Dave Rosgen – Flow 2015, Lunch Keynote, Portland, Oregon, April 29th, 2015

IAN CHISHOLM: Settle down here. Hello, my name is Ian Chisholm. I work with the Minnesota Department of Natural Resources. I'm standing in front of you today not only to get you to be quiet but also to introduce our keynote lunch speaker Dave Rosgen. Dave comes to us today with over five decades of experience working with rivers and applying and sharing that understanding with others. And whether you think highly of him for that or otherwise, he has changed the way we view and deal with rivers; that's undeniable. I've had the luxury, and I think the luck, of knowing him in some capacity for over 25 years. He has an important message for us in light of hydrologic uncertainty and river stewardship, and so without further ado, I give you Dave Rosgen.

DAVE ROSGEN: Thanks, Ian. We'll see if you can eat and think at the same time and maybe even carry on. So if there is anything that I say that may offend you, it's Ian's fault because he's the one that invited me to be a luncheon speaker. But I'll start with kind of a funny story. I was coming out of an airport heading to Chicago to a fancy hotel. The hotel had this fancy bus, pretty good-sized bus. So I along with 40 people were crammed in this bus and we're heading to this fancy hotel in Chicago and I was supposed to give a presentation there to about 500 people about fluvial geomorphology. So I sat down next to this gal and so after a few minutes—I was dressed like I normally do, in my wranglers and boots and hat—and so I turned to her. I say, "So how come you're going to this fancy hotel?" She says, "Well, I'm going to a scientific conference." I say, "Oh, that's good." I say, "Well, what's it about?" She looked at me and she says, "You know, I don't think you'd understand." And I said, "Oh, it must really be complex." "Oh, you don't have a clue." And I said, "Well, what is it?" She looked at me, "Well, if you must know, it's fluvial geomorphology," and I went, "Whoa!" "I told you," she said. So there's kind of a lull in the conversation and so finally she looks back at me. She says, "Well, what's someone like you doing, going to a fancy hotel like that?" Then I paused and I say, "Hell, I've got to give an all-day presentation on fluvial geomorphology." She says, "Oh, my God, you're not Dave Rosgen?"

Anyhow looks are deceiving. So go ahead and eat. I hope I don't interrupt your digestive processes.

(Slide 2) We're going to try to go through some information that deals with uncertainty to a certain extent, but there's actually more certainty of things that we actually know about. But you know what I find the problem is? Sometimes we don't apply all the stuff we really know. It's hard because of political and social economics, a lot of things that interrupt science and applications of science that we know should be applied.

But, again, what we're looking at, the topic here is the uncertainty that we're facing; however, with instream flows and river management there are some certainties. You can be certain that there will be increased demands for water in diminished or limited supplies. Number two is our population growth and development will continue, requiring more water for urban use which is a constant demand.

Flow extremes are expected due to climate change and land uses that influence extremes. Within the same year, you can have a massive flood and drought, and we're seeing these extremes of flow conditions. So we have to recognize that that's here, it's not something we're going to forecast because we've already observed it, and it's not going away. So this is a certainty. We also have a certainty that there's going to be continued demand as our population continues for production of food and a lot of that comes from irrigated agricultural practices -- my thing is not to put a fence around something to say, "Hey, we shouldn't go there," but figure out a better way to do things because the reality is we are going to be faced with how we deal with these continuing demands.

When I do watershed evaluations, we look at the four C's. The first C is to understand the cause of change, the cause of impairment, the cause of problems we have with instream flows or erosion, deposition or erosional processes, and the list goes on.

Once we understand the cause, we have to understand the consequence, the "so what?" So, yeah, we have another diversion. What is our geomorphic threshold within watersheds? How much change is too much change? How can we work with management, and how can we work with these systems to try to offset some of the impairments that we've seen in our river systems?

The next C is the cure. How can we go about taking care of this problem? Part of the cure has to do with management, preventative actions in terms of how we go about accessing the watershed and the utilization of water or possibly misuse of water.

And then the last has to do with the communication. The communication is critical because we have to communicate with those that may have caused the impairment. We have to communicate with those who might have some funding or a budget who can actually pay to do restoration. So these are things we have to be aware of as we face these challenges about conflicting and competing uses of water under the constraints that we live in and the continued demands on the water resources.

