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Marker Development

Presented To

National Academy of Sciences

By

M. R. Adams
Rockwell Hanford Operations

May 1987

APPROVED FOR PUBLIC RELEASE
V. Buckland 8/1/94

MASTER

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Here's What We'll Talk About

- Why Mark Disposal Sites
- The Design Rationale for Markers
- How Did Archaeological Analogies Point the Way to Marker Design
- Marker Design Details
- Marker Development to Date

Responsibility per 40 CFR 191

"Disposal systems shall be ... Identified by the most permanent markers and records practicable to indicate the dangers of the wastes and their location."

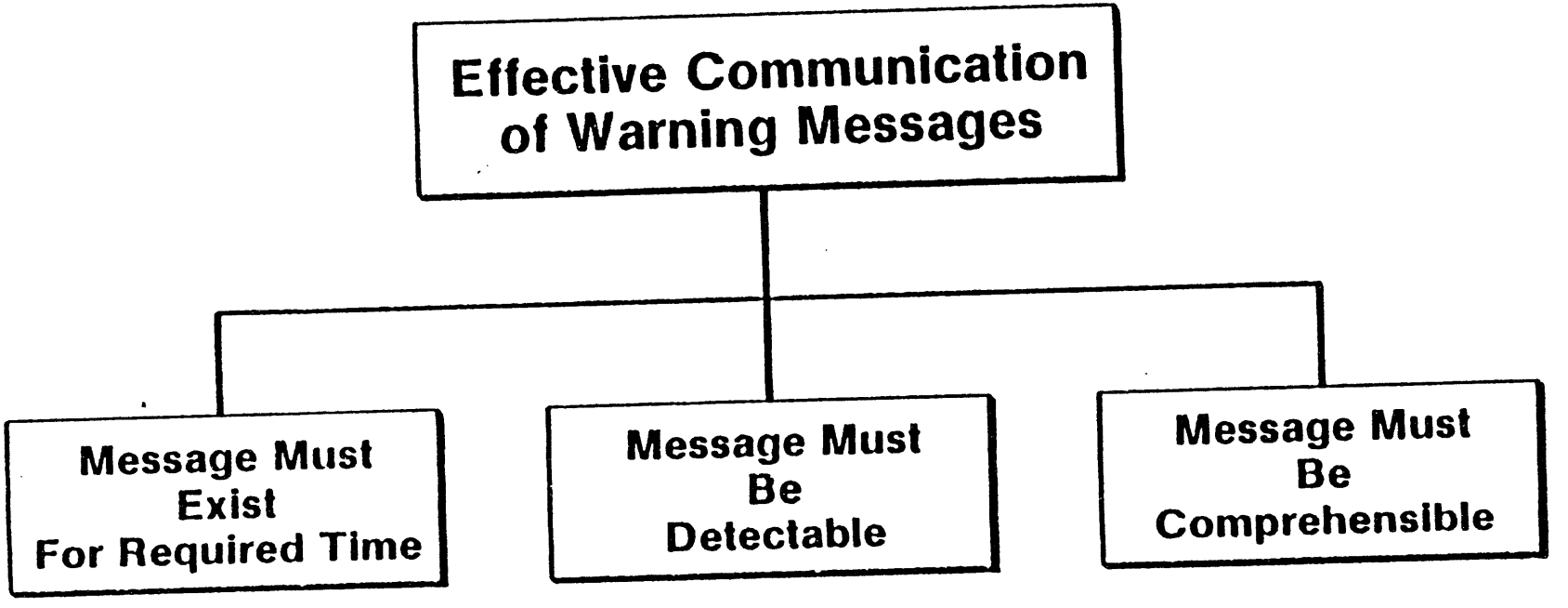
Social Responsibility

- Regulations stress that no undue burden be placed on future generations
- Intrusion by humans is often most credible worst case scenario
- Accurate prediction of human actions not possible
- Barriers cannot be constructed that will absolutely preclude determined human intrusion
- Implication: Mark sites to warn the intruder and fulfill regulatory and social responsibilities

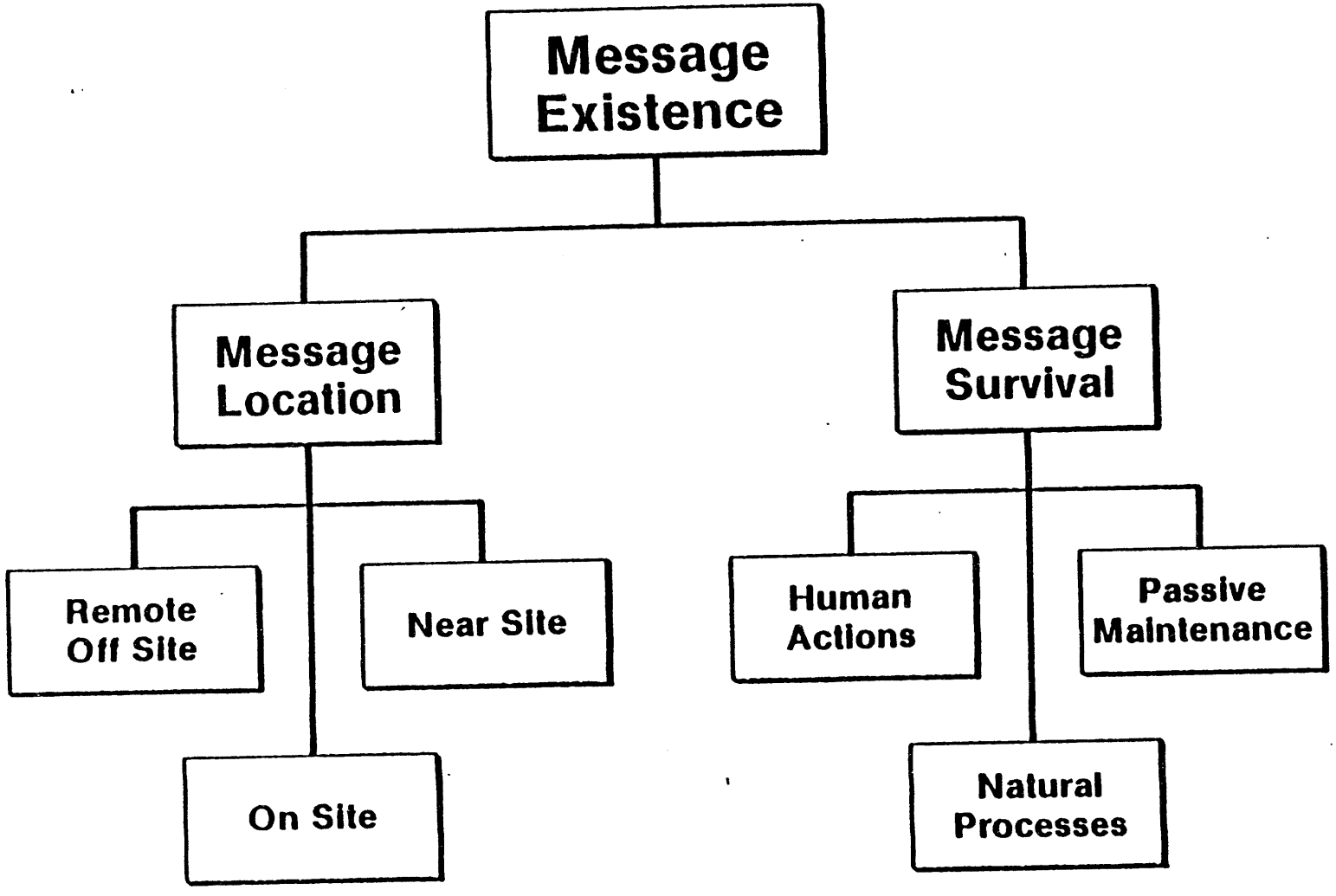
Hanford Waste Management Technology Plan
Technical Issue SST-8

