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Environmental Decision-Making and Risk Management: A New Paradigm for Regulators*

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Introduction

The Need

The current paradigm used by all federal agencies when preparing NEPA documents is descriptive. It is a qualitative assessment

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with a decision made subjectively. There is no standardized process used to determine what components are included in the assessment. Scoping too often is separated from public participation. Descriptions of the existing environments are described in words with large technical appendices filled with tables of numbers and graphics. However, there is no attempt to explain what this description means. Is the environment "good" by some criteria? The affected environments associated with each alternative are also described by words, tables, of numbers, and graphic charts and plots. How is a regulatory decision-maker to know what it all means? How can she have confidence that the decision is sound and easily explained and justified to anyone who asks? She cannot. Regardless, BLM staff and managers have helped to establish and maintain an environmentally-responsible and economically worthwhile mining industry on public lands in the US, with direct and indirect societal benefits beyond the immediate project site.

The problems with the current paradigm are more extensive than only the above description. The responsible regulator cannot definitively document that *all* the important components were included in the assessment, and the unimportant ones left off. The alternatives not equally assessed. We have all seen EISs where the Preferred Alternative is described in detail, the No Action Alternative briefly addressed, and all the other alternatives suggested by the project proponent, cooperating agencies, tribes, or the public dismissed without full and equal treatment.

To complete a NEPA document under the current paradigm too much time and effort is required. A mining company usually plans on 5 years before having a Record of Decision on their environmental permit. Regulatory agency staff are overwhelmed by wading through extensive text and trying to figure out what decision to make and–more importantly–how to justify it. As a result, too many NEPA documents are not sufficiently technically sound and legally defensible.

Part of the problem is how the entire mineral project regulatory compliance schedule is sequenced. As you will learn from this article, changing the sequence in which tasks are addressed not only facilitates a decision being made more robustly and defensibly, but also more quickly. When the modern paradigm introduced in this article is properly executed, there is no reason why even the most complex and contentious mining EIS cannot be completed well and confidently in 15–18 months.[1]

The Modern Paradigm

The modern paradigm is an approach to the assessment of environmental impacts associated with a major federal action so that the results fully comply with BLM Handbook 1790-1, CEQ guidelines in 40 CFR 1500-1508, and NEPA itself. By explicitly addressing the deficiencies of the current paradigm it informs better decisions that benefit the environment, society, the project proponent, and the regulatory agency. The modern paradigm requires *no* changes in current statutes or regulations. It eliminates *subjectivity* as a factor in decision-making. It is a standardized, consistent *process* that produces *project-specific results* reflecting local values and beliefs.

As a regulator responsible for directing and approving NEPA documents, in addition to other Bureau responsibilities, you gain an objective basis for making high-quality decisions, a decision that is technically sound and legally defensible, and the ability to do more with fewer resources and lower budgets.

This article presents what is needed to make high quality environmental decisions, how to develop the necessary information and data, the risks to be managed and how to manage those risks.

[1] For the full explanation read my book, *Quantifying Environmental Impact Assessments Using Fully Logic*, published 2005 by Springer-Verlag; ISBN: 0-387-24398-4.

Premises

Because we are asking to you to make major changes in your thinking and actions regarding environmental impact assessments under current statutes and regulations, you need some context that justifies making such changes. There are five important premises that make adoption of the modern paradigm reasonable, practical, and easy:

- NEPA does not mandate protection of the environment. Instead, it requires agencies to follow a particular process in making decisions and to *disclose the information/data that was used to support those decisions*. (NEPA, 1969)
- EISs "are used to inform decisions – not to justify already-made decisions." (40 CFR 1500-1508)
- "Significantly affect the quality of the human environment" is subjective, so a mechanism that quantifies *significantly* is highly advantageous to you.
- "Human environment" is more than the natural one. It also includes the economic and societal environments of the project and its location. Mining companies require a so-called "social license" to operate; a broad and inclusive definition of human environment grants them that license.
- You want to conduct the NEPA process correctly, quickly, and with confidence in your decision.

