division maintain separate datasets.

Street centerlines: The State of Hawai`i does not have official current street centerline base maps. With easily more than 10 known datasets, there is often not a consistent use of road networks even within one agency. References include:

| | |
|---|---|
| Tiger | http://www.state.hi.us/dbedt/gis/tgrmjrds.htm |
| | http://www.state.hi.us/dbedt/gis/tgrothrds.htm |
| USGS | http://www.state.hi.us/dbedt/gis/majroads.htm |
| | http://www.state.hi.us/dbedt/gis/othroads.htm |
| City & County Honolulu | ftp://gisftp.hicentral.com/LayrZips/streets.zip |
| | ftp://gisftp.hicentral.com/LayrZips/majroads.zip |
| GDT Dynamap | http://www.bts.gov/gis/download_sites/gdt/maindownload.html |

| | |
|---|---|
| BTS National Highway Planning Network | http://www.bts.gov/gis/download_sites/ntad02/newusdownloadform.html |
| Hawai`i DOT | State Federal-Aid Highway Network |
| | County Federal-Aid Highway Network |

Before 1991, when the Highways Division disbanded its Mapping Section, the State Department of Transportation (DOT) in partnership with the United States Geological Survey (USGS) maintained statewide base maps of the entire road network in Hawai`i. No comprehensive or coordinated effort has taken place since that time. Only two counties, Hawai`i and the City and County of Honolulu, have made concerted efforts in updating and correcting their respective road network base maps. Of these two counties, currently only the City and County of Honolulu makes its data available for public use and incorporates a regular workflow for updating the road network. The road network Hawai`i County developed under its 911 project is generally accessible only to those that provide emergency services such as the police and has not been regularly updated.

Of the 4,200 miles of public roads, roughly 600 miles under County jurisdiction and 900 miles under State jurisdiction or roughly 1,500 miles statewide are classified as Federal-Aid highways (as defined under 23 CFR Part 470) http://www.fhwa.dot.gov/hep/23cfr470.htm and are eligible to receive Federal Highway Trust Fund monies. The State Department of Transportation, as the pass-thru agency for these federal funds, is required to maintain an updated dataset and base maps of these facilities under the Highway Performance Monitoring System (HPMS). The State's HPMS is part of the national highway transportation system database, which incorporates a nationwide inventory of highway systems.

Maintaining a valid HPMS dataset is considered to be an item of *national significance*, and is considered fundamental for each state in meeting the requirements established under 23 Code of Federal Regulation (CFR), Part 1.5. Its purpose is to provide data that reflects the extent, condition, performance, use and operating characteristics of the nation's highways. The Federal Highway Administration (FHWA) requires annual HPMS updates from all State highway agencies, and this data is in turn utilized to help determine each states fair share annual apportionment of Highway Trust Fund monies.

The FHWA, realizing that much of the HPMS dataset and base maps have not been accurately updated since the early 90s, has approved funding a Digital Videolog project that will provide panoramic (driver's perspective) digital imagery at 10.56'/.002 mi intervals, street centerline files accurate to within three meters, and the respective datasets of the inventory and condition of the associated infrastructure assets. The DOT has awarded the contract to Mandli Communications, Inc. and is anticipating most of the work to be completed by January 2004.

**Data Sources:**

There are a large number of both public and private sources for transportation data, some of which have already been mentioned. The most comprehensive publicly available general transportation framework datasets are maintained by the Bureau of Transportation Statistics (www.bts.gov/gis/), the USGS, and Census TIGER.

Street centerlines: While comprehensive and popular, the accuracy of such datasets available from the USGS and TIGER are generally not reliable to within 15 meters. The same holds true for the popular, privately developed Geographic Data Technology (GDT) Dynamap street centerline dataset (www.geographic.com). The accuracy parameters of the County of Hawai`i and City and County of Honolulu street centerlines are unknown at this time.

**Standards:**

The FGDC is developing framework standards based on those previously established by the USGS and Army Corps of Engineers. The standard is found on the FGDC's Ground Transportation Subcommittee web site at http://www.bts.gov/gis/fgdc/.

Previously, the Army Corps and USGS suggested transportation base map scales of 1:24,000, which was basically mostly suitable for master planning. The National Research Council, however, suggested parcel base maps to have larger scales of up to 1:600, which were suitable for something like tax assessments. However, because of Governmental Accounting Standards Board Statement 34 (GASB 34) or more formally, Governmental Accounting and Financial Reporting Standards: Statement 34, (http://accounting.rutgers.edu/raw/gasb/st/summary/gstsm34.html) government agencies are now required to provide a financial accounting of all their assets. This means that not only do they have to account for all their roads and bridges, but also all the ancillary assets along these facilities. Moreover, they need to provide a suitable condition assessment of these assets to generate a valuation. For examples, the locations and conditions of the signs along the facilities or the location and condition of guardrails, streetlights, etc. To accomplish this, the base maps will need to have larger scales similar to the parcel maps; these are the types of revisions that the FGDC committee is working on.

**Priority:**

Developing complete and current street centerline base maps for all public roads statewide with accuracy within five meters should be the top priority for this framework dataset.

**Estimated total investment in this theme:**

Total investments in transportation framework data are unknown. The DOT's three line Divisions (Airports, Harbors, and Highways) have probably invested over $ 3 million in the development of both the data and GIS programs.

Street Centerlines: The County of Hawai`i and the City and County of Honolulu have invested more than $1 million. DOT Highways has invested roughly $1 million dollars into its GIS and data.

**Estimated current state and local contributions:**

DOT Highways will be spending $700,000 this year to complete the Digital Videolog project that will result in updated highways base maps. Local interest is high in the video log project, but current investments are unknown.

**What is needed:**

Street centerlines, accurate to within 5 meters are needed for the remaining 2,700 miles of public roads as well as those restricted access roads owned by the military or any public agency.

**What is the likely source:**

Some Federal Funds may be available, particularly for the military under Homeland Security, however the County agencies fuel tax revenues are probably the most likely source to fund the balance of this project.

**Estimated total investment needed to complete this theme:**

If other agencies would piggyback on the DOT's digital videolog project, most of these 2,700 miles of roads can be completed within $200,000 as all mobilization and much of the equipment costs have already been covered. The basic data capturing activities can be completed within a budget of $100,000.

**Estimated current allocation of funding**

$700,000

**Estimated budget shortfall:**

$300,000

**Possible ways to overcome this gap:**

County participation with the DOT's videolog project.

**Most appropriate data steward:**

The various public agencies (i.e. counties) responsible for the maintenance of these facilities would be the most appropriate data steward.

**Maintenance Process:**

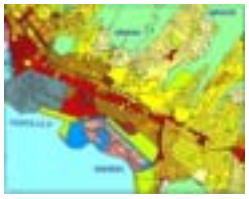
The digital videolog cycle for Federal-Aid Highways should be completed at most every other year. Other public roads can go on a 4-year or more cycle.

**Estimated Maintenance cost:**

For Federal-Aid Highways: $400,000 every two years

For other public roads: $400,000 every four years

# CHAPTER 6: CADASTRAL



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**Theme Description:**

All federal, state and local government agencies as well as local businesses and the public use cadastral information for a wide variety of programs and purposes. The definition of 'cadastral' is "A record of interests in land, encompassing both the nature and extent of interests. Generally, this means maps and other descriptions of land parcels as well as the identification of who owns certain legal rights to the land (such as ownership, liens, easements, mortgages, and other legal interests). Cadastre information often includes other descriptive information about land parcels".[8] The parcel layer is probably the most frequently used cadastral dataset in the State of Hawai`i. It is often the foundation on which other layers, such as street centerlines, easements, zoning and other government units, are built.

**Status:**

Each county in the state (Hawai`i, Maui, Kauai and the City and County of Honolulu) maintains cadastral information within their jurisdiction. Most counties plan on storing property boundaries in a Geographic Information System (GIS) for display, query and analyses, but only the City and County of Honolulu (CCH) currently update property boundaries as parcels are subdivided or consolidated. Maui and Hawai`i counties are working towards that end, and Kauai has plans to maintain parcels in a Computer Aided Design (CAD) system in the future. Maui, Hawai`i and Kauai counties currently license their parcel layer at least annually from Geographic Decision Systems International (GDSI, www.gdsihawaii.com). All counties continue to maintain hand drafted property tax plat maps and they all scan their hand-drafted maps after they are updated. As their GIS programs mature, it is expected that they will transition fully to the digital maintenance of parcels using a GIS or CAD system, or both.

All counties also use a relational database management systems (RDBMS) to collect, store and analyze real property assessment data. This data can be linked to the GIS for spatial analysis. CCH's GIS routinely copies relevant tabular information from the Real Property Assessment database such as landowners and assessed values.

[8] Huxhold, William E, (1991). Introduction to Urban Geographic Information Systems. Oxford Press.

CCH maintains a multi-purpose cadastral layer in their GIS. This layer is composed of lines and polygons, which represent units of land ownership, or tax parcels, and other coincidental features associated with property boundaries such as parks, easements and zoning. CCH links their parcels layer to both the tax assessment database known as CAMA (Computer Aided Mass Appraisal), located in the Real Property Assessment Division of the Department of Budget and Fiscal Services (BFS), and to the permit database POSSE (Public One Stop Service) in the Department of Permitting and Planning (DPP). These linkages greatly expand CCH's ability to spatially analyze data.

Two "views" of the parcel data have been developed to support both the permitting function in DPP and also the tax appraisal function in BFS. A view can contain a particular set of spatial layers or "themes" that may be distinguished symbolically according to the requirements of a department. The view used mainly by DPP for regulatory purposes is known as the Legal Parcel view. This view shows the outlines of subdivisions that have been approved by DPP. The view used by BFS (and most others) is called the Tax Parcel view. Some of the subdivisions in the Tax view may not be recognized by DPP because they do not conform to the departments zoning ordinances. [9]

Subdivisions or consolidations are the basis for changing the boundary lines. On a regular basis property owners submit subdivisions or consolidation for approval, and are reviewed by several departments prior to posting into the database. As of 2003, most parcels on Oahu are either in the Tax Parcel or Legal Parcel Layer. Some 'floating' parcels may not be included at this time. These are usually associated with concession stands or parking lots that are taxed.[10]

CCH is currently involved in a contract to re-engineer maintenance and workflow procedures. This effort will improve the overall parcel maintenance system and automate the production of the tax plat maps. It will also enable more timely distribution of the data after updates occur.

For the Hawai`i, Maui and Kauai Counties' parcels, the layer is updated annually by GDSI based on the scans of the hand-drafted maps. The hand-drafted maps are kept up-to-date and scanned regularly.

**Data Sources*:***

**The City and County of Honolulu:**

[9] As part of their *re-modernization* contract, CCH's cadastral data structure will undergo substantial changes in the near future as migration to ESRI's geodatabase takes place. For example, *Legal* parcels may change to *regulatory* parcels.

[10] The new geodatabase design will incorporate these and other new features that will support the creation of a plat map using the GIS.

The Honolulu parcel layer was originally digitized from hand drafted linen maps located in DPP (formerly Department of Land Utilization). With the exception of remote interior areas, most maps were at a scale of 1 in = 100 feet in the urban areas and 1 in = 200 feet in the rural areas. Parcels were digitized relative to a tic grid control system, derived from a grid matrix aligned with the Hawai`i survey monument control points. An 8-digit Tax Map Key (TMK) was then assigned based on the tax maps located at BFS (formerly Dept of Finance, Tax Maps Section).[11]

Some rural interior areas were not included on the linen base maps or the original tax plat maps. These property boundaries had to be derived from the best available sources, such as the Forest Reserve maps (scale 1:24000) from the State Survey Office, hypsography and aerial ortho photos. The interpreted lines were drafted onto a plotted base map (1:1000) containing the tic grid control point reference system and digitized.

For large subdivisions, digital submission of subdivisions in CAD format registered to a standard projection is sometimes merged into the database. Otherwise, Coordinate Geometry program (COGO) coordinates are taken off subdivision maps and manually entered into the GIS when no registered CAD files are available (usually for smaller subdivisions).

**Hawai`i County, Maui County, and Kauai County**

Hawai`i, Maui and Kauai counties all utilize GDSI's parcel data layer. This layer was developed by GDSI, and was based on the 22 x 36 inch plat maps maintained for tax assessment purposes by each county. Plat map sheets range in scale from 1 inch = 40 feet to 1 inch = 5000 feet. GDSI digitized parcel boundaries from these plat maps, added a 9-digit TMK number[12] to each parcel, registered each digitized plat map in geographic coordinates, and merged them together into a single island wide data layer of parcel boundaries. This information is updated on an annual basis.

**Standards:**

Standards in use by CCH are contained in several documents. Two documents often used are: "Standards/Quality Control Procedures for Subdivision Updates" and "Region Rules for Parcel Editing".

**Priority:**

A seamless and accurate parcel layer for the entire State of Hawai`i. This would ensure the data is easily accessible to those who need it most, especially agencies and individuals responsible for civil defense and homeland security.

[11] The 8 digits correspond to a zone (1digit), section (1 digit), plat (3 digits) and parcel (3 digits).

[12] The TMK number for all counties except Honolulu is 9 digits. The digits correspond to an island, or divison, number (1 digit), zone (1 digit), section (1 digit), plat (3 digits) and parcel (3 digits).

Each county should strive to build a system to store, update and analyze a digital layer of parcels and associated data. In the long run, a return on investment will be realized by providing improved workflows and faster update methods. This would alleviate excessive time lag between property boundary/ownership changes and when these changes are reflected on the digital map.

**Estimated total investment in this theme:**

$500,000

**Estimated current state and local contributions:**

ESTIMATE $400K currently allocated.

**What is needed**:

Easement lines and building footprints, which are part of the cadastral fabric, are needed for Hawai`i, Maui and Kauai Counties. CCH has a contract currently to add to its existing building footprint layer (see Chapter 9 - Structures). Easements will be added and maintained in CCH's cadastral layer.

Parcels need to be kept up to date using a GIS or CAD system in all counties. Funding opportunities need to be sought for those counties where no funding exists for GIS.

**What is the likely source:**

The counties.

**Total investments needed to complete this theme:**

$1 million (estimate)

**Estimated budget shortfall:**

Over $600,000

**Possible ways to overcome this gap:**

Raise Property Taxes and allot % of Property taxes to support GIS cadastre projects. Obtain with Federal Government funding to support National Map and Homeland Security issues.

**Most appropriate data steward:**

City and County of Honolulu: DPP coordinates with Real Property Assessment in BFS to maintain accurate/timely cadastral information.
Hawai`i County: Planning Department
Maui County: Real Property Tax Division of the Finance Department
Kauai County: Not known at this time

**Maintenance Process:**

City and County of Honolulu: On average, parcels are entered within one month of DPP's approval. However, the TMK may not officially be assigned to the parcel by BFS until the subdivision has been recorded with the State Bureau of Conveyance. During this period of time the features of the newly subdivided parcels are placed into a separate layer (Legal). Once BFS has received the recorded subdivision from the State Bureau of Conveyance (if ever), new TMKs are assigned and these are incorporated into the tax parcel fabric. This generally occurs within one to six months after approval of the subdivision by the DPP.

Hawai`i County: annual refresh of the parcel layer by GDSI. Hand drafted maps kept up to date and scanned.

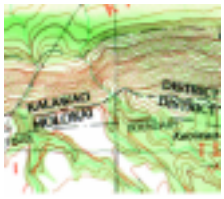
Maui County: annual refresh of the parcel layer by GDSI. Hand drafted maps kept up to date and scanned.

Kauai County: annual refresh of the parcel layer by GDSI. Hand drafted maps kept up to date and scanned.

**Estimated Maintenance cost:**

City and County of Honolulu: $70,000/year
Hawai`i County: Not Known
Maui County: Not Known
Kauai County: Not Known

# CHAPTER 7: GOVERNMENTAL UNITS



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**Theme Description:**

For the purposes of this chapter, Government Units include any boundaries, jurisdictions, taxation units or administrative areas that are created and/or defined by various Federal, State and County agencies. (see Table C)

**Status:**

Several Government Unit and boundary layers already exist as digital files. Many of the boundaries were extracted from the U.S. Geological Survey 1:24,000 Digital Line Graphs. In some cases, these boundaries have been refined and updated by the responsible agency. One such case is the State Forest Reserves boundaries, which have been updated by the Department of Land and Natural Resources, Division of Forestry and Wildlife. In certain cases, these government units are or could be subsets of other existing data layers, and therefore, if not already done, could be extracted to create the desired layer. For example, Hawaiian Home Land boundaries were derived from the parcel layer.

**Table C**

| Governmental Unit/Boundary | Source(s) | Metadata | Status | Avail-ability | Where? | Remarks |
|---|---|---|---|---|---|---|
| State of Hawai`i | State | | Exists | Free | State Web Site | |
| Judicial Districts | State | Y | Exists | Free | State Web Site | |
| School Districts | State DOE | Y | Exists | Free | State Web Site | |
| State Lands | State DLNR | Y | Exists | Free | State Web Site | |
| State Land Use District Boundaries | State LUC | Y | Exists | Free | State Web Site | |
| State Forest Reserves | State DLNR | Y | Exists | Free | State Web Site | Part of Reserves Layer |
| State Parks | State DLNR | Y | Exists | Free | State Web Site | Part of Reserves Layer |
| State House Districts | State Office | Y | Exists | Free | State Web Site | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | of Elections | | | | | |
| State Senatorial Districts | State Office of Elections | Y | Exists | Free | State Web Site | |
| Congressional Districts | State Office of Elections | Y | Exists | Free | State Web Site | |
| Hawaiian Home Lands | State DHHL | Y | Exists | Free | State Web Site | |
| Special Management Areas | State CZM | Y | Exists | Free | State Web Site | |
| Hunting Areas | State DLNR | Y | Exists | Free | State Web Site | |
| Historic Land Divisions (Ahupuaa) | State DLNR | Y | Exists | Free | State Web Site | Oahu only |
| Fire Response Zones | State DLNR | Y | Exists | Free | State Web Site | |
| Enterprise Zones | State DBEDT | Y | Exists | Free | State Web Site | |
| Natural Area Reserves | State DLNR | Y | Exists | Free | State Web Site | Part of Reserves Layer |
| Marine Life Conservation Districts | State DLNR | Y | Exists | Free | State Web Site | Part of Reserves Layer |
| National Parks | DOI National Park Service | Y | Exists | Free | State Web Site | Part of Reserves Layer |
| National Wildlife Refuges | DOI FWS | Y | Exists | Free | State Web Site | Part of Reserves Layer |
| Development Plan Areas | Counties | Y | Exists | Free | State Web Site | |
| Conservation District Subzones | State DLNR | Y | Exists | Free | State Web Site | |
| ALISH | State DOA | Y | Exists | Free | State Web Site | |
| Hydrographic Units | DOI USGS | Y | Exists | Free | State Web Site | |
| Census Statistical Areas | DOC Census Bureau | Y | Exists | Free | State Web Site | |
| Fisheries Management Areas | State DLNR | Y | Exists | Free | State Web Site | |
| Watersheds | State CZM | Y | Exists | Free | State Web Site | |
| Wetlands | DOI FWS | Y | Exists | Free | State Web Site | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Parcels - Oahu | City and County of Honolulu | Y | Exists | Free | City Web Site | |
| Parcels - Maui | County of Maui | Y | Exists | Free | State Web Site | |
| Parcels - Other Islands | GDSI | Y | Exists | Licensed | GDSI | |

**Data Sources:**

Federal, State and County agencies, particularly those responsible for administering these units, would be the first and authoritative source for checking and updating each of these data layers. For example, the National Park Service is the authority on National Park boundaries, the State Department of Land and Natural Resources is the authority on State Forest Reserves, the City and County of Honolulu is the authority on the Oahu parcels, etc. It is logical that these agencies would review and as appropriate, update the datasets that are currently being distributed. There are also certain private sources, such as the GDSI Neighbor Island parcel datasets that exist and are being used as a standard product (see 0CHAPTER 0:CHAPTER 6: CADASTRAL).

**Standards:**

1:24,000 is a de-facto standard for scale. NAD 83 is another de-facto standard for datum, although many organizations are still making the transition from NAD 27/Old Hawaiian to NAD 83. UTM Zone 4 or 5 is used for 1:24000 mapping. The counties, however, tend to use State Plane.

**Priority:**

Complete a seamless parcel layer for entire state, and evaluate existing boundaries based on such a parcel layer. Government unit boundaries which are determined to be inaccurate should then be updated.

**Estimated total investment in this theme:**

$1.5 million since 1990, not including parcels.

**Estimated current state and local contributions:**

TBA

**What is needed:**

There is a need for public agencies to acquire the parcel data layers that are not already public information. Since Maui and Hawai`i Counties have recently acquired the parcel

data for their respective jurisdictions, the Kauai County parcel data layer is the only such dataset that is still proprietary. It is a goal to acquire the rights to the Kauai dataset so that all of the parcel databases are public information.

**What is the likely source:**

The likely source for the Kauai parcel layer is the GDSI parcel data, which is the de-facto standard.