- Passive site control necessary for periods from 100 to 10,000 years
- Various types of waste disposed on site will be identified by markers
- Marking methods must be selected, evaluated and demonstrated
- Marker locations, materials and emplacement procedures must be specified

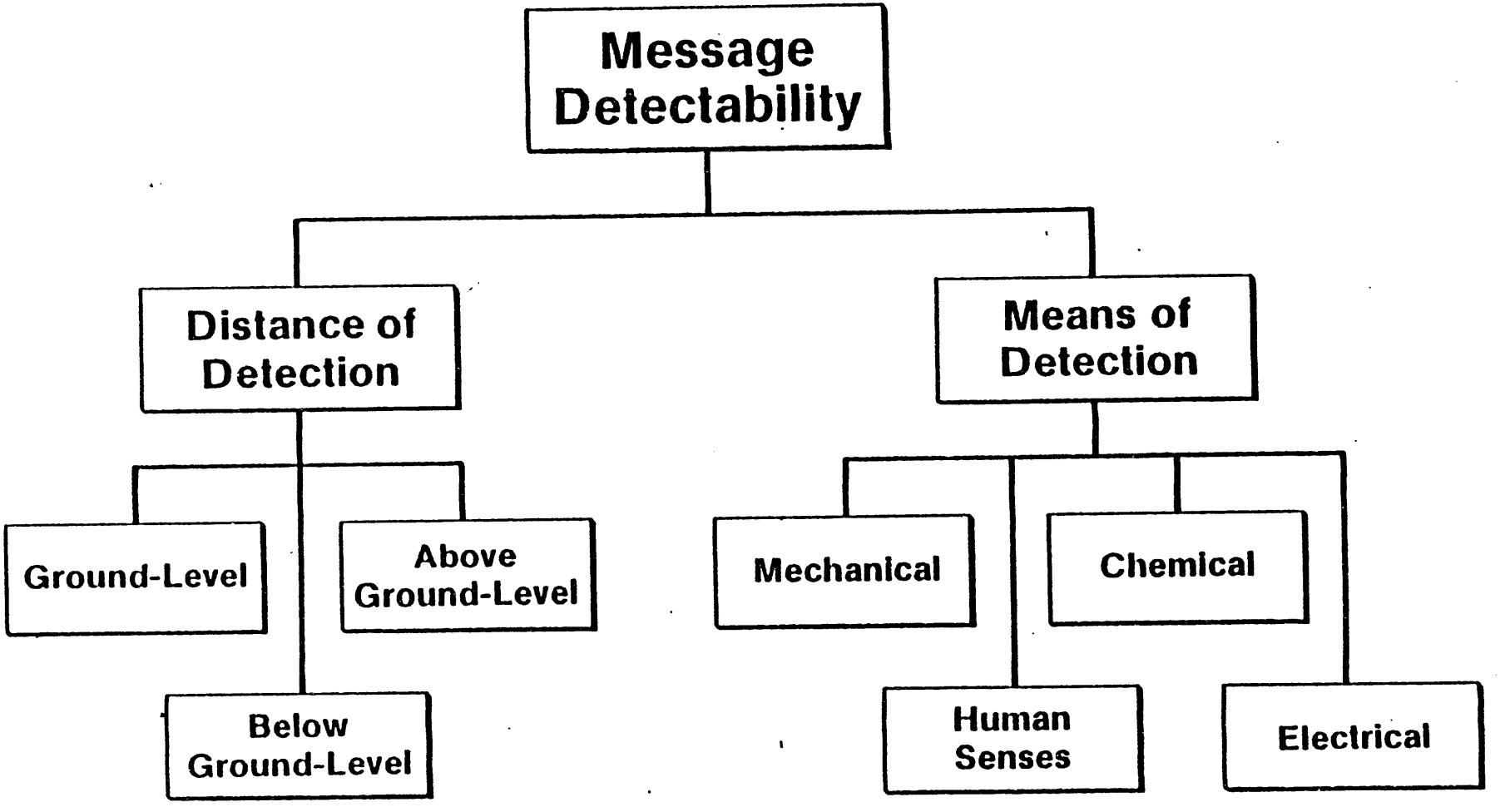
Designing a Marker System



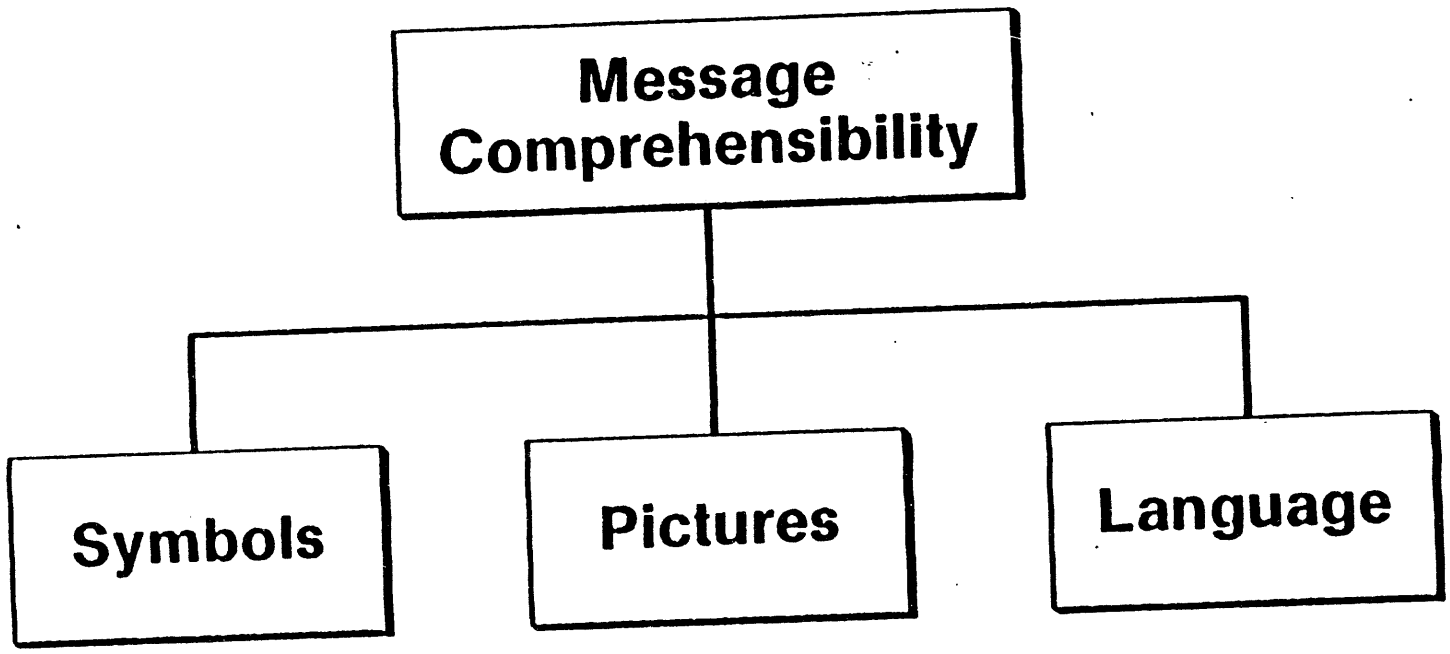
What are the Factors in Message Existence?



What are the Factors in Message Detectability?



What Are The Factors In Message Comprehensibility

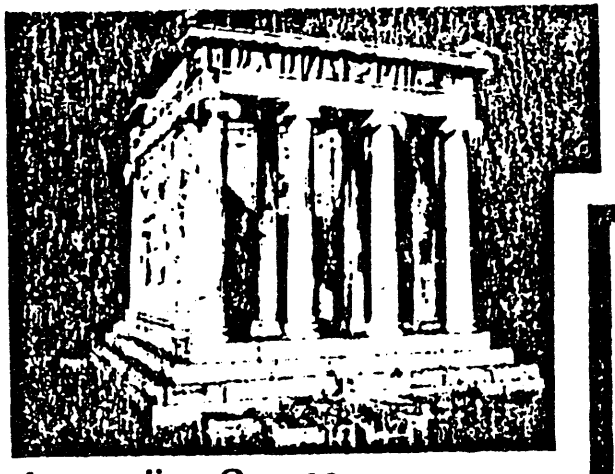


Archaeological Analogies Provide Information Relating to:

