Nord Est SUD Ouest INTERREG IIIC

PROJET COFINANCE PAR L'UNION EUROPEENNE

DISMA : SIG, Gestion des désastres avec l'accent sur le patrimoine culturel

DISaster MAnagement GIS with emphasis on cultural sites

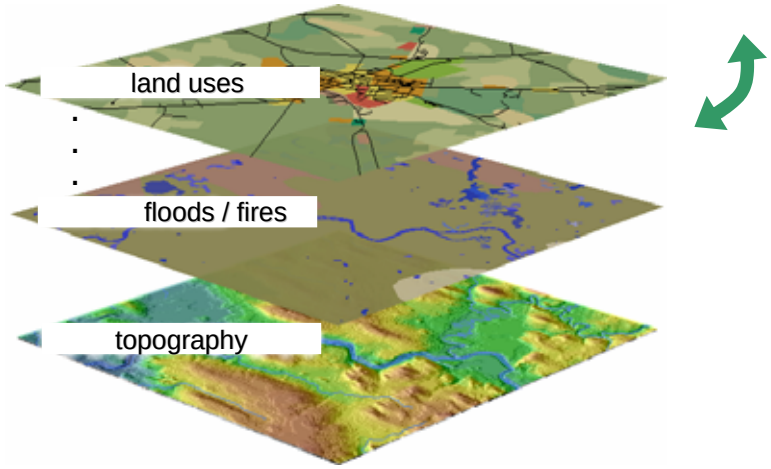
CEPAM, Sophia-Antipolis Valbonne, France

28 February 2007

Dr. Kalliopi Tzivanaki

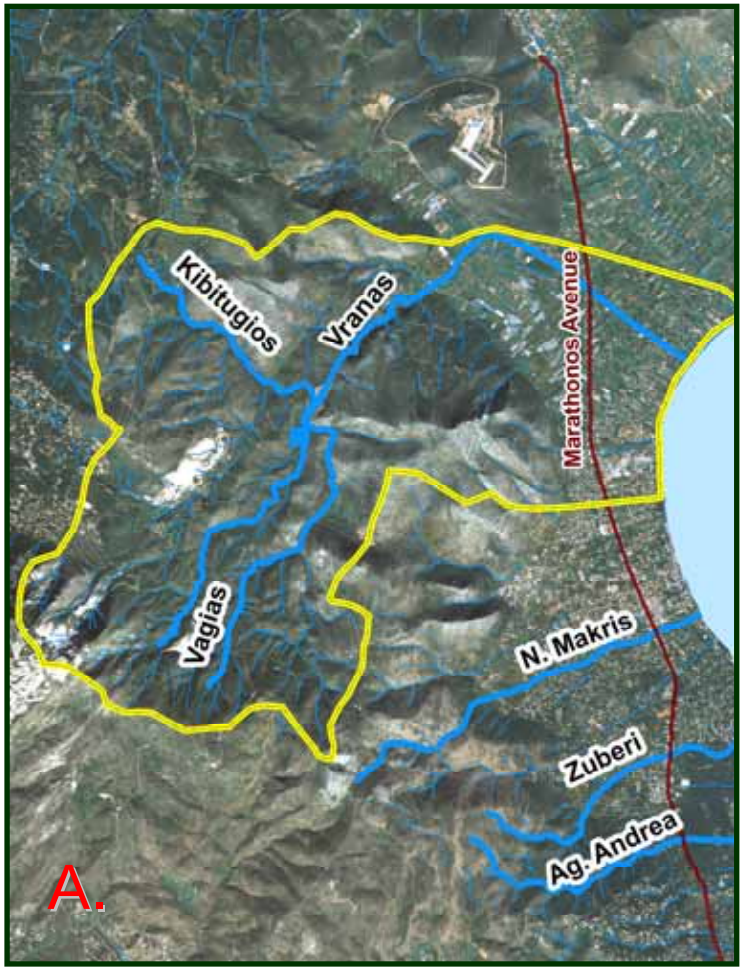
The concept

Risk Assessment



VULNERABILITY of cultural sites

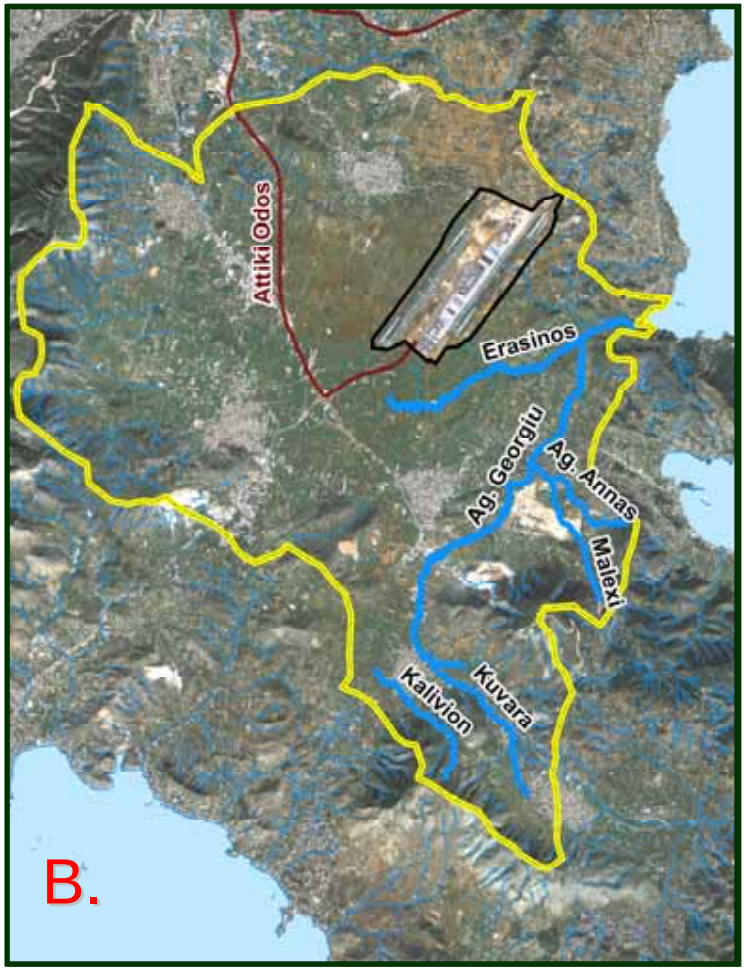
Study Areas (1/2)



A. Rapentosa Basin

B. Erasinos Basin

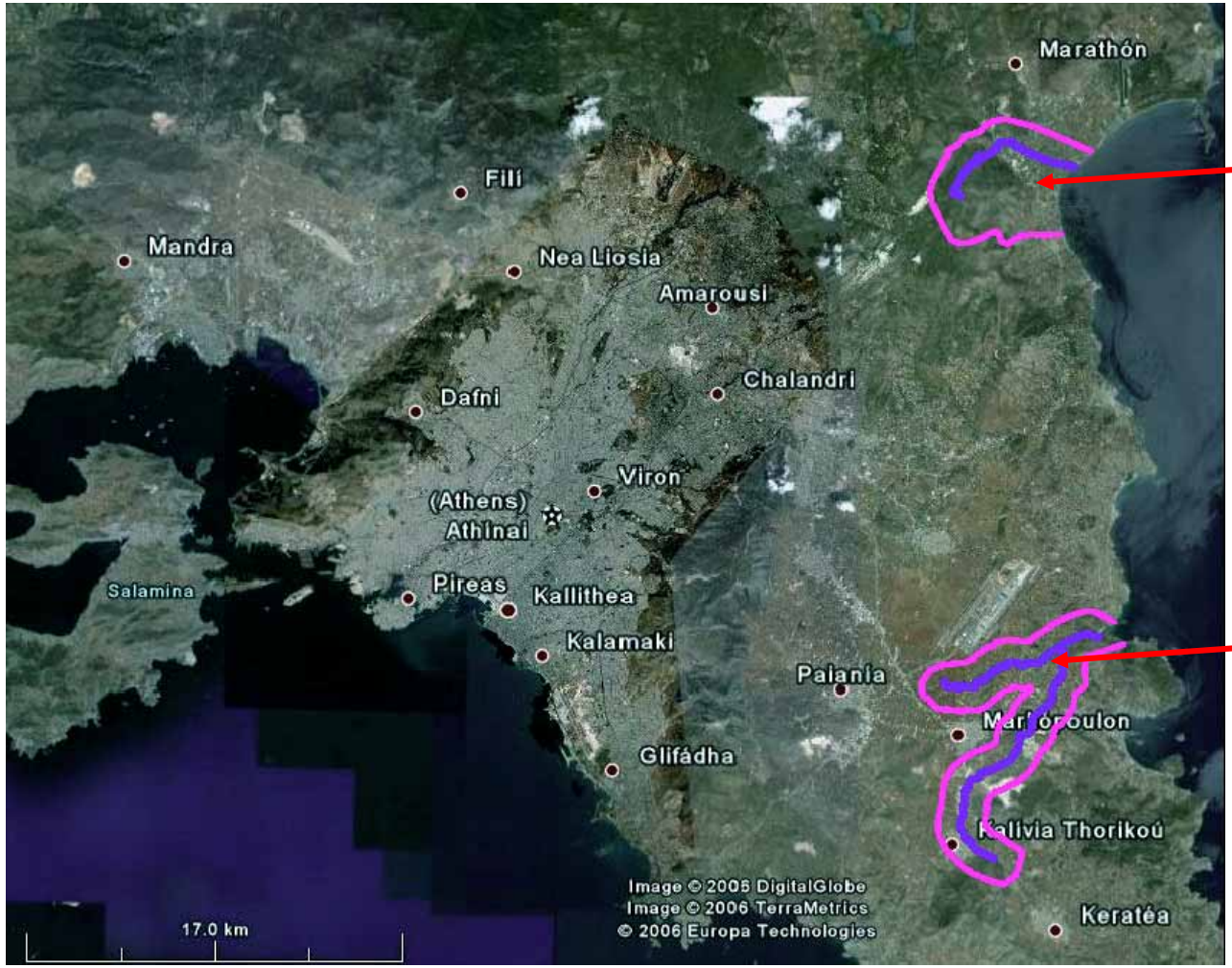
Study Areas (1/2)



