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DATA REQUIREMENTS FOR VALUING EXTERNALITIES - THE ROLE OF EXISTING PERMITTING PROCESSES

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State regulators and utility officials are paying increasing attention to the issues of externalities associated with new electricity resources. A growing number of states are requiring utilities to factor externalities, particularly residual environmental damages, into their decision-making processes for new resources. The assessment of such externalities, whether on a qualitative or quantitative basis, requires regulators and utilities to acquire and analyze a wide range of data and information. Resource developers, whether they are utilities or entities selling power to utilities, also will have to collect and provide data through processes specified by utilities or regulators. These requirements will undoubtedly impose new burdens on all parties involved in the development of electricity resources.

While the assessment of externalities, or residual impacts, will place new demands on regulators, utilities, and developers, existing processes already require certain data and information that may fulfill some of the data needs for externality valuation. This paper examines existing siting, permitting, and other processes and highlights similarities and differences between their data requirements and the data required to value environmental externalities. It specifically considers existing requirements for siting new electricity resources in Oregon and compares them with the information and data needed to value externalities for such resources. This paper also presents several observations about how states can take advantage of data acquired through processes already in place as they move into an era when externalities are considered in utility decision-making. It presents other observations on the similarities and differences between the data requirements under existing processes and those for valuing externalities. This paper also briefly discusses the special case of cumulative impacts. And it presents recommendations on what steps to take in future efforts to value externalities.

VALUATION OF EXTERNALITIES--STATUS AND DATA REQUIREMENTS

Externalities are those impacts of one activity on other activities that are not priced in the marketplace. According to Baumol and Oates (1975) an externality is said to exist when two conditions hold: 1) the utility or operations of one economic agent, A, include nonmonetary variables whose values are chosen by another economic agent, B, without regard to the effects on A and 2) B does not pay A compensation equal to the incremental costs inflicted on A.

By definition, the persons or firms bearing the costs associated with an externality absorb them without compensation. The costs are the result of impacts that can include fairly tangible damages, such as increased health care or depressed property values, and less tangible effects, such as reduced attractiveness of a scenic vista. Many of the latter type of impacts fall into the category of non-market values since they include effects on resources and goods that are typically not bought and sold in markets.

Electricity generation involves a wide range of potential and actual environmental impacts. Legislative, permitting, and regulatory requirements directly or indirectly control certain environmental impacts, implicitly causing them to become internalized in the cost of electricity generation. Electricity generation, however, often produces residual environmental impacts that meet the definition of an externality.

Importance of Externalities to Utilities and Regulators

Ottinger (1990) suggests two reasons why utility regulators should require and will increasingly require consideration of environmental externalities in utility resource planning. First, utility service has historically been regarded as imbued with the public interest. Utility commissions oversee the fulfillment of that obligation. Second, the future is likely to hold more stringent legislative and regulatory environmental controls. Since such controls may apply to existing resources, it would be imprudent to permit utilities to make investments now that would be subject later to substantial and costly retrofits to meet future, more stringent requirements. While regulators and utility policy makers have many options for incorporating environmental externalities in the planning and ratemaking processes, the fundamental question they face is what is the correct value to assign to the uncompensated damages resulting from the externalities.

Externality valuation has the objective of determining the total economic cost of the damages imposed on society by a specific activity. In the case of powerplants, as in many situations, this can be a difficult task for a number of reasons. First, probably not all the damages can even be identified. Second, interactions occur among the pollutants and other kinds of primary environmental disruptions caused by a powerplant. For example, air pollutants from a single powerplant interact with one another and may affect the final damages caused. Third, it is unlikely that specific individuals can be identified who will be damaged by the plant and unlikely that the extent of their damages can be predicted accurately. This issue leads to considerations of risks and probabilities, rather than deterministic predictions of the actual damages that will occur. Fourth, environmental externalities should not be considered only during the electricity generation process, but during all stages of what has been termed the "fuel cycle," or all steps leading up to, during, and after electricity generation from a plant throughout its life cycle (Callaway and Currie 1989). In actual practice, approaches have been simplified for valuing externalities in the face of such imposing difficulties.

Valuation Approaches

Buchanan (1990) identifies three general approaches for valuing externalities. One approach is the complete listing and quantification of economic costs associated with each type of damage caused by the residual environmental effects. This is typically the most difficult and complex approach. The second approach is determining the cost to mitigate each residual effect. And the third approach is determining the costs of placing controls on the source that would prevent residual impacts. This approach is usually the least difficult and complex.

Using the third approach, quantifying control costs, reflects the assumption that the marginal costs society has elected to impose through emission (and other environmental disruption) regulations equal the marginal benefits that society receives from avoiding environmental damages. If pollution control regulations were driven strictly by economic optimization criteria, then the marginal cost of the required controls *would* equal the marginal benefits of reducing emissions by one additional unit. Under these conditions, the marginal value of the residual damages associated with an externality would be simply the marginal control cost. There are, however, many obvious and not so obvious reasons why this approach is unlikely to give an accurate estimate for the value of residual damages.[2] Nevertheless, for practical reasons this approach has been used in almost all cases by states that have attempted to value externalities so far.

Experiences of Key States

Three states have taken the lead in specifying numerical values to be used by utilities in valuing environmental externalities: New York, Wisconsin, and Vermont (Foley and Lee 1990). Wisconsin and Vermont use a simple adder to account for the differences in externalities produced by different resources, such as combustion and non-combustion (demand-side management) resources.

Other states have taken various steps to address powerplant externalities. Without prescribing exactly how to proceed, Oregon has ordered utilities to consider external costs when they are evaluating the cost-effectiveness of alternative resources. Although California has no mechanism in place yet for utilities to follow, the state has conducted the most comprehensive analysis of the issues surrounding the valuation of externalities.

In addition to state activities, the Bonneville Power Administration (Bonneville) has made significant progress in addressing externalities. Seminal studies sponsored by Bonneville have attempted to quantify the damages associated with environmental impacts (for example, ECO 1986). In a resource acquisition planned for fall 1990, Bonneville will include the costs associated with environmental externalities (BPA 1990) in accordance with the guidelines provided by the Northwest Power Planning Council (NWPPC 1986).