(Slide 3) So what are some recommendations? We got to be looking at the conservation and management of water resources. The conservation of water is so important. Las Vegas, they are paying people and they've already spent millions of dollars for people to roll up their lawns and put in desert vegetation that doesn't require water. This is going to happen in a lot more places, especially in urban setting as we're starting to look at re-use of water, in terms of treatment for waste water. Eventually you might even see a transmission line going across from the ocean to Las Vegas and Arizona because people who made dry camps realize they got limited water resources so we may have an ocean front property in Arizona after all. As we're bringing in that water from the ocean, we're probably going to be looking at desalinization plants, and probably in my life time that's going to happen because we're seeing dwindling supplies with continued demand, especially in population centers that have made these dry camps like in Vegas, Los Angeles and Phoenix, etcetera.

Another main direction is how can we restore a lot of our impaired steams so they can make better use of the same water. This has been a big issue because we've got some realities to face because instream flows are limited and are set a lot of times illegally, and so as a channel changes because of disturbance, all of a sudden we find we don't have enough depth or we don't have the right conditions for certain species, age class or life cycles from a fisheries' perspective.

Well, the reality is in the certainty that they're probably not going to give you more water, unless we can change some management and uses of water where we can get more. But this has been more of a challenge, so we have to think about how we can restore the physical and the biological functions of river systems, which includes floodplains, floodplain connectivity to handle floods and a range of flows, and the riparian ecosystem.

(Slide 4) So one of the big things that we find that is important, and some of the talks we heard earlier this morning were reminders of that, is what happens if we don't develop a master plan for a watershed that involves everybody, including the agencies and land owners. The master plan starts bringing together the objectives of what are we are trying to accomplish in terms of livelihood, in terms of goals and objectives, this includes fisheries, land values and the list goes on. A master plan has to address not only the community but we have to conduct assessments to determine what's broke, what happened, why did that become an impairment, what can we do about it? When we start doing the master plan and we start to identify common problems, that's the best in-road to common solutions, and common solutions have to address not only the cause of the problem but also deal with individuals and landowners to help solve some of their problems, maintain their way of life, but do it in such a way that we can maintain our fisheries, maintain flow in semi-arid regimes, develop riparian ecosystems, wildlife, and the list goes on.

And the reason I mention this, the Blackfoot challenge in northwestern Montana, which involves federal and state agencies, landowners and Trout unlimited, a lot of cooperators that had come together to be able to say, "Hey, here is the problem." Again, they've had past logging and mining and a lot of agricultural use that has not made a good effective use of water. And as result, people realize that some of these values were being diminished in terms of fisheries and things that affected everybody.

When you do a master plan, you neighbor up. That means by neighboring up you realize that together you can solve individual problems. But an individual trying to solve his own problems without neighboring up, good luck. Then you are into the social, economic, and political battles. But using peer pressure of individuals to say, "Hey, you know, we've got to think about this fishery," which is part of the recreation and economic value in that part of Montana, as well as producing livestock and different management activities. That the good news is the government came in and developed a program so they can actually pay to drill wells or to develop ponds to where they could then put water into the pond. Instead of doing a flood irrigation system, they actually paid the individual landowners for big irrigation systems. So you'd have the cost and the infrastructure but someone will try to use less water. A lot of these ranchers couldn't afford it, but by bringing people together who could have some solutions and say, "Hey, you want a center pivot? We'll buy it. All you have to do is manage it or maintain it."

And basically they started to have more and more water available to go in-stream. And these are things that we've seen occur that if one individual just went up to a landowner, "So you guys are using too damn much water on that floody irrigation. You got to be stopping that." Well, you know how would end. But if all your neighbors come together and they started realizing that, hey, this is for the good of the watershed and the good of everybody, we are finding that financially there are some ways of going about this that can use a lot less water to be more efficient with the available water. So there are some good lessons out there about neighboring up associated with the master plan.

(Slide 5) Now the master plan, again, has to focus on common goals and objectives for all users for all people. And also the assessment looks at the nature, extent and the location, and the process is influenced by impairment, what went wrong. Because if you are going to fix something, you got to know how it works, number one. Then you have to know what broke. And this is very important, again, to be able to understand and communicate.

We also develop a whole series of restoration scenarios and management solutions to common problems. This is a very key part; we've been doing master plans for a lot of years to identify a treatment or a solution because a lot of people don't like to go collect data for data collection purposes alone. We only collect data that is driven by understanding the process that we can then turn around and utilize that data to develop design solutions and concepts that address the impairment and that meet the objectives associated with the master plan and again the players, the land owners and the agencies within the system.

