

Appendix K

PROCESS GRANT BENEFIT ESTIMATION

K.1 Overview

Process mitigation leads to policies, practices, and projects that reduce risks (MMC, 2002). The goal of this section of the report is to estimate net benefits for specific process grants within three general types of mitigation-related activities:

- A. information/warning (risk communication)
- B. multi-hazard mitigation plans
- C. building codes

The analysis below should be considered to be one step beyond a qualitative analysis, for reasons that follow. The benefits of a process grant likely involve two components:

1. spawning and encouraging the development of mitigation plans and activities, such as building codes
2. enhancing the probability that mitigation actions will be taken

As such, it would be difficult to estimate the benefits of a process grant, isolating these from the benefits of actual mitigation activities. Working from the end point of mitigation, assume that individuals' tendency to mitigate (e.g. adopt new building code regulations) increases by some factor, say 50 percent. This in turn leads to benefits in terms of reduced damages from hazards. One would have to isolate the contribution to these benefits from the process grant alone to do an accurate benefit-cost analysis of process grants. However, doing so would be complicated. An individual's propensity to mitigate might increase because his neighbor convinced him to do so, or because his assessment of risk increased. Are these changes due to the process grant and how would we know? Measuring the benefits of hazard risk reduction are most easily done in terms of reduced property damage or a reduction in injuries or mortality. Again, these savings can be directly tied to mitigation activities themselves, but perhaps without the initial process grant, the activities would not have been undertaken (e.g. new building codes would not even exist).

Because of this complexity, and because virtually no known study isolates the benefits of a process grant from benefits of mitigation actions, it is assumed that the net benefits from mitigation activities (total benefits minus the costs of implementation) that are related to a process grant, inclusive of the cost of the process grant, are rough indicators or measures of the net benefits of a process grant.

The limited resources of this study do not allow primary methods to be used to assess the benefits of process grants in these categories. The next best approach is to base benefits estimates on the "Benefits Transfer" approach using existing literature and expert judgment. However, strictly speaking, this approach can not be applied, because no data on process grant benefits are available in any study the project team could find. One generally undisputed

outcome in the literature that gauges the effectiveness and accuracy of the Benefit Transfer approach is that the transfer context should be as similar as possible to the original study context. For example, if one wishes to use literature to assess the effectiveness of a process grant for developing new building codes in southern California's urban areas, specifically targeting reduced earthquake damage to multi-dwelling buildings (apartment buildings), then the ideal study is one with the same conditions. Therefore, it is best to consider the analysis below a step beyond a *qualitative analysis*.

K.2 Analysis

With the time available for this project the project team looked across a wide range of studies in all three categories of process grants. No studies were found that explicitly and carefully focused on the benefits of a process grant only, or isolated the two components above. Only two studies were found that could be used to examine a specific process grant and its cost. One study examines impacts from a grant to study the impacts on damages to woodframe homes from earthquakes (Porter et al. 2004). The other examines impacts from an improved multi-hazard planning network, again related to earthquake damages (URS Group, 2001). Both studies were conducted in California. In both cases, the mitigation action costs and benefits are included in the calculations. The project team's assumption is that the benefit-cost ratios provided in these studies roughly pertain to the benefits of a process grant in these categories. In one case, the grant cost is added to the total mitigation costs, and the resulting net benefits and benefit-cost ratio are used to represent the benefit-cost ratio for the process grant.

Benefits from reduced hazard risk are typically calculated as estimates of damages avoided, including lives saved, and materials damage avoided. Costs are the costs of the process grant. Ideally, the estimated ratio of the approximate process grants, by category, based on coded information on benefits, cost, location, and other site specific variables would be calculated. If several process grant studies were available, the analyst could weigh the quality of each study and evaluate which study would be appropriate for a transfer.

K.2.1 Process Grants for Information/Hazard Warnings, and Risk Communication

Process grants might also be used to fund improved communication of risks or better warnings of natural hazards. Current issues in risk communication are summarized in Bostrom and Lofstedt (2003), and a report on the state of the art in effective hazards communication is offered by Mileti (2004).