Of all the states, New York, through its Public Service Commission (NYPSC), has gone the farthest in prescribing a quantification approach and the parameters that will be used. Massachusetts has developed a similar approach, but there the utilities have taken the lead in making it operational. The approaches used in both states rely on a point system that assigns scores to various environmental externalities. In New York, air, water, and land impacts are included. The NYPSC has identified several attributes of each type of impact that are to be assigned points depending on the magnitude or qualitative measure of their severity. Weights are assigned to each attribute based on 1) the relative cost of controlling or mitigating each attribute or 2) the damages attributable to the residual impacts. The weights are multiplied by the points for each attribute, and the resultant scores are summed for each proposed resource. For air emissions, the NYPSC derives appropriate weights based on pollution control costs estimated for coal plants.

Though many states have started to address externalities in utility resource planning and acquisition, approaches so far have been quite simplified. As a result, many deficiencies, such as those listed below, remain in the current approaches:

- No approach has looked at the entire fuel cycle. This gap may be critical for some resources.
- In state approaches, the effects of geographic location on impacts are accounted for only on a limited basis, if at all.
- Little recognition is given to the fact that marginal and average impacts differ and both values are subject to change over time.
- Cumulative effects have not been explicitly incorporated.

Comprehensive valuation of environmental externalities would improve upon existing valuation processes by filling these four gaps.

Externality Valuation Information Needs

The purpose of powerplant environmental externality valuation is to place an economic value on the damages that a powerplant will cause, after all required control and mitigation measures have been implemented. Valuing the resulting externalities requires analyzing several steps in a complex process. This process typically consists of four steps.

The first step is the primary disruption to the environment. This step includes the release of air pollutants, discharge of water pollutants, disruption of a scenic vista, and so on.

The second step involves the linkage between the primary disruption and affected systems. In the case of air emissions, this step may include dispersion of the plume from a powerplant and the chemical reactions in that plume that convert initial pollutants or precursors into the pollutants that affect humans, animals, materials, production processes, etc.

The third step is the actual effect of the environmental disruption on affected systems and their responses. Such effects and responses include physical damage to materials and organisms, health damages, changes in market prices, and changes in behavior.

The final step is the translation of the effects into quantified economic costs.

Each of the four steps requires analysis and quantification. Models have been developed for several externalities to characterize these steps and quantify their effects. In all cases, data, information, and models used should be specific to the powerplant and location being considered.

For all resources, information should be obtained on land use, fish and wildlife, water quality, air quality, and solid and hazardous waste impacts. Primary impacts (such as pollutant emissions) need to be determined for each resource, in each of these impact areas, as the first step in quantifying the economic costs of resultant externalities.

Additional information and data may be required for specific resource types. For example, municipal solid waste plants might produce certain air pollutants that would not be produced by other powerplants.

In addition, it may be important to obtain information on additional stages in the fuel cycle for specific powerplants. For example, potential impacts during decommissioning of a nuclear powerplant may be significant; whereas, they might be negligible during decommissioning of many other powerplants.

Using Information from Other Siting/Permitting Processes

New powerplants are subject to numerous approvals prior to construction and operation. Table 1 shows the variation in permit requirements for 12 types and sizes of new powerplants in Oregon. The requirements range from three possible or probable permits for a 10-MW photovoltaic plant to 14 permits for a 50-MW geothermal plant.

Existing permitting and other processes can be useful sources of information for valuing externalities. The remainder of this paper looks in more detail at what the permitting requirements are in a single state, with the intent of identifying potential sources of information for externality assessments and gaps in those sources. Recognizing potential overlaps and gaps in the data required by different processes is the first step in developing a coordinated approach that can minimize the burden on resource developers, utilities, and regulators alike.

EXISTING PERMITTING AND SITING REQUIREMENTS IN OREGON

We use Oregon as an example to illustrate the kinds of information typically required by existing permitting and siting processes. Requirements will vary by state, however, so other states need to be studied on a case-by-case basis. The information presented here is limited to requirements at the powerplant site; therefore, information on other parts of the fuel cycle is not presented.[3] Impacts from nongenerating stages in the fuel cycle tend to be more generic, anyway, and often do not require site-specific assessments.

The following discussion is based on Hendrickson et al. (1990) and sources discussing specific regulations and requirements. It focuses on general environmental and siting requirements first; then discusses land, air, and water requirements; and finally, discusses requirements that are powerplant-specific.

The Council and Bonneville

Oregon and other states in the Pacific Northwest are greatly influenced by the activities of the Northwest Power Planning Council (Council). The Council was established by the Pacific Northwest Electric Power Planning and Conservation Act (Regional Act) to "set forth a general scheme for implementing conservation measures and developing resources . . . with due consideration by the Council for (A) environmental quality . . . [and] (C) protection, mitigation, and enhancement of fish and wildlife and related spawning grounds and habitat . . . ." The Council's policies are directed primarily at Bonneville, the region's federal power-marketing agency. Bonneville, which supplies 48 percent of the region's power (Bain 1989, p. 69), has a major influence on the entire electricity-generating system in the Pacific Northwest.

As noted earlier, Bonneville will conduct a competitive acquisition for new generation resources in the fall of 1990 (BPA 1990). Given Bonneville's federal status, this acquisition will trigger the environmental review requirements of

