Two approaches to flood magnitude and frequency computation for ungaged or inadequately gaged sites are used. One is regression analysis in which the magnitude of the 100-year flood (Q_{100}) at each gaging station in the general area is related to such parameters as drainage area (A), stream slope (S), areas of lakes and ponds upstream (L), basin width (W), and annual precipitation(P). The resulting equation, in the form, $Q_{100} = a A^b S^c L^d W^e P^f$, is used to estimate the 100-year flood at ungaged sites; the basin parameters are measured from maps. The other method uses unit hydrographs and statistically derived design rainstorms. Each method has advantages and disadvantages, supporters and detractors.

Flood characteristics are substantially modified by works of man. Flood-control reservoirs, retention basins, and certain land treatments generally reduce the magnitudes of floods and may have a major impact on flood-plain use. Development of an urban basin with pavement and sewers generally increases flooding, especially the magnitudes of the more frequent floods on small streams. The Geological Survey and others are investigating the "urbanization effect" by operating special urban-area gaging stations and calibrating rainfall-runoff models.

With regard to flood-plain use, a floodway is the main channel of a stream plus portions of the adjacent flood plain that in the future, are to be kept free of all structures. The floodway fringes are the remaining portions of the flood plain and building and filling are permitted there with certain restrictions. The floodway fringes are so located that their complete filling or obstruction would raise the 100-year flood profile by no more than a specified amount ordinarily less than a foot. The hydraulic computations are fairly straightforward but economic, legal, political, and ecologic factors make the matter of floodway use somewhat controversial. Transportation is involved as railroad rights of way are often in the floodway and the right to maintain and modify embankments and structures located there is not yet clear. Hydraulic design of bridges, especially those on secondary roads, could raise problems. In densely populated areas with flat-gradient streams, even minor additional flooding may be intolerable. Extremely wide flood plains provide natural reservoirs for floodflow storage and widespread filling of them may increase floodflow downstream. Problems are plentiful in floodway design, but few of them are technical.

Water-surface profiles of 100-year flood events, computed by different agencies, often disagree substantially even when identical values of discharge are used. A great deal of judgment in data interpretation is involved and there is no universally applicable procedure. The Water Resources Council's Bulletin 15 (an updated version is being prepared) was designed to help unify procedures at gaged sites. Most differences are resolved locally by the agencies involved. Some States coordinate the various values submitted before adopting an official regulatory flood value for zoning purposes. A National Academy of Sciences panel studies both sides of the very few unreconcilable differences. The value accepted by the panel is official for virtually any purpose.

Hydrologic techniques, though far from perfect, provide a technical basis for flood-plain management decisions that can dramatically reduce the horrendous damages resulting from past encroachments on flood plains.

IMPACT OF FLOOD PLAIN REGULATION ON RAIL TRANSPORTATION

D. S. Bechly, Engineer-Structures, Illinois Central Gulf Railroad

In the remarks that I am about to make, I would like to bring to you some thoughts, based upon my experience, as to the impact that proposed flood plain regulation may have upon the railroad segment of the transportation industry. In making these remarks I am speaking as an engineering officer of the Illinois Central Gulf Railroad and my data base, so to speak, is confined to the impact on that particular railroad. However, as it is one of the principal railroads of the country and operates throughout the length of the Mississippi River Valley, I would believe that these remarks would be typical for the railroad industry.

The purpose of the presentation this afternoon is to attempt to make you aware of the topic of flood plain regulation. The widespread formulization of such regulation is a current and ongoing thing, and most of us in the railroad industry have not yet had to come to grips with it. As the previous speakers have indicated, the current concept was developed primarily in connection with the underwriting of Flood Protection Insurance Programs which, in my understanding, have been developed primarily for the housing industry. Nevertheless, the present and forthcoming regulations will definitely affect the railroads of the country. This effect will not necessarily be bad, but it could be

a troublesome problem if we do not all become aware of flood plain regulations and recognize our involvement with them.

The railroads of the United States of America were built, to the greater extent, during the middle and latter parts of the 19th Century. When their alignments were selected, those pioneers attempted to find the most economical route between two points and quite often followed rivers and their valleys to do this. This provided a route with the minimum rise and fall particularly necessary for the low powered stream locomotives of those days. But where did this method of location place the railroads? In flood plains! And not just crossing the flood plains, but running longitudinally through them from end to end. Naturally, any regulation of flood plains must have an effect on the railroads. These regulations will not, of course, force the railroads from their present location, because I believe all of them will permit continuance of existing usage. It is in the acts of maintenance, reconstruction, improvement and new construction that their impact will come.

