Government of India & Government of The Netherlands

Technical Assistance
HYDROLOGY PROJECT

DHV CONSULTANTS & DELFT HYDRAULICS with HALCROW, TAHAL, CES, ORG & JPS

VOLUME 5
GIS – CREATION OF DATASETS

OPERATION MANUAL

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1 CREATION OF GIS – DATA SETS

1.1 INTRODUCTION

GIS (Geographic Information System) technology provides the conventional maps with something extra. GIS enables to bring together maps developed separately. Through the process of multiple overlaying it enables to place one map over the top of another and build an interrelationship, to reveal the characteristics of common areas. The essential requirement is to bring the maps into digital format before carrying out the map overlays. Under the HP, GIS datasets are being created for the entire project area. CGWB is responsible for procuring from Survey of India digital toposheets of 1:250,000 scale. The different state groundwater agencies have taken up the task of creating GIS datasets on 1:50,000 scale that would include creation of digital toposheets and thematic maps of five different themes. The GIS dataset will be made available to the surface and groundwater agencies.

The establishment of the Hydrological Information System (HIS) will rely on the data emerging from the dedicated monitoring network established under the project. The groundwater monitoring network is made up of point data sources consisting of gauging sites or observation wells or piezometers, which provide required data from well defined locations. Such points are well distributed over the entire network. The field measurements from such point data source (static and dynamic) are collected regularly through manual measurements/Digital Water Level Recorders (DWLR) and systematically organised in a dedicated groundwater/surfacewater data base. Using the analytical tools the data are being interpreted for understanding the surface water/groundwater flow systems, water quality changes, groundwater resource availability, etc.

For improved understanding of the hydrological/hydrogeological system and for refining the water resource estimations, additional spatial data on surface drainage, land-use, geomorphology, slope, Soils, geology and structures, and man-made (anthropogenic) features are required. The field measurements, when analysed in combination with the spatial data, vastly enhance the understanding of the hydrological system. The GIS tool enables to visualise the real world through integration of the different layers of spatial information and point data.

Digital maps, generated from the toposheets and the thematic data interpreted from satellite imageries, when linked to attribute data stored in the database, provide a new understanding of the water resource system. Linking the point features and the relational database through a spatial relationship will be achieved through GIS tools, which is part of the dedicated groundwater software. GIS will help create, store, manipulate and output map layers.

The availability of GIS tools in the dedicated software will provide new possibilities such as:

- Map elaboration,
- Regional assessment,
- Provide the gateway for modelling studies.

The dedicated groundwater software, has GIS tools for layer wise data manipulation, production of contour maps, slope maps, area calculation, well log presentation, generation of cross section and Digital Image Processing. The supporting hardware with the agencies include, digitizers, scanners, plotters, etc.

The selection of different themes for creation of GIS data sets has been guided by the relevance and commonality to both surface and ground water analysis. Surface water analysis required a minimum set of thematic data on land use, Soil, topography and drainage, while GW analysis additionally require spatial data on geology, geomorphology, structures and lineaments. General supporting data cover settlements, transport network and administrative boundaries. It is envisaged that the minimum data set will be augmented by additional spatial data sets in the course of time.

1.2 WHY GIS?

GIS is an important part of any information system because it provides the platform for using and processing spatial data. GIS will be used to:

- display graphically the spatial data stored in the database, such as the locations of observation wells or rainfall stations;
- display geographical information in the form of map layers, such as thematic maps on land use, Soil, topography and geology;
- display geographical information in the form of images, such as satellite images or areal photographs;
- prepare customised maps according specific map specifications (scale, projection, legend, etc.) by combining individual map layers and spatial data from the database;
- manage and maintain spatial data from the database by making user specified spatial selections and database queries, such as by theme, by spatial feature, by time period, or by a combination of these;
- carry out spatial analysis, such as the aggregation of point measurements over a specified area unit, interpolation and contouring and theme overlaying;
- prepare derived data for inputs to simulation models, such as groundwater models.

1.3 WORK PLAN

To generate GIS data sets on selected themes for integration in the Surface and Ground Water Data Centres in 9 participating States, and in the National Data Centres

1.4 METHODOLOGY

The following methodology applies:

a) The State Ground Water agency will have the responsibility within its state for generating and distributing spatial data sets to the State Surface Water agency and the Central Water Commission and the Central Ground Water Board. The State Level Technical Committee will support the activity;
b) The Surface water and groundwater agencies in each state will integrate data in the respective Data Centres;
c) The Central Water Commission and the Central Ground Water Board will integrate data in the National Data Centres;
d) Data to be generated through outsourcing as per standard methodology;
e) The Spatial data sets will be in 1:50,000 scale in 9 states covered by more than 2600 SoI toposheets; the scale will be 1:250,000 at national level.

1.5 PROCUREMENT PROCESS

Five different procurement actions are involved in the generation of spatial datasets under HP (see Table 1.1). This manual addresses only fresh generation of satellite derived digital thematic data and digitisation of existing thematic maps.

Data Set	Procurement Process
Fresh generation of satellite derived thematic digital data	Hiring the services of State/National Remote Sensing Agencies
Procurement of existing paper maps and digital data	Direct procurement
Procurement of existing digital restricted topomap data	Direct procurement from SoI after clearance from MOD
Digitisation of existing paper maps (including SoI unrestricted maps)	Hiring the services of State/National Remote Sensing Agencies
Digitisation of restricted SoI maps	Direct procurement from SoI, after MOD clearance

Table 1.1: Different Procurement Processes

1.6 SCOPE AND OPERATION MANUAL

Services from a large number of national/state remote sensing agencies can be procured in the preparation of spatial data sets. This Operation Manual provides technical guidelines for the preparation of uniform and consistent spatial datasets by multiple vendors, by standardising the methodology and input and output products.

The chapters of the Operation Manual include:

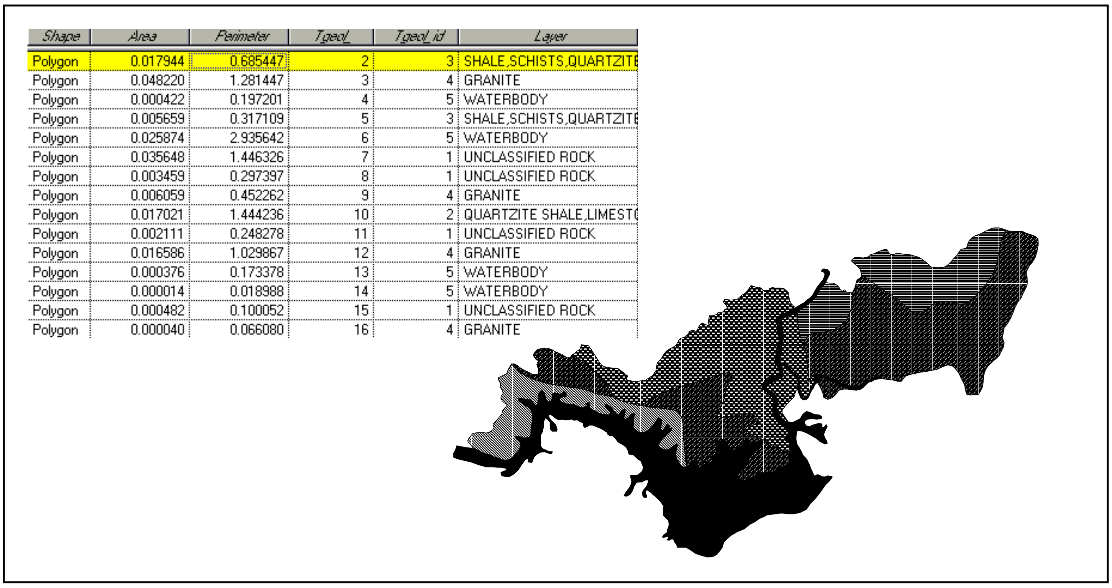
- an overview of data types and models in GIS;
- an overview of spatial data sets;
- theme wise data generation methodology;
- spatial database organization;
- data specifications- map projection, digitisation accuracy, and registration accuracy;
- data coding standards;
- output file naming convention;
- internal QC and external QA, and
- specification for deliverable product.

2 OVERVIEW OF DATA TYPES AND MODELS IN GIS

2.1 DATA TYPES AND MODELS

Data for a GIS comes in three basic forms:

- *Spatial data*, made up of points, lines, and areas, is at the heart of every GIS. Spatial data forms the locations and shapes of map features such as rivers, forests, or cities.
- *Tabular data* is information describing a map feature. For example, a map of well locations may be linked to information about the well construction.
- *Image data* includes such diverse elements as satellite images, aerial photographs, and scanned data—data that's been converted from paper to digital format.



Shape	Area	Perimeter	Tgeol_	Tgeol_id	Layer
Polygon	0.017944	0.685447	2	3	SHALE,SCHISTS,QUARTZITE
Polygon	0.048220	1.281447	3	4	GRANITE
Polygon	0.000422	0.197201	4	5	WATERBODY
Polygon	0.005659	0.317109	5	3	SHALE,SCHISTS,QUARTZITE
Polygon	0.025874	2.935642	6	5	WATERBODY
Polygon	0.035648	1.446326	7	1	UNCLASSIFIED ROCK
Polygon	0.003459	0.297397	8	1	UNCLASSIFIED ROCK
Polygon	0.006059	0.452262	9	4	GRANITE
Polygon	0.017021	1.444236	10	2	QUARTZITE SHALE,LIMESTO
Polygon	0.002111	0.248278	11	1	UNCLASSIFIED ROCK
Polygon	0.016586	1.029867	12	4	GRANITE
Polygon	0.000376	0.173378	13	5	WATERBODY
Polygon	0.000014	0.018988	14	5	WATERBODY
Polygon	0.000482	0.100052	15	1	UNCLASSIFIED ROCK
Polygon	0.000040	0.066080	16	4	GRANITE

Figure 1.1: Tabular data and spatial data

In addition, this data can be further classified into two types of data models:

- *Vector data model* - discrete features, such as well locations and data summarised by area, are usually represented using the vector model.
- *Raster data model* - continuous numeric values, such as elevation, and continuous categories, such as Soil types, are represented using the raster model.

2.2 SPATIAL DATA

Spatial data includes points, lines and areas.

- *Points* represent anything that can be described as a *x, y* location on the face of the earth, such as boreholes, rainfall stations, gauging stations, and buildings.
- *Lines* represent anything having a length, such as roads and rivers.
- *Areas*, or *polygons*, describe anything having boundaries, whether natural or administrative, such as the boundaries of states, and forests.

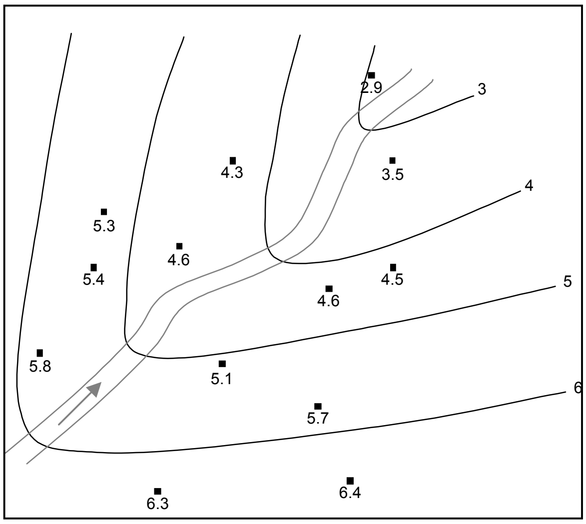


Figure 2.2: Vector Model

The spatial data of points, lines and areas is part of the vector model (see Figure 2.2). With a *vector model*, each feature is defined by *x, y* locations in space (the GIS connects the dots to draw lines and outlines, creating lines and areas).

Features can be discrete locations or events, lines, or areas. When analysing vector data, much of the analysis involves working with (summarising) the attributes in the layer's data table. The attributes are the properties of the spatial features.

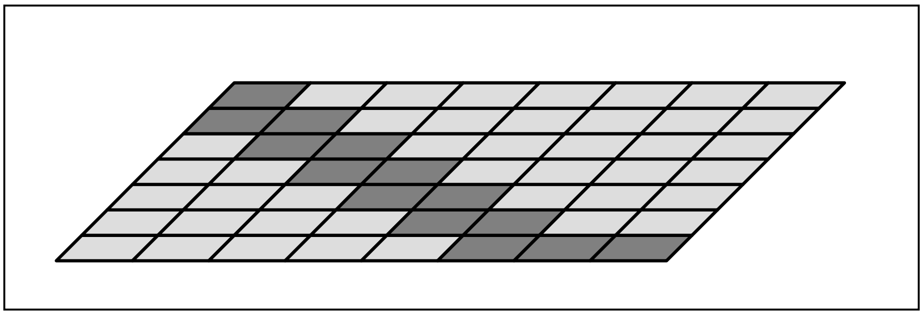


Figure 2.3: Raster model

Another model is the raster model (see Figure 2.3). With the *raster model*, features are represented as a matrix of cells in continuous space. A point is one cell, a line is a continuous row of cells, and an area is represented as continuous touching cells.

Each raster layer represents one attribute (although other attributes can be attached to a cell). And most analysis occurs by combining the layers to create new layers with new cell values.

The cell size used for a raster layer will affect the results of the analysis and how the map looks. The cell size should be based on the original map scale and the minimum mapping unit. Using too large a cell size will cause some information to be lost. Using a cell size that is too small requires a lot of storage space, and takes longer to process, without adding additional precision to the map.

2.3 TABULAR DATA

Tabular data for use in a GIS can be obtained already packaged with spatial data or it can be collected on field forms and entered in the information system.

Data from text files, spreadsheets, or databases like borehole properties, groundwater levels, or groundwater analysis results can be used in a GIS. With the correct spatial data the GIS can link the tabular data with the spatial data. For example, well locations can be presented as points on a geohydrological map. Or the well data can be linked with measured groundwater levels to allow the creation of groundwater level contour maps.

2.4 IMAGE DATA

Images can be displayed as map layers along with other spatial data containing map features. Image data offers a quick way to get spatial data for a large area and is more cost- and time-effective than trying to collect layers of data like buildings, roads, lakes, etc., one at a time. However, image data is one file, or layer, so it can not be broken down into the different components and data attached to them separately. Image data is the best choice if a point of reference is to be added to vector data without attaching additional information.

Images can also be attributes of map features. In other words, images can be added to other map features so that clicking on the feature will display the image. For example, clicking on the point that represents the well may open a picture of a monitoring well.