Making Environmental Decisions

A high quality decision is built on an objective measure of the significance of each alternative's impact on the existing environments. This objective measure is a comparison of each alternative future

condition to existing condition, and must encompass the economic and societal environments as well as the natural environment. It is very important to the development of a high quality decision that it is based on all values and beliefs that are most important to *everyone* participating in the assessment's scoping.

We achieve high quality environmental decisions when we objectively measure existing and alternative future environmental conditions comprehensively, equally, and robustly, base the objective measures on all the most important components, and determine the most important components from broad input during scoping.

I cannot stress strongly enough the value of broad public participation and input during the scoping phase of the assessment process. Implementation of the modern paradigm provides you with the tools to easily incorporate large amounts of data into the analyses. The computer does all the heavy lifting of crunching numbers and turning them into meaningful information. And during the scoping phase, as you will read later in this article, the data are scanned into the computer so the number of participants is not an issue with which you should be concerned. The greater the number of people contributing to the scoping process, the stronger is the foundation for your decision.

Statutory and Regulatory Adherence

The Bureau's NEPA Handbook 1790-1 says the process to follow for a quality decision includes scoping the EIS, conducting the analysis and documenting the process and conclusions in draft and final Environmental Impact Statements.

During the scoping process, you should define the proposed action sufficiently for a solid understanding by everyone reading the description, develop–and implement–a strategy for public involvement and interagency/intergovernmental coordination and consul-

tation so that you can demonstrate exactly how you identified data and information needs.

In order to conduct the appropriate analyses, you need to have collected sufficient relevant data, analyze it appropriately, and finally select the preferred alternative. Because you have incorporated information on the most important economic, natural, and societal components of the human environment, the preferred alternative will be the most pragmatic that is economically feasible to the mining company, environmentally minimizes (through avoidance or mitigation) negative impacts while endorsing positive impacts, and societally acceptable to the broadest set of public values and beliefs.

Risks to be Managed

There are many risks associated with environmental decision making; some are related to the decision itself, some to the information used to support your decision, and some to the socio-political environment in which you work. Five important risks that need to be effectively managed are;

1. Not having the appropriate tools that guide and support your decision.
2. Making a "poor" decision based on any of several criteria.
3. Making a decision based on insufficient information.
4. Basing a decision on an assessment that did not include all relevant alternatives.
5. Having your decision appealed or challenged in court.

The modern paradigm eliminates or minimizes these risks by providing you with objective criteria on which to make a technically sound and legally defensible decision.

Scoping

Introduction

Every solid and enduring structure is built on a strong foundation. For a NEPA document that foundation is scoping. One of the excuses heard to avoid making any change in procedures is that all projects are different so each responsible office must re-invent the wheel to design scoping on a project-specific basis. It is certainly true that each project and location is unique and must have an environmental assessment specific to the local values, beliefs, and conditions. This need is easily accommodated by a consistent approach that can be applied everywhere, and which yields project-specific answers. The benefits of such consistency are many, including increased quality, shortened time, and greater incorporation of local values and beliefs. The modern paradigm's approach to comprehensive scoping includes the above benefits as it reduces the risk of omitting something important.

Scoping Conduct Overview

The modern paradigm equates scoping and public participation as the means of strengthening both the assessment and the decision made from it. Regulators and project proponents are asked to encourage stakeholder and public[2] attendance meetings that will determine the scope of the environmental assessment. The larger the pool of participants, the more comprehensive is the range of values provided as input to determine which components should be considered in the specific project's environmental impact assessment. Because the computer is analyzing the input data, there is no prac-

[2]Including Native American tribes and environmental NGOs.

tical limit to the number of participants contributing to scoping the assessment. Processing time is not a factor.

In brief, there are two parts to establishing the assessment's scope: identifying candidate components and rating each one as a quantitative consensus of all contributors. The modern paradigm also broadly defines the concept of "environment." Many people associate the term with the natural world, but we all live also in economic and societal environments. While individuals might assign higher value to one of these environments than to the others, these differences will vary enough there is no justification for not including all three. The assessment will be more robust because it includes all three environments. Also, decisions are easier because you are not trying to directly compare junipers and jobs or osprey and open space.