**Estimated total investment need to complete this theme:**

$250,000

**Estimated current allocation of funding:**

$50,000

**Estimated budget shortfall:**

$200,000

**Possible ways to overcome this gap:**

State and Federal agencies should help the Counties acquire these datasets.

**Most appropriate data steward:**

The most appropriate data stewards are the appropriate Counties.

**Maintenance Process:**

The Counties should be responsible for maintaining the parcel layer.

**Estimated maintenance cost:**

Unknown

# CHAPTER 8: UTILITIES

Coordinators:

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**Theme Description:**

Utilities comprise a variety of different layers of infrastructure data managed primarily by local government agencies or private utility corporations. The following layers are identified as belonging in this chapter:

Water
Wastewater
Storm drains
Telecommunications (telephone, fiber optic, cable, microwave, satellite)
Electric
Gas

**Status:**

Much of the information for this chapter has not been received in time for this draft. Some information for Oahu has been acquired but nothing for the other counties.

A high percentage of both county and private utility data for Oahu is in digital form or is in the process of being converted to digital form. Updates are occurring on an ongoing basis.

**Data Sources:**

Source documents come in a variety of forms: 1) as-built drawings, 2) inspector copies, 3) work order forms 4) State half-size drawings, 5) older features drafted onto the 200 scale counter books, 6) connection permit and work order maintenance forms, 7) features drafted onto GIS-produced base maps, and 8) CAD files.

**Standards:**

For the local government utilities, priority has been placed on water and wastewater utilities with a high emphasis being placed on the updating of storm drains. Priorities for private utilities have not been received.

**Priority:**
**Estimated total investment in this theme:**

The total investment in this theme for the county utility data is estimated to be between $2 to $5 million. Investment data for private utilities has not been received.

**Estimated current state and local contributions:**

Estimated $500,000 for the county.

**What is needed:**

Require that future as-built plans be submitted in electronic format, which would be imported into the GIS for updates to the existing layers.

**What is the likely source:**

Engineering companies that have been contracted to construct the utilities would provide digital copies of design plans and as-built drawings.

**Estimated total investment needed to complete this theme:**

Estimated $1 to $2 million.

**Estimated current allocation of funding**

Estimated $500,000.

**Estimated budget shortfall:**

$1,500,000.

**Possible ways to overcome this gap:**

Undetermined at this time (04/03).

**Most appropriate data steward:**

The City and County of Honolulu and its designated agencies for local government utilities. The private utilities will maintain their respective data layers.

**Maintenance Process:**

Ongoing on a daily basis.

**Estimated Maintenance cost:**

Estimated at $250,000 per county utility layer per year.

# CHAPTER 9: STRUCTURES

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**Theme Description:**

Structures are considered to be all human-made fixed features that are planned, designed, engineered, and constructed to withstand most environmental conditions for the life of the structure. However, this definition would include all manner of transportation structures, utility structures, infrastructure, tunnels, bridges, dams, underground fuel tanks, and a host of other structures that should not be overlooked but would already be inventoried as part of other themes. The primary inventory of structures consists of buildings. In the broadest meaning of the term "buildings", nearly everything that is fixed, human-made, and protects life or property is a building. The CADD/GIS Technology Center' Spatial Data Standard provides perhaps a more concise concept in the following definition:

"Buildings are structures located on the face of the earth that were created, by man, to protect man and his possessions from the environment; or to enhance man's activities."

Maps showing the location and shape of building structures are needed to support many types of government services, including land use planning, construction permit approvals, tax assessment, utility management, homeland security, and other major programs. Building locations and outlines data are used by various agencies to assess the physical characteristics or constraints of specific site locations. Government review of site location conditions can be accomplished quickly and effectively using digital databases of these structures and their physical conditions. Thus, the integration of geographic representation of building structures, i.e. their outlines and locations, with object datasets that describe the physical characteristics of the structures, comprise what is commonly referred to as a spatial database of building footprints.

**Status:**

A central repository and complete spatial inventory of buildings for the State of Hawai`i does not exist. However, building information can be found at many levels of government, facility management offices, insurance companies, planning firms, survey firms, and architectural/engineering firms. The type of information that exist for

buildings range from as-built plans in hard copy and CADD files, GIS layers, aerial photography, imagery, permit or administrative data. The City & County of Honolulu (CCH), Department of Permitting and Planning (DPP) continually gather building information as part of the permitting process (see Chapter 6 - Cadastral). Currently, CCH is in the process of creating a GIS building footprint dataset for all of Oahu. All information pertaining to building external and internal structures as 3-Dimensional (3-D) objects are part of the Building Dataset. Once buildings are constructed, modifications do occur overtime that alter the physical structure and are, to a degree, tracked.

Based on interviews with Larry Kanda of the State Civil Defense is also compiling building information as well for the State of Hawai`i.

**Data Sources:**

**Existing Sources:**
Sanborn Map Company has historically maintained paper maps that contain building outlines (footprints), as well as general information about construction types, height, stories, and date built. Other private firms also have numerous building footprints that have been created for planning or construction projects that could be acquired.

Facility managers maintain and manage property spaces updating boundaries, floor plans, and building modifications.

Air survey companies have current and historical air photography of Hawai`i urban areas that could be used to determine building outlines.

CCH and other local planning and permitting departments acquire building plans and information as part of the permitting process. In the case of CCH, the plans and building information are in the process of being scanned, for historical documents, and in developing digital submission standards for new building permits and construction plans.

Hawai`i Department of Transportation, Airports Division is also in the process of scanning all building engineering plans. Hawai`i State Survey Office is scanning all of their stored maps that have current as well as historical value. Hawai`i Department of Land and Natural Resources (DLNR) are considering the feasibility of developing a public land trust system and would likely have facility maps or plans of property.

Many federal facilities, like 300 Ala Moana Blvd. (Prince Kuhio Federal Building) maintain digital floor plans and building information using CAD software linked to a relational database. These other sources could be available for compiling a building dataset.

**Potential Sources:**

There are many means of acquiring building location and dimensions using Light Detection and Ranging (LIDAR), radar, remote sensing, aerial photography, ground surveys, ground laser scanning, and ground photography.

Federal Emergency Management Agency (FEMA), DLNR, and Research Corporation of the University of Hawai`i (RCUH) are planning to utilize LIDAR to scan the terrestrial surface of Hawai`i. LIDAR collects both horizontal and vertical positional information on the ground from an aircraft. LIDAR utilizes an Inertial Measurement System (IMS) and Global Positioning System (GPS) to correct for acquisition errors while providing positional data.

Radar is similar to LIDAR and is also a potential data source. Point clouds are then analyzed to extract features such as buildings.

Typical aerial photography requires costly processing of aerial photographic film, image scanning, individual processing of stereo images, and rectification. Technology like Lieca's ADS40 provides remote sensing from aircraft that can provide seamless stereo swaths, in multi-spectral bands, accurately rectifying images using IMS and GPS. While this approach dramatically reduces the number of control points, this does not entirely remove the need for ground control points.

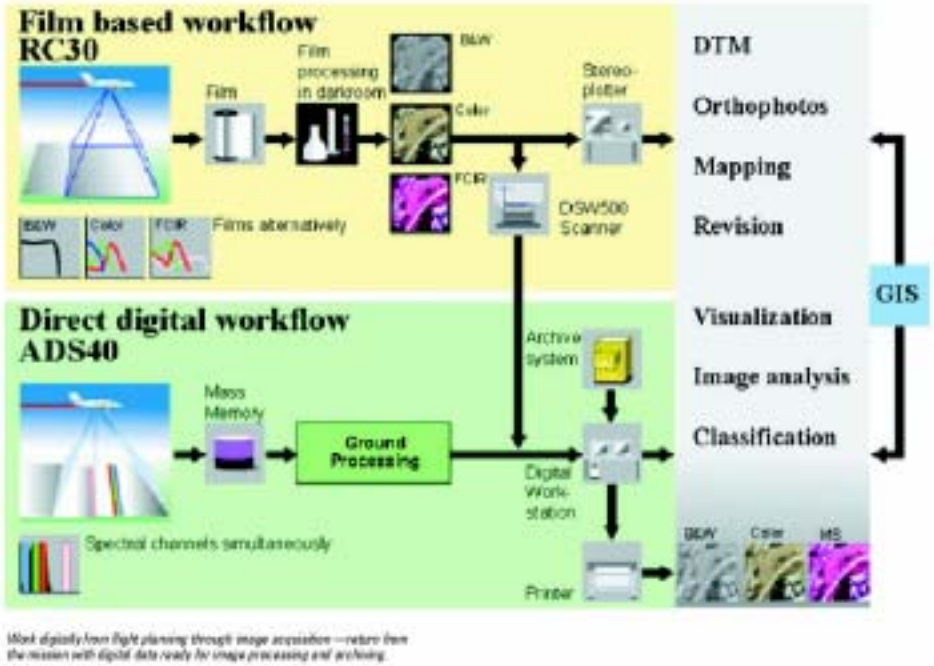


**Figure 1**

Ground photography of buildings can enhance the existing body of aerial imagery. Ground photography of infrastructure can be integrated into a 3D view and would be highly detailed compared to aerial views that have been stretch across a 3D model of a building.

GPS surveys of sites and ground controls provide highly accurate positional information. In conjunction with GPS Surveys, LIDAR technology provides site acquisition of building structures. Ground laser scanner and software is capable of providing as-built structural information and could be integrated with a LIDAR acquisition as simple x, y, and z coordinates.

**Standards:**

No standards are established

**Priority:**

The priority for information about residential, commercial and government building structures is very high. Because of the current awareness and apparent risks to buildings from many types of hazards, there is a desire to be prepared for any event, however unlikely.

**Estimated Total Investment in this theme:**

Currently, less than $50k has been spent for a building dataset compilation. This does not take into account any ongoing acquisition of building information that is part of current government business processes, planning or construction projects.

**Estimated current state and local contributions**:

$100k may be contributed to acquire current information. The existing GIS infrastructure and staff would also be contributed to maintaining the building dataset, and roughly estimated at $100k annually.

**What is Needed?**

Accurate ground control points, both vertical and horizontal, are needed to correct existing building layers. Because of the relationship of buildings to parcel boundaries the relative accuracy between these datasets needs to be very accurate. Having stated this, the parcel base needs to be rectified using accurate control points.

Existing building datasets need to be converted and updated using remote sensing or aerial photography.

Processed LIDAR and digital aerial imagery of urban areas, with 6 inch or better resolution would provide detailed information that would meet the current needs for accurate building locations.

Data would need to be complied from different agencies, planning and permitting departments and property tax assessment departments.

Business processes would need to be adjusted to maintain the building datasets.

**What is the likely source?**

With the current funding constraints, priority areas, using existing information could be acquired from local government and aerial survey companies. Homeland security could be a source of funding and would likely be requesting this type of data. Additionally, agencies like FEMA, RCUH, Civil Defense, and DLNR are interested in LIDAR acquisitions for updating of FIRM maps and maybe able to acquire the needed funding. The USGS would seem to be the best coordinator for LIDAR or high-resolution push broom scanning to ensure that a broader user base would benefit.

**Estimated total investment needed to complete this theme:**

Using the current method and piece meal approach, it may cost as much as $2 million to complete over the next 4 to 6 years.

**Estimated current allocation of funding:**

Roughly $100k has been allocated for acquisition of building information.

**Estimated budget shortfall:**

$1,900,000

**Possible ways to overcome this gap:**

Not considered.

**Most appropriate data steward:**

Local government should produce, maintain, and distribute the information.

**Maintenance Process:**

**Estimated Maintenance cost:**

$100k annually

# CHAPTER 10: PHYSICAL ENVIRONMENT AND NATURAL HAZARDS

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**Theme Description**:

The natural environment consists of four "spheres": the biosphere and the physical environment of the atmosphere, hydrosphere, and lithosphere (the earth's crust). Natural processes result in changes to the environment that occur on temporal scales ranging from hours to millions of years. In this chapter, the lithosphere is divided into the subcategories of **Geology** and **Soils**, the latter reflecting some organic as well as physical properties. Atmospheric conditions fall within the subcategory of **Weather and Climate**, which represents short-term and long-term time scales respectively. The hydrosphere is covered in the Hawai`i I-Plan chapters on Hydrography and Marine Layers.

For each of these physical environment subcategories, long-term conditions are mapped as semi-permanent base layers. Historical, empirical data is also used to map changes in the natural environment. Medium-term changes (e.g. climatic warming, sea level rise or coastal erosion) may be so gradual that they are measured as trends. Continuous observations can be divided temporally into categories based on observed natural breaks (e.g. droughts or the overlapping lava flows that comprise the twenty-year eruption of Kilauea volcano). Shorter-term conditions are often mapped as discrete events. Map layers showing the locations of monitoring stations can be useful when combined with sensor readings.

Some, but not all, changes in the natural environment are treated as hazards, which could potentially result in catastrophic events. Even a gradual change may be considered a natural hazard. Taking the example of coastal erosion, the result can be extensive long-term property loss as well as an increased risk of future catastrophic events (e.g. tsunami runup). Natural hazard mapping can be broken into two categories: delineated areas susceptible to a hazard in the either the likeliest or the worst-case scenario, and detailed maps showing the degree of sensitivity of areas to the hazard.

Risks from natural hazards may be amplified when there is a concurrence of different natural processes (e.g. tsunami coinciding with wind, high tide and rain). So for the subcategory **Natural Hazards**, this chapter does not exclude natural processes in the hydrosphere or the biosphere. For example, wildfire risk is measured by the organic fire

fuel levels, drought and wind conditions, and — especially on the Island of Hawai`i — the location of current lava flows. Natural hazards of concern to Hawai`i include: coastal erosion/sea level rise, high waves, tsunami, inland landslide, drought, stream flood, hurricane, windstorm, earthquake, volcanic hazards (emissions, ground deformation and eruptions), and wildfire.

Mapping the risks from natural hazards uses a combination of modeling and empirical, historical data. Whereas an epidemiologist studying a mosquito-born disease might be interested in total quarterly rainfall, a natural hazards planner might want data on the frequency and severity of the largest storms. Unlike other themes covered in the I-Plan, where a single authoritative source is preferred, there are advantages to having multiple analyses of a hazard risk, based on different mixes of historical data and modeling assumptions.

Physical environment and natural hazards as envisioned in the Hawai`i I-Plan is primarily a scientific rather than a policy theme. However, the intended use and even the choice of map name of some of these scientific layers may suggest policy implications (e.g. Flood Insurance Rate Maps and Tsunami Evacuation Zones). The Structures chapter of the Hawai`i I-Plan provides some additional layers of use for natural hazard preparation and mitigation planning. Other planning layers used by Natural Hazard preparedness are not covered in the Hawai`i I-Plan, such as fire response maps showing areas where each agency has primary fire responsibility. A final clarification is to note that this chapter covers natural but not manmade hazards, which are often included among "environmental hazards".

**Status:**
Status information is summarized in a table at the end of this section.

**Geology**
*Semi-permanent base*: The USGS (U.S. Geologic Survey) Hawai`i Volcano Observatory (HVO) has completed an internal GIS version of the Geologic Map of the Island of Hawai`i (http://volcanoes.usgs.gov/About/Highlights/HawaiiMap/HawaiiMap.html), which it has shared with other Federal agencies. As of May 2003, the I-map (USGS Geologic Investigative Series http://pubs.usgs.gov/products/maps/i-maps.html) has been reviewed (including metadata) and is on its way to the publication group in Menlo Park for approval. Recent geologic maps have been created for portions of Haleakala Crater on East Maui, but the paper geologic maps for the remainder of the State are dated, lack spatial accuracy, and have undocumented coordinate systems. These limitations also apply to an unregistered, scanned version of a 1988 USGS statewide geologic map that is freely distributed (http://geology.about.com/library/bl/maps/blhawaiimap.htm).

*Historic events*: HVO has produced geologic maps of lava flows on the Island of Hawai`i (http://hvo.wr.usgs.gov/kilauea/history/caldergeology_map.html, http://hvo.wr.usgs.gov/maunaloa/hazards/historicalflows.html) and Maui (http://hvo.wr.usgs.gov/volcanoes/haleakala/cratermap_large.jpg). HVO regularly

updates its map of current lava flows on the east rift zone of Kilauea Volcano (http://hvo.wr.usgs.gov/kilauea/summary/Current_map.html).

The most complete historical, empirical data on locations of earthquake hypocenters (epicenters and depths) with attributes information for date, time and magnitude might be available from the USGS National Earthquake Information Center (NEIC; http://neic.usgs.gov/neis/states/hawaii/hawaii.html) which is collocated with the NOAA/NGDC World Data Center for Seismology in Denver. The Advanced National Seismic System (ANSS) maintains an easily accessible online catalog of earthquake hypocenters going back to 1959 (http://quake.geo.berkeley.edu/cnss/catalog-search.html). Documentation on the historic 1823 to 1959 portion of the earthquake catalog (predating modern instrumentation) is given in Klein and Wright, USGS Professional Paper 1623, available at http://geopubs.wr.usgs.gov/prof-paper/pp1623.

*Monitoring locations*: On the Island of Hawai`i, HVO has mapped sites island-wide to monitor volcanic deformation using equipment that include: tilt meter, stainmeter, dry-tilt, leveling and GPS stations. For Haleakala on Maui, HVO also has a limited number of seismic and deformation sites. Finally, HVO monitors volcanic emissions from the current Kilauea eruption including sulphur dioxide emissions rates.

**Soils**

*Semi-permanent base*: NRCS has SSURGO-certified maps of all Hawaiian Islands based on soil maps published in the 1970s based on research conducted in the 1950s and 1960s. The focus of this existing soil survey mapping was on agricultural land uses and was generalized for other areas. The southern and western portions of the Island of Hawai`i are currently being re-mapped in greater detail. This new mapping effort covers the Hawai`i Volcanoes National Park, and thus reflects a shift in the purpose to include conservation uses. New soil classes have been created in the process. HAVO data may be released as early as 2003 and the Kona area possibly in 2004.

To make soils data more meaningful to end users, the NRCS National Soil Information System (NASIS; http://nasis.nrcs.usda.gov/) provides Hawai`i soil survey data on CDs that contain a polygon boundary file, a soil properties database, and a program called Soil Data Viewer (http://www.itc.nrcs.usda.gov/soildataviewer/about.htm). The program guides the user through the expert interpretation of the data to pull out layers such as crop suitability or highly erodable soils. The decision tree used in the Soil Data Viewer is a national standard that incorporates localized parameters applicable to Hawai`i.

NRCS recommends use of the more detailed (1:24,000) SSURGO soil survey maps for Hawai`i rather than the more generalized (about 1:250,000) STATSGO soil associations map layers. A STATSGO Soils Browser CD (http://www.nrcs.usda.gov/technical/techtools/stat_browser.html) is available for Hawai`i.

**Weather and Climate**

*Semi-permanent base*: Many layers exist or will soon be available that characterize of the norm and range of climatic conditions in Hawai`i.

The Office of Planning has digitized estimated daily solar radiation contours from the former Department of Planning and Economic Development, Energy Division 1985 "Sunshine Maps" for the five largest islands (http://www.state.hi.us/dbedt/gis/solrad.htm).

Related to solar radiation, NRCS has digitized adjusted pan-evaporation isolines from a 1985 report by the Department of Land and Natural Resources (DLNR) Division of Water and Land Development (DOWALD) (Report R75, Ekern, P.C. and Chang, J. 1985).

The State Office of Planning digitized the mean annual rainfall isolines (http://www.state.hi.us/dbedt/gis/rainfall.htm) from the mylar maps associated with the DOWALD Rainfall Atlas of Hawaii (Report R76, Giambelluca, T. W. et al 1986)). NRCS digitized the mean monthly rainfall isolines from the printed version of this atlas. These maps cover the six largest islands at differing scales.

The PRISM (Parameter-elevation Regressions on Independent Slopes Model) Climate Mapping Project based at Oregon State University has modeled layers using 1961-90 data for Hawai`i Average Monthly or Annual Precipitation. The NRCS National Water and Climate Center (NWCC), releases these PRISM layers as a grid with a 30 second (about 1 kilometer) cell size (http://www.wcc.nrcs.usda.gov/climate/prism.html). Due to a shortage of funding, Hawai`i is the only state where the PRISM 30" precipitation data is only available as an ASCII grid. NRCS hosts data for all other states in E00 format as well.

PRISM precipitation data as well as Hawai`i Average Monthly or Annual / Minimum, Maximum or Mean Temperature is distributed at higher resolution (15" cell size) under a licensing fee agreement from Climate Source (http://www.climatesource.com/products.html). Climate Source will soon be releasing monthly and annual Hawai`i PRISM layers for: extreme precipitation, extreme temperature, humidity, hot days (i.e. maximum temperature >= 90F), and degree days. An example of the last is: Heating Degree Day units are computed as the difference between the base temperature and the daily average temperature (calculated by Base Temp. - Daily Ave. Temp.).

*Historic data and monitoring locations*: Historical meteorological measurements taken at monitoring stations along with the locations of the stations are available from archives located at the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC; http://www.ncdc.noaa.gov/oa/ncdc.html).

