

GIS Applications for Water, Wastewater, and Stormwater Systems

U.M. Shamsi



Taylor & Francis
Taylor & Francis Group

Boca Raton London New York Singapore

A CRC title, part of the Taylor & Francis imprint, a member of the
Taylor & Francis Group, the academic division of T&F Informa plc.

Contents

Chapter 1	GIS Applications	
Learning Objective		2
Major Topics		2
List of Chapter Acronyms		2
Introduction		2
What Are GIS Applications?		3
History of GIS Applications		4
4M Applications		6
Advantages and Disadvantages of GIS Applications		6
Advantages		7
GIS Applications Save Time and Money.....		7
GIS Applications Are Critical to Sustaining GIS Departments.....		7
GIS Applications Provide the Power of Integration.....		8
GIS Applications Offer a Decision Support Framework.....		8
GIS Applications Provide Effective Communication Tools.....		9
GIS Applications Are Numerous.....		9
Disadvantages.....		12
Success Stories		13
San Diego.....		13
Boston.....		13
Cincinnati		13
Knoxville.....		14
Dover		14
Charlotte		14
Albany County		14
GIS Applications Around the World.....		15
Evolving GIS Applications and Trends.....		15
Future Applications and Trends		16
GIS Application Development Procedure		19
Application Programming		20
GIS-Based Approach.....		20
GIS Customization		20
Scripting		20
Extensions		21
External Programs.....		23
Application-Based Approach		24
Useful Web Sites		24
Chapter Summary		24
Chapter Questions.....		25
Chapter 2	Needs Analysis	
Learning Objective		28
Major Topics		28

List of Chapter Acronyms	28
Ocean County's Strategic Plan	28
Introduction	28
Needs Analysis Steps.....	29
Step 1. Stakeholder Identification.....	30
Step 2. Stakeholder Communication	30
Introductory Seminar	31
Work Sessions and Focus Groups	31
Interviews	31
Step 3. Resource Inventory.....	32
Step 4. Need Priorities.....	33
Step 5. System Design.....	33
Data Conversion (Mapping).....	33
Database	34
Software Selection	36
Hardware Selection	37
User Interface.....	38
Step 6. Pilot Project	40
Step 7. Implementation Plan.....	41
Step 8. Final Presentation	43
Needs Analysis Examples	43
Pittsburgh, Pennsylvania	43
Borough of Ramsey, New Jersey.....	44
The City of Bloomington, Indiana	45
San Mateo County, California	45
Chapter Summary	45
Chapter Questions.....	46
Chapter 3 Remote Sensing Applications	
Learning Objective	48
Major Topics	48
List of Chapter Acronyms	48
Albany County's Remote Sensing Application.....	48
Introduction.....	49
Remote Sensing Applications.....	51
Remote Sensing Satellites	52
Spatial Resolution.....	53
Low-Resolution Satellite Data	53
Medium-Resolution Satellite Data.....	54
High-Resolution Satellite Data	56
High-Resolution Satellites	56
High-Resolution Imagery Applications	58
Data Sources	59
Digital Orthophotos	59
USGS Digital Orthophotos	60
Case Study: Draping DOQQ Imagery on DEM Data.....	62