One might question whether the railroads are doing any new construction, but they are. Generally not in spectacular new long through routes, but in small segments here and there of a half mile to five miles each. To serve an industry, reach a mine, improve alignment or reduce a grade. There are also new railroad facilities constantly being constructed, ranging from the spectacular multi-million dollar automatic freight car classification yards to smaller storage yards, sidings, repair tracks or other facilities that may be required to keep a railroad running. We have been involved in a flood plain encroachment in one such activity; namely, a study for a possible new classification yard. In this instance, the solution required the lateral shifting of the yard's location to move it out of the flood plain. The effect of this on the cost of the project was not determined, and there were, undoubtedly, both plus and minus cost factors. The important point to be noted is early recognition of the infringement, so that adjustments in the plan will not be required at a later date if the project should go forward. While the change was readily accomplished in this case, it is easy to see how certain types of proposed construction along or across a flood plain could be drastically affected, or even made impossible, by some of the types of regulation that have been enacted or are being proposed. For example, a fill and a small bridge for a track to serve an industrial spur could be constructed across a minor flood plain and probably so built that they would resist the occasional flood of consequence even though partially damming the stream and causing the water elevation on the upstream side of the embankment to be higher than it would have been if the embankment had not been built. Most flood plain regulations would now prohibit such construction and require that enough of the plain be bridged with spans of sufficient length to prevent the impoundment of any water or change in its velocity. This could be economically unfeasible and the spur, and possibly the industry it was to serve, would not be built. Whether this is good or not the regulations have been properly administered. If, by administration of sound regulations a railroad has been prevented from constructing a line that would be both hazardous to itself and to the public, this is, undoubtedly good. If, on the other hand, arbitrary administration of a poorly developed regulation prohibits construction that would not, in fact, have adversely affected either the owner or the public, this is not good. The agencies with whom I have discussed the problem indicate their intention to recognize the practical economic needs of all concerned; the owner, the business community and the public, when considering the environmental and philosophical aspects of each case in order to not unnecessarily restrict the growth of the community.

As an engineering and maintenance of way officer of a railroad, with my primary responsibility being for its bridges and buildings, I am personally more concerned with the effects of flood plain regulation on the maintenance of our existing facilities. The regulations generally indicate that maintenance of existing facilities in flood plains will be permitted and that permits to perform routine maintenance work will not be required. This obviously includes everything from surfacing the track, replacing worn-out cross ties or repairing grade crossings to painting bridges and buildings, repairing or replacing individual bridge members and oiling or greasing the machinery of a movable bridge. Where, however, does routine maintenance stop and some type of construction that requires a permit start? For example, ditching, widening or raising an embankment, cutting brush and weeds, placing riprap around ends of bridges to prevent scour, re-driving individual bents of timber trestles and numerous similar items. To the railroader these are all ordinary maintenance operations and have historically been performed year in and year out without any thought of outside permission. Remembering that a large percentage of many railroads' mileage lies within flood plains, will this continue to be the case?

Then take the instance of reconstruction of facilities; the so-called additions and betterments, or capital account work such as the replacement of an existing bridge. Here we probably enter into a field where permits will be required. Of course, they may already be required in some States for certain types of streams, but it appears to me that the flood plain regulation will broaden this concept widely so that it will include virtually every bridge, trestle or culvert replacement. This will require time, patience and paperwork. To obtain the time, and who knows how much time will be required to process the permit, longer range planning will be necessary. Reaction to an inspection calling for reconstruction will be delayed except in cases of a true emergency. It is recognized that most railroad bridge reconstruction is done with a certain amount of long range planning, but quite often this planning has been rather general and subject to last minute adjustment of priorities based upon changing field conditions. Will this continue to be possible?

Of particular concern to our railroad, and I am certain to many of our counterparts, is the fact that when our roads were built, it was often the practice to build long timber trestles through river bottoms and other areas of low lying ground, even though not required for drainage purposes. They were built because trestle construction was less costly than building an embankment using mules and slip scrapers. This was particularly true where a source of fill was at some distance from the site. Over the last 30 year period we have had an ongoing effort to replace much trestle of this nature with fill as each trestle came up for renewal. This has been done both because fill would cost less than trestle construction, and to eliminate fire hazards and maintenance problems. Such fill has only been placed after a thorough drainage investigation was made and it was found that the old lengthy bridge was not required for waterway purposes. We made these studies because we were no more interested in causing a flood or washing out our tracks than anyone else. However, on a non-critical branch line we may sometimes be willing to risk a slight wash-out at the bridge end during times of a 100 year flood to gain the lower cost benefit of the other 99 years of economical service. I do not consider this reckless management, but the question is not raised as to whether such self-determined options will continue to be available under the administration of flood plain regulations. One would hope that they will, but we should be prepared to face the fact that they may not. Regardless of this feature, we probably will have to face the fact that it may take lengthy and time-consuming negotiation to arrive at permission to fill an unnecessary portion of an existing bridge.