2.5 USING DATA IN GIS

2.5.1 USING GEOGRAPHIC DATA

A GIS stores information about the world as a collection of themed layers that can be used together. A layer can be anything that contains similar features such as geological units, watershed boundaries, lakes, groundwater level contours, or wells. This data should contain a geographic reference, such as a latitude and longitude co-ordinate. To work, a GIS requires geographic references.

2.5.2 MAP PROJECTIONS

All the data layers must match up correctly to be drawn on top of each other or combined to see relationships. This means they must be in the same map projection and co-ordinate system. Several issues are involved in choosing a map projection and co-ordinate system, including where the area being mapped is located, how large the area is, and whether precise measurement of distance or areal extent is needed.

2.5.3 CO-ORDINATE SYSTEMS

The co-ordinate system specifies the units used to locate features in two-dimensional space and the origin point of those units. To obtain conformity the map sheets in each state will be transformed to the polyconic projection using the central latitude and longitude projection origin of the State. This ensures that the data is already in the same co-ordinate system and projection. If data is being collected from other sources, though, verification of the projection is needed.

2.5.4 USING GEOGRAPHIC ATTRIBUTES

Each geographic feature has one or more attributes that identify what the feature is, describe it, or represent some magnitude associated with the feature. The type of attribute values may be distinguished in:

- Categories
- Ranks
- Counts
- Amounts
- Ratios

Categories are groups of similar things. They help to organise and classify the data. All features with the same value for a category are alike in some way and different from features with other values for that category. For example, wells may be categorised by whether they are production wells, monitoring wells, or exploratory wells. An example of using categories is the groundwater categorisation map, which is based on the results of the water balance calculations (see Figure 2.4).

Category values can be represented using a numeric code or text. Text values are often abbreviations to save space in the table.

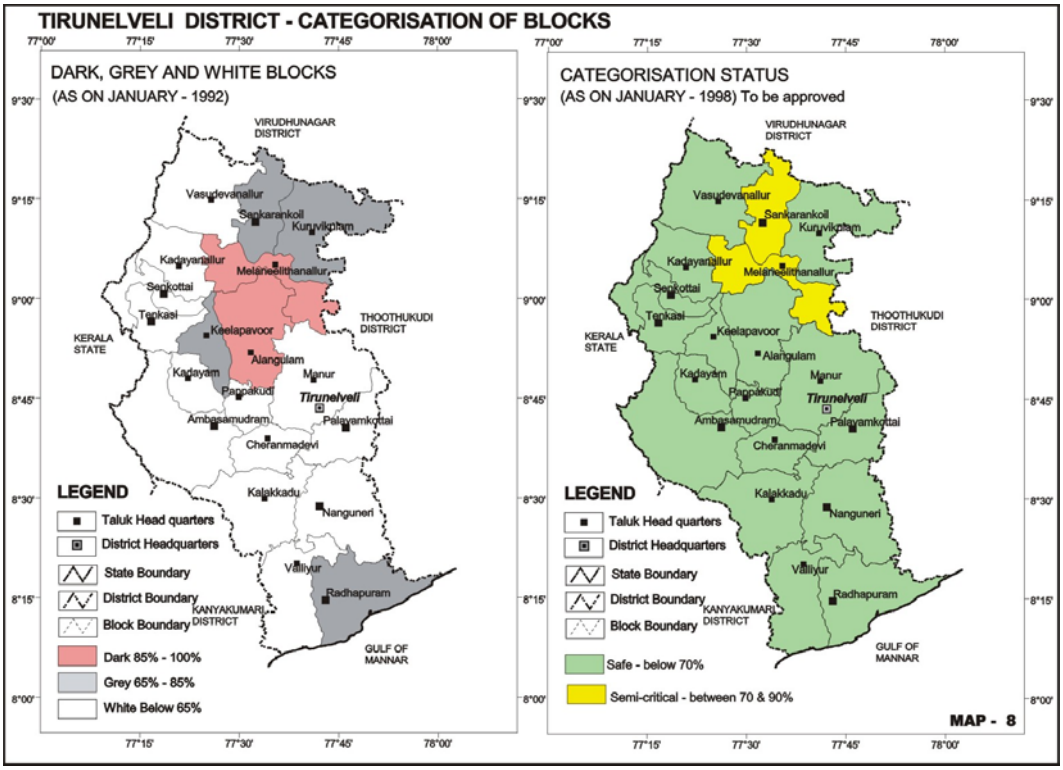


Figure 2.4: Example of maps using category

Ranks put features in order from high to low. Ranks are used when direct measures are difficult or if the quantity represents a combination of factors. For example, ranks are used to indicate the vulnerability of groundwater to contamination. Ranks may be assigned based on another feature attribute, usually a type or category. For example, Soils of a certain type may be assigned the same suitability for growing a particular crop.

Counts and amounts show total numbers. A count is the actual number of features on the map. An amount can be any measurable quantity associated with a feature such as the number of boreholes in a district. A count or amount shows the actual value of each feature as well as its magnitude compared to other features.

Ratios show the relationship between two quantities and are created by dividing one quantity by another, for each feature. For example, dividing the number of people in a block by the number of water supply wells gives the average number of people per well in the block. Using ratios evens out differences between large and small areas or areas having many features and those having few, so the map more accurately shows the distribution of features.

Two special ratios are proportions and densities.

Proportions show what part of a total each value is. For example, dividing the number of wells with a working DWLR in each block by the total number of monitoring wells in each block gives the proportion of wells with a DWLR in operation in each block. Proportions are often presented as percentages (the proportion multiplied by 100).

Densities show the distribution of features or values per unit area. For example, by dividing the population of a block by its land area in square kilometre, gives a value for people per square kilometre.

Categories and ranks are not continuous values—there are a set number of values in the data layer, and more than one feature may have the same value.

Counts, amounts, and ratios are continuous values—each feature potentially has a unique value anywhere in the range, between the highest and lowest values. That is important to realise, because knowing how the values are distributed between the highest and lowest values will help to decide how to group them for presentation, in order to see the patterns.

2.6 METADATA

Metadata is frequently described as "data about data." Metadata is additional information (besides the spatial and tabular data) that is required to make the data useful. It is information one needs to know in order to use the data. Metadata represents a set of characteristics about the data that are normally not contained within the data itself. Metadata could include:

- Information about who created the data;
- Information about when the data was created;
- Definitions of the names and data items;
- A keyword list of names and definitions;
- An index of the inventory and the keyword list for access;
- A record of the steps performed on the data including how it was collected;
- Documentation of the data structures and data models used;
- A recording of the steps used on the data for analysis.

Spatial metadata is important because it not only describes what the data is, but it can reduce the size of spatial data sets. By creating metadata, a standard is created in naming, defining, cataloging, and operating the spatial data. This in turn is a vital foundation for understanding, collaborating, and sharing resources with others.

Spatial metadata is important, because it supports easier spatial data access and management. Metadata provides a guide to the casual and novice user's question, "How do I know what to ask for?" Metadata can provide information on what is available in an area of interest, where the information is, how current it is, what format it is in, and what use constraints apply. For spatial data professionals, metadata provides feature- and attribute item-level metadata management. This way, updates are easily accommodated and integrated into daily use of the data. Metadata is not an end in itself; it is a tool that will greatly improve the work with spatial data and increase the overall GIS benefits.

2.7 CARTOGRAPHY

Mapping is an essential function of GIS. A map can present data in a fashion that other types of presentation media cannot. And best of all, the user does not need to be a skilled cartographer to make maps with a GIS.

Maps from a GIS are created from data in the GIS database. This means that any changes in the GIS database will be automatically reflected in the next printing of a map, allowing changes to a map to be made with minimal effort and cost.

GIS gives the layout and drawing tools that help to make great presentations with clear, compelling documents. GIS may also be employed as a multimedia technology—delivering digital audio and video information linked to maps, charts, and tables.

3 DIRECTORY OF SPATIAL DATA

3.1 SELECTION OF MINIMUM SPATIAL DATASETS

The selection of primary themes for minimum GIS data sets has been guided by the relevance and commonality to both surface and ground water component of HP. Surface water analysis requires a minimum set of thematic data on land use, Soil, topography and drainage, while GW analysis will additionally require spatial data on geology, geomorphology, structures, lineaments and hydrogeomorphology. General supporting data cover settlements, transport network and administrative boundaries. This only constitutes a minimum spatial data set, considering the time and manpower constraints. For example data on irrigation command areas, canal network and other water use sectors such as industries though useful will be difficult to generate immediately. It is envisaged that the minimum data set will be augmented by additional spatial data sets in course of time.

The primary data layers are shown in Figure 3.1. The last six themes are digitized from existing Survey of India maps (and other maps such as AISLUS National Watershed Atlas and State survey department maps) while the other 5 themes are derived from appropriate satellite data. The directory of spatial data in Table 3.1 lists the themes, input and output data, and generation methodology.

3.2 INVENTORY OF EXISTING SPATIAL DATA SETS AND FRESH GENERATION REQUIREMENTS

The extent of fresh data generation requirements has been assessed based on the inventory of existing data sets in map and digital format, generated under national and state programmes (Figure 3.2). The existing data sets have been reviewed under a set of standard criteria (level of thematic classification, mapping and thematic accuracy, age of data, and availability - Table 3.2) for acceptance. Additional generation of data sets (thematic mapping and digitisation, digitisation of existing maps and format conversion of existing digital data sets) will be defined for each state. The preparation of these data sets have been as per the standard methodology, to ensure consistency and uniformity amongst the participating states.

3.3 DATABASE ORGANISATION

The spatial database for each participating state will be organised with 15 minutes by 15 minutes geographic area, corresponding to a SoI 1:50,000 scale map sheet, as the basic map tile. Each map tile will be assigned a unique number, The map tiles covering the state will be precisely identified by superposing the 15 min by 15 min framework on the state map in a suitable scale. Thematic coverage of any specific hydrologic or administrative unit will be generated by digitally mosaicing the map tiles.

Standard and unique TIC Id’s will be created for each cross-section of latitude and longitude at 15 minutes interval. All maps will be digitised by taking TIC points at four corners of each 15 minute tile, and the appropriate Id will be assigned. Additional registration points (permanent manmade features) will be digitised to enable co-registration of scanned maps without lat-long details. The registration point Id will be the map tile number followed by a serial number.

All the map sheets (of each theme) in each state will be transformed to the polyconic projection using the central latitude and longitude of projection origin of the State, by using the same *.prj file (text file containing input and output parameters to be used in map projection).

The list and structure of primary data elements are shown in Table 3.3. The code for each primary theme coverage as also the data structure of the Look up Table (LUT) is listed in respective thematic chapters. Each primary data coverage will be named as for example Landuse54j14 representing the theme and SoI map sheet number, and all associate files will have this identification as the prefix.