- Message Existence
- Message Detectability
- Message Comprehensibility

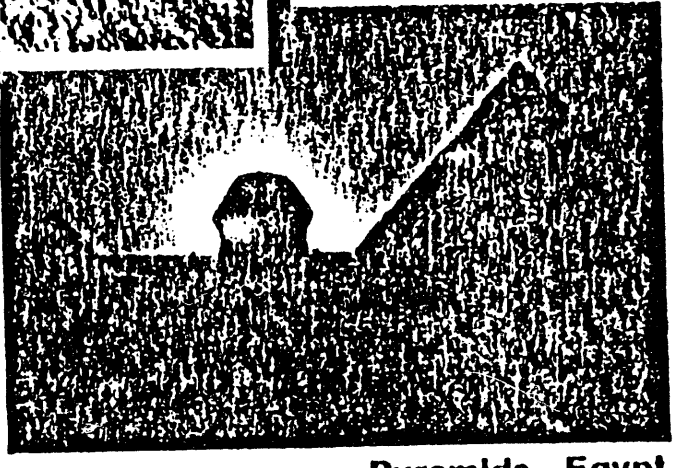
Stonehenge, England

Great Wall, China



Acropolis, Greece

Serpent Mound, Ohio



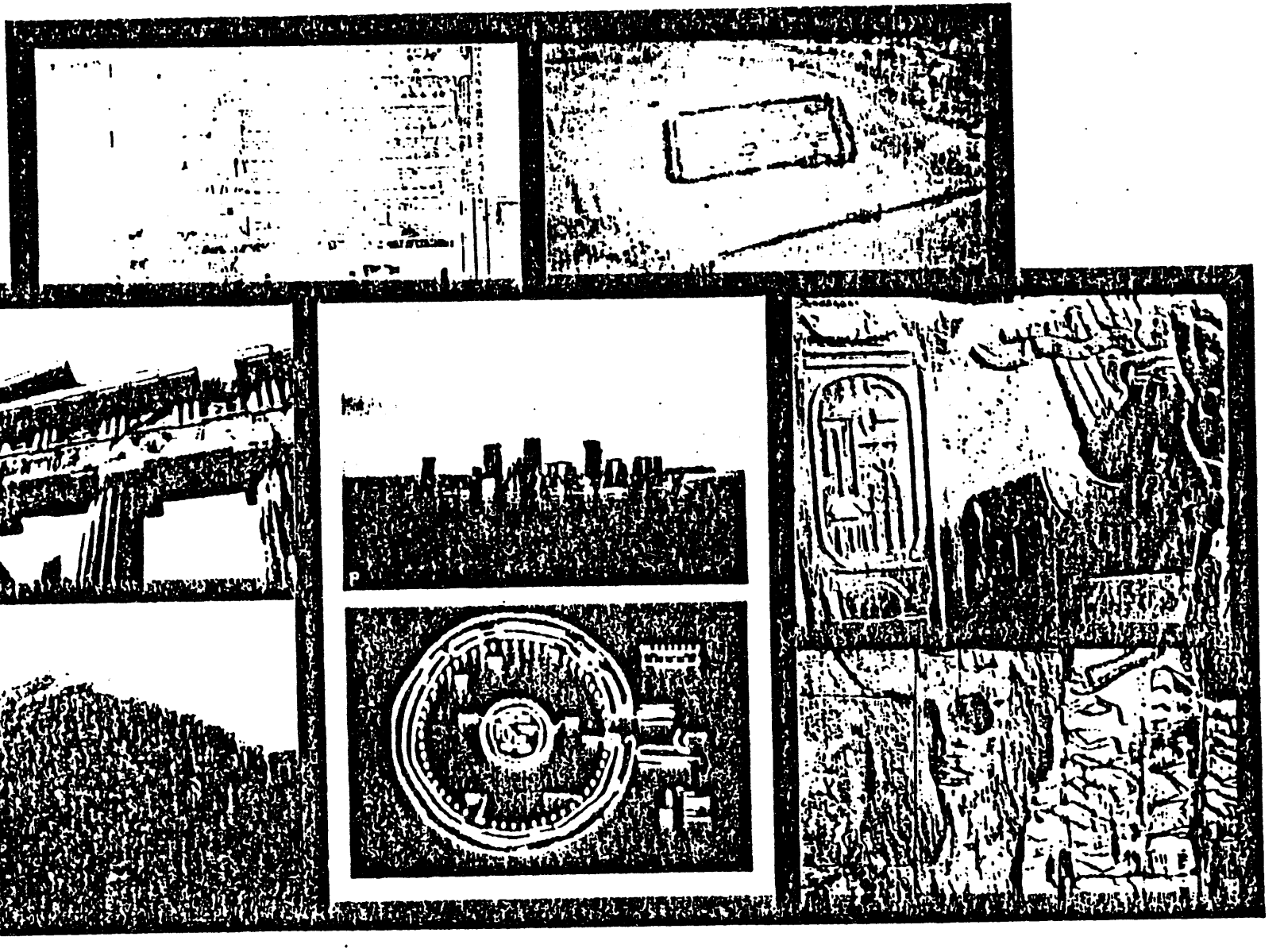
Pyramids, Egypt

Archaeological Analogies Examined:

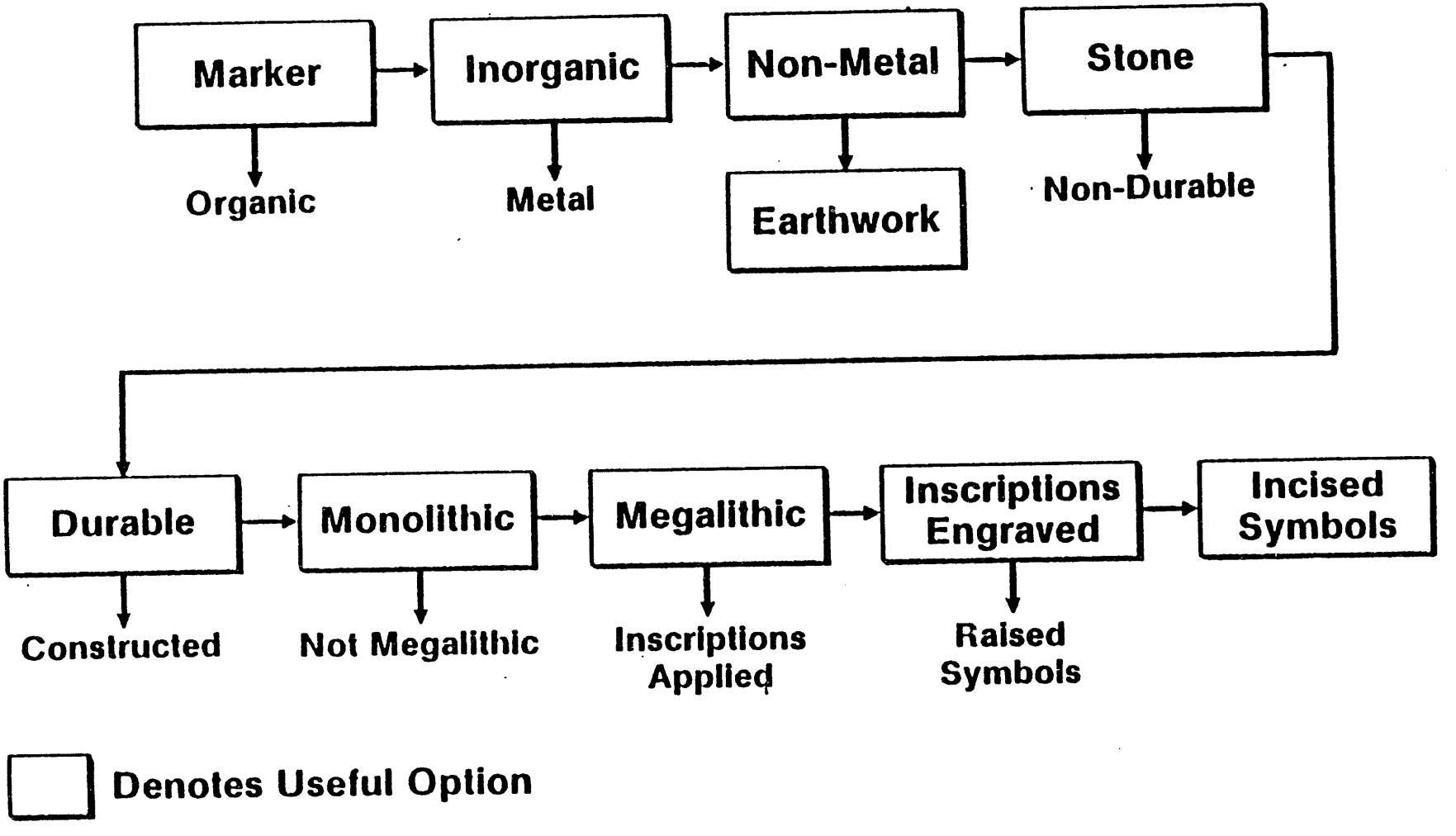
• Pyramids, Egypt	5,000 Years
• Stonehenge, England	5,000 Years
• Serpent Mound, Ohio	3,000 Years
• Acropolis, Greece	2,400 Years
• Great Wall, China	2,200 Years

Lessons Learned from Ancient Markers

- Materials used should have little intrinsic value (example: Pyramids)
- Markers should delimit area and provide redundancy (example: Stonehenge)
- Markers should have associated texts (example: Pyramids)
- Metals should not be used (example: Acropolis)
- Durable (non-organic) materials should be used
- Markers should be detectable at eye-level (positive example: Stonehenge) (negative example: Serpent mound)
- Language conveys most detail
- Symbols function only as long as the culture that created them
- Granites and basalts are the most durable materials
- Size should be at least 2 times human size (example: Stonehenge)
- Associated written records are important (example: Pyramids)