There were no studies we could find that completely assessed the benefits and costs of a process grant in this category, but the one with the most relevance was a cost-effectiveness study for reducing the risks from radon gas (Marcinowski and Napolitano 1993; Doyle et al. 1990). There are examples of risk-reducing projects, but these differ from process grants because the costs are typically associated with direct hazard reduction.⁷³ There are also hundreds of studies that assess the likely adoption of various hazard mitigation activities. These should not be ignored, and could perhaps be used in a qualitative assessment. For example, the radon risk studies (see

⁷³ For example, see the discussion of the use of the FEMA benefit-cost analysis module for estimating the net benefits of flood hazard reductions (http://www.demo.dcc.state.nc.us/mitigation/case_mecklenburg.htm)

Åkerman, Johnson, and Bergman (1991) or Smith et al. 1995) suggest that when faced with mitigation costs, individuals do assess the information provided to them and many do adopt mitigation, or engage in averting behavior.

There are also studies about information campaigns and their effectiveness that demonstrate that such programs can be highly beneficial to society (e.g. the Smokey the Bear advertising campaign, which reduced forest fires), and studies of government-funded programs to label goods and services which pose risks to consumers (e.g., Golan et al., 2000, conclude that nutrition labeling programs have been effective, and cite a case study by the Food and Drug Administration that showed benefits outweighed costs)⁷⁴.

The closest study that could be found addresses the cost-effectiveness of the U.S. Environmental Protection Agency's public information program to urge public testing for radon, before and during real estate transactions (Doyle et al., 1990; Marcinowski and Napolitano, 1993). Doyle et al. (1990) surveyed 920 households to gauge responses to the public information and awareness campaign on radon, which they name the "Washington, D.C. Radon campaign." This campaign was a cooperative effort between WJLA-TV, Safeway foodstores, and Air Check, Incorporated (see Chapter 2 details in Doyle et al., 1990). As part of the campaign, radon test kits were sold at 125 Safeway stores at a 50% discounted price. Doyle et al. (1990) offer no estimate of the cost of this program.

They estimate that only 1.2% of the group of households with radon concentrations exceeding the EPA action level of 4 picocuries per liter of air, or pCi/L, took remedial actions in response to the campaign. They conclude somewhat negatively:

"A radon testing and information campaign aimed at the general public was shown to result in very low ultimate mitigation rates. Many of those who claimed to mitigate did not do so in an effective way...many of those who did test could not recall their radon reading or recalled it incorrectly." [Doyle et al., 1990, p. 55]

The Macinowski and Napolitano (1993) analysis also considered the basic standard level set at 4 pCi/L. The authors apparently did not know the exact response rate to the public information campaign, stating only that it is known to be less than 100 percent. However, they conclude that even if only 10 percent of all homeowners test and mitigate, 220 lives would be saved annually, and that the EPA information program would be cost-effective. This might be high, given the findings by Doyle et al. (1990).

The conclusion is based on the comparison of cost per life saved (in the range of \$400,000 to \$2.4 million) to the value of a statistical life (in 1991, \$2 million to \$10.5 million). The authors state that the cost of a radon public information program would be about \$2.2 to \$3.3 billion per year nationally (they state 0.2 to 0.3 percent of the \$115 billion the nation spent on pollution control in 1991). However, it is not clear whether this total program cost includes testing (such

⁷⁴ FDA estimates that the benefits of enhanced nutrition information (e.g. reduced fat and cholesterol) greatly exceed the costs of the program to provide such information. This study would not be appropriate for use in this analysis however, because the nature of the risks associated with fat and cholesterol are quite different than those associated with natural hazards.

as mentioned above by Doyle et al., 1990), mitigation, and other activities that are over and above any program cost that might be construed to be a process grant.

