

**Environmental Compliance in Quarrying Operations:
A Computer-Based Decision Support System**

by

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ABSTRACT

Quarry operators must continue to change and adapt environmental compliance methods to meet increasingly demanding regulations. To fulfill industry needs, a computer-based decision support system has been developed to facilitate legal and environmental decisions that mine operators are required to make with regards to stormwater. The comprehensive stormwater programming provides a model for subsequent programming in areas of environmental concern such as: air, groundwater, noise, aesthetics, vegetation, wetlands, hazardous wastes, storage tanks, and wildlife habitats. Operators will utilize the system's user-friendly interface consisting of mouse driven responses and limited keyboard entries on a desktop computer. The system is easy to upgrade according to the user's needs and changes in current laws and regulations. Data input models, user interfaces, and support of decision making are explained. Using this approach, the user has complete control over all steps of the decision making process. A stormwater example is selected to demonstrate the potential benefits of the support system to environmental decision makers.

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TABLE OF CONTENTS

ABSTRACT	ii
ACKNOWLEDGMENTS.....	iii
TABLE OF CONTENTS.....	iv
LIST OF FIGURES	vi
LIST OF TABLES	vii
CHAPTER I. - INTRODUCTION.....	1
1.1 Statement of Problem.....	1
1.2 Objectives/Approach.....	1
CHAPTER II. - LITERATURE REVIEW.....	3
2.1 Two Major Resource Use Philosophies.....	3
2.2 Reasons for Emergence of Environmental Issues.....	3
2.3 Sources of Law	4
2.3.1 Constitutions.....	4
2.3.2 Statutes	4
2.3.3 Court Organization and Procedure	5
2.3.4 Administrative Regulations.....	5
2.4 Sources of Federal Environmental Regulatory Power.....	5
2.5 Legal Responses to the Environmental Problem	6
2.5.1 Common Law Actions.....	6
2.5.1.1 Negligence.....	6
2.5.1.2 Trespass.....	7
2.5.1.3 Nuisance	7
2.5.1.4 Strict Liability	7
2.5.2 Command and Control Regulations.....	7
2.5.2.1 Performance Standards.....	8
2.5.2.2 Ambient Standards.....	8
2.5.2.3 Design Standards	8
2.5.2.4 Behavioral Standards.....	8
2.5.2.5 Information Standards.....	9
2.5.3 Mandated Rational Planning	9
2.6 The Regulatory Explosion	9
2.6.1 United Kingdom.....	9
2.6.2 United States.....	11
2.7 Regulatory Compliance Issues	14
2.7.1 Cost of Compliance	14
2.7.2 Attitude of the Regulated Community.....	14
2.8 Currently Available Compliance Aids	15
2.8.1 Reference Materials	15
2.8.2 Software.....	16
2.8.3 Personnel.....	16
2.9 Decision Support Systems.....	17
2.9.1 Introduction	17

2.9.2 Definition.....	17
2.9.3 Components.....	18
2.9.4 Characteristics	18
2.9.5 Appropriate Applications	21
2.9.6 Benefits.....	21
CHAPTER III. – SOFTWARE CONSTRUCTION.....	23
3.1 Planning.....	23
3.1.1 Needs Assessment	23
3.1.2 Problem Diagnosis	24
3.1.3 Key Decisions and Goals.....	24
3.2 Addressing User Needs and Identifying Available Resources	25
3.2.1 Addressing User Needs	25
3.2.2 Available Resources.....	26
3.2.2.1 Hardware and Software Used for Development	26
3.2.2.2 Delivery of the System	27
3.2.2.3 Available Sources of Information.....	27
3.3 Best Development Approach	27
3.4 Design.....	28
3.4.1 User Interface.....	28
3.4.2 Model Base.....	28
3.4.3 Database	30
3.5 Construction: Putting the DSS together	30
CHAPTER IV. - USING EDESS.....	45
CHAPTER V. - CONCLUSIONS AND RECOMMENDATIONS.....	63
5.1 Conclusions	63
5.2 Recommendations	63
REFERENCES.....	65
APPENDIX A. - LISTING OF EDESS PROGRAMMING MODULES.....	67
APPENDIX B. - A PERMIT DATABASE	82
B.1 Program Overview	82
B.2 Application Installation	82
B.3 Steps in Running ENV_PERMITS From FoxPro	83
B.4 Menu and Submenus.....	83
B.4.1 File.....	83
B.4.2 Update.....	84
B.4.3 Mining.....	84
B.4.3.1 Permits.....	84
B.4.3.2 Authorities.....	84
B.4.3.2 Departments.....	85
B.4.4 Quarrying	85
B.4.5 Queries	85
B.4.5 Address	86
B.4.6 Help	86
APPENDIX C. - COSTS OF SOFTWARE.....	88
VITA.....	89

LIST OF FIGURES

Figure 2.1 - Regulatory Explosion (Source: DuPont Directions).....	10
Figure 2.2 - Environmental Assessment Protocol (Hambidge, et al., 1993).....	12
Figure 2.3 - A Generic Decision Support System.....	19
Figure 2.4 - The Characteristics and Capabilities of DSS (Turban, 1993).....	22
Figure 3.1 - EDeSS General Flow (after Turban, 1993).....	29
Figure 3.2 - Authorware Toolbar.....	33
Figure 3.3 - A Selection of Pushbutton Responses.....	34
Figure 3.4 - Construction of EDeSS Responses to User Queries.....	35
Figure 3.5 - Choice Between Information and Question and Answer Session.....	36
Figure 3.6 - Queries With the User Direct the Interaction.....	37
Figure 3.7 - Jumping to Another Authorware File.....	38
Figure 3.8 - pH Compliance Determination.....	39
Figure 3.9 - Paging Model Used in EDeSS.....	40
Figure 3.10 - Jumping Out to a Non-Authorware Application.....	41
Figure 3.11 - Packaging Option in Authorware.....	42
Figure 3.12 - Library Function Within EDeSS.....	43
Figure 3.13 - Construction of a Pull-Down Help Menu.....	44
Figure 4.1 - Flow of the EDeSS Stormwater Choices.....	46
Figure 4.2 - Title Screen.....	47
Figure 4.3 - Introductory Screen.....	48
Figure 4.4 - Selection From Different Environmental Areas.....	49
Figure 4.5 - Choice of Question and Answer Session or Information on VPDES.....	50
Figure 4.6 - A Choice Offered in EDeSS.....	51
Figure 4.7 - VPDES Permit Contact Information.....	52
Figure 4.8 - Use of a Scanned Map to Show Locations and Addresses of Agencies.....	53
Figure 4.9 - Qualifier Question For Determination of VPDES Permit Need.....	54
Figure 4.10 - Another Qualifier Question For Determination of VPDES Permit Need.....	55
Figure 4.11 - Choices of VPDES Permit Information.....	56
Figure 4.12 - Interaction with the pH Compliance Determination Module.....	57
Figure 4.13 - Information Screen About Cost and Term of VPDES General Permit.....	58
Figure 4.14 - Monitoring Requirements for Permit.....	59
Figure 4.15 - Definition Available to EDeSS User.....	60
Figure 4.16 - Penalty Information in EDeSS.....	61
Figure 4.17 - Printing Options in Authorware.....	62

LIST OF TABLES

Table 2.1 - Possible Environmental Permits Needed for Quarrying in Virginia (Source: VDEQ, 1993)	13
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CHAPTER I. - INTRODUCTION

1.1 Statement of Problem

In 1992, nearly 1,600 companies operating over 3,200 surface quarries and underground mines produced 1.2 billion tons of crushed stone valued at \$5.5 billion (National Stone Association, 1994). Although stone production continues to provide the foundation of the nation's construction industry, increasing environmental pressures are straining the quarrying industry's ability to obtain permits and comply with the regulations. Penalties for compliance failure can include plant shutdown, civil fines in the thousands of dollars per day per violation, and criminal charges. To meet the increasing challenges, quarry managers have relied on text references and some computerized systems that often do not contain current legislation and regulations, are not interactive, and do not have multimedia capabilities. Expensive personnel and consulting services are often used without a guarantee of successful compliance. Therefore, the quarrying industry needs a concise and user-friendly system to provide quarry managers with current environmental information.

1.2 Objectives/Approach

Environmental compliance can be achieved and stiff penalties avoided if legal requirements are incorporated into mine plans and production processes. However, most quarry operators are frustrated by the complexity and excess of environmental regulations.

The objective of this research is to determine methods of successful environmental compliance, model an area of concern, and develop software that presents information on permits, requirements, and governing agencies at the federal and state levels. The software includes models for permitting, analysis, calculations, and evaluations for the state of

Virginia. Additionally, the software construction is explained in detail so that users will be able to customize the software functions and extrapolate the included models to include other environmental areas of concern with their respective federal, state, local and site-specific legal requirements. The user-friendly and adaptable software includes multimedia capabilities and is flexible enough to incorporate other software if needed. Moreover, all levels of quarry operators can use the interactive software program.

CHAPTER II. - LITERATURE REVIEW

2.1 Two Major Resource Use Philosophies

In the 1900's the United States adopted two philosophies concerning the environment: conservationism and preservationism (Anderson, Mandelker, and Tarlock, 1990). Conservationism involves the moderation of present resource use to assure plentiful supplies in the future (Ibid). This was the dominant philosophy until the late 1960's and "stressed the use of scientific principles to make rational resource use choices." As part of their manifest destiny, citizens felt compelled to reclaim arable lands, dredge and fill swamps, and dam rivers for flood control. "Environmental contamination was the price of material progress" (Ibid).

Contrary to conservationism, preservationism deals with safeguarding large tracts of land and water from all unnatural intrusions. Scientific and democratic reasons for disturbance would not be acceptable. Since the late 1960's preservation has become a much more influential philosophy in society for reasons described below.

2.2 Reasons for Emergence of Environmental Issues

Citizens of the United States realized that they "had been polluting the country and the world with a variety of practices that threatened environment and had the potential to destroy the quality of life for decades to come" (Hobby, 1991). The Council on Environmental Quality gave the following reasons for the sudden emergence of environmental quality as a major issue: (1) Post World War II growth in affluence permitted people to relocate to the suburban communities. "These people witnessed firsthand the degradation of the very amenities they had relocated to enjoy." (2) The synthetic organic chemical industry developed more sophisticated monitoring devices. (3)

An untimely oil spill backed environmental causes. (4) Energy was transferred from 'messy' civil rights actions and the Vietnam War to a movement that was 'clean' for America (Anderson, Mandelker, and Tarlock, 1990).

2.3 Sources of Law

The major sources of U.S. law include: (1) federal and state constitutions; (2) federal and state statutes; (3) interpretations of the Constitution and statutes by the state supreme court, the U.S. Supreme Court, and the inferior federal courts; and (4) state and federal administrative regulations and decisions (Maley, 1979). Constitutions and statutes originate in the legislative branch of the federal and state governments, while the judicial branch of government interprets the constitutions and products. The executive branch of government issues and enforces regulations.

2.3.1 Constitutions

"The Federal Constitution has been the supreme law of the Federal Government since its adoption" in 1789. Similarly, each state has a state constitution which provides the supreme law for the state governments (Maley, 1979).

2.3.2 Statutes

Article I, Sec. 8 of the U.S. Constitution authorizes the U.S. Congress to make laws (Maley, 1979). Bills are introduced in both houses of Congress. If an appropriate committee supports a bill, it will be debated and voted upon. If the bill is passed in one house, it is sent to the other body in Congress for approval. If both senate and house approve the bill, it is submitted to the President for signature. The President can sign the bill to make it law or veto it. A veto overridden by a two-thirds vote in both houses becomes law. States enact laws in a similar manner to that of the federal government.

2.3.3 Court Organization and Procedure

Trial courts or courts of the first instance are where a trial is first held (Maley, 1979). The trial court has the responsibility for determining questions of fact on a controversy, applying rules of law, and rendering a decision. Appellate courts only decide questions of law and base their decisions on the record made in the trial court (Ibid). States generally have municipal courts, district courts, and state supreme courts. Cases from the U.S. courts of appeals and state supreme courts may be appealed to the highest court in the land, the Supreme Court of the United States (Ibid).

2.3.4 Administrative Regulations

“Regulations are prepared and issued by Federal agencies through delegation of authority by presidential executive order or by Federal statute. These regulations are the agency statement designed to interpret, implement and standardize the administration of a particular law” (Ibid).

2.4 Sources of Federal Environmental Regulatory Power

Findley and Farber (1992) outlined the specific powers that the federal government must use to regulate the environment. These include the following: the power to regulate interstate commerce; the power to tax and spend; the power to enter into treaties; and the power to regulate the use of public lands. The United States Supreme Court “has made clear that the commerce power not only extends to ‘the use of channels of interstate or foreign commerce’ and to ‘protection of the instrumentalities of interstate commerce . . . or person or things in commerce,’ but also to ‘activities affecting commerce. . . . So long as Congress can rationally conclude that a class of activities, taken together, has a substantial effect that crosses state lines, the Court will uphold the statute.” The property clause

provides that “Congress shall have Power to dispose of and make all needful Rules and Regulations respecting the Territory or other Property belonging to the United States.”

“Congress possesses both the powers of a proprietor and of a legislature over the public lands.” Congress also “has broad powers to make treaties with foreign nations on matters of international concern” such as the hunting of migratory birds. The Constitution authorizes Congress to spend money in pursuit of the public interest. Congress has “free reign in determining where that public interest lies.”

2.5 Legal Responses to the Environmental Problem

Anderson, Mandelker, and Tarlock (1990) explain some of the legal responses to the environmental problems. These include common law actions that command and control regulation.

2.5.1 Common Law Actions

Common law is “a body of rules and principles relating to the government and security of persons and property” (Sullivan, 1993). Common law tort actions are brought by injured plaintiffs. These actions force those who generate external costs to bear those costs as a means of moving toward a more efficient allocation of resources (Anderson, Mandelker, and Tarlock, 1990).

2.5.1.1 Negligence

Negligence is “conduct which falls below the standard established by law for the protection of others against unreasonable risk of harm . . .” (Ibid). It requires a ‘breach of duty of care’ which deals with conduct rather than conditions. The defendant in a negligence case must be charged with having done some act, or failed to do some act he/she

had a duty to undertake in a manner which violates a standard of care by negligence or recklessness (Ibid).

2.5.1.2 Trespass

Trespass requires an intentional injury or interference with a plaintiff's possessory interest in land or property—an entry on a plaintiff's realty, either by the defendant, or by some physical or observable object which the defendant has caused to enter (Sullivan, 1993). This common law mechanism provides less than a fully effective remedy in pollution cases because of the often invisible and chronic nature of pollutants.

2.5.1.3 Nuisance

Private nuisance is an unreasonable interference with a plaintiff's use and enjoyment of his land. Noise, odors, air pollution, and water pollution often comprise private nuisances. Injunctive relief is a positive outcome for the plaintiff. Contrary to private nuisances, public nuisances are not tied to interference with enjoyment and use of property. Rather they are "unreasonable interferences with a general right of the public" (Anderson, Mandelker, and Tarlock, 1990).

2.5.1.4 Strict Liability

Strict liability means that if a party has performed a certain action or failed to perform a required action, then the party is guilty.

2.5.2 Command and Control Regulations

Command and control regulations define certain kinds or amounts of pollution as legal or illegal and subject operators to fines or criminal convictions. These regulations

involve control externalities by subsidizing or taxing those who do or do not pollute, respectively (Ibid).

2.5.2.1 Performance Standards

“Performance standards establish an acceptable level of protection or control without specifying the particular method to be used for complying with them” (Ibid). Effluent (water) and emission (air) standards specify a mean or maximum permissible discharge of a pollutant from a type of source. Performance standards are not effluent limitations. Standards applied to a type of source are output-oriented, but limitations are applied to single identified sources (Ibid).