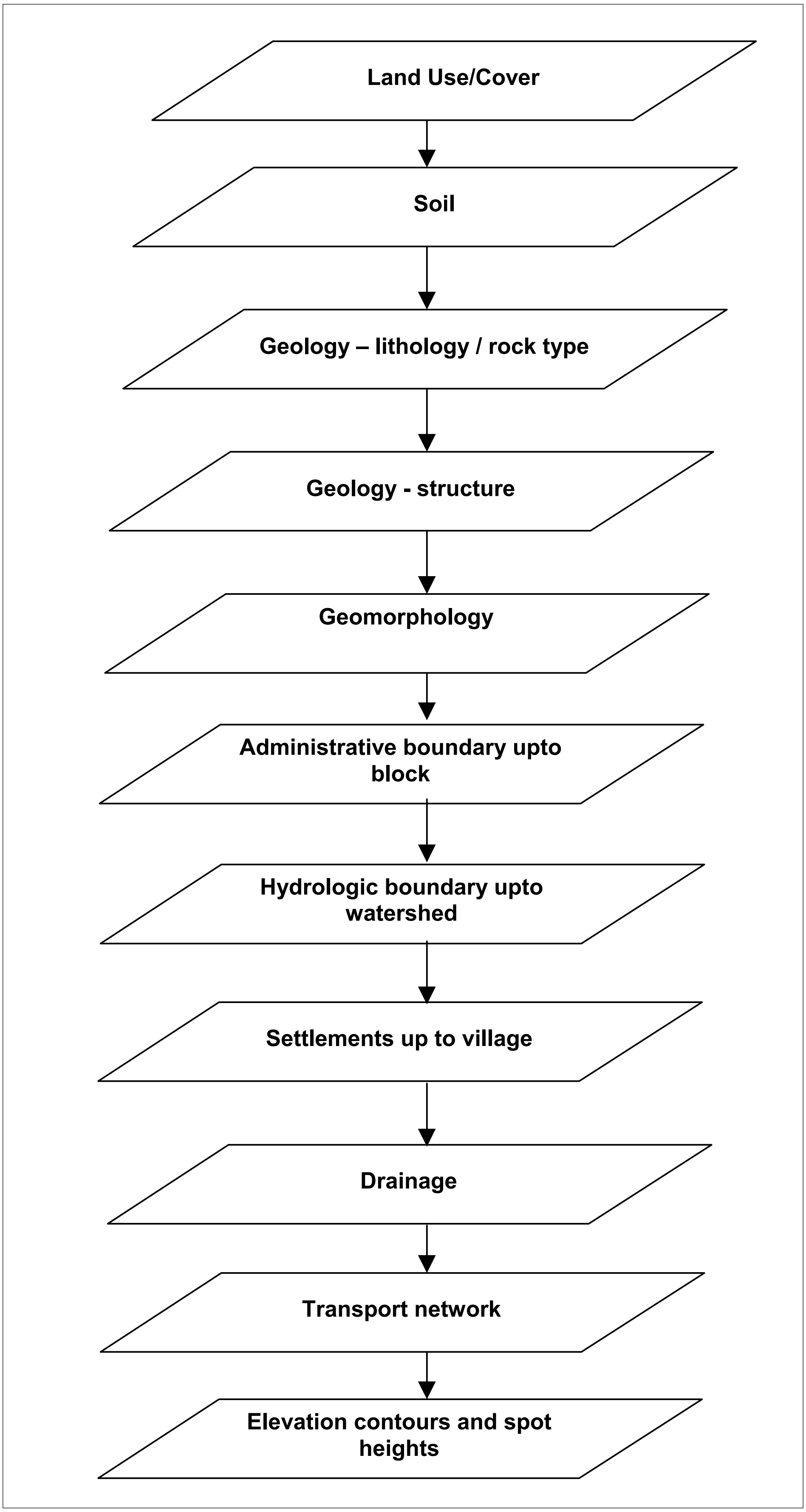


Figure 3.1: Primary data layers

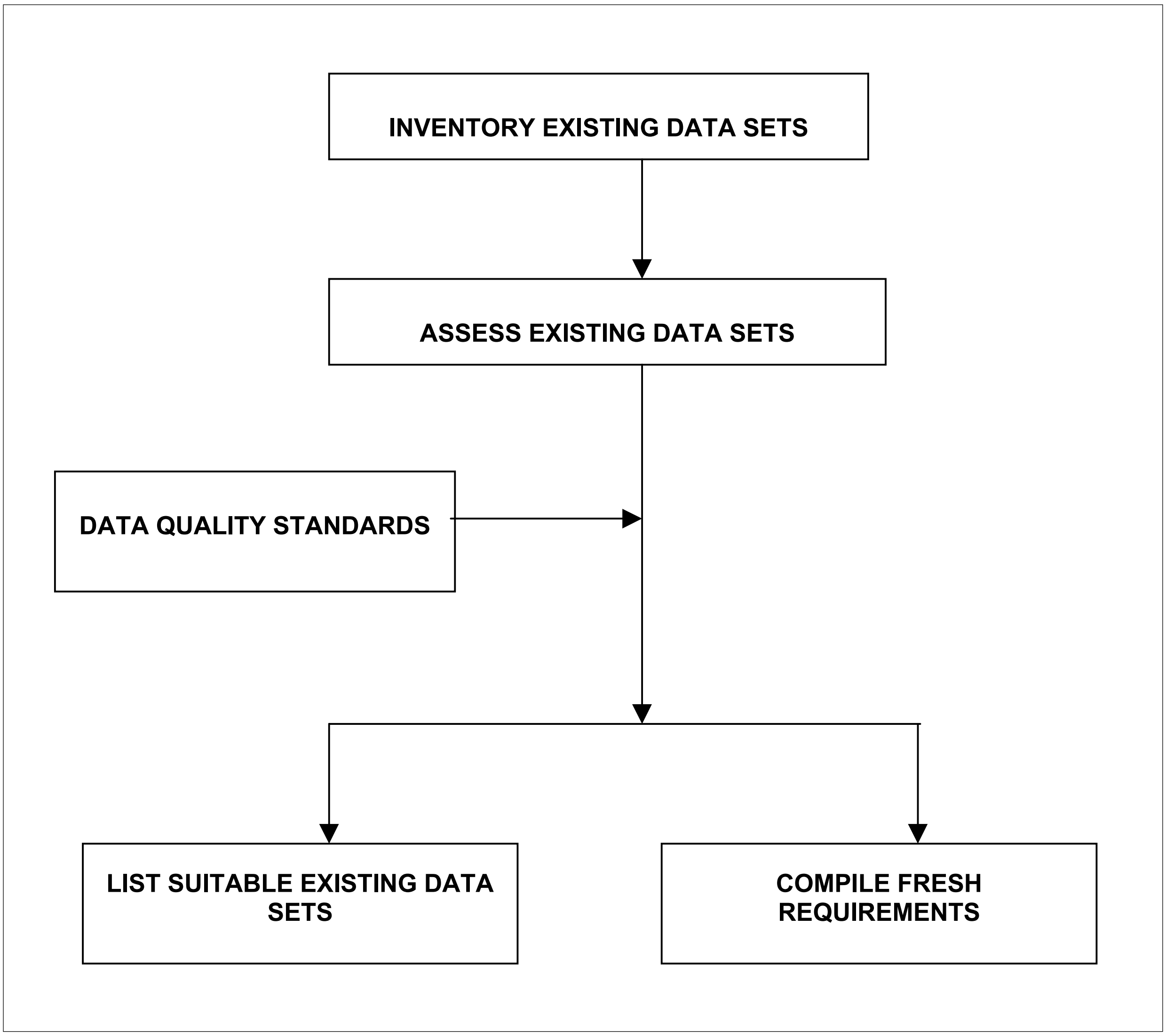


Figure 3.2: Data inventory modality

Primary Data	Source of Data	Fresh Generation Process	Output data
1. Land Use/ Cover	IRS Satellite LISS III Sensor[1]	Visual interpretation and digitisation	Digital file of spatial data and attribute data upto Level III categories,
2. Soil	IRS Satellite LISS III Sensor	Visual interpretation and digitisation	Digital file of spatial data and attribute data of Soil categories upto Soil series association
3. Geology – lithology	IRS Satellite LISS III Sensor	Visual interpretation and digitisation	Digital file of spatial data and attribute data upto lithologic units and local macroscopic features
4. Geology - structure	IRS Satellite LISS III Sensor	Visual interpretation and digitisation	Digital file of spatial data and attribute data as per classification
5. Geomorphology	IRS Satellite LISS III Sensor	Visual interpretation and digitisation	Digital file of spatial data and attribute data as per classification
6. Administrative boundary	SoI and State survey map	Digitisation	Digital file of spatial data and attribute data upto block boundary
7. Hydrologic boundary	Watershed Atlas of India of AISLUS; SoI map in 1:50,000 scale	Interpretation and Digitisation	Digital file of spatial data and attribute data upto watershed boundary
8. Settlements	SoI 1:50,000 scale map	Digitisation	Digital file of spatial data and attribute data upto village
9. Drainage	SoI 1:50,000 scale map	Digitisation	Digital file of spatial data and attribute data of all drainage in SoI map
10. Transport network	SoI 1:50,000 scale map	Digitisation	Digital file of spatial data and attribute data of all railroad and upto track road
11. Contours and spot heights	1:50000 scale SoI map	Digitisation	Digital file of spatial data and attribute data of all 20 m contours and spot heights in SoI map

Table 3.1: Spatial Data Directory

[1] Preferable for fresh mapping of selected theme

S. No.	Item	Specifications
1	Scale	1:50,000
2	Projection	Polyconic
3	<u>Thematic accuracy</u>	
	Minimum spatial unit	0.01 Km^2
	Classification accuracy	95 percent
4	Mapping accuracy- Planimetric accuracy	25 m
5	<u>Age of thematic map / level of detail</u>	
	Land use (level III)	5 years
	Geology (lithologic units/local macroscopic structures)	10 years
	Geomorphology (landforms)	
	Soil (Soil series association)	10 years
	Drainage (as in toposheet)	10 years
	Contour (20 m interval)	20 years
	Settlements (upto villages)	as in SoI map
	Transport (upto village /cart roads)	5 years (or as in SoI map)
	Administrative boundaries (upto block)	5 years (as in SoI map)
		Latest (as per State survey Dept)
	Hydrologic boundaries (upto watershed)	derived from AISLUS Watershed Atlas and SoI map
6	<u>Digital data specifications</u>	
	Location reference to include lat-long and permanent features	corresponding to SoI map of 1:50,000 scale
	Data tile	
	Coordinate units	metre
	Registration accuracy between themes	12.5 m
	Planimetric accuracy	12.5m
	Sliver polygon tolerance	25 m^2
	Weed tolerance	12.5 m
	Coordinate movement tolerance	12.5 m

Table 3.2: Specifications for Spatial Data

Feature Type	Feature Class	Feature Code	Attribute Table
1. Land Use/ Cover	Poly	LU- Code	LUSE. Lut
2. Soil	Poly	SoIL-Code	SoIL.Lut
3. Geology – lithology	Poly	LITH-CODE	LITH.Lut
4. Geology - structure	Line	STRU-Code	STRU.Lut
5. Geomorphology	Poly	GU-Code	GU.Lut
6. Administrative boundary	Poly	ADMIN-code	ADMIN.LUT
7. Hydrologic boundary	Poly	WS-Code	WS.Lut
8. Settlements			
Location	Point	SettlP-Code	SettlP.Lut
Extent	Poly	SettlA-Code	SettlA.Lut
9. Drainage			
Minor Streams	Line	DRNL-Code	DRNL.Lut
Major rivers	Poly	DRNP-Code	DRNP.Lut
10. Transport network			
Road/ Rail	Line	TRNPT-Code	TRNPT.Lut
11. Contours	Line	-	-
Spot heights	Point	-	-

Table 3.3: List and Structure of Primary Data Elements

4 LAND USE/COVER

4.1 CLASSIFICATION SYSTEM

The land use/cover map will be prepared as per the classification scheme in Table 4.1. Any category unique to a geographic area and not included in the scheme will be labeled as ‘others – Specific category”.

4.2 INPUT DATA

The input data comprise:

- IRS LISS III geocoded False Colour Imagery (FCC) in 1:50,000 scale of two time periods (Kharif and Rabi season);
- SoI map in 1:50,000 scale;
- Collateral data in the form of maps, area statistics, and reports.

4.3 METHODOLOGY

The land use/cover categories will be visually interpreted (based on interpretation key developed for the area) into line maps; the mapped categories may vary from map sheet to map sheet depending on ground conditions. The interpretation process will involve reference to collateral data to enable incorporation of features (such as forest boundaries from SoI map and from State Forest department records) and establish consistency with existing maps and statistics (such as existing maps on land use, wastelands and salinity affected lands and 7 fold land classification statistics of State Revenue department). Delineation of Kharif and Rabi crop lands and discrimination of level II and III categories will require interpretation of two season satellite data. All surface waterbodies (reservoirs, lakes, and tanks) will be referenced to SoI map, and updated for recent constructions based on most recent satellite data. The extent of waterspread will be as in SoI map, and satellite data for new constructions. The classified map will have standard feature codes (see Table 4.1).

Field visits will be organized both for collection of ‘ground truth’ to aid and finalize interpretation, and to estimate the classification accuracy. The interpretation process will be continued till the classification conforms to output data accuracy specifications (Table 3.2).

The overall classification accuracy will be estimated through ‘Kappa Coefficient’, which is a measure of agreement between the classified map and ground conditions at a specified number of sample sites.

The classified map will be scanned and digitised using an appropriate scanner following standard procedure. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled and coded as defined in the LUSE.Lut (Table 4.1 and 4.2). The coverage will then be transformed into polyconic projection and coordinate system in meters. The transformation process will involve geometric rectification through Ground Control Points (GCPs) identified on the input coverage and corresponding SoI map. The data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

4.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

Level I	Level II	Level III	LU-Code
1. Built-up land			01-00-00
	1.1 Towns and cities		01-01-00
	1.2 Rural settlements -villages		01-02-00
2. Agricultural land			02-00-00
	2.1 Crop land		02-01-00
		2.1.1 Kharif cropped	02-01-01
		2.1.2 Rabi cropped	02-01-02
		2.1.3 Double cropped	02-01-03
	2.2 Fallow		02-02-00
	2.3 Plantations (includes tea, coffee, rubber, arecanut and others)		02-03-00
	2.4 Aquaculture		02-04-00
3. Forest			03-00-00
	3.1 Evergreen/semievergreen		03-01-00
		3.1.1 Dense	03-01-01
		3.1.2 Open	03-01-02
	3.2 Deciduous		03-02-00
		3.2.1 Dense	03-02-01
		3.2.2 Open	03-02-02
	3.3 Scrub forest		03-03-00
	3.4 Forest blanks		03-04-00
	3.5 Forest plantations		03-05-00
	3.6 Mangrove		03-06-00
4. Wastelands			04-00-00
	4.1 Salt affected		04-01-00
	4.2 Waterlogged		04-02-00
	4.3 Marshy/swampy land		04-03-00
	4.4 Gullied/ravinous land		04-04-00
	4.5 Land with scrub		04-05-00
	4.6 Land without scrub		04-06-00
	4.7 Sandy area		04-07-00
	4.8 Barren rocky/ stony waste		04-08-00
	4.9 Others		04-09-00
5. Water			05-00-00
	5.1 River/stream		05-01-00
	5.2 Reservoir/lake/tank		05-02-00
	5.3 Canal		05-03-00
6. Others			06-00-00
	6.1 Inland wetlands		06-01-00
	6.2 Coastal wetlands		06-02-00
	6.3 Grass land/grazing land		06-03-00
	6.4 Salt pans		06-04-00

Table 4.1: Land Use /Cover Classification Scheme/ Code (LUSE.LUT)

Field Name	Field Type	Field Width	Key
LU- Code	I	8	Y
Lev 1	C	30	N
Lev 2	C	30	N
Lev 3	C	30	N

Table 4.2: Data Structure

5 SOILS

5.1 CLASSIFICATION SCHEME

The Soil categories of each SoI map sheet area will be delineated and coded with reference to the Order, sub-order, Great Group, sub-group, family and Soil series and/or associations as per Keys to Soil Taxonomy, Sixth Edition, 1994, USDA Soil Conservation Service. The coding scheme will follow NRIS standard developed by the Department of Space[1]. The standard classification scheme and code (SoIL.LUT) is shown for two sample Soil units at order level, which can be extended to other units and upto series level.

5.2 INPUT DATA

The input data comprise:

- Geocoded IRS LISS III FCC imagery of summer scene with minimum vegetation covers; when needed Kharif and Rabi season imagery may be used;
- Collateral information such as existing maps on Soil, geology, geomorphology and land use, and climatic data;
- SoI map in 1:50,000 scale.

5.3 METHODOLOGY

The interpretation key, based on acquired satellite data and in reference to SoI topographic map and existing geological and geomorphologic map and soil map (in any scale), will be prepared. Physiography units will be delineated, and further stratified into possible soil scapes based on variations in geology, landform, parent material, elevation, slope, aspect, natural vegetation, etc. Sample strips will be selected based on variability in landform, geology and image interpretation elements. Detailed field investigations (soil profile, minipit and auguring) will be conducted in sample strips. At least 20 profiles will be examined in a SoI toposheet area. The actual number of profiles will depend on the variability of terrain. Mini- pit and auger bore data will supplement profile investigations. An objective grid based observations may also be made to avoid bias. Typifying pedons are selected and describes as per standard procedures. Horizon-wise soil samples are collected and analysed for physical and chemical properties for Soil classification. Mineralogical class is established using available information. Meteorological data is used in establishing Soil temperature, moisture regimes and preparation of ombrothermic diagrams. Locale specific interpretation key is developed between the physiographic unit/ image interpretation and Soil categories based on study of sample strips.

[1] National (Natural) Resources Information System (NRIS) – Node Design and Standards, Doc. No. SAC/RSA/NRIS-SIP/SD-01/97, Space Applications Centre, Ahmedabad, April 1997

Soil units are delineated by drawing boundaries based on interpretation key and auger bore checking. The Soil classes are randomly verified in the field. The legend is finalised on completion of classification validation, and appropriate codes (Table 5.1) are assigned.

The overall classification accuracy will be estimated through 'Kappa Coefficient', which is a measure of agreement between the classified map and ground conditions at a specified number of sample sites.

The classified map will be scanned and digitized using an appropriate scanner. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Table 5.1 and 5.2. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. The transformation process will involve geometric rectification through Ground Control Points (GCPs) identified on the input coverage and corresponding SoI map. The data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process. Additional quality assurance will include ensuring delineation of all physiographic units at the pre-field stage, study of atleast one profile for each prominent Soil series, and post-classification validation over atleast 10 percent of the area using auger bore data and road-cuts.