So we find that if you have a common problem, you better have a common solution so that you can do something about it rather than just have data and say, "We got trouble." But if we don't provide, prescribe and develop alternatives for management and a restoration direction on how can we fix it and so can better accommodate what flows we have, then you're just going to have another meeting which is going to just be the same old, same old. So again we should be directing this to make a difference.

(Slide 6) So conservation of water, again, has encouraged better conservation for urban, agricultural and industrial uses, so we've got to figure how to reuse water, how to be more efficient with water, and if we are looking at a lot of the urban settings you've got to look at the development of green infrastructure, retrofitting past poor development where they are not using the soil for infiltration and bioremediation, and getting rid of the concrete or at least using impervious concrete.

There are a lot of things that are being done today that are going to help reduce a lot of the wasteful use of water in urban setting. We are pleased to see better planning on new developments that are underway. But we got to go back and take care of some of these problems that we've created by poor planning and get it corrected.

Agricultural irrigation. Okay, this is something we've been working with a lot of ranchers on, a lot of people in the West, not only just for restoration. The Ruby River, for example, in southwestern Montana, a bunch of the landowners got together for the master plan for this basin even though legally they could dry up that stream, but they recognized that if they did—and they are entitled to do this—if they did that, it would wipe out a fishery resource which is economically important in that part of Montana. So as a result they proportionally reduced how much water they would traditionally use to leave more water to go in the stream.

Now if someone would have come along from the government and said, "You guys, you can't do that." But if you do this for the common good, it takes on a whole different field.

And this is something that is exciting because we've got to figure out how to communicate, "How can we work towards some solutions that will help the system and help everybody?" Even though you may get a little less water, you feel good about your contribution. Again we've got to do more of that proportion of sharing of water when we get such a limited supply that you can't dry up some of these systems. So we have to understand that there are different land uses that can lead to diminished flow. And the land uses that we find going on today just drive me nuts because I think, "we know better than that." And the real challenge is escaping from the old habits rather than accepting the new ideas, so we have a tendency to create oversize channels, we have a tendency to do things that you've got to be kidding me. And I was curious about some of the discussions on 404 permits on regulatory. Because I know one thing, the guys in regulatory with the CORE tell me this: if the civil works part of the CORE came to them to get a 404 permit to do trapezoidal channels with rip rap and gabion walls and all that stuff that affects aquatic habitat, they wouldn't get the permit. How do we continue to do work that diminishes aquatic habitat by the same agency that is supposed to protect and enhance fisheries or aquatic resources. I don't know how that works so maybe we will figure that out yet today.

(Slide 7) So what have we learned about this?

(Slide 8) This is the Walla Walla River taking mountain free water in Oregon after the '64 flood. So what do you think they did to fix this thing? Typical levied, over-wide trapezoidal channel, eliminated the floodplain. This took away the ability of the stream to take care of itself. You are going to have aggradation of sediment during the higher flows because it's too wide and shallow. As a result, the stream is going to attack the levies which it does, so what do you think they did to fix this? Yeah, same treatment, they just went back, dredged it out, rebuilt the levies. I got a call last year from the CORE wondering if I could give them some advice about this very location because it keeps eating the levies – so what a surprise. So when are we going to get it right? And so, again, we have got to figure out how to make better use of water not only as a stable functioning conveyance of sediment and flow but also to meet the values, such as fisheries, recreation and the visual values.

(Slide 9) We spent a lot of money to destroy the visual and ecological functions in the name of flood control or navigation, and we are slow to get away from those designs. I fight this, I make a lot of suggestions; not all of them are always followed. But these people travel at night. They don't think we see them because of the camo, but this is what we got to stop as seen in this 1976 photo as they were doing that on the big Thompson River following the flood that killed 147 people. I was involved with that restoration. I was a forest hydrologist at that time but we had to restore 27 miles. So we had to get a stop to that work right away because they were already making it worse. And what's wrong with this photo? They're oversizing the channel to handle floods when in reality the channel now can't accommodate for the flood – that's the wrong design so it's already doing impairments.

(Slide 10) This is on the Big Thompson following the 2013 flood. This picture was taken in 2014 but look at the width-depth ratio. See, this is money spent for emergency flood relief. I look at this and I go, "They have got the wrong width-depth ratio. Again they have oversized the channel." And you know what the answers are? I had put on a training session right after this flood for the agency and I said, "Whatever you do, don't haul off the wood and the trees—thousands of trees came down with this flood—because you are going to use them. You will need them for restoration. So whatever you do, don't do that." Well, guess what? Right away they had contracts to cut up and pack up the wood and haul it off and destroy it, which could have been a good solution for revetment, habitat enhancement and flow resistance that would help the stream and the fish.