2.5.2.2 Ambient Standards

Ambient Standards are minimum conditions that must be met in an indoor or outdoor environment. They place quality standards on the receiving water or the air. However, ambient standards “are meaningful only when used in tandem with performance or design standards applicable to individual source” (Ibid).

2.5.2.3 Design Standards

Design standards specify the manner in which equipment, structures, products, and production processes must be constructed or arranged in order to protect against health and safety hazards (Ibid).

2.5.2.4 Behavioral Standards

Behavioral standards prescribe procedures intended to reduce the incidence of injury or illness (Ibid).

2.5.2.5 Information Standards

Information standards “require that information be supplied to affected parties or to the governmental agency charged with protecting the public” (Ibid).

2.5.3 Mandated Rational Planning

Mandated rational planning laws require a rational decision—one that collects available data, presents alternative choices, and assesses the consequences of proposed actions in light of statutory goals. The issue is often whether an activity should be allowed at a given location and whether permits should be granted (Ibid).

2.6 The Regulatory Explosion

Increased environmental awareness has affected industrial activities worldwide. For comparison, a country such as the United Kingdom has just begun to consider environmental issues involved with mining (Hambidge, et al., 1993). The United States, on the other hand, has increased its regulations of industry at an explosive rate over the past 25 years (Fig. 2.1).

2.6.1 United Kingdom

Some mining projects in the United Kingdom may be required to assess the impact of their activities on the environment in terms of an environmental assessment (similar to the US’s Environmental Impact Statement). Environmental assessment (EA) can act as an important tool in business decision making for diversification and expansion activities in Great Britain. No “. . . standard definition of the term EA exists at present, and the guidance on the undertaking of this process is also scarce” (Ibid). The British Aggregate Construction Materials Industries has taken the initiative by producing an environmental code of practice, which contains the minimum requirements with which member companies

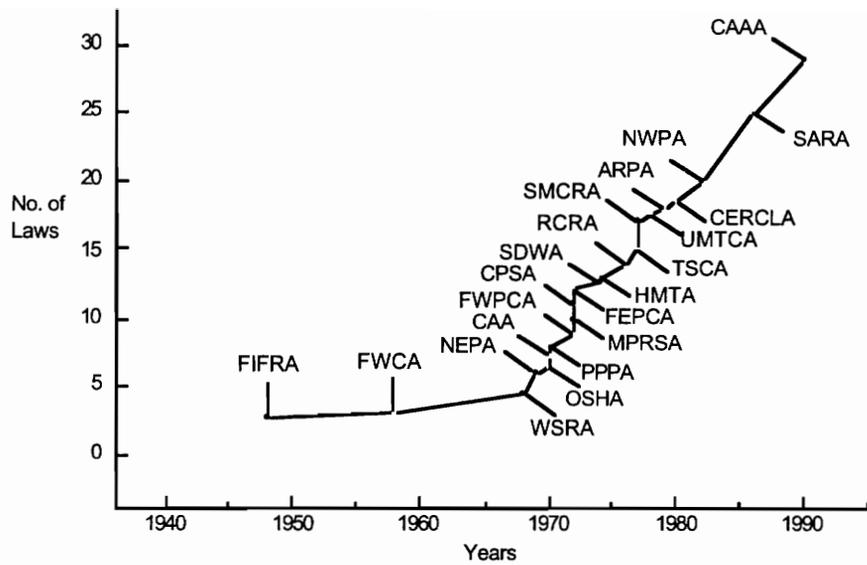


Figure 2.1. Regulatory Explosion (Source: DuPont Directions).

should comply (Ibid). It is expected that the scrutiny of the statements will be more demanding in the future; therefore Hambidge composed an environmental assessment protocol (Figure 2.2).

A study in the UK identified a clear requirement for the industry to develop public confidence by demonstrating its commitment to high levels of environmental performance. Industries need corporate environmental statements, environmental site appraisals, regular monitoring of performance and periodic audits/reviews. In the UK, the general area of environmental policy and environmental management is developing rapidly and the agenda continues to change. “The goalposts are constantly being moved. . . . The gap between the leaders and the led is growing and this presents a continuing challenge for all of those in the public, private, and environmental sectors who regard the minerals industry as an important part of our economy” (Menzies, 1994).

2.6.2 United States

“Tidal wave” (Paty, 1994) and “juggernaut” (Samuelson, 1994) are terms used to refer to the number and complexity of environmental regulations which have strained the mining industry’s compliance ability in the United States. For example, a quarrying company in Goshen, New York, spent \$100,000 on a yearlong archeological survey of Look-Out Mountain as required by the State Department of Environmental Conservation (Nieves, 1994). Costs for compliance are soaring and penalties for violations are tough. Penalties for noncompliance can include plant shutdown, criminal charges, and civil fines in the thousands of dollars per day per violation. The “out of sight–out of mind” philosophy is no longer allowed. Quarries in Virginia are subject to at least a dozen different environmental permits which regulate nearly every aspect in an operation (Table 2.1).

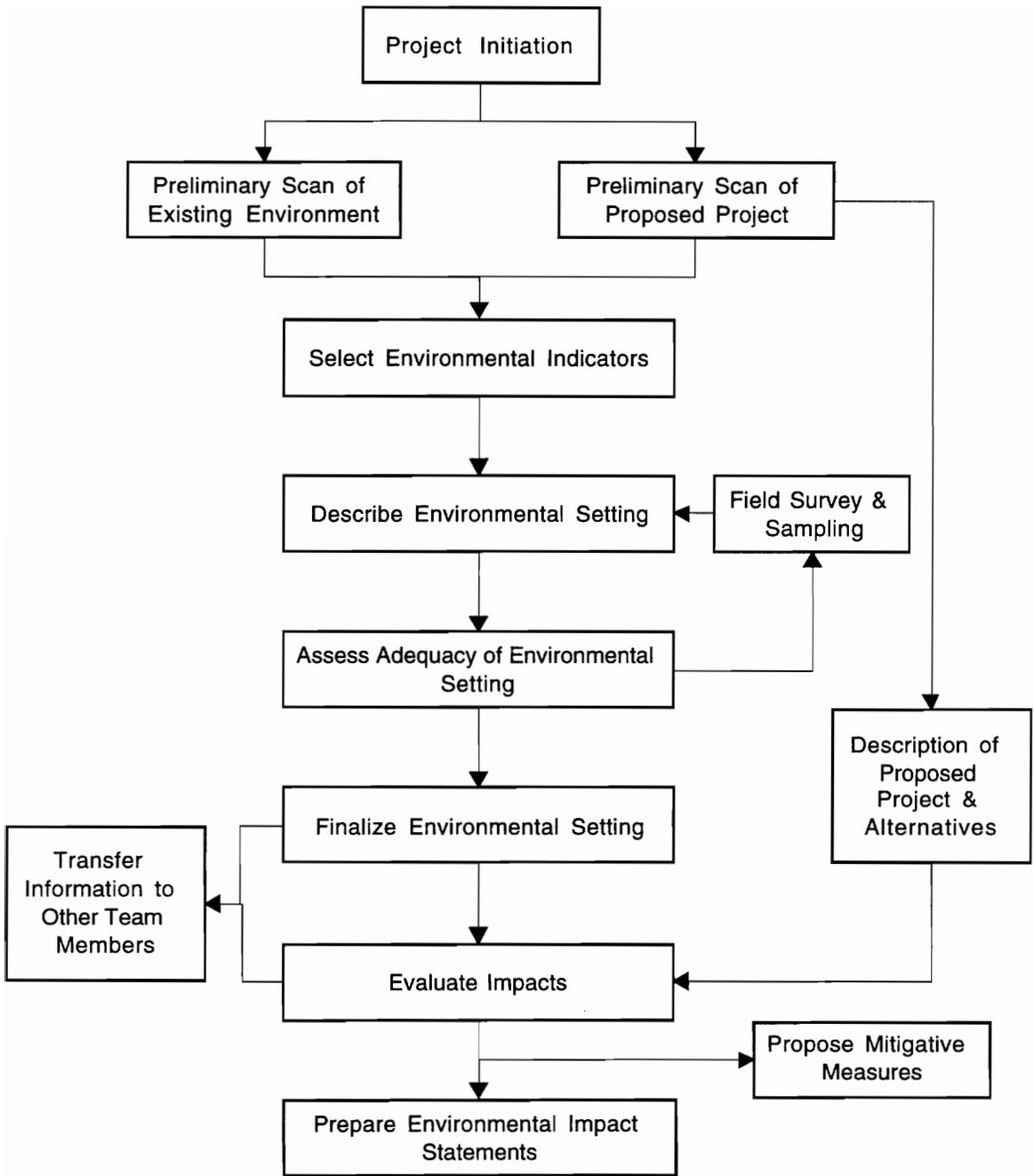


Figure 2.2. Environmental Assessment Protocol (Hambidge, et al., 1993).

Table 2.1. Possible Environmental Permits Needed for Quarrying in Virginia (Source: VDEQ, 1993)

Permit Name	Delegated Agency
Existing Sources Registration and Standards	Department of Environmental Quality–Air Division
Minor New or Modified Source Construction	Department of Environmental Quality–Air Division
Major New or Modified Source Construction	Department of Environmental Quality–Air Division
Prevention of Significant Deterioration	Department of Environmental Quality–Air Division
Virginia Pollutant Discharge Elimination System	Department of Environmental Quality–Water Division
Virginia Pollution Abatement	Department of Environmental Quality–Water Division
Virginia Water Protection	Department of Environmental Quality–Water Division
UST Corrective Action Plan	Department of Environmental Quality–Water Division
Groundwater Withdrawal	Department of Environmental Quality–Water Division
Solid Waste Landfill Permit	Department of Environmental Quality–Waste Division
Construction in Waters of the Commonwealth and Wetlands	Virginia Marine Resources Commission
Pesticide Applicator Permit	Department of Agriculture and Consumer Services

2.7 Regulatory Compliance Issues

2.7.1 Cost of Compliance

“Everyday Americans have finally awakened from their 20-year environmental hangover to realize the enormous costs incurred by environmental regulations” (Paty, 1994). Between 1981 and 1990, the Environmental Protection Agency estimated that the nation spent \$640 billion in the pursuit of clean air and water (Portney, 1991). “Recovery plans for 306 listed species under the Endangered Species Act (ESA) would cost approximately \$884,164,000, according to a study by the National Wilderness Institute” (Gordon, 1994). These “recovery” plans do not guarantee a replenishment of the species , and the species may not be “endangered” at all (Ibid). Under the ESA, the cost of the recovery plan for the Atlantic Green Turtle is \$88,236,000, for the blunt nosed lizard, \$70,000,000. The average cost per species is \$3.06 million. “When a ‘species’ is formally declared endangered, then any activity—whether it be mining, clearing dead brush, grazing cattle, adding onto a home or anything else that is considered to harm, harass, wound or kill a single federally protected beetle or bird—violates the ESA and carries a possible \$25,000 fine and a year in jail” (Gordon, 1994).

2.7.2 Attitude of the Regulated Community

Some quarrying companies only change their operating procedures when threatened with fines or jail terms, while other companies progressively change their practices to more effectively coexist with their surroundings. Whether or not companies comply with the growing environmental regulations for fear of financial or criminal penalties, environmental stewardship can pay big dividends in today’s operating environment. Strict adherence to regulations as well as good site appearance, low emissions, reduced vibrations and noises,

and excellent neighbor relations will often determine whether a quarry's permits and zoning would be renewed.

2.8 Currently Available Compliance Aids

A variety of resources are currently used for environmental compliance purposes. Reference materials, computer software, and personnel are typically used to promote environmental responsibility through additions or corrections to guides, or by word of mouth.

2.8.1 Reference Materials

Existing reference materials are currently presented in different formats. For example, the National Stone Association (1993), a trade organization for the aggregates industry, published a guide which is divided into three sections: policies and procedures; practices and requirements; and references and resources. The goals of this guide include: understanding the fundamentals of the US federal environmental regulations as they apply to the aggregates industry; learning how to apply the highest environmental standards to the daily monitoring of operations; and identifying the warning signs of a potential environmental problem. Similarly, Vulcan Materials Company's Mideast Division (1993) addressed the same subject areas in an in-house environmental handbook which divides relevant topics by physical description (e.g. wetlands, surface water, underground storage tanks). The intention of the handbook is to educate Vulcan's operations personnel about environmental regulations. It is not an exhaustive reference for all of the pertinent regulations, nor is it a statement of detailed standards or procedures for every aspect of operations. It includes information on permits, recordkeeping, and penalties for noncompliance.

2.8.2 Software

There are many software products available which help organize environmental data. *Pollution Engineering* lists 388 such programs (Rich, 1993). “Such programs were designed primarily for use after someone has determined what data is required to be collected” (Ibid). Those programs help with compliance efforts but do not help the user interpret and apply environmental regulations (Cox, 1993). Analysis is a critical and usually expensive portion of compliance efforts.

Other computer software such as REGSCAN (Regulation Scanning, 1994) and FastRegs (OSHA-Soft, 1994) provide only text scanning and hyperlinking search capabilities. Another computer-oriented search technique known as WestLaw (West Publishing, 1993) provides for access to the text of current and proposed laws, regulations, and relevant court decisions. However, use of the service requires extensive training, and knowledge of basic legal terms.

2.8.3 Personnel

Common resources employed to assist with environmental regulations include expensive and often redundant staff, consultants, and lawyers. Typically, efforts of these people focus on determining what must be done in response to a particular problem in accordance with existing law and/or regulations rather than promoting preventive measures (Cox, 1993). For example, \$200,000 in legal fees were spent to avoid a \$50,000 non-compliance penalty in a midwestern area (Hobby, 1991).

2.9 Decision Support Systems

2.9.1 Introduction

A Decision Support System (DSS) is a package of computer hardware and software used to access and process data, develop managerial displays, and provide recommended courses of action (Ignizio, 1991). The concept is to include the decision maker in the system as much as possible in order to enhance the performance of the user. No concise definition of DSS exists, but a few of the meanings of DSS have been compiled.

2.9.2 Definition

“A decision support system is an interactive, flexible and adaptable computer based information system, specially developed for supporting the solution of a particular management problem for decision making. It utilizes data, it provides easy user interface, and it allows for the decision maker’s own insights” (Turban, 1993). Keen and Scott-Morton (1978) also said that “DSS couples the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions.” DSS also uses models that support all phases of decision making while accessing and processing data, developing managerial displays, and providing recommended courses of action.

Decision support systems must make maximum use of the latest technology in computers and software to make it as easy as possible for managers and other personnel to interact and use powerful computerized systems for information management and problem analysis. DSS represents a “convergence of: computer hardware and software technology, especially microprocessor systems and data processing and information-systems theory and applications” (Moore, 1984).

2.9.3 Components

The components of a DSS include a database system, modeling, dialog subsystem, and a user (Fig. 2.3). A database is a collection of interrelated data organized in such a way that it corresponds to the needs and structure of an organization and can be used by more than one person for more than one application. A model is a simplified representation of reality. A dialog subsystem covers all aspects of the communications between the user and the DSS, and the decision maker is the user (Turban, 1993).

2.9.4 Characteristics

Because of the limited agreement on the exact definition of DSS, Turban (1993) said most systems have only some of the following features (Fig. 2.4):

1. DSS provides support for decision makers mainly in semistructured and unstructured situations by bringing together human judgment and computerized information. Such problems cannot be solved (or cannot be solved conveniently) by other computerized systems, such as electronic data processing or management information systems, nor by management science.
2. Support is provided for various managerial levels, ranging from top executives to line managers.
3. Support is provided to individuals as well as to groups. Many organizational problems involve group decision making. The less structured problems frequently require the involvement of several individuals from different departments and organizational levels.
4. DSS provides support to several interdependent and/or sequential decisions. Many organizational problems involve group decision making.