The NCDC station locator website has a complete listing of all weather stations in Hawai`i (http://www.ncdc.noaa.gov/oa/climate/stationlocator.html), but only provides generalized coordinates (degrees and minutes). The State Office of Planning digitized a

1997 DLNR layer of the locations of rain gauges, which is likely to have more accurate locations but is possibly dated (http://www.state.hi.us/dbedt/gis/raingauge.htm).

Monthly summaries from a large subset of these weather stations are posted at (http://www.wrcc.dri.edu/summary/climsmhi.html). Honolulu has a NOAA National Weather Service (NWS) Forecast Office in Honolulu which also posts daily as well as recent data for a single weather station on each island (http://www.prh.noaa.gov/hnl/pages/hiclimate.html).

*Current Weather and Weather Forecasts*: The Honolulu NOAA NWS Forecast Office is one of the 122 national weather forecast offices (http://www.prh.noaa.gov/pr/hnl/). The NOAA National Weather Service has traditionally made weather satellite imagery and weather forecasts available as graphic products stripped of their geo-referencing information. Scientists at the NWS Pacific Regions Headquarters, which is also located in Honolulu, are taking a leading role in building Internet capabilities for viewing current weather forecasts, data and imagery (such as Doppler radar captured at four stations in H Hawai`i) available real-time in georeferenced spatial format (http://www.prh.noaa.gov/hq/wx_rug.ppt).

**Miscellaneous**

*Semi-permanent base*: NRCS has created a layer called Major Land Resource Areas (MLRA) for Hawai`i that is useful for smaller scale maps (http://www.nrcs.usda.gov/technical/land/mlra/mlrahi.html with legend at http://www.nrcs.usda.gov/technical/land/mlra/mlralegend.html). The MLRA is defined as a combined mapping unit that incorporates: Physiography (i.e. landforms), Geology, Climate, Weather, Soils, Biological Resources and Human Activities (Agriculture and Urban Development). The spatial revision of MLRA for Hawai`i was completed in 2001, but the definitions of the mapping units are still being fine-tuned.

**Natural Hazards**

Under sponsorship of the State Civil Defense (SCD; http://www.scd.state.hi.us), the Hawai`i Statewide Hazard Mitigation Forum (http://www.mothernature-hawaii.com/aboutus.html) was established in 1998 to raise public awareness on reducing losses due to natural hazards. Within the Forum, the Multihazard Science Advisory Committee (MSAC) brings together physical science and engineering expertise. This technical group is intended to represent access to an evolving comprehensive base of knowledge on natural hazard phenomena. Within its members, existing GIS spatial hazard layers have been inventoried and new layers created. Other entities within the Forum include: the State of Hawai`i Earthquake Board, Tsunami Board, and Hurricane Board, which allow members to discuss data issues, numerical models, and layers.

This state initiative ties in with the Federal Emergency Management Agency (FEMA) MultiHazard Mapping Initiative (MMI). Together FEMA and NOAA have just launched a national web site for hazards (http://www.hazardmaps.gov/atlas.php).

Although not a source of digital, spatial data, a general reference is the Atlas of Natural Hazards in the Hawaiian Coastal Zone which was produced for USGS (http://geopubs.wr.usgs.gov/i-map/i2761/). Details on the many subcategories of the natural hazard layers are provided below.

***Coastal erosion/Sea Level Rise***

Detailed maps of long-term historic beach erosion have been created for portions of western and central Maui by the UH SOEST Coastal Geology Group (http://www.soest.hawaii.edu/coasts/cgg_main.html).

Headland landslides/rockslides involve some different modeling considerations.

The mapping of coastal erosion presumes the accurate location of the current coastline, which is a high priority project covered in the marine layers chapter. To avoid double counting, costs for continued mapping of coastal erosion are listed there.

***Tsunami***

A point layer of recorded tsunami wave heights from five tsunami events has been created by State Office of Planning (http://www.state.hi.us/dbedt/gis/tsunhts.htm) based on Loomis H.G. (1976).

The State Civil Defense (SCD) sponsored Tsunami Technical Review Committee (TTRC) meets twice a year to review tsunami hazard mapping, warning, preparedness, response and recovery issues. SCD participates in the NOAA National Tsunami Hazard Mitigation Program (NTHMP) which has a national strategy to reduce tsunami risks to coastal residents. NTHMP is composed of 5 western coastal states (Alaska, California, Hawai`i, Oregon, Washington) and 3 federal agencies (NOAA, USGS, FEMA). NTHMP in turn has a Tsunami Inundation Mapping Effort (TIME; http://www.pmel.noaa.gov/tsunami/time) housed at the NOAA Pacific Marine Environmental Laboratory (PMEL; http://www.pmel.noaa.gov/tsunami).

NTHMP began funding tsunami inundation mapping in Hawai`i in 1999, and the recent status is shown at http://www.pmel.noaa.gov/tsunami/time/hi/population/index.shtml. The mapping status is summarized into three initiatives: pre-NTHMP, NTHMP and DOD/NASA (collaborative mapping by the Department of Defense and the National Aeronautics and Space Administration).

The pre-NTHMP mapping presumably refers to the tsunami evacuation zone maps that are available from the State Office of Planning (http://www.state.hi.us/dbedt/gis/tsunevac.htm) that were produced by the Pacific Disaster Center (PDC; http://www.pdc.org/iweb/) in 1998 based on earlier maps created by the UH Joint Institute for Marine and Atmospheric Research (JIMAR; http://ilikai.soest.hawaii.edu/JIMAR/).

The NTHMP maps are created from worst-case modeling that looks at seismic events, which can occur inside or outside of the Hawaiian archipelago, bathymetry, and storm

wind and rain conditions. One set of numerical models developed by PMEL and UH (http://www.pmel.noaa.gov/tsunami/research.html) are considered to be best suited for external seismic events, whereas other models developed by the UH and Ocean Engineering (http://www.soest.hawaii.edu/tsunami) may be more useful for localized earthquakes. As better bathymetric data becomes available, PDC will be able to refine existing tsunami inundation maps using these models.

Tied into the PMEL hazards assessment is a warning system of which the NOAA Pacific Tsunami Warning Center (http://www.prh.noaa.gov/pr/ptwc) is the local node.

***Inland Erosion/Landslide/Rockslide***

While many of the data components are available for estimating which areas have highest risk for inland erosion, no known models have been created. NRCS expert interpretation of soils properties (programmed into the SSURGO Soil Data Viewer discussed earlier) for highly erodable soils can be used as a first cut at landslides. For rockslides, the geologic properties together with slope might be important parameters to model. Slides can be triggered by heavy rain, flooding or seismic events. Slides can be triggered by heavy rain, flooding or seismic events. Hawai`i State DOT has released a rockfall study of Oahu highways. The USGS Water Resources Group has issued reports with mapping of historic debris flows and hazard areas, but not comprehensively.

***Wildfire/Drought***

Historic wildfire boundary layers have been produced by several agencies including the National Park Service (NPS) and the U.S. Fish and Wildlife Service (FWS).

In Hawai`i, wildfire risk modeling can follow three approaches: 1) climatic conditions which can be measured by the Standardized Precipitation Index; 2) vegetation mapping as a source of fire fuel; and 3) monitoring where new lava flows might reach the edge of vegetation (rather than staying within areas previously covered by earlier flows).

***Hurricane/Windstorm/Storm Surge***

The overwash resulting from storm surge during Iniki, the last hurricane to hit Hawai`i, was digitized by UH SOEST Coastal Geology Group from aerial photography (http://www.state.hi.us/dbedt/gis/iniki_ovrwsh.htm).

PDC has used a proprietary TAOS (The Arbiter of Storms) Model to simulate the storm surge created by hurricanes similar to historical events using low resolution bathymetry and coastal elevation utilizing historical hurricane data (http://www.pdc.org/iweb/capabilities/tropicalcyclone.html). The model needs to be ported to a supercomputer before it can be run using available high-resolution the bathymetry and elevation data and validated for Hawai`i.

In Hawai`i wave set-up is the principal cause of coastal flooding, rather than surge alone. A new model for Storm-Induced Coastal Flooding including both surge and wave set-up has been developed by Kwok Fai Cheung of the University of Hawai`i, Department of Ocean & Resources Engineering. This model has been validated using the Hurricane

Iniki data. It outputs surge, waves, and run-up as a function of time, and it could be used to develop additional overwash zones on other islands based on specified storm scenarios.

Jon Peterka of (Cermak Peterka Petersen, Inc.) and Gary Chock of (Martin & Chock, Inc.), with funding from NASA Office of Earth Science, have created models of hurricane wind speeds and topographic effects (http://www.martinchock.com/Orographicshort1.htm). Peterka's hurricane and typhoon model incorporated an analysis of tropical cyclone track statistics in portions of the Central and Western Pacific basins, to determine the regional average recurrence intervals and frequency of occurrence for mapping hurricane and typhoon wind speeds for Hawai`i and Guam. After testing physical models of island terrain in wind tunnels, Chock constructed a Wind Speed-up Phenomenological Model for predicting mean and peak gust wind "speed-up" based on numerical and landform analysis of a 30M DEM representation of topography. The model has been extended to map wind speedup for all areas of Oahu, Kauai, and to Lanai and Molokai. However, refinements are planned for these islands and further scientific work is needed for Maui and Hawai`i, due to the large land masses on those two islands that are anticipated to create significant mesoscale effects.

Tracking hurricanes and tropical storms is a specialized function within weather forecasting. PDC has a real-time Internet GIS application (http://atlas.pdc.org/) that shows the previous, current and forecast storm positions. This site also has historical storm tracks.

***Flood***

The Federal Emergency Management Agency (FEMA) produces Digital Flood Insurance Rate Maps (DFIRMs; http://www.msc.fema.gov/dfirm.shtml) at a scale of 1:24,000 for all islands except Niihau. The focus in Hawai`i has been for 100-year flood maps rather than 500-year maps. The resolution of the existing DFIRMs is not very useful for Hawai`i; the City and County of Honolulu regularly cleans the Oahu maps to conform to the scale of their parcel fabric. The State Office of Planning is one source for DFIRM data (http://www.state.hi.us/dbedt/gis/dfirm.htm)

FEMA has initiated a flood map modernization effort, which calls for acquiring LIDAR imagery as described in the elevation and bathymetry chapter. Once the imagery is collected and elevations derived, FEMA will derive new flood map products using historical/empirical information combined with modeling.

***Earthquake***

USGS has produced six probabilistic Seismic-Hazard Maps for Hawai`i (http://pubs.usgs.gov/imap/2000/i-2724). Of these maps, the "Peak Horizontal Ground Acceleration with 10% Probability of Exceedance in 50 years" sheet has been identified as the preferred source for earthquake hazard definition.

State Civil Defense and the Hawai`i Earthquake Advisory Committee will be developing project priorities and seeking funding on both mapping the seismic qualities of soils and the risks of liquefaction, which is of greatest concern to coastal alluvial areas.

***Volcanic eruption/lava flow/emissions***

In addition to the historic lava flow mapping discussed within the geology subcategory, a 1:250,000 scale map has been created for Lava Flow Hazard Zones on the Island of Hawai`i (http://www.state.hi.us/dbedt/gis/vhzones.htm).

HVO has created lavashed (sic) maps to model the advance rates of lava flows and thereby determine the amount of warning time that would be expected for evacuation of selected existing and proposed facilities, in particular Kulani Prison (http://hvo.wr.usgs.gov/products/OF98794/OF98794_2.html - prob).

Finally a 2003 publication titled Map Showing Lava Inundation Zones for Mauna Loa, Hawai`i estimates the areas threatened by lava flows from the next eruption of Mauna Loa (http://geopubs.wr.usgs.gov/map-mf/mf2401/).

| Layer | Source | Scale, Standards, etc. | Status |
|---|---|---|---|
| **Geology** | | | |
| Geologic Maps of Hawaiian Islands | USGS HVO (Hawai`i Volcano Observatory) trusdell@usgs.gov | Island of Hawai`i (1:100,000) reviewed for quality standards and metadata created. | Island of Hawai`i soon to be released; East Maui partial |
| Lava flow boundaries (with dates of flows) | USGS HVO (Hawai`i Volcano Observatory) trusdell@usgs.gov | Coverages of volcanoes on the Island of Hawai`i and Haleakala on East Maui. Historical data can show where earlier flows are covered by newer flows (not on Geologic map). | GIS version for internal use; Scans released; Continuous update for Kilauea |
| Earthquake hypocenters (epicenters and depths) with date, time and magnitude | Advanced National Seismic System (ANSS) http://quake.geo.berkeley.edu/cnss/catalog-search.html | Accuracy has improved over time. Point locations in degrees with four decimal places. | Complete; Continuous update |
| Volcanic monitoring locations and measurements (seismicity, deformation and emissions) | USGS HVO (Hawai`i Volcano Observatory) | Measurements are as accurate as technology permits | Internal Use; Continuous Update |
| **Soils** | | | |
| Hawai`i Soil Series | USDA Natural Resources Conservation Service (NRCS) pat.shade@hi.usda.gov | 1:24,000 scale. SSURGO certified. | Complete; On CD; Updating portions of Island of Hawai`i |
| Hawai`i Soil | USDA NRCS | Estimated scale is 1:250,000. | Same as |

| | | | |
|---|---|---|---|
| Associations | pat.shade@hi.usda.gov | STATSGO certified. | Soil Series |
| **Weather and Climate** | | | |
| Solar radiation ("sunshine maps") | Office of Planning http://www.state.hi.us/dbedt/gis/solrad.htm | Isolines at varying scales. Modeled information so accuracy less of an issue. | Complete |
| Pan-evaporation | USDA Natural Resources Conservation Service (NRCS) pat.shade@hi.usda.gov | Isolines at varying scales. Modeled information so accuracy less of an issue. | Complete |
| Rainfall (Median Annual) from Rainfall Atlas of Hawaii | Office of Planning http://www.state.hi.us/dbedt/gis/rainfall.htm | Isolines at varying scales. Modeled information so accuracy less of an issue. | Complete |
| Rainfall (Mean Monthly) from Rainfall Atlas of Hawaii | USDA NRCS pat.shade@hi.usda.gov | Isolines at varying scales. Modeled information so accuracy less of an issue. | Complete |
| Rainfall (Average Annual and Monthly) from PRISM & NRCS | USDA NRCS http://www.ftw.nrcs.usda.gov/prism/prismdata_state.html | Grids with 30" cell size. PRISM methods well established. | ASCII Grid complete; EOO not funded |
| Rainfall (Average Annual and Monthly) from PRISM & Climate Source | Climate Source http://www.climatesource.com/products.html | Grids with 15" cell size. PRISM methods well established. | Complete; License Fee |
| Temperature (Average, Maximum and Minimum, Annual and Monthly) | Climate Source http://www.climatesource.com/products.html | Grids with 15" cell size. PRISM methods well established. | Complete; License Fee |
| Extreme Precipitation | Climate Source http://www.climatesource.com/products.html | Grids with 15" cell size. PRISM methods well established. | Under production; License Fee |
| Extreme Temperature | Climate Source http://www.climatesource.com/products.html | Grids with 15" cell size. PRISM methods well established. | Under production; License Fee |
| Humidity | Climate Source http://www.climatesource.com/products.html | Grids with 15" cell size. PRISM methods well established. | Under production; License Fee |
| Hot Days (i.e. maximum temperature >= 90F) | Climate Source http://www.climatesource.com/products.html | Grids with 15" cell size. PRISM methods well established. | Complete; License Fee |
| Degree Days (i.e. difference between base and daily average) | Climate Source http://www.climatesource.com/products.html | Grids with 15" cell size. PRISM methods well established. | Complete; License Fee |
| Weather Station Locations | USDA NRCS National Climatic Data Center (NCDC) http://www.ncdc.noaa.gov/oa/climate/stationlocator.html | Most complete list of stations. Rounded to nearest degree. | Complete; Continuous Update |
| Rain Gauge Locations | Office of Planning http://www.state.hi.us/dbedt/gis/raingauge.htm | Stations as of 1997. Accurate to nearest second. Includes 1997 measurements. | Complete; Not up-to-date |
| Weather Station Measurements (Monthly Summaries) | Desert Research Institute (DRI) http://www.wrcc.dri.edu/summary/climsmhi.html and | Most recent month only. | Large subset of weather stations |

| | | | |
|---|---|---|---|
| Weather Station Measurements (Daily and 30-day) | NOAA National Weather Service (NWS) Honolulu Forecast Office http://www.prh.noaa.gov/hnl/pages/hiclimate.html | Most recent 30-day only. | Only four weather stations |
| **Miscellaneous** | | | |
| Major Land Resource Areas (includes physical, biological and human-altered environment) | USDA Natural Resources Conservation Service (NRCS) pat.shade@hi.usda.gov | Estimated scale 1:1,000,000 | Complete; Map unit definitions under review |
| **Natural Hazards** | | | |
| Beach Erosion | UH School of Ocean and Earth Sciences and Technology (SOEST) Coastal Geology Group http://www.soest.hawaii.edu/coasts/cgg_main.html | High precision needed to calculate rates of erosion. Process involves creating new coastal orthoimagery. | Major beaches on Maui completed |
| Tsunami Wave Heights (historical) | Office of Planning http://www.state.hi.us/dbedt/gis/tsunhts.htm | Accuracy unknown | Complete |
| Tsunami Evacuation Zones (before 1999) | Office of Planning http://www.state.hi.us/dbedt/gis/tsunevac.htm | Accuracy varies | Partial coverage of at-risk population |
| Tsunami Inundation Maps (since 1999) | Tsunami Inundation Mapping Effort (TIME) Status: http://www.pmel.noaa.gov/tsunami/time/hi/population/index.shtml UH SOEST and Ocean Engineeing (locally-generated tsunami) http://www.soest.hawaii.edu/tsunami | Improved modeling | Partially Complete; To be revised with better bathymetry |
| Historic Wildfire Burn Areas | Various: National Park Service (NPS) Sandy_Margriter@nps.gov U.S. Fish & Wildlife Service (FWS) ron_salz@fws.gov | Digitized from annotation of 1:24,000 quads | Island of Hawai`i incomplete; 0% other islands; Update needed |
| Hurricane Iniki overwash | Office of Planning http://www.state.hi.us/dbedt/gis/iniki_ovrwsh.htm | Source: aerial photography | Complete |
| Storm Surge using the Arbiter of Storms (TAOS) model | Pacific Disaster Center (PDC) http://www.pdc.org/iweb/capabilities/tropicalcyclone.html | Validation will be needed after running using high quality data, in particular bathymetry. | Model developed; Not yet run with detailed HI data |
| Storm-Induced Coastal Flooding | UH Department of Ocean and Resources Engineering cheung@oe.eng.hawaii.edu | Validated using Iniki data | Available for testing storm |

| | | | |
|---|---|---|---|
| | | | scenarios |
| Hurricane wind speeds and topographic effects ("Wind Speed-up" using Peak/Mean Envelope Methodology) | Martin & Chock Inc. and Cermak Peterka Petersen (CPP), Inc. http://www.martinchock.com/Orographicshort1.htm | Hurricane/typhoon wind speeds modeled for Hawai`i and Guam, but topographic effects portion only calibrated for Hawaiian conditions of smaller, lower islands (not yet Islands of Maui or Hawai`i) | Initial for Oahu, Kauai, Lanai & Molokai; Oahu refinement funded |
| Storm tracks (for real-time storms the previous, current and forecast positions; and historical storm paths) | PDC http://atlas.pdc.org/ | A single point is used to locate the eye of a storm which is a relatively large feature. | Complete Historical; Continuous update in real-time |
| Digital Flood Insurance Rate Maps | Federal Emergency Management Agency (FEMA) via Office of Planning http://www.state.hi.us/dbedt/gis/dfirm.htm | Current DFIRMs use 1:24,000 contour lines; Future will use LIDAR for elevation and/or orthoimagery for horizontal base | Complete; Revision in progress |
| Seismic Hazards | U.S. Geological Survey http://pubs.usgs.gov/imap/2000/i-2724 | Accuracy does not apply to this predictive model | Complete |
| Lava Flow Hazard Zones (generalized) | Office of Planning http://www.state.hi.us/dbedt/gis/vhzones.htm described in http://pubs.usgs.gov/gip/hazards/maps.html | Scale 1:250,00 | Complete |
| Lava Inundation Zones for Mauna Loa, Hawai`i (estimates of threatened areas) | USGS HVO (Hawai`i Volcano Observatory) trusdell@usgs.gov http://geopubs.wr.usgs.gov/map-mf/mf2401/ | Accuracy does not apply to this predictive model | Complete; Scans released |

**Data Sources:**
Some contacts for sources listed below can be found in the Status section.

**Geology:**
The sources available from the U.S. Geological Survey's Hawaiian Volcanoes Observatory are well documented in this chapter, but additional sources for future geological data are the numerous departments and programs within UH SOEST including its Hawai`i Institute for Geophysics and Planetology (http://www.higp.hawaii.edu/).

**Soils:**
NRCS is the source for soils mapping for agricultural and now for conservation purposes. Hawai`i Civil Defense (http://www.scd.state.hi.us) is seeking funding for research into soils mapping for seismic analysis.