But, again, right back into big, oversized channels, so now if you look at the amount of flow in terms of the usable area and the depth and some of the habitat you would like to see and look at that long straight reach, it's going to have to be fixed because that ain't it. You know what the sad part is? They have spent millions of dollars doing this work and then when I confronted them, they said, "Well, we'll probably come back and maybe we will just redo it." Who in the hell is going to pay you to do that? If there is not enough money to do it right the first time, then who in the hell is going to pay to come back and correct it?

I find this as a real, real shame. We should have a master plan in place, just like we do with the fire preparedness, for flood preparedness and know what type of dimensions, pattern and profile, what kind of stream type. What do we do following these emergency conditions when we have major floods or fires? So we've got to understand a direction that meets objectives but this isn't it. But they have spent a lot of money with this and a lot of time. Again, we have got to start all over if we are going to make this a functioning physical and ecological system.

(Slide 11) This was a new project two years ago in Arkansas. People think that's restoration because there are root wads occasionally stuck in the bank, I guess they're for some fish that can actually make it from one root wad to the next one for cover. But anyhow, that ain't it either.

(Slide 12) This is in Ontario, Canada. You know, we have some Canadian friends here, I am sure. You are not personally responsible for this. But anyhow, these are time-released bedload capsules, some people call them gabions, but you see a pretty nice little riparian veg in between, right in here, but they have to clean this out after every flood because it is a flood control project. That's because the deposition of a high width-depth ratio channel aggrades the stream during the flood and overtops the banks, so every year they have got to clean it out.

(Slide 13) Again in an urban setting, how much rock do we want to continue to throw at something as stabilization while we actually kill that river with big expense while losing function and value? So we have to think about what are the alternatives? People are saying, "Hey, we don't want concrete, we don't want gabions. We used to have a river here." So we have got to figure out how we can accommodate a lot of people who are worried about flood risk, they are worried about fisheries, but these are things we have got to think about and we have got to get away from these programs.

(Slide 14) This picture was in Texas—where we are trying to redo some of this conveyance stability stuff.

(Slide 15) Stream crossings – again we have to recognize you're going to have floods as well as droughts. How can we design stream crossings where we don't have the contraction scour, velocity barriers, and a lot of fish passage issues as well as instability of the excess shear created by the down-cut channels that we are seeing here? So, again we know how to design but I can't tell you how hard it is to get engineers and the people in agencies to get away from the standard practice of putting all flows through one contracted opening.

(Slide 16) So we have got to start doing a lot better. This design is something I worked on with the Maryland Highway Department, where before this design they have lost this crossing multiple times with different designs, So getting tired of replacing it, instead of using a "one size fits all" and the hurricanes have to go through it too, I said, "Drain the floodplain as a separate system. Maintain the width-depth ratio of the main channel so that you don't have contraction scour below, you don't have such a high velocity through the main bankfull channel and set the pipes at the invert". But see the difference in elevation between the bankfull channel with freeboard and these particular floodplain drains - they only drain at the incipient point of flooding. Then we made a bench in this entrenched channel.

(Slide 17) And this is the downstream side but we made a bench as a little floodplain bench against the high banks. This is in an urban setting, so even though you don't have a big floodplain, it worked well as a floodplain,

(Slide 18) and then at high water that is what it looks like.

So this design crossing has been through many hurricanes, that is now 12 years old, they have never spent a dime for maintenance but it is a good fishery, it maintains the width-depth ratio of the channel, and it accommodates the flood. We have got to start thinking about how we have to change our design concepts to where we can drain the floodplains as a floodplain.

One of the things we are finding with changing climate and changes in land use, is a lot of people think we have to oversize our channels to accommodate build-out or the unknown of increased flows. The mistake that we are making is you don't increase the channel size, you increase the floodplain, because that's what we're seeing increase in the frequency and magnitude from development and from the climate change is the big water – the flood flows. And you don't do that by oversizing your channel; you oversize your floodplains. Maintain the lower width-depth ratio of the main channel. I'll show you some other things I want to leave as a take-home message for you.