The first task of the scoping meeting is to ask attendees to accept the potential components identified by the lead agency in each of the three environmental categories: Economic, Natural, Societal. These are broad and inclusive terms such as "Jobs," "Traffic," "Water Quality," "Air Quality," "Aesthetics," and "Sustainability." Details are added later in the scoping process. Because of practical considerations when determining relative importance, we strongly recommend a limit of eight inclusive components within each category.

Representative Components

The following components are those we use for our testing and demonstration database: the Digem-Anmill Mining Company's proposed Burro's Breath Mine.

Economic:

- Jobs
- Infrastructure
- Housing
- Tax base
- Traffic volume
- Medical care
- Sustainability
- Urban growth

Natural:

- Endangered Species
- Habitats
- Wetlands
- Hydrology
- Air quality
- Water quality
- Slope stability
- Ground water

Societal:

- Aesthetics
- Noise
- Recreation
- Quality of life
- Health effects
- Environmental justice
- Cultural heritage

Determining Importance

Preparing to compare values

The modern paradigm goes well beyond identifying what components in each of the three environmental categories are valued by the project proponent, public, tribes, and cooperating agencies. Calculating the relative weight of importance of each component provides you with three important benefits:

1. You can demonstrate compliance with the Bureau's Handbook 1790-1 and CEQ guidelines that you have included *all* important components in the assessment, and not spent time and resources on unimportant ones.

2. You can demonstrate that no individual or interest group has been excluded from the process (except by their choice), and that each expression of values and beliefs has been analyzed equally.
3. You have a solid basis for objectively characterizing the existing and alternative environments based on the relative importance of each component in each category.

Determining the relative importance weight of each component takes three steps.

Step 1: Generate Pairs

The computer generates the 28 pairs of the 8 components in each category. For the natural environment these pairs are:

- Air quality/Water quality
- Air quality/Slope stability
- Air quality/Habitats
- Air quality/Wetlands
- Air quality/ESA species
- Air quality/Ground water
- Air quality/Hydrology
- Water quality/Slope stability
- Water quality/Habitats
- Water quality/ESA species
- Water quality/Wetlands
- Water quality/Ground water
- Water quality/Hydrology
- Slope stability/Habitats
- Slope stability/ESA species
- Slope stability/wetlands
- Slope stability/Ground water
- Slope stability/Hydrology
- Habitats/ESA species
- Habitats/Wetlands
- Habitats/Ground water

- Habitats/Hydrology
- ESA species/Wetlands
- ESA species/Ground water
- ESA species/Hydrology
- Wetlands/Ground water
- Wetlands/Hydrology
- Ground water/Hydrology

Component pairs are also created for the economic and societal components.

Step 2: expressing preferences

Determining the relative importance of each component within a category depends on the comparison of each component with every other component. This requires some thought by everyone participating, but the process is fundamentally no different than that which we use when we vote for candidates for political office, make choices from menu items in a restaurant, select which brand and model of vehicle to buy, and make all the many decisions we do on a daily basis.

The comparison scale we use (Table 1) was developed in the early 1970s by Dr. Thomas L. Saaty, a mathematical economist at the University of Pittsburgh. He developed this scale to use for planning, resource allocations, and priority setting by governments. He has applied it world-wide in political, economic, and societal policy decision-making. The almost-40 year history of this scale justifies its use in comparing each pair of components within each of the three categories.