**Weather and Climate:**

Climatic data for Hawai`i is being collected and modeled by the UH Water Resources Research Center WRRC (http://www.wrrc.hawaii.edu/), the UH Joint Institute for Marine and Atmospheric Research (JIMAR; http://ilikai.soest.hawaii.edu/JIMAR/), the UH Hilo Department of Geography and Environmental Studies (http://www.uhh.hawaii.edu/~geograph)as well as by the NRCS National Water and Climate Center (NWDC) and the NOAA National Climatic Data Center (NCDC).

Historic monitoring station location coordinates and archived measurements data should be mined from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC; http://www.ncdc.noaa.gov/oa/ncdc.html).

**Natural Hazards:**
Natural hazards data sources are likely to come mostly from the member organizations of the State Hazard Forum's Multi-Hazard Scientific Advisory Committee: Martin & Chock, Inc. (engineering firm), PDC, NOAA NWS, NOAA Information Center (ITIC; http://www.prh.noaa.gov/itic), UH SOEST Ocean & Resources Engineering, UH JIMAR, UH SOEST Coastal Erosion Group, USGS HVO, UH Civil Engineering, DLNR Flood Control and Dam Safety Section, and the State Office of Planning.

**Standards:**

**Geology**
In 2000, a Digital Cartographic Standard for Geologic Map Symbolization was publicly reviewed (http://ncgmp.usgs.gov/fgdc_gds/mapsymb/mapsymbpdfs.html). The proposal is expected to be revised and submitted to the FGDC in 2002-03.

A North American Digital Geologic Map Data Model is under development through an agreement between the Digital Geologic Mapping Committee of the Association of American State Geologists (AASG) and the USGS National Geologic Map Database project (http://geology.usgs.gov/dm).

**Soils**
The SSURGO version 2 database structure of the NRCS Hawai`i soil survey data together with the Hawai`i metadata meets the FGDC Soil Geographic Data Standard. This standard is for detailed soil series data at a 1:24,000 scale. (http://www.fgdc.gov/standards/documents/standards/soils). STATSGO, which is not referenced in the standard, is an aggregation of the data contained in SSURGO.

**Weather and Climate**
An FGDC Spatial Climate Subcommittee was formed in 1999 (http://www.wcc.nrcs.usda.gov/fgdc/subcommittee). The subcommittee has not released any proposed standards, but has endorsed the PRISM program.

Weather data is currently stored in various formats (GRIB, netCDF, GINI, Archive II, BUFR, McIDAS, Gempak, METAR as well as text), none of which is GIS friendly.

**Natural Hazards**
FEMA has started discussing standards with the FGDC (http://www.fgdc.gov/fgdc/coorwg/2002/cwgjan02.html and http://www.fgdc.gov/02nsdi/agency/fema.pdf). It should be noted that FEMA intends to use I-Teams to help coordinate hazards data collection.

FEMA has specific standards for its Digital Flood Insurance Rate Maps (DFIRMs) listed at http://www.fema.gov/fhm/frm_bsmp.shtm.

**Priority:**

The building and infrastructure planning and design community utilizes geology, soils and natural hazards data (e.g. earthquake potential, and wind speed-up). Similarly transportation agencies are concerned with natural hazards; several recent landslides in the past couple of years have partially or completely closed highways on Oahu resulting in high repair costs and economic repercussions to local communities.

Soils data is traditionally used for agriculture, which has historically been the third largest sector of Hawai`i's economy. The National Park Service's funding of soils mapping within the Park shows the importance of soil information for non-agricultural applications like conservation. Soils are an important component of water resource management as well.

Weather data is probably the most frequently requested of any type of spatial data, but it is mostly delivered as a final product stripped on the necessary spatial referencing. Geo-referenced, historic weather data for user-defined time periods would be useful to the scientific community in particular. Climate data has wide applicability. Both, precipitation and evapotranspiration (the combined loss of water to the atmosphere via the processes of evaporation and plant transpiration) are important for hydrologic models such as aquifer recharge.

Weather/climate, soils and geology are all base layers for natural hazards analysis.

Natural hazards mapping for the purposes of mitigation and disaster planning have high priority given Hawai`i's setting. Analysis of annualized losses indicates that the highest threats in Hawai`i are: 1) hurricane, 2) seismic, and 3) volcanic hazards. The economic fallout from hurricane Iniki on the island of Kauai lasted for a decade. Kilauea is the most active volcano in the world, and Mauna Loa is showing signs of possible renewed activity.

The priority is high enough that funding for natural hazards mapping has benefited core FGDC themes in the I-Plan, namely Digital OrthoImagery where NRCS is funding the bulk of acquiring the Emerge statewide color infrared DOQQs, and Bathymetry and Elevation where FEMA and local partners are funding the acquisition of LIDAR.

**Estimated total investment in this theme:**

Investment in mapping the physical environment and natural hazards is not easily broken out from other activities performed by organizations. A narrow view would include the labor and equipment of dedicated mapping professionals. A broad view would include:

- the cost of imagery purchased from soil survey or natural hazards budgets,
- the cost of purchasing, manning and maintaining monitoring equipment, and
- the cost of developing models and potentially run-time on super-computers.

Estimates of annual investment are shown below as a range to indicate both views. However, imagery costs incorporated in earlier chapters are not included in this section to avoid double counting.

**Geology:** Hawai`i Volcanoes Observatory has been constantly monitoring Kilauea and Mauna Loa volcanoes for over 90 years, with mapping as one of the products of its work. By the narrowest definition, the costs in Hawai`i of mapping volcanism would include 1.5 permanent employees and their equipment taking NPS staff support into account. Additional costs were incurred for Hawai`i data at USGS in Menlo Park. Monitoring instrumentation costs and seismological data archiving need to be considered. (Annual investment: $120,000 - $1,000,000 annually)

**Soils:** NRCS employs six staff for soil survey mapping in Hawai`i. Additional costs are incurred for Hawai`i data at NRCS in Fort Worth. In support of these activities, USDA has paid the lion's share of the cost of acquiring color-infrared DOQQs (Digital Ortho Quarter Quads) from the Emerge system from 1999 to the present. (Annual investment: $300,000 - $400,000 annually, DOQQs not included)

**Weather and Climate:** Much of the climatic mapping effort in Hawai`i dates from the mid-1980s. The recent costs for PRISM by Oregon State University, NRCS and Climate Source were not determined. Map-like graphics are the primary product of almost all investment in meteorological monitoring equipment, personnel, weather imagery, forecast modeling and data archiving. (Annual investment: Unknown amount for PRISM - $2,000,000 annually)

**Natural Hazards:** Natural hazards mapping is usually budgeted in combination with disaster preparation mapping including evacuation routes and structures. Many of the data layers are ad hoc projects (unlike the FEMA flood insurance maps). In addition to government agencies, PDC, which is a non-profit organization, has a large investment in natural hazards data and models. (Estimated total investment: $1,000,000 - $2,500,000)

**Estimated current state and local contributions:**

The state and counties have contributed towards individual physical environment and natural hazard projects on an ad hoc basis. Over the last decade, the State Office of Planning has often created digital versions of layers mapped by other organizations. Maui County funded its coastal erosion maps. There continues to be county participation in hurricane wind speed-up mapping. For flood mapping, FEMA has been partnering with the state and counties to fund LIDAR acquisition.

**What is needed:**

**Geology**: National efforts on producing a geologic map data model standard need to be evaluated for Hawai`i. Mapping lava flows will continue as the current Kilauea eruption progresses into its third decade. Pending final approval of the Geologic Map of the island of Hawai`i in the I-map digital data series, planning now needs to be initiated to create geology maps for the other main Hawaiian Islands. This would probably require a new, multi-year funding initiative within USGS Geologic Division. (Needed: Continued funding at present levels, plus new initiative: estimate $100,000 / year for five years.)

**Soils**: While NRCS and NPS have covered the current update of soils series data collection and the conversion of the older soil maps, they foresee a need for further documentation on the Hawai`i decision tree for expert interpretation of soil properties. (Needed: Estimate $20,000)

When the Island of Hawai`i is complete, NRCS foresees a need to update the other Hawaiian Islands to include greater detail in the conservation lands and to adjust for changes in agricultural land use over the past forty years. (Needed: Continued funding at present levels)

**Weather and Climate**: Precise locations of meteorological monitoring stations need to be collected and linked to historic as well as current measurement data. In addition to actual readings, data quality needs to be captured (e.g. notations when rain gauges are filled to capacity). Because Hawai`i has great climatic variability over short distances, the dataset might be expanded to include some privately owned and operated meteorological stations. The database needs to be warehoused in a format that allows free-form temporal queries rather than predetermined time increments. This cleaned data should be the source for PRISM and other potential climatic modeling efforts such as by UH researchers or the State Climatologist. (Needed: Estimate $100,000)

One climatic measure that needs to be modeled and mapped is evapotranspiration. The solar radiation and pan-evaporation map layers are indicative of the maximum potential evaporation, but land cover needs to be added to the model. (Needed: Estimate: $250,000)

The National Weather Service is proceeding with its plans to provide real-time weather information in a spatially geo-referenced format through the Internet. Pilot projects combining this data with traditional geographic data layers should be encouraged. (Needed: Continued funding at current levels plus new funding initiative to turn pilot Internet project into production system.)

**Natural Hazards**: At present, some of the immediate needs for natural hazards mapping — in addition to acquisition of imagery, bathymetry and LIDAR for elevation — include:

1) completion of the High Wind modeling for Maui and Hawai`i and refinement of the model for Kauai, using the Chock Speed-up Methodology (Needed: $450,000),
2) porting the Storm-Induced Coastal Flooding model to be available to be run for hypothetical storm scenarios as well as in real-time for actual storms on the supercomputer at the Maui High Performance Computer Center (MHPCC; http://www.mhpcc.edu) (Needed: To be determined),
3) continued funding of tsunami inundation mapping (Needed: To be determined), and
4) funding of engineering assessments of the seismic qualities of soils and the risks of liquefaction, which is of greatest concern to areas built on coastal alluvial areas, due to local ground motion amplification. (Needed: To be determined)

**What is the likely source:**

**Geology:** USGS
**Soils:** NRCS
**Weather and Climate:** NOAA, USGS and NRCS
**Natural Hazards:** FEMA, USGS (earthquake and volcanic hazards), NOAA (hurricane and tsunami) and DOD

**Estimated current allocation of funding:**

See investment in theme for geology, soils, and weather and climate. For natural hazards, estimated current allocation of funding is $400,000 mostly in ad hoc projects.

**Estimated budget shortfall:**

**Geology:** A new initiative to produce digital geologic maps for seven Hawaiian Islands is being considered by USGS Geologic Division and is not considered to be a shortfall in the I-Plan.

**Soils:** $20,000 needed for soil interpretation.

**Weather and Climate:** The most immediate budget shortfall is the NRCS budget for funding PRISM data for Hawai`i at the same level as other states. Although the total shortfall is probably greater, OSU has estimated that the amount needed to created EOO and polygon versions of precipitation layers is $500.

Neither the layer of precise locations of weather stations nor the evapotranspiration climate layer have been budgeted by any agency (Combined estimate is $350,000).

***Natural Hazards:*** Completion of the High Wind speed-up mapping is an identified shortfalls (Estimated costs $450,000). Funding for the SOEST locally-generated tsunami inundation hazards map is on hold. PMEL does not show any progress on externally-generated tsunami inundation maps as of May 2001

(http://www.pmel.noaa.gov/tsunami/time/hi/index.shtml). Coastal erosion mapping is covered in the marine layers chapter.

**Possible ways to overcome this gap:**

The first places to look are USGS for geology, NRCS for soils, NOAA and NRCS for weather and climate, and FEMA and USGS for natural hazards.

FEMA been transferred to the newly created Department of Homeland Security(DHS), which will alter its mission and possibly lead to new avenues of funding. Also, within DHS, a new agency called the National Cyber Security Division (NCSD) has been set up under the Department's Information Analysis and Infrastructure Protection Directorate.

A separate source of funding is NASA, which funded the development of the Peterka/Chock hurricane winds models.

**Most appropriate data steward:**

**Geology**: HVO and/or UH SOEST

**Soils**: NRCS

**Weather and Climate**: Probably UH JIMAR, NOAA NWS, or NRCS

**Natural Hazards**: The likeliest candidates for now are USGS-HVO, PDC, UH SOEST and NOAA International Tsunami Information Center. Possibly State Civil Defense at a later date when they come up to speed on GIS.

**Maintenance Process:**

**Geology:** Data maintenance has long been recognized as a necessity for volcanic activity on the Island of Hawai`i and seismic monitoring statewide.

**Soils:** Currently, the NRCS for soils maps is primarily data maintenance. In updating the soils maps to include conservation purposes, NRCS is also revisiting agricultural areas where land use has changed.

**Weather and Climate:** Today, climate maps are generally built from thirty years accumulated data, so maintenance will not be an important issue for a long while. In the future, there may be a call for mapping climate change such as global warming. The focus on weather has always been on mapping from new data. The layer with precise locations of weather stations and their dates of operation would need to be maintained.

**Natural Hazards:** Updating data for natural hazards is likely to be required as new natural hazard models are developed, improved instrumentation or scientific advances

lead to better data, or a major natural disaster occurs (such as large magnitude earthquake, resumption of volcanic eruption at Mauna Loa, tsunami, or hurricane).

**Estimated Maintenance cost:**

Maintenance of weather station locations layer might cost $5,000 annually, if GPS field work were needed. Mostly where data maintenance is needed, it is already included in the budgets, with the exceptions of natural hazards mentioned above. The annual costs of maintaining natural hazards data is likely to vary greatly from one year to the next.

# CHAPTER 11: CULTURAL RESOURCES

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It is essential to note that cultural resources data for the State of Hawai`i cover a variety of agencies, resource types and stewards. While some this data is available from public sources, others of it are proprietary or restricted for security and sensitivity of data reasons. Topics and contacts are provided for general guidance only to acquaint the reader with the types of information potentially available; please refer to Table D for specific agencies, information and specific contacts.

**Theme Description:**

Cultural resources refer to the wide variety of non-renewable features and elements, structures and objects that may have both tangible and intangible qualities and are representative of both natural and man-made processes. In Hawai`i, cultural resources cover a wide range of time periods, geographical areas, ecosystems, islands and ethnic communities. Cultural resources and associated data can be representative of legendary, pre-contact, post-contact and contemporary time periods. Cultural resources considered essential to a cultural resource theme are geographic names, historic sites, Land Commission Awards, *ahupua'a* and land divisions, archeological sites/reports, cultural landscapes, cemeteries, hunting areas, and subsistence/gathering areas.

**Status:**

Cultural resources data is represented many ways through physical surveys, architectural recording processes, site inventories and for example, through oral histories, legends, and ‘olelo no’eau (proverbs). The wide variety of formats and types of cultural resources data is challenging to compile and inventory. Data and information to populate this theme is distributed across the state of Hawai`i between federal, state, local and non-governmental agencies as well as individuals, families and research institutions.

**Sources:**

National Register of Historic Places
National Historic Landmarks (NHL)
National Park Service, Pacific Island Support Office
National Memorial Cemetery of the Pacific at Punchbowl
State of Hawai`i Board of Geographic Names
State of Hawai`i Department of Land and Natural Resources (DLNR)

State of Hawai`i Department of Forestry and Wildlife (DOFAW)
State of Hawai`i Division of Aquatic Resources (DAR)
State of Hawai`i Department of Health
DLNR State Historic Preservation Division (SHPD)
DHHL Cultural Preservation Program
Office of Hawaiian Affairs
Hawai`i Heritage Program (Marine Gap)
State of Hawai`i Archives
Wai Hona ʻAina database of Land Commission Awards
Cultural Landscape Inventory Program (CLI)
CLAIMS database (National Park Service, Cultural Landscape Assessment, Inventory and Management System; restricted internal program currently)
Center for Conservation Research and Training/UHM (Aquatic Gap)
Hawaiian Electric Company
Local land planning and architecture firms (various)

**Standards:**

Due to the wide variety of data sources and types, standards for data include the Federal Geographic Data Committee (FGDC) standards for metadata and others such as USGS mapping standards for accuracy. In some cases, agencies/organizations have individual standards for data collection regarding GIS and GPS data.
http://www.fgdc.gov/
http://www.nps.gov/gis/data_info/standards.html

**Priority:**

Compilation of cultural resources metadata to clearinghouses for potential access is a priority as well as coordination between agencies and organizations to strengthen communication, partnerships and data sharing. Cultural resources data is critical for prudent resource management, planning, permitting and consultation processes at both the state and federal levels as well as for education and outreach purposes.

**Estimated Total Investment in this Theme:**

Undetermined at this time; many participants and agencies; many projects underway.

**Estimated Current State and Local Contributions:**

All agencies, organization and partners currently stewarding data for this theme individually bear the costs; they may in some cases have grants and other funding to provide assistance. Federal agencies currently bear the cost of their personnel, programs and data independently. Leveraging resources across all agencies and partnerships should be encouraged to continue and expand to minimize data redundancy and duplication of efforts.

**What is needed:**

1.Geographic Names
2. Historic Sites
3. Land Commission Awards
4. *Ahupua'a* and Land Divisions
5. Archeological sites/reports
6. Cultural landscapes
7. Cemeteries
8. Hunting areas
9. Subsistence/gathering areas

**What is the likely source:**

See Table D for contact persons and additional information

**1. Geographic Place Names**
The Geographic Place Names Database is a concise database of geographic names in the State of Hawai`i, including but not limited to Hawaiian language names inclusive of correct diacritical marks per the Hawai`i Board of Geographic Names.[13] This database is linked to the ongoing United States Geologic Survey (USGS) quad sheet revision and recasting project currently underway for quadrangle sheets of the State of Hawai`i.

**2. Historic Sites (RESTRICTED)**
Historic Sites data bases and shape files are maintained by various agencies and identify sites and structures on the state and federal registers of sites with historic significance and meeting criteria for inclusion or consideration.

**3. Land Commission Awards**
Land Commission Awards are documents pertaining to the Land and Boundary Commission Awards granted as part of The Great Mahele of 1848 and other activities. "This event (The Great Mahele) separated and defined the undivided land interests of King Kamehameha III and the high ranking chiefs and *konohiki*, and led to the end of the feudal system that existed in the Hawaiian Islands." [14]

**4. *Ahupua'a* and land divisions**
"*Ahupua'a* have been generally and conceptually described as tracts of land extending from the summit of the mountain to the sea and on to the outer edge of the reef. All

[13] Hawaii Board of Geographic Names is composed of individuals appointed by the Governor and representatives of the State of Hawaii, Department of Business, Economic Development and Tourism (DBEDT). It is a multi-agency group who serves to review place names and provide guidance and recommendations on new place names. Contact: Craig Tasaka

[14] The Great Mahele: Hawaii's Land Division of 1848
University of Hawaii Press, 1958
John J. Chinen

*ahupua'a* were given names and their boundaries were carefully defined. The names were descriptive or derived from legendary or historical sources. The boundaries were known to residents more often by their natural features rather than by man-made boundaries." [15]

"An *ahupua'a* typically included a wide variety of natural resources, from marine to food species to salt sources and habitation areas at the shore to agricultural lands on the middle slopes, to wood, fiber and other resources of the upland forests. Accordingly, each ahupua'a formed a cultural landscape that often allowed the community to be economically self-sufficient to a marked degree."[16]

**5. Archeological sites/reports (RESTRICTED)**
These sources include a variety of field and site reports, maps, photographs and bibliographical information pertaining to cultural sites in the Hawaiian Islands.

**6. Cultural Landscapes**
Cultural landscapes are defined as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity or person of exhibiting other cultural or aesthetic values." [17]

Cultural landscapes may be generally defined as those areas where geographical, physical, intangible and cultural elements are entwined to produce a continuous environment [6]. Ideally, data related to cultural landscapes include historical significance over time, existing conditions and use as well as natural and built characteristics and landscape features; dynamic natural and cultural processes and the concerns of traditionally associated peoples.

**7. Cemeteries**
Information about cemeteries could include local, state and federal (veteran's cemeteries). Contact agencies for information about cemeteries in Hawai`i include the State of Hawai`i Department of Health and the Veteran's Administration. There are also private groups who conduct cemetery cleanups and inventories such as The Cemetery Research project (N. Purnell, director) and various Chinese benevolent societies who care for and utilize the Chinese cemeteries.

**8. Hunting Areas**

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[15] Resource Units in Hawaiian Culture (revised edition)
The Kamehemeha Schools Press, 1992
Donald D. Kiloani Mitchell, Ed.D.

[16] "Kalaupapa National Historical Park Landscape Characteristics"
manuscript, Dr. Robert J. Hommon, September 1997.

[17] National Register Program, Preservation Brief #36, Protecting Cultural Landscapes
Charles Birnbaum, 1994. (need to check this further)

Hunting areas are those in which the State of Hawai`i, Division of Forestry and Wildlife (DOFAW) programs permits hunting by various methods at various times of year and seasons for ungulates.

**9. Subsistence/Gathering Areas**
Subsistence/gathering areas are areas used traditionally for collection and subsistence purposes; may include data on areas currently used or historically used.