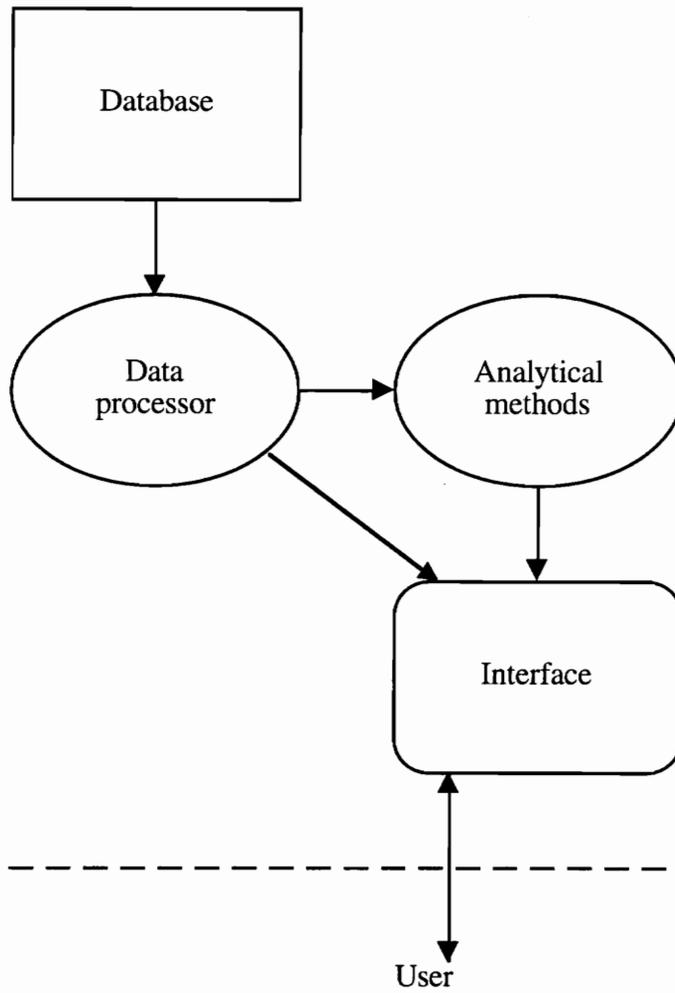


Figure 2.3. A generic decision support system (Ignizio, 1991).

5. DSS supports all phases of the decision-making process: intelligence, design, choice, and implementation.
6. DSS supports a variety of decision-making processes and styles; there is a fit between the DSS and the attributes of the individual decision makers (e.g., the vocabulary and decision style).
7. DSS is adaptive over time. The decision maker should be reactive, being able to confront changing conditions quickly and adapt the DSS to meet these changes. DSS are flexible so users can add, delete, combine, change, or rearrange basic elements (providing fast response to unexpected situations). This capability makes possible timely and quick ad hoc analyses.
8. DSS is easy to use. Users must feel “at home” with the system. User-friendliness, flexibility, strong graphic capabilities, and an English-like dialog language can greatly increase the effectiveness of DSS. This ease of use implies an interactive mode.
9. DSS attempts to improve the effectiveness of decision making (accuracy, timeliness, quality), rather than its efficiency (cost of making the decision, including the charges for computer time).
10. The decision maker has complete control over all steps of the decision-making process in solving a problem. A DSS specifically aims to support and not to replace the decision maker. The decision maker can override the computer’s recommendation at any time in the process.
11. DSS leads to learning, which leads to new demands and the refinement of the system, which leads to additional learning, and so forth, in a continuous process of developing and improving the DSS.

12. DSS are relatively easy to construct. End-users should be able to construct simple systems by themselves. Larger systems could be built in users' organizations with only minor assistance from information systems (IS) specialists.

13. A DSS usually utilizes models (standards, custom-made). The modeling capability enables experimenting with different strategies under different configurations. Such experimentation can provide new insights and learning.

14. Advanced DSS are equipped with a knowledge component that enables the efficient and effective solution of very difficult problems.

2.9.5 Appropriate Applications

Decision support systems have proven to be valuable tools in many business situations. As a result of success, more systems have been developed in areas such as: budget analysis, personnel reports, production scheduling, inventory control, credit evaluation, budget preparation, project scheduling, course selection, tuition analysis, buying software, approving loans, negotiating, and buying computers (Turban, 1993). Decision support systems can assist with structured, semistructured, and unstructured decisions alike.

2.9.6 Benefits

Turban (1990) said that the benefits of decision support systems can include: ability to support solution of complex problems; fast response; ability to try several different strategies under different configurations; new insights and learning; facilitation of communication; improved management control and performance; cost savings; objective decisions; and improved managerial effectiveness. Furthermore, DSS can be instructional and educational to users as well.

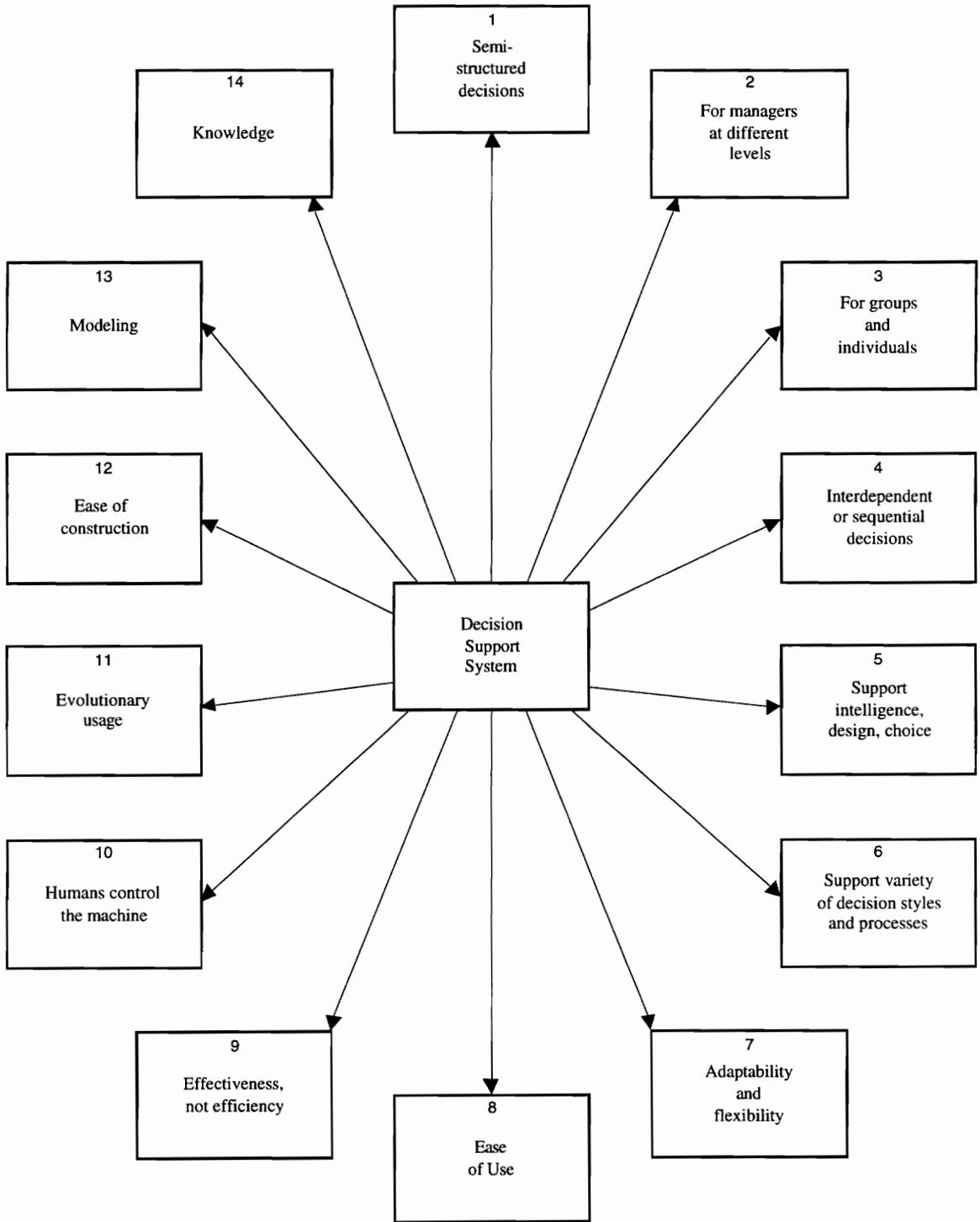


Figure 2.4. The Characteristics and Capabilities of DSS (Turban, 1993).

CHAPTER III. – SOFTWARE CONSTRUCTION

3.1 Planning

Turban (1993) cited the following phases in building a DSS: planning, research, analysis, design, construction, implementation, maintenance and documentation, and adaptation. Planning assesses the needs, diagnoses the problem(s), and defines the objectives of the DSS. Research determines how to address user needs and what resources are available. Analysis ascertains the best development approach and the necessary resources. The design phase includes language interface dialog, model base, and database components. Construction involves putting the DSS together. Evaluation, demonstration, orientation, training, and deployment are components of the implementation phase which is followed by maintenance and documentation of the DSS. Adaptation is the process in which the phases in building a DSS are continually repeated in order to update and improve the system. The following sections expand upon the aforementioned phases of construction for the environmental decision support system.

3.1.1 Needs Assessment

Quarry operators must continue to change and adapt environmental compliance methods to meet the increasingly demanding regulations. With so many laws and regulations, quarry operators need up-to-date information on permits, laws, regulations, calculation ability, and prompt compliance determination in order to avoid stiff criminal and/or civil penalties. Managers require assistance with various areas of environmental concerns and related questions regarding permitting and compliance measures needed for air, aesthetics, groundwater, hazardous wastes, noise, storage tanks, surface water, vegetation, wetlands, and wildlife habitats during the development, operation, and closure

phases of mining. Therefore managers often seek resources which aid in assessing environmental compliance needs.

3.1.2 Problem Diagnosis

Currently, computer reference materials have not been identified which are specifically designed for easy interaction with quarry management. Current references are text based and non-interactive, do not perform calculations, and have no multimedia capabilities. No interactivity and limited upgradability with current references can result in user frustration. Thus a search for applicable laws must currently be conducted through a myriad of generic material without the assurance of successful compliance (Woofter, et al., 1995).

3.1.3 Key Decisions and Goals

The software package “**Environmental Decision Support System**” (EDeSS) has been developed to facilitate mine operator decision making regarding environmental responsibilities. EDeSS will decide what permits need to be applied for, what actions are necessary to be in compliance, and what governing agencies are on the federal and state levels. EdeSS can perform simple calculations, ask questions, and determine permit applicability from the user responses. Additionally, the program allows ‘what-if’ analysis and presents managerial information such as maps, pictures, and chronologies. Because of the numerous and ever changing environmental aspects in the quarrying industry, EDeSS will not model each environmental area. However, stormwater permitting is modeled and exemplified in Chapter 4. Other areas were not modeled because understanding and modeling all areas of concern would be beyond the scope of this thesis work, and their respective regulations are more apt to change quickly. Furthermore, the state level laws and regulations focus on the state of Virginia, because broader coverage would also be an

enormous undertaking. Stormwater permitting was chosen for modeling over other areas because stormwater legislation and regulations are the most steadfast in the environmental areas. Hopefully, the model programming used for stormwater permitting will allow users to program their own site-specific laws and regulations and interpretations for other areas of environmental concern.

This system will increase the consistency of interpretation and application of laws and regulations within user groups. Decision support system approaches foster problem prevention, accommodate modifications to reflect changes in laws and regulations, facilitate consistency of implementation of company structure, and advance ready response in a more understandable format (Turban, 1993). A successful DSS must be simple, adaptive, and user friendly to mine operators and managers as well as other people, including students, regulatory personnel, and the general public, who may use the software for its inherent educational abilities.

3.2 Addressing User Needs and Identifying Available Resources

3.2.1 Addressing User Needs

EDeSS emphasizes assisting and involving managers through interactions, click/touch buttons, limited keyboard entries, graphics, and models. The software named Authorware by Macromedia was used to create EDeSS. Runtime versions of Authorware creations can be distributed freely such as on a single floppy diskette. EDeSS has abilities like printing, storage of values, and access to databases simply with clicks of buttons. For example, an EDeSS user can run a Virginia permit assistance program created in Microsoft FoxPro (Appendix B).

Conventional programming could have been used to help quarry managers, but Authorware provides more modularity, visual programming and flowlines, icons, maps, and multimedia capabilities. Expert programming could have been used to assist management, too, but outcomes of interactions are less predictable and consistent than in a sequentially programmed system. Another advantage of Authorware use is that programming training is minimal, whereas expert system proficiency could take months. Generally, Authorware is an extremely user friendly developmental tool with an appealing and understandable format. Little training is needed for authors to create instructional end products. For details about software costs, see Appendix C.

3.2.2 Available Resources

3.2.2.1 Hardware and Software Used for Development

A Power Macintosh 7100/66AV with 32 Megabytes (Mb) of Random Access Memory (RAM) and 500 Mb of internal hard drive space was used for developing, processing, and storing the EDeSS system. A 13-inch color monitor, an Apple Color OneScanner, and a 340 Mb external drive were used as well.

The software tools used include Authorware 2.2 for Macintosh and Windows. Authorware requires a minimum of 2.3 Mb of RAM for operations and 10 Mb of hard drive space for installment (Macromedia and Apple Computer, 1993). Virginia Tech has a site license for Authorware. MS FoxPro was used for the optional permit assistance database and requires 6.3 Mb of RAM for operation and 3.8 Mb on a hard drive for installation.

3.2.2.2 Delivery of the System

EDeSS can be delivered to quarry management on Macintosh or Windows platforms. EDeSS requires a minimum of 2 Mb of RAM for operation of the executable version (RunAPM or RunAPW) and 2 Mb of available hard drive space depending on media uses (Macromedia, 1993). The only software needed to run EDeSS is the Authorware “packaged” version of EDeSS on floppy diskette for either Windows or Macintosh. However, a “packaging” option was not available on Virginia Tech’s version of Microsoft FoxPro. In addition, EDeSS can be operated normally on smaller screens such as laptops—an Apple Powerbook 520c was used for some development.

3.2.2.3 Available Sources of Information

Information and interpretations of confusing laws and regulations have come from trade association handbooks, quarry company managers and environmental guides, academia, consultants, and text-based government guides such as the Business and Industry Guide to Environmental Permits. Information from handbooks produced by trade associations such as the National Stone Association as well as information from Vulcan Materials Company’s handbook was available for use. Text from government documents at the federal and state levels was used. Advice from consultants, environmental engineers, professors, and researchers was also included.

3.3 Best Development Approach

EDeSS was constructed with some advanced planning, so that at least part of the effort in developing this first system can be reused in future improvements to EDeSS. Such an approach can lead to the development of additional models for site specific environmental situations. In order to develop a complete version of EDeSS, the efforts of

persons familiar with permitting requirements and regulations at a specific quarry or a group of quarries will be required.

3.4 Design

The design phase of EDeSS's construction involved detailing specifications of the system components, structure, and features. Figure 3.1 shows a model of EDeSS's components and structure. The dialog, model, and data management are included within EDeSS, but the data, the user, and other computer systems are external to EDeSS. Features of EDeSS include click/touch buttons, limited keyboard entries, multimedia, paging, help screens, print screens, questions and answers, educational objectives, save functions, libraries of images and text, non-Authorware program execution, and Run Authorware "packaging." All these features will be explained later in the construction phase.