Preferences are recorded on forms (Figure 1), one for each category. There are several benefits to using these forms when participants express their preferences:

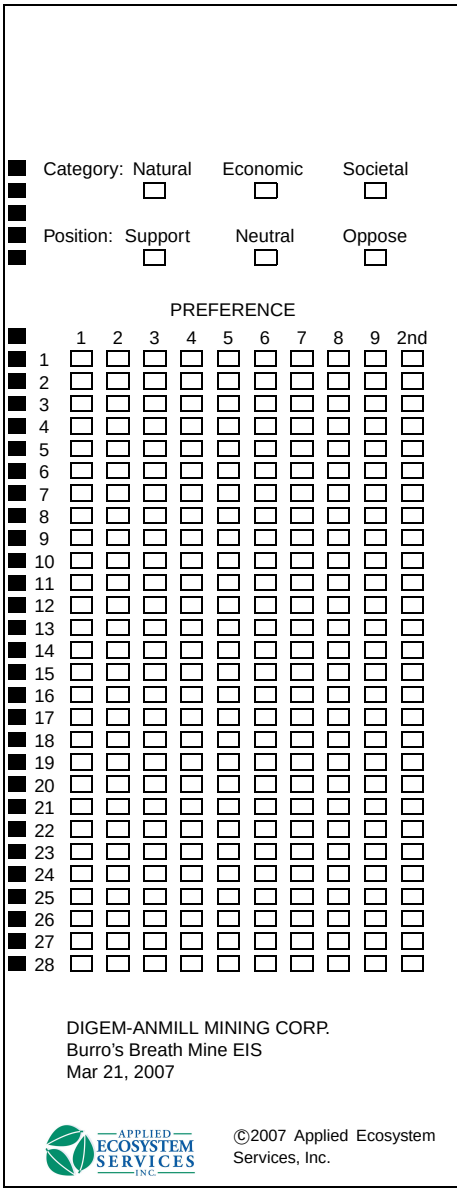

Figure 1: The Optical Mark Recording form used to express preferences for one of each pair of candidate components.

Table 1: The scale for rating preference of one component over another during NEPA scoping.

Value	Definition
1	Equal importance
3	Weak importance of one over another
5	Strong importance of one over another
7	Demonstrated importance of one over another
9	Absolute importance of one over another
2, 4, 6, 8	Intermediate values between two definitions

- The process is anonymous. While we write a sequential number on each form so it can be associated with a database record for audit purposes, there is no individual who can be associated with any particular form.
- Having each participant self-select his position on the project (supporter, neutral, opponent) documents that no group has been systematically excluded from participating and, of equal importance, that each vote is equal to every other vote.
- No one can "game" the system to drive to a pre-determined conclusion.

The results are a quantitative measure of consensus, with each participant contributing to the outcome. Preferences can be collected at multiple meetings on different days and different locations to ensure the broadest public participation in the process.

Step 3: calculating relative importance weights

This step is modified by Dr. Thomas Saaty's *The Analytical Hierarchy Process for Multi-Criteria Decision-Making*[3]. For each category,

[3] 1990. RWS Publications, ISBN: 0-9620317-2-0.

the choices on pair-wise comparisons are collected into a symmetrical table. Table 2 shows the symmetrical matrix for the societal factors in the Burro's Breath Mine EIS. For demonstration purposes, the choices were created by a random number generator based on 60 participants in the scoping process. There were 13 project supporters, 14 neutral, and 33 opponents. The individual choices range from 1–9, but after they are averaged the extremes have low influence and most of the components are fairly close. This does not mean that they have nearly equal importance to the 60 participants.

In the mathematics of linear algebra, symmetrical matrices can be characterized by a single number called the *Eigenvalue*. The principal Eigenvalue characterizes the entire matrix. Associated with the Eigenvalue is an Eigenvector which, when normalized, represents the relative weight of importance of each component as a consensus of all participants. For the Burro's Breath Mine EIS, the importance weight of each component in the three categories is shown in Figure 2.

What You Have Accomplished

At this stage of scoping the environmental impact assessment you have accomplished a number of important objectives:

1. Under H-1790-1 you have implemented a sound strategy for consultation with agencies, tribes, and the public.
2. Under H-1790-1 you have identified the important data needs.
3. You can demonstrate that you have included all important factors, and left out unimportant ones.
4. You can show that the components included in the assessment are neither arbitrary nor capricious.

Table 2: The societal components arranged as a symmetrical table showing average preferences for each component pair.