(Slide 19) So, if we look at what's been happening in a lot of agricultural areas in terms of draining the landscape and the loss of fisheries where they have a high potential for fisheries, always understand what the central tendency of the river is:

(Slide 20) It's trying to build a new channel on its own. So it's actually building a new floodplain inside of that previous channel, because as soon as it does that, it reduces the erosion against the high bank before that was contributing sediment. So basically, you're seeing the central tendency to develop a low width-depth ratio channel inside some of these entrenched systems.

(Slide 21) This has developed a fairly good fishery with a low width-depth ratio, low water temperature, and good in-stream cover even though that was a straightened canal at one time. So if we know that, and that you can't always put it back up on top because they still have to farm that field and they don't want that saturated condition, but at least with design you can get your fisheries back by making a channel within a channel and understanding that central tendency and working with that.

(Slide 22) This is a project I was involved with. This is following a major fire in grussic granite materials in Colorado. There's a box culvert there that’s totally filled up - that’s a six-foot deep box, 20-foot wide. It filled up in the first storm. So the county came in and put a bunch of culverts on top of that to get some drainage. Of course, it is a major barrier to fish downstream.

(Slide 23) So what we did – we built a main bankfull channel and then put the flood pipes, flood relief valves, at the floodplain level. We took that same box and we had it lifted up about halfway distance, and actually changed the steam type - filling in and out so that it makes better use of the water. Now you don’t have a fish barrier, plus you can maintain sediment transport through that system, and then when you have a flood, where does the flood go?

(Slide 24) On the floodplain, which we had to construct.

(Slide 25) So if we look at land use and heavy use on riparian vegetation where we changed composition, we’ve had some major instability issues related to stream widening. What happens with these kinds of systems is when we start losing our riparian vegetation, we decrease flow resistance, increase bank erosion, and get a real wide shallow stream. Years ago they would clear the riparian vegetation that’s using water to use that water for agriculture and other purposes. So what happened? The stream widened. As the stream widened, it elevated water temperature, had more evaporative loss because it has more surface area, it decreases sediment transport capacity, aggraded, and then as the stream aggraded, the stream couldn’t have the efficiency to move the fine sediment and the stream became subterranean. That was it. They lost their surface water when they set out to gain more water by eliminating the riparian veg.

(Slide 26) So we’ve got to understand the importance of managing our livestock, and this is a good example in north central Nevada, where I worked with a ranch on setting up grazing management strategies, to where we didn't protect the stream with a fence, we just managed the livestock within that pasture. This was a different ownership downstream, but the upstream section is developing a low width-depth ratio channel with a floodplain, no restoration involved. That's just understanding the central tendency of the stream to fix itself, given the right opportunities. So now we've got a fishery for the same flow upstream, but look – compare the difference upstream to downstream, in terms of water temperature, cover and habitat considerations when you have a change in stream type because of grazing.

(Slide 27) This is looking back upstream. So you can see the same flow is going to work really well. You don't need more water; you basically have the habitat upstream, but as soon as you get downstream, guess what? You're in a situation that you've lost your habitat and your depth.

(Slide 28) So restoration of the river system – in some cases we can't obtain more water, but how can we best utilize the existing flows, knowing you're going to have droughts and you're going to have floods?

We have to think about incised or entrenched rivers. We have to think about the aggrading river system, where the bed elevation base level is raising. We think about the physically-altered systems, those that have been straightened and lined, levied et cetera. What are we going to do about those? And then we have to think about water depletions. And this is a big factor.

In Colorado, the Denver Water Board has taken water from the west side of the continental divide, through the tunnels, to where the population is in Denver. Well, now they're entitled even more than they've already taken. So now, you've got this oversized Colorado River in the upper end of it, and people are just desperate, like "What are we going to do?" Because it's a big channel with diminished flows, so now we are going to lose our depth. The only solution is, you're going to have to looking at build a channel within a channel to accommodate the new flow. We've had to do this on the lower Blanco River in Colorado associated with a trans-basin diversion that had an interstate compact that we couldn't do a thing about. All that water, the majority of it, went to New Mexico through a tunnel. So here we had this oversized channel built with 600cfs, that some days, during the highest peaks, you might get 200, but then when they didn't want the flood, you got the flood. But base flow was 10cfs. And so here's this huge channel that is now not in balance with the flows. And so what we had to do is make a channel within a channel to match the new flow but still be able to accommodate the flood, which we were able create and it improved fish habitat, greatly decreased water temperature, and was a positive project. So these are things we've done below reservoirs to match the new flow based on operational hydrology, which is a reality. But if we don't physically go in there and change a lot of those dimensions to match a new flow, then we're still going to be wringing our hands about "What do we do?