Estimated Total Investments Needed to Complete this Theme:

Individual determinations by category still need to be made in consultation with data stewards and appropriate partners. (This will have to be fleshed out in the next draft)

General categories will include:

Heritage datasets and databases (already existing)
Maintenance, archiving and update costs by program stewards.
Future projects and funding needs that can be identified for leveraging.

Table D

| Theme | Source | Contact | Remarks |
|---|---|---|---|
| Geographic Names | State of Hawai`i Board of Geographic Names (pages with current and approved names including diacritical marks posted to web site)<br>Website/Link: www.state.hi.us/dbedt/gis/ | Craig Tasaka<br>Renee Louis | Metadata: in process |
| Historic Sites | DLNR State Historic Preservation Division (SHPD) | Eric Komori | |
| | National Register of Historic Places | Weblink | |
| | National Historic Landmarks (NHL) in Hawai`i | weblink; National Park Service, PISO | |
| Land Commission Awards | State Archives records | | |
| | Wai Hona Aina database of LCA | Vicki Creed<br>Paige Barber | Proprietary; web-based; fee contract for access |
| *Ahupua'a* and land divisions | DLNR State Historic Preservation Division (SHPD) | Eric Komori | |
| | National Park Service, Pacific Islands Support Office | Melia Lane-Kamahele<br>Sandy Margriter | |
| | DHHL Cultural Preservation Program | | |
| Cultural landscapes | National Park Service, Pacific Islands Support Office, Cultural Landscape Inventory Program (CLI) and CLAIMS database | Melia Lane-Kamahele<br>Laura Carter Schuster | in progress |

| | | | |
|---|---|---|---|
| | Local land planning/landscape architecture firms who contract their services to provide cultural landscape reports, preservation planning and interpretation services. | | |
| Cemeteries | National Park Service, Pacific Islands Support Office<br>Reference documents: Kalaupapa Cemetery Directory, 1991, produced by The Cemetery Research Project, N. Purnell. | Melia Lane-Kamahele<br>Tom Fake | restricted data for management purposes pertaining to cemetery areas of Kalaupapa NHP. |
| | State of Hawai`i Department of Health | undetermined at this time | |
| | National Memorial Cemetery of the Pacific at Punchbowl | Veteran's Administration | |
| Hunting areas | State of Hawai`i,DLNR, DOFAW | Ron Canarella<br>Michael Constantinides | ArcView shape files and database available but portions may be restricted. |
| Subsistence/ gathering areas- Terrestrial | National Park Service, Pacific Islands Support Office | Melia Lane-Kamahele<br>Laura Carter Schuster | |
| | Hawaiian Electric Company (HELCO)<br>study conducted by HECO via Luciano Minerbi et al. to determine corridors and areas of use by Native Hawaiians re: line routing and future planning | Barbara Cooper (Hilo) | . |
| Subsistence/ gathering areas- Aquatic | CCRT/UHM . (Aquatic GAP) | Mike Kido, Dan Dorfman et al | stream assessments – i.e. Limahuli; work in progress |
| Subsistence/ gathering areas- Marine | Hawai`i Heritage Program (Marine GAP) | Shannon McElvaney<br>Dan Dorfman | |
| | State of Hawai`i, Division of Aquatic Resources (DAR) | Linda Shea-Flanders<br>Athline Clark | ongoing study of potential Marine Protected Areas (MPAs) |

**Estimated current allocation of funding:**

$250,000 in 2003 (various agencies for projects and tasks ongoing or archiving, maintenance and update of information) Note that the current allocation of funding does not include the value of heritage and legacy datasets already in place by various agencies.

**Estimated budget shortfall:**

$1,000,000.00

**Possible ways to overcome this gap:**

Undetermined at this time (06/2003)
Obvious solutions will be to partner and leverage funds, ensure data standards for compatibility and monitor for redundancy of efforts, data etc. Topical priorities will need to be determined in consultation with various agencies. From this process, identification of funds for leveraging and projects can be done.

**Most Appropriate Data Steward:**

Individual agencies will steward their own data based on sub-theme. Suggest that all metadata be posted to the State of Hawai`i clearinghouse maintained by Department of Business/Economic Development and Tourism (DBEDT).

**Maintenance Process:**

Maintenance of hardware, software and data will be borne by the individual agencies providing stewardship for particular themes and metadata. The individual agencies and organizations will also be responsible for security and archiving issues.

**Estimated Maintenance Costs:**

These costs will be dependent upon individual agencies and organizations internal structure, personnel and systems.

**Guidance:**

There are a variety of laws, regulations and policies at both the federal and state levels that provide guidance to cultural resource activities within the State of Hawai`i. These include but are not limited to the following:

Federal:
1906 Antiquities Act
1916 National Park Service Organic Act
1964 Wilderness Act
1935 Historic Sites Act
1966 National Historic Preservation Act (NHPA) (36 CFR Part 800/Section 106)
1969 National Environmental Policy Act (NEPA)
1979 Archeological Resources Protection Act (ARPA)
1990 Native American Graves Preservation and Repatriation Act (NAGPRA)
1998 Omnibus Management Act
2001 National Park Service Management Policies

State:
Hawai`i Revised Statutes, Chapter 6E (Historic Preservation)
Public Access Shoreline Hawai`i (PASH), August 1995
Hawaiian Homes Commission Act, 1920.

# CHAPTER 12: TERRESTRIAL LAYERS

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**Theme Description:**

*Land use* corresponds to the socio-economic description (or functional dimension) of a given area. For example, areas used for residential, industrial or commercial purposes, for farming or forestry, for recreation or conservation purposes, etc. It may be possible to infer land use from land cover and vice versa. But situations are often complicated and the link is not always evident. Unlike land cover, land use is difficult to 'observe'. For example, it is often difficult to decide if grasslands are used for agricultural purposes or not. Often, there is overlap between these two themes. Distinctions between land use and land cover and their definition have impacts on the development of classification systems, data collection and information systems in general (European Environment Agency [EEA], 2003).

*Land cover* corresponds to a biophysical description of the earth's surface. In short, it is that which overlays or currently covers the ground. This description enables various biophysical categories to be distinguished such as areas of vegetation (e.g., trees, bushes, fields, lawns), bare soil, hard surfaces (e.g., rocks, buildings) and wet areas and bodies of water (e.g., watercourses, wetlands) (EEA 2003).

*Federal or State Listed Species*[18] *and Habitat* correspond to any information regarding the status and location of rare, threatened, or endangered[19] species and/or native natural communities. These locations are tracked throughout the state of Hawai`i for the purpose of providing the most comprehensive and up-to-date status information on rare species or native communities that are in danger of local extirpation or extinction (United States Fish and Wildlife Service [USFWS], 2003).

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[18] Listed species**:** A species, subspecies, or distinct vertebrate population segment that has been added to the Federal lists of Endangered and Threatened Wildlife and Plants as they appear in sections 17.11 and 17.12 of Title 50 of the Code of Federal Regulations (50 CFR 17.11 and 17.12). The State also has laws protecting species from island to island.

[19] Endangered**:** The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

*Agricultural Land* corresponds to those lands zoned as agricultural on which various crops, plantations, or trees are grown.

*Invasive Species* are introduced species that are harmful to Hawai`i's native ecosystems and species as well as agriculture and the general welfare of the economy.

**Status:**

*Land use:* There is only one land use layer that covers the 8 main islands in a uniform manner. A more detailed layer covers Oahu only. The details of these two layers follow:

The State Office of Planning (OP) has State Land Use District Boundaries for the 8 main Hawaiian Islands for the years 1991, 1993, 1995, and 2000. The layers depict areas as land use zones consisting of conservation, rural, agriculture, and urban. The layers where digitized from 1:24000 mylars obtained from the State Land Use Commission (LUC).

City and County of Honolulu (CCH) has detailed *land use* down to the parcel level in the zoning layer (Oahu only). It has attributes such as residential, commercial, neighborhood business, community business, agriculture, conservation, military, Federal, apartment, industrial, etc., as well as categories indicating degree of density, etc.

*Land cover*: There are a variety of sources of land cover data but few that cover the entire 8 main islands in a uniform manner. The National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP) and the Hawai`i Gap Analysis Project (HI-GAP) both seek to do just that.

NOAA C-CAP created land cover layers for the 8 main islands using a nearly cloud free mosaic of NASA's Landsat 7 Enhanced Thematic Mapper (ETM) imagery.[20] The islands were broken into classes of major land cover features such as developed, cultivated land, grassland, forest, scrub lands, wetland, bare land, and water. The C-CAP land cover classification scheme can be seen in detail at http://www.csc.noaa.gov/crs/lca/tech_cls.html.

HI-GAP, a consortium of public and private conservation organizations is working on a land cover layer derived from Landsat 7 Advanced Thematic Mapper (ETM) imagery. The data is being prepared and compiled in compliance with the United States Geological Survey (USGS) National Gap Program[21] and is supported by local cooperators. Final products will be 5 hectare Minimum Mapping Units (MMU) in both raster and shape file formats. The land cover will be classified into ecological systems determined by a

[20] Landsat 7 Enhanced Thematic Mapper (ETM) imagery: An eight-band multispectral scanning radiometer onboard the Landsat 7 satellite that is capable of providing high-resolution imaging information of the Earth's surface (NASA Earth Observatory. 2003)

[21] USGS National Gap Program seeks to to provide regional assessments of the conservation status of native vertebrate species and natural land cover types and to facilitate the application of this information to land management activities. (see http://www.gap.uidaho.edu)

combination of factors such as elevation, precipitation, slope, aspect, and dominant and sub dominant vegetation types. HI-GAP statewide land cover datasets will be available in 2005. For more details contact the Hawai`i Natural Heritage Program (HINHP).

*Federal or State Listed Species*[22] *and Habitat:* There are a variety of sources for statewide information pertaining to the status and location of listed species and rare and/or critical habitat. Although the data is statewide, the coverage is uneven both spatially, temporally, and taxonomically. Spatially, federal and state lands are the most well surveyed with many large privately owned tracts (and even some state and local government tracts) having never been surveyed. Temporally, species status on military training areas is probably the most up to date with many datasets being current as of 2003. However, many areas in the state haven't been surveyed specifically for rare species for 10 to 20 years or more. Taxonomically, forest birds are probably the best covered with yearly state organized forest bird surveys which attempt to revisit each transect every 5 years. Plants are well-inventoried on military lands but there is no systematic statewide survey for plants or invertebrates. The distribution and status of the Hawaiian hoary bat (the only land mammal in Hawai`i) is not well known and it has not been updated since the early 1990's.

HINHP, a program affiliated with the Center for Conservation, Research and Training (CCRT) at the University of Hawai`i (UH) has the largest statewide spatial dataset of *rare, threatened, and endangered plants, animals, and natural communities* in the state. HINHP's Natural Diversity Database and GIS Layers consist of information on the status and location of rare species and natural communities throughout the state. The data is provided primarily to government organizations and researchers in order to assist them in land use planning, natural resource management, and biological research. The data is restricted due to its sensitive nature; however it is available upon request for appropriate projects. The data covers all federally listed and state listed species as well as those classified as globally rare by NatureServe, an international organization comprised of 76 Heritage programs that tracks the worldwide status of at risk species. HINHP also has a dataset detailing remaining native vegetation communities for the 8 main islands based on elevation, rainfall, slope, aspect, and dominant and sub-dominant vegetation digitized at a 1:24,000 scale.

The US Fish and Wildlife Service, an agency of the Department of the Interior (DOI) has proposed *Critical Habitat* layers that demarcate "specific geographic areas, whether occupied by listed species or not, that are determined to be essential for the conservation and management of listed species, and that have been formally described in the Federal Register." The proposed critical habitat designations cover 47 plants for the Island of Hawai`i (Big Island), 83 plant species for Kauai and Niihau, 61 plant species for Maui and Kahoolawe, 46 plant species for Molokai, 32 for Lanai, 99 plant species for Oahu, and 5 plant species for the Northwestern Hawaiian Islands (USFWS, May 28, 2002). Contact USFWS at 808-541-3441 to check on availability of layers.

*Agricultural Land:* There are a variety of sources of data layers demarcating agricultural lands in the land cover category, however there are a few layers that specialize in issues of particular to agriculture such as crop type, soil type (see Chapter 10, Physical Environment and Natural Hazards), or productivity.

The Land Study Bureau of the University of Hawai`i prepared an inventory and evaluation of the State's land resources during the 1960's and 1970's. The inventory detailed agricultural land productivity ratings for Kauai, Oahu, Maui, Molokai, Lanai and Hawai`i. The Bureau grouped all lands in the State, except those in the urban district, into homogeneous units of land types. It described their condition and environment; rated the land on its over-all quality in terms of agricultural productivity; appraised its performance for selected alternative crops; and delineated the various land types and groupings based on soil properties and productive capabilities. Statewide data layers compiled from information gathered from 1965 to 1972 are complete. The data is publicly available.

*Invasive Species:* The Coordinating Group on Alien Pest Species (CGAP)[23] oversees Invasive Species Committees (ISC) on Oahu, Maui, Molokai, Lanai, Kauai, and Hawai`i. Each ISC maps, monitors, and controls invasive weed and pest species on each island. Each ISC maps the location of serious invasive and/or incipient alien species specific to each island. They work closely with the Hawai`i Department of Agriculture as well, tracking down and killing the most noxious species. Data is in various states of completion and may or may not be readily available. This should change over the next year as the Hawai`i Natural Heritage Program works to compile all data into one format and make it available over the web under contract to the National Biological Information Infrastructure's (NBII) Pacific Basin Information Node (PBIN).

**Data Source:**

*Land use:*
State Office of Planning (OP), http://www.hawaii.gov/dbedt/gis/download.htm
City & County of Honolulu (CCH), http://gis.hicentral.com

*Land cover:*
State Office of Planning (OP), http://www.hawaii.gov/dbedt/gis/download.htm
NOAA Coastal Change Analysis Program (C-CAP), http://www.csc.noaa.gov/crs/lca/m_eight.html
Hawai`i Gap Analysis Project (HI-GAP), http://www2.hawaii.edu/~hinhp/
Hawai`i Natural Heritage Program (HINHP), http://www2.hawaii.edu/~hinhp/

*Federal or State Listed Species*[24] *and Habitat:*

[23] The Coordinating Group on Alien Pest Species is a multi-agency partnership that seeks to coordinate more effective protection for Hawaii's economy, environment, health, and way of life from harmful alien pests. See http://www.hear.org/cgaps/ for more information.

State Office of Planning (OP), http://www.hawaii.gov/dbedt/gis/download.htm
Hawai`i Natural Heritage Program (HINHP), http://www2.hawaii.edu/~hinhp/

*Agricultural Land:*
State Office of Planning (OP), http://www.hawaii.gov/dbedt/gis/download.htm

*Invasive Species:*
Maui Invasive Species Committee (MISC), http://www.hear.org/misc
Oahu Invasive Species Committee (OISC), http://www.hear.org/oisc
Big Island Invasive Species Committee (BIISC), http://www.hear.org/bimac
Molokai Invasive Species Committee (MoMISC), http://www.hear.org/momisc
Kauai Invasive Species Committee (KISC), http://www.hear.org/kisc
Lanai Invasive Species Committee (LanISC), http://www.hear.org/cgaps for now.
Hawai`i Natural Heritage Program (HINHP), http://www2.hawaii.edu/~hinhp/

**Standards:**

*Land use:*
State Office of Planning (OP), metadata associated with each file at
http://www.hawaii.gov/dbedt/gis/download.htm
City & County of Honolulu (CCH), http://gis.hicentral.com

*Land cover:*
State Office of Planning (OP), metadata is associated with each file at
http://www.hawaii.gov/dbedt/gis/download.htm
NOAA C-CAP, metadata associated with each file can be found at
http://www.csc.noaa.gov/crs/lca/m_eight.html
Hawai`i Gap Analysis Project (HI-GAP), National Gap Analysis Standards, Version 2.0.0. (February 16, 2000) at http://www.gap.uidaho.edu/handbook/Standards/default.htm

*Federal or State Listed Species*[25] *and Habitat:*
State Office of Planning (OP), http://www.hawaii.gov/dbedt/gis/download.htm
Hawai`i Natural Heritage Program (HINHP), information on standards and Heritage mapping methodology can be found at the NatureServe web site at
http://www.natureserve.org/prodServices/heritagemethodology.jsp
U.S. Fish and Wildlife Service Endangered Species Program http://endangered.fws.gov/

*Invasive Species Distribution:* The various ISC's map alien species locations using 1:24000 USGS Quadrangles and/or a combination of Global Positioning Systems (GPS).
Maui Invasive Species Committee (MISC)
Oahu Invasive Species Committee (OISC)
Big Island Invasive Species Committee (BIISC)
Molokai Invasive Species Committee (MoMISC)
Kauai Invasive Species Committee (KISC)

Lanai Invasive Species Committee (LanISC)
Hawai`i Natural Heritage Program (HINHP), http://www2.hawaii.edu/~hinhp

**Priorities**
The Terrestrial layers were selected by the Hawai`i GIS community as a set of framework data layers. While not one of the original FGDC layers, they make up a crucial component in analyzing the condition and stresses on the natural environment. These layers are each important in combination with other spatial data layers in comprehensive planning for the Hawaiian Islands. It will take a combination of data organization and new purchases to achieve the goals in this chapter. Layers such as land use and agriculture need a coordinated data management plan. Land cover requires a high-resolution imagery product for analysis. Species and Habitat data efforts will include funding to database existing records as well as cooperation between the Hawai`i Natural Heritage Program and the Bishop Museum, an effort currently underway.

**Estimated total investment in this theme:**

*Land use:*
State Office of Planning (OP): unknown
City & County of Honolulu (CCH): unknown

*Land cover:*
State Office of Planning (OP): unknown
NOAA Coastal Change Analysis Program (C-CAP): unknown
Hawai`i Gap Analysis Project (HI-GAP), $100,000

*Federal or State Listed Species and Habitat:*
Hawai`i Natural Heritage Program (HINHP) has invested a total of $10,000,000 to $15,000,000 over an 18 year period.

*Agricultural land:* unknown

*Invasive species:* Costs associated with this collecting data and mapping this theme total in the millions if you look at the number of agencies involved with managing various invasive species.

**Estimated current state and local contributions:**

*Land use:*
Office of Planning (OP): unknown
City and County of Honolulu (CCH): unknown

*Land cover:*
Hawai`i Gap Analysis Project (HI-GAP): $250,000

*Federal or State Listed Species and Habitat:*

Hawai`i Natural Heritage Program (HINHP): $50,000 annually

*Agricultural land:* unknown

*Invasive species*: unknown

**What is needed:**

*Land use:* The state needs an up-to-date land use map that is uniform throughout the islands and more detailed and accurate than current land use maps. The OP and the LUC could perhaps work with the Counties and CCH to come up with a standard set of land use classifications which best suit the needs of all through a series of workshops and focused meetings.

*Land cover:* The ability to update land cover is based on the availability of current remotely sensed imagery. We need complete statewide datasets of remotely sensed data on which to base our land cover classification (see details of imagery costs in Chapter 3, Imagery). Previous work on land cover classification using Landsat 7 ETM data has shown that 30 meter pixels are just too coarse for most land cover classification needs. Higher resolution data such as Space Imaging's IKONOS[26] imagery or Digital Globe's Quickbird[27] imagery are needed. Imagery must be orthorectified to better than National Map Accuracy Standards (NMAS 1:12,000 CE 90%) and the land cover should be created using imagery of this caliber as the base layer. The state needs a uniform statewide land cover data layer in order to monitor watershed, forest, and stream health to name but a few. A good land cover layer can also help managers protect the ocean by showing areas of barren ground that are susceptible to erosion. It is well documented that what happens on the land effects the near shore marine ecosystems.

*Federal or State Listed Species and Habitat:* The state needs a uniform and up-to-date source of information on the status and location of rare, threatened, and endangered species and natural communities. Currently, there is a lot of duplication of effort with many organizations mapping species information already mapped by others, sometimes 3 times over. These datasets often end up being combined at some point, which causes data confusion that requires still more effort. By organizing mapping efforts, pooling resources, and/or storing data under one roof in a clearinghouse for all, we could increase efficiency, eliminate duplication of effort, and do a better job protecting the unique plants

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[26] Space Imaging Corp's IKONOS Pro imagery, both 1 and 4-meter products are the highest accuracy orthorectified products derived from IKONOS imagery that do not require ground control. Consistent 10-meter CE90 product accuracy provides global access to 1:12,000 National Map Accuracy Standards (NMAS). http://www.spaceimaging.com/products/IKONOS/pro.htm

[27] Digital Globe's Quickbird ortho imagery, both 70cm and 2.8-meter products are the highest accuracy orthorectified products derived from Quickbird imagery that do not require ground control. Consistent 10.2-meter CE90 product accuracy over USA only at 1:12,000 NMAS. See details at http://www.digitalglobe.com/products/ortho.shtml

and animals of Hawai`i. Data and mapping standards need to be created so that these datasets can be pulled together more easily for storage, analysis, and dissemination.

*Agricultural land:* The state needs a uniform and up-to-date source of information on the status, type, and location of crops and plantations in Hawai`i. Data and mapping standards need to be created so that these datasets can be pulled together for storage, analysis, and dissemination.