A. Rapentosa Basin

B. Erasinos Basin

Study areas (2/2)



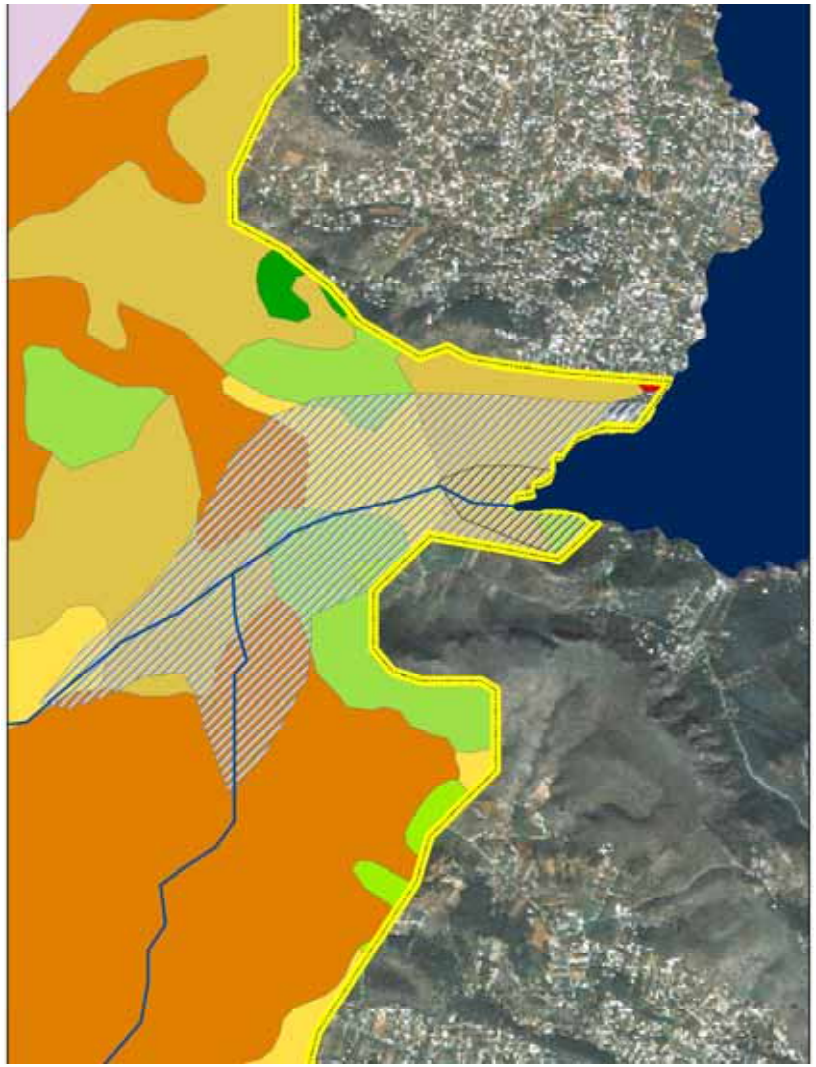
Rapentosa basin

Erasinos

Criteria

- prominent cultural sites
- high density of cultural sites
- rapid population growth
- high change rate of land use
- susceptible to frequent FLOODS and forest FIRES

Floods



- ✓**maximum flood extent highlighted in grey**
- ✓**need to isolate the affected areas**

High resolution Digital Terrain Model

- Colour aerial photographs
  (Hellenic Military Geographic Service)

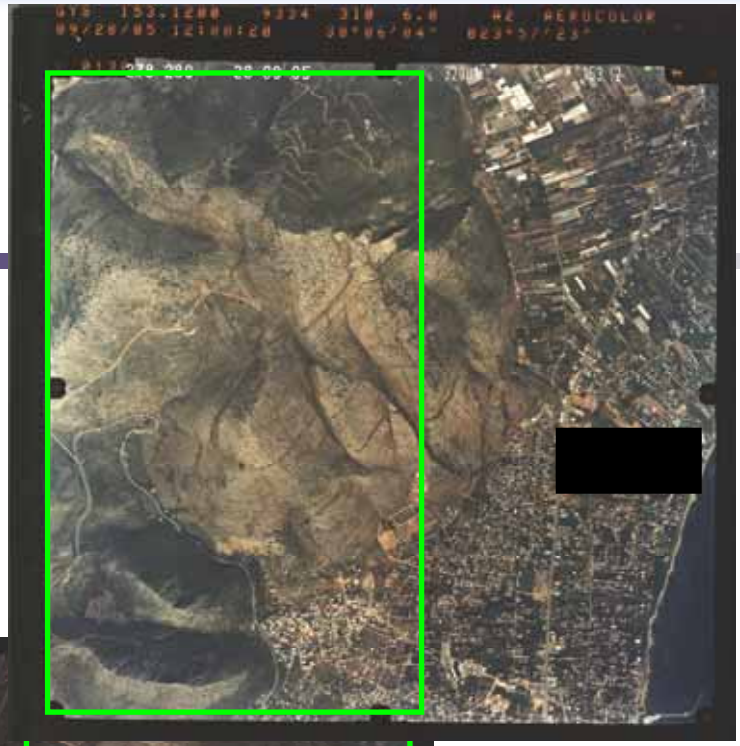
SCALE 1:15,000

DATE September 2005

- DTM Horizontal resolution, 15m

- X, Y, Z $\rightarrow$ location of cultural heritage sites

aerial photograph



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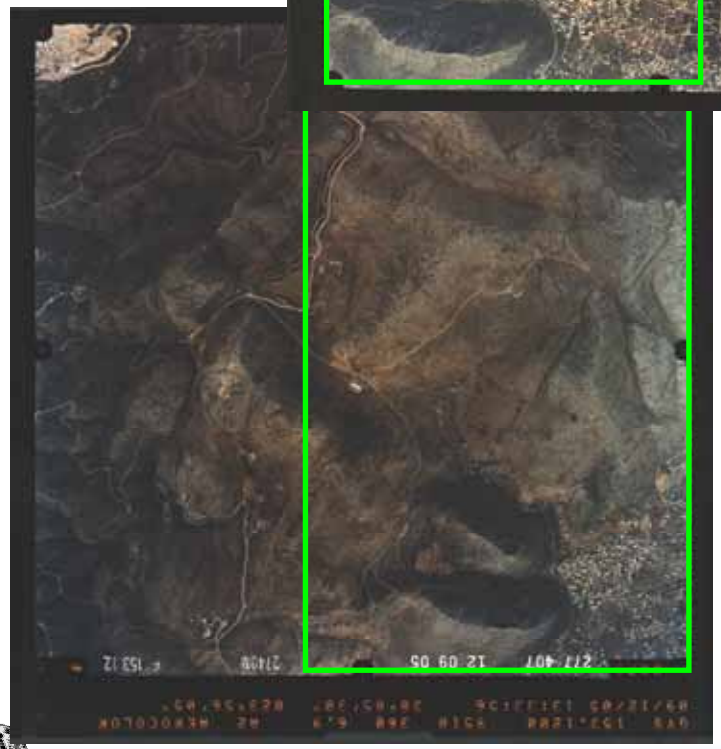
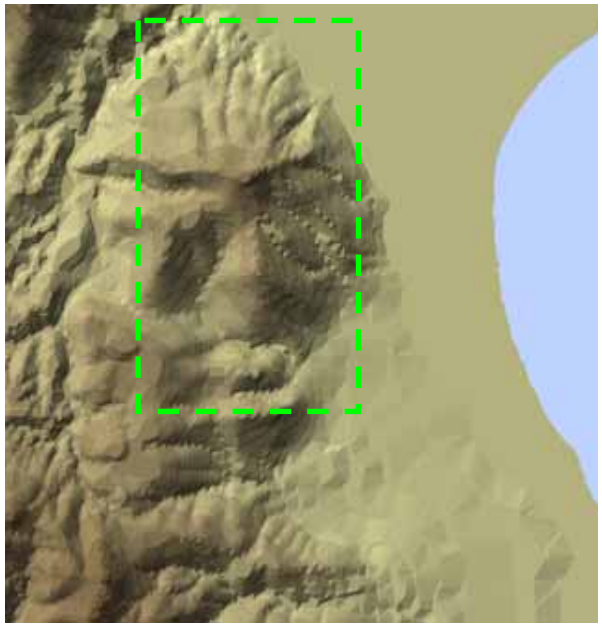