Examples of Remote Sensing Applications	62
LULC Classification	62
Soil Moisture Mapping	65
Estimating Meteorological Data	66
Geographic Imaging and Image Processing Software.....	66
ERDAS Software Products	66
ERDAS Software Application Example.....	68
ArcView Image Analysis Extension	69
MrSID.....	69
PCI Geomatics	70
Blue Marble Geographics	71
Future Directions	72
Useful Web Sites	73
Chapter Summary	73
Chapter Questions.....	73
Chapter 4 DEM Applications	
Learning Objective	76
Major Topics	76
List of Chapter Acronyms	76
Hydrologic Modeling of the Buffalo Bayou Using GIS and DEM Data	76
DEM Basics	77
DEM Applications	79
Three-Dimensional (3D) Visualization.....	79
DEM Resolution and Accuracy.....	80
USGS DEMs.....	81
USGS DEM Formats	82
National Elevation Dataset (NED)	83
DEM Data Availability	83
DEM Data Creation from Remote Sensing	84
Image Processing Method.....	84
Data Collection Method.....	84
LIDAR.....	85
IFSAR.....	85
DEM Analysis.....	86
Cell Threshold for Defining Streams.....	86
The D-8 Model.....	86
DEM Sinks.....	87
Stream Burning	88
DEM Aggregation	88
Slope Calculations.....	88
Software Tools	88
Spatial Analyst and Hydro Extension.....	90
ARC GRID Extension	93
IDRISI	94
TOPAZ	95

Case Studies and Examples.....	95
Watershed Delineation	95
Sewershed Delineation.....	101
Water Distribution System Modeling	103
WaterCAD Example.....	104
Useful Web Sites	105
Chapter Summary	105
Chapter Questions.....	106

Chapter 5 GPS Applications

Learning Objective	108
Major Topics	108
List of Chapter Acronyms	108
Stream Mapping in Iowa	108
GPS Basics	109
GPS Applications in the Water Industry	110
Surveying.....	111
Fleet Management.....	111
GPS Applications in GIS.....	111
GPS Survey Steps.....	112
GPS Equipment	113
Recreational GPS Equipment	113
Basic GPS Equipment.....	114
Advanced GPS Equipment	115
Survey Grade GPS Equipment.....	116
Useful Web Sites	117
Chapter Summary	117
Chapter Questions.....	118

Chapter 6 Internet Applications

Learning Objective	120
Major Topics	120
List of Chapter Acronyms	120
Dublin's Web Map.....	120
Internet GIS	122
Internet Security	123
Internet GIS Software.....	124
Internet GIS Applications	124
Data Integration.....	124
Project Management	124
3D Visualization Applications	126
Case Studies.....	126
Tacoma's Intranet and Mobile GIS	126
Montana's Watershed Data Information Management System.....	127
Useful Web Sites	128

Chapter Summary	128
Chapter Questions.....	128

Chapter 7 Mobile GIS

Learning Objective	130
Major Topics	130
List of Chapter Acronyms	130
Mobile GIS Basics.....	130
Mobile GIS Applications.....	131
Wireless Internet Technology	133
GPS Integration	133
Useful Web Sites	134
Chapter Summary	135
Chapter Questions.....	135

Chapter 8 Mapping

Learning Objective	138
Major Topics	138
List of Chapter Acronyms	138
Los Angeles County's Sewer Mapping Program.....	138
Mapping Basics	139
Map Types.....	139
Topology.....	139
Map Projections and Coordinate Systems.....	140
Map Scale.....	140
Data Quality	140
Data Errors	141
Map Accuracy	141
Map Types.....	142
Base Map.....	142
Digital Orthophotos.....	143
Planimetric Maps	143
Small-Scale Maps	144
Advantages of GIS Maps	145
GIS Mapping Steps	147
Needs Analysis.....	147
Data Collection	148
Data Conversion.....	148
Capturing Attributes	148
Capturing Graphics	149
Digitization.....	149
Scanning.....	150
Data Conversion Software.....	150
Data Processing.....	153
Data Preparation.....	153
Topological Structuring.....	153