5.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, along with a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

Order	Sub Order	Great group	Sub group	Code
Alfisols	Aqualfs	Linthaqualfs	Typic Plithaquaifs	01-01-01-01
		Naatraqualfs	Vertic Natraqualfs	01-01-02-01
			Alabic Glossic Natraqualfs	01-01-02-02
			Glossic Natraqualfs	01-01-02-03
			Millic Natraqualfs	01-01-02-04
			Typic Natraqualfs	01-01-02-05
		Duraqualfs	Typic Duraqualfs	01-01-03-01
		Fragiaqualfs	Aeric Fragiaqualfs	01-01-04-01
			Plinthic Fragiaqualfs	01-01-04-02
			Umbric Fragiaqualfs	01-01-04-03
			Typic Fragiaqualfs	01-01-04-04
		Kandiaqualfs	Arenic Kandiaqualfs	01-01-05-01
			Grossarenic Kandiaqualfs	01-01-05-02
			Plinthic Kandiaqualfs	01-01-05-03
			Plinthic Kandiaqualfs	01-01-05-04
			Aeric Umbric Kandiaqualfs	01-01-05-05
			Typic Kandiaqualfs	01-01-05-06
		Glossaqualfs	Arenic Glossaqualfs	01-01-06-01
			Grossarenic Glossaqualfs	01-01-06-02
			Aeric Glossaqualfs	01-01-06-03
			Mollic Glossaqualfs	01-01-06-04
			Typic Glossaqualfs	01-01-06-05
		Albaqualfs	Aeric Vertic Albaqualfs	01-01-07-01
			Chromic Vertic Albaqualfs	01-01-07-02
			Vertic Albaqualfs	01-01-07-03
			Udollic Albaqualfs	01-01-07-04
			Aeric Albaqualfs	01-01-07-05
			Aquandic Albaqualfs	01-01-07-06

Order	Sub Order	Great group	Sub group	Code
			Mollic Albaqualfs	01-01-07-07
			Durinodic Albaqualfs	01-01-07-08
			Typic Albaqualfs	01-01-07-09
		Umbraqualfs	Aquandic Umbraqualfs	01-01-08-01
			Arenic Umbraqualfs	01-01-08-02
			Grossarenic Umbraqualfs	01-01-08-03
			Ferrudalfic Umbraqualfs	01-01-08-04
			Typic Umbraqualfs	01-01-08-05
		Epiaqualfs	Aeric Chromic Vertic Epiaqualfs	01-01-09-01
			Aeric Vertic Epiaqualfs	01-01-09-02
			Chromic Vertic Epiaqualfs	01-01-09-03
			Vertic Epiaqualfs	01-01-09-04
			Aquandic Epiaqualfs	01-01-09-05
			Arenic Epiaqualfs	01-01-09-06
			Grossarenic Epiaqualfs	01-01-09-07
			Aeric Umbric Epiaqualfs	01-01-09-08
			Udollic Epiaqualfs	01-01-09-09
			Aeric Epiaqualfs	01-01-09-10
			Mollic Epiaqualfs	01-01-09-11
			Umbric Epiaqualfs	01-01-09-12
			Typic Epiaqualfs	01-01-09-13
		Endoaqulfs	Aquandic Endoaqualfs	01-01-10-01
			Arenic Endoaquanlfs	01-01-10-02
			Gossarenic Endoaqualfs	01-01-10-03
			Udollic Endoaqualfs	01-01-10-04
			Aeric Endoaqualfs	01-01-10-05
			Molic Endoaqualfs	01-01-10-06
			Umbric Endoaqualfs	01-01-10-07
			Typic Endoaqualfs	01-01-10-08
	Boralfs	Paleboralfs	Antic Paleboralfs	01-02-01-01
			Vitrandic Paleboralfs	01-02-01-02
			Aquic Paleboralfs	01-02-01-03
			Oxyaquic Paleboralfs	01-02-01-04
			Abruptic Paleboralfs	01-02-01-05
			Mollic Paleboralfs	01-02-01-06
			Typic Paleboralfs	01-02-01-07
		Fragiboralfs	Andic Fragiboralfs	01-02-02-01
			Vitrandic Frgiboralfs	01-02-02-02
			Aquic Frgiboralfs	01-02-02-03
			Oxyquic Frgiboralfs	01-02-02-04
			Typic Fragiboralfs	01-02-02-05
		Natriboralfs	Typic Natriboralfs	01-02-03-01
		Cryoboralfs	Lithic Mollic Cryoboralfs	01-02-04-01
			Lithic Cryoboralfs	01-02-04-02
			Vertic Cryobralfs	01-02-04-03
			Aquic Cryoboralfs	01-02-04-04
			Oxyaquic Cryoboralfs	01-02-04-05
			Psammentic Cryoboralfs	01-02-04-06
			Mollic Cryoboralfs	01-02-04-07
			Glossic Cryoboralfs	01-02-04-08
			Typic Cryoboralfs	01-02-04-09
		Eutroboralfs	Lithic Eutroboralfs	01-02-05-01
			Vertic Eutroboralfs	01-02-05-02
			Andic Eutroboralfs	01-02-05-03
			Vitrandic Eutroboralfs	01-02-05-04
			Aquic Arenic Eutroboralfs	01-02-05-05
			Glossaquic Eutroboralfs	01-02-05-06
			Aquic Arenic Eutroboralfs	01-02-05-07

Order	Sub Order	Great group	Sub group	Code
			Oxyaquic Eutroboralfs	01-02-05-08
			Pasmmentic Eutroboralfs	01-02-05-09
			Arenic Eutroboralfs	01-02-05-10
			Mollic Eutroboralfs	01-02-05-11
			Glossic Eutroboralfs	01-02-05-12
			Typic Eutroboralfs	01-02-05-13
		Glossoboralfs	Lithic Glossoboralfs	01-02-06-01
			Andic Glossoboralfs	01-02-06-02
			Vitrandic Glossoboralfs	01-02-06-03
			Aquic Glossoboralfs	01-02-06-04
			Oxyaquic Glossoboralfs	01-02-06-05
			Pasammentic Glossoboralfs	01-02-06-06
			Eutric Glossoboralfs	01-02-06-07
			Typic Glossoboralfs	01-02-06-08
	Ustalfs	Durustalfs	Typic Durustalfs	01-03-01-01
		Plinthustalfs	Typic Plinthustalfs	01-03-02-01
		Natrustalfs	Vertic Natrustalfs	01-03-03-01
			Grossarenic Natrustalfs	01-03-03-02
			Aquic Arenic Natrustalfs	01-03-03-03
			Aquic Natrustalfs	01-03-03-04
			Arenic Natrustalfs	01-03-03-05
			Petrocalcic Natrustalfs	01-03-03-06
			Salidic Natrustalfs	01-03-03-07
			Mollic Natrustalfs	01-03-03-08
			Typic Natrustalfs	01-03-03-09
		Kandiustalfs	Grossarenic Kandiustalfs	01-03-04-01
			Aquic Arenic Kandiustalfs	01-03-04-02
			Plinthic Kandiustalfs	01-03-04-03
			Aquic Kandiustalfs	01-03-04-04
			Arenic Aridic Kandiustalfs	01-03-04-05
			Arenic Kandiustalfs	01-03-04-06
			Aridic Kandiustalfs	01-03-04-07
			Udic Kandiustalfs	01-03-04-08
			Rhodic Kandiustalfs	01-03-04-09
			Typic Kandiustalfs	01-03-04-10
		Kanhapulstalfs	Lithic Kanhaplustalfs	01-03-05-01
			Aquic Kanhaplustalfs	01-03-05-02
			Aridic Kanhaplustalfs	01-03-05-03
			Udic Kanhaplustalfs	01-03-05-04
			Rhodic Kanhaplustalfs	01-03-05-05
			Typic Kanhaplustalfs	01-03-05-06
		Paleustalfs	Aquertic Paleustalfs	01-03-06-01
			Oxaquric Vertic aleustalfs	01-03-06-02
			Udertic Pleustalfs	01-03-06-03
			Vertif Paleustalfs	01-03-06-04
			Psammentic Paleustalfs	01-03-06-05
			Grossarenic Paleustalfs	01-03-06-06
			Aquic Arenic Paleustalfs	01-03-06-07
			Plinthic Paleustalfs	01-03-06-08
			Aquic Arenic Paleustalfs	01-03-06-09
			Oxyaquic Paleustalfs	01-03-06-10
			Petrocalcic Paleustalfs	01-03-06-11
			Arenic Aridic Paleustalfs	01-03-06-12
			Arenic Paleustalfs	01-03-06-13
			Calcidic Paleustalfs	01-03-06-14
			Aridic Paleustalfs	01-03-06-15
			Kandic Paleustalfs	01-03-06-16
			Rhodic Paleustalfs	01-03-06-17

Order	Sub Order	Great group	Sub group	Code
			Ultic Paleustalfs	01-03-06-18
			Udic Paleustalfs	01-03-06-19
			Typic Paleustalfs	01-03-06-20
		Rhodustalfs	Lithic Rhodulstalfs	01-03-07-01
			Kanhaplic Rhodustalfs	01-03-07-02
			Udic Rhodustalfs	01-03-07-03
			Typic Rhodustalfs	01-03-07-04
		Haplustalfs	Lithic Haplustalfs	01-03-08-01
			Aquertic Haplustalfs	01-03-08-02
			Oxyaquic Vertic Aplustalfs	01-03-08-03
			Udertic Haplustalfs	01-03-08-04
			Vertic Haplustalfs	01-03-08-05
			Aquic Arenic Haplustalfs	01-03-08-06
			Aquulitic Haplustalfs	01-03-08-07
			Aquic Haplustalfs	01-03-08-08
			Oxyaquic Haplustalfs	01-03-08-09
			Psammentic Haplustalfs	01-03-08-10
			Arenic Aridic Haplustalfs	01-03-08-11
			Arenic Haplustalfs	01-03-08-12
			Aridic Haplustalfs	01-03-08-13
			Kanhaplic Haplustalfs	01-03-08-14
			Ultic Haplustalfs	01-03-08-15
			Udic Haplustalfs	01-03-08-16
			Typic Haplustalfs	01-03-08-17
	Xeralfs	Durixeralfs	Natric Durixeralfs	01-04-01-01
			Vertic Durixeralfs	01-04-01-02
			Aquic Durixeralfs	01-04-01-03
			Abruptic Haplic Durixeralfs	01-04-01-04
			Abruptic Durixeralfs	01-04-01-05
			Haplic Durixeralfs	01-04-01-06
			Typic Durixeralfs	01-04-01-07
		Natrixeralfs	Vertic Natrixeralfs	01-04-02-01
			Aquic Natrixeralfs	01-04-02-02
			Typic Natrixeralfs	01-04-02-03
		Fragixeralfs	Andic Fragixeralfs	01-04-03-01
			Vitrandic Fragixeralfs	01-04-03-02
			Mollic Fragixeralfs	01-04-03-03
			Aquic Fragixeralfs	01-04-03-04
			Ochreptic Freagixeralfs	01-04-03-05
			Typic Fragixeralfs	01-04-03-06
		Plinthoxeralfs	Typic Plinthoxeralfs	01-04-04-01
		Rhodoxeralfs	Lithic Rhodoxeralfs	01-04-05-01
			Petrocalcic Rhodoxeralfs	01-04-05-02
			Calcic Rhodoxeralfs	01-04-05-03
			Ochreptic Rhodoxeralfs	01-04-05-04
			Typic Rhodoxeralfs	01-04-05-05
		Palexeralfs	Vertic Palexeralfs	01-04-06-01
			Aquandic Palexeralfs	01-04-06-02
			Andic Palexeralfs	01-04-06-03
			Vitrandic Palexeralfs	01-04-06-04
			Aquic Palexralfs	01-04-06-05
			Petrocalcic Palexeralfs	01-04-06-06
			Arenic Palexeralfs	01-04-06-07
			Natric Palexeralfs	01-04-06-08
			Calcic Palexeralfs	01-04-06-09
			Plinthic Palexeralfs	01-04-06-10
			Ultic Palexeralfs	01-04-06-11
			Haplic Palexeralfs	01-04-06-12

Order	Sub Order	Great group	Sub group	Code
			Mollic Palexeralfs	01-04-06-13
			Typic Palexeralfs	01-04-06-14
		Haploxeralfs	Lithic Mollic Haploxeralfs	01-04-07-01
			Lithic Ruptic-Xerocherptic Haploxeralfs	01-04-07-02
			Lithic Haploxeralfs	01-04-07-03
			Vertic Haploxeralfs	01-04-07-04
			Aquandic Haploxeralfs	01-04-07-05
			Andic Haploxeralfs	01-04-07-06
			Vitrandic Haploxeralfs	01-04-07-07
			Aquultic Haploxeralfs	01-04-07-08
			Aquic Haploxeralfs	01-04-07-09
			Natric Haploxeralfs	01-04-07-10
			Psammentic Haploxeralfs	01-04-07-11
			Plinthic Haploxeralfs	01-04-07-12
			Calcic Haploxeralfs	01-04-07-13
			Ultic Haploxeralfs	01-04-07-14
			Mollic Haploxeralfs	01-04-07-15
			Type Haploxeralfs	01-04-07-16
	Udalfs	Agrudlfs	Typic Agrudalfs	01-05-01-01
		Natrudalfs	Vertic Natrudalfs	01-05-02-01
			Glossic Natrudalfs	01-05-02-02
			Mollic Natrudalfs	01-05-02-03
			Typic Natrudalfs	01-05-02-04
		Ferrudalfs	Aquic Ferrudalfs	01-05-03-01
			Typic Ferrudalfs	01-05-03-02
		Glossudalfs	Fragic Glossudalfs	01-05-04-01
			Aquandic Glossudalfs	01-05-04-02
			Andic Glossudalfs	01-05-04-03
			Vitrandic glossudalfs	01-05-04-04
			Oxyaquic Glossudalfs	01-05-04-05
			Arenic Glossudalfs	01-05-04-06
			Haplic Glossudalfs	01-05-04-07
			Typic Glossudalfs	01-05-04-08
		Fraglossudalfs	Aquic Fraglossudalfs	01-05-05-01
			Oxyaquic Fraglossudalfs	01-05-05-02
			Typic Fraglossudalfs	01-05-05-03
		Fragiudalfs	Umbreptic Fragiudalfs	01-05-06-01
			Mollic Fragiudalfs	01-05-06-02
			Glossaquic Fragiudalfs	01-05-06-03
			Aqueptic Fragiudalfs	01-05-06-04
			Albaquic Fragiudalfs	01-05-06-05
			Aquic Fragiudalfs	01-05-06-06
			Oxyaquic Fraguidalfs	01-05-06-07
			Glossic Fragiudalfs	01-05-06-08
			Ochreptic Fragiudalfs	01-05-06-09
			Typic Fragiudalfs	01-05-06-10
		Kandiudalfs	Plinthaquic Kandiudalfs	01-05-07-01
			Aquic Kandiudalfs	01-05-07-02
			Oxyaquic Kandiudalfs	01-05-07-03
			Arenic Plinthic Kandiudalfs	01-05-07-04
			Grossarenic Plinthic Kandiudalfs	01-05-07-05
			Arenic Kandiudalfs	01-05-07-06
			Grossarenic Kandiudalfs	01-05-07-07
			Plinthic Kandiudalfs	01-05-07-08
			Rhodic Kandiudalfs	01-05-07-09
			Mollic Kandiudalfs	01-05-07-10
			Typic Kandiudalfs	01-05-07-11
		Kanhapludalfs	Lithic Kanhapludalfs	01-05-08-01