TABLE 1. Oregon Permit Requirements

License/Permit	52 MW Geothermal	18 MW Wind	18 MW MSW Incinerator	18 MW PV	18 MW Hydro	583 MW Coal	197 MW Fluidized Bed Coal	139 MW Single cycle CT	428 MW Combined Cycle CT	18 MW Wood Cogen	18 MW Gas Cogen	428 MW Coal gasif. Combined Cycle
NEPA EIS or EA	P	P	P	P	Y	P	P	P	P	P	P	P
SEPA EIS	X	X	X	X	X	X	X	X	X	X	X	X
Certificate of Convenience and Necessity	X	X	X	X	X	X	X	X	X	X	X	X
State siting agency approval	Y	X	X	P	X	Y	Y	Y	Y	X	X	Y
Local land use approval	P	Y	Y	Y	P	Y	Y	Y	Y	Y	Y	Y
Optional FERC QF certification	Y	Y	Y	Y	Y	X	X	X	X	P	P	X
FERC hydroelectric liense	X	X	X	X	Y	X	X	X	X	X	X	X
State hydroelectric permit(s) related to bed, banks, and diversion	X	X	X	X	P	X	X	X	X	X	X	X
Federal geothermal lease	P	X	X	X	X	X	X	X	X	X	X	X
State geothermal permit(s)	P	X	X	X	X	X	X	X	X	X	X	X
State/local emission permit	P	X	Y	X	X	Y	Y	Y	Y	Y	Y	Y
Nonattainment permit	P	X	P	X	X	P	P	P	P	P	P	P
PSD permit	P	X	P	X	X	P	P	P	P	P	P	P
NESHAPS permit	X	X	P	X	X	X	X	X	X	X	X	X
NPDES permit	P	X	P	X	X	Y	P	P	P	P	P	P
UIC or state underground injection permit	Y	X	X	X	X	X	X	X	X	X	X	X
Corps permit for structure in navigable water	X	X	X	X	Y	P	P	X	P	P	P	P
Corps dredge and fill permit	P	P	P	P	Y	P	P	P	P	P	P	P
FUA certification to DOE	X	X	X	X	X	X	X	P	P	X	P	X
State/local MSW incinerator permit	X	X	Y	X	X	X	X	X	X	X	X	X
State/local permit for ash/waste disposal	P	X	Y	X	X	Y	Y	X	X	Y	X	Y
Water acquisition permit	Y	X	P	X	Y	Y	Y	X	Y	P	P	Y

Key: Y = probably yes; X = Probably not; P = Possibly

Source: Hendrickson et al. (1990)

NEPA, the National Environmental Policy Act (see following discussion). A wide range of environmental data and information will have to be obtained on proposed generation resources under the NEPA requirements. In addition, the Council has spelled out a 10-step process that the Bonneville Administrator is to use to quantify all environmental externalities directly attributable to a resource (NWPPC 1986).

The details of the methods and data Bonneville will use to assess externalities are not available at this time. Clearly, however, resources developed in Oregon under this acquisition will have to meet both the NEPA data requirements and the requirements of Bonneville's externality assessment process.

NEPA

NEPA is the basic national charter for protecting the environment. Its requirements are directed specifically at federal agencies, but its implementation has led to requirements likely to affect new powerplants in every state. NEPA requires federal agencies to prepare an environmental impact statement (EIS) for major federal actions significantly affecting the quality of the environment. An EIS is not a permit, but can be the major process to reveal and address potential environmental impacts. An EIS is a detailed report comparing environmental impacts of alternative options for achieving specific purposes and needs. The need for an EIS can be triggered through actions related to siting a powerplant, such as issuance of a federal license or permit, transfer of federal lands, or federal financing.

Though many states do, Oregon does not have a state environmental policy act to implement NEPA. In Oregon, NEPA is applied only when federal agencies or funding are involved, which is often true of large-scale hydroelectric plants and generators, such as geothermal plants, that are located on federal land.

Perhaps the most important step in the NEPA process is choosing which environmental impacts to focus on. All powerplants are likely to result in some environmental effects. The nature and magnitude of these effects is very much dependent on specific project features, such as the fuels and technologies employed and the location of the project. NEPA stipulates that all significant environmental effects must be assessed. NEPA states that significance requires consideration of both the context and the intensity of an impact (40 CFR 1508.27). Intensity refers to the severity of the impact. Context means the setting in which the impact occurs.

In judging which impacts are significant and clearly insignificant, decision-makers must consider a number of factors when assessing the intensity of an impact within its unique context. Uncertainty of intensity or context is usually resolved by assuming a reasonably foreseeable extreme (Alton, Dowty and Schmidt 1989). A great deal of scientific uncertainty or substantial controversy about an impact tends to bring about a conclusion of significance. Other factors that should be considered include potential effects on human health; possible effects on unique geographical features, such as nearby cultural or historic resources, parklands, prime farmlands, wetlands, or wild and scenic rivers; whether seemingly insignificant individual actions result in a significant impact when taken cumulatively; and potential adverse effects to endangered or threatened species.

Thus, NEPA assessments are comprehensive in their treatment of environmental effects. However, specific information needs are dependent on site and plant characteristics. NEPA requires the information to complete an assessment to be the best available. If information that is essential to making a reasoned decision is not available, but the costs of obtaining it are not exorbitant, federal agencies are to include the information when preparing an EIS (40 CFR 1502.22).

Another key NEPA provision is the requirement to include cumulative impacts in environmental impact assessments. NEPA regulations define cumulative impacts as those that result from the incremental impact of an action when added to impacts of other past, present, and reasonably foreseeable future actions (40 CFR 1508.7).

The regulations go on to state that "Cumulative impacts can result from individually minor but collectively significant actions taking place over time." When evaluating proposed energy projects, analyses of cumulative impacts may require three perspectives:

- The inclusion of all present and potential emitters or polluters in relation to a particular resource (e.g., new powerplant).

- The inclusion of all portions of the fuel cycle related to the generating plant, rather than the generating portion only.

- The interactive impacts between a new powerplant and the existing power generation system. For example, in the Pacific Northwest, the development of new thermal plants is likely to affect the operations of the Columbia River hydro system; thus, Bonneville's EISs include analyses of system-wide impacts.

An EIS may be structured to include an analysis of the value of environmental externalities. NEPA does not specifically address externalities, but EISs are currently being prepared that incorporate these values. NEPA states that if a cost-benefit analysis is relevant to choosing among environmentally different alternatives, such an analysis shall be incorporated by reference or appended to the document (40 CFR 1502.23). When such an analysis is prepared, the EIS must contain a discussion of the relationship between the analysis and any analyses of unquantified impacts, values, and amenities. However, comparisons of varying alternatives within an EIS need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations (40 CFR 1502.23).

Powerplant Siting Laws

Many of Oregon's environmental impacts data requirements are imposed through the general siting process. In Oregon, the need for a powerplant site certificate is triggered when a powerplant with a generating capacity greater than 25-MW or solar collecting facilities covering more than 100 acres of land are going to be constructed. For cogeneration plants fired by agricultural or wood waste, a certificate is required if the plant has a capacity of 50-MW or more. The certificate is issued by the Oregon Energy Facility Siting Council (EFSC). The EFSC implements a one-stop siting process for energy facilities. Through this process, a wide range of issues is addressed including public health and safety, water rights, socio-economic impacts, environmental impacts, historic and cultural resource impacts, and others. In accordance with the one-stop requirement, all other state and local agencies must issue the appropriate permits, licenses, and approvals once the EFSC has issued its site certificate (Bain 1989, p. 79).