aerial photograph

photogrammetric processing

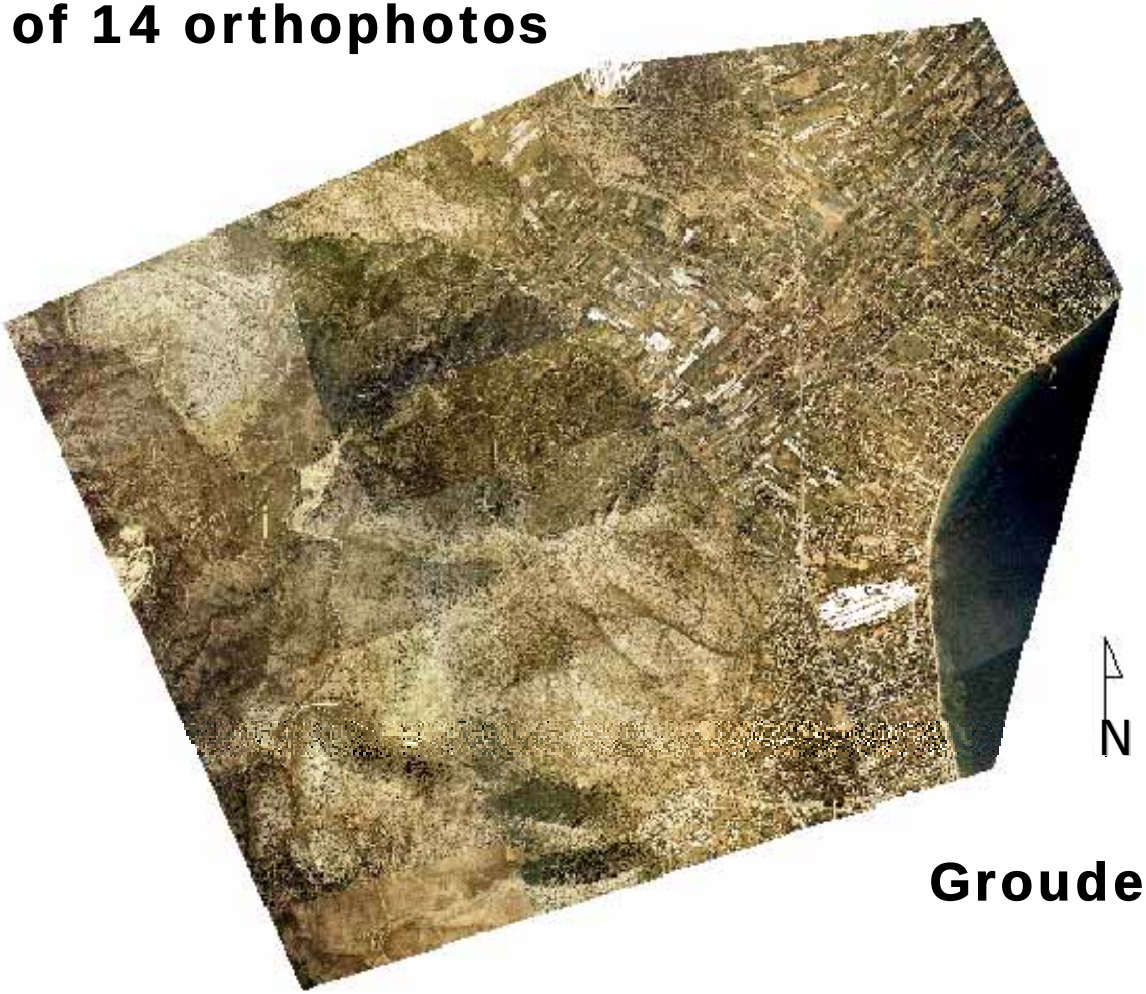
⇒

Digital Terrain Model (DTM)



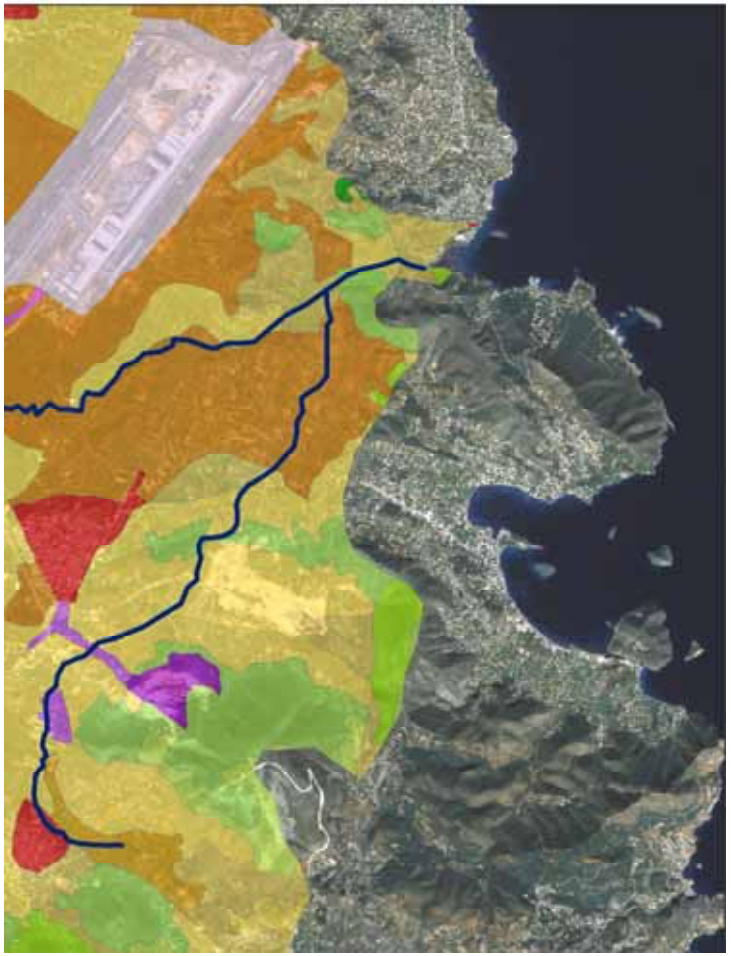
Orthophoto-mosaic

Mosaic of 14 orthophotos



Groudel size: 35 cm

Overview (e.g. Floods)



- 112 - Discontinuous Urban Fabric
- 121 - Industrial or Commercial Units
- 124 - Airports
- 131 - Mineral Extraction Sites
- 133 - Construction Sites
- 142 - Sports and Leisure Facilities
- 221 - Vineyards
- 222 - Fruit Tree and Berry Plantations
- 223 - Olive Trees
- 242 - Complex Cultivation Patterns
- 243 - Principally Agriculture, with Natural vegetation
- 312 - Coniferous Forest
- 323 - Sclerophyllus Vegetation
- 324 - Transitional Wood-land Shrubs
- 321 - Natural Grasslands

different value per hectare for each land use type

Photointerpretation (1/2)

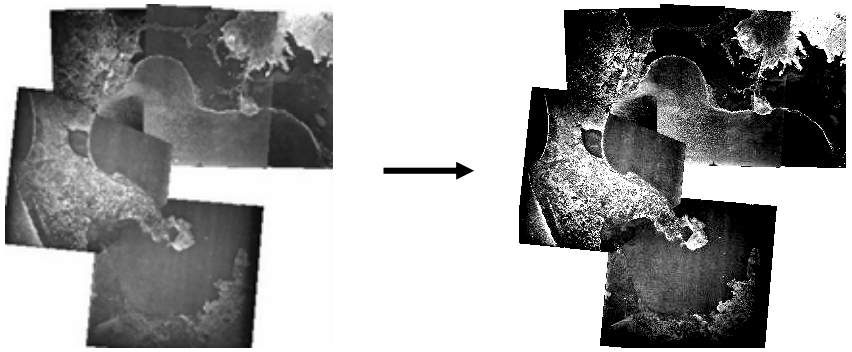
Objective:

Production of 1:5,000 Land Use map to include:

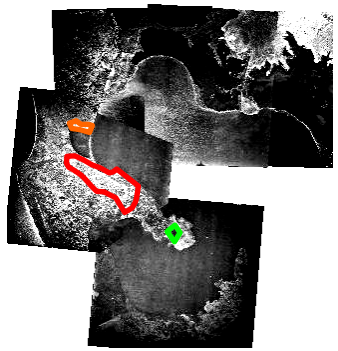
- 1. Urbanised areas
- 2. Industrial areas
- 3. Agricultural land
- 4. Forest areas
- 5. Bare soil
- 6. Roads

Photointerpretation (2/2)