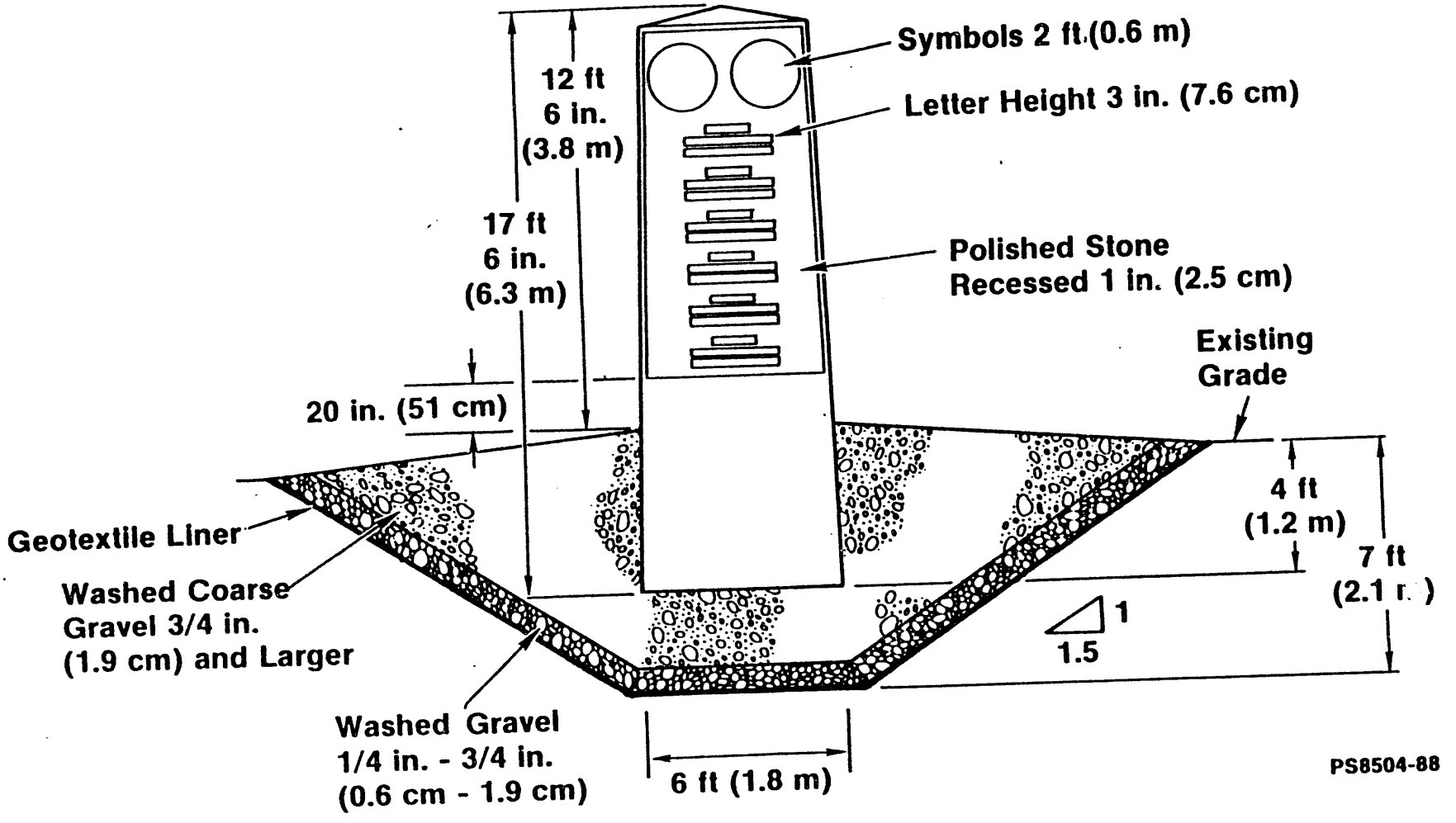
Identification of Useful Design Options



Design Conclusions and Guidelines

- Redundancy is required
- System of surface and subsurface markers is indicated
- Offsite records will be established