Chapter 345 of the Oregon Administrative Rules (OAR) presents the rules followed by the EFSC. OAR 345 Division 40 provides guidance to powerplant developers by specifying areas of the state that are "suitable," "less suitable," and "unsuitable" for powerplant siting. Areas are categorized both according to whether they meet certain criteria and are in specific regions of the state. These specifications, along with EFSC's one-stop siting mission, alleviate some of the potential burdens on developers.

For large powerplants (more than 200-MW), except combustion turbine and geothermal plants, proposers must file a Notice of Intent (NOI) at least 12 months before making a siting application (OAR Ch. 345, Div. 20). The NOI includes plant location, land area, status of decisions regarding filing for the site certificate and construction permits, plans for a study of environmental impacts, and the sources of cooling water. The NOI also partially addresses the fuel cycle by requiring a description of the method for disposal of waste heat, wastes, and spent nuclear fuel.

The actual site permit application varies by powerplant type. For biomass and fossil-fuel plants, applicants must submit, among other information, the following (OAR Ch. 345, Div. 111):

- a description of the facility

- a description of the site and existing environment

- a description of construction and operation processes and their attendant environmental impacts

- a description of required decommissioning or waste disposal sites and methods.

As in the NOI, the requirements include stages in the fuel cycle other than just construction and operation.

For nuclear plants, similar requirements apply. In addition, the applicant must provide a cost analysis that includes mitigation costs for identifiable social, health, safety, and environmental impacts (OAR Ch. 345, Div. 76). Nuclear plants also are required to develop a plan for decommissioning in accordance with Nuclear Regulatory Commission rules (OAR Ch. 345, Div. 26).

The most detailed requirements are specified for hydroelectric and geothermal plants. These are discussed in later sections.

Land Use Approval

As in most states, approvals related to land use in Oregon originate primarily at the local level. Oregon is fairly unique in that the Oregon Land Conservation and Development Commission (LCDC) plays a significant role in establishing overall land use policies that can affect powerplant siting.

In Oregon, each county is required to have a comprehensive land use plan. The local plan must be consistent with the 19 Statewide Planning Goals (ODOE 1985). One goal requires an inventory of 12 resources, including lands for open space, wildlife areas and habitats, historic areas, and cultural areas. Conflicts between protection of these resources and other uses must be identified and resolved. Other goals concern specific areas such as estuaries, beaches and dunes, and coastal shorelands. Local governments are to translate these goals into implementing ordinances regulating land use.

Local land use permits require reviews to ensure protection of public health, safety, and general welfare; to comply with statewide planning goals; and to comply with city or county comprehensive plans. Local governments are required to consider special purpose zoning, such as historic preservation sites; water quality; soils suitability; fish and wildlife; and noise. Although requirements vary by county, the processes used by each county to issue required permits are likely to identify most of the land impacts that would have to be analyzed to assess powerplant externalities.

Powerplants and appurtenances on federal land, however, are not typically subject to local land use requirements. When powerplants or associated facilities or access roads are to be constructed on federal land, the agency administering the land must approve. The approval may be through a use permit, authorization, lease, or an easement. This process is one mechanism for triggering the NEPA requirements.

Clean Air Act Requirements

The Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to establish national primary and secondary ambient air quality standards for air pollutants "which may reasonably be anticipated to endanger public health or welfare" (Clean Air Act). Ambient air quality standards have been established for several air pollutants produced by powerplants. States are required under the Act to classify areas into one of three categories, by pollutant, depending on whether pollutant levels are worse than the primary or secondary standards, are better than the standards, or cannot be classified because of insufficient data or information.

States are required to develop state implementation plans (SIP's) that provide for attainment of the national standards. States are permitted to develop requirements that are stricter than the national ones and Oregon has done so in some areas.

Under the Clean Air Act requirements, four permits could be required for a new powerplant: 1) a state emission permit, 2) a nonattainment permit, 3) a prevention of significant deterioration permit, and 4) a permit for construction approval under a program related to hazardous air pollutants for which no ambient air quality standard is applicable.

Nonattainment permits are required for new plants proposed for areas where ambient air standards are not being met. One condition of these permits is use of emission control designated as providing the lowest achievable emission rate (LAER), i.e., the most stringent emission limitation in any SIP.[4] A prevention of significant deterioration (PSD) permit is required for proposed powerplants in areas that meet ambient air standards. This permit requires the applicant to employ the best available control technology (BACT), which is basically the best control, given considerations of cost, energy, and environmental impacts. The permit also requires a fairly comprehensive analysis of the probable air quality, visibility, soils, and vegetation impacts of the plant if areas such as national parks or wilderness areas may be affected.

In Oregon, any person intending to establish a new or modified source of air contaminant emissions must obtain an Air Contaminant Discharge Permit from the Department of Environmental Quality (DEQ) or a local air pollution agency (OAR Ch. 340, Div. 20). Specific information requirements for this permit vary depending on the quantity and type of pollutants, and the plant location. The following information is generally required from applicants:

- o a description of the nature, location, design capacity, and typical operating schedule of the source, including specifications and drawings showing its design and plant layout
- o an estimate of the amount and type of each air contaminant emitted by the source in terms of hourly, daily, seasonal, and yearly rates, showing the calculation procedure
- o a construction schedule
- o information needed to determine that BACT or LAER technology, whichever is applicable, would be applied
- o when needed, an analysis of the air quality and/or visibility impact, including meteorological and topographical data, and specific details of models used
- o when needed, an analysis of the air quality and/or visibility impacts, and the nature and extent of commercial, residential, industrial, and other source emission growth in the affected area that has occurred since January 1, 1978.

Air quality/visibility analyses are required when sources exceed preestablished emission rates for specific pollutants (OAR, Ch. 340, Div. 20). These rates range from 100 tons per year of carbon monoxide to 1 ton per year of vinyl chloride. The regulations do not cover carbon dioxide. If modeling demonstrates that emissions would exceed significant rates, then BACT must be employed. If the source still does not meet the standards, a more detailed analysis of emissions may be used to demonstrate compliance. If it is clear that the standards will be exceeded, the developer may challenge the requirements and conduct his or her own risk assessment. However, this last step has rarely been invoked in Oregon.