	Aesthetics	Noise	Recreate	Quality	Health	Env. Justice	Cultural	Urban
Aesthetics	1.00	2.26	3.07	2.29	2.31	3.54	4.02	3.11
Noise	0.44	1.00	2.97	2.83	2.08	2.62	2.00	3.03
Recreation	0.33	0.44	1.00	2.93	3.29	3.25	2.95	3.34
Life Quality	0.43	0.28	0.25	1.00	2.72	3.39	2.31	2.63
Health	0.32	0.34	0.35	0.48	1.00	2.57	3.10	3.32
Env. Justice	0.38	0.50	0.33	0.34	0.30	1.00	2.28	2.67
Cultural Heritage	0.31	0.34	0.30	0.37	0.30	0.43	1.00	2.65
Urban Growth	0.38	0.39	0.32	0.30	0.44	0.37	0.38	1.00

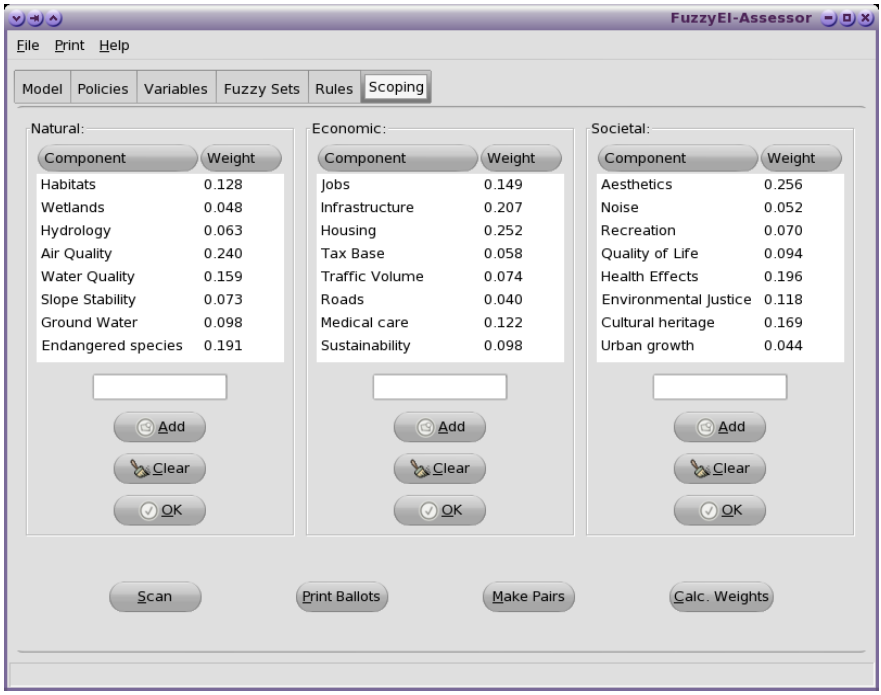

Figure 2: The relative weight of each component in the three categories for the Burro's Breath Mine EIS.

5. You now can quantitatively characterize existing and alternative future environments, weighted by the importance of each component.

Adding details to the model

Variables and multi-value sets

There is more to the scoping process with the modern paradigm. As noted above, the selected components of the assessment are very broad. These components can have sub-components, and both components and sub-components will have variables that are the details to be assessed. For example, the Air Quality component can have variables of RegionalHaze, FugitiveDust, and Particulates (Figure 3), and the Habitats component can have sub-components for Fish, Mammals, Birds, and Amphibians. You can have as many sub-components and variables as are necessary to completely describe the environments.

The variables are the basic units of the existing and alternative future environments. Each variable is defined by a set of multi-value terms (e.g., Low, Medium, High; Few, Some, Many; Large, Moderate, Small; Close, Near, Far). The degree of membership in each multi-value set is related to measurements you make, or the magnitude of change under each alternative. Full details are in my book.

The variables and their term sets are evaluated along a subjective scale of overall environmental "suitability," "acceptability," or "goodness." The terms are interchangeable, but represent what people want from a combination of the economic, natural, and societal environments.