3.4.1 User Interface

The user interface component "covers all aspects of the communication between a user" and EDeSS. "It includes not only the hardware and software, but also factors that deal with ease of use, accessibility, and human-machine interaction" (Turban, 1993). Dialog features click/touch buttons, limited keyboard entries, multimedia, paging, help screens, print screens, questions and answers, and educational objectives. The dialog interface is manipulated through the use of the mouse which provides for a user-friendly environment.

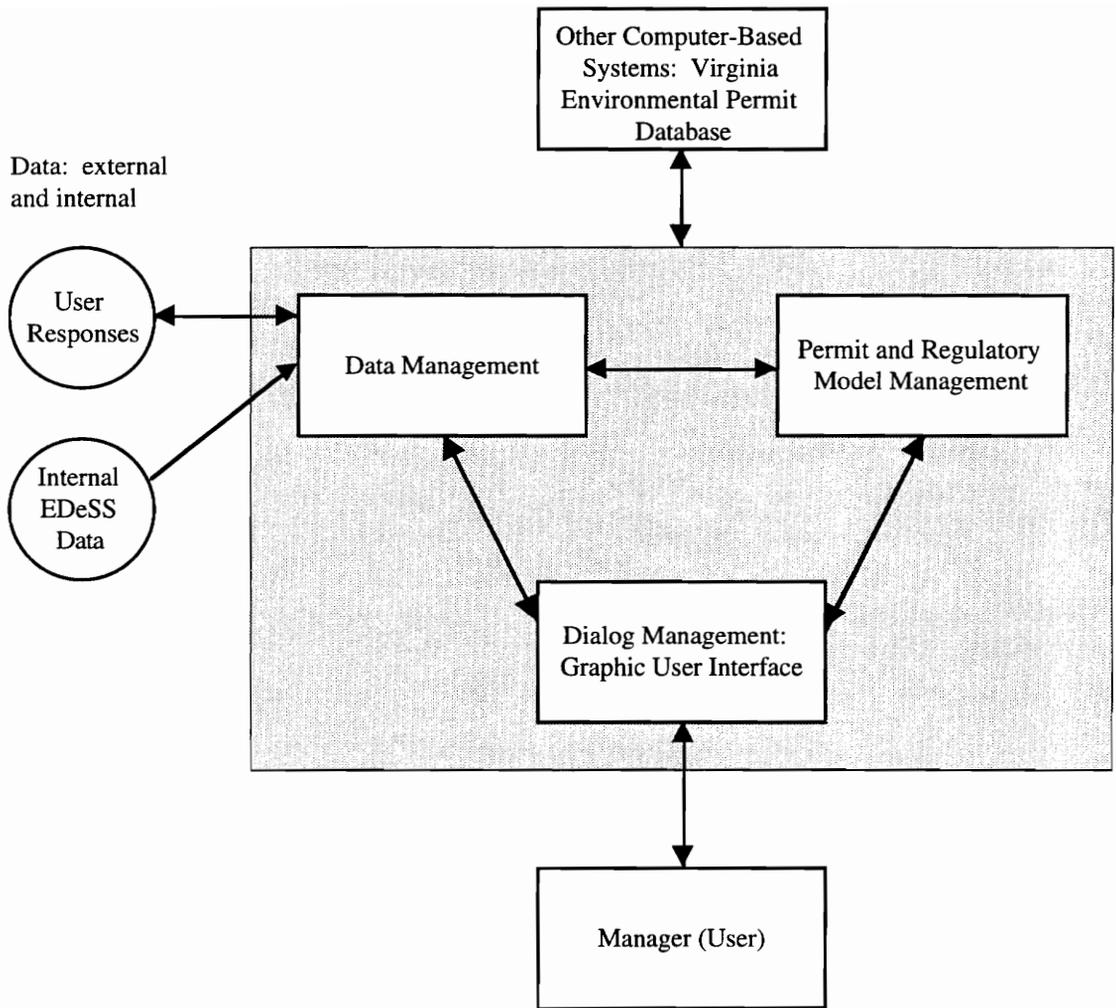


Figure 3.1. EDeSS general flow (after Turban, 1993)

3.4.2 Model Base

“Model base contains models that provide the analysis capabilities” in EDeSS. “The ability to invoke, run, change, combine, and inspect models is a key capability in DSS that differentiates it from the traditional Computer-Based Information System (CBIS)” (Turban, 1993). Program flowlines and icons provide inherent modeling of some legal processes. These flowlines promote easy modifications to reflect legal developments on a site-specific basis in a more appealing and understandable format. Queries control the interactions while different choice paths allow for “what-if” analysis. All of these features will be explained later in the construction phase.

3.4.3 Database

“A database is a collection of interrelated data organized in such a way that it corresponds to the needs and structure of an organization and can be used by more than one person for more than one application” (Turban, 1993). Some data in EDeSS is internal, but other data must be obtained from the user. Repeatedly used graphics, text, and calculations are stored in “libraries.” EDeSS even “Jumps Out” to another program solely used for database management.

3.5 Construction: Putting the DSS together

The construction phase is the technical implementation of the design. Authorware’s toolbar provides the drag and drop icons needed for construction of EDeSS. The display icon is “used to present an object on the screen” (Macromedia and Apple Computer, 1993). The animation icon makes objects move, whereas the erase icon removes objects. The wait icon delays all action until the user clicks another key. The decision icon represents a “series of paths that the application may take” (Ibid). The interaction icon presents a choice

of responses and branching to which the user responds. The calculation icon “performs arithmetic or special control functions.” A map icon allows grouping of other icons.

The following figures exemplify the programming aspects that were used in the construction of EDeSS. These screens are not displayed to the general user but are important background components for a programmer. The figures are explained so that future programmers might use the ideas for custom applications at a specific location with site-specific permits and regulations. Figure 3.2 displays option buttons used to create user-friendly responses in Authorware. The programmer can then construct push button responses from a list of icons (Figure 3.3). The interactive flow in Figure 3.4 demonstrates the development of a basic query system. For each icon in a query, the programmer develops a choice between information inputs or a question and answer session (Figure 3.5). Constructed queries offer the user choices which direct the program flow (Figure 3.6). Figure 3.7 shows EDeSS’ capability to “JumpTo” another Authorware program. In order to limit keyboard entries, the programmer can construct a model, such as pH compliance determination, which requires only a number entry by the user (Figure 3.8). Paging is also an important aspect in developing the EDeSS program so that the user can go backward and forward between different screens by simply clicking a button (Figure 3.9). Figure 3.10 exemplifies EDeSS’ capability to access non-Authorware programs such as database managers. EDeSS “packaging,” another vital feature of the program, allows users without a licensed copy of the Authoring tools to execute the program anyway. This allows free distribution of an executable EDeSS file to any user (Figure 3.11). A programmer can also use the library function which allows storage of calculation, interaction, and display icons in external files (Figure 3.12). Within an application the programmer can reference the icons several times without increasing

memory use. Finally, 'Help' screens can be constructed at any point in the program (Figure 3.13).



Figure 3.2. Authorware Toolbar.

Pushbutton Options

Title: **Position & Size...**

Optional Key(s):

Active If TRUE: **Perpetual**

Button Type

Erase Feedback

After Next Entry

Not Judged

Try Again

If Inactive **Dim** **Hide**

Response Type... **Cancel**

OK • Edit Map **OK**

Response Type

<input checked="" type="radio"/> Pushbutton	<input type="radio"/> Conditional
<input type="radio"/> Click/Touch	<input type="radio"/> Text
<input type="radio"/> Clickable Object	<input type="radio"/> Keypress
<input type="radio"/> Movable Object	<input type="radio"/> Tries Limit
<input type="radio"/> Pull-down Menu	<input type="radio"/> Time Limit

OK **Cancel**

Figure 3.3. A selection of pushbutton responses.

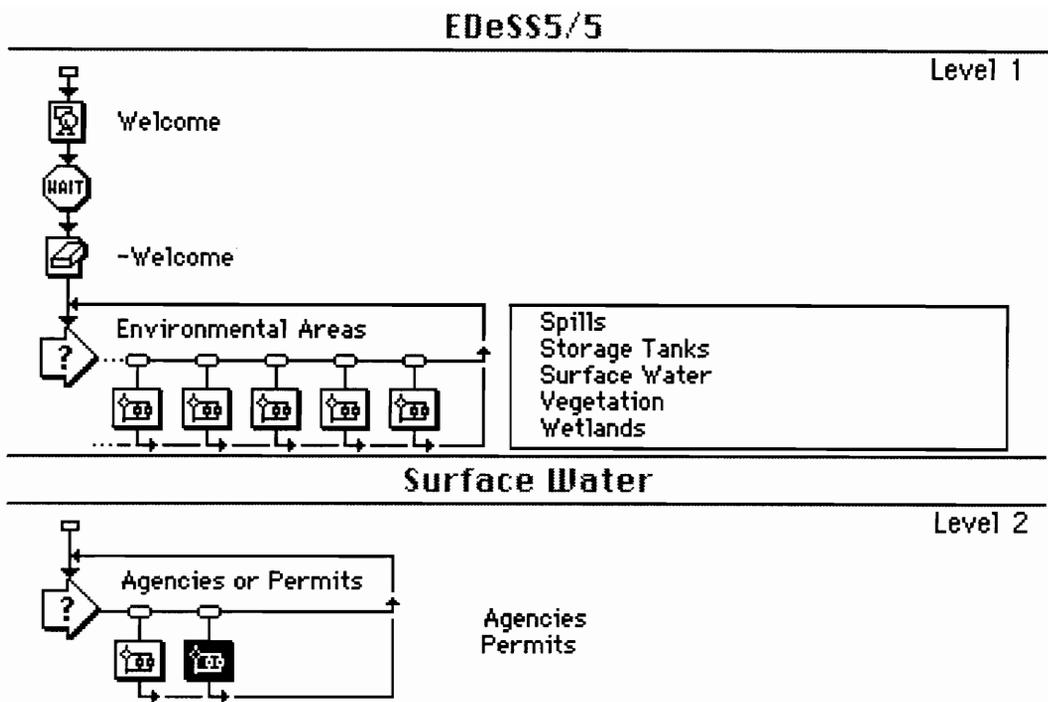


Figure 3.4. Construction of EDeSS responses to user queries.

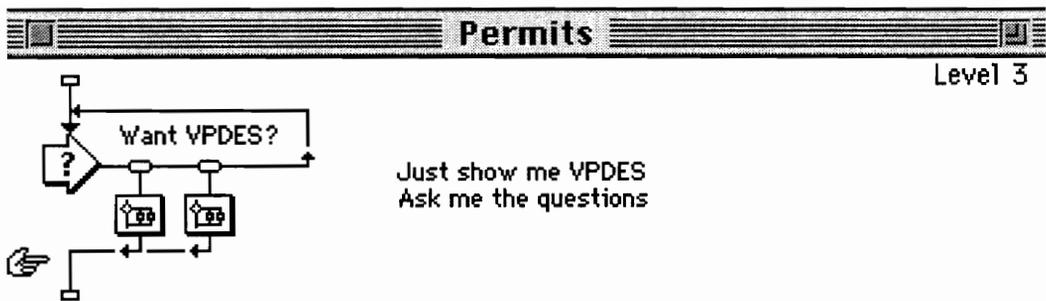


Figure 3.5. Choice between information and question and answer session.

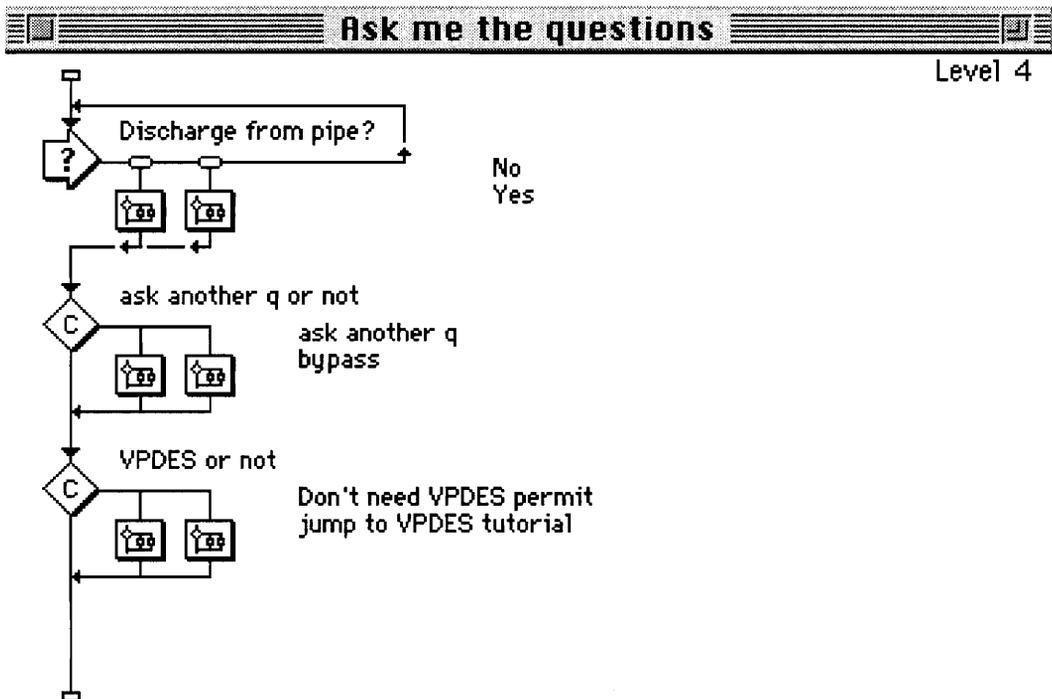


Figure 3.6. Queries with the user direct the interaction.

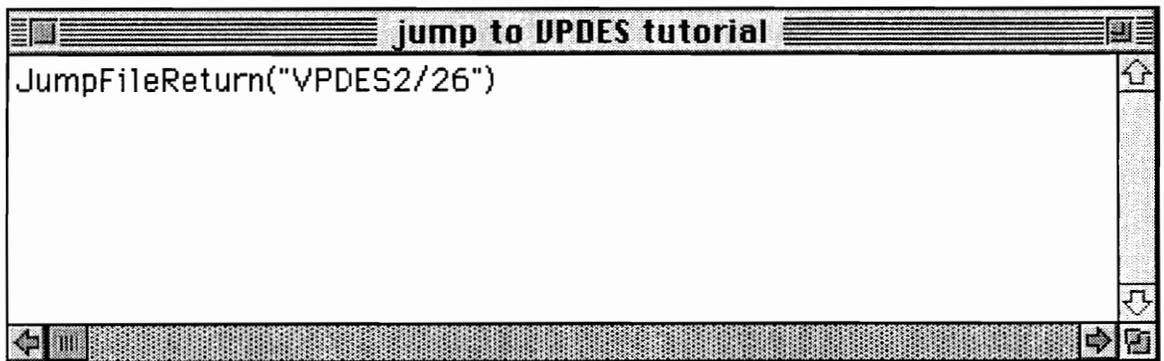


Figure 3.7. Jumping to another Authorware file.