Issuing a new permit may require a public hearing. For energy facilities, the hearing may be consolidated with the hearing requirements for site certification conducted by the Oregon EFSC.

Clean Water Act and Other Water Pollution Requirements

The Clean Water Act (CWA) authorizes federal and state control of pollutant discharges into U.S. waters and municipal sewer systems. In Oregon, a person responsible for such discharges must obtain a permit (CWA Section 402) from the Oregon DEQ, Water Quality Division. Specific standards must be met to obtain such a permit. The technology-based standards reflect the nature of the pollutants. For conventional pollutants (suspended solids, fecal coliform, oil, etc.), best pollution control technology (BCT) is required. BCT is defined in terms of costs and benefits. For toxic and nonconventional pollutants, best available control technology economically achievable (BAT) is required. Definition of BAT is based on considerations of cost, but not cost-benefit analysis.

In Oregon, the DEQ has established 19 water basins with their own water quality goals and regulations. Permits are considered on a case-by-case basis, and the size of the receiving stream is considered (Miles, Craig, and Greene 1984). The DEQ uses standard permit application forms developed by the EPA. Form 1 requests general information about the facility including its location, a topographic map extending at least one mile past the property boundaries, and characteristics of the discharge. Applicants for powerplants that discharge process wastewater must complete Form 2D. The following is part of the information and data required:

- location and name of water body receiving the discharge

- operations that contribute to each point source, average flows, and treatments applied to each wastewater

- frequency of discharges, maximum and minimum flow rates, and duration

- maximum and average flows of specific pollutants including biochemical oxygen demand, chemical oxygen demand, total organic carbon, total suspended solids, ammonia, and pH

- maximum and average flows of nearly 150 other pollutants, if present

- a listing of toxic and hazardous pollutants, from a list of over 350, which are expected to be discharged.

For powerplants that discharge only nonprocess wastewater, such as noncontact cooling water, applicants must complete Form 2E. This form requires in part the following information:

- location and name of receiving waters

- maximum mass and concentration in effluent of biochemical oxygen demand, total suspended solids, total residual chlorine, oil and grease, chemical oxygen demand, total organic carbon, ammonia, discharge flow, pH, and winter and summer temperatures

- description of seasonal and intermittent flows

- description of treatment systems.

These data requirements are fairly comprehensive and should be adequate for the initial step in valuing water-related externalities, that of quantifying relevant discharges. However, the lack of modeling or risk assessment requirements in the standard permitting process means that little other information is produced for valuing externalities.

Intentional discharges to groundwater are regulated primarily by the federal Underground Injection Control (UIC) Program (Section 1421 of the Safe Drinking Water Act). Under the Act, EPA has issued regulations for underground injection programs that are administered by Oregon, primarily by the DEQ.

Finally, a permit is required from the Army Corps of Engineers for dams or dikes constructed in navigable waters (see later discussion). If a hydroelectric project is licensed by FERC, the requirements are usually included in the FERC license. For projects exempt from the FERC process, the Corps requires a separate permit. Other facilities associated with powerplants may require FERC licensing if they are in or affect navigable waters. In addition, discharges of dredged or fill materials generally require permits from the Corps.

FERC Certification of Qualifying Facilities

Sections 201 and 210 of the Public Utilities Regulatory Policies Act (PURPA) create a special class of power generating facilities designated as qualifying facilities (QFs). QFs are typically cogeneration facilities and small powerplants. PURPA exempts such facilities from several federal acts and most state public utility regulations.

In turn, however, owners of hydroelectric QFs must provide special information to the Federal Energy Regulatory Commission (FERC). Developers must submit an Environmental Report that includes the following information (18 CFR Ch. I, Sec. 4.41(f)):

- a description of federal and state recommended measures to protect and improve water quality; an explanation of why any measures were rejected; and a description of the applicant's alternate measures

- a description of groundwater impacts and measures proposed to mitigate them.

In addition, the applicant must submit information essentially the same as that discussed in the following section on FERC hydroelectric licensing.

Licensing of Hydroelectric Facilities

FERC imposes special requirements on hydroelectric generating plants. The Federal Power Act requires developers of hydroelectric facilities that do not qualify for an exemption to obtain a license from FERC prior to construction. The applicant must prepare a detailed environmental report, and FERC will normally prepare an EIS for newly constructed hydroelectric facilities.

For hydroelectric plants of greater than 5-MW capacity regulated by FERC, applicants must submit detailed information on the project. Permit applicants must provide the following environmental information required to assess environmental impacts (18 CFR Part 4, Subpart E):

- the location and description of the relevant water body
- minimum, mean, and maximum stream flows at plant intake and a description of the baseline water quality
- a description of the affected environment
- construction and operation impacts on water quality including quantification of effects on downstream temperature, turbidity, and nutrients
- mitigation and enhancement measures proposed to address water quality impacts
- a report on fish, wildlife, and botanical resources
- expected impacts on fish, wildlife, and botanical resources
- mitigation, enhancement, and protection measures proposed for fish, wildlife, and botanical resources and the costs of mitigation measures
- similar information on historic, archeological, recreational, and aesthetic resource impacts; socioeconomic impacts; and mitigation measures
- a description of current and proposed land use.

Similar, but less detailed, information is required by FERC for smaller hydroelectric plants.

For dams located on navigable waters, a permit must be secured from the Army Corps of Engineers. A set of policies applies to the permit requirements including the following (33 CFR Part 320.4):

- Probable impacts, including cumulative effects, must be evaluated.
- The evaluation must consider economics, aesthetics, general environmental concerns, wetlands, fish and wildlife, land use, and water quality.
- Mitigation is deemed to be an important part of the review process and it can include avoiding, minimizing, rectifying, reducing, or compensating for resource losses.

Under the FERC regulations, proposers also must consult with all appropriate federal and state agencies before applying to FERC. In Oregon, the applicant must consult with the Oregon DEQ. The applicant must also explain the proposed project's consistency with relevant state, local, and regional plans including the Northwest Power Plan and the Columbia Basin Fish and Wildlife Program. As noted, exemptions and reduced requirements are available to applicants proposing relatively small projects.

Federal law requires FERC hydroelectric licensees to comply with state water laws. Oregon has developed extensive, comprehensive policies and requirements for hydroelectric development. This is one area in which Oregon is quite unique.