This second involvement in this bridge replacement aspect can be in the type of structure to use. Except for main stream crossings, we have found the greatest economy in the use of trestle type construction. Here I speak of treated timber trestles with 13 foot span lengths. We find these trestles to be satisfactory even though they do, from time to time during periods of high water, require the removal of quantities of drift accumulated on the upstream side. The closely spaced bents and the drift accumulation may cause a slight damming of the stream which, while practically insignificant, may technically be an obstruction that will not be permitted. This brings out the economics of longer spans. On our railroad we replace from 10 to 15 thousand lineal feet of timber trestle annually at a cost of approximately $300 per lineal foot. To replace this with steel or concrete trestle with span lengths in the 30 foot range would cost $500 per lineal foot. Longer girder spans in the 100 foot length category which could be required to pass moderately heavy drift, cost nearly $1,500 per foot. To go to truss spans of greater length raises the cost by two to four times this amount. What level of flood protection can we afford?

I am not bringing up the aforementioned examples as a scare tactic; nor as an attempt to talk against reasonable flood plain management, but I am concerned about unreasonable or arbitrary administration of flood plain regulations. In other aspects of my railroad duties, I am involved in water pollution control. Here I have seen some very arbitrary and economically unjustified decisions by administrative bodies where they have forced us to toe the line to the letter of the law without regard for cost even though only a slight additional benefit would be gained. I would hope that this does not become the case in flood plain management.

There are a number of problems that need to be considered by the railroads in connection with the management of flood plains. One is consistency in regulations. Our railroad, for example, operates in 13 States covering 283 counties and an uncounted number of townships.

Theoretically, all of these units could have different flood plain regulations. Hopefully this will not be true. We in the transportation industry who are affected by such geographically oriented differences should work together for unification wherever possible.

In addition to working toward consistency of regulation, the transportation industry should strive, in every way that it can, to insure that permit applications are reviewed by competent personnel. This probably will be reasonably assured when dealing with the States and large metropolitan agencies. There is, however, a possibility that in the smaller units of government the review may be by non-professionals. Here, the problem exists of their not being aware of the consequences of arbitrary decisions. Nor may they have the background necessary for reasonable judgements. What, if any, the appeal process would be remains to be seen. But if an appeal is necessary, it will involve further project delay. This could be particularly significant in the field of industrial site location where the manufacturer to be served by the railroad must get his plant under construction on schedule if it is to be a profitable enterprise.

In summation, as for the impact of flood plain regulation on the railroads, it becomes apparent that these regulations will require longer range planning in order to obtain the necessary permits for construction within a flood plain, and they may result in higher first costs. There will, of course, be compensating benefits; primarily the development of relatively flood-proof construction and the not insignificant benefit of management of the entire flood plain. This may preclude upstream construction by others of large building projects, parking lots or similar features, which, in the past, have caused the railroads serious problems because of resulting increased rates of runoff.

I do not feel that the railroads need to be afraid of flood plain regulation, as it has always been to our advantage to carefully design and construct our facilities in a manner that will minimize the risk of consequent flood damage. This has been done because the railroads have recognized that they are in business to stay and that they must live with whatever they build. Nevertheless, the probability remains that flood plain regulation will increase the time required for the planning of a project and possibly will unnecessarily increase the cost of that project. This will be up to the judgement of the reviewing agency and hence not in the hands of the owner.

IMPACT OF FLOOD INSURANCE PROGRAM ON HIGHWAY TRANSPORTATION

Samuel V. Fox, Hydraulic Engineer, Texas Highway Department

Flood plain management and flood plain insurance has had an impact on the transportation community. I can't deny that, but it is not something that started just recently either. It dates back to Executive Order 11296 that the President of the United States, then President Johnson, issued dealing with Federally financed programs in flood plain areas or hazardous areas. This began the move toward individual Federal agency concern, the development of more agency regulations, and more agency involvement in flood plains. Of course, we unlike the railroads, have the Federal Highway Administration, then the Bureau of Public Roads, to take care of us and out of their infinite wisdom, in 1967, they jumped in early and developed certain interpretations from the Executive Order. At first some State highway engineers felt more strain from Federal regulation; however, when the smoke cleared, we found out that we were not really as far apart as we first thought and that we in the transportation field, in many areas of the country, were already being guided by a very sincere concern about our involvement in the flood plain. But in the absence of centrally concerted efforts with respect to building in flood plains we mostly had to steer our own course. This meant the development of design standards on a State to State, county to county, and city to city basis, to reflect various levels of moral, ethical and legal concern with an eye on staying within certain budgetary constraints.

Because of Executive Order 11296 other agencies began to be more involved. Flood plain insurance came upon the scene in 1968, the Corps of Engineers developed their Flood Plain Information Reports, concerns for the 100 year flood event surfaced, and contracts were negotiated for studies by consulting engineers, and so it went.

The Federal Flood Insurance Program has had a subtle impact on the transportation community. Witness the fact it was enacted in 1968 and this is the first serious meeting to discuss its relation to transportation. With its associated criteria there are evolving local ordinances and State ordinances that have or will have a tremendous impact on highway transportation, city transportation facilities, and county transportation facilities. But I think that even though this TRB session is aimed at discussing impact from the Flood Plain Insurance Program, if we are really going to understand the total picture and involve ourselves in the total concept we in the transportation community are going to have to think of ourselves as being involved in the total flood