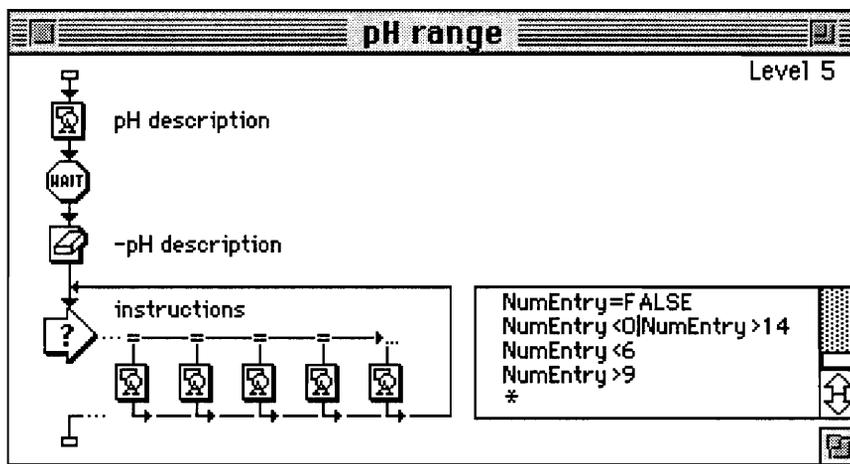


Figure 3.8. pH compliance determination.

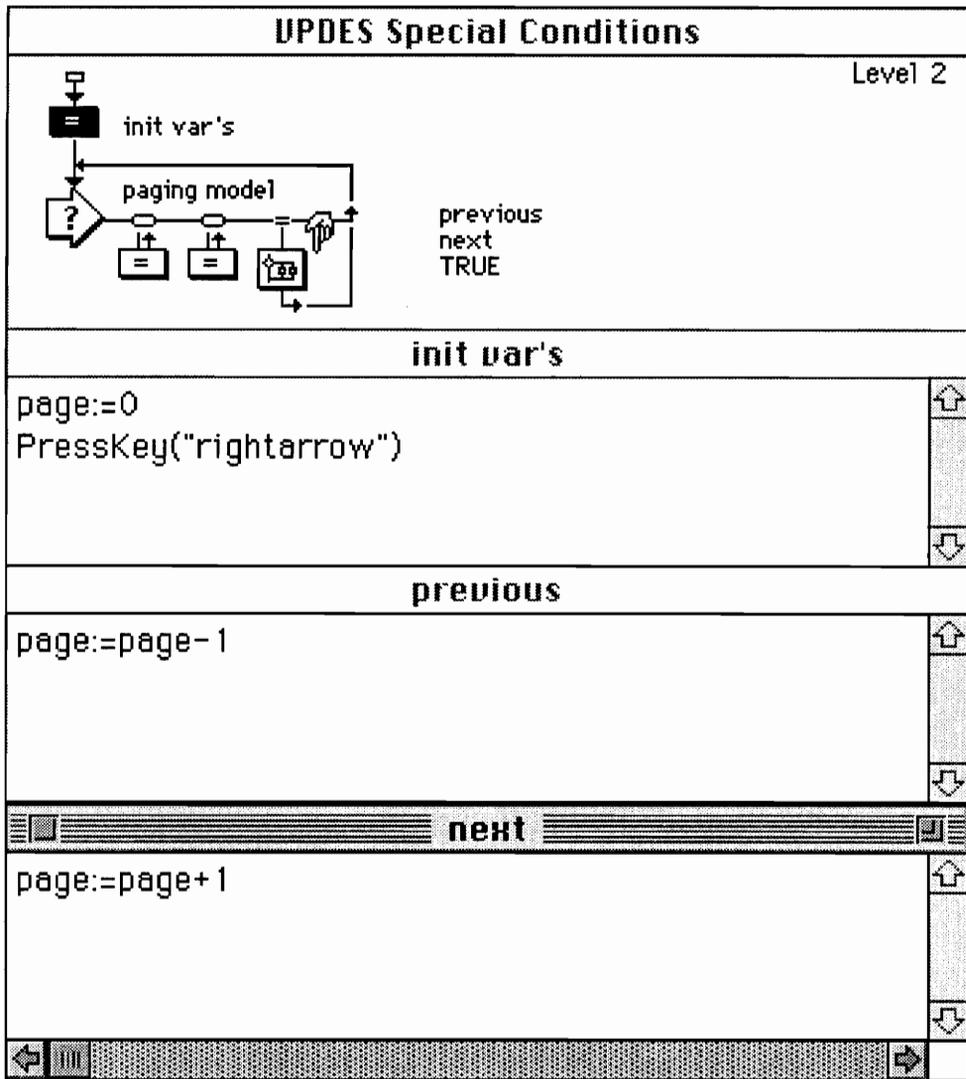


Figure 3.9. Paging model used in EDeSS.

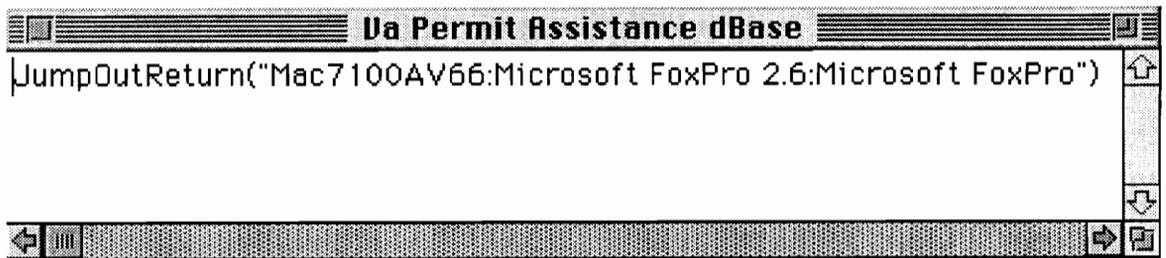


Figure 3.10. Jumping out to a non-Authorware application.

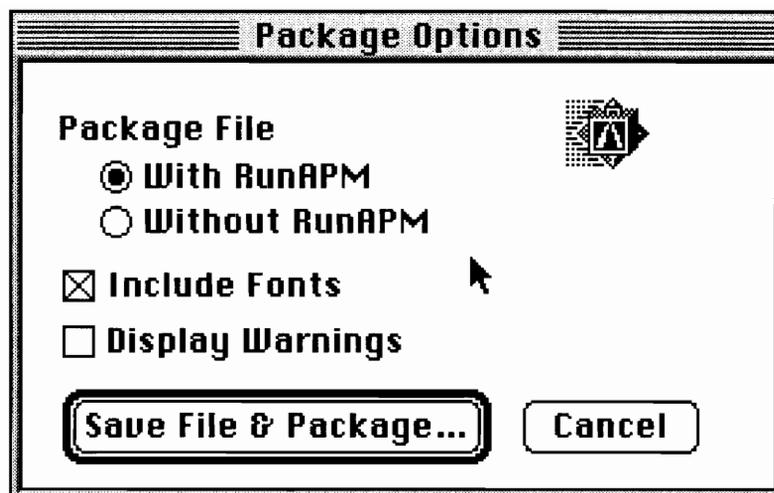


Figure 3.11. Packaging option in Authorware.

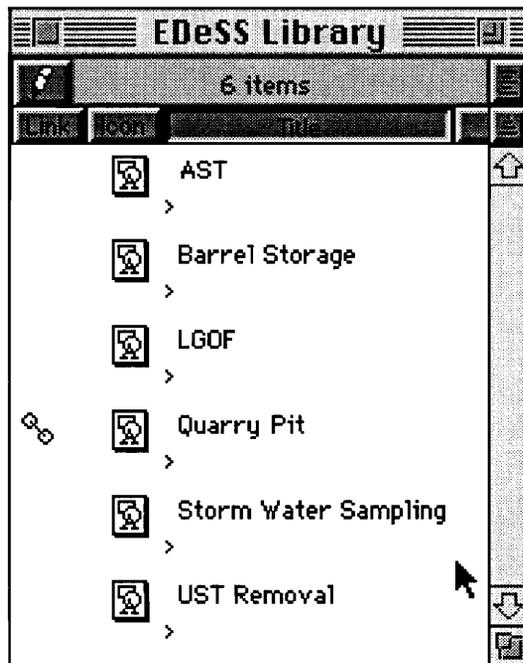


Figure 3.12. Library function within EDeSS.

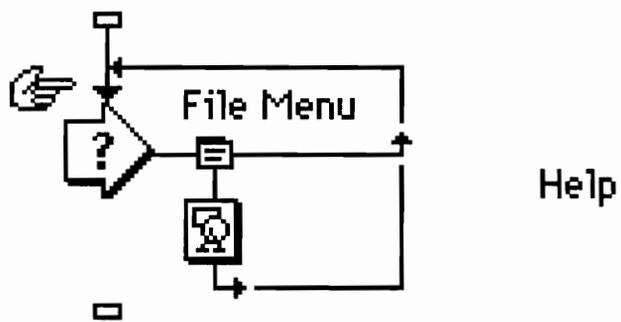


Figure 3.13. Construction of a pull-down help menu.

CHAPTER IV. - USING EDESS

Initiation of EDeSS requires double clicking on the RunAPM icon on a Macintosh platform or executing the EDeSS batch file through the File/Run “Windows” command. The title screen credits the Mining and Minerals Engineering Department of Virginia Tech for development of EDeSS. An introductory form briefly describes EDeSS’ capabilities.

Figure 4.1 shows the flow of EDeSS that is demonstrated in the following example interactions. The interactions start with title and introductory screens (Figures 4.2 and 4.3) and move to an environmental area choice screen (Figure 4.4). Upon selecting the stormwater button, the program moves on to various interactions under the stormwater category. Figure 4.5 shows how the user may choose to be asked questions, see Virginia Pollution Discharge Elimination System (VPDES) permit information, or move back to the main menu. At any time during the use of EDeSS, a ‘quit’ option is available in a pull-down menu. If ‘agencies’ were selected in Figure 4.6, the user could see the agency titles, addresses, and phone numbers responsible for permit issuance (Figure 4.7). Figure 4.8 shows the use of a scanned map to show specific locations and addresses of agencies. If ‘permits’ were selected in Figure 4.6, the user would have to answer some qualifying questions to check if a VPDES permit were required (Figures 4.9 and 4.10) and EDeSS “JumpsTo” another Authorware program called VPDES. The user can choose to see more information about the VPDES permitting, choose from a variety of categories (Figure 4.11), and move back and forth between categories and questions allowing for ‘what if’ analysis. The ‘sampling and monitoring’ subcategory contains a calculation function to determine whether a user-entered value for pH would be in compliance (Figure 4.12). EDeSS users can also read about general permit information such as costs and terms, monitoring requirements, definitions, and penalties (Figures 4.13 through 4.16). Printing an EDeSS screen is always an option, too (Figure 4.17).

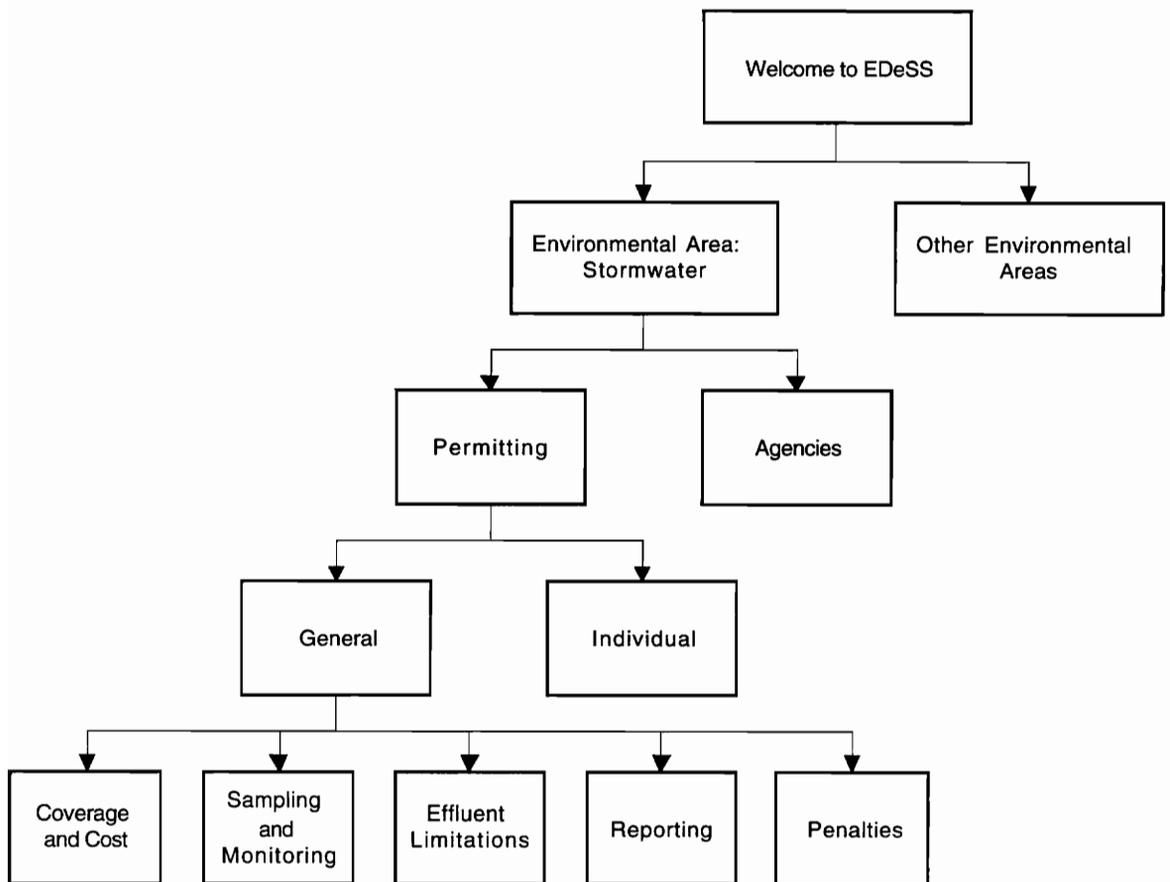


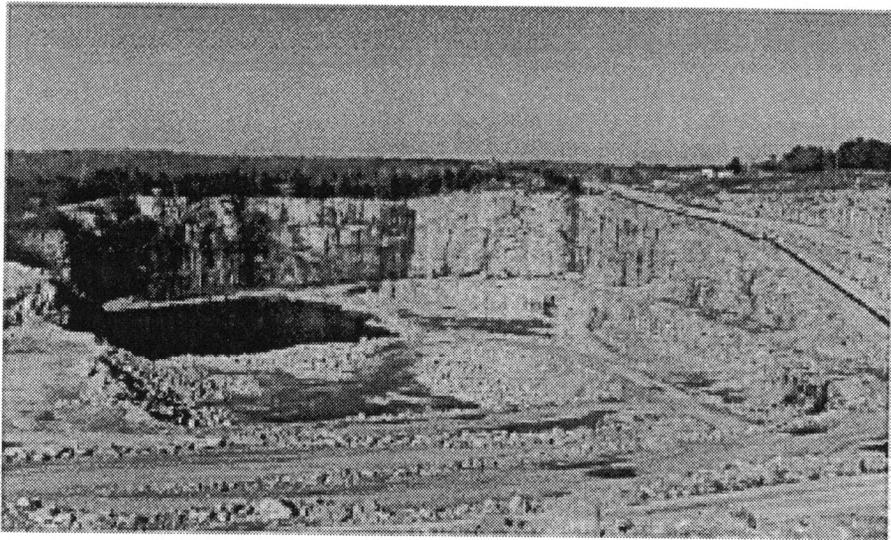
Figure 4.1. Flow of the EDeSS stormwater choices.

Welcome to EDeSS.

A Computer Based Environmental Decision
Support System.

Figure 4.2. Title screen.

EDeSS has been developed to facilitate decision making that quarry operators are required to make regarding environmental responsibilities.