Order	Sub Order	Great group	Sub group	Code
			Aquic Kanhapludalfs	01-05-08-02
			Oxyaquic Kanhapludalfs	01-05-08-03
			Rhodic Kanhapludalfs	01-05-08-04
			Typic Kanhapludalfs	01-05-08-05
		Paleudalfs	Vertic Paleudalfs	01-05-09-01
			Anthraquic Paleudalfs	01-05-09-02
			Plinthquic Paleudalfs	01-05-09-03
			Glossaquic Paleudalfs	01-05-09-04
			Albaquic Paleudalfs	01-05-09-05
			Aquic Paleudalfs	01-05-09-06
			Oxyaquic Paleudalfs	01-05-09-07
			Arenic Plinthic Paleudalfs	01-05-09-08
			Grossarenic Plinthic Paleudalfs	01-05-09-09
			Psammentic Paleudalfs	01-05-09-10
			Arenic Paleudalfs	01-05-09-11
			Grossarenic Paleudalfs	01-05-09-12
			Plinthic Paleudalfs	01-05-09-13
			Glossic Paleudalfs	01-05-09-14
			Rhodic Paleudalfs	01-05-09-15
			Mollic Paleudalfs	01-05-09-16
			Typic Paleudalfs	01-05-09-17
		Rhodudalfs	Typic Rhodudlfs	01-05-10-01
		Hapludalfs	Aquic Lithic Hapludalfs	01-05-11-01
			Lithic Hapludalfs	01-05-11-02
			Aquertic Chromic Hapludalfs	01-05-11-03
			Aquertic Hapludalfs	01-05-11-04
			Oxyquic Vertic Hapludalfs	01-05-11-05
			Chromic Vertic Hapludalfs	01-05-11-06
			Vertic Hapludalfs	01-05-11-07
			Andic Hapludalfs	01-05-11-08
			Vitrandic Hapludalfs	01-05-11-09
			Psammaquentic Hapludalfs	01-05-11-10
			Psammantic Hapludalfs	01-05-11-11
			Aquic Arenic Hapludalfs	01-05-11-12
			Arenic Hapludalfs	01-05-11-13
			Anthraquic Hapludalfs	01-05-11-14
			Albaquultic Hapludalfs	01-05-11-15
			Albaquic Hapludalfs	01-05-11-16
			Glossaquic Hapludalfs	01-05-11-17
			Aquultic Hapludalfs	01-05-11-18
			Aquollic Hapludalfs	01-05-11-19
			Aquic Hapludalfs	01-05-11-20
			Oxyaquic Hapludalfs	01-05-11-21
			Glossic Hapludalfs	01-05-11-22
			Glossoboric Hapludalfs	01-05-11-23
			Ultic Hapludalfs	01-05-11-24
			Mollic Hapludalfs	01-05-11-25
			Typic Hapludalfs	01-05-11-26
Andisols	Aquands	Cryaquands	Lithic Cryaquands	02-01-01-01
			Pergelic Cryaauands	02-01-01-02
			Histic Cryaquands	02-01-01-03
			Thaptic Cryaquands	02-01-01-04
			Typic Cryaquands	02-01-01-05
		Placaquands	Lithic Placaquands	02-01-02-01
			Duric Histic Placaquands	02-01-02-02
			Duric Placaquands	02-01-02-03
			Histic Placaquands	02-01-02-04
			Thaptic Placaquands	02-01-02-05

Order	Sub Order	Great group	Sub group	Code
			Typic Placaquands	02-01-02-06
		Duraquands	Histic Duraquands	02-01-03-01
			Acraquoxic Duraquands	02-01-03-02
			Thaptic Duraquands	02-01-03-03
			Typic Duraquands	02-01-03-04
		Vitraquands	Lithic Vitraquands	02-01-04-01
			Duric Vitraquands	02-01-04-02
			Histic Vitraquands	02-01-04-03
			Thaptic Vitraquands	02-01-04-04
		Melanaquands	Lithic Melanaquands	02-01-05-01
			Acraquoxic Melanaquands	02-01-05-02
			Hydric Pachic Melanaquands	02-01-05-03
			Hydric Melanaquands	02-01-05-04
			Thaptic Melanaquands	02-01-05-05
			Typic Melanaquands	02-01-05-06
		Epiaquands	Petroferric Epiaquands	02-01-06-01
			Duric Epiaquands	02-01-06-02
			Histic Epiaquands	02-01-06-03
			Alic Epiaquands	02-01-06-04
			Hydric Epiaquands	02-01-06-05
			Thaptic Epiaquands	02-01-06-06
			Typic Epiaquands	02-01-06-07
		Ndoaquands	Lithic Endoaquands	02-01-07-01
			Petroferric Endoaquands	02-01-07-02
			Duric Endoaquands	02-01-07-03
			Histic Endoaquands	02-01-07-04
			Alic Endoaquands	02-01-07-05
			Hydric Endoaquands	02-01-07-06
			Thaptic Endoaquands	02-01-07-07
			Typic Endoaquands	02-01-07-08
	Cryands	Geliccryands	Typic Gelicryands	02-02-01-01
		Melanocryands	Lithic Melanocryands	02-02-02-01
			Alic Melanocryands	02-02-02-02
			Vertic Melanocryands	02-02-02-03
			Typic Melanocryands	02-02-02-04
		Fluvicryands	Lithic Fluvicryands	02-02-03-01
			Vitric Fluvicryands	02-02-03-02
			Typic Fluvicryands	02-02-03-03
		Hydrocryands	Lithic Hydrocryands	02-02-04-01
			Placic Hydrocryands	02-02-04-02
			Aquic Hydrocryands	02-02-04-03
			Thaptic Hydrocryands	02-02-04-04
			Typic Fluvicryands	02-02-04-05
		Vitricryands	Lithic Vitricryands	02-02-05-01
			Aquic Vitricryands	02-02-05-02
			Thaptic Vitricryands	02-02-05-03
			Humic Xeric Vitricryands	02-02-05-05
			Xeric Vitricryands	02-02-05-06
			Ultic Vitricryands	02-02-05-07
			Alfic Vitricryands	02-02-05-08
			Humic Vitricryands	02-02-05-09
			Typic Vitricryands	02-02-05-10
		Haplocryands	Lithic Haplocryands	02-02-06-01
			Alic Haplocryands	02-02-06-02
			Aquic Haplocryands	02-02-06-03
			Acrudoxic Haplocryands	02-02-06-04
			Vitric Haplocryands	02-02-06-05
			Thaptic Haplocryands	02-02-06-06

Order	Sub Order	Great group	Sub group	Code
			Xeric Haplocryands	02-02-06-07
			Typic Haplocryands	02-02-06-08
	Torrands	Vitritorrands	Lithic Vitritorrands	02-03-01-01
			Petrocalcic Vitritorrands	02-03-01-02
			Duric Vitritorrands	02-03-01-03
			Aquic Vitritorrands	02-03-01-04
			Calcic Vitritorrands	02-03-01-05
			Typic Vitritorrands	02-03-01-06
	Xerands	Vitrixerands	Lithic Vitrixerands	02-04-01-01
			Aquic Vitrixerands	02-04-01-02
			Thaptic Vitrixerands	02-04-01-03
			Alfic Humic Vitrixerands	02-04-01-04
			Alfic Vitrixerands	02-04-01-05
			Ultic Vitrixerands	02-04-01-06
			Humic Vitrixerands	02-04-01-07
			Typic Vitrixerands	02-04-01-08
		Melanoxerands	Pachic Melanoxerands	02-04-02-01
			Typic Xelanoxerands	02-04-02-02
		Haploxerands	Lithic Haploxerands	02-04-03-01
			Aquic Haploxerands	02-04-03-02
			Thaptic Haploxerands	02-04-03-03
			Calcic Haploxerands	02-04-03-04
			Ultic Haploxerands	02-04-03-05
			Alfic Humic Haploxerands	02-04-03-06
			Alfic Haploxerands	02-04-03-07
			Humic Haploxerands	02-04-03-08
			Typic Haploxerands	02-04-03-09
	Vitrands	Ustivitrands	Lithic Ustivitrands	02-05-01-01
			Aquic Ustivitrands	02-05-01-02
			Thaptic Ustivitrands	02-05-01-03
			Calcic Ustivitrands	02-05-01-04
			Humic Ustivitrands	02-05-01-05
			Typic Ustivitrands	02-05-01-06
		Udivitrands	Lithic Udivitrands	02-05-02-01
			Aquic Udivitrands	02-05-02-02
			Thaptic Udivitrands	02-05-02-03
			Ultic Udivitrands	02-05-02-04
			Alfic Udivitrands	02-05-02-05
			Humic Udivitrands	02-05-02-06
			Typic Udivitrands	02-05-02-07
	Ustands	Durustands	Aquic Durustands	02-06-01-01
			Thaptic Durustands	02-06-01-02
			Humic Durustands	02-06-01-03
			Typic Durustands	02-06-01-04
				02-06-01-05
		Haplustands	Lithic Haplustands	02-06-02-01
			Aquic Haplustands	02-06-02-02
			Dystric Vitric Haplustands	02-06-02-03
			Vitric Haplustands	02-06-02-04
			Pachic Haplustands	02-06-02-05
			Thaptic Haplustands	02-06-02-06
			Calcic Haplustands	02-06-02-07
			Dystric Haplustands	02-06-02-08
			Oxic Haplustands	02-06-02-09
			Ultic Haplustands	02-06-02-10
			Alfic Haplsutands	02-06-02-11
			Humic Haplustands	02-06-02-12
			Typic Haplustands	02-06-02-13

Order	Sub Order	Great group	Sub group	Code
	Udands	Placudands	Lithic Placudands	02-07-01-01
			Aquic Placudands	02-07-01-02
			Acrudoxic Hydric Placudands	02-07-01-03
			Acrudoxic Placudands	02-07-01-04
			Eutric Vitric Placudands	02-07-01-05
			Vitric Placudands	02-07-01-06
			Hydric Pachic Placudands	02-07-01-07
			Pachic Placudands	02-07-01-08
			Hydric Placudands	02-07-01-09
			Thaptic Placudands	02-07-01-10
			Eutric Placudands	02-07-01-11
			Typic Placudands	02-07-01-12
		Durudands	Aquic Durudands	02-07-02-01
			Acrudoxic Durudands	02-07-02-02
			Hydric Pachic Durudands	02-07-02-03
			Thaptic Durudands	02-07-02-04
			Typic Durudands	02-07-02-05
		Melanudands	Lithic Melanudands	02-07-03-01
			Anthraquic Melanudands	02-07-03-02
			Alic Aquic Melanudands	02-07-03-03
			Alic Pachic Melanudands	02-07-03-04
			Alic Thaptic Melaundands	02-07-03-05
			Alic Melanudands	02-07-03-06
			Aquic Melanudands	02-07-03-07
			Acrudoxic Vitric Melanudands	02-07-03-08
			Acrudoxic Hydric elanudands	02-07-03-09
			Acrudoxic Melanudands	02-07-03-10
			Pachic Melanudands	02-07-03-11
			Eutric Hydric Melanudands	02-07-03-12
			Hydric Pachic Melanudands	02-07-03-13
			Pachic Mealnudands	02-07-03-14
			Eutric Pachic Melanudands	02-07-03-15
			Vitric Melanudands	02-07-03-16
			Hydric Melanudands	02-07-03-17
			Thaptic Melanudands	02-07-03-18
			Ultic Melanudands	02-07-03-19
			Typic Melanudands	02-07-03-20
		Fulvudands	Hydric Lithic Fulvudands	02-07-04-01
			Lithic Fulvudands	02-07-04-02
			Alic Fulvudands	02-07-04-03
			Aquic Fulvudands	02-07-04-04
			Acrudoxic Hydric Fulvudands	02-07-04-05
			Acrudoxic Ultic Fulvudands	02-07-04-06
			Acrudoxic Fulvudands	02-07-04-07
			Hydric Pachic Fulvudands	02-07-04-08
			Eutric Pachic Fulvudands	02-07-04-09
			Pachic Fulvudands	02-07-04-10
			Hydric Thaptic Fulvudands	02-07-04-11
			Hydric Fulvudands	02-07-04-12
			Thaptic Fulvudands	02-07-04-13
			Eutric Fulvudands	02-07-04-14
			Typic Fulvudands,	02-07-04-15
			Lithic Hydrudands	02-07-05-01
			Aquic Hydraudands	02-07-05-02
			Acrudoxic Thaptic Hydrudands	02-07-05-03
			Acrudoxic Hydrudands	02-07-05-04
			Thaptic Hydrudands	02-07-05-05
			Eutric Hydrudands	02-07-05-06

Order	Sub Order	Great group	Sub group	Code
			Ultic Hydrudands	02-07-05-07
			Typic Hydrudands	02-07-05-08
		Hapludands	Lithic Hapludands	02-07-06-01
			Petroferric Hapludands	02-07-06-02
			Anthraquic Hapludands	02-07-06-03
			Aquic Duric Hapludands	02-07-06-04
			Duric Hapludands	02-07-06-05
			Alic Hapludands	02-07-06-06
			Aquic Hapludands	02-07-06-07
			Acrudoxic Hydric hapludands	02-07-06-08
			Acrudoxic Thaptic Hapludands	02-07-06-09
			Acrudoxic Ultic Hapludands	02-07-06-10
			Acrudoxic Hapludands	02-07-06-11
			Vitric Hapludands	02-07-06-12
			Hydric Thaptic Hapludands	02-07-06-13
			Hydric Hapludands	02-07-06-14
			Eutric Thaptic Hapludands	02-07-06-15
			Thaptic Hapludands	02-07-06-16
			Eutric Hapludands	02-07-06-17
			Oxic Hapludands	02-07-06-18
			Ultic Hapludands	02-07-06-19
			Alfic Hapludands	02-07-06-20
			Typic Hapludands	02-07-06-21

Table 5.1: Standard Soil Classification and Code (SoiL.LUT)

The coding scheme will be extended to series level using the following table:

Soil Unit	Order	Sub-order	Great Group	Sub-group	Family	Series
Code	AA	BB	CC	DD	EE	FF

Field Name	Field Type	Field Width	Key
SOIL-Code	I	8	Y
Order	C	15	N
Sub-order	C	15	N
Great Group	C	30	N
Sub-group	C	50	N
Family	C	50	N
Series	C	50	N

Table 5.2: Structure of Data

6 GEOLOGY – LITHOLOGY

6.1 CLASSIFICATION SCHEME

The standard classification scheme for lithology unit and rock type (and code) is shown in Table 6.1 while the structure of data is described in Table 6.2. Only those units present in the map area will be classified, and any other unit present in the area and not covered by the scheme will be mapped and provided appropriate code.