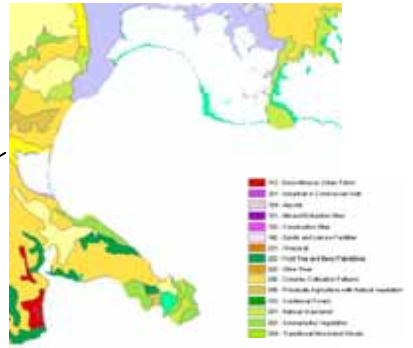
Refinement of the orthophoto mosaic by histogram enhancement and/or highpass filtering



Photointerpretation and digitization over the orthophoto mosaic



Vector data processing and production of final land use digital map

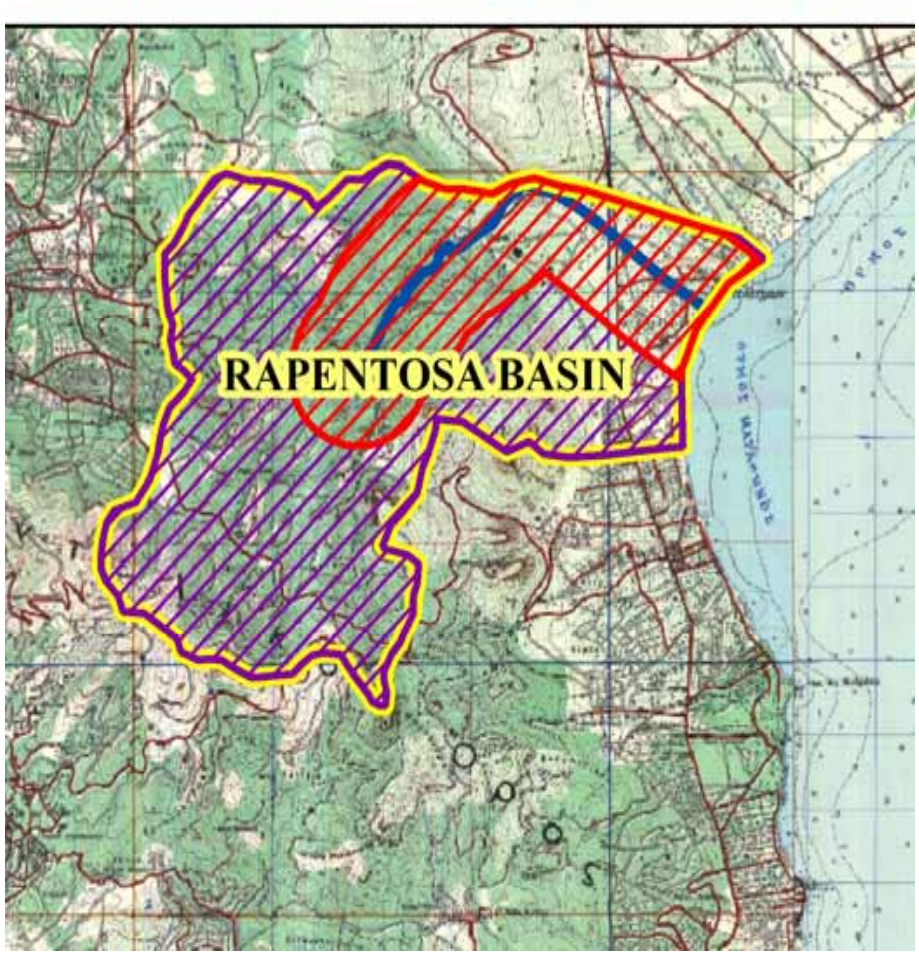


Flood !

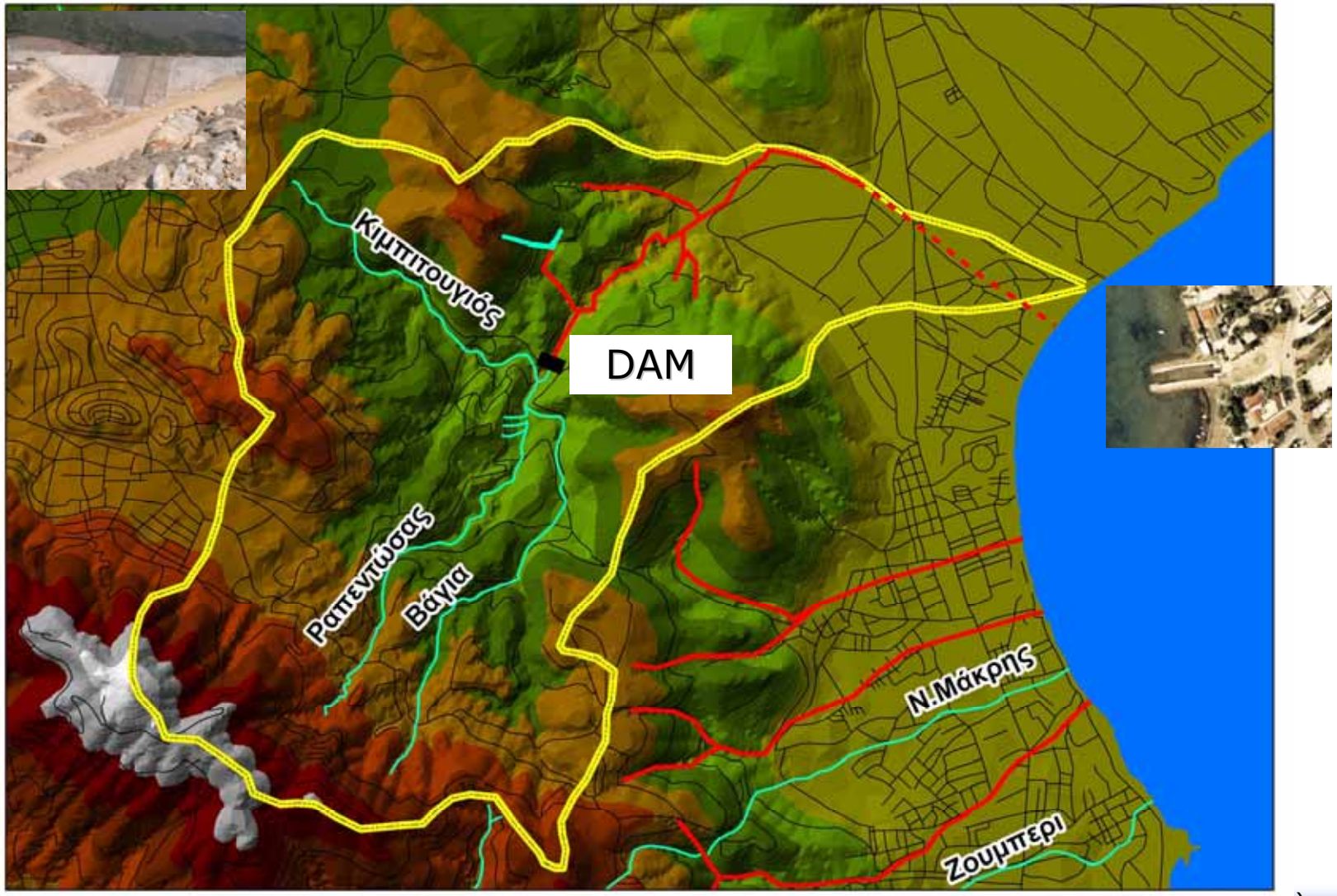
Return period = 50 years

Wider area

Buffer Zone (2km)