Oregon has taken several steps to coordinate activities related to hydropower projects. The Strategic Water Management Group was established in 1985 to coordinate state responses to FERC hydroelectric actions. It comprises representatives from state agencies such as the Water Resources Department, Department of Fish and Wildlife, ODOE, Economic Development Department, Department of Land Conservation and Development, Department of Forestry, and others. One duty of the Group is monitoring applications related to hydroelectric projects. A Hydro Task Force was also created to ensure that other relevant state agency concerns are brought up. The Task Force also serves as staff to the Group on FERC project licensing matters (Bain 1989, p. 104-105). The Task Force has instituted a process for state approval of new projects that outlines the steps developers must follow.

The Water Resource Commission develops relevant policies and the Water Resources Department (WRD) implements them. These policies affect the data requirements and procedures of the EFSC in its powerplant siting activities.

Oregon law sets stringent minimum conditions for siting hydroelectric plants, including the following (NERA 1990, p. 25):

- a project cannot be approved that may result in *mortality or injury to anadromous salmon and steelhead resources* except when the applicant proposes to modify an existing facility to restore or enhance anadromous fish populations within that river system

- any hydroelectric activity shall be consistent with the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program for the protection and enhancement of regional fish and wildlife resources

- the project may cause no net loss of wild game fish or recreational opportunities unless proposed mitigation measures are approved

- water quality, wildlife, scenic and aesthetic values, historic, and other sites shall be maintained or enhanced.

Cumulative impacts are considered in the case of hydroelectric facilities. If the EFSC determines that pending, approved, or existing hydroelectric facilities could have cumulative impacts, it must conduct a consolidated review of the applications. Resources covered in the review include anadromous salmon and steelhead; recreational opportunities; water quality; soils; scenic and aesthetic values; wildlife; threatened or endangered species; wetlands; agricultural and forest lands, etc. If cumulative impacts are probable, then the EFSC must conduct a study of individual and cumulative impacts. If the impacts violate minimum standards, then the EFSC refuses one or more pending facilities until the impacts are below the minimum standards (OAR Ch. 345, Div. 79).

Geothermal Resource Permitting Requirements

The federal government has special provisions for geothermal resource development on federal lands. Under the Geothermal Steam Act of 1970 the Department of the Interior (DOI) is given the authority to execute leases for geothermal resource development on most federal lands. A permit is required for exploration prior to execution of a lease and specific rules are laid out for all stages of development. Many of the rules focus on environmental impacts (43 CFR Part 3260).

The DOI's Bureau of Land Management prepares an Environmental Assessment (EA) that includes a description of the project, evaluation of the environmental impacts, descriptions of alternatives, and mitigation measures applied. The information in the EA is used to determine whether an EIS is required. The lessee may be required to provide data on the quantity and quality of the geothermal resource and water, including heat and fluid flow data. The lessee is required to submit for approval an operation plan that identifies areas of potential disturbance; methods for waste disposal; a description of environmental protection measures; and provisions for collecting data on existing air and water quality, noise, and ecological systems.

In Oregon, in addition to the EFSC's general powerplant siting and permitting requirements, permit requirements exist for drilling geothermal wells on non-federal lands. Drilling permits must be obtained from the Department of Geology and Mineral Industries (DOGAMI) for certain resources (high-temperature resources or deep wells). For wells not regulated by DOGAMI, a groundwater appropriation permit must be obtained from the Oregon Water Resources Commission (NERA 1990, p. 29).

Geothermal well drilling permit applications to the DOGAMI must include the following information (OAR Ch. 632, Div. 20):

- location and elevation of the floor of the proposed derrick
- estimate of the depths to be drilled
- nature and character of the resources sought
- other information as may be required.

The DOGAMI circulates the application to several other state agencies including the Water Resources Department, DEQ, Department of Fish and Wildlife, Department of Land Conservation and Development, and ODOE (NERA 1990, p. 28).

A permit is also required from the DOGAMI if reinjection is planned. Conditions on the permit include that reinjection shall not pollute state waters, create a public nuisance, impair beneficial water uses, or degrade the habitat of aquatic life. The permit requires an explanation of the system used; a map; fluid characteristics including quality, quantity, chemical contents, reactivity, toxicity, and temperature; and characteristics of the injection zone, hydrology of the surrounding area, and subsurface maps (OAR Ch. 632, Div. 20). Reinjection requirements are based on federal regulations (40 CFR Subpart D, Sec. 146.34).

Summary of Oregon Requirements

Table 2 summarizes the preceding discussion of information collected in Oregon that could be used to analyze externalities. The table depicts information collected through both state and federal processes. Requirements related to water and air environmental impacts in Oregon derive largely from federal laws. For land impacts, Oregon has comprehensive statewide land use policies that are implemented at the local level. The existing requirements are likely to produce essential data for determining the amount of primary environmental disruptions associated with externalities, but in only certain cases will they produce data and information relevant to other steps in the process required to value externalities.

CUMULATIVE IMPACTS - A SPECIAL CASE

The analysis of cumulative impacts deserves special attention here because it cuts across several issues related to the valuation of externalities and corresponding data requirements.[5] As the previous section illustrates, cumulative impacts are not addressed in a comprehensive and consistent way in Oregon and probably most other states. This section briefly discusses the role of cumulative impacts in externality valuations.

Intuitively, pollution controls on new facilities should be tightest in regions where existing pollution levels are the highest. The Clean Air Act and Clean Water Act exemplify this concept through their tiered control technology requirements. For example, the Clean Air Act requires use of best available control technology in attainment areas, but requires control to the stricter lowest achievable emission rate in nonattainment areas.

This approach can be justified on theoretical grounds as illustrated in Lee et al. (1990)[6] for air pollution. The theoretical argument is based on the assumption that environmental impacts should be controlled to their economically efficient level, taking into account both control costs and the damage costs of uncontrolled impacts. Marginal control costs increase and the marginal benefits of each additional reduction in environmental damages decrease as tighter and tighter controls are imposed. To satisfy the economic efficiency criterion, controls should be required up to the point where the marginal control cost equals the marginal benefits of reduced damages. For a single powerplant in isolation, the intersection of the marginal control cost curve and marginal benefits curve for that plant determine the optimum control level.