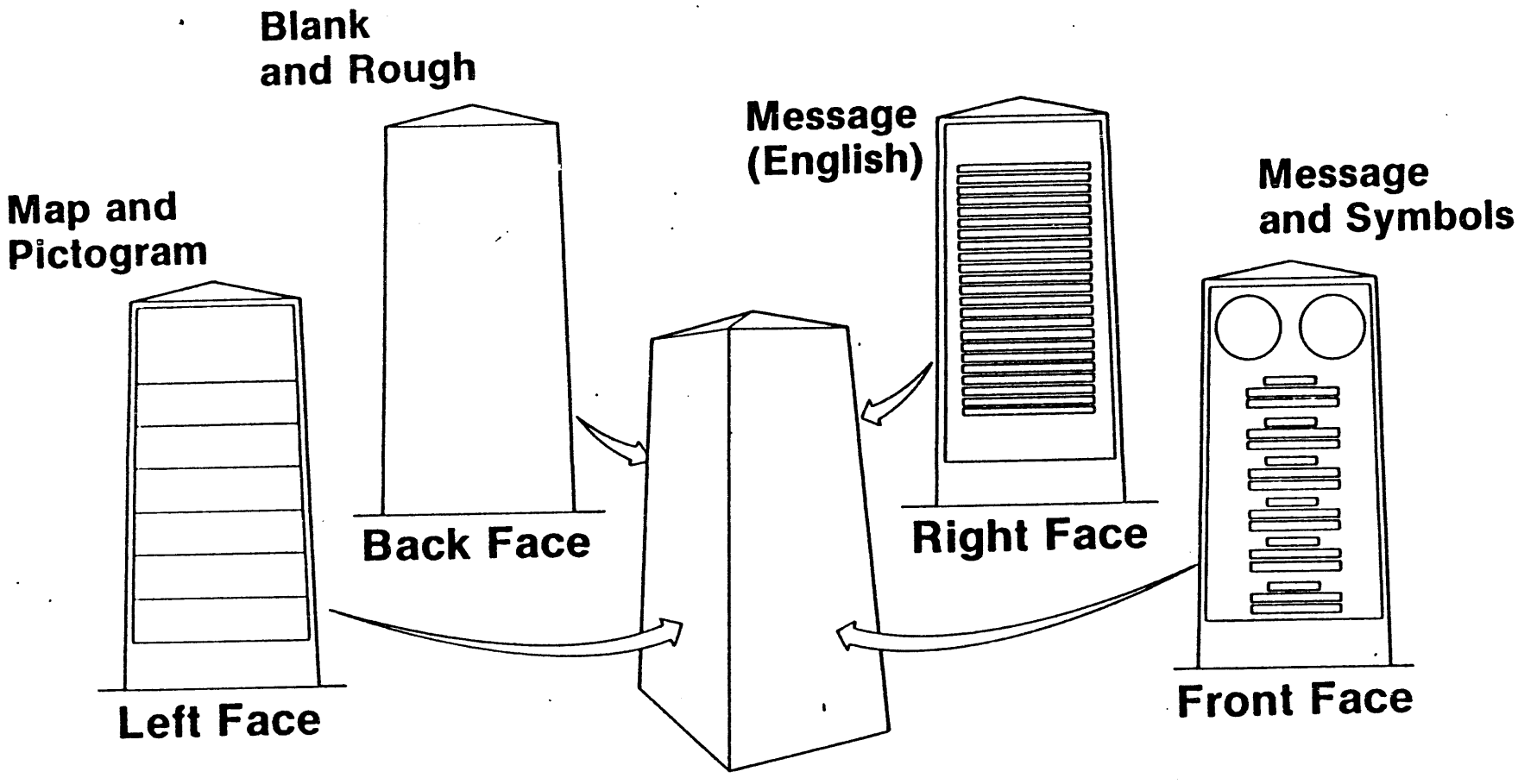
Marker Key Dimensions



Design Conclusions and Guidelines
Surface Markers

- Place on perimeter or pattern to indicate obvious border (for example: to be able to reconstruct markers due to loss or damage)
- Position markers such that viewer at one marker may see next marker on either side
- Place in well drained foundation to avoid efflorescence
- Use megalith of basalt or granite stone
- Use tapered configuration with pyramidal top
- Use raised boss around message surfaces and at marker base
- Use incised message on polished surfaces
- Use multiple languages, symbols and pictograms
- Make greater than twice human size

Four Faces of Surface Marker



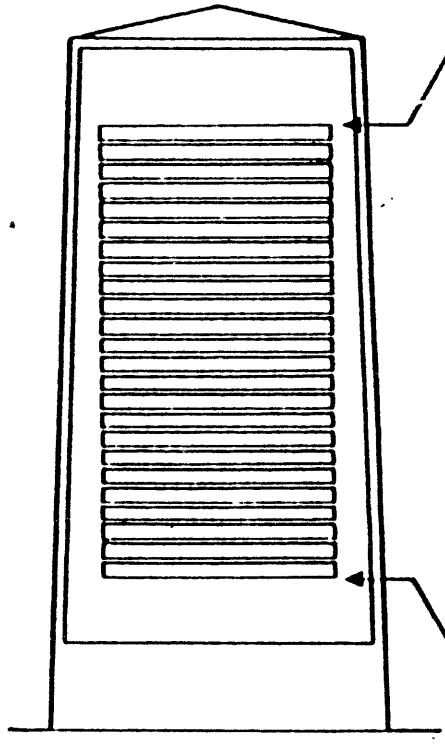
PS8504-89

Level 1 & 2 Message

(English)	DANGER RADIOACTIVE WASTE DO NOT DIG HERE
(French)	DANGER DÉCHETS RADIOACTIFS NE PAS CREUSER ICI
(Arabic)	خطر نفايات مشعة لاتحفر هنا
(Spanish)	PELIGRO RESIDUOS RADIOACTIVOS NO CAVAR AQUI
(Russian)	ОПАСНО РАДИОАКТИВНЫЕ ОТХОДЫ НЕ КОПАТЬ В ЭТОМ МЕСТЕ
(Chinese)	危險 此處埋有放射性垃圾. 禁止挖掘
(Yakima)	TBD

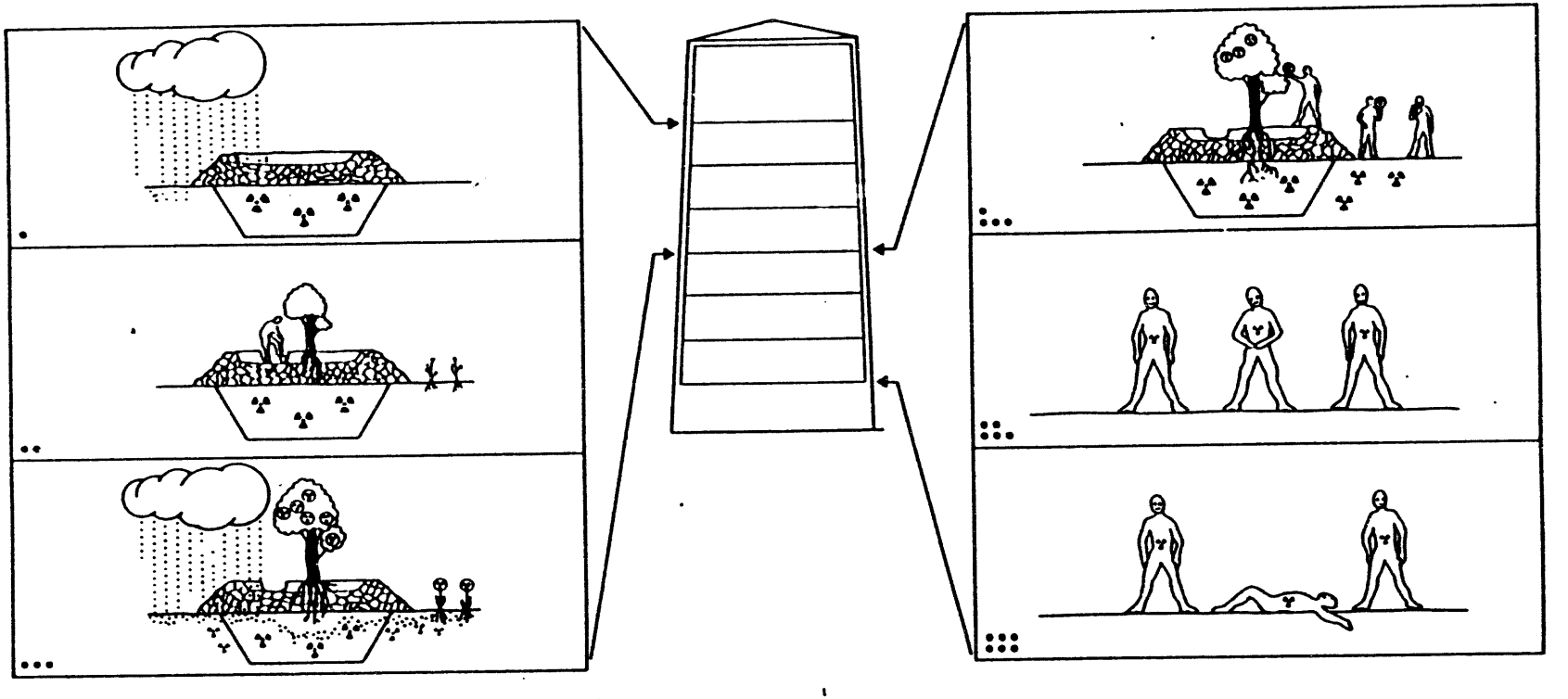
PS8505-166(Ref)