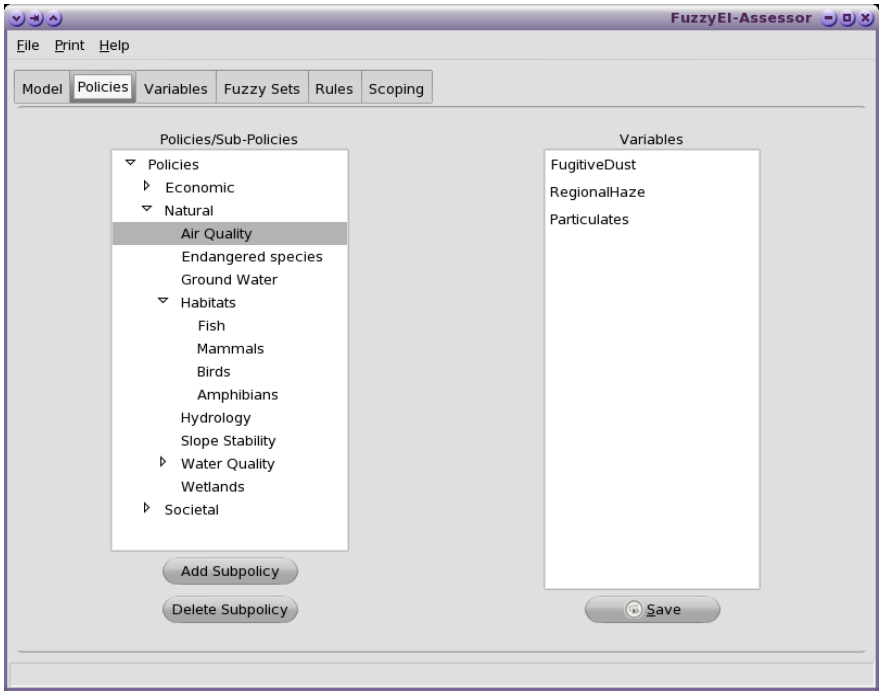

Figure 3: Some sub-components and variables in the Burro's Breath Mine EIS.

Rules

Rules are the fundamental basis for characterizing existing and alternative future environments. They express the dynamics of the ecosystems as understood by technical experts and are used in the model to approximate the reasoning such experts apply to explain the observed and forecast dynamics. These experts may include technical specialists working for the Bureau, private consultants, staff in federal and state resource agencies, university faculty, and anyone else you want to include.

Rules are expressed as IF-THEN constructs that approximate how human experts think about system dynamics. They do not contain fixed numbers (although they can), but express the dynamics of the systems as words. As examples:

```
IF slope is Steep
AND vegetation_cover is Low
AND soil is Thin OR erodability is High
AND antecedent_soil_moisture is Near Saturation,
THEN erosion_risk is Highly Increased.
```

and

```
IF discharge is directly into a receiving water body
THEN no process water can be discharged from the site.
```

These are examples of conditional rules; the conditions must be met (to varying degrees) to produce an output in the multi-value set "erosion_risk" and "water_discharge." There can also be unconditional rules in an approximate reasoning model. In our implementation of the modern paradigm with our approximate reasoning modeling software, both conditional and unconditional rules contribute to the solution. The system also accommodates the so-called "dueling experts" where both opinions are set as rules in the model.

Cumulative impacts

For years regulatory agencies with NEPA compliance responsibilities have struggled with how to incorporate cumulative impacts in a meaningful way. The modern paradigm easily incorporates cumulative impacts as rules within the model. A simplistic example might be:

```
IF mill_particulate_output is High,
AND other_dischargers are in the airshed,
THEN regional_haze is Increased.
```

Environments

What Do The Data Mean?

With the traditional paradigm of describing the existing conditions and proposed alternatives, the baseline data and projected changes are expressed with words, tables of numbers, and illustrative plots and graphs. Two of the questions that can reasonably be asked of these descriptions are: What do the descriptions mean in terms of environmental goodness? and How significant are changes from the existing conditions to those of each alternative future condition? It is very difficult, if not impossible, to answer these questions when working with the traditional paradigm.