It should be noted that for radon, most all of the high risk (when the concentration is over 4 pCi/L) occurs in only about 6 percent of U.S. homes. The average lifetime risk of getting lung cancer from exposure to radon in these homes is quite high: 1 in 50 (for a non-smoker the average falls to 1 in 500, which would still be considered a high risk). Averaging across all homes in the U.S., average risks would be quite low because most homes have radon levels below the EPA action level.

The validity of the radon risk example for use in assessing other natural hazard risks (flood, hurricanes, earthquakes) would depend on key differences between radon risk and natural hazard risk. One immediate difference is that radon gas releases are ongoing, while most of the natural hazards of interest would be sporadic or episodic. Another is that radon gas is colorless and odorless, giving no cues as to the risks. The validity would also depend on whether the hazard risks are highly concentrated in a few local areas, and the difference between the mortality risks in those areas and the mortality risks in homes with high concentrations of radon.

Another study that has relevance on the value of communicated risk information was a study of land fill or waste disposal siting by Bernknopf et al. (1997). In this study the authors examine the value of improved geographic information system (GIS) maps, weighing the costs of improving the maps and the resulting benefits in terms of avoided expected losses in property values. They find that the net benefits for their example context of Loudoun County, Virginia, are approximately \$0.34 million. Using the cost and benefit numbers provided in their analysis, the implied benefit-cost ratio is 1.29. Benefits are expressed as the difference in expected losses when using one of two maps, and are solely couched in terms of average county property values.

We assume that for risk information, the benefit-cost ratio is 1.2, which is lowered from the Bernknopf et al. factor of 1.29 because of the discussion for the radon study.

K.2.2 Process Grants for Multi-Hazard Mitigation Plans

Mecklenburg County, North Carolina (which contains the city of Charlotte) recently revamped the use of, and type of floodplain maps because these were out of date. In the process of doing this, they county realized they had an opportunity to consider regulation of new development, adding future flood protection. Overall, this fits into the category of a multi-hazard mitigation plan.

The Mecklenburg floodplain is an area that has floods that led to 754 claims and \$13 million in insured losses, up to the year 2000 (Canaan, 2000). The County hired a consulting firm at a cost of \$1.4 million to update its maps. It also hired a consulting firm to assess flood losses, using the NIBS/FEMA HAZUS methodology (EQE, 2000).

The EQE (2000) study is informative, but it is not exactly a process grant, nor is the analysis consistent with the idea study that could be used here. The consultants use methods, including the Federal Insurance Administration's depth-damage curves, to assess damages in the

Mecklenburg floodplain under several scenarios, including projected future losses. Estimates of the percentage of buildings damaged by floods matching three scenarios are presented in this report, varying from 3.3 percent (for schools and libraries) to a high of 39.4 percent (business/professional and technical service buildings).

They project a total increase in structure damage from \$8.5 to \$25.2 million, based on a comparison between new estimates of current damage using the new floodplain delineation and future damage, projecting growth and development within the newly delineated floodplain. They suggest that County pursue mitigation measures to avoid this \$16.7 million increase in structural damage, with similar analysis for avoiding content damage. Reversing this picture, one could say that the study would lead to savings of \$16.7 million in structural damage, and \$16.4 million in content damage, if mitigation measures are adopted to avoid the future scenario. The study mentions that removing the structures from the floodplain would cost approximately \$12 million. One estimate of net benefits in the structural damage avoidance is then about \$3 million (\$16.7m less \$12m, less \$1.4m for the process grant), or a benefit-cost ratio would be about 1.25 (\$16.7/13.4).