(Slide 29) This is something I put together that represents stream succession scenarios. These are actual rivers; it's not hypothetical and there are more scenarios than depicted here. I can take you to every one of those locations. What this points out is if you're going to do river restoration, if you're studying river impairment and habitat problems, we have to know "What is the right scenario for your stream that's related back to the fluvial landscape type or valley types?" You have to also know what stage that stream is in, and the most important, what's the stable form or the endpoint that we need to be at, based on the central tendency of rivers which we know occurs. It's not one answer, and that's what this shows. And in urban areas, we have to understand confined systems, so we have to find reference reaches that are stable and functioning in confined environments. Just realize that these scenarios exist and it's very helpful when you're doing assessment and developing design scenarios that take care of some of these problems.

(Figure 30) If you don't remember anything else of what I've been presenting or fixing to tell you, don't forget this slide; this is probably the most important concept. And I'm trying to get this across to the people who continue to make a "one size fits all" channel based on a flood capacity design. You've got to think about the four stages. The four stages: the first is groundwater-fed low flow channel. We also relate that to the inner berm, which relays about 30 to 40% of mean annual discharge geomorphically related back to a flow regime. The next stage is the bankfull channel, or termed ordinary high water by the core, they're starting to realize that it should be bankfull discharge, because everybody has a different definition of ordinary high water. But nonetheless, it should be bankfull. Then the floodplain is the active floodplain, the incipient point of flooding beyond that bankfull condition. The last stage handles the big water, the big floods.

You can manage these other surfaces like floodplains and terraces for recreation and trails but you don't want to build houses there. But one of the things we have been doing in restoration is getting away from the "one size fits all" system and developing a four-stage channel system because it's the most efficient hydraulically, it requires less cross-section area because it is most efficient to move sediment. So it gives you a lower width-depth ratio, so by having that inner berm channel and a lower depth ratio bankfull, then you move sediment. And if you can't take care of sediment, you are going to lose habitat.

So you have got to recognize that when you have these floods, and that's what we see with increased development in the watershed and increased flood peaks due to the climate change, then that's what the next levels are for. Every time you break that flow onto another level, you are reducing the risk of flow convergence against the high bank. You also have a water table that allows you to colonize vegetation within the floodplain in terms of the banks, as well as different vegetation for the terrace bank which is an abandoned floodplain.

Remember this: This is a direction we have to go with a lot of these systems that have been made over wide and are not functioning in terms of sediment transport or flow or fisheries, and this is something we have constructed a lot of.

(Slide 31) So I will show you a few more pictures, here is a case where we had a braided channel that used to be meandering. This picture was in '86, and I did that project. But in the 1930s, the stream went from 60-foot wide to 800 and growing, never could recover until we went in and made it this.

(Slide 32) We created a new floodplain, a single thread bankfull channel with a low flow channel. The project was featured in National Geographic water issue one year.

(Slide 33) Then the Blanco River, which again this is above the diversion, had a problem again as a braided channel, but in the past was a meandering system. With the braided channel, we had to basically corral more of the flow and make a four-stage channel.

(Slide 34) This picture was taken in the late fall so everything is cured out even though there is a lot of grass and vegetation and willows. But again if you look close, you will see a low flow channel, which is our inner berm, a bankfull channel, an active floodplain, and then a low terrace. We constructed four stages. It turned out to be very effective.

(Slide 35) This shows again a close up view where for beaver activity we can make these ponds where they relocate from the river into these different ponds. We use the ponds to get material to rebuild the floodplains. But again you can see the low flow channel feature that gives you good depth against wood and a lot of native material we use for structure.

(Slide 36) Then here comes the flood. The good thing about the flood, it deposited fine sediment and 10 million seedlings out on that surface,

(Slide 37) which then basically today looks like this. There are elk calving in there and the willows provide good shade and conditions. So this again is something that I want to point out is that a lot of our impaired streams even with the same flow or adjusted dimensions to match a new flow can maintain some consistency for biological function and value.

(Slide 38) Some people say, "You don't need restoration; just leave it alone, it will fix itself." This has been going on over 120 years. That's imported water going over Poudre Pass Creek going down into the Poudre River system from the west side of the upper Colorado River basin. Again that's a legal thing they can do. This is west slope cut throat habitat, but that's been eroding and going on for years, so you think we should do something about that?" And my answer, "Well, yeah, and we know how to do something."