*Invasive species:* A uniform and up-to date-source of information on the status and location of invasive species is needed. Currently these datasets are dispersed and stored in disparate databases. Data and mapping standards need to be created so that these datasets can be compiled for storage, analysis, and dissemination. By organizing mapping efforts, pooling resources, and/or storing data under one roof in a clearinghouse for all, we could increase efficiency, eliminate duplication of effort, and do a better job managing our natural resources and protecting public health, the economy, and tourism.

**What is a likely source:**

*Land use:* The Department of Land and Natural Resources (DLNR), CCH, the LUC, the Counties, and the Military all have information on land use. A combined effort and/or workshops could help to bring these datasets together in a uniform way.

*Land cover:* Funding for imagery is likely come from a consortium of federal, state, local, and private organizations. The Hawai`i IKONOS Consortium is currently receiving orders from over half a dozen public and private organizations who are working together to create a common imagery dataset that can be used for land use and land cover mapping (see the Chapter 2, Imagery). The Military services, the National Park Service (NPS), the CCH, DLNR, and many others have mandates to track land cover. If these groups pulled resources they could eliminate duplication of effort and complete a set of data that benefits all parties.

*Federal or State Listed Species and Habitat:* The USFWS, NPS, The Nature Conservancy of Hawai`i (TNCH), US Army, Maui Pineapple Company's Puu Kukui Preserve, DLNR Division of Forestry and Wildlife (DOFAW) and Division of Aquatic Resources (DAR), Bishop Museum, National Tropical Botanical Garden (NTBG), Pelea Pacifica, USGS Biological Resource Division (BRD), and many others all have information on the location of rare species and habitat. All these organizations and many more need to track rare and legally protected species. By organizing efforts, pooling resources, and storing data under one roof in a clearinghouse for all, we could increase efficiency, reduce or eliminate duplication of effort, and do a better job protecting resources.

*Agriculture land:* The United States Department of Agriculture's (USDA) Farm Service Agency (FSA) and the Natural Resource Conservation Service (NRCS), and the Hawai`i Department of Agriculture (HDOA) as well as the big private agricultural concerns all have data on the location of crops, plantations, and forestry operations.

*Invasive species:* The ISCs, USDA Forestry, TNCH, Maui Pineapple Company, US Army, NPS, DLNR, UH, HDOA, USDA FSA, Bishop Museum, and others, all have data on the location of invasive species.

**Estimated total investment to complete this theme:**

*Land use:*
State Office of Planning (OP): unknown
City & County of Honolulu (CCH): unknown

*Land cover:*
State Office of Planning (OP): unknown
Hawai`i Gap Analysis Project (HI-GAP): $200,000

*Federal or State Listed Species and Habitat:* The backlog of data at the HINHP would take 5 years to map and input. Estimated cost to update the database with existing data could run up to $5,000,000 with an estimated $1,000,000 annually to maintain the data.

*Agricultural land:* Unknown

*Invasive species:* There is currently a backlog of data that may take a year to clean up and input, estimate of $100,000 needed.

**Estimated current allocations of funding**:

*Land use:*
State Office of Planning (OP): unknown
City & County of Honolulu (CCH): unknown

*Land cover:*
State Office of Planning (OP): unknown
Hawai`i Gap Analysis Project (HI-GAP): $200,000

*Federal or State Listed Species and Habitat:*
Hawai`i Natural Heritage Program (HINHP): $50,000 annually

*Agricultural land:* unknown

*Invasive species:* unknown

**Estimated budget shortfall:**

*Land use:* unknown

*Land cover:* $250,000

*Federal or State Listed Species and Habitat:* $950,000

*Agricultural land:* unknown

*Invasive species:* $250,000

**Possible ways to overcome this gap:**

*Land use:*
State Office of Planning (OP): Legislative action both at the State and Federal levels.
City & County of Honolulu (CCH): unknown

*Land cover:*
State Office of Planning (OP): Federal, State, or private grants or funds as well as public and private partnerships could best support the creation and maintenance of this layer
Hawai`i Gap Analysis Project (HI-GAP): has no budget shortfall at this time.

*Federal or State Listed Species and Habitat:* In the long run, the theme would best be supported by a consortium of federal, state, local, and private organizations that pooled resources, supplemented by contracts and grants to help pay for the management and maintenance of this important data layer.

*Agricultural land:* Federal, State, or private grants or funds as well as public and private partnerships could best support the creation and maintenance of this layer.

*Invasive species:* Federal, State, or private grants or funds as well as public and private partnerships could best support the creation and maintenance of this layer.

**Most appropriate data steward**:

*Land use:* It could be OP or another clearinghouse yet to be established.

*Land cover:* It could be OP or another clearinghouse yet to be established. The HINHP under a contract from NBII's PBIN will be acting as a clearinghouse for biological datasets and the HI-GAP land cover dataset as well as other framework datasets will be disseminated on this web site.

*Federal or State Listed Species and Habitat:* HINHP is the likely steward as they all ready maintain the most comprehensive database and GIS repository of endangered species observation data since 1985.

*Agricultural land:* It could be OP or another clearinghouse yet to be established or USDA's FSA or other.

*Invasive species:* The HINHP will be acting as a clearinghouse for biological datasets including invasive species under a contract from NBII's PBIN.

**Maintenance Process:**

*Land use:* Land use should be updated on at least a five year cycle and use a repeatable method so that change detection and/or other spatial analyses can be conducted and rates or extent of change can be quantified. This would require the constant acquisition of high-resolution orthoimagery as well as image classification and ground verification on a cyclical basis. Areas of high or rapid change may require more frequent updates.

*Land cover:* Land cover should be updated on a five year cycle and use a repeatable method so that change detection and/or other spatial analyses can be conducted and rates or extent of change can be quantified. This would require the constant acquisition of high-resolution orthoimagery as well as image classification and ground verification on a cyclical basis. Areas of high or rapid change may require more frequent updates.

*Federal or State Listed Species and Habitat:* Develop partnerships and facilitate database integration and update between USFWS, DLNR, DOD, NPS, TNCH, Bishop Museum, and others who manage rare native species across the state. This would reduce or eliminate duplication of effort, thus increasing efficiency across all agencies.

*Agricultural land:* Agricultural lands should also be inventoried on a regular basis in order to assess the amount of land under cultivation as well as the types of crops being grown. This would require the constant acquisition of high-resolution imagery and image classification on a cyclical basis as well as grown verification.

*Invasive species:* Invasive species should be mapped on a regular basis as crews work to eradicate them. Large scale mapping of invasive species can occur in conjunction with the land cover mapping updated on a five year cycle using a repeatable method in order to conduct change analysis so that patterns and rates of change in the landscape can be quantified. Again, this would require the constant acquisition of high-resolution imagery and image classification on a cyclical basis as well as ground verification.

**Estimated maintenance cost**:

*Land use:* $500,000

*Land cover:* $250,000

*Federal or State Listed Species and Habitat:* $1,000,000

*Agricultural land:* $100,000

*Invasive species:* $250,000

**Reference List**

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NASA Earth Observatory. (2003). Glossary. Retrieved June 4, 2003, from http://earthobservatory.nasa.gov:81/Library/glossary

# CHAPTER 13: MARINE LAYERS

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**Theme Description:**

Marine data are not considered framework data layers in most spatial data infrastructure plans. However, due to Hawai`i unique geography, coastal and marine data are essential to Hawai`i's spatial data community. Marine data included here are *shoreline*, *marine characterizations*, *ocean water quality*, *marine managed areas*, and *marine uses*.

*Shoreline* data are very dynamic. Shorelines are a physical feature that can change on a daily to yearly basis. Hawai`i itself has over 1052 miles of shoreline. Representing such an expansive and dynamic feature in a GIS can be very difficult. To complicate matters, discrepancies exist in how shorelines are defined between various levels of government. For example, the State of Hawai`i defines the shoreline as being the upper wash of the wave at normal times or the natural vegetation or debris line (http://www.hawaii.gov/dlnr/lmd/rules/Ch13_222-Amend-Compil_Stand.pdf)
In contrast, shorelines depicted on National Oceanic and Atmospheric Administration (NOAA) nautical charts are based on mean lower low water lines.

*Marine characterization* covers a broad category of marine data layers, including benthic and mid-water habitats, benthic substrate, and living organisms within the ocean water column. Knowledge of the benthic and mid-water habitats and structures in the ocean environment is important for coral reef and fisheries management.

*Ocean water quality* in this context uses ocean remote sensing to determine sea state, water quality, clarity, and harmful organisms in the water.

*Marine Managed Areas* are areas off-shore in marine waters that have special management conditions on them, such as no fishing of certain species, no fishing at all, or restricted fishing at certain times.

*Marine Use* data layers cover a wide range of activities including commercial and recreational uses. These types of data sets are hard to find but essential to ocean and fishery management.

**Status:**

*Shoreline*: While the State does not have one digital representation of the shoreline, it does have an official shoreline definition. It is defined as the high tide mark as shown by the wash of the waves or the vegetation line, and is determined on a per-parcel basis when a Shoreline Determination Survey is required in the permitting process (www.hawaii.gov/dlnr/lmd/rules/Ch13_222-Amend-Compil_Stand.pdf).

Because of differences in legal definitions, there is not one consistent use of shoreline data among federal, state, and local agencies. Five known data sets representing Hawai`i's shoreline are used within the State. All of these data sets have been derived from different base sources, and none are considered both complete and accurate.

United States Geological Survey (USGS) has 1980 DLG based National Hydrography data that depicts Hawai`i's shoreline, however newer NHD data was just released in 2002.

NOAA also has a defined shoreline depicted on nautical charts for Hawai`i. The shoreline represented on charts are based on mean lower low water lines, are tide-controlled, and are represented at different scales depending on the chart. The shorelines in the nautical chart are also used to determine the legal boundaries for the U.S. Exclusive Economic Zone and state/federal water boundaries. NOAA has also produced a historic high-resolution digital vector shoreline for Hawai`i. The shoreline data originated from scanned raster copies of archived coastal survey maps based on tide-controlled photography used in the production of NOAA nautical charts. The dates of this data range from 1911 – 1986.

Geographic Data Corporation Inc. has a shoreline data set for Hawai`i known to be of good quality, but the source of their data is unknown.

The University of Hawai`i School of Ocean and Earth Science and Technology Coastal Geology Group, led by Chip Fletcher, has created high-resolution vegetation shoreline data from aerial photography for the islands of Maui and portions of Oahu. Historic shorelines were also created in these same areas.

*Marine Characterization*: There are several initiatives currently under way to define marine characterization throughout the Hawaiian archipelago.

In 2002, NOAA contracted with Analytical Laboratories of Hawai`i to map approximately 60% of the main eight Hawaiian islands coral reef habitats in water depths less than 30 meters at a minimum mapping unit of one acre. This work concentrated on using visual interpretation to map coral reef benthos with three different remote sensing platforms: high-resolution satellite imagery, aerial photographs, and hyperspectral imagery. In 2003, NOAA has contracted with STI, Inc. to continue the mapping of the near-shore coral reef habitats using hyperspectral technology. The resulting 40% of the coral reef habitat maps should be completed in 2004.

The USGS, lead by Pat Chavez, is studying the coral reefs of Molokai, Oahu, and Maui. These studies include coral reef mapping, monitoring, remote sensing, sediment transport studies, and collection of tide, wave, and current data from remote stations.

The University of Hawai`i Underwater Research Laboratory is doing work on marine characterization in the main eight Hawaiian islands, although contacts and exact data sources are unknown at this time.

IKONOS high-resolution imagery is being utilized by NOAA Ocean Service (NOS) to map coral habitats in the remote Northwestern Hawaiian Islands (NWHI). NOAA Marine Fisheries Service (Fisheries) are also working in the NWHI to survey the benthic and mid-water habitats and structures (depths less than 200 meters) using side-scan, multi-beam, acoustic, and visual identification. The data should be released by 2007.

*Ocean Water Quality*: Few initiatives are underway to map ocean water quality and conditions. NOAA is interested in mapping and monitoring these ocean conditions, and has set up a Hawai`i CoastWatch node to provide sea surface temperature (SST), chlorophyll, and wave height data to the public. They also have programs looking at special events, such as eddies being formed off the Big Island, which are correlated to high fish productivity areas, and harmful algal blooms (HAB) off Hawai`i and other parts of the world. NOAA Fisheries also has data on buoys and drifters recording oceanographic data throughout the Pacific.

NOAA Fisheries and the University of Hawai`i are completing a Pacific Atlas that compiles and documents oceanographic data for the Pacific Ocean. The atlas will include climatology data, including SST data, HAB data, and mean sea surface heights. The data will also be represented through time series to look at climatology changes of the Pacific Ocean over certain time frames. The project should be completed by 2004.

The State and the University of Hawai`i are leading a more detailed effort to address harmful algal blooms in Hawai`i. Celia Smith from the University is creating a planning strategy for potential harmful algal bloom events in Hawai`i.

*Marine Managed Areas*: There is a national initiative by the NOAA National Marine Protected Area (MPA) Center to inventory the marine managed or protected areas in the United States. The State Division of Aquatic Resources (DAR) has contributed to this inventory.

Besides efforts to map existing marine managed areas (MMA), DAR has contracted with the Hawai`i Natural Heritage Program to perform a marine gap analysis in Hawai`i. The Marine Gap Analysis Program (GAP) is compiling marine data around the islands to develop a strategy for creating a network of MMAs. The first focus area is Maui with hope for expanding the project to all main eight islands.

*Marine Uses*: The main source of marine use data is NOAA nautical charts. NOAA charts depict buoy data, harbor and navigation channels, restricted areas, and dumping

sites. However, other data, such as commercial and transport lanes and telecommunications and utility cables, are not well documented, due to restricted access by the military and utility companies. Other data not included on the charts are local features such as moorings and marinas.

NOAA, Coast Survey, in partnership with OceanGrafix, LLC, offer mariners official nautical charts continually updated by NOAA cartographers to the latest Notice to Mariners and to all Critical Safety Information known to Coast Survey in advance of its publication in a Notice. From NOAA digital files OceanGrafix prints corrected charts, to order, for sale to mariners through the Oceangrafix retail network under the brand name Charts-on-Demand.

Other considerations about marine uses are recreational and commercial use conflicts. Having a data layer of safety areas and existing and potential conflict areas is important. Also any new security zones that may arise out of the Homeland Security efforts will have to be mapped and represented on nautical charts and state maps.

**Data Source:**

*Shoreline*:

- USGS, www.usgs.gov
- NOAA, www.noaa.gov
- NOAA Historical Shoreline, www.csc.noaa.gov/products/shorelines/shpform.htm
- Geographic Data Corporation, Inc., www.gdtcorporation.com
- University of Hawai`i School of Ocean and Earth Science and Technology Coastal Geology Group, www.imina.soest.hawaii .edu:80/coasts/cgg_main.html

*Marine Characterization*:

- NOAA Data, www.coris.noaa.gov/data/welcome.html
- NOS 2002 benthic study (coral reef maps and non-registered photography collected during the project) provided by the Biogeography website, biogeo.nos.noaa.gov/projects/mapping/pacific/territories/data
- NOAA 2004 mapping efforts will be provided to the public through the NOAA Biogeography website, www.biogeo.nos.noaa.gov
- USGS study of coral reefs of Molokai, Oahu, and Maui, walrus.wr.usgs.gov/coralreefs/hi_gate.html
- Contacts for methodology and data regarding the automated benthic habitat classification technique are Rick Stumpf (Richard.Stumpf@noaa.gov) and Kris Holderied (Kris.Holderied@noaa.gov).

*Ocean Water Quality*:

- NOAA Environmental Satellite, Data, and Information Service (NESDIS) CoastWatch, coastwatch.nmfs.hawaii.edu
- NOAA Marine Fisheries Service, www.nmfs.hawaii.edu
- NOAA Coral Reef Ecosystem Investigation, coral.nmfs.hawaii.edu

*Marine Managed Areas*:

- NOAA Marine Protected Areas Center, http://www.mpa.gov
- DLNR, Division of Aquatic Resources (DAR), www.state.hi.us/dlnr/dar

*Marine Uses*:

- NOAA nautical charts, chartmaker.ncd.noaa.gov
- Homeland Security, www.ready.gov
- Local Notice to Mariners
- Military
- Utility companies
- State and private marinas

**Standards:**

*Shoreline*:
FGDC Shoreline Working Group, www.csc.noaa.gov/metadata/shoreline_profile.html
State Legal Description, www.hawaii.gov/dlnr/lmd/rules/Ch13_222-Amend-Compil_Stand.pdf

*Marine Characterization*: NOAA has created benthic classification schemes for Hawai`i with input from federal, state, and local scientists and researchers, biogeo.nos.noaa.gov/projects/mapping/pacific/main8

*Ocean Water Quality*: unknown

*Marine Managed Areas*: FGDC Marine Boundary Working Group www.csc.noaa.gov/mbwg/htm/action.htm

*Marine Uses*: unknown

**Priority:**

Although there is a general desire for one common shoreline used by all organizations, the main priority for a Marine Layer is a digital accurate representation of the State shoreline. Although shoreline delineation can be difficult because of it's dynamic nature, one representation and methodology of the shoreline at a point in time would help serve the many management and research activities in Hawai`i. The second priority for a Marine Layer is a complete and detailed benthic habitat inventory for the Hawaiian archipelago.

**Estimated total investment in this theme:**

*Shoreline*: Approximately $600,000 has gone to the University of Hawai`i in the past few years for vegetation line and historic shoreline mapping. NOAA has contributed at least $200,000 – 300,000 to vectorize historical shorelines for Hawai`i.

Approximately $700,000 has been invested for NOAA chart updates and new shoreline delineation in the Northwestern Hawaiian Islands.

*Marine Characterization*: NOAA has invested approximately 2 Million dollars to the mapping of coral reef habitats in the Hawaiian archipelago.

*Ocean Water Quality*: NOAA maintains a collection of satellites and infrastructure to collect ocean data for the world. Total investment in this theme is unknown at this time.

*Marine Managed Areas*: It is estimated that the NOAA Marine Protected Area (MPA) Center has invested over $350,000 to the inventory of marine managed or protected areas in the United States. The State Division of Aquatic Resources (DAR) has contributed to this inventory through staff time and resources in pulling together the data and information.

The State DAR has also invested an estimated $135,000 towards the Marine GAP project.

*Marine Uses*: Again, over $700,000 has been invested in chart updates for the NWHI. Over $50,000 has been invested in Coast Pilot guides for the main eight Hawaiian Islands in 2001.

**Estimated current state and local contributions:**

**What is needed:**

*Shorelin*e: While it may be a common goal to have one shoreline, differences in management needs, mandates, accuracies, and use of the data prevent that from happening. However, there is a need to have some common standards regarding shorelines.

- The federal government should agree to one common shoreline definition. As of 2003, NOAA and USGS signed an agreement to use one definition for both NOAA and USGS mapping products.
- The State of Hawai`i needs to have an accurate digital representation of the shoreline at a date in time. Because of the legal definition of the state shoreline, the data set would be based on a compilation of individual parcel surveys or based on existing work being done by the University of Hawai`i. Regular updates to the shoreline data set can help to address the dynamic nature of the coasts in Hawai`i and the management and legal issues around changing shorelines.
- Federal, state, and local partners agree to multiple shorelines based on scale of use. A 1:24,000 scale shoreline could be used for federal purposes, 1:6000 scale for state needs, and 1:200 scale for the parcel-level mapping needed for permit review. A modification of this solution would be to dictate what data formats are used to create the shoreline, forcing particular quality control on shoreline development as is in efforts for federal shoreline mapping. Agencies that play a

role in shoreline delineation would need to be involved, these may include Coastal Zone Management Hawai`i, the DNLR/DAR, the U.S. Coral Reef Task Force, USGS, and NOAA.

Because there are so many different versions of shorelines in use today, having one clearinghouse to serve up the data is important. A shoreline clearinghouse would house all the shoreline data sets created in Hawai`i so users can select the most appropriate shoreline data set for their need.

One of the strongest limitations to mapping shorelines is representing ambulatory, legal boundaries in a GIS. NOAA has encountered this with many marine features and is currently developing a handbook to help users understand the issues and steps needed to represent legal definition through digital representations.

*Marine Characterization*: The immediate need seen for mapping habitats is coordinating existing mapping efforts between agencies and organizations.

One way to increase coordination is to have a habitat-mapping clearinghouse. Where the different habitat maps created by different organizations can be available to the community. More detail maps are also needed to look at species level data. Currently, the NOAA products serve as a base line for habitats and structures, but more detail maps need to be created.

There is also a need to integrate and investigate different collection and research methods to create benthic habitat maps. Acoustic data and remote sensing imagery are the top two data formats, but the data collected and their methodologies are not integrated very well. Research needs to be done to find out how these different collection methodologies complement each other.

The Natural Heritage Program, through the Marine Gap Analysis Program (GAP) initiative, is looking to develop a benthic landscape ecology working group to compile ecosystem management schemes for Hawai`i. They are interested in getting support and knowledge from the community.