With the modern paradigm. both questions are answered as part of the analytical process. The mechanism for answering the first question is the Environmental Condition Index (ECI); a quantitative measure of the overall "goodness," "suitability," or "acceptability" of the existing conditions and all the alternatives, based on the same set of components and variables identified during scoping. Because the computer is crunching the numbers, there is no limit to the

number of alternatives that can be compared. There are pragmatic limits, however, in describing the alternatives for use in the model.

The question of impact significance is incorporated into the ECI for each alternative. The international impact assessment community's professional practitioners have defined significance using eight attributes; these are fully described in my book. These attributes can be quantified and applied to each alternative. Of equal value for regulatory decision-making under NEPA, the relative values of the existing conditions and each alternative can be directly compared. ECI values that are close do not significantly differ; values further apart may be significantly different, but will most likely not be the preferred alternative.

Environmental Condition Index (ECI)

Without glazing your eyes with the mathematics involved, the ECI is calculated as the degree by which the variables and sub-components in each component in each of the three categories contributes to the overall desirability of the total environment. Each component is weighted by its relative importance so the ECI is a valid representation of the values and beliefs local to the project site and surrounding area.

The ECI for existing and alternative future conditions are:

- Inclusive.
- Comprehensive.
- Quantitative.
- Derived from actual measurements and Best Professional Judgments of experts.
- Incorporate measurements of impact significance.
- Application of extensive rules of environmental dynamics.

- Fully compliant with NEPA, CEQ regulations, and the Bureau handbook.

- Based on extensive input of a range of agency, stakeholder, and the public's values and beliefs.

The ECI values for existing and future conditions gives you an objective set from which to select the preferred alternative. In addition, these ECI values facilitate and support your decision because they are technically sound and legally defensible.

Quantitative Decision Support

It is very important that you understand the most important aspect of the modern paradigm: no computer model makes any decision. You do. Regardless of how the modern paradigm is implemented, for example our proprietary approximate reasoning model, it is a decision-support system, not a decision-making system. You retain total control over the process and the decision.

However, the modern paradigm does provide meaningful benefits over the traditional paradigm. For example, existing conditions and alternative future conditions are quantified using the same criteria. Also, the calculated ECIs reflect local values, the most important components, and a quantitative consensus of expert rules describing how the systems work. Because your technical experts and the public determined the project-specific dynamics you can document the process was highly inclusive in gathering the information needed for your decision. In brief, the complete process is technically sound, legally defensible, timely, and cost effective.

Summary

In this article you have been resented with a new paradigm for NEPA compliance that is:

- Fully complies with Handbook 1790-1.
- Fully complies with CEQ guidelines.
- Fully complies with NEPA because your decision is soundly based.
- Requires NO changes in current statutes or regulations.

By applying this new paradigm, you gain an objective basis for making a high quality decision, a decision that is technically sound and legally defensible, and the ability to do more with fewer resources and lower budgets. Your environmental decisions are based on: an objective measure of each alternative's impact significance, the comparison of each alternative future condition to the existing condition, and the assurance that all components most important to everyone participating in assessment scoping have been included.

You manage your risks by minimizing or eliminating: not using appropriate decision tools, making a poor decision, making a decision based on insufficient information, conducting an assessment that did not include all relevant components, and having your decision appealed or challenged in court.

Conclusions

1. Environmental impact assessment for land use planning, resource allocation decisions, and NEPA compliance is not a zero-sum game. There is no winner and no loser. Environmental decision-making involves trade-offs which, when well done, are a pragmatic balance.

2. The natural, economic, and social environments are highly dynamic and adaptable. Every decision changes the current state of all three environmental categories, and they also change from natural, internals shifts. But, this displacement from what appears to be a stable position is normal, and another local stable state will be established until the next disturbance.

3. Environmental decision-making is not expected to be perfect; there is no single, right answer because we cannot know the future. We manage risks by using appropriate data and robust analyses that support a technically sound and legally defensible decision. After all, we can say that a reason the Bureau has a minerals program is to find ways to make environmentally responsible mining happen.