Level 3 Message



"THIS AREA CONTAINS DISPOSAL SITES FOR LONG-LIVED RADIOACTIVE WASTES. EACH DISPOSAL SITE IS MARKED BY A RAISED MOUND OF EARTH AND ROCK. THESE MOUNDS ARE DESIGNED TO KEEP WATER, ANIMALS, AND HUMANS AWAY FROM THE DANGEROUS MATERIAL. DO NOT BUILD HOUSES ON THE MOUNDS. DO NOT PLANT CROPS ON THE MOUNDS. DO NOT DIG FOR WATER WITHIN THE AREA OUTLINED BY THESE MARKERS. THE SOIL BELOW THE MOUNDS DOES NOT LOOK, FEEL, OR SMELL UNUSUAL, BUT IT IS CONTAMINATED BY RADIOACTIVE WASTES. DISTURBING THE MOUNDS DOES NOT CAUSE IMMEDIATE SICKNESS OR DEATH. DISTURBING THE MOUNDS MAY CAUSE EXPOSURE TO HUMANS TO RADIOACTIVITY WHICH MAY RESULT IN CANCER AND DEATH. ILLNESS MAY NOT OCCUR FOR SEVERAL YEARS AFTER EXPOSURE. THESE DISPOSAL SITES AND MARKERS WERE BUILT BY THE UNITED STATES GOVERNMENT IN _____."

Pictogram Message



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Arrangement of Surface Markers

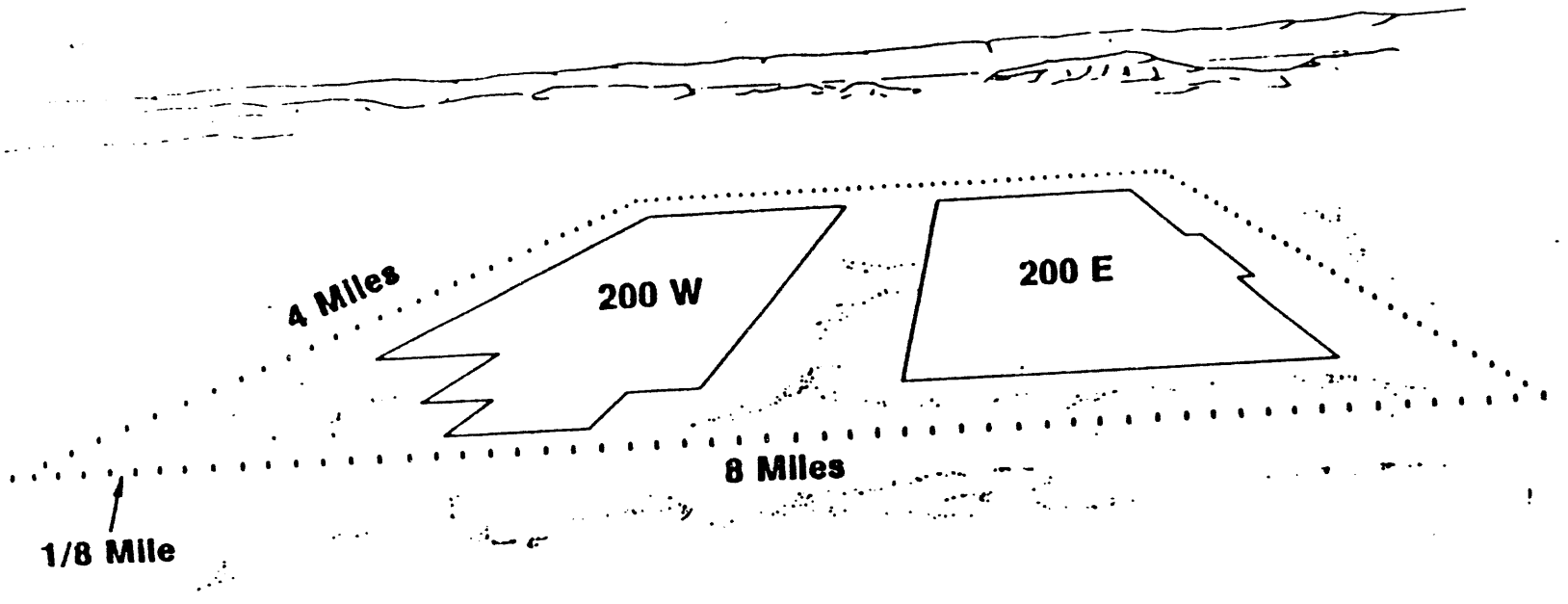
Perimeter surface markers

- Will mark a perimeter approximately 8 miles by 4 miles around East and West areas
- Will be positioned approximately 1/8 mile apart, so that a person standing at one marker will be able to see the next respective marker on each side
- Will have a "No Trespassing" message (The "No Trespassing" message is yet to be determined)

Barrier surface markers

- Will mark at least the corners of the protective barrier blocks and will be placed in added spots for any irregular shaped barrier blocks
- Will be positioned so that a person standing at one marker will be able to see the next respective marker on each side
- Will have the "Do Not Dig Here" messages and other information as shown

Perimeter Surface Markers



Subsurface Marker Testing

The five subsurface marker types were tested and compared for their ability to withstand:

- Chemical shock
- Mechanical shock
- Thermal shock

Laboratory tests included:

- Compressive strength
- Thermal shock (ASTM C-484)
- Thermal crazing (ASTM C-544)
- Alkali resistance (ASTM C-614)
- Color retention (ASTM C-538)
- Chemical resistance (ASTM C-650)

Field emplacement tests will be conducted to determine survivability during construction

Subsurface markers placed in a field test barrier plot will be recovered at five year intervals to determine durability

Granite Specifications

- 0.4% maximum water absorption by weight
- 160 lb/ft^3 minimum density
- 19,000 PSI minimum compressive strength
- 1,500 PSI minimum modulus of rupture
- 12 minimum abrasive hardness per ASTM method C-241