EDeSS contains information and interactions about permits, legal requirements, and governing agencies.

Figure 4.3. Introductory screen.

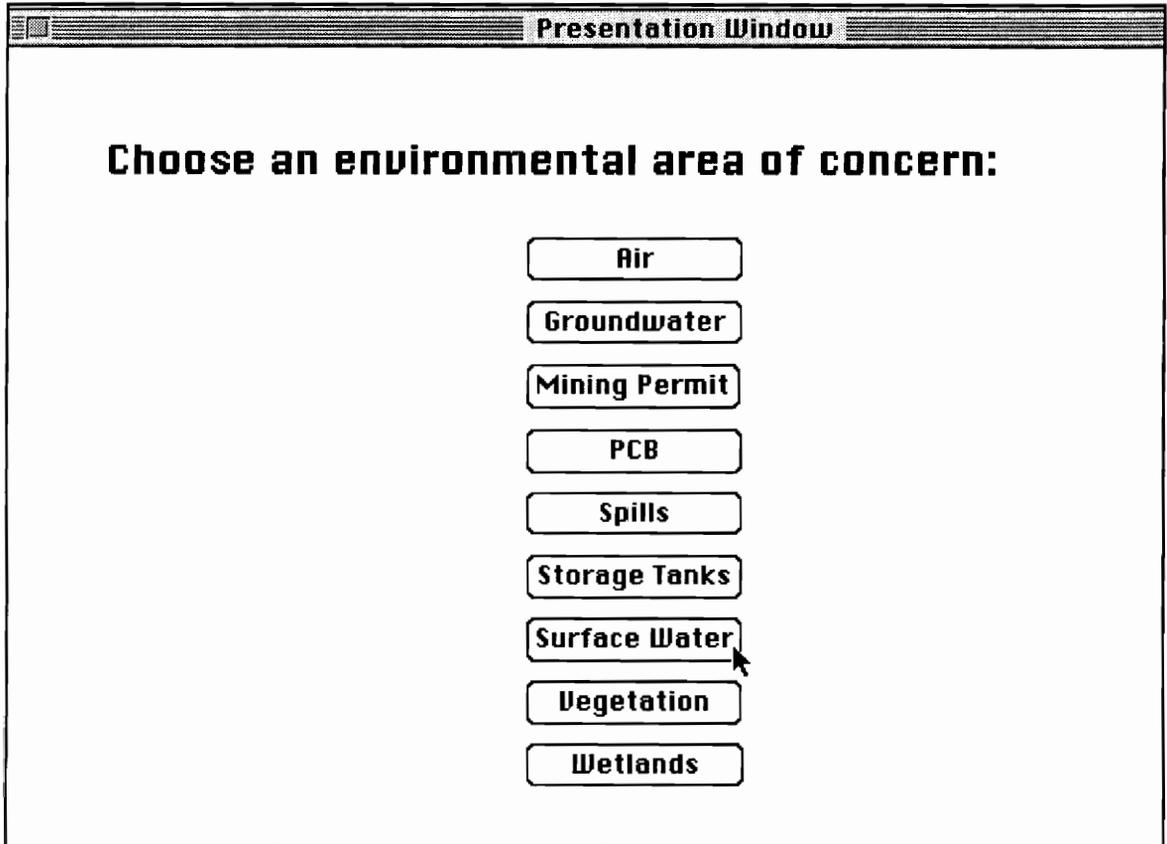


Figure 4.4. Selection from different environmental areas.

**Welcome to the interactive questionnaire.
You will first be asked a series of questions
to determine if you need a NPDES permit.**

**If EDeSS determines that you need a
permit, then you will be presented with an
in-depth tutorial about the NPDES permit
application process and requirements.**

**If you do not need a permit, you will return
to this screen.**

**If you know you need to see the NPDES
information, press the second button.**

Ask me questions

Just show me NPDES

Return to Previous Screen

Figure 4.5. Choice of question and answer session or information on NPDES.

**Do you want to learn
about the agencies or the
permits associated with
surface water?**

Select one.

Agencies

Permits

Return to Main Menu

Figure 4.6. A choice offered in EDeSS.

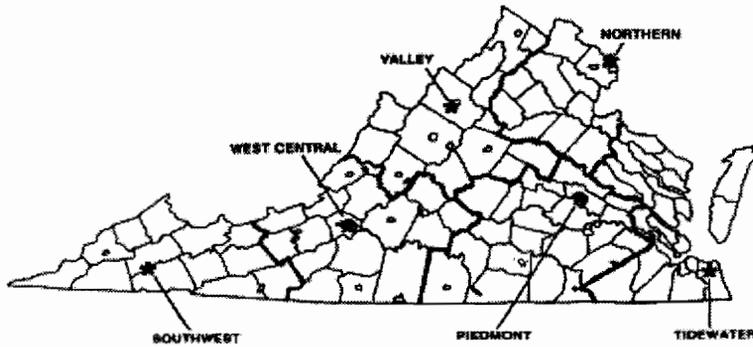
Presentation Window

The State Water Control Board and DEQ-Water Division regulate the use of water to protect the natural supply from contamination and overuse.

**State Water Control Board
P.O. Box 11143
Innsbrook Corporate Center
Richmond, VA 23230
(804) 527-5000**

Figure 4.7. VPDES Permit contact information.

Regional Water Control Board Offices



Southwest
Routes 19 & 825
Abingdon, VA 23210

Piedmont
PO Box 11143
Richmond, VA 23230

Tidewater
Pembroke II, Suite 310
Virginia Beach, VA 23460

West Central
3015 Peters Creek Rd.
Roanoke, VA 24019

Northern
1519 Davis Fork Rd., Suite 14
Woodbridge, VA 22192

Valley
116 N. Main Street
Bridgewater, VA 22812

Continue

Figure 4.8. Use of a scanned map to show locations and addresses of agencies.

Do you discharge or propose to discharge any pollutant into or by waters of the Commonwealth from a pipe or ditch?

Yes

No

Figure 4.9. Qualifier question for determination of VPDES permit need.

Will any stormwater discharge from your industrial facilities or from local stormwater collection systems?

Yes

No

Figure 4.10. Qualifier question for determination of VPDES permit need.

These are some VPDES subcategories. Make a selection from the following items by clicking on the button.

- [Coverage, Time, Cost](#)
- [Permit Registration Statement](#)
- [Local Government Ordinance Form](#)
- [Fact Sheet](#)
- [Sampling & Monitoring Requirements](#)
- [Effluent Limitations](#)
- [Reporting](#)
- [SWPPP Requirements](#)
- [Storm Water Management](#)

- [Return to Main Menu](#)

Figure 4.11. Choices of VPDES permit information.

**Enter your pH value:
(Press Return when finished)**

▶ **8**

Good. 8 is an acceptable value

Figure 4.12. Interaction with the pH compliance determination module.

Cost and Term of Permit

\$200 for the General Permit versus several thousand for individual permits

**Term of the General Permit is up to five years from the effective date of the regulation.
(Virginia Aggregates Association, 1994)**

Figure 4.13. Information screen about cost and term of VPDES general permit.

Quarries must abide by the monitoring requirements specified in the Permit, including:

Amount of effluent, concentration, and other measurements

Volume of effluent discharged from each point source

Proper installation, use, and maintenance of monitoring equipment and methods

Type, amount of effluent, and the quantity of pollutants discharged

Test procedures for the analysis of pollutants

Continue

Figure 4.14. Monitoring requirements for permit.

Definition of Permit

An agreement which binds the owners to design requirements and the operators to performance procedures and standards.

Businesses may have to obtain a permit from the state to construct and operate a facility if it will produce pollution, has the potential to be hazardous, involves dredge or fill in waterways, or includes ground water removal. (DEQ, 1993)

Figure 4.15. Definition available to EDeSS user.

Penalties for Not Complying

Willful violations:

\$2,500 to \$25,000 per day of violation

1 year of prison

Habitual violations of the same offense:

\$50,000/day/violation

2 years of prison

Figure 4.16. Penalty information in EDeSS.

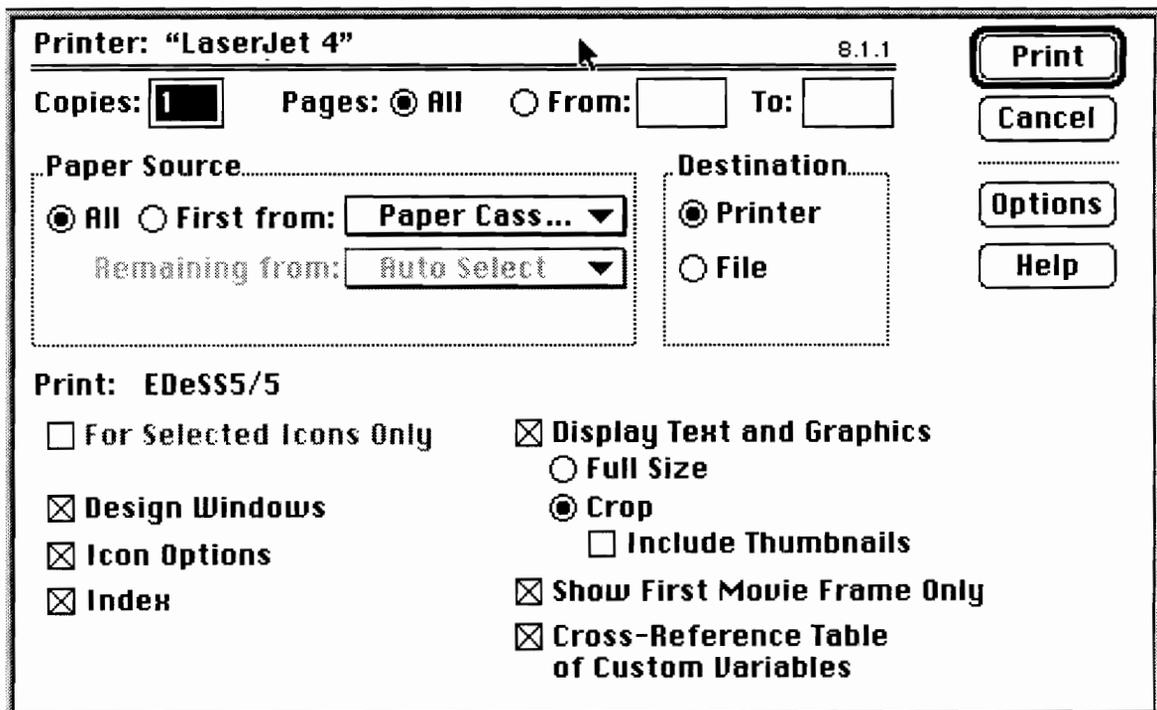


Figure 4.17. Printing options in Authorware.

CHAPTER V. - CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The regulatory scheme is changing at an accelerated pace, and quarrying companies must use the best practices for adherence to environmental regulations. However, the quarry industry only has access to text-based reference materials, which essentially consist of a reiteration of existing environmental laws and regulations. Quarry companies should provide their operators with current and easily understood information necessary for complying with the enormous number and complexity of environmental requirements. Managers should incorporate a computer-based decision support system and environmental databases into daily operations to assist with site-specific problem solving and legal procedures. EDeSS provides an interactive and friendly computing environment with calculation and multimedia presentation capabilities. It also utilizes models, provides access to databases, and displays graphics obtained from trade associations, quarrying companies, academia, and government publications. The user-friendly interface consists of mouse driven responses and limited keyboard entries on a desktop computer. Changes in federal and state laws, as well as site-specific requirements, can easily be reflected through EDeSS's visual representation scheme.

5.2 Recommendations

Additions and improvements to EDeSS will increase its potential as an on-site decision support system. Improvements may be based on the extensive modeling, explanation, and programming of the stormwater permitting process. In addition to expanding EDeSS to cover more regulatory subjects, the program could include mine plan drawings within the graphics libraries, expansion of accessible database information, and

information and analyses for federal, state, and local levels of requirements. The programming also needs to be continually repeated to adapt to changing user and legal requirements.

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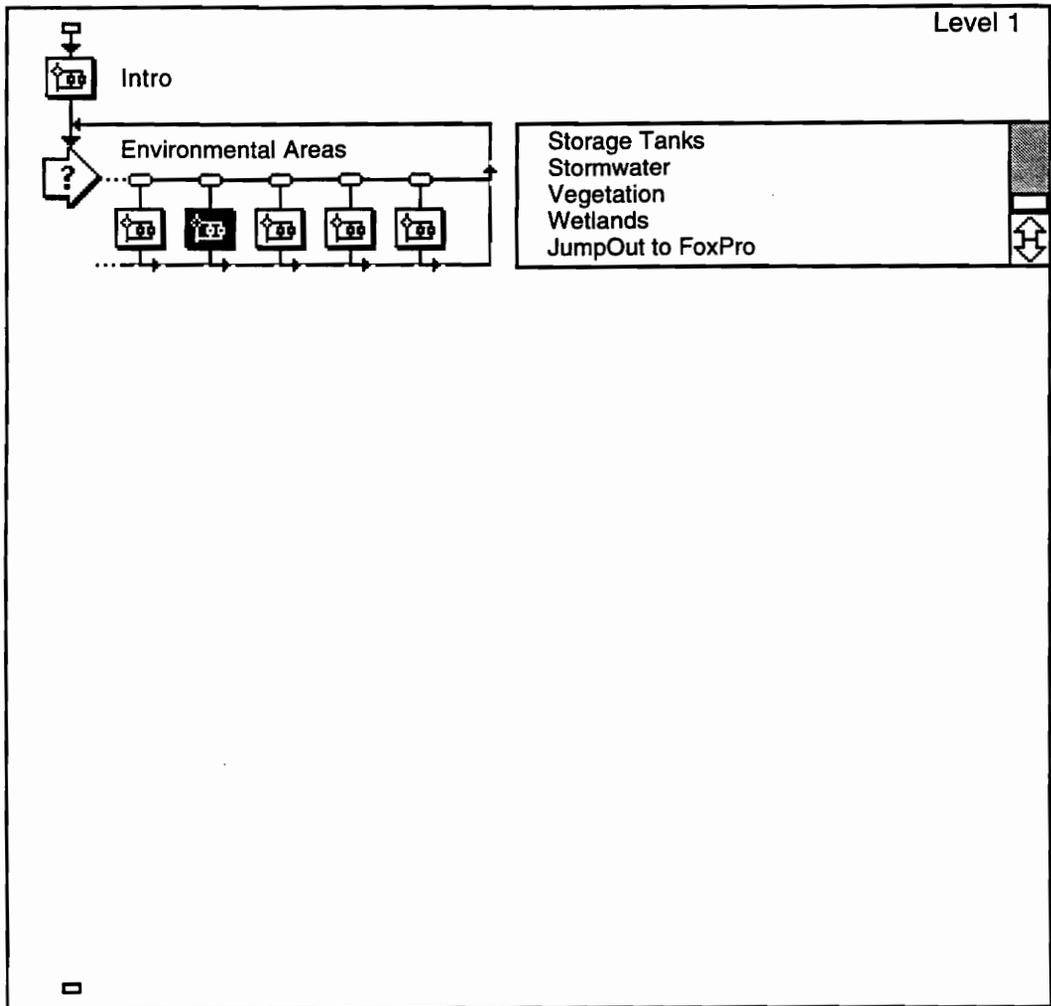
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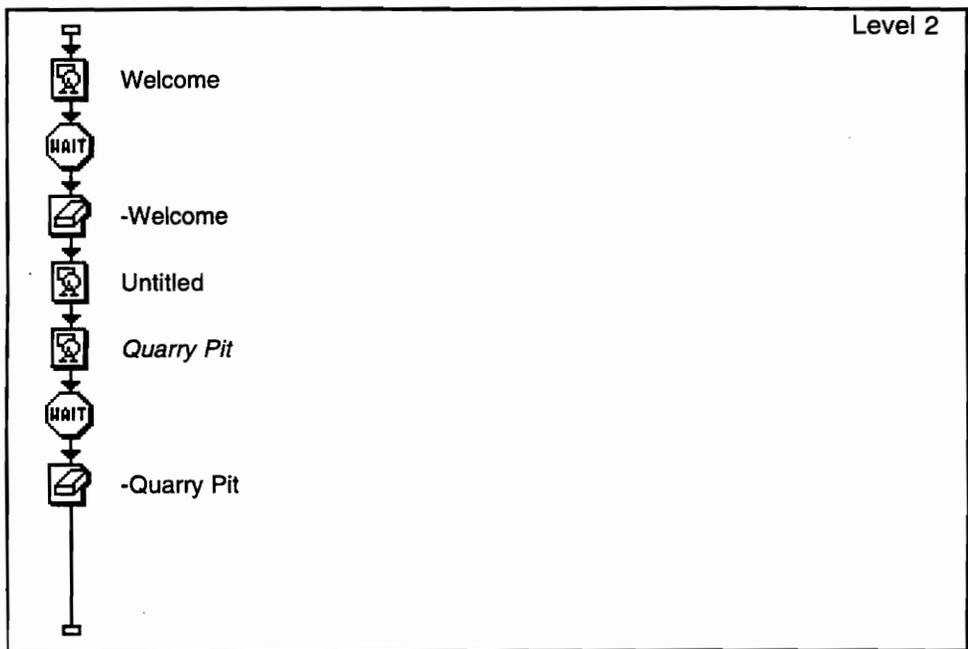
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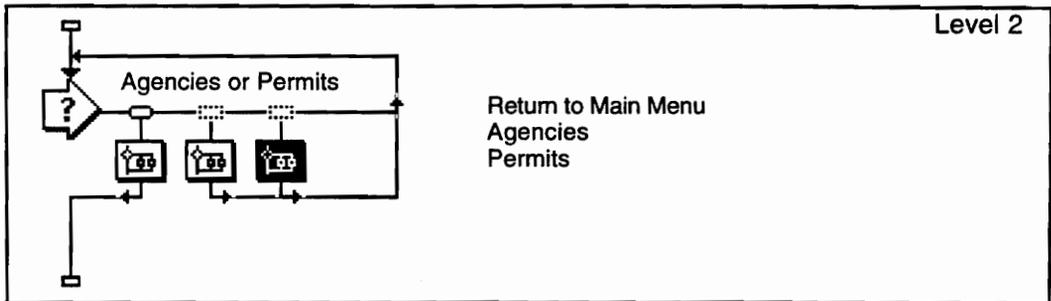
APPENDIX A. - LISTING OF EDESS PROGRAMMING MODULES