The TriNet project (see URS Group, 2001) is one of the only other studies found that might be used to assess the effectiveness of a process grant in this area. The project emphasizes improved building codes, but was funded under FEMA's Mitigation Grant Program with other features, including a plan for improved data transmission, improved spatial resolution of the geographic variation in earthquake ground motions, and improved motion sensors. These features were designed as part of an overall plan to reduce damage from earthquakes, so it might be best placed in this multi-hazard plan category. The grant is a process grant, for a total of \$16.76 million. The impact of the grant was not only on reduced building damage, but also on reductions in power outages, and reduced casualties. In addition to the grant's cost, there were costs of \$23.1 million for replacing/retrofitting old code buildings, and \$12.4 million in developing codes for new buildings. The total net benefits of mitigation, excluding the process grant, were estimated to be \$37.8 million. Assume that the process grant can be added as a cost, and that the net benefits of the project are then total benefits minus total costs. By adding the \$16.76 million to the estimate provided in the report, net benefits are still positive. Put another way, the benefit-cost ratio without the grant cost is 2.06. The benefit-cost ratio, including the grant as part of costs, falls to 1.4, but is still above one. The assumption is that the benefit-cost ratio that is relevant to the process grant is the same 1.4.

Another study that has some relevance was recently completed by the North Carolina Division of Emergency Management (see NCDDEM in conjunction with FEMA, 2004). This study assesses the savings (benefits) of a hazard mitigation grant to relocate and elevate homes in the floodplain in Belhaven, North Carolina, as they accrued from avoided losses from Hurricane Isabel. The grant, including state matching funds, was for about \$9.3 million. Preliminary estimates indicate that within 2 years of the grant being provided, a return on investment of about 37% has been achieved. It is too early to consider this a complete benefit-cost ratio, but the study is optimistic regarding the return on this mitigation grant.

K.2.3 Process Grants for Changed/Improved Building Codes

This category pertains to the adoption of various building codes to mitigate against hazard damage, most frequently from earthquakes. Earthquakes cause property damage depending on the intensity that buildings are shaken. At the more moderate end of impacts, there will be the need for slight repairs and at the more severe end, entire structures can collapse and be beyond repair. Under many zoning plans various urban or regional zones are designated with codes as to their seismic risk, and building codes are adjusted to factor seismic loads. The benefits of more earthquake-resistant buildings (again, not a process grant per se) are going to be related to reduced property damage, injury, and mortality rates (Schulze et al. 1987).⁷⁵

The risk and economic issues are similar to the ones above in this category of process grants, with two important additional features:

1. Tradeoff of destroying existing structures with loss in buildings of historical value and importance or loss of low-income housing; and
2. Perception of some buildings as public goods, and building code adoption as a public good; differentiation with privately owned buildings.

Porter et al. (2004) provide an extensive and careful analysis of the benefits of retrofitting woodframe homes. This is the one paper that does seem to tie the analysis to a process grant (\$5.2 million for the CUREE-California Woodframe Project). Most analyses of the benefits of building codes, such as theirs, focus on property damage. Benefits are measured as losses averted, whether these be in minor repair bills over time, or more major reconstruction. Using a series of equations and Monte Carlo simulation of some of the probability distributions involved, the authors estimate whether retrofitting is cost-effective for areas corresponding to 1,653 California zip-codes. Assuming a 3 percent discount rate and a 30 year planning horizon, the authors estimate that the reduced future earthquake repair cost exceeds the cost to retrofit a certain small house (by adding foundation bolts, structural sheathing to unbraced cripple walls, and the strapping water heater to the frame), if the house were located in any of about half of California ZIP Codes (781 of 1,653). An above-code design for a particular townhouse building is estimated similarly to reduce future earthquake repair costs by more than the additional construction cost of exceeding code requirements, if the building were located in any of 300 California ZIP Codes.

Porter et al. (2004) also examine the benefits of high-quality construction, finding that median savings stemming from reduced seismic risk are from \$1,000 to \$10,000 over a thirty year period. The paper argues for frequent construction inspection, based on the results.