(Slide 39) But here is what they are doing. That's a ten-yard end dump truck. And is that the solution? No. But I can't tell you how many times we see this.

(Slide 40) Another good example of stream succession, this stream is down cut, used to be a meandering low width-depth ratio on top, E stream type, down cut to a G into an F and then built a new floodplain in the bed of the old channel which is now the floodplain of the new channel.

(Slide 41) Now watch this next picture. I've taken ten steps from where I was standing, where the water was going through one big contracted opening culvert that took the flood, and this just had a flood. You can see a little bit of turbid water. This picture is downstream. This is near Ignacio, Colorado, southwestern Colorado. The results from the previous slide are because we drained everything through one pipe **[00:45:00]** and that's contraction scour, down cutting, we lowered lower base level, and had tremendous impairment in terms of sediment and fisheries just because of a stream crossing.

(Slide 42) What do we do about bank erosion, changes in riparian vegetation,

(Slide 43) the amount of sediment, and loss of habitat? You know, I go all over the country and we found some great solutions. But it's not riprap, it's not gabions, it's not concrete; it's working with the natural tendencies of rivers and trying to get riparian vegetation reestablished, but you've got to buy time with some type of structure.

(Slide 44) So what we have been doing, this is the better route. This had four major floods. This is toe wood. Toe wood is different from engineered log jams because it covers the full length of an outside bank. It's submerged wood so it doesn't rot and it's bedded back into the banks so you don't have to cable it in any way. The buoyancy effect of the wood is offset by counter-buttressing with material that you fill over the wood and those logs are like thirty- forty-foot long but basically then we put in layers of vegetation. So we have had really great success with toe wood and most people look at it and don't even know it's a structure. But there are hundreds of logs that are submerged there – unbelievable habitat. My friends with Montana Fish Wildlife and Parks have been monitoring these projects and have found unbelievable fish response, so it creates great habitat with great flow resistance all by using native materials. Most people don't even know we were there, which to me is progress.

(Slide 45) So if we again look at the use of riparian vegetation on the upper third of the bank and the lower section is the wood because then fish can utilize that and that's where we lose most of our banks at the toe. So, again, that's thousands of feet of that, if you are up around the Bitterroot River near victor Montana, that's where that is located.

(Slide 46) Nevada Creek, we had a do a multistage channel because it is below a

(Slide 47) reservoir, but then they have floods. This thing flooded after we did that work. This again utilized toe wood, created a bankfull bench and a channel within a channel. The first year after construction, the floodwaters were on the terrace. The entire valley was under water for over 30 days. We didn't replace anything. There were no logs lost, no trees lost.

So it's a stable way of helping fisheries make a better use of low flows in these impaired systems. So, again, I'm trying to show the importance of doing restoration with available limited flows and handling floods.

(Slide 48) Again, what has happened with poor diversion structures, they washed out, so what do they do, they put them back just like they were and it will happen again.

(Slide 49) So we do a lot of work on diversions that are fish friendly but yet people get their water. What we try to do with this is we have to put in a structure to be able to get a differential head to take water and get it into a diversion again with a bypass.

(Slide 50) Here is an example step-pool cross vane diversion on the Blue River. A big problem with larger diversions is that a lot of times they take too much water but 200 feet further down or sometimes half a mile, they drop that water back down in the river. So you end up with this dewatered section with minimum flows that are really problematic.

(Slide 51) So this is a step-pool cross vane with a sediment sluice on the left side. That's a gate that controls the amount of sediment that goes back to the river so it doesn't go into your diversion canal, so it controls the flow.

(Slide 52) Also you will see a bypass flow so the fish don't go back down the ditch but they go back into the river, so the debris and fish return back to the river, and again it's a controlled flow with a differential head.

If I did probably nothing else, for the rest my career, I could just go around the west and replace old pushup dams that are so cheap and a lot of diversions that have fish passage and instability problems. But again people want to get their water so we have to figure a better way of developing designs that don't adversely impact the river system.

(Slide 53) And this is a close up view of one we put up on Crystal Creek on the Heart Rock Ranch in Idaho. Again this is the bypass that brings the fish back into the stream, not into the diversion.

(Slide 54) What do you do if you fall on major floods? This was the Big Thompson in 1976. This is the same location, if you actually back that up a little, if you look at that house on the right side there is a peaked roof at that location and there's two cottonwoods right here, okay, that's just to give you an idea. That's where the north fork comes in to the big Thompson at Drake.