There is also a need to have NMFS mid-water habitat (depths less than 200 meters) data collected in the main eight Hawaiian islands. NMFS does not have any projects or initiatives in the main eight, but this is seen as a needed data set. Building partnerships in the upcoming years could help NMFS focus attention to the main eight.

*Ocean Water Quality*: The greatest need in this area is to coordinate between agencies when looking at the sources and contributing factors to degraded ocean water quality.

*Marine Managed Areas*: There is a need for a marine managed area clearinghouse that can serve the community. There is also a need to have the state and federal marine management areas (including aquaculture and management zones created by the state) to be incorporated into NOAA nautical charts. Having these data on the charts will help

marine vessels to avoid these protected areas. Coordination between the State, the MPA Center, and NOAA Office of Coast Survey will help to ensure these data are incorporated into the charts.

*Marine Uses*: The greatest need for marine use data is to put digital and non-digital spatial data on the NOAA nautical charts and other state maps. This includes environmental data (e.g., coral reef habitats, marine managed areas, and special use zones), transport lanes, commercial uses, and recreational uses.

There is also a need to get Hawai`i's NOAA charts in vector or electronic format. NOAA has a current initiative to make all the paper maps into Electronic Nautical Charts (ENC). These charts can be brought into a GIS or other mapping software to use for coastal management and navigation.

In order to get Hawai`i's ENCs, the first step would be to determine the priority areas for the State, with harbors and heavy navigation areas being designated first. This list would then go to NOAA's Navigation Manager for Hawai`i, Gerry Wheaton, to determine the timeline for starting the process. The third step would be to find NOAA and outside funds for Hawai`i's 21 charts (including the northwestern Hawaiian islands).

**What is the likely source:**

*Shoreline*: There are two likely sources for a shoreline, one federal and one state. NOAA is mandated to determine the federal shoreline, while the State DLNR/DAR would be the logical source for a state shoreline.

*Marine Characterization*: The likely source for a habitat-map clearinghouse would be NOAA. NMFS plans to host and serve essential fish habitat data online for the main eight and the NWHI in the next year. Expanding their data clearinghouse or adding another clearinghouse with complementary data would help all managers and researchers have access to the many classification schemes and data available in Hawai`i.

The NOAA Coral Reef Program also has a coral reef data clearinghouse called the Coral Reef Information System (CoRIS). CoRIS is designed to be a single point of access to NOAA coral reef information and data products. Making sure any local clearinghouse for habitat data is tied to this federal network is essential.

To satisfy the need for more detail habitat maps, the State seems to be a logical source, as well as the University and other partners. As more areas are mapped and identified in more detail, these data can be added to a state-wide map.

The Natural Heritage Program has also offered to host a clearinghouse in conjunction with the Marine GAP project, with appropriate funding.

*Ocean Water Quality*: Coastal Zone Management Hawai`i's Coastal Erosion Subcommittee could facilitate a study looking at the impacts of soil and coastal erosion

on ocean water quality. A soil erosion study could be done through a federal and state partnership looking at coastal land effects on ocean water quality and turbidity. This project could also tie into EPA's non-point source pollution and the Natural Resources Conservation Services' land-based pollution effects on coral reef health initiatives.

Other possible sources of data and information are the State Department of Health and City and County of Honolulu Board of Water Supply sewage and street outfalls and water monitoring sites, and SurfRider Foundation's SurfCheck program monitoring water quality at Hawai`i's beaches.

*Marine Managed Areas*: NOAA plans to serve data for existing marine management areas, but the State should serve data for more localized areas.

NOAA and the State will need to lead the effort to ensure that marine managed areas are represented on the NOAA nautical charts and other state maps.

*Marine Uses*: NOAA through nautical chart updates.

**Estimated total investment needed to complete this theme:**

*Shoreline*: A State shoreline should be created by the DLNR/DAR through in house staff or a contract to the University of Hawai`i. Funding the University of Hawai`i would continue the current initiative by Chip Fletcher to map vegetation lines for all of the main eight Hawaiian islands. It is estimated it would cost approximately $300,000 for the island of Oahu (including $170,000 for imagery collection) and over $700,000 for the Big Island, with Maui already completed. An estimated $700,000 would be needed to complete the other five.

An updated federal shoreline would be estimated at over one million for all main eight islands.

*Marine Characterization*: NHP/Marine GAP would require $20,000 startup costs to host a clearinghouse.

NMFS would require small additional funds to increase server capabilities to host the data. The estimated cost would be $8000.

*Ocean Water Quality*: NMFS estimates $120,000 would be needed for staff time and additional hardware to finish the Pacific Ocean Atlas.

*Marine Managed Areas*: The state can maintain a data layer of marine managed areas and ensure these areas and any new regulations are represented on the nautical charts. Minimal cost is estimated once the areas are delineated. The main funding is needed to originally compile and create data used to site the marine managed areas originally. The Natural Heritage Program has offered to serve the data for the State for a start-up cost of $50,000.

*Marine Uses*: The estimated cost to make one NOAA nautical chart in electronic format is $12,500, so the total needed for all 21 charts of Hawai`i is $262,500.

**Estimated current allocation of funding:**

*Shoreline*: $300,000 in grants from various sources to University of Hawai`i.
*Marine Characterization*: Current Coral Reef Task Force funding has already been allocated at over 2 million dollars. The HINHP was provided $135,000 for the two-year Marine GAP project.
*Ocean Water Quality*: unknown
*Marine Managed Areas:* unknown
*Marine Uses*: unknown

**Estimated budget shortfall:**

*Shoreline:* Estimate $300,000 to complete the island of Oahu, $700,000 for the Big Island, and over $700,000 to complete the other five.
*Marine Characterization*: $28,000
*Ocean Water Quality*: $120,000
*Marine Managed Areas*: $50,000
*Marine Uses:* $262,500.

**Possible ways to overcome this gap:**

*Shoreline*: Possible funding sources are the Coastal Zone Management Hawai`i's Shoreline Subcommittee, USGS, NOAA, and the respective counties.
*Marine Characterizations*: Possible funding source is the U.S. Coral Reef Task Force
*Ocean Water Quality*: Possible funding sources are the U.S. Coral Reef Task Force, NOAA, and State Division of Aquatic Resources
*Marine Managed Areas*: Possible funding sources are the State, NOAA, and the MPA Center.
*Marine Uses*: Possible funding source is the private industry.

**Most appropriate data steward:**

*Shoreline*: The most appropriate steward for a federal shoreline is NOAA. The State shoreline should be maintained by DLNR/DAR (with the data distributed by the Hawai`i Office of Planning GIS Program).
*Marine Characterization*: NOAA CoRIS
*Ocean Water Quality*: NOAA NESDIS
*Marine Managed Areas*: MPA Center
*Marine Uses*: NOAA nautical charts

**Maintenance Process:**

*Shoreline*: Maintenance would require using current data sources, such as aerial photography, satellite images, etc., to look at changes of the shoreline every five years. These changes could then be incorporated into both a state and federal shoreline.
*Marine Characterization*: Data would serve as a baseline with updates or re-mapping every five to ten years.
*Ocean Water Quality*: unknown
*Marine Managed Areas*: Updated as new areas are designated or every two to three years.
*Marine Uses*: Updated as areas change.

**Estimated maintenance cost:**

*Shoreline*: State DLNR/DAR would need to invest approximately $50,000 every five years to maintain the shoreline data by updating areas of change and estimated $2 Million to redo the entire shoreline for each islands every 10 years at over one million dollars.

NOAA would need $10,000 – 20,000 every few years to update the nautical charts in areas that have changed due to natural and human events.

*Marine Characterization*: NHP/Marine GAP would require $5,000 for maintenance per year to host a clearinghouse.

*Ocean Water Quality*: unknown

*Marine Managed Areas*: Maintenance costs for the NH/Marine GAP would approximately be $2000 a year for hosting data

*Marine Uses: unknown*

# CHAPTER 14: SCANNED MAPS


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**Theme Description:**

Throughout the state of Hawai`i there are various ad hoc efforts to scan (rasterise) hard copy maps and other spatial data such as plans and photos. It is difficult to clearly define what the "map" refers to in the sense that many organizations maintain geographic materials together. Maps, plans, sketches, engineering drawings, building plans, architectural drawings, design plans, satellite images and air photos are all tools of the trade.

This review of scanned maps is focused on the rasterization of existing materials in existing special collections. In addition for the need to scan maps, especially old or valuable one, indexing and database entry is essential for this resource to of much value. Access to such collections is also an issue, both for the public and private sectors.

**Status:**

**Data Source:**

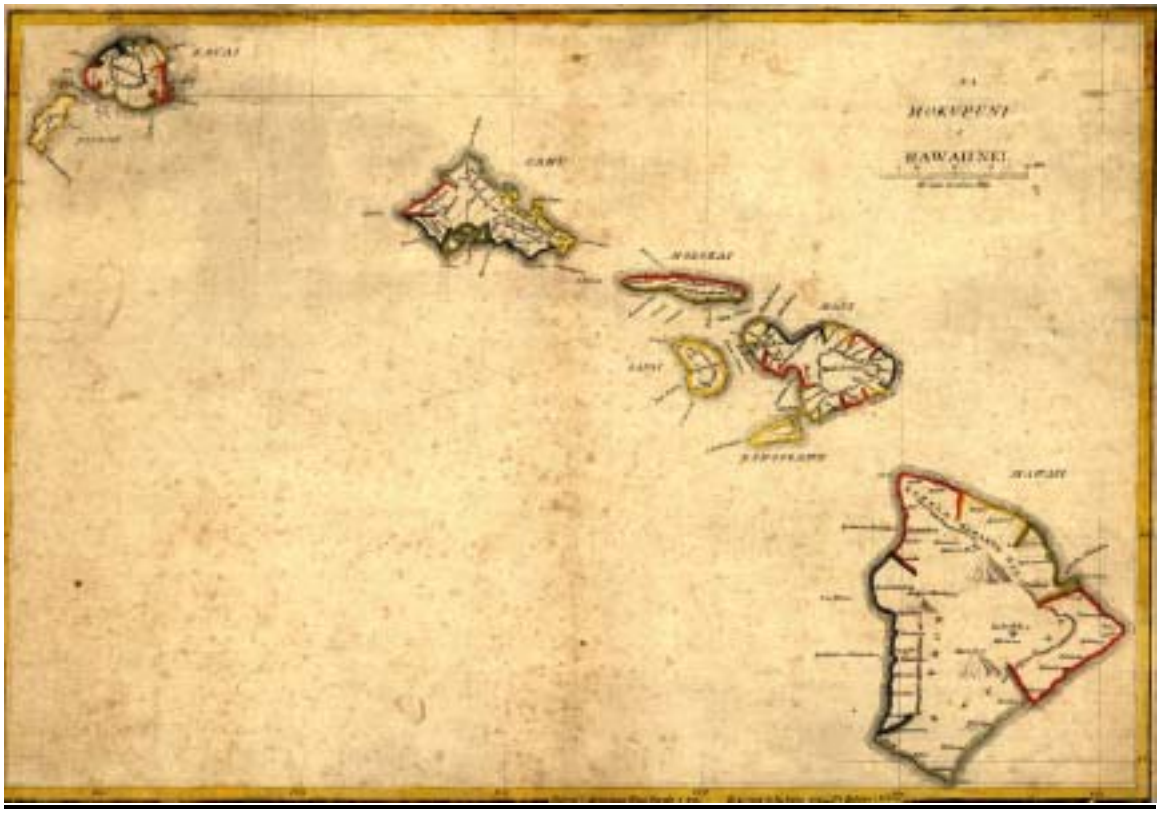
Maps exist in many organizations throughout the state. Many government agencies from federal, state, and county have large amounts of maps. The Library of Congress's Map Collection is being scanned as well. Many individual agencies and divisions within governments have large amounts of maps. Private organizations have less in volume, but none the less are important to recognize. There is potential commercial interest in selling maps also.

**Standards:**

No standard has yet been established. Everyone who is doing scanning is operating independent of standards or as a group working towards integration of efforts and the sharing of information to a community external to their agency. The Library of Congress is doing one of the larger programs of map scanning. They have a large collection of maps, and have made many available on the web with a complex search engine to locate maps of interest. The URL to there site shows how a more mature effort looks; http://memory.loc.gov/ammem/gmdhtml/gmdhome.html .

**Priority:**

No set priority has been set or discussed. As this action is being done by individual agencies, each agency defines priority and value of this work. To address this lack of coordination and protocol, the first efforts by the local agencies is to come together and begin discussing the scope of work. There needs to be some idea of who has the collections and how many items exist. Coordination of file formats is of great importance. The method of cataloging and index is equally important. The establishment of metadata standards is also needed.




One of the first maps printed in Hawai`i, Library of Congress Collection

**Estimated total investment in this theme:**

As this effort to convert hard copy maps into raster data is so varied in nature, it is difficult to anticipate a cost. There are methods to estimate certain types and methods of imaging and storage which will begin to define costs. Whether outsourcing or in-house efforts are done, the same time and materials are required.

Technology has played a major role in determining the cost and feasibility of scanning maps. New large format color scanners are now on the market, starting in the low $20,000 range. This is a major change from a decade ago when the equipment was so costly and cumbersome that few agencies would even consider massive scanning projects. The availability of cheap computer memory and the newer fast chip sets have really only recently made such undertakings possible.

**Estimated current state and local contributions:**

Many state and local activities are underway in various forms. Several different agencies were polled for this initial investigation. State Archives has a large format scanner (grayscale), and have begun scanning file plans and other maps in their special collection, several thousand to date. Historic Preservation has been scanning maps related to archeological reports. Their efforts are mainly focused on later vectorizing the data for use in GIS. The Map Collection at Hamilton library has no large format scanner and there are no plans to begin scanning.

The City and County of Honolulu has begun a major effort to scan over 2 million documents and maps. Already 750,000 such materials have been scanned and are also accessible in the City's robust document Land Information System (HOLIS). The City has outsourced the work. Kamehameha Schools has been working on scanning their entire special collection, consisting of maps, air photos, building plans, etc. This work is being done internally with a large format color scanner.

Costs are difficult to assess, many agencies have purchased large-format scanners and are doing the work with current staff. Large format scanners cost about $25,000 alone. For a successful project, one also needs a powerful workstation, imaging software, cataloging and indexing software (database), and storage solutions.

The other alternative is to completely outsource the effort. This can cost on average $1 per page up to several dollars per map.

**What is needed:**

This effort is being done by agencies that feel the need to do this. As prices drop for equipment, and technology makes this type of effort both cheaper and easier, more agencies will adopt this procedure. Standards will develop most likely as more agencies begin to use and distribute data in this format.

Forming a group of interested agencies to discuss these efforts would strengthen the effort and help clear up the many unanswered questions. The development and adoption of standards and review of other map scanning efforts worldwide would help local participants better accomplish the large task.

**What is the likely source:**

Each agency tasked with stewardship of existing collections. As the ownership of these special collections bridges federal, state, county agencies and some private ownership, no easy one solution to funding currently exists for this effort. For the next few years it seems likely that individual efforts funded internally will continue to be the main method of scanning maps.

**Estimated total investment need to complete this theme:**

There can never be a completion of this theme as maps and other spatial data are produced each day. There maybe a time in some distant future that all data is store digitally, even in vector format, however with the massive amount of existing data already in hard copy format clearly many millions of dollars are required to meet the existing inventory.

**Estimated current allocation of funding:**

It is difficult to accurately measure current spending on this effort. This is especially the case when agencies are performing the task in-house as staff time is not always listed as cost. Also, the purchase of the $25,000 scanner is really an investment spread out over the life of the equipment.

**Estimated budget shortfall:**

As no coordinated effort in this area has been established here in Hawai`i, the shortfall is not relevant. Once the true number of maps, there size and condition is known, the cost for both in-house scanning or outsourcing would be easy to calculate.

**Possible ways to overcome this gap:**

There is little likelihood that much more efforts will be done outside of what is already underway. While there maybe desire to have all hard copy maps rasterised, the large cost and backend infrastructure needs will keep the current pace, with gradual increases. External funding may be available, especially if local agencies were to band together. Grants or other funding probably could be found, or sharing costs by a partnership is something that needs to be explored.

**Most appropriate data steward:**

The agencies that are in current stewardship of the hard copies are best suited to continue in this role. Discussions should begin to the sharing of map collections. The actual stewardship of the hard copy and probably the scanned version is probably best done by the current owner. However the sharing and dissemination of such data maybe best done by a group such as HIGICC or a similar group.

**Maintenance Process:**

It is just as important in the digital realm as with the physical storage of hard copy materials to provide protection and upkeep. This includes file format conversions and back-up services of hard drives. New database technology whereby rasters can easily be stored in relational databases may hold a key future in this effort.

**Estimated maintenance cost:**

It will always be the case that it is less expensive to maintain the data then to rasterise it in the first place. These cost will vary depending on the organization, and there use and storage of the material.

# CHAPTER 15: DATA DISTRIBUTION/PUBLISHING

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## Theme Description:

Data Distribution/Publishing:
Data Distribution and Publishing refers to the mechanisms used to share and publish geospatial data. In Hawai`i, this includes several GIS data download sites and one National Spatial Data Infrastructure (NSDI) Metadata Clearinghouse Node. In addition, much geospatial data is shared informally, via email attachments, CDs, etc.

Metadata:
No discussion of data distribution is complete without discussing metadata. Metadata is commonly referred to as "data about data." In relation to geospatial data sets, metadata should provide information as to a data set's origin, content, quality, condition and availability.

The two most common metadata standards for geospatial data are the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM) Version 2, and the International Organization for Standardization ( ISO) International Standard 19115 for Geographic Information - Metadata. The FGDC Standard is a widely used national standard, while the ISO standard is an international standard which is likely to eventually be adopted by the FGDC. The HIGICC will have to choose which of these standards it will adopt.

In Hawai`i, there is a wide range of adherence to the practice of creating metadata. Some agencies don't create it at all, others create metadata that is not compliant with any standard, and still others create FGDC compliant metadata.

## Status:

Data Distribution/Publishing:

Many of the most commonly used data sets in Hawai`i are already distributed on line, either via FTP or via web browser download. For example, both the State of Hawai`i GIS Program and the City and County's Honolulu Land Information System (HOLIS) have over 50 data layers each available for download. Another way that geospatial data is made available in Hawai`i is through web services, for example using ESRI's ArcIMS to allow queries of the State's or the County's GIS databases.

In addition to the publicly distributed databases, there are numerous data sets that are not available, for a variety of reasons. Some data sets have distribution restrictions either because they are proprietary (e.g., GDSI parcel data) or because they contain sensitive information (e.g. archaeological sites, rare species). Other data sets are not available because they were created for a specific project, because they haven't been quality checked, or because there is no easy mechanism to distribute the data. Another common reason for not distributing data sets is that they haven't been properly documented (i.e., metadata has not been created).

Metadata:

Data publishers often don't create metadata for their geospatial data – data is frequently exchanged with little or no documentation. When metadata is created, it is often missing key information – for example metadata may not contain information about the data's datum or projection, or doesn't contain information describing attributes. Much of the metadata available, although it may contain all of the relevant necessary information for proper use of the data, may not be FGDC compliant (e.g., the State of Hawai`i uses .txt files which describe source, projection and attribute information, but are not in a compliant form). Other metadata may be FGDC compliant, but still doesn't contain the information necessary to properly use the data (e.g., the City and County of Honolulu has a great deal of FGDC compliant metadata that lists identification information, but does not describe attribute values, source information, dates, etc.).

Currently, there is one NSDI Metadata Clearinghouse Node in Hawai`i , hosted by the Office of Planning In addition, geospatial data users can query the National Biological Information Infrastructure (NBII) clearinghouse node.

**Data Sources:**

Data Distribution/Publishing:

There are multiple sources of on-line geospatial data in Hawai`i, as listed in Appendix E. The key data distribution/publishing sites are:

State of Hawai`i GIS Program Download Site: http://www.state.hi.us/dbedt/gis/
State of Hawai`i GIS Program IMS Site: http://gis.state.hi.us/website/OPMap
Honolulu Land Information System (HOLIS) Download Site: ftp://gisftp.hicentral.com/
Honolulu Land Information System (HOLIS) Interactive Mapping Sites:
http://gis.hicentral.com/website/parcelzoning/viewer.htm,
http://gis.hicentral.com/website/ecodev/ed.asp
Pacific Basin Information Node (PBIN): http://pbin.nbii.gov/
Pacific Disaster Center (PDC) Interactive Mapping Site: http://www3.pdc.org/iweb/
Maui High Performance Computing Center (MHPCC) Data Download FTP Site:
ftp://sync.mhpcc.edu (Currently hosting USDA DOQQs for download).

Metadata:

Currently, there is one Z39.50 NSDI Metadata Clearinghouse Node using I-Site in Hawai`i , hosted by the Office of Planning and accessed through the FGDC metadata clearinghouse: http://www.fgdc.gov/clearinghouse/clearinghouse.html

In addition, Hawai`i GIS users access the National Biological Information Infrastructure (NBII) Metadata Clearinghouse: http://www.nbii.gov/datainfo/metadata/clearinghouse/

## Standards:

Data Distribution/Publishing:

There are no standards in Hawai`i for data distribution or publishing at this time. Data is available for download at the various download sites listed above in either http or ftp format. Many of the interactive mapping sites listed above use ESRI's ArcIMS, though the use of this software is not required, nor is it an established standard.