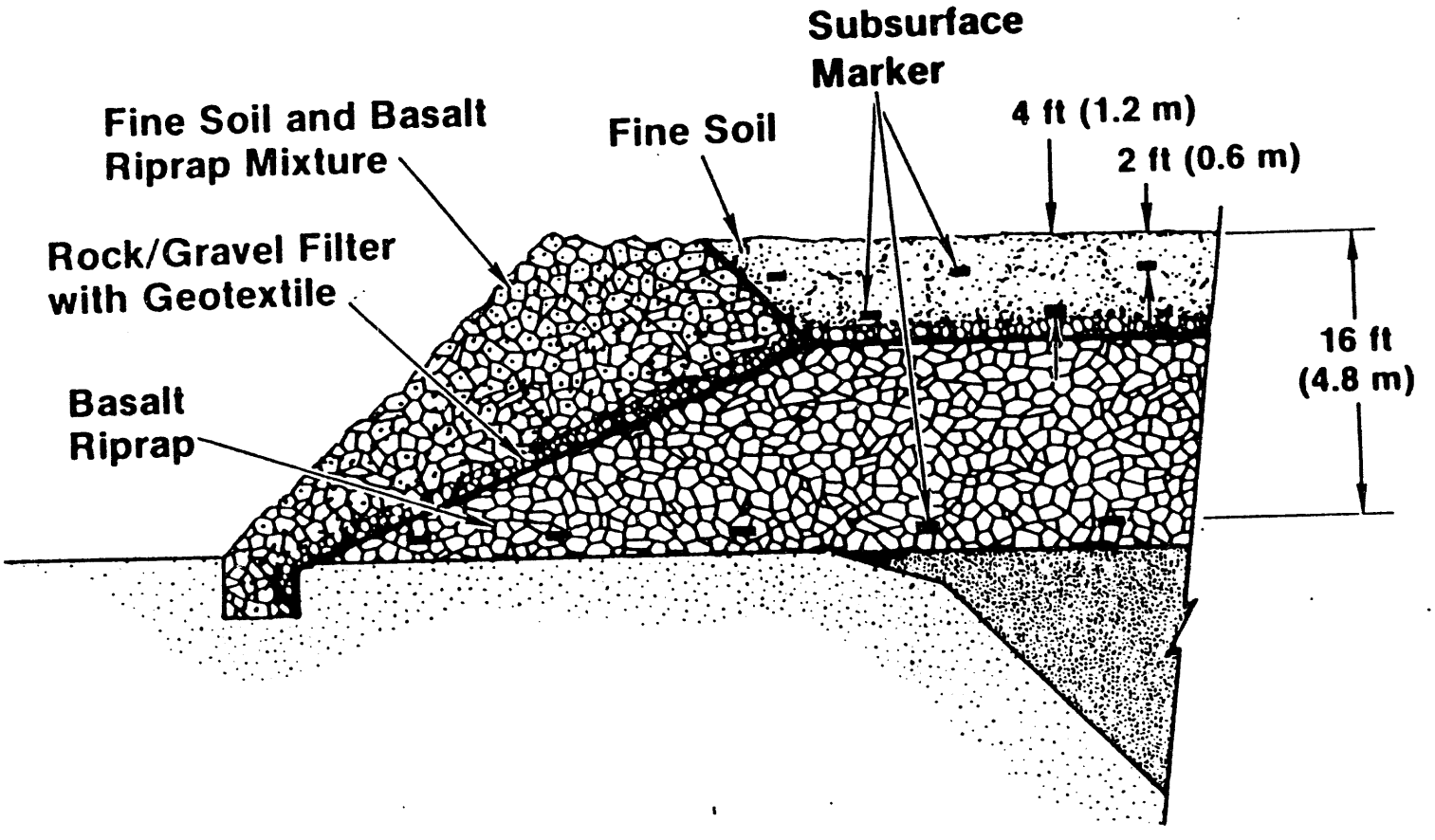
Design Conclusions and Guidelines
Subsurface Markers

- In general, largest potsherds found have been of five inch size
- Use stoneware or porcelain with survivability of thousands of years
- Place at various depths for greater chance of discovery

Subsurface Marker Materials and Details

- Five different compositions will be tested and compared including porcelain and stoneware types with and without clear overglaze
- Typical body composition is pioneer kaolin, clay kaolin, silica, nepheline syenite with yellow clay stain added 15 percent by weight
- All types have magenta glaze in the incised lettering and are fired to 2,200° F
- Four types were ram pressed at 60 tons
- One type was poured into a mold

Arrangement of Subsurface Markers



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Subsurface Marker Testing

The five subsurface marker types will be tested and compared for their ability to withstand:

- Chemical Shock
- Mechanical shock
- Thermal shock

Field emplacement tests will be conducted to determine survivability during construction

Subsurface markers placed in a field test barrier plot will be recovered at five year intervals to determine durability

Laboratory tests underway include:

- Compressive strength
- Thermal shock (ASTM C-484)
- Thermal crazing (ASTM C-544)
- Alkali resistance (ASTM C-614)
- Color retention (ASTM C-538)
- Chemical resistance (ASTM C-650)

Subsurface Marker Prototype Test Results

- Compressive strength test indicates lenticular forms (D and E) strongest with average load 1,600 to 2,300 pounds respectively. Type A weakest at 940 pounds.
- Thermal shock test caused no failure of any specimen.
- Thermal crazing test caused types A, D and E to fail at 420 °F, B and C failed at 510 °F.
- Alkali resistance test caused negligible weight change on types A, C and D; weight gain on type B and weight loss in type E. White glassy appearance developed on type E.
- No darkening occurred on any type when subjected to color retention test.
- None of the types were affected by 10% HCl or 10% KOH in chemical resistance test except type E noted a slight loss of gloss on KOH test.

Marker Development Completed to Date

- Subsurface and surface marker prototypes designed
- Message definition documentation complete for surface markers
- Surface marker purchase requisition and specification complete
- Record keeping requirements documented
- Subsurface marker tests by U. S. Testing (Los Angeles) complete

Marker Development Remaining

- Procure prototype granite surface marker
- Prepare feasibility studies on use of basalt markers
- Place subsurface markers in barrier test plot
- Perform field surveys to determine surface marker placement interval
- Monitor marker performance in the field

Conclusions

- Marking Systems Based on Archaeological Analogs
- Marking Radioactive Waste Disposal Sites for 10,000 Years -- Achievable Objective
- Major Progress Has Been Made in Defining, Designing and Testing Markers

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Offsite Records

- Federal regulatory guidance provides that copies of records be transferred to:
  - Chief executive of nearest municipality, county and county zoning board or planning agency
  - State governor
  - Records must include location and quantity of radioactive wastes in the disposal site
- Consultants to the office of nuclear waste isolation have recommended:
  - System which provides combination of written records in multiple locations
  - Location of disposal sites on 7.5 minute quadrangle U.S.G.S. topographical maps
- Guidance abstracted from RHO, DOE and regulatory sources indicates:
  - Recordkeeping should include hazardous and mixed wastes as well as radioactive waste
  - Records may be original, reproduced copy or legible microfilm

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END