6.2 INPUT DATA

The input data comprise:

- Geocoded IRS LISS III FCC imagery in 1:50000 scale of summer season (with minimum vegetation cover); where necessary Kharif or Rabi season data will be additionally used;
- Existing geological and hydrogeological maps and literature.

6.3 METHODOLOGY

Classification and mapping of lithologic units/rock types is performed through visual interpretation of image characteristics and terrain information, supported by the *a priori* knowledge of general geologic setting of the area. The description of rock types/lithologic units is provided in Table 6.3.

The tone (colour) and landform characteristics, and relative erodibility, drainage, Soil type, land use/cover and other contextual information are used in classification. Acidic and arenaceous rocks are lighter in tone compared to basic/argillaceous rocks. Coarse grained rocks with higher porosity and permeability appear brighter as compared to fine grained rocks with higher moisture retaining capacity. Highly resistant rock formations occur as different hill types depending on their texture and internal structure, while the easily erodible rocks occur as different types of plains and valleys. Dentritic drainage indicates homogeneous rocks, while trellis, rectangular and parallel drainage patterns indicate structural and lithologic controls. Coarse drainage texture indicates highly porous and permeable rock formations, while fine drainage texture is present in less pervious formations. Coarse textured and light coloured Soils indicate acidic/arenaceous rocks rich in quartz and feldspars, while fine textured and dark coloured Soils indicate basic/argillaceous rocks. Convergence of evidence from different interpretation elements will be followed for reliable classification. The contacts of identified rock types will be extended over large areas based on tonal contrast or landform on satellite imagery. Inferred boundaries (where the contrast is not adequate) is marked by different symbol. The rock types are mapped and labeled as per classification scheme (Table 6.1).

After preliminary interpretation field visit is conducted for proper identification and classification of rock types.

The overall classification accuracy will be estimated through ‘Kappa Coefficient’, which is a measure of agreement between the classified map and ground conditions at a specified number of sample sites.

The classified map will be scanned and digitised using an appropriate scanner. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Table 6.1 and 6.2. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. The transformation process will involve geometric rectification through Ground Control Points (GCPs) identified on the input coverage and corresponding SoI map. The data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

6.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

Rock Group	Rock Type/ Lithologic Unit	LITH-Code
Unconsolidated Sediments		01-00
	Gravel	01-01
	Sand & silt	01-02
	Clayey sand & silt	01-03
	Sandy clay	01-04
	Clay	01-05
	Alternating sequence of sand/silt and clay	01-06
	Colluvium	01-07
Residual cappings		02-00
	Laterite	02-01
	Bauxite	02-02
	Kankar	02-03
	Chert	02-04
	Detrital Laterite	02-05
Deccan Traps and Intertrappeans		03-00
	Inter & intra- trappean sand/clay bed	03-01
	Tuffacious Basalt	03-02
	Vesicular Basalt	03-03
	Amygdaloidal Basalt	03-04
	Massive Basalt	03-05
	Red/Green Bole	03-06
Older Volcanics/Metavolcanics		04-00
	Basalt	04-01
	Rhyolite	04-02
	Dacite	04-03
	Andesite	04-04
Semi-consolidated Sediments		05-00
	Sandstone & conglomerate	05-01
	Shaly sandstone	05-02
	Sandstone with shale/coal partings	05-03
	Shell Limestone/Limestone	05-04
	Sandy Shale	05-05
	Shale with sandstone partings	05-06
	Shale/Coal/Lignite	05-07
Consolidated sediments		06-00
	Thin bedded Sandstone/Quartzite	06-01
	Thin bedded Limestone/Dolomite	06-02
	Thick bedded/Massive Limestone/Dolomite	06-03
	Thick bedded Sandstone/Quartzite	06-04
	Shaly Limestone	06-05
	Conglomerate	06-06
	Shale with Limestone/sandstone Bands/Lenses	06-07
	Shale	06-08
Plutonic rocks		07-00
	Granitic/Acidic rocks	07-01
	Alkaline rocks	07-02
	Basic rocks	07-03
	Ultrabasic rocks	07-04
	Quartz reef	07-05
	Pegmatite/Aptite/Quartz vein	07-06

Table 6.1: Rock groups and Rock type/lithologic unit classification (LITH-LUT) (proposed by NRSA in RGDWTM mapping project)

Note: Rock type and stratigraphy to be assigned in case by case basis as per GSI classification.

Field Name	Field Type	Field Width	Key
LITH-Code	I	4	Y
Rock Group	C	30	N
Lithologic Unit	C	50	N
Rock Type	C	50	N
Stratigraphy	C	50	N

Table 6.2: Structure of Data

Rock Type/ Lithologic Unit	Description
Unconsolidated Sediments	Quaternary sediments associated with alluvial, deltaic, coastal, eolian, flood plains, valley fills, etc. Based on their composition, 7 litho-units are identified in this group as shown below
Gravel	Comprising of granular sediments of 2-4 mm size
Sand and Silt	Comprising of granular sediments of 2-1/256 mm size
Clayey Sand/Silt	Comprising of dominantly granular sediments with significant clay content
Sandy Clay	Comprising of dominantly non-granular sediments with significant sand content.
Clay	Comprising of dominantly non-granular sediments having <256 mm particle size
Alternating Sequence of Sand/ Silt and Clay	Interbedded granular (sand/silt) and non-granular sediments (clay in different proportions)
Colluvium	Assorted mixture of cobbles, pebbles, sand, silt and clay
Residual Cappings	Duricrusts associated with remnants of planar surfaces. Occur as plateaus, mesas, buttes, etc. 4 litho-units are identified in this group as shown below.
Laterite (Ferricrete)	Hard and pisolitic oxidised crust at surface underlain by soft lithomargic clays formed by deep chemical weathering and enrichment of iron oxides by leaching.
Bauxite (Alecrete)	Same as above, but formed due to enrichment of aluminium oxide.
Kankar (Calcrete)	Produced by the formation of calcium carbonate nodules.
Chert (Silcrete)	Cryptocrystalline silica; occur as bands or layers of nodules.
Detrital Laterite	Formed by deposition of laterite / ferrugenous detritus as valley fills.
Deccan Traps and Intertrappeans	Upper Cretaceous to Palaeocene volcanic flows like Deccan basalts and their equivalents. Based on their aquifer characteristics, 6 litho-units are identified in this group as shown below.
Inter-/Infra-trappean Sand/Clay bed	Thin beds of semi-consolidated sediments occurring between different lava flows and also at the base of Deccan traps.
Tuffacious Basalt	Soft, friable and porous besalt formed mainly by volcanic tuff.
Vesicular Basalt	Hard and vesicular basalt with limited porosity.
Amygdaloidal Basalt	Vesicular basalt filled with amygdales.
Massive Basalt	Hard and massive basalt. Fracturing and weathering lead to the development of secondary porosity and permeability.
Red / Green Bole	Red / Green clay beds of 0.5-5 m thickness occur between different lava flows.
Older Volcanics/Metavolcanics	Volcanic rocks of different composition of Precambrian age.
Besalt	Hard and massive basalts.
Rhyolite	Hard and massive rhyolites.
Dacite	Hard and massive dacites.
Andesite	Hard and massive andesites.
Semi-consolidated Sediments	Upper Carboniferrous to Pliocene sediments comprising of mainly Gondwanas, Rajamundry Sandsone, Nari, Gaj series, Cretaceous beds to Trichy etc, which are partially consolidated, soft and friable having significant intergranular pore spaces. Based on their composition in this group as shown below.
Sandstone and Conglomerate	Comprising of dominantly granular sediments with insignificant shale / clay content.
Shaly Sandstone	Comprising of dominantly granular sediments with significant shale / clay content.
Sandstone with Shale/Coal partings	Dominantly granular sediments, interbedded with shale, clay or coal partings.
Shell Limestone/Limestone	Mainly formed by cementation of shell fragments and oolites.
Sandy Shale	Comprising of dominantly non-granular sediments with significant sand content.
Shale with Sandstone Partings	Mainly shale/clay, coal, lignite formations with thin sandstone partings.
Shale/Coal/Lignite	Comprising of dominantly non-granular sediments with insignificant sand content.
Consolidated Sediments	Mainly Precambrian to Cambrian sedimentaries of Cuddapah, Delhi, Vindhyan

Rock Type/ Lithologic Unit	Description
	Groups and their equivalents, comprising of fully consolidated sediments without any intergranular pore spaces (except the bedding places). Based on their aquifer characteristics, 8 litho-units are identified in this group as shown below.
Thin Bedded Sandstone/Quartzite	Hard and indurated sandstone/quartzite with a no. of well defined bedding planes.
Thin Bedded Limesone/Dolomite	Thin bedded, flaggy limestone / dolomite with a no. of defined bedding planes.
Thick Bedded / massive Limestone / Dolomite	Hard and massive limestone/dolomite with very few bedding planes.
Thick Bedded Sandstone/Quartzite	Hard and massive sandstone/quartzite, without any intergranular pore spaces.
Shaly Limestone	Dominantly limestone with significant shale content as impurity or with shale intercalations.
Conglomerate	Hard and massive conglomerate without significant intergranular pore spaces
Shale with Limestone/ Sandstone Bands / Lenses	Mainly shale sequence with bands and lenses of limestone/sandstone
Shale	Hard and compact shale/claystone
Plutonic Rocks	Include a variety of hard and massive plutonic igneous rocks with no primary porosity.
Granitic / Acidic Rocks	Hard and massive plutonic rocks of granitic/acidic composition.
Alkaline Rocks	Hard and massive plutonic rocks of alkaline composition.
Basic Rocks	Hard and massive plutonic rocks of basic composition.
Ultrabasic Rocks	Hard and massive igneous rocks of ultrabasic composition.
Quartz Reef	Hard and brittle quartz reefs.
Pegmatite/Aplite/Quartz Vein	Hard and brittle veins of Pegmatite/Aplite/Quartz
Granite and Gneissic Complexes/ Migmatitic Complexes	Include Peninsular gneissic complex and equivalents with granitic intrusions, and migmatitic complexes.
Granite & Gneissic Complex	Comprising of gneisses and granites in roughly same proportion.
Grantic Gneiss	Mainly comprising of gneisses with granitic lenses.
Migmatitic Complex	Hard and massive migmatities.
Migmatite with Granite Lenses	Hard and massive migmatites with lenses of granite.
Metamorphics	Include, a variety of metamorphosed igneous, sedimentary and volcanic rocks.
Gneiss	Gneisses of different mineral composition with crude to well developed foliations.
Schist	Crudely foliated schists of different composition.
Quartzite	Hard and brittle quartzites.
Slate	Slates with well developed slaty cleavage.
Phyllite	Crudely foliated phyllites.
Calc Gneiss	Calcareous gneisses with crudely to well-developed foliations.
Calc Schist	Crudely foliated calcareous schists.
Limestone / Marble	Hard and brittle limesone / marble.

Table 6.3: Description of rock types/ lithologic units

7 GEOLOGY – STRUCTURES

7.1 CLASSIFICATION SCHEME

The geological structures will be mapped as per the classification scheme in Table 7.1. Only those units present in the map area will be classified, and any other unit present in the area and not covered by the scheme will be mapped and provided appropriate code.

7.2 INPUT DATA

The input data comprise:

- Geocoded IRS LISS III FCC imagery in 1:50,000 scale of summer season (with minimum vegetation cover); where necessary Kharif or Rabi season data will be additionally used;
- Existing geological and hydrogeological maps and literature.

7.3 METHODOLOGY

Different types of primary and secondary geological structures (attitude of beds, schisticity/foliation, folds, lineaments, circular features, etc.) can be visually interpreted by studying the landforms, slope asymmetry, outcrop pattern, drainage pattern, and stream/river courses. Lineaments (faults, fractures, shear zones, and thrusts) appear as linear and curvilinear lines on the satellite imagery, and are often indicated by the presence of moisture, alignment of vegetation, straight drainage courses, alignment of tanks/ponds, etc. Lineaments are further sub-divided based on image characteristics and geological evidence.

The attitude of beds (strike and dip) are estimated by studying the slope asymmetry, landform, drainage characteristics, etc. For instance horizontal to sub-horizontal beds show mesa/butte type of landform, dentritic drainage pattern and tonal/colour banding parallel to the contour lines; inclined beds show triangular dip facets, cuestas, homoclines and hogbacks. The Schistosity/foliation of the rocks are shown as numerous thin, wavy and discontinuous trend lines. Non-plunging and plunging folds are mapped from the marker horizons. Non-plunging folds produce outcropping in parallel belts, and plunging folds produce V or U shaped outcrop pattern. Doubly plunging folds are indicated by oval shaped outcrops. Further classification into anticline or syncline can be made on the basis of dip direction of beds. Circular features, representing structural domes/ basins, sub-surface igneous intrusions, salt domes, etc. show circular to quasi-circular outcrops and trend lines with radial/ annular drainage pattern. Reference to existing literature can support confirmation of interpreted details. The geological structures will be mapped with standard symbols.

The pre-field structural map will be checked in the field and validated.

The overall classification accuracy will be estimated through ‘Kappa Coefficient’, which is a measure of agreement between the classified map and ground conditions at a specified number of sample sites.