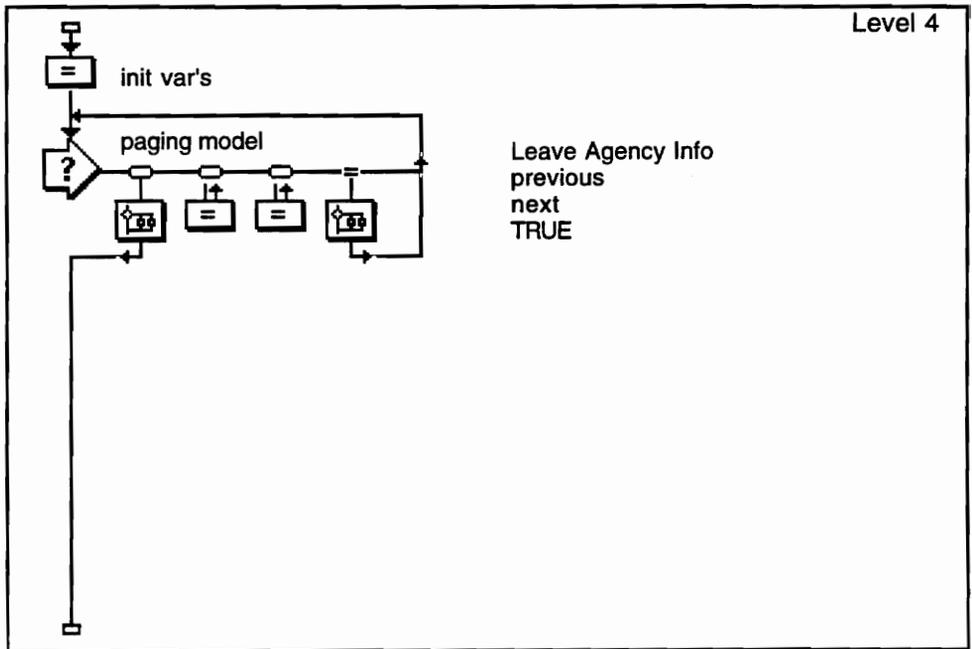


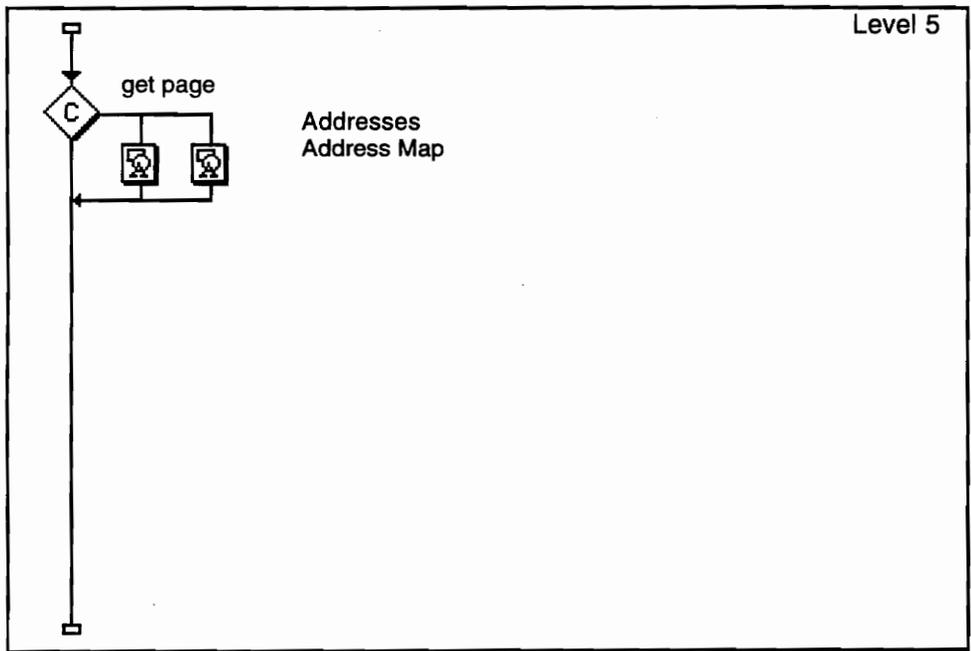
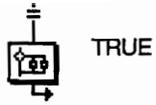
EDeSS5/24

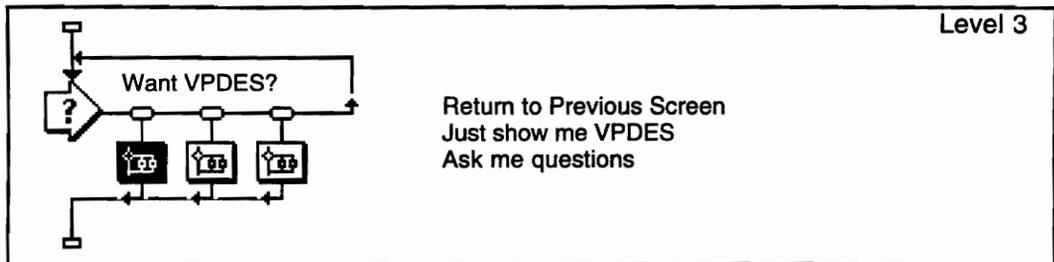


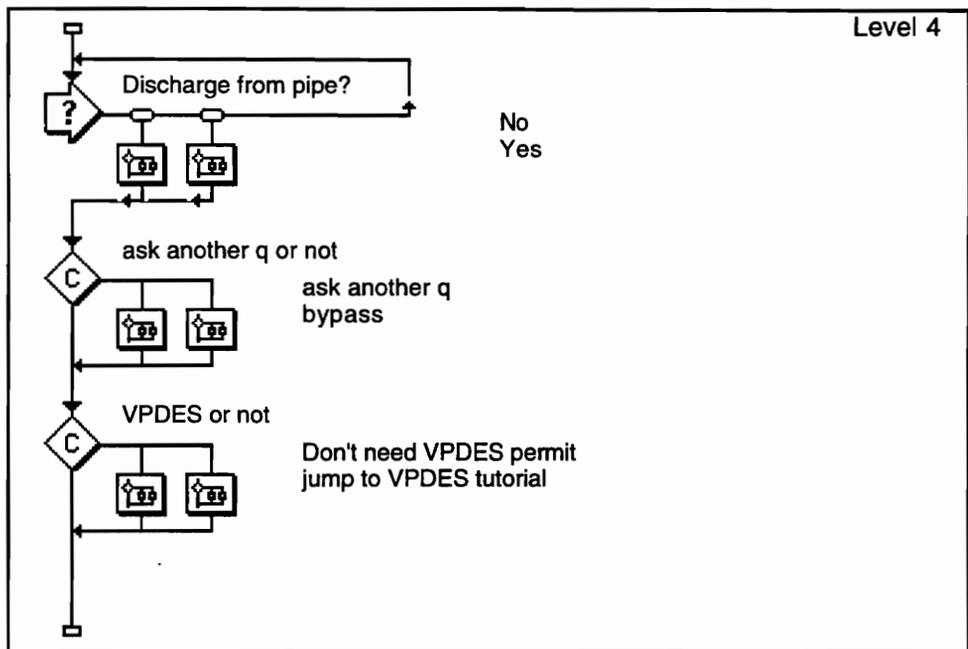


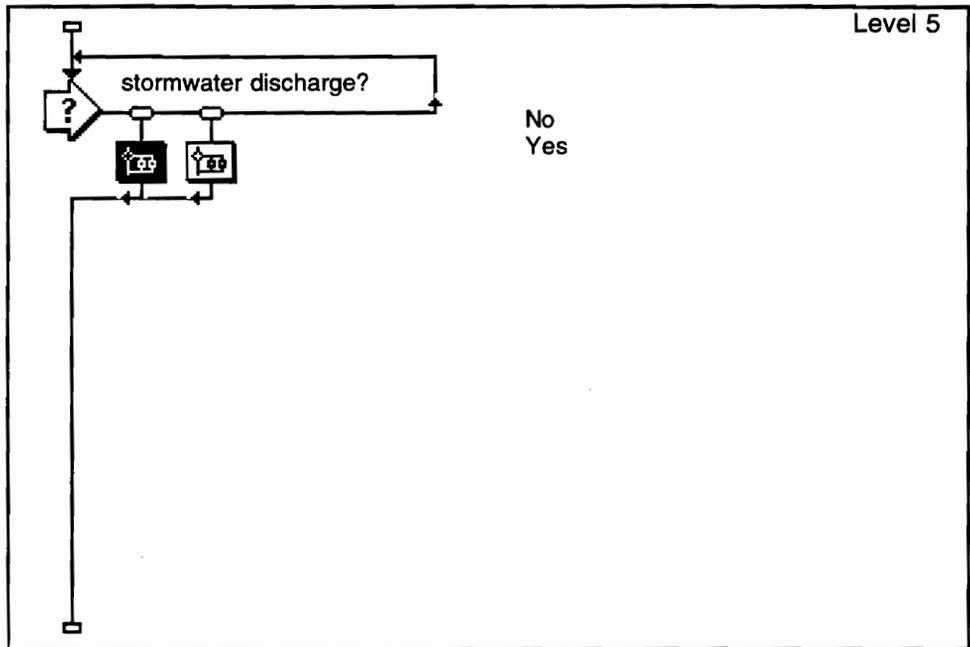


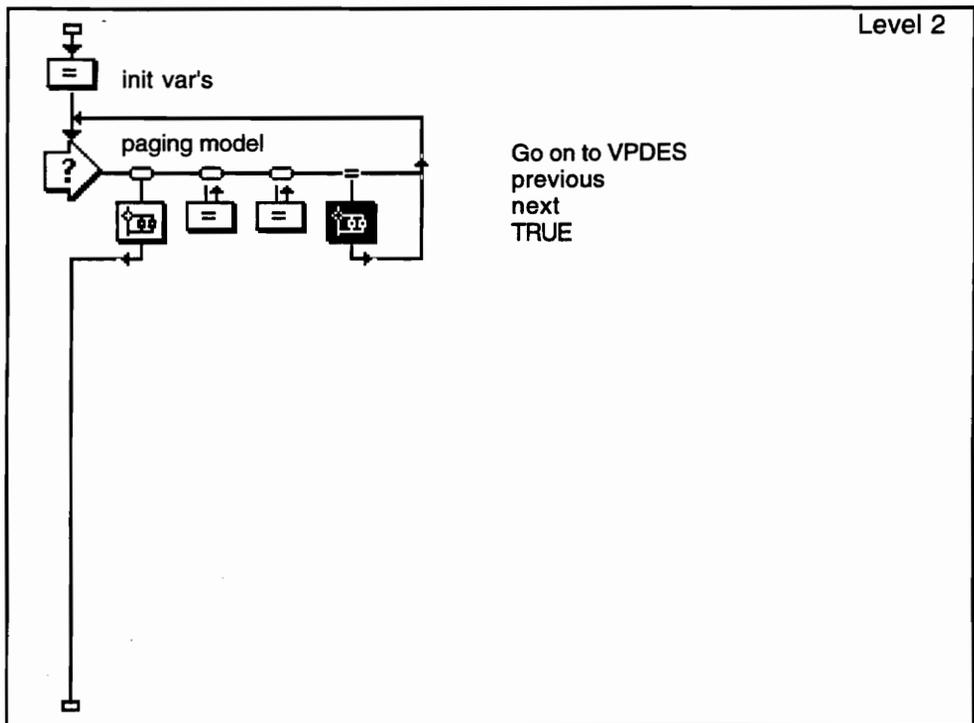


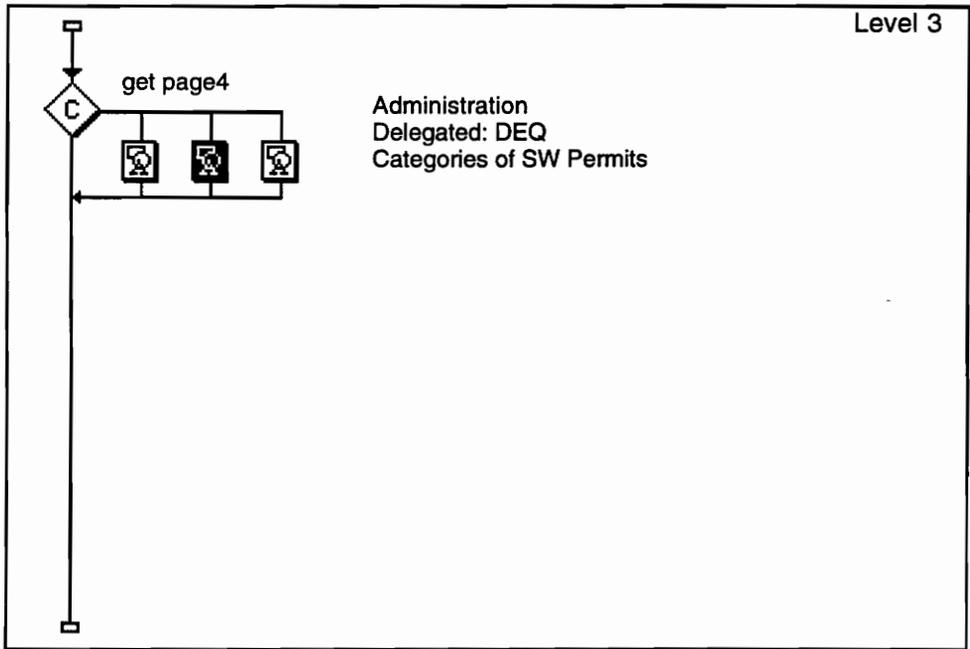
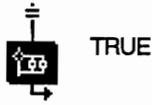