Rapentosa Catchment

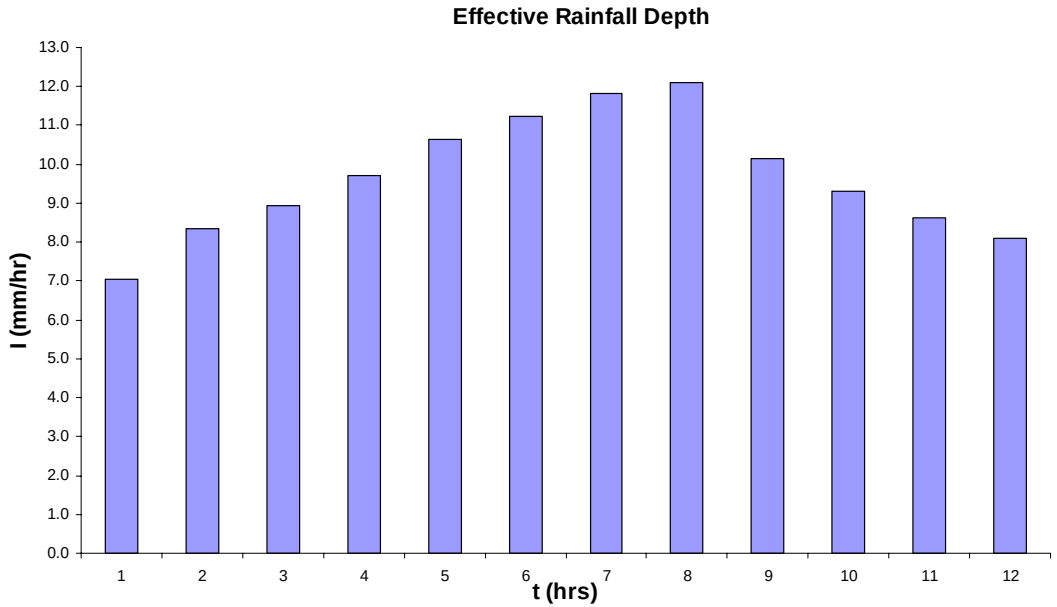


Design Hyetograph derivation

- Intensity-Duration-Frequency curve

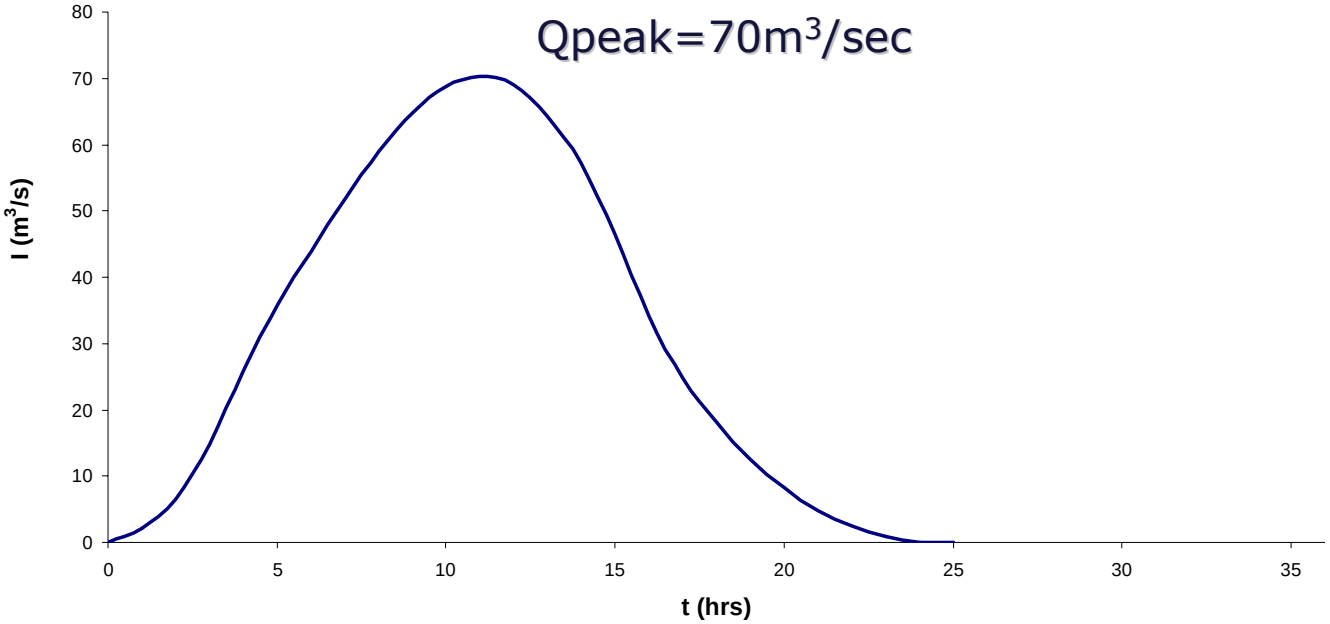
$$i = 23.28 \cdot T^{0.3} \cdot t^{-0.5} \text{ (mm/h)},\ T\text{[yrs]}, t\text{[h]}$$

- Return period T=50yrs, duration t=12hrs
- SCS loss method (CN=62, effective rainfall depth)
- Time step Δt = 1hr



Inflow Flood Hydrograph

- Upstream of Rapentosa Dam: Catchment Area=23,4km^2
- Resulted from
  - Design Effective Hyetograph (T=50yrs, t=12hrs)
  - Synthetic Triangular Uh (1hr)

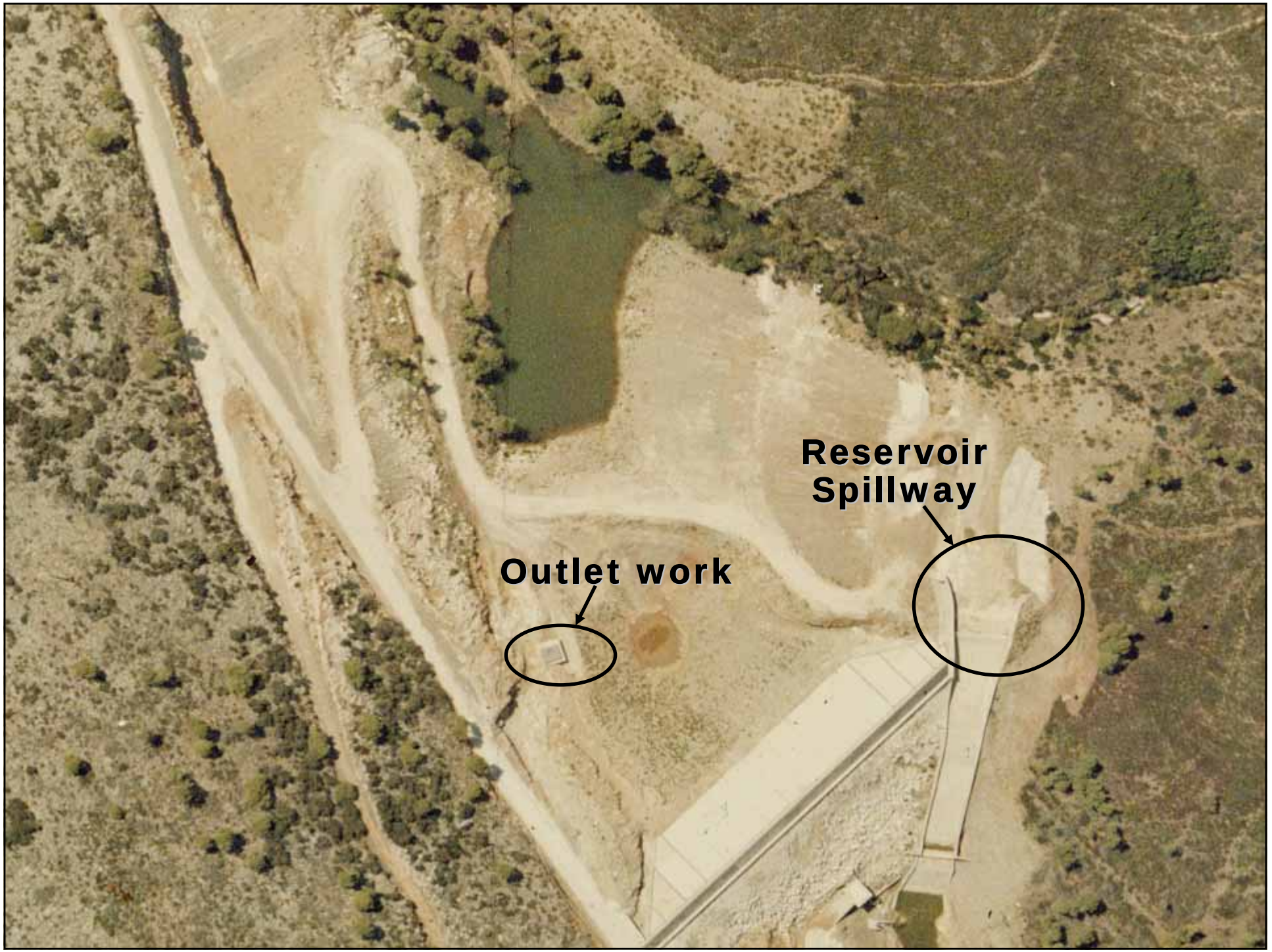


Flood Protection Dam

Catchment Area: 23.4 km^2

Technical Characteristics

- *Height: 38 m*
- *Frontal spillway dimensions: 20m x 4m*
- *Outlet work: D=0.7m , L=80m, Qmax = 4 m^3/s*