The classified map will be scanned and digitised using an appropriate scanner. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Table 7.1 and 7.2. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. The transformation process will involve geometric rectification through Ground Control Points (GCPs) identified on the input coverage and corresponding SoI map. The data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

7.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

Structure	Sub- categories	STRU-Code
Bedding		01-00
	Horizontal (dip angle between 0 and 5 degrees)	01-01
	Gentle (dip angle between 5 and 15 degrees)	01-02
	Moderate (dip angle between 15 and 45 degrees)	01-03
	Steep(dip angle between 45 and 80 degrees)	01-04
	Vertical to sub-vertical(dip angle greater than 80 degrees)	01-05
	Overturned (beds are overturned)	01-06
Schistosity/ Foliation		02-00
	Moderate (dip angle less than 45 degrees)	02-01
	Steep(dip angle between 45 and 80 degrees)	02-02
	Vertical to sub-vertical (dip angle greater than 80 degrees)	02-03
	Overturned (Schistosity / foliation overturned)	02-04
Faults/ Fractures/ Lineaments/ Shear zones/ Thrusts		03-00
	Confirmed	03-01
	Inferred	03-02
Folds		04-00
	Anticline/ Antiform	04-01
	Syncline/Synform	04-02
	Folds to be classified as non-plunging, plunging, doubly plunging and overturned	04-03
Circular features		05-00
	Structural dome	05-01
	Structural basin	05-02
Trend lines		06-00
Escarpment		07-00

Table 7.1: Geologic Structure Classification and Code (STRU-LUT)
(proposed by NRSA in RGDWTM mapping project)

Field Name	Field Type	Field Width	Key
Stru-Code	I	4	Y
Structure	C	30	N
Sub-Structure	C	100	N

Table 7.2: Structure of Data

8 GEOMORPHOLOGY

8.1 CLASSIFICATION SCHEME

Geomorphic units/ different landforms will be mapped as per the classification scheme (and code) in Table 8.1, and the structure of data is described in Table 8.2. While the scheme is comprehensive only those units present in the area to be mapped will be classified, and any other unit present in the area and not listed in Table 8.1 will be classified and appropriate code/symbol used.

8.2 INPUT DATA

The input data comprise of:

- Geocoded IRS LISS III FCC imagery in 1:50000 scale of summer season (with minimum vegetation cover); where necessary Kharif or Rabi season data will be additionally used
- Existing geological and hydrogeological maps and literature

8.3 METHODOLOGY

The geomorphic units/ landforms in the classification scheme are described in Table 8.3. The satellite imagery will be visually interpreted into geomorphic units/ landforms based on image elements such as tone, texture, shape, size, location and association, physiography, genesis of landforms, nature of rocks/ sediments, and associated geological structures. The topographic information in SoI topomaps aids in interpreting satellite imagery. Three major geomorphic units – hills and plateaus, piedmont zones, and plains- based on physiography and relief. Within each zone different geomorphic units will be mapped based on landform characteristics, their areal extent, depth of weathering, thickness of deposition, etc.

The interpreted geomorphic units/landforms will be verified through field visits, in which the depth of weathering, nature of weathered material, thickness of deposition, nature of deposited material, etc. are examined at nala and stream cuttings, existing wells, lithologs of wells drilled, etc.

The overall classification accuracy will be estimated through ‘Kappa Coefficient’, which is a measure of agreement between the classified map and ground conditions at a specified number of sample sites.

The classified map will be scanned and digitized using an appropriate scanner. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Table 8.1 and 8.2. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. The transformation process will involve geometric rectification through Ground Control Points (GCPs) identified on the input coverage and corresponding SoI map. The HP data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

8.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

Zone	Geomorphic Unit	Sub- categories	Landforms	GU-Code
Hills and Plateaus	Structural hills			01-01-00-00-00
	Denudational hills			01-02-00-00-00
	Plateaus			01-03-00-00-00
		Upper		01-03-01-00-00
		Undissected		01-03-01-01-00
		Moderately dissected		01-03-01-02-00
		Highly dissected		01-03-01-03-00
		Middle		01-03-02-00-00
		Undissected		01-03-02-01-00
		Moderately dissected		01-03-02-02-00
		Highly dissected		01-03-02-03-00
		Lower		01-03-03-00-00
		Undissected		01-03-03-01-00
		Moderately dissected		01-03-03-02-00
		Highly dissected		01-03-03-03-00
	Valleys			01-04-00-00-00
		Structural valley		01-04-01-00-00
		Intermontane valley		01-04-02-00-00
			Linear/Curvilinear ridge	01-00-00-00-01
			Cuesta	01-00-00-00-02
			Mesa	01-00-00-00-03
			Butte	01-00-00-00-04
			Dome (Structural)	01-00-00-00-05
			Dome (massive)	01-00-00-00-06
			Inselberg	01-00-00-00-07
Piedmont Zone	Pediment			02-01-00-00-00
		Buried pediment		02-01-01-00-00
		Dissected pediment		02-01-02-00-00
		Pediment-Inselberg complex		02-01-03-00-00
	Piedmont slope			02-02-00-00-00
	Piedmont alluvium			02-03-00-00-00
		Shallow		02-03-01-00-00
		Moderate		02-03-02-00-00
		Deep		02-03-03-00-00
	Bajada			02-04-00-00-00
		Shallow		02-04-01-00-00
		Moderate		02-04-02-00-00
		Deep		02-04-03-00-00
			Linear/Curvilinear ridge	02-00-00-00-01
			Cuesta	02-00-00-00-02
			Mesa	02-00-00-00-03
			Butte	02-00-00-00-04
			Dome (Structural)	02-00-00-00-05
			Dome (massive)	02-00-00-00-06
			Inselberg	02-00-00-00-07
Plains	Pediplain			03-01-00-00-00
		Weathered		03-01-01-00-00
		Shallow		03-01-01-01-00
		Moderate		03-01-01-02-00
		Deep		03-01-01-03-00
		Buried		03-01-02-00-00
		Shallow		03-01-02-01-00
		Moderate		03-01-02-02-00
		Deep		03-01-02-03-00
			Linear/Curvilinear ridge	03-01-00-00-01
			Cuesta	03-01-00-00-02
			Mesa	03-01-00-00-03
			Butte	03-01-00-00-04
			Dome (Structural)	03-01-00-00-05
			Dome (massive)	03-01-00-00-06
			Inselberg	03-01-00-00-07
			Valleyfill-Shallow	03-01-00-00-08
			Valleyfill-Moderate	03-01-00-00-09
			Valleyfill-Deep	03-01-00-00-10

Zone	Geomorphic Unit	Sub- categories	Landforms	GU-Code
	Etch plain			03-02-00-00-00
		Shallow weathered		03-02-01-00-00
		Moderately weathered		03-02-02-00-00
		Deeply weathered		03-02-03-00-00
			Linear/Curvilinear ridge	03-02-00-00-01
			Cuesta	03-02-00-00-02
			Mesa	03-02-00-00-03
			Butte	03-02-00-00-04
			Dome (Structural)	03-02-00-00-05
			Dome (massive)	03-02-00-00-06
			Inselberg	03-02-00-00-07
			Valleyfill-Shallow	03-02-00-00-08
			Valleyfill-Moderate	03-02-00-00-09
			Valleyfill-Deep	03-02-00-00-10
	Stripped plain			03-03-00-00-00
		Shallow basement		03-03-01-00-00
		Moderate basement		03-03-02-00-00
		Deep basement		03-03-03-00-00
			Linear/Curvilinear ridge	03-03-00-00-01
			Cuesta	03-03-00-00-02
			Mesa	03-03-00-00-03
			Butte	03-03-00-00-04
			Dome (Structural)	03-03-00-00-05
			Dome (massive)	03-03-00-00-06
			Inselberg	03-03-00-00-07
			Valleyfill-Shallow	03-03-00-00-08
			Valleyfill-Moderate	03-03-00-00-09
			Valleyfill-Deep	03-03-00-00-10
	Flood plain			03-04-00-00-00
		Older/Upper		03-04-01-00-00
		Shallow		03-04-01-01-00
		Moderate		03-04-01-02-00
		Deep		03-04-01-03-00
		Younger/ Lower		03-04-02-00-00
		Shallow		03-04-02-01-00
		Moderate		03-04-02-02-00
		Deep		03-04-02-03-00
			Channel bar	03-04-00-00-01
			Point bar	03-04-00-00-02
			River terrace	03-04-00-00-03
			Natural levee	03-04-00-00-04
			Backswamp	03-04-00-00-05
			Cut-off meander	03-04-00-00-06
			Abandoned channel	03-03-00-00-07
			Ox-bow lake	03-04-00-00-08
			Paleochannel	03-04-00-00-09
			Buried channel	03-04-00-00-10
	Alluvial plain			03-05-00-00-00
		Older/Upper		03-05-01-00-00
		Shallow		03-05-01-01-00
		Moderate		03-05-01-02-00
		Deep		03-05-01-03-00
		Younger/ Lower		03-05-02-00-00
		Shallow		03-05-02-01-00
		Moderate		03-05-02-02-00
		Deep		03-05-02-03-00
			Channel bar	03-05-00-00-01
			Point bar	03-05-00-00-02
			River terrace	03-05-00-00-03
			Natural levee	03-05-00-00-04
			Backswamp	03-05-00-00-05
			Cut-off meander	03-05-00-00-06
			Abandoned channel	03-05-00-00-07
			Ox-bow lake	03-05-00-00-08
			Paleochannel	03-05-00-00-09
			Buried channel	03-05-00-00-10
	Deltaic plain			03-06-00-00-00
		Older/Upper		03-06-01-00-00
		Shallow		03-06-01-01-00
		Moderate		03-06-01-02-00
		Deep		03-06-01-03-00
		Younger/ Lower		03-06-02-00-00
		Shallow		03-06-02-01-00
		Moderate		03-06-14-02-02

Zone	Geomorphic Unit	Sub- categories	Landforms	GU-Code
		Deep		03-06-00-02-03
			Channel bar	03-06-00-00-01
			Point bar	03-06-00-00-02
			River terrace	03-06-00-00-03
			Natural levee	03-06-00-00-04
			Backswamp	03-06-00-00-05
			Cut-off meander	03-06-00-00-06
			Abandoned channel	03-06-00-00-07
			Ox-bow lake	03-06-00-00-08
			Paleochannel	03-06-00-00-09
			Buried channel	03-06-00-00-10
	Coastal plain			03-07-00-00-00
		Older/Upper		03-07-01-00-00
		Shallow		03-07-01-01-00
		Moderate		03-07-01-02-00
		Deep		03-07-01-03-00
		Younger/ Lower		03-07-02-00-00
		Shallow		03-07-02-01-00
		Moderate		03-07-02-02-00
		Deep		03-07-02-03-00
			Beach	03-07-00-00-01
			Beach ridge	-3-07-00-00-02
			Beach ridge & Swale	03-07-00-00-03
			complex	03-07-00-00-04
			Swale	03-07-00-00-05
			Off-shore bar	03-07-00-00-06
			Spit	03-07-00-00-07
			Mud flat	03-07-00-00-08
			Salt flat	03-07-00-00-09
			Tidal flat	03-07-00-00-10
			Lagoon	03-07-00-00-11
			Sand dune	03-07-00-00-12
			Channel island	03-07-00-00-13
			Paleochannel	03-07-00-00-14
			Buried Channel	
	Eolian plain			03-08-00-00-00
		Shallow		03-08-01-00-00
		Moderate		03-08-02-00-00
		Deep		03-08-03-00-00
			Sand dune	03-08-00-00-01
			Stabilised dune	03-08-00-00-02
			Dune complex	03-08-00-00-03
			Interdunal depression	03-08-00-00-04
			Interdunal flat	03-08-00-00-05
			Playa	03-08-00-00-06
			Desert Pavement	03-08-00-00-07
			Loess	03-08-00-00-08
			Paleochannel	03-08-00-00-09
			Buried Channel	03-08-00-00-10

Table 8.1: Geomorphic Classification Scheme and Code (GU-LUT);
(proposed by NRSA in RGDWTM mapping project)

Field Name	Field Type	Field Width	Key
GU-Code	I	10	Y
Descr-Level 1	C	50	N
Descr-Level 2	C	50	N
Descr-Level 3	C	50	N
Descr-Level 4	C	50	N
Descr-Landform	C	50	N

Table 8.2: Structure of Data

Geomorphic Unit/ Landform	Description
Structural Hills	Linear to arcuate hills showing definite structural trends.
Denudational Hills	Hills formed due to differential erosion and weathering, so that a more resistant formation or intrusion stand as mountains/ hills.
Plateaus	Elevated flat uplands occupying fairly large area (greater than 5 km x 5 km) and bound by escarpments/steep slopes on all sides. Based on their geomorphic position, they are classified into 3 categories – 1) Upper, 2) Middle and 3) Lower. Further based on dissection, these Upper, Middle and Lower Plateaus have been further classified into undissected, moderately dissected and highly dissected categories.
- Undissected	A plateau (upper/middle/lower) which is fully preserved in its original form and has not been dissected.
- Moderately Dissected	A plateau (upper/middle/lower) dissected by deep valleys/gullies changing the original form considerably.
- Highly Dissected	A plateau (upper/middle/lower) more frequently dissected by deep valleys separating into individual mesas/buttes.
Valleys	Low lying depressions and negative landforms of varying size and shape occurring within the hills associated with stream/nala courses.
Structural Valleys	Narrow linear valleys formed alone the structurally weak planes, like faults, fractures, lithological-contacts etc.
Intermonate Valley	Small valleys occurring within the structural/denudational hills.
Linear / Curvilinear Ridge	A narrow linear/curvilinear resistant ridge formed by dolerite dyke, quartz reef, quartzite bed, etc.
Cuesta	An isolated hill formed by gently dipping (5-100) sedimentary beds having escarpent/steep steep slopes on one side and gentle dip slopes on the other side.
Mesa	Flat-topped hills having width 2 km to 250 m.
Butte	Flat-topped hills having width <250 m.
Dome (Structural)	Dome shaped hills of structural origin.
Dome (Massive)	Dome shaped hills formed by exfoliation and sheeting of plutonic rocks.
Inselberg	An Isolated hill of massive type abruptly rising above surrounding plains.
Pediment	Gently undulating plain dotted with rock outcrops with or without thin veneer of Soil cover.
Buried Pediment	Same as above, but buried under unconsolidated sediments.
Dissected pediment	Same as pediment, but dissected.
Pediment-Inselberg Complex	Pediment dotted with a number of inselbergs which cannot be separated and mapped as individual units.
Piedmont Slope	Slope formed by bajada and pediment together.
Piedmont Alluvium - Shallow - Moderate - Deep	Alluvium deposited along foot hill zone due to sudden loss of gradient by rivers/streams in humid and sub-humid climate. Based on the thickness, it is divided into 3 categories – 1) Shallow (0-10 m), 2) Moderate (10-20 m), and 3) Deep (more than 20 m).
Bajada - Shallow - Moderate - Deep	Detrital alluvial out-wash of varying grain size deposited along the foot hill zone in arid and semi-arid climate. Based on the thickness, it is divided into 3 categories – 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (>20 m).
Alluvial Fan	A fan shaped mass of sediment deposited at a point along a river where there is a decrease in gradient.
Talus Cone	A cone shaped deposit of coarse debris at the foot of hills/ cliffs adopting the angle of repose.
Pediplain-Weathered - Shallow Weathered - Mod. Weathered - Deeply Weathered	Gently undulating plain of large areal extent often dotted with inselbergs formed by the coalescence of several pediments. Based on the depth of weathering, weathered pediplains are classifed into 3 categories – 1) Shallow (0-10 m), 2) Moderate (10-20 m), and 3) Deep (more than 20 m)
Pediplain-Buried - Shallow - Moderate	Same as above, but buried under transported material. Based on the total thickness of transported material and depth of weathering, buried pediplains are classified into 3 categories – 1) Shallow (0-10m), 2) Moderate (10-20 m), and 3) Deep (more than 20 m).