Data Management	154
Quality Control	155
Map Production	155
Case Studies.....	156
Borough of Ramsey, New Jersey.....	156
City of Lake Elsinore, California	158
Allegheny County, Pennsylvania	159
Useful Web Sites	159
Chapter Summary	160
Chapter Questions.....	160
Chapter 9 Mapping Applications	
Learning Objective	162
Major Topics.....	162
List of Chapter Acronyms	162
Customer Service Application in Gurnee	162
Common Mapping Functions	164
Thematic Mapping	164
Spatial Analysis.....	164
Buffers	164
Hyperlinks	167
Water System Mapping Applications.....	167
MWRA Water System Mapping Project	167
Service Shutoff Application.....	167
Generating Meter-Reading Routes	169
Map Maintenance Application.....	169
Wastewater System Mapping Applications.....	169
Public Participation with 3D GIS.....	169
Mapping the Service Laterals.....	170
Stormwater System Mapping Applications.....	173
Stormwater Permits.....	173
Chapter Summary	175
Chapter Questions.....	175
Chapter 10 Monitoring Applications	
Learning Objective	178
Major Topics.....	178
List of Chapter Acronyms	178
Monitoring Real Time Rainfall and Stream-Flow Data in Aurora.....	178
Monitoring Basics.....	179
Remotely Sensed Rainfall Data	179
Satellite Rainfall Data	180
Radar Rainfall Data	181
NEXRAD Rainfall Data	181
NEXRAD Level III Data.....	181
Estimating Rainfall Using GIS.....	183

Radar Rainfall Application: Virtual Rain-Gauge Case Study	184
Flow-Monitoring Applications	187
SCADA Integration.....	187
NPDES-Permit Reporting Applications	188
Monitoring via Internet	189
Monitoring the Infrastructure	190
Useful Web Sites	190
Chapter Summary	191
Chapter Questions.....	191

Chapter 11 Modeling Applications

Learning Objectives	194
Major Topics	194
List of Chapter Acronyms	194
Temporal-Spatial Modeling in Westchester County	194
H&H Modeling	195
Application Methods	196
Interchange Method.....	197
Subbasin Parameter Estimation	198
Runoff Curve Number Estimation.....	199
Water Quality Modeling Data Estimation	200
Demographic Data Estimation.....	202
Land-Use Data Estimation.....	204
Interface Method.....	205
HEC-GEO Interface	207
HEC-GeoHMS	207
HEC-GeoRAS	207
Watershed Modeling System	208
GISHydro Modules	208
GISHydro Prepro	209
GISHydro Runoff.....	210
ArcInfo Interface with HEC Programs.....	210
Intermediate Data Management Programs	211
Interface Method Case Study	212
Integration Method	212
EPA's BASINS Program	213
BASINS Examples.....	217
MIKE BASIN.....	218
Geo-STORM Integration	219
ARC/HEC-2 Integration	219
Integration Method Case Study	220
Which Linkage Method to Use?	221
Useful Web Sites	222
Chapter Summary	222
Chapter Questions.....	223

Chapter 12 Water Models

Learning Objective	226
Major Topics	226
List of Chapter Acronyms	226
City of Germantown's Water Model	226
GIS Applications for Water Distribution Systems	227
Development of Hydraulic Models	229
Software Examples	231
EPANET	231
H ₂ ONET™ and H ₂ OMAP™	232
Demand Allocator	235
Skeletonizer	235
Tracer	235
WaterCAD™ and WaterGEMS™	235
MIKE NET™	236
Other Programs	237
EPANET and ArcView Integration in Harrisburg	237
Mapping the Model Output Results	242
Network Skeletonization	243
Estimation of Node Demands	249
Demand-Estimation Case Studies	252
Newport News, Virginia	252
Round Rock, Texas	252
Lower Colorado River Authority, Texas	253
Estimation of Node Elevations	253
Pressure Zone Trace	255
Chapter Summary	255
Chapter Questions	255

Chapter 13 Sewer Models

Learning Objectives	258
Major Topics	258
List of Chapter Acronyms	258
MapInfo™ and SWMM Interchange	258
GIS Applications for Sewer Systems	259
Sewer System Modeling Integration	260
Software Examples	261
SWMM	261
Useful SWMM Web Sites	264
SWMM Graphical User Interface	264
XP-SWMM and XP-GIS	266
GIS Data for SWMM	267
Estimating Green-Ampt Parameters Using STATSGO/SSURGO GIS Files	267
GIS Applications for SWMM	270