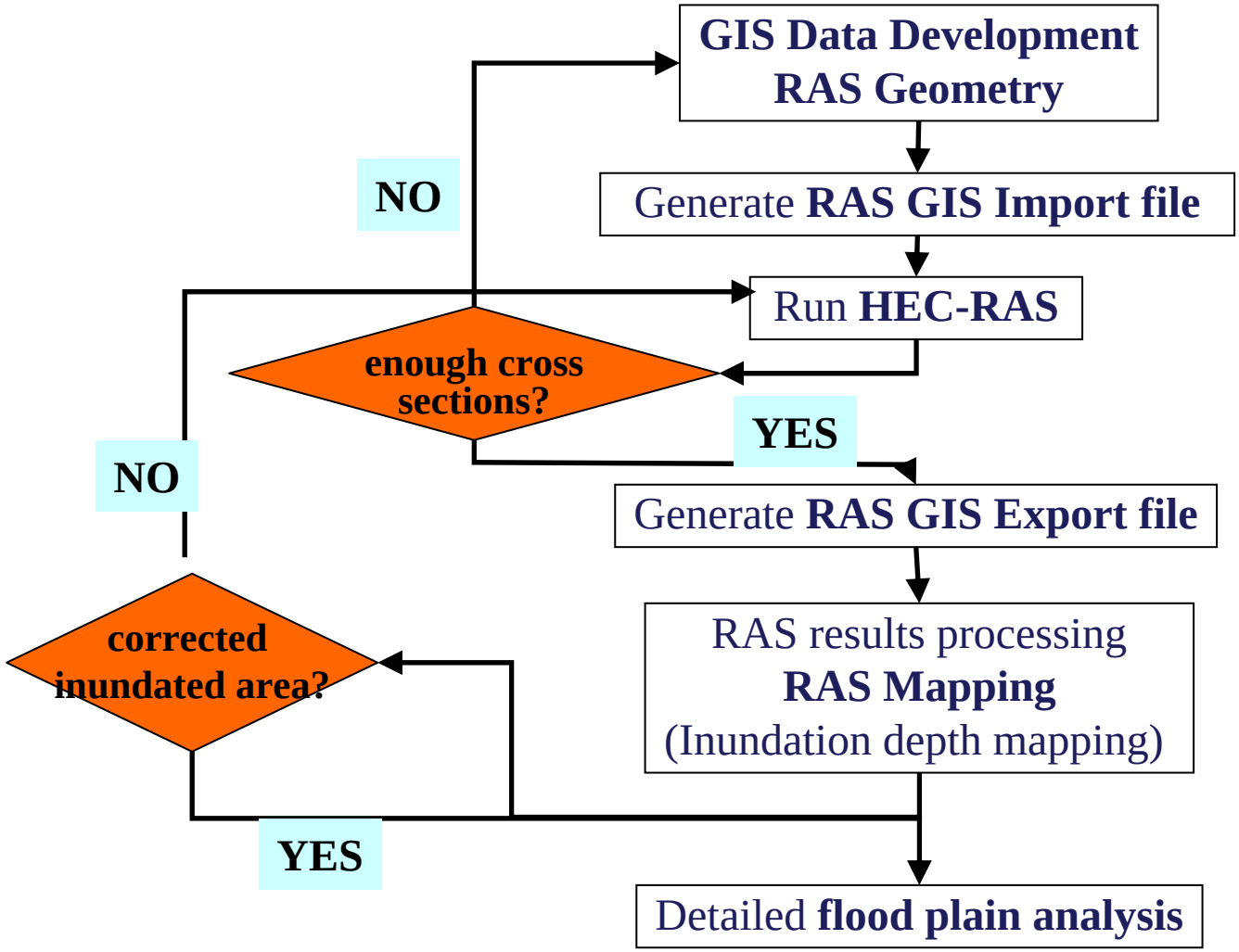

Reservoir
Spillway
Outlet work

Selected software

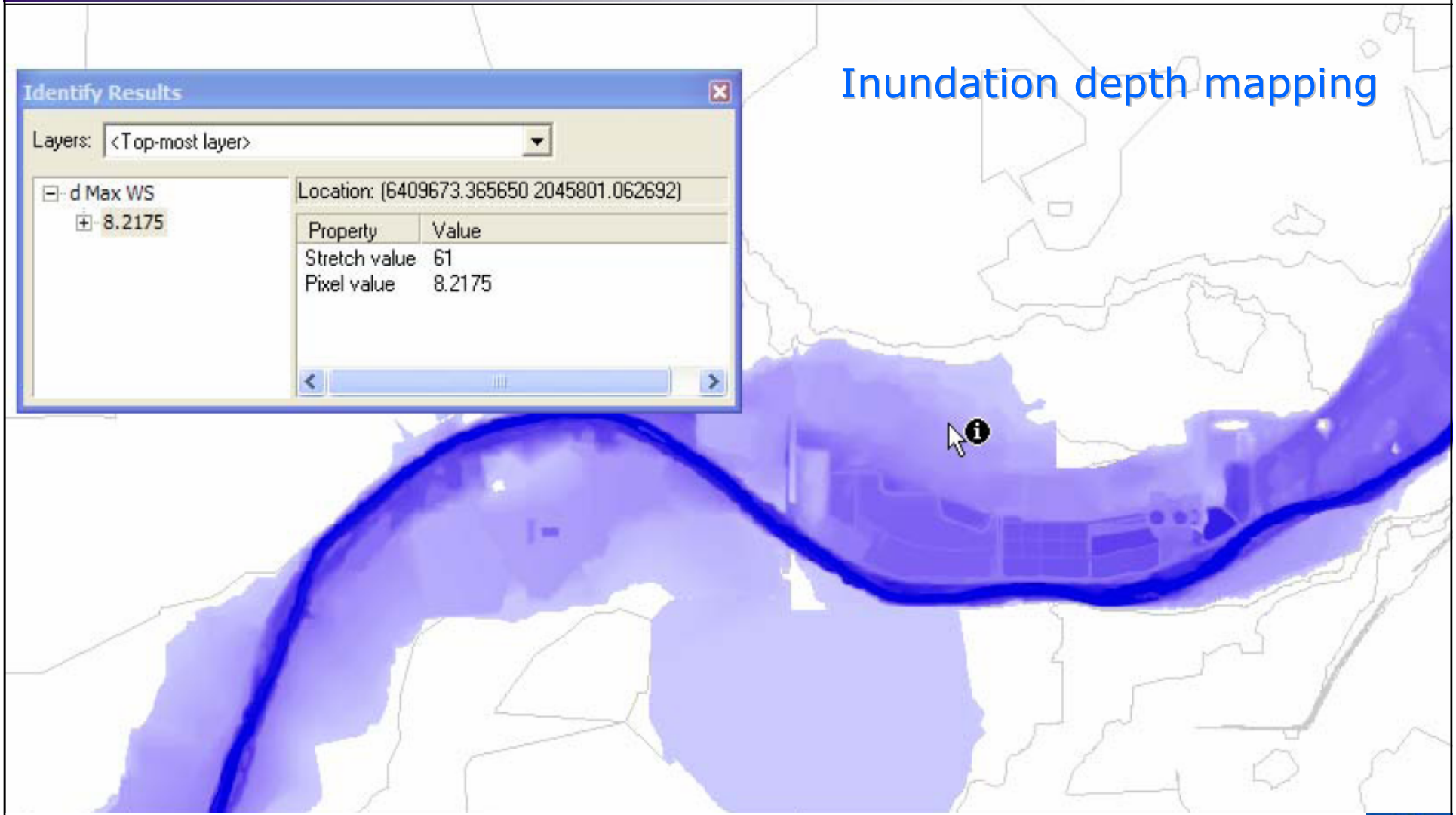
- ArcGIS version 9.1
- Geographical Information System
  - Integrates graphic data and variety of info from databases
  - Management and display of info ➔ geo-referenced framework
  - Spatial linkages with water features ➔ Hydraulic & Hydrologic models

- HEC – HMS Modeling
- Hydrologic Engineering Centre - Hydrologic Modelling System
  - simulation of rainfall-runoff processes of dendritic watershed systems – outflow hydrograph at the exit of each sub-basin
  - sub-basin geometry, loss rate method, channel routing method and baseflow method
  - will run under different meteorological scenarios

Model Integration Framework for Floodplain Mapping



HEC-GeoRAS Example



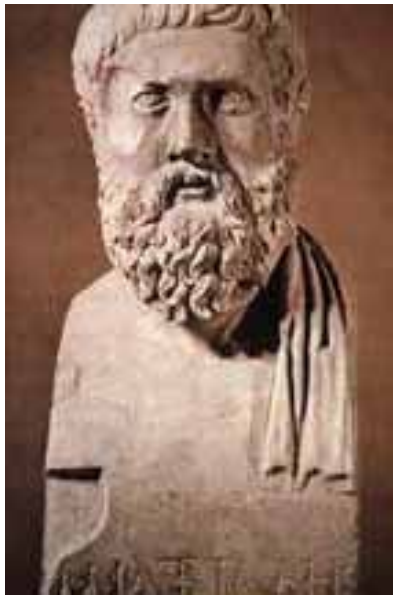
Cultural heritage in GR 1/2

Abundance of information !!!

Retrieval ?
Availability ?
Diffusion ?
Integration ? (within)
Integration ?

TARGET: Systematic -> objective approach

Cultural heritage in GR 2/2



- Common management framework for cultural heritage
- Archaelogists' mentality
- Cure rather than prevent !