Geomorphic Unit/ Landform	Description
- Deep	
Etch Plain - Shallow Weathered - Mod. Weathered - Deeply Weathered	A plain formed by deep chemical weathering and stripping. Based on the depth of weathering, etch plains are classified into 3 categories – 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Stripped Plain - Shallow Basement - Mod. Basement - Deep Basement	Gently undulating plain formed by partial stripping (erosion) of older pediplains. The presence of rock outcrops along valleys and deeply weathered zones along inter-stream divides indicate the stripped plains. Based on depth to basement, it is classified into 3 categories – 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Valley Fill - Shallow - Moderate - Deep	Valleys of different shapes and sizes occupied by valley fill material (partly detrital and partly weathered material). They are classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Flood Plain	Alluvium deposited along the river/stream courses due to repeated flooding. It is classified into 2 categories -–1) Older/Upper and 2) Younger/Lower.
Flood Plain-Older/Upper - Shallow - Moderate - Deep	Same as above. Older refers to earlier cycle of deposition and upper refers to higher elevation8. Based on the thickness of alluvium, it is classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Flood Plain-Younger/ Lower - Shallow - Moderate - Deep	Same as above. Younger refers to late cycle of deposition and lower refers to lower elevation. Based on the thickness of alluvium, it is classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Alluvial Plain	Nearly level plain formed by the deposition of alluvium by major rivers. It is further classified into 2 categories – 1) Older /Upper and 2) Younger / Lower.
Alluvial Plain-Older / Upper - Shallow - Moderate - Deep	Same as above. Older refers to earlier cycle of deposition and upper refers to higher elevation8. Based on the thickness of alluvium, it is classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Alluvial Plan-Younger / Lower - Shallow - Moderate - Deep	Same as above. Younger refers to late cycle of deposition and lower refers to lower elevation. Based on the thickness of alluvium, it is classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Deltaic Plain	Alluvial plain formed by the distributary network of the rivers/ streams at their confluence with sea, it is further classified into 2 categories – 1) Older / Upper and 2) Younger/Lower.
Deltaic Plain-Older / Upper - Shallow - Moderate - Deep	Same as above. Older refers to earlier cycle of deposition and upper refers to higher elevation. Based on the thickness of alluvium, it is classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Deltain Plain – Younger / Lower - Shallow - Moderate - Deep	Same as above. Younger refers to late cycle of deposition and lower refers to lower elevation. Based on the thickness of alluvium, it is classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Channel Bar	Sand bar formed in the braided river course due to vertical accrition of the sediments.
Point Bar	Sand bar formed at the convex side of meandering river by lateral accrition of sediment.
River Terrace	Flat upland adjoining the river course, occurring at different levels and occupied by river-borne alluvium. It indicates the former valley floor.
Natural Levee	Natural embankment formed by deposition of alluvium on river bank due to flooding.
Back Swamp	Depressions formed adjacent to natural levees in the flood plains of major streams/rivers. Occupied by clay & silt with or without water.
Cut-off Meander	Meander loop of a matured river, cut-off from the main stream / river, filled with river-borne sediments.

Geomorphic Unit/ Landform	Description
Abandoned Channel	An old river bed cut-off from the main stream, occupied by channel-lag / channel-fill material.
Ox-bow Lake	A lunate shaped lake located in an abandoned meandering channel.
Coastal Plain	Nearly level plain formed by marine action along the coast, mainly containing brackish water sediments. It is further classified into 2 categories – 1) Older / Upper and 2) Younger / Lower.
Coastal Plain- Younger / Upper - Shallow - Moderate - Deep	Same as above. Older refers to earlier cycle of deposition and upper refers to higher elevation. Based on the thickness of alluvium, it is classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Coastal Plain – Younger / Lower - Shallow - Moderate - Deep	Same as above. Younger refers to late cycle of deposition and lower refers to lower elevation. Based on the thickness of alluvium, it is classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Beach	Narrow stretch of unconsolidated sand / silt deposited by tidal waves along the shore line.
Beach Ridge	A linear ridge of unconsolidated sand/ silt parallel to the shore line.
Beach Ridge and Swale Complex	A group of beach ridges and swales occurring together.
Swale	Linear depression occurring between two beach ridges.
Offshore Bar	Embankments of sand and gravel formed on the sea floor by waves and currents, occurring parallel to the coast line.
Spit	Off-shore bar attached to the land at one end and terminating in open water at the other.
Mud Flat	Mud deposited in the back swamps and along tidal creeks.
Salt Flat	Flat lands along the coast comprising of salt encrustations.
Tidal Flat	Flat surface formed by tides comprising of mostly mud and fine sand.
Lagoon	An elongated body of water lying parallel to the coast line and separated from the open sea by barrier islands.
Channel island	An island formed in the braided river course.
Eolian Plain - Shallow - Moderate - Deep	A plain formed by the deposition of wind blown sand dotted with a number of sand dunes. Based on the thickness of sand sheet and dissection, it is classified into 3 categories - 1) Shallow (0-10 m), 2) Moderate (10-20 m) and 3) Deep (more than 20 m).
Sand Dune	Heaps of sand of different shapes and sizes formed by wind action in the desertic terrain.
Stabilized Dune	Same as above, but stabilised.
Dune Complex	Group of sand dunes occurring together which cannot be mapped separately.
Interdunal Depression	Depression occurring between sand dunes.
Interdunal Flat	Flat land occurring between sand dunes.
Playa	Dry lake in an interior desert basin.
Desert Pavement	Flat or gently sloping surfaces, developed on fans, bajadas and desert flats formed by concentration of pebbles after removal of finer material by wind action.
Loess	Deposit of wind-blow silt.
Palaeochannel	An earlier river course filled with channel lag or channel fill sediments.
Buried Channel	Old river course filled with channel lag or channel fill deposits, buried by recent alluvium / Soil cover.

Table 8.3: Description of Geomorphic units and Landforms

9 ADMINISTRATIVE UNITS

9.1 CLASSIFICATION SCHEME

The primary layers of administrative units upto Block will be created. The code is created to account also for future expansion of database to States outside HP.

Administrative Unit	State	District	Tahsil	Block
Code	AA	BB	CC	DD

Table 9.1: Classification Scheme and Code for Administrative Units (ADMIN.LUT)

9.2 INPUT DATA

The input data comprise:

- Most recent SoI map in 1:50,000 scale;
- Latest map from State Survey Department in comparable scale, and list of administrative unit names.

9.3 METHODOLOGY

The list of administrative units with names will be obtained from State Revenue Department, and the information on boundaries from most recent SoI map will be updated with the help of State Survey department map. It will be desirable to prepare a fresh cartographic product of such boundaries on clean polyester film for scanning and digitisation.

The administrative unit map will be scanned and digitized using an appropriate scanner. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Table 9.1. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. Since the State survey department maps may not have accuracy similar to SoI map, the transformation process will involve geometric rectification through Ground Control Points (GCPs) identified on the input coverage and corresponding SoI map. The data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

9.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

10 HYDROLOGIC UNITS

10.1 CLASSIFICATION SCHEME

The primary layers of hydrologic units upto watershed will be created. The classification scheme follows the hierarchical system of watershed delineation developed by AISLUS.

Hydrologic Unit	Region	Basin	Catchment	Sub-Catchment	Watershed
WS-Code	A	B	CC	DD	EE

Table 10.1: Classification Scheme and Code for Hydrologic Units (WS-LUT)

10.2 INPUT DATA

- SoI map in 1:50,000 scale SoI map in 1:50,000 scale;
- Watershed Atlas of India from All India Soil and Land Use Survey (AISLUS) in 1:1 million scale.

10.3 METHODOLOGY

The hydrologic boundary upto watershed in AISLUS Atlas is drawn from 1:250,000 scale SoI maps (and further into sub-watershed using 1:50,000 scale SoI maps) but shown in 1:1 million scale map. The boundary delineation of hydrologic units at different hierarchical level in AISLUS classification is also based on keeping the unit size relevant to river valley project and flood prone river management. Thus the hydrologic boundaries need to be updated using 1:50,000 scale SoI map, generally following the stream order (rather than point of interception such as dam, barrage, etc.). The six water resources regions are as suggested by Dr. Khosla in 1949. Each water resources region is delineated into basins, drained by a single major river or a group of small rivers or a major distributary of a major river. Each basin is subdivided into catchments, drained by a single major river or a group of small rivers or a major tributary of a major river such as Cauvery. Each catchment is divided into sub-catchments, drained by a single river or a group of small rivers or a major distributary of a major river like Vaigai. Each sub-catchment is divided into watersheds, drained by a single river or group of small rivers or a tributary of a major river.

The hydrologic unit map will be scanned and digitised using an appropriate scanner. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Table 10.1. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. The data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

10.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

11 SETTLEMENTS

11.1 CLASSIFICATION SCHEME

All urban settlements (towns) and rural settlements (villages) will be mapped as per the coding scheme below:

Type	Code
Settlement	01-00
- Town/ City	01-01
- Village	01-02

Table 11.1: Settlement Classification Scheme and Code (SettlP.LUT & SettlA. LUT)

Field Name	Field Type	Field Width	Key
SettlA(&SettlP)-Code	I	4	Y
Type	C	30	N
Sub-category	C	30	N

Table 11.2: Structure of Data

It is not proposed to categorize the settlements by size, which can be performed in the GIS by attaching population data.

11.2 INPUT DATA

The input data comprise:

- most recent SoI map in 1:50,000 scale;
- Census data and maps;
- most recent IRS LISS III FCC geocoded imagery in 1:50,000 scale.

11.3 METHODOLOGY

The location of towns and villages will be mapped from SoI map, and updated with reference to Census map and satellite data.

The settlement boundary will be taken from SoI map (and village boundary from revenue or census map), and updated with reference to satellite imagery. In case of sparse distribution of settlement, only the main part of settlement will be shown.

The settlement location and spread map will be scanned and digitised using an appropriate scanner. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Section 13.1. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. The data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

11.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

12 TRANSPORT NETWORK

12.1 CLASSIFICATION SCHEME

The classification scheme for roads and rail is shown in Table 12.1

Type	Sub-category	TRNPT-Code
Metalled Road		01-00
	National highway	01-01
	State highway	01-02
	District road	01-03
	Village road	01-04
Un- Mettaled Road		02-00
	National highway	02-01
	State highway	02-02
	District road	02-03
	Village road	02-04
Tracks		03-00
Rail		04-00

Table 12.1: Road Classification Scheme and Code (TRNPT.LUT)

Field Name	Field Type	Field Width	Key
TRNPT-Code	I	4	Y
Type	C	30	N
Sub-category	C	30	N

Table 12.2: Structure of Data

12.2 INPUT DATA

The input data comprise of:

- most recent SoI map in 1:50,000 scale;
- maps from State Transport department.

12.3 METHODOLOGY

The road and rail alignments from SoI map will be mapped and symbolized. All roads will be classified into specified categories, while all rail tracks will be shown as single category. .

The road and rail map will be scanned and digitised using an appropriate scanner. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Section 12.1. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. The HP data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

12.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

13 DRAINAGE

13.1 CLASSIFICATION SCHEME

The classification will cover perennial, seasonal and peripheral categories. Minor streams and rivers will be represented by line, while the major rivers with edges in the SoI map will bbe represented by polygon.

Table 13.2 Drainage Classification Scheme and Code (DRNL.LUT and DRNP.LUT)

Drainage Type	Code
Perennial Stream/River	01
Seasonal Stream/River	02
Ephemeral Stream/River	03

Field Name	Field Type	Field Width	Key
DRNL-Code/ DRNP-Code	I	2	Y
Description	C	30	N

Table 13.2: Structure of Data

13.2 INPUT DATA

The input data comprise:

- Most recent SoI map in 1:50,000 scale;
- Flow data from State Water Resources Department.

13.3 METHODOLOGY

The drainage details will be digitized from SoI map in 1:50,000 scale. Where necessary flow data from the State Water Resources Department and kharif and rabi season satellite imagery may be used to support further classification into perennial, seasonal and ephemeral streams/rivers. Major rivers with defined water edge will be represented by polygons while minor streams will be shown as lines.

The road and rail map will be scanned and digitized using an appropriate scanner. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Section 12.1. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. The HP data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

13.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.

14 CONTOURS AND SPOT HEIGHTS

14.1 CLASSIFICATION SCHEME

All contours of 20 m interval in SoI map in 1:50,000 scale will be represented as lines and spot heights will be shown as points. The contour will be coded as integer by its value (ContL.LUT), and spot heights will be coded as 58J14S1, where the first five alphanumeric characters represent the SoI map number, and the next two characters represent the sequential number of spot heights within the sheet (ContP.LUT).

14.2 INPUT DATA

The input data comprise:

- SoI map in 1:50,000 scale

14.3 METHODOLOGY

The contours and spot heights from SoI map will be scanned and digitised. The Arc/Info coverage will be created and edited to remove digitisation errors, and the topology will be built. The features will be labeled as per codes/symbols defined in Section 14.1. The coverage will then be projected and transformed into polyconic projection and coordinate system in meters. The data specification standards in Table 3.2 need to be conformed. The resulting GIS coverage will be backed up in CD and labeled with corresponding SoI map sheet number, theme, generating agency, and generation date.

Internal quality control and external quality audit will be at different critical stages of mapping and digitisation process.

14.4 OUTPUT PRODUCTS

Five copies of GIS coverage with appropriate file names and format in CD and two B/W hardcopies of thematic map will be delivered by the vendor, alongwith a report on input data used, interpretation and digitisation process, internal QC statement, and contact address for clarifications.