When all existing sources of environmental damages are taken into account, however, different requirements emerge. For example, in the case where four identical powerplants exist and a fifth is being added, the combined marginal

TABLE 2. Availability of Data and Information in Oregon for Valuing Externalities

Component of Valuation	Type of Resource: Land	Water	Air
Baseline conditions	Yes; through local permits	Yes, for hydro plants; through state and federal requirements	Some information; through federal and state requirements
Quantities of primary disruptions	Yes; through local permits	Yes; through state and federal requirements	Yes; through state and federal requirements
Linkage of disruptions to affected systems	No	Yes, for hydro plants; through state and federal requirements	No, except for modeling required in special cases; through state requirements
Effects on systems	Some; through local permits	Yes, for hydro plants; through state and federal requirements	No, except for special cases; through state requirements
Economic impacts	No	No	No
Fuel cycle	Some; through local permits	Yes, for decommissiong and waste disposal in some cases; through state and federal requirements	No
Cumulative impacts	No	Yes, for hydro plants; through state and federal requirements	Only through prescribing controls on environmental impacts; through state and federal requirements

control cost and benefits curves would capture the combined effects of all five plants. This represents a situation where cumulative impacts are taken into account. Under these circumstances, it can be shown that the optimal control level is tighter for the new plant than if it were analyzed in isolation.

This result suggests that where existing pollution levels are higher, tighter controls on new plants are justified and the societal benefits are higher. This theoretical finding is supported empirically by recent arguments in California that certain out-of-state air quality damages should be valued at one-tenth their in-state value (CEC 1989).

Since the incremental cost of damages caused by each new powerplant depends on the existing level of environmental damages, externality valuations should take such cumulative effects into account. In Oregon, only state permitting requirements for hydroelectric plants require cumulative impacts assessments. In almost all other cases, except those where NEPA is triggered, the processes focus on meeting specific pollution standards with no, or only indirect, consideration of cumulative impacts. Consequently, there is likely to be limited information available through existing processes that can be applied to studies of cumulative impacts. Collecting such information and data could improve current siting and permitting processes as well as provide the basis for comprehensive externality valuations.

CONCLUSIONS AND OBSERVATIONS

Information for just a single state provides many useful insights into how other states can best take advantage of current processes in their efforts to value powerplant externalities. Driven largely by federal laws, states have in place many mechanisms to identify, quantify, and mitigate environmental impacts. These mechanisms, however, do not necessarily produce information on residual impacts, that is, externalities. This section presents observations and conclusions about 1) the match between the data collected under existing processes and those data needed to value externalities and 2) gaps that need to be filled.

Federal Requirements--Primary Environmental Disruptions

Major federal laws regulate the environmental impacts of new powerplants. The Clean Air Act, Clean Water Act, and NEPA can affect the major types of pollutants produced by powerplants. These laws and others impose their requirements either through direct federal processes or processes delegated to the states.

How states implement the federal requirements varies. Generally, the federal requirements provide a good starting point for determining what individual states will do.

As a rule, it appears that the federal laws as implemented by the states should lead to good information and data on the amounts of primary environmental disruptions, particularly in the area of air and water pollution. Because federal laws focus primarily on reducing externalities to specified levels, they lead to quantitative information about the quantities of primary environmental disruptions, such as the amounts of air pollutants emitted. These quantities comprise the first of the four quantification steps required in valuing externalities. Information on the other three steps, however, is less likely to be available.

Other Steps in the Valuation of Externalities

The approaches implemented by states that have valued externalities so far have been shortcuts to convert the amount of primary environmental disruptions into economic costs. Ultimately, accurate and credible valuation approaches will require more complete analyses of 1) the linkage between the primary disruption and affected systems, 2) the actual effect on such systems and their responses, and 3) the economic costs.

Current data requirements under federal laws address the first and second items only in certain circumstances under NEPA and, possibly, in the case of air quality impacts. In Oregon, air quality permits require plume dispersion modeling and risk assessments for powerplants under certain circumstances.

To determine the economic costs of externalities, control and mitigation cost data have been used in some cases as measures of the societal costs of externalities. Federal processes require some information on control and mitigation measures. Because the requirements are not designed for valuing externalities, however, they are inconsistent and incomplete.

Overall, existing procedures require little of the information necessary to address the three steps listed above in the externality valuation process.

State Diversity

We have presented some of the unique process requirements in Oregon. This information suggests that individual states are likely to have special information and data requirements in place that reflect atypical state characteristics.

In Oregon, for example, hydroelectric projects receive special attention. The state requirements are driven by federal requirements, but also respond to regional interest in monitoring and preserving water resources. In states where air quality is a major issue, such as California and New York, environmental regulations and requirements and externality quantification methods focus on air quality impacts (Foley and Lee 1990). It is likely that other states already have in place special processes and requirements that can provide data for valuing externalities of special interest.

The Fuel Cycle

Both federal and state environmental processes focus principally on the electricity generation stage of the fuel cycle. Existing externality valuation methodologies are also oriented toward impacts during generation.

Oregon siting requirements, however, partially address other portions of the fuel cycle. In most cases, siting certificate applicants must provide information on methods for disposal of spent nuclear fuel and wastes and on decommissioning. Nevertheless, a full valuation of externalities will require more complete data on other segments of the fuel cycle than are obtained under either federal or typical state processes.

Cumulative Impacts

As we have noted, the interactions among existing sources can be important in determining the value of damages caused by a new powerplant. Such cumulative effects are often overlooked or only implicitly recognized in externality valuations.

Federal and Oregon laws require assessments of cumulative impacts associated with hydroelectric resources. Other than the NEPA requirements applying to all federal actions, hydroelectric resources are the only ones for which explicit cumulative impact data and analysis are likely to be required in Oregon.

Coordination of Data Requirements and Submittals

Coordinated and centralized data requests can ease the burdens on resource developers who are required to submit information for valuing externalities. One-stop powerplant siting processes are an example of mechanisms to ease such burdens. Oregon's EFSC provides one example of a state agency with such authority. Other, but not all, states have agencies with similar authority. Because of their coordinating role, the federal NEPA process and state versions of the process also can reduce potential burdens on developers.

General Observations and Recommendations

Our analysis does not provide any insights about states with NEPA-like processes because Oregon does not have one. Nevertheless, it seems apparent that states that have their own NEPA-like process will be better prepared to set up procedures and data requirements for valuing externalities.