Classification

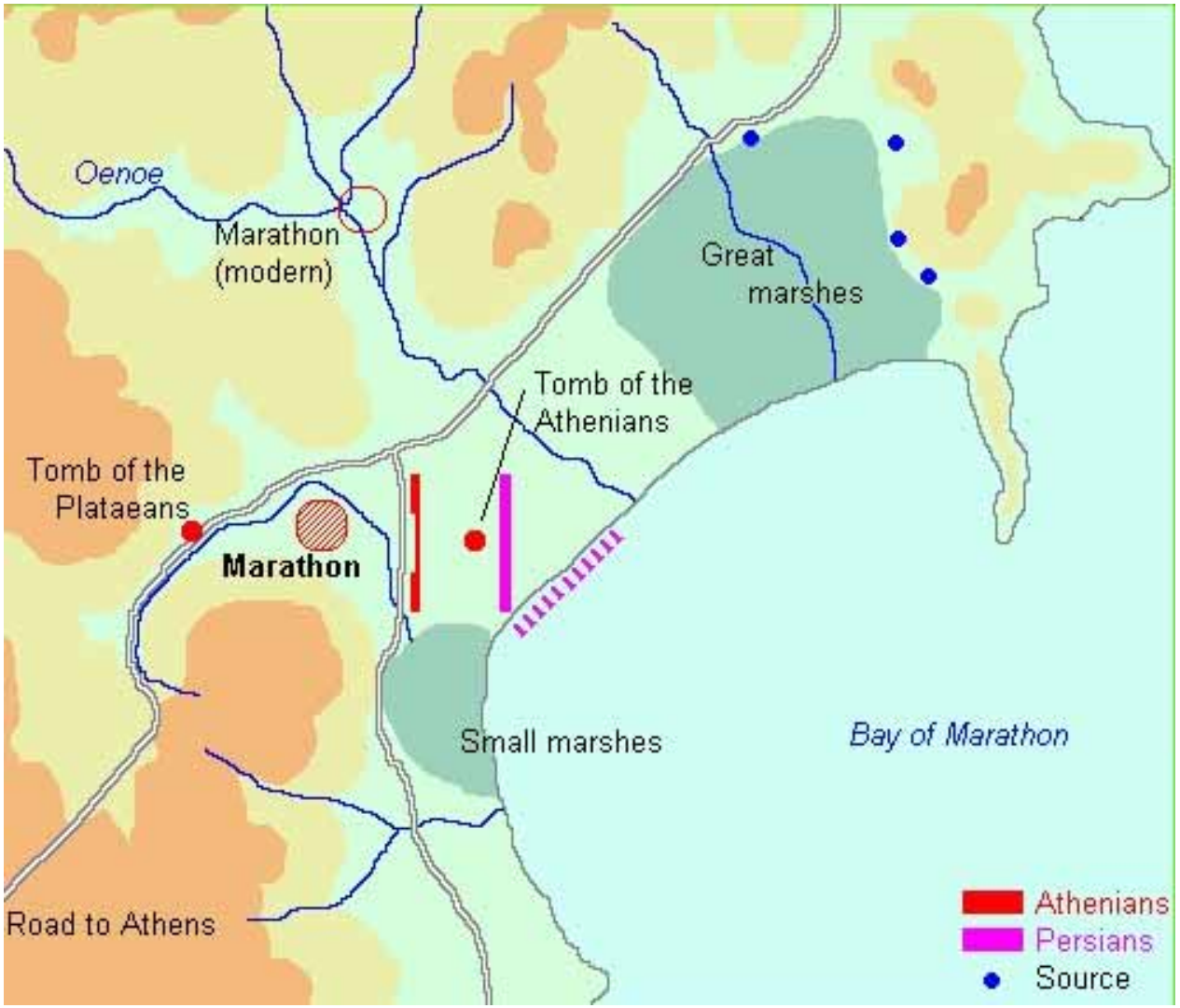
Group A

- living landscapes
- landscapes of memory
- archival material & scientific works
- excavational places and features (open excavations or future field works)

Group B

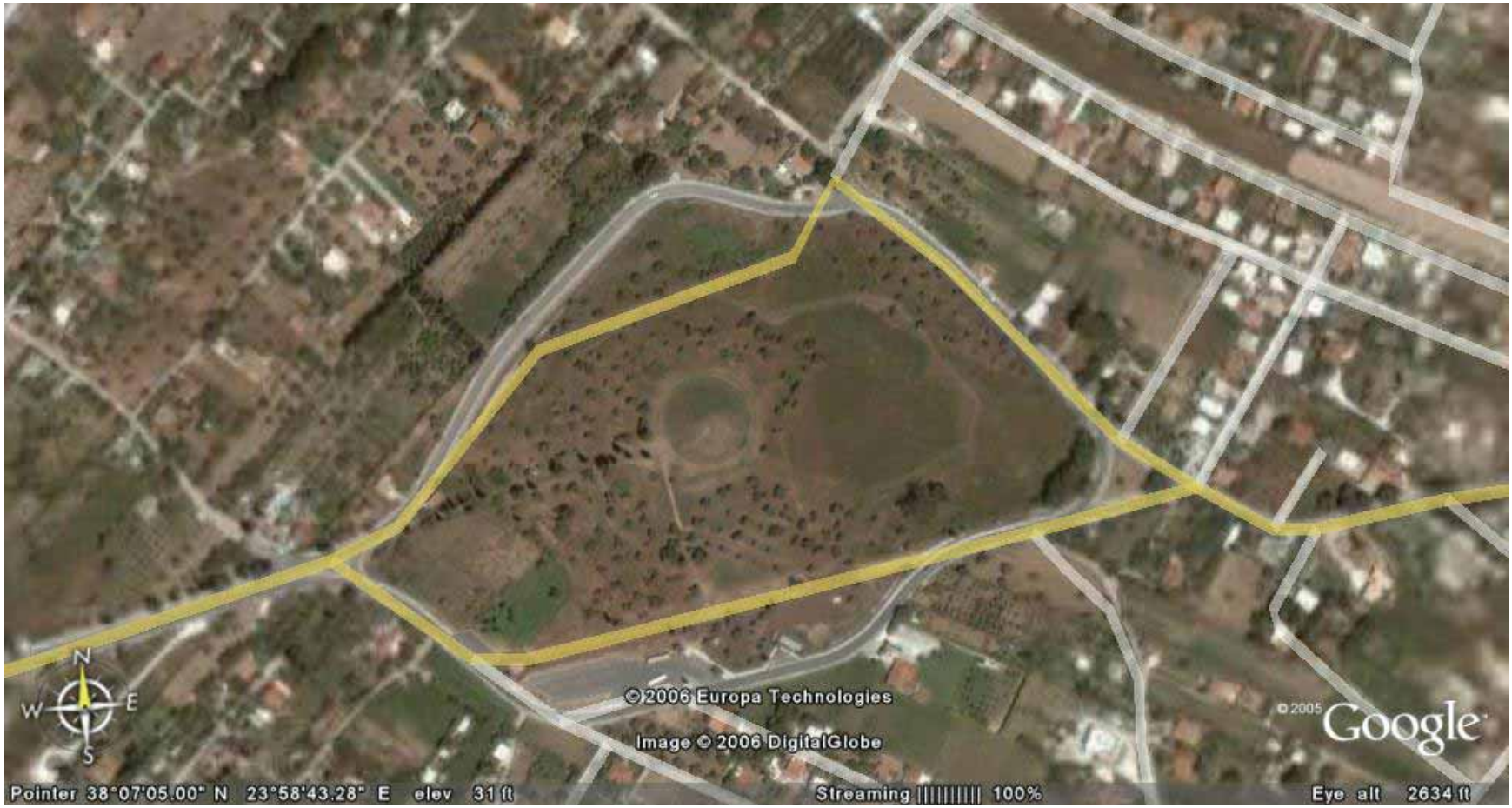
- caves with archaeological / palaeoanthropological interest
- museums
- open-air monuments
- ecosystems (natural landscapes)
- maritime heritage (coastal and underwater features)

Tumulus of Athenians- Marathon



Tumulus of Athenians - Marathon

Tumulus of Athenians



Questionnaires

Intrinsic (condition of cultural asset)

Environmental (natural setting)

Socio-economic (community)

Organisational/Institutional (state)

Vulnerability

Hazard ⇨ Vulnerability ⇨ Risk

⇩

- exposure
- coping capacity
- social factor
- event
- conditions

Vulnerability

The degree of susceptibility to damage from a hazardous phenomenon or activity

function ranging between **0** and **1**

various factors related to:

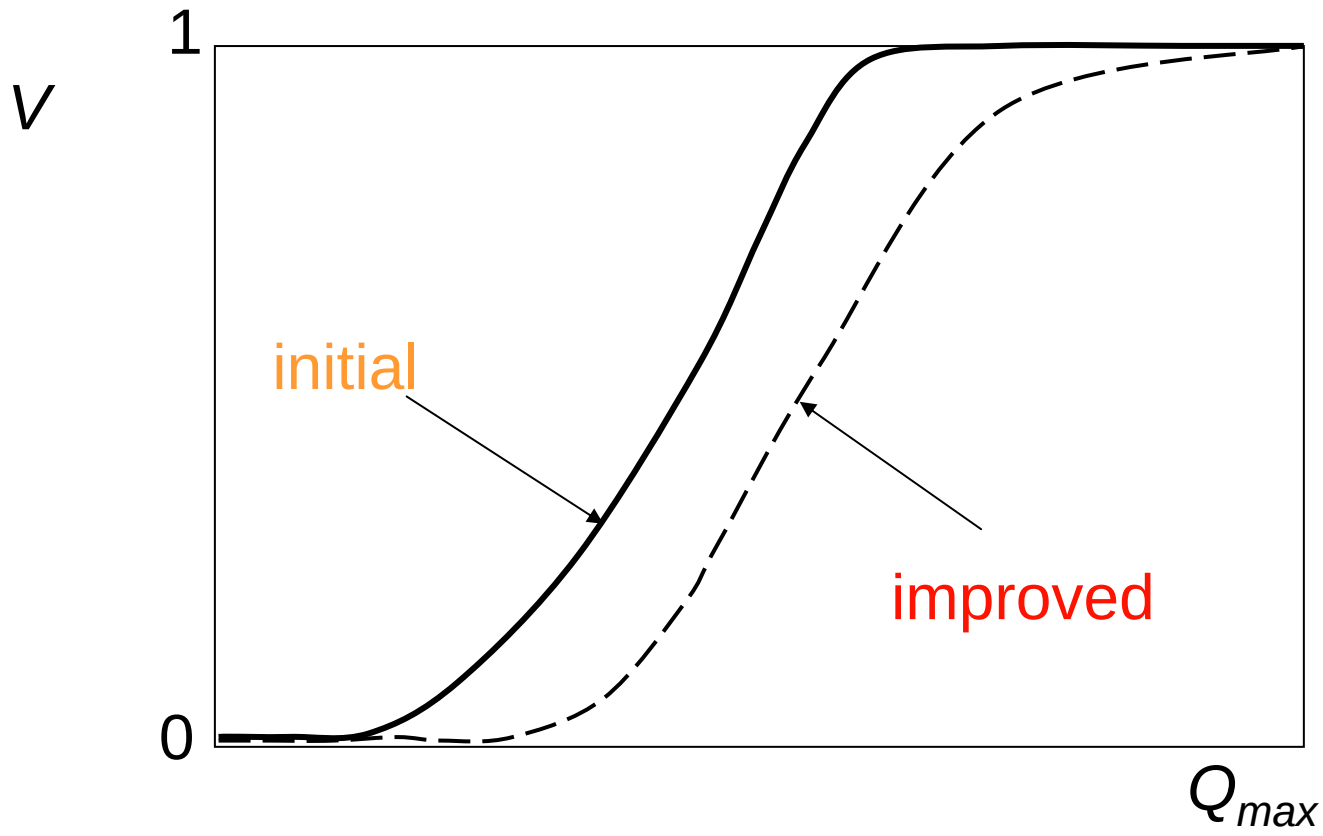
- exposure (E)
- coping capacity (S)
- social factor *(SF)*
- magnitude of the event *(Q_{max})*
- conditions and interrelated factors (internal or external) *(I)*

$$V = f\ (E, S, SF, Q_{max}, I)$$

Vulnerability reduction

- changing the exposure of the affected system
- improving the coping capacity
- improving social capacities to deal with the phenomenon
- mitigating the magnitude of the phenomenon and its potential consequences
- controlling internal and external factors and their interrelations

Vulnerability



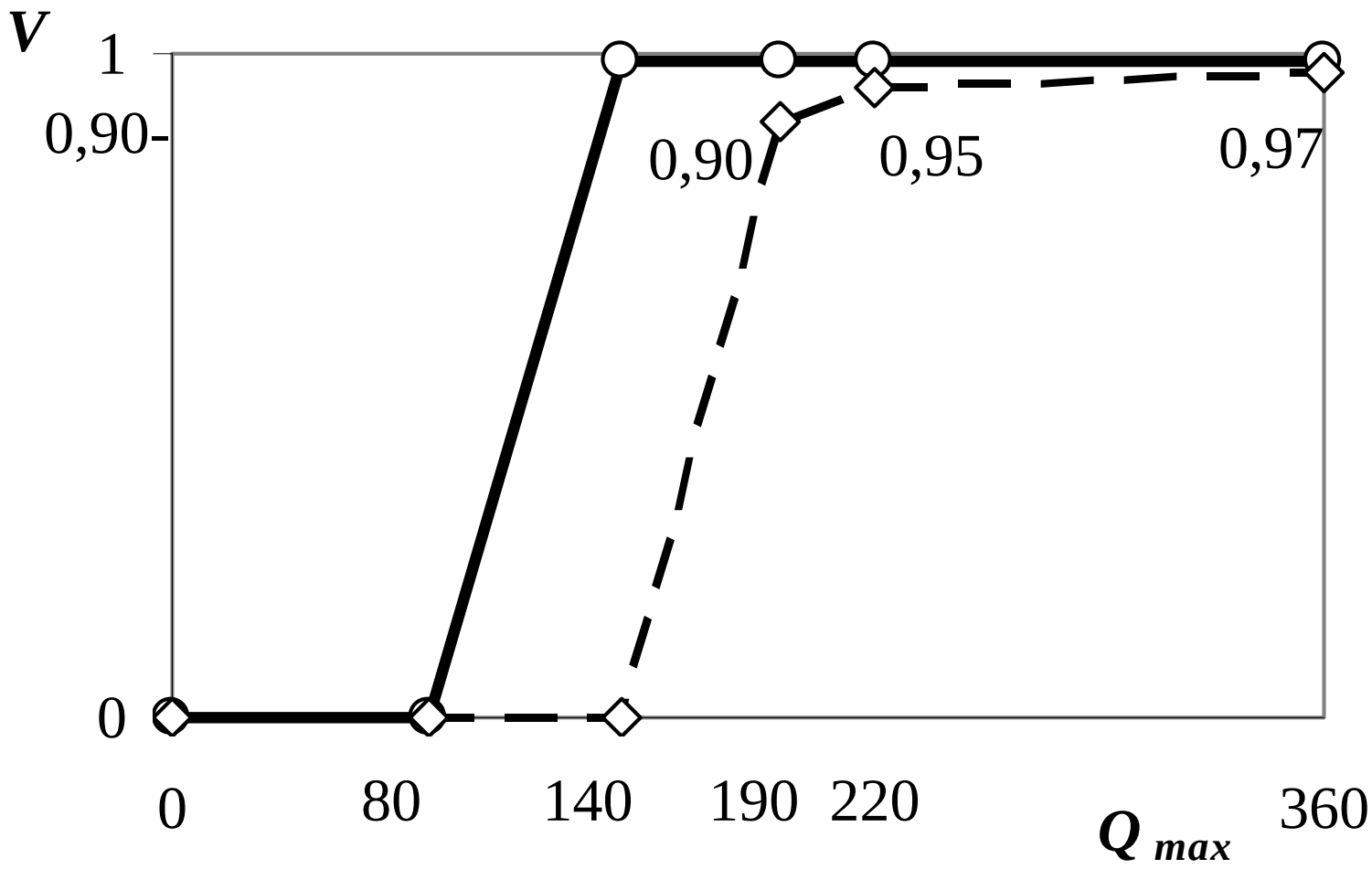
$$R(D) = \int_0^{\infty} x \cdot v(x) \cdot f_D(x) dx$$

Vulnerability: Example

i	Return period (y)	Peak discharge (m3/s)	Initial potential consequences (M€)	Consequences after improvement (M€)	Vulnerability (-)
1	2	80	0		0.001
2	10	140	400	0	0.001
3	50	190	800	720	0.900
4	100	220	1170	1112	0.950
5	1000	360	3000	2910	0.970

R(D) = 56,06 M€/y => Improvement 72,92%

Vulnerability: Example



Risk

an existing threat to a system (life, health, property or the environment) given its existing vulnerability

$$\{R\} = \{H\} \square \{V\}$$

$$\{R\} = \{H\} \times \{V\} \quad \text{(simplification)}$$

$$R(D) = \int_0^{\infty} x \cdot V(x) \cdot f_D(x) dx$$

$$R(D) = \sum_{i=1}^{n} \left(\frac{x_i + x_{i+1}}{2} \right) \cdot \left[F(x_{i+1}) - F(x_i) \right] \cdot \left(\frac{V_i + V_{i+1}}{2} \right)$$

Vulnerability of flood prone areas

- Hazard events simulation/generation
- Magnitude ←→ recurrence interval
- Magnitude ←→ inundation area
- Inundation area ←→ damage

Improvements

- River training
- Protection measures
- Event mitigation
- Improved infrastructure
- Better governance
- Public awareness
- Lesser exposure

Optimization

- ✓ Each measure or project: Certain cost and impact
- ✓ Combination of measures as alternative solution
- ✓ Reduced vulnerability is achieved
- ✓ The optimal vulnerability is found

Complications

- Flood: 2-D phenomenon
- Uncertainty for identifying inundated areas
- Fuzziness in quantifying the damage
- Damages are direct and indirect
- Damages can not be measurable
- Vulnerability should be assessed based on holistic approach
- Future conditions are unknown

Vulnerability cont. 1/2

Prioritisation of a set of sites according to the following criteria:

1. Economic value
2. Uniqueness
3. Aesthetic/environmental value
4. Touristic value
5. Archaelogical/envir./scientific perspectives
6. Social Awareness

1. Exposure to hazard
2. Repeated occurrence of damage in the past
3. Unsatisfactory monitoring
4. Protection list

Vulnerability cont. 2/2

24 cultural sites in the two study areas

											Total	Vulnerability Index
Arch. Site of Brauron:	3	2	3	7	1	4	1	1	24	19	65	**1**
Brexiza:	4	11	7	12	2	14	2	2	16	13	83	**2**
Tumulus of Athenians:	6	1	15	1	20	1	3	3	22	22	94	**3**

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Flood - economic impacts

PRE:

- Insurance in Agriculture

POST:

- V.A.T. declarations
- Power consumption

Website http://www.hazardcentre.eu