Metadata:

Hawai`i's NSDI metadata clearinghouse node uses the ANSI standard Z39.50 (http://www.blueangeltech.com/Standards/GeoProfile/geo22.htm) for the query, search, and presentation of search results to web clients. Currently, the metadata stored in the clearinghouse node uses the FGDC Content Standard for Digital Geospatial Metadata, Version 2.0 (FGDC-STD-001-1998; http://www.fgdc.gov/metadata/contstan.html).

As mentioned above, the two common standards used for geospatial metadata are the FGDC standard and the ISO standard. There are plans to merge the two standards into one in 2003. Specifically, "The US will adopt ISO 19115 as FGDC Version 3 and will expect and support the new XML structure as the primary service exchange. The existing required search fields will be mapped against the new ISO field targets, so the Z39.50 search "will go through" using the same old tags." (See http://clearinghouse4.fgdc.gov/fgdcfaq/showquestion.asp?faq=6&fldAuto=148)

Once the FGDC/ISO metadata standard harmonization activity is completed, Hawai`i's Clearinghouse node should be converted to use the FGDC Version 3 / ISO 19115 standard.

The NBII Clearinghouse Node uses the NBII Metadata Standard (FGDC-STD-001.1-1999), which is an enhancement of FGDC metadata standard (http://www.fgdc.gov/standards/status/sub5_2.html).

## Priority:

Data Distribution/Publishing:

The establishment of downloading or interactive web sites should have a fairly high priority, as it makes data sharing easier.

Metadata:

The maintenance of Hawai`i's metadata clearinghouse node should be given a high priority, as the node could be the best mechanism for geospatial data discovery and to reduce duplication of effort in the creation and maintenance of GIS data.

**Estimated total investment in this theme:**

Data Distribution/Publishing:

Unknown. The various download and interactive mapping sites are maintained by a variety of governmental entities in and outside of Hawai`i, with varying degrees of investment in both dollars and staff time.

Metadata:

Unknown. In the case of the NSDI Clearinghouse Node maintained by the Office of Planning, there has been no monetary investment. The site was set up on an existing web server using free I-Site software. Investment of staff time has been minimal as well, due to lack of resources, which has resulted in some down time for the node, as well as a very minimal set of metadata records being housed on the node.

**Estimated current state and local contributions:**

Data Distribution/Publishing:

Almost all data distribution and publishing is done at the state and local level in Hawai`i, with some download/interactive mapping sites being housed and maintained by federal agencies.

Metadata:

The State of Hawai`i Clearinghouse Node is maintained entirely by State government. The NBII Clearinghouse is a partnership between local, state, federal and private agencies and organizations.

**What is needed:**

Data Distribution/Publishing:

There are no pressing needs at this time.

Metadata:

There should be one metadata clearinghouse for data developed in Hawai`i , to which all data developers/holders would submit their metadata for publication.

In order to have a successful metadata clearinghouse, GIS data developers/publishers must be encouraged to develop useful, compliant metadata.

A decision must be made as to whether the Office of Planning will continue to host the node, and whether this will be the only Hawai`i clearinghouse node, housing all of the metadata from various GIS data holders in the State (i.e., State, County, Private, Non-profit). Other possible hosts for a single, comprehensive node would be the Pacific Disaster Center (PDC), the Maui High Performance Computing Center (MHPCC) the University of Hawai`i (UH), and the Pacific Basin Information Node (PBIN). Another option would be for each county to host their own node. Issues to consider in making the decision would include staffing and funding to maintain the node, as well as the future organizational placement and structure of the Office of Planning.

**What is the likely source:**

Unknown.

**Estimated total investment needed to complete this theme:**

More staff time, possible server upgrade or new server ($7,000).

**Estimated current allocation of funding:**

$0

**Estimated budget shortfall:**

$0 - $7,000

**Possible ways to overcome this gap:**

Unknown

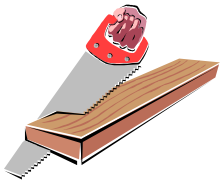
**Most appropriate data steward:**

State of Hawai`i, Office of Planning.

**Maintenance Process:**

A mechanism needs to be established for the host of the node to receive metadata from participants. Most likely, this would require that data holders submit compliant XML files to whatever agency is hosting the node, which would then publish the file.

# CHAPTER 16:CROSS-CUTTING ISSUES



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**Theme Description**

Three issues crosscut two or more of the data layers. A statewide resolution of these issues is required to increase the ability to share data among various users.

SPATIAL CO-REGISTRATION OF FEATURES

The lack of spatial co-registration of features is one of the biggest hindrances to both cartographic and analytic uses of GIS, and one of the most costly to rectify. One of the most frequently noticed examples of spatial mis-registration is between the parcel level data maintained by the counties, and the TIGER data maintained by the U.S. Census Bureau. The TIGER data was derived from smaller-scale, national data sets that are less spatially accurate than the parcel data derived from larger-scale, county data sets. Street centerlines from the TIGER data often do not follow the road casings on the parcel data. Sometimes they are off by only a few feet, sometimes they are off by hundreds of feet. One result is that cartographically you cannot efficiently use the TIGER lines (which have street names as attributes) to place street names in the parcel road casings. Another result is that analytically you cannot efficiently use census block data in an overlay analysis with parcel-base data. Both of these reduce the potential savings that can be realized through the sharing of data.

The solution is to use a common base layer and build the other layers in reference to it – spatial co-registration of features. This is part of the incentive behind the seven NSDI Framework layers. If everyone uses the same framework layers, then there is a better chance that their data products will spatially co-register. If a census block boundary follows a road, and a county zoning boundary follows that same road, then they should both use the same feature representation of that road in their data layer to ensure spatial co-registration. And that road feature should align within the road casing on the parcel data layer.

Spatial co-registration of features is very costly if done after the data has been created, although this can sometimes be justified by the benefit to be derived. Registering the TIGER data to the parcel data layer is an example of a high-benefit activity. GIS users creating new data layers should identify their framework basemap features and be sure to maintain spatial co-registration during their data creation process. This can be done at

little or no additional cost (it can sometimes be less costly) and the long-term benefit is significant.

## HAWAIIAN PLACE NAMES

Hawaiian place names and other Hawaiian words in databases can require special characters to correctly spell the word. These two characters are the macron and the glottal stop. The macron is placed above certain vowels to indicate a lengthening of the sound and the glottal stop is placed between two vowels to indicate a brief break in the sound. These special characters do not cause any problem in GIS data layers if used consistently and if coded consistently. Unfortunately, this has not been the case. Most data layers do not use the special characters at all. This can result in confusion because the special character can completely change the meaning of a word. Its absence can make two names look the same when they are not. It also makes comparisons and data relationships less precise when one data layer uses special characters and the other does not. Even if two data layers both use the special characters, they may not code them the same way resulting in mismatches at the data level.

Efforts are underway to standardize the spelling of Hawaiian place names and to standardize the way they are coded. The Hawai`i Board of Geographic Names and the University of Hawai`i are both involved in this. GIS users should follow these guidelines to improve their ability to share data sets.

## ADDRESSES AND GEOCODING

Geocoding is the process of locating a feature on the map based on its address. Addresses suffer from the same lack of standards in the use of Hawaiian names with special characters as described earlier. In addition, some counties use hyphens as part of their address numbers. Newer GIS software can handle hyphenated addresses, but older software could not. Also, in some counties, consistent addresses have not been assigned in the rural areas. All of these issues make geocoding less efficient.

Standards need to be defined both for the reference data sets that are used for geocoding and for the address data sets that are being geocoded. Ideally, once the standard reference data set has been established, users entering address data will be able to quickly check and make sure they have a valid address. This issue is critical for emergency response and homelands security, as well as for many health, elections, and business users.

# LIST OF TERMS

ARPA – Archeological Resources Protection Act
BRD - USGS Biological Resource Division
BTS – Bureau of Transportation Statistics
CAD – Computer Aided Design
CAMA – Computer Aided Mass Appraisal
CBN – Cooperative Base Network (geodetic control)
C-CAP - Coastal Change Analysis Program
CCH – City and County of Honolulu
CCRT – Center for Conservation, Research and Training
CLAIMS - Cultural Landscape Assessment, Inventory and Management System
CLI – Cultural Landscape Inventory
COGO – Coordinate geometry
CoRIS – Coral Reef Information System
CORS - Continuously Operating Reference Stations
CSDGM – FGDC Content Standard for Digital Geospatial Metadata
CWRM – State Commission on Water Resource Management
DAR – Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawai`i
DBEDT – Department of Business/Economic Development and Tourism, State of Hawai`i
DEM - Digital Elevation Model
DFIRM – Digital Flood Insurance Rate Map
DHHL – Department of Hawaiian Home Lands
DLG – Digital Line Graph
DLNR – Department of Land and Natural Resources, State of Hawai`i
DOFAW – Division of Forestry and Wildlife, Department of Land and Natural Resources, State of Hawai`i
DOH – Department of Health
DOQQ – Digital Ortho Quarter Quad
DPP – Department of Permitting and Planning, City and County of Honolulu
DRG – Digital Raster Graphic
ENC – Electronic Nautical Charts
ESRI - Environmental Systems Research Institute
ETM – Landsat 7 Enhanced Thematic Mapper
FBN – Federal Base Network (geodetic control)
FEMA – Federal Emergency Management Agency
FGDC – Federal Geographic Data Committee
FHWA – Federal Highway Administration
GAP – Gap Analysis Program
GDSI – Geographic Decision Systems International
GDT – Geographic Data Corporation, Inc.
GIS – Geographic Information Systems
GNIS – Geographical Names Information System
GPS – Global Positioning System
HAB – Harmful algal bloom

HALS - Hawai`i Association of Land Surveyors
HDOA - Hawai`i Department of Agriculture
HELCO – Hawai`i an Electric Company
HI-DOT - Hawai`i Department of Transportation
HI-GAP - Hawai`i Gap Analysis Project
HIGICC – Hawai`i Geographic Information Coordinating Council
HINHP - Hawai`i Natural Heritage Program
HOLIS - City and County of Honolulu's Honolulu Land Information System
HPMS – Highway Performance Monitoring System
HVO – USGS Hawai`i Volcano Observatory
IDP – Imagery derived product
IMS – Inertial Measurement System
ISO 19115 – International Organization for Standardization Standard 19115 for Geographic Information – Metadata
LIDAR – Light Detection and Ranging
MHPCC – Maui High Performance Computer Center
MMA – Marine Managed Area
MMU – Minimum Mapping Units
MPA – Marine Protected Area
NAD (27,83) – North American Datum of (1927, 1983)
NBII - National Biological Information Infrastructure
NED – National Elevation Dataset
NEPA - National Environmental Policy Act
NGS – National Geodetic Survey
NHD – National Hydrography Dataset
NHL – National Historic Landmarks
NHPA – National Historic Preservation Act
NIMA – National Imagery and Mapping Agency
NMD – National Map Division, United States Geological Survey, Department of Interior, United States Federal Government
NMFS – National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Department of Commerce, United States Federal Government
NOAA – National Oceanic and Atmospheric Administration, Department of Commerce, United States Federal Government
NOS – National Ocean Services, National Oceanic and Atmospheric Administration, Department of Commerce, United States Federal Government
NRCS - Natural Resource Conservation Service
NSDI – National Spatial Data Infrastructure
NSRS – National Spatial Reference System
NSSDA - National Standard for Spatial Data Accuracy
NTBG - National Tropical Botanical Garden
NWHI – Northwestern Hawaiian Islands
NWI – National Wetlands Inventory
OP – State of Hawai`i Office of Planning
PASH – Public Access Shoreline Hawai`i
PBIN – Pacific Basin Information Node

PDC – Pacific Disaster Center
POSSE – Public One Stop Service, the City and County of Honolulu's automated permit tracking and workflow system.
RCUH – Research Corporation of the University Hawai`i
RDBMS – Relational database management system
RMSE – Root Mean Squared Error
SAR – Synthetic aperture radar
SHPD – State Historic Preservation Division, Department of Land and Natural Resources, State of Hawai`i
SOEST – School of Ocean and Earth Science and Technology – University of Hawai`i
SST – Sea surface temperature
SDTS – FGDC Spatial Data Transfer Standard
STORET – Environmental Protection Agency's Storage and Retrieval database used for water quality information
TIGER – Topologically Integrated Geographic Encoding and Referencing System (U.S. Census)
TMK – Tax map key
TNCH - The Nature Conservancy of Hawai`i
TNM – The National Map
UH – University of Hawai`i
UHM – University of Hawai`i, Manoa
USFWS – U.S. Fish and Wildlife Service
USGS - United States Geological Survey, Department of Interior, United States Federal Government
UTM – Universal Transverse Mercator (map projection)

# LIST OF STANDARDS

FGDC (Federal Geographic Data Committee) Geospatial Positioning Accuracy Standards, Part 2:Standards for Geodetic Networks (FGDC-STD-007.2-1998),

FGDC Spatial Data Transfer Standard (SDTS), Part 6:Point Profile (FGDC-STD-002.6).

FEMA Base Map Standards for new Digital Flood Insurance Rate Map (DFIRM) products – vertical RMSE of 18.5 centimeters; horizontal RMSE of 1 meter; and DEM point spacing of 5 meters. http://www.fema.gov/mit/tsd/mm_lidar.htm.

Federal Geographic Data Committee (FGDC), Geospatial Positioning Accuracy Stands, and Part 3: National Standard for Spatial Data Accuracy (NSSDA). See FGDC-STD-007.3-1998. http://www.fgdc.gov/standards/status/sub1_3.html.

Federal Geographic Data Committee (FGDC), Draft Standard for Digital Elevation Data. http://www.fgdc.gov/standards/documents/proposals/prodigel.html.

Hawai`i's NSDI metadata clearinghouse node uses the ANSI standard Z39.50 (http://www.blueangeltech.com/Standards/GeoProfile/geo22.htm)

Currently, the metadata stored in the clearinghouse node uses the FGDC Content Standard for Digital Geospatial Metadata, Version 2.0 (FGDC-STD-001-1998; http://www.fgdc.gov/metadata/contstan.html).

The NBII Clearinghouse Node uses the NBII Metadata Standard (FGDC-STD-001.1-1999), which is an enhancement of FGDC metadata standard (http://www.fgdc.gov/standards/status/sub5_2.html).

The two standards for the National Hydrography Dataset will be applicable to the Hydrography theme. These standards are described in "USGS Technical Instructions for the National Hydrography Dataset-High Resolution,", November 1997, and the "USGS National Mapping Program Technical Instructions: Standards for National Hydrography Dataset" July 1999.

Stream naming conventions will follow those reported in Geographical Names Information System (GNIS). Hydrologic unit naming conventions will follow those outlined in the Federal Geographic Data Committee (FGDC) proposal, version 1.0, March 1, 2002 Federal Standards for Delineation of Hydrologic Unit Boundaries.

# URL LISTING BY CHAPTER

EXECUTIVE SUMMARY
http://www.higicc.org/about.asp
http://www.state.hi.us/dbedt/gis/gicc.htm
http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html
http://www.fgdc.gov
http://www.fgdc.gov/I-Team/strategic.html

CHAPTER 1:GEODETIC CONTROL
http://www.ngs.noaa.gov/datasheet.html

0CHAPTER 2: ELEVATION/BATHYMETRY
http://www.higicc.org/
http://www.fema.gov/mit/tsd/mm_lidar.htm.
http://www.fgdc.gov/standards/status/sub1_3.html.
http://www.fgdc.gov/standards/documents/proposals/prodigel.html.

CHAPTER 3:IMAGERY
www.digitalglobe.com
www.rsi.com
www.spaceimaging.com
www.sti-services.com
http://www.fgdc.gov/metadata/meta_stand.html
http://www.asprs.org/asprs/resources/standards.html
http://oceanservice.noaa.gov/mapfinder/products/photos/welcome.html
http://rmmcweb.cr.usgs.gov/public/nmpstds/doqstds.html

CHAPTER 4:HYDROGRAPHY
http://waterdata.usgs.gov/HI/nwis
http://www.epa.gov/STORET/dbtop.htm/
http://nhd.usgs.gov/index.html
http://www.state.hi.us/dbedt/gis/dlnraq.htm
http://mapping.usgs.gov/standards/
http://geonames.usgs.gov/
http://www.fgdc.gov/standards/status/huc.html
http://nhd.usgs.gov/index.html
http://www.epa.gov/storet/

CHAPTER 5:TRANSPORTATION
Title 23 Code of Federal Regulations (CFR) Part 460
http://www.state.hi.us/dbedt/gis/tgrmjrds.htm
http://www.state.hi.us/dbedt/gis/tgrothrds.htm
http://www.state.hi.us/dbedt/gis/majroads.htm
http://www.state.hi.us/dbedt/gis/othroads.htm

ftp://gisftp.hicentral.com/LayrZips/streets.zip
ftp://gisftp.hicentral.com/LayrZips/majroads.zip
http://www.bts.gov/gis/download_sites/gdt/maindownload.html
http://www.bts.gov/gis/download_sites/ntad02/newusdownloadform.html
http://www.fhwa.dot.gov/hep/23cfr470.htm
http://www.fhwa.dot.gov/legsregs/directives/cfr23toc.htm
www.bts.gov/gis/
www.geographic.com
http://www.bts.gov/gis/fgdc/
http://accounting.rutgers.edu/raw/gasb/st/summary/gstsm34.html

CHAPTER 6:CADASTRAL
www.gdsihawaii.com

CHAPTER 7: GOVERNMENTAL UNITS
http://www.state.hi.us/dbedt/gis/index.html

CHAPTER 8:UTILITIES

CHAPTER 9:STRUCTURES

CHAPTER 10: Physical Environment and Natural Hazards
http://geology.about.com/library/bl/maps/blhawaiimap.htm
http://neic.usgs.gov/neis/states/hawaii/hawaii.html
http://www.hazardmaps.gov/atlas.php
http://pubs.usgs.gov/imap/2000/i-2724
www.ocs.orst.edu/prism/prism_new.html
http://geology.usgs.gov/dm
http://www.fgdc.gov/standards/documents/standards/soils
http://www.fgdc.gov/fgdc/coorwg/2002/cwgjan02.html
http://www.fgdc.gov/02nsdi/agency/fema.pdf

CHAPTER 11:CULTURAL RESOURCES
http://www.fgdc.gov/
http://www.nps.gov/gis/data_info/standards.html

CHAPTER 12:TERRESTRIAL LAYERS
http://www.csc.noaa.gov/crs/lca/tech_cls.html
http://www.gap.uidaho.edu
http://www.hawaii.gov/dbedt/gis/download.htm
http://gis.hicentral.com
http://www2.hawaii.edu/~hinhp/
http://www.hear.org/misc
http://www.hear.org/oisc
http://www.hear.org/bimac
http://www.hear.org/momisc

http://www.hear.org/kisc
http://www.hear.org/cgaps
http://www2.hawaii.edu/~hinhp/
http://www.gap.uidaho.edu/handbook/Standards/default.htm
http://www.natureserve.org/prodServices/heritagemethodology.jsp
http://endangered.fws.gov/
http://www.spaceimaging.com/products/IKONOS/pro.htm
http://www.digitalglobe.com/products/ortho.shtml
http://midwest.fws.gov/endangered/glossary/index.html
http://earthobservatory.nasa.gov:81/Library/glossary

CHAPTER 13:MARINE LAYERS
http://www.hawaii.gov/dlnr/lmd/rules/Ch13_222-Amend-Compil_Stand.pdf
http://www.hawaii.gov/dlnr/lmd/rules/Ch13_222-Amend-Compil_Stand.pdf
www.usgs.gov
www.noaa.gov
www.gdtcorporation.com
www.imina.soest.hawaii .edu:80/coasts/cgg_main.html
www.coris.noaa.gov/data/welcome.html
biogeo.nos.noaa.gov/projects/mapping/pacific/territories/data
www.biogeo.nos.noaa.gov
walrus.wr.usgs.gov/coralreefs/hi_gate.html
coastwatch.nmfs.hawaii.edu

CHAPTER 14:SCANNED MAPS
http://memory.loc.gov/ammem/gmdhtml/gmdhome.html

CHAPTER 15:DATA DISTRIBUTION/PUBLISHING
http://gis.state.hi.us
http://www.state.hi.us/dbedt/gis/
http://166.122.100.126/website/OPMap/
ftp://gisftp.hicentral.com/
http://gis.hicentral.com/website/parcelzoning/viewer.htm
http://gis.hicentral.com/website/ecodev/ed.asp
http://pbin.nbii.gov/
http://www3.pdc.org/iweb/
ftp://sync.mhpcc.edu
http://gis.state.hi.us:210
http://www.nbii.gov/datainfo/metadata/clearinghouse/
http://www.blueangeltech.com/Standards/GeoProfile/geo22.htm
http://www.fgdc.gov/metadata/contstan.html).
http://clearinghouse4.fgdc.gov/fgdcfaq/showquestion.asp?faq=6&fldAuto=148
http://www.fgdc.gov/standards/status/sub5_2.html