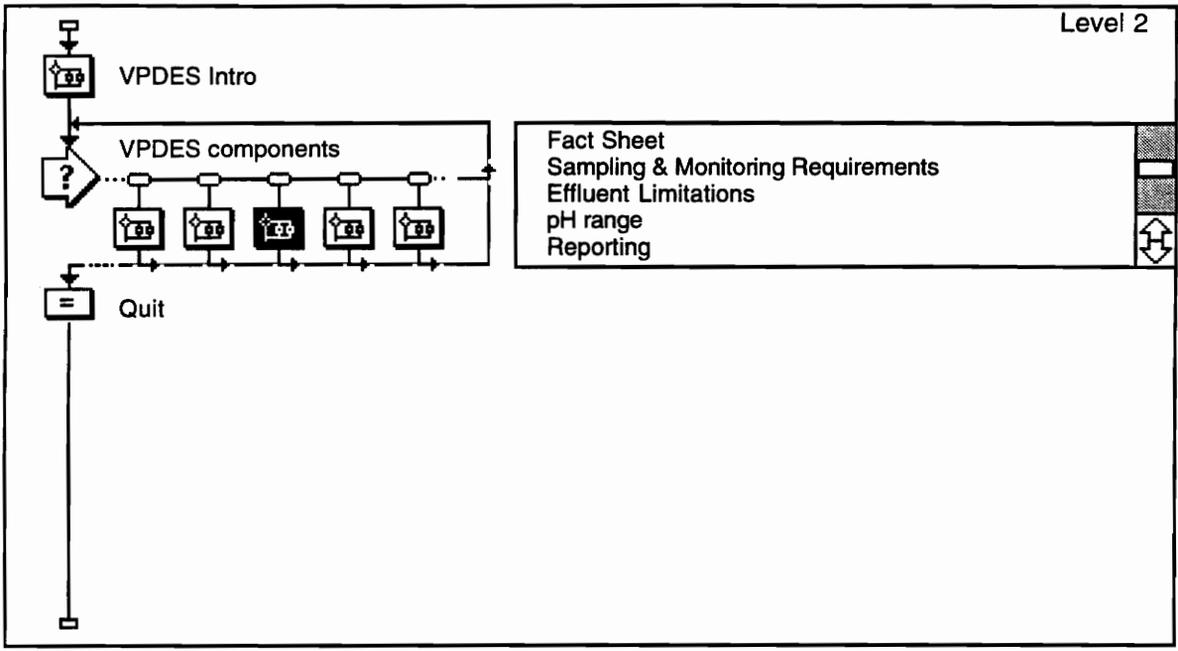




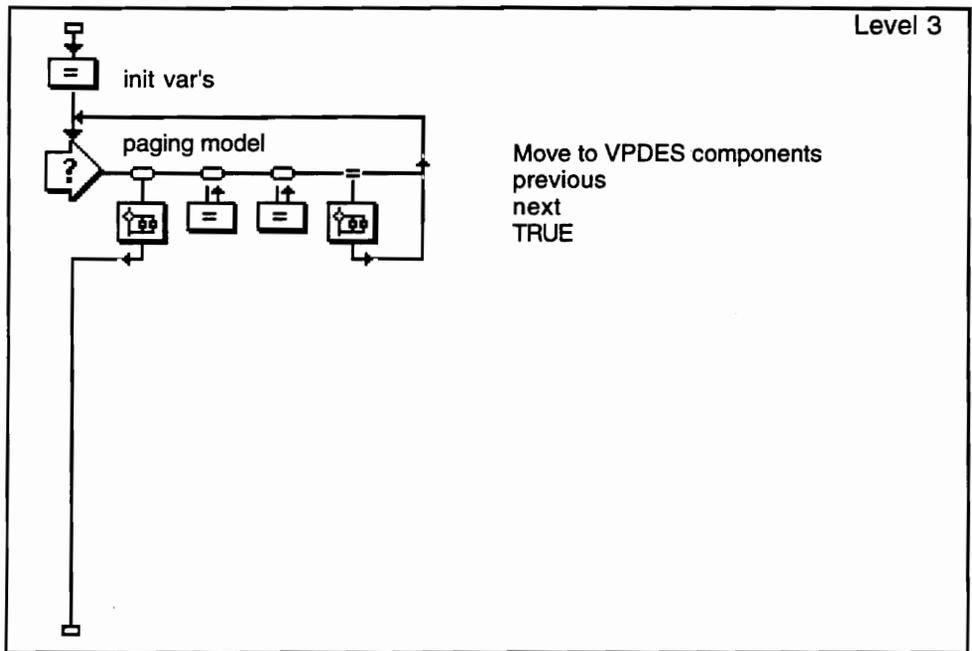


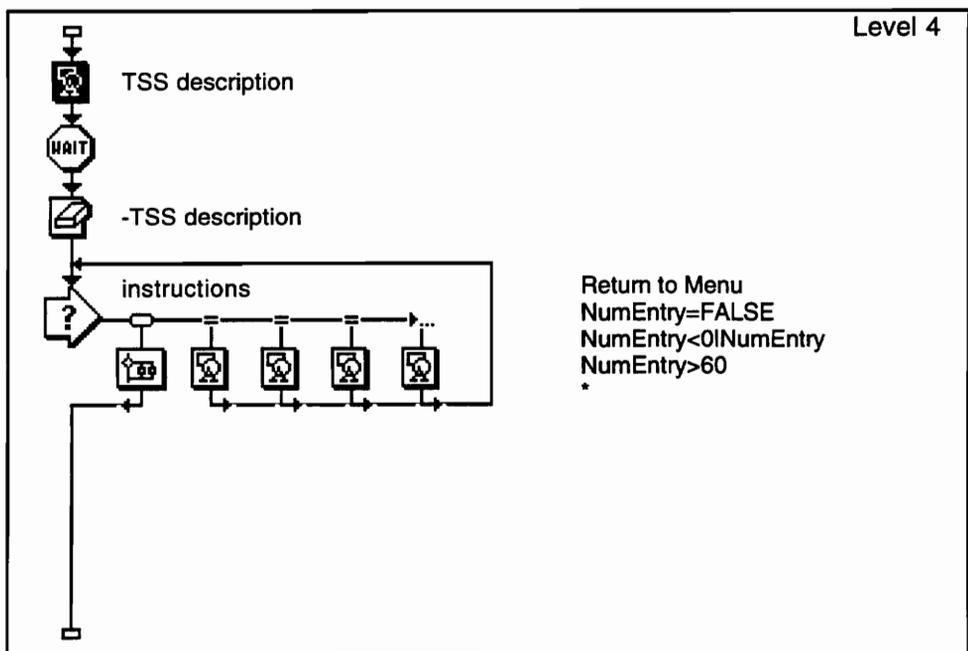


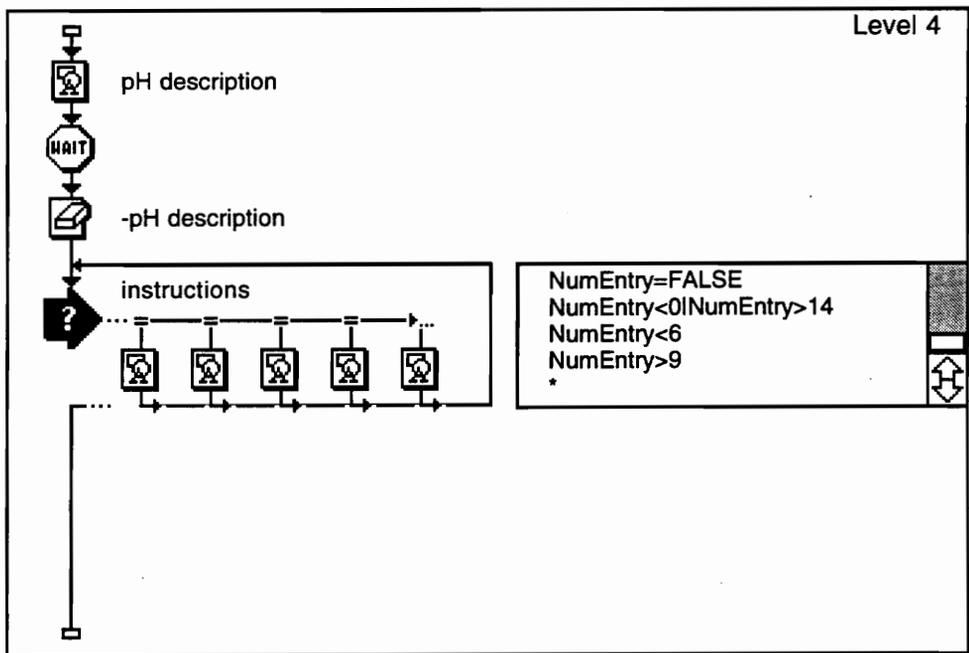
VPDES General Permit



VPDES Intro







APPENDIX B. - A PERMIT DATABASE

B.1 Program Overview

ENV_PERMITS is a database management application developed by Ravi Kanniganti and Christopher Woofter in Microsoft FoxPro for Macintosh. The program can be accessed from EDeSS or run alone in FoxPro. This application was developed for managing data regarding various environmental permits required for the mining and quarrying industries in the state of Virginia. It allows users to retrieve information about required permits, administrative bodies, contact persons and agencies, costs, and fees of each permit. Although ENV_PERMITS only covers mining and quarrying environmental permits, the model established by its application allows for expansion into all types of industries and permits.

ENV_PERMITS can be used by any person who has some basic knowledge of using a computer and a mouse. All queries can be generated by simply clicking on the main menu and pull-down menus. A help system is incorporated to facilitate using and updating the application.

B.2 Application Installation

Microsoft FoxPro 2.6 for the Macintosh is required for using ENV_PERMITS. An executable version could be built with a commercially available version of FoxPro. Virginia Tech's educational version of the software does not allow for executable file construction, whereas professional versions do. Once constructed, an executable ENV_PERMITS does not require the FoxPro software for distribution and operation in Macintosh or Windows environments.

B.3 Steps in Running ENV_PERMITS From FoxPro

A. Copy the complete application along with the tables and programs into the FoxPro subdirectory.

B. Double click the FoxPro execution icon.

C. Execute the “Do” command in one of two ways:

1. Clicking on the *Program* menu and selecting *Do*. This action brings up the list of programs available in the directory. Select *Env_Permits.mpr* from the list.
2. Type the command “Do Env_Permits.mpr” in the command box of FoxPro.

B.4 Menu and Submenus

Once the command *Do Env_permits* has been issued, ENV_PERMITS displays a menu and submenus. The structure of menus and submenus and their functions are explained below.

B.4.1 File

The menu ‘File’ consists of three submenus:

- a) Print Query: When this submenu is selected, the recent query results are sent to the printer.
- b) FoxPro Main Menu: Selecting this submenu closes the current application and the system sets to the main menu of FoxPro.
- c) Exit FoxPro: Selecting this submenu quits FoxPro.

B.4.2 Update

This Menu allows the user to update, add, and delete records in the database in order to keep up with changes in permits. The procedure for updating and adding records to the database is given in the submenu 'Help on Updating' within the 'Help' menu.

B.4.3 Mining

This menu is used to generate reports on permits which are applicable to the mining business. There are three submenus under the Mining menu:

B.4.3.1 Permits

This submenu allows the user to generate reports on permits applicable to mining. The need for these permits can be either possibly or probably. The three submenus under 'Permits' allow the user to select the permits which are probably required, possibly required or all the permits irrespective of the need.

- 1) Probably: This submenu generates a report of the permits which are probably required for mining.
- 2) Possibly: this sub menu generates a report of the permits which are possibly required for mining.
- 3) All: This submenu generates the reports of the permits for mining irrespective of the need.

At the end of all reports the application prompts for saving the reports. The reports can be saved on a file or can be sent to a printer.

B.4.3.2 Authorities

This submenu generates reports on legal authorities for permits which are applicable to the mining business. There are two submenus under this menu.

- 1) List of Authorities: This submenu generates a report containing the authorities which are applicable for mining permits.
- 2) Permits:Authorities: This submenu generates a report which contains the list of permits applicable to mining and the corresponding authorities applicable for those permits.

B.4.3.2 Departments

This submenu generates a report on the departments that are applicable to the mining permits. There are two submenus under this menu:

- 1) List of Department: This submenu generates the report containing the list of departments which are applicable to the mining permits.
- 2)Permits:Department: This submenu generates the report containing the permits and the corresponding departments applicable for mining.

B.4.4 Quarrying

This menu allows the user to generate various reports on permits which are applicable to quarries. The structure and functions of all submenus are similar to those of mining.

B.4.5 Queries

This menu supports the queries which are commonly raised by the end user. The queries supported by this application are listed below:

1. What department distributes a given permit?
2. What authorities are attached to a given permit?

3. What is the fee for a given permit?
4. On which page number in the permits guide can I get more information on a particular permit?
5. What is the term for a permit?

These queries can be answered by clicking on the appropriate submenus of the menu 'Queries'. Once a submenu is selected with the mouse right button, the list of available permits in the database comes up and the application prompts the user to input the permit number to be used for answering the query. In order to obtain hard copies of the query results, the submenu 'Print query' should be selected from the menu 'File'.

B.4.5 Address

This menu comes up with the address and the phone number details for the selected department which is done by clicking the appropriate submenu. The submenus under the menu 'Address' are as follows:

- a) DACS: This gives the address for Dept. of Agriculture and Consumer Services.
- b) DEQ-WATER: This gives the address for the DEQ-Water division.
- c) DEQ- WASTE: This gives the address for the DEQ- Waste division.
- d) VMRC: This gives the address for the Virginia Marine Resources Commission.

B.4.6 Help

This menu supports the help on the application, updating the database and on the FoxPro. There are three submenus under this menu:

- a) Help on ENV_PERMITS: Gives general background of the permits procedure and about the applicable laws.
- b) Help on Updating: Gives help on updating the database.
- c) Help on FoxPro: Helps with FoxPro interface and language.

APPENDIX C. - COSTS OF SOFTWARE

The retail price of Authorware Professional Version for Macintosh or Windows at Campus Tech was \$4,995. Neuron Data sells expert system software called Nexpert Object for Windows for \$7,313 (September 27, 1994). The Authorware used for development of EDeSS was obtained through Virginia Tech's site license agreement. The "Runtime" or "Packaged" distribution of an end product like EDeSS is free with Authorware.

VITA

Christopher L. Woofter was born December 16, 1971 in Petersburg, Virginia. He graduated from Brunswick Senior High School in Lawrenceville, Virginia in 1989. He worked four consecutive summers for Vulcan Materials Company while completing a Bachelor's Degree in Civil Engineering at Virginia Tech. He began to pursue a Master's Degree in Mining Engineering at Virginia Tech in the fall of 1993.