K.3 Conclusions/Caveats

Information on the benefits and costs of process grants is scant, at best. The analysis above draws heavily on similar analyses, as only two studies allow a direct comparison of some type of

⁷⁵ The Schulze et al. (1987) study is dated, but these authors use simulation methods and conclude that expected benefits from adopting uniform building codes that reduce wind, property damage, and reduce mortality from earthquakes along the Southern San Andreas fault outweigh the costs, at an assumed 4.5% real discount rate.

benefits to the cost of the grant (URS Group, 2001; Porter et al., 2004). Therefore, in each category the benefits relative to the costs of mitigation actions (not process grants per se) are mainly considered, but the table reflects consideration of whether the process grant would tip the balance so that net benefits were negative (or the benefit-cost ratio was less than one). When the difference between benefits and costs of mitigation is large relative to the cost of the process grant, it is more likely that a process grant is cost-effective.

Recall that there are no available benefit-cost analyses for category A, the natural hazard risk communication studies. This category is split into two separate subcategories, risk warnings, and risk education. It is more likely that a process grant will have positive net benefits when it relates to direct warnings. The project team used information from the radon risk public information program study (the Washington Study), and differences between the radon context and the natural hazards context have been noted above.

Table K-1 Conclusions on likely benefit-cost ratio for process grant categories

Category of Process Grant	Likely Net Benefits or Benefit-Cost Ratio
A1. Risk Communication (warnings)	Qualitative Adjustment from Radon - Judgment Only- Positive (1.2)
A2. Risk Communication (education)	Inconclusive
B. Multihazard Mitigation	1.25 - Weakly Positive (1 to 1.4)
C. Building Codes	Positive (> 1)

Many of the process grants analyzed are for earthquake-related damages, and are most likely related to building codes. One of the grants (Grant 7201) is for Steel buildings, but no information is available on grants or mitigation activities in that category. Grants related to Tsunami guides and grading are most likely falling into the multi-hazard category. Except for Steel Buildings and for the seismic map project, a conservative estimate of the benefit-cost ratio applicable for process grants in these categories is 1.25 to 1.4. This range is based on the Mecklenberg studies and the URS Group report, which is most applicable to multi-hazard grants. As there is a map involved for the seismic mapping process grant, another estimate to confirm this range for the benefit-cost ratio is 1.29, which based on the Bernknopf et al. (1997) study of the value of map information. Applying this study assumes that property value changes fully capitalize the hazard warning effects via the housing market.

Building code process grants likely have a larger benefit-cost ratio. In addition, if a process grant is small, it is quite likely that its net benefits will be positive, based on the Litan et al. study of earthquake mitigation. The reason is that their average benefit-cost ratio is about 3. Therefore, any process grant that is small, and which does not have negative consequences in obtaining mitigation, will only slightly raise costs, and therefore slightly reduce the benefit-cost ratios in this category.

First, as noted above, most of the literature available does not assess the benefits of a process grant in any of the above categories. Rather, some of the literature assesses the benefits and costs of a particular mitigation action itself.

Based on logic and effectiveness in other contexts (see Golan et al., 2000) there is reason to believe that process grants provide positive net benefits in many situations. The mitigation action in many cases would never have taken place if a process grant had not spawned the initial plan or building code that led to implementation. A simple, common sense conclusion would be that when net benefits from mitigation in a particular category, exclusive of a process grant, are large, then a small process grant certainly cannot much reduce the net benefits, so any grant in that category is likely to be positive. However, when actual mitigation is quite costly to the individual, it is much less likely that a process grant is going to lead to positive net benefits.

Some caveats are warranted. It has to be stated clearly here that in the project team's literature search, no studies were found that specifically estimated the benefits of a process grant, which is the goal of this analysis. Possible key differences between radon risk communication and a natural hazard risk warning were noted: it is not known, however, if the Doyle et al. (1990) finding of about 1.2 percent adoption would pertain to natural hazard mitigation adoption. Therefore, one view of this is that none of the estimates are free from concern regarding their accuracy. Only available information is being used, which largely pertains to benefits and costs for mitigation activity grants.

Second, there is still not enough information on the effectiveness in terms of adoption of a mitigation action in the literature to generalize in the above categories. Third, blanket categorical benefit-cost ratios are unwise. Last, there is likely substantial regional variation in adoption rates, and hence, regional variation in the effectiveness of process grants (e.g. see Lindell and Prater, 2002).