Our analysis of Oregon's processes and requirements demonstrates that existing processes in most states are likely to provide data and information adequate to partially assess powerplant externalities. States are likely to be best situated to collect information on primary environmental disruptions.

Major gaps, however, are probable in three areas: 1) parts of the fuel cycle other than electricity generation, 2) steps in externality valuation other than the primary environmental disruptions, and 3) cumulative impacts.

The valuation of externalities is a complex task. The success of state efforts to successfully include externality valuations in their utility planning and acquisition processes will depend to a large extent on the defensibility of their approach and the burdens that it places on developers. Based on our analysis, we present the following recommendations aimed at both minimizing the burdens of providing the necessary data and increasing the validity of the required analyses:

1. Agencies responsible for developing externality valuation procedures should inventory and assess current siting and licensing requirements that may provide some of the required information. Gaps in current requirements should be identified.

2. Steps should be taken to centralize and coordinate data collection. Externality valuation data collection might need to be incorporated in current processes or data collection under current requirements might best be incorporated in an overall integrated data collection process.

3. Alternative methods for valuing individual externalities should be assessed as the basis for determining the best approach for each externality and establishing appropriate data and information reporting requirements.

4. Procedures should be established for collecting information on control and mitigation costs and damages associated with all impacts.

5. Processes should be developed for collecting and analyzing data on cumulative impacts for all environmental impact types.

6. Processes and criteria should be developed for determining which stages of the fuel cycle to evaluate for various generating resources and what data to require.

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REFERENCES

Alton, C.C., P.M. Dowty, and O.L. Schmidt. 1989. *Commonly Asked Questions on the NEPA Process*. Bonneville Power Administration, Portland, Oregon.

Bain, D. 1989. *Development Framework for PURPA Resources in Oregon*. Oregon Department of Energy, Salem, Oregon.

Baumol, W.J. and W.E. Oates. 1975. *The Theory of Environmental Policy: Externalities, Public Outlays, and the Quality of Life*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Bonneville Power Administration (BPA). 1990. *BPA Generating Resource Acquisition Process*. DOE/BP-1436, Portland, Oregon.

Buchanan, S.C. 1990. "Estimating Environmental Costs of Energy Resources." *The Electricity Journal*, V.3, N.6, Seattle, Washington.

California Energy Commission (CEC). 1989. *Valuing Emission Reductions for Electricity Report 90*, Staff Issue Paper #3R, Sacramento, California.

Callaway, J.M. and J.W. Currie. 1989. *A Framework for Incorporating Externalities into Least-Cost Planning Procedures in Massachusetts*. Battelle Pacific Northwest Laboratories, Richland, Washington.

Clean Air Act. 42 USC 7401-7642.

Clean Water Act. 33 USC 1342, Sec. 402.

ECO Northwest (ECO). 1986. *Estimating Environmental Costs and Benefits for Five Generating Resources*. Prepared for Bonneville Power Administration, Portland, Oregon.

Foley, L.O. and A.D. Lee. 1990. "Scratching the Surface of the New Planning: A Selective Look." *The Electricity Journal*, V.3, N.6, Seattle, Washington.

Hendrickson, P.L., S.A. Smith, A.G. Thurman, R.L. Watts, and S.A. Weakley. 1990. *Preconstruction Schedules, Costs, and Permit Requirements for Electric Power Generating Resources in the Pacific Northwest*. PNL-7420, Pacific Northwest Laboratory, Richland, Washington.

Federal Power Act. 16 USC 812(b).

Geothermal Steam Act of 1970. 30 USC 1001-1025.

Miles, T.R., Jr., L.S. Craig, and W.T. Greene. 1984. *Guide to Oregon's Environmental Permits for Biomass Energy Projects*. Prepared for Oregon Department of Energy, Salem, Oregon.

National Environmental Policy Act (NEPA). 40 CFR 1500 - 1508.

National Economic Research Associates, Inc. (NERA). 1990. *An Evaluation of State Environmental Requirements and Permitting Procedures in the Bonneville Power Administration's Resource Acquisition Process*. Seattle, Washington.

Northwest Power Planning Council (NWPPC). 1986. *Northwest Conservation and Electric Power Plan, Volume Two*, Appendix II-A. Portland, Oregon.

OAR Ch. 345, Div. 20.

OAR Ch. 345, Div. 26.

OAR Ch. 345, Div. 76.

OAR Ch. 345, Div. 79.

OAR Ch. 345, Div. 111.

OAR Ch. 632, Div. 20.

Oregon Department of Energy (ODOE). 1985. *Regulation of Small Scale Energy Facilities in Oregon, Background Report Vol. 2.* Salem, Oregon.

Ottinger, R.L. 1990. "Getting at the True Cost of Electric Power," in *The Electricity Journal*, V.3, N.6, Seattle, Washington.

Pacific Northwest Electric Power Planning and Conservation Act (Regional Act). Pub. Law No. 96-501, Sec. 4.(c)(2), 94 Stat. 2706 (1980).

Public Utilities Regulatory Policies Act (PURPA). 16 USC 824a-3.

Safe Drinking Water Act. 42 USC 300h.

18 CFR Part 4, Subpart E.

18 CFR Ch. I, Sec. 4.41(f).

33 CFR Part 320.4.

40 CFR Subpart D, Sec. 146.34.

43 CFR Part 3260.

ENDNOTES

1. Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

2. One obvious reason is that legislation and regulations set emission and other requirements through a political process, not through economic optimization. A less obvious reason is that even if the regulated marginal control cost did equal marginal benefits, it would be incorrect to simply multiply the marginal cost times the quantity of residual pollution to calculate total residual impacts because marginal benefits (avoided marginal damages) are likely to decrease as the amount of residual pollution declines.

3. The major permit and license requirements are included, but certain types of permits, such as building permits and special transportation permits, are not included.

4. This requirement is important because it illustrates a regulatory approach to require controls with marginal costs that are higher where marginal benefits of control are likely to be higher.

5. The term "cumulative impacts" can be interpreted differently in different settings. Here we mean total impacts, taking into account existing sources of environmental degradation and new sources.

6. Lee, A.D., M.C. Baechler, J.M. Callaway, L.O. Foley, and C.S. Glantz. 1990 (forthcoming). *Information for Bonneville's Quantification of Environmental Externalities*. Pacific Northwest Laboratory, Richland, Washington.

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