AVSWMM.....	270
AVSWMM RUNOFF Extension	271
AVSWMM EXTRAN Extension.....	274
Task 1: Create EXTRAN input file	274
Task 2: Create SWMM EXTRAN output layers in ArcViewGIS	277
SWMMTools.....	278
AGSWMM	280
PCSWMM GIS™.....	281
SWMM and BASINS	282
SWMMDUET	283
AVsand™	284
Other Sewer Models.....	284
DHI Models.....	284
MOUSE™	284
MIKE SWMM™	285
MOUSE GIS™	285
MOUSE GM™	286
InfoWorks™	287
SewerCAD™ and StormCAD™	289
Sewer Modeling Case Studies.....	289
XP-SWMM and ArcInfo Application for CSO Modeling.....	289
AM/FM/GIS and SWMM Integration.....	290
SWMM and ArcInfo™ Interface.....	290
Hydra™ and ArcInfo™ Interface.....	291
Useful Web Sites	291
Chapter Summary	291
Chapter Questions.....	292

Chapter 14 AM/FM/GIS Applications

Learning Objective	294
Major Topics.....	294
List of Chapter Acronyms	294
Hampton's Wastewater Maintenance Management	294
Infrastructure Problem.....	295
AM/FM/GIS Basics.....	297
Automated Mapping (AM).....	298
Facilities Management (FM)	300
Automated Mapping (AM)/Facilities Management (FM).....	300
AM/FM/GIS Systems	300
AM/FM/GIS Software	300
ArcFM	302
Cityworks	304
Chapter Summary	305
Chapter Questions.....	305

Chapter 15 Maintenance Applications

Learning Objective 308
Major Topics 308
List of Chapter Acronyms 308
Buncombe County’s Sewer System Inspection and Maintenance 309
Asset Management 310
GASB 34 Applications 312
Wet Weather Overflow Management Applications 312
 AutoCAD Map GIS Application for CMOM 313
CCTV Inspection of Sewers 314
 Convert Existing Video Tapes to Digital Files 315
 Digitize Existing VHS Tapes 316
 WinCan 317
 Retrofit Tape Systems with Digital Systems 317
 Record Directly in Digital Format 319
 Linking Digital Movies to GIS 319
Video Mapping 321
Thematic Mapping of Inspection Data 322
Work Order Management 325
Water Main Isolation Trace 327
Case Studies 328
 Isolation Trace Case Studies 328
 Sewer System Inspections in Washington County 328
 Sewer Rehabilitation in Baldwin 330
Useful Web Sites 333
Chapter Summary 333
Chapter Questions 333

Chapter 16 Security Planning and Vulnerability Assessment

Learning Objective 336
Major Topics 336
List of Chapter Acronyms 336
GIS Applications in Planning 336
Security Planning 337
 Vulnerability of Water Systems 338
 Vulnerability of Sewer Systems 338
GIS Applications in Vulnerability Assessment 338
Security Modeling Software 340
 H₂OMAP™ Protector 340
 WaterSAFE™ 340
 VSAT™ 342
Security Planning Data Issues 342
Useful Web Sites 343
Chapter Summary 343
Chapter Questions 343

Chapter 17 Applications Sampler	
Learning Objective	346
Major Topics	346
List of Chapter Acronyms	346
Drainage Area Planning in Sofia.....	346
Pipe Rating Program in Buncombe County	347
Water System Modeling in Tucson	352
Water System Modeling in the City of Truth or Consequences.....	353
Background	355
Building the MIKE NET Model from Various Data Sources.....	355
ArcGIS and ArcFM Integration in Belgium	356
Water System Master Planning in Prague	358
Water Quality Management in Mecklenburg County	360
Water Master Planning in Sueca, Spain.....	362
Chapter Summary	364
Chapter Questions.....	364
Appendix A Acronyms.....	365
Appendix B Conversion Factors.....	371
References	373
Index.....	389