(Slide 55) But after that work was done, I took this picture 35 years later. That's that same roof and those are the two cottonwoods.

(Slide 56) So again what was done there—again this was away from the highway—was to make a single-thread step-pool channel, like we saw here.

(Slide 57) Again some of the problems we are finding in agriculture, we end up with a lot of gulleys and a lot of diversions that trap fish that again are down cut channels so we don't have a good water table.

(Slide 58) And so again by putting in the right diversions and trying to maintain stability, one thing we've been doing is putting the river back on top. This used to be an incised river.

(Slide 59) This is a constructed channel with toe wood and transplant vegetation. We did 13 miles of stream near Hailey Idaho, but why did we do this? Because they wanted a natural fishery, they didn't want to stock it, they wanted to have natural reproduction.

(Slide 60) But they also had 1300 acres and they had close to 40 cfs, they're flood irrigating and they lost a lot of that water, 40 cfs from the Big Wood River. And that water when it came back down it didn't even get back to the Big Wood as a return flow, so basically they had a hard time irrigating that. We put in 40 of these oxbow lakes, filled up the gullies with these continuous fills and interconnected the oxbows. Not only did that raise the water table so it had better forage production with no flood irrigation but it returned over 75% of that flow back to the Big Wood. It's also interconnected so fish can come up from the Big Wood through that system that's used for multiple purposes now legally for not only irrigation, but for forage production and hay, livestock and fisheries. So we got it legally changed, so you can have compatible use.

(Slide 61) This is one of the old channels which is an oxbow; it's good for rearing habitat as well as water **[unintelligible]**.

(Slide 62) So why do we do this? We do this because it's good for the river and it's good for the fish and it's good for us. Thank you very much.

IAN CHISHOLM: We've got time for a couple of questions if there's anyone that wants to query Dave. Come on. There you go.

SPEAKER: Do we have access to **[unintelligible]**?

IAN CHISHOLM: Yeah, I think that's going to be part of all the talks. Anyone else? Something tough now. Yeah, go ahead, could you announce -- Chris Kudrow.

SPEAKER: So **[unintelligible]**.

DAVE ROSGEN: Everybody hear that question? "We've been doing this for 50 years. Why do you have to still keep saying the same story? When are people going to actually change from some of these practices we're seeing?" That was the question. Any other questions? That's the big question. Luckily I get a few professors in my courses that they do go back and try to make a change, but institutionally a lot of the professors that are teaching in engineering were taught by their professors and they never went to the field. They just taught. They continued to teach what they were taught. Tenure is misspelled. It should be ten years of field experience so they go out and actually implement these things that don't work, they have a chance to see it and then they realize we've got to change.

I think tradition has been driving this big time in a lot of our disciplines. It's a real problem. I wish I had the best answer. I've probably trained close to 16,000 people, 40 at a time, and I know a lot of those individuals, a lot of you in the audience, and you're one of them. Have we got the message across? Yeah. But you guys may understand we have a pecking order in organizations and I've been talking to the peckees, so we have to get a hold of the bosses. In any organization, you know – and I hate going to Washington; I've had to go a few times. But, you know, we're going to have to get the message on up to those who can actually make political legal changes. And it's slow. Again, people are trained to be comfortable in what they were trained to do, and unfortunately we've got to retrain a lot of people unfortunately. Question?

DAVE ROSGEN: Okay. What happens if you try to build an oversized culvert and then try to put a bench in it? Good luck making it stay that way because of the sheer stress that comes down through with the flood takes out a lot of those depositional surfaces, so you're better to design the crossing whether you're talking about a culvert or not, to match the width-depth ratio and grade but you got to have enough free board during the flood that you don't get back water. Then you drain the floodplain. Again like the picture I showed you, you don't have to have a massive floodplain. Nice to have, but if you don't, at least if you put the next inverts at the floodplain level, then you maintain the distribution of energy, sediment transport, and fisheries and maintain that low flow and bankfull channel. But as soon as you try to oversize it and then you're trying to fit something within the culvert, ever crawled in one of those things? How am I going to keep all that stuff there? You know, it doesn't work. It's very, very difficult. Now again if it becomes that much more expensive, you may want to think about a bridge, a clear span, and we've been doing a lot of those because by the time you do this it's not that much more expensive anymore. We're getting some pretty good bridge designs